Sabbatical Report

Industry and Research Experience in Solid Fuel Rocket Motor Development and Coursework in Field Programmable Gate Array (FPGA) Technology to Enhance Faculty Expertise

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Prepared for the Sabbatical Leaves Committee Sept 2021

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Statement of Purpose:

The purpose of this sabbatical was to complete professional work in aerospace and develop supplementary expertise in the areas of rocketry and field programmable gate arrays (FPGA).

Solid Fuel Rocket Experience:

After completing coursework in pyrotechnic safety and solid rocket propellant, I spent over 2000 hours working with the non-profit Sugar Shot to Space (SS2S) on non-toxic solid fuel propellant testing in composite motors and 150 hours working for the for-profit U.S. Rockets characterizing and testing a new high specific impulse (ISP) propellant formula as part of their three stage to orbit program. Finally, I collaborated with Monterey Machine Products and developed the first Community College Hybrid rocket which was successfully launched in 2021. The intent of completing professional work in rocketry was twofold: first to develop substantial personal expertise that can translate to our students and second to enhance the connection between the Mt. SAC engineering program and the substantial aerospace industry in Southern California. A follow-on benefit is that this rocketry work will allow the award-winning Mt. SAC rocketry team to tackle more sophisticated projects.

Development of FPGA Expertise

In addition to completing 120 hours of online coursework in FPGAs, I consulted with industry experts from Northrop, Boeing, Ensign Bickford, JPL and Intel on the industrial applications of FPGAs and how best to prepare students for the workforce. I also worked with faculty from Cal Poly Pomona, Cal State LA, Cal State Long Beach and UCLA on best practices in FPGA instruction. This work led to the development of a new FPGA Digital Electronics Course to support students in electrical and computer engineering certificate and transfer students.

Body of Report

I wrote in my proposal that I would "Work for Sugar Shot to Space (SS2S) to develop a space capable rocket platform using KNO_3 and $C_6H_{14}O_6$based propellant. (600 hours)" I committed that I would be part of at least one static test and one scale launch attempt. The reality is that I spent over 2150 hours between the Mojave test site, the SS2S site and the maker space at Mt. SAC. The SS2S team completed 21 static tests, 7 scale launches and a full-scale launch. I also worked for US rockets as part of a 3 stage to orbit project, obtained my level 3 high power rocket certification, served as a judge for the experimental sound rocket association, traveled to south America to collaborate on an international rocketry project and developed a partnership with a local aerospace company that mentored Mt. SAC students to launch the first community college hybrid rocket. I also completed course work in FPGA technology and built partnerships with local industry and transfer institutions to enhance our electrical engineering certificate and transfer programs.

Coursework:

Rocket Propulsion Coursework: Design and Make Your Own Solid Fuel Rockets: John Wickman

Objective:

- Learn How Rocket Motors Work
- Learn The Key Rocket Motor Design Parameters & How to Use Them
- Design and Build an Experimental Solid Fuel Rocket Motor
- Test and Characterize Your Solid Fuel Rocket Motor

Topics:

- The Key Rocket Motor Design Parameters & How to Use Them
- How To Design for Specific Thrust & Chamber Pressure Curves
- Design A Rocket Motor to A Specific Peak Pressure & Pressure Curve
- Make A Rocket Nozzle
- Mix and Cast Solid Rocket Propellant
- Cut and Prepare Propellant Cartridges
- Learn To Formulate a Variety of Solid Propellants
- Learn How Solid Propellants Really Work
- Learn How to Determine Burn Rate Parameters
- Pull Cores & Trim Propellant Grains
- Drill and Tap Rocket Chamber Bulkheads
- Assemble Your Rocket Motor
- Learn How to Do a Thermal and Stress Analysis on Your Rocket Motor
- Different Igniters Including Pyrogen Igniters
- Make an Igniter for Your Motor
- Test Fire Your Rocket Motor from A Historic Control Panel

- Analyze Chamber Pressure Data from Your Test Firing
- Post Fire Examination Techniques on Your Motor - What to Look For
- Calculate C-star and C-star Combustion Efficiency for Your Motor
- Determine Burn Rate Data from The Test

Highlights:

- This course was an amazing experience. Professor Wickman brings 60 years of rocket experience and has lived the development of rocketry in the United States. This course was an intense 30 hours of lecture and lab plus an additional 60 hours of out of class work that was incredibly transformational.
- Professor Wickman's textbook is superb at balancing analysis with the necessity of getting out on the test pad and making measurements. I loved his discussion of analysis paralysis.
- I enjoyed this course so much I signed up for it again for summer 2021.

FIG 1: Mason and Wickman at CP Technologies

Fig 2: Mason's fabricated experimental ANCP motor on the test stand.

Cal Pyro Certification Coursework

Objective:

- Learn State pyrotechnics law
- Learn State pyrotechnics regulations
- Understand requirements for safe hazardous materials transportation
- Understand requirements for safe Rocket construction, operation and motor storage

Topics:

- State pyrotechnics law
- State pyrotechnics regulations
- Rocket launch site size
- Rocket Launch safety
- Rocket Ignition systems
- Spectator distances
- Spectator notification
- Rocket misfires
- Rocket Launch conditions
- Rocket Retrieval Safety
- Rocket Motor Requirements
- Resident Storage of Rocket motors and motor components
- Prohibited Activities

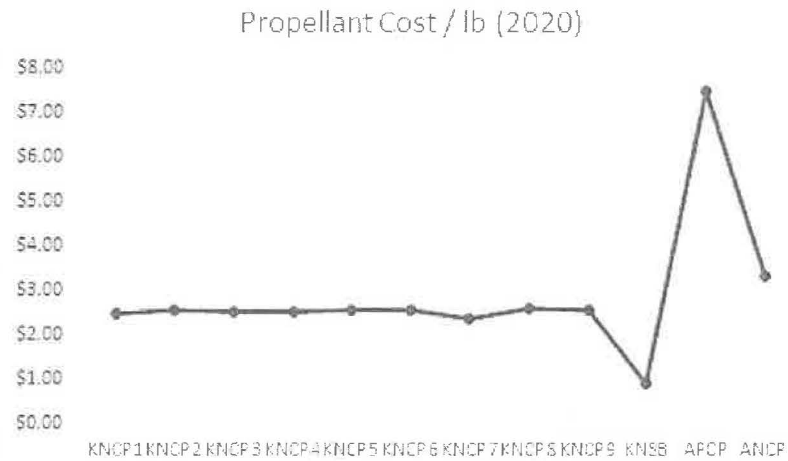
Comments:

- This course was offered virtually. It was clear that Cal Pyro focuses primarily on fireworks and most of the regulations referenced fireworks instead of rockets.
- The exams given for rockets are based on materials that are 55 years old and reference technologies no longer in use such as zinc sulfur rockets.
- The state is working to create an online exam tool for rocket certifications and is not offering in person exams due to COVID-19.
- As of Sept 2021, the online exam is still not available.
- The discussion of keeping a journal of launches and networking with existing pyro operators was useful. The number of active rocket pyro operators in the state is small and Cal Pyro is actively encouraging more people to complete the license.

PVC Motors and Propellant Development

After completing John Wickman's course, I did a trade study on different propellants currently in use. My interest was in using a propellant that met the following requirements:

- Costs
- Toxicity
- Manufacturability
- Performance
- Robustness



I had experience with three solid propellant families, based on ammonium nitrate, ammonium perchlorate and potassium nitrate. The graph above illustrates the relative costs of each of the common propellants. The KNSB propellant was ultimately selected due to its low cost, low toxicity, and ease of manufacture.

Once the oxidizer and fuel were selected, a series of tests were completed to optimize the performance and robustness of the propellant. A variety of additives were tried including red iron oxide (to increase performance), several viscosity modifiers and different plasticizers to attempt to make the propellant less brittle.

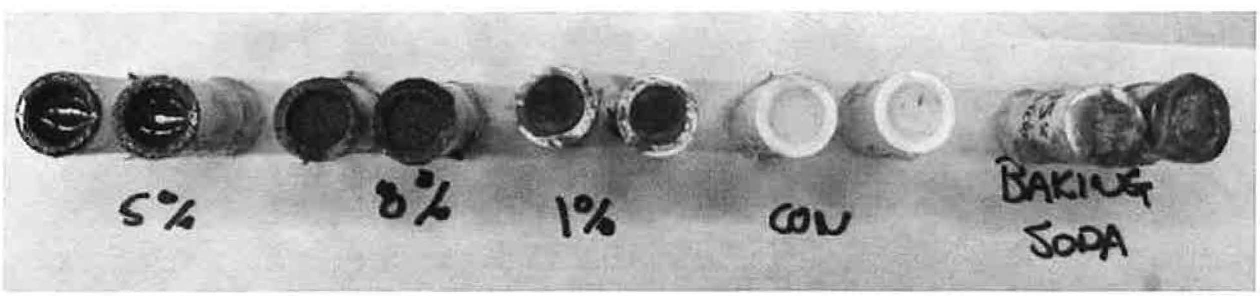


FIG 1: Test samples for burn rate modifiers before burn

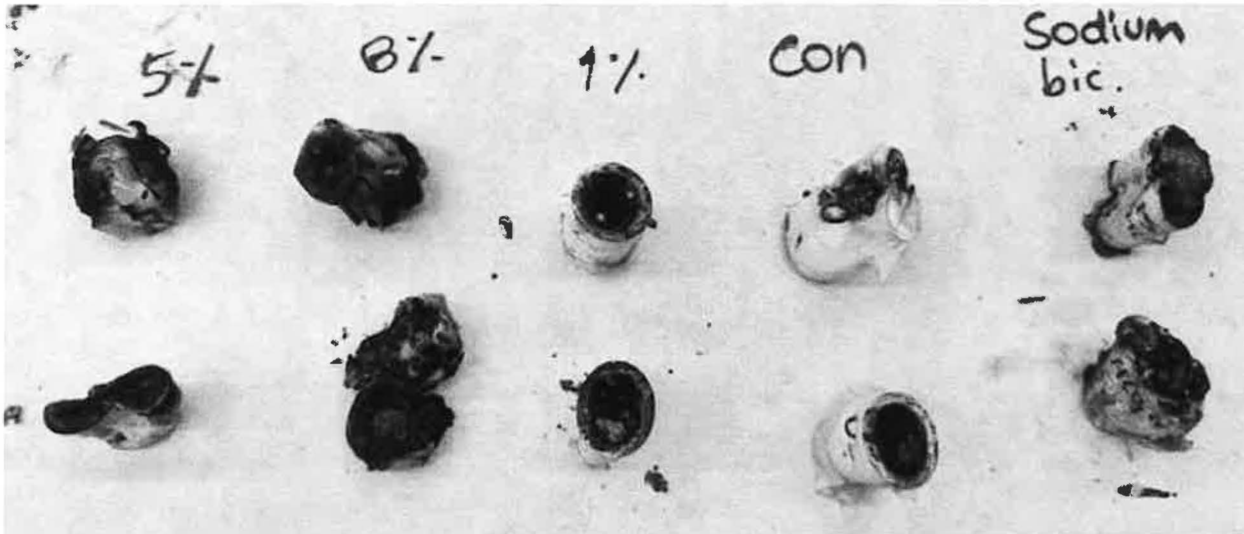


FIG 2: Test samples for burn rate modifiers after burn.

Strand tests were completed with the same formulations to determine impact on burn rate. The strand tests allowed for a quick and accurate measurement of burn rate at atmospheric pressure.

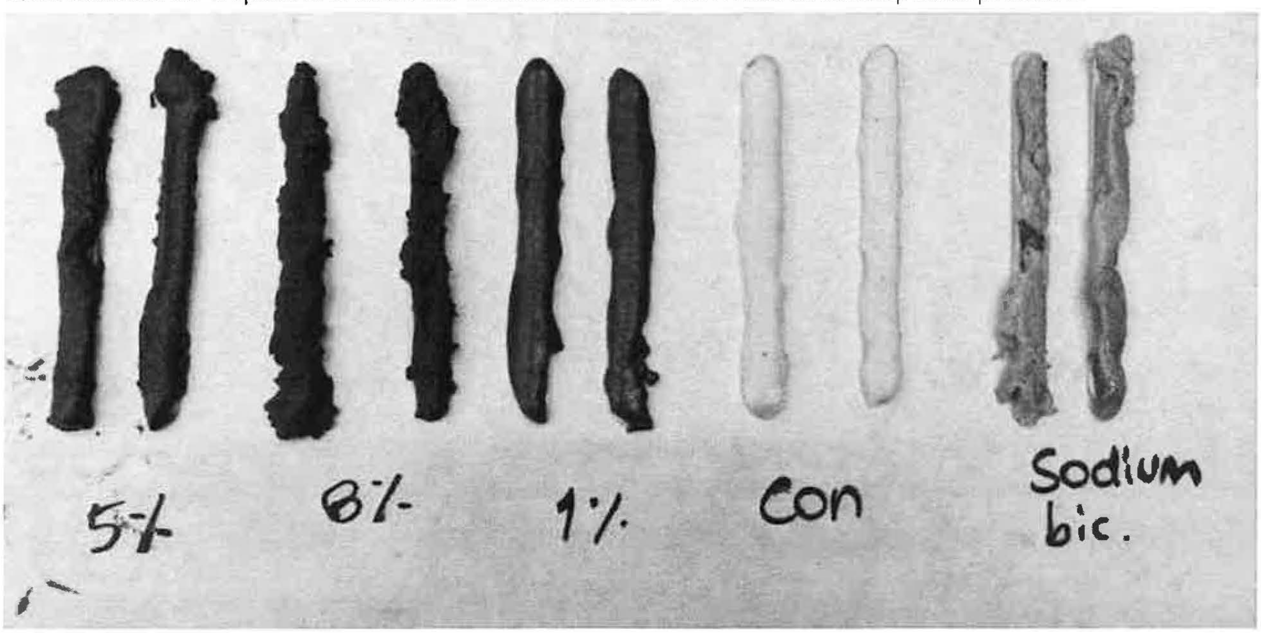


FIG 3: Strand rate samples

A series of single use PVC motors were developed to test the propellant formulation as a function of pressure. The pressure could be varied by changing the diameter of the nozzle throat. The motor design called for the propellant to run at very low pressure (~250psi).

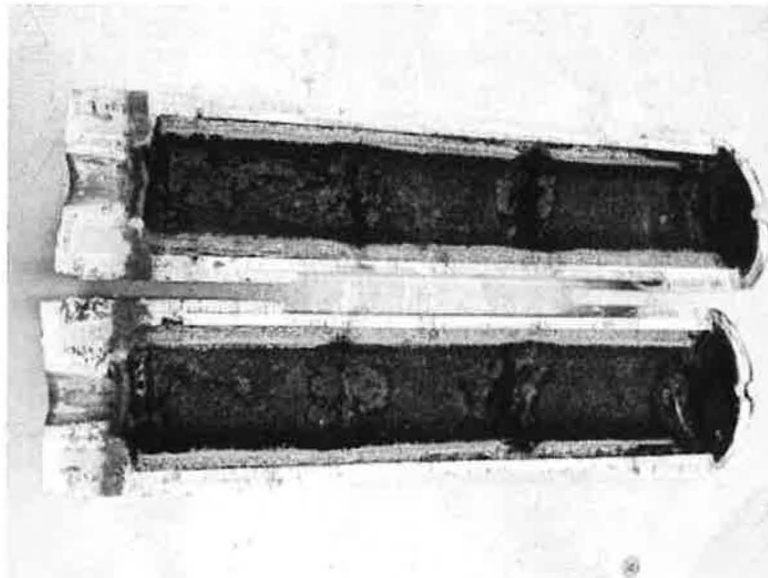


FIG 4: Completely burned Propellant

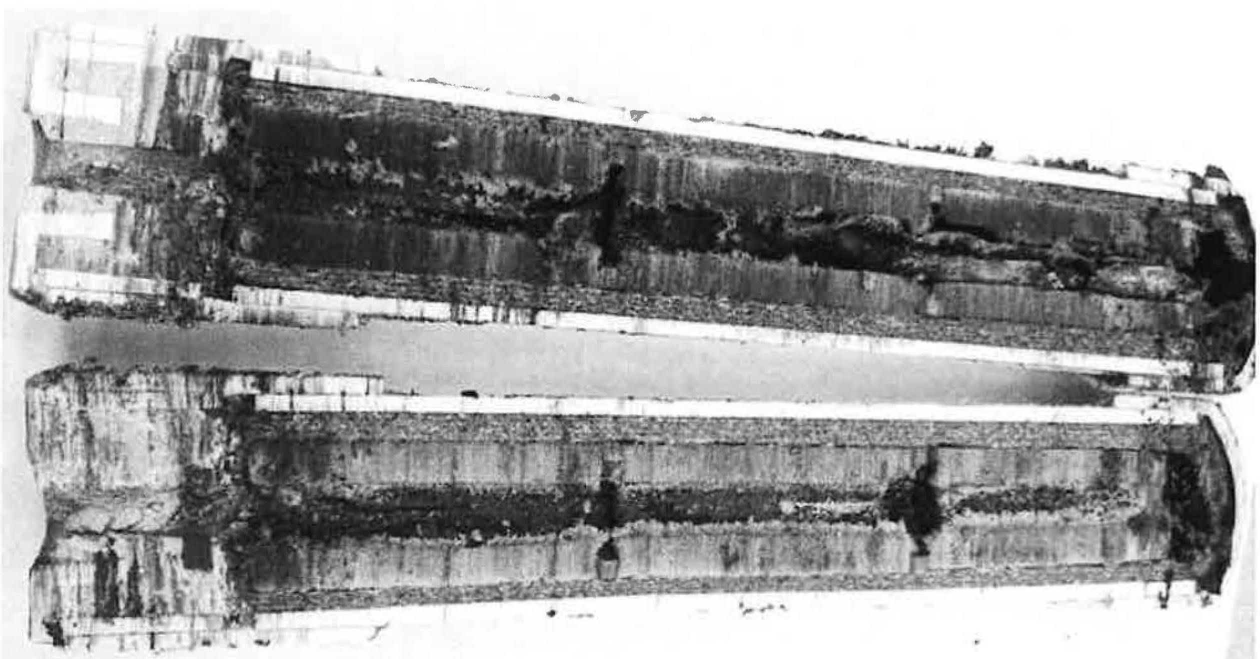


FIG 5: Propellant had an excess of plasticizer and did not burn completely.

Based on the testing completed, a formulation of 65% KN, 34.9% Sb, .09% FeO3 and .01% glycerin as selected. This resulted in a stable burning propellant at low pressure with excellent pourability. An added bonus is that the propellant is water soluble so that cleanup of is easy and reuse of components just requires soaking them in water.

Fig 6: Prepping a motor to fire again after test fire. The wonder of a water soluble propellant.

Early Work Launching the KNSB Propellant Formulation:

The propellant formulation was tested on several scale rockets. I attached a camera to the side of the test rocket below to capture a nice aerial view of the test site.

In repeated tests, the propellant met our expectations as it was easy to manufacture, had good performance and was inexpensive to produce. Shown below is a long burn low pressure test rocket using the KNSB formulation.

Static Testing:

Instrumentation Development:

A motor is characterized by collecting pressure and force data and derive a set of fundamental measures from test quantities and the mas of propellant. The techniques that SS2S used needed updating to reflect modern electronic data acquisition techniques which led to the development of a series of load cell plates which were fabricated to match the different sized test motors used by SS2S. Initially I developed a wireless digital load cell readout system that fed data to a cellphone app. This was used for the first four static tests. After losing data due to link integrity failure, I designed a wired replacement with a higher resolution analog load cell amplifier and data acquisition system. The load cell shown was designed for the large 8" SS2S motors and the 12" US rockets motor. This load cell has a capacity of 50,000N and used all twisted pair differential cables shielded with Kevlar to protect it from excess heat.

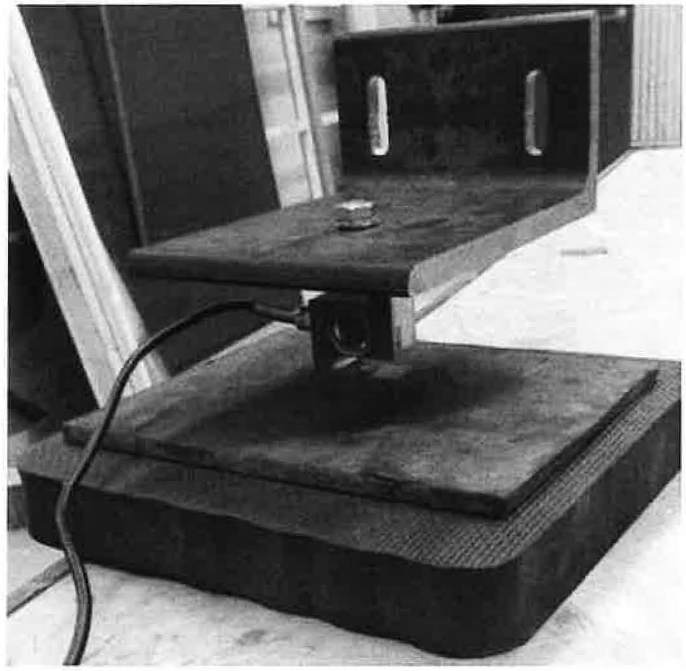


FIG 1: 50000N Load Cell

Pressure data was read out using off the shelf 1500 PSI pressure transducers packed with high pressure grease. These had a built-in amplifier and were interfaced to the same analog system used for the load cells. The pressure transducers were easy to move from one test motor to another, but their connectors were not rated for the elevated bulkhead temperatures associated with many of the tests which meant they required frequent replacement.

FIG 2: 1500PSI Pressure Transducer

Small Scale Tests

Any new propellant needs to be characterized experimentally prior to use in a flight vehicle. This led to a series of small-scale tests over several months to investigate the following questions and related questions.

- Characterize burn rate parameters
- Motor thermal and stress analysis
- Propellant temperature burn-rate dependence

To facilitate these measurements a series of small motors were fabricated and used to complete dozens of tests over a four-month period.

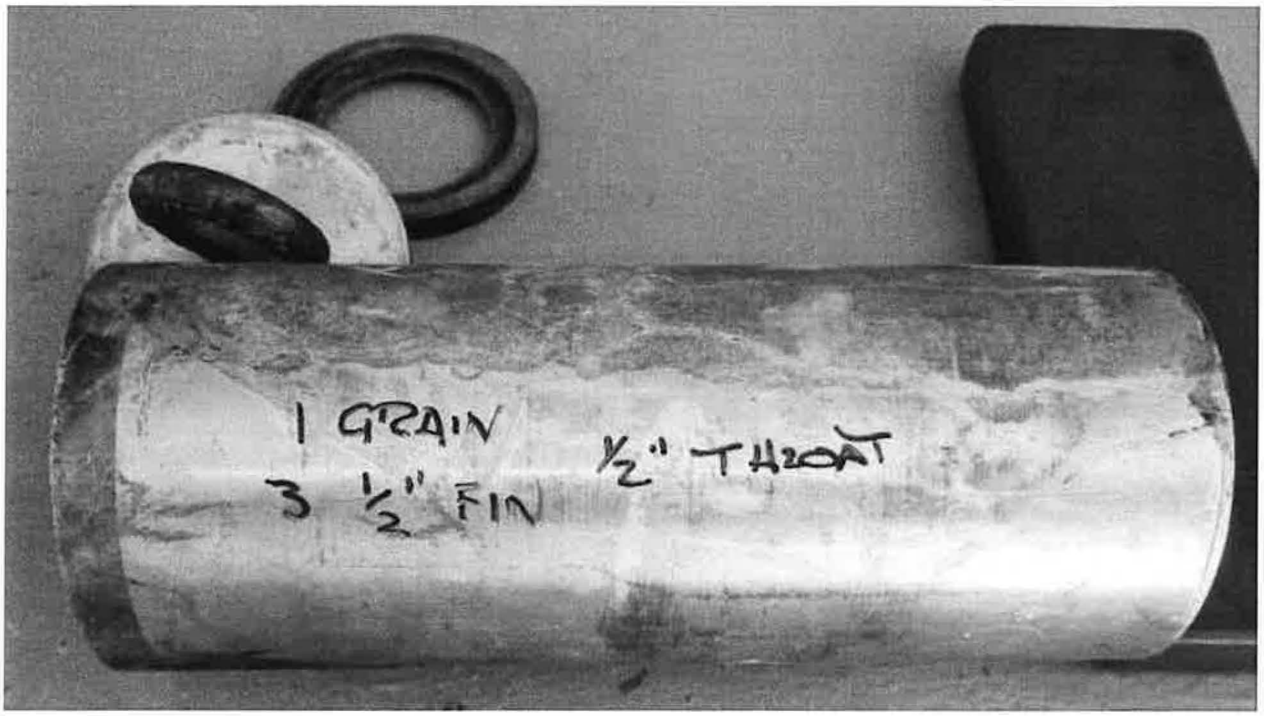


FIG 3: 4" Test motor

For each test the motor was designed so that the nozzle would eject if the motor over pressurized. The nozzle was staked to the ground with a chain to prevent it from traveling any substantial distance. The motors were fired nozzle up so that in the event of failure the motor would be pushing into the ground. In this picture you can also see the SS2S test stand with some instrumentation on the left hand side.

FIG 4: Static Motor test stand

FIG 5: Static Motor Test

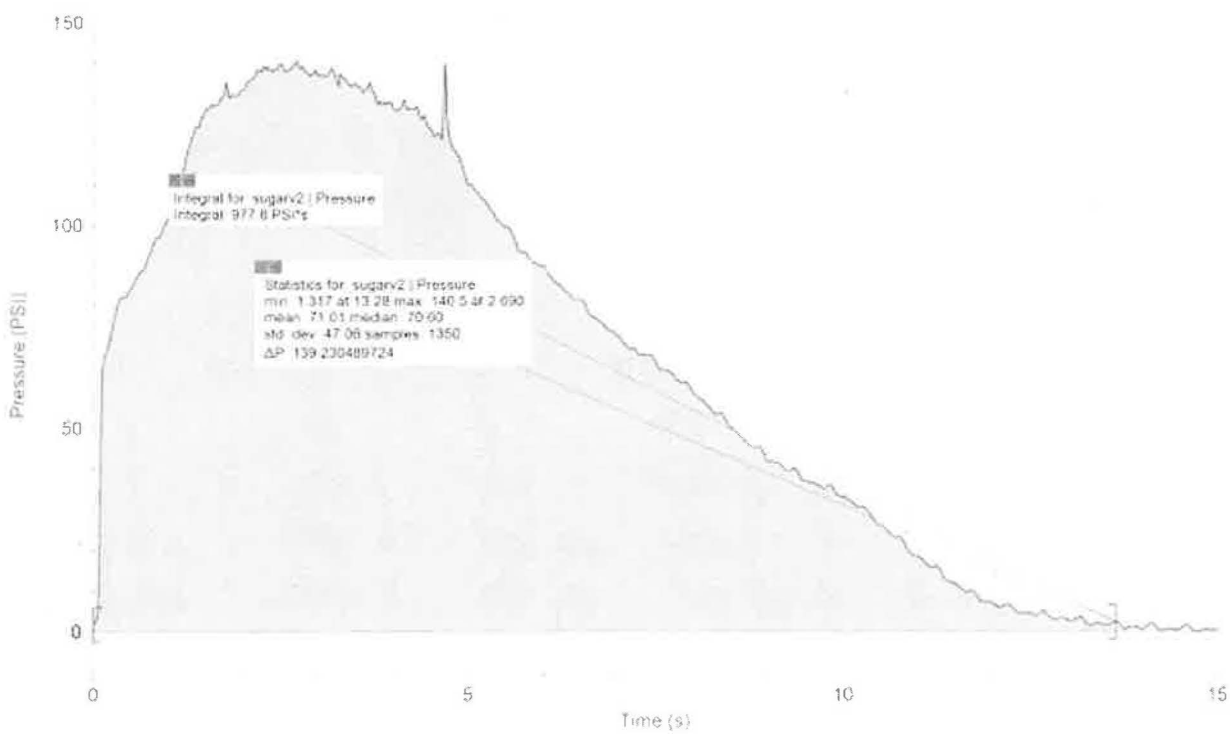


FIG 6: Pressure Transducer data from static test

Full Scale Static Tests

To manufacture full scale 8" diameter grains, I designed a fabricated a series of jigs to hold the casting tubes and cores. The cores were made from a variety of materials including polyethylene, and aluminum wrapped in polyethylene tape. Since each grain would weigh approximately 40lbs, the casting tubes needed support to keep them circular so that they would fit into the motor after casting. A number of iterations were performed with the ultimate version using laser cut acrylic top and bottom plates for ease of removal and laser cut wooden stands to support the casting tube.

FIG 7: Grain casting jig

While most of the grains would be cast and stored at the test site in Mojave, occasionally it would be necessary to transport grains between locations. A Low explosives transport magazine was fabricated along with the appropriate vehicle signage to allow propellant grains to be transported. I completed the application for a low explosive user permit and a low explosive manufacturer's permit, but due to COVID-19, no new permits were being issued.

FIG 8: Low explosives transport magazine

The design of the motor used called for tapered grains. In the early static tests this was accomplished by using cores of different diameter and then stacking the grains with the largest diameter core at the bottom. The reason for the tapered core is that that mass flow rate is the largest at the bottom, and insufficient core diameter could lead to over pressurization and premature motor failure. The figure at right shows the grain stack for the full-scale static test.

The motor was assembled using a jig to precisely align the grains onto the nozzle plate. Once the grains were aligned, they were tensioned, and the forward bulkhead was installed. The assembled motor is shown at right. This motor contained 137 lbs. of propellant in four grains. The forward bulkhead was one inch thick 6061 aluminum with a single pressure transducer port. A 304-steel nozzle plate was used with a 4x1 expanding nozzle tig welded to the bottom. One-inch-thick aluminum retaining rings held in the forward bulkhead and the rear nozzle plate with ¼-20 hardware. The hardware was designed so that the nozzle plate would blow out in the case of over pressurization.

FIG 8: Assembled Static Test motor

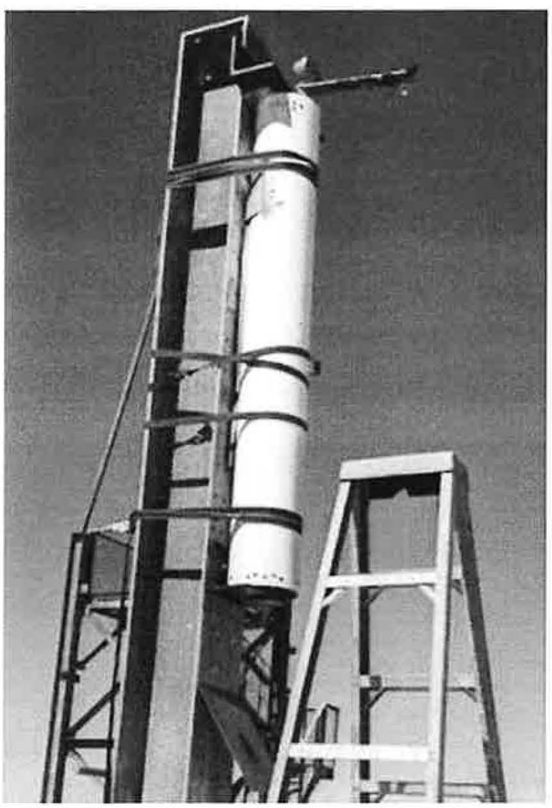


FIG 9: Motor on test stand

FIG 10: Motor Ignition

FIG 11: Static Motor failure

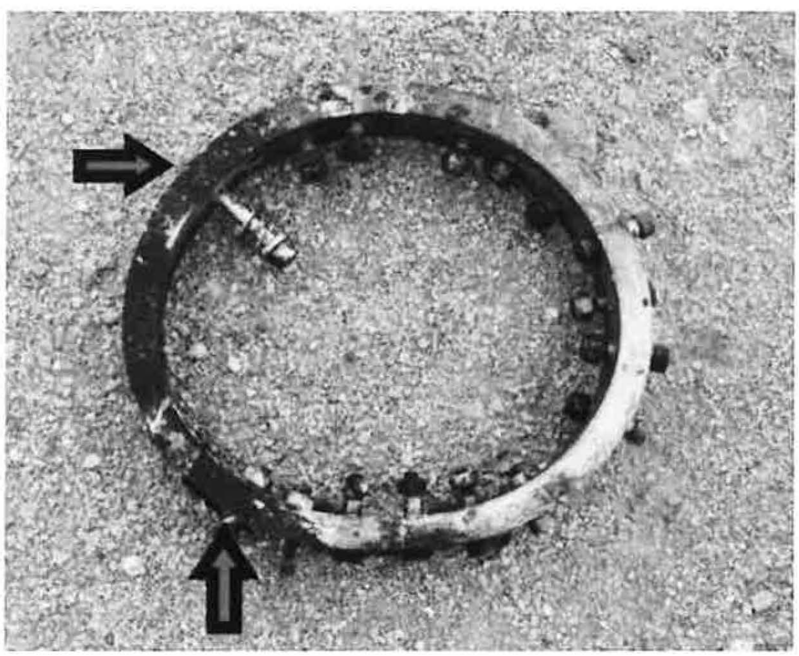


FIG 12: Motor Failure diagnosis, retaining ring retention failure

The first two full scale static tests failed in a similar way. In the first case, the motor retention hardware was undersized with an insufficient safety factor. In the second case, the nozzle plate o-ring did not seal adequately. Fortunately, in both cases, the nozzle support plate blew out as designed and the motor was otherwise undamaged. Unfortunately, the test stand was damaged in the second test which necessitated length repairs as discussed in a subsequent section. A decision was made to test the motor in ground and nozzle up. Nozzle up testing is not preferred because the solids can't exit the motor and there is hot slag left on the forward bulkhead which makes motor reuse more difficult. In the image at right we dug a hole and buried approximately five feet of the motor underground.

