Internet of Things (IoT) from Satellites, Now and the Future

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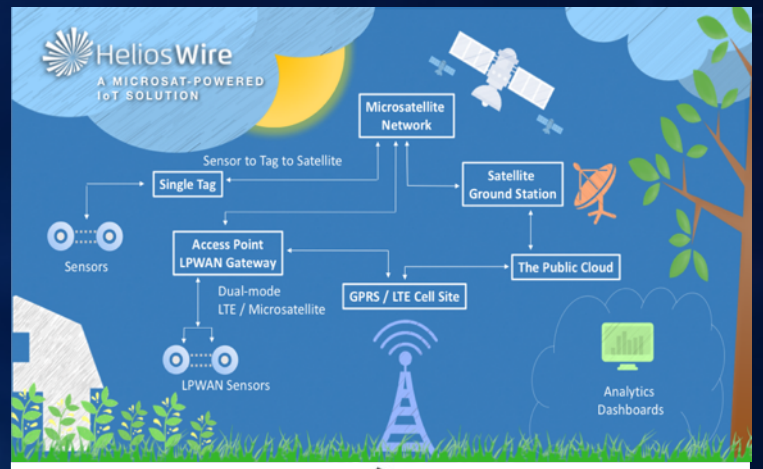
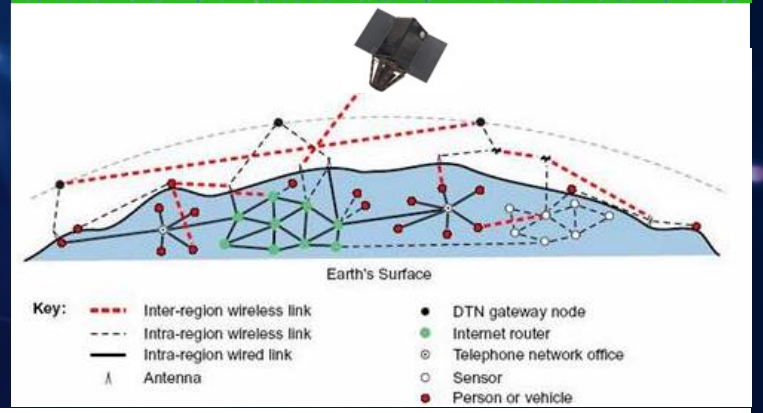
Overview

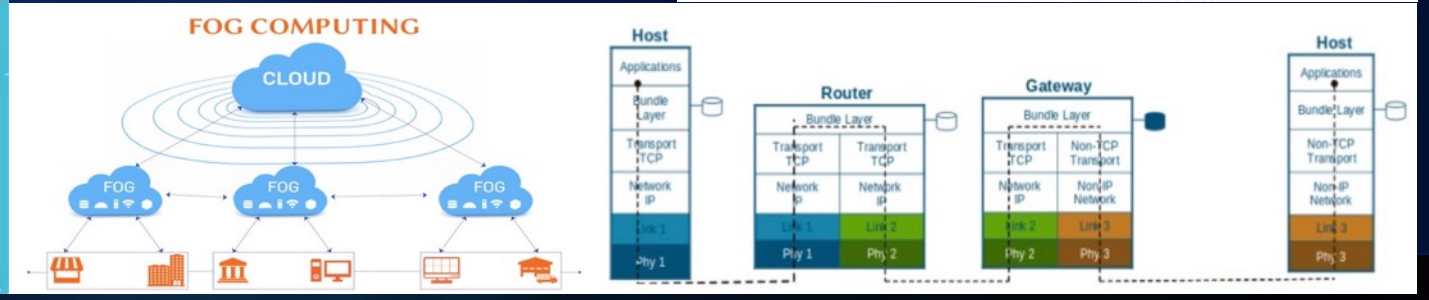
- The emphasis with satellites today are real time low latency systems which have also accomplished custom M2M services (the predecessor to IoT).
- The Big LEOs in the 2000s focused on real-time voice circuits and leaving video and data to the geostationary systems.
- Today with VoIP, video-over-IP, OTT streaming, and IoT all on an IP network, you now need to move away from circuit switched systems to a full wireless TCP/IP network.
- *The future requires that IoT from satellites need to co-exist with the growing and emerging IoT Industry (this is what Helios Wire is planning to achieve).*
  - The following trades are some that you need to go through to determine your type of service and at what cost to the customer

System Design Trade Topics using Satellites

- Real time service with low latency data versus delay tolerant network (DTN) data services
- Direct to user versus interface through a backhaul link
- Custom stand alone user equipment versus modified user terminals
- Circuit switched versus integrated IP network for IoT services
- Unique delay tolerant network in an IP network architecture
- Distributed memory cloud or “foggy” system storage architecture
- Embedded cyber security system architecture





