

GREN Resilience WG

End Report Presentation
GNA-G Community VCs
September 2026

Co-chairs:

- Steve Maddocks (AARNet),
- Harold Teunissen (SURF) &
- Erik-Jan Bos (NORDUnet)



Contents

1. Introduction & What is the GREN
2. Some words on the history of the GREN
3. GREN Resilience WG process
4. GREN Resilience WG end report
5. Conclusion & Recommendations
6. Q&A

Contents

- 
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Note on TLP:Amber

- Assessing our networks, vulnerabilities, and resilience
- That is information we should not share openly, hence:
- “Limited disclosure, restricted to participants’ organization and its clients (see Terminology Definitions)”.
- Source: <https://www.cisa.gov/news-events/news/traffic-light-protocol-tlp-definitions-and-usage>



Background



- Evolution of design principles for R&E Networks:
 - Initially: Connectivity
 - Until early 2000s: Performance
 - Into the 2010s: Reliability
 - Towards the 2020s: Security
- More recently, the goals of Reliability and Security have intersected
 - Witnessed by examples of expected sabotage or other malicious attacks on physical infrastructure
- Question has come up: Is the GREN sufficiently resilient?



The Global R&E Network

- The GREN is the global interconnection of Research and Education Networks (RENs), enabling seamless, high-performance collaboration for science and education worldwide



Link to video:

<https://www.youtube.com/watch?v=HMuC-rceVBU>

Contents

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4. GREN Resilience WG end report
5. Conclusion & Recommendations
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GREN System 'ANA', in 2014

[Home](#) > [Advanced North Atlantic 100 Gbit/s Ring for R&E Operational](#)

Advanced North Atlantic 100 Gbit/s Ring for R&E Operational

November 17, 2014



Share:



ANA-200G delivers on its promise

New Orleans, LA, USA – November 17, 2014

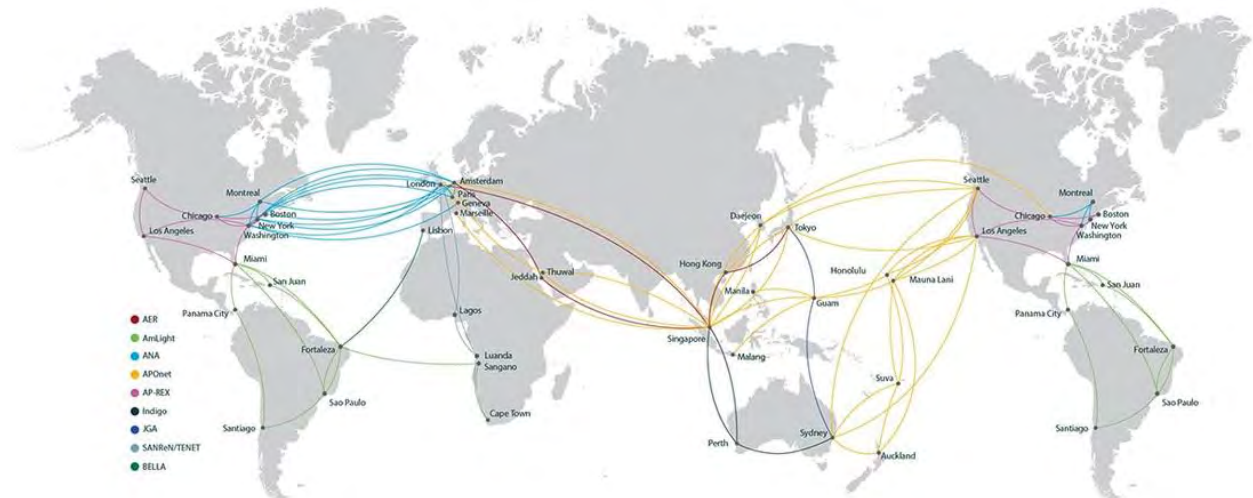
Internet2, NORDUnet, CANARIE, and SURFnet, four advanced Research and Education (R&E) Networks from both sides of the North Atlantic Ocean, today announced the completion of a collaborative advanced network, called ANA-200G, that spans the North Atlantic, enabling R&E users to transfer data between North America and Europe at speeds that were previously only possible within the continents.

