



Nanosat Launcher Business Plan.

For the 2012 NewSpace Business Plan Competition.

1. Executive Summary.

1.1. Stage one proposal summary

Unreasonable Rocket believes there is a real need for a responsive commercial nanosat launcher. The nanosat market is maturing with real missions and real funding. The growth of this market is limited by launch availability and the restrictions associated with the status of nanosats as secondary payloads. Secondary payload status precludes a whole range of possible missions by imposing very stringent rules on the payload. In addition the launch wait can be measured in years. It's very difficult to do iterative scientific development when the iteration cycle is measured in years. Unreasonable Rocket intends to solve this problem by providing dedicated nanosat launches without any of these restrictions. We will do this using the simplest possible pressure fed launcher, launched offshore. We have the technology in hand for all major systems with built and tested prototypes .of tanks, structures, engines, guidance and control. We have manufactured and flown guided liquid rockets of equivalent complexity to our proposed launcher. The next step is to put together a full time team to integrate the technology and provide this much needed service to this growing market.

1.2. The market and our value proposal.

The global launch market is a multibillion dollar business. Over the long term this is the market we want to address. Our Staged approach provides a realistic and limited risk path to address this market. For the first round of capital and I n this proposal we have focused on achieving the first profitable plateau in a multiyear and multi-step plan. In the last 5 years the nanosat has transitioned from an interesting idea sponsored by a few universities to a market with satellites

performing real missions funded by a broad range of customers. The number of manifested nanosat missions in 2011 increased by more than three times over the previous 5 year average. There are now multiple organizations that have flown repeat missions. There are 250+ nanosats presently waiting for a ride.

Our solution is superior to the existing secondary launch market in that it removed both schedule and compliance uncertainty.

Unreasonable Rocket intends to offer scheduled quarterly launches on dedicated launchers for a price of \$400K., and launches with custom schedules for 600K.. Given the current price and market size the initial market we intend to address is about \$10M per year in 2012 and growing.

1.3. Competition

The only present day competition is the secondary payload market. If you place no value on your time have no schedule constraints and are patient the secondary payload market is probably a lower cost alternative to the services we offer. If you have real mission needs and any realistic time valuation this is not realistic competition.

Unreasonable Rocket is not the only company currently pursuing a dedicated Nanosat launcher. Garvey Spacecraft corporation , Ventions LLC and Dynetics also have nanosat launcher programs.. All three of these efforts are SBIR funded and have launch concepts based on traditional ranges. . Only Ventions has flown a guided vehicle and its concept is a very complex turbo pumped vehicle that will be expensive to duplicate. When you throw the vehicle away simple is lower cost.

1.4. The Team

Unreasonable Rocket was one of four teams to build and fly vehicles for the NASA lunar landing competition. Our vehicles were more mass efficient and an order of magnitude lower cost than the other competitors. Unreasonable founder Paul Breed is CTO and founder of NetBurner Inc. (est 1998) Paul has been a serial entrepreneur profitably designing, producing and selling complex computer controlled engineering products in multiple fields for more than 25 years.

1.5. Details of the proposed launcher.

Many articles have been written on minimum cost design for launch vehicles.

A recurring theme is the “big dumb rocket”, big relative to the payload size, and dumb as in simple. Our first vehicle design embraces these concepts and is a simple 3 stage pressure fed launcher using room temperature dense peroxide/hydrocarbon propellants. This vehicle will be small enough to handle by humans without assistance.

1.5.1. Tanks and Structures.

Unreasonable has negotiated a joint venture/development agreement with Microcosm/Scorpius Space Launch systems to develop peroxide compatible composite tanks. Microcosm/SSLCS is a well-known defense and SBIR house with extensive experience and connections in the space launch community. This relationship gives Unreasonable access to extremely lightweight structures and tanks.

1.5.2. Propulsion

Unreasonable is the first group to ever fire a regenerative cooled liquid rocket motor built with modern 3D additive manufacturing. We intend to use this technology to develop all of our

upper stage motors and mechanical systems.

1.5.3. Avionics

In most aerospace electronics systems the cases, cabling and connector weight exceeds the active electronics weight. Using modern electronics capabilities we reduce the vehicle avionics to a single light weight unit. Unreasonable Rocket has previously demonstrated success building and flying integrated avionics systems of this type.

