

Competitive Analysis 06 AUG 2014

An important consideration in this business plan is the competitive landscape for the desired market.

Government sponsored flights can be acquired at non-competitive prices (free) but have many drawbacks for their users. The first is, of course, that they are very rare. Most users do not have access to free launches even if operating under a government grant for development. Second, they are unreliable. Whims of the sponsoring organization or flight, can change and push secondary payloads off or indefinitely delay the flight. Third, free is rarely free. Assorted costs of review, testing, handling, delays, and fees can easily add up to a commercial launch price. In fact, the commercial launch prices are frequently the handling fees for a nearly free launch.

The next option for a payload to fly is the commercial offerings for launch services. There are nearly four major types of commercial launch provider organizations currently in business.

- 1) Currently flying systems with large payload that may carry hitchhiker secondary payloads of the desired size and the clearinghouses that operate with them.
- 2) Developmental Large payload systems that may move into group number 1.
- 3) Developmental Nano-Launch systems that may fly in direct competition.
- (4) There are no currently flying Nano-Launch systems to discuss for the fourth class.

1) Currently Flying Large Payload systems.

Existing launchers are all relatively large payload and very high cost vehicles. For information purposes, a quick chart showing the organization (national or corporate) and the systems they operate is shown in Table 1.

India PLSV GSLV	United Launch Alliance Delta IV Atlas 5 400/500	Intrn. Launch Svcs (ILS) Proton Angara	Boeing Space Services Delta II SeaLaunch *
Japan JAXA H-IIB	Lockheed Martin Athena (LMLV, LLV)	Arianespace Ariane 5	China Long March
SpaceX - Falcon 9 Falcon 1	Orbital Sciences Taurus Minotaur Pegasus Antares (Taurus II)	Roscomos (Russia) Dnepr * Shtil Soyuz	Ukraine Zenit-2 SeaLaunch * Dnepr * Tsiklon

Table 1. Existing Space launch providers.

Obviously, the price (hundreds of millions of dollars) of these launch services precludes them from being a primary competitor for a Nano-sat launch vehicle. Hitchhiker, or space available, flights are occasionally allowed on these flight but the investment of the customer in their payload and in the high price for their launch service, severely limits what, where, and who is allowed to fly as a

secondary payload. Additionally Space available is often a misnomer since the primary mission's on-orbit consumables is frequently added or deleted to match the payload weight to the available payload capacity, so there isn't any 'space available'

These current launch services reduces down to some scattered programs and a clearinghouse for a subcontracted services. The premier subcontracting launch provider is Spaceflight Services, an spinoff of Andrews Space in Seattle WA. Their pricing matrix as of 2013 is reproduced here in Table 2.

Payload Class	Containerized Payloads				MicroSat Class		
	1U	3U	6U	12U	50 kg	180 kg	300 kg
Length (cm)	10	34	36.6	36.6	80	100	125
Height (cm)	10	10	10	22.6	40	60	80
Width (cm)	10	10	22.6	22.6	40	60	80
Mass (kg)	1	5	10	20	50	180	300
Low Earth Orbit (LEO)	\$125k	\$325k	\$595k	\$995k	\$1,750k	\$4,950k	\$6,950k
Geosynchronous Transfer Orbit (GTO)	\$250k	\$650k	\$995k	\$1,950k	\$3,250k	\$7,950k	\$9,960k
Geosynchronous / Low Lunar Orbit (GSO/LLO)	\$490k	\$995k	\$1,990k	\$3,250k	\$6,500k	\$15,900k	\$19,900k

Table 3. Spaceflight Services pricing in US dollars with our initial market highlighted (June2013)

Note that these prices have not shown any signs of lowering, and in fact have inflated considerably since the CubeSat concept was first introduced. Back in the early 2000's prices were advertised as \$40k per U to LEO. Now, with realistic market costs, they are three times that initial estimate.

