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Upwards from Downunder: My Early Days of Rocketry in Australia

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Although I am an Australian and was born in Brisbane, Australia in 1951, it was while we were living in the small town of Boone, Iowa (population 12,000) in October, 1957 that my interest in astronautics began. That is when the Soviets launched Sputnik I into orbit, becoming the first artificial satellite to orbit the Earth. I was six years old at the time and realized that something exciting had happened, that had everyone talking, out of both wonder and fear. They were all expecting the US to be the first into space, just like they were first in developing the atomic and hydrogen bombs. American technology was supposed to be superior of that in the Soviets in every regard – especially in rocketry and space. After all, the U.S. had obtained the cream of the crop of German rocketeers – the managers, scientists, engineers, and technicians that had successfully developed the V-2 rocket, which was years ahead of anything comparable in either the US or the Soviet Union at the time.

However, it was not the launch of Sputnik I, followed soon by Sputnik II, and Explorer I (the first US satellite) that really piqued the interest of this six-year old boy. It was my father who did that. Although he was a full-time missionary (that is the reason we were in Iowa and not back in Australia), he had previously been a mechanical engineer and expert machinist during World War II. The love of making things, both mechanical and electrical, never left him for the rest of his life. He made tape recorders, hi-fi radios and record players, amplifiers, pumps, transformers, slide projectors, and many other things, basically from scratch. During our four years in Iowa, my dad became interested in making telescopes. He first made a reflector telescope with a four and a half inch mirror which he ground himself. With the help of a young man attending the Iowa State College in nearby Ames, he ground a six-inch mirror which he put into a new and larger reflective telescope he made. This telescope was capable of viewing the celestial objects at up to 400x magnification, and on many dark Iowan nights I remember viewing in awe the craters and maria of the Moon, the rings of Saturn, the red spot and moons of Jupiter, and some hazy redish patches and polar caps on Mars. My dad even made a motor that allowed the telescope to move, following the apparent rotation of the celestial objects due to the rotation of the Earth. That way we did not have to keep moving the telescope when the target object drifted out of the field of view. I was in awe of these majestic sights and longed to be able to visit them in person some day. Of course, fed by the science fiction of the time, I wondered at what great civilizations or creatures were there to be discovered.

My dad made several telescopes, including a refractive telescope that he gave to a friend, and also a small telescope we called the "Sputnik" telescope, because it was designed to view the passing of the satellites as they passed overhead during twilight when the satellites were still lit but we were in near darkness. I do not remember the details of how it worked, or even how well it worked, because seeing a white spot travelling across the sky was not nearly as interesting as looking at the other celestial bodies. I did not realize what a great technical achievement I was witnessing. That came later when I started to learn physics and building rockets of my own, which had to wait until after we moved back to Australia in 1960.

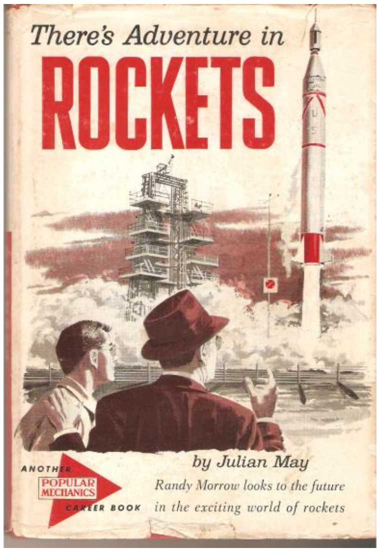
Trevor and Father Vivian Displaying Some of Vivian's Handiwork in their House in Boone Iowa in 1959. *From front to back are: camera to transfer print to 16mm slide film; 16mm slide projector (which Vivian invented); refractor telescope made for a friend; the "Sputnik" telescope; 6" reflector telescope with tracking motor. This photograph accompanied an article that appeared in an article about the Sorensens in the Des Moines Register and Tribune in 1959.*

PART I – THE FIRST FALTERING STEPS

Up until my first year of high school I wanted to be a medical doctor when I grew up (my mother and aunt were nurses). I remember the incident that changed my mind. My sister Beth also became a nurse and although she didn't live at home, she shared a bedroom with my other sister Marvia when she was home. Shortly after we moved to Lambton I remember going into their room and started looking at the medical textbooks that Beth had in their bookshelves. It was when I looked at the textbook on skin diseases (with colour plates) that I decided that I did not want to be a doctor after all.

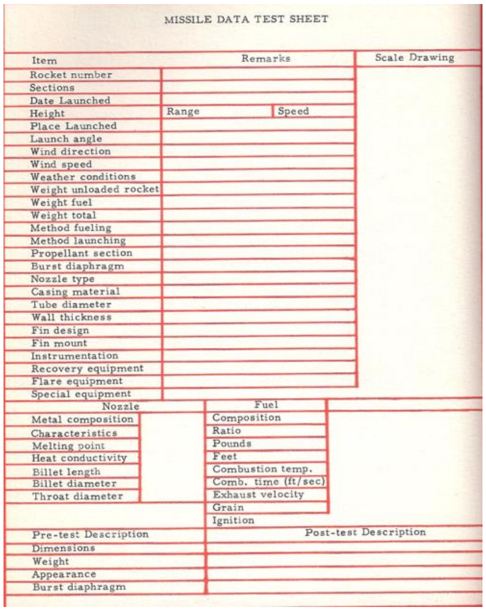
This was 1964 and the manned space programs of America and the Soviet Union were in their infancy. Every mission brought new firsts and it was very exciting. The Americans had started their Gemini program, which sent two astronauts into orbit with each mission. The Soviets were flying their Vostoks and Soyuz spacecraft, each of which carried either two or three cosmonauts. I was fascinated with these missions and kept newspaper articles about them in a scrapbook (which I still have). When I discovered a book (I don't remember the name of it) on the theory of rocketry in the Newcastle Public Library, I was hooked. The mathematics was beyond me sinceI was only in 1st Form at Newcastle Boys' High School (NBHS), but I started designing liquid propellant rockets that I hoped to build. The first one I designed was six inches in diameter and about six feet high with a parachute recovery system and a radio transmitter.

