

Edge Case: Definition

“An **edge case** is a situation or environment that lies at the extreme boundaries of normal system operating conditions—**geographically, operationally, or technically**—where standard assumptions or designs **begin to break down.**”



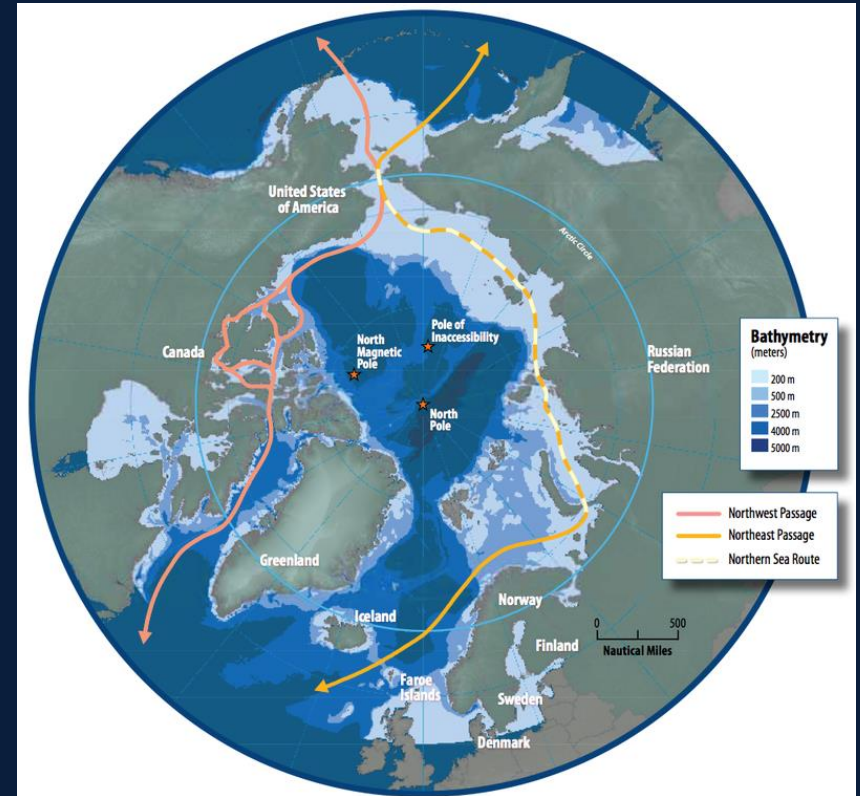
GNSS Edge Case: Arctic vs Mid-Latitudes

- Poor satellite geometry: Signals arrive at low angles → increased error.
- Longer signal paths through atmosphere → greater susceptibility to distortion.
- Severe ionospheric interference near auroral oval → signal fluctuation, loss.
- Sparse ground infrastructure → fewer corrections, limited spoof/jam detection.
- Magnetic compasses unreliable near the North Magnetic Pole.
- High spoofing/jamming risk in low-surveillance zones.

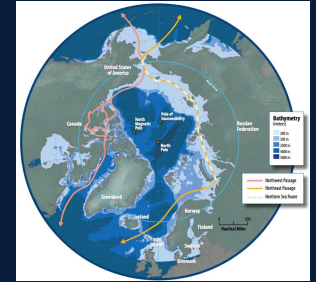


Arctic Emerging as Strategic and Competitive Theatre

- Melting sea ice is opening strategic Arctic shipping lanes.
- Arctic holds vast untapped resources—oil, gas, rare earths.
- Major powers (Russia, China, U.S., NATO allies) are increasing military and commercial presence.
- Communications and navigation infrastructure is sparse and fragile.
- Contest over Arctic access is accelerating—both physically and digitally.



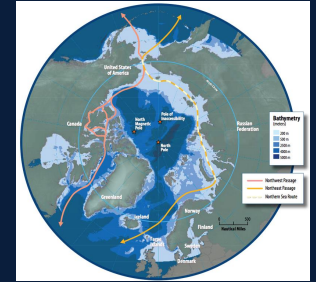
Arctic GNSS Interference



Novel/Unique Aspect	Why It Matters in the Polar Region
Exploiting low satellite angles	Makes Arctic receivers more vulnerable to ground jammers
Jamming + auroral interference	Amplifies effects and masks intent
Persistent, ambiguous jamming	Creates gray zone pressure without open conflict
Arctic-specific EW systems	Enables disruption in otherwise unreachable terrain
Strategic infrastructure targeting	Threatens global data and nav links via Arctic
Space-based vectors	Unprecedented and difficult to detect



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GPS JAMMING INCIDENT – March 24-25, 2024

- Widespread reports in Europe of GPS jamming March 24-25.
- Over 1,600 aircraft impacted across two days.
- Jamming concentrated in Eastern Europe.
- Source suspected to be Russia's Kaliningrad exclave.
- Multi-constellation interference (GPS, GLONASS, BeiDou, Galileo).



NOAA Space Weather Center – March 24-26, 2024

- NOAA issues geomagnetic storm warnings for March 24-25.
- Confirmed geomagnetic storm on March 24.
- Storm caused by coronal mass ejection (CME).
- M-class and X-class solar flares intensified March 23-24.
- **G4 (Severe) storm levels reached - Kp index = 8.**
- **Ionospheric effects confirmed on March 24-26.**



Why Edge Cases Are So Important

- Edge cases reveal system limits: where assumptions break down.
- Edge cases are where adversaries push: low visibility, high impact.
- Failure in edge cases can cascade: breakdowns propagate in complex systems.



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- Edge cases are where adversaries push: low visibility, high impact.
- Failure in edge cases can cascade: breakdowns propagate in complex systems.
- **Edge cases shape innovation: solutions built for the edge often benefit the whole!**

