

AIAA-01-3838

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***History of the Reaction Motors Super
Performance 90% H₂O₂/Kerosene LR-40
Rocket Engine***

***M. C. Ventura, E. J. Wernimont
General Kinetics LLC, Lake Forest, CA
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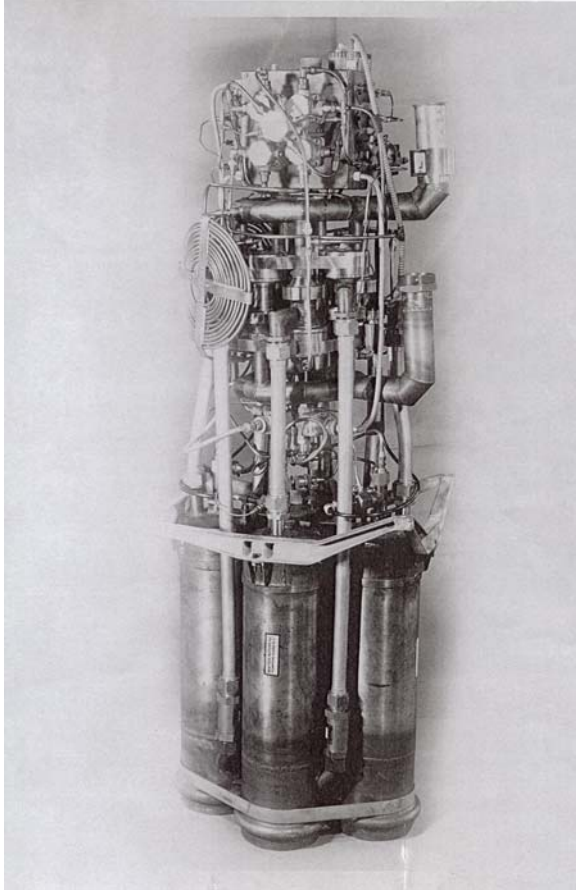
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Summary

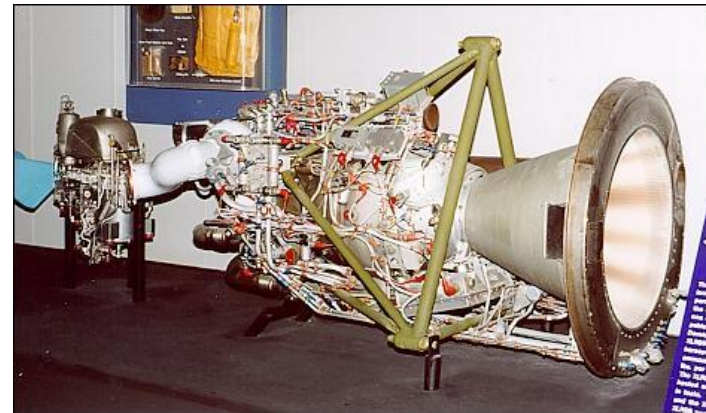
- History of Reaction Motors Inc. (RMI)
- History of LR-40
- LR-40 Accident
- LR-40 Layout and Technical Details
- Potential Upgrades
- Potential Performance
- Conclusions

History of RMI

ORIGINAL 6000C4 ASSEMBLY - AUGUST 29, 1945



- Founded 1941, 4 amateur rocketeers, 1 week older than Aerojet
- Located in NJ
- Rapid expansion in 1940's to 1950's
- Peaked at ~ 1750 heads
- Many innovations and “firsts”
 - Man-rated, reusable, tube wall chamber, closed loop cycle engine, etc...
- XLR-11 (X-1, breaks sound barrier)
- XLR-99 (X-15 main engine)
- Surveyor, rocket on rotor, Hyprox, Bullpup
- Marotta



