An Investigation of Fading on a Short Range 900MHz radio link

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Steve Shearer Oct 2009

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Introduction

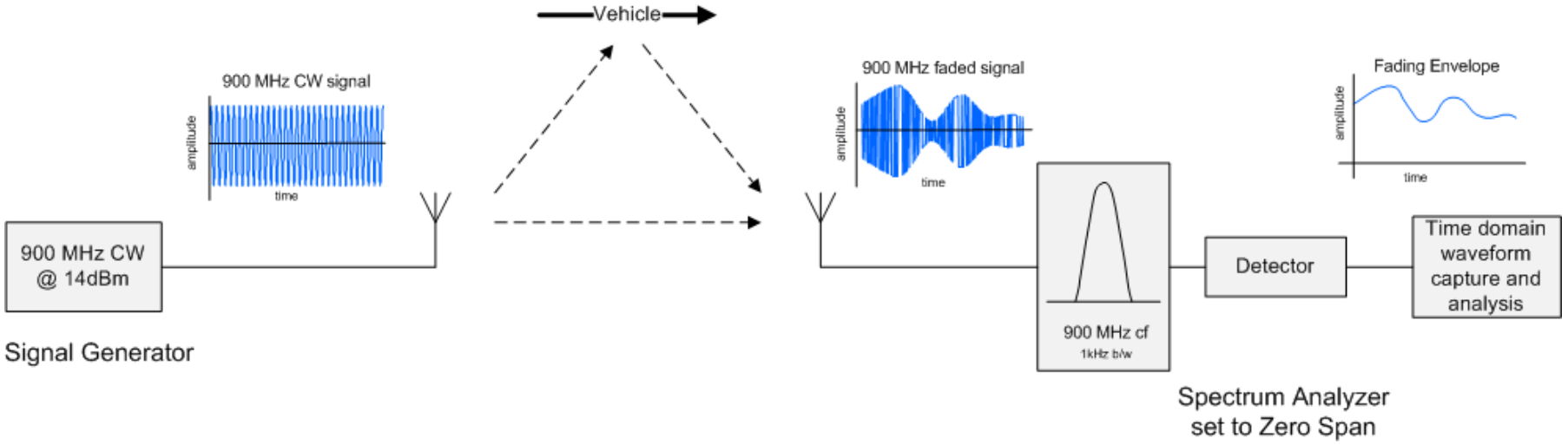
- **Considerable effort has been spent understanding radio channels for the SUN environment**
  - There is agreement on using appropriate channel models suited to the particular deployment/modulation type
- **Most modeling has been done in either AWGN or a Pseudo Static environment**
- **But there is little clarity on stationarity or fade rate of a typical short range channel**

Objective

- **Noting that a 900MHz cordless phone exhibits "fluttering" due to passing traffic:-**

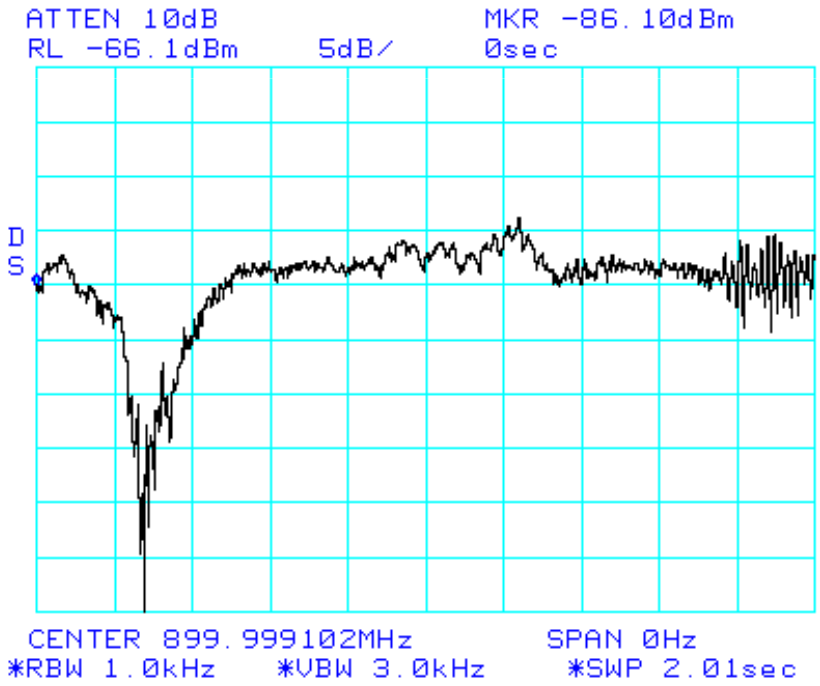
- **This presentation seeks to investigate further by setting up a simple experiment to answer the following questions**
  - Does fading occur in short links?
  - How bad is this fading?
  - How often does it occur?
  - What are the characteristics of the fading?

