Bring in as Captain, then back in as Lt Col. Don't bring in as 0-6. Is a very valuable resource, but must be handled carefully. Job must be made more palatable, both for officers and airmen. Aircraft has a bad name. Cann policies have really hurt the reputation and morale of maintenance personnel.

60 MAW/LGM

Believe dual qualified actually helps, instead of hinders. (SMSgt Thomas disagrees, thinks one system helps.) One-system base is easier to manage but two-system has some advantage. Have more flexibility with size due to overhead. Most important question is who does what? Do compete for talent. Key is to be able to man the shop and keep the qualified people. (Need to Code 51 the lower ranking people). Code 51 needed for E-4 and E-5s. C-5 is not just another normal system. Need stringent control over people to maintain talent..

Travis: Two-thirds of force under 30 years. Has losses in 3 and 5 level. MSgt Crew Chief - see attached chart. Currently is a negative influence - have complaints from Staffs and Techs who are ranked out of a job. Only have three MSgts now. Have well qualified and competent motivated Staff and Tech Sergeants. Rank doesn't make a crew chief. Manning and skills adequate for ute rate flying now. Using crew team concept good, but causes problems. Biggest problem lack of stability at lower and intermediate levels (4/5/6-year levels). Need a managed flow. Try to spread turnover. Primary limiting factor to bringing more

GRADE	CAFSC	AUTH	ASSIGNED	%	QUALIFIED YES	QUALIFIED NO
CMS	43191	8	4	50	3	1
SMS	43191	17	7	41	4	3
MS	43171E	54	26	45	23	3
TS	43171E	61	52	85	52	
SSGT	43151E	140	83	61	83	
	43131E		3		2	1
SGT	43151E	264	119	46	118	1
	43131E	0	5		1	4
A1C	43151E	0	106	62	106	
	43131E	113	78		58	20
AMN	43151E	0	2		2	
	43131E	0	140		32	108

Man power auth. / Crew Chief assigned

16 Jan 75

35 3

all Trainees Report for 1A pr

C-5s to Travis is ramp space. Beyond that, no real problem to bringing Altus flying to Travis. Rated supplement. Must have some formality of training. Must be orderly gaining of experience. Best is to bring in early. Problem with older guys.

8. Comments on PDM Concept

a. Is it adequate?

b. How could it be improved?

c. Is there a requirement for permanent field teams to specialize in rigging, corrosion control, install depot level TCTOs, etc.

d. Could MAC support)

e. How large a team)

DEPOT TCTO INSTALLATION CRITERIA

Current	Clock Hrs	M/H
MAC	16	48
Others	8	25

22 AF/LG

Must recognize we have a problem. Could possibly support an in-house PDM effort at Charleston.

9. Comments on Cann actions/policy

a. Is canning impacting safety?

b. Has the more stringent (no cann) policy for the ramps/doors/gear impacted operations to any great degree?

c. How can we improve?

22 AF/LG

No-cann policy in general is good. Must be tempered with some judgment. Don't really need the aircraft to fly. 20-Day-No-Fly policy is too unflexable, costing manpower, hurting morale. Improvement --

Set a policy with judgment and stick to it. If AFLC cannot support 20-day-no-fly policy, then don't make wings do it.

60 MAW/LGM

Impact safety maybe if wear out faster. Has built divergent policies: on-time departure/minimum equipment list/all up aircraft versus 20-day-fly policy. Cann -- single most detriment to morale. Really shakes up the crew concept and pride. Many other headaches and extensive effort in tracking such actions. (Capt Felton, Rig Team Chief, will quickly be in position to ground two aircraft a day.) No cann policy is going to force to 4-star level. We are going to either have a liberal cann policy or a fleet of no-fly aircraft. (Look at 30 or 32-day-no-fly policy. Study shows takes that long to get 85% parts). Are tearing up some parts by canning too much. May be should have no-cann list. Have let the Ops side of house drive maintainability with MEL.

10. Comments on Maintenance Training

a. Is it adequate?

b. Are getting the most out of our FTD?

c. Should we require refresher training?

22 AF/LG

Training -- Problem training of people off shore. Have slipped through training before get there. Also people going to FTD going to non-MAC units not working C-5.

60 MAW/LGM

Travis has 85% thru FTD and setting up with FTD a 20-hour APG refresher course.

11. Comment on morale of our maintenance personnel.

a. Officers

Effect of the rated supplement

b. NCOs

Level and quality

22 AF/LG

Biggest morale factor is cann of parts.

60 MAW/LGM

MAC/CS letter suggesting not use maintenance personnel on details too weak. Twenty-eight maintenance full-time security police augmentees (NO WAFS). Morale tracks with success. Presently 3-400% better than ever before. Better management. Some irritants.

12. Comment on the status of our Quality Control.

a. Is it adequate?

b. How can it be improved?

22 AF/LG

Have a deficiency. If had a QC like in 66-1 wouldn't have the current problem. Don't believe have the best people.

13. Comment on NRTS reporting and emphasis of getting assets evacuated. Must minimize amount of time between removal of an asset and shipment to the repair activity.

22 AF/LG

Not enough emphasis in this area. Look at manning and supervision. All inspection reports show this to be a problem. A tough problem. Need emphasis and training in this area. DIFM Asset Control.

14. Comment on effect of "delay" scoring on quality/cost/safety of maintenance.

Is there a better system?

FINAL COMMENTS

Gen Gonge: Look at moving Altus C-5 flying to Dover and Travis. Move C-130 squadron from Little Rock into a school environment.

Gen Morris: Can't afford anything but the very best top people. Need to hold on to our trained people. Need diff philosophy on handling our key NCO specialists. Movement of personnel must be changed. Maintenance Squadron Commander. AMS needs the technical expertise. Other squadrons need just a good people manager.

60 MAW/LGM

Use and integration of Reserve Forces. Are fully integrated -- no differentiation. Are used as a total asset. Don't believe in breakout of these forces.

CAPTAIN FELTON
RIGGING TEAM CHIEF

1. What are the main parts being found defective?

Answer: #7 yoke bearings, #7 hooks, yoke bearings in general on all rest. Program link pins, indicator parts in general, rollers over-alignment eccentric, some damage on the eccentrics, both upper/lower eccentrics for yoke, some corrosion. Found missing screws, bolts, washers. (One case, two missing back to back).

2. Is there any trend as to location?

Answer: #7 on wear/battered/beating -- hook -- yoke; corrosion throughout all positions.

3. Are the TCTO instructions adequate?

Answer: No. Team making a lot of changes. Some of the aircraft could not have been rigged under current TO instructions.

How can you tell when properly rigged?

Answer: 30# pull and hooks seated prior.

4. How critical is leveling the aircraft prior to starting rigging?

Answer: Not too critical, should set on level ramp.

5. What are the major deficiencies being found?

Quality of maintenance? (A: Some maintenance malpractice, rods in backwards, gaps in fore aft yoke alignment, rods misadjusted.)

Adequacy of inspection requirement? (A: Inadequate)

Evidence of abuse? (A: Some.)

Corrosion problems? (A: Fair amount, will require a lot of attention.)

Adequacy of training for our personnel? (A: Some good, some not. Overall system looked like had not been worked on to any great extent.)

6. Is the team identifying condition of parts by location and tail number? How are they reporting? Are URs being submitted? Exhibits tagged and forwarded to San Antonio ALC? (Want to look at some).

Answer: Yes.

7. How can safety of aircraft door/ramp be assured?

Answer: Still working problem.

NEW YORK TIMES
Friday, June 13, 75

Mr. Witkin tells of the USAF findings on the cause of the C-5 accident near Saigon.

Open Latches Cited in Vietnam Air Crash Fatal to 155

By RICHARD WITKIN

Special to The New York Times

WASHINGTON, June 12—The unlocking of three of 14 latches on a rear-entry ramp caused the crash of a C-5A cargo plane carrying children out of Vietnam in April, the Air Force announced today.

A total of 155 persons were killed, including 98 of the 247 children on board the Lockheed plane, the largest in the world.

The investigating board said that, with the three locks open, the tremendous pressure inside the plane exerted excessive force on the rest of the locks. The ramp they were holding in place broke loose, along with an adjacent pressure door.

These massive metal structures flew rearward as 63,800 cubic feet of air went out the now-open rear of the plane in less than a second. In doing so, they rammed into critical parts of the interior structure severing cables needed to control the plane.

The pilot started a slow descent from the plane's 23,000-foot altitude, heading back to Saigon's Tan Son Nhut Airport. But because of the damage to the controls, he had to crash-land in rice paddies short of the runway. The plane broke up and burned.

C-5A's Under Restrictions

There was speculation that the plane might have been sabotaged, but the crash investigators ruled this out.

The inquiry board made a number of recommendations for modification of the rear-entry locking system, for re-routing some of the vital cables and hydraulic and other lines, and for study of whether more extensive changes were needed.

Meantime, Air Force spokesmen said that the remaining 77 C-5's in the transport fleet would continue to be flown, under restrictions imposed after the April crash.

The plane's rear entryways now must be kept locked, so that all loading and unloading must be done through the nose entries. And passengers have been barred from all C-5A flights for the time being.

The giant plane, nicknamed the Galaxy, has been a focus of controversy since its earliest days, when deficiencies in the wing structures and other problems led to large excess costs. The weakness in the wings threatened to cut the plane's lifetime to half, or even less, of what the design had called for.

Congress is currently considering new appropriations to beef up the wings and thereby prolong the plane's usefulness.

In commenting on the Saigon crash, the inquiry board said that it "could not conclusively determine the reason for the unlocking of the ramp locks because a significant number of parts were not recovered.

Looting Hampered Recovery

The recovery efforts, while highly productive, were hampered by the fact that much debris had fallen into the water (the plane was over the South China Sea when the entryway blew open) and looters at the crash scene had made off with some parts.

The pressure seal at the rear of the plane is made up essentially of two heavy structures which, when in place, form a reverse "L". The same two structures, when deployed downward, form the rampway over which trucks, tanks and other cargo can normally be loaded aboard the craft.

In the in-flight configuration, the "horizontal" part of the "L" sits at an angle of perhaps 25 degrees above horizontal, and the "vertical" part leans forward.

It is the "horizontal" part that has the 14 locks, seven on each side, to hold the total system in place. The three that came unlocked were the forward three on the right side of the plane.

The inquiry board said in a summary of its report:

"Although the board was not able to pinpoint the exact cause of the failure, it was able to trace the sequence close enough to ensure that subsequent actions will prevent a recurrence. Equally important, it was conclusively determined that there was no structural deficiency involved and that the ramp and pressure door failed only as a result of a dynamic overload."

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS MILITARY AIRLIFT COMMAND
SCOTT AIR FORCE BASE, ILLINOIS 62225

SPECIAL ORDER
A-29

4 April 1975

COL BERNARD A WAXSTEIN, 126-26-0303FR, 22AF/JA, Travis AFB CA, is detailed to investigate the 4 April 1975 aircraft accident involving USAF C-5 acft No. 80218 which occurred approximately seven miles from Saigon, VN. The investigation will be conducted under the provisions of AFR 110-14, 1 Nov 73, as amended. Officer is auth to interview personnel, take statements and testimony, and examine records he deems appropriate. All records, files, and correspondence relative to the accident, within the control of the Air Force and not otherwise privileged or exempt by applicable directives, will be made available to the investigating officer. AFM 120-3, 20 Nov 69, will be used as a procedural guide. Report will be prepared IAW AFM 120-3, Chapter 11, and will include recommendations but a summary of the evidence will be prepared in lieu of findings.

FOR THE COMMANDER

HEADQUARTERS MILITARY AIRLIFT COMMAND OFFICIAL

HIRAM GRIFFIN, Colonel, USAF
Director of Administration

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C-5 CATEGORY III JOINT TEST FORCE

SPECIAL REPORT

3-15-71

INVESTIGATION OF PRESSURE DOOR INCIDENT

C-5 SN 68-225, 22 FEB 71, McCHORD AFB, WASHINGTON

Reviewed and Approved:

WILLUM H. SPILLERS, JR, Colonel, USAF
Director, C-5 Category III Joint Test Force

FOR OFFICIAL USE ONLY

SPECIAL REPORT

3-15-71

INVESTIGATION OF PRESSURE DOOR INCIDENT

C-5 SN 68-225, 22 FEB 71, McCHORD AFB, WASHINGTON

PROBLEM:

1. Aircraft ground accident - damage to pressure door and aft ramp complex. Left and right pressure door actuator failed allowing pressure door to free fall to the ground.

INVESTIGATION:

2. The ramp and pressure door was positioned to the drive-in mode. The right hand pressure door seal did not retract and the operation was stopped prior to movement of the ramp. The seal was then manually retracted and the opening operation was resumed. The pressure seal did not stay in the retracted position and the pressure door "Duckbill" cam on the right side hung up on the seal as the ramp continued downward. This increased the loading on the right hand pressure door lower actuator (already pressurized to the fully extended position) until it failed in tension at the cylinder cap. This failure was by mechanical leverage only and not by hydraulic pressure. The resulting loss of hydraulic pressure allowed the left hand pressure door lower actuator to retract as the entire weight of the door was transmitted to it. The pressure door then practically free fell until it hit the ground. The door had thus extended beyond its fully deployed position (drive-in mode) and this caused the left hand actuator to fail in compression/bending at the rod end.

CONCLUSIONS:

3. Probable Cause: The right pressure seal did not retract. The seal caught the opening pressure door and forced it to bend inboard past the fixed throw limit of the actuation causing it to fracture in tension due to the excessive mechanical leverage involved. The seal did not retract because two rivets had sheared rendering the side seal actuators inoperative. These rivets connect the pressure seal actuator to the control boxes. T.O. 1C-5A-4-1 shows that these should be MS-20615-3M (MONEL) rivets. The two failed rivets were made of aluminum.

ACTION TAKEN:

4. The investigating team inadvertently duplicated this pressure seal failure during a demonstration of the drive-in mode on C-5 68-227. However, the operation was stopped in time to avert failure of the pressure door lower actuators, and the door did not drop.

5. A UMR is being submitted on the pressure side seals. Both lower pressure door actuators will be forwarded to LGC for metallurgical analysis to determine failure mode. The failed rivets will be forwarded to verify composition material.

6. The following warning should be published as a Safety Supplement to T.O. 1C-5A-9.

WARNING

Prior to operating the pressure door and ramp to the drive-in position, position one man at each side of the pressure door to monitor and assist the seal retraction. They will insure the pressure door seal has fully retracted prior to any movement of the cargo ramp. Failure to comply could result in damage to the aircraft or serious injury to personnel.

7. An interim safety supplement was published by LGC to disconnect the pressure door seals. The seals will be retracted and deployed manually. This will be an interim fix only.

RECOMMENDATIONS:

8. Recommend LGC install a sequencing cycle in the seal actuators to prevent movement of the ramp and pressure door in the event the seals fail to retract.

9. Recommend that in the event of future incidents of this nature a team be sent to the place where the incident occurred. The incident on aircraft 68-225 occurred 22 February 1971 at McChord AFB, Washington. The damaged parts were removed and placed aboard the aircraft and returned to home station arriving here on the 26th of February making it extremely difficult to determine cause, whether it be material or operator failure.

2 Atch
1. Operator's Statement
2. Operator's Statement

Operator's Statement 26 Feb 71

On the morning of 22 Feb 71, SSgts Bain and Darby and myself went to eat breakfast while MSgt Bergen and the rest of the loadmasters prepared the aircraft for offloading. AFter eating, we returned to the aircraft and relieved MSgt Bergen and the rest of the loadmasters so they could go eat. The aircraft was in the aft kneeled position with the ramp and pressure door in the truck bed loading position. Air Freight arrived with a 40 K loader. I directed the K loader into position and we offloaded 4 pallets of cargo. Air Freight backed the K loader away from the aircraft and departed to get the onload. I directed SSgt Bain to go to the flight deck and monitor the ATM's. I directed SSgt Darby to act as outside scanner. After everyone was in position and in interphone contact, I closed the ramp and pressure door, selected drive-in mode and I positioned the ramp operate switch to "Open"; the left pressure door seal retracted but the right one did not retract all the way. I released the switch and manually retracted the right pressure door seal. The pressure door had not moved. I then positioned the ramp operate switch to "Open" and proceeded to open the ramp and pressure door. When the ramp reached approximately the co-planer position the pressure door cocked to the right, the right upper hinge hook wiggled and the pressure door started to fall. When the pressure door started to fall, I released the ramp operate switch and the door continued to fall to the ground. After the pressure door fell I told SSgt Bain I was going to shut off the ATM's. I shut down the ATM and departed the aircraft. There was a maintenance man outside the aircraft with a radio. I told him to shut down the air cart and call ACP and have them call the A/C and tell him of the incident, and call Ground Safety and the photographers. I left SSgt Bain and Darby to keep people away from the aircraft and I went to the snack bar to inform MSgts Bergen and Lam of the incident. The pressure door fell at approximately 1025 hours local time.

Operator's Statement 26 Feb 71

On the morning of the 22nd February 1971, MSgt Forsythe, SSgt Bain and myself relieved MSgt Bergens crew for chow. The aircraft was in the aft kneeled position in the truckbed mode and a 40 K loader was next to the ramp for offloading of four pallets. We offloaded the four pallets and the K loader left the aircraft. MSgt Forsythe directed me to be ground scanner for the operation of the ramp and pressure door to the drive-in mode. The ramp was closed and the pressure door locked to the ramp. I checked all locks to insure that they were all secure. I informed MSgt Forsythe that it was all clear to operate the ramp and doors. The ramp support pads deployed, the left pressure door seal retracted and the right did not retract completely. MSgt Forsythe retracted the seal manually. MSgt Forsythe ask me if it was clear on the ground to open the ramp and doors. I told him all clear. The ramp lowered to approximately coplaner position and the pressure door twisted to the right and at the same time the pressure door fell aft, struck the center door and then fell to the ground.

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MANUAL
MAINTENANCE

C-5 CATEGORY III JOINT TEST FORCE

SPECIAL REPORT

3-25-71

EVALUATION OF C-5 AFT LOADING SYSTEM MAINTENANCE

31 March 1971

Reviewed and Approved:

[signature]

WILLUM H. SPILLERS, JR., Colonel, USAF
Director, C-5 Category III Joint Test Force

FOR OFFICIAL USE ONLY

EVALUATION OF C-5 AFT LOADING SYSTEM MAINTENANCE

I. PROBLEM:

Difficulties with the operation, maintenance and component failures on the C-5 aft loading system have resulted in serious malfunctions, i.e., Door Free-Fall. Proficiency of personnel working on the system is inadequate.

II. FACTORS BEARING ON THE PROBLEM:

1. Many manhours are being expended during troubleshooting and repair of the aft loading system.

2. Technical data is extremely lengthy.

3. Many TCTO's have been complied with or are pending compliance.

4. There is presently one Safety Supplement (1C-5A-2-12SS-15, Short Title: Aft Pressure Door Warnings) which affects fifteen separate paragraphs prior to operation of aft doors.

5. There are two Operational Supplements (1C-5A-2-12S-2B, Short Title: Aft Ramp Hydraulic Actuating Assembly Installation and 1C-5A-2-12S-27, Short Title: Manual Override Levers) affecting 28 paragraphs prior to using the manual override levers.

6. Training provided to maintenance personnel has been limited to theory of operation and maintenance using a classroom mock-up.

7. Some failures have allowed the aft pressure door to fall.

   a.. Aircraft -225 - Feb 71 - Door fell - Seal actuator failure.

   b. Aircraft -221 - Jan 71 - Door fell - Cylinder Assy failure, lower pressure door.

   c. Aircraft -0008 - Jul 70 - Door fell - while using the manual override.

III. DISCUSSION:

The maintenance problems presently being experienced with the aft loading system are directly related to lack of practical training and lack of experience on the system. Adequacy of present training is sub-standard for the "line" mechanic who is responsible for performing maintenance on the aft loading system. This training consists of classroom demonstration on theory of operation while observing a mock-up training device. No practical training in rigging and repair of this highly sophisticated system exists at present. Troubleshooting, rigging and repair of this demanding system is left to the average 5-level experienced mechanic who, at best, possesses limited knowledge of the system and little, if any, practical experience. Reliability of components within the aft loading system has caused some concern by maintenance and flight crew personnel. Operation of the pressure door and aft ramp in any mode is considered extremely risky, with the anticipation that a catastrophic failure may occur at any time during the operation. Here again, training and experience will enhance reliability, if personnel are able to detect premature failure or substandard operation prior to a catastrophic failure.

