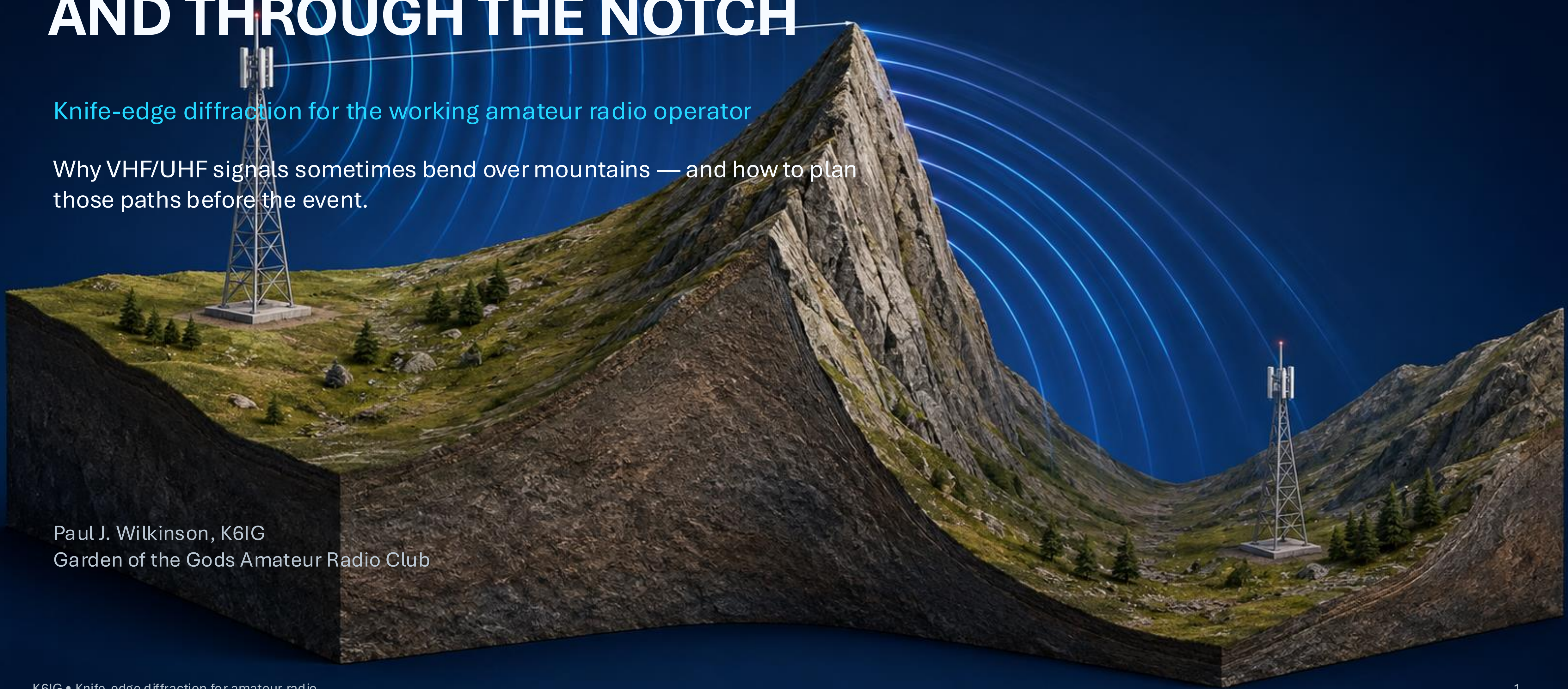
HAM CLUB TECHNICAL PROGRAM

OVER THE RIDGE AND THROUGH THE NOTCH



Knife-edge diffraction for the working amateur radio operator

Why VHF/UHF signals sometimes bend over mountains — and how to plan those paths before the event.

Paul J. Wilkinson, K6IG
Garden of the Gods Amateur Radio Club

Quick term primer

The radio vocabulary used in this presentation.

HF: 3–30 MHz; often uses ionospheric skywave propagation.

VHF: 30–300 MHz; includes 6 m and 2 m amateur bands.

UHF: 300 MHz–3 GHz; includes 70 cm and 23 cm.

Simplex: station-to-station communication on one frequency, no repeater.

Repeater: an elevated relay station that receives and retransmits.

Shadow zone: area behind an obstacle where direct rays do not reach.

Antenna gain: directing power in a favored direction, measured in dB.

Yagi: a directional antenna commonly used for VHF/UHF weak-signal work.

TERM **VHF/UHF:** radio bands where local terrain and antenna height strongly affect whether a path works.

Glossary I: radio and path terms

Use this as a reference slide or appendix.

RF: radio frequency energy used for wireless communication.

LOS: line of sight; direct straight path between antennas.

Skywave: HF energy refracted by the ionosphere.

Groundwave: signal following the Earth's surface, important at lower frequencies.

Scatter: energy redirected by terrain, weather, or irregularities.

Tropo: tropospheric propagation due to lower-atmosphere conditions.

S-unit: receiver meter unit; often roughly 6 dB per S-unit, but not always.

Mode: signal format: FM voice, SSB, CW, FT8, packet, Winlink, etc.

Bearing: direction to aim a directional antenna.

Preamp: low-noise amplifier near the receiver that improves weak-signal reception.

TERM **glossary:** a quick reference for the presentation's technical terms.

Glossary II: model and math terms

The terms behind the calculations.

Diffraction: wave bending around an edge or through an opening.

Fresnel zone: a volume around the direct path where signals combine constructively.

v: dimensionless parameter describing obstruction severity.

J(v): estimated diffraction loss in dB as a function of v.

Free-space loss: normal spreading loss without terrain obstruction.

Obstruction loss: extra loss caused by terrain blocking or clipping the path.

DEM: digital terrain elevation data.

SRTM: Shuttle Radar Topography Mission elevation dataset.

USGS 3DEP: high-resolution U.S. national elevation data.

ITU-R P.526: international recommendation covering radio-wave diffraction methods.

TERM **J(v):** the obstruction-loss estimate from the knife-edge diffraction curve or approximation.

Glossary III: operating and tool terms

Words you will hear in the field-planning workflow.

SPLAT!: open-source Signal Propagation, Loss, and Terrain analysis tool.

Radio Mobile: browser-based or desktop terrain propagation tool.

HeyWhatsThat: visibility and Fresnel-zone scouting tool.

VOACAP: HF propagation prediction tool based on ionospheric models.

Go-kit: portable radio equipment prepared for deployment.

EmComm: emergency communications.

Rover: mobile contest station that operates from multiple locations.

Grid square: Maidenhead locator used in VHF contests.

Cross-band: relay or operation using different bands for input/output.

Fallback band: alternate band selected when the primary path fails.

TERM **terrain profile:** a side-view slice of elevation along the radio path between the stations.

The everyday mystery

Signals get through — even when they shouldn't.

Portable VHF operation aimed across a mountain path

Stand on the west side of Colorado Springs and the Front Range looks like a wall built to block VHF/UHF.

Line-of-sight calculations often say "no."

Ridge-blocked paths still sometimes work.

The difference is added path loss, not magic.

If we can estimate the loss, we can plan the station.

The real question is not "blocked or clear?" It is "how much loss?"

TERM **line of sight:** a direct, unobstructed straight path between the transmitting and receiving antennas.

