



ROOT BEER

Routing Operations Observational Technology: Building to Enable Education and Research.

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UC San Diego

Cybersecurity Innovation for
Cyberinfrastructure: Transition to
Cyberinfrastructure Resilience

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Why R&E Routing Needs an Observatory

R&E networks (campus, regional and U.S. backbone (Internet2) — prefer R&E routes over commodity routes to preserve specialized capacity for science.

Optimal for collaboration; brittle for security. The same policies that accelerate scientific workflows amplify the global blast radius of a single misconfiguration!

What we are defending against

Accidental or malicious routing configurations that can disrupt or misdirect data flows. Internet2 described 3 such incidents in 2024.



Commodity → R&E

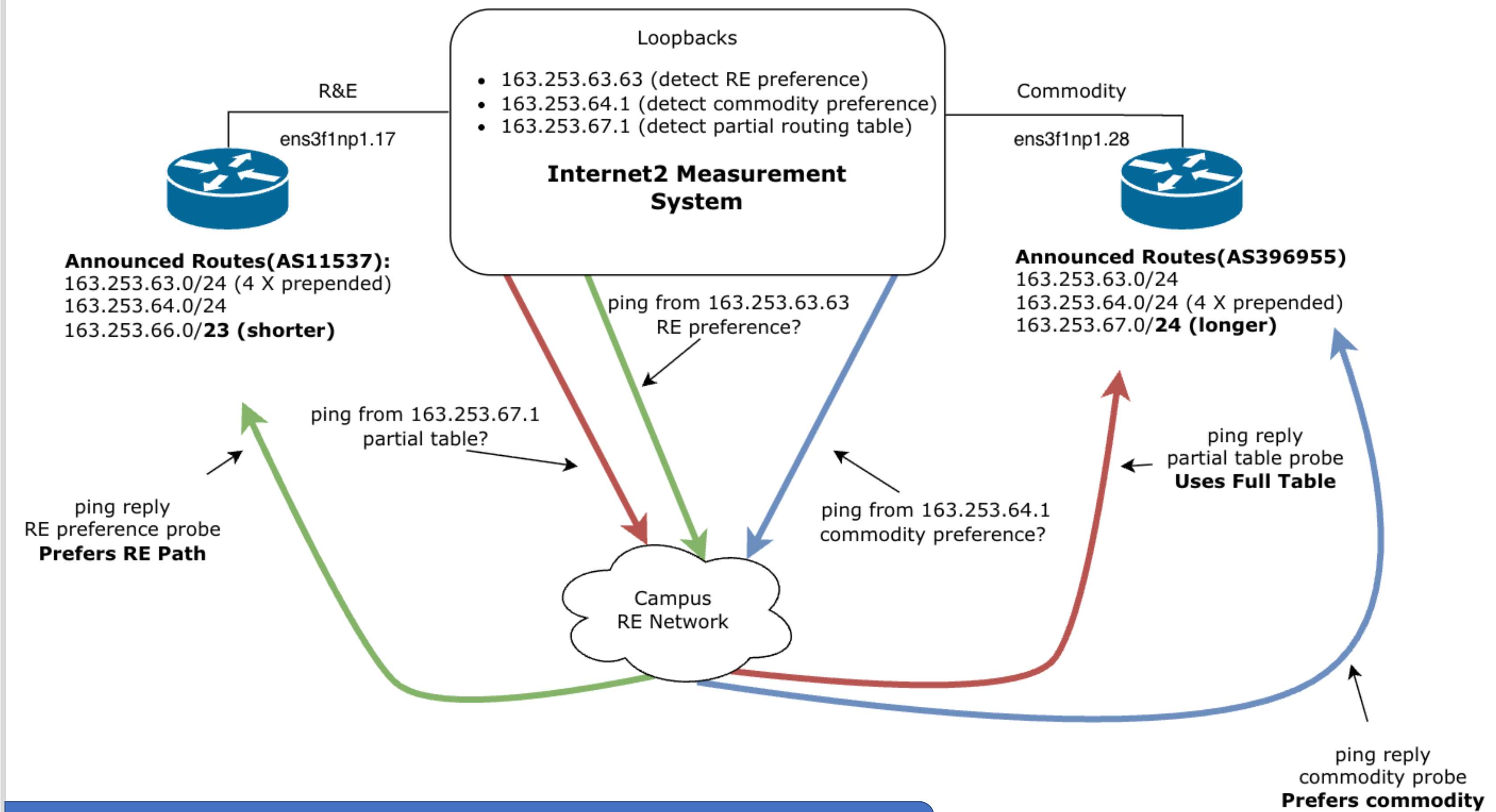
Commercial routes leak *into* R&E, inducing delays / outages.

