LEVEL II

NWC Technical Memorandum 3

(14) NWC-TM-3064

(1) SC

20000726126

(6)

AIR-LAUNCHED MISSILE STRUCTURAL FAILURE/DAMAGE STUDY

by

(10) C. F. Jawor
Aeromechanics Division
Systems Development Department

(11) APRIL 1977

(12) 39 p.

Naval Weapons Center
China Lake, California 93555

(9) Technical memo. Jun-Dec 76,

403 019
78 09 22 075

FOREWORD

This report contains the results of a study of missile structural failure/damage data. This study was made to identify major problem areas and common causes of failure/damage to airborne missiles which should be avoided in future missile design and Fleet deployment. Funding for this study was provided by the Naval Air Systems Command under Air Task A03W-03P2/008B/6F32.300-000.

The work presented in this report was conducted during the period of June 1976 through December 1976.

The primary sources of failure/damage data were the Fleet Support Branch of the Fleet Engineering Division at NWC and the Fleet Analysis Center, NWS, Corona Annex.

This report is released at the working level for information purposes only.

Ray W. Van Aken, Head
Aeromechanics Division
Systems Development Department
15 February 1977

NWC TM 3064, published by Code 3162, 30 copies.

3

CONTENTS

SUMMARY

A study of structural failure/damage data, from various sources, such as inspection reports, fleet unsatisfactory reports and accident/incident reports, for air launched missiles was performed to determine major problem areas and common causes for the failure/damage. Missiles for which failure/damage data were studied are: SIDEWINDER (AIM-9), SPARROW (AIM-7), SHRIKE (AGM-45), BULLPUP (AIM-12), PHOENIX (AIM-54), STANDARD ARM (RIM-66, -67) and WALLEYE (AGM-62). The most common causes of structural failure/damage were found to be careless and negligent handling, and captive flight environment overstress caused by excessive motion at moveable control surfaces. Corrosion due to inadequate packaging and storage conditions was also a common cause of damage. Recommendations for investigation and study of these causes of failure/damage are made.

INTRODUCTION

This report contains the results of a study of missile structural failure/damage data, made in order to identify major problem areas and common causes of failure/damage that should be avoided in future missile design and fleet deployment.

Although data on failures/damage was readily available, the type or format of the data was varied and was the limiting factor in the study. The first portion of the study is based on data gathered at NWC and Pt. Mugu from data files of personnel involved in the fleet support effort of the various missiles. This data varied from summaries of failure damage to informal notes (reference 1-18). Data from these sources was adequate to provide a basis for categorizing failure/damage by common cause of failure, but quantitative data was lacking since there was no means of correlating number of failures and missiles from the varied data. The major problem encountered with gathering data was that there is no control point (such as the library) where reports such as references 10 and 11 can be found, these reports are disseminated to individuals, and were kept in their files at their discretion.

The second portion of the study is based on data received from the Fleet Analysis Center (FLTAC) N.W.S., Corona Annex. Although all data on fleet missile problems is collected at FLTAC, it is put into coded computer data banks, and requires programming a computer code to retrieve any particular type of data such as structural failure/damage.

The data from FLTAC provided numerical data based on number of inspections reported via the Shore Maintenance Data Collection System (SMDCS).

DISCUSSION

Data on structural failures and physical damage to missiles compiled from various sources are listed by missile in Table I. To facilitate further analysis of the failure/damage data, categorization by source or cause of failure/damage was necessary. Table II shows the data from Table I listed under four categories of cause of failure/damage. The four categories for cause of failure/damage chosen were: 1. Corrosion, 2. Handling, 3. Quality Control/Assurance, and 4. Captive Flight Environment. Although design deficiency may be a cause in some failures, it was not listed as a separate category, since it may be a factor in each of the four categories chosen. There may also be some overlap in the cause of the failures listed, as for instance; undetected damage during handling or storage may cause a failure during captive flight.

Each of the four categories can be broken down further as follows:

CORROSION: Due to packaging, storage conditions, or inadequate design (improper materials, lack of corrosion protection, etc.)

HANDLING: Improper procedures, personnel error, or inadequate design for handling.

QUALITY CONTROL/ASSURANCE: Manufacturing, inspection or design deficiency (excessive tolerances, inadequate or improper specification of heat treatment, etc.)

CAPTIVE FLIGHT ENVIRONMENT: Overstress, weather, or design deficiency.

Table III is a summary of failure/damage data of Table I and is listed by missile, component and category of failure. Due to the varied sources of data, it was not possible to make a quantitative assessment of the failures/damage, but it is apparent that the majority of failures were due to overstress during captive flight and handling.

To obtain a quantitative set of data on structural failures/damage to missiles the Fleet Analysis Center (FLTAC) at Corona Annex, Naval

TABLE 1. Structural Failure Data.

Missile	Component Description	Type of Failure/Defect	Cause	Fix	Comments	Ref.
AIM-9B (Sidewinder)	Missile	Broke in 2 pieces after launch	Overstress	Lock on fins during captive flight	Three incidents reported 1971 thru 1974	15
do	G & C securing screws	Loose screws	...	...	Probable cause fin flutter (excessive moment @ joint)	15
do	G & C unit front joint attach screws	G & C unit separated	...	...	do	15
do	Dome	Damaged in flight	Rainstorm during flight	...	Two incidents reported 1971-1974	15
do	Dome	Damaged	Handling	...	One (1) incident reported 1971-1974	10, 15
do	Warhead joint	Warhead separated from missile	Excessive load on joint	Lock fins during captive flight	Separation occurred on arrested landing. Two (2) incidents 1971-1974	15
do	Rolleron cager	Corrosion of cager	Environment	Improved coating	Pt. Mugu fix	16
AIM-9C/D	Joint	Unequal gap between coupling ring & component	Flight load overstress	Lock fin control surfaces during captive flight	Fault detected after captive flight	1
do	Joint motor tube coupling ring groove	Crack	Flight load overstress	Lock fin (canard) control surfaces during captive flight	Crack detected after captive flight	1
do	GCG coupling ring grooves	do	do	do	do	1
do	TDD coupling ring grooves	do	do	do	do	1
do	Warhead coupling ring grooves	do	do	do	do	1

TABLE 1. (Contd.)

Missile	Component Description	Type of Failure/Defect	Cause	Fix	Comments	Ref.
AIM-9C/D	TDD & motor tube coupling ring screws	Corrosion, wrong screw, or loose screw	...	...	Detected after captive flight—several incidents	1
do	Rolleron cager	Broken detent	Handling	...	Detected during inspection before flight	1
do	Wing assemblies	Corrosion	Leaky containers	Container redesign		4
do	Bearing seals (rolleron)	Missing epoxy	Loss of epoxy Q.A.	Seal design change	Detected during maintenance check	4
do	Clamp ring GCG	Broken	Flight load overstress	Lock fin control surfaces during captive flight	Crack detected after captive flight	2
do	Snap ring, which holds outer bearing on rolleron in place	Snap ring & bearing seal broken during vibration & shock testing	Design fault	New snap ring	Detected during fleet use qualification testing	11
do	Wings	Corrosion	Inadequate packaging (packaged in wooden boxes)	Package in leak proof containers	Corroded during shipping & storage	11
AIM-9D	Rolleron caging device	Shearing of rolleron caging device	Absence of caging clips during captive flight	Proper installation of caging clips	Caging clips loosened & lost during captive flight	2, 3
do	Nose cone covers	Covers become loose after handling	Poor design	None	Loss of covers increases potential of damage to GCG and dome during handling	12
do	Dome	Broken	Improper handling	...	Broken during shipping/handling	6
do	Warhead	Broke off missile	Flight load overstress	Lock on fin control surfaces during captive flight	Broke off during arrested landing	5, 8
do	Rolleron damper assembly	Damper leaking oil	Q.C. or handling	Q.A.	Defect found during checkout of wing assembly	11

TABLE 1. (Contd.)