What you will be able to do

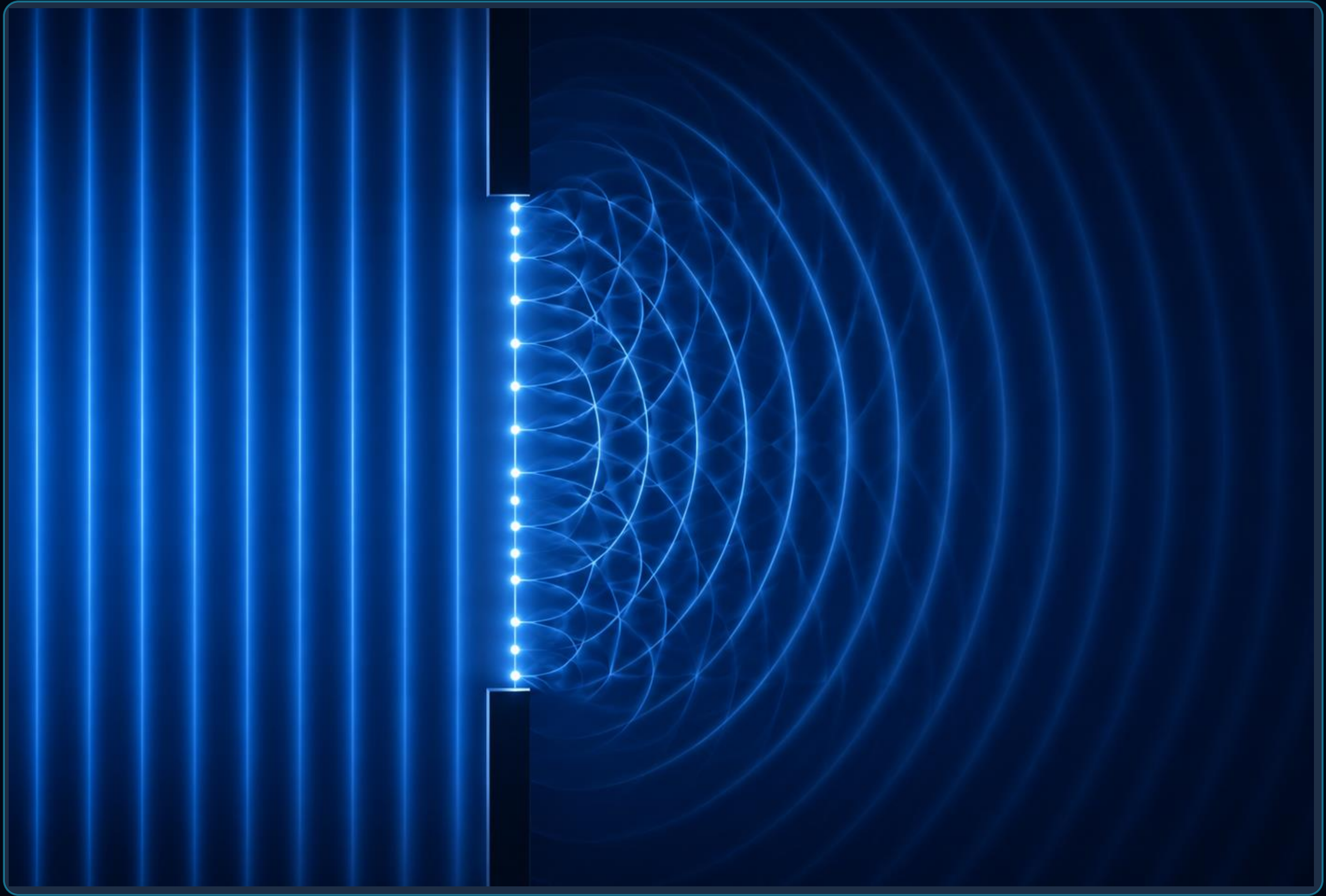
A practical propagation checklist for ridge-blocked paths.

1	**Explain**	why a ridge can behave like a new radio source
2	**Estimate**	when Fresnel-zone blockage becomes serious
3	**Translate**	the parameter v into added path loss in dB
4	**Plan**	height, antenna gain, band choice, and relay options
5	**Verify**	predictions with field tests and club logs

TERM **path loss:** the total reduction in signal strength between transmitter and receiver; obstruction loss adds to normal free-space loss.

Radio waves are waves, not laser beams

Huygens' Principle explains why an edge can become a new source.



Wavefronts bend from an edge into the shadowed region

The "radio waves = light rays" model works until an edge is involved.

Huygens' Principle: every point on a wavefront acts like a tiny radiator.

A ridge crest, roofline, or canyon rim can become a secondary source.

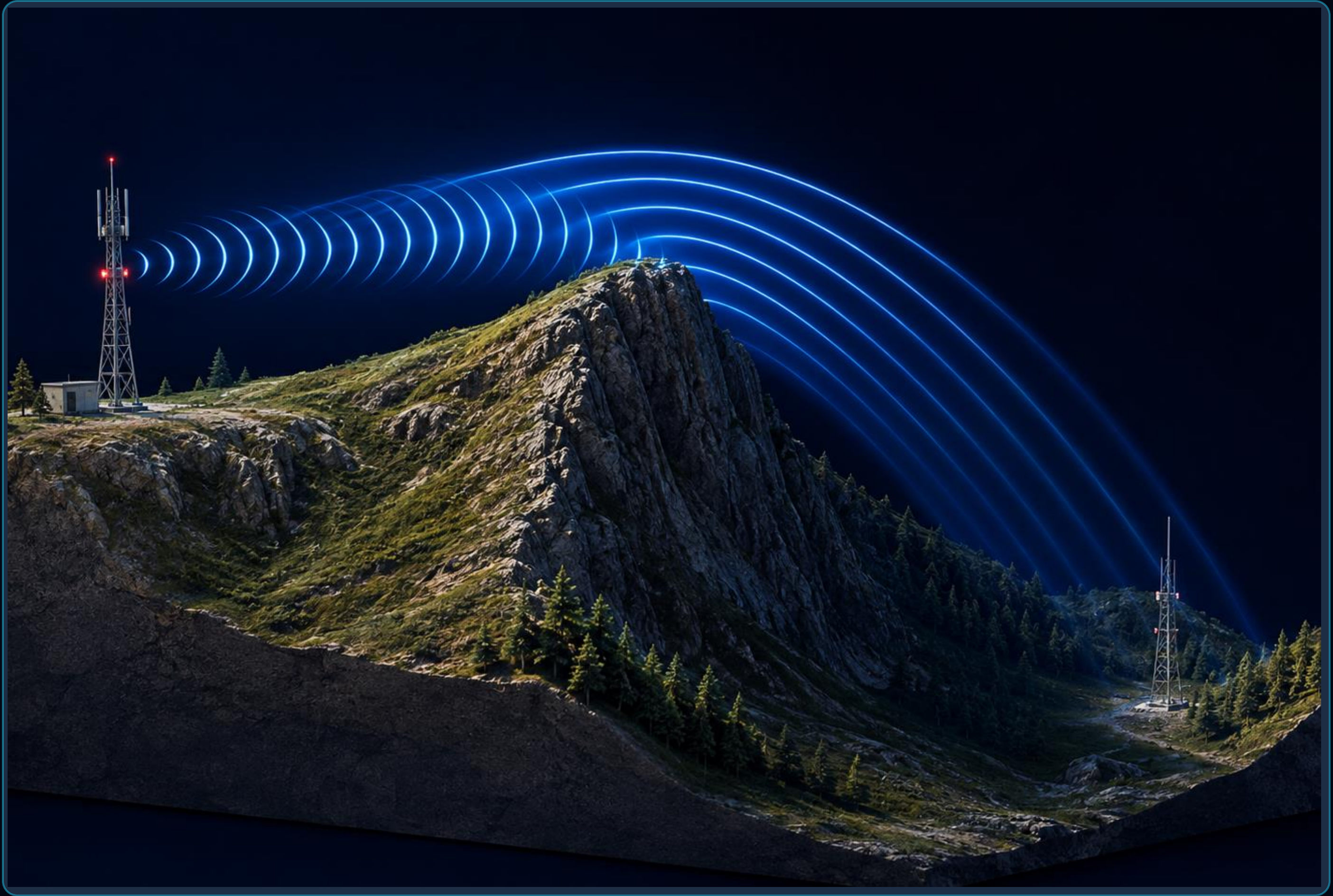
Energy spreads into the geometric shadow behind the obstacle.

At the edge, the wave does not simply stop. Some energy bends around.

TERM **Huygens' Principle:** a wave model saying each point on a wavefront creates secondary wavelets that combine to form the next wavefront.

Knife-edge diffraction in one picture

A ridge crest diffracts energy into the shadow zone.



Original 3D terrain illustration of a ridge diffraction path

The ridge is not "transparent." It is an aperture with a penalty.

Best textbook case: one sharp, dominant ridge.

Most useful at VHF/UHF, where terrain can act like a knife edge.

A blocked path is still a path — with added diffraction loss.

Broad ridges and multiple ridges require more advanced models.

TERM **knife edge:** an idealized sharp obstacle that diffracts a wave; a narrow mountain ridge is often close enough for planning.

The shadow zone is not completely dark

Diffraction fills some of the area behind the obstacle.

