JONES DAY

51 LOUISIANA AVENUE, N.W. • WASHINGTON, D.C. 20001.2113

TELEPHONE: +1.202.879.3939 • FACSIMILE: +1.202.626.1700

DIRECT NUMBER: (202) 879-3630
BOLCOTT@JONESDAY.COM

June 16, 2016

VIA ELECTRONIC FILING

Marlene H. Dortch
Secretary
Federal Communications Commission
445 12th Street S.W.
Washington D.C. 20554

Re: Oral *Ex Parte* Notice
GN Docket No. 14-177, IB Docket Nos. 15-256 and 97-95;
RM-11664; and WT Docket No. 10-112

Dear Ms. Dortch:

On June 14, 2016, representatives of The Boeing Company ("Boeing") met with Edward "Smitty" Smith, legal advisor to Chairman Thomas Wheeler, to discuss the above-referenced proceeding and, more specifically, the significant potential for co-primary spectrum sharing between the proposed Upper Microwave Flexible Use ("UMFU") service and next-generation broadband satellite communications systems in the 37.5-40.0 GHz band. Participating on behalf of Boeing were Bruce Chesley, Jeff Trauberman, Carlos Nalda, and the undersigned. The discussion tracked closely with the attached presentation.

Thank you for your attention to this matter. Please contact the undersigned if you have any questions.

Sincerely,

Bruce A. Olcott
Counsel to The Boeing Company

Attachments

V-band Satellite and Terrestrial Spectrum Sharing: Statistical Analysis

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Recent Activities Conducted

- **Technical interaction with multiple 5G operators and suppliers**
  - Review of sharing and interference analyses
  - Technical discussions of link budget assumptions, 5G system goals, and 5G beamforming approaches
- **Statistical modeling of satellite – 5G interference**
  - Generic 5G system model similar to other analyses
  - Results are consistent with prior analysis
    - Satellite interference into terrestrial system is minimal at ITU PFD levels
    - 5G interference into satellites remains the closest scenario
  - Further work is required
- **Second Meeting With FCC Staff on Technical Findings (June 2)**

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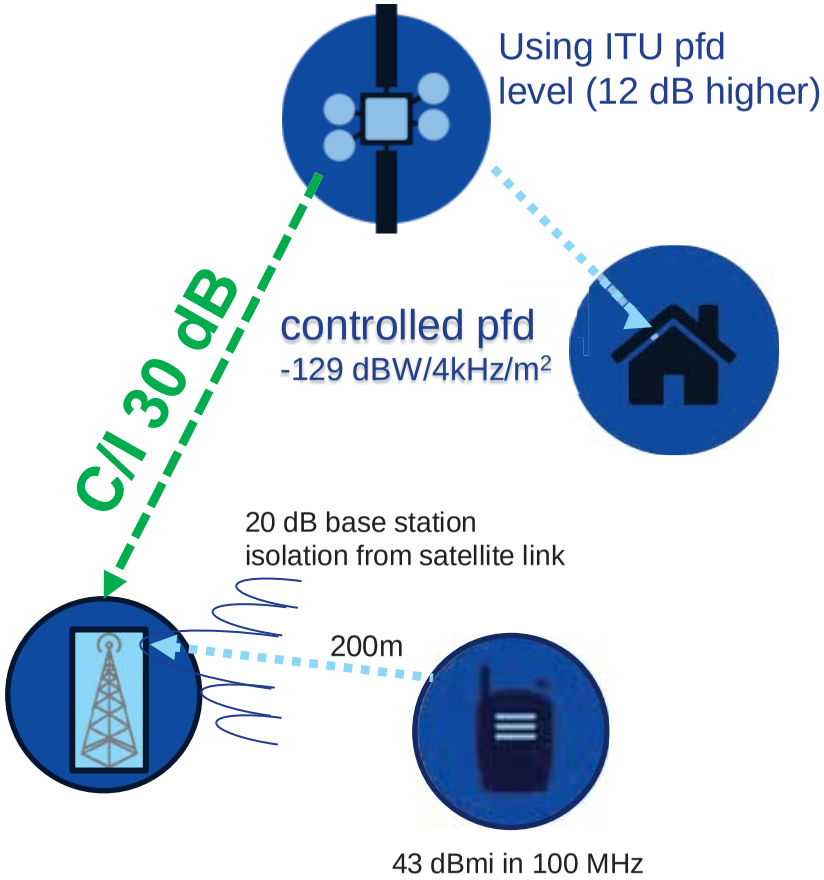
Satellite Operations and 5G Receivers Mobile to Base Station Link (Return)