1.5.4. Launch Platform Concepts

For regulatory purposes the launch vehicle must be launched far from any population area. This can be done with either a boat or an aircraft. Determining the correct approach is a trade study that is still to be completed.

1.5.5. Regulation

Regulatory compliance costs, have significant hardware side effects. Regulatory compliance must be part of the design effort from the very beginning. Unreasonable has experience with FAA permits and a good working relationship with a number of FAA personnel. Recognizing FAA compliance in the design phase of the vehicle has allowed Unreasonable to create a unique solution that minimizes overall cost.

1.6. Risks

The primary risk is technical. Can we actually do what we have proposed for the costs our business model proposes? Unreasonable Rocket has fired rockets from 50 to 25,000 lb thrust,

with 9 different propellant combinations. We have built experimental tanks with structural efficiencies /mass fractions as good as any aerospace pressure vessel. We have built and flown guided controlled liquid rocket vehicles. We have flown said vehicles 5 or more times in a single day with an operating team of three or less.

1.7. Financial highlights.

Income Statement \$ thousands	2013	2014	2015	2016	2017
Revenue	\$0	\$1,200	\$4,500	\$9,000	\$13,500
R+D and Production Material	\$225	\$465	\$780	\$1,240	\$1,680
Operating Expenses	\$60	\$108	\$118	\$118	\$118
Salaries/Benefits	\$400	\$590	\$860	\$1,130	\$1,410
EBITA	(\$685)	\$37	\$2,742	\$6,512	\$10,292

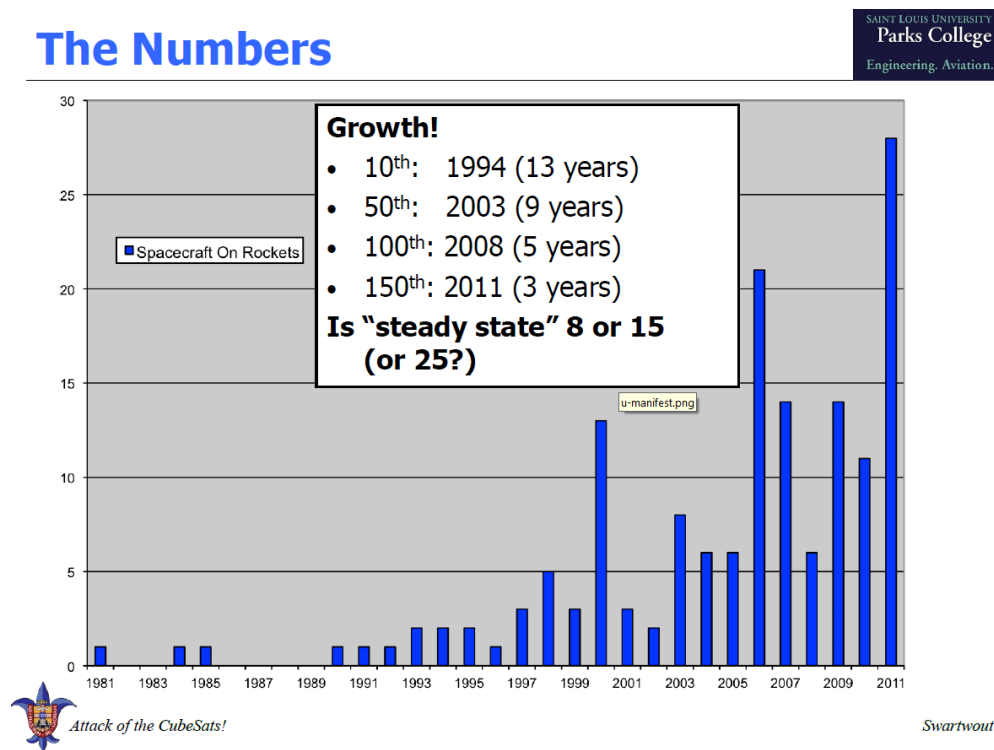
Cash Flow \$ 1000	2013	2014	2015	2016	2017
Operating Net Income (Loss)	(\$685)	\$37	\$2,742	\$6,512	\$10,292
Capital /Fixed asset purchases	(\$450)	(\$250)	(\$400)	(\$400)	(\$400)
Taxes	\$0	(\$13)	(\$960)	(\$2,279)	(\$3,602)
Investment Proceeds	\$1,500	\$0	\$0	\$0	\$0
Founder Contribution	\$150	\$150	\$0	\$0	\$0
Starting Balance	\$50	\$566	\$490	\$1,872	\$5,705
Ending Balance	\$566	\$490	\$1,872	\$5,705	\$11,994

