

High-Level Wireless Digital Communications for Program and Engineering Managers

Instructor:

Scott R. Bullock

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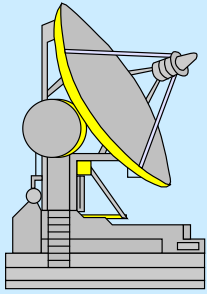
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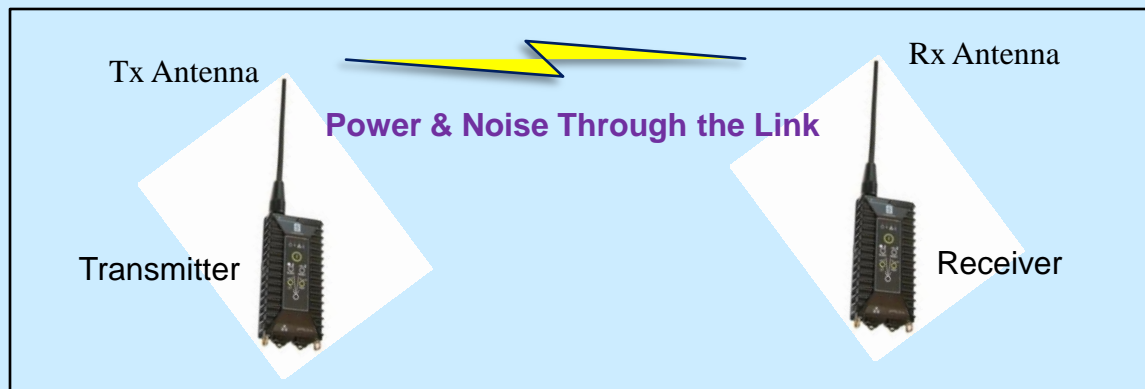
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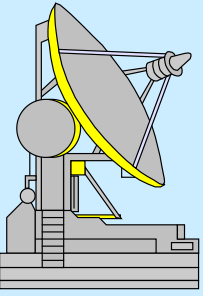


Link Budget



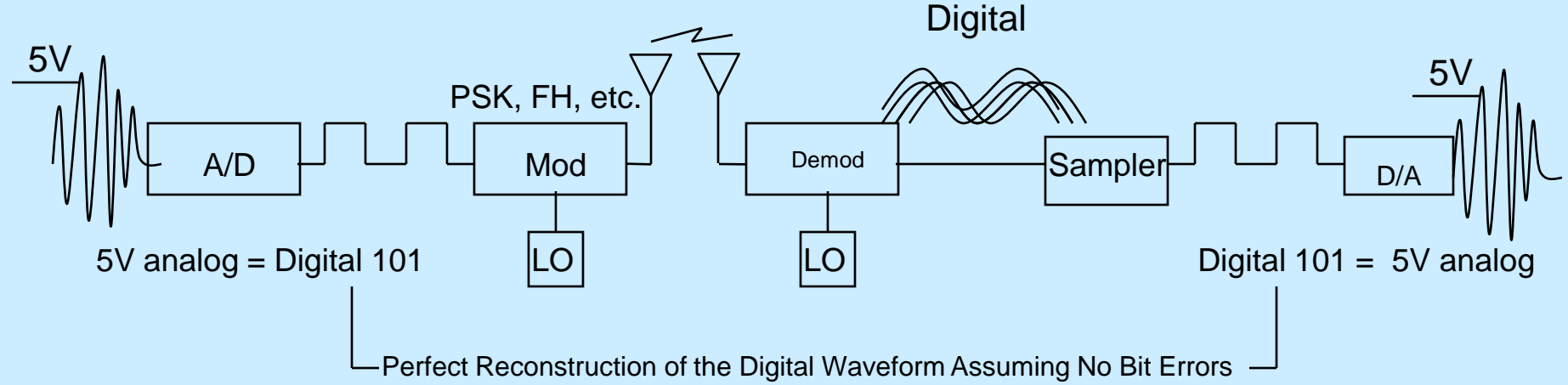
- Link - Connects the Transmitter to the Receiver
- Budget - Allocation of Power and Noise through the Link
- Tracks Signal & Noise Levels from Tx PA to Rx Detector (LNA)
 - Power Output (PA), Tx Losses, Channel Losses, Rx Losses
 - Signal/Noise at Receiver's Detector
 - Required S/N (or E_b/N_0 for BER)
- Used in Solving Tradeoffs
 - Size, cost, data rate, LPI/LPD, waveform, coding, etc.



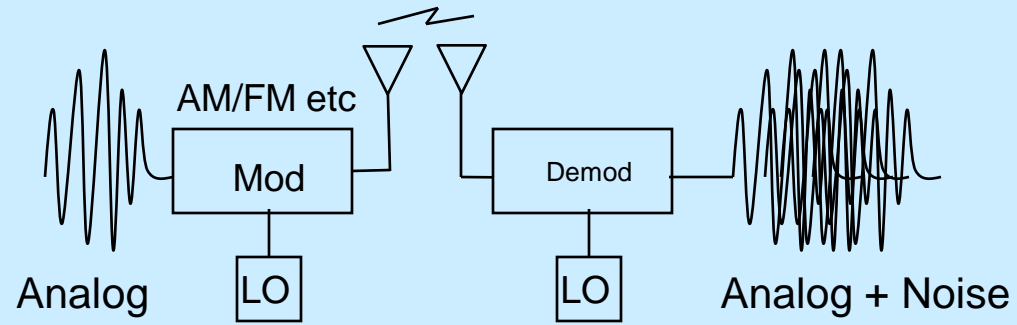


Digital vs. Analog Comms

Digital System



Analog System



Digital Modulation Creates Frequency Waveform (Sinc)

