WEDA Pacific Chapter Meeting

Hydrographic Surveys – Best Practice Examples – Contractor Perspective

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Basics of Single Beam High Frequency Surveying

- 200kHz frequency regarded as the **"Standard Frequency"** – Most commonly employed transducer frequency by the USACE in river and harbor navigation projects (EM 1102-2-1003 paragraph 3-5.a)
- **Best frequency for most precise depth measurement** due to frequency characteristics and concentrated beam widths (< 8^{o})
- Recommended for projects with consolidated (firmer) bottoms and smoother grades

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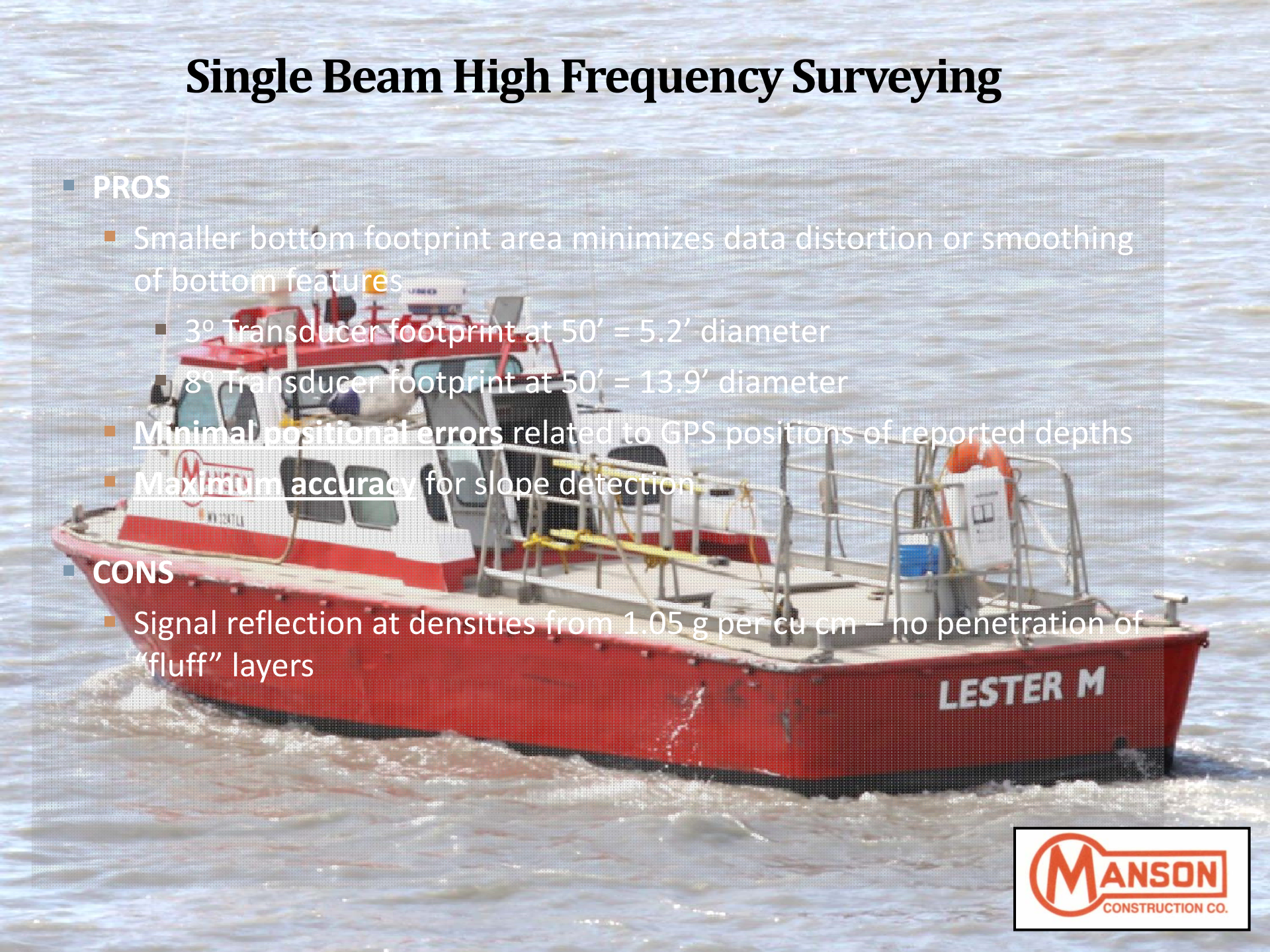
Single Beam High Frequency Surveying

- **PROS**
  - Smaller bottom footprint area minimizes data distortion or smoothing of bottom features
    - 3º Transducer footprint at 50’ = 5.2’ diameter
    - 8º Transducer footprint at 50’ = 13.9’ diameter
  - **Minimal positional errors** related to GPS positions of reported depths
  - **Maximum accuracy** for slope detection
- **CONS**
  - Signal reflection at densities from 1.05 g per cu cm – no penetration of “fluff” layers



