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How the Internet routed around Cable Damage in the Baltic Sea

Internet event analysis with **RIPE Atlas**

Alun Davies | SEE 13, Sofia Bulgaria | 7 April 2025

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ripestat operational

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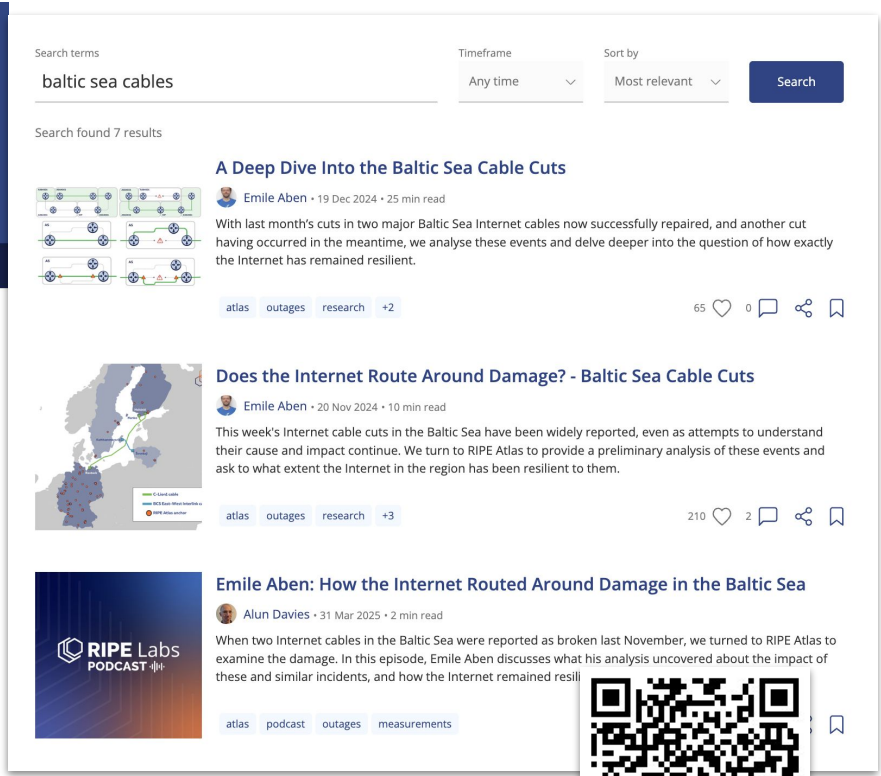

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Emile Aben

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About the author

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Based in Amsterdam, NL

I'm a data scientist at the RIPE NCC. I'm a chemist by training, but have been working since 1998 on Internet related things, as a sysadmin, security consultant, web developer and researcher. I am interested in technology changes (like IPv6 deployment), Internet measurement, data analysis, data visualisation, sustainability and security. I'd like to bring research and operations closer together, ie. do research that is operationally relevant. When I'm not working I like to make music (electric guitar, bass and drums), do sports (swimming, (inline) skating, bouldering, soccer), and try to be a good parent.

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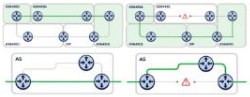


A Deep Dive Into the Baltic Sea Cable Cuts

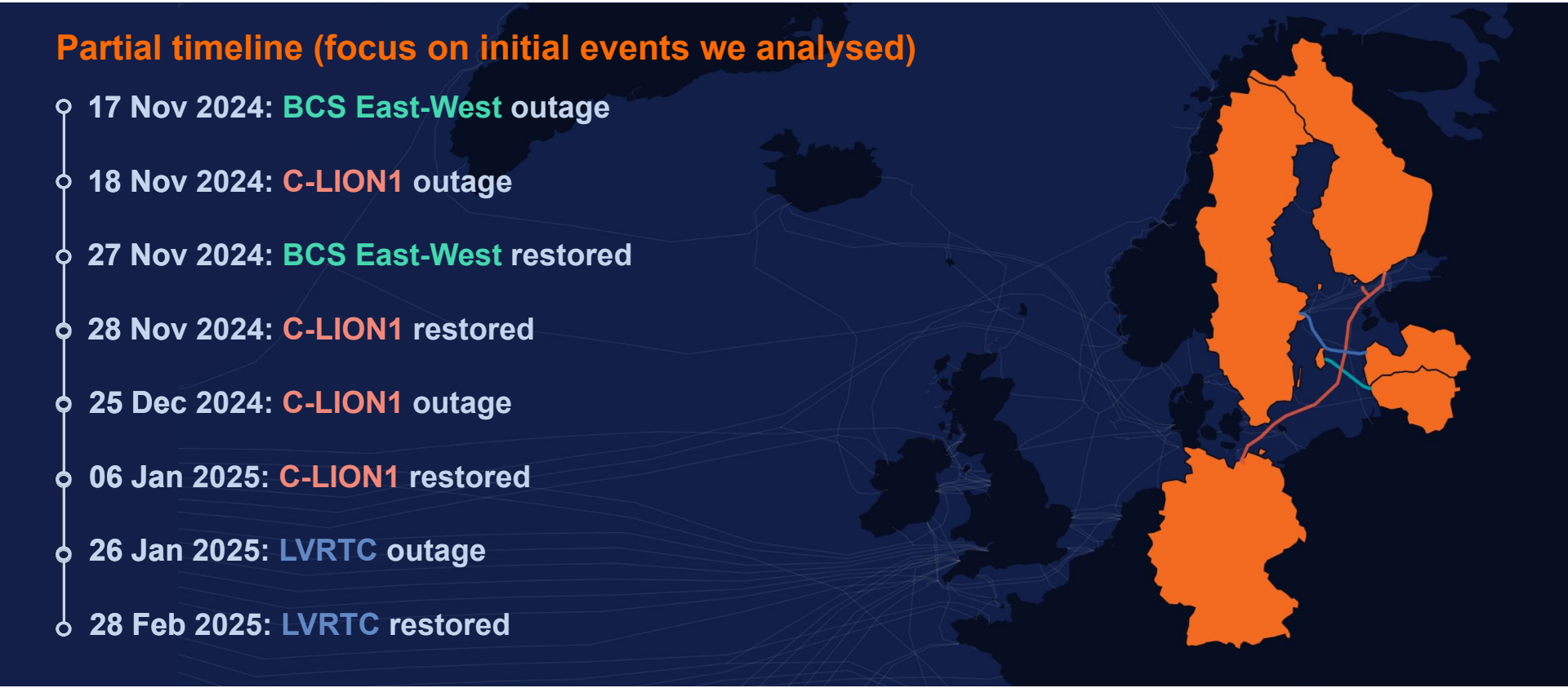
Emile Aben • 19 Dec 2024 • 25 min read

With last month's cuts in two major Baltic Sea Internet cables now successfully repaired, and another cut having occurred in the meantime, we analyse these events and delve deeper into the question of how

Baltic Sea cable damage

Partial timeline (focus on initial events we analysed)

- 17 Nov 2024: BCS East-West outage
- 18 Nov 2024: C-LION1 outage
- 27 Nov 2024: BCS East-West restored
- 28 Nov 2024: C-LION1 restored
- 25 Dec 2024: C-LION1 outage
- 06 Jan 2025: C-LION1 restored
- 26 Jan 2025: LVRTC outage
- 28 Feb 2025: LVRTC restored



Baltic Sea cable damage

Media coverage

Two Baltic Sea cables disrupted – is this 'hybrid warfare'?

By **Annie Turner** - 19 November 2024

European governments point finger at Russia over Baltic cable cuts

Investigations are underway into two subsea cable breaches in the Balt
and European governments are starting to suggest that Russia is behin

Mary Lennighan
November 20, 2024

3 Min Read

Sweden opens inquiry into damaged undersea cable as Nato deploys ships

A vessel has been seized al
optic line, probably due to

Damaged cables appear to be accident, Finland says

3 December 2024

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George Wright
BBC News

December 31, 2024

Christmas Day Cable Cuts in the Baltic Sea

Written by Alexander Lott

bmarine telecommunic
Lithuania, Russia, an
. In addition, an underv
ut by a ship anchor. Th
ll involving a foreign c
or over a hundred kilom
cident occurred in Oct
nber 2024, and the Ea
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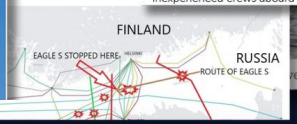


Sweden Investigates New Cable Break Under Baltic Sea

e authorities are looking into possible damage to an undersea
east of Gotland island. NATO has stepped up its surveillance
he region.