My close friend, John Farrell, also caught the rocketry bug with me. He introduced me to a book he found in the Scone Public Library. It was a 1958 book for youth called *There's Adventure in Rockets*[1] by Julian May. This was a fictional account of an American high school amateur rocketry club that designed, built, and flew solid propellant rockets. Besides telling the tale of these teenagers, it also gave the basic principles of rocketry. I found the book exciting and wanted to do something similar. It was with this book that I realized that it was possible to build small solid propellant rockets, and so I decided to shelve the plans for the liquid propellant rocket (which I never did build) and instead learn the basics of how to build, fly, and recover rockets using the much simpler solid propellants.



Because of the May book I planned to use a pendulum switch to fire the parachute ejection mechanism (although the book did not reveal its design). I also used the example Missile Data Sheet from the book for my later large rockets. Of course, I had to copy the book's example with a typewriter. I used carbon paper to make extra copies (this was before photocopy machines). Although the May book gave a lot of general information, it lacked specifics, like the ingredients of the propellant. I had to search other sources to find that answer. I found out from magazine articles that the propellant used for most amateur rockets was called "micrograin" which was made of zinc dust and sulphur. I decided that I should use the same. However, initially I could not find the mixture ratio and had to experiment to find what worked (more on this later).

[1] In Australia I checked this book out of the library several times, but never found it in a bookstore. However, I never forgot this book, and when I started bidding on eBay in the late 1990s, I was surprised to find this book available. Of course I bid on and won it. At last I had my own copy! In the following years I came across other copies on eBay and couldn't resist buying a couple extras copies for $5 or less each.



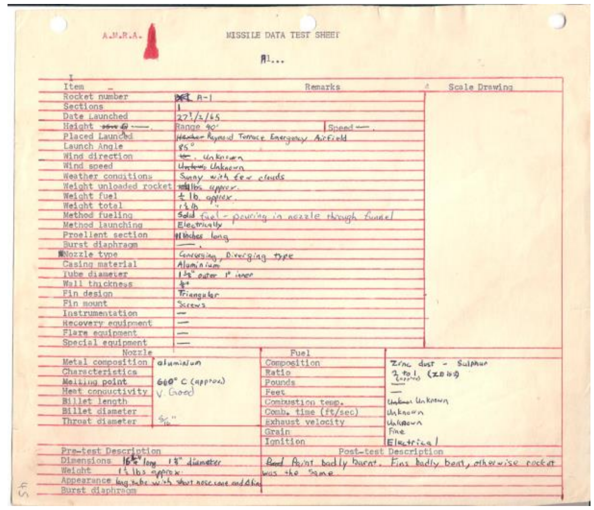
MISSILE DATA TEST SHEET

Item	Remarks		Scale Drawing
Rocket number			
Sections			
Date Launched			
Height	Range	Speed	
Place Launched			
Launch angle			
Wind direction			
Wind speed			
Weather conditions			
Weight unloaded rocket			
Weight fuel			
Weight total			
Method fueling			
Method launching			
Propellant section			
Burst diaphragm			
Nozzle type			
Casing material			
Tube diameter			
Wall thickness			
Fin design			
Fin mount			
Instrumentation			
Recovery equipment			
Flare equipment			
Special equipment			

Nozzle		Fuel	
Metal composition		Composition	
Characteristics		Ratio	
Melting point		Pounds	
Heat conductivity		Feet	
Billet length		Combustion temp.	
Billet diameter		Comb. time (ft/sec)	
Throat diameter		Exhaust velocity	
		Grain	
		Ignition	

Pre-test Description	Post-test Description
Dimensions	
Weight	
Appearance	
Burst diaphragm	

Missile Data Test Sheet Example from *There's Adventure in Rockets*



A.M.R.A. MISSILE DATA TEST SHEET

A1...

Item	Remarks		Scale Drawing
Rocket number	A-1		
Sections	1		
Date Launched	27/2/65		
Height —	Range 90'	Speed —	
Placed Launched	Raymond Terrace Emergency Airfield		
Launch Angle	85°		
Wind direction	Unknown		
Wind speed	Unknown		
Weather conditions	Sunny with few clouds		
Weight unloaded rocket	lbs. approx.		
Weight fuel	½ lb. approx.		
Weight total	1½ lb "		
Method fueling	Solid fuel – pouring in nozzle through funnel		
Method launching	Electrically		
Proellent section	inches long		
Burst diaphragm	—		
Nozzle type	Converging, Diverging type		
Casing material	Aluminium		
Tube diameter	1⅛" outer 1" inner		
Wall thickness			
Fin design	Triangular		
Fin mount	Screws		
Instrumentation	—		
Recovery equipment	—		
Flare equipment	—		
Special equipment	—		

