RRS NEWSLETTER

THE OFFICIAL JOURNAL OF THE REACTION RESEARCH SOCIETY INC.

VOLUME 47: NUMBER 09 SEPTEMBER 1990

OF, BY AND FOR EXPERIMENTAL ROCKETRY AND THE AMATEUR ROCKETEER

IN THIS ISSUE:

EDITOR IN CHIEF AND SECRETARY/TREASURER: PHILIP V. PESAVENTO

FROM THE EDITOR:

What a launch!!!! We finally ended up with two static tests on Saturday with some work parties and two launches on Sunday. The first static firing was for testing a new solid fuel for Scott Claflin's hybrid rocket developments. Scott used his gaseous oxygen test rig. Very nice runs. The second static firing was Tom Mueller's ablatively cooled LOX/kerosine engine (I got this confused two newsletters ago and called it a hybrid rocket. Sorry Tom!) Ablative liners ranged from polyurethane to a combination of polyurethane for the chamber and graphite for the nozzle to an all graphite liner. The two launches on Sunday included Leonard Olive's Modified BETA, and the Society's mail rocket. More under Preliminary Launch Report.

RAMBLINGS:

I am continuing in this issue with a new section entitled NEW HORIZONS IN ROCKETRY. In this section I am going to give overviews concerning different topics on cutting edge technologies in the field of rocketry. I eventually want to propose a number of projects that could eventually give the RRS the capability of reaching Near-Earth-Space and possibly even Low Earth Orbit!
This may sound like wild speculation and pure science fiction, so that is why I have choosen the subtitle "Selected topics in speculative rocketry". I have been researching the possibility of building a Single Stage to Orbit launch vehicle for a number of years and it turns out that there are several approaches that (on paper at least) will work, and possibly within the budget of an organization like the RRS. Stay tuned!

One of the things that I have noticed concerning the various static tests that have taken place this year is the problems people have had with ignition and with having to build complex tankage and feed systems. They had to spend as much time debugging their test rigs as they did testing their rocket motors and propellant combinations. While this could be chalked up to experience, it makes for very slow progress in the development of new motors, injectors, and propellants. If the Society had a tried and proven test rig that could be used by the membership, the members could concentrate on making making advances in rocketry instead of reinventing the wheel. I am extremely impressed and commend the efforts of those people who have done all of the test rig construction on their own. It is a tribute to their persistance, ingenuity and motivation to collect all of the hardware, assemble and debug it. Yet I also see an opportunity to improve the rate of innovation in the Society through some standardization of test rigs. What do you think?

PRELIMINARY LAUNCH REPORT FOR THE SEPTEMBER 1990 LAUNCH

Munsey Road was very washboard coming in from the Mojave side of the dry lake. A number of work parties were in evidence including a party rebuilding and painting the static test stand and also we were able to get a backhoe which was filling in washes and ruts in the down range road. The two static tests scheduled for Saturday, Scott Claflin's gaseous oxygen hybrid and Tom Mueller's ablatively cooled LOX/kerosine motor were being prepared for their test runs. Ted Cortapassi was setting up the data aquisition system to take data on Tom's test.

Another work party was started with the assistance of the backhoe, and the logs were replaced on top of the bunker and just about everybody chipped in nailing the strapping to hold the logs in place. Telephone cables were strung from the blockhouse to the bunkers and tracking as well. At this point we all broke for lunch.

After lunch another work party was started clearing sand out of the bunlkers that had filled with drift, and a particularly obnoxious sage bush near the bunker was removed. A straight road was also cut to tracking with the aid of the backhoe.

Scott made three tests of a new solid fuel for his hybrid motor he is developing. The fuel was particle board. The three tests started out with a misfire when there wqas an ignition failure, but the remaining tests went off without a hitch.

Tom also had some ignition problems and it took six trys before he finally achieved ignition. The flame was large, orange and bushy, indicating that it was fuel rich, and later inspection of the ablative liner showed that the motor was burning outside the chamber.

Sunday morning the two rockets to be launched were loaded with fuel. An attempt was made to use both the north and south launch racks, but a bolt on the north rack's pivot sheared, and both launches were made from the south rack. The first rocket to be launched was Leonard Olive's rocket. It had welded tail fins, and some kind of a divider in the combustion chamber. When the rocket had risen about 20 to 30 feet out of the launch rack, the bulkhead blew out. The rocket fell back inside the launch rack. The mail rocket was sized into the south rack after inspection showed no damage from the first rocket's anomalous operation. The rocket burned out at about 75 foot altitude, and it began tumbling. The parachute did not activate because the totsal flight time was shorter than 10 seconds. A normal flight would have burned out at an altitude nearer 150-200 feet, and that would have given a flight in the 20 to 40 second range. The parachute deployment timer mechanism was tested on the ground and was found to be functional. The mai survived intact.

