GNSS Interference at Airports and GBAS as a Tool of its Detection

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The active introduction of automated vehicle guidance systems has led to uncontrolled and unauthorized rise in production and sales of jamming appliances meant to obstruct vehicle control systems. A wide range of radio frequency GNSS signal jammers are readily available to buy online at low prices.

A negative side effect of all this is the damage to on-board navigation equipment and FMS in not only unmanned aerial vehicles, but also man-operated civil aviation aircraft as well as ATC navaids and surveilance.

Radio frequency authorities around the world were not ready for such rapid spread of illegal (but often unconscious) use of household radio interference gadgets on restricted professional-use frequencies.

The impact of jamming and error-inducing interference is not taken into account in existing on-board equipment as ICAO requires member states to eliminate such interference in their respective airspaces.

In the worst case scenario, they should timely issue a NOTAM advising airspace users of such radio interference. These ICAO guide-lines are reflected in a Resolution of the 41st UN General Assembly.

Weak GPS and SBAS signals are most suseptible to interference.

Timely detection of interference with GNSS signals and timely informing of aircraft crews and air traffic controllers is the essential means of ensuring flight safety and reducing risks of interference with aircraft landing.

A practical means of detecting and counteracting such interference are ground-based augmentation systems/GBASes that are located within the airport perimeter.

Advantages of GBAS in Detection of Interference with GNSS Signals

- ✓ timely real-time warning of aircraft and ATM on presence of "blocking" local GPS interference in the terminal area of an airport,
- ✓ mitigation of "noise" interference to the GPS signal in the terminal management area using GBAS technology σ_{prgnd}; (onboard protection level HPL/VPL),
- ✓ detection of non-compliance with ICAO integrity standard for GNSS signals,
- ✓ detection of spoofing interference in the terminal management area and immediate warning of aircraft crews and controllers.

Variants of GNSS Local Interference with Airport Landing Systems GBAS

I Option

That's how it should be

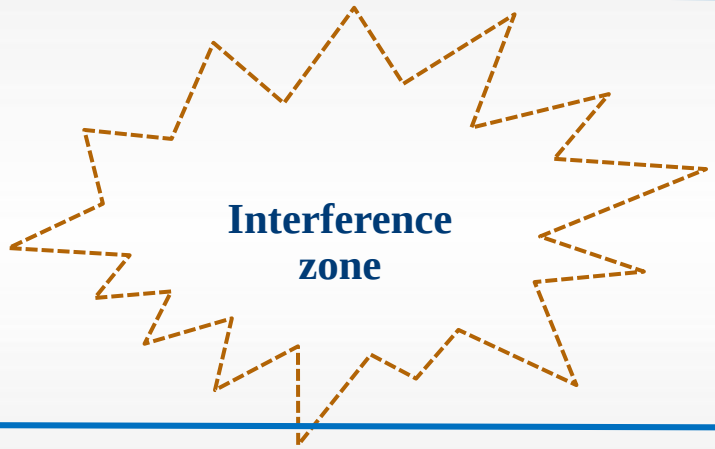
There is no interference

II option

It happens sometimes:

no problem for GLS

(landing by GNSS).



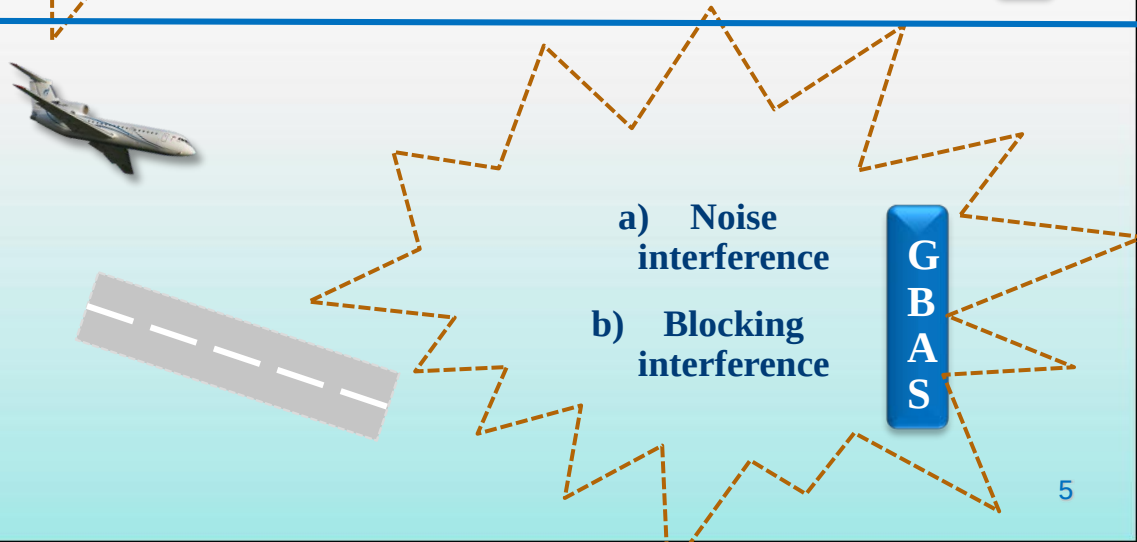
III Option

This happens sometimes (very rarely):

no problem for safety since

a) Either - no problem for continuity,

b) Or - there is a problem for continuity



Variants of GNSS Local Interference with Airport Landing Systems GBAS

IV Option

The most likely of the rare situations:

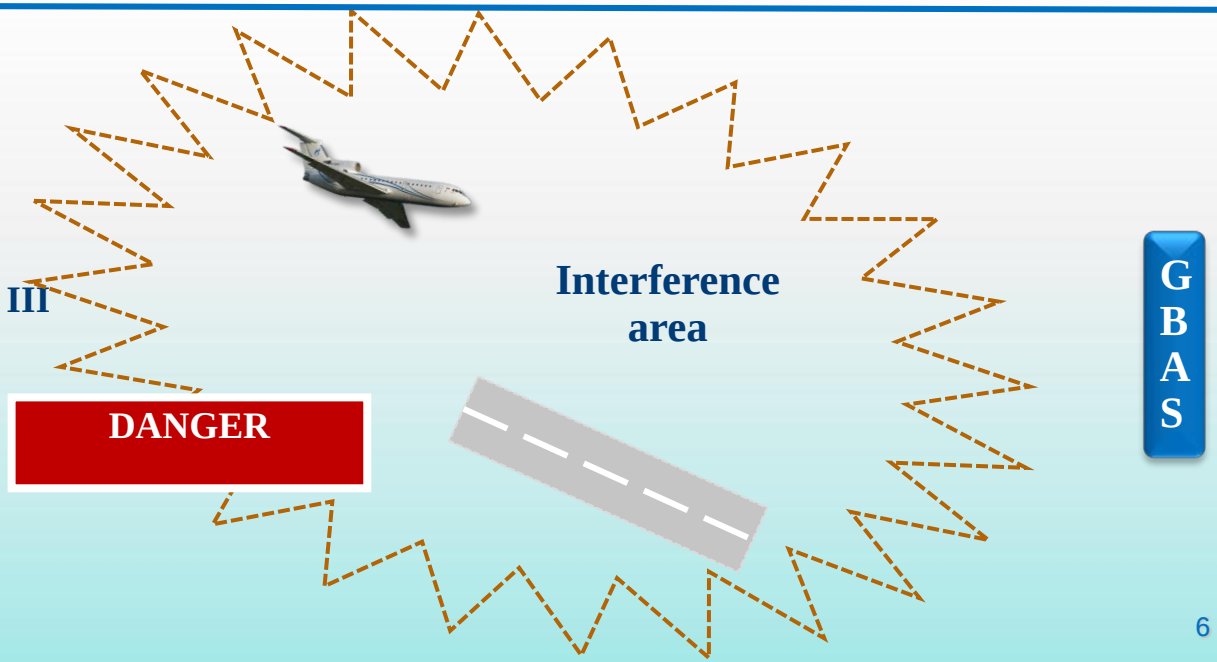
there is no problem for safety, but it's

a problem for continuity

V Option

Unlikely situation:

There may be a problem for GLS Cat III



GPS satellites Malfunction on August 24, 2023

On August 24, 2023, GBAS stations registered instances of unreliable operation of GPS satellites, and that not only in differential, but also in autonomous modes. ATM providers and aircraft crews were promptly notified.

In an area of about 10,000 sq.km, there were massively cases where the forecast of RAIM availability for GPS on-board did not correspond to the actual RAIM and aircraft could not reliably use GPS navigation.

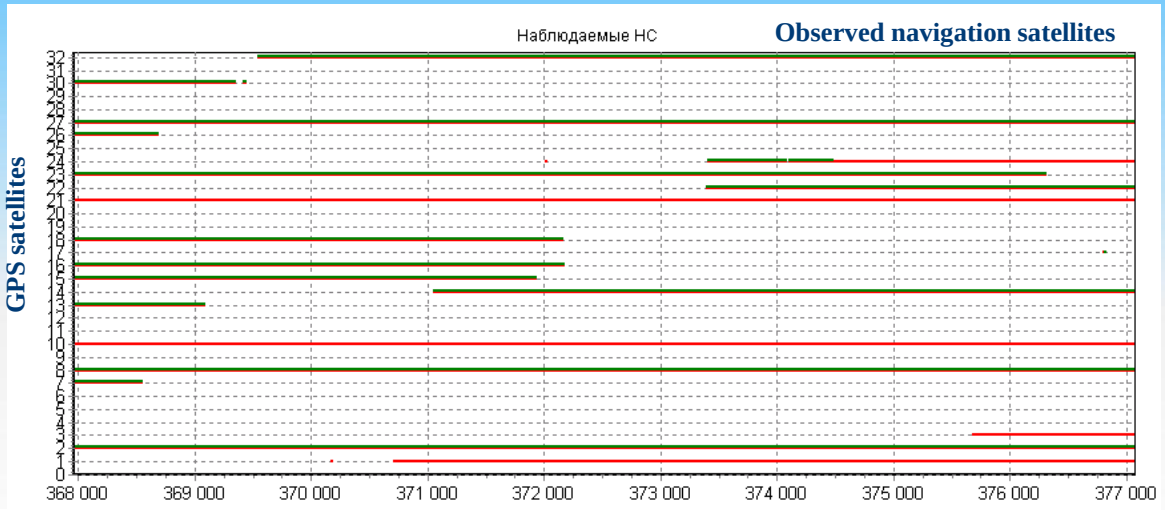
First signs of satellite anomalies occurred around 06:00 UTC.