R&E → Commodity

R&E routes leak *out* to commercial nets e.g. return traffic from cloud

- Task 1 Measure & analyze** Detect leaks across the R&E / commodity boundary.
- Task 2 Operationalize** Dashboard inside Internet2's Insight Console.
- Task 3 Engage & evaluate** Workshops, Tech Exchange, impact metrics.

Measuring a Remote RE Network's Routing Policy



The interface on which response arrives identifies whether responder's AS selected R&E or commodity route — turning every responsive host (~2,700 R&E ASes) into a routing-policy vantage point

4 Nov 2024 single-day snapshot of global R&E footprint

18,953

R&E PREFIXES PROBED

2,659

ORIGIN R&E ASes

97.7%

ASes WITH ≥ 1 RESPONSIVE VP

81.3%

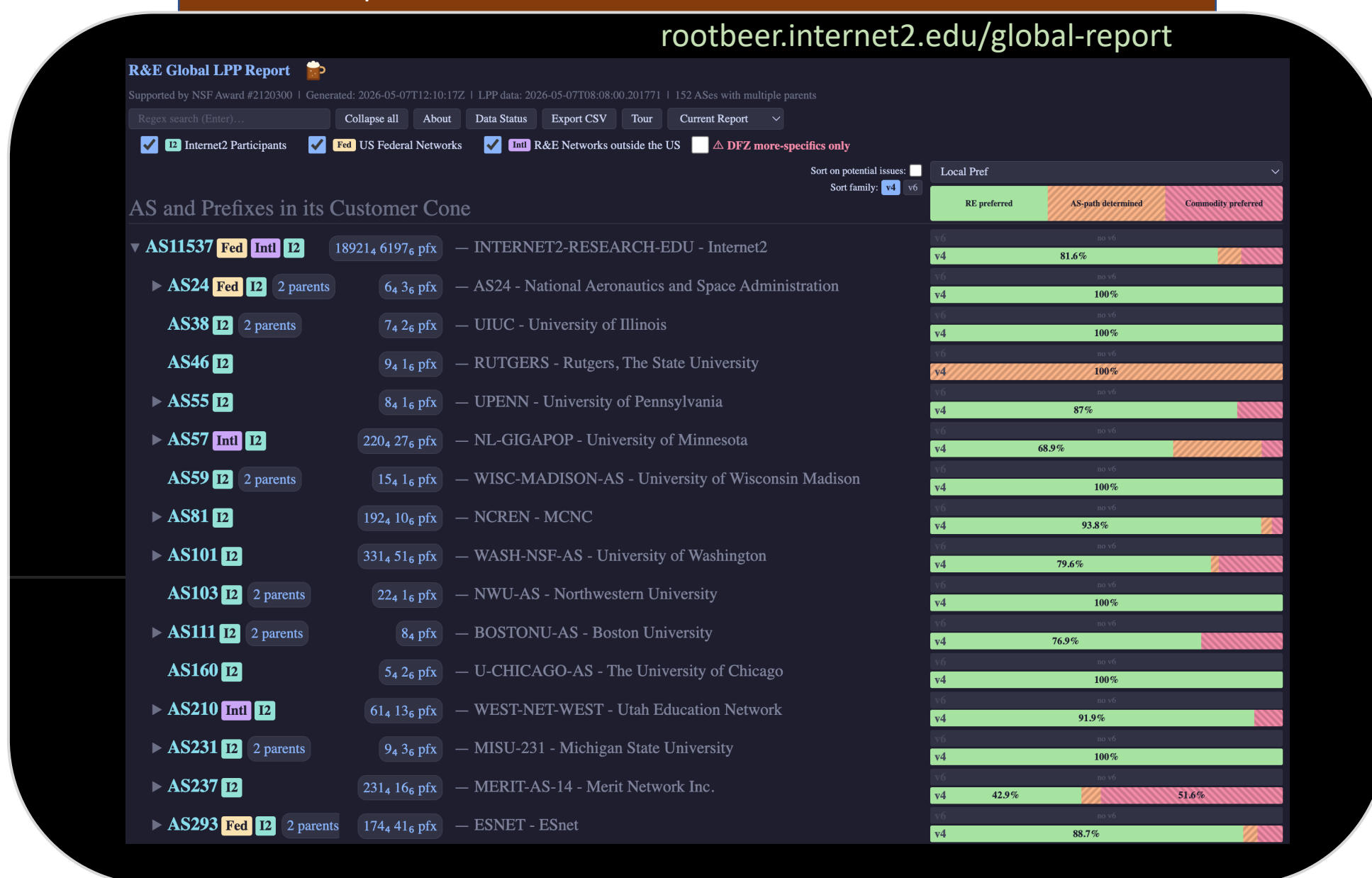
PREFIXES ALWAYS PREFERRING R&E SO ~1/5 PREFIXES LIKELY HAVE PROBLEM

Tools live at rootbeer.internet2.edu

D6: Global R&E LPP Report

The view of Internet2's local preference for its different AS's address space.

