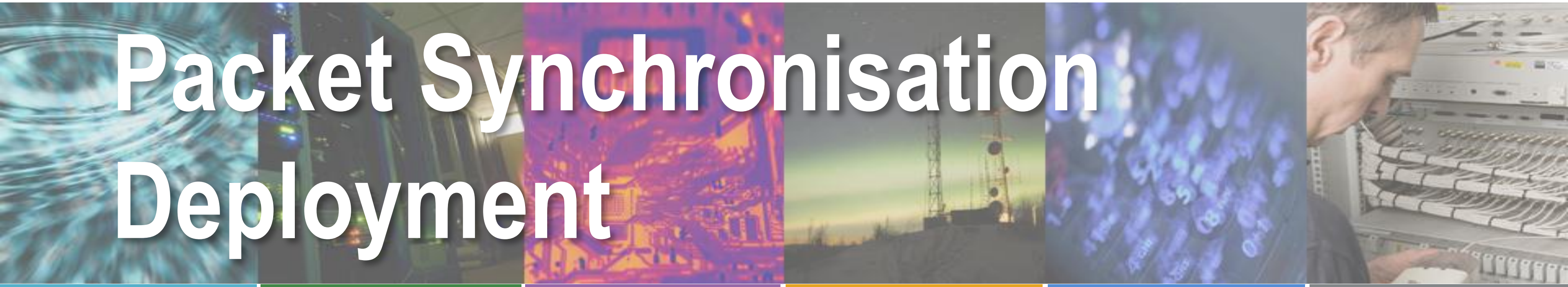
Packet Synchronisation Deployment



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LTE/EPC & Converged Mobile Backhaul – Dec 2011

Introduction

- The packet sync revolution is here...
  - Evolving telecom networks can mean loss of physical layer connectivity for sync via traditional TDM sync path
- Sync still required at network edge applications
  - Air interface of mobile base stations is a big driver (frequency and/or phase depending on deployment
- All Ethernet/IP architectures being rolled out across many networks
  - Some mobile operators now have no SDH or TDM remaining in the access network
- However, frequency and phase accuracy requirements are still present for the air-interface
  - Trusty 2.048MHz is still in the mix
  - A large consideration when changing the backhaul technology is how to maintain the sync previously provided via TDM

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Mobile Sync Requirements

- **GSM, UMTS-FDD, LTE-FDD** requires ±50ppb frequency accuracy at the air interface of RBS
- **LTE-TDD** requirements (TS 36.133, TS 36.922)
  - ±10µs phase accuracy between distributed RBS (large cell)
  - ±3µs phase accuracy between distributed RBS (small cell)
- **LTE-Advanced co-ordinated MultiPoint (CoMP)** may require as low as ±1µs phase accuracy between distributed RBS (TR 36.814)
  - Varied methods of deploying CoMP, firm sync requirements are yet to emerge
  - This level of phase accuracy is difficult using packet transport using current systems and network architecture

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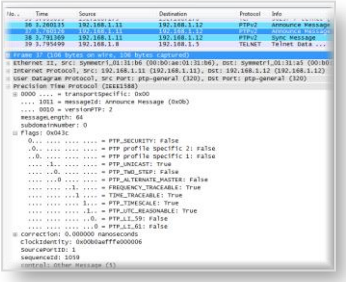
Mastering the Master Clock

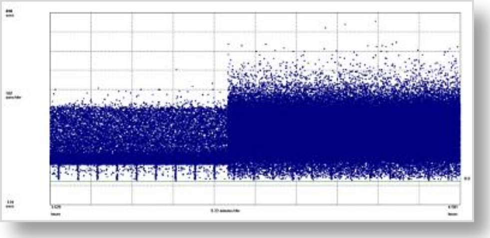
- The timing budget starts at the master clock(s)
  - Here, the user has full control over sync quality
- 1PPS & Time Of Day accuracy at the receiver is affected if cable infrastructure settings are ignored
  - Incorrect antenna cable length delay adds ~45ns inaccuracy for every 10 meters
  - In a 100m run, if unset can cause almost ½ µs error before the clock is distributed
- GPS Jamming becoming a concern
  - Important to have a resilient and redundant systems
  - Other PRC reference choices becoming available
    - PTP/Rb PRC
    - eLORAN
    - Other GNSS systems

From Master Clock to RBS - PTPv2

- Accurately time-stamped packets from master clock used to derive clock at the slave device.

