Assigning Uplink Resources for the Universal Access Transceiver (UAT)

April 2004

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Background

- UAT data link fielded initially with the SF-21 East Coast initiative
- Uplink products from ground station UATs are the major incentive to equip with Automatic Dependent Surveillance Broadcast (ADS-B)
  - Flight Information Services – Broadcast (FIS-B): Weather and aeronautical information
  - Traffic Information Service – Broadcast (TIS-B): Traffic information derived by ground-based sensors
- Challenge is how to coordinate limited uplink resources most effectively among ground stations

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Outline

- UAT and Ground Broadcast Transceiver (GBT) overview
- Proposed resource assignment approach
- Tool for evaluating resource assignment
- Future work needed

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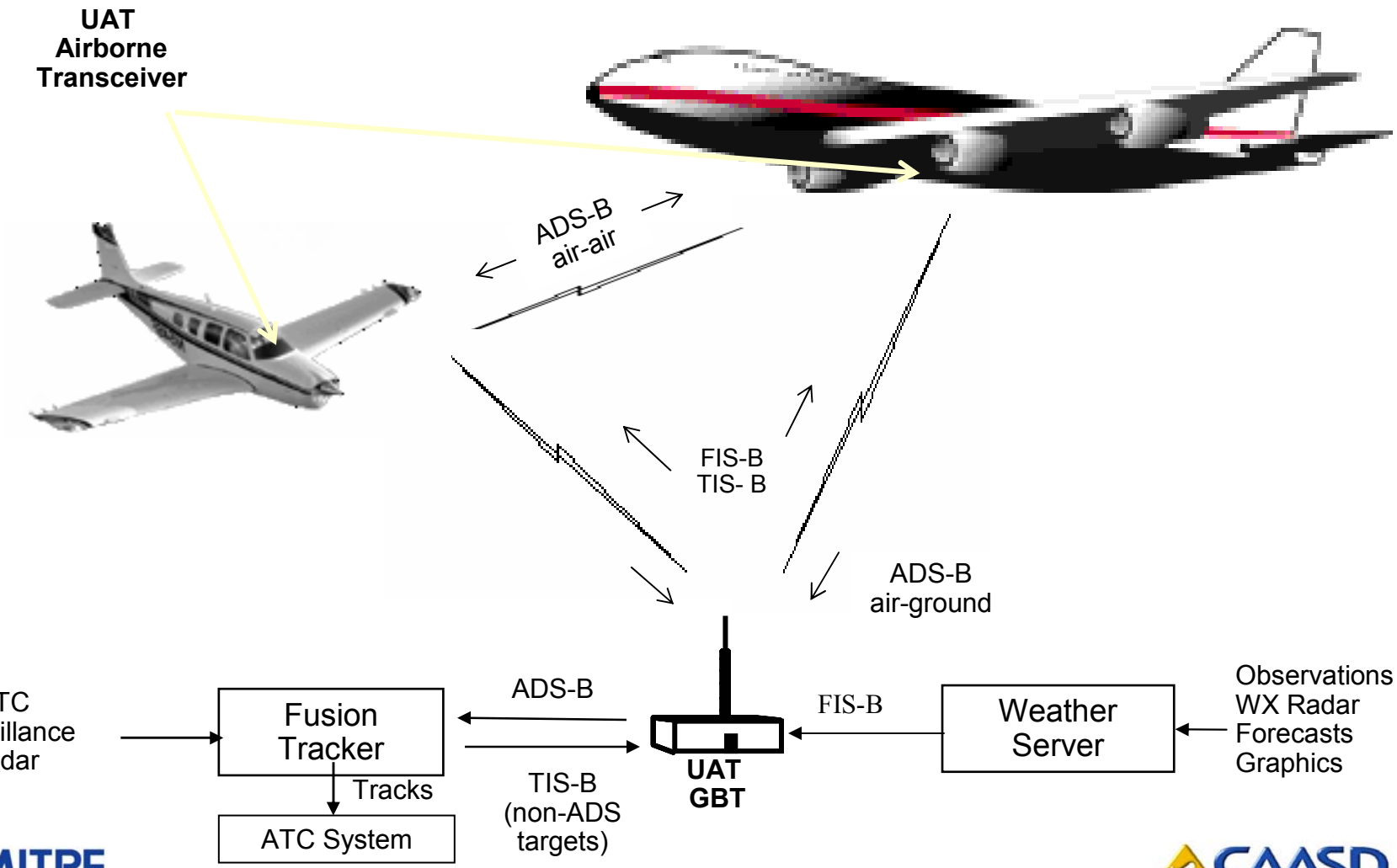
UAT Applications and Connectivity



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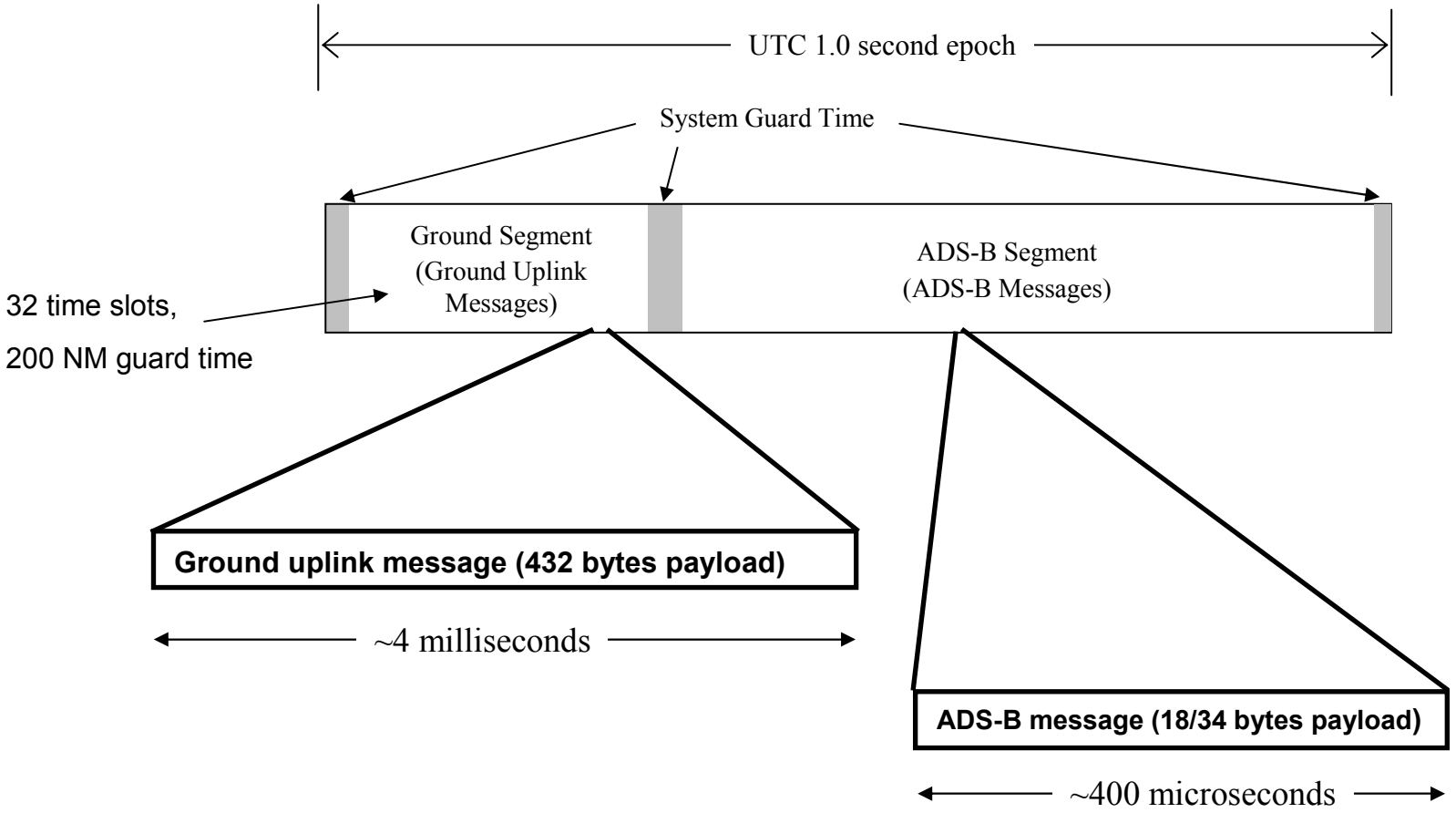
UAT Media Access: Overview



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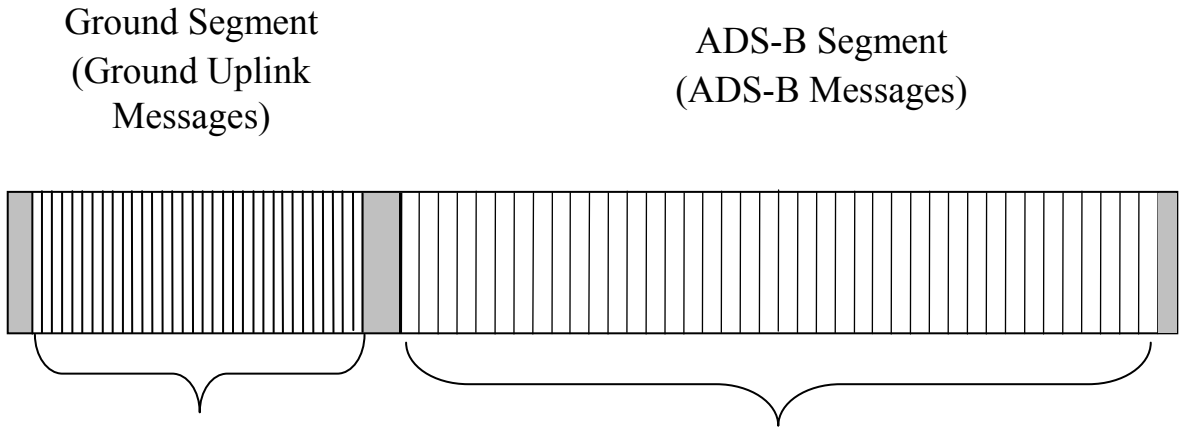
UAT Media Access: GBT



Time Slots for Ground uplink messages (32)

TIS-B Transmission Windows (8 groups of 5) for multiple TIS-B uplinks in ADS-B format

