HOW DID WE GET HERE?

The History and Future of Cyberattacks against Industrial Control Networks

Greetings

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- USAF Retired
- Lecturer, Blogger, Mentor, Conference Organizer

@hacks4pancakes on the things

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

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**

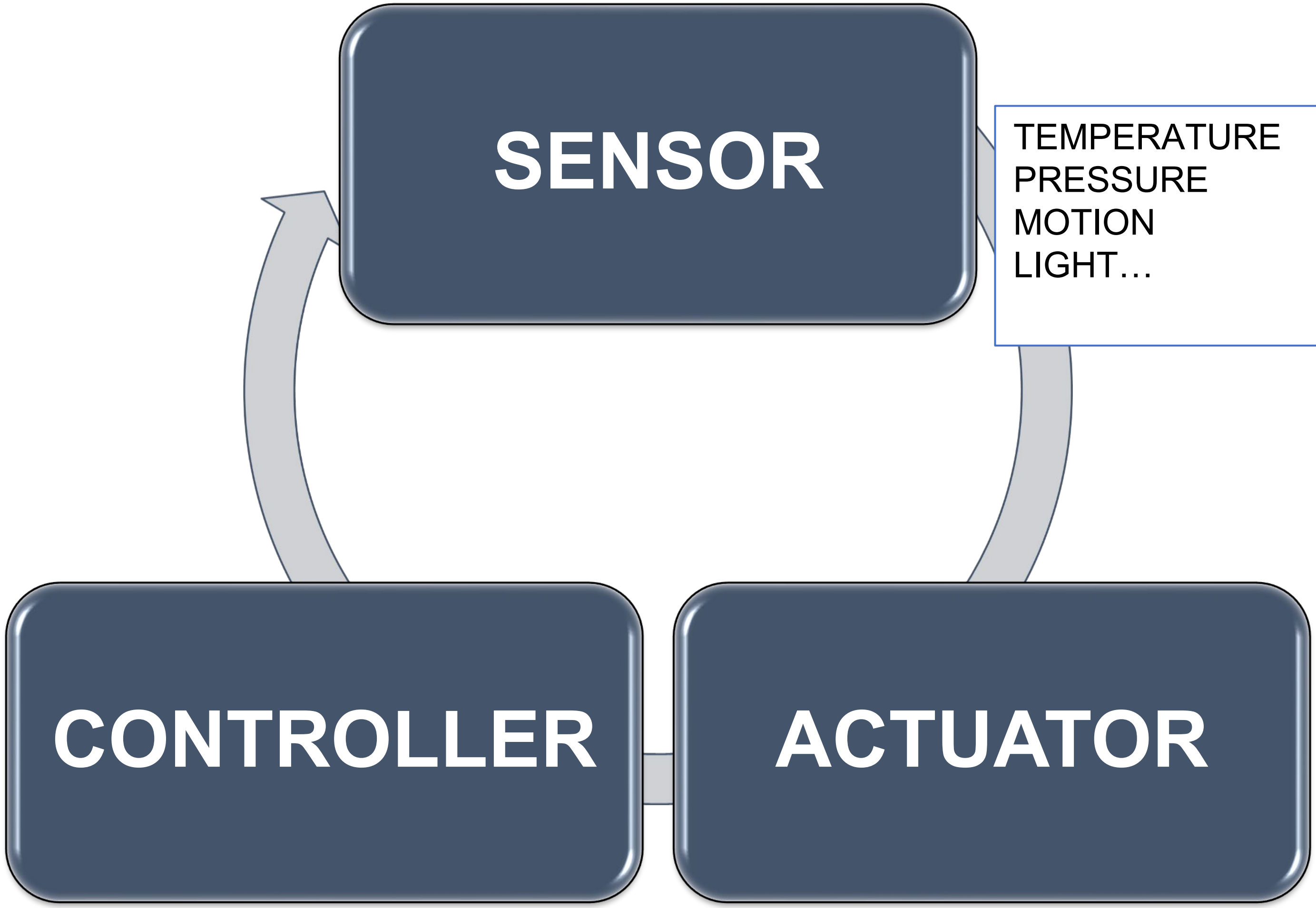
Industrial Control Systems provide some level of automation for the control of industrial processes

What is an Industrial Control System?

