The CubeSat Orbcomm

This is a comparison of the Orbcomm first generation satellites to what could be done with a 3U CubeSat. The intent is to show that as similar system, with better cost to utility could be built. If you assume that the Orbcomm system is good, then this is better. Unfortunately, Orbcomm filed for bankruptcy for developmental debt relief, so while the financial viability of this system is better than the Orbcomm, is not guaranteed to be good, or profitable.

Orbcomm Satellites were :

- Each satellite weighs 42 kg (92 lb).
- Two disc-shaped solar panels articulate in 1-axis to track the sun and provide 160 watts of power.
- Each satellite has a 56 kbps back-haul radio transceiver to a ground station.
- As of December 31, 2006, ORBCOMM reported 225,000 billable subscriber communicators on the company's U.S.-based gateway control center
- Each spacecraft carried 17 data processors and seven antennas. These were designed to handle 50,000 messages per hour. [~ 14 message per sec,]
- The antenna is built from a 2.6 meter long boom for VHF/UHF communications.
- normally receive at 2400 bps on 148 MHz to 149.9 MHz. (VHF)
- Normally transmit at 4800 bps on 137 MHz to 138 MHz (VHF) and 400.05 - 400.15 MHz. (UHF)
- Message size is 6 to 250 bytes typical (no maximum).
- The Orbcomm satellites cost $135 million for 26 units or 5.2 million each.
- The Orbcomm ground stations were required in areas of service (a few per continent, 18 currently) since the satellite didn't push data between them. Costs per ground station are somewhat unknown, but Telephone cell tower sites are generally several million dollars each.
- Orbital constellation has an orbital altitude of 825 km and inclination of 45 Degrees. 28 total in 5 orbital planes, or 8 in each of 3 planes with 2 in two additional orbital planes. And of course they drift now that they are out of station keeping propellant.
- Customer communication devices (User Terminals) made by several companies with assorted prices and capabilities.

Compare this with a 3U CubeSat

- Each Satellite weighs 3 kg (6.6lbs)

===>> **1/14th of Orbcomm mass**. But the off-the-shelf systems have gotten smaller and cheaper. These include Attitude Determination and Control (ADACS, magnetometers, Magnetic torquers, reaction wheels, star,sun, and limb sensors, etc) Power conditioning and storage, command and control, and obviously structure.
RF and processing electronics have become much smaller due to cellphone economics including adaptable chip solutions and Software defined radio processing.

- 340x100 mm sides, can fold out, or with two folds. make a pair of steerable wings like the Orbcomm. Consider it as about 12 cube panels (113x100) worth of area pointed.

- From a Bucarest/Romania reference project, triple junction solar cells have an output of approximately 2 V/cell, an efficiency of 23.5%, and a 41x 42.4 mm cell area. With a solar incident power of 1321 watts per m3. calculations are:

Each cell area = 1.738 E-3 m3
Each Cell power = 0.540 Watts
Cell pairs at 86 mm wide
In 330 mm length put 7 pairs
4 wings or 2 double wide wings gives a total of 56 cells
Total wings power = 30.2 Watts

===>> **1/5 of the Orbcomm power** available.
(Note, since this calculation, (2010) these cells are much more commonly available (cheaper) as small triangular pieces (TASC) and better configurations can increase the area available for collection. The efficiency is also up to 29% [Theoretically up to 70 watts] http://www.spectrolab.com/DataSheets/PV/space/TASC_ITJ_datasheet.pdf)

- PacSat CubeSats use 1200/9600/38.5 kbps per channel on amateur radio frequencies (140, 440, 1200, 2400 MHz) This is in comparison to the Orbcomm using 56, 4800, and 2400 kbps split into maybe 17 channels. Orbcomm does have a dynamic allocation license (when available?) radio spectrum allocation. If we assume a 9600 cross-band (TBD) system then we get.

===>> 1/17 to 1/2 of Orbcomm communications per channel, but probably limited to power available which is again probably 1/5.

- CubeSat Antennas. This is a difficult topic, but in many ways system performance goes by aperture area, so a CubeSat needs a full sized antenna, or will have reduced performance. Of course frequency selection (or availability) will drive antenna design requirements as much as anything. Similarly, more advanced electronics make phased arrays easy to implement and wifi dishes have already been deployed from CubeSats. Far a better equivalent antenna, a 2.6M long inflatable boom can be used. Inflatable wifi antenna, UV stabilized inflatable structures, and a CubeSat compatible inflation systems have all been developed locally for a research budget of less than $100k. Fabrication would take less than a man week. These devices are easy, small, and relatively inexpensive.

===>> A fully functional match for the Orbcomm antenna is easily built for much less money, mass, and volume.

- Pumpkin CubeSat Kit based off-the-shelf parts (in 2010) are about $300k + $240k launch. Of course volume buys would reduce these costs, and the launch price is more of an estimate, since many are 'free' with mere service charges for handling. Some components, such as the communications package, and antenna, would need to be custom developed so the prices listed for these in the pumpkin catalog is mostly a placeholder. A CubeSat and Launch for approximately $540k, or less, is compared to the bulk price of $5200k.

===>> **1/10 of Orbcomm costs per satellite**. This gives a fully operational (full coverage) constellation for 1/10th the cost, with additional communications throughput capability added at a later time as the market grows. Even at 100% capacity, using the 1/5 capable satellites at 1/10th cost, the constellation would cost 1/2 as much.

- A quick look at ground-stations shows that a PacSat digital unattended ground-station parts run at about $5k plus manpower and facilities. Permitting, construction, Internet feeds, and occasional visitation of maintenance staff are all relatively unknown, but savings can be had. If by nothing else, then by only putting ground stations in a limited service area to start. This also suggests that cross satellite data forwarding, while the constellation has relatively low data usage, can save money.

===>>> Less expensive ground infrastructure is possible.

- Satellite Orbits, To assume the same service footprint per satellite, and therefor range and path loss, the CubeSats will need to be in a similar orbital constellation. There is a question of orbit selection for standard CubeSat flights. But if an entire constellation is being launched, then a dedicated vehicle can be purchased, at a per CubeSat savings, certainly. Alternately, for individual flights a 3 kg payload boost adapter could be added, with low thrust electric propulsion using the available CubeSat Systems (solar power, attitude, control, communications,etc) and just fly to the selected constellation position. This would also be useful for replacement satellites. This adapter would be inexpensive to develop (Resistojet and tank) but would double the $240k launch costs.

===>> Orbital position depends on available launch opportunities as much as anything, but has many options.

- User terminals can be as simple as a Yaesu TH-D7 hand-held radio or a custom transceiver attachment to a cell phone. There is a plethora available, but the actual unit will depend on frequency selection and commercial producers.

===>> User Terminals can be as simple or complex as desired.

This is all AMSAT/CubeSat off-the-shelf or easy parts and open designs without advantages of large lot purchases. It appears that a CubeSat based Orbcomm could be considerably less expensive to produce than the existing system. The actual financial situation at Orbcomm looked like about 330 Million dollars spent, much of that to ground-stations and finance charges. Another point is that the Orbcomm Dollars are 1991-2000 while the CubeSat Numbers are circa 2010.

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