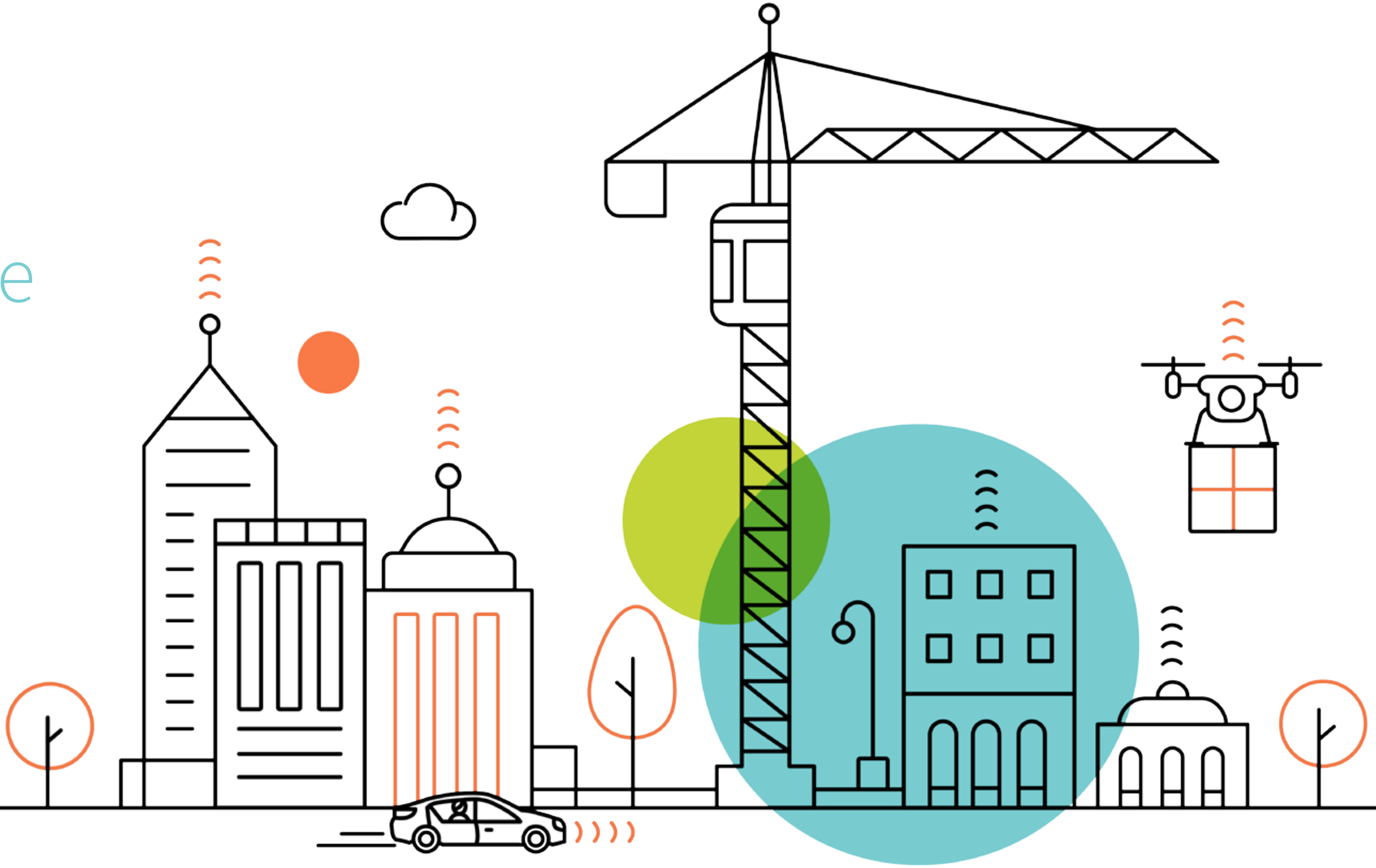
ctia Everything Wireless™

6 GHz VLP Interference



July 2020

RKF Link Budget Equation

- $I = EIRP + G_{FarField} - L_{PropagationPath} - L_{SpectralOverlap} - L_{Polarization} - L_{feed} + G_{Rx\text{-}to\text{-}VLP}$
  - I (dBW) = Interference Power from VLP (aggregate or single-entry (i.e., due to single VLP device))
  - EIRP (dBW) = VLP EIRP within VLP channel bandwidth (baseline: 14 dBm)
  - $G_{FarField}$ (dB) = VLP far field gain that includes body loss
  - $L_{PropagationPath}$ (dB) = Propagation Path loss including Clutter loss
  - $L_{SpectralOverlap}$ (dB) = 10*log10(spectrum overlap between VLP channel and victim channel / VLP bandwidth), also called frequency-dependent rejection.
  - $L_{polarization}$ = Polarization Loss of 3 dB
  - L_{feed} (dB) = Feederloss of victim receiver
  - $G_{Rx\text{-}to\text{-}VLP}$ (dBi) = Gain of victim FS Rx towards VLP based on the angle off-boresight

$G_{FarField}$ includes body loss, but also includes antenna mismatch and polarization mismatch

- The CDF chart RKF used for antenna gain combined with body loss was based on measured data collected by Wireless Research Center of North Carolina.
- Data was measured over the full sphere surrounding test subjects, and thus any antenna mismatch is built into these measurements.
- Polarization is impacted by the body as well, so polarization mismatch is built into these measurements. Using additional polarization mismatch would be double counting.