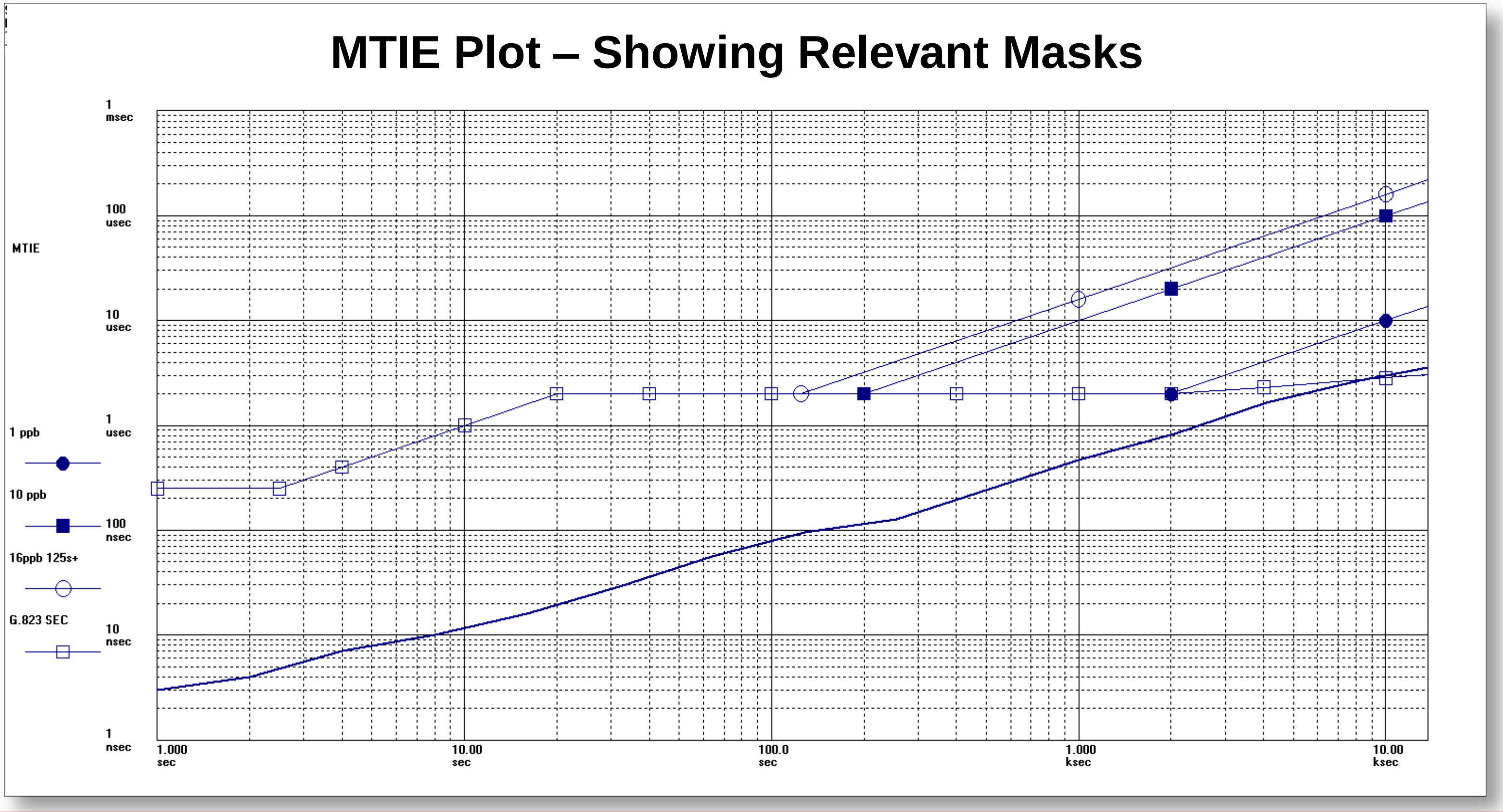


- Various methods of network deployment:
  - Embedded slave clocks in RBS
  - Embedded in cell site gateway with sync out feeding existing RBS
  - Standalone slave clocks feeding existing RBS
- Performance is difficult to guarantee under all network conditions
  - QoS and network constraints mitigate
  - Sync monitoring of selected sites is key



- Noticeable variation in slave clock performance between vendors
  - Packet metrics and packet KPIs are not standardised yet
- On path support (transparent clocks & boundary clocks) becoming prevalent in infrastructure equipment