Technical data interpretation is a tremendous task for the maintenance man. The rigging portion of T.O. 1C-5A-2-12 on the aft loading system alone consists of some 282 pages. One hundred forty-eight (148) green TOPS sheets supplement or change the rigging instructions. The constant changing of tech data contributes to problems being experienced with normal maintenance. Scroll checklists have been a problem in the past. A recent -1 conference held at Lockheed-Georgia Company 1-12 Mar 71 recognized this problem, wherein the scroll checklist was not assigned a technical order number. When T.O. 1C-5A-2-12 was changed or updated, the scroll checklist was not changed to agree with these T.O.'s. With the assignment of a technical order number to the scroll checklist, which will be kept current anytime the -1 or the -2-12 is updated or changed, this problem should be eliminated.

IV. CONCLUSIONS:

Training and experience, coupled with a higher degree of system reliability, plus a continued effort to maintain tech data in a useable state, will show a marked improvement during operation and maintenance action. Further system refinements may be required after these immediate problems are solved. Design changes are needed to prevent/interrupt operation when component failure would result in catastrophic damage (door falling).

V. ACTIONS RECOMMENDED:

1. Recommend Hq MAC establish a requirement to provide maintenance training that permits the mechanic to gain practical experience in troubleshooting, rigging and repair. The mechanic should be required to demonstrate his practical proficiency as well as pass a written examination prior to performing maintenance on a "line" aircraft.

2. Regardless of operation (normal or manual override), the system should be designed so that it does not allow operation which will permit the door to fall.

3. ECPs have been proposed to prevent identified system failures. These ECPs should be thoroughly tested on a Lockheed aircraft prior to fleet incorporation, to insure that regardless of actuator failures or manual sequencing, the pressure door will not free-fall.

4. Revisions to technical data related to the aft loading system should be incorporated into the basic publication as soon as possible. The large number of TOPS pages and references to Safety or Operational Supplements requires the mechanic to cross-reference excessively in search of changes to operating, maintenance or rigging procedures. Special emphasis must be placed on the use of tech data during accomplishment of maintenance tasks on the Aft Loading System.

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MINOR ☐ Rev. #1

DATE MODEL SERIAL OPERATOR	LOCATION OF ACCIDENT / BRIEF ACCOUNT OF ACCIDENT	PROBABLE ~~PRESUMED~~ CAUSE (PRELIMINARY)	CAUSE OR PROBABLE CAUSE	REMEDIAL ACTION	ECD	ACK
8 Oct. 1970 C-5A Ship 0008 Gelac AIRCRAFT GELAC (USA) ENGINE G.E.(USA)	Vicinity of Pope AFB, N.C. During functional flight test of aft door complex at 3,000' and 150K, the aft pressure door separated from the A/C. The front 1/3 and the aft 1/3 of the center cargo door also separated from the A/C. The side doors and the bottom side of the hayloft area were also damaged. The aft troop compartment frangible bulkhead collapsed, some head-liners came loose and the environmental access door was pulled from its hinges. The A/C returned to Pope AFB and made an uneventful landing.		Aircraft was apparently pressurized an undetermined amount at the time the aft door system (ADS Mode) was initiated. As the pressure door disengaged from the ramp hinges, the door was abruptly forced aft, causing it to free itself from the upper hinges. The door then fell from the aircraft. Rev. #1 - When the aft door complex opening operations were initiated, the airplane was pressurized sufficiently to cause failure of the aft center door, the pressure door, and the side doors simultaneously. (Continued on Sheet 2 of 5).	The investigation will determine what corrective actions are necessary to prevent this type of mishap. Special procedures have been written for Ship 0008 to ensure that the aircraft is completely depressurized prior to operation of the aft door system. Inflight operation of aft door system on all aircraft, except Ship 0008, is prohibited, pending certain improvements in the system. Rev. #1 - The following data will be included in the ADS 10 Minute Warning Checklist: o Requirement for flight engineer to depressurize the airplane by placing the pressurization MODE selector switch to the "MANUAL" position and the outflow valve to the "FULL OPEN" position. (Continued on Sheet 2 of 4).	10-30-70 REV. DATE Rev. #1 - 1[illegible]	10-3[illegible]

J. Arnold, Manager
Aerospace Safety Engineering Dept.

REPORT NO. (C-5A 70-6)

CAUSE OR PROBABLE CAUSE: (Continued)

The airplane was pressurized due to the fact that the Flight Engineer had pressurized the airplane contrary to the Flight Briefing instructions and he did not fully depressurize the airplane prior to operating the aft door complex. Contributing cause was the fact that ADS checklists were not utilized and the pilot-in-command did not confirm "no pressurization" prior to operating the aft door complex. Contributing cause was material factor in that the calibration requirements of the Cabin Pressure Gage allowed .5 psi pressure in the aircraft while the needle showed zero.

REMEDIAL ACTION: (Continued)

o Flight Engineer will have challenge item "OUTFLOW VALVE OPEN" and Loadmaster will have acknowledgement item "OUTFLOW VALVE FULL OPEN" to the Flight Engineer prior to operation of the aft door complex.

o Loadmaster challenge item "CLEAR TO OPEN DOORS" and response item for pilot to loadmaster of "CLEAR TO OPEN DOORS".

Provide checklist procedures in T.O. 1C-5A-1 for Flight Engineer to ensure uniform/standard method of depressurizing the airplane.

Provide checklist procedures in Section III, T.O. 1C-5A-1, for the Flight Engineer to follow in event of rapid or explosive depressurization. At present, this data is in narrative format.

FTM 44-5A-256, 12 October 1970, recommends that an electrical interconnect be made between the co-pilot's aft door "ARM" switch and the outflow valve or some similar design to prevent loss of pressure door in flight. D/72-19, IDC E-19-5382-70, dated 14 October 1970, D. O. Gunson to C. B. Payne, Subject: "Loss of LAC 0008 Pressure Door in Flight, FTM 44-5A-256" states that an operational procedure has been established to preclude further incidents of this nature. D/72-19, IDC E-19-5377-70, dated 14 October 1970, R. O. Dickinson to H. L. Cooper, Subject "Procedure to Insure Delta P in Cabin Prior to Opening Rear Pressure Door", requests that the attached procedure be included in appropriate Maintenance/Operational Handbooks for "Depressurizing Cabin Prior to Opening AFT Pressure Door to the ADS Mode". These procedures will be reviewed by TADJET crew members and the C-5A TADJET JTP at Pope AFB and included in the TADJET ADS Checklists prior to ADS flight operations. Engineering's opinion is that an electrical interconnect will degrade the reliability of both systems and additional hazards could result.

REMEDIAL ACTION: (Continued)

Specific instructions issued to H. V. Blalock by W. E. Hensleigh regarding future ADS flight operations at Pope AFB are:

1. For all flight operations on ADS missions, a Flight Engineer or pilot will be at the Flight Engineer's panel. W. B. Hanley's primary function is to assist the assigned Flight Engineer on Ship 0008 in the performance of his Flight Engineer's duties. Hanley's secondary function is to maintain currency in the C-5A as pilot.

2. H. V. Blalock will be primary pilot for ADS flights, and he will normally fly in the left seat. The AF pilot will be permitted to fly ADS drops from the left seat on a trade-off basis, but on any ADS build-up in platform weight flight H. V. Blalock will fly the mission from the left seat as "Pilot-In-Command" (PIC).

3. Challenge and response check lists were made mandatory for all flights.

4. Revise TADJET ADS check lists to show Flight Engineer placing Pressurization Control to "MANUAL", outflow valve "FULL OPEN", and loadmaster confirmation that outflow valve is "OPEN". In addition, for the first few flights, the co-pilot's clear vision window will be opened to insure that no pressurization exists and to determine if this additional requirement should be on the check list.

5. The Functional Check Flight check list in T.O. 1C-5A-6CF-1 will be used for any future FCF's on the ADS Door System and two engineers will be aboard the airplane.

6. Applicable portions of the C-5A "Engineering Flight Test Briefing Guide" will be utilized by H. V. Blalock for his flight crew briefings prior to flight.

Closure of this item is requested.

LOCKHEED-GEORGIA COMPANY

A DIVISION OF LOCKHEED AIRCRAFT CORPORATION

MARIETTA, GEORGIA 30063

In reply refer to:

15 July 1975

LGD/610862

SUBJECT: Contract F41608-75-D-A016, Request No. 0006, Task 4, C-5A APEX Study Group, Failure Mode Analysis of Ramps, Visor and Aft Pressure Door, Submittal of Interim Report, Data Item DI-S-3601A

TO: San Antonio ALC/MME-5
Kelly AFB, TX 78241

THRU: AFPRO/EN
Lockheed-Georgia Company
Marietta, GA 30063

ENCL: (a) Ten (10) copies of Lockheed-Georgia Company Letter Report, dated 11 July 1975, Titled: Failure Mode Analysis of Ramps, Visor and Aft Pressure Door, Interim Report

(b) Ten (10) copies of Lockheed-Georgia Company Letter Report, dated 15 July 1975, Titled: Minor Improvements to the Present C-5A Forward and Aft Ramp Locking Systems, Partial Engineering Report

1. Request No. 0006, Task 4, authorized the Contractor to conduct a study of the ramps, visor and aft pressure door to investigate those areas where changes may be desirable to enhance the safety of the C-5A aircraft.

2. The enclosure (a) and (b) reports provide the Contractors interim findings as a result of the study. The final report, as required by the subject request, will be submitted by 20 August 1975.

3. In that this study relates to post-accident investigation of the Ship 0021 accident and since it coincides with a request made by our outside counsel in lawsuits filed in relation to that accident, we have provided a copy of the reports to such attorneys.

LOCKHEED-GEORGIA COMPANY

O. V. Braun
Contracts Department

OVB/HLF:jw

CC: San Antonio ALC/PPWAA

APPROVED FOR TRANSMITTAL James L Beasley DATE 15 July 75
AFPRO/EN

Exh 72

Subject: Contract F41 3-75-D-A016, Request No. 0006, Task 4, C-5A APEX Study Group, Failure Mode Analysis of Ramps, Visor and Aft Pressure Door, Submittal of Interim Report, Data Item DI-S-3601A

DISTRIBUTION: (H. L. Fant, D/72-87, Ext. 3738)

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LETTER REPORT

DATED: 15 July 1975

LOCKHEED-GEORGIA COMPANY

A DIVISION OF LOCKHEED AIRCRAFT CORPORATION

MARIETTA GEORGIA

TITLE

MINOR IMPROVEMENTS TO THE PRESENT C-5A FORWARD AND AFT RAMP LOCKING SYSTEMS

PARTIAL ENGINEERING REPORT

15 JULY 1975

CONTRACT F41608-75-D-A016

REQUEST NO. 0006
TASK 4

SUBMITTED UNDER

MODEL C-5A REFERENCE

PREPARED BY G. A. Dobson GROUP

CHECKED BY W. M. Perry APPROVED BY W. M. Perry
C-5 Fuselage Group Engineer

APPROVED BY C. L. Wharton, Jr.
C-5 Structures Design Manager

APPROVED BY D. O. Gunson
C-5 Design Manager

REVISION DATE	REVISED BY	APPROVED BY	PAGES AFFECTED	BRIEF DESCRIPTION OF CHANGES MADE

FOREWORD

This technical report furnished in connection with Order Number 6, Task 4, of Contract F41608-75-D-A016, C-5 Engineering Services, was prepared solely for the purpose of responding to such order, which was issued as a requirement under said Contract as a part of an Air Force program of examination of systems and procedures on the C-5A aircraft for the purpose of preventing accidents, which program is supplemental to the investigation conducted in accordance with AFR 127-4 of the accident of C-5A 68-218 which occurred on 4 April 1975 and was prepared in part by individuals participating in said accident investigation. It is understood that this report is a privileged document since it is being submitted as a supplement to such accident investigation and for the purpose of preventing accidents. This report shall not be disclosed outside of the Government and shall not be duplicated, used or disclosed in whole or in part for any purpose other than to evaluate the task. The data subject to this restriction is contained in all sheets.

This report contains partial results of a study which is presently in process. These results contain recommendations relative to restoring the aft complex of the C-5A aircraft for normal use.

The submittal of this report satisfies in part the requirements of Contract F41608-75-D-A016.

INTRODUCTION

On 1 July 1975, an informal meeting was held at the Lockheed-Georgia Company with San Antonio ALC personnel for the purpose of discussions relative to the status of APEX study tasks. During the course of discussions, San Antonio personnel requested Lockheed's position relative to actions required to restore the aft complex to normal use. Lockheed personnel stated that to date all studies and evaluations of the aft opening complex had revealed no technical reasons for any basic actions other than to restore the system to its original configuration, replace all worn or damaged parts, and rig the system to existing prescribed procedures utilizing trained depot level teams at the operating bases. It was further suggested that these trained depot personnel remain at the operating bases to perform periodic maintenance and rigging actions until such time as appropriately trained field personnel were made available to accomplish the task.

Lockheed personnel advised that during the incorporation of TCTO 1C-5A-1768, some maintenance difficulties were being encountered by the Field Teams. These were briefly discussed in general terms and San Antonio was advised that Lockheed was studying these difficulties and would recommend actions that could alleviate them at the time that the Task 2 ramp lock study report was submitted. This document contains the results of the analyses of these problems and the recommendations for San Antonio ALC considerations.

MINOR IMPROVEMENT REVISIONS TO THE PRESENT SYSTEM

During incorporation of TCTO 1C-5A-1768 information reported by the Field Team Engineers was analyzed in an effort to determine if any revisions were desirable to improve the function of the existing system and to alleviate the necessary maintenance actions. These items are discussed in the following paragraphs.

1. Lock Actuation Speed

The first item reported by the Field Team Engineers was that the forward ramp lock system appeared to operate too fast which may be a contributing factor in the sheared or bent programing link pins and cracked bellcranks. Preliminary data on damaged parts, found during incorporation of TCTO 1C-5A-1768, indicates that approximately 45% more sheared programing link pins and 93% more cracked bellcranks were found on the forward system than on the aft system. The aft ramp system operates at approximately half the speed of the forward system, and so the forward ramp system was tested with a restrictor installed that gave it a speed that is similar to the aft ramp speed. Test results indicate that the slower speed gave a much smoother operation to the system and hence reduced the inertia and dynamic loads on the system. This change will increase the service life of the system and should be considered for incorporation.

2. Program Link Revision

A second problem reported was that occasionally a hook impacted the under side of the pin prior to engaging the pin as the bellcrank went over center. A study of the geometry and kinematics of the hook travel and pin engagement showed that by a small adjustment in the length of the flat program link the impact of the hook on the yoke pin could be minimized for locks 1 through 4 on the forward ramp and 2 through 6 on the aft ramp. Aft ramp lock No. 1 appears to be satisfactory as is. The programing link change does not appear to significantly improve engagement of the No. 7 Aft Ramp Lock. The No. 7 Aft Ramp Lock improvements are discussed in Item No. 8.

3. Programing Link Pins

Investigation of the shearing of the programing link pins showed that these pins could be shearing due to the dynamic forces resulting from the operating inertia of the locks. The pin which failed most frequently was the pin which attaches the links to the hook. The current pin size is 3/16 inch dia. and it is possible to increase the size of this pin to 1/4 inch without manufacturing new hooks. It should be noted that closely controlled conditions are required when redrilling the hooks due to the characteristics of the material from which the hooks are made.

4. Mechanical Lock Indicators

Most of the mechanical indicators, it is reported, are not color coded correctly. Those installed on the aircraft have been repainted since delivery and no longer give the correct color indication. These can be brought back to correct configuration by using colored tape and a heat shrinkable clear tubing. No design change is necessary and immediate action should be initiated to color code the indicators correctly.

5. Bellcrank Material Change

Failure of some bellcranks has been experienced. Inspections reveal that the bellcranks fail in the lug fillet area. Consideration has been given to changing the material from 7075-T6 aluminum to either PH17-4 or 15-8MO steel. The advantages of this change are:

a) Existing design will be approximately 2.5 times stronger.

b) The potential for stress corrosion is reduced.

c) Wear in mating parts is decreased.

d) Both PH17-4 and 15-8MO steels are stainless, hence corrosion problems are reduced.

6. Forward Ramp No. 1 Bellcrank Push Rod

Reports indicated the forward, No. 1, connecting rod on the forward ramp system is too short. The rod is such that an acceptable length of thread engagement can be obtained; however, the witness hole requirement cannot be satisfied. This rod should be lengthened approximately .25 inches.

7. No. 7 Aft Ramp Yoke Guide Chamfer

The yoke guide at all lock positions, except No. 7 aft ramp, have a chamfer on the lower side to preclude yoke interference when closing the aft ramp. This No. 7 yoke guide should be modified to add a chamfer similar to all other yoke guides. Several examples have been found in the fleet where the yoke has hooked under the guide. This chamfer will reduce this problem.

8. Aft Ramp No. 7 Hook

Several cases were reported of the aft ramp No. 7 lock hook impacting the lower side of the yoke pin. This general condition was discussed under Item 2 above where a programing link length change will improve all other lock positions. The No. 7 hook; however, is not significantly improved by this method and other possibilities were investigated. Investigations show two methods of rectifying this condition. They are:

a) A new hook can be designed to give a better throat to yoke pin engagement together with a program link change, or

b) A new concept for programing the hook movement into the engaged position. This new concept is envisaged to be a guide cam on each side of the hook in lieu of programing links. Initial investigations show this to be the most cost effective method.

9. Lock Actuating Rods

Damage to connecting rods is reported to be high. Consideration has been given to changing the material of the tube from aluminum to steel.

The advantages of this change are:

a) Less susceptible to damage.

b) Tensile strength increases approximately 1.5.

c) Column strength increases approximately 1.5.

The disadvantages are:

a) The system can interact higher loads due to the increase column and tensile loads and can thus influence adjacent locks to a greater degree.

b) The rods are currently the weakest link in the system and any interaction between locks is limited by the rods. This limit will be altered in an unfavorable direction by a change of material to steel and substantial analysis will be required to assure that no other adverse affects will be initiated.

RECOMMENDATIONS

It is recommended that of the previous nine items the following be considered for incorporation into the existing C-5A forward and aft ramp lock systems, in order to minimize the required maintenance actions.

1) Forward lock actuation speed reduction
2) Program link revisions
4) Mechanical lock indicator update
6) Forward ramp No. 1 bellcrank push rod length revision
7) The No. 7 aft ramp yoke guide chamfer
8) The No. 7 aft ramp lock programing concept by a cam rather than by programing links.

It is also recommended that Item 5, which proposes a change in the bellcrank material be incorporated as a spares only change in the near term, with consideration being given to replacing all bellcranks at the next scheduled PDM.

Item 3, which proposed to increase the programing link pin size from 3/16 to 1/4 inch dia. due to the pin shearing in service is not recommended for incorporation as this problem will be alleviated by incorporation of Items 1 & 2.

Item 9 is not recommended for incorporation as any increase in the stiffness of this rod system is considered to be detrimental for reasons stated previously.

MIL-STD-882

15 JULY 1969
Superseding
MIL-S-38130A
6 June 1966

TT-9

MILITARY STANDARD

SYSTEM SAFETY PROGRAM FOR SYSTEMS AND ASSOCIATED SUBSYSTEMS AND EQUIPMENT: REQUIREMENTS FOR

FSC MISC

FOREWORD

The Department of Defense System Safety Program's principal objective is the protection of the public and the individual. This is closely followed by its concern to conserve the other national resources.

To insure that these receive due consideration, this military standard has been written and approved by the Department of Defense and is mandatory for use by all departments and agencies of the Department of Defense effective 15 JULY 1969.

The degree of safety achieved in a military system is directly dependent upon management emphasis. Management emphasis on safety must be applied by the Government and contractors during the conception, development, production, and operation of each military system.

The results of the system safety effort is dependent upon the procuring agency clearly stating safety objectives and requirements, and the Contractor's ability to translate these into functional hardware.

Recommended corrections, additions, or deletions should be addressed to the Air Force Systems Command (SCIZ), Andrews AFB, Washington, D.C. 20331.

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APPENDIX

1. SCOPE

1.1 Purpose. The purpose of this standard is to provide uniform requirements and criteria for establishing and implementing system safety programs and to provide guidelines for preparing System Safety Program Plans (SSPP).

1.2 Application. This standard is applicable to Department of Defense procurement of military systems, subsystems, and equipment, such as aeronautical, nautical, vehicular, missile, space, electronics, weapons and munitions. This standard will be used during concept formulation, contract definition, engineering development, production, and operational phases.

1.3 Implementation. This standard will be used in preparing safety requirements for inclusion in contract work statements. system safety program plans, and other contractual documents.

1.3.1 Each provision of this standard shall be considered for the extent of applicability, deviations, or supplementary requirements. Where the paragraph or subparagraph of this standard would require duplication, wholly or in part, of design, analysis, test, demonstration, or organizational requirements already specified by the procuring activity, those requirements, functions and efforts shall be identified and utilized in the plan rather than be duplicated. This standard applies to those activities through which a contractor manages his system safety effort to the extent specified in the contract statement of work and approved SSPP. The SSPP shall be incorporated or referenced in contractual documents as necessary to define the safety program.