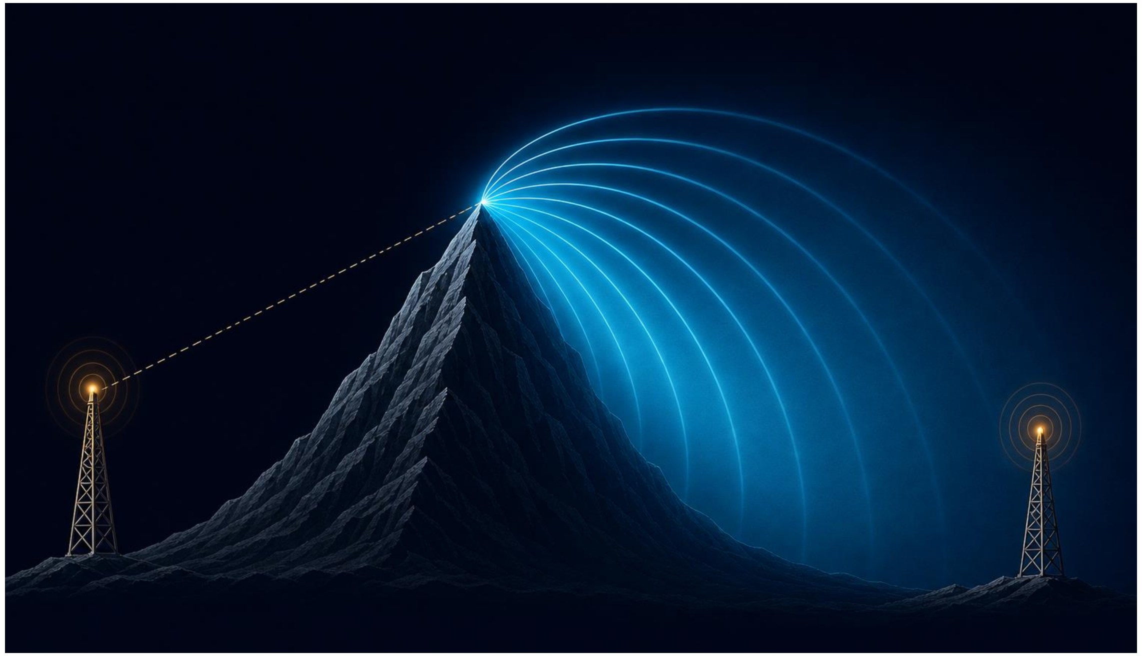


Illustration: original; adapted from ITU-R P.526-16.

In optics, the shadow looks dark. In radio, the shadow can still contain useful signal.

The edge produces a new spreading wavefront.

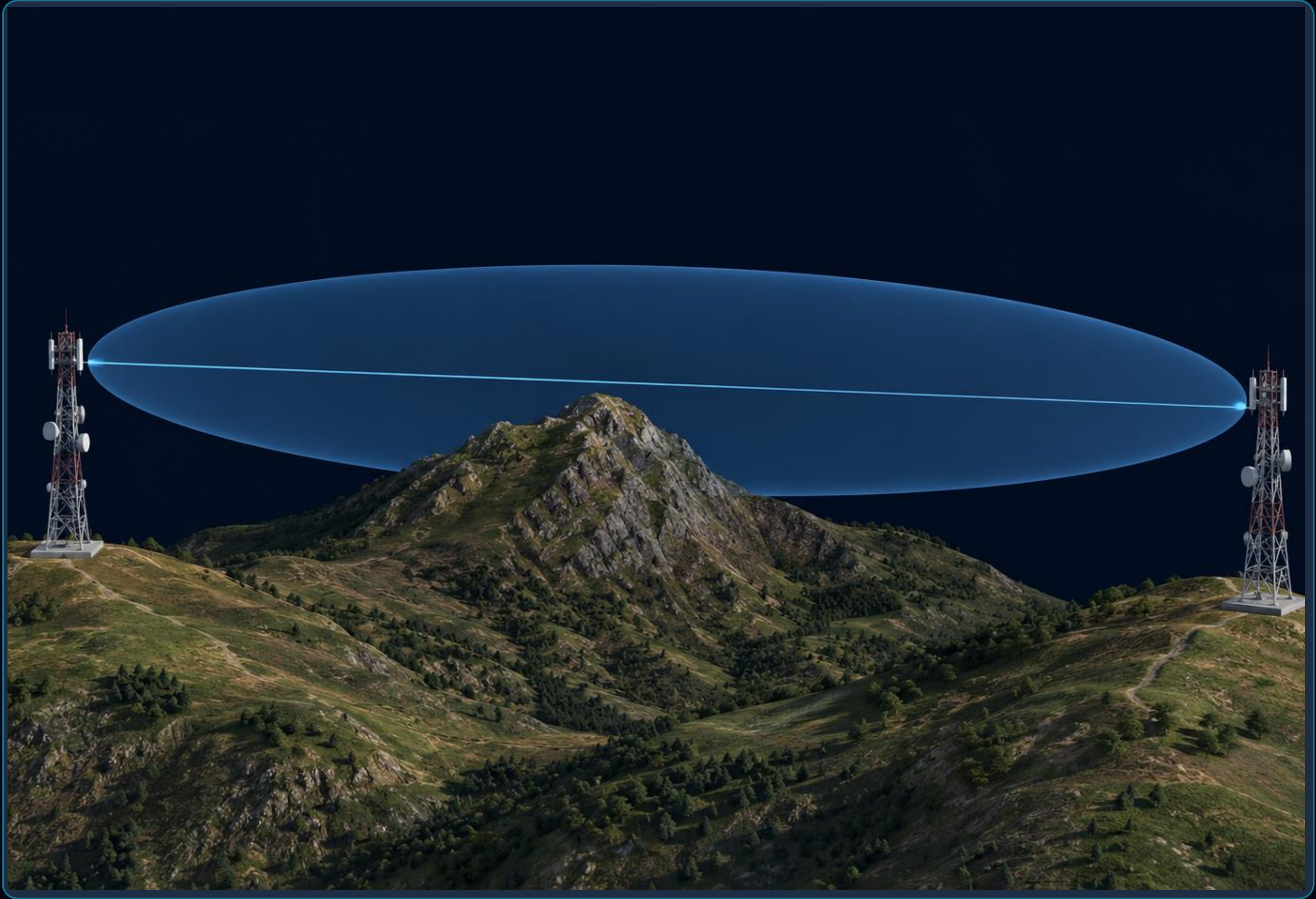
Signal strength drops as the receiver moves deeper into the shadow.

The transition is gradual, not on/off. • Operators can exploit this when the link budget has enough margin.

TERM **shadow zone:** the region behind an obstruction where no direct straight-line signal path exists, but diffracted energy may still arrive.

Fresnel zones: clearance is three-dimensional

Line of sight is only the centerline of the path.



The first Fresnel zone is a volume around the direct path

What “clear” really means

Signals in the first Fresnel zone add mostly constructively.

Obstacles inside that zone begin stealing signal.

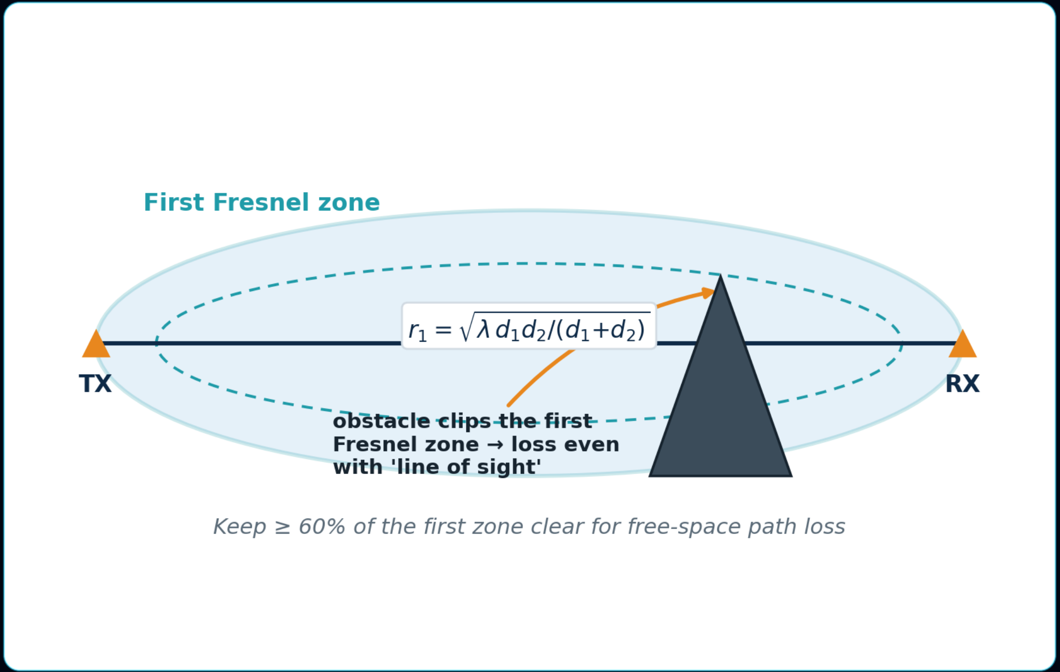
A topographic map can show clear LOS while the Fresnel zone is clipped.

For near free-space performance, clear about 60% of the first zone.