It should also be noted that these launch opportunities are not really responsive to customer needs in any meaningful way. The destination are selected by the launch provider and primary customer, the payload contents are severely restricted, and the schedule is set by the primary launch customer without any concern for the secondary payloads. If they are not approved and ready, the secondary payloads are replaced by ballast at the expense of the secondary payload. Spaceflight Services can, apparently, contract out to Andrews Space for an orbital kick stage for the GSO/LLO missions.

2) Developmental Large Payload Systems

Projects are underway, at assorted rates, to develop the next generation of large launch vehicles. Many of these hope to significantly lower the price per kilogram of orbital delivery. This, however, will not lower the price per launch the orders of magnitude necessary to fly dedicated small missions. It is thought that in some cases, flights may become so regular, the space available flights would become more common, but the other limitation such as destination and contents would still apply. The current developmental large launch vehicle systems are shown in Table 3

NASA SLS	Stratolaunch Systems Stratolaunch	Andrews Space Aces / Gryphon	Spacedev Streaker
Brazil Cyclone 4 (Ukraine) VLM/VLS	Scorpius/Microcosm SR-M Sprite	SpaceX Falcon 9R Falcon Heavy	Arianespace Vega Ariane 6
ATK ALV	E'Prime S-III		

Table 3 Developmental Larger Launch vehicles

Developmental vehicles may be nothing more than a design (Gryphon), or can be just a mothballed launcher that currently doesn't have any customers (Falcon I).

Note: completely ended programs and companies (such as Beal, T/Space, AirLaunch LLC, FalconSLV, and Otrag are not shown, At least the assets and ideas have to be somewhat active to be considered here.

3) Developmental Nano-Launch systems

We define this as a launch vehicles with a payload of less than about 100 kg. While this is technically inclusive of Micro-Satellite launch vehicle, an inexpensive enough vehicle could eat into the Nano-Launch market. Plus plans change.

We look at several key areas.

Result : This is the overall competitive bottom line.

Payload : When available, this is the announced or intended vehicle capability.

Price : Announced, or intended price point. May vary wildly depending on launch rate.

Update : The last time a news release was seen from this organization. A measure of survival

Progress : apparent technical and/or financial progress

Technical : What technology they seem to be pursuing. Often times their 'hook'

Other aspects that may be important, but are rarely available would be such things as the payload flexibility in regards to what can be carried, the mission orbit capability, and how far they have progress in such issues of licensing or facilities. Unfortunately these are at best rumors.

Since these are legitimate future competition, each will be treated individually:

AeroJet / Rocketdyne – Spartan

Result : higher payload and Price, Probably Stalled Development

Payload : 20 to 100 kg.

Price : \$5M to \$8M

Update : 8/7/2013

Progress : NASA Select SBIR 2012 Phase I (KSC)

Technical : Heritage 3stage Solid

Coalition of several small business suppliers, and launch from Kodiak AK (and KSC, VAFB Wallops with some build out) seem to have some government support. Wireless Intravehicle Communications System (WICS) was supported at Invocon by the SBIR. They did not win the Phase II <http://invocon.com/index.html>

Armadillo aerospace – Cluster.

Result : suborbital toward space tourism, currently mothballed

Payload : “Micro-Satellite”

Price : ?

Update : Blogs and news reports regularly

Progress : Was making good progress

Technical : Low cost liquid

Armadillo is personally funded by John Carmack (Id Software) and has produced some interesting vehicles including winning some Grumman Lunar lander prizes. While they have meandered some with peroxide, and steerable parachute recovery, they are always making progress and flying (and crashing) bigger and better VTOL vehicles.

Update: as of August 2013, Armadillo announced that the company has been mothballed and everyone is gone. <http://armadilloaerospace.com/n.x/Armadillo/Home>

Blue origin - ???

Result : Apparently a Larger Manned System

Payload : ??

Price : ?

Update : Very secretive

Progress : ???

Technical : First Peroxide, now Lox kero

Very Secretive and successful rocket company that is financed by Jeff bezos of Amazon.com fame. Has won some government grants for manned capsule work. They state that they are working to lower the cost of human spaceflight.

