
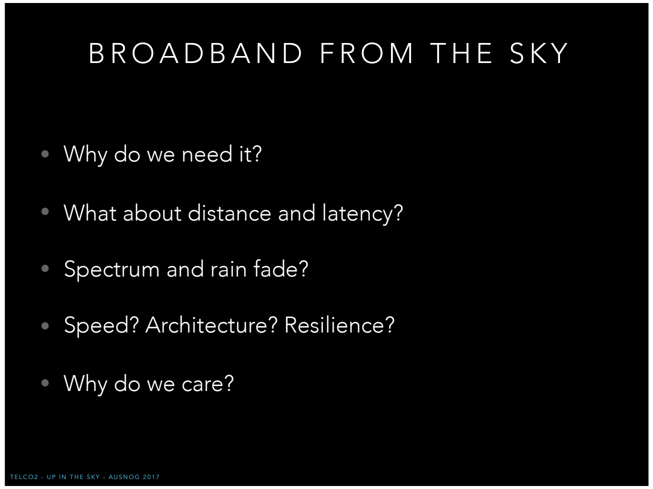


We're going to talk about Satellite Broadband today. So here are a few of the points we'll cover - but really what I want you to take away is a little bit of language. I want you to learn three satellite bands, and three satellite orbits, so that you can understand how the game is changing, and start to have intelligent conversations about how to integrate new satellite technology into your networks.


Why do we think about this?

This chart is based on one from Communications Research Canada, and is probably fifteen years old by now. You've got population density per square kilometre along the X axis. Y axis is a comparative measure of cost and complexity. Today with gPON and 700 MHz LTE the fibre & fixed wireless curves are pushed to the left a bit, but there are still curves, and they still cross.

What matters here is that as population density thins out, satellite becomes the least costly and complex method of delivering broadband.

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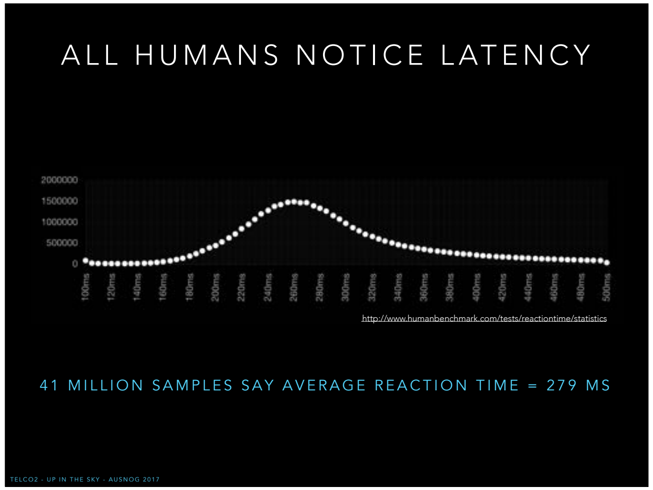
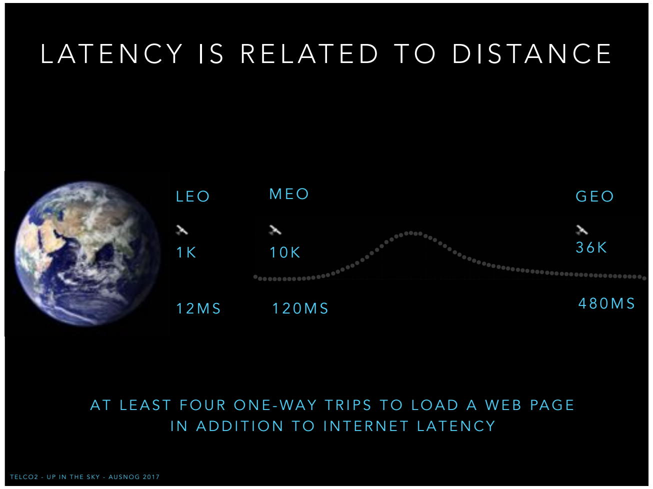
The thing is, latency matters a lot to broadband.