ANA-200G is a redundant 100 Gbit/s ring between four open exchange points spanning the North Atlantic. The ring nature of ANA-200G without single points of failure protects against an outage in the unprotected individual 100 Gbit/s transmission paths. ANA-200G builds on the success and the lessons learned in the pilot phase that started in June 2013^[1] and ended last month, and was called ANA-100G.

Source:
[NORDUnet website](#)

History of the GREN

- The Global R&E Network (GREN) has grown organically
 - First, every R&E Network purchased the links they thought they need
 - Adding structure since 2013 with the creation of the Advanced North Atlantic (ANA) Collaboration, sharing investments
 - Since then, several other collaborations have formed such as APOnet, AER, and others.

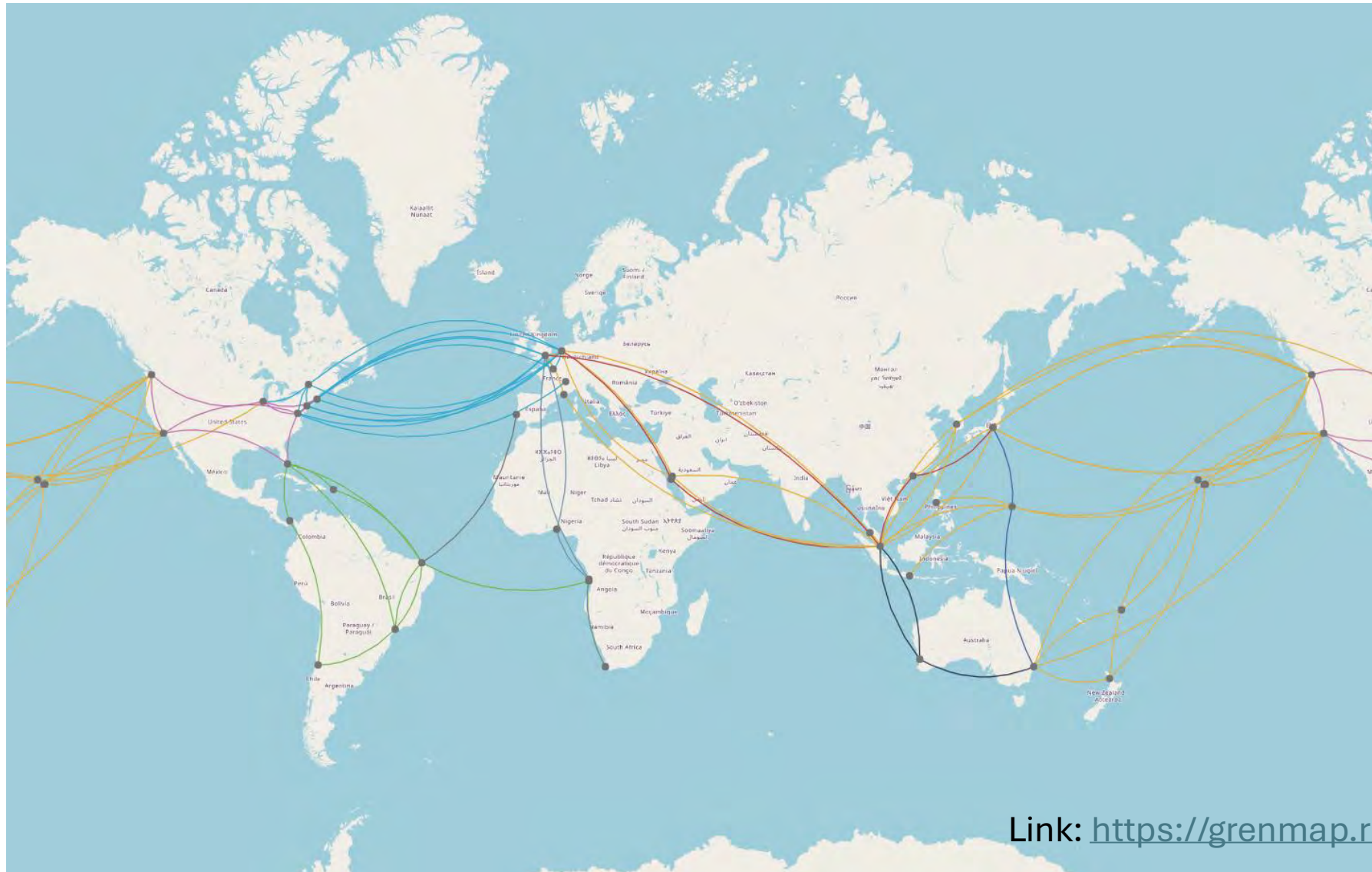


GREN 'systems' (from GNA-G website)



Image needs an update

GREN 'systems' (by GNA-G Map WG)



Link: <https://grenmap.rnp.br/>

Contents

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4. GREN Resilience WG end report
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6. Q&A

Context for the GREN Resilience WG

- Purpose:
 - To investigate the vulnerability of the Global R&E Network (GREN) infrastructure
 - To perform a risk analysis
 - To produce suggestions on how to improve the GREN resilience
- Idea has come through the GNA-G Leadership Team
 - Sponsor for this work was David Wilde (AARNet)
 - Draft charter written by David Wilde (AARNet) & Harold Teunissen (SURF) & Erik-Jan Bos (NORDUnet)

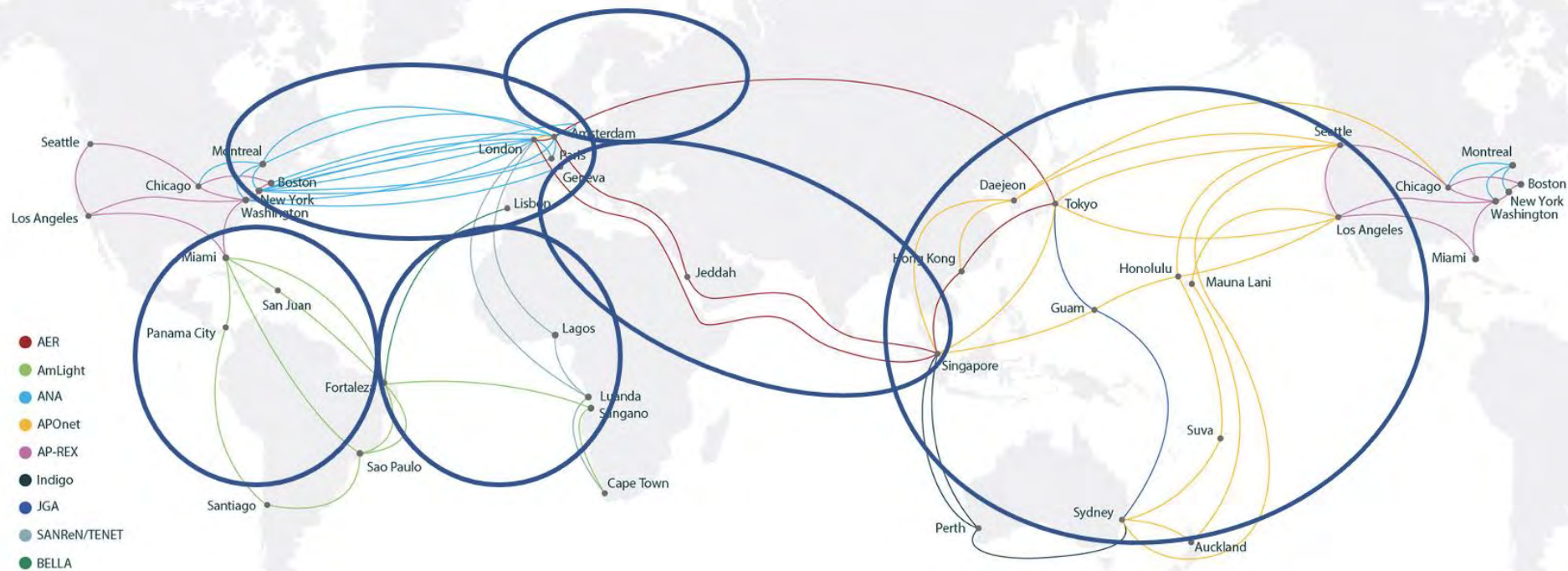
WG Process (1/2)

