SCHWEITZER ENGINEERING LABORATORIES

Our Cyber Security History and Future

Trustworthy Cyber Infrastructure for the Power Grid

April 3, 2015

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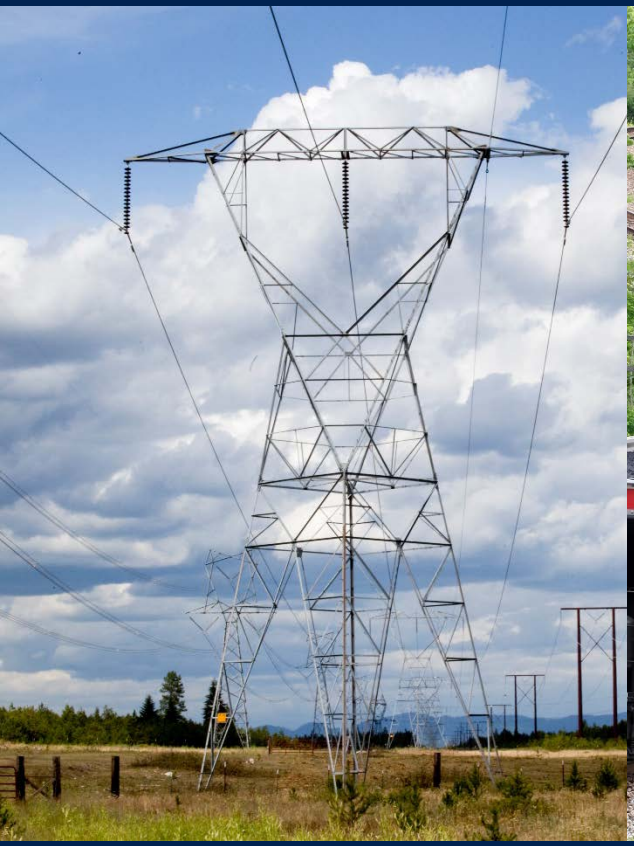
President, Schweitzer Engineering Laboratories, Inc.

Delivering Energy at the Speed of Light

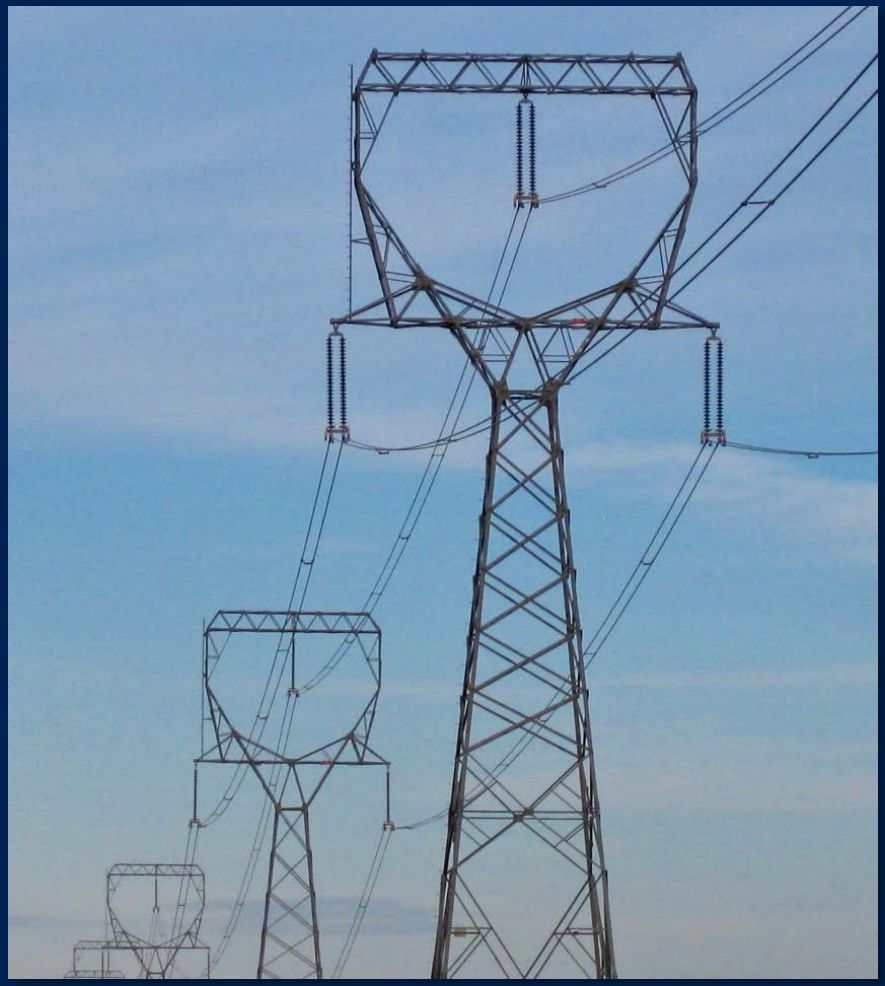


186,000 mi / sec

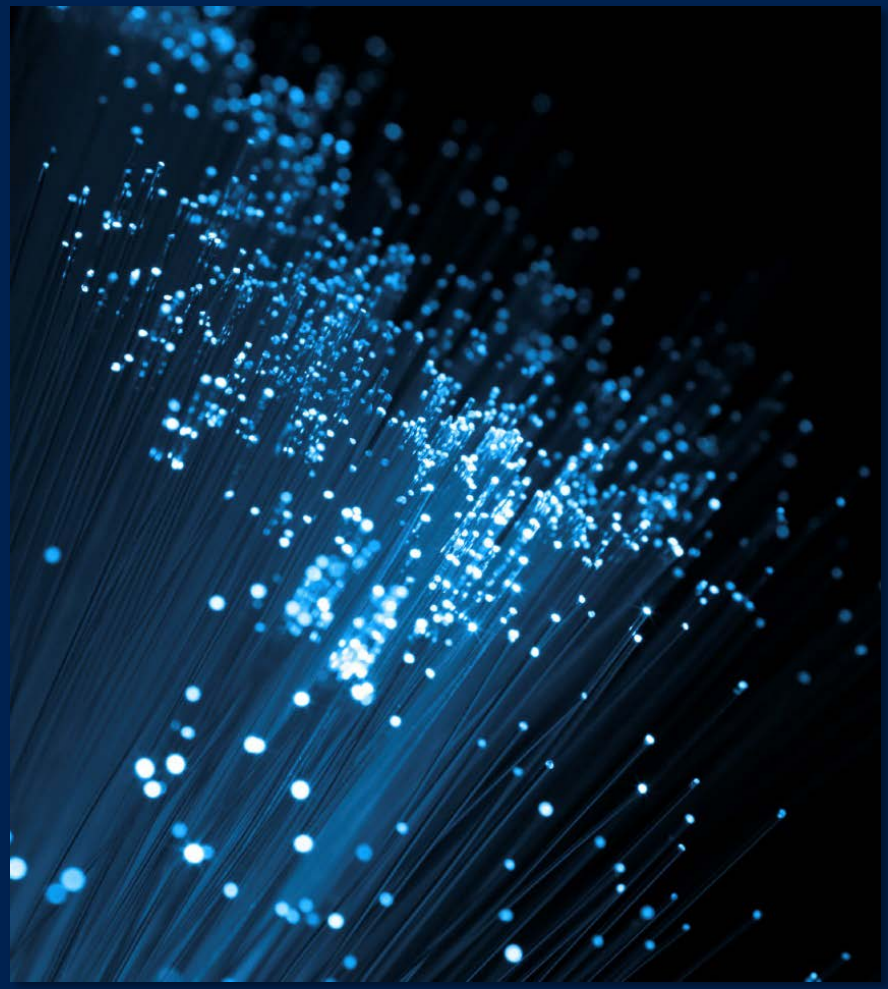
50 mi / hr

30 mi / hr

Faster Than Information in Fiber



300,000 km / sec



200,000 km / sec

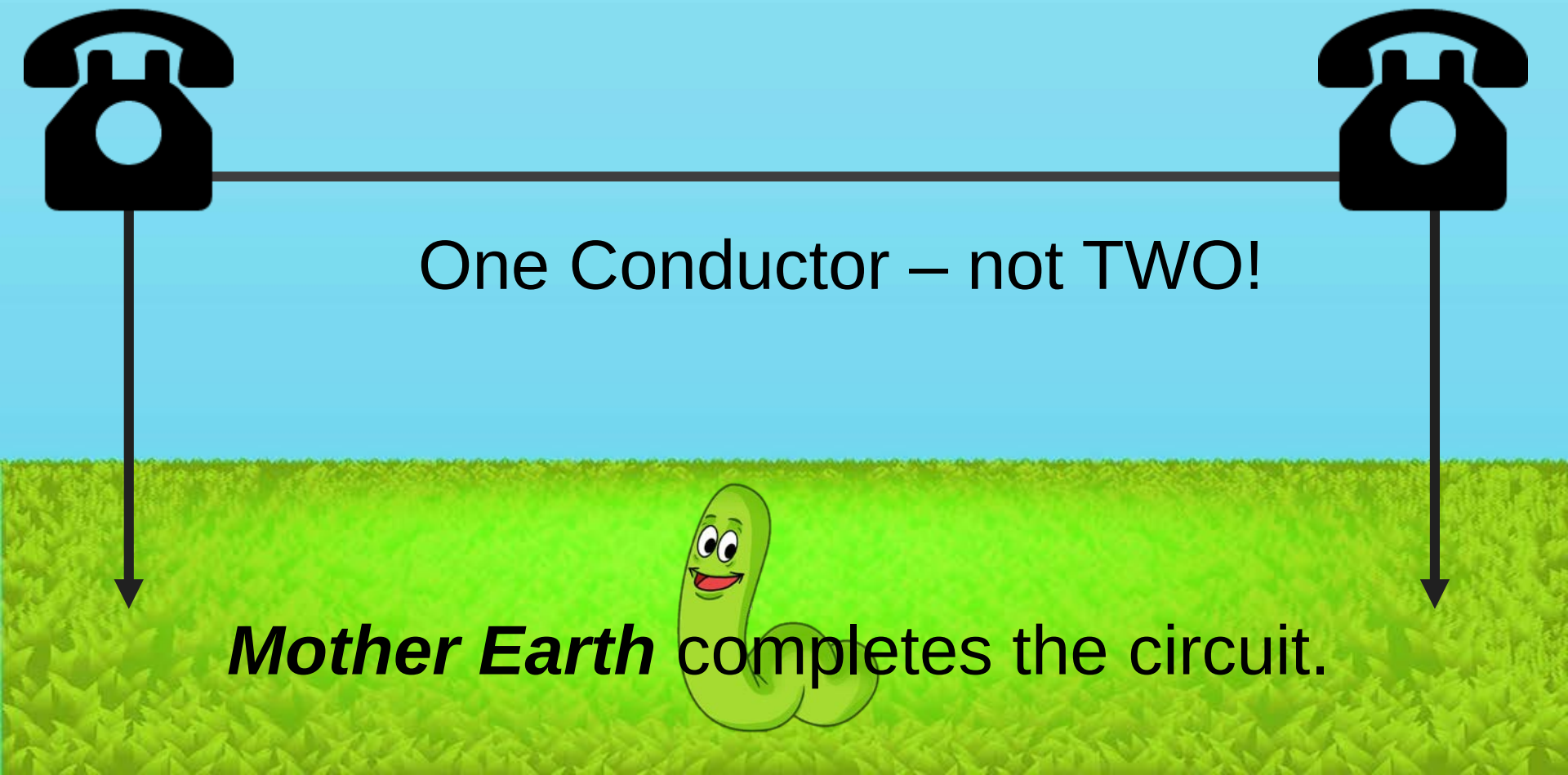
Staying Safe in the Information Age

- What can we learn from history?
- What makes the power system work?
- How can technology contribute?
- Avoiding the weaknesses.
- *Benefiting from the strengths.*