Each transmission window can convey a series of up to 38 TIS-B uplinks

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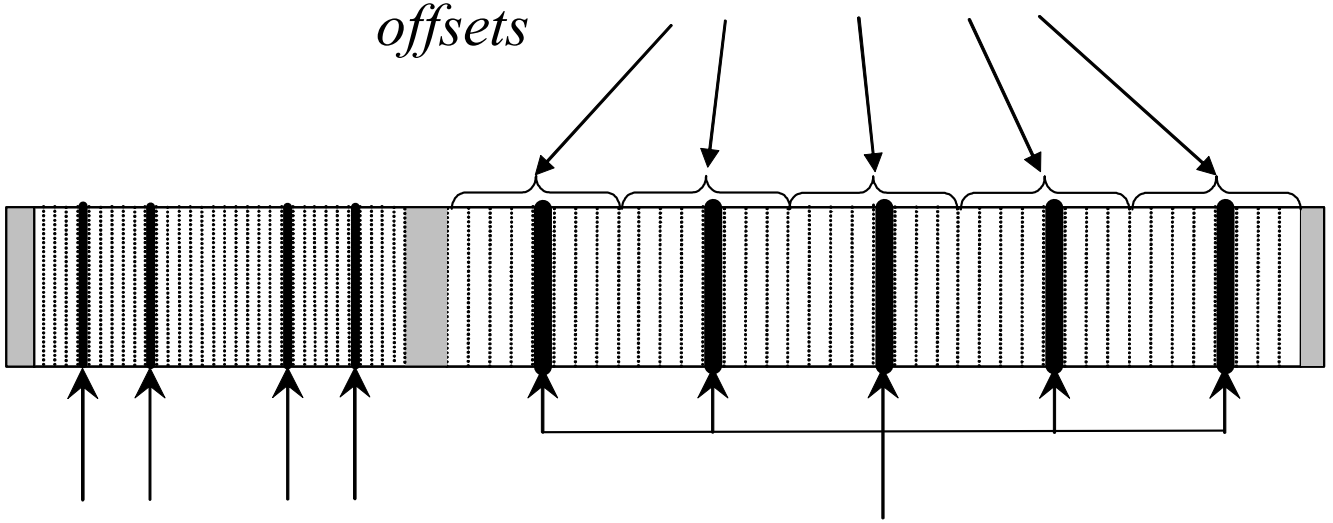
Example GBT Resource Assignment for East Coast

5 TIS-B *transmission intervals*, each containing 8 TIS-B transmission windows at various *offsets*



GBT configuration item "CHANNEL_LIST" (~14 kbps for FIS)

GBT configuration item "OFFSET" (190 TIS-B targets per second)

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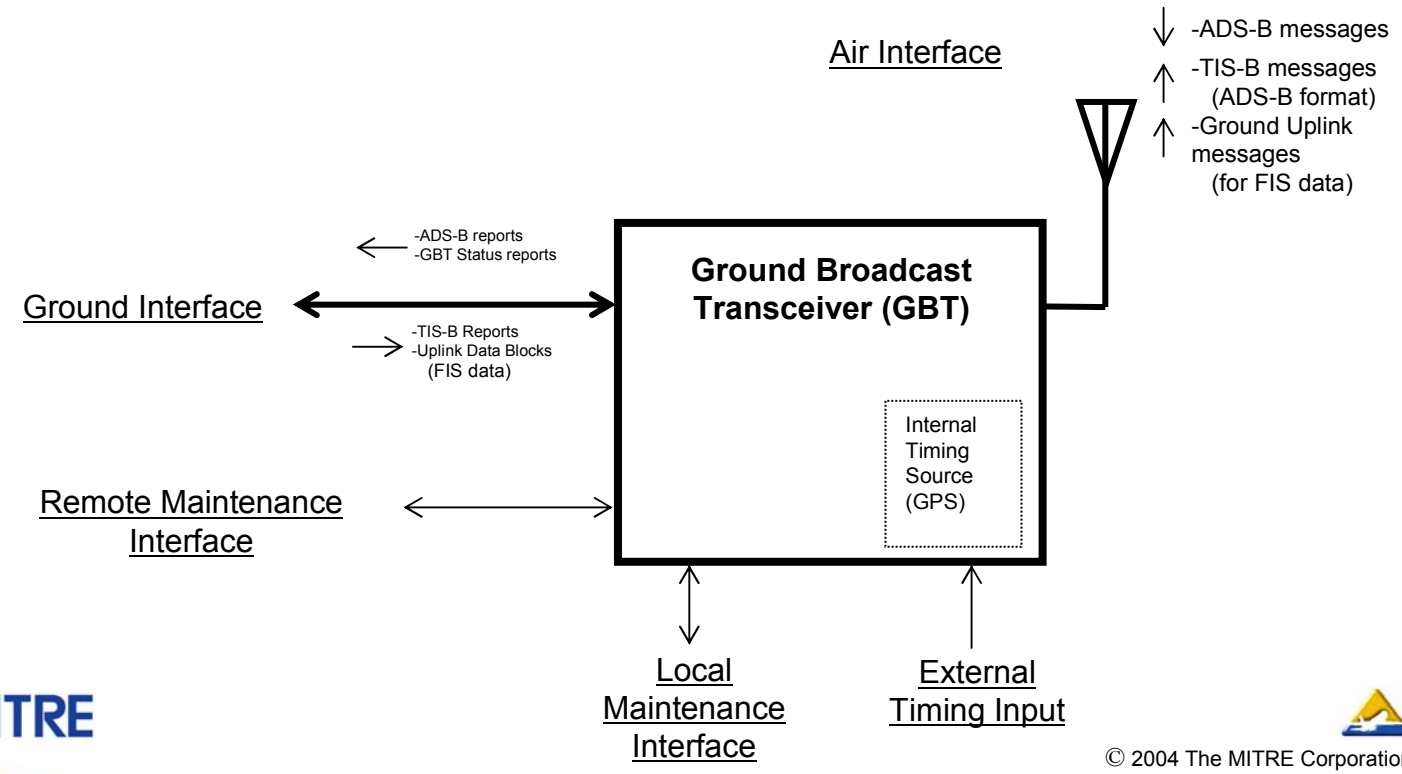
GBT Overview

- Standard National Airspace System (NAS) automation interface for ADS-B
- Internal Global Positioning System (GPS) timing source for transmitter control and ADS-B time stamping
- Uplink resource assignments can be established/changed remotely



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Sensis Corporation GBT Top View

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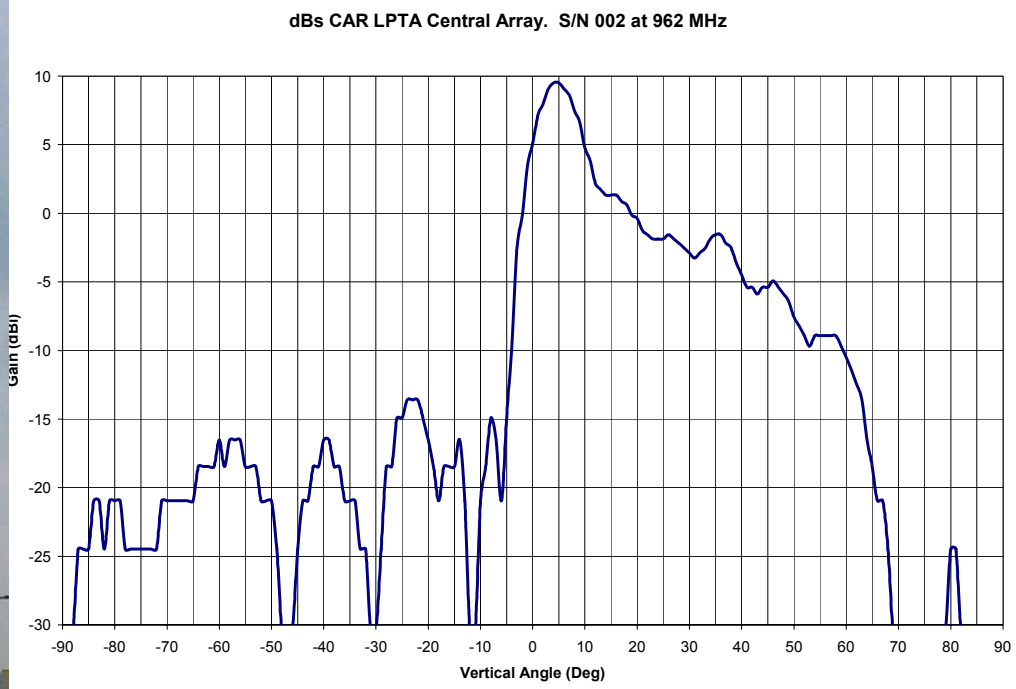
GBT Antenna: dB Systems 5100a



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Planning a GBT Network

- **Operational Objectives**
  - **Enable each GBT to provide broadcast traffic and weather information**
  - **Support low altitude users (GA) with high density of ground stations**
  - **Prevent overload of largely redundant information for users at high altitude**
  - **Assume service objective is met if each airspace user is provided service to at least one GBT at all times**

- **Techniques to help meet the objectives--given the limited resource**
  - **Multiple station classes in terms of interference protection afforded**
  - **Manage bandwidth needed for each station**
    - **Tailoring update cycles by product**
    - **Tailoring geographic scope by product—but ensuring reasonable product "look ahead" for the pilot**

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Proposed Resource Assignment Strategy

- Assume that GBT assignments are based on eight aggregations of time slot resources for FIS-B and TIS-B
  - Each of these time slots are referred to as “channel” throughout remainder of this presentation
- Proposed strategy based on a three-tiered cellular layout
  - Highest tier GBTs afforded highest protection. These stations provide service to high altitude users and are selected to ensure horizon blockage by “co-channel” competitor
  - Lower tiers are increasingly more dense geographically with more aggressive channel reuse. These are used to “fill in” lower altitude gaps left by the tiers above

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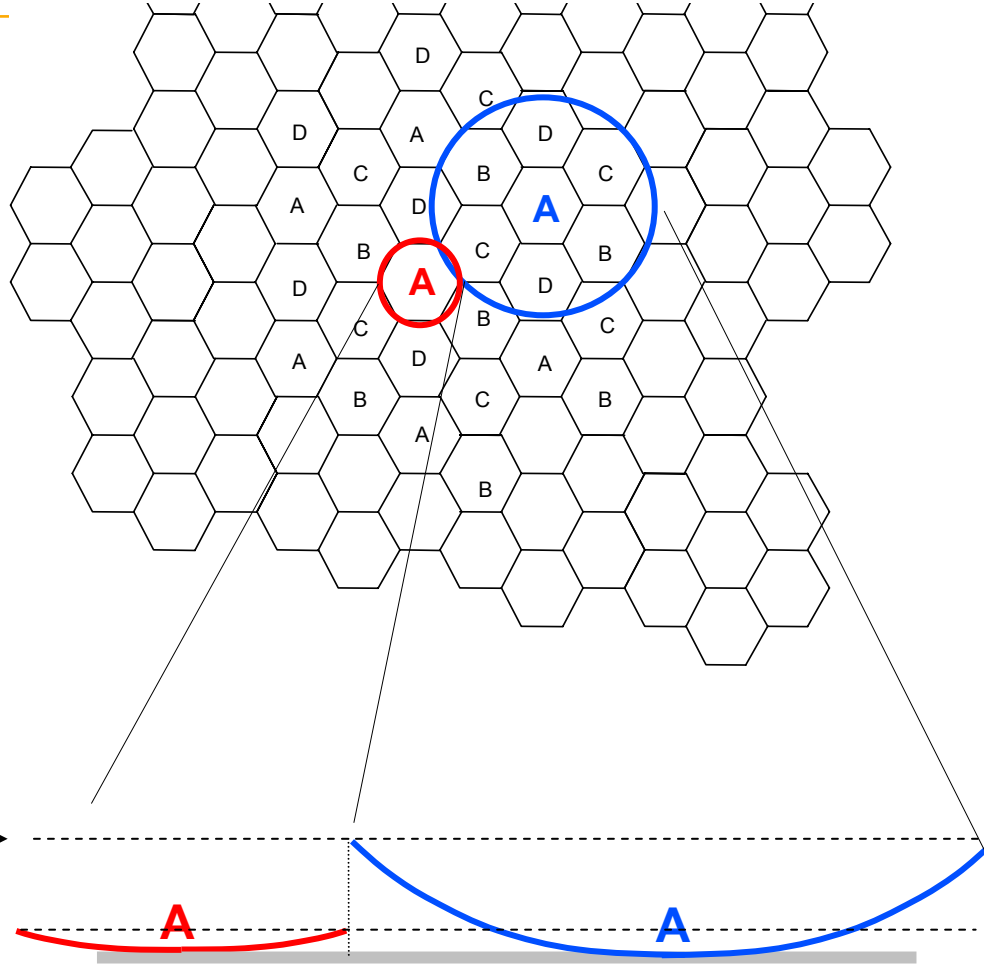
Relationship Between Floor and Ceiling of a Tier for N=4