<http://www.blueorigin.com/>

Copenhagen Suborbitals - MSV

Result : Non-commercial, suborbital – Not currently a competitor.

Payload : Manned capsule

Price : ?

Update : Daily on Facebook.com

Progress : Rapid

Technical : Open Source turbo-pumped liquid propellant vehicle

An extremely active group that is more of a Danish cooperative than a conventional business. They are open source and charity/crowd funded. So far they have built large amateur solid, hybrid, and liquid vehicles and launched from their submarine towed ocean platform. Their stated goal is a manned suborbital flight then eventually a manned orbital flight. Although they have no announced commercial launch plans, they re-task easily and have experience and capabilities that would apply.

<http://copenhagensuborbitals.com/>

Dynetics - Multipurpose Nano-Missile System (MNMS)

Result : Uncompetitive in price, stalled.

Payload : 10kg

Price : \$1M

Update : Oct 2011

Progress : Test firing in July 2010

Technical : Simple clustered liquid modules

This is an US Army funded project on a 4 year timetable started in 2008 to build a small modular vehicle from one to 8 standardized Nitrous/Ethane liquid modules and a small upper stage. The projected payload is 10kg to LEO at a launch price of \$1M per flight. Apparently \$7M in funding was used up in later 2010.

<http://www.dynetics.com/>

DARPA - Airborne Launch Assist Space Access (ALASA)

Result: Uncompetitive in Size and Price

Payload : 100kg

Price : >\$1M

Update : Jan 2013

Progress : Typical well funded corporate effort

Technical : Conventional Solid with expensive aircraft.

ALASA is to be an airborne launch vehicle with DARPA funding to loft a 100 (lb or kg depending on announcement) payload to LEO with a per flight cost of around \$1M. This is rumored to assume a quite large flight rate of one flight per week to amortize the overhead. Three main competitors are Boeing, Lockheed Martin and Virgin Galactic. Also partnered or funded are L3 Colman aerospace, Northrop Grumman, Space Information Laboratories and Ventions. The initial \$46M in further funding should run out in September 2013 with a follow-on contract for 36 launches.

http://www.darpa.mil/Our_Work/TTO/Programs/Airborne_Launch_Assist_Space_Access_%28ALASA%29.aspx

DARPA/NASA/Army - Soldier-Warfighter Operationally Responsive Deployer for Space (SWORDS)

Result: Canceled, but interesting marker indicator.

Payload : 25kg

Price : ~\$1M

Update : March 2014

Progress : Typical corporate effort

Technical : LOX/CH4 Cluster Tank 3 stage.

Several government contract to develop a 3 stage vehicle for the army. Swords unfortunately had difficulties in their multi, interlocking propellant tank design and was deemed technologically deficient. SWORDS was canceled 13MAR2014.

Environmental Aeroscience Co (eAc) – Multiple

Result: Defunct with inferior hybrid technology.

Payload : 300 - 1000kg

Price : ?

Update : 2004

Progress : Sporadic depending on government contracts.

Technical : hybrid or solid.

eAc was a consulting hybrid rocket company often joining forces with Ceseroni and/or Exquadrum Corporation to work government contracts. They have worked on multiple projects for launch vehicles all with less than 1000 lbs payload capacity. They primarily supply hybrid rocket motor technology to other companies for government funded research studies. Eac was a supplier for parts and technology for the SpaceShip One, winner of the Anasari X-Prize. Suspect they have some (quiet) developmental money from an Exquadrum LV contract in 2013.

<http://hybrids.com/index.html>

Exoge Aerospace – OTRAG-ish vehicle

Result : Out of business, overly complex/costly vehicle.

Payload : ?

Price : ?

Update : Nov 2008

Progress : ?

Technical : Modular vehicle with liquid propellants

Exoge was planning a modular vehicle with 4 modules to create a sub orbital vehicle and 64 modules to get a small satellite to orbit. Nitrous oxide and Propane modules were being tested with the intention of piston pump propellant feed. Or maybe peroxide and kerosene ? Website now off-line.

www.exoge.com = DNS error

Firefly Space Systems - Alpha

Result : Uncompetitive in size, and in price.

