ATSC M/H Synchronization based on GPS (Epoch)

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Overview

- ATSC System Time Overview
- Potential Enhanced Applications ATSC M/H
- Conclusions

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Who We Are

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- Founded by original GPS architects
- Provider of timing and location solutions using broadcast TV
- Dual-use technology supporting commercial and public safety applications

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- Broadcast equipment manufacturer:
  - M/H Exciters
  - M/H Multiplexers and Encoders
  - M/H Test & Measurement
- Initially introduced concept of System Time

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What is System Time?

- ATSC System Time creates a direct relationship between GPS and ATSC emissions
- GPS is commonly used as a timing and frequency calibration reference in broadcast and communications networks: examples include T-DMB, DVB-H, WiMAX, CDMA and MediaFLO
- Potentially can be used to enhance ATSC M/H

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Why is a Precision Time Reference Important?

- Enhanced system performance: supports enhanced handoff; enables diversity (frequency, physical, time); supports both MFNs and SFNs
- Minimal investment: One GPS receiver at transmitter, can be implemented with new equipment for ATSC M/H
- Interoperability: Supports potential interoperability with non-ATSC networks (WiMAX, FLO etc)
- Extensibility: Provides platform for future applications; also aligned with SMPTE and EBU Task Force on Synchronization

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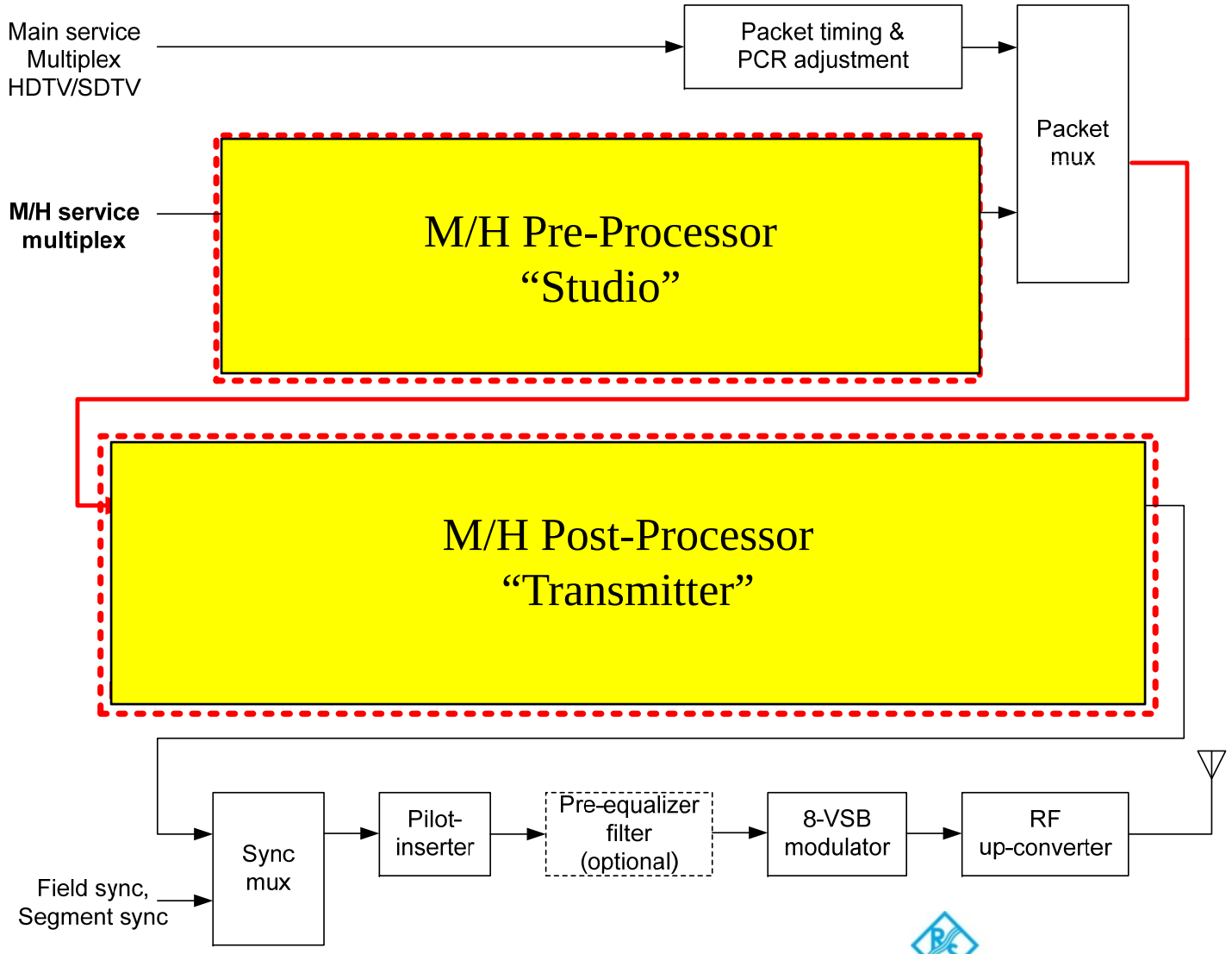
M/H System Block (review)



