How Did We Get Here?

The History and Future of Cyberattacks against Industrial Control Networks

BlueHat IL 2023

Greetings

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Why I'm Here

Industrial Control Systems (ICS) make our modern world function, and they are under attack.

Today's Primer:

- ICS Concepts, Architecture, and Theory
- Failure Points and Consequences
- A Brief History of ICS
- 25 Years of ICS Cyberattacks
- Current State and Challenges
- What's Next?

ICS Concepts and Theory

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What is an Industrial Control System?

First, let's understand a "process"

- "Industrial processes are procedures involving chemical, physical, electrical or mechanical steps to aid in the manufacturing of an item or items, usually carried out on a very large scale" – Wikipedia

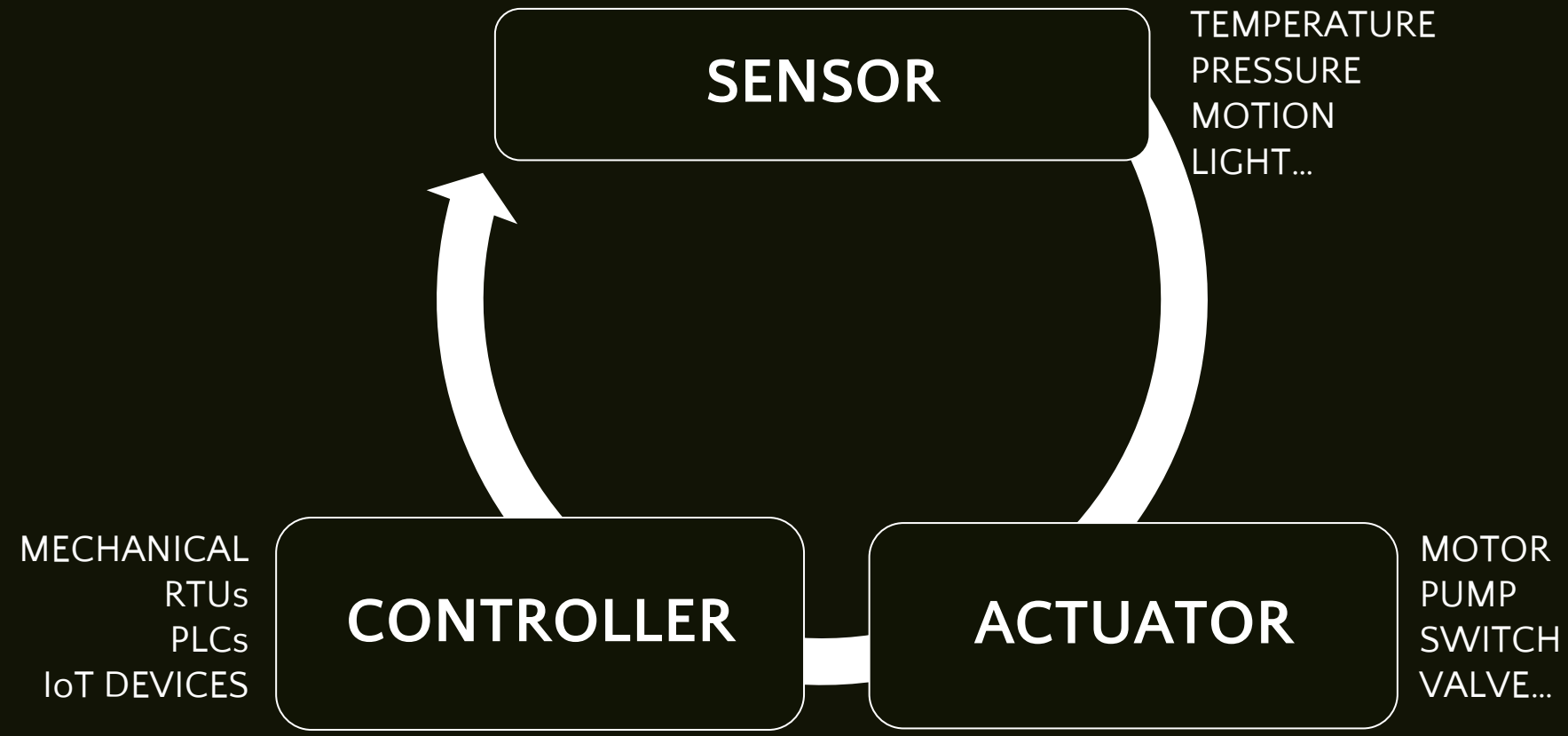
Processes must be controlled in a defined way by something

