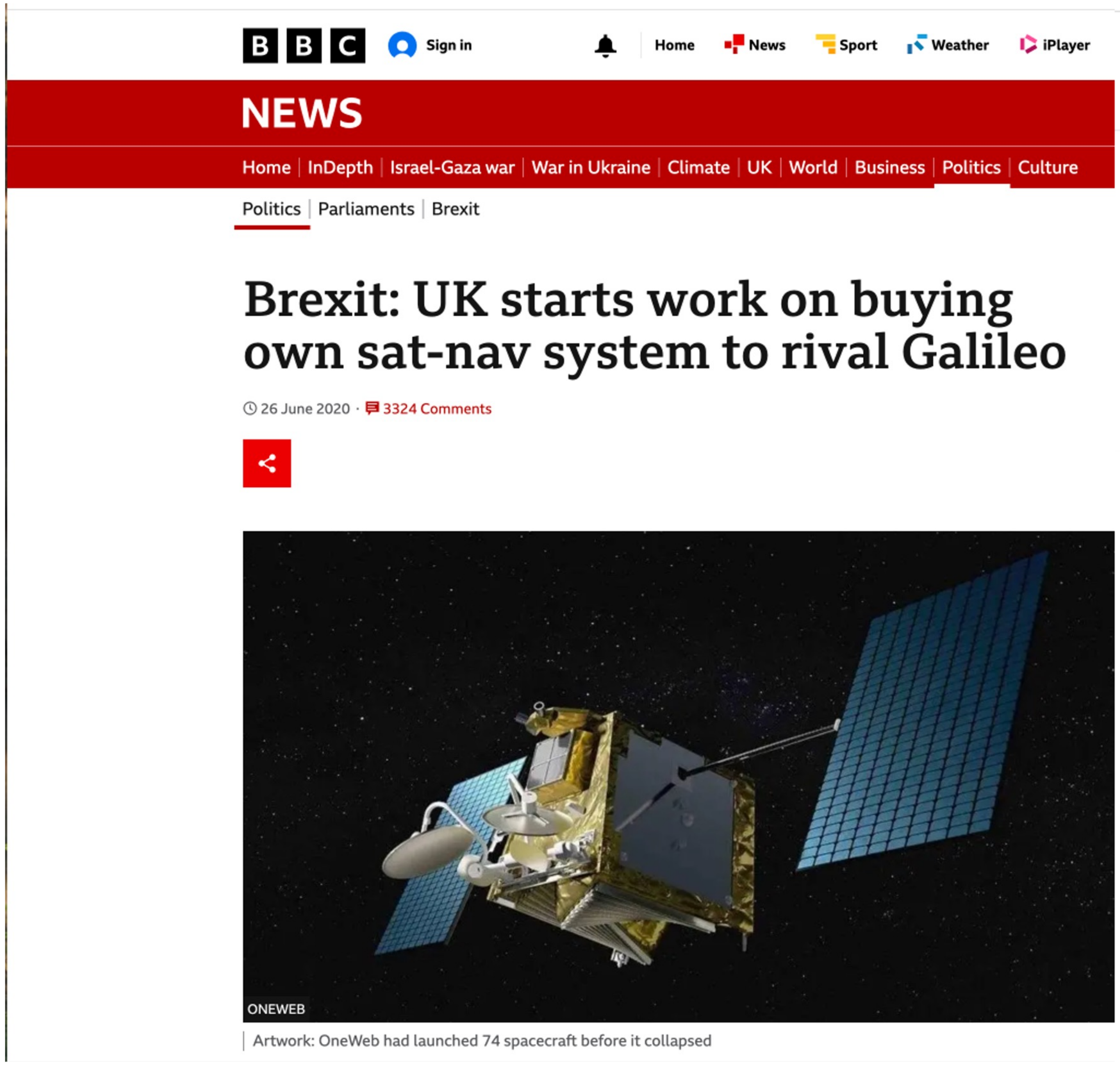
PNT EXPLAINER PNT BEST PRACTICES RESILIENCE CHECKLIST PNT GUIDANCE PNT TRAINING

Royal Institute Of Navigation

RESILIENT PNT RESOURCES PORTAL

BEST PRACTICES ONE PAGER

Daily Telegraph
SIX NATIONS PULL-OUT
Start your rugby weekend with 25 pages of unrivalled coverage
mps up pressure on EU
Out at last – and it's such a relief that we did it
Allison Pearson
SHINE ...IT'S A GLORIOUS NEW BRITAIN
weekend
JOURNALISM YOU CAN TRUST · BRITAIN'S FASTEST GROWING READERSHIP
What next?
SPECIAL EDITION
OCRACY
BYE BYE EU!
BYE BYE EU!
FROM JUST £15
SECRETS OF THE MASKED SINGER
BY JONATHAN ROSS
AS WE FINALLY QUIT EU..
MAKE LEAVE... NOT
PM'S BREX SUCCESS
'LET'S B UK TOGET
Missing you already...
Free souvenir supplement
27 letters from Europe
+Ian McEwan & Marina Hyde
Brexit special
Saturday 1 February 2020
The Guardian
The day we said goodbye
Jonathan Freedland
How does a nation say goodbye to its neighbours? With a lump in its throat and a poignant song of farewell - or with cheers and a raised middle finger of defiant good riddance? The answer that Britain gave at 11pm on Friday 31 January 2020 was: both.
The UK broke from the European Union on a late winter's night with jubilation and regret, as divided on the day of leaving as it had been in
THE TIMES
Britain's most trusted national newspaper
SATURDAY
February 1 2020 | thetimes.co.uk | No 73071
How to cure a bad back
What the experts do
The Vogue editor who went rogue
Emily Sheffield reveals all
ONLY £2
Farewell to EU
Leavers celebrate in Parliament Square
The Scrum
SIX NATIONS
DAILY Mirror
MOMENT
wakes up to a future
stronger. For the sake



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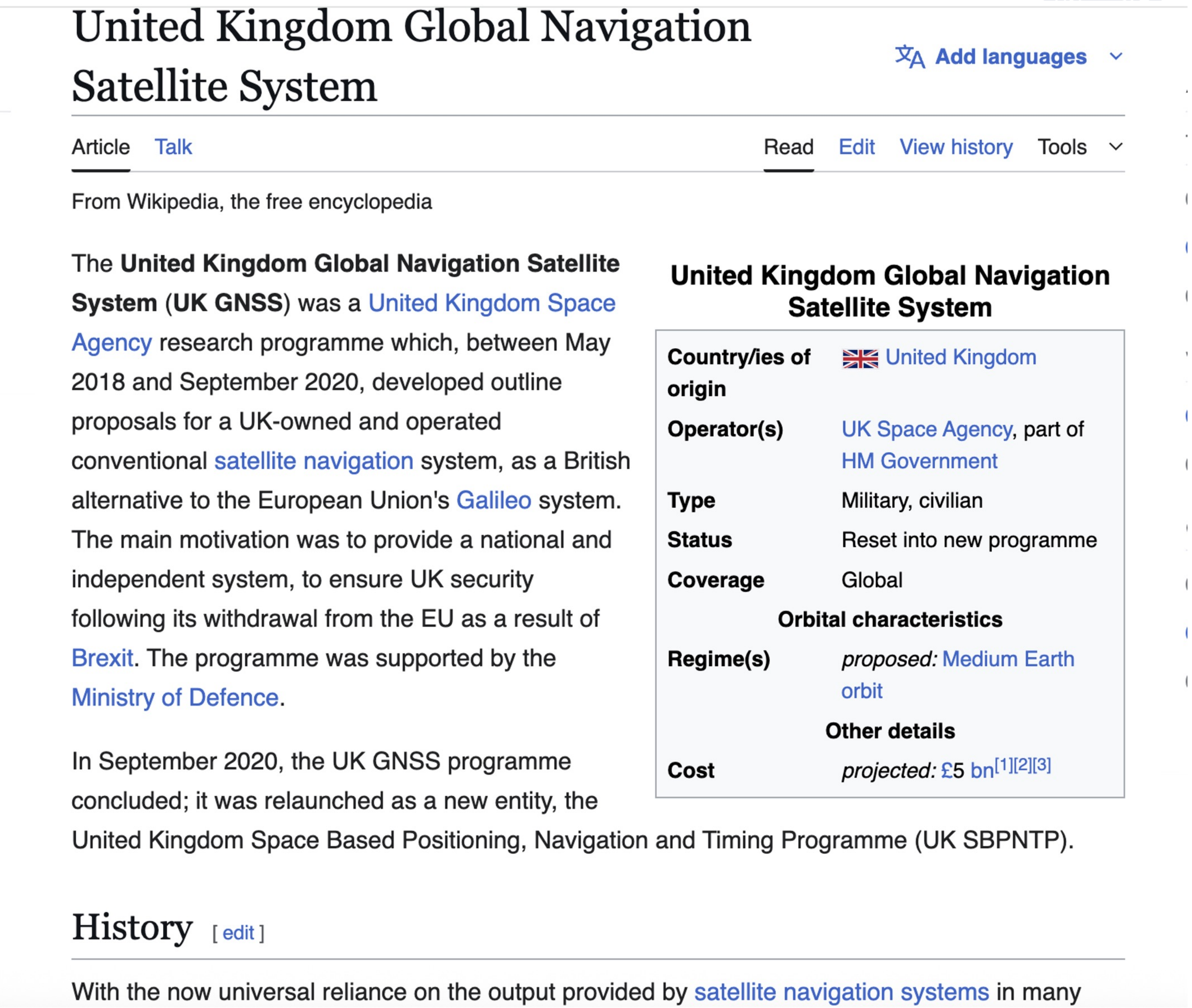
Brexit: UK starts work on buying own sat-nav system to rival Galileo

26 June 2020 · 3324 Comments

Artwork: OneWeb had launched 74 spacecraft before it collapsed



United Kingdom Global Navigation Satellite System

From Wikipedia, the free encyclopedia

The **United Kingdom Global Navigation Satellite System** (**UK GNSS**) was a United Kingdom Space Agency research programme which, between May 2018 and September 2020, developed outline proposals for a UK-owned and operated conventional satellite navigation system, as a British alternative to the European Union's Galileo system. The main motivation was to provide a national and independent system, to ensure UK security following its withdrawal from the EU as a result of Brexit. The programme was supported by the Ministry of Defence.

