



MODELLING OF THE INTERNET ON AS LEVEL

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TNO innovation
for life

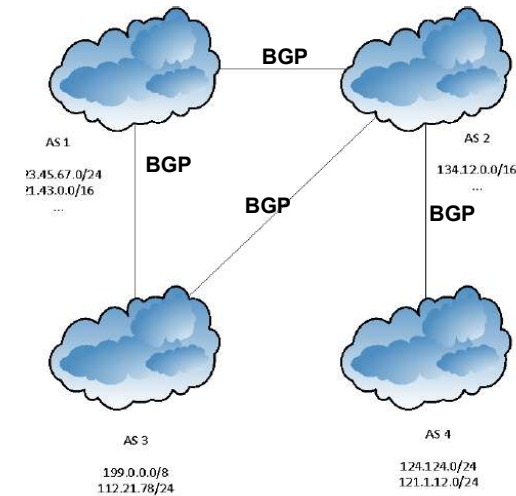
AGENDA

- › The Internet at AS level?
- › Available data & analyses tools
- › TNO's Common Sense BGP tool
- › Purpose & Scope of the model
- › BGP simulation models
- › csBGP for What-if scenario Analysis
- › Discussion



THE INTERNET AT AS LEVEL?

- › The Internet consists of “islands”
- › An “island” is an Autonomous System (AS)
- › Each AS is controlled one operator:
 - › Internet Service providers
 - › Internet Exchanges (Amsterdam Internet Exchange, AMS-IX)
 - › ...
- › The Border Gateway Protocol (BGP) is used to inform the AS's *that agree to transfer each others traffic*, which other AS's can be reached through them.
- › Seems simple but in practice complex and: no authentication or encryption

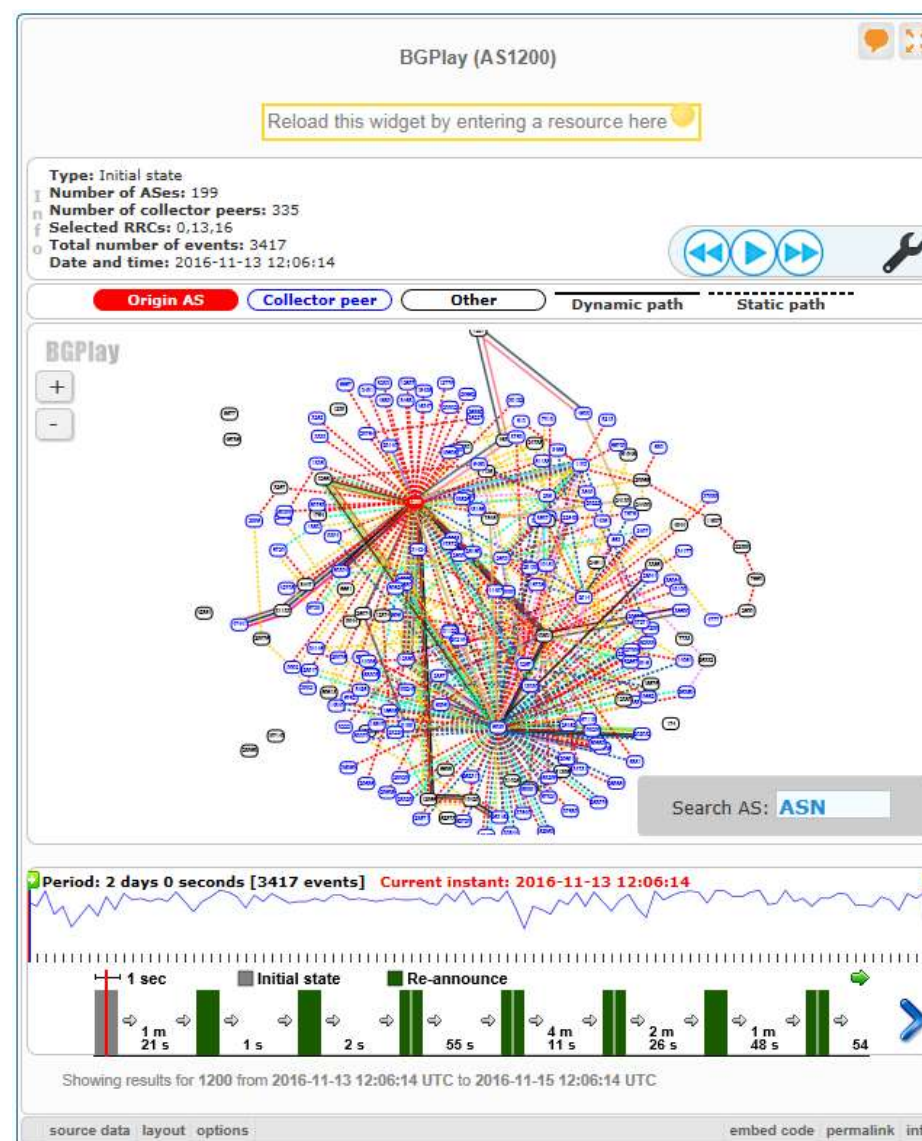


THE INTERNET AT AS LEVEL?

- › What information is there available to model actual networks?
- › RIPE!
- › AMS-IX connected to other AS's



RIPE NCC: Réseaux IP Européens
Located in Amsterdam



AVAILABLE DATA & ANALYSES TOOLS

- › RIPE NCC collects:
 - › information about the Internet on AS level in their RIPEStat database
 - › data from a large number of “Anchors” and “Probes” in their RIPE Atlas

Locations of 22 Remote Route Collectors: collecting BGP information from Route Beacons

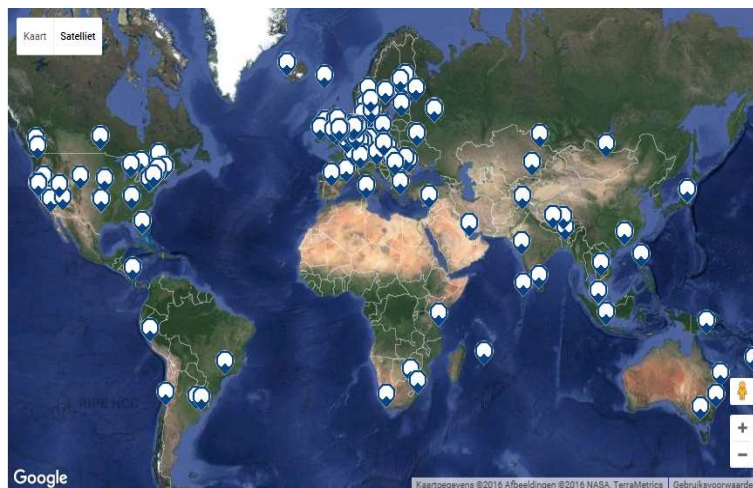


RIPE NCC: Réseaux IP Européens Network Coordination Centre

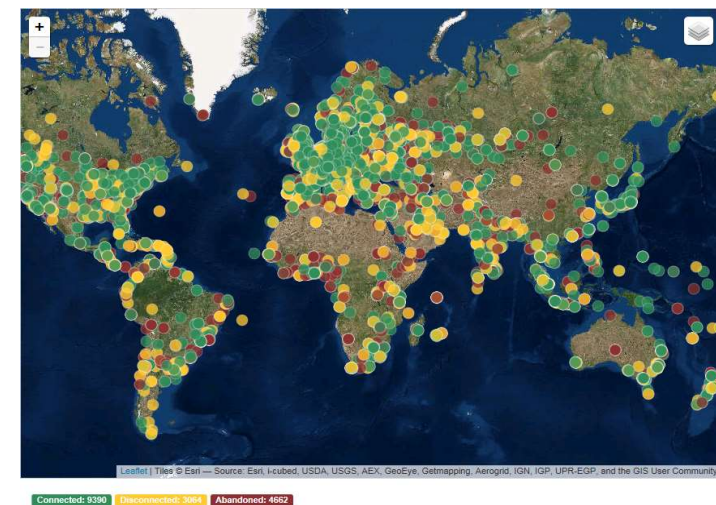
AVAILABLE DATA & ANALYSES TOOLS



- › RIPE Atlas:
 - › Statistical information on the performance of the Internet
 - › Probes: actively measure connectivity through ping, traceroute, DNS, SSL/TLS, NTP and HTTP
 - › Anchors: enhanced probes with more measurement capacity:
Constantly probed & regional targets for user-defined measurements
 - › Volunteers that host probes earn credits to perform own measurements...