The analysis of GPS signals performed by *NPPF Spectr* showed that GPS satellites (10, 21) appeared receiving unreliable ephemeris data.

Furtheron the number of such satellites was growing. In the period from 9:00 to 15:00 out of 10 to 12 observed only 4 to 6 satellites appeared using quality ephemeris data (at 12:00, only two had good ephemerides).

For Comparison Performance Data in the Russian Cities of Kaliningrad and Kurgan are given

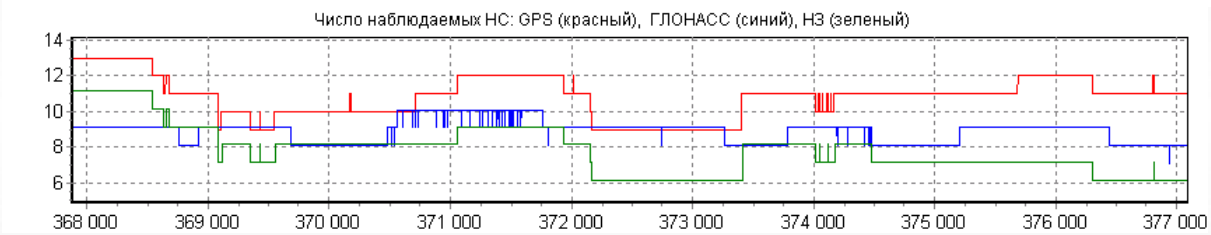
August 24, 2023 06:00. Kaliningrad



Red color — observed satellites,

Green — satellites with good ephemerides

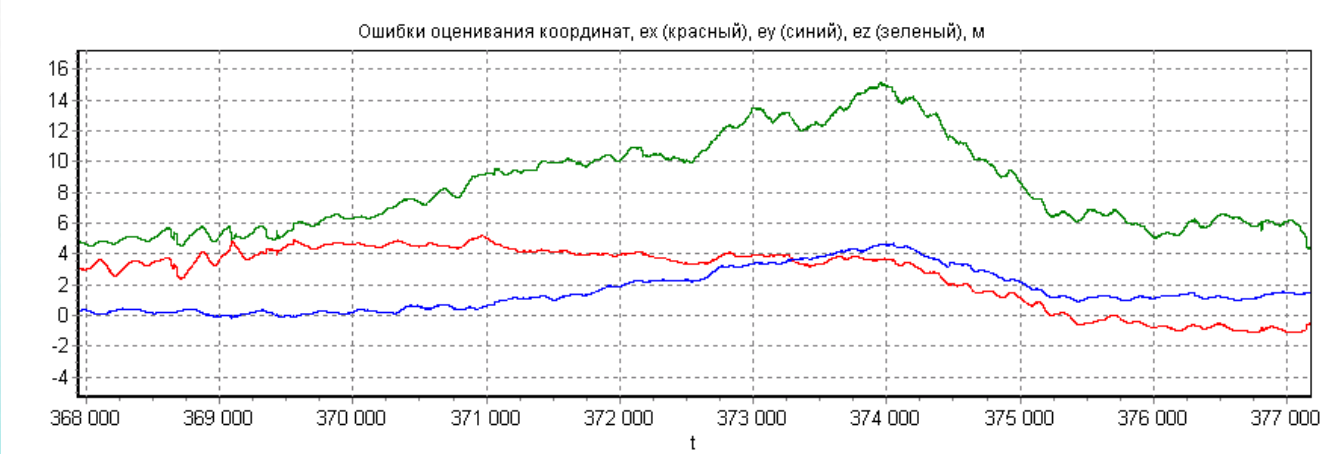
The brown color is a distortion due to the overlapping of green and red colors.