Boeing Satellite Systems

- **5G performance impacted < 0.2 dB using higher ITU operating limit**

Mobile Handsets to Base Station		
5G Mobile EIRP	43.0	dBm
Mobile to Base Station Distance	200.0	m
Mobile to Base Station Path Loss[1]	141.2	dB
Transmit Bandwidth	100.0	MHz
5G Mobile PFD at Base Station	-118.9	dBW/4kHz/m^2
Satellite PFD at Base Station	-129.0	dBW/4kHz/m^2
5G Base Station Rx Isolation	20.0	dB
C/I due to Satellite Interference	30.1	dB
Rx Gain at 5G Base Station [2]	27.0	dB
5G Received Power at Base Station	-71.2	dBm
Received Noise Power	-87.0	dBm
5G Return Link C/N	15.8	dB
5G Return Link C/(I+N)	15.6	dB
Interference Degradation	0.16	dB
Interference to Noise ratio, I_{SAT}/N_{5G}	-14.3	dB
	3.7	%



[1]Rappaport, Theodore; Ben-Dor, Eshar; Murdock, James N.; Qiao, Yijun, "38 GHz and 60 GHz Angle-dependent Propagation for Cellular & Peer-to-Peer Wireless Communications." IEEE ICC 2012 - Wireless Communications Symposium.
[2]Fox, R.; Kung, A; "Comments of Straight Path Communications, Inc." Petition for Rulemaking of the Fixed Wireless Communications Coalition to Create Service, RM-11664, January 5, 2015.

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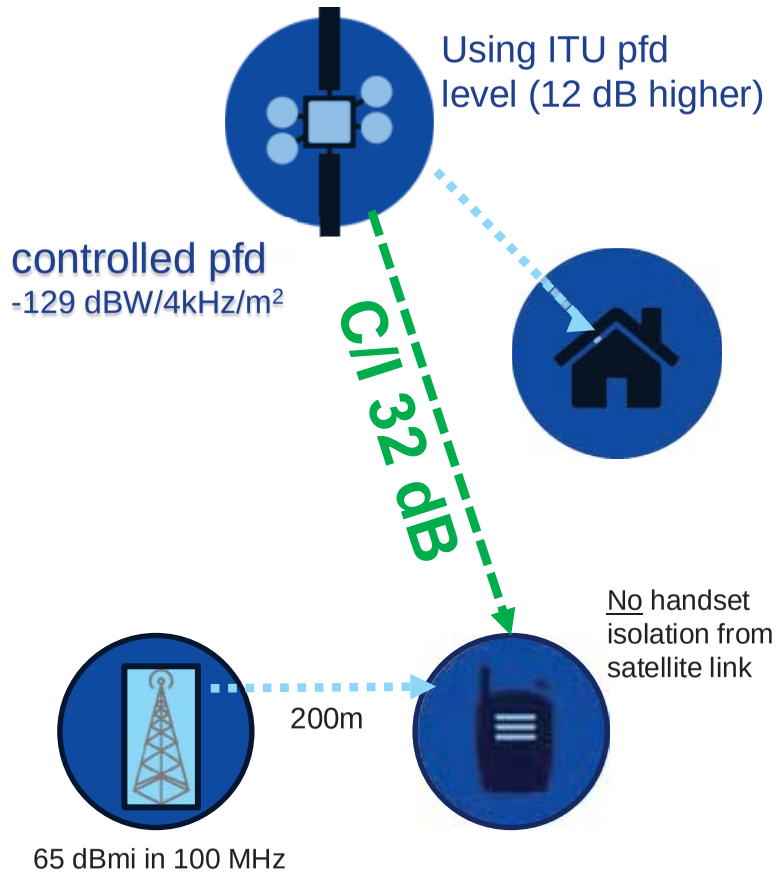
Satellite Operations into 5G Users Base Station to Mobile Link (Forward)