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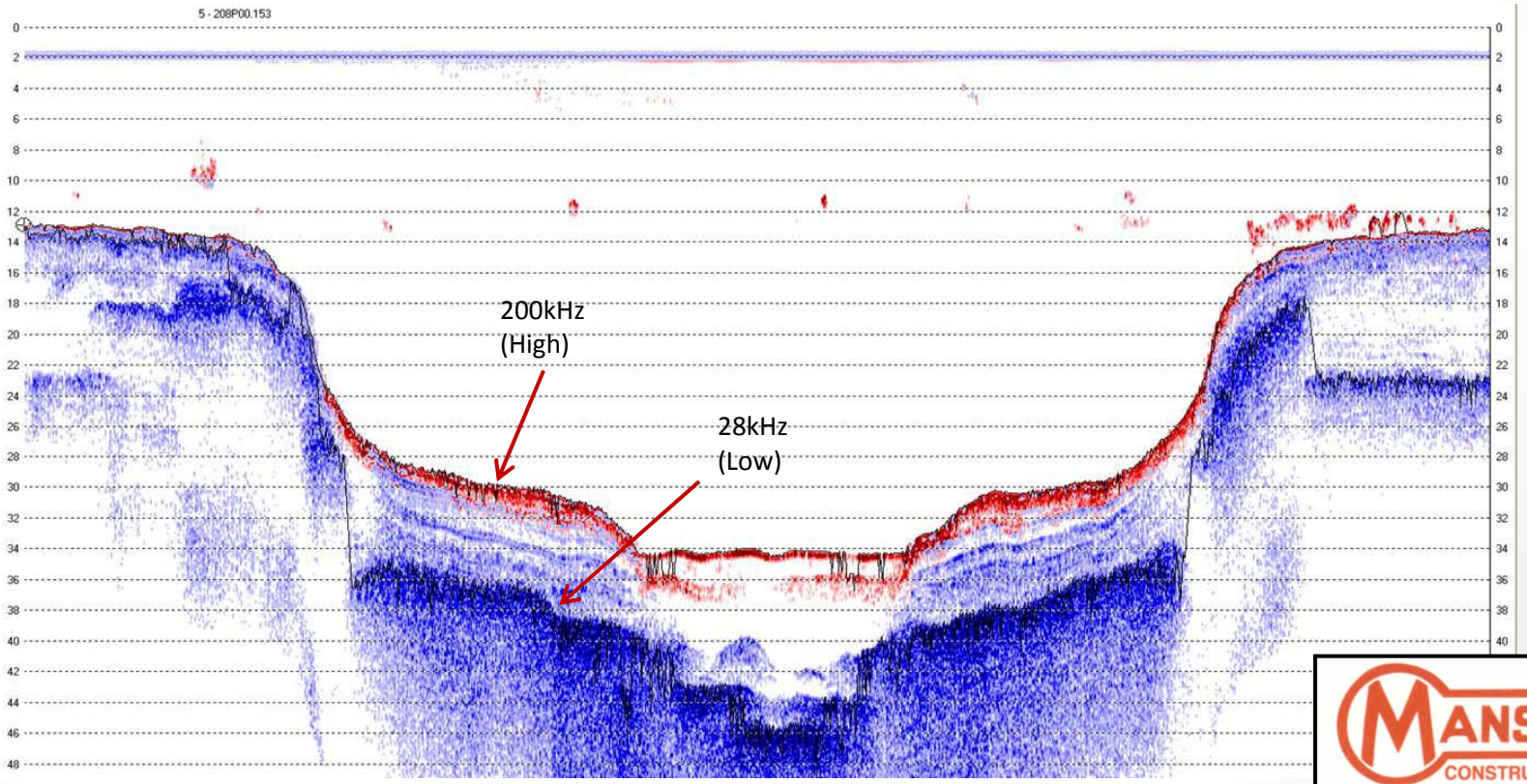
Basics of Single Beam Low Frequency Surveying

- 28kHz considered the typical low frequency
  - Frequency ranges from 20 to 50kHz are used
- Subject to less signal attenuation which allows for greater depth measurement and penetration of less consolidated material



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Single Beam Low Frequency Surveying

- **PROS**
  - Ability to penetrate less consolidated material layers – "fluff"
- **CONS**
  - Larger beam widths result in distortion and smoothing of bottom features (lower resolution)
  - Significant positional errors due to large footprint
    - Frequencies vary from 20kHz to 50kHz
    - Beam widths vary from 15° to 33°
      - 15° @ 50' = 25.8' diameter footprint
      - 20° @ 50' = 34.2' diameter footprint
      - 30° @ 50' = 50.0' diameter footprint
  - Distorted slope detection
  - Determination of "Navigable Depth" can be precarious as post processing is subject to operator interpretation