- **Regular cellular reuse patterns are based on reuse of N channels where N = 1, 3, 4, 7, 9, 12, 13 etc.**
- **The relationship between the floor of service and ceiling of service can be determined for any value of N**



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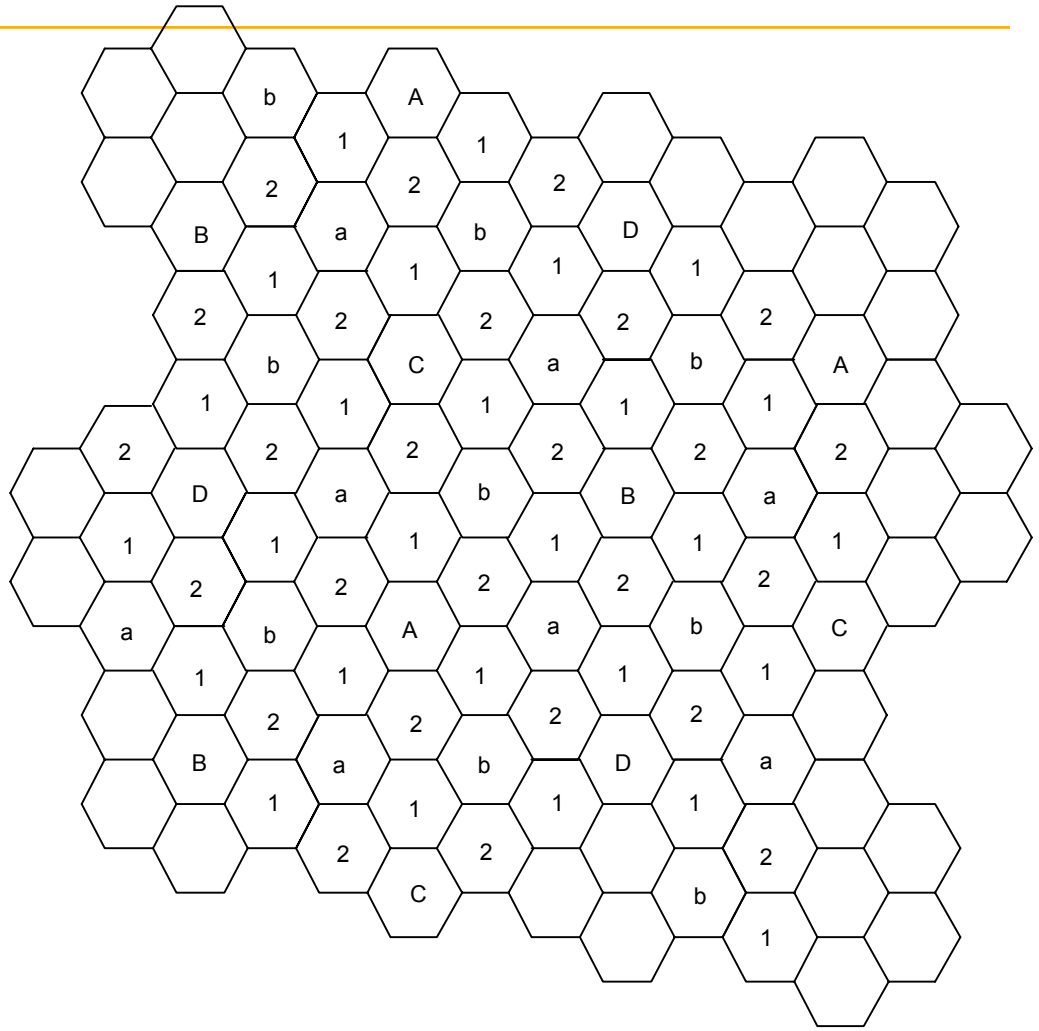
Ideal Three Tier Layout

- Use of three tiers appears to be a good fit for the GBT operational objectives if N= (4,3,3) where the upper - most tier is listed first
- The (4,3,3) tiered approach requires
  - 4 channels for the 1st tier→A-D
  - 2 additional channels for the 2nd tier→a-b. (1st tier channels as a group constitute the 3rd channel)
  - 2 additional channels for the 3rd tier →1-2. (1st and 2nd tier channels constitute the 3rd channel)



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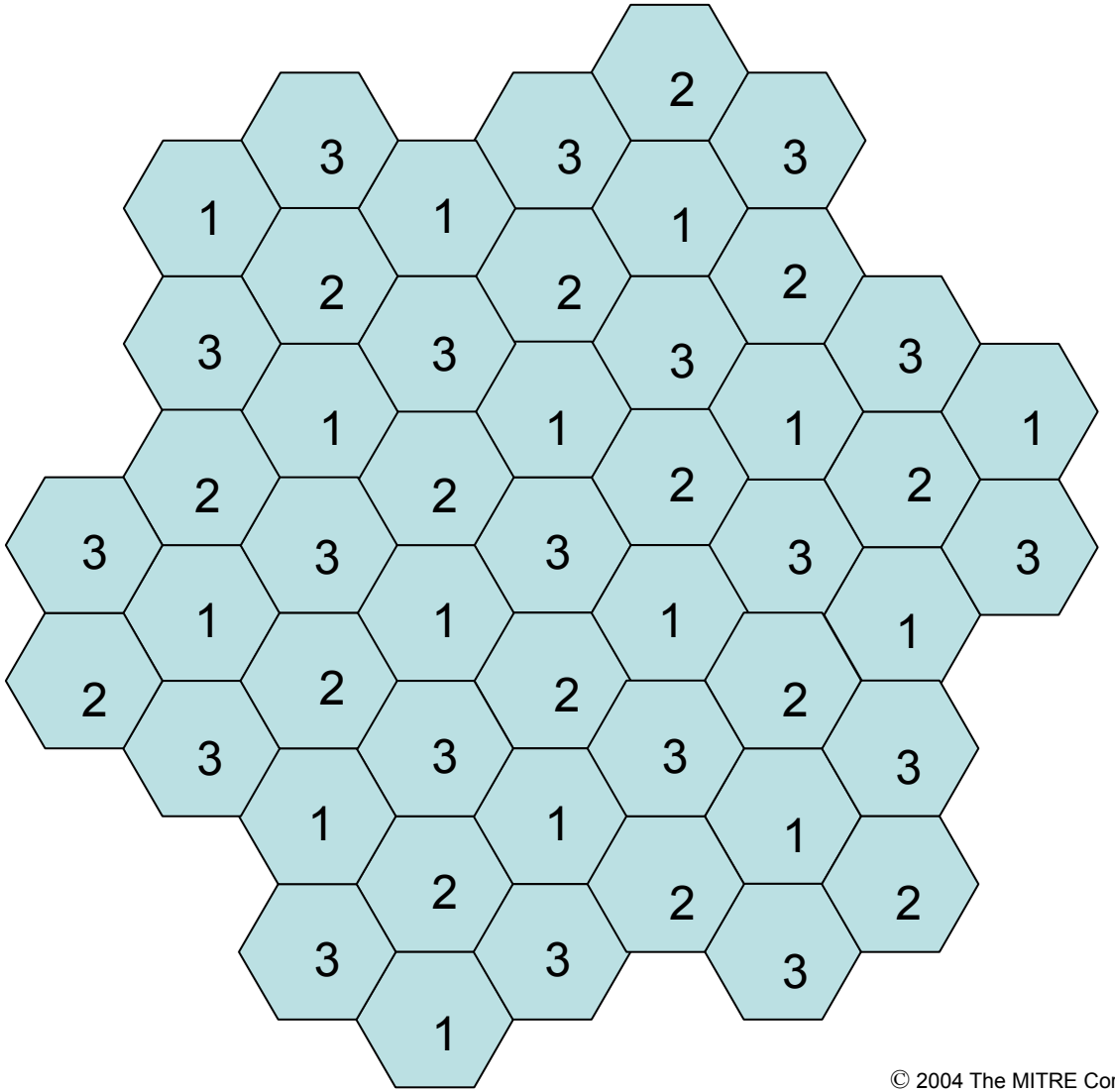
3rd Tier Layout



