Effects of Power and Frequency on Penetration Range and Data Rates

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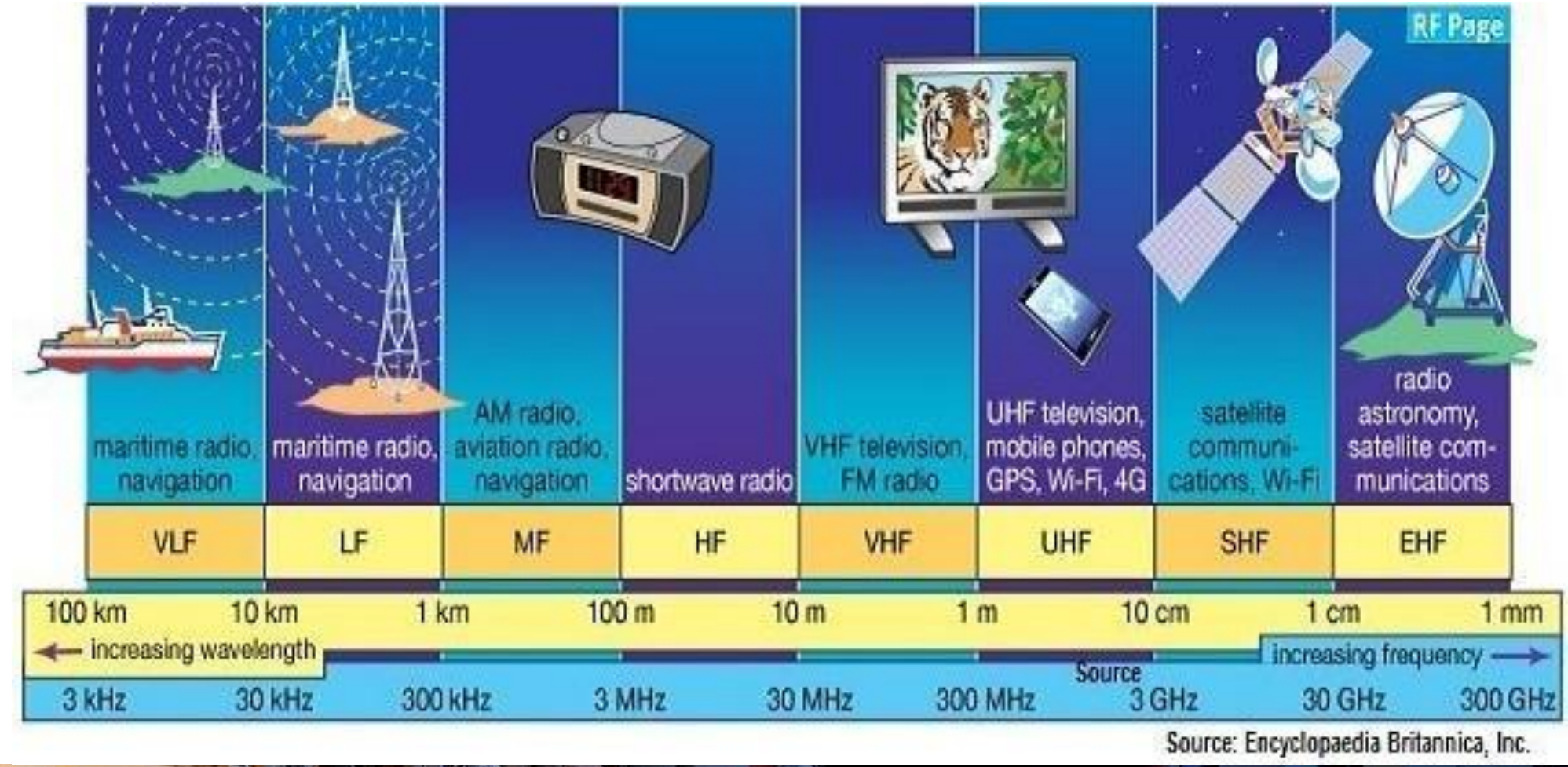
DIGITAL CONTROL