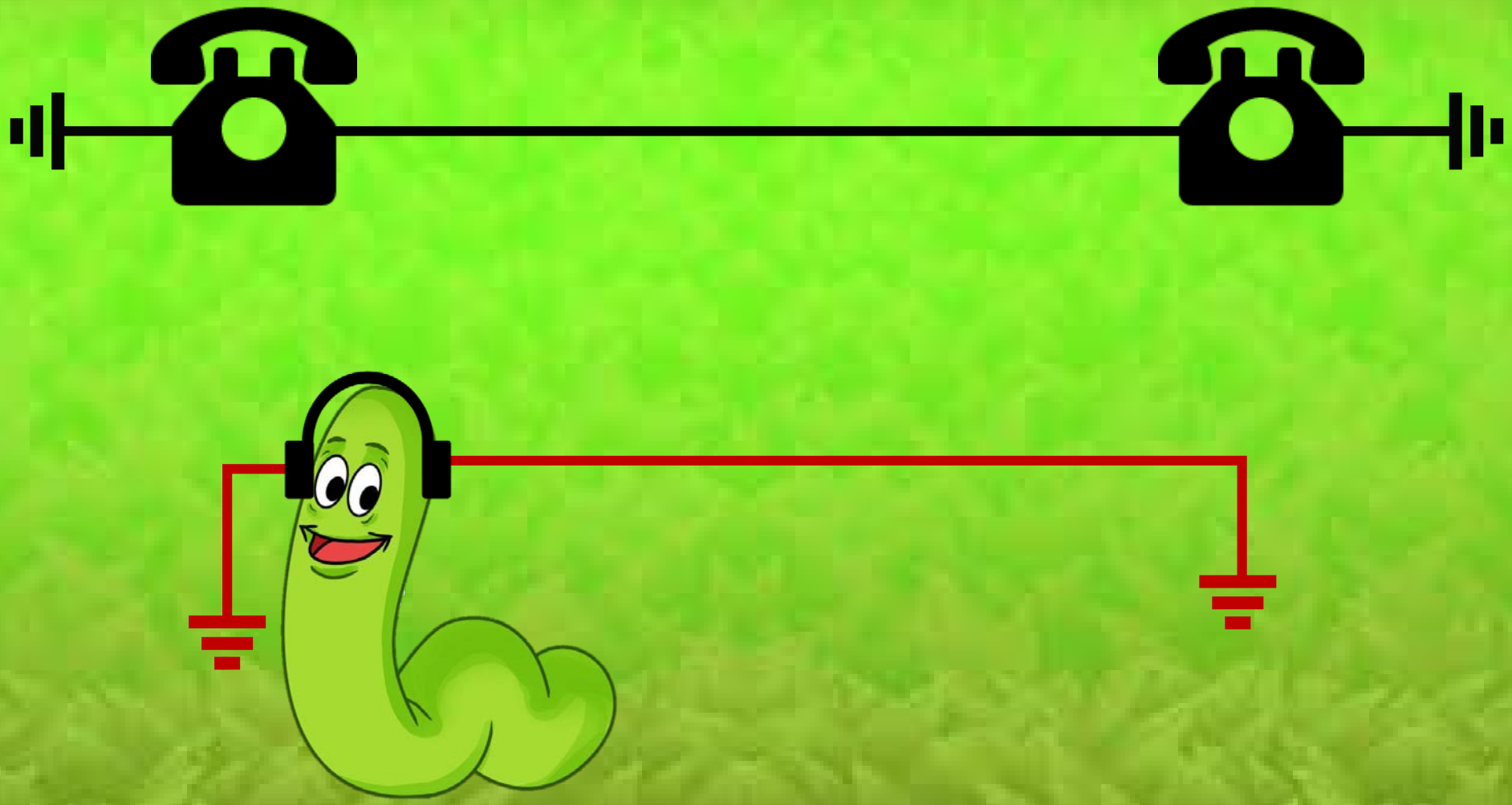
Technology Has Risks

- Earth-return field telephones WW1
- Local oscillator radiation WW2
- False Beacons (Meaconing)

Field Telephones with Single-Pole Earth-Return Save Wire

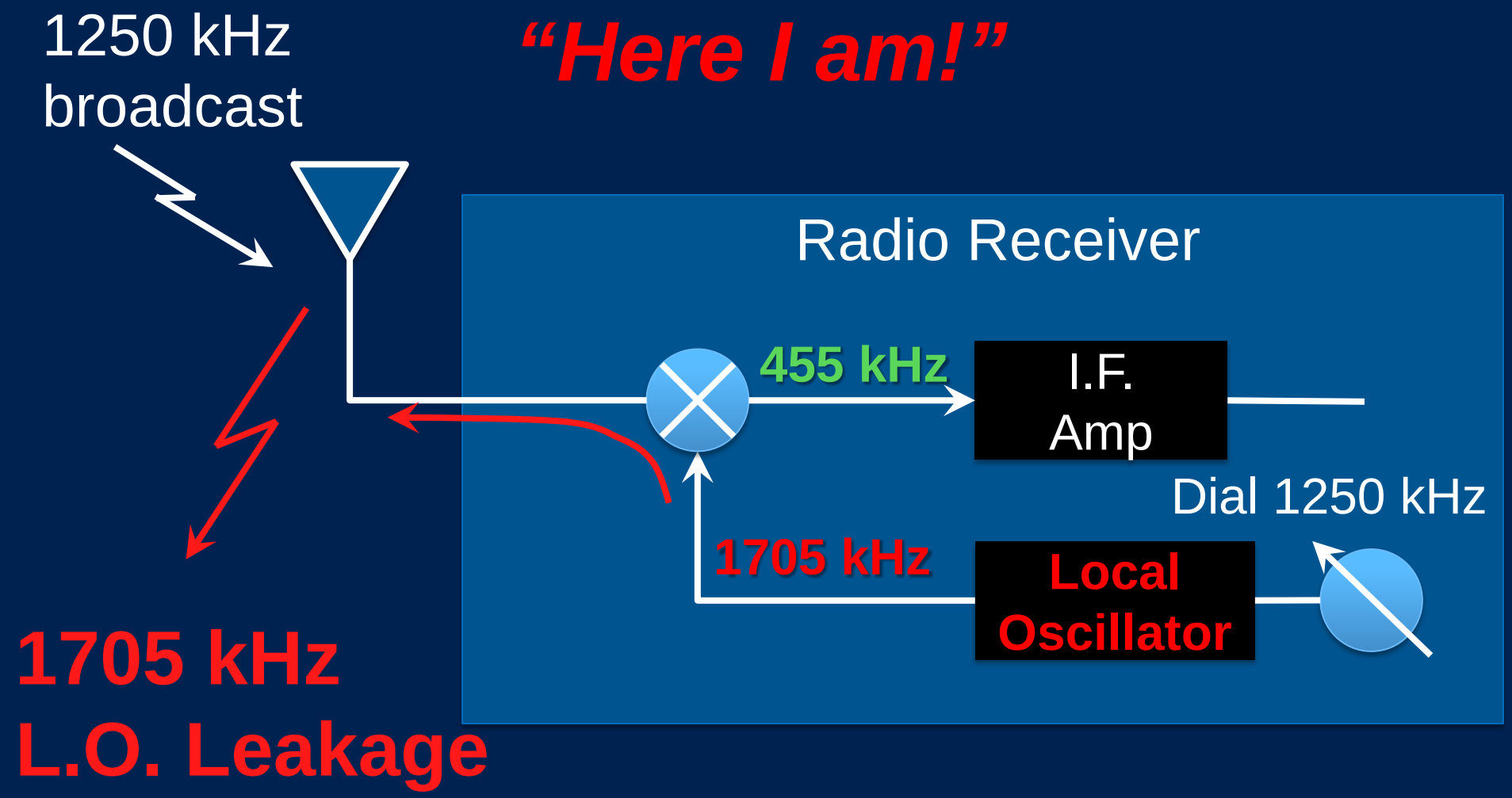


…but the Enemy Can Worm In!



Local Oscillator Leakage Whispers,

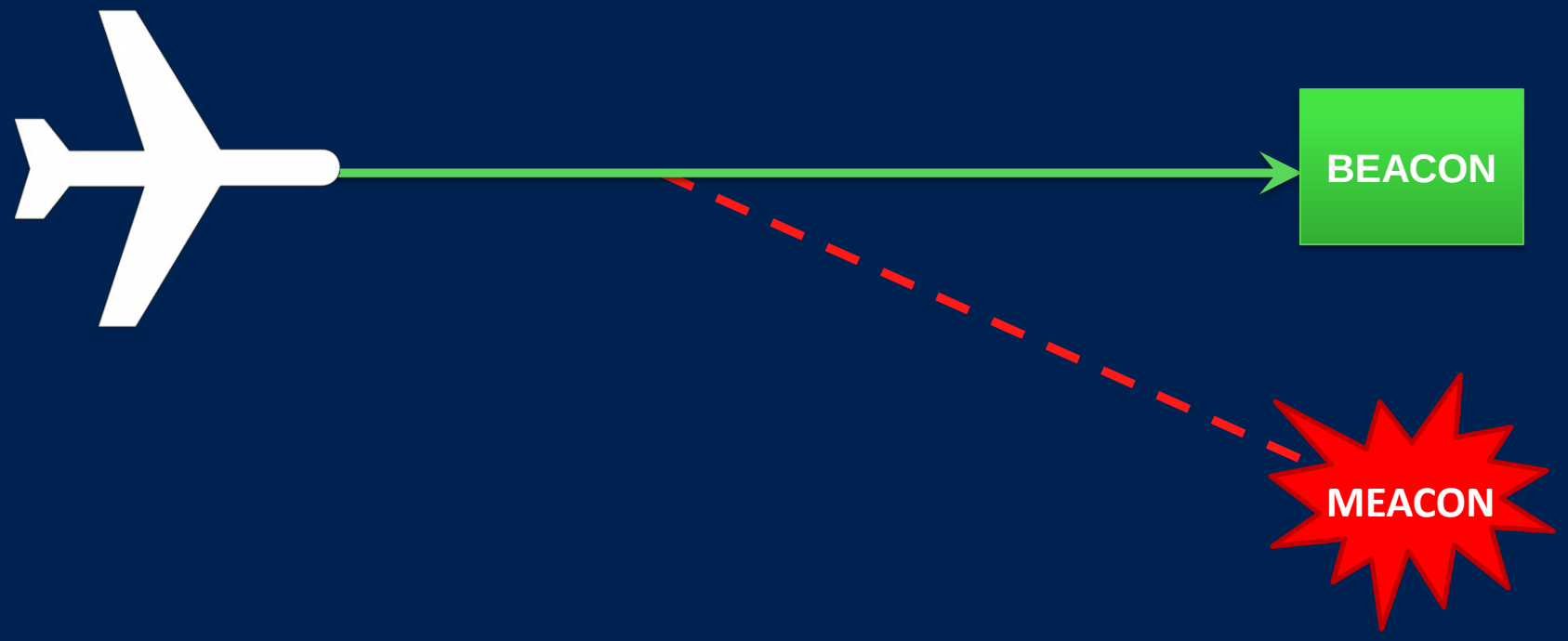
"Here I am!"