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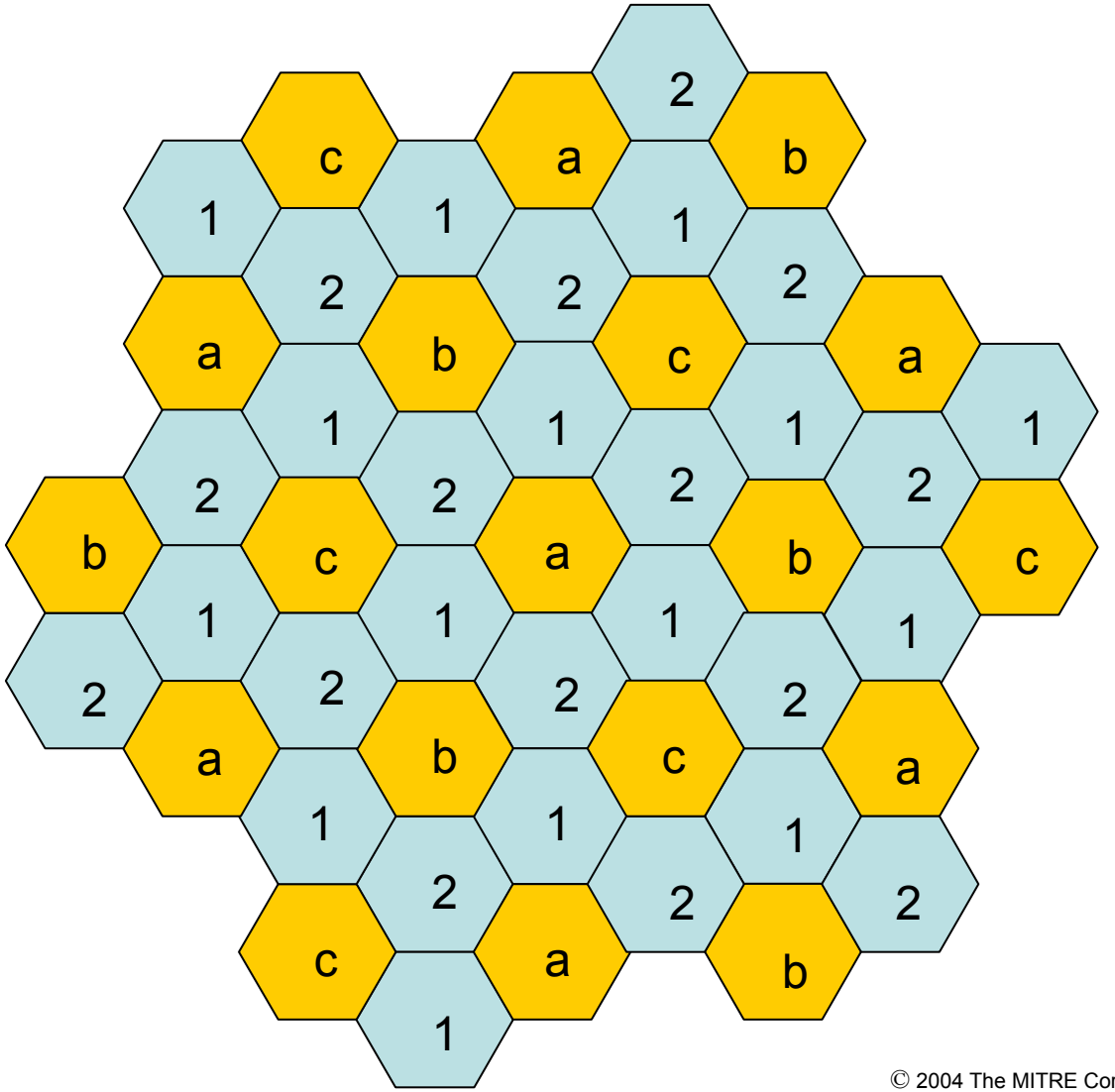
2nd and 3rd Tier Layout



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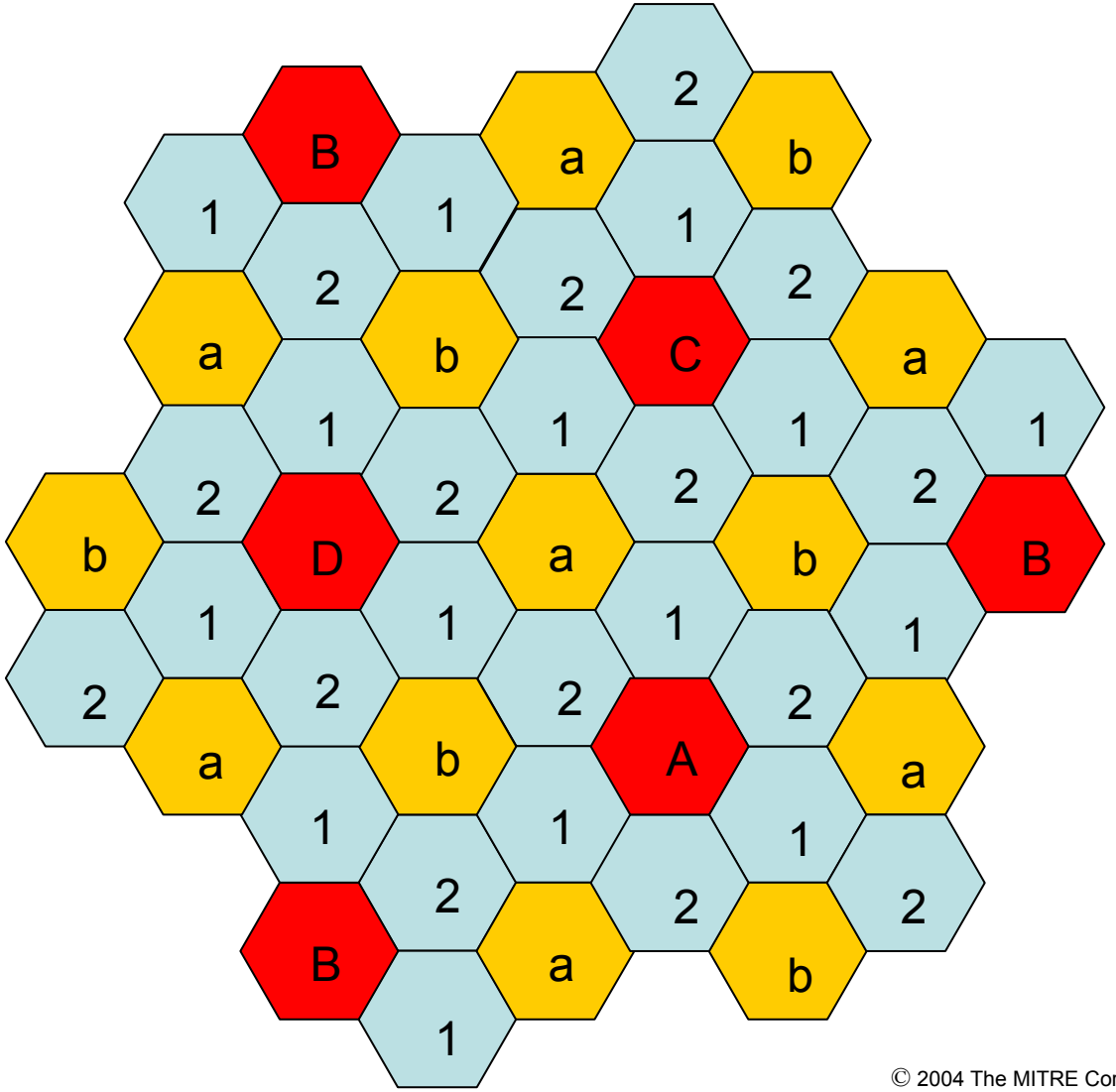
1st, 2nd and 3rd Tier Layout



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What if GBT site geometry is not ideal?

- Reasonable geometry is critical for top tier. This tier should be easiest to optimize in a dense network of GBTs
  - If network is not dense, the assignment challenge is lessened

- Ensure enough altitude "guard band" between floor of one tier and the ceiling of the one below to absorb non-ideal geometry
  - N=(4,3,3) example for ideal geometry case
    - Tier 1: 48,600' – 7200'
    - Tier 2: 16,200' – 2400'
    - Tier 3: 5400' – 800'

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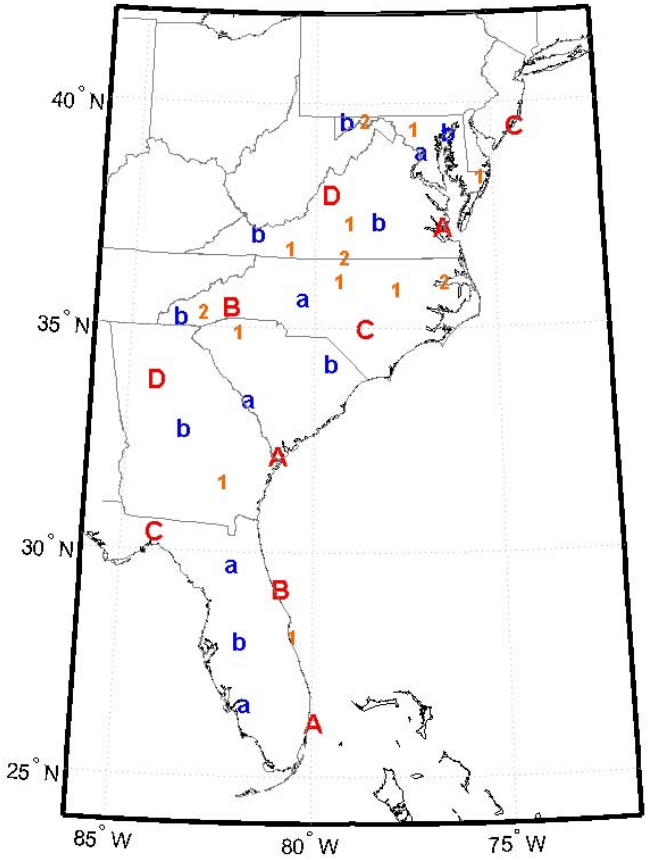
Three Tier Channel Plan for East Coast



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Initial Mapping of GBT Resources to "Channels"

Tier	GBT Logical Channel ID*	GBT CHANNEL LIST Assigned (FIS-B slots)	GBT OFFSET Assigned (TIS-B Transmission Windows)
1	A	1, 7, 13, 19, 25	1
	B	2, 8, 14, 20, 26	2
	C	3, 9, 15, 21, 27	3
	D	4, 10, 16, 22, 28	4
2	a	5, 11, 23, 29	5
	b	6, 12, 24, 30	6
3	1	17, 31	7
	2	18, 32	8

*Designations are used in this presentation only to help highlight the tiers

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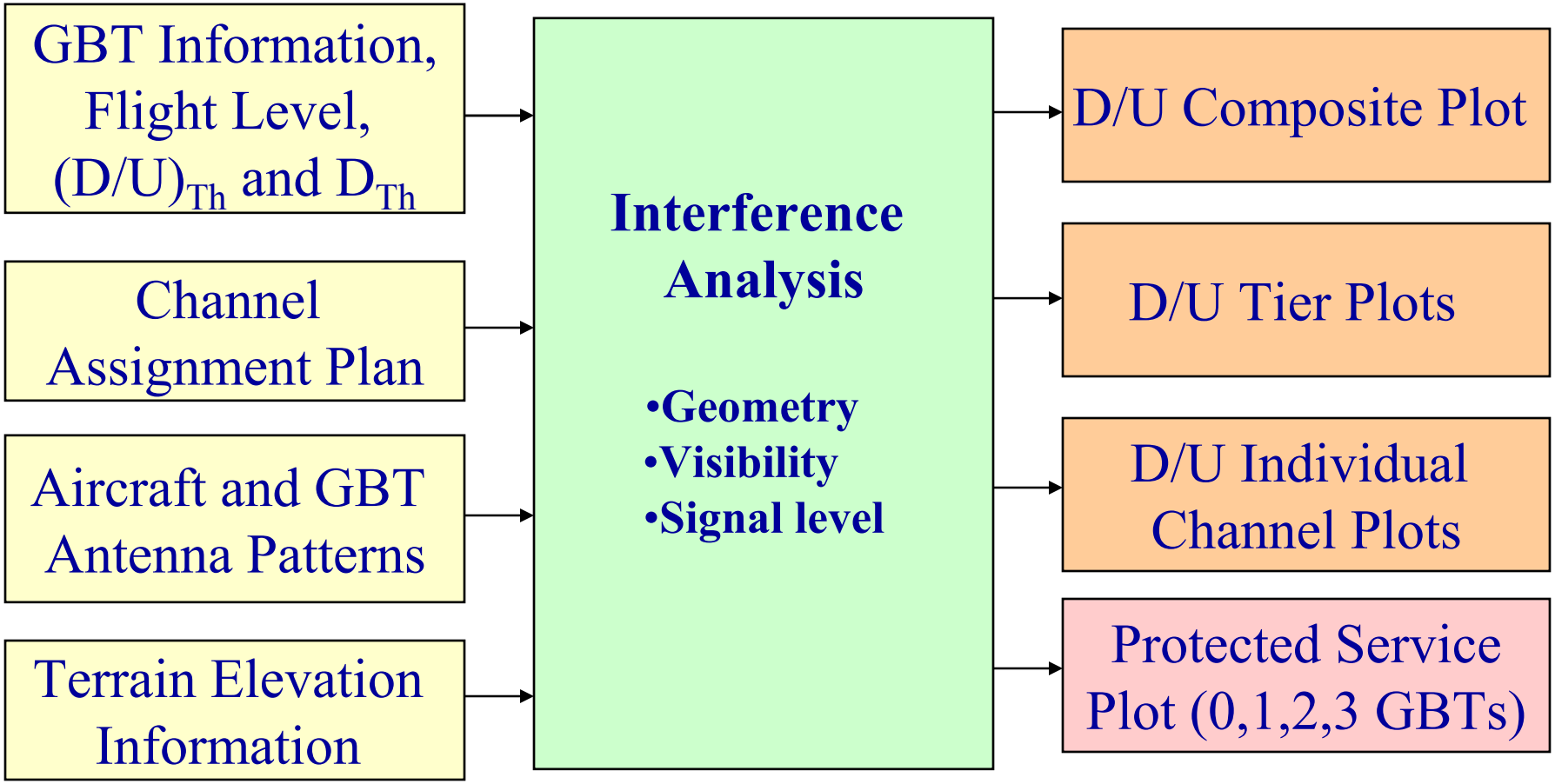
Tool Block Diagram