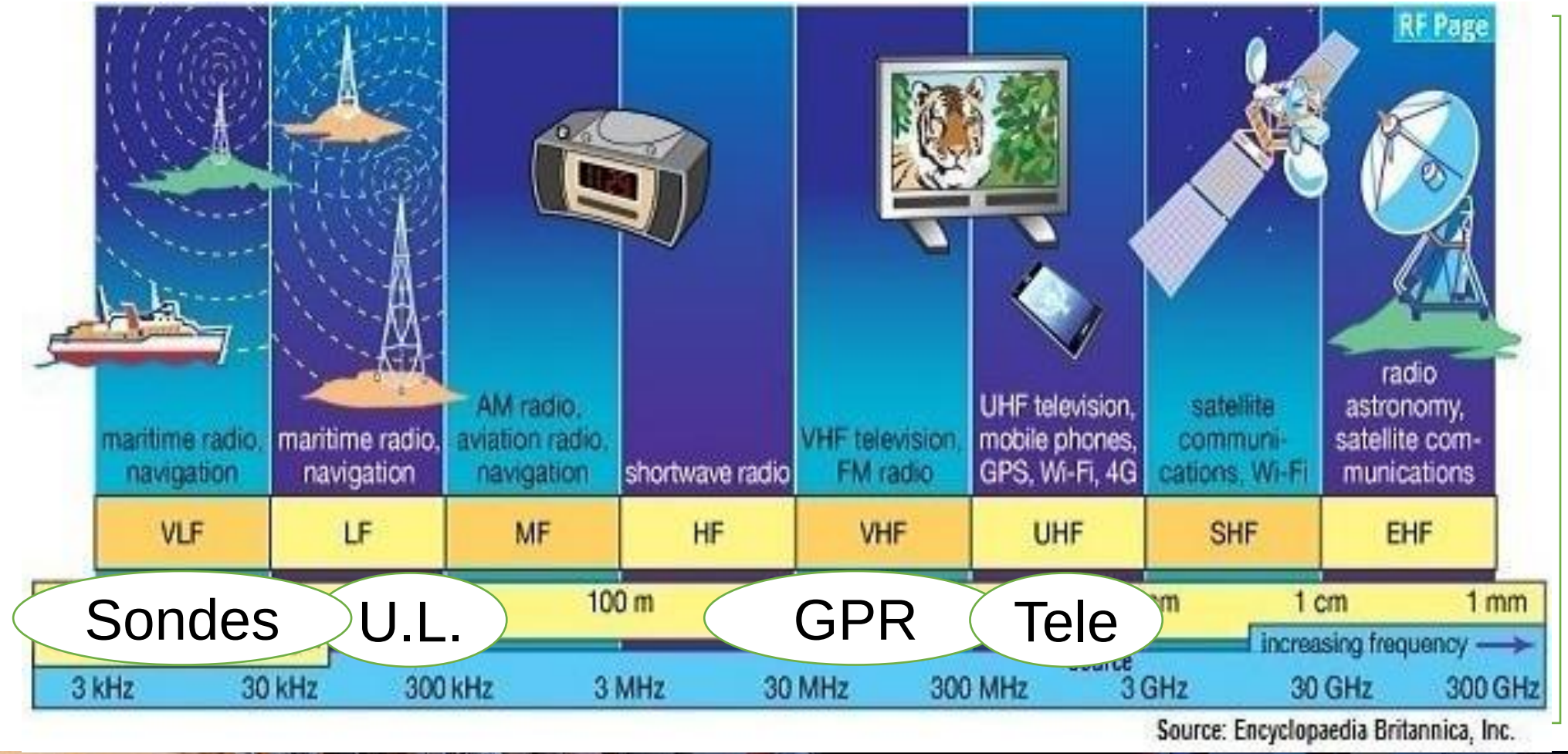
Agenda

1. Electromagnetic Spectrum
   - Frequencies used in HDD
2. Frequency Trade-offs
   - Higher vs. Lower
3. Power Trade-offs
   - Higher vs. Lower
4. Environmental Factors
   - Active and Passive Interference
5. Selecting and Configuring Equipment
   - Balancing Trade-offs with the Job and Environment