FIG 13: In ground nozzle up static testing

This static test was successful and while we could not obtain force data (since there is no place to mount a load cell when the motor is underground) we did obtain excellent pressure data. The propellant was running at low pressure with reasonable performance. At this point we could progress to flight tests.

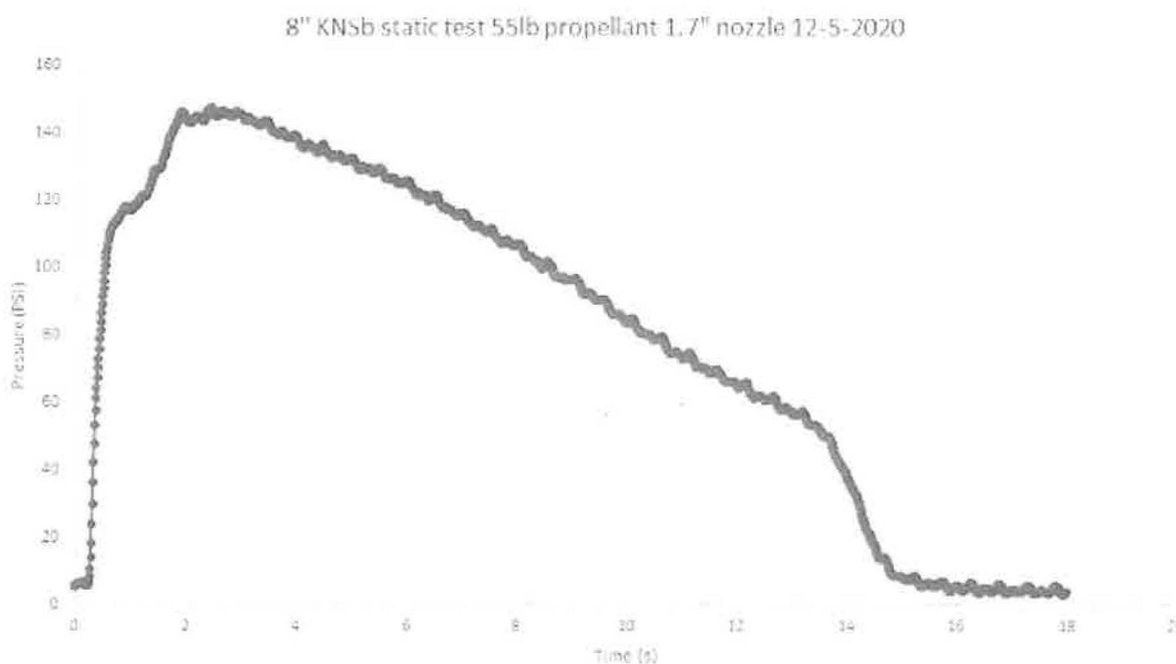


FIG 14 Pressure transducer data from 8" Static test

Launch Facility Maintenance and Upkeep

As SS2S is a heavy user of the test site, and we had damaged some test site infrastructure, SS2S was asked to repair infrastructure. The SS2S team requested permission to locate a new launch rail (See next section) and a static test rail to support future tests.

I had the opportunity to repair one of the static test beams that the SS2S team had damaged in one of the tests discussed previously. A 50000 lb. miniature hydraulic cylinder, clamps and a rosebud torch were able to get the damaged I-beam back into shape.

In addition, I completed repairs on a large flame bucket that was damaged by another of our tests with the repaired version shown below.

FIG 1 Test stand under repair

FIG 2 Repaired flame bucket

Launch Rail Development:

The launch facilities at the test site range in capacity from 10lb to 400 lbs. The typical rails that are used for testing have a 100lb capacity. With the design of the full-scale rocket weighing in at 500 lbs., the SS2S team was concerned that the existing launch rails would be insufficient. In addition, the high-capacity rails are complicated, difficult to setup and costly to repair in the event of a failed launch. The decision was made to design and fabricate a simple high-capacity rail based on the Newman design used for the 100 lb. rails. The design with a preliminary model of our full-scale rocket is shown at right.

FIG 1 Design of launch rail

Surplus steel was obtained, and I completed the fabrication during Dec/Jan 2021. The rail was designed to be truck portable with a base launch rail of 20 feet with an additional rail extension of 10 feet. The rail was installed at the test range at the end of Jan 2021 and used for the remainder of the SS2S launches. Planned upgrades include replacing the manual screw jack lift with a hydraulic cylinder and moving the pivot forward to increase the lifting moment arm.

FIG 2 Launch rail as fabricated

Development of Avionics (Deployment and Tracking)

The state of the art in avionics (the electrical and software systems that know the state of the rocket and trigger events during a flight) has moved quickly in the past decade. The avionics that SS2S were using were circa 2010 and required an avionics bay that was six inches in diameter and eighteen inches long, adding substantial weight and drag to the project. I iterated through the design and fabrication of 6 different avionics boards, until finally setting on one that was 1.6 x 2.6x 0.5" and weighed 24 grams including the telemetry backpack.

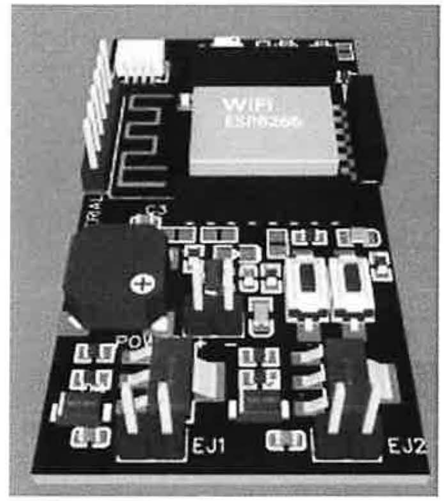


FIG 1: REV 6.0 of SS2S Avionics Board

A thermoplastic polyurethane (TPU) case was designed a fabricated to accommodate the board and a rechargeable battery suitable for 3 hours of run time. This case was designed to clip onto the recovery harness of the rocket and included a facility to attach a reflective mylar streamer so that the avionics could be recovered separately if the rocket failed catastrophically (something that happened often during the year of testing).

FIG 2: TPU case for SS2S Avionics Board

As rockets often land far from their launching point, I developed a series of GPS tracking boards with telemetry to provide real time location information on the rocket for tracking purposes and as a check for the altimeter-based avionics. One of the major challenges with this design is that commercial GPS units lock out at 59,000 feet or velocities of 1200 mph. I worked with a GPS manufacturer to implement these limits in the way defined by COCOM so that the GPS would not consistently drop out shortly after launch when the velocity exceeded the limit. I went through four board revisions before finalizing on a 2.5" x 1" by 1.4" package. Again, a TPU case was fabricated to accommodate a board, battery and recovery streamer.

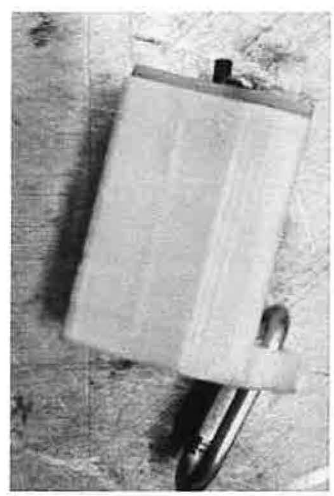


FIG 3: SS2S GPS in TPU Case

To receive all the telemetry data from the Avionics and GPS system, ground station software was written, and a ground station was fabricated. The LORA telemetry protocol was selected, and I worked with two Chinese module fabricators to obtain boards that would meet project needs. After substantial iteration, a 433MHz Patch antenna and a 900 MHz patch antenna on magnetic tilt bases proved effective in the field with the LORA modules. Data Integrity was maintained for ~8 miles with ground station tests going from the top of buzzard peak to the Lowes in West Covina. In flight the modules proved to never run out of range returning data from up to 12 miles away.

FIG 4: Mason testing ground station

The avionics and GPS systems were tested in multiple flights using commercial motors in collaboration with the Mojave Desert Advanced Rocket Society (MDARS). I joined MDARS and did a total of 7 test flights using their launch rail out of North Edwards. The final form of the avionics and GPS performed well, and data was recovered even in the event of a ballistic recovery.

Complex flights such as those planned by SS2S require multiple stages. One of the more challenging aspects is how to know when to fire additional stages after liftoff. In particular, a second or third stage should only be fired if the rocket is within its nominal flight profile including the altitude and attitude of the rocket. If a stage is fired when the rocket is tilted over at a significant angle, then the rocket could leave the cleared airspace and be not just a in violation of its FAA waiver, but a danger to populated areas. In this avionics system we measure altitude two different ways, one using a barometric pressure sensor and the other using a GPS. A complementary filter is used with the GPS and barometric data to obtain an accurate altitude. From

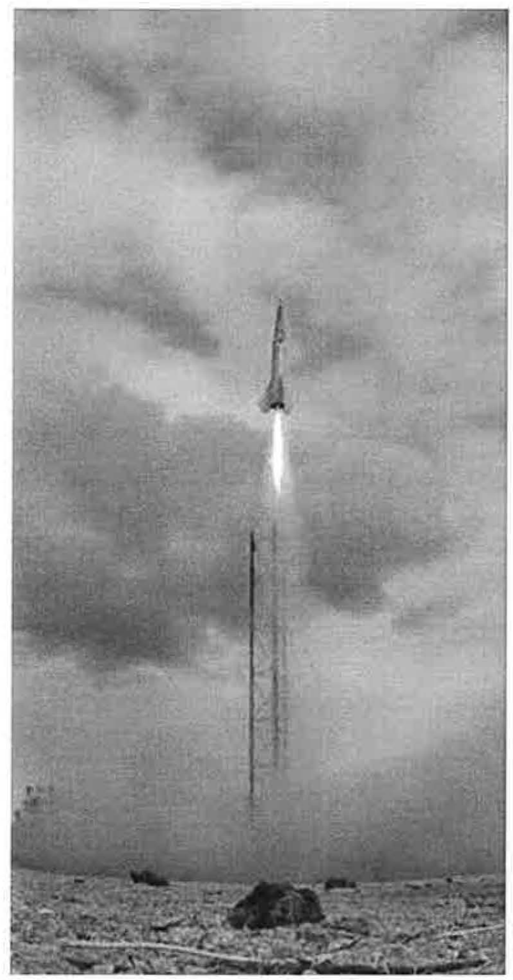


FIG 5: Avionics and GPS Flight test

the time rate of change of these sensors we can get a measure of velocity. Velocity and altitude requirements must be met for stages to be fired. For this to work there needs to be good correlation between the measured GPS and barometric data so a series of flight tests were made to create error models for the sensors. The graph below shows the results of one such test as well as integrating an onboard accelerometer as a third method of determining altitude.

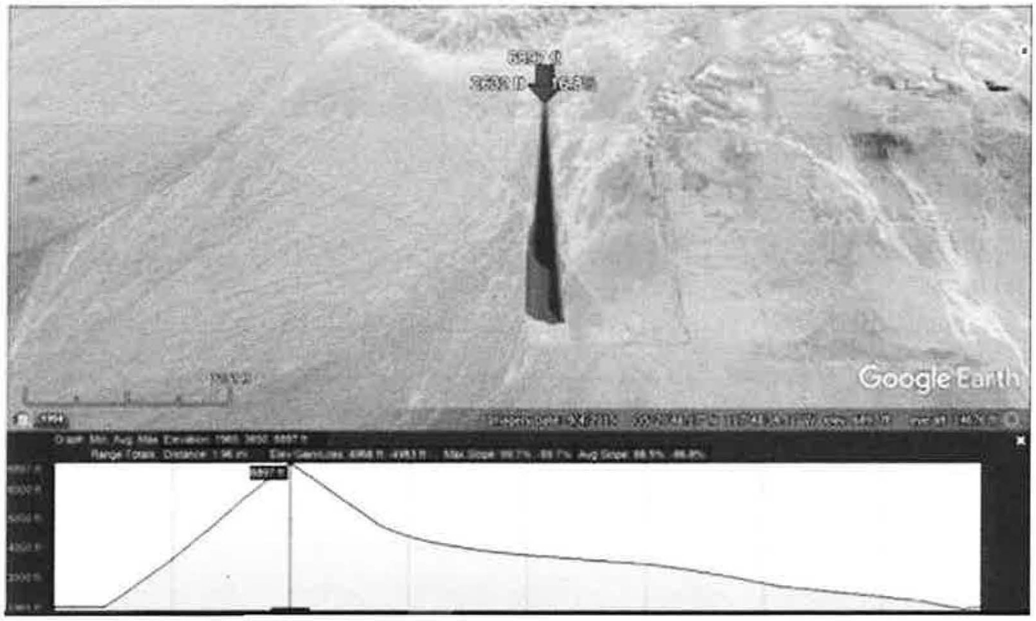


FIG 6: Ground station software

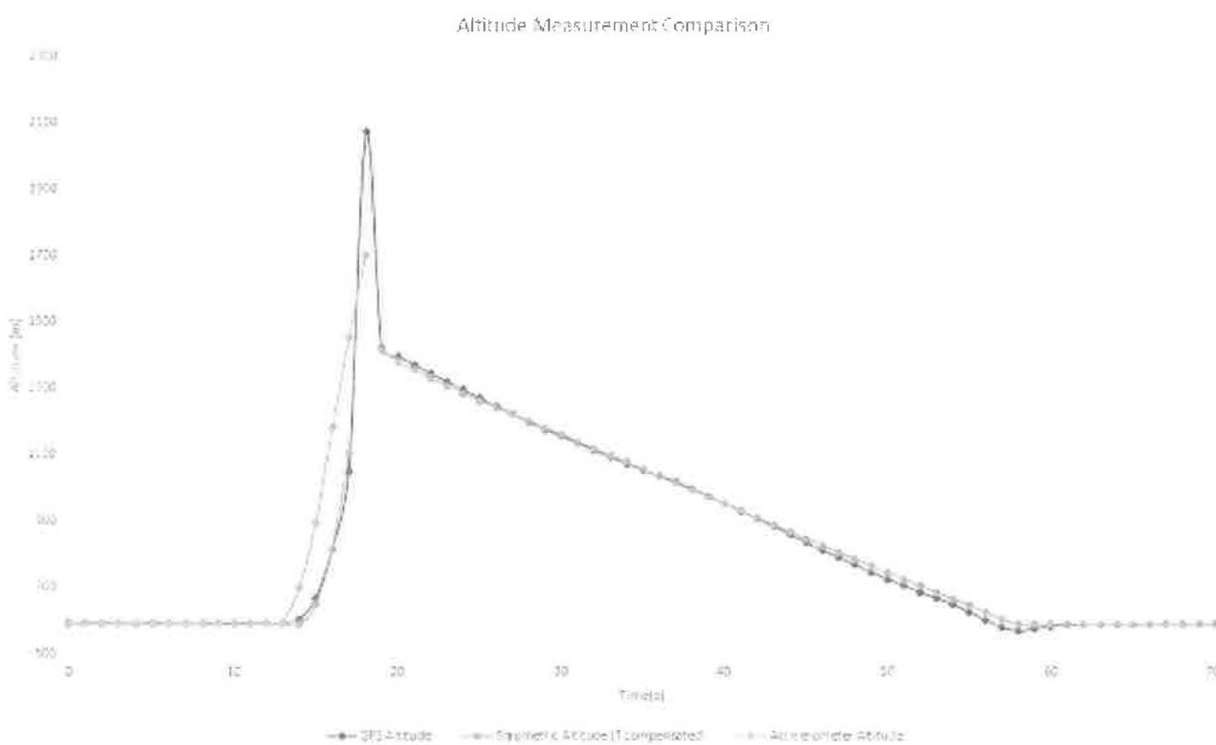


FIG 7: Avionics and GPS Altitude measurement comparison. Note GPS lockout at ~1300m.

8" Short Motor Test

After 7 months of testing and development the SS2S team decided to implement what they had learned in a test flight. The motor case that had been used for all the static tests might still have some life left in it, so the decision was made to design a flight rocket around that case. A 8 cell finocyl using nylon sheets would be used to increase thrust at lift off. This would also provide a further test bed for the avionics and recovery hardware that was developed for the 100,000 ft flight.

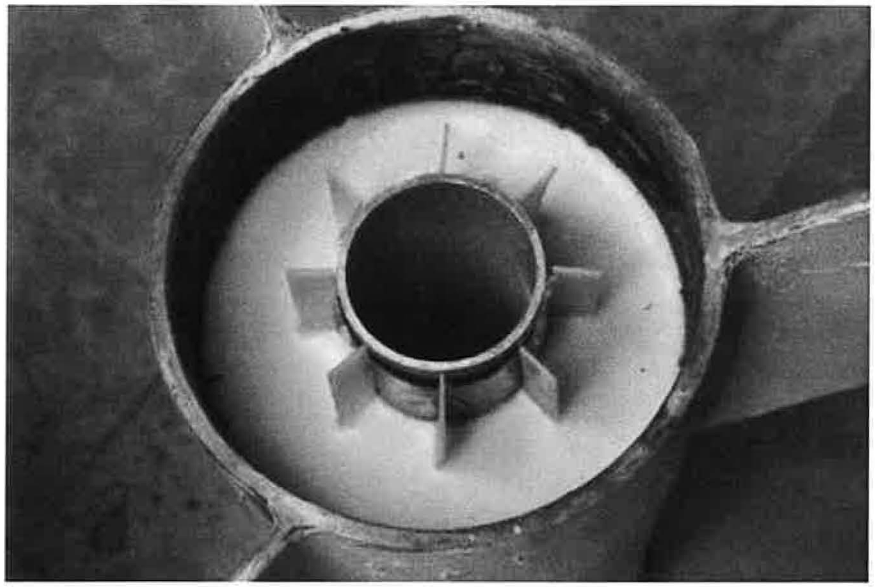


FIG 1: 8 fin finocyl grain with nylon strips

A commercial 8" nose cone was used, and I designed and fabricated a transition that would also serve as a recovery bay with an integrated side looking camera. I cut the fins from surplus phenolic and used epoxy modified with glass fibers to bond them tip to tip to the motor.

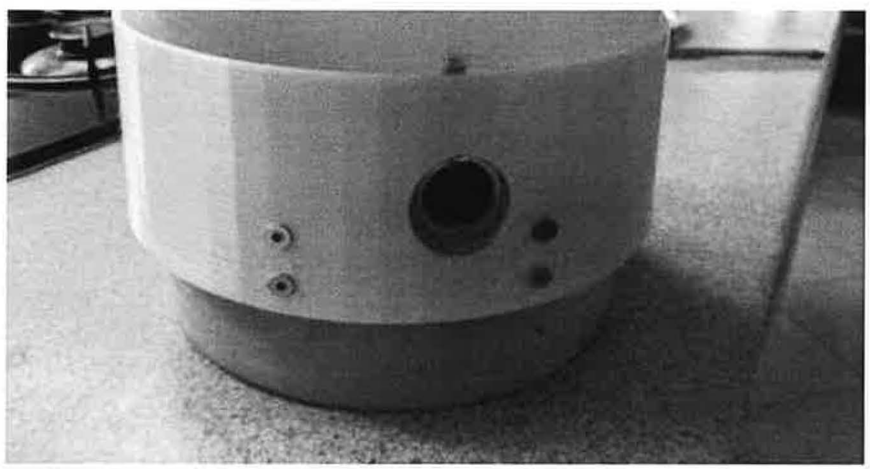


FIG 2: TPU transition with integrated camera

This would also be the first use of the SS2S launch rail described in a previous section, so custom nylon hardware to mount the rocket to the rail had to be designed and machined. This hardware was to go on to be standardized for future flights and prove robust in a variety of circumstances.

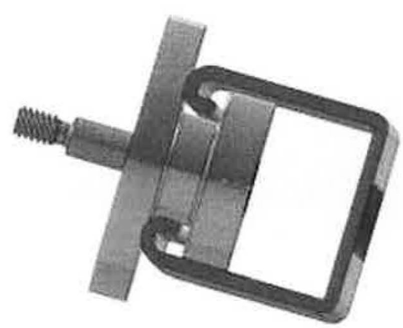


FIG 3: Launch lug design

After 3 days of pouring grains and assembly the rocket was prepped on the pad. At only 78 lbs. it was light enough that several people could mount it on the rail. There had been several challenges in the assembly. The nylon fins did not want to debond from the propellant and there had not been sufficient provision to remove them. A great deal of stress was placed on the grain and micro cracks were observable at the grain surface. During the mounting process there was concern that the grain had cracked. A cracked grain provides a much larger burn area and means that it is likely that the motor will over pressurize. In addition, this case had been used for multiple tests and was showing signs of delamination. With some concern the group decided to proceed but moved to underground bunkers some distance from the launch pad to observe the launch via remote video.

FIG 4: Short 8" motor on the launch rail

FIG 5: Short 8" motor launch test result

Propellant Revision for Flight: Finocyls

After substantial review of the static test data for the 8" motors, it was determined that there was insufficient thrust off the pad to insure a safe flight. A primary safety criterion for flight is the thrust to weight ratio of the rocket. The rocket needs to be going fast enough when it leaves the rail for the fins to contribute to moving the center of pressure back far enough for the rocket to fly straight. The SS2S team decided to move from straight cores to a finocyl core. A finocyl has a series of "fins" in this case circular sections off the central core. These fins give additional burning area and produce more thrust on lift off. While the team had used finocyls in their small-scale launch, there had been insufficient attention to detail on how to use and debond finocyl elements. A full investigation was warranted.

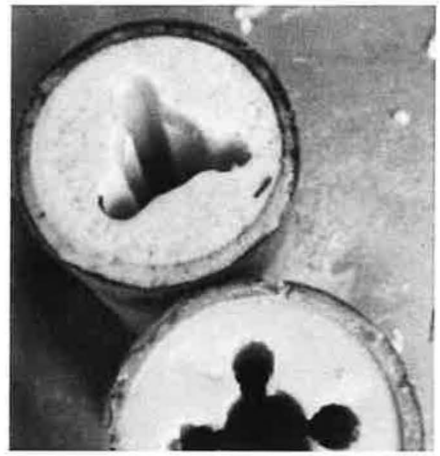


FIG 1: Sample finocyl grains

A challenge with finocyls is how to fabricate the fins without fracturing the brittle propellant. A number of test grains were made with many different materials including nylon, polypropylene, Teflon, polyethelene wrapped wood dowels. What ultimately proved most successful was to use threaded rod wrapped in wax paper and then wrapped in polyethylene tape. The threaded rods could be "unscrewed" from the propellant as is shown at right. Two sample finocyl grains are shown above.

FIG 2: Preparing finocyl grains

A modeling package for finocyl grains was obtained and models of both the 4" scale test grains and the 8" full scale grains were made.

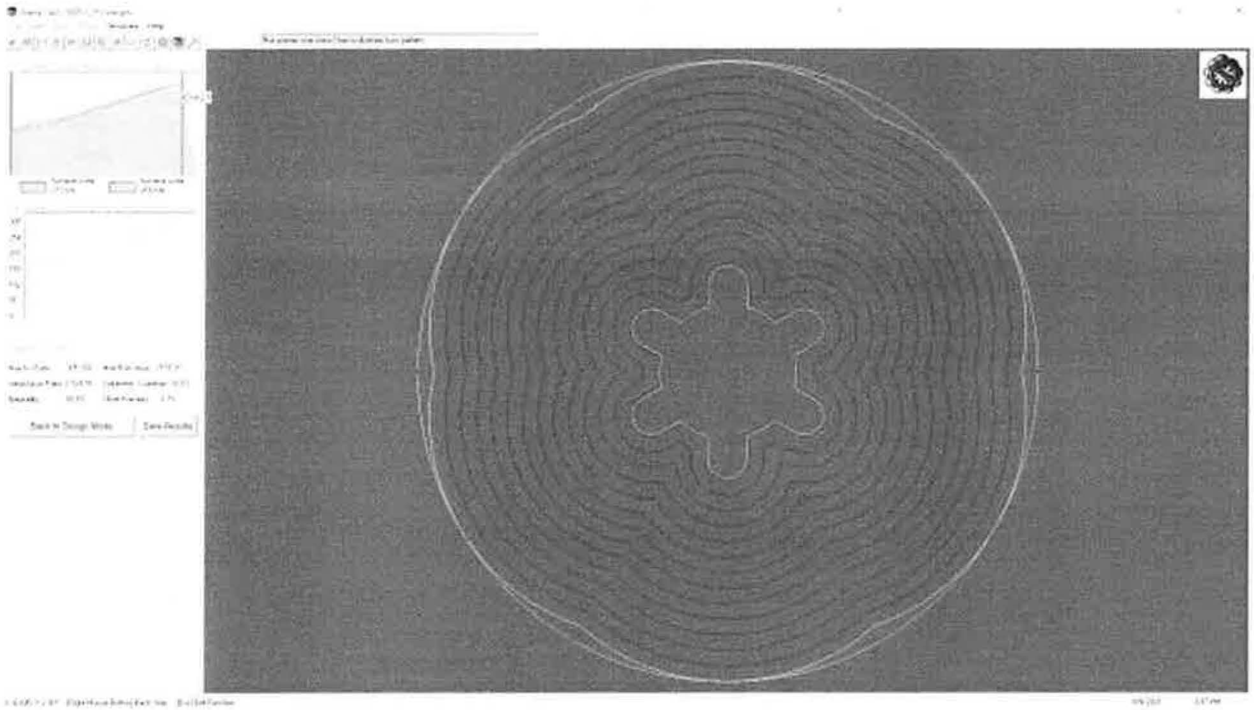


FIG 3: Finocyl burn modeling

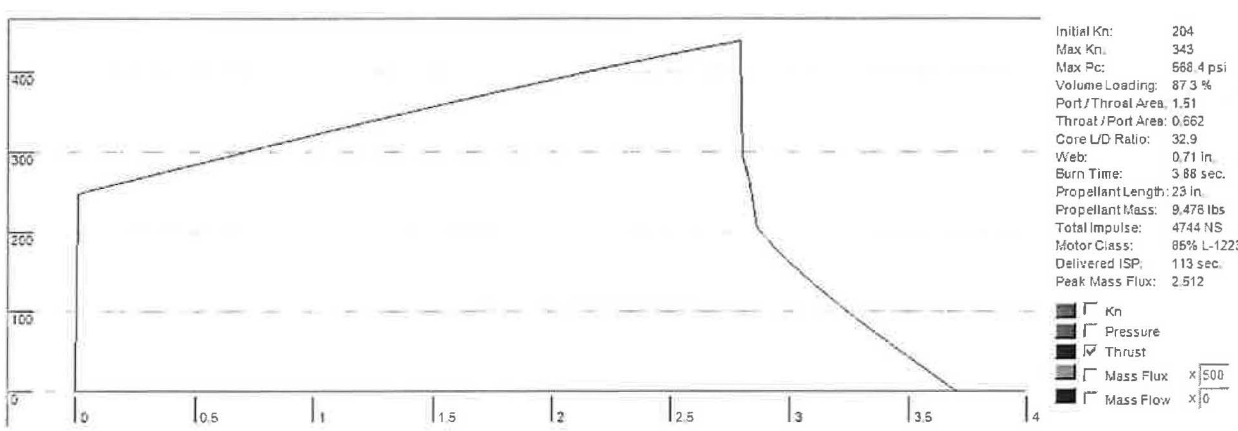


FIG 4: Finocyl pressure model for 4" test motor

A series of static tests were performed with both 4" finocyl grains and full scale 8" grains. These showed an improved initial thrust compared to our non finocyl grains and gave us the confidence to move forward to flight tests.

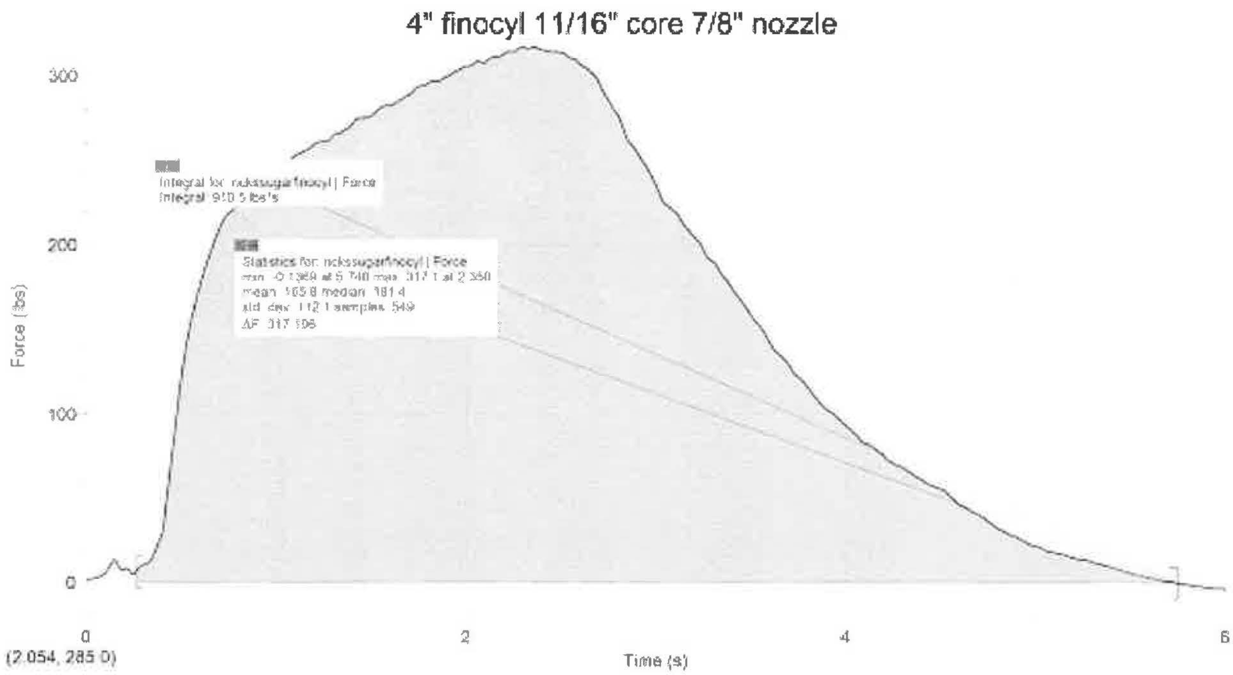


FIG 5: Finocyl thrust data for 4" test motor

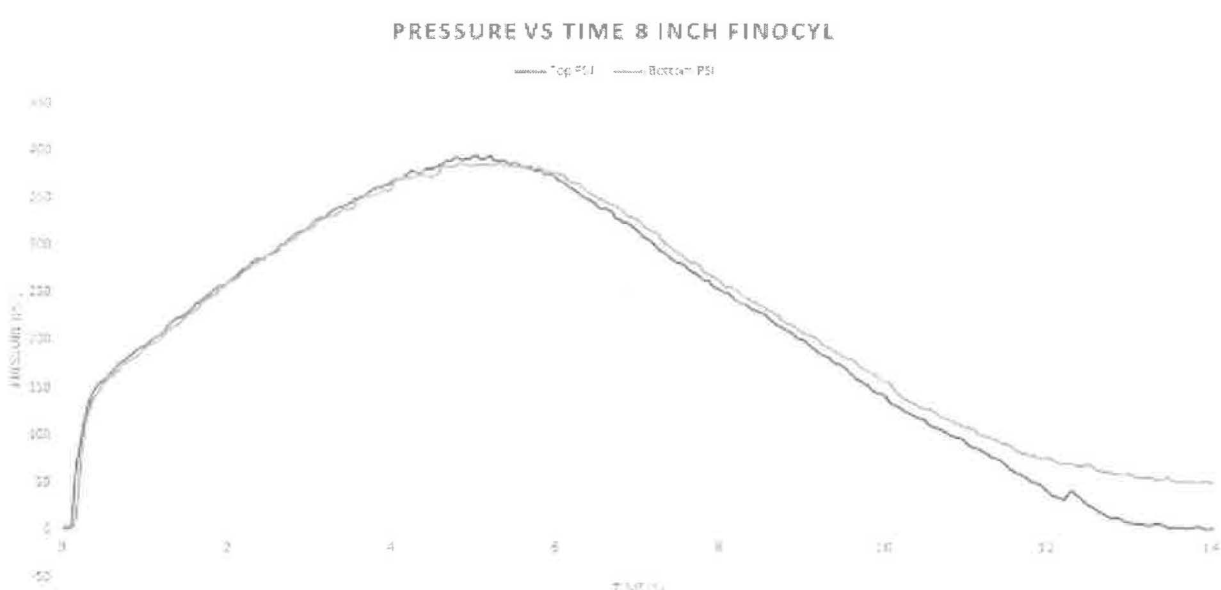


FIG 6: Finocyl pressure data for 8" test motor

Full Scale Launch

The team goal for the year was to launch a rocket above 100,000 feet for under $1000 in consumables. After some discussion the design was simplified to a boosted dart. A boosted dart uses a large booster with a small diameter heavy dart laden with instruments on top. The booster gets the dart up to high speed (over mach-3 in this case) and above as much atmosphere as possible and then separates from the dart. The dart is heavy and has a small cross section so can coast to high altitudes. The team decided to build a test dart to understand the separation electronics.