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Parameters Used

- GBT output power 25 watts
- GBT antenna dBs 5100a
- Minimum signal threshold -87 dBm (~4 dB margin)
- D/U threshold 16 dB (~6 dB margin)

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Output

- **GBT-oriented contours: The contour representing the D/U limit associated with a selected ground station at the altitude slice input by the user (separate contours for Channel and Offset assignments)**

- **Area contours: Contours representing areas of protected service by 0, 1, 2, etc ground stations at the altitude slice input by the user (separate contours for Channel and Offset assignments)**

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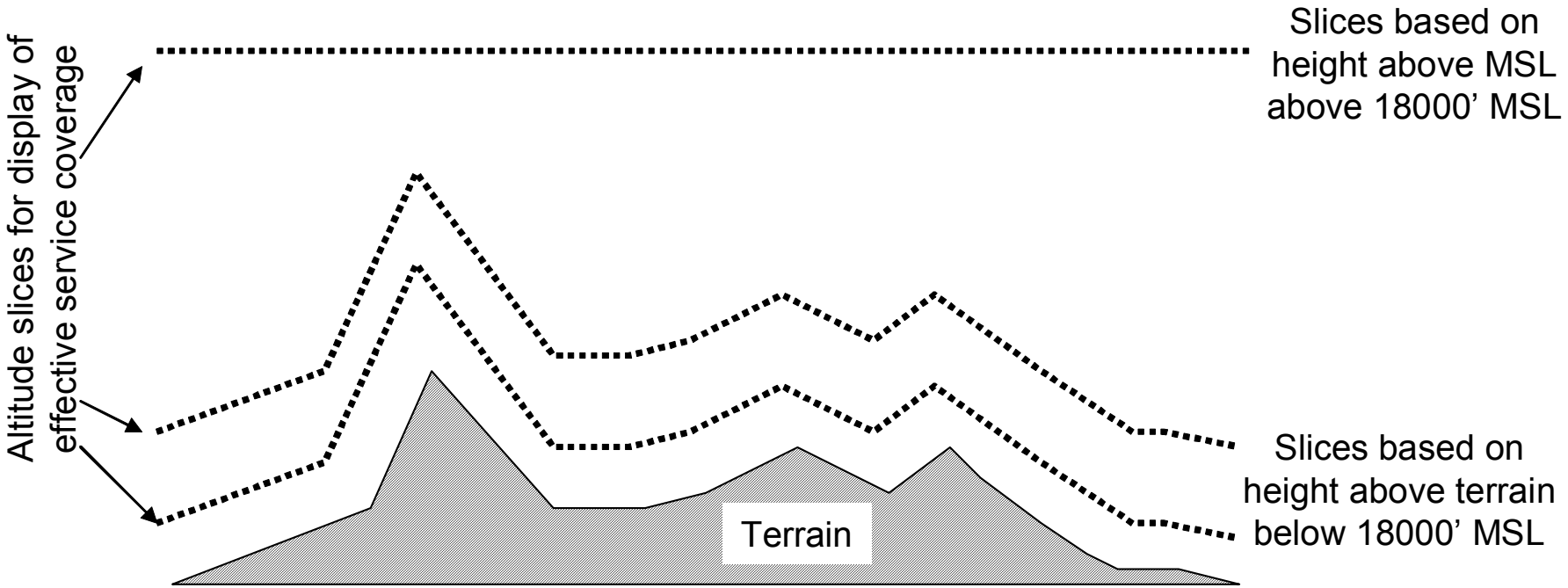
Altitude Slices for Tool Output



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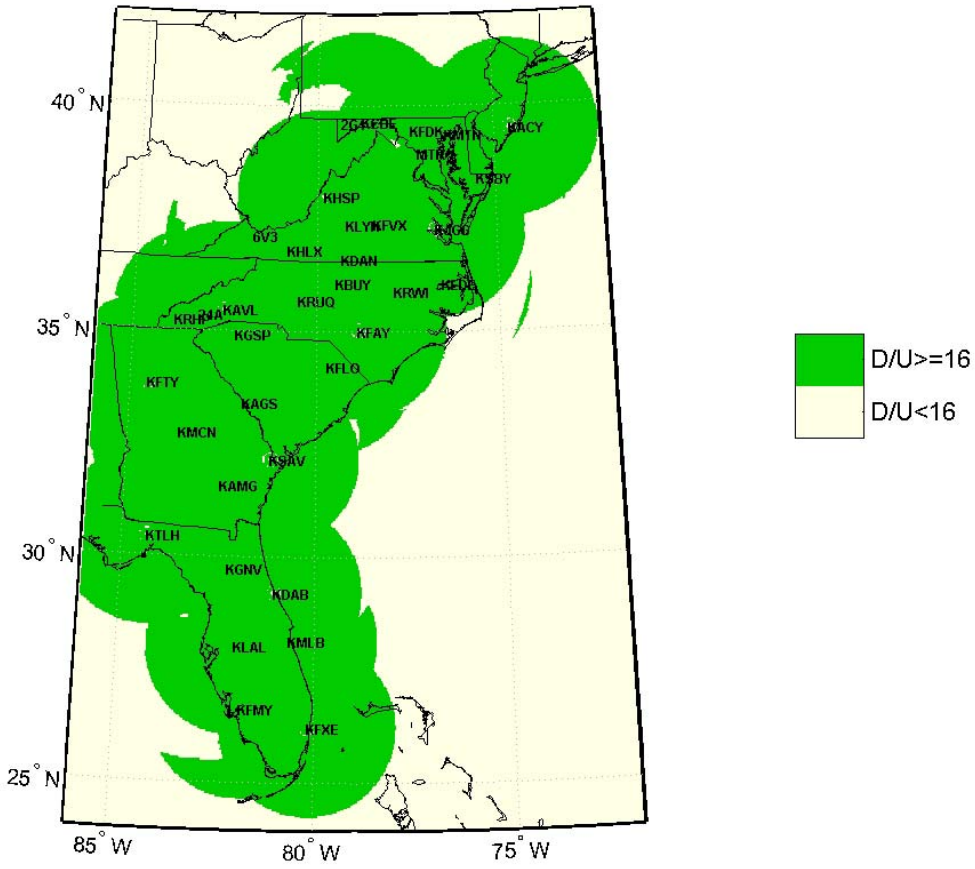
All-channel results (40000 ft. AMSL)



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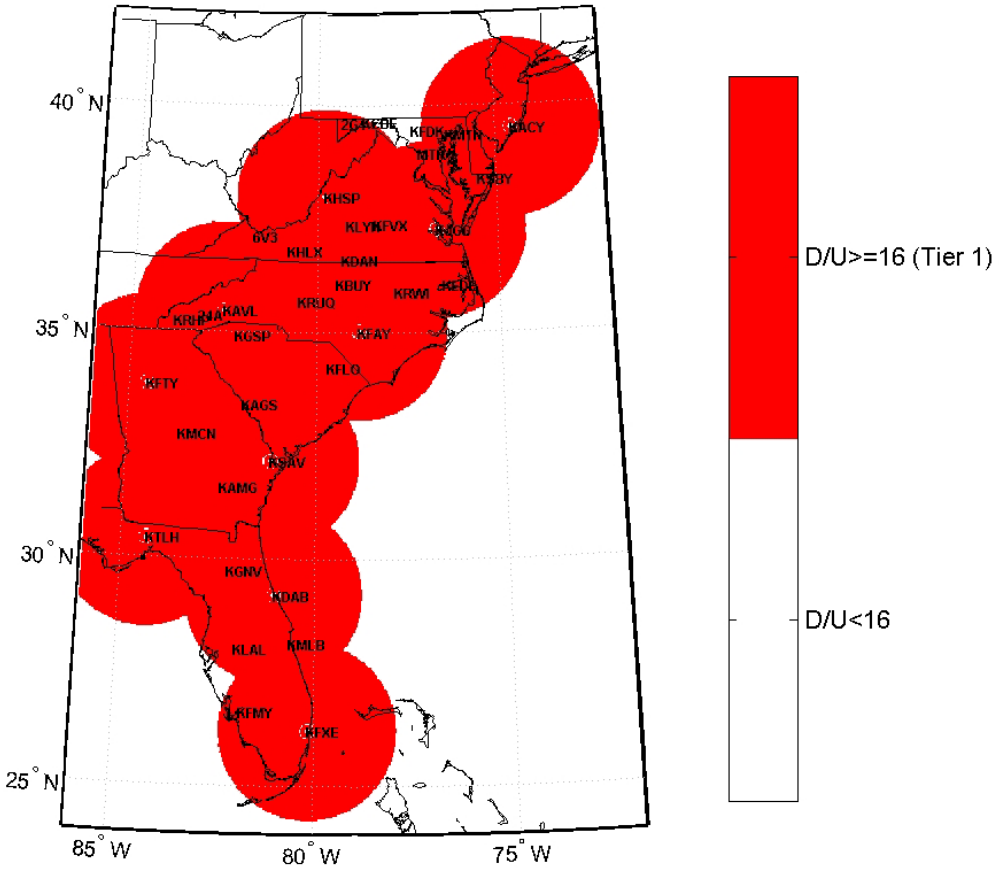
Tier One Channel Results (40,000 Feet)