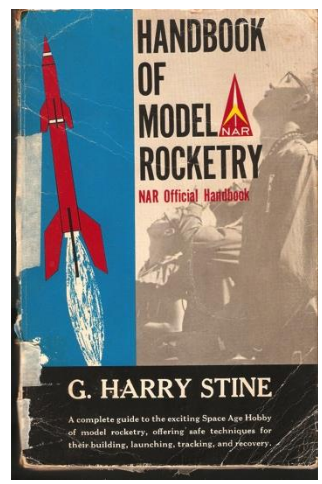
Nozzle		Fuel	
Metal composition	aluminium	Composition	Zinc dust - Sulphur
Characteristics		Ratio	2 to 1 (approx) (ZnS)
Melting point	660° C (approx)	Pounds	
Heat conductivity	V. Good	Feet	—
Billet length		Combustion temp.	Unknown
Billet diameter		Comb. time (ft/sec)	Unknown
Throat diameter	5/16"	Exhaust velocity	Unknown
		Grain	Fine
		Ignition	Electrical

Pre-test Description	Post-test Description
Dimensions 16¾" long 1⅛" diameter	Paint badly burnt. Fins badly bent, otherwise rocket was the same.
Weight 1½ lbs approx.	
Appearance long tube with short nose cone and 4 fins	
Burst diaphragm	

AMRA Missile Data Test Sheet for A-1

My father was thrilled that I wanted to do rocketry as a hobby, because I would need to use his workshop. This would provide him an opportunity to teach me some of his mechanical skills, such as operating the metal lathe and welding. My mother was not exactly thrilled, but she was very supportive of me in this hobby, as long as I didn't injure anyone (I didn't) or damage our house or its contents (in this I was partly unsuccessful).

The sulphur I bought from the Chemist (later Marvia's boyfriend/finance/husband, Terry Thompson, supplied me with the sulphur because he worked for the Wholesale Drug Company). The zinc dust was purchased from paint stores. Both powders were very cheap at that time.



In 1965 Dad gave me a military 3-inch rocket body that someone had given him. The rocket was empty, although it had fins and a built-in nozzle (but no nose cone). It was made of steel and painted military olive drab. It was one of the small unguided rockets that aircraft would carry for bombarding the ground. I longed to build it into a flying rocket, but never did and had to leave it behind when we moved to America in 1969.

Model Rockets

About this time I also discovered that you could buy model rockets commercially. There was a company, Model Rocket Industries, in Punchbowl (Sydney) that advertised in an Australian hobby magazine. I wrote to them and ordered one of their catalogues, and started buying some kits and rocketry supplies from them. I initially bought an Estes Astron Scout for 7/6 (seven shillings and sixpence or ~75c) and three rocket engines for 3/3 (33c) each. The Astron Scout was a small rocket with a short pressed paper body, long balsa fins and nose cone, and no parachute – it was meant to tumble to a soft landing. We launched this in February, 1965 along with our A-1 rocket, but more about that later. At about the same time I also bought an Astron Mark, which with the substitution of a parachute for the its supplied streamer, became the basis of the model rockets that I would later teach at children and youth camps in both Australia and America.

I was thrilled when in 1965 I discovered a book in Ell's Bookstore in downtown Newcastle called *Handbook of Model Rocketry* by G. Harry Stine (who was the founder of the National Association of Rocketry). This was a wealth of information about rockets in general and model rockets specifically. Although it was not as helpful for our larger metal amateur rockets, for which we made our own propellant and nozzles, it did provide a lot of additional information (launch systems, instrumentation, rocket stability and flight theory, altitude determination, etc.) that was very useful in our rocketry projects. It soon became well worn and grubby due to being used as a reference in our workshop. The book shown in the image at right is of my original book (with masking tape repairs to the spine, creased cover, and loose pages). The two areas that the book did not help me with were the design of the rocket engine for our rockets, and the design of a suitable parachute recovery system. Model rockets use a blow-through system from the top of the commercial rocket engine for ejecting the parachute, and that method would not work for our micrograin rockets, which were far too powerful.

First two model rockets bought from Model Rocket Industries in Sydney (photo from 1963 American Estes catalogue)

Rocket Car (~1965)

I don't remember exactly when this happened, but I wanted to build a model rocket car. I made a small car (wheeled vehicle) out of an Erector (Mechano) set and mounted one of the Estes model rocket engines onto it. Late one weekend afternoon when nobody was around, I put the car on Turner Street in front of our house. I ignited the engine with my electrical ignition system. Immediately after ignition the car shot forward a few feet, then went airborne and started doing some very entertaining somersaults and cartwheels with the engine burning. It was not the result I was looking for, but it was spectacular. I didn't find the time to troubleshoot and try this one again.

Rocket Manufacturing (1964-1969)

My father had a workshop with a metal lathe, drill press, welding machine, and several tools (including soldering irons, etc.) that we used in manufacturing our rockets. For the test rockets we made the nozzles and nose cones out of wood, using the metal lathe (my dad didn't have a wood lathe in Australia). Once we started the "A" series of larger metal rockets, we made the nozzles and nose cones initially out of aluminium. The nozzle was turned out of a solid piece of aluminium. However, the nose cones were generally larger and the large blocks of solid aluminium were too dear, so my father and I built a small blast furnace[2] in our garage. We made a square out of bricks with a small opening on one side where we placed a pipe with an L-joint on its end and pointing up in the middle of the brick square. We covered the end of the L-tube with heavy wire grill. We then filled in the square with coke. The metal tube was attached to the blower end of a horizontal cylindrical vacuum cleaner via a hose.

After making the blast furnace, the first step in making the aluminium piece we wanted (usually the nose cone) was to make an exact model of it in wood on the lathe. We then filled a tin with wet Plaster of Paris. We coated the wooden nose cone with oil and placed it tip first into the wet Plaster of Paris all the way to its base. We then tapped the mould[3] tin to dislodge any bubbles that might have formed during the insertion. After the Plaster of Paris was almost dry, we would remove the wooden nose cone by the screw eye that we had previously inserted into the end. This would then leave an impression of the nose cone. We let the mould dry for a couple days before using it.