TERM **Fresnel zone:** a football-shaped volume around the direct path; objects in it can reduce signal even when the centerline is clear.

The first Fresnel-zone radius

The clearance requirement depends on wavelength and path geometry.



Graphic: first Fresnel zone and obstacle intrusion

$$r_1 = \sqrt{(\lambda \cdot d_1 \cdot d_2 / (d_1 + d_2))}$$

r_1: radius of the first Fresnel zone at the point of interest

λ: wavelength of the signal, in meters

d_1: distance from transmitter to the obstacle

d_2: distance from obstacle to receiver

Example: on a 50 km, 440 MHz path, the midpoint first-zone radius is roughly 65 m.

TERM **wavelength (λ):** the physical length of one RF wave cycle; wavelength equals the speed of light divided by frequency.

Why UHF diffraction is harder

Shorter wavelength makes the same ridge “look taller” electrically.

- The diffraction parameter v contains 1/λ.
- For the same ridge and distances, shorter wavelength increases v.
- Higher bands can still work when antenna gain and site placement compensate.
- That is why 2 m may work when 70 cm does not — unless you bring more antenna gain.

TERM **frequency:** how many RF cycles occur per second; higher frequency means shorter wavelength.

The one number that matters: v

The Fresnel–Kirchhoff diffraction parameter condenses the geometry.

$$v = h\sqrt{\left(2/\lambda \cdot \left(1/d_1 + 1/d_2\right)\right)}$$

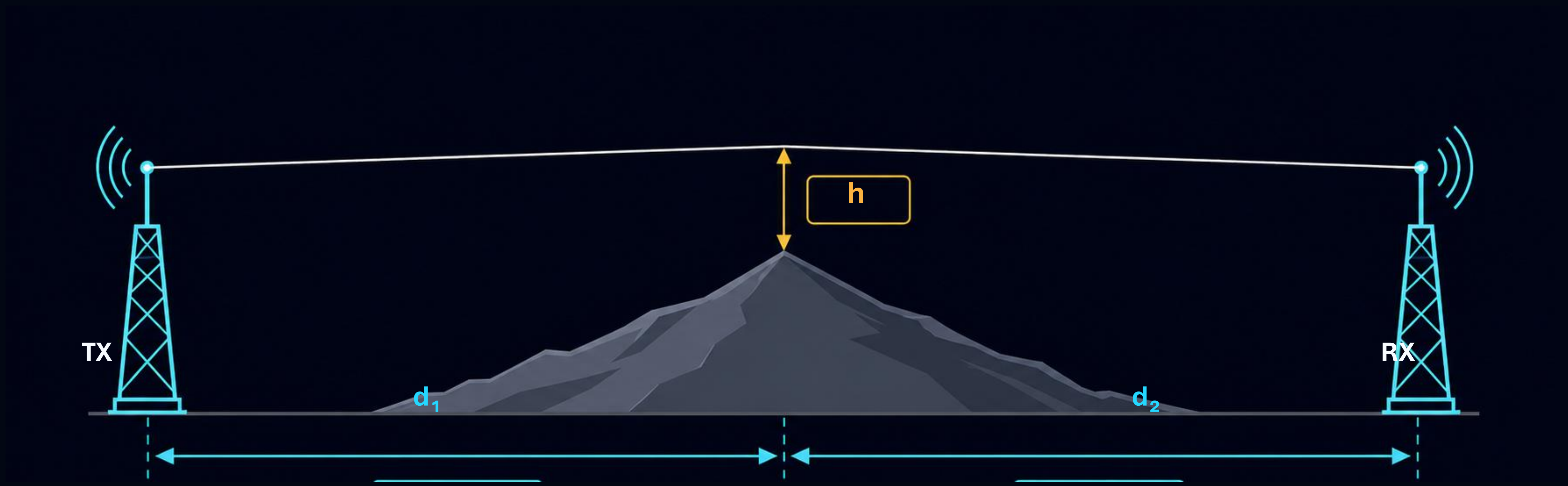
- **h** Obstacle height above the direct line, in meters. Negative h means the obstacle is below line of sight.
- **λ** Wavelength of the signal, in meters. Shorter wavelength raises v.
- **d_1** Distance from transmitter to the obstacle, in meters.
- **d_2** Distance from obstacle to receiver, in meters.
- **v** A dimensionless summary of how deep the obstruction is. Higher v means more loss.

TERM **Fresnel–Kirchhoff parameter v:** a single number that turns ridge geometry and wavelength into an estimate of obstruction severity.

Reading the geometry

h, d_1, and d_2 are measured relative to the direct path.

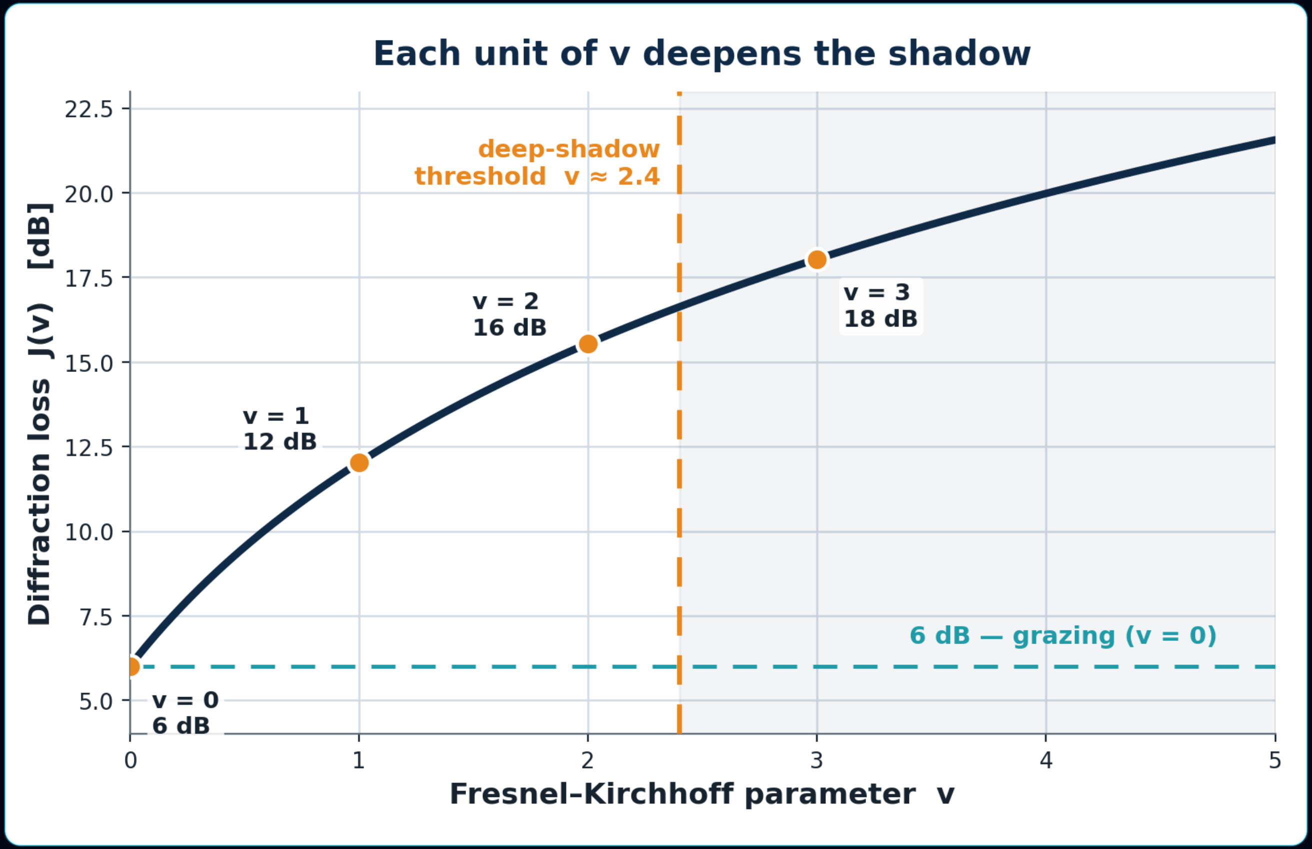
- h is measured above the direct TX–RX line, not above sea level.
- d_1 and d_2 are measured from each terminal to the obstacle.
- Moving the station or antenna changes h and may reduce loss dramatically.



TERM **h:** the obstacle height above the straight TX–RX line, not the obstacle elevation above sea level.

Diffraction loss rises fast

At v = 0 you are already down about 6 dB.



