All Digital HD

HD Multiplex Field Trial at KKLZ, Las Vegas

Philipp Schmid
Research Engineer at Nautel

January/February 2018

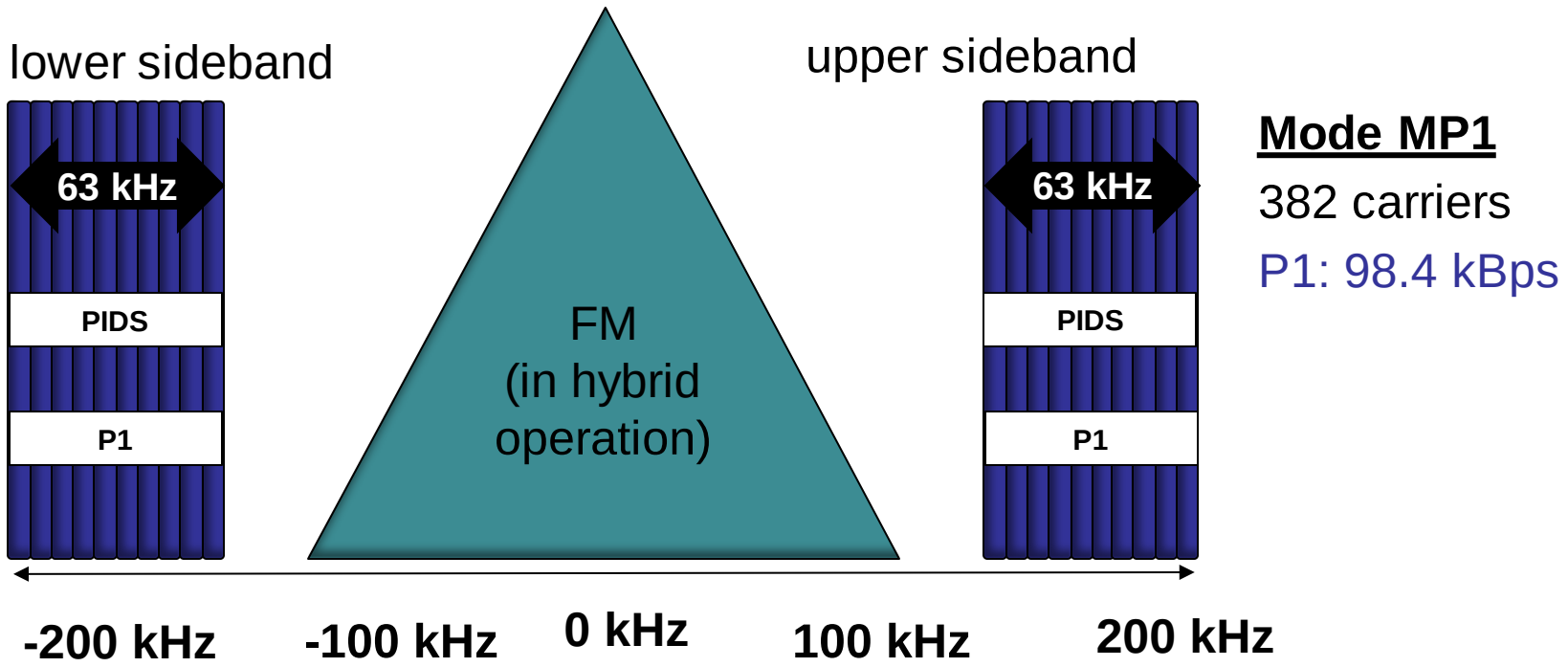
nautel

Making Digital Broadcasting **Work.**

Presentation Agenda

- All Digital Signal Configurations
  - All Digital Service Modes
- Field Trials
  - MP5 Performance
  - Single versus Dual Sidebands
  - HD Multiplex Tests
- Fitting into today's channel allocations
- Applications
- KKLZ Live Demonstration

HD Radio: Hybrid IBOC Service Mode MP1



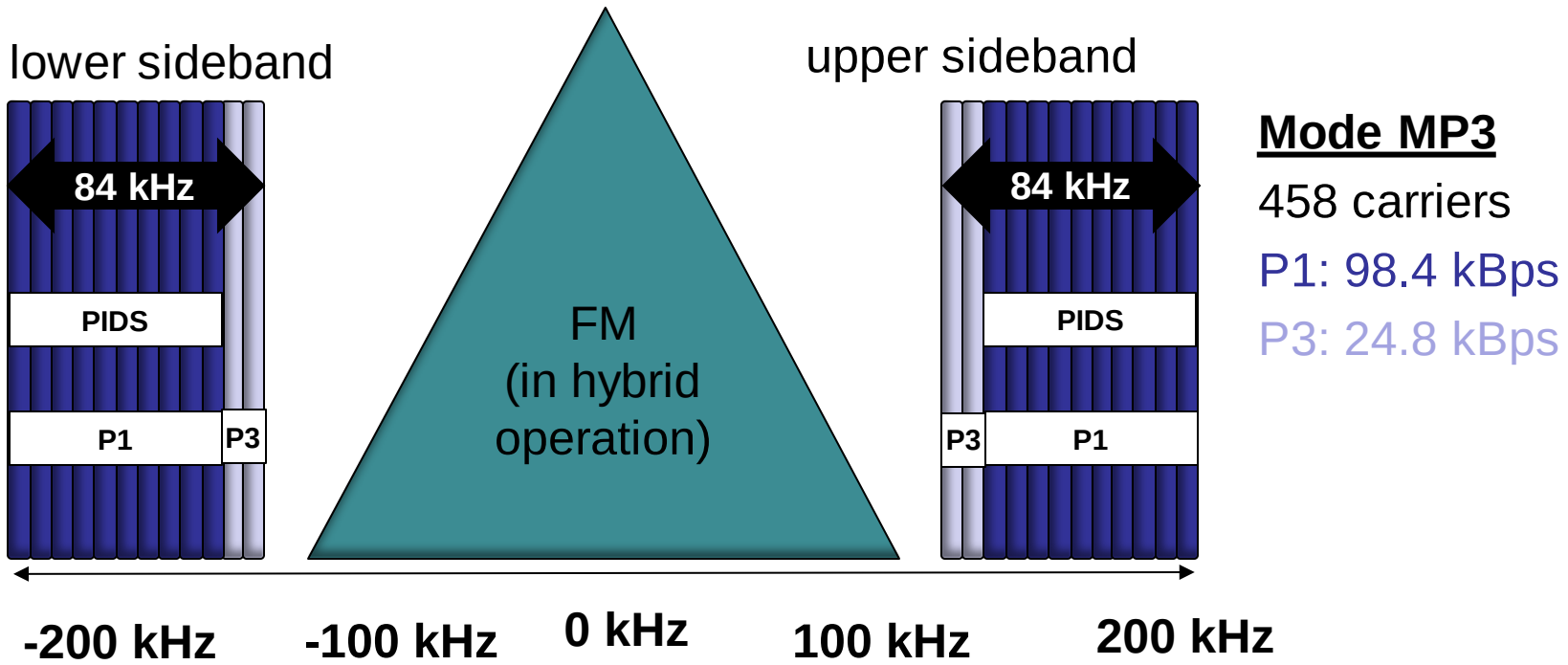
Mode MP1

382 carriers

P1: 98.4 kBps

- **98.4 kbps**: up to 4 audio services (2 typical)

HD Radio: Hybrid IBOC Service Mode MP3



Mode MP3

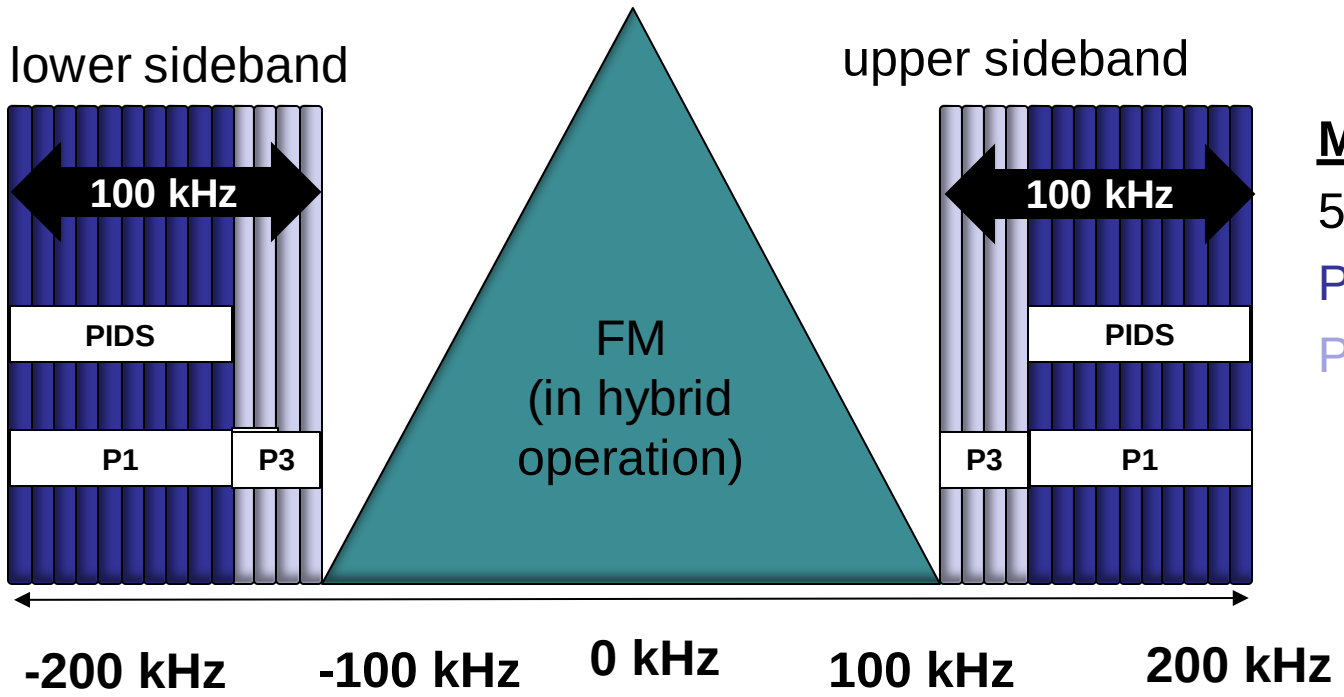
458 carriers

P1: 98.4 kBps

P3: 24.8 kBps

- **123.2 kbps**: up to 5 audio services (3 typical)
- Most common configuration today

HD Radio: Hybrid IBOC Service Mode MP11



Mode MP11

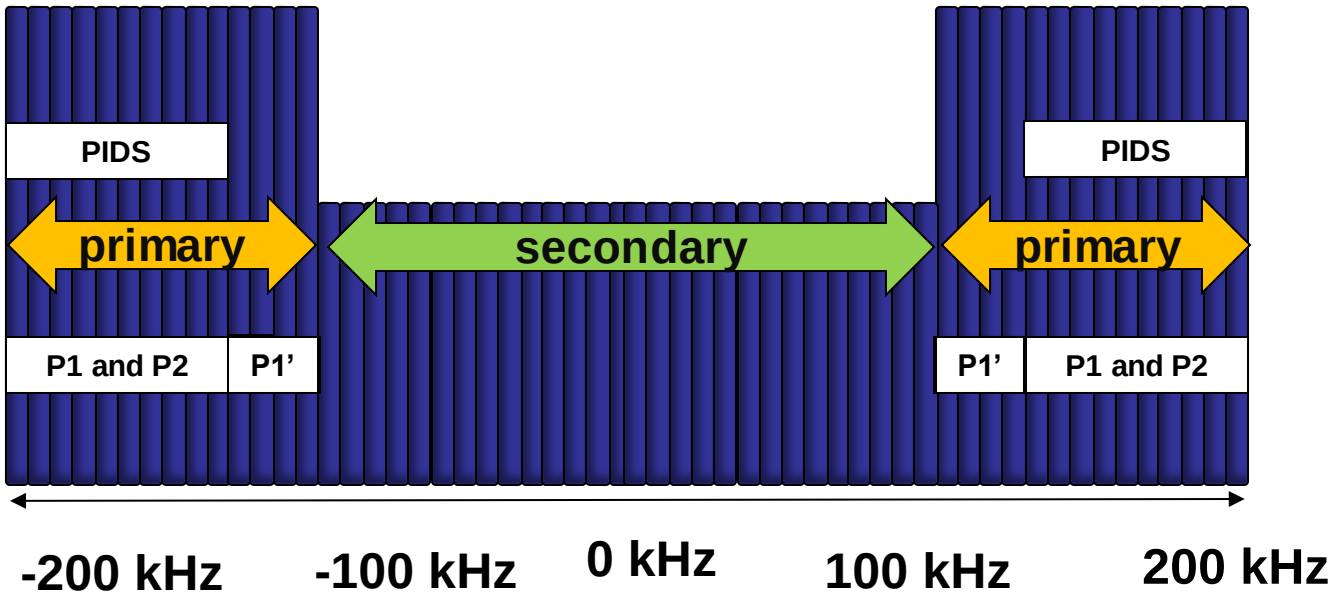
534 carriers

P1: 98.4 kBps (all RX)