Experimental Setup



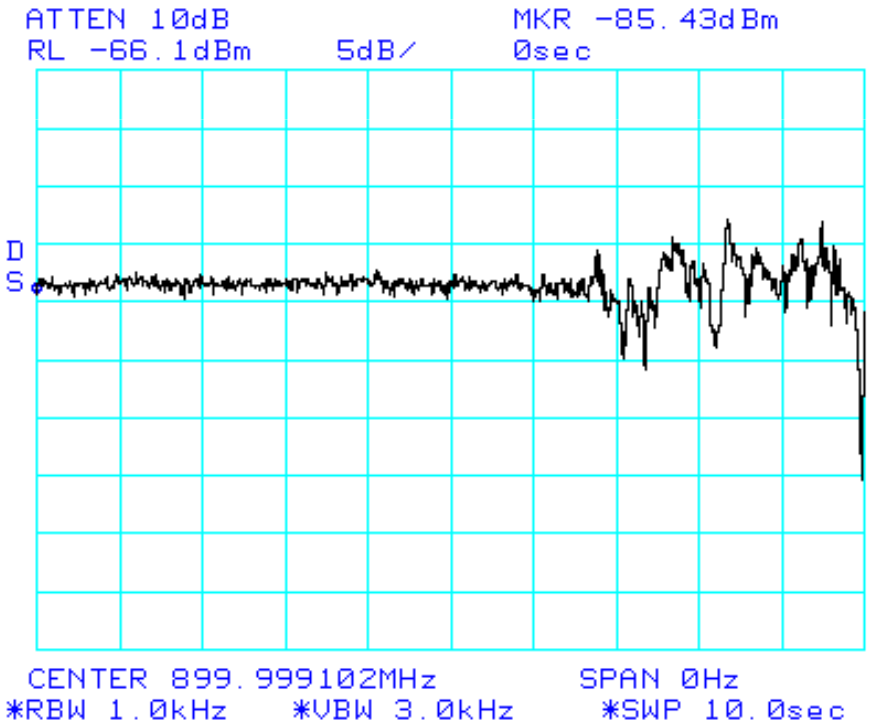
Does Fading Occur?

- **Diagram shows time domain output of "zero span" spectrum analyser for one vehicle passing by**
  - >25dB deep fade
  - ~200ms wide
  - Disturbance continues for more than 2 seconds
- **These fades occur for almost every vehicle that passes by**