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



TEMPERATURE
PRESSURE
MOTION
LIGHT…

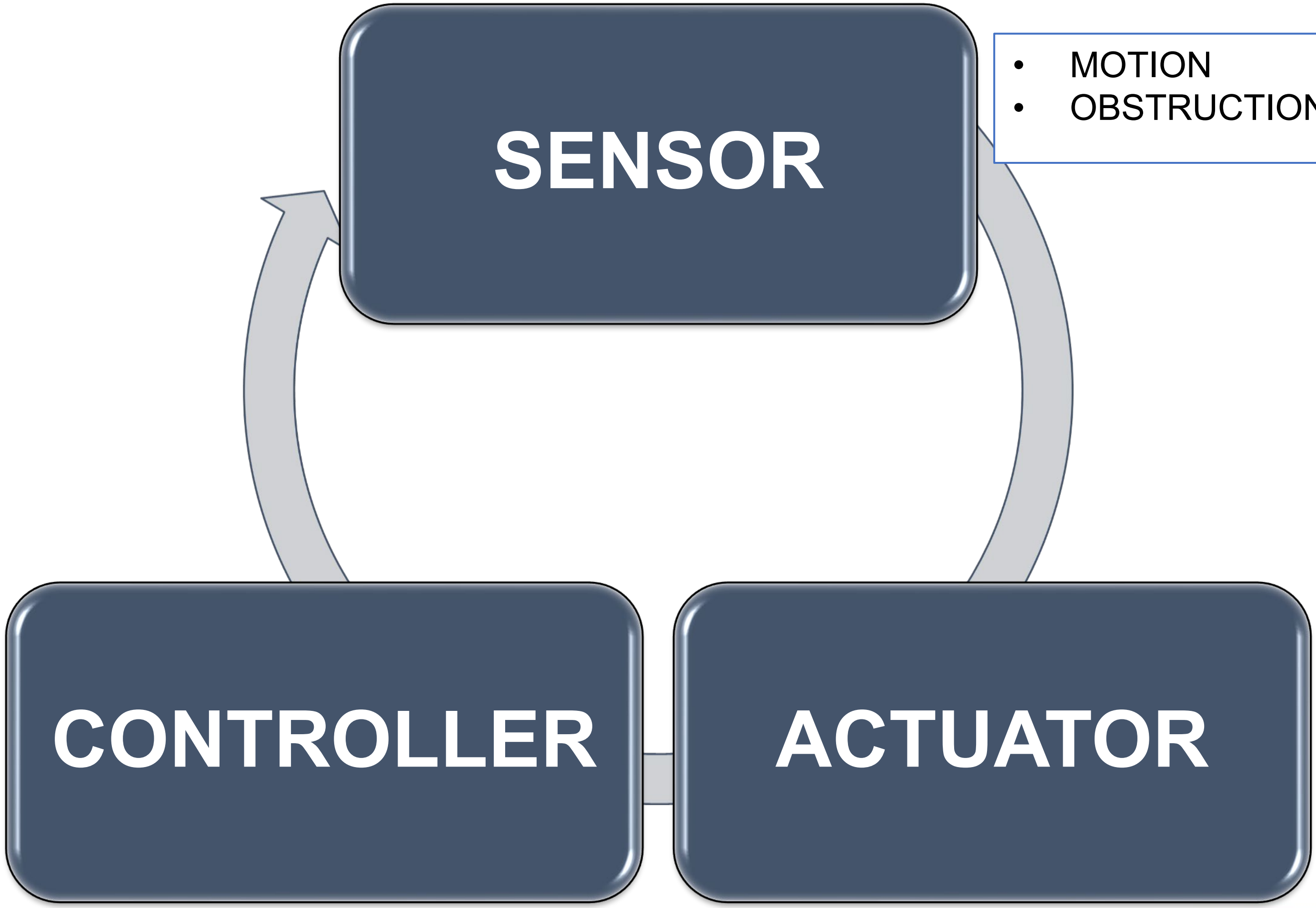
MECHANICAL
RTUs
PLCs
IoT DEVICES

MOTOR
PUMP
SWITCH
VALVE…

Process Control Loops

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

Obligatory hotel example



- MOTION
- OBSTRUCTION

- MOTOR (Rotation)

