



CANADIAN BASIC AMATEUR RADIO EXAM PREPARATION

SECTION 7 **E** RADIO WAVE PROPAGATION





**THIS COURSE IS BEING TAUGHT TO THE JULY 15, 2025 UPDATE
OF THE CANADIAN BASIC AMATEUR RADIO EXAM QUESTIONS.**

SECTION 7 QUESTION CATEGORIES:

B-007-001: TYPES OF RADIO WAVE PROPAGATION

B-007-002: IONOSPHERE STRUCTURE AND IONIZATION

B-007-003: SKIP ZONE, SKIP DISTANCE AND MULTI-HOP PROPAGATION

B-007-004: FADING, ABSORPTION, AND POLARIZATION EFFECTS

B-007-005: SOLAR ACTIVITY AND ITS IMPACT ON HF PROPAGATION

B-007-006: MAXIMUM USABLE FREQUENCY (MUF) AND RELATED CONCEPTS

B-007-007: VHF/UHF AND ENHANCED PROPAGATION MODES

B-007-008: SCATTER PROPAGATION MODES



QUESTION SECTION B-007-001:

TYPES OF RADIO WAVE PROPAGATION

B-007-001: TYPES OF RADIO WAVE PROPAGATION

RADIO: INTRODUCTION

- RADIO IS A **WIRELESS TECHNOLOGY** FOR **TRANSMITTING AND RECEIVING INFORMATION**, SUCH AS SOUND, IMAGES, AND DATA, USING RADIO WAVES—A TYPE OF ELECTROMAGNETIC RADIATION
- **WAVES** ARE TRANSMITTED AND **PROPAGATE** THROUGH THE ATMOSPHERE AND SPACE, ENABLING COMMUNICATION OVER VAST DISTANCES WITHOUT PHYSICAL CONNECTIONS.
- IN A BASIC RADIO SYSTEM, A TRANSMITTER MODULATES A CARRIER WAVE WITH THE INFORMATION SIGNAL, AN ANTENNA RADIATES IT, AND A RECEIVER DEMODULATES THE WAVE TO EXTRACT THE ORIGINAL CONTENT.

B-007-001: TYPES OF RADIO WAVE PROPAGATION

RADIO: SPECTRUM

VLF – VERY LOW FREQUENCY

LF – LOW FREQUENCY

MF – MEDIUM FREQUENCY

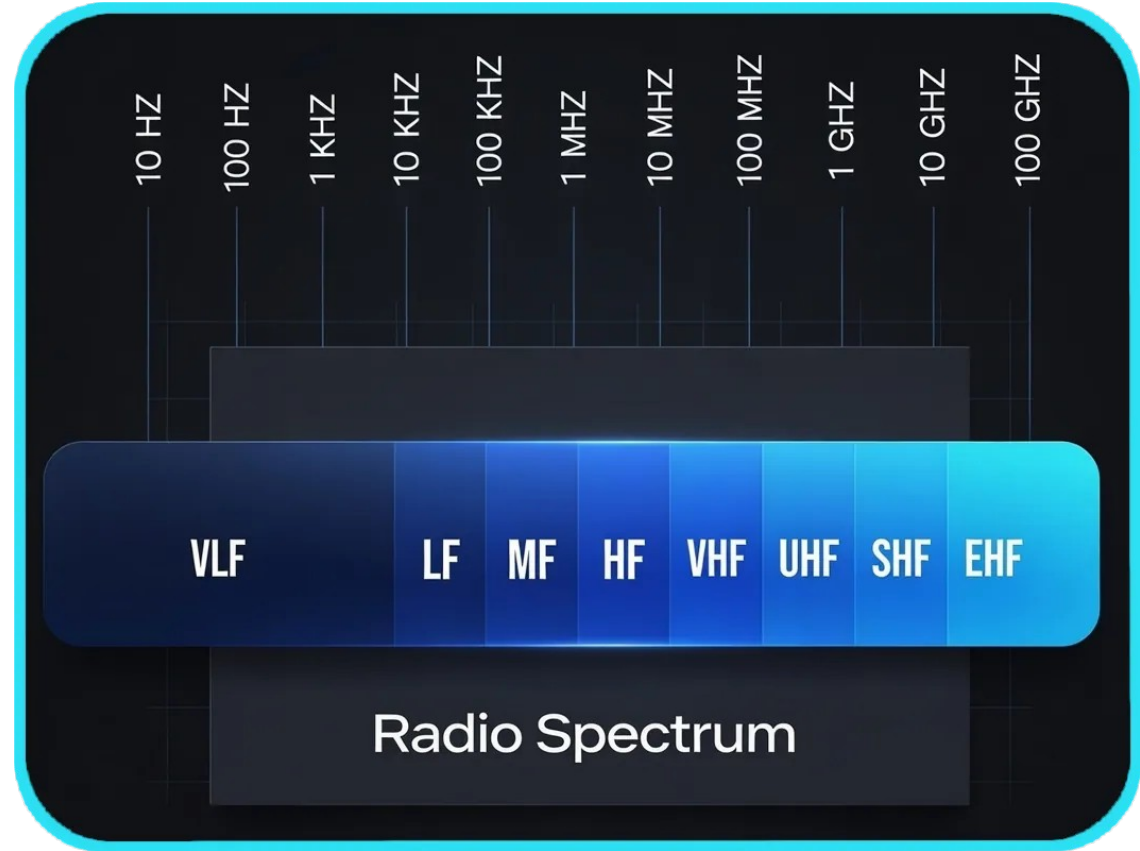
HF – HIGH FREQUENCY

VHF – VERY HIGH FREQUENCY

UHF – ULTRA HIGH FREQUENCY

SHF – SUPER HIGH FREQUENCY

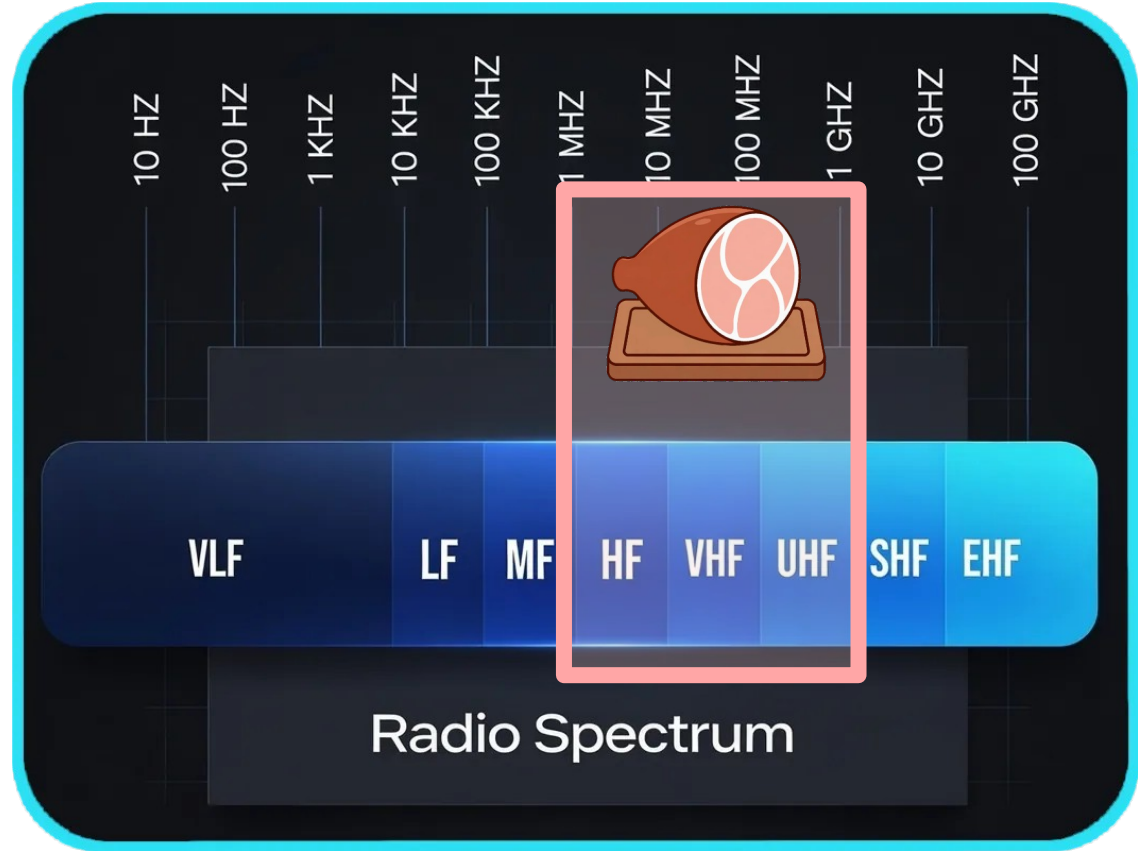
EHF – EXTREMELY HIGH FREQUENCY



B-007-001: TYPES OF RADIO WAVE PROPAGATION

RADIO: SPECTRUM

**HAM RADIO IS
GENERALLY FOCUSED ON
HF, VHF AND UHF
BUT THERE ARE HAM
ALLOCATIONS IN
LF, MF, SHF & EHF TOO**



B-007-001: TYPES OF RADIO WAVE PROPAGATION

RADIO: BANDS



- THE RADIO SPECTRUM IS LIKE A LONG, CONTINUOUS ROLL OF FILM
- THE FREQUENCIES SPAN FROM VERY LOW (EX: A FEW Hz) TO EXTREMELY HIGH (HUNDREDS OF GHz).
- PRACTICAL USE REQUIRES DIVIDING IT INTO MANAGEABLE, BOUNDED **SEGMENTS** FOR SPECIFIC PURPOSES: BROADCASTING, AMATEUR RADIO, AVIATION, MOBILE PHONES, RADAR, ETC.
- THESE SEGMENTS OF FREQUENCIES ARE REFERRED TO AS “**BANDS**”

B-007-001: TYPES OF RADIO WAVE PROPAGATION

RADIO: BANDS

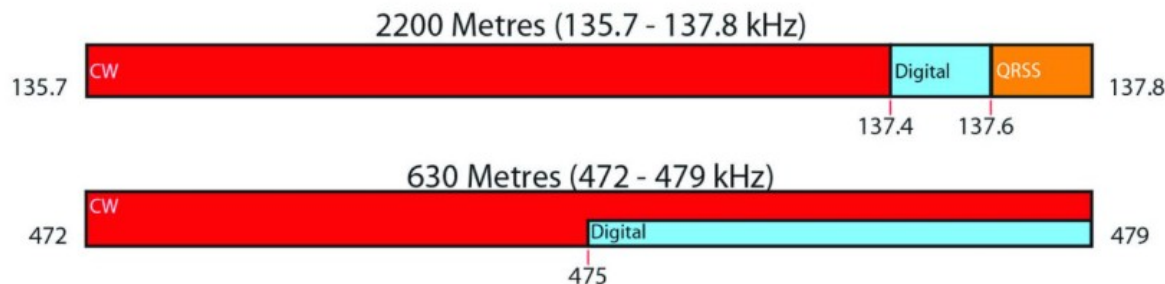
- IN HAM RADIO, THE BANDS ARE NAMED BY THEIR **APPROXIMATE WAVELENGTH IN METERS**.
- **EXAMPLE: THE 20M BAND**
 - IT COVERS FREQUENCIES FROM 14.000 MHz TO 14.350 MHz IN CANADA
 - $\lambda(\text{metres}) = \frac{300}{f(\text{MHz})}$
 - AT THE LOW END (14.000 MHz): $\lambda \approx 300 / 14 = 21.43$ METERS
 - AT THE HIGH END (14.350 MHz): $\lambda \approx 300 / 14.35 \approx 20.91$ METERS
 - WITH SOME ROUNDING, IT IS KNOWN AS THE **20M BAND**. ALL OF THE HAM BANDS FOLLOW THIS CONVENTION.