Missile	Component Description	Type of Failure/Defect	Cause	Fix	Comments	Ref.
AIM-9G	Dome	Damaged in flight	Rainstorm	...	Six (6) incidents reported 1971-1974	15
do	Rolleron cager detent	Cager detent broken	...	Material change	...	15
do	Missile	Water damage	Leaky container	Improve container design & inspection	Several incidents reported	15
do	Umbilical breakaway screws	Umbilical hang-up	Helicoils for screws inserted poorly	Q.A. insert helicoils properly	Launching problem. Launch delay caused	16
AIM-9H	Dome	Crack in GCG lens	Handling	...	Crack noticed during tone-check	11
AIM-9L	Dome	Broken	Handling	...	Broken during burn-in at Pt. Mugu	13
do	Rolleron caging assembly	Breakage of locking part of rolleron caging assembly which is plastic	Improper handling	None	Failures during handling	14
AIM-9	Rolleron wheel	Wheel shifted on hub causing scuffing inside wall of case assembly	Loosened wheel on hub due to high centrifugal forces—no vanes in front of rolleron Air Force missile	Install flow vanes used on Navy missiles & tighten force fit tolerances wheel/hub	Failures occurred during wind tunnel & flight tests	18
AIM-7D (SPARROW)	Wing	Wing lost during captive flight	Overstress due to flutter—wing unlocked	...		15
AIM-7D AIM-7E AIM-7E2	Wing stud	Wing clips & wing studs broken loss of wings	Flutter instability wings flap against stops causing overstress on studs	Wing clips to hold wings stationary during captive flight	Intermittent incidents date back to early 60's. Occurred on F4B aircraft. Failure could not be repeated when monitored during flight tests	16

TABLE 1. (Contd.)

Missile	Component Description	Type of Failure/Defect	Cause	Fix	Comments	Ref.
AIM-7E	Missile	Broke in two after firing	Overstress	...	Overstress probably caused by wing flutter (reference listed cause unknown)	15
do	Pitch wing	Wing separated from missile	Flutter	...	Pitch wing separated after launch	15
do	Radome & antenna	Damaged	Foreign object in flight	...	2 occurrences during captive flight—1 foreign object and 2nd unknown cause	15
do	Wing assy.	Damaged	Turbulence/wing instability	...	Eleven (11) assy's reported damaged after captive flight 1971 thru 1974	15
AIM-7E & AIM-7E2	Radome	Damaged/shattered radome	Handling	...	3 occurrences 1971-1974. Dropped missile during handling	15
AIM-7E2	G & C	G & C damaged	Poor packaging	...	Damaged in container	15
do	Warhead Mk 38/0	Weld defects	Manufacturing poor Q.C.	Q.A.	18 occurrences of weld defects 71-74	15
AIM-12B (BULLPUP)	Aft warhead joint	Weld failed	...	Add 47 rivets at joint		16
do	Aft warhead joint	Insufficient number of rivets	Q.C. inspection	Improve Q.A.	Only 43 rivets found at joint where 47 called for	16
do	RF antenna connector	Broken	Improper handling	...	Broken during shipping/handling	7
AGM-45A (SHRIKE)	Wing shaft bearing	Corrosion	Moisture intrusion	Waterproof bearing seals or add anti-corrosive coating to bearing	195 incidents FY 1972. Processed at NARF (Naval Air Rework Facilities)	17
do	Damper assembly	Leaking—failed specified test	Q.C. and captive flight environment	Improve Q.A.	7.8% failure rate Jan thru March 1972. Reduced to 2.1% failure rate for FY 72.	17

TABLE 1. (Contd.)

Missile	Component Description	Type of Failure/Defect	Cause	Fix	Comments	Ref.
AGM-45A	Umbilical cables	Damaged	Handling	Handling procedure	High rate of damage reported FY-72	17
AGM-62 (WALLEYE)	Aluminum wing	Loss of wing	Flutter	Material change to fiberglass	Material not necessarily cause of flutter--fix questionable	16
do	Wing/fin assembly	Damaged	Handling	...	Six (6) sets reported damaged 1971-1974	15
(CHAPARRAL)	O-ring between gas generator & servo-block	Leakage at joint	Poor teflon coating	Tighter inspection & call out on o-ring drawing	Quality control problem	9
RIM-66B, -67A (STANDARD ARM)	Dorsal fins	Damaged	Handling	...	Damaged during storage unloading and loading handling (3 incidents, July thru Sept. 1974)	10

11

TABLE 2. Failure/Damage--Grouped by Cause.

Cause of Failure/Damage	Missile	Components
Corrosion	AIM-9B	Rolleron cager
	AIM-9C/D	Wings
	AIM-9G & AGM-45A	Various Components
	AGM-45A	Wing shaft bearing
	AIM-9C/D	Coupling ring screws
Handling	AGM-45	Umbilical cables
	AIM-9, AIM-7, AGM-45	Domes, radomes
	AIM-12B	RF antenna
	AGM-62	Wing/fin assy.
Quality control/ quality assurance	AIM-9	Bearing seals
	AIM-9	Rolleron damper assy.
	AIM-9	Umbilical breakaway screws assy.
	AIM-7 & AIM-12B	Weld defects
	CHAPARRAL	O-ring
Captive flight environment	AIM-9, AIM-7	Domes
	AIM-9	Coupling rings, joints, screws
	AIM-9	Rolleron cager, rolleron snap ring, hub-rolleron
	AGM-45	Damper assy.
	AIM-7	Wing studs, clips, wings
	AGM-62	Wing

12

TABLE 3. Summary of Failure/Damage Data By Missile.

Missile	Component	Cause & Type of Failure/Damage
AIM-9	Dome	Handling & captive flight environment (rain)--Damage
	Joints	Captive flight overstress-cracks and breaking
	Rolleron caging assembly	Quality control and captive flight environment--bearing seals, dampers, snap ring, caging device.
	Wings	Corrosion
	Fins	Captive flight--flutter creating overstress condition on missile joints
AIM-7 (SPARROW)	Radome & antenna	Handling and captive flight damage.
	Wing assy.	Captive flight overstress wing studs and clips broken, loss of wings during captive and free flight.
AGM-45 (SHRIKE)	Wing damper assy.	Quality control and captive flight environment--failed specified test, leaking after flight.
	Wing shaft bearings	Corrosion
	Umbilical cables	Handling damage
AGM-62 (WALLEYE)	Wing/fin assy.	Handling--damage
	Wings-aluminum	Captive flight--flutter
AIM-12 (BULLPUP)	Aft warhead joint	Quality control mfg.--welded joint failure.
	R.F. antenna connector	Handling--damage

Weapons Station, Seal Beach, was requested to provide a summary of the physical defects and number of occurrences reported via Shore Maintenance Data Collection System (SMDCS) inspection reports for a period of 3 years (CY '73 - CY '75) for several missiles. Table IV shows the FLTAC data. The data do not indicate the cause of failures, but the type of defects/failures indicate that the majority occurred during handling and captive flight. The wing hub or lock damage reported on the AIM-7 (SPARROW) missile is due to the captive flight environment since it is of the same type shown in Table I.