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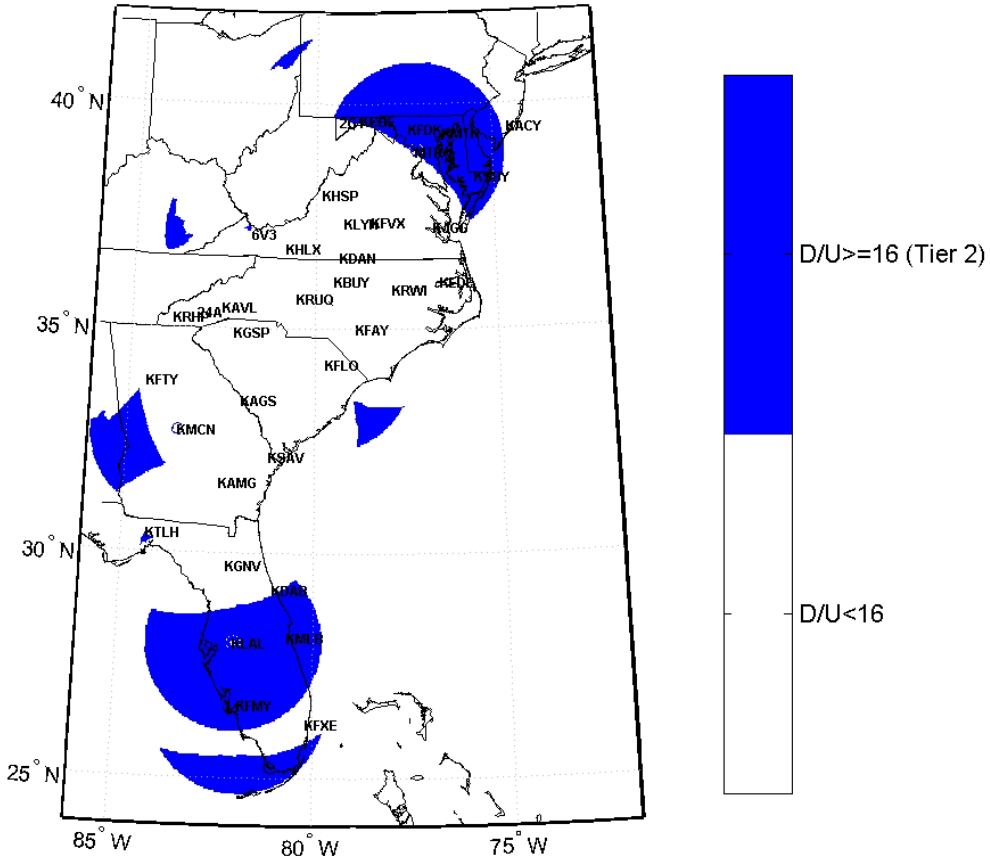
Tier Two Channel Results (40,000 Feet)



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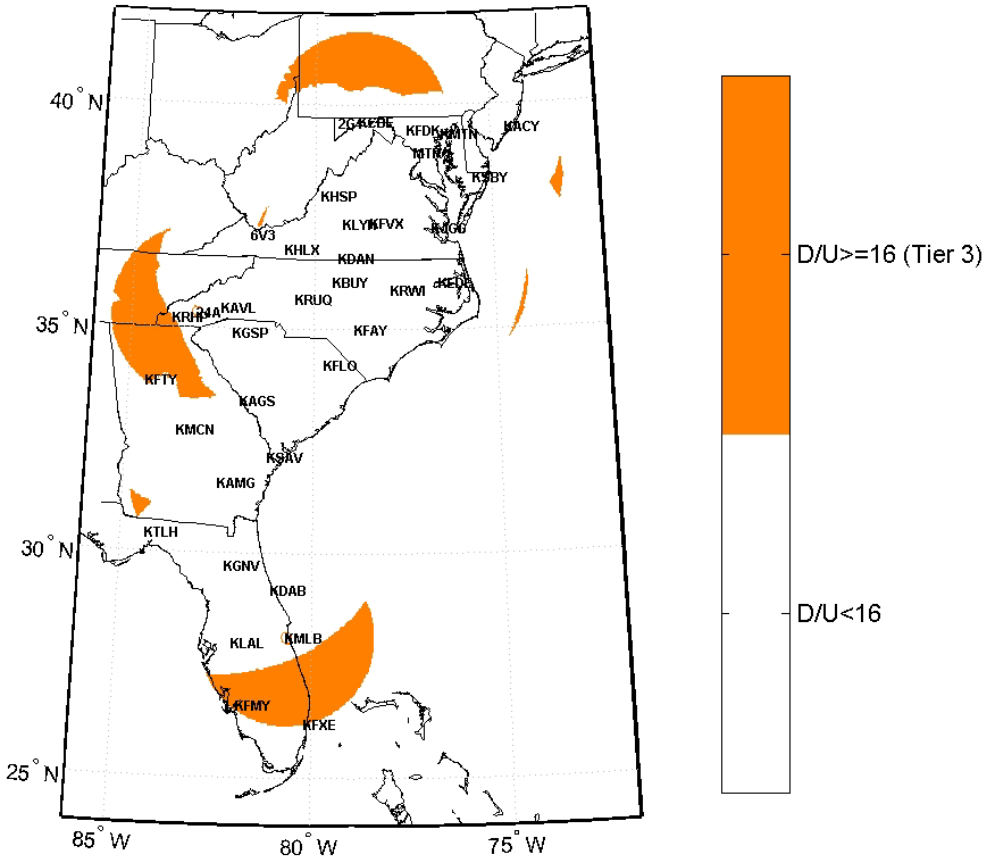
Tier Three Channel Results (40,000 Feet)



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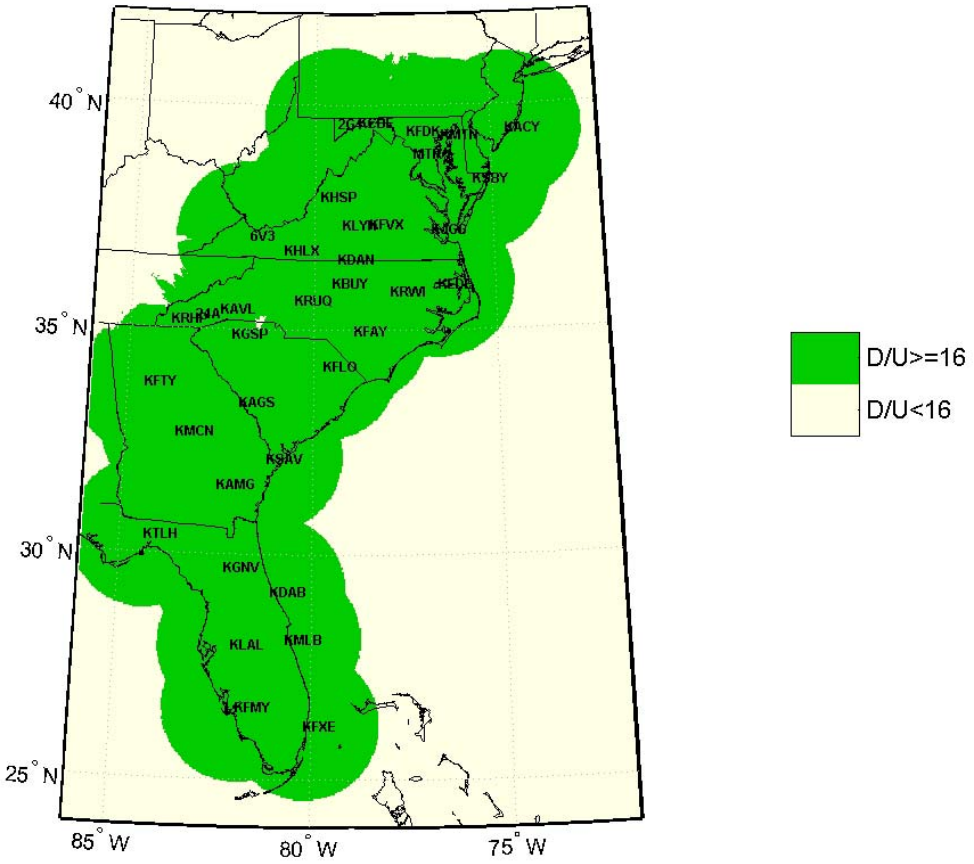
All-channel Results (10,000 Feet AGL)



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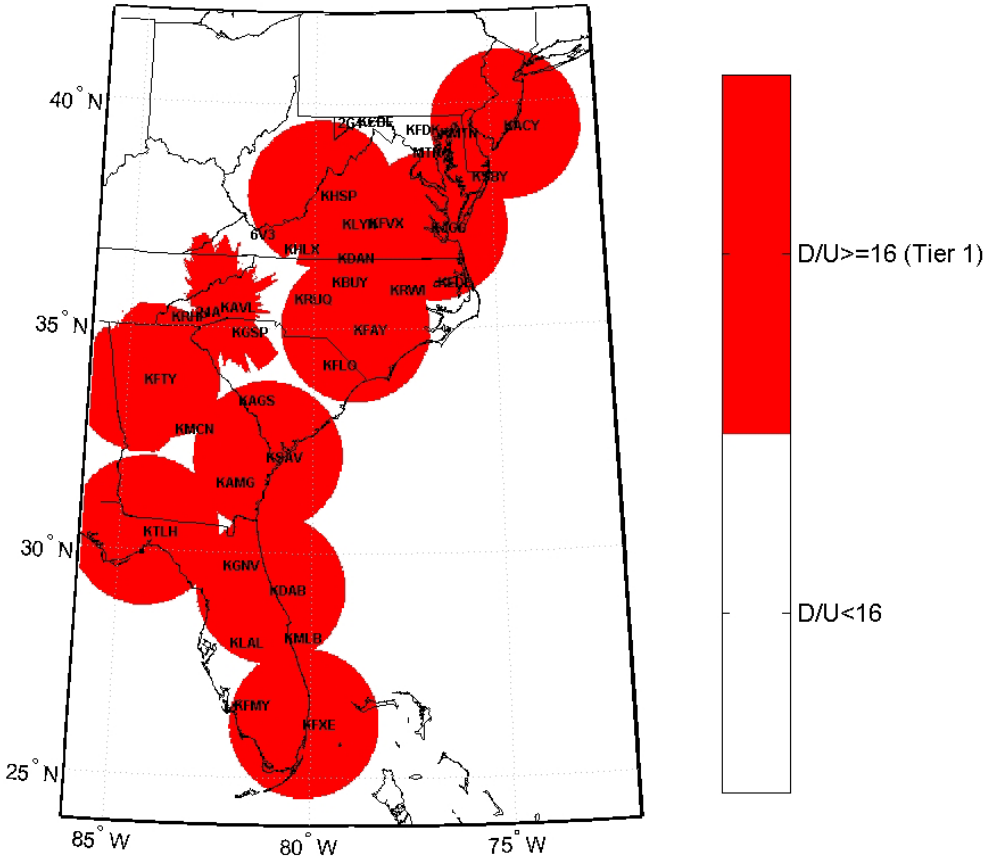
Tier One Channel Results (10,000 Feet AGL)