Diffraction loss J(v) versus Fresnel–Kirchhoff parameter v

Operator translation

v = 0: ridge grazes LOS → ~6 dB loss

v ≈ 1: moderate obstruction → around 12 dB

v ≈ 2: serious obstruction → roughly 16–20 dB

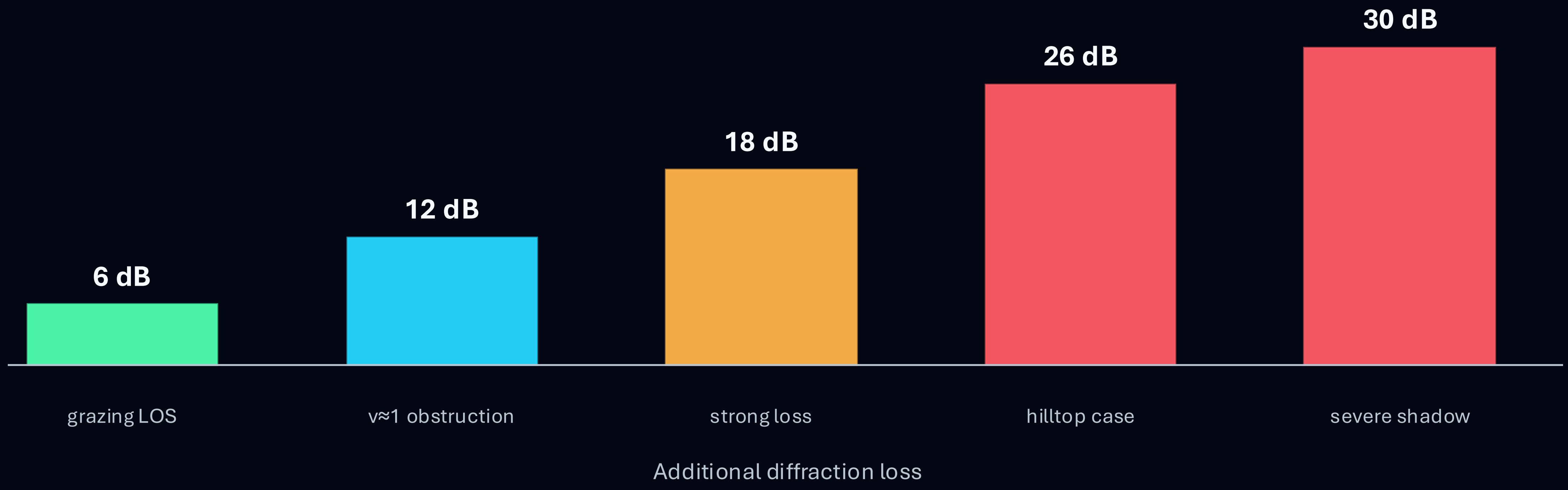
v > 2.4: deep shadow → needs gain, elevation, or relay

TERM dB (decibel): a logarithmic way to describe signal ratios; 10 dB is a factor of 10 in power, and 3 dB is about a factor of 2.

dB in the field: what loss feels like

A few dB matter; tens of dB change the operating plan.

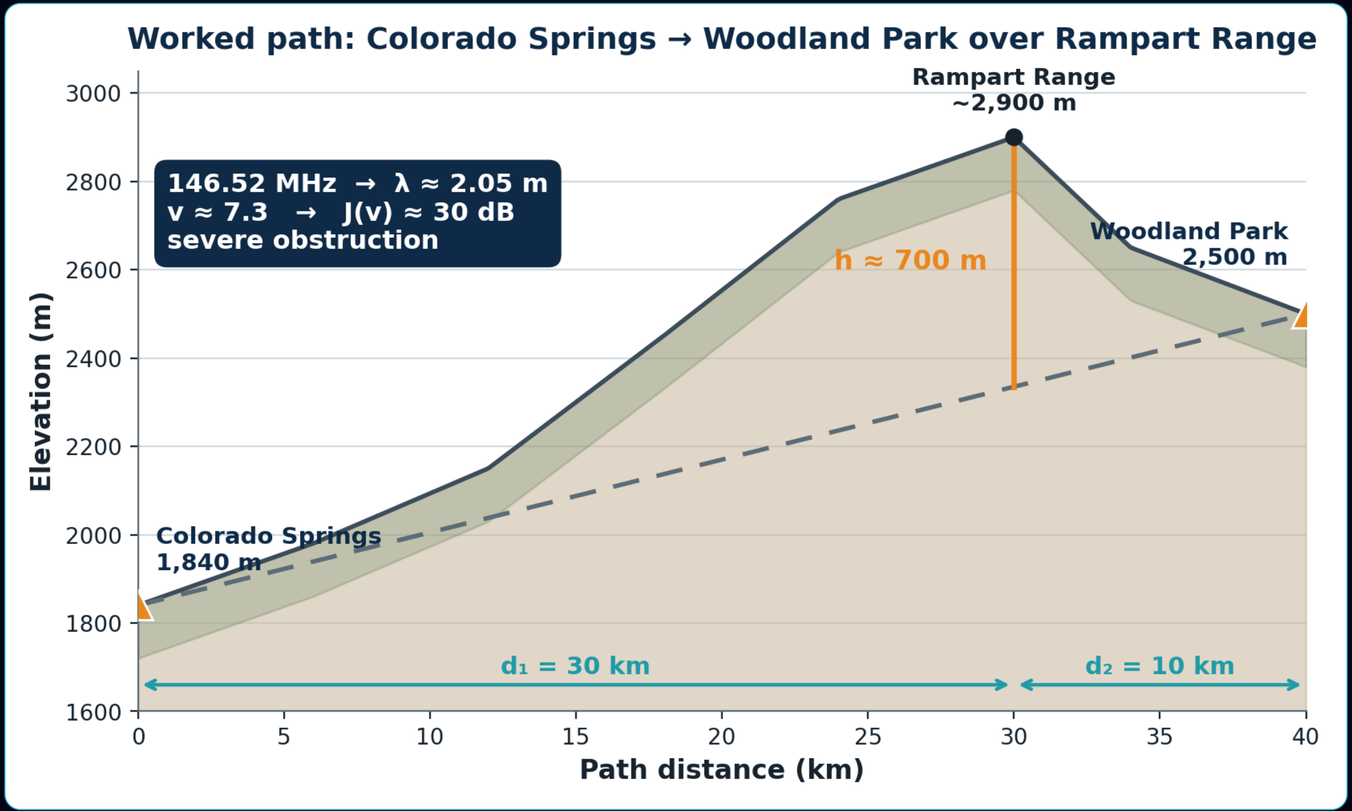
- +10 dB power means 10× transmitter power.
- +10 dB can also come from antenna gain or better placement.
- Loss is not mysterious: it is a link-budget number.
- Once estimated, choose gain, height, power, or relay.



TERM **link budget:** an accounting of gains and losses from transmitter to receiver; the path works when received signal exceeds required level.

Worked example: Colorado Springs → Woodland Park

Rampart Range creates a severe ridge obstruction on 2 m simplex.



