K717.0413-80

Declassified IAW E.O. 12958 by the
Air Force Declassification Office and
Approved for Public Release.
Date: 8-15-06

[redacted] AFCSAMI- 7002491

PROJECT CHECO SOUTHEAST ASIA REPORT

DO NOT DESTROY
30 DAY LOAN
RETURN TO SAMID
RM 1D 384 PENTAGON

13505

SPECIAL HANDLING REQUIRED
NOT RELEASABLE TO FOREIGN NATIONALS
The information contained in this document will not be disclosed to foreign nationals or their representatives

GROUP-1
Excluded from automatic downgrading and declassification.

K717.0413-80
c. 3

20080910237

02491 17002491

[redacted]

Declassified IAW E.O. 12958 by the
Air Force Declassification Office and
Approved for Public Release.
Date: 8-5-06

PROJECT
Contemporary
Historical
Examination of
Current
Operations
REPORT

SECOND GENERATION WEAPONRY IN SEA

10 SEPTEMBER 1970

HQ PACAF

Directorate, Tactical Evaluation
CHECO Division

SPECIAL HANDLING REQUIRED
NOT RELEASABLE TO
FOREIGN NATIONALS

The information contained in this document will not be disclosed to foreign nationals or their representatives.

Prepared by:

MR. MELVIN F. PORTER

Project CHECO 7th AF, DOAC

K717.0413-80

[redacted]

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

The public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing the burden, to Department of Defense, Washington Headquarters Services, Directorate for Information Operations and Reports (0704-0188), 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.
PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)	8. PERFORMING ORGANIZATION REPORT NUMBER
Department of the Air Force Headquarters Pacific Air Forces, CHECO Division Hickam AFB, HI	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT

A -- Approved for Public Release

13. SUPPLEMENTARY NOTES

14. ABSTRACT

Project CHECO was established in 1962 to document and analyze air operations in Southeast Asia. Over the years the meaning of the acronym changed several times to reflect the escalation of operations: Current Historical Evaluation of Counterinsurgency Operations, Contemporary Historical Evaluation of Combat Operations and Contemporary Historical Examination of Current Operations. Project CHECO and other U. S. Air Force Historical study programs provided the Air Force with timely and lasting corporate insights into operational, conceptual and doctrinal lessons from the war in SEA.

15. SUBJECT TERMS

CHECO reports, Vietnam War, War in Southeast Asia, Vietnam War- Aerial Operations, American

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			19b. TELEPHONE NUMBER *(Include area code)*

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS PACIFIC AIR FORCES
APO SAN FRANCISCO 96553

OFFICE OF THE CHIEF OF STAFF

PROJECT CHECO REPORTS

The counterinsurgency and unconventional warfare environment of Southeast Asia has resulted in the employment of USAF airpower to meet a multitude of requirements. The varied applications of airpower have involved the full spectrum of USAF aerospace vehicles, support equipment, and manpower. As a result, there has been an accumulation of operational data and experiences that, as a priority, must be collected, documented, and analyzed as to current and future impact upon USAF policies, concepts, and doctrine.

Fortunately, the value of collecting and documenting our SEA experiences was recognized at an early date. In 1962, Hq USAF directed CINCPACAF to establish an activity that would be primarily responsive to Air Staff requirements and direction, and would provide timely and analytical studies of USAF combat operations in SEA.

Project CHECO, an acronym for Contemporary Historical Examination of Current Operations, was established to meet this Air Staff requirement. Managed by Hq PACAF, with elements at Hq 7AF and 7AF/13AF, Project CHECO provides a scholarly, "on-going" historical examination, documentation, and reporting on USAF policies, concepts, and doctrine in PACOM. This CHECO report is part of the overall documentation and examination which is being accomplished. Along with the other CHECO publications, this is an authentic source for an assessment of the effectiveness of USAF airpower in PACOM.

ROLAND W. CAMPBELL, Major General, USAF
Chief of Staff

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS PACIFIC AIR FORCES
APO SAN FRANCISCO 96553

REPLY TO ATTN OF: DOVD

10 September 1970

SUBJECT: Project CHECO Report, "Second Generation Weaponry in SEA" (U)

TO: SEE DISTRIBUTION PAGE

1. Attached is a SECRET NOFORN document. It shall be transported, stored, safeguarded, and accounted for in accordance with applicable security directives. SPECIAL HANDLING REQUIRED, NOT RELEASABLE TO FOREIGN NATIONALS. The information contained in this document will not be disclosed to foreign nationals or their representatives. Retain or destroy in accordance with AFR 205-1. Do not return.

2. This letter does not contain classified information and may be declassified if attachment is removed from it.

FOR THE COMMANDER IN CHIEF

Maurice L. Griffith

MAURICE L. GRIFFITH, Colonel, USAF
Chief, CHECO Division
Directorate, Tactical Evaluation
DCS/Operations

1 Atch
Proj CHECO Rprt (S/NF),
10 Sep 70

DISTRIBUTION LIST

1. SECRETARY OF THE AIR FORCE

   a. SAFAA 1
   b. SAFLL 1
   c. SAFOI 2

2. HEADQUARTERS USAF

   a. AFNB. 1

   b. AFCCS
      (1) AFCCSSA 1
      (2) AFCVC 1
      (3) AFCAV 1
      (4) AFCHO 2

   c. AFCSA
      (1) AFCSAG. 1
      (2) AFCSAMI 1

   d. AFOA. 2

   e. AFIGO
      (1) OSIUAM. 3
      (2) IGS 1

   f. AFSG. 1

   g. AFNIATC 5

   h. AFAAC 1
      (1) AFACMI. 1

   i. AFODC
      (1) AFPRP 1
      (2) AFPRC 1
      (3) AFPRE 1
      (4) AFPRM 1

   j. AFPDC
      (1) AFDPXPS. 1
      (2) AFDPMD 1
      (3) AFDPW. 1

   k. AF/RD. 1
      (1) AFRDP. 1
      (2) AFRDQ. 1
      (3) AFRDQRC. 1
      (4) AFRDR. 1

   l. AFSDC
      (1) AFSLP. 1
      (2) AFSME. 1
      (3) AFSMS. 1
      (4) AFSPD. 1
      (5) AFSSS. 1
      (6) AFSTP. 1

   m. AFTAC. 1

   n. AFXO 1
      (1) AFXOD. 1
      (2) AFXODC 1
      (3) AFXODD 1
      (4) AFXODL 1
      (5) AFXOOAB. 1
      (6) AFXOSL 1
      (7) AFXOOSN. 1
      (8) AFXOOSO. 1
      (9) AFXOOSS. 1
     (10) AFXOOSV. 1
     (11) AFXOOTR. 1
     (12) AFXOOTW. 1
     (13) AFXOOTZ. 1
     (14) AFXOOCY. 1
     (15) AF/XOX 6
     (16) AFXOXXG. 3

3. MAJOR COMMAND

a. TAC

(1) HEADQUARTERS
- (a) DO. 1
- (b) DPL 2
- (c) DOCC. 1
- (d) DREA. 1
- (e) DIO 1

(2) AIR FORCES
- (a) 12AF
  - 1. DORF 1
  - 2. DI 1
- (b) T9AF(DI). 1
- (c) USAFSOF(DO) 1

(3) WINGS
- (a) 1SOW(DOI) 1
- (b) 23TFW(DOI). 1
- (c) 27TRW(DOI). 1
- (d) 33TFW(DOI). 1
- (e) 64TAW(DOI). 1
- (f) 67TRW(C). 1
- (g) 75TRW(DOI). 1
- (h) 316TAW(DOP) 1
- (i) 317TAW(EX). 1
- (j) 363TRW(DOI) 1
- (k) 464TFW(DOIN). . . . 1
- (l) 474TFW(TFOW). . . . 1
- (m) 479TFW(DOF) 1
- (n) 516TAW(DOPL). . . . 1
- (o) 4410CCTW(DOTR). . . 1
- (p) 58TAC FTR TNG WG. . 1
- (q) 4554CCTW(DOI) . . . 1

(4) TAC CENTERS, SCHOOLS
- (a) USAFTAWC(DA). . . . 2
- (b) USAFTARC(DID) . . . 2
- (c) USAFTALC(CAL) . . . 1
- (d) USAFTFWC(CRC) . . . 1
- (e) USAFAGOS(DAB-C) . . 1

b. SAC

(1) HEADQUARTERS
- (a) DOPL. 1
- (b) XPX 1
- (c) DM. 1
- (d) DI. 1
- (e) OA. 1
- (f) HO. 1

(2) AIR FORCES
- (a) 2AF(DICS) 1
- (b) 8AF(DO) 2
- (c) 15AF(DI). 1

c. MAC

(1) HEADQUARTERS
- (a) DOI 1
- (b) DOO 1
- (c) MACHO 1
- (d) MACOA 1

(2) AIR FORCES
- (a) 22AF(OCXI). 1

(3) WINGS
- (a) 61MAWg(OIN) 1
- (b) 62MAWg(OCXP). . . . 1
- (c) 436MAWg(OCXC) . . . 1
- (d) 437MAWg(OCXI) . . . 1
- (e) 438MAWg(OCXC) . . . 1

(4) MAC SERVICES
- (a) AWS(AWCHO). 1
- (b) ARRS(XO). 1
- (c) ACGS(CGO) 1

d. ADC

(1) HEADQUARTERS
(a) DO. 1
(b) DOT 1
(c) XPC 1

(2) AIR DIVISIONS
(a) 25AD(OIN) 1
(b) 29AD(ODC) 1
(c) 20AD(OIN) 1

e. ATC
(1) ATXPP-X 1

f. AFLC

(1) HEADQUARTERS
(a) XOX 1

g. AFSC

(1) HEADQUARTERS
(a) XRSG. 3
(b) SDA 1
(c) CSH 2
(d) DLXP. 1
(e) ASD(ADJT) 1
(f) ESD(ESO). 1
(g) RADC(EMOEL) 2
(h) ADTC(ADGT). 1
(i) ADTC(ADBRL-2) 1

h. USAFSS

(1) HEADQUARTERS
(a) ODC 1
(b) CHO 1

(2) SUBORDINATE UNITS
(a) Eur Scty Rgn(OPD-P) . 1
(b) 6940 Scty Wg(OOD) . . 1

i. AAC

(1) HEADQUARTERS
(a) ALDOC-A 1

j. USAFSO

(1) HEADQUARTERS
(a) CSH. 1

k. PACAF

(1) HEADQUARTERS
(a) DP 1
(b) IN 1
(c) XP 2
(d) CSH. 1
(e) DOVD 5
(f) DC 1
(g) DM 1
(h) DOVH 1

(2) AIR FORCES
(a) 5AF
1. CSH 1
2. DPL 1
(b) Det 8, ASD(DOASD). . 1
(c) 7AF
1. DO. 1
2. DIP 1
3. DPL 1
4. TACC. 1
5. DOAC. 2
(d) 13AF
1. CSH 1
2. DI. 1
(e) 7/13AF(CHECO). . . . 1

(3) AIR DIVISIONS
(a) 313AD(DOI) 1
(b) 314AD(DPL) 2
(c) 327AD
1. DO. 1
2. DI. 1
(d) 834AD(DO). 2

(4) WINGS
- (a) 8TFW(DCOA) 1
- (b) 12TFW(DCOI). 1
- (c) 35TFW(DCOI). 1
- (d) 56SOW(WHD) 1
- (e) 347TFW(DCOOT). 1
- (f) 355TFW(DCOI) 1
- (g) 366TFW(DCO). 1
- (h) 388TFW(DCO). 1
- (i) 405FW(DCOI). 1
- (j) 432TRW(DCOI) 1
- (k) 460TRW(DCOI) 1
- (l) 475TFW(DCO). 1
- (m) 1st Test Sq(A) 1

(5) OTHER UNITS
- (a) Task Force ALPHA(DXI). . 1
- (b) 504TASG(DO). 1
- (c) Air Force Advisory Gp. . 1

m. USAFE

(1) HEADQUARTERS
- (a) DOA. 1
- (b) DOLO 1
- (c) DOO. 1
- (d) XDC. 1

(2) AIR FORCES
- (a) 3AF(ODC) 2
- (b) 16AF(ODC). 2
- (c) 17AF(OID). 1

(3) WINGS
- (a) 36TFW(DCOID) 1
- (b) 50TFW(DCO) 1
- (c) 66TRW(DCOIN-T) 1
- (d) 81TRW(DCOI). 1
- (e) 401TFW(DCOI) 1
- (f) 513TAW(OID). 1

(4) GROUPS
- (a) 497RTG(TRCOD). 5

4. SEPARATE OPERATING AGENCIES
- a. ACIC(DOP). 2
- b. AFRES(XP). 2
- c. USAFA
  - 1. CMT 1
  - 2. DFH 1
- d. AU
  - 1. ACSC-SA 1
  - 2. AUL(SE)-69-108. . . . 2
  - 3. ASI(ASD-1). 1
  - 4. ASI(HOA). 2
- e. AFAFC(CEH) 1
- f. ANALYTIC SERVICES, INC . 1

5. MILITARY DEPARTMENTS, UNIFIED AND SPECIFIED COMMANDS, AND JOINT STAFFS

a. COMUSJAPAN 1
b. CINCPAC (SAG) 1
c. CINCPAC (J301) 1
d. CINCPACFLT (Code 321) 1
e. COMUSKOREA (ATTN: J-3) 1
f. COMUSMACTHAI 1
g. COMUSMACV (TSCO) 1
h. COMUSTDC (J3) 1
i. USCINCEUR (ECJB) 1
j. USCINCSO (DCC) 1
k. CINCLANT (0021) 1
l. CHIEF, NAVAL OPERATIONS 1
m. COMMANDANT, MARINE CORPS (HQMC) 1
n. CINCONAD (CHSV-M) 1
o. DEPARTMENT OF THE ARMY (TAGO) 1
p. JOINT CHIEFS OF STAFF (J3RR&A) 1
q. JSTPS 1
r. SECRETARY OF DEFENSE (OASD/SA) 1
s. CINCSTRIKE (STRJ-3) 1
t. CINCAL (HIST) 1
u. MAAG-CHINA/AF Section (MGAF-0) 1
v. HQ ALLIED FORCES NORTHERN EUROPE (U.S. DOCUMENTS OFFICE) 1
w. USMACV (MACJ031) 1

6. SCHOOLS

a. Senior USAF Representative, National War College 1
b. Senior USAF Representative, Armed Forces Staff College 1
c. Senior USAF Rep, Industrial College of the Armed Forces 1
d. Senior USAF Representative, Naval Amphibious School 1
e. Senior USAF Rep, U.S. Marine Corps Education Center 1
f. Senior USAF Representative, U.S. Naval War College 1
g. Senior USAF Representative, U.S. Army War College 1
h. Senior USAF Rep, U.S. Army C&G Staff College 1
i. Senior USAF Representative, U.S. Army Infantry School 1
j. Senior USAF Rep, U.S. Army JFK Center for Special Warfare 1
k. Senior USAF Representative, U.S. Army Field Artillery School . . 1
l. Senior USAF Representative, U.S. Liaison Office 1

7. SPECIAL

a. The RAND Corporation 1
b. U.S. Air Attache, Vientiane 1

TABLE OF CONTENTS

	Page
FOREWORD	xi
CHAPTER I - INTRODUCTION	1
CHAPTER II - FIRST OF THE EO BOMBS - WALLEYE	3
Deployment	4
Summary of Early Launches	11
Resumption of Evaluation	15
CHAPTER III - PAVE WAY I	18
The "How" of PW I	19
PAVE WAY I Deployment	21
Cost Effective Comparisons	24
Production Phase and Zero CEP	30
M-118 LGB - Bolt	38
Known Deficiencies and Projected Improvements - PW I	43
CHAPTER IV -- PAVE WAY II	49
Ironing Out Deficiencies	54
Caveat on PAVE WAY Evaluation	56
CHAPTER V SHRIKE AND STANDARD ARM MISSILES	59
AGM-78 STANDARD ARM	62
Enemy High-Threat Areas Move South	66
CHAPTER VI -- ROCKEYE II	71
Phase II Evaluation	74

FOOTNOTES

Page

Chapter II 78
Chapter III 79
Chapter IV 83
Chapter V 84
Chapter VI 86

GLOSSARY 87

FIGURES

1. (C) WALLEYE Functional Block Diagram 14
2. (C) PAVE WAY I (MK 84/KMU 351) 20
3. (C) Tactical Recon, 100 MM AA Gun 42
4. (C) Impact of PAVE WAY 42
5. (C) Revetment Reexcavated and Ammunition Cases Stockpiled 44
6. (C) Results of Direct Hit by PAVE WAY 44
7. (C) STANDARD ARM Missile with Ordnance Section 62
8. (S) AGM-78 Electronic BDA Logic and Indications 64
9. (S/NF) Estimated Active SAM Deployment (Sep 69) 66
10. (S/NF) Estimated Active SAM Deployment (Jan 70) 66
11. (S/NF) Estimated Active SAM Deployment (Mar 70) 68
12. (C) Cutaway Drawing of ROCKEYE II 72
13. (C) ROCKEYE Carriage and Function 72
14. (C) ROCKEYE Operational Sequence 72
15. (S) Phase II Evaluation 74
16. (C) Pre-Strike Photo, AAA Site 76
17. (C) Post-Strike Photo, AAA Site 76
18. (C) Tactical Reconnaissance 14 76

FOREWORD

The application of technological advances in weaponry received new impetus as a result of Southeast Asian operations. Weapons such as laser guided bombs and video guided missiles were tested, evaluated, and introduced into operational inventories with impressive results. Highlights and lessons learned since the introduction of these and other new weapons are recorded in this Project CHECO Report.

CHAPTER I

INTRODUCTION

A look at any modern munitions manual will attest to the great variety of bombs used by USAF in the Southeast Asia conflict. Big bombs (15,000 pounds), little bombs (a pound or less), and a whole spectrum in between; special purpose bombs, armor piercing, smoke, incendiary, high drag, low drag, cluster bombs, and a myriad of others are shown. Fuzes: proximity, long-delay, instantaneous, anti-tamper, anti-disturbance, electromagnetically activated, seismic activated, the list runs to hundreds. Tables on weapons effects, probabilities of target destruction, and ballistic characteristics fill shelves.

One of these characteristics which the bombs have in common: they are almost all ballistic in delivery. As has been aptly stated, they are basically "dumb bombs." Regardless of mode of delivery--visually, computerized, or radar directed--once they are released they simply follow whatever physical set of ballistic characteristics befits their peculiar aerodynamic makeup, speed, and angle of delivery at release. During their fall, they are acted upon by other (usually unprogrammed) physical factors. Primary among these are unforecast wind shear and ballistics dispersion; no two bombs are released at exactly the same microsecond, along exactly the same angle, or with exactly the same aerodynamic characteristics. A nick incurred in storage, a lug welded a few thousandths of an inch offset or a minute bend of a fin can

significantly alter the paths of individual bombs in freefall.

The war in Southeast Asia gave a hitherto unparalleled opportunity to combat test a new generation of weaponry--the "smart bomb"--the bomb that knows where it is going and actively seeks its target. This report addresses this new weapons generation. It will stress the introduction, use and evaluation of PAVE WAY I laser guided bombs, the MK-1 Mod 0 WALL-EYE and PAVE WAY II electro-optical (EO) series of bombs, the anti-radiation AGM-45 SHRIKE missile and its greatly improved and larger counterpart, the AGM-78 STANDARD ARM. The ROCKEYE II, which falls ballistically but operates either as a shaped charge or a fragmentation bomblet depending upon impact resistance, is also covered. All these weapons, although previously tested at various centers in CONUS, received their baptism of fire in the combat areas of Southeast Asia, and it is their introduction by USAF in this theater that is documented in this report.

CHAPTER II

FIRST OF THE EO BOMBS - WALLEYE

The first of the new "smart bombs" operationally employed by the USAF in Southeast Asia was the MK 1 Mod 0 WALLEYE, initially designated the AGM-62. Developed at China Lake Naval Ordnance Test Center, Calif., the WALLEYE was a glide, air-to-surface weapon with an automatic tracking electro-optical TV guidance system for use against targets visually acquired and identified. Produced at a cost between $31,500 and $39,500 (depending upon the Mark/Mod number and production series), the WALLEYE weighed approximately 1,125 pounds assembled, with a warhead weighing 829 pounds and a total explosive component of 435 pounds. The warhead was an eight-point linear shaped charge (LSC) which provided two kill mechanisms: radial cutting action caused by extremely high velocity jets of molten metal, and a follow-on blast effect.[1/]

The WALLEYE was comprised of three sections--guidance, warhead, and control. The most sophisticated section was the guidance unit, consisting of a television camera with a gyro-stabilized vidicon and associated circuitry. Once locked on to the pilot-selected target, it automatically tracked that surface object while generating the control signals required to guide the weapon to a Circular Error Probable (CEP) of 15 feet.[2/]

From its inception, the WALLEYE was most suitable against hard and semihard targets such as thermal power plants, POL tank areas, and railroad and highway bridges--which the jet cutting action often weakened so

that structures collapsed of their own weight. Targets which produced heavy shadows or sharp intersecting lines of contrast were best suited for AGM-62 strikes, and included such targets as railroad tunnels and caves with well-defined entrances. The control section equipment accepted signals from the guidance section, translating them into commands to wing-fins to keep the missile on target, and since guidance became automatic once the WALLEYE was locked-on and launched, the pilot was free to take evasive action, a significant "plus" in an AAA, SAM, or MIG area.

Deployment

Under the nickname COMBAT EAGLE, Tactical Air Command deployed six modified F-4D aircraft and eight WALLEYE-qualified crews to Ubon Royal Thai Air Base, Thailand, for combat evaluation of the weapon/aircraft system in July 1967. It was originally intended to have the evaluation conducted for a period of 60 days with not less than 50 effective sorties flown.[3/] The primary objective of the team was to identify the most effective parameters of the system (in tactics, logistics, and maintenance), as well as any deficiencies.