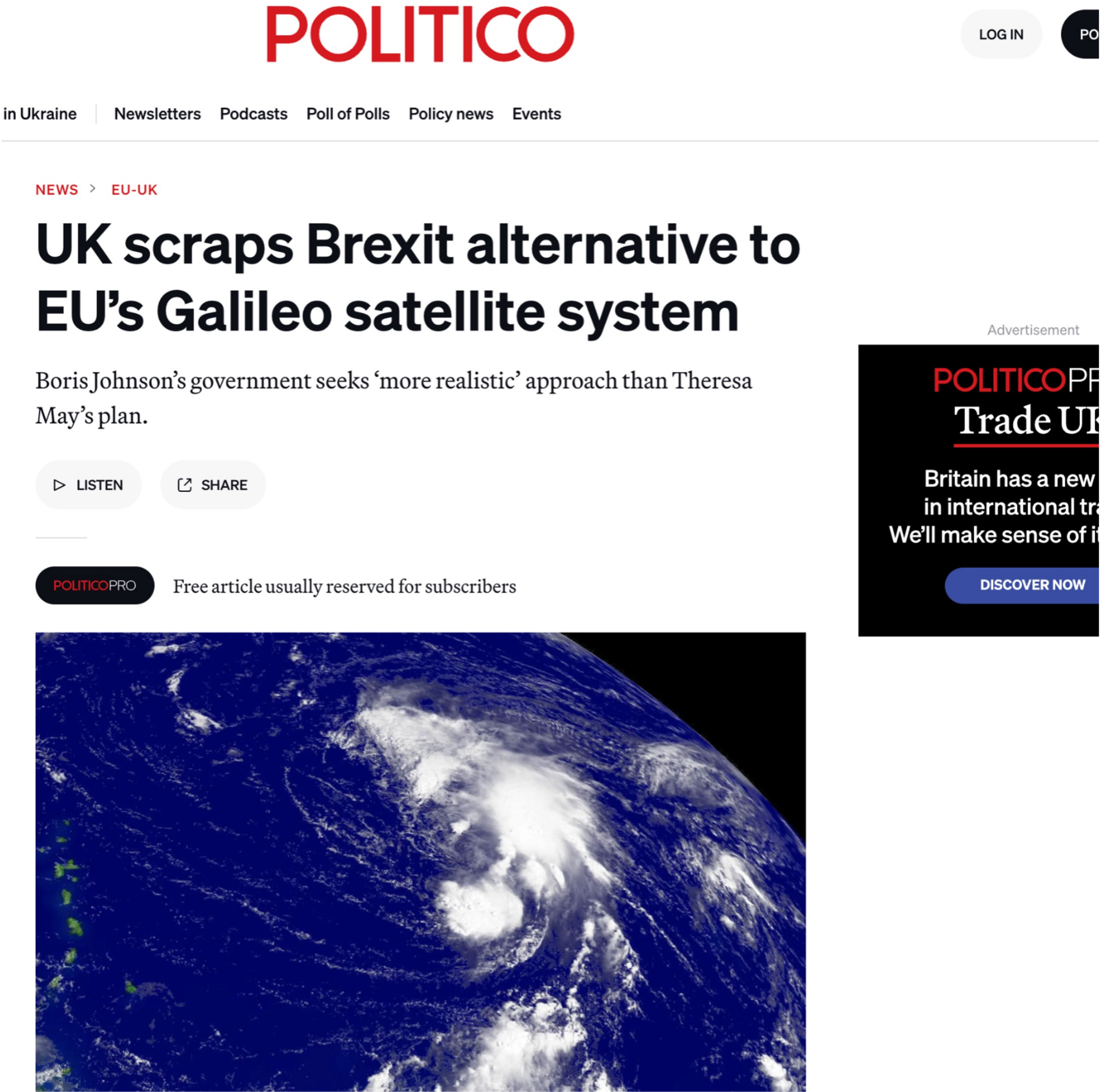
United Kingdom Global Navigation Satellite System

Country/ies of origin	🇬🇧 United Kingdom
Operator(s)	UK Space Agency, part of HM Government
Type	Military, civilian
Status	Reset into new programme
Coverage	Global
Orbital characteristics	
Regime(s)	*proposed:* Medium Earth orbit
Other details	
Cost	*projected:* £5 bn[1][2][3]

In September 2020, the UK GNSS programme concluded; it was relaunched as a new entity, the United Kingdom Space Based Positioning, Navigation and Timing Programme (UK SBPNTP).

History [edit]

With the now universal reliance on the output provided by satellite navigation systems in many



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UK scraps Brexit alternative to EU's Galileo satellite system

Boris Johnson's government seeks 'more realistic' approach than Theresa May's plan.

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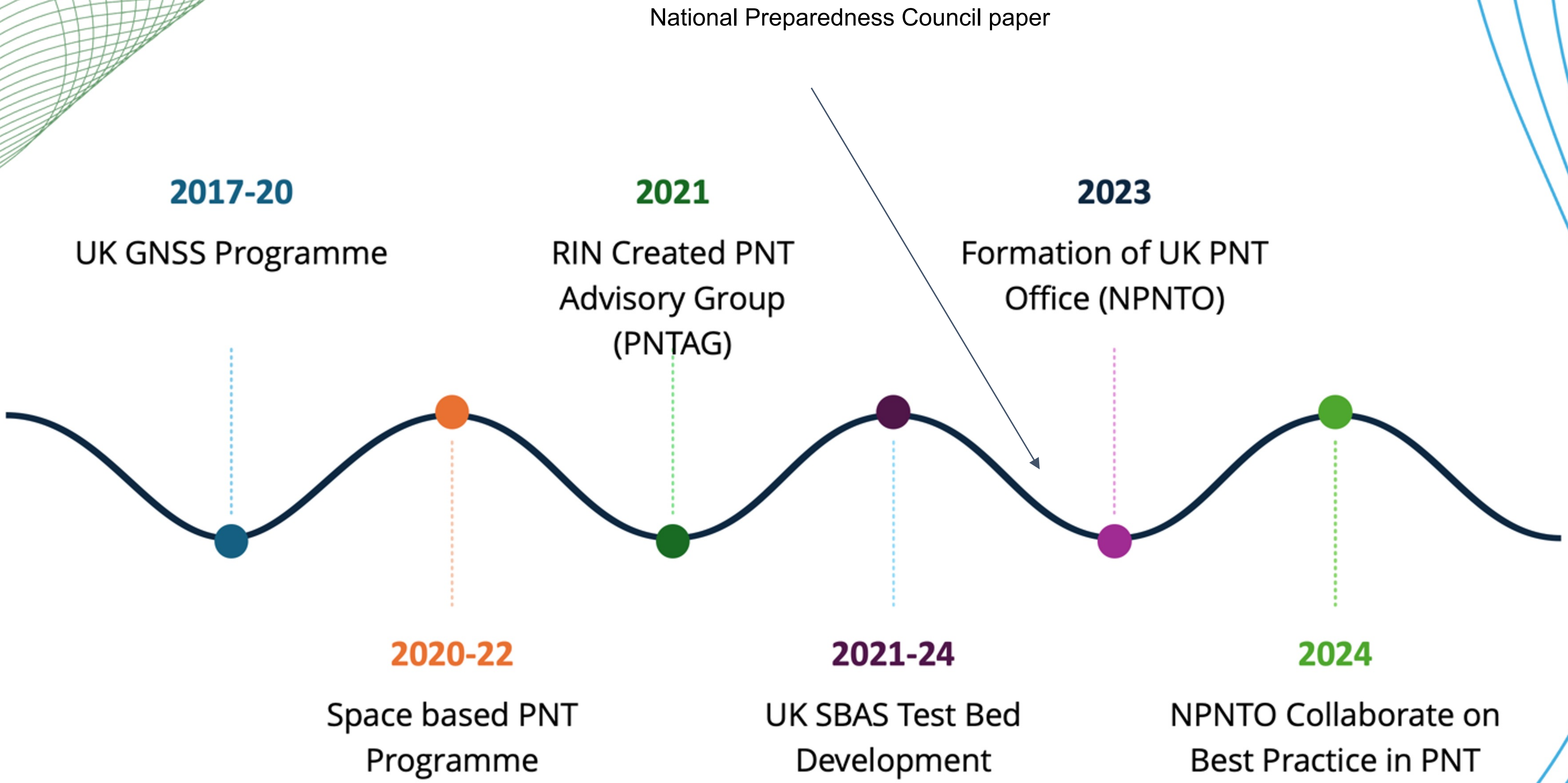


2017-20

UK GNSS Programme

2020-22

Space based PNT Programme

2021

RIN Created PNT Advisory Group (PNTAG)

2021-24

UK SBAS Test Bed Development

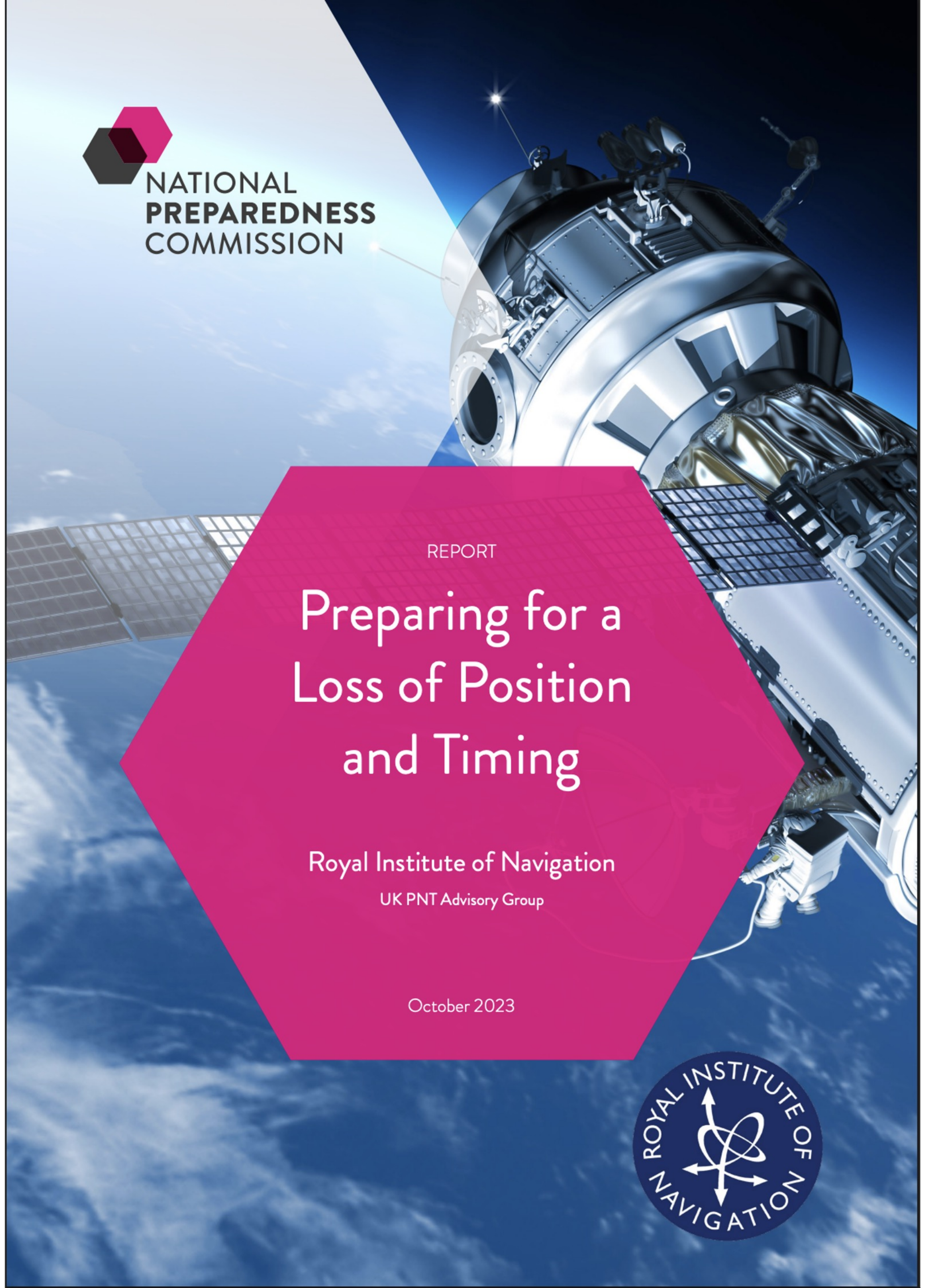
National Preparedness Council paper

2023

Formation of UK PNT Office (NPNTO)