Industrial Control Systems provide some level of automation for the control of industrial processes

Process Control Loops

- Every Industrial Control System is made up of at least one Process control loop
- Control loops must have 3 components

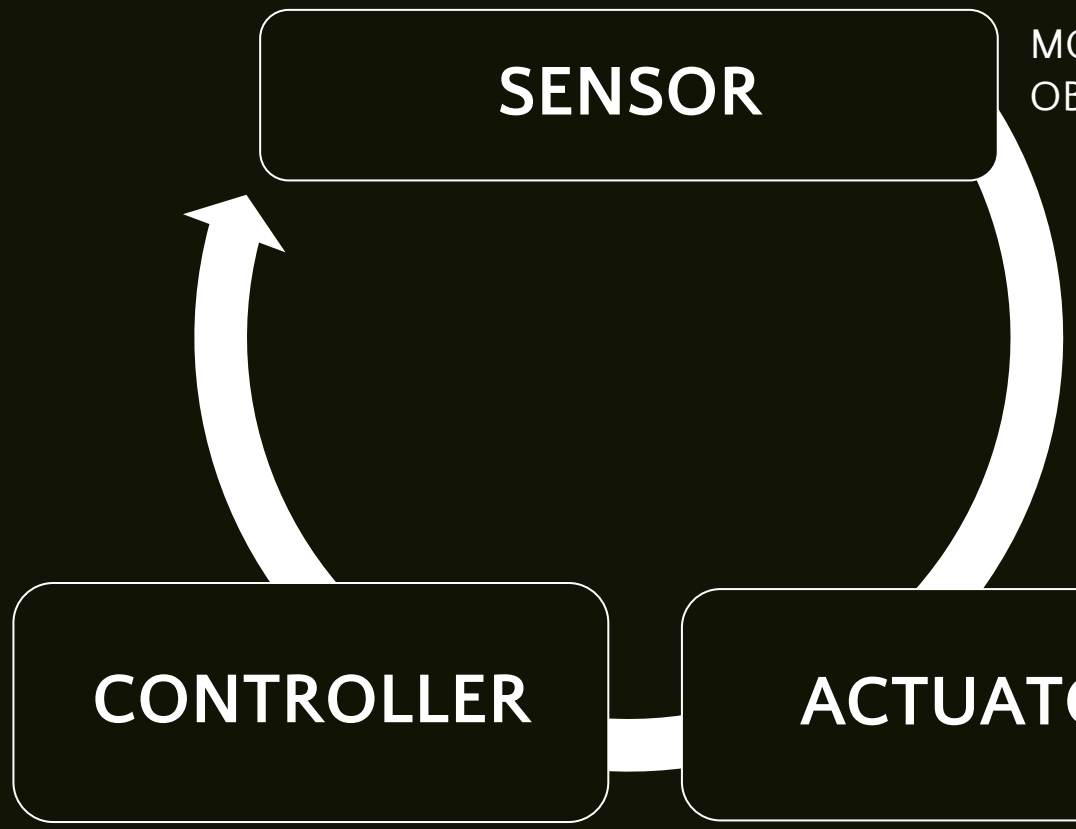
Process Control Loops



Process Control Loops

When am I supposed to rotate?
When am I supposed to stop rotating?

Is someone in the door?
Is the door obstructed?
What is the motor state?



MOTION OBSTRUCTION

- MOTOR (Rotation)