1705 kHz – 1250 kHz = 455 kHz

Morale(?) Receiver

Pull Aircraft Off Course With False Beacons

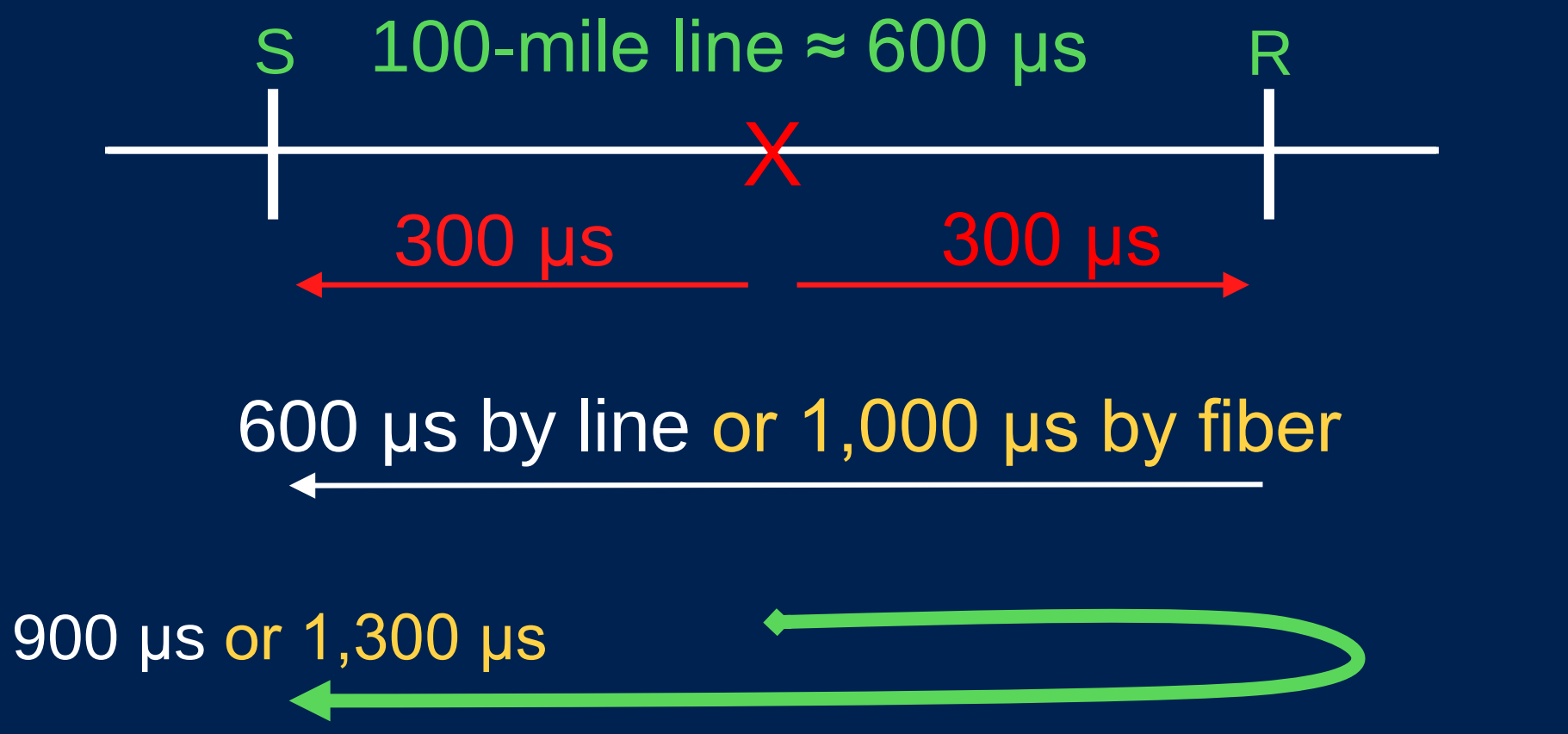


Some Basic Thoughts

- Power systems are inherently stable.
- They can run without “cyber.”
- Protection must always be available.
- Maintaining protection usually means taking primary equipment out of service.
- Faults must be cleared FAST!

Communicate more, depend on it less.

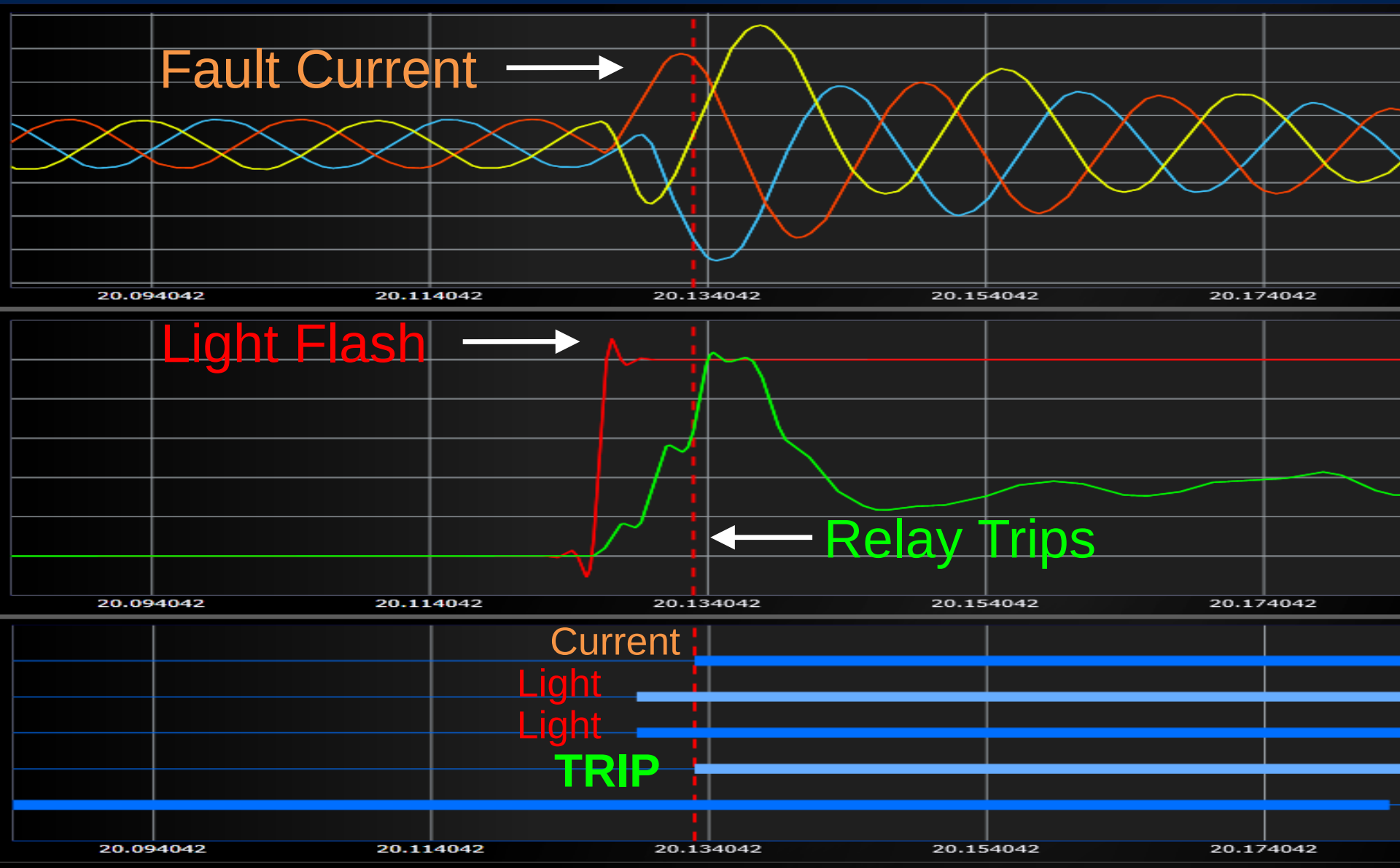
Speed of Light Limits Relay Time



The fastest communications path is the line

Trip *Fast* on Current and Light

Trip in 4 ms

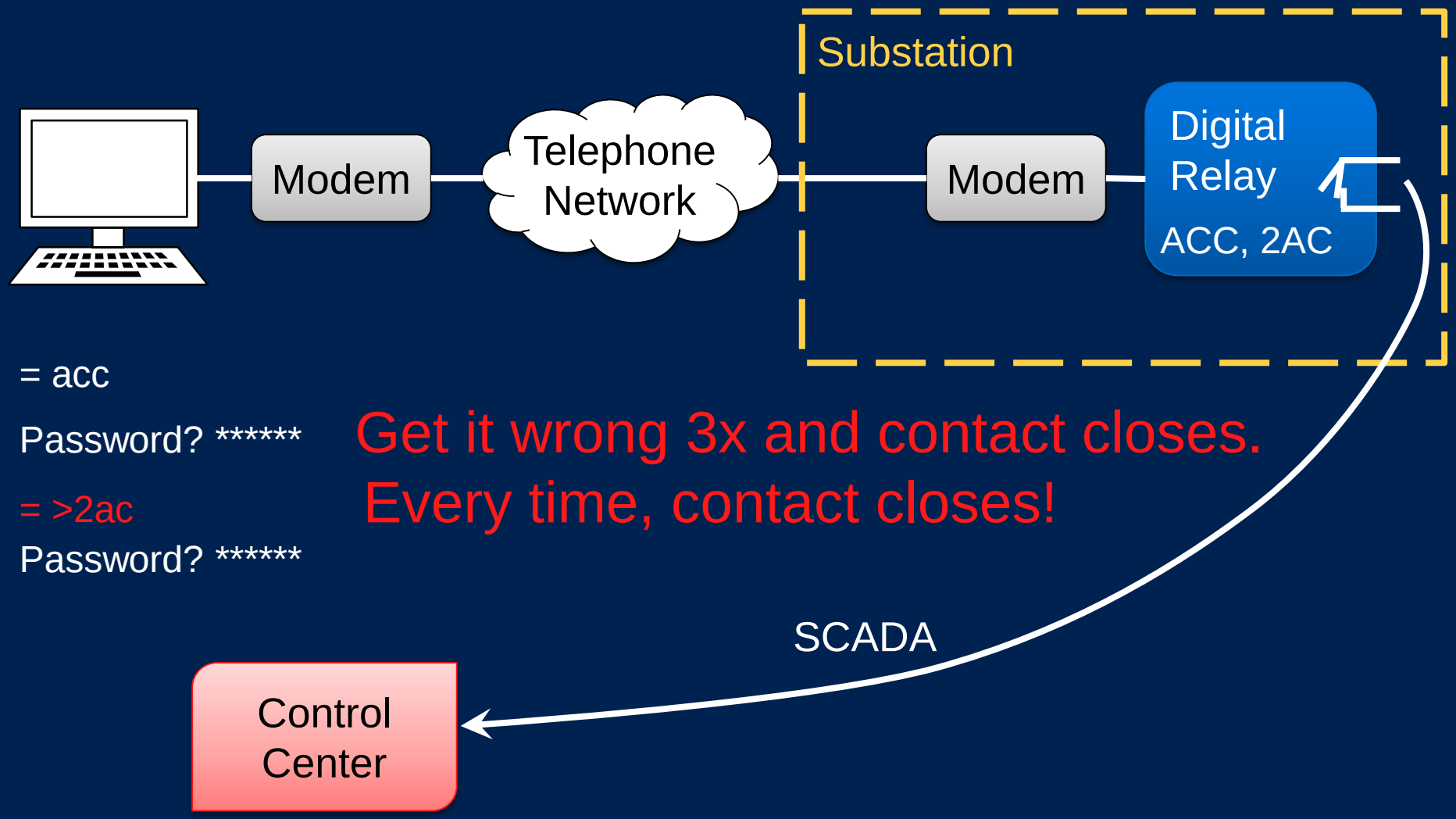

Fault Current
20.094042
20.114042
20.134042
20.154042
20.174042
Light Flash
Relay Trips
20.094042
20.114042
20.134042
20.154042
20.174042
Current
Light
Light
TRIP
20.094042
20.114042
20.134042
20.154042
20.174042

SEL-21 Security in 1984

- Two access levels
- Jumper to disable trip
- Alarm contacts
- Firmware checksums

