



<b>SAFETY INFORMATION</b>	 <b>АВИАЦИОННАЯ АДМИНИСТРАЦИЯ КАЗАХСТАНА</b>
<b>MITIGATION OF CONSEQUENCES OF FAILURES IN GPS / GNSS</b>	
Date: 28.04.2026	№: GNSS 2024-0001
Flight Operations, ATM/ANS, AAK	Revision: <b>02</b>

## 1. PURPOSE

1.1. This safety information has been published in order to recognize and mitigate the consequences of failures in the Global Positioning System (GPS) / Global Navigation Satellite System (GNSS).

## 2. PAGE CONTROL

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## 2. BACKGROUND

Recent GPS/GNSS jamming and spoofing activities reported by civil air operators operating globally and air traffic management/air navigation services (*hereinafter ATM/ANS*) pose a potential safety of flight risk to civil aviation. GNSS signals are vulnerable to interference because of their extremely low power. Some sources of interference include ionosphere effects, solar activity, GNSS repeaters, and intentional acts of jamming and/or spoofing. GNSS interference can occur in any location at any time. Currently GNSS interference is persistent in and near conflict areas around the world. GNSS interference has been used to prevent drone use at highly attended events (e.g. Euro 2024, Olympics), military have used it near border areas/sensitive protected areas, and commercial drivers of trucks/taxis use GNSS interference to jam or spoof their locations. Furthermore, certain law enforcement agencies have the capability to use counter-drone systems to jam or spoof GNSS signals and force unauthorized drones to land.

An analysis of the reports received by the Aviation Administration of Kazakhstan (*hereinafter AAK*) through the system of mandatory and voluntary reporting shows that the number of reports of a temporary loss or degradation of the quality of the GPS signal has a 189.47% increase compared to 2025.

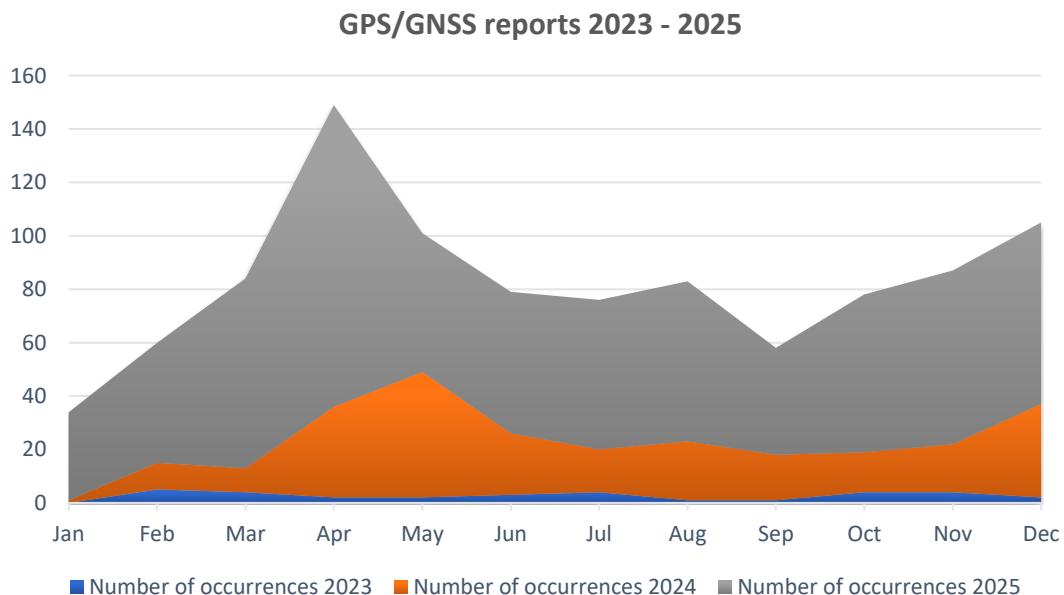



Figure 1. The ratio of Reports received by year

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The rate of reports of loss/deterioration of the GNSS/GPS signal per 10,000 flights in the airspace of the Republic of Kazakhstan in 2025 increased 3 times compared to 2024.