Although corrosion is listed often in Table IV, the number of occurrences is insignificant when compared to those that are apparently due to handling or captive flight.

The summary of defects/failures presented in Table IV counts each report of a given physical defect, therefore, any defect reported more than once from separate inspections at separate locations for the same occurrence of that defect would result in multiple counts. For this reason, the number of occurrences reported in Table IV cannot be compared with any reports that deal with the frequency of occurrence of a given defect versus the number of times a given defect is reported.

Previous experience by FLTAC indicates that this discrepancy (a defect on the same missile reported more than once) should be less than 5% of the numbers (defects) reported in Table IV.

Table V provides data that allows the data of Table IV to be evaluated in relation to the total number of inspections reported during the three year time period covered, the number of go inspections (inspections with no defects), the number of defects reported that have no physical damage significance, etc.

Specific types of failure/damage are shown as a percentage of number of inspections in Table VI. Only the top nine failure/damage percentages are shown. The SPARROW (AIM-7) wing hub or lock damage exceeds the next type of damage reported by a factor of 5.

There are a number of dramatic statistics that can be obtained from the data shown in Table IV and V. For instance, taking a particular type of defect reported as a percentage of NOGO records with defects shows that the SPARROW wing hub or lock damage accounts for 33% of damage reported on the SPARROW. Similarly, 19% or approximately 1 of every 5 defects reported on the SHRIKE missile are radome damage. Damaged domes or radomes account for 4.6% of all defects reported for the missiles in Table IV.

Requirements for air launched missiles dictate that missile protuberances, such as control surfaces, be removable and packaged separately for logistical purposes (ease of packaging, storage and handling).

TABLE 4. Air Launch Missile Physical Defect Reporting Summary 1 January 1973 through 31 December 1975.

AIM-54 (PHOENIX)

SECTION	DEFECTS QTY	CODE	DESCRIPTION
ARMAMENT	3	ACP	CONNECTOR(S) PIN(S) BENT/DAMAGED (SPECIFY WHICH CONNECTOR(S) IN NARRATIVE)
	2	ACR	EXCESSIVE CORROSION
	14	ADO	OTHER DAMAGE
	10	AMO	OTHER DEFECT OR MISSING ITEM
	21	ATA	TDD ANTENNAS, ANY DAMAGE
CABLE	3	CAD	CABLE DAMAGE
CONTROL	2	CBD	ELECTRICAL POWER SUPPLY BATTERY ASSY DAMAGED
	3	CCD	CONNECTOR(S) DAMAGED
	52	CCO	REAR ANTENNA RADOME DAMAGE, OTHER
	1	CCP	CONNECTOR(S) PIN(S) BENT/DAMAGED (SPECIFY WHICH CONNECTOR(S) IN NARRATIVE)
	3	CCR	EXCESSIVE CORROSION
	40	CDO	OTHER DAMAGE
	2	CDR	DROPPED
	59	CHL	HYDRAULIC FLUID LEAK
	93	CHP	HYDRAULIC POWER SUPPLY FLUID LEVEL LOW
	1	CPD	ELECTRICAL POWER SUPPLY ELECTROLYTE EXIT PORT DAMAGED
	2	CRC	REAR ANTENNA RADOME CUT
	1	CUD	ELECTRICAL UMBILICAL DAMAGED
	2	CUL	COOLANT UMBILICAL CONNECTOR LEAKING
	2	CXM	EXTERNAL MAINTENANCE REQUIRED
FIN	1	FCR	EXCESSIVE CORROSION
	16	FDO	OTHER DAMAGE
GUIDANCE	6	GDO	OTHER DAMAGE
	4	GRC	RADOME CRACKED
	1	GRD	RADOME SCRATCHED

TABLE 4. (Contd.)

AIM-54 (PHOENIX)

SECTION	DEFECTS QTY	CODE	DESCRIPTION
PHOENIX ALL UP ROUND	3	MCM	COMPONENT/PART MISSING
	1	MCR	EXCESSIVE CORROSION ON ALL SECTIONS
	15	MDO	OTHER DAMAGE
	1	MDR	MISSILE DROPPED
	49	MFA	FUSELAGE INSULATION, CUTS
	17	MFB	SECTION LAP JOINT BOLTS, ANY MISSING
	77	MFD	FUSELAGE INSULATION, DENTS/GOUGES
	18	MMO	OTHER DEFECT OR MISSING ITEM
	10	MSD	FUSELAGE METAL SKIN, DENTS/FLATS
	5	MUS	ELECTRICAL UMBILICAL WORN GUIDE SLEEVES
	4	MXM	EXTERNAL MAINTENANCE REQUIRED
PROPULSION	2	PAD	ARMING MECHANISM, ANY DAMAGE
	8	PCC	ROCKET MOTOR EXIT CONE CHIPPED
	7	DPO	OTHER DAMAGE (EXPLAIN IN REMARKS)
WING	5	WPD	PANEL, DENTS
	4	WPO	PANEL DAMAGED, OTHER

TABLE 4. (Contd.)

AIM-9 (SIDEWINDER)

SECTION	DEFECTS QTY	CODE	DESCRIPTION
FIN	180	FNC	CORRODED TO EXCESS
GUIDANCE CONTROL GROUP	562	CBD	CRACKED OR BROKEN DOME
	10	CBM	CRACKED OR BROKEN MIRROR
	273	DBG	DEFECTIVE FIN BOOTS OR GROMMETS
	1	DFC	DAMAGED FIRING CONTACTS
	46	DPD	SCRATCHED OR PITTED DOME
	700	DPM	PAINT ABRASIONS SCRATCHES OR METAL PITTING
	12	FDD	FINS DAMAGED OR DENTED
	4	GAP	STRIPPED GAS PLUG
	113	GCD	DAMAGED TDD ALIGNMENT SLOT OR TDD/TLM
	16	GCR	CORRODED TO EXCESS
	6	GFB	FIN BRACKET DAMAGE
	1	GFZ	FUZE CABLE DAMAGED/DEFECTIVE
	17	DZO	TLM CABLE DAMAGED/DEFECTIVE (DESCRIBE IN NARRATIVE)
	3	GTDD	TDD CABLE DAMAGED/DEFECTIVE
	201	GWD	WATER INTRUSION, WATER SOAKED
	23	IID	ILLEGIBLE IDENTIFICATION
	1	NLO	NITROGEN LOW
	10	PMI	PIN MISSING
ROCKET MOTOR	19	RAG	FAILED ALIGNMENT GUAGE TEST
	675	RCB	CONTACT BUTTON ASSY DAMGAGE OR CORRODED
	12	RCD	CONTAINER DAMAGED
	16	RCR	COUPLING RING CORRODED
	13	RFB	FWD. BULKHEAD CORRODED
	61	RFD	FUZE CONTACT PLUNGER DAMAGE OR CORROSION
	3	RHA	FAILS HANGER ALIGNMENT CHECK
	110	RHD	NON-PROPULSIVE HEAD CLOSURE DAMAGE
	1	RHT	FAILED LAUNCHER HOUSER TEST
	54	RIF	RIF ASSY GASKET MISSING OR DAMAGED
	1107	RII	ILLEGIBLE IDENTIFICATION
	1	RIT	INTEGRITY TEST FAILURE
	85	RLO	LAUNCH HANGER NOT SECURE OR DAMAGED

TABLE 4. (Contd.)