B-007-001: TYPES OF RADIO WAVE PROPAGATION

RADIO: THE LOW & MEDIUM FREQUENCY HAM BANDS

2200M – 135.7-137.8kHz

630M – 472-479 kHz



NOTE: THESE ARE VERY SPECIALIZED BANDS. THE AVERAGE HAM OPERATOR WON'T BE USING THESE OFTEN/AT ALL.

B-007-001: TYPES OF RADIO WAVE PROPAGATION

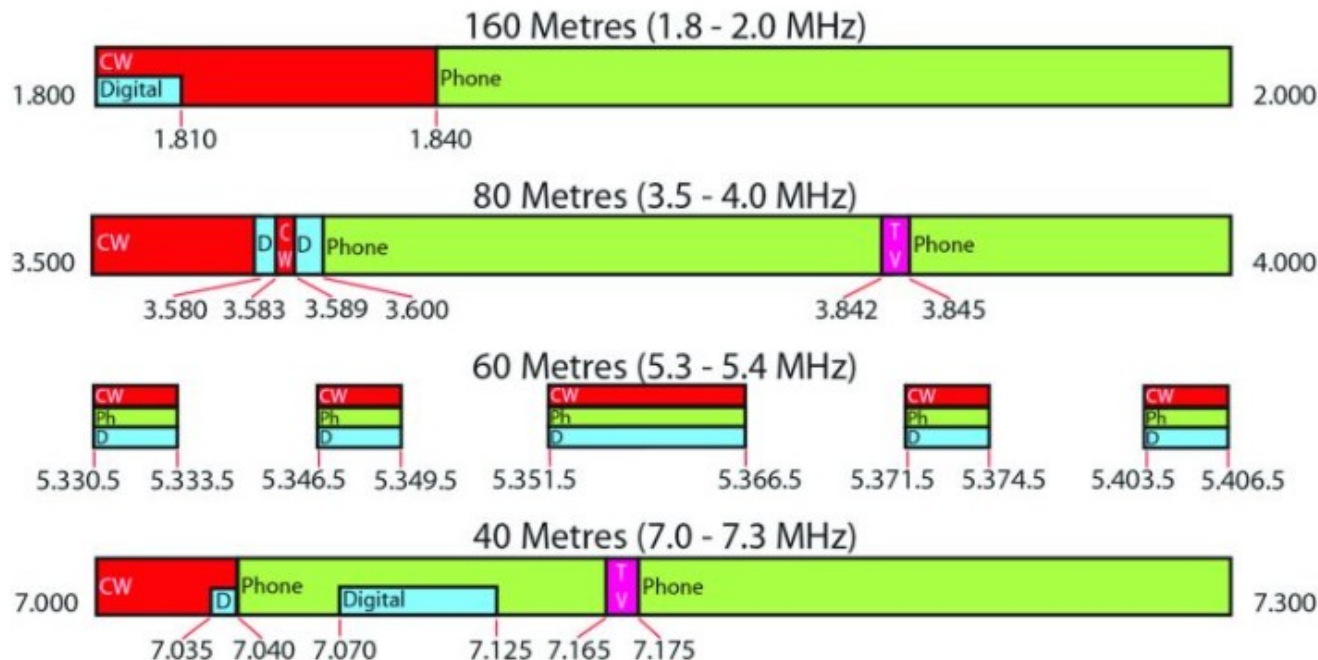
RADIO: THE LOW HF HAM BANDS

160M – 1.8-2MHz

80M – 3.5-4MHz

60M – 5.33-5.40MHz

40M – 7-7.3MHz



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B-007-001: TYPES OF RADIO WAVE PROPAGATION

RADIO: THE HIGH HF HAM BANDS

30M – 10.1-10.150MHz

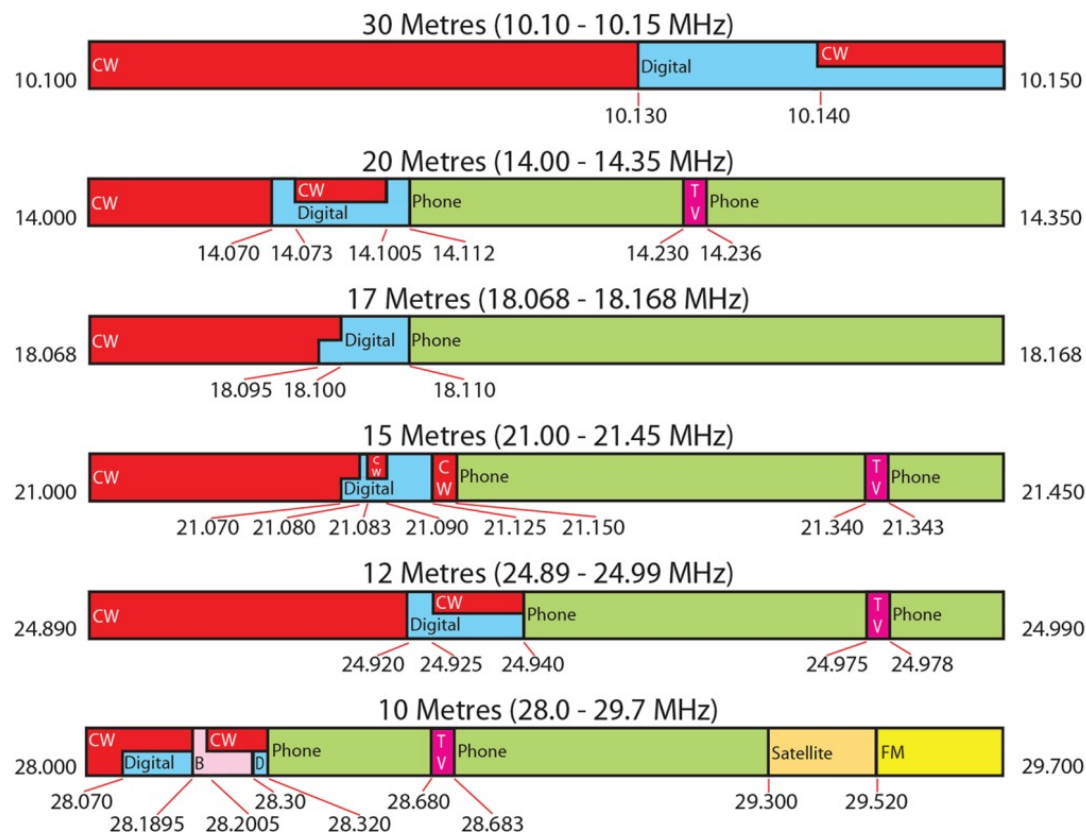
20M – 14-14.350MHz

17M – 18.068-18.168MHz

15M – 21-21.450MHz

12M – 24.89-24.99MHz

10M – 28-29.700MHz



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B-007-001: TYPES OF RADIO WAVE PROPAGATION

RADIO: COMMON VHF/UHF HAM BANDS



6M – 50-54MHz

● **2M – 144-148MHz**

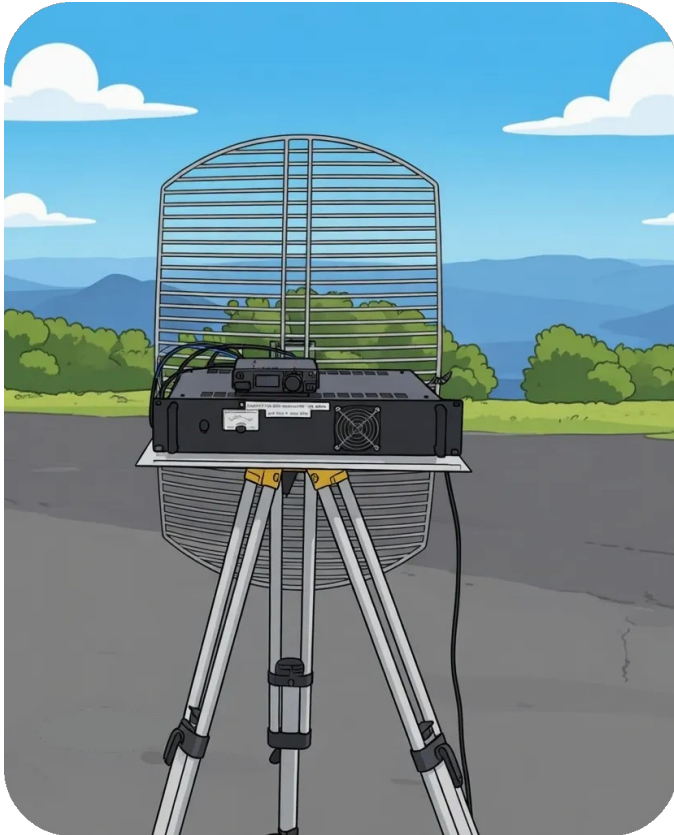
● **1.25M – 222-225MHz**

● **70CM – 430-450MHz**

← **Less Common**

B-007-001: TYPES OF RADIO WAVE PROPAGATION

RADIO: LESS COMMON UHF/SHF/EHF HAM BANDS



33CM – 902-928MHz

23CM – 1240-1300MHz

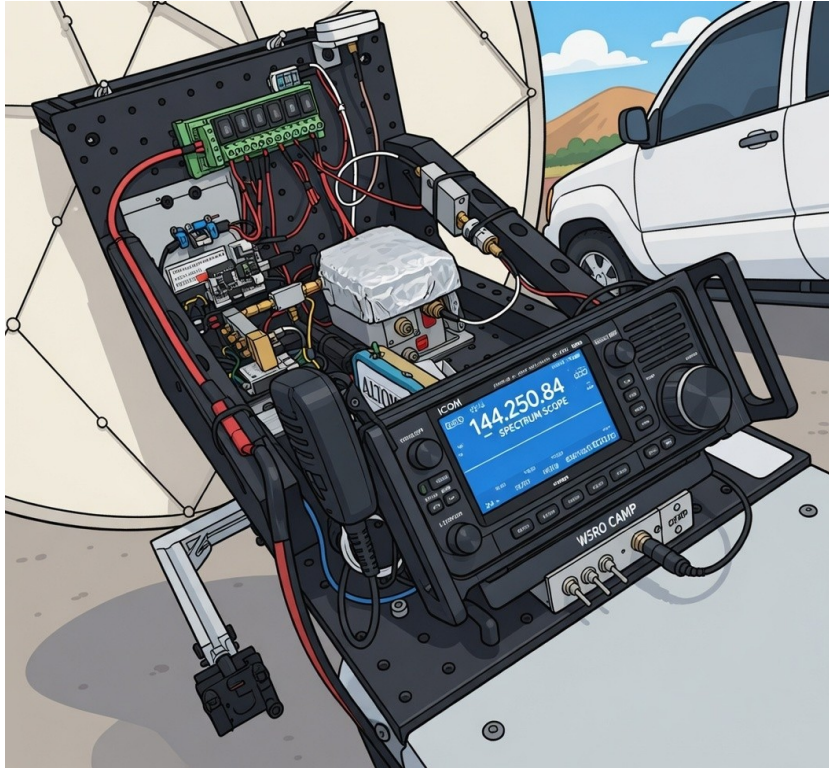
13CM – 2300-2450MHz

MICROWAVE BANDS

**NOTE: THESE ARE VERY SPECIALIZED BANDS THAT
WILL REQUIRE TECHNICAL EQUIPMENT.**

B-007-001: TYPES OF RADIO WAVE PROPAGATION

RADIO: LESS COMMON UHF/SHF/EHF HAM BANDS



**ANOTHER EXAMPLE:
10 GHz EME (EARTH-
MOON-EARTH)
“MOONBOUNCE” USING
3CM MICROWAVE TO
COMMUNICATE BY
REFLECTING SIGNALS OFF
THE MOON!**