Another work party was started after the launches. The steel tables legs were cast in concrete, and a trench for the new north bunker was started. Thankyou to Frank, George, Donald, Steve, Dave, Mark, Brian, Phil, Leonard, Scott, and any other people who participated in any of the work parties. Thank you Larry and Bob for the safe launch.

PRELIMINARY LAUNCH REPORT (continued)

NOTES: One of our coresponding members, Bill Lewis drove down from San Jose to see the launch and meet with other members of the RRS. Welcome to the Society Bill!

The post flight inspection of the mail rocket indicated that the fin bracket had not been assembled under the nozzle hold down bolts. The extra length that would have been taken up by the thickness of the bolts protruded sufficiently into the nozzle throat to crack the graphite cast throat insert. Chunks of it fell out during ignition, which was a partial reason for the erratic flight. The other was the lack of mechanical hold downs for the fin bracket. The fuel oxidizer ratio for the flight was 75/25 where the ratio normally used is 80/20. It is not known whether the short burn time was due mostly to the change in fuel oxidizer ratio or to the damaged throat insert.

On the way back in to the MTA Sunday morning , George and I came in the back Munsey Road direction from Ridgecrest. We were stopped by som foremen from the Arciero Ranch who told us that they were going to be closing the East gate that you must go through to get to the MTA from Ridgecrest.

There was an anomaly concerning the fit up of the burst disks to Leonard Olive's rocket. The standard ones did not fit and either a standard set were cut down, or a new set were cut. I have not heard anything official concerning the possible effect this could have had on the bulkhead bolt failure.

ROSTER OF ATTENDEES, 09/22/90-
(Not in alphabetical order)

D. Trimborn
O. Tarditti
R. Isaad
J. Gross
A. Gross
S. Chen
T. Cortopasi
W. Kruse
D. Crisalli
L. Teebken
R. Anderson
M. Anderson & Guest
T. Mueller
S. Claflin
B. Wherley
M. Grant
P. Pesavento
S. Luhn
J. Luhn
C. Chen
L. Olive
M. Phillips
G. Dosa
W. Lewis & Guest

ROSTER OF ATTENDEES, 09/23/90-
(Not in alphabetical order)

F. Miuccio
G. Dosa
P. Pesavento
R. Anderson
M. Anderson & Guest
L. Teebken
S. Luhn
L. Olive
D. Trimborn
L. Ero & Guest

Selected Topics in Speculative Rocketry

SINGLE STAGE TO ORBIT LAUNCH VEHICLES II

INTRODUCTION

Last month I began this series with a rough outline of all of the options available with state of the art technology for propulsion of a single stage launch vehicle into LEO or NES (Low Earth Orbit and Near Earth Space). In this issue I will delve a little more deeply into some studies which were done in the last ten years that give some idea as to which propulsion options give the best tradeoff between cost, performance and complexity.

PROFFESIONAL STUDIES OF THE SSTO

Figure 1 shows a list of on board power source chemical propulsion concepts evaluated by NASA in the late 1960's prior to the cessation of all airbreathing propulsion work/studies/ research in 1970. While the original study was predominantly to develop a two stage fully reusable launch vehicle, there were some attempts to sneak in a preliminary single stage to orbit (SSTO) version of the vehicle. The efforts were not altogether fruitless but the end result was classified (it still is) but a number of the original researchers were allowed to declassify major portions of the study. The original study comprised 9 volumes (very thick) and was the most exhaustive evaluation of airbreathing launch vehicle propulsion ever made. This study was summarised in three reports published between 1985 and 1986. (See references 1,2,and3). This study was done by Marquardt, Rocketdyne and Lockheed. A second review of work done by Aerojet was published in 1987 (reference 4) that sings the praises of Aerojet's contribution to advanced air breathing propulsion, the the air-turbo-ramjet. They have evendeveloped a solid fueled version of this device, which may be of some interest to hybrid rocket aficionados. (See reference 5). The most recent study was one performed by a team comprised of the University of Stuttgart, MBB (Messerschmitt-Boelkanow-Blohm)and Rolls Royce. (reference 6). It evaluated both the two stage and single stage to orbit fully reusable concepts.

All of the reports indicate several conclusions in common. The first and probably most important is that the direct ascent to orbit (NASA Space Shuttle type) launch profile even with airbreathing engines gives the highest payload to gross takeoff weight ratio of any of the configurations studied. The second was that all of the proposals used LH2 and LOX for fuel and oxidizer (though the Marqurdt ejector ramjet test engine was run on three fuel oxidizer combinations, LH2/LOX, RP1/LOX, and RP1/H2O2). The third was that the performance differences between the various propulsion configurations was such that the payload to dry weight ratios were within a factor of 3 of each other, between 6 and 20 percent payload to dry weight. Remember that the payload to gross takeoff weight (GTO) not dry weight for the Space Shuttle is 3 percent. The equivalent payload to GTO ratios are from 2 to 6 percent. The summary graphs from the NASA study for phase 1, 2, and 3 (each a slightly more detailed study) shown in Figure 2 shows this result.