- Charter discussed with CEOs in July 2024
 - Green light was given for the WG to start the work
 - The Charter of the WG is available online at:
<https://www.gna-g.net/wp-content/uploads/2025/01/GREN-Resilience-WG-Charter-v1.0.2.pdf>
- Three co-chairs:
 - Steve Maddocks (AARNet)
 - Harold Teunissen (SURF)
 - Erik-Jan Bos (NORDUnet)
- Several fruitful meetings since Q4 2024 until Q4 2025

WG Process (2/2)

- Scope of the WG: Focus on reviewing the network architecture itself, i.e.:
 - Interconnections between R&E Networks
 - Global R&E Exchange Points (GXPs)
 - The links between GXPs
- Goal of the WG:
 - Perform a high-level risk review of the GREN
 - Identify the resilience to accidental and malicious incidents
 - From there, to come up with recommendations for improving the GREN resilience
- Approach of the WG:
 - Examine the GREN by region first, using as much as possible the knowledge and experience of the people involved in the GREN Systems, e.g. ANA, APOnet, AER, BELLA, and AmLight
 - After that, the regions will be brought together for a global view
- After thorough analysis, recommendations for future procurements and investments will be made, for substantially increasing the resilience of the GREN

Our GREN 'systems'





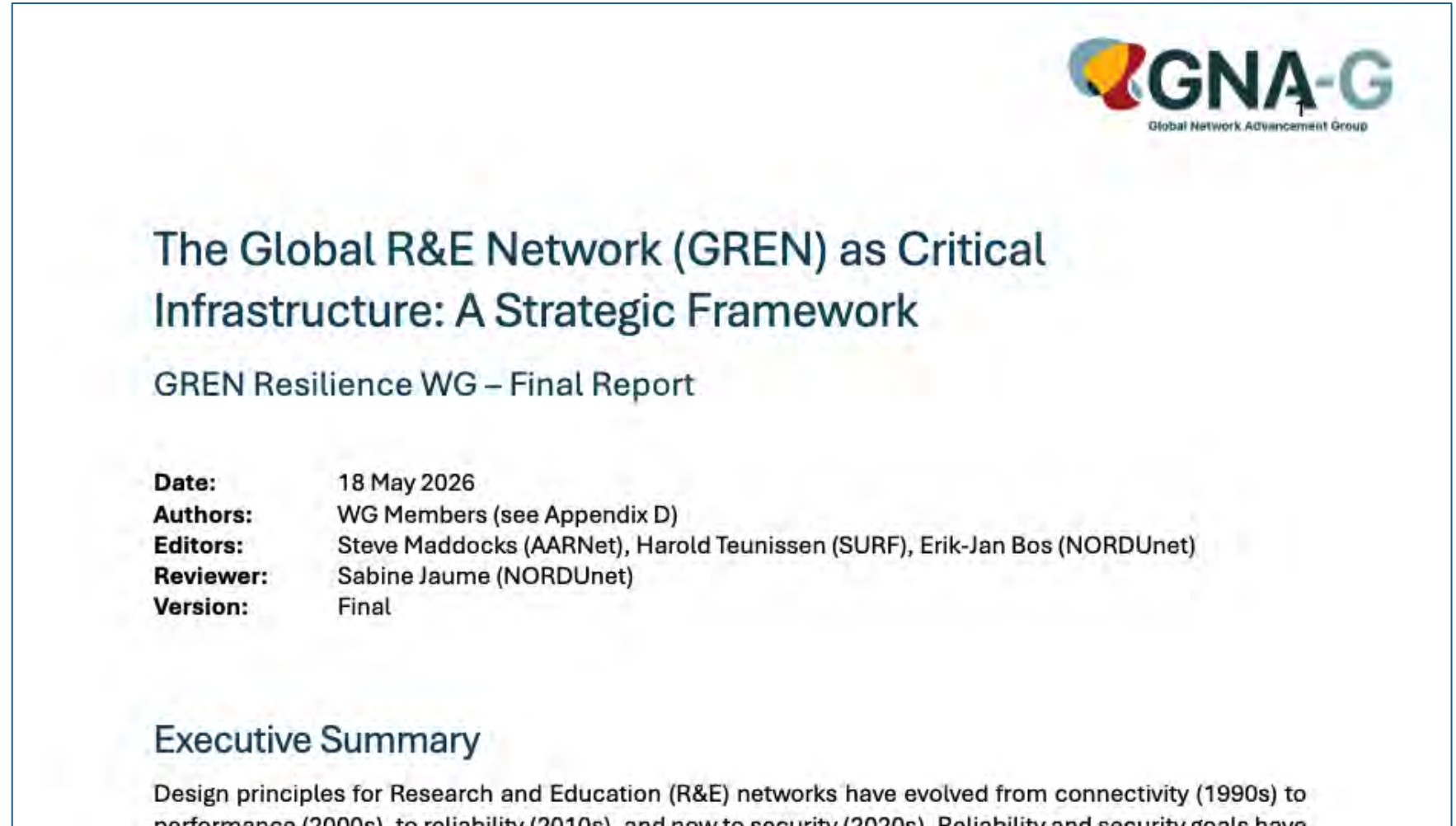
First Findings

- The GREN systems (ANA, APOnet, etc.) appear resilient, but a more thorough analyse is needed
- The GREN is suffering from weak spots in the global Internet architecture, e.g.:
 - the Red Sea, as an area with many submarine cables in a narrow body of water
 - Marseille and Singapore, as locations where many submarine cables come ashore on a very small strip of land
- Backhaul from Cable Landing Station to GXP or R&E Network could be shared between links, need further analysis
- The overall resilience of the GREN is unknown at this stage, as cross referencing the implementations of links between GREN system has never been done

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6. Q&A

The WG's End Report



Link to the report:

<https://www.gna-g.net/wp-content/uploads/2026/06/GREN-Resilience-WG-Final-Report-final.pdf>

Contributors (a big Thank You!)

