

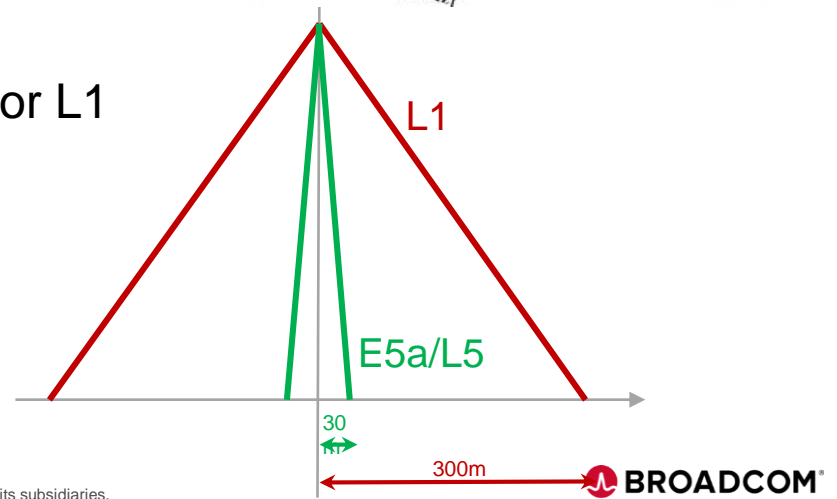
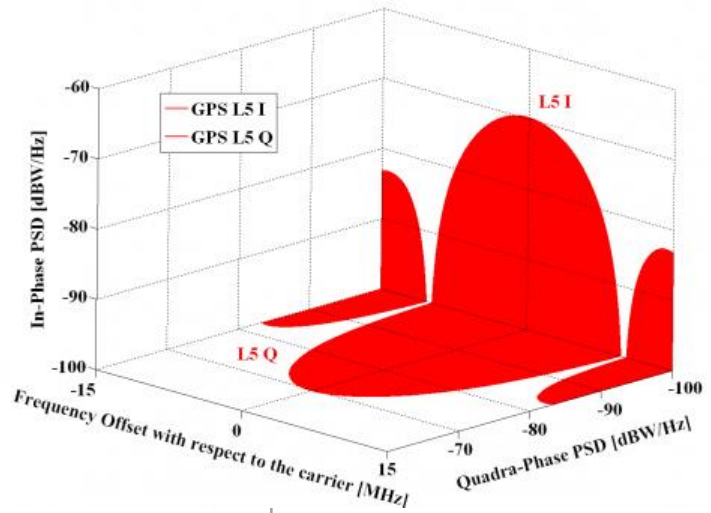