Once you get past say 320 ms to deliver a piece of information to a screen, most people are going to notice it's slow.

This is science, not opinion. 41 million samples worth of science, not opinion.

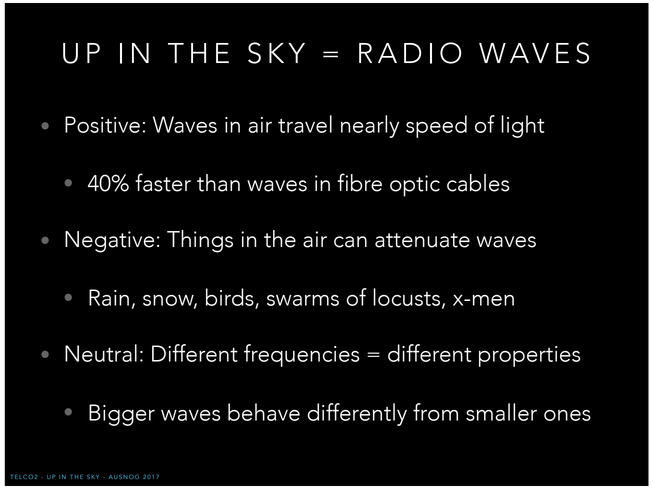
Don't let the satellite salespeople tell you otherwise.



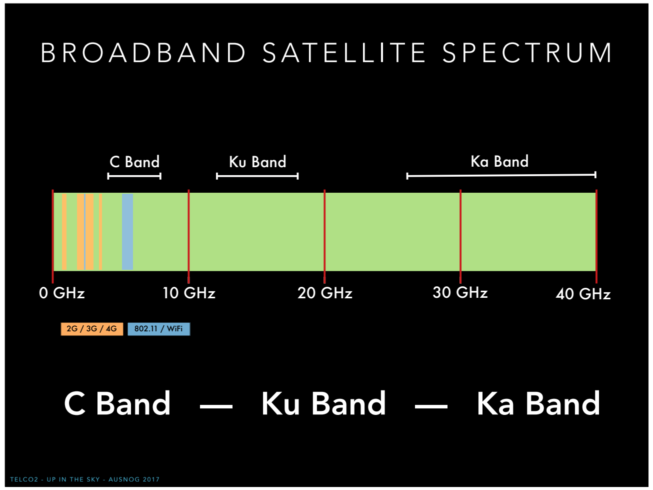

This view is roughly to scale, and I've put the curve where it belongs. And here's our first three things - orbital levels. Low Earth, Medium Earth, and Geostationary Orbits.

We'll get to specifics on LEO, MEO, and GEO later. For now the take-away is that that most satellite services we know and use today are of the GEO variety - with latencies of more than 400ms. On geostationary satellite services, the Internet feels slow to pretty much everyone.

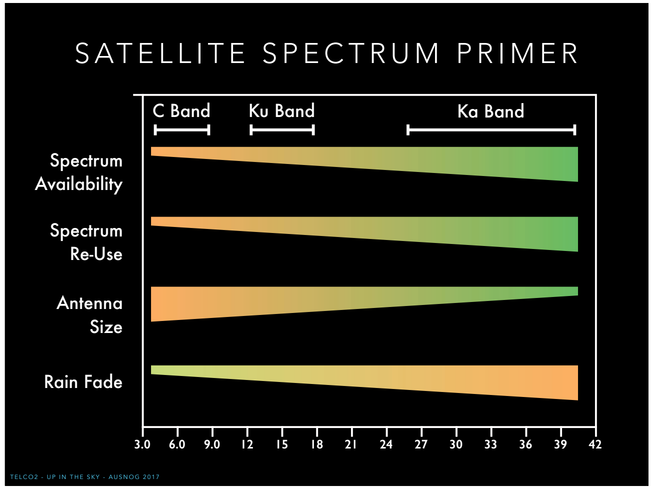

Let’s take a step back and learn something about satellite, then hopefully get you excited about new things to come.



