

Google's plan for a broadband satellite constellation

In our recent industry report, we analyzed Google and Facebook's potential interest in satellite and drone technologies, concluding that it made more sense for Facebook rather than Google to acquire a satellite operator such as O3b or Avanti. Our analysis assumed that Facebook's ambitions to deliver backhaul to support increased (but modest amounts of) mobile bandwidth (on the order of 100MB/month per person) would be better suited to using satellite technology than Google's plans which appeared to have shifted more towards high speed broadband access and video delivery.

However, it has emerged today that Google in fact is planning to build an advanced Ku and Ka-band LEO constellation with a much larger amount of bandwidth than can be provided by O3b. An April 2014 presentation used by NSR as a "discussion guide" in market surveys to support the plan describes a 70 satellite LEO constellation with a hybrid Ku-Ka payload at approximately 400 miles from Earth. The satellites are depicted in polar orbits, with crosslinks between planes. Each satellite would have 7Gbps of capacity, with 1.2Gbps Ka-band beams and 600Mbps Ku-band beams, plus intersatellite links with "5 choices of network paths" (presumably 4 crosslinks plus a downlink) and "on-board IP routing." The user terminal is a "40cm square flat panel antenna" with "no moving parts" which clearly must be using Kymeta's technology.

We understand that key members of the project team include Brian Holz, former CTO of O3b (whose LinkedIn profile now lists him as a Director at Google in Mountain View CA since April 2014 even though he is still on the O3b website) and Dave Bettinger, former CTO of iDirect (whose LinkedIn profile now lists him as Director of Engineering at "Undisclosed" since May 2014). The rumored project cost is \$10B and Google is said to have been working with SS/L on the project since earlier this year (the purported Google interest in acquiring Skybox Imaging may even have been a cover story to avoid any undue attention being paid to the project). The ITU filing for the project was made by a company named WorldVu Satellites Limited in Jersey, which was established in November 2012.

There is a major discrepancy in the system description given by NSR (though it is unclear if they understood this issue), in that a 70 satellite polar LEO constellation at ~400 miles altitude would be almost identical to Iridium (Iridium is at an altitude of 485 miles) and therefore would have the same low elevation angles at Iridium (a minimum of roughly 8 degrees above the horizon at the equator).



This is untenable for a widely deployed terrestrial Ka-band network for business or home use and more importantly is incompatible with the minimum elevation angle for a flat panel Kymeta antenna pointing straight up into the sky, which is unlikely to work below about 25 degrees elevation angle. Moreover, it is unlikely that 70 LEO satellites with a broadly similar payload to O3b (7 Gbps per satellite would imply 10-12 beams, comparable to the 10 beams on each O3b satellite) would cost anything close to \$10B. Our belief is that in fact the full \$10B constellation would be expected to include 280 satellites and 70 satellites would just represent the Phase 1 initial deployment, costing perhaps \$3.5B or so, assuming 7 launches of 10 satellites on Space X's Falcon 9, similar to Iridium NEXT. The 280 satellite constellation would be almost identical to Teledesic's proposed 288 satellite constellation (after it was downscaled from the original 840 satellite design), which had a minimum elevation angle of 25 degrees. We would speculate that the description of a 70 satellite constellation was probably included so that potential participants in the market research would not reject the concept as simply unbelievable and/or so that potential competitors would not appreciate the full scope of Google's ambitions.

Assuming this is the case, then the initial deployment would presumably use steerable beams, similar to O3b to cover only a subset of the potential coverage footprint (which would be nearly the entire continental US for a single satellite). Then once the rest of the constellation was deployed (which could depend on whether the business plan was a success or if other objectives are realized, as discussed below), the gaps could be filled in by the other satellites where necessary (Iridium provides contiguous coverage with 48 beams on each of its 66 satellites, which would be similar to the total number provided by a 280 satellite WorldVu constellation with 10-12 beams per satellite). Initial operational capability could probably be achieved in about 4-5 years (2-3 years for development plus the same again for launches), i.e. by the end of 2018, with the 280 satellite constellation fully deployed about 4-5 years after that, assuming adequate launch opportunities were available (though deployment by 2018 may be challenging given the current backlog on the SpaceX manifest).

Of course, the Google WorldVu constellation would have better (higher minimum elevation angle) performance further away from the equator, where the orbital planes are closer together, and would also have to avoid interfering with both geostationary satellites (at least in the Ku-band), and with O3b's equatorial orbit Ka-band system. As a result, it seems highly likely that the system would be integrated with O3b, to enable efficient coordination within the Ka-band, with O3b providing supplementary equatorial coverage where WorldVu will have the lowest elevation angles, and we



would therefore speculate that the undisclosed source of the recent investment to pay for the launch of the next two batches of O3b satellites may well have been Google.

The obvious question that arises is what would Google's objectives be in deploying an expensive satellite constellation with relatively limited capacity via-a-vis either geostationary Ka-band satellites or terrestrial high speed data solutions (particularly fiber). We believe that the answer lies in Google presenting a credible threat to existing broadband providers, to force them to upgrade their infrastructure. That was the rationale for Google's investment in Clearwire, which proved very successful in persuading Verizon to undertake a rapid 4G LTE buildout, and is also a key reason behind Google Fiber in the US, which is proving equally successful in persuading AT&T and others to upgrade their broadband networks. In building the first phase of WorldVu, Google probably intends to demonstrate that it could threaten incumbent broadband providers anywhere in the world, by delivering capacity into their country (presumably for local wireless distribution and/or direct access for higher value customers) if it chose to focus the beams there. If Google is successful in persuading them to upgrade their networks, then that would be \$3.5B well spent, even if the business plan for WorldVu (like that for Clearwire) is a failure.

Despite the limited elevation angles achieved by the first 70 satellites, WorldVu could still provide backhaul for drones and/or terrestrial cellular networks, if a decision was made not to spend the rest of the \$10B budget on deploying additional satellites, because these platforms could support more complex (i.e. non-flat) antenna structures. Google's drones should be proven and available in the same timeframe as the first phase of the constellation, and at that point a decision can be made on whether it would be more cost effective to invest in drones or additional satellites. In any case, in 5 years' time it should be very clear whether incumbent telcos are upgrading their infrastructure to deliver the broadband capabilities Google wants to support its video and other high bandwidth services, and therefore whether Google still needs to invest in infrastructure at all.