The first tactical strike by the COMBAT EAGLE team was launched on 24 August 1967 against the Quang Khe ferry crossing in North Vietnam, with the primary target a concrete pier. Two AGM-62s were launched from approximately five miles away (a slant range of 40,000 feet) and both impacted on target. A large section of the pier was blown out, and a 50-foot barge was sunk when both missiles hit in virtually the same spot on the pier next to where the barge was moored.[4/]

[redacted]

Six days later, a flight of four F-4Ds, Spitfire Flight, attacked the Long Khap Highway Bridge, a 380-foot long, four-span steel and concrete bridge. Spitfire One and Two rolled in, acquired their target visually and on their video scopes, and after locking on, launched one missile each from a slant range of approximately 21,000 feet. One missile impacted on the center span and pier, dropping three spans of the bridge. The second slid over and hit a tree approximately 100 feet beyond. Since Spitfire One and Two had already accomplished their missions, the remaining two aircraft returned their ordnance to Ubon.[5/]

No further flights were made until 17 September when Spitfire Flight again returned to North Vietnam, this time to attack the That Khe Highway Bridge over the Song Ky Cung River, in Route Package VI-A. Its rather spectacular results illustrated how accurate and effective the system could be. This bridge, on North Vietnamese highway Route 4, was made of steel beam construction and earth abutments, and was 620 feet long by 24 feet wide. Spitfire's lead element made simultaneous launches from approximately six miles out, in a 25-degree dive angle at Mach .9. Both missiles hit the first pier north of the center of the bridge, while a third WALLEYE fired by Spitfire Four impacted at the pier on the north shoreline. The center span of the bridge dropped into the river; the north end of the center truss dropped immediately, while the south end hung momentarily, and then the entire truss of the span fell into the river. Spitfire Three could not maintain a lock-on and retained his ordnance.[6/]

[redacted]

On 19 September, Hudson Flight struck the Lang Con Railroad Bridge northwest of Hanoi. This bridge was of concrete and steel truss construction with concrete piers and abutments, approximately 158 feet long by 14 feet wide, and was attacked during relatively poor weather conditions (6 to 8,000-ft. overcast). The first missile exploded in the truss work and appeared to do considerable damage. The second impacted on the northwest pier. Although no post-strike photography was available and the rails remained intact, the strike crews estimated the superstructure and pier damage rendered the Lang Con Bridge unserviceable.[7/]

These initial strikes were directed against relatively low-threat areas so that all launch requirements could be satisfied with a minimum of risk. On the next mission on 3 October, however, Hudson Flight ran into their first significant defensive reaction on their run in to strike the East Cau Bang Highway Bridge. A flight of MIGs was called out by warning agencies and Hudson made a diversionary turn in their direction. The MIGs apparently broke off the intercept, then made another attempt as the flight turned back toward the target; however, the diversion caused by the turn left the enemy either too far out or too short of fuel and the MIGs returned to base. Hudson continued on to the target.[8/]

The East Cau Bang Bridge spanned the Bang Giang River at Cau Bang, 68 NM northeast of Thai Nguyen. It supported traffic on NVN Route 3J/4K, through Cau Bang, Bac Kan, Thai Nguyen, and down to the Hanoi area. Interdiction of it, or a similar bridge one-half mile west, would force traffic to reroute over longer and less desirable road systems. The

east bridge appeared to have piers and abutments of concrete, and probably a concrete deck. It was of single deck construction, approximately 200 feet by 16 feet. The west bridge had concrete piers and earth abutments, 390 feet by 12 feet.[9/]

Although the flight encountered light 37-mm antiaircraft fire over the target, three passes were made to drop the bridge. Neither Lead nor Hudson 02 could get a release because of malfunctions, so the Number Three aircraft rolled in and fired from approximately two and one-half miles out. The missile impacted squarely on the center pier, dropping the second span from the western shore.[10/]

Five days later, Harpoon Flight returned to Cau Bang to take out the west bridge, also with one missile. A direct hit on the third span from the west dropped both ends of it into the water. With ordnance remaining, the flight proceeded to their alternate target, the Bac Kan storage facility. On this strike only a few miles away, Harpoon 03 and 04 rolled in, positioning themselves for simultaneous releases at a group of eight warehouse type buildings. Number Three launched his weapon on the first pass, the missile hitting directly on the aiming point between the first two rows of buildings, destroying four of them and damaging the other four. A ball of flame about 100 feet high flared up, lasting four or five seconds before it subsided. Number Four could not acquire the target and retained his WALLEYE for return to base (RTB), as did Harpoon Lead. The flight leader reasoned that because of the extended time they

had spent in the vicinity of the two targets, and the damage inflicted by 03's weapon, it would not be necessary for 04 to expend; accordingly, he elected to return to Ubon.[11/]

A few of the deficiencies (and eccentricities) of the AGM-62 appeared on the next mission on 17 October against the Lang Son Railroad Bridge. Neither Olds 01 nor 02 could maintain a lock on this 240-foot long concrete structure. Both aircraft achieved several lock-ons; however, in each instance the weapon lock would run off the aim point to one side of the bridge or the other, all the way to the shoreline and then lock on to the shore. Olds 03 and 04 had much the same difficulty. They eventually got lock-ons that apparently were holding, but after they released, both weapons broke lock and ran to shore. This was accounted for only by the fact that the bridge was too symmetrical, both in structure and in light/dark contrast, and the weapons could not find a contrast point to hold on for a lock.[12/]

The first determined ground reaction came on a 23 October mission fragged for two bridges over the Song Thuong Be River. Harpoon Lead's target was the On Highway Bridge; Harpoon 02 was to attack the Lang Dang Railroad Bridge. Intelligence had briefed for heavy 37-mm, 57-mm and 85-mm antiaircraft fire, and for possible MIG intercept. The briefing turned out to be accurate except that the MIGs did not make an appearance. It was assumed Harpoon 02 would have difficulty locating his target, and if this proved true, he was to attack the On Bridge with Harpoon Lead.[13/]

After refueling over the Tonkin Gulf, Harpoon Flight simulated a photo recon pass that ran down the NE railroad, across Hanoi and out the west side of North Vietnam. Approaching the target area, the flight began picking up flak, and when 01 and 02 began their runs the antiaircraft fire became very heavy, forcing Lead to delay his lock-on. Both aircraft expended on the On Bridge, a wooden structure, 100 feet by 15 feet. Lead's weapon sailed over his target and impacted on a small bridge 100 feet north, destroying it. The Number Two pilot scored a direct hit on the On Bridge, which disintegrated, throwing debris a hundred feet in the air. The flight rejoined and egressed successfully. No losses were incurred from the heavy flak, but it did have the effect of making target video acquisition and lock-on more difficult.[14/]

It was apparent that sharp target contrast was a critical factor in maintaining a high success rate with the WALLEYE. As a result, nearly all missions were fragged for late morning or afternoon flights when sun angles were favorable for sharp shadows and good contrast. Even this was insufficient when there was inherently poor contrast between the target and its background. On 22 October, Hudson Flight aborted a strike on the Lang Nac Railroad Bridge because of poor contrast, when repeated passes failed to get a lock-on to the bridge. The mission commander made the decision not to attack his alternate target because of its being located in similar or worse terrain, and all four aircraft returned to base with their weapons unexpended.[15/]

On succeeding missions, other difficulties manifested themselves; among them, weather and flak made target acquisition difficult, lock shifts occurred in the weapon, and in one case, there was a tumbling missile. When a flight of four attacked the Lang Dang Railroad Bridge on 5 November, Lead's missile impacted 15 feet short, leaving the span intact. Number Two and Number Four could not attain lock, and Number Three's master arm switch was turned off.[16/]

On 6 November, Olds Flight was fragged for the Lang Bun and Lang Con Bridges on the northwest railroad. As the flight approached the primary target (Lang Bun), they observed that a 6,500-foot overcast obscured it, while the secondary target (Lang Con) was visible. The second element, Olds 03 and 04, attacked this bridge, while the lead element performed Combat Air Patrol (CAP). Only one aircraft was to release on this pass, and his WALLEYE impacted directly in the center of the bridge. The crew estimated that the bridge was unserviceable, although the rails still appeared to cross the stream. Upon rejoining, Lead noticed a hole in the overcast over Lang Bun, and leaving the second element to CAP for him, he dropped down to attack it. The weapon passed over the bridge and impacted approximately 20 to 50 feet beyond it. The crew had an excellent picture, and although they had to press in close because of poor target/background contrast, they were certain they had a good lock upon release, and were "sure" of a direct hit. The only explanation for the overshoot appeared to be the lack of good definition between the bridge and the background.[17/]

A restrike on Lang Bun was attempted two days later by Buick Flight,

still with unsatisfactory results. Number Two's missile hit approximately ten feet short without apparent target damage. Lead's WALLEYE released normally, but after three to five seconds it was seen to pitch up about 15 degrees, to begin oscillating and then tumbling. About two-thirds of the way to the target, it pitched down and impacted about 1,000 feet short of the bridge.[18/] The flight proceeded to their first alternate, the Ban Cho Highway Bridge. Here Buick 03 and 04 rolled in, with both assigned to the target. Upon taking his eyes off the element leader on the run in, Number Four observed a bridge directly ahead, and since it looked like the assigned bridge, he locked on and released. In reality, the bridge he hit was the Ban Thai Oum Bridge, a causeway over two dams, and it apparently did not suffer significant damage. The narrow field of vision in the scope, the nearness of the targets to each other, and the similarity of appearance between them were the cause of the misidentification. Number Three made three runs at the Ban Cho Bridge, but when he could not attain satisfactory lock-ons, he returned to base with his weapon.[19/]

Summary of Early Launches

This late rash of unsatisfactory launches and attempts to launch did not alter the fact that--when all went favorably--the WALLEYE/F-4D combination was a devastatingly effective weapons system. Through 8 November, 14 targets had been struck and 22 missiles launched. Thirteen WALLEYEs hit their target, two were near misses and caused possible damage, and seven missed. Of those targets struck, six bridges were

destroyed, two were damaged, and one received possible damage from a near miss. Four buildings were destroyed and four damaged; one pier was damaged and a barge sunk.[20/]

The early targets were hand-picked for good contrast and light defenses, and for the most part, were struck during periods of excellent weather. Later, WALLEYEs were used against targets of higher priority, which took the flights into more heavily defended areas and against targets not selected primarily for sharp contrast but for tactical importance. These and other factors, such as worsening weather conditions in the north, tended to degrade strike effectiveness.[21/]

No AGM-62 missions were flown between 8 November 1967 and 18 January 1968; during this time, planners worked to assess the program, especially with a view toward identifying those deficiencies which tended to degrade effectiveness.[22/] Some of these deficiencies were readily apparent from design data alone. Since the WALLEYE used a TV guidance system, it was susceptible to the same things that might confuse or hinder human vision--especially camouflage--or interposition of some screen such as smoke, dust, or clouds. The WALLEYE's field of vision was far narrower than that of the human eye and having once lost its target might not reacquire it. Its guidance function involved discriminating between light-dark contrast around the aiming point at lock-on; therefore it could be "fooled" by too much symmetry. If, for example, a bridge had a series of trusses with identical configuration, the guidance system might select one after another,

attempting to lock on the "best" without finding it, and so run to the shoreline. High contrast decoy targets placed in the vicinity of intended primary targets could conceivably lure the WALLEYE from its pre-launch track, and simple camouflage could remove contrast to the point where the guidance system would not achieve lock-on at all.[23/]

Other deficiencies were not inherent but were simply problems involving the state of the art. One problem area lay in providing satisfactory displays in the aircraft cockpits without jeopardizing other systems and capabilities. A missile design compatible with the supersonic capabilities of the carrying-aircraft was considered highly desirable, and the U.S. Navy was in a continuing program to develop improvements which would allow supersonic carriage and launch.[24/]

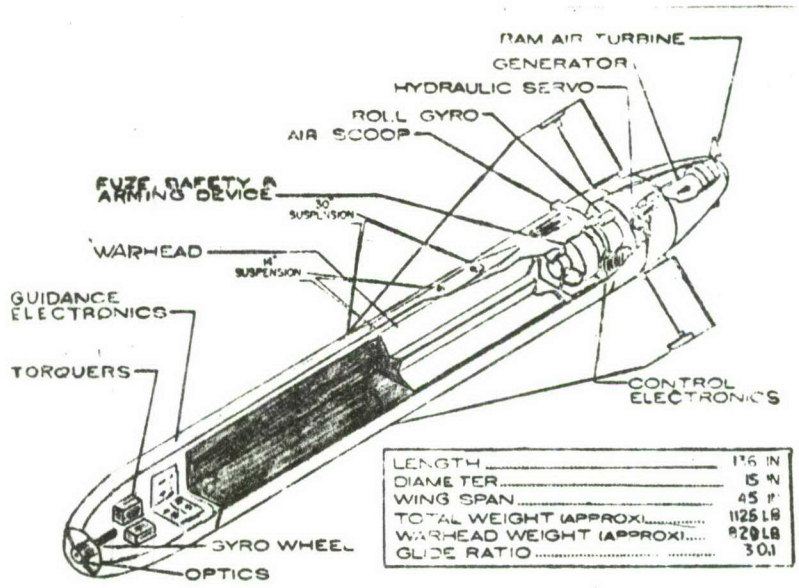
The greatest advantage of the WALLEYE was its pinpoint accuracy--well within the stated 15-foot CEP when launch and target parameters were favorable--which provided reduced aircraft exposure for insured target destruction. The AGM-62 standoff capability also reduced risk to those aircraft exposed in a strike. Average launches were released at a slant range of around 22,000 feet from target at altitudes averaging above 8,500 feet above ground level--a distinct survival plus--well above small arms and automatic weapons fire. No aircraft were lost in the first three months of USAF WALLEYE evaluation.[25/]

Other advantages accruing to the F-4D/WALLEYE combination lay in the capability of the aircraft to carry other stores (ALQ-71/QRC-160,

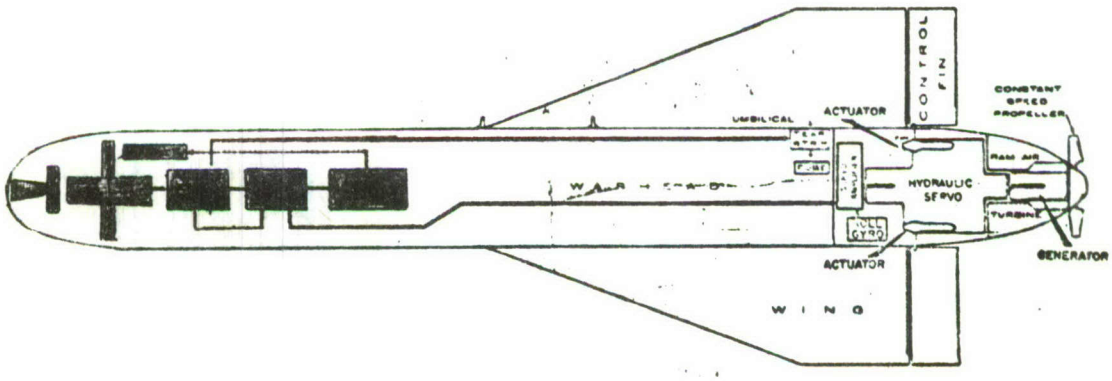
AIM 4, 7, and 9 missiles, and SUU-23 pods) without serious degradation of aircraft performance except for the Mach .9 limitation on WALLEYE carriage--and when it was released, the aircraft was in immediate CAP configuration.

Aircrews believed the two-man concept of the F-4D constituted a definite advantage in technique for use of the AGM-62. After visually acquiring and identifying his target, the aircraft commander placed it under his gunsight pipper. This allowed him to keep his head up out of the cockpit and, since the weapon was in boresight mode, place the target near the center of the video display. The Guy in Back (GIB) then located and identified the target on his display and aligned it in the "gate" (four intersecting lines constituting a 2.6 mil look-angle in the center of the display, within which the missile tracked upon release), and locked-on. After lock-on, and while the aircraft was in the delivery envelope, the aircraft commander verified the target on his display and assumed the lock in the front seat. After his launch, the pilot was free of any requirement to guide it visually and he could take whatever evasive action was deemed necessary. The weapon continued to "home" on the area of greatest contrast within the 2.6 mil tracking gate. The flexibility of the weapon/airframe combination allowed electronic countermeasures (ECM) pod formation to be flown up to, and even during, simultaneous launch; or, if outside SAM threat areas, a fluid four formation could be flown for better MIG defense.[26/] (Fig. 1 shows schematic

CONFIDENTIAL



WALLEYE
FIGURE 1



WALLEYE FUNCTIONAL BLOCK DIAGRAM

FIGURE 1

CONFIDENTIAL

diagram of the WALLEYE glide bomb.)

Resumption of Evaluation

After the two-month period of inactivity, WALLEYE operations were resumed on 18 January 1968, with an attack against one of North Vietnam's most strongly defended targets, the Bac Giang Thermal Power Plant, well within the SAM ring and about 22 NM northeast of Hanoi on the northeast railroad. The mission was fragged as a coordinated attack on this lucrative target. Four AGM-62 strike aircraft were to be supported by four F-105F IRON HAND SAM killers, four F-4D flak suppressors, and two F-4D MIG CAP aircraft. The WALLEYE-carrying aircraft used pod formation to give overlapping ECM protection from their ALQ-71 pods during roll-in and final attack, planning for a simultaneous release of four weapons. The IRON HAND F-105s were to fire AGM-45 SHRIKE missiles at FAN SONG (SAM) or FIRE CAN (heavy AAA) radars as they came up, while the flak suppression aircraft were to expend CBU-24 and CBU-29 on active anti-aircraft installations.[27/]

Otter Flight, carrying the WALLEYEs, came under a coordinated SAM attack from the moment of roll-in and, from that time until release, had a steady SAM launch indication. Two SAMs were observed to detonate below and to the rear of the flight. Just prior to planned release, at least four MIG-17s attacked Otter Flight. Otter 03 and 04 had lock-ons at the time, so they released and turned into the MIGs. Four seconds later, Lead and Otter 02 also launched and turned to engage the MIGs.

During the ensuing battle and egress, Otter 02 was shot down in the target area (cause unknown, but probably by MIGs). Panda Flight observed Otter Lead chasing a MIG-17, but in turn, Otter Lead had a MIG on his tail. Panda saw Otter Lead fire an air-to-air missile which went up the MIG tailpipe and detonated; the MIG crashed with no parachutes observed. Otter Lead, however, was damaged in the running fight and the crew was forced to eject about 20 miles from the target area, with two good chutes seen and good beepers heard. Throughout the attack and subsequent air-to-air battle, heavy 37, 57, and 85-mm antiaircraft fire covered the area. Target damage was unknown at the time, but was photographed on 24 February 1968, at which time the facility appeared to be intact and operational.[28/]

Until the bombing halt, Ubon F-4Ds with WALLEYEs continued to launch strikes in North Vietnam and against validated targets in Laos since that time. The weapons system, even with its known limitations, showed great promise for the future. Improved displays were developed, designed to greatly improve viewing contrast between target and background, especially in poor lighting conditions.[29/]

Even as evaluation of the WALLEYE missile was reaching completion with the weapon being placed into normal operational status, work on the first of the PAVE WAY series of bombs was nearly finished. It was designed to modify ordinary "iron bombs" into "smart bombs," using either the Laser Guided Bomb (LGB) system or the WALLEYE-Proved Electro-Optical system. The 435th Tactical Fighter Squadron (TFS) at Ubon

continued to use the WALLEYE when targeting indicated it could be successfully employed, as against caves, uncamouflaged bridges, and other high contrast targets. Advantages of the AGM-62s of long standoff launch range and freedom for pilots' "launch and leave" maneuvering, were well known and relied upon.

Typically successful WALLEYE missions were flown throughout 1968 and 1969. One such included a sortie against an NVA/Pathet Lao cave in northeast Laos near Route 912, a well-traveled infiltration route, on 3 October 1969. The pilot visually acquired the target at 20,000 feet slant range, attained video lock-on at 18,000 feet, and launched the weapon at 16,000. Although the small size of the cave mouth required several dry passes to get satisfactory lock-on, the missile guided perfectly, impacted dead center, and completely destroyed the cave. 30/

The disadvantages of the WALLEYE, however, were equally well known. The high cost of the missile compared to iron bombs, the necessity for extensive pre-strike targeting, and even the time of day for proper shadow contrast made the PAVE WAY I laser guided bomb particularly attractive to planners. This follow-on weapon was not prone to the limitations that made WALLEYE targeting so restrictive. WALLEYE-fragged missions were being flown at the rate of approximately four a month by late 1969.

CHAPTER III

PAVE WAY I

At the time WALLEYE was introduced into the SEA conflict, the Southeast Asia Operational Requirement (SEAOR) 100, 30 March 1967, had already established the need for a laser guided weapon to provide accurate weapons delivery from standoff distances.[1/] The AGM-62 could provide significant standoff capability of about 40,000 feet slant range. Once launched, the weapon freed the delivery aircraft for evasive action or for acquisition of other targets, a notable improvement over the AGM-12 BULLPUP which required the pilot to remain locked-on to the target until weapon impact. The WALLEYE, however, was suitable only to high contrast targets and was impractical at night, which limited its application.