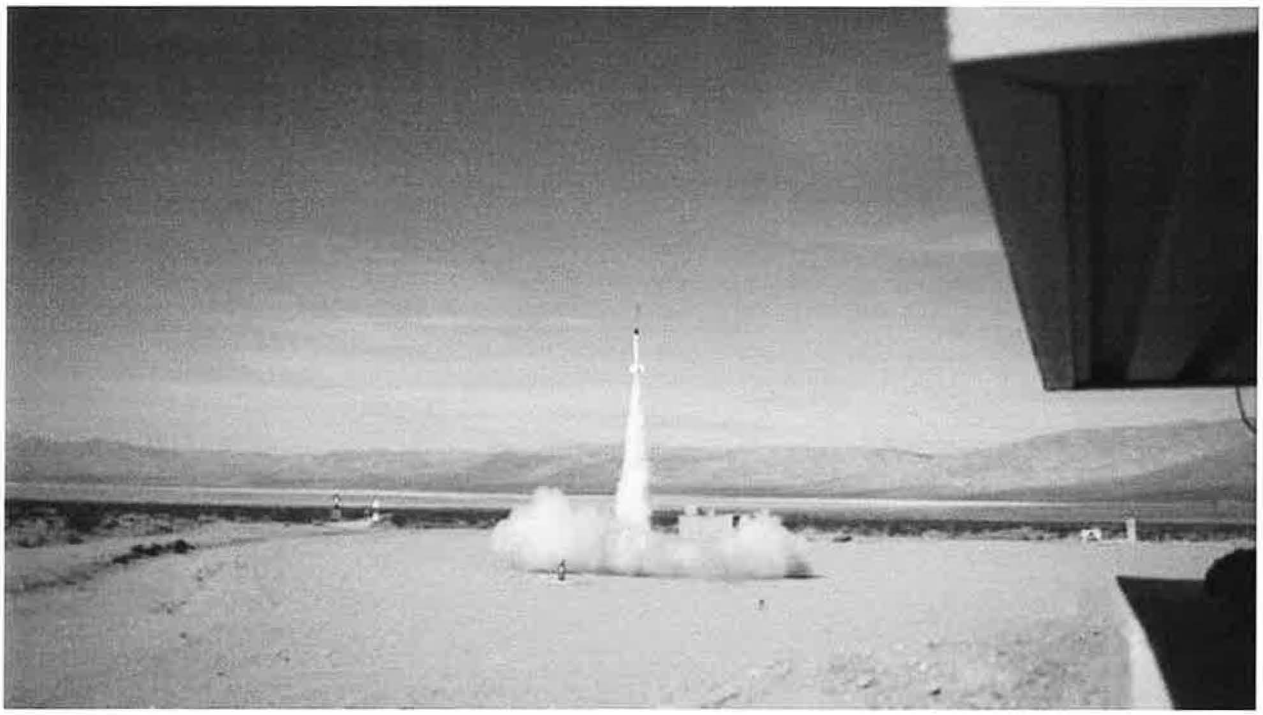


FIG 1: Boosted Dart scale test

After the half scale launch, it was clear that the technique used for casting the finocyls using the nylon strips was inappropriate. Additionally, the well-used tube was clearly not capable of holding the required pressure. After the test dart and the finocyl investigation were completed, the team moved forward with the full-scale launch.

FAA Waiver Request

Since this flight would be going into protected airspace (the flight was modeled at 100,000 ft) and using 221 lbs. of propellant, a full FAA waiver was required. Over the next month developed a set of monte carlo software for dispersion analysis and other software packages to meet the FAA I corresponded with the FAA over the course of six weeks to meet these requirements and eventually produced the waiver request shown in appendix 2.

Rocket Fabrication and Flight

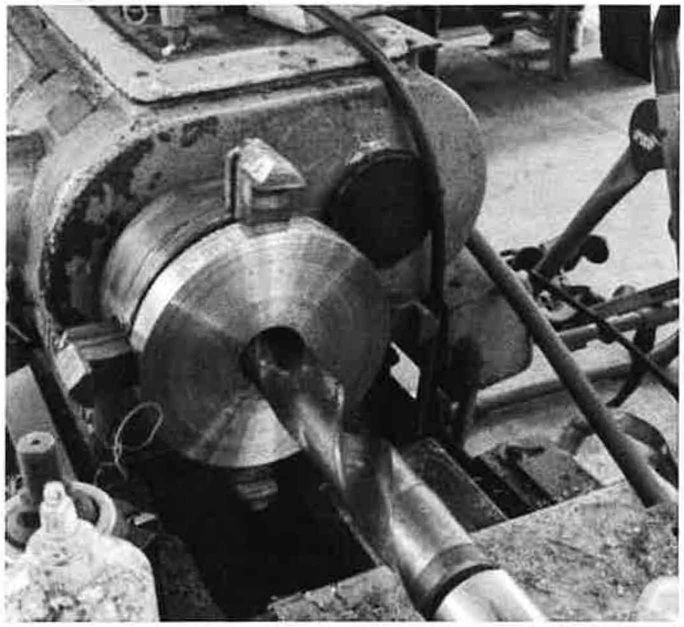


Fig 1: Fabricating a heavy-duty stainless nozzle plate

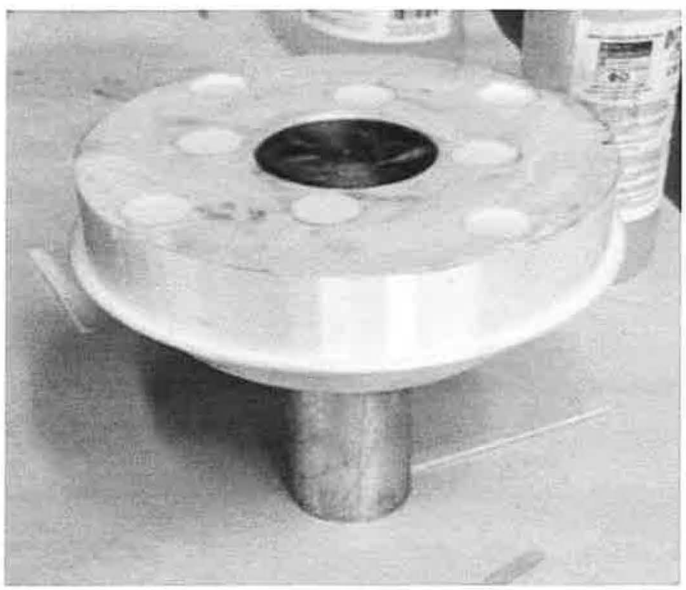


Fig 2: Casting a epoxy microsphere aluminum reinforced transition

Fig 3: Deflection testing the fins

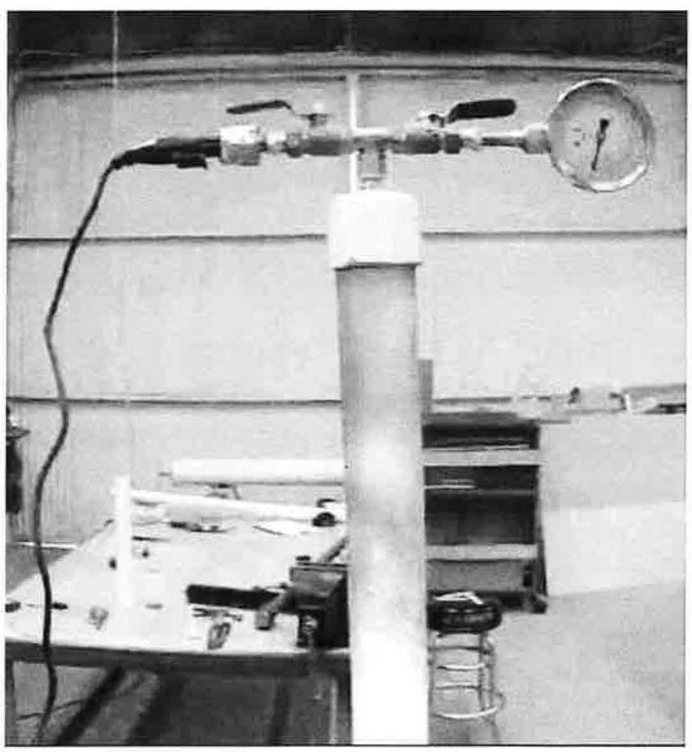


Fig 4: Testing ejection charges for function in near space environment

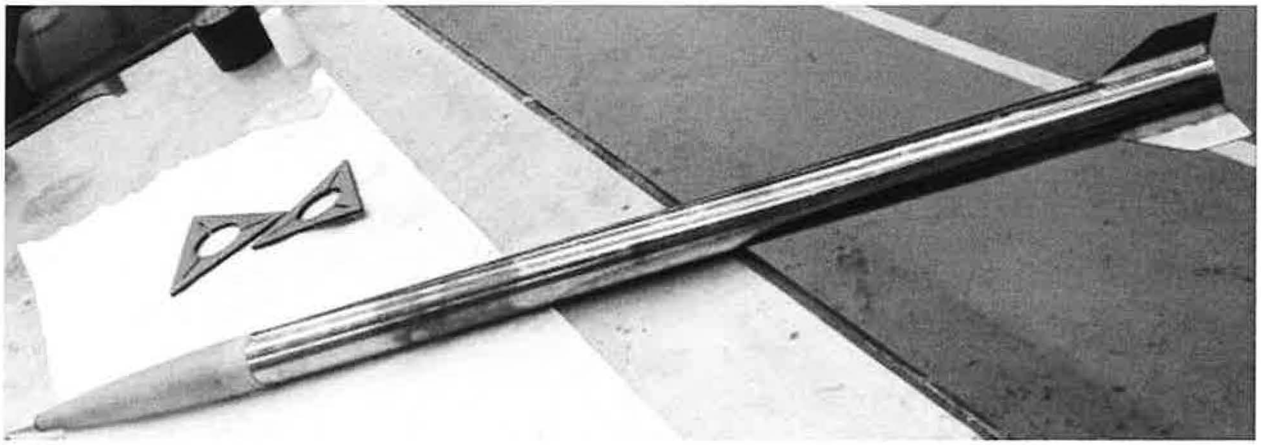


Fig 5: Boosted dart filled made of stainless tubing with tig welded fins filled with 17lbs of lead with radio transparent fiberglass nosecone.

Fig 6: Downward looking camera in dart

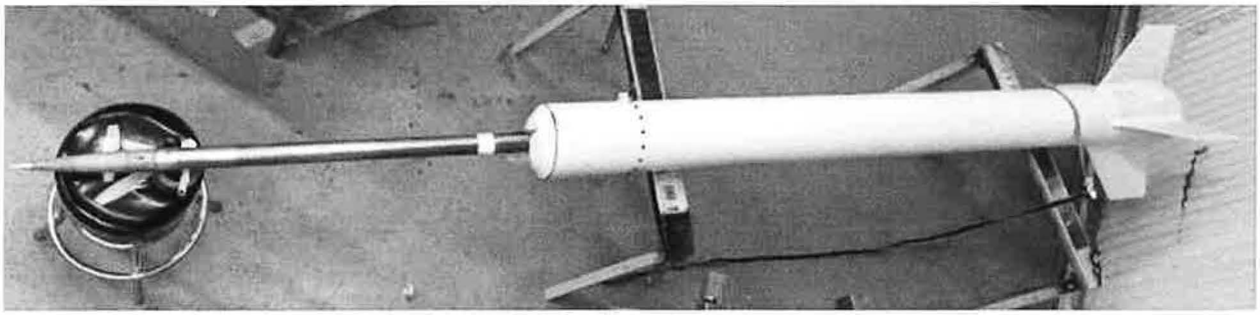


Fig 7: Test assembly of rocket and dart.

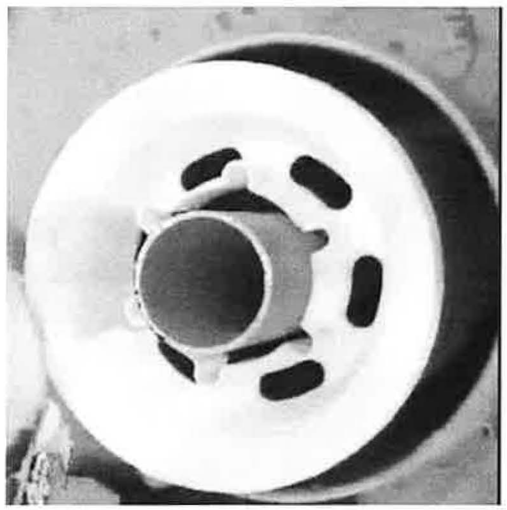


Fig 8: 3D printed pour assembly for case bonded grains.

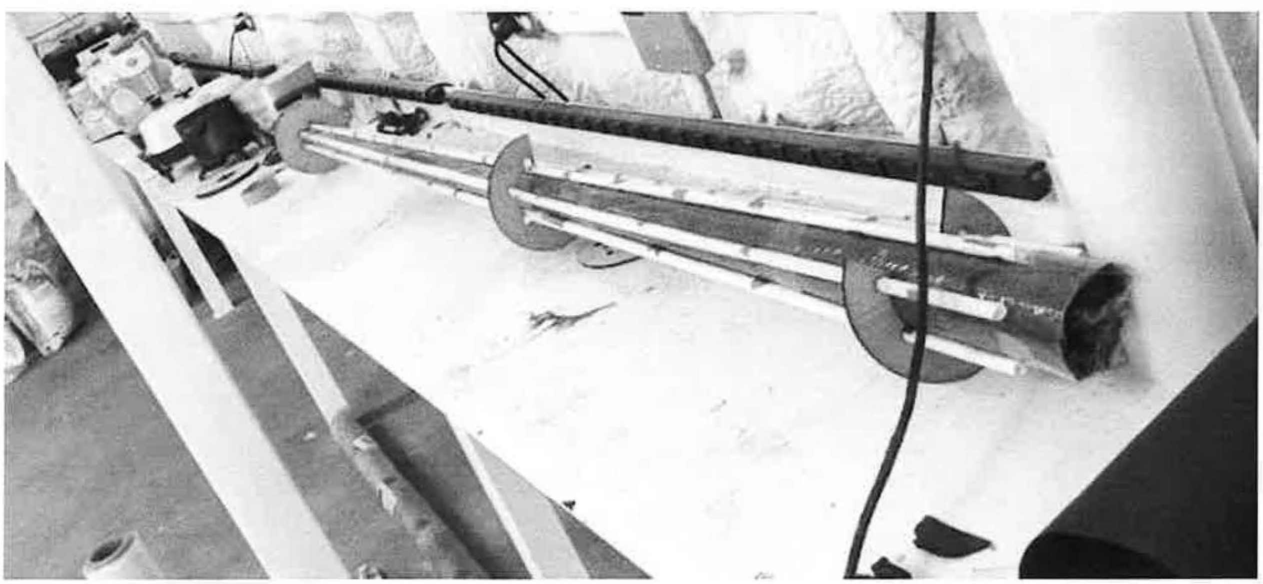


Fig 9: Finocyl assembly wrapped in polyethelene

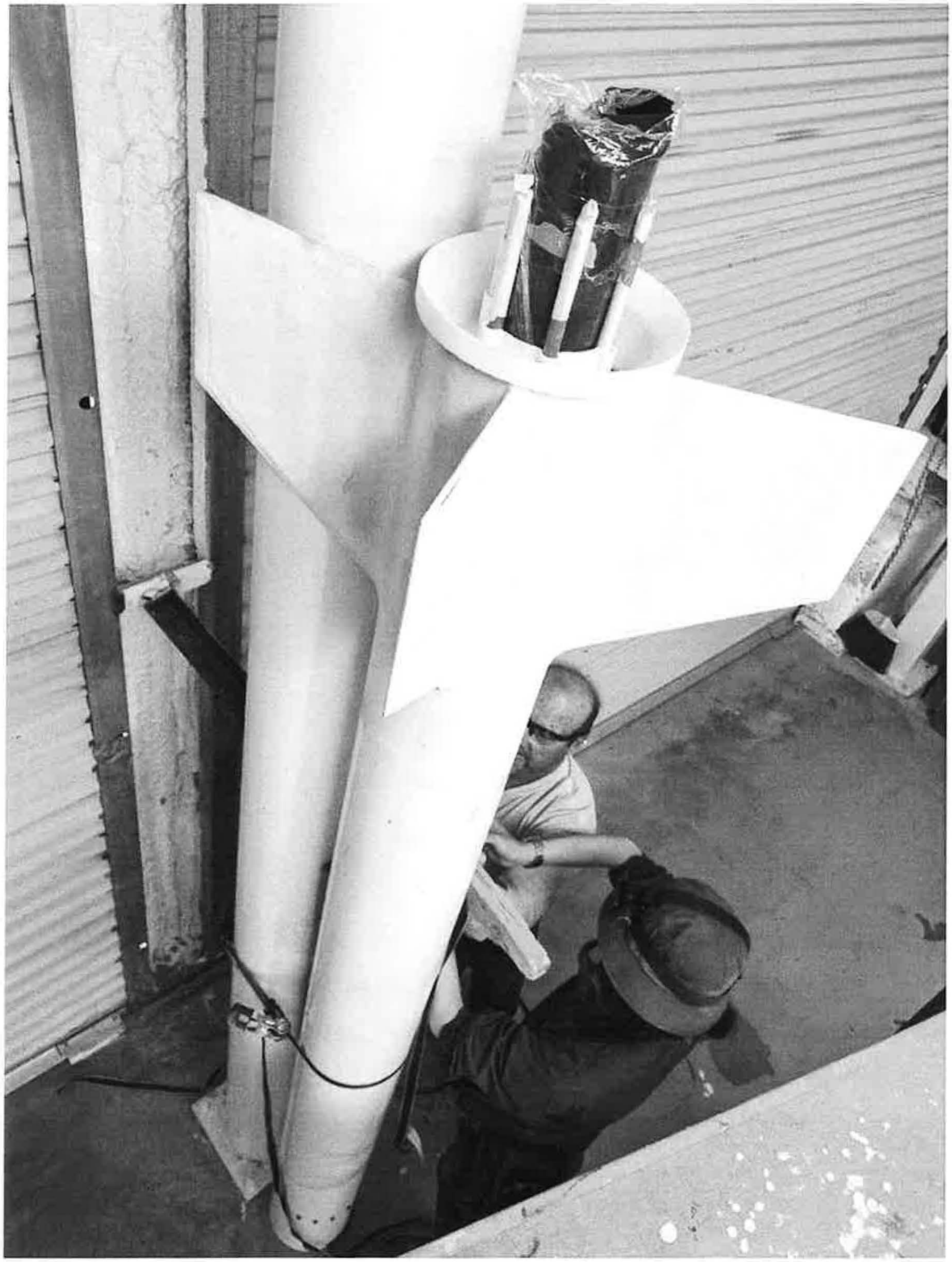


Fig 10: Finocyl assembly installed in tube for case bonding.

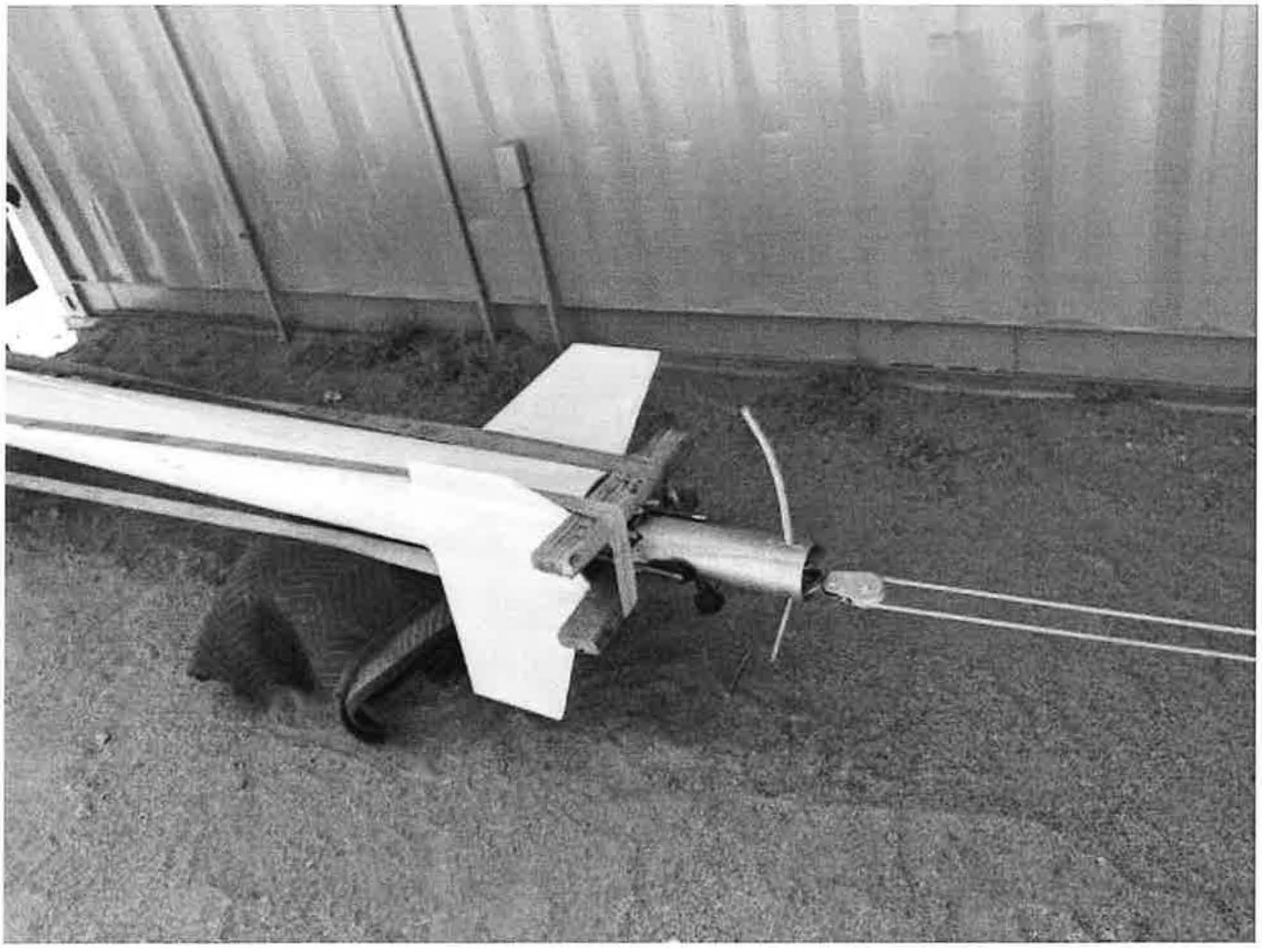


Fig 11: Removing the mandrel after propellant has hardened.

Fig 12: Moving booster to launch rail

Fig 13: Lifting the booster up on the rail

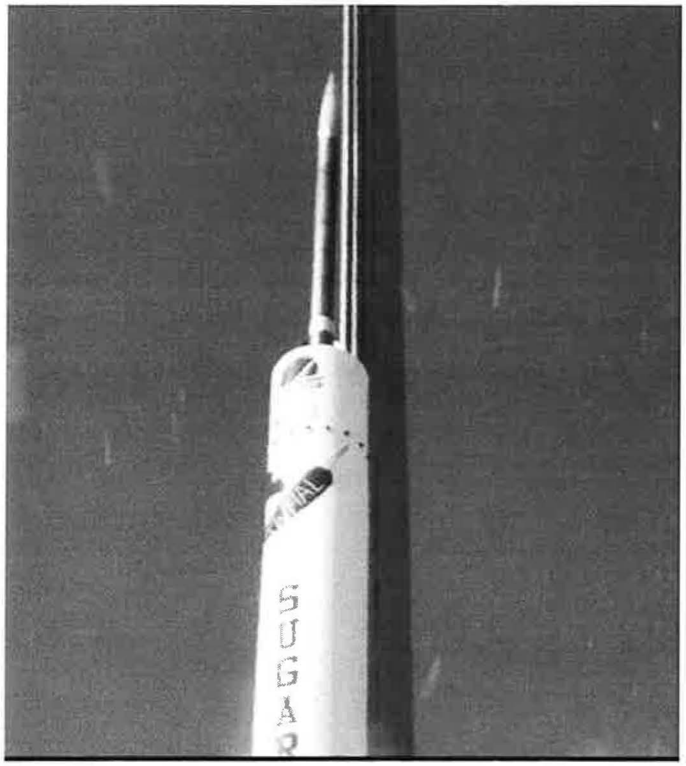


Fig 14: Immediately after ignition

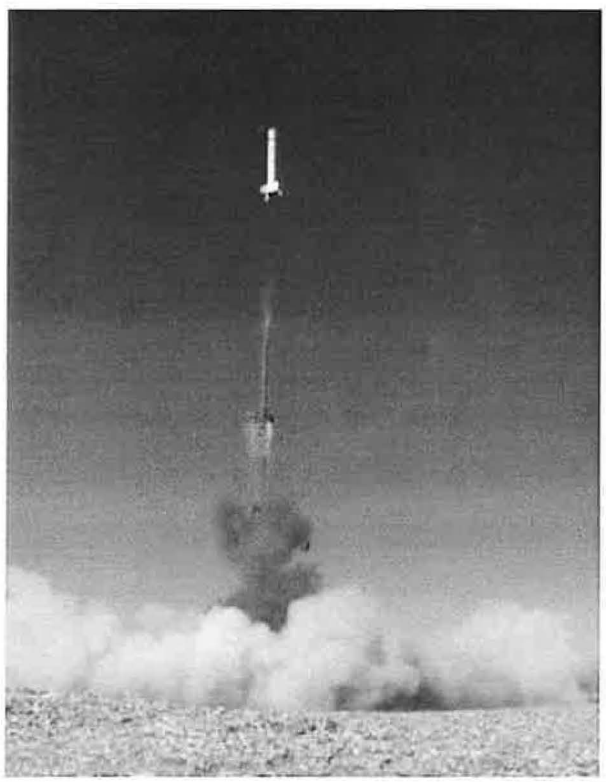


Fig 15: Booster accelerates at 120g off the launch rail

Fig 16: Start of the mushroom cloud

Tripoli Rocket Certification

"Tripoli is a non-profit organization dedicated to the advancement and operation of amateur high-power rocketry." Due to covid shutting down much of the government certification boards that required in person testing, I arranged with MDARS to obtain my Tripoli Level 3 high power rocket certification. This is the highest level of certification that offered by Tripoli and requires that the individual have completed two previous levels and fly a complex high-power rocket that they entirely design and fabricate. The Tripoli level 3 requires a complete flight and fabrication proposal (see Appendix 1) to be submitted and reviewed by two members of the Tripoli Advisory Panel. I built a 6" diameter fiberglass rocket designed to take a 3" single use motor. I equipped it with all the avionics and tracking equipment I had developed for SS2S. The rocket flew successfully in Feb of 2021 as shown in the photo below:

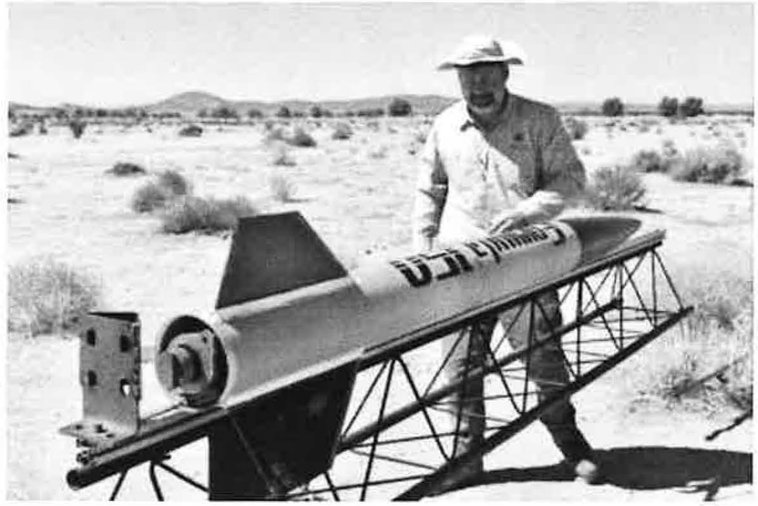


FIG 1: Mason with 6" Diameter Level 3 rocket

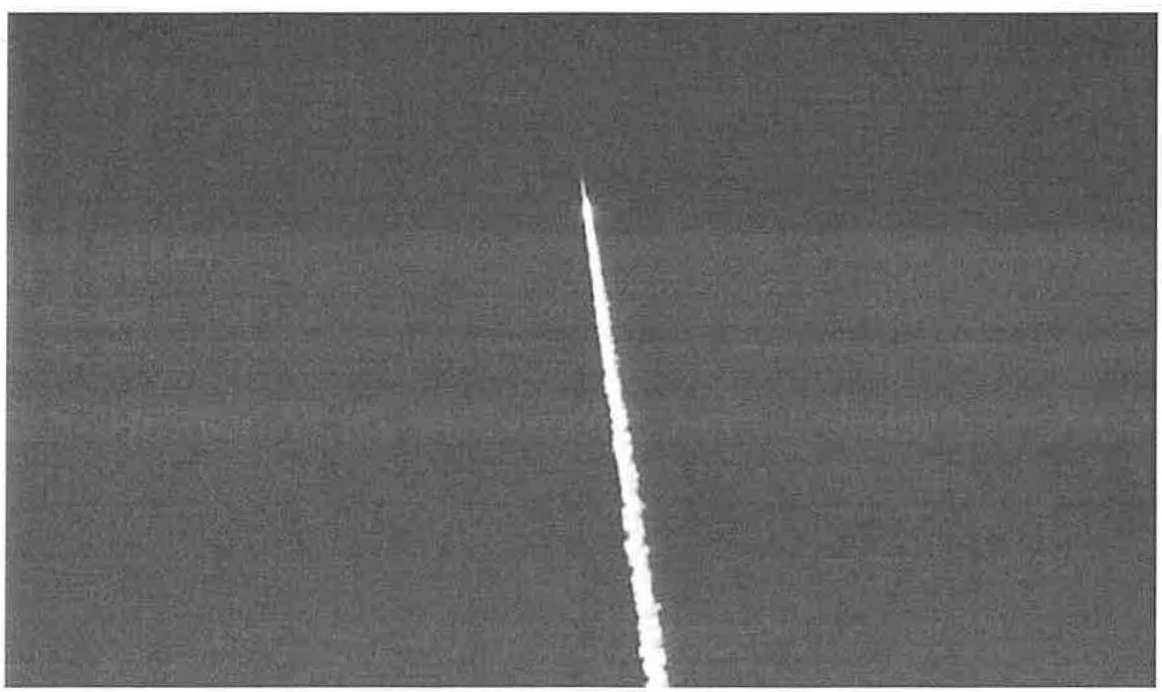


FIG 2: Mason Level 3 rocket FORMULA 150 flying at MDARS on Feb 27,2020

Experimental Hybrid Rocket Motor.

FIG 1: Fabricated motor with custom test stand and load cell

Unlike conventional solid fuel rockets where the oxidizer and the fuel are mixed into a single solid matrix, hybrid rockets have a separate liquid oxidizer and a solid fuel cell. As part of my work with SS2S, I had met David Griffiths who owns the aerospace contractor Monterey Machine Products located in West Covina. David is a Mt. SAC Alumni and was thrilled to find out that the college had an active rocketry program and agreed to advise me in the development of a hybrid motor. The motor uses self-pressurized nitrous oxide (NOS) in an aluminum feed tank into a Urbanski-Colburn (UC) valve with a polypropylene fuel grain. The grain is pre-heated with a conventional Ammonium Perchlorate Composite propellant (APCP) grain prior to the injection of the nitrous oxide. The combustion temperatures of 5000-6000°F, required a nozzle stack made from graphite and phenolic in place of the conventional steel nozzles used previously.

After fabricating a test motor, I completed 9 static tests. Over the course of testing, there were two major challenges, first getting the propellant sufficiently eroded to mix with the NOS and second having the UC valve open at the right time to ignite the engine. The first challenge was addressed by including copper in the APCP which served as a catalyst for the nitrous oxide. The valve timing was addressed by incrementally moving the feed tube relative to the ignition charge until reliable ignition was achieved.

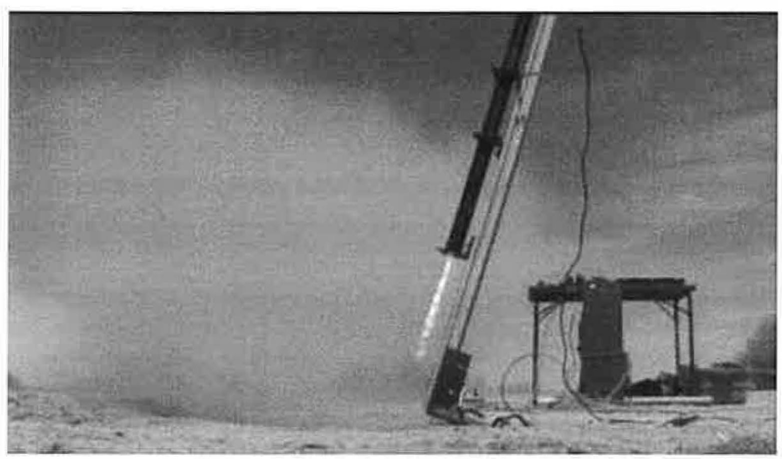


FIG 2: Successful test fire of hybrid motor with mach diamonds

Another challenge of working with Hybrid and bipropellant rockets is that separate controls are required to fill the oxidizer and fuel tanks, vent the tanks in event of error and fire the ignition charge etc. To address this, a ground support unit (shown below) was designed and fabricated to serve as a reliable way to test and fire current and future hybrid or bipropellant projects.