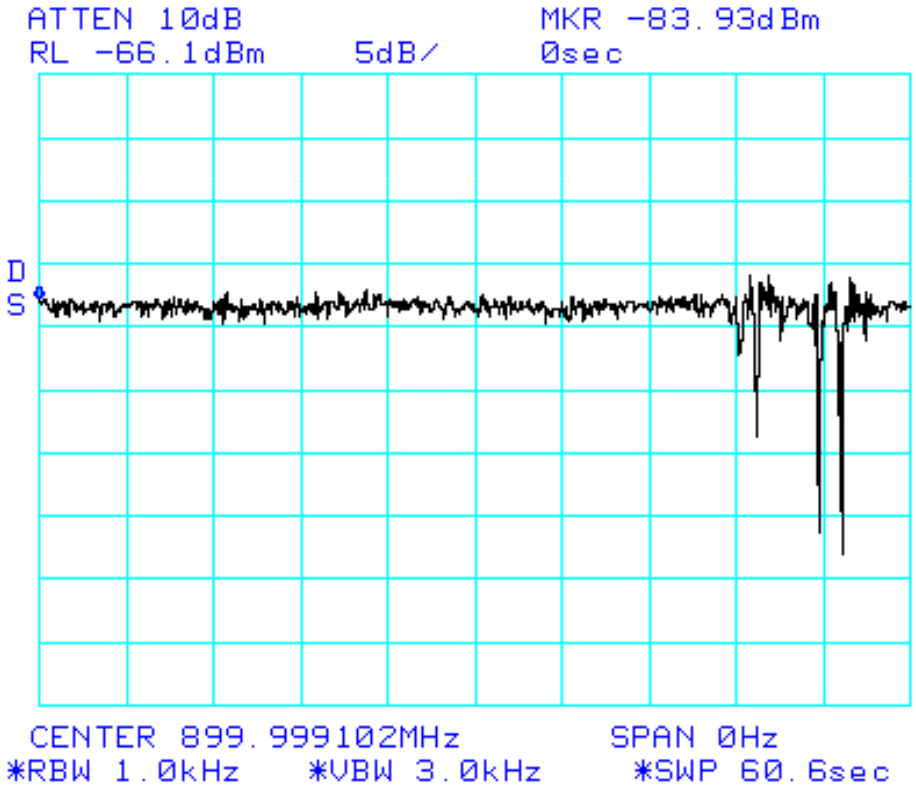
Single Fade – General Observations

- **Size of vehicle affects depth and length of fade**
  - A bus or garbage vehicle cause larger effects
  - Motorbikes cause lesser effects
- **Vehicles on the "near" side of the street have bigger effects than vehicles on the "far" side**
- **Slow moving vehicles seem to give several observable deep fades**
  - Faster vehicles seem to appear more often as a single fade
- **Disturbance starts several seconds before deep fade and lasts several seconds after the fade**



How Often do fades occur?

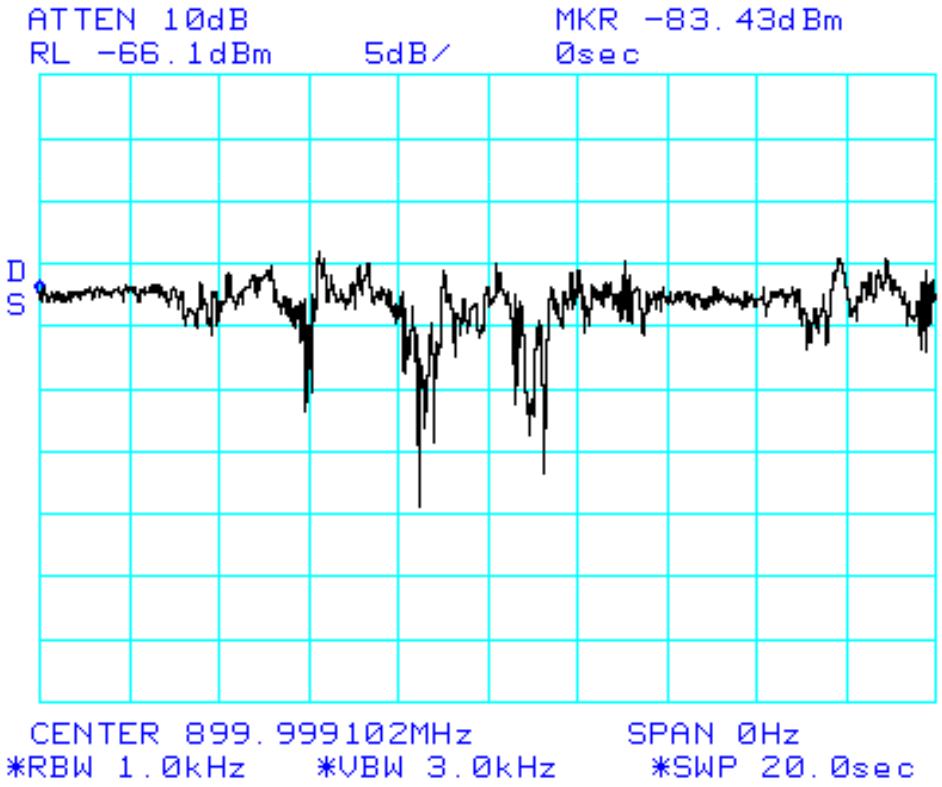
- **Low traffic times**
  - Long periods with no activity
- **Diagram indicates three vehicles passing by in 60 seconds**
- **Observations in windy conditions show varying signal strength** [1]
  - Presumably caused by the swaying of the trees