Payload : 400kg

Price : \$8+ M

Update : July 2014

Progress : Animations

Technical : Autogenous feed LOX/methane, All carbon composite, Plug cluster Aerospike first stage propulsion. Hawthorn CA, Failed credit check, Leader is ex Virgin galactic, ex SpaceX, ex ?? PhD propulsion “guru”.

<http://www.fireflyspace.com/>

Garvey Spacecraft Corporation – Prospector Nanosat Launch Vehicle, 10/240 etc.

Result : Probably the closest real competitor, but still higher priced.

Payload : 10kg

Price : “Above secondary payload prices” (> \$595k of Spaceflight Services)

Update : News June 2013

Progress : Very good, several subscale suborbital flights

Technical : Conventional low cost liquid 2 stage

Garvey and team has been making progress in the Mojave at the Friends of Amature Rocetry site with involvement of the CSU-Long Beach and financial support from the NASA SBIR program and AirForce contracts (20+ on usaspending.gov). “It would cost more than flying as a secondary payload because it’s like flying first class instead of standby,” Garvey said.

<http://www.garvspace.com/> (2012)

Generation Orbit Launch services - GoLauncher 2

Result : Inferior tech and probably high price

Payload : 45kg

Price : Stated as low-cost ?

Update : July 2013 (frequently Facebook)

Progress : Still receiving grants.

Technical : Air launched hybrid

Formed in Oct. 2011 to develop nanosat launcher using a supersonic aircraft that would release a solid rocket. GoLauncher 1 is suborbital and yet to fly. The latest concept, GoLauncher2, is a biz-jet dropped two stage lox/paraffin hybrid vehicle for orbital flight. Partnered with assorted companies for propulsion and funded from assorted grants. Their launcher seems to require \$25M in development funds plus perhaps the purchase and maintenance of the aircraft.

<http://www.generationorbit.com/>

Hawaii Space Flight Laboratory – Super-Stryper-SPARK

Result : Uncompetitive in price.

Payload : 165 kg

Price : \$10M to \$12 M

Update : May 2013

Progress : Close to first launch (Delayed from 3Q2012)

Technical : Conventional Solid.

This group is actually pretty close to flying. It is a University of Hawaii launch site run by Vandenberg and Sandia labs using the Super-Stryper sounding rocket and a spinning upper stage (Space-borne Payload Assist Rocket) and funded by the Office of Responsive Space (DoD-ORS) to the tune of nearly \$30M. They seem mostly interested in flying their own payloads.

<http://hsfl.hawaii.edu/>

Interorbital Systems - Neptune N5,30,1000

Result: Imaginary Amateurs with a lot of PR

Payload : 30kg

Price : \$375k

Update : Frequently (Mar 2014)

Progress : Announced moon landing by 2003.

Technical : Acid liquid rocket clusters.

Ron and Randa Milliron have been working on and announcing their orbital launch capability for many years. They announced an imminent lunar landing in the early 2000's. They have apparently put together the equivalent of a large sounding rocket and repeatedly announced imminent launch from the ocean. Each time they claim a lack of investment is the cause of their postponement. They have sold small 'Cansat' kits, the size of a soda can, for \$8000 each. They claim these kits include launch to LEO, but there is serious doubts about that ever happening. They have announced an imminent suborbital launch several years ago. Launched small demo rocket march 2014.

<http://www.interorbital.com/>

JP Aerospace – Airship to Orbit (ATO)

Result : Probably not technically feasible.

Payload : Crewed

Price : Unknown

Update : Frequently

Progress : Regular balloon flights

Technical : 3 types of airships.