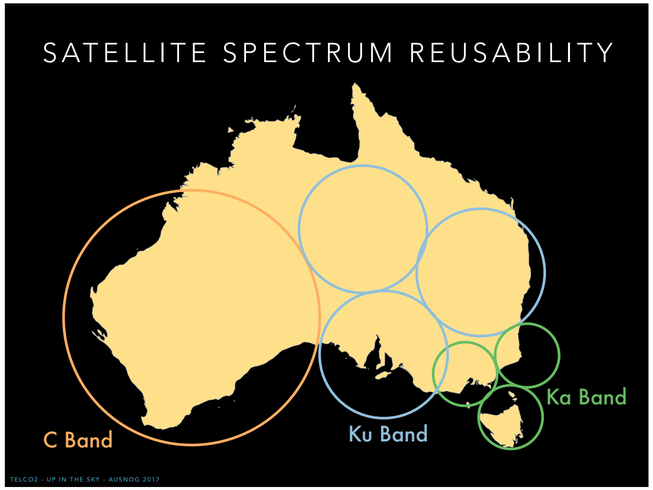

Some of you know I do a few things with radio, and it happens that all the principles of radio communications hold true even when one end of the link is up in the sky. So we’ve got a few things to think about.




Now the second three terms I want you to learn today are on this page.
C Band = 4 - 8 GHz
Ku Band = 12 - 18 GHz
Ka Band = 26 - 40 GHz
Notice Ka band has a lot more spectrum than C or Ku. That's important.
I've thrown the cellular and Wi-Fi bands on the slide too for comparison.



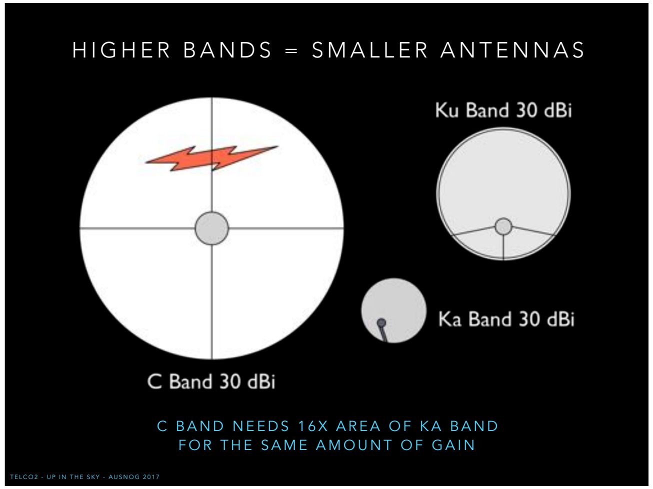

Here's a bit of a primer showing the three bands and their characteristics.
We saw availability in the last slide. It's pretty obvious there's more spectrum available in Ka band.
We'll cover re-use, antenna size, and fade in the next slides.



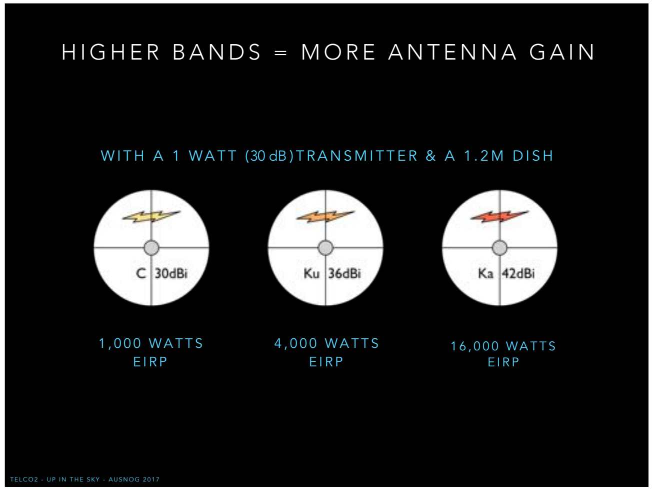

Re-use is taking the same frequencies and sending them down multiple times in different places.
Here our C-band coverage is huge. The plus is great coverage. The minus is that your little bit of spectrum is used. You can't practically make that beam much smaller. Higher spectrum, on the other hand…

While Ku band has maybe 4 times smaller beams and thus re-use, Ka band can have 16 to 20 times re-use in the same area compared to C Band.