$G_{FarField}$ is based on measured data

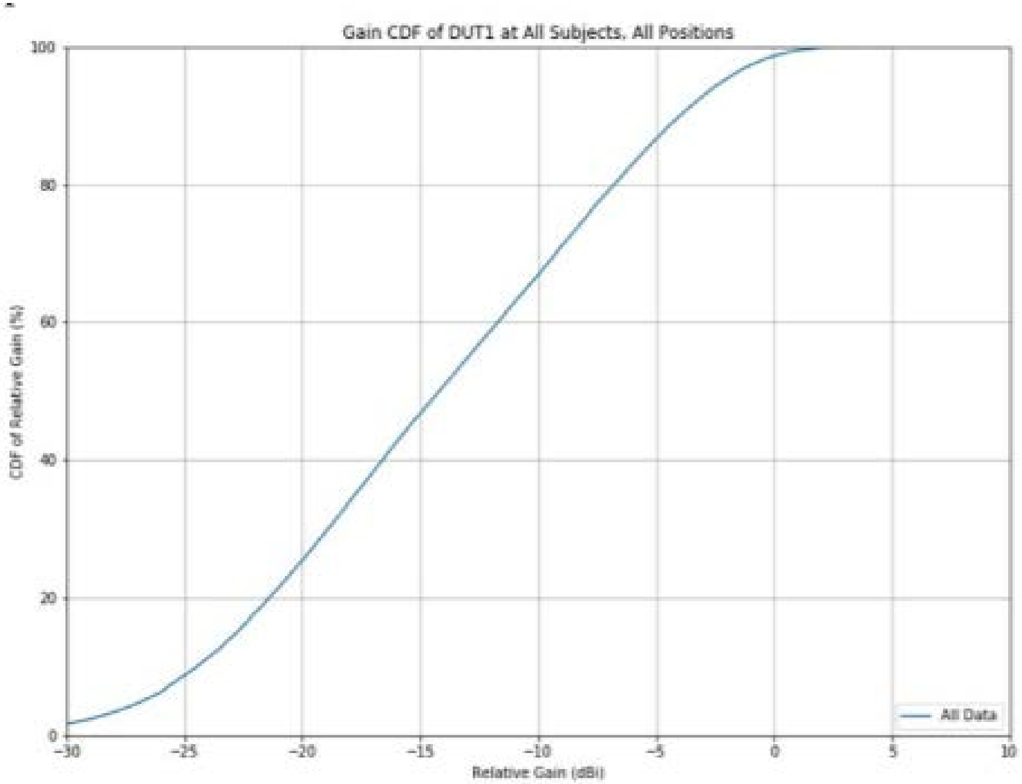


Figure 26 - Gain CDF of DUT1 for all 6 Subjects and 6 Positions

From Wireless Research Center of North Carolina

- Measured over the full sphere surrounding subject wearing a VLP device
- Measurement of this data captures several different loss factors and combines into a single CDF
  - Captures RLAN antenna gain
  - Captures body loss
  - Captures polarization mismatch

$L_{PropagationPath}$ – for real-world examples

- RKF uses WINNER II, including built-in clutter loss for distances between 30m and 1km.
- Real-world examples show scenarios where there is no clutter, no obstructions, no terrain.
- Free space path loss is appropriate in these examples.

Constant variables in link budget

- $L_{SpectralOverlap}$ (dB) = 7.3 dB; For a 30 MHz FS channel, and a 160 MHz VLP channel
- $L_{polarization}$ = 0 dB; As previously noted, polarization mismatch is built into $G_{FarField}$
- L_{feed} = 2 dB; same as used by RKF

Real-world conditions show VLP interference

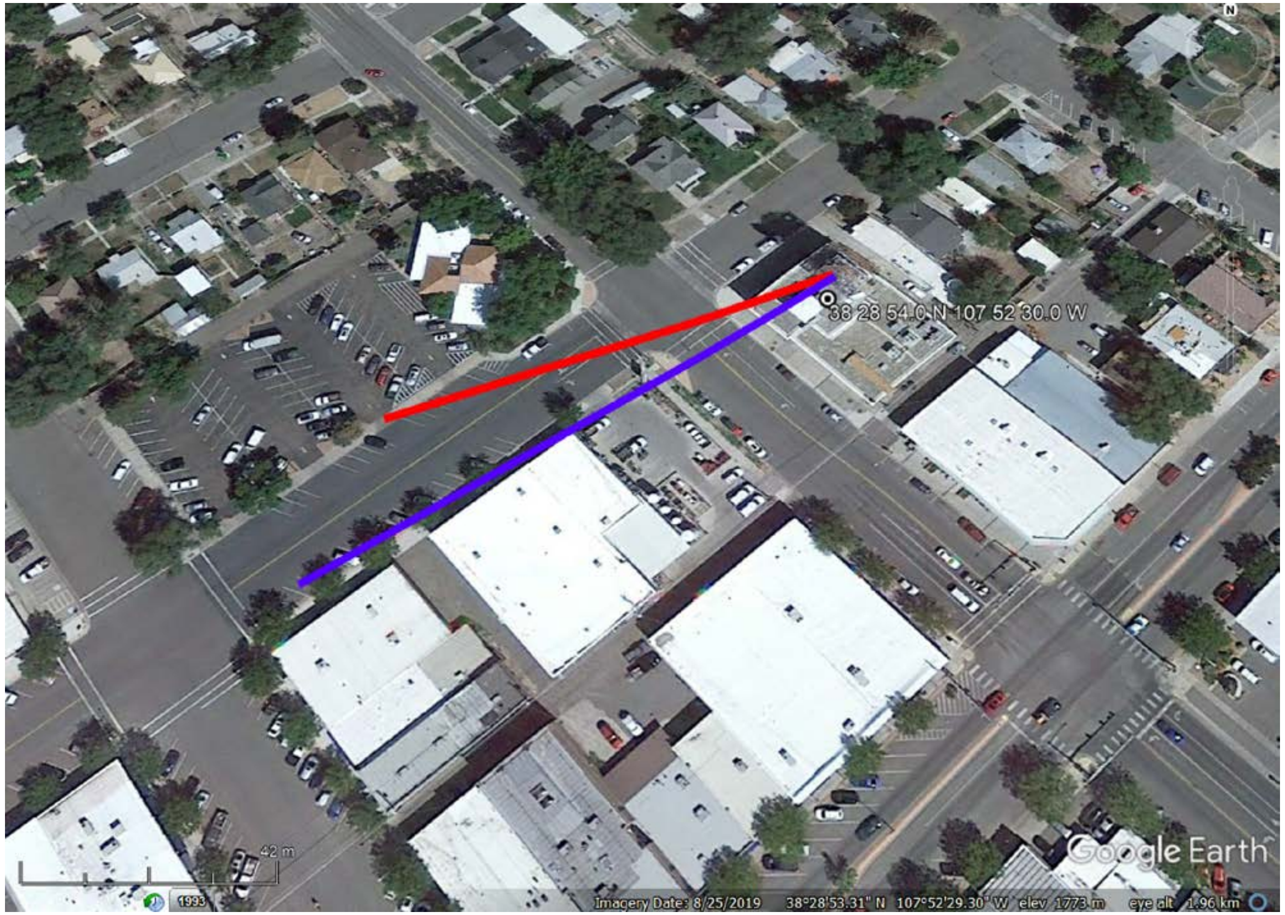
	RKF	KAN32	KAX33	KBC41	KBI49	KCA76	Units	Formula
RLAN Bandwidth	160	160	160	160	160	160	MHz	a
Maximum RLAN Power	14	14	14	14	14	14	dBm	b
Body Loss / RLAN Antenna Mismatch	CDF from Wireless Research Center of North Carolina						dB	c
Feeder/System Loss	-2	-2	-2	-2	-2	-2	dB	d
Polarization Mismatch	-3	Included in CDF from Wireless Research Center of North Carolina					dB	e
FS Antenna Height AGL		26.8	39.6	21.3	38.1	28.9	m	g
RLAN Device Height AGL		1	1	1	1	1	m	h
FS-RLAN Distance (slant)		103.3	113.7	102.0	118.0	79.1	m	i
Degrees to FS		15	20	10	30	20	degrees	j
FS Antenna Model		Western Electric KF15676	Gabriel USR 10P	Western Electric KS15676	Andrew UHX8-59H	CommScope UHX10-59K		
FS Gain		-9.5	-9	-2.5	-4.7	-9	dB	k
Prop. Loss (FSPL)		88.4	89.6	88.4	89.9	86.2	dB	l = 32.45 + 20*log(f) + 20*log(i/1000)
Bandwidth Adjustment 160/30 MHz	*7.3*	*7.3*	*7.3*	*7.3*	*7.3*	*7.3*	*dB*	m = 10*log(160/30)
RLAN Interference at FS Receiver (30 MHz)		*-93.2*	*-93.9*	*-86.2*	*-89.8*	*-90.5*	*dBm*	n = b + c +d + e + k - l - m
FS Noise Figure	*5.0*	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*	*dB*	o
FS System Noise Floor in 30 MHz	*-94.2*	*-96.2*	*-96.2*	*-96.2*	*-96.2*	*-96.2*	*dBm*	p = -174 + o + 10*log(30000000)
TOTAL I/N		3.0	2.3	10.1	6.4	5.8	dB	q = n - p
Interference Exceedance		9.0	8.3	16.1	12.4	11.8	dB	r = q + 6