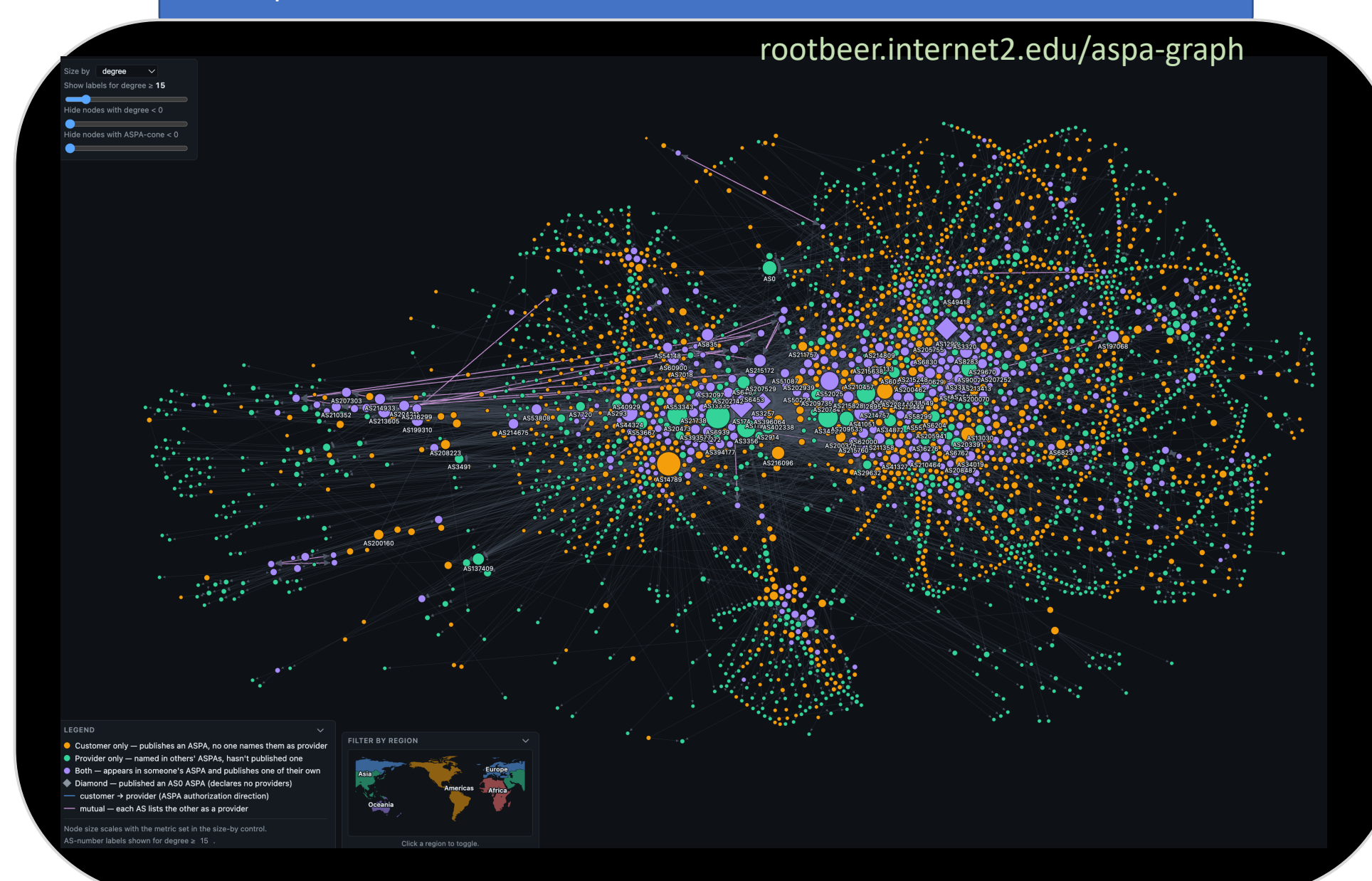
rootbeer.internet2.edu/global-report



D7: Global ASPA Coverage Visualization

A view of the global ASPA topology, with ASPA-rank and search capabilities.