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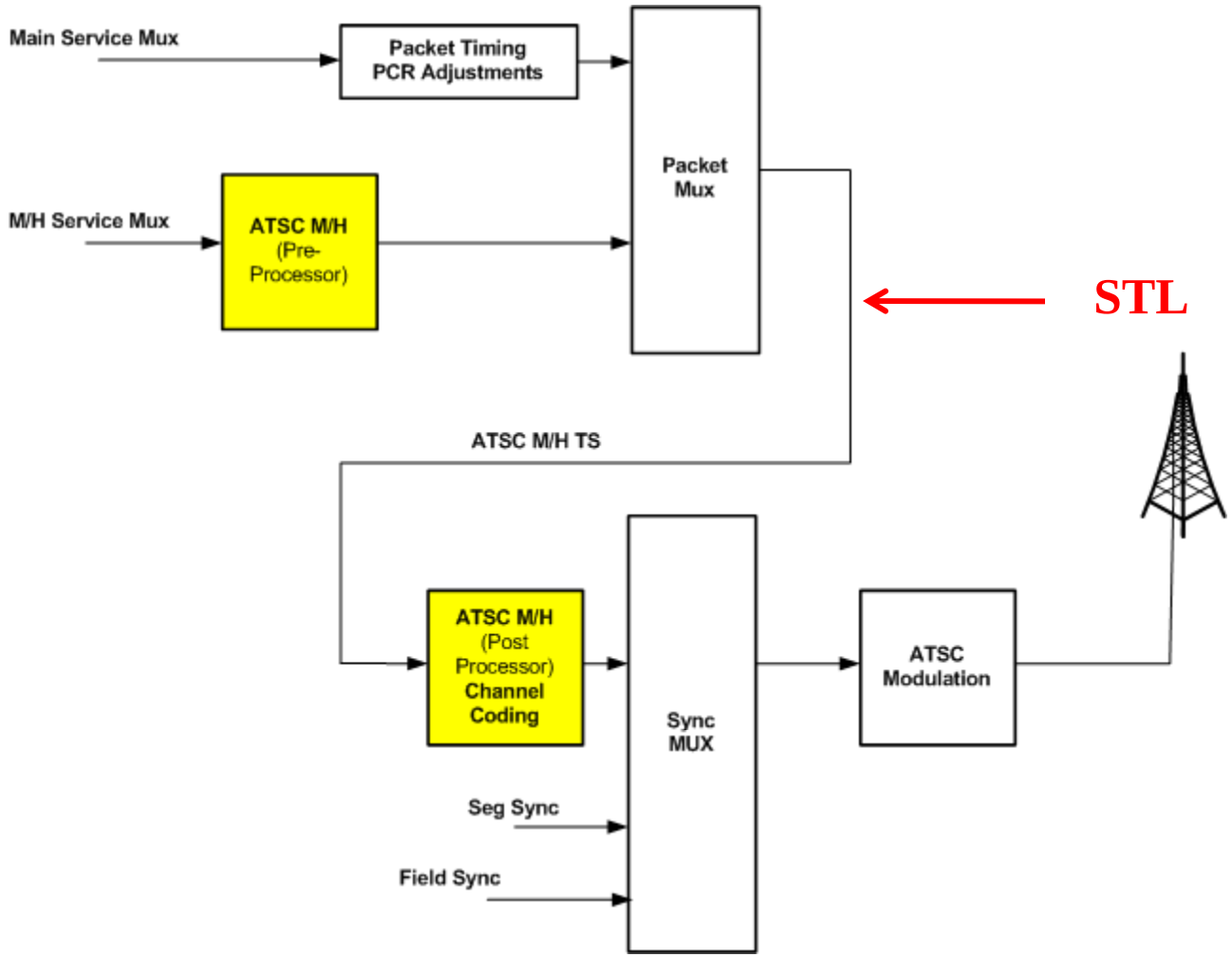
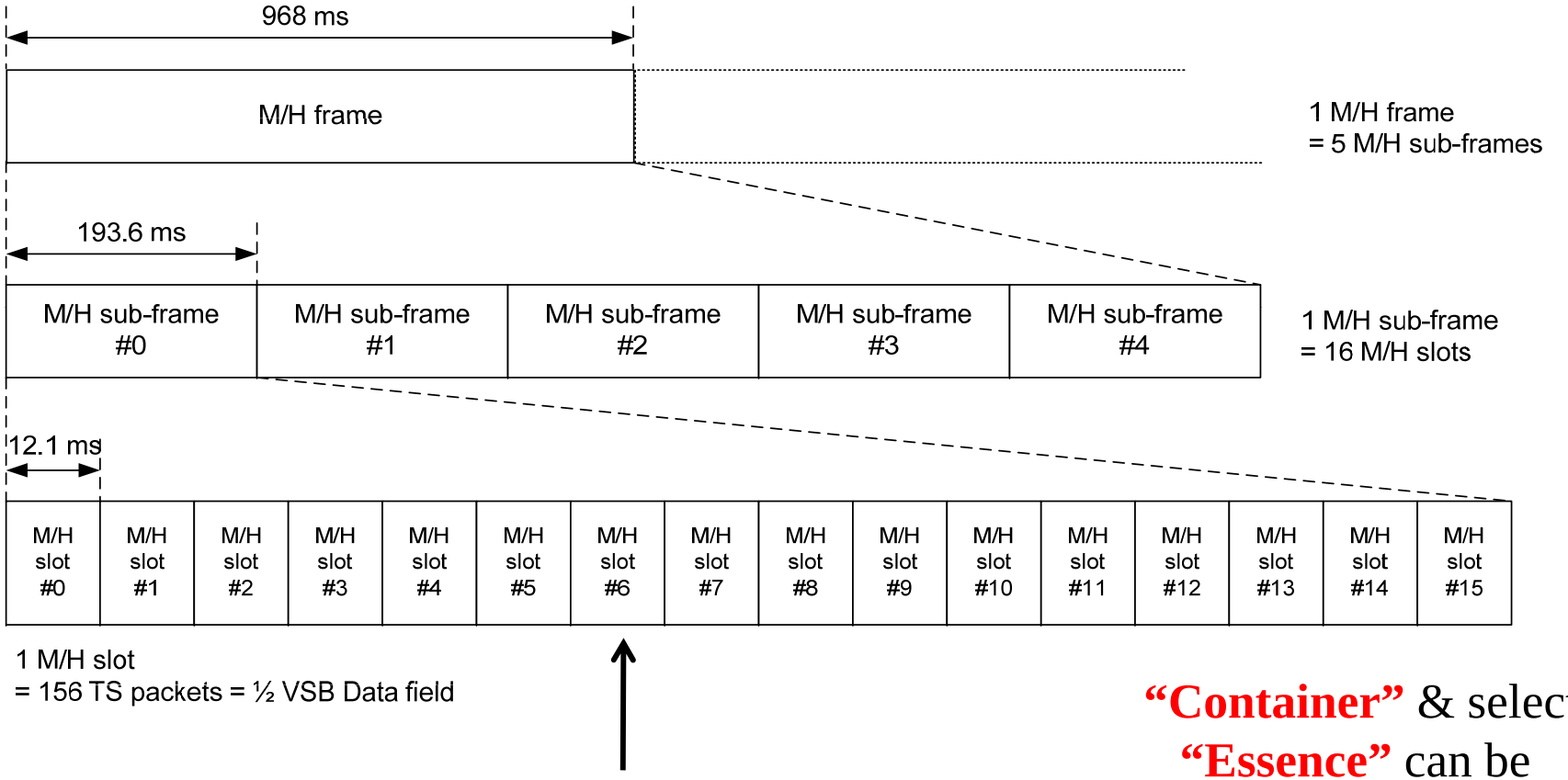
Simplified System Block



M/H Frame is a virtual "Container"



Mobile / Handheld **"Essence"**
Content , metadata, etc

"Container" & select **"Essence"** can be synchronized across stations (Network)

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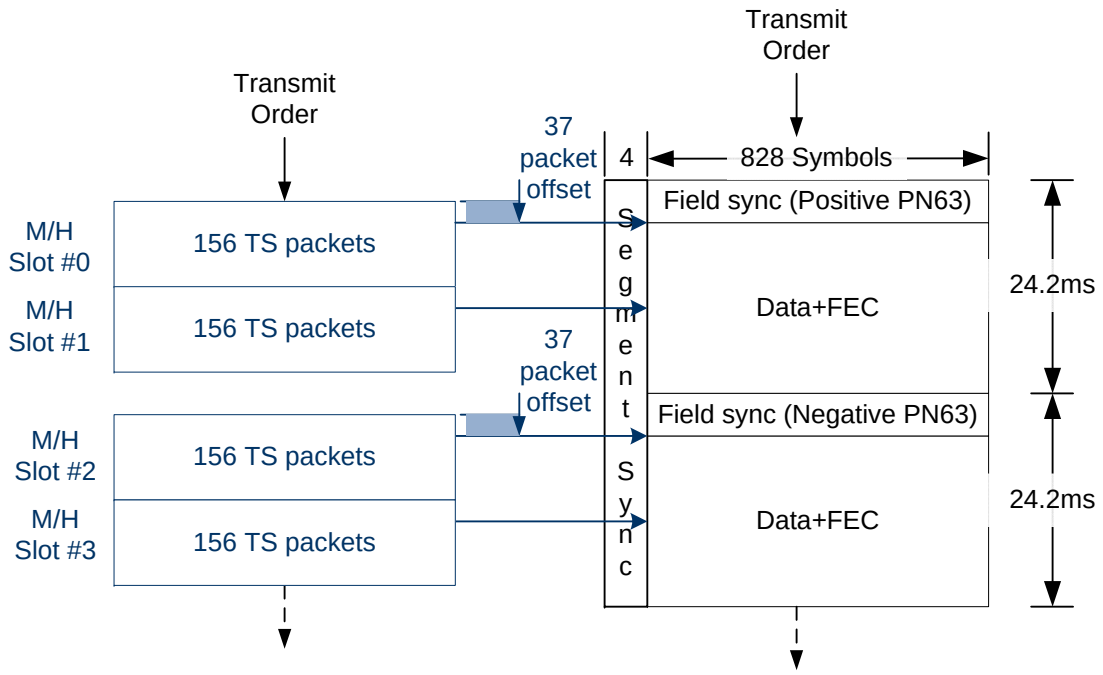
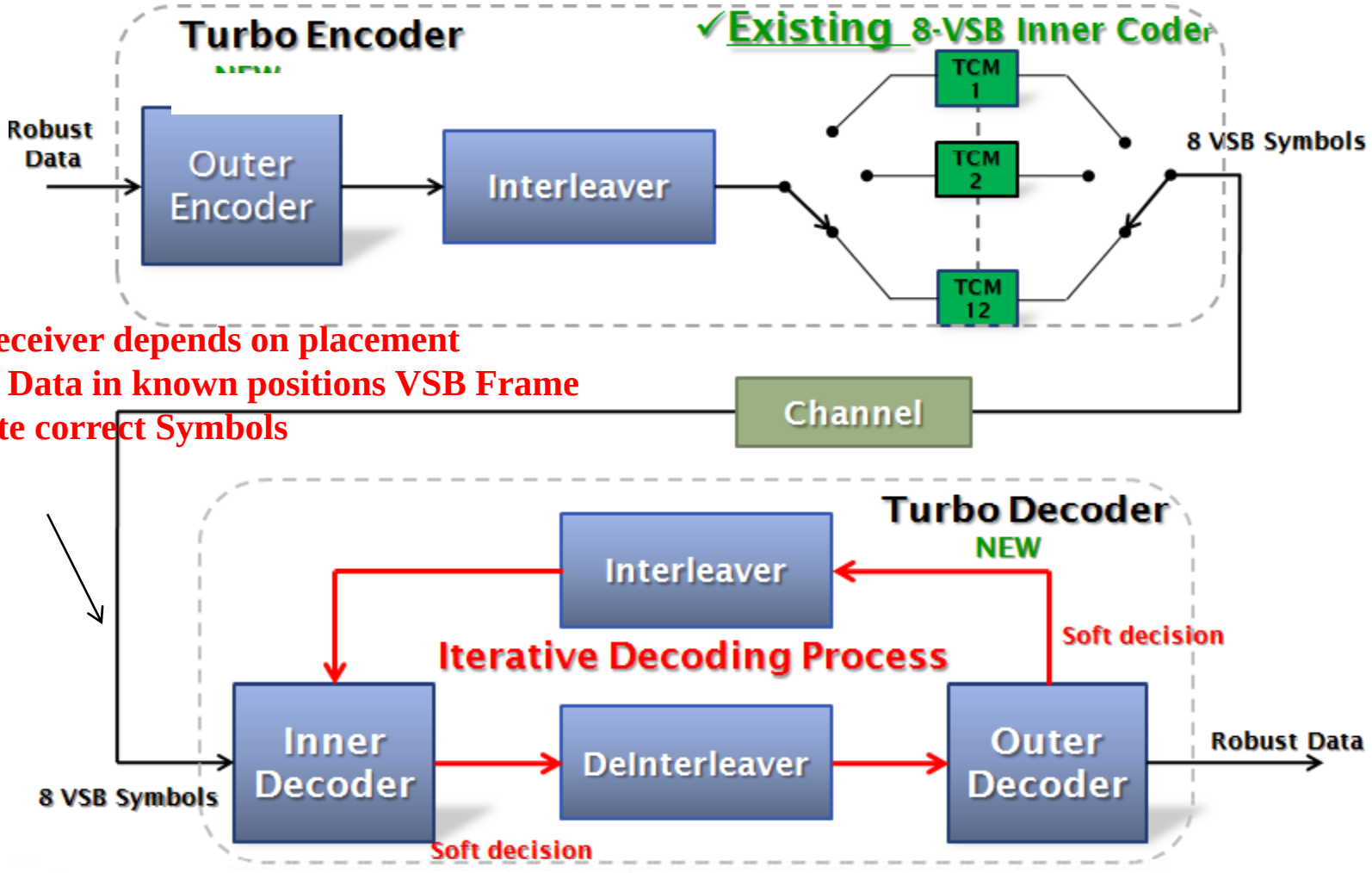
M/H Slot Position (Tightly Synchronized VSB Frame)