B-007-001: TYPES OF RADIO WAVE PROPAGATION

VHF PROPAGATION (LINE-OF-SIGHT / DIRECT WAVE)

- FOR VHF (AND HIGHER) FREQUENCIES, COMMUNICATION BETWEEN NEARBY TRANSCEIVERS IS TYPICALLY VERY RELIABLE AND PREDICTABLE FOR LOCAL COMMUNICATIONS.
- VHF IS **LINE-OF-SIGHT** - THIS MEANS THE SIGNAL TRAVELS IN A STRAIGHT LINE FROM TRANSMITTER TO RECEIVER, MUCH LIKE LIGHT. IT IS THE PRIMARY MODE FOR VHF/UHF COMMUNICATIONS WHEN THERE ARE NO MAJOR OBSTACLES.

B-007-001: TYPES OF RADIO WAVE PROPAGATION

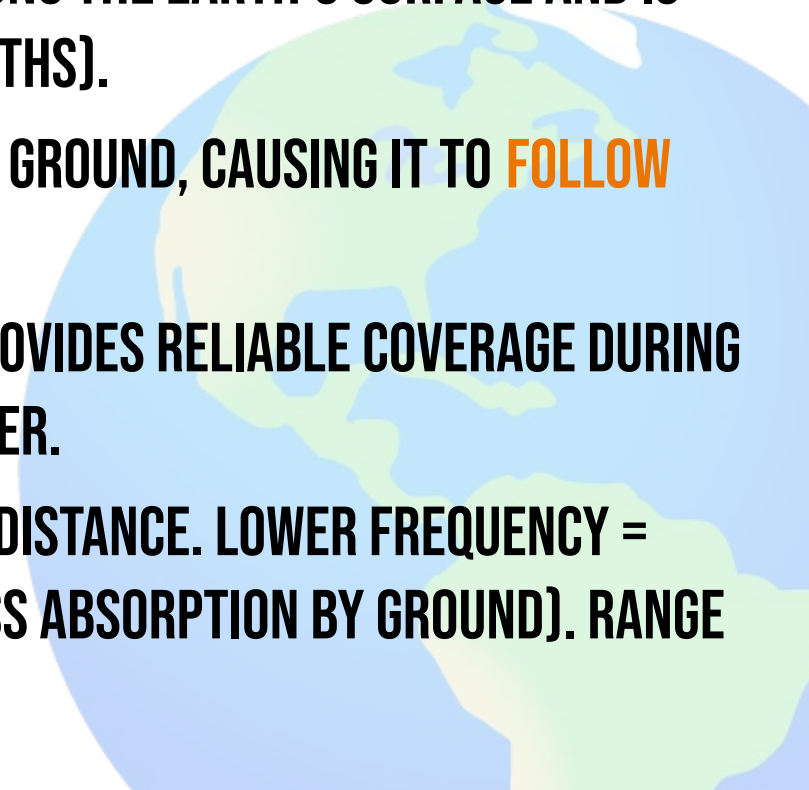
VHF PROPAGATION (LINE-OF-SIGHT / DIRECT WAVE)

- **HOWEVER, THESE SIGNALS CAN EXTEND PAST THE VISIBLE HORIZON. THE LOWER ATMOSPHERE (TROPOSPHERE) BENDS RADIO WAVES SLIGHTLY DOWNWARD DUE TO CHANGES IN AIR DENSITY/REFRACTIVE INDEX, ALLOWING SIGNALS TO TRAVEL A BIT FARTHER THAN OPTICAL LINE-OF-SIGHT (TYPICALLY 15-20% FARTHER DEPENDING ON CONDITIONS).**

B-007-001: TYPES OF RADIO WAVE PROPAGATION

GROUND WAVE PROPAGATION

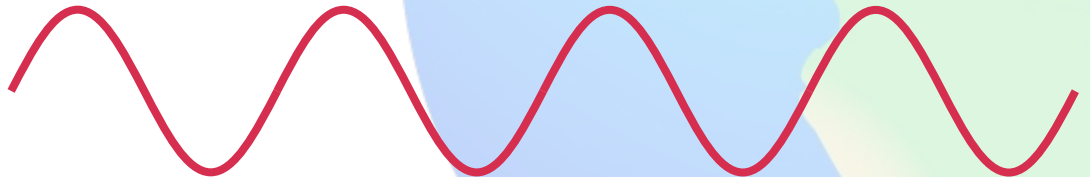
- **GROUND WAVE** (ALSO CALLED SURFACE WAVE) TRAVELS ALONG THE EARTH'S SURFACE AND IS MOST USEFUL AT LOWER FREQUENCIES (LONGER WAVELENGTHS).
- THE LOWER PART OF THE WAVEFRONT INTERACTS WITH THE GROUND, CAUSING IT TO **FOLLOW THE EARTH'S CURVATURE** TO SOME EXTENT.
- AT LOWER HF (EX: 160M OR 80M BANDS), GROUND WAVE PROVIDES RELIABLE COVERAGE DURING THE DAY WHEN SKY WAVE MAY BE ABSORBED BY THE D-LAYER.
- 160M OFFERS THE GREATEST GROUND WAVE PROPAGATION DISTANCE. LOWER FREQUENCY = LONGER WAVELENGTH = BETTER GROUND WAVE RANGE (LESS ABSORPTION BY GROUND). RANGE DECREASES AS FREQUENCY INCREASES TOWARD VHF (6M).



B-007-001: TYPES OF RADIO WAVE PROPAGATION

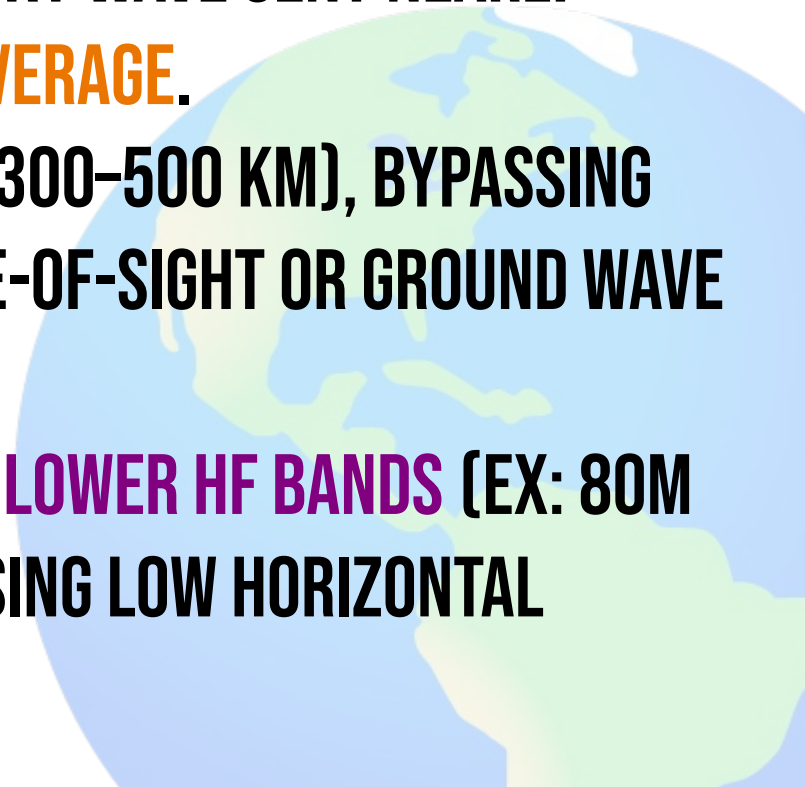
SKY WAVE PROPAGATION (IONOSPHERIC)

- **SKY WAVE** (ALSO CALLED **IONOSPHERIC WAVE** OR SKIP) INVOLVES SIGNALS TRAVELLING UPWARD TO THE IONOSPHERE, REFRACTING BACK TO EARTH, ENABLING BEYOND-LINE-OF-SIGHT AND **LONG-DISTANCE CONTACTS**. THIS IS THE MAGIC OF HF RADIO! WORLD-WIDE COMMUNICATION!
- **LONG-DISTANCE (DX) COMMUNICATIONS ON HF BANDS VIA MULTIPLE HOPS/REFRACTIONS.**



B-007-001: TYPES OF RADIO WAVE PROPAGATION

NVIS – A SPECIAL CASE OF SKY WAVE

- **NVIS** (NEAR VERTICAL INCIDENCE SKYWAVE) IS SKY WAVE SENT NEARLY STRAIGHT UP FOR **RELIABLE MEDIUM-RANGE COVERAGE**.
 - NVIS FILLS THE "SKIP ZONE" GAP (TYPICALLY 0-300-500 KM), BYPASSING OBSTACLES LIKE MOUNTAINS/HILLS WHERE LINE-OF-SIGHT OR GROUND WAVE FAILS.
 - **IT'S IDEAL FOR REGIONAL/EMERGENCY NETS ON LOWER HF BANDS** (EX: 80M OR 40M DAYTIME, 160M OR 80M NIGHTTIME) USING LOW HORIZONTAL ANTENNAS.
- 



QUESTION SECTION B-007-002:

IONOSPHERE STRUCTURE AND IONIZATION

B-007-002: IONOSPHERE STRUCTURE AND IONIZATION

FORMATION AND IONIZATION OF THE IONOSPHERE

- THE **IONOSPHERE** EXISTS BECAUSE OF THE **SUN'S ENERGY** INTERACTING WITH EARTH'S UPPER ATMOSPHERE.
- HIGH-ENERGY SOLAR RADIATION KNOCKS ELECTRONS OFF ATOMS IN THE UPPER ATMOSPHERE (MAINLY NITROGEN AND OXYGEN), CREATING **FREE ELECTRONS** AND **POSITIVE IONS**.
- **ULTRAVIOLET** (UV) LIGHT FROM THE SUN IS THE PRIMARY DRIVER OF IONIZATION (X-RAYS ALSO CONTRIBUTE BUT UV IS EMPHASIZED HERE FOR HAM RADIO CONTEXT).
- PEAK SOLAR RADIATION OCCURS AROUND **NOON**, MAXIMIZING IONIZATION.
- OVERNIGHT, IONS AND ELECTRONS RECOMBINE, REDUCING IONIZATION UNTIL SUNRISE REBUILDS THE LAYERS.