Notes:

1. Four of the five sites have ultra high performance FS antennas. FS sites with standard performance antennas would experience higher interference.
2. The I/N calculated in this table is for a VLP device that is not body worn – full distributions that include the body loss CDF are shown in slides below.

Unlicensed VLP devices will cause interference at all of the sites assessed by CTIA.

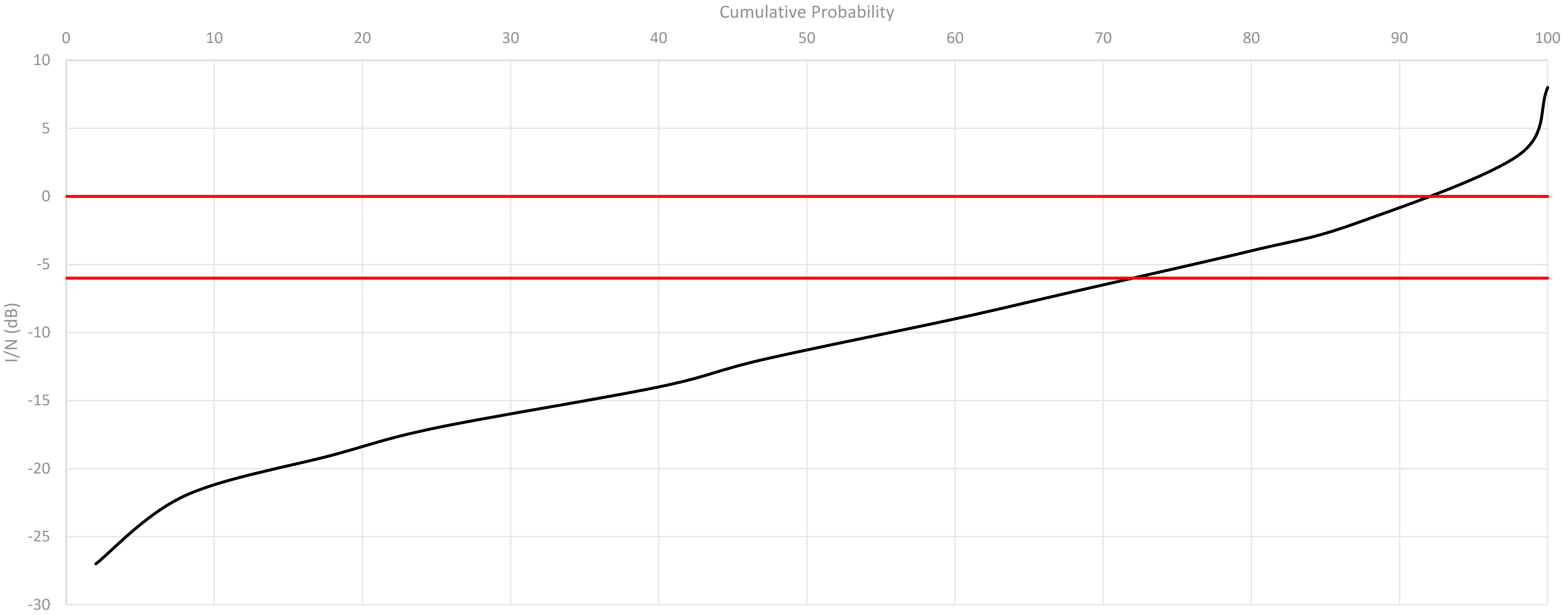