A need existed for a guided bomb requiring no specific target features, only a view of the target unrestricted by weather. Ideally, an entirely new weapons system would not have to be developed. Stocks of existing general purpose (GP) bombs could be modified using the guidance system from the AGM-45 SHRIKE, along with the laser illuminator/seeker units being developed. Based upon this, SEAOR authority was received in July 1967 for development of the laser modification equipment for the MK 84 2,000-pound and the M-117 750-pound bombs, with a proposed CEP of 40 feet as the design goal. The PAVE WAY task force, a joint Air Force Systems Command/Tactical Air Command group, was organized in August 1967

at Eglin AFB, Florida, where the weapon and its tactics were subsequently developed.[2/]

The "How" of PW I

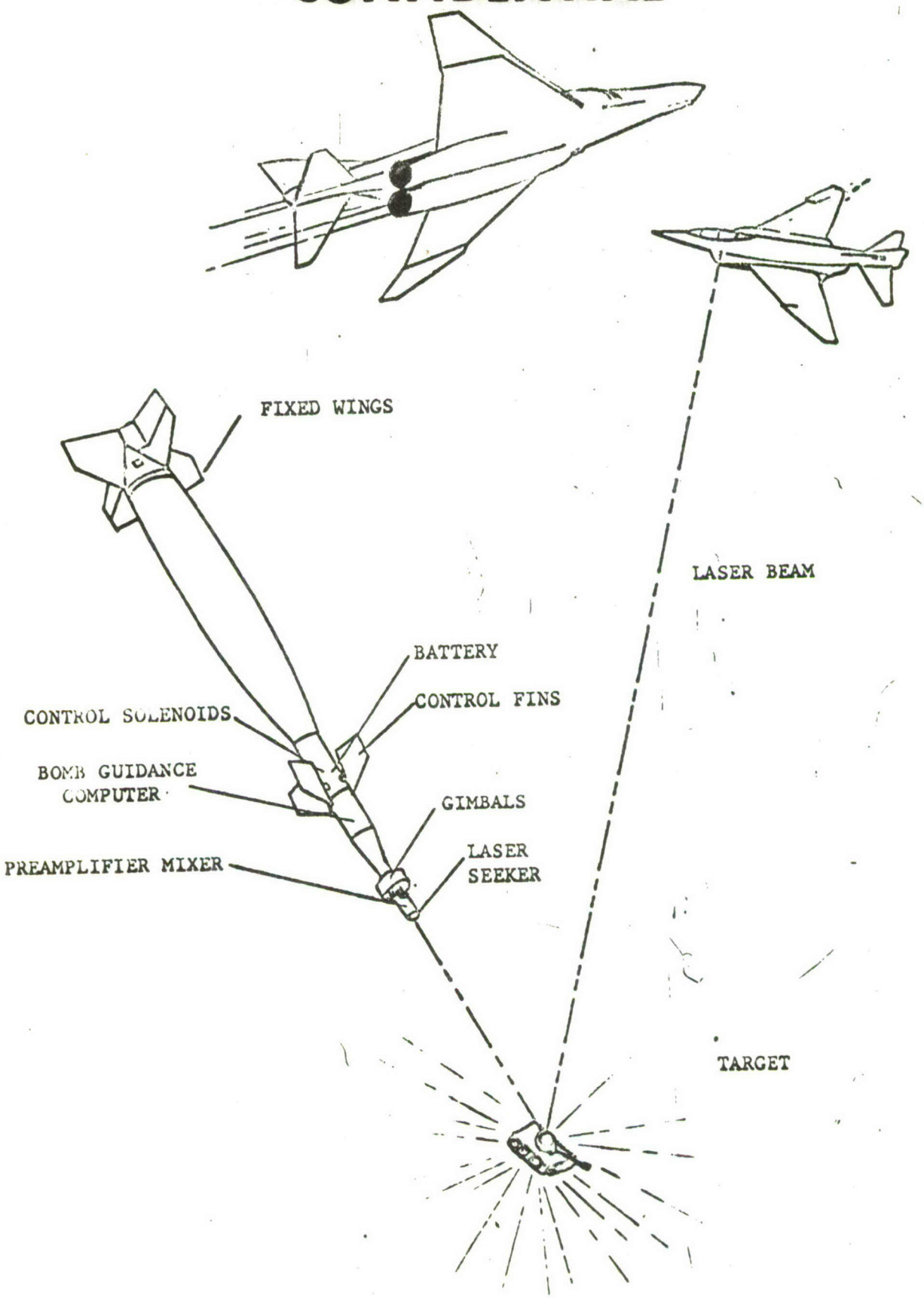
The value of the PAVE WAY (PW) I system came about from the mating of three subsystems (two of which were already in the Air Force ordnance inventories) to produce a relatively low cost guided bomb without going through the expensive and time-consuming research and development of an entirely new weapon. The most used PW I through late 1968 and all of 1969 consisted of the MK-84 GP bomb (a long-standing inventory item, already proved reliable, rugged, and capable of producing great cratering, blast, and fragmentation effects), an AGM-45 SHRIKE control activator (also in the inventory and proved reliable), and the KMU 351/B laser seeker.[3/]

In operation, the target was illuminated by a designator--a laser "gun" located in a companion aircraft. Also prominent in developmental work is a system utilizing the bombing aircraft itself for necessary illumination. The seeker looked at this narrow spectral band, usually at the 1.06 micron wavelength generated by the laser (either the neodymium yttrium aluminum garnet (YAG) or the glass laser commonly used in the designator), and created an offset position error if the flight of the bomb did not coincide with the target line of sight. The seeker depended only upon reflected energy at the proper wavelength, rejecting ambient or incidental spectra, such as fires and flares, and ignoring

target characteristics such as contrast and temperature.[4/]

Having "found" its illuminated aiming point, the seeker attempted to keep the target centered at the intersection of its four-quadrant silicon detector. Through adapted plumbing for the SHRIKE missile control system, the seeker activated canard fins which directed the bomb toward its target. The movable fins operated in an "on-off" fashion, either fully deflected or released to return to the slip-stream as directed by the seeker unit. The fins made the flight of the bomb what aircrews described as an undulating glide rather than a smooth continuous arc toward the target.[5/] To compensate for the abrupt moments of force imposed by the canard controls, augmented roll stabilization fins were attached to the MK-84 body. (Fig. 2)

When properly aimed, the designator served as a "link" between the PAVE WAY pilot and the target, and thus the laser largely diminished pilot errors in weapons delivery, inaccurate weapon release mechanisms, and unpredictable ballistics characteristics which previously contributed to large circular error probabilities in freefall ordnance delivery. With all systems operating properly, pilots found their aiming point was infinitely less critical than with visual bombings, because it was necessary only to drop the bomb into a large conically shaped "basket" whose apex was at the target. If the bomb were released at 10,000-12,000 feet, the diameter of the cone at the point where bomb guidance started was roughly one mile across. Once inside the cone, the bomb could begin



PAVE WAY I (MK 84/KMU 351)

FIGURE 2

aerodynamic maneuvering toward the 1.06 micron reflection on the ground illuminated by the designator.[6/]

PAVE WAY I Deployment

The deployment of a combat implementation and evaluation group to the 8th Tactical Fighter Wing at Ubon, Thailand, originally scheduled for April 1968, began in May of that year and continued into August. The plan authorized the delivery of approximately 107 weapons (59 M-117 and 48 MK-84 bombs) for evaluation purposes. Primary evaluation data were to be provided by aircrew debriefings and inflight recordings, with photographic backup to be used when available. In the final report, however, all scores presented were photo confirmed during combat operations. With the 433d TFS acting as the project squadron, the initial evaluation showed a CEP of 45 feet for the M-117 laser guided bombs and a CEP of 20 feet for the MK-84. Only those weapons which guided were included in the accuracy data; bombs which did not guide were considered ballistic. These figures were based upon a small data base, but as shown from the complete 1969 data, they were not unrealistic and were actually quite conservative.[7/]

The formal combat test and evaluation of the PAVE WAY I LGB (M-117/KMU-342B and MK-84/KMU 351B, respectively) was terminated at Ubon on 8 August 1968, with the final determination that the system was operationally suitable and effective for use in Laos and in NVN Route Package I combat environments. All bombs in the evaluation program were released between 10,000 and 12,000 feet above ground level (AGL) in a 40-to-50-degree dive using direct mode of release at 450 knots calibrated

airspeed. The evaluation took place in Route Package I exclusively, against generally light to moderate 37/57-mm AAA defenses. Neither extensive 85/100-mm antiaircraft artillery nor SAM defenses were encountered and no battle damage or combat losses were incurred.[8/]

Thirty-five M-117/KMU 342Bs were released during the evaluation, but two of the impacts could not be identified by either KB-18 strike camera photography or RF-4 post-strike reconnaissance and were deleted from the CEA/CEP statistics. Of the remaining 33 bombs, eight were gross errors introduced through improper crew procedures, and three bombs were unguided because of guidance system malfunctions. Computing only those released which did not involve personnel errors or KMU kit malfunctions, the CEA/CEP for the 750-lb. laser guided bomb worked out to 65/45 feet.[9/]

The MK-84 2,000-pound bomb with the KMU 351B seeker kit fared better in the test and evaluation program. Thirty-one were dropped with two being excluded from the evaluation, one for an airburst at fuze arming safe separation time and the other unguided because of an aircraft pylon malfunction. Eight gross errors occurred. Two were the result of personnel procedure and six suffered guidance malfunction or failure. For the remaining 21 bombs, the CEA/CEP was shown to be 32/20 feet, well within design criteria.[10/]

For several reasons, it was recommended that the M-117 PAVE WAY program be discontinued when the stock of available kits was expended.

The M-117 was equipped with tail fin controls, and this configuration was apparently not as accurate as the canard configuration on the nose of the MK-84. In addition, the M-117 was a thinner skinned bomb, less effective for cratering or penetration. It had a tendency for bomb break-up and low order detonation upon impact when fuzed in the delay mode.

The MK-84 was more accurate, could withstand impact shock well, and could penetrate deeply enough for its 946-pound warhead to gouge out a significantly larger crater. (In medium soil, for example, the MK-84 could blast a 49-foot wide, 13-foot deep crater, as opposed to the M-117's 35-foot wide, seven-foot deep crater.)[11/] This took on added significance inasmuch as the bulk of PAVE WAY targets during the period were roads, where the size of the crater could make the difference between complete interdiction and merely causing one way traffic for the period it took for repairs. This was often the case. On balance, the rationale boiled down to this: if a target was worth assigning a guided bomb--with its expensive seeker head, guidance and control equipment--then cost effectiveness alone dictated that it be mated to a heavier, all-purpose and more accurate bomb.[12/]

The possibilities for additional uses of laser guided bombs were already beginning to be envisioned. At various times, it was suggested that C-130 Blindbat aircraft carry a designator, that O-2 FACs use it, that a single ship concept be developed wherein an F-4 with a pylon-hung movable designator pod be carried, that the B-57G align an illuminator

with its Night Observation Device (NOD) to deliver MK-82/KMU 388B bombs, and that the A-1 be certified to carry the PW I MK-84 because of long loiter time. The PAVE WAY I system was also programmed to use the M-118/KMU 370B 3,000-lb. bomb for greater blast effect. Simultaneously, the entire PAVE WAY guided bomb concept was expanded to include the PW II and PW III--Electro-Optical and Infrared seekers. All of these possibilities were the subject of much message traffic through 1968 and 1969. Some were adopted; others were discarded on one basis or another. One thing was clear: if the ultimate purpose was the destruction of a point target, the guided bomb had become an operational reality.

Cost Effective Comparisons

Disregarding such area targets as truck parks, storage areas, and enemy base camps, it was soon apparent that improved accuracy would be likely to have high payoffs in cost effectiveness. Immediately following the initial evaluation of PAVE WAY I M-117s and MK-84s in 1968, the 7AF Directorate of Tactical Analysis published a report titled "PAVE WAY Utility and Cost Effectiveness in SEA."

Prior to this, Hq USAF, AFGOA, had prepared a cost effectiveness report on guided weapons based in part on WALLEYE use in Southeast Asia and stateside evaluation of the PAVE WAY system (AFGOA 68-1). The Seventh Air Force Directorate of Tactical Analysis continued cost effective studies on PAVE WAY use. Because of different criteria and evaluation parameters, findings in the various reports differ in some respects. One

study used the unit cost of early "hand-made" MK-84 PAVE WAY bombs ($7,080 according to AFGOA Report 68-1) and another, the cost of the 1970 production model ($5,839/7AF DOA). There were differences in targets and target areas used, and loss rates were based on 1967 operations in the North Vietnam Route Packages rather than those experienced in the STEEL TIGER areas of Laos in 1969 and 1970. Taken within their time frames and criteria for analysis, each of the studies is valid, and each showed the value of the guided weapon against lucrative point targets.

The 1968 7AF DOA report, based upon the small initial sample and using CEA/CEP figures, which since improved spectacularly, showed that for specific point targets, more than 20 times as many targets could be hit using PW I laser guided bombs than could be hit using 750-pound free-fall bombs in the same number of sorties. PAVE WAY would also be cheaper in dollar cost and involve fewer losses than the other systems compared. Taking into consideration the many variables involved the comparative effectiveness of hitting such a target as a 10-ft. by 100-ft. bridge with the different systems was dramatically portrayed.[15/] Some variables were airframe attrition, crew loss (there were no combat losses during the tests), hour-cost of flying, systems reliability, refueling, weapons and ground support, weapons effects, and ballistics.

[redacted]

Hitting 10' by 100' Target

Weapon	Sorties Required to Get 50% Probability of Hitting Tgt	Dollar Cost to Get 50% Probability of Hitting Tgt
MK-84 LGB	2 Bomber passes 2 Bombs per pass 1 Illuminator	$ 71,000
MK-84 Freefall Delivered in pairs	191	3,180,000
M-117 LGB	7 1/2 Bomber sorties 7 1/2 Illuminators	420,000
M-117 Freefall Delivered gps of 6	64	1,082,000
WALLEYE	2 1/2 (5 weapons) 5 passes	112,620
AGM-12C BULLPUP	9 1/2 (19 passes)	268,000

With improved accuracy following the initial evaluation (therefore increased probability of hitting the target per sortie), the illustrated contrast between LGB effectiveness and that of free fall delivery would be even greater.

Another interesting highlight in the report also showed the value of the standoff capability of the smart bomb system. With the ability to release ordnance at 10,000 feet or higher (within limits accuracy actually improved with higher altitudes), the necessity for descending into the high-threat, low-altitude regions was largely removed. As a result, there were no F-4/PW I losses during the period of the report. At the time of the evaluation, the largest percentage of antiaircraft

[redacted]

[redacted]

defense in Laos and Route Package I, where all deliveries took place, consisted of small arms, automatic weapons, and 37/57-mm AAA.[16/]

If a return to the heavier AAA and SAM threat areas were made, this of course would not be the case. The theater loss rate for F-4 attack missions in Route Packages I through VI from 1 October 1967 through 31 March 1968 was 2.64 per thousand sorties, of which about 1.68 were attributable to ground fire and the rest to SAMs, MIGs, and unknown causes. With the proved standoff capability of the PW I delivery, the risk from ground fire would be greatly reduced. An estimated loss rate of 1.87 per 1,000 sorties was predicted for PAVE WAY missions should a return to the heavily defended North Vietnamese heartland take place.[17/] As small as these figures might appear, per one thousand sorties, when speaking of a two-and-a-half-million-dollar aircraft and crew, and of the added sorties the "saved" aircraft could accomplish, the improved rate takes on added importance. At the estimated difference in loss rates, the PAVE WAY F-4 could be expected to accomplish 156 more missions in the high-threat areas before aircraft attrition than its counterpart with free fall munitions.[18/]

The foregoing was not meant to disparage the use and efficacy of general purpose freefall bombing. An area target such as a canopy covered truck park not only would not need, but could not use single bomb pinpoint accuracy. In similar situations, the ballistic dispersion and overlapping effect of many bombs over a wide range dictated free-

[redacted]

fall delivery. The guided bomb was intended for, and came into its own against, point targets.

The previous illustration showing cost effectiveness against a 10-ft. by 100-ft. bridge was but one of many possible targets for PAVE WAY munitions. Among others were strong points, AAA positions, vehicles, buildings, and lines of communications (LOCs) such as roads and railroads. On-going analysis by 7AF DOA through March 1970 showed interesting comparisons in cost effectiveness, particularly against two of these types of targets, AAA positions and LOCs. The AAA figures represented actual experience gained from the expenditure of 322 PAVE WAYs, and from 1,366 sorties delivering general purpose bombs and CBUs.[19/] The cost figures included variable cost per flying hour, expenses of maintenance and ground support. They did not include those costs associated with aerial refueling, any aircraft losses or SAR expenses, or prorated costs of the laser installation. Cost comparisons of PAVE WAY versus conventional weaponry (MK-82 500-pound bombs and CBU) for the two target types show the following:[20/]

CONVENTIONAL	PAVE WAY
AAA	AAA
5.08 Sorties per gun destroyed	1.48 Sorties per gun destroyed
$1,662 Flying cost per sortie	$1,662 Flying cost per sortie
$5,950 Weapons cost per sortie	$11,678 Weapons cost per sortie
$7,612 Total sortie cost	$13,340 Total sortie cost
Times 5.08 Sorties	Times 1.48 Sorties
$38,650 Per AAA destroyed	$19,700 Per AAA destroyed

It was less expensive to destroy antiaircraft artillery with PAVE WAY munitions. With LOCs, however, the reverse turned out to be true: 21/

LOCs CUT	LOCs CUT
3.08 Sorties per cut	1.15 Sorties per cut
$1,662 Flying cost per sortie	$1,662 Flying cost per sortie
$2,460 Munitions cost (12 MK-82)	$11,678 Weapons cost per sortie
$4,122 Total sortie cost	$13,340 Total sortie cost
Times 3.08 Sorties	Times 1.15 Sorties
$12,700 Per LOC cut	$15,360 Per LOC cut

It could be easy from much of the foregoing to consider the guided bomb a panacea; however, the latter figures (LOC cuts) showed this was not always the case. PAVE WAY was an important addition to the weapons options available to strike planners. A specific given segment of a road (such as a bridge) might be an ideal target for PAVE WAY, but roads, railroads, trails, and bypasses were not point targets, and as such

favored freefall delivery of general purpose bombs.

Production Phase and Zero CEP

As crews gained more proficiency and weapons entered the production phase, PAVE WAY I CEPs shrank to a figure rarely encountered in previous weapons. The MK-84 PAVE WAY had been designed for a 40-foot CEP and most people would have been more than happy with any figure less than that. Yet from the beginning of operational use of the production model, CEAs were almost as good as the CEP criteria, and CEPs diminished to zero.

Forty-two deliveries of MK-84 laser guided bombs during December 1968 and January 1969 (confirmed by photographic BDA) showed a 65-foot CEA and a CEP of zero. Twenty-six of the 42 bombs were scored as direct hits, which by definition meant that "Zero" was the minimum radial distance within which 50 percent or more of the weapons impacted.[21/]

Under PACAF Manual 55-25, data on the weapon system accuracy continued to be reported. There were 184 impacts observed on KB-18 strike film between 11 January 1969 and 16 July 1969. The average miss distance was 17 feet; the CEP remained at zero. These impacts accounted for approximately one quarter of the total MK-84 guided bombs delivered during the period. Ideal delivery parameters appeared to be 440 to 460 knots (106 deliveries with a 5-foot CEA) at a 50-degree dive angle (34 deliveries with an 8 foot CEA), at an altitude between 10,000 and 12,000 feet above ground level (123 deliveries with CEAs between six and ten feet).[22/]

But these figures do not fully illustrate the value of PAVE WAY deliveries in actual operations. The month of September 1969--a typical month for PW I deliveries--more clearly depicts the use and value derived from the smart bomb concept in terms of results accomplished. On 1 September, Banyan Flight, three F-4Ds of the 433d TFS at Ubon, released six weapons at four separate targets in Laos, including a bridge and three different caves. Two weapons were launched at the bridge, both scoring direct hits and collapsing it. Each of the weapons launched at the cave mouths also scored direct hits, and all three caves were destroyed. Scores for the day were: six releases, six guided weapons, six direct hits, and all four targets destroyed.[23/]

Of four releases made by Honda Flight on 6 September, two were reported as direct hits, one was 15 feet long at one o'clock and one was five feet at ten o'clock. The BDA was one road cut, one ford cut, one bridge destroyed, and one results not observed (RNO).[24/]

On 8 September, Cadillac Flight launched three MK-84 PAVE WAYs at a cave in the karst south of Mu Gia Pass. One bomb hit 50 feet wide at nine o'clock, and the others were direct hits. The BDA report showed the cave was only damaged, but peripheral bomb damage included four structures destroyed and one large sustained secondary fire.[25/]

Cadillac Flight worked again on 9 and 10 September, releasing nine bombs, scoring five direct hits, three within 20 feet and one at 300 feet. The 300-foot overshoot fell unguided and therefore was not

evaluated in the scoring. The BDA for the two days included one bridge destroyed, one ford cut, four roads interdicted, and one road partially cut.[26] The method for determining whether a PAVE WAY was unguided was to drop ordinary ballistic MK-82s simultaneously with the PW release. If the PAVE WAY impacted with the MK-82 500-pound bombs, it was considered ballistic and unguided, and was not evaluated for accuracy with the guided bombs. Ballistic PAVE WAYs were, however, entered into the "reliability" statistics. If the PAVE WAY impacted on target and separate from the MK-82s, it was considered guided. If it impacted separately from the MK-82 bombs but definitely off-target, it was considered partially guided and was entered into the accuracy evaluation.[27]

The PAVE WAY strikes in September continued in much the same manner, ending with eight bombs being expended on the 30th. Of the eight, six were direct hits, one was ten feet off at 12 o'clock, and one impacted 30 feet away under partial guide. Two cave targets were damaged and possibly destroyed, while a bulldozer took two direct hits and was totally demolished. September had only five no-guides, three for equipment malfunction and two unknown.[28] The box score for the month was as follows:

PW I DEL'D	DIRECT HITS	PERCENT DIR HITS	SYSTEM* RELY-%	SYSTEM** PERF-%	SYSTEM# EFFECT-%	CEA-FEET	CEP-FEET
88	47	53	94	82	88	11.4	0

The BDA for September PW I strikes included 33 road cuts, six road slides, six fords destroyed, two bulldozers destroyed, one military vehicle destroyed, three bridges destroyed, four caves destroyed, four caves damaged, and four military structures destroyed.[29/]

For the year 1969, a summary of day MK-84/KMU 351B releases showed the increased accuracy and increased use of the lasser guided bomb. There was also a significant change in targeting as the AAA threat in strike areas in Laos became more pronounced and the PAVE WAY began to be used in an AAA suppression role.[30/]

* System Reliability - Percent derived from ratio of guided weapons to unguided weapons.

** System Performance - Percent of guided weapons which impacted within 20 feet of target/aimpoint (crater radius).

\# System Effectiveness - Percent of guided weapons vs number of weapons which inflicted target damage, i.e., BDA.

[redacted]

1969	REL	DIR HITS	% DIR HITS	UNGUIDE	% RELY	CEA-FT	CEP-FT
JAN	35	20	60.6	2	94.3	33.0	0
FEB	40	29	72.5	1	97.5	8.7	0
MAR	76	45	75.0	16	78.9	20.0	0
APR	204	140	77.7	24	88.2	6.0	0
MAY	199	117	58.9	43	78.4	--*	0
JUN	116	67	58.0	18	80.0	9.7	0
JUL	60	36	60.0	8	84.6	6.2	0
AUG	166	88	53.0	29	79.0	4.7	0
SEP	88	47	53.0	5	94.0	11.4	0
OCT	111	56	52.0	24	85.2	10.0	0
NOV	238	130	54.6	38	83.6	7.8	0
DEC	268	148	55.2	47	79.0	8.0	0
TOTALS	1,601	923	60.9	255	85.2	--	0

The Circular Error Average for the year, based on overall summaries (including but not breaking out the month of May), was 9.55 feet, with gross errors (unguided) not counted. With a CEA well within the lethal

* CEA figures not available for May.