Baltic subsea cable damage was accidental, not sabotage - US and European officials

Refutes all claims of Russian sabotage

January 20, 2025 By: Niva Yadav Have your say

Subsea cable damage in the Baltic Sea in recent months was likely the result of maritime accidents, not Russian sabotage, according to several US and European intelligence officials.

As reported by The Washington Post, US and European officials have gathered evidence - including intercepted communications - which have concluded that anchors were dragged across the seabed accidentally because of inexperienced crews aboard poorly maintained

edish Coast Guard vessel in the Baltic Sea. Sweden also investigated the severing

Baltic Sea cable damage

Measuring damage with RIPE Atlas

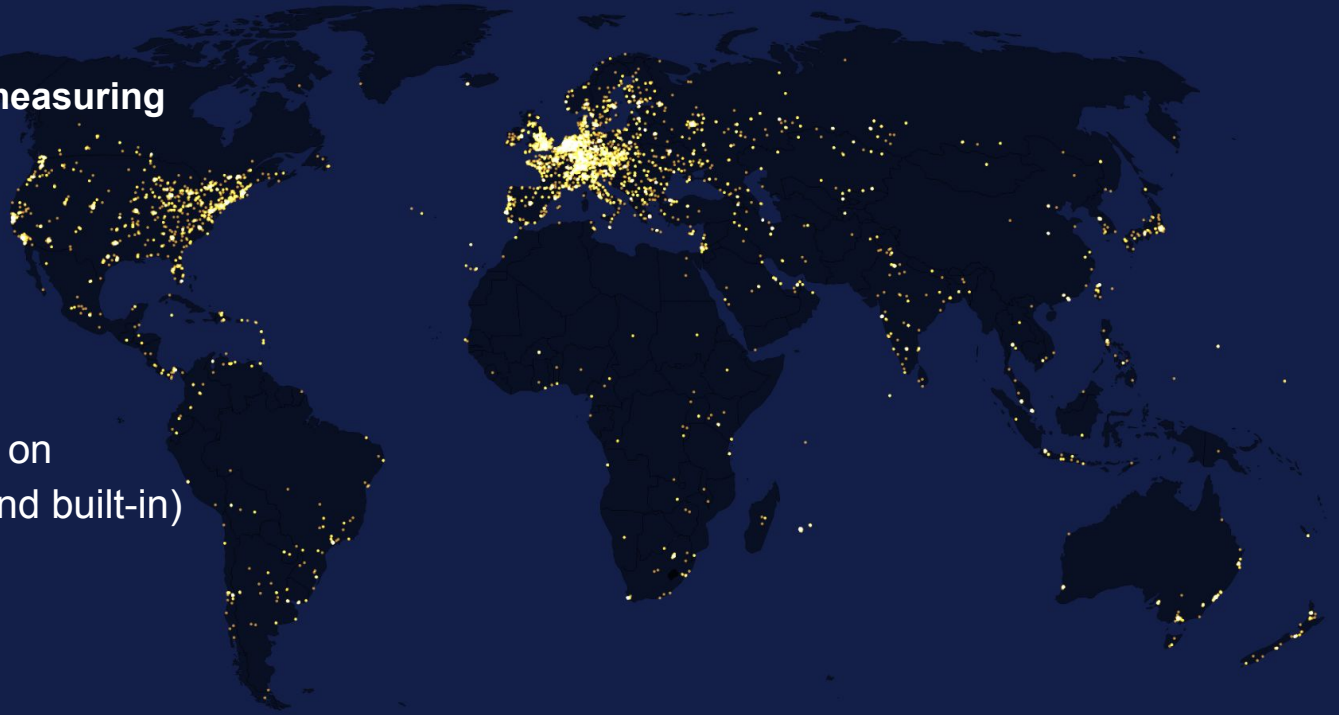
RIPE Atlas

A global network of probes measuring the Internet in real time

13,400+ probes connected

800+ anchors deployed

35,000+ daily measurements on average (both user-defined and built-in)



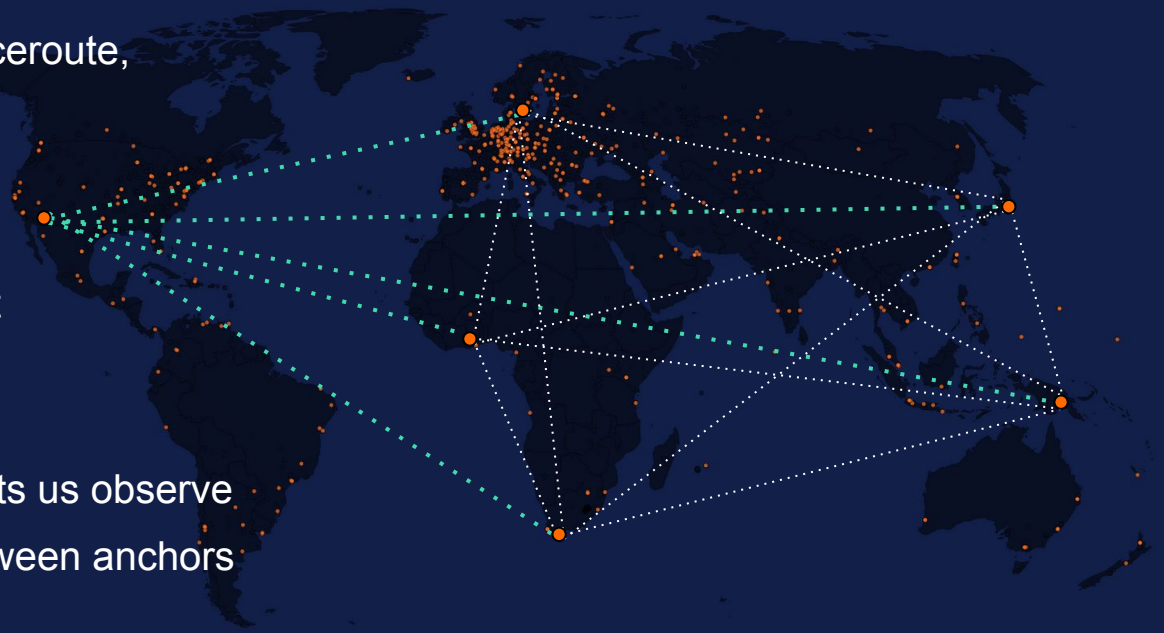
Measuring damage with RIPE Atlas

Anchor mesh

RIPE Atlas anchors support ping, traceroute, DNS, HTTP/S measurements

Each anchor performs ongoing ping measurements to all other anchors at four-minute intervals

Resulting ‘mesh’ of measurements lets us observe latency changes and packet loss between anchors