KAN32



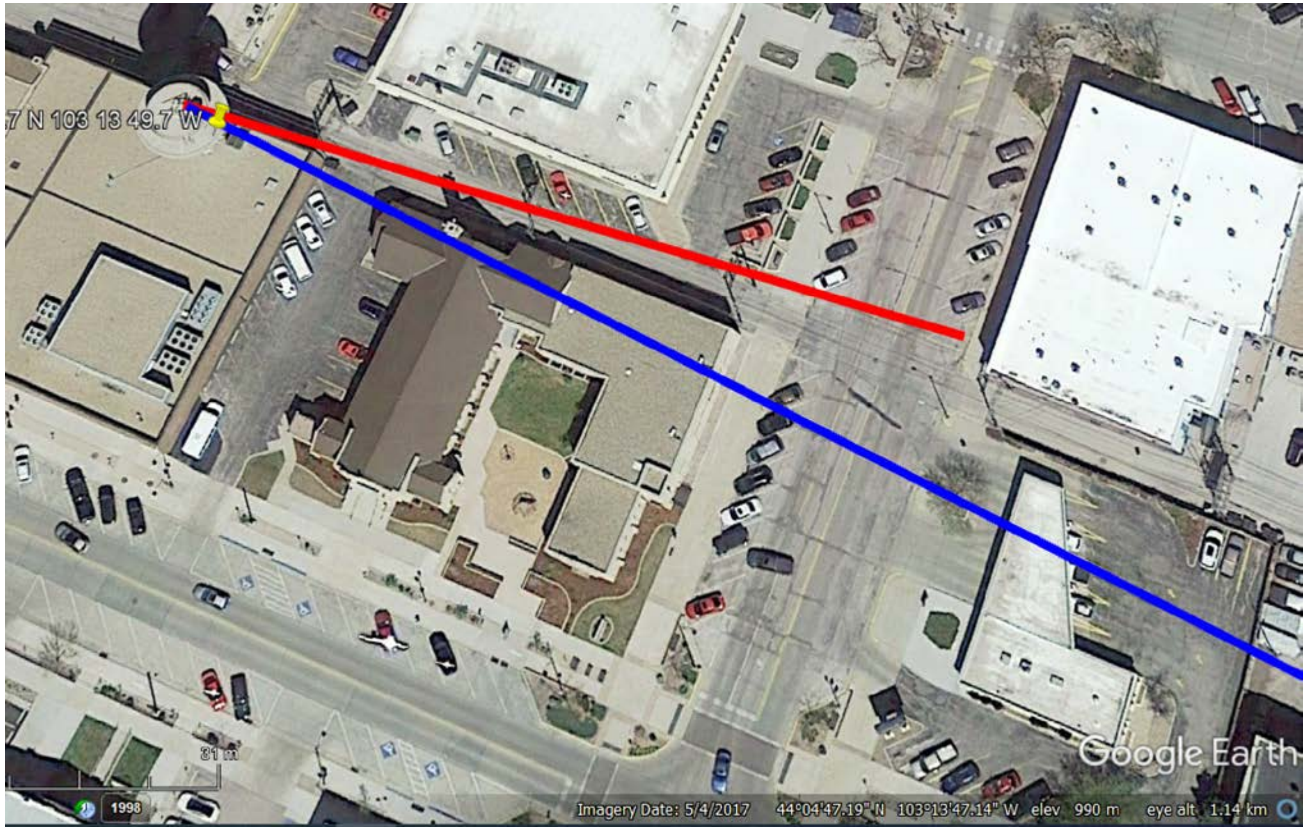
View of site from interfering location

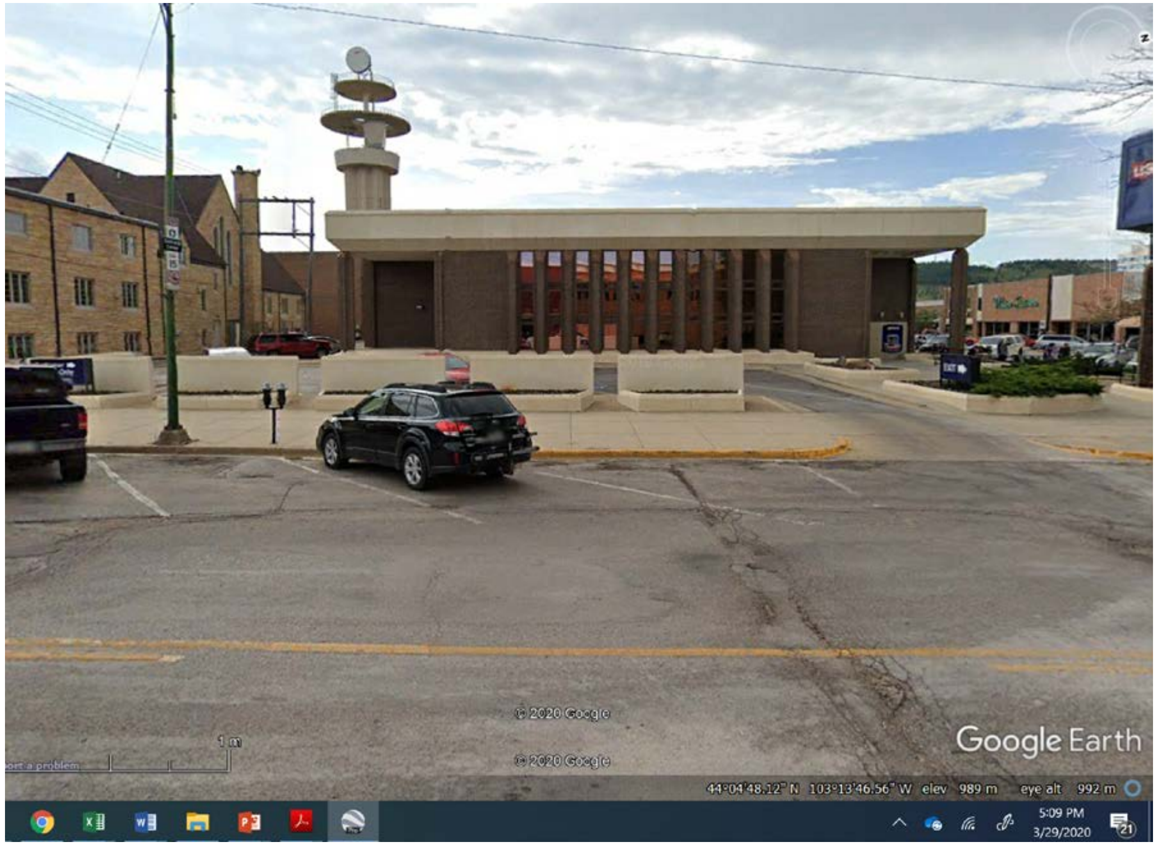
- Blue line: microwave antenna centerline
- Example: Red line is 103 m to a pedestrian with a Personal Area Network (clearly no clutter, foliage, or terrain obstructions)
- I/N = -6 dB threshold exceeded with 28% probability; I/N = 0 dB threshold exceeded with 8% probability