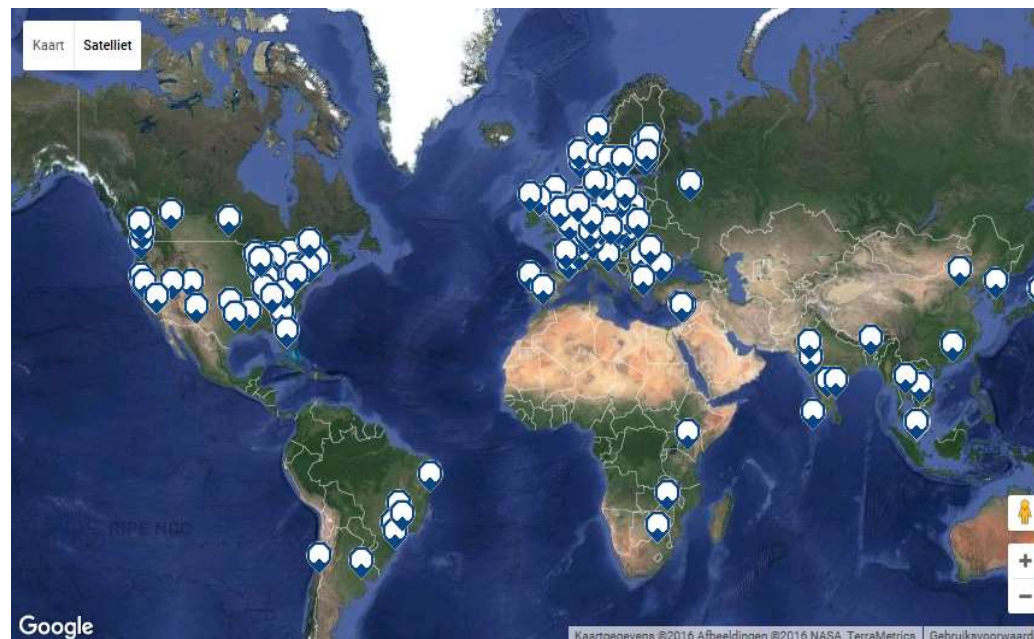
226 RIPE Atlas Anchors



9390 Active Probes (green)

AVAILABLE DATA & ANALYSES TOOLS

- › RIPE Atlas also:
 - › users can select NLNOG Ring nodes as destinations for their measurements when setting up new, periodic user defined measurements or one-off measurements



RIPE Atlas NLNOG RING nodes



AVAILABLE DATA & ANALYSES TOOLS

- › BGP Looking Glass Servers:
 - › acts as a limited, read-only portal to routers of whatever organization is running the Looking Glass server.
 - › Typically, publicly accessible LG servers are run by ISPs or NOCs
 - › <http://www.bgp4.as/looking-glasses> (info & software)
 - › LG widget on the RIPE site to query RCC's

Result of the RIPE BGP Looking Glass query for prefix 91.200.16.0/22



BGP Looking Glass (91.200.16.0/22)

Reload this widget by entering a resource here

⚙️ **Advanced Settings**

▼ 14 RRCs see 133 peers announcing 91.200.16.0/22 originated by AS1200. [EXPAND EVERYTHING]

- ▶ RRC11 in New York City, New York, US sees 1 ASN originating 91.200.16.0/22. (AS1200)
- ▶ RRC03 in Amsterdam, Netherlands sees 1 ASN originating 91.200.16.0/22. (AS1200)
- ▶ RRC13 in Moscow, Russian Federation sees 1 ASN originating 91.200.16.0/22. (AS1200)
- ▶ RRC01 in London, United Kingdom sees 1 ASN originating 91.200.16.0/22. (AS1200)
- ▼ RRC06 in Tokyo, Japan sees 1 ASN originating 91.200.16.0/22. (AS1200)
 - ▼ AS1200 is seen as the origin by 2 peers.
 - ▶ 202.249.2.169 is announcing route AS2497 AS3257 AS1103 AS1200.
 - ▶ 202.249.2.185 is announcing route AS25152 AS2914 AS12859 AS1200.
- ▶ RRC07 in Stockholm, Sweden sees 1 ASN originating 91.200.16.0/22. (AS1200)
- ▶ RRC04 in Geneva, Switzerland sees 1 ASN originating 91.200.16.0/22. (AS1200)
- ▶ RRC05 in Vienna, Austria sees 1 ASN originating 91.200.16.0/22. (AS1200)
- ▶ RRC16 in Miami, Florida, US sees 1 ASN originating 91.200.16.0/22. (AS1200)
- ▶ RRC00 in Amsterdam, Netherlands sees 1 ASN originating 91.200.16.0/22. (AS1200)
- ▶ RRC10 in Milan, Italy sees 1 ASN originating 91.200.16.0/22. (AS1200)
- ▶ RRC12 in Frankfurt, Germany sees 1 ASN originating 91.200.16.0/22. (AS1200)
- ▶ RRC15 in Sao Paulo, Brazil sees 1 ASN originating 91.200.16.0/22. (AS1200)
- ▶ RRC14 in Palo Alto, California, US sees 1 ASN originating 91.200.16.0/22. (AS1200)

Showing results for 91.200.16.0/22 as of 2016-11-08 15:52:00 UTC

source data embed code permalink info

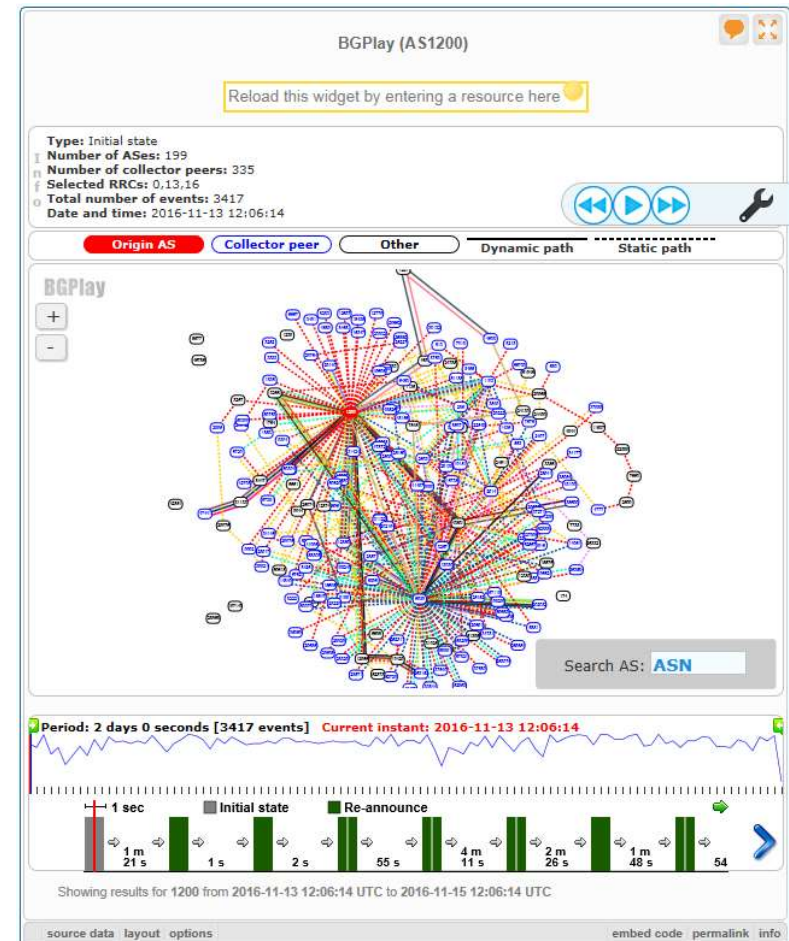
AVAILABLE DATA & ANALYSES TOOLS

- › GeoIP from MaxMind:
 - › Maps IP Address to Geographic locations

- › RIPE Widgets:
 - › Extract, filter and display Internet related information from RIPEStat database
 - › BGPlay: Visualize BGP topology & dynamics
 - › latencyMON: ping statics from probes
 - › Speedchecker: bandwidth measurements
 - › Observed Network Activity (M-Lab)
 - › <https://stat.ripe.net/widget/list>

<https://stat.ripe.net/widget/bgplay>

<https://atlas.ripe.net/measurements/#!tab-builtin>



BGP connectivity and activity for AS1200 (AMSIX, red node)

AVAILABLE DATA & ANALYSES TOOLS

Examples of use:

- › Analysis of the attack on the DNS service provider “Dyn”
 - › October 21 2016, a DDoS attack against Dyn’s DNS infrastructure caused issues for a list of well known services: Twitter, GitHub, Spotify, Netflix,...



