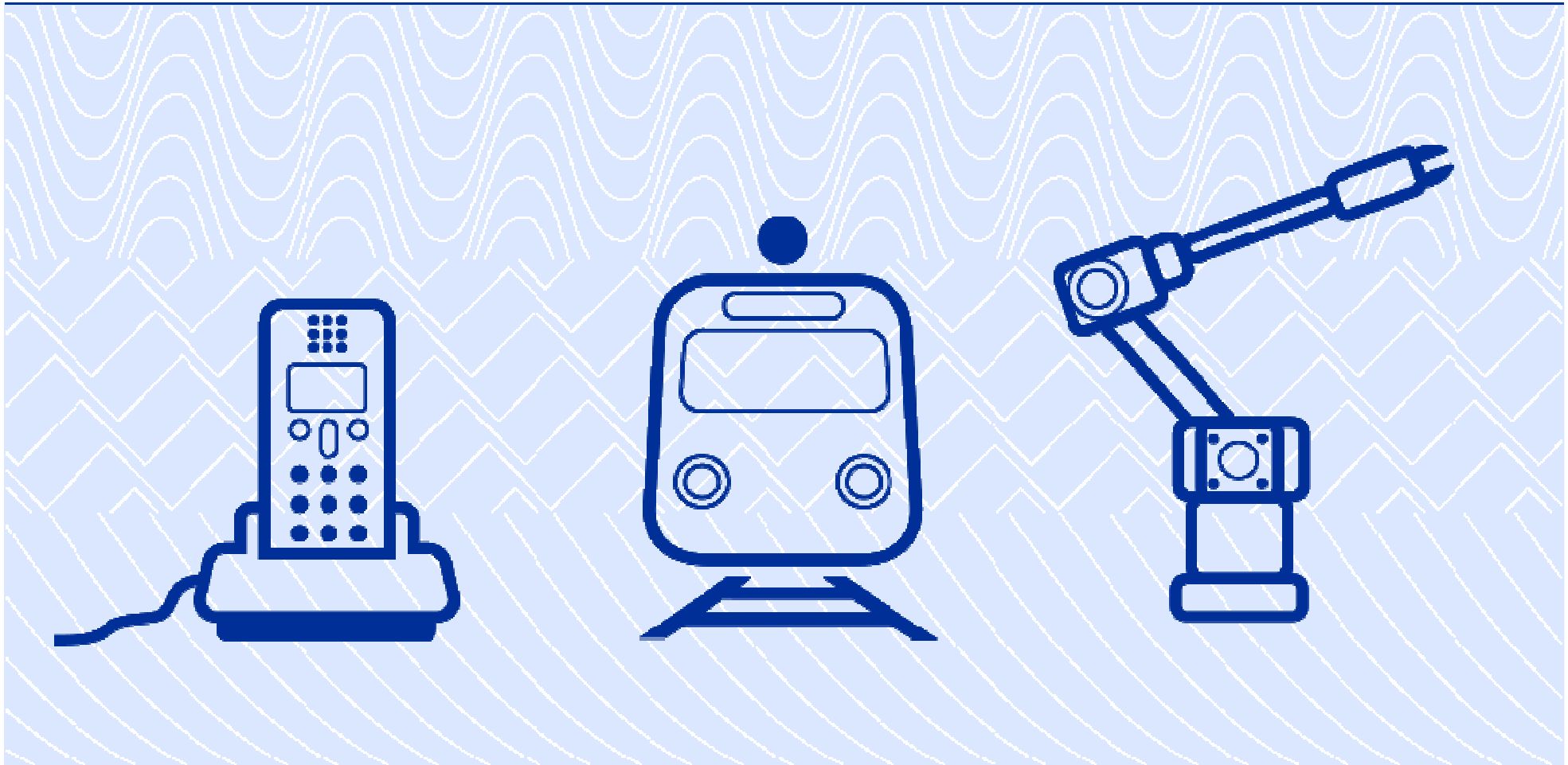


MM Wave Communications; It's time has come.....Finally after 125 years



Agenda

- History of MM Wave Technology
- Modern Times
- Technology and Performance
- Applications
- Regulatory Environment
- Conclusions
- Predictions.....

History

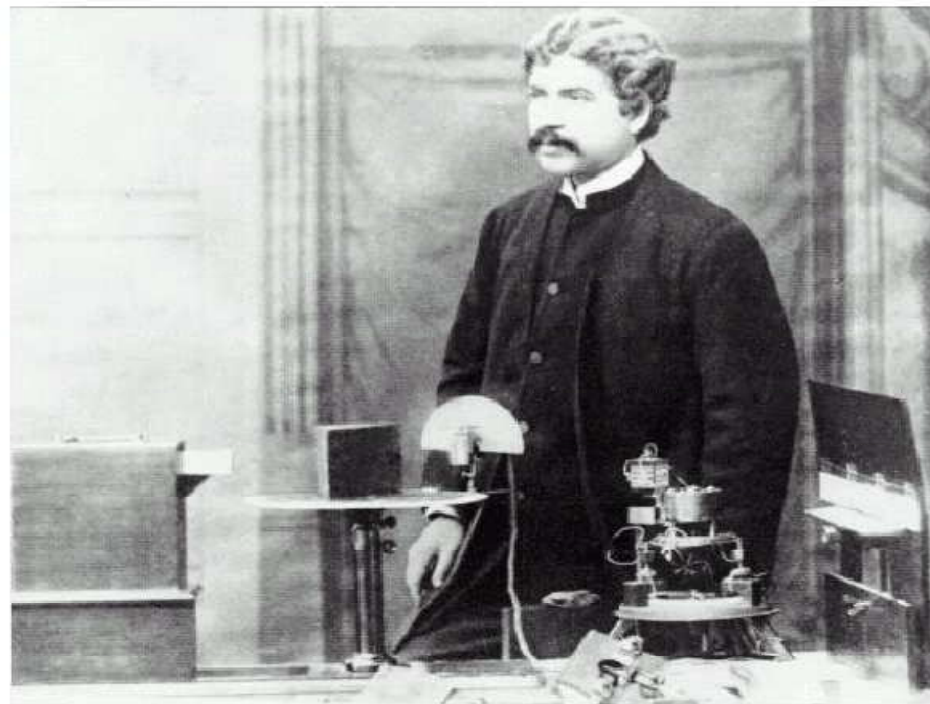
MM Wave (10-1mm) 30-300 GHz

“The inventor has transmitted signals to a distance of nearly a mile and herein lies the first and obvious and exceedingly valuable application of this new theoretical marvel.”

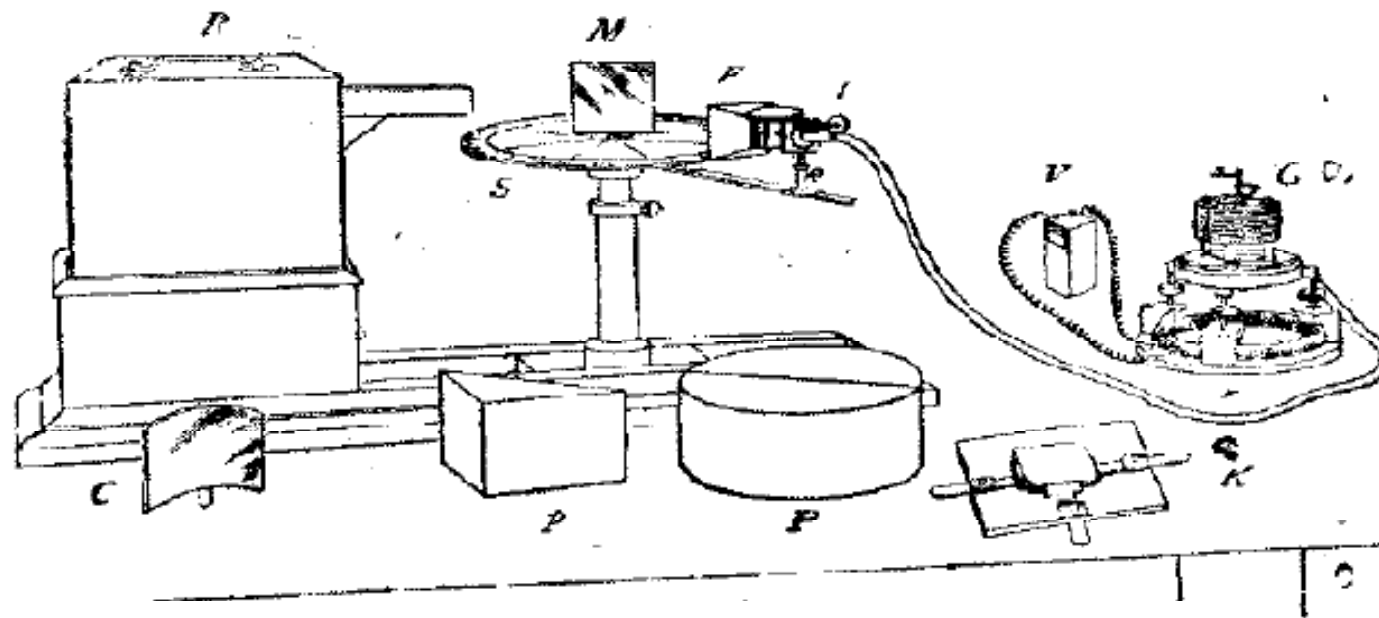
1896 Daily Chronicle of England

MM Wave (at 60 GHz) is the Oldest Demonstrated Communications Technology. Before Marconi et al

