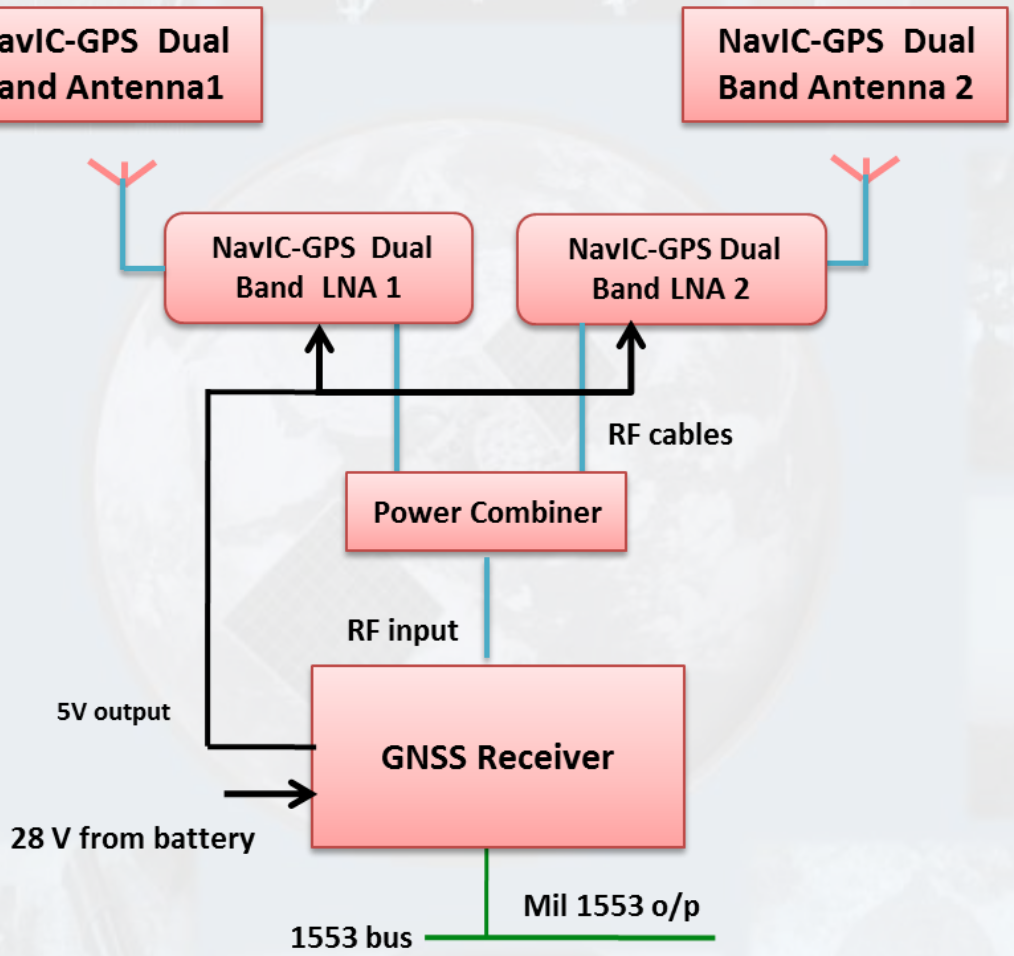
Waterbody Induced Large Multipath Error in onboard NavIC Receiver in Low Altitude Flying Vehicles: A Case Study