Boeing Satellite Systems

- **5G Performance impacted < 0.6 dB using higher ITU operating limit**

Base Station to Mobile Handsets		
5G Base Station EIRP	65.0	dBm
Mobile to Base Station Distance	200.0	m
Mobile to Base Station Path Loss[1]	141.2	dB
Transmit Bandwidth	100.0	MHz
5G Base Station PFD at Mobile	-96.9	dBW/4kHz/m^2
Satellite PFD at Mobile	-129.0	dBW/4kHz/m^2
5G Mobile Rx Isolation	0.0	dB
C/I due to Satellite Interference	32.1	dB
Rx Gain at 5G Mobile[2]	13.0	dB
5G Received Power at Mobile	-63.2	dBm
Received Noise Power	-87.0	dBm
5G Forward Link C/N	23.8	dB
5G Forward Link C/(I+N)	23.2	dB
Interference Degradation	0.60	dB
Interference to Noise ratio, I_{SAT}/N_{5G}	-8.3	dB
	14.9	%



[1]Rappaport, Theodore; Ben-Dor, Eshar; Murdock, James N.; Qiao, Yijun, "38 GHz and 60 GHz Angle-dependent Propagation for Cellular & Peer-to-Peer Wireless Communications." IEEE ICC 2012 - Wireless Communications Symposium.
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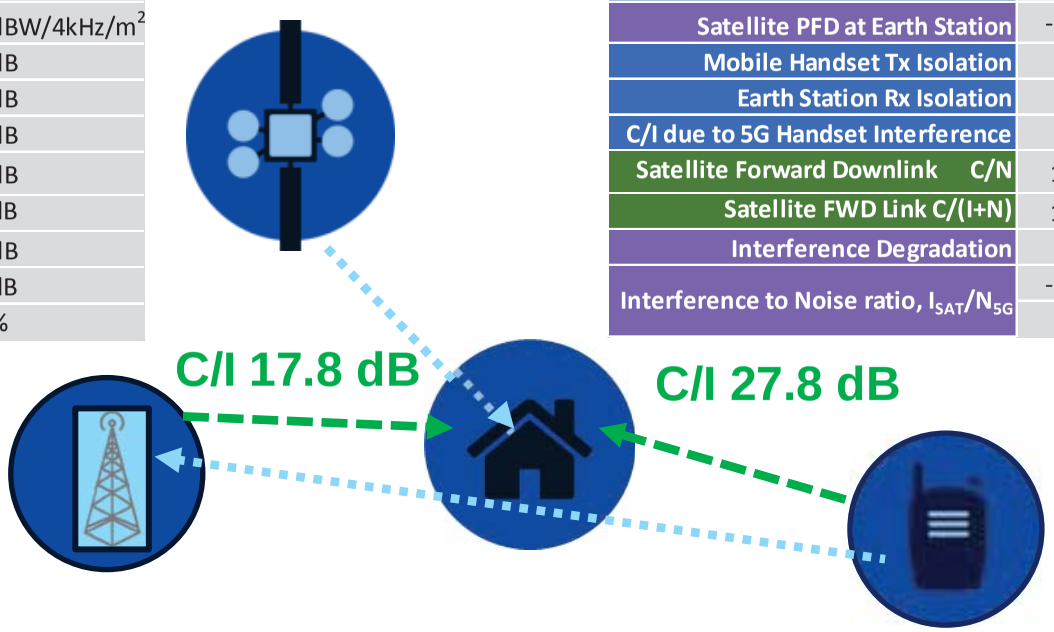
5G User Operations into Satellite Earth Station Receivers

Boeing Satellite Systems

- **Two scenarios considered in statistical link budgets**
  - 5G Mobile Handset into Satellite Receive Earth Station
  - 5G Base Station into Satellite Receive Earth Station

5G BASE STATION INTO RECEIVE EARTH STATION		
5G Mobile Base Station EIRP[1]	65.0	dBm
Handset to Earth Station Distance	100.0	m
Handset to Earth Station Path Loss[2,3]	130.0	dB
Base Station Transmit Bandwidth	100.0	MHz
Base Station PFD at Earth Station	-85.8	dBW/4kHz/m^2
Satellite PFD at Earth Station	-138.0	dBW/4kHz/m^2
Base Station Tx Isolation	20.0	dB
Earth Station Rx Isolation	50.0	dB
/I due to 5G Base Station Interference	17.8	dB
Satellite Forward Downlink C/N	11.20	dB
Satellite FWD Link C/(I+N)	10.33	dB
Interference Degradation	0.87	dB
Interference to Noise ratio, I_{SAT}/N_{5G}	-6.56	dB
	22.1	%