The number of observed navigation satellites:
GPS red color,
GLONASS blue color
The navigation task is green

Coordinate estimation errors:

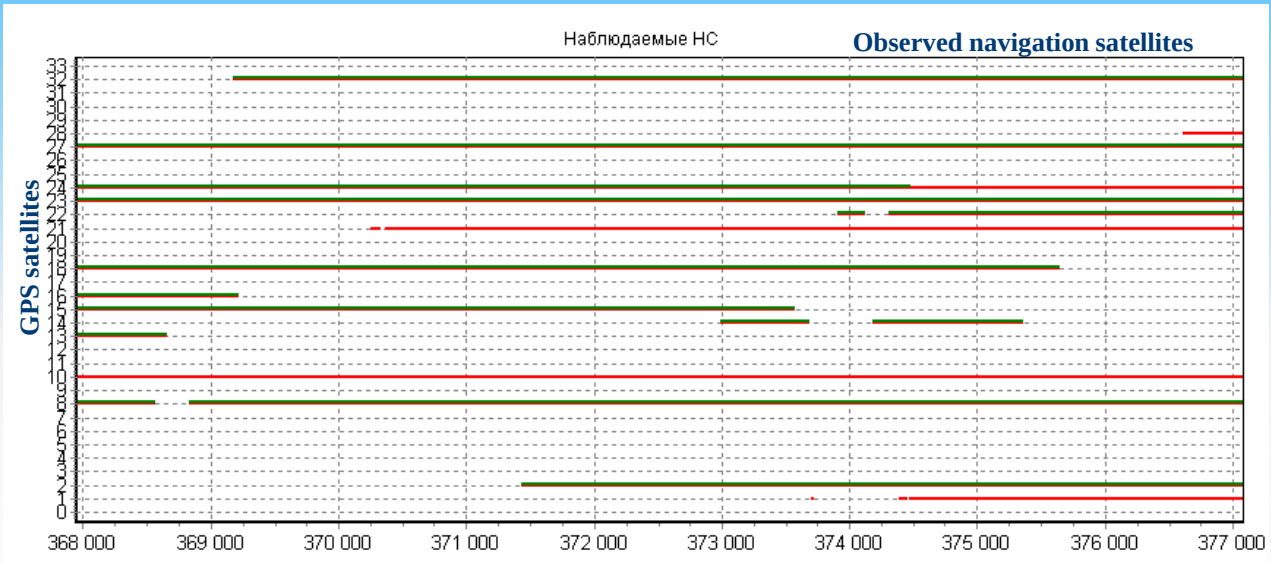
Ex red color,
Ey blue color
Ez green color



GPS signal failures in August 2023 are due to the fact that ephemerides stopped updating.

For Comparison Performance Data in the Russian Cities of Kaliningrad and Kurgan are given

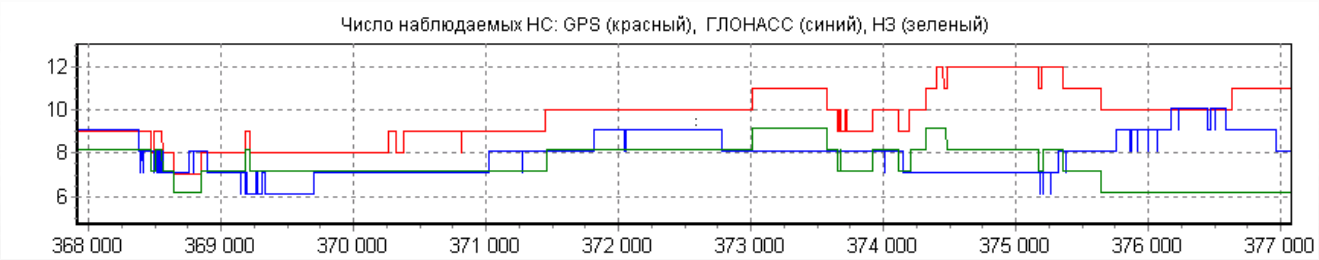
August 24, 2023
06:00. Kurgan



Red color — observed satellites,

Green — satellites for which there are not rejected ephemerides,

The brown color is a distortion due to the overlapping of green and red colors.



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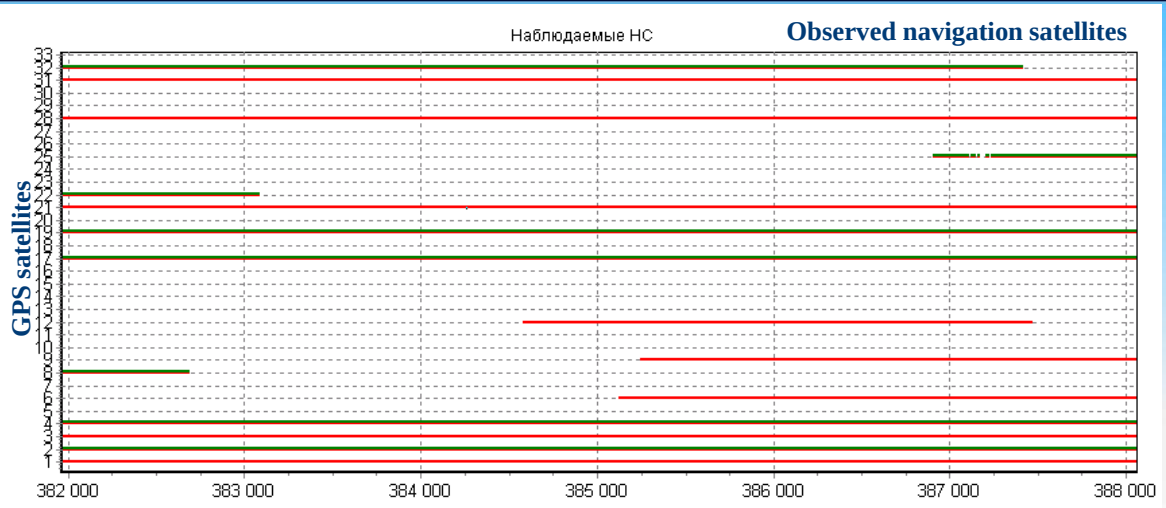