Lower orbits can mean more and smaller spots too - but don't want to get ahead of ourselves.




Now let's talk about antennas.
Here we've got three, all with the same gain, or ability to focus energy.
Imagine the Ka here is 300mm - the size of a piece of paper. The Ku receiver is 600 mm - it's a Sky dish. And the C-band antenna is 1.2 meters across.
All have the same amount of gain.
The C band antenna needs 16 times the area of the Ka band antenna to get the same amount of gain.

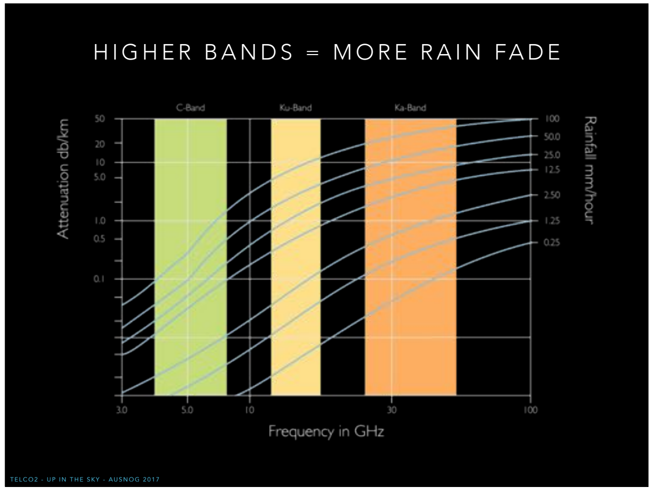



And the converse of antenna size is gain. Here we use the same size dish at the three different bands.

These are pretty striking figures. With the same size dish you get can get 16x the power at Ka as you can at C band.

Seems like Ka band is the win. The marketing people love it. Smaller, hotter, faster are all things they can sell. It's great…


But higher bands mean more rain fade.




This is a pretty dense chart, so if you're curious, have a look offline.
Your takeaway should be that during tropical rainstorms, C band keeps going, Ku band can experience problems, and Ka band will just go away. We're not talking about Hurricane Harvey type rain - that's the top line, 96 mm per hour of rain. No just 1/4 of that intensity of rain is enough to knock a Ka band broadband service offline. And if you're in a tropical region, you can expect your service uptime over the long run might only be 99 and a half or 99.7 percent due to rain fade events. Meanwhile a C band service will just keep on going.

