At the present time, no party “A”’s new GPS receiver design incorporating fully integrated “LightSquared” filter (and there now is only one known party “A”) is available for testing by party “B” (if party “B” is thought to not agree with the design assumptions of party “A”). Ergo, the debate centers on forward looking statements and opinions from the two sides of the argument of whether terrain based transmitters should be allowed in a satellite based transmitter band (whether any GPS receiver design is capable of continuing operation given the proposed new noise floor in the environment). To try to assist in the resolution of this debate, I offer my forward looking statements and opinions for consideration, formed from my understanding of “back of the envelope” design engineering estimation art and observation of the art in general. I further offer advice to our governmental decision makers in how to do their jobs:

LightSquared, or any competitor using near frequency strong terrestrial transmission, will produce an off-band signal that will be received by the GPS receiver because of the bandwidth of the GPS receiver "patch" antenna. This is called "quality factor" or "Q" and is a measure of center frequency divided by 3db bandwidth. Unfortunately, GPS uses a high frequency, and Q diminishes with frequency (why radios and TVs all use a lower frequency IF stage, to get better transmitter station selectivity, and do not count on the antenna or RF stage for much help there).

GPS receivers can use a DSP computer to, and we will use the analogy of a noise canceling headset, make an interference signal "anti-noise" to add into the desired signal with noise, to remove the noise from the desired signal. Unfortunately, the signal must also be heard in the signal plus noise coming from the antenna to the DSP computer input.

Design assumption: the filter between the patch antenna and the first LNA RF amplifier inside the GPS antenna must reduce the LightSquared interference signal amplitude down to equal to or lesser than the desired GPS signal before the DSP computer, using its true means and methods, can be effective at eliminating the proposed LightSquared noise perceived by the GPS receiver.

1. If you have zero loss at the GPS bandpass, how much LightSquared signal attenuation do you need over the entire noise spectrum bandpass? Let's do a "back of the envelope" engineering guesstimate:

You need to reduce the power spectral density of the noise to or below the power spectral density of the signal. Power spectral density is measured in watts per square foot.

Watts (the undesired is stronger, goes proportionally):

db = 10 log Pi/Pr
  How much does LightSquared transmit - don't know, claim keeps changing.
  How much effective radiated power from a GPS satellite - a spec for that.

db = 10 log 15,750/300
db = 17.2

Square Feet (the undesired is closer, goes inverse square proportionally):

db = 10 log Rr**2/Ri**2

How far away is LightSquared - assume 1000 feet
How far away is a GPS satellite - assume 11,000 miles x 5,280 feet per mile
Surface of a sphere is 4 x Pi x (radius squared)
The 4 and the Pi factor out

db = 10 log (11,000 x 5,280)**2 / 1,000,000
db = 95.3

Attenuation required = 17.2 + 95.3 = 112.5db

2. If you have zero loss at the GPS bandpass, how much LightSquared signal attenuation do you need over the entire noise spectrum bandpass? Let's do this another way, using "the other side of the envelope" engineering numbers, but where do we get those:

Power level and orbital lifetime limit
http://gpsinformation.net/main/gpspower.htm

Which limits have been exceeded on the majority of satellites
http://www.glonass-center.ru/en/GPS/

Which is why it is not working well
http://www.raimprediction.net/ac90-100/summaries.php?id=npa_nobaro

But we knew well in advance that GPS was cratering
http://www.gpsworld.com/gnss-system/block-iif-follow-or-failure-7265

GPS is supposed to be at around -130dbm on the ground for recently launched GPS satellites. However, the decades older satellites (the majority of satellites are beyond service life) are running around -150dbm. We have no choice but to use beyond service life GPS satellites in the active constellation in order to obtain 24/7 operation of the only PNT system we control, so we must design to those.

LightSquared's lower, re-re-revised (they're going to turn it way up later, they admit) power level is -30dbm "near" their tower. Don't expect a definition of "near" from LightSquared, and keep in mind that LightSquared keeps changing numbers.

Attenuation required = -30dbm - (-150dbm) = 120db

3. But what does this mean:

db is a log scale so 10db is a factor of 10, 20db is 100, 30db is 1000, 40db is 10,000, 50db is 100,000...

120db is 10**12 = LightSquared 1,000,000,000,000 times stronger than GPS.