RMI: Rise and Fall

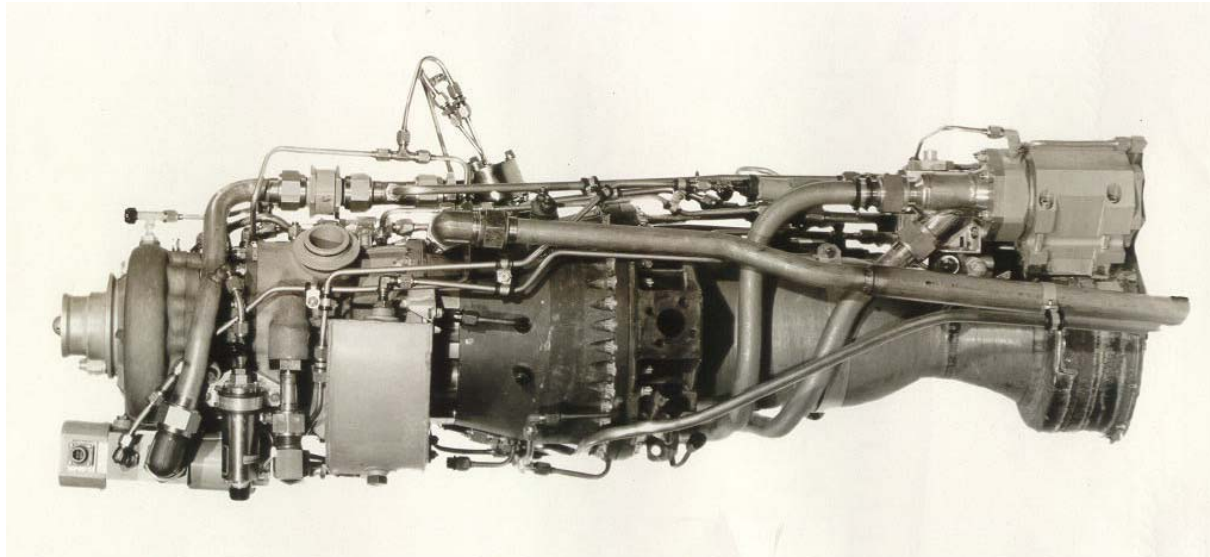
- Company peaks in 1960's @ 1750 heads
- Unable to get Apollo contracts or other big jobs after XLR-99
- Financial problems sell company to Rockefeller's
- RMI later sold to Thiokol, becomes Thiokol RMD
- Thiokol sells off RMD in 1970, auctions off physical assets
- Morton acquires corporate assets in Chicago, throws them away
- National Archive destroys documents
- Non-physical evidence of RMI virtually obliterated

History of LR-40



- 1950's need for aircraft rocket engine assist
- Two engines developed: AR2-3 and LR-40
- LR-40 was produced for Chance-Vought, F8U
- Engine design process started in mid 1950's
- Qual engines (two) built and tested in 1957
- Completed PFRT, demo'd single burn with continuous throttling for 5400 seconds
- One of the qual. motors failed on test stand
- One remaining engine currently with GK