Unconsolidated Material - High vs. Low Frequency

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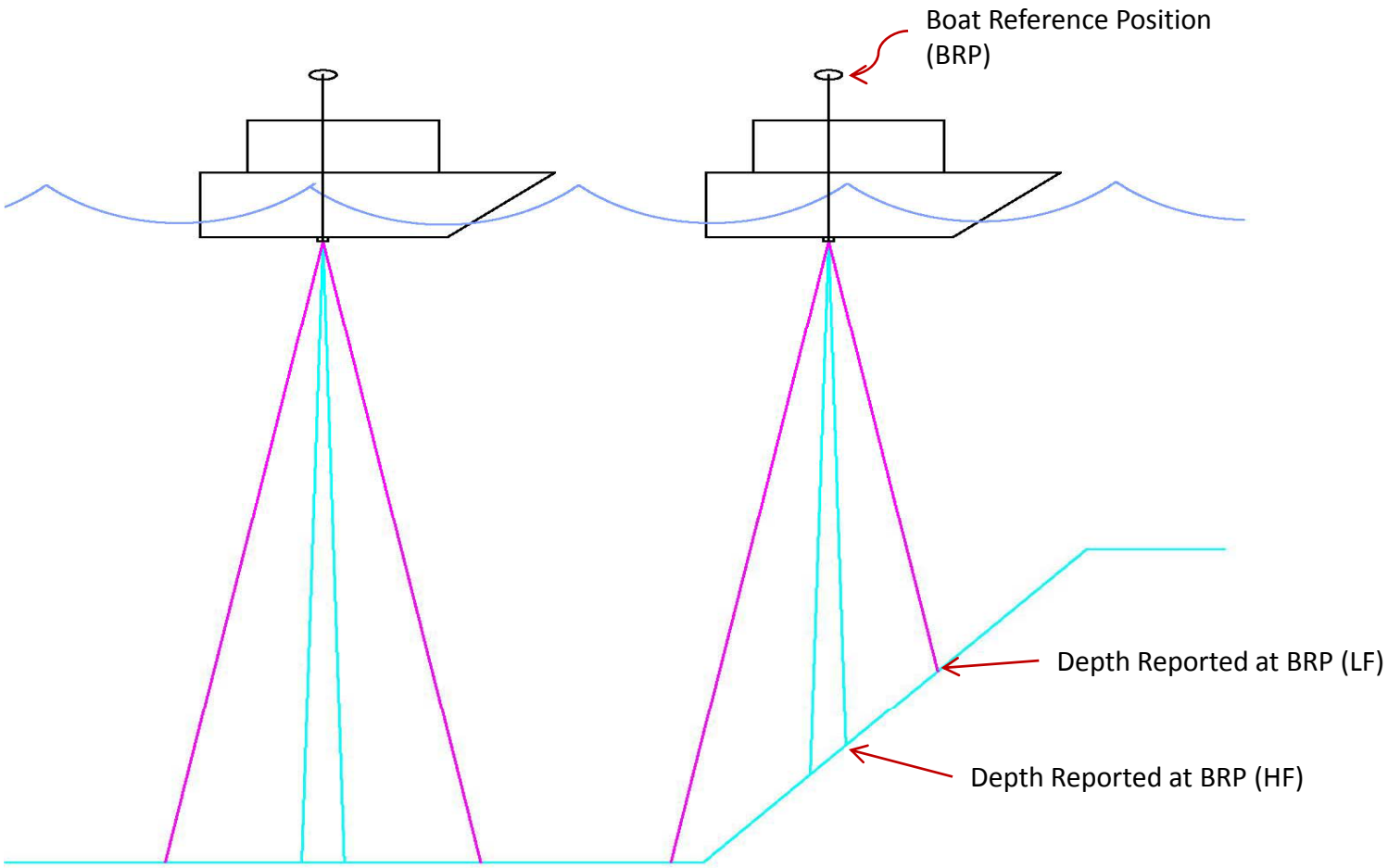
Slope Detection - High vs. Low Frequency