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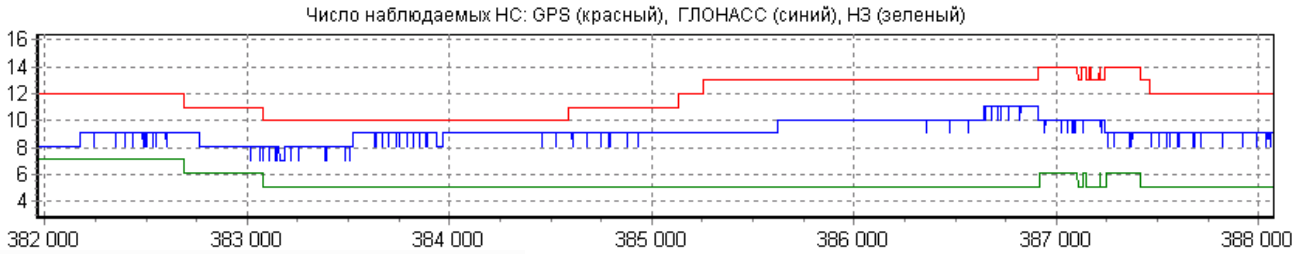

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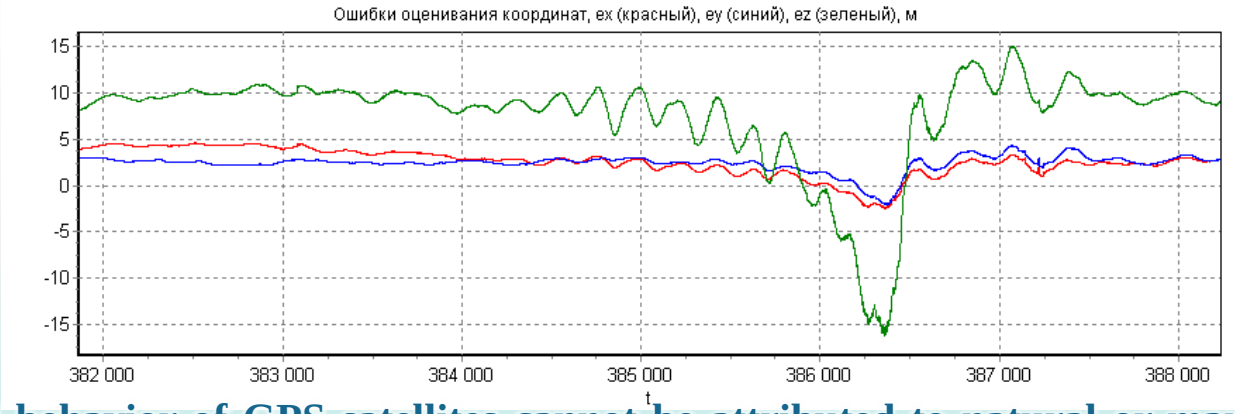


The reasons for this abnormal behavior of GPS satellites cannot be attributed to natural or man-made interference and there is no certainty that such a phenomenon will not happen again at any time. Therefore, the optimal solution for aircraft navigation and landing systems will be the simultaneous use of alternative satellite constellations e.g. GPS and GLONASS as implemented in GBAS

Effect of Local Man-Made Noise Interference on GPS signals at Domodedovo Airport

SNR (noise/signal from the calculated one) for GPS navigation satellite No. 8 in conditions of abnormal external influence

SNR (noise/signal deviation from the calculated one) for GPS navigation satellite No. 14 in conditions of abnormal external influence