First look

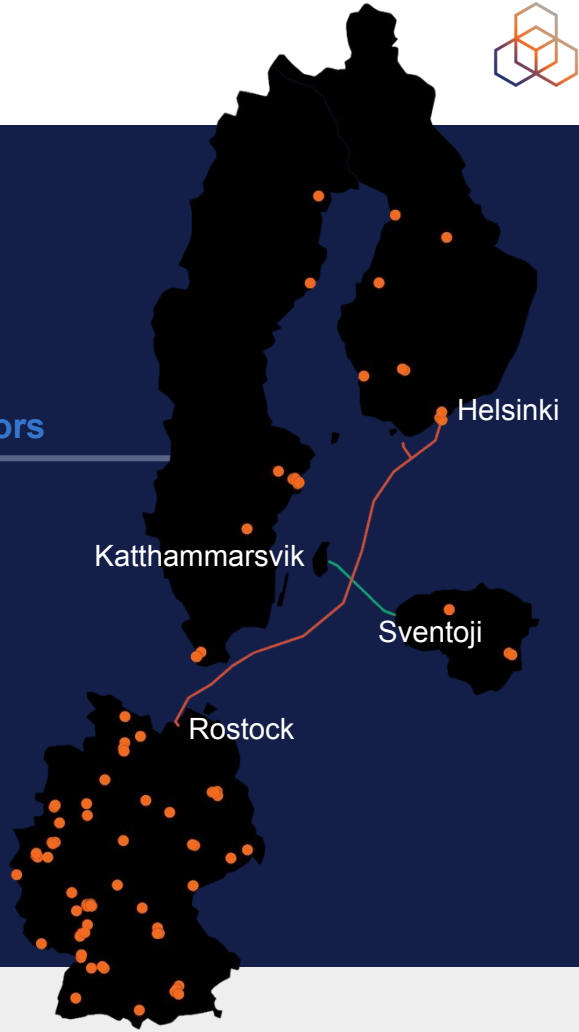
17-18 November

BCS East-West: Sweden-Lithuania

C-LION1: Germany-Finland

We looked at results in the RIPE Atlas anchor mesh between these countries around reported time of the event

Country	# anchors
Germany:	100
Sweden:	15
Finland:	12
Lithuania:	5



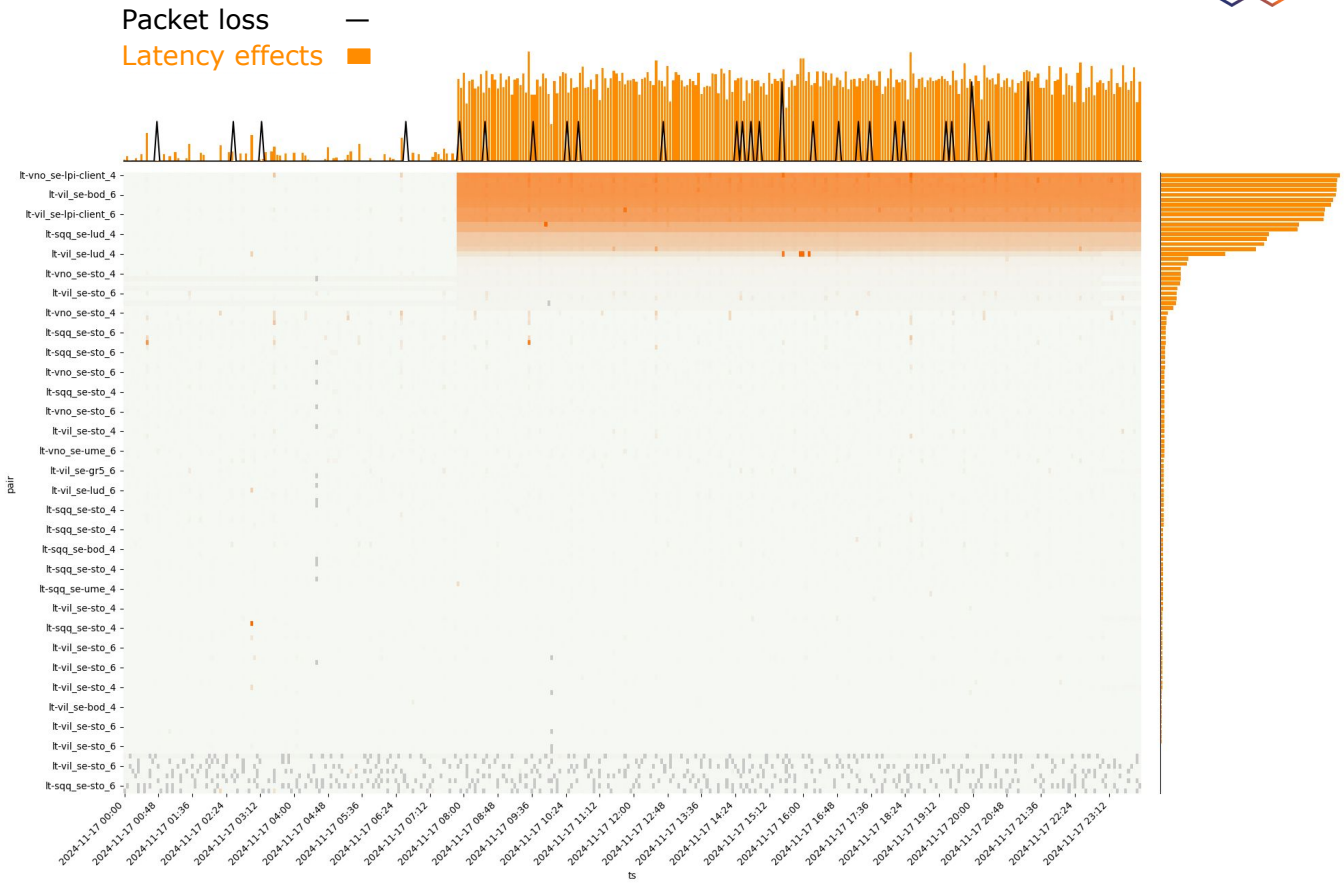
BCS East West

Latency shift

12 hour before/after time of event

Latency increase of approx 10-20 ms shortly before 08:00 UTC on 17 November

We subtract the minimum latency for a path during our observation period to make the latency jumps comparable



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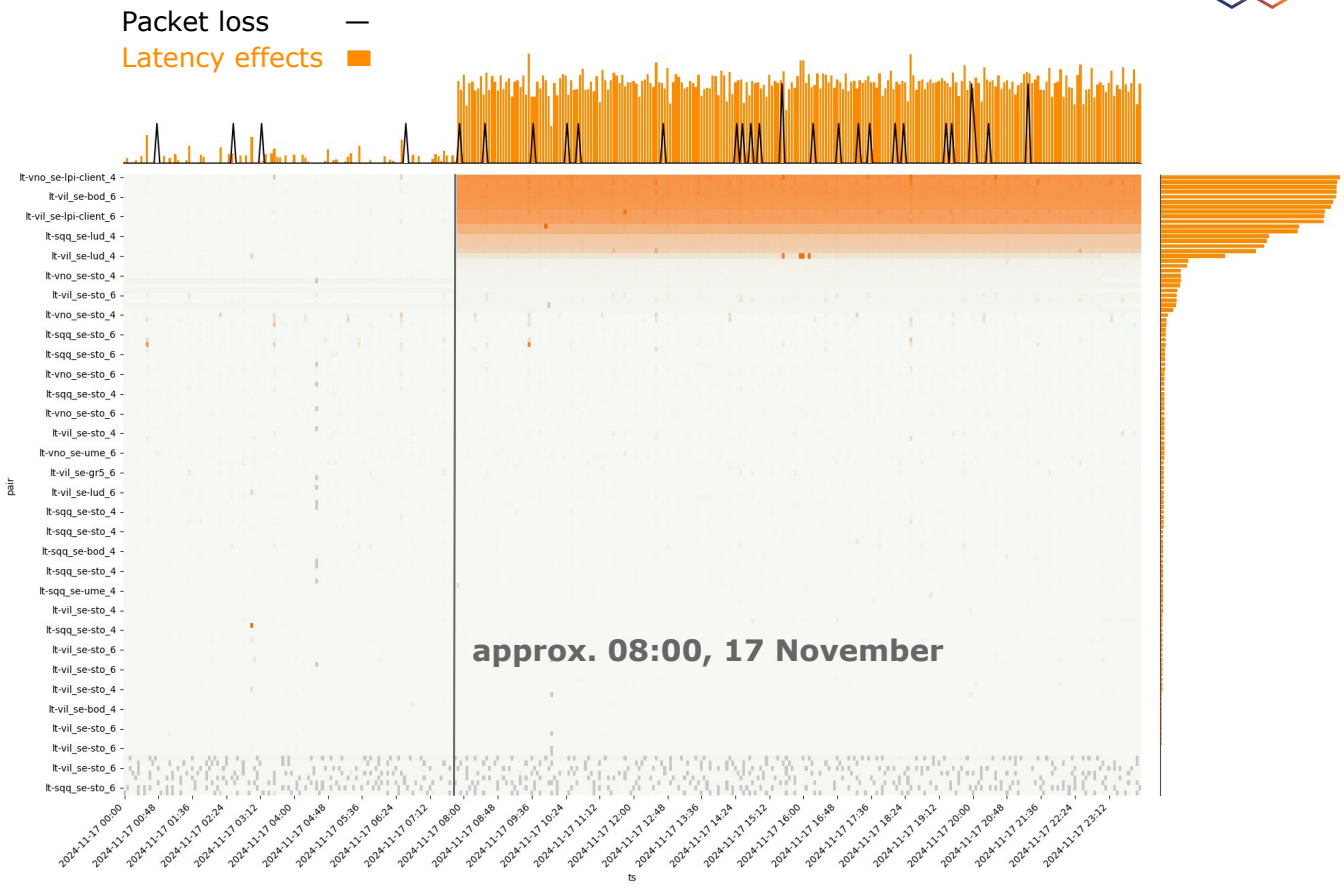
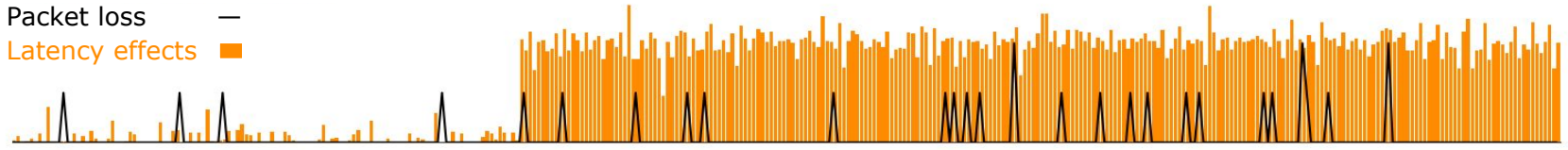