[redacted]

radius of the MK-84 bomb, it would be expected that bomb damage assessment should be impressive, and such was the case. Of the 1,346 weapons scored as guided, 1,015 registered BDA, for a 75.4 effectiveness rating.

Total MK-84/KMU-351B BDA for the year was as follows:[31/]

Road cuts	582
Ford cuts	181
Bridges destroyed	11
Caves	41
AAA sites dest/dam	87
Trucks destroyed	22
Bulldozers destroyed	21
POL pipelines cut	18
Secondary expl/fires	29
Mil structures dest	20
Stored supplies	2
Docks destroyed	1

Roads and fords constituted the majority of the targets for 1969, but a noticeable swing toward AAA destruction took place during the last two months of the year. Through October, only eight AAA/automatic weapons positions had been hit. In November, 19 were hit, and in December 51 were reported destroyed and 9 damaged. Three of the guns killed were 57-mm, a formidable threat to air operations in Laos.[32/]

The effectiveness of the MK-84 PAVE WAY against AAA positions was attributed to two factors. One was the weapon's capability of being released from the outer limits of the antiaircraft gun's effective range with accuracy. The other was that the blast effect of the 2,000-pound bomb was sufficient to silence the weapon with a near miss and totally destroy it with a direct hit.[33] Perhaps one of the toughest tests the PAVE WAY concept faced was during the dramatic "Rescue at Ban Phanop" in which a crewmember of a downed F-4, Boxer 22 Bravo, was rescued after 51 hours in hostile territory.[34] The survivor was at the bottom of a river valley in northeastern Laos. In a towering karst (limestone) outcropping overlooking him, several caves protected 57-mm, 37-mm, and 23-mm guns which posed a constant threat to the search and rescue (SAR) effort. In two days, 20 PAVE WAYs were launched against the gun positions and "contributed immeasurably to the rescue of Boxer 22B."[35]

In the near-impenetrable karst, nothing short of a bomb inside the mouth of the cave could destroy the guns, but as the survivor later said:[36]

> *"...There were all sorts of heavies. The PAVE WAYs knocked out the gun to the east of me--due east. The big problem was--the way they described the karst was that it was scalloped along the bottom--every foot was a cave just scalloped. The second day with the PAVE WAYs they didn't hit the gun but they knocked the mountain down in front of it...but it wasn't enough though and they /the enemy/ were able to take the gun out and set it 20 or 30 feet away in another similar position. And the 57 site itself took three days of everything to knock it out....When the PAVE WAYs would hit, it would physically throw me into the air about two inches--a beautiful feeling!"*

It was an accepted axiom that the most difficult target to destroy in a war of this type had proved to be tube artillery. Usually AAA was found to be effectively revetted, and anything other than a direct hit did not harm the weapon. A near miss could silence it by incapacitating the crew or even by knocking the weapon over, but a new crew could set the piece back in position and start to fire it again within minutes or hours. Even a hit on the outside bank of the revetment ten feet from the tube usually did little to damage the tube, merely covering it with dirt and debris and silencing it for a few hours.

A weapon frequently used for AAA suppression was one or another of the CBU family--primarily the CBU-24--which substituted pinpoint accuracy for a multitude of small bomblets on the probability that one or more of them would fall within the gunpit itself. Although the bomblets were effective against personnel and light vehicles, the guns themselves were virtually invulnerable to the relatively small fragments. "Suppressed" or "silenced" were the words generally used in the BDA reports. With increased usage of PAVE WAY, however, the word "destroyed" became more prominent in post-mission reports. Bombs were actually hitting on or in the revetments, and guns could realistically be reported as "killed."[37/]

The saga of the destruction of such a weapon; the finding, a near miss, and the eventual direct hit by a PAVE WAY bomb are told in the following section, on the M-118 laser guided bomb. It was an important

kill because the AAA involved was the NVN 100-mm antiaircraft tube, and it shows the difficulties involved in actually destroying such artillery.

M-118 LGB - Bolt

In an effort to further expand capabilities of the laser guided bomb concept, Headquarters USAF directed a Southeast Asia combat evaluation of the M-118 LGB, with its guidelines supplied by the Tactical Air Warfare Center (TAWC) Supplement to TAC OPlan 9, October 1969, and the Seventh Air Force OpOrd 534-70 of 15 October 1969.[38/]

The M-118--largest bomb in normal use in the SEA conflict--carried the nomenclature of a 3,000-pound demolition bomb (3,020 lbs. loaded weight) of which 1,888 pounds consisted of Tritonal explosive, nearly twice that of the MK-84. A light-cased bomb, it was considered primarily to be used as a blast weapon, not for cratering, since with any delay in the fuze, the bomb would break up prior to fuze delay expiration.[39/]

The M-118 showed excellent blast effectiveness against military vehicles such as tanks, bulldozers, and trucks, and also against storage areas and truck parks, where its high radius of lethal overpressures created damage beyond capabilities of the MK-84. An example of this was demonstrated when an M-118 hit one of two trucks parked on opposite sides of a road. The only parts identifiable following the strikes were three tires. A third truck parked 50 feet away was blown completely over and, although still identifiable, was considered destroyed.[40/]

Fifteen M-118/KMU 370B bombs were evaluated between 15 October 1969 and 9 November 1969 with successful results. Tactics did not differ from

those used in MK-84/KMU 351B delivery; however, because of the few kits available, bombs were released only in suitable weather conditions--the majority of them from 12,000 feet--to allow for maximum guidance time. In addition, special store loadings were defined to keep center of gravity limits within those prescribed for the F-4D when carrying the heavier weapons.[41/]

Pilots and crews of the same squadron (433d TFS) conducted the evaluation, so that no extensive training and familiarization problems were involved. A flight of four aircraft usually made up the LGB teams, plus illuminator aircraft. Two F-4Ds, each loaded with one M-118/KMU 370B on each inboard pylon, comprised the strike team. The other two F-4s were for flak suppression and photo chase. The PAVE WAYs were delivered from a 45° angle dive at 12,000 feet AGL, with the illuminator aircraft flying a standard designator pattern, also at 12,000 feet. A wide selection of targets was struck, with BDA documentation provided by KB-18 strike cameras, photo chase aircraft, and whenever possible, by poststrike RF-4 reconnaissance flights.[42/] The first mission took place on 15 October.

The first day's strikes were not spectacular. Four Bolt M-118s were released and recorded impact points of 20 feet at 12 o'clock, five feet at 9 o'clock, 20 feet at 9 o'clock, and one direct hit on a tractor-trailer. The BDA was better, however, than the circular errors would have indicated: one ford approach cut, a road undercut, a truck

damaged, with the road partially cut, and the tractor-trailer destroyed.[43]

On 16 October, two bombs were released, one scoring a direct hit and cutting a road. The other, directed at a ford, went unguided when a cloud drifted between the illuminator aircraft and the target. The bomb hit 135 feet away at 8 o'clock and cut the road leading to the ford.[44]

Four days later, Bigot 3 launched two M-118 PAVE WAYs at a bulldozer discovered about 20 miles northwest of Tchepone, Laos, near the junction of Routes 911 and 91. On his first pass, the bomb was observed to impact 10 to 15 feet short, severely damaging the bulldozer and completely denuding the target area of vegetation. With his comeback pass on a reciprocal heading, Bigot 3 scored a direct hit on the bulldozer, totally destroying it, as recorded by post-strike, low-level KB-18 strike camera passes.[45]

A bulldozer was also the target on 24 October, again in northeastern Laos. The first weapon was misdirected off the bulldozer and onto a roadside bunker into which it impacted squarely, also cutting the road. The second bomb was perfectly guided, scoring a 0/0 on the bulldozer.[46]

On 25 October, four PAVE WAY M-118s were launched, two at a bridge and two at a cave opening. The first scored a direct hit, destroying one section of the bridge. The second, also aimed at the bridge, had a mid-air collision with one of the MK-82 spotter bombs and went unguided.

The first of two bombs directed at the cave proceeded 20 feet wide at 3 o'clock and started a secondary POL fire; the second scored a direct hit but total damages could not be observed. The cave front, however, was cleared of all trees and undergrowth.[47/]

The last of the 15 bombs used in the evaluation was not expended until 9 November when it was used against a 37-mm AAA position. It made a perfect hit, destroying the gun and the site to wrap up the evaluation.[48/]

The summary for the M-118/KMU 370B evaluation was comparable to known scores for the MK-84 PAVE WAY:[49/]

REL WPN	DIR HIT	% DIR HITS	NON GUIDE	SYST RELY-%	SYST PERF-%	SYST EFF-%	CEA FT	CEP FT
15	8	57.0	2	86.7	100	100	5	0

Among recommendations made after the evaluation were two which were operationally significant.[50/] The M-118 LGB should be used on a selective basis against such targets as AAA sites, vehicles, known truck park storage areas, and targets vulnerable to the high blast and overpressure characteristics of the 3,000-pound demolition bomb. The production of M-118 LGB KMU 370A/B kits should be increased from 90 to 100 kits per month as soon as possible. Amplifying the first of these recommendations, the 8th Tactical Fighter Wing suggested that "...the recent increase in AAA reactions will probably lead to the employment of the M-118L against AAA sites. It is expected that this weapon will be highly effective against these targets."[51/]

A pictorial drama verifying the validity of the suggestion began on 23 October 1969 when a film frame from a photo reconnaissance mission revealed the existence of a 100-mm AAA gun two and a half miles southwest of the Ban Karai Pass, one of the most heavily traveled infiltration routes from North Vietnam into Laos. The weapon was deeply revetted and well masked by surrounding vegetation and, with its effective range approaching 40,000 feet, posed a definite threat to U.S. interdiction efforts along Route 912.[52/] The area was surrounded by towering karst, making the selection of run-in headings difficult, and the undeniable power of the gun emphasized the old axiom: "Don't get into a spitting contest with antiaircraft guns!" Nonetheless, it was necessary that the heavy AAA weapon be neutralized. (Fig. 3)

The first strike was placed on the site on 13 November 1969, using the Bolt M-118. The PAVE WAY impacted 13 to 14 feet from the rim of the revetment, and the site was silenced, the gunpit filled with debris, and the surrounding area stripped of foliage for a hundred feet. The revetment wall, however, provided sufficient protection so that the gun remained intact. (Fig. 4)

Subsequent photography revealed no attempts to reactivate the site, and the position seemed abandoned; accordingly, for several weeks no restrikes were planned. Photography on 12 January 1970, however, showed that not only had the revetment been reexcavated, and the debris removed, but ammunition cases had been stockpiled nearby. The decision was made


"TAC RECCE"
100 MM AAA GUN
2.5 NM SW BAN KARAI PASS
23 OCT 69 APRX TOT: 1130H
UEYT 507Q FRAME: 81RLS
171539N1060908E
6884

FIGURE 3



FIGURE 4

[redacted]

to make another PAVE WAY strike. (Fig. 5)

The second Bolt M-118 was launched on 22 January and scored a direct hit. Post-strike photography showed the revetment had been nearly obliterated, the gun carriage was blown out of the pit, and the tube blasted about 50 feet away. (Fig. 6) The photograph showed rare and incontrovertible evidence of the destruction, and provided evidence of the potentiality of the M-118 Laser Guided Bomb for AAA killing.

Known Deficiencies and Projected Improvements - PW I

Excluding normal logistics and maintenance deficiencies associated with "debugging" of any new weapon, a few operational deficiencies appeared to be inherent with PAVE WAY I delivery and its operational capabilities. Chief among them was weather. Since the designator aircraft had to illuminate the target, and the seeker unit had to "see" the reflected energy, clouds between either the designator and the seeker or the target broke the link between them and the bomb went ballistic. Even haze could diffuse the laser beam to the point that the seeker unit could not detect it.

One partial solution came in the form of long-range navigation (LORAN) bombing into the basket. If the illuminator aircraft could get below the clouds to designate the target, it was possible for the bomb-carrying F-4 to release by LORAN, the bomb commencing guidance after it was in a position to pick up the laser reflection.

[redacted]

The LORAN approach to making effective LGB release was incorporated into the night bombing program in STEEL TIGER and BARREL ROLL. Laser designators installed in Blind Bat C-130s illuminated targets with success approaching that of day delivery, and results were encouraging even though weather conditions prevented employment of LGBs on a wider scale. Between November 1969 and January 1970, 21 road cuts, four ford approach cuts, and a bridge approach cut were effected through Blind Bat/ F-4D laser guided bomb teams working at night. Three of these were dropped using the F-4D LORAN system and all three were direct hits.[53/]

A second drawback to the LGB system involved the necessity for a second aircraft to do the target designating, thereby exposing two aircraft instead of one. Even though no PAVE WAY I F-4s had been lost since inception of the program, a self-contained illumination system would insure a significantly low-loss rate in the event of the enemy's introduction of heavy AAA and SAMs into the operational areas. Developmental work was proceeding on a pod-mounted, gimbal designator which could rotate in sufficient elevation and azimuth that the bombing aircraft could acquire, illuminate, and release on its own targets. The new designator would also assure greater productivity because every aircraft over a strike zone would have attack capability and not be restricted to the illuminator function alone. Steps were already being taken to increase this productivity. As more illuminators came into the inventory, productivity was increased by scheduling three aircraft flights, of which two were designator-equipped and also carried PW I bombs. In this way, after

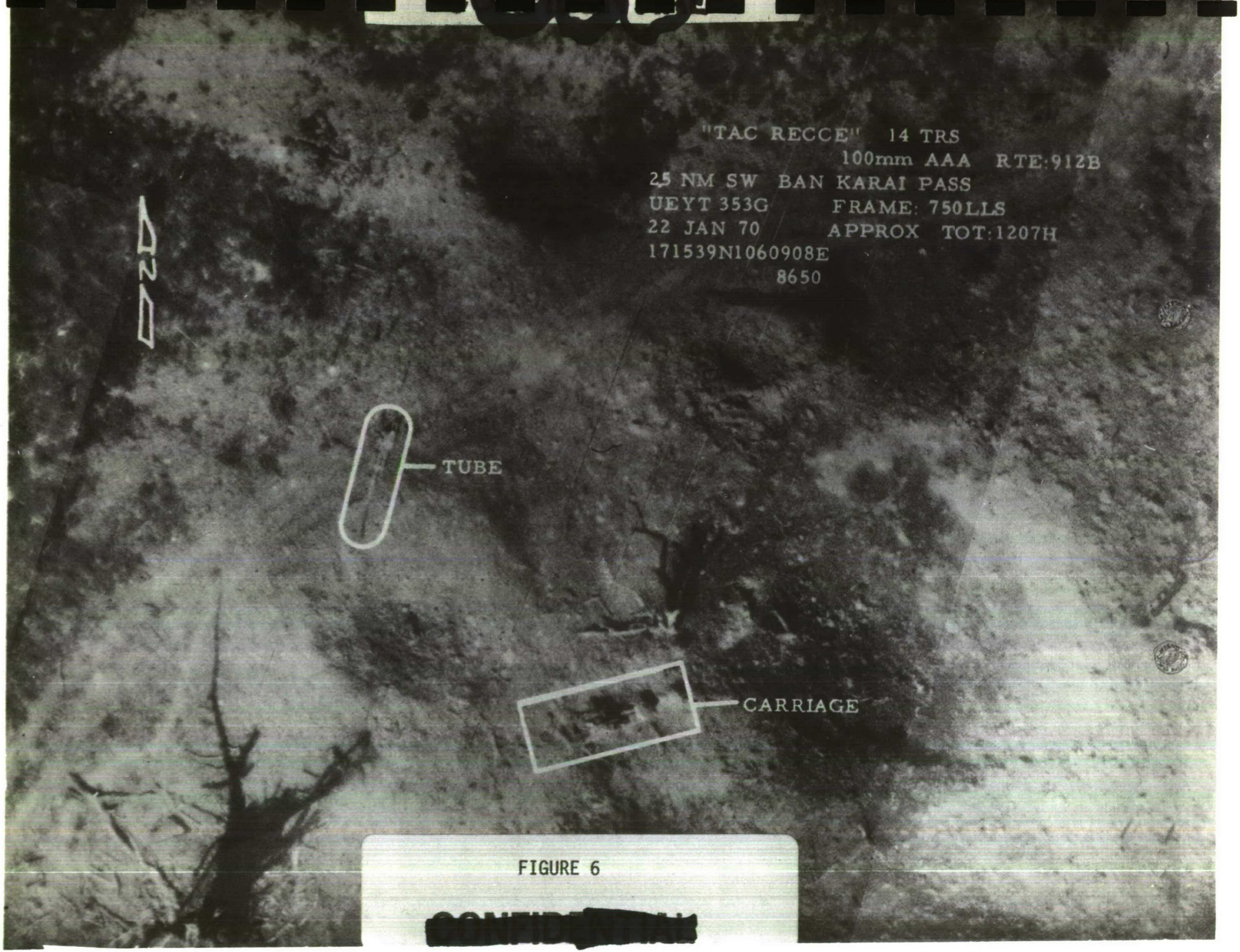

"TAC RECCE" 14 TRS
100mm AAA RTE:912B
25 NM SW BAN KARAI PASS
UEYT 353G FRAME: 750LLS
22 JAN 70 APPROX TOT:1207H
171539N1060908E
8650
TUBE
CARRIAGE

FIGURE 6



FIGURE 5

[redacted]

the first strike was made, the designator aircraft could illuminate further targets for each other. There were even tests of combination detector/illuminators, tying in the laser designator with Low-Light-Level TV (LLLTV), Starlight Scopes, and other detectors for self-illuminated night work.[54/]

There was an attempt to get one promising combination of airframe/detector/designator/bombing systems, the TROPIC MOON III program, into SEA operations as rapidly as possible. The B-57G long-loiter jet bomber was configured with multi-sensor equipment--LLLTV, Forward Looking Radar, Forward Looking Infrared (FLIR), tied in with laser illuminator/range-finders and carrying MK-82/KMU 388B bombs for nighttime missions. The possibilities for combinations of several sophisticated aircraft/detector/computer/seeker systems were being thoroughly explored in CONUS and Southeast Asia.[55/]

In the process of improving the sophistication of systems, however, unsuspected problems were encountered. The new YAG laser target designators (LTD), employing a .5 mil rather than a 1.0 mil beam but having increased power, arrived at Ubon and were operational by 15 January 1970.[56/] It had been anticipated that guidance accuracy and systems reliability (percent of guided to unguided bombs) would improve, but the January unguided rate, using both systems, was among the highest on record. Of 225 MK-84 day PW I releases, 54 failed to guide, giving a systems reliability of 79 percent. Far worse was that of the M-118 PAVE WAY: of

[redacted]

15 releases, seven did not guide, for a reliability rate of only 57 percent, of the eight which did guide, however, all were O/O--direct hits.[57]

After the January 1970 results, the 8th TFW noted with concern that CEAs and CEPs were higher, although much of the increase was attributed to weather conditions, new aircrew training, and the fact that enemy gun positions were being more expertly camouflaged. It did appear, though, that overall performance of the new designator was being degraded, and the Wing requested technical assistance to study the laser pattern characteristics of the new LTD and see if there were any discrepancies in the seeker heads themselves.[58]

Although they used the same delivery parameters as with the old illuminator, the users did not consider the results satisfactory. In a message from the 8th Tactical Fighter Wing to Hq 7AF, the 8th Tactical Fighter Wing posed several questions about the new system. In part, the message read:[59]

> *"Since the incorporation of the new laser target designators (LTD) a greater number of 20-to-30-foot misses have been noted against AAA sites than were previously obtained, and two-thirds of the unguided bombs have been against AAA sites as well. Some concern has been expressed as to whether the new laser beam divergence of .5 mil as opposed to 1.0 mil for the old LTD is responsible for different laser pattern characteristics, i.e., is the energy trapped in the pit, does camouflage or the geometry of the gun emplacements themselves tend to deform the reflected laser energy, or does the increased power of the new LTD cause the seeker head to be saturated for short periods of time?*

"Request any technical assistance that can be provided in regard to these questions. Recommend tests be conducted on typical 23-mm, 37-mm, and 57-mm gun emplacements to determine the effect of the .5 mil pattern on these pinpoint targets."

One anomaly suggested an immediate possible fix in tactical use. While the number of no-guides against AAA emplacements increased, the new laser gun provided outstanding results against roads and road segments, which indicated a difference in reflection characteristics between the two types of targets.[60/] At normal delivery parameters of 12,000 feet and about 17,000 feet slant range, the YAG beam would develop a reflected light spot on the ground of approximately eight feet, while the laser glass rod would give a reflection of about twice that size. It was considered conceivable that the narrow beam of the YAG designator, if accurately directed into a revetted gun position, might reflect very little energy, and that which was reflected could come back out in a generally vertical cone shape, leaving the delivery aircraft with an inadequate basket into which to place the bomb.[61/]

It was recommended that the laser designator operators be directed to designate the edge of the AAA revetments rather than the center of the pit.[62/] It was later suggested that since most of the no-guides fell short, probably from gravitational forces, the beam should be directed against the far edge of the revetment rather than the near bank.[63/]

Further, the 8th Tactical Fighter Wing planned to increase the beam size of the new illuminator to 1.0 mil to see if this improved accuracy. They evaluated different illumination altitudes to determine the effect

[redacted]

on delivery accuracy. The 8th TFW had already requested a visual scope with greater magnification than the currently used four-power eyepiece, and Aerospace Systems Development (ASD) pursued the development of a zoom lens which would aid in finding, identifying, and designating pinpoint targets.[64/]

Pending further evaluation and testing, it was believed that none of these interim fixes and tactics was necessarily conclusive. CINCPACAF directed continuing efforts to improve PW I reliability and also requested that a full shop test console and personnel be airlifted to Ubon as soon as possible, so that 100 percent checkout of laser guidance kits could be performed.[65/]

Whether through changes in tactics, improved equipment reliability, or aircrew proficiency, systems reliability improved during February and March. System reliability for the MK-84 PW I rose to 85 percent in March, while the M-118 PAVE WAY came up to an acceptable 80 percent.[66/]

[redacted]

[redacted]

CHAPTER IV

PAVE WAY II

Chief competitor, if it could be called a competitor, to the laser guided bombing system was the contrast TV seeker incorporated into PAVE WAY II. Critics of the laser guided PAVE WAY bombs contended that someone must continually illuminate the target after weapon delivery, thus denying the USAF the launch-and-leave capability it desired (and which it had only in WALLEYE and in anti-radiation missiles such as SHRIKE (AGM-45) and STANDARD ARM (AGM-78). The contrast seeker, as employed in PAVE WAY II, restored that capability since it homed on target contrast after release, allowing aircraft to depart the area or search for new targets. Laser proponents argued that the contrast seeker was less likely to acquire a target or remain locked-on after release. As it turned out, there was room for both weapons in the target spectrum in Southeast Asia.