# Dual Frequency performance in mass market

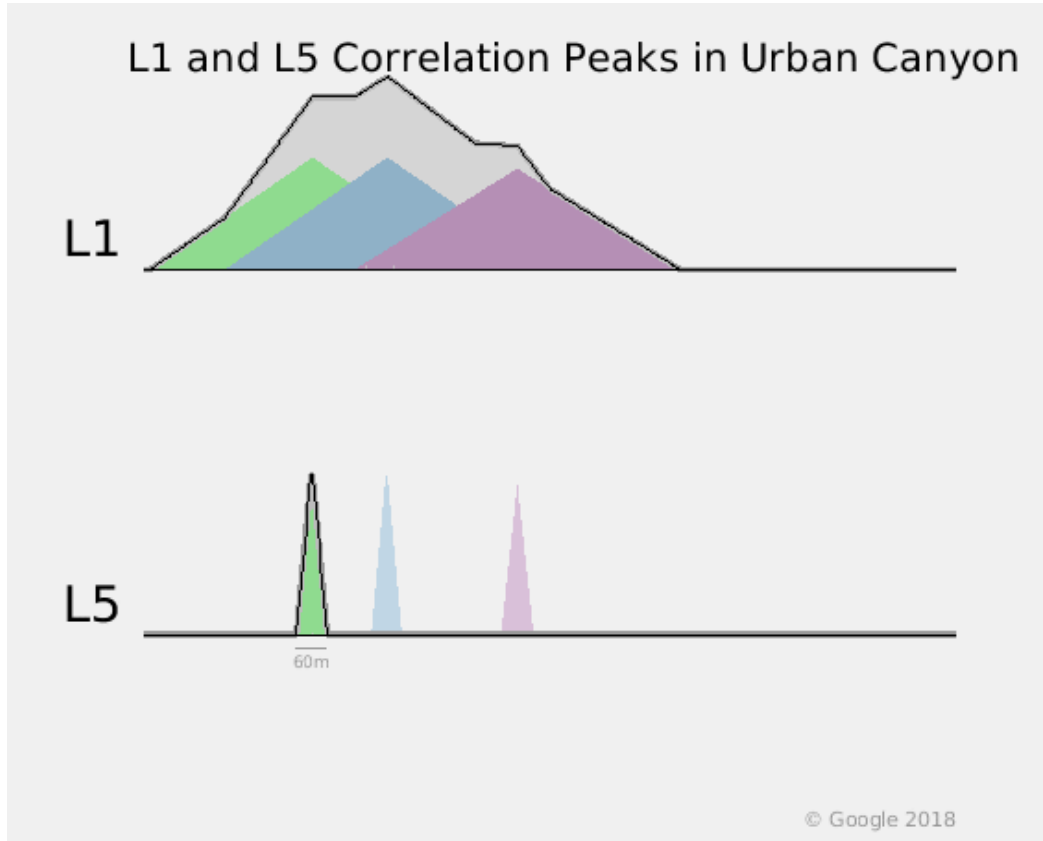


# GAL E5a/GPS L5 signal characteristics

- Center frequency 1176.45 MHz
- More powerful signals
- Pilot signal has no data bits
  - Use simple PLL versus Costas loop
  - 6dB theoretical tracking advantage
- Chipping rate 10.23 MHz versus 1.023MHz for L1