112.5db is 10**11.25 = LightSquared 177,827,941,000 times stronger than GPS, by geometery ratio watts/(foot**2).

Really really really really big signal strength differential between the weak desired signal and the new super strong noise floor environment! Somehow, LightSquared accusing the PNT committee of being off by 32 times doesn't seem like much (only 15db)!

You can adjust the number down as LightSquared offers new lower power limits, and up as they increase their power, as they claim they will in the future. And you can adjust the number up as you decide on lower effective range limits (how far from the LightSquared cell tower your GPS should not work). You get the idea how this is done.

Hint, the antenna design will buy you something, which is not accounted for here, but not that much.

Hint, the DSP ability might be a tiny bit better than assumed, and this is the dimension where discovery and invention might make things maybe conceivably a little better considerably eventually far into the future (LightSquared should wait for that).

Hint, the configuration might be changed to allow multiple lesser attenuation filters in series, perhaps separated by amplifiers, but no amplifier can be allowed to saturate from the off-band interference signal, and "sneak paths" for the strong interference signal around filter segments, such as the power circuitry for the amplifiers, or the printed circuit board dielectric, will easily destroy this topology option.

Anyway you approach the problem of separating a small signal (like a flashlight on the moon), from a large signal (like a nuclear bomb detonation from 1000 feet away), you are going to have a big engineering challenge ahead of you. With LightSquared and every one else who wants to repurpose spectrum from satellite transmission to terrestrial transmission (you can build a flashlight from the moon detector, but it no longer can work in a totally new noise floor environment of having a nuclear bomb detonation 1000 feet away). Good luck, because we need a PNT system, and Loran has been terminated. It will probably be some other country's navigation satellite system which their military controls (Glonass (Russia), Compass (China), Galileo (European)) that we will become dependent on for infrastructure operation in the United States of America.

eLoran was better than GPS for accuracy and for availability, only cost $12M/yr to operate, could not be jammed, worked where GPS did not anywhere within the confines of the 50 states and coastal waters.

That was an M, not a B.

A billion seconds ago, it was 1959.

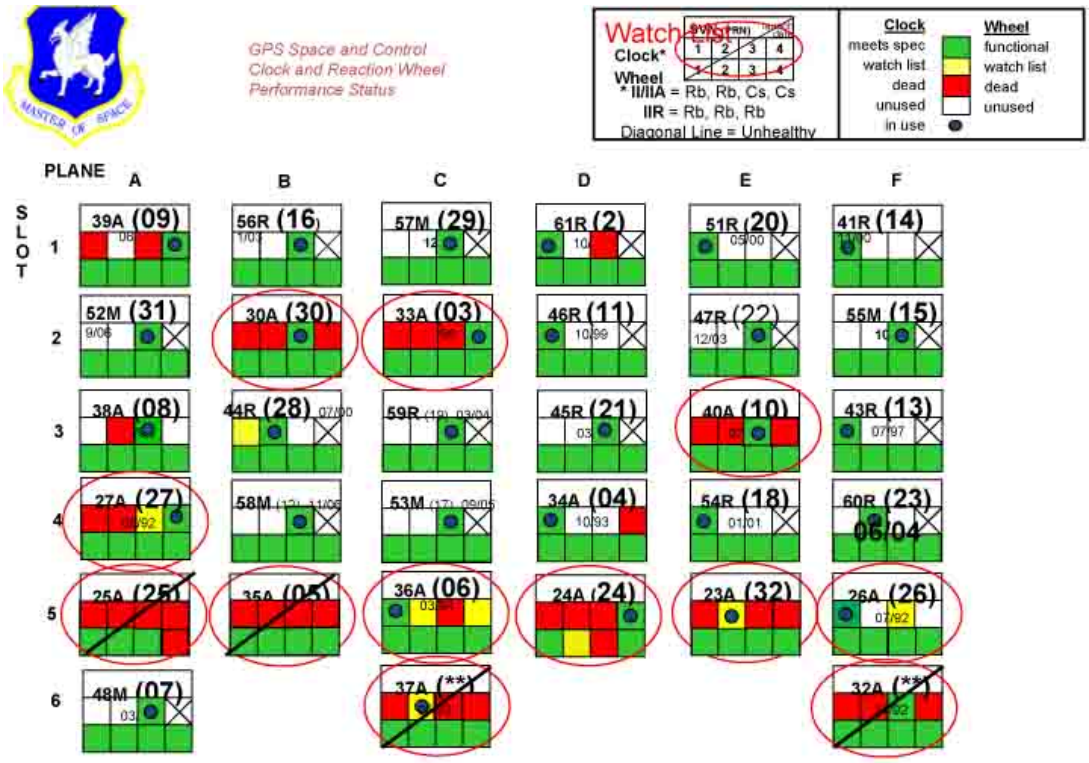
A billion minutes ago, Jesus was alive.