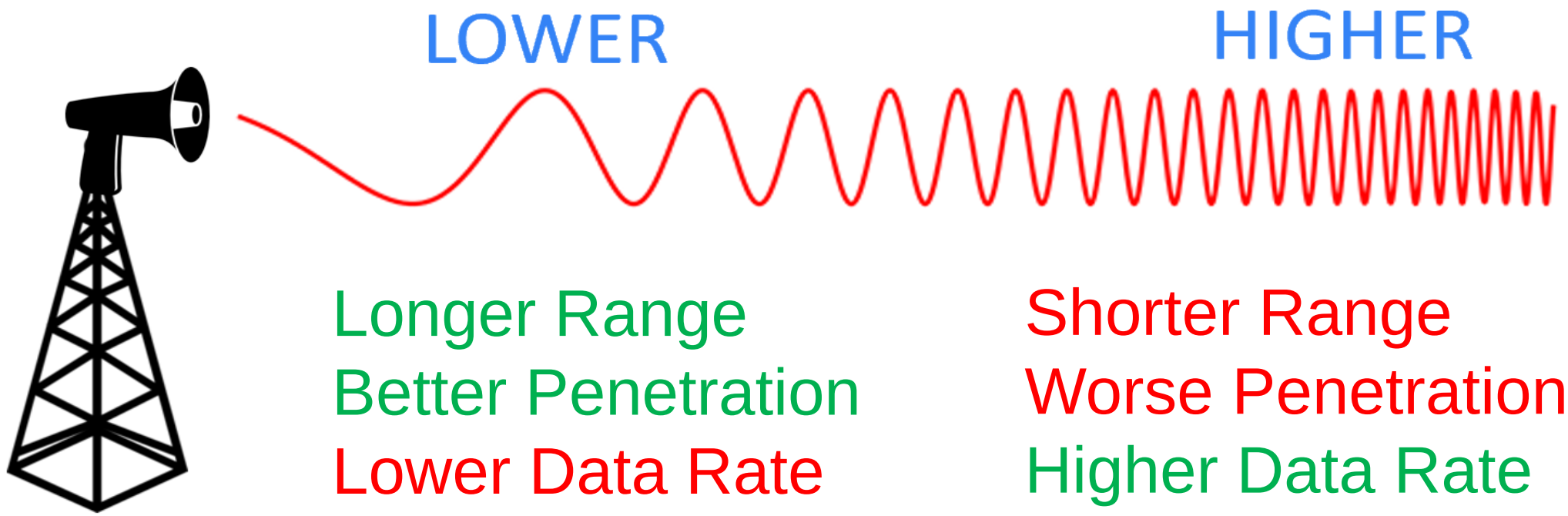
Electromagnetic Spectrum



HDD Spotlight



Frequency Tradeoffs



Longer Range
Better Penetration
Lower Data Rate
Larger Antenna

Shorter Range
Worse Penetration
Higher Data Rate
Smaller Antenna

Lower Frequencies - For Example

50 kHz and 200 kHz: Fish finding

3–30 MHz: Short wave radio

2-40 MHz: Ultrasound

Higher Frequencies - For Example

900 MHz Cordless Telephones

2.4G WiFi

5G vs. 2.4G Cell Towers

Lower Frequencies - The Science

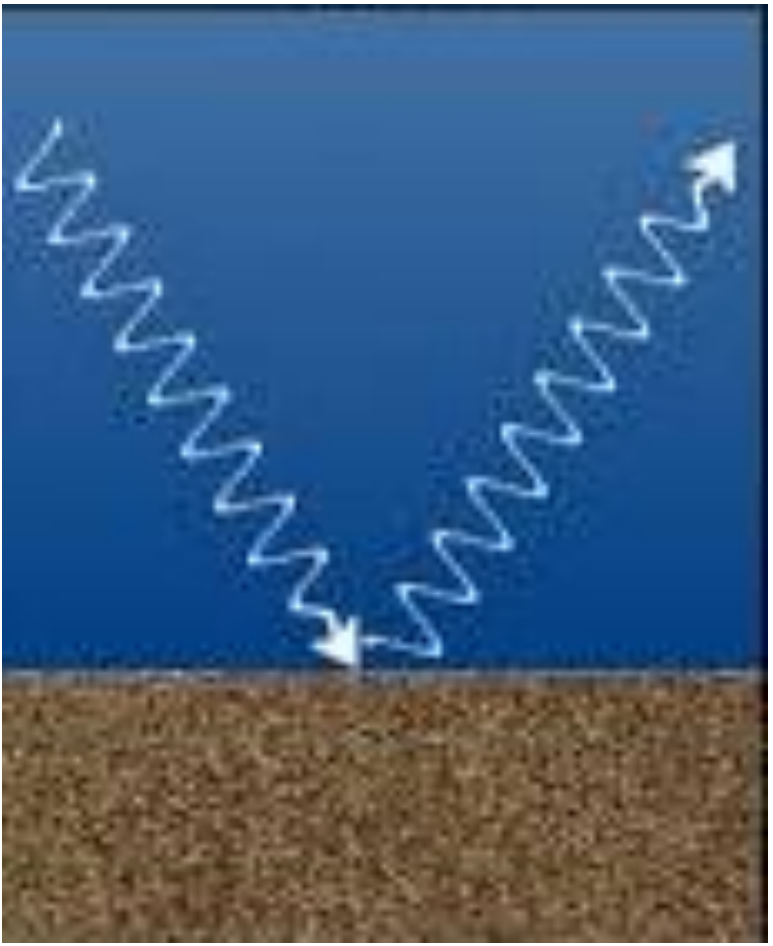
Less cycles per second

Fewer bits to flip (lower data rates)

Longer wavelength (longer antenna)

Less interactions (wider wave spacing)