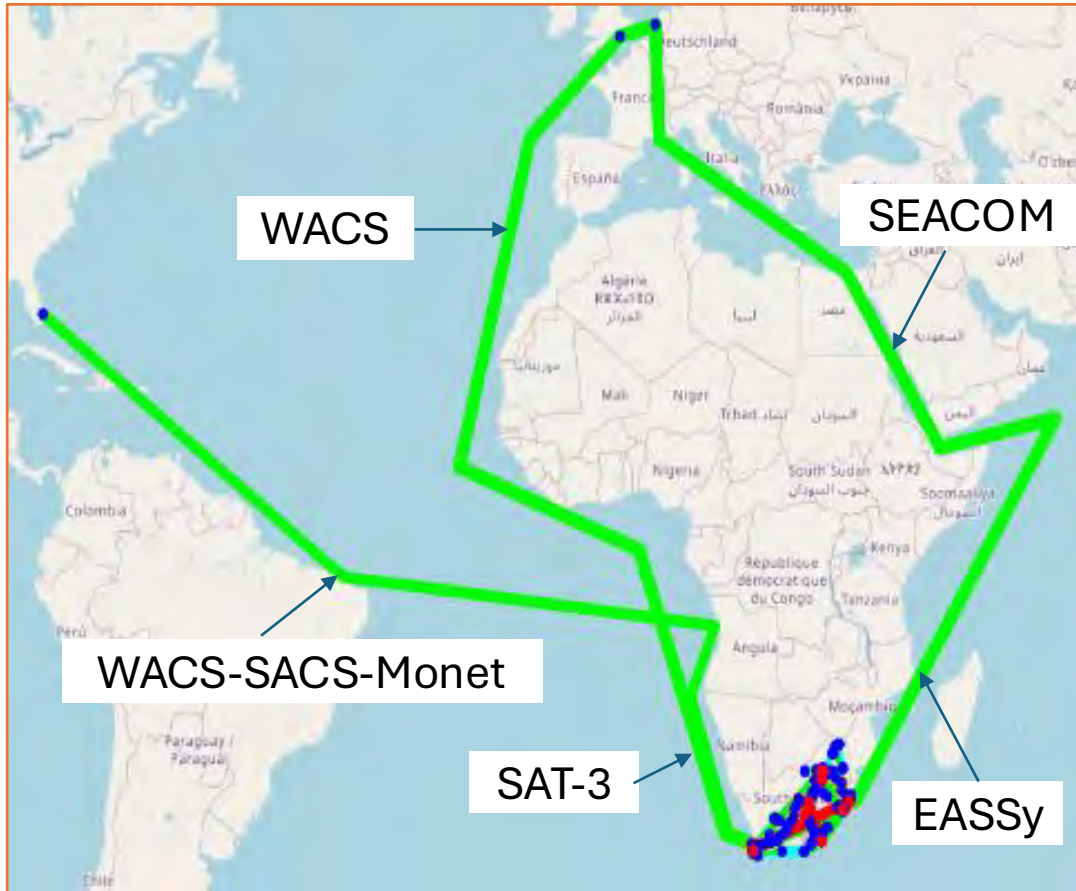
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Inventory of GREN Resources created

- Created an inventory, with input from many R&E Networks
 - Systems
 - Services
 - GXPs
- Snapshot only
- Help understand the GREN Resilience