J.C. Bose and 60 GHz



Bose Apparatus

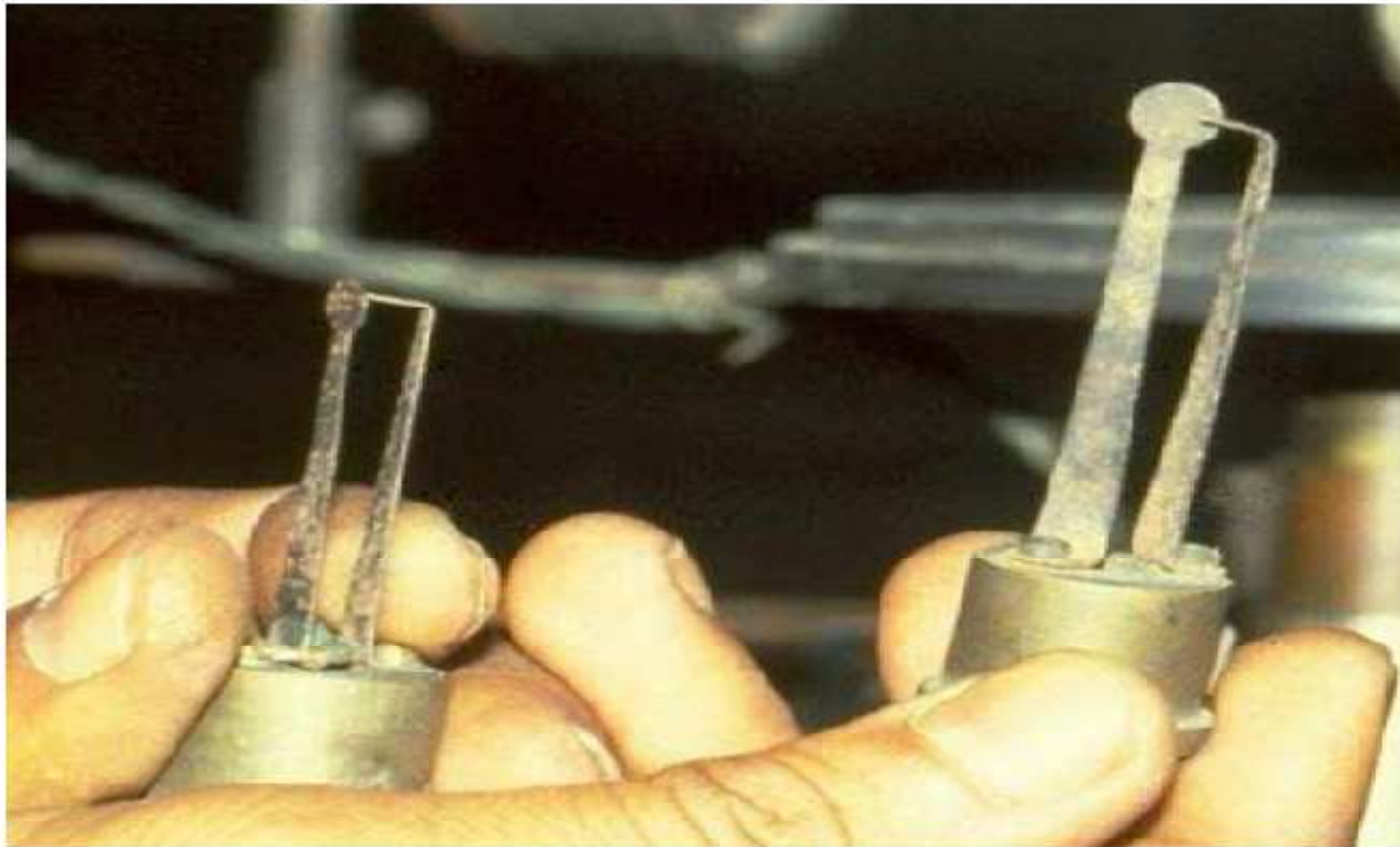


R, radiator ; S, spectrometer-circle ; M, plane mirror ; C, cylindrical mirror ; *p*, totally reflecting prism ; P, semi-cylinders ; K, crystal-holder ; F, collecting funnel attached to the spiral spring receiver ; *t*, tangent screw, by which the receiver is rotated ; V, voltaic cell ; *r*, circular rheostat ; G, galvanometer.

60 GHz Source, Antenna and Polarizer



Point Contact Detectors



60 GHz Polarizer: Book with tin foil between the pages



Double Prism Attenuator



Bose's Achievements

- 1895 demonstration of 60 GHz communications: 2 years before Marconi
- Semi conducting crystals and PN junctions
- MM wave components and assemblies
- Predicted existence of EM radiation from the sun and atmospheric absorption

J. C. Bose Continued

- Demonstration in London of setting off some explosives at almost a mile and ringing a bell using his 60 GHz communications apparatus
- First annoying cell phone ring tone and first remote controlled bomb!
- Why then is he not recognized as well as Marconi et al ?
- British class system at the time did not recognize non British born scientist, especially one without a peerage.....
- His next research caused him to loose any credibility he had...

Talking to plants

Prince Charles was Right



Modern Times

- 1950s; Bell Labs used buried MM Wave 300 GHz circular waveguide in advance of fiber optics
- 1960s; MM Wave Radio Astronomy developed high performance components and assemblies
- 1970s; Military radar, radiometer, smart missiles/munitions and communications programs enhanced the industrial base
- 1980s; US Government MMIC phase I and II developed commercial industrial base for MM Wave ICs
- 1990s; Broad emergence of commercial and government applications and programs
 - Auto radar at 24 and 77 GHz
 - Satcomm at 20, 30, 44, 60 GHz
 - Commercial products from 18 to 77 GHz

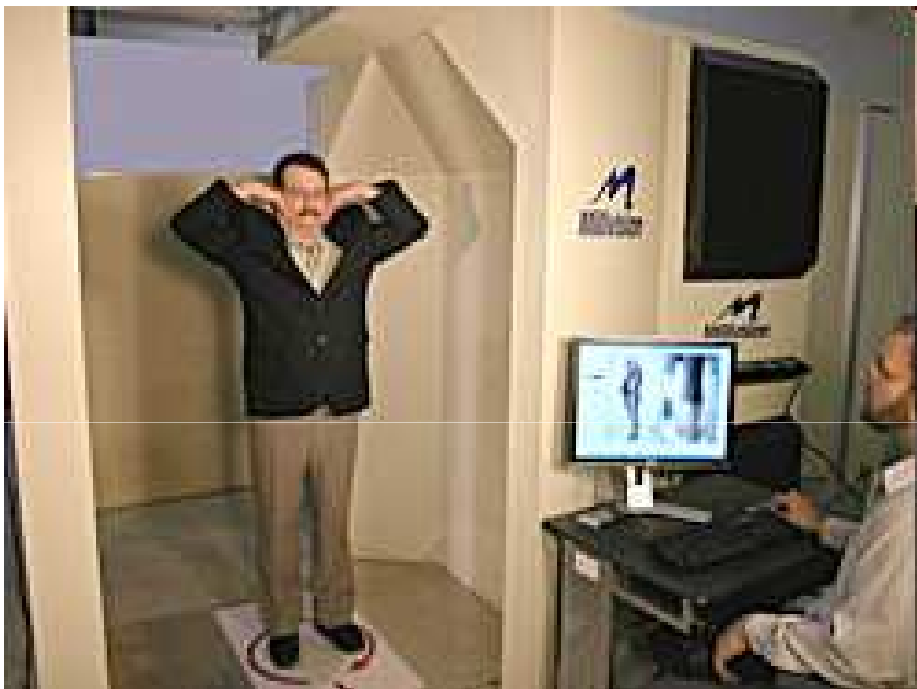
Modern Times.....