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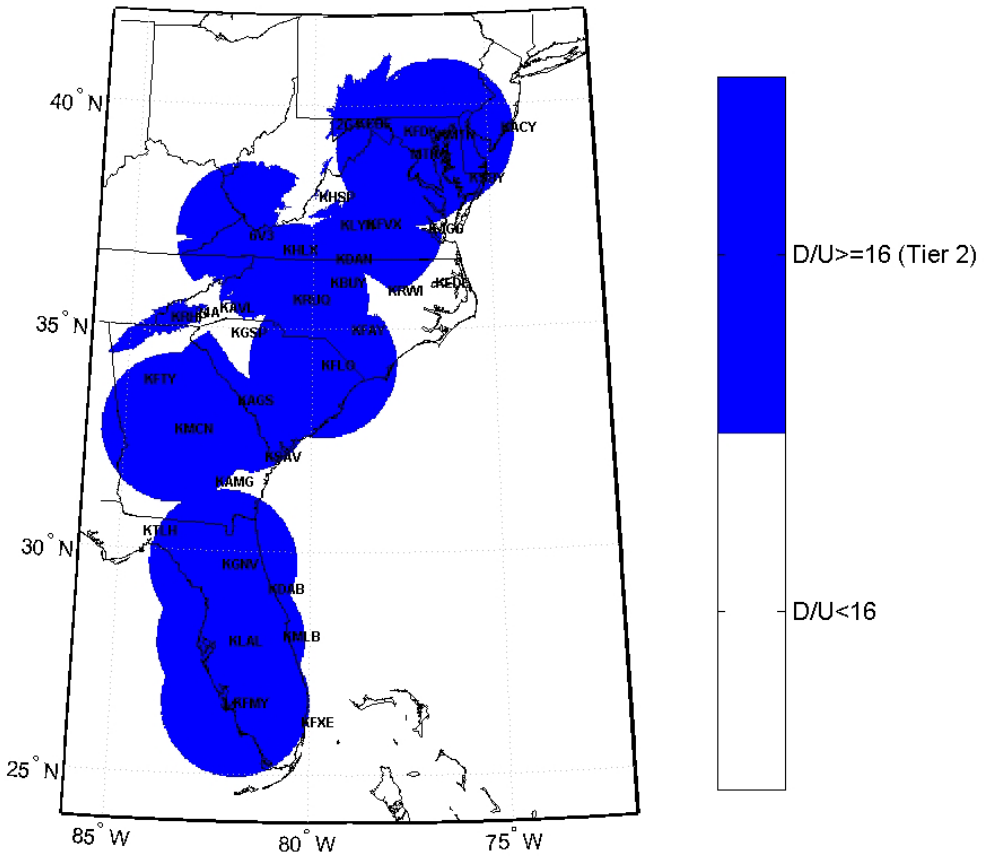
Tier Two Channel Results (10,000 Feet AGL)



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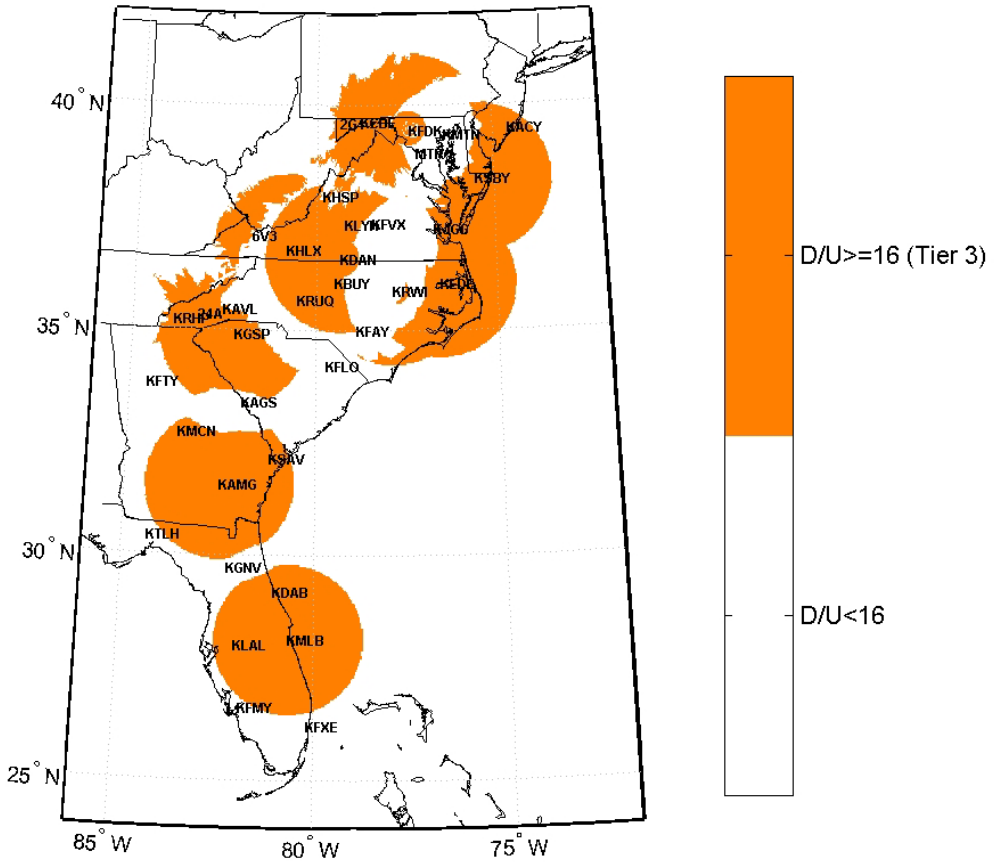
Tier Three Channel Results (10,000 Feet AGL)



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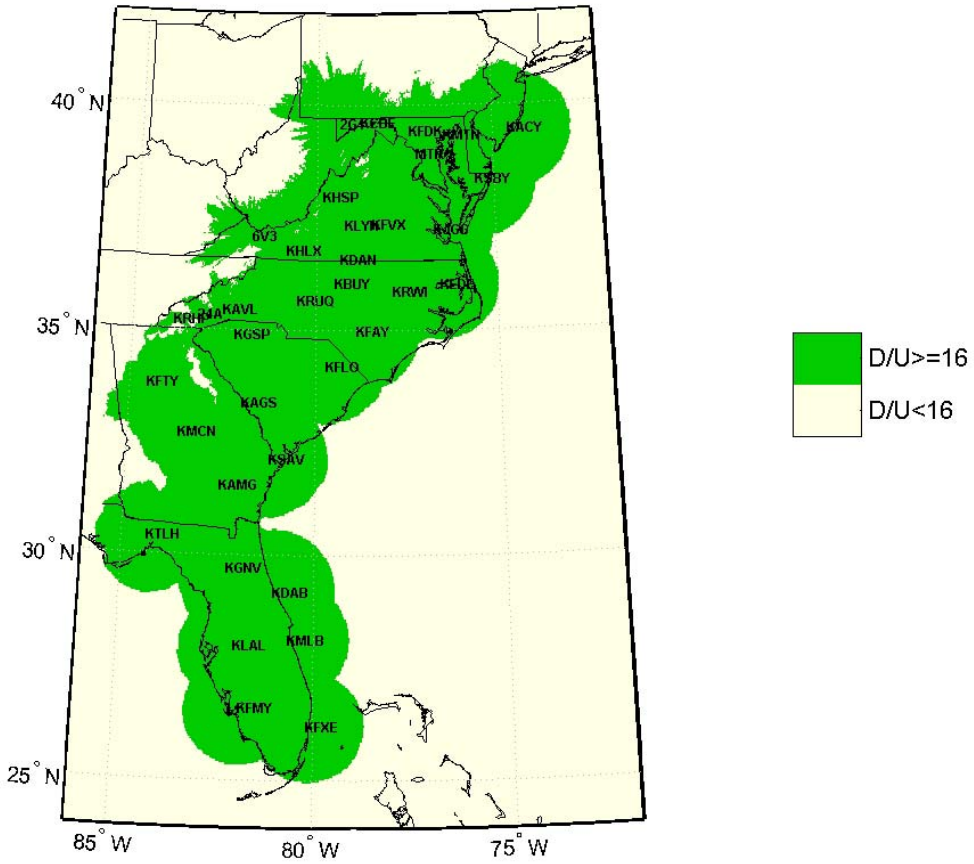
All-channel Results (3,000 Feet AGL)



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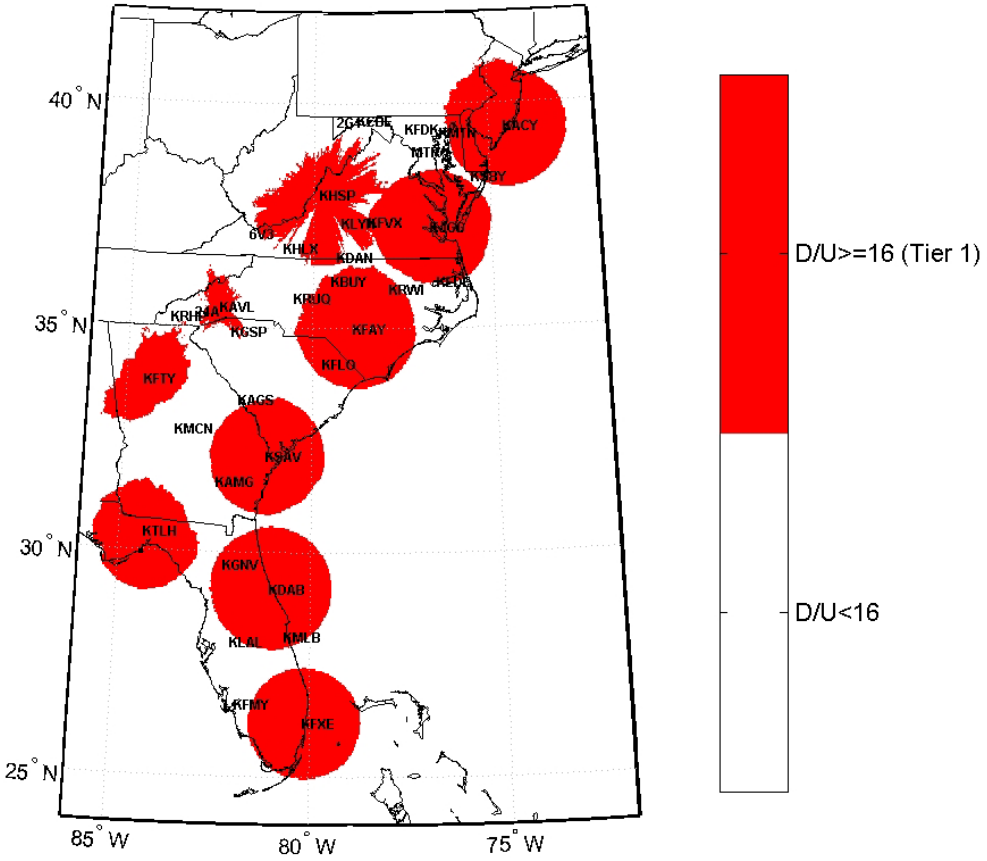
Tier One Channel Results (3,000 Feet AGL)