Higher Frequency - The Science



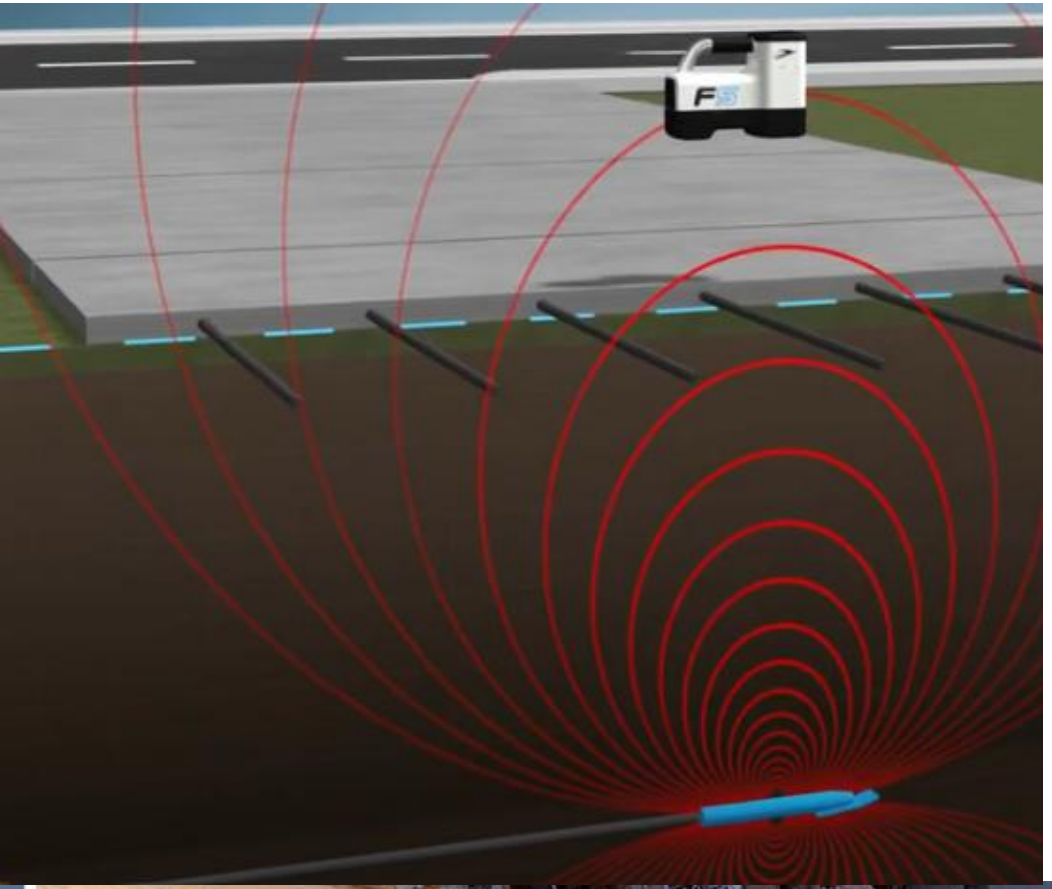
More cycles per second

More bits to flip (higher data)

Shorter wavelength (smaller antenna)

More interactions (tighter wave spacing)

Lower Frequency - HDD Applications

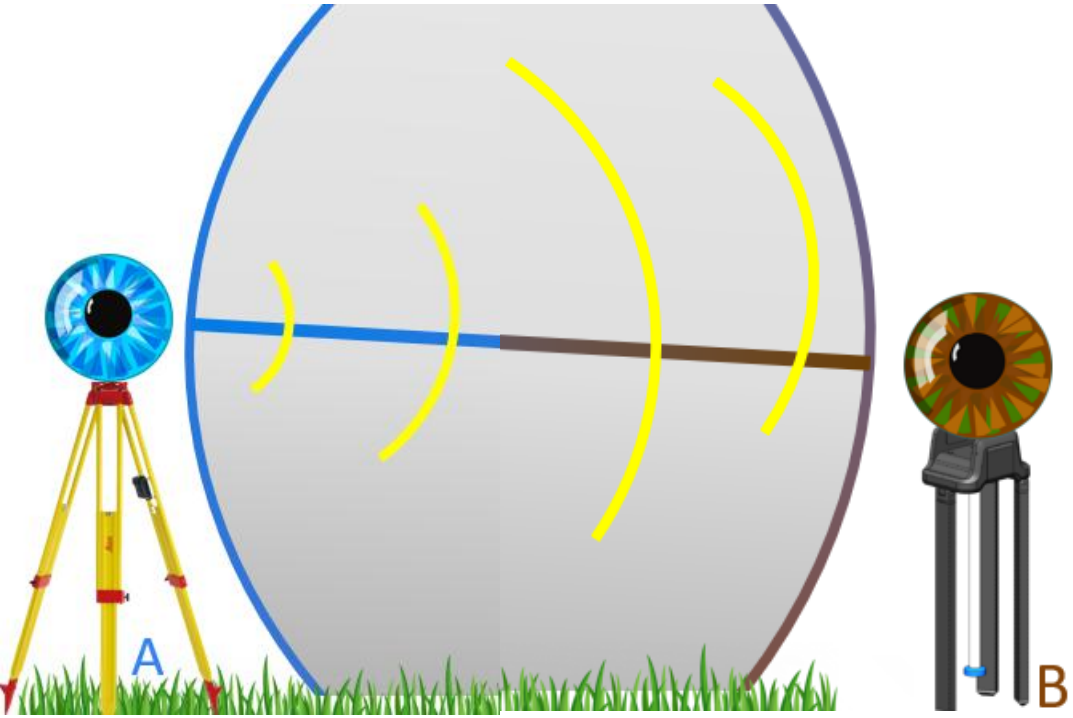


Sondes – Passive Interference (rebar)