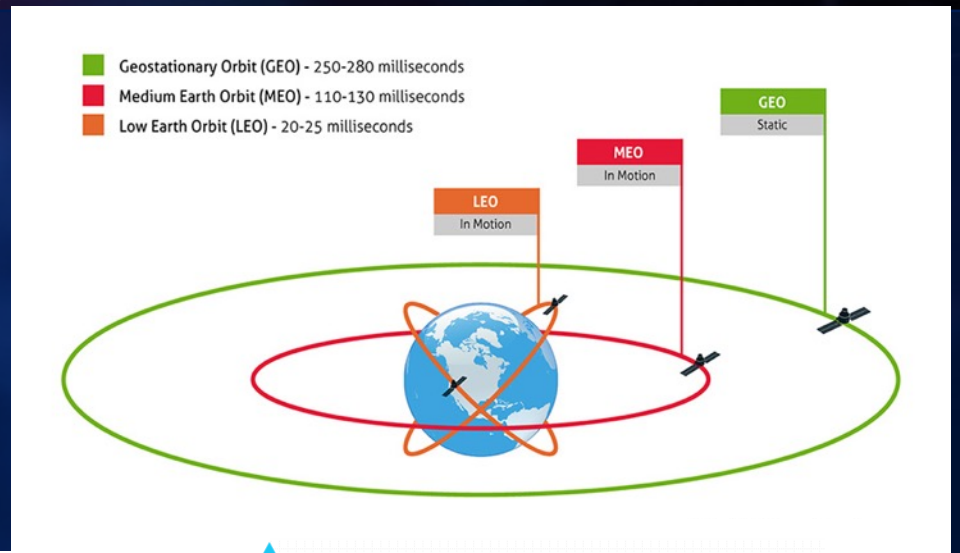


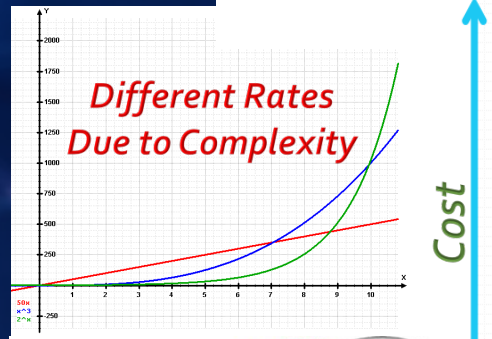
Real-Time vs Delay Tolerant

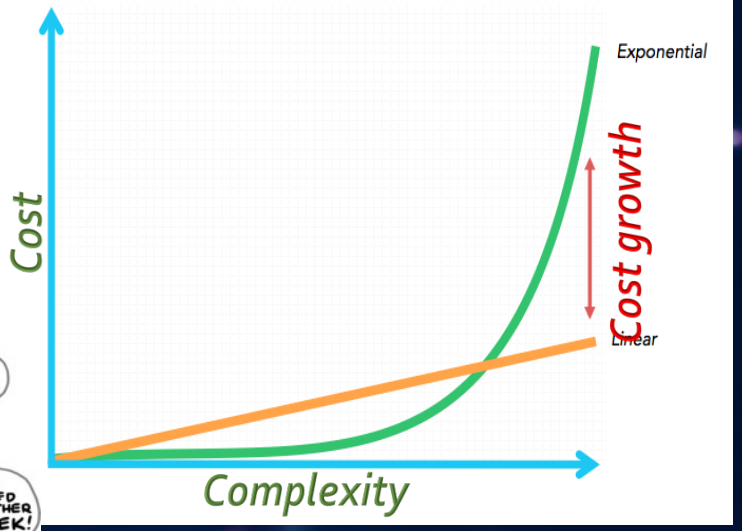
- Real time, low latency system from space dictates
  - Low Earth orbit (low latency) < 1000 km
  - Full Earth coverage (24/7)
  - Fast processing on satellites or bent-pipe system
  - Complex multiple access scheme for streaming and real time services (more complex if bent-pipe)
- All of these requirements drives cost up a steep exponential curve

- Delay Tolerant Network (DTN) systems from space are developed for specific needs
  - Initially designed for NASA's deep space communications within an IP network
  - Now for machine-to-machine (M2M) and a growing part of the emerging Internet of Things (IoT) ecosystem

- DTN systems eliminates the need for 24/7, complex access schemes and real-time service for streaming, which drives high cost systems
  - Avoids new complex designs and potential scope creep in the requirements for real-time systems