We used paper and lighter fluid to light the coke blocks in the blast furnace and once it had taken hold, we turned on the blower (vacuum cleaner), which blew air out through the L-tube and into the fire, intensifying it. In the middle of this coke fire we had a small crucible, in which we put pieces of aluminium. After the aluminium melted, we added some powdered alum to bring the impurities to the surface where we would skim them off (we wore heavy gloves, aprons, and safety glasses while working on this). Once the aluminium was all melted and nearly all impurities gone, we would pick up the crucible with tongs and pour the molten aluminium into the plaster mould. Once the mould was filled, we would tap the tin with a hammer to dislodge bubbles. After the aluminium had solidified and cooled completely, we would either remove it by pulling it out or by breaking the Plaster of Paris mould. The resulting nose cone (or other piece) was the right size and shape, but fairly rough. We then mounted it on the metal lathe to finish it off using the lathe tool and fine emery paper for the final polishing. The resulting aluminium nose cone was not as smooth as ones made from aluminium block, but didn't look too bad once painted.

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[2] It was actually a smelter, but we called it a "blast furnace" because it sounded more grandiose and it did have a blower to create a "blast"

[3] "mold" in American English

The rocket body was initially made of aluminium tube, but after several explosive failures, we changed to steel. The aluminium (later steel) nozzle was secured in the body tube by screws, as were the fins made from sheet aluminium (later rockets had the fins brazed in place). At the top end of the combustion chamber was a bulkhead, which was also screwed into place using several metal screws (later rockets had this bulkhead welded into place). For the later rockets (A-4 on) we welded two metal loops onto the side of the rocket (one near the rear and one near the front) to act as launch lugs that fitted over a launch rod, which was between four and eight feet long.

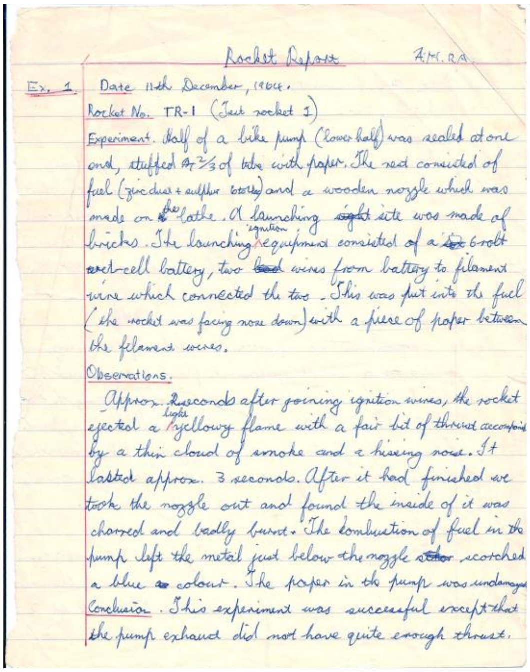
For the B-series rockets we tested several different parachute ejection systems, including a couple that used model rocket engines as the means to open up the payload section of the rocket and blast out the parachute (by pushing or pulling). The triggering mechanism for the parachute release was a pendulum switch. This was made on the lathe with parts made of brass. One of the model rocket engine methods used a wooden piston containing the model rocket engine. This wooden piston with hollowed section was also made on the metal lathe.

Basement Bomber (1964-1965)

Once I had determined which propellant we were going to use for the rocket, I needed to determine the correct proportions and test the burning characteristics of it. Being in 1st Form, determining the correct ratio empirically was beyond my knowledge at the time, so I relied on trial and error. One afternoon I mixed up a small batch of zinc dust and sulphur (micrograin), and donning my army surplus gas mask (which I had bought for 1/6 or 15c), I tested it in my chemistry lab area under the house (which was also the laundry area). I used potassium permanganate and glycerine to ignite the powder, which I had placed on a tin lid on my mother’s washing machine. When the potassium permanganate burst into flame a few seconds after the addition of the glycerine, it ignited the propellant. Micrograin made a most satisfying grey mushroom cloud when it burned in the open. A large mushroom cloud of poisonous zinc sulphide then billowed up to the low ceiling of the laundry, up through the floor boards, and into the kitchen. Unfortunately my mother was there at the time, and to say I got in trouble was an understatement, especially when she saw the top of the washing machine that had the paint burned off. From that time I moved my propellant tests to outside and to when my mother was not home.

Bike Pump Fizzers (1964)

The next thing to do after testing the propellant was to get a rocket engine to work with it. My first experiments to attempt this involved taking a bike pump and cutting it half, with each half making a strong tube for the rocket engine’s combustion chamber. I still have the original reports written in 1964, which I am reproducing here. Although these tests weren’t spectacular, at least the engines did not explode, so we thought it was time to attempt to launch a rocket with the same propellant. John Farrell helped me with these tests.



Rocket Report A.M.R.A.

Ex. 1. Date 11th December, 1964.