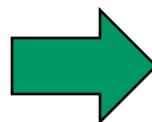
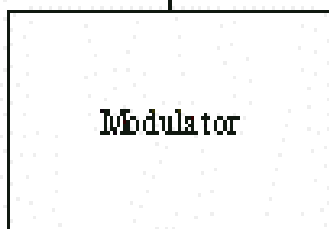


Digital Data

Time Domain

V t

BPSK Modulation

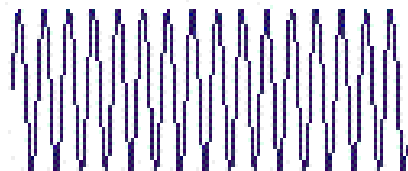


Frequency Domain

P_{dBm}

f

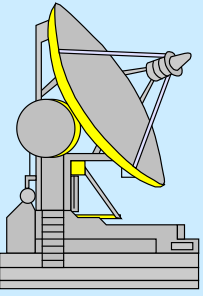
Null to Null Bandwidth
 $2/PW$
 $2 \times \text{Bit/Chip Rate}$



Direct Sequence Digital Modulation

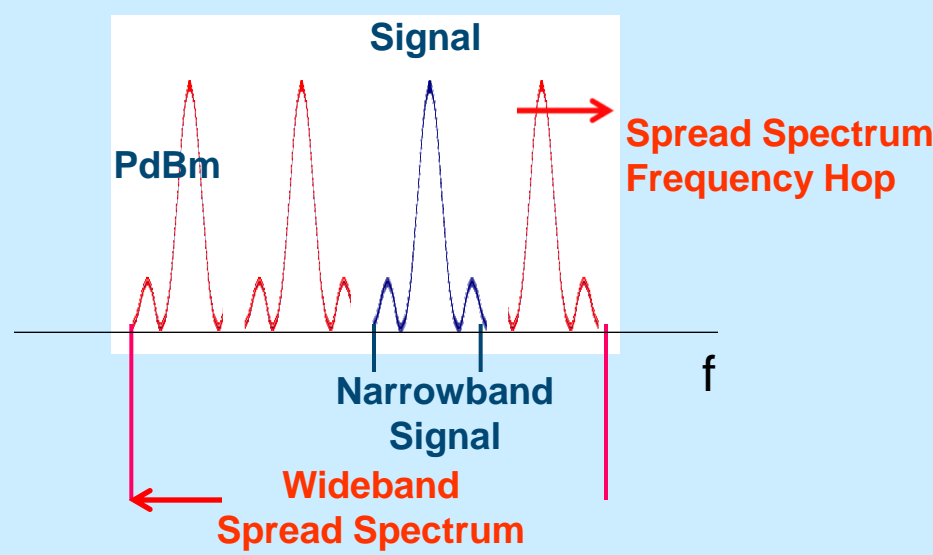
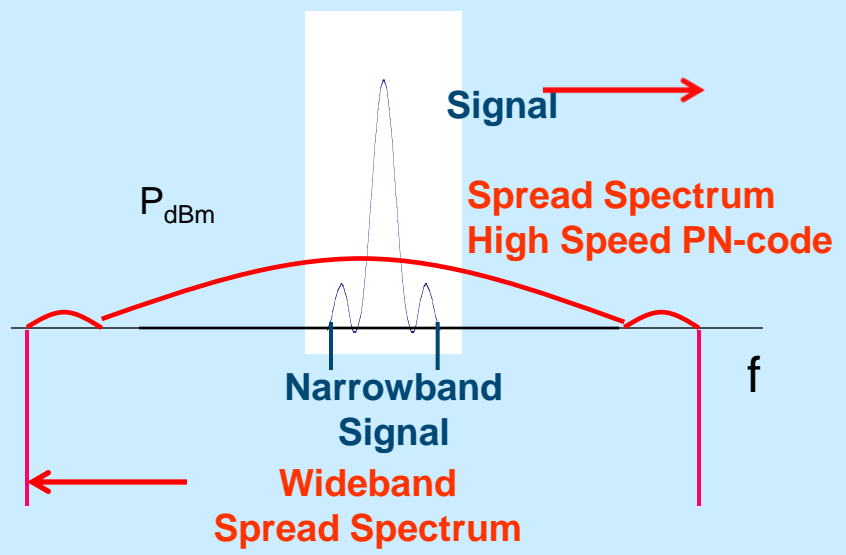
Shifts the phase of the carrier frequency according to the data

Carrier Frequency



Spread Spectrum for Direct Sequence and Frequency Hop

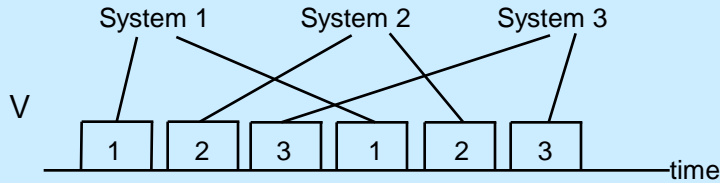
- Spread Spectrum uses more bandwidth than is required to send data



Faster pseudo-random code spreads the bandwidth
Higher the code rate, wider the bandwidth

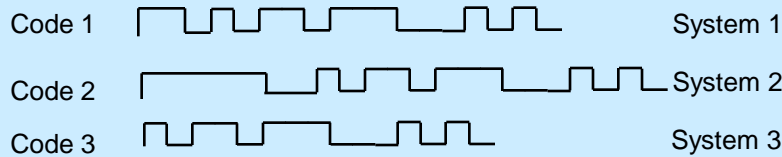
Frequency hop spreads the bandwidth
More frequencies, wider the bandwidth

Multiple User Techniques



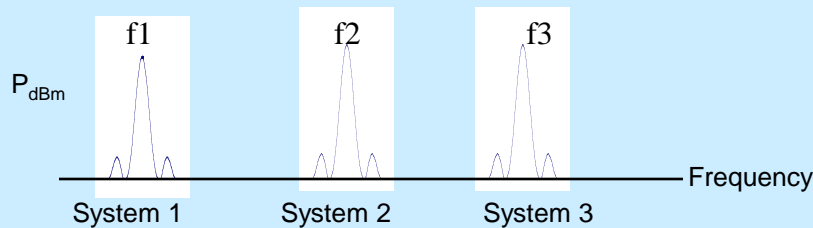
a. Time division multiple access

Time Division Multiple Access (TDMA)
Users divided up in time slots.



b. Code division multiple access.