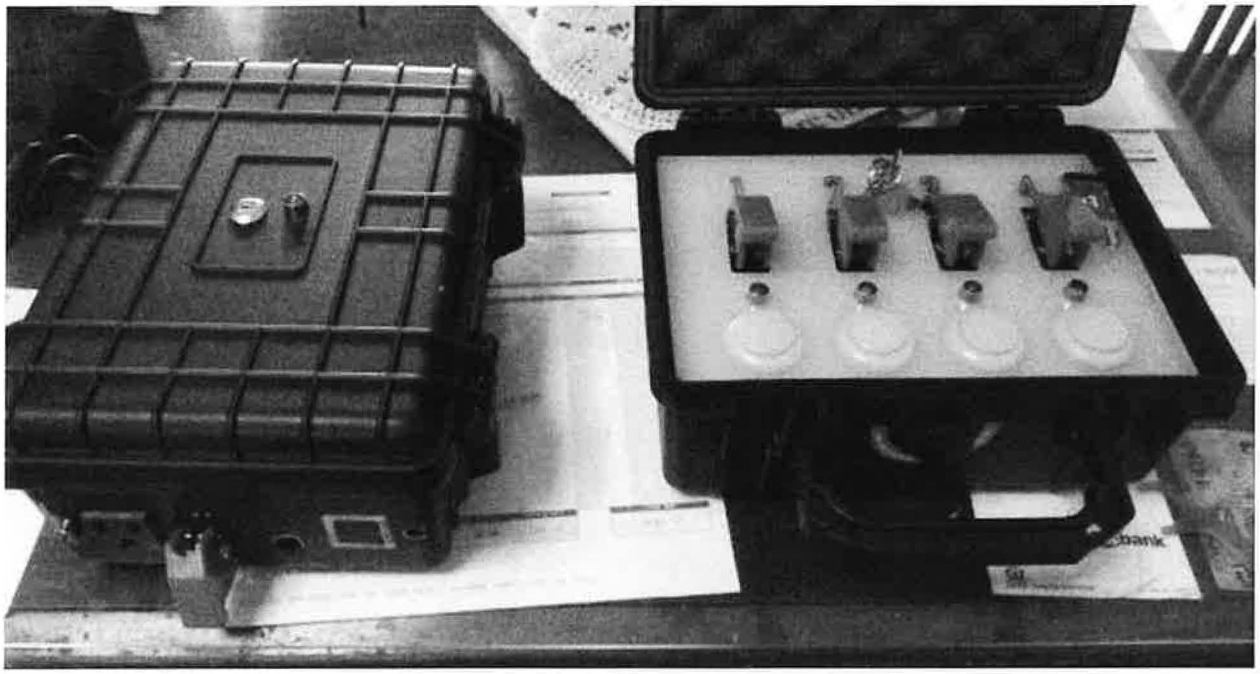


FIG 3: Ground support equipment for hybrid and future bipropellant tests to support Mt. SAC rocketry

After sufficient static testing was completed, a conventional rocket airframe was fabricated for the hybrid motor along with recovery equipment. A miniature version of the RF GPS tracker developed for the SS2S 100K flight was used along with a miniature version of the avionics. The rocket was flown successfully in May of 2021 and completely recovered, though there were some issues with the deployment during the flight. This marked the first successful hybrid rocket flight by a community college group.

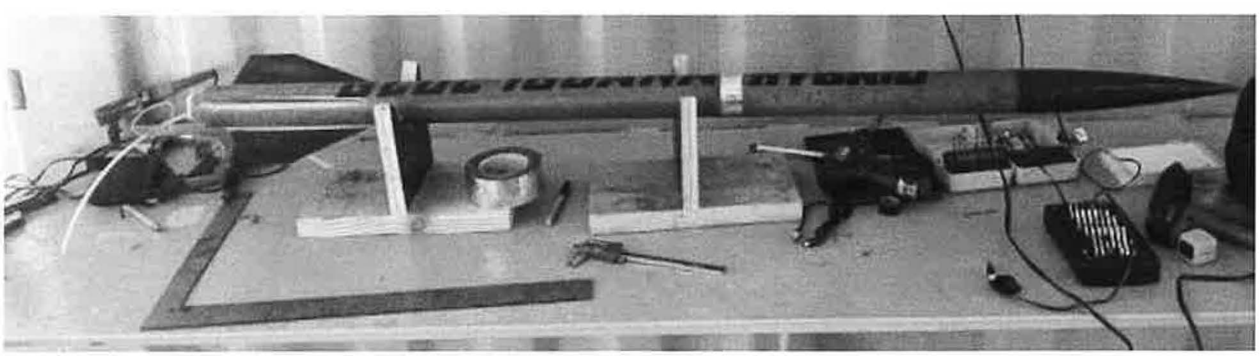


FIG 4: Blue Iguana Hybrid Rocket Vehicle flown to 2230 feet on May 15, 2021

Other Work:

The work I had done with SS2S and US Rockets was well known during 2020-21 in the experimental rocketry community. In June of 2021, I was invited to serve as a judge for the Experimental Sounding Rocket Association's Intercollegiate Rocket Engineering Competition. I worked as part of a 4-judge panel of industry experts to judge an international slate of university experimental solid and hybrid rocket teams for both their poster sessions, and conference paper presentations.

In June of 2021, I visited the Universidad de Ingenieria y Technologia in Lima, Peru. SS2S received a request from a South American University rocketry collaboration to launch an experimental solid fuel rocket motor developed by a collaboration of doctoral candidates who could not obtain clearance to launch. I ran their motor through our simulation package and cross checked with a variety of other motor performance and aerodynamics packages and determined that their proposed project did not meet minimum requirements for a safe launch. While SS2S could not launch their motor, we had many fruitful discussions about experimental motors, and it was instructive to see how rocketry is integrated into the curriculum at a top South American engineering school.

Future Work:

I continue to work for SS2S and US rockets in a much-reduced capacity. For US Rockets, I am developing their FAA proposal to flight test their 12inch stage including all monte carlo and landing dispersion modeling. For SS2S, while the KNSB propellant technology and the finocyl design and fabrication techniques were well proven as part of this project, it was determined that the case bonded fiberglass case was incompatible with the brittleness of the KNSB green propellant. As a result, the team is moving forward to using a thin wall unlined stainless steel case with casting tubes. The propellant burns at a sufficiently low temperature (1250-1320°F) in operating pressure regime that stainless steel does not lose temper and can be used without a liner. This simplifies fabrication by allowing welding and improves propellant volumetric efficiency which partially offsets the high weight of stainless steel. We have fabricated a static test motor including forward domed bulkhead and nozzle and grain fabrication is planned for the end of September with static testing slated for October 2nd.

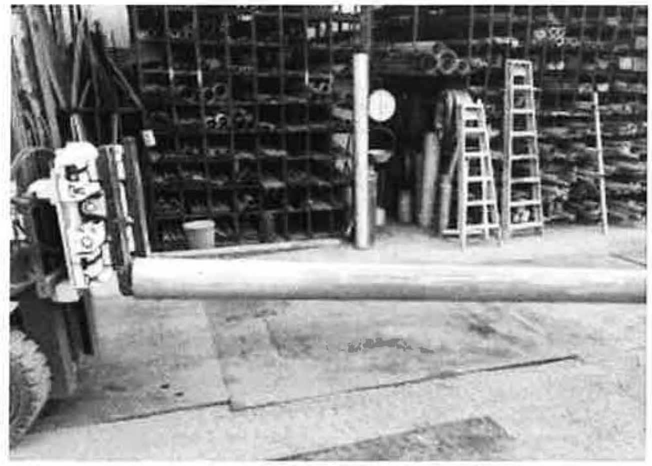


FIG 2: Most of the SS2S Team 2020-21

US Rockets

I was contracted to do propellant characterization for US rockets in collaboration with Davie Bauld and assisted by Andrew Irvine. I prepared a series of 4 reports based on series of static tests, with each series containing between two and our firings. Included is an abbreviated sample report:

Objectives:

Determine the following empirical parameters:

- Max Pressure
- Average Pressure
- max Force
- Average Force
- Total Impulse
- Grain Mass

From these parameters determine the following parameters for the propellant:

- ISP
- C*
- a
- n

Four burns were performed using identical propellant grains in a static test motor. Pressure was measured using a 2500PSI pressure transducer and force measured with a 100 kg load cell.

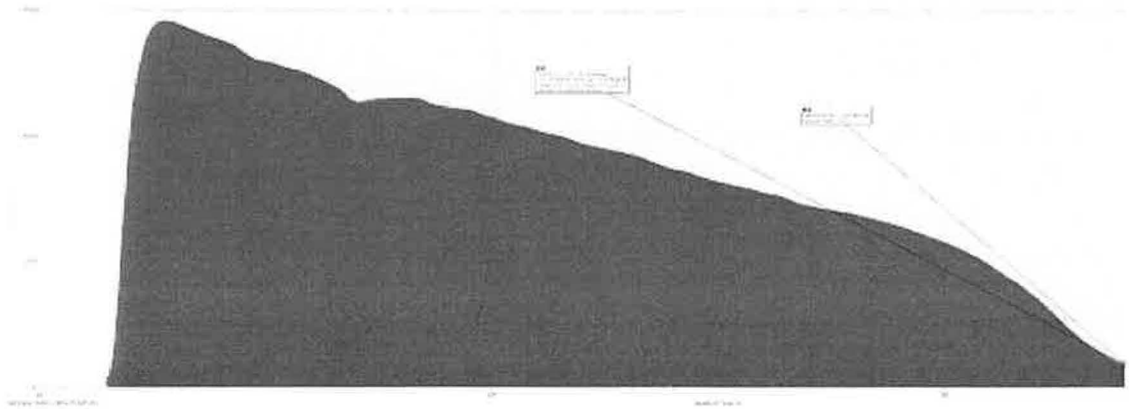
Calibration:

Pressure calibration was performed from the manufacturers datasheet and verified using a compressor. The compressor only allowed us to test at ~120PSI which was far from full scale for the tests. Uncertainty in pressure measurements is +- 10 PSI

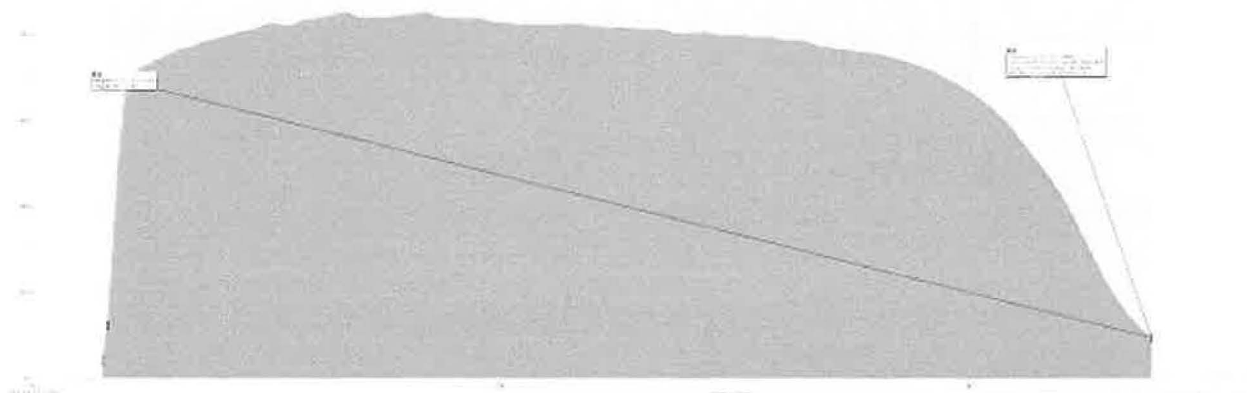
Force calibration was performed using one of the team members balancing on the load cell given his known weight. While the team member professed to know his weight and the calibration was full scale, it provided difficult for him to balance on the load cell platform consistently, so our repeatability was low. Uncertainty in force measurements is +- 10 lbs.

Data:

Burn 1: 21/64" Nozzle Diameter



Pressure vs Time 21/64 Nozzle APCP SF propellant



Force vs Time 21/64" Nozzle APCP SF propellant

- Max Pressure 1458 +- 10 PSI
- Average Pressure 822 +- 10 PSI
- max Force 85 +- 10 lb.
- Average Force 72 +- 10 lb.
- Total Impulse 161 lbs. +- 20 lbs.

Visual Observations:

Low smoke. Substantial nozzle erosion from 21/64 to 25/64".

3 more grains were burned with variations in throat diameter.

Notes:

Grain mass was not recorded at the time of the experiment so is estimated from propellant density and grain geometry. Assuming a propellant density of 0.06 lb./ in^3 and 2 grains with a 52mm diameter and 19mm core we obtain the following.

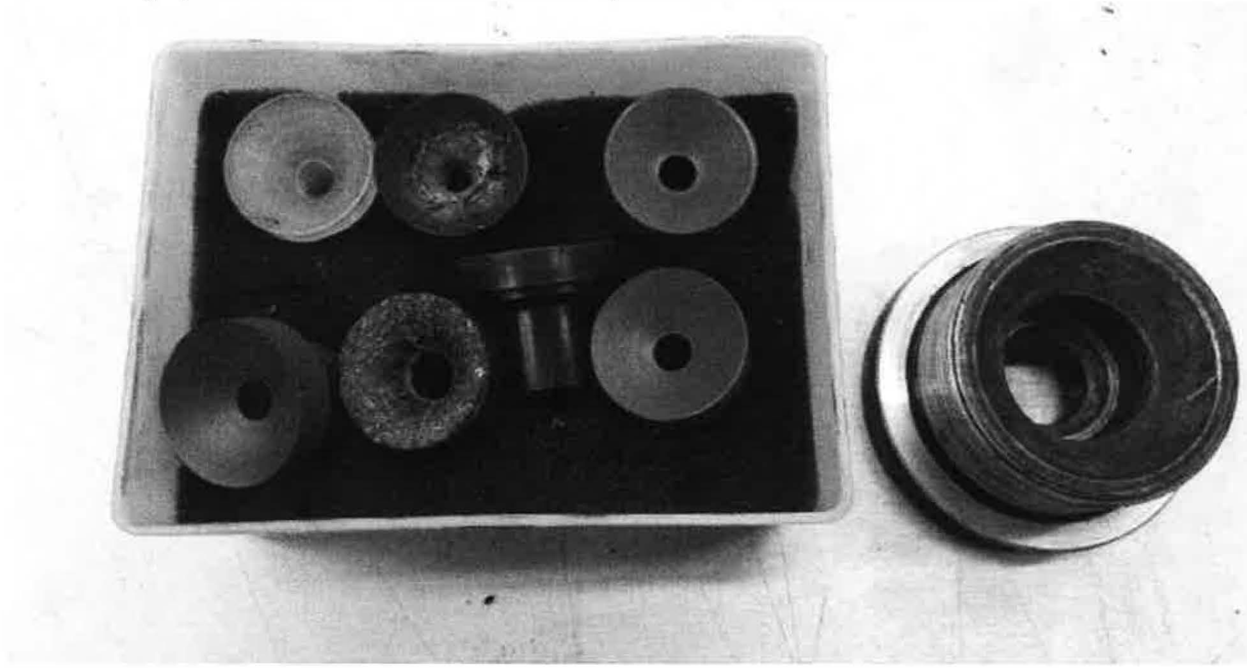
- Grain Mass .86 lb. +- .2lb

Nozzle erosion was significant during all tests.

ISP Calculations:

Propellant ISP 183s - 53 + 86s. These large uncertainties are due to the uncertainty in the propellant mass and the force scale calibration. The author is only confident that the propellant ISP is between 130 s and 270 s which is hardly useful. With accurate values for the mass of the propellant grains, the uncertainty could be reduced substantially.

I fabricated graphite nozzles for US Rockets to their specifications for use in their tests.



In addition I worked with an assistant Ryan Lau to refurbish a large horizontal test rail for use by US rockets to test their full scale motor. I adapted the force and pressure transducers used for SS2S to fit the US rockets parameters and provided software support and data analysis for their full-scale test.

The US rockets full scale test was completed successfully in May 2021. I provided pressure and force data analysis and ISP characterization for the propellant which is proprietary to US Rockets.

Certification and Construction of Type IV Magazine

A type IV magazine was constructed in compliance with state and federal codes in order to store rocket motors. No inspections were available to be carried out due to COVID-19. I am in the process of requesting an inspection for October 2021. The magazine consists of a compliant metal storage container made of at least 14-gauge steel with a non-sparking liner. It is placed inside a compliant secondary containment unit, and steel storage container. I look forward to the full approval of the type IV magazine soon.

FPGA Work

FPGA Coursework: Introduction to FPGA Design for Embedded Systems

Objectives:

- Learn what an FPGA is and how this technology was developed
- Determine how to select the best FPGA architecture for a given application
- How to use state of the art software tools for FPGA development
- How to solve critical digital design problems using FPGAs

Topics:

- A Brief History of Programmable Logic
- CPLD Architecture
- LUTs and FPGA Architecture
- LUTs for Logic Design

- Designing Adders
- Designing Multipliers
- Create a design in Quartus Prime
- Compile a Design
- View the RTL
- Timing Analysis with Time Quest
- Simulate a design with ModelSim
- Xilinx CPLD Architecture
- Xilinx Small FPGAs
- Xilinx Large FPGAs
- Altera CPLDs and Small FPGAs
- Altera Large FPGAs9m
- Microsemi Single-chip FPGA solutions
- Lattice Single-Chip FPGA solutions
- Advanced Schematic Entry for FPGA Design- Drawing and Hierarchy
- Improving Productivity with IP Blocks
- Improving Timing with Pipelining
- FPGA IO: Getting In and Getting Out
- Pin Assignments: Making them Spot On!
- Programming the FPGA
- Becoming one with Q: Qsys System Design

Highlights:

- This course was somewhat disappointing as it didn't have much in the way of concrete projects to complete.
- The course did do a good job of comparing and contrasting the different FPGA families which helped drive the decision as to what hardware to implement for the Mt. SAC course.
- I discovered that I generally prefer to work with text / graphic based resources instead of videos to learn electronics / software.

Real Digital Curriculum

- Objectives
  - Combinational Circuit Structure
  - Schematic Capture and Circuit Simulators
  - Structural vs. Behavioral design
  - Using the ISE/WebPack VHDL tools
- Lecture Topics
  - Inputs and outputs, switch logic
  - Diodes and transistors
  - CMOS, logic gates and ICs
  - Logic circuits, truth tables, representations, SOP & POS forms
  - Logic equations, behavioral vs. structural, basic Verilog
  - Boolean Algebra
  - K-maps
  - Multiplexors, decoders,
  - Verilog for Combinational Circuits
  - Circuit Delays and Glitches
  - Electronic memory and basic cells

- Latches, Flip-flops, and Registers
- Counters, Registers, and the
- 7Seg Display
- Adders and Multipliers
- Arithmetic and Logic Unit (ALU)
- State machine implementations
- 36 Behavioral implementation of state machines in Verilog
- Clock domains and clocking considerations
- Sampling and processing inputs
- Output signal timing issues

- Highlights
  - Implemented a stopwatch in a FPGA
  - Implemented a reaction time monitor in an FPGA
  - This course was thorough and provided a number of excellent laboratory projects. While the FPGA board used is dated by today's standards, it provided a solid set of fundamentals in digital logic and the FPGA.

Embedded Design using Programmable Gate Arrays:

- Objectives
  - Basic familiarity with the Verilog Hardware Description Language
  - Introduction to Programmable gate array hardware
  - Introduction to Digital Signal Processing with the FPGA
  - Use of Soft-Core Processors
- Lecture Topics
  - Programmable Logic Devices
  - Hardware Description Language
  - Verilog Syntax and Concepts
  - Structural Models in Verilog
  - Behavioral Models in Verilog
  - Finite State Machines
  - Controller-Datapath Architecture
  - Verilog Design Automation
  - Programmable Gate Array Hardware
  - Hardware Components and Peripherals
  - Auxiliary Ports and Peripherals
  - Hardware Expansion Port and Connectors
  - Auxiliary Hardware Peripherals
  - Digital Signal Processing, Communications and Control
  - Sampling and Quantization
  - Discrete Time Sequences
  - Discrete Frequency Response
  - Analog Output
  - DSP Embedded System
  - IIR Digital Filter
  - FIR Digital Filter
  - FIR Compiler
  - Direct Digital Synthesis Compiler

    - Frequency Generator
    - Frequency Shift Keying
    - Phase Shift keying
    - Quaternary Phase Shift Keying
- Linear Finite Shift Register
- Data Communication
- Digital Control
- Pulse Width Modulation
- Embedded Soft Core Processors
- Programmable Amplifier and Analog-to-Digital Converter
- Frequency Counter

Highlights:

- This course was considerably more sophisticated than the real digital course, and had correspondingly more challenging projects.
- The course hardware was again dated compared to the state of the art. This seems to be an ongoing problem as hardware development moves incredibly quickly, while curriculum takes significant time to develop. While the hardware and software tools are outdated, the core concepts are still relevant. Even though the course was only written 11 years ago, there were some challenges getting the tools chains to work on modern hardware.
- Developed a Sine-Cosine Look-Up Table in an FPGA, which I enjoyed because I had always implemented this using a Taylor series approximation.
- Implemented a FPGA based DTMF Generator. I have had the students implement DTMF generators using analog components, but this was a nice way to see how digital techniques can accomplish the same goals.
- Servomotor Control. Generating PWM signals is at the core of much of robotics, and this project illustrated the wide applicability of FPGAs.
- Digital-to-Analog Converter. This is a project I have had students do using a discrete resistor ladder. Being able to connect a 20th century project to modern techniques was very satisfying.

Xylinx Online Coursework

- Objectives
    - digital design flow in Xilinx programmable devices
    - using Vivado design software suite
    - Fundamental HDL modeling principles

Topics

- Lab1 - Modeling Concepts
- Lab2 - Numbering Systems
- Lab3 - Multi-Output Circuits
- Lab4 - Tasks, Functions, and Testbench
- Lab5 - Modeling Latches and Flip-Flops
- Lab6 - Modeling Registers and Counters
- Lab7 - Behavioral Modeling and Timing Constraints

- Lab8 - Architectural Wizard and IP Catalog
- Lab9 - Counters, Timers, and Real-Time Clock
- Lab10 - Finite State Machines
- Lab11 - Sequential System Design using ASM Chart

Highlights

- I selected to use Xilinx products for the FPGA course due to their wide industrial adoption and their commitment to support college and universities.
- The Vivado suite is updated regularly, and I found that even during the year, a version change required substantial updates.
- While the course content duplicated much of what was done in the previous two courses, it was useful to see how to implement these activities on hardware that we will use at Mt. SAC.

Work with Industry Advisors

Northrop

My contact at Northrop uses FPGAs in defense related work. The timeline to certify military hardware is long and even more importantly, they have to guarantee support for products over a long product life cycle. FPGA are used for signal processing and in radar and sonar applications and allow engineers to reuse previous work and quickly implement changes. Northrop is using Xylinx and Intel (Altera) FPGA products. They are currently actively seeking to hire candidates with FPGA experience in their payload and ground systems division.

Boeing

My contact at Boeing uses FPGA in space satellite work. He discussed the long timeline to certify hardware for space, and how since the costs of space certification are high, vendors were only willing to certify a few products. However, FPGAs are available in radiation hardened, space certified packages and are incredibly flexible to meet requirements. Another major feature of FPGA for satellite applications is that they are also power efficient. First the FPGA what would have been a number of components in previous designs and second, FPGA have a variety of low power modes that allow them wake on signal application and allow complete control of clock modes. Boeing uses Xylinx and Acetel FPGA devices. At the time of discussion, Boeing was looking to hire 39 engineers with FPGA experience within their various divisions.

Ensign Bickford:

My contact at Boeing uses FPGA in space exploration work including lunar and mars missions. While touching on the same issues of limited certified hardware availability he emphasized the radiation hardness of FPGA hardware. While FPGA can be sensitive to involuntary reconfiguration due to Single Event Upsets (SEU) induced by radiation, a variety of SEU mitigation techniques have been introduced. In particular, since the devices now have millions of system gates, it is possible to build redundant systems on chip and have multiple units continually check each other for identical results. Ensign Bickford uses a variety of FPGA devices depending on application but mainly devices from the Xylinx family. They are currently actively seeking to hire engineers with FPGA experience in my contacts office.

JPL

My contact at JPL uses FPGA for high-speed measurements of telecommunications systems. Since he works with massively multichannel systems, the FPGA can process the samples in a parallel manner instead having to serialize the data for a microprocessor. This makes it easier to associate the samples with a specific time. Since all the samples are available at the same time, inter-channel operations are simplified. Since all the data is available at the same time, storage and retrieval requirements are removed which reduces computational latency. My contact is not aware of what FPGA are in use generally at JPL, but he uses Xylinx products due to the quality of their integrated development environment. He is not aware if JPL is hiring FPGA engineers.

Intel

My Intel contact works as part of the customer experience group tasked with providing support for customers using FPGAs in military related applications. He cited the flexibility of FPGAs and the capacity to adapt to any standard. Intel provides a complete set of intellectual property cores along with reference designs and development kits. He sees the primary advantages of FPGA as allowing shorter time to market and less engineering risk due to the configurability. He has worked mainly with contractors implementing software defined radio and cryptography applications. Intel uses only Intel FPGA products. They are actively seeking engineers with FPGA experience in the Irvine and San Jose office.

Work with University Partners

Cal Poly Pomona

I met with Mohamed Rafiquzzaman who is the primary digital electronics and FPGA instructor at Cal Poly Pomona. He is also the author of the text book "Digital Logic: With an Introduction to Verilog and FPGA based design". He advised me that Cal Poly uses Xylinx based Basys boards for their laboratories. He reviewed my proposed course outline and made suggestions and was supportive or articulating the Mt. SAC course to Cal Poly Pomona. Two of my industry advisors for this project are alumni of Cal Poly Pomona.

Cal State LA

On separate occasions I met with Fred Daneshagaran and Charles Liu. Fred originally had encouraged me to develop the course. He advised me that CSULA uses Xylinx based Baesys boards for their laboratories. I worked with Charles who coordinates the FPGA courses at CSULA who reviewed the course. Charles is now the chair of Electrical and Computer engineering at CSULA and is moving forward to approve articulation for the new course for CSULA transfer students. One of my industry advisors is an alumnus of CSULA.

Cal State Long Beach

We discussed articulation of the course under development to their ET 255 and 255L courses. They are using the older Baesys II boards, but are updating their program to use more modern Xylinx based hardware in the lab. In particular, we discussed creating a pathway for Mt. SAC students to CSULB in Electrical Engineering Technology. I also had the opportunity to meet with three of our alumni who are current student Electrical Engineering students at CSULB who raved about the program and their opportunities. One of my industry advisors is an alumnus of CSULA.

UCLA

I met with Greg Pottie, chair of the UCLA electrical engineering program. He has originally suggested offering this course to better prepare students for transfer to UCLA. He reviewed the course outline I had prepared and made suggestions for improvement. While he was ready to move forward with approval for articulation, he is no longer chair of the department, so is working with the current chair to articulate our new course. UCLA uses Xylinx FPGAs in their laboratory courses. One of my industry advisors is an alumnus of UCLA.

Conclusions (Summary with Statement of Value to the College)

In my proposal I had the following two goals:

1. Accomplish significant professional work in the field of rocketry by working within a rocketry collaboration to contribute to the development of a space capable solid fuel rocket platform.
2. Learn the current state of the art in VHDL and Verilog FPGA programming languages, complete a number of projects in these languages and develop a new Digital FPGA course to support the engineering program.

Spending a year working in aerospace with SS2S gave me an opportunity to learn about all aspects of solid fuel rockets. Being part of a small team meant that I was doing everything from Avionics to Welding. Working with US Rockets meant that I could be a smaller part of the development of a space capable solid fuel rocket platform. I met a stretch goal by collaborating with Monterey Machine products on the development and flight of the first community college-based hybrid rocket. I also had the opportunity to serve as a judge for the largest University experimental rocketry competition and work with an international collaboration in South America. I wrote in my proposal in reference to our rocketry team, "I have definitely hit a wall in my ability to take the team any further. " Having the opportunity to work with solid fuel and hybrid rocketry experts for the past year has allowed me to blow past that wall and I look forward to bringing my new expertise to share with Mt. SAC students.

I have completed coursework in VHDL and Verilog FPGA devices along with projects in those languages and developed a new Digital FPGA course. I also worked with Industry advisors and universities to make sure the course met the needs of both employers and our transfer partners.

Statement of Value to the College:

Teaching

As a community college faculty member, my first job is to be an excellent teacher. This sabbatical experience has provided an incredible opportunity for me to contextualize my teaching by drawing directly from examples of how I recently applied course concepts in the workplace.

Networking

Working with the major players in the experimental rocketry industry has given me access to the people who want to hire our students. Space X started at our test facility, and Elon musk installed our helipad and hired his first three employees from our facility. I have had a constant demand for interns and student workers. Even with the pandemic, I have placed 3 students in different aerospace industries and have started talks with two more since we are back on campus.

Course Curriculum Support

I am energized to revitalize our engineering curriculum to meet the needs of industry. I am looking forward to teaching engineering 1 in the fall and introducing new projects based on my work experience. I have asked our chair to assign me to the Engineering 24 course in 2022 so that I can bring best industry practices to that course. My experience writing process control documentation will bring a new component to the Engineering 1C course. The work I did this year will have a long-term effect in course updates and improvements to reflect industry practice.

Rocket Team

This experience has provided the tools to take the team to the next level. At a rocket team alumni meeting this Fall, I found out that Mt. SAC rocket team alumni are currently leading the rocket teams at Cal Poly Pomona, CSULA, CSULB and UCSD. The students that have graduated are employed at NASA, Space X, Rocket Labs and aerospace companies across Southern California. The collaboration that we have started with Monterey Machine products to launch the successfully launch the first community college hybrid rocket will lead to the launch of the first community college bi-propellant rocket. I am in talks with philanthropist Foster Stanback to support Mt. SAC as a major center in preparing engineering technicians with a focus on rocketry and Southern California new space industries.

For many 2020 was a difficult year with COVID looming over every decision. For me the past academic year was an opportunity to work with an incredible team at a remote location in the Mojave Desert and take advantage of online learning opportunities. I return to campus in 2021 revitalized and with new knowledge and opportunities to offer our amazing students.

Benefits to Professional Growth

Taking a sabbatical to focus on rocketry had a major transformational effect on me. While my department is incredibly collaborative, as the only Engineering faculty member with a background in Electrical Engineering and Software, my opportunities for collaboration are limited since I am the only full-time faculty member who teaches these classes. A big part of this sabbatical was the opportunity to work as part of high functioning engineering team. As a faculty member I am used to doing all the system engineering for student projects, and as a former department chair, I am used to herding a group of brilliant individualists in the vague direction of program progress. It was incredibly gratifying to work under effective engineering management that led a team to be highly productive. In addition, getting to experience the process of engineering design review and critical design review on projects that are years in scope gave me tools to bring back to support my own projects. Finally, the connections that I made in the experimental solid rocket community gave me new friendships with people who share my vision of humanity using technology to solve problems, and share the ultimate goal that as humans we are destined to spread out past the bounds of this small planet.

Detailed Record of the Sabbatical Activities

Month	Activities

August-September	1. Complete Experimental Rocket Motor course (30 hours of instruction)
	  a. In class instruction by John Wickman at Casper International.
	2. Complete simulations for SS2S static test
	3. Develop CAD models for SS2S static test motor.
	4. Write up log of experimental rocket flights for submission for Pyrotechnic license.
	5. Start collecting signatures from licensed operators for Pyrotechnic license.
	6. Complete Pyrotechnics safety course (10 hours coursework)
	  a. Complete CAL Pyro Rocketry Safety course by Mark Holthas

October	1. Complete Verilog coursework (30 hours coursework)
	  a. Intro to FPGA design (coursera)
	  b. Digilent Verilog modules
	2. Finalize design for SS2S static test motor including:
	  a. nozzle insert
	  b. nozzle retention
	  c. retention plate
	  d. nozzle diverging cone
	  e. forward bulkhead
	  f. motor body
	  g. grain casting tubes
	  h. thermal liner
	3. Meet with licensed pyrotechnic operators and obtain their letters of support for permit.

