November 2023

Indexing Europe's Internet Resilience



Robbie Mitchell mitchell@isoc.org

What we'll cover

- Why we are seeking to better inform decision-makers.
- What can we learn from recent incidents?
- Strengths and weaknesses within Europe
- The industry and Internet community have a role to play in improving the Internet's resilience.



pulse.internetsociety.org

Your Data Dashboard







Shutdowns: Where do Internet Shutdowns take place?

Technologies: What is the state of deployment of technologies critical for the evolution of the Internet?

Concentration: How much are services concentrated in the hands of a few?

Resilience: How robust is the Internet ecosystem?



Internet Society Pulse Internet Resilience Index (IRI)

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<u>Methodology:</u> https://pulse.internetsociety.org/wp-content/uploads/2023/07/Internet-Society-Pulse-IRI-Methodology-July-2023-v2.0-Final-EN.pdf

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The Internet Resiliency Index (IRI)

pulse.internetsociety.org/resilience

The framework collates around 30 sets of public metric data that relate to **four pillars** of a resilient Internet:

Infrastructure	Performance		Security	Market Readiness
The existence and availability of physical infrastructure that provides Internet connectivity.	The ability of the network to provide end-users with seamless and reliable access to Internet services.	ne i disr th	ne ability of the etwork to resist intentional or unintentional ruptions through ne adoption of security chnologies and sest practices.	The ability of the market to self- regulate and provide affordable prices to end-users by maintaining a diverse and competitive market.



What can we learn from recent incidents?



AS4804 outage

- The outage lasted 10 hours
- It affected the fixed broadband and mobile communications of over 10 million individuals and 400,000 businesses and services.
- Issue believed to be related to BGP Maximum-Prefix filter.
- Signs of lack of resilience were clear to see



15 November 2023

Optus Outage Exposes Australia's Internet Resilience



Aftab SiddiquiCategories:Senior Manager, InternetResilienceTechnology - Asia-Pacific,Internet Society

A minor technical slip-up by Australia's secondlargest operator causes one-third of Australians to lose Internet and mobile connectivity.



Australia – Internet Resilience Index

🚭 Australia

Infrastructure			53%
Cable ecosystem	31%	Fibre 10km reach	31%
Mobile connectivity	91%	Network coverage	96%
		Spectrum allocation	79%
Enabling infrastructure	45%	Data centers	44%
		Number of IXPs	46%
Performance			51%
Fixed networks	41%	Fixed download	21%
		Fixed jitter	85%
		Fixed latency	59%
		Fixed upload	19%
Mobile networks	58%	Mobile download	75%
		Mobile jitter	66%
		Mobile latency	53%
		Mobile upload	41%

Security			65%
Enabling technologies	82%	Secure web traffic	96%
		IPv6 adoption	50%
Domain name system security	64%	DNSSEC adoption	100%
		DNSSEC validation	28%
Routing hygiene	44%	MANRS	47%
		Upstream redundancy	41%
Security threat	82%	DDoS protection	60%
	10-104	Global cybersecurity	97%
		Secure Internet servers	84%
Market readiness			58%
Market structure	55%	Affordability	95%
		Upstream provider diversity	35%
		Market diversity	39%
Traffic localization	62%	Domain count	41%
		EGDI	96%
		Peering efficiency	52%



Internet Resilience

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AS812 outage

- The outage lasted 19 hours.
- It affected 12 million subscribers and indirectly affected millions of others.
- Cost the economy nearly 142 million USD and Rogers 150M USD in customer credits.
- Rogers has also never provided a Root Cause Analysis



9 September 2022

Rogers Outage: What do we Know After Two Months?



Jim Cowie Former Resident Advisor, Internet Society

Categories: Concentration, Resilience

Hiding operational failures in darkness helps nobody.



Canada – Internet Resilience Index

(+) Canada

Infrastructure			67%
Cable ecosystem	49%	Fibre 10km reach	49%
Mobile connectivity	90%	Network coverage	96%
		Spectrum allocation	77%
Enabling infrastructure	67%	Data centers	879
		Number of IXPs	469
Performance			59%
Fixed networks	59%	Fixed download	609
		Fixed jitter	829
		Fixed latency	599
		Fixed upload	419
Mobile networks	60%	Mobile download	789
		Mobile jitter	66%
		Mobile latency	489
		Mobile upload	46%

Security			619
Enabling technologies	82%	Secure web traffic	96%
		IPv6 adoption	481
Domain name system security	58%	DNSSEC adoption	1009
		DNSSEC validation	159
touting hygiene	35%	MANRS	121
		Upstream redundancy	585
ecurity threat	82%	DDoS protection	601
		Global cybersecurity	981
		Secure Internet servers	849
Market readiness			593
Market structure	63%	Affordability	931
		Upstream provider diversity	379
		Market diversity	595
raffic localization	55%	Domain count	419
		EGDI	865
		Peering efficiency	439



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AS3269 and AS16232 outage

- Outage lasted 5 hours
- It affected one-third of Italy's Internet users.
- Cost the economy nearly 142 million USD and Rogers 150M USD in customer credits.
- Rogers has also never provided a Root Cause Analysis



8 February 2023

Italy's Internet Outage a **Perfect Storm**



Massimiliano Stucchi

Categories: Resilience

Europe, Internet Society

Regional Technical Advisor -

Italy's recent Internet outage was a failure that was years in the making and could have been negated through greater interconnectivity.



Italy – Compare the Pair

AS3269 TIM



AS30722 Vodafone Italia





Italy – Internet Resilience Index

Italy

nfrastructure			72%
Cable ecosystem	71%	Fibre 10km reach	71%
Mobile connectivity	95%	Network coverage	99%
		Spectrum allocation	85%
Enabling infrastructure	49%	Data centers	39%
		Number of IXPs	60%
Performance			39%
ixed networks	42%	Fixed download	25%
		Fixed jitter	89%
		Fixed latency	53%
		Fixed upload	21%
Abile networks	37%	Mobile download	38%
		Mobile jitter	53%
		Mobile latency	14%

Security			68%
Enabling technologies	63%	Secure web traffic	84%
		IPv6 adoption	14%
Domain name system security	63%	DNSSEC adoption	100%
		DNSSEC validation	26%
Routing hygiene	68%	MANRS	76%
		Upstream redundancy	60%
Security threat	80%	DDoS protection	60%
		Global cybersecurity	96%
		Secure Internet servers	79%
Market readiness			71%
Market structure	66%	Affordability	95%
		Upstream provider diversity	59%
		Market diversity	50%
Traffic localization	77%	Domain count	80%
		EGDI	84%
		Peering efficiency	69%



Internet Resilience

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Internet Resilience in Europe: Strengths and Weaknesses



Overall Internet Resilience – By Region

Overall Resilience
Infrastructure
Performance
Security
Market Readiness

Overall Resilience





Overall Resilience - Countries in Europe





Switzerland- Internet Resilience Index

🛟 Switzerland

Infrastructure			80%	Security			78%
Cable ecosystem	92%	Fibre 10km reach	92%	Enabling technologies	82%	Secure web traffic	93%
Mobile connectivity	99%	Network coverage	99%			IPv6 adoption	54%
		Spectrum allocation	100%	Domain name system security	84%	DNSSEC adoption	100%
						DNSSEC validation	68%
Enabling infrastructure	45%	Data centers	44%				
		Number of IXPs	46%	Routing hygiene	73%	MANRS	79%
Performance			76%			Upstream redundancy	67%
				Security threat	71%	DDoS protection	28%
Fixed networks	79%	Fixed download	65%			Global cybersecurity	87%
		Fixed jitter	89%			Secure Internet servers	93%
		Fixed latency	76%	Market readiness			56%
		Fixed upload	87%				
Mobile networks	74%	Mobile download	77%	Market structure	57%	Affordability	96%
		Mobile jitter	60%			Upstream provider diversity	49%
		Mobile latency	59%			Market diversity	35%
		Mobile upload	90%	Traffic localization	56%	Domain count	41%
				inamic localization	50%		
						EGDI	88%



Internet Resilience

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data source: Pulse Internet Resilience Index

Peering efficiency

42%

Iceland – Internet Resilience Index

 lceland

Infrastructure			85%	Security			79%
Cable ecosystem	92%	Fibre 10km reach	92%	Enabling technologies	71%	Secure web traffic	98%
Mobile connectivity	88%	Network coverage	91%			IPv6 adoption	10%
		Spectrum allocation	82%	Domain name system security	98%	DNSSEC adoption	100%
Enabling infrastructure	72%	Data centers	44%			DNSSEC validation	97%
		Number of IXPs	100%	Routing hygiene	60%	MANRS	76%
Performance			66%			Upstream redundancy	43%
renormance			00%	Security threat	86%	DDoS protection	92%
Fixed networks	69%	Fixed download	100%			Global cybersecurity	80%
		Fixed jitter	67%			Secure Internet servers	89%
		Fixed latency	57%	Market readiness			61%
		Fixed upload	46%				01/0
Mobile networks	64%	Mobile download	50%	Market structure	56%	Affordability	95%
		Mobile jitter	70%			Upstream provider diversity	48%
		Mobile latency	85%			Market diversity	31%
		Mobile upload	60%	Traffic localization	66%	Domain count	41%
						EGDI	96%
						Peering efficiency	62%



Internet Resilience

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Figure 1. Bulgaria lags the rest of Europe in digitization

Source: European Commission, Digital Economy and Society Index (DESI), 2020.

BROOKINGS

https://www.brookings.edu/articles/can-bulgaria-catch-the-digital-wave-defining-the-policy-priorities/

Bulgaria – Internet Resilience Index

🛑 Bulgaria

Infrastructure			78%	Security			71%
Cable ecosystem	66%	Fibre 10km reach	66%	Enabling technologies	70%	Secure web traffic	93%
Mobile connectivity	89%	Network coverage	95%			IPv6 adoption	17%
		Spectrum allocation	73%	Domain name system security	72%	DNSSEC adoption	100%
Enabling infrastructure	84%	Data centers	91%			DNSSEC validation	43%
	0170	Number of IXPs	78%	Routing hygiene	78%	MANRS	88%
Performance			70%			Upstream redundancy	67%
Performance			70%	Security threat	63%	DDoS protection	36%
Fixed networks	61%	Fixed download	28%			Global cybersecurity	67%
		Fixed jitter	89%	-		Secure Internet servers	86%
		Fixed latency	90%	Market readiness			53%
		Fixed upload	56%				
Mobile networks	77%	Mobile download	82%	Market structure	67%	Affordability	92%
		Mobile jitter	72%			Upstream provider diversity	61%
		Mobile latency	59%			Market diversity	53%
		Mobile upload	86%	Traffic localization	39%	Domain count	18%
						EGDI	77%
						Peering efficiency	27%



Internet Resilience pulse.internetsociety.org

Overall Resilience - Countries in Europe



Overall Resilience - Countries in Europe



Ukraine- Internet Resilience Index

- Ukraine

Infrastructure			50%
Cable ecosystem	39%	Fibre 10km reach	39%
Mobile connectivity	69%	Network coverage	72%
		Spectrum allocation	61%
Enabling infrastructure	44%	Data centers	31%
		Number of IXPs	56%
Performance			46%
Fixed networks	68%	Fixed download	26%
		Fixed jitter	91%
		Fixed latency	95%
		Fixed upload	76%
Mobile networks	32%	Mobile download	17%
		Mobile jitter	49%
		Mobile latency	21%
		Mobile upload	43%

Security			63%
Enabling technologies	67%	Secure web traffic	90%
		IPv6 adoption	13%
Domain name system security	70%	DNSSEC adoption	100%
		DNSSEC validation	40%
Routing hygiene	63%	MANRS	72%
		Upstream redundancy	54%
Security threat	48%	DDoS protection	0%
		Global cybersecurity	66%
		Secure Internet servers	72%
Market readiness			53%
Market structure	65%	Affordability	87%
		Upstream provider diversity	36%
		Market diversity	71%
Traffic localization	42%	Domain count	19%
		EGDI	80%
		Peering efficiency	30%



Internet Resilience

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Ukraine- Internet Resilience Index

🗕 Ukraine

Infrastructure			50%
Cable ecosystem	39%	Fibre 10km reach	39%
Mobile connectivity	69%	Network coverage	72%
		Spectrum allocation	61%
Enabling infrastructure	44%	Data centers	31%
		Number of IXPs	56%
Performance			46%
Performance Fixed networks	68%	Fixed download	
	68%	Fixed download Fixed jitter	26%
	68%		26% 91%
	68%	Fixed jitter	26% 91% 95%
	68%	Fixed jitter Fixed latency	26% 91% 95% 76%
Fixed networks		Fixed jitter Fixed latency Fixed upload	26% 91% 95% 76%
Fixed networks		Fixed jitter Fixed latency Fixed upload Mobile download	46% 26% 91% 95% 76% 17% 49% 21%

Security			63%
Enabling technologies	67%	Secure web traffic	90%
		IPv6 adoption	13%
Domain name system security	70%	DNSSEC adoption	100%
		DNSSEC validation	40%
Routing hygiene	63%	MANRS	72%
		Upstream redundancy	54%
Security threat	48%	DDoS protection	0%
		Global cybersecurity	66%
		Secure Internet servers	72%
Market readiness			53%
Market structure	65%	Affordability	87%
		Upstream provider diversity	36%
		Market diversity	719
Traffic localization	42%	Domain count	19%
		EGDI	80%
		Peering efficiency	30%



Internet Resilience

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Ukraine – IPv4 and v6 Interconnection (APNIC REx)





https://rex.apnic.net/as-interconnections?allocationType=ipv4,ipv6&economy=UA

Ukraine – ASN Dependency (IIJ Internet Health Report)

	Autonomous System		Population coverage ③		AS coverage ③
	Q Search	Total	Direct ↓	Indirect	Total
AS15895	KSNET-AS "Kyivstar" PJSC, UA	23.5%	22.5%	0.7%	1.5%
AS21497	UMC-AS PrJSC "VF UKRAINE", UA	10.0%	9.7%	0.2%	1.5%
AS34058	LIFECELL-AS Limited Liability Company "lifecell", UA	5.7%	5.6%	0.0%	0.1%
AS6849	UKRTELNET JSC "Ukrtelecom", UA	3.5%	3.3%	0.2%	1.5%
AS25229	VOLIA-AS Kyivski Telekomunikatsiyni Merezhi LLC, UA	3.2%	3.1%	0.1%	1.0%
AS13188	TRIOLAN CONTENT DELIVERY NETWORK LTD, UA	2.5%	2.5%	0.0%	0.1%
AS3255	UARNET-AS State Enterprise Scientific and Telecommunication Centre "Ukrainian Academic and Research Network" of the Institute for Condensed Matter Physics of the National Academy of Science of Ukraine (UARNet), UA	9.9%	2.1%	7.8%	11.6%
AS15377	FREGAT "Fregat TV" Ltd., UA	1.2%	1.2%	0.0%	0.1%
AS3326	Datagroup PRIVATE JOINT STOCK COMPANY "DATAGROUP", UA	6.9%	1.1%	5.8%	11.4%
AS31148	FREENET_LLC Freenet LTD, UA	1.2%	1.1%	0.1%	0.3%

https://ihr.iijlab.net/ihr/en-us/countries/UA?af=4&last=3&date=2023-08-24&rov_tb=routes





Limitations

Limitations

- The data is pulled from external public sources, not always up-to-date.
 - An indicator is not included if data is missing on more than 25% of countries in the Index.
- Without in-country measurements, it's difficult to validate the data.
 - RIPE Atlas and OONI are doing great work in this area, but more is needed.
- Some of the data undergoes processing, normalization, and weighing, we use a methodology that is reproducible.
 - You can see raw numbers via API. Email us for access pulse@isoc.org
- Ultimately, the Index benchmarks countries with one another and helps decision makers recognize gaps and weaknesses to conduct further study into validating these and work towards addressing them.



We all have a role to play

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Take aways

- Understanding what's happening upstream and beyond your shores is equally important as knowing your network's health.
- Having an insightful national measurement system in place improves the resolution of the health of the edge.
- Your network's health and the health of the whole of Europe's Internet are interconnected. We all have a role to play to make sure it is robust and secure.



Not if, but when



9 September 2022

Rogers Outage: What do we Know After Two Months?



Jim Cowie Former Resident Advisor, Internet Society

Categories: ent Concentration, net Resilience

Hiding operational failures in darkness helps nobody.



8 February 2023 Italy's Internet Outage a Perfect Storm



Italy's recent Internet outage was a failure that was years in the making and could have been negated through greater interconnectivity. NO NO

15 November 2023

Optus Outage Exposes Australia's Internet Resilience



Senior Manager, Internet Technology - Asia-Pacific, Internet Society **Categories:**

Resilience

A minor technical slip-up by Australia's secondlargest operator causes one-third of Australians to lose Internet and mobile connectivity. Who's next?

Canada, July 2022

Italy, February 2023

Australia, November 2023



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Contribute to Pulse pulse@isoc.org **Review** the Pulse IRI methodology





Thank you



Robbie Mitchell mitchell@isoc.org