2024

NPNTO Collaborate on Best Practice in PNT



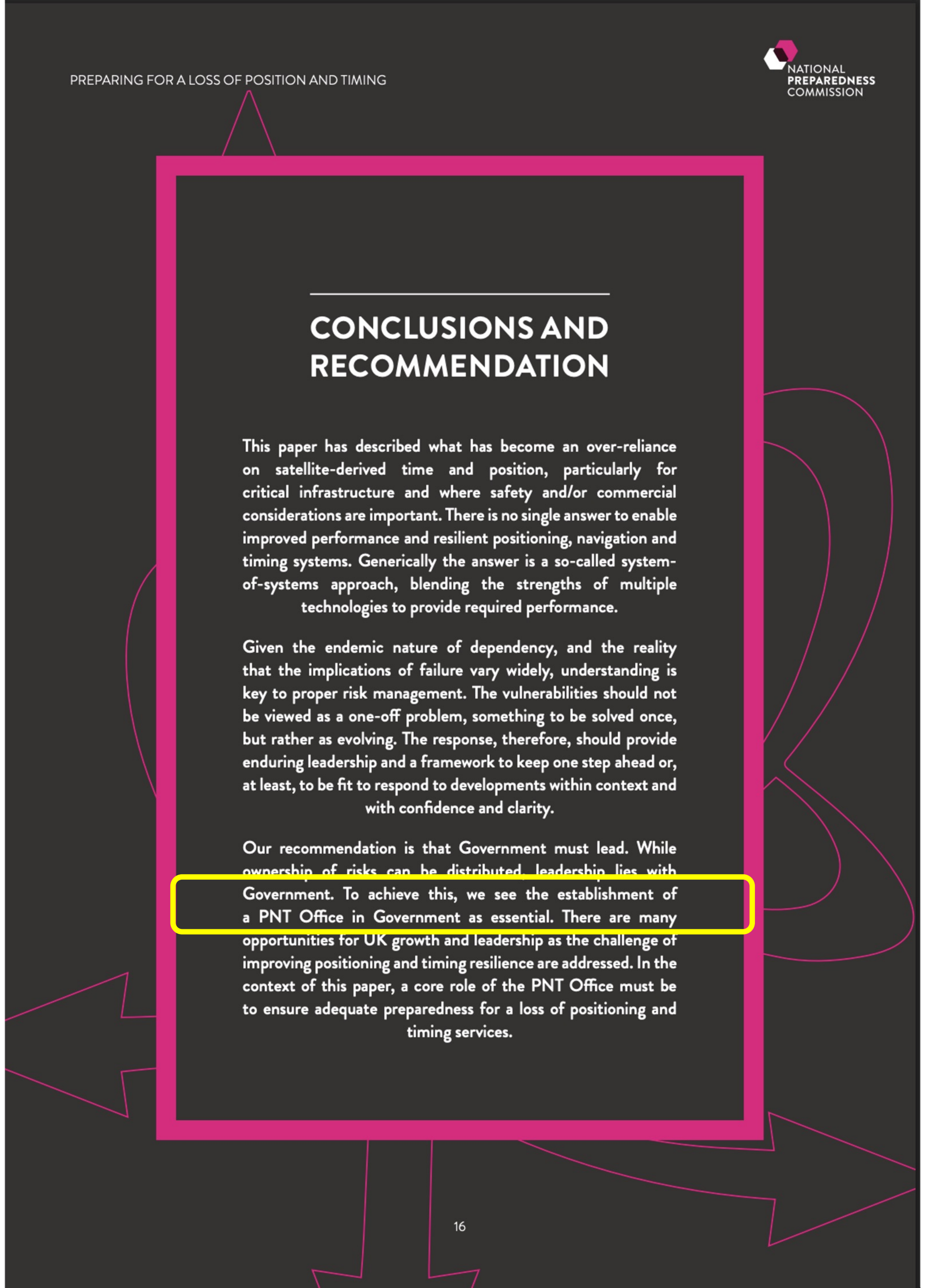
NATIONAL
PREPAREDNESS
COMMISSION

REPORT

Preparing for a Loss of Position and Timing

Royal Institute of Navigation
UK PNT Advisory Group

October 2023



PREPARING FOR A LOSS OF POSITION AND TIMING

NATIONAL
PREPAREDNESS
COMMISSION

CONCLUSIONS AND RECOMMENDATION

This paper has described what has become an over-reliance on satellite-derived time and position, particularly for critical infrastructure and where safety and/or commercial considerations are important. There is no single answer to enable improved performance and resilient positioning, navigation and timing systems. Generically the answer is a so-called system-of-systems approach, blending the strengths of multiple technologies to provide required performance.

Given the endemic nature of dependency, and the reality that the implications of failure vary widely, understanding is key to proper risk management. The vulnerabilities should not be viewed as a one-off problem, something to be solved once, but rather as evolving. The response, therefore, should provide enduring leadership and a framework to keep one step ahead or, at least, to be fit to respond to developments within context and with confidence and clarity.

Our recommendation is that Government must lead. While ownership of risks can be distributed, leadership lies with Government. To achieve this, we see the establishment of a PNT Office in Government as essential. There are many opportunities for UK growth and leadership as the challenge of improving positioning and timing resilience are addressed. In the context of this paper, a core role of the PNT Office must be to ensure adequate preparedness for a loss of positioning and timing services.

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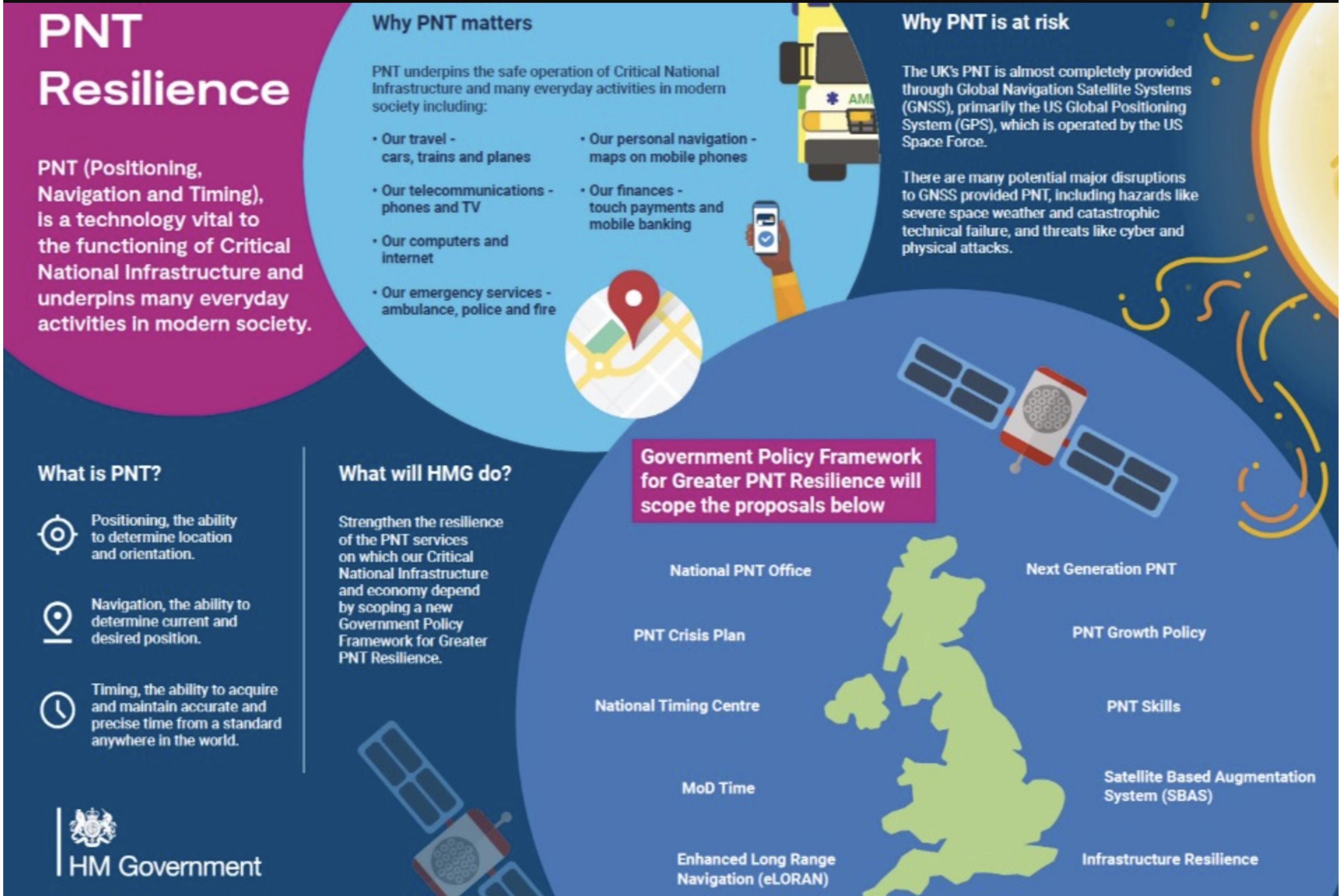


PNT Resilience

PNT (Positioning, Navigation and Timing), is a technology vital to the functioning of Critical National Infrastructure and underpins many everyday activities in modern society.

Why PNT matters

PNT underpins the safe operation of Critical National Infrastructure and many everyday activities in modern society including:

- Our travel - cars, trains and planes
- Our telecommunications - phones and TV
- Our computers and internet
- Our emergency services - ambulance, police and fire
- Our personal navigation - maps on mobile phones
- Our finances - touch payments and mobile banking

Why PNT is at risk

The UK's PNT is almost completely provided through Global Navigation Satellite Systems (GNSS), primarily the US Global Positioning System (GPS), which is operated by the US Space Force.

There are many potential major disruptions to GNSS provided PNT, including hazards like severe space weather and catastrophic technical failure, and threats like cyber and physical attacks.

What is PNT?

Positioning, the ability to determine location and orientation.

Navigation, the ability to determine current and desired position.

Timing, the ability to acquire and maintain accurate and precise time from a standard anywhere in the world.

What will HMG do?

Strengthen the resilience of the PNT services on which our Critical National Infrastructure and economy depend by scoping a new Government Policy Framework for Greater PNT Resilience.

Government Policy Framework for Greater PNT Resilience will scope the proposals below

National PNT Office

PNT Crisis Plan

National Timing Centre

MoD Time

Enhanced Long Range Navigation (eLORAN)

Next Generation PNT

PNT Growth Policy

PNT Skills

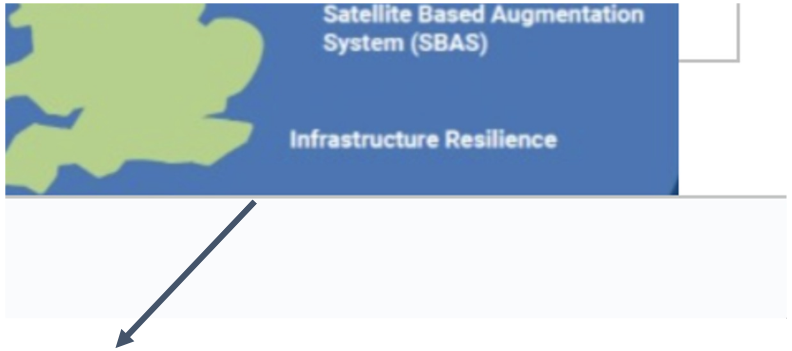
Satellite Based Augmentation System (SBAS)

Infrastructure Resilience

HM Government

RIN STRATEGY

Membership, Groups, Events, Partnerships	Learning and Development “Online PNT University”	Expert Advice and Guidance “Learned Society”