WHO CARES?

While a liquid fueled version of this kind of propulsion may be out of the range of the expertise and financial resources of the RRS, it may be useful to consider the possibilty of trying to do this with a solid fuel/ liquid oxidizer system. While this may or may not give sufficient performance to achieve LEO, it would still be a worthwhile exercise because the same systems would be needed as far as transitioning between rocket, supercharged ramjet and pure ramjet mode, without the handling difficulties of LH2, and the the weight savings due to the higher volume energy density may compensate for the slightly lower Isp of the solid fueled vehicle. There is also the option of not going for full SSTO but only attempting to do a two stage fully reusable launch vehicle.

A POSSIBLE SCENARIO

The first step in the critical path to an RRS developed Launch vehicle capable of NES and even possibly LEO is to develop a hybrid rocket. This is a solid fueled/liquid oxidizer type system. The second step would be to develop a solid fueled ramjet (SFRJ) engine/ vehicle. The third step would be to integrate the hybrid rocket and SFRJ so that the hybrid rocket would boost the SFRJ to flight speed, after which the inlet would open and the oxidizer would shut down or be used only for a pilot burner during ramjet mode. Once the SFRJ had flamed out due to lack of oxygen, the next step would be to close the inlet and turn the hybrid rocket back on until you reached orbit or ran out of fuel. The development of a solid fueled air-turbo-ramjet in the vein of the Aerojet concept might be the next step and finally an integration of the air-turbo-ramjet with the hybrid rocket being the final version. The simpler hybrid rocket SFRJ (akin to the Marquardt Ejecter Ramjet) may prove to have better performance and/or improved simplicity and reliability of fewer moving parts and lower costs over the more complex air-turbo-ramjet/hybrid rocket.(I should start using the acronyms like ATR/HR instead of writing this out all of the time.) A somewhat schematic version of the SFRJ/HR and ATR/HR are shown in Figure 3.

REFERENCES

1) Synerjet for Earth/Orbit Propulsion: Revisiting the 1966 NASA/Marquardt Composite (Airbreathing/Rocket) Propulsion System Study.- W. Escher- SAE Paper 851163-1985

2) Airbreathing and Rocket Propulsion Synergism: Enabling Measures for Tommorrow's Orbital Transports -W. Escher, R. Teeter, E. Rice- AIAA-86-1680

3) Advanced Airbreathing Propulsion: Enabling Key to Affordable Aerospace Transportation- R. Cooper, W. Escher- AIAA A86-32534

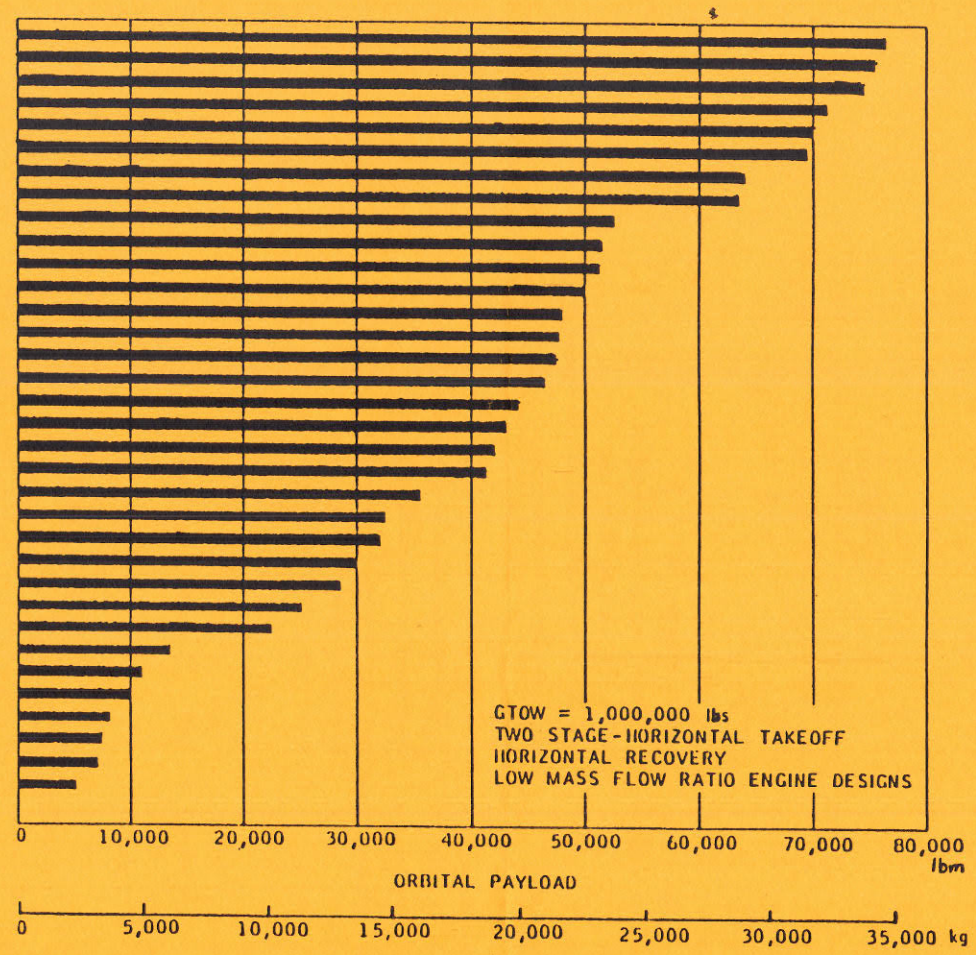
4) Combined Cycle Propulsion for Hypersonic Flight- D. Kors- AIAA Paper, 1987