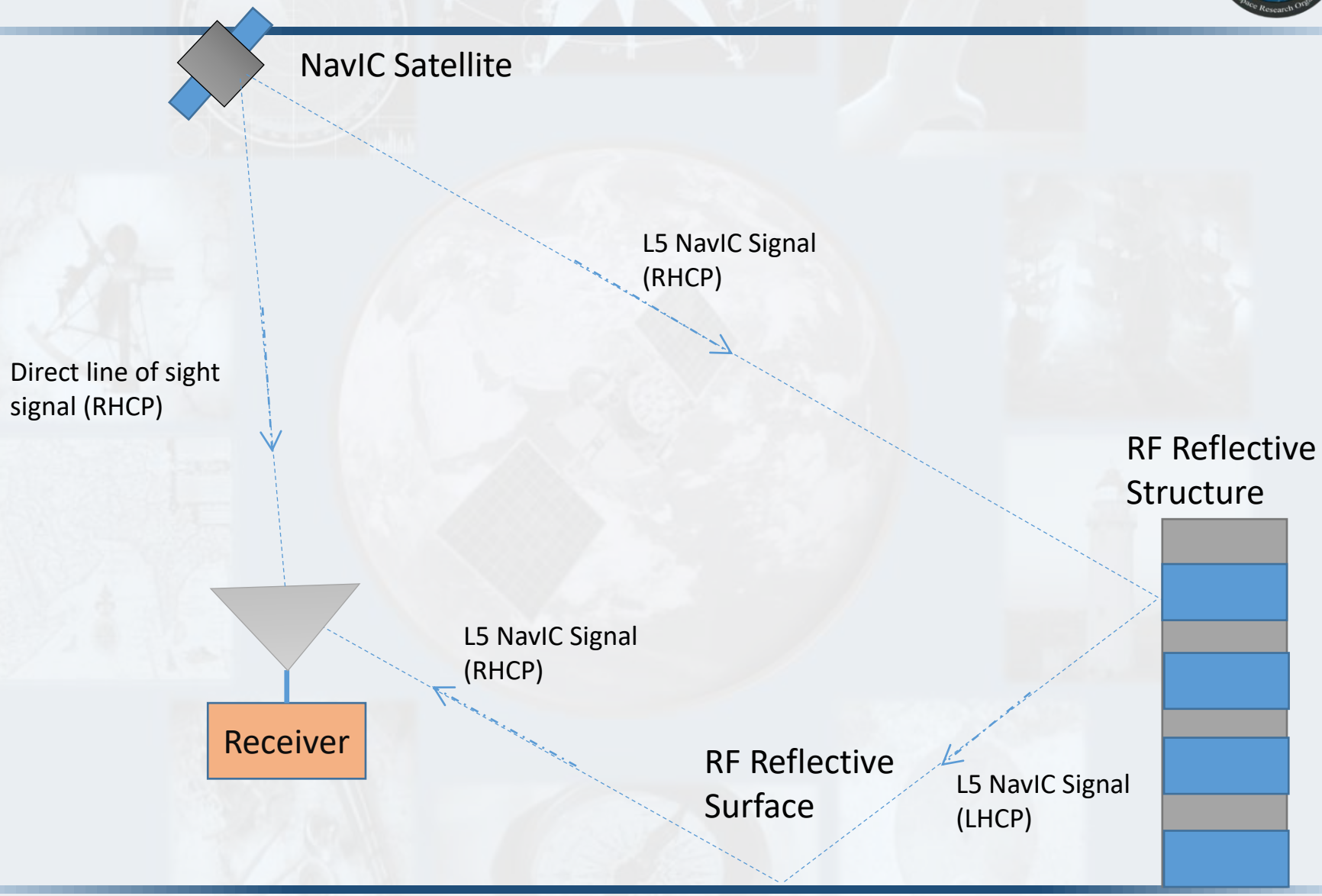
Vinoj V S[*], Aneesh K Thampi[$], Biju V S[$], Anand Shankar OT[$], Mohammed Basim A[$], Krishan Kumar[$], C Radhakrishna Pillai[#], S Sasikumar[&], E S Padma Kumar[^]
ISRO Inertial Systems Unit, ISRO, Thiruvananthapuram, India

[*]Deputy Division Head, [$]: Design Engineers , [#]: Group Director, [&]: Deputy Director, [^]: Director, ISRO Inertial Systems Unit

GNSS Receiver Configuration for Low Altitude Highly Maneuverable Vehicles

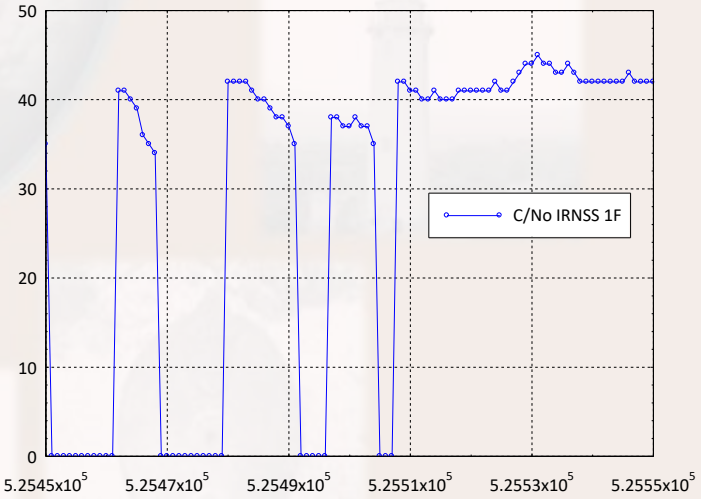


Impact of Multipath on low Attitude Vehicles



Difference between Normal Multipath and Multipath during Re-acquisition Phase

- Multipath in case of static receiver happens when the direct LOS and multipath signal are available simultaneously
- High maneuverability and satellite re-tracking
- Hot reacquisition algorithm and possibility for locking with multipath signal
- Possibility of re-tracking a multipath signal during re-tracking phase
- Issue can occur in code phase measurements
- Symptom: Drastic CNO change



