Micro & Nanosatellite Launch Capabilities from the Star Bus GEO Commercial Communications platform.

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Basic Questions

- What is this?
  - Shared launch from a larger commercial GEO communications Satellite
    - This is called a Piggyback Rideshare

- Who would provide this?
  - Commercial GEO communications satellite owners.
    - Trivia - Most satellites are now owned and operated by private/commercial enterprises.

- Why would the commercial satellite owner do this?
  - Commercial space is governed by free market economics. The ultimate mission is not science, technology or defense rather it is the realization of profits. To that ends:
    - Existing assets will be leveraged to provide additional revenue streams.
      - When a company buys up to four satellites every year with the corresponding launch service you have a lot to work with.
      - Efforts will be made to reduce the cost of procurement of these assets

- Why would a micro or nano-satellite owner want to share a ride to orbit with a commercial spacecraft?
Rideshare Features

1. **Frequent and predictable launch opportunities** on reliable launch vehicles (could be several years between ESPA opportunities – STP-2 is past 2010?)

2. Looking at business case for making a generic ESPA / LightBand interface standard on Intelsat satellites with open nadirs – concept would be a “taxi” service to orbit at **significantly lower cost than a dedicated launcher** (putting additional passenger in cab)

3. **Shock exposure is significantly reduced** due to attenuation by hosting satellite structure. Loads into Nano/MicroSat will be well understood. Lateral launch loads much lower as compared to radially-cantilevered orientation on ESPA

4. **Launch provider needs to integrate only the hosting satellite** - **significantly reducing costs and coordination issues at launch site** (documentation, safety, security, fueling option, integration simpler). Host spacecraft essentially acts as an additional launch vehicle stage for piggyback rider.

5. **Don't need to wait for multiple spacecraft programs to simultaneously be ready to launch**, will take first available Nano/MicroSat provided that it has completed protoflight/acceptance testing and is encompassed by generic qualification of hosting/piggyback composite
6. Drop off of MicroSat possible closer to desired orbit – less compromise since multiple objectives not required. Piggyback can be ejected in GTO, or GEO whenever engines not being fired (even LEO possible depending upon launch service utilized).

7. Housekeeping telemetry, command and power can be made available during prelaunch and pre-separation periods. T&C of MicroSatellite imbedded into host spacecraft capability.

9. Since the majority of commercial spacecraft are recurring builds, it is unlikely that major slips in hosting satellite schedule will occur (don’t need to wait for many months/years due to technical issues).

10. Pricing is a function of Intelsat opportunity cost (i.e. loss of hosting satellite life due to lower orbit resulting from carrying piggyback mass). Consequently lower-energy ejection of piggyback will result in much lower taxi fare to orbit - cost is incremental with lift requirements and is “highly” competitive with alternative technologies. ESPA launches are highly-subsidized – will be more difficult to justify in the future. “Per-kilogram costs equivalent to large-launcher prices (2-3x less than dedicated launchers)
Intelsat has procured 3-4 satellites per year for over 20 years
(One company, privately held, with 3 to 4 launches per year)
General Concept

MicroSat <100 kg
Separation Interface
Deployment
Structural Adaptor
Spacecraft
Central Support Cylinder

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Piggyback Rideshare

Dedicated Launch Vehicle
(Atlas5/Delta4 ESPA)

Falcon 1
Dnepr
Cosmos
Athena
Minotaur
Pegasus
Etc....
<table>
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<th>MISSION APPROACH</th>
<th>ADVANTAGES</th>
<th>DISADVANTAGES</th>
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| Dedicated Launch Vehicle | ● Control more mission parameters for injection of microsatellite  
● Accommodates greater variety of missions  
● Greater schedule flexibility for unexpected delays | ● Highest Cost (Launch vehicle, Mission operations)  
● MEO, GEO, & HEO may not be possible or extremely expensive.  
● Dedicated LV is impractical for nano satellites only mission. |
| Secondary Payload Adaptor | ● Cost reduction over dedicated LV  
● Able to launch constellation architecture mission.  
● Nanosatellite launch capable  
● LEO orbits | ● Cost reduction is variable based on number of co-passengers.  
● Very Infrequent launch opportunities  
● Schedule is tied to several other programs  
● More mission constrained (mass, C.G. Volume) |
| Rideshare | ● Assured Launch date  
● Faster turn around for launch opportunities  
● Competitively priced  
● GEO & other high perigee orbits available.  
● Nanosatellite launch capable | ● Mission constraints on mass and CG  
● Least schedule flexibility – launch date is fixed to within a couple months.  
● LEO orbits are more difficult |
Part of a Larger Concept of Commercially Hosted Payloads

Visible Sensor Hosted Payload

GEO Communications Satellite with Extra Capacity

Ultraviolet Hosted Payload

Outgrowth of Hosted Payloads Leveraging Existing Assets For New Sources of Revenue.