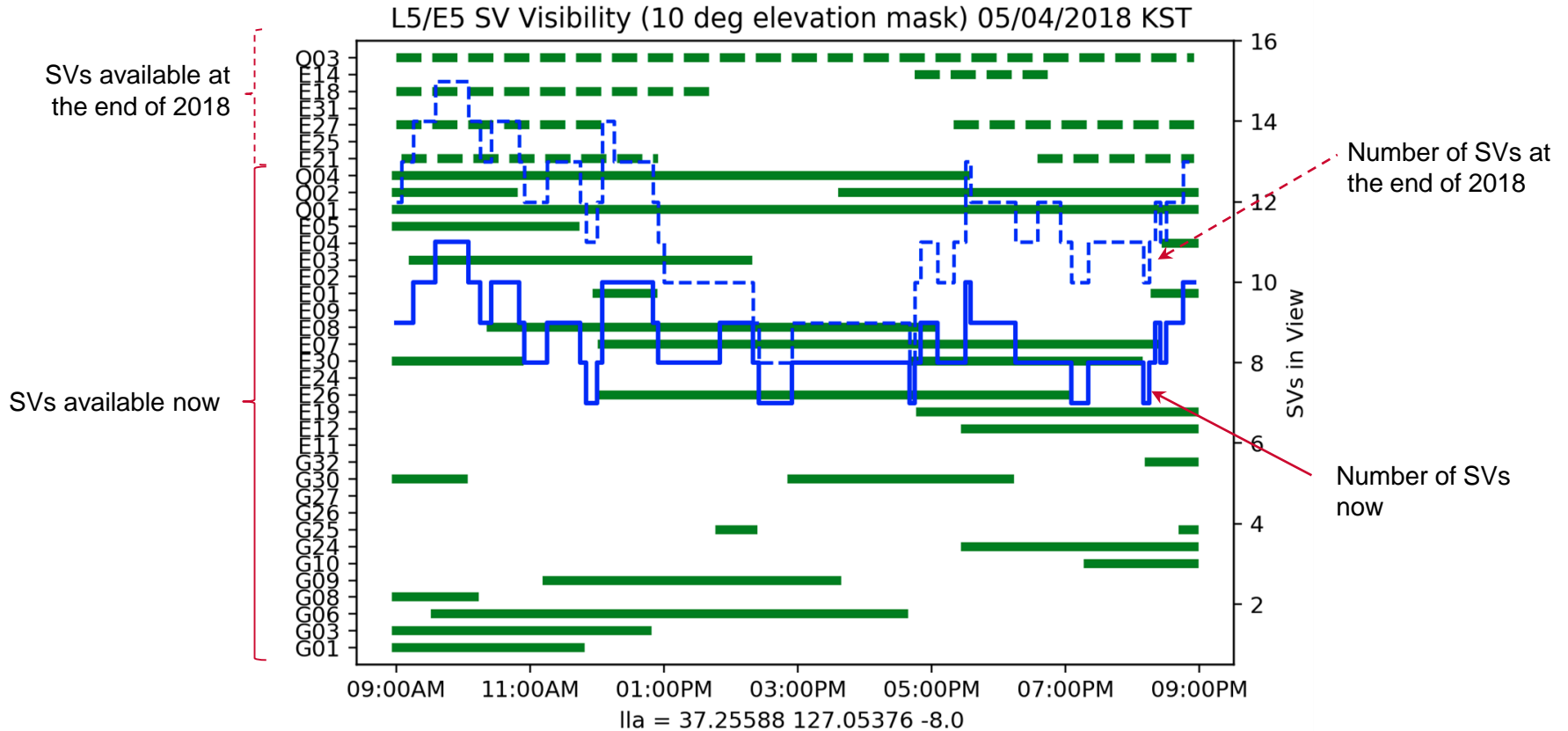


# How does multipath affect L1 and how does it affect L5



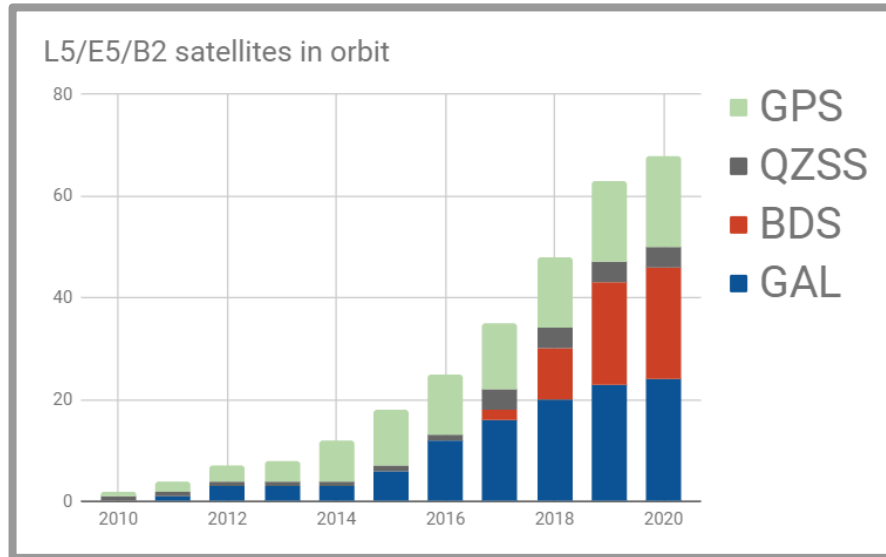
*GIF courtesy of Google*

# L5 GNSS Forecast



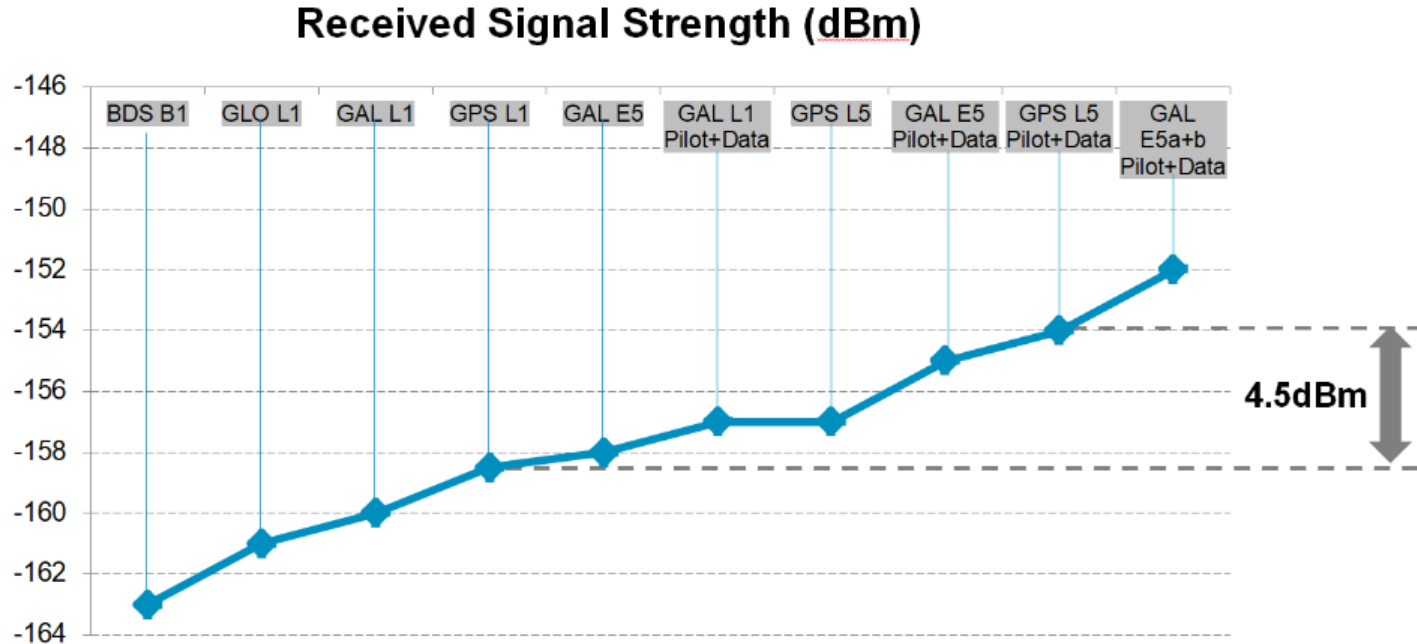
# L5/E5 satellites in orbit

GAL	0	1	3	3	3	6	12	16	20	23	24