Code Division Multiple Access (CDMA)
Users have different codes

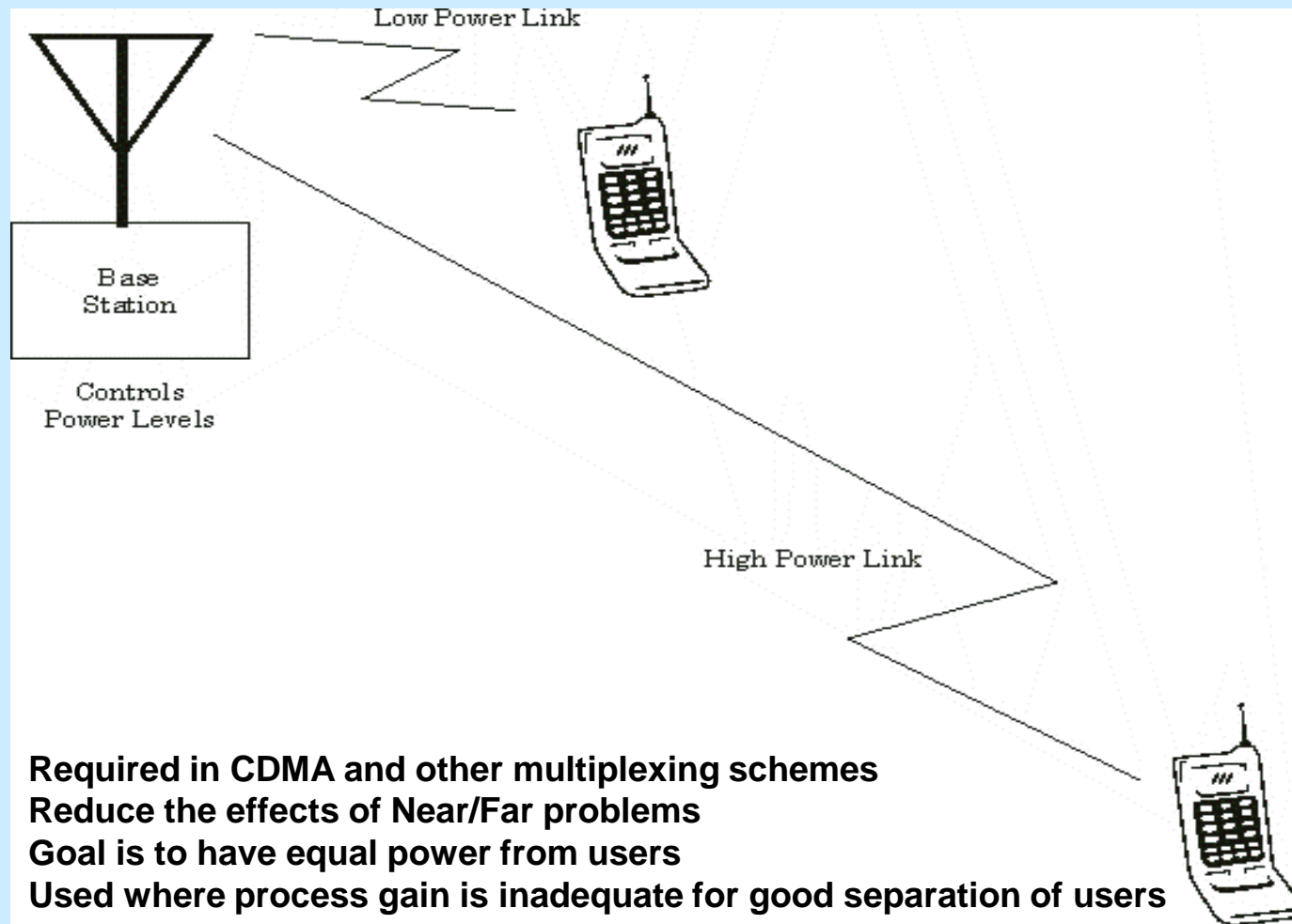


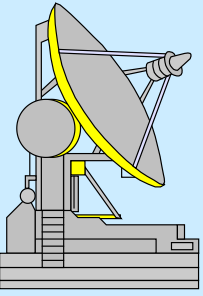
c. Frequency division multiple access.