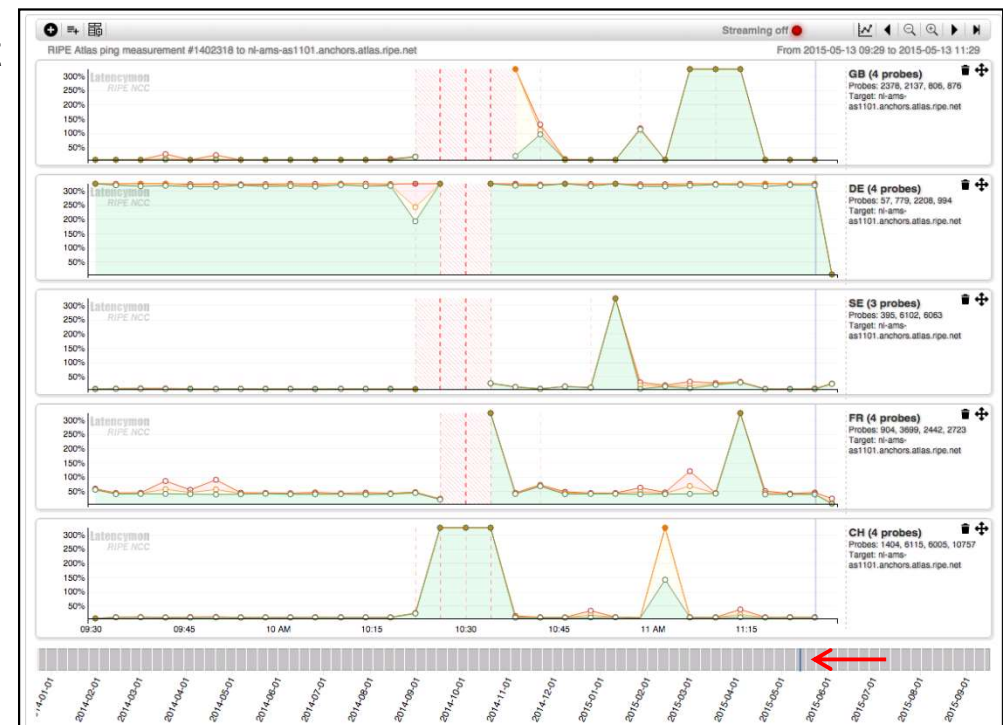
https://labs.ripe.net/Members/massimo_candela/a-quick-look-at-the-attack-on-dyn

- › May 13 2015, the Amsterdam Internet Exchange (AMS-IX) was involved in an outage that occurred during maintenance.



https://labs.ripe.net/Members/massimo_candela/new-ripe-atlas-tool-latencymon

latencyMON results: RTT & Packet loss for pings to an Anchor in AMS-IX from probes in GB, DE, SE, FR, CH



AVAILABLE DATA & ANALYSES TOOLS

- › CAIDA / Archipelago
- › Archipelago (Ark) is CAIDA's active measurement infrastructure

The traceroute data collected by Ark infrastructure is pre-processed to AS-topologies

The AS-topology data is collected by the ASStuary tool and displayed on a geographical map

Number of “AS-hops”



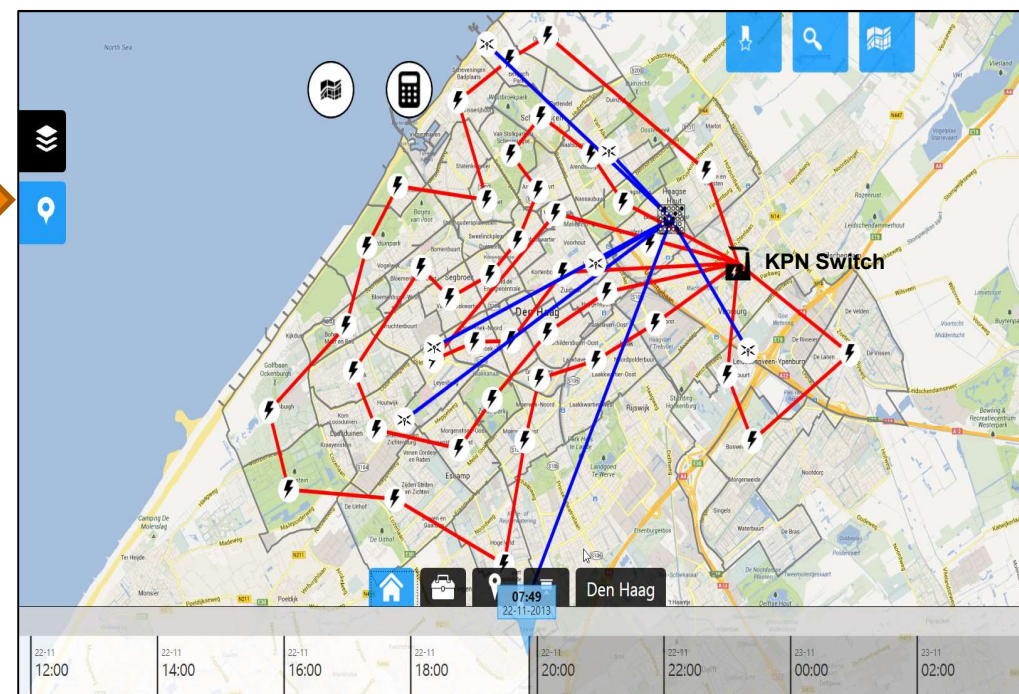
AVAILABLE DATA & ANALYSES TOOLS

- › TNO's csWeb: Web-based user friendly GIS application to perform spatial analysis
- › Import & combine up-to-date information on critical objects (hospitals, etc.), population etc.
- › Apply filters to data, and style it, see what's important: make Common Sense



Locations of C2000 base stations in The Hague

Electric Grid & C2000 chain effects



TNO'S ASTUARY TOOL

- › GUI based on TNO's csWeb → AStuary
- › Incorporates RIPE Widgets & "life" data from various source.

Easy access to:

- › BGPlay, latencyMON, TraceRoute
- › Other RIPE widgets
- › CAIDA AS-Topology
- › IXP, Members, ...
- › Sea cable data
- › Selects appropriate GeolP data

- › Estuary: where a river meets the sea.

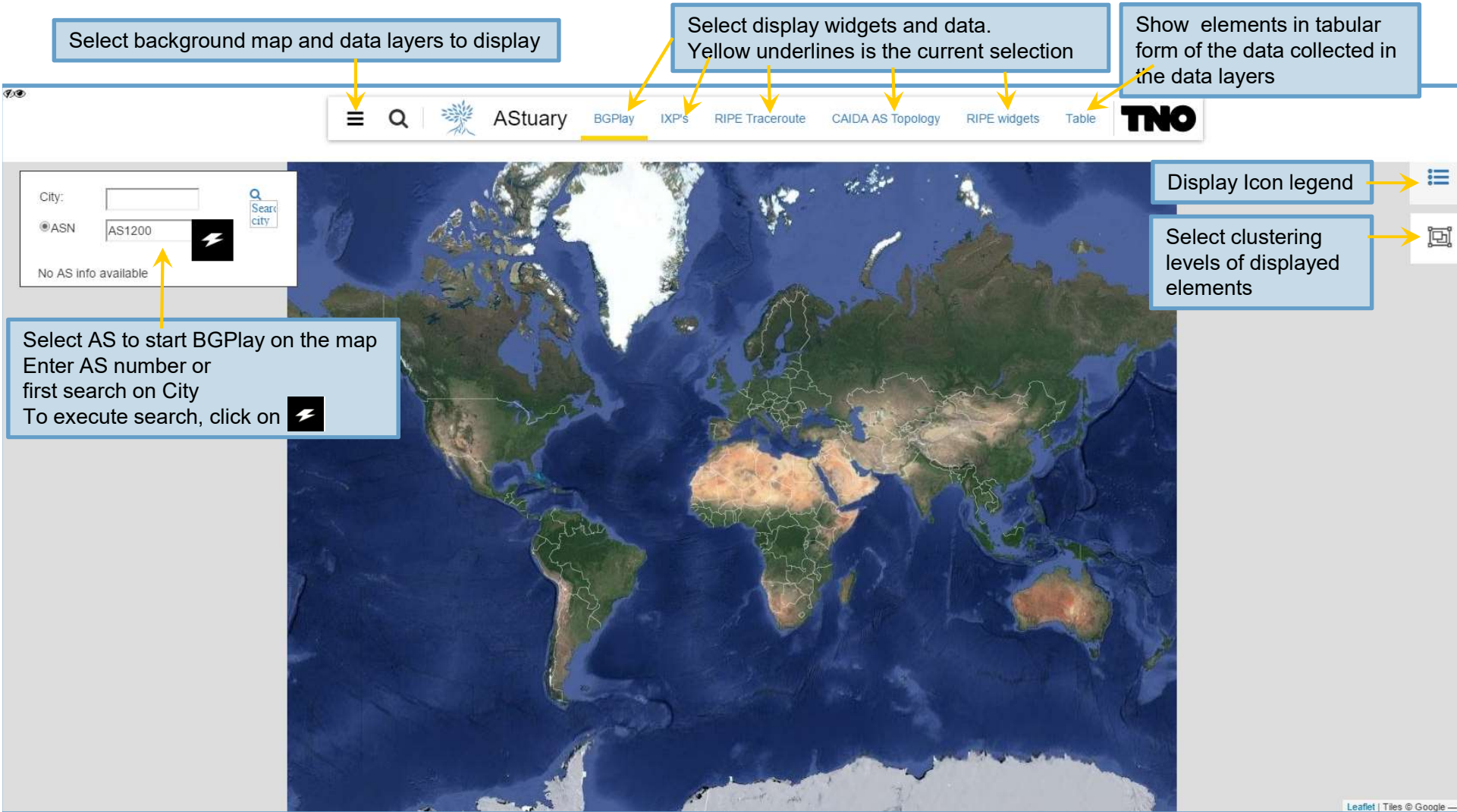
Either with rich ecosystems or heavily populated by humans