- 2000s; Finally the real mass market driver.....
- Consumer and industrial electronics
 - Auto collision avoidance technology 24 and 77 GHz



Consumer and Industrial Electronics

- Contraband detection



Consumer Electronics

Uncompressed HD
extensions using
60 GHz wireless HDMI



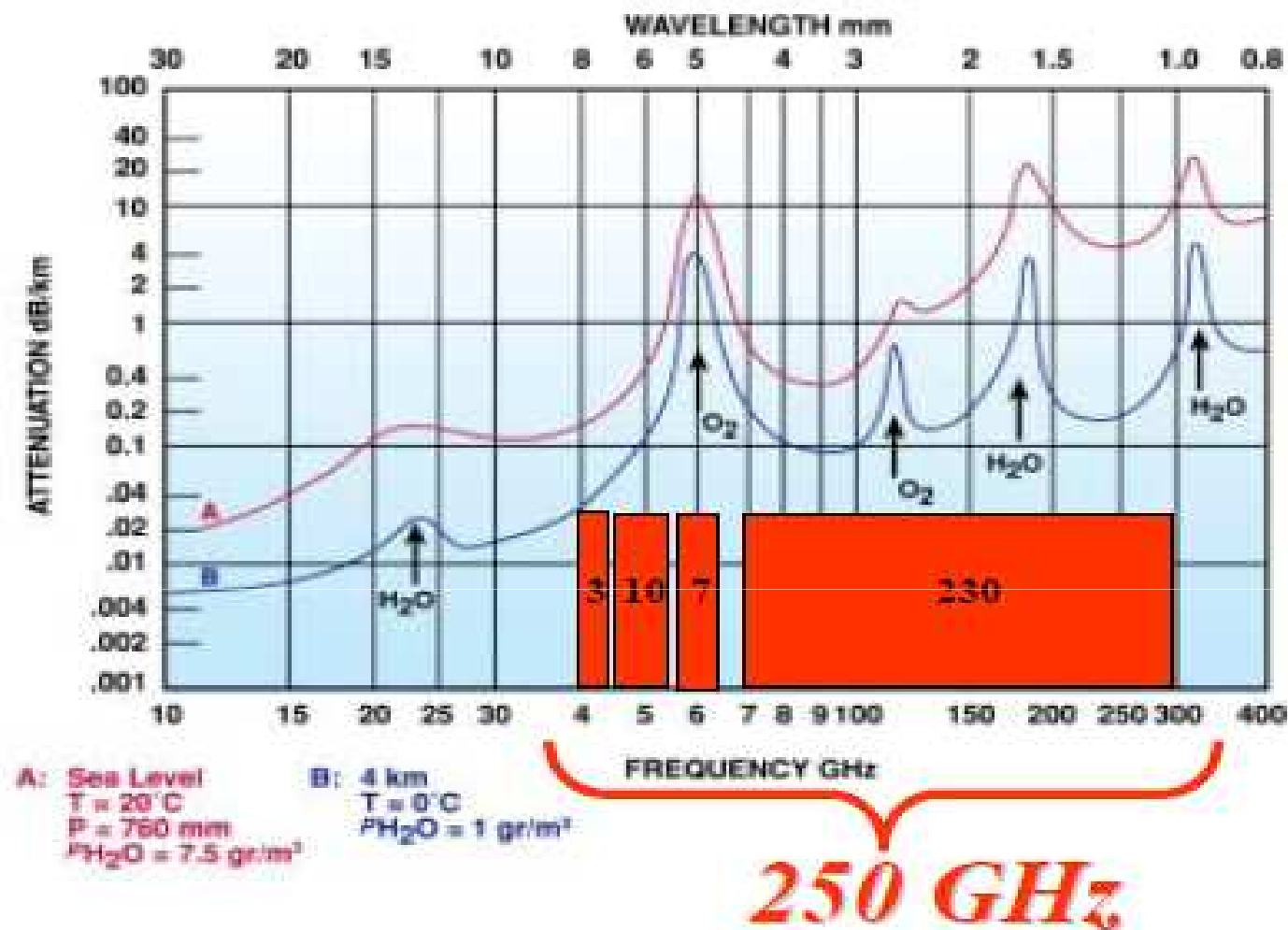
And Next at Your Local Best Buys

- 60 GHz 802.11 access points and NICs
- Seamless 2.4, 5.8, and 60 GHz operation at multi gigabit rate...
- **Wi-Fi Bluetooth, UMB and 60 GHZ Shipments Should Reach \$700 Million by 2013, Says ABI**
- **Why now and not in 2000?**
 - Low cost SiGe MMICs with total transceiver on a chip
 - Demand is now here
 - I Phone, I Pad, Blackberry, mobile data hogs
 - Networks being built to support these services
 - Wi-Fi
 - WiMax
 - LTE

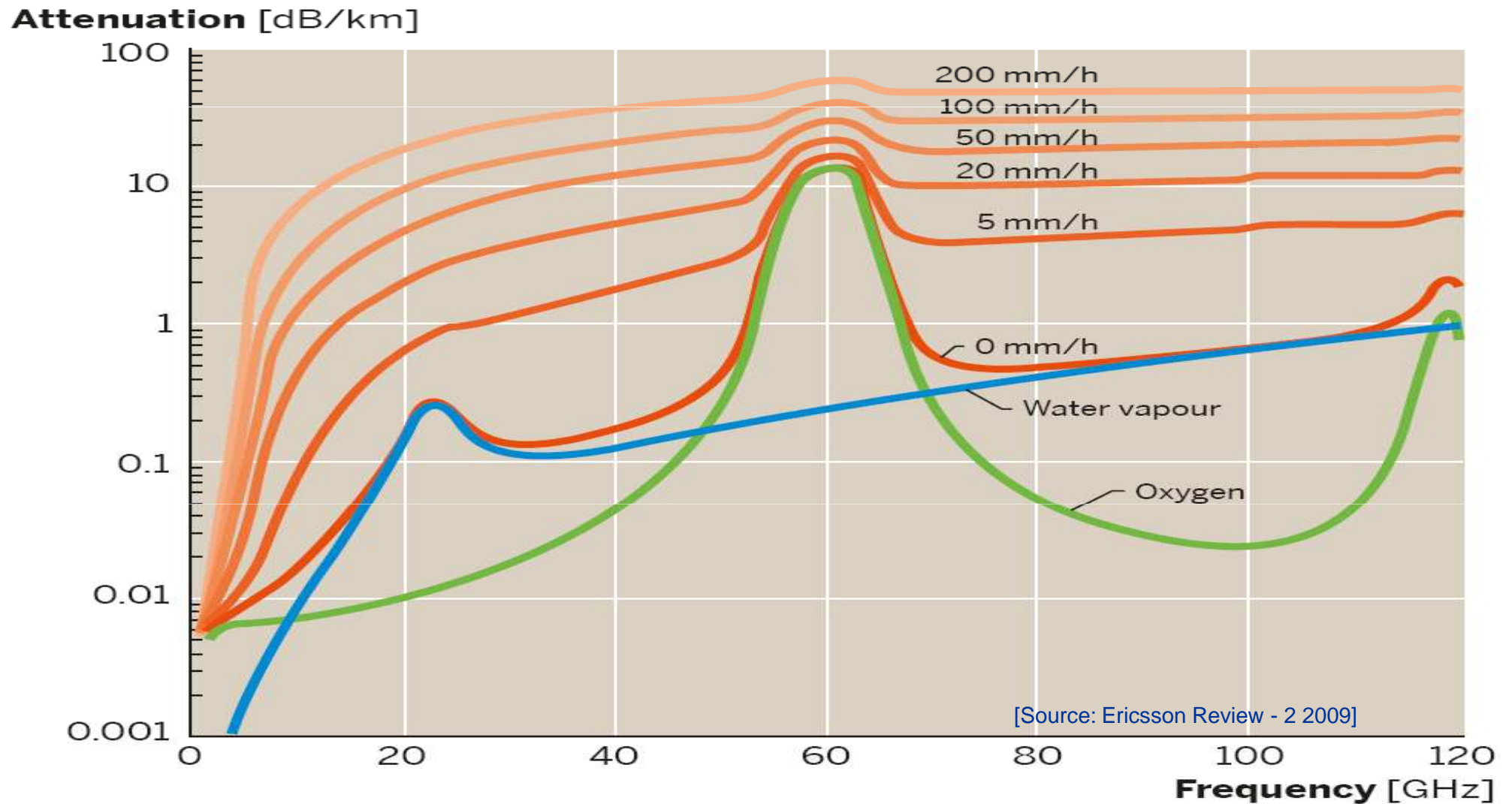
Technology and Performance

- MM Wave propagation is well understood
- Rainfall data in mm/hour is well quantified worldwide
- Long term measurements have validated the models
 - Competing models agree in the end, Crane vs. ITU/CCITT
- There are very few surprises and the models are conservative
 - Usually works better than expected
 - If there is a problem with rain it is usually one of the following
 - Water leakage and shorting
 - Laminar water buildup on the radome
 - Wind and lightning can cause secondary effects

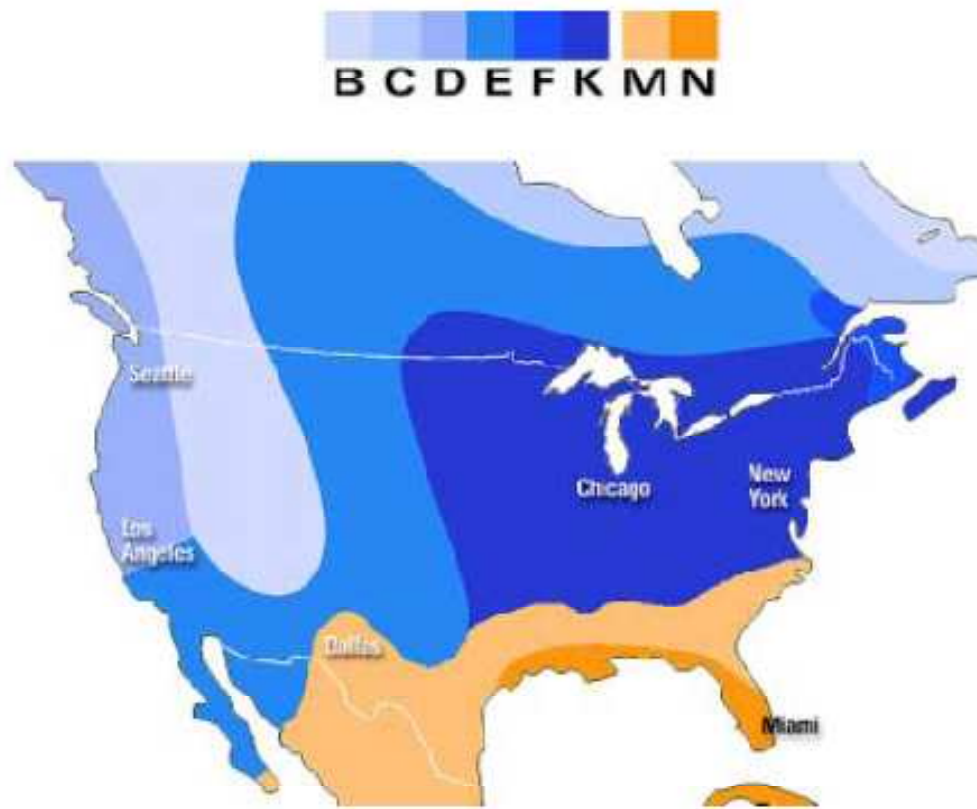
Lots of Spectrum, 7 GHz at 60 GHz and 10 GHz at 70/80 GHz