Tested - PTPv2 Slave Performance

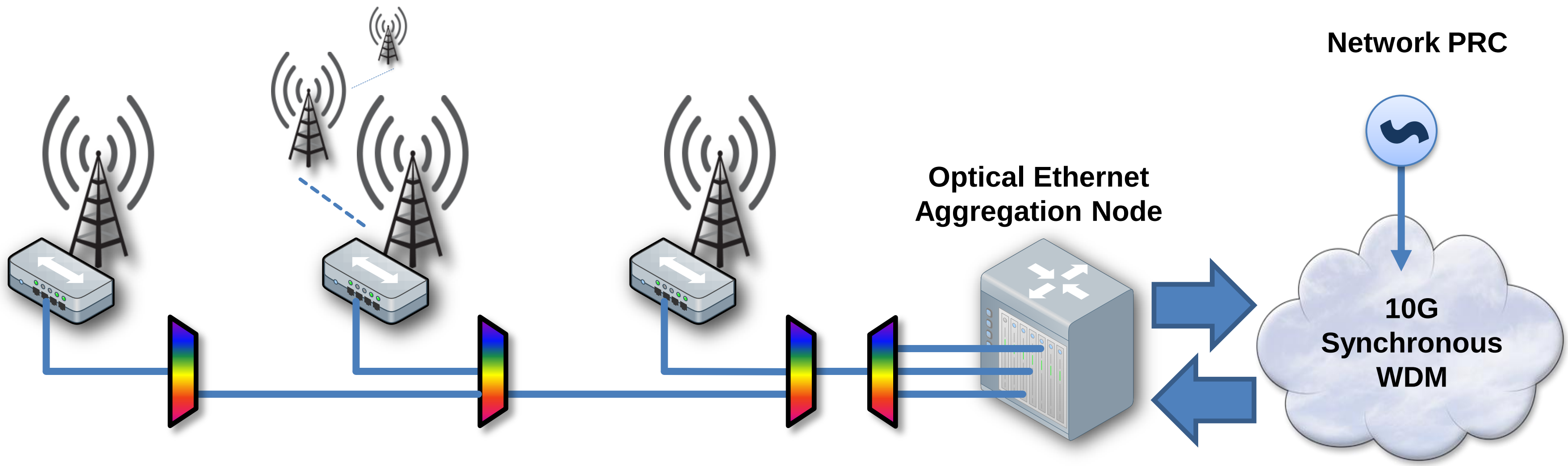


3x Network hops until microwave, 2x Microwave hops, 1x multi-service switch, then PTPv2 Slave clock (external)
2.048MHz monitored at both PTP clients, measurement reference is GPS
Performance within G.823 & 16ppb required for RBS sync input (G.8261.1)

Master Clock to RBS - SyncE

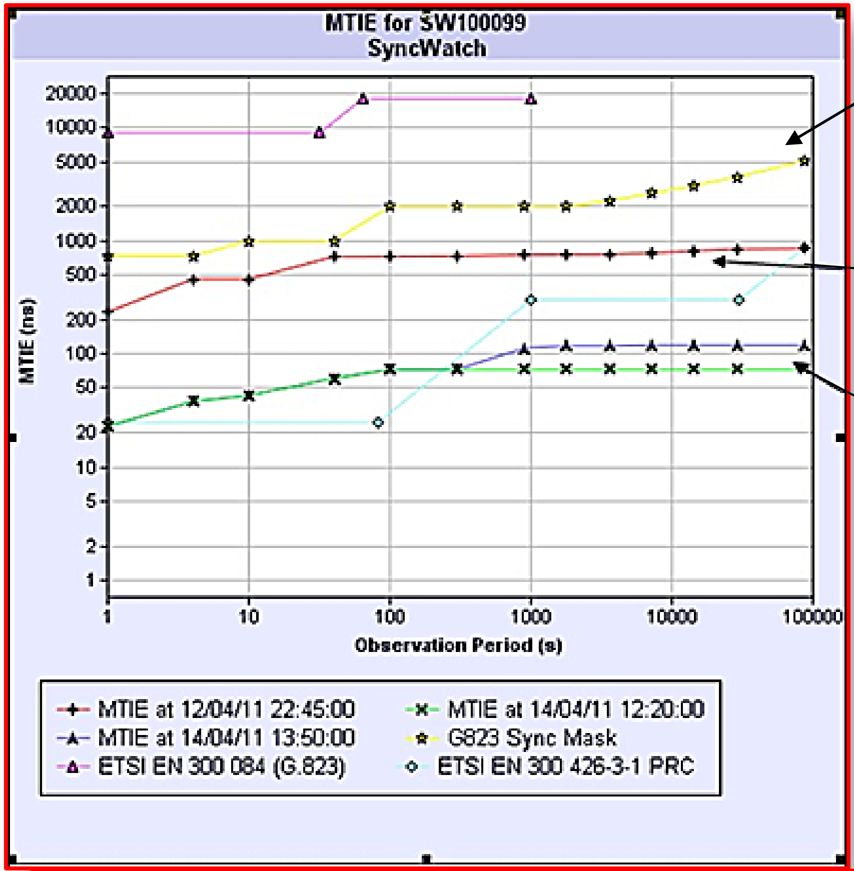
- Physical layer, frequency only distribution currently…
  - Talk in the standards of adding time-code distribution to SyncE in future
- Now well supported as standard by infrastructure equipment
- Benefit is that it is not affected by traffic loading so performance is deterministic
- Seeing big interest in SyncE as a 'drop in' sync replacement for SDH core and access networks
  - Especially when utilising existing GSM, GSM-R and 3G base stations
- Possibility to use existing SDH Sync Supply Units (SSU) alongside SyncE distribution
  - Recovered SyncE clock jitter can be attenuated by SSU and reinserted, allowing longer sync chains