1.3.2 When the scope and magnitude of a program does not warrant the requirement for a comprehensive system safety program, the procuring activity shall specify to the contractor the minimum acceptable safety program requirements.

1.3.3 The safety life cycle as described herein (see 4.2) is for a system program which includes all phases: concept formulation, contract definition, development, production, and operational. Since all system programs do not follow the phases as distinctly as stated, each system safety program plan and activity must be tailored to the specific requirements and peculiarities of the system or project. The sequence of activities described in the safety life cycle, however, shall be accomplished at some time during the life cycle to insure that a balanced, effective system is developed. Accordingly, when a system program does not require a formal contract definition phase, the essential safety activities for that phase shall be accomplished early in the development phase.

2. REFERENCED DOCUMENTS

None applicable to this standard.

3. DEFINITIONS. The following definitions apply to this standard.

3.1 Safety. Freedom from those conditions that can cause injury or death to personnel, damage to or loss of equipment or property.

3.2 System. A composite, at any level of complexity, of operational and support equipment, personnel, facilities, and software which are used together as an entity and capable of performing and/or supporting an operational role.

3.3 System safety. The optimum degree of safety within the constraints of operational effectiveness, time and cost, attained through specific application of system safety management and engineering principles throughout all phases of a system's life cycle.

3.4 System safety management. An element of program management which insures the accomplishment of the system safety tasks including identification of the system safety requirements; planning, organizing, and controlling those efforts which are directed toward achieving the safety goals; coordinating with other (system) program elements; and analyzing, reviewing, and evaluating the program to insure effective and timely realization of the system safety objectives.

3.5 System safety engineering. An element of systems engineering involving the application of scientific and engineering principles for the timely identification of hazards and initiation of those actions necessary to prevent or control hazards within the system. It draws upon professional knowledge and specialized skills in the mathematical, physical, and related scientific disciplines, together with the principles and methods of engineering design and analysis to specify, predict, and evaluate the safety of the system.

3.6 Contractor. An industrial or governmental agency engaged to provide services or products within agreed limits.

3.7 Prime contractor. One who enters into agreement directly with the Government to provide a product or service.

3.8 Integrating contractor. The contractor assigned responsibility by the procuring activity for overall scheduling and system interface of associate contractor activities and equipment, and for the furnishing of specified support services which are common to two or more of the contractors.

3.9 Associate contractor. A prime contractor for the development or production of subsystems, equipments, or components meeting specifications furnished or approved by the procuring activity. An associate contractor can be one member of a group of contractors developing and producing a complete system.

3.10 Subordinate (sub)contractor. One who enters into agreement with a prime contractor or other subordinate contractor to provide a product or a service.

3.11 Crash safety. A manned-system characteristic that allows the system occupants to survive the impact and evacuate the vehicle in potentially survivable accidents. Crash safety implies:

(a) Crashworthiness
(b) Provisions for timely evacuation

3.12 Crashworthiness. The capacity of a vehicle to act as a protective container and energy absorber during potentially survivable impact conditions.

3.13 Hazard. Any real or potential condition that can cause injury or death to personnel, or damage to or loss of equipment or property.

3.14 Hazard level. A qualitative measure of hazards stated in relative terms. For purposes of this standard the following hazard levels are defined and established: Conditions such that personnel error, environment, design characteristics, procedural deficiencies, or subsystem or component failure or malfunction:

(a) Category I - Negligible

.... will not result in personnel injury or system damage.

(b) Category II - Marginal

.... can be counteracted or controlled without injury to personnel or major system damage.

(c) Category III - Critical

.... will cause personnel injury or major system damage, or will require immediate corrective action for personnel or system survival.

(d) Category IV - Catastrophic

.... will cause death or severe injury to personnel, or system loss.

4. GENERAL REQUIREMENTS

4.1 System safety program. The contractor shall establish and maintain an effective system safety program that is planned and integrated into all phases of system development, production, and operation. The system safety program shall provide a disciplined approach to methodically control safety aspects and evaluate the system's design; identify hazards and prescribe corrective action in a timely, cost effective manner. The system safety program activities shall be specified in a formal plan (see 5.2) which must describe an integrated effort within the total program. The system safety program shall be based upon such factors as the system objectives, criticality of the safety requirements, the complexity of design, and total cost. The system safety program objectives are to insure that:

(a) Safety consistent with mission requirements is designed into the system.
(b) Hazards associated with each system, subsystem, and equipment are identified and evaluated, and eliminated or controlled to an acceptable level.
(c) Control over hazards that cannot be eliminated is established to protect personnel, equipment, and property.
(d) Minimum risk is involved in the acceptance and use of new materials and new production and testing techniques.
(e) Retrofit actions required to improve safety are minimized through the timely inclusion of safety factors during the acquisition of a system.
(f) The historical safety data generated by similar system programs are considered and used where appropriate.

4.2 System safety program activities and sequences. The application of this military standard to a specific contract requires a complete review of the standard to determine the degree of applicability of each paragraph to the contract. The safety requirements will vary depending on the amount of research, development, test, and engineering, and the intended use of the contract end item. The following paragraphs will give a general indication of when the requirements of this standard should be met during the development of a system for the Department of Defense when the formal DOD development process is applied. (See Appendix B).

4.2.1 Concept Formulation Phase. A formal SSPP is not required in the concept formulation phase. As system concepts and functions are identified, safety studies shall be performed to determine the adequacy of design concepts to meet the essential safety characteristics of the system. These studies also shall:

(a) Evaluate technical approaches to system safety design features.
(b) Identify possible safety interface problems.
(c) Highlight special areas of safety consideration, such as system limitations, risks, man-rating requirements.
(d) Define areas requiring further safety investigation and describe safety tests or data needed from exploratory or advanced development activities.

4.2.1.1 A preliminary hazard analysis (see 5.8.2.1) shall be performed as an integral part of the system concept studies to identify inherent hazards, or risks, associated with each design.

4.2.1.2 The contractor shall submit a summary statement of any additional safety design analysis, test, and demonstration requirements and recommendations resulting from these studies and analyses which are not already specified by the procuring activity.

4.2.2 Contract Definition

4.2.2.1 Contract Definition Phase (CDP) (Phase A). In his response to a Request for Proposal (RFP) for CDP, the contractor:

(a) Shall submit a preliminary SSPP (as a separate entity) prepared in accordance with the requirements of the RFP. The SSPP shall describe the proposed integrated effort of how the contractor plans to conduct his system safety program to meet the requirements of the RFP, specifically:

(1) A firm proposal on the contractor's efforts and activities during the Contract Definition Phase (Phase B).

(2) A planning purpose proposal for evaluating the contractor's program for the Engineering Development Phase.

(b) Shall, in addition to preparing the SSPP:

(1) Perform necessary studies and analyses to define the system's safety technical specifications, performance requirements, and its operating safety characteristics. A preliminary hazard analysis (see 5.8.2.1) of the system in its intended operating environment shall be performed or revised to identify potential hazards and inherent risks. A system/subsystem/equipment safety interface study shall be performed to insure that compatibility between subsystem-equipment is maintained and safety is not degraded.

(2) Make tradeoff studies as necessary to reflect the impact on system safety requirements, and the identification of inherent risks and the required safety decisions.

(3) Identify and include in the appropriate specifications any resulting qualitative and quantitative requirements for the system, and subsystems including Government Furnished Equipment (GFE), and the proposed test plans to demonstrate their achievement.

(4) Submit a preliminary hazard analysis summary report which:

a. Identifies potential hazards and methods planned to eliminate or control them.

b. Outlines undefined areas requiring guidance or decisions.

c. Describes technical risks or problems in design. The contractor shall delineate the subsystem and component safety requirements for subcontractors and suppliers in order to meet the overall essential system safety requirements. The safety requirements for GFE and related data will be defined at this time and be submitted to the procuring activity for necessary action.

4.2.2.2 Contract Definition Phase (CDP) (Phase B). The contractor shall implement the SSPP as accepted or approved by the procuring activity. System safety studies shall be performed during system engineering, tradeoff studies and formulation of data requirements to insure that safety design requirements as identified in CDP Phase A are refined, updated and further expanded as necessary. Specifically the contractor will:

(a) Submit a firm SSPP for the Engineering Development Phase. This plan shall update the preliminary SSPP with a detailed description of aotivities, reviews, safety studies, analyses, and tests to be accomplished during the Engineering Development Phase Also, the SSPP shall include the projected activities anticipated during the production and operational phases to accomplish the objectives of 4.2.4 and 4.2.5.

(b) Update the system safety studies, analyses, and test plans to define safety design requirements and criteria. System safety personnel shall participate in system tradeoff studies to insure that the highest degree of safety is achieved consistent with performance and system requirements.

(c) Update safety requirements in the system specifications and criteria.

(d) Submit a system safety work breakdown statement for the engineering development program.

4.2.3 Engineering Development Phase. The system safety program during this phase is an amplification and the implementation of the program defined in the previous phases. The action is predominantly on the part of the contractor with the responsible Department of Defense organization monitoring the program. System and subsystem hazards, and operating hazard analyses shall be evaluated in phase with program reviews. The contractor's system safety organization will insure effective and timely implementation of the approved SSPP. It is during the early phases of engineering design that the system safety program can be most effective with the least impact on schedules, and provide the greatest potential on cost saving. To provide support to the system engineering program, the system safety engineering activities shall include, but not be limited to the following:

(a) Furnishing safety design criteria; establishing safety objectives; and, reviewing preliminary engineering designs to identify hazards, methods of detection, and any required safety changes.

(b) Performing hazard analyses and safety studies to evaluate the system design.

(c) Establishing test requirements and insure that safety verification of design and data are included in the engineering test program.

(d) Participating in technical design and program reviews.

(e) Reviewing and providing inputs to preliminary system operator and maintenance publications, emergency procedures, etc.

(f) Evaluating results of failure analyses and accident investigations; recommending corrective action.

(g) Determining, evaluating, and providing safety considerations in tradeoff studies.

(h) Reviewing engineering documentation (drawings and specifications) to insure safety coverage.

(i) Identifying required safety and protective equipment and devices.

(j) Providing safety inputs to training courses.

4.2.4 Production Phase. The contractor shall identify critical production techniques, assembly procedures, facilities, testing and inspection requirements which affect system safety. Adequate procedures shall be invoked through the planned, controlled, and scheduled system of quality control and monitoring specified contractually to insure that safety achieved in design is maintained during production. Corrective action shall be taken to eliminate, reduce or control hazards so identified. These corrections shall include necessary changes to engineering documentation. An audit shall be performed to identify any new system safety hazards which may result from the introduction of engineering changes. The impact of such changes on safety shall be evaluated to determine whether the previously established safety level of the system has been maintained; if not, redesign or change procedures shall be initiated to obtain the contracted level of safety.

4.2.5 Operational Phase (including disposal). The system safety program during the Operational Phase, and subsequent disposal, will include, but not be limited to the following functions:

(a) Operational safety review of system to determine if design, operating and maintenance procedures, and emergency procedures are adequate, based on user experience.

(b) Evaluation of design changes and modifications to operational equipment to insure inherent safety is not degraded.

(c) Continual review of operator and maintenance publication changes to insure that safety requirements, procedures, and cautions are adequate.

(d) Analyze system accidents/incidents or failures which caused, or could cause, an unsafe condition, and initiate corrective action.

(e) Data collection and analysis from system deficiency reports submitted by operating (user) personnel.

(f) Approval and application of procedures for disposal of hazardous material and equipment.

4.3 System safety organization. The contractor's organization shall be responsible for managing and performing the overall system safety program. The responsibilities and functions of those directly associated with system safety policies and implementation of the program shall be clearly defined. The authority delegated to this organization and the relationship between line, staff, and interdepartmental, project, functional, and general management organizations shall be identified. It is not the intent of this standard to prescribe or imply organizational structure, management methodology, implementation procedures, or internal documentation.

4.4 System safety program milestones. The system safety program shall be planned and scheduled to permit the contractor and the procuring activity to review its status, including the results achieved, at critical safety program checkpoints. These formal reviews and assessments of the system safety effort shall be performed concurrently with overall program milestones, such as requirements reviews, design reviews, and inspections. Safety milestones will be identified in a manner permitting evaluation of the effectiveness of the system safety effort. These milestones shall be presented in the SSPP and implemented as approved by the procuring activity.

5. DETAILED REQUIREMENTS

5.1 General. A system safety program is a formal approach to eliminate hazards through engineering, design, education, management policy, and supervisory control of conditions and practices. It insures the accomplishment of the system safety management and engineering tasks.

5.2 System Safety Program Plan (SSPP). The SSPP will be prepared in accordance with this standard and implemented as directed by the procuring activity. The SSPP, as approved by the procuring activity and incorporated into the contract, becomes the basis for contractual compliance. A sample SSPP outline is provided in Appendix A. When an integrating contractor is designated he will be responsible for the overall preparation, integration, and implementation of the SSPP. The plan shall describe an integrated effort within the total project, and shall include but not be limited to:

CONTRACT

(a) Identification of system activities (i.e. design analyses, tests, demonstrations) specified elsewhere by the procuring activity and show how they will be used to preclude duplication.

(b) Providing specific information showing how the contractor will meet the safety requirements during development and manufacture including the design concepts to be utilized.

(c) The manner of demonstrating quantitative system safety requirements (if specified).

(d) A detailed listing of specific tasks.

(e) A current description of each task to be performed.

(f) Identification of the organization unit with the authority and responsibility for executing each task.

(g) The method of control to insure execution of each task.

(h) The scheduled start and completion dates of each task.

(i) Procedures for problem identification and solution.

(j) Procedures for recording and reporting status of actions to resolve problems.

(k) Method of assimilation and dissemination of system safety requirements to designers and associated personnel to expedite correction of known deficiencies.

(l) Designation of milestones, definitions or interrelationships, and estimation of personnel and man-hours required for system safety program activities and tasks.

(m) Periodic recording and reporting of predicted and achieved system and equipment safety.

(n) Delineate the safety data and analyses (including GFE) required of and to the integrating and associate contractors.

(o) Identification of special safety studies, research and test data.

(p) Safety data coordination flow.

(q) Range, flight, and operational test safety programs.

(r) The mathematical methods to be used; e.g. describe the appropriate models and analytical techniques to be employed.

5.3 Reviews.

5.3.1 Program and Design reviews. Safety shall be an integral part of all program and design reviews held for the system, subsystem, or equipment. System safety program reviews shall be conducted as part of the scheduled overall design and/or program reviews to assess the status of compliance with the overall safety program objectives. This review shall identify any deficiencies of the system with respect to safety and provide guidance for further development which may be required. The procuring activity shall be notified prior to each system safety program review, to permit participation by the safety organization of the procuring activity. Additional ad hoc safety reviews may be scheduled or required at the discretion of the contractor or the procuring activity. Minutes of these system safety program reviews shall be recorded, and made available to the procuring activity.

5.4 System safety criteria and considerations.

5.4.1 General. System designs and operational procedures developed by each contractor should consider, but not be limited to, the following:

STRESS CORROSION

(a) Avoiding, eliminating or reducing significant hazards identified by analysis, design selection, material selection, or substitution. Composition of a propellant, explosive, hydraulic fluid, solvent, lubricant, or other hazardous material shall provide optimum safety characteristics.

(b) Controlling and minimizing hazards to personnel, equipment, and material which cannot be avoided or eliminated.

(c) Isolating hazardous substances, components, and operations from other activities, areas, personnel, and incompatible materials.

(d) Incorporating "fail-safe" principles where failures would disable the system or cause a catastrophe through injury to personnel, damage to equipment, or inadvertent operation of critical equipment.

(e) Locating equipment components so that access to them by personnel during operation, maintenance, repair, or adjustment shall not require exposure to hazards such as chemical burns, electrical shock, electromagnetic radiation, cutting edges, sharp points, or toxic atmospheres.

(f) Avoiding undue exposure of personnel to physiological and psychological stresses which might cause errors leading to mishaps.

HUMAN ENGR'G.

(g) Providing suitable warning and caution notes in operations, assembly, maintenance, and repair instructions; and distinctive markings on hazardous components, equipment, or facilities for personnel protection. These shall be standardized in accordance with the requirements of the procuring activity.

(h) Designing to minimize damage by enemy action.

(i) Minimizing severe damage or injury to personnel and equipment in the event of an accident.

5.5 Hazard levels. The hazard levels, Category I (Negligible); Category II (Marginal); Category III (Critical); and Category IV (Catastrophic) as defined in section 3, shall be used as a qualitative measure of a system's hazards. These categories may be further defined by the procuring activity or by the contractor in the SSPP.

5.6 System safety precedence. Actions for satisfying safety requirements in order of precedence are specified below:

(a) Design for minimum hazard. The major effort throughout the design phases shall be to select appropriate safety design features; e.g. fail safe, redundancy.

(b) Safety devices. Known hazards which cannot be eliminated through design selection shall be reduced to an acceptable level through the use of appropriate safety devices.

(c) Warning devices. Where it is not possible to preclude the existence or occurrence of an identified hazard, devices shall be employed for the timely detection of the condition and the generation of an adequate warning signal. Warning signals and their application shall be designed to minimize the probability of incorrect personnel reaction to the signals, and shall be standardized within like types of systems, in accordance with the directives of the procuring activity.

(d) Special procedures. Where it is not possible to reduce the magnitude of an existing or potential hazard through design, or the use of safety and warning devices, the contractor shall develop special procedures. Precautionary notations shall be standardized in accordance with the directives of the procuring activity.

5.7 Design criteria/specifications. When design criteria specified by the procuring activity is proved inadequate in regards to safety, the contractor shall report the deficiency and recommend corrective actions with supporting evidence to the procuring activity.

5.8 Analyses. Analyses are performed to identify hazardous conditions for the purpose of their elimination or control. Analyses shall be made to examine the system, subsystems, components and their interrelationship to include logistic support, training, maintenance, and operational environments. The analyses shall be accomplished to do the following:

(a) Identify hazards and determine any needed corrective actions.

(b) Determine and evaluate safety considerations in tradeoff studies.

(c) Determine and evaluate appropriate safety design requirements.

(d) Determine and evaluate operational, test, and logistic safety requirements.

(e) Determine whether the qualitative objectives or quantitative numeric requirement established by the procuring activity have been achieved.

5.8.1 Qualitative or quantitative analysis. Qualitative and/or quantitative analyses will be performed as specified by the procuring activity. These analyses shall be revised when changes are made in components, subsystems, or total systems. The various types of hazard analyses are described below.

5.8.1.1 A qualitative analysis provides a technical assessment of the relative safety of a system design.

5.8.1.2 A quantitative analysis provides a numerical assessment of the relative safety of a system design. A quantitative analysis will determine:

(a) The probability of occurrence of critical or catastrophic hazards.
(b) The calculated system, subsystem, or equipment numeric requirement risk level.

5.8.2 <u>System hazard analyses</u>.

5.8.2.1 <u>Preliminary hazard analysis</u>. A preliminary hazard analysis shall be performed as the initial analysis task during the acquisition of a system. This analysis shall be a comprehensive, qualitative study. Such information shall be used in the development of safety criteria to be imposed in performance or design specifications. Areas to be considered shall include, but are not limited to the following:

(a) Isolation of energy sources.
(b) Fuels and propellants: their characteristics, hazard levels and quantity-distance constraints, handling, storage, transportation safety features, and compatibility factors.
(c) System environmental constraints.
(d) Use of explosive devices and their hazard constraints.
(e) Compatibility of materials.
(f) Effect of transient current, electrostatic discharges, electromagnetic radiation, and ionizing radiation to or by the system. Design of critical controls to prevent inadvertent activation and employment of electrical interlocks.
(g) Use of pressure vessels and associated plumbing, fittings, mountings, and hold-down devices.
(h) Crash safety.
(i) Safe operation and maintenance of the system.
(j) Training and certification pertaining to safe operation and maintenance of the system.
(k) Egress, rescue, survival, and salvage.
(l) Life support requirements and their safety implications in manned systems.
(m) Fire ignition and propagation sources and protection.
(n) Resistance to shock damage.
(o) Environmental factors such as equipment layout and lighting requirements and their safety implications in manual systems.
(p) Fail safe design considerations.
(q) Safety from a vulnerability and survivability standpoint; e.g., application of various types of personnel armor (metals, ceramics and glass), fire suppression systems, subsystems protection, and system redundancy.
(r) Protective clothing, equipment or devices.

(s) Lightning and electrostatic protection.
(t) Human error analysis of operator functions, tasks, and requirements.

5.8.2.2 Subsystem hazard analysis. This is an expansion of the preliminary hazard analysis. It shall be performed to determine, from a safety consideration, the functional relationships of components and equipments comprising each subsystem. Such analysis shall identify all components and equipments whose performance degradation or functional failure could result in hazardous conditions. The analysis should include a determination of the modes of failure and the effects on safety when failures occur in subsystem components.

