Aerospike plus External Tank Create new launcher

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In the 1950s and 60s the J2 engine was used as an upper stage on the Saturn rockets. When used at lower altitudes efficiencies suffered due to atmospheric pressure. Plans existed at that time to use a new rocket technology that automatically compensated for varying atmospheric pressure increasing performance.

http://en.wikipedia.org/wiki/Image:Annular−Aerospike.jpg
http://www.astronautix.com/stages/satt250k.htm

This was one of the reasons a linear aerospike engine was chosen for the ill−fated SSTO program. This aerospike used SSME components

http://en.wikipedia.org/wiki/Aerospike_engine

But just as the J2 and SSME components can be made into an aerospike configuration, any rocket engine hardware can also be made into this configuration. Annular aerospike just means round. Linear of course means a line. Annular is nice because it can fit at the base of a long cylinder, which is the favored shape for a rocket element. Truncated aerospike saves a little weight, and provides a flat surface on which to mount a ballistic style heat shield, like they used to use on the Mercury Gemini and Apollo capsules. So, a fairly lightweight balloon tank structure can withstand re−entry by entering heat sheild first, with fairly light ablative cooling around the base.

Now, consider the Space Shuttle's External Tank (ET)

http://en.wikipedia.org/wiki/Space_Shuttle_external_tank

It masses 762,1 metric tons and carries 629.3 metric tons of liquid oxygen and 106.3 metric tons of liquid hydrogen.

Now consider the RS−68 rocket engine from Pratt & Whitney

http://www.pw.utc.com/vgn−ext−templating/v/index.jsp?vgnextrefresh=1&vgnextoid=cc242b1f547ee010VgnVCM10

In an aerospike configuration this likely would generate 350 metric tons of thrust.

So,three RS−68 pump sets and controllers, could be configured into large 8.4 meter diameter truncated annular aerospike only 1.5 meters tall and massing 15.3 metric tons and producing 1,050 metric tons at lift−off.

This is nearly the first stage of an ARES launcher, but no SRBs and no upper stages.

With a total mass of 777,4 metric tons and a thrust at lift off of 1,050.0 metric tons acceleration at lift off without SRB is 1.35 gees − with the ability of the structure to withstand re−entry.

The ideal delta−vee of this sort of configuraiton, assuming a 440 sec Isp, we have

777.4 total
629.3 LOX
106.3 LH
440.0 Isp
9.82 g0
4320.8 Ve m/sec
0.9462 u
12630.0 Vf m/sec

a final velocity of 12.63 km/sec. With gravity and air drag losses of 2 km/sec, final velocity is around 10 km/sec − nearly escape velocity. Adding a 60 metric ton payload to this configuration allows us to achieve orbit with it and the vehicle. In this configuration I favor hanging the 60 ton payload behind the ET in front of the aerospike. An added segment to the ET, forming a disk shaped volume 8.4 meters in diameter and 3.6 meters tall.

And it would look something like this;

http://www.astronautix.com/graphics/b/bigsint2.gif

and have this performance

837.4 total
629.3 LOX
106.3 LH
440.0 Isp
9.82 g0
4320.8 Ve m/sec
0.8784 u
9105.2 Vf m/sec

By ganging together three of these bad boys and providing for the outer tanks to feed half each the needs of the inner tank, we have effectively a two stage system. The upper or central stage has the same performance as above, and the first two stages have the following performance;

2392.2 total
1258.6 LOX
212.6 LH

0.6150 u1
4124.2 Vf m/s

Which means that this configuration could project 60 tons payload plus the complete central stage to escape velocity.

By making this payload mass propellant, additional maneuvering can be achieved beyond Earth orbit. For example, landing on the moon with rocket assist, or landing on Mars with aerobraking and rocket assist − Using the ullage − or the gases remaining at high pressure in the tanks after theyh're technically empty, power can be generated from the hydrogen and oxygen along with water, for an extended period of time.