AStuary



SELECT, VISUALIZE, ANALYZE



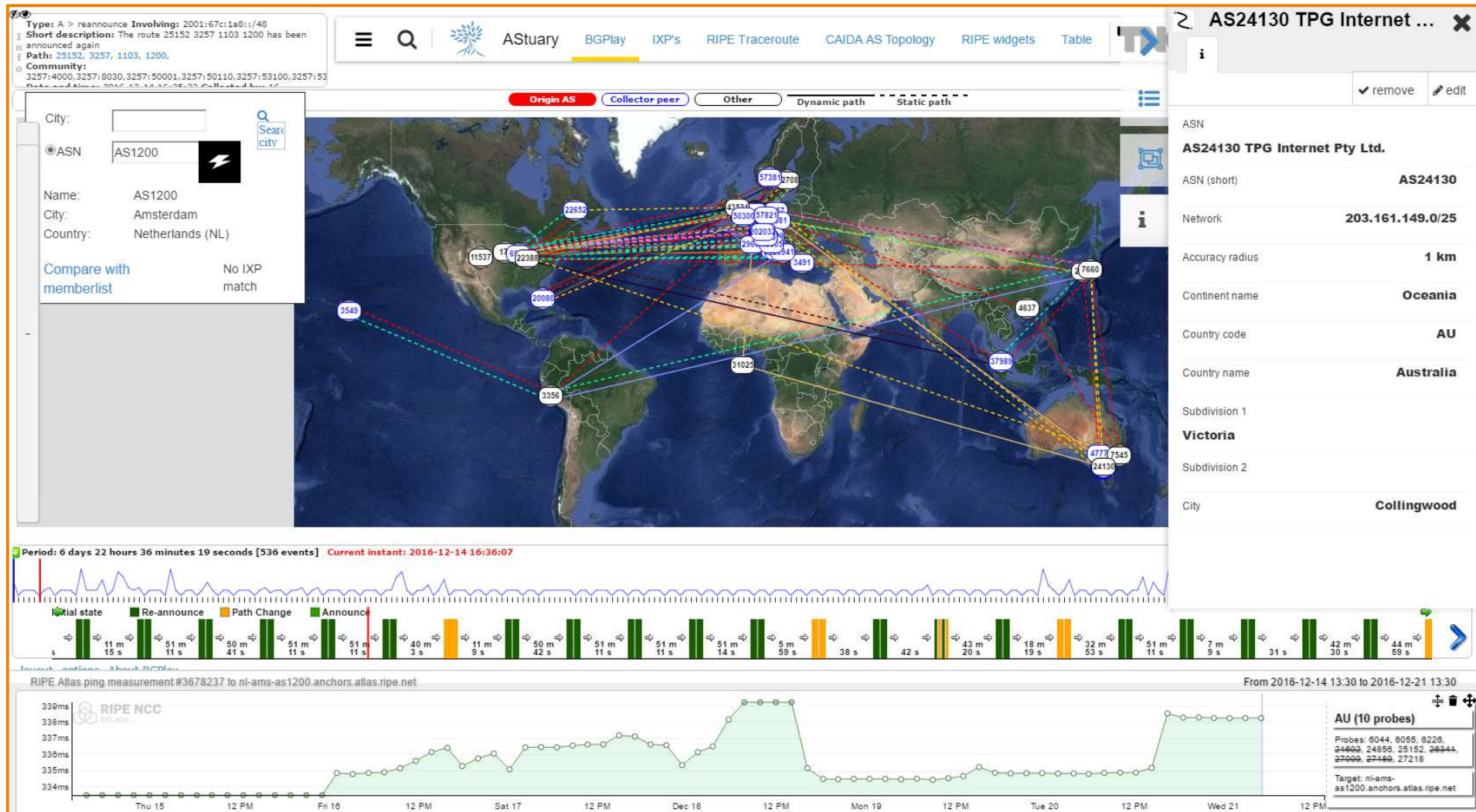
The screenshot shows the AStuary web interface. At the top, there is a navigation bar with the AStuary logo, a search icon, and several menu items: BGPlay, IXP's, RIPE Traceroute, CAIDA AS Topology, RIPE widgets, and Table. The 'BGPlay' item is highlighted with a yellow underline. To the right of the navigation bar is the TNO logo.

Callout boxes provide the following instructions:

- Select background map and data layers to display:** Points to the navigation bar.
- Select display widgets and data. Yellow underlines is the current selection:** Points to the 'BGPlay' menu item.
- Show elements in tabular form of the data collected in the data layers:** Points to the 'Table' menu item.
- Select AS to start BGPlay on the map:** Points to the 'AS1200' input field in the search panel.
- Enter AS number or first search on City:** Points to the 'City' input field in the search panel.
- To execute search, click on [lightning bolt icon]:** Points to the search button in the search panel.
- Display Icon legend:** Points to the legend icon in the top right corner.
- Select clustering levels of displayed elements:** Points to the clustering icon in the top right corner.

The main area of the screen is a world map showing network connections. The search panel on the left includes a 'City' input field, a 'Search city' button, a radio button for 'ASN', an 'AS1200' input field, and a search button with a lightning bolt icon. Below the search panel, it says 'No AS info available'.

At the bottom right of the map, there is a small text: 'Leaflet | Tiles © Google'.



➤ Average latency from AS1200 (AMSIX) to probes in AUS in msec.