P3: 49.6 kBps (limited RX)

- **148 kbps**: up to 4 audio services (50kbps data)
- IBOC encroaches on FM carrier

HD Radio: All Digital IBOC Service Modes



Mode MP6

up to 4 audio

P1: 49.6 kBps

P2: 48.8 kBps

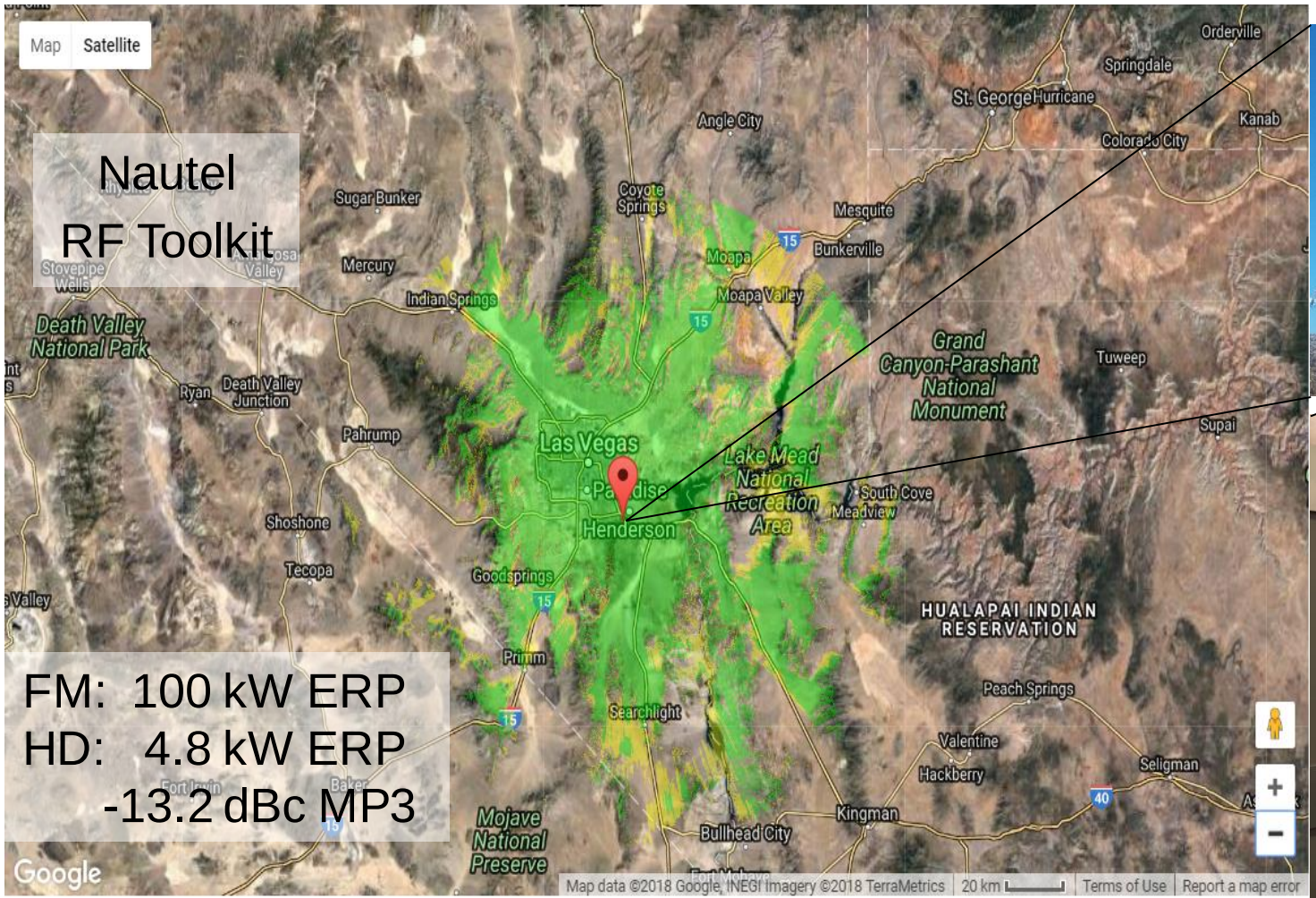
Secondary carriers are at **<3.2%** of licensed FM power

- leads to sub-optimal band allocation

Secondary carriers lack receiver support

P1' is a time delayed version of P1 for added robustness

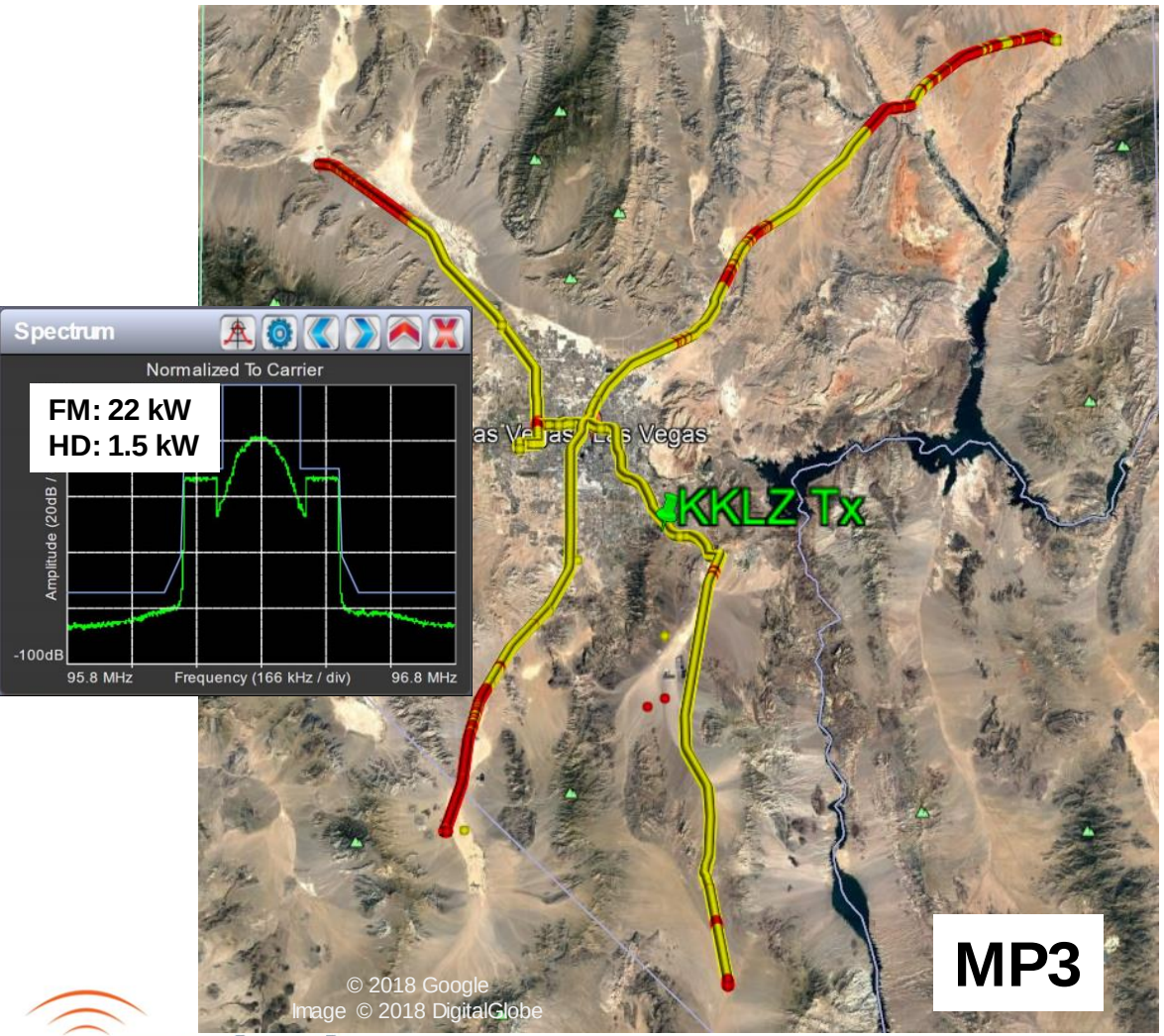
KKLZ On Air Tests

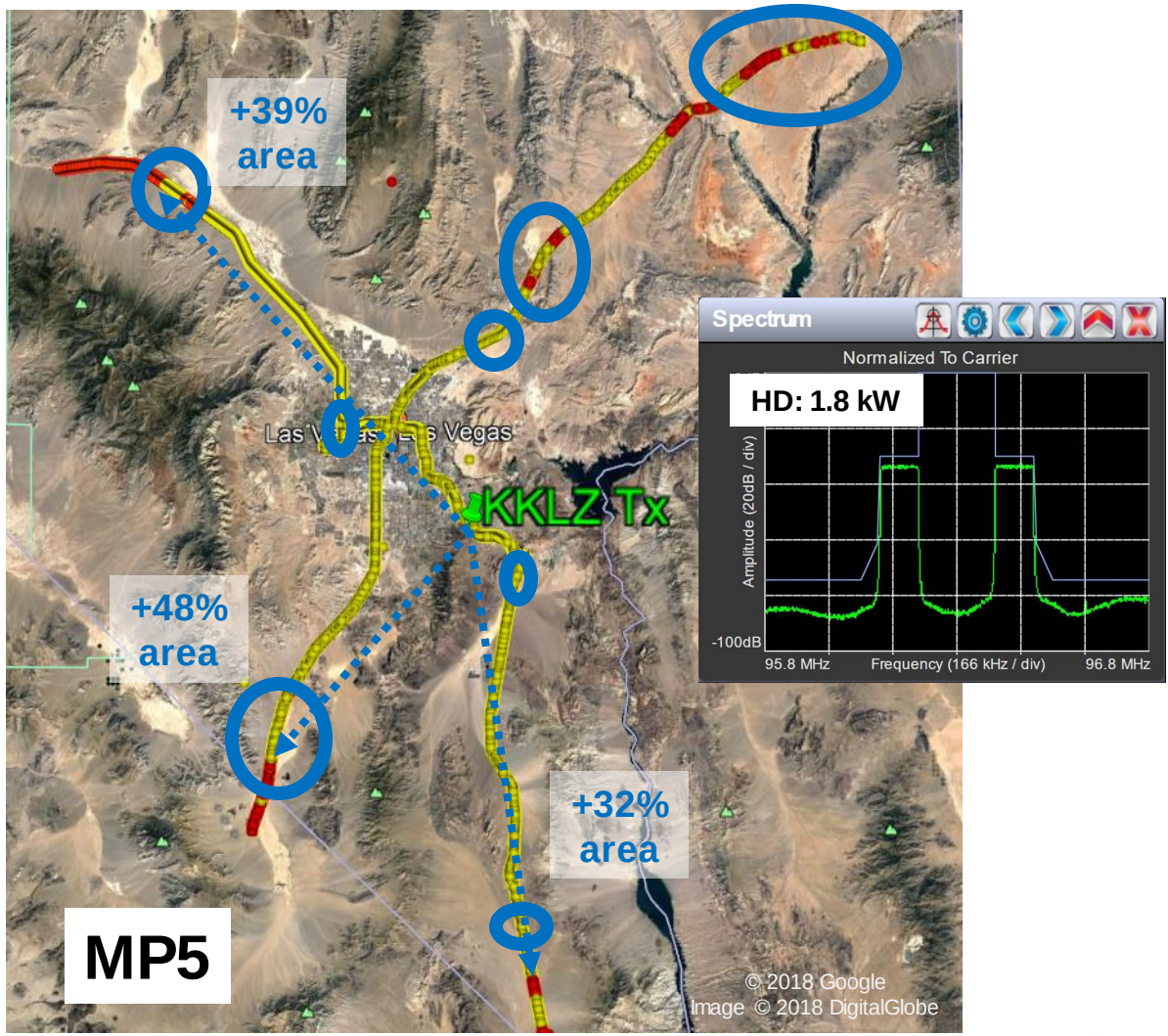


nautel

Making Digital Broadcasting **Work.**

KKLZ: MP5 Improved Coverage (HD1)