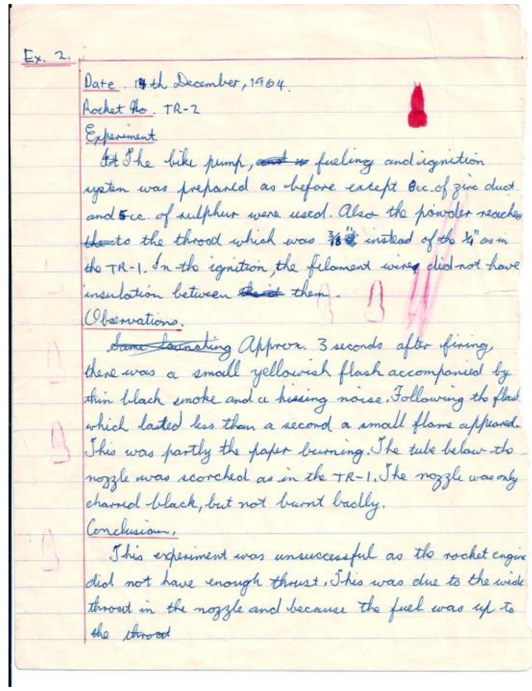
Rocket No. TR-1 (Test rocket 1)

Experiment. Half of a bike pump (lower half) was sealed at one end, stuffed ~~A~~ 2/3 of tube with paper. The rest consisted of fuel (zinc dust + sulphur 60:40) and a wooden nozzle which was made on the lathe. A launching ~~sight~~ site was made of bricks. The launching ignition equipment consisted of a ~~six~~ 6-volt ~~wet~~-cell battery, two ~~lead~~ wires from battery to filament wire which connected the two. This was put into the fuel (the rocket was facing nose down) with a piece of paper between the filament wires.

Observations.

Approx. 2 seconds after joining ignition wires, the rocket ejected a light yellowy flame with a fair bit of thrust accompanied by a thin cloud of smoke and a hissing noise. It lasted approx. 3 seconds. After it had finished we took the nozzle out and found the inside of it was charred and badly burnt. The combustion of fuel in the pump left the metal just below the nozzle ~~a~~ scorched a blue ~~a~~ colour. The paper in the pump was undamaged.

Conclusion. This experiment was successful except that the pump exhaust did not have quite enough thrust.



Ex. 2.

Date 14th December, 1964.

Rocket No. TR-2

Experiment.

~~It~~ The bike pump, ~~and is~~ fueling and ignition system was prepared as before except 8cc. of zinc dust and 5cc. of sulphur were used. Also the powder reached ~~the~~ to the throat which was 3/16" instead of the 1/4" as in the TR-1. In the ignition, the filament wires did not have insulation between ~~them~~ them.

Observations.

~~Some launching~~ Approx. 3 seconds after firing, there was a small yellowish flash accompanied by thin black smoke and a hissing noise. Following the flash which lasted less than a second a small flame appeared. This was partly the paper burning. The tube below the nozzle was scorched as in the TR-1. The nozzle was only charred black, but not burnt badly.

Conclusion.

This experiment was unsuccessful as the rocket engine did not have enough thrust. This was due to the wide throat in the nozzle and because the fuel was up to the throat

Original Reports of the Test Firings of the Bike Pump Rockets TR-1 and TR-2 in 1964

IYBM (1965)

After the almost successful bike pump static tests (at least they didn't explode!), it was time to try a rocket engine in flight. This resulted in the creation of my IYBM (Inter-Yard Ballistic Missile) in January, 1965. I took an aluminium tube about six inches long and glued some balsa wood fins to it. With my dad's help we made a small rounded wooden nose cone on his lathe (this was the beginning of my learning how to use the lathe). The nose cone was secured in the body tube by screws. We also made a small wooden nozzle, similar to the one used in the bike pumps. By this time I realized that I had the propellant mixture wrong and so this IYBM used one that was closer to our final mixture. I fuelled the rocket and added the ignition filament wire to it. I secured the wire in place, probably using a bit of tape (which also served to prevent the propellant from falling out).

Launch day arrived. Since this was a small rocket and I didn't really have transportation (my dad was away), I decided to launch it in my backyard. At this time I was not aware of the purpose of launch rods (i.e., to keep the rocket on track until it has built up enough speed for the fins to keep it stable), so I just sat the rocket on a board with the ignition wires attached to a six-volt motorcycle battery and switch. At ignition there was a whoosh and the rocket, trailing smoke, arched up and over the fence into a neighbour's backyard (behind and to the left of our house). The rocket attained a maximum altitude of about 20 feet and maximum range of probably 50 feet. I hurriedly scrambled over the fence and retrieved the still smoking rocket. Fortunately, the neighbour never knew he had been attacked and so did not retaliate! However, I had successfully launched an IYBM – probably the first in Australia (at least the first to not use a commercial rocket engine,).

RAB – Rocket Assisted Bicycle (~1965)

My house in Lambton was on top of a fairly high hill and there were a couple other hills on my bike route to Boys' High. When I started to build rockets and saw how powerful they were, I got the crazy idea of using rocket boosters to help propel me up the hills (like the JATO[4]-assisted takeoffs used by military aircraft). I knew that a lot of heat was generated by the rockets and there was also the need to have protection in case of an explosion. My plan was to use two of the A-series rockets (without fins) mounted on either side of the rear axle. Between the rockets and my legs would be a half-inch wooden shield with aluminium lining. Ignition would be electrical, with a 6-volt motorcycle battery hooked to ignition wires through a switch on the handlebars.

[4] Jet-Assisted Take Off, also sometimes known as RATO – Rocket-Assisted Take Off

I was not stupid enough to build this and use it without testing. That's what saved me, because I could not come up with a good way to test the whole system in operation without having a human rider. As a result, this just remained as a plan and was never built. That is probably one reason that I am still alive and have all my limbs intact.

Formation of AMRA (1964)

I do not remember how it happened, but I got my closest friends interested in rocketry as well and they joined me in forming the Amateur and Model Rocketry Association (AMRA) in 1964. This club was not a high school organization (I was afraid they would not let us do everything we wanted to do). I was the leader of AMRA since I was the founder and the driving force behind it.