A billion hours ago, our ancestors were living in the stone age.

A billion days ago, no bi-ped walked on the earth.

A billion dollar infusion is immediately necessary to restore the GPS satellite constellation to have all satellites become within service life limit constraints.

eLoran should be turned back on again (tell the Department of Homeland Security, they are demonstrably not paying attention), because our modern infrastructure cannot operate without a PNT system - everything from telephones to the electric power grid to banking.
http://www.loran.org/ILAArchive/ArchiveIndex.htm



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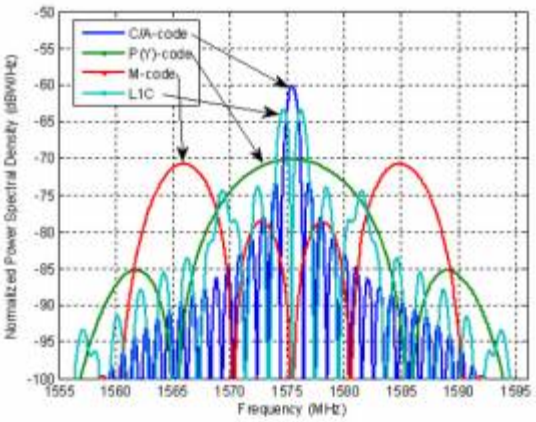
Government, unfortunately, is run predoninently by two groups of professionals, MBAs and lawyers. Since when has any MBA or lawyer ever had a decent detailed understanding of how anything works? These two groups of professionals want further additional public comment supporting the LightSquared terrestrial LTE transmission environment. You will not normally find an engineer voluntarily making the following proposal, as it is in opposition to the ethical practices guidelines of the National Society of Professionl Engineers; but this proposal has been requested by our government:



We now provide the balanced argument for the proponent position of licensing LightSquared for terrestrial LTE transmission at power levels materially above GPS satellite transmission power levels:

That argument is for our right to make a profit. Our implementor has found that the only possible way to effect a post patch antenna pre LNA rf preamplifier placed passive filter which will produce 140db of LightSquared attenuation (both the now proposed 10L band and the eventually to be used 10H band) reference it's GPS attenuation is with a sealed unit multipole resonant cavity filter. This filter is avaliable for purchase today, not just a prototype only for use in a few select laboratories. This filter is the size of a brick. This filter costs $1,200.00 to buy. This filter is required in every aircraft, every precision guided bomb, every car navigation system, every boat navigation system, every banking terminal and every powerplant and every telephone system timing system, every cell telepone position location system which determines cell tower service, every mobile personal computer system position location system; only so long as there is one or more of approximately 40,000 LightSquared terrestrial LTE transmitters within some number of miles. Without such a transmission environmental modification, there is no need for our filter on any of this GPS equipment, there is no need to replace all GPS antennas with new containing our filter (we make no profit from newly created economic stimulus business). With the LightSquared transmission environmental modification of terrain based LTE service, all of this GPS antenna equipment must be replaced with otherwise duplicated equipment containing our brick sized $1,200.00 filter, or the GPS receiver will not any longer function (we reap a windfall as the only provider at this time of technology which will resolve technological deficiency in our entire singular PNT infrastructure, thereby creating the largest ever economic stimulus condition observed by man).