Effect of Local Man-Made Noise Interference on GPS signals at Domodedovo Airport

Fig. 3a. Resulting pseudorange error for satellite #8, m

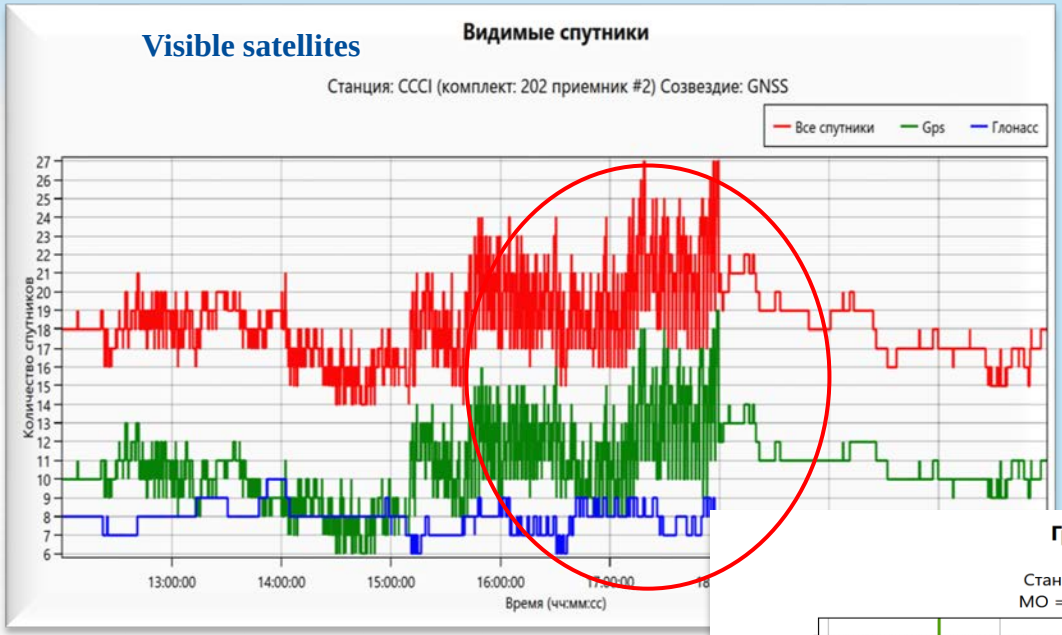
Рис. 3б. Resulting pseudorange error for satellite #10, m

Differential correction error through external influence rises by 10-20%. The error was detected and compensated for by GBAS.

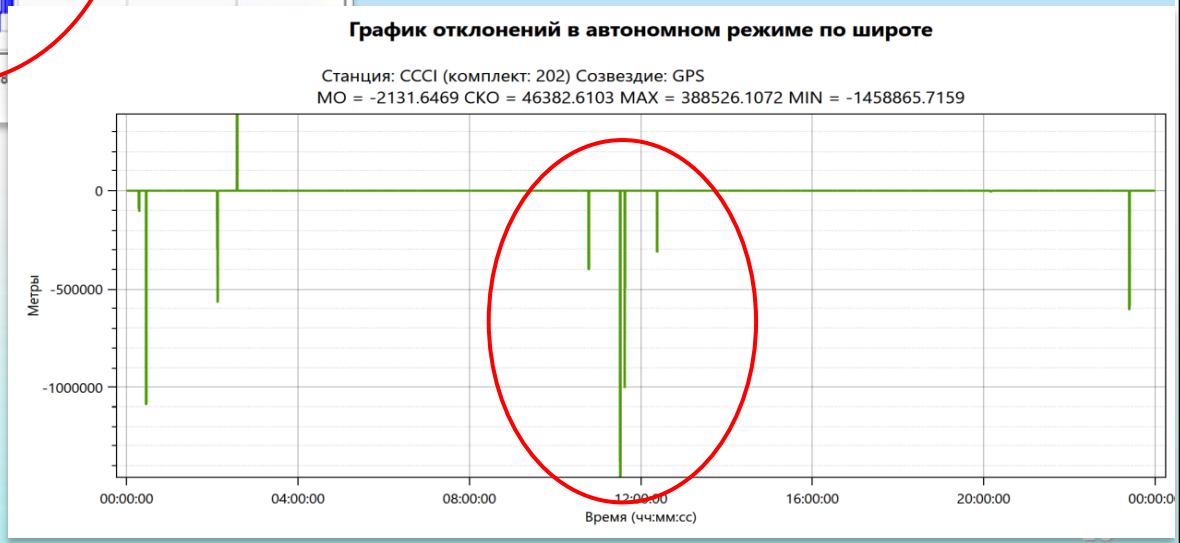
GNSS monitoring system registered corrupted Satellite signals. It was used for initiating measures eliminating the source of interference.