Rainfall Tends to Equalize ALL Bands

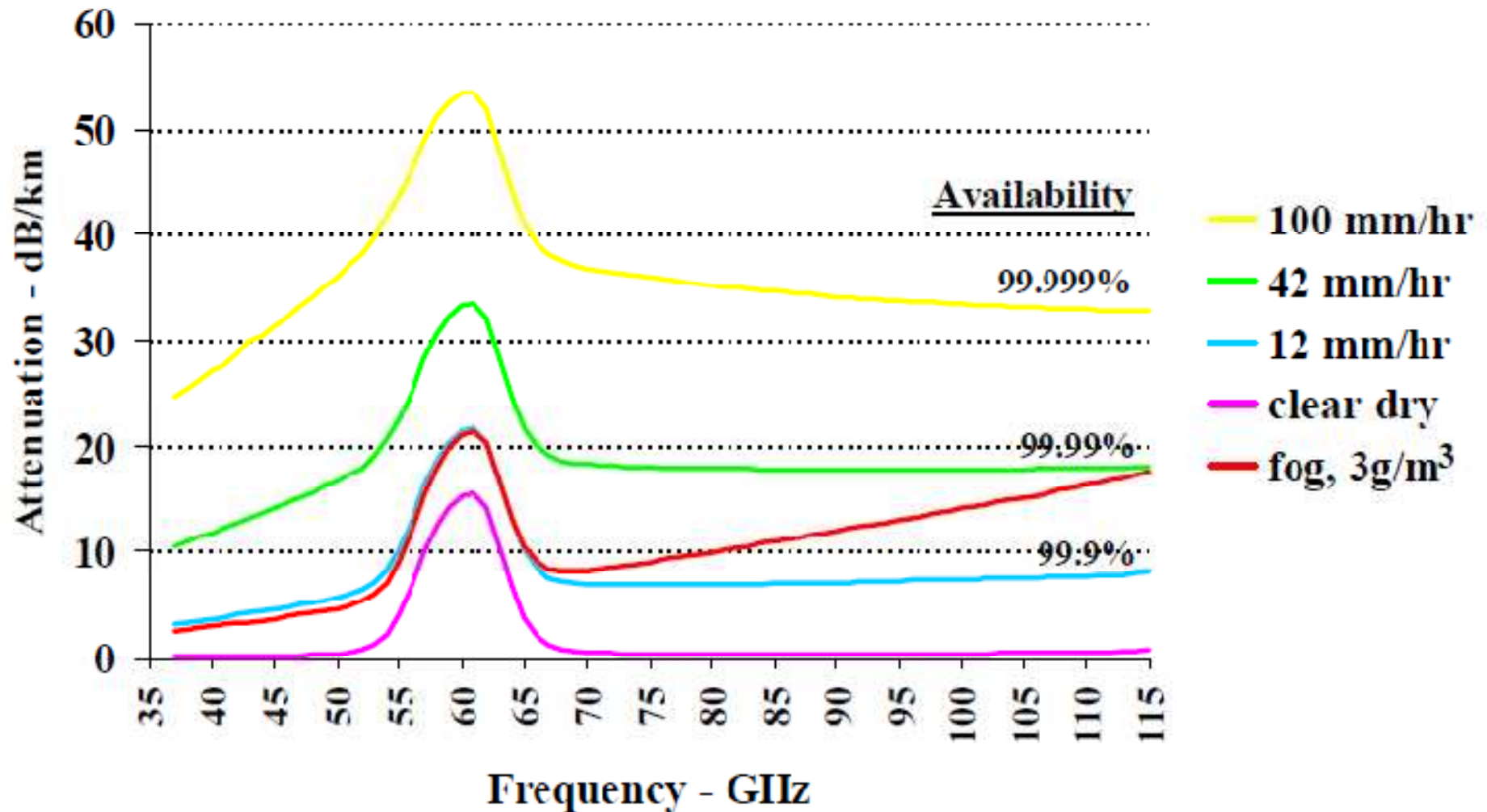


North American Rain Zones

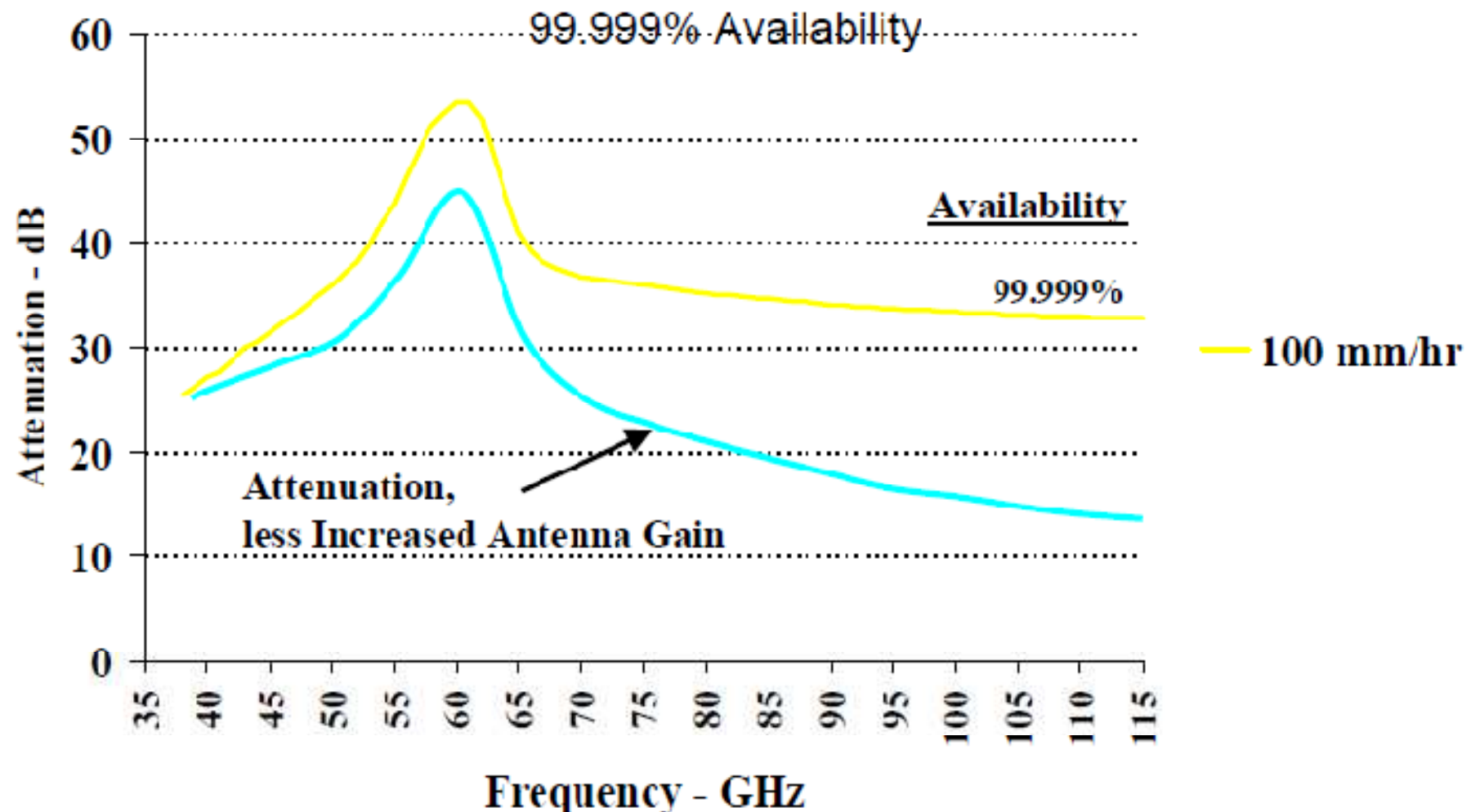


- Almost all is Rain Zone K or better
- Rain Zone N is the worst case and is only the Gulf Coast