- M/H Slots are mapped to consecutive portions of VSB Data fields:
  - 1 M/H Slot = ½ VSB Data field
  - M/H slots are offset 37 packets relative to half data field boundaries
  - Synchronous relationship so receivers can discover physical layer



Effective M/H Turbo Code Block



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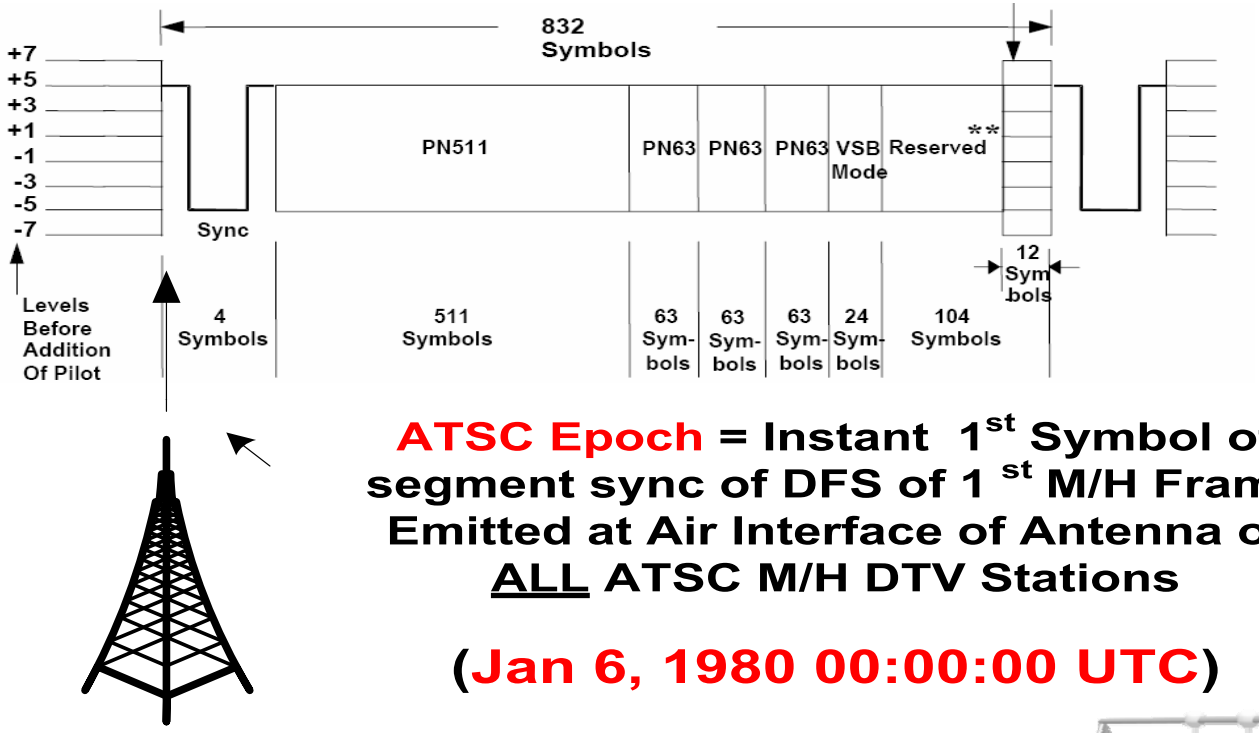
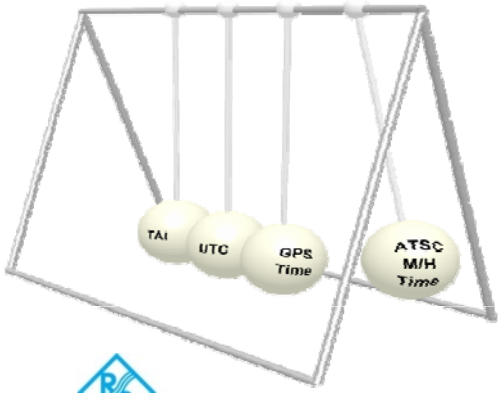
Defining ATSC System Time (Epoch)



ATSC Epoch = Instant 1st Symbol of segment sync of DFS of 1 st M/H Frame Emitted at Air Interface of Antenna of ALL ATSC M/H DTV Stations

(Jan 6, 1980 00:00:00 UTC)

1PPMF (1 Pulse Per M/H Frame) = Time beginning of M/H VSB Frame should be emitted Air Interface DTV Antenna



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ATSC System Time Metrics

GPS / ATSC Epoch = Jan 6, 1980 00:00:00 UTC

VSB Frames M/H (MPH) Frame = 20

Symbols per M/H Frame = 10,416,640 Symbols

Packets (M/H Frame) = 12,480

$$(ATSC\ ST) = (GPS\ Time) \times \frac{4809375}{4654936}$$

"Integer Relationship"

ATSC System Time = # M/H Frames since Epoch

1PPMF = 1 Pulse per M/H Frame

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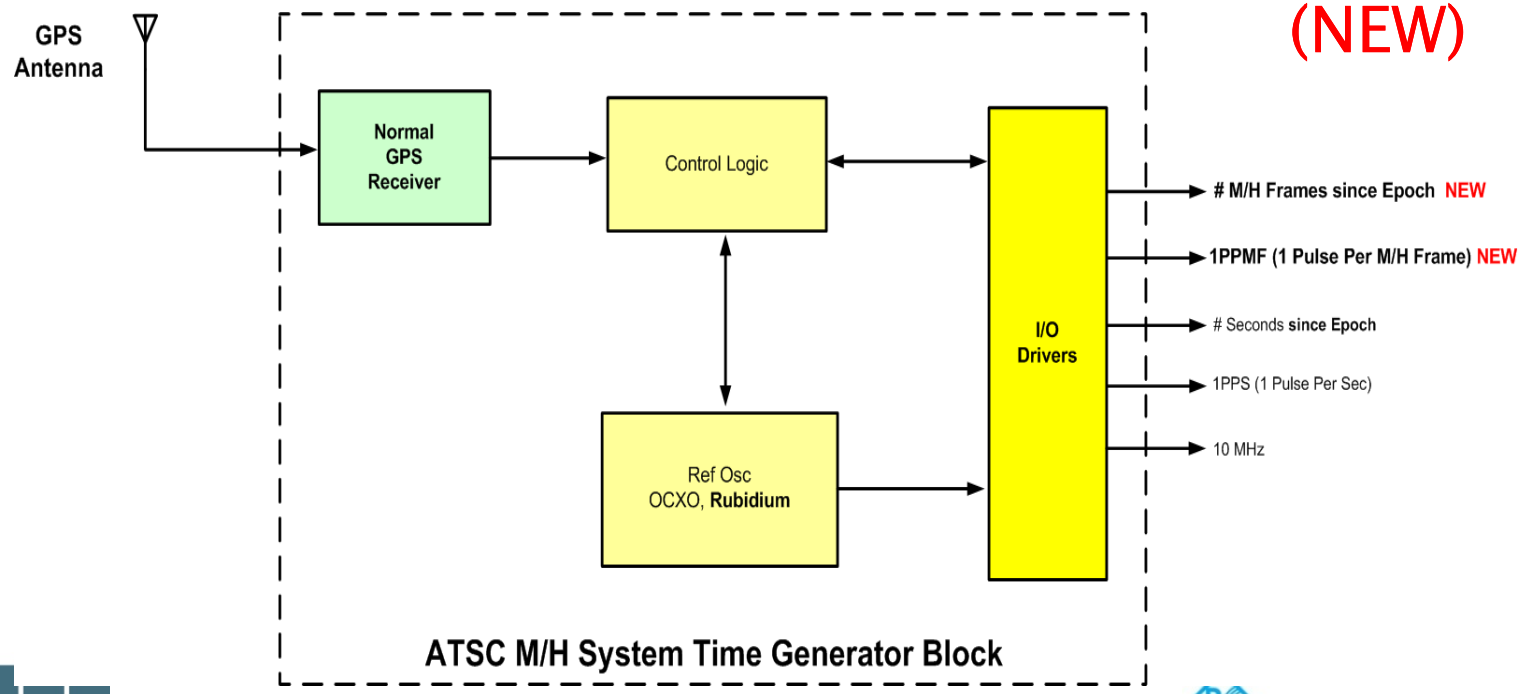
ATSC M/H New Reference Signal