Particle Camera Hosted Payload

50 Kg Microsatellite Rideshare

75 Kg Microsatellite Rideshare

100 Kg Microsatellite Rideshare

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Weight reduction scheme based on Lightband usage
Allows common cone for large and small Lightband Separation System
(from Planetary Systems Corp.)
STAR-2 Overview

- Flexible payload accommodation
  - Payload powers up to 5100 W
  - Two 2.3m deployable antennas (one on East and one on West side)
  - Several options for accommodating additional antennas or optical / remote sensing instruments on the earth deck
    - Single fixed antenna up to 2m, two fixed antennas up to ~1.3m, etc.
  - Ample area for payload components and/or secondary payloads
- Two to Four panels per solar array wing, populated with multi-junction cells
- Li-Ion batteries
- Separate thermal zones for payload, bus, and batteries
  - Comfortably accommodates (conducted) payload thermal dissipations of over 2700 W
- Flight proven ACS system
  - Uses Earth Sensor/Sun Sensor suite, or optionally Star Tracker suite to achieve ±0.1° Circular Pointing Error (for platform)
  - Can provide precise knowledge and pointing performance for secondary payloads / instruments
- Reliable and simple propulsion system
  - Pressure-regulated, bipropellant, transfer orbit design reconfigured to simple monopropellant blowdown system for on-orbit operations
- Launch mass up to 3200 kg
  - Comfortably accommodates 450 kg payload mass

Payload DC Power

2 kW
3.4 kW
5.1 kW
Layout and View Constraints

Physical Interference With C-Band Waveguide

No Interference With Ku-Band Waveguide (or Ka-Band Waveguide)
Rideshare Adaptor Cone ties directly into Center Cylinder Hard points.
Key Points

- Microsatellite Rideshare may not be viable for many reasons
  - Economics (microsatellite too large and requires too much resources)
  - Nadir Deck has an antenna tower
  - Host satellite has difficult waveguide routing (i.e. large C-Band runs) that interfere with the adaptor cone

- Nanosatellites due to their smaller size and typically reduced complexity allow for more flexibility for the technical interface.
  - Allows more opportunities to match with a host satellite.
    - There are still some unique design challenges.

- Lower Risk to Host Satellite
  - Even if nanosatellite does not deploy the mission impacts to the host would be significantly lower than for a microsatellite.
  - Still possible to get full 15 year plus operations for small nanosatellite mass.
Spacecraft Zenith Area

Not much room Available

But not impossible

A P-Pod can go here

A Nano-Sat can go here
P-POD Clearance & Deployment
Nano-Satellite “Saddle Bags”

When the host has a Nadir Antenna System
This is how to accommodate Nanosatellites.

Attachment points on antenna Support brackets.
~1 cubic foot, less then 10kg.
Drop-off Options During Orbit Raising

(A) Injection Orbit
(B) Ground Station Contacts
(C) Perigee Raising LAE Burn(s)
(D) Geosynchronous Orbit
(E) Apogee Lowering LAE Burn(s)
(F) Target Longitude

GEO ACCESS
HEO ACCESS
GTO ACCESS
During GEO Deployment

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Propellant Consumed & Mission Life Impacts

Propellant Consumed based on Separation Location During GTO -
Based on a 76Kg Microsatellite Rideshare Mission

Change to Operational Mission Life During Due to Propellant Consumed
Based on a 76Kg Microsatellite Rideshare Mission

LAE Burn 1  LAE Burn 2  LAE Burn 3  LAE Burn 4
GTO Maneuver

Prop. Consumed (kg)

0  5  10  15  20  25  30  35  40  45

OML Delta (years)

0  0.2  0.4  0.6  0.8  1.0  1.2  1.4

LAE Burn 1  LAE Burn 2  LAE Burn 3  LAE Burn 4
GTO Maneuver

Prop. Consumed Star 2.3 (kg)  Prop. Consumed Star 2.4 (kg)

OML Delta Star 2.3 (yrs.)  OML Delta Star 2.4+ (yrs.)
Recurring Cost Elements

- Interface hardware $ 
- Integration / system validation $ 
- Dynamics analysis / system testing $ 
- Shipping Deltas* $ 
- Mission analysis / simulation $ 
- Launch Site Processing / checkout $ 
- Launch / Mission Operations $ 
- Launch Service Deltas* (performance) $? 
- Insurance Deltas* $ 
- Host S/C Orbit Raising Propellants $$

*Cost deltas, if any, will be passed on to hosted passenger
Summary

- Intelsat is evaluating business cases for Piggyback Rideshares
- Intelsat is working with Orbital to find suitable partners
- Commercial Piggyback Rideshare is the most cost efficient manner to provide access to space for MicroSats and NanoSats
- Commercial Piggyback provides several advantages over ESPA for GEO and GTO missions

Piggyback Rideshare is another alternative to get small satellites to space reliably and economically
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