Example Link Availability for Rain Zone K

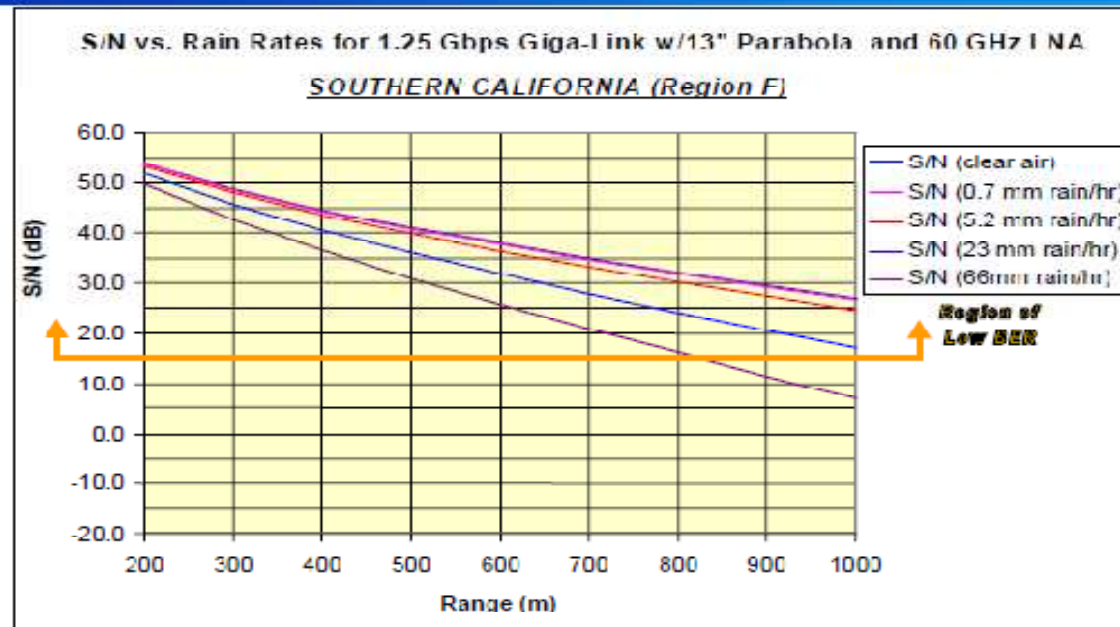


Rainfall Largely Offset by Increased Antenna Gain



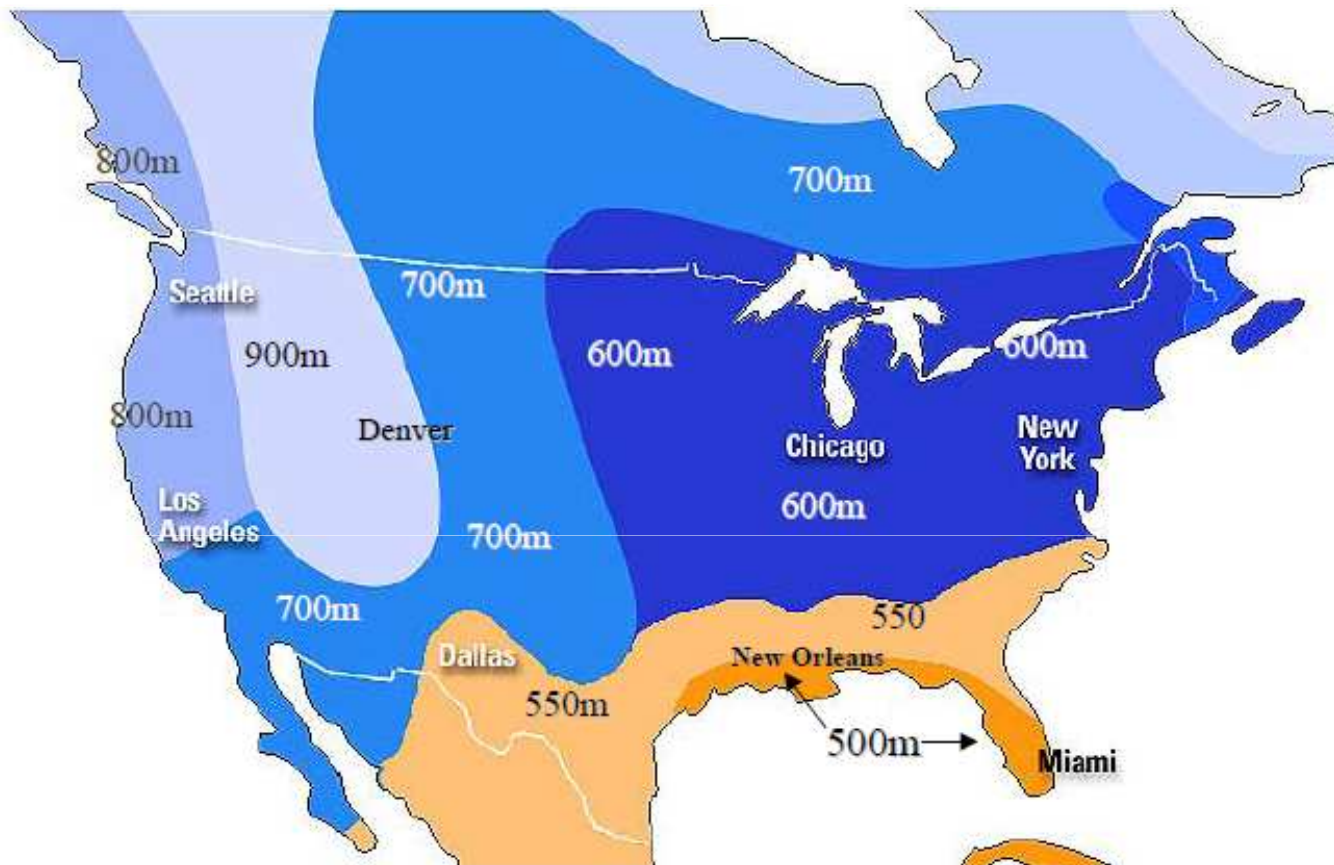
Typical MM Wave Radio Range Data Presentation

GigaLink™ Family of Radios

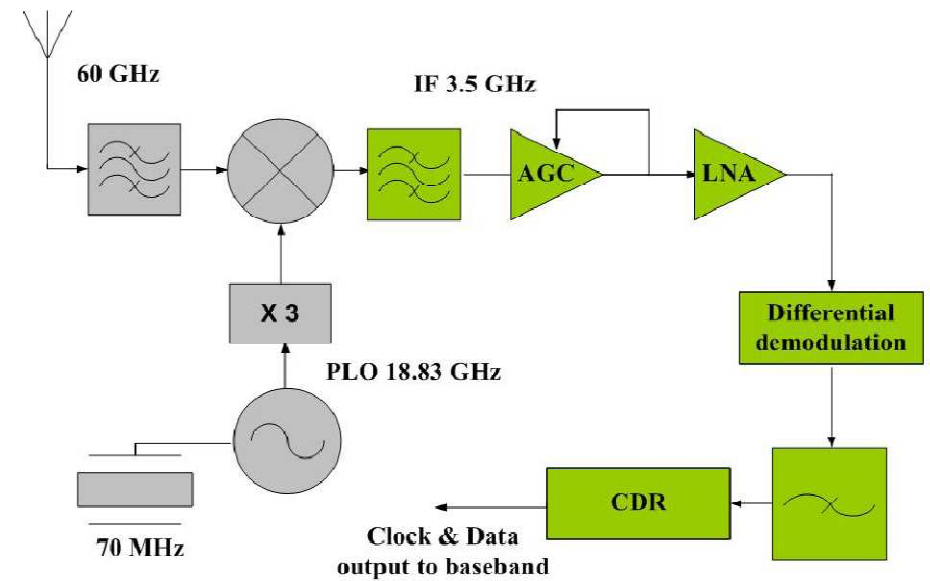
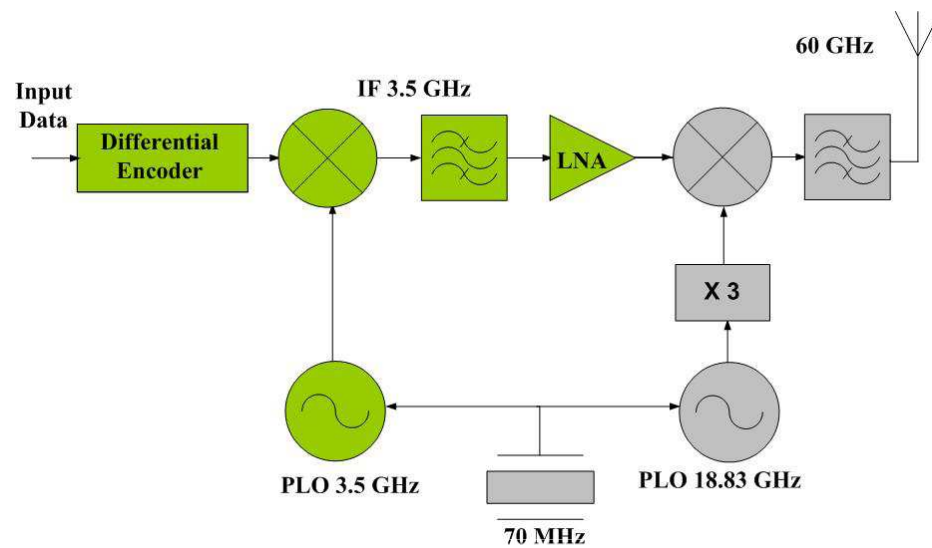