AIM-9 (SIDEWINDER)

SECTION	DEFECTS QTY	CODE	DESCRIPTION
ROCKET MOTOR (CON'T)	72	RMD	MOTOR DROPPED (EXPLAIN IN REMARKS)
	2	RND	NOZZLE DAMAGED (RUSTED, CORRODED)
	25	RNS	NOZZLE WEATHER SEAL CRACKED OR PUNCTURED
	2991	RPD	PHYSICAL DAMAGE (CORROSION, DENTS, CUTS, RUST, ETC)
	4	RSD	RUBBER SEAL DAMAGED OR MISSING
	38	RTD	THREAD DAMAGE (COUPLING RING DAMAGE)
SAFE-ARM DEVICE	41	SAK	ALIGNMENT KEY MISSING
	23	SCC	COLOR CODE BAND MISSING
	35	SCP	CONNECTOR PINS BROKEN OR BENT
	333	SGD	GASKET DAMAGED, LOOSE OR MISSING
	51	SHS	HERMETIC SEAL BROKEN
	58	SII	ILLEGIBLE IDENTIFICATION
	398	SPD	PHYSICAL DAMAGE
	451	SSA	SHOCK ABSORBER DAMAGED, LOOSE OR MISSING
	58	SWD	WATER DAMAGE OR CORROSION
TARGET DETECTOR DEVICE	53	TCD	CONNECTOR DAMAGED
	2008	TCE	EXCESSIVE CORROSION
	21	TCG	COUPLING RING GROOVE DAMAGED
	272	TCM	COMPONENT MISSING
	66	TCR	COUPLING RING MISSING, BROKEN, CORRODED, ETC.
	44	TDC	THREADS DAMAGED OR CORRODED
	13	THD	HOUSING PHYSICALLY DAMAGED
	405	TII	IDENTIFICATION ILLEGIABLE
	16	TOD	O-RING DAMAGED OR MISSING
	60	TOG	O-RING GROOVE DAMAGE
	661	TOT	OTHER PHYSICAL DAMAGE
	73	TPD	LOCK PIN/GUIDE PIN MISSING, BROKEN, BENT, CORRODED ETC
	27	TRD	RADOME (RF WINDOW) DAMAGE
	2484	TRI	RUBBER INSERT LOOSE, MISSING OR DAMAGED
	141	TSD	SCREW MISSING, BROKEN, CORRODED OR DAMAGED
	38	TWD	WATER SOAKED, WATER DAMAGED OR EXPOSED TO WEATHER
	31	TXM	EXTERNAL MAINTENANCE REQUIRED (CONDITION CODE E) (DESCRIBE IN NARRATIVE)

TABLE 4. (Contd.)

AIM-9 (SIDEWINDER)

SECTION	DEFECTS QTY	CODE	DESCRIPTION
UMBILICAL CABLE	45	UCC	UMBILICAL CABLE COVERING PHYSICAL DAMAGE OTHER THAN SEPARATION FROM CONNECTOR SLEEVE
	167	UCD	UMBILICAL BLOCK CONNECTOR/CONNECTOR PINS BENT, BROKEN, SHEARED, SHORTED, BURNED, OR MISSING
	2	UCG	UMBILICAL CONNECTOR BLOCK GASKET DEFECTIVE, LEAKING MISSING OR OTHER PHYSICAL DAMAGE
	6	UCM	UMBILICAL CABLE MISSING
	5	UCS	UMBILICAL CABLE COVERING SEPARATION FROM BLOCK CONNECTION SLEEVE
	2	UCT	UMBILICAL CABLE FAILS TS-3037/G ELECTRICAL CONTINUITY TEST
	7	UCW	UMBILICAL CABLE CORRODED, OR WEATHERED
	6	UNL	UMBILICAL BLOCK CONNECTOR NITROGEN OUTLET AND/OR LINE BENT, BROKEN, OR SHEARED
	1145	UPD	UMBILICAL PHYSICAL DAMAGE
	68	URP	UMBILICAL CABLE REPAIRED/REPLACED
	2514	USD	UMBILICAL BLOCK CONNECTOR SCREWS DEFECTIVE, LOOSE, MISSING, DAMAGED, STRIPPED
WARHEAD	3	WCB	YELLOW BANK MISSING
	116	WCD	EXTERIOR CONTAINER DAMAGE
	249	WCO	HEAVY RUST OR CORROSION ON WARHEAD
	17	WCR	COUPLING RING DEFECTS
	5	WDM	DAMAGED MATING ENDS
	5	WEE	EXPOSED EXPLOSIVE
	197	WII	ILLEGIBLE IDENTIFICATION (MARK, MOD, SERIAL NUMBER, LOT NUMBER)
	26	WIS	IMPROPER STORAGE OF WARHEAD, MOISTURE IN INTERIOR OF CONTAINER
	415	WPD	PHYSICALLY DAMAGED (DESCRIBE IN NARRATIVE)
	37	WSD	BULGES AT END OF SKIN, CRACKS OR HOLE IN SKIN
WING	46	WDO	PHYSICALLY DAMAGED, OTHER THAN AS LISTED HERE, (DESCRIBE IN NARRATIVE)

TABLE 4. (Contd.)

AIM-9 (SIDEWINDER)

SECTION	DEFECTS QTY	CODE	DESCRIPTION
WING (CON'T)	46	WNC	CORRODED TO EXCESS
	46	WRU	CRACKS OF FLAWS DETECTED (X-RAY)

20

TABLE 4. (Contd.)

AIM-7 (SPARROW)

SECTION	QTY	CODE	DESCRIPTION
FLIGHT CONTROL GROUP	37	AWCL	AWC-44 LOOSE
	1739	WHL	WING HUB OR LOCK DAMAGED
	165	YCA	CABLE DAMAGED OR BROKEN
	362	YCH	CHIMNEY, EPU, DAMAGED
	24	YCM	COMPONENT MISSING (EXPLAIN)
	36	YCO	CORROSION EXCESSIVE
	18	YCS	EPU CHIMNEY SEAL DAMAGED
	31	YCT	CABLE TUNNEL DAMAGE
	13	YEC	ELECTRICAL CONNECTION BAD
	2	YEF	EPU FIRED
	206	YHD	WING HUB(S) DAMAGED
	4	YHL	HYDRAULIC OIL LEAK EXCESSIVE
	210	YHW	HARNESS, WIRING, DAMAGED OR BROKEN
	4	YMD	MISSILE OR SECTION DROPPED
	35	YMO	MOISTURE INTRUSION
	30	YOT	OTHER
	18	YPB	PIN, BROKEN, SHORTED ETC.
	1978	YPD	PHYSICALLY DAMAGED (DESCRIBE IN NARRATIVE)
	209	YPL	PLUG BURNED OR DAMAGED
	210	YTC	TUNNEL COVER OR RELATED PARTS DAMAGED
	7	YUC	UMBILICAL CABLE DAMAGED
	5	YUP	UMBILICAL PLUG DAMAGED OR SHORTED
	13	YWR	WINDOW ASSY, REAR ANTENNA, DAMAGED
	2	ZHW	HARNESS, WIRING, DAMAGED OR BROKEN
	3	ZMO	MOISTURE INTRUSION
RADOME	83	XRD	RADOME DAMAGED
ROCKET MOTOR	11	RMI	MOISTURE INTRUSION
SPARROW ALL UP ROUND	3	ZMO	MOISTURE INTRUSION
TARGET SEEKER GROUP	4	XAN	ANTENNA DAMAGE, FRONT
	61	XCA	CABLE DAMAGED OR BROKEN

TABLE 4. (Contd.)