5.8.2.3 System hazard analysis. The prime or integrating contractor shall conduct reviews or studies which define the safety integration and interface requirements of the total system. Analyses shall be performed of subsystem interfaces to determine the safety problem areas of the total system. Such analyses shall include, but not be limited to, review of subsystems interrelations for:

(a) Compliance with safety criteria.
(b) Possible independent, dependent, and simultaneous failures that could present a hazardous condition.
(c) Insuring that the normal operation of a subsystem cannot degrade the safety of another subsystem or the total system. When changes occur within subsystems, the system safety hazard analysis shall be changed accordingly. In the manned systems, consideration shall be given to crash safety, escape, egress, rescue, and survival.

5.8.2.4 Operating hazard analyses. Analyses shall be performed to determine safety requirements for personnel, procedures, and equipment used in installation, maintenance, support, testing, transportation, storage, operations, emergency escape, egress, rescue, and training during all phases of intended use as specified in the system requirements. Engineering data, procedures, and instructions developed from the engineering design and initial test programs shall be used in support of this effort. Results of these analyses shall provide the basis for:

(a) Design changes where feasible to eliminate hazards or provide safety devices, and safeguards.
(b) The warning, caution, special inspections and emergency procedures for operating and maintenance instructions including emergency action to minimize personnel injury.
(c) Identification of a hazardous period time span and actions required to preclude such hazards from occurring; and
(d) Special procedures for servicing, handling, storage and transportation.

5.9 Action on identified hazards. Action shall be taken to eliminate or minimize hazards revealed by analyses or related engineering efforts. Catastrophic and critical hazards shall be eliminated or controlled. If these hazards cannot be eliminated, or controlled to a specified probability of occurrence, the alternative controls will be immediately presented to the responsible procuring activity for resolution. Reporting shall be in accordance with the provisions of the System Safety Program Plan.

5.10 Supplier and subcontractor system safety program. Procedures shall be established to assure that the supplier and subcontractor system safety programs are consistent with overall system requirements. The contractor shall perform surveillance of the supplier and subcontractor system safety activities and insure adequate performance. Where the contractor and subcontractor determine that it is needed for satisfactory analyses, the contractor shall furnish in a timely manner sufficient system technical information to the subcontractor to enable the latter to consider system effects in a subsystem safety analysis.

6. DATA

6.1 Data requirements. The selected data requirements in support of this standard will be reflected in the Contractor Data Requirements List (DD Form 1423), attached to the request for proposal, invitation for bid, or the contract, as appropriate.

6.2 Data acceptance. Contractor-prepared data delivered in accordance with 6.1 to the procuring activity, shall be subject to review and approval by the procuring activity. In the absence of notification to the contrary within the time period specified in the contract, the data will be considered accepted. Non-delivered data shall be filed and maintained by the contractor for the duration of the contract period, but shall be made available for review and use by authorized representatives of the procuring activity upon request.

6.3 Acquisition and use of safety data. Safety data provided by the procuring activity should be used as a design aid to prevent repetitive design deficiencies. The contractor shall maintain liaison with other data sources to enable identification and evaluation of hazard and safety design deficiencies.

7. SAFETY TESTING

Tests shall be proposed in the SSPP to validate the safety of the product, including those tests already specified by the procuring activity. Safety tests shall be integrated into appropriate test plans. Where complete safety testing costs would be prohibitive, partial design verification of safety characteristics or procedures may be demonstrated by laboratory test, functional mockups or model simulation, when approved by the procuring activity.

Safety tests shall be performed on critical devices or components to determine the degree of hazard or margin of safety of design. Induced or simulated failures will be considered for demonstrating the failure mode of critical components. The detailed test plans for all tests shall be reviewed to insure that:

(a) Safety is adequately demonstrated.
(b) The testing will be carried out in a safe manner.
(c) All additional hazards introduced by testing procedures, instrumentation, test hardware, etc., are properly identified and minimized.

8. TRAINING

8.1 Safety Training for Operator and Maintenance Personnel. Safety information on approved methods and procedures will be included in instruction lesson plans and student examinations for the training of system (operator and maintenance) personnel. Protective devices and emergency equipment will be identified and included in training. Safety training aids, exhibits and displays may be used.

9. EFFECTS OF STORAGE, SHELF-LIFE, PACKAGING, TRANSPORTATION, HANDLING AND MAINTENANCE

The program shall consider, analyze, identify the effects of storage, shelf-life, packaging, transportation, handling and maintenance on the safety of the product. This shall include items such as:

(a) Identification of major or critical characteristics of safety significant items which deteriorate with age, environmental conditions, and other factors.
(b) Procedures for periodic field inspection or tests (including recall for test) of items to establish continuing acceptable levels of performance for parameters under test.
(c) Special safety procedures for maintenance or restoration.

10. INTEGRATION OF ASSOCIATED DISCIPLINES

10.1 Relationship to system engineering. Where the system engineering process is used as the mainstream engineering analysis effort, system safety requirements shall interface with the other engineering disciplines and tradeoff studies made in the interest of an optimum total system design.

Custodians:
Army - AV
Navy - AS

Preparing activity:
Air Force - 10

Reviewer activities:
Army - AV, AT, EL, WE, MU, MI
Air Force - 10
Navy - AS

Project No. MISC-0484

APPENDIX A

SYSTEM SAFETY PROGRAM PLAN OUTLINE

1. General
   - 1.1 Introduction
   - 1.2 Scope and purpose
   - 1.3 Application and implementation
   - 1.4 Applicable documents

2. Safety organization, responsibilities, and authority
   - 2.1 Integrating contractor organization and responsibilities
   - 2.2 Associate contractor organization and responsibilities
   - 2.3 Subcontractors responsibilities
   - 2.4 System safety working groups

3. System safety program milestones

4. System safety criteria
   - 4.1 Definitions
   - 4.2 Hazard level categories
   - 4.3 System safety precedence
   - 4.4 Special contractual requirements
   - 4.5 Identification and dissemination

5. System safety analyses
   - 5.1 Identification of analysis techniques
   - 5.2 Qualitative and quantitative analyses
   - 5.3 Preliminary hazard analysis
   - 5.4 Subsystem hazard analysis
   - 5.5 System hazard analysis
   - 5.6 Operating hazard analyses

6. Safety activities
   - 6.1 Safety data
     - 6.1.1 Identification of data requirements - deliverable and non-deliverable data
     - 6.1.2 Acquisition and use of safety data
       - 6.1.2.1 Hazard data collection
       - 6.1.2.2 Document tree and data flow
       - 6.1.2.3 Documentation and files
       - 6.1.2.4 Format for reports and data submittal
       - 6.1.2.5 Accident prevention, investigation, and reporting
       - 6.1.2.6 Safety reports
   - 6.2 Training
     - 6.2.1 Crew qualification, training and certification
     - 6.2.2 Maintenance personnel training and qualification

☆ U. S. GOVERNMENT PRINTING OFFICE: 1973-714-914/907

7. Audit program
8. Ground handling, storage, servicing and transportation
9. Facilities and support requirements
10. Other system safety matters (not otherwise covered)

CONCEPT FORMULATION PHASE	A
DOD conditional approval to initiate engineering development	RFP issued and definition contractors selected
1. Conduct concept safety studies. 2. Perform preliminary hazard analysis. 3. Define system safety performance envelope and requirements (i.e., maximum peacetime accident rate, etc.) 4. Select system safety effectiveness measures (i.e. estimated number of major accidents avoided vs cost of a proposed safety change). 5. Orient exploratory and advanced developments to enhance the safety feasibility of conceptual designs. 6. Incorporate safety assessment in the technical development plan.	Safety efforts in this phase involve actions by the procuring activity in preparing for Phase B of contract definition, and contractor response to the Request for Proposal (RFP). 1. Procuring activity: (a) Incorporate safety requirements into the statement of work. (b) Identify safety data to be provided to the definition contractor; e.g. preliminary hazards analysis (PHA), tradeoff studies. (c) Identify safety data to be required from the contractor, such as a System Safety Program Plan, Preliminary Hazard Analysis, concept safety analysis, etc. 2. Contractor: (a) Prepare and submit a proposed System Safety Program Plan. (b) Perform a preliminary hazard analysis, or revise, update, and refine the existing PHA provided by the procuring activity. (c) Identify system safety requirements in the system specifications (includes GFE requirements). (d) Include in tradeoff studies the impact on system safety requirements, and the required safety decisions to be made by the procuring activity.

SYSTEM LIFE CYCLE - SAFETY ACTIVITI

CONTRACT DEFINITION PHASE		
B	C	E
Definition contractor's proposals submitted	Proposals evaluated and development contractors selected	D e
Safety actions in this phase essentially involve efforts to be accomplished by the definitional contractor or contractors. 1. Implement the approved contract definition phase system safety program plan. 2. Update and complete the preliminary hazard analysis. 3. Verify or propose modifications to the RFP safety performance specifications provided in the RFP. 4. Update safety studies, analyses and test plans to define safety design requirements criteria, and the operating safety characteristics of the system. 5. Define and identify system safety requirements for the CEI specifications, including those to be developed and produced by subcontractors, and specify safety design criteria, objectives, and goals. 6. Insure highest degree of safety consistent with requirements is maintained during system tradeoffs. 7. Identify the safety decisions required to be made prior to proceeding into the development phase. 8. Submit a firm system safety program plan for the engineering development phase. 9. Submit system safety work breakdown statement for engineering development program.	In this phase the procuring activity evaluates the proposals submitted in response to the definition contracts, preparatory to the selection of a contractor for the development and production phases. Some typical safety matters to be evaluated are: 1. The proposed system safety program plan for the development phase and how it satisfies the applicable safety management and system safety engineering requirements. 2. Review and evaluate the results of the hazards analyses, and other related analyses which define the safety design features. 3. The safety requirements of the system specifications. 4. Make the required safety decisions based upon tradeoff proposals.	1 a 2 e a i 3 t s 4 C 5 m 6 v 7 o 8 v c c 9 s 10 ta 11 co 12

ITIES

ENGINEERING DEVELOPMENT PHASE	PRODUCTION PHASE
DOD approval for initiation of engineering development	DOD decision to produce operational quantities
1. Implement the program approved in the previous phase. 2. Furnish design criteria; establish safety objectives; and review preliminary engineering designs. 3. Evaluate the system design through hazard analyses and safety studies. 4. Insure that designs meet CEI specifications. 5. Establish test requirements in test program. 6. Participate in program reviews. 7. Provide input and review operating publications. 8. Evaluate analysis and investigation results; recommend corrective actions (redesign/change). 9. Participate in tradeoff studies. 10. Review engineering documentation. 11. Provide inputs to training courses and aids. 12. Prepare progress reports.	Assure that safety achieved in design is maintained during production through: quality control, specified monitoring, identifying critical techniques, procedures, facilities, inspections and tests, and by audits of engineering changes. Initiate redesign or changes to meet requirements.

N PHASE	OPERATIONAL PHASE
oduce operational	Acceptance of first operating unit
achieved in de- during produc- ity control, ng, identifying s, procedures, tions and tests, ngineering changes. or changes to meet	1. Perform operational safety review and tests to determine if design, operating and maintenance procedures, and emergency procedures are adequate. 2. Evaluate updating changes and modifications to operational equipment and publications to insure inherent safety is not degraded. 3. Analyze accidents, incidents, and failures, to identify unsafe conditions; eliminate these conditions, and provide a feedback system to avoid these conditions in systems under development and in future systems. 4. Review and approve hazardous material disposal procedures.

SPECIFICATION ANALYSIS SHEET

Form Approved Budget Bureau No. 119-R004

INSTRUCTIONS

This sheet is to be filled out by personnel either Government or contractor, involved in the use of the specification in procurement of products for ultimate use by the Department of Defense. This sheet is provided for obtaining information on the use of this specification which will insure that suitable products can be procured with a minimum amount of delay and at the least cost. Comments and the return of this form will be appreciated. Fold on lines on reverse side, staple in corner, and send to preparing activity.

SPECIFICATION MIL-STD-882 SYSTEM SAFETY PROGRAM FOR SYSTEMS AND ASSOCIATED SUBSYSTEMS AND EQUIPMENT: REQUIREMENTS FOR

ORGANIZATION		CITY AND STATE
CONTRACT NO.	QUANTITY OF ITEMS PROCURED	DOLLAR AMOUNT $

MATERIAL PROCURED UNDER A

☐ Direct Government Contract ☐ Subcontract

1. HAS ANY PART OF THE SPECIFICATION CREATED PROBLEMS OR REQUIRED INTERPRETATION IN PROCUREMENT USE?

   A. GIVE PARAGRAPH NUMBER AND WORDING.

   B. RECOMMENDATIONS FOR CORRECTING THE DEFICIENCIES.

2. COMMENTS ON ANY SPECIFICATION REQUIREMENT CONSIDERED TOO RIGID.

3. IS THE SPECIFICATION RESTRICTIVE?

   ☐ YES ☐ NO IF "YES", IN WHAT WAY?

4. REMARKS (Attach any pertinent data which may be of use in improving this specification. If there are additional papers, attach to form and place both in an envelope addressed to preparing activity.)

SUBMITTED BY (Printed or typed name and activity) DATE

DD Form 1426

FOLD

POSTAGE AND FEES PAID

OFFICIAL BUSINESS

Hq. Air Force Systems Command

(SCIZS)

Andrews Air Force Base

Washington, D. C. 20331

FOLD

II - DESIGN - AFT RAMP LOCKING SYSTEM DEFECTIVE

a - CONSTRUCTED OF 7075 T-6 ALLOY WHICH IS SUBJECT TO STRESS CORROSION METALLURGICAL LAB ANALYSIS REPORT 2JUL75

b - DEPEND ON INTERACTION OF TOO MANY PARTS EXH 104 + 105

c - NOT FAILSAFE - PLUG DOOR SAFER MIL STD 882 - 5.4.1(b) 5.6(a)

D - COMPONENT NOT READY ACCESSIBLE FOR INSPECTION

E - TOLERANCES + CREEP NOT CONSIDERED

F - TEMPERATURE + LOAD SENSITIVE EXH 70

G - WEAR + IMPACT.

H - INSPECTION + MAINTENANCE INTERVAL

II - DESIGN UNSAFE

a - POSITIVE LOCK - OR FAIL SAFE

b - VERIFICATION

c - INDICATORS OR WARNING LIGHTS

D - MULTIPLE FAILURE

II - UNRELIABLE

a - 8 INCIDENTS EXH 69

b - RIGGING PROBLEMS EXH 116

c - VERIFICATION

D - POSITIVE LOCK + FAIL SAFE MIL STD 882 5.4.1(b)

E - UNRELIABLE INDICATORS + WARNING LIGHTS

F - POSITIVE - TEST

11- MAINTAINABLE

a- NO MAINTENANCE INTERVAL

b- VERIFICATION

C- POSITIVE POSITION - RIGGING PINS

D- INSPECTION (SCHEDULE + POSIBILITY)

E - PARTS TOLERANCE, INSPECTION + ADJUSTMENT

F - MANUAL INSTRUCTIONS

G - POSITIVE TEST FOR LOCKING

H - MAN HOURS FOR RIGGING

I - EASE OF REPLACEMENT.

~~F- STANDARD RIGGING PINS EXH 99 PAGE VII~~

11- COMPLEXITY

a- INTERRELATION OF PARTS

b- TIE ROD ADJUSTMENT - INDICATION OF LIMITS

c- TOLERANCES

D- HIGH PROBABILITY FOR MIS RIGGING

11 TOLERANCES

a- TEMPERATURE (EXH 70) (EXH 98), 116

B- LEVEL (EXH 99)

C- STRESS LOADING

D- PART WEAR

E INSPECTION + VERIFICATION

F CROSS WINDS (EXH 98)

11- RIGGING CORRECTLY

a- FIELD, HELL, + MODIFICATION INSPECTION

b- CHANGING TIE ROD LENGTHS

C- MANUAL INSPECTION.

11- MAINTENANCE MANHOURS.

A- REQUIREMENT FOR COMPLETE RIGGING

11- OUT OF RIGGING INTOLERANCE

17- RIGGING- SAFETY.

11 a) - RIGGING PINS

a- ORGINALLY NOT PROVIDED

b- POSITIVE OVERCENTER POSITION.

C- SECURING LOCK

MIL STD 882 PAR 5.6(B)

11-b LOCKING PINS

a- ORGINALLY NOT PROVIDED

b- POSITIVE LOCK

C- PREVENT OPENING

11-C COMPLEXITY.

A - UNDERSTANDING

B - INTERRELATIONSHIP

C - RIGGING CHECK + VERIFICATION

D - PREVIOUS.

11-D OUT-OF RIG + FAILURE

A - UNLOCKING FORCE VS FORCE ON UNLOCKED LOCK

B -

11-E INDICATOR + WARNING LIGHT MIL STD 882 5.6(b) + (C)

A - POSITIVE POSITION

B - KNOWN REFERENCE

C - FALSE INDICATION

D - RELIABILITY + DEPENDABILITY.

11 F PROGRAM LINKS

A - POSITIVE BELLCRANK POSITION

B - ELIMINATED FROM SYSTEM.

II-G RIGGING TOLERANCES EXH 98

A - TEMPERATURE EXH 70

B - UNLEVEL RAMP

C - CROSS WINDS

D - CREEP - TIE ROD TOO LONG EXH 69 PAGE 4

E - PREVIOUSLY GIVEN

F - UNLOCKING PULL FORCE 15-20# EXH 47

II H - PREDICTABLE LOADS + STRESSES

A LOCKHEED DATA - UNAVAILABLE TO DATE

II I PREDITABLE LOADS + STRESS

A - DESIGN CRITERIA EXH 99

B - STRESS CORROSION. METALLURGICAL LAB ANALYSIS REPORT 2 VOL 25

II J PROTECTION FOR STRESS CORROSION MIL-STD-882 PAR 5.4.J(4)

A - DESIGN STRESS

B - EXTRA THICKNESS

C - FATIGUE + CREEP CONSIDERATIONS

II K. DISCONTINUITIES.

A - KNOW FACT - STRESS CONCENTRATIONS

B - JUST DRAWING REVIEW

II L REQUIREMENT OF RE-RIGGING

UNDER MAINTAINABILITY

II M - SECURING TIE RODS

A - NEED NEW COTTER PINS

B - OVER EXTENSION OF TIE ROD ADJUSTMENT

11-N- POSITIVE OVERCENTER POSITION

A - NEGATIVE — UNLOCKING FORCE TEST

B - NO RIGGING + LOCKING PINS

C - PREVIOUS.

11 O RIGGING PINS PREVIOUS.

11-P. LOCKING PINS PREVIOUS

11-Q - REPEAT OF 11-D

11- R - REPEAT OF 11Q + 11 D

11 S PREDICTABLE LEVEL OF FATIQUE

A LOCKS FAILED IN FATIQUE TEST — ______ CYCLES

B - CHANGE IN TIE ROD DIMENSION INDICATE CREEP

12 CORRECT DEFECTS

A - 8 INCIDENTS EXH. 98 PAR 6

B - LIBERTY N.C. SIMULAR FAILURE

1 - DAMAGE TO TORQUE DECK

2 - PRESSURE SEPARATED FROM LOWER LINE.

C - RIGGING PROBLEMS KNOWN

D - MANUAL PROBLEMS

E - STRESS CORROSION

F - VERIFICATION

G - NEED FOR POSITIVE INDICATION -

H - LOCKING + RIGGING " PINS

I - INTERACTION OF LOCKS

J - INDICATORS + WARNING LIGHTS.

K - PROGRAM LINK -

L - RIGGING TOLERANCES

M - TIE ROD FAILURES.

N - CONSIDER EXPLOSIVE DECOMPRESSION

13 - PASSENGERS IN CARGO COMPARTMENT
JUST IN EXHIBIT ___
1 - CRASH POTENTIAL
2 - NOISE - ENVIROMENTAL CONTROL
3 - PALLETS SEATS REQUIRED

14 - FMEA
A - SYSTEM ANALYSIS DIAGRAM
B - FAULT TREE DIAGRAM
C - SINGLE FAULT CRITERIA
D - CONSIDER MULTI-FAULT MODE
E - OUT OF RIGGING +
F - WEAR + TOLERANCE OF PARTS
G - PREVIOUS MULTI-FAULT INCIDENTS
H - EXPLOSIVE DECOMPRESSION
1 - AFT DOOR
15 - 2 - TORQUE DECK
3 - HYDRAULIC LINE + CONTROL CABLES
I ASSET NOT USED FOR LOCKS + FLIGHT CONTROLS

15- STATIC + FATIQUE TESTING

A- NO COMPONENT TESTING INDICATED

B- LOCK FAILED AFTER 10,929 cycles

C- NO RELIABILITY OR LOAD TESTING

D- SINGLE TEST INADEQUATE

E- HYDRAULIC SYSTEM ONLY EXH. 117

16- EXPLOSIVE DECOMPRESSION

SEE -14

17- IMPACT OF EXPLOSIVE DECOMPRESSION

SEE LIBERTY N.C. INCIDENT

18- SAFETY ENGINEER ANALYSIS

A- VERY LITTLE RECORD

B- JIM CORRENT DEPOSITION

C- MATHEMATICAL MODEL OF ASSET NOT GIVEN (MIL STD-882 PAR 5.2Y

D- NEEDED QUALIFIED ENGR.