November	1. Complete Vivado Coursework (30 hours coursework)
	  a. Digilent Vivado Modules
	  b. Xylinx Vivado Training Modules
	2. Fabricate responsible items for SS2S static test motor:
	  a. retention plate
	  b. nozzle retention
	  c. forward bulkhead
	3. Develop thermal and pressure management sensors and test suite.
	4. Test sensors in vacuum.
	5. Start manufacturing rocket fuel grains. (About 250lbs of fuel to process)
	6. Start construction of class IV magazine

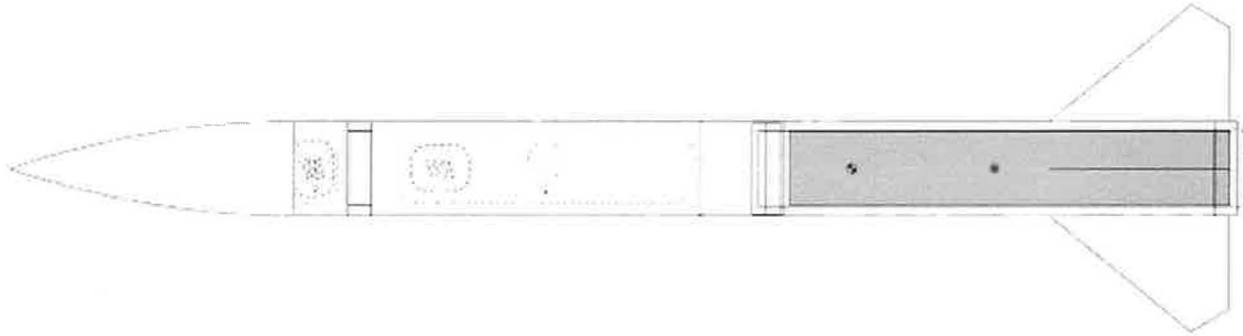
December	1. Zoom with CSULA and CPP FPGA faculty
	2. Complete VHDL coursework (30 hours coursework)
	  a. Real digital Curriculum Online through digilent
	3. Assemble full scale SS2S static test motor
	4. Complete rocket fuel grains and perform x-ray inspection.
	5. Test full scale SS2S static test motor.
	  a. Develop launch rail system
	  b. Design and fabricate Strain gauge system for thrust characterization
	  c. Design and fabrication thermocouple and non-contact IR sensor system for thermal characterization
	  d. Collect and analyze data from test.
	6. Complete construction of Class IV magazine

January	1. Purchase and Evaluate 3 FPGA boards 2. Analyze full scale SS2S static motor test 3. Complete final CAD for full scale flight vehicle 4. Complete simulations for full scale flight vehicle 5. Complete dispersal analysis for full scale flight vehicle 6. Start FAA Level 3 space flight approval process
February	1. Tripoli Level 3 certification 2. Work with fabrication partners on full scale launch vehicle a. airframe b. nosecone c. bulkheads d. nozzle e. payload bay f. recovery systems 3. Static test SS2S booster motor 4. Analyze booster motor static test data.
March	1. Update FAA level 3 space flight approval process 2. Range test telemetry and avionics systems • Design a Telemetry package suitable for a rocket • Design a Telemetry ground station • Fabricate a prototype flight computer, telemetry package and ground station: • Static test the prototypes in a vacuum chamber • Flight test the prototype: 3. Test assemble microcosm launch rail and perform repairs as needed.
April	1. Advance full scale vehicle production milestones: a. Motor casing b. Motor Liner c. Casting tubes d. Nozzle and retention e. Forward bulkheads f. Avionics i. telemetry ii. flight computer iii. power bus iv. recovery deployment g. Fins and Fin Can h. Airframe i. Couplings j. Avionics Bay k. Nose cone l. Feature coupling 2. Evaluate and maintain launch facilities.
May:	1. Complete full scale vehicle production milestones: a. Motor casing b. Motor Liner c. Casting tubes d. Nozzle and retention e. Forward bulkheads f. Avionics i. telemetry ii. flight computer

	iii. power bus iv. recovery deployment g. Fins and Fin Can h. Airframe i. Couplings j. Avionics Bay k. Nose cone l. Feature coupling 2. Launch SS2S full scale rocket 3. Recover rocket
First half of June	1. Follow up visit with CSULA and CPP to review FPGA course. 2. Analyze flight data 3. Serve as Judge for Experimental Sounding Rocket Association international competition

Appendix 1: FAA Waiver

Supplemental Information for Line 5, FAA Form 7711-2



Description of All Major Rocket Systems

Propulsion

a. Potassium Nitrate - Sorbital (KNO_3 - Sb) – 65/35 O/F ratio
b. 1400 mm (55.12 inches) of characterized propellant in four 236 mm (9.29") diameter Bates grains; nomex liner and spiral wound cardboard tubes coated with duraglas; RTV on bulkheads and at grain boundaries.
c. Motor is 60" long, 10" dia, .1875" wall DOM 6061 T6 Al tubing; steel nozzle in bonded graphite / aluminum carrier. Nozzle and closure retained by Al rings fastened with 10-32 FH machine screws.
d. Motor Data based on Richard Nakka's SRM.

Kn: 308-400 ± 5	PMax: 637 psi ± 24 PSI	Vol Loading: 89.9% ± .5%
Web: 80.5mm / 3.16"	Burn Time: 11.8 s ± 0.17s	Prop Length: 55.12" ± 1"
Mass: 96.29 kg / 212.3 lbs ± 4 lb	Motor Class: Q 10189 ± 150	Delivered ISP: 126±3

Airframe

a. Fincan is 60" motor (12" diameter Carbon fiber tubing) coupled to 60" Carbon Fiber avionics/parachute bay.
b. 3:1 ratio 36" long G10 ogive nosecone - 4" Al tip. 12.0" dia, 157" overall length.
c. Fins are .125" Carbon Fiber trapezoidal design with .5" beveled leading and trailing edges
d. Fins are located 138" from nose tip.

Avionics

a. Altus Metrum Telemetrum (Pressure / accelerometer-based)
b. Missleworks RRC3 (Pressure / accelerometer-based)
c. Eggfinder Mini Transmitter (GPS / RF Based)
d. Samsung smarthome tracker (GPS / Cellular)

Recovery

a. 120" hemispherical on rear avionics bay deployed at 2000 feet (41 fps descent)

b. 48" cross-form on avionics bay deployed at apogee (105 fps descent)

Conditions	Wind	Launcher Configuration	Alt (Ft AGL)	Range (ft)
Zero Winds	Calm	0 AZM; 0 deg Elev	42350 ft	325 ft
Late Dec Winds 8AM	3mph SE	-20 AZM 2 deg Elev	42019 ft	5075 ft
Late Dec Winds 4PM	6mph W	80 AZM 4 deg Elev	49050 ft	10730 ft

Table 1 - Highest Altitude (AGL) and Maximum Range (Ft) Expected to be reached were obtained using OpenRocket 15.03 and 2017-18 NOAA wind data Mojave Station and manually input into Open Rocket.

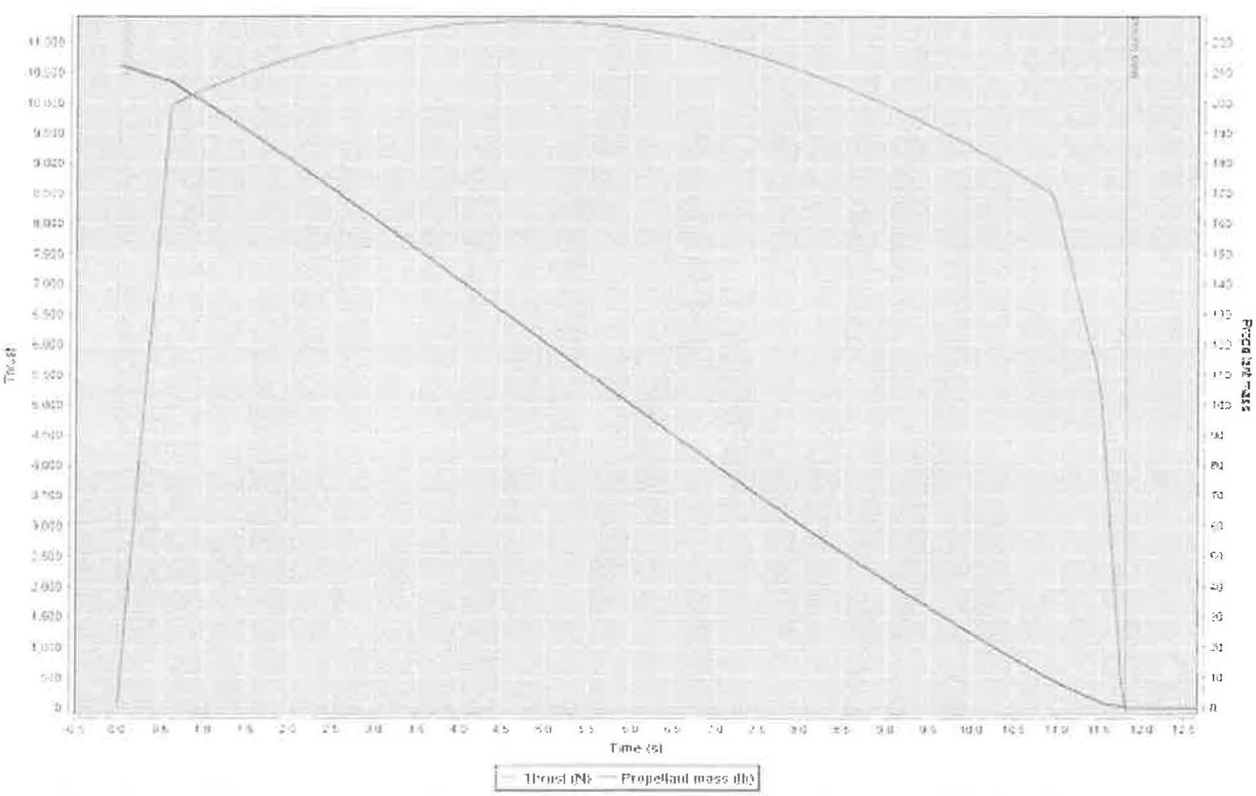
Parameter	Nominal Value
Launch Tower Ht.	240"
Launch site Altitude	2025'
Landing site Altitude	2024'
Temperature	68 deg F
Barometric Pressure	94.251 KPa
Latitude	35.346793 N
Longitude	-117.808194 W

Table 3 - Launch Site Parameters

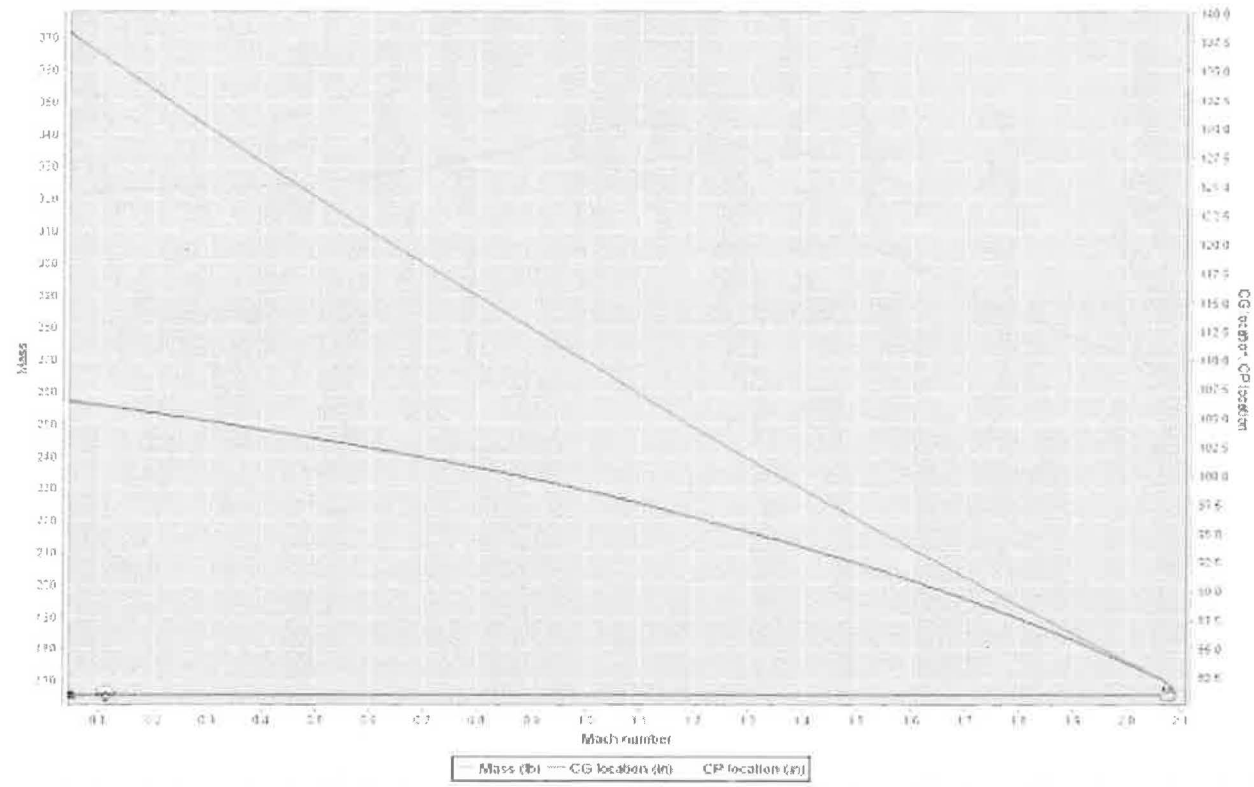
Table 2 - Static stability characteristics for the rocket at Launch and burnout are show in Table 3. OpenRocket 15.03 is used to predict Centers of pressure as a function of Mach number. A stable vehicle requires a minimum static margin of 1-2 calibers (rocket diameters)

Dynamic Stability Characteristics:

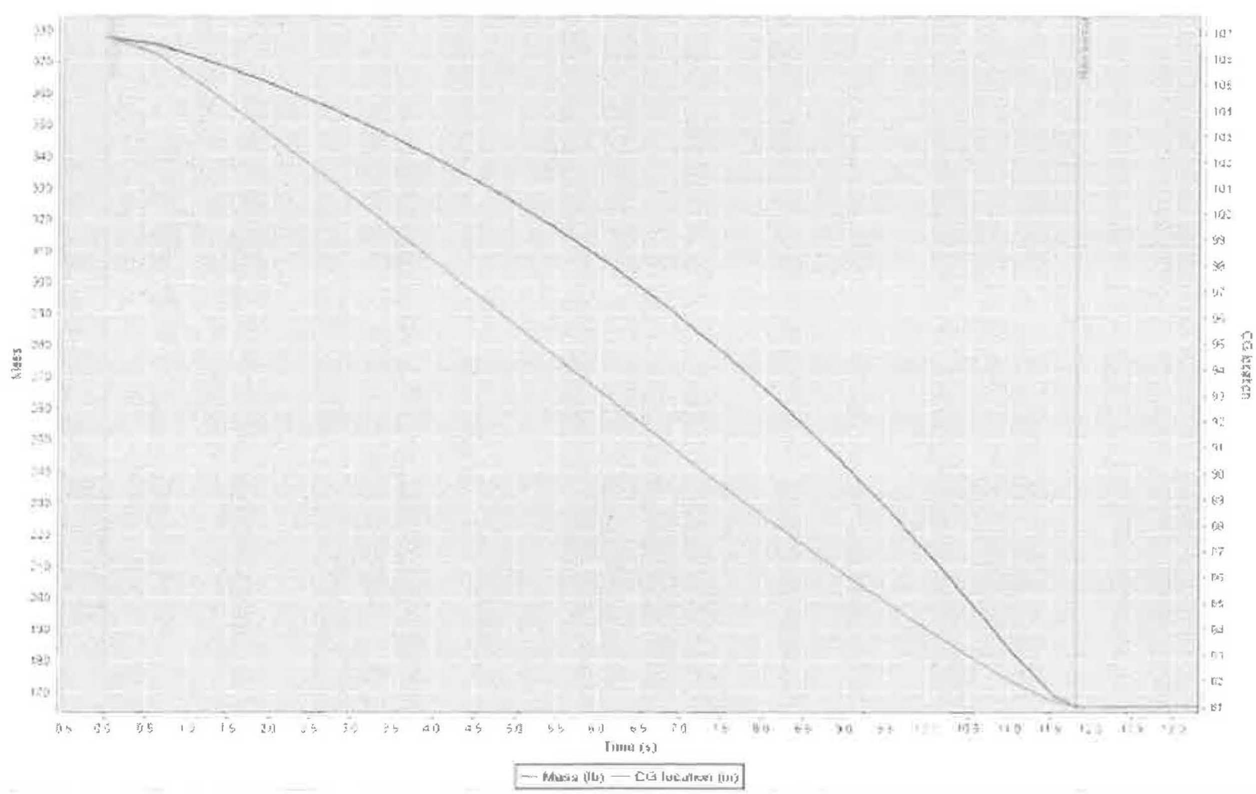
Plots:



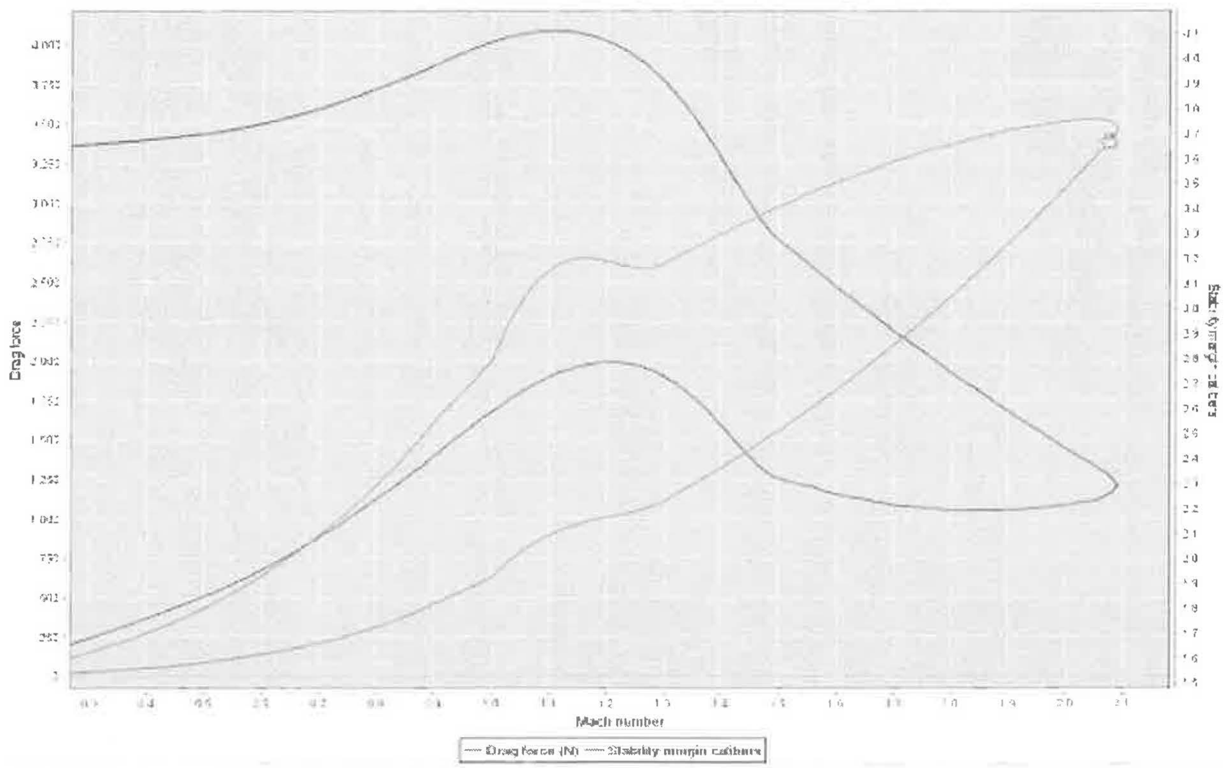
- Thrust (N) and Propellant Mass(lbs) vs. Time (s)



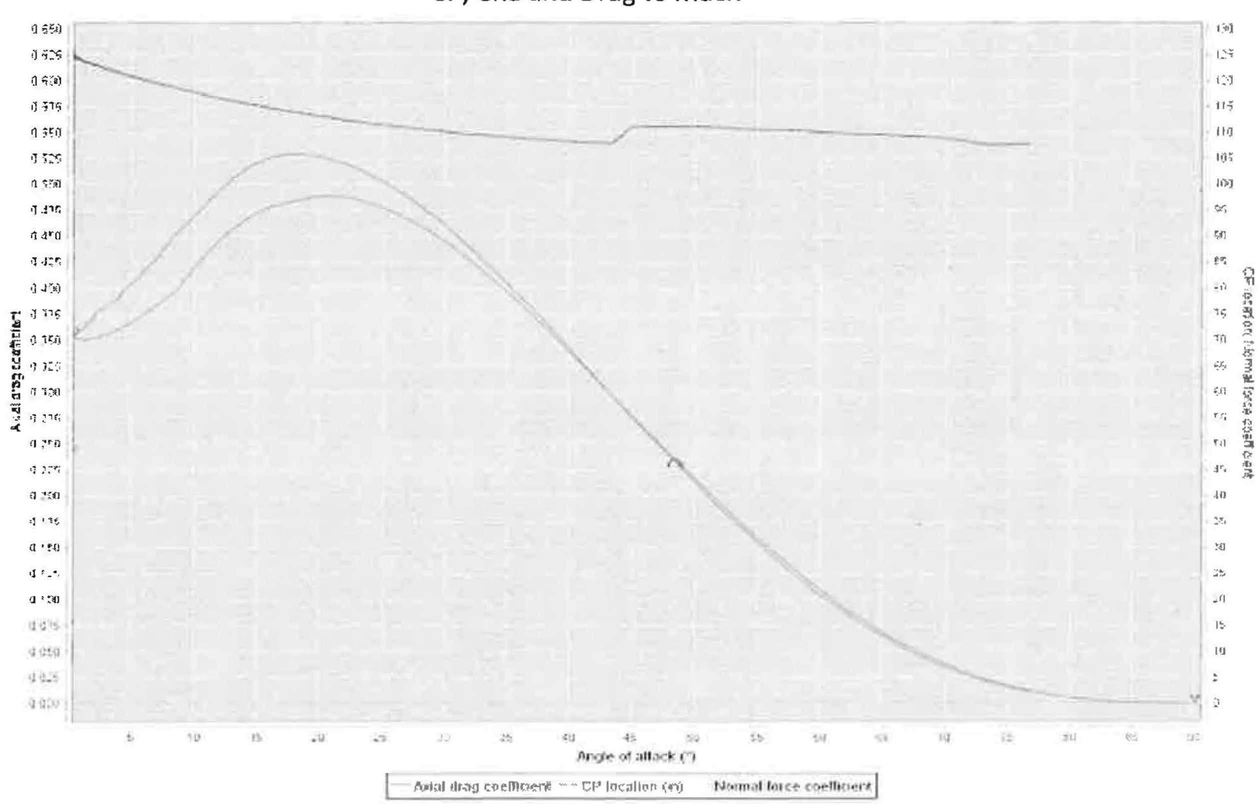
CP, CG and Mass vs Mach



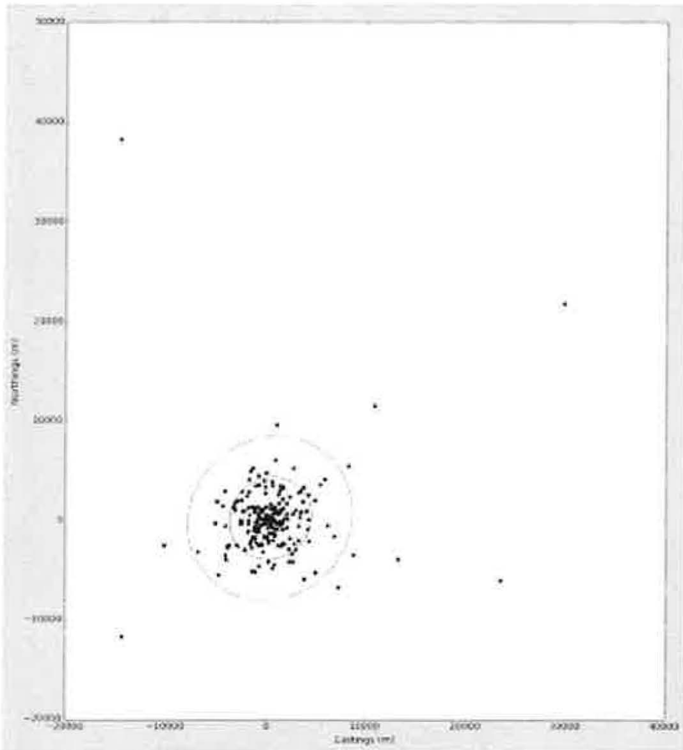
CG and Mass vs Time at Burnout



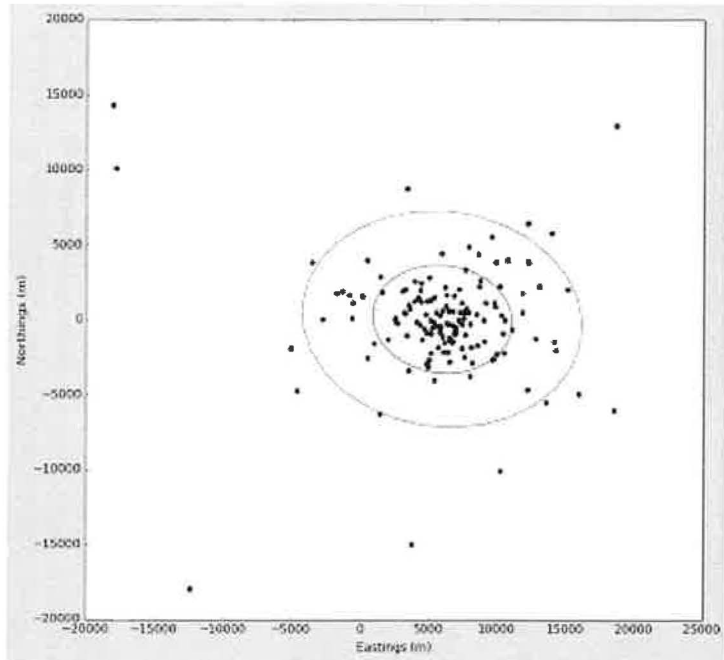
CP, Cna and Drag vs Mach



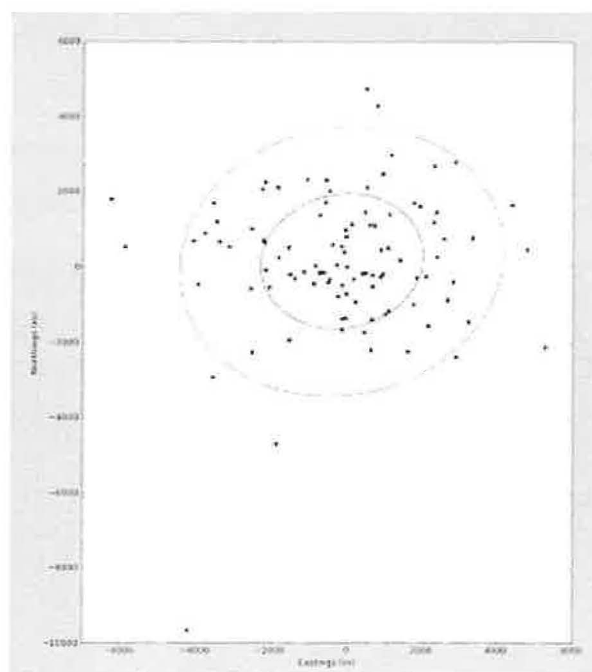
CP, Cn and Ca vs Angle of Attack



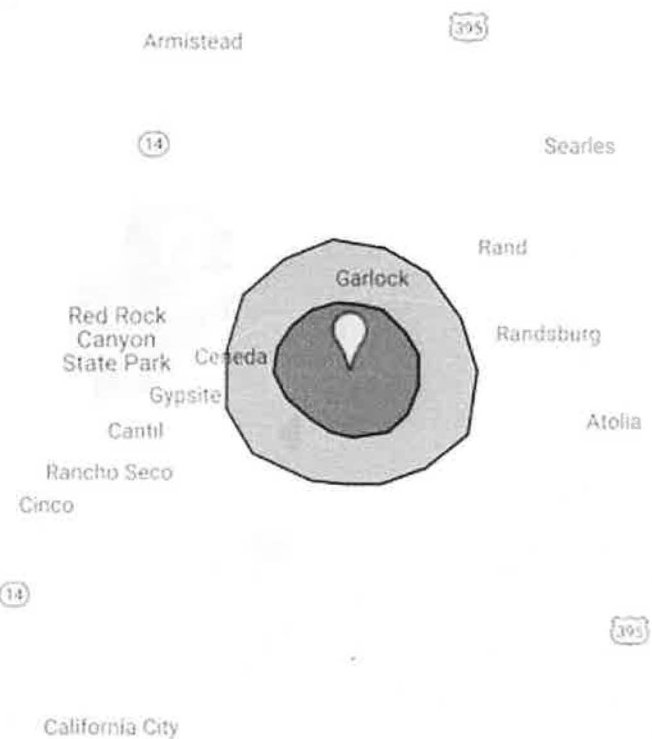
3 Sigma Dispersion Zero Wind (No Recovery)



3 Sigma Dispersion FAR Site, CA Wind (No Recovery)



3 Sigma Dispersion 4PM Far Site, CA Wind (with Recovery)



Estimated visual representation of dispersion zone superimposed on map for reference

Table of Parameters for 6-DOF Dispersion Analysis

Parameter	Value
CD	20%
CoP	10%
CN	10%
CDd	10%
CDp	10%
Launch Declination	1 degree
Thrust	1%

Dispersion plots for ballistic and recovered impacts have been generated using Cambridge rocket Simulator models[1] for 6 DOF rocket trajectory simulation.

[1] **Eerland, W J**, **Box, S** and **Sóbester, A** (2017). 'Cambridge Rocketry Simulator – A Stochastic Six-Degrees-of-Freedom Rocket Flight Simulator'. Journal of Open Research Software 5(1)

Support Equipment

a. Tracking equipment includes RF receivers, GPS receivers, antennae, computers, extra batteries and cabling.
b. FRS radios are used between team members, support personnel and launch organizers.

Safety Procedures

a. Range safety, launch preparation, launch event and post-launch checklists will be used.
b. Two-way communication via FRS radios is critical for communicating activity to event staff. Team members communicate launch prep and launch status to event organizers. Event Launch Control Officer directs sequence of launches and uses event public address system to inform attendees.

Mishap Procedures/Emergency Facilities

a. Local first aid and emergency management available from team support personnel (Emergency Medical Technician) as well as FAR launch Organizers and emergency personnel in California City, Ca.
b. Nearest hospital is located in Tehachapi, CA.

Appendix 2: Level III Certification Documentation

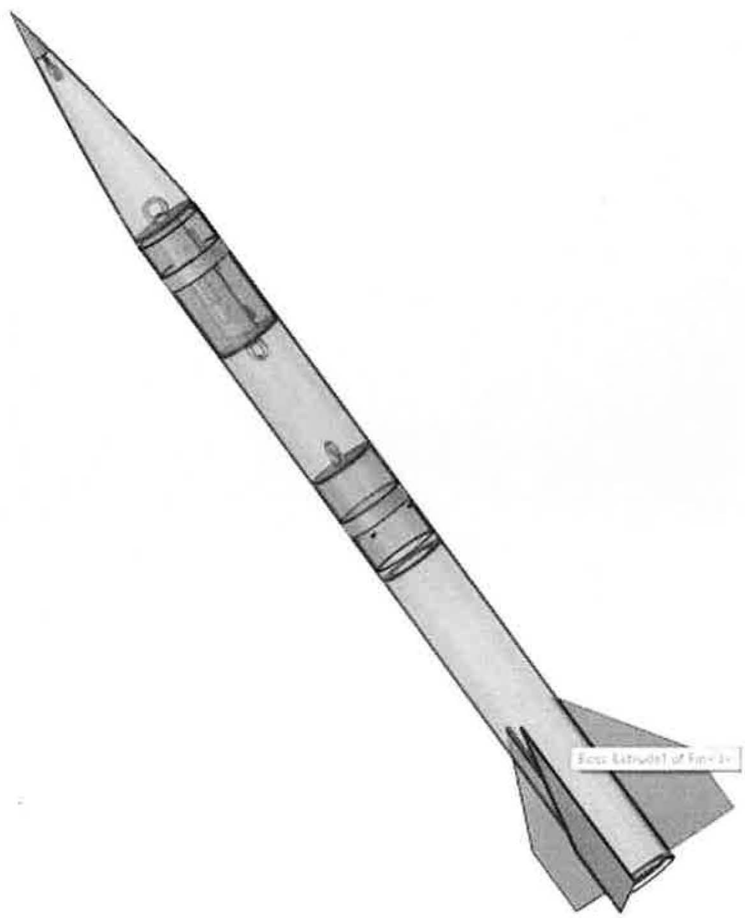
Level 3 Certification Report

Martin Mason TRA 14163

Martin S. Mason
profmason@gmail.com
(909) 569-3050

Project name: Formula 150DD

Advisors: Kevin Metzler, Michael Ostby



Introduction:

After completing my Level 1 for the first time in 2014(at Balls 23), I purchased a Formula 98 kit from then Rocketry warehouse with the intent of building it for my level 2, but I instead flew my level 1 rocket (A 4" patriot) a second time. That formula 98 kit sat in my garage for a couple of years while my Tripoli membership lapsed. I continued to mentor the college rocket team, and the kit eventually became the parts donor for the 2017 and 2018 rocket teams 4" experimental minimum diameter builds. A team member found the original fin section which inspired me to buy a new Formula 98 kit from Mad Cow to build up this rocket for my level 3 attempt. After completing the Formula 98, and siming it with the M1350 motor, I was concerned that the estimated 15500ft would be pushing the available waiver and lead to a more difficult recovery. From a sale at Composite warehouse, I purchased the next size up Formula 150 and assembled it for my L3 rocket. The Formula 150 is 6 inches in diameter and 95.5 inches long with 3 clipped delta fins. The completed weight without motor is 24.3lb and 35.8 lb with the motor.

Planned Certification motor	Aerotech M1350 DMS
Projected Altitude	7500ft +- 500ft AGL
Drogue Deployment	54" at Apogee
Backup Drogue Deployment	1s after Apogee
Main Deployment	72" at 1500 ft AGL

My goals going forward are to continue to mentor the college rocket team, and to collaborate on experimental rocket motor programs. While I primarily work in Amateur Rocketry and fly at FAR, I serve as the secretary and chief flunky for the TFAR Tripoli chapter. I am volunteering with ESRA and since they are getting involved with Tripoli, it is worth getting my Tripoli certifications back in order. I require all my student team members to obtain their level 1 certification.