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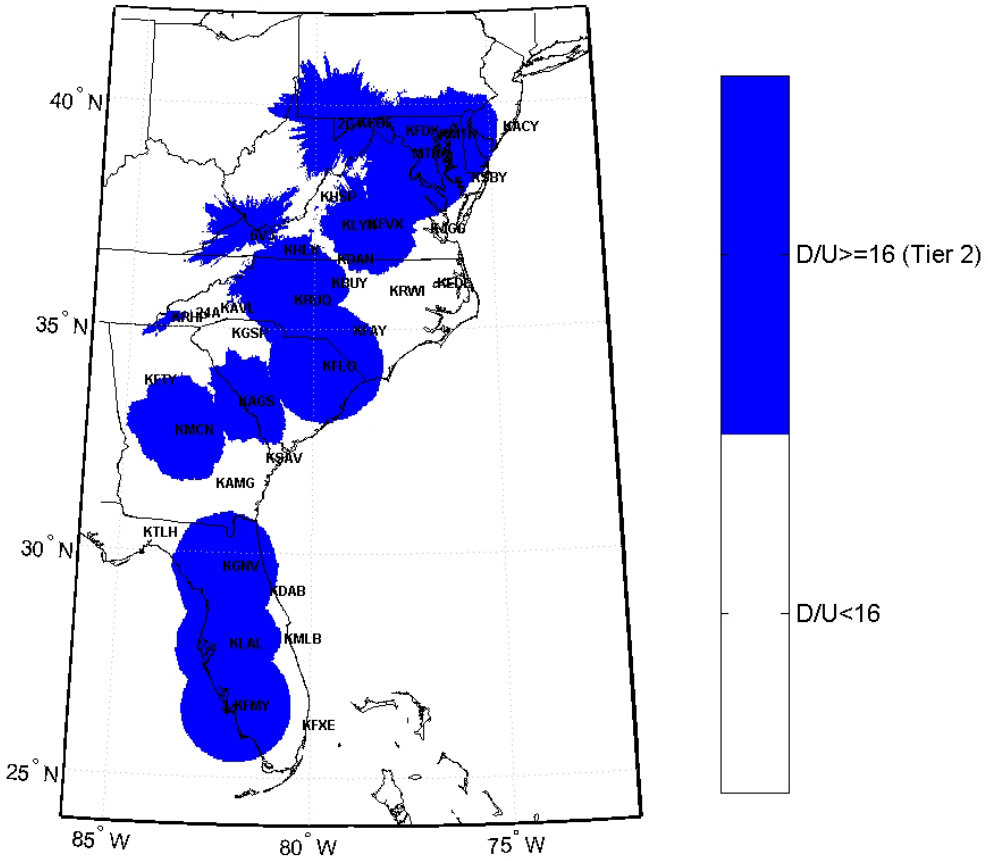
Tier Two Channel Results (3000 Feet AGL)



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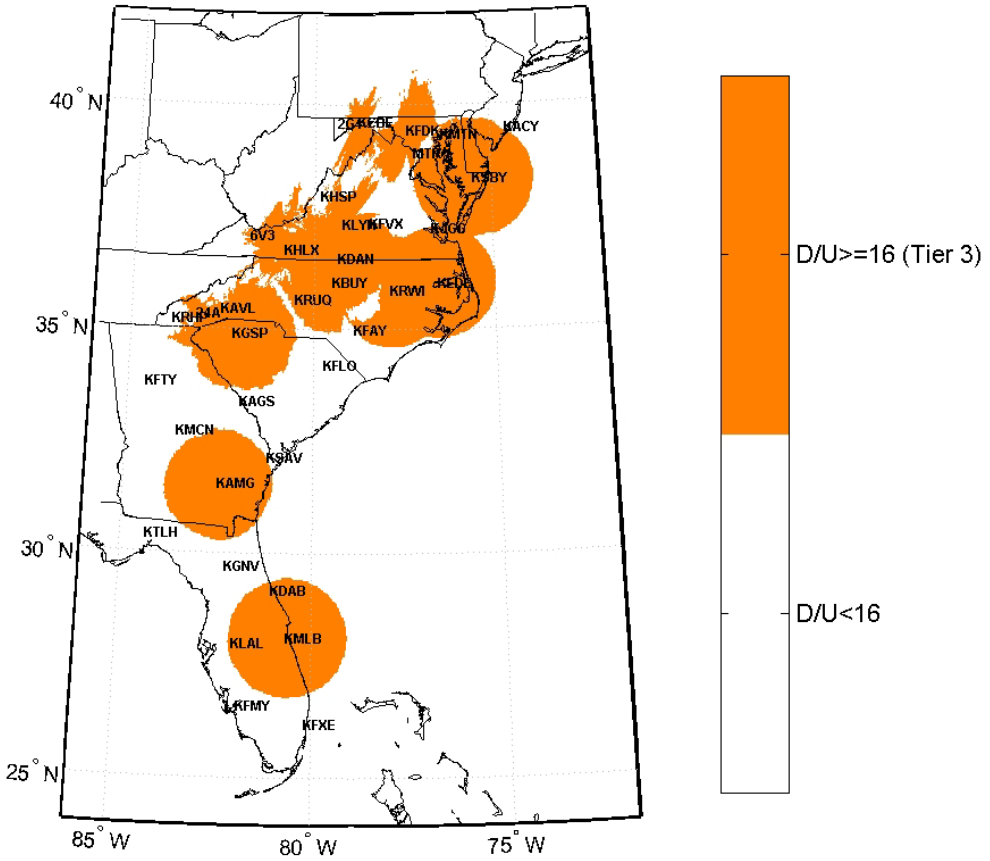
Tier Three Channel Results (3000 Feet AGL)



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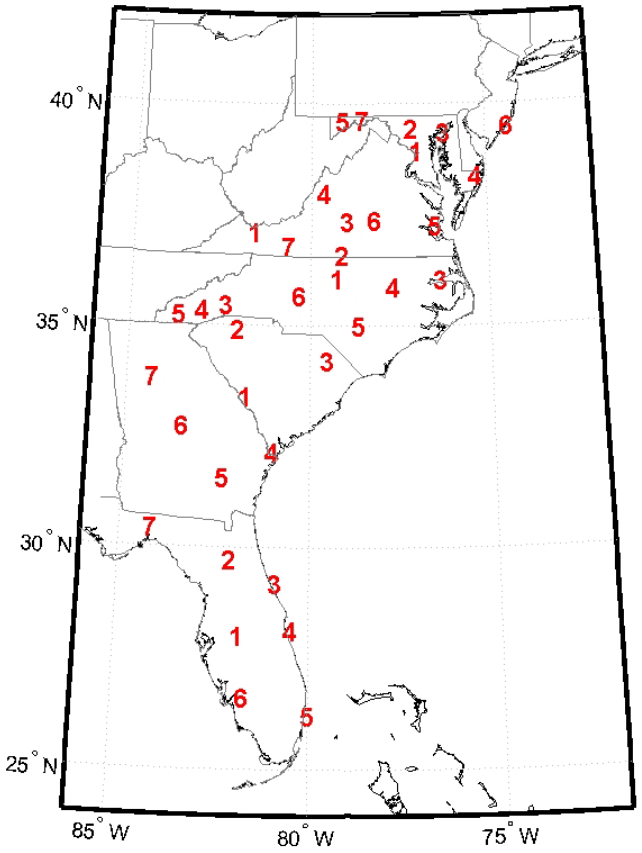
“Flat” Channel Plan



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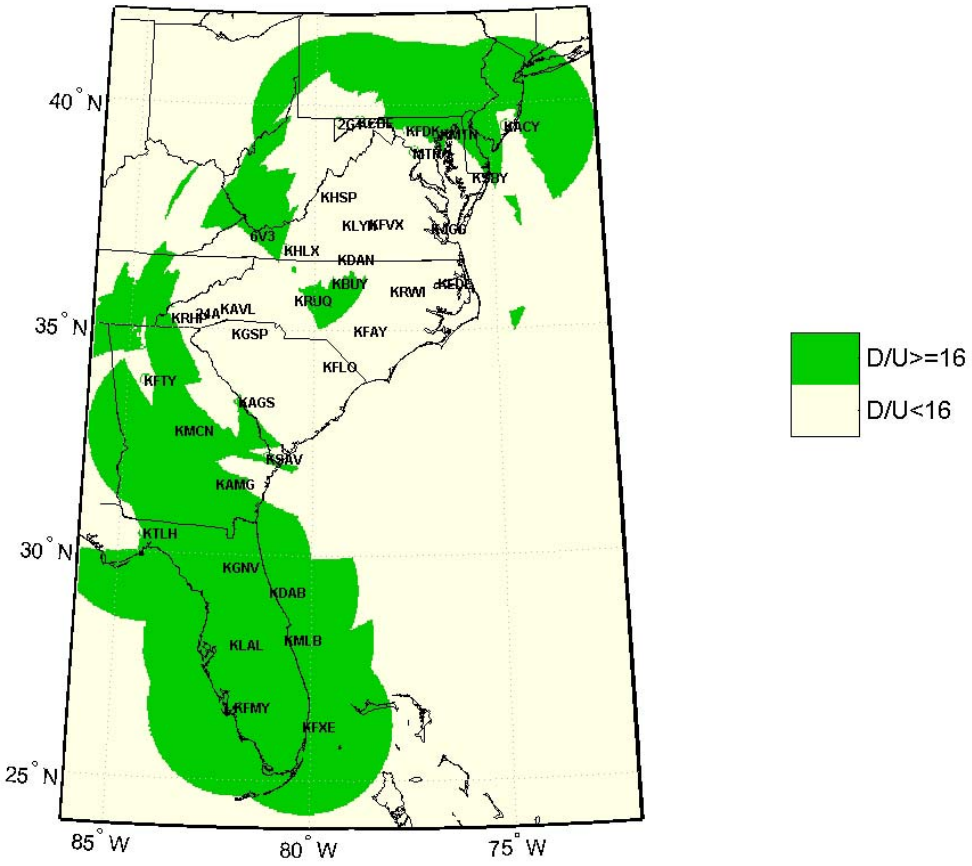
"Flat" Plan All-channel Results (40000 Feet AMSL)



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Conclusions/Future Work

- Tiered approach appears promising
- Need to ensure expansion to a much larger GBT network
- Assignments used here were made manually by sight. An automated assignment tool is desirable
- This plan assumed all 36 sites were established at once. Need to examine impact on plan for incremental fielding of GBTs
  - Changing GBT channel assignments should be easier than very high frequency (VHF) communications or navigational aids
  - Can be done remotely
  - Channel transparent to pilot
- Optimization of the evaluation tool needed
  - Preprocessing of terrain data for candidate sites
  - Partition GBT network into coordinated regional areas
- Assignment and evaluation tools need to be produced for operational use by Airport Surveillance Radar (ASR)

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