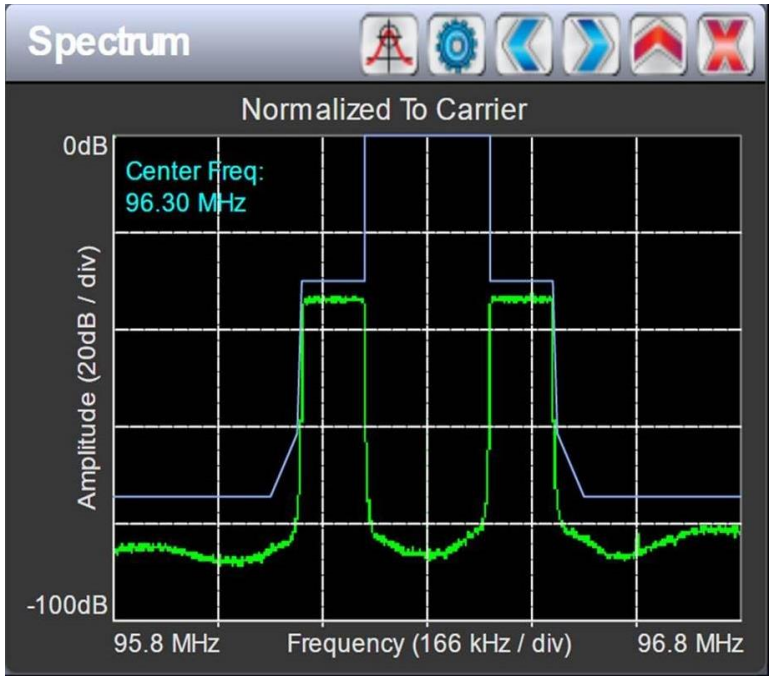




nautel

Making Digital Broadcasting **Work.**

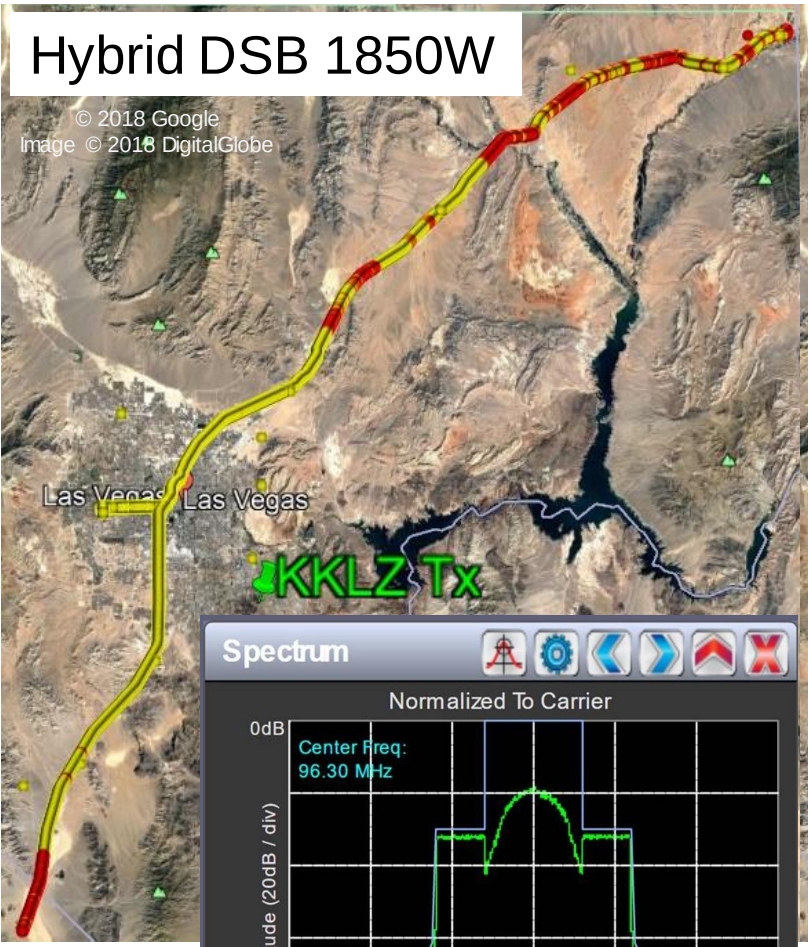
All Digital MP5 Takeaway



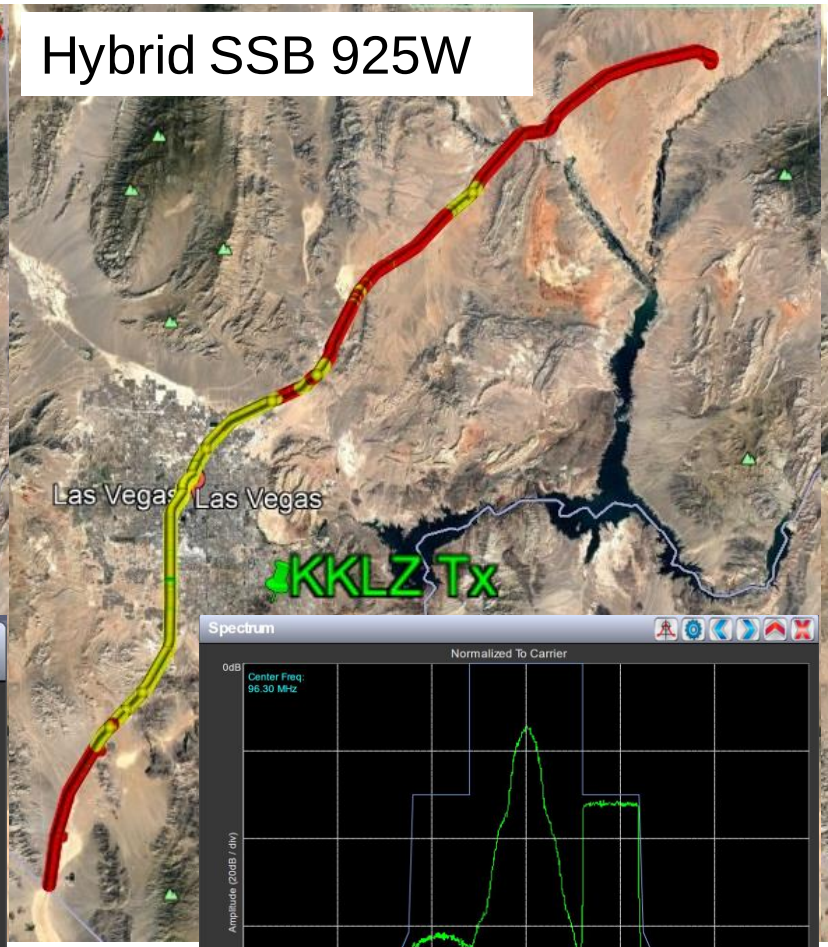
- MP5/6 P1 main program is very robust
  - 20% more power => 30-50% more coverage
- All-digital and Hybrid MP5 possible
  - both were tested no substantial difference
- Wide receiver support
  - some handheld units may not support MP5/6
- Nautel can support further MP5 tests
  - not available in production at this time
  - requires additional transmitter overhead
- Is it robust enough for single sideband?