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

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**

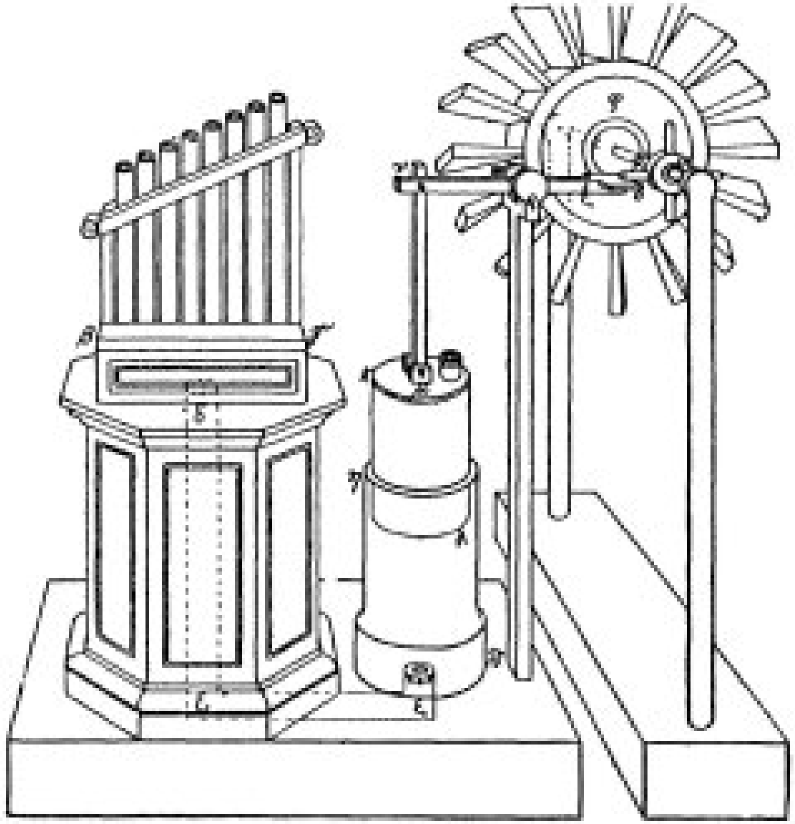
We Rely on Industrial Control Systems, Today