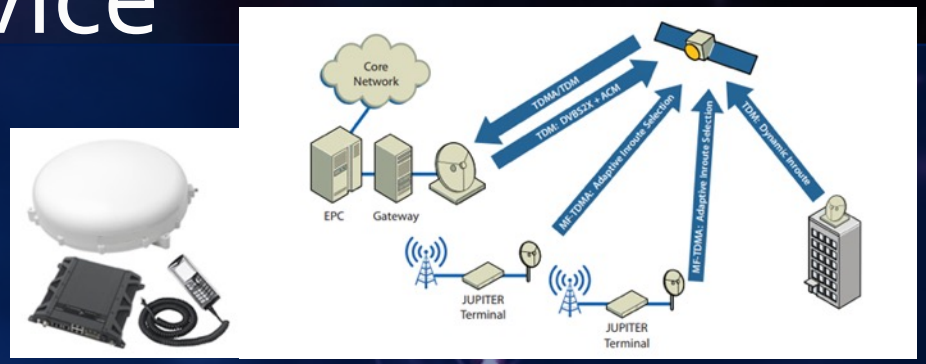


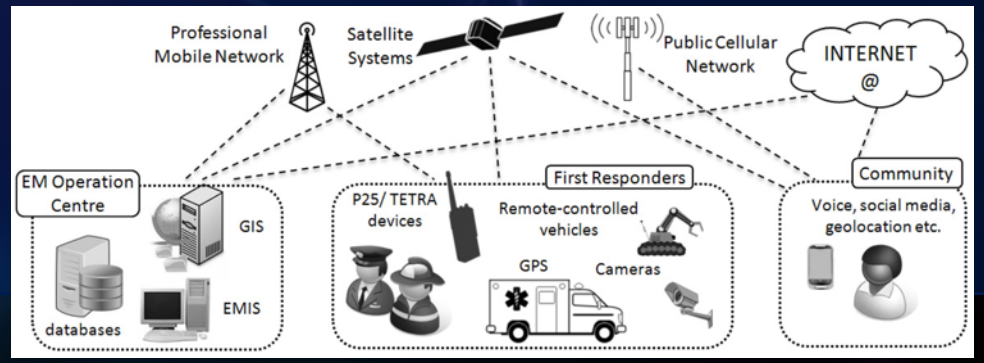




Direct to user or backhaul service

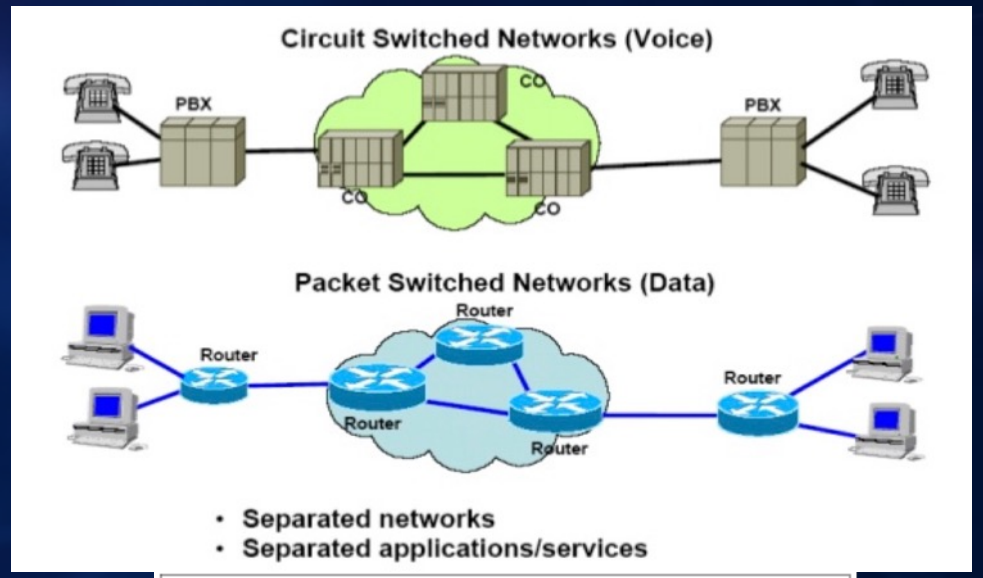
- **Custom handhelds to users from satellite or a backhaul access point/terminal?**
  - Custom handhelds or small terminals from satellites are expensive and create a complex layer 1 (link layer) access scheme
  - A customer access point (CAP) terminal that backhauls aggregated set of users to the satellites are more efficient in using satellite to ground spectrum and allows many more individual users simultaneously
- **Custom developed user terminals or modifying the wireless radio to talk to the satellites?**
  - Current satellite systems used today have custom networks that require custom radios, translation circuitry, and software to interface to the terrestrial IP network (Similar to 3G cellular interface to the internet)
  - The current satellite systems are modified circuit switched systems that translates the unmodulated bits to IP packets for the IP networks
- ***Future satellite systems must be transparent to the 4G/5G terrestrial systems and initially focus on a TCP/IP wireless backhaul service utilizing SDR technologies***