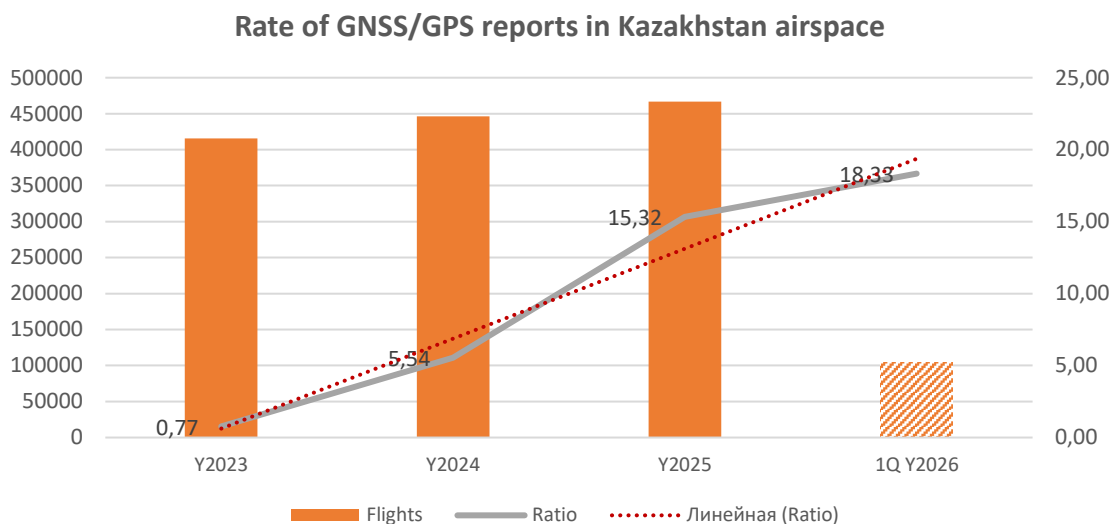


Figure 2. Rate of reports by 10 000 flights

As part of the risk management process, the safety problem "SI-64 GNSS signal manipulation leading to navigation or surveillance degradation" was identified and the following risk model was developed:

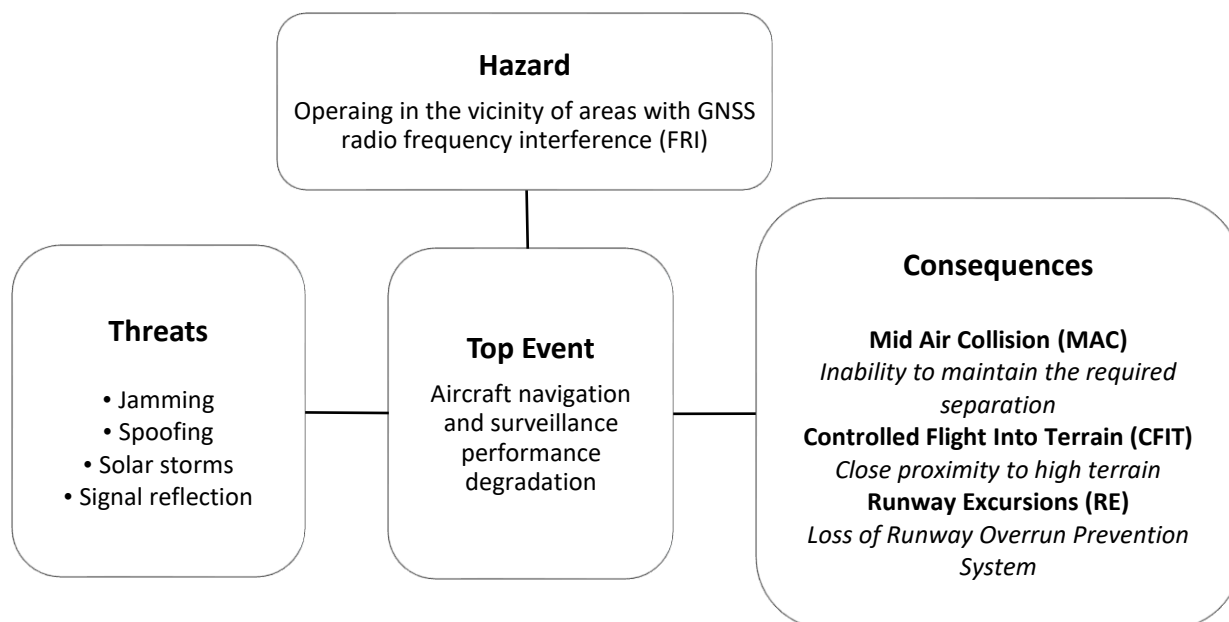



Figure 3. Risk Model

A **hazard** is a condition with the potential to cause an unsafe operational state, loss, or damage. This risk assessment considers operating in the vicinity of areas affected by GNSS-RFI as the source of potential degradation of aircraft communications (CPDLC), navigation, and surveillance systems.

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**Threats** are understood as a potential cause of a top event or precursors of an undesired safety state. The different threats and their likelihood of affecting normal operations are key considerations in conducting an accurate risk assessment. Broadly, the degradation of an aircraft's communications (CPDLC), navigation, and surveillance performance may result from the following precursors.


Jamming	Locally generated RFI is used to “drown out” satellite signals. Possible sources: PPD – Personal Privacy devices, TV broadcast station malfunction, and military RFI. Easier recognition. The effects of jamming are typically immediate and noticeable by the flight crew, as systems fail to receive GNSS signals.
Spoofing	Counterfeit GNSS signals are broadcast and decoded by airborne receivers, resulting in a false position displayed in the cockpit and used by avionics. (Position Manipulation). Detecting spoofing is more challenging and not immediate for flight crews, which poses a greater safety risk than jamming.
Solar Storms	Electromagnetic interference from space weather events such as solar CMEs “drowns out” the GNSS satellite signals.
Signal Reflection	Reflection and/or refraction of GNSS signals due to objects such as buildings or <a href="#">ionospheric scintillation</a> .

Table 1. GNSS-RFI precursors

**Consequences** are defined as a potential accident scenario resulting from a top event, which might result in loss or damage. The impact of RFI is specific to the model and modification status of the GNSS receiver, the aircraft manufacturer's integration of the receiver in a particular aircraft make/model, and the radio frequency (RF) performance of the GNSS antenna(s).

The information provided in Table 2 below indicates possible consequences. However, any potential impact on your fleet should be considered in consultation with the Original Equipment Manufacturer (OEM). It is recommended that operators develop or update their own risk model using an appropriate assessment methodology, considering their exposure to threats and the effectiveness of safety controls within their operation. Additional information on the general effects of GPS/GNSS interference, jamming, and spoofing is provided in section [4. GPS SPOOFING IMPACT MATRIX](#).

Systems affected / Potential Accident scenarios		CFIT	MAC	RE
Navigation	Downgraded aircraft position computation. GPS (Loss of GPS primary)	X		
	Loss of FLS <sup>1</sup> , GLS <sup>2</sup> , SLS <sup>3</sup> deviations, and loss of RNP <sup>4</sup> and RNAV <sup>5</sup> capability	X		
	Abnormal differences between Ground Speed and true Airspeed	X		
Surveillance	Loss of Terrain Awareness Warning System (TAWS) Undue TAWS Alerts false “Pull up” calls (or no calls)	X		
	Terrain display shift on ND	X		
	Loss of ADS-B <sup>6</sup> Out Reporting False ADS-B Out Position Reporting		X	
	Loss of Traffic Alert and Collision Avoidance System (TCAS)		X	

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Systems affected / Potential Accident scenarios		CFIT	MAC	RE
Communication	Loss of CPDLC <sup>7</sup> and SATCOM <sup>8</sup>		X	
Others	Loss of Runway Overrun Prevention System – (ROPS) or Runway Situation Awareness Tools (RAAS)			X