LR-40 Accident



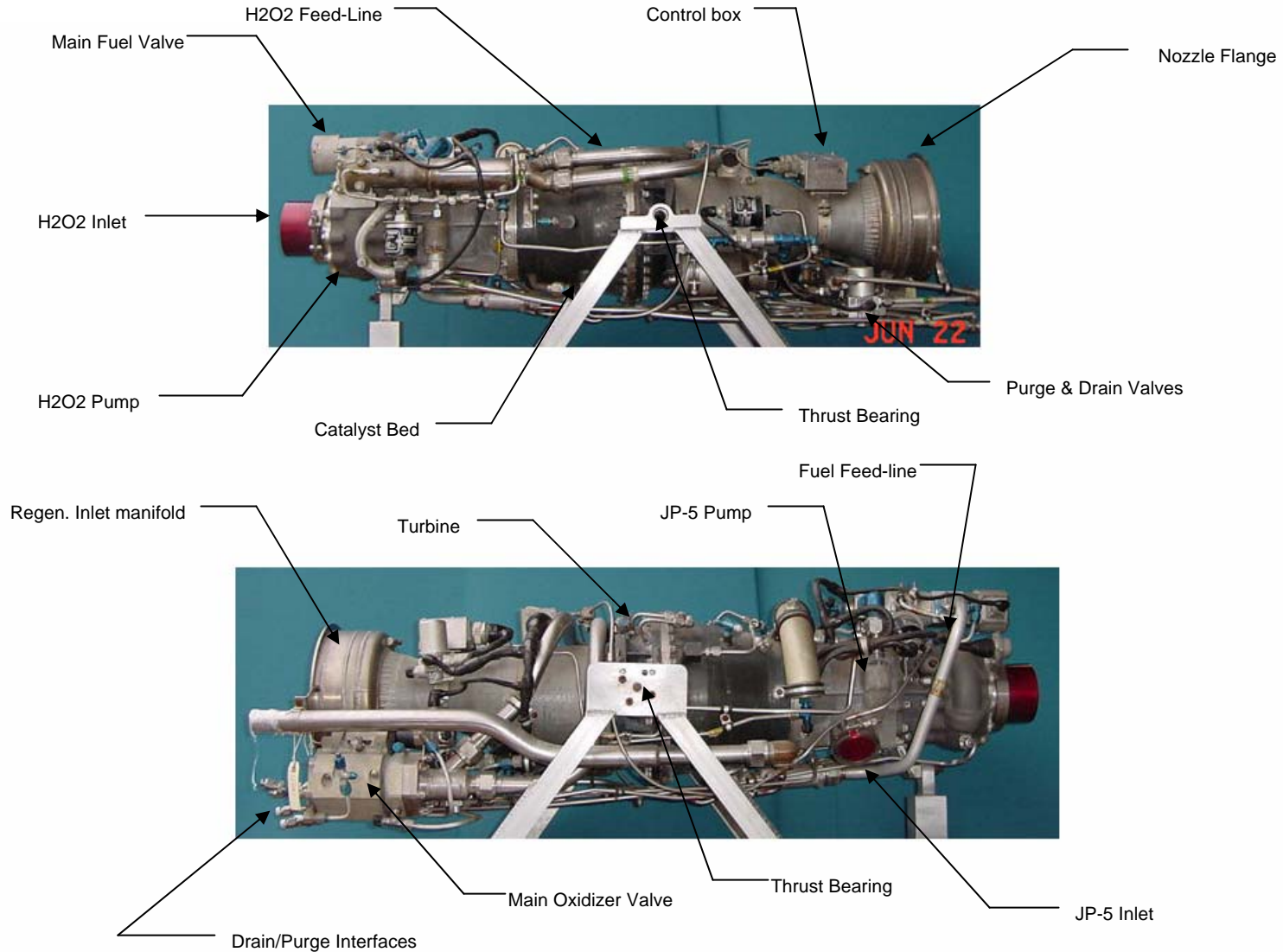
- Engine on RMI test stand with Chance-Vought technicians, conducting TP maintenance training
- Inter-propellant pump cavity drain plug left installed
- Pump seals leak into cavity
- Drain plug was turned, thread failure caused friction
- Lubricant in plug or in cavity along with propellant and thread friction ignites
- Cavity explodes, kills Chance-Vought employee, injures others
- LR-40 program cancelled.

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LR-40 Features

- In-line assy of TP and combustion chamber
- Closed loop cycle, one catalyst bed drives turbine
- Single shaft TP
- Tube wall chamber
- Continuous throttle, mono-propellant operation
- Tank head start
- Starts in any orientation
- Nozzle flange for skirt extension
- Long demonstrated life, > 5400 seconds