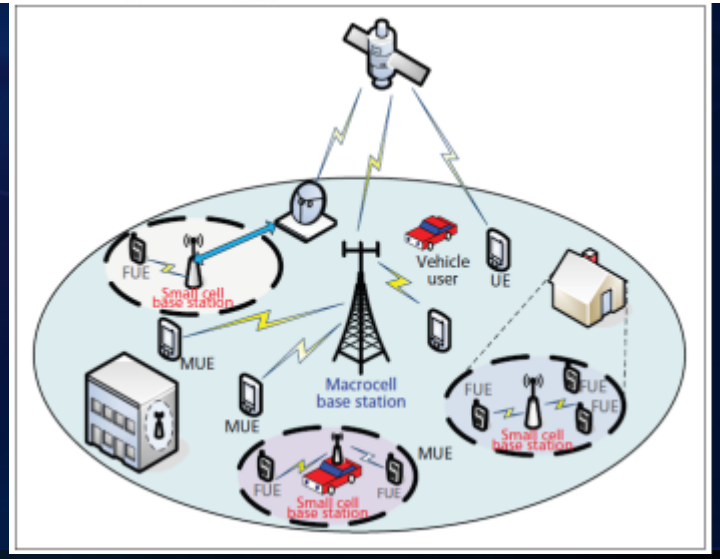




Circuit switched or integrated IP network

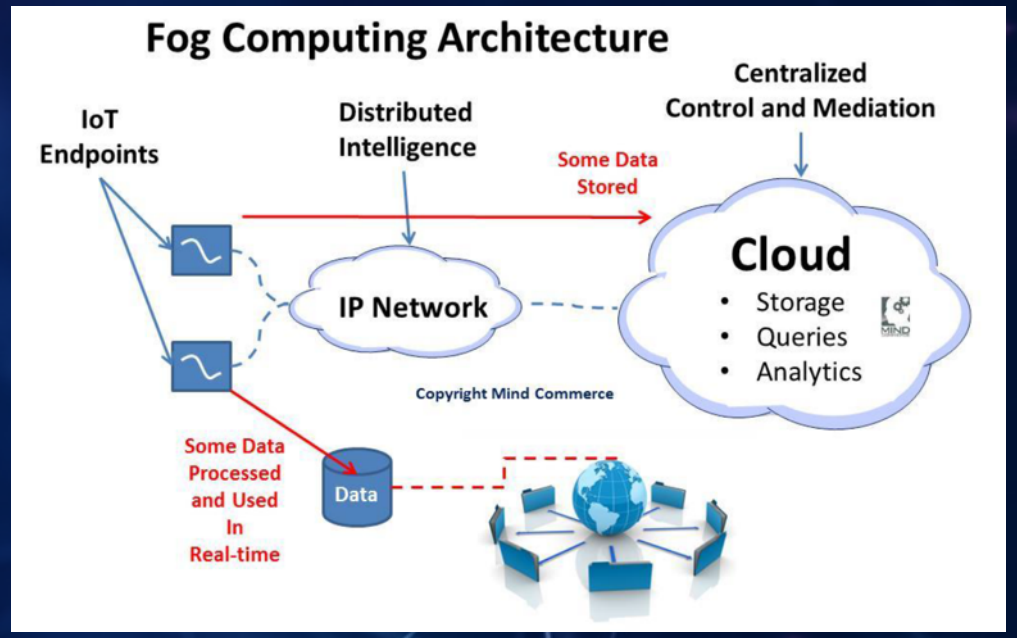
- Most satellite systems are circuit switched at the link layer (layer 1)
  - Dedicated point-to-point connections (bent-pipe, digitally switched, etc.)
  - Initially developed for secure connection by MILSATCOM
  - Easier to implement through the delays in satellite communications
  - Doesn't easily allow new service adoption at the IP layer or higher
- A packet switched IP Network through space allows more network centric services
  - More efficient than circuit switched system
  - Integrate a modified delay tolerant network (DTN) in multiple layers (CCSDS, PPP, etc.)
  - Introduction of VoIP and other IP applications has shown the desire for this service in the last couple of years