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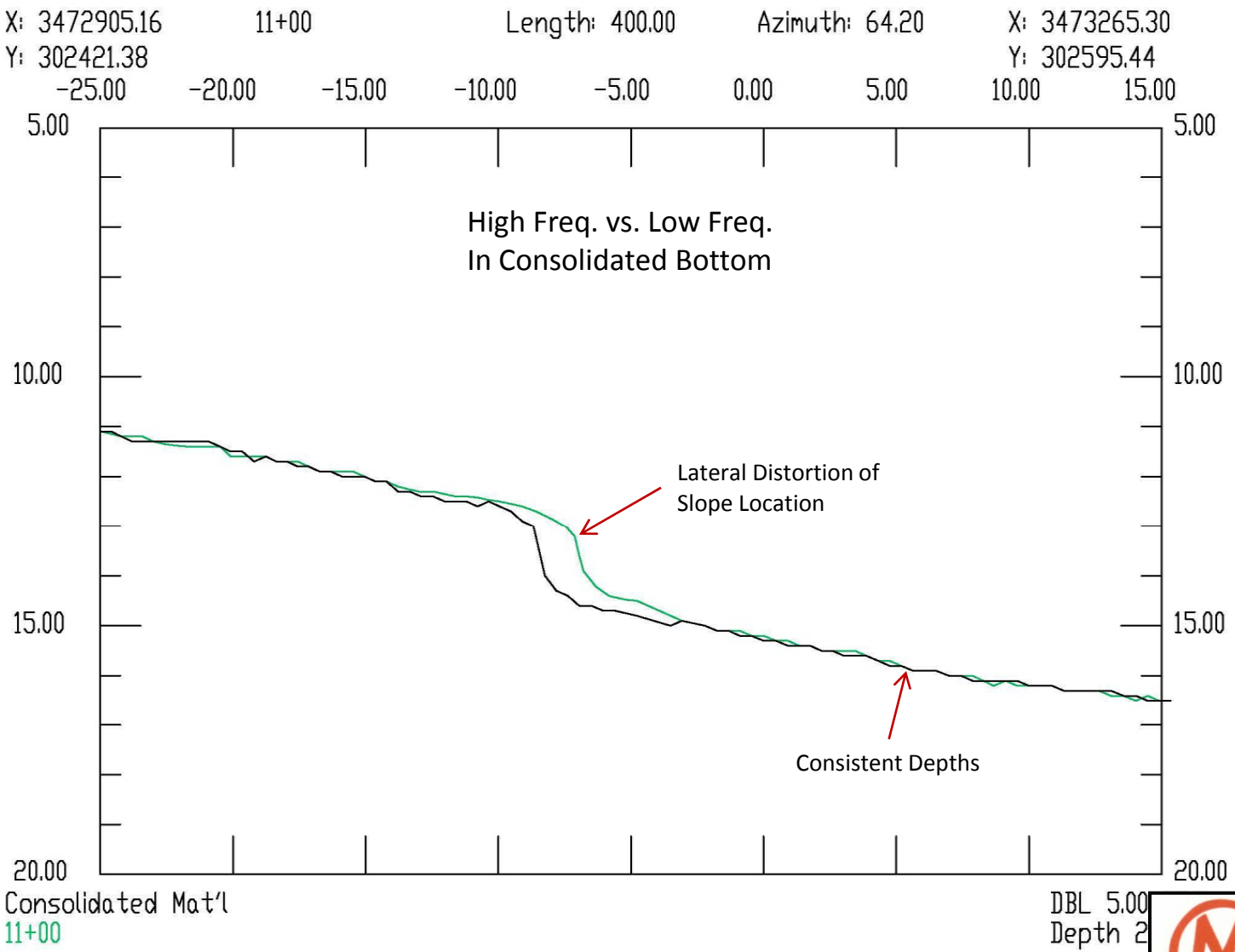
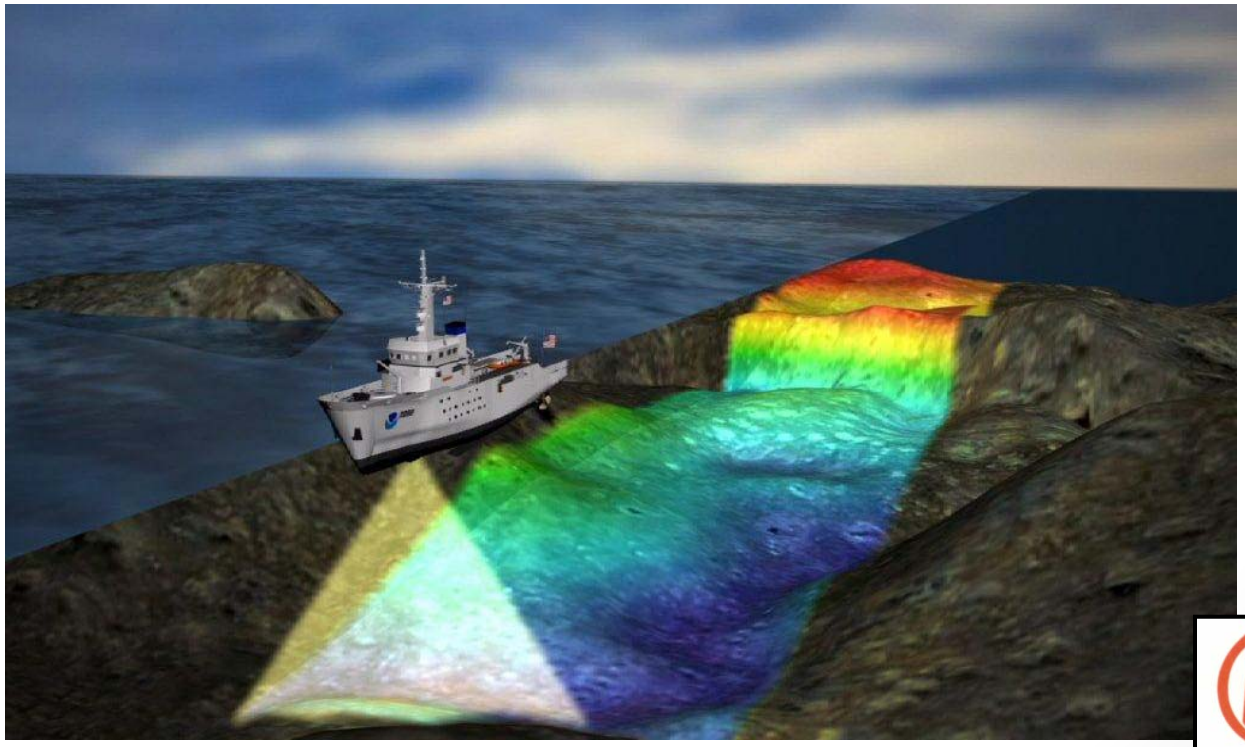
Consolidated Material - High vs. Low Frequency