BCS East West

Packet loss

Baseline of 0% packet loss

(with occasional spikes)



No significant increase in packet loss at time of the cable outage (shortly before 08:00 UTC)

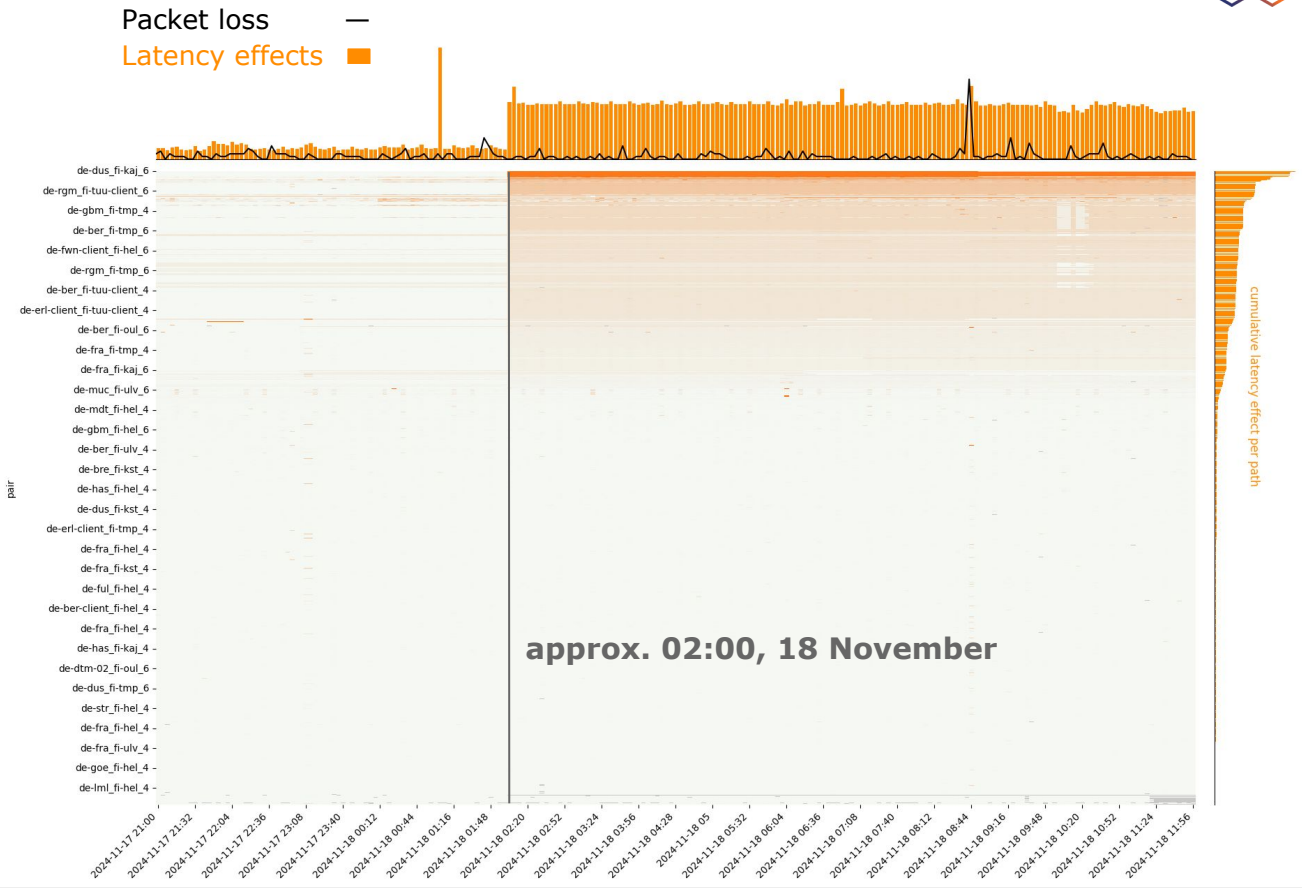
C-LION1

Latency shift

Latency increase of approx 5ms a little after 02:00 UTC on 18 November

Packet loss

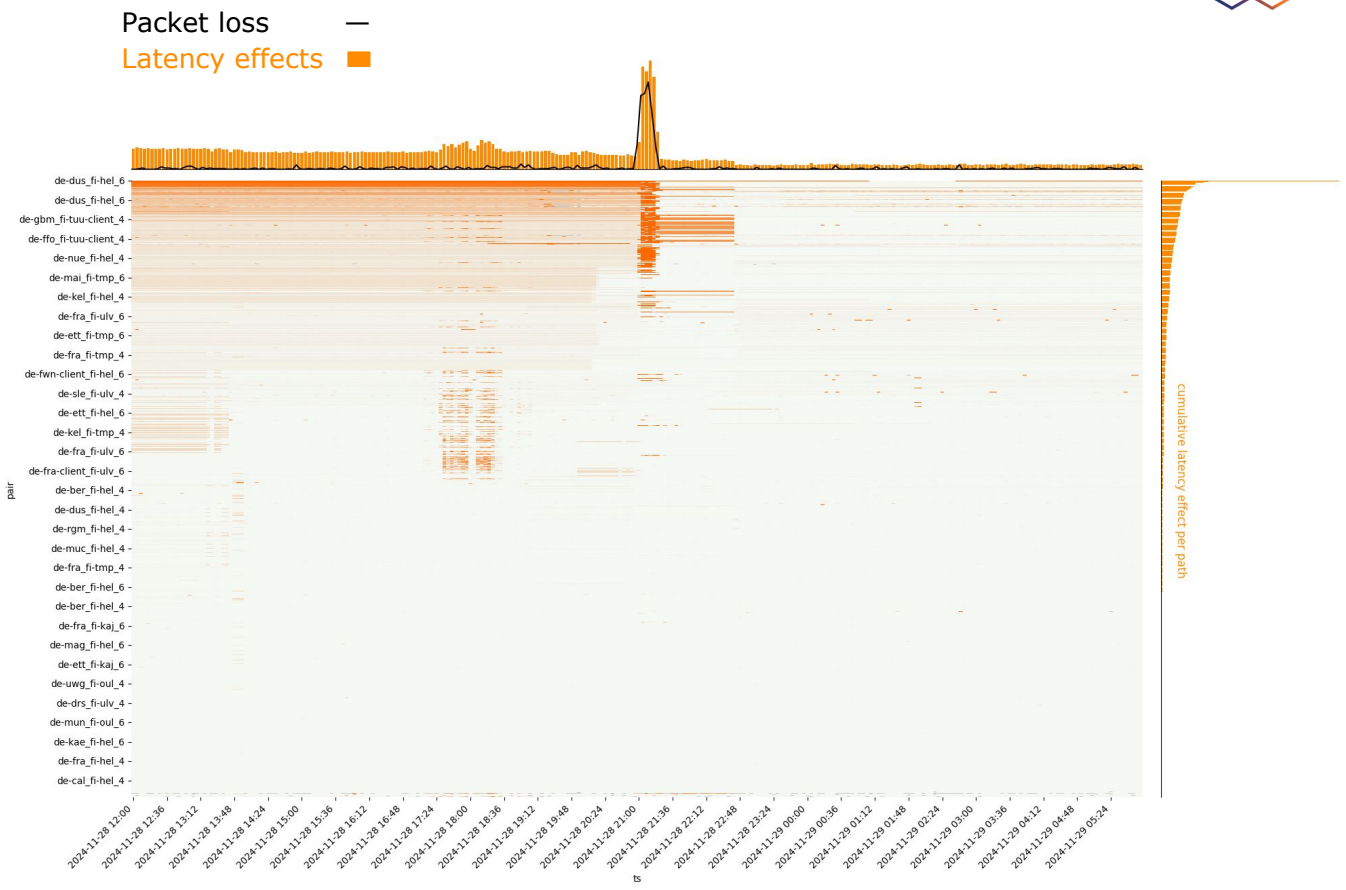
Again, no significant increase in packet loss at time of outage