Terrain profile and obstruction geometry

2 m FM simplex: 146.52 MHz

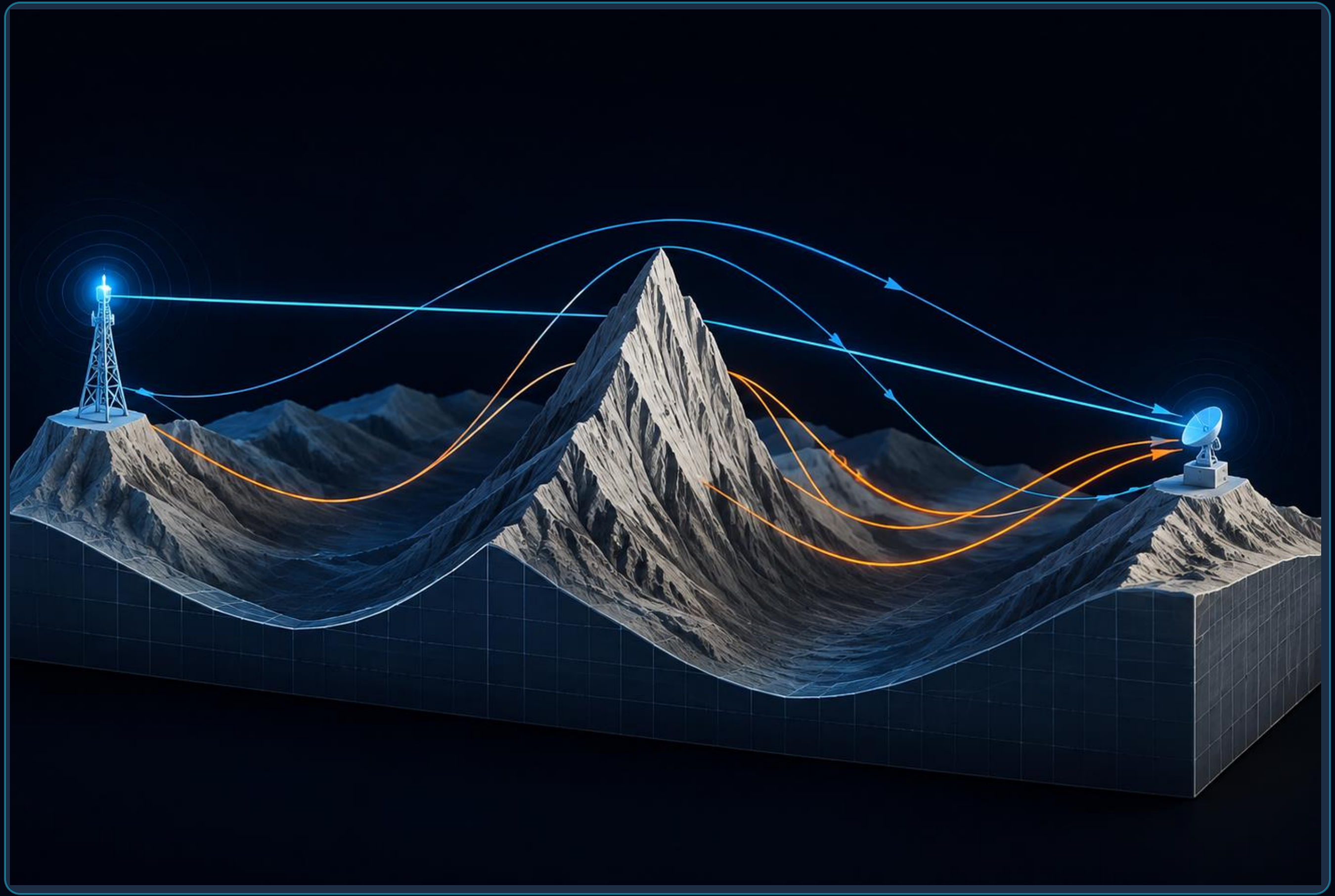
λ	≈ 2.05 m
h	≈ 700 m above direct line
d_1	≈ 30 km to ridge
d_2	≈ 10 km to receiver
v	≈ 7.3
J(v)	≈ 30 dB extra loss

Translation: marginal at best with 50 W and a modest antenna; better geometry matters more than optimism.

TERM **simplex:** direct station-to-station communication without a repeater; terrain and antenna placement matter more because there is no elevated relay.

Elevation usually beats power

Change the geometry before reaching for the amplifier.



Changing site height changes the path geometry

Two ways to gain margin

Option A: more power

50 W → 500 W = +10 dB
More current, heat, battery, and hardware.

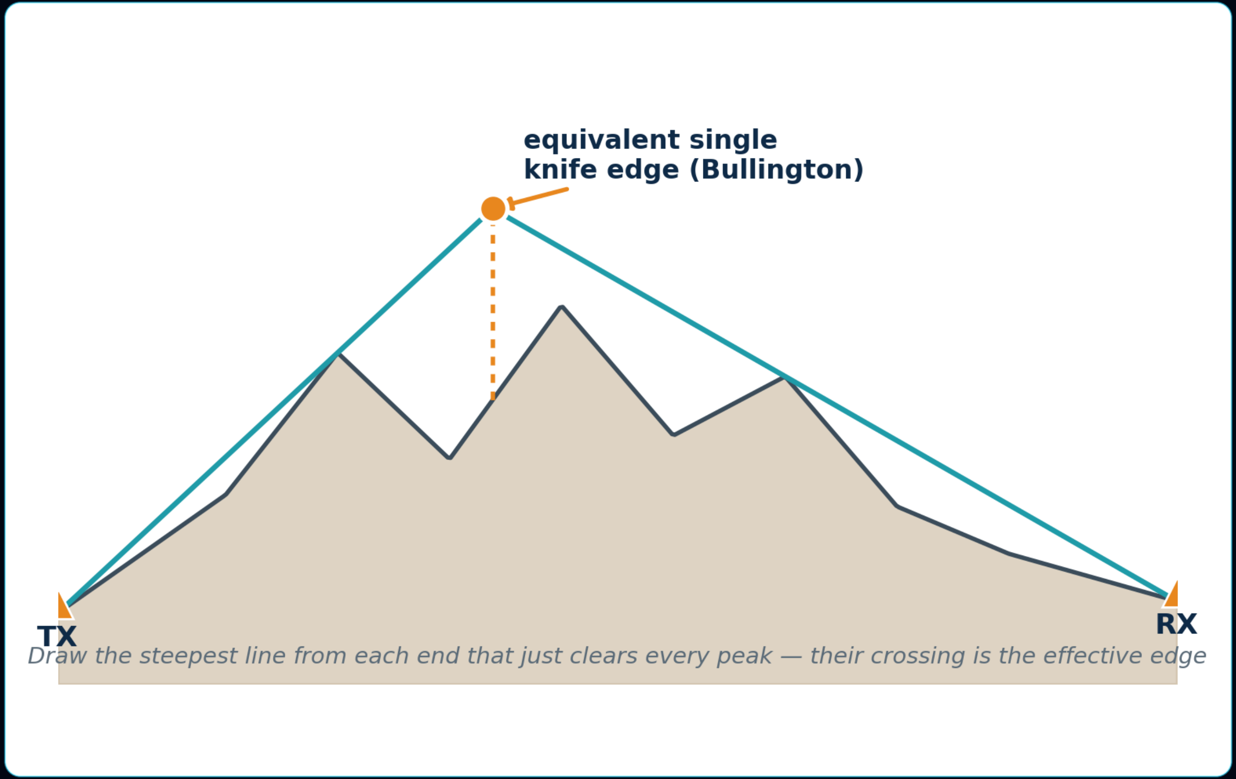
Option B: better site

Move higher or improve antenna height to reduce h. In the article example, a hilltop site reduced estimated loss by several dB without adding RF power.

TERM **system margin:** how much extra signal strength remains after all losses; positive margin means the link should work reliably.

Real terrain rarely gives one perfect edge

Multiple ridges require approximations or terrain software.



Bullington method: multiple ridges become one equivalent edge

Models you may see

Bullington	collapses multiple obstacles to one effective edge
Epstein–Peterson	handles successive edges individually
Deygout	finds the dominant edge first, then secondary edges
Longley–Rice	terrain-based model used by SPLAT! and Radio Mobile

TERM **Bullington method:** a practical approximation that replaces multiple terrain obstructions with one equivalent knife edge.

What the software is doing

Terrain tools turn map data into a propagation estimate.

1 **Elevation data**
digital terrain model: SRTM, USGS 3DEP

2 **Path profile**
terrain height along the TX–RX line

3 **Radio model**
Longley–Rice, knife-edge, or related model

4 **Loss estimate**
extra dB plus coverage/path maps

5 **Field test**
real signal reports to calibrate the model

Portable station and terrain-aware planning

Software is not a magic oracle; it is a structured way to combine terrain, frequency, antenna height, and model assumptions.

The best club practice is to save field results and compare them with predictions.

TERM **DEM:** Digital Elevation Model: gridded terrain elevation data used to build a path profile.

Free tools every VHF operator should know

Do the terrain work before you load the go-kit.

1 Scout

HeyWhatsThat

visibility, ridge scouting, Fresnel-zone overlays

→

2 Profile

SPLAT! / Radio Mobile

Longley–Rice path profiles and coverage maps

→

3 Decide

gain / height / power / relay

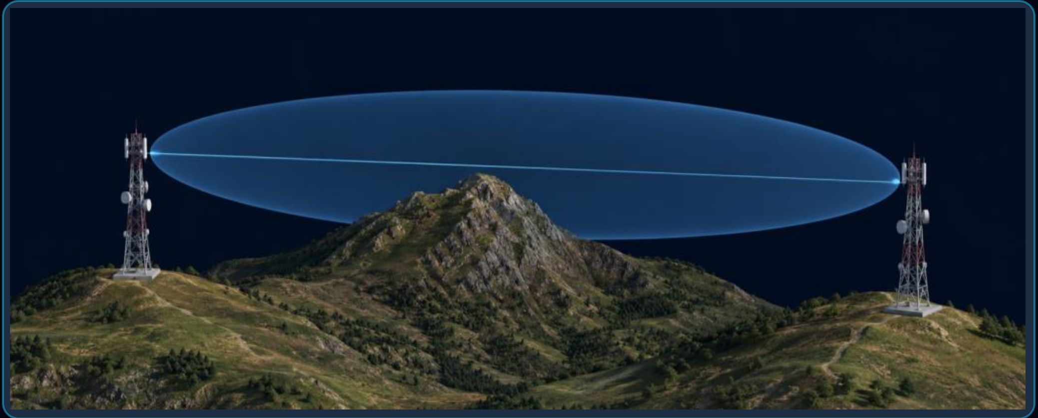
choose how to close the link budget

→

4 Verify

field test + log

compare predicted loss to measured performance



Terrain + Fresnel-zone visualization

SPLAT!: open-source path and coverage analysis.