Detection of “False" Satellites by GBAS

Visible satellites



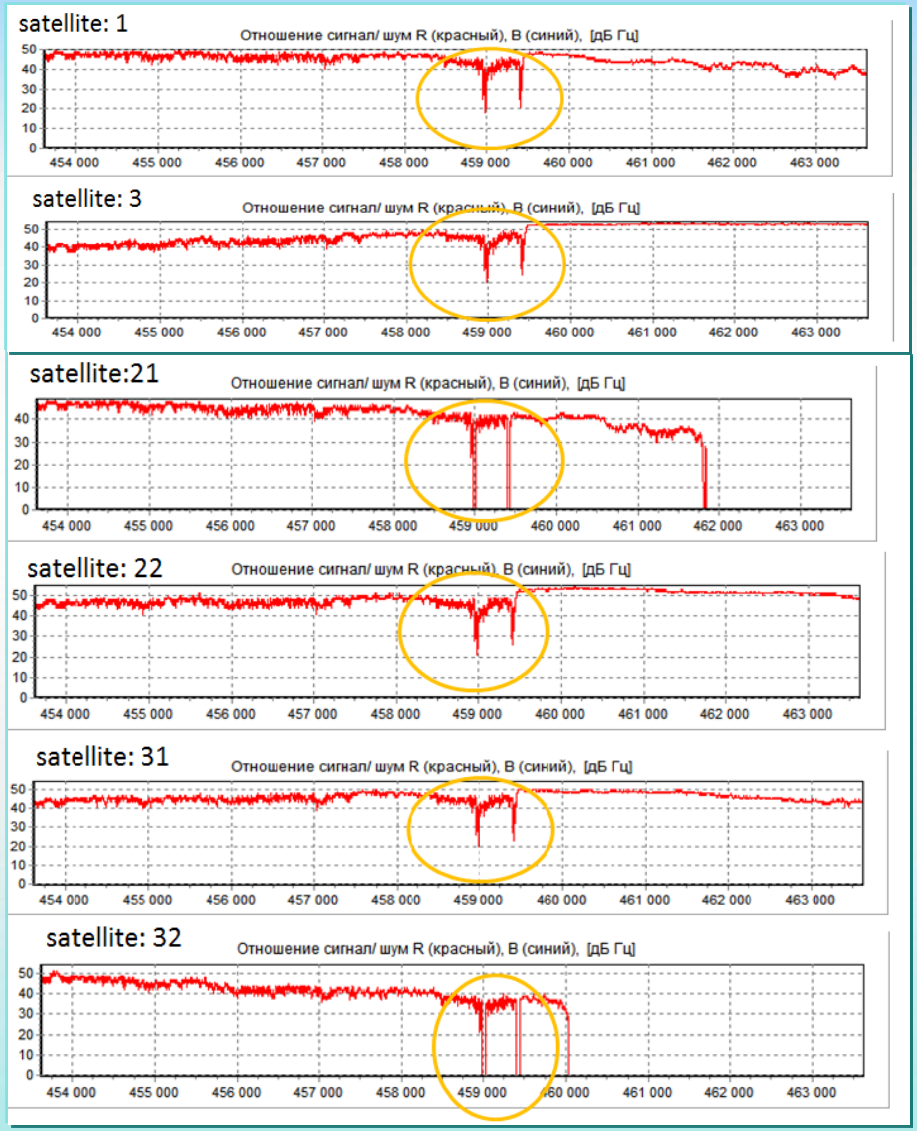
Deliberate radio interference from the ground:



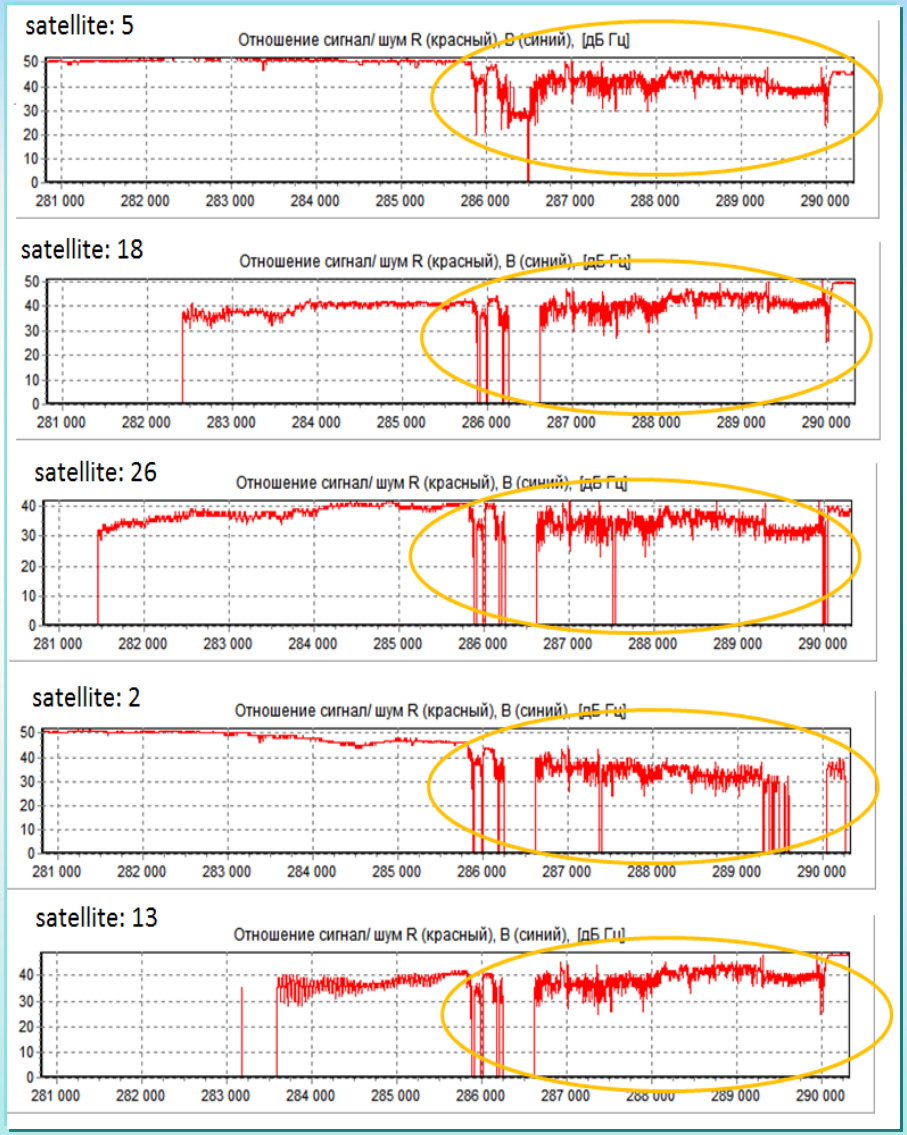
Graph of latitude deviations in non-differential mode for GPS