Basics of Multi-beam Surveying

- Developed by the US Navy in the 1960's for deep-water mapping
- Developed and marketed for shallow water applications since the 90's
- Recommended for projects requiring 100% coverage of subject area such as new work rock removal



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Multi-beam Beam Surveying

- **PROS**
  - Multi-beam systems provide 100% bottom coverage
  - Can cover swaths of the bottom up to 14 times the water depth (not recommended)
  - High resolution
  - Effective shoal or strike detection
- **CONS**
  - Multi-beam systems operate on high frequency - no ability to penetrate through “fluff” layers
  - **Resolution and accuracy diminish in the outer beams** of the swath due to vessel heave, pitch and roll, and beam spreading
  - Significantly more time to process data

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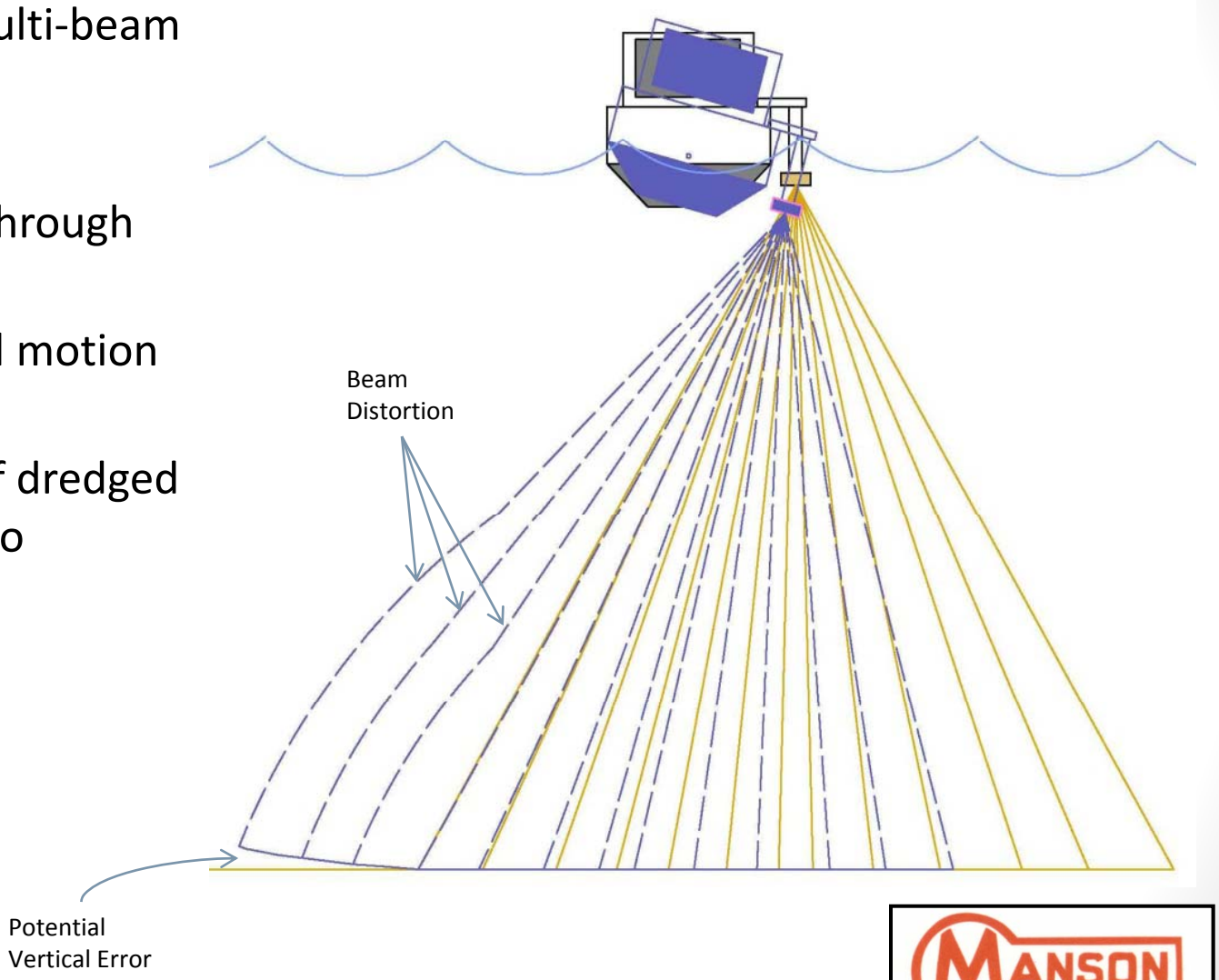
Multi-beam Beam Surveying