An **ATSC System Time Generator (STG) is a device that generates a** frequency reference signal (such as 10 MHz), a 1 pulse per M/H frame (**1 PPMF**) reference signal, and a counter representing ATSC ST.

1PPMF
1 Pulse Per M/H Frame
(NEW)



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Technical Advantage

- All data in every M/H frame will have a simple timing relationship relative to ATSC ST and the 1PPMF reference signal

- ***Some facts about ATSC System Time***
  - ATSC ST is uniform and monotonically increasing
  - There are no leap seconds or any other adjustments to worry about, ever
  - There is an exact integer relationship between GPS Time and ATSC ST given by:

$$(ATSC\ ST) = (GPS\ Time) \times \frac{4809375}{4654936}$$

- Since all synchronization is nominally referenced relative to ATSC ST and the 1 PPMF signal, there are no “sliding time references” or “wrap-around” cases to deal with. This avoids some of the ambiguity that can arise when using a non-ATSC aligned timing reference like a one pulse per second (1 PPS) which might occur at an awkward time within an M/H frame

- This globally defined timing reference is valid for both SFNs and MFNs.

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Applications that will benefit

- Channel Change (Consumer Experience)
- Handoff / Roaming (Regional Area)
- Diversity Techniques (Local Area)
  - Frequency
  - Time
  - Transmitter (SFN)
- New SFN Architectures
- Positioning Services

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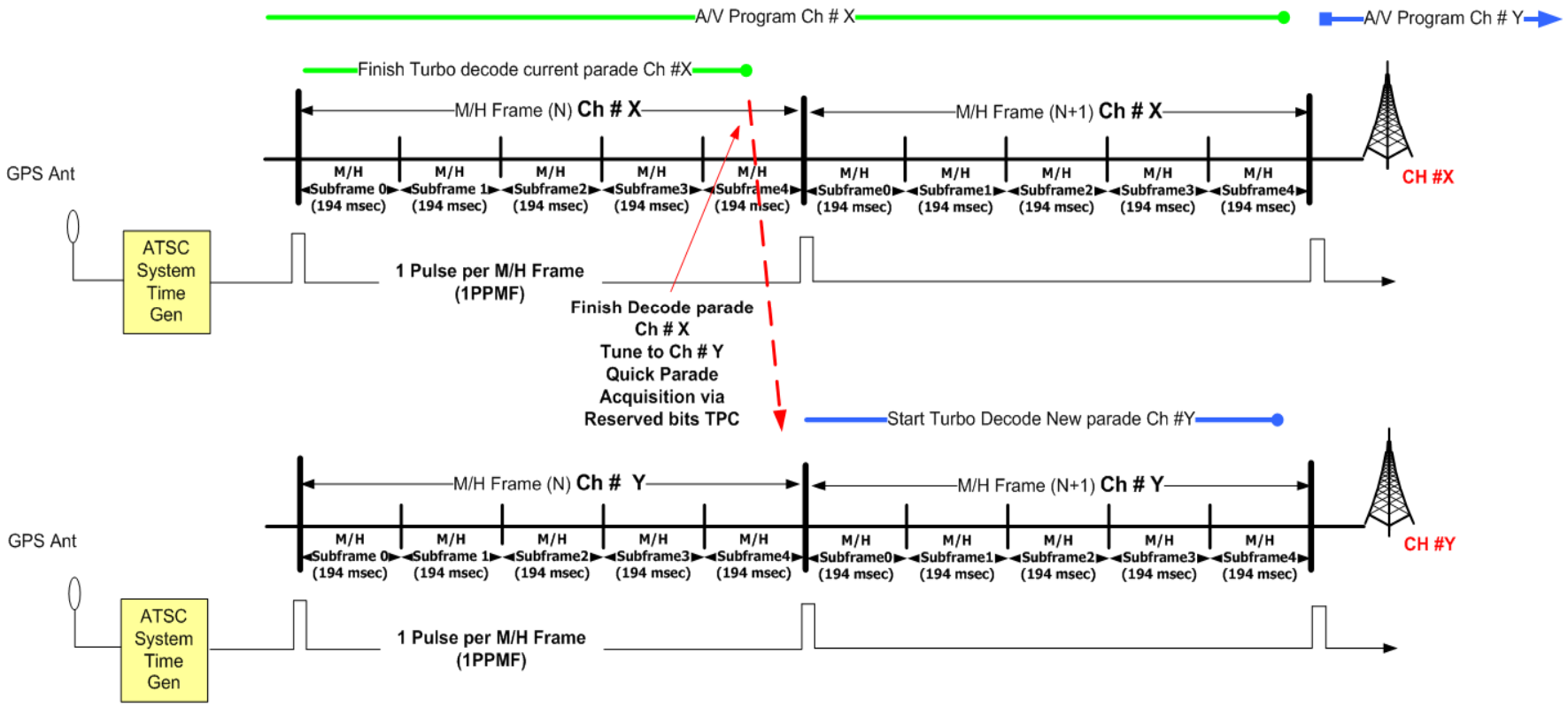
Channel Change Improvement