In November 1968, Maj. Gen. George B. Simler, in a letter to Maj. Gen. Gordon F. Blood, then DCS/Operations, Seventh Air Force, mentioned his views on electro-optical (contrast TV) guided ordnance. He said:[1/]

> *"...I agree that the Laotian targets offer fewer opportunities for the sharp definition and bulk of bridge/building type targets found in NVN. However, after having flown the WALLEYE EO system in an F-4D in Florida and having seen the improvement in the 5" focal length lens and smaller range gate of the MK-84 EO bomb, I believe there are targets in Laos against which the usefulness and accuracy of EO weapons can be demonstrated."*

[redacted]

After listing several targets such as the Ban Laboy Ford, Ban Ta Boua Laboui Highway Ford, and Ban Phanop vulnerable highway segment, he added:[2]

> *"Because of the potential of this system, I urge you to use it adroitly. Have someone do some intensive work on target study, best light and contrast (shadow) analysis, etc. The system has great potential for TAC air, especially in regard to increased delivery precision, standoff release altitude, and consequent smaller force requirements in a high-threat area."*

Deployment of the PAVE WAY Det II to SEA was scheduled for 15 January 1969, with arrival at Ubon to take place on 16 January. The deployment was successfully accomplished by MAC C-141, which arrived at Ubon on 17 January. Immediately, work was begun to build up the MK-84 KMU 353B seeker kits for the first captive flights and initial launches.[3] After the first checkout captive flights on 28 January proved highly successful, the unit attempted actual drops beginning on 7 February 1969. In this evaluation phase, the first attempt returned to base at Ubon with the weapon because of a release malfunction and low fuel.[4] On 8 February 1969, the first successful launches were made on a ford and causeway about four miles from Route 12 in Laos (UTM Coords WE 08532328), and the pilots estimated impacts at 25 feet, 8 o'clock, and 60 feet at 6 o'clock. Actual BDA awaited post-strike photo interpretation. During these early launches, the three-inch lens was used and the releases were not considered part of the formal evaluation of the system.[5]

The third release of PAVE WAY II took place the next day, 9 February 1969, and achieved a direct hit, cratering a highway ford at WE 76952570, two miles south of the intersection of Routes 23 and 911 in North STEEL TIGER. Moderate AAA was predicted but none was observed; the target was acquired at an altitude of 15,000 feet, lock-on at 12,000 feet, and the slant range at release was 18,900 feet. This strike was also made with the three-inch lens system, but demonstrated the potential in the PAVE WAY II concept. The 435th TFS conducted the strikes because of its familiarity with the WALLEYE system.[6/]

Release number four was almost a carbon copy of the third launch and again registered a direct hit, cratering a ford at WE 76952570, the same location hit by release number three. These strikes took place about 20 nautical miles south of the highly defended and strategically important Ban Phanop area and about equidistant from the North Vietnamese border. It was noted that the direct hit of the previous day's strike was completely repaired during the night, so the crew repeated the strike with identical BDA. Results of the first six strikes by PW II registered three direct hits, one 25 feet at 8 o'clock (road cut, however), another 25 feet at 8 o'clock (no observed BDA), and one 60 feet at 6 o'clock (no apparent damage).[7/]

The period during which the three-inch lens was used was termed a requalification period for the aircrews and was not considered part of the PW II evaluation. However, pilots' estimates of the circular error average and probability, many of which were verified by KB-18

photography, showed the following results:[8]

"Release # 1, 25' @ 8 o'clock
 # 2, 60' @ 6 o'clock
 # 3, 0/0
 # 4, 0/0
 # 5, 0/0
 # 6, 25' @ 8 o'clock (photo confirmed road cut)
 # 7, 10' @ 6 o'clock (cratered ford)
 # 8, 0/0
 # 9, Unreported (FAC and crews est ford cut)
#10, 300' @ 6 o'clock
#11, 0/0
#12, 15' @ 6 o'clock
#13, 10' @ 6 o'clock
#14, 10' @ 12 o'clock

CEA = 33.6' *CEP = 10' (Assuming release #9 crater overlapped the ford, would be within 15 feet.)"*

The aircrew requalification portion of the evaluation was completed on 21 February 1969, and the formal evaluation using the five-inch lens system began the following day. The results of the launches on 22 February would have elicited favorable comment under any circumstances, but even more so considering they were the first four releases of a weapons system unproved in combat. Two aircraft, each carrying two MK-84 EO guided bombs, were directed against an NVA cave storage complex near Ban Ban, off strategic Route 7 leading to the Plain of Jars in Laos. Three cave entrances were struck with the following results:[9]

"Miss Distance and Direction:

Rel 1, Direct hit on Cave No. 1.
Rel 2, Ran down entrance roadway on Cave No. 2, 60 feet from lock-on point at 7 o'clock.
Rel 3, Direct hit on Cave No. 2.
Rel 4, Direct hit on Cave No. 3.

"Target Damage:

Primary explosion within Cave Nr. 1.
None.
Primary explosion within Cave No. 2.
Primary and secondary explosion within Cave No. 3. Smoke and debris were observed coming from Cave No. 2 opening, indicating the Cave Complex was interconnected. Cave No. 3 was located 260' from Cave No. 2."

After completion of 22 releases through 1 March 1969, an update of miss distance and target damage was made. Determination of the CEA/CEP was made by KB-18 strike camera, RF-4 post-strike photography, aircrew observance, or a combination. Photographic interpretation was thought to have the greatest validity, but all three methods showed remarkable consistency in their estimates. With the exception of gross errors on bomb numbers 5, 8, 20, and 22*, none of which appeared to guide properly, the seeker/guidance system seemed to work as well as that of WALLEYE and was less expensive. The CEA for the effective 18 bombs was 8.1 feet, with a CEP of zero. Eleven of the PAVE WAY II bombs were direct hits, while only two (outside those with gross errors) exceeded ten feet--well within the crater area of the 2,000-pound bomb.[10/]

* 4,000, RNO, 2,700, and 1,900 feet, respectively.

The total evaluation continued through release number 35 and was terminated on 5 April 1969.[11/] To evaluate maximum standoff distance for the weapon system, the last several flights incorporated single pass releases and multi-aircraft simultaneous releases like those necessary in a high-threat environment. Five road intersections and a bridge were selected for these targets. Two releases were made simultaneously from two aircraft using a pod roll-in to simulate a dense AAA/SAM envelope of the type found over North Vietnam prior to the bombing halts. Photo reconnaissance showed that the last six bombs released during this portion of the evaluation scored three direct hits, plus one at five feet, one at 20 feet, and one which impacted on its lock-on point but exploded 475 feet from the target because of a boresight malfunction. Release number 35, the last of the evaluation, was directed at the selected bridge and totally destroyed it, as substantiated by KB-18 film and post-strike photo interpretation. As an illustration of the standoff capability of the PAVE WAY II, the slant range release distance for the last six bombs exceeded 30,000 feet.[12/]

Ironing Out Deficiencies

As with the PAVE WAY I, the PAVE WAY II evaluation uncovered many of the same bugs found in the introduction of any new weapons system, e.g., only an 80 percent out-of-container reliability, low battery reliability, excessive weapon buildup time, unavailability of technical data for kit storage, and the possible need for improved boresight procedures. In addition, because it was an electro-optical system,

PAVE WAY II suffered from the same obstacles that tended to limit WALLEYE effectiveness. Several missions were aborted for target weather, lowered visibility in haze or smoke, and target signature which differed significantly from that forecast. Regarding the reliability of the weapon itself, a production engineering and qualification program was funded and turned over to Air Force Systems Command to provide KMU 353B kits, containers, and Aerospace Ground Equipment (AGE) designed for improved reliability and maintenance. These features were scheduled for incorporation into the December 1969 production shipments.[13/]

Results of the PAVE WAY II evaluation were considered a resounding success from the standpoint of force requirements, accuracy, standoff capability, and ease of interface with already available delivery platforms, i.e., the WALLEYE configured F-4Ds at Ubon. In a message to PACAF, AFSC, Seventh Air Force, and other contributing agencies, the Air Force Chief of Staff stated:[14/]

> *"The operational results obtained under PAVE WAY II are commendable and have provided a significant addition to the USAF weapons inventory. All participating commands are congratulated for an outstanding job, exceedingly well done."*

The PAVE WAY II teams had already received a vote of confidence in a message from the Deputy Commander, 7AF/13AF at Udorn, Thailand, in which he confirmed the accuracy of the system. He said:[15/]

[redacted]

"I have reviewed the evidence and results of your PW II strike on the bridge and ford at Sam Neua in BARREL ROLL. These targets had previously been "off limits" because of the extreme sensitivity of some installations in proximity to this bridge and ford.

"Your demonstrated competency and accuracy with PW II enabled us to secure Embassy approval to strike these targets. Your destruction of these targets has enhanced the reputation of 7AF and has forced the enemy to revise his tactics, now that this vital LOC is disrupted.

"Please convey my admiration and deep appreciation to all of your personnel involved in this clear demonstration of superior airmanship."

A Chief of Staff message to AFSC dated 30 July 1969, reconfirmed Air Staff interest in the program, and in the schedule to introduce the production model of the KMU 353B MK-84 EO guidance kit with the previously mentioned engineering changes. Arrival of the production model was slated for early March 1970, but unanticipated delays appeared to make May 1970, a more realistic date for introduction of the off-the-line system into SEA.[16/] In the meantime, 25 service test model kits were to be maintained at Ubon for contingency operations, should they become necessary, against bridges, power plants, and other lucrative high contrast targets. Expenditure of WALLEYE missiles was to be continued to maintain crew proficiency and insure aircraft launch system reliability.[17/]

Caveat on PAVE WAY Evaluation

The spectacular CEAs and CEPs exhibited in PAVE WAY I and II throughout their evaluations and operational use could provide a possibly

[redacted]

unrealistic view of necessary force requirements. With an established CEA of around 10 feet and a continuing CEP of zero, it might appear that two aircraft could provide a probability of 1.0 for destruction of a given point target, since more than 50 percent of the scored bombs made a direct hit and the average of all bombs was within the lethal radius of the bomb.

It must be taken into consideration, however, that more than one aspect of the concept was being evaluated. The scores used to compute the circular error average were predicated on the properly functioning bomb, a properly illuminated target in the case of PW I, a good lock-on with continuing lock in the case of PW II, and the bomb released within acceptable parameters. Bombs with malfunctioning seekers, or dropped out of the basket, for example, were deleted from CEA scoring. In other words, this portion of evaluation assessed only the accuracy of the perfectly functioning bomb itself. As was obvious, all bombs did not function perfectly, nor were they all released within acceptable parameters. Some fell prey to the deficiencies that keep any system from being 100 percent perfect. These unguided bombs, however, were reflected in the reliability portion of the evaluation. These two aspects--systems reliability versus CEA/CEP of the guided bomb--balanced judiciously, and taking into consideration those deficiencies occurring on the ground before flight, weather effects, dudded bombs, and the effectiveness of enemy defenses such as revetting, could then give a more realistic assessment of the bomb and of the bombing system as a whole.

[redacted]

Experience showed that despite the zero CEP for PAVE WAY munitions, it was unrealistic to think of one strike sortie delivering one PW as equal to one enemy gun destroyed. Taking into consideration all factors, combat experience showed that a more realistic expectation would be that one and a half strike sorties delivering a total of three PAVE WAYs would result in the destruction of an enemy AAA gun.[18/]

Two and a half years of smart bombs, WALLEYE, PAVE WAY I and PAVE WAY II showed that when employed against selected targets, the guided bomb concept provided a highly satisfactory, operationally effective bombing system.

[redacted]

CHAPTER V

SHRIKE AND STANDARD ARM MISSILES

A different kind of guided weapon depended upon the enemy himself for guidance. Heavy AAA and SAMs of North Vietnam became potent threats to U.S. air superiority in late 1965 and 1966 and these weapons systems relied upon radar for gun laying and tracking. It was from this enemy radar emission that the AGM-45 SHRIKE and the AGM-78 STANDARD ARM derived their guidance.

The USAF had used the SHRIKE in its various modifications in SEA as a standard air-to-ground missile since 1966. The weapon nullified enemy radar capability, but its degree of known success varied because of difficulty in assessing damage. It operated by homing on enemy S-band radar transmissions, and the detonation of its 51-pound warhead sprayed a pattern of small steel balls to effect damage. The holes left by pellet penetration were far too small to be seen in photographic coverage, and initially, target destruction or damage was assumed if the transmitting radar went off the air at or about the expected time of missile detonation. As a result of this criterion, the first several launches were described as "successes," until it was realized that simply turning off the radar, reducing it to dummy load, or placing the equipment in standby removed the guidance principle from the SHRIKE. Since it proceeded from that point in a ballistic trajectory, valid BDA was not possible under these circumstances, but in the beginning this was not known.

[redacted]

The SHRIKE was first launched from a USAF aircraft in SEA on 18 April 1966. An F-~~105~~100F WILD WEASEL aircraft, leading a flight of three F-105s on a SAM search and destroy mission in Route Package I, detected a FIRE CAN (NVN gun laying radar) emitter six miles northwest of Dong Hoi and launched an AGM-45A.[1] The F-105 pilots tracked the missile and intended to deliver additional ordnance in the area of the AGM detonation. The SHRIKE disappeared in a haze layer and was not visually reacquired, but shortly thereafter the FIRE CAN went off the air and did not come back up for the remainder of the mission. The launch was estimated to be successful.[2]

Nearly all of the early SHRIKE attacks took place in Route Package I, because this was an ideal area in which to develop operational tactics. The radar emitters there were more geographically isolated than in the heavily clustered Hanoi/Haiphong rings, and this isolation reduced the possibility of radar ambiguity in detecting and tracking by the missile. The first launch caused an almost immediate change in enemy radar mode of operation. Before the launch, the gun-laying radar came up as soon as aircraft entered their area and would remain on the air 10 to 12 minutes. After the launch, the enemy greatly reduced this on-air time to a very few minutes--seldom more than two or three--and coverage was often intermittent and sporadic.[3] Whether the strike "killed" the emitter or not, introduction of the missile still performed a useful role as it degraded enemy radar by reducing active emission time.

[redacted]

A SEAOR dated 25 June 1966 spelled out the desired capabilities for an anti-radiation missile (ARM) to be used primarily against SAM installations.[4/] Ideally, the missile should have the capability to detect and home in on minimum radar emissions (dummy load) and also have as close to absolute selectivity as possible, to solve the ambiguity problem. After lock-on and launch at a particular radar, all other emissions should be blocked out so the SHRIKE would not waver in its seeking and end up hitting nothing. Also, if possible, a memory circuit should be incorporated into the missile so that if an enemy radar went off the air after launch, the SHRIKE could home on its last computed position instead of merely going ballistic. An increased standoff range was desired, a marking capability was considered necessary, and it was requested that the seeker handle all three (S, X, and C bands) frequencies to cover more types of radar.[5/]

Regardless of its deficiencies, the SHRIKE remained a valuable adjunct to WILD WEASEL/IRON HAND (radar hunter-killer team) operations through 1966, 1967, and 1968. It might not be known whether a given emitter had been destroyed or damaged by the missile, but the fact that the emitter was forced to leave the air made the enemy's radar environment less effective. The SHRIKE permitted the killer portion of the team and nearby strike aircraft to operate in a greatly reduced risk envelope. In 1966, 436 SHRIKEs were launched in SEA, 1,322 in 1967, and only 523 in 1968.[6/] The halt to strike operations on 31 March 1968 in

all North Vietnamese Route Packages except RP I (which removed NVN's densest radar environment from the overall picture), and the subsequent November total halt possibly accounted for the dropoff.

An even more graphic falloff in AGM-45 expenditures took place in 1969 when the USAF recorded only six launches.[7/] With the only confirmed radar threat confined to North Vietnam, opportunities for radar targets were greatly reduced, although routine photo recon flights transitted RP I and received protective cover.

AGM-78 STANDARD ARM

Even though use of the SHRIKE decreased in 1968 and 1969, it was natural that an improved anti-radiation missile capability be sought. The U.S. Navy's STANDARD ARM went far toward providing this improved performance. The AGM-78 incorporated several improvements over its smaller counterpart.

Like the SHRIKE, the STANDARD ARM had a passive seeker guidance system, but it was a much larger weapon (1,300 pounds, with a 220-pound warhead). It had greater standoff capability and a memory circuit to keep the missile on the proper trajectory, even if enemy radar emission were turned off. An important addition was that the AGM-78 did not have to be fired in boresight toward the enemy radar, but could be launched at an angle and would turn to the target after release. Initial employment, however, was fired boresight so as not to alert the enemy

STANDARD ARM MISSILE
WITH ORDNANCE SECTION

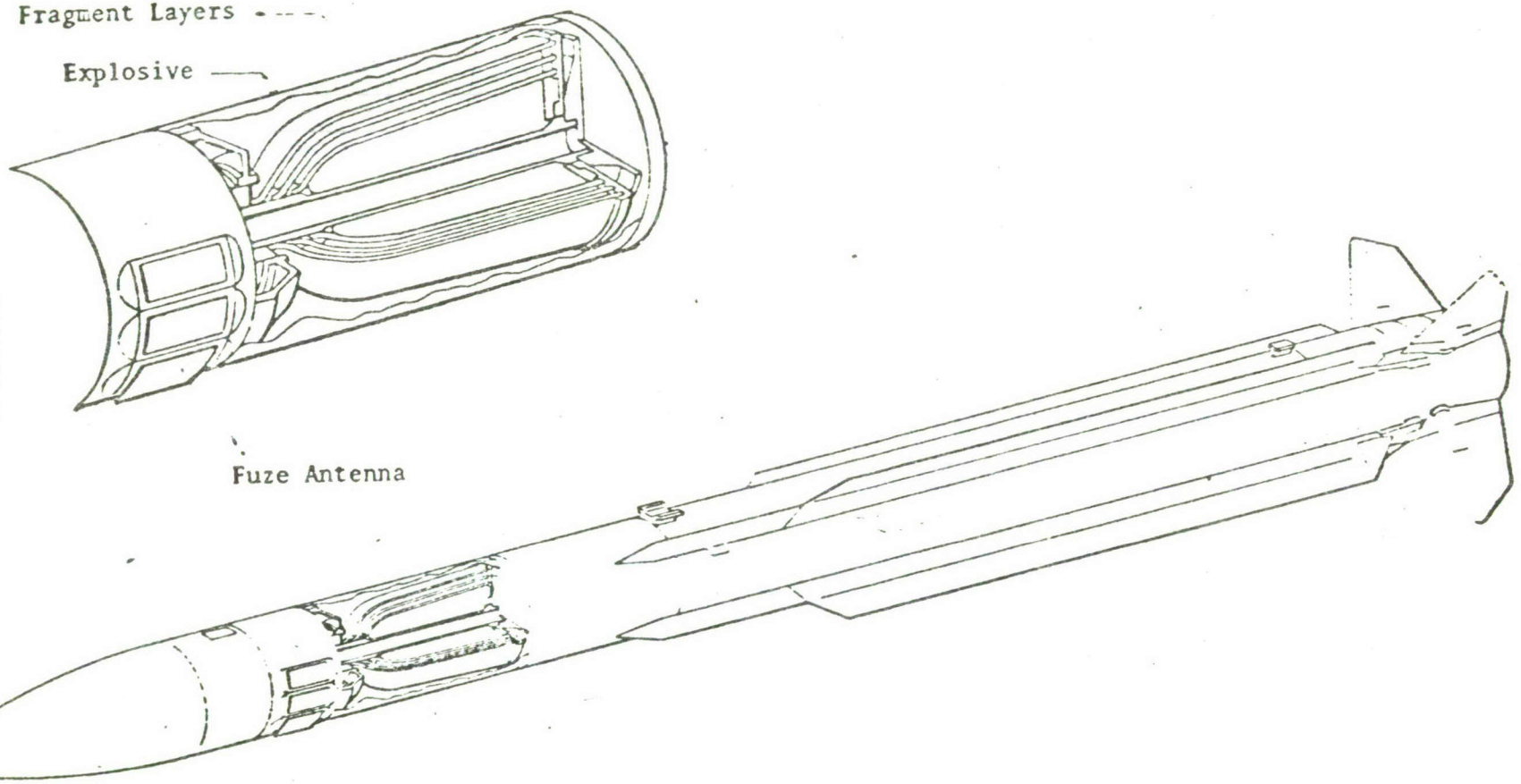


FIGURE 7

to any change in tactics which would signify the introduction of a new weapon. The maximum standoff range of the STANDARD ARM was 70 to 75 NM from an altitude of 40,000 feet.[8/]

Only eight AGM-78A missiles were reported fired in SEA during 1968 by USAF, but advanced modifications continued to undergo Category II/III testing at the White Sands Missile Range in the U.S.[9/] Among test objectives of the missile were attempts to determine direction finding (DF) discrimination in a multitarget environment, susceptibility to random emissions from transmitters, vulnerability to decoy transmitters, and other countermeasure tactics in a combat environment.[10/]

Among problems which appeared during the upgrading of the AGM-78A through the B, C, and D models were those of compatibility with the aircraft. The F-105F was modified to launch the AGM-78A, but when configured for that particular missile, it could not launch the B, C, and D versions, and conversely, the F-105 modified for the later models could not launch the AGM-78A. The A missile had an analogue missile control module, while the B and later models were digital missile control configured. As a result, the missile control panels for each were different, although the launcher adapter and suspension gear were common to all. When modified to accept the AGM-78B, the F-105F was redesignated the F-105G.[11/] It was planned that after completion of the AGM-78B-modified F-105 program, the remaining AGM-78A missiles would be updated to AGM-78C configuration.[12/]

[redacted]