Radio "UP" Time % of Year	Rain Rate (Region F) mm/Hr	Max. Range for BER = 1×10^{-7}
99	0.7	1,496 m
99.9	5.2	1,373 m
99.99	23	1,057 m
99.999	66	825 m

Typical Range Presentation for 5 9s Availability, LT 5 minutes per year outage due to rain! Note 60 GHz, 70/80 GHz 2X to 3X

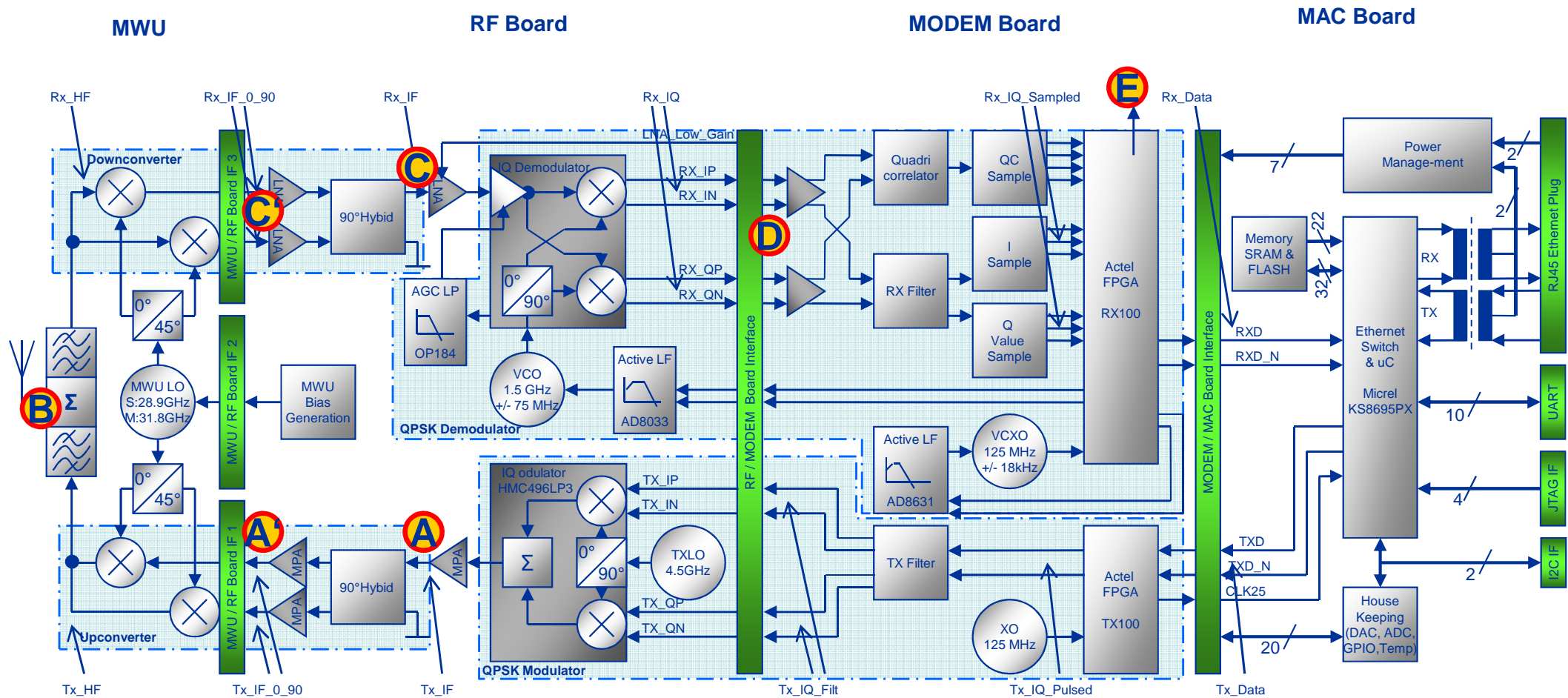


Typical Block Diagram



System Overview

System Architecture (detailed)