2. Unreasonable Rocket's value proposition market and potential competition.

Overall the global launch market is a multibillion dollar business. In the 10 to 15 year time frame this is the market we would like to address. Before we do that we intend to demonstrate both our business and technical capabilities at a lower cost of entry. For the first 3 to 5 years we will only be addressing the small sat/nanosat launch market.

In the last 5 years the nanosat has transitioned from an interesting idea sponsored by a few universities to a market with satellites performing real missions funded by a broad range of customers. The number of manifested nanosat missions in 2011 increased by more than three times over the previous 5 year average. There are now multiple organizations that have flown repeat missions. There are 250+ nanosats presently waiting for a ride.

You can see this growth in the following graph from a presentation by Michael Swartwout at the Small Sat conference.



All nanosats launched to date have flown as secondary payloads on other missions. Getting a ride as a secondary payload is a lot like hitchhiking, you stand by the side of the road trying to look presentable and unthreatening, hoping that some driver will stop and pick you up. The car that stops to give you a ride may not be going where you really want to go, you must decide, take the ride close to where I want to go, or continue to stand in the road and wait? If your standing by the side of the road holding a strange piece of equipment the drivers can't identify you aren't going to get a ride. If your nanosat has a piece of equipment, propulsion, radio, energetic batteries, pyro deployment features, whose risks the primary payload can't fully understand, you're not going to get a ride. To date I do not believe that any nanosat with active chemical propulsion has been flown. Estimates of the cost of qualifying such a propulsion system to fly as a secondary payload are in excess of \$1.5M

As a secondary payload the Nanosat has the following limitations:

- Cannot choose their orbit or schedule.
- Cannot have energetic propulsion.
- Cannot have energetic radio emissions.
- Cannot have energetic/pyro deployment features.
- Cannot have timely access to the launcher to load things like biological samples, active reagents etc...
- US based payloads have ITAR problems with foreign launchers.

With these limitations the current published price (SpaceX) for a secondary 3U launch is \$350K, this does not include the hidden costs of maintaining your team while waiting months or years for a launch. It does not include the costs of negotiating with the primary payload any additional validation and verification the primary payload may require.

Our proposed launcher is a simple pressure fed vehicle with just four valves and three actuators per stage. After a two year development plan we will do ocean based launches every quarter with custom launches at any time available for an additional 50% fee.

2.1. Traditional Aerospace as competition

One could argue that the hitch hiking is viable competition to Southwest Airlines, but the convenience, risk reduction and hassle minimization more that make up for the cost difference. All of the existing traditional aerospace companies suffer from this hitch hiking problem.

2.2. Other Nanosat launcher as competition

Unreasonable Rocket is not the only company to notice this market, there is a long list of companies talking about Dedicated Nanosat launchers. Virgin Galactic, Xcor Aerospace, Ventions, Dynetics all have built real hardware and have talked about nanosat launchers,

2.2.1. Virgin Galactic and Xcor

Both Virgin and Xcor talk about doing nanosat launches after they have their suborbital manned vehicles operational. I see the following limitations in their plans:

- Their primary focus for at least the next three years is elsewhere.
- The proposed vehicles don't have enough mass or delta v performance to deliver a viable nanosat launcher to a point where it can make orbit as a single additional stage.
- The fact that the first stage is a manned vehicle imposes additional requirements that farther reduce the performance available.

2.2.2. Ventions LLC

Ventions is a viable Nanosat competitor. Their development is SBIR funded and their technical approach is traditional aerospace with E-beam welded tanks and tiny turbo pumps, a very complex system. They may actually build a functional 500lb GLOW nanosat launcher, but gross liftoff mass and propellant efficiency are the prime metrics we are trying to optimize. We are trying to optimize cost above all else.

