



Test Operational Readiness Review



Combustion Wave Ignition System Spider Testing

FEBRUARY 9, 1998





AGENDA



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- INTRODUCTION
 - TEST APPROACH
 - TEST OBJECTIVES
 - PROGRAM PLAN/SCHEDULE
 - TESTING SUMMARY - X33 CWI SPIDER RIG
 - 7R SPIDER RIG VS. FLIGHT DESIGN COMPARISONS
 - TEST HARDWARE
 - TEST SCHEMATICS
 - CWI SPIDER 7R VS. DESIGN 9R HARDWARE COMPARISONS
 - INSTRUMENTATION
 - FLOWMETER/ORIFICE REQUIREMENTS





AGENDA

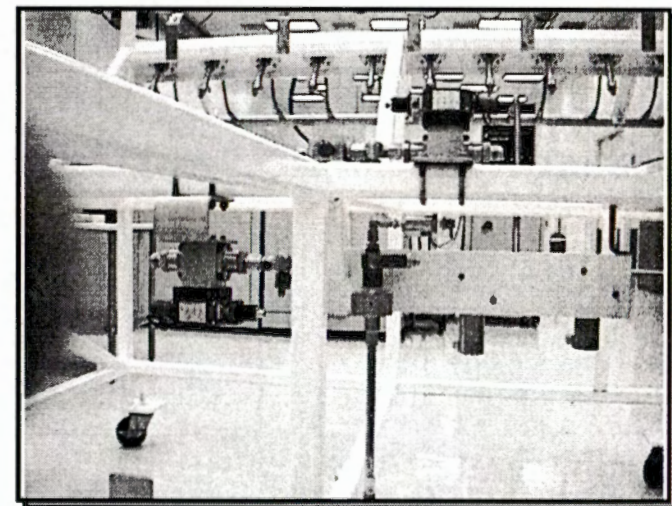
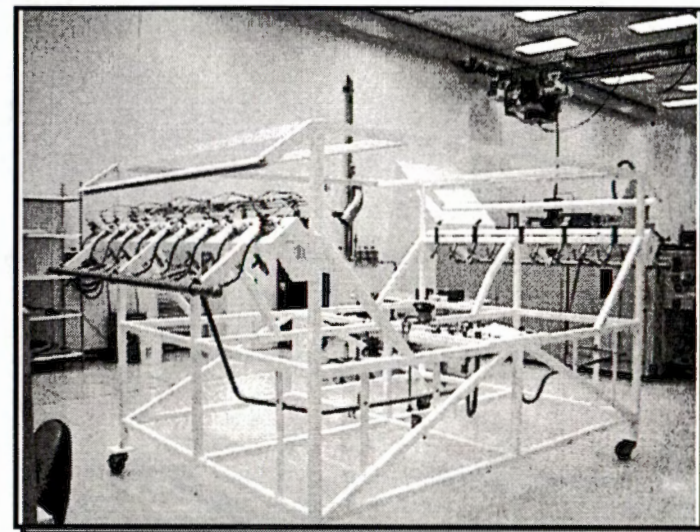


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- **FLUID REQUIREMENTS - Propellants/Purges/Jackets**
 - **MISSION TEST START CONDITIONS**
 - **TEST START/SHUTDOWN SEQUENCES**
 - **TEST MATRIX SUMMARY**
 - **TEST LOGIC**
 - **DATA REDUCTION SUMMARY**
 - **TEST REQUEST FORM**
 - **FMECA FAILURE ANALYSIS SUMMARY**



- **Test Approach:**

- 20 Triaxial Igniters (flight config.)
- Premix Chamber (flight config.)
- J-2 Spark Plug, Cable & Exciter (flight config.)
 - Two Spark Plugs Active
- Flight Type CWI Run Valves; S/O, Check, 3-way
- Flight CWI System Configuration
 - 19 Inert Chambers, 1 Active Injector
- Engine Flowrates and Pressures during Ign.
- Engine Start Cryogenic Temperature Propellants
 - Closely simulate Engine CWI system priming