Frequency Division Multiple Access (FDMA)
Users operate on different frequencies



Power Control for Near/Far Problems



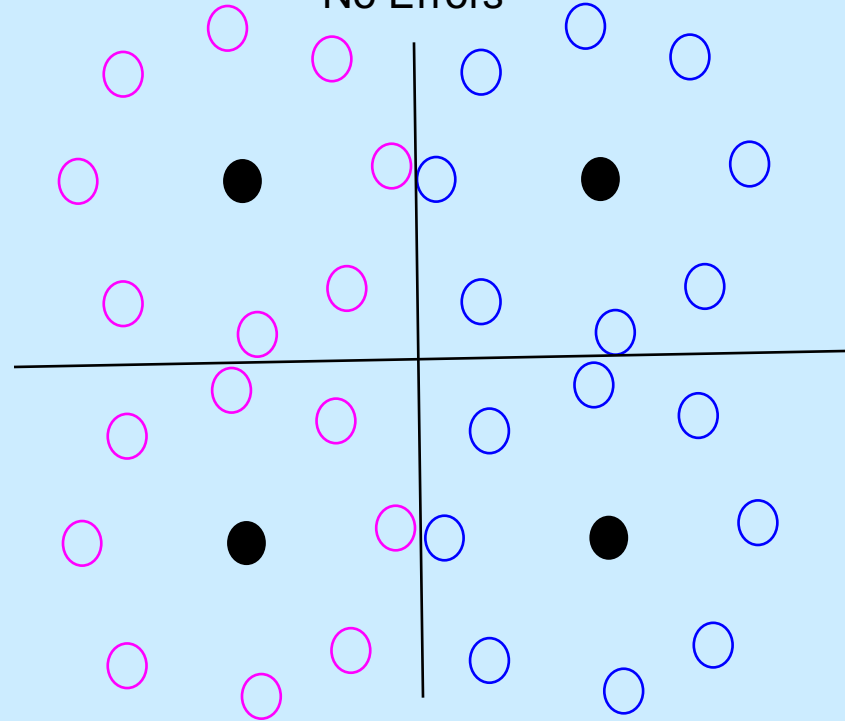
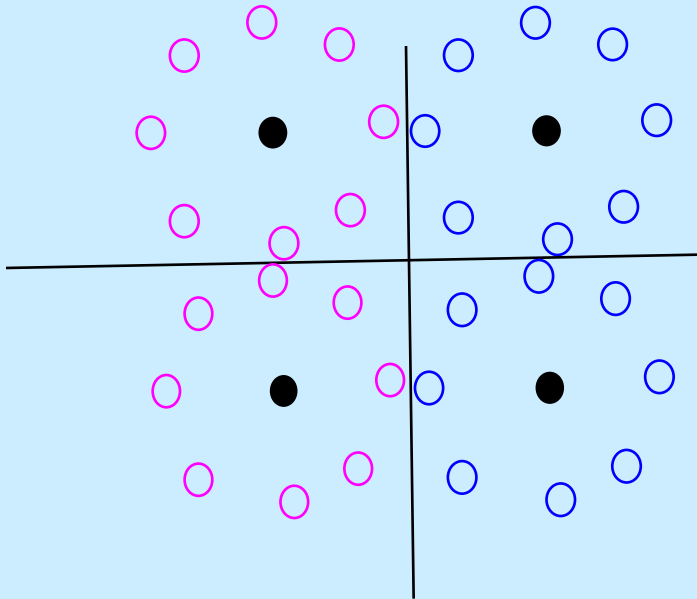


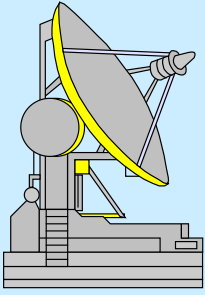
Improvements To Eliminate Errors in QPSK



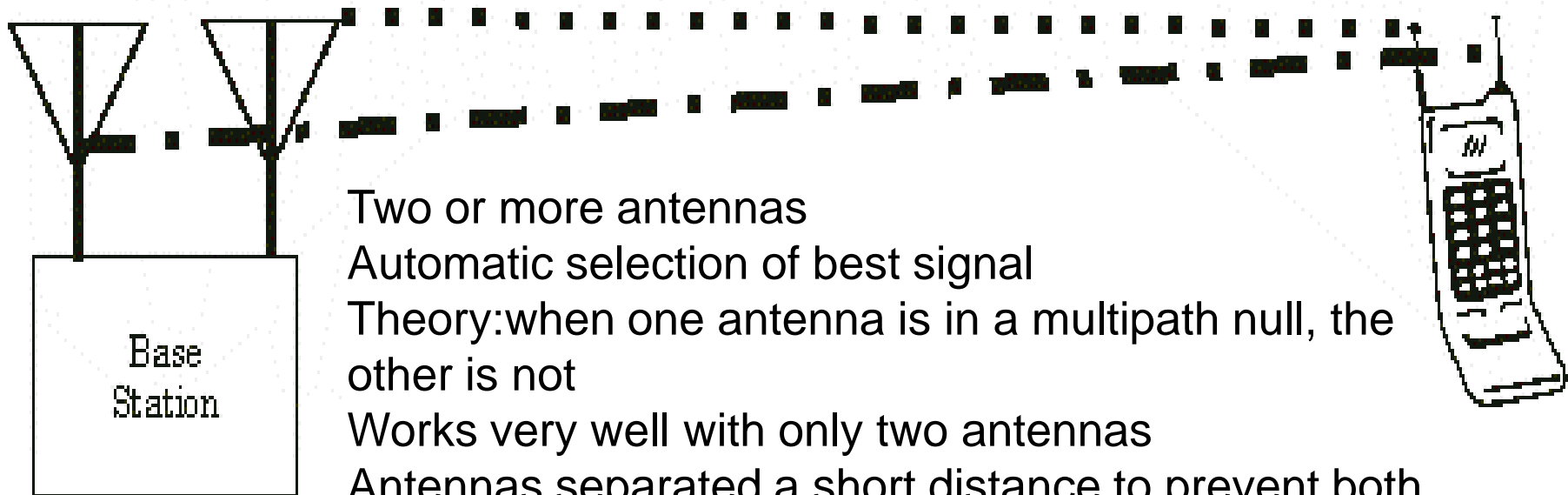
- Bit rate same
- Decrease BW
- Decrease Noise
- No Errors