Radio Mobile Online: browser-based profile modeling.

HeyWhatsThat: quick visibility and Fresnel scouting.

USGS 3DEP / SRTM: elevation datasets behind the tools.

TERM **Longley–Rice:** an irregular-terrain radio propagation model widely used for VHF/UHF path and coverage prediction.

Emergency communications: plan for the worst path

Predictability matters when repeaters and cell towers are unavailable.

Identify critical simplex paths before the incident.

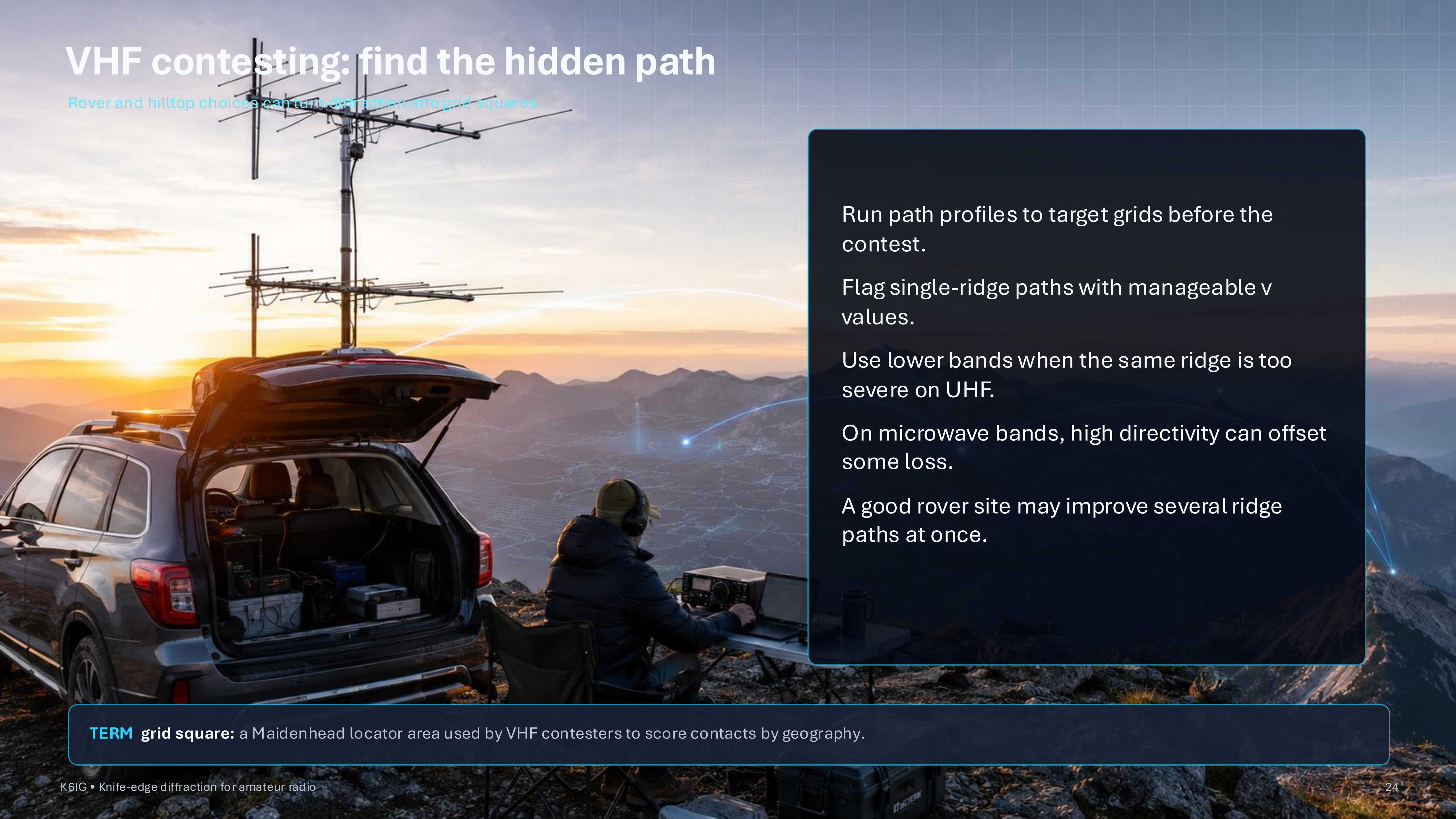
Calculate whether terrain loss fits the link budget.

Preselect alternate hilltop positions and relay sites.

Document antennas, bearings, expected signal strength, and fallback bands.

A predictable 15 dB ridge loss can be easier to plan around than a fluctuating scatter path.

TERM **ARES/RACES:** amateur radio emergency-service organizations that provide communications support when normal systems are impaired.



VHF contesting: find the hidden path

Rover and hilltop choices can turn diffraction into grid squares.

Run path profiles to target grids before the contest.

Flag single-ridge paths with manageable v values.

Use lower bands when the same ridge is too severe on UHF.

On microwave bands, high directivity can offset some loss.

A good rover site may improve several ridge paths at once.

TERM **grid square:** a Maidenhead locator area used by VHF contesters to score contacts by geography.

Operator playbook

When the path is ridge-blocked, work the geometry.

Move higher

Lower effective h before adding power.

Aim at the edge

Peak on the diffracting ridge, not necessarily the receiver.

Use gain wisely

A Yagi can buy more than an amplifier.

Try lower bands

2 m may bend better than 70 cm in the same geometry.

Have relays ready

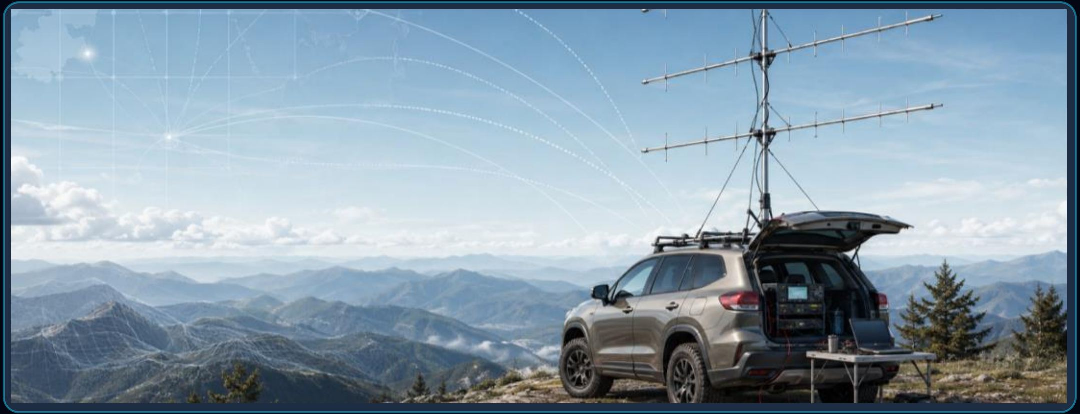
Preplan hilltop operators or cross-band options.

TERM **bearing:** the compass direction to point a directional antenna; with diffraction, peak may occur at the ridge edge rather than the receiver.

A practical field-test procedure

Close the loop between prediction and measured performance.

1. **Predict** — terrain profile & expected loss
2. **Schedule** — coordinated beacon or net
3. **Point** — bearing, polarity, antenna height
4. **Measure** — S-meter, audio, decode rate
5. **Log** — compare model with reality



Rover-style test setup

Test during a clear, low-multipath period; then repeat under different conditions.

Record coordinates, antenna height, power, gain, polarity, bearing, frequency, mode, and received signal.

TERM **polarization:** the orientation of the electric field; mismatched polarization can cause large signal loss.

Decision tree: will this path work?

A simple process for ARES/RACES, club events, and contests.