AIM-7 (SPARROW)

SECTION	DEFECTS QTY	CODE	DESCRIPTION
TARGET SEEKER GROUP (CONT'D)	6	XCM	COMPONENT/PART MISSING (DESCRIBE IN NARRATIVE)
	8	ZCO	CORROSION EXCESSIVE
	3	ZMO	MOISTURE INTRUSION
WARHEAD	11	WMI	MOISTURE INTRUSION, SUBMERGED, WATER SOAKED
WAVEGUIDE	11	ZWG	REAR ANTENNA WAVEGUIDE DAMAGED

TABLE 4. (Contd.)

AGM-45 (SHRIKE)

SECTION	DEFECTS QTY	CODE	DESCRIPTION
CONTROL	104	CCR	EXCESSIVE CORROSION
	3	CIC	IGNITER CABLE DAMAGE
	975	CPD	CONTROL SECTION PHYSICAL DAMAGE (DESCRIBE IN NARRATIVE)
	12	CQA	QA REJECT
	123	CSS	STRIPPED SCREWS, UNABLE TO REMOVE
	48	CUD	UNBILICAL DAMAGED
	32	CUM	UMBILICAL MISSING
	8	CUR	BROKEN PINS IN UMBILICAL RECEPTICLE
GUIDANCE	35	GCR	EXCESSIVE CORROSION
	116	GPD	GUIDANCE SECTION PHYSICAL DAMAGE
	48	GQA	QA REJECT (REQUIRES EXTERNAL MAINTENANCE, CONDITION CODE E, ETC.)
	663	GRD	RADOME DAMAGE
	10	GSS	STRIPPED SCREWS, UNABLE TO REMOVE
	475	GTD	TDD ANTENNA DAMAGE
ROCKET MOTOR	9	MCD	AFT CLOSURE DAMAGE
	35	MCR	EXCESSIVE CORROSION
	14	MDR	MOTOR DROPPED
	1	MFW	FRAYED MOTOR WIRE
	103	MID	IGNITER DEFECT
	65	MIP	IGNITER OUT OF POSITION
	90	MPD	MOTOR SECTION PHYSICAL DAMAGE
	49	MQA	QA REJECT
	7	MSS	STRIPPED SCREWS
SHRIKE ALL UP ROUND	15	RCM	MOISTUE IN CONTAINER
	23	RCR	CORROSION ON ALL SECTIONS
	34	RDR	ROUND DROPPED
WARHEAD	16	WCD	BAD WARHEAD CABLE
	32	WCR	EXCESSIVE CORROSION
	2	WFW	FRAYED WIRE
	93	WPD	WARHEAD SECTION PHYSICAL DAMAGE

TABLE 4. (Contd.)

AGM-45 (SHRIKE)

SECTION	DEFECTS QTY	CODE	DESCRIPTION
WARHEAD (CONT'D)	10	WQA	QA REJECT
	1	WSA	FUZE SAFE-ARM IN UNSAFE CONDITION

TABLE 4. (Contd.)

RIM-66, -67 (STANDARD ARM)

SECTION	QTY	CODE	DESCRIPTION
AUTOPILOT BATTERY	19	APD	PHYSICAL DAMAGE
	21	APM	PLUG MECHANICAL BAD (RECESSED PIN)
	4	AWD	WATER DAMAGE OR CORROSION
	4	PPD	PHYSICAL DAMAGE
	3	PWD	WATER DAMAGE OR CORROSION
	1	PWS	WEATHER SEAL SCREWS CORRODED
GUIDANCE	10	GRD	RADOME DAMAGE
	1	GRT	RADOME TIP LOOSE
	4	GWD	WATER DAMAGE OR CORROSION
ORDNANCE	11	OAD	ANTENNA DAMAGE
	38	OCD	DAMAGED MARK 20 CABLE
	50	OPD	PHYSICAL DAMAGE
	2	OWD	WATER DAMAGE OR CORROSION
OTHER	5	BDA	BDA ANTENNA DAMAGED
	45	MDM	DORSAL FINS DAMAGE
STEERING CONTROL UNIT	7	SAC	ACTUATORS LEAKING FLUID
	21	SPD	PHYSICAL DAMAGE
	1	SPM	PLUG MECHANICAL BAD (PINS RECESSED)
	1	SSP	SHEARED TAIL RETAINING PIN
	2	STO	TAILS OFF CENTER
	6	SWD	WATER DAGE OR CORROSION
STANDARD ARM ALL UP ROUND	28	MPD	OTHER MISSILE PHYSICAL DAMAGE
	11	MWD	OTHER WATER DAMAGE OR CORROSION

TABLE 4. (Contd.)

AGM-62 (WALLEYE)

SECTION	DEFECTS QTY	CODE	DESCRIPTION
ARMAMENT	279	APD	PHYSICALLY DAMAGED
	11	ASH	SMALL HOLE IN SECTION
	8	APH	PUNCTURE HOLES IN SECTION
	4	AFM	FOREIGN MATTER PRESENT
	4	AHP	HARD POINT DECAL MISSING
	2	AMF	FILTER MOUNTING STUDS SHEARED
BOOSTER, FUZE	4	BPD	PHYSICALLY DAMAGED
	1	BBT	THREADS DAMAGED
CONTROL	56	CRD	RAT BLADE DAMAGED
	26	CWS	WATER IN SECTION
	23	CPD	PHYSICALLY DAMAGED
	9	CHL	HYDRAULIC OIL LEAKING
	6	CRV	RAT VIBRATION PRESENT
	4	CBM	RAT BLADES MISSING
	3	CRC	RAT SPLINE CRACKED
FILTER	3	FPD	PHYSICALLY DAMAGED
FUZE	11	ZBF	BOOSTER FROZEN
	3	ZPD	PHYSICALLY DAMAGED
GUIDANCE	1	GCM	CAGER OPERATION FAILED MECHANICALLY
	43	GPD	PHYSICALLY DAMAGED
HARNESS	7	HPD	POTTING DAMAGED
	3	HNS	SERIAL NUMBER MISSING
	1	HCD	CONNECTOR DAMAGED
	1	HCL	CONNECTOR LOOSE IN MOLD
	1	HEO	ELECTRICALLY OPEN

TABLE 4. (Contd.)
AGM-62 (WALLEYE)

SECTION	DEFECTS QTY	CODE	DESCRIPTION
PROBE	2	PPD	PHYSICALLY DAMAGED
TRIGGER	3	TPD	PHYSICALLY DAMAGED

27

TABLE 5. Air Launch Missile Inspection Report Summary
1 January 1973 Through 31 December 1975.

Number	AIM-54 (PHOENIX)	AIM-9 (SIDEWINDER)	AIM-7 (SPARROW)	AGM-45 (SHRIKE)	RIM-66, -67 (STANDARD ARM)	AGM-62 (WALLEYE)
Inspection Records Processed	5817	86288	9658	21285	3520	7793
GO Result Records	4247	62579	3429	17294	2397	5586
NOGO Result Records	1570	23703	6229	3991	1123	2207
NOGO Records w/o Defect Code	69	5597	388	469	126	1116
NOGO Records w/Defect Code	1501	18112	5841	3522	997	1091
<u>Defects Reported</u>:						
Physical Defects	580	20504	5562	3251	295	519
Functional Defects	799	26	327	453	414	573
Overage Pyrotechnics	...	1188	1364	141	413	109
Other*	169	518	79	...	42	...
Total	1548	22236	7332	3845	1164	1201

* "Other" category includes:
- Gas Grain Expended
- Invalid Defect Code Reported
- Defects reported "other"
- Modification required
- X Ray required

TABLE 6. Failure/Damage—Relative to Number of Inspections for Different Types of Damage.