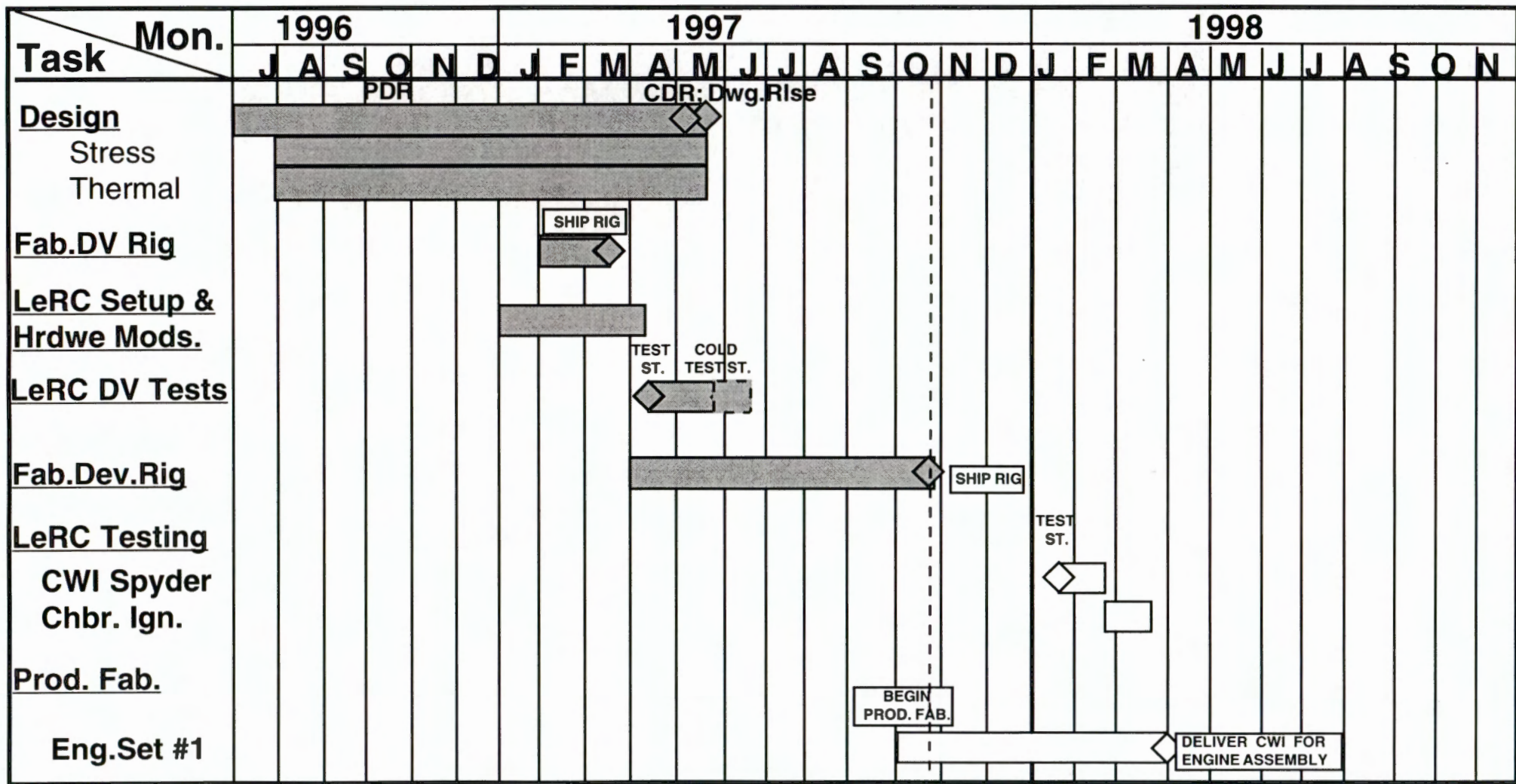
CWI SPIDER TEST RIG OBJECTIVES - NASA LEWIS

TEST OBJECTIVES

- Define low pressure ignition and transient CWI system characteristics
- Evaluate proposed Engine CWI start sequence: Verify CWI event sequencing and timing
- Verify flight type valve operation and performance
- Evaluate Premixer pre-detonation chamber pressure PC and Mixture ratio MR ignition performance
- Map CWI operations vs. Pilot Element ignition envelope
- Provide confirmation of injector ignition w/ X-33 scaled injector
- Demonstrate resiliency to FMECA failure modes scenarios