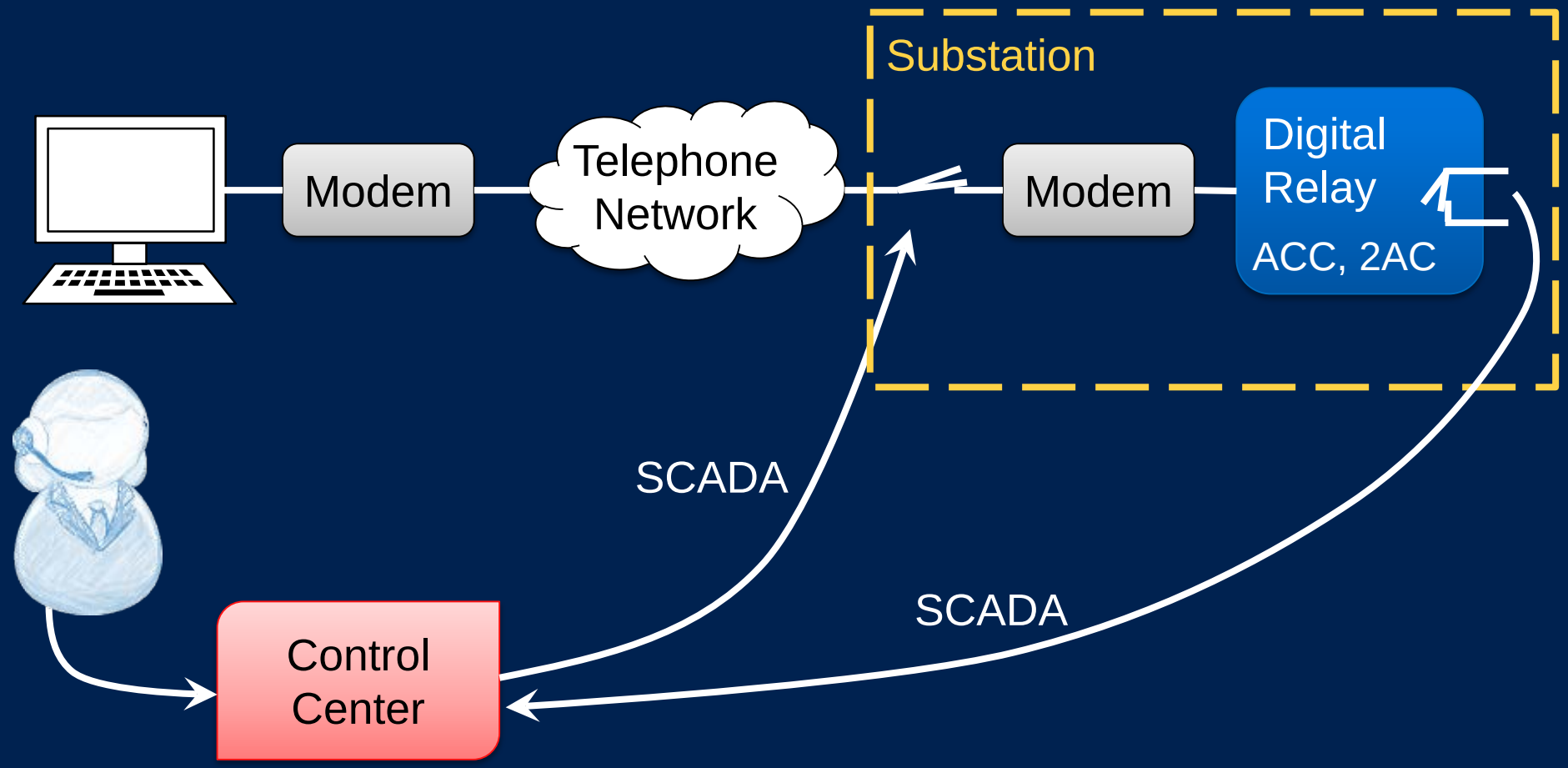

```
*ACC
Password: ? @@@@@@
Invalid Password

Password: ? @@@@@@
Invalid Password

Password: ? @@@@@@
Invalid Password
Access Denied
```

Two-Party Authentication in 1984



SCADA Op Connects Phone Line

You call in; if op knows you, then access



Authentication Slow Could be toll call

Concerns About Intrusions Into Remotely Accessible IEDs, Controllers, and SCADA Systems

27th Western Protective Relay Conference

Spokane, WA

October 24 – 26, 2000

Dr. Paul W. Oman

Dr. Edmund O. Schweitzer

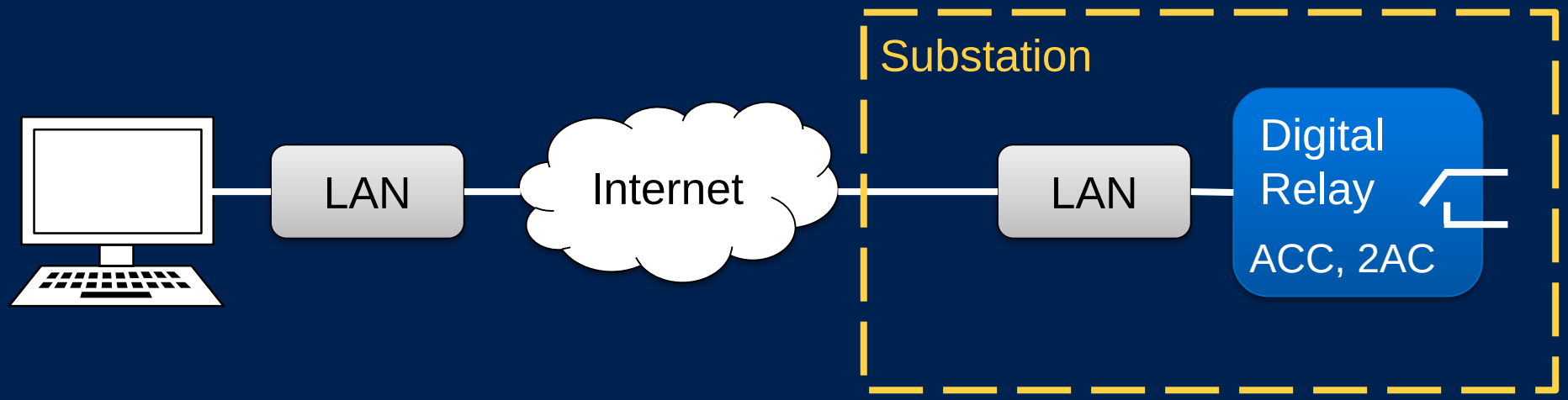
Dr. Deborah Frincke

What's Causing the Increased Risk? WPRC, Spokane, WA Oct 2000

- Pressure to Downsize, Automate, Cut Costs
- Instability in Electric Utility Job Market
- Rapid Growth of Computer Literacy
- Widespread Availability of Hacker Tools
- Shift From Proprietary Systems to Distributed Systems With Open Protocols
- FERC 888 / 889 Requirements
- Increased Access via Modems and Internet
- Increasing Espionage and Terrorism

Connectivity = Convenience + Risk

2001: Relay with Ethernet Port



- Fast and “free”
- Very convenient…to good and bad guys

Q: *“Why would anyone put an Ethernet port on a relay?”* A: *“Market Pressure!”*


THE BEST WAY TO PREDICT
THE FUTURE IS TO
INVENT IT
– Alan Kay

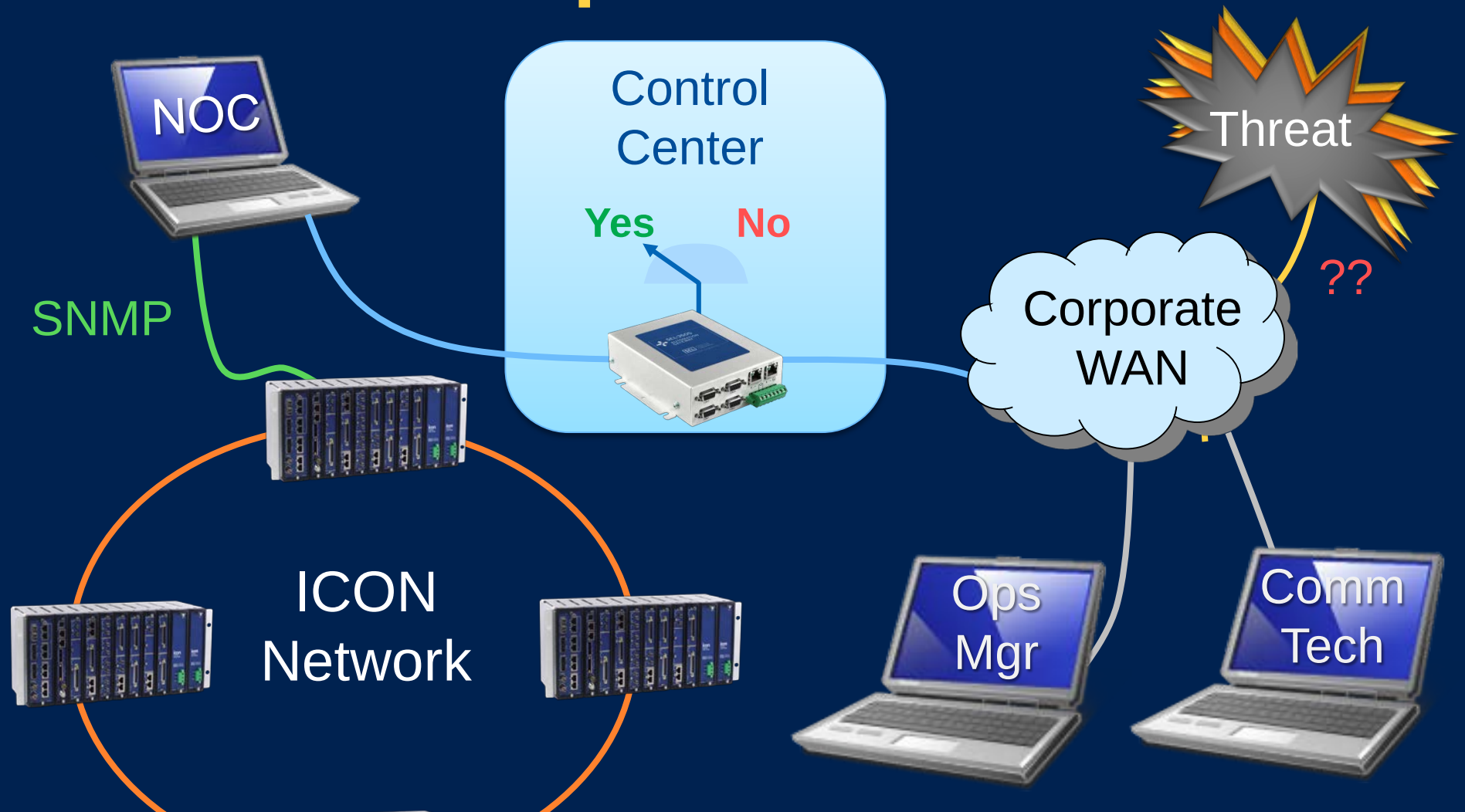
Regulations Fall Short

- Take years to emerge, all the while the tech and threats change.
- One-size-fits-all probably fits no one.
- Tell bad guys what we ***will*** and ***won't*** do.
- Compliance and security are different.

Government: Teach and Advise

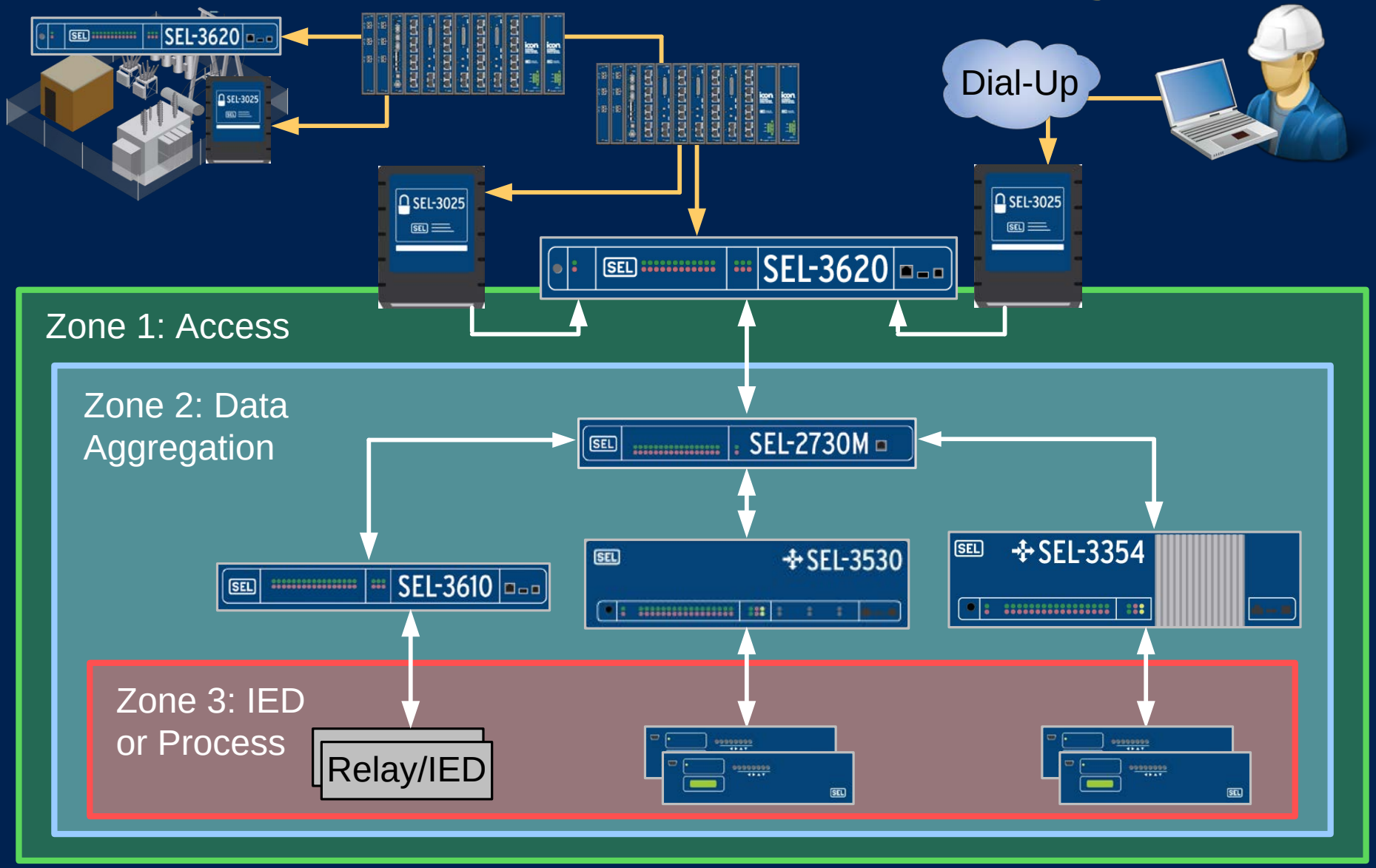
- Teach the threat, with all due respect to sources and methods.
- Advise, on best ways to secure communications and information systems.