Table 2. GNSS-RFI potential consequences

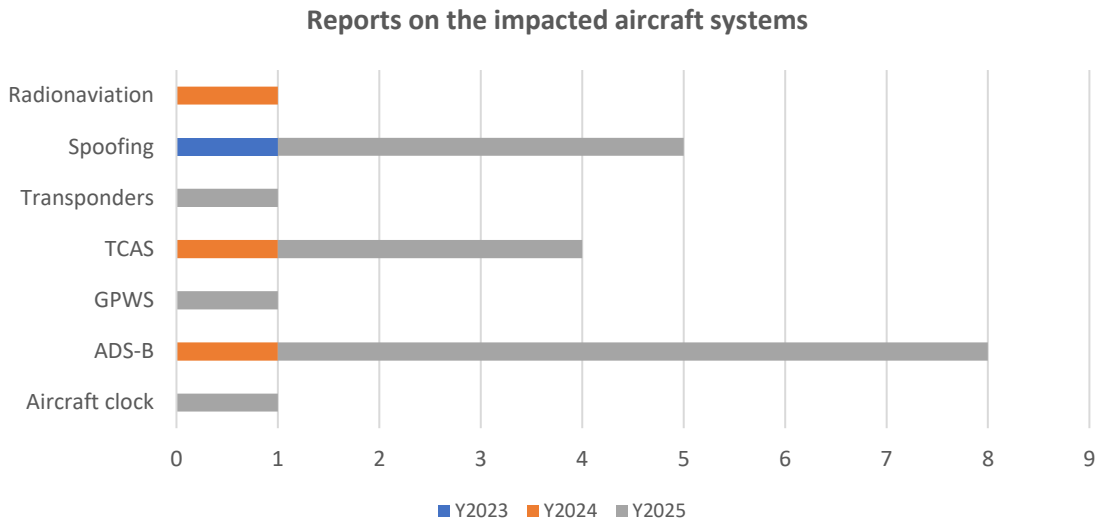
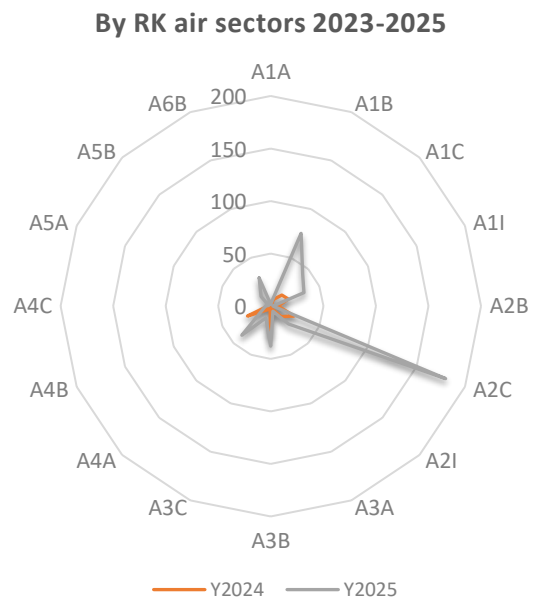
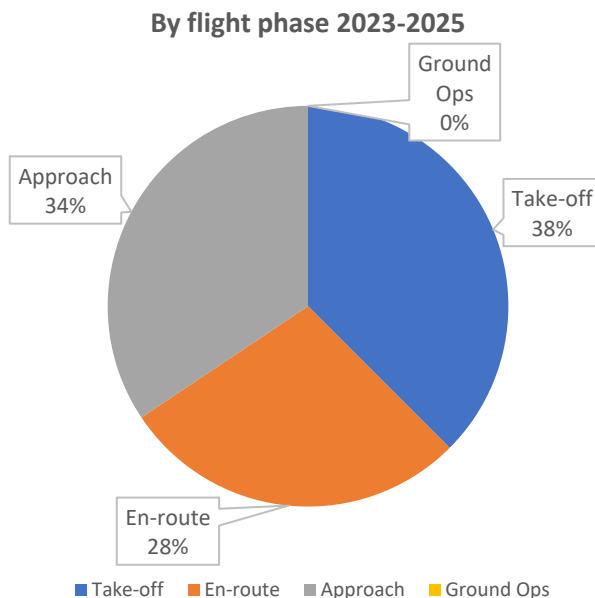


Figure 4. Reports on the impact on aircraft systems received through the RK Reporting System

Additional statistics on GPS/GNSS reports registered in the AAK safety database.