Telemetry – with Obstacles

Utility locators and GPR – high penetration, low resolution

Higher Frequency - HDD Applications



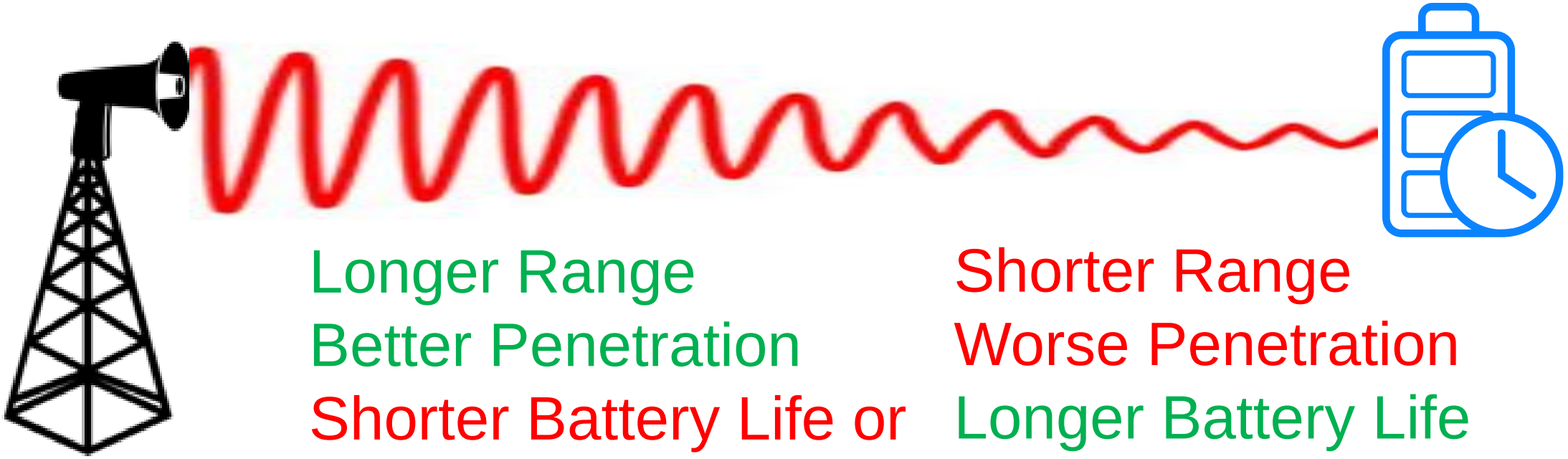
Sondes – Active Interference

Telemetry - Line of Sight

IoT and **Larger Data Needs**

GPR - High resolution, low penetration

Power Tradeoffs



Longer Range
Better Penetration
Shorter Battery Life or
Larger Battery
More Heat Generated