C-LION1 repair

28 November (17:30 UTC): C-Lion1 cable repair ship reported leaving the area after successful repair

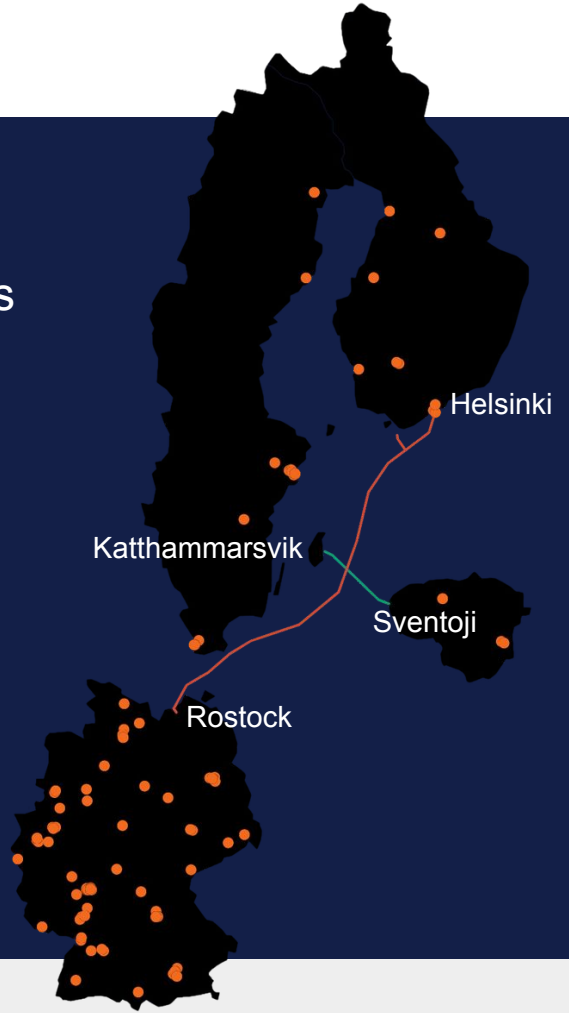
Unclear what exactly causes these latency effects and the temporary increase in packet loss…



Summing up

There was a relatively minor but visible shift in latency for around 20-30% of paths between observed anchors

But there was no concurrent increase in packet loss



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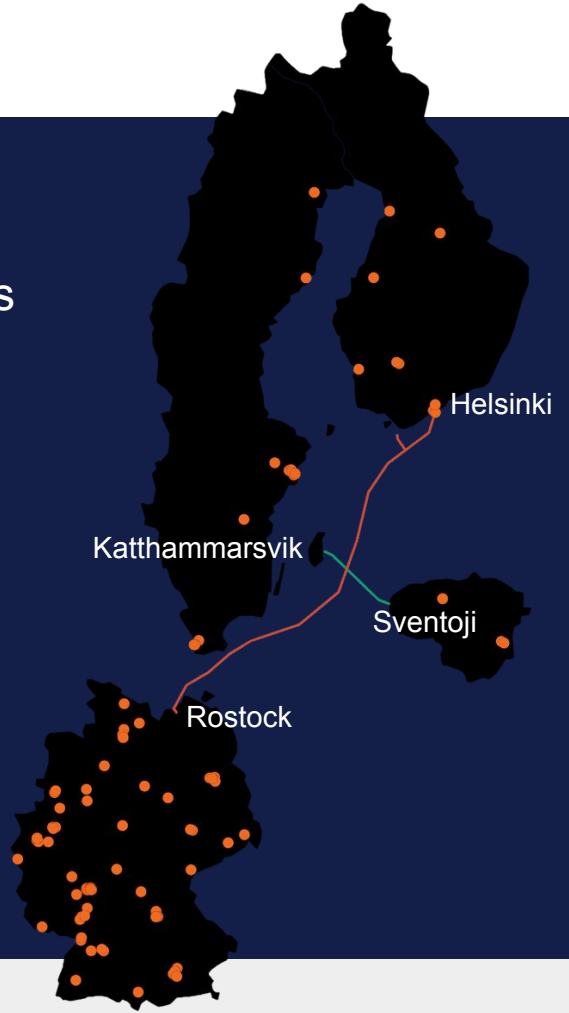
The Internet routed around damage!