JPA is pursuing high altitude balloons to incrementally fly to orbit. They have been flying weather balloons on trusses to around 100k' for many years on a volunteer basis for educational purposes. Their stated goal is to build a very high altitude station (140k'), that then launches an exotic electrically propelled mile long balloon vehicle (Vee shaped) to float to 200k;, then climb and accelerate to orbital velocity over 5 days. John Powel has stated that he “thought there were 100 reasons why this wouldn't work, now he only thinks there are 10”. They have published a book and built subscale models with SBIR funds. They claim to be seven years from their orbital flight. They have test fired small hybrid rockets with electromagnetic 'afterburners'. A fun group of volunteers moving pretty slowly but steadily.

<http://www.jpaaerospace.com/>

Masten Space Systems – Xsomething

Result: Successful VTOL vehicle company

Payload : ?? kg

Price : Unknown

Update : Regular updates

Progress : Multiple Flying vehicles

Technical : Very challenging concepts

The Masten team won the Level 2 Lunar lander challenge (\$1M) and has supplied NASA with a demonstration VTOL vehicle. They are very involved in VTOL flight and seem to be focused on lunar lander designs with only a slight hint of possible orbital aspirations. Hardware and components are offered for sale. They fly fairly often in Mojave CA.

<http://masten.aero/>

Microlaunchers inc – Microlauncher

Result: Very Small, Imaginary Amateur but not a competitor.

Payload : 0.45 kg

Price : Unknown

Update : Sporadic comments

Progress : Powerpoint presentations

Technical : Very challenging concepts

Charles Pooly is an imaginative individual that speaks of the new satellite revolution that will parallel the Personal Computer revolution. Many of his ideas have merit, but unfortunately he is a loner that doesn't seem to concentrate on any one concept long enough to produce a product. His launcher payload is actually smaller than a Cubesat and the vehicle is not particularly scalable. He has been touting the concept of small satellites since before the CubeSat revolution. Some of what he still says has become yesterdays news.

<http://microlaunchers.com/>

Open Spaces inc – ???

Result: Very Small, Imaginary.

Payload : 50 kg

Price : Unknown

Update : Kickstarter 9/5/2014

Progress : HPR Video

Technical : CANADIAN Liquid or Solid or something.

Nova Scotia Canada group (Tyler Reyno) trying to raise money for a CANADIAN launch service. Seems much more about the Canadian, than the technology since they are fundraising to define a design, build a demo motor/engine, perform market study, setup a corporation and make a business case. Canadian suppliers, for a Canadian company staffed with Canadians. While the Canadian aspect has merit, that is all this group seems to have. Mostly press coverage. They seem to have missed the fact that Nova Scotia is a poor site for sun synchronous launches (overflies eastern seaboard).

<http://www.openspaceorbital.com/#!/home/mainPage>

Premier Space Systems Inc. - Nanolaunch project

Result : Suborbital

Payload : 45kg

Price : ?

Update : Feb 2012

Progress : Orbital is far future plan.

Technical : Air launched solid

Some professional pilots who apparently own a MiG 21. They claim to have a coalition of about 3 other groups to use hybrid and/or solid rockets, avionics, space propulsion, and mission design. They seem to be more interested in getting a F-15 and chartering jet flights than actually performing orbital space launch. Mostly speak of suborbital atmospheric flights. Very similar to Generation orbit.

<http://premierspacesystems.com/>

Rocket Labs LTD – Electron

Result : Larger payload and price, uncompetitive.

Payload : 100kg

Price : \$5M

Update : Jul 29 2014

Progress : Recruiting

Technical : Conventional.

The group from Auckland founded in 2007 by New Zealander, Peter Beck, with a subsidiary in the United States (or vice versa), has a few monopropellant and hybrid vehicles under their belts. They use Carbon fiber tanks, Secret regeneratively cooled lox/ kerosine engines, 3 stages, and a cluster of the second stage engines for the first stage. Unknown how well they are funded, but they appear to be trying to apply to SpaceX's Falcon I market.

<http://www.rocketlabusa.com/>

Rocket Launch Services LLC – NE- 2

Result : Suborbital, Underfunded, unrealistic.