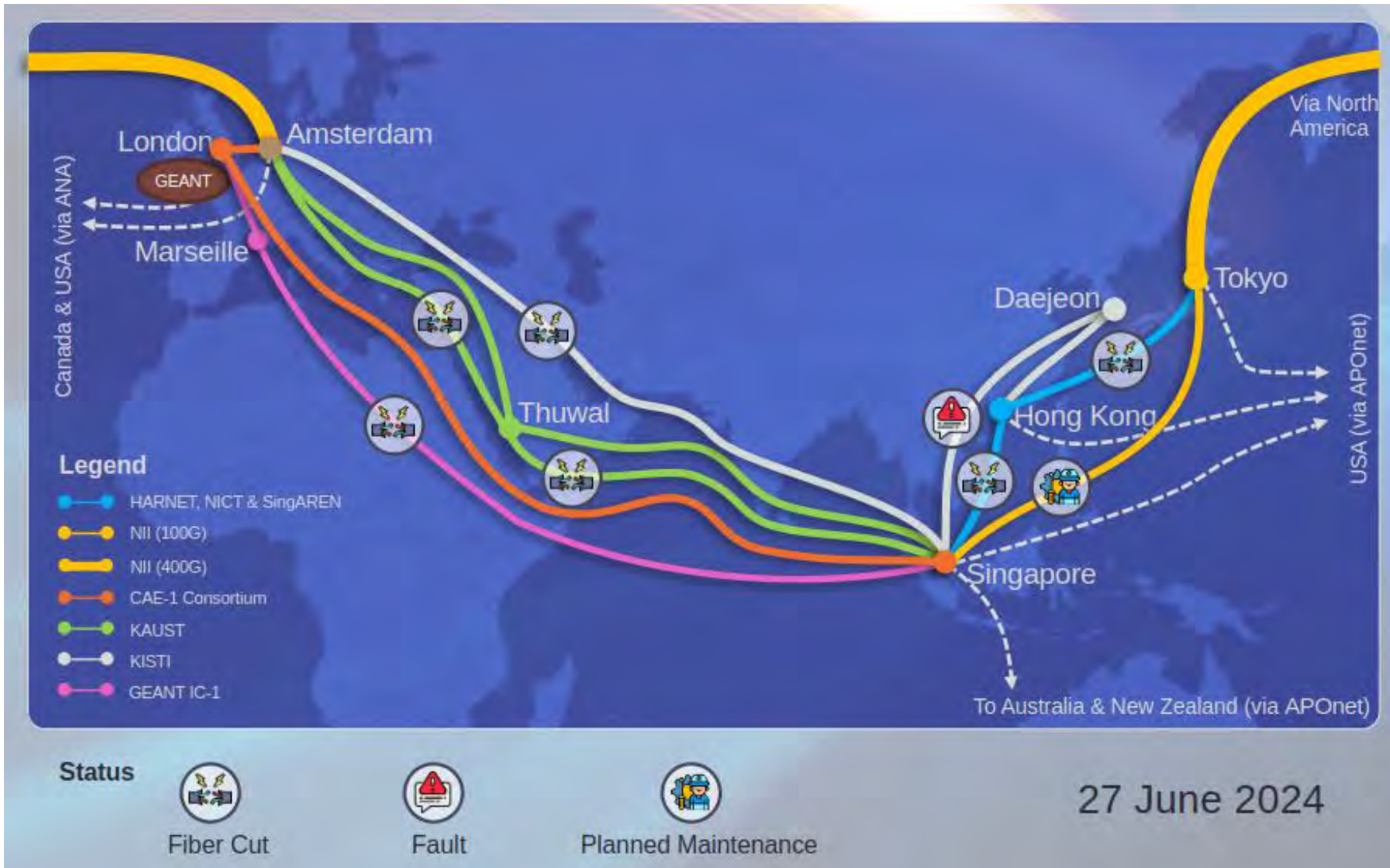
SA NREN Undersea cable breakages



Slide courtesy of Ajay Makan (SANReN)

- 4 Dec 2023 to 22 July 2024
 - Eastern Africa Submarine Cable System (EASSy), 2x10G outage
- 22 Jan 2024 and 14 March to 30 April 2024
 - West Africa Cable System (WACS), 100G outage
 - Alternate routes: SEACOM, SACS
- 26 Jan to 27 Jan 2024
 - South Atlantic Cable System (SACS), 100G Outage
 - Alternate routes: SEACOM, WACS, SAT-3
- 3 March to 17 May 2024
 - South Atlantic 3 (SAT-3/WASC), 2x10G outage
 - Alternate routes: SEACOM till 12 May, SACS, WACS from 30 April 2024
- 12 May to 1 June 2024
 - SEACOM 100G outage
 - Alternate routes: SACS, WACS, SAT-3 from 17 May 2024

An example of a near miss (AER, June 2024)