MP5 Single Sideband Performance

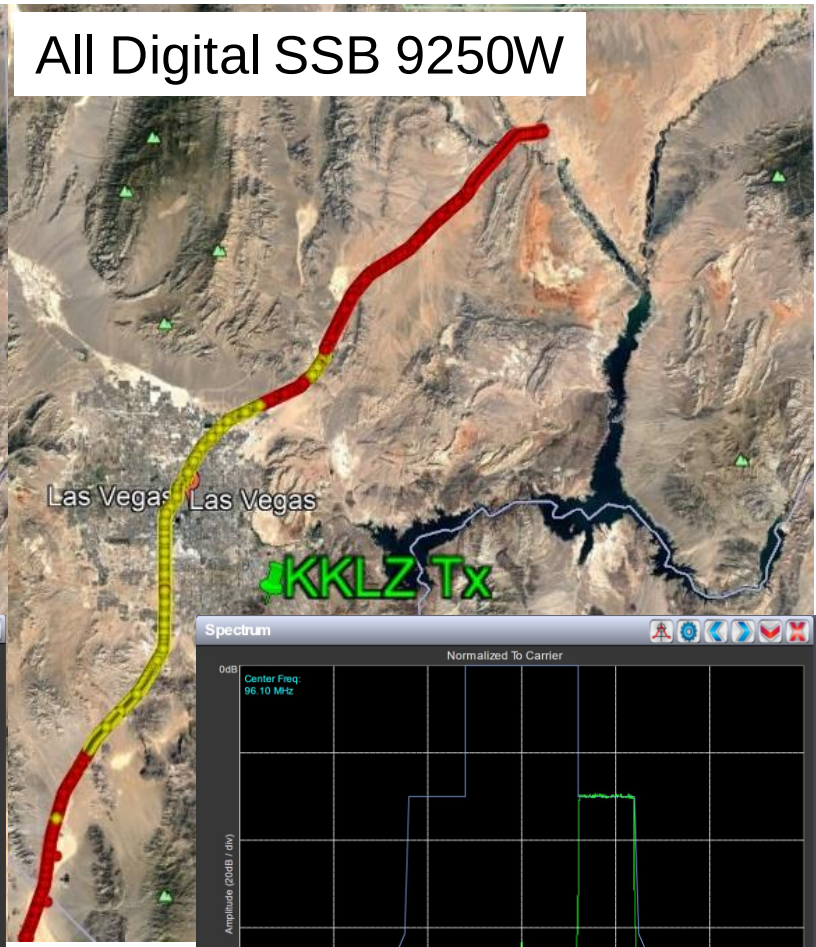
Hybrid DSB 1850W



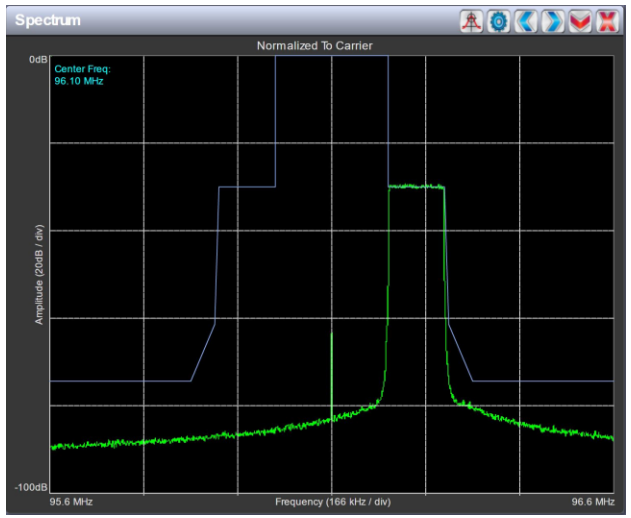
Hybrid SSB 925W



All Digital SSB 9250W



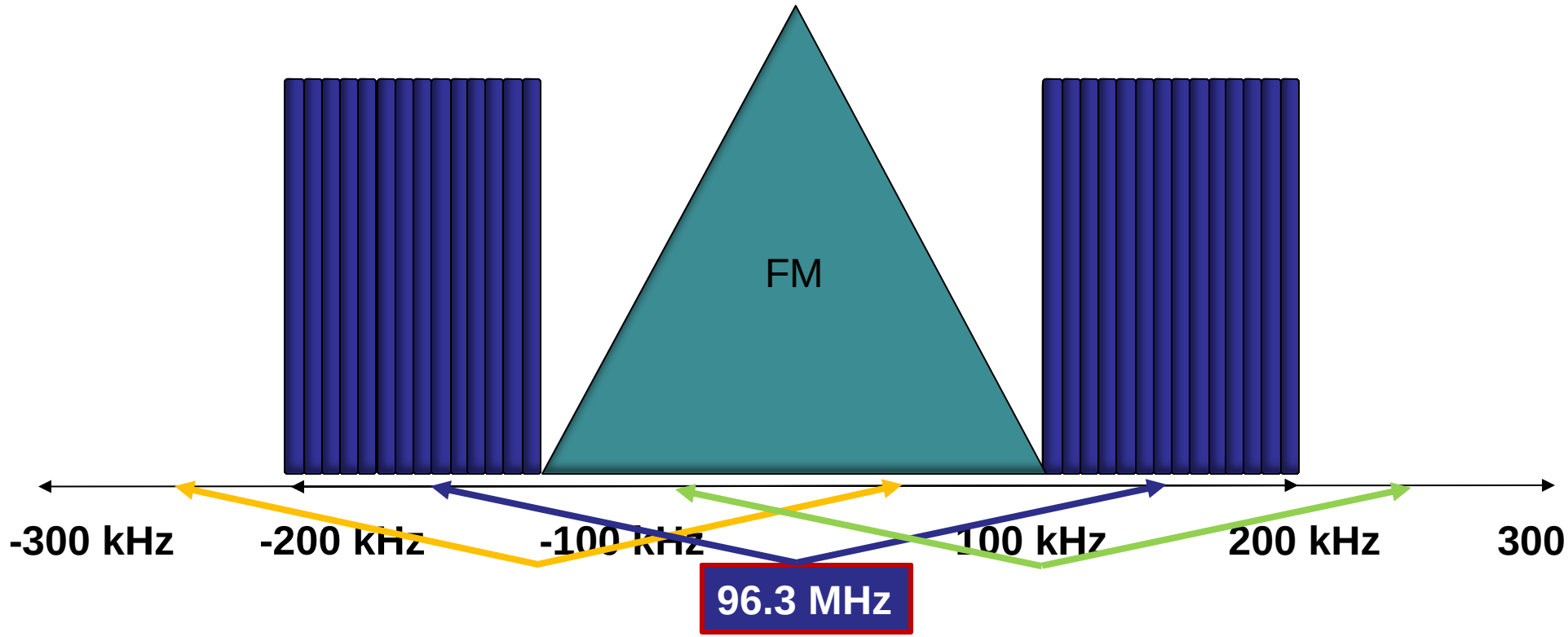
Single Sideband Takeaway



- Significant hit in coverage (expected), but works
  - loss of frequency diversity, 3dB sideband loss
  - FEC rate reduced from 2/5 to 4/5
- Not supported on all HD receivers
  - Acquisition time increases from 1-2s to 7s
  - Ford explorer struggles to acquire, solid when locked
  - Receivers are certified with dual sideband only
- SSB not recommended at this time

Research: Why did 10x power increase not improve coverage?
Hypothesis: Better crest factor reduction required – clipping in receiver AGC? Worked better with HD Multiplex …

HD Multiplex: Interleaving IBOC Signals



600 kHz wide

1512 carriers

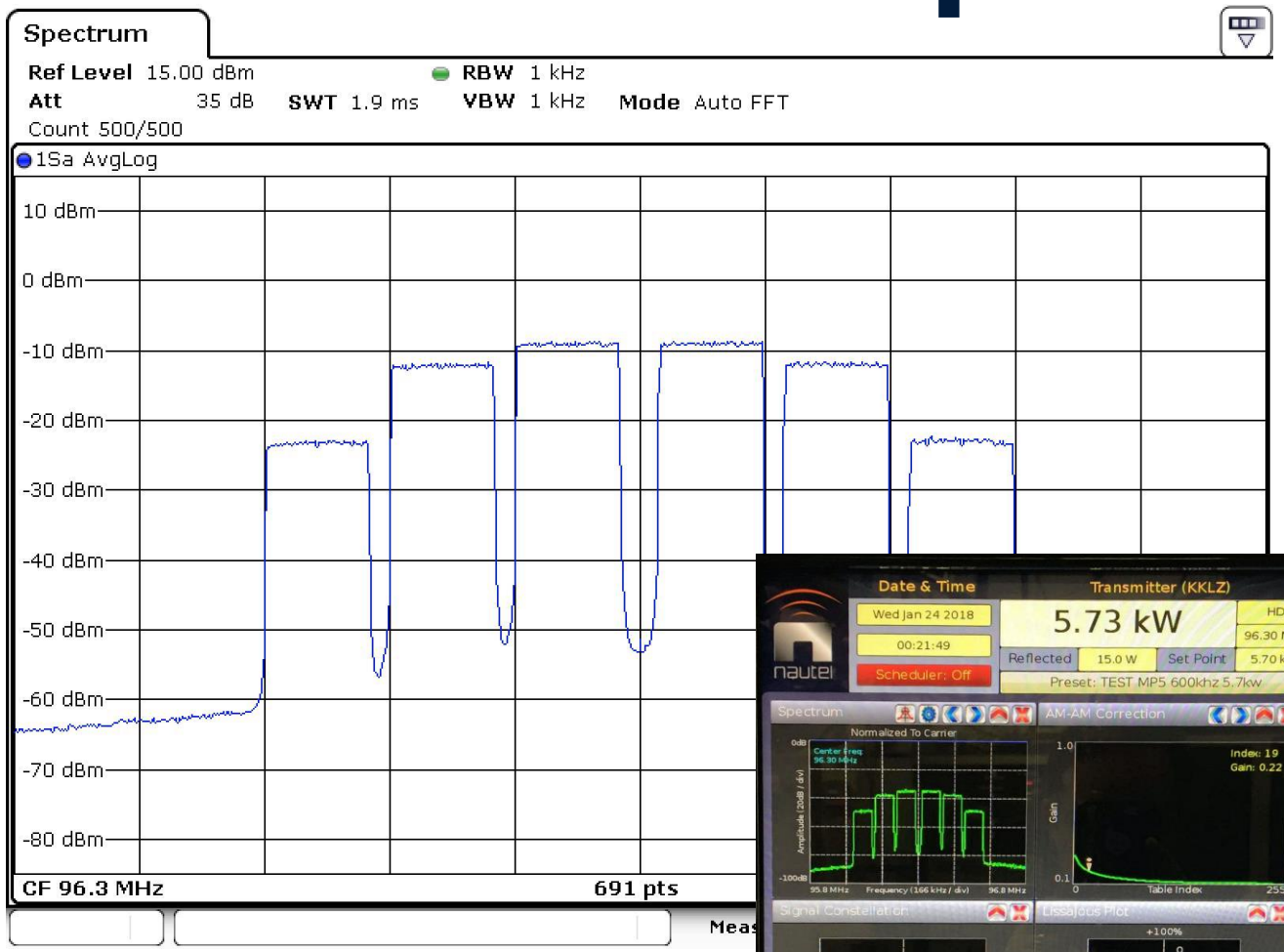
369.9 kbps

15 audio services

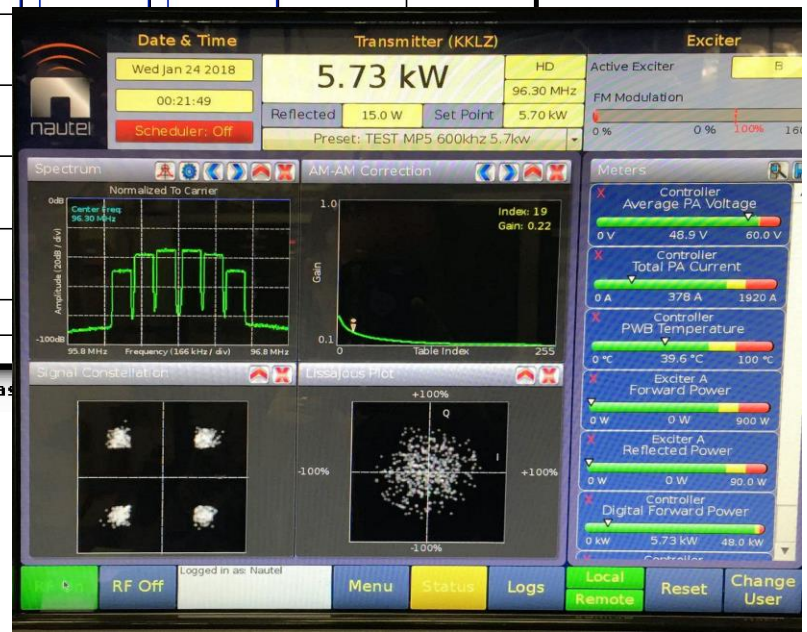
Compatible with todays receivers

European tuning required for center carriers

Tested HD Multiplex Signals



Date: 24.JAN.2018 01:59:29



600 kHz MP3 at 96.3 MHz

Spot checked at studio

(17.5 miles/18 km)

15 audio services on 96.2/3/4

(AudioVox/Insignia/Test Rx)

Ford Explorer tunes 96.3 only

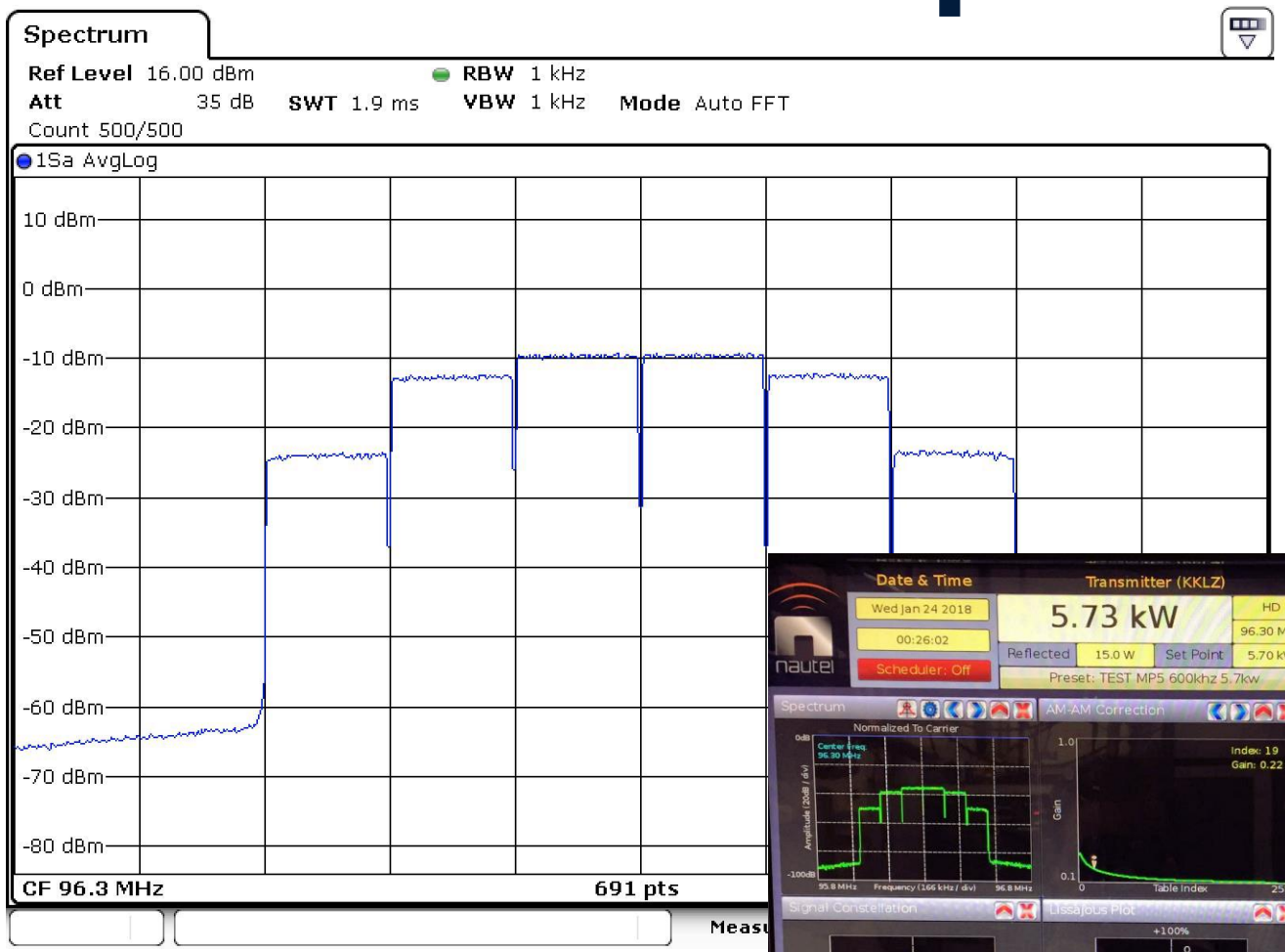
(5 audio serves received)