Satellite Based Augmentation System (SBAS)
Infrastructure Resilience

PNTAG <> NPNTO Partnership on Resilient PNT Best Practices

Royal Institute Of Navigation

RESILIENT PNT RESOURCES PORTAL

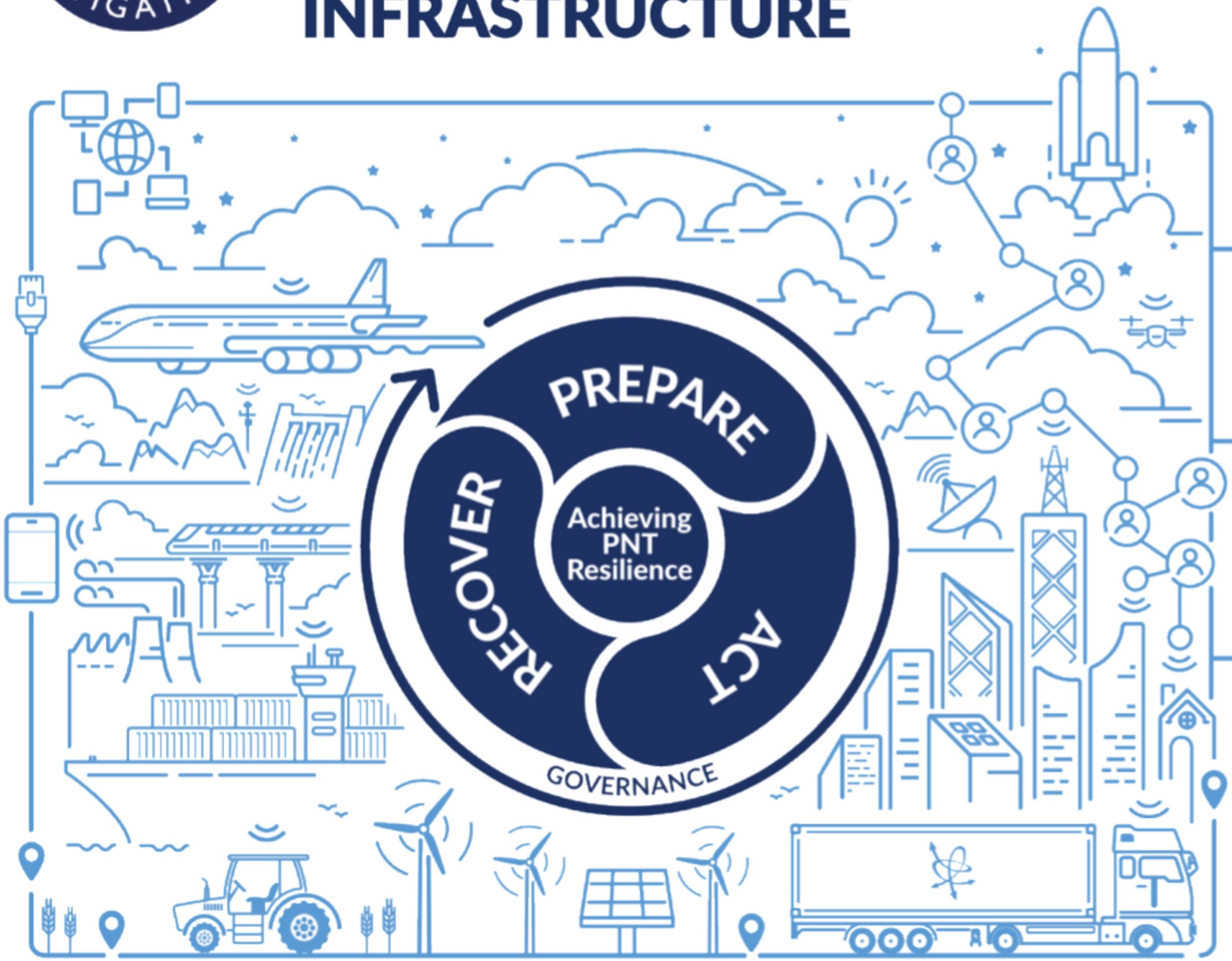
Best Practice Guidelines
Key info for this audience

- ➢ PNT leaders are already very well-versed in resilient PNT and the concepts within the Best Practice Guidelines
- ➢ These guidance materials are for the Critical National Infrastructure operational and delivery streams

- ➢ The Guidance provides
  - “Key principles on a page” - Board level / senior management discussions
  - Checklists - actionable and metricating progress in improvements
  - Mitigation plans - help to visualise where current gaps are
  - Still in development: annual “fire drills” for PNT

THREE STAGES FOR ACHIEVING PNT RESILIENCE IN CRITICAL NATIONAL INFRASTRUCTURE

All CNI sectors rely on Position, Navigation, and Timing (PNT) services from satellite systems and other sources. Organisations should develop, implement, and embed a Prepare-Act-Recover PNT resilience framework to ensure systems that rely on PNT services can recover effectively from disruption caused by technological failures, naturally occurring events, or malicious activity.



PREPARE FOR PNT DISRUPTIONS

1. Include PNT resilience in existing governance, cyber-risk, and business continuity frameworks.
2. Test system responses to understand effects of PNT disruptions on system behaviour.
3. Build a mitigation strategy to improve resilience and preserve safety, security and economic performance.

ACT WHEN PNT DISRUPTIONS OCCUR

1. Detect disruption events as soon as possible after they occur.
2. Take planned steps to preserve essential levels of safety, security, and economic wellbeing.
3. Monitor, measure, and record the impact of disruptions on system performance.

RECOVER FROM PNT DISRUPTIONS

1. Return to standard operations when safe and secure to do so.
2. Assess mitigation effectiveness and update response plans and continuity frameworks.
3. Share lessons learned when reporting incidents and their associated impacts.

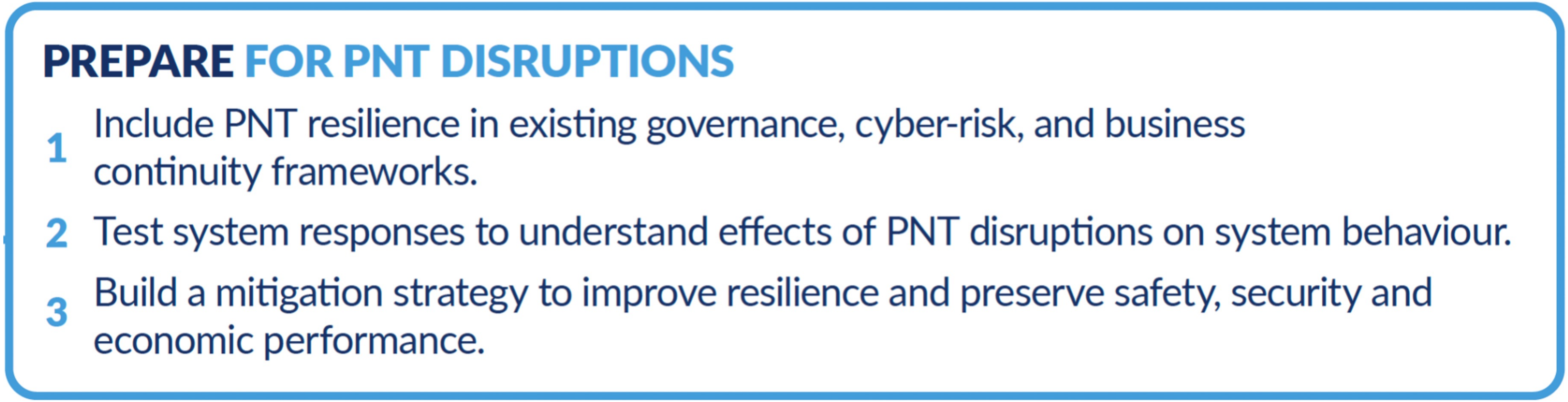
GET THE PNT RESILIENCE CHECKLIST

Loss of PNT services is now a critical risk on the UK's National Risk Register.

Checklist and resources: www.rin.org.uk/resilient_pnt

Issue 1-00

Key Principles for Resilient PNT



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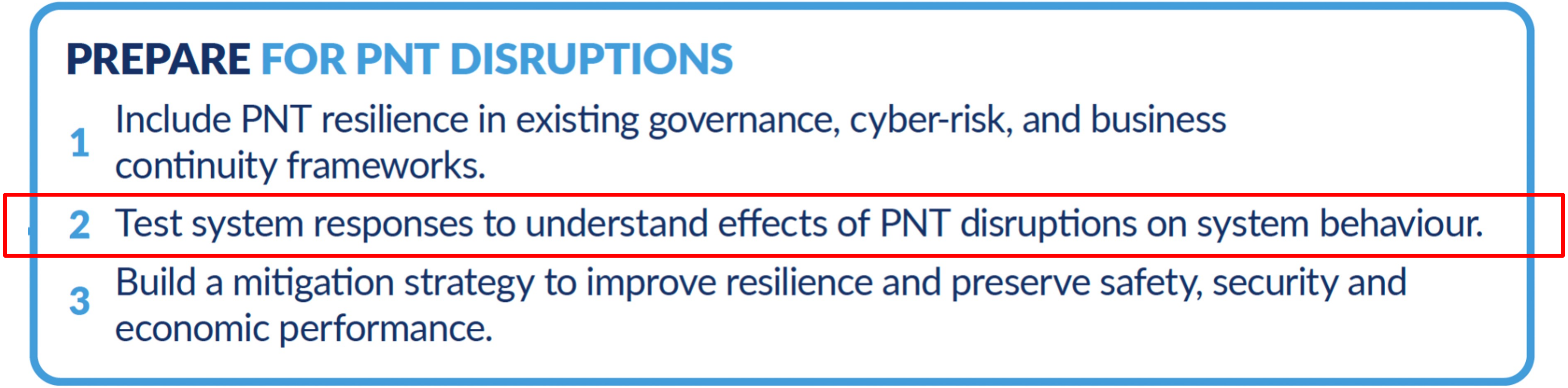

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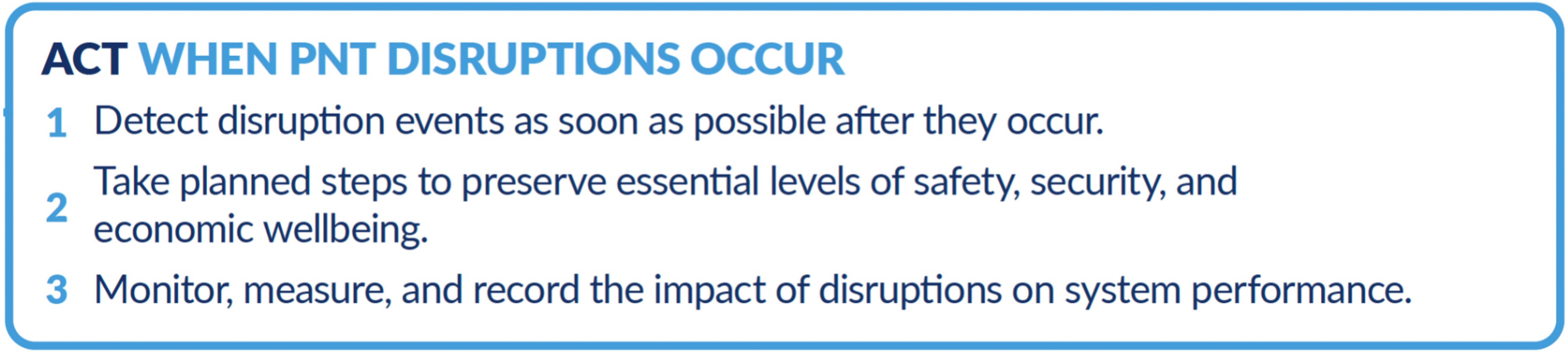

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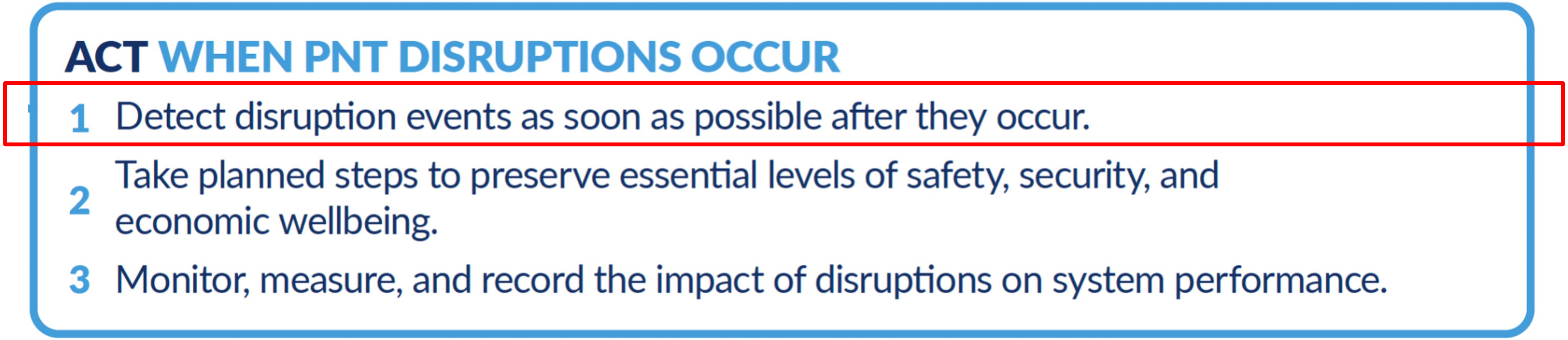