SCADA Op Can Enable Link



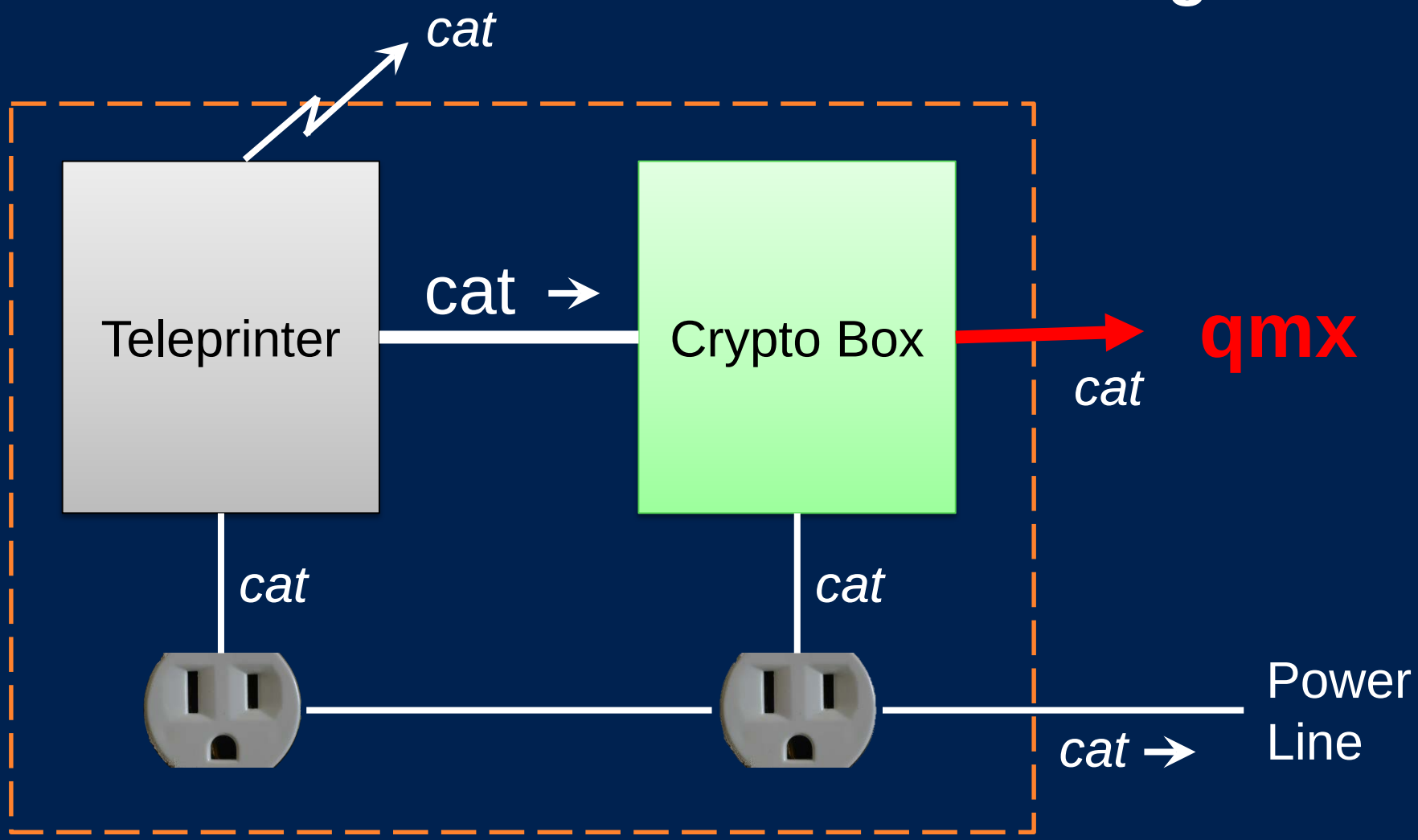
You're only exposed when remote access is required.