Tested - Packet Optical System



- Method of transporting sync and data backhaul to/from RBS
- Use of passive optical splitters instead of active nodes
  - No jitter or wander introduced to SyncE
  - Zero ‘hops’ for PTPv2
- Better sync at ‘head end’ base stations allows budget for longer ‘chains’ of microwave-to-microwave links with ‘in spec’ sync at the furthest node

Packet Optical System - Results



Yellow – G.823 Sync mask.

Red - The performance of the E1 based sync in the existing network

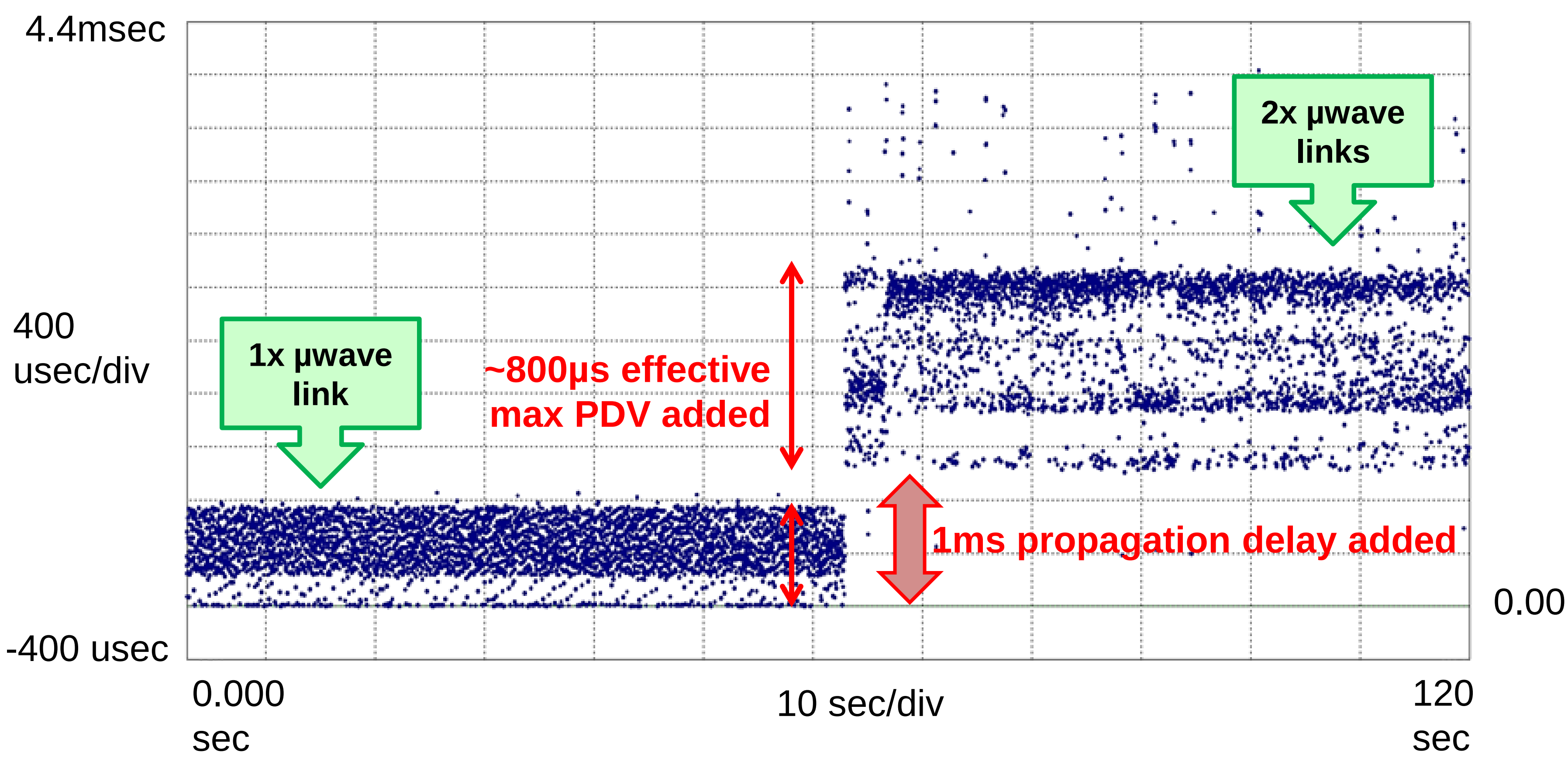
Green - The even better performance with SyncE over Packet Optical System.