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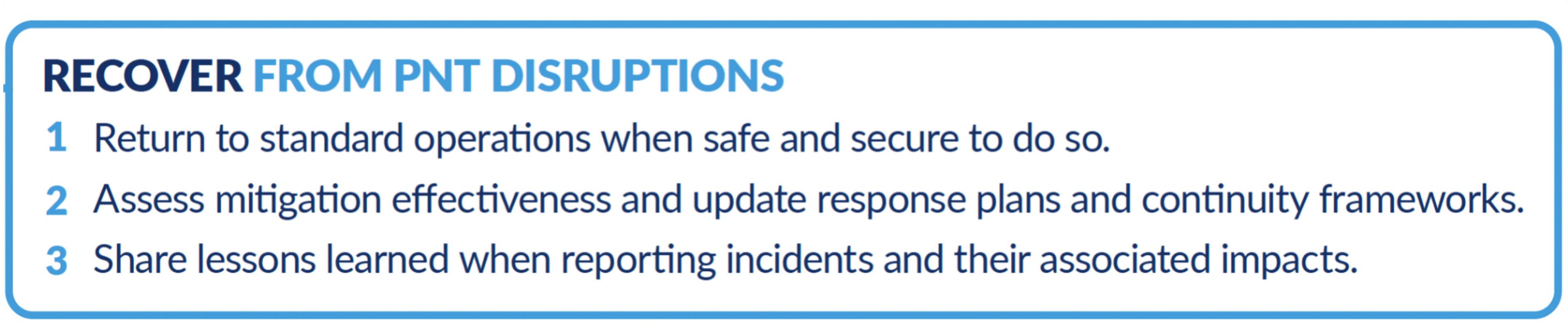

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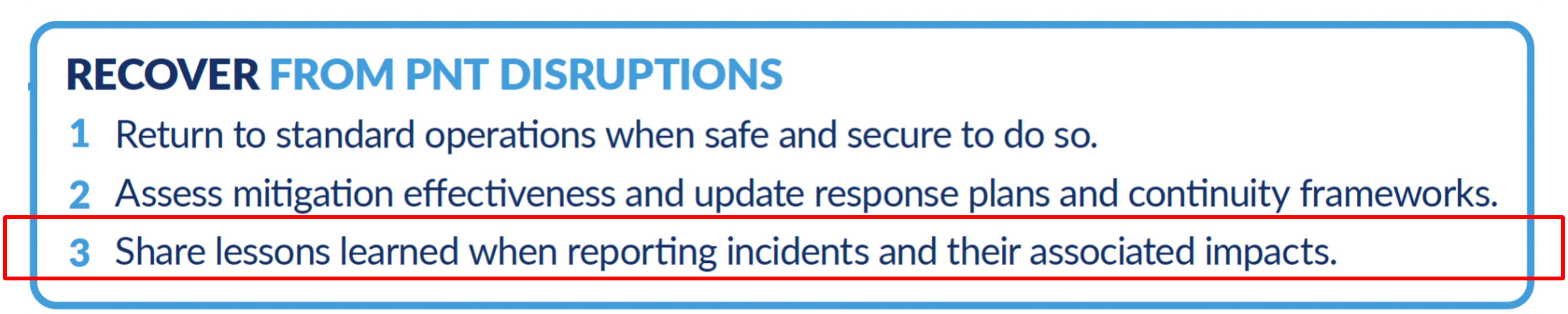

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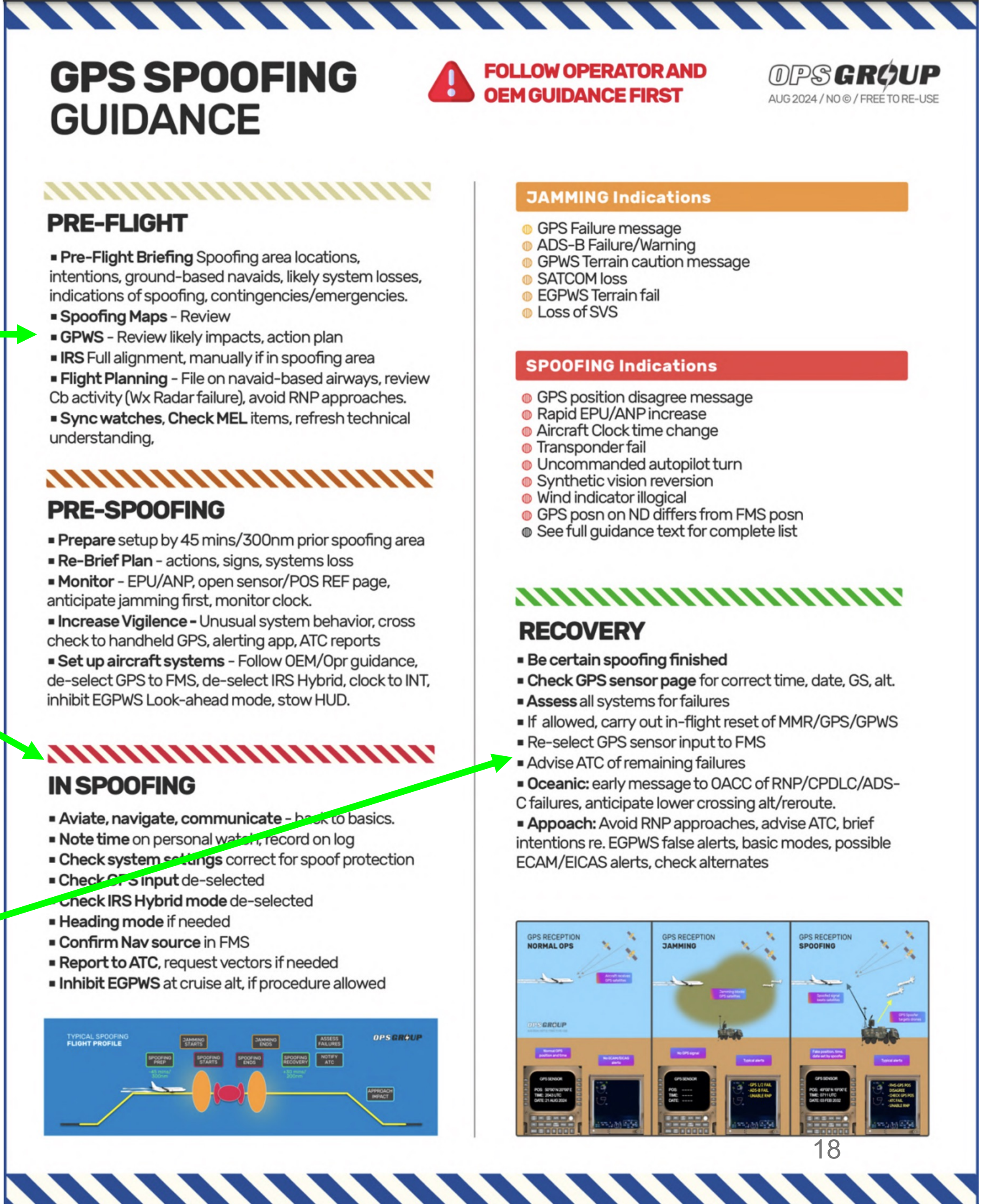

GPS SPOOFING GUIDANCE

FOLLOW OPERATOR AND OEM GUIDANCE FIRST

OPSGROUP
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PRE-FLIGHT

- **Pre-Flight Briefing** Spoofing area locations, intentions, ground-based navaids, likely system losses, indications of spoofing, contingencies/emergencies.
- **Spoofing Maps** - Review
- **GPWS** - Review likely impacts, action plan
- **IRS** Full alignment, manually if in spoofing area
- **Flight Planning** - File on navaid-based airways, review Cb activity (Wx Radar failure), avoid RNP approaches.
- **Sync watches, Check MEL** items, refresh technical understanding.

PRE-SPOOFING

- **Prepare** setup by 45 mins/300nm prior spoofing area
- **Re-Brief Plan** - actions, signs, systems loss
- **Monitor** - EPU/ANP, open sensor/POS REF page, anticipate jamming first, monitor clock.
- **Increase Vigilence -** Unusual system behavior, cross check to handheld GPS, alerting app, ATC reports
- **Set up aircraft systems** - Follow OEM/Opr guidance, de-select GPS to FMS, de-select IRS Hybrid, clock to INT, inhibit EGPWS Look-ahead mode, stow HUD.

IN SPOOFING

- **Aviate, navigate, communicate** - back to basics.
- **Note time** on personal watch, record on log
- **Check system settings** correct for spoof protection
- **Check GPS input** de-selected
- **Check IRS Hybrid mode** de-selected
- **Heading mode** if needed
- **Confirm Nav source** in FMS
- **Report to ATC,** request vectors if needed
- **Inhibit EGPWS** at cruise alt, if procedure allowed

JAMMING Indications

- GPS Failure message
- ADS-B Failure/Warning
- GPWS Terrain caution message
- SATCOM loss
- EGPWS Terrain fail
- Loss of SVS

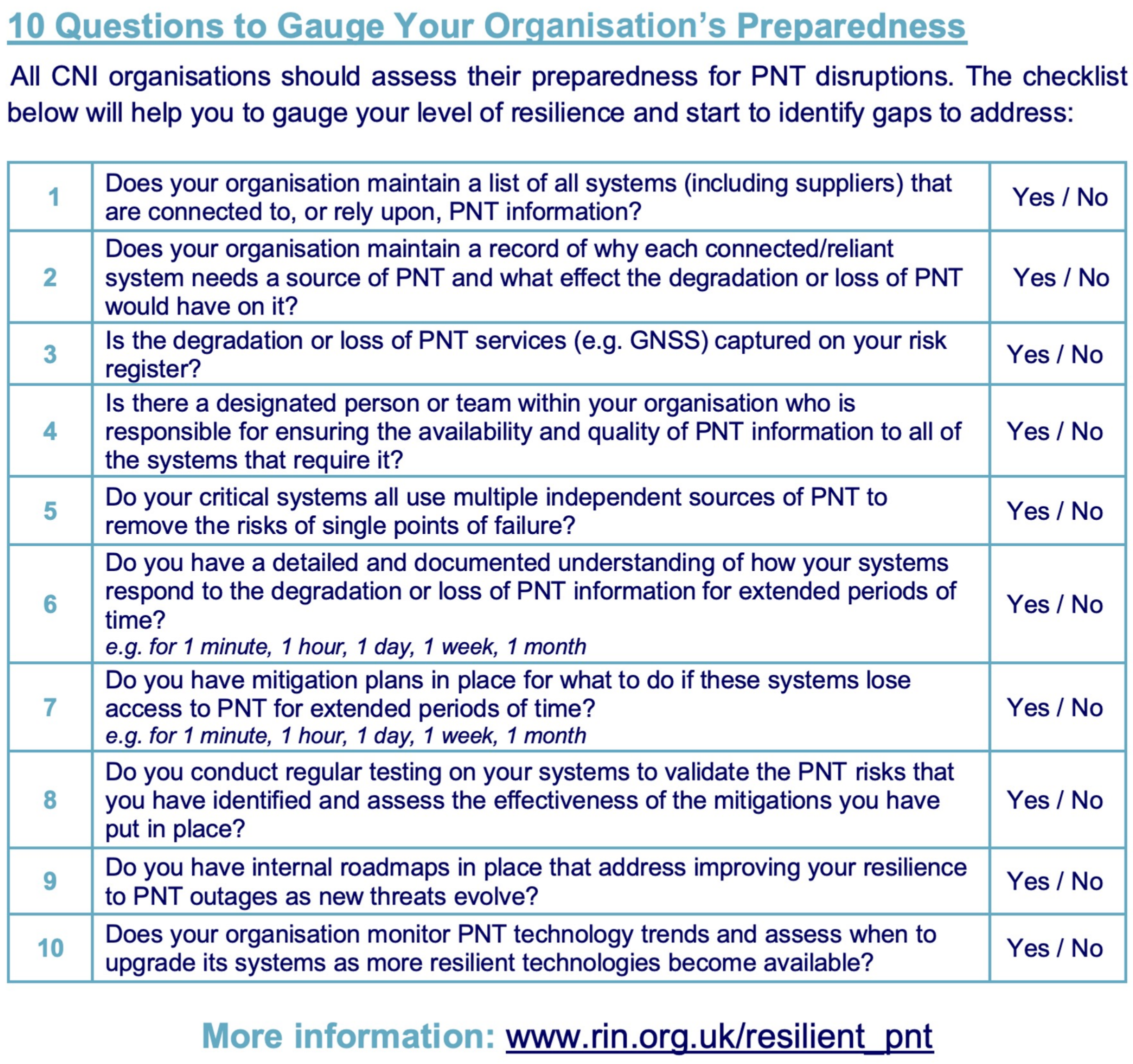
SPOOFING Indications

- GPS position disagree message
- Rapid EPU/ANP increase
- Aircraft Clock time change
- Transponder fail
- Uncommanded autopilot turn
- Synthetic vision reversion
- Wind indicator illogical
- GPS posn on ND differs from FMS posn
- See full guidance text for complete list

