

# Chapter 1

---

## The Basics of Wireless



# Wireless Network Architecture



*Four layers—from the device in your hand to wide-area and backup connectivity.*

Most people are familiar with Wi-Fi and Cellular. They operate at the edge of the network - the first layer.

## Mobility / Access

Phones • Tablets • Vehicles • Sensors • Cameras • Devices

## Distribution

Site and Wider Area Connectivity • Resilient Connections • Towers • Trailers

## Backhaul / Backbone

Extended Distance and High-Capacity Transport • Redundant Connections

## Backup / Isolated Coverage

Wireless Modems • Satellite

- ▶ Every band has design parameters — distance, capacity, modulation, line of sight, and congestion. Generalizations about link stability can be inaccurate. Reliable links are built by evaluating and designing systems within these parameters.
- ▶ For example: 70/80 GHz experiences higher rain fade than lower frequencies. It is often labeled unreliable — but when designed for the appropriate distance and operating rain zone, it is highly stable while delivering significantly higher throughput and inherent security.

# What is Wireless?



*The right connection for the right job — wireless and wired working together*

## Wireless Augments Wired Infrastructure.

Wireless and wired work together. The goal is always the right connection for the right job — not wireless instead of fiber, but wireless where it makes the most sense.

NWT's strength is not a single technology — it is the ability to design systems that combine communication technologies correctly under real-world conditions.

**Every design is an application of these variables within real-world constraints.**

### Distance

How far must the signal travel?

### Throughput

How much data must be delivered?

### Reliability

How consistent must delivery be?

▶ *Wireless is not a product—it is a system defined by physics*

## Why does this matter?

### Where wired can't reach

Moving vehicles, remote sites, temporary locations — wireless fills the gaps fiber never will.

### Speed and flexibility

A wireless link can be live in hours. The same wired connection takes weeks — permits, trenching, cable runs.

### Always the right tool

The best systems combine both. Fiber where it makes sense. Wireless where it doesn't. NWT designs for the whole picture.

- ▶ *No single 'best' wireless — only the right tool for each job*
- ▶ *It is not simply a tradeoff of reliability, distance, and throughput — it is applying the correct system for the application.*

# Three Rules That Govern All Wireless



*Frequency, modulation, and bandwidth — understand these and everything else makes sense*

## Rule 1 — Frequency

*Frequency determines how a signal travels through the world.*



### Lower Frequency

Farther range · Penetrates obstacles · Less data · RF noise floor challenges

*Ex: 216–450 MHz: 50+ km LOS*



### Higher Frequency

More data · Shorter range · Line of sight

*Ex: E-Band 80 GHz: ~3 km, multi-gigabit*

## Rule 2 — Modulation

*Modulation determines how much data is packed onto a signal.*

### More data packed in

Higher throughput requires a stable, clean signal. Many systems can adjust this automatically based on conditions — ACM (Adaptive Coding and Modulation)

▲ more data / less data ▼

### Less data packed in

Travels farther, handles noise and interference better. Signal stability determines what is achievable.

## Rule 3 — Bandwidth

*Bandwidth is the width of the frequency channel assigned to a link.*

### Wider channel

More capacity — more data flows simultaneously. Wider channels are harder to find in congested spectrum.

*802.11ad/ay (WiGig) at 60 GHz uses a 2,160 MHz channel — wider than the entire ISM (Industrial, Scientific & Medical) band shared by all WiFi, Bluetooth & Zigbee.*

**Spectrum is finite — higher frequencies offer far more of it.**

► *These three rules interact — frequency governs range, modulation governs data density, bandwidth governs channel capacity. Every wireless design evaluates all three.*

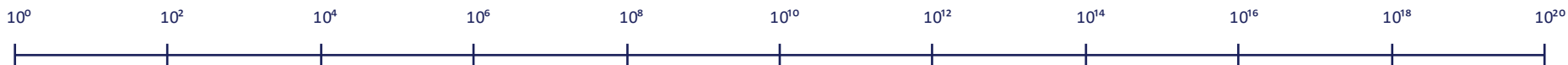
# The Electromagnetic Spectrum



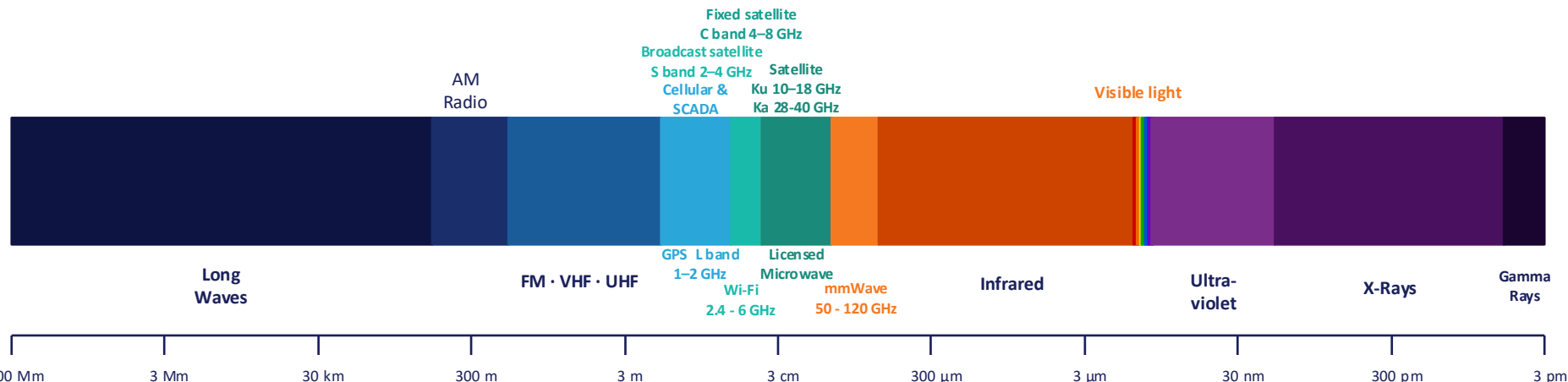
Radio waves, microwaves, light — all the same phenomenon at different frequencies

Frequency (Hz)

→ increasing frequency



← Radio Frequencies — Wireless Communications →



Wavelength

← increasing wavelength

▶ Radio waves and visible light are the same phenomenon — electromagnetic energy. The only difference is frequency.