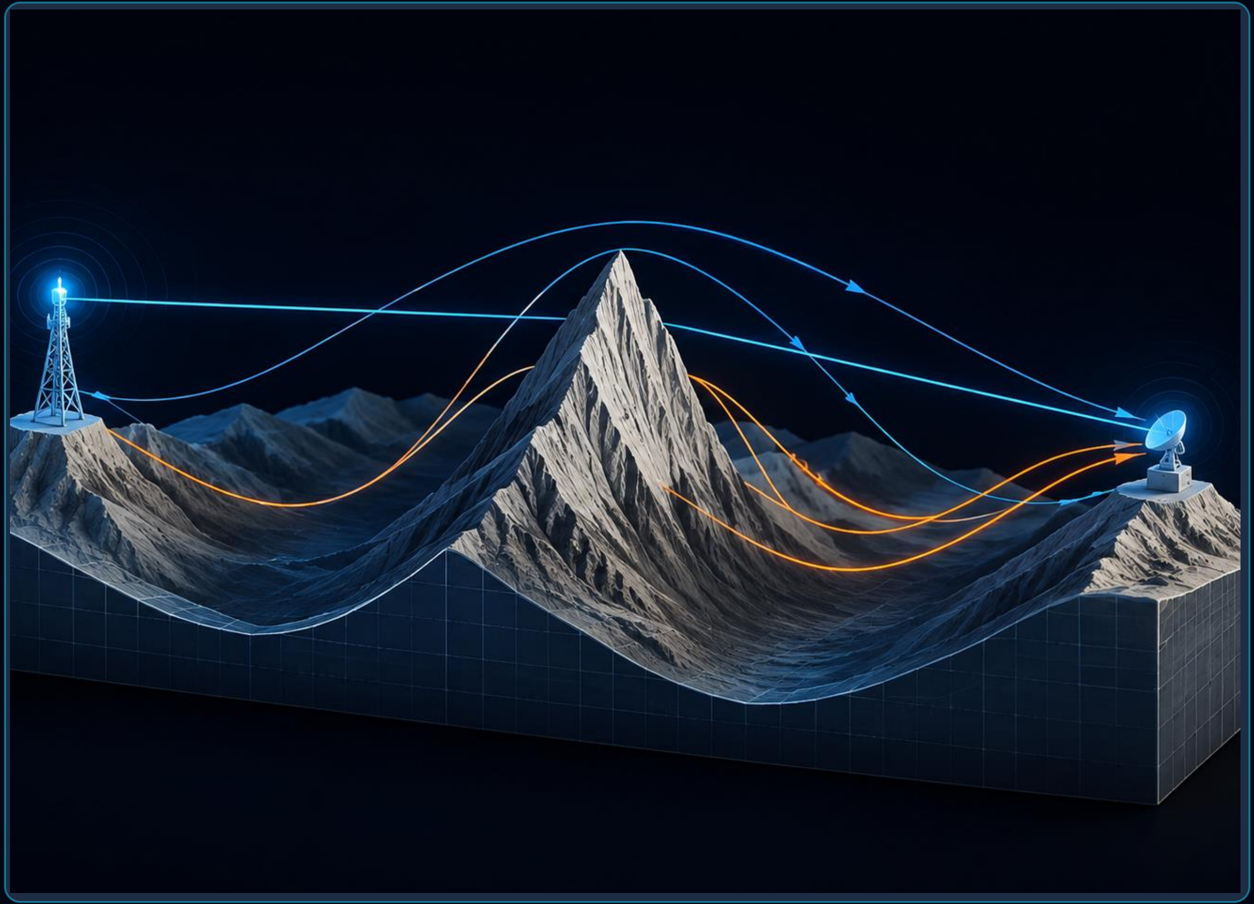
1 · Check
line of sight

2 · If blocked,
find the ridge

3 · Estimate
v and loss

Where the simple model breaks down

Knife-edge math is useful — but terrain is messy.



Real terrain can add multipath, scatter, and non-ideal ridge shapes

Broad, rounded ridges behave like extended obstructions.

Multiple edges add complexity and can increase loss.

Foliage, buildings, local clutter, and polarization can shift results.

Tropospheric enhancement or scatter may produce stronger-than-predicted signals.

Always field-test critical paths.

TERM **multipath:** multiple signal paths arriving with different delays and phases; they can add, cancel, or distort the signal.

Mini exercise for the club

Use the numbers to choose a deployment site.

Given

146.52 MHz simplex

d_1 = 12 km from TX to ridge

d_2 = 18 km from ridge to RX

ridge h = 80 m above direct line

antennas: 50 W + 9 dBd Yagis

Ask

What is λ?

Estimate v.

Is this a mild, moderate, or severe obstruction?

Would moving 100 m higher help more than adding power?

Presenter note: $\lambda \approx 2.05$ m; $v \approx 0.93$; treat as moderate, likely workable with directional antennas.

TERM **dBd:** antenna gain in dB compared with a half-wave dipole; dBi is compared with an ideal isotropic radiator.

The big takeaways

Knife-edge diffraction rewards operators who plan.

1

A ridge is not always a wall.

It can diffract energy into the shadow zone.

2

Loss is calculable.

The v parameter turns geometry into dB.

3

Elevation is leverage.

Improving geometry often beats adding power.

4

Use tools, then test.

SPLAT!, Radio Mobile, and field logs build confidence.

TERM **deterministic physics:** the result follows from the geometry and wavelength; it is not just random band-condition luck.

Sources and credits

Built from the user-provided K6IG article and presentation materials.

Reference sources

Wilkinson, Paul J., K6IG. “Over the Ridge and Through the Notch.” accepted by QST for publication. Awaiting publication date.

International Telecommunication Union. Recommendation ITU-R P.526-16, Propagation by diffraction, November 2025.

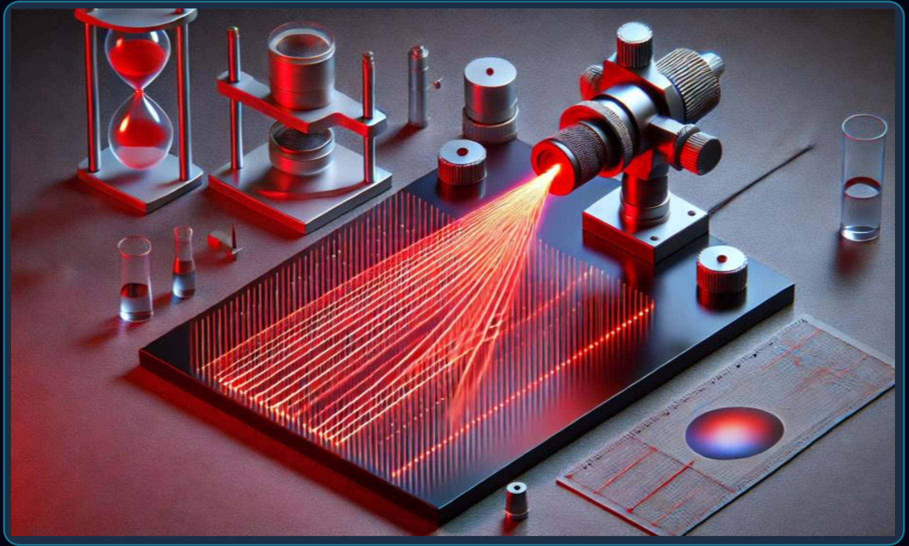
U.S. Geological Survey, 3D Elevation Program (3DEP); NASA JPL, Shuttle Radar Topography Mission (SRTM).

Figures and visual credits

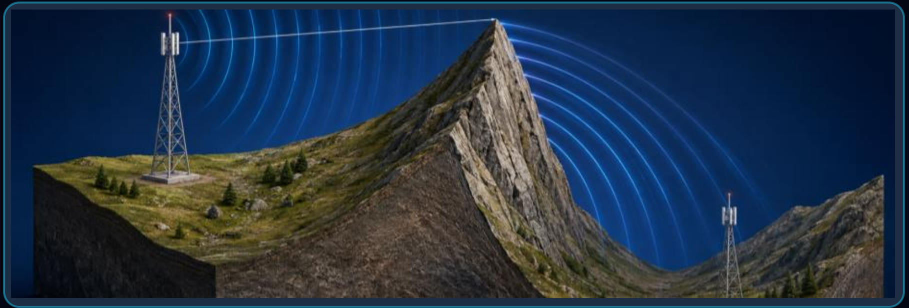
Slides 9–17: original editable instructional diagrams, adapted from the diffraction methods in ITU-R P.526-16.

Terrain-profile examples: original presentation models; elevation-data references are USGS 3DEP and NASA/JPL SRTM.

Illustrative images, including the two images on this page: original AI-generated concepts for this deck, not field photographs or scale maps.



AI-generated illustrative concept



AI-generated instructional visual

TERM **source basis:** the documents and presentations used to create the final combined slide deck.

Questions?

The ridge is not the enemy.
It is a diffraction aperture waiting to be aimed.

Suggested club follow-up: choose your most difficult local simplex path, model it, then test it together.

Paul J. Wilkinson, K6IG