- Increase Symbol S/N
- Provides twice the data rate
- Same BW
- No Errors



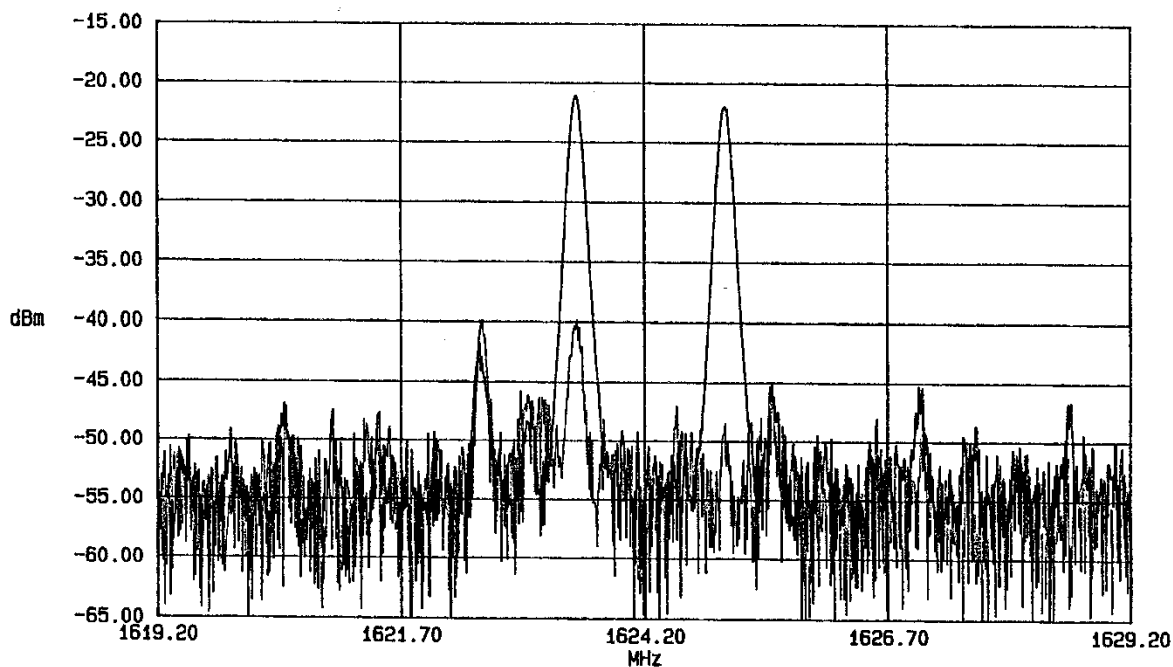


Antenna Diversity Example



Two or more antennas
Automatic selection of best signal
Theory: when one antenna is in a multipath null, the other is not
Works very well with only two antennas
Antennas separated a short distance to prevent both antennas from being in the null
Lab example with 2.4 GHz wireless modem connection - Separation approximately 5"

Adaptive Filter with Two Interfering Signals

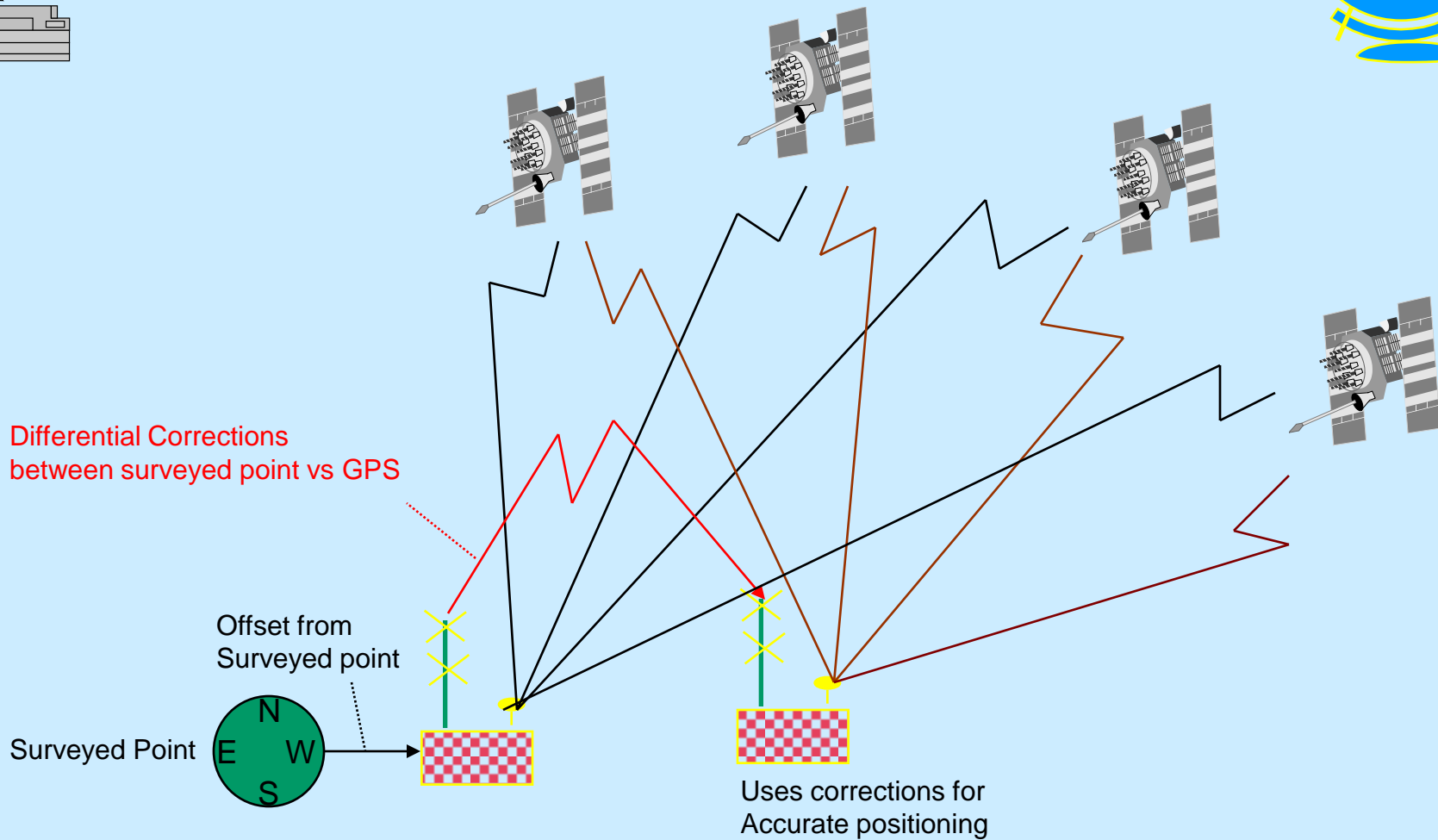
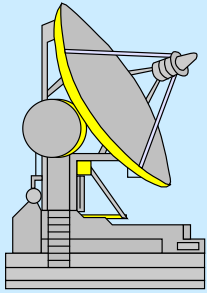