2.2.3. Dynetics (Tim Pickens)

Dynetics worked on a simple pressure fed N₂O Nanosat launcher under an SBIR contract. It is my understanding that the contract was not continued and Dynetics has stopped working on this project.

2.2.4. Other NewSpace, Masten, Armadillo etc..

Both Masten and Armadillo are working on unmanned suborbital reusable vehicles.

Neither one has announced formal plans to develop a nanosat launcher, but it would be a logical extension of their existing business. AS their primary focus is on reusable vehicles both will have the exact same focus and performance limitations as the Virgin and Xcor will.

3. Sales and Marketing Plan

We plan to offer a simple proposition. Fixed price, fixed terms no technical hassles, just a simple service. You give us a satellite, tell us the orbit you want it in and we launch it. Unlike existing launch contracts, we don't get paid unless we deliver what we promised, a ride to the orbit of your choice. We replace a long drawn out negotiation process with a simple business transaction that should fit on a single page contract. The potential customers are relatively easy to identify

Vehicle Dry Mass		239	Kg					
Vehicle Glow		1042	Kg					

4.1.1. Tanks and Structures.

Unreasonable has negotiated a joint venture/development agreement with Microcosm/Scorpius Space Launch systems to develop peroxide compatible composite tanks. Microcosm/SSLCS is a well-known defense and SBIR house with extensive experience and connections in the space launch community. This relationship gives Unreasonable access to extremely lightweight structures and tanks. We have built 5 prototype tanks that have the mass fractions and peroxide compatibility we need for the finished vehicle.



We have tested these tanks to failure and this failure matched our calculations.

4.1.2. Propulsion

Unreasonable is the first group to ever fire a regenerative cooled liquid rocket motor built with modern 3D additive manufacturing. We intend to use this technology to develop our 2nd and 3rd stage motors and mechanical systems. Our first generation of 3D printed motor has in excess of 25 minutes of firing time and has exceeded all our expectations.

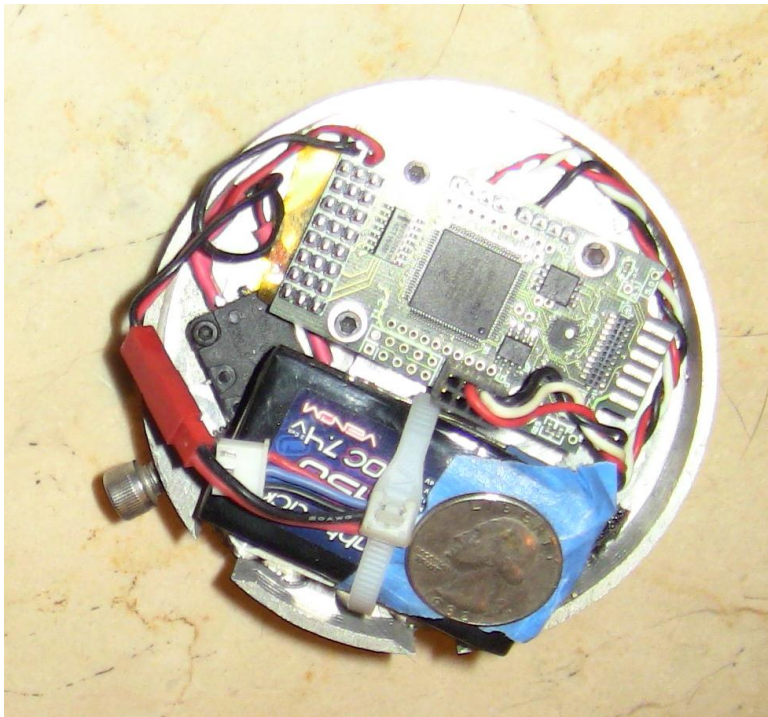


The next step is to build a 2nd stage 300lb thrust class version of our 75lb motor. The thermodynamics and cooling are easier for the larger motor.

In addition to the 3D printed motors we will evolve a first stage motor from the bipropellant 700lb peroxide hydrocarbon motor we developed for the Lunar Lander Challenge.