Additional Design Features

- **Distributed Cloud Service (Foggy Architecture)**
  - Design satellites and customer access points to have mini-cloud storage capability
  - Since IoT sensor or tag will be “smart” devices, we need to take advantage of this with edge computing
  - Distribute cloud processing near the sensor or edge creates an “edge-fog cloud” system



- **Cyber Security at Multiple Layers with AI**
  - Smart Security based on artificial intelligence and machine learning will impact all economic sectors
  - Focus on multi-layer cyber security architecture
  - Integrate space and time awareness, learning, decision focus, adapting, sustainable, scalable, and system integrated using the foggy storage architecture

Helios Wire Vision

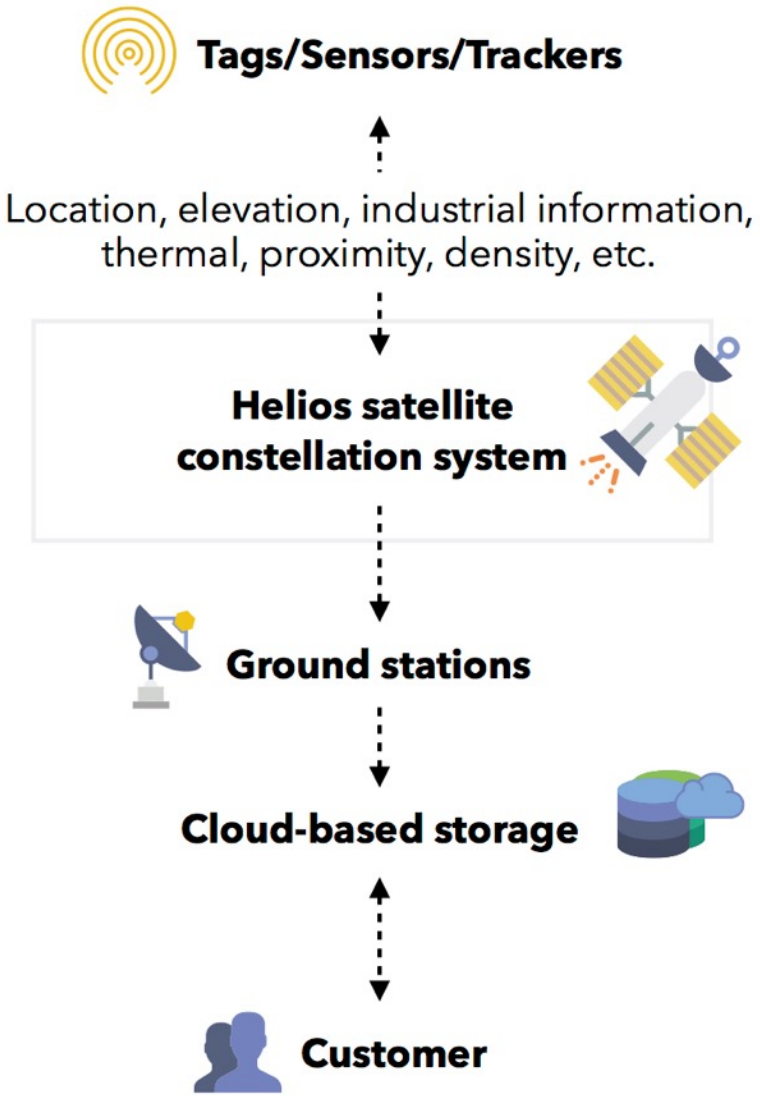
Space-enabled, machine-to-machine / **Internet of Things** service specifically designed for **high volume** market applications.