Payload : 5kg

Price : \$20k suborbital

Update : Aug 26 to Sept 26 2013

Progress : Subscale rocket motor firings

Technical : Film cooled autogenous liquid propellants

(RLS is probably just Jonathan McCabe) The NE-1 is a suborbital liquid propellant reusable sounding rocket being developed in Wisconsin. Hoping to use the Spaceport Sheboygan on the shore of Lake Michigan in June of 2014, they had a kickstarter campaign. The Ne-2 is the orbital follow on version but has very few details. One detail they do mention is using patented OBTEC votex technology (where they tested their motor) , but still use a graphite throat insert.

<http://rocketlaunchservice.com/>

Rocketplane/Kistler – K-1, Rocketplane

Result : Defunct

Payload : Large and small, manned and unmanned.

Price : Almost every price was announced

Update : Personal and corporate Bankruptcy filings in 2010

Progress : Some assets purchased at auction by new holding company.

Technical : Varied.

Pioneer Rocketplane, Then RocketPlane Ltd., Then Rocketplane-Kistler. They technically had two vehicles under development and NASA money. The Kistler K-1 was a larger two stage reusable vehicle that was “80%” done but still need 100% more money. The RocketPlane was a Suborbital aircraft that could launch a Bantam upper stage. Either idea could have worked with enough development money, but never did.

<http://www.rocketplane.com/>

SHIPinSPACE –

Result : Only Announced Tourism

Payload : 48 to 95 passengers

Price : \$1M to \$2.8M

Update : Sept 2013

Progress : \$7.78M in funding received

Technical : Varied.

European group with a Rocketplane style design that drops multiple personal reentry capsules. Noteworthy because it would make a good reusable first stage for a small launch vehicle. Received \$7.8M of seed funding of the expected \$250M required to build the system.

<http://uk.linkedin.com/pub/fabrizio-boer/17/300/a>

Whittinghill aerospace LLC – mCLV

Result : Inferior technology leading to high price, probably defunct.

Payload : 25kg

Price : ?

Update : Sept 2012 SBIR payment

Progress : SBIR contract paperwork in may 2013

Technical : N2O Hybrid

The SBIR proposal chart describes a project to use an OTRAG approach, in which each stage is a cluster of a basic propulsion module, to build a low-cost nano-sat launcher: A modular minimum Cost Launch System (mCLS) for nano-satellites. They have won phase I and II SBIR grants. George Whittinghill has been Chief Technologist for Virgin Galactic, a program manager in propulsion projects at NASA and the Air Force, and was involved with AMROC. Ian Whittinghill was the "founder and

student director" of the USC Rocket Propulsion Lab. TRL 6 at end of \$600k PH2, 4-2-1+apogee kick spun 4th stage with n20 hybrid rockets.
<http://whittinghillaerospace.com/>

XCOR – Lynx MKIII

Result : Suborbital for a long time

Payload : “several nanosats”

Price : >> \$500k

Update : May 2013

Progress : Suborbital flights, no progress on orbit.

Technical : a rocket plane lofting a two stage ... idea.

XCOR is primarily a suborbital tourism company that has announced that their MKIII vehicle will have the ability to carry a small upper stage for satellite delivery. No details are given for this dorsal pod two stage launcher. The company has already flown two version of rocket planes and is building the Lynx MK I. They also produces several liquid rocket engines and pump sets.

<http://www.xcor.com/>

Zig Aerospace - Z1

Result : Inferior Tech, Defunct

Payload : 5kg

Price : \$200,000

Update : 2008

Progress : None noted

Technical : Two Stage Hybrid

Zig Aerospace of King George, Virginia, was developing the Z-1 small launch vehicle. Intended to launch nanosatellites and similar small payloads, Z-1 has a maximum payload capacity of five kg (11 pounds) to LEO. The two-stage vehicle, was powered by hybrid propellants, is intended to cost less than \$200,000 per launch. In 2008 Zig Aerospace was in the midst of a 3-year development program. Once the Z-1 vehicle entered operations, the company expected to be able to conduct launches as frequently as once a month.

Zigaero.com (now a Japanese site ?)