

**LMSC-HREC TR D951498**

**SPARTAN RELEASE ENGAGEMENT  
MECHANISM (REM)  
STRESS AND FRACTURE ANALYSIS**

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by

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FOREWORD

This report presents a summary of the results of work performed by the Lockheed Missiles & Space Company, Inc., Huntsville Research & Engineering Center under Contract NAS8-35599 for the NASA-Marshall Space Flight Center, Huntsville, Alabama. The NASA-MSFC Contracting Officer's Representative for the study is N.C. Schlemmer, EP46.

## INTRODUCTION

This document contains the revised stress and fracture analysis of the Spartan REM hardware for current load conditions and mass properties. The Spartan REM structure is shown in Fig. 1. Figure 2 depicts a detail of the latching mechanism.

The stress analysis was performed using a NASTRAN math model of the Spartan REM adapter, base, and payload. Appendix A contains the material properties, loads, and stress analysis of the hardware. The computer output and model description are in Appendix B.

Factors of safety used in the stress analysis were 1.4 on tested items and 2.0 on all other items.

Fracture analysis of the items considered fracture critical was accomplished using the MSFC Crack Growth Analysis code. Loads and stresses were obtained from the stress analysis. The fracture analysis notes are located in Appendix A and the computer output in Appendix B.

All items analyzed met design and fracture criteria.