Missile	Description of Damage and component	Missile Section	% Damaged (number reported damaged ÷ number of inspection records processed)
AIM-7 (SPARROW)	Overstress damage to wing hub or lock	Flight control group	20.1
AIM-9 (SIDEWINDER)	Handling damage to umbilical	Umbilical	4.2
AGM-62 (WALLEYE)	Handling physical damage	Armament section	3.6
AIM-9	Corrosion & handling damage such as dents and cuts to rocket motor	Rocket motor	3.5
AGM-45 (SHRIKE)	Handling damage to radome	Guidance	3.1
AIM-9	Rubber insert loose, missing or damaged in target detecting device (TDD)	Target detecting device (TDD)	2.9
AIM-9	Excessive corrosion TDD	Target detecting device (TDD)	2.3
AIM-54 (PHOENIX)	Dents, gouges & cuts in fuselage insulation/handling	Fuselage	2.2
RIM-66, -67 (STANDARD ARM)	Handling damage to ordnance	Ordnance	1.5

There have been and are many problems, as shown by the failure/damage data, associated with removable (mostly quick-disconnect) control surfaces. Every missile has had (or has) an instability, vibration, or flutter problem, which required costly analysis and fixes in an attempt to eliminate structural failures/damage. Typical examples of control surface caused failures are the: AIM-9 (SIDEWINDER) joint failures, due to overstress caused by wing flutter, which requires wing locks during captive flight and the AIM-7E (SPARROW) which has an ongoing problem, as shown by the number of wing studs and lock damage, although locks are used to prevent flutter. The locks used on the SPARROW wings are probably insufficient to prevent vibration caused by the free play due to tolerance build-up at the quick disconnect joint of the wing to shaft. Recently, the AIM-7F (SPARROW), with a different wing-to-shaft joint than the -7E model, has required design changes to resolve a flutter problem during free-flight. The AGM-45 (SHRIKE) missile had costly dampers added to the control section to prevent flutter of the quick disconnect wings during captive flight. Another problem with removable components has been water intrusion and corrosion at the mating joints of the parts.

The number of damaged domes and umbilical connectors during handling indicates that the protection used is inadequate or has a reverse effect on handling care, i.e., since a cover should protect a component from damage, it can therefore be subjected to rough and careless handling with the protection provided.

Table VII shows the number of physical defects as a percentage of inspections for each missile. The SPARROW missile had the highest percentage of defects (37.1%), this does not include the 1,978 physical defects described in the Appendix. The Appendix is a discussion of pertinent background information regarding the structural physical damage data provided by FLTAC.

CONCLUSIONS

Types of failure/damage vary with time period, missile, type of use and inspection stations reporting the failure/damage. This conclusion is illustrated by comparing data of Table I, which were predominantly reported during the 1967 through 1974 time period and data of Table IV which is for CY 1973 through 1975. The primary cause of structural failure/damage of Table I was on the AIM-9 (SIDEWINDER) missile joints, which eventually was shown to be due to overstress conditions resulting from dynamic excursion of the missile caused by fin flutter. This problem was resolved prior to the 3 year period (1973-1975) reported by FLTAC, which shows the major damage problem on the SIDEWINDER to be umbilical damage. Another example of the shift of type and cause of damage is the corrosion damage on the AGM-45 (SHRIKE) missile. For CY 1973-1975

TABLE 7. Proportion of Physical Defects Reported for Each Missile Relative to Number of Inspection Records Processed.

Missile	Inspection Records Processed	Physical Defects Reported	% (physical defects ÷ inspection records)
AIM-7 (SPARROW)	9658	3584*	37.1*
AIM-9 (SIDEWINDER)	86288	20504	23.8
AGM-45 (SHRIKE)	21285	3251	15.3
AIM-54 (PHOENIX)	5817	580	10.0
RIM-66, -67 (STANDARD ARM)	3520	295	8.4
AGM-62 (WALLEYE)	7793	519	6.7

* Does not include the 1,978 reported physical defects described in the Appendix.

data reported by FLTAC (Table IV), corrosion damage accounts for less than 1% of the missiles inspected, whereas reference 11 shows 17% of the missiles with corrosion damage for FY 1972. A reason for this shifting of types and causes of damage is due to the emphasis placed on a problem area when it becomes acute.

An overall view of the data studied indicates that handling and overstress conditions (not accounted for in design) during captive flight are the two major causes of structural failure/damage on air launched missiles.

The majority of handling failure/damage appear to be caused by carelessness and inadequate protection of fragile parts of the missile during handling.

The majority of overstress conditions during flight have been caused by free floating, quick disconnect, moveable control surfaces, where the flutter or vibration of the surfaces causes high load conditions on attachment points and missile joints.

RECOMMENDATIONS

Since a majority of failures/damage occur during handling of missiles, it is recommended that a strong and ongoing program to eliminate negligence and carelessness be established. The program recently initiated by COMNAVAIRSYSCOM and the Fleet units (see Appendix) should be fully supported. It is also recommended that a review and investigation of the effectiveness of protective coverings on fragile missile components such as domes and umbilical connectors be initiated.

While there is no assurance that nonremovable control surfaces will not cause problems, the problems encountered with quick-disconnect removable surfaces (failures, damage and cost of fixes versus the logistics requirement) should be investigated. Although corrosion problems, due to inadequate packaging, have subsided in the last few years, there still appears to be a need for improvement as some corrosion during shipping and storage is being reported.