5) Advanced Air-Breathing Propulsion Concepts for Winged Launch Vehicles- U. Schoettle, H. Grallert, and F. Hewitt- Acta Astronautica Vol. 20 pp 117-129, 1989

6) Solid Fueled Gas Generator ATR- W. Calvo, K. Christensen, and M. Fedun- AIAA-86-1682

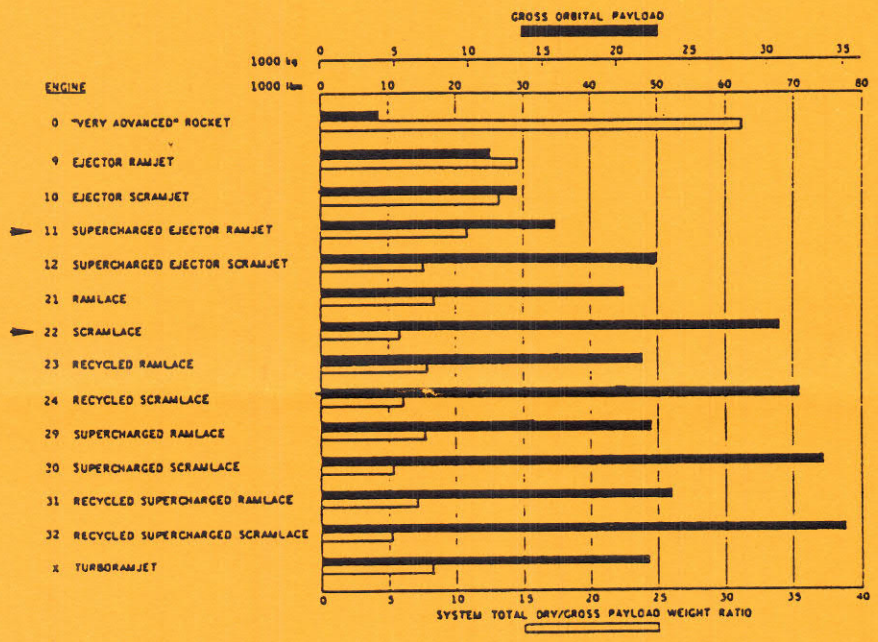
32 Recycled Supercharged ScramLACE ●
24 Recycled ScramLACE ●
30 Supercharged ScramLACE ●
22 ScramLACE ●
28 Recycled Supercharged Air Augmented LACE-Convertible Ramjet
20 Recycled Air Augmented LACE-Convertible Ramjet
26 Supercharged Air Augmented LACE-Convertible Ramjet
18 Air Augmented LACE-Convertible Ramjet
12 Supercharged Ejector SCRAMJET ●
31 Recycled Supercharged RamLACE ●
23 Recycled RamLACE ●
29 Supercharged RamLACE ●
21 RamLACE ●
27 Recycled Supercharged Air Augmented LACE-Ramjet
19 Recycled Air Augmented LACE-Ramjet
15 Supercharged Basic Air Augmented Rocket-Convertible Ramjet
25 Supercharged Air Augmented LACE-Ramjet
17 Air Augmented LACE-Ramjet
10 Ejector SCRAMJET ●
7 Basic Air Augmented Rocket-Convertible Ramjet
11 Supercharged Ejector Ramjet ●
2 Hyperjet-Scramjet
14 Supercharged Basic Air Augmented Rocket-Ramjet
9 Ejector Ramjet ●
6 Basic Air Augmented Rocket-Ramjet
4 Recycled Basic LACE
1 Hyperjet
34 Recycled Augmenter LACE
33 Augmenter LACE
16 Supercharged Basic Air Augmented Rocket-SCRAMJET
3 Basic LACE
13 Supercharged Basic Air Augmented Rocket
8 Basic Air Augmented Rocket-SCRAMJET
5 Basic Air Augmented Rocket