BDS	0	0	0	0	0	0	0	2	10	20	22
QZSS	1	1	1	1	1	1	1	4	4	4	4
GPS	1	2	3	4	8	11	12	13	14	16	18
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020

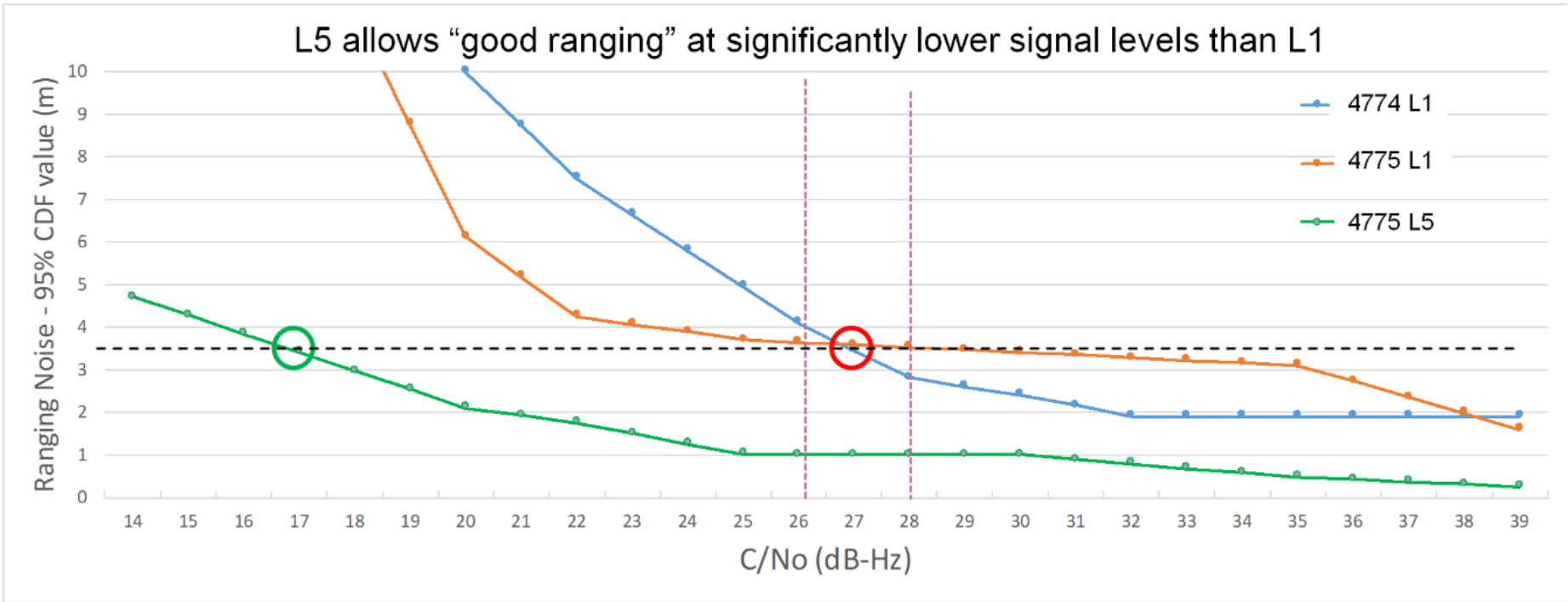


Only based on the increasing available signals in space, L5 receivers improve their performance significantly year over year!