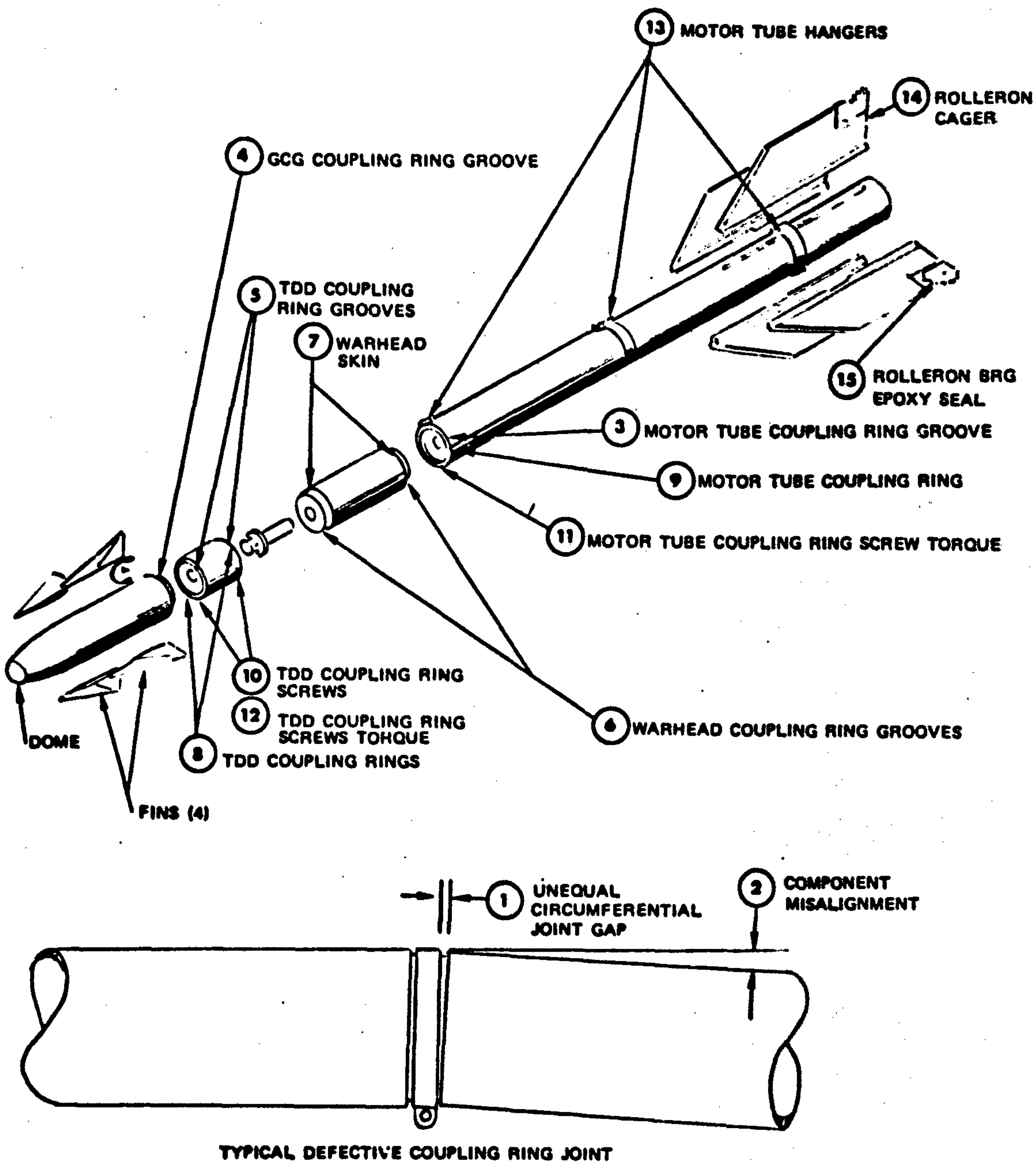

FIGURE 1. AIM-9C/9D Missile Failure Points.

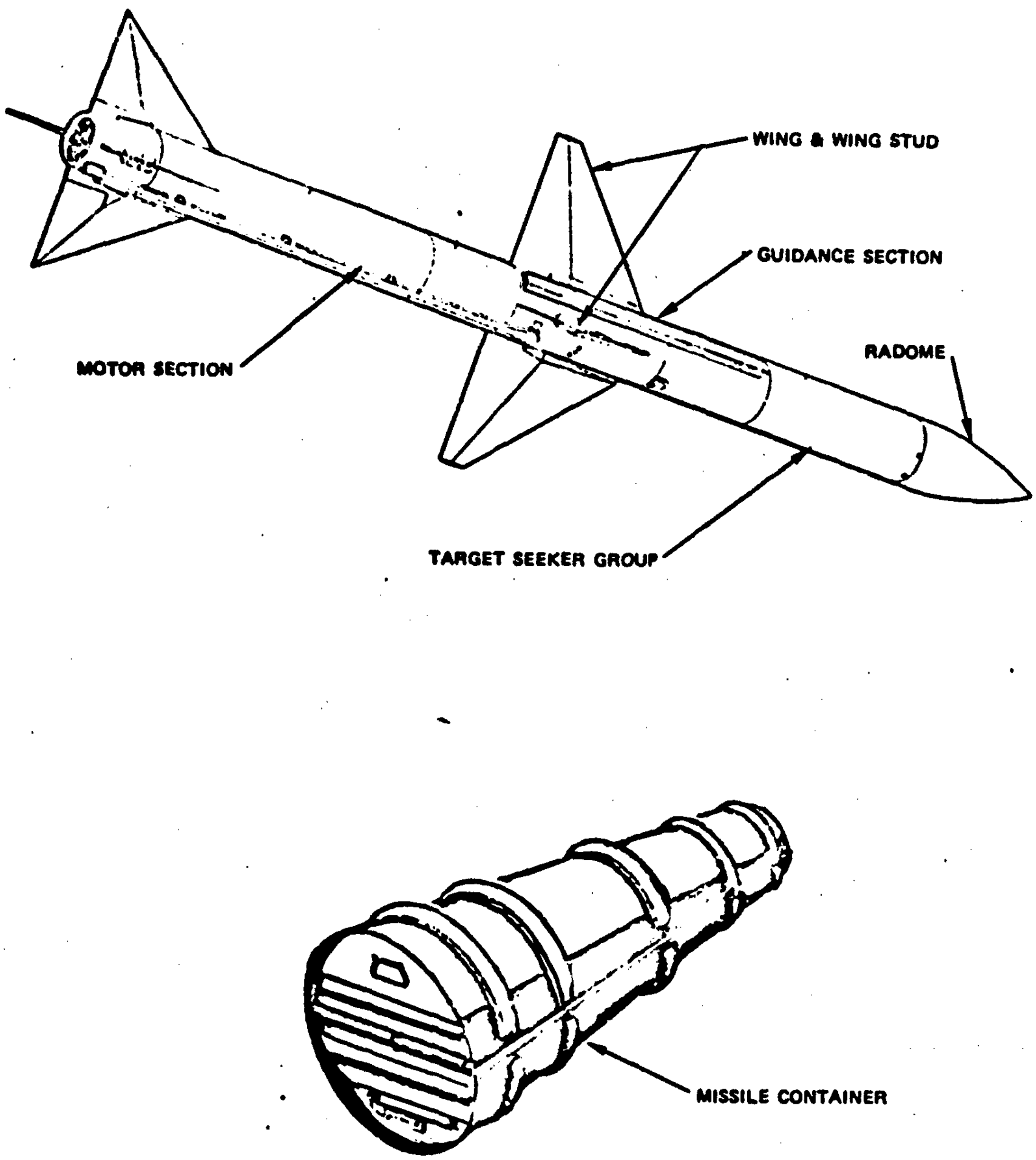

FIGURE 2. AIM-7 Missile Damage/Failure Points.

BIBLIOGRAPHY

1. Summary of AIM-9C/D System Trouble Points 1968-1969. No report number.

2. Memo Reg. 5568-50-68 "Weapons Debrief, U.S.S. Coral Sea" 9 May 1968.

3. Naval Message 8249 NAVAIRSYSCOMREPAC "AIM-9D Caging Device Failure" dated 2 Dec 1967.

4. Memo Reg. 5562-8025 "Mk 1 Mod 0 Wing Rolleron; Fleet Problems with" 1 April 1968.

5. Naval Message 151438Z Sep 68. U.S.S. Constellation to NAVAIRSYS-COMHQ, "Aircraft Incident Report"

6. Unsatisfactory Material/Condition Reports No's. 0282, 0265, 0272, 0284 CVA-64 WEPS 10-29 to 11-07, 1968.

7. Field Service Activity Report - BULLPUP - 25 Oct thru 10 Nov 1968.

8. Field Service Activity Reports - SIDEWINDER - 20 Oct-30 Oct 1968.

9. "Problems Encountered and Solved in Chaparral R&D Program" dated 13 Oct 1967. No memo number.