19- COMPLY WITH EXH 95

A- NOT ASSET

B- DID NOT USE C-130, C-141 EXPERIENCE WITH LOCK FAILURES

C- SAFETY DEPARTMENT DID NOT MONITOR SYSTEM ADEQUATELY

D- DID NOT HAVE ENGR'S TO CONVERSE WITH DESIGN SECTION.

19 A - NOT USE FOR RAMP + LOCKING SYSTEM
PREVIOUSLY STATED

19-B - MINUTELY EXAMINE
A-RELIED ON DESIGN ENGR - (CURRANT DEPOSITION)

19-C - HAZZARD IN AFT RAMP, LOCKS, PRESSURE DOOR
+ HYDRAULIC LINES + CONTROL CABLE
- PREVIOUS INCIDENT - - CURRANT DEPOSITION

19-D - C-130 + C-141 LESSONS -
CURRANT DEPOSITION

20 - AEROSPACE SAFETY ENGINEERING DEPT
1-NO LICENSE PROFESSIONAL ENGR
2-MOST WITHOUT ENGINEERING DEGREE

21 - MANUAL DEPARTMENT COMPETENCY EXH 116
JUSTINE DEPOSITION

22 - LOCKHEED AWARE PRE-ACCIDENT FAILURE
FROM EXHIBITS

23 - COVERED UNDER 11 + 11 a

24. MAINTAIN ABILITY -
1-REQUIRED FULL RIGGING

25 - PLUG DOOR - PREVIOUS IN FAIL SAFE
FAA - EXH 59, 60, 13

26 - CHANGE COMMITTEE REJECTION

27 - CHANGE JUSTIFICATION.

28 - REQUIRED CHANGES

29 STUDY - LOADS + STRESS
OUT OF RIG CONDITION

30 - WEIGHT + SAFETY (EXH 98) PAR 4

31 - MANAGEMENT OF DESIGN.

33 - QUALITY CONTROL - DATA?

34. CANNIBILIZATION

35 - HYDRAULIC LINES AND CONTROL CABLE -
FROM EXHIBITS

36 - PREVIOUSLY GIVEN

37 - MANUAL - RIGGING + LOCKING PINS
PREVIOUS

38 - INADVERTENT OPENING DATA?

39 — PRESSURIZATION — FAIL SAFE FEATURE

40 - ELECTRIC WARNING. — PREVIOUS.

41 - MISRIGGING — PREVIOUS

42 — FREQUENT MALFUNCTION.

43 — FREQUENT ADJUSTMENT

44 - MINOR ERRORS

45 - SAFE OPERATED + MAINTAINED

46 — CASTASTROPHIC FAILURE MODE
HAZARD ANALYSIS — — PREVIOUS

47 — MAINTENANCE MANUAL WARNING.

48 FAILURE TO WARN — TRAINING

49 - FAILURE TO WARN MECHANICS
MISADJUSTMENT OF MECHANICAL AND/OR
ELECTRICAL INDICATORS

50 - FAILURE TO WARN - MINOR ERRORS

51 - FAILURE TO WARN - RIGGING VERIFICATION

52 - CONTRACT REQUIREMENTS
1 - MIL - STD - 882 PAR 5.2, 5.7, 5.9

53 - FAILURE TO TRAIN
1) LESSON PLANS + EXAMINATION (MIL STD 882 PAR 5.1

54 - PROPERLY INSPECT + TEST DATA ?
1 - MANUAL

55 - FAILURE TO TRAIN
SAME AS 49

56 - TECH - REP ASSISTANCE
EXHIBITS + DEPOSITIONS

57 - CORRECT. DEFECTS EXH 71
(PRE[illegible])

58- WEIGHT REDUCTION GOALS

SEE 30

59- INCOMPETENT SAFETY DEPT

SEE 20

60- ADEQUATE SAFETY ENG'R'G

SEE - 69

61- INCOMPETENT - PREPARE MANUAL

SEE 72 4

62- WILLFUL + DELIBERATE - DEFECTS

DATA ?

63- FAILURE TO WARN - RIGGING VERIFICATION

SEE 51

64- EXH 72 Page 2

65- DESIGN A FAIL-SAFE LOCK

66- GIVEN -

67- SAME AS 64

II - DESIGN AFT RAMP LOCKING SYSTEM DEFECTIVE

a - CONSTRUCTED OF 7075 T-6 ALLOY WHICH IS SUBJECT TO STRESS CORROSION — METALLURGICAL LAB ANALYSIS REPORT 2JU775

b - DEPEND ON INTERACTION OF TOO MANY PARTS — EXH 104 + 105

C - NOT FAILSAFE - PLUG DOOR SAFER — MIL STD 882 5.4.1(A) 5.6(A)

D - COMPONENT NOT READY ACCESSIBLE FOR INSPECTION

E - TOLERANCES + CREEP NOT CONSIDERED

F - TEMPERATURE + LOAD SENSITIVE — EXH 70

G - WEAR + IMPACT

H - INSPECTION + MAINTENANCE INTERVAL

II - DESIGN UNSAFE

a - POSITIVE LOCK - OR FAIL SAFE

b - VERIFICATION

C - INDICATORS OR WARNING LIGHTS

D - MULTIPLE FAILURE

II - UNRELIABLE

a - 8 INCIDENTS — EXH 69

b - RIGGING PROBLEMS — EXH 116

C - VERIFICATION

D - POSITIVE LOCK + FAIL SAFE — MIL STD 882 5.4.1(A)

E - UNRELIABLE INDICATORS + WARNING LIGHTS

F - POSITIVE - TEST

UNITED STATES DISTRICT COURT

FOR THE DISTRICT OF COLUMBIA

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IN RE AIR CRASH DISASTER
NEAR SAIGON, SOUTH VIETNAM
ON APRIL 4, 1975

Misc. No. 75-0205
All Cases

---X

ELEANOR S. DOBSON, Administratrix of the Estate of JO-AN K. PRAY, Deceased, and on behalf of all others similarly situated,

-and-

FRIENDS FOR ALL CHILDREN, INC., as Special Administrator of the Estate of TRAN THI BA and Seventy-Five other decedents,

Plaintiffs,

Civil Action No.
75-0874

-against-

LOCKHEED AIRCRAFT CORPORATION, A California Corporation,

Defendant and Third-Party Plaintiff,

-against-

THE UNITED STATES OF AMERICA,

Third-Party Defendant.

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PLAINTIFFS' SUPPLEMENTAL ANSWERS TO DEFENDANT LOCKHEED'S WRITTEN INTERROGATORIES

Plaintiffs Burke C. Pray and Eleanor S. Dobson hereby submit answers to the contention interrogatories propounded by defendant Lockheed Aircraft Corporation (hereinafter referred to as Lockheed). At the time of this submittal, discovery is still in progress, important witnesses are yet to be deposed, and documents are yet to be received and/or analyzed. Plaintiffs reserve the right to change, alter, expand, refine, exclude, or otherwise modify the answers provided herein as indicated by further formal and informal discovery in this proceeding and as otherwise appropriate. Additionally, some of the contention interrogatories request legal as opposed to factual answers. Plaintiffs research on these legal questions is ongoing. The answers provided represent plaintiffs legal positions <u>at this time.</u> Plaintiffs also reserve the right to change, alter, expand, refine, exclude, or otherwise modify these legal answers as indicated by further research, analysis and discovery and as otherwise appropriate.

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INTERROGATORY NO. 62: Set forth the title, citation and enacting state of all statutes, regulations or codes relied upon as a basis for plaintiff's action.

ANSWER 62: District of Columbia Code §16-2701, et seq. (wrongful death) and §12-101 (survival). Plaintiffs also rely upon statutes, regulations and codes permitting recovery for breaches of express and/or implied warranties, such being described in answers to Interrogatories 64 and 65.

INTERROGATORY NO. 63(a): Set forth each and every specific act, or omission on the part of defendant Lockheed Aircraft Corporation upon which plaintiff relies for the contentions as contained in paragraph of the complaint that said accident was caused by the negligence of said defendant, its officers, agents and employees, in the design, manufacture, assembly, testing, modification and inspection of the C5-A aircraft.

ANSWER 63(a). Acts and/or omissions on the part of Lockheed were direct and proximate causes of the subject accident and constitute negligence on the part of Lockheed, its officers, agents and employees:

(1) Maintenance manual T.O. IC-5A-2-12, effective January 16, 1975, and certain sections and figures of such manual including Section 3-80 (Aft Ramp Lock Subsystem Removal), Section 3-81 (Aft Ramp Lock Subsystem Installation), Figure 3-44 (Aft Ramp Rigging Instructions), Section 3-168 (Aft Ramp Rigging Instructions) and Section 3-173 (Aft Ramp Mechanical Rigging Verification), as well as corresponding sections relating to the forward ramp, were defective in that said manual and the referenced sections and figures were inadequate, unclear, misleading, poorly organized, improperly illustrated, unduly and needlessly complex, internally inconsistent, improperly referenced, false, lacking in necessary directives, improperly formatted, lacking in necessary warnings and cautions, not geared to the skill levels of the mechanics who were to perform the subject tasks and otherwise negligently prepared. Specific examples of such defects include:

(a) The failure to employ the job guide format.

(b) The failure to compile all the instructions related to the removal and installation of a given component of the aft ramp locking system in one place in said manual.

(c) The lack of clear and complete directives in Sections 3-80 and 3-81.

(d) The use in Section 3-81, paragraph a, of the unclear, misleading and vague instruction "Install the components of the aft ramp in the reverse order of removal" rather than clearly delineating each step to be performed by the mechanic when installing a given component of the aft ramp locking system.

(e) The use in Section 3-81, paragraph b, of the unclear, misleading and vague reference to Figure 3-44 rather than clearly delineating the specific steps in Figure 3-44 to be performed by the mechanic in rigging the aft ramp locks after installing a given component of the aft ramp locking system.

(f) The use of unclear, confusing, inconsistent, and needlessly complex instructions in Figure 3-44.

(g) The use of unclear, misleading and false illustrations in Figure 3-44.

(h) Illustrating in Figure 3-44 the installation of a tierod in a manner which would instruct the mechanic to install a tierod backwards.

(i) The failure to reference back to paragraphs c, d, and e of Section 3-81 after the mechanic had gone to Figure 3-44 to rig the aft ramp locks in accordance with the instructions contained in paragraph b of Section 3-81.

(j) The lack of clear and complete directives in Section 3-168 and in paragraph d of said Section.

(k) The failure to delineate in Section 3-168 the specific rigging steps to be performed upon installing a given component of the aft ramp locking system (rather than rigging steps to be performed upon installing any and all aft ramp lock mechanisms), and to eliminate unnecessary rigging steps for the given installation task.

(l) The use in Section 3-168 of all encompassing rigging instructions for "aft ramp lock mechanisms" which needlessly complicate the task of the mechanic.

(m) The use of a misleading and false title for Section 3-173.

(n) The lack of clear and complete directives in Section 3-173.

(o) The use of misleading, unclear and false language in paragraph c of Section 3-173, to-wit, "Ramp locks shall be <u>verified</u> as follows" [emphasis added].

(p) The failure to warn that the procedures in 3-173, if followed completely, would not verify the rigging of the aft ramp locking system, in that such procedures could not confirm that the rigging of the aft ramp locking system had been done correctly.

(q) The lack of warnings in Sections 3-80, 3-81, 3-168 and 3-173, and in Figure 3-44 that the failure to replace a cotter key could result in a hazardous condition.

(r) The misleading use, without necessary explanation, of the 30 pounds minimum pull force requirement in the instructions contained in Figure 3-44.

(s) The lack of a warning in Sections 3-81, 3-168 and 3-173, and in Figure 3-44 that the rigging tolerances and checks could be effected by temperature differentials, unlevel ramps, and cross winds.

(t) The failure to provide adequate troubleshooting procedures.

(u) The use of unclear, misleading and false figure references in Section 3-80.

(v) The interruption of Section 3-173 by more than forty pages of non-pertinent material.

(w) The failure to reference on page 3-439 the continuation of Section 3-173 to page 3-485.

(x) Other defects.

Maintenance manual T.O. 1C-5A-2-12 and the referenced sections and figures improperly required the Air Force mechanics to depend solely upon their unguided judgment when performing maintenance tasks on the forward and aft loading systems, including the removal and installation of components of the aft ramp locking system, the rigging of the aft ramp locking system, and the verification of the rigging of the aft ramp locking system.

Prior versions of maintenance manual T.O. 1C-5A-2-12 and the referenced sections and figures were similarly defective.

Maintenance manual T.O. 1C-5A-2-12, and supplements thereto, were prepared and then submitted by Lockheed to the Air Force for the purpose of instructing Air Force mechanics in the performance of maintenance tasks on the forward and aft loading systems of the C5A, including the removal and installation of components of the aft ramp locking system, the rigging of the aft ramp locking system, and the verification of the rigging of the aft ramp locking system. The maintenance manual prior to the accident, improperly and negligently instructed the Air Force mechanics in the performance of such tasks. Lockheed was and is responsible for the contents of said manual, including the referenced sections and figures.

(2) Lockheed prior to the accident failed to correct the defects in maintenance manual T.O. 1C-5A-2-12 and the referenced sections and figures even though Lockheed had full knowledge of such defects, and the consequences of such defects, prior to the accident.

(3) The hydraulic lines and control cables were defectively routed in the torque deck area in that such lines and cables were located in the unprotected and vulnerable bottom section of the torque deck area and were unreasonably close to the aft cargo door complex. Lockheed also failed to comply with its written representations to the Air Force that it would locate control and hydraulic lines away from fuselage openings.

(4) There was a failure to consider prior to the accident the consequences to the hydraulic lines and control cables located in the torque deck area, and to the flight control systems generally, if the bottom structure of the torque deck area was punctured or otherwise damaged.

(5) Lockheed prior to the accident failed to correct the defective routing of the hydraulic lines and control cables in the torque deck area even though Lockheed had full knowledge of such defects, and the consequences of such defects, prior to the accident.

(6) There was a failure to provide adequate redundancy of flight controls in the aft portion of the aircraft and in the torque deck area, as well as through the aircraft generally.

(7) There was a failure to utilize adequate design criteria in the design of the flight control systems (location, number, type, etc.) in the aft portion of the aircraft and in the torque deck area, as well as throughout the aircraft generally.

(8) There was a failure to provide alternate means for control of the aircraft in the event of damage to the hydraulic lines and control cables located in the torque deck area.

(9) Lockheed prior to the accident failed to correct the lack of adequate flight control redundancy in the aft portion of the aircraft and in the torque deck area even though Lockheed had full knowledge of such defects, and the consequences of such defects, prior to the accident.

(10) There was a failure to provide a verification procedure and/or means by which the mechanic could confirm that the rigging of the aft ramp locking system had been done correctly.

(11) The design of the aft ramp locking system prior to the accident was defective in that such system was unsafe, unreliable, unmaintainable, much too complex, required rigging tolerances that were too close, was often difficult and frequently impossible to rig correctly, created the need for excess and unnecessary maintenance, was intolerant to out-of-rig conditions, made rigging critical to aircraft safety and created an extremely hazardous condition if a lock was not as far as the nominal overcenter position, performed poorly in service, and was not in accordance with the state of the art and/or recognized design criteria. For example:

(a) Such design did not include rigging pins or other similar devices. The use of rigging pins would have provided a simple means by which the nominal overcenter position of the lock could be visually verified. The use of rigging pins would also have provided a simple means to physically secure the position of the locks not directly involved in the installation task, and would have eliminated the necessity to rerig the locks not so directly involved.

(b) Such design did not include locking pins or other similar devices. The use of locking pins would have provided a simple means to physically secure the position of the locks during flight. The use of locking pins would have also provided a simple means to isolate the effect of aft ramp-lock component failure and/or out-of-rig condition when the system was locked.

(c) Such system was so complex and poorly designed as to preclude being understood by Air Force mechanics, as to preclude being rigged correctly, and to necessarily produce out-of-rig conditions.

(d) The locking system was not designed to withstand the out-of-rig condition and/or failure of more than one lock, in spite of the fact such multiple out-of-rig conditions and/or failures were easily foreseeable.

(e) Such design included no indicators, mechanical or electrical, which could be relied upon to confirm that the locks were nominally overcenter. The accuracy of the mechanical and electrical indicators were directly (and improperly) dependent on the correct placement of the bellcrank in the first instance.

(f) The program link pins were so poorly designed and deficient that they were eliminated as a means of rigging verification prior to and at the time of the accident.

(g) The rigging tolerances of the system were much too critical and the rigging of the system could not withstand changes in temperature, unlevel ramps and cross winds.

(h) The components of the aft ramp locking system were not designed to withstand predictable loads and stresses encountered in properly rigged and/or out-of-rig conditions.

(i) Components of the aft ramp locking system, such as the bellcranks, were improperly made out of certain aluminum alloys which reduced such parts' ability to withstand the predictable loads and stresses and greatly increased such parts' susceptibility to corrosion and stress corrosion.

(j) Inadequate measures were taken to protect the components of the aft ramp locking system from stress corrosion and corrosion.

(k) The bellcranks and other components of the aft ramp locking system contained discontinuities which greatly reduced the ability of such parts to withstand loads and stresses and greatly increased such parts' susceptibility to corrosion and stress corrosion.

(l) The system was designed so that a mechanic would have to re-rig the entire locking system after installing only a single lock component.

(m) Inadequate means (cotter keys) were utilized to secure the tierods once installed.

(n) The system did not provide a means by which the overcenter position of the lock(s) could be visually verified.

(o) The system did not provide a means to physically secure the position of locks not directly involved in the installation task so as to eliminate the necessity to rerig the locks not so involved.

(p) The system did not provide a means to physically secure the position of the locks during flight.

(q) The system was designed so that failure(s) and/or out-of-rig condition(s) of one lock would cause failure(s) and/or out-of-rig condition(s) of other locks.

(r) The design of the system was based on an inadequate design criteria, the single fault plus undetectable fault criteria. This design criteria precluded any consideration of (1) accommodating the design of the aft ramp locking system to withstand more than one fault and/or (2) the consequences to such locking system of more than one fault.

(s) The component parts of the aft ramp locking system were not designed to withstand predictable levels of fatigue.

(t) Other design defects.

(12) Lockheed prior to the accident failed to correct the defects in the design of the aft ramp locking system even though Lockheed had full knowledge of each and every such defect, and the consequences of such defects, prior to the accident.

(13) The cargo compartment was not properly designed to carry passengers under any circumstances even though it was contemplated by Lockheed and represented to the Air Force that the cargo compartment could be used to transport passengers.

(a) The structure was not capable of withstanding the impacts associated with a crash or hard landing.

(b) Passengers could not be briefed in the cargo compartment due to noise level.

(c) The environment was inadequate for passengers due to high noise levels and poor temperature control.

(d) There was a lack of oxygen equipment to adequately handle passengers.

(e) Other design defects.

(14) There was a failure to conduct an adequate failure mode and effects analysis (FMEA) on the aft ramp locking system. The FMEA failed to consider any series of multi-fault modes (other than undetectable faults) including single structural fault coupled with single maintenance fault. The FMEA inadequately and inaccurately analyzed several of the single fault modes relevant to the aft ramp locking system considered in the study. The FMEA failed to consider certain single fault modes relevant to the aft ramp locking system. The FMEA failed to take account of possible out-of-rig conditions of the aft ramp locking system and of normal wear and tear. On numerous occasions before the accident, Lockheed was aware of incidents involving the forward and/or aft C-5A ramps caused by multiple failures. It also was aware that at

least some of these incidents were alleged to have resulted from out-of-rig conditions. In spite of this knowledge, Lockheed failed to revise the FMEA to take account of such multiple failures and/or out-of-rig conditions. The FMEA was otherwise defective.

(15) There was a failure to conduct adequate static and fatigue testing of the aft cargo door complex, the aft ramp locking system and the components of the aft ramp locking system. Such static and fatigue testing employed inadequate methodology. There was an inadequate number of component tests. The tests were conducted contrary to established test criteria. The results of the test were misinterpreted and/or misapplied to the design of the aft cargo door complex and the aft ramp locking system. Such static and fatigue testing was otherwise defective.