[1] Not shown in this diagram

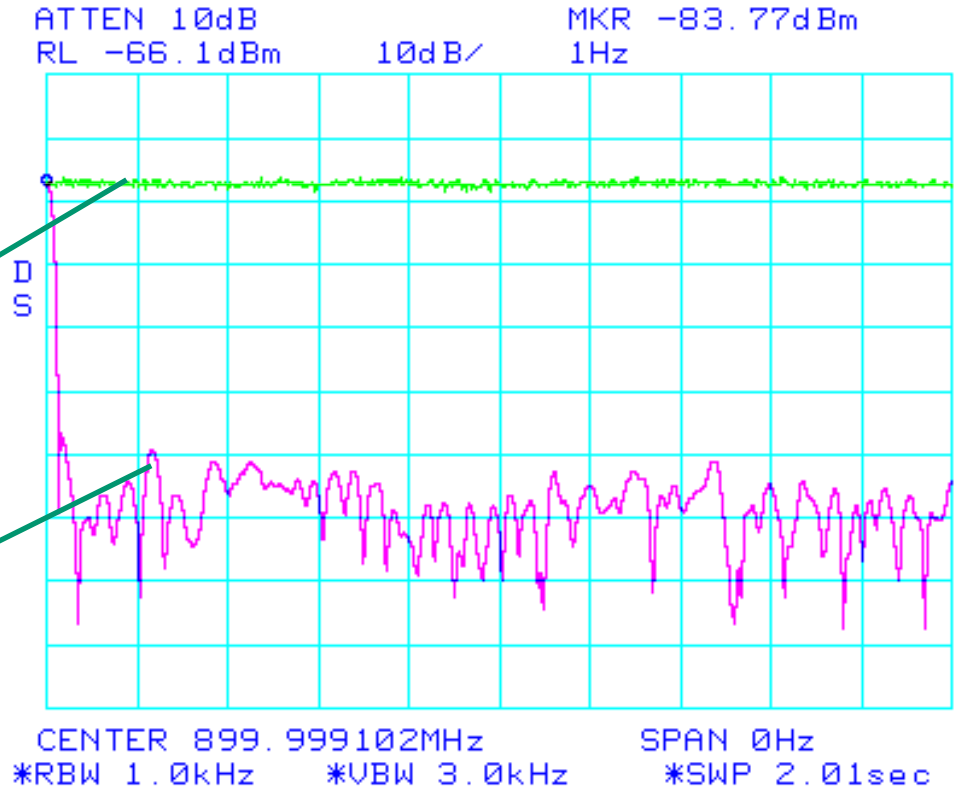
High Traffic

- Diagram shows a continuous set of disturbances that may last for several hours
- Vehicles pass by every 2 or 3 seconds
- Each vehicle causes more than 6 seconds disturbance
- The overlap leads to continuous disturbance



Fade Characteristics Setup

- **Analyzer set up to record:-**
  - "zero span" demodulator output (green)
  - Fourier transform (red)
- **Measurement captured in quiet conditions for reference**