Doubling the payload of the central tank to 120 metric tons by putting in two disk shaped inserts, each 8.4 meters in diameter and each 3.6 meters long, a total of 7.2 meters − the following central stage performance is attained

The cargo volume and payload are nearly that of a Boeing 747 cargo plane but the range is Earth orbit;

897.4 total
629.3 LOX
106.3 LH
440.0 Isp
9.82 g0
4320.8 Ve m/sec
0.8197 u
7402.1 Vf m/sec

Which with the 4.1 km/sec outer stage boost and the 2 km/sec gravity and air drag loss, allows this configuration to orbit 120 metric tons (262,000 pounds) of payload (along with the central stage).with return of all the parts.

Which is equivalent to the Saturn V launch system, but at far lower costs given the recovery of all the components and far simpler configuration and hardware than either space shuttle or Saturn V − while affording complete reusability.

Placing in Earth orbit or landing on the Moon or landing on Mars a complete External Tank sized pressure vessel with even a small amount of useable payload − one way − permits building up rather quickly and efficiently, habitable volume, in the manner of the successful Skylab system at very little added cost.

By making the aerospike engine removeable from the tank which is left in place, the engine with heat shield,and controls, is easily recovered while the habitable module and payload is left in place.

Delta−v needed to move inside Earth Moon system (speeds lower then Escape velocity) in km/s

http://upload.wikimedia.org/wikipedia/en/b/be/Deltavs.jpg

So, recovery of the 15.3 ton engine and hardware from various locales involve

Locale kps tons prop.
GEO 1.6 6.9
Luna 3 15.4
Mars 6.4 52.0

The Mars return propellant can be obtained partly by reducing the
So, the system even when placing an 8.4 m diameter habitable cylinder that's 53 to 60 meters long.

Once a capacity to obtain oxygen on Mars or the Moon are in place, by reducing oxides to their component parts and extracting the oxygen, using nuclear or solar power in place, then we can consider the following

Mars Moon GEO
52.0 15.4 6.9 total
7.5 2.2 1.0 hydrogen
44.5 13.2 5.9 oxygen

We only need carry the following;

2.2 tons hydrogen + local oxygen to return from Moon
6.9 tons total to return from GEO (no local supply)
7.5 tons hydrogen + local oxygen to return from Mars

So, with this chemical system we have a means to put large habitable volumes in place in a manner similar to that used by skylab.

If you've ever erected a wind mill or radio tower, you'll know that its rather simple to take something and lower from vertical to horizontal position with cables light frame work and attachment points.

http://users.frii.com/nussbaum/images/upright1.JPG

Its equally simple to lower a cylinder into a horizontal position, after detaching it from a stable base, without a frame − made even simpler by lower gravity.

So, a vertical landing of the vehicle on the moon or mars would be the first step. Next, would be to secure the vehicle with cables to attachment points dug in around the vehicle. Then detach the ET from the base and lower into horizontal position − the reverse of erecting a tower. Then, the engine system departs − to return to Earth via aerobraking, and reuse.

VonBraun planned to use this system to erect the Mars return vehicle which was to glide to the surface of Mars and land on skids − from his 1947 and later 1952 studies.

The RL10 engine can be adapted to produce a sub−scale model of the system just described

http://www.pw.utc.com/vgn−ext−templating/v/index.jsp?vgnextrefresh=1&vgnextoid=eb6607b06f5eb010VgnVCM10

An annular aerospike engine consisting of 3 engine sets adapted to a truncated annular aerospike produces 33.8 metric tons of thrust. This produces a system that's 2.67 m in diameter and 16.9 m long. One unit carries two tons into LEO aboard a 2.67 m diameter by 1.25 m thick disk. Three units ganged together carries four tons into LEO aboard a 2.67 m diameter by 2.50 m thick disk.

So, the sub−scale system for approximately $30 million a copy, proves the basic setup, and the larger system at $900 million a copy, provides considerable capabilities.

It is interesting to note that a 2.67 m diameter cylinder 16.9 m long is suitable for short stays on the moon and mars. That is, these smaller systems can be adapted to support the larger systems by providing less commitment of resources but still have a usable capability.

