Critical Infrastructure, Software Engineering, & Complexity

From Dagstuhl

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Critical Information Infrastructure

What the Heck is Critical Internet Infrastructure Anyway?

Framing from ENISA

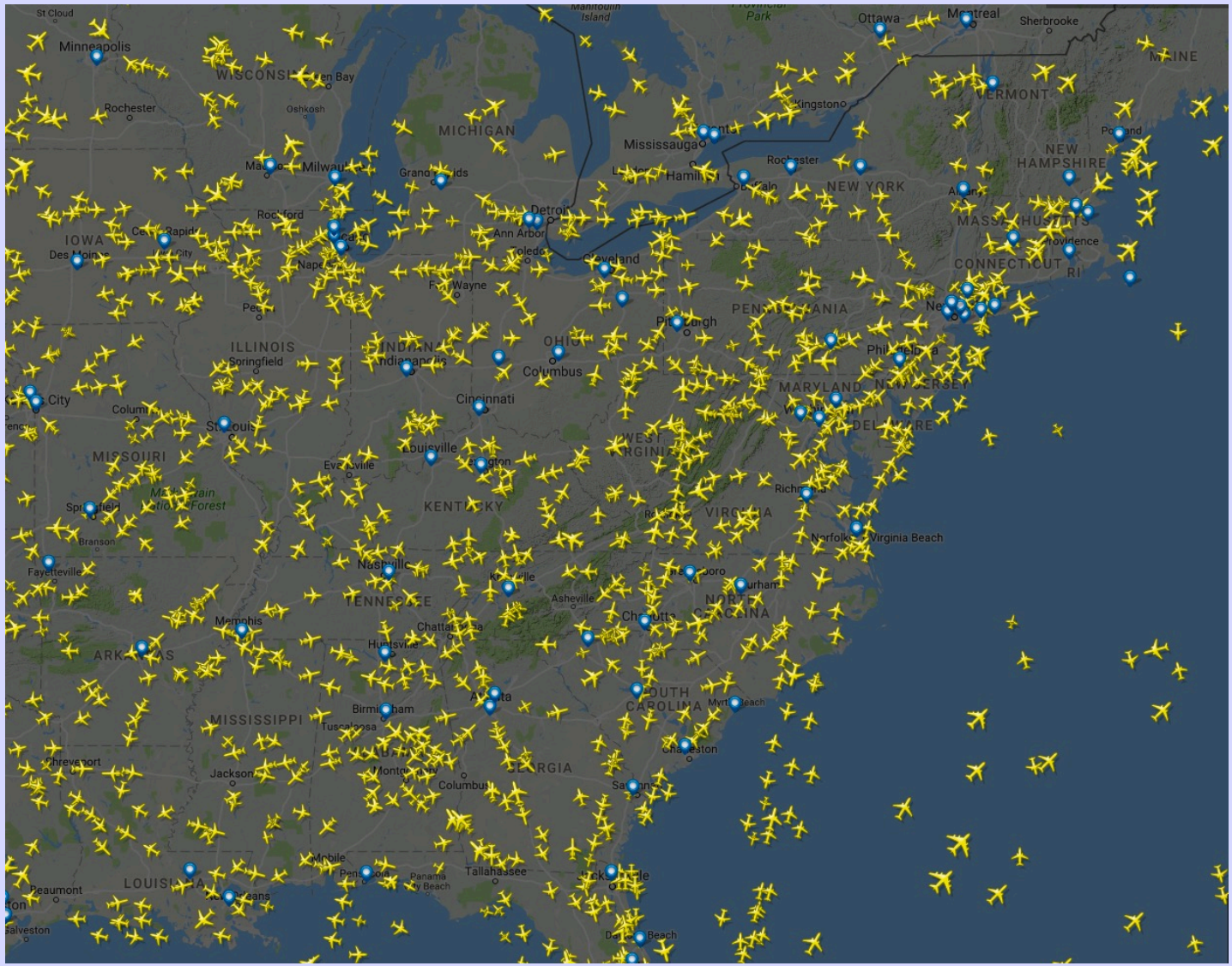
- **Critical Infrastructure**: an asset, system or part thereof located in Member States that is essential for the maintenance of vital societal functions, health, safety, security, economic or social well-being of people, and the disruption or destruction of which would have a significant impact on a Member State as a result of the failure to maintain those functions.
- **Critical Information Infrastructure**: Information infrastructure (like networks, hardware, software, etc.) that is critical to the functioning of a nation or country, like IT that supports health- or energy-sectors.