AMRA was founded in late 1964 and lasted all the way until the end of high school in 1969. The organization was based on that of the fictional rocketry club in the Julian May book (which was based on a real amateur rocketry club in Illinois in the late 1950s). The leader of that club was called the Director of Range Operations (DRO), so that was the title that I took. The founding members of AMRA in 1964 were:

Trevor Sorensen	**Director or Range Operations (DRO) and president**
John Farrell	**Director of Technical Engineering (DTE) and VP**
Ross Johnson	**Director of Tracking and Recovery (DTR)**
Phillip Archer	**Director of Timing and Firing (DTF)**
John Groom	**Chief of Airframe Development (CAD)**
Jeff Richards	**Director of Engineering (DE)**

By 6th Form (1969) there were 11 members of AMRA (with final position noted):

Trevor Sorensen **Director of Range Operations (DRO)**
President of AMRA; overall coordination and guidance

John Farrell **Director of Technical Engineering (DTE)**
VP of AMRA; design, development and testing of parachute recovery system; development and construction of BP cabin and support equipment; design and development of internal sensors and camera systems

Phillip Archer **Range Safety Officer (RSO)**
Checks and enforces safety practices at launching range; checks that area is clear of aircraft and unauthorized personnel; arming of firing panel

Jeff Richards **Director of Aeronautical Engineering (DAE)**
Design and construction of rocket body (nose cone, fins, lugs, etc.)

Colin Taylor **Director of Tracking and Recovery (DTR)**
Setup, calibration, and coordination of tracking stations; recovery of rocket after flight; assistance in design and construction of rocket internal recovery system

John Masters **Director of Biological Payloads (DBP)**
Research, selection, and preparation of biological payloads (BP); cabin design and biological sensors development

Leo Pinczewski **Director of Engineering (DE)**
Treasurer of AMRA; overall engineering and coordination; launching pad design and construction; nozzle, heat shield, and bulkheads construction

Steven Dumpleton **Director of Countdown Procedure & Launching (DCPL)**
Preparation of rocket and firing system for launching (or test firing); countdown procedure and firing

Phillip Graham **Director of Electronics and Telemetry (DET)**
Design, construction, and testing of telemetry system; design & construction of firing panel and launching system

John Wurth **Director of Design and Supply (DDS)**
Drawing of all rocket plans; ordering and obtaining supplies. John took Technical Drawing in school and drew a beautiful plan for the B-2 rocket.

David Cocking **Director of Data Reduction and Computation (DDRC)**

Analytical predictions of rocket stability characteristics and trajectory; analysis of actual flight data; mathematical support for all departments

Unfilled **Director of Propulsion Research (DPR)**

Propellant research and testing; nozzle design

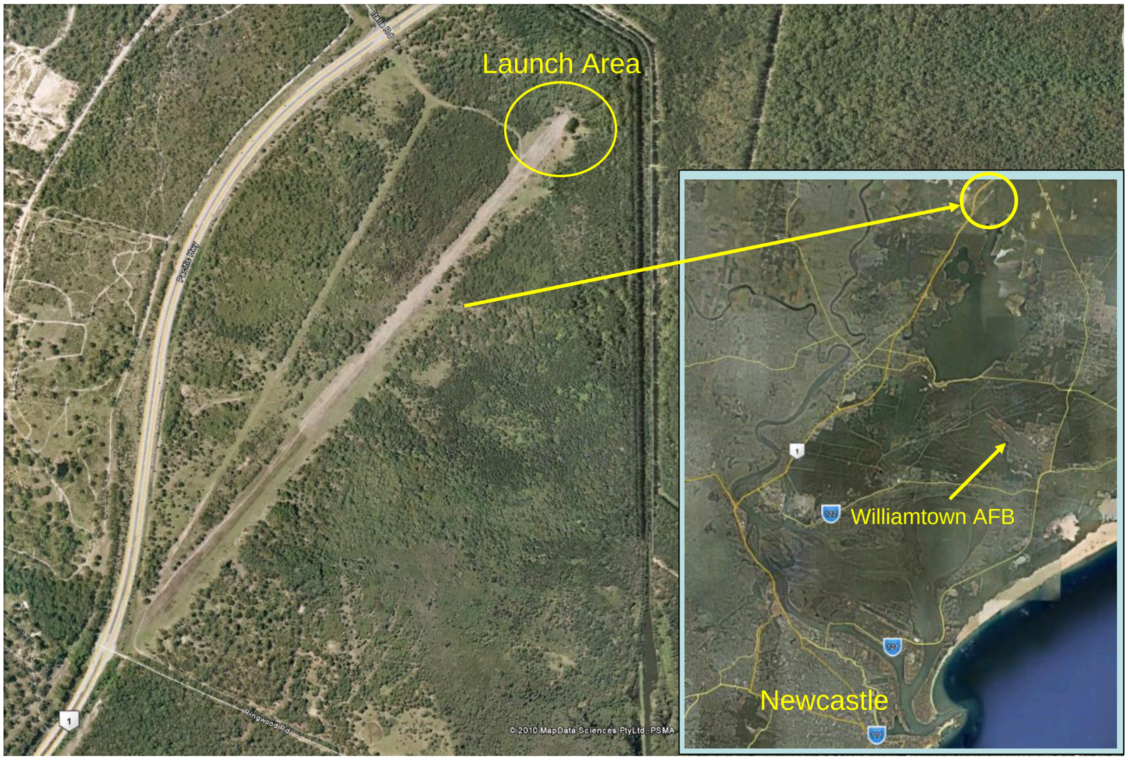
We met and did our planning at school during lunchtimes, although some of the boys (especially John Farrell) would come to my house to help work on the rockets. Leo did a good job as treasurer. Every week between October 1968 and May 1969 he collected the weekly dues from the members – 5c each. Some boys contributed more than others. I still have the financial records of AMRA, and here are the total contributions in descending order: Pinczewski - $1.60, Farrell - $1.35, Taylor $1.35, Masters - $1.35, Sorensen - $1.20, Graham - $1.20, Dumpleton - $1.15, Cocking - $0.80, Richards - $0.70, Wurth - $0.45, and the cheapskate of AMRA was….Phillip Archer - $0.05. The total income from fees was $11.20. This might not seem like much, but our rockets were remarkably cheap. Zinc dust was 40c a pound and we got sulphur for free. For instance, the expenses for the B-4 (we already had the steel body tube, which was muffler pipe and cost about $2) were: 40c for zinc dust, 51c for transfers (decals), 9c for shock cord rubber, 12c for shock cord line, and 40c for batteries. We reused the B-3 nylon parachute, the material for which had cost us $1.50.