Design Overview and Flight simulations

Airframe	6" Rocketry Warehouse fiberglass Formula 150
Avionics	Eggtimer Quantum, Eggtimer Apogee
Tracking	Custom LORA GPS, LORA Mini Tracker
Recovery	54" Drogue Chute 72" Main Chute

Open rocket and RAS Aero have been used to determine flight parameters such as C/P, C/G, performance, and recovery. Prior to launch, actual C/G and component weights can be measured and will be used to update the models.

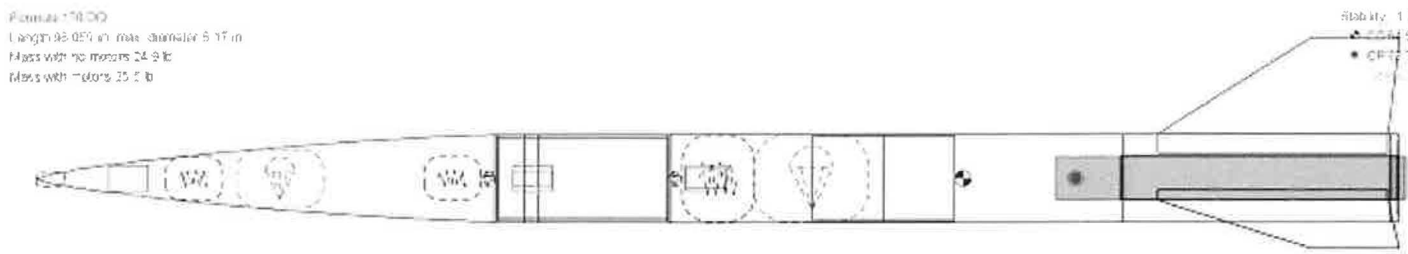


Figure 1: Scale drawing (1:10) of rocket with M1350 motor

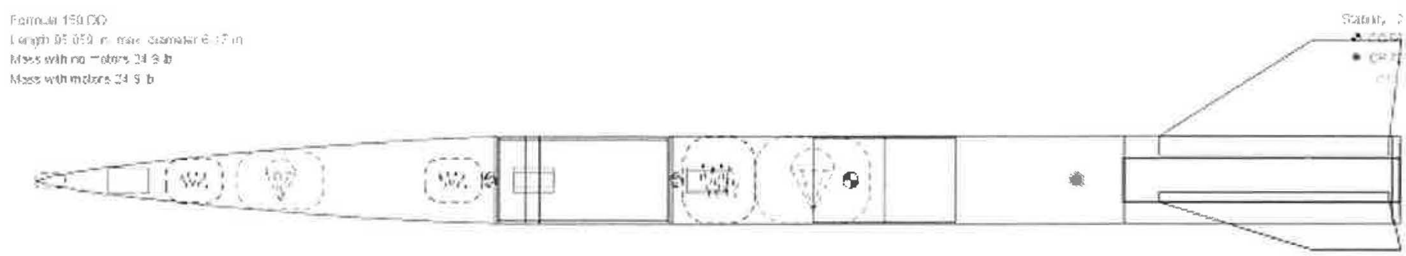


Figure 2: Scale drawing (1:10) of rocket without motor installed.

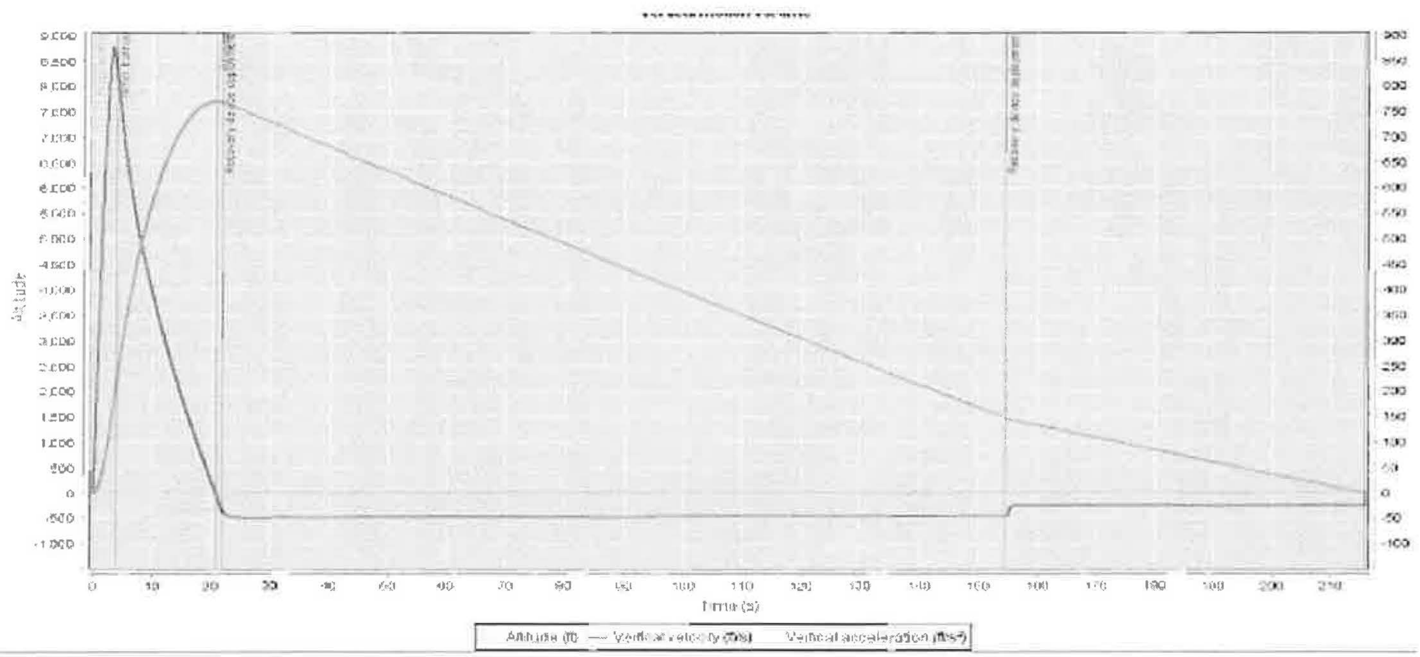
From these diagrams, the stability margin minimum is 1.37 calibers, which is in the desired stability range of 1-2 Calibers.

Preliminary flight simulations using M1350 using OpenRocket

Center of Pressure	72.3 inches from nose
Center of gravity	64.5 inches from nose (Note this was measured to within 1/8" using the completed rocket)
Mass at lift off	35.5 pounds (Weighing the rocket recorded 35.8 pounds)
Total impulse	5179 Ns
Burn time	3.84s
Velocity at end of rail	79 ft/s

Maximum expected velocity	878 ft/s (mach 0.8)
Maximum expected acceleration	334 ft/s^2 (10.5g)

Simulation performed using openrocket assuming 5mph winds and the MDARS launch site.



This fits well within the 22,000 AGL waiver available at MDARS.

Recovery System Data:

Drogue deployment time	22s
Velocity at drogue deployment	45 ft/s +- 20ft /s
Main Deployment time	156s
Velocity at main deployment	45 ft/s + 10 ft/s

Time Data:

Time to burnout	3.9s
Time to apogee	21s
Optimal Ejection delay	22s

Landing Data:

Time to Landing	216s
Range at landing	1300ft
Vertical Velocity at landing	-23.8 ft/s

Construction:

Nose Cone:

- A 6" commercial thick wall fiberglass nosecone.
- An Aluminum nose tip will be used to mitigate the heating due to the high speeds.
- A forged ¼-20 eyebolt will be threaded into the tip, passed through a forward bulkhead with nuts on either side. Soluble thermal adhesive will be used to secure the threads.
- This forged eyebolt will serve as the forward point of attachment for the recovery system.
- A 24ft section of 4.5mm Kevlar (2000lb axial rating) shockcord will be attached to the forged eyebolt using a bowline and the end gaffer taped to the line. The cord will be sheathed in a 12" section of 1" tubular nylon on either end sealed with heat shrink to reduce chances of frame zipper.
- At the 8ft point on the shockcord, a ¼" swivel will be installed attached to a 54" nylon drogue chute.
- At the 16ft point on the shockcord, a custom LORA 433MHz GPS M8 transmitter will be installed.
- At the 22ft point on the shockcord, a 10" Kevlar blanket will be installed.
- The two ~4' sections of shockcord will be folded accordion style and lightly secured with paper tape
- Immediately behind the Kevlar blanket, a 2 gram black powder charge and a second 2.5 gram (or more based on deployment testing) will be installed which will be connected to the fore end of the AV bay.

Nosecone GPS Parachute
Kevlar AVBay

Figure: Forward recovery layout to accurate scale.

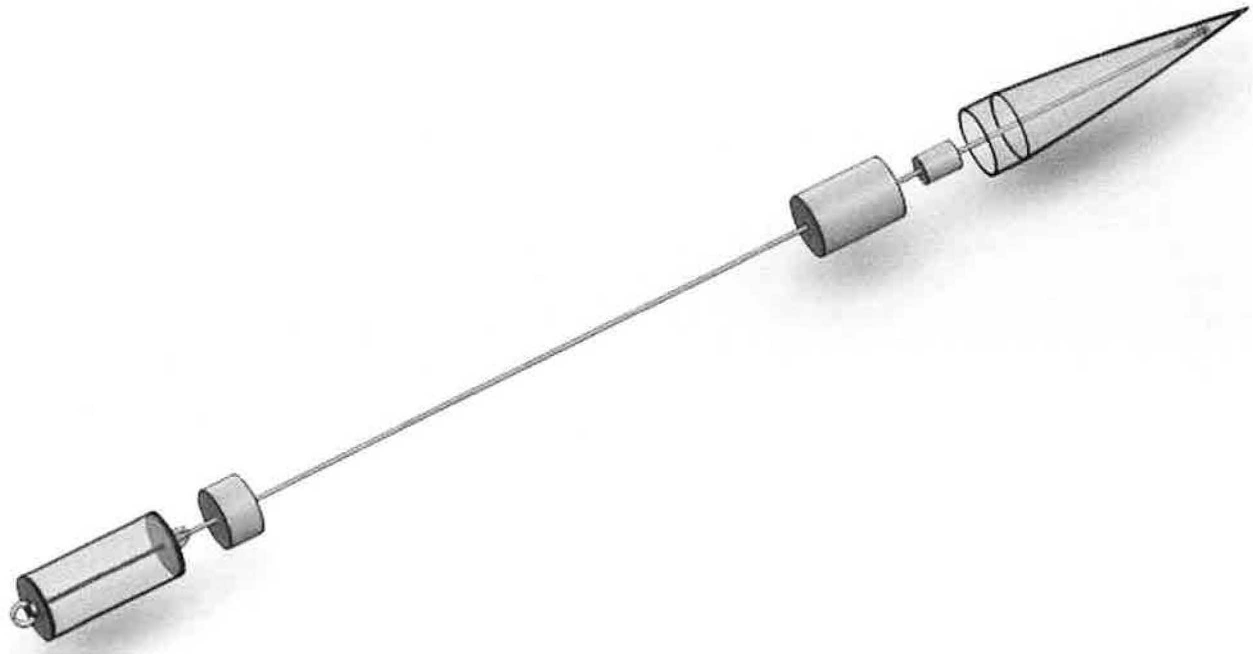


Figure: Detail view with scaled shock cord to preserve detail.

AV Bay

- This is a 12" section of thick wall fiberglass coupler tube with a 1" section of 6" OD tube glued to it for a switch band with stepped 1/8" fiberglass bulkheads on either end.
- A M8 rod with a forged M8 eyebolt passed through the top bulkhead of the AV bay, along with a pair of holes for the deployment charge wires.
- The end of the shock cord from the previous section is attached to the forged eyebolt using a bowline and the end gaffer taped to the line.
- A laser cut nylon AV bay is attached to the M6 rod via nylon hoops.
- Primary Avionics are an Eggtimer Quantum setup to deploy drogue at 1s after apogee and Main at 1500 ft. The Quantum is armed remotely. The author has flown the quantum more then a dozen times successfully in 3,4 and 5 inch rockets over 10,000ft.
- Backup avionics is an Eggtimer Apogee setup to deploy drogue at apogee. A small hole in the switch band is provided for Philips screw driver access to the mechanical switch on the apogee. The author has flown the apogee in 3 and 5 inch rockets 3-4 times.
- A backup 915Mhz miniGPS unit will provide additional tracking information.
- The M8 rod passes through the bottom AV bulkhead and is terminated with another forged M6 eyebolt. Soluble thermal adhesive will be used to secure the threads.

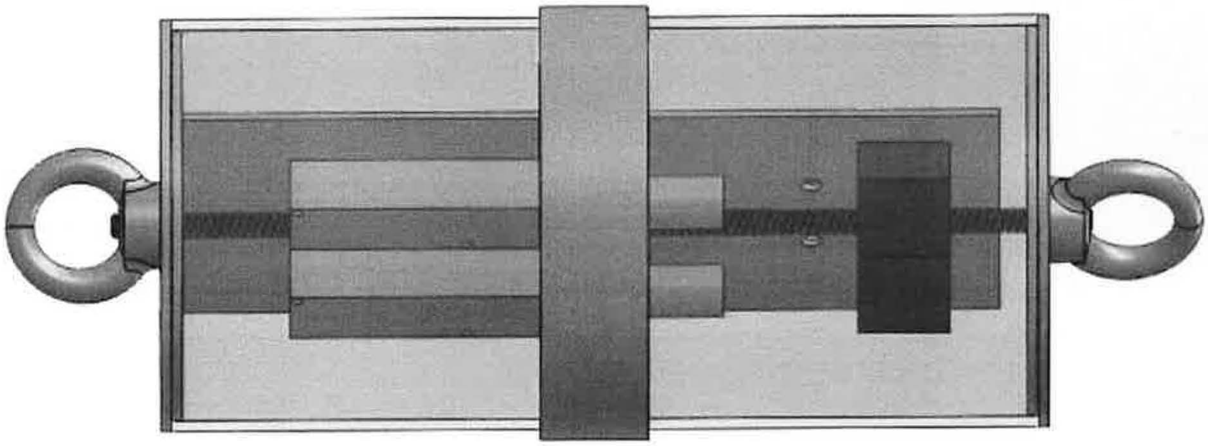


Figure: AV Bay with Avionics

Recovery Bay

- The recovery bay is a 24" section of commercial thick wall fiberglass tubing.
- A 15ft section of 4.5mm Kevlar (2000lb axial rating) shockcord will be attached to the forged eyebolt using a bowline and the end gaffer taped to the line. The cord will be sheathed in a 24" section of 1" tubular nylon on either end sealed with heat shrink to reduce chances of frame zipper.
- A 2 gram (or more based on deployment testing) black powder charge will be installed which will be connected to the aft end of the AV bay.
- At the 1ft point on the shockcord, a 12" Kevlar blanket will be installed.
- At the 10ft point on the shockcord, a loop will be attached to a 72" nylon main chute.

AV Bay Kevlar Parachute
Mount Bay

Figure: Aft recovery layout

Mount bay

- The mount bay consists of a 10" coupler is used to couple the Recovery bay to the motor bay.
- A 1/8 thick fiberglass bulkhead is epoxied to the end of a 6" coupler.
- A 3/8-16 eye-bolt is secured to the tapped threads in the forward bulkhead of the M1350DMS motor.
- The end of the shock cord from the previous section is attached to the eyebolt using a bowline and the end gaffer taped to the line.

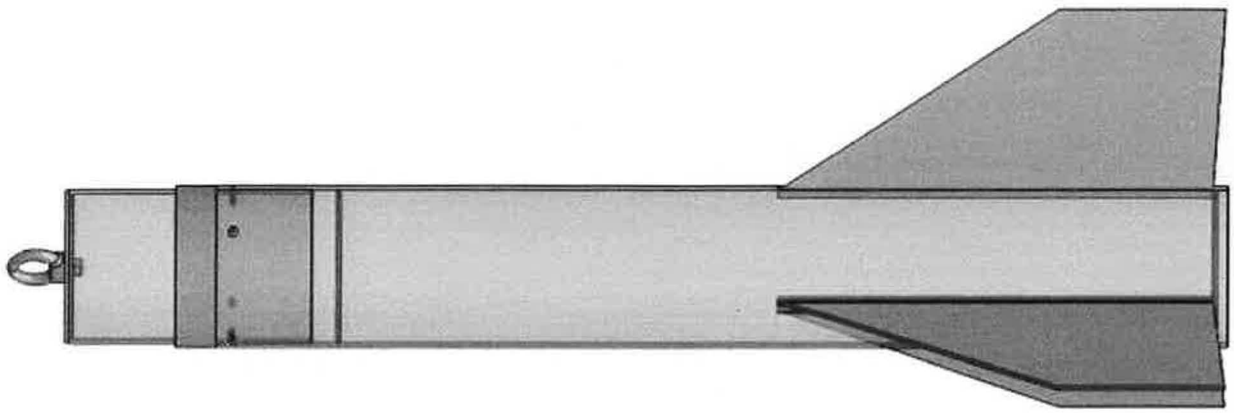
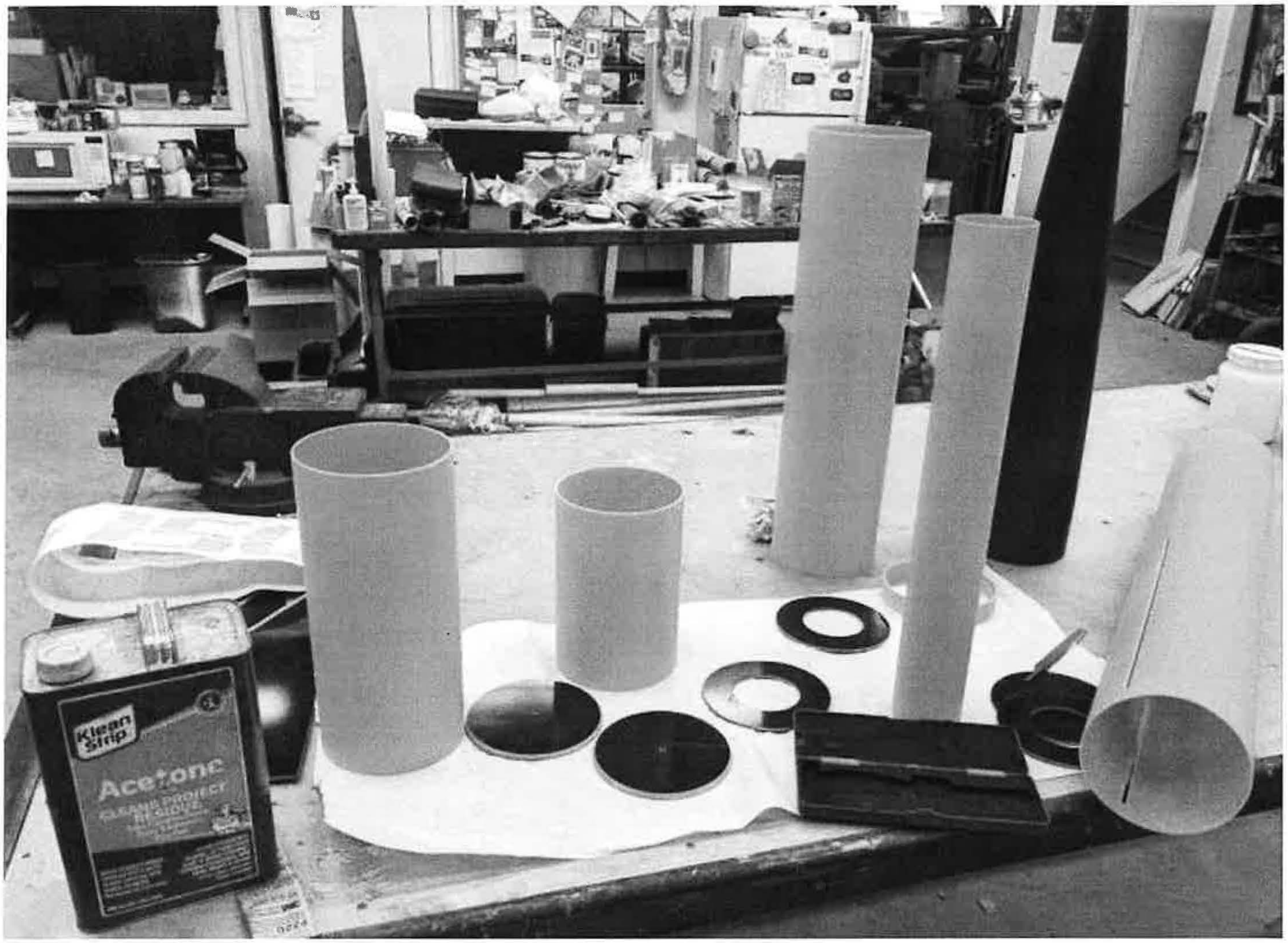


Figure: Mount bay and Motor Bay

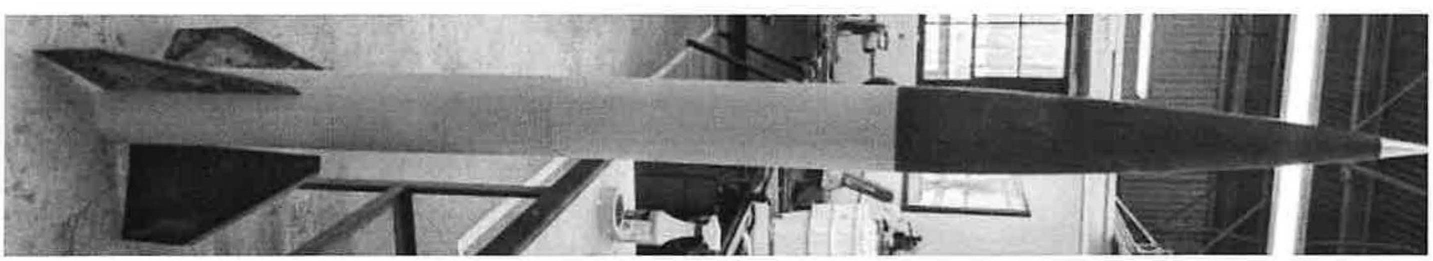
Motor tube:

- 4x 6-32 button head cap screws are used to secure the coupler to the forward mount bay
- A laser cut fin jig is created to set the 120 degree angles and the tube is inserted in the jig.
- The fins are inserted into the jig and tacked in place.
- Internal fin fillets are made using syringe injection.
- The fins are attached using through fin construction with external ½" fillets made using MAXbond 24hour epoxy with glass microsphere filler.
- MAXBond 24 hour epoxy used to bond all other fiberglass elements.
- A pair of holes are drilled in the aft centering ring, and insert nuts are epoxied to the backside to use for motor retention.
- The centering rings are installed with one butted against the aft end of the fin tabs, and the other located 3inches from the forwarded end of the motor tube.
- A pair of centering rings are epoxied to the inside of the motor bay with appropriate internal and external fillets.
- A custom aluminum retainer is installed to prevent the spent motor from ejecting out the back of the rocket.

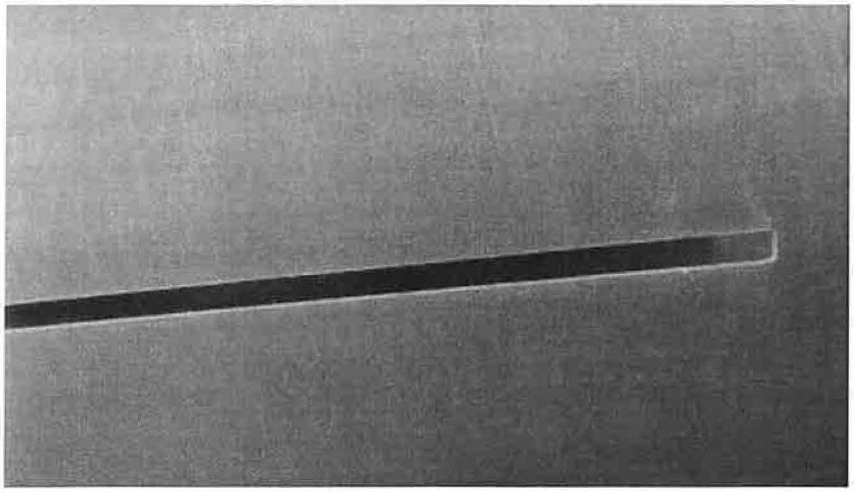
Construction Documentation:



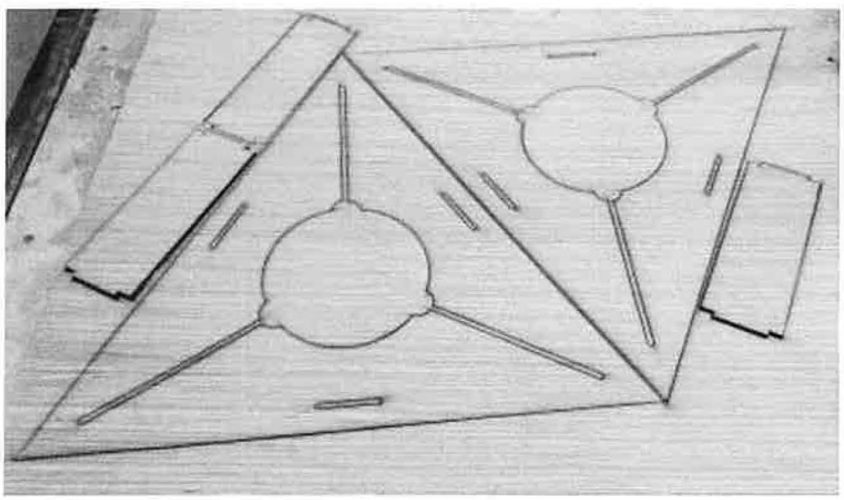
Step 1: Inventory parts and remove any mold release with acetone



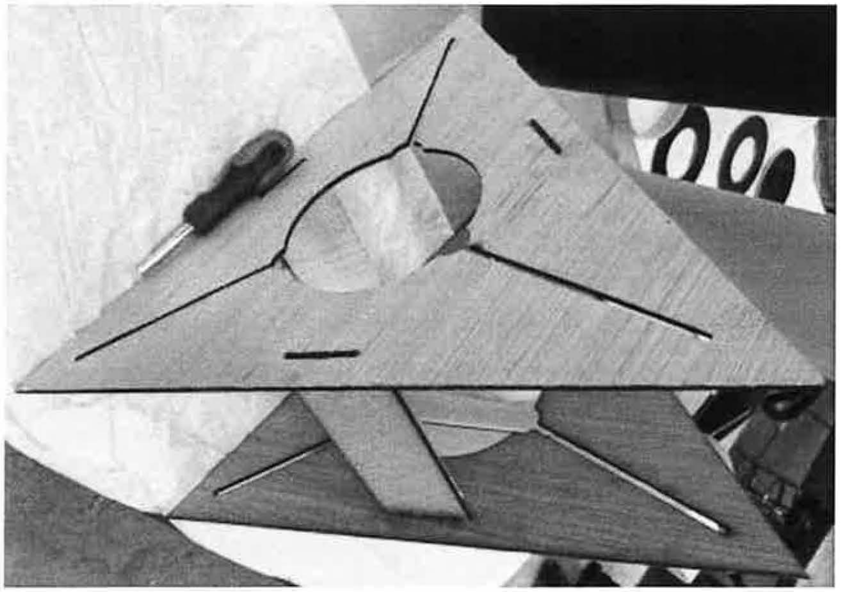
Step 2: Assemble all pieces to check fitment and determine what prep is required.



Step 3: File fin slots square

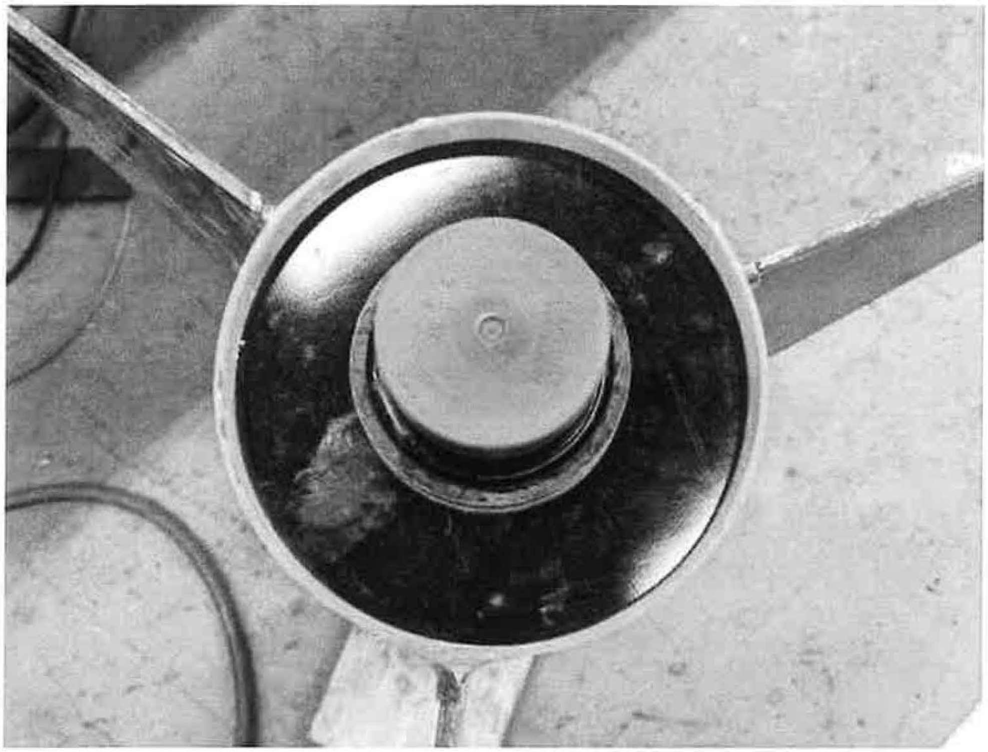


Step 4: Design and cut fin alignment jig

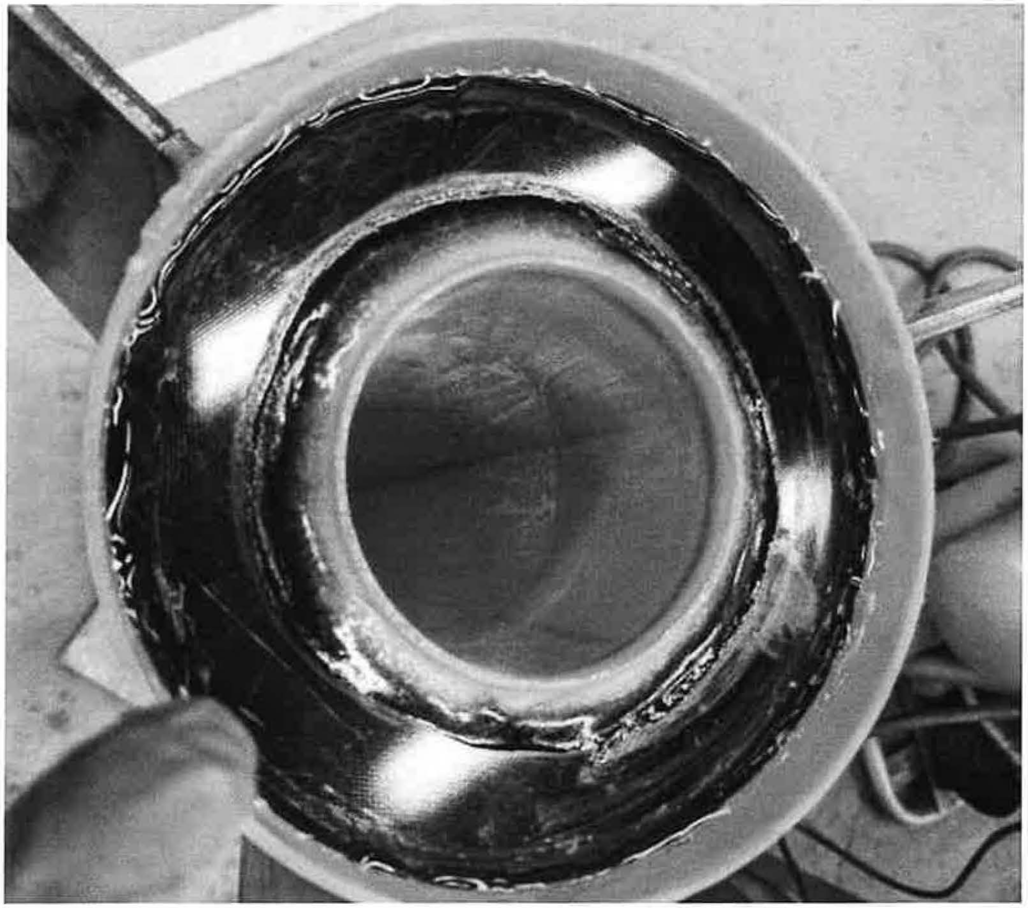


Step 5: Assemble Fin Alignment Jig

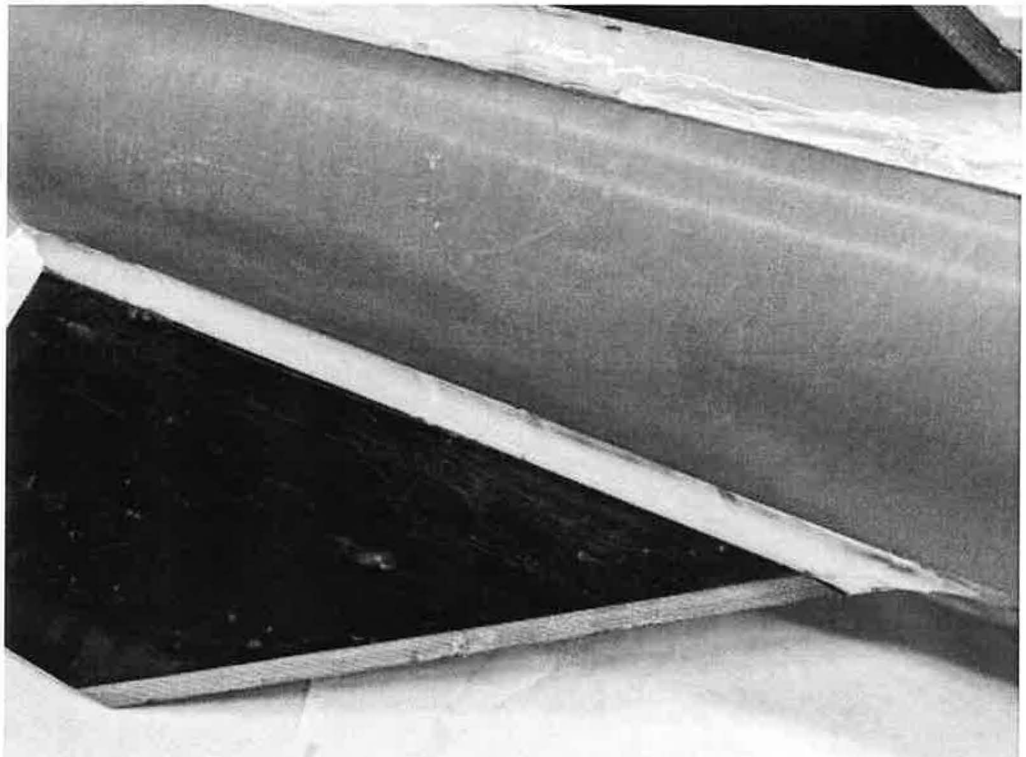
Step 6: Assemble fins and layup epoxy fillets.



