Open SG Smart Grid Spectrum Allocation Discussion

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Spectrum Allocation Rationale

- Approaching spectrum allocations requires balancing a number of factors, starting with:
  - What spectrum ranges will work for an application?
  - What blocks of applicable spectrum are available and/or feasible to acquire?
  - How is the case made for use of a particular block of spectrum?
- The first two of these issues are being addressed by UTC and Micronet working in parallel.
  - UTC has identified two bands that appear potentially viable and has initiated discussions on them with FCC and DOE
  - An analysis these and other bands with parametric calculations to establish what arguments can best be used in building the case of how, when and why the Smart Grid might best utilize this spectrum
  - It is likely that the SG-Net Database/Planning Tool will be extremely helpful in building the case for various network traffic requirements

Activities to Date

- UTC has proposed two bands for Smart Grid:
  - 1800 – 1830 MHz Federal Microwave Band
  - 14000 – 14500 MHz Satellite (Ku) Uplink Band
- Two white papers examining technical issues in these bands have been provided
  - Analysis of 1800 MHz Band for Smart Grid
  - Issues and Analysis of Prospective Frequency Allocations for Smart Grid Applications
    - The second paper is an update and expansion of the first

1800 – 1830 MHz

- In the paper entitled *Issues and Analysis of Prospective Frequency Allocations for Smart Grid Applications,* the case is made for using the band for Point-to-Point backhaul
- If the 1800 – 1830 MHz band is shared with existing Federal Microwave Facilities, the Smart Grid use of the band should be as a Point-to-Point (PTP) Backhaul band, with traditional frequency coordination procedures used to manage levels of interference

1800 – 1830 MHz (cont)

- This argument is further supported by the fact that Canadian use of the band includes Point-to-Point and this provides cross-border compatibility with Canada, a key UTC argument for Smart Grid use of the band.
- An approach outlined in the paper is to establish a frequency plan of 56 Full Duplex Channels of 240 KHz each

1800 – 1830 MHz (cont)

- A key provision is the argument that the FCC allow the narrow 240 KHz channels to be aggregated to fit traffic loading in a particular application
- The use of Adaptive Modulation is recommended to provide additional resilience against fading on longer paths
- There are valid arguments for and against this approach, but Federal use of the band in the past has allowed channels as narrow as 500 KHz

1800 – 1830 MHz (cont)

- Arguments against the PTP approach have been provided by DTE
  - A new protocol development would be required to utilize adaptive modulation in narrowband channels, so broadband use would be preferable
  - WIMAX and LTE are already developed as industry broadband standards
  - A green field approach that moves out the incumbents and utilizes broadband is one alternative

1800 – 1830 MHz (cont)

- A green field approach to the band as promoted by DTE has benefits for the Federal Government
  - The microwave equipment being used is obsolete
  - The 1850-1910 MHz channels are already being used on the border by Immigration & Customs
  - Moving to another band would provide a viable alternative and justify an overdue equipment upgrade
- However, using this band for broadband area coverage still leaves the open question of cross-border Smart Grid traffic with Canada, and the resulting ability to connect seamlessly with their grid

1800 – 1830 MHz (cont)

- Arguments in support of the PTP approach:
  - AMI base station traffic of 2-4 Gigabytes per Data Aggregation Point (DAP) per month is anticipated, and the FAN will probably not exceed those numbers
  - For these types of applications, WIMAX and LTE at small base stations located at substations may be overkill considering the limited spectrum available in this band
  - In all probability, most Monitoring & Control broadband sites should be located in the 14 GHz band where adequate spectrum is available

1800 – 1830 MHz (cont)

- Aggregation of narrowband PTP channels provides a significant degree of flexibility in frequency planning, and does not necessarily limit the user to a 240 KHz channel bandwidth
- Adaptive modulation is widely used in a variety of PTP radio bandwidths already, with 5 MHz for example being utilized by one Motorola radio in the 4.9 GHz band
- Extending this down to 240 KHz should not be a major obstacle as a fading mechanism that is essentially independent of RF Bandwidth