NOTE: Engines No. 35 & 36 not included

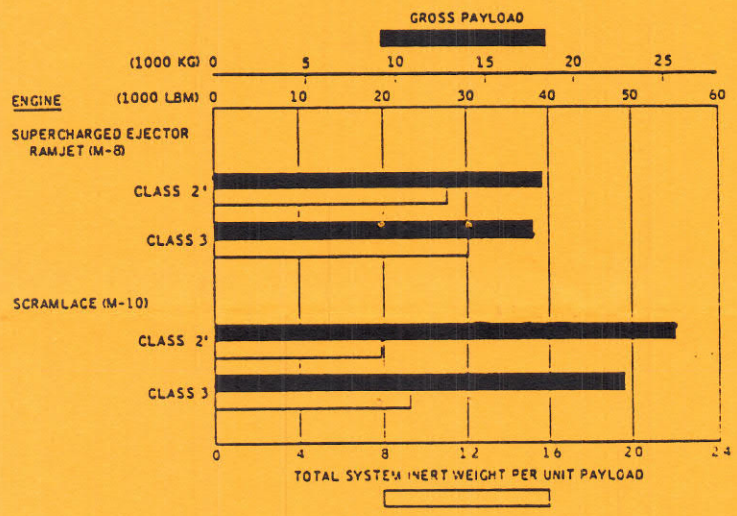


Class 0 Systems Payload Performance Ranking

Figure 1

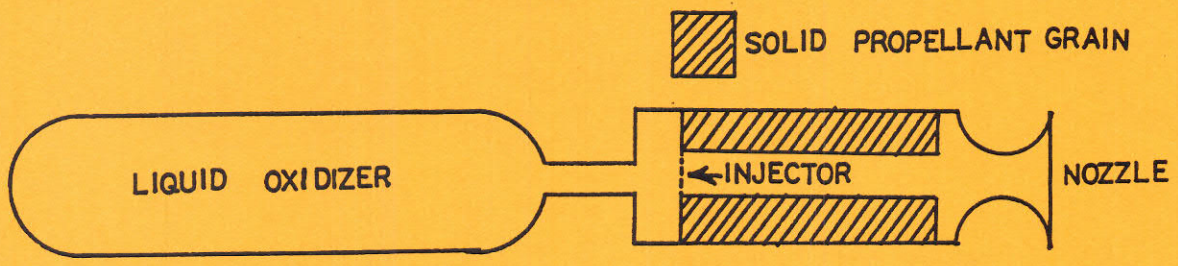


Class 1 Systems Payload Performance Ranking

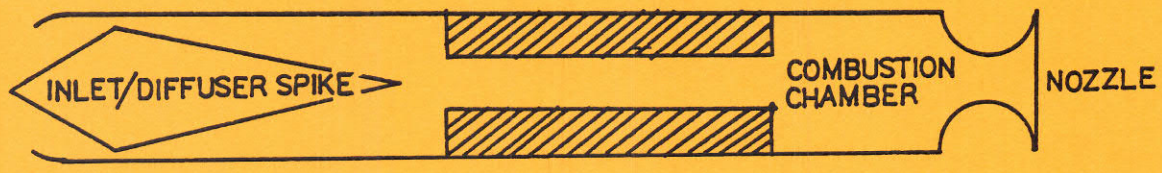


Class 2'/ 3 Payload Performance Comparisons

Figure 2

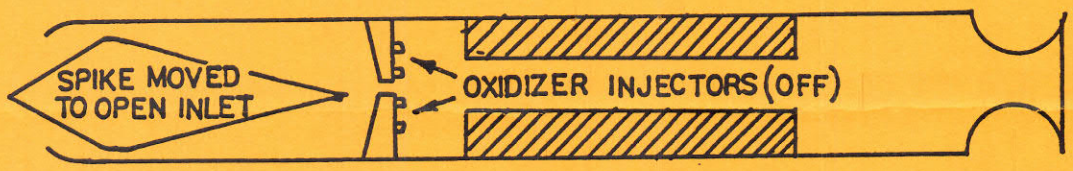


(HR) HYBRID ROCKET SCHEMATIC