Why Systems Fail

- Vulnerabilities vs Operational Gaps

- If it was part of the "plan" it's an event, if it is not then it's a "disaster"

Normal US East Coast



A Poorly Tested Patch to the US Air Control

Flypocalypse

Just a Quick Patch

Device and System Vulnerabilities

- Protection of routers and switches from direct attack are common practice, but less commonly practiced than it should be
- Where is fiber? The PoPs? DataCenters?
- Wireless devices and infrastructure have some unique vulnerabilities.
- Human error and weak operational practice are major issues

Why Systems Fail

- Most security holes are due to buggy software.
  - As of 1998, 85% of CERT advisories described problems not fixable with cryptography.
  - About half of all new holes are due to buffer overflows.
- "Patch and pray" is no way to run an Internet.
- Patches are often hard to install, and can cause their own problems (and holes).
  - *No* responsible administrator of a production machine will install *any* patch without extensive testing.

Defense Strategies

- We're not going to get rid of buggy code.
  - We've been trying for far too long to have any realistic hope of success now.
- We can't do much about lack of cyber diversity – the "network effect" is too strong.
- We can try to reduce central points of failure.
- We must learn how to compose secure components, and how to build secure distributed systems out of insecure pieces.

Major Control Systems

Non-linear interactions of these can produce seriously disastrous results

- Routing
- MPLS Control Plane: LDP and RSVP
- DNS
- RPKI (and NTP)
- CDNs shifting traffic
- Peer to Peer Traffic Engineering
- Automated Traffic Engineerng
- Reactive Configuraton of Network
- OpenFlow
- TCP Congestion Mechanisms
- Interaction with Human Behavior (e.g. redialing)

Fat Finger Friday

The first Friday of each month, we take out one control system

- We will learn how to take it out, i.e. Vulnerability Analysis
- Minimal interventions to cause maximal affect
- We will pre-announce, so the world will think about defenses
- We can measure and analyse

Resilience Mechanisms

- Metric: correlation in spikes in help desk calls
  - AMAZON: rate of sales drop
  - Airlines – almost accidents investigated
- Airlines investigate all non-critical events
  - Maybe partial causes
  - Correlated events are perhaps the problem – interactions
    - Investigate subcritical because want to avoid the correlated cases
- What other systems should we look at
  - Power?
  - Old telcos?

Resilience Mechanisms Can Be Our Enemy

- Resilience mechanisms are designed with particular failure modes in mind. When circumstances fall outside those boundaries, their [re]actions can interact with control systems in unanticipated ways.

- E.g. SONET restoration under Layer Three healing under CDN traffic shifting.

Data Applicability

- Ambiguity
- Accuracy = Resolution, Precision, and Validity
- Inconsistency
- Missing Data and Bias
- Missing Meta-Data
- Issues of duration of measurement and shifts in what one is measuring.
- Issues with resolution of results over sample size/rate.
- Issues of representation of sample set, e.g. Route Views sees the 'clue core'.
- Be sure to understand how the data were collected

Software Engineering

- Formal Methods would be useful
- In devices
- In protocols
- Software Engineering is rare in the hardware vendor culture
- It is starting to be exercised in the OS and Applications Vendors

Complexity - the Enemy of Analysis, Reliability, Repairability, Scalability

Everything, Unless You are Paid by the Hour

But Where is CII?

- Let's assume that public agencies such as ENISA can easily identify Critical Infrastructure
- How do they figure out how it connects to the Internet so they can identify Critical Internet Infrastructure?
- And how do they discover inter-ISP connectivity?

Topology is Hard

- Maybe Critical Infrastructure does not want to disclose connectivity as it may make them more vulnerable
- Providers view interconnection as NDA
- Research into Internet topology is primitive and error prone
- Public data are weak despite braggadocio

"10 Lessons from 10 Years of Measuring and Modeling the Internet's Autonomous Systems"

Matthew Roughan, Walter Willinger, Olaf Maennel, Debbie Perouli, and Randy Bush

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And Then What?

- Are we going to regulate how Critical Infrastructure connects to the Internet?
- Are we going to regulate how Internet providers inter-connect?
- Are we going to regulate a provider's infrastructure?