- Errors inherent in Multi-beam Surveys:
  - Beam spreading
  - Beam distortion through water column
  - Sea-State induced motion errors
  - Non-uniformity of dredged bottom can lead to inconsistencies



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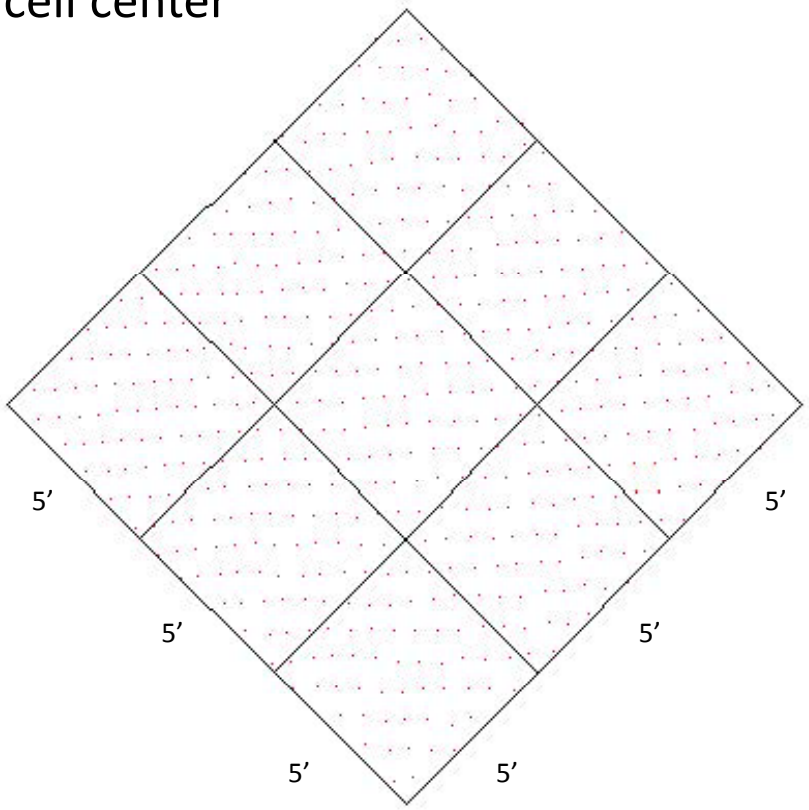
Multi-beam Beam Surveying

- Post processed data sorting methods:
  - Cell or Bin Size
  - Minimum depth
  - Maximum depth
  - Average depth
  - Closest to cell center



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Cross Section of Sorted Multi-Beam Data
(Minimum vs. Average vs. Closest to Cell Center)

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Multi-beam Beam Surveying

Inefficiencies of Multi-beam Surveying:

- Large, Constantly Changing, Survey Areas
- Data Collection & Processing are time consuming
- Significant increase in labor time between survey and analysis
  - Renders data less actionable
  - Costly delays in determining acceptance
  - Worsened if survey indicates further clean up is required
- Increases amount of non-productive dredging required (Clean-up)
- Greater uncertainty than with single beam high frequency surveys

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USACE Recommended Survey Applications
(EM 1110-2-1003)

- **Single Beam Acoustic Surveys** (paragraph 3-5.a)
  - Soft bottom material and/or maintenance dredging - **this category represents the vast majority of USACE projects**
    - Navigation projects containing soft sand/silt bottoms
    - Projects with soft, featureless and relatively continuous channel bottoms

- **Multi-beam Acoustic Surveys** (paragraph 3-5.b&c)
  - Hard bottom material and new work
    - Newly authorized navigation projects containing hard bottom material-rock or highly compacted material
    - Maintenance dredging of existing navigation projects containing hard bottom or otherwise hazardous material
    - Navigation projects where low under-keel clearances are anticipated over potentially hazardous bottom conditions, hazardous cargo is transported
    - Projects where bottom sediment could adversely affect transiting naval vessels
    - Underwater investigation surveys-of/around docks, dams, power plants, abutments, piers, jetties, bulkheads, and other structures requiring full bottom coverage and/or object detection. If these surveys are considered critical, 200% coverage is usually recommended

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Issues With Differing Criteria in Survey Methods within the Same Contract

- “Hydrographic surveys (soundings) for final payment purposes will be made by the Government. The Contracting Officer will select the type of survey to be performed (single-beam vs. multi-beam) and the transducer frequency to be used. Once the survey method (type and transducer frequency) is selected, the government will strive to use the selected method throughout the contract period. However, the Contracting Officer reserves the right to change the survey method at any time according to his sole discretion.”