B-007-002: IONOSPHERE STRUCTURE AND IONIZATION

FORMATION AND IONIZATION OF THE IONOSPHERE

- THE IONOSPHERE HAS DISTINCT REGIONS (**LAYERS**) AT DIFFERENT ALTITUDES, EACH AFFECTING RADIO WAVES DIFFERENTLY.
- **DAYTIME:**
 - F2 REGION: ~250-400+ KM (HIGHEST AND MOST PERSISTENT)
 - F1 REGION: ~150-250 KM
 - E REGION: ~90-150 KM
 - D REGION: ~50-90 KM (CLOSEST TO EARTH)



B-007-002: IONOSPHERE STRUCTURE AND IONIZATION

FORMATION AND IONIZATION OF THE IONOSPHERE

- **NIGHTTIME:**
 - D REGION: DISAPPEARS
 - E REGION: WEAKENS
 - F1 + F2: COMBINE INTO ONE LAYER



B-007-002: IONOSPHERE STRUCTURE AND IONIZATION

ROLE OF EACH REGION IN RADIO PROPAGATION

- EACH LAYER INTERACTS WITH HF SKY WAVES DIFFERENTLY—SOME **REFRACT** (BEND/REFLECT) SIGNALS USEFULLY, WHILE OTHERS **ABSORB** THEM.
- THE D REGION **PRIMARILY ABSORBS** HF SIGNALS (ESPECIALLY LOWER FREQUENCIES) RATHER THAN REFRACTING THEM BACK TO EARTH.
- LOWER-FREQUENCY BANDS (LIKE 160M AND 80M) SUFFER **HEAVY ABSORPTION** IN THE DAYTIME D REGION, LIMITING THEM TO GROUND WAVE OR VERY SHORT SKY-WAVE PATHS. HIGHER BANDS (EX: 20M, 15M) PENETRATE THE D REGION BETTER AND REACH THE F LAYERS FOR LONG-DISTANCE SKIP.
- THE F2 LAYER'S **HIGHER ALTITUDE** ALLOWS **GREATER SKIP DISTANCES** PER HOP (LONGER DX CONTACTS), AND F2 PERSISTS DAY AND NIGHT WITH STRONG IONIZATION.



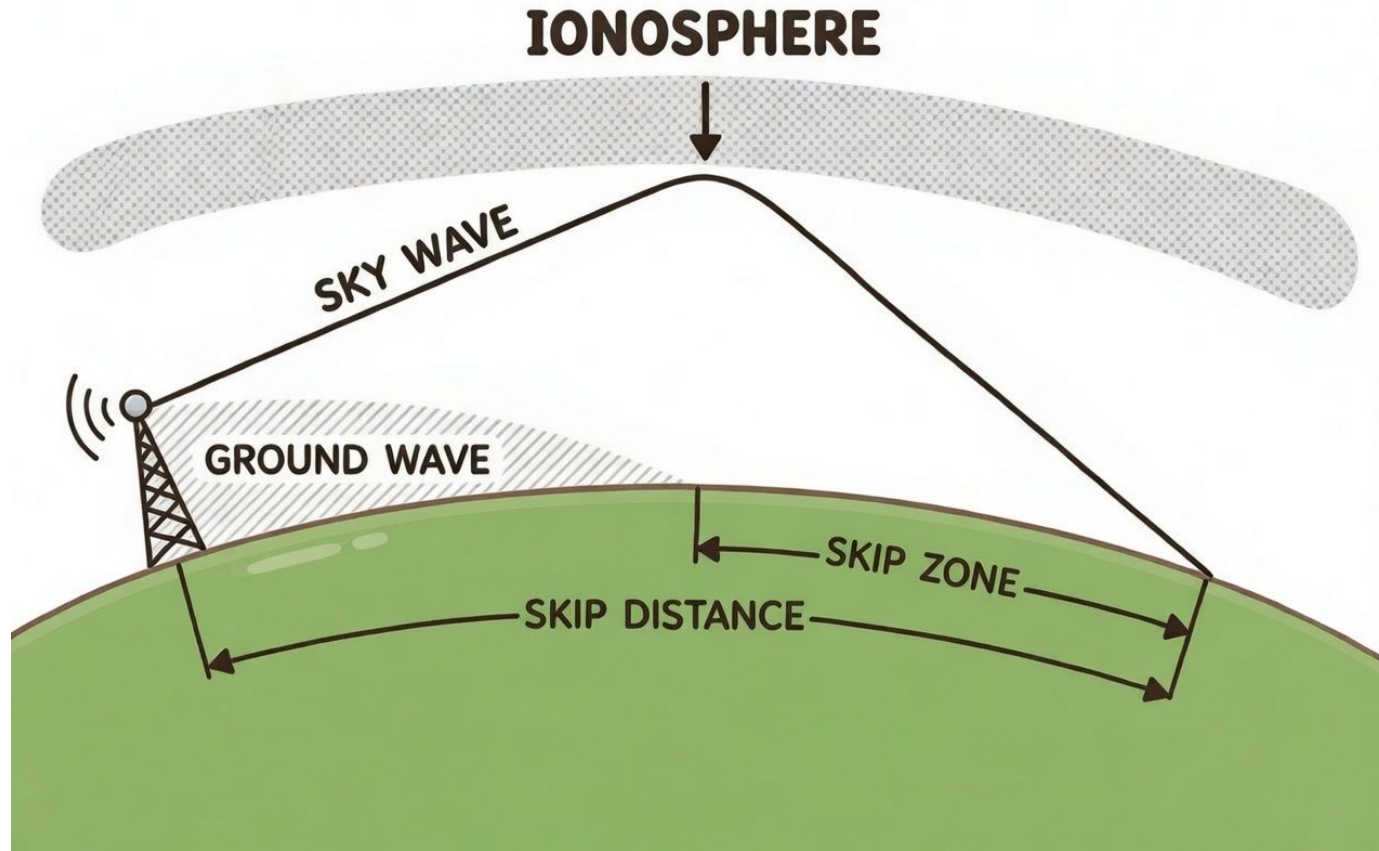
QUESTION SECTION B-007-003:

SKIP ZONE, SKIP DISTANCE, AND MULTI-HOP PROPAGATION

B-007-003: SKIP ZONE, SKIP DISTANCE AND MULTI-HOP PROPAGATION

SKIP ZONE AND SKIP DISTANCE – THE "DEAD ZONE" PROBLEM

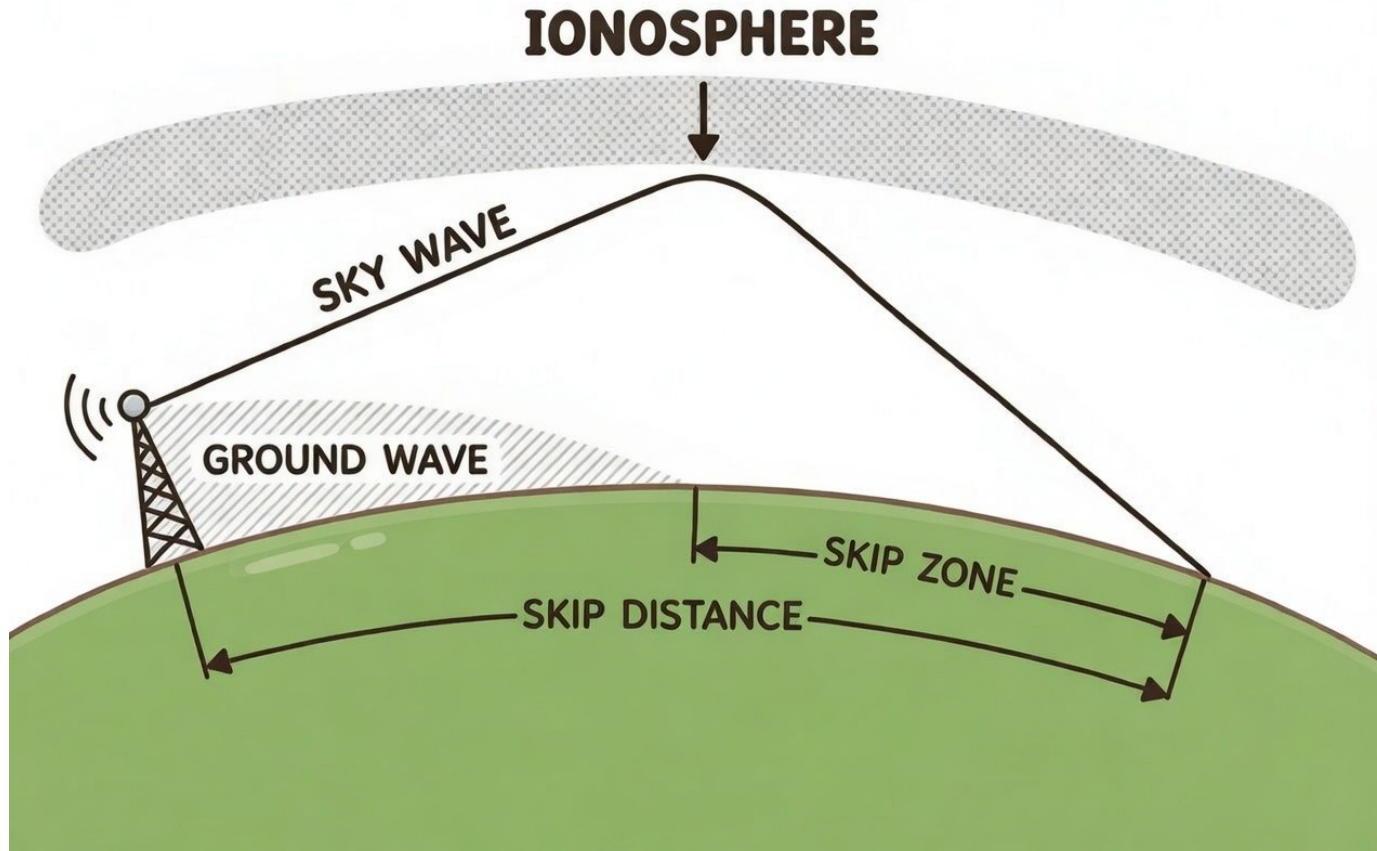
SKY WAVE DOESN'T
COVER EVERY DISTANCE;
THERE'S OFTEN A **GAP**
WHERE NEITHER GROUND
WAVE NOR THE FIRST
SKY-WAVE HOP REACHES.