LR-40 Layout and Technical Details



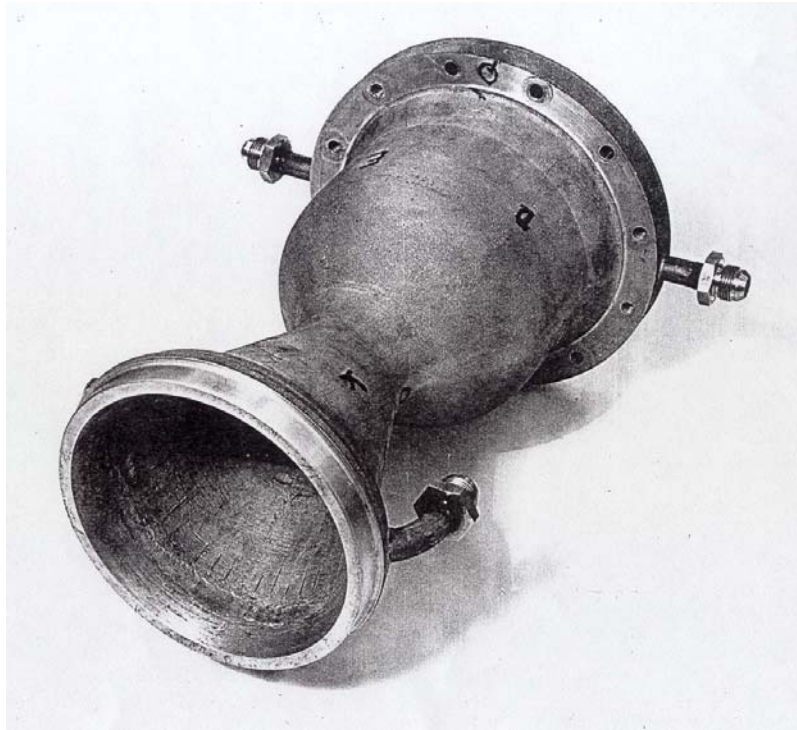
LR-40 Performance

Parameter	Units	CPIA LR40	Thiokol LR40	GK LR40	AR2-3
Thrust	(lbf)	3500-8000 (2)	3500-10,200 (3)	3500-10,200 (4)	3300-6600
Specific Impulse	(lbf-sec./lbm)	220	257	257 (7)	241
O/F ratio		7.1	7	7	8
Chamber pressure	(psia)	530	530	530	280 (6)
Mass, dry	(lbm)	213	215	215	256
Length	(inches)	42	46.6	42	32.1
Diameter	(inches)	15.3	14	15.3	19.8
Oxidizer		MIL-H-6005C	90% H2O2	90% H2O2	90% H2O2
Fuel		MIL-F-5624C (JP5)	JP5	Kerosene	Kerosene
Expansion ratio		8.5:1	8.5:1	5.6:1	12:01
Thrust coefficient		1.645	1.645		
Turbo-pump					
Oxidizer flow rate	(lbm/sec.)	151 (1)	34.75		
Fuel flow rate	(lbm/sec.)	37 (1)	4.95		
Oxidizer inlet pressure					
Min. NPSH, start	(ft.)	21.1			47 (5)
Min. NPSH, run	(ft.)	15.7			
Fuel inlet pressure					
Min. NPSH, start	(ft.)	18.2			44 (5)
Min. NPSH, run	(ft.)	14.7			
Speed	(rpm)	18,800	18,800	18,800	26,500
Environmental temp. limits	(deg. F)		-35 to 160		
Power	(Vdc)	17 to 29			

Notes:

- 1) Units are GPM.
- 2) Thrust and Isp are values at 50,000 ft. CPIA notes that engine is continuously throttleable from 3500 to 10,000 lbf, and can throttle to 1000 lbf in mono-propellant mode.
- 3) Thrust and Isp are vacuum.
- 4) Thrust and Isp are vacuum. Throttle to 1000 lbf in mono-propellant mode.
- 5) Assumed to be start NPSH and psia
- 6) Pressure assumed to be at low thrust level. High thrust level pressure estimated at ~ 560 psia.
- 7) Expansion ratio = 8.5

LR-40 Potential Upgrades



- Aluminum chamber
- Nozzle extension
- Injector upgrade
- Upgrade to 98% H₂O₂ with catalyst upgrade

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Estimated Performance of LR-40 with 98% H2O2/JP-10

Thrust, alt. (lbf)	15,250
Isp (sec.)	324
O/F ratio	6.75
Pc (psia)	557
Weight, dry (lbm)	> 257
Expansion ratio	250:1
Length (in.)	> 92.0
Pump	
Speed (rpm)	18,800
Ox. NPSH (ft.)	15.7
Fuel NPSH (ft.)	14.7

Conclusions

- Summarized the heritage and history of RMI and the LR-40
- Discussed the pertinent features of the LR-40
- Proposed options for potential upgrades