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”
look IDENTICAL 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
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

https://orbitaldebris.jsc.nasa.gov/
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…….
Gathering data for the Colorado fire from multiple satellites. The fire is spreading north toward Monument, CO along the I-25 corridor, as seen on your device. Would you like me to send an evacuation notice?
Evacuation notice sent. I will continue sending you updates on the Colorado forest fire every 15 minutes until you tell me to stop.
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!

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Questions?
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