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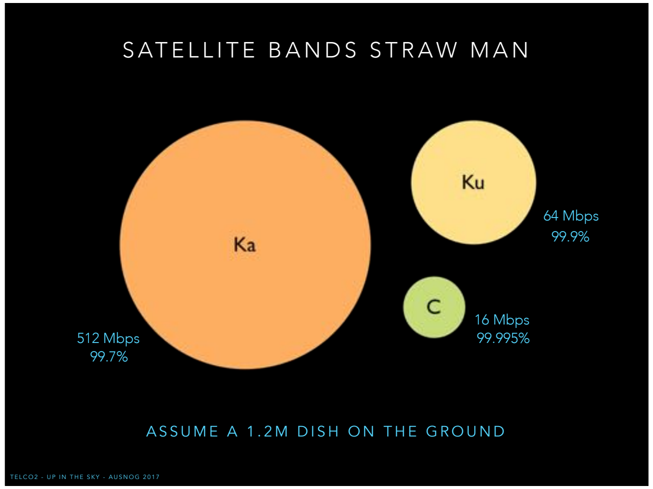
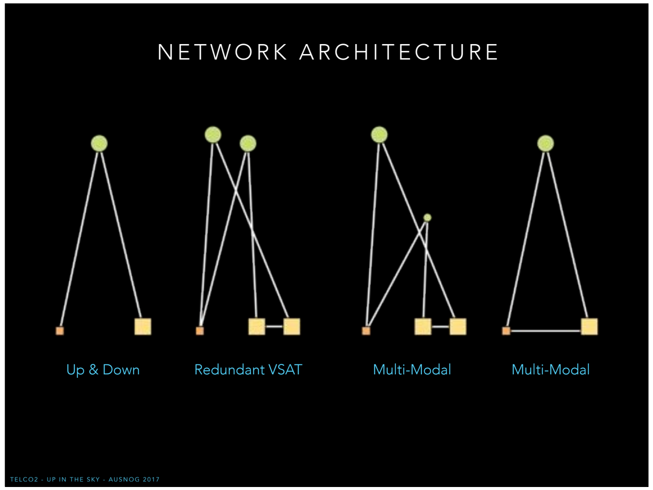
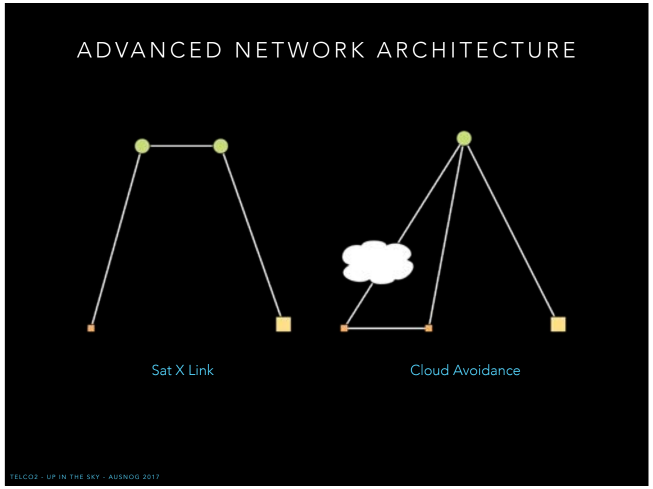



How does it all stack up?
This is a straw man, and these are rough numbers. But to give you a rough idea, with the same sized dish on the ground, this is what you might get in terms of throughput and availability.
You can get better than 99.7% uptime on a Ka band service - even five nines - but you need a six or seven meter dish to make that happen.




Now a little bit on architecture. Green ball is our satellite. Little orange square is our remote network, and big yellow square is our earth station.

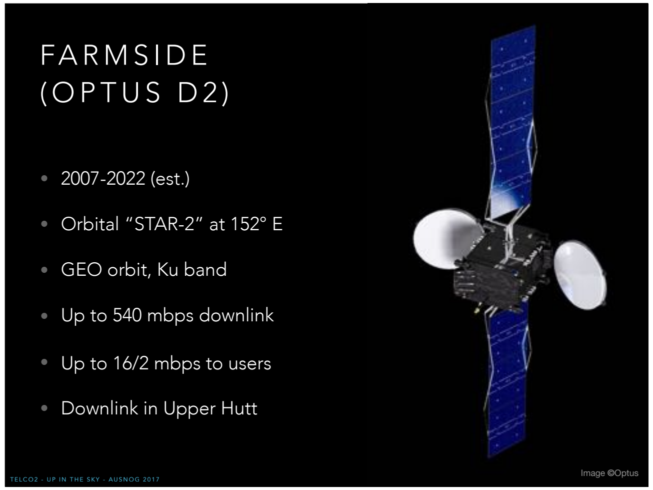



This is a real architecture coming into play, in particular due to the fact that tropical rainstorms rarely have intense cells that cover entire islands at once. We'll see a crazy application for this a bit later.


Now to re-introduce the three orbit levels, and at the same time a couple of networks per level.


Geostationary orbit is around 36,000 km away from Earth.