CDF for KAN32



KAX33

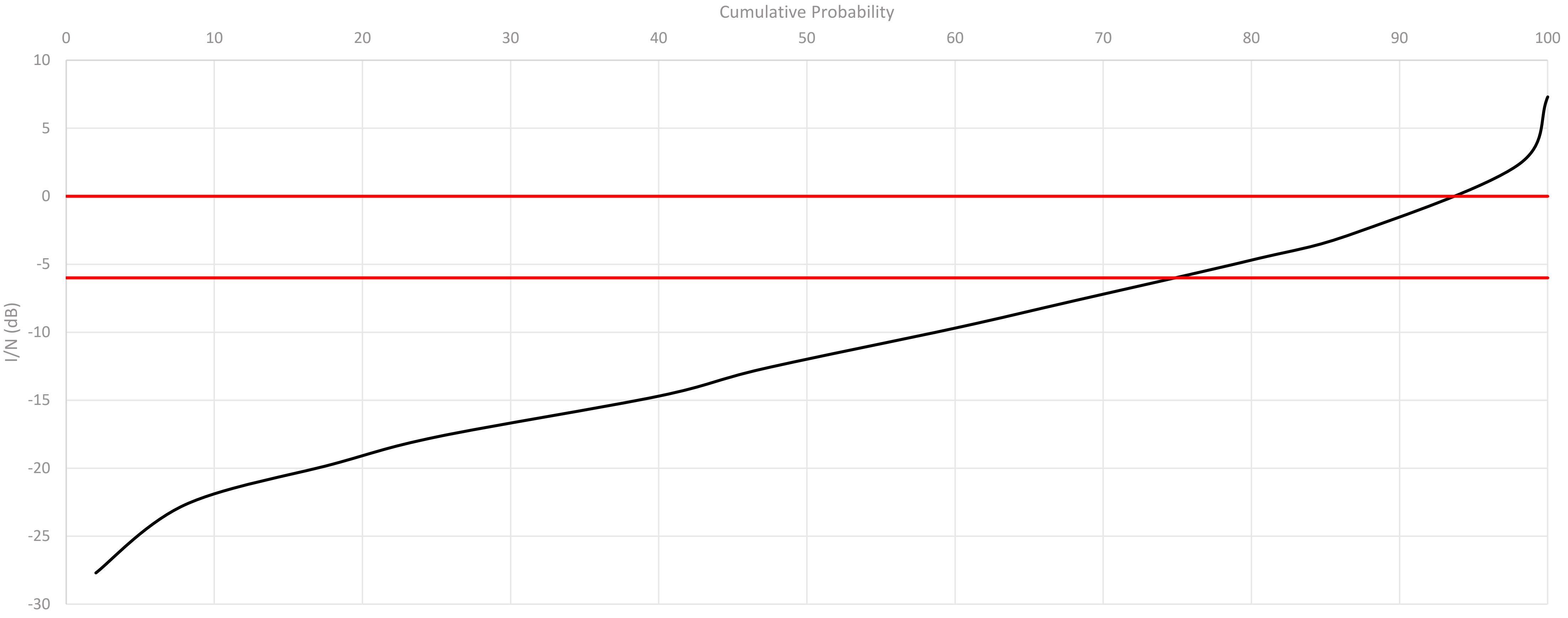




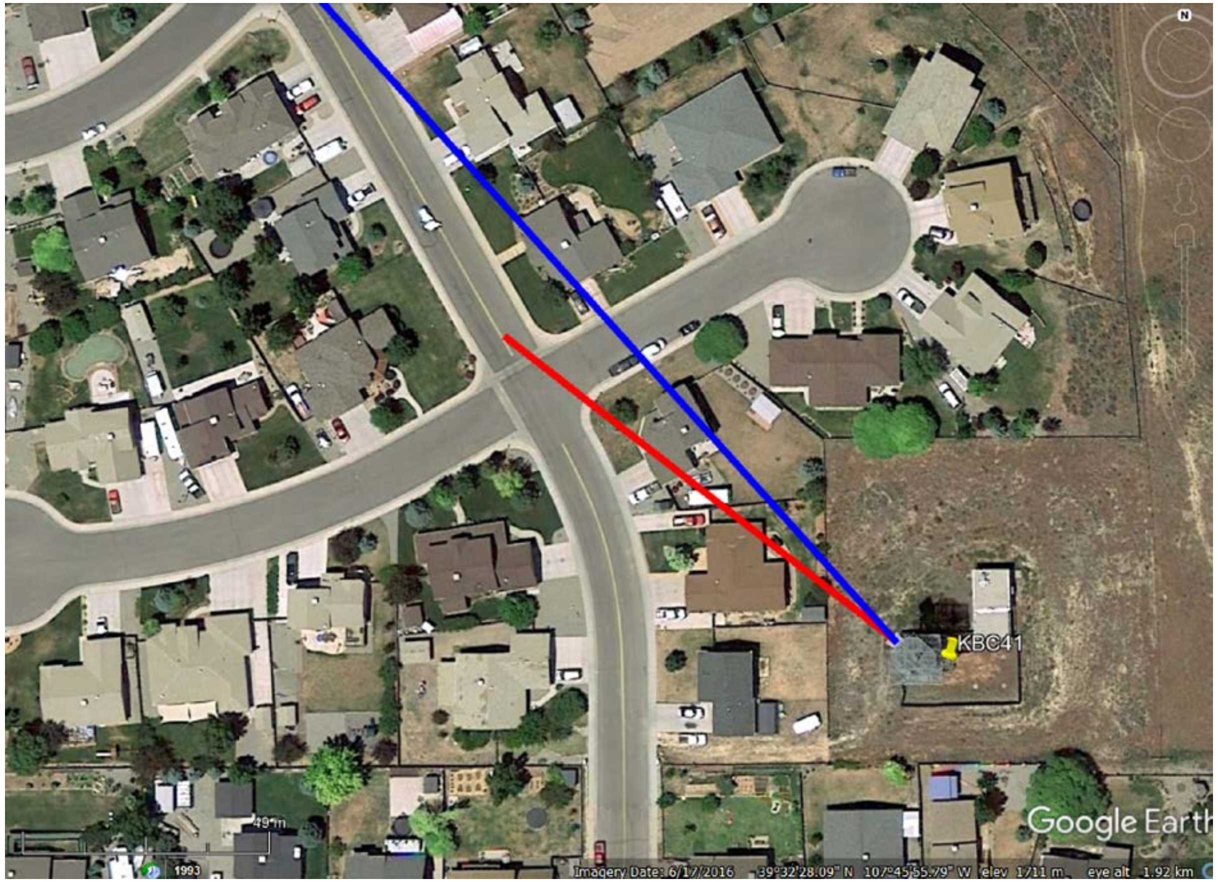
View of site from interfering location

- Blue line: microwave antenna centerline
- Example: Red line is 114 m to a pedestrian with a PAN (clearly no clutter, foliage, or terrain obstructions)
- I/N = -6 dB threshold exceeded with 26% probability; I/N = 0 dB threshold exceeded with 7% probability