5G MOBILE HANDSET INTO RECEIVE EARTH STATION		
5G Mobile Handset EIRP[1]	43.0	dBm
Handset to Earth Station Distance	100.0	m
Handset to Earth Station Path Loss[2,3]	130.0	dB
Handset Transmit Bandwidth	20.0	MHz
Handset PFD at Earth Station	-100.8	dBW/4kHz/m^2
Satellite PFD at Earth Station	-138.0	dBW/4kHz/m^2
Mobile Handset Tx Isolation	15.0	dB
Earth Station Rx Isolation	50.0	dB
C/I due to 5G Handset Interference	27.8	dB
Satellite Forward Downlink C/N	11.20	dB
Satellite FWD Link C/(I+N)	11.11	dB
Interference Degradation	0.09	dB
Interference to Noise ratio, I_{SAT}/N_{5G}	-16.57	dB
	2.2	%



1	Fox, R.; Kung, A; "Comments of Straight Path Communications, Inc." Petition for Rulemaking of the Fixed Wireless Communications Coalition to Create Service, RM-11664, January 5, 2015.
2	Akdeniz, M.R.; Yuanpeng Liu; Samimi, M.K.; Shu Sun; Rangan, S.; Rappaport, T.S.; Erkip, E., "Millimeter Wave Channel Modeling and Cellular Capacity Evaluation," Selected Areas in Communications, IEEE Journal on , vol.32, no.6, pp.1164,1179, June 2014
3	Angle-dependent Propagation for Cellular & Peer-to-Peer Wireless Communications." IEEE ICC 2012 - Wireless Communications Symposium.

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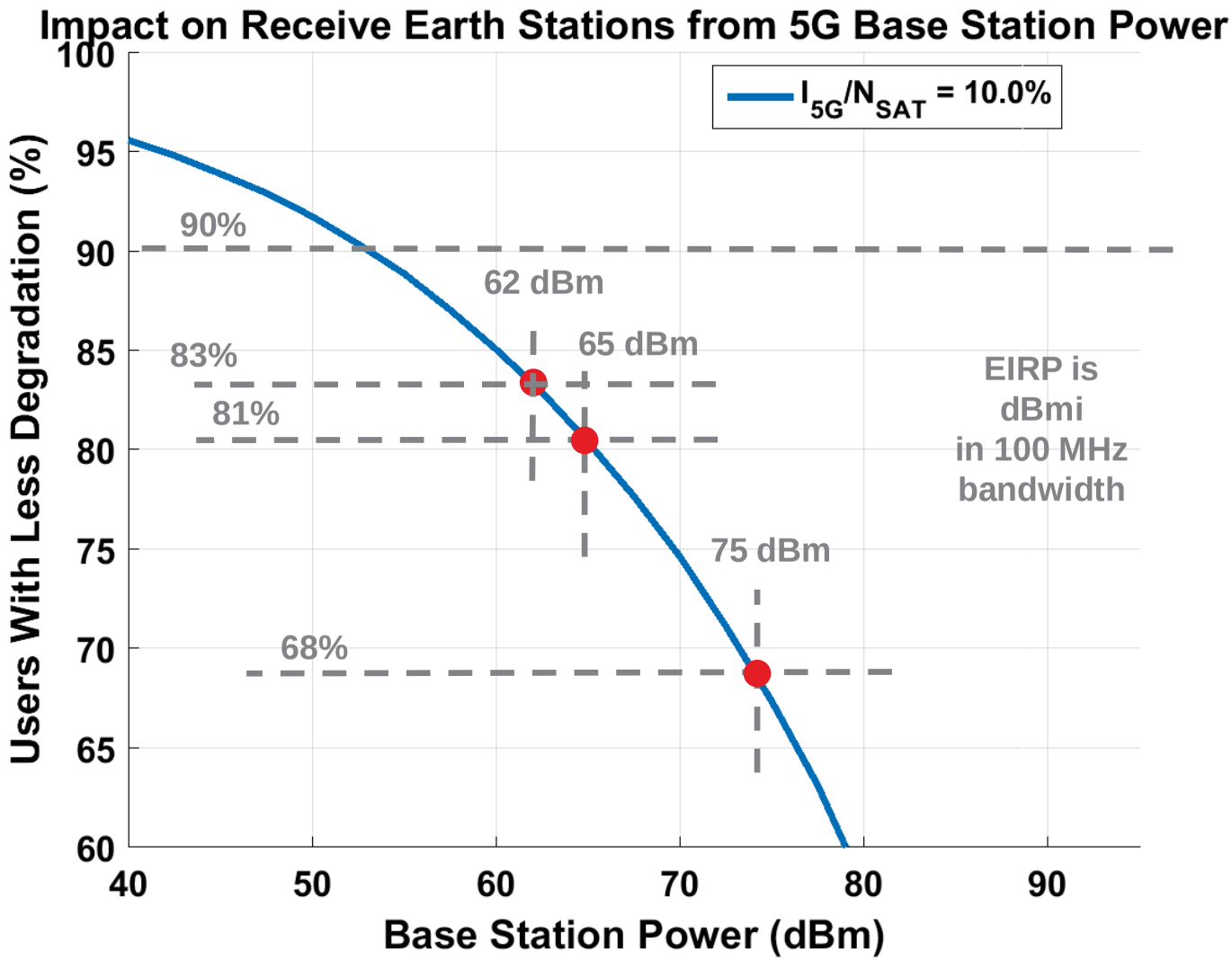
5G Base Station Interference vs. Base Station Power