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- **Program Plan:**
 - 5 CWI System Sets
 - 4 Engine Sets & 7R CWI Spider
 - 5 Central Distribution Networks (1 7R CDN)
 - 110 Triaxial Elements (20 7R CWI Triaxial Elements)
 - Flight Mission
 - Total Starts: 22 Starts / 3790 Seconds / 250 Seconds per Flight
 - CWI System Qualification
 - **Single Element/CWI System Testing - LeRC *Completed***
 - **Spider Testing - LeRC**
 - Engine Testing - SSC
 - (Slave Ignitor in Single Cell Testing - MSFC)

CWI Program Plan Schedule Key Milestones





CWI System Spider Test Rig Testing Summary



Test Series	Description	X-33 Tank Start Condition	Qty.	Prop.Temp.
1	System Blowdowns	N/A	20	Cryogenic
2	Combustion Wave (CW)/Pilot Start Sequence	Michael SRD Min Malmstrom	4 2 2	Cryogenic ↓
3	Tank Pr. Variance SRD. Ox./Malm. Fuel Malm. Ox./SRD Fuel SRD Min. Ox./Mich. Fuel Mich. Ox./SRD Fuel Malm. Ox./Mich. Fuel Mich. Ox./Malm. Fuel	Mission Investigative	2 2 2 2 2 2	
4	Tank Pr. Variance Lowest Ox./25% High Fuel 25% High Ox./Lowest Fuel	Envelope Investigative	6 6	
5	Chbr. Seq. & Chbr. MR. Verification W/ CW & Pilot Fixed	Michael Malmstrom SRD Min	4 4 4	
6	MC Sequence & MR Variance W/ CW & Pilot Fixed	Michael Malmstrom SRD Min	6 6 6	
7	Failure Modes Testing	Michael	10	
	Total -		92	





7R Spider Rig Vs. Flight Spider Comparison



<u>Parameter</u>	<u>7R Spider Rig</u>	<u>X-33 Flight Spider</u>
CW Tubing		
5/8 " Premixer Outlet	1	1
1/2" Right Angle Lines	2	2
1/2" Manifold Lines	2	2
1/4" Pilot Inlet Line	20	20
CWI Exhausts	20	20
CW Exhaust Area	0.0458 sq.in.	0.0458 sq.in.
CW Orif. Size: Fuel/Ox.	N/A / .120	N/A / .120
Pilot Ignitor Element:		
Propellant Sources	Common w/ CW Sys	Common w/ CW Sys
LeeJet Sizes Fuel/Ox.	350 Lohm/350 Lohm	350 Lohm/350 Lohm
Prop. Lines	Same Config. as Flt.	Flight-weight
Valves: ON/OFF	Same Perf. as Flt.	Flight-weight
Check	Same Perf. as Flt.	Flight-weight
3-Way	Same Perf. as Flt.	Flight-weight
Spark System (#)	J-2 (2 per rig)	J-2 (2 per rig)
Insulation CWI/Fuel systems	Easy Req-7R insulation	9R insulation





CWI Spider Test Injector/Chamber Comparison & Requirements



<u>Parameter</u>	<u>X-33 Injector</u>	<u>Active Inj./Chbr.</u>	<u>Inert Inj./Chbr.</u>
Element Type	Coax.	Coax.	Tube
Pc (psia)	857	140	40
Mixture Ratio(O/F)	5.85	5.85	N/A
# of Elements	168	8	7
Flowrates (Total)			
Oxidizer Side	25.5	1.214	N/A
Fuel Side	4.38	0.207	N/A
GN2 Side	N/A	N/A	0.104
Post or FeedTube			
I.D.	0.0781	0.0781	0.116
Wall Thickness	0.014	0.014	N/A
Orifice Dia.	0.0490	0.0490	N/A
Post Length	1.17 to 1.64	1.17	N/A
Recess:	0.1	0.1	N/A
Fuel Gap (Nom.):	0.017	0.017	N/A
Injection Velocity			
Oxidizer (ft/s)	65	65	N/A
Fuel (ft/s)	1473	1473	N/A
GN2 (ft/s)	N/A	N/A	315
Chamber Thrt. (in)	3.259	0.711	0.500
Chamber Dia.	4.876	1.490	0.750
Chamber Length	7	7	7