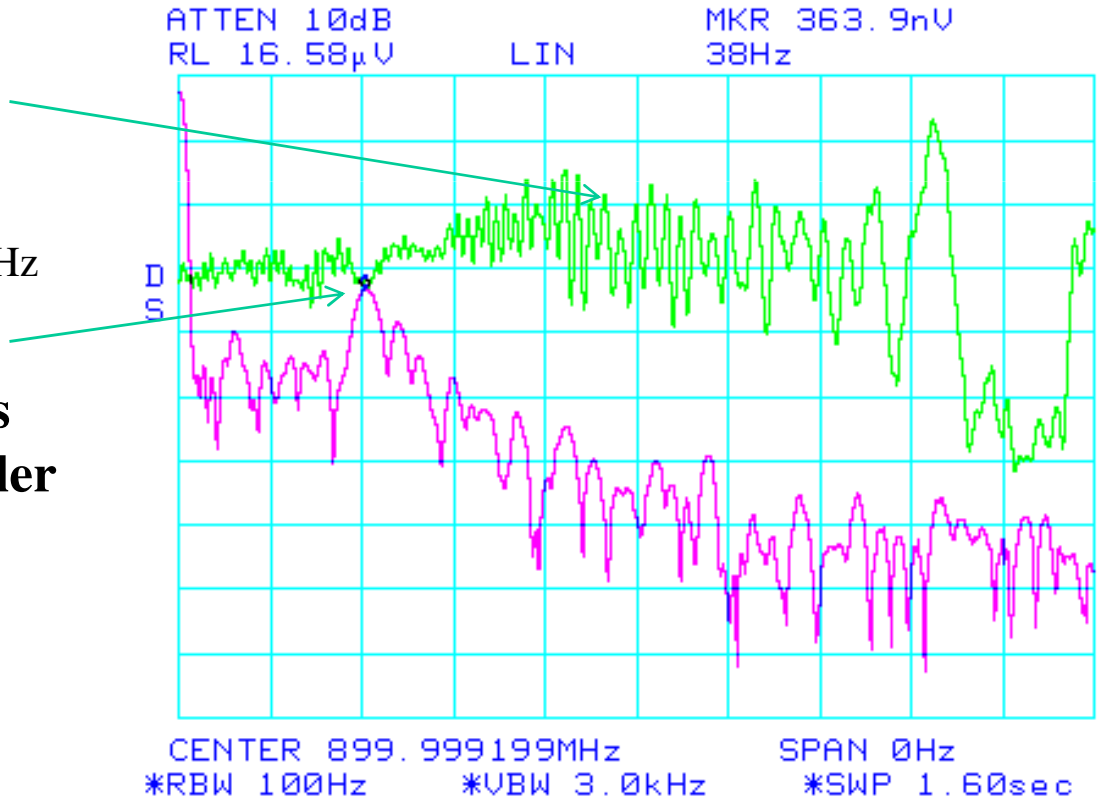


Time domain
200ms/div

Frequency domain
15Hz/div

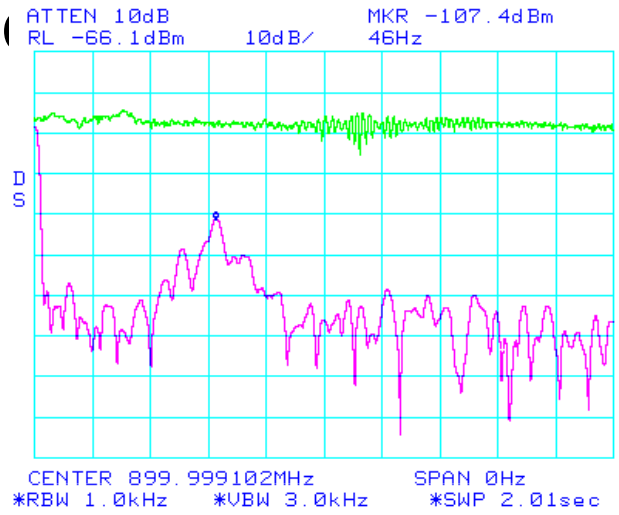
Fade Characteristics Measurement

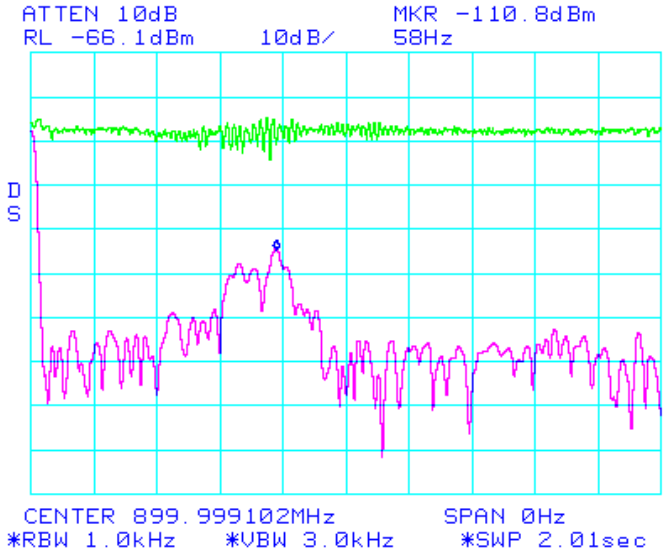
- **Diagram shows results of one vehicle passing**
- **Note distinctive Doppler on the time domain waveform**
  - ~6 cycles per div = 37.5Hz
- **Fourier analysis shows dominant 38Hz Doppler indicating ~30mph**

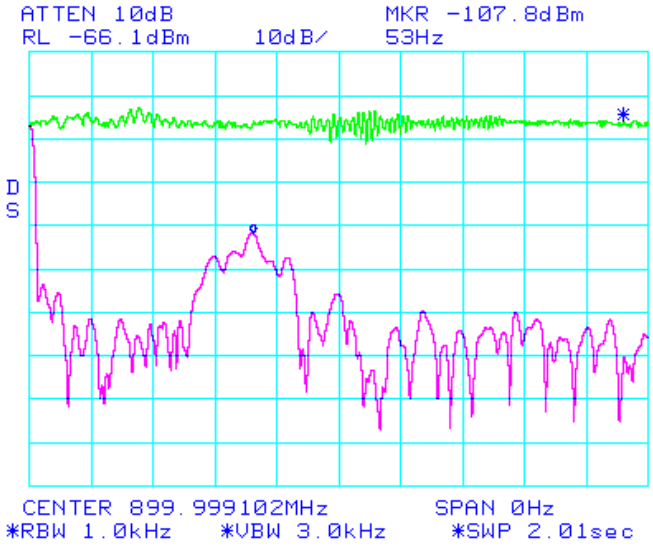


Fade Characteristics M

- **Predominant Doppler indicates vehicle speeds of :-**
  - 58Hz ~45mph
  - 53Hz ~40mph
  - 46Hz ~35mph