10. Reports of Accidents, Incidents, Malfunctions & Dangerously Defective Ordnance 1 July 1974-30 Sept 1974, Prepared by Naval Weapons Laboratory, Dahlgren, Virginia.

11. Airborne Weapons Corrective Action Program (AWCAP) Reports - SIDEWINDER and WALLEYE, 1975 and 1976, No report number.

12. Memo Reg. 5568-53-68, "Securing Dome Covers, Comments Concerning" 14 May 1968.

13. Memo Reg. 5586-479-75 "Categorization of AIM-9L Hardware Failure" W. V. Gunther," Sept 1975.

14. Memo Reg. 5586-159-76 "Sidewinder AIM-9L Failure Reports as Reviewed by the Failure Review Team (FRT); status of" W. V. Gunther, 23 March 1976.

15. Accidents, Incidents and Defective Ordnance Quarterly Report (Report Period 8/1/71-12/31/74), by Naval Surface Weapons Center, White Oak, Silver Spring, Maryland, dated 22 Jan 1975.

16. Naval Missile Test Center, Pt. Mugu, Information from Structures and Environmental Engineering Groups Aug. 2, 1976.

17. Shrike Guided Missile Quality Surveillance Report for FY 1972, Tech Memo 85-1207, Fleet Missile Systems Analysis and Evaluation Group Annex, NWS, Seal Beach, Corona, Ca., March 1974.

18. Informal Note - Rolleron Wheel Shift During Wind Tunnel and Flight Tests. No date.

19. "Results of Air Launch Missile Physical Damage Susceptibility Study," Fleet Analysis Center, NWS, Seal Beach, Corona Annex. Memo Ser 8252/39 dated 6 October 1976.

Appendix

DISCUSSION OF PERTINENT BACKGROUND INFORMATION REGARDING ALM STRUCTURAL/PHYSICAL DAMAGE SUSCEPTIBILITY

1. It has been shown in the past that the vast majority of physical damage to Air Launch Missiles is detected on units returned to the Weapon Station from Fleet deployment. A program was recently implemented by COMNAVAIRSYSCOM and the Fleet units to bring about a reduction in this shipboard handling damage. This program has not yet been in force long enough for its effort to be reflected in current data. However, preliminary indications suggest that a noticeable reduction in damage resulting from negligent and careless missile handling will result.

2. In the following, a brief discussion of facts relevant to physical damage consideration for each of the six Air Launch Missiles addressed in this study is presented.

a. PHOENIX (AIM-54)

The PHOENIX missile fuselage, except for the radome, is externally insulated with sheet cork bonded in place with a film adhesive and covered with nylon sheet (NOMEX). The function of this insulation is to provide heat protection for the missile components. By its nature, this insulation is susceptible to tears, scrapes, etc., and it is this damage which comprised approximately 25 percent of the PHOENIX Physical Defect codes considered in this study.

b. SIDEWINDER (AIM-9)

A report of an earlier study included a discussion of SIDEWINDER visual inspection failure rates for the time period 1972-1974. The sample analyzed consisted of 7721 visual inspections conducted during the reporting period. These 7721 inspections represent the last inspection of a given GCG during a particular year. Results of these inspections were used to calculate GCG visual failure rates. The visual failure rate represents the proportion of the sample GCGs that were sent to NAVAIREWORKFAC solely on the basis of a visual inspection without a follow-on functional test because heavy physical damage prevented testing on the AN/DSM-78. The overall Visual Inspection Failure Rate was 0.13 (1042/7721). The distribution of defects for the 1042 rejected

GCGs showed that the three most frequent defect categories (cracked domes, umbilical screws, and skin damage) account for 61% of the total number of defects.

c. SPARROW (AIM-7)

The 1978 "Physical Damage" defects listed for the Flight Control Group was used for some time to report "AWC-44 Loose" defects until a unique code was created for that defect. AWC-44 (Air Launch Weapon Change -44) added an assortment of gaskets, grommets and pressure pads in the cable tunnel and cable connector areas to preclude water intrusion into the section. During visual inspection, the integrity of the adhesive bond between the inside surface of the shell and the gasket added at the umbilical connector is evaluated. Improper priming of the metal surface prior to application of the bonding agent can and does result in an improper bond in this area and the resultant "AWC-44 Loose" defect code being reported. This defect is readily corrected at the Weapons Station without the need to send the unit to the DOP for repair, and it does not represent a significant susceptibility to the unit to physical damage.

This is not the case, however, with the "Wing Hub or Lock Damaged" defect which was the most frequently reported serious physical defect for the SPARROW missile.

d. SHRIKE (AGM-45)

The 975 CPD (Control Section Physical Damage) defects reported in enclosure (1) is inflated considerably by the presence of a considerable number (in excess of 500) of cases where that code was used, in the absence of a unique code for the purpose, to report screening and repair/replacement of the Barometric Pressure Switch in the control section. The remainder of the BPD defect codes covered a wide range of miscellaneous defects with no single defect prominent.

An earlier FLTAC study addressed the SHIRKE High Failure/Replacement Items from repair/rework data. The following is a synopsis of that study as it relates to physical damage.

(1) Guidance Section

An evaluation of the data revealed the following items were major contributors to the SHRIKE guidance section repair at NARF during the reporting period 1969-1973: 511 TDD antennas replaced and 359 radomes replaced. Brief descriptions of the test results, replacement rates, and the reasons for the replacement of each item follows:

38

TDD Antennas

A categorization of the reasons the antennas were replaced revealed that 418 were replaced due to physical damage and corrosion; 61 were missing upon receipt of the guidance section at NARF; 16 failed an electrical test; and the reasons for the replacement of the remaining 16 antennas were undetermined. There was a total of 706 guidance sections repaired and 511 antennas replaced for an average replacement rate of 0.72 (511/706). This means that slightly less than one antenna is replaced per guidance section repaired.

Radomes

The primary reason for the replacement of 348 radomes was due to physical damage and corrosion which accounted for 97% of all radomes replaced. The remaining 11 guidance sections which required radome replacement had missing radomes when the guidance sections were received at NARF. The radome replacement rate for guidance sections repaired at NARF is determined to be 50.8% (359/706).

(2) Control Section

The subassemblies and parts with the highest number of replacements at NARF for SHRIKE control sections resulting from physical damage during the period 1969-1973 were wing shaft bearings and umbilical cable assemblies.

Wing Shaft Bearings

A total of 285 wing shaft bearings were replaced, corrosion being the sole reason. The cause of corrosion is probably salt water intrusion during Fleet deployment. At this time it is not known to what extent these corroded wing shaft bearings affect missile reliability or performance.

Umbilical Cable Assemblies

A total of 169 umbilical cable assemblies were replaced: 83 were replaced for physical damage and/or corrosion; 76 were missing; and the remaining 10 failed an electrical continuity test. The umbilical cable is a frequently handled item during onloading and downloading operations aboard an aircraft carrier which may explain the high percentage.

c. STANDARD ARM (RIM-66, -67)

There is no background information pertinent to the subject of Physical Damage available for the STANDARD ARM.

e. WALLEYE (AGM-62)

The Ram Air Turbine (RAT) blade damage (including missing blades) continues to represent the most significant form of physical damage to the WALLEYE other than scratches, dents, and other external damage categorized "Physical Damage." An earlier study showed that RAT blade damage accounted for over 61 percent of the RATs replaced or repaired at the DOP.