4.1.3. Avionics

In most aerospace electronics systems the cases, cabling and connector weight exceeds the active electronics weight. Using modern electronics capabilities we reduce the vehicle system avionics to a single light weight PCB assembly. Unreasonable Rocket has previously demonstrated success building and flying integrated avionics systems of this type. The board shown below is a 32 bit CPU, 3 axis gyro, 3 axis accelerometer, 3 axis magnetometer, altimeter (not needed for orbital) all packaged in a 4" airframe. Add an external GPS and this is the full controller..



All connections to actuators and sensors are over an industrial serial bus, minimizing the weight and cost of the wiring. In addition with modern Lithium polymer batteries putting the battery at the point of load weighs less than the cabling that would be necessary to carry the power to an actuator.. Both of Unreasonable Rockets's flying vehicles from the LLC used this architecture.

4.1.4. Launch Platform Concepts

For regulatory purposes the launch vehicle must be launched far from any population area. This can be done with as a sea launch or from an aircraft, or from land at a remote location.

Determining the correct approach is a trade study that is still to be completed.

4.1.4.1. Sea Launch Concept

The vehicle will be built and integrated in the factory. It will then be installed into a sealed container. This container will be transported to the launch site on a offshore fishing vessel,. The sealed launcher will be attached to a balancing arm and weight and set in the water. This configuration is very similar to a spar buoy and causes the vehicle to sit upright with minimal pitching and rolling and leaves it relatively immune to sea state. After deploying the spar buoy the host vessel will retreat to a safe distance and command the launch.

4.1.4.2. Air Launch Concept

The vehicle will be mounted below a Cessna Caravan and flown out to sea. It will then be dropped under parachute and launched after the Caravan has established the necessary clearance. This can be done with very little modification to the Caravan as the Caravan already has

structural hard points to mount amphibian floats and ground clearance to have a belly pod on unimproved runways. (The founder is a licensed A/P aircraft mechanic and has experience with this sort of modification) This configuration has more flexibility with launch location and weather immunity, but has added capital expenses.

4.1.4.3. Remote Location Concept

There are a number of U.S. locations where a launch could be done on land, such as the Kodiak Space port or the Kwajalein Atoll. For the small nanosat launch that will be our first product the logistics costs of going to these remote locations likely outweigh the savings compared to a sea or aircraft launch. However land launch has the added benefit of easily scaling to larger sizes, where the sea and air launch do not scale as easily.

4.1.5. Regulation

Regulatory compliance costs, have significant hardware side effects. The range safety systems on traditional launch vehicles cost more than we are planning to charge for a full launch, and weigh more than our payload. Unreasonable has experience with FAA permits and a good working relationship with a number of FAA personnel. Recognizing FAA compliance in the design phase of the vehicle has allowed Unreasonable to create a unique solution that minimizes overall cost. The launch will first stage will launch far enough away from third parties to have our radius of potential harm constrained by physics. Our second and third stages are light weight composite structures incapable of surviving high-speed flight in the atmosphere. This greatly simplifies the verification process needed for regulatory compliance. We are

familiar with the FAA AST office and have discussed this regulatory launch concept with the FAA AST chief engineer and found general agreement as to the validity of this approach.

4.2. Risks

The primary risk is technical and budgetary. Can we actually do what we have proposed for the costs our business model proposes? Unreasonable Rocket has fired rockets from 50 to 25,000 lb thrust, with 9 different propellant combinations. We have built experimental tanks with structural efficiencies /mass fractions as good as any aerospace pressure vessel. We have built and flown guided controlled liquid rocket vehicles. We have flown said vehicles 5 or more times in a single day with an operating team of three or less.

5. Management team and advisors.

Unreasonable Rocket was one of three teams to build and fly multiple vehicles for NASA lunar landing competition . Our vehicles were more mass efficient and an order of magnitude lower cost than the other competitors.

Unreasonable has also established partnerships with Microcosm for tank and structure development, Flowmetrics for aerodynamics and fluid flow solutions, and the FAR test facility for hot fire static testing and early flight test.

Unreasonable Rocket's founder Paul Breed is CTO and founder of NetBurner Inc. (est 1998) Paul has been a serial entrepreneur profitably designing, producing and selling complex computer controlled engineering products in multiple fields for more than 28 years.