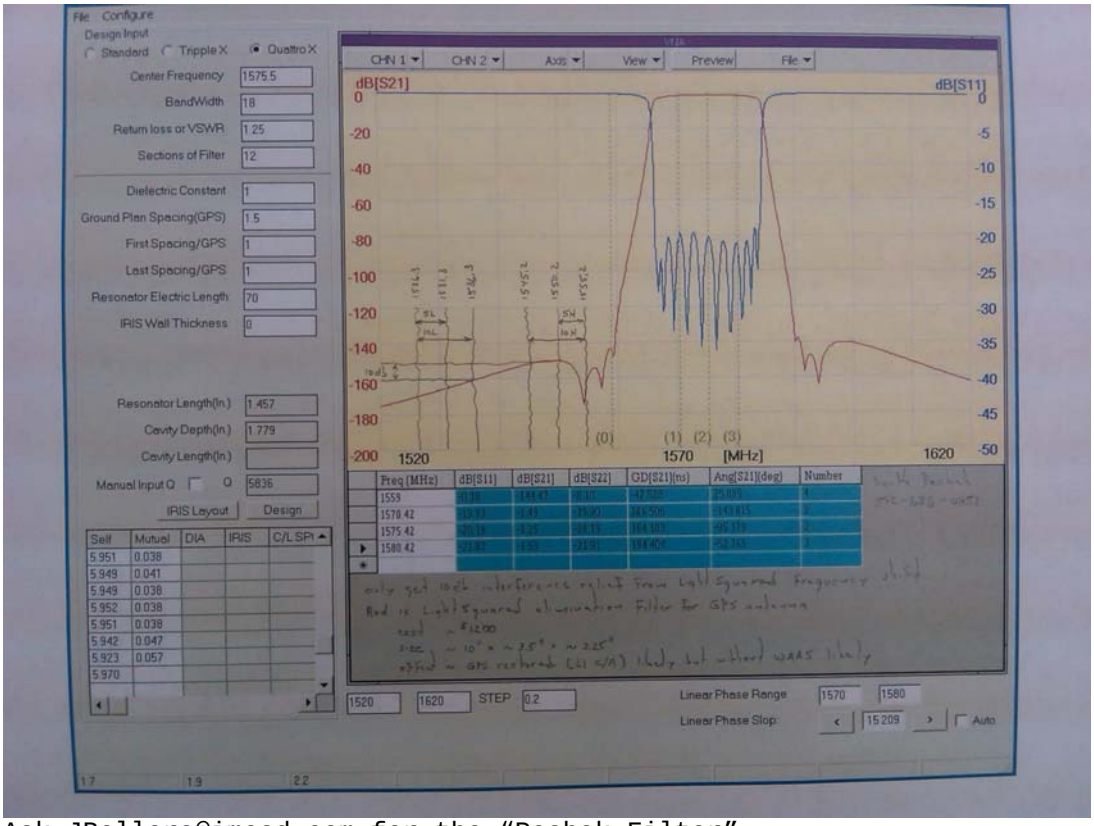
Certainly, as other manufacturers copy our filter technology, the newly required LightSquared attenuation filter will not shrink in size significantly, nor decrease in cost materially, because of the sealed unit configuration and the device physics, along with the sudden demand level for this product.

Yes, this 140db LightSquared elimination filter is real. Yes, anyone can buy one now. Yes, we put significant effort into smaller and lighter and less precious metals - this is as good as it is likely to ever get. We just made new physics, don’t ask for more.

Think of it like television. Back in the 1950s you licensed NTSC channels 2 and 5 in Green Bay, Wisconsin. Why not channels 3 and 4 and 6; since the lower band is 2 through 6 and the least expensive band to operate in? Because of something called db / decade – how a filter works. The FCC, back then, possessed people with engineering knowledge, knew that this system design requirement for “vertical wall filters” would make the television receiving set too (large, heavy, power hungry, hot) expensive for the consumer to ever be able to afford.

It is a real problem when the federal government has a technical agency, where people, perhaps a whole society, die if it looses technical competence. The FAA, first totally refusing to allow GPS in certificated aircraft when it was the only world wide navigation system, now shutting down all other forms of navigation system in favor of GPS “sole use”, while we look at the satellite status foil above to see what satellites still have what reaction wheel performance (ability to point the GPS antenna toward earth) and what clock redundancy (ability to know the time). The DHS, shutting down eLoran, even though it was better and more cost effective and unjammable than GPS, leaving us with no back-up PNT system, while virtually everything in modern society is totally dependent on a working PNT system. The

FCC, who can no longer figure out bandwidths and guardbands based on simple well known electronics engineering knowledge.



Ask JBellora@imcsd.com for the “Peshak Filter”

Any Questions:

B. Keith Peshak
Technical Director
TailLight Consortium
800 Oak Crest Lane
Georgetown, Texas 78628
512-636-0851
keithpeshak@localnet.com