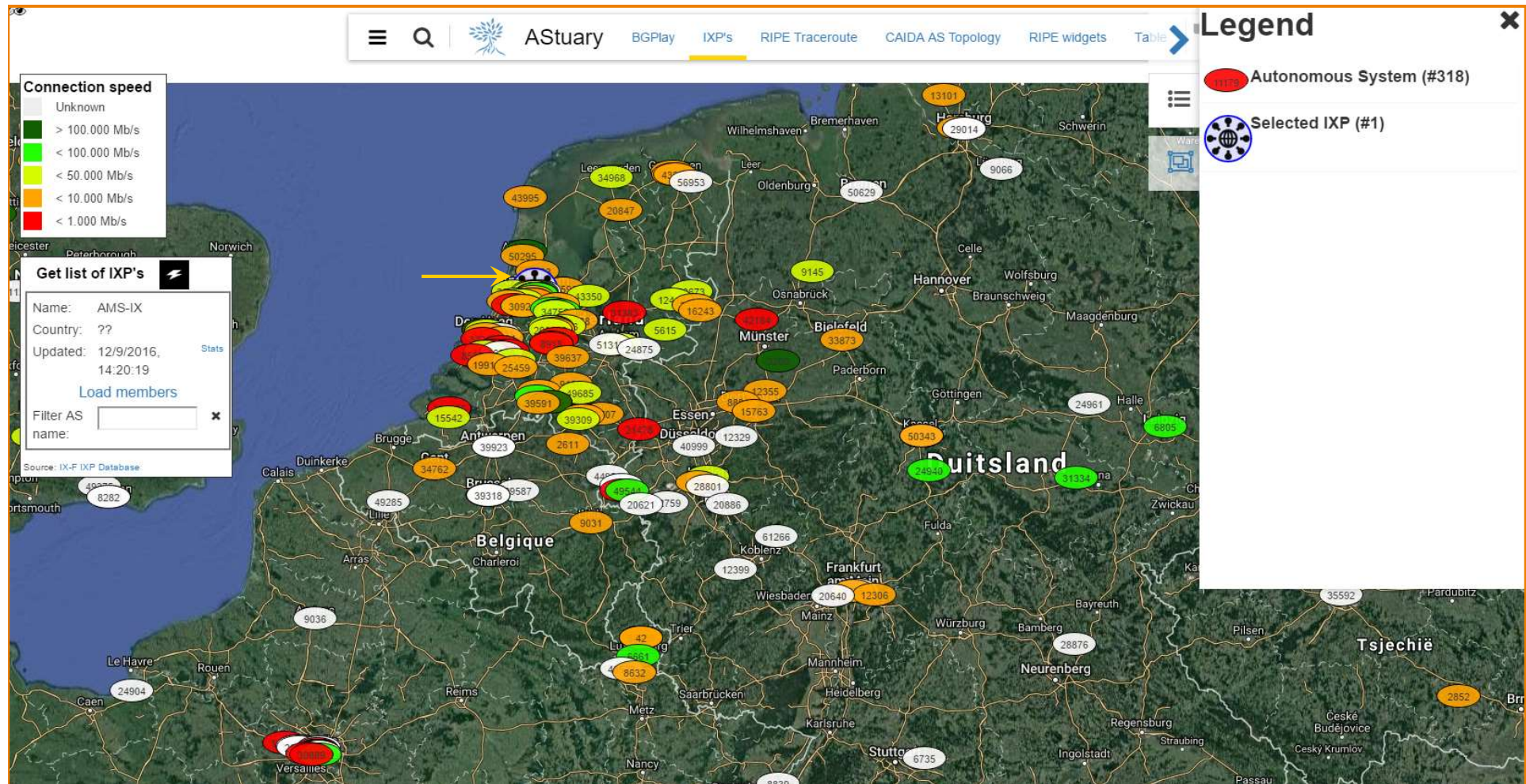
The screenshot displays the AStuary website interface. At the top, there is a navigation bar with the AStuary logo and menu items: BGPlay, IXP's (highlighted), RIPE Traceroute, CAIDA AS Topology, RIPE widgets, and Table. The main content area features a world map with various IXPs marked by colored circles and numbers. A sidebar on the left contains a 'Get list of IXP's' section with a search box and a 'Filter AS name:' input field. The right sidebar shows a detailed view for the 'Reykjavik Internet Exchange' (RIX), including its name, short name, URL, creation date, country code, and public status. A small line graph under the 'Stats' section shows traffic volume in Gbit/s over a 24-hour period.