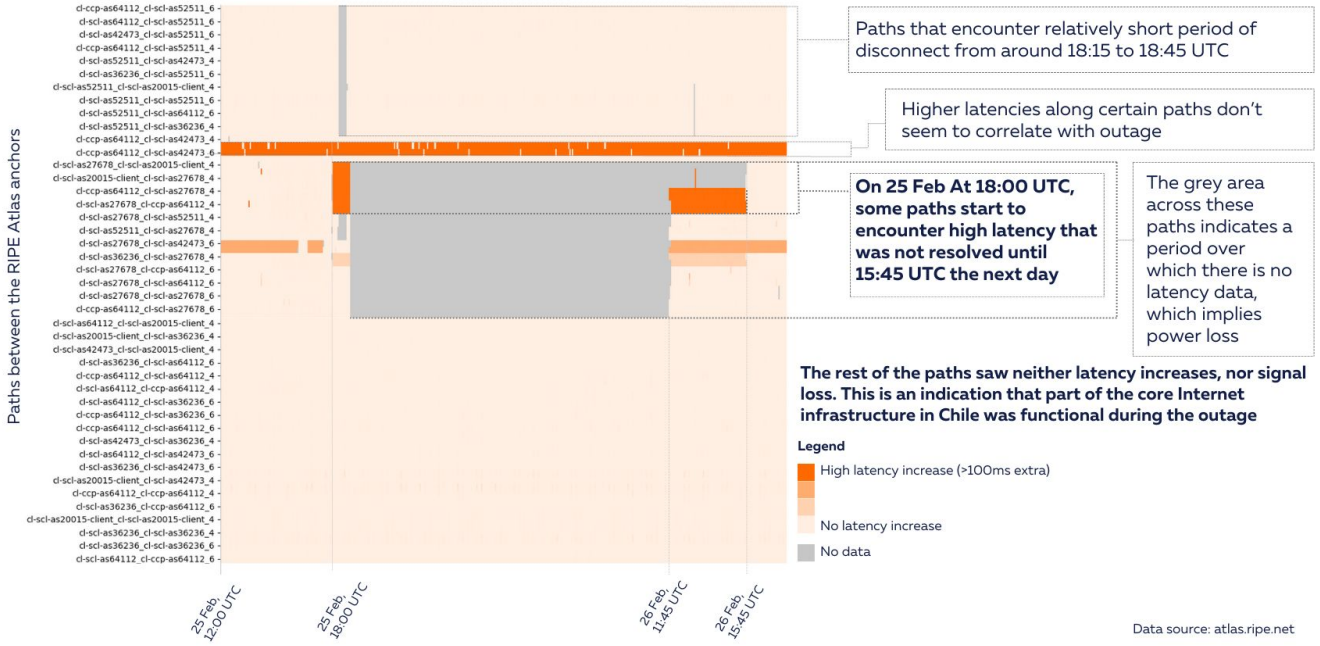


Beyond the Baltic Sea

Anchor mesh measurements have broad potential for getting insights into outages

Chile Power Outage

On 25 February, at around 18:00 UTC, a nationwide power outage affected Chile. The RIPE Atlas anchors (Internet measurement devices) in Chile give us a glimpse of how the Internet infrastructure coped with the power outage. Here's a breakdown of the effects we saw on the paths between the anchors.

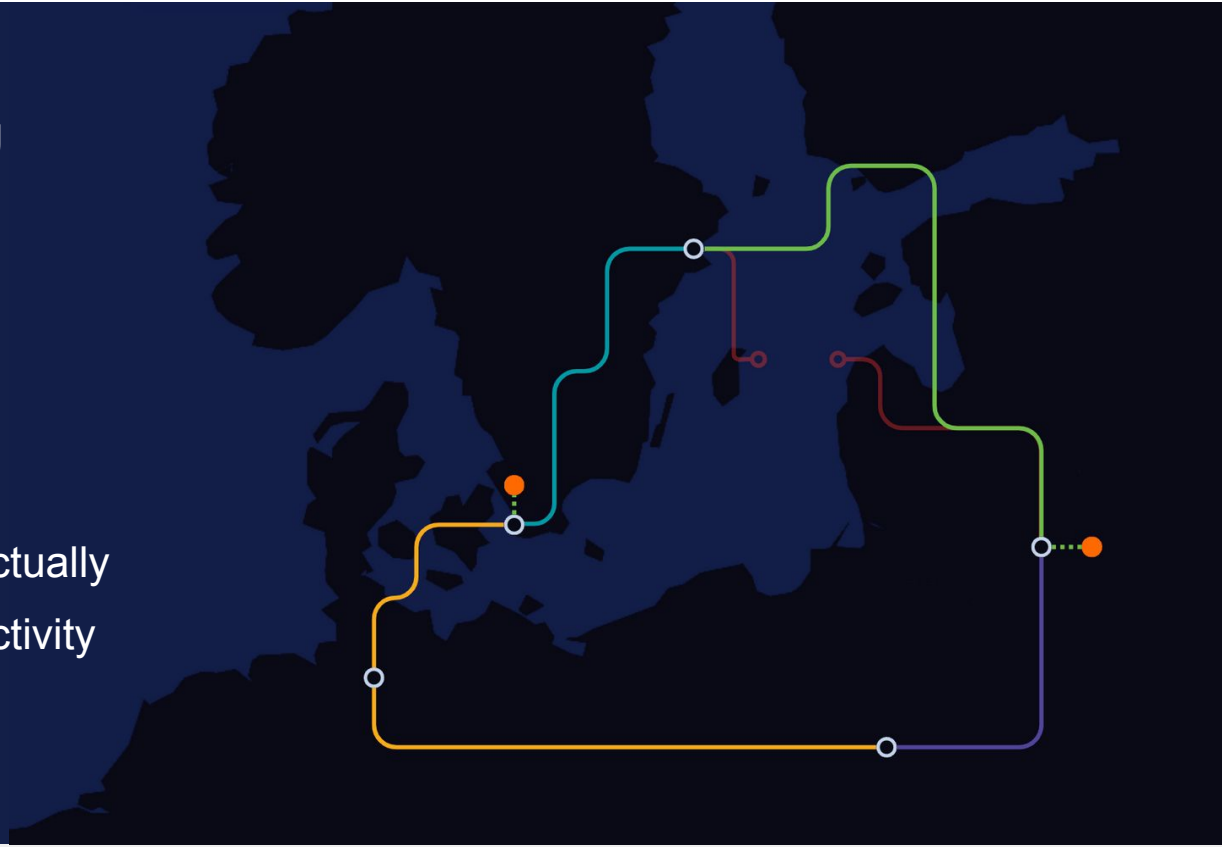


Deeper dive

Initial analysis was based on ping (end-to-end latency) data

We followed this up with in depth analysis using traceroute data

Aim: to examine how the paths actually changed while end-to-end connectivity was maintained



Levels of resilience

Inter-domain rerouting:

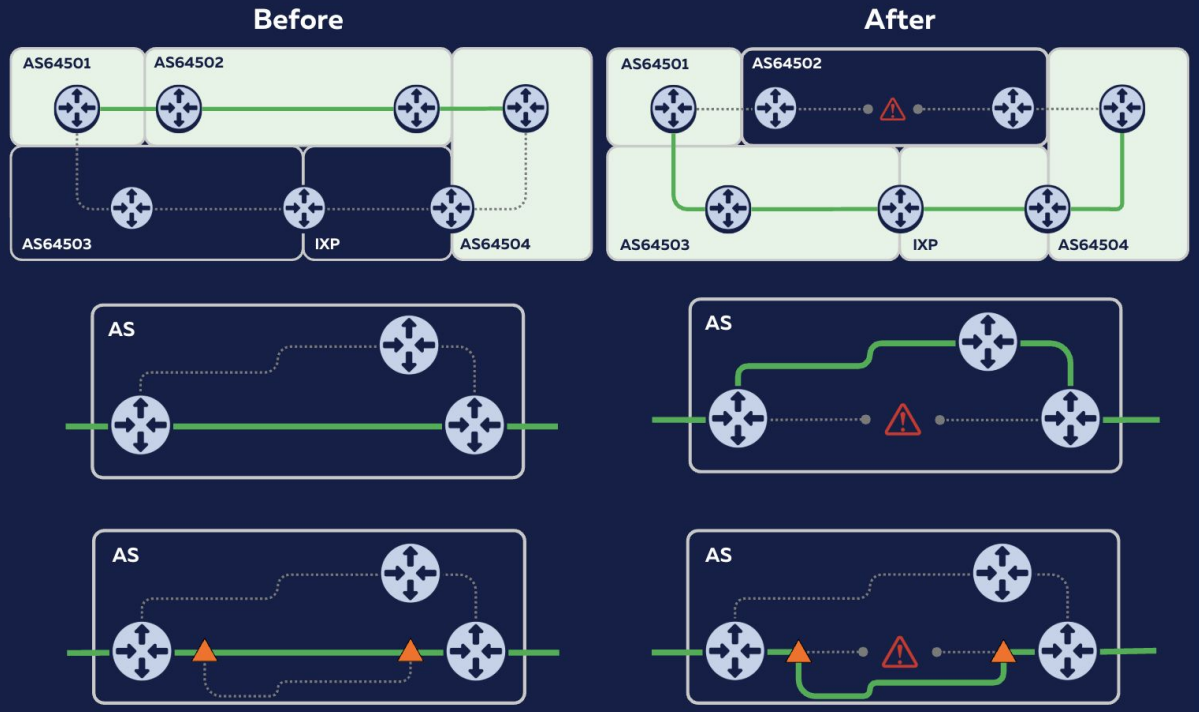
Traffic rerouted through alternative ASes/IXPs (eBGP routing protocol)

Intra-domain rerouting:

Rerouting *within* networks over alternative paths (IGP: OSPF, IS-IS)

Circuit-level rerouting:

Rerouting along alternative circuit-level connections between routers (same IP address!)

