



Copyright © 2017 Raytheon Company. Published by The Aerospace Corporation with permission. *Customer Success Is Our Mission* is a registered trademark of Raytheon Company.



Fast Forward to the Future.....2037

- Intentionally picked 20 years 2037
 - Halfway point (40 years) for a average professional career
 - According the B of LS- 67,000 aerospace engineers employed in US
- Present and Future decision makers in this audience

What are the impacts of technology advances?



...Innovation is hard because "solving problems people didn't know they had" & *"building something no one needs"* Iook <u>IDENTICAL</u> at first"...

-Aaron Levie, CEO at BOX



2037: Five Trends Driving Space Ground Systems

- 1. Ubiquitous Internet of Things
- 2. Use of Quantum Computing
- 3. Exponential Growth in Orbital Debris
- 4. Increased Cyber Security
- 5. Layman use of Artificial Intelligence





Ubiquitous Internet of Things (IoT)

- Allows for data and systems to be remotely accessed
- Interconnectivity of 'smart devices'
 - Controlling your thermostat satellite from your smart phone
- Radio-Frequency Identification (RFID)
 - Chip and Antenna- transmitting barcode
- RFID allows system awareness of all components
 - Amazon Echo Dot
 - Public or private cloud



IoT: Ground System Impacts

- Satellites are aware of which sites can support contacts
 - Sense required hardware RFID from space
 - Inactive RFID is an outage
 - Mobile ground sites
- Instantaneous data delivery
 - Data type associated to systems
 - No system/data outages
 - RFID identifies system and user privilege levels
 - Modular ground systems supporting multiple data paths
- Collection management invisible to the requestor
- Everything has an RFID, changing Configuration Management
 - Software patching
 - Hardware refreshes
- Fundamentally changes the job of satellite TT&C and Mission Management



Raytheon

Use of Quantum Computing

- Revolutionary Changes in Computation
 - Quantum computing is continuous all states in a moment in time
 - Classic computing is discrete
 - Can handle NP-complete
 - Applications
 - Search
 - Number factoring





- Effect on Space Ground System?
 - Fully optimize all space and ground resources against operational needs
 - Ability to re-task near instantly for missed or highly desired data
 - System is self aware of all collection and communication opportunities
 - Autonomous systems with real time command and control of Satellite Swarm
 - Antennas with ability of contacting many satellite simultaneously
 - Continuous visibility
 - Able to process mission data from hundreds of spacecraft concurrently into single products
 - Precision forecasting will give decision makers early warning to respond to events
 - Operators can now focus on goals based tasking

Exponential Growth of Orbital Debris

- Tremendous impact of orbital debris
 - Estimated 100 million pieces of debris smaller than 1 cm
 - 1 cm object in LEO travelling about 7 km/sec = 550 lb travelling at 60 m/hr
 - 27,000 pieces are larger than 10 cm
 - 500,000 larger than a marble



Exponential Growth of Orbital Debris

- What are the effects on Space Ground Systems?
 - Space can no longer be modeled as empty due to gravity perturbations
 - Quantum/Zettaflop computing will be required
 - More rapidly maneuverable spacecraft
 - Predictive location algorithms as spacecraft move too often for TLEs
 - Real-time command and control through multi-phased arrays
 - Increased desire for quick launch, short life spacecraft
 - Less expensive 'throw away" spacecraft
 - Modular, scalable ground allows for continuous change of missions



Increased Cyber Security

- Cyber Maneuvers
 - Transition from a "Sit, Wait, Detect, Recover" CONOP to "Automated Reconstitution"
 - Self patching to remove vulnerabilities
 - Shift from review of audit-logs to meta data detection and recovery using analytics
- Quantum Encryption
 - Quantum key distribution
 - Guarantee secure communication with ability to detect Eavesdropping
- Shift from Cyber Warriors to a Continuous Self-Healing, Resilient System



Layman Use of Artificial Intelligence

- Voice recognition will be mainstream
 - Voice command and control
 - Facial expression and voice will be main inputs to computers
- You don't have to say anything ...
 - Vocal cords to be read
 - Special Forces and SWAT team can work without sound
- AI systems will capture human finite knowledge
 - More sentient computers
- Let's Talk.....

A Ground System Example





Raytheon

Voice Recognition Ground System Example





Raytheon

Voice Recognition Results





2037 Operational Ground System

- How do we harness this technology now?
 - Create a vision based on Mission Needs then employ services
 - Develop a concept of operations that leans towards the future
 - Take measured risks to open wider avenue for onboarding technologies
 - Employ mission based system engineering and architecture development
- Engage the next generation
- Don't stop advocating to solve problems that people don't know they have!



Thank You!

Co-authors

Walid Al-Masyabi Sr. Principal Software Engineer waalmasyabi@raytheon.com

Maggie Nagengast Systems Engineer III <u>Maggie.e.Nagengast@raytheon.com</u>

Questions?



References

- (1) 34 Billion devices connected to the internet by 2020
 - http://www.businessinsider.com/how-the-internet-of-things-market-will-grow-2014-10
- (2) Aerospace company first buyer of a quantum computer
 - https://www.bloomberg.com/news/articles/2013-05-30/what-quantum-computing-can-do-for-you
- (3) 21,000 pieces of space debris larger than 4 inches and growing
 - http://www.space.com/16518-space-junk.html
- (4) 2015 Cyber crime statistics
 - https://www.symantec.com/security-center/threat-report
- (5) Google voice search statistics
 - http://searchengineland.com/voice-search-explosion-will-change-local-search-251776
- (6) Universal Product Code (UPC) replaced by smart labels (RFID)
 - <u>http://electronics.howstuffworks.com/gadgets/high-tech-gadgets/rfid.htm</u>
- (7) Orbital Debris
 - <u>https://orbitaldebris.jsc.nasa.gov/</u>