The main differences between B and C missiles were that the latter provided increased reliability and cost reduction modifications. Frequency coverage of both missiles extended through 2.65 to 3.2 GigaHertz (GHz - 1,000,000,000 cycles per second), 4.8 to 5.3 GHz, and 8.8 to 9.6 GHz.[13/] The AGM-78A was responsive only to S-band (e.g., FAN SONG and FIRE CAN radars) radiation, while the B and C configuration included S, C, and X-band coverage, improved seeker sensitivity, active fuzing visual marker BDA components, and other improvements. Completion of the update program was to provide a November 1971 inventory of approximately 470 AGM-78B/C missiles with the capability to attack a variety of high-threat EW/GCI and missile guidance radars including BARLOCK, BIGBAR, and those for the SA-2, modified SA-2, and the SA-3 surface-to-air missile systems.[14/]

If the SHRIKE was a first generation anti-radiation missile, continuing improvements to the STANDARD ARM unquestionably placed it in the second generation category. As mentioned previously, one of the serious deficiencies of the early SHRIKE was the difficulty of obtaining valid BDA, or under certain conditions, even determining where and when the missile detonated. Under visual conditions, the insertion of a spotting charge in the missile could show the point of impact, but actual damage assessment remained questionable. With this in mind, an electronic BDA subsystem was developed and incorporated into late model STANDARD ARMs.[15/] With the BDA system to keep score by registering hits, and a smoke signal to mark "hit" targets, follow-on aircraft could locate and

[redacted]

[redacted]

AGM-78 Electronic BDA Logic and Indications

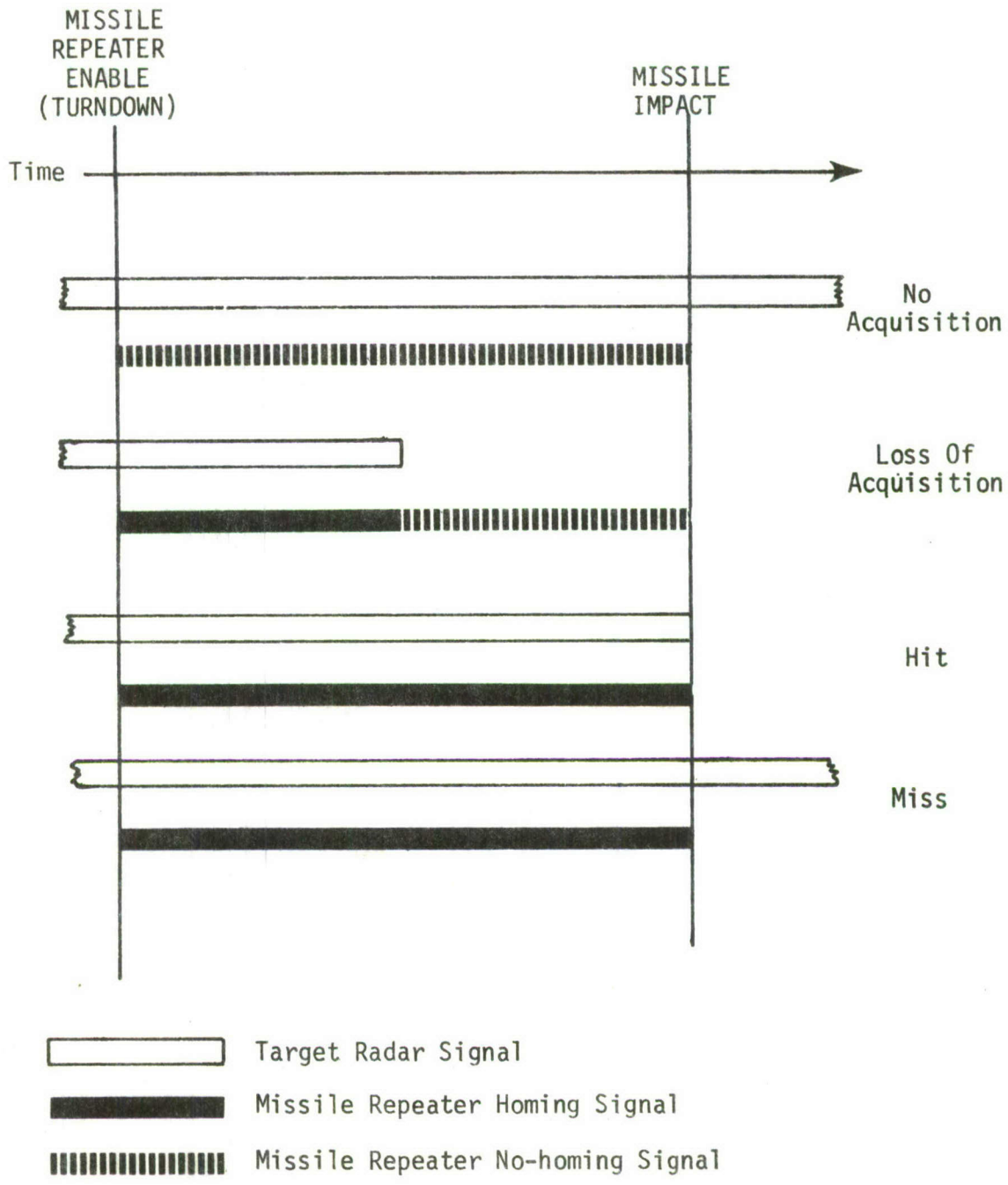


FIGURE 8

[redacted]

saturate the target area with iron bombs to destroy even revetted components of the enemy radar system.

In its essentials, the BDA subsystem consisted of a radar pulse repeater unit housed in the dorsal fin of the AGM-78 and an avionics display set installed in the launch aircraft. (Fig. 8) The repeater picked up the victim's radar signal from the missile's seeker head and retransmitted it as a coded echo at the target's own pulse repetition frequency (PRF). If no signal were received from the seeker head, the repeater transmitted a self-generated pulse train at a unique PRF. Thus the launch aircraft, with its own avionics, received enough elements of information to determine the degree of success or nonsuccess of the launch. The crew could determine with its Radar Homing and Warning (RHAW) equipment directly from the target radar itself, whether that radar were transmitting and could tell whether the missile were tracking from the repeater display. When the homing or no-homing signal from the missile ceased, assumption of impact allowed the crew to make the following assessments: 16/

HIT - Both homing signal and radar transmission received during flight; both stopped after impact. A hit may be assumed.

MISS - Both signals received during missile flight; homing signal stopped after impact but target radar continued to transmit. A miss may be assumed.

NO ACQUISITION - A no-homing signal received throughout missile flight until impact. Missile never tracked victim radar.

LOSS OF ACQUISITION - Missile tracked target radar for some time but was not tracking just before impact. No valid hit or miss assessment may be made.

[redacted]

The foregoing description has been highly simplified, but the BDA subsystem for the AGM-78 contained such sophisticated refinements as computerized discrimination circuitry (to verify that signals constitute a valid pulse train and do not originate from a "noise source" such as other radars), predictive gates (to predict impact time and further verify the selected target), and computerized display logic to remove as much guesswork as possible from the crew in BDA assessment.[17/]

Enemy High-Threat Areas Move South

Use of the anti-radiation missile had dwindled after the bombing halts, since the majority of high-threat areas were essentially in sanctuary. (Figs. 9, 10) It became apparent in late 1969, however, that the North Vietnamese were increasingly anxious to protect their infiltration routes, Barthelemy, Mu Gia North and South, Nape, and Ban Karai Passes, by moving heavy AAA and SAM installations into these areas. Intelligence figures depicted the high-threat SAM areas in September 1969 as one solid cluster around the Hanoi/Haiphong ring, another around the strategic Thanh Hoa area, and a third at Vinh, which did not impinge upon the Laotian Border.[18/]

By the end of November, the ring at Vinh had been increased to the point that it extended into Laos at Nape Pass, and by early January a SAM site in the Dong Hoi area was within range of the Ban Karai area. In October 1969, photographic reconnaissance for the first time confirmed the existence of 100-mm AAA in Laos in the Ban Karai Pass area. Although

[redacted]

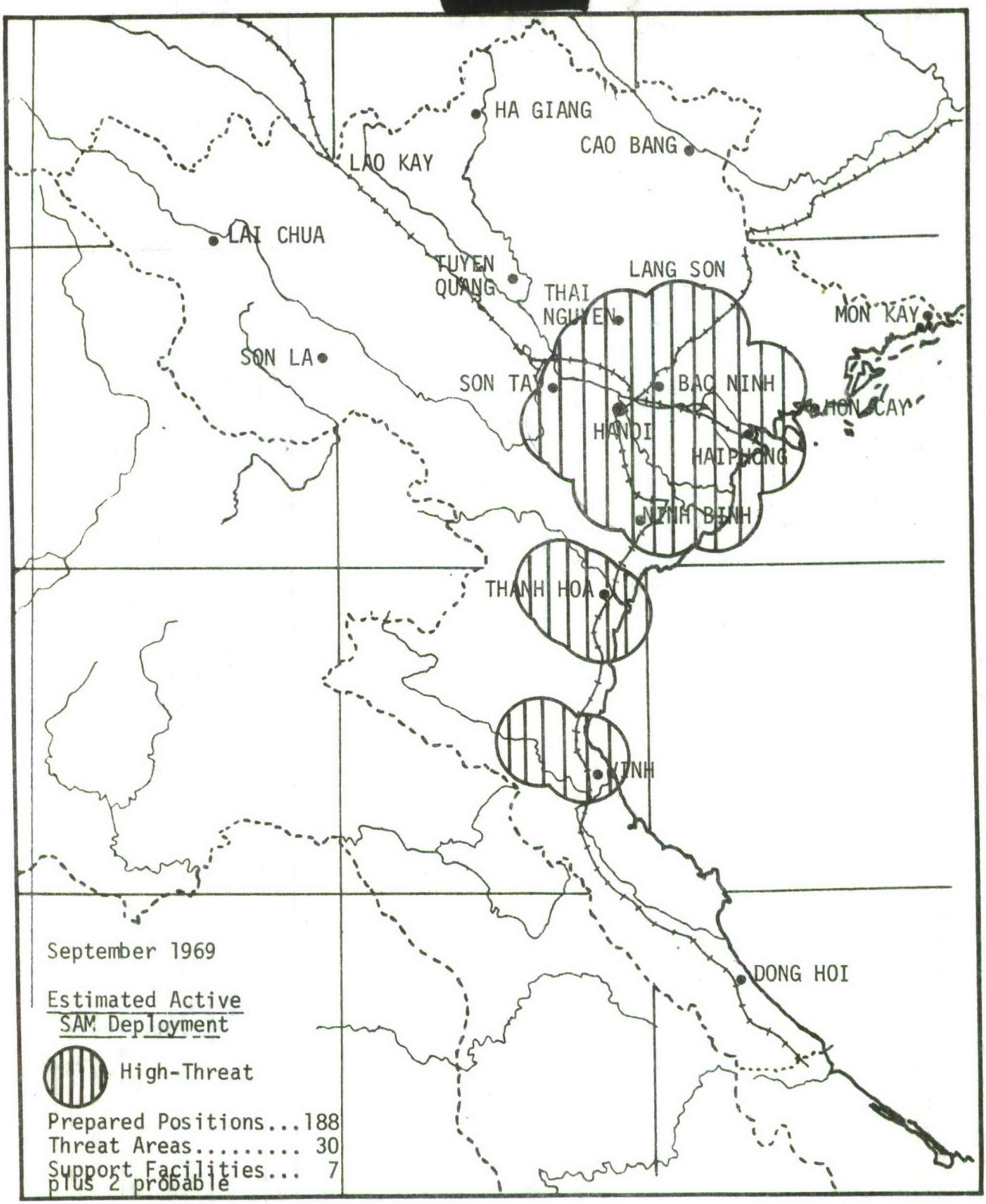

HA GIANG
CAO BANG
LAO KAY
LAI CHUA
TUYEN QUANG
LANG SON
THAI NGUYEN
MON KAY
SON LA
SON TAY
BAC NINH
HON GAY
HANOI
HAIPHONG
NINH BINH
THANH HOA
VINH
DONG HOI
September 1969
Estimated Active SAM Deployment
High-Threat
Prepared Positions...188
Threat Areas..... 30
Support Facilities... 7
plus 2 probable

FIGURE 9

there was no evidence yet of gun control radar in Laos, this type radar could pose a threat to B-52s and other strike aircraft in the region of the passes should it appear.[19/]

In the 29 November 1969 issue of the Seventh Air Force Weekly Air Intelligence Summary, a DIO stated:[20/]

> *"NVN has obviously concluded it no longer needs all of its AA weapons to defend Hanoi and Haiphong, thereby enabling them to move more MAA (medium) and HAA (heavy) weapons into the pass areas and Laos. The increase in AAA activity is indicative of the importance of these vital LOCs and of his determination to defend and maintain them."*

Within a short time, this statement became prophetic. Both SAM and 100-mm AAA were fired at ARC LIGHT forces in the Ban Karai area before the end of December. There was enemy SAM reaction on 19 December when two SA-2 GUIDELINE missiles were launched through Ebony cell (B-52s) striking near Ban Laboi Ford. These were the first SAMs fired at manned aircraft since May 1969, although several had been launched against Bumpy Action drones.[21/] Strong FAN SONG and SA-2 guidance signals were received. Both the ARC LIGHT Strike force and ECM aircraft started jamming immediately and took evasive action. The missiles were observed coming up through an undercast at the five and seven o'clock positions of the B-52s, passing through the flight's altitude and detonating 2,500 to 3,000 feet above them.[22/] Although the planes could not determine accurate line of position on the launch site, the SAMs appeared to come from just inside the NVN Border. One week later in the same general area, 100-mm AAA was directed at another ARC LIGHT force, this time from within Laos itself. None of

the aircraft received damage but they were forced to climb above the 36,000-foot range of 100-mm guns.[23/]

The threat continued to grow, and with it, retaliatory strikes by WILD WEASEL/IRON HAND F-105s and by F-4s carrying CBUs and general purpose ordnance. On 27 January 1970, at least two and possibly three SAMs were fired at an unarmed RF-4C recon aircraft and its escort. The following day, three to five SAMs fired on another recon aircraft, its IRON HAND, and other escort aircraft. Seabird 2, one of the IRON HAND F-105s, was shot down, probably by AAA. One SHRIKE was fired, the escort aircraft dropped ordnance and strafed the SA-2 launch site, and several secondary explosions were observed.[24/]

On 1 February, the southernmost SAM site (VN 374) with two launchers was photographically confirmed just 4.5 nautical miles north of Ban Karai. On 2 February, an F-4 Strike flight out of Ubon was attacking a nearby AAA site when they observed the SAM location. The SAM site was in the process of launching an SA-2 at an overflying reconnaissance mission when the F-4s swung over and struck it with CBUs and conventional ordnance. One SAM was seen to rise approximately 1,500 feet in the air, then fall back to the ground and impact near the site. The site was put completely out of commission, and the next day, photography revealed it had been completely cleared and all equipment moved.[25/]

As a result of the heavy-threat areas along the NVN/South Laos Border, special restrictions were placed on the employment of ARC LIGHT sorties.

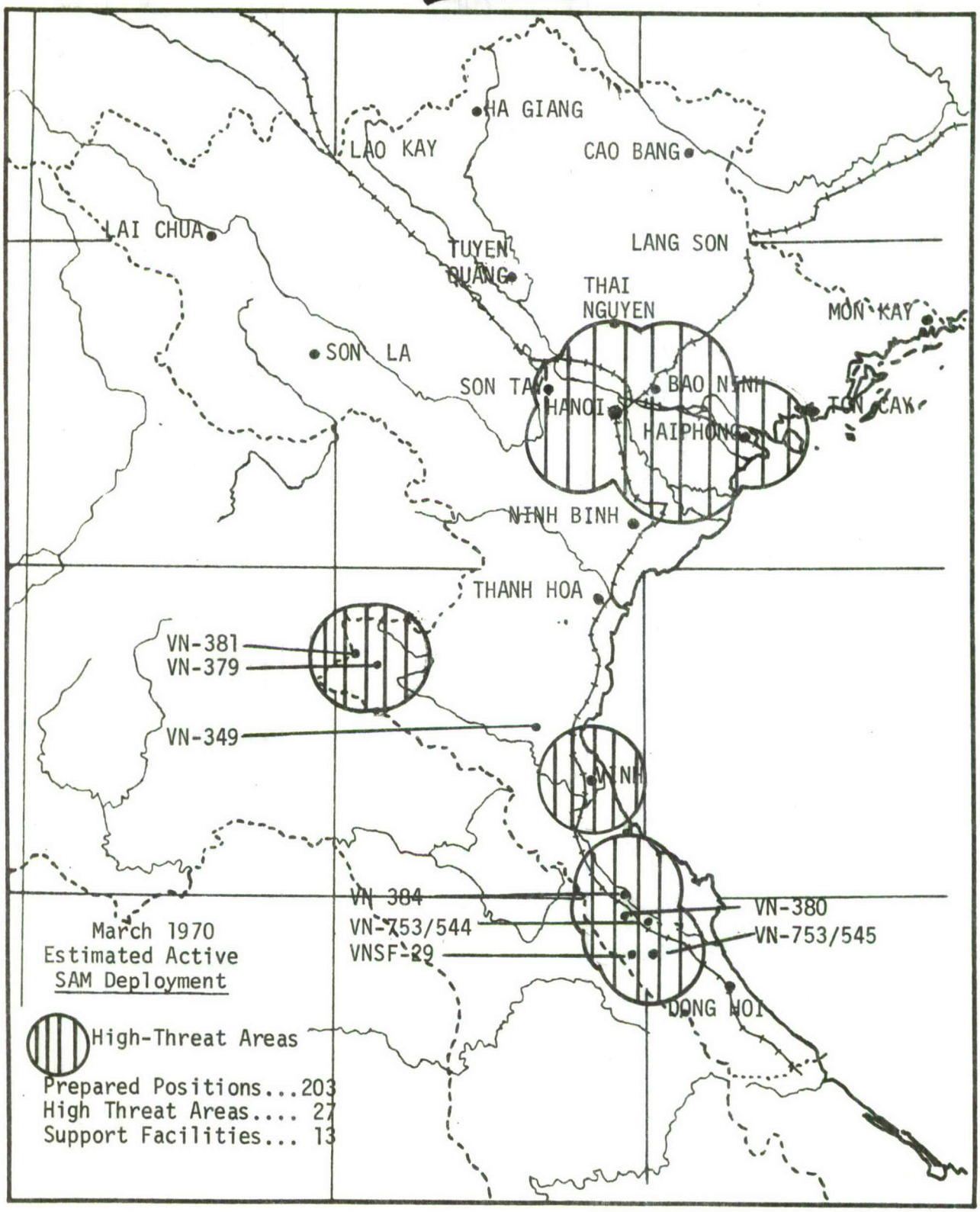


FIGURE 11

[redacted]

No B-52s were to be flown into known high-threat SAM areas. In areas of a high 100-mm AAA threat, operations were to be conducted only at night, above 38,000 feet, and without any follow-on attack by a second cell.[26/]

Protection for RF-4C recon sorties in Route Package I was provided by IRON HAND F-105s and F-4s, as for attack sorties in high-threat areas in Laos. During the December 1969, January and February 1970 period, only one USAF AGM-45 SHRIKE was fired and there were no STANDARD ARMS fired.[27/] With no gun-laying radar associated with the 100-mm AAA sites, anti-radiation missiles were not called for against them. In virtually every attack against SAM sites, the site was visually acquired and immediately struck with conventional ordnance.

Other reasons precluded indiscriminate use of SHRIKE and STANDARD ARM launchings by USAF in their operating areas along the NVN/Laos Border and in RP I. Although the U.S. Navy conducted several SHRIKE launches in protection of their reconnaissance forces in the other Route Packages, the radar environment was entirely different. From Gulf of Tonkin orbits, Navy aircraft could assume that any S band (FAN SONG or FIRE CAN) radar emission was automatically hostile and could react with a launch without further verification. Operations within the USAF areas of Laos presented significantly different problems. Definite verification of enemy emission was necessary there, as was the axis of attack when the aircraft fired its missile. Numerous friendly S band radars were located in Thailand and Laos, and with the 75-mile standoff range of the AGM-78, for example,

a mistaken acquisition or axis of launch could have proved highly unfortunate.[28/]

It must be assumed, however, that if the AAA/FIRE CAN and SAM/FAN SONG threats to the Laotian Border areas increased, a subsequent increase in use of the anti-radiation missiles by USAF would have followed.