For the launches we wore helmets, either army surplus World War II Australian steel helmets or construction helmets/hard hats. They were painted white (except for Steven's) and had the letters of our position in red decals on the front of the helmet. Mine had **DRO**.

AMRA Launch Facilities

The first metal rocket we launched (A-1) was at an old World War II emergency airstrip north of Raymond Terrace. We used my dad's car as shelter. The A-2 through A-4 were launched close to Wallsend High School and we sheltered either behind the car or behind an old abandoned refrigerator. The A-5 was launched on the beach at Tiona and we hid behind a sand dune. The A-6 through A-8 were launched in the shallow waters of Lake Wallis at Tiona and we used trees on the shore as cover. The B-1 was launched at Ash Island across the river from the BHP steelworks and we built a small bunker out of heaped sand, sheet metal, and stones. B-2 through B-4 were also launched at Ash Island and we used some large steel pipes with sandbags in front of the opening facing the launch pad as bunkers (see photos).

Final AMRA launch site in Australia – on Ash Island near Newcastle (actual area difficult to identify because area has been extensively developed since 1969)

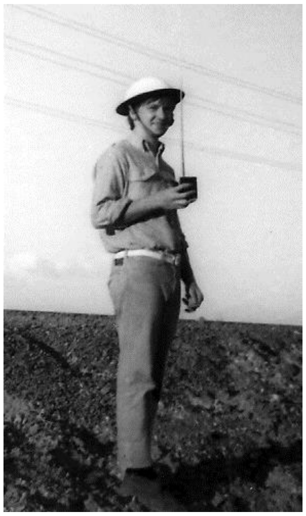


AMRA Launch Facility #1 where A-1 was launched

Tiona – Sites for the launches of A-5 through A-8

Dad (helmet on left), John Masters & Colin Taylor in bunkers at Ash Island Range

Phillip Archer and John Masters testing communications at Ash Island Range



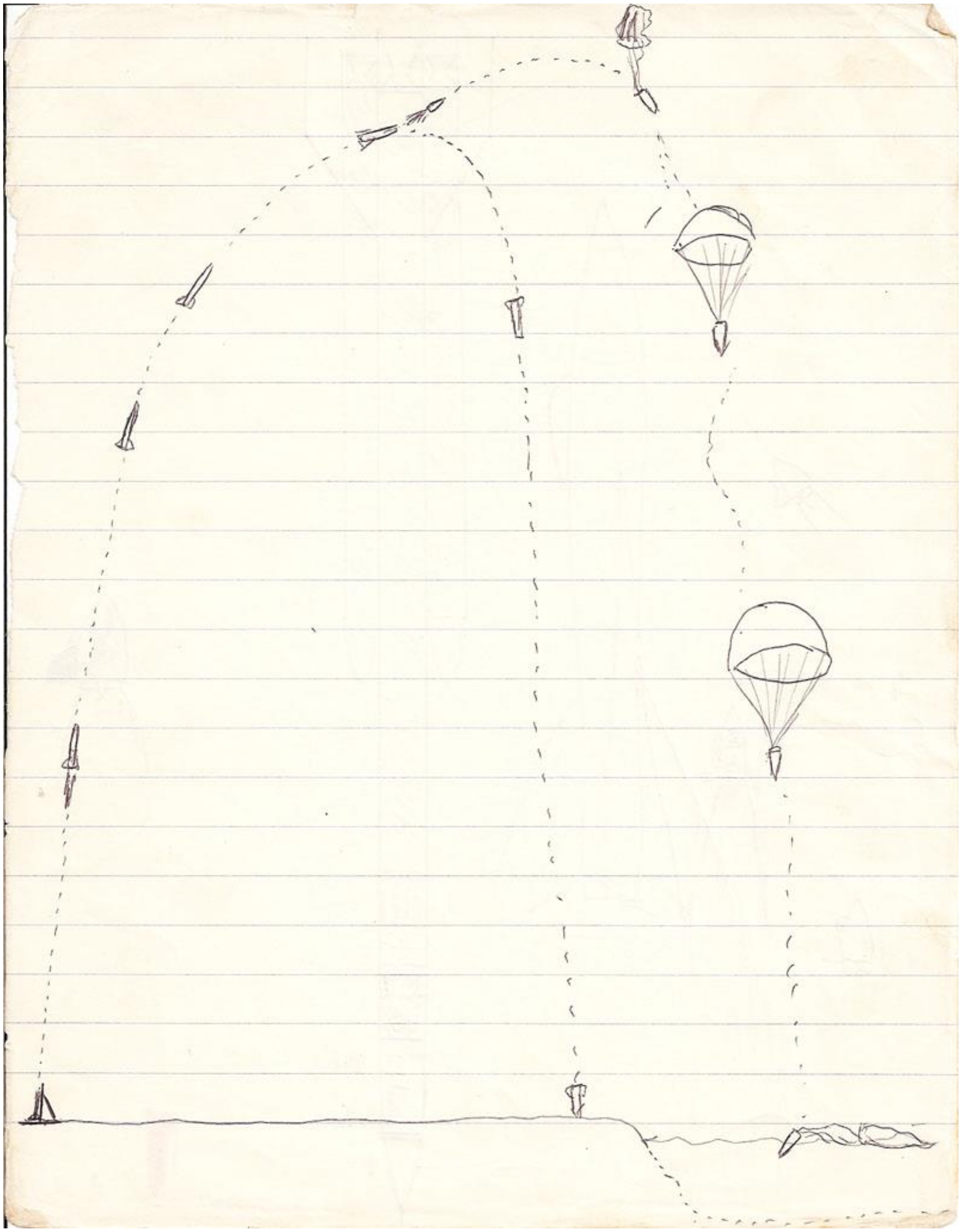
Colin Taylor in bunker (above) and ready to recover rocket (r) at Ash Island Range (different launches)