(16) There was a failure to consider the potential impact of an explosive decompression on the aft ramp locking system, the aft pressure door, the aft ramp, the torque deck area, and the hydraulic lines and control cables located in the torque deck area. There was also a failure to modify the design of the aft ramp locking system, the aft pressure door, the aft ramp, the torque deck area, and the hydraulic lines and control cables located in the torque deck area, so as to minimize the impact of such an explosive decompression.

(17) Lockheed prior to the accident failed to consider the impact of an explosive decompression on, and/or modify accordingly the design of the aft ramp locking system, the aft pressure door, the aft ramp, the torque deck area, and the hydraulic lines and control cables located in the torque deck area, even though Lockheed was aware prior to the accident that an explosive decompression could severly impact each of such systems.

(18) There was a failure to perform adequate safety engineering analyses of the aft ramp locking system, the aft pressure door, the aft ramp, the torque deck area, and the hydraulic lines and control cables located in the torque deck area, including the failure to perform an adequate hazard analysis.

(19) There was a failure to comply with the System Safety Engineering Plan promulgated by Lockheed and submitted to the Air Force as part of the C5 contract proposal.

(a) There was a failure to adequately perform the tasks included in the "Advanced System Safety Engineering Technique".

(b) There was a failure to "minutely examine" the various facets of the design of the aft ramp locking system, the aft pressure door, the aft ramp, the torque deck area, and the hydraulic lines and control cables located in the torque deck area, and to accurately assess the safety factors involved.

(c) There was a failure to accurately delineate the hazards existent in the aft ramp locking system, the aft pressure door, the aft ramp, the torque deck area, and the hydraulic lines and control cables located in the torque deck area.

(d) There was a failure to apply the engineering lessons learned on the C130 and C141 to the C5 and particularly to the aft ramp locking system, the aft pressure door, the aft ramp, the torque deck area, and the hydraulic lines and control cables located in the torque deck area.

(e) Other failures to comply.

(20) The safety assurance department of Lockheed during the design phase and subsequent thereto up to the accident lacked the requisite engineering competence to perform the required and necessary safety engineering analyses and to perform the safety engineering tasks delineated in the System Safety Engineering Plan. Additionally, the safety assurance department lacked the requisite knowledge of the aft ramp locking system, the aft pressure door, the aft ramp, the torque deck area, and the hydraulic lines and control cables located in the torque deck area, to competently perform such safety engineering analyses and tasks.

(21) The maintenance manual drafting department of Lockheed during the design phase and subsequent thereto up to the accident lacked the requisite competence to prepare maintenance manuals which instructed Air Force mechanics as to how to perform most complex maintenance tasks on the C5; and more specifically such department lacked the competence to prepare maintenance manual T.O. 1C-5A-2-12 and Sections 3-80, 3-81, 3-168 and 3-173 and Figure 3-44 therein. Additionally, such department lacked the competence to adapt said instructions to the skill level of the mechanics who were to perform the maintenance tasks.

(22) Lockheed was aware of the pre-accident failures of the forward and aft ramp systems of the C5 and of the pre-accident failures of the pressure door, ramp and ramp lock systems, and aft located hydraulic lines of the C141 and C130. In spite of the knowledge of these failures, Lockheed failed to redesign the aft ramp locking system, the aft pressure door, the aft ramp, and the torque deck area of the C5, to relocate the hydraulic lines and control cables in the torque deck area of the C5; and to make needed changes in

maintenance manual T.O. 1C-5A-2-12. In spite of the knowledge of these failures, Lockheed also failed to reexamine and revise the FMEA as such pertained to the aft ramp locking system, the aft pressure door, the aft ramp, the torque deck area, and the hydraulic lines and control cables located in the torque deck area of the C5.

(23) There was a failure to design the aft ramp locking system so as to reduce the number and complexity of the maintenance tasks to a minimum.

(24) There was a failure to design the aft ramp locking system so that a component could be simply and quickly replaced.

(25) The design of the aft cargo door complex was defective in that, in addition to 63(a)(11): (a) There was a failure to make the aft ramp and pressure door "plug" type doors, instead of doors as large as the fuselage openings around them; (b) there was a failure to meet all military specifications and Federal Aviation Administration specifications applicable to the aft cargo door complex and routing of hydraulic lines and control cables; (c) the design of the components of the aft ramp locking system had inadequate margins of safety; (d) there was a failure to take account of the consequences of having all parts in the aft ramp complex at either their maximum or minimum tolerances; (e) the aft cargo door complex was so inadequately designed that even Lockheed engineers and other employees could not properly rig the system; and (f) other defects.

(26) There was a failure to adequately and properly consider proposed corrections to the design of the aft ramp locking system prior to the accident. Proposed corrections to such system were rejected by the Change Candidate Committee and other management of Lockheed on the basis of contract cost and profit-potential considerations rather than engineering merit. Proposed corrections were considered strictly in terms of whether the existing design met the original specifications, without any consideration as to whether such specifications were adequate and in need of redefinition. Such consideration of proposed corrections to the design of the aft ramp locking system was otherwise defective.

(27) In those instances where Lockheed did submit proposals to the Air Force to correct the design of the aft ramp locking system, the aft ramp and/or the aft pressure door, Lockheed failed to properly document and support such proposals for correction.

(28) Lockheed prior to the accident knew that the Air Force mechanics were having extreme difficulty in rigging the aft ramp locking system. In spite of this knowledge, Lockheed failed to redesign the aft ramp locking system and/or redraft maintenance manual T.O. 1C-5A-2-12. Also in spite of this knowledge and in spite of the knowledge of the pre-accident failures of the forward and aft ramp systems of the C5 and of the pre-accident failures of the pressure door, ramp and ramp lock systems, and aft located hydraulic lines of the C141 and C130, Lockheed failed to incorporate into the design of the aft ramp locking system and/or maintenance manual T.O. 1C-5A-2-12 a rigging verification procedure and/or means which would confirm that the rigging of the aft ramp locking system was done correctly.

(29) There was a failure to study the loads and stresses which the aft ramp locking system and its components would be subjected to during various out-of-rig conditions and/or as a result of the failure of various combinations of locks or components of locks.

(30) Weight and cost considerations were permitted to outweigh engineering and safety necessity in the design of the aft ramp locking system and its components. For example, certain of such components were made of aluminum alloys, which were inferior and inadequate in their ability to withstand loads--stresses and stress corrosion-corrosion, in order to satisfy certain weight reduction and cost goals.

(31) The management of the design, manufacture and testing of the aft ramp locking system, the aft pressure door, the aft ramp, the torque deck area, and the hydraulic lines and control cables located in the torque deck area, was inadequate and inferior. Lockheed's mismanagement occurred in at least the following respects: permitting schedules and cost considerations to disproportionately affect safety and design decisions; failing to meet various contract requirements or goals; failing to prevent problems with respect to missing parts, false documentation, bogus parts, removal of parts, parts shortages, inadequate control of parts, quality control and assurance, and manufacturing; engaging in inadequate planning and failing to anticipate and avoid financial problems caused by management mistakes; inadequate supervision of design; and failing to adopt management policies, practices, and procedures which would have prevented serious problems from developing.

(32) There was a failure to exercise proper quality control in the manufacture of the components of the aft ramp locking system.

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(33) There was a failure to properly fabricate the components of the aft ramp locking system.

(34) There was a failure to design the aft ramp locking system to accommodate the practice of cannibilization which Lockheed knew to be a "fact of life" with regard to aircraft owned by the Air Force.

(35) Hydraulic lines and control cables were located in the bottom of the torque deck area which lacked sufficient strength to withstand in-flight opening of the aft cargo door complex and/or impact of the aft pressure door or aft ramp.

(36) The location of the critical hydraulic lines and control cables in the vulnerable unprotected bottom portion of the torque deck area created an inherently dangerous and unsafe condition.

(37) The extremely complex and defective design of the aft ramp locking system coupled with the defective maintenance manual T.O. 1C-5A-2-12 and the failure to utilize either locking pins or rigging pins created an inherently dangerous and unsafe condition.

(38) The aft ramp locking system was not designed to prevent inadvertent in-flight opening(s) of the aft cargo door complex as a result of an out-of-rig condition(s) and/or failure(s) of a component(s) of the locking system.

(39) There was a failure to design the aircraft so that it could not be pressurized if the aft cargo door complex was not fully and properly locked.

(40) There was a failure to provide a reliable electrical warning system to warn pilots and other crewmembers in the cockpit and elsewhere that the aft cargo door complex was not fully and properly closed and locked.

(41) There was a failure to design an aft ramp locking system which could not be intentionally or inadvertently misrigged.

(42) The aft ramp locking system was defective as evidenced by the fact that in normal operational use, frequent malfunctions rendered such locking system unreliable and unsafe.

(43) The design of the aft ramp locking system was defective in that normal operational use required frequent adjustments to the rigging of such system.

(44) There was a failure to design the aft ramp locking system so that minor errors in the rigging of the aft ramp locking system could not create an inherently dangerous and unsafe condition.

(45) The aft ramp locking system was not designed so that it could be safely operated and maintained by Air Force mechanics.

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(46) There was a failure to eliminate the catastrophic failure modes actually described in the failure mode and effects analysis and those which should have been described in the failure mode and effects analysis with respect to in-flight opening(s) of the aft cargo door complex, in-flight failure(s) of the aft ramp locking system, in-flight damage to the bottom portion of the torque deck area and in-flight severing of the hydraulic lines and control cables located in the bottom portion of the torque deck area.

(47) The maintenance manuals, flight manuals, training films and other instructional material prepared by Lockheed and submitted to the Air Force were defective in that they did not adequately warn of the defects identified in subsections 63(a)(1)-63(a)(46) and the consequences of such defects.

(48) There was a failure to warn in the training materials prepared by Lockheed and submitted to the Air Force of the defects identified in subsections 63(a)(1)-63(a)(46) and the consequences of such defects.

(49) There was a failure to warn the Air Force and/or its mechanics that a minor misadjustment to the mechanical or electrical indicators would result in those indicators being unreliable.

(50) There was a failure to warn the Air Force and/or the Air Force mechanics that minor errors in the rigging of the aft ramp locking system could create an inherently dangerous and unsafe condition, could cause the aft ramp locking system to appear to be fully and securely locked when in fact it was not fully and securely locked and could result in the aft cargo door complex opening in flight.

(51) There was a failure to warn the Air Force and/or its mechanics that the rigging verification procedure provided in Section 3-173 of maintenance manual T.O. 1C-5A-2-12 was not in fact a rigging verification procedure and did not in fact confirm that the rigging of the aft ramp locking system was correctly done.

(52) There was otherwise a failure to warn the Air Force and/or its mechanics of the defects identified in subsections 63(a)(1)-63(a)(46), as was required by contract.

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(53) There was a failure to adequately train or instruct Air Force mechanics in the proper maintenance procedures required to guarantee a safe aft ramp locking system and to assure that the aft cargo door complex would be fully and properly locked under all circumstances prior to departure.

(54) There was a failure to properly inspect and test the C5 both prior to its delivery to the Air Force and subsequent thereto up to the time of the accident to determine whether the aft ramp locking system was defective and to determine whether maintenance manual T.O. 1C-5A-2-12 was adequate to instruct the Air Force mechanics in the removal and installation of components of the aft ramp locking system and in the related rigging and rig verification of the aft ramp locking system.

(55) There was a failure to train and/or instruct Air Force mechanics to recognize and prevent the hazards presented by the design defects identified in subsections 63(b)(1)-63(b)(2); 63(b)(10)-63(b)(12); 63(b)(37); 63(b)(41); and 63(b)(44).

(56) Following delivery of the C5 to the Air Force, Lockheed's "Product Support" personnel at the various Air Force bases failed to properly assist the Air Force mechanics in maintaining the aft cargo door complex including the proper rigging of the aft ramp locking system.

(57) The failure to cure, correct and eliminate the design defects and deficiencies identified in subsections 63(a)(1)-63(a)(18); 63(a)(22)-63(a)(25); 63(a)(28)-63(a)(29); and 63(a)(34)-63(a)(46) despite the fact that Lockheed had full knowledge of such defects and deficiencies prior to the accident and that such deficiencies and defects individually or in combination could result in a crash of, and/or explosive decompression in, the C5 constitutes extreme recklessness, fraud and malice on the part of Lockheed, its officers, agents and employees.

(58) Permitting weight reduction goals and cost considerations to outweigh engineering and safety necessities and in so doing permitting the manufacture of the C5 with the design defects and deficiencies identified in subsections 63(a)(1)-63(a)(18); 63(a)(22)-63(a)(25); 63(a)(28)-63(a)(29); and 63(a)(34)-63(a)(46), knowing that such defects and deficiencies individually or in combination could result in the crash of, and/or explosive decompression in, the C5, constitutes extreme recklessness, fraud and malice on the part of Lockheed, its officers, agents and employees.

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(59) Permitting an incompetent safety assurance department to perform safety engineering analyses with respect to the aft cargo door complex, including the aft ramp locking system, knowing that defects and deficiencies in the aft cargo door complex and the aft ramp locking system individually or in combination could result in the crash of, and/or explosive decompression in,

the C5, constitutes extreme recklessness, fraud and malice on the part of Lockheed, its officers, agents and employees.

(60) Permitting the C5 to be delivered to the Air Force without the performance of adequate safety engineering analyses with regard to the aft cargo door complex, including the aft ramp locking system, and/or to be delivered with bogus parts, knowing that defects and deficiencies in the aft cargo door complex and the aft ramp locking system individually or in combination could result in the crash of, and/or explosive decompression in, the C5, constitutes extreme recklessness, fraud and malice on the part of Lockheed, its officers, agents and employees.

(61) Permitting an incompetent department to prepare maintenance manual T.O.1C-5A-2-12 which was to be used to instruct Air Force mechanics in the performance of the most complex maintenance tasks on the forward and aft ramp loading systems, knowing that the failure to so perform the maintenance activities could result in the crash of, and/or explosive decompression in, the C5, constitutes extreme recklessness, fraud and malice on the part of Lockheed, its officers, agents and employees.

(62) The conscious, willful and deliberate decision not to cure the defects and deficiencies identified in subsections 63(a)(1)-63(a)(56) to avoid the expenses which would be incurred in taking the necessary corrective action, to avoid the effect which acknowledgement of the defects would have had upon the sale of the aircraft, and the resulting loss of revenues and profits which Lockheed would sustain, knowing that such failure to cure said defects and deficiencies individually or in combination could result in the crash of, and/or explosive decompression in, the C5, constitutes extreme recklessness, fraud and malice on the part of Lockheed, its officers, agents and employees.

(63) Failing to warn the Air Force and/or its mechanics that the rigging verification procedure provided in Section 3-173 of maintenance manual T.O. 1C-5A-2-12 was not in fact a rigging verification procedure and did not in fact confirm that the rigging of the aft ramp locking system was correctly done, knowing that the failure to properly rig the aft ramp locking system could result in the crash of, and/or explosive decompression in, the C5, constitutes extreme recklessness, fraud and malice on the part of Lockheed, its officers, agents and employees.

(64) Lockheed's other acts and/or omissions were done with extreme recklessness, fraud and malice.

(65) There was a failure to design a fail-safe locking system for the aft cargo door complex.

(66) Lockheed otherwise failed to satisfy the terms of the C5 contract, as amended from time to time.

(67) Other acts and/or omissions. SEE 62

INTERROGATORY NO. 63(b): State the specific manner and way in which each of the acts or omissions of negligence referred to in 63(a) above caused or contributed to the accident involving said aircraft.

ANSWER 63(b): Each of the acts and/or omissions referred to in 63(a) above caused or contributed to the crash of the subject aircraft.

(1) If maintenance manual T.O. 1C-5A-2-12, effective January 16, 1975, (maintenance manual) and the referenced sections and figures had not been defective as indicated and had not possessed each of the specific examples of such defects, the Air Force mechanics, who were competent and eager to perform the maintenance tasks correctly, would have properly rigged the aft ramp locking system of the subject aircraft and the "misrigging", which Lockheed alleges occurred to the aft ramp locking system, would not have occurred, the aft ramp locking system would not have failed, and the accident would have been avoided.

(a^1) If the maintenance manual had employed the job guide format and/or had compiled all the instructions relating to the removal and installation of a tierod(s) of the aft ramp locking system in one place in said manual, and all other defects in the manual had been eliminated, the Air Force mechanics would have known precisely what steps to perform upon removal and installation of a tierod(s) of the aft ramp locking system, said Air Force mechanics would have properly rigged the aft ramp locking system of the subject aircraft and the "misrigging", which Lockheed alleges occurred to the aft ramp locking system, would not have occurred, the aft ramp locking system would not have failed, and the accident would have been avoided.

(b^1) If Sections 3-80, 3-81, 3-168 and 3-173 and Figure 3-44 had contained clear and complete directives, if such sections and figure had contained clear and complete references and had been properly arranged, if the illustrations in Figure 3-44 had been clear and accurate and not unclear, misleading and false, if Section 3-81 had clearly delineated each step to be performed by the mechanic when installing tierod(s) of the aft ramp locking system, and if Section 3-168 had set out in clear form only the necessary rigging steps to be performed upon installing said tierod(s) and had eliminated unnecessary rigging steps for such installation task, the Air Force mechanics would not have been required to depend solely on their unguided judgment when performing said maintenance tasks, said mechanics would have properly rigged the aft ramp locking system of the subject aircraft and the "misrigging", which Lockheed alleges occurred to the aft ramp locking system, would not have occurred, the aft ramp locking system would not have failed, and the accident would have been avoided.

(c1) If Section 3-173 had not possessed a misleading and false title, if such Section had not contained misleading, unclear and false language and if such Section had contained a warning that this "Verification Section" did not in fact verify the rigging of the aft ramp locking system in that such procedures could not confirm that the rigging of the aft ramp locking system had been done correctly, the Air Force mechanics would not have been misled to believe that the procedures in Section 3-173, given a positive completion of such procedures, demonstrated conclusively that the rigging of the aft ramp locking system had been done correctly. Said defects caused and/or contributed to the "misrigging", which Lockheed alleges occurred to the aft ramp locking system, to the failure of the aft ramp locking system, and consequently to the accident.

(d1) If Sections 3-80, 3-81, 3-168 and 3-173 and Figure 3-44 had contained warnings that the failure to replace a cotter key could result in a hazardous condition, the alleged failure to replace a cotter key (Lockheed's allegation which is not adopted by plaintiffs) would not have occurred.

(e1) If the maintenance manual had contained a "true" aft ramp mechanical rigging verification section, which could confirm that the rigging of the aft ramp locking system had been done correctly, and if said manual provided adequate troubleshooting procedures, the Air Force mechanics would have been able to detect rigging errors, the Air Force mechanics would have properly rigged the aft ramp locking system of the subject aircraft and the "misrigging", which Lockheed alleges occurred to the aft ramp locking system, would not have occurred, the aft ramp locking system would not have failed, and the accident would have been avoided.

(f1) If the corresponding sections relating to the forward ramp had not been similarly defective and if the manual had not contained "specific example defects" s and n, the Air Force mechanics would not have learned to be distrustfull of the maintenance manual, and the Air Force mechanics would not have been required to depend solely on their unguided judgment when performing maintenance tasks on the aft ramp locking system. These defects caused and/or contributed to the "misrigging", which Lockheed alleges occurred to the aft ramp locking system, to the failure of the aft ramp locking system, and consequently to the accident.

(2) See 63(b)(1).

(3) If the hydraulic lines and control cables had been properly routed in the torque deck area and had been appropriately protected, the hydraulic lines and control cables would not have been severed on impact of the aft pressure door upon the bottom structure of the torque deck area, control of the aircraft would not have been lost, and the crash would have been avoided.

(4) See 63(b)(3).

(5) See 63(b)(3).

(6) If there had been adequate redundancy of flight controls in the aft portion of the aircraft and in the torque deck area, control of the aircraft would not have been lost and the crash would have been avoided.

(7) See 63(b)(6).

(8) If there had been alternate means to control the aircraft in the event of damage to the hydraulic lines and control cables located in the torque deck area, control of the aircraft would not have been lost and the crash would have been avoided.

(9) See 63(b)(6) and 63(b)(8).

(10) If there had been a verification procedure and/or means by which the Air Force mechanics could have confirmed that the rigging of the aft ramp locking system had been done correctly, the Air Force mechanics would have been able to detect rigging errors, the Air Force mechanics would have properly rigged the aft ramp locking system of the subject aircraft and the "misrigging", which Lockheed alleges occurred to the aft ramp locking system, would not have occurred, the aft ramp locking system would not have failed, and the accident would have been avoided.

(11) If the design of the aft ramp locking system had not been defective, if such design had been safe, reliable, maintainable, less complex and in accordance with the state of the art and/or recognized design criteria and if the system had been designed so that it could be rigged correctly, the aft ramp locking system would not have failed and the accident would have been

avoided; moreover, the "misrigging", which Lockheed alleges occurred to the aft ramp locking system, would not have occurred, the aft ramp locking system would not have failed and the accident would have been avoided.