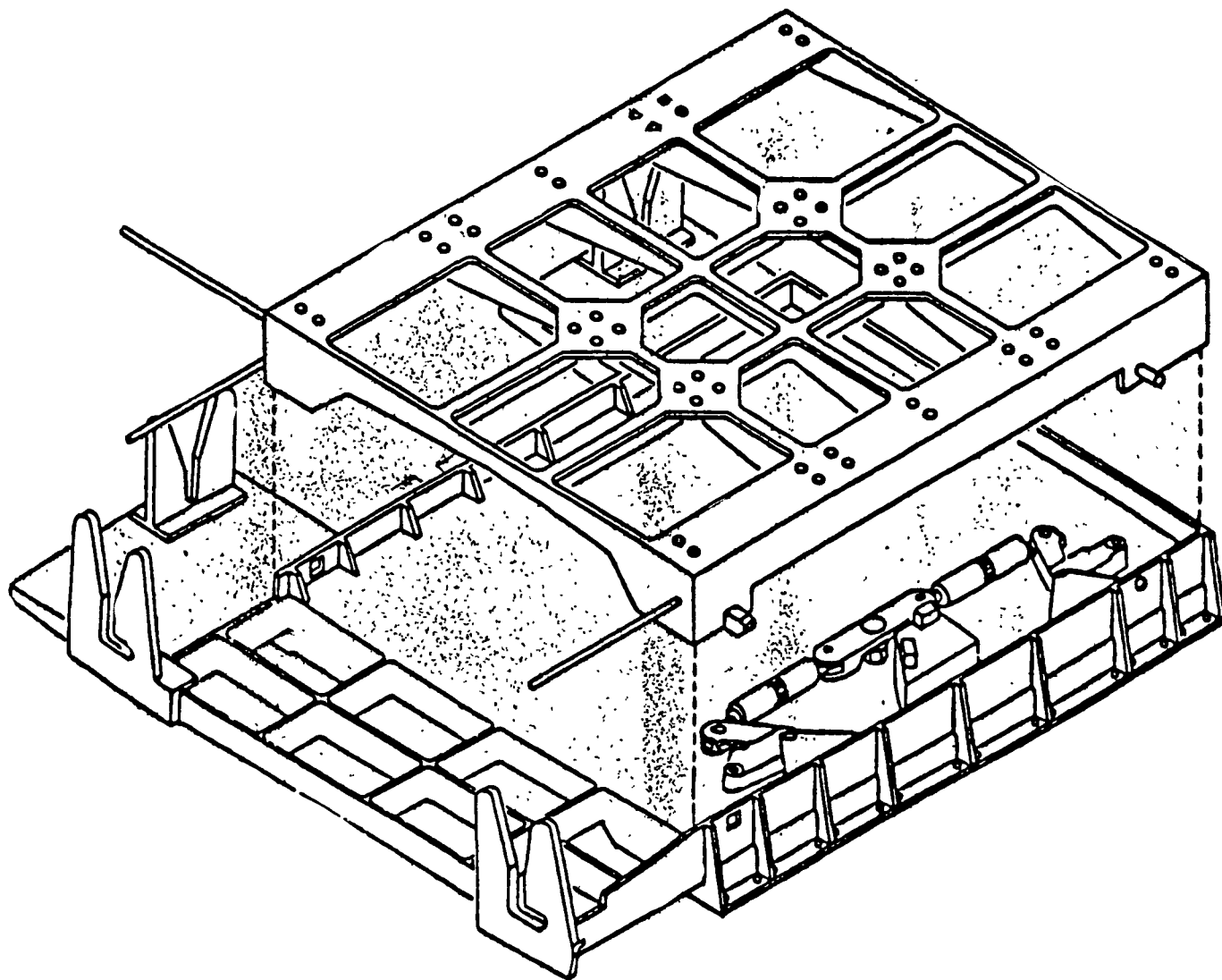


Fig. 1 Spartan REM

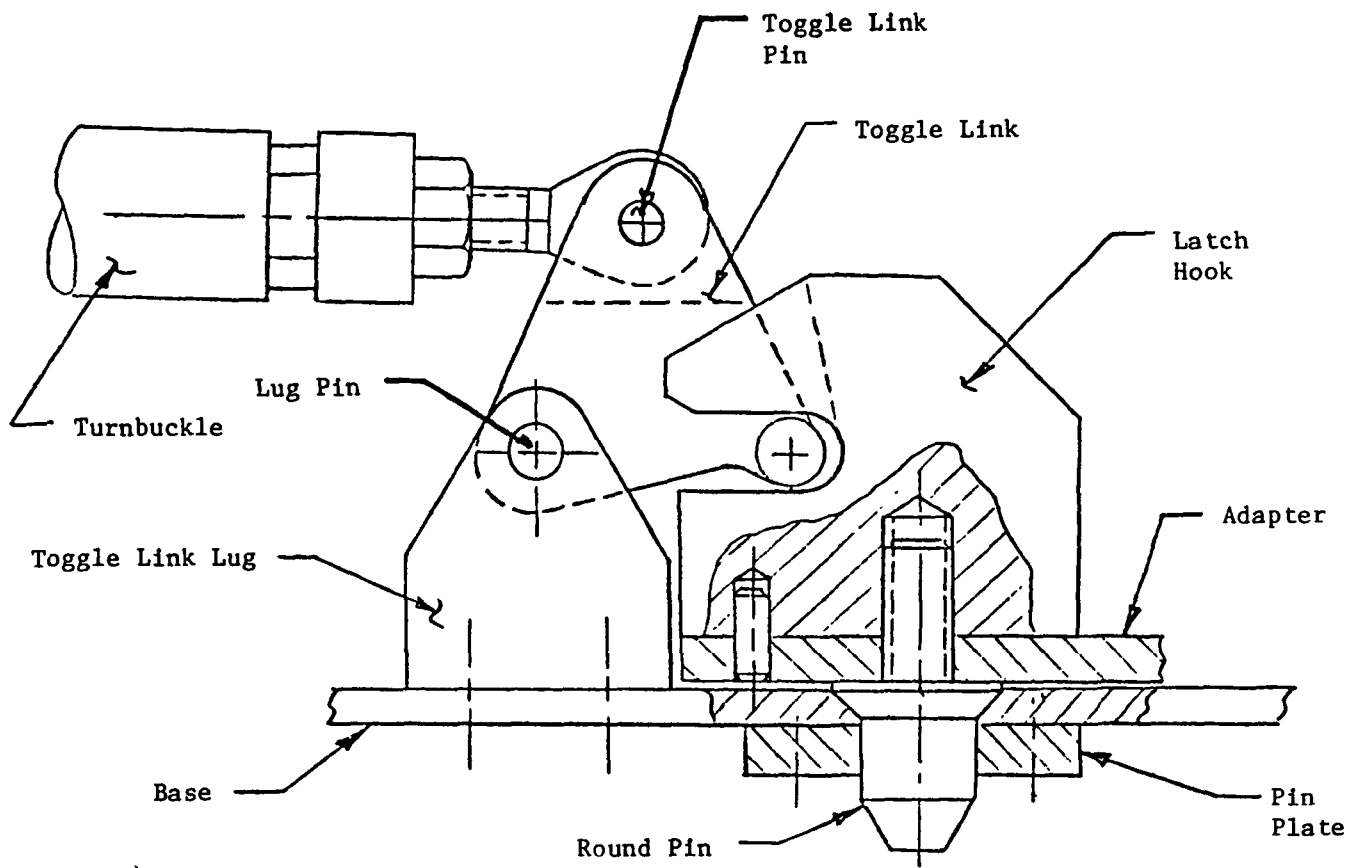


Fig. 2 Latching Mechanism

## SPARTAN REM MARGIN SUMMARY

Item	Load Case	M.S.	Page	Comment
Toggle Link (30A60695)	4.3/-2.0/7.1	3.21	4.12	Transverse Load on Lug (Turnbuckle Connection Shear on Latching Post Transverse Load on Lug (Support)
		1.95	4.14.1	
		5.9	4.15.1	
Toggle Link Lug (30A60694)	4.3/-2.0/7.1	2.51	4.4.0	Transverse Load on Lug
		0.38	4.5.1	
Mounting Bolt	4.3/-2.0/7.1	0.71	4.9.0	Bending Interaction
Lug Pin (30A60698)	4.3/-2.0/7.1	2.39	4.12	Shear Bending
		1.08	4.15.2	
Toggle Link Pin (30A60700)	4.3/-2.0/7.1	1.22	4.13	Shear Bending
		0.53	4.14.0	
Turnbuckle (30A60699)	4.3/-2.0/7.1	1.81	4.16	Bearing Tension on Threads
		2.15	4.17	
Bellcrank (30A60696)	Torque 1521 in.-lb	0.6	4.18	Shear on Spline Limit Torque on Shaft Torsion on Shaft Compressive Stress on Spline Lug Tension
		0.42	4.20	
		0.88	4.20	
		0.09	4.21	
		3.3	4.23	
Round Pin (30A60642)	4.3/-2.0/7.1	0.78	4.24	Shank Shear
Square Pin 30A60643	4.3/-2.0/7.1	0.78	4.24	Shank Shear
Round Pin Plate (30A60645)	4.3/-2.0/7.1	0.8	4.30	Shear Tear Out Shear Bearing Bolt Shear
		1.25	4.31	
		1.92	4.32	
		1.30	4.30	
Mounting Bolts NAS1960C	4.3/-2.0/7.1			
Square Pin Plate (30A60644)	4.3/-2.0/7.1	1.81	4.32	Shear Tear Out Bending
		0.37	4.33	

## SPARTAN REM MARGIN SUMMARY (Concluded)

Item	Load Case	M.S.	Page	Comment
Rod Holder Screws (30A60647) 30A60648	Max Rod Load 1560/lb	0.39	4.36	Interaction
	Double Strike	0.33	4.38	Shear
Base Mount- ing Bolts	4.3/-2.0/7.1	0.96	4.39	Interaction
Base/PDM Bolts Nuts	4.3/-2.0/7.1	0.63	4.40	Interaction
		0.60	4.40	Tension
Adapter	4.3/-2.0/7.1	2.15	4.45	Tension
Base	4.3/-2.0/7.1	1.29	4.45	Tension
Adapter/Pin Interface	4.3/-2.0/7.1	0.798	4.25	Shear Tear Out
Pin Bearing on Conical Start	4.3/-2.0/7.1	Large	4.27.1	