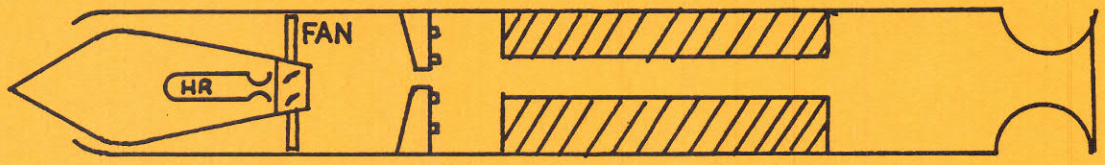


(SFRJ) SOLID FUELED RAMJET SCHEMATIC

SFRJ/HR COMBINED CYCLE ENGINE IN ROCKET MODE

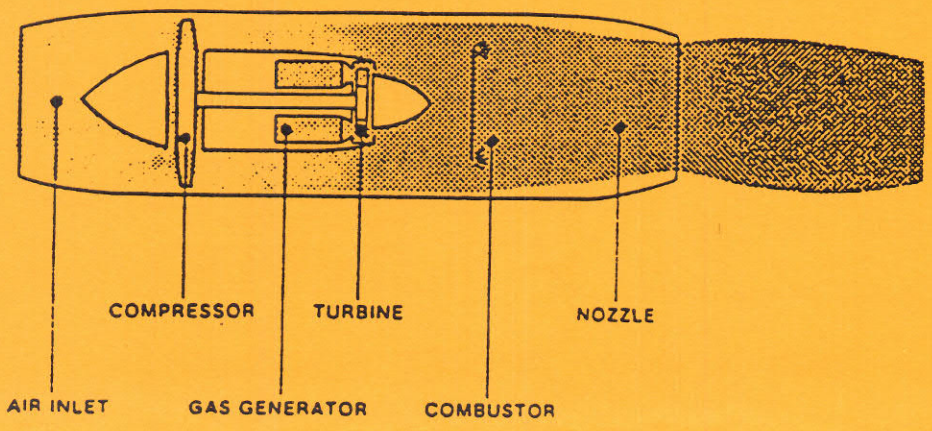


SFRJ/HR COMBINED CYCLE ENGINE IN RAMJET MODE

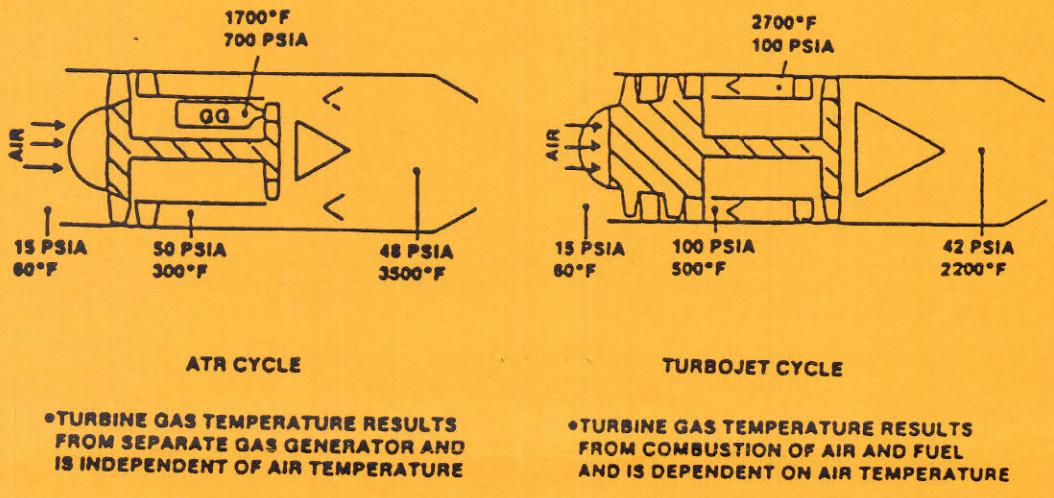


SOLID FUELED GAS GENERATOR ATR/SFRJ/HR COMBINED CYCLE ENGINE

Figure 3

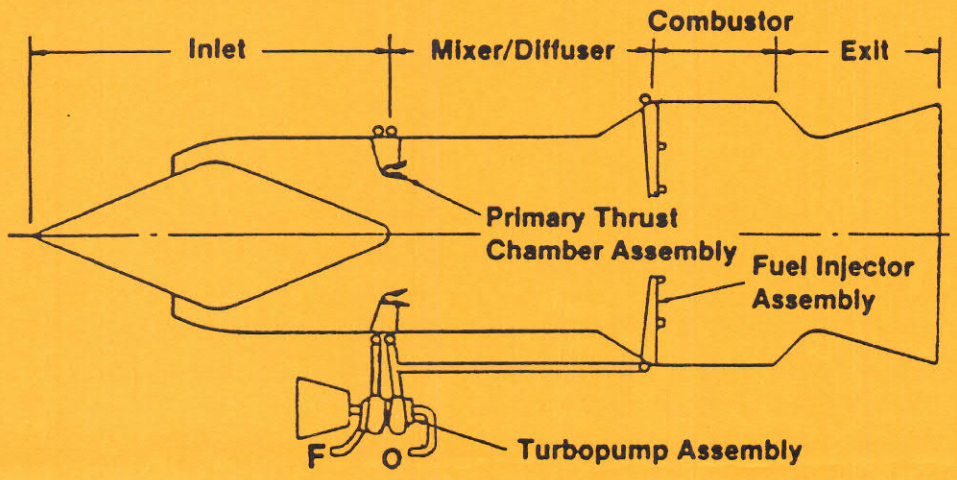


ATR engine schematic.