Measurement performed over a period of a month in a live network.
Multiple fibre distribution units over 200+ km live network (6 equipment 'hops')
Traffic running at 100% throughput

Microwave Sync Transport

- Microwave is a ‘harsh’ environment for PTPv2 transport
  - Adaptive Coding and Modulation – link speed varies, usually due to weather conditions
  - Above can cause variable buffering
  - Blocking of PTPv2 packets can occur if frames are already in the process of being transmitted
- Native SyncE should not incur the above (PTPv2) issues but expect jitter increase per ‘hop’
- Proprietary solutions provide exclusive channels for PTPv2 traffic or transfer SyncE
- Testing is key to define maximum acceptable chain length for sync

Tested - PTPv2 – Adding a µwave Link



Network traffic load at 90% at all times (PTPv2 traffic was in highest QoS class)
1ms change in propagation delay as effect of added link (symmetric)
Large increase in PDV compared to fixed line 'hops'

Deployment Considerations

- In the transition to packet networks both packet **AND** physical layer measurements/metrics are key
  - R&D – Algorithm development,
  - Customer Trials – Technology & Service Assurance
- Standards - ITU SG15/Q13 looking at:
  - Network Limits & Clock performance
    - G.826x/G.827x series
  - Packet-based Metrics
    - Predicting client performance based on packet network behaviour
  - Liaison with 3GPP, MEF, NGMN Alliance
  - Use Physical Layer where possible
- Testing
  - For Sync, building test-beds & models is the most reliable way to guarantee performance before deployment
  - Monitor & Measure after deployment

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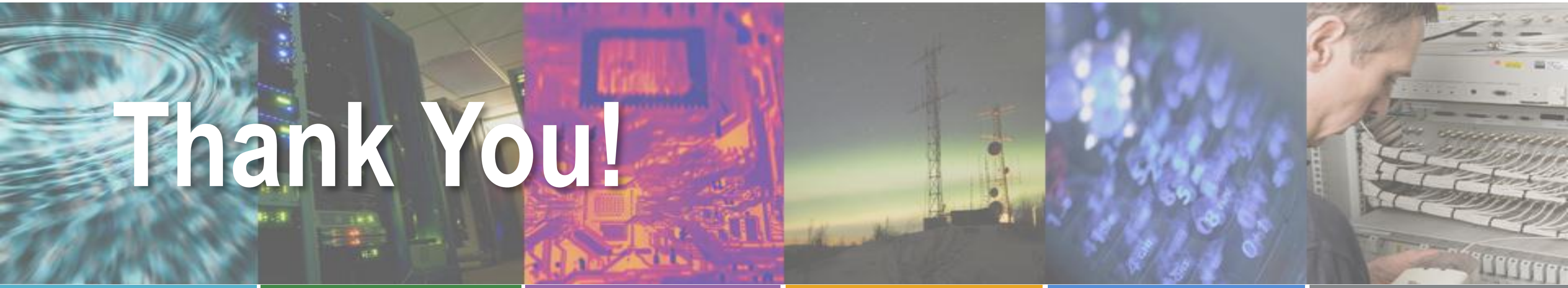
Thank You!