CHAPTER VI

ROCKEYE II

When the USAF introduced ROCKEYE II into the SEA combat arena, it brought into the ordnance inventory a weapon similar to CBU 24/49. A cluster weapon delivered in an aerodynamic container, ROCKEYE II opened at a preset interval after release from the aircraft to disperse bomblets in an area-coverage pattern. The similarity, however, ended there; the ROCKEYE's functioning was unique. The ROCKEYE II bomblet (MK-118 Mod 0) was a moderately dart-shaped munition, 13.5 inches long and 2.1 inches in diameter, weighing 1.32 pounds. Of this total weight, only .39 pounds made up the warhead, but because of its 2-inch copper-lined octagonal-shaped charge, it was capable of punching a hole through seven and a half inches of armor plate or nine inches of cold-rolled steel.[1/]

The shaped charge was extremely effective against hard targets such as tanks, bulldozers, vehicles, and antiaircraft guns. All the bomblets from one release would not contact hard targets, however, and for this reason the fuzing system of the MK-118 used two separate sensing elements which discriminated between hard and soft targets. If at impact the bomblet contacted steel, concrete, or other relatively hard surfaces, the shaped charge was instantly detonated. If, on the other hand, the bomblet fell on open ground and began to penetrate the surface, the shaped-charge fuze did not function and the time-sense fuze took over to detonate the MK-118 as a blast and fragmentation weapon.[2/] Thus, the

ROCKEYE bomblet contained dual effectiveness against a variety of targets. Directed against a truck park, for example, the bomblet would penetrate soft barriers such as foliage or camouflage without exploding. Bomblets that hit trucks would detonate in the shaped charge mode, while those that did not would provide blast and fragmentation effect against personnel and materiel.[3/]

Two hundred forty-seven individual bomblets were carried in each container. After the preset delay time of 1.2 to 4.0 seconds from release, an internal aluminum linear shaped charge (ALSC) was activated, splitting the thin skinned container longitudinally and releasing the bomblets. Because of a spinning moment set up by the fins of the container, the individual bomblets separated as soon as the clamshell opened; however, being streamlined themselves (unlike the spherical CBU-24), their ballistics dispersion was not great.[4/] Where CBU 24/49 would leave a circular pattern 800 feet in diameter, ROCKEYE released from the same altitude would provide an elliptical pattern approximately 200 feet by 300 feet. This pattern put a premium on delivery accuracy but also gave a high probability of kill, if the ROCKEYE II pattern covered the target area. Then, too, the CBU 24/49 left a "doughnut" pattern which with perfect delivery could surround the target with bomblets yet leave the center unscathed. The pattern for ROCKEYE gave a relatively even density throughout the impact area.[5/] (Figs. 12-14)

Although the U.S. Navy and Marines had used the weapon for a year

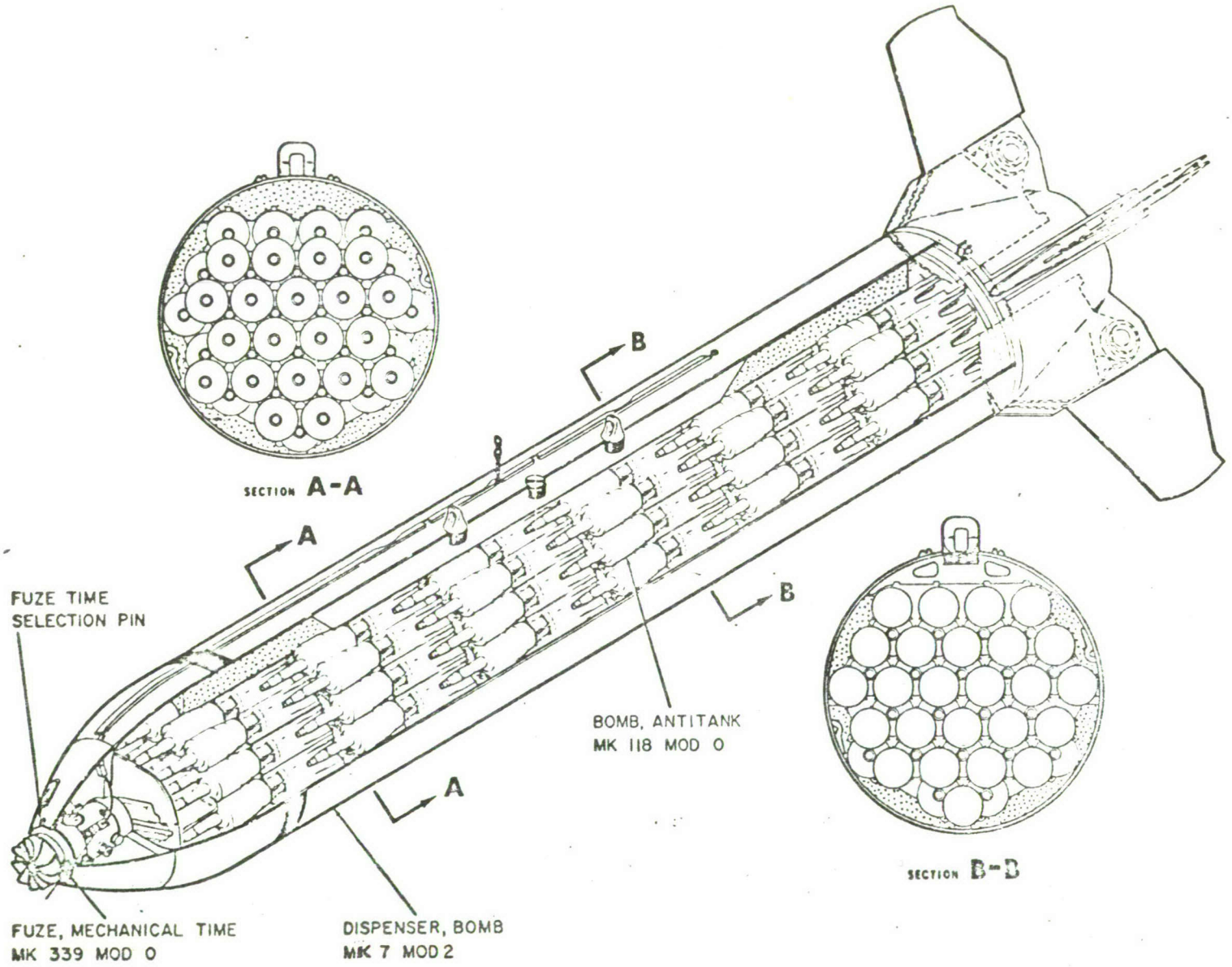
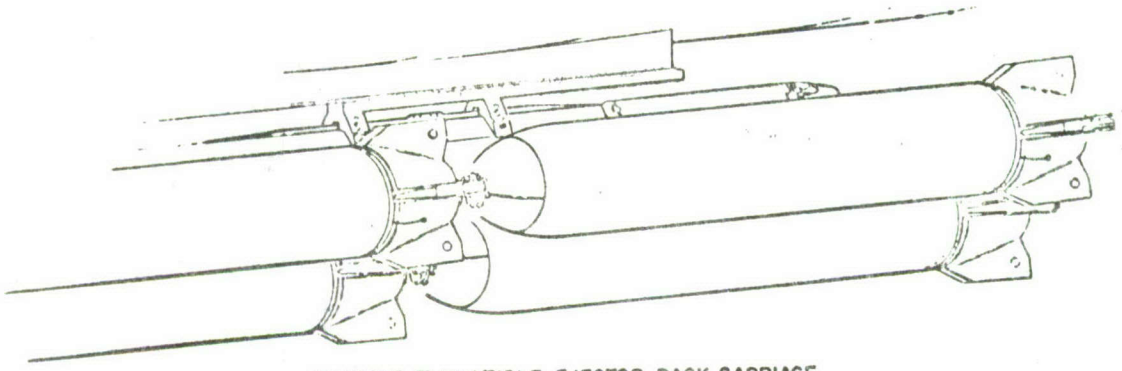
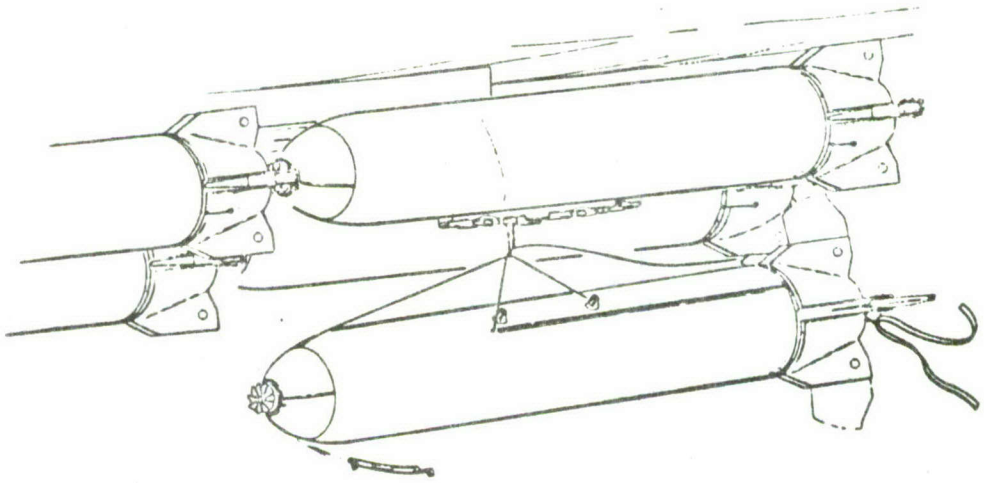


FIGURE 12

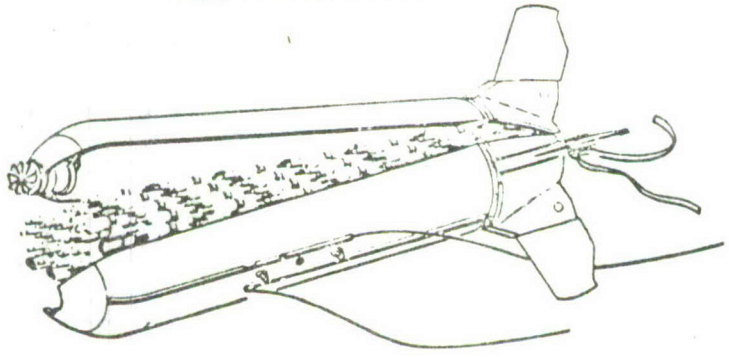
— *Cutaway of ROCKEYE II showing full bomblet load.*



ROCKEYE II MULTIPLE EJECTOR RACK CARRIAGE



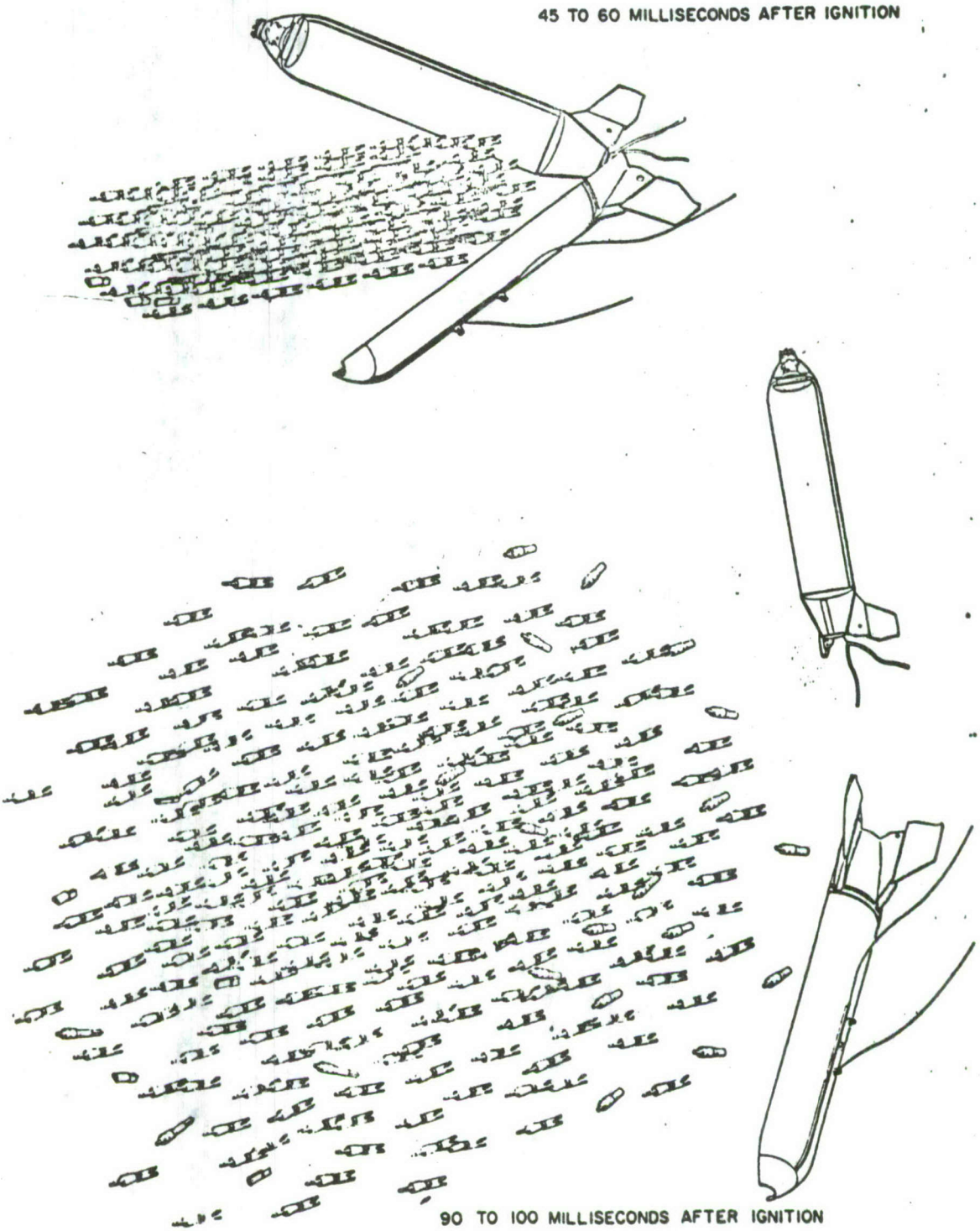
ARMING WIRE EXTRACTION
FIN RELEASE BAND SEPARATION
FUZE RELEASE BAND SEPARATION
FUZE TIMING STARTS



15 TO 25 MILLISECONDS AFTER IGNITION

FIGURE 13

CONFIDENTIAL



— *ROCKEYE II operational sequence.*

FIGURE 14

CONFIDENTIAL

in Southeast Asia, USAF testing took place at Nellis AFB, Nevada, from 15 July to 4 September 1969. The weapon arrived in SEA in October and was given to the 432d Tactical Reconnaissance Wing at Udorn, Thailand, for combat evaluation under the guidance and assistance of a TAC ROCKEYE II Introduction team. The evaluation took place in two Phases, the first between 29 October and 21 November 1969, the second from 11 to 24 December 1969. The objectives of Phase I were to refine delivery tactics, determine the effectiveness of the weapon against available targets, and to establish the adequacy of maintenance technical data.[6/] The available targets were to include tanks, trucks, roadbuilding equipment and buildings, known POL pipelines, and gun emplacements. In the actual evaluation, only six trucks were attacked (all at the same time); all other targets consisted of gun emplacements ranging from 37-mm through 100-mm AAA.[7/]

As taken directly from the evaluation report published by Hq 7AF, Directorate of Tactical Analysis, some of the highlights were as follows:[8/]

> *"The target on the afternoon of 11 November was a 57-mm AAA installation with four gun positions. After six passes and six ROCKEYEs released, crew reports that four of the ROCKEYE patterns covered the target were confirmed. All four of the guns were silenced. On the afternoon of the 17th, the target was a 37-mm position with one active gun. After the strike aircraft had expended its ROCKEYE, the FAC (F-4D) noticed that the gun had started to fire on the recon aircraft as the RF-4 began his photo run. The FAC delayed the recon's post-strike pass, made a run himself, and dropped a ROCKEYE. The reconnaissance aircraft then made his photo pass (which later confirmed that the*

ROCKEYE pattern had dropped squarely across the gun position) and received no fire from the ground. Two days later, scheduled to attack a four-position 37-mm site, both FAC and recon aircraft were fired upon as soon as they entered the area, which pinpointed the locations of the AAA quickly. All four guns were firing when the strike aircrews rolled in, but after one ROCKEYE pass all guns were silent. Another 37-mm site with three guns was struck. After two passes and four ROCKEYE canisters expended, three photo-confirmed patterns fell in the target area and all three guns were silenced."

A total of 100 ROCKEYEs were dropped on 75 passes during the Phase I evaluation, on a total of 45 AAA positons and six trucks. Three trucks were destroyed and three damaged. Assessment of damage to AAA was more difficult owing to the small entrance hole made by the bomblet when impacting against a hard target. However, it was noted that 12 guns were seen firing during the attacks, and in all 12 cases, delivery of ROCKEYEs silenced the weapons.[9/]

Phase II Evaluation

Phase II evaluation was undertaken in December to supplement finding of the Phase I evaluation, except that the purpose of the Phase II test narrowed the spectrum of targets to gun-killing alone. In this portion of the evaluation, 80 ROCKEYE II canisters were dropped. Extensive preflight briefing and target study were implemented. The crews carried Polaroid photocopies of all targets as an aid in locating the sites and also for recording impact patterns while the scenes were still fresh in their minds.[10/]

[redacted]

PHASE II EVALUATION

DAY	DATE	DESCRIPTION	STRIKE RESULTS	PHOTO INTERPRETATION DAY (by day after strike)
1	11 Dec	4 PSN AAA 1 PSN OCC	Damage to weapon highly probable.	(1) All positions unoccupied. (3) Struck position still unoccupied. New position occupied.
2	12 Dec	2 PSN AAA 2 PSN OCC	Revetment hit, no damage to wpn noted.	(2) Both positions unoccupied. (8) No change.
3	13 Dec	CANCELLED BECAUSE OF WEATHER		--
4	14 Dec	4 PSN AAA 2 PSN OCC	No impacts on target.	(1) One position occupied. (8) All positions unoccupied.
5	15 Dec	REPORTED 57-mm AAA, ACTUALLY A BUNKER	No damage to bunker.	(1) Weather. (2) No change. (3...) Coverage discontinued.
6	16 Dec	3 PSN AAA 2 PSN OCC	One occupied revetment hit; no damage to weapon noted.	(1) All positions unoccupied. (9) No change.
7	17 Dec	4 PSN AAA 2 PSN OCC	Impacts near one occupied position; no damage to weapon noted.	(1) All positions unoccupied. (9) No change.
8	18 Dec	6 PSN AAA 1 PSN OCC	Impacts near occupied position; no visible damage to weapon.	(1) Weather. (2) All positions unoccupied. (9) No change.
9	19 Dec	STANDDOWN		--
10	20 Dec	1 PSN AAA 1 PSN OCC	WX precluded damage assessment.	(1) Weather. (2) Position unoccupied. (8) No change.

FIGURE 15

[redacted]

[redacted]

PHASE II EVALUATION

(Figure 15--Cont'd.)

DAY	DATE	DESCRIPTION	STRIKE RESULTS	PHOTO INTERPRETATION DAY (by day after strike)
11	21 Dec	1 PSN AAA 1 PSN OCC	4 impact patterns near target; no damage to target noted.	(1) Position unoccupied. (7) No change.
12	22 Dec	STANDDOWN		--
13	23 Dec	2 PSN AAA 2 PSN OCC	Impacts on one position. Weapon probably damaged. Impacts near second position; no apparent change.	(1) Both positions still occupied. (2) Both positions unoccupied. (3) No change.
14	24 Dec	2 PSN AAA 1 PSN OCC	MK-82 bombs and CBU-24 used instead of ROCKEYE. No damage to weapon noted.	(1) Position unoccupied. (2) No change.

[redacted]

[redacted]

Results of Phase II evaluation fairly well backed up findings of the initial combat tests. Impact patterns were dense and when any pattern covered an occupied gun position, the gun ceased firing, in most cases to the end of the evaluation. Delivery accuracy, posed by the small size of the pattern, was difficult, and photo confirmation of guns destroyed or damaged was equally difficult. The scale and resolution of photography were inadequate to detect positively the kind of damage anticipated from ROCKEYE II. Photo interpretation of one target showed three individual bomblet impacts within the gun revetment, but PIs were unable to detect damage to the gun itself. Wrap-up analysis after the evaluation showed three active gun positions had definitely been hit, and six others probably were hit. In any event, no gun position covered by ROCKEYE was observed to fire again on the day it was struck; most sites were evacuated within one day and remained so through the evaluation. Only in one instance were guns returned to a site following evacuation of the positions.[11/]

Phase II evaluation was covered by extensive follow-on photo reconnaissance to help establish a data base on strike results. From Day 1 through 14, attempts were made to acquire photo coverage of each struck target area daily. At times, weather prevented suitable photographic coverage, and quite often photos simply showed no change from the previous day's pictures. Figure 15 provides statistical results and significant photographic notations.[12/]

[redacted]

[redacted]

As an illustration of a fairly typical ROCKEYE II strike, Day 2 provided a good example. Pre- and post-strike photography showed pattern and coverage of at least one of the ROCKEYE canisters and also illustrated the difficulty of interpreting valid BDA. (Figs. 16, 17)

The target was two occupied 37-mm AAA sites located overlooking Route 7 in Laos about midway between Ban Ban and the North Vietnamese Border. Two F-4s from the 432d TRW at Udorn, Liner 01 and 02, made up the strike force; Falcon 10 was the FAC and RF-4C "Jumpy" performed the pre-strike and post-strike reconnaissance. Liner 01's first pass was made in the dive-toss mode and malfunctioned, dropping the ROCKEYEs 3,000 feet short at 6 o'clock. Liner 02, dropping in direct mode, visually scored 100 feet at 12 o'clock and was credited with coverage of gunpit "A" and possible hits on gun position "B." Eight weapons were delivered in four passes, all made through continuous 37-mm and automatic weapons ground fire, both from the target sites and from another 37-mm complex to the west of the primary target. The second site was silenced with CBU-24 following the initial ROCKEYE drops. No ground fire was received from any positions during the post-strike recon pass.[13/]

Weather prevented following-day reconnaissance but on the fourth day (Fig. 18) it was clear enough to show not only the impact pattern of the ROCKEYE bomblets but that the entire site had been evacuated. It remained unoccupied throughout the remainder of the evaluation.[14/]

[redacted]

[redacted]