- 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

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



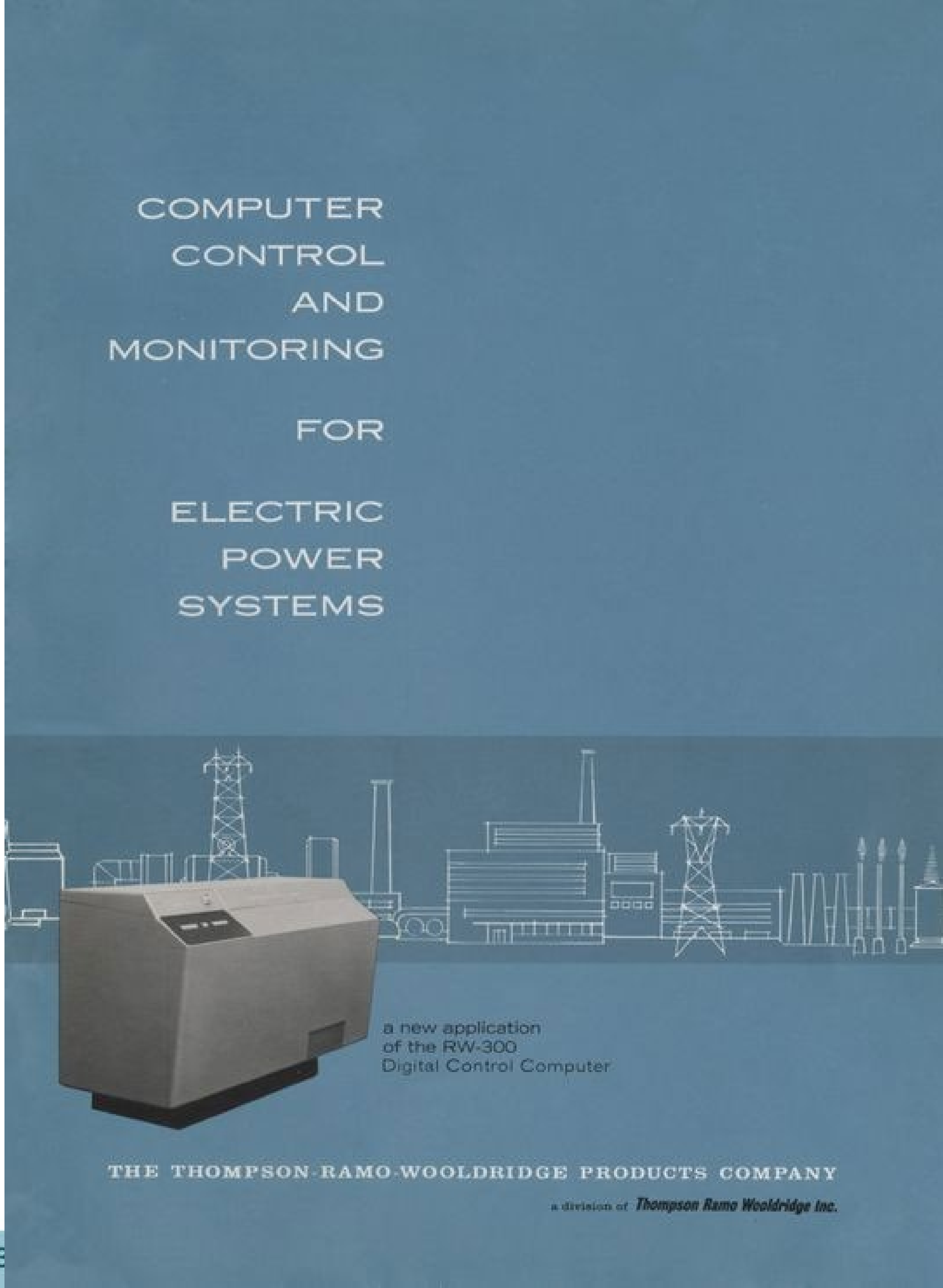
ICS Through the 20th Century

- 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.



COMPUTER
CONTROL
AND
MONITORING

FOR

ELECTRIC
POWER
SYSTEMS

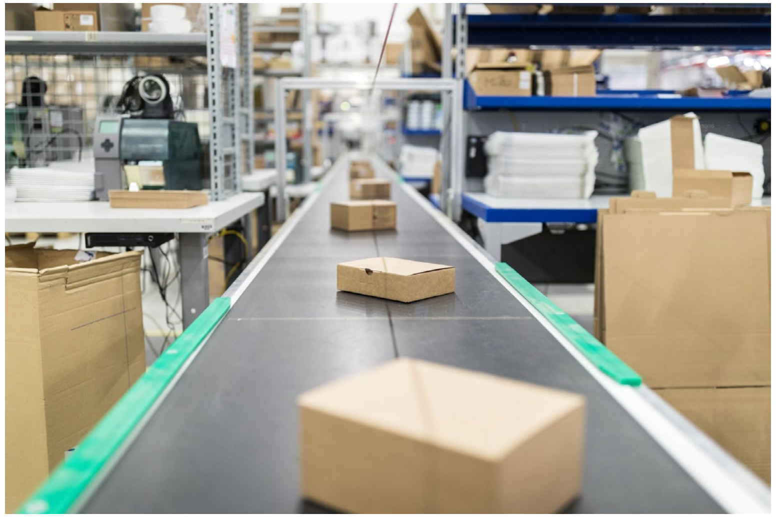
a new application
of the RW-300
Digital Control Computer