CENTER FREQUENCY = 1624.2 MHz SPAN = 10 MHz REFERENCE LEVEL = -15 dBm
RESOLUTION BANDWIDTH = 100 kHz VIDEO BANDWIDTH = 30 kHz

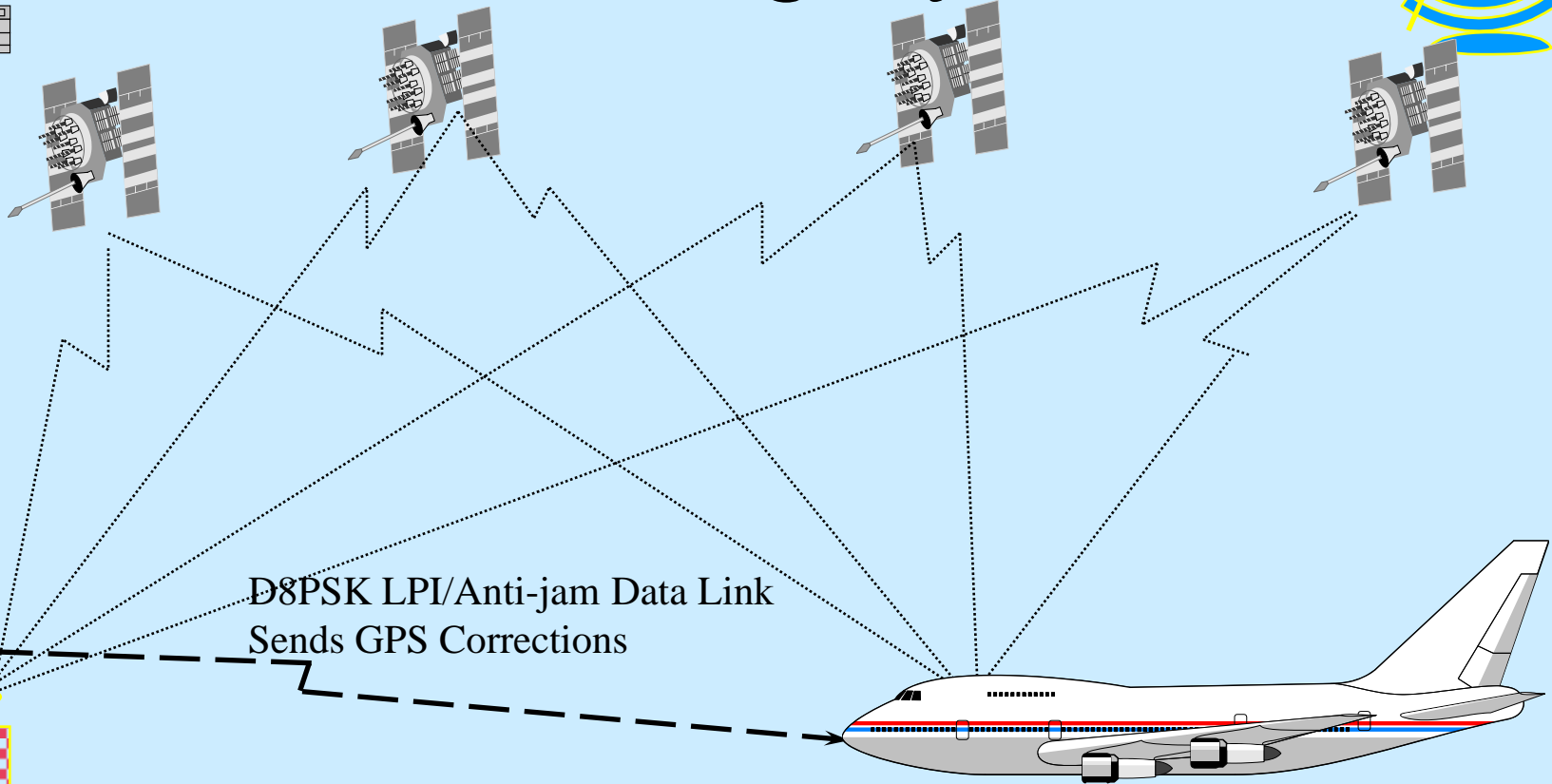
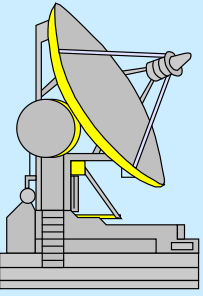
INTERFERERS WITHOUT ALE
INTERFERERS WITH ALE