RECOVERY

- **Be certain spoofing finished**
- **Check GPS sensor page** for correct time, date, GS, alt.
- **Assess** all systems for failures
- If allowed, carry out in-flight reset of MMR/GPS/GPWS
- Re-select GPS sensor input to FMS
- Advise ATC of remaining failures
- **Oceanic:** early message to OACC of RNP/CPDLC/ADS-C failures, anticipate lower crossing alt/reroute.
- **Appoach:** Avoid RNP approaches, advise ATC, brief intentions re. EGPWS false alerts, basic modes, possible ECAM/EICAS alerts, check alternates

Self-scoring tools

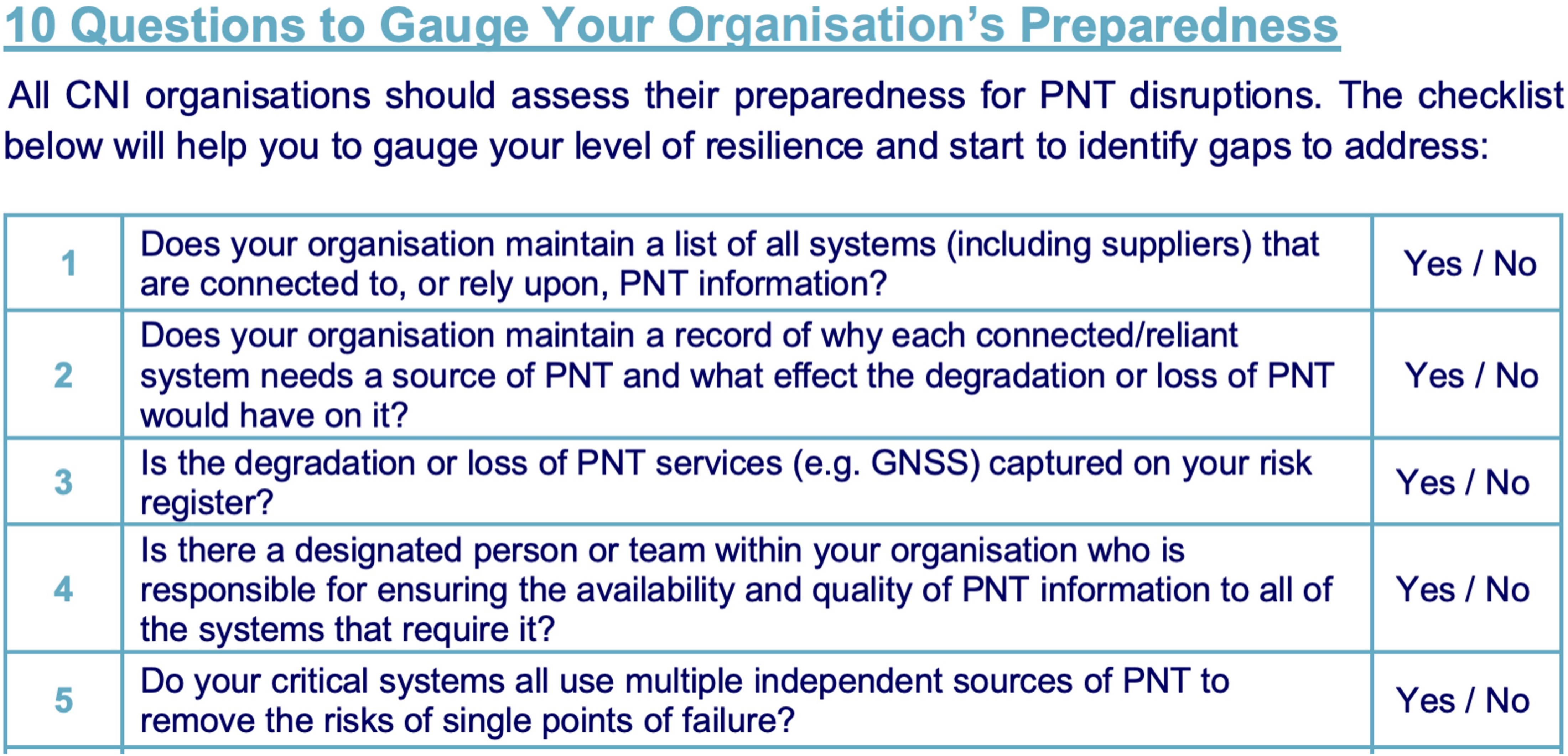


10 Questions to Gauge Your Organisation's Preparedness

All CNI organisations should assess their preparedness for PNT disruptions. The checklist below will help you to gauge your level of resilience and start to identify gaps to address:

1	Does your organisation maintain a list of all systems (including suppliers) that are connected to, or rely upon, PNT information?	Yes / No
2	Does your organisation maintain a record of why each connected/reliant system needs a source of PNT and what effect the degradation or loss of PNT would have on it?	Yes / No
3	Is the degradation or loss of PNT services (e.g. GNSS) captured on your risk register?	Yes / No
4	Is there a designated person or team within your organisation who is responsible for ensuring the availability and quality of PNT information to all of the systems that require it?	Yes / No
5	Do your critical systems all use multiple independent sources of PNT to remove the risks of single points of failure?	Yes / No
6	Do you have a detailed and documented understanding of how your systems respond to the degradation or loss of PNT information for extended periods of time? *e.g. for 1 minute, 1 hour, 1 day, 1 week, 1 month*	Yes / No
7	Do you have mitigation plans in place for what to do if these systems lose access to PNT for extended periods of time? *e.g. for 1 minute, 1 hour, 1 day, 1 week, 1 month*	Yes / No
8	Do you conduct regular testing on your systems to validate the PNT risks that you have identified and assess the effectiveness of the mitigations you have put in place?	Yes / No
9	Do you have internal roadmaps in place that address improving your resilience to PNT outages as new threats evolve?	Yes / No
10	Does your organisation monitor PNT technology trends and assess when to upgrade its systems as more resilient technologies become available?	Yes / No

More information: www.rin.org.uk/resilient_pnt



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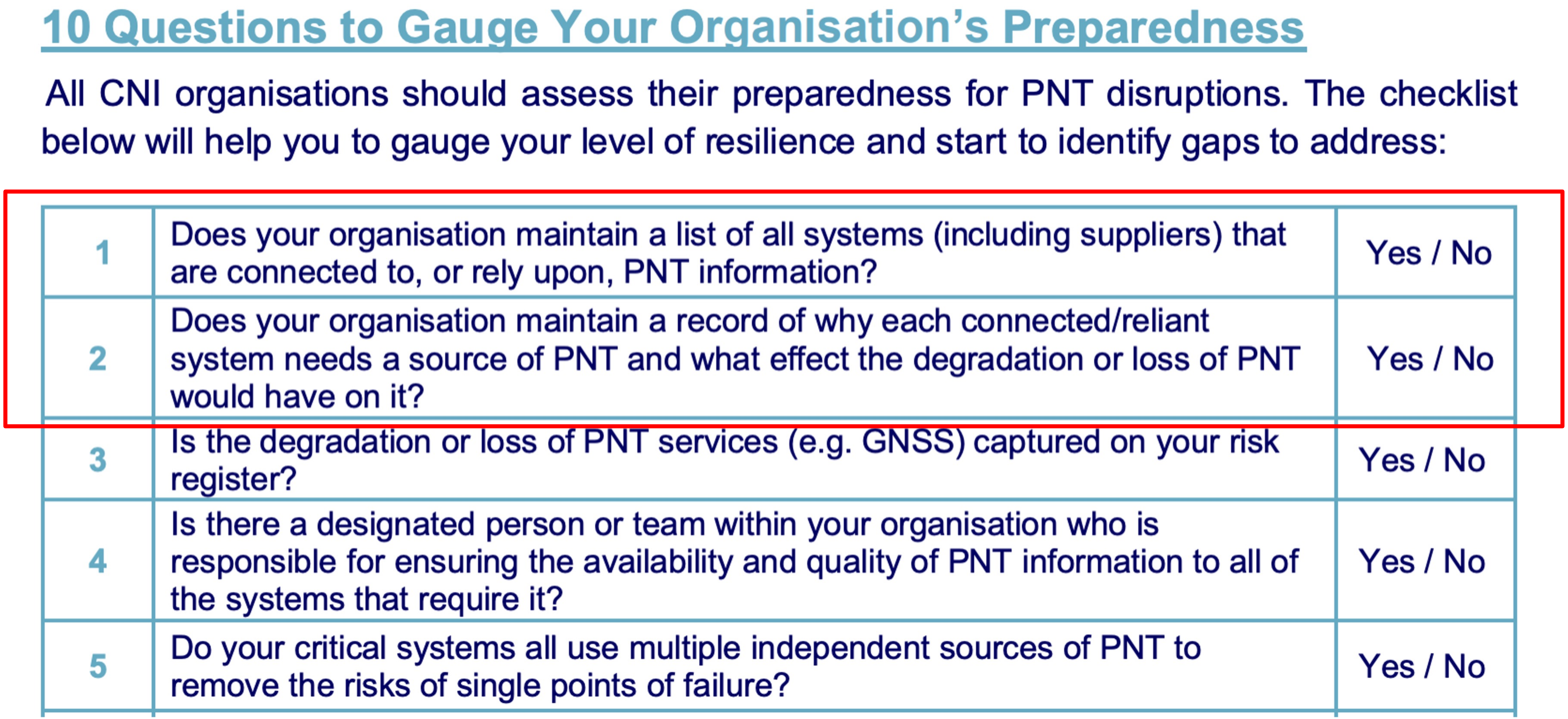