By adding four similar elements to the original cluster of three, we have a seven element cluster at launch. This produces the following result;

600
2942.4 1471.2 735.6
6041.8 2932.2 1377.4
0.4870 0.5017 0.5340
2884.1 3010.0 3299.7
2884.1 5894.1 9193.8

Which means that 600 metric tons can be lofted into orbit in a cargo section that's 31 meters long and 8.4 meters in diameter. This is nearly the mass of a fully loaded module in the first table. This allows us, looking at our delta vee table, to send a payload of 60 tons to the moon or mars AND BACK − with recovery of ALL components. Of course, if a portion of the ET is divided off and used as a permanent habitation module on the moon or mars, then a shortened segment can be returned, and reused to deploy additional habitation modules.

This would work for the smaller systems for lunar or orbital operation. .

The sub−scale system made with RL10 engine components crafted into annular aerospikes would loft 20 tons into LEO! And provide a means to send 2 tons to the moon and return it safely to Earth, while providing for total reuse of the launch system. One way flights would deploy 2.67 m diameter cylinders on the moon. Unpiloted operations could deploy systems on Mars as well, with return of the hardware, but this would tie up hardware for years at a time.

But, these two air frames, with variations provide for a wide range of launch capabilities.

RL−10 based

1 element − 2 tons LEO
3 element − 4 tons LEO
7 element −20 tons LEO

RS−68 based

1 element − 60 tons LEO
3 element − 120 tons LEO
7 element − 600 tons LEO

The 600 ton system could deploy nearly 500 tons to GEO and return. This would be sufficient for a sizeable Solar Power Satellite. Moon base and Mars base schemes are also possible. This would allow 60 to 120 tons to be placed on the moon on regular basis with complete recovery of the vehicle.

NUCLEAR THERMAL ROCKET

The addition of a nuclear thermal rocket capability would provide high levels of space power while at the same time doubling the payloads carried. A thermal nuclear rocket based on the old NERVA rocket could be the basis of a NERVA based element.

http://en.wikipedia.org/wiki/NERVA

Here the 629.3 tons of oxygen is replaced with a 24 ton nuclear thermal rocket capable of producing 120 tons of thrust with a specific impulse of 900 seconds. The nuclear reactor is bi−modal, which means that it can also produce electrical energy for any payload. There are actually two cores, one in the GW range for rocket operations, and the other in the 5 MW range for power operations sharing the same gamma ray shielding. The same heat shield and expansion nozzle design is used to expand the working fluid from the nuclear reaction chamber. A portion of the hull surface is used as a heat sink for the smaller reactor.

ET−N

41.8 tons − structure
24.0 tons − nuclear rocket
334.2 tons − LH
200.0 tons − payload

This system can be carried atop the seven element cluster described earlier − into LEO. Once there it can impart an additional 7.2 km/sec to the craft. This is enough to carry it and 200 tons of useful load to the moon or mars and back − with complete recovery of the vehicle. Locating a source of hydrogen on the moon (water) with a nuclear energy source and an electrolysis system, provides for air, water, and hydrogen refueling. Thus, payloads could be increased and stay times extended.

The nuclear component has a 70 m length and a 15 m diameter to accomodate the large amount of hydrogen required. The nuclear reactor component is located at the base of this tank, while the payload is located as an 8.4 m diameter insert into the nose of the larger vehicle. This allows the propellant and tank itself to shield the crew from cosmic rays as well as radiation from the aft located nuclear reactors when operated.

The 15 m diameter and 70 m long airframe could be adapted to create habitation modules of larger size and over 100 tons to deposit on the Moon or Mars or on orbit. Launched into orbit atop the ET−N stage, and released at their destination. This would require a launch center at each location with some sort of high crane to remove the forward portion from the lander. The nuclear reactor would also be operating during take off and landing so shielding at these times and then initiating shut down would be necessary.