Defense-in-Depth for Secure Connectivity

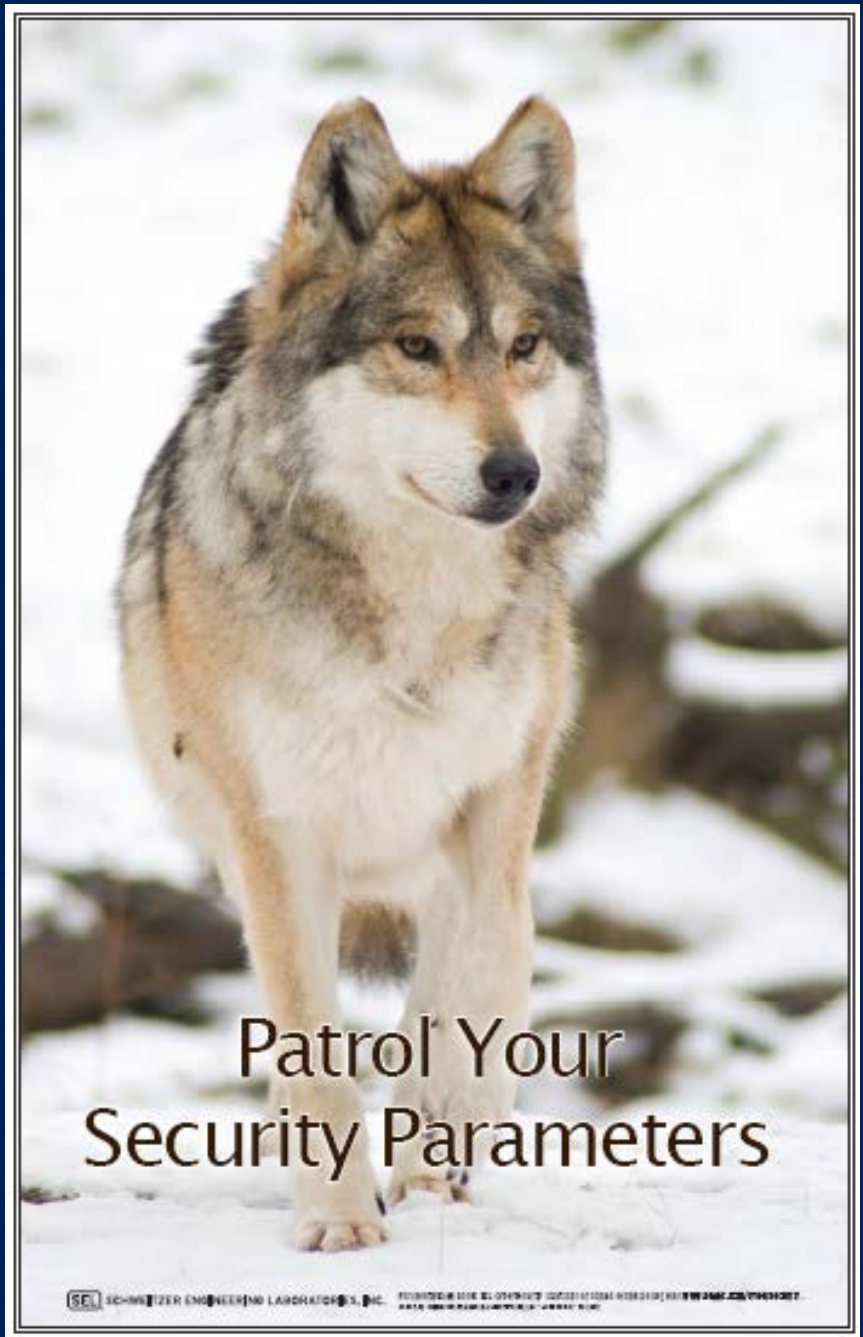


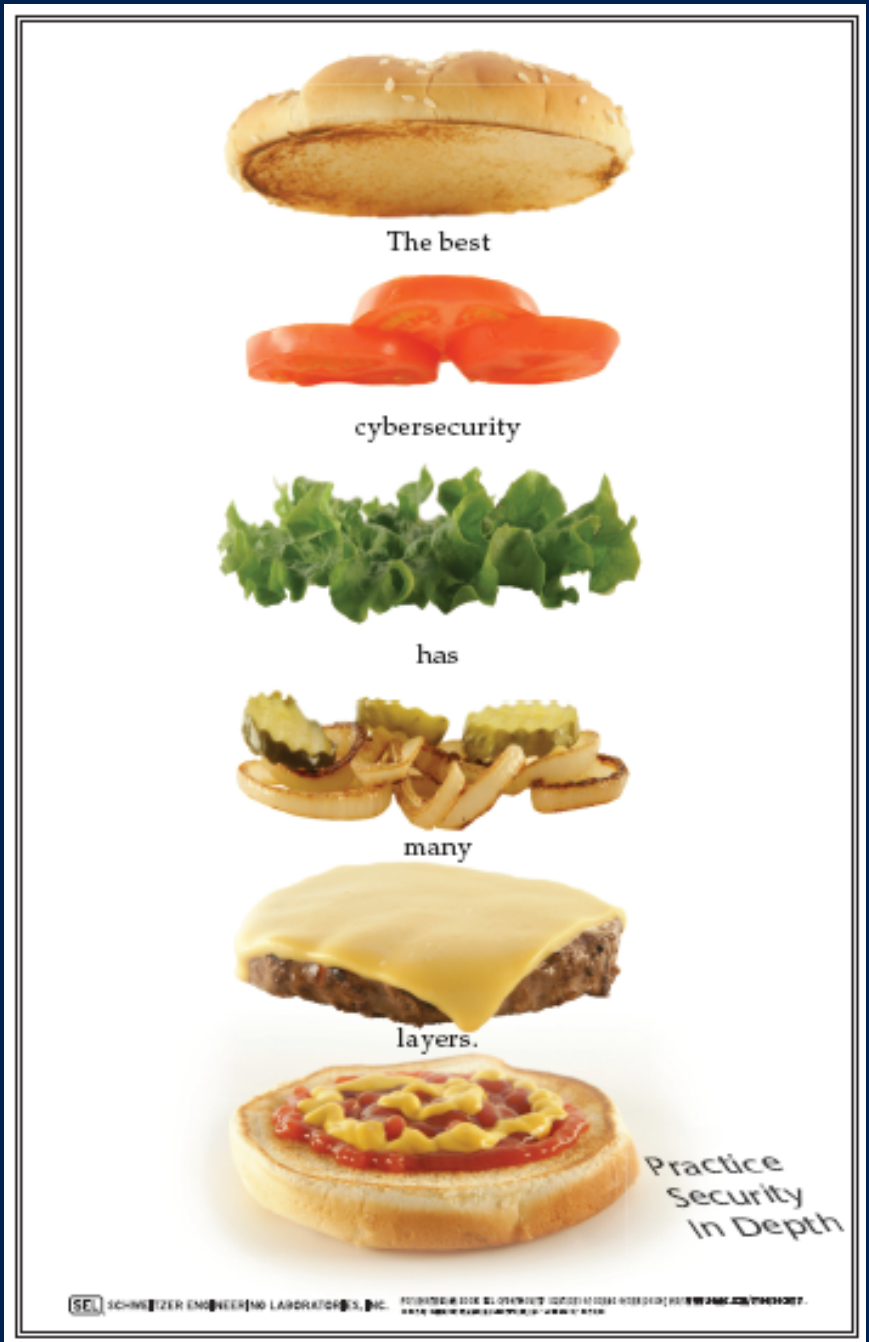
TEMPEST: Shield, Filter, Mask

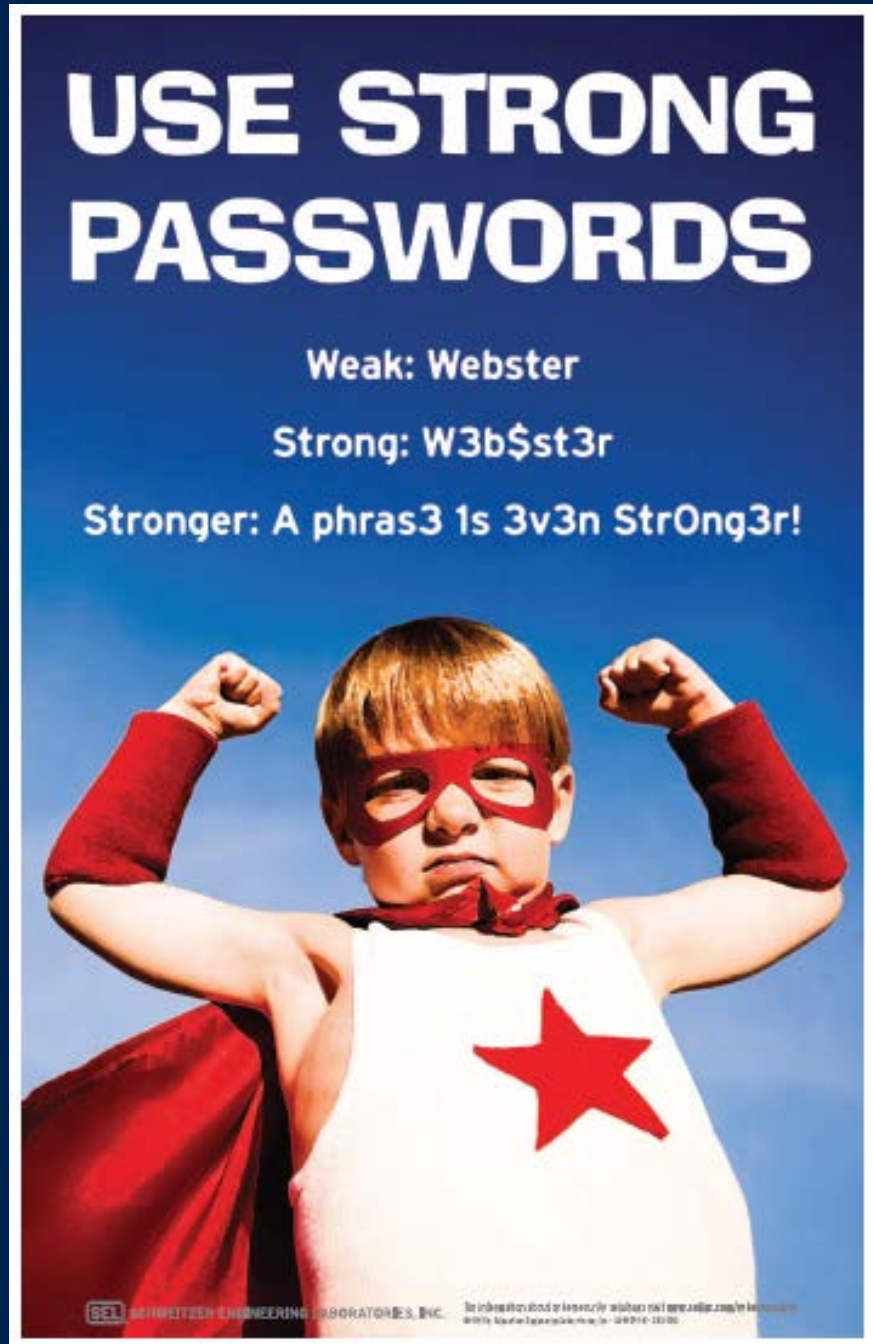
Don't let the "cat" out of the bag



Security Perimeter = "Bag"


Patrol Your
Security Parameters


The best
cybersecurity
has
many
layers.
Practice
Security
In Depth


USE STRONG PASSWORDS
Weak: Webster
Strong: W3b$st3r
Stronger: A phras3 1s 3v3n StrOng3r!
SEL SCHWEITZER ENGINEERING LABORATORIES, INC.


I DON'T SHARE MY TOOTHBRUSH OR MY PASSWORD!
SEL SCHWEITZER ENGINEERING LABORATORIES, INC.

Ships in products, get up to 90 at a time for free!

Physical *and* Cyber Protection

SEL-3622 Security Gateway

Senses *Motion and Door Opening*

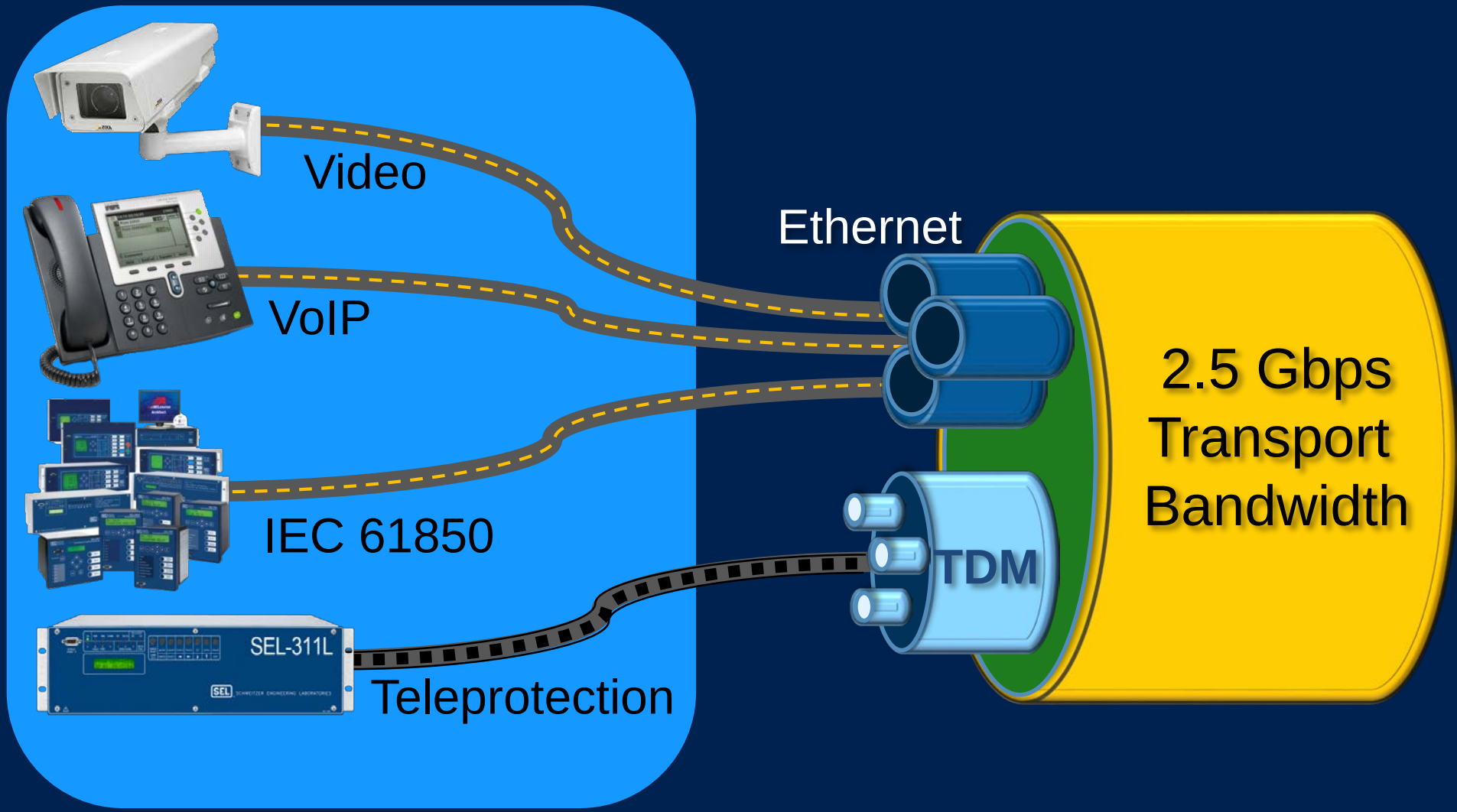
Detect *Light and Cable Disconnect*

Dependable Communications for Critical Infrastructure

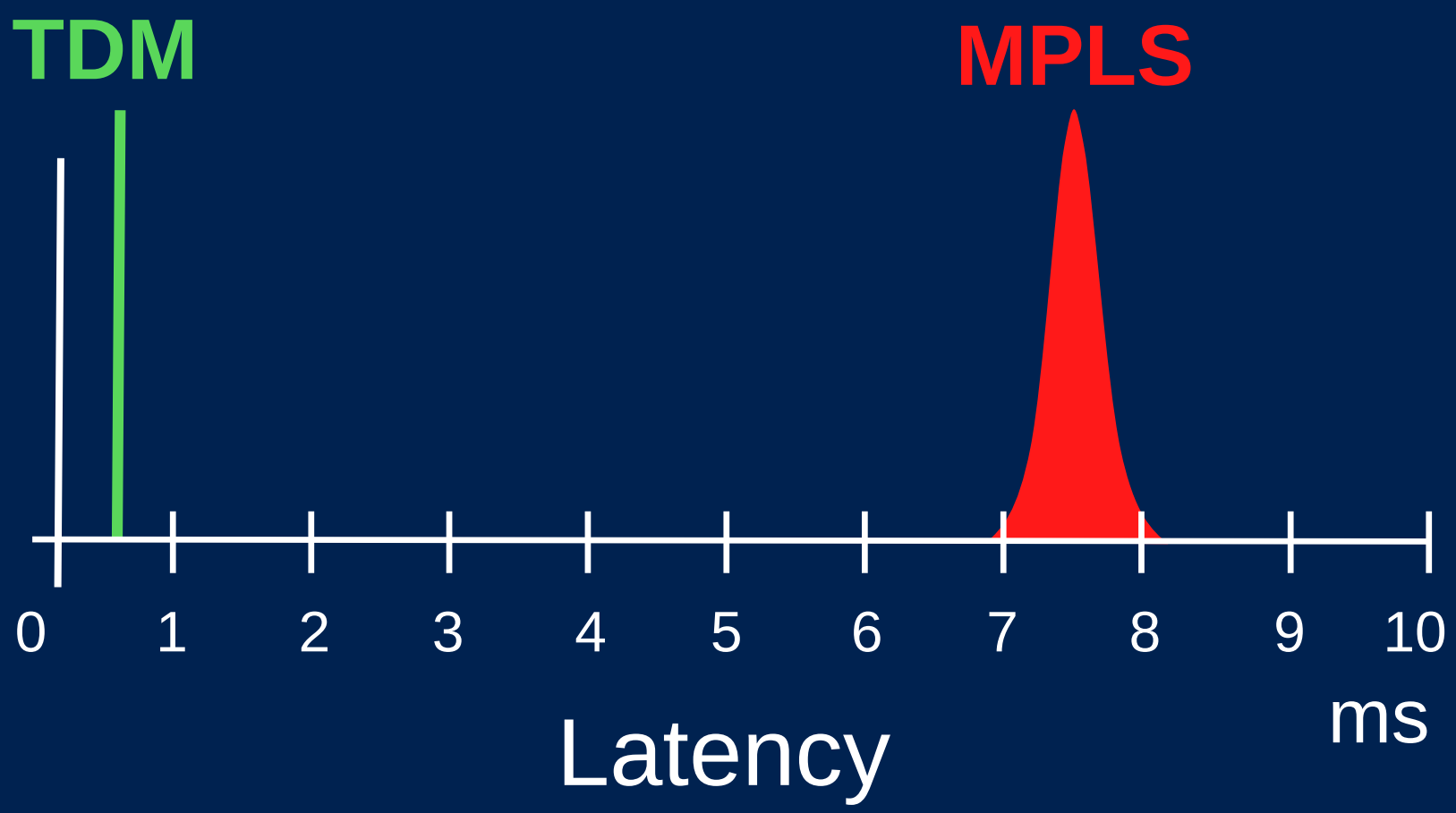
- ✓ Utility rated
- ✓ 5 ms network healing
- ✓ Deterministic communications
- ✓ Absolute microsecond network time
- ✓ Best of TDM and Ethernet features
- ✓ “Clean sheet” design: performance, security quality, manufacturability, and price