CDF for KAX33



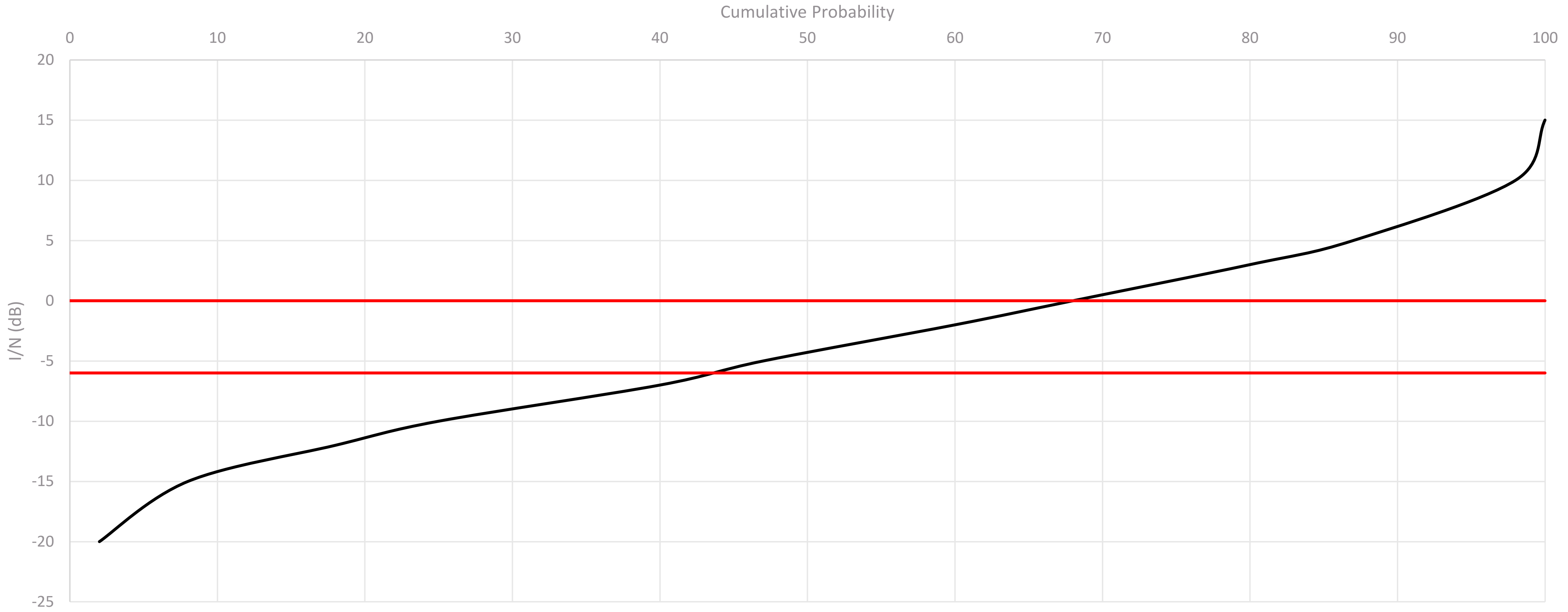
KBC41



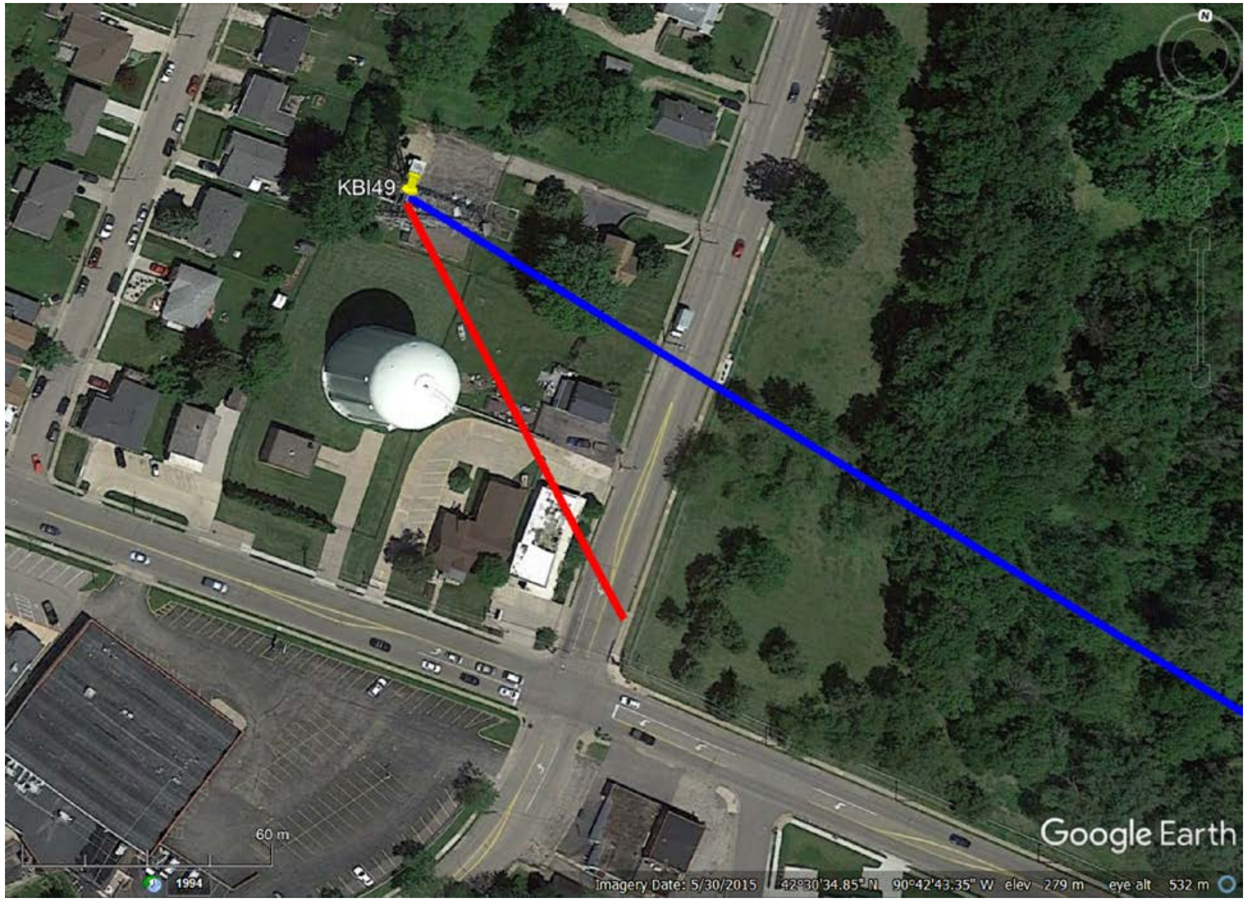
View of site from interfering location

- Blue line: microwave antenna centerline
- Example: Red line is 102 meters to a pedestrian using a PAN (clearly no clutter, foliage, or terrain obstructions)
- I/N = -6 dB threshold exceeded with 57% probability; I/N = 0 dB threshold exceeded with 32% probability