B-007-003: SKIP ZONE, SKIP DISTANCE AND MULTI-HOP PROPAGATION

SKIP ZONE AND SKIP DISTANCE – THE "DEAD ZONE" PROBLEM

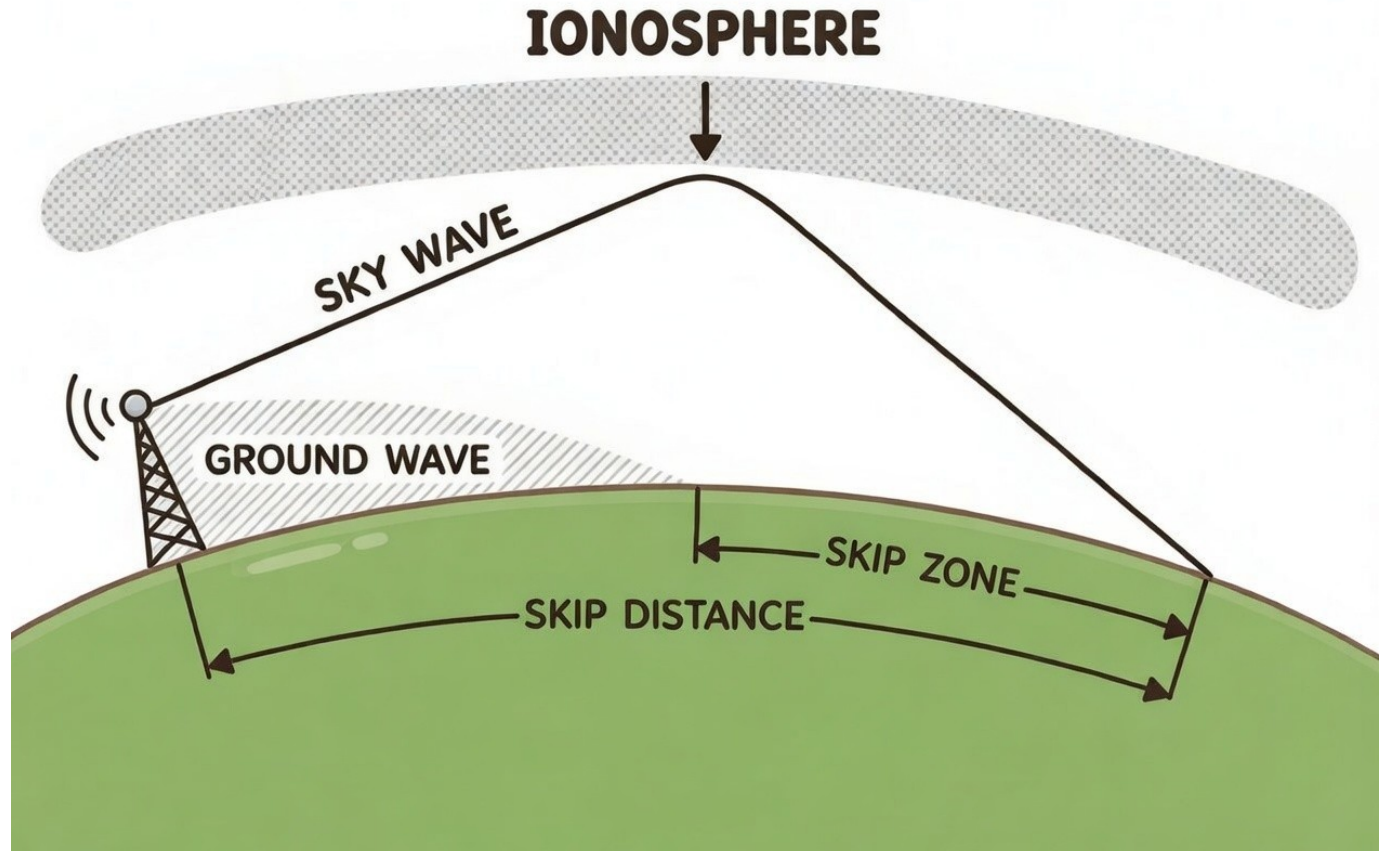
SKIP DISTANCE IS THE:
MINIMUM DISTANCE
REACHED BY A SIGNAL
AFTER ONE REFLECTION
BY THE IONOSPHERE



B-007-003: SKIP ZONE, SKIP DISTANCE AND MULTI-HOP PROPAGATION

SKIP ZONE AND SKIP DISTANCE – THE "DEAD ZONE" PROBLEM

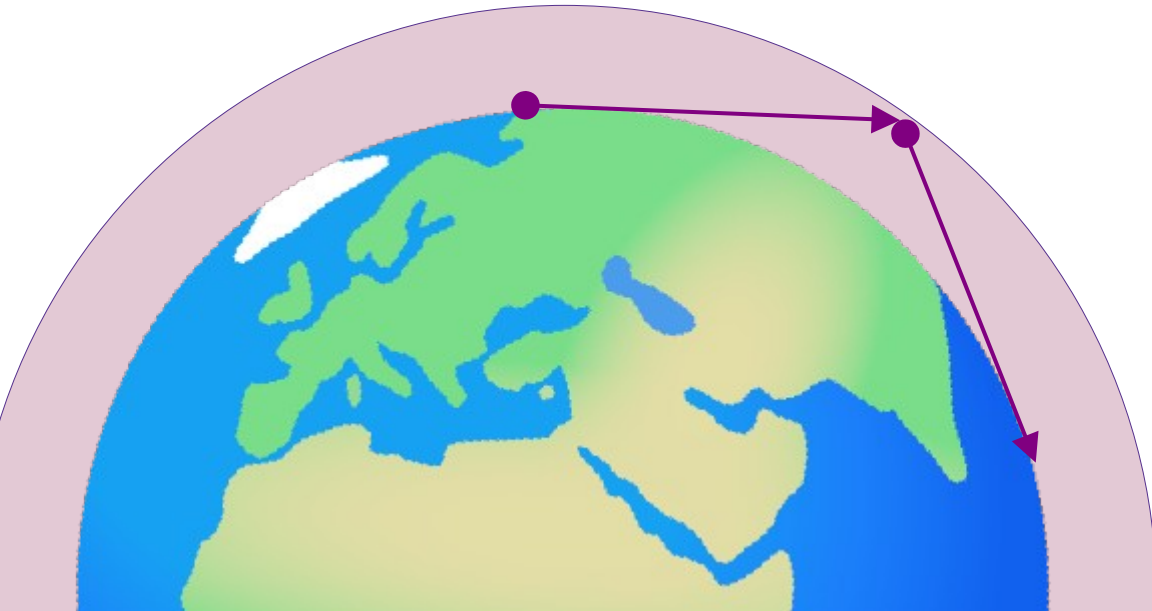
SKIP ZONE IS:
A ZONE BETWEEN THE
END OF THE GROUND
WAVE AND THE POINT
WHERE THE FIRST
IONOSPHERE-REFRACTED
WAVE RETURNS TO
EARTH



B-007-003: SKIP ZONE, SKIP DISTANCE AND MULTI-HOP PROPAGATION

SKIP ZONE AND SKIP DISTANCE – THE "DEAD ZONE" PROBLEM

- THE MAXIMUM DISTANCE ALONG THE EARTH'S SURFACE THAT IS NORMALLY COVERED IN ONE HOP USING THE F2 REGION IS 4,000 KM. THE EXTRA HEIGHT GIVES THE SIGNAL THE LONGEST REACH.

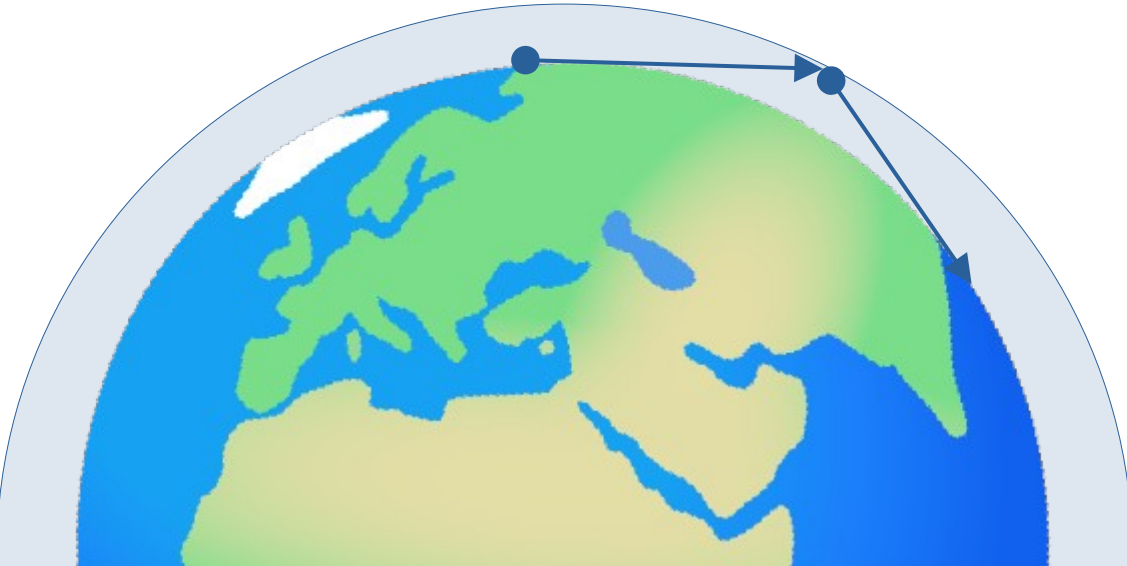


F2

B-007-003: SKIP ZONE, SKIP DISTANCE AND MULTI-HOP PROPAGATION

SKIP ZONE AND SKIP DISTANCE – THE "DEAD ZONE" PROBLEM

- THE MAXIMUM DISTANCE ALONG THE EARTH'S SURFACE THAT IS NORMALLY COVERED IN ONE HOP USING THE E REGION IS 2,000 KM. E IS LOWER → SHORTER HOP



E

B-007-003: SKIP ZONE, SKIP DISTANCE AND MULTI-HOP PROPAGATION

MULTI-HOP PROPAGATION FOR VERY LONG DISTANCES

- FOR DISTANCES BEYOND A SINGLE HOP (EX: TRANSOCEANIC), SIGNALS **BOUNCE MULTIPLE** TIMES.
- A 5000 KM DISTANCE EXCEEDS TYPICAL SINGLE-HOP (EVEN F2 ~4000 KM), SO THE SIGNAL REFLECTS OFF THE IONOSPHERE, THEN THE EARTH, THEN IONOSPHERE AGAIN, ETC. IN A MULTI-HOP CONFIGURATION.
- THE SIGNAL **REFLECTS** OFF THE EARTH MUCH LIKE THE IONOSPHERE.