Provided the receiver can tune to the desired sideband it **works**

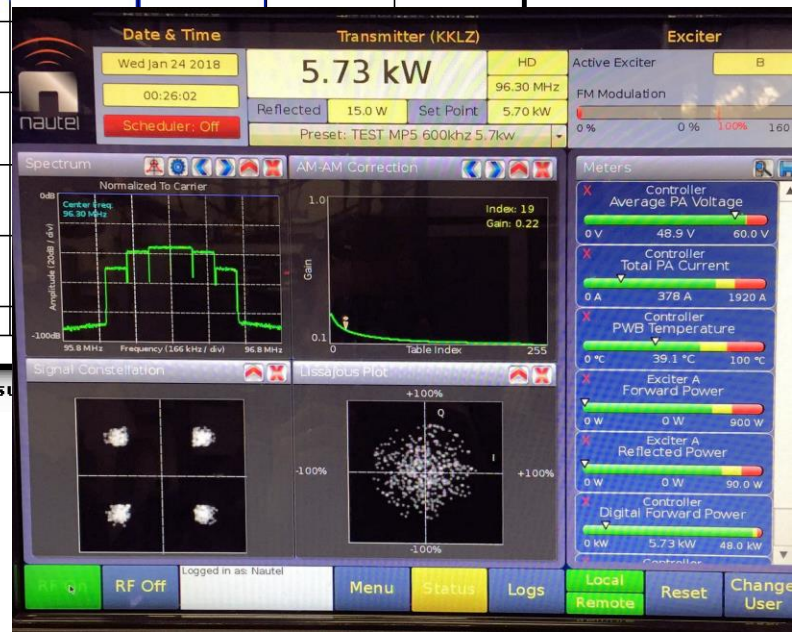
nautel

Digital Broadcasting **Work.**

Tested HD Multiplex Signals



Date: 24.JAN.2018 02:01:12



600 kHz MP5 at 96.3 MHz

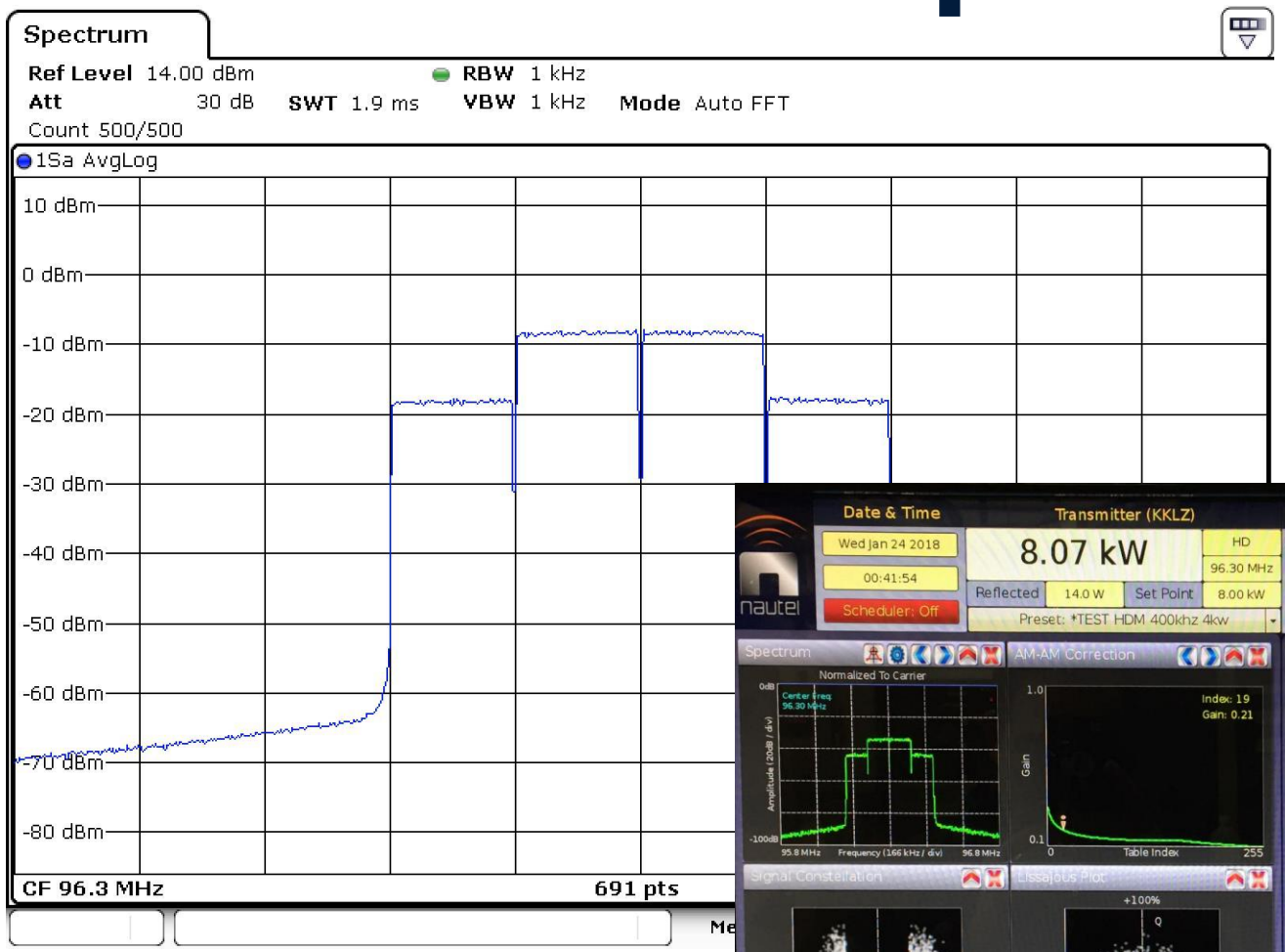
Spot checked at studio

all 9 services received provided the receiver can tune to sideband

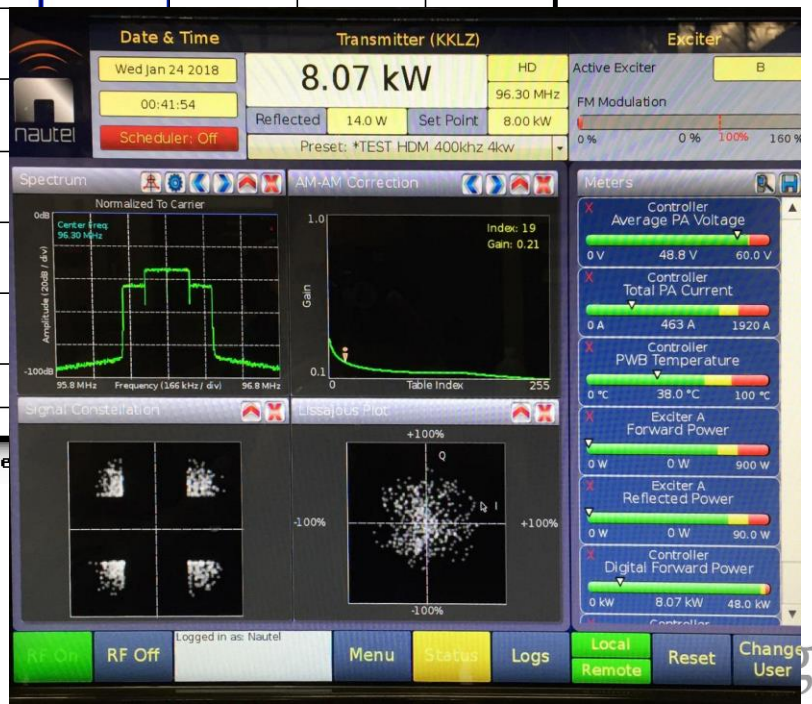
nautel

Digital Broadcasting **Work.**

Tested HD Multiplex Signals



Date: 24.JAN.2018 01:52:25



400 kHz MP5/MP6 at 96.3

Test Drive #1

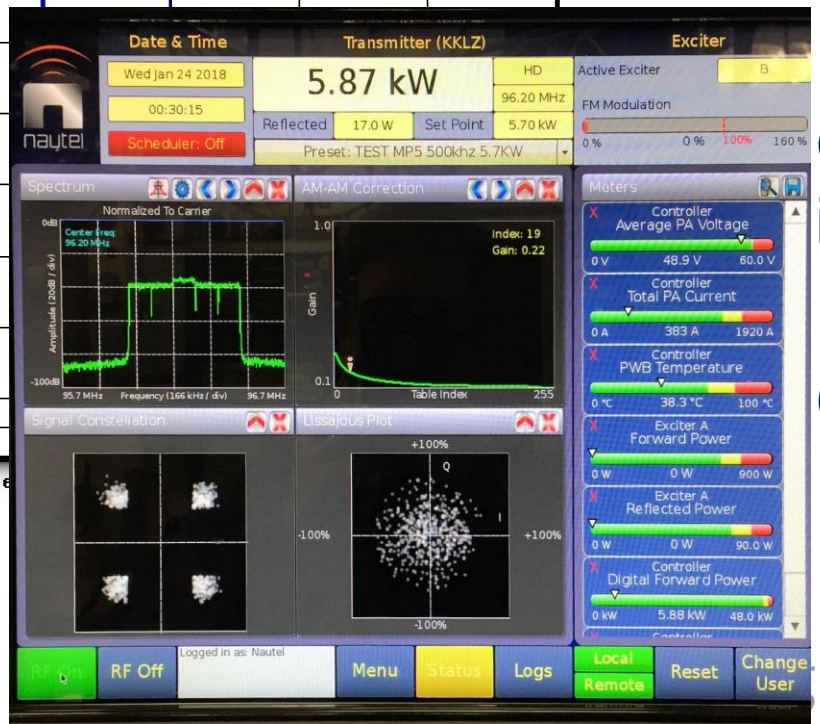
tuning frequencies at 96.1, 96.3 and 96.5 MHz