AMRA Launch Pads

The first launch pad we made for the A-Series was made of wood. Attached to a large wooden base was a pair of parallel wooden rails about four feet long and set at an elevation angle of ~85 degrees from the base. These two rails had a wooden support beam each going from near the top of the launch rail to the base. The rocket sat between the two rails with one of its fins passing through between the rails. The rocket was only resting on the rails by force of gravity, so a non-axial thrust from the rocket engine could cause the rocket to leave the rail before it reached the end. This basic design was used for the first five rockets in the A Series, although it had to be rebuilt several times.

From the model rockets we bought and built, we learned about launch rods with launch lugs on the rocket body. This enabled a near-vertical launch if desired and ensured that the rocket did not leave the launch angle prematurely, since it kept the rocket on course until enough velocity had been obtained to keep the rocket on the desired flight path.

Starting with the A-4 and for all subsequent launches, we used a steel launch rod (from 3/8” to ½” in diameter) attached to a large flat steel plate base. The rod was four feet long for the A series and six to eight feet long for later series. The rod was bolted in place so that the launch pad was easily transported. Next to the rod at the bottom of the plate, a hole was cut in the plate to allow the passage of the ignition wires to the end of the rocket and to allow the rocket exhaust to go into the ground rather than just reflect off the base onto the rocket as it was rising. This type of launch pad worked well.



AMRA Rockets

Having shelved the plans for a liquid-propellant rocket, my friends and I concentrated on developing our skills with the solid propellant rockets. We decided to do a systematic approach of mastering the skills required by developing series of rockets, where each series was designed to master a required skill, and successfully launching three rockets in that series before progressing to the next series. Each subsequent series would be more sophisticated and challenging. Here are the series as we planned them[5]:

[5] See some of the conceptual plans for these rockets in the Appendix

Series	Dimensions	Objectives/ Description	Results
A	1.125"* x 15.5" to 1.125" x 17.5"	Fundamental flight vehicle research (especially rocket engine & flight dynamics). No parachute (except A-7) or instrumentation. A-5, A-7 & A-8 carried dye for water landing.	Completed 8 launched 1965-1966
B	1.625" x 28" to 1.625" x 50"	Development of reliable parachute recovery system and continued flight research. Only instrumentation was for parachute system (B-2 also had auxiliary smoke generators)	Incomplete 5 launched 1966-1975
C	3.5" x 120" (revised)	Proposed 1964 – revised 1974. Same parachute system as Series B. Instrumentation includes cabins for biological payloads, cameras, sensors, and telemetry system. Replaced in series sequence by Series G (1974).	Planned
D	2.125" x 55" (1st stage) 1.625" x 30" (2nd stage)	Two stage rocket using originally proposed C-series booster and Series B upper stage. Proposed in 1966.	Planned
E	2.125" x 60"	Booster/glider using radio control for landing. Contains cabin and emergency parachute. Proposed 1966.	Planned
F	3.125" x 65"	Two-section rocket using retro-rocket to soft land payload section. Contains BP cabins, R/C, landing legs with suspension, telemetry & emergency parachute system. Booster recovered by parachute. Proposed 1966.	Planned
G	2" x 87.5" (low altitude) 2" x 112" (high altitude)	Two section rocket using Series B parachute system. Contains cameras, sensors, and telemetry system. No BP. Proposed in 1974 as intermediate series before Series C. GB-1 was high altitude version with vapour generator and no parachute or instrumentation to test the booster. G-1 was low altitude instrumented version with parachute.	Prototype (GB-1) launched in 1975 G-1 almost completed but not flown

* Note: Diameter is outside diameter

In Australia we successfully completed Series A and launched several rockets in Series B, although we never finished developing a reliable recovery system. At university in America I continued the experiments and launched another rocket in the B-series as well as a special rocket (GB-1). These latter activities will be described in the last section of this chapter.

In the next part of the series we learn how a little knowledge can be a very dangerous thing! Trevor takes what he has learned and with his teenage accomplices, attempts to build and fly rockets made of metal that they built themselves. This included building the rocket motors they eventually used. Learn of their close encounter with the Royal Australian Air Force as you follow the series in the next Quarterly Update.