Shorter Range
Worse Penetration
Longer Battery Life
or
Smaller Battery

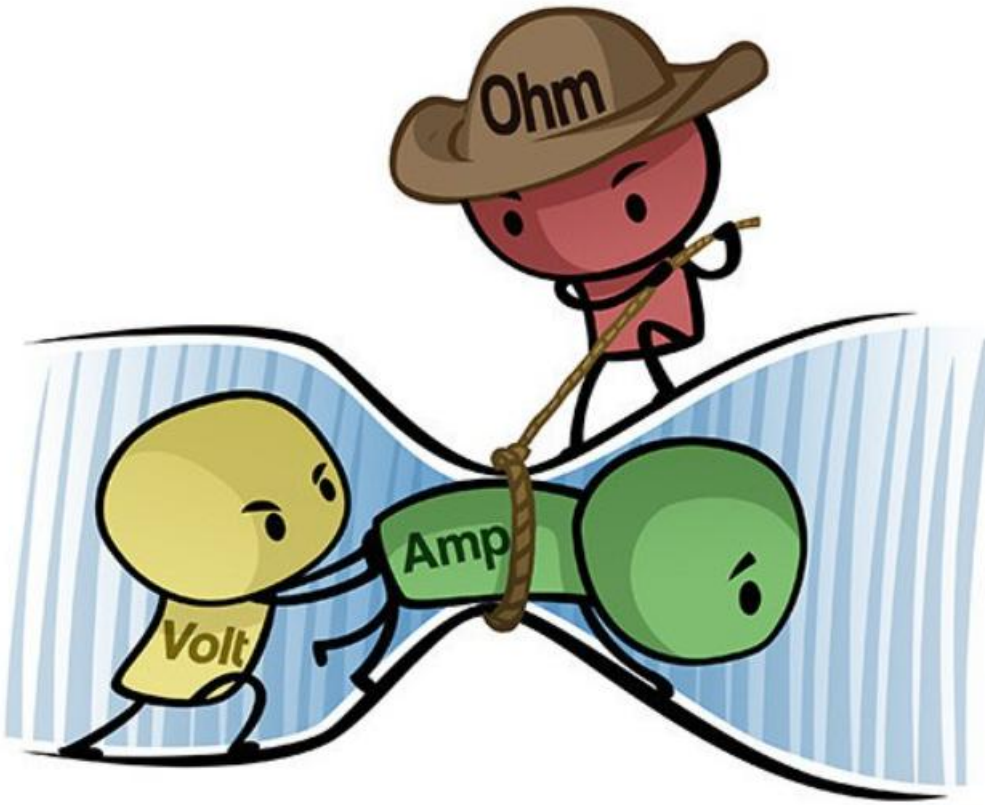
Power - For Example

50 W vs.100 W light bulbs

Pen light vs. Torch light

Walkie Talkie vs. Radio Station

Power - The Science



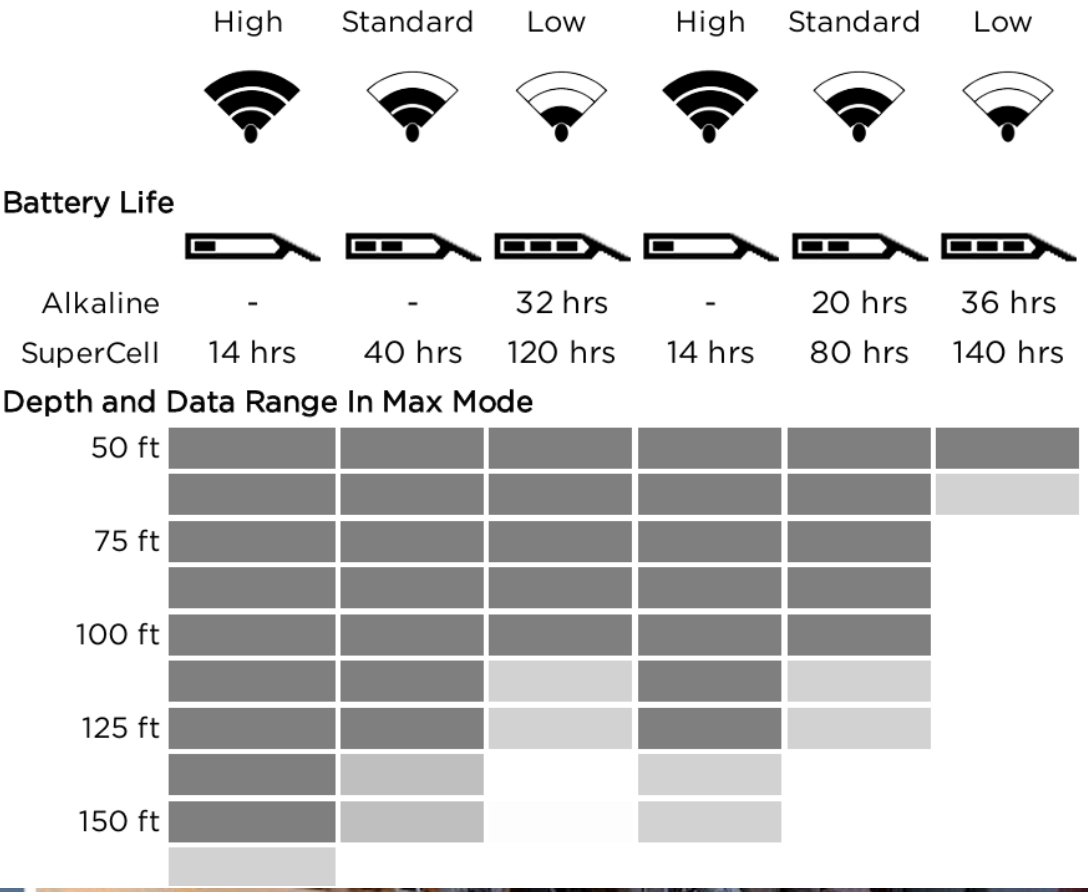
Battery rating: Voltage & Amp-hrs

Power = Voltage x Current

Watt = Unit of Power = J/s

Joule = Unit of Work and Heat

Power - HDD Applications



More Power

More Range (Deeper Bore)

Shorter Battery Life (Shorter Bore)

Or more size/heat/wireline

Less Power

Less range (Shallow Bores)

Longer Battery Life

Environmental Factors

Active and Passive Interference

Passive Interference

What's in the ground?

Rebar or rails?

Salt or iron?

What's between the locator and the drill?

Hills or buildings?

Trees or fences?

Active Interference

What's transmitting nearby?

- Towers?
- Electric Dog Fences?
- Cables?