NASA image: https://images.nasa.gov/#/details-51a-104-029.html "Astronat Dale A. Gardner achieves a hard dock with the previously spinning Westar VI satellite. Gardner uses a "stinger" device to stabilize the communications satellite."




Optus D2 is a 1,160 kg satellite, around 2m by 4m.
Capacity numbers are not published by Farmside or their gateway provider, however radio license 164431 shows a 54 MHz channel from Upper Hutt to Optus D2. The best Newtec satellite modems on the market today do around 10 bits per hertz, so I think I’m being generous with 540 mbps.

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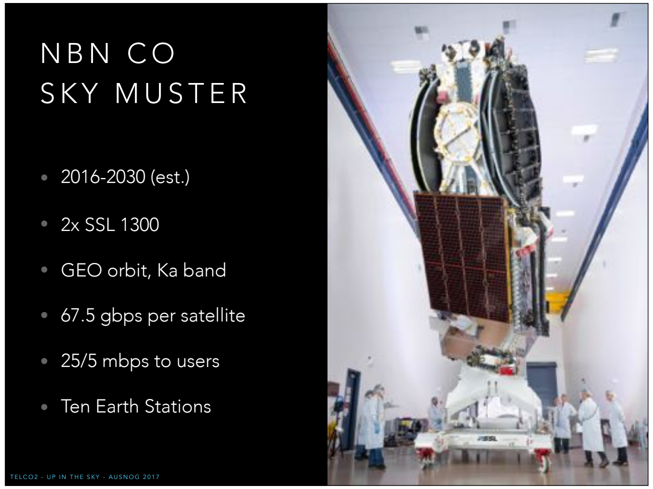
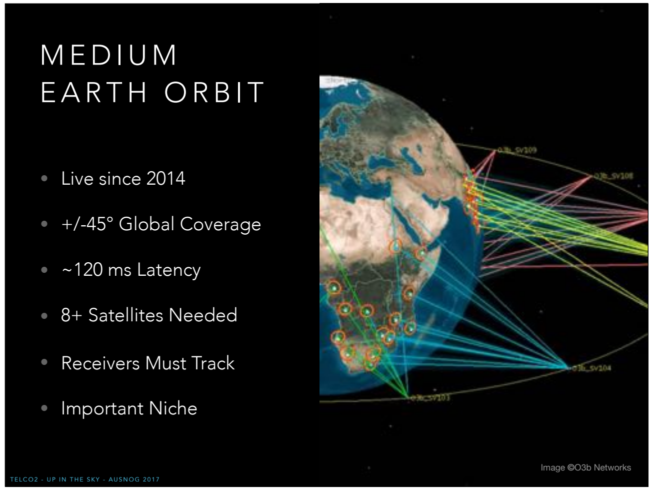



We’re looking at the second NBNCo Sky Muster satellite, and I left some engineers in for scale. This one project is putting 135 gbps of capacity in the skies over Australia. It’s Ka band, which means it will have rain fade issues, but for the most part its remote users are in places it doesn’t rain a lot. Still at least 430 ms latency from its GEO orbit, but heaps faster than New Zealand’s farmside service.
It’s also more than 6 metric tonnes, five times bigger than Optus D2 and one of the largest communications satellites in operation.




Medium Earth Orbit starts around 8,000 km away from Earth.