Deterioration of GPS Performance Detected by GBAS

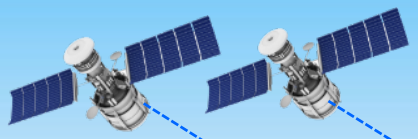
at the airport of Makhachkala



at the airport of MinWody



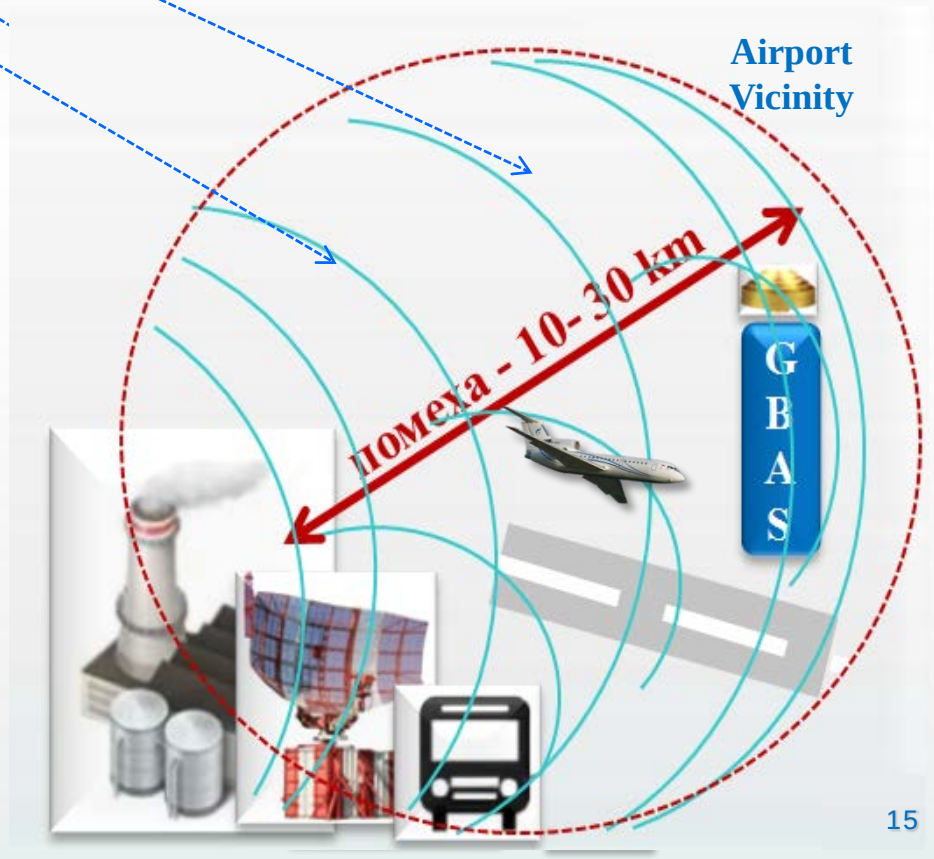
Recently, massive cases of deliberate unauthorized interference with satellite signals have been recorded



2023 local interference with GPS was observed in Domodedovo airport, whereas there was no interference with GLONASS

Local interference in an airport is mostly at GPS frequency since it is the common frequency for readily available gadgets and UAVs.

The range of radar jammers and anti–UAV devices, illegal GPS jammers often used by truck and taxi drivers, is 10-40 km. Those mostly do not affect GLONASS signals.



As per ICAO, maximum efforts should be made by airport managements and government agencies to prevent presence of unauthorized radio interference to GNSS signals in areas of civil aircraft operations.

The research carried out shows that the main sources of interference with GPS signals are taxis and trucks using GPS jammers. States need to align penalties for use of these devices with possible consequences of a loss of ability to navigate by civil aircraft, first and foremost in final approach stage.