icon - The Best of TDM and IP Communication

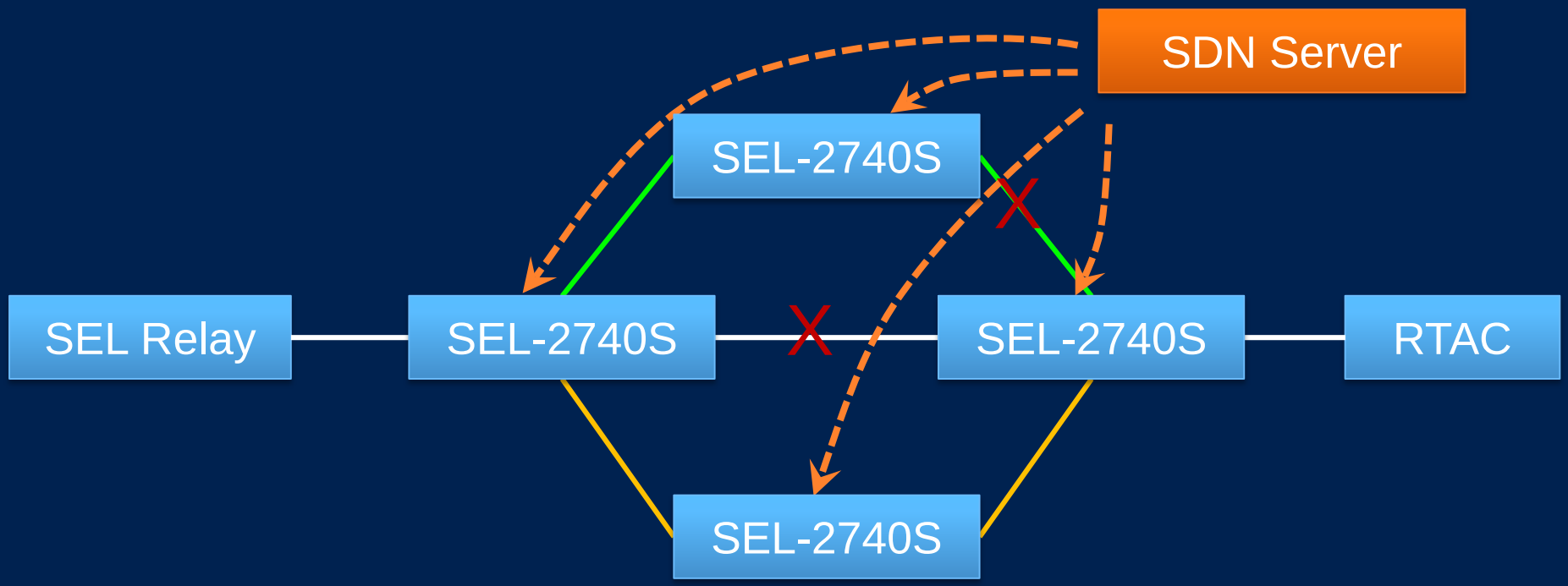
INTEGRATED COMMUNICATIONS OPTICAL NETWORK



We Chose TDM Because It's *Fast* and Doesn't Jitter



Reset Network Complexity With Software-Defined Networking



Primary Path Backup Path Secondary Path

Pilot: “Where Am I?”

- Airspeed, barometric altimeter, compass
- Celestial Navigation
- Charts (Jeppson, flying mail)
- ADF receives NDBs and radio stations
- VOR, DME, ILS; Radar Altimeter
- GPS
- Inertial Navigation Systems

GPS works great, and we have other tools

Power Engineer: “What Time is It?”

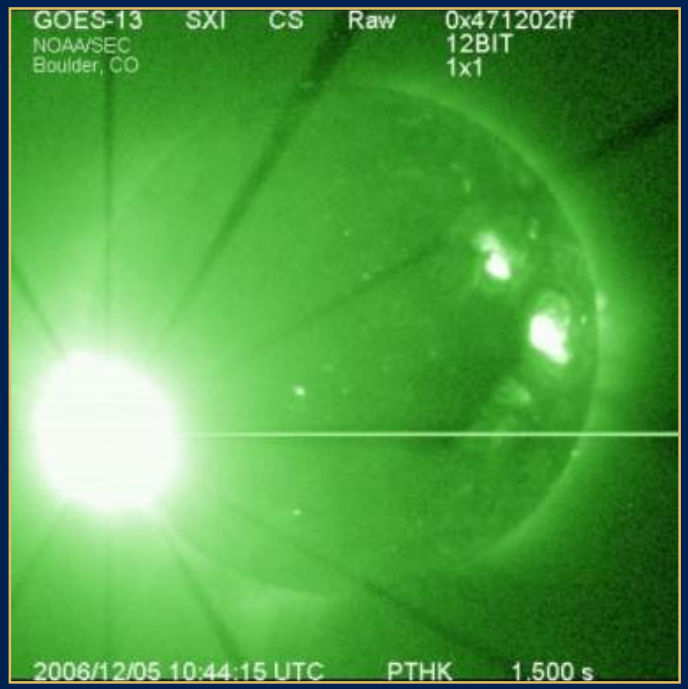
- Substations seldom move
- Satellites <<100 ns
- Terrestrial Network Time <<100 ns
- Disciplined Standards with very low drift rates for excellent holdover
- VLF Broadcasts ~ 1 ms

GPS works great, and we have other tools

GPS Time Is Not Guaranteed!

We need robust solutions.

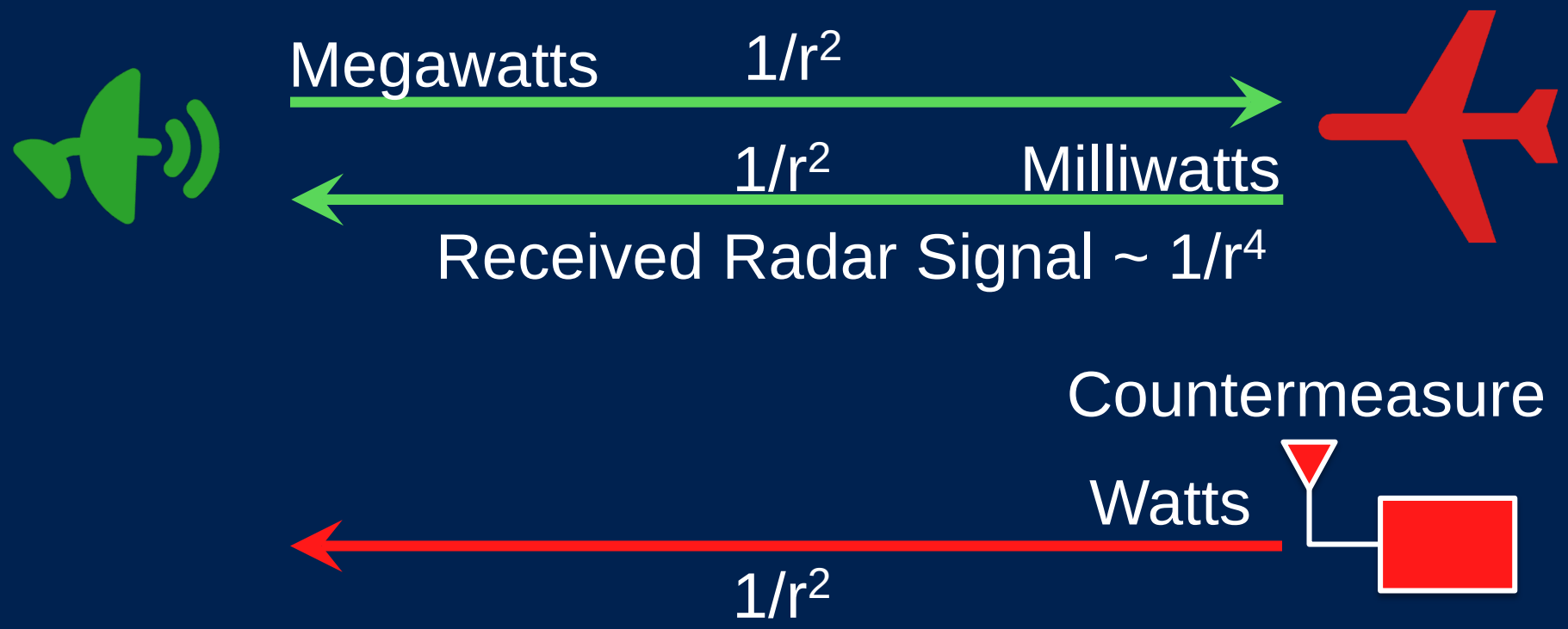
- Jam, spoof, or interfere (NAVWAR)
- Equipment failure
- DoD control
- Solar flares



"On December 6, 2006, a solar flare created an unprecedented intense solar radio burst causing large numbers of receivers to stop tracking the GPS signal."