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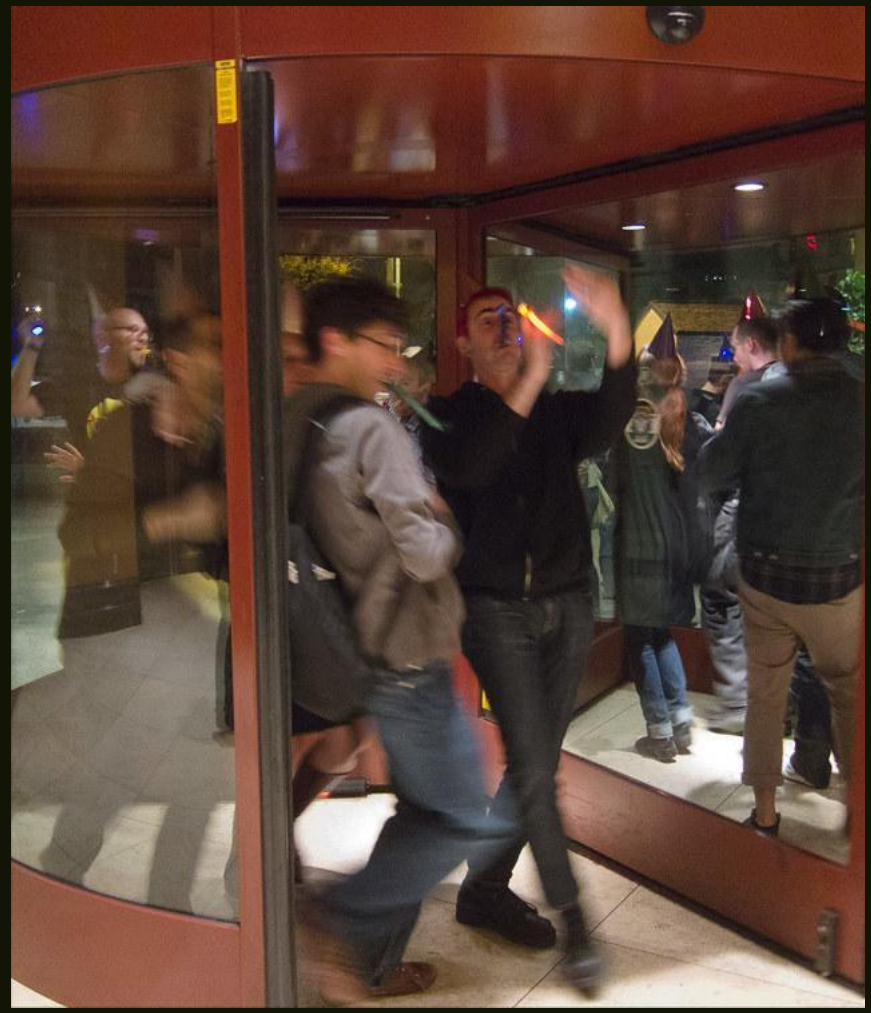
What Can Go Wrong?

The Actuator…

1. **Fails to start** when it's supposed to
2. **Fails to stop** when it's supposed to
3. **Starts too early** or **too late**
4. Goes on for the **wrong period of time**



Why is this Important?

- December, 1984 – Bhopal, India Plant Disaster
- Union Carbide India Limited (UCIL) pesticide plant
- Triggered by refrigeration system failure
- Safety system malfunction and bypass compounded degradation and poor system maintenance
- Over half a million people exposed to toxic methyl isocyanate (MIC), thousands dead
- Industrial systems operating in incorrect ways have real, kinetic impacts

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We Rely on Industrial Control Systems, Today

- Essential utilities at scale
- Manual controls are limited and no longer universal
- Just in time logistics
- Transportation
- Not just electrical power…
- Essential quality of life and safety
- Real Consequences