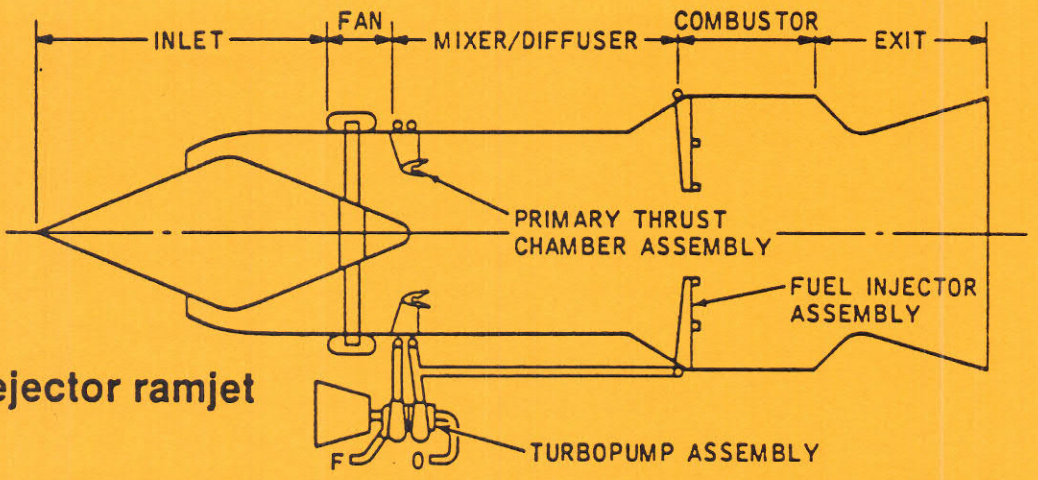


ATR eliminates material limits of turbine.

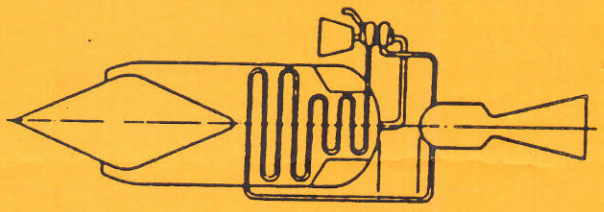
Figure 4A Schematics of Several Engine Cycles (References 2 & 4)



Ejector ramjet cycle

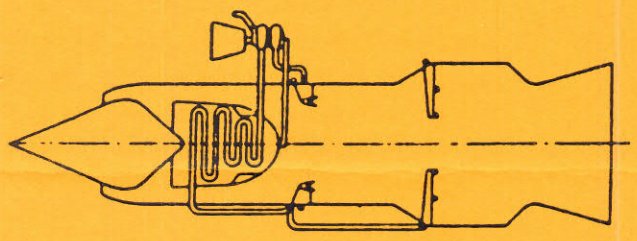


Supercharged ejector ramjet



BASIC LACE I_{SP} = 1000

ϕ = 8



RAMLACE I_{SP} = 1400

ϕ = 4.5

Figure 4B Schematics of Several Engine Cycles (References 2 & 4)

GLOSSARY:

Isp ..... Specific Impulse- A way of measuring fuel consumption or "gas milage" for rockets and air breathing flight engines. Given as Pounds Thrust Per Pound of Fuel burned per Second.

ATR ..... Air Turbo Ramjet- A type of combined cycle engine characterized by the use of bipropellant gas generator to drive the fan as opposed to air and an on board fuel like a turbojet engine. Aerojet's Baby.

SFRJ..... Solid Fueled Ramjet- Similar in configuration to a solid fueled rocket and a hybrid rocket it is characterized by having a solid propellant grain (usually but not always a metal from the grouping of Be, Al, Mg, or Li) and using A ram compression inlet to compress atmospheric air to support combustion of the fuel to provide thrust.

ERJ ..... Ejector RamJet- Basically a rocket motor in a duct and operated such that when the engine reaches ramjet takeover speed, the oxidizer is shut off and only fuel is injected. Marquardt's Baby.

SERJ ..... Supercharged Ejector RamJet- An Ejector RamJet incorporating a fan to increase subsonic Isp (which in an ERJ is basically that of the rocket)for improved subsonic Isp performance. Another Marquardt Baby.

SCRAMJET .. Supersonic Combustion RAMJET- An engine cyle that uses hydrogen fuel for airbreathing propulsion at speeds exceeding Mach 6. Theoretical upper limits for useful thrust are for speeds up to Mach 25.

LACE..... Liquid Air Cycle Engine- A large heat exchanger using LH2 as a coolant con denses atmospheric air which is then turbopumped into an essentially conven tional rocket engine. Allen Bond's revolutionary engine which was going to power the British HOTOL (Rolls Royce designation RB422) was in this class of device. Yet another one of Marquardt's Babies.

TOPIC: SEPTEMBER 22-23 LAUNCH

PRESENTER: Robert Anderson,Designated Pyro-op and Administrative Member, RRS

OVERVIEW: Bob went over the ssafety rules, task assignments and logistics for the upcoming launch.Tentative start time for the launch was 10:00AM.