CDF for KBC41



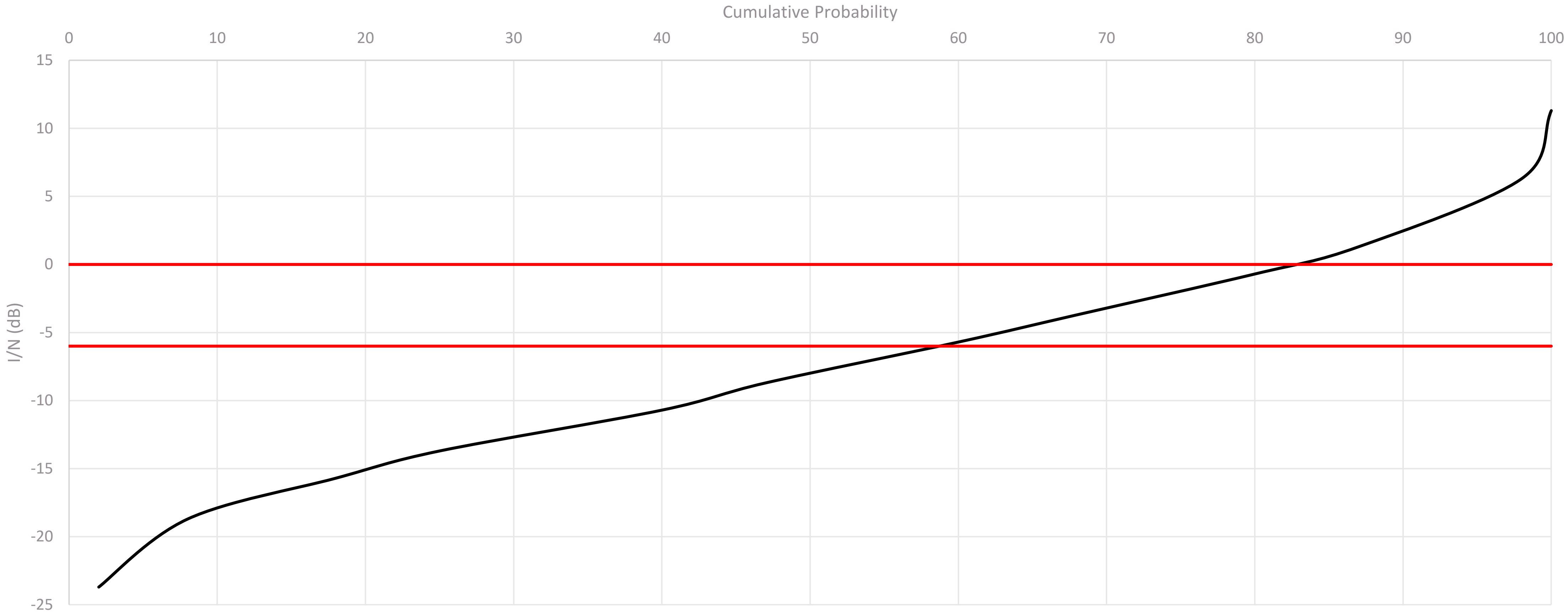
KBI49



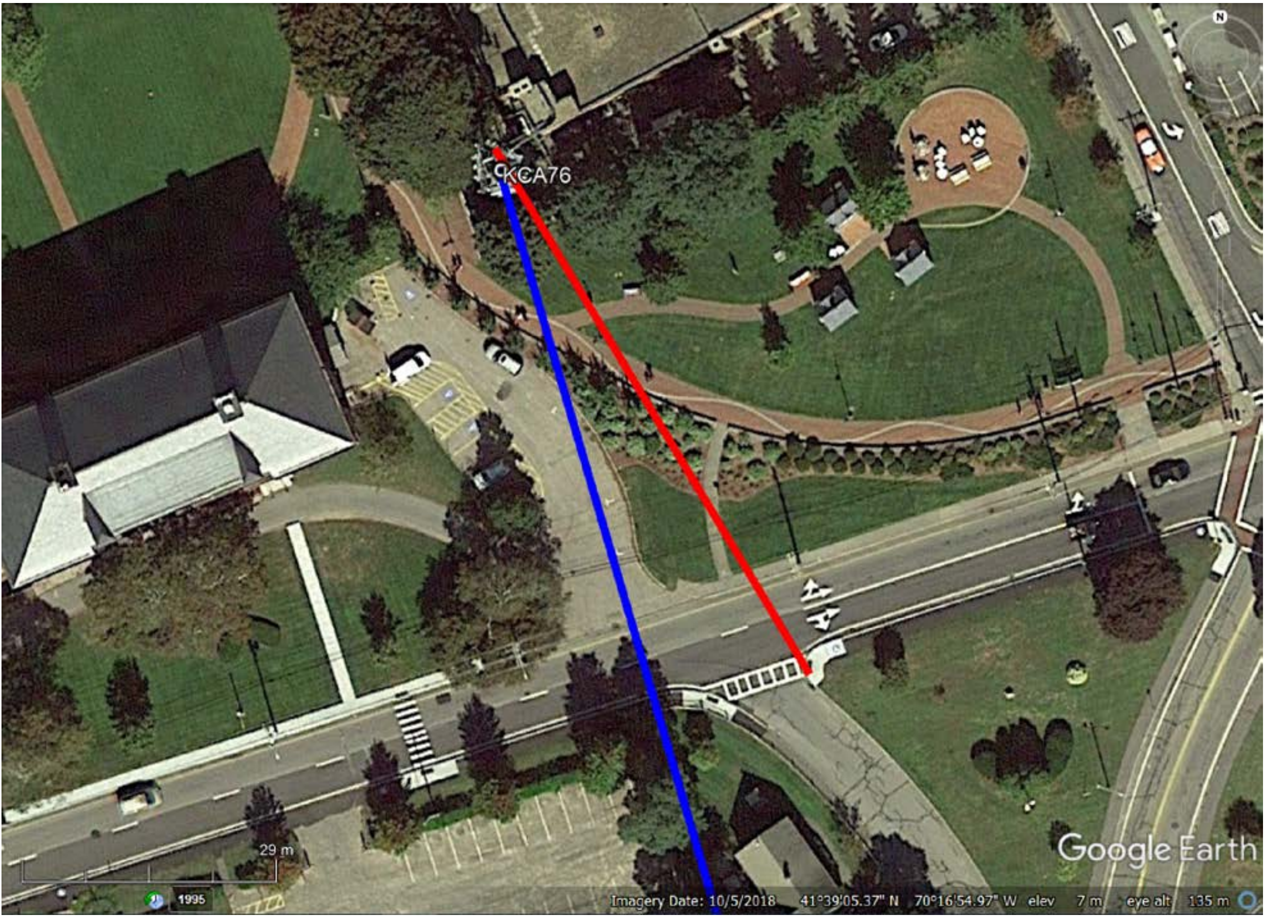
View of site from interfering location

- Blue line: microwave antenna centerline
- Example: Red line is 118 meters to a pedestrian using a PAN (clearly no clutter, foliage, or terrain obstructions)
- I/N = -6 dB threshold exceeded with 42% probability; 0 dB threshold exceeded with 17% probability