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Example

A high frequency, single beam pre-dredge survey is conducted for maintenance dredging on an entrance channel. A multi-beam survey is later imposed for final acceptance:

- Potential for costly dredge downtime for processing and analysis
  - Significantly more time required for processing
  - Dredge stands by while survey is analyzed
- Potential ambiguous, extensive clean up beyond that originally estimated

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Example

A low frequency pre-dredge is performed in a turning basin or other area characterized by a soft bottom for maintenance dredging. A multi-beam survey is imposed for payment and final acceptance.

- The pre-dredge precludes “fluff” layer from the available quantities
- After dredge survey (multi-beam) detects areas above grade
  - Will require significant over-dredging to lower “fluff” layer
  - Potential legal implications related to environmental permits
  - Potential issues with the excavation of unclassified materials
  - Will Considerably reduce paid volumes
  - Significant clean up work to remove material that would not be detected with low frequency
    - Low production and inflated cost
    - Considerable risk to contractor

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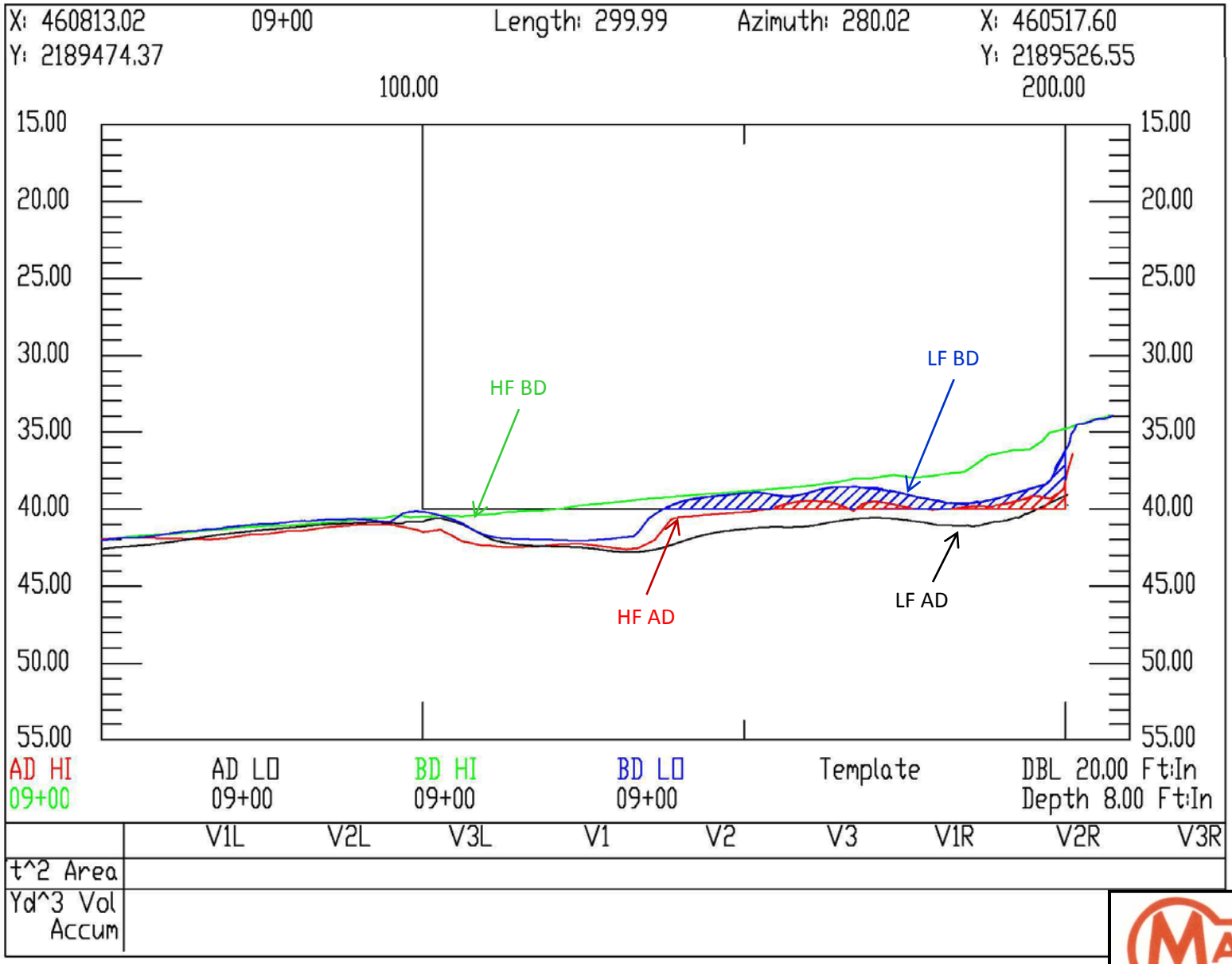
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55.00
HF BD
LF BD
HF AD
LF AD
AD HI
09+00
AD LO
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BD HI
09+00
BD LO
09+00
Template
DBL 20.00 Ft:In
Depth 8.00 Ft:In
V1L
V2L
V3L
V1
V2
V3
V1R
V2R
V3R
t^2 Area
Yd^3 Vol
Accum