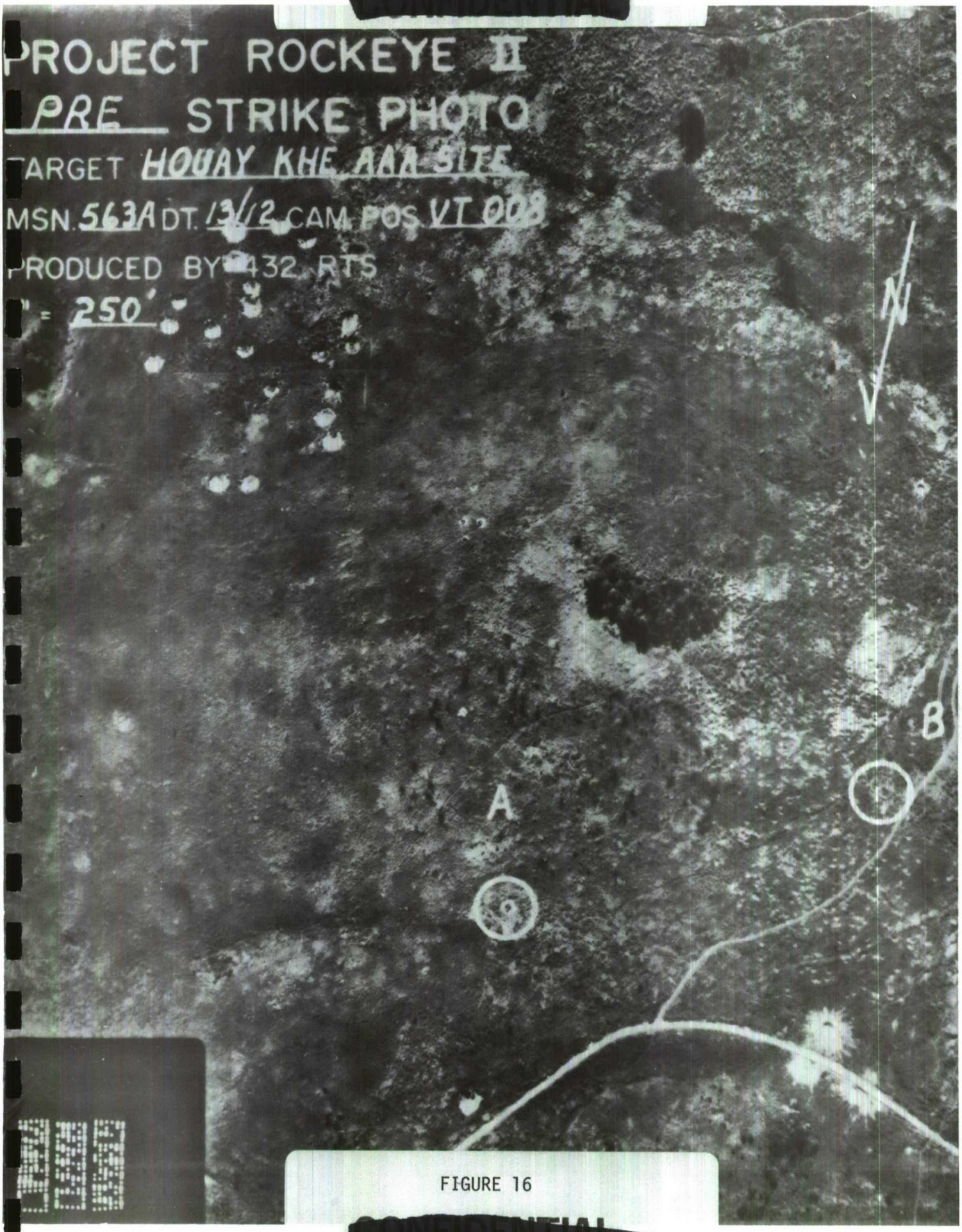


FIGURE 16

[redacted]

[redacted]



FIGURE 17

[redacted]

[redacted]

TACTICAL RECONNAISSANCE 14
Name: HOUAY KHE AAA
COORDS: 193015 N 10356



FIGURE 18

[redacted]

[redacted]

In the pilots' view, ROCKEYE II deserved further study and evaluation, taking into consideration the dual effectiveness of the MK-118 bomblet and the observed results when patterns did cover the target. They were of the opinion, however, that delivery accuracy remained a problem, although they believed accuracy could be improved through intensive target pre-study and perhaps through shortening the fuze arming time to allow lower release. Visual acquisition of a camouflaged gun site was difficult at best and, on some occasions, pilots pressing in to acquire and line up on a gun position passed through their optimum release altitudes before expending, resulting in unopened or partially opened canisters. Because of this problem, some weapons had to be recorded as duds; however, good hits might have been scored if targets had been acquired earlier or if arming time had been shortened. One of the recommendations made by pilots participating in the evaluation was that a cockpit-selectable option for opening height be incorporated into the weapon.[15/]

Both phases of the combat test and evaluation showed that ROCKEYE II was an effective flak suppressant ordnance. Its disadvantage, compared to CBU-24, was its small dispersal pattern, necessitating extremely accurate delivery. The pattern may have been compensated for by the weapon's high bomblet density and the fact that if it did impact on an AAA gun, the gun could be considered "killed" not just silenced. It was recommended that ROCKEYE II be incorporated into the USAF inventory of operational weaponry.[16/]

[redacted]

[redacted]

FOOTNOTES

CHAPTER II

1. (S) Final Rprt, CNO Project O/V 52, WALLEYE MK 1 Mod 0, 26 Mar 68;
   (S) Working Paper, Hq 7AF/13AF, DI, AGM-62 Usage, undated.

2. (S) Working Paper, Hq 7AF/13AF, DI, AGM-62 Usage, undated.

3. Ibid.

4. Ibid.

5. (C) OpRep 4, 8th TFW, Ubon RTAB, Thailand, to AIG 913, DI, 08590, 300815Z Aug 67;
   (S) OpRep 3, 8th TFW, DI, 98594, Mission Summary, 301250Z Aug 67.

6. (C) OpRep 4, 8th TFW to AIG 913, DI, 08368, 170940Z Sep 67.

7. (S) Rprt, 8th TFW to CSAF, COMBAT EAGLE, 27 Sep 67;
   (C) OpRep 4, 8th TFW to AIG 913, DI, 09412, 190750Z Sep 67.

8. (S) OpRep 4, 8th TFW to AIG 913, DI, 10051, 030945Z Oct 67.

9. (S) Summary, Hq 7AF/13AF DM, WALLEYE Launch, and Target Photo, 13 Mar 68.

10. (S) OpRep 4, 8th TFW to AIG 913, DI, 10051, 030945Z Oct 67.

11. (S) OpRep 4, 8th TFW to AIG 913, DI, 10186, 080800Z Oct 67.

12. (S) Rprt, 8th TFW to CSAF, COMBAT EAGLE, 181200Z Oct 67;
    (S) OpRep 4, 8th TFW to AIG 913, DI, 10420, 170659Z Oct 67.

13. (S) OpRep 3, 8th TFW to AIG 913, DI, 10570, Pinnacle, 230609Z Oct 67;
    (S) Rprt, 8th TFW to CSAF, COMBAT EAGLE, 231240Z Oct 67.

14. Ibid.

15. (S) OpRep 4, 8th TFW to AIG 913, DOI 10634, 250700Z Oct 67.

16. (S) OpRep 3, 8th TFW to CINCPAC, 8th TFW 002, 050742Z Nov 67;
    (S) OpRep 4, 8th TFW to AIG 913, DOI 038, 050743Z Nov 67;
    (S) Summary, Hq 7AF/13AF, DM, WALLEYE Launch, 13 Mar 68.

[redacted]

(This page is UNCLASSIFIED.)

17. (S) Rprt, 8th TFW to CSAF, COMBAT EAGLE, 070621Z Nov 67;
(C) OpRep 4, 8th TFW to AIG 913, 060711Z Nov 67.

18. (S) OpRep 4, 8th TFW to AIG 913, DOI 076, 080830Z Nov 67.

19. Ibid;
(S) Summary, Hq 7AF/13AF, DM, WALLEYE Launch, 13 Mar 68.

20. (S) Summary, Hq 7AF/13AF, DM, WALLEYE Launch, 13 Mar 68.

21. (S) Msg, Hq 7AF to Zen 13 AF, 300932Z Nov 67 with msg quote, CINCPACAF, subj: WALLEYE, 182147Z Nov 67.

22. Ibid.

23. (S) Working Paper, Hq 7AF/13AF, DI, AGM-62 Usage, undated.

24. Ibid.

25. (S) Research--OpReps 3, 4, COMBAT EAGLE Documents, Hq 7AF, DOA, CHECO Personnel, Evaluation Period.

26. (S) Interview, Maj Gary L. Thompson and Capt Robert C. Ettinger, COMBAT EAGLE Aircraft Comdrs, 435th TFS, Ubon RTAFB, Thailand, by CHECO Personnel, 17 Mar 68. (Hereafter cited: Thompson-Ettinger Interview.)

27. (S) Rprt, 8th TFW to CSAF, F-4D/WALLEYE Launch, 220905Z Jan 68;
(S) OpRep 3, 8th TFW, Pinnacle, 181430Z Jan 68;
(S) Intelligence Briefing for Dep Comdr, 7AF/13AF, 19 Jan 68.

28. Ibid.

29. (S) Msg, CSAF to TAC, subj: COMBAT EAGLE, 061726Z Nov 67;
(S) Thompson-Ettinger Interview.

30. (S) Msg, 8th TFW to CINCPACAF, subj: WALLEYE Launch Rprt Summary for Oct 69, 040912Z Nov 69.

CHAPTER III

1. (S) Rprt, Hq PACAF, DOTE, subj: Combat Accuracy, PAVE WAY I - MK 84/KMU 351/B, 27 Aug 69.

2. Ibid.

3. Ibid.

4. Ibid.
(S) Working Paper, 68-10, Hq 7AF, DOA, subj: PAVE WAY Utility and Cost Effectiveness in SEA, 15 Dec 68. (Hereafter cited: PW Utility and Cost Effectiveness Paper.)

5. (C) Interview, Lt Col Mervin L. Evenson, 433d TFS, PW I Project Officer, Ubon RTAFB, Thailand, by Project CHECO Personnel, 2 Feb 70.

6. (S) PW Utility and Cost Effectiveness Paper;
(U) Article, "Aviation Week and Space Technology," 19 Jan 70;
(S) Research of Technical Papers, Project CHECO Archives, TSN AB, RVN;
(S) Rprt, Hq PACAF DOTE, subj: Combat Accuracy, PW I, 27 Aug 69.

7. (S) Rprt, Hq PACAF DOTE, subj: Combat Accuracy, PW I, 27 Aug 69.

8. (S) Msg, 7AF to CINCPACAF, subj: PW Combat Test and Evaluation, 271115Z Aug 68.

9. Ibid.

10. Ibid.

11. (C) Pamphlet, Hq 7AF, Conventional Airmunitions Guide, 15 Nov 69.

12. (C) Interview, Lt Col James M. Clark, Hq 7AF DOTM (Munitions), by CHECO Personnel, 5 Mar 70.

13. (S) Summary, Hq USAF, Management Summary (Update), 28 Jan 70.

14. (S) Ibid;
(S) Rprts, 7AF, Analysis of PW I Monthly Recaps for CY 69.

15. (S) PW Utility and Cost Effectiveness Paper.

16. Ibid.

17. Ibid.

18. Ibid.

19. (S) Working Paper, Hq 7AF DOA, subj: PW/Conventional Munitions Cost Comparison, Apr 70.

20. (S) Rprt, PACAF DOTE, subj: Combat Accuracy, PW I MK-84/KMU 351/B, 27 Aug 69.

21. Ibid.

22. (S) OpRep 4, 8th TFW, Sep 69;
(S) Recap, OpRep 4, 8th TFW, Oct 69.

23. Ibid.

24. Ibid.

25. Ibid.

26. (S) Definitions, Form O-16, 8th Combat Support Gp, "Summary of PW I Laser Guided Bomb Scores," undated.

27. (S) OpRep 4, 8th TFW, Sep 69;
(S) Recap, OpRep 4, 8th TFW, Oct 69.

28. Ibid.

29. (S) Rprts, 7AF, Analysis of PW I Monthly Recaps for 69.

30. (S) Summary, 8th TFW, Summary of PW I MK-84, 1 Jan-31 Oct 69, 1 Nov 69;
(S) Summary, 8th TFW, Summary of PW I MK-84, Nov 69, 8 Dec 69;
(S) Summary, 8th TFW, Summary of PW I MK-84, Dec 69, 4 Jan 70.

31. (S) Summary, 8th TFW, Summary of PW I MK-84, Dec 69, 4 Jan 70.

32. (S) Plan, 7AF, Munitions, FY 72, 7AF Force Improvement Plan, Jan 70, Annex J. (Hereafter cited: FY 72 7AF Force Improvement Plan.)

33. (S) Summary, 8th TFW, PW I, Monthly Summary, Dec 69, 4 Jan 70.

34. Ibid.

35. (S) CHECO Rprt, Hq PACAF, DOTEC, "Rescue at Ban Phanop, 5-7 Dec 69," 15 Feb 70.

36. (S) FY 72 7AF Force Improvement Plan.

37. (S) Summary, 8th TFW, Summary of Combat Operational Evaluation, Nov 69.

38. (C) Pamphlet, Hq 7AF, Conventional Airmunitions Guide, 15 Nov 69.

39. (S) Summary, 8th TFW, Summary of Combat Operational Evaluation, Nov 69;
(S) Rprt, Hq 7AF, subj: Combat Evaluation - M-118 LGB, Dec 69.

40. Ibid.

41. Ibid.

42. (S) Rprt, Hq 7AF, Individual Release Data and Results, Combat Evaluation, PAVE WAY I M-118, Dec 69, App B. (Hereafter cited: Individual Release Data and Results.)

43. Ibid.

44. (S) Msg, 8th TFW to CSAF, subj: Bolt M-118 Releases, 231005Z Oct 69.

45. (S) Individual Release Data and Results.

46. Ibid.

47. Ibid.

48. (S) Summary, 8th TFW, Summary of PW I (M-118) Scores, 15 Oct through 9 Nov 69.

49. (S) Rprt, 7AF, subj: Combat Evaluation, M-118 LGV, Dec 69.

50. (S) Summary, 8th TFW, Summary of Combat Operational Evaluation, Nov 69.

51. (S) Interview, Lt Col Mervin L. Evenson, 433d PW Project Officer, 2 Feb 70.

52. (S) Rprt, 8th TFW, PW I Recap for Night Releases, Nov 69-Jan 70, 5 Feb 70.

53. (U) Article, Aviation Week and Space Technology, 19 Jan 70.

54. Ibid.

55. (S) Rprt, 8th TFW to CSAF, PW I Monthly Report, Jan 70, 121013Z Feb 70.

56. Ibid.

57. (S) Rprt, 8th TFW to CSAF, PW I Monthly Report, Jan 70, 161108Z Mar 70.

58. (S) Msg, 8th TFW to 7AF/DPLR/DAFSC 260942Z Feb 70.

59. (S) Msg, Comdr, 8th TFW, Col Standfield to 7AF DO, Maj Gen Bevan, subj: PAVE WAY I, 211007Z Feb 70.

60. (S) Msg, ASD, Wright-Patterson AFB, Ohio to Det 6, ASD/DAFSC, TSN AB, RVN, 132224Z Mar 70.

61. Ibid.

62. (S) Msg, 8th TFW to 7AF, DOT, 100920Z Apr 70.

63. Ibid;
(S) Msg, ASD to Det 6, ASD/DAFSC, TSN AB, RVN, 132224Z Mar 70.

64. (S) Msg, CINCPACAF to CSAF, subj: LGB Performance, 030428Z Apr 70.

CHAPTER IV

1. (S) Ltr, Maj Gen George B. Simler, Dir of Ops, DCS/Plans and Operations, Hq USAF, to Maj Gen Gordon F. Blood, DCS/Operations, Hq 7AF, subj: Targets for EO Weapons, 30 Nov 68.

2. Ibid.

3. (S) Msg, ASD, WPAFD to AFSC, 151745Z Jan 69;
(S) Msg, 8th TFW to CSAF, 260232Z Jan 69.

4. (S) Msg, 8th TFW to CSAF, subj: PW II Highlight Rprt, 070645Z Feb 69.

5. (S) Msg, 8th TFW to CSAF, subj: PW II Highlight Rprt, 080515Z Feb 69.

6. (S) Msg, 8th TFW to CSAF, subj: PW II Highlight Rprt, 090600Z Feb 69.

7. (S) Form 4, Hq 7AF, subj: PW II Results, 12 Feb 69.

8. (S) Highlight Rprts, 8th TFW, Feb 69.

9. (S) Highlight Rprt, No 17, 8th TFW to CSAF, CINCPACAF, 7AF, 240127Z Feb 69.

10. (S) Msg, 8th TFW to CSAF, subj: PW II Highlight Rprt (Update), 151105Z Mar 69.

11. (S) Msg, 8th TFW to CSAF, subj: PAVE WAY II Evaluation, 101005Z Apr 69.

12. (S) Msg, 8th TFW to CSAF, subj: PW II Evaluation, 310700Z Mar 69.

13. (S) Msg, CSAF to PACAF, subj: EO Guided Bomb, 252235Z Apr 69.

14. Ibid.

15. (S) Msg, Dep Comdr, 7AF/13AF, Udorn, Thailand to 8th TFW, 161050Z May 69.

16. (S) Msg, CSAF to AFSC, subj: EO Guided Bomb, 302212Z Jul 69;
(S) TAWC Sup 1 to TAC OPlan 41, PW II EO Guided Bomb, Oct 69.

17. (S) Msg, Maj Gen J. F. Kirdendall, 7AF DCS/O to Maj Gen E. C. Hardin, Jr., PACAF DO, 191200Z Sep 69.

18. (S) Talking Paper, 7AF, DOA, PAVE WAY Comparisons, Apr 70.

CHAPTER V

1. (S) Weekly Air Intelligence Summary, 2AD, 23 Apr 66.

2. Ibid.

3. (S) WAIS, 7AF, 28 May 66.

4. (S) SEAOR No 52, FY 66, 25 Jun 66.

5. Ibid.

6. (S) Rprt, Hq USAF, Management Summary (Update), 26 Jan 70.

7. Ibid.

8. (S) Talking Papers, Hq 7AF, 1968 Fighter Weapons Symposium, undated.

9. (S) Msg, AFMDC, Holloman AFB, New Mexico, to CSAF, subj: F-105F AGM-78B CAT II/III Test Firing Report, 311930Z Mar 69.

10. Ibid.

11. (S) Msg, USAFTFWC, Nellis AFB, Nev. to 7AF DOC, subj: AGM-78/PAVE WAY II, 092121Z Oct 69.

12. (S) Msg, TAC to Hq 7AF, DOTACLO, subj: TACLO-7AF Activity Report (22-29 Sep 69), 071203Z Oct 69.

13. Ibid.

14. (S) Msg, CSAF to AFSC, subj: Systems Management Directive for AGM-78, 232122Z Dec 69.

15. (C) Naval Air Systems News, Vol 3, No 1.

16. Ibid.

17. Ibid.

18. (S) WAIS, 7AF, 6 Sep 69;
(S) WAIS, 7AF, 3 Jan 70.

19. (S) WAIS, 7AF, 29 Nov 69.

20. Ibid.

21. (S) WAIS, 7AF, 27 Dec 69.

22. (S) WAIS, 7AF, 3 Jan 70.

23. Ibid.

24. (S) WAIS, 7AF, 31 Jan 70.

25. (S) Interviews, Col D. M. Standfield, Comdr 9th TFW, and Lt Col Mervin L. Evenson, 433d TFS, Ubon RTAFB, Thailand, by CHECO Personnel, 25 Feb 70;
(S) WAIS, 7AF, 7 Feb 70;
(S) WAIS, 7AF, 7 Mar 70.

26. (TS) Rprt, PACAF, DOTE, Summary, Air Operations SEA, Jan 70. (Extract is classified SECRET.)

27. (TS) Rprts, PACAF, DOTE, Air Operations SEA Summaries, Dec 69, Jan 70, Feb 70. (Extract is classified SECRET.)

28. (C) Naval Air Systems News, Vol 3, No 1;
(C) Interviews, Maj Gary R. Braun and Maj Clifford A. Jackson, USMC, 7AF, DOCF, by CHECO Personnel, Mar and Apr 70.

CHAPTER VI

1. (C) Naval Air Systems News, Vol 3, No 1.

2. Ibid;
   (S) Final Rprt, ROCKEYE II Combat Evaluation, Phase II, 1 Jan 70.

3. Ibid.

4. (U) Interviews, Maj Gary R. Braun, USMC, Hq 7AF, DOCF, by CHECO Personnel, Mar 70.

5. Ibid.

6. (S) Rprt, Hq 7AF, DOA, Combat Evaluation, ROCKEYE II, Dec 69.

7. Ibid.

8. Ibid.

9. Ibid.

10. (S) Rprt, 432d TRW, ROCKEYE II Combat Evaluation, 1 Jan 70.

11. Ibid.

12. (S) Ibid, Atchs 1.1 and 1.2.

13. (S) Ltr, 432d TRW, DCOO to 7AF, DPLR/DOAT, subj: ROCKEYE II Weekly Rprt (11-16 Dec 69), 17 Dec 69;
    (S) Ltr, 432d TRW, DCOO to 7AF, DPLR/DOAT, subj: ROCKEYE II Weekly Rprt (11-16 Dec 69), 17 Dec 69, Atchs 1 and 2;
    (S) Rprt, 432d TRW, Final Rprt, ROCKEYE II Combat Evaluation, 1 Jan 70.

14. (S) Interviews, Maj Joseph F. Greenfield, 432d TRW, ROCKEYE II Project Officer, Udorn, Thailand, by CHECO Personnel, 4 Feb 70.

15. Ibid.

16. (S) Rprt, 7AF, DOA, Combat Evaluation, ROCKEYE II, Dec 69.

GLOSSARY

AAA	Antiaircraft Artillery
AFSC	Air Force Systems Command
AGE	Aerospace Ground Equipment
AGL	Above Ground Level
ALSC	Aluminum Linear Shaped Charge
ARM	Anti-Radiation Missile
ASD	Aerospace Systems Development
BDA	Bomb Damage Assessment
CAP	Combat Air Patrol
CBU	Cluster Bomb Unit
CEA	Circular Error Average
CEP	Circular Error Probable
CINCPACFLT	Commander-in-Chief, Pacific Fleet
CONUS	Continental United States
Det	Detachment
DF	Direction Finding
ECM	Electronic Countermeasure
EO	Electro-Optical
EW	Early Warning
FLIR	Forward Looking Infrared
GCI	Ground-Controlled Intercept
GHz	GigaHertz
GIB	Guy in Back
GP	General Purpose
HAA	Heavy Antiaircraft
LGB	Laser Guided Bomb
LLLTV	Low-Light-Level Television
LOC	Line of Communications
LORAN	Long-Range Navigation
LSC	Linear Shaped Charge
LTD	Laser Target Designator
MAA	Medium Antiaircraft
MAC	Military Airlift Command
mm	millimeter

NE	Northeast
NM	Nautical Mile
NOD	Night Observation Device
NVA	North Vietnamese Army
NVN	North Vietnam
OpOrd	Operations Orders
OPlan	Operations Plan
PACAF	Pacific Air Forces
POL	Petroleum, Oil, and Lubricants
PRF	Pulse Repetition Frequency
PW	PAVE WAY
Recon	Reconnaissance
RHAW	Radar Homing and Warning
RNO	Results Not Observed
RP	Route Package
RTB	Return to Base
SAM	Surface-to-Air Missile
SAR	Search and Rescue
SEA	Southeast Asia
SEAOR	Southeast Asia Operational Requirement
TAC	Tactical Air Command
TAWC	Tactical Air Warfare Center
TFS	Tactical Fighter Squadron
TFW	Tactical Fighter Wing
USMC	United States Marine Corps
UTM	Universal Transverse Mercator