<sup>1</sup> - FMS Landing System  
<sup>2</sup> - GBAS Landing System (Ground Based Augmentation System)  
<sup>3</sup> - SBAS Landing System (Satellite Base Augmentation Systems)  
<sup>4</sup> - Required Navigation performance  
<sup>5</sup> - GNSS Based area Navigation  
<sup>6</sup> - Automatic Dependent Surveillance-Broadcast  
<sup>7</sup> - Controller Pilot Data Link Communication  
<sup>8</sup> - Satellite Communications

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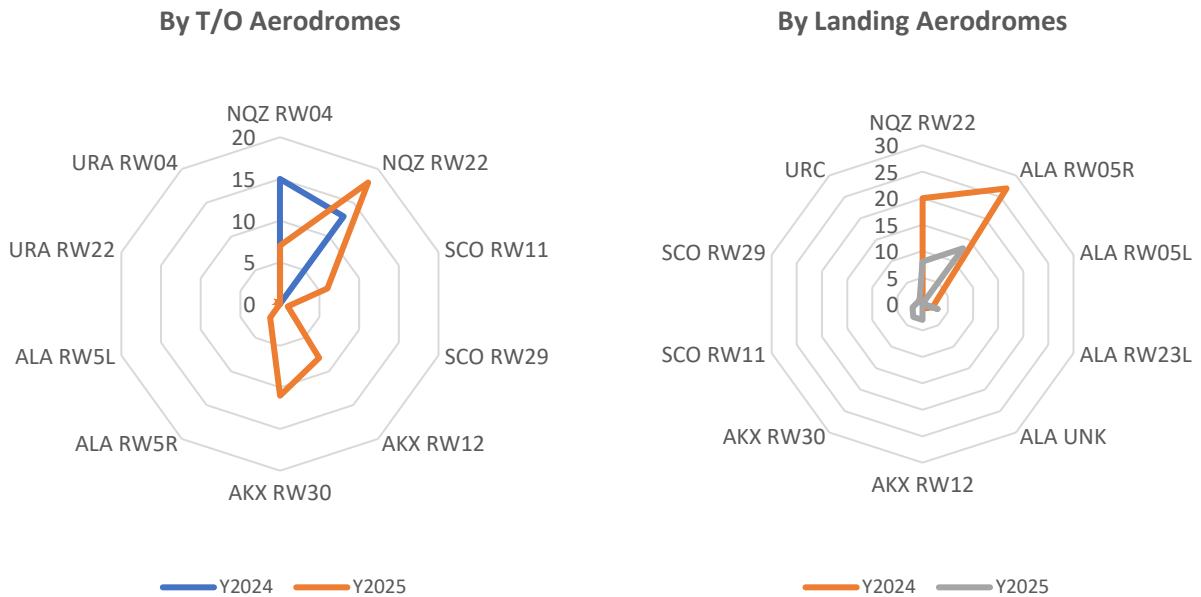


Figure 5. Distribution of registered GPS/GNSS reports by flight phases, sectors and aerodromes


**3. PREVENTIVE CONTROLS**

**Preventive controls** should be understood as a barrier preventing a threat from becoming a top event. A set of prevention controls configures the organization's mitigation strategy to reduce and control the risk of GNSS-RFI.

<b>Preventive Controls from the Operator's Perspective</b>	
Flight planning	Checking NOTAMS related to known or expected GNSS-RFI Checking the availability of non-GNSS-based routes, procedures, and approaches (ILS, VOR, and DME) Consider limitations caused by inoperative radio navigation systems to operate in GNSS-RFI-affected areas.
En route	Enforce action ECAM/EICAS and FCOM or supplemental procedures for loss of GNSS.
Post-flight	Technical report in the maintenance logbook in case any cockpit effects related to GNSS-RFI are experienced Establish maintenance/operations feedback after troubleshooting GNSS-RFI reports Report any suspected GNSS-RFI events to relevant regional and international organizations When RFI is identified, aircraft data should be sent to OEMs for further investigation.