Summary

- *"Local conditions and unique project requirements will dictate the optimum type of survey system and frequency to be used. However, for navigation and dredge payment surveys, the acoustic survey system and/or transducer frequency should remain constant throughout the project duration – and clearly identified in construction specifications"*

  USACE EM 1110-2-1003 (paragraph 9-6.d)

- To avoid in-appropriate or erroneous applications, we must use the most appropriate survey methods, as noted in USACE Survey Manual (EM1110-2-1003), to achieve the most cost efficient project result.

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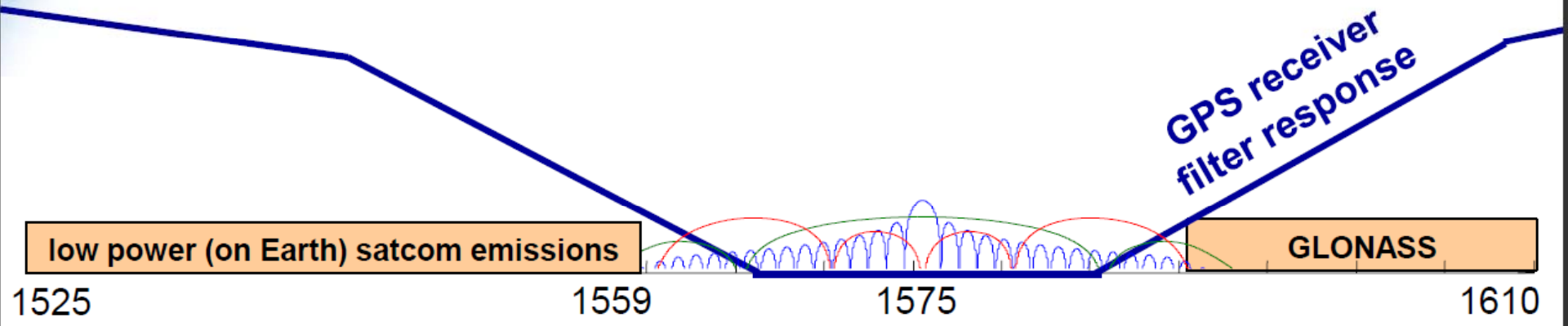
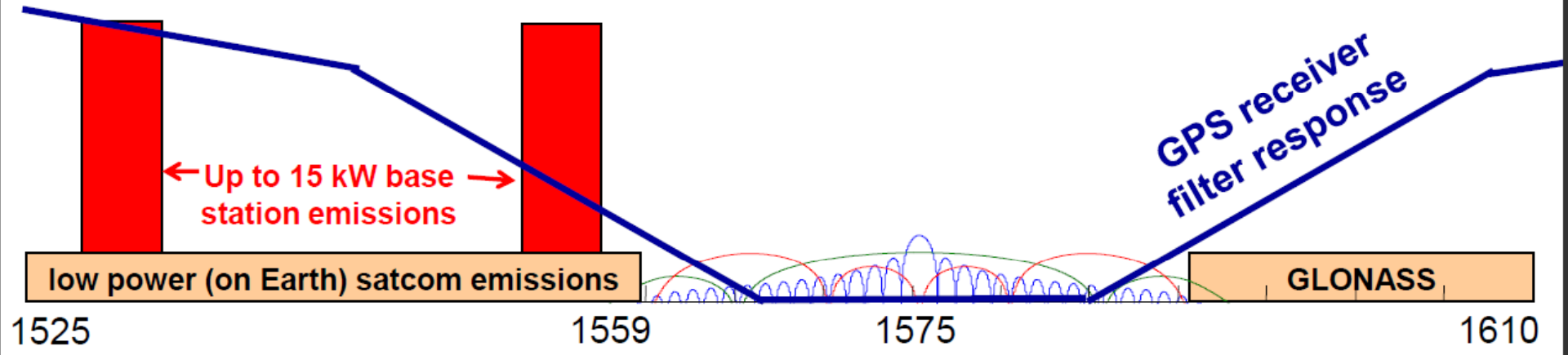
Illustration of Concerns with LightSquared

Situation before LightSquared



Situation with LightSquared



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