SUBSCALE NUCLEAR

A subscale version could use a variant of NEBA III designs and carried aboard the RL10 based launcher. This system could carry 7 tons throughout the solar system to provide extension of unpiloted robot exploration while providing tremendous power for these systems.

http://www.spacedaily.com/news/jupiter−europa−03f.html

A larger, reusable version of NASA's JIMO. This system could dispatch nuclear submarines to the subsurface oceans of Jupiter's icy moons and establish a network of robot explorers throughout the solar system in advance of human exploration.

ADVANCED NUCLEAR

The 15 m diameter and 140 m long module can be adapted with an appropriately sized pusher plate to create an ORION style nuclear pulse rocket, with a nuclear thermal maneuvering rocket − capable of putting 400 tons on the moon or mars and returning it to Earth, or sending 100 to 200 tons payloads ANYWHERE IN THE SOLAR SYSTEM. This allows expanding the larger system of habitation modules across the solar system.

BUSINESS CASE

TOURISM

The sub−scale RL−10 based system consisting of 3 elements in each vehicle, costing a total of $200 million to develop, allows a pilot with four paying passengers to attain low−earth orbit with a fully reusable system. The Merrill Lynch World Weatlh Report indicates that there are over 8 million people worth over $1 million. There are nearly 1,000 billionaires in the world! Their age and sex and interests are such that many of these may be interested in space tourism. There are over 10,000 people worth $200 million or more.

A fleet of 3 vehicles, consisting of 9 elements in the total fleet could sustain bi−weekly operations from White Sands Missile Range to LEO − affording 200 people per year − or less than 2% of the people worth $200 million or more. A reasonable market penetration for a system once operational.

At a cost of $5 million per passenger, a total of $1,000 million per year can be earned. With 1/3 of this going toward operational costs, and 1/2 going toward additional research, $500 million per year can be accumulated toward building larger systems, and $166 million in pre tax profits can be earned against a $560 million capital cost of equipment and launch hardware.

SATELLITE NETWORK

A single element launcher can place 2 metric tons into LEO. This is sufficient to place a communications satellite similar to that proposed for the Teledesic network into LEO

http://en.wikipedia.org/wiki/Teledesic

An additional six launch elements − configured for unpiloted 'freighter' launch at $400 million capital cost − would permit launches of two satellites each massing one ton − every 6 days.− providing 60 launches per year, and 120 satellites per year. I envision a network that has 3 operational levels;

Level I − 240 satellites − 2 years
Level II− 360 satellites − 3 years
Level III− 600 satellites − 5 years

Standardized design of satellite components and large volume purchase of standardized elements provide for costs of less than $2 million per satellite. Thus, strong tourism sales will support strong growth of the satellite network proposed here.

These satellites are placed in polar orbit and have an advanced phased array antenna system that allows the satellites to paint multiple stationary doppler corrected cells on the surface of the Earth permitting very simple ground stations and handsets to communicate directly with the satellites. These broadband wireless ground stations operate anywhere on Earth. During early stages the bandwidth in transmit mode is limited whilst the bandwidth in receive mode is the same in all cases.

Each satellite communicates with others in the network via an open optical laser communications setup that takes the place of optical fibers in terrestrial installations. The open optical system consists of an optical transmitter receiver in each satellite connected to a telescope in each satellite that gimbals to maintain the connection as the satellites move relative to one another. Four optical links per satellite are available. They have a 20,000 GHz bandwidth each − providing a backbone for up to 50 billion time domain channels worldwide.

Channels cost as little as $10 per channel per year for audio only, and go up to $60 per channel per year for full duplex wireless broadband internet service. The system provides seamless global coverage. Handsets and ground stations come in a variety of configurations and cost extra as do services to connect this network to other existing terrestrial networks.

50 billion channels when fully subscribed at $10 per month (companies and individuals will have more than one channel at this price) will retrieve $500 BILLLION per year from the $65,000 billion global market − and provide a sound basis for growth of these markets. Subscriptions of only 3% of the available capacity will allow this operation to generate $15 billion in profits (since costs are all covered in the solar powered automated space system) which is equal to what is spent by NASA today. Subscriptions greater than 3% would of course allow rapid expansion of space launch infrastructure.