Massive allocation of unique

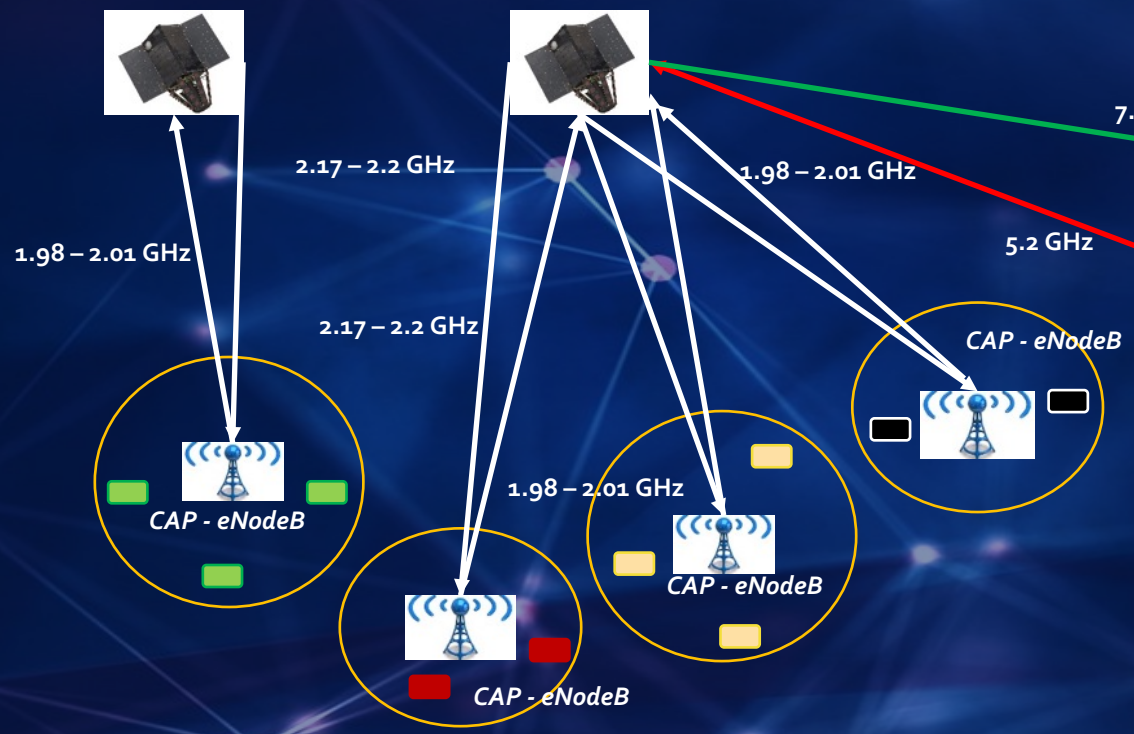
60 MHz of S-band MSS

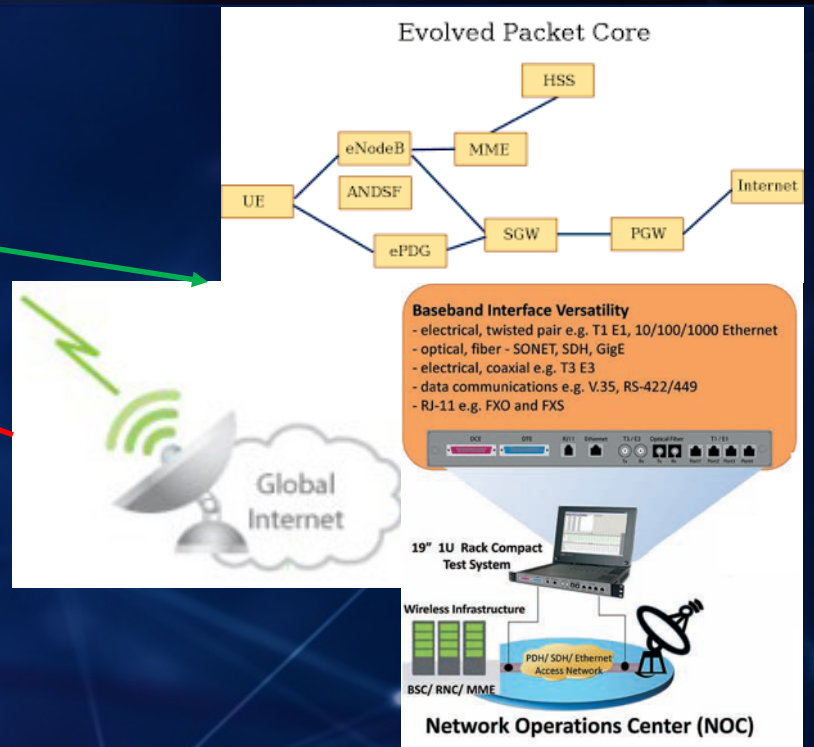
(Mobile Satellite Services) spectrum, through Australian administration.