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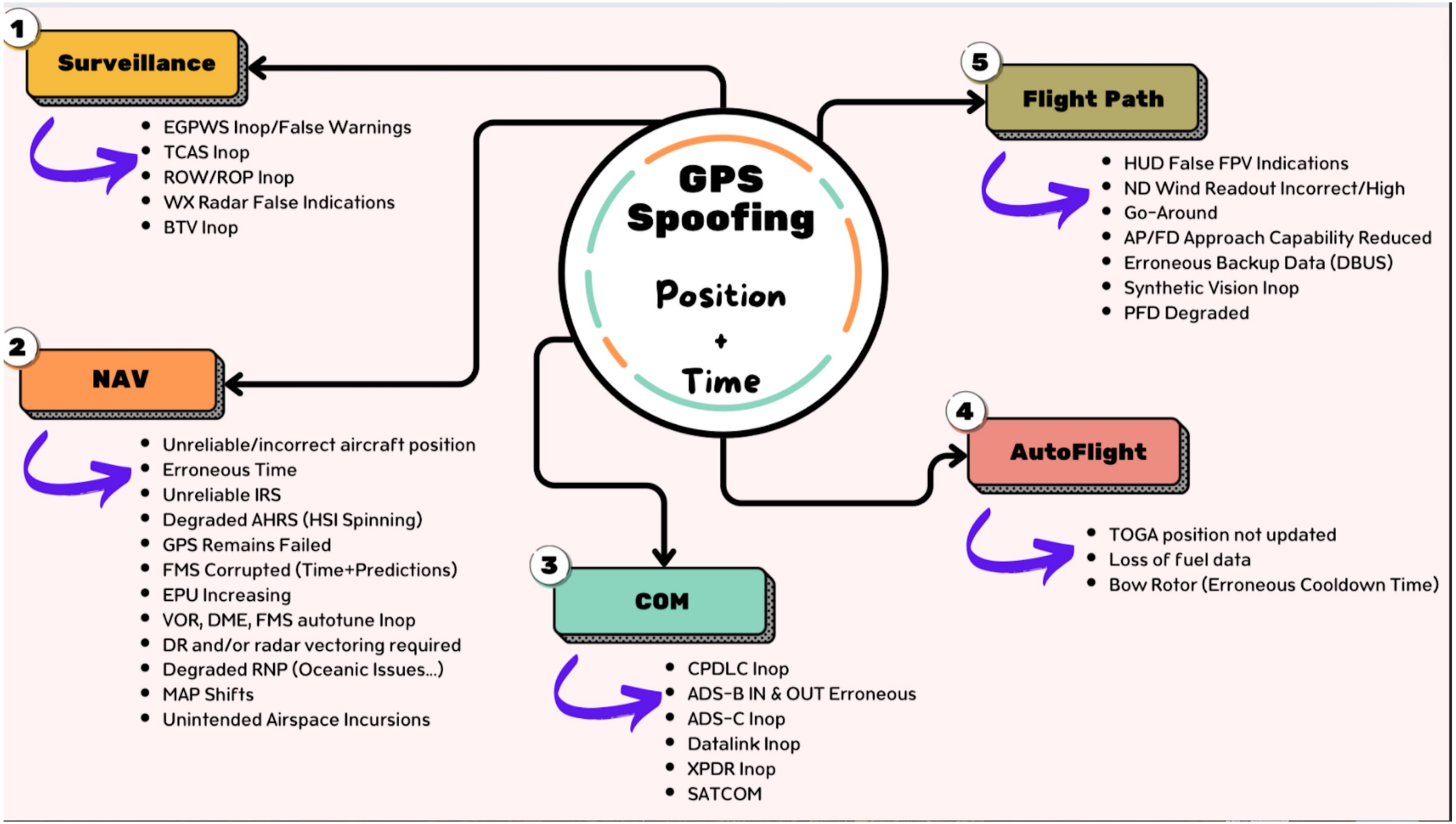
OpsGroup report example connectivity map



GPS Spoofing

Position + Time

1 Surveillance

- EGPWS Inop/False Warnings
- TCAS Inop
- ROW/ROP Inop
- WX Radar False Indications
- BTV Inop

2 NAV

- Unreliable/incorrect aircraft position
- Erroneous Time
- Unreliable IRS
- Degraded AHRS (HSI Spinning)
- GPS Remains Failed
- FMS Corrupted (Time+Predictions)
- EPU Increasing
- VOR, DME, FMS autotune Inop
- DR and/or radar vectoring required
- Degraded RNP (Oceanic Issues...)
- MAP Shifts
- Unintended Airspace Incursions

3 COM

- CPDLC Inop
- ADS-B IN & OUT Erroneous
- ADS-C Inop
- Datalink Inop
- XPDR Inop
- SATCOM

4 AutoFlight

- TOGA position not updated
- Loss of fuel data
- Bow Rotor (Erroneous Cooldown Time)

5 Flight Path

- HUD False FPV Indications
- ND Wind Readout Incorrect/High
- Go-Around
- AP/FD Approach Capability Reduced
- Erroneous Backup Data (DBUS)
- Synthetic Vision Inop
- PFD Degraded

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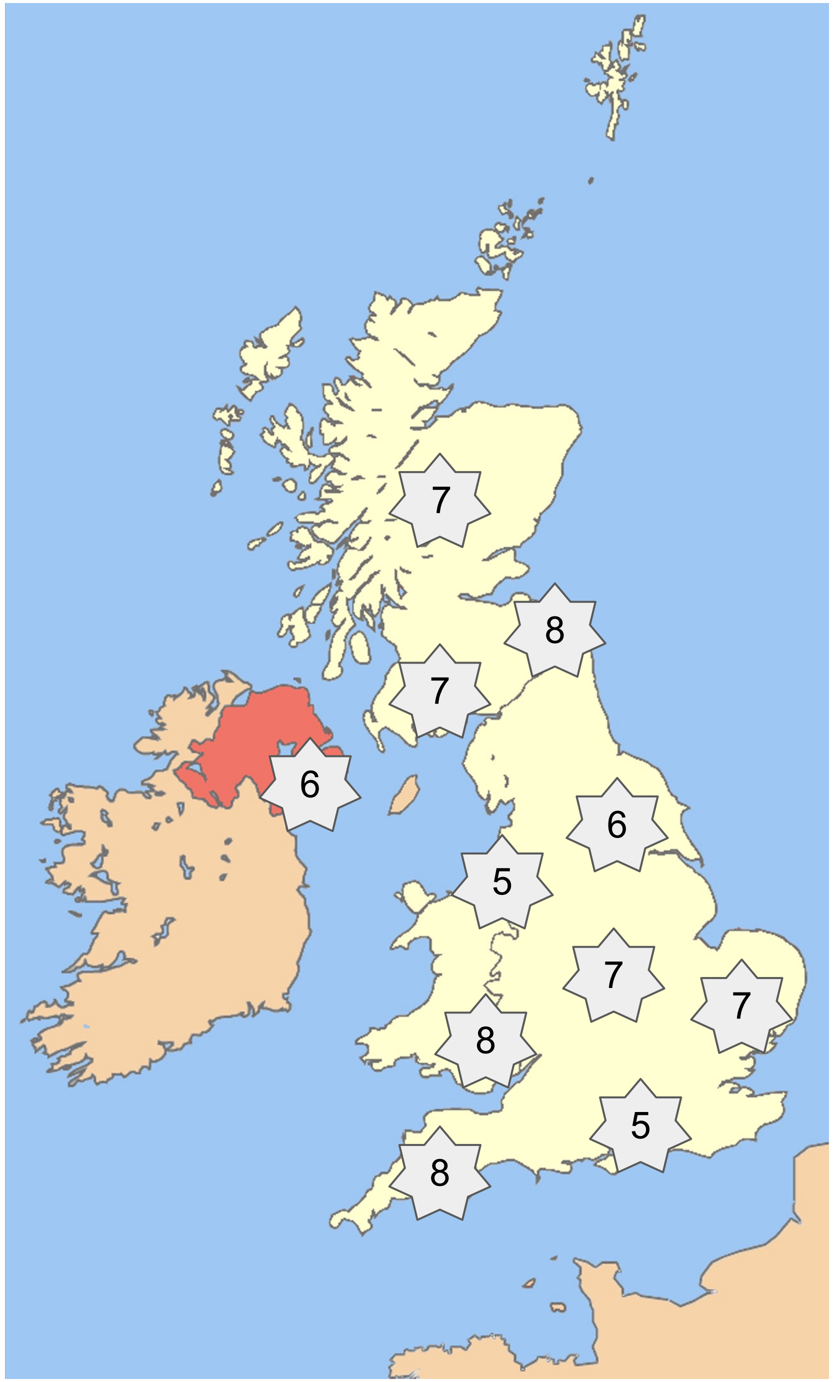
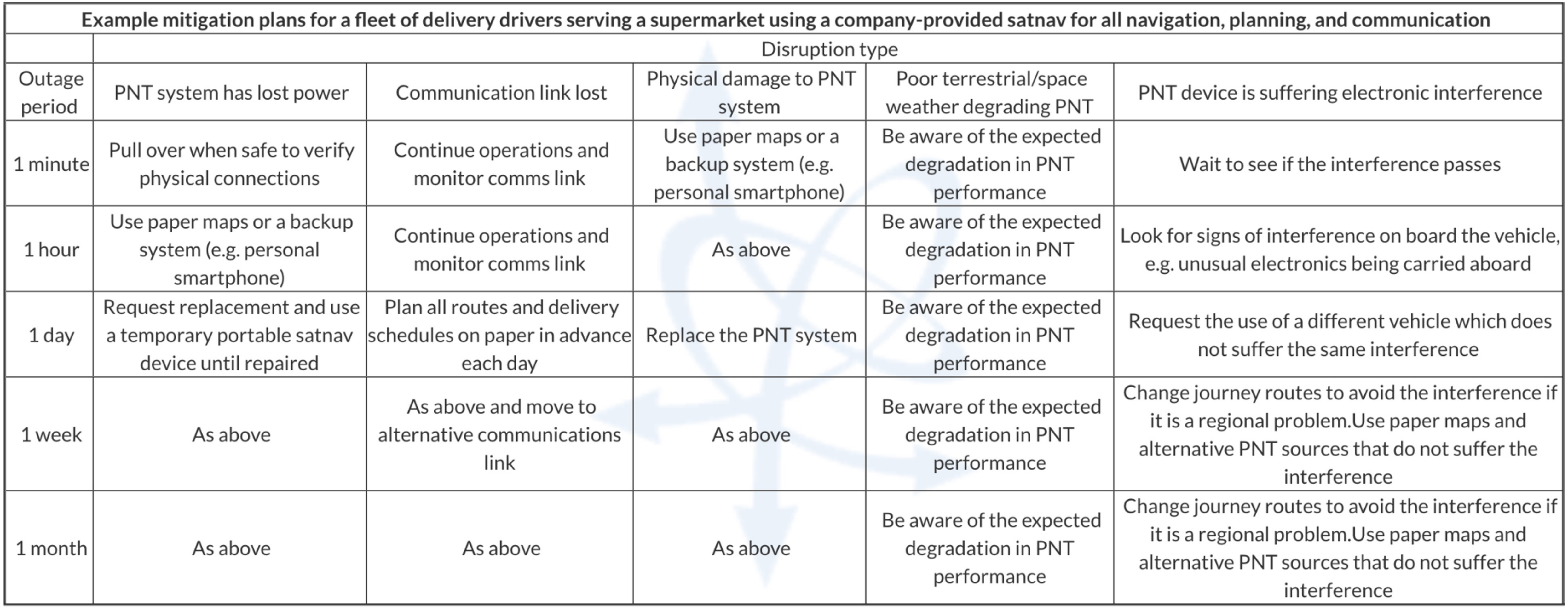
More information: www.rin.org.uk/resilient_pnt

Resilience checklist

- Scope for providing KPIs or similar metric to help assess how the UK's providers for any given sector/CNI are faring
- Scope for a multi-year "getting to ten" strategy for resilient PNT for each CNI
- Can help with gap analyses in existing/ongoing programmes