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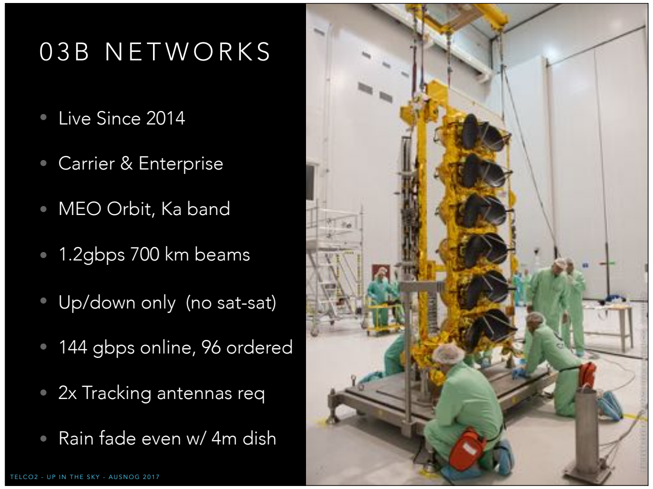
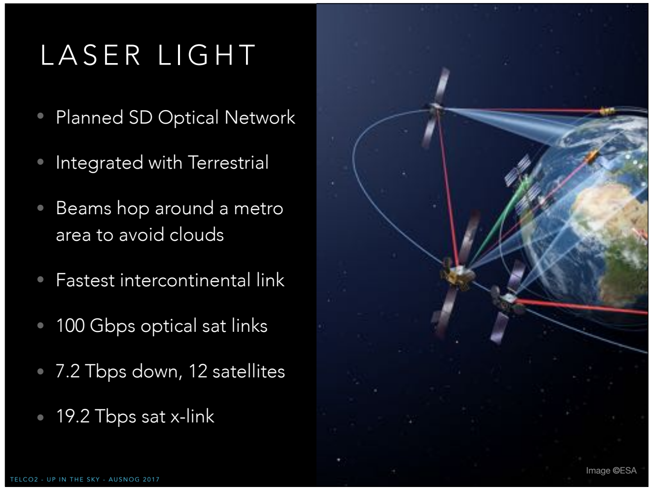



O3b has revolutionised telco networks in the Pacific, and it's what got me interested in modern satellite systems. It has its problems though - namely rain fade. In O3b's launch market, the Cook Islands, service to its 4 m dishes regularly fades for a minute or two at a time when ever it rains heavily. In American Samoa where carrier ASTCA installed 7 m dishes, there are still occasional fades. ASTCA combines O3b with a limited amount of fibre connectivity via MPLS tunnels to deliver a robust hybrid solution.

As you can see this is not a big satellite. It's 450kg, so the entire operational cluster of O3B today weighs less than one Sky Muster satellite.




Laser Light intends to be the world's first all-optical satellite network. It will be the world's fastest intercontinental link, and will concentrate on linking data centres, corporations, and government/military sites. Laser is especially attractive to government users as it can't easily be eavesdropped.

Laser light will have 72 100 Gbps laser heads trained on earth stations for a total of 7.2 Tbps of capacity, and 48 400 Gbps laser heads dedicated to space based cross-connect.

Image: http://www.esa.int/spaceinimages/Images/2016/02/Inter-satellite_laser_links

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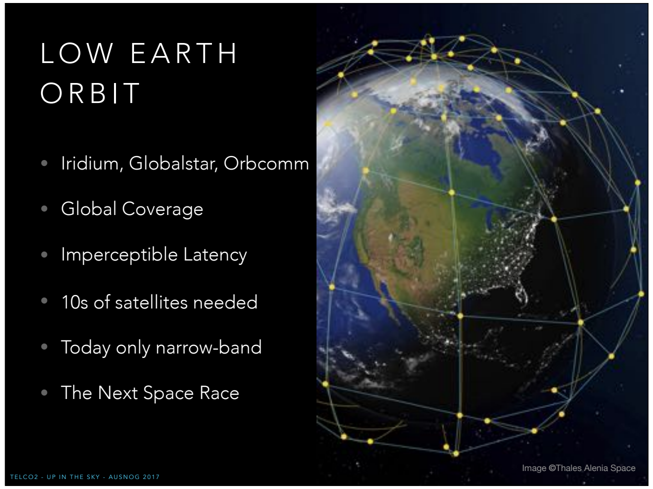
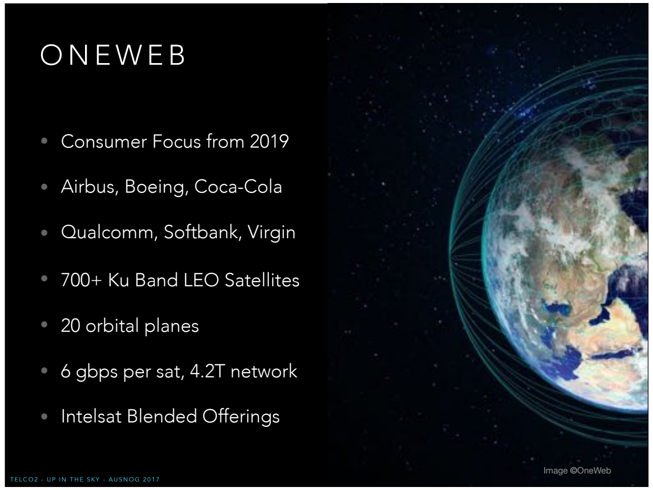