Boeing Satellite Systems

- **Link impact as a function of base station power**
  - Number of satellite users impacted increases with increasing base station power
  - In addition to 10% system noise increase, satellite system capacity drops ~15% between 62 and 75 dBm per 100 MHz



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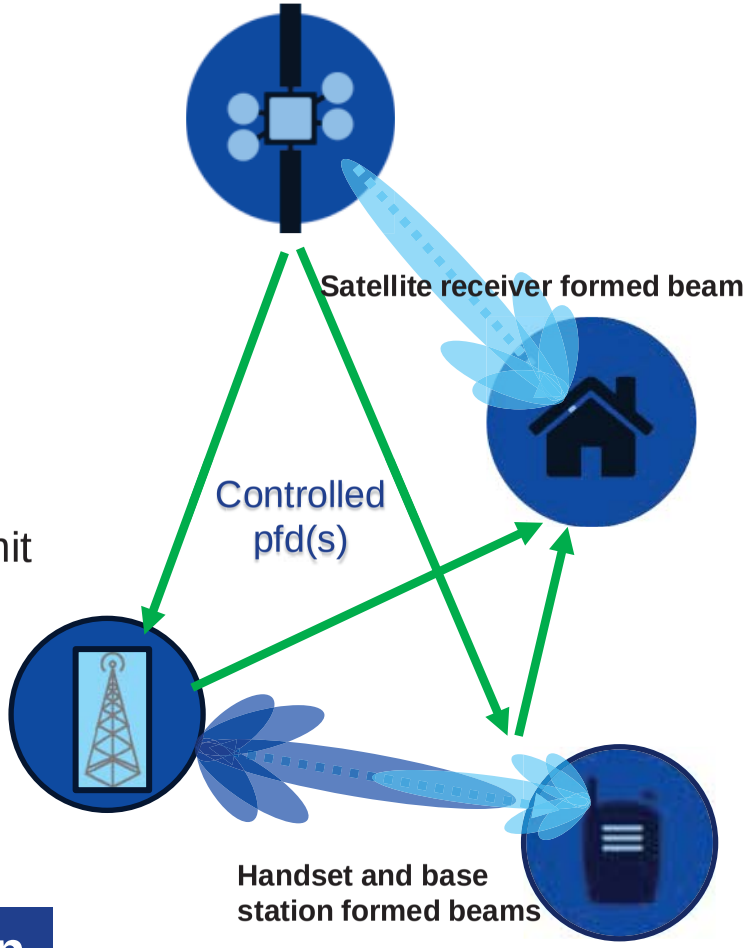
Path forward for 37.5-40.0 GHz - Recommendations

- **Measures to ensure efficient spectrum use:**
  - Remove prohibition on satellite end user receivers
    - Allow unrestricted deployment of satellite receivers
  - Permit satellite downlinks at (or near) ITU PFD levels
  - Require mobile services to use beam forming
    - Facilitate both inter- and intra-service sharing
    - Apply modest off-axis sidelobe isolation requirements consistent with planned 5G system design(s)
  - Require mobile services to use power control
    - Limits interference into LOS satellite user terminals
  - Adopt base station transmitter power / EIRP density limit
    - Reduces aggregate interference into upward facing satellite user terminals
    - Limits near the current FCC proposed value support high data rate 5G service over broad range of cell sizes
  - Require disclosure of base station locations
    - Enables satellite user terminal nulling and LOS selection



Significant further study and consultation with wireless industry required

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