A Brief History of ICS

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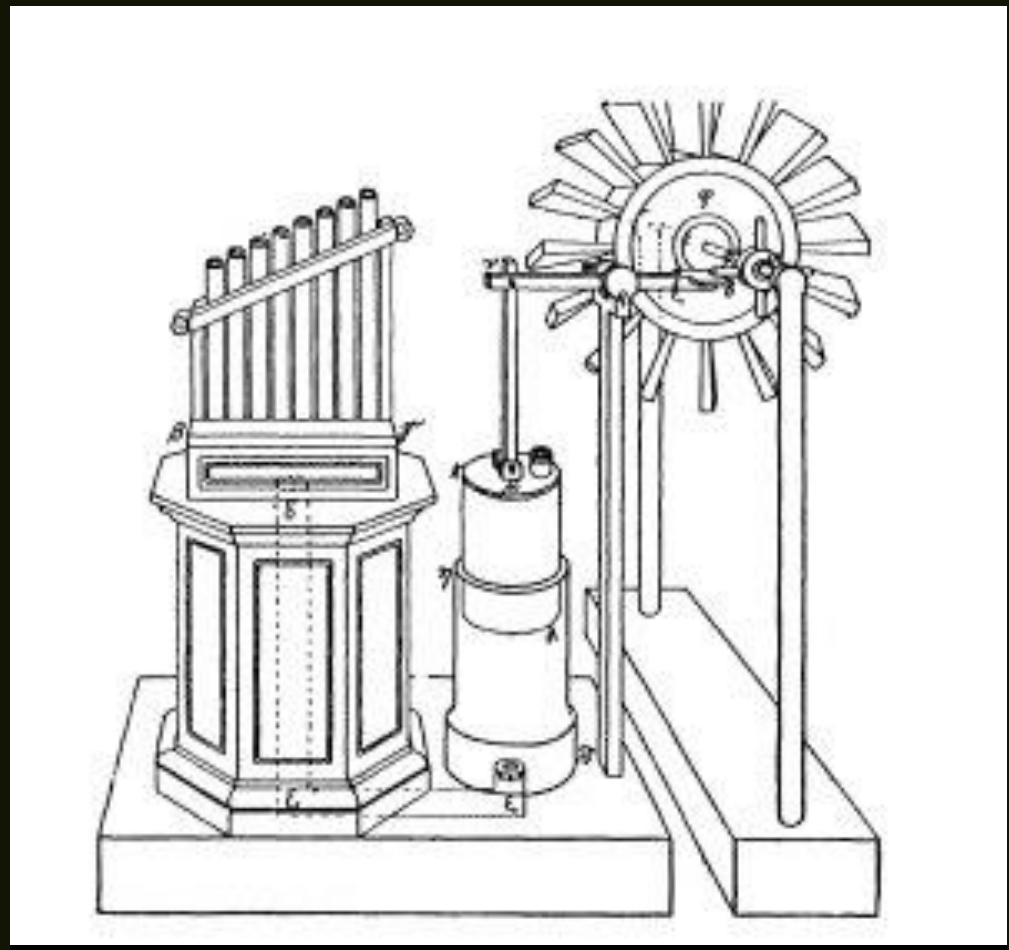
The Beginning

- Industrial Control Systems can be **mechanical, analog, or digital**
- Earliest ICS were mechanical
- Ktesibios's water clock in Egypt ~270 B.C.
- Cornelis Drebbel – first furnace thermostat in 1620
- Early industrial control was heavily focused on maritime, time, and trains
- Gears and weights provide control, instead of humans

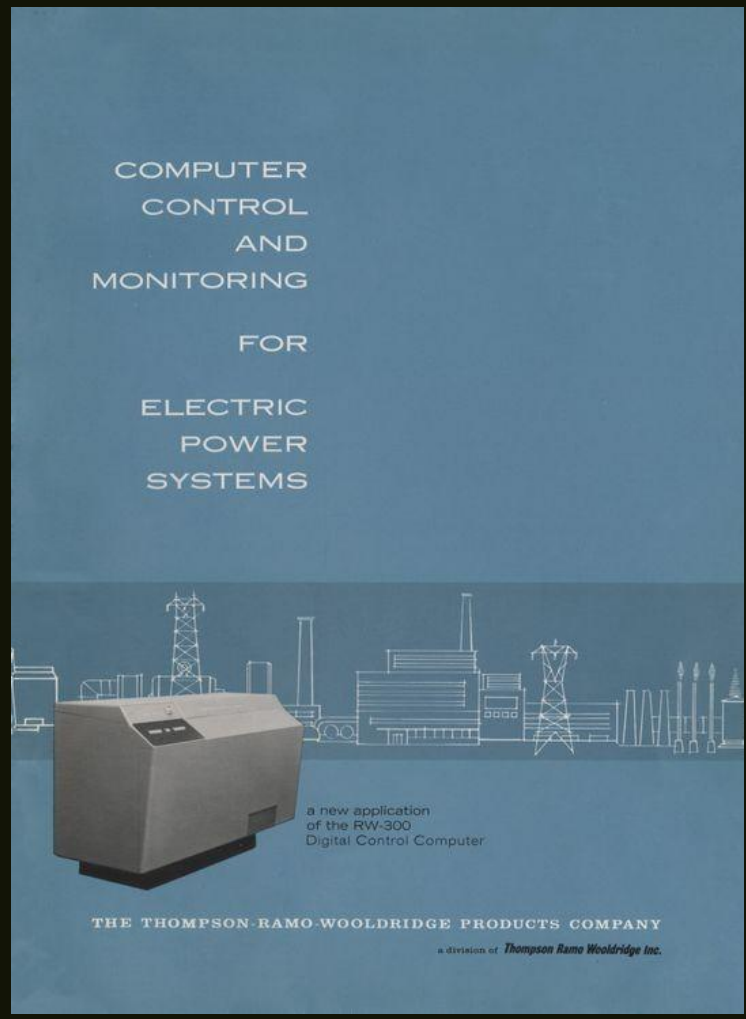


ICS Through the 20th Century

- Mass-production manufacturing
- Urbanization
- Aviation
- Migration to analog electronic control devices
- Electronic circuits, instead of gears and weights, provide control