(a)(1[1]) If the design had incorporated rigging pins or other similar devices, the Air Force mechanics would have had a simple and visual means to verify that the locks were in the correct nominal overcenter position, the Air Force mechanics would have used the rigging pins to check the rigging upon installation of the tierods, they would have quickly seen that the lock(s) were not in the correct position, such mechanics would have properly rigged the aft ramp locking system of the subject aircraft and the "misrigging", which Lockheed alleges occurred to the aft ramp locking system, would not have occurred, the aft ramp locking system would not have failed, and the accident would have been avoided.

(a)(2[1]) Moreover, if the design had incorporated rigging pins or other similar devices, the Air Force mechanics would only have had to rig the effected locks, they would have been able to concentrate on the effected locks, errors would not have been induced as to the other locks, and the procedures would have been greatly simplified with the corresponding reduction in potential for errors. For the reasons stated herein, the failure to so incorporate rigging pins into the aft ramp locking system caused and/or contributed to the "misrigging", which Lockheed alleges occurred to the aft ramp locking system, to the failure of the aft ramp locking system, and consequently to the accident.

(b) If the design had incorporated locking pins or other similar devices, the locks would have been physically secured in the correct position during flight, the failure and/or out-or-rig condition of one lock(s) would not have adversely effected other locks since such other locks would have been independently physically secured in the correct position, the impact of a failed and/or out-or-rig lock(s) would have been isolated, given the elimination of other design defects in the system the aft ramp locking system would not have failed, and the accident would have been avoided.

(c) If the design had not been so complex, it would have been understood by the Air Force mechanics, it would not have produced out-of-rig conditions, it would have been able to withstand multiple out-of-rig conditions, a failure and/or out-of-rig condition of one lock(s) would not have resulted in the failure and/or out-of-rig condition of other locks, the Air Force mechanics would have installed the tierods correctly and rigging errors would not have occurred during the installation, given the elimination of other design defects in the system the aft ramp locking system would not have failed and the accident would have been avoided; moreover, the Air Force mechanics would have properly rigged the aft ramp locking system of the subject aircraft and the "misrigging", which Lockheed alleges occurred to the aft ramp locking system, would not have occurred, the aft ramp locking system would not have failed, and the accident would have been avoided.

(d) If the aft ramp locking system had been designed to withstand multiple out-of-rig conditions or failures, multiple lock failures and/or out-of-rig conditions of aft ramp locks would not have caused the failure of the aft ramp locking system, and given the elimination of other design defects in the aft ramp locking system, the accident would have been avoided.

(e) If the mechanical and electrical indicators had been properly designed, the Air Force mechanics would have been assisted in verifying the positioning of the bellcrank of each rigged lock, the Air Force mechanics would have been better able to detect incorrect positioning of said bellcranks, and they would not have been misled to believe that the bellcranks were positioned correctly. Said failure to properly design the mechanical and electrical indicators caused and/or contributed to the "misrigging", which Lockheed alleges occurred to the aft ramp locking system, to the failure of the aft ramp locking system, and consequently to the accident.

(f) If the program link pins had been properly designed and utilized in the aft ramp locking system of the subject aircraft at the time of the accident, the Air Force mechanics would have had a visual means of verifying portions of the rigging of the aft ramp locking system. The failure to so design and utilize program link pins caused and/or contributed to the "misrigging", which Lockheed alleges occurred to the aft ramp locking system, to the failure of the aft ramp locking system, and consequently to the accident.

(g) If the rigging tolerances of the system had been less critical and the rigging of the system could have withstood changes in temperature, unlevel ramps, and crosswinds, the Air Force mechanics would have been better able to satisfy the necessary rigging requirements. Said defects caused and/or contributed to the "misrigging", which Lockheed alleges occurred to the aft ramp locking system, to the failure of the aft ramp locking system, and consequently to the accident.

(h) If the tierods, the bellcranks, hooks, yokes, other lock components and the locks (as a unit) had been properly designed to withstand predictable loads and stresses encountered in properly rigged and/or out-of-rig conditions (multiple and single), the aft ramp locks and tierods would not have failed due to an inability to withstand predictable loads and stresses, given the elimination of other design defects in the system the aft ramp locking system would not have failed, and the accident would have been avoided.

(i)(1^1) If components of the aft ramp locks, such as the bellcranks, had not been improperly made out of a certain aluminum alloy, such components would have been better able to withstand the predictable loads and stresses encountered in properly rigged and/or out-of-rig conditions (multiple and single), and the potential of aft ramp locks for failure due to an inability to withstand predictable loads and stresses would have been greatly reduced. For the reasons stated herein, the making of said components out of said aluminum alloy caused and/or contributed to the failure of the aft ramp locking system and consequently to the accident.

(2^1) If components of the aft ramp locks, such as the bellcranks, had not been improperly made out of a certain aluminum alloy, such components would have been much less susceptible to stress corrosion and corrosion, and aft ramp locks would not have failed due to stress corrosion and/or corrosion. For the reasons stated herein, the making of said components out of said aluminum alloy caused and/or contributed to the failure of the aft ramp locking system and consequently to the accident.

(j) If adequate measures had been taken to protect components of the aft ramp locks from stress corrosion and corrosion, components of aft ramp locks would not have failed due to stress corrosion and/or corrosion. The failure to so protect components of the aft ramp locks from stress corrosion and corrosion caused and/or contributed to the failure of the aft ramp locking system and consequently to the accident.

(k)(1^1) If the bellcranks and other components of the aft ramp locks had not contained discontinuities, such components would have been better able to withstand the predictable loads and stresses encountered in properly rigged and/or out-of-rig conditions (multiple and single), and the potential of aft ramp locks for failure due to an inability to withstand predictable loads and stresses would have been greatly reduced. For the reasons stated herein, such discontinuities caused and/or contributed to the failure of the aft ramp locking system and consequently to the accident.

(2^{1}) If the bellcranks and other components of the aft ramp locks had not contained discontinuities, such components would have been much less susceptible to stress corrosion and corrosion, and the potential of aft ramp locks for failure due to stress corrosion and/or corrosion would have been greatly reduced. For the reasons stated herein, such discontinuities caused and/or contributed to the failure of the aft ramp locking system and consequently to the accident.

(l) See 63(b)(11)(a)(2^{1}).

(m) To the extent Lockheed's allegation concerning the failure to replace cotter keys for tierods 2 and/or 3 on the right side is correct, the failure to provide more adequate means of securing the tierods once installed made the failure of tierods 2 and/or 3 on the right side much more likely.

(n) See 63(b)(11)(a)(1^{1}).

(o) See 63(b)(11)(a)(2^{1}).

(p) See 63(b)(11)(b).

(q) If the system had been designed so that component failure(s) and/or out-of-rig condition(s) in one lock would not have caused failure(s) and/or out-of-rig condition(s) in other locks the impact of a failed and/or out-of-rig lock(s) would have been isolated, given the elimination of other design defects in the system the aft ramp locking system would not have failed, and the accident would have been avoided.

(r) See 63(b)(10)-63(b)(12); 63(b)(14)-63(b)(17); 63(b)(22)-63(b)(25); 63(b)(29); 63(b)(37)-63(b)(46); 63(b)(65); 63(b)(11)(d). Failure to use multi-fault design criteria caused and/or contributed to the defects existing in the aft ramp locking system. If such multi-fault design criteria had been utilized and corresponding revisions in the aft ramp locking system design had occurred, the aft ramp locking system would not have failed, and the accident would have been avoided.

(s) If the tierods, the bellcranks, hooks, yokes, other lock components and the locks (as a unit) had been properly designed to withstand predictable fatique loads encountered in properly rigged <u>and/or</u> out-or-rig conditions (multiple or single), the aft ramp locks and tierods would not have failed due to an unability to withstand predictable fatigue loads, given the elimination of other design defects in the system the aft ramp locking system would not have failed, and the accident would have been avoided.

(12) See 63(b)(11).

(13) If the cargo compartment had been properly designed to carry passengers, even under emergency conditions, and if defects a-e had been remedied, the potential for death and injury of the persons located in the cargo compartment and in the upper level would have been greatly reduced in said accident.

(14) See 63(b)(3)-63(b)(12); 63(b)(15)-63(b)(17); 63(b)(22)-63(b)(25); 63(b)(29); 63(b)(37)-63(b)(46); 63(b)(65).

(a^1) Failure to consider multi-fault conditions in the FMEA caused and/or contributed to the defects existing in the aft ramp locking system. If such multi-fault conditions had been considered in the FMEA and corresponding revisions in the aft ramp locking system design and location of the hydraulic lines and control cables had occurred, the aft ramp locking system would not have failed and the accident would have been avoided; moreover, the control of the aircraft would not have been lost and the crash would have been avoided.

(b^1) The failure to adequately consider all single fault modes in the FMEA caused and/or contributed to the defects existing in the aft ramp locking system and to the consequences of such defects delineated in the above references.

(c^1) If the FMEA had been properly conducted and/or revised, including the consideration of multi-fault conditions and out-of-rig conditions, and the design of the aft ramp locking system and the location of the hydraulic lines and control cables in the torque deck area had been consistent with such proper FMEA, the aft ramp locking system would not have failed and the accident would have been avoided; moreover, the control of the aircraft would not have been lost and the crash would have been avoided.

(15) See 63(b)(11)(h, i, k, and s); 63(b)(29).

The failure to conduct adequate static and fatigue testing of the aft cargo door complex, the aft ramp locking system and the components of the aft ramp locking system caused and/or contributed to the failure of the aft ramp locking system and consequently the accident.

(16) If there had been consideration of the potential impact of an explosive decompression on the aft ramp locking system, the aft pressure door, the aft ramp, the torque deck area, and the hydraulic lines and control cables located in the torque deck area, and if there had been a modification of the design of the

aft ramp locking system, the aft pressure door, the aft ramp, the torque deck area, and the hydraulic lines and control cables located in the torque deck area, so as to minimize the impact of such an explosive decompression, the defects in said systems and parts of systems would have been avoided. The failure to so consider explosive decompression caused and/or contributed to the failure of the aft ramp locking system and consequently to the accident; moreover, said failure caused and/or contributed to the loss of control of the aircraft and consequently the crash.

(17) See 63(b)(16).

(18) See 63(b)(3) - 63(b)(17); 63(b)(21)-63(b)(67).

If the safety engineering analysis had been properly conducted, the defects identified in 63(a) would have been highlighted, and if the design had been correspondingly revised consistent with such proper safety engineering analysis, for the reasons indicated in the above references, the aft ramp locking system would not have failed and the accident would have been avoided; moreover, the control of the aircraft would not have been lost and the crash would have been avoided.

(19) See 63(b)(18).

(20) See 63(b)(18).

(21) See 63(b)(1).

(22) See 63(b)(1) - 63(b)(12); 63(b)(14)-63(b)(17); 63(b)(23)-63(b)(25); 63(b)(28)-63(b)(29); 63(b)(34)-63(b)(46); 63(b)(65).

The failure to redesign the aft ramp locking system, the aft pressure door, the aft ramp, the torque deck area, to relocate the hydraulic lines and control cables in the torque deck area, and to make needed changes in maintenance manual T.O. 1C-5A-2-12 in light of the pre-accident failures caused and/or contributed to the failure of the aft ramp locking system, the aft cargo door complex and consequently the accident. The failure to reexamine and revise the FMEA as such pertained to the aft ramp locking system, the aft pressure door, the aft ramp, the torque deck area, and the hydraulic lines and control cables located in the torque deck area in light of the pre-accident failures caused and/or contributed to the failure of the aft ramp locking system, and consequently the accident.

(23) If the aft ramp locking system had been designed so as to reduce the number and complexity of the maintenance tasks to a minimum, the Air Force mechanics would have been better able to install the tierods correctly

and rig the aft ramp locking system without error. Said defects in the design of the aft ramp locking system caused and/or contributed to the "misrigging", which Lockheed alleges occurred to the aft ramp locking system, to the failure of the aft ramp locking system, and consequently to the accident.

(24) See 63(b)(11)(a); 63(b)(23).

(25) See 63(b)(11).

If Lockheed had not engaged in the acts and/or omissions set forth in 63(a)(25), the aft cargo door complex would not have failed and the accident would have been avoided.

(26) See 63(b)(11); 63(b)(22); 63(b)(25); 63(b)(28).

The failure to adequately and properly consider proposed corrections to the design of the aft ramp locking system prior to the accident caused and/or contributed to the "misrigging" which Lockheed alleges occurred to the aft ramp locking system, to the failure of the aft ramp locking system and consequently to the accident.

(27) If Lockheed had properly documented and supported their proposals for correction, the defects in the design of the aft ramp locking system might have been reduced.

(28) See 63(b)(1)-63(b)(12); 63(b)(14)-63(b)(25); 63(b)(29); 63(b)(34)-63(b)(46); 63(b)(65).

(29) See 63(b)(11)(h, i, k, m).

(30) See 63(b)(1) - 63(b)(29); 63(b)(31)-63(b)(67).

Permitting weight and cost considerations to outweigh engineering and safety necessity in the design of the aft ramp locking system caused and/or contributed to the "misrigging" which Lockheed alleges occurred to the aft ramp locking system, to the failure of the aft ramp locking system, and consequently to the accident.

(31) See 63(b)(1) - 63(b)(30); 63(b)(32)-63(b)(67).

The failure to properly manage the design, manufacture and testing of the aft ramp locking system, the aft pressure door, the aft ramp, the torque deck area, and the hydraulic lines and control cables located in the torque deck area caused and/or contributed to the "misrigging" which Lockheed alleges occurred to the aft ramp locking system, to the failure of the aft ramp locking system, and consequently to the accident.

(32) The failure to use proper quality control in the manufacture of the components of the aft ramp locking system, caused and/or contributed to the failure of the aft ramp locking system and consequently to the accident.

(33) The failure to properly fabricate the components of the aft ramp locking system caused and/or contributed to the failure of the aft ramp locking system and consequently to the accident.

(34) See 63(b)(1)-63(b)(2); 63(b)(10); 63(b)(11); 63(b)(23); 63(b)(25); 63(b)(28); 63(b)(38)-63(b)(46).

The failure to design the aft ramp locking system to accommodate the practice of cannibilization caused and/or contributed to the "misrigging" which Lockheed alleges occurred to the aft ramp locking system, to the failure of the aft ramp locking system, and consequently to the accident.

(35) See 63(b)(3) - 63(b)(9).

If by design the bottom structure of the torque deck area had sufficient strength to withstand in-flight openings of the aft cargo door complex and/or impact of the aft pressure door or aft ramp, the hydraulic lines and control cables located in the torque deck area would not have been severed, the control of the aircraft would not have been lost and the crash would have been avoided.

(36) See 63(b)(3) - 63(b)(9); 63(b)(35).

(37) See 63(b)(1)-63(b)(2); 63(b)(10) - 63(b)(12); 63(b)(23)-63(b)(25); 63(b)(28)-63(b)(29); 63(b)(34); 63(b)(38)-63(b)(46); 63(b)(65).

(38) See 63(b)(11); 63(b)(14); 63(b)(25); 63(b)(39)-63(b)(46).

The failure to design the aft ramp locking system to prevent said inadvertent in-flight openings of the aft cargo door complex caused and/or contributed to the "misrigging" which Lockheed alleges occurred to the aft ramp locking system, to the failure of the aft ramp locking system, and consequently to the accident.

(39) If by design the aircraft could not have been pressurized if the afr cargo door complex was not fully and properly locked, the accident would have been avoided.

(40) If the electrical warning system to the pilots and other crewmembers in the cockpit and elsewhere had been properly designed to warn the pilots and other crewmembers that the aft cargo door complex was not fully and properly closed and locked, the accident would have been avoided.

(41) See 63(b)(10) - 63(b)(12); 63(b)(14); 63(b)(18) - 63(b)(20); 63(b)(23) - 63(b)(25); 63(b)(28); 63(b)(34); 63(b)(38) - 63(b)(46); 63(b)(65).

The failure to design an aft ramp locking system which could not be intentionally or inadvertently misrigged caused and/or contributed to the "misrigging" which Lockheed alleges occurred to the aft ramp locking system, to the failure of the aft ramp locking system, and consequently to the accident.

(42) See 63(b)(11).

Designing the aft ramp locking system in a manner so that in normal operational use frequent malfunctions rendered such locking system unreliable and unsafe, caused and/or contributed to the misrigging which Lockheed alleges occurred to the aft ramp locking system, to the failure of the aft ramp locking system, and consequently to the accident.

(43) See 63(b)(11).

Designing the aft ramp locking system in a manner that normal operational use required frequent adjustments to the rigging of such system caused and/or contributed to the "misrigging" which Lockheed alleges occurred to the aft ramp locking system, to the failure of the aft ramp locking system, and consequently to the accident.

(44) The failure to design the aft ramp locking system so that minor errors in the rigging of the system could not create an inherently dangerous and unsafe condition caused and/or contributed to the "misrigging" which Lockheed alleges occurred to the aft ramp locking system, to the failure of the aft ramp locking system, and consequently the accident.

(45) See 63(b)(11); 63(b)(38)-63(b)(44); 63(b)(46); 63(b)(65).

Designing the aft ramp locking system so that it could not be safely operated and maintained by Air Force mechanics caused and/or contributed to the "misrigging" which Lockheed alleges occurred to the aft ramp locking system, to the failure of the aft ramp locking system, and consequently to the accident.

(46) See 63(b)(1)-63(b)(12); 63(b)(14); 63(b)(23)-63(b)(25); 63(b)(28)-63(b)(29); 63(b)(34)-63(b)(46); 63(b)(65).

The failure to eliminate said catastrophic failure modes caused and/or contributed to the "misrigging" which Lockheed alleges occurred to the aft ramp locking system, to the failure of the aft ramp locking system, and consequently to the accident.

(47) Cognizant of the design defects referred to in 63(a)(47), Lockheed's failure to warn the Air Force of the inherently dangerous characteristics of such defects prevented the Air Force and its maintenance crews from appreciating the extent of the hazard posed by such defects and from exercising the corresponding extraordinary care and concern in maintaining the aft ramp

locking system which, but for a warning, would not have been recognized as constituting an inherently dangerous system. The failure to so warn caused and/or contributed to the "misrigging" which Lockheed alleges occurred to the aft ramp locking system, to the failure of the aft ramp locking system, and consequently to the accident.

(48) Cognizant of the design defects referred to in 63(a)(48), Lockheed's failure to warn the Air Force of the inherently dangerous characteristics of such defects prevented the Air Force and its maintenance crews from appreciating the extent of the hazard posed by such defects and from exercising the corresponding extraordinary care and concern in maintaining the aft ramp locking system which, but for a warning, would not have been recognized as constituting an inherently dangerous system. The failure to so warn caused and/or contributed to the "misrigging" which Lockheed alleges occurred to the aft ramp locking system, to the failure of the aft ramp locking system, and consequently to the accident.

(49) See 63(b)(11)(e).

Cognizant of the design defects in the mechanical and electrical indicators referred to in 63(a)(49), Lockheed's failure to warn the Air Force of the inherently dangerous characteristics of such defects prevented the Air Force and its maintenance crews from appreciating the extent of the hazard posed by such defects and from exercising the corresponding extraordinary care and concern in use of the mechanical and electrical indicators which, but for a warning, would not have been recognized as endangering the safe operation of the aircraft. The failure to so warn caused and/or contributed to the "misrigging" which Lockheed alleges occurred to the aft ramp locking system, to the failure of the aft ramp locking system, and consequently to the accident.

(50) See 63(b)(44).

Cognizant of the fact that minor errors in the rigging of the aft ramp locking system could create an inherently dangerous condition, Lockheed's failure to so warn the Air Force of such an inherently dangerous defect in the aft ramp locking system prevented the Air Force and its maintenance crews from appreciating the extent of the hazard posed by such defect and from exercising the corresponding extraordinary care and concern in rigging the aft ramp locking system which, but for a warning, would not have been recognized as constituting an inherently dangerous system. The failure to so warn caused and/or contributed to the "misrigging" which Lockheed alleges occurred to the aft ramp locking system, to the failure of the aft ramp locking system, and consequently to the accident.

(51) See 63(b)(1); 63(b)(10).

Cognizant that the rigging verification procedure provided in Section 3-173 of maintenance manual T.O. 1C-5A-2-12 was not in fact a rigging verification procedure and did not in fact confirm that the rigging of the aft ramp locking system was correctly done, Lockheed's failure to warn the Air Force of this inherently dangerous defect prevented the Air Force and its maintenance crews from appreciating the extent of the hazard posed by such defect and from exercising the corresponding extraordinary care and concern in the use of Section 3-173, which, but for a warning, would not have been recognized as endangering the safe operation of the aircraft. The failure to so warn caused and/or contributed to the "misrigging" which Lockheed alleges occurred to the aft ramp locking system, to the failure of the aft ramp locking system, and consequently to the accident.