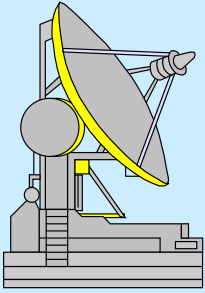


Differential GPS

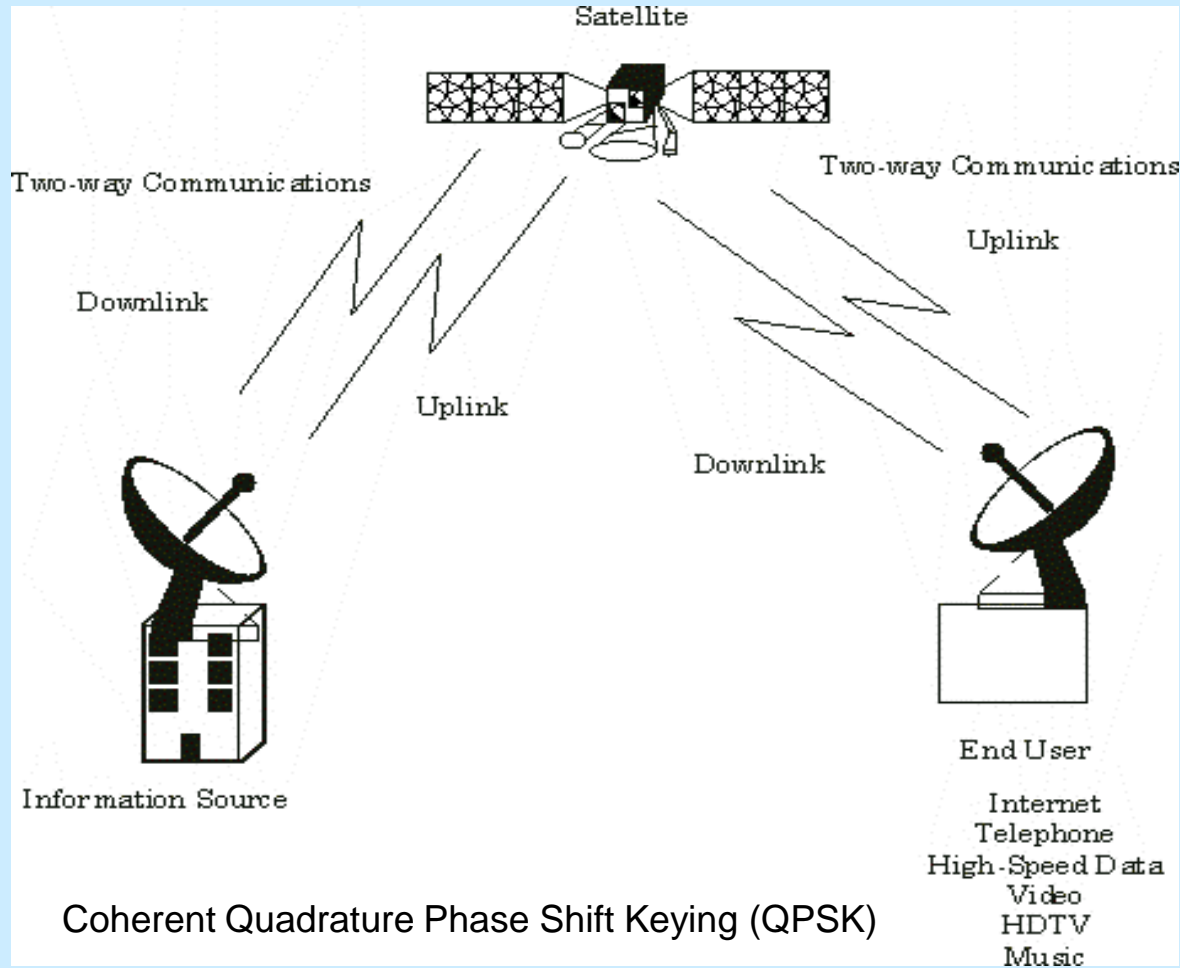


GPS Landing Systems



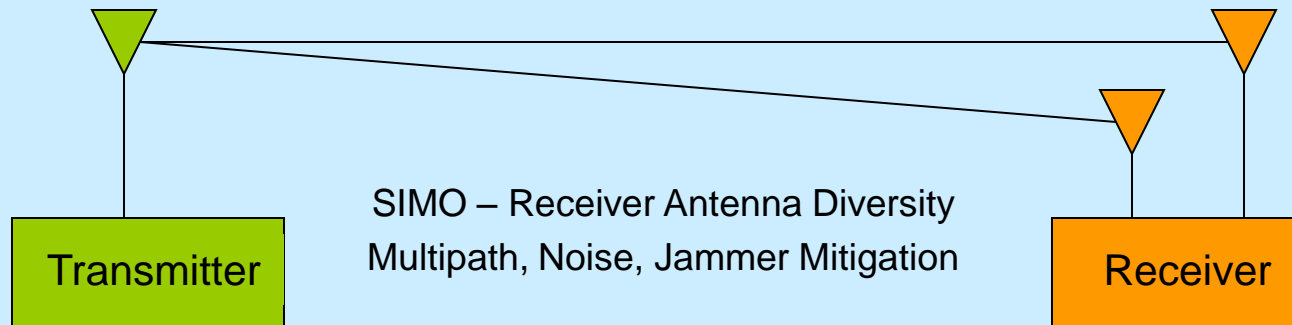
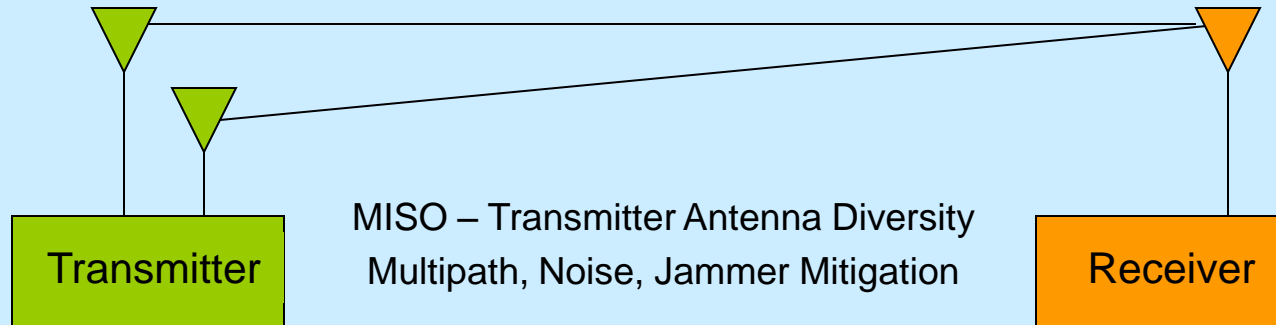
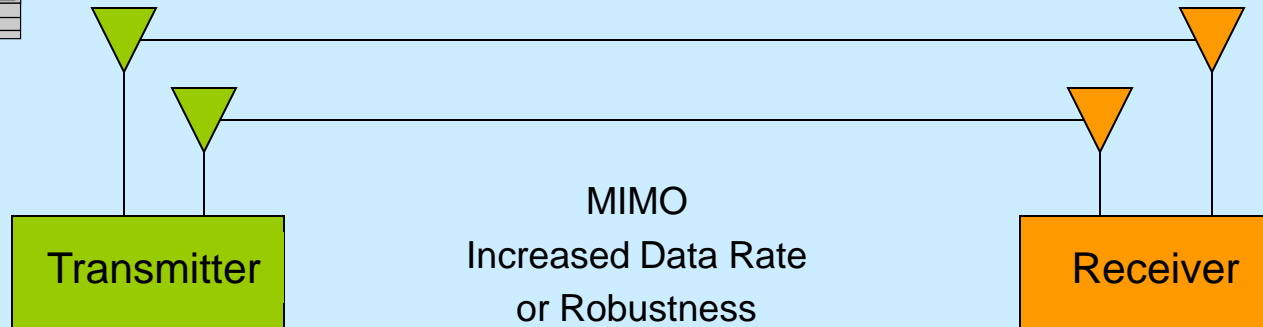