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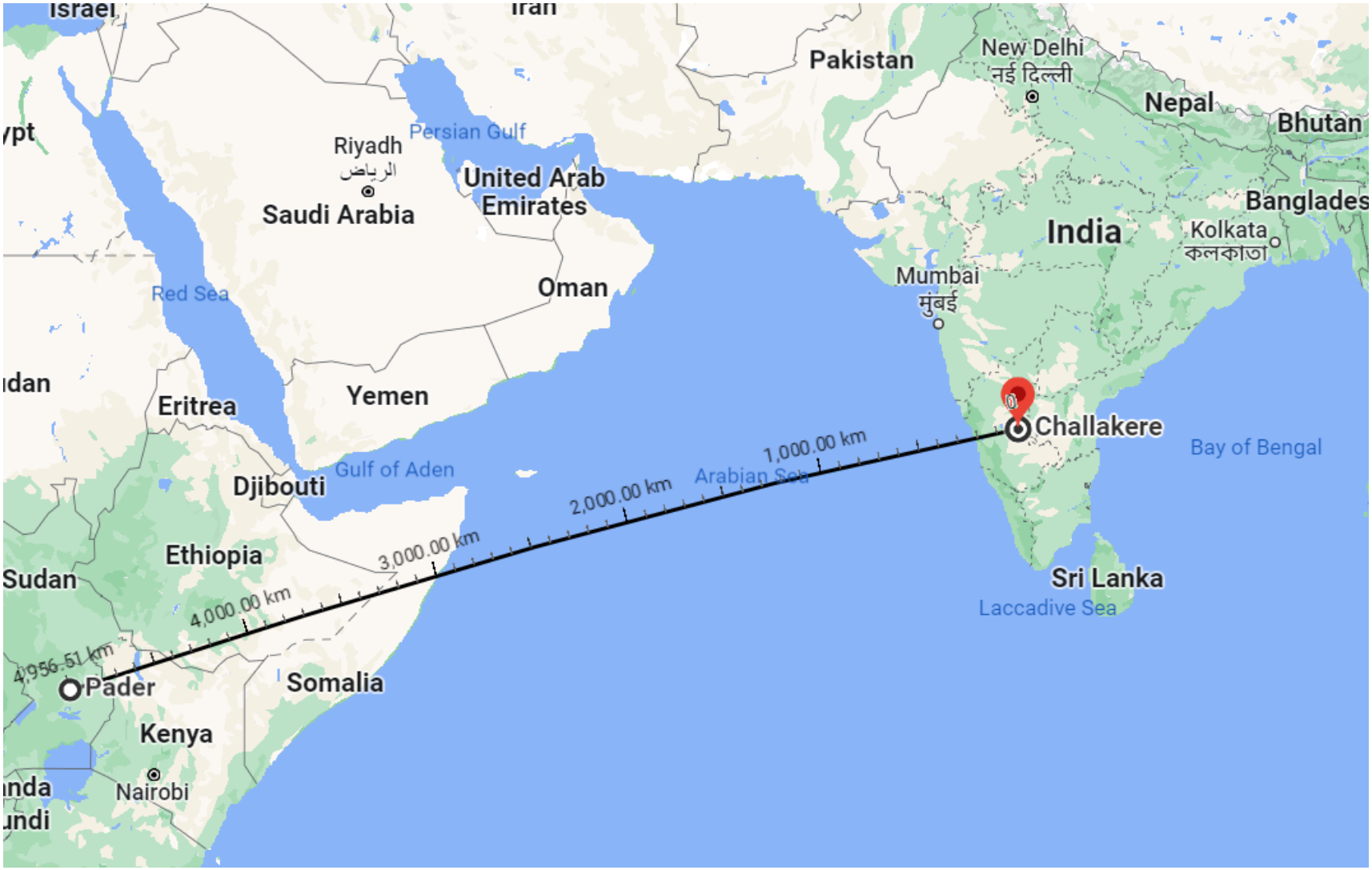
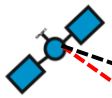


Case Study:

Lat = 2.5909 long= 32.9862 alt = 35,808.25 km



Satellite

Range 37905.691 km
Relative velocity: -48.17 m/s

lat=14.4418, long=76.53837, alt= 2474.9 m

Helicopter

LOS signal

Path 1

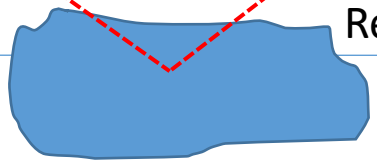
Range: 37904.99 km
Relative velocity: -1.95 m/s