Paul's experience developing embedded computer hardware and software includes both JPL qualified software, high volume consumer devices.

Paul has managed technical teams from 2 to 35 people and run business or business units in fields as diverse as formula 1 boat data loggers and military electronics systems.

Ben Brockert has assisted in the preparation of this business plan and would become a key member of the Unreasonable team.

Ben Brockert brings unique experience from the suborbital launcher industry, having worked at Masten Space Systems and Armadillo Aerospace. At Masten Space Systems he focused on operations, taking on project management, coordination with local and federal authorities, and running rocket test operations. This culminated in the company's \$1.15M win in the Northrop Grumman Lunar Lander Challenge and the first in-flight engine restart of a vertical takeoff-vertical landing vehicle. At Armadillo Aerospace he focused primarily on design and construction and was responsible for many aspects of launch systems, including rocket engine development, launch pad infrastructure, propellant handling, and mechanism design, enabling Armadillo's first near-space launches.

Two people do not make a team, for this plan to be successful the team will need to be expanded and several key roles will need to be filled. Unreasonable Rocket has been approached by a number of people in the NewSpace arena with the skills needed to fill out the team. These individuals have expressed an interest in working with us. Without secure funding and a formal business structure in place it would be unethical to name names and risk peoples existing positions. Unreasonable Rocket would gladly obtain and share employment commitments under NDA as part of the due diligence involved in a funding the proposed business.

6. Financial highlights (cash flow, income statement, & balance sheet)

6.1. Income Statement

Income Statement \$ thousands	2013	2014	2015	2016	2017
Revenue	\$0	\$1,200	\$4,500	\$9,000	\$13,500
R+D and Production Material	\$225	\$465	\$780	\$1,240	\$1,680
Operating Expenses	\$60	\$108	\$118	\$118	\$118
Salaries/Benefits	\$400	\$590	\$860	\$1,130	\$1,410
EBITA	(\$685)	\$37	\$2,742	\$6,512	\$10,292

6.2. Cash Flow Model.

Cash Flow \$ 1000	2013	2014	2015	2016	2017
Operating Net Income (Loss)	(\$685)	\$37	\$2,742	\$6,512	\$10,292
Capital /Fixed asset purchases	(\$450)	(\$250)	(\$400)	(\$400)	(\$400)
Taxes	\$0	(\$13)	(\$960)	(\$2,279)	(\$3,602)
Investment Proceeds	\$1,500	\$0	\$0	\$0	\$0
Founder Contribution	\$150	\$150	\$0	\$0	\$0
Starting Balance	\$50	\$566	\$490	\$1,872	\$5,705
Ending Balance	\$566	\$490	\$1,872	\$5,705	\$11,994

6.3. Simplified launch campaign cost models.

Single Vehicle launch material cost	\$120,975
Launch Labor	
Labor Cost	\$151,250
Full Launch Cost	\$272,225
Stand alone Price at 50% margin	\$544,450

Launches per campaign	4
Vehicle cost no Labor	\$59,475
Launch Campaign Per vehicle costs	\$15,000
Per vehicle Labor	
Share of Launch Campaign	\$11,625
Launch Campaign Labor	
Allocated Labor costs	\$118,250
Total Per vehicle Launch Cost	\$204,350
Price at 50% margin	\$408,700

7. Offering of the company

Unreasonable Rocket is looking for funding on the order of \$1.5M 100% of the funds will be used for capital equipment , salary's other than the founders and direct operations costs.

The principal founder will continue to contribute at least \$150K/yr to the operation and draw no income until the organization is cash flow positive. Pre money valuation is negotiable and dependent on the specific terms. The initial valuation would be in the \$3M to \$6M range.

This is not a pump and dump project. The intent is to build a cash flow positive company creating real value and servicing real needs in the multi billion dollar launch services business, accomplishing this allows a multitude of exit strategies.

Supporting Data.