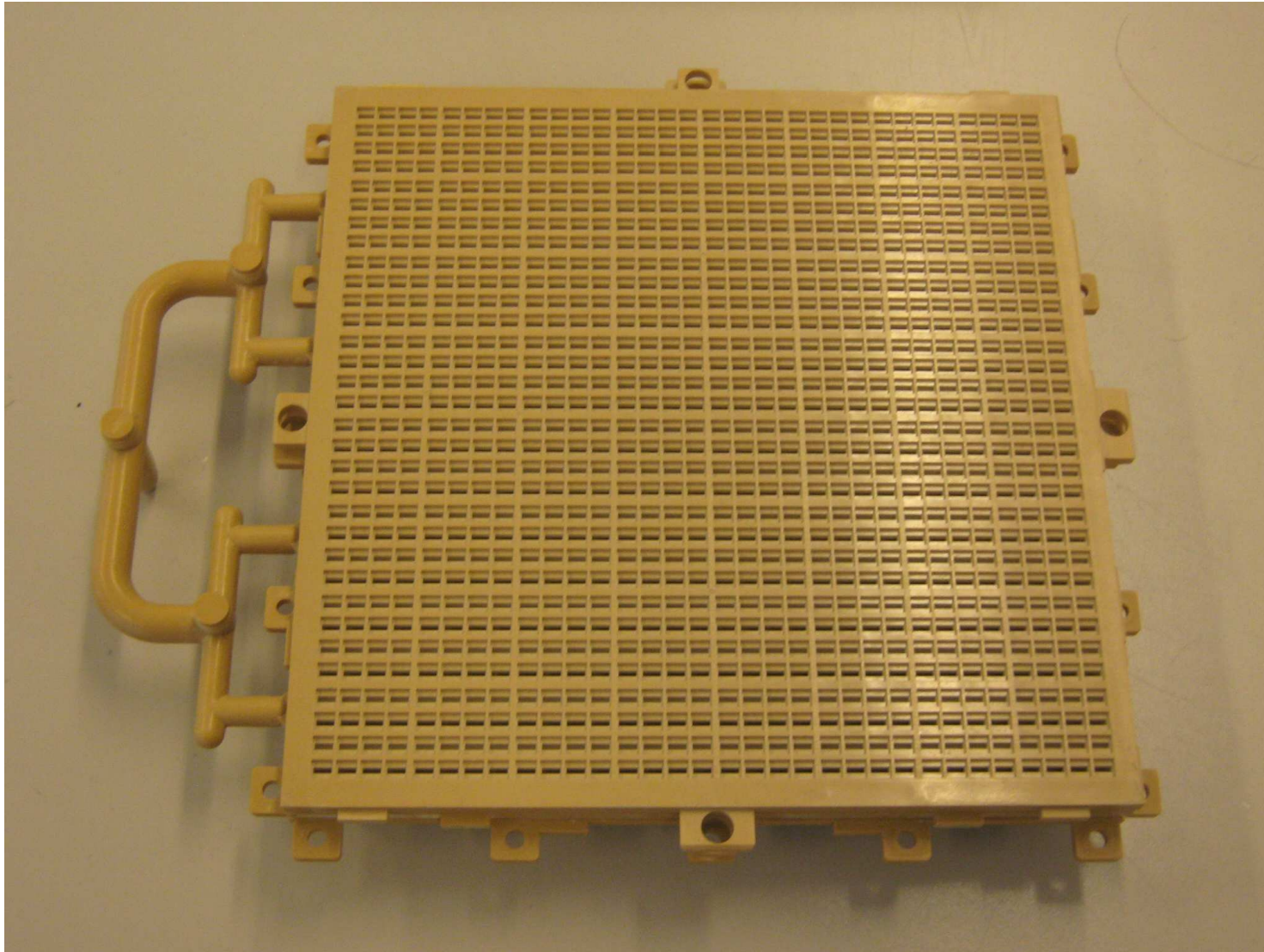


Technology

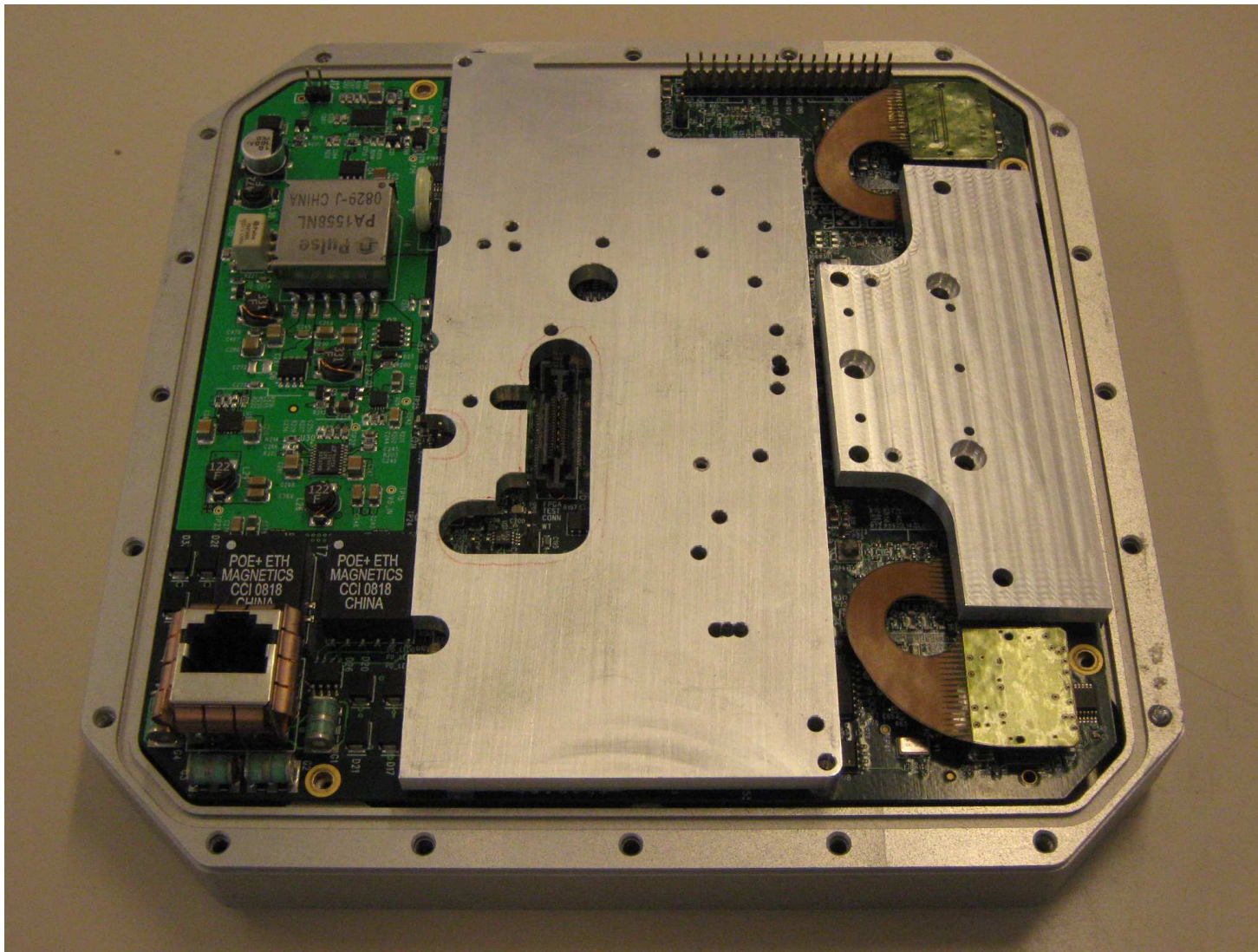
- Antennas are usually reflector types up to 60 cm



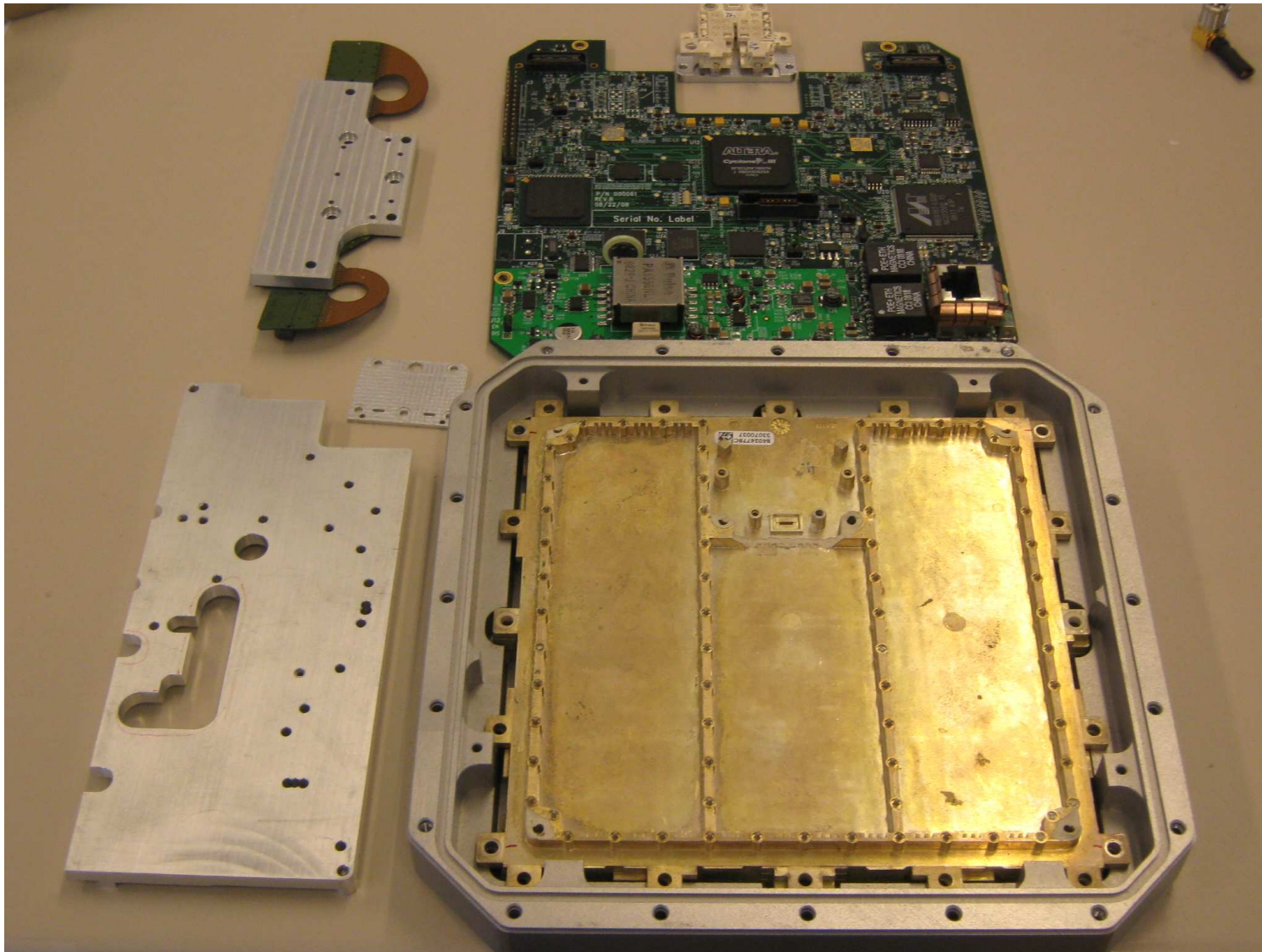
H&S has Pioneered the use of Metalized Plastics Planar Antennas, Highest Performance and Lowest Costs



Radios are Highly Integrated



Integration Continued



Typical Specifications 60, 70/80 GHz

- Power into antenna; +20 dBm
- Antenna Gain; 35 to 50 dBi, 8 to 60 cm
- Antenna beamwidths; 4 to .5 degrees
- Noise figure; 6 dB
- Data rates; 100 Mbs to 1 Gbs, multi Gbs soon
- Interface; Ethernet IP
- Interface; Cat 5/6 and or fiber
- Power; Typical POE or POE +
- Environment; outdoor, -45 to +55 C
- MTBF calculated; 20 + years
- Price; 18 K per link to 5 K per link, quantity dependant
- Management; GUI and SNMP