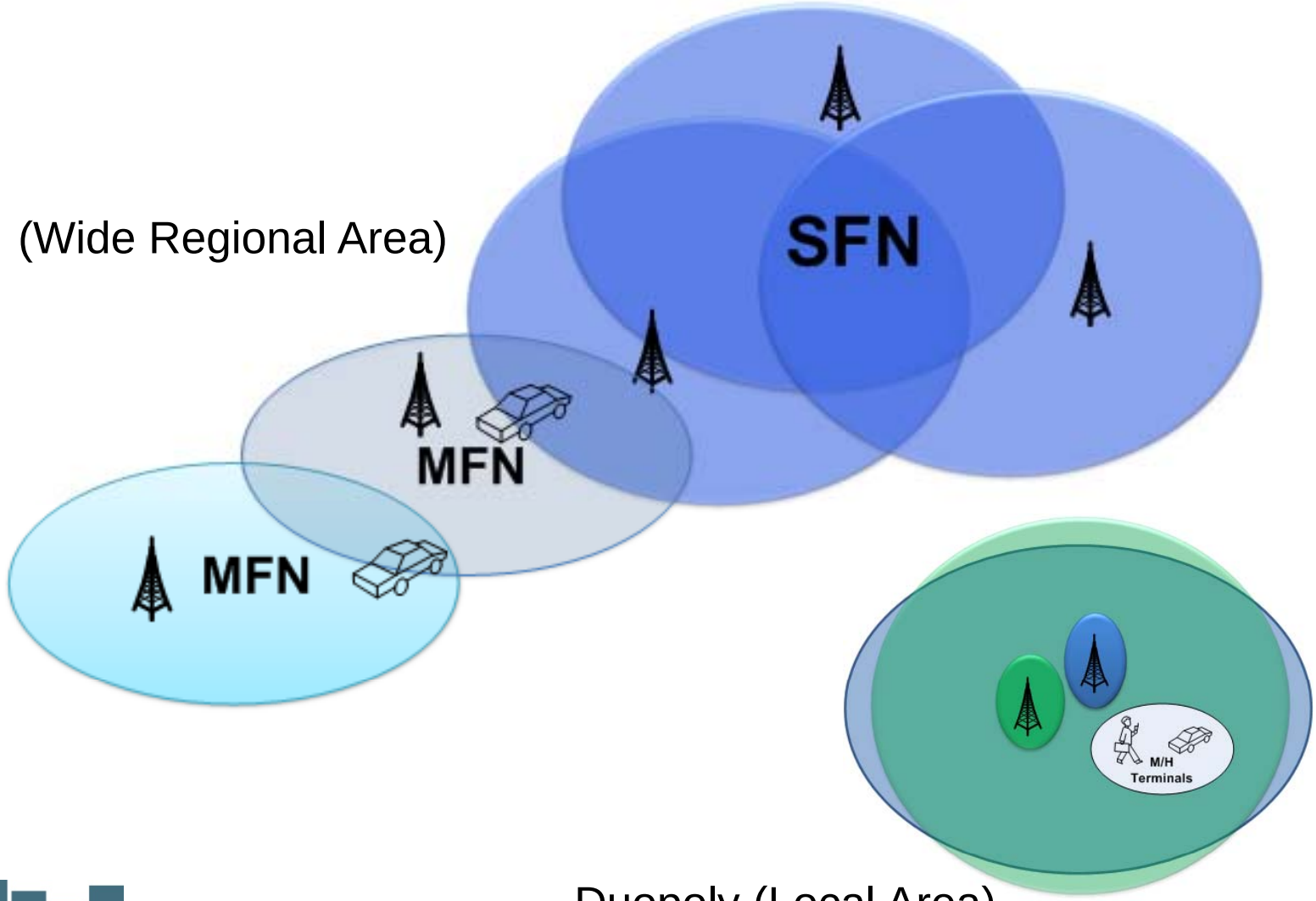


Local Broadcast Channel Acquisition

Synchronized Containers (M/H Frame)

Non Synchronous Essence (Content)

Broadcast Applications: Handoff, Diversity



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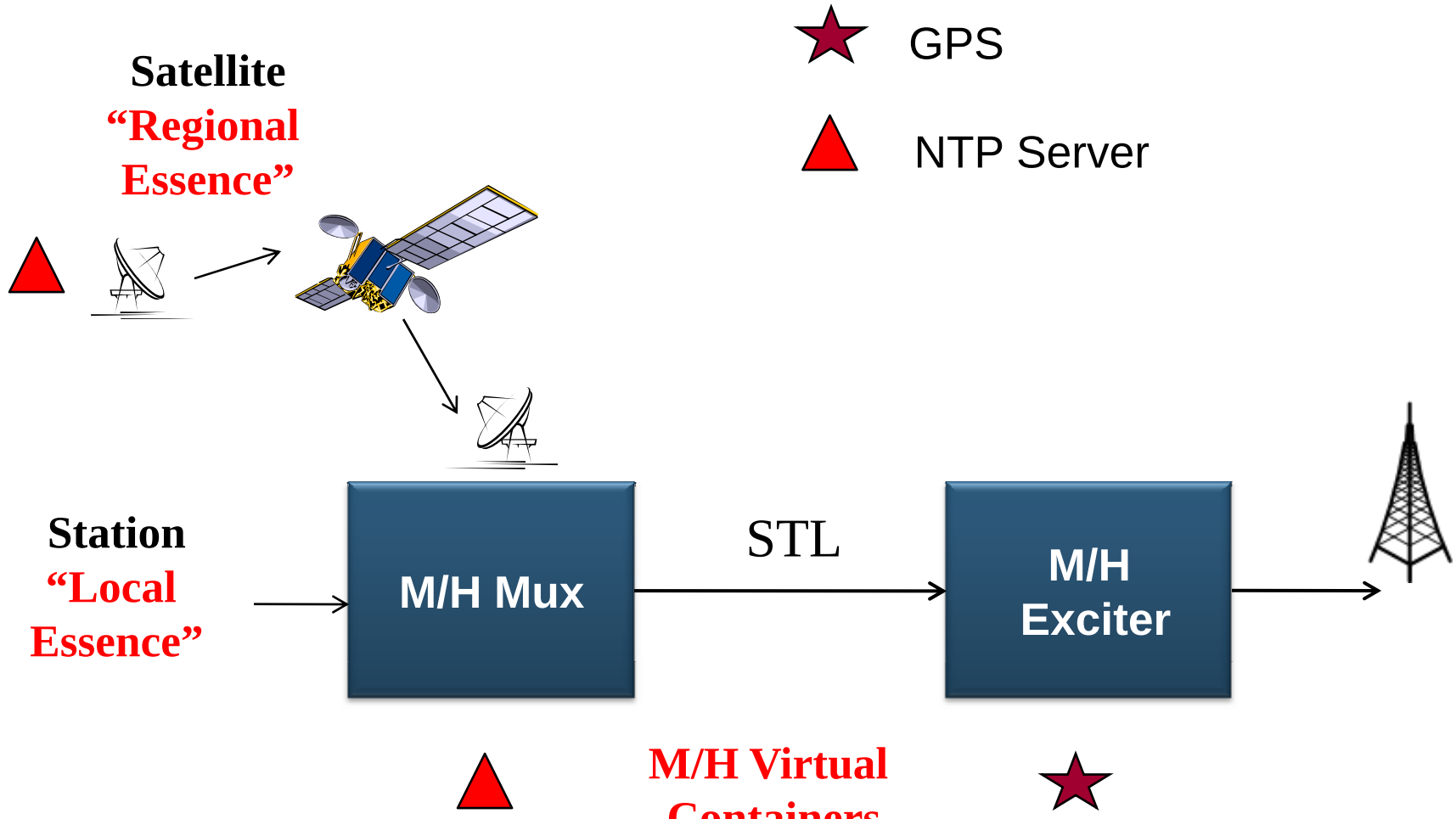
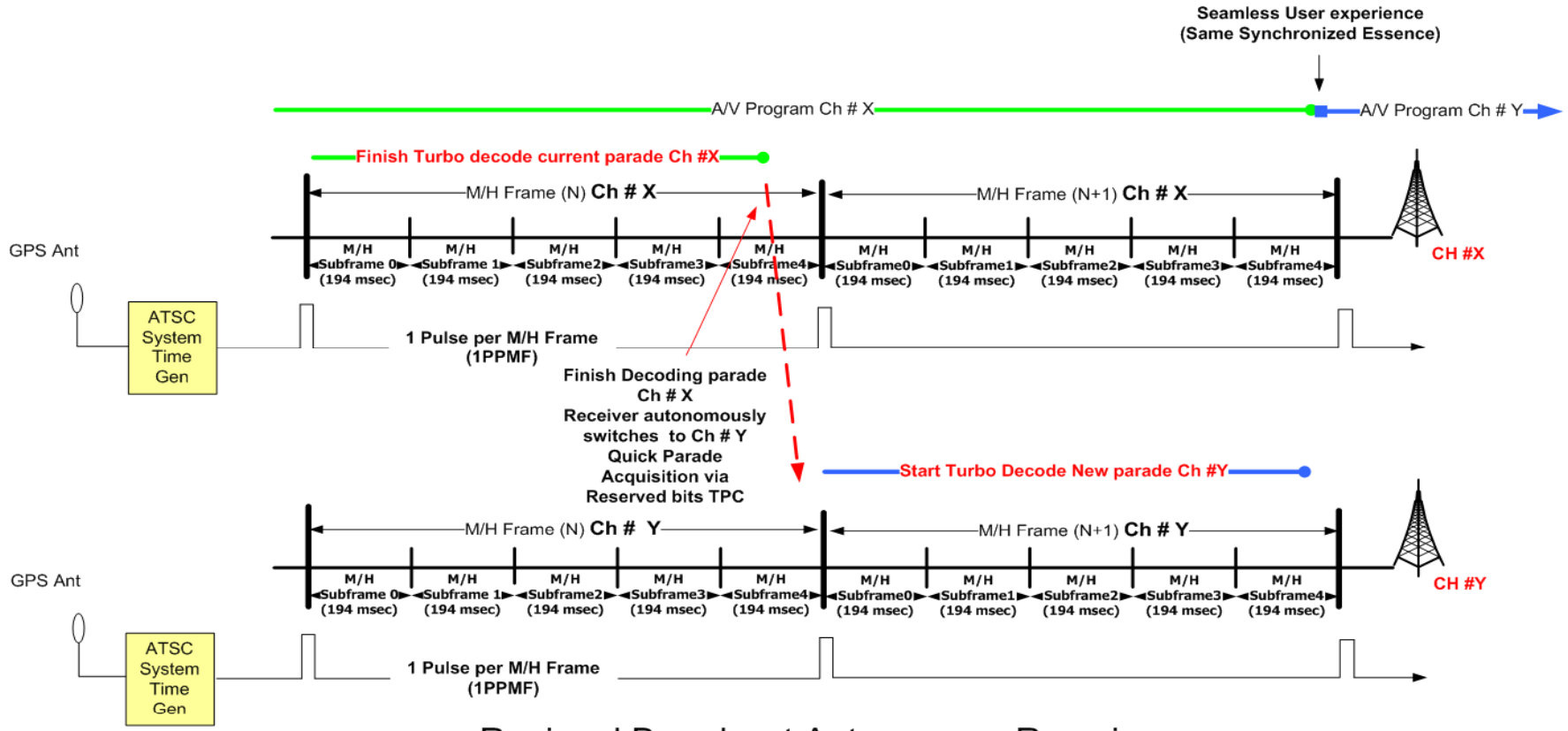
Synchronization “Essence and Containers”