(52) Cognizant of the design defects referred to in 63(a)(52), Lockheed's failure to warn the Air Force of the inherently dangerous characteristics of such defects prevented the Air Force and its maintenance crews from appreciating the extent of the hazard posed by such defects and from exercising the corresponding extraordinary care and concern in maintaining the aft ramp locking system which, but for a warning, would not have been recognized as constituting an inherently dangerous system. The failure to so warn caused and/or contributed to the "misrigging" which Lockheed alleges occurred to the aft ramp locking system, to the failure of the aft ramp locking system, and consequently to the accident.

(53) The failure to adequately train or instruct Air Force mechanics in the proper maintenance procedures required to guarantee a safe aft ramp locking system and to assure that the aft cargo door complex would be fully and properly locked under all circumstances prior to departure, caused and/or contributed to the "misrigging" which Lockheed alleges occurred to the aft ramp locking system, to the failure of the aft ramp locking system, and consequently the accident.

(54) See 63(b)(1)-63(b)(2); 63(b)(10)-63(b)(12); 63(b)(14)-63(b)(25); 63(b)(28)-63(b)(34); 63(b)(38)-63(b)(44); 63(b)(46); 63(b)(65).

The failure to so properly test and inspect the C5 caused and/or contributed to the "misrigging" which Lockheed alleges occurred to the aft ramp locking system, to the failure of the aft ramp locking system, and consequently to the accident.

(55) The failure to train and/or instruct the Air Force mechanics to recognize and prevent the hazards presented by the design defects referred to in 63(a)(55), caused and/or contributed to the "misrigging" which Lockheed alleges occurred to the aft ramp locking system, to the failure of the aft ramp locking system, and consequently to the accident.

(56) The failure of the "Product Support" personnel to properly assist the Air Force mechanics in maintaining the aft cargo door complex including the proper rigging of the aft ramp locking system, caused and/or contributed to the "misrigging" which Lockheed alleges occurred to the aft ramp locking system, to the failure of the aft ramp locking system, and consequently to the accident.

(57) See 63(b)(1)-63(b)(18); 63(b)(22)-63(b)(25); 63(b)(28)-63(b)(29); 63(b)(34)-63(b)(46).

(58) See 63(b)(1)-63(b)(18); 63(b)(22)-63(b)(25); 63(b)(28)-63(b)(29); 63(b)(34)-63(b)(46).

(59) See 63(b)(1)-63(b)(18); 63(b)(22)-63(b)(25); 63(b)(28)-63(b)(29); 63(b)(34)-63(b)(46).

(60) See 63(b)(1)-63(b)(18); 63(b)(22)-63(b)(25); 63(b)(28)-63(b)(29); 63(b)(34)-63(b)(46).

(61) See 63(b)(1)-63(b)(2); 63(b)(10); 63(b)(21).

(62) See 63(b)(1)-63(b)(56).

(63) See 63(b)(1)-63(b)(2); 63(b)(10); 63(b)(21).

(64) See 63(b)(1)-63(b)(56).

(65) See 63(b)(1)-63(b)(64).

(66) See 63(b)(1)-63(b)(65).

<u>INTERROGATORY NO. 63(c):</u> State the exact date and time involved and the place or position where each of the alleged acts or omissions referred to in 63(a) above occurred as to said defendant.

<u>ANSWER 63(c):</u> The acts and/or omissions set forth in 63(a), and their consequences, occurred during the time between the earliest design stages of the C-5A beginning around 1964 and the time of the accident on April 4, 1975 (and continued thereafter). Each of the acts and omissions occurred in Georgia. Such acts and/or omissions also occurred in several other jurisdictions, including without limitation, the District of Columbia, California, Ohio, Delaware, Oklahoma, South Carolina, Illinois and Texas.

INTERROGATORY NO. 64(a): Set forth the basis for said plaintiff's allegation that defendant Lockheed Aircraft Corporation gave said plaintiff's decedent an implied warranty that the aforesaid aircraft, together with its component parts, was of merchantable quality and reasonably fit for the purposes for which it was intended, designed, and manufactured, assembled, sold, overhauled, and used, and that said aircraft andits component parts were free of all defects. If plaintiff claims that any statutes, rules, regulations, or ordinances impose responsibility upon said defendant Lockheed Aircraft Corporation for such an implied warranty, set forth the text thereof.

ANSWER 64(a): Lockheed gave plaintiffs' decedent an implied warranty that the aircraft, together with its component parts, was of merchantable quality and reasonably fit for the purposes for which it was intended, designed and manufactured, assembled, sold, overhauled and used, and that the aircraft and its component parts were free of all defects. Lockheed breached said implied warranty. The bases upon which plaintiffs contend that Lockheed gave said implied warranty are as follows:

1. Sections 2-314 and 2-315 of the Uniform Commercial Code as adopted in the District of Columbia and Georgia.

2. The common law of the District of Columbia and Georgia under which a manufacturer of an inherently dangerous product such as an airplane, who owes an extremely high duty of care to passengers using the airplane, impliedly warrants that it is reasonably fit to fly and free of all defects.

3. The terms of the C5 contract signed by Lockheed, as amended from time to time, which impliedly warrant that the aircraft is safe, airworthy and fit for its intended use, including the carrying of passengers.

4. Representations made by Lockheed to the Air Force pre-contract (including the terms of the bid proposal), at the time of the contract and amendments thereto and subsequent to the contract (including the delivery of the aircraft) which impliedly warrant that the aircraft is safe, airworthy and fit for its intended use, including the carrying of passengers.

5. Air Force regulations impliedly requiring that aircraft purchased from manufacturers be safe, airworthy and fit for its intended use. The specific regulations are yet to be determined.

6. Other bases.

INTERROGATORY NO. 64(b): State the specific manner and way in which the warranty referred to in 64(a) was allegedly breached and how such breach caused or contributed to the accident involving said aircraft as alleged in paragraph . of the complaint.

<u>ANSWER 64(b):</u> See answers to 63(a) and 63(b) which are incorporated herein by reference.

<u>INTERROGATORY NO. 64(c):</u> State the exact date and time involved and the place or position where the alleged breach of implied warranty referred to in 64(a) above occurred as to said defendant.

<u>ANSWER 64(c):</u> See answers to 63(c) which are incorporated herein by reference.

<u>INTERROGATORY 65(a):</u> Set forth the basis for said plaintiff's allegation that defendant Lockheed Aircraft Corporation gave said plaintiff's decedent an express warranty that the aforesaid aircraft, together with its component parts, was of merchantable quality and reasonably fit for the purposes for which it was intended, designed, and manufactured, assembled, sold, overhauled, and used, and that said aircraft and its component parts were free of all defects. If plaintiff claims that any statutes, rules, regulations or ordinances impose responsibility upon said defendant Lockheed Aircraft Corporation for such an express warranty, set forth the text thereof.

<u>ANSWER 65(a):</u> Lockheed gave plaintiffs' decedent an express warranty that the aircraft, together with its component parts, was of merchantable quality and reasonably fit for the purposes for which it was intended, designed and manufactured, assembled, sold, overhauled and used, and that the aircraft and its component parts were free of all defects. Lockheed breached said express warranty. The bases upon which plaintiffs contend that Lockheed gave said express warranty are as follows:

1. Section 2-313 of the Uniform Commercial Code, as adopted in the District of Columbia and Georgia.

2. The terms of the bid proposal submitted by Lockheed in connection with the C5.

3. The terms of the C5 contract signed by Lockheed, as amended from time to time.

4. Air Force regulations requiring that aircraft purchased from manufacturers be safe, airworthy and fit for its intended use. The specific regulations are yet to be determined.

5. Other bases.

INTERROG/ RY NO. 65(b): State t specific manner and way in which the warranty referred to in 65(a) was allegedly breached and how such breach caused or contributed to the accident involving said aircraft as alleged in paragraph of the complaint.

ANSWER 65(b): See answers to 63(a) and 63(b) which are incorporated herein by reference.

INTERROGATORY 65(c): State the exact date and time involved and the place or position where the alleged breach of express warranty referred to in 65(a) above occurred as to said defendant.

ANSWER 65(c): See answers to 63(c) which are incorporated herein by reference.

INTERROGATORY NO. 66: Set forth each and every specific defect in the aforesaid aircraft upon which plaintiff will rely in connection with the allegations of strict liability set forth in paragraph of the complaint.

ANSWER 66: See answers to 63(a) which are incorporated herein by reference.

INTERROGATORY NO. 79: State the full name and last known address of every witness known to you or to your attorneys who has any knowledge regarding the facts and circumstances surrounding the happening of the accident referred to in the complaint including but not limited to eyewitnesses to such accident, medical witnesses and other experts having knowledge thereof.

ANSWER 79: The only such witnesses of which plaintiff is aware are those identified in Air Force reports of investigations into the accident. The portions of the reports produced for plaintiffs have also been produced for defendants, and are equally available to both parties. It is therefore unnecessary to set forth all the names and addresses contained in those reports.

Burke C. Pray

BURKE C. PRAY, Co-Administrator of the Estate of JO-AN K. PRAY, Deceased

STATE OF New Jersey)
) to-wit:
COUNTY OF Burlington)

LAW OFFICES
LEWIS, WILSON,
EWIS & JONES, LTD.
ARLINGTON, VA. 22216

I, Irene A. Churchill, a Notary Public in and for the State and County aforesaid, do hereby state that the above Burke C. Pray did appear before me this 10th day of July, 1979, and after being first duly sworn, did depose and state that the above Plaintiffs' Supplemental Answers to Interrogatories are true and correct to the best of his knowledge, information and belief.

DUPLICATE

LOCKHEED-GEORGIA COMPANY
A DIVISION OF LOCKHEED AIRCRAFT CORPORATION
MARIETTA, GEORGIA 30063

In reply refer to:

15 July 1975

LGD/610862

SUBJECT: Contract F41608-75-D-A016, Request No. 0006, Task 4, C-5A APEX Study Group, Failure Mode Analysis of Ramps, Visor and Aft Pressure Door, Submittal of Interim Report, Data Item DI-S-3601A

TO: San Antonio ALC/MME-5
Kelly AFB, TX 78241

THRU: AFPRO/EN
Lockheed-Georgia Company
Marietta, GA 30063

ENCL: (a) Ten (10) copies of Lockheed-Georgia Company Letter Report, dated 11 July 1975, Titled: Failure Mode Analysis of Ramps, Visor and Aft Pressure Door, Interim Report

(b) Ten (10) copies of Lockheed-Georgia Company Letter Report, dated 15 July 1975, Titled: Minor Improvements to the Present C-5A Forward and Aft Ramp Locking Systems, Partial Engineering Report

1. Request No. 0006, Task 4, authorized the Contractor to conduct a study of the ramps, visor and aft pressure door to investigate those areas where changes may be desirable to enhance the safety of the C-5A aircraft.

2. The enclosure (a) and (b) reports provide the Contractors interim findings as a result of the study. The final report, as required by the subject request, will be submitted by 20 August 1975.

3. In that this study relates to post-accident investigation of the Ship 0021 accident and since it coincides with a request made by our outside counsel in lawsuits filed in relation to that accident, we have provided a copy of the reports to such attorneys.

LOCKHEED-GEORGIA COMPANY

O. V. Braun
Contracts Department

OVB/HLF:jw

CC: San Antonio ALC/PPWAA

APPROVED FOR TRANSMITTAL James L. Beasley DATE 15 July 75
AFPRO/EN

Subject: Contract F41 5-75-D-A016, Request No. 0006, Task 4, C-5A APEX Study Group, Failure Mode Analysis of Ramps, Visor and Aft Pressure Door, Submittal of Interim Report, Data Item DI-S-3601A

DISTRIBUTION: (H. L. Fant, D/72-87, Ext. 3738)

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LGD Desk	82-02/24
~~W. H. Hoeing (w/encl)~~	~~72-87/73~~

DATED: 15 July 1975

LOCKHEED-GEORGIA COMPANY

A DIVISION OF LOCKHEED AIRCRAFT CORPORATION

MARIETTA GEORGIA

TITLE

MINOR IMPROVEMENTS TO THE PRESENT C-5A
FORWARD AND AFT RAMP LOCKING SYSTEMS

PARTIAL ENGINEERING REPORT

15 JULY 1975

CONTRACT F41608-75-D-A016
REQUEST NO. 0006
TASK 4

SUBMITTED UNDER

MODEL C-5A REFERENCE

PREPARED BY G. A. Dobson GROUP

CHECKED BY W. M. Perry APPROVED BY W. M. Perry
C-5 Fuselage Group Engineer

APPROVED BY
C. L. Wharton, Jr.
C-5 Structures Design Manager

APPROVED BY
D. O. Gunson
C-5 Design Manager

REVISION DATE	REVISED BY	APPROVED BY	PAGES AFFECTED	BRIEF DESCRIPTION OF CHANGES MADE

FOREWORD

This technical report furnished in connection with Order Number 6, Task 4, of Contract F41608-75-D-A016, C-5 Engineering Services, was prepared solely for the purpose of responding to such order, which was issued as a requirement under said Contract as a part of an Air Force program of examination of systems and procedures on the C-5A aircraft for the purpose of preventing accidents, which program is supplemental to the investigation conducted in accordance with AFR 127-4 of the accident of C-5A 68-218 which occurred on 4 April 1975 and was prepared in part by individuals participating in said accident investigation. It is understood that this report is a privileged document since it is being submitted as a supplement to such accident investigation and for the purpose of preventing accidents. This report shall not be disclosed outside of the Government and shall not be duplicated, used or disclosed in whole or in part for any purpose other than to evaluate the task. The data subject to this restriction is contained in all sheets.

This report contains partial results of a study which is presently in process. These results contain recommendations relative to restoring the aft complex of the C-5A aircraft for normal use.

The submittal of this report satisfies in part the requirements of Contract F41608-75-D-A016.

INTRODUCTION

On 1 July 1975, an informal meeting was held at the Lockheed-Georgia Company with San Antonio ALC personnel for the purpose of discussions relative to the status of APEX study tasks. During the course of discussions, San Antonio personnel requested Lockheed's position relative to actions required to restore the aft complex to normal use. Lockheed personnel stated that to date all studies and evaluations of the aft opening complex had revealed no technical reasons for any basic actions other than to restore the system to its original configuration, replace all worn or damaged parts, and rig the system to existing prescribed procedures utilizing trained depot level teams at the operating bases. It was further suggested that these trained depot personnel remain at the operating bases to perform periodic maintenance and rigging actions until such time as appropriately trained field personnel were made available to accomplish the task.

Lockheed personnel advised that during the incorporation of TCTO 1C-5A-1768, some maintenance difficulties were being encountered by the Field Teams. These were briefly discussed in general terms and San Antonio was advised that Lockheed was studying these difficulties and would recommend actions that could alleviate them at the time that the Task 2 ramp lock study report was submitted. This document contains the results of the analyses of these problems and the recommendations for San Antonio ALC considerations.

MINOR IMPROVEMENT REVISIONS TO THE PRESENT SYSTEM

During incorporation of TCTO 1C-5A-1768 information reported by the Field Team Engineers was analyzed in an effort to determine if any revisions were desirable to improve the function of the existing system and to alleviate the necessary maintenance actions. These items are discussed in the following paragraphs.

1. Lock Actuation Speed

   The first item reported by the Field Team Engineers was that the forward ramp lock system appeared to operate too fast which may be a contributing factor in the sheared or bent programing link pins and cracked bellcranks. Preliminary data on damaged parts, found during incorporation of TCTO 1C-5A-1768, indicates that approximately 45% more sheared programing link pins and 93% more cracked bellcranks were found on the forward system than on the aft system. The aft ramp system operates at approximately half the speed of the forward system, and so the forward ramp system was tested with a restrictor installed that gave it a speed that is similar to the aft ramp speed. Test results indicate that the slower speed gave a much smoother operation to the system and hence reduced the inertia and dynamic loads on the system. This change will increase the service life of the system and should be considered for incorporation.

2. Program Link Revision

A second problem reported was that occasionally a hook impacted the under side of the pin prior to engaging the pin as the bellcrank went over center. A study of the geometry and kinematics of the hook travel and pin engagement showed that by a small adjustment in the length of the flat program link the impact of the hook on the yoke pin could be minimized for locks 1 through 4 on the forward ramp and 2 through 6 on the aft ramp. Aft ramp lock No. 1 appears to be satisfactory as is. The programing link change does not appear to significantly improve engagement of the No. 7 Aft Ramp Lock. The No. 7 Aft Ramp Lock improvements are discussed in Item No. 8.

3. Programing Link Pins

Investigation of the shearing of the programing link pins showed that these pins could be shearing due to the dynamic forces resulting from the operating inertia of the locks. The pin which failed most frequently was the pin which attaches the links to the hook. The current pin size is 3/16 inch dia. and it is possible to increase the size of this pin to 1/4 inch without manufacturing new hooks. It should be noted that closely controlled conditions are required when redrilling the hooks due to the characteristics of the material from which the hooks are made.

4. Mechanical Lock Indicators

Most of the mechanical indicators, it is reported, are not color coded correctly. Those installed on the aircraft have been repainted since delivery and no longer give the correct color indication. These can be brought back to correct configuration by using colored tape and a heat shrinkable clear tubing. No design change is necessary and immediate action should be initiated to color code the indicators correctly.

5. Bellcrank Material Change

Failure of some bellcranks has been experienced. Inspections reveal that the bellcranks fail in the lug fillet area. Consideration has been given to changing the material from 7075-T6 aluminum to either PH17-4 or 15-8MO steel. The advantages of this change are:

a) Existing design will be approximately 2.5 times stronger.
b) The potential for stress corrosion is reduced.
c) Wear in mating parts is decreased.
d) Both PH17-4 and 15-8MO steels are stainless, hence corrosion problems are reduced.

6. Forward Ramp No. 1 Bellcrank Push Rod

Reports indicated the forward, No. 1, connecting rod on the forward ramp system is too short. The rod is such that an acceptable length of thread engagement can be obtained; however, the witness hole requirement cannot be satisfied. This rod should be lengthened approximately .25 inches.

7. No. 7 Aft Ramp Yoke Guide Chamfer

The yoke guide at all lock positions, except No. 7 aft ramp, have a chamfer on the lower side to preclude yoke interference when closing the aft ramp. This No. 7 yoke guide should be modified to add a chamfer similar to all other yoke guides. Several examples have been found in the fleet where the yoke has hooked under the guide. This chamfer will reduce this problem.

8. Aft Ramp No. 7 Hook

Several cases were reported of the aft ramp No. 7 lock hook impacting the lower side of the yoke pin. This general condition was discussed under Item 2 above where a programing link length change will improve all other lock positions. The No. 7 hook; however, is not significantly improved by this method and other possibilities were investigated. Investigations show two methods of rectifying this condition. They are:

a) A new hook can be designed to give a better throat to yoke pin engagement together with a program link change, or

b) A new concept for programing the hook movement into the engaged position. This new concept is envisaged to be a guide cam on each side of the hook in lieu of programing links. Initial investigations show this to be the most cost effective method.

9. Lock Actuating Rods

Damage to connecting rods is reported to be high. Consideration has been given to changing the material of the tube from aluminum to steel.

The advantages of this change are:

a) Less susceptible to damage.

b) Tensile strength increases approximately 1.5.

c) Column strength increases approximately 1.5.

The disadvantages are:

a) The system can interact higher loads due to the increase column and tensile loads and can thus influence adjacent locks to a greater degree.

b) The rods are currently the weakest link in the system and any interaction between locks is limited by the rods. This limit will be altered in an unfavorable direction by a change of material to steel and substantial analysis will be required to assure that no other adverse affects will be initiated.

RECOMMENDATIONS

It is recommended that of the previous nine items the following be considered for incorporation into the existing C-5A forward and aft ramp lock systems, in order to minimize the required maintenance actions.

1) Forward lock actuation speed reduction
2) Program link revisions
4) Mechanical lock indicator update
6) Forward ramp No. 1 bellcrank push rod length revision
7) The No. 7 aft ramp yoke guide chamfer
8) The No. 7 aft ramp lock programing concept by a cam rather than by programing links.

It is also recommended that Item 5, which proposes a change in the bellcrank material be incorporated as a spares only change in the near term, with consideration being given to replacing all bellcranks at the next scheduled PDM.

Item 3, which proposed to increase the programing link pin size from 3/16 to 1/4 inch dia. due to the pin shearing in service is not recommended for incorporation as this problem will be alleviated by incorporation of Items 1 & 2.

Item 9 is not recommended for incorporation as any increase in the stiffness of this rod system is considered to be detrimental for reasons stated previously.