Table 3. GNSS-RFI Preventive controls

Ensure preventive controls are documented, implemented, and trained as required. It is recommended that a contingency/mitigation procedure be outlined to prevent threats from degrading navigation, surveillance, and other avionic system performance and flight crews are informed and provided with relevant guidance to safely identify and respond to GNSS-RFI.

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**Recovery controls** Consider the barriers listed in Table 5, which can enhance air operators' operational systems based on standard operating procedures and policies to prevent a top event from escalating into an accident.

<b>Operators / Recovery controls</b>	
En route	Enforce abnormal/emergency procedures as appropriate Establish/enforce procedures regarding cross-checking position using other available navigation systems (radio nav aids, e.g., VOR, DME), INS, and visual references. Establish/enforce procedures for location cross-check with air traffic control (ATC) before attempting troubleshooting Establish/enforce procedures to revert to available alternate navigation systems (VOR, DME, INS) radar vectors from ATC. Establish/enforce requirements to notify ATC about GNSS-RFI, and if cockpit annunciation of ADS-B OUT failure is available, add that information to communications with ATC.
Approach	Enforce procedures to conduct conventional arrival/approach procedures

Table 4. GNSS-RFI recovery controls

Ensure recovery controls are documented, implemented, and trained as required. It is recommended that additional safety controls, such as dead reckoning, be identified as an alternative navigation method (If applicable).

Operators are recommended to review and establish a process for continuously updating technical information about GNSS interference from OEMs. This will ensure that necessary changes to operational procedures are communicated and implemented across the organization.

**ATM/ANS providers should:**

- Collect information on GNSS degradations in coordination with the AAK, National Telecommunications Authorities, and promptly notify the related outcomes to air operators and to other airspace users;
- Assess the impact of loss or anomalies of GNSS-based timing on CNS systems;
- Issue NOTAMs to provide relevant information to airspace users (as appropriate and determined at State level);
- Provide reliable surveillance coverage that is resilient to GNSS interference, as well as maintain essential conventional navigation infrastructure operational (Instrument Landing Systems, Distance Measuring Equipment (DME), Very High Frequency omnidirectional range (VOR) in support of conventional navigation procedures;
- Ensure that their contingency plans include procedures to be followed in case of large-scale GNSS jamming and/or spoofing events;
- Monitor the traffic closely to prevent any deviation from the flight track/route

**Authorized organization in the field of civil aviation should continue to:**

- Coordinate actions with ATM/ANS providers and airspace users;
- Maintain conventional navigation infrastructure, particularly Instrument Landing Systems, are retained and fully operational;

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- Coordinate appropriate and proactive mitigating measures as a matter of high priority, including the issuance of NOTAMs, e.g. describing affected areas and related limitations (as appropriate and determined at State level);
- Facilitate the establishment by ATM/ANS service providers of a process to collect information on GNSS degradations, in coordination with the relevant National Telecommunications Authorities, and promptly notify the related outcomes to air operators and to other airspace users;
- Continue discussion at a national level to restrict the usage of GNSS jammers.

#### All parties concerned:

- Report cases of loss/deterioration of the GNSS/GPS signal, including recorded facts of their impact on aircraft systems;
- Flight crew members are encouraged to report “real-time” reports to ATC during a GNSS interference incident and follow-up with a written report including the following information:
  1. *Aircraft type and registration information,*
  2. *Date, time, and location of GNSS interference,*
  3. *Phase of flight,*
  4. *Instrument approach type (if applicable),*
  5. *Altitude,*
  6. *Make/Model of GPS receiver,*
  7. *Maintenance actions (if applicable and known),*
  8. *GNSS interference description, and*
  9. *Consequences/operational impact on your flight*

This will greatly help in data collection and analysis to develop solutions to eliminate and/or mitigate the effects of these failures.