Regional Broadcast Autonomous Roaming



Regional Broadcast Autonomous Roaming

Synchronized Containers (M/H Frame)

Select (Regional) Synchronized Essence (Content)

Note: will also use announcements via
Cell Information Table (CIT M/H)

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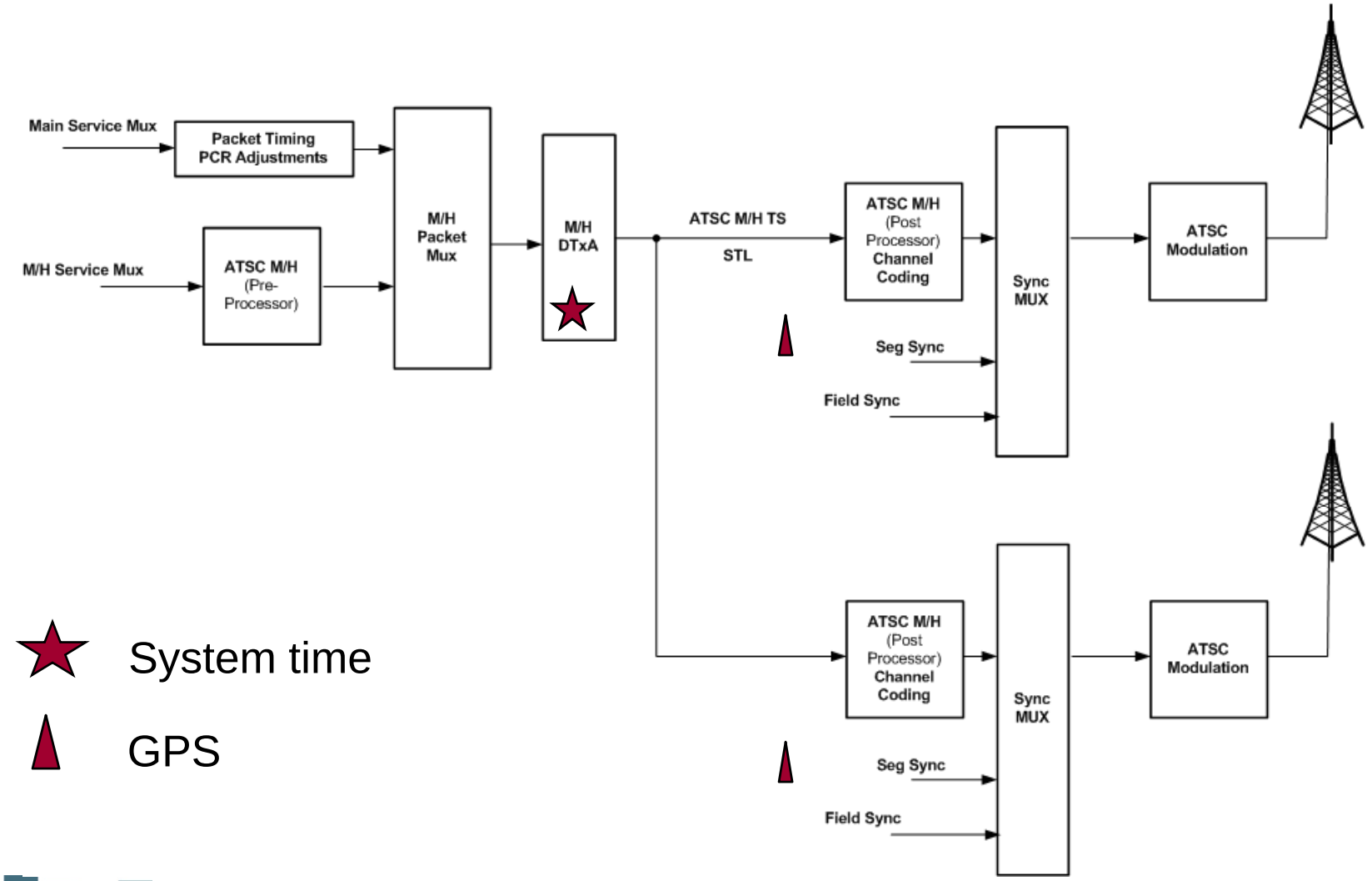
System Time Distributed Transmission (A/110)



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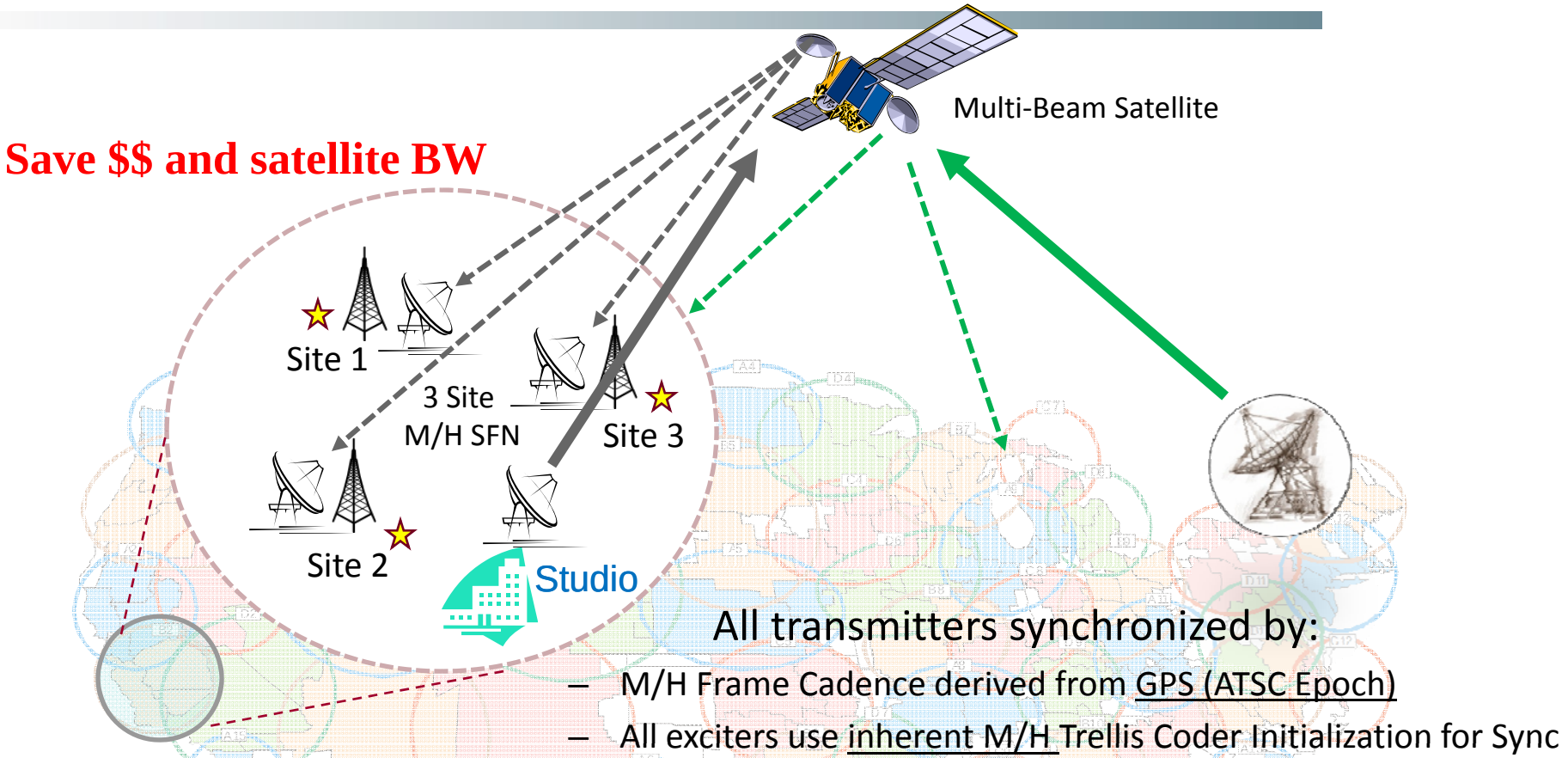
New SFN Architecture With National Content Overlay

Novelty: **First Time ever SFN with Re-Mux on Network Edge is possible**



All transmitters synchronized by:

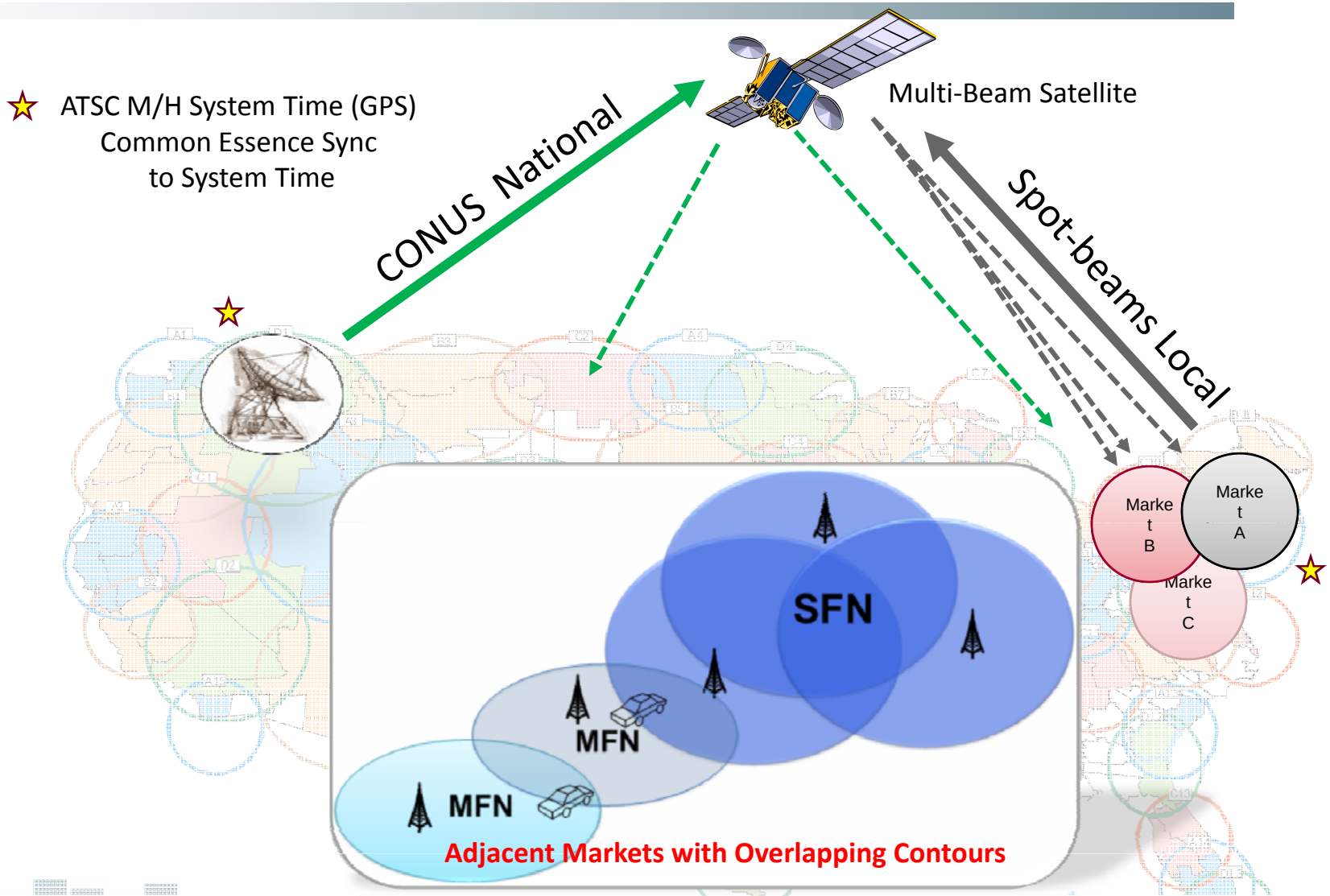
- M/H Frame Cadence derived from GPS (ATSC Epoch)
- All exciters use inherent M/H Trellis Coder Initialization for Sync

Local Station Spot-beam (Local Content < 19.39 Mbps ATSC M/H TS)

CONUS National Content (Mobile)