Center is single sideband in MP6 with 10 dB gain

FM power ⇔ HD Power

Tested HD Multiplex Signals

Date: 24.JAN.2018 02:03:21



500 kHz MP5/MP6 at 96.2 MHz

Drive Test #2

tuning frequencies at 96.1, 96.2 and 96.3 MHz

2 frequencies for Ford Explorer

Center is single sideband in MP6 with added power

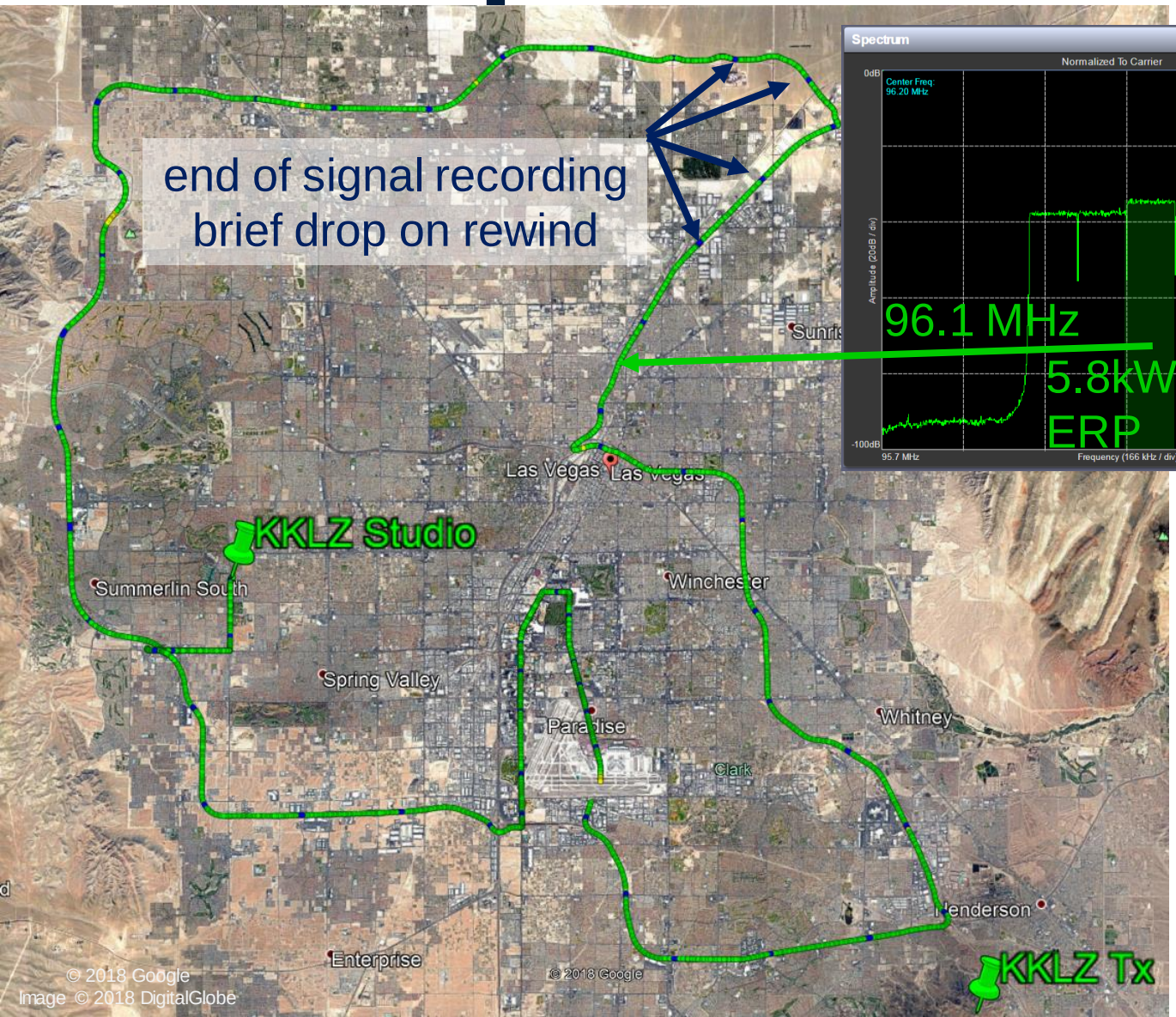
LSB falls on 2nd adjacent

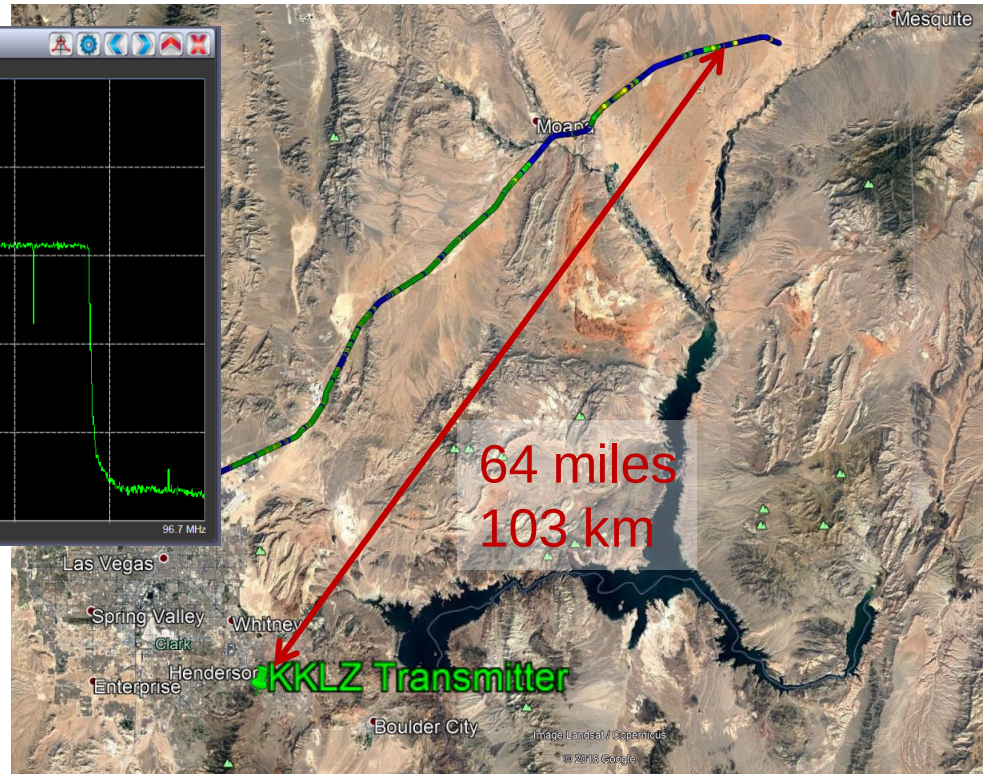
(no experimental authorization)

nautel

Digital Broadcasting **Work.**

HD Multiplex Field Trial





HD Multiplex Works

Realtime modulator required for scientific coverage results

Making Digital Broadcasting **Work.**


HD Multiplex
Solid on LV Strip
© 2018 Google
Google Earth
1977
36°06'58.47" N 115°10'25.65" W elev 641 m eye alt 1.17 km

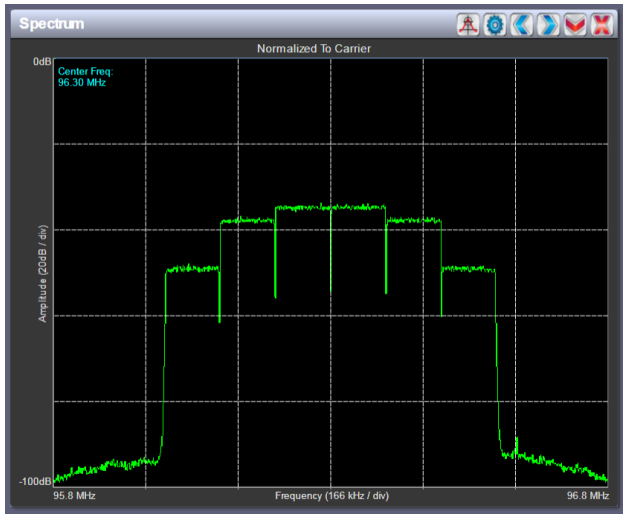
HD Multiplex

- expected drop out in airport tunnel
- quick recovery on exit

HD Multiplex

- brief drop out behind lone mountain (23 miles / 37 km)
- dual sideband tests are solid

HD Multiplex Takeaway



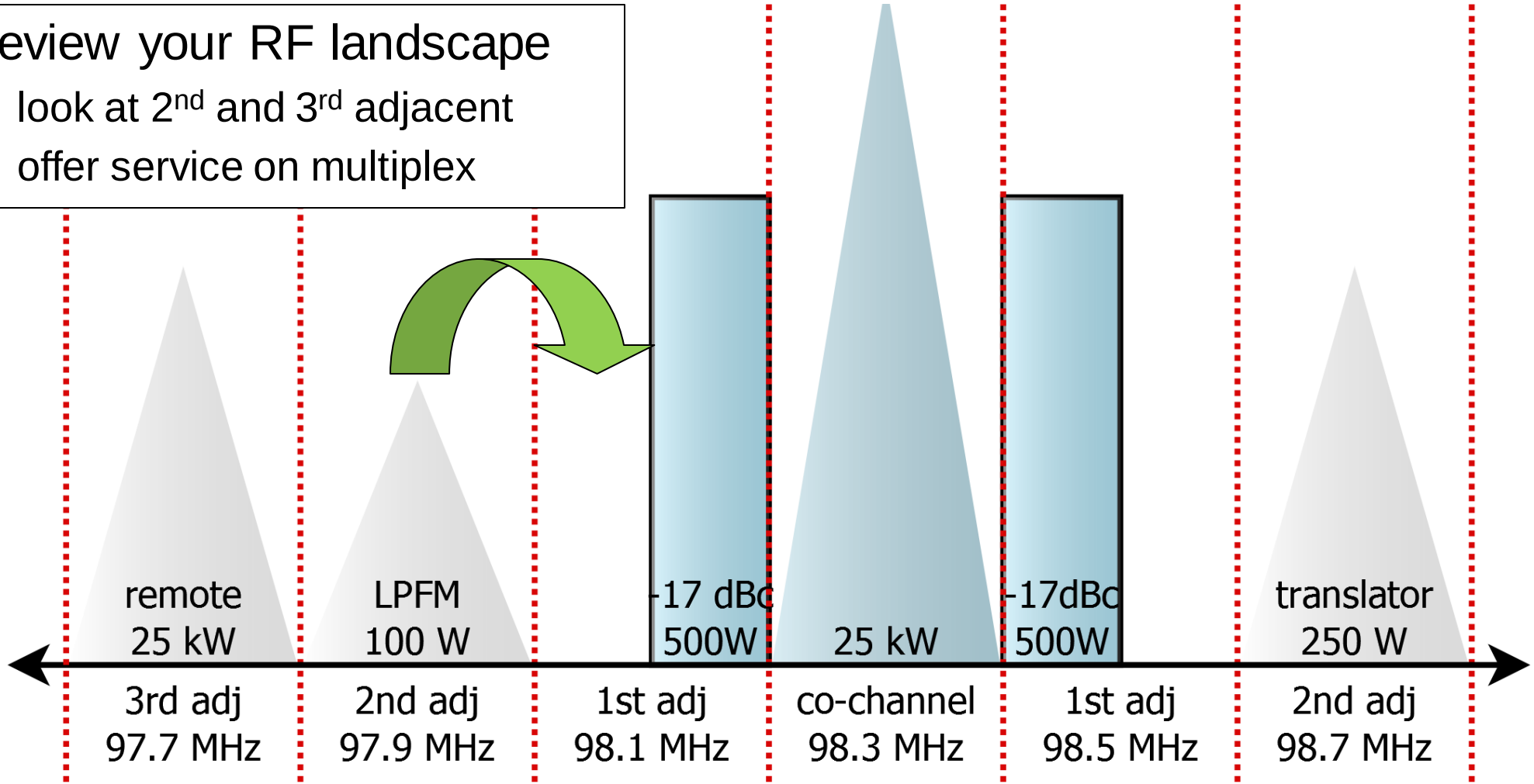
- Nautel's HD Multiplex algorithm is validated on air
  … it works
- Nautel needs to develop a real time modulator for further scientific tests.
  - Recorded vectors are limiting
- If receivers can tune to the frequency all dual sideband modes work on all tested receivers.
- Consider single sideband modes **experimental**.
- HD Multiplex is not legally approved for broadcast

- How do we find the required frequencies?