Digitization of ICS

- First industrial computer – Louisiana Power & Light, 1958
- First digital ICS – Texaco, 1959
- Development of the transistor and small, cheap computing machines
- By 1971, there were 41 manufacturers of ICS computers
- Ladder logic, and serial protocols instead of simple circuits, provide control



Bennett, Stuart. (2004). Control and the Digital Computer: The Early Years. Measurement and Control. 37. 10.1177/002029400403701002.

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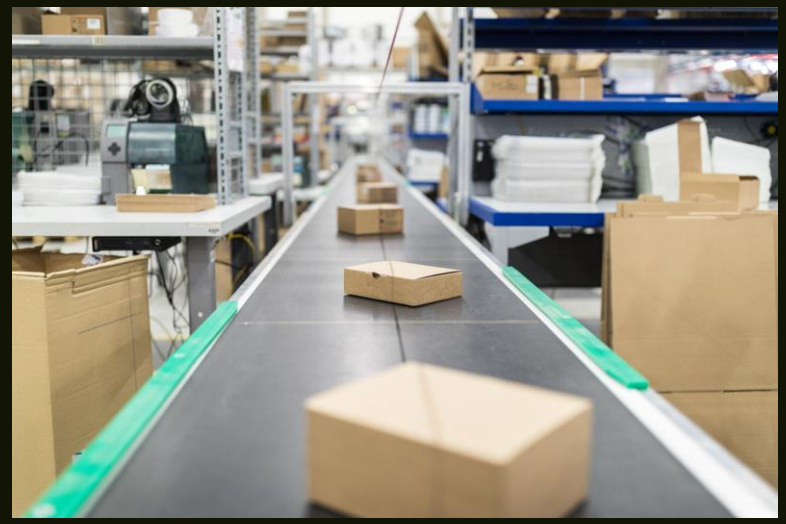
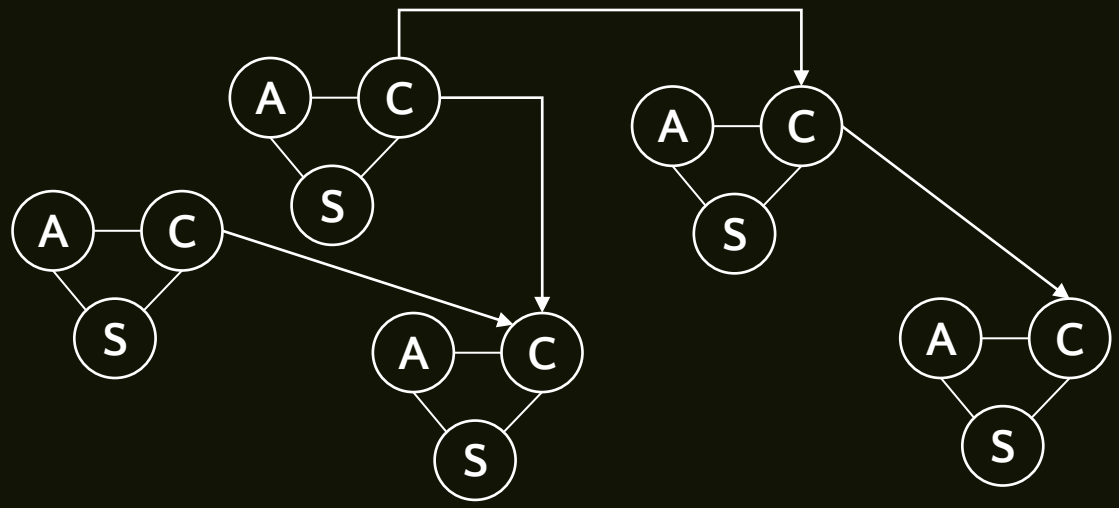
Let’s Understand ICS A Little Better

- A single control loop is limited
- A complex process is made up of many control loops
- Require human or automated synchronization





Distributed Control and SCADA

- Modern computers can provide granular efficiency and telemetry
- Distributed Control Systems – Limited Geography
- SCADA – Wide scale, deeper analytics

IT/OT Convergence

- Commercial computing equipment is **cheap** and **readily avail**able
- Shift from custom software and hardware to **enterprise vendors**
- Networks increase **efficiency** and **remote capability**
- **Cost savings** drive business choices

Unfortunately, the threat landscape is much larger against networked, popular operating systems and protocols…

More Presence and Power,
More of a Target...