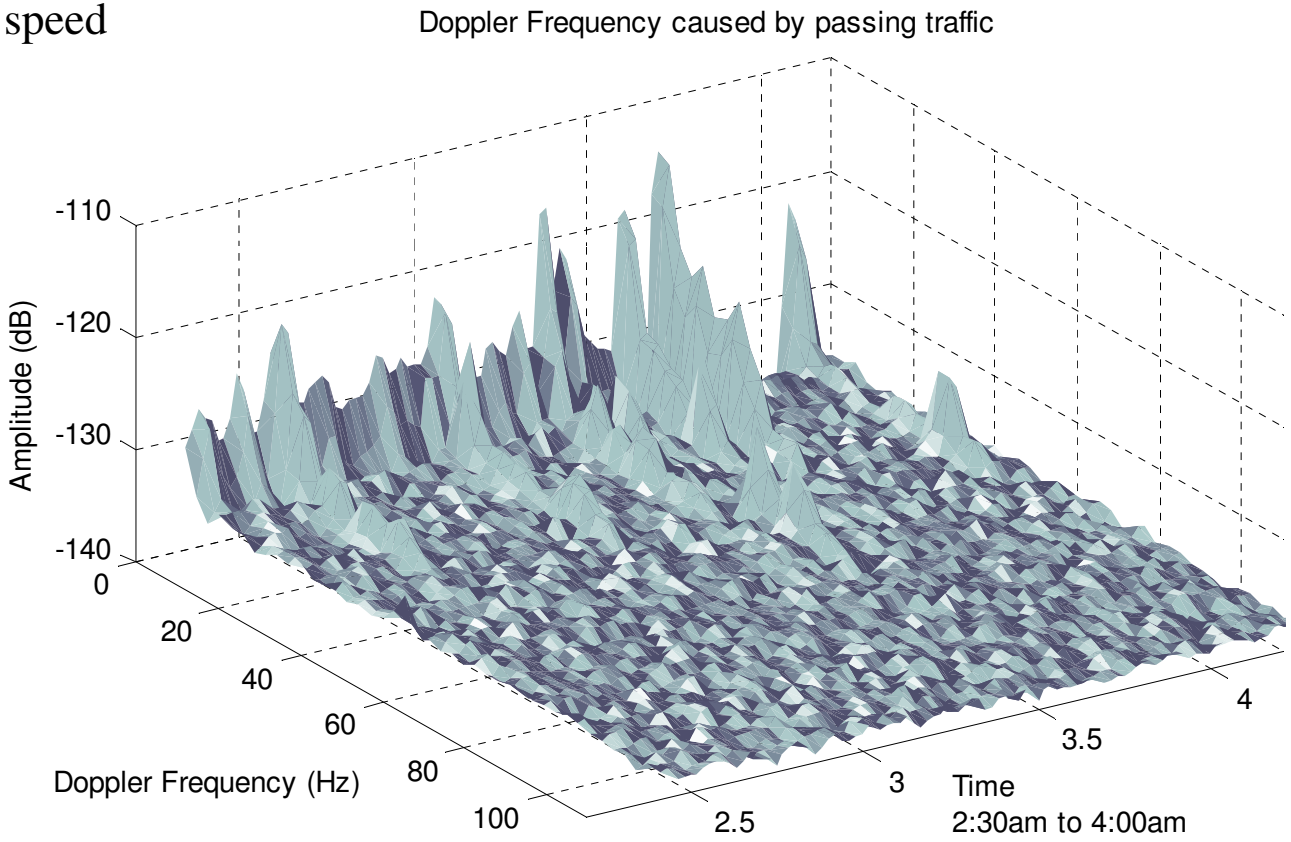


Long Term Measurements

- **Equipment set to continuously record 2.5 second time domain sweeps approximately every 7 seconds**
  - Sweeps are logged to a PC
- **The PSD of each sweep is calculated and a matrix is computed where**
  - X corresponds to the time of the sweep
  - Y corresponds to the Doppler frequency
  - Z represents the amplitude in dB
- **PSD's are averaged in time using a 30 point Hamming window to enhance visibility**
  - Approximately 3 minute averaging