Allocating All Digital HD Multiplex

Review your RF landscape

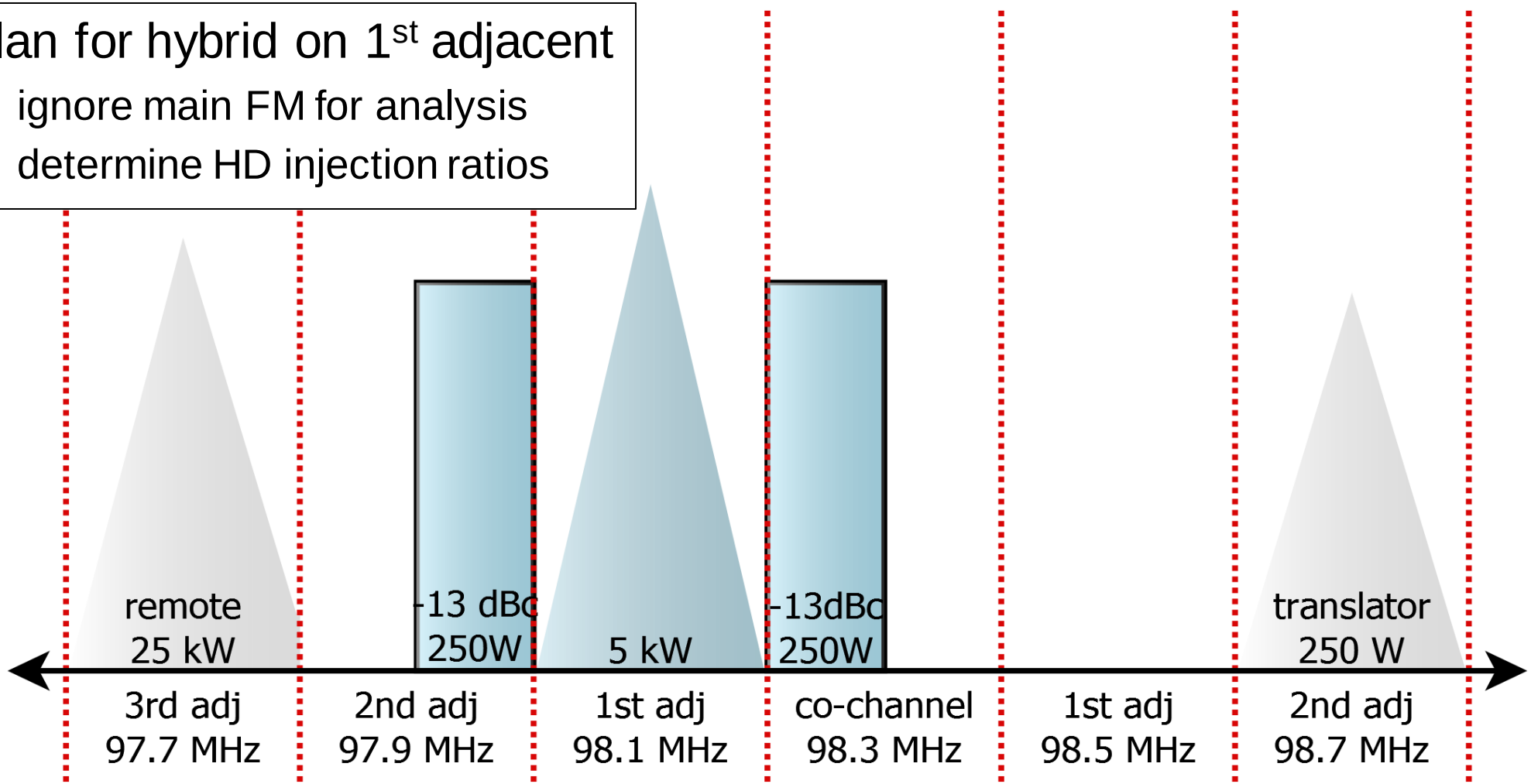
- look at 2nd and 3rd adjacent
- offer service on multiplex



Allocating All Digital HD Multiplex

Plan for hybrid on 1st adjacent

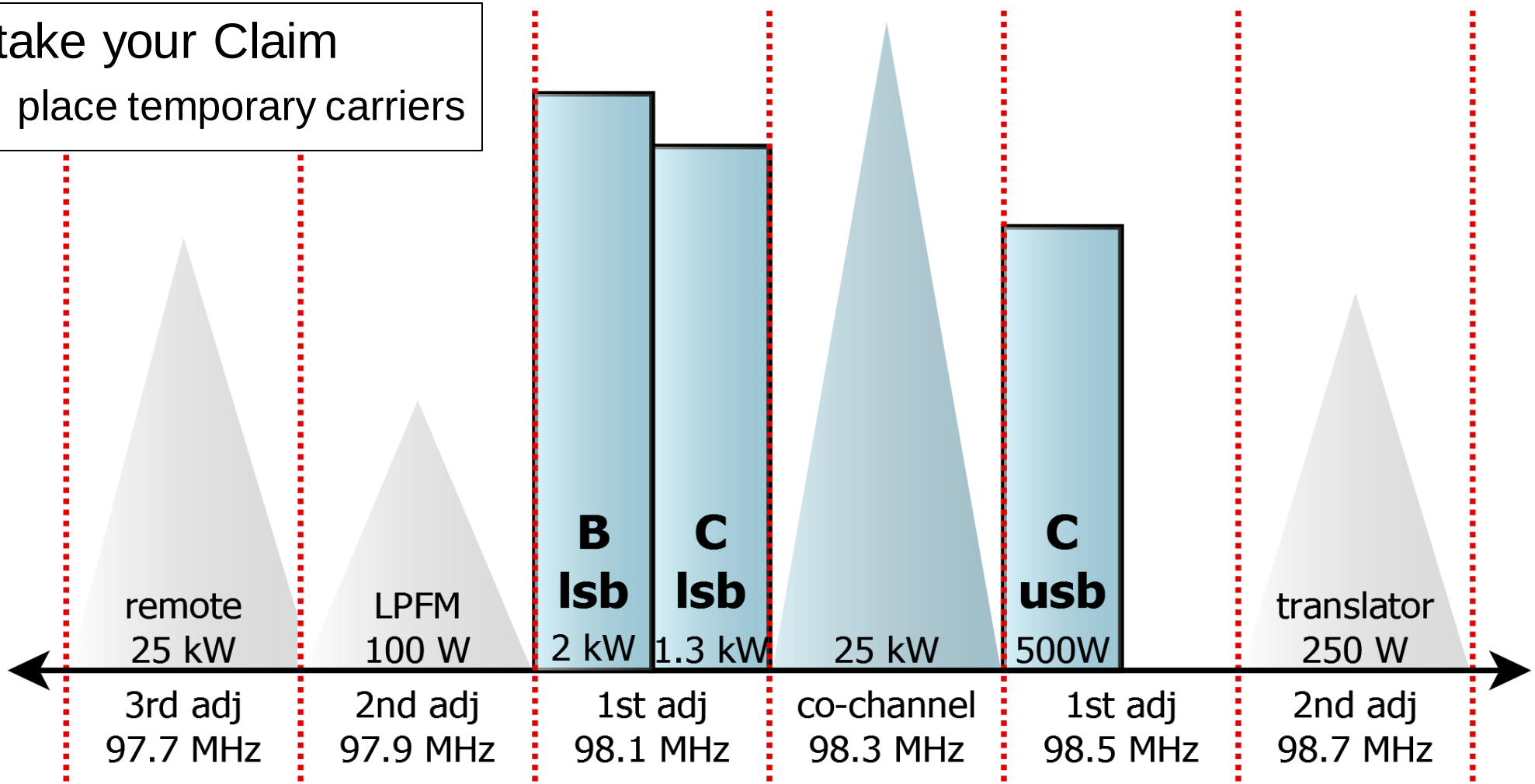
- ignore main FM for analysis
- determine HD injection ratios



Allocating All Digital HD Multiplex

Stake your Claim

- place temporary carriers

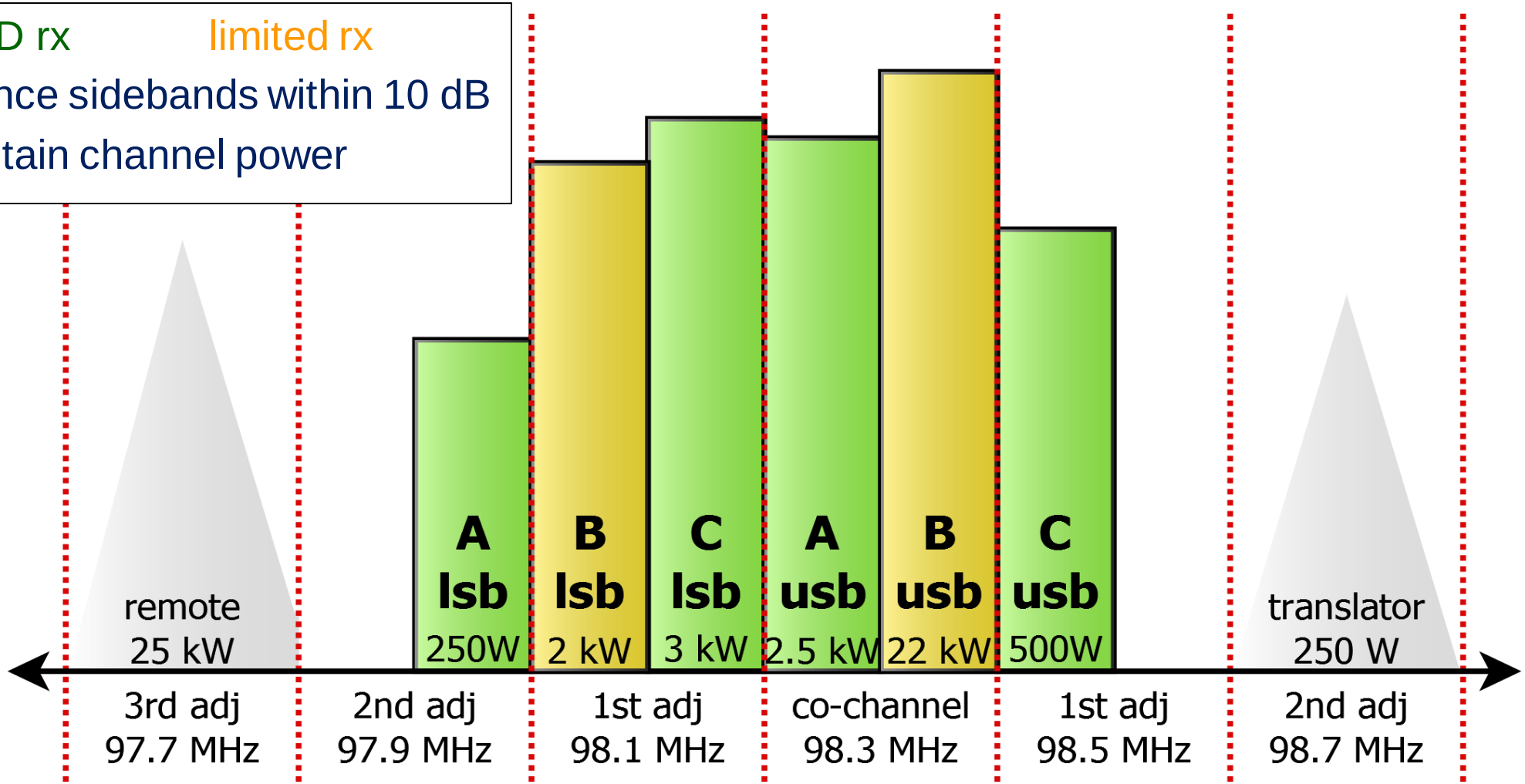


Allocating All Digital HD Multiplex

all HD rx limited rx

balance sidebands within 10 dB

maintain channel power



When is it time for digital HD Multiplex?