NavIC Receiver

Reflected Signal

Path 2

Range: 3.124 km
Relative velocity: -42.27 m/s



Water body

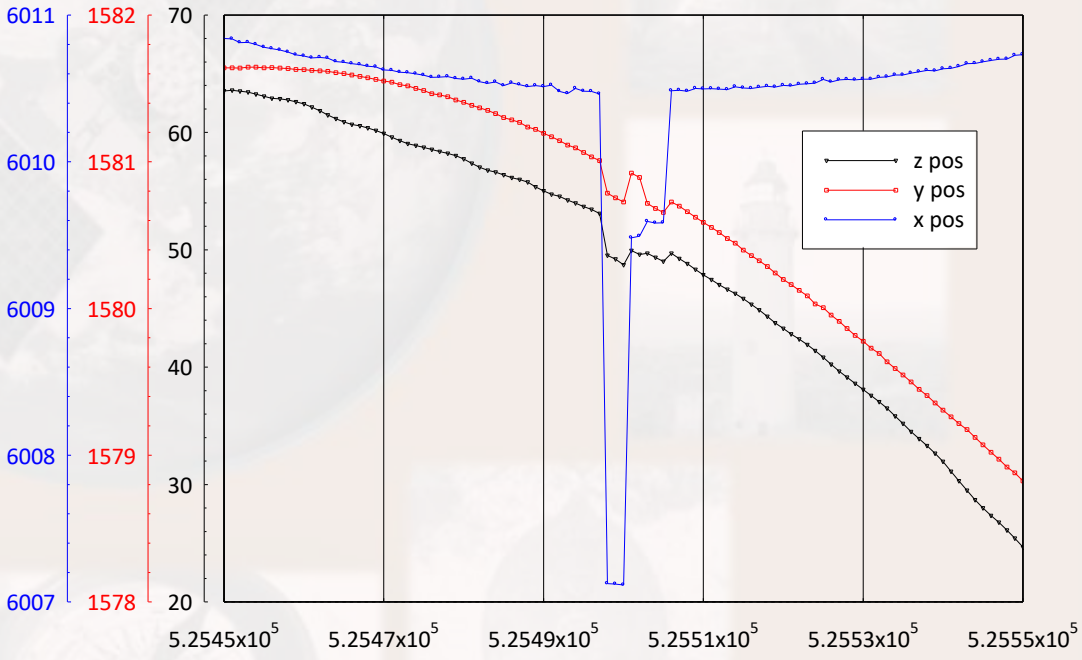
lat=14.4380, long=76.5160, alt=535m

	Range	Doppler
Path 1:	37905.691 km	-48.17 m/s
Path 2:	37908.114 km	-44.22 m/s
Diff :	2.423 km	3.9m/s

Large Position Error due to Multipath

- 8 continuous samples of erroneous solution with valid PDOP was observed (~3km and 3m/s)
- The error in position and velocity occurred when IRNSS 1F satellite was re used after short tracking loss. Based on reference receiver data at IISU, it was confirmed that satellite data is healthy.

- During low altitude flight, frequent tracking loss due to roll rate is expected and the re-tracked signal may be due to multipath
- This leads to error more than half code phase offset and can be hence more than 150m for a single satellite



Large Position Error due to Multipath

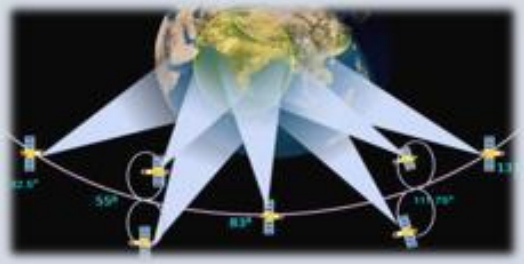
- Frequent track loss and re tracking was happening for one of the IRNSS. C/No of the satellite was low during the observation (35-38 dB Hz).
- From receiver data, it was observed that error is observed in both pseudorange and delta range measurements for the satellite which are independent measurements.
- Receiver data also clearly indicates that there are no errors with respect to satellite time reconstruction algorithm and atmospheric correction computations.
- The available data pointed towards the possibility of reflected signal being captured by the receiver.
- Capture of reflected signal would result in a pattern identical to that observed during the sortie in C/No, pseudo-ranges and delta-ranges.

Conclusion

- A multipath error of more than half chip is possible in GNSS receiver with side looking antenna
- The error in terms of kilometres is possible due to multipath
- The carrier to noise ratio variation is a good indication of the multipath
- A typical case of such error is reported in ISRO's Re-entry Launch vehicle experiment
- It can also prevented by suitable selection of antenna location and antenna pattern
- Proper design of the carrier to noise ratio threshold variation can be used to mitigate this type of errors

References

- Dai, W., Huang, D., & Cai, C. (2014). Multipath mitigation via component analysis methods for GPS dynamic deformation monitoring. GPS Solutions, 18(3), 417–428
- Evans, A. G., Comparison of GPS Pseudorange and Biased Doppler Range Measurements to Demonstrate Signal Multipath Effects, Proceedings of the Fourth International Symposium on Satellite Positioning, Austin, TX, May 1986.
- Design document of high dynamic NavIC Receiver by ISRO



Thank You