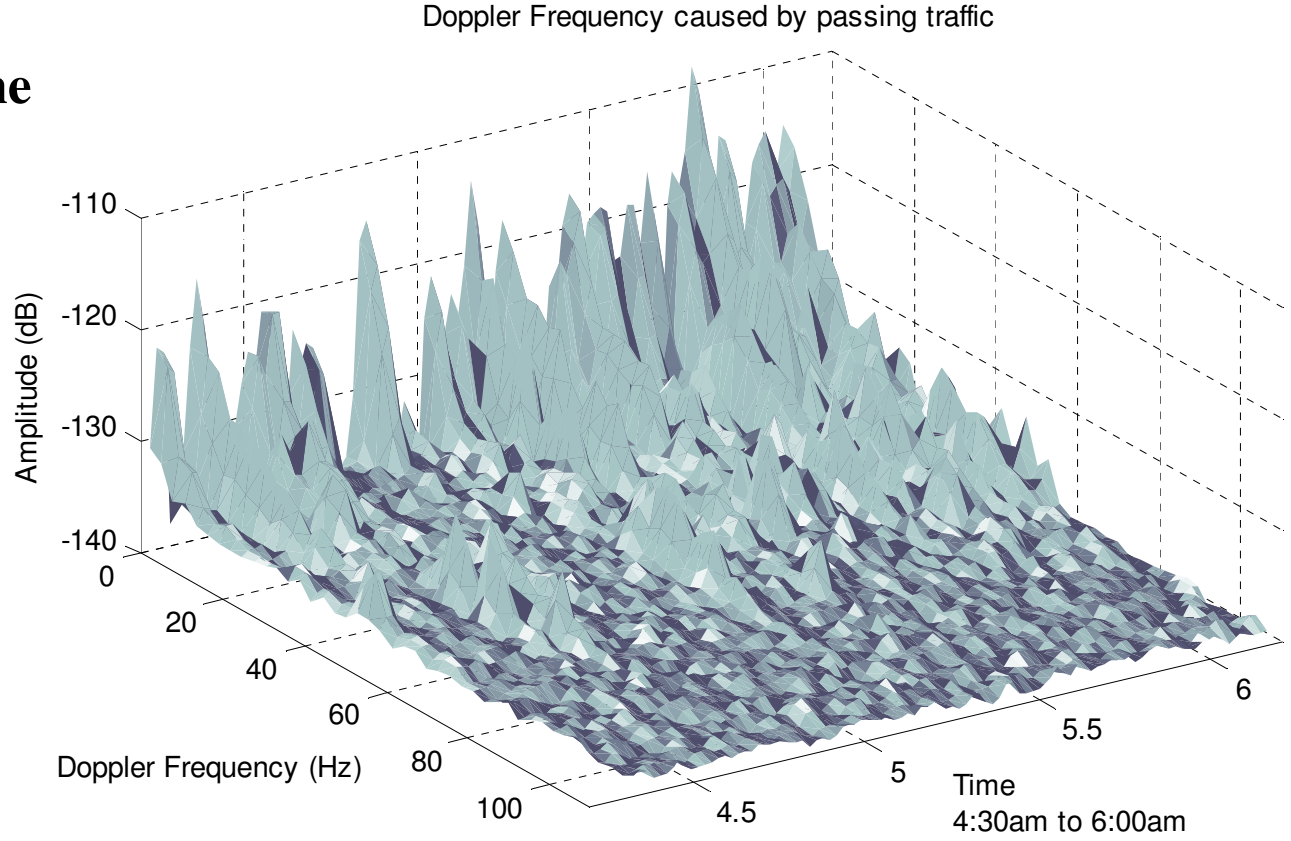
Early Morning

- **Graph shows Doppler caused by infrequent traffic in the early hours of the morning**
  - Note occasional speed limit violators
- **Note quiet spells**



