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Windsond radio range troubleshooting

A working telemetry link is essential for the Windsond system.
In ideal conditions, Windsond can achieve 100 km of range. But for this, a series of factors must all work well. In order to fix inadequate telemetry performance, it is important to first understand what factor(s) causes the failure. Without such understanding, mitigations will be guesses that may or may not work.

Spotting radio range issues
Radio range issues manifest as a total loss of contact with the sonde before the expected range of 10s of kilometers, prompting the software to issue a warning “no contact with sonde” warning in the sonde window.

Radio range issues may be preceded by an unexpectedly low reception quality number, expressed as a number 0-100% in the program. A signal in the 0-20% range is so weak that it may cut out at any time. (Even weak signals are either received correctly, or not at all – the data will not be corrupted.) However, some issues can cut out the signal without warning. Noticing if the signal loss is sudden or gradual is one important clue to finding the cause.

Here are some issues that are **not** related to radio range:

- If there’s no contact with the sonde at any distance, even within a few meters. Try pairing the sonde with the receiver (in the main window of the PC program).
- Problems acquiring a GPS position, as GPS is a different radio. GPS problems are reported to the receiver, which warns specifically about GPS.
- Failure for sondes to cut down if they manage to enter the “cutting down” mode.

Spotting receiver-to-sonde range issues
Radio range issues also include the inability to set a cutdown altitude in flight, giving a “action not confirmed” text when changing the cutdown altitude or pressing the “cut-down now” button.
If the data from the sonde is received with expected strength, that eliminates many of the possible causes. See “interference” as the most likely cause. “Receiver electronics” is also a possible cause, which requires Sparv Embedded to identify and service.

If sondes manage to enter the “cutting down” mode but fails to fall down, this is not a radio range issue but a sonde hardware problem.

Factors

These are the factors to differentiate:

- Sonde electronics and antenna
- No clear line of sight
- Interference
- Receiver antenna placement
- Receiver antenna
- Receiver electronics

Sonde electronics and antenna

The sonde needs to generate the radio signal at the correct power, and the sonde antenna needs to radiate the signal efficiently.
Note that the user needs to straighten each sonde antenna so it points straight down.

How to identify: It's unlikely that two sondes both have radio problems. Compare the reception quality from two sondes held at the same distance from the receiver, simultaneously or closely in time. Make sure that both sonde antennas are pointing straight down without nearby conductive materials, and that none of them have a blocked line-of-sight to the receiver. A distance of 5-10 meters from the receiver should suffice. If one sonde generates reception numbers 5 percentage points lower or more, the sonde is faulty.

How to fix: Sondes need to be repaired by Sparv Embedded. Sondes still under warranty are repaired or replaced for free.

No clear line of sight

If something obscures the direct path between the sonde and the receiver, it will attenuate the signal. This may be a person, vehicle, building, hills or dense trees. For high soundings or in strong winds, sondes can reach an elevation of only a few degrees above the horizontal plane, as seen from a stationary receiver.
Once the sonde falls down, it will inevitably fall below the horizon and lose connection – this is normal behavior.

How to identify: In the data, the reception will be good until there is a sudden drop in the average reception number when the sonde drifts behind the obstruction. The problem will not appear for soundings with better line-of-sight. Try to visually spot if anything can obstruct the view towards the sonde, as seen from the receiver antenna location.

How to fix: Move the receiver antenna. If mounted on a car roof, it may be possible to drive to a location with a better view of the sky.

Interference

Once the distance to the sonde increases, the signal from the sonde may appear weaker to the receiver than unrelated transmissions on the same radio frequency. This is analogous to how hearing a particular voice in a crowded room is easier at close distance. The risk is more acute in the free frequency band 433-435 MHz and around populated areas, where there's a bigger risk of unrelated radio activity.
Depending on the source, interference may be continuous, sudden or occasional.

How to identify: If the signal from the sonde is strong but suddenly drops out (completely or now and then), this is a strong indication of interference. There's a good chance the interfering signal isn't present at other times and places, so other soundings may proceed without any problem.
Other radio traffic can sometimes be identified by listening to the frequency with a comm radio.

Note that complete dropout will also occur if the sonde runs out of battery – this is preceded by a battery below 3.3V, so it can be distinguished from interference.

Radio transmitters close to the Windsond receiver are especially likely to jam the signal, even at other frequencies. This is called out-of-band interference and occurs due to the relatively high signal levels; a transmitter 10 meters from the ground station can easily inject million times more powerful signals into the receiver than a flying sonde does.

Interference is the prime suspect if the sonde fails to receive cutdown commands from the receiver; while the immediate surroundings of the receiver may block far, interfering radio from drowning of the signals from the sonde, the sonde's altitude gives a free path from any point on the ground to the sonde, giving many opportunities to jam commands from the receiver.

How to fix: When the signal is jammed, only removing the interfering signal or moving away from it will make the radio link recover.
See if turning off any nearby transmitters makes the link recover, such as comm radios and satellite radios. Also, even moving 10-20 meters away can decrease the interference significantly. Cell radio towers emit strong signals so it's best to avoid them.
Some badly designed electronics and machinery can cause radio interference.
For the next time, the operator can monitor the radio traffic and/or pick another frequency. Perhaps it's possible to do soundings further away from interfering activities.

Receiver antenna placement

The magnetic base antenna is designed to work best when placed on a metallic surface, such as a car roof.

How to identify: A sub-optimal placement may decrease the signal by perhaps 5 percentage points (actually dB). Simply move the antenna while observing the signal strength. Holding a hand within 30 cm of the antenna can affect the sensitivity, so move away before observing the signal strength.

Receiver antenna

How to identify: Turn on a sonde at 5-10 meter distance. Compare two antennas by screwing them into the same SMA antenna port of the receiver. Even though RR2 has two ports, using the same port eliminates the receiver electronics as the cause. A difference in reception > 3 percentage points (dB) indicates an antenna problem, though a truly broken antenna will show a drop of 10 or more. The magnetic base antenna, when placed correctly, may have a few points higher reception than the whip antenna.

Notes:
The antenna coaxial cable is prone to breaking, possibly without visible marks, if the cable is bent sharply or pressed, such as if the cable is in the way when slamming a car door shut. The result is the same as with a broken antenna.

The antenna cable has a male SMA connector, with a center pin receded by a few mm. If this pin is pushed in further, it cannot make contact. Here's the correct position:

Antennas are tuned to specific frequencies, so the included antennas cannot be replaced by any other antenna with a SMA connector. Also, antennas must not be deformed.

While it's possible to extend coaxial cables, this is generally not recommended due to the additional signal attenuation of long cables and multiple connectors. It's better to place the receiver close to the antenna and extend the USB cable to the PC.

How to fix: Sparv Embedded can test and replace antennas.

Receiver electronics

How to identify: The signal will constantly appear relatively weak, regardless of which antenna is used. With a RR2, only one of the two antenna ports is likely affected, so check if a single antenna gives the same signal strength regardless of what antenna port it's connected to. (The unconnected antenna port should report a much weaker signal.) While testing, keep a sonde at a 5-10 meter distance and don't move the antenna while moving the antenna between the ports. The signal from the two ports can be observed in the reception plot in the sonde window.
The signal strength can also be compared between two different receivers.
If only a single RR1 or RR4 is available, it's best to send the receiver and the antennas to Sparv for troubleshooting.

How to fix: Receivers have to be serviced by Sparv Embedded.