Site n Re-Mux (**National** + **Local**) 19.39 Mbps M/H TS is Broadcast

New Inter-Market Roaming

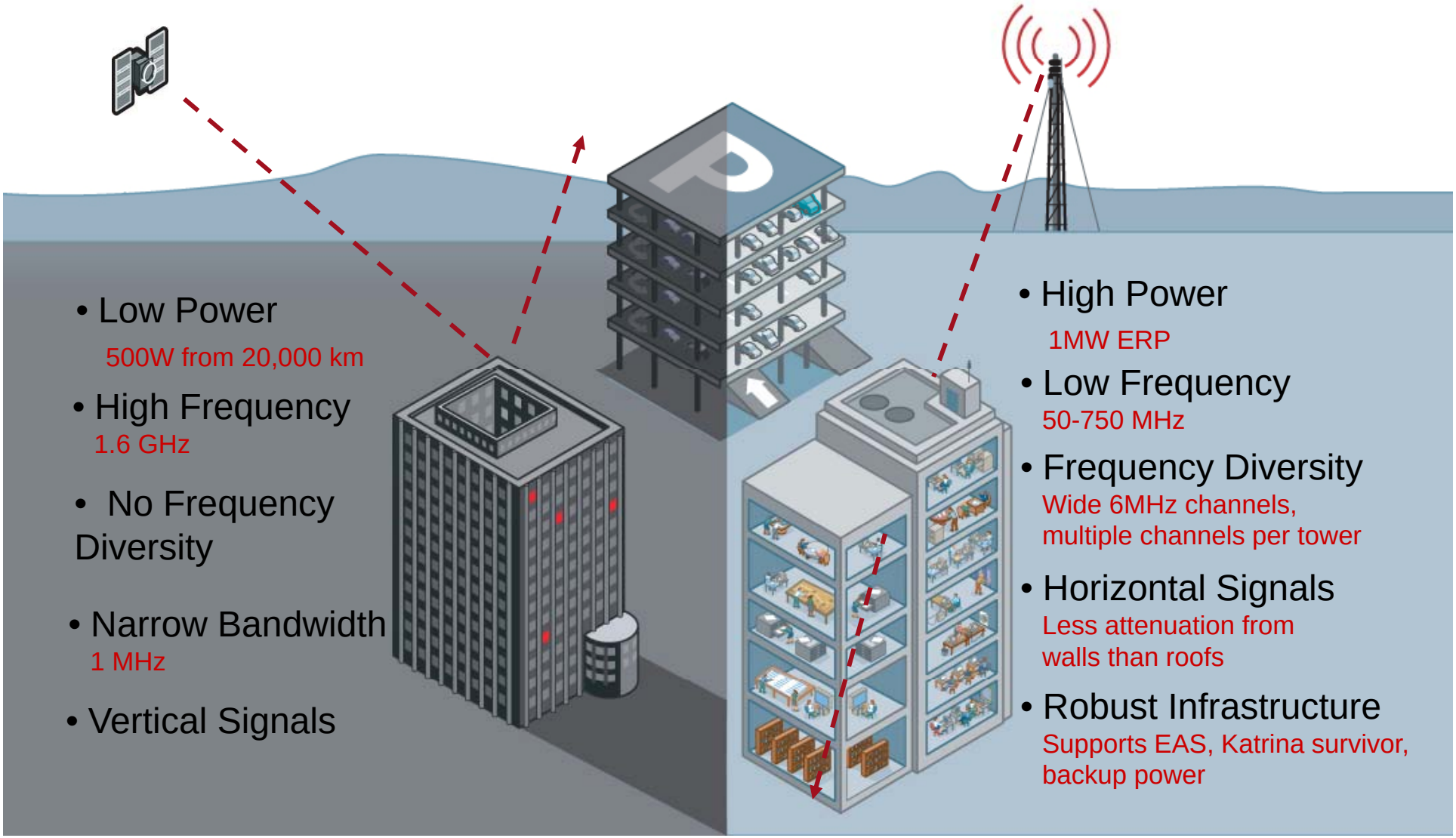


Seamless Roaming and Frequency Diversity

SFN to SFN or MFN possible with System time

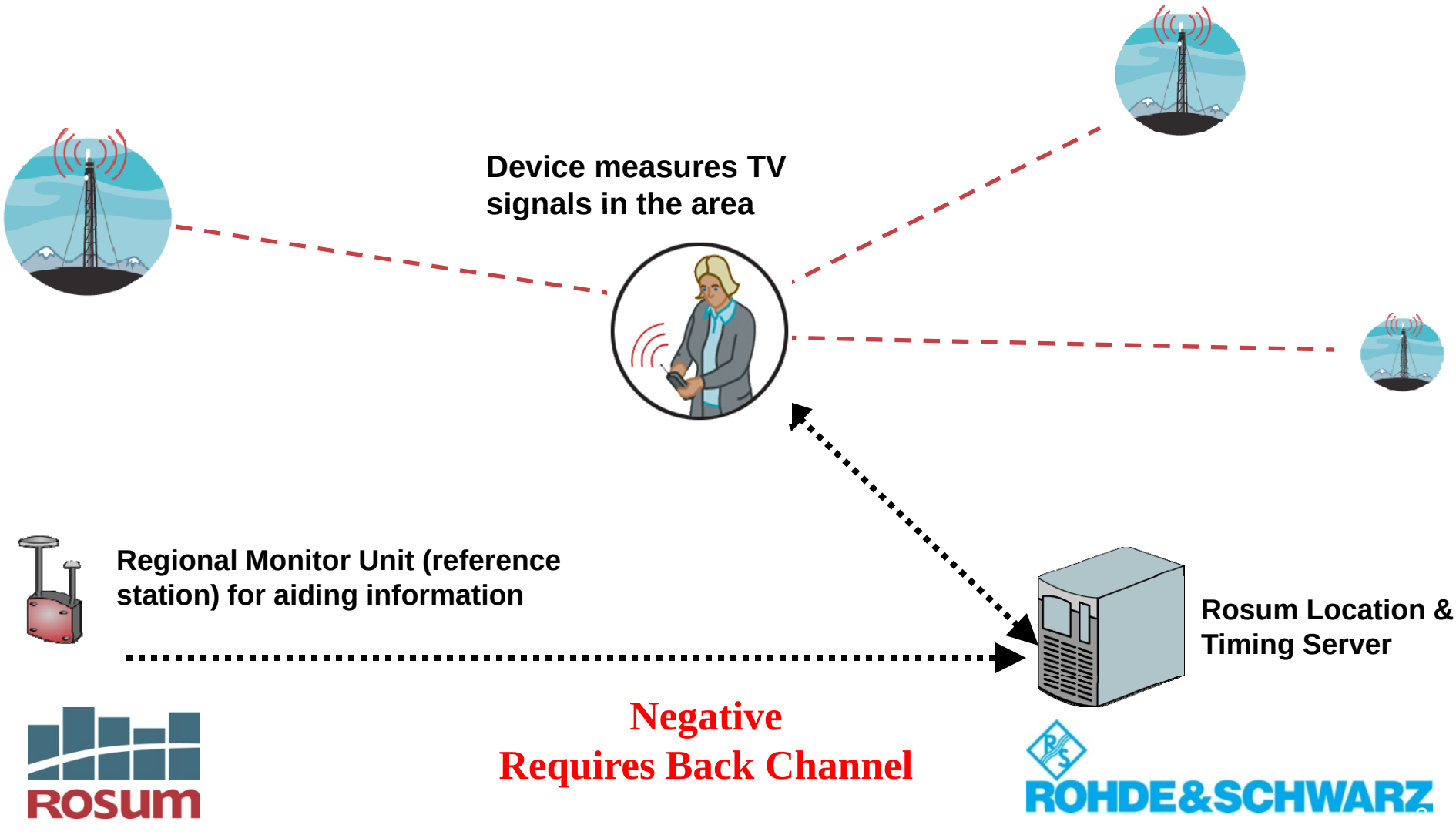
TV based Positioning is a natural complement

The broadcast TV infrastructure is highly correlated with population density, and offsets many of GPS' vulnerabilities



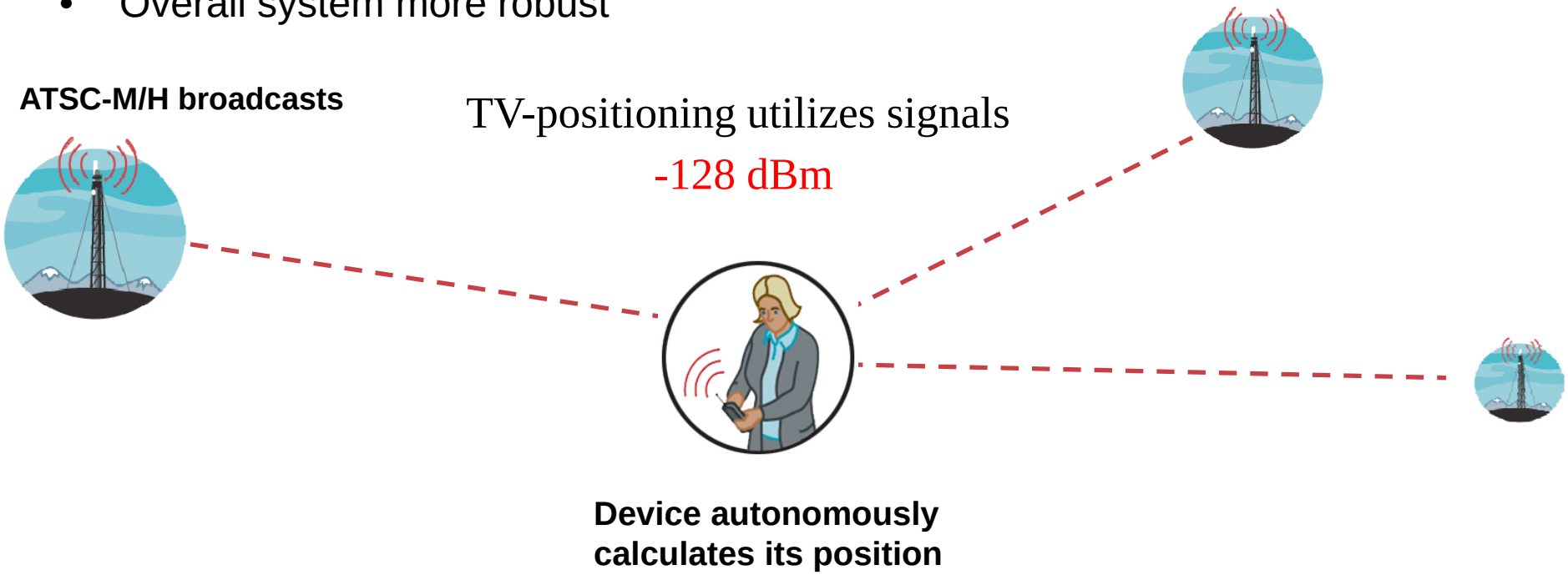
Rosum TV-Positioning Today

- Rosum currently uses reference infrastructure to tell the receiver what signals to expect



TV-Positioning in ATSC-M/H

- Supports autonomous positioning for unconnected devices (PMPs etc)
- No ancillary inputs required for location determination
- Overall system more robust



Requires No Back Channel

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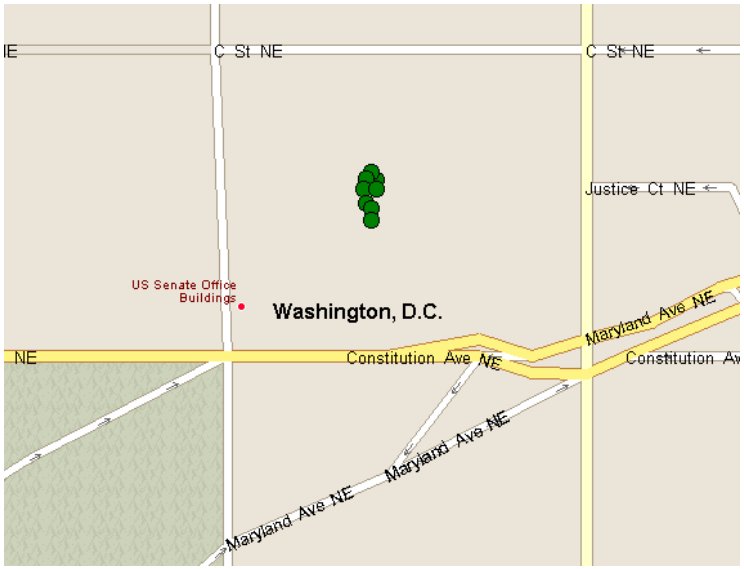
TV-Positioning in GPS-Unavailable Environments

Propagation of TV enables use for **positioning indoors in GPS-denied environments;** wide bandwidth enables mitigation of signal multipath

Midtown Manhattan, lobby level

Senate Hart Building, Washington DC



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Commercial Positioning & Timing Applications

- System Time enhances a variety of positioning and timing applications

- Commercial applications include:
  - Location-based services
    - Self-navigation
    - Friend finder
    - Location-enabled mobile social networks
  - Location-based advertising
  - DRM
  - TBD

Augmentation and Compensation for GPS

- GPS has three major well-documented vulnerabilities:
  - Poor performance indoors and in urban areas
  - Susceptibility to natural RF interference
  - Susceptibility to manmade interference (jamming / spoofing)

- This is a recognized threat to commercial and public safety communications networks

Public Safety Positioning & Timing Applications

- Public safety / homeland security applications:
  - Positioning and timing for first response indoors and in urban areas where GPS is challenged
  - Location-aware receivers for alerts in support of WARN Act
  - Timing and frequency for public safety communications networks
  - Timing and frequency for intelligence networks
  - E911

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Questions

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