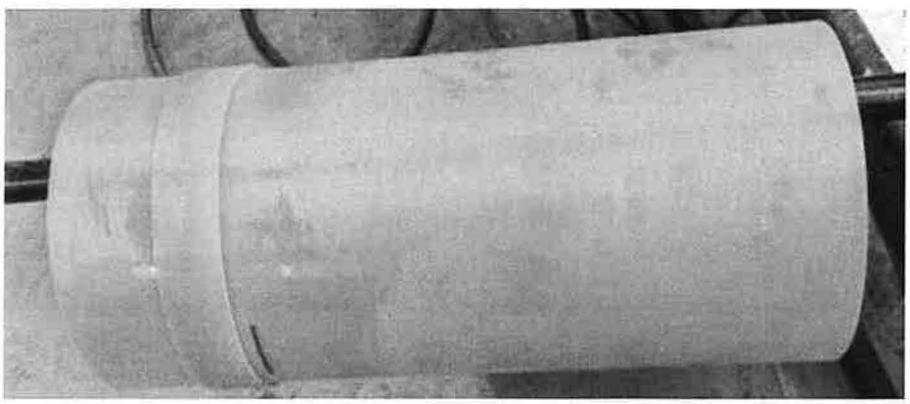
Step 7: Check centering ring alignment and motor fitment



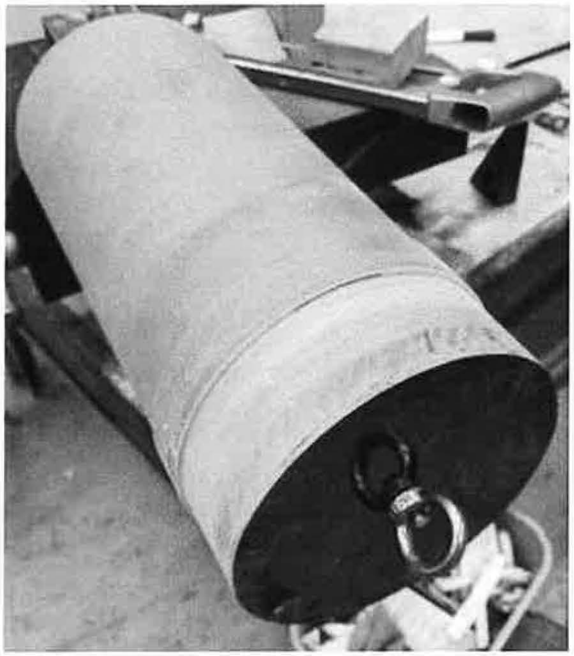
Step 7: Epoxy centering ring to motor mount. Use soluble adhesive to attach centering ring to body tube.



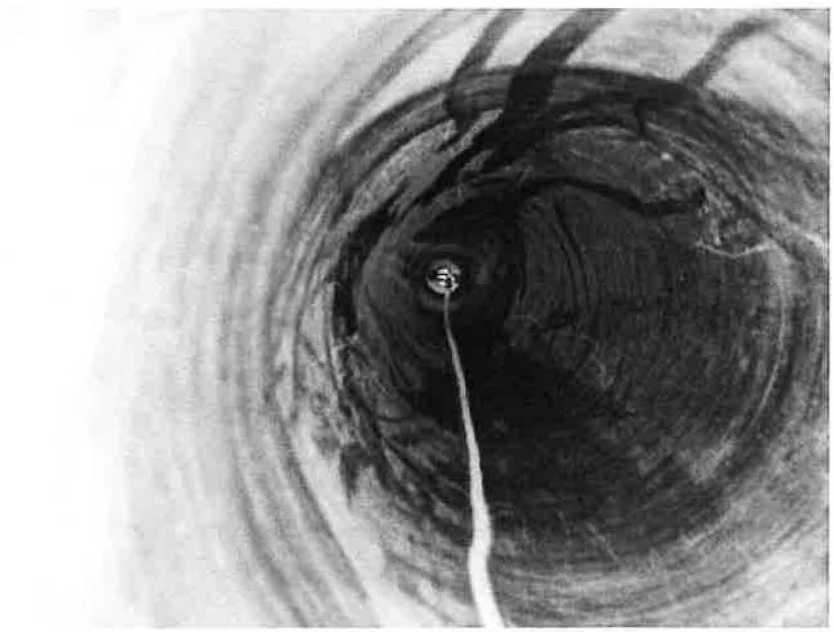
Step 8: Lightweight gel coat on fin fillets.



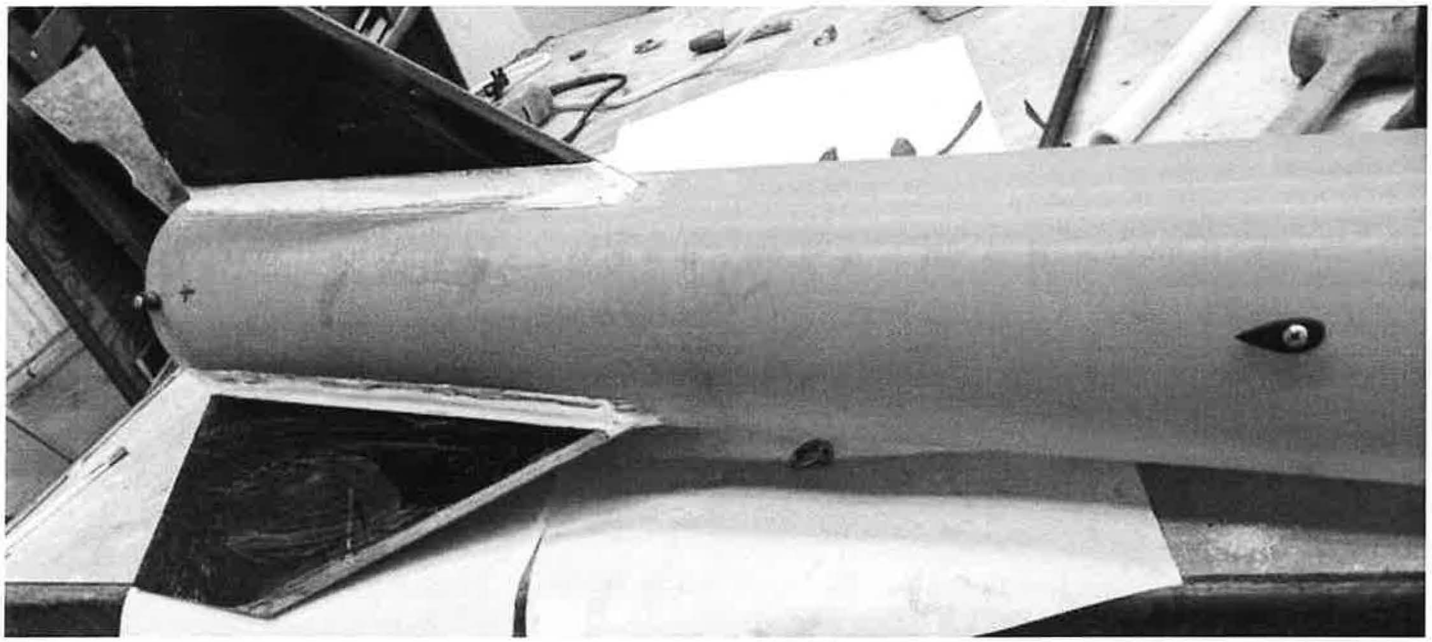
Step 9: Epoxy switch band/nose cone stop to AV bay



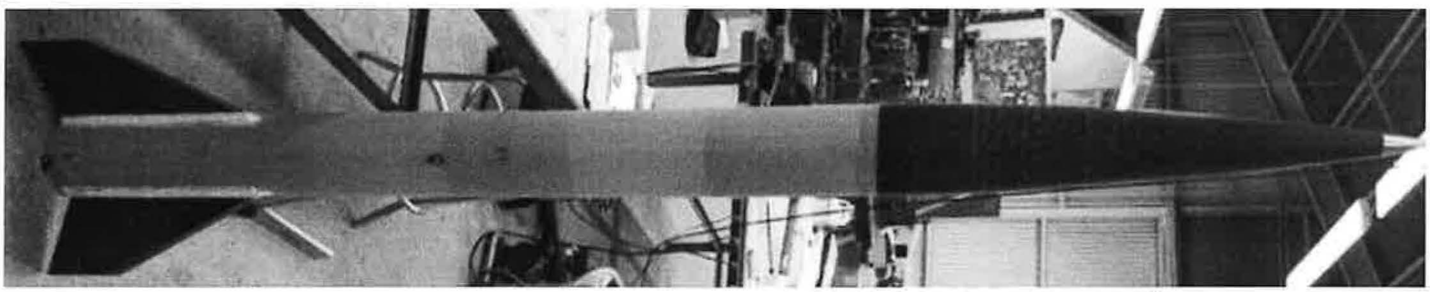
Step 10: Sand AV Bay to insure good fitment in nose cone.



Step 11: Install ¼-20 eyebolt into aluminum tip of nosecone.



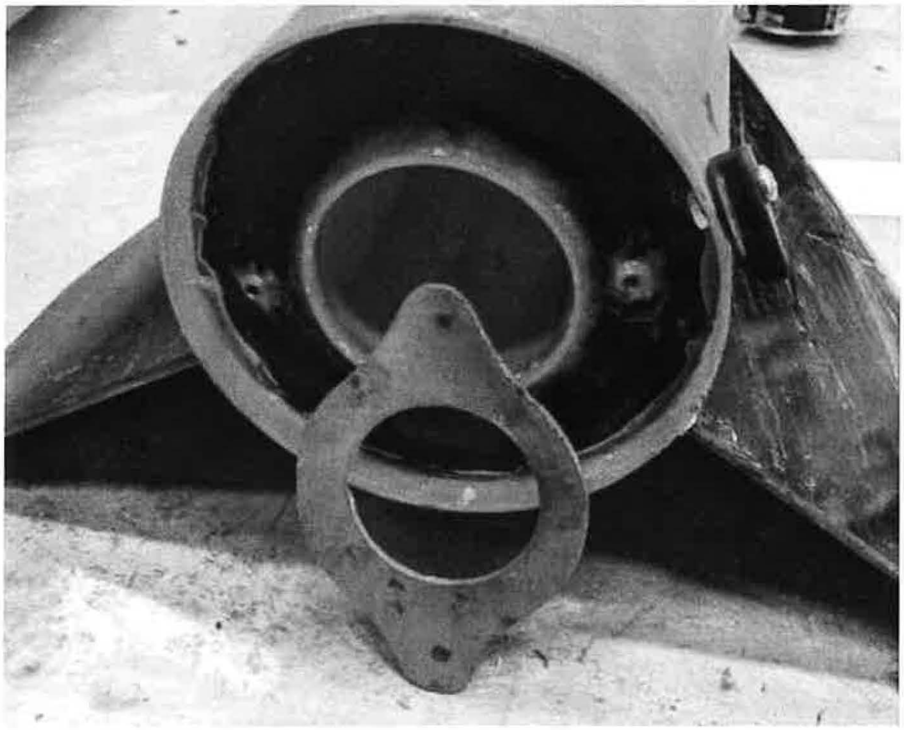
Step 12: Install rail buttons



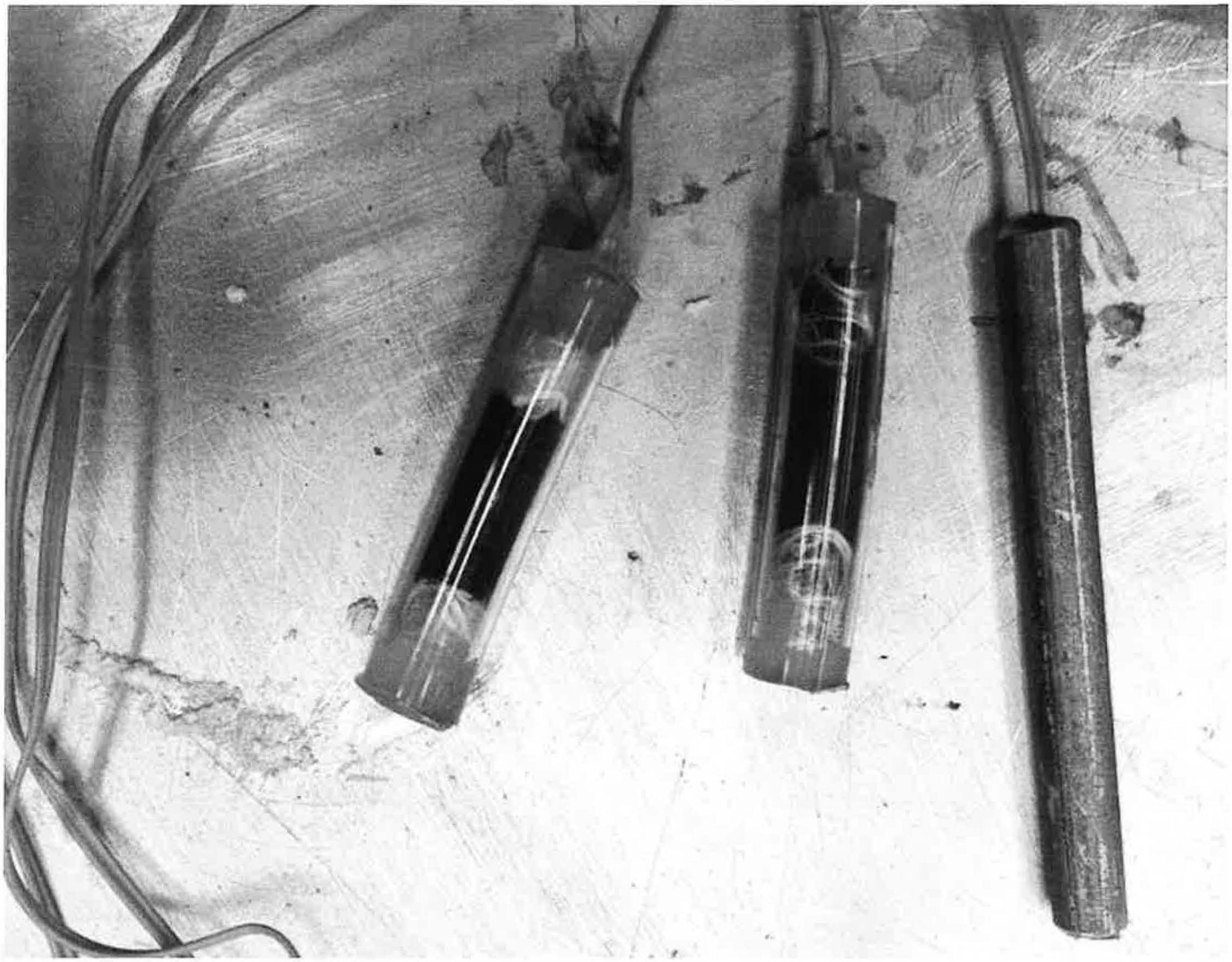
Step 13: Reassemble rocket and check fitment of all parts. Test separation of nose cone section with 6psi air.

Step 14: Layout main recovery materials from left to right including 3/8" motor mount eyebolt, nomex blanket, 72" parachute, GPS module and 8mm eyenut.

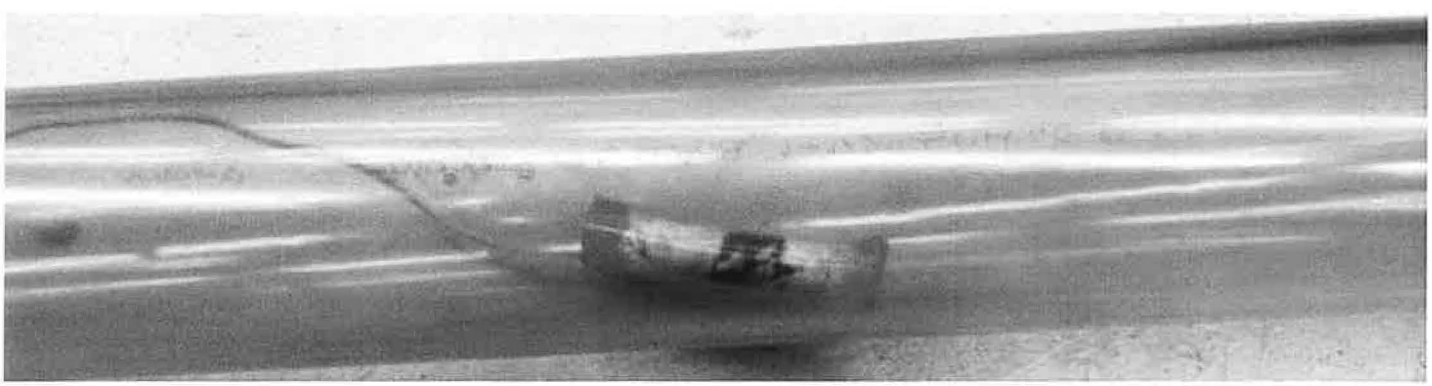
Step 15: Layout drogue recovery equipment from left to right including nosetip with eyebolt, GPS, 54" drogue chute, nomex blanket, Apogee deployment unit, 8mm eyenut.



Step 16: Epoxy rear motor retention nuts and fabricate motor retention bracket.

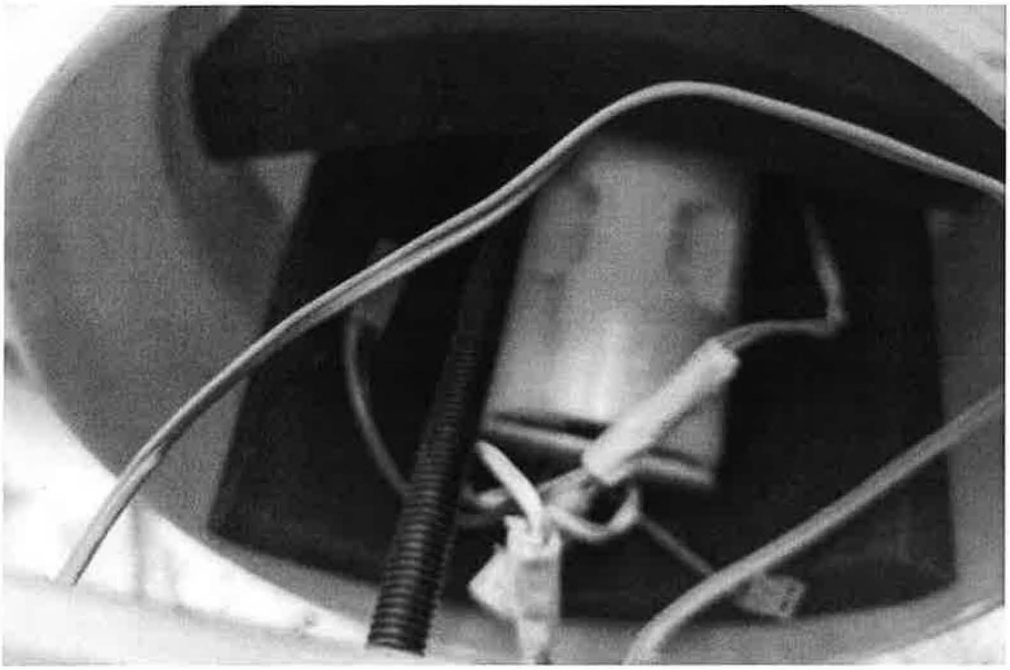


Step 17: Fabricate ejection charges. Two left charges are 1 gram black powder in vinyl tubes sealed with hotglue. The right tube is an backup 1 gram Jim Jarvis style high pressure ejection charge.



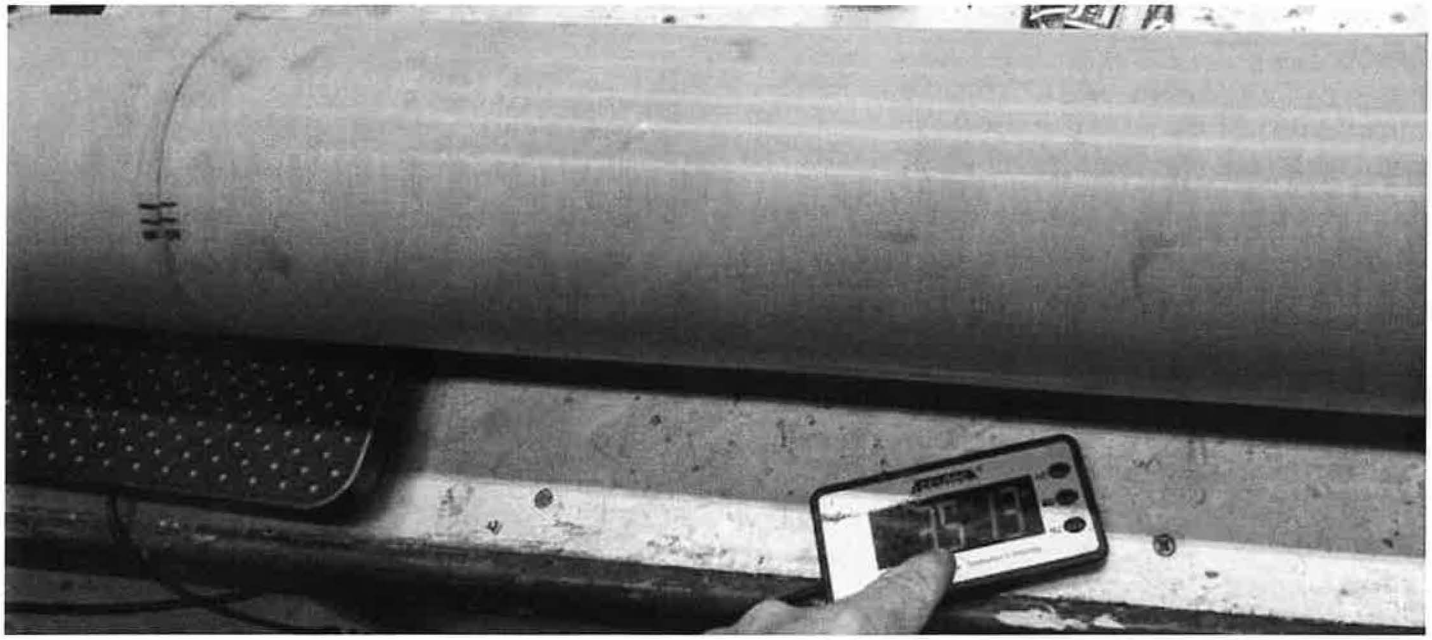
Step 18: Test charges in pressure chamber with pressure transducer. Pump the pressure in the tube down to match the pressure at altitude and then measure the positive pressure generated by the ejection charge.

Step 19: Run a simulated flight with the pressure pot pumped down to the appropriate pressure to simulate altitude and thus flight for both the apogee and quantum altimeters. Replace black powder charges with Christmas lights so that apogee deployment by both altimeters and main deployment can be observed at the appropriate pressure.

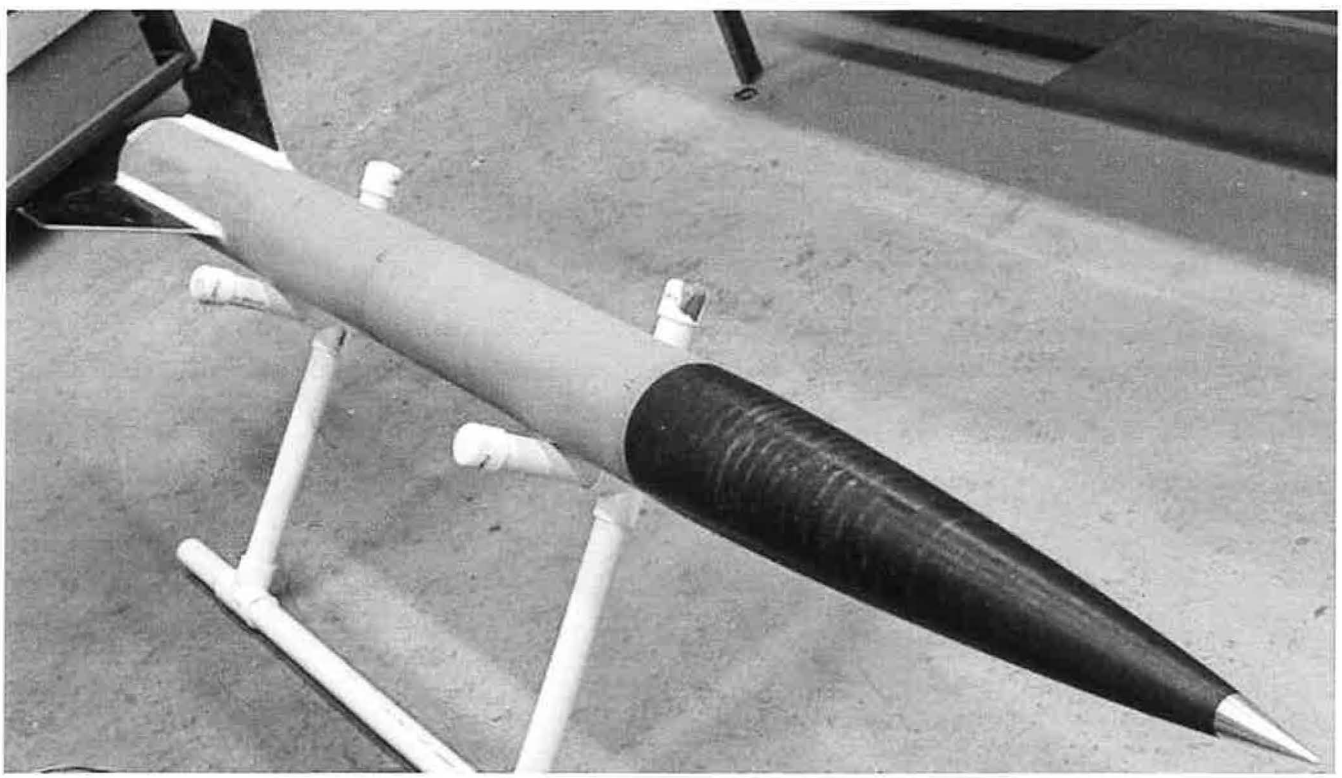


Step 20: Install the Quantum wireless Avionics unit in the AV Bay in its custom TPU enclosure. Run the wires with strain relief through both bulkheads in preparation for installing ejection charges.

Step 21: Experimentally determine the CG by balancing the rocket on a round wood rod and marking the location of the balance point.



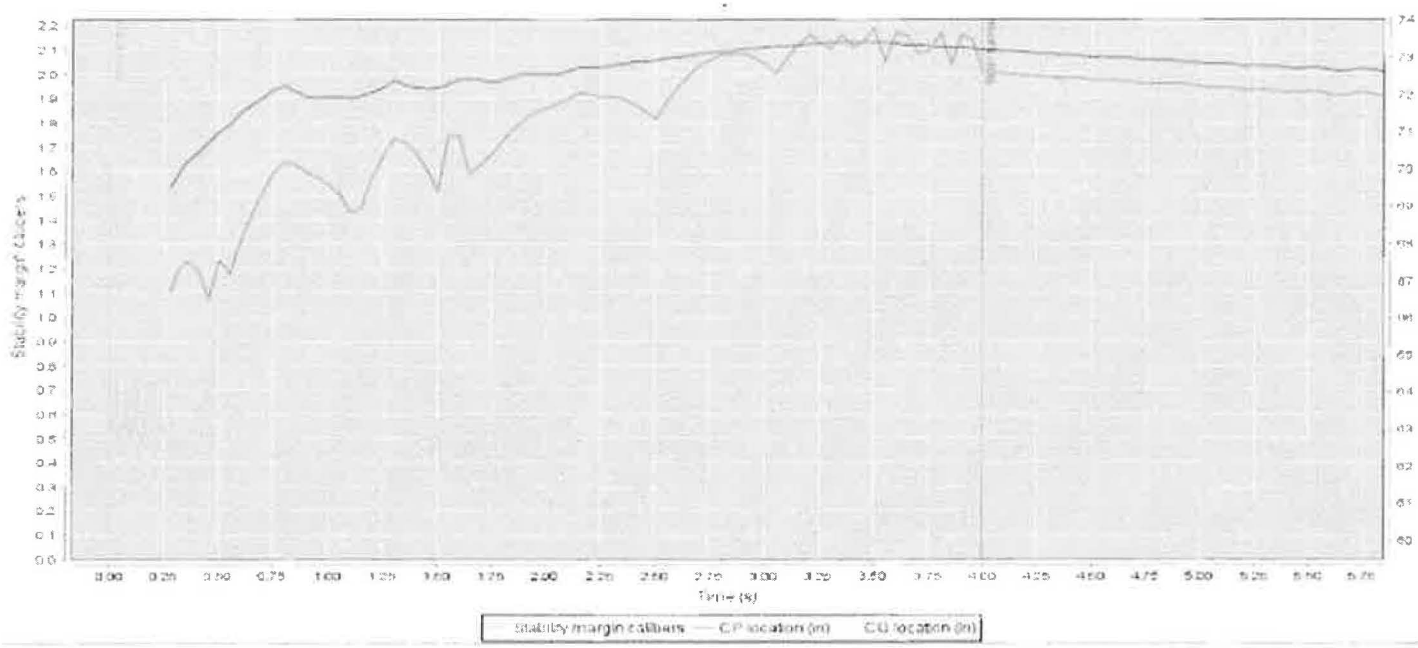
Step 22: Determine the experimental weight of the entire rocket.



Step 23: Assemble a stand to hold the completed rocket until transport to the launch field.

Conclusion:

The measured weight of 35.8 oz is within 1% of the simulated weight of 35.5oz. The measured CG of the rocket is 64.5" is with ½ % of the calculated value of 64.6. This leads to a reasonable confidence in the simulation used to determine performance. There are two different published values of CP for the rocket: 71.5" and 72.5" from the tip. The second value is consistent with the simulator model and give 1.25 caliber of stability. The first value gives 1.15 caliber of stability. These values are both within an acceptable range.



The CP, CG and stability of the rocket during flight shows that it remains in a stable configuration through the predicted trajectory.

Any questions please contact profmason@gmail.com

Appendix 3: Partial Journal of launch activities for 2020-21

June 20 2020
>Launcher Type: Newman 20-Foot
>Rocket Type: Experimental Solid
>Number of Stages: One-Stage
>Recovery Type: Two-Stage-Deployment-Parachute
>Total Impulse: 9102-N-Sec
>Altitude: 10000-ft
>Number of Launches: 2
Attempt 2x 4" experimental solid launches. If the first launch is good early AM, then will attempt a 2nd after recovery. The team tentatively plans to camp Friday night to get on the rail for the waiver open on Saturday AM, but this is subject to change and the team may just drive out early AM. We will bring our own ground support etc.
SS2S will be making some 10" grains Friday and Saturday and keeping an eye on the students. Will be good to be back

July 4
>Rocket Engine/Motor Type: High-Power Rocket Motor
>Thrust: 5500-N
>Total Impulse: 51373-N-sec
>Test Stand: Extra-Large I-Beam
>Number of Static Firings: 1
SS2S will bring ground support equipment and mounting. Would like to use large or X large rail since 8". Motor is only 63" long. Motor is low pressure and low efficiency. Testing commercial high pressure fiberclass motor case (from commercial reverse osmosis application) 8" 500 psi on a 1200 psi rated pipe.