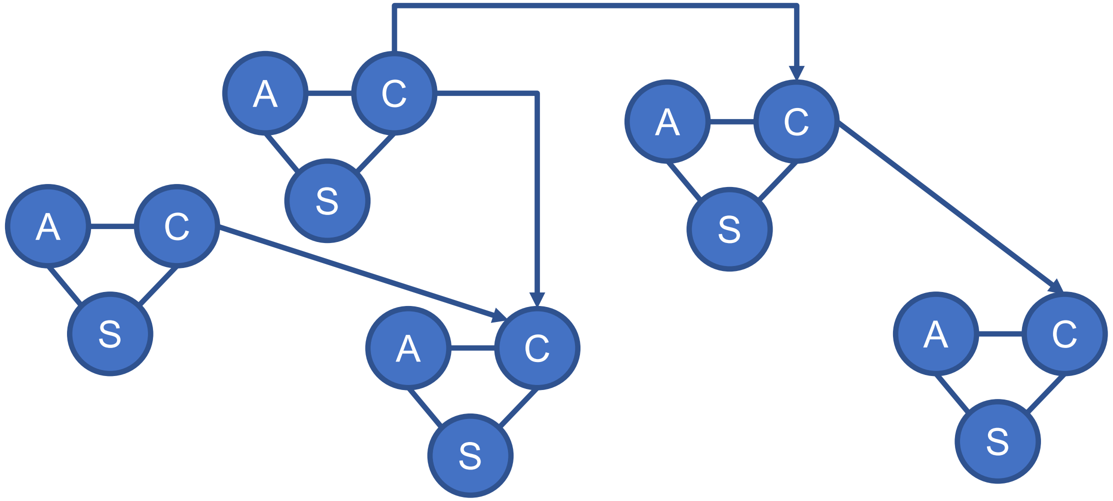
THE THOMPSON-RAMO-WOOLDRIDGE PRODUCTS COMPANY

a division of *Thompson Ramo Wooldridge Inc.*

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

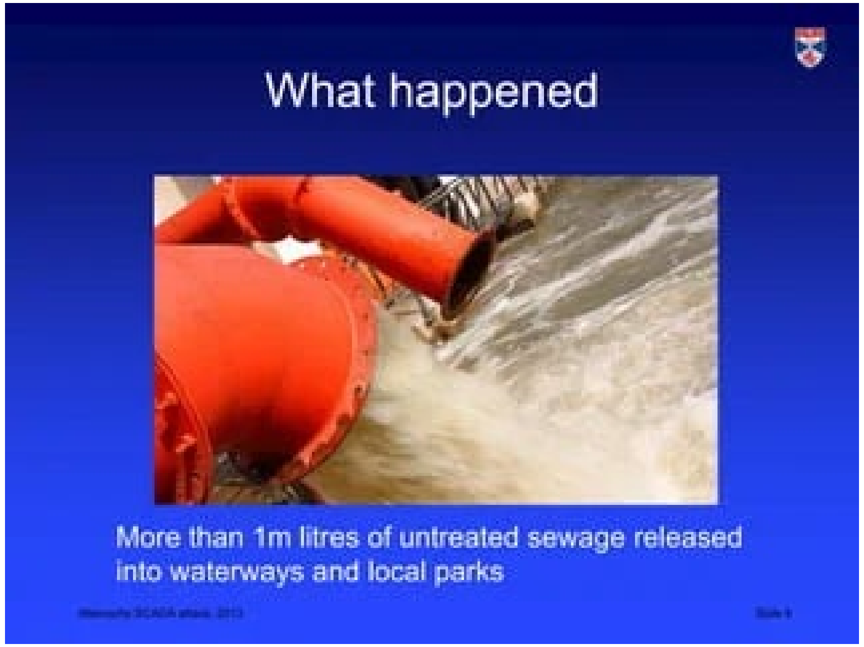
- Commercial computing equipment is **cheap** and **readily available**
- Shift from custom software and hardware to **enterprise vendors**
- Networks increase **efficiency** and **remote capability**
- **Cost savings** drive business choices

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

More Presence and Power, More of a Target…

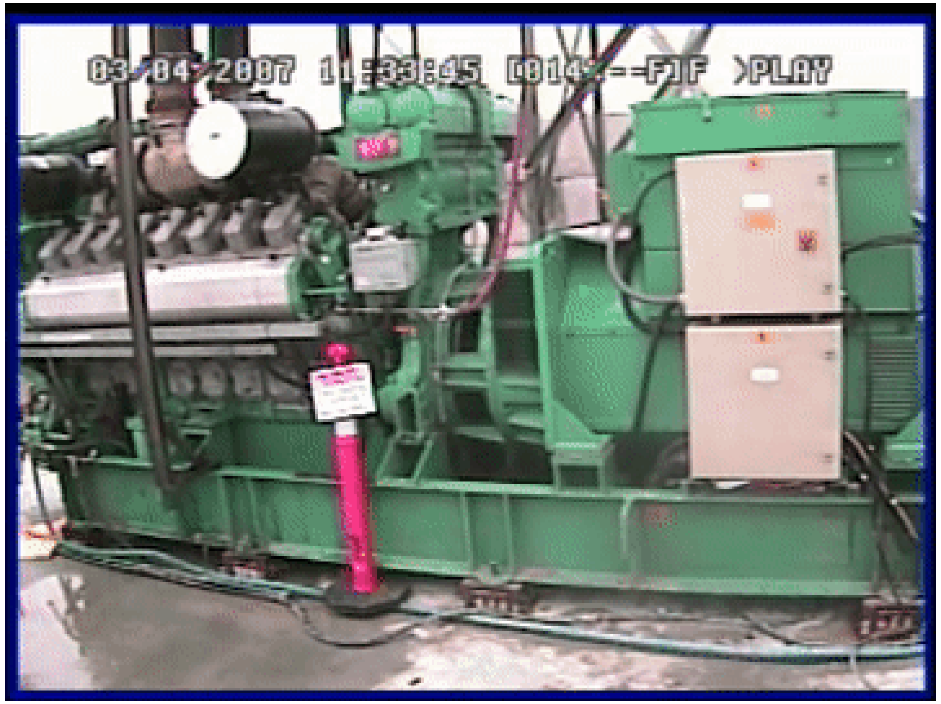
Early Attacks against ICS

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



What happened

More than 1m litres of untreated sewage released into waterways and local parks



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

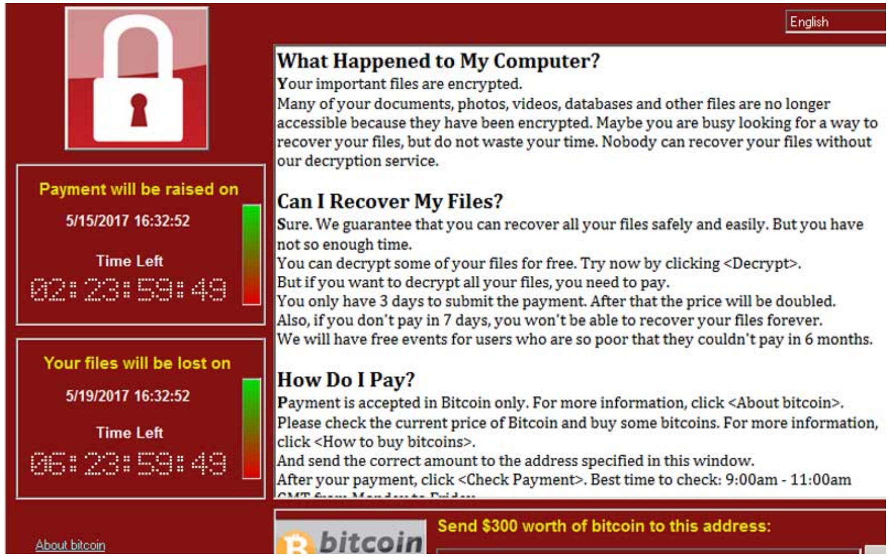
- **Ukraine is a long-term test bed for kinetic cyberattacks**
- December 2015 – cyber attack cuts power to quarter million Ukrainians for ~six hours
  - BlackEnergy 3 malware as vector
- December 2016 – second attack on Ukranian power grid, with additional disruptive elements, more sophisticated and 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 – Ransomware and PIPEDREAM

- ICS cyberattacks are evolving and becoming more efficient
- Ransomware, Colonial Pipeline, and commodity malware impacts
- 2022 - PIPEDREAM toolkit lowering the barrier to entry…



Payment will be raised on

5/15/2017 16:32:52

Time Left

02:23:59:49

Your files will be lost on

5/19/2017 16:32:52

Time Left

06:23:59:49

What Happened to My Computer?

Your important files are encrypted.

Many of your documents, photos, videos, databases and other files are no longer accessible because they have been encrypted. Maybe you are busy looking for a way to recover your files, but do not waste your time. Nobody can recover your files without our decryption service.

Can I Recover My Files?

Sure. We guarantee that you can recover all your files safely and easily. But you have not so enough time.

You can decrypt some of your files for free. Try now by clicking <Decrypt>.

But if you want to decrypt all your files, you need to pay.

You only have 3 days to submit the payment. After that the price will be doubled.

Also, if you don't pay in 7 days, you won't be able to recover your files forever