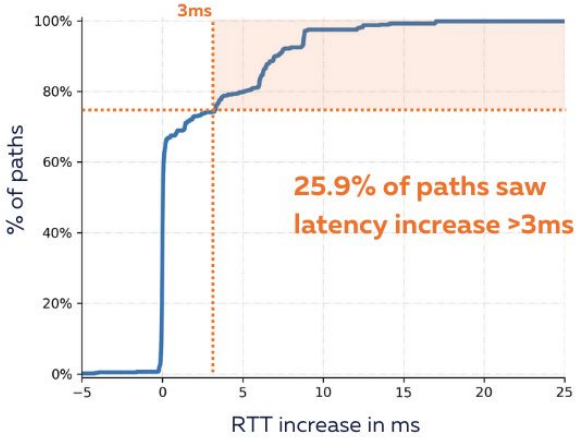


Levels of resilience

Of the 2,141 paths between anchors in Germany and Finland used for this analysis:

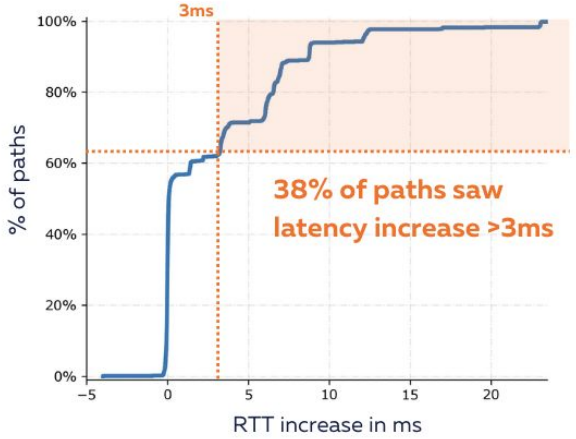
Inter-domain rerouting

RTT profile for **637** paths where inter-domain routing changed.



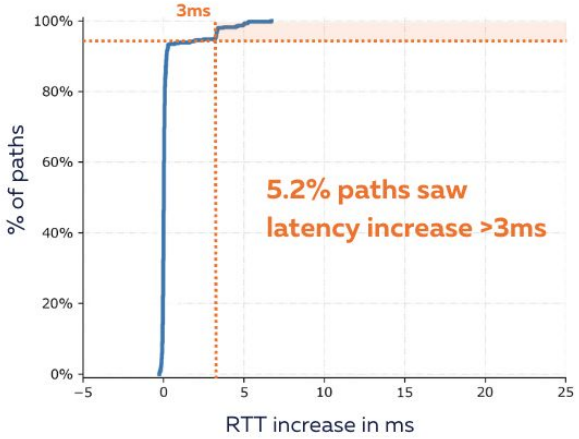
Intra-domain rerouting

RTT profile for **1,044** paths with IP-level changes, but no inter-domain changes.



Circuit-level rerouting

RTT profile for **460** paths with no inter-domain or intra-domain changes.



Resilience is not guaranteed

Cable damage in Africa

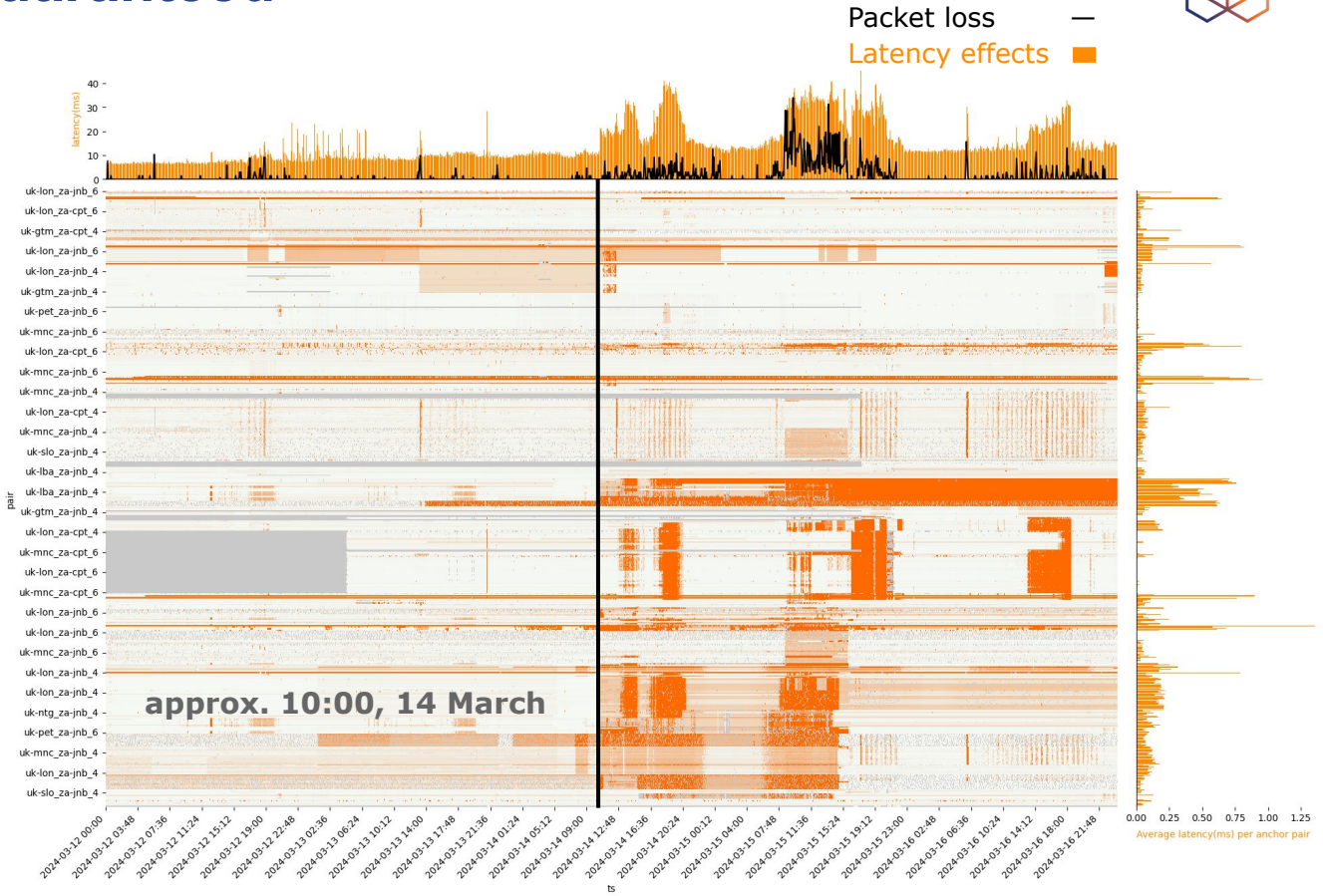
14 March 2024: Submarine landslide off coast of Cote d'Ivoire resulted in damage across multiple cables:

- ACE: Africa Coast to Europe
- MainOne
- SAT-3: Submarine Atlantic 3/West Africa Submarine Cable
- WACS: West Africa Cable System

Resilience is not guaranteed

Latency shift *with* packet loss

Latency increases of approx 20-30 ms accompanied by concurrent increase in packet loss



Conclusions

In the Baltic Sea:

- “The Internet routed around damage”
- Internet resilience depends on multiple levels of redundancy
    - Redundancy between networks
    - Redundancy within networks (circuit and routing)

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But resilience is not guaranteed

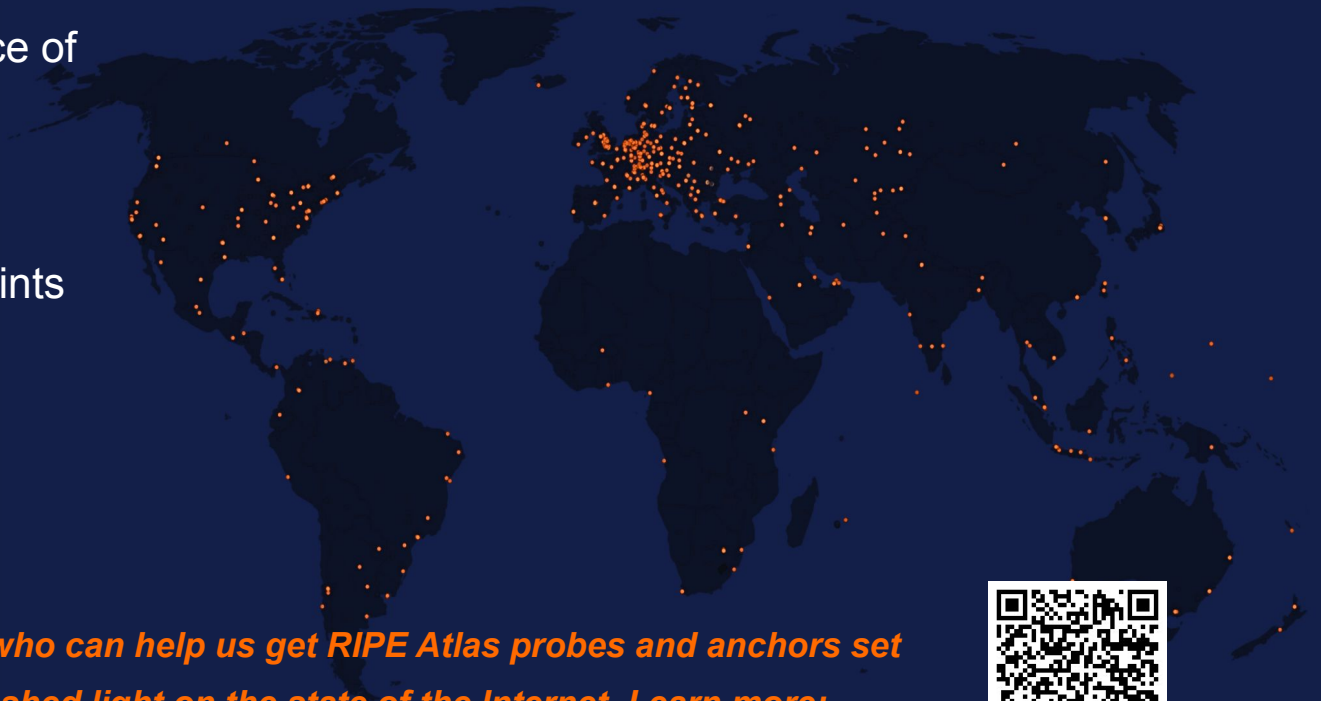
We have to keep monitoring, measuring, understanding

RIPE Atlas coverage - how far can we see?

RIPE NCC is a neutral source of Internet measurement data

To gain visibility into Internet events, we need vantage points

Coverage is key!

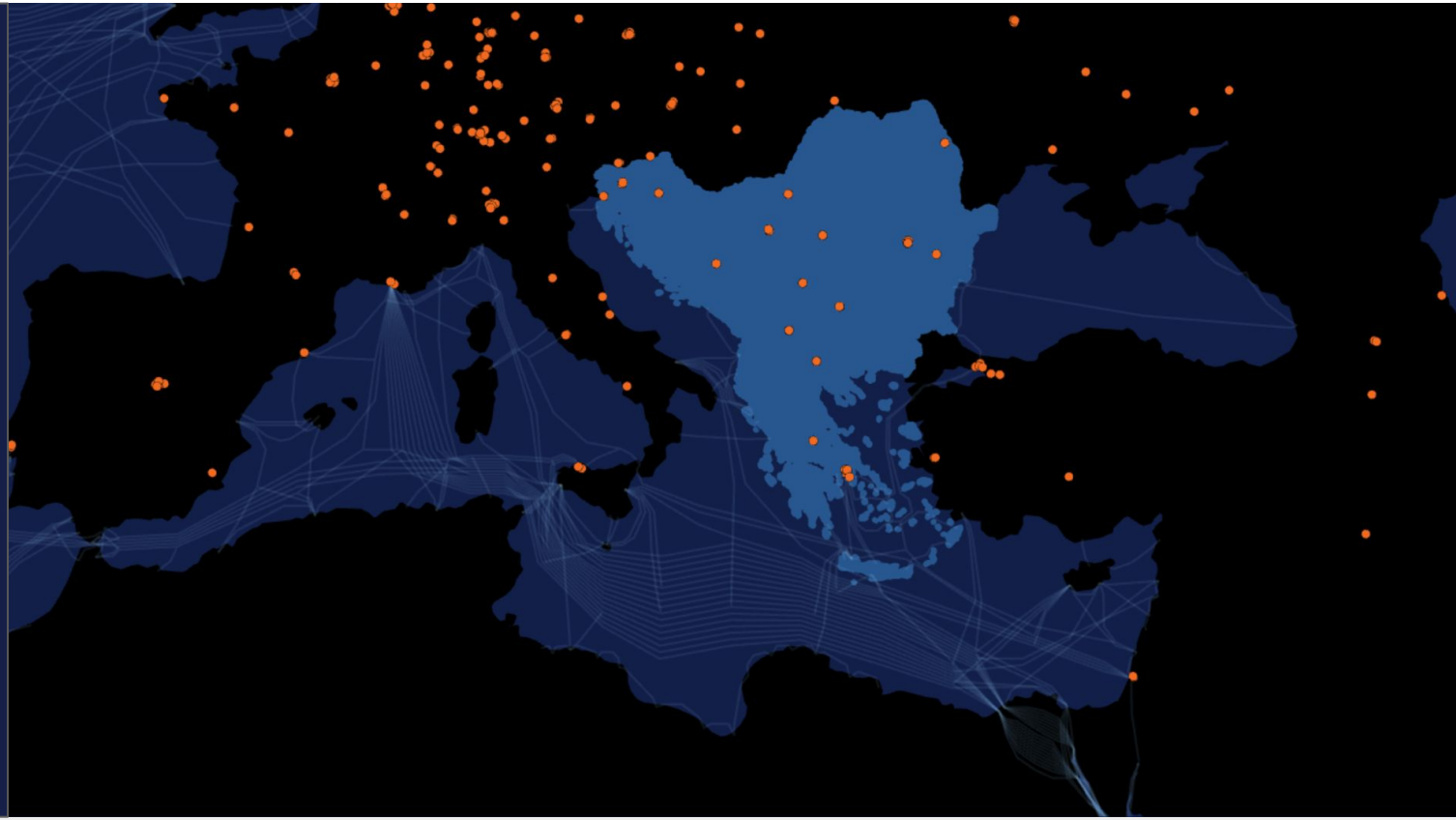


We are actively seeking hosts who can help us get RIPE Atlas probes and anchors set up in locations where they can shed light on the state of the Internet. Learn more:

RIPE Atlas coverage - how far can we see?

SEE anchors

RO: 7
BG: 7
RS: 3
HR: 1
GR: 5
AL: 0
BA: 1
SI: 2
MK: 2
ME: 0



RIPE Atlas coverage - how far can we see?

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RIPE Atlas coverage - how far can we see?

jvaquero

Fork

Public By Joaquin Vaquero Ortiz Edited Apr 3

Anchors by country

The table below is a live view of RIPE Atlas anchor diversity per country

Country Codes (comma separated, no spaces)

```
viewof cc_list = Inputs.text({label: "Country Codes (comma separated, no spaces)"})
```

Country code	Nr of anchor	Nr of cities w a...	Nr of ASNs w a...	landings	Cables with lan...	Cable Count	List of cities w ...	List of ASNs ...
AF	1	1	1	0		0	kbl	138322
AG	0	0	0	3	celia eastern-c...	3		
AI	0	0	0	1	eastern-caribb...	1		
AL	0	0	0	2	eagle trans-adri...	4		
AM	1	1	1	0		0	evn	51225
AN	0	0	0	0		0		
AO	1	1	1	7	nzadi-cable-sy...	5	lad	37468
AR	4	4	4	3	firmina malbec t...	7	bhi bue ttd vgg	28109 4270 2...
AS	0	0	0	1	hawaiki samoa-...	2		
		8	22	0		0	fkt hit inn klu lei ...	48362 34347 ...

RIPE Atlas coverage - how far can we see?

Questions & Comments

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THANK YOU!