# L5 GNSS receivers have higher sensitivity, because the signal strength is higher

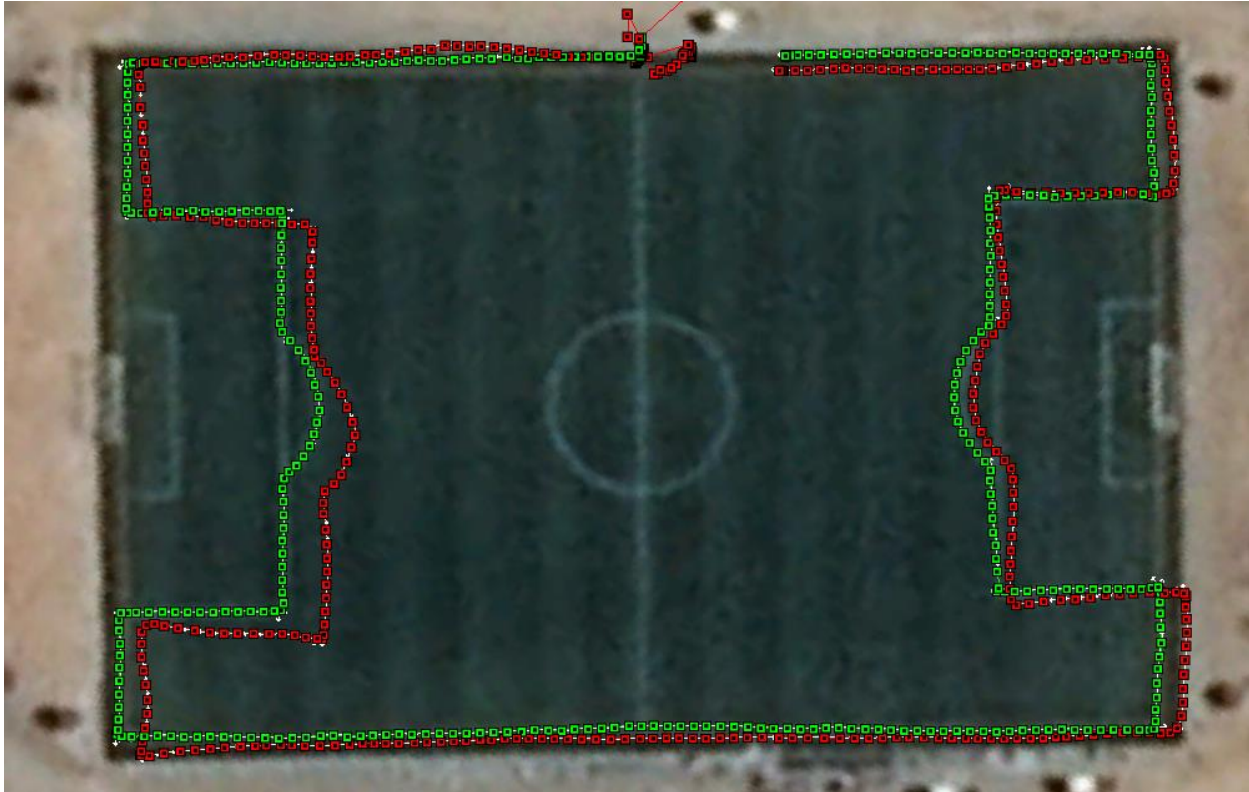


# Range error in function of signal power (L1 and L5)



Red: BCM4774 (L1)