Satellite Two-Way Communications

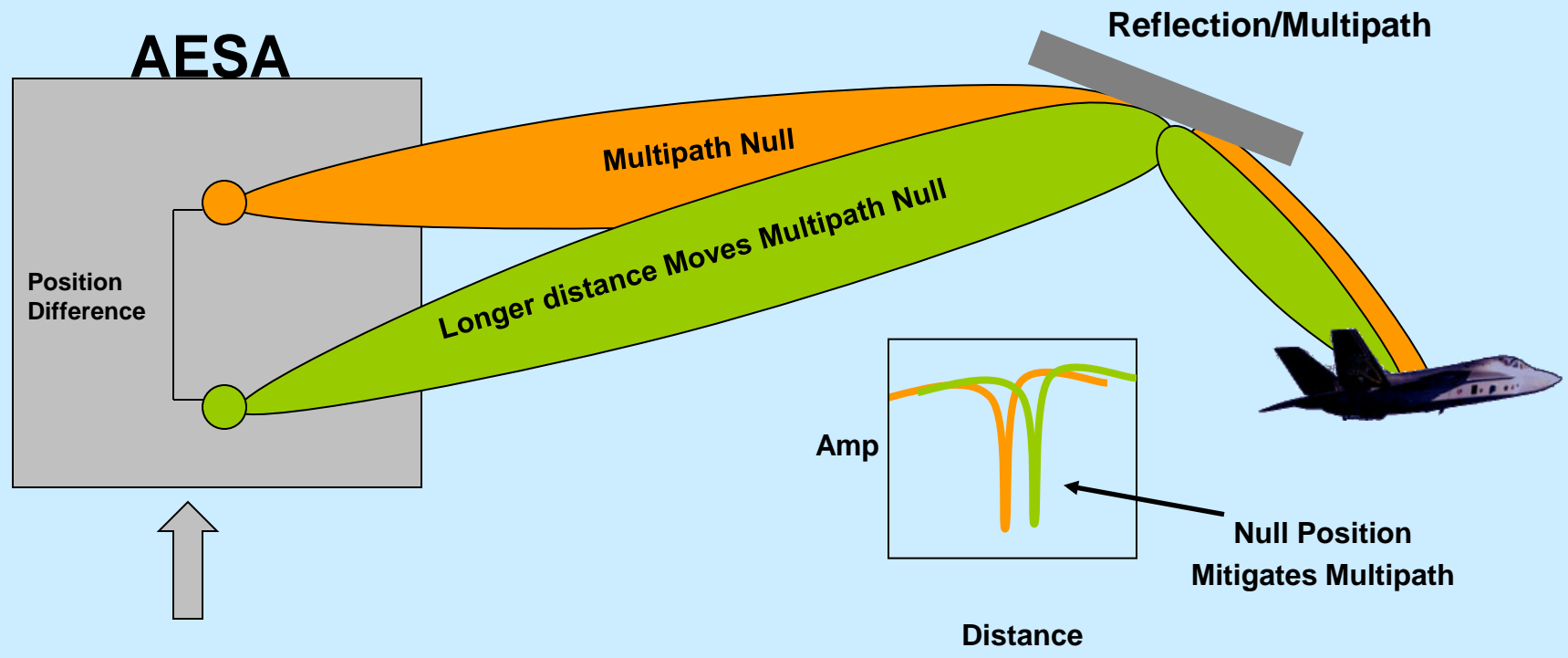
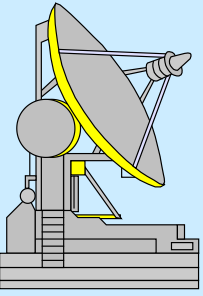




MIMO, MISO, SIMO Monitor & Control



Beam Positioning of AESAs to Mitigate Multipath



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