700 MHz D Block

- This band was briefly examined for potential Smart Grid use.
- While propagation characteristics of the band are excellent, the available bandwidth and necessary coexistence with the Public Safety community does put limitations on Smart Grid Use
- Considering these limitations, this band is considered of secondary importance

Wireless Performance at 14 GHz

- With a total bandwidth of 500 MHz, this band can support multiple 30 MHz channels, and provides the capability to support both WIMAX or LTE Broadband PMP and Backhaul PTP services
- Rain sensitivity will limit PTP path lengths to 1-2 miles for high operational availability requirements
- Lower availability traffic can be carried on paths of 10-20 miles in length in this band

14,000 – 14,500 MHz (cont)

- There are interference issues with the Ku band satellite uplink facilities, that do not appear to be insurmountable
- Interference into a WIMAX/LTE base station by a nearby satellite uplink site can easily disable the base station
- The same is true at 6 GHz when a nearby satellite uplink site transmits into a co-channel PTP microwave receiver
- When two such facilities have the potential to interfere, they cannot share a common channel, leading to the likely need for channel hopping

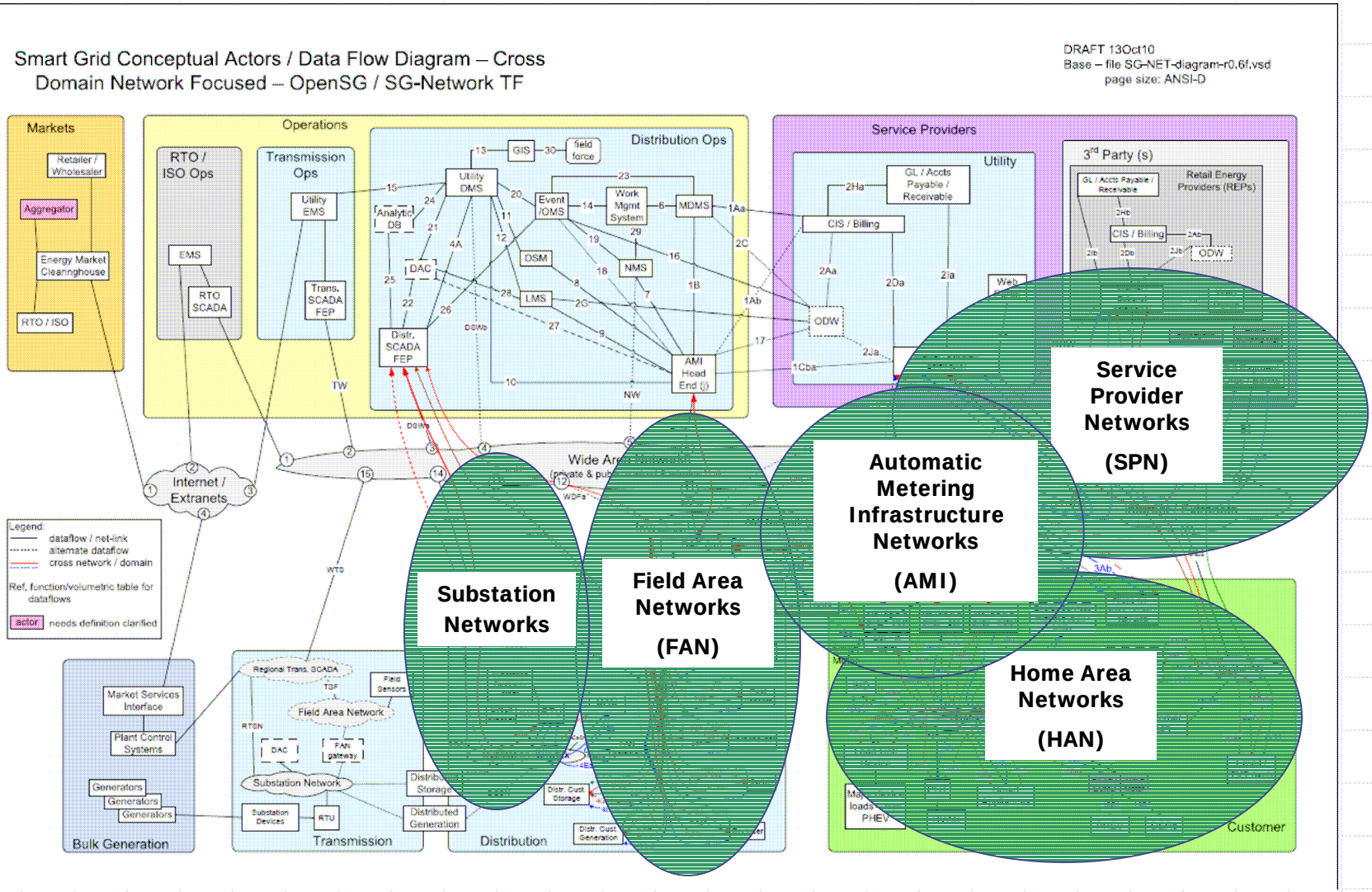
(14,000 – 14,500) MHz

- For paths of Length 1-2 miles, fade margins of 30-40 db are possible in (200 mm/hr) Heavy Rain depending on antenna sizes
- For Light Rain (10 mm/hr), 30-40 db fade margins are possible over 10-20 mile paths, depending on antenna sizes

14 GHz Potential Smart Grid Apps

- There are a number of networks within the Smart Grid, each having their own requirements, coverage areas, etc.
- Five candidates are addressed here:
  - Field Area Networks
  - Substation Networks
  - Automatic Metering Infrastructure Networks
  - Service Provider Networks
  - Home Area Networks

Candidate Wireless Networks for 14 GHz



Field Area Networks (FAN)

- Assumption: Field Devices do not necessarily tie to a substation and can be distributed over the entire service area of the utility