Hole to be Drilled in Adapter	4.3/-2.0/7.1	7.28	4.49	Tension
Locator Rod 30A60649	1560 lb	0.015	4.38.1	Plastic Bending

REM FRACTURE CONTROL SUMMARY

DRAWING NO.	DESCRIPTION	MATL	CLASSIFICATION		RATIONALE	PFC CAT		CRITICAL CRACK SIZE (IN)	INSPECTION	
			EXP	PFC		NFC	FC		LIMIT (IN)	TYPE
30A60641	ADAPTER	2219-T87AL		X	REDUNDANT LOAD PATH	X				DP
30A60681	BASE	2219-T87AL	X		REDUNDANT LOAD PATH					
30A60697	BELCRANK SHAFT	A286 CRES		X	LOW STRESSES	X		.415	.25	ET
30A60696	BELCRANK	4340 STL		X						IMP
30A60699	TURNBUCKLE	4340 STL		X	AFT ONLY 5% OF PRELOAD	X				
30A60695	TOGGLE LINK	4340 STL		X				.23	.05	ET
30A60700	TOGGLE LINK PIN	INCONEL 718		X				.104	.1	ET
30A60694	TOGGLE LINK LUG	INCONEL 718		X				.165	.05	ET
30A60698	LUG PIN	INCONEL 718		X				.146	.10	ET
30A60690	LATCH HOOK	INCONEL 718		X	LOW COMPRESSIVE LOAD	X				
30A60642	ROUND PIN	INCONEL 718		X				---	.1	ET
30A60645	ROUND PIN PLATE	INCONEL 718		X				1.065	.05	ET
30A60643	SQUARE PIN	INCONEL 718		X				---	.1	ET
30A60644	SQUARE PIN PLATE	INCONEL 718		X				.98	.05	ET
NA519600	MOUNTING BOLTS	A286 CRES	X		REDUNDANT LOAD PATH					
30A60702	LINK HOUSING	4340 STL		X	LOAD STRESSES	X				
30A60703	LINK ROD	4340 STL		X	↓					
30A60647	ROD HOLDER - 1 & 4	2219-T87AL		X	LOW STRESS	X		---	---	NONE
30A60648	ROD HOLDER - 2 & 3	2219-T87AL		X	LOW STRESS	X		---	---	NONE
30A60649	LOCATOR ROD	2219-T87AL		X	LOW STRESS	X				
30A60684	AFT GUIDE - 1	2219-T87AL	X		LOW COMPRESSIVE LOADS	X		.18	.10	ET
30A60685	AFT GUIDE - 2	2219-T87AL	X							
30A60686	POST GUIDE - 3	2219-T87AL	X							
30A60687	POST GUIDE - 4	2219-T87AL	X							
30A60701	GUIDE BAR	2219-T87AL	X		↓					
NA51955C	PLATE BOLTS	A286 CRES	X		REDUNDANT LOAD PATH					
NA51955C	GUIDE HOLDER BOLT	A286 CRES	X		LOW COMPRESSIVE LOADS	X				

\* NO CRACK GROWTH; ET - Eddy Current; MP - Magnetic Particle.