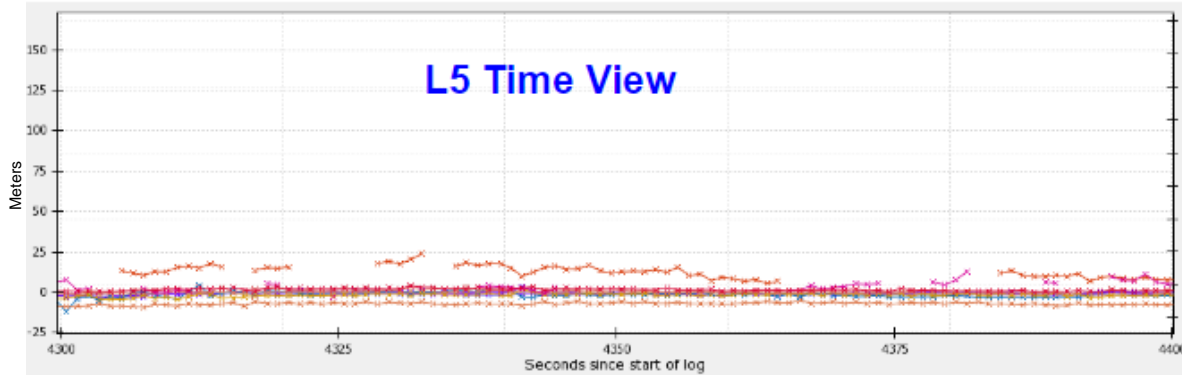
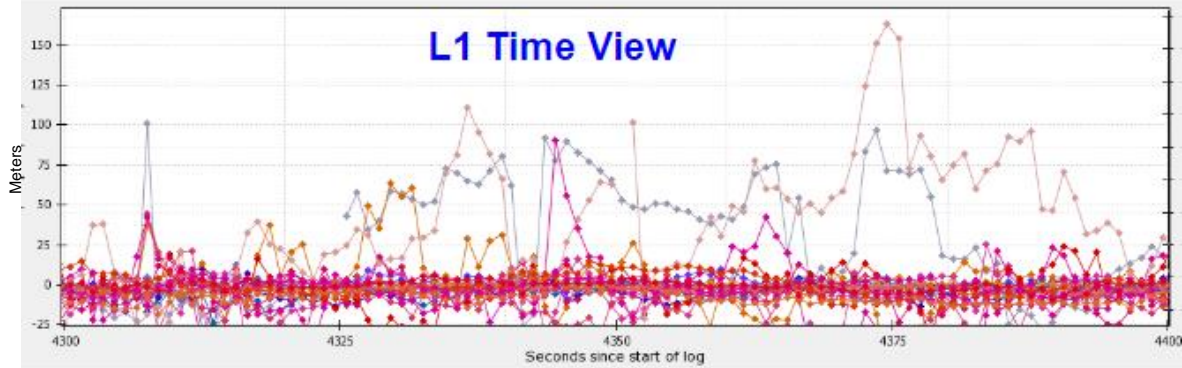
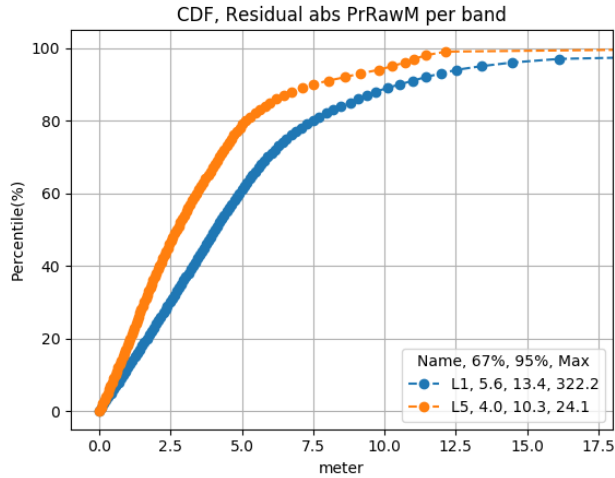
Green: BCM4775 (L1+L5)





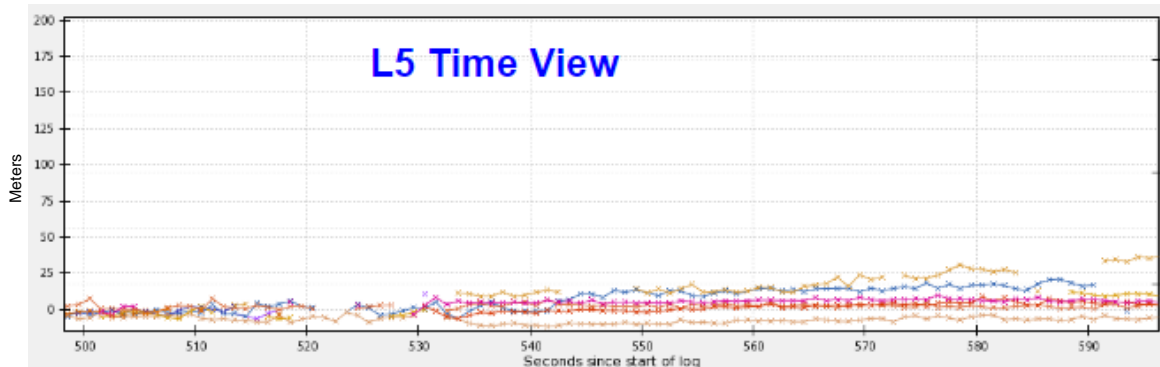
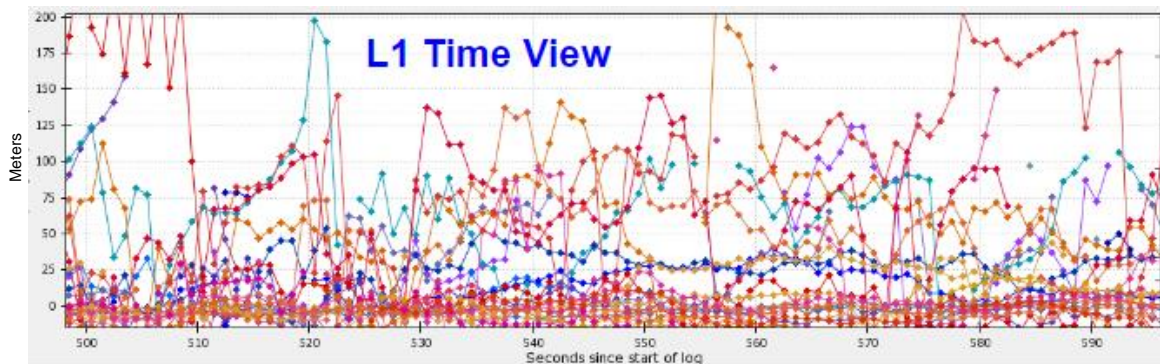
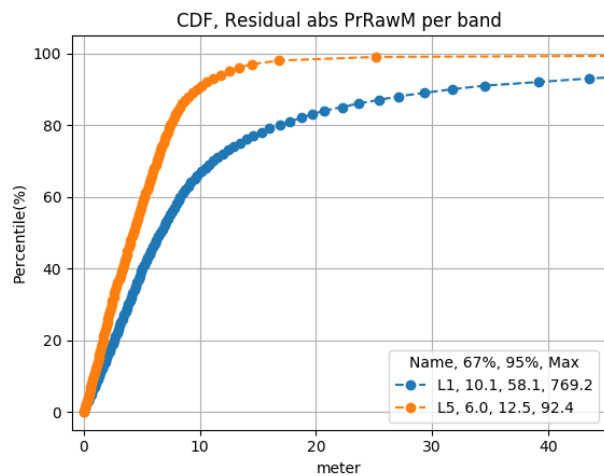
# Open Sky