Low Earth orbit is the new space race. Several companies intend to launch thousands of new satellites into North-South polar orbits around 800-1,200 kilometres from Earth.




Greg Wyler, who founded O3b, has pulled in 1.7 billion in investment for a project that could take 3-4 billion in total.

They've already started making tiny, tiny satellites, only 150 kg each, for their network. These satellites are 1/40th the size of Sky Muster.

Their "Progressive Pitch" antenna technology will allow re-use of Ku band frequencies already in use by other satellites without interference.

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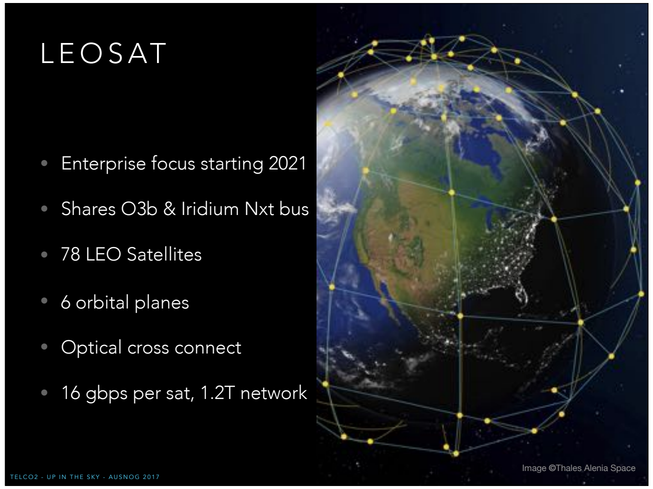
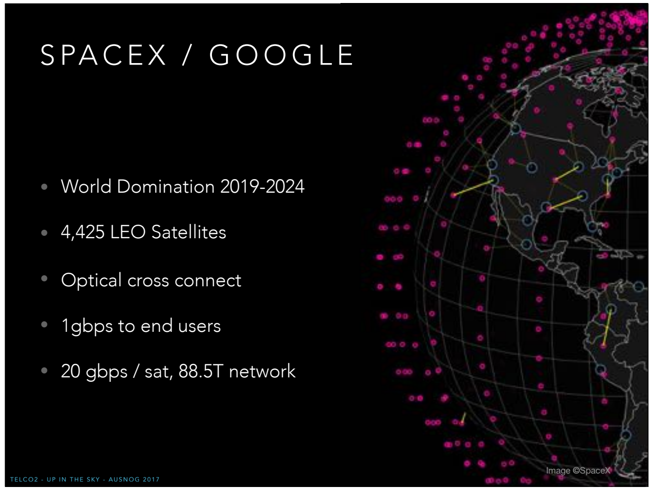



LeoSat is a European venture partnered with Thales Alenia Space. It will use the same satellite platform as O3b and Iridium Next. Their focus is on the corporate market.




SpaceX wants to put 4,400 satellites in orbit. Right now there are 1,459 total. As they own their own launch company, they have a very serious chance of success.

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TITAN AEROSPACE SOLARA
PURCHASED BY GOOGLE 2014, SHUT DOWN 2017
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# UP IN THE SKY

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