- Assumption: Individual Device Frequency of Read Status/Data varies from every 2 minutes to every 4 hours with an average payload of 250 bytes with message latency averaging 2 sec
- For 10,000 devices delivering 1000 bytes/hour, the FAN traffic would be 10 Mbytes/hour

Substation Networks

- Assumption: 256 KB/s at each substation for SCADA and Security Monitoring
- For a sample of 500 Substations, network traffic of 16 Mbytes/sec would be generated over the entire network

Home Area Networks

- Assumption: 100 KByte/s HAN Interface supporting message payloads for 30 HAN devices per meter, with no overhead
- Assumption: Entities other than Homes will utilize the HAN connections as well, including farms with outbuildings, multi-building factories, etc. For such entities, 100 HAN devices per meter would not be unreasonable
- For a large Metropolitan area with 2.5 Million homes, each with 30 HAN devices, and an additional 50,000 businesses with 100 devices, the total network traffic generated is 8 Gbytes/sec without protocol overhead

Service Provider Networks

- Assumption: 100 Mbytes/s to support wireless day-day transactional traffic for each supplier/reseller
- With 100 suppliers/resellers, this would generate 10 Gigabytes/s of data

AMI Networks

- Assumption: 2 - 4 Gigabytes of traffic per month generated by 7500 meters
- Assumption: Traffic cited is AMI traffic only and does not include HAN traffic

Applications

- A 14 GHz Base Station located at a Substation could carry the Substation Network traffic at a high reliability and Field Area Network Device traffic within its coverage area at a reduced level of reliability
- Additional channels can/should be used for high capacity backhaul, typically with an MPLS WAN alternate routing for redundancy for data elements requiring higher reliabilities

14 GHz Base Stations

- One logical approach is to use CDMA in order to minimize the effects of co-channel interference from satellite facilities
- This can be coupled with multiple channel transmission and the use of channel hopping by meters and field devices