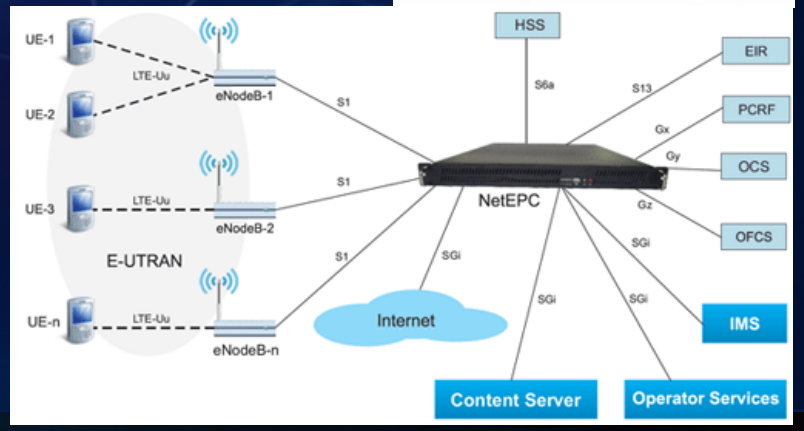
System infrastructure



Helios Wire - System Architecture Overview







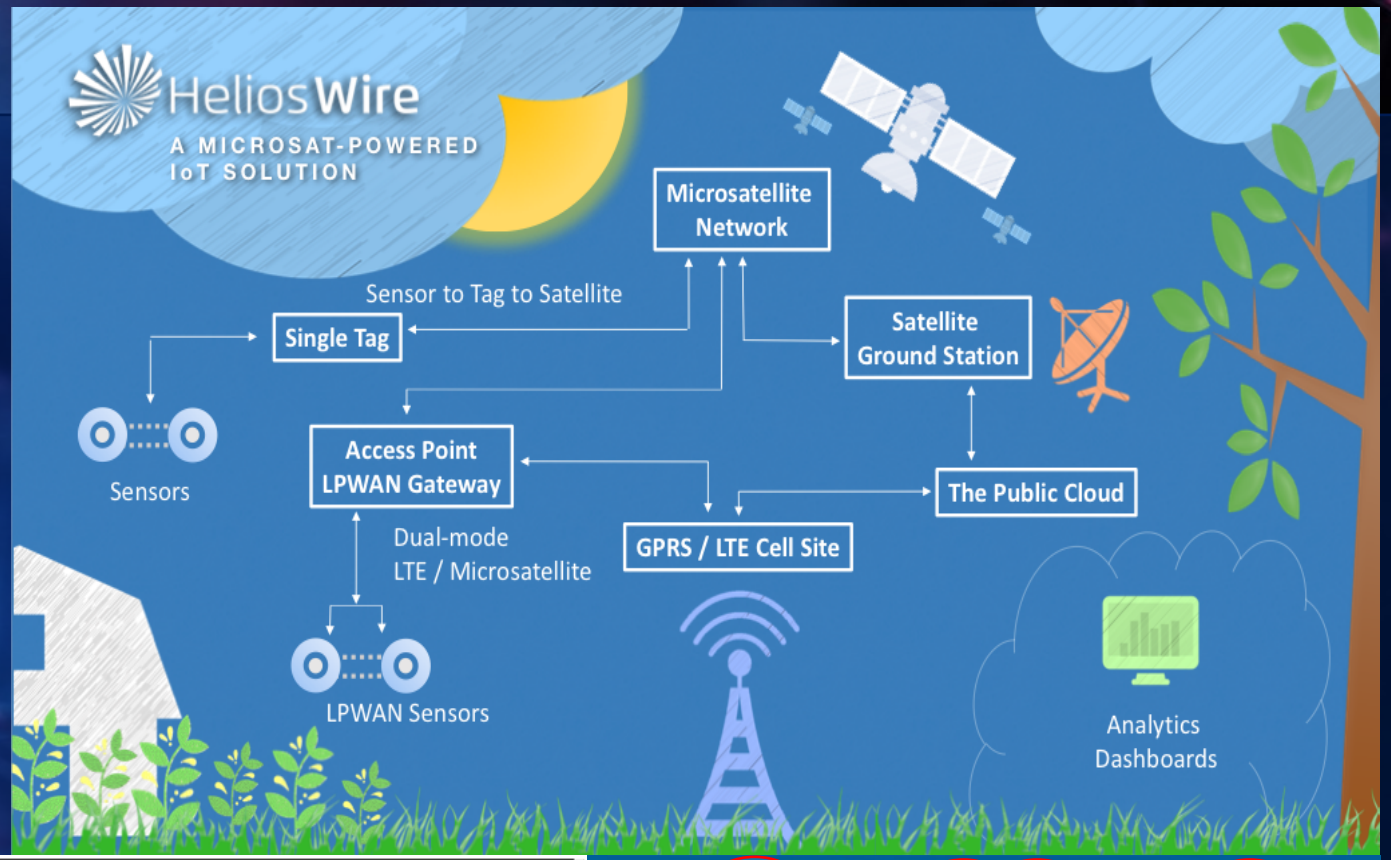
- **Helios Wire system overview of a "heterogeneous network" over satellite for next generation M2M and IoT markets**
  - Evolved Packet System introduces flat, packet only architecture
  - Separate signaling and data paths for enhancements
  - Enables all IP voice and data services
  - Provides standards based interoperability with other networks