CDF for KBI49



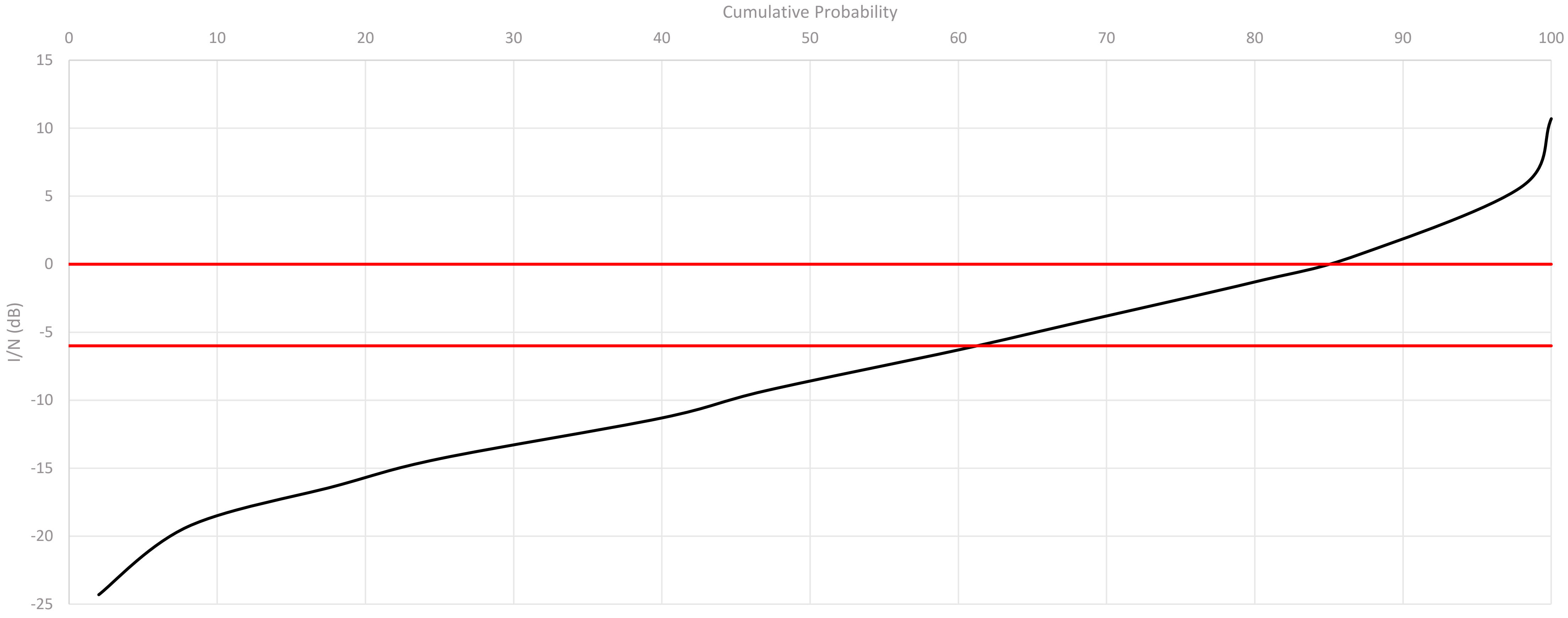
KCA76



View of site from interfering location

- Blue line: microwave antenna centerline
- Example: Red line is 79 meters to a pedestrian using PAN (clearly no clutter, foliage, or terrain obstructions)
- I/N = -6 dB threshold exceeded with 38% probability; I/N = 0 dB threshold exceeded with 15% probability

CDF for KCA76

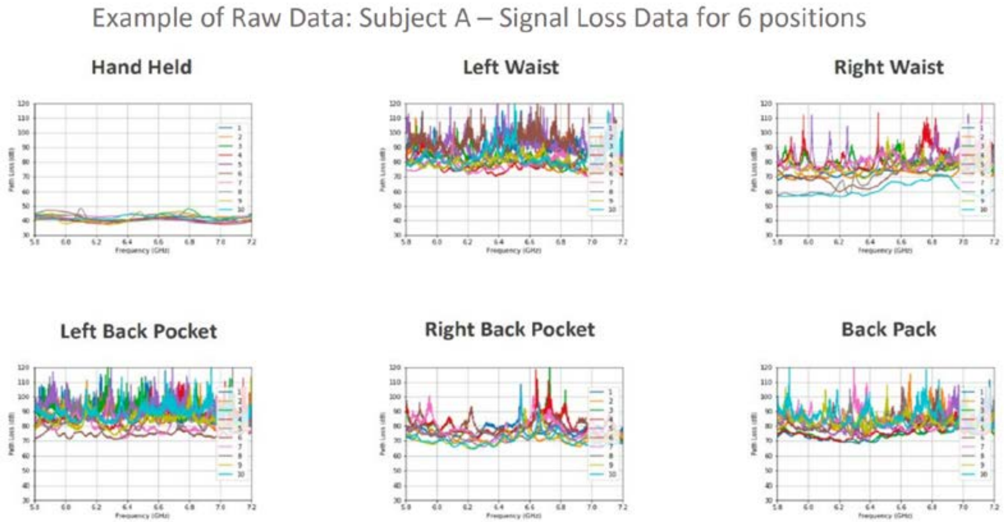


RLANs admit VLP will consistently require 14 dBm EIRP

- The RLAN filing on 03182020, advocating for a VLP EIRP of 14 dBm, admits that this power level will be required regularly.
- This clearly contradicts the RLAN claims in interference studies – that power control will greatly reducing interference to incumbents.
- For example, a device in the right or left back pocket, experiencing considerable body loss to the glasses, can have a line-of-sight condition to an FS receiver – as in the situations we assess above.

RLAN March 18, 2020 Filing: VLP Losses Require 14 dBM

Figure 3:



VLP interference to FS receiver in line-of-sight

Device in right rear pocket

Single-emitter link budget analysis is appropriate

- RKF's Monte Carlo analysis states that most cases where interference threshold is exceeded is caused by a single device.
- Monte Carlo techniques are more suited to situations with a large number of inputs, such as an aggregation of interference from multiple devices.
- The single link budget for these five examples shows that interference from the single device is likely.
- If the Monte Carlo analysis predicts levels of aggregate interference less than levels from a single interfering device in these real-world examples, then the input assumptions used in the Monte Carlo analyses are probably skewed to attempt to minimize predicted interference levels.

Summary

- RLAN stakeholders used overly optimistic assumptions regarding VLP transmit power, which will result in significant interference to Fixed Service incumbents.
- All five locations assessed by CTIA would experience interference levels well above the threshold of -6 dB I/N.
- VLP devices could readily be equipped with an AFC – managed through their controlling device or smartphone – and adequately protect incumbents.
- If the RLAN companies are unwilling to take the simple precaution of an AFC, then VLP must be limited to a maximum transmit power of -10 dBm EIRP.