AUG 1
>Rocket Engine/Motor Type: High-Power Rocket Motor
>Thrust: 928-lbs
>Total Impulse: 40079-N-sec
>Test Stand: Extra-Large I-Beam
>Number of Static Firings: 1
3 Grain version of the motor that we fired on July 4th. Decreased pressure by 25% and Upgraded retention hardware to 10x safety factor. We will provide support equipment. SS2S crew will camp the night before as we have a lot of assembly to do so that we can get the test done as early as possible.

AUG 15
>Rocket Engine/Motor Type: Experimental Solid
>Thrust: 580-lbs
>Total Impulse: 19820-N-sec
>Test Stand: Buried
Bury case in ground nozzle up at location near lunar pad. SS2S will arrive about 5 PM Friday.

AUG 15
>Launcher Type: Newman 20-Foot
>Rocket Type: Experimental Solid
>Number of Stages: Two-Stage
>Recovery Type: Two-Stage-Deployment-Parachute
>Total Impulse: 1350-N-Sec
>Altitude: 3400-ft
>Number of Launches: 1
Small K 3" sugar motor booster to a F commercial sustainer. Will provide ignition and all support. We are postponing our static test for two weeks.

SEPT 4-5

>Launcher Type: Newman 20-Foot
>Rocket Type: Model Rocket Motor
>Number of Stages: One-Stage
>Recovery Type: Single-Stage-Deployment-Parachute
>Total Impulse: 500-lbs-sec
>Altitude: 4,000-ft
>Number of Launches: 1
: Low powered launch to test roll stabilizing mechanism

SEPT 4-5
>Rocket Engine/Motor Type: Experimental Solid Motor
>Thrust: 100 -lbs
>Total Impulse: 300 -lbs-sec
>Test Stand: Small Inverted
>Number of Static Firings: 5
Single grain BATES motor testing.
>

SEPT 19
>Launcher Type: Newman 20-Foot
>Rocket Type: Experimental Solid Motor
>Number of Stages: Two-Stage
>Recovery Type: Two-Stage-Deployment-Parachute
>Tracker Frequency: 900 MHz
>Total Impulse: 2,200-N-Sec
>Altitude: 18,000-ft
>Number of Launches: one
Will do either this 2-stage or a 1,100 Nsec single stage launch to 11,000'

SEPT 19
>Thrust: 120-N
>Total Impulse: 480-N-sec
>Test Stand: Small Inverted
>Number of Static Firings: 3
Continuation of the 'ambient temperature / burn rate experimenting. Single 960 gram grains (3) at different temperatures.

NOV 7

>Launcher Type: Newman 10-Foot
>Rocket Type: Experimental Solid
>Number of Stages: One-Stage
>Recovery Type: Single-Stage-Deployment-Parachute
>Total Impulse: 1,000-N-Sec
>Altitude: 3,000-ft
>Number of Launches: 1
Low cost launch platform component test

NOV 20
>Rocket Engine/Motor Type: Experimental Solid Motor
>Thrust: 4,000-N
>Total Impulse: 40,000-N-sec
>Test Stand: Personal
>Number of Static Firings: 1

8" fiberglass case sugar motor. Will be tested in the ground, nozzle up.

DEC 18
>Rocket Engine/Motor Type: Experimental Solid Motor
>Thrust: 4820-N
>Total Impulse: 29200-N-sec
>Test Stand: Personal
>Number of Static Firings: 1
SS2S staff is coming out to complete the test stand concrete pour on Friday, and then assemble the motor on the portable 1000lb vertical Ibeam test stand we made last weekend. This is the final use of this case (getting shorter and shorter) for a single neutral case bonded finocyl grain as a scale model for our big motor. Currently working on Class III waiver for February.

DEC 18
>Launcher Type: Newman 20-Foot
>Rocket Type: Experimentall Rocket Motor
>Number of Stages: One-Stage
>Recovery Type: Single-Stage-Deployment-Parachute
>Total Impulse: 2449-N-Sec
>Altitude: 4820-ft
>Number of Launches: 1
This is a 5inch short rocket on a 3inch sugar motor.
>

JAN 2
>Launcher Type: Personal
>Rocket Type: Experimental Solid
>Number of Stages: One-Stage
>Recovery Type: Single-Stage-Deployment-Parachute
>Total Impulse: 25904-N-Sec
>Altitude: 12700-ft
>Number of Launches: 1
Scale test of larger 8" rocket using motor that has been 8" static tested. We are pushing to get it done around the holiday madness. It looks like a giant 8" version of the lil Ivan rocket. We will be launching off the unistrut rail out on the moon pad. Fins are cut, nose cone and transition are done. Need to do avionics, make the launch rail mounts, layup the fins and update the nozzle. If everything isn't ready we will push to the 16th and will spend the 2nd working on the launcher.
>

JAN 16
>Launcher Type: Newman 20-Foot
>Rocket Type: Model Rocket Motor
>Number of Stages: Two-Stage
>Recovery Type: Three-Stage-Deployment
>Total Impulse: 11,000-N-Sec
>Altitude: 18,000-ft
>Number of Launches: 1
Testing staging electronics for Sugar Shot to Space program
>

JAN 16
>Rocket Engine/Motor Type: Experimental Solid Motor
>Thrust: 300-N
>Total Impulse: 1,000-N-sec

>Test Stand: Personal
>Number of Static Firings: Several
Will be static testing steel nozzle use with sugar propellant for the Tripoli research testing project. Motor will be designed to eject the nozzle.
>

JAN 16
>Rocket Engine/Motor Type: Experimental Solid Motor
>Thrust: 3200-N
>Total Impulse: 13129-N-sec
>Test Stand: Extra-Large I-Beam
>Number of Static Firings: 1
Mt. SAC KNSb 5" motor static test. Can use any of the larger vertical ibeams. This motor is recommissioned by the new team after being flown/static tested 5x last season. New forward bulkhead with a pressure transducer port.
>

JAN 16
>Launcher Type: Newman 20-Foot
>Rocket Type: Experimental Solid
>Number of Stages: One-Stage
>Recovery Type: Single-Stage-Deployment-Parachute
>Total Impulse: 3100-N-Sec
>Altitude: 4500-ft
>Number of Launches: 1
Test telemetry on and cross talk between RF modules. 3" knsb motor in 5" airframe. >

JAN 16
>Rocket Engine/Motor Type: Experimental Solid Motor
>Thrust: 80-lbs
>Total Impulse: 430-N-sec
>Test Stand: Personal
>Number of Static Firings: 5
Mason will be testing a series of PVC motors and SS2S will be doing some steel nozzle tests out on the small test stand past the 2 story test stand.
>

FEB 6
>Rocket Engine/Motor Type: Experimentalr Rocket Motor
>Thrust: 2700-N
>Total Impulse: 18600-N-sec
>Test Stand: Personal
>Number of Static Firings: 1
>Testing smaller KNSB 8" motor with new finocyl designs. Last finocyl mold elements didn't debond well so continuing to refine design. Will use the new small test stand back behind the two story test stand.
>

FEB 6
>Launcher Type: Newman 20-Foot
>Rocket Type: Experimental Solid
>Number of Stages: One-Stage
>Recovery Type: Single-Stage-Deployment-Parachute
>Total Impulse: 13129-N-Sec
>Altitude: 10700-ft
>Number of Launches: 1
Will launch the KNSb motor static tested at previous FAR day. Prep for FAR 1030.
>

FEB 6
>Launcher Type: Newman 20-Foot
>Rocket Type: Experimental Solid
>Number of Stages: One-Stage
>Recovery Type: Single-Stage-Deployment-Parachute
>Total Impulse: 320-N-Sec
>Altitude: 2200-ft
>Number of Launches: 2-3
Fly at least one of the 38mm motors that we have been static testing and preferably two along with the 4" motor.

FEB 6
>Rocket Engine/Motor Type: Experimental Solid Motor
>Thrust: 30-90-lbs
>Total Impulse: 350-600-N-sec
>Test Stand: Personal
>Number of Static Firings: 8
Testing some 38mm 4 grain and 4" single grain motors plus delay grain formulations out on the back rail behind the two story test stand. 38mm motors are 4 grain small I. 4inch motors are 1 grain and medium J.

FEB 20
>Launcher Type: Newman 20-Foot
>Rocket Type: Experimental Solid
>Number of Stages: One-Stage
>Recovery Type: Single-Stage-Deployment-Parachute
>Total Impulse: 4,000 Nsec-N-Sec
>Altitude: 2200ft
>Number of Launches: one
L-impulse KNSB 'sugar' motor on a tube fin rocket.
May stay the night to work on concrete forms Sunday.

MARCH 6
>Group: US Rockets
>Rocket Engine/Motor Type: Experimental Solid Motor
>Thrust: 2,100-lbs
>Total Impulse: 31.500-lbs-sec
>Test Stand: Large Horizontal
>Number of Static Firings: 1
Change from March 6 test date
>

March 19
>Group: US Rockets
>Rocket Engine/Motor Type: Experimental Solid Motor
>Thrust: 2,100-lbs
>Total Impulse: 31,500-lbs-sec
>Test Stand: Large Horizontal

>Number of Static Firings: 1
The motor is a 12" OD aluminum case motor about 48" long with a 33" star fuel grain. At 150 lbs propellant it will nominally produce about 2100 lb thrust for 15 seconds. 15 KS 2100 - P - SF4. The test is to measure the actual vs estimated. Target pressure 750 psi average.

March 20
>Rocket Engine/Motor Type: Commercial Hybrid Engine
>Thrust: 260-N
>Total Impulse: 920-N-sec
>Test Stand: Personal
>Number of Static Firings: 4Testing the GSE and ignition propellant grains for 38mm NOX HDPE hybrid. Will test out on the small ibeam stand out past the 2 story test stand with a fixture that bolts to the stand. Will test until we run out of NOX. Also have some micrograin KNSB motors (E size) to test out on the same stand.
>

April 16
>Launcher Type: Personal
>Rocket Type: Experimental Solid
>Number of Stages: One-Stage
>Recovery Type: Single-Stage-Deployment-Parachute
>Tracker Frequency: 915 and 433 MHz
>Total Impulse: Q-lbs-sec
>Altitude: 98000-ft
>Number of Launches: 1
Postpone march 20th waiver flight to April 17th pending FAA approval due to high winds predicted this weekend. Flight will remain the same 8inch booster to dart on the moonscape rail. We will arrive Wednesday and pour grains Wednesday and Thursday with integration on Friday for Saturday launch.
>

APRIL 17

>Name: US ROCKETS
>Rocket Engine/Motor Type: Experimental Solid Motor
>Thrust: 2,100-lbs
>Total Impulse: 31,500 -lbs-sec
>Test Stand: Large Horizontal
>Horizontal Sled: Yes
>Number of Static Firings: 1
The motor is a 12" OD aluminum case motor about 48" long with a 33" star fuel grain.
>At 150 lbs propellant it will nominally produce about 2100 lb thrust for 15 seconds.
>15 KS 2100 - P - SF4. The test is to measure the actual vs estimated.
>Target pressure 750 psi average.
>

MAY 1
>Launcher Type: Newman 20-Foot
>Rocket Type: Experimental Solid
>Number of Stages: One-Stage
>Recovery Type: Single-Stage-Deployment-Parachute
>Tracker Frequency: MHz
>Total Impulse: 4,000-N-Sec
>Altitude: 5,000-ft
>Number of Launches: 1
>Drone Use:
KNSB sugar propellant flight test of $25 rocket. Second flight using a L-impulse motor. Might change the motor to a M-inpulse sugar motor to test the Elmers School Glue construction.
Total cost of the entire airframe, ebay, fin can, avionics (Eggtimer 'Apogee') and propellant was $25. Only other materials used were the parachute and motor case that I previously made.
>
>This was part of the 'Under $100 M-impulse Rocket Project' that once included the launch pad.

JUNE 5

Launcher Type: Newman 20-Foot
Rocket Type: Experimental Solid
Number of Stages: One-Stage
Recovery Type: Two-Stage-Parachute-Deployment
Total Impulse: 19,981.6-N-Sec
Altitude: 20780-ft

Appendix 4: Sabbatical Application

Sabbatical Proposal for Martin Mason, Department of Physics and Engineering for 2020-21

I have two goals for my sabbatical:

3. Accomplish significant professional work in the field of rocketry by working within a rocketry collaboration to contribute to the development of a space capable solid fuel rocket platform.
4. Learn the current state of the art in VHDL and Verilog FPGA programming languages, complete a number of projects in these languages and develop a new Digital FPGA course to support the engineering program.

Executive Summary: Mixed proposal: Project and Coursework

Complete the following online/classroom coursework:

1. VHDL (40 hours) online
2. Verilog (30 hours) online
3. Vivado (30 hours) online
4. Pyrotechnic Safety (10 hours) online
5. Solid Rocket Propellant (30 hours) classroom

Apply for the following Licenses:

1. Pyrotechnic Operator Rocket Class 3
2. Low Explosive Users Permit

Complete the following project components:

1. Work for SS2S for a minimum of 600 hours including
    a. Static test of experimental high power rocket motor
    b. Launch of experimental high power rocket
2. Develop a course in Field Programmable Gate Arrays.
3. Construction of Type IV rocket storage magazine

NASA Wallops Test flight 2012 with Mt. SAC payload

Part I: Work within an agile solid fuel experimental rocket collaboration to develop a space capable platform that uses less than $1000 in consumables.

Background:

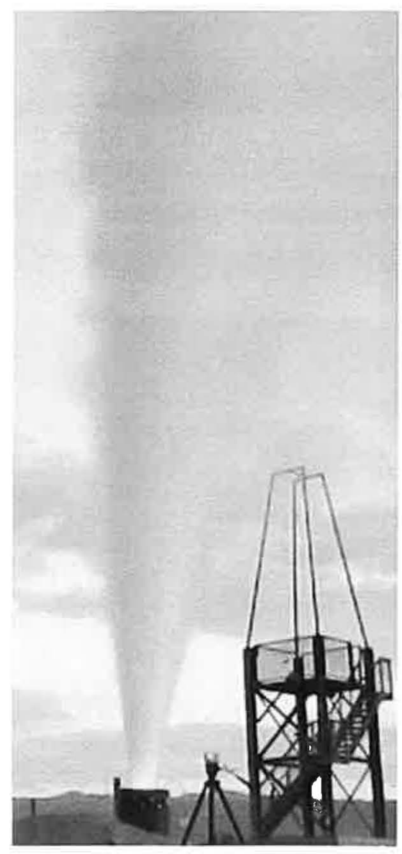
In 2012, I worked with two doctoral students from the University of Michigan to fabricate an experimental cosmic ray detector(As an aside, this was a miniaturized version of my senior project)[i]. I spent a week at Wallops flight facility fabricating, testing and then integrating the payload into a Terrier Improved Orion sounding rocket which was then launched into space, recovered and the data extracted. The following year I mentored a group of 12 students in an engineering 99 project in collaboration with Estrella Mountain College(EMC) in Arizona and Cal Poly Pomona. Mt. SAC students developed an experimental payload to test the suitability of magnesium based aerogels for particle capture. Cal Poly Pomona provided the aerogels and EMC built the launch platform[ii]. The dozen Mt. SAC students travelled to Black Rock, completed their payload integration, assisted EMC with the launch and recovery of the rocket. The rocket travelled to 87,000 feet and was recovered, at that time a record for a community college project. 5 of those students have since completed aerospace engineering degrees and are in the industry working at NASA, JPL, SPACE X and more.

In 2015, the Mt. SAC rocketry team was born, having a mission proposal accepted into the Intercollegiate Rocket Engineering Competition (IREC). I organized an engineering 99 course and the team designed, fabricated and tested their entry. Six students travelled with me to New Mexico to launch at Space port America. Mt. SAC was the only community college team to successfully launch and recover a rocket, and one of only 13 out of 103 teams to successfully meet all launch objectives.

The engineering program has made rockets a part of the curriculum, with building L1 certification rockets during the fall which are used by the Engineering 6 (Physical computing) students to launch their electronics payloads. The rocketry team at Mt. SAC has had a ripple effect at local colleges with Cal Poly (Led by all Mt. SAC alum) winning the national FAR 10/30 challenge, Mt. SAC alumni leading the CSULB rocketry payload team and Mt. SAC alumni starting and leading rocketry teams at UNLV and CSULA.

NASA Wallops Test flight 2012 with Mt. SAC payload

The expense of commercial high power rocket motors led me to direct the team to move into experimental propulsion. I worked to develop relationships with the Reaction Research Society and the FAR Site which work with the FAA and Edwards air force base to provide a launch facility for commercial and university rocketry projects. For the past three years, the rocket team has focused on experimental solid fuel motors using KNO_3 and $C_6H_{14}O_6$ with Al and Fe_2O_3 as burn rate modifiers. The team has competed at the FAR 10/30 and launched roughly six times per year. They have delivered papers and posters to aerospace and general engineering conferences winning two 1st place awards, one 2nd place and one 3rd place.



However, I have definitely hit a wall in my ability to take the team any further. I have degrees in math, physics and robotics engineering. 7 of our past 12 flight have resulted in either a recovery failure or a Catastrophe On Take Off (CATO). A decade ago, I did a sabbatical to complete a Master's degree in Robotics. This had a transformational effect on what I could do with the robotics team, which has since gone on to win the World competition, win state 8 of the last 9 years and win the Judges award at the World competition last year. This part of the proposal is to develop the necessary skills and knowledge base in rocketry by working with a collaboration of rocketry experts.

Working within a high performance rocketry collaboration that completes 3-5 static tests or launches per year gives an opportunity to move up the learning curve rapidly in all areas of the rocketry discipline. This part of the proposal is to develop the necessary skills and knowledge base in rocketry by working with a collaboration of rocketry experts.

My Proposal:

SS2S 12" 250lb propellant static b

1. Work for Sugar Shot to Space (SS2S) to develop a space capable rocket platform using KNO_3 and $C_6H_{14}O_6$based propellant.(600 hours) I met the SS2S team three years ago and have been working with Rick Maschek for the past two years as our FAR liaison. Rick Maschek is the project director for SS2S and he has invited me to join the project for the 2020-21 year. I would be located out in Mojave for thirty 12 hour days to work on site on grain production, testing, system integration, static testing and launch under the guidance of the SS2S team. I would also spend another thirty 8 hour days offsite on computational modeling, permit filing and fabrication. The SS2S project plan fits well with the parameters of a sabbatical with a static test scheduled for Dec of 2020 and a full scale space shot in June of 2021.

In my discussions with the project director Rick Maschek, he has identified the following areas in which I will take a primary role under the guidance of one of the project leads:

- Trajectory simulations
- Motor grain design
- Motor thermal issues
- Materials study (composite, metallic, etc.)
- Aerodynamic assessment
- Payload instrumentation studies
- Reduced scaled motor design(s) and testing
- Instrumentation design and detail testing
- Launcher interface and ground support design
- Recovery system design & detail testing
- Full Drawing package
- Instrumentation qualification testing
- Downlink systems
- Vehicle recovery and data analysis

2. Work with the SS2S team to master the process of obtaining a FAA class 3 waiver to launch a vehicle with an impulse above 40,000Ns. This would also include bringing me into compliance with state and federal regulations with regards to experimental solid fuel propellants. I have worked with Mt. SAC risk management and public safety consistently throughout the rocketry program, and have been fortunate to have licensed alumni under whom we could operate. However in order to grow and continue there needs to be an appropriately licensed faculty member on campus. This includes the following:

- Obtaining my state Pyrotechnic Operator Rocketry Class III License.

- Obtaining my federal Low Explosives User Permit
- Construct a complaint Type IV storage magazine for rocket propellant and complete all ATF inspections.

3. Coursework: I will complete two courses in high power rocketry:

- Solid Propellant: Course taught by John Newman or John Wickman or the equivalent 30 hours of instruction
- Pyrotechnic Operator: 10 hours

Benefit to the College:

The products of this project are as follows:

- Simulations that are directly adaptable into student projects in the Engineering 7 course (Programming applications for Engineers). When I co-wrote this course 5 years ago, we contextualized the course with automotive, architectural and controls applications. When next teaching this course I would develop a new project that directly leveraged the work of this sabbatical.
- Engineering process control documentation directly applicable to the Engineering 1C critical thinking and technical communication course. We are offering the engineering 1C course for the first time this Spring, and I am leading the collaboration of Brandon Saller, Carolyn Robinson, Pat Ash and John Hill to develop this course. A significant portion of my role as a test engineer is process control documentation which will serve as a model for student expectations in the Engineering 1C course. At least one of the engineering 1C course projects will be based on the work I do with SS2S systems.
- Ongoing access to internships and employment. Networking within the experimental rocketry industry leads to constant demand for interns and student workers. The Mojave Spaceport lists 72 unfilled technical positions. This is a unique opportunity to create significant internship and job placement opportunities for Mt. SAC students.

This work experience will improve my teaching effectiveness as follows:

- Allow me to contextualize my teaching by drawing directly from examples of how I applied course concepts in the workplace.
- Strengthen the college's academic program. Having recent professional aerospace experience in a high profile program lends credibility to our program when our rocket team competes for spots in national or international rocket programs.

This work experience will give me the tools to lead our rocket team to the next level. The Mt. SAC rocket team has already made a dramatic impact on student lives with 100% of the team participants either transferring to 4 year engineering programs or still in enrolled on campus. The skills learned during this sabbatical would allow me to professionalize the rocketry team and allow it to be compliant with state and federal codes. It would also give the students ongoing access to participating in high power rocketry with the potential of launching their projects into space. Perhaps more importantly having recent experience in the aerospace industry would contextualize my teaching and allow me to provide more explicit career advice to engineering students. Engineering as a constantly changing field for which there is no substitute for industry experience in retaining skill currency.

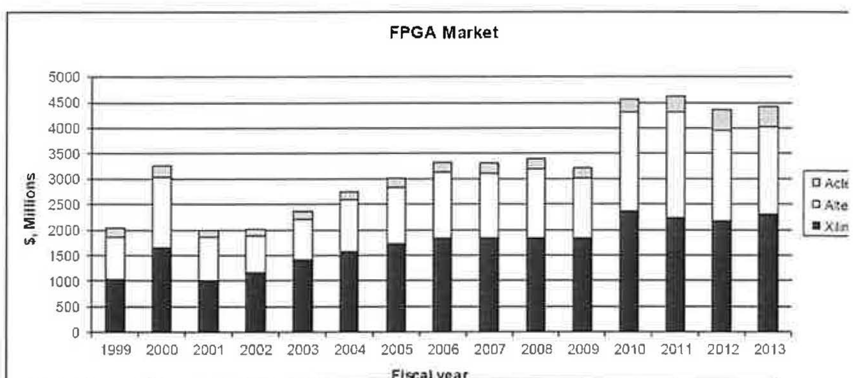
Benefit to my professional growth and enrichment:

I have been teaching and consulting for 23 years and have 15 years left in my teaching career. Taking a sabbatical to focus on robotics had a major transformational effect on me and the Mt. SAC program. I have published in robotics, served as a consultant and been featured on robotics TV shows on ABC, Discovery and in China on Youku and CGTV. The robotics team is institutionalized now, with over half the engineering faculty involved in running the team. I have been passionate about rockets since my college days when I had the opportunity in 1992 to intern for TRW space and defense. I look forward to spending an incredibly intense year learning as much as possible about high power rocketry and in turn transforming our fledgling rocketry team.

PART 2: Learn the current state of the art in VHDL and Verilog FPGA programming languages, complete a number of projects in these languages and develop a new Digital FPGA course to support the engineering program.

Background:

At the 2017 Cal State LA Engineering articulation meeting, I met with Fred Daneshgaran from the electrical and computer engineering department. In our conversation about articulation and program compatibility, I asked him about what he saw as missing from the Mt. SAC Electrical and Computer engineering(ECE) program. He called out the lack of a Field programmable gate array (FPGA) course in digital electronics in the Mt. SAC program, something they require for all of their lower division ECE students. In further conversations in late October 2019 with Greg Pottie, Department Chair of Electrical and Computer engineering at UCLA, he reiterated the importance of an FPGA course for lower division electrical and computer engineering students and offered to advise and review any course that Mt. SAC developed. My FPGA work has been non-existent for the past 25 years and the state of the art has changed tremendously. The FPGA market has grown tremendously as in the past decade as it has largely replaced the Application Specific Integrated Circuit (ASIC) in industry with over 90,000 new FPGA product starts last year. (Electrical Engineering Times) The market



Zvi Or-Bach, FPGAs as ASIC Alternatives EETimes 04-21-2014

leaders are Xilinx and Altera, one of which didn't exist during my university course. The primary FPGA programming languages are VHDL and Verilog. The Verilog and VHDL languages that I was introduced to in 1991 bears little resemblance to the modern stable releases. (Think about the differences between a DOS computer and a modern windows machine) In addition, architecture and implementation has changed with FPGAs moving out of the domain of telecommunications and into high performance, computationally intensive systems particularly data centers due to their high performance per watt.

Over the past six years, I have developed 4 new courses including writing all labs and lectures for Engineering 6, Engineering 50A and co-developing Engineering 1 with Carolyn Robinson and Engineering 7 with Eugene Mahmoud. I also completed a total revision of the Engineering 44 laboratory curriculum including developing 34 new laboratories, and moved the course from discrete instrumentation to computer based instrumentation. Each of these courses has since been institutionalized as part of our program including having adjunct teach one or more sections.

I visited CSULA in September and met with students and staff to obtain a sense of the scope of their FPGA lecture and lab course. While the fundamental concepts haven't changed, the technology has. I would need to first train in modern FPGA techniques, then develop a set of laboratories and projects and finally create the appropriate course outline and ancillary materials to allow this course to be offered.

My Proposal:

1. Coursework:
    a. Complete online coursework in VHDL (40 class hours) "Real Digital" curriculum offered by Digilent
    b. Complete online coursework in Verilog (30 class hours) "Embedded Design using programmable gate arrays" curriculum offered by Digilent
    c. Complete online coursework in Xilinx integrated development environment (IDE) Vivado (30 class hours) as the "Digital Design with Vivado" course offered by Xilinx
2. Purchase and evaluate 3 different FPGA boards using a Lattice FPGA core, a Xilinx core and a Intel core.
3. Course Development
    a. Visit CSULA and CPP digital FPGA courses to verify course scope.
    b. Develop and test all laboratories and course projects for the full semester course.
    c. Write course measureable objectives, student learning outcomes, and course curriculum.
    d. Submit course outline for curriculum approval.

Benefits to the college:

A new Engineering course (Engineering 26) would be developed including all curriculum, laboratories and projects. This course would be institutionalized to fill a critical need identified by our transfer partners for engineering students.

Benefits to my professional growth and enrichment:

While I have substantial experience with microcontrollers, sensors and signal processing, I have a short fall in the fastest growing segment of the electronics industry. In particular, FPGAs are an ideal way to tackle computer vision problems, an area where I had worked for over a decade (2005-2015). Developing these materials will lead to better transfer outcomes for students and direct job placement. Finally, I enjoy developing curriculum and this project would give me the opportunity to develop a course that serves students and cannot be created with the expertise and resources that currently exists on campus.

Detailed Schedule and Itinerary:

Preliminary comments:

1. The SS2S project has two primary milestones in December and June, but there are tests and slippage associated with every project.
2. The contract seems to suggest that sabbaticals are for Fall (late August to December), Spring (late February to mid-June), or Spring and Fall only (August to December and late February to mid-June). Judging by my reading of the contract, these are the only times I should be scheduling for my sabbatical work. However, the SS2S project runs year round with the primary launches in December, January and May, June.

Month	Activities
August-September	7. Complete VHDL coursework (30 hours coursework) 8. Complete simulations for SS2S static test 9. Develop CAD models for SS2S static test motor. 10. Write up log of experimental rocket flights for submission for Pyrotechnic license. 11. Start collecting signatures from licensed operators for Pyrotechnic license. 12. Complete Pyrotechnics safety course (10 hours coursework) 13. Collect signatures and paperwork for Low Explosives users permit.
October	4. Complete Verilog coursework (30 hours coursework) 5. Finalize design for SS2S static test motor including: a. nozzle insert b. nozzle retention c. retention plate d. nozzle diverging cone e. forward bulkhead f. motor body g. grain casting tubes h. thermal liner 6. Submit paperwork for Low explosives users permits. 7. Meet with licensed pyrotechnic operators and obtain their letters of support for permit.
November	7. Complete Vivado Coursework (30 hours coursework) 8. Fabricate responsible items for SS2S static test motor: a. retention plate b. nozzle retention c. forward bulkhead 9. Develop thermal and pressure management sensors and test suite. 10. Test sensors in vacuum.

	11. Start manufacturing rocket fuel grains. (About 250lbs of fuel to process) 12. Start construction of class IV magazine 13. Submit paperwork for Pyro Operators permit.
December	7. Visit CSULA and CPP FPGA courses 8. Complete Experimental Rocket Motor course (30 hours of instruction) 9. Assemble full scale SS2S static test motor 10. Complete rocket fuel grains and perform x-ray inspection. 11. Test full scale SS2S static test motor. a. Develop launch rail system b. Design and fabricate Strain gauge system for thrust characterization c. Design and fabrication thermocouple and non-contact IR sensor system for thermal characterization d. Collect and analyze data from test. 12. Complete construction of Class IV magazine
January	7. Purchase and Evaluate 3 FPGA boards 8. Develop and test four laboratories for FPGA course 9. Analyze full scale SS2S static motor test 10. Complete final CAD for full scale flight vehicle 11. Complete simulations for full scale flight vehicle 12. Complete dispersal analysis for full scale flight vehicle 13. Start FAA Level 3 space flight approval process
February	5. Develop and test four laboratories for FPGA course 6. Work with fabrication partners on full scale launch vehicle a. airframe b. nosecone c. bulkheads d. nozzle e. payload bay f. recovery systems 7. Static test SS2S booster motor 8. Analyze booster motor static test data.
March	4. Develop and test 4 laboratories for FPGA course 5. Update FAA level 3 space flight approval process 6. Range test telemetry and avionics systems • Design a Telemetry package suitable for a rocket • Design a Telemetry ground station • Fabricate a prototype flight computer, telemetry package and ground station: • Static test the prototypes in a vacuum chamber • Flight test the prototype: 7. Test assemble microcosm launch rail and perform repairs as needed.
April	3. Develop and test 4 laboratories for FPGA course 4. Advance full scale vehicle production milestones: m. Motor casing n. Motor Liner

	o. Casting tubes p. Nozzle and retention q. Forward bulkheads r. Avionics i. telemetry ii. flight computer iii. power bus iv. recovery deployment s. Fins and Fin Can t. Airframe u. Couplings v. Avionics Bay w. Nose cone x. Feature coupling 5. Evaluate and maintain launch facilities.
May:	4. Develop FPGA course outline, SLOs and measurable objectives in time for course submission deadline. 5. Submit FPGA course 6. Complete full scale vehicle production milestones: a. Motor casing b. Motor Liner c. Casting tubes d. Nozzle and retention e. Forward bulkheads f. Avionics i. telemetry ii. flight computer iii. power bus iv. recovery deployment g. Fins and Fin Can h. Airframe i. Couplings j. Avionics Bay k. Nose cone l. Feature coupling 7. Complete FAA space flight approval process
First half of June	4. Follow up visit with CSULA and CPP to review FPGA course. 5. Launch SS2S full scale rocket 6. Recover rocket 7. Analyze flight data

Abstract:

The primary goal of this project is to accomplish significant professional work in the field of engineering by working within a rocketry collaboration to contribute to the development of a space capable solid fuel rocket platform. This would elevate the competitiveness of the Mt. SAC rocketry team, bring relevant industry practice to the Mt. SAC engineering program and contextualize

engineering courses. The secondary goal is to address a critical need identified by our transfer partners to develop the necessary in-house skill set in the VHDL and Verilog FPGA programming languages, complete a number of projects in these languages and develop a new Digital FPGA course to support the engineering program.

Academic works:

In preparation for the sabbatical, I have reviewed the following papers and texts:

- Rocket Propulsion Elements George P.Sutton Wiley Publ.2010
- Handbook of Model Rocketry G.Harry Stine Wiley Publ. 2001
- Experimental Composite Propellant Terry W.McCreary, Ph.D., 2000
- Solid Propellant Rocket Motor Design and Testing R.A.Nakka 1987
- Fundamentals of Solid-Propellant Combustion K.K.Kuo & M.Summerfield 1984
- Solid Rocket Motor Metal Cases NASA SP-8025
- Solid Rocket Motor Performance Analysis and Prediction NASA SP-8039
- Mechanical Design of Rocket Motors Michael Milling Madsen and Jorgen Franck 1984

Abstract for Board of Trustees:

Martin Mason worked for Sugar Shot to Space (SS2S) and US rockets on experimental solid fuel rockets. With SS2S he completed design, simulation and fabrication in support of more than 17 static tests, 7 scale flight tests and an attempt at a near space rocket launch. With US Rockets he served as chief test engineer for their three stage to orbit motor development program for small satellite deployment. He collaborated with Monterey Machine products to produce the first successful community college hybrid rocket. He was selected to judge the International University Experimental Rocketry competition and traveled to South America to work with a university collaboration on experimental solid fuel rockets. He also updated his skills with coursework in Field Programmable Gate Arrays (FPGA) and worked with industry and academic partners to develop a new course in Digital Logic with FPGAs, and facilitate employment opportunities for Mt. SAC students.

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[i] Rogacki,S., Zurbuchen,T. "A time digitizer for space instrumentation using a field programmable gate array" Review of Scientific Instruments (Vol.84, Issue 8)

[ii] Dong, Winny , Faltens, Tanya , Kok, David , Li, Mingheng , Pan, Yu Hsin (Cindy) , Slackey, Cornelius "Capturing CO2 with MgO Aerogels" EPA Grant Number: SU835339 California State Polytechnic University - Pomona