#### Useful Links:

To send information to the AAK, use the link to [Aviation Voluntary Reporting System](#).

[GPSJAM GPS/GNSS Tracker](#)

[GPS Spoofing & Jamming Map](#)

[GNSS Threat Assessment Tool by EUROCONTROL](#)

[IATA Lite Safety Risk Assessment on Space Weather/Spectrum interference](#)

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### 4. GPS SPOOFING IMPACT MATRIX

Spoofting effect	Aircraft Handling <i>Flight Crew</i>	ANSP/ATC <i>Air Traffic Controller</i>	Operational <i>Aircraft Operator</i>
GPS receiver failure	Impacts other systems - May appear recovered but still contaminated		- AOG if receiver becomes 'bricked*' (NVM corrupted) - Repair time days or weeks <b>COST</b>
FMS position degraded or failed	- Undetected off-track navigation - Loss of situational awareness - Unplanned entry into Danger Area, other FIR's	- Lateral loss of separation - Vectoring (often many aircraft) - increased workload	- Potential Accident/Incident <b>RISK</b>
Unable RNP	- Restricted to conventional enroute navigation and approaches - Unable RNP SID/STAR - Reduced Oxygen Escape route options	- RNP-4 or better based separation not available e.g., North Atlantic - RNP App/SID/STAR not useable - Increased vectoring for initial approach	- Potential diversion <b>COST</b>
Map Shift	- Wrong runway selection - Loss of situational awareness	- Loss of separation during landing - Risk of landing on closed runway	- Potential Accident/Incident <b>RISK</b>
IRS	- Hybrid IRS may cause false FMS position or failure		
GPWS	- False EGPWS alerts - Startle effect - Lowered trust in GPWS system overall - Delayed responses - Go-around from unusual altitude/ position - Nuisance alerts cause stress, distraction - Risk of response in low energy aircraft state, stall.	- Level busts - loss of separation due to unexpected EGPWS response maneuver.	- Potential Accident/Incident - Passenger injury <b>RISK</b>
Weather Radar	- May impact ability to detect Cb - Ground clutter function not available		- Potential flight into convective activity - Passenger injury <b>RISK</b>
Aircraft Clock	- Incorrect time displayed on clock		

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Spoofting effect	Aircraft Handling <i>Flight Crew</i>	ANSP/ATC <i>Air Traffic Controller</i>	Operational <i>Aircraft Operator</i>
	- Incorrect time fed to other systems		
Datalink (ADS-C, CPDLC)	- CPDLC not available, switch to voice (VHF, HF) - ADS-C not available - Oceanic RCP/RSP cannot be met, PBCS tracks not avail - Reroutes or lower levels can be expected	European capacity constraints due to overuse of VHF - Oceanic PBCS separation not available	- Reroute - Diversion - Lower level, higher fuel burn <b>COST</b>
ADS-B	- Unable to fly in ADS-B required airspace	- ADS-B only airspace not available - ADS-B based separation not available - Risk of incorrect ADS-B based position on screen	- Reroute - Cancellation <b>COST</b>
HUD&SVS	- HUD must be stowed - SVS not available - Degraded situational awareness		
ELT	- Potential for incorrect aircraft position broadcast in emergency	- SAR may receive incorrect aircraft position	- SAR in wrong location <b>RISK</b>
RAAS (Runway)	- Unavailable, or may give false warning		- Potential Accident/Incident <b>RISK</b>
ROPS (Runway)	- Unavailable, or may give false warning		- Potential Accident/Incident <b>RISK</b>
SATCOM	- May be unavailable		
EFB	- Some applications use GPS position and will not work correctly (e.g., moving map) - Situation awareness degraded		
Internet/Wi-Fi	- Some reports of Wi-Fi not working correctl		- Pax inconvenience
Overall: Complexity of multiple interconnected failures	- Complex go-arounds with multiple failures - Emergency margin of safety reduced		- Potential Accident/Incident <b>RISK</b> - Diversion <b>COST</b>

\*“Bricked” device is an electronic device that is no longer functional due to corrupted firmware, a hardware problem, or other damage.