Income Statement \$ thousands	2013	2014	2015	2016	2017
Revenue	\$0	\$1,200	\$4,500	\$9,000	\$13,500
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EBITA	(\$685)	\$37	\$2,742	\$6,512	\$10,292
Man power					
Skilled Eng	3	4	5	6	8
Tech	2	4	7	10	12
Misc	1	1	2	3	3
Salaries/Benefits					
Engineers	270000	360000	450000	540000	720000
Technicians	100000	200000	350000	500000	600000
Misc Staff	30000	30000	60000	90000	90000
Total	400000	590000	860000	1130000	1410000
Operating Expenses					
Facility	30000	30000	30000	30000	30000
Insurance	15000	50000	50000	50000	50000
Utilities etc..	8000	8000	8000	8000	8000
Travel/ Trade Shows etc..	6500	20000	30000	30000	30000
Total	59500	108000	118000	118000	118000
Average Sale Price		400000	450000	450000	450000
Revenue Launches	0	3	10	20	30
Vehicle/Test Assemblies Built	3	5	12	21	32
Launch Campaigns	3	4	4	8	8
Vehicle Material cost per	45000	45000	45000	40000	40000
Launch Campaign cost	30000	60000	60000	50000	50000
Campaigns	1	4	4	8	8
Total Material costs	135000	225000	540000	840000	1280000
Total Launch campaig costs	90000	240000	240000	400000	400000
COGS (No Labor)	225000	465000	780000	1240000	1680000
Available Technical Labor Hours	9800	15680	23520	31360	39200
Availbile Technical Labor/Launch	3266.667	3136	1960	1493.333	1225

Launch Cost Model

		COTS	Material	Labor	
Nose End					
	Nose cone Aero shell	0	1500	160	
	Nose cone separation mech	0	300	20	
	Nano Sat ejection system	0	300	20	
	Pay Load	0	0	0	
Avionics					
	GPS/MEMS IMU	3500	0	0	
	Actuator control	0	500	80	
	Telemetry	200	0	0	
	Battery	200	0	0	
Third Stage					
	Tank/Composite Structure	0	2500	160	
	QD/Fill system	0	100	20	
	Press valve	0	300	10	
	Fuel Valve	0	300	10	
	Ox Valve	0	300	10	
	Pressureization system	0	1500	40	Small electric autogenius pump
	Motor	4000	1200	20	3D Printed with after mods
	Motor Mount	0	50	20	
	TVC actuators	300	0	0	
	Roll controll TVC	75	0	0	
	Integration	0	1500	100	
Interstage					
	Seperation Ring	0	200	20	
	Seperation Actuator	0	200	20	
					19025
Second Stage					
	Third Stage Support	0	200	20	
	Tank/Composite Structure	0	3000	160	
	QD/Fill system	0	100	20	
	Press valve	0	500	10	
	Fuel Valve	0	500	10	

	Ox Valve	0	500	10	
	Pressureization system	0	1500	40	Small electric autogenius pump
	Motor	8000	2400	20	3D Printed with after mods
	Motor Mount		100	20	
	TVC actuators		600	40	Silver ball clone
	Roll controll TVC	150	0	0	
	Battery for 2nd Stage	250	0	0	
	Integration		3000	100	
First Stage					20800
	Second Stage Support Structure	0	200	20	
	Tank/Composite Structure	0	4000	160	
	QD/Fill system	0	100	20	
	Press valve	0	500	10	
	Fuel Valve	0	500	10	
	Ox Valve	0	500	10	
	Pressureization system	0	1500	40	
	Motor	0	4000	160	Made from aluminum billet in house
	Motor Mount	0	100	20	
	TVC actuators	0	600	40	Silver ball clone
	Roll controll TVC	150	0	0	
	Battery for 1st Stage	250	0	0	
	Self Distruct?	0	0	0	
	Hold down system	0	250	40	
	Integration	0	3000	100	
Externals					15650
	Packaging for Transport	0	2000	160	
	Cots	17075			
	Materials	38400			
	Labor Hours	1790			
Launch Prep					
	Test Propellant	7500			
	Test Setup	0	2000	160	
	Test Tear down	0	0	160	

Direct Launch costs					
	Propellant	7500			
	Setup		2000	160	
	Scrub Days		2000	160	
	After analysis		0	160	
Launch Campaign costs					
	Launch Facility/Boat	37500			7.5K per day 5 days
	Crew Food and lodging	5000			(3 crew)