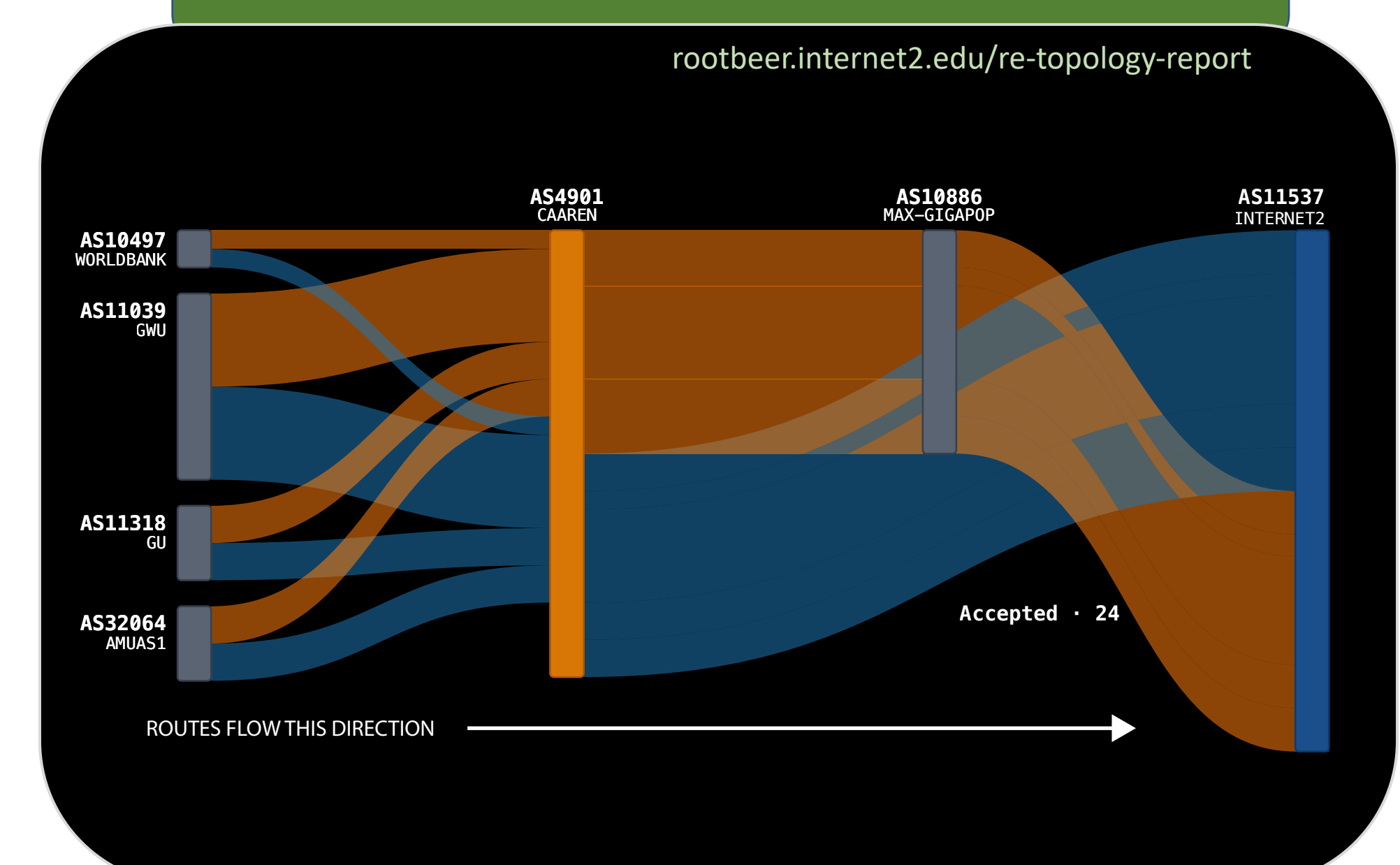
rootbeer.internet2.edu/aspa-graph



D10: Global R&E AS-Topology Observatory

All the inbound routes visible at Internet2 that were announced by CAAREN.

rootbeer.internet2.edu/re-topology-report



D1: RPKI-ROA Planner

DEPLOYED

Plans and validates RPKI Route Origin Authorizations across operator prefix inventories. Reconciles ARIN WHOIS, RouteViews history, RIPE-IRR route objects and CAIDA AS-name data

D2: RPKI-ROA Visualizer

DEPLOYED

Educational and operational tool that visualizes Route Origin Validation (ROV) coverage across an operator's footprint — supports campus training and rapid pre-deployment review.

D3: BGP Local-Preference Probe

DEPLOYED

On-demand active probe that determines whether a network prefers R&E paths (Internet2) over commodity paths for a queried prefix — using the dual-VRF technique (§03).

D4: IRR AS-SET Planner

TESTING

Generates a candidate IRR as-set object reflecting an ASN's R&E customer cone. Compares against existing RADB membership lists and exports a ready-to-register template.

D5: RPKI-ASPA Planner

BETA

Recommends RFC 9582 AS Provider Authorizations for an ASN, derived from observed BGP paths plus CAIDA AS-relationships, with explicit warnings about backup-provider visibility limits.

D6: Global R&E LPP Report

DEPLOYED

Daily routing-policy report covering ~2,700 R&E ASes — hierarchical customer-cone roll-ups, DFZ more-specific detection, RPKI-ROA & ASPA coverage, per-AS prefix drill-down.

D7: Global ASPA Coverage Visualization

DEPLOYED

Interactive d3 force graph of every published ASPA on the Internet, cross-validated against CAIDA's inferred AS-relationships — surfaces where ASPA disagrees with peer/customer/provider inference.

D8: Global R&E BGP Route Report

WIP · 4-6 MO

Expanded global R&E visibility — conceptually parallel to Internet2's existing BGP Route Report but spanning the global R&E topology, with per-prefix integrity attributes (RPKI / IRR / community tags).

D9: Global R&E Prefix-List Mgmt

WIP · ~12 MO

System to maintain, operationalize, and publish a curated global R&E prefix list — the foundation for Internet2's new International R&E peering policy and a prerequisite for safe filtering.

D10: Global R&E AS-Topology Observatory

WIP · ~12 MO

Interactive AS-level explorer including non-best (back-up) paths, fed by participating NRENs via iBGP+ADD-PATH peering — augmenting Internet2's view of the global research network.