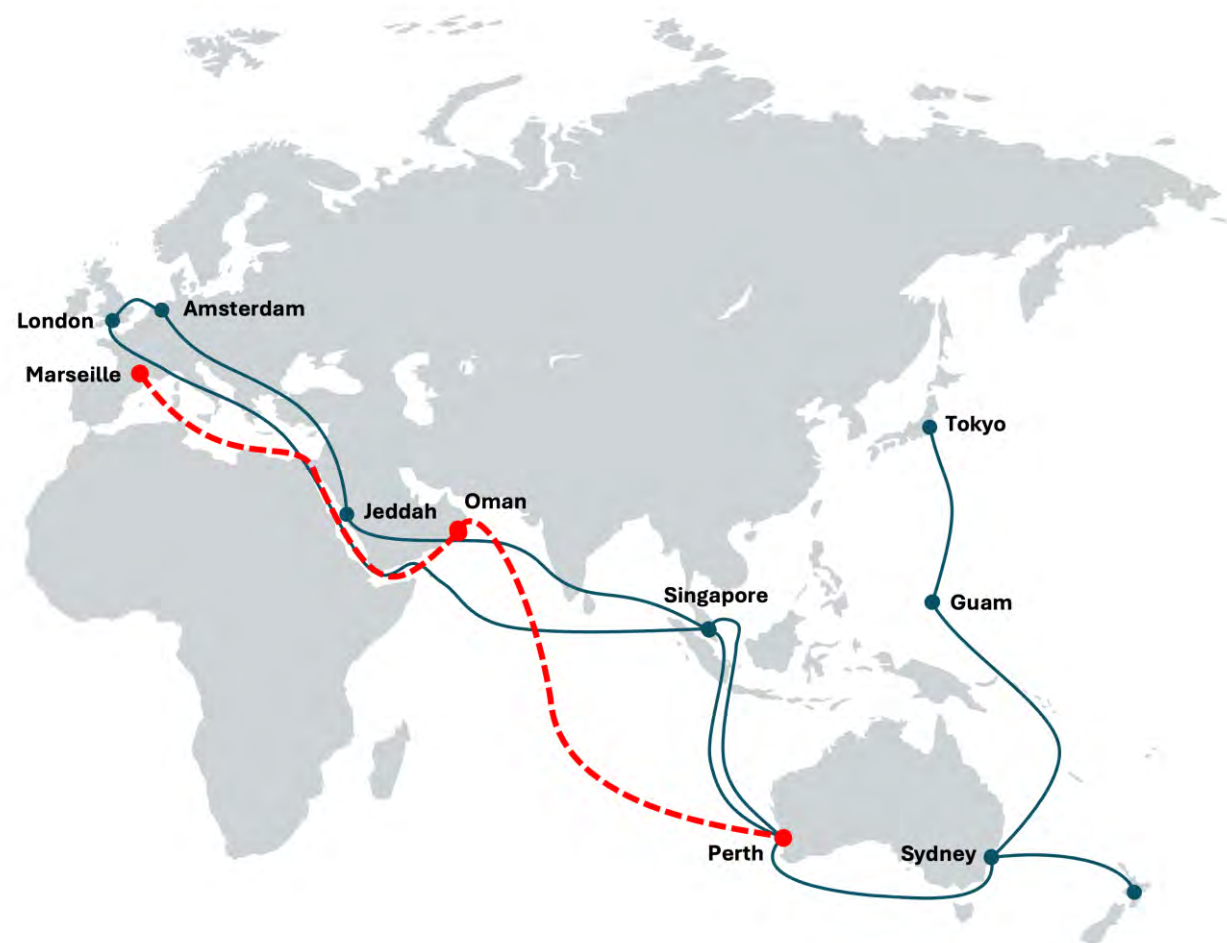
Slide courtesy of
Francis Lee (SingAREN)

Myths on GREN Resilience

- “Somebody else will fix this”
- “Submarine cables are repaired quicky”
- “It has worked well for so long, so no need to worry about it”
- “Satellites will come to the rescue when there is a major outage on submarine cable in a region”

Case Study 1:

Blue Raman – Oman – Perth



Case Study 2: Polar Connect



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Main conclusion

“Simply adding more (intercontinental) capacity and cable systems to the GREN certainly improves resilience but with diminishing returns in cost and time unless supported by additional measures”

Recommended actions

Resilience must be addressed through a balanced portfolio of actions:

- Define minimum service levels for long disruptions and pre-agree traffic prioritisation
- Prioritise critical workflows and users during crises, guided by a decision framework agreed in advance
- Invest in the human network (relationships, contact paths, and joint exercises)
- Coordinate investment across systems, i.e. on a global scale, to maximise return
- Expand the geographic footprint and diversity of Global R&E Exchange Points (GXPs), particularly in the Southern Hemisphere and pursue longitudinal diversity (north–south as well as east–west)

Final recommendation to GNA-G LT

- Establish a standing group, with a mandate to guard and increase GREN resilience; initial activities could include:
 - Liaising with the Business Continuity (BC) group
 - Defining traffic prioritisation schemes
 - Conducting a shared inventory of R&E-owned resources and metadata in automatable formats (a potential collaboration with the GNA-G GREN Map WG)
 - Analysing dependencies on external platforms (e.g., Zoom)
- New group should publish an annual “GREN Resilience Report” covering:
 - The state of the GREN (with year-on-year changes)
 - Recommended actions

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Thank you! Questions?

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