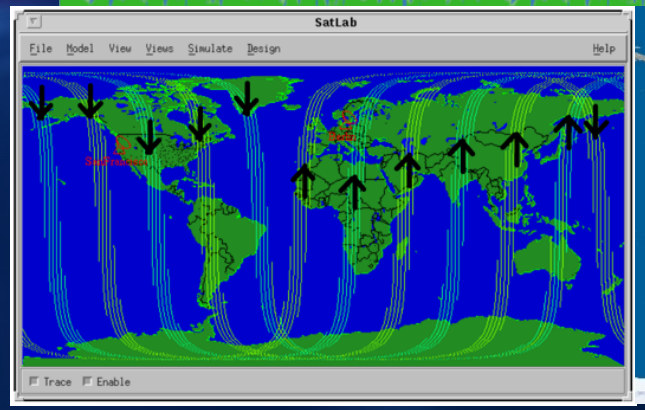
Evaluating Long Range LPWAN Technologies

	NB-IoT	LTE-CATM1 (eMTC)	EC-GSM-IoT	Sigfox	LoRa	RPMA
Waveform/Modulation	OFDMA Modulation - Half Duplex (standalone, guard band or in band)	OFDMA Modulation - Full Duplex (in band only). Supports QAM	TDMA/FDMA, GMSK & 8PSK (in band GSM only)- Half Duplex	BPSK in Europe, GFSK in USA using a UNB modulation & pseudo-random freq hopping	CSS Modulation (chirp spread spectrum),	DSSS (Direct Sequence Spread Spectrum), TDD frame structure
Frequency	Typ freq is 800MHz, up to 14 bands from 700MHz - 2GHz. Bandwidth is 180 - 200kHz.	Typ freq is 1900MHz, in LTE carrier. Bandwidth is 1.4MHz max.	Typ freq is 900MHz, in GSM carrier. Bandwidth varies.	868MHz European, 902MHz USA	868MHz European, 915MHz USA	2.4 GHz ISM band
Data Rate	250kb/sec max, typical 100kb/sec	1Mb/sec max, typical 384kb/sec	70kb/sec (GMSK), 240kb/sec(8PSK)	100 b/sec	Typ 10kb/sec, 290 bits - 38.4 kb/sec range	Typ 624kb/sec
Range/Distance	Within LTE carrier range or GSM legacy network. MNO must support. Up to 20km	Within LTE carrier range or GSM legacy network. MNO must support. Up to 25km	Within GSM carrier range, designed to utilize legacy GSM networks	3 - 10km city, 30 - 50km rural	~15km city, ~50km rural	~25km city, ~80km rural
Network Type	Star Network	Star Network	Star Network	Star Network	Star Network	Star Network
Max Nodes per Access Pt	Up to 200K, typ 50,000 users	Up to 1M users/cell	Up to 190K, typ 50,000 users	Up to 25K users/cell	Up to 40K users/cell	Up to 500K users/cell
Power Consumption	User Element transmit power of 20-23 dBm, less than 15uA idle mode	User Element transmit power of 20-23 dBm, less than 15uA idle mode	23 - 33 dBm, similar to NB-IoT	Typ Standby mode of 2uA, Transmit mode of 45mA @ 14dBM	Typ Standby mode of 1.5mA, Transmit mode of 10.5mA (sleep at .1uA)	From 21 - 30 dBm, with higher range on UL TX
Link Budget	164 dB	155.7 dB	154 - 164 dB	149 dB	157 dB	177 dB
Battery Life Estimate	10 years	10 years	10 years	10 years	10 years	15 years
Bandwidth of signal	180kHz	1.08MHz	2.4MHz - 600kHz	100Hz - 200Hz	125kHz	1MHz
Signal Latency	1.5 - 10 seconds	10-15 msec	700 msec - 2 sec	2 secs/ packet, 3 sent each time on pseudo random freq	Avg latency is 2 secs, with message duration of 40msec - 1.2 secs	Avg latency is 2.3 seconds

Helios Wire System

- Leverage the business cost model of Space 2.0 (cubesat systems)
- Leverage lower cost launches for smaller satellites to deploy the constellation
- Leverage existing IoT technologies and network infrastructure
- Focus on low cost IoT service where latency isn't the primary driver (which drives cost)
- Develop a unique DTN network that is a satellite-based "heterogeneous network"





Thank You !

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