EARLY LUNAR LANDING

After the global communications network is operational and sales are being made, an additional $1 billion can be spent retrofitting the six freighter elements for piloted operation, and performing research into creating two six launch element clusters. These clusters will loft an additional lunar landing element to provide the placement of 4 tons on the moon and returning it safely to Earth − with recovery of all vehicle elements. At this point, we have the first commercial landing on the moon, and a return of man to the moon after a lengthy haitus. Assuming strong subscription rates an additional $1 billion per year is spent developing additional hardware for use on the moon. A flight rate of one flight per month is sustained by this program, adding 40 tons of hardware per year to the lunar surface. Additional hardware can be use to create inflatable structures on orbit and on the moon for short stays (lunar and orbiting hotels) I already have a number of people interested in these flights at $83 million each.

SOLAR POWER SATELLITE

TOURISM

Construction of the RS−68 based component, which first puts 60 tons on orbit in a single element can orbit 120 passengers. A three element RS−68 unit can place 120 tons and 240 passengers on orbit. They can also place very large inflatable structures for an extended hotel in space.

A seven launch element RS−68 base component can place 600 tons and 1,200 passengers on orbit and hundreds of tons and hundreds of passengers to the moon and mars.

Since the recurring costs for each launch are spread across a larger number of passengers, prices can drop, and volume increase accordingly. Twenty ton payloads and 120 passengers can go to the moon. Flights to orbit will cost around $30,000 at this point and flights to the moon $1 million.

Services and quality of service markedly improve. Additionally scientific support services are offered to NASA and other agencies who wish to establish a manned presence on the moon or on orbit and when we get to it Mars.

Eighteen elements built at a cost of $15 billion and operated bi−weekly to the moon and orbit provides travel for thousands to the moon and Earth orbit, Additional elements committed for two years to mars travel are also built at this time based on accumulated experience on the moon as well as experience on Mars with unmanned probes.

The subscale systems are also configured for unmanned Mars operations in advance of the larger manned mars systems to follow.

In the end trips to Mars with trip times on the order of two years and stay times on the order of 180 days − would be provided at a cost of $10 million for up to 24 people.

At this point all the elements in place largely following A CASE FOR MARS by Zubrin can be followed with this system

SOLAR POWER SATELLITE

The ability to launch very large inflatable optics into GEO using these RS−68 based engine sets permits the creation of 1 GW to 2 GW solar power satellites. An additional 42 launch elements costing an additional $21 billion permits launch of 350 ton power sat EACH week capable of beaming energy by Infrared solar pumped laser at 0.9 micron to desert areas in the US West already configured with low cost solar panels. I've described elsewhere how this system works. The end result is that 10x the energy can be produced in a year from solar panels illuminated with IR laser energy than from sunlight alone.

A 2 GW powersat costing $0.20 per peak watt, has a cost of $400 million at launch. It produces 8,766,000 MWh of energy on Earth. If sold at $50 per MWh the system produces $438.3 million per year − providing a substantial return on investment from just ONE satellite. With one satellite launch per week 100 GW per year can be added to the global inventory. Each satellite pays for itself in one year, and provides a return every year. In as little as two years of operation over $40 billion PER YEAR can be made from energy sales. More than justifying the original fleet of 42 launch elements.

Energy sales in the global economy are $2 trillion per year currently and are growing at 4% per year. Total installed capacity is 12,000 GW. 4% growth is a need for 480 GW. Clearly adding 100 GW of solar power satellites each year will not meet all this need. Further, as coal and fossil fuel equipment is retired at a rate of 4% to 6% per year − a demand for over 1,000 GW can be envisioned.

The ability to beam power to wherever its needed means these systems can also capture wheeling costs. Clearly growing to 400 flight elements with daily launches of satellites massing 350 tons to GEO is possible with revenues in the hundreds of billions of dollars, with substantial profits.

This will allow the development of the additional components mentioned and funding of the development of solar system resources.

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