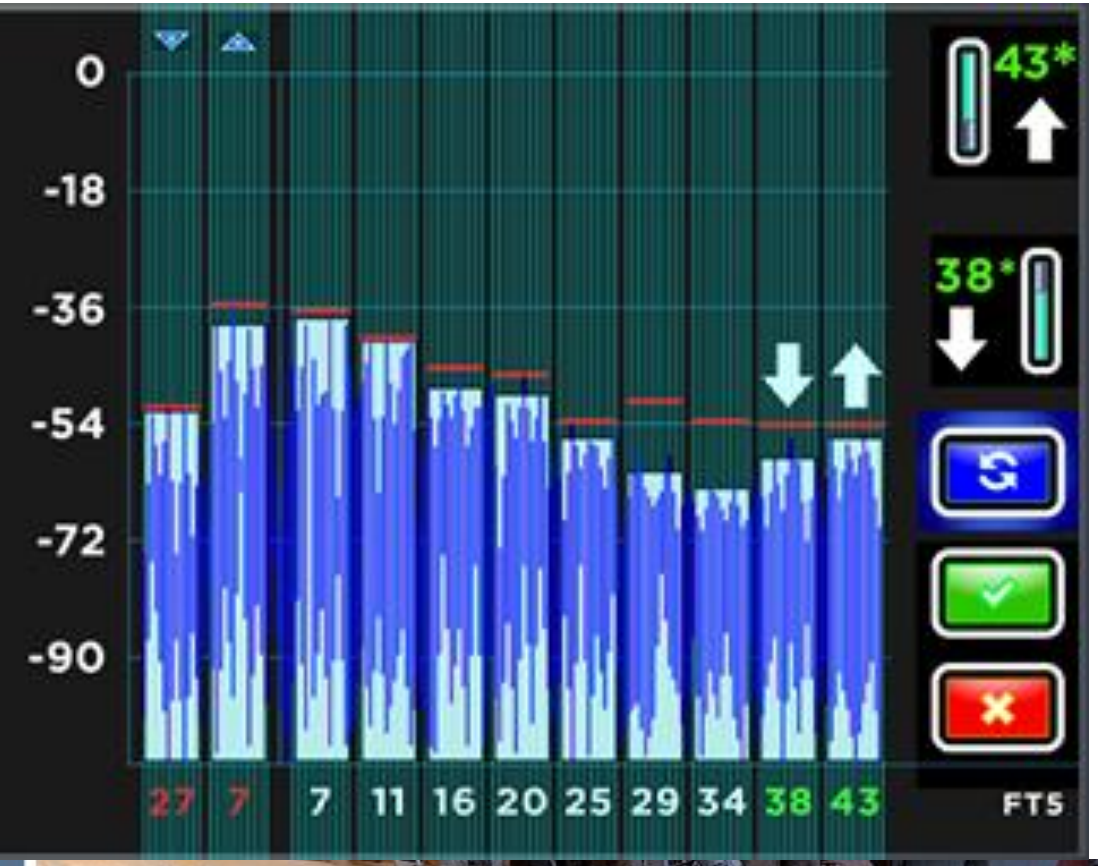
What's transmitting in the ground?

- Cathodic Protection?
- Cables?

Selecting and Configuring Equipment

Balancing Trade-offs with the Job and Environment

Sondes – Below Ground



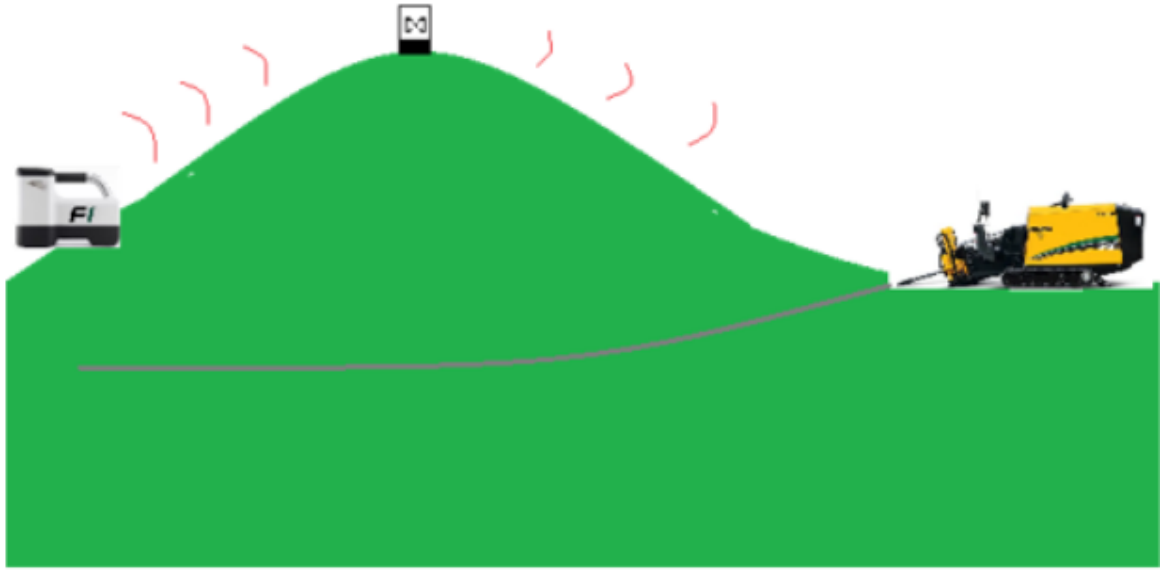
Frequencies (sub-kHz, 7.5-45 kHz)
Go low for passive, high for active