B-007-003: SKIP ZONE, SKIP DISTANCE AND MULTI-HOP PROPAGATION

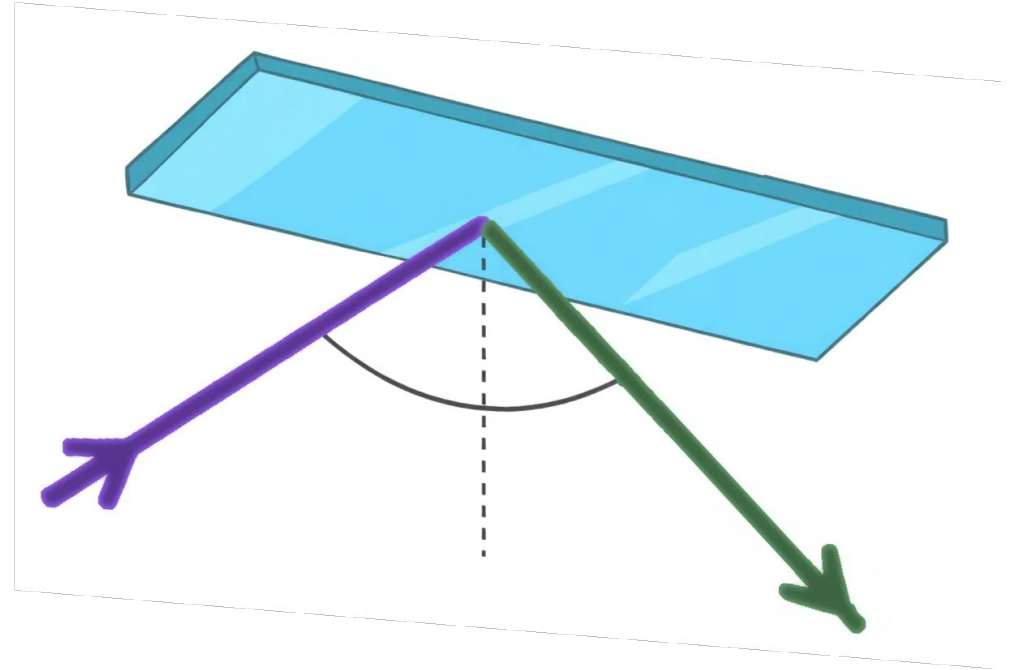
FACTORS AFFECTING SKIP DISTANCE

- **SKIP DISTANCE** IS GEOMETRY-DEPENDENT: RADIATION ANGLE, LAYER HEIGHT, AND FREQUENCY ALL PLAY ROLES.
- THE QUESTION BANK USES "**REFLECTION**" INTERCHANGEABLY WITH **REFRACTION** FOR SIMPLICITY, BUT TECHNICALLY IT'S REFRACTION/BENDING THAT CAUSES SKIP.
- WHEN THE ANGLE BETWEEN THE GROUND AND THE EMITTED RADIATION IS SMALLEST (LOWER TAKEOFF ANGLE) WAVES TRAVEL FARTHER BEFORE HITTING THE IONOSPHERE → LONGER SKIP.
- STEEPER ANGLE HITS IONOSPHERE SOONER → SHORTER SKIP.

B-007-003: SKIP ZONE, SKIP DISTANCE AND MULTI-HOP PROPAGATION

FACTORS AFFECTING SKIP DISTANCE

- **ANGLE OF INCIDENCE = ANGLE OF REFLECTION**





QUESTION SECTION B-007-004:

FADING, ABSORPTION, AND POLARIZATION EFFECTS

B-007-004: FADING, ABSORPTION, AND POLARIZATION EFFECTS

D-REGION ABSORPTION ON LOWER HF FREQUENCIES (DAYTIME ISSUE)

- REMEMBER THIS MNEMONIC:



D Layer

+

Daytime

=



AM BROADCAST RADIO IS STRONGER AND FARTHER AT NIGHT FOR THIS REASON

B-007-004: FADING, ABSORPTION, AND POLARIZATION EFFECTS

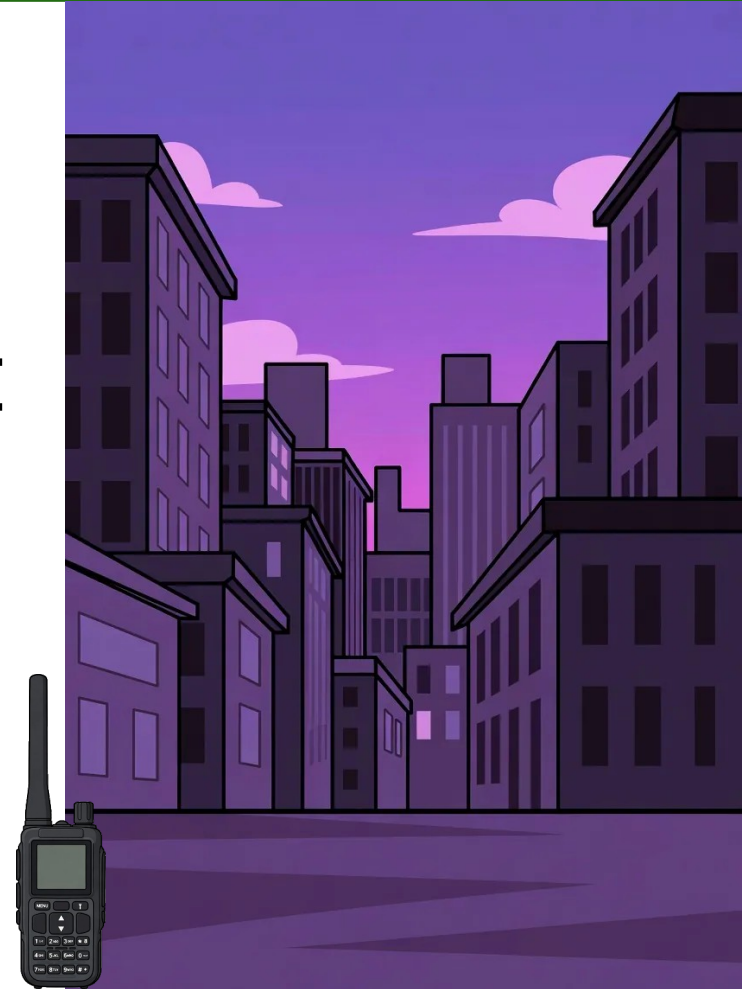
MULTIPATH PROPAGATION AND FADING

- SIGNALS OFTEN ARRIVE VIA MULTIPLE PATHS (DIFFERENT HOPS, REFLECTIONS), CAUSING **INTERFERENCE**.
- **SIGNAL FADING** IS AN EXAMPLE OF THIS.
- **PHASE DISTORTION** - BEYOND AMPLITUDE FADING, MULTIPATH CAN DISTORT THE SIGNAL WAVEFORM (ESPECIALLY WITH MODULATION).
- **WIDER SIGNALS** (EX: SSB VOICE ~2-3 KHZ VS. CW ~100 HZ) SPAN MORE FREQUENCIES; DIFFERENT FREQUENCIES EXPERIENCE DIFFERENT FADING → "MUFFLED" OR DISTORTED AUDIO (SELECTIVE FADING HITS PARTS OF THE SIGNAL MORE THAN OTHERS).

B-007-004: FADING, ABSORPTION, AND POLARIZATION EFFECTS

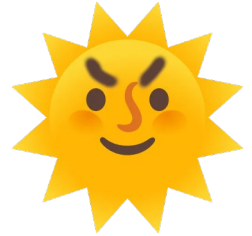
MULTIPATH PROPAGATION AND FADING

- B-007-004-004 WHILE USING A 2-METRE HAND-HELD TRANSCEIVER IN AN URBAN SETTING, YOU NOTICE THAT MOVING LESS THAN ONE METRE CAN SEVERELY ATTENUATE YOUR RECEIVED SIGNAL. WHAT IS THE LIKELY CAUSE
ANSWER: SIGNALS ARRIVING ON DIFFERENT PATHS CANCEL ONE ANOTHER.
- URBAN VHF/UHF MULTIPATH FROM BUILDINGS CAUSES RAPID, DEEP FADES — TINY MOVEMENTS SHIFT PHASES DRAMATICALLY.



IONOSPHERIC DISTURBANCES AND POLARIZATION EFFECTS

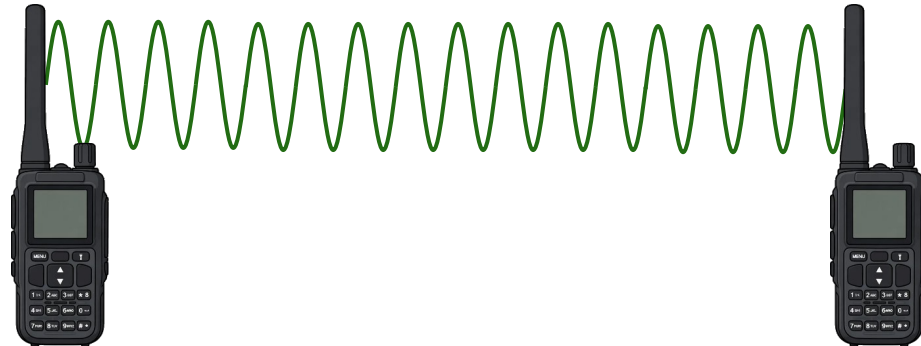
- **SUDDEN CHANGES AND EARTH'S MAGNETIC FIELD ADD COMPLICATIONS.**
- **SUDDEN IONOSPHERIC DISTURBANCE (SID) (EX: SOLAR FLARE X-RAY BURST) STRENGTHENS D-REGION ABSORPTION → WIPES OUT LOWER HF.**
- **HIGHER BANDS PENETRATE BETTER. EX: 20M → 15M OR 10M**



B-007-004: FADING, ABSORPTION, AND POLARIZATION EFFECTS

IONOSPHERIC DISTURBANCES AND POLARIZATION EFFECTS

- B-007-004-007 ON THE VHF AND UHF BANDS, THE POLARIZATION OF THE RECEIVING ANTENNA IN RELATION TO THE TRANSMITTING ANTENNA IS VERY IMPORTANT, YET ON HF BANDS IT IS RELATIVELY UNIMPORTANT. WHY IS THAT SO? ANSWER: **THE REFRACTION IN THE IONOSPHERE CHANGES THE WAVE'S POLARIZATION**



B-007-004: FADING, ABSORPTION, AND POLARIZATION EFFECTS

IONOSPHERIC DISTURBANCES AND POLARIZATION EFFECTS

- B-007-004-010 WHAT EFFECT DO REFRACTION, REFLECTION AND FARADAY ROTATION HAVE ON A RADIO WAVE? **CHANGE THE POLARIZATION**
- FARADAY ROTATION (DUE TO EARTH'S MAGNETIC FIELD IN THE IONOSPHERE) TWISTS LINEAR POLARIZATION RANDOMLY OVER THE PATH → HF SIGNALS ARRIVE WITH MIXED POLARIZATION, SO **HF ANTENNA ORIENTATION MATTERS LESS** THAN ON LINE-OF-SIGHT VHF/UHF.



