



2027 Challenge: Operational Resilience in Contested Environments





Operational Resilience in Contested Environments

1. Challenge Summary: In contested environments, adversaries deliberately disrupt sensing, communications, and navigation through cyber-attacks, electromagnetic spectrum interference, and the denial of global navigation satellite systems (GNSS). Combined with austere and extreme physical conditions, these actions constrain freedom of action by limiting mobility, slowing decision-making, and restricting command-and-control (C2). As a result, both military operations and other vital security functions, such as the protection of critical infrastructure, are exposed to heightened risk.


The Alliance seeks practical, interoperable sensing, communication and positioning, navigation, and timing solutions that maintain operational effectiveness at the tactical edge when connectivity and assured navigation cannot be assumed. Solutions should enable coordination, safe movement and situational awareness and be inherently resilient to spectrum contestation and GNSS denial when deployed across mixed and austere terrain. This includes the detection and classification of adversary communications and assets whilst protecting friendly ones. Together, such capabilities would enhance operational resilience, freedom of action and continuity of operations.

2. Illustrative Scenario: An Allied response force is deployed to a partner nation after disruption to a regional airport and energy infrastructure. Visibility is degraded and the electromagnetic environment is subject to adversary jamming, further compounded by friendly countermeasures. Conventional radios prove unreliable and GNSS access is actively denied, limiting C2 and freedom of manoeuvre.

A forward unit deploys an uncrewed aerial system to perform reconnaissance on potential threats. Using GNSS-independent navigation and a multi-spectral sensing package, this detects an unmarked convoy approaching restricted airport access roads despite visual obscuration. Information is relayed using a resilient mesh radio network that dynamically routes data across tactical, satellite and civilian 5G data links. By correlating this information with high-definition satellite imagery from a civilian provider and analysis of electromagnetic emissions, the unknown convoy is identified as adversary. An unmanned ground vehicle, fitted with an electromagnetic-signature-reducing-coating, is then deployed to perform further reconnaissance under cover of darkness. Throughout the operation, the unit maintains coordination and safe movement across varied and austere terrain without reliance on assured access to the electromagnetic spectrum.

3. Exemplar Enabling Technologies: The following list provides illustrative examples of technologies that may contribute to this challenge. The list is not exhaustive, and NATO DIANA encourages integrated and novel approaches that extend beyond it:

Spectrum Management

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- Methods for monitoring spectrum availability, including the detection of low-interference and under-utilised bands.
 - Solutions for detecting and characterising electromagnetic radiation, including weak, intermittent and low-probability-of-intercept emissions.
 - Artificial intelligence (AI)-enabled approaches to dynamic spectrum management in congested electromagnetic environments.

Resilient Communication Systems

- Low-probability-of-intercept data links, for example using millimetre and terahertz radiation, that maintain reliable communications in contested environments.
- High-bandwidth, interference-resistant terrestrial and space-based communication systems that sustain connectivity when conventional radio-frequency links are degraded or unavailable.
- Self-configuring and autonomously deployable mesh networking technologies that provide resilient communications without reliance on fixed infrastructure.

Adaptive Sensing Technologies

- Software-defined systems using cognitive features, such as AI-enabled spectrum awareness and channel deconfliction, to adapt to evolving conditions.
- Integrated sensing and communications approaches for efficient spectrum usage with minimised hardware complexity and electromagnetic footprint.
- High-sensitivity sensing technologies, including quantum-enabled solutions, for measuring weak signals and detection and ranging with reduced probability of interception under contested conditions.

Resilient Navigation, Positioning and Timing

- Inertial measurement units, magnetic sensors and vision-based approaches using terrain and celestial observations that enable accurate navigation without relying on external signals.
- Alternatives to GNSS such as navigation systems utilising low Earth orbit satellites or radio-frequency signals of opportunity.
- Resilient timing and synchronisation solutions that enable the distribution of trusted time references in GNSS-denied environments.

Protection and Mobility

- Advanced materials and surface treatments that enable electromagnetic signature reduction, including frequency-selective surfaces and metamaterials.
- Platform protection and mobility-enabling approaches that reduce detectability and support movement in visually degraded and denied environments.
- Portable systems for collecting signals and imagery intelligence, such as edge sensors equipped with wideband receivers and embedded AI, for identifying adversary emissions amongst background noise.