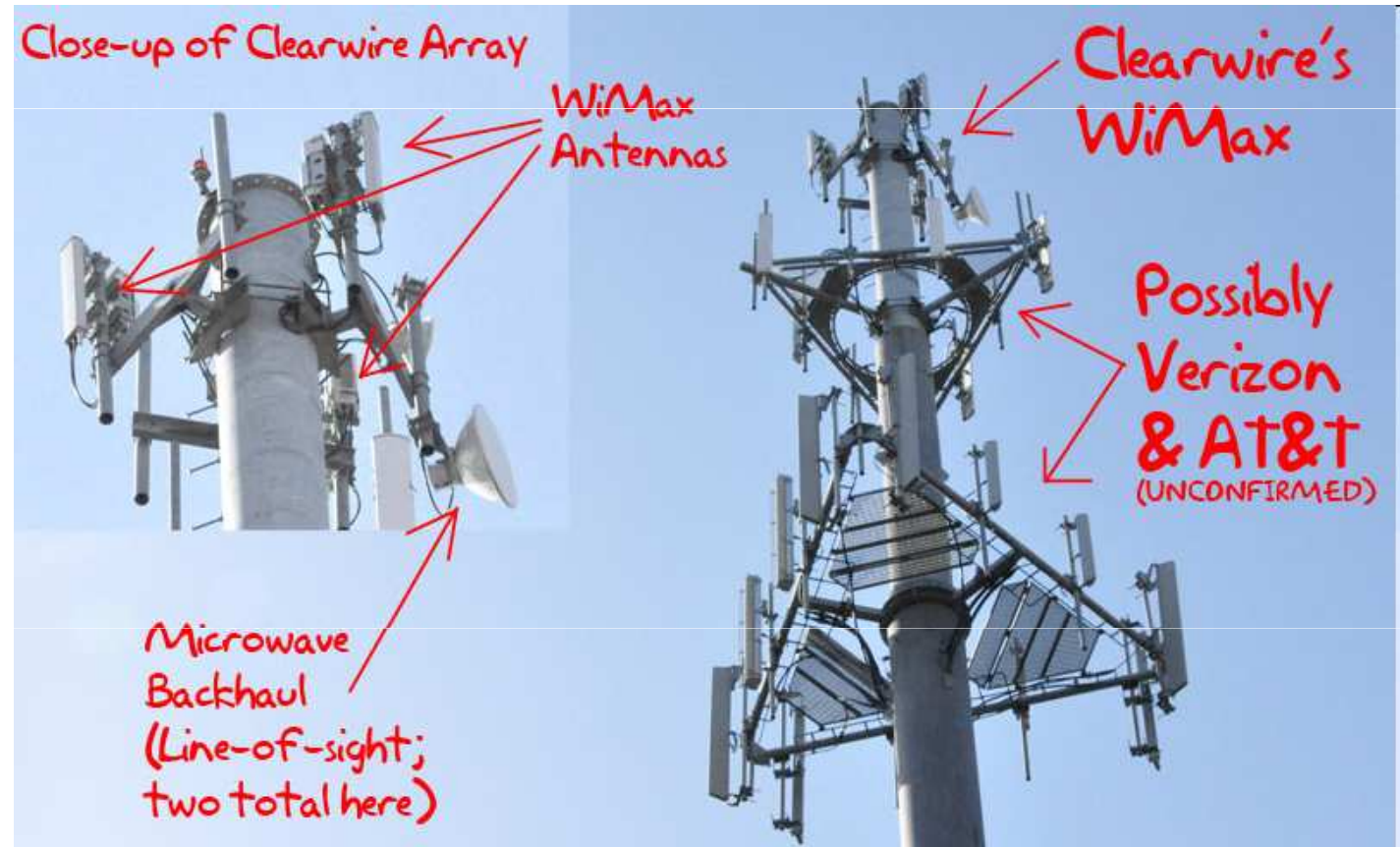
Applications

- Enterprise connectivity
- Video camera connectivity and backhaul
- Backhaul aka cell site connectivity
- Temporary or portable
- Redundancy
 - Fiber
 - Cable
 - FSO
 - Technology

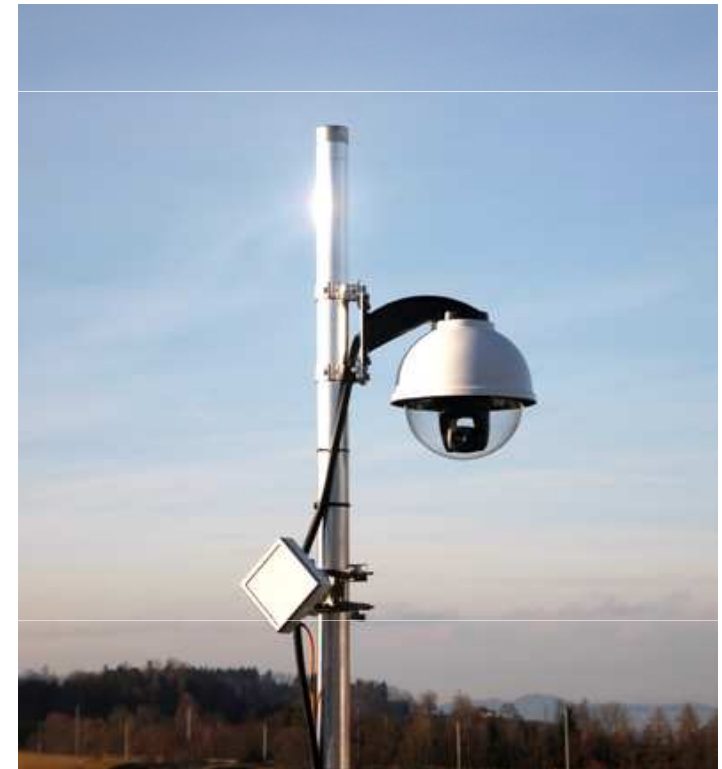
Enterprise



Cellular Backhaul



Video Surveillance



Temporary or Portable

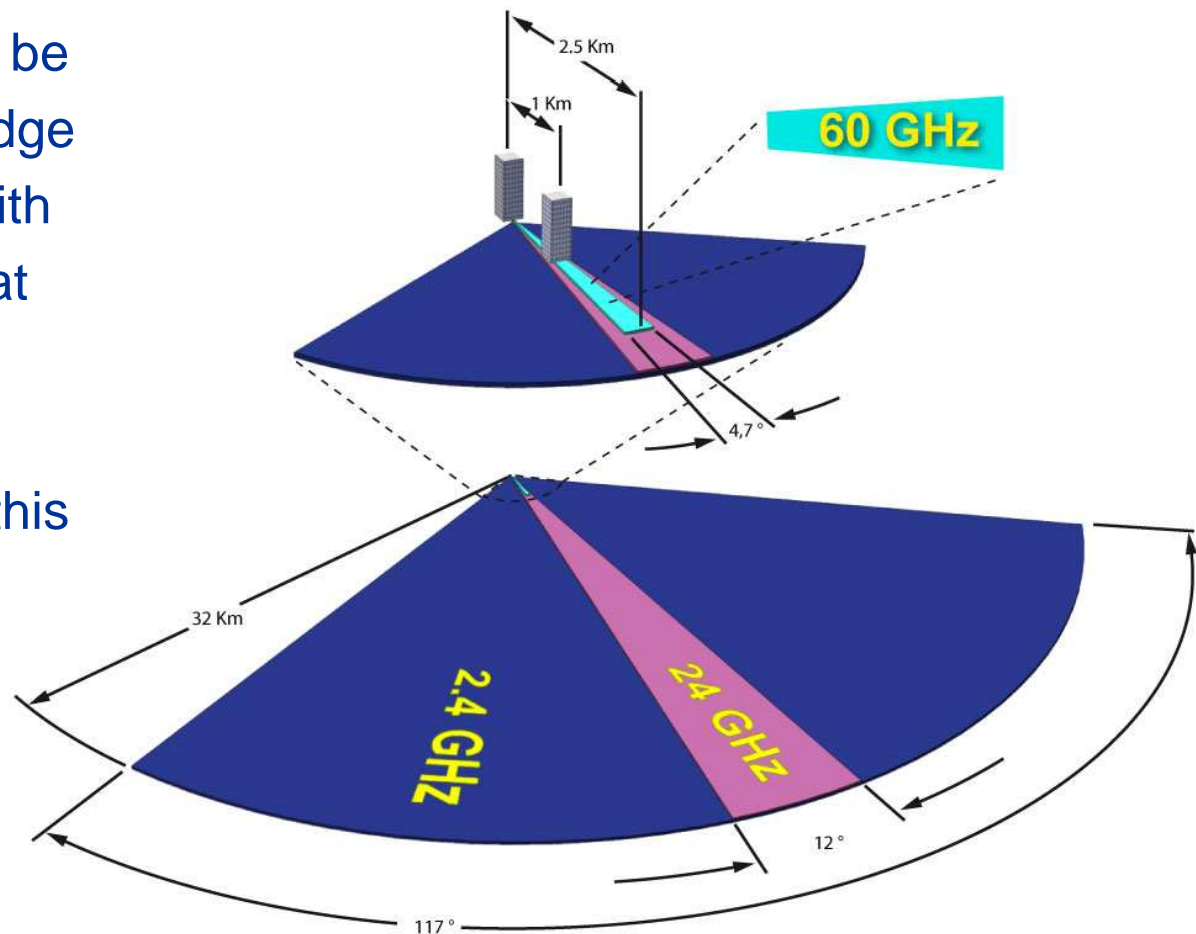


Redundancy to Fiber/Cable and FSO



Antenna Aperture Provides Security aka Spatial

- A 60 GHz signal can only be intercepted in the tiny wedge – and will only interfere with another 60 GHz link in that very wedge.
- With 2.4 GHz or 24 GHz this is quite a different story!



Regulatory Environment

- 57-64 and up to 66 GHz available worldwide unlicensed band
 - Propagation makes it highly unlikely interference will be an issue
 - Antenna beamwidth give further isolation
 - Powers into the antenna at MM Wave frequencies are low, typically +20 dBm into the antenna
 - FCC, Industry Canada, ETSI, Mexico, Japan, Australia etc have written rules allowing deployment
- 71-76 and 81-86 GHz available worldwide on a “light licensed” basis
 - Propagation at 70/80 GHz is similar to 38 GHz in that on a clear dry day it will propagate many Km, thus power control is mandatory
- 94 GHz available in most places where 70/80 GHz is available
 - 1 GHz or less allocated so not as attractive
- 105 and 140 GHz being considered next for 10 Gbs and up

Conclusions

- MM Wave communications is here and now
 - Small start ups initiated it followed by all the major system integrators
- Market is real
 - 50 million year 2009
 - 75 million year 2010
 - 150 million year 2012
 - 750 million year 2015
- For high bandwidth cell 3G and 4 G backhaul, only game in town that competes with fiber bandwidths
- Prices are dropping due to volume and technology
 - \$350 per MMIC 2008 GaAs
 - \$35 per MMIC 2009 SiGe Cmos
 - 3.50 per MMIC 2011 SiGe Cmos 12 in wafer process
- Regulatory environment supportive and consistent

Predictions

10 Gbs by 2011

40 Gbs by 2014

\$4000 per link, at 1 Gbs by 2011-12

\$2500 per link at 2.5 Gbs by 2014-15

60 GHz will not supplant 70/80 GHz and reverse

Market will be large enough for big and small to profit 1.5 B by 2016

J.C Bose will be proven right that one can communicate with plants,
but they may not be from this planet.....

Actual Man Talking to an Alien Plant..... Questions from the Audience?



Thank you

Wayne Pleasant

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