QUESTION SECTION B-007-005:

SOLAR ACTIVITY AND ITS IMPACT ON HF PROPAGATION

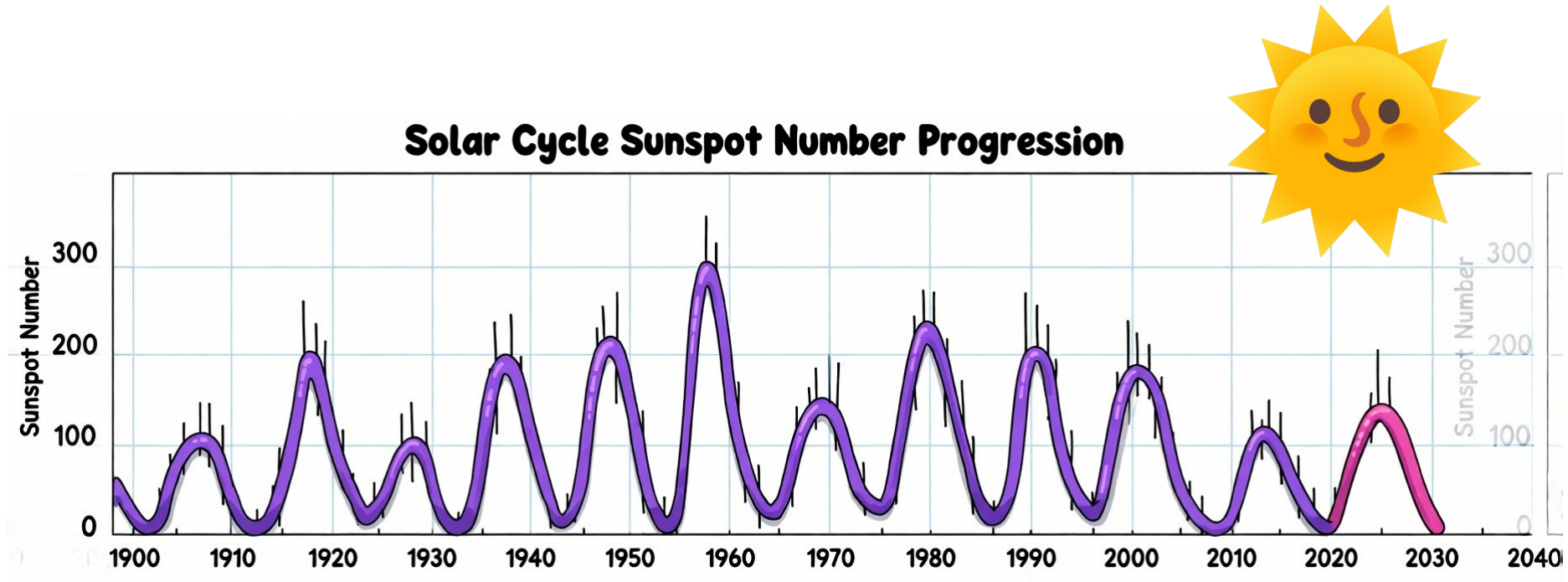


THE SOLAR CYCLE AND SUNSPOTS

- THE SUN GOES THROUGH **PREDICTABLE CYCLES** THAT DRAMATICALLY AFFECT RADIO PROPAGATION AND EARTH'S WEATHER ALIKE.
- SUNSPOTS INDICATE ACTIVE REGIONS ON THE SUN THAT EMIT MORE ULTRAVIOLET (UV) AND EXTREME ULTRAVIOLET (EUV) RADIATION → STRONGER IONIZATION OF THE UPPER ATMOSPHERE.
- THE AVERAGE SUNSPOT CYCLE IS **11 YEARS**.

B-007-005: SOLAR ACTIVITY AND ITS IMPACT ON HF PROPAGATION

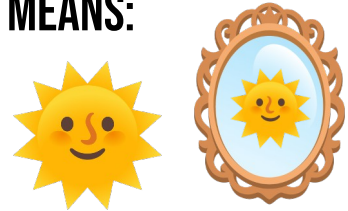
THE SOLAR CYCLE AND SUNSPOTS



B-007-005: SOLAR ACTIVITY AND ITS IMPACT ON HF PROPAGATION

SOLAR FLUX AND MEASURING SOLAR ACTIVITY

- WHY **SOLAR FLUX INDEX** (SFI) IS IMPORTANT FOR HF RADIO: THE IONOSPHERE ACTS LIKE A GIANT MIRROR FOR HF SIGNALS, BOUNCING THEM BACK TO EARTH SO WE CAN MAKE LONG-DISTANCE CONTACTS. THE KEY FACTOR IS THE ELECTRON DENSITY IN THOSE REFLECTING LAYERS (ESPECIALLY THE F2 LAYER). WHEN THE SUN IS MORE ACTIVE, IT PUMPS OUT MORE ULTRAVIOLET AND X-RAY RADIATION, WHICH INCREASES IONIZATION AND CREATES A DENSER, MORE EFFECTIVE "MIRROR." HIGHER SFI NUMBERS DIRECTLY REFLECT STRONGER SOLAR ACTIVITY, WHICH MEANS:
 - GREATER ELECTRON DENSITY IN THE IONOSPHERE
 - STRONGER, MORE RELIABLE REFRACTION/REFLECTION OF HF SIGNALS
 - BETTER PROPAGATION CONDITIONS — OFTEN LONGER SKIP DISTANCES, STRONGER SIGNALS, AND OPENINGS ON HIGHER BANDS (LIKE 10M, 12M, 15M) THAT MIGHT OTHERWISE BE DEAD
- IN SHORT: THE HIGHER THE SFI, THE MORE "COOPERATIVE" THE IONOSPHERE TENDS TO BE FOR HF DX AND GENERAL SKYWAVE COMMUNICATION.



B-007-005: SOLAR ACTIVITY AND ITS IMPACT ON HF PROPAGATION

SOLAR FLUX AND MEASURING SOLAR ACTIVITY

- THERE ARE LOTS OF EXCELLENT WEBSITES THAT PUBLISH REAL-TIME CONDITIONS THAT IMPACT RADIO PROPAGATION.

- 'JUST-THE-GRID' IS ONE OF THEM:

[HTTPS://SOLARCDX.COM/JUST-THE-GRID/](https://solarcdx.com/just-the-grid/)

- ALL COMMUNICATION FREQUENCIES THROUGHOUT THE SPECTRUM ARE AFFECTED IN VARYING DEGREES BY: THE SUN



THE GRID®

Space Weather Monitoring - Real-Time HF Conditions - [Help](#)

Solar Wind ↑ 446 km/sec	IMF Bx 1.49 nT	Phi Angle 291 deg
K index 1.67	IMF By -3.88 nT	Radio Blackout R0
A index 6	IMF Bz 0.27 nT	Solar Radiation S0
SUNSPOT # 43	IMF Bt 4.16 nT	Geomag Storm G0
10.7cm SFI 130	Plasma Temp ↓ 63K	XRAY Status B8.5



QUESTION SECTION B-007-006:
MAXIMUM USABLE FREQUENCY (MUF)
AND RELATED CONCEPTS

B-007-006: MAXIMUM USABLE FREQUENCY (MUF) AND RELATED CONCEPTS

CRITICAL FREQUENCY – THE VERTICAL LIMIT

- OBSERVATORIES PROBE THE IONOSPHERE AT VERTICAL INCIDENCE. THEY ARE MEASURING **THE CRITICAL FREQUENCY**.
- THE CRITICAL FREQUENCY IS THE **HIGHEST RADIO FREQUENCY THAT CAN BE REFLECTED STRAIGHT BACK TO EARTH** BY A PARTICULAR IONOSPHERIC LAYER WHEN TRANSMITTED VERTICALLY UPWARD (AT NORMAL INCIDENCE).
- ABOVE THIS FREQUENCY, RADIO WAVES PENETRATE THROUGH THE LAYER AND **ESCAPE INTO SPACE**.
- BELOW IT, THEY ARE **REFLECTED/REFRACTION BACK DOWN**, ENABLING SKYWAVE PROPAGATION FOR HF RADIO COMMUNICATIONS.

B-007-006: MAXIMUM USABLE FREQUENCY (MUF) AND RELATED CONCEPTS

MAXIMUM USABLE FREQUENCY (MUF) – THE OBLIQUE REAL-WORLD LIMIT

- **MUF** IS THE HIGHEST FREQUENCY AT WHICH A SIGNAL WILL REACH A GIVEN DESTINATION
- FREQUENCIES **BELOW MUF** ARE REFRACTED BACK (GOOD SKIP).
- FREQUENCIES **ABOVE MUF** PENETRATE OUT INTO SPACE (LOST).



B-007-006: MAXIMUM USABLE FREQUENCY (MUF) AND RELATED CONCEPTS

FACTORS AFFECTING MUF VARIATION



- THE ANSWER IS ALWAYS THE **SUN**.
- SOLAR RADIATION DRIVES DAILY AND LONG-TERM CHANGES.
- WHEN THE SOLAR UV RADIATION INCREASES, MUF INCREASES
- B-007-006-007 AT WHAT POINT IN THE SOLAR CYCLE DOES THE 20-METRE BAND USUALLY SUPPORT WORLDWIDE PROPAGATION DURING DAYLIGHT HOURS? **ANSWER: AT ANY POINT IN THE SOLAR CYCLE**

B-007-006: MAXIMUM USABLE FREQUENCY (MUF) AND RELATED CONCEPTS

PRACTICAL WAYS TO CHECK PROPAGATION AND SEASONAL EFFECTS

- ONE WAY TO DETERMINE IF THE MAXIMUM USABLE FREQUENCY (MUF) IS HIGH ENOUGH TO SUPPORT 28 MHZ PROPAGATION BETWEEN YOUR STATION AND WESTERN EUROPE IS TO **LISTEN FOR 10M BEACON STATIONS**. BEACONS TRANSMIT CONTINUOUSLY, MUCH LIKE THE TIME STATIONS. IF YOU CAN HEAR THEM ON THE DESIRED BAND, THAT BAND IS OPEN.
- **DAYTIME IN SUMMER** KILLS 160M AND 80M BANDS.





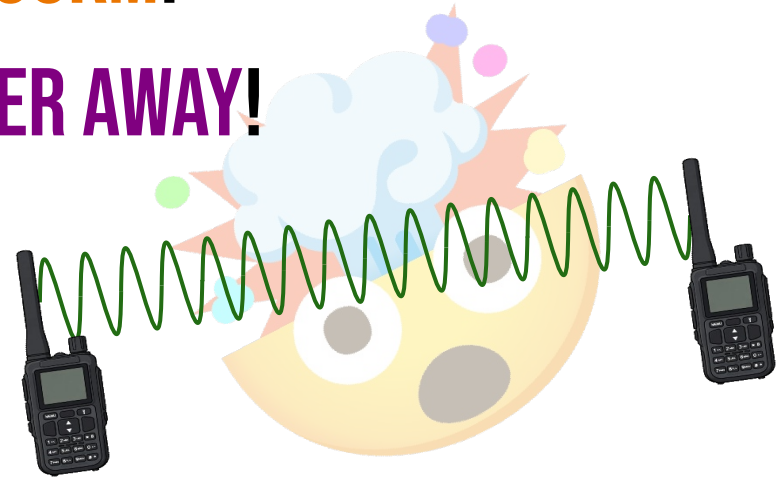
QUESTION SECTION B-007-007:

VHF/UHF AND ENHANCED PROPAGATION MODES

B-007-007: VHF/UHF AND ENHANCED PROPAGATION MODES

NORMAL VHF/UHF PROPAGATION AND TROPOSPHERIC EFFECTS

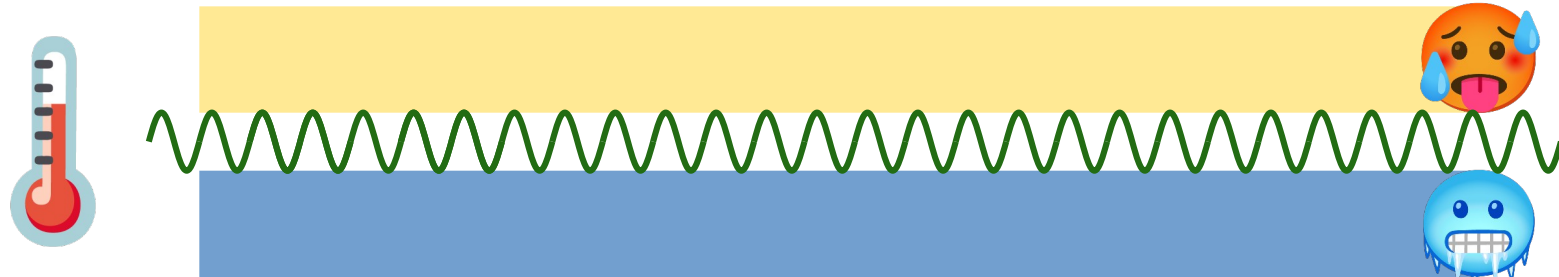
- VHF/UHF IS MOSTLY LINE-OF-SIGHT, BUT THE **TROPOSPHERE** (LOWER ATMOSPHERE) EXTENDS RANGE VIA BENDING AND **DUCTING**.
- THE APPROXIMATE RANGE OF THIS IS **800KM!**
- IT LETS YOU **CONTACT STATIONS FARTHER AWAY!**



B-007-007: VHF/UHF AND ENHANCED PROPAGATION MODES

NORMAL VHF/UHF PROPAGATION AND TROPOSPHERIC EFFECTS

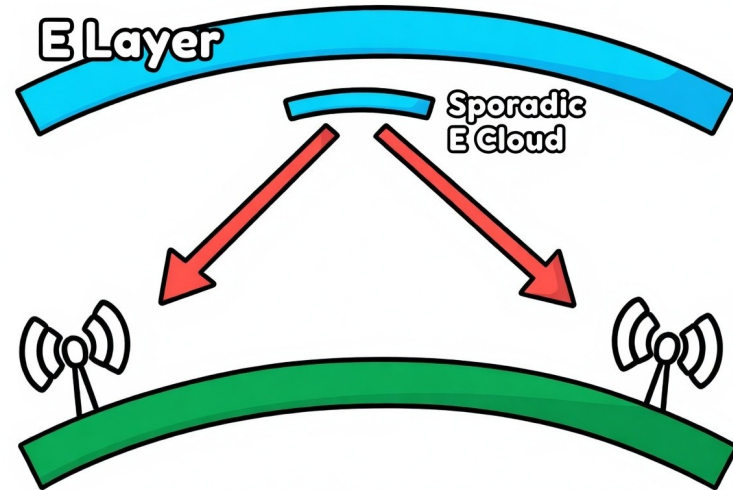
- **A TEMPERATURE INVERSION** TRAPS SIGNALS IN A "DUCT" BETWEEN COOL/MOIST AIR BELOW AND WARM/DRY AIR ABOVE, GUIDING VHF/UHF WAVES HUNDREDS OF KM ALONG THE EARTH'S CURVATURE—GREAT FOR 2 M/70 CM DX DURING STABLE WEATHER (EX: HIGH-PRESSURE SYSTEMS, COASTAL AREAS).



B-007-007: VHF/UHF AND ENHANCED PROPAGATION MODES

SPORADIC-E PROPAGATION (MOSTLY ON 6 METRES)

- **SPORADIC-E** IS THE MOST COMMON "ENHANCED" MODE FOR VHF, CAUSED BY DENSE IONIZED PATCHES (LIKE A CLOUD) AT **E-REGION HEIGHT**.
- THIS IS MAINLY ONLY FOR **6M**. ANY HIGHER FREQUENCIES WILL USUALLY CUT RIGHT THROUGH INTO SPACE.



AURORAL PROPAGATION (VHF PHENOMENON)

- AURORA (NORTHERN LIGHTS) SCATTERS VHF SIGNALS OFF IONIZED PARTICLES IN THE **E REGION**.
- AURORA FORMS IN OVAL AROUND MAGNETIC POLES; SIGNALS SCATTER OFF AURORAL CURTAINS TO THE **NORTH**, SO POINT BEAM **NORTH** FOR BEST CONTACTS (EVEN IF STATION IS EAST/WEST/SOUTH).

B-007-007: VHF/UHF AND ENHANCED PROPAGATION MODES

AURORAL PROPAGATION (VHF PHENOMENON)

B-007-007-009 WHICH ANALOG EMISSION MODE IS THE MOST RELIABLE IN AURORAL PROPAGATION? **ANSWER:** CW, BECAUSE IT IS READABLE EVEN WHEN DISTORTED

AURORAL SIGNALS OFTEN HAVE ROUGH, RASPY TONE (DOPPLER BROADENING FROM PARTICLE MOTION); SSB VOICE BECOMES GARBLED, BUT NARROW CW (MORSE) CUTS THROUGH.





QUESTION SECTION B-007-008:

SCATTER PROPAGATION MODES

B-007-008: SCATTER PROPAGATION MODES

HF SCATTER PROPAGATION (FILLING THE SKIP ZONE)

- SCATTER ON HF USES IRREGULARITIES IN THE IONOSPHERE (OFTEN D OR LOWER E REGION) TO REDIRECT SMALL PORTIONS OF THE SIGNAL INTO AREAS **UNREACHABLE BY NORMAL GROUND WAVE OR SINGLE-HOP SKY WAVE.**
- IF YOU RECEIVE **A WEAK, DISTORTED SIGNAL CLOSE** TO THE MAXIMUM USABLE FREQUENCY, IT'S PROBABLY SCATTER.

HF SCATTER PROPAGATION (FILLING THE SKIP ZONE)

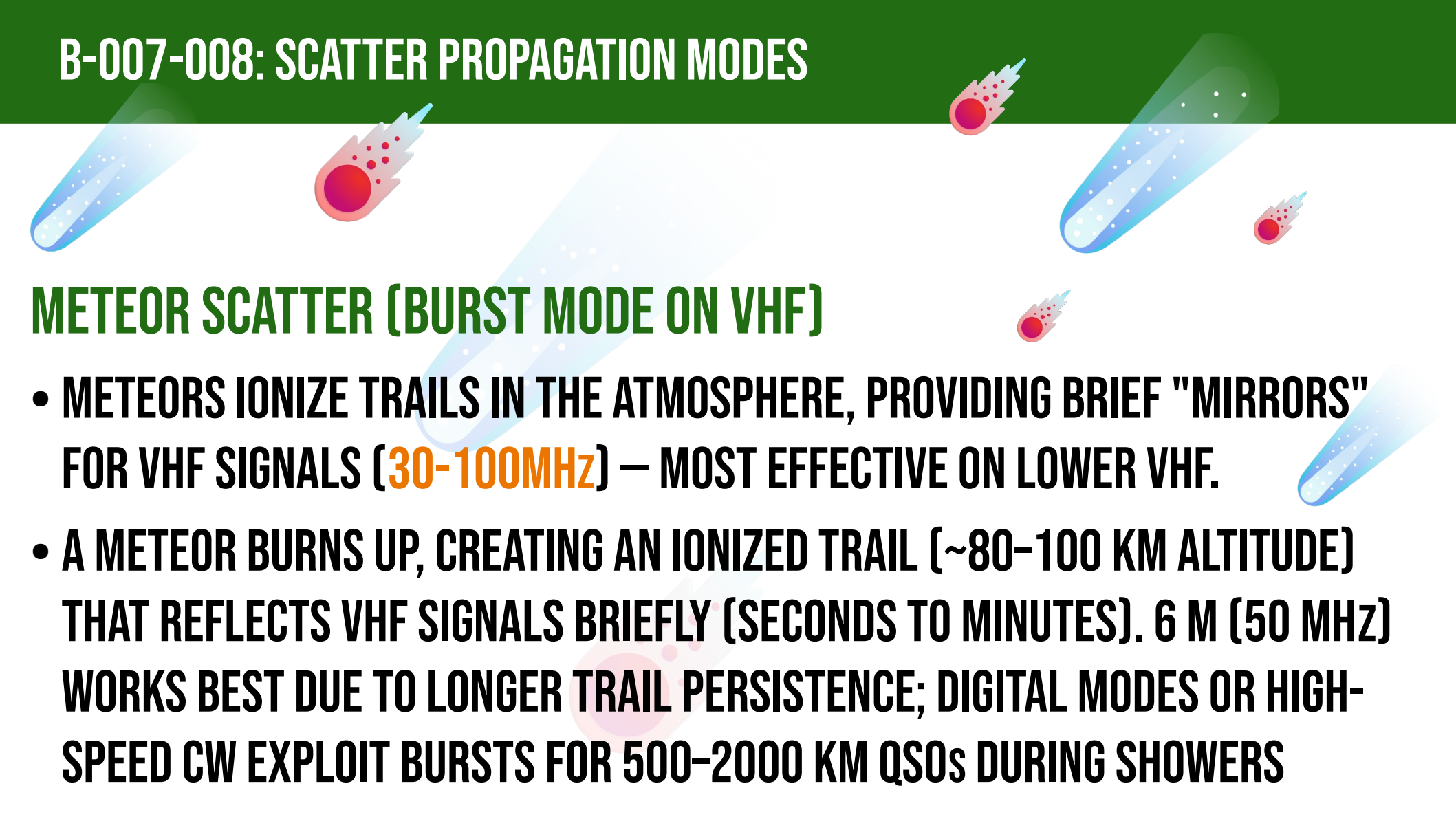
- **WHY IS SCATTER WEAK & DISTORTED?**
 - **ENERGY SCATTERED INTO THE SKIP ZONE THROUGH SEVERAL RADIO-WAVE PATHS BEING REDIRECTED IN MANY DIRECTIONS.**
 - **ONLY A SMALL PART OF THE SIGNAL ENERGY IS SCATTERED INTO THE SKIP ZONE.**

B-007-008: SCATTER PROPAGATION MODES

TROPOSPHERIC SCATTER (VHF/UHF BEYOND HORIZON)

- **TROPOSPHERIC SCATTER** USES SMALL **DENSITY VARIATIONS AND WATER-VAPOUR** IN THE LOWER ATMOSPHERE TO SCATTER VHF/UHF SIGNALS OVER LONG DISTANCES (OFTEN 400–1500 KM) WITHOUT NEEDING DUCTING.
- SIGNALS SCATTER OFF TURBULENT VOLUMES IN THE TROPOSPHERE (COMMON VOLUME BETWEEN TX AND RX ANTENNAS), ENABLING RELIABLE BUT WEAK PATHS FAR BEYOND LINE-OF-SIGHT (USED COMMERCIALY FOR POINT-TO-POINT LINKS AND BY HAMS FOR VHF/UHF DX).

B-007-008: SCATTER PROPAGATION MODES



METEOR SCATTER (BURST MODE ON VHF)

- METEORS IONIZE TRAILS IN THE ATMOSPHERE, PROVIDING BRIEF "MIRRORS" FOR VHF SIGNALS (30-100MHz) — MOST EFFECTIVE ON LOWER VHF.
- A METEOR BURNS UP, CREATING AN IONIZED TRAIL (~80-100 KM ALTITUDE) THAT REFLECTS VHF SIGNALS BRIEFLY (SECONDS TO MINUTES). 6 M (50 MHz) WORKS BEST DUE TO LONGER TRAIL PERSISTENCE; DIGITAL MODES OR HIGH-SPEED CW EXPLOIT BURSTS FOR 500-2000 KM QSOs DURING SHOWERS



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