TOPIC: MAIL FLIGHT
PRESENTER: Frank Miuccio, President, RRS

OVERVIEW: Frank discussed the details of the mail flight. There will be 23 first day covers celebrating the 20th anniversary of the first moon landing.

TOPIC: LIQUID STATIC TEST
PRESENTER: Thomas Mueller, Associate Member, RRS

OVERVIEW: Tom discussed the details of his three ablatively cooled kerosine/LOX motors.

THE RRS GENERAL MEETING SEPTEMBER 1990

The following is a list of the attendees at the September 1990 General Meeting:

F. Miuccio
W. Majdali
L. Teebken
R. Anderson
C. Chen
T. Cortopasi
R. Isaad
T. Mueller
G. Dosa
S. Chen
L. Olive
J. Gross
W. Kruse
O. Tarditti

REPORT FROM THE SECRETARY/TREASURER- Presented By F. Miuccio P of the RRS:
No change in financial status to report

REPORT FROM THE PRESIDENT- Presented by F. Miuccio President of the RRS:
We have received our silk screen logo for making upo RRS T-shirts and jackets. Frank also discussed the Hawthorne Airshow results. 34 people signed the guest list, a new record! Work party sign up sheets were discussed and passed around. Steve Luhn will be providing a backhoe/ tractor for some of the work party activities scheduled during the launch weekend.

September 7 is the final inspection date for rockets to be launched at the September launch. There will also be a work party at this launch. Frank Miuccio is the chairperson for this committee and the following projects need volunteers:

Static Test Stand Upgrade
Bunker Rebuild
Workbench Installation
Overhead Protection Test Stand
Tracking Stand
Secondary (Cross) Range Marker Installation
Other Assorted Projects

OVERHEAD PROTECTION COMMITTEE

HISTORY: Computer simulations run by R. Anderson on his home computer indicated that the blockhouses' and bunker's roofs may not be thick enough to withstand penetration by the impact of a single stage Standard Beta rocket from peak altitude. P. Pesavento volunteered to do further research into the subject, and with invaluable data gathered from copies of balistics and fortification literature supplied to him by J. Gross, was able to complete a report published and distributed at the November 1988 meeting. It was concluded that experimental data was needed. G. Dosa drew up some preliminary drawings of an apparatus to test the conclusions of the theoretical report, and A. Yehle volunteered to complete the final design work on the apparatus and let the Society know what materials and when a work party or parties would be needed for its construction. (Editor's note: No one has ever been injured at an RRS launch since the Society's founding in 1943). Alan has requested a work party to build the test barrier.

STATUS: A work party to construct the barrier is on the agenda for the September launch.

AIRSHOW COMMITTEE

HISTORY: The RRS has set up exhibits at several airshows in the area over the years as a means of recruiting and also to make some money from the sale of Society publications and rocket mail covers. Airshows at which the RRS has set up exhibits include those at Edwards Air Force Base, China Lake Naval Warfare Center, and the Hawthorne Airport Airshow.

STATUS: The Hawthorne Airshow took place August 25-26. The S/T extends many thanks to all of the volunteers for their hard work and dedication. Special thanks to F. Miuccio and D. Trimborn, Committee chairpersons.

VIDEO COMMITTEE

HISTORY: Since the RRS was founded in 1943, it has accumulated a large amount of 8 and 16mm film as well as videotape shot at various launches from 1947 to the present. It was desired not only to archive this old film, but also to make an up-to-date promotional film for the Society with narration and musical accompaniment. A committee chaired by O. Tarditti and D. Trimborn was formed to investigate the costs of doing this project.

STATUS: Donald and an assistant filmed the entire June 1990 Static Firing and will have a finished, edited version of it ready by the September 1990 meeting. This video is now available to members. Contact donald for price and delivery information. There is also a "Voyager" and "Whitey" video available.

LAWSUIT

HISTORY: A lawsuit was filed against the Reaction Research Society by a group calling itself the Pacific Rocket Society claiming ownership of half of the land owned by the RRS known as the Mojave Test Area or MTA.

STATUS: Our counter offer to settle the suit was rejected by the plaintif.

September 1990 LAUNCH

HISTORY: A launch is tentatively scheduled for September 22-23, 1990.

STATUS: Two static firings and two launches were accomplished. Read the section PRELIMINARY LAUNCH REPORT in this issue for more information.

The next General Meeting of the Reaction Research Society will be held on Friday, October 12, 1990 at the offices of the Pacific Energy Corp. at the Sanwa Bank Building in Commerce CA.

NOTE: Any contributions to the Newsletter in the form of letters to the editor, or articles must be recieved two weeks prior to the Monthly meeting. Any correspondance received after this time will be published the following month.

REACTION RESEARCH SOCIETY
P.O. BOX 90306
LOS ANGELES, CA 90009