- All HD receivers will tune to main program (98.3 C:HD1)
  - Main program **drops** by HD receiver penetration percentage
  - Slight increase in coverage to FM main program today
  - 98.3 HD2/3/4 remain unchanged and are not considered
- All HD Receivers will add 98.1 A:HD1/2/3/4
  - Listener increase by union(HD1/2/3/4) * HD receiver penetration
  - Assume double listeners vs main program across 4 services

- HD Multiplex spectrum more valuable at 33% HD Receiver penetration
  - Today **27.7% in New York** (reported by Radio Magazine - Feb 20, 2018)
- Sideband B at 98.2 MHz doubles coverage area
  - Consider single sideband operation and tune to 97.9 MHz/98.5 MHz
  - Good for dedicated service application due to tuning/SSB limitation …

Dedicated Service: Smart Vehicles

2500 vehicle fleet

Upload

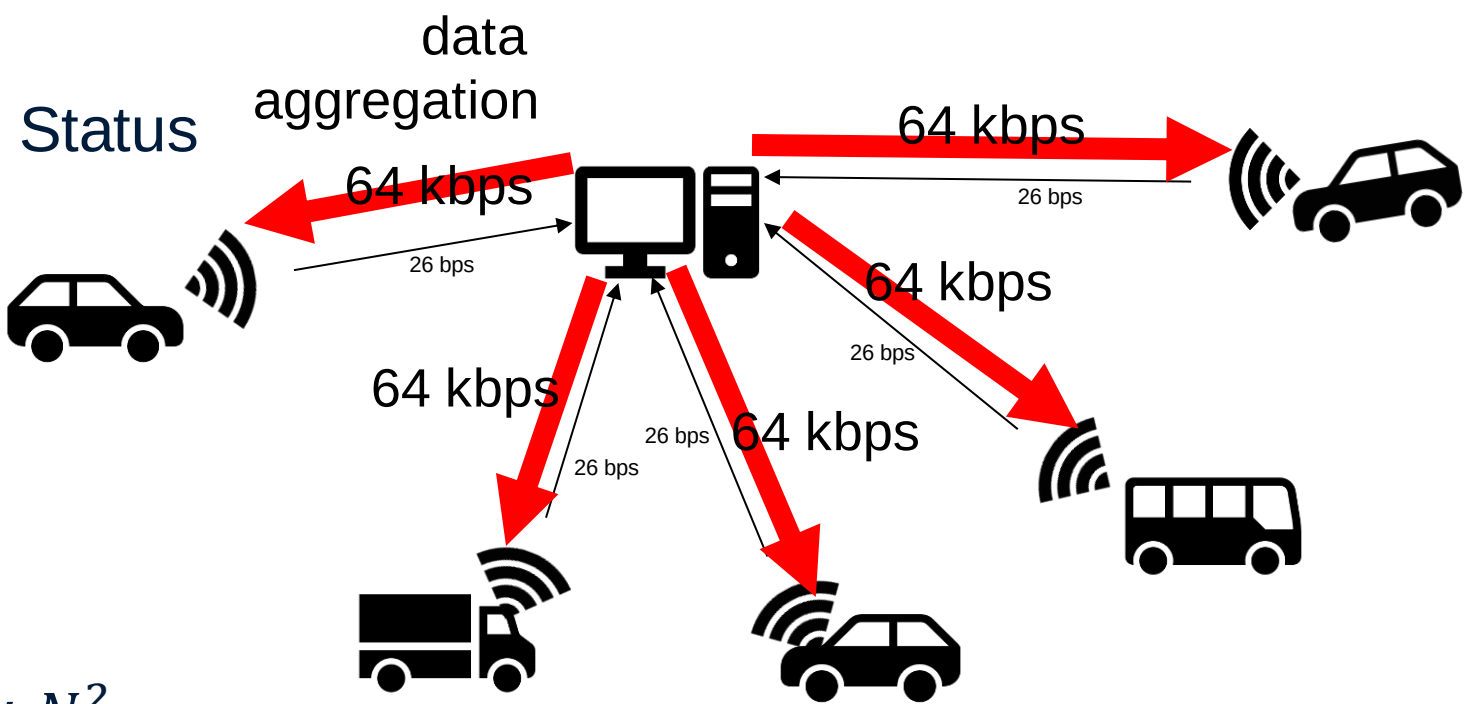
32 Bytes @ 10s

- Long/Lat, Speed, Dir, Status
- Total data 64 kbps

Download

Total 150 Mbps

- 1582 GBytes/day
- 577 TeraBytes/year
- not scalable grows by N^2



Dedicated Service: Smart Vehicles

2500 vehicle fleet

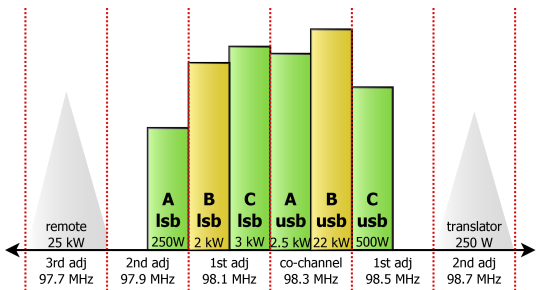
Upload

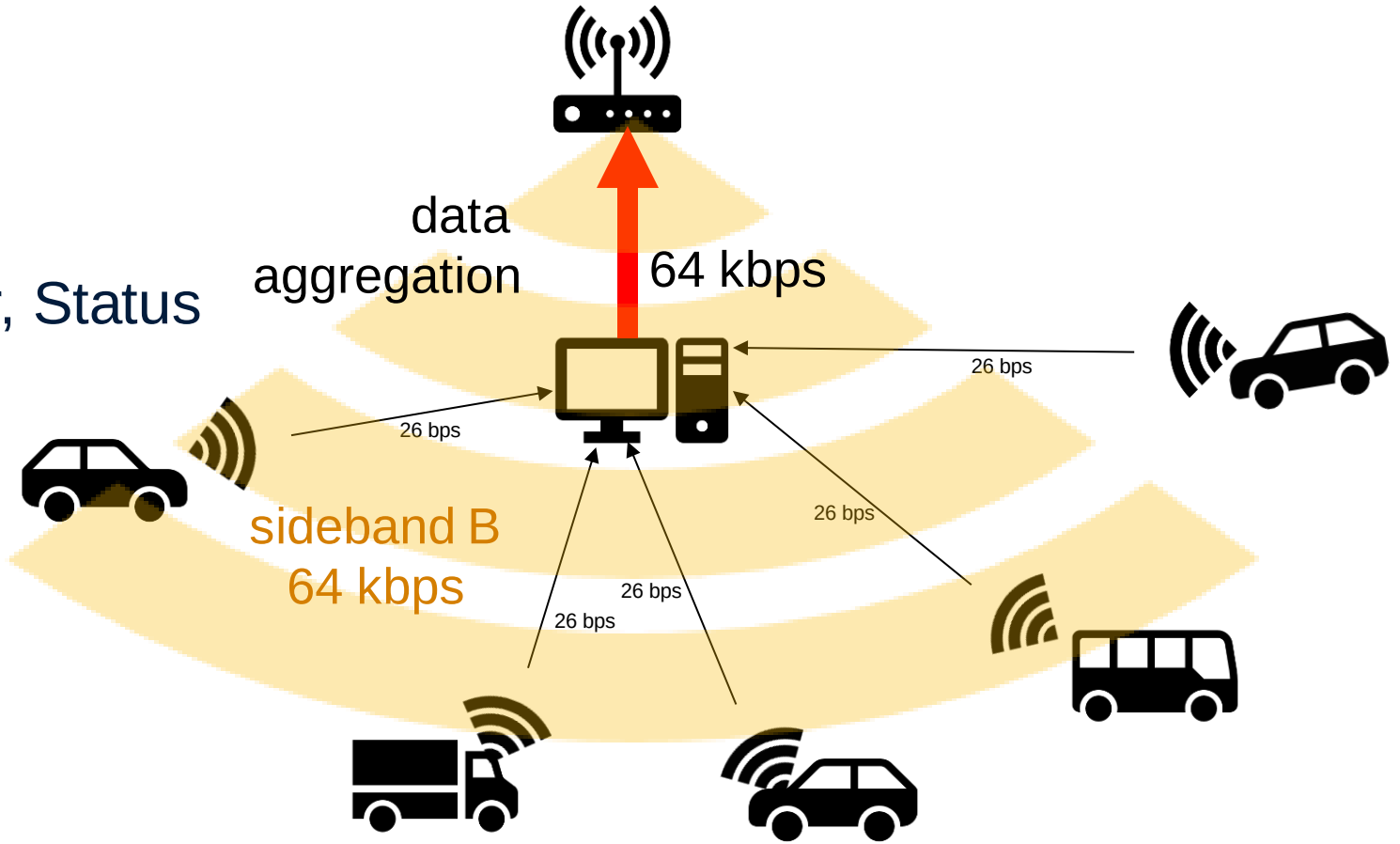
32 Bytes @ 10s

- Long/Lat, Speed, Dir, Status
- Total data 64 kbps

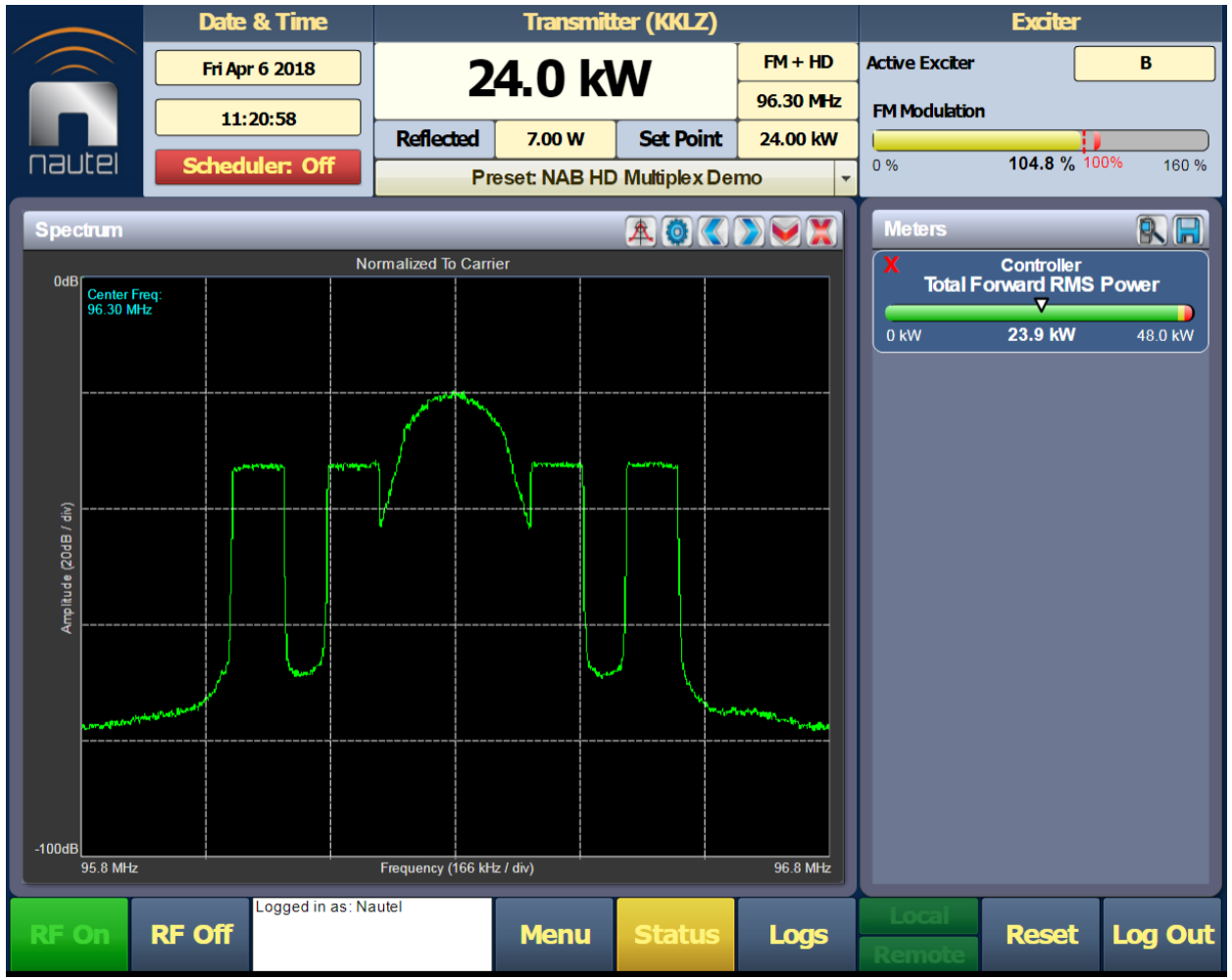
Download

HD Multiplex:





KKLZ Live Demo



Example of intermediate use of HD Multiplex

- Maintains FM signal
- Typically keep hybrid center sidebands
  - demo makes them independent sidebands
- Add-on additional IBOC carriers

Demo:

- 4 single sidebands (3 audio)
- 12 audio services
- 400 kbps capacity

nautel

Making Digital Broadcasting **Work.**

In Summary

- All digital service modes MP5/6 offer increased coverage
- HD Multiplex has been shown to work on-air
- A proposed allocation method has been shown
- All Digital applications have been illustrated
- HD Multiplex is demonstrated live on-air at KKLZ
- Nautel is ready to support further testing

  … lets find more frequencies to test on

Thank You

- Thanks to Beasley Media Group for use of the KKLZ Transmitter
  - Thanks to Mike Cooney for making this happen
  - Thanks to station engineers Steve Griesbach and Ray Fodge
- Thanks to our partners
  - David Layer and test crew with NAB Pilot
  - Russ Mundschenk with DTS/Xperi
- Thanks to all the folks at Nautel that helped to make this happen
  - Thanks to Joey Kloss for spending those long nights on Black Mountain