Power (low, mid, high)
As low as possible for the job

Clean calibrations

Change on the fly

Telemetry – Above Ground



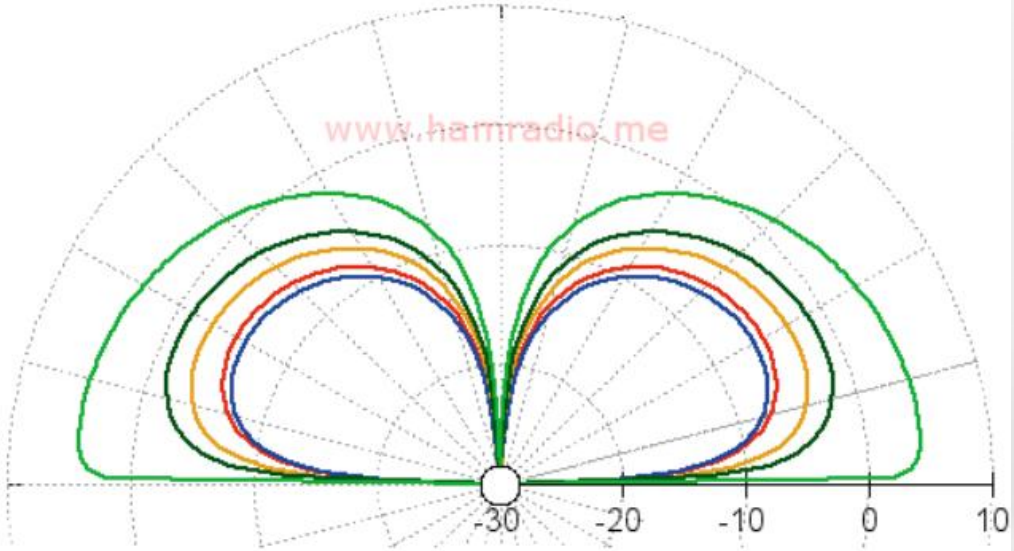
Frequencies (419 MHz – 2.4 GHz)

Power (10mW-1W)

Repeaters (Receive and Transmit)

Antenna Types / Height (Receive)

Telemetry – Antennas



Short whip (1/4 wave dipole)

Long whip (1/2 over 1/4 wave)

Yagi (directional)

Filters and Ground planes

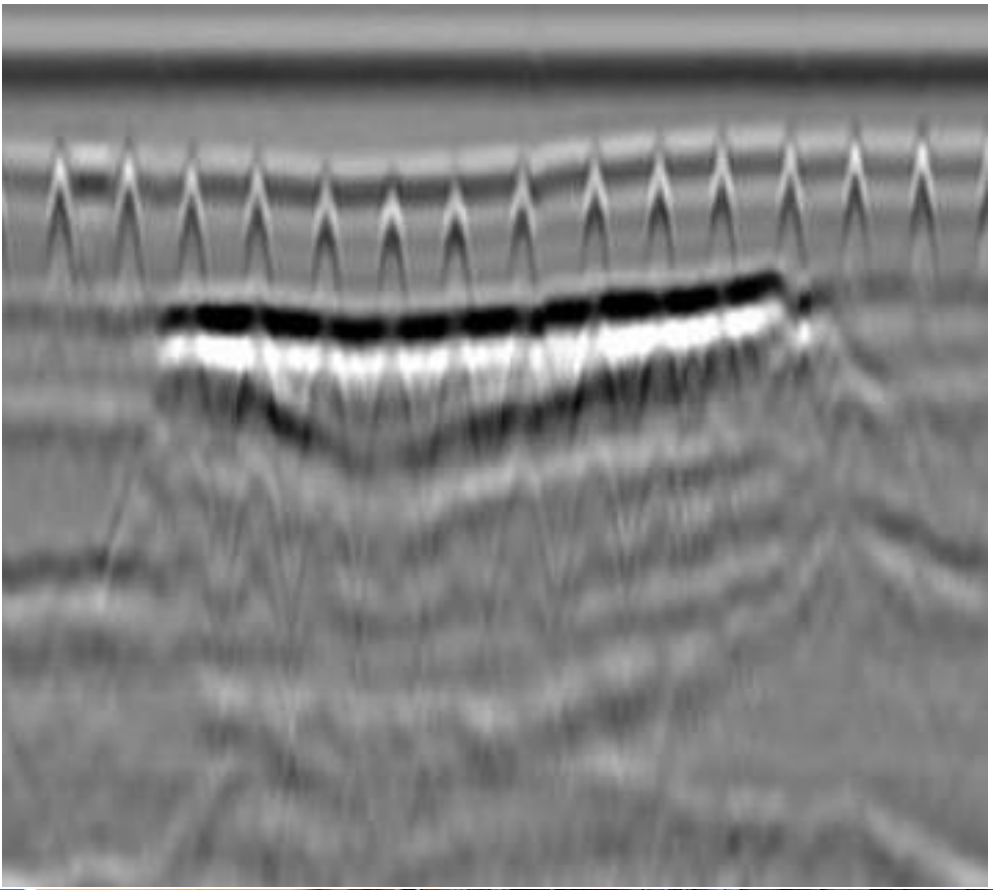
Utility Locators – Electromagnetic Locates

Low Frequency: 100Hz – 1 kHz

Medium Frequency: 8 kHz-33 kHz

High Frequency: 65 kHz-200 kHz

GPR – Mapping Additional Context



Pipes, tanks, and other utilities

Bedrock, changes soil & rock type

Voids, bombs, graves…

Moisture/gas dynamics in soils

Tree roots

Groundwater

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Questions?

Learn more

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