Early Attacks against ICS

- 2000 – Maroochy Shire Sewage Spill
- 2007 – Idaho National Labs Aurora Generator Test

Stuxnet: Pandora's Box

- Worm discovered in 2010
- Suspected development as early as 2005
- Disrupted Iranian nuclear program through centrifuge tampering
- First known cyberweapon targeting ICS
- Highly complex, required deep knowledge of specific process and control systems

Most of us are familiar with the story of Stuxnet, but it remains a key point in history, and likely inspired future attacks / capabilities

German Steel Mill

- 2014 – “under the radar” report of cyberattack against steel mill
- German government’s Bundesamt fur Sicherheit in der Informationstechnik (BSI) annual findings report
- Knowledgeable attackers
- Caused control system failures resulting in “massive damage”

Ukraine Power Grid Cyberattacks

- **Ukraine is a long-term test bed for kinetic cyberattacks**
- December 2015 – cyber attack cuts power to quarter million Ukrainians for ~six hours
  - BlackEnergy 3 malware as vector
- December 2016 – second attack on Ukranian power grid, with additional disruptive elements, more sophisticated and repeatable tactics
  - CRASHOVERRIDE / Industroyer malware specifically targets power
  - Disruption to restoration efforts – holistic process
- Cyberattacks reportedly continue against Ukraine during war

TRISIS

- **Safety** is a key consideration in processes for a reason
- **Safety Instrumentation Systems** supplement analog and human safety controls
- 2017 – TRISIS/TRITON targeted Triconex safety systems
- Deep implications for human safety and process operation

Recent History – Water, Ransoms, & PIPEDREAM

- ICS cyberattacks are evolving and becoming more efficient
- 2021 – Oldsmar, Florida water treatment facility compromise
- Ransomware, Colonial Pipeline, and commodity malware impacts
- 2022 – PIPEDREAM toolkit lowering the barrier to entry…

The Bottom Line

- **Criminals** will always try to make money
- States will always **spy**
- **Sabotage** will always be an element of warfare and geopolitics
- Computers **make this more accessible**

ICS Cybersecurity in 2023

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Daily DFIR Casework in 2023

Commodity Malware

Insider Threats

State Adversaries

The State of Modern Industrial Networks

- There is **awareness** of cyber threats
- Organizations are **under-resourced**
- **Regulation** is limited and haphazard
- **Verticals vary vastly** in maturity
- Many **faulty assumptions** by executives and practitioners
- **Tool** and **research** landscape is relatively immature

Challenges in Industrial Security and Response

- Process **consequences**
- System **sensitivity** and **safety**
- **Legacy** technology and lifecycles
- **Proprietary** infrastructure and warranties
- **Low-level** devices
- Legacy security tooling
- Growing **divergence** between cybersecurity training and ICS cybersecurity
- Focus on **bugs,** when **process** is the real concern

Real Solutions are Holistic

- Understanding **Environment** and **Assets**
- **Secure Architecture** and **Vulnerability Management**
- Interpersonal **Relationship**s
- **Preparation** (Incident Response, Business Continuity, Disaster…)
- **Passive Monitoring** and Detection
- **Consequence-Driven** Planning and Evaluation

The Near Future...

- OT workforce reaching **retirement** age
- ICS DFIR **skill divergence**
- Immense spaces to cover in **research** and **tool** development
- **PIPEDREAM** socialized a concerning concept
- **Barrier to entry** continues to lower
- Global **financial conditions** drive efficiency for adversaries, too

We Need You!

Leaders: Executive buy-in, awareness of programs and process environments, bridge-building, resourcing

Practitioners: Attention to process environments, adaptability, consequence and process focus

Researchers: Tools, strategies, reverse engineering of industrial devices beyond simple bugs

Voters and Citizens: Concern for industrial systems that make our world work, even if they ‘always work’.

Thank You!

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