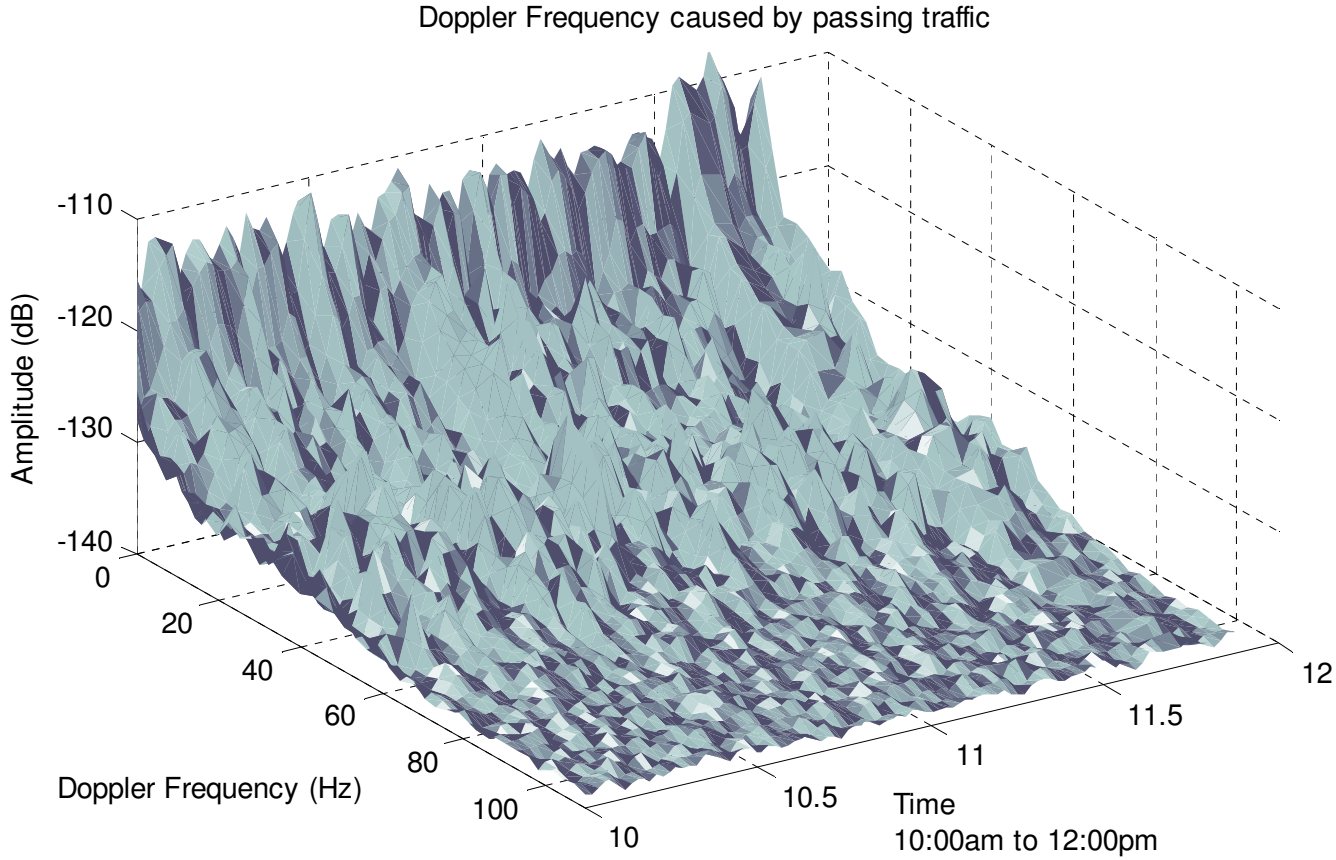
Dawn

- **Traffic volume increases around dawn**
  - Some Doppler at 70Hz
- **Less quiet time**



Morning

- **Increased traffic causes continuous Doppler**



Observations

- **Fading is observed to occur due to passing traffic**
  - Fading depth is dependant upon vehicle size and distance of the vehicle from the houses
  - 25dB fades are quite common and can last 100's of ms
- **Each vehicle causes several seconds of fading as it passes by**
  - Rush hour traffic can result in very long spells (several hours) of continuous fading
- **Fading exhibits characteristic Doppler fading dependant upon vehicle speed**
  - commonly as high as ~60Hz (45mph) even in a 35mph zone
  - Could be higher than 80Hz (70mph) depending upon environment

Conclusion

- **This simple experiment replicates a typical SUN house-to-house, short range, 900MHz radio link**
- **Many SUN radio channels will be non-stationary even though the end points are fixed**
  - The degree of non-stationarity will likely be deployment specific
- **The Coherence time of the channel could be quite short**
  - (10's of ms)
- **SUN modems should not rely on the channel being stationary for the length of the data packet**
  - Which could be as long as 0.4s for 2047byte packets at 40kbps

Thank You