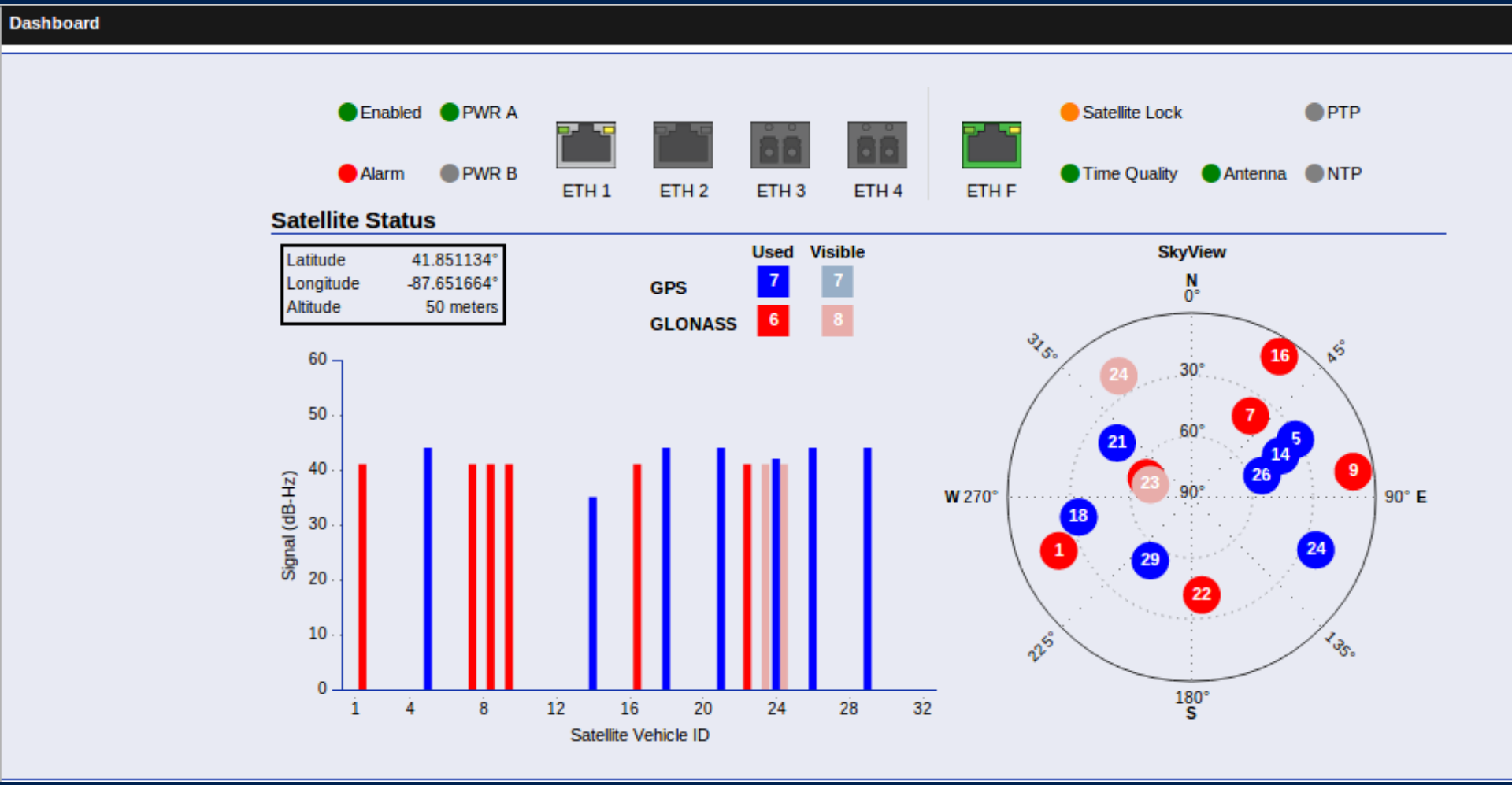
– NOAA Press Release

Detect, Jam, Spoof Radar



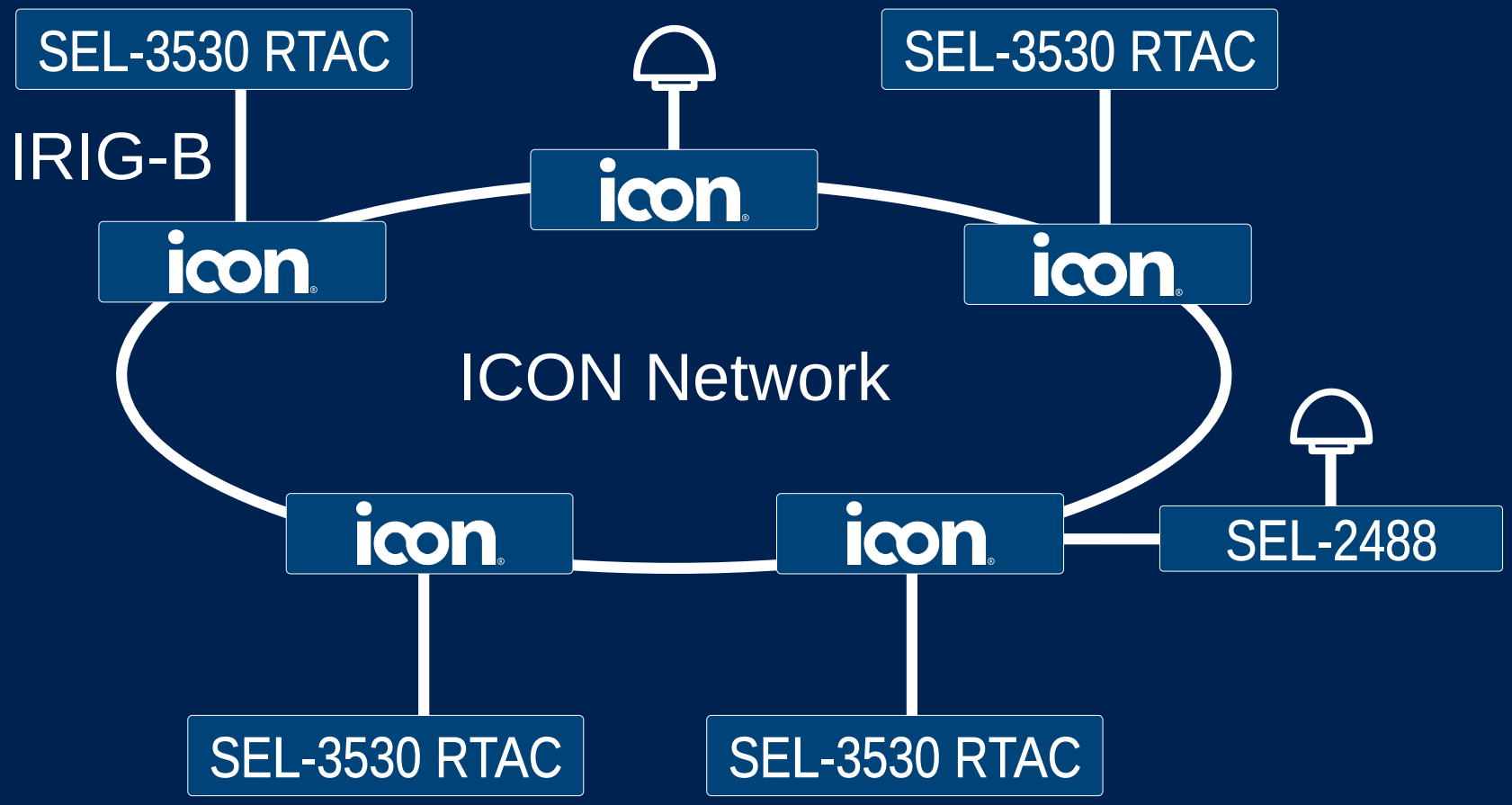
Countermeasure >> Reflection

SEL-2488 Clock Compares Time from GPS *and* GLONASS Satellites



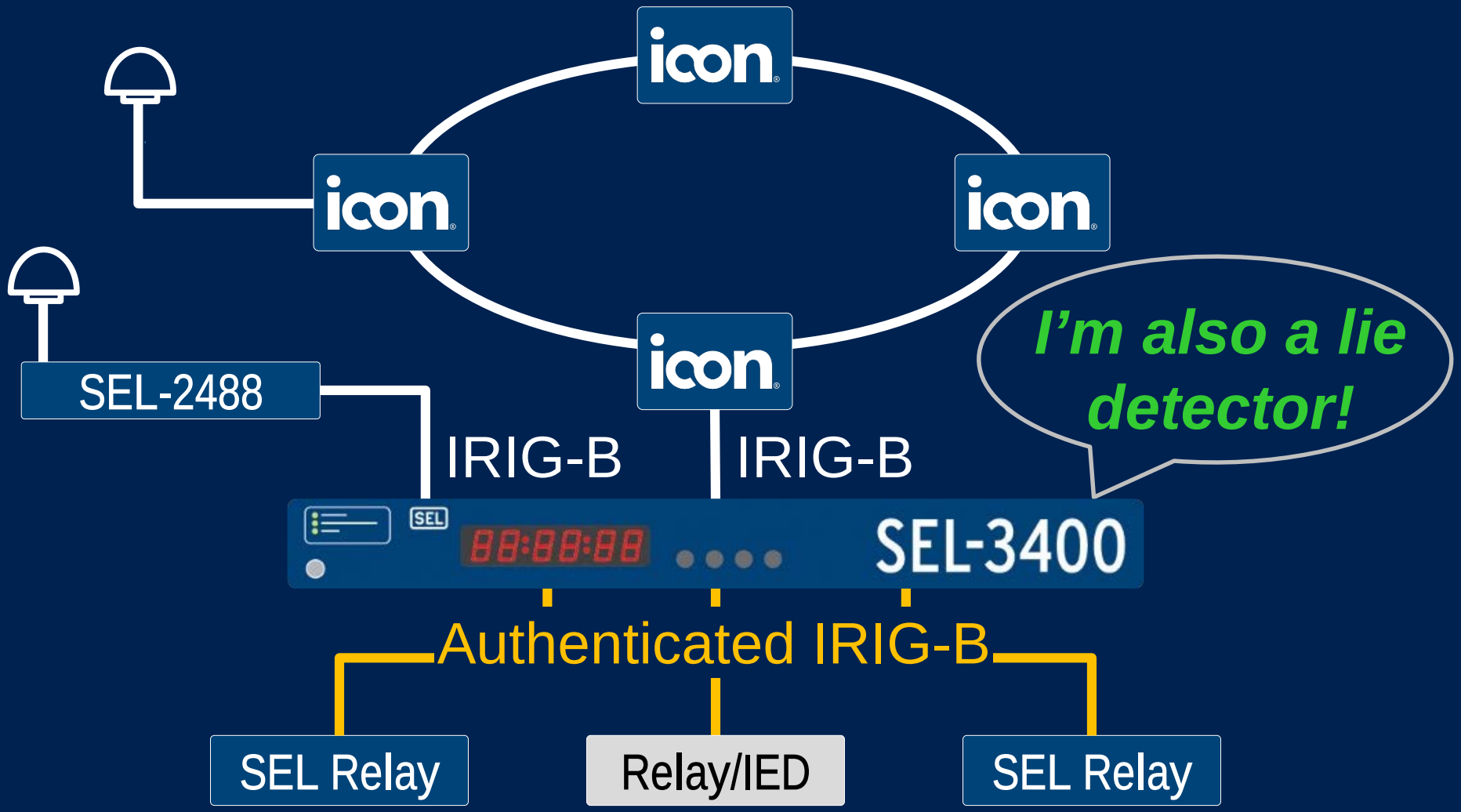
ICON Distributes Precise Time

<100 ns and NO GPS Risks

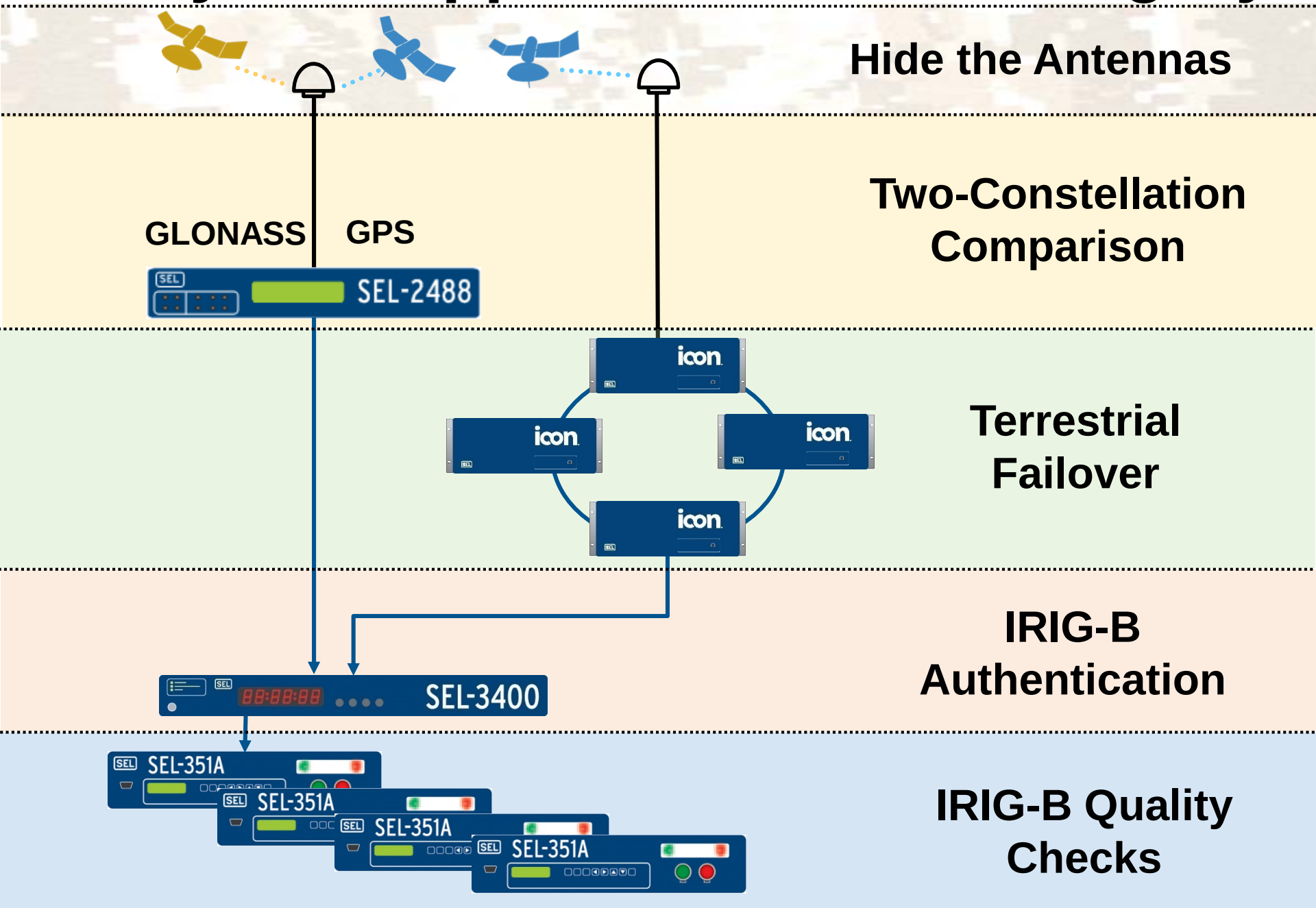


SEL-3400 Authenticates Time

Alarms if Time Differs, but Good Quality Bits



A Layered Approach to Time Integrity



Serious Suggestions

- ***Never*** connect SCADA to Internet
- Operate *private and secure* control networks
- Consider TDM, not just packet comms
- Apply defense in depth; layers of security
- Learn, innovate, educate
- Encourage our government to teach the threat
- Security Plans: *Private and Compartmented*
- Understand the “physics” of electric power

The History and The Future

- Power systems run without “cyber.”
- Computers and communications add to the safety, reliability, and economy of electric power.

We can build cyber-safe solutions!