## CDF Plot



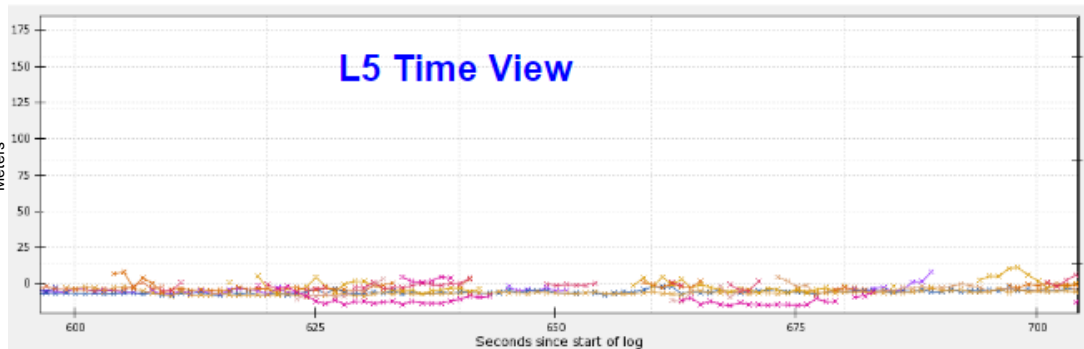
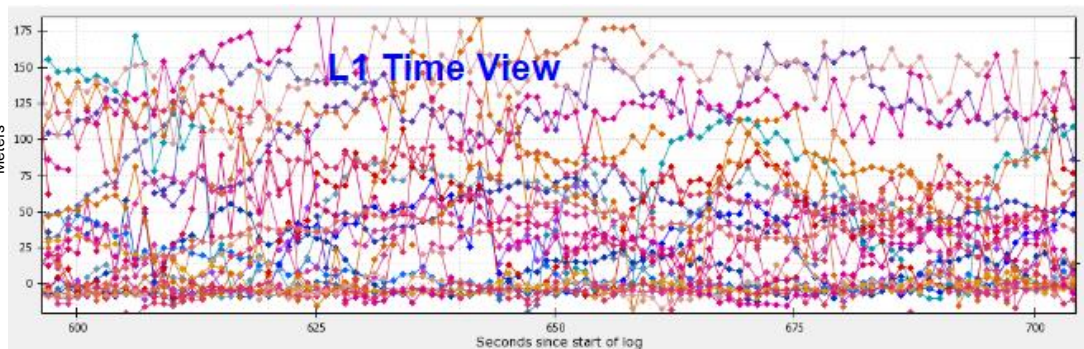
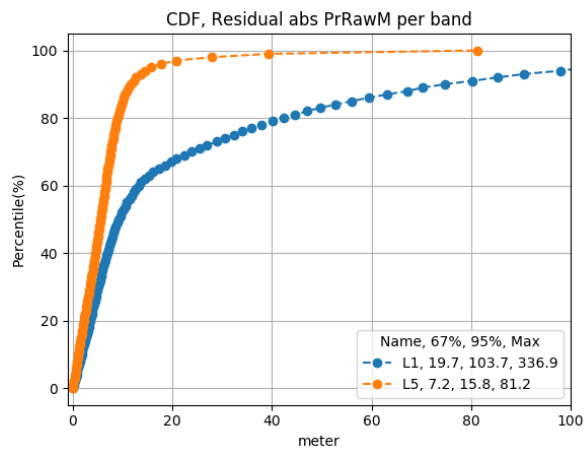
# Urban Driving

## CDF Plot

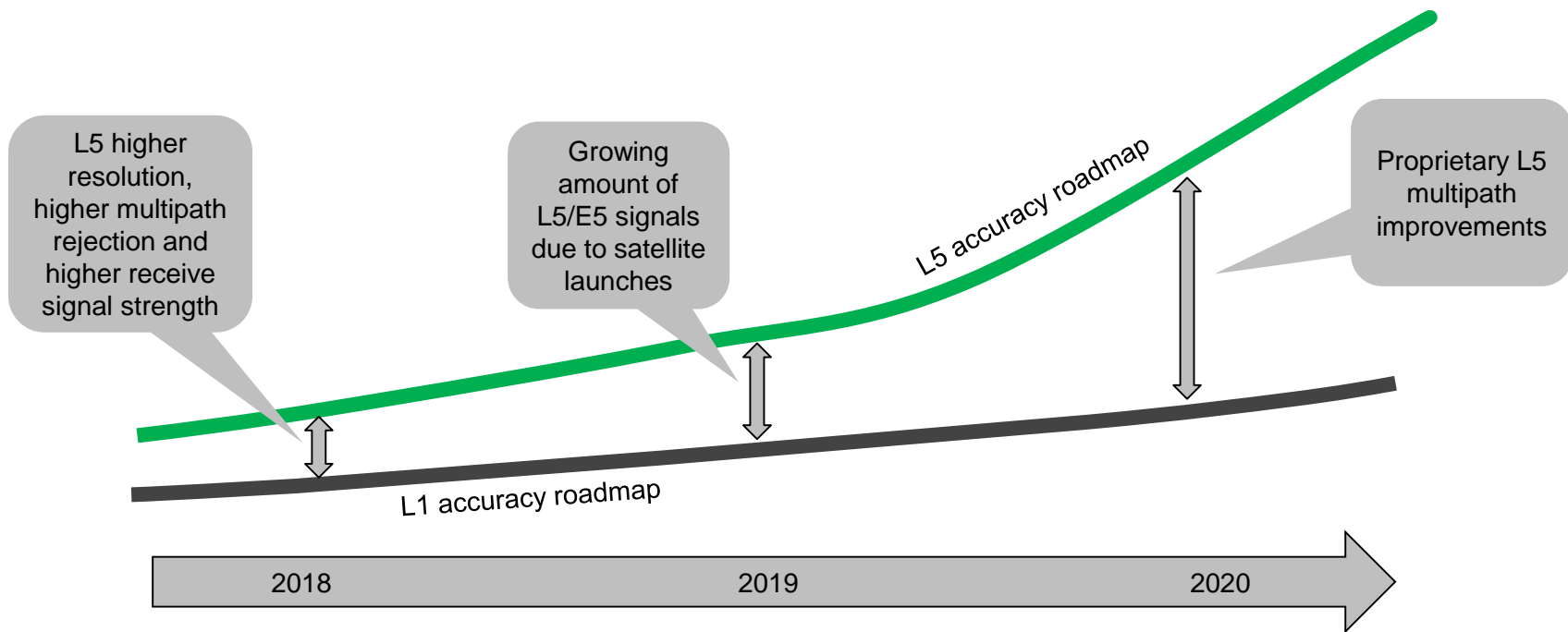


# Urban Pedestrian

## CDF Plot



# Summary: L5 has a faster accuracy improvement roadmap



## Summary and next steps

- Until today mass market devices were single frequency only
- Industry is moving towards dual frequency
  - Increase of accuracy in open environment
  - More robust to multipath in urban scenarios
- Number of SVs broadcasting in the L5 band are growing every year
- Carrier phase measurements have been improved
  - E.g Better cycle slip detection
- Broadcom HW (BCM4775) is also capable of tracking the full E5 signal and L2
  - E5a+E5b might be enabled in future releases
- Broadcom Successfully tested RTK and PPP internally