› All IXP's known to the IX-F on a world map

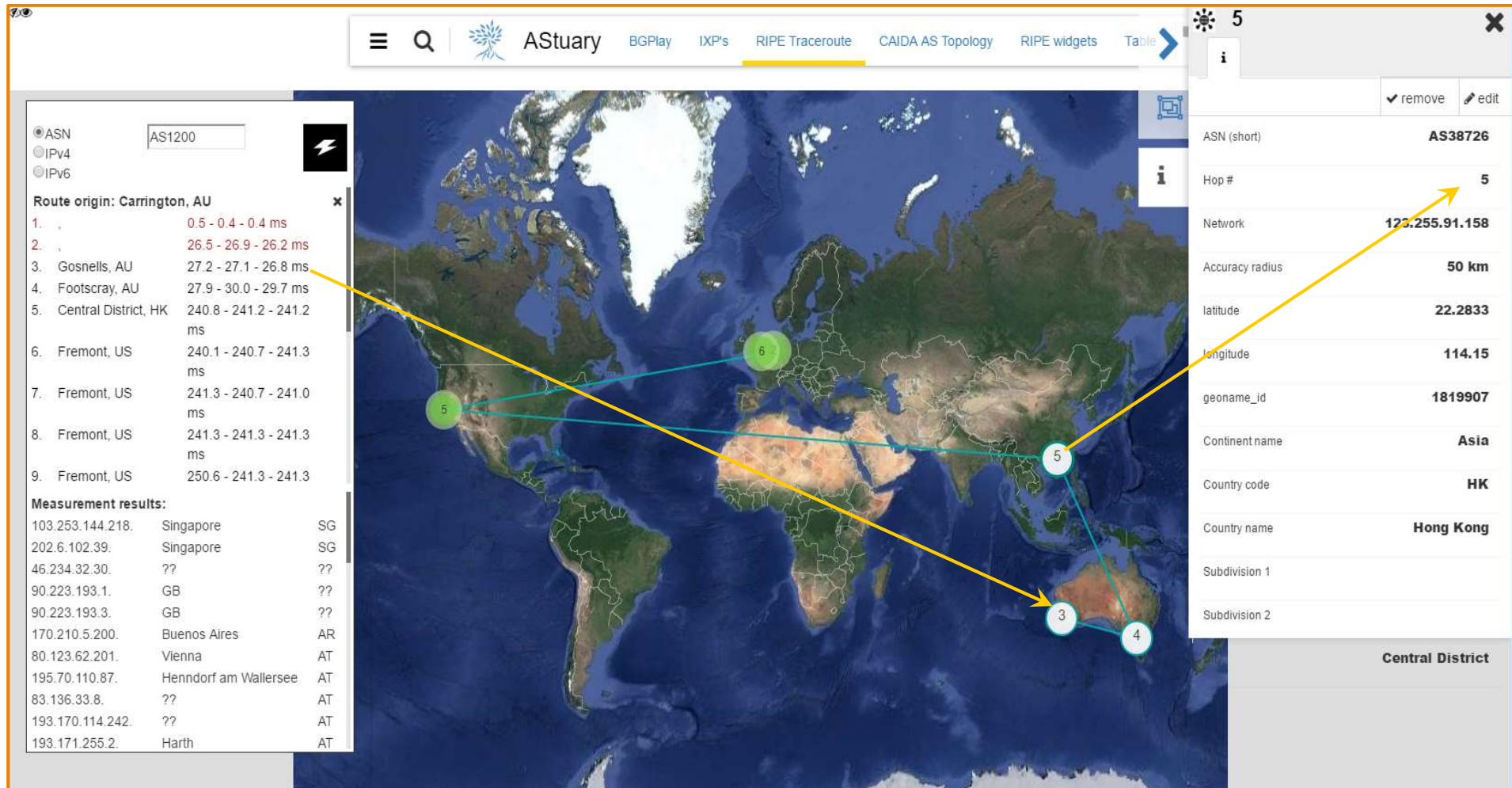


Astuary IXP MEMBERS

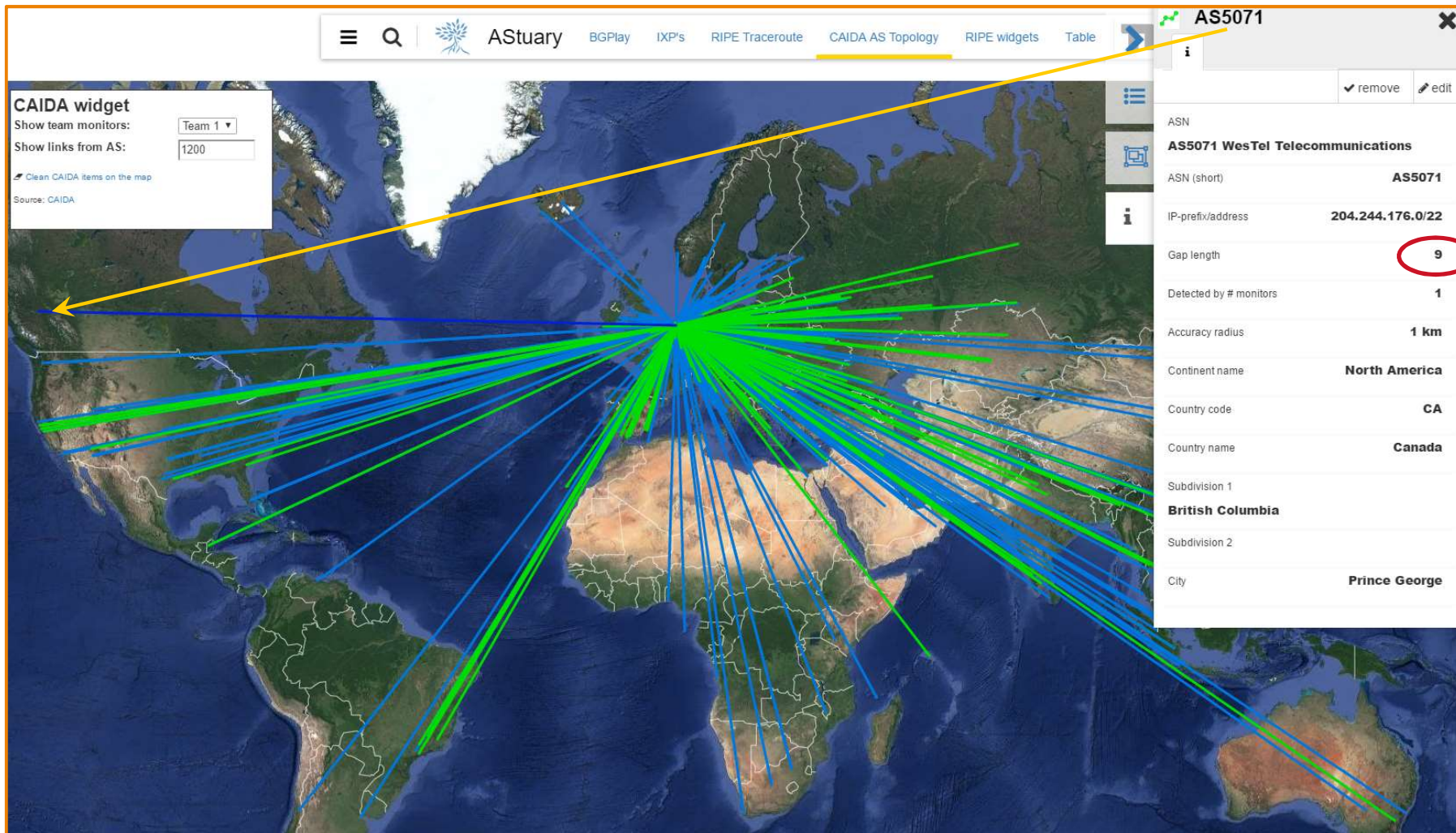
bert.boltjes@tno.nl



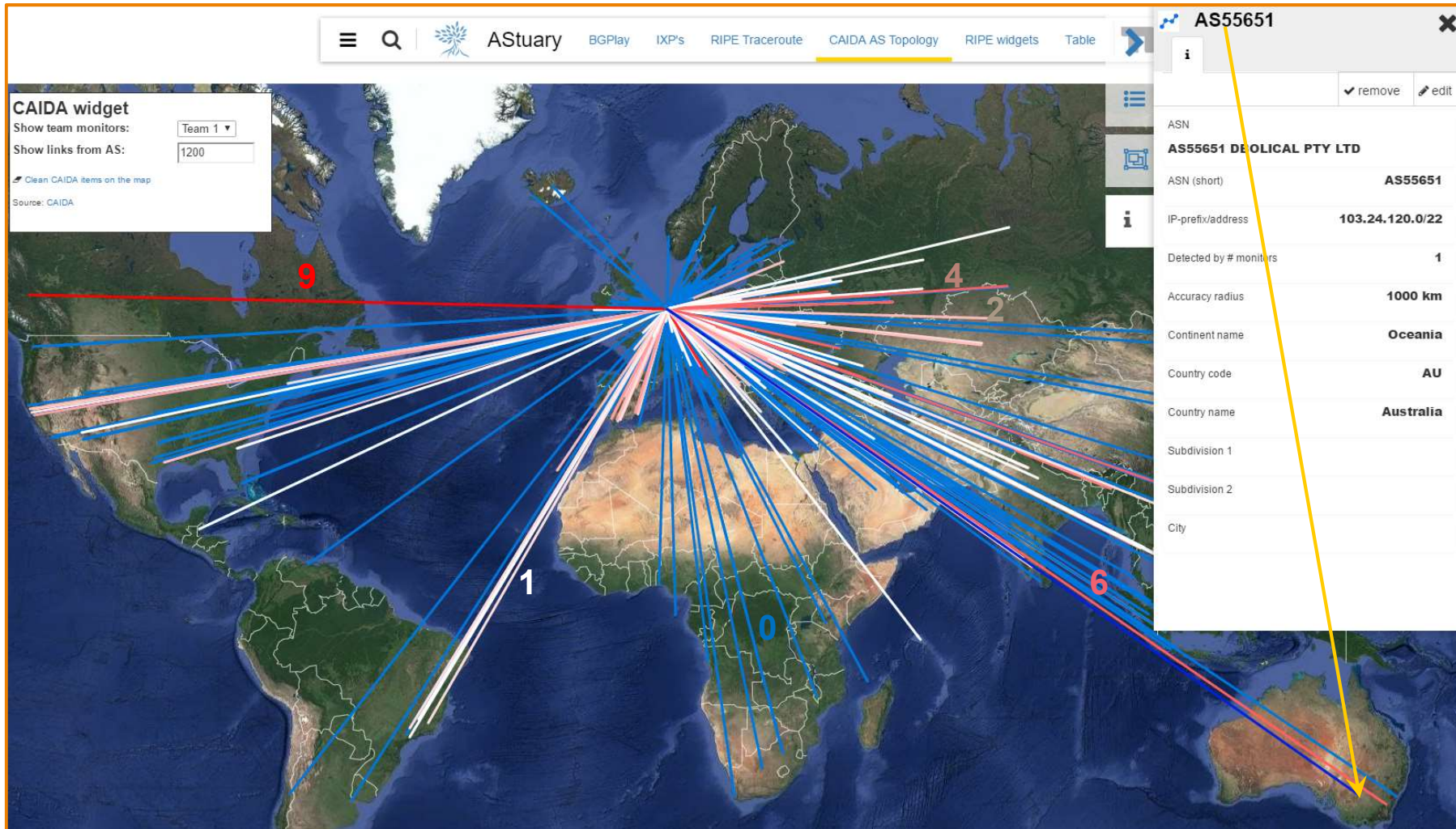
› AMS-IX (nearly hidden round-white icon with 3 black spots) and its 318 members



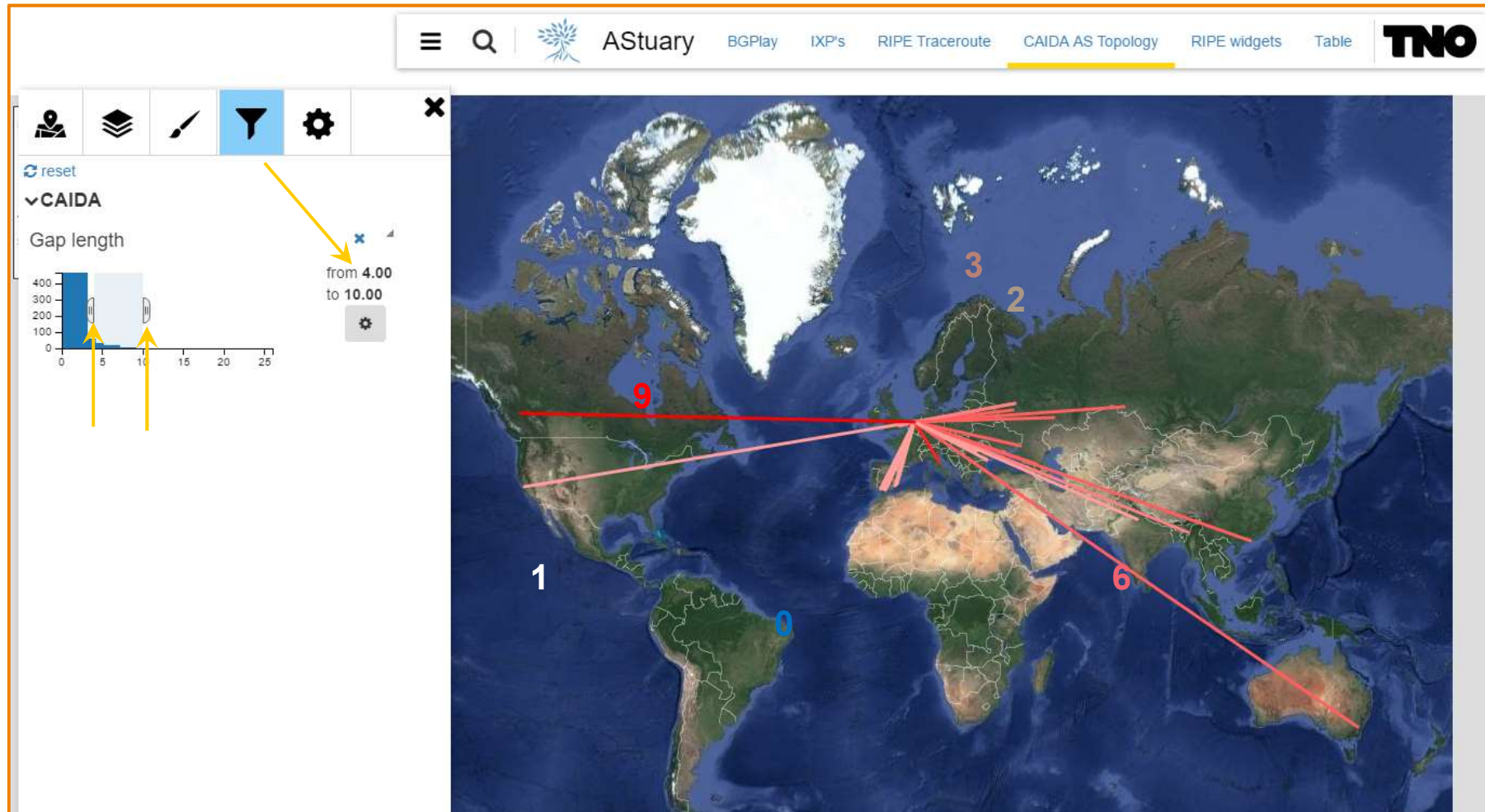
- › Traceroute measurement from RIPE probe near Carrington (AUS) to the AMSIX
- › Carrington is near Sydney...



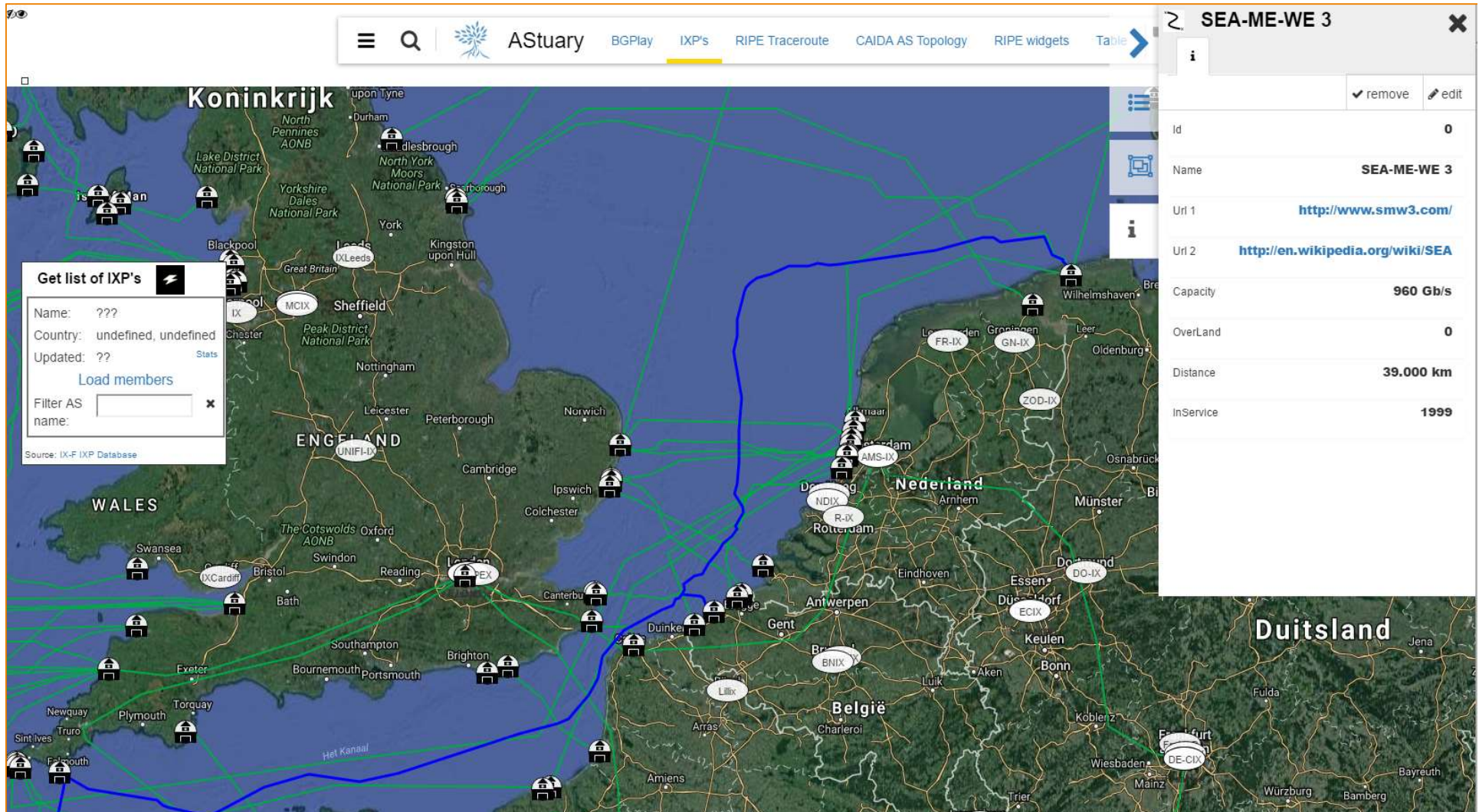
- › AS-topology:
 - › Direct links (no intermediate AS): light blue.
 - › Indirect links (1 or more intermediate AS-es): green
- Number of AS-hops



› AS-topology: up to 9 intermediate AS-es (red link)

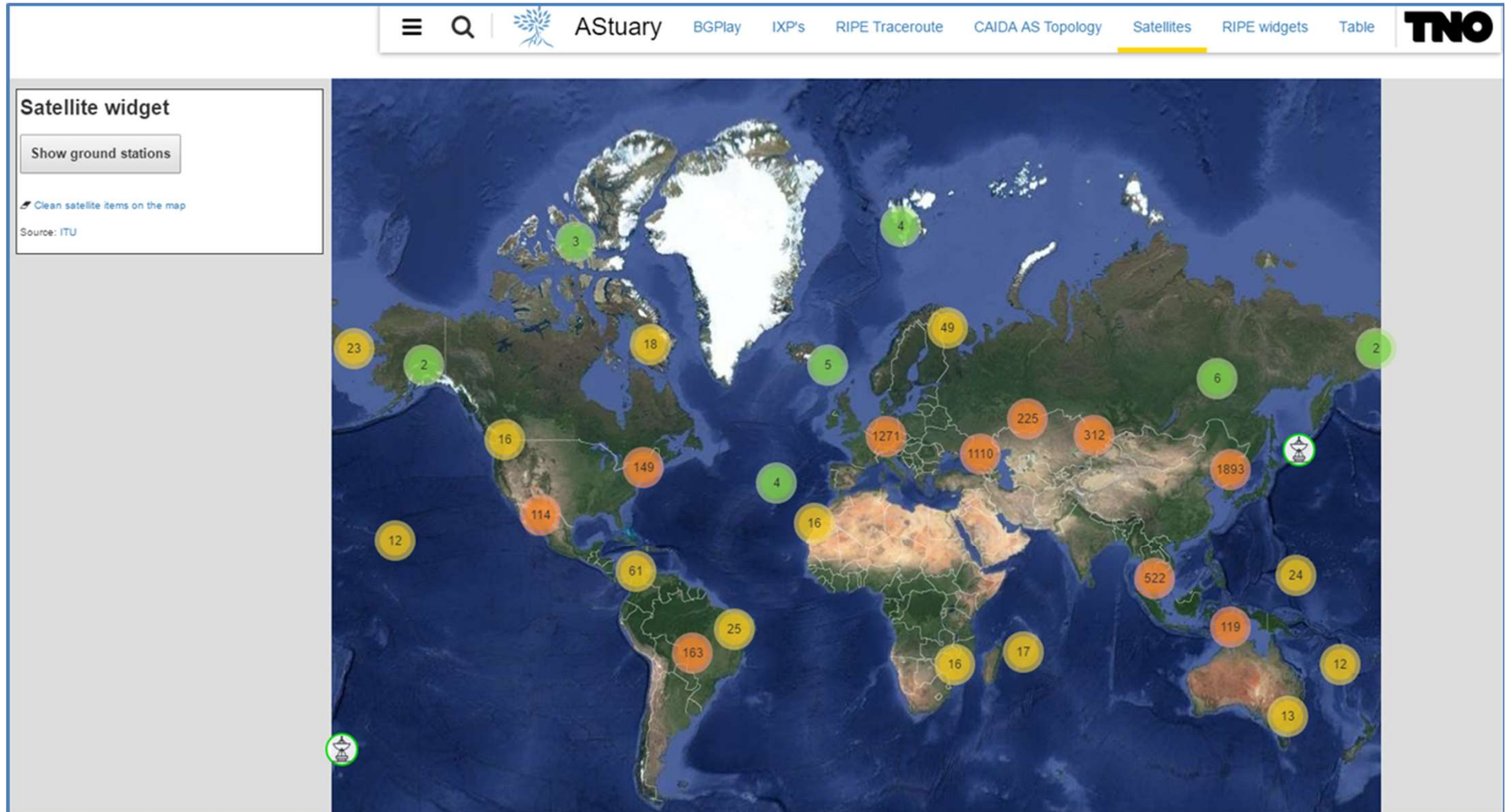


- › AS-topology: filtering using the value of gap length attributes of links



› Click on a cable shows details on its owner, URL, data capacity etc.

› Including physical infrastructures...



› 6434 satellite ground stations that communicate with geostationary satellites (ITU_



The screenshot shows the Astuary website interface. At the top, there is a navigation bar with the Astuary logo and various menu items: BGPlay, IXP's, RIPE Traceroute, CAIDA AS Topology, Satellites (highlighted), and RIPE widgets. Below the navigation bar is a map of a rural area with several satellite ground station icons. A 'Satellite widget' is visible on the left side of the map, containing a 'Show ground stations' button and a 'Clean satellite items on the map' option. On the right side, a detailed information panel for station 'HOL-RNA-BRM-001' is displayed. The panel includes a 'remove' button and an 'edit' icon. The station details are as follows:

Station name	HOL-RNA-BRM-001
Satellite name	EUTELSAT 2-7E
POSITION	7
ADM	HOL
BR IFIC/WIC	2510
CATEGORY	N
LONGITUDE	6.2
LATITUDE	53.283

› Click on an icon reveals its name, satellite, Tx & Rx Frequencies etc. [view](#)



The screenshot shows the Astuary website interface. The top navigation bar includes links for BGPlay, IXP's, RIPE Traceroute, CAIDA AS Topology, Satellites (highlighted), and RIPE widgets. The main content area displays an aerial satellite image of a ground station facility in a desert environment. A blue circular icon with a satellite symbol is overlaid on the image. To the right, an information panel for the station 'LIBYA' is open, showing the following details:

Station name	LIBYA
Satellite name	ARABSAT 1-B
POSITION	26
ADM	LBY
CATEGORY	N
LONGITUDE	13.235
LATITUDE	32.343

› South of Tripoli: the single listed ground station in Libya...

MORE DATA:

- › Information on physical landlines are difficult to find.
- › Data Centres: information available at cost (<http://www.datacentermap.com/>)

› ...

Currently there are **4109** colocation data centers from **119** countries in the index.





AS Locations ▾

- Select all
- Name
- ASN
- ASN (short)
- Network
- Accuracy radius
- Continent name
- Country code
- Country name
- Subdivision 1
- Subdivision 2
- City
- URL
- E-mail
- Peering policy
- Connection list
- Connection speed
- From
- Lat
- Lon

▾

geoJSON

CSV

Filter

Name	ASN	ASN (short)	Connection speed	Network	City	E-mail
Aryaka Networks, Inc.	AS11179 Aryaka Networks, Inc.	AS11179	1.000 Mb/s	185.114.76.0/22		ops@aryaka.com
Affiliis Ltd.	AS12041 Affiliis Canada, Corp.	AS12041	10.000 Mb/s	89.188.32.0/19		pvlaar@affiliis.info
Cable & Wireless Netherlands BV	AS1273 CW Vodafone Ltd	AS1273	20.000 Mb/s	90.244.196.0/22	Yeovil	
Carrier 51 uG	AS12732 Carrier51 GmbH, GutCon GmbH	AS12732		193.34.120.0/22		alf@all.de
BIT BV	AS12859 BIT BV	AS12859	10.000 Mb/s	212.114.104.0/22	Amsterdam	peering@bit.nl
AusRegistry	AS134390 AusRegistry Anycast system	AS134390	1.000 Mb/s	91.237.174.0/23		wolfgang.nagele@ausregistry.com.au
Adobe Systems	AS15224 Adobe Systems Inc.	AS15224	10.000 Mb/s	185.34.188.0/22		peering@adobe.com
CAIW Diensten B.V.	AS15435 KABELFOON CAIW Autonomous System	AS15435	40.000 Mb/s	83.128.208.0/24	Aalsmeer	peering@caiw.nl
BusinessConnect BV	AS15693 BUSINESSCONNECT	AS15693		195.191.120.0/23		peering@as15693.net

« < 1 2 3 4 5 6 7 8 ... 83 > »

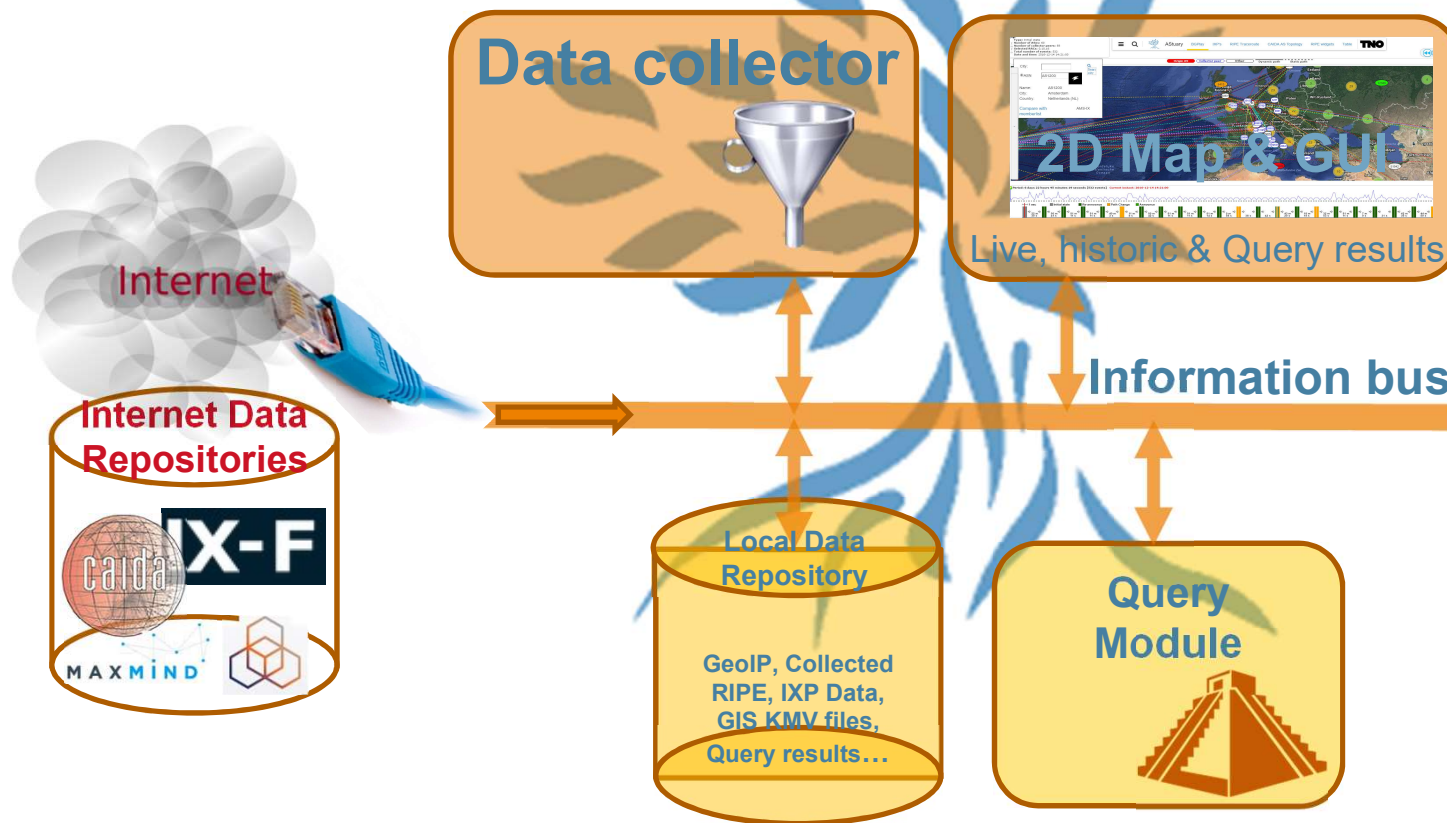
› Only the checked items are exported

TNO'S COMMON SENSE BGP TOOL



WHAT-IF SCENARIO ANALYSIS

AStuary



Current idea on the TNO AS-level consequence prediction environment

› **THANK YOU FOR YOUR ATTENTION**

TNO innovation
for life

RESERVE SLIDES

DISCUSSION