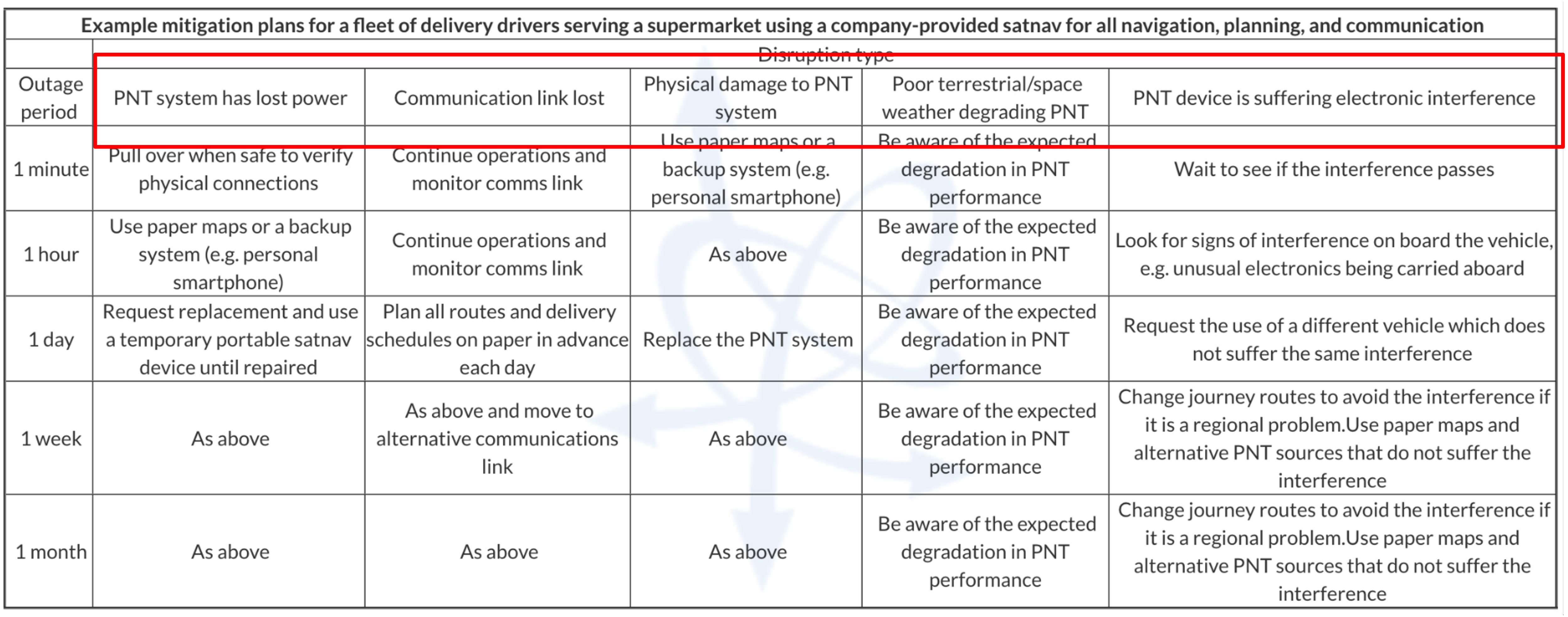
Example mitigation plan



Example mitigation plans for a fleet of delivery drivers serving a supermarket using a company-provided satnav for all navigation, planning, and communication

	Disruption type				
Outage period	PNT system has lost power	Communication link lost	Physical damage to PNT system	Poor terrestrial/space weather degrading PNT	PNT device is suffering electronic interference
1 minute	Pull over when safe to verify physical connections	Continue operations and monitor comms link	Use paper maps or a backup system (e.g. personal smartphone)	Be aware of the expected degradation in PNT performance	Wait to see if the interference passes
1 hour	Use paper maps or a backup system (e.g. personal smartphone)	Continue operations and monitor comms link	As above	Be aware of the expected degradation in PNT performance	Look for signs of interference on board the vehicle, e.g. unusual electronics being carried aboard
1 day	Request replacement and use a temporary portable satnav device until repaired	Plan all routes and delivery schedules on paper in advance each day	Replace the PNT system	Be aware of the expected degradation in PNT performance	Request the use of a different vehicle which does not suffer the same interference
1 week	As above	As above and move to alternative communications link	As above	Be aware of the expected degradation in PNT performance	Change journey routes to avoid the interference if it is a regional problem.Use paper maps and alternative PNT sources that do not suffer the interference
1 month	As above	As above	As above	Be aware of the expected degradation in PNT performance	Change journey routes to avoid the interference if it is a regional problem.Use paper maps and alternative PNT sources that do not suffer the interference

Example mitigation plan



Example mitigation plans for a fleet of delivery drivers serving a supermarket using a company-provided satnav for all navigation, planning, and communication					
	Disruption type				
Outage period	PNT system has lost power	Communication link lost	Physical damage to PNT system	Poor terrestrial/space weather degrading PNT	PNT device is suffering electronic interference
1 minute	Pull over when safe to verify physical connections	Continue operations and monitor comms link	Use paper maps or a backup system (e.g. personal smartphone)	Be aware of the expected degradation in PNT performance	Wait to see if the interference passes
1 hour	Use paper maps or a backup system (e.g. personal smartphone)	Continue operations and monitor comms link	As above	Be aware of the expected degradation in PNT performance	Look for signs of interference on board the vehicle, e.g. unusual electronics being carried aboard
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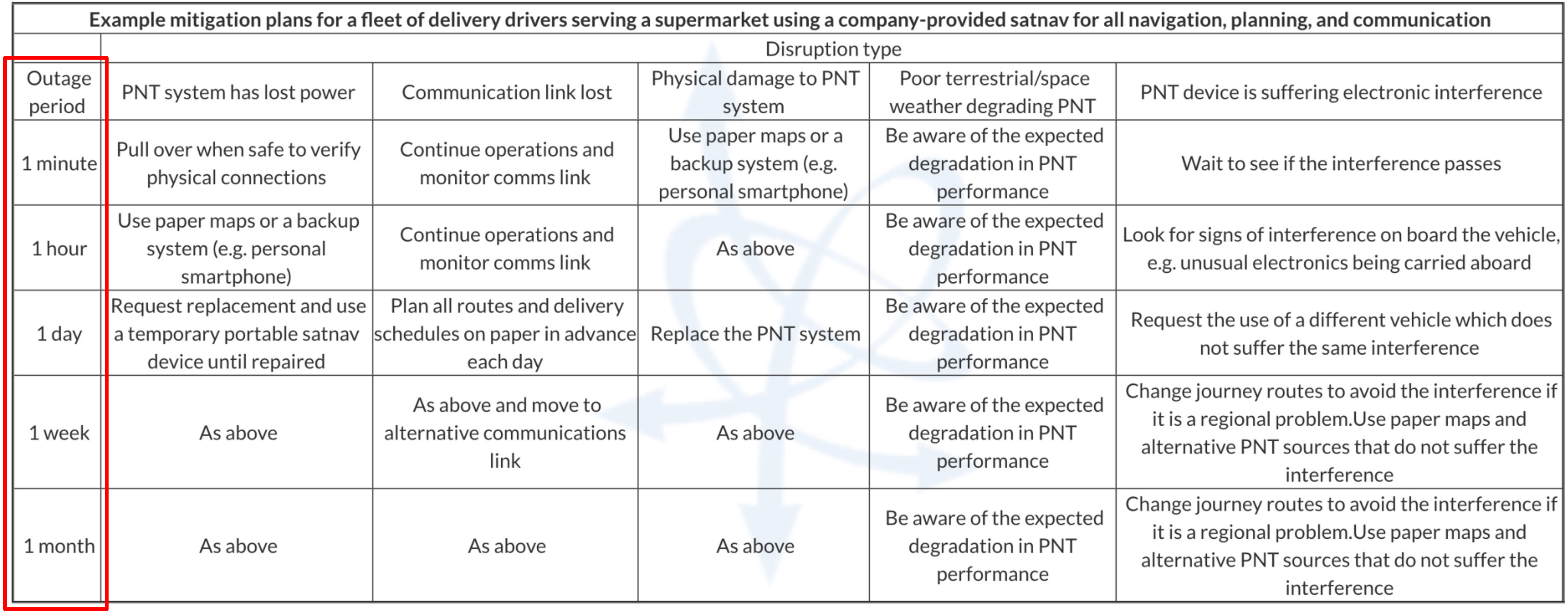
Example mitigation plan



Example mitigation plans for a fleet of delivery drivers serving a supermarket using a company-provided satnav for all navigation, planning, and communication

	Disruption type				
Outage period	PNT system has lost power	Communication link lost	Physical damage to PNT system	Poor terrestrial/space weather degrading PNT	PNT device is suffering electronic interference
1 minute	Pull over when safe to verify physical connections	Continue operations and monitor comms link	Use paper maps or a backup system (e.g. personal smartphone)	Be aware of the expected degradation in PNT performance	Wait to see if the interference passes
1 hour	Use paper maps or a backup system (e.g. personal smartphone)	Continue operations and monitor comms link	As above	Be aware of the expected degradation in PNT performance	Look for signs of interference on board the vehicle, e.g. unusual electronics being carried aboard
1 day	Request replacement and use a temporary portable satnav device until repaired	Plan all routes and delivery schedules on paper in advance each day	Replace the PNT system	Be aware of the expected degradation in PNT performance	Request the use of a different vehicle which does not suffer the same interference
1 week	As above	As above and move to alternative communications link	As above	Be aware of the expected degradation in PNT performance	Change journey routes to avoid the interference if it is a regional problem.Use paper maps and alternative PNT sources that do not suffer the interference
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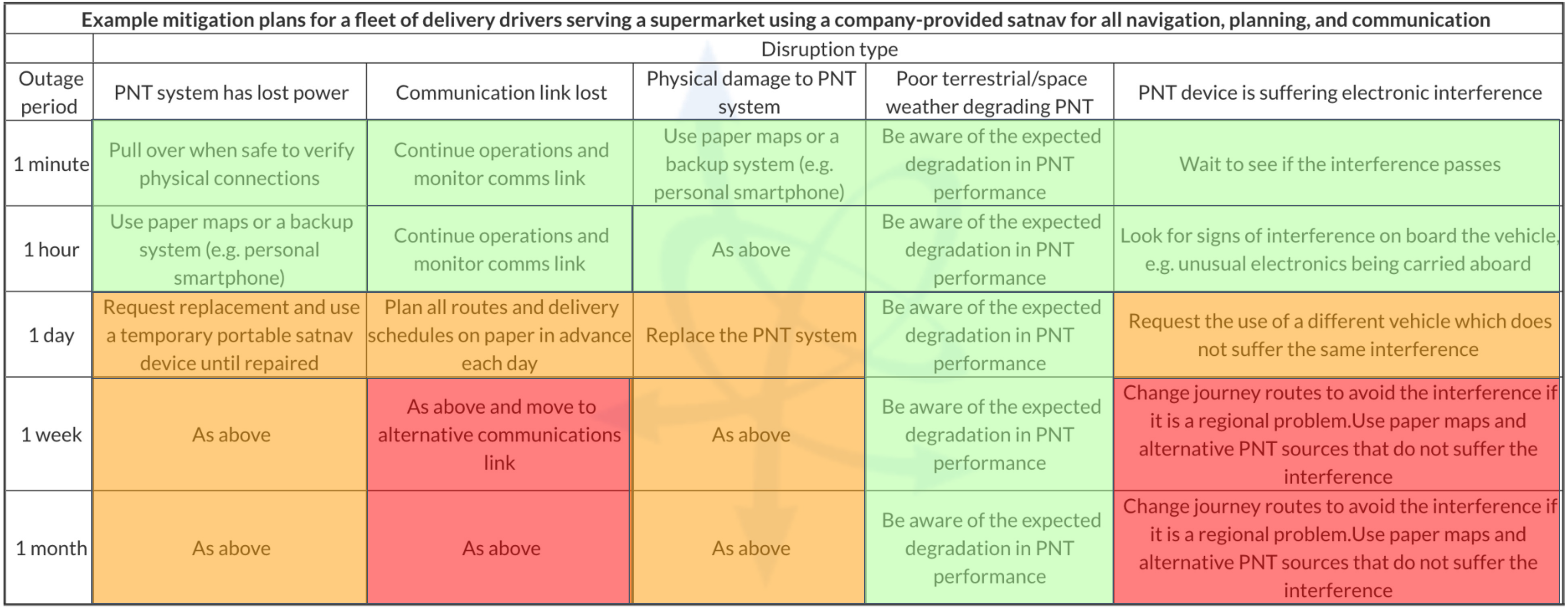
Example mitigation plan



Example mitigation plans for a fleet of delivery drivers serving a supermarket using a company-provided satnav for all navigation, planning, and communication					
	Disruption type				
Outage period	PNT system has lost power	Communication link lost	Physical damage to PNT system	Poor terrestrial/space weather degrading PNT	PNT device is suffering electronic interference
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Fire Drill concepts

The concept can range from a table top paper studies using the tools from our programme, right up to full real-world testing (Hardware in the loop)

The long term goal is an annual event that CNI are *legally required to perform* in order to use PNT in safety-critical applications

(Chinanews.cn December 29, 2006)

Final thought - Maritime “OpsGroup report!

Will be published by end of 2025

Mariners please fill out the survey!

https://tinyurl.com/RINSurvey2025

Join the Discord channel

Fill out the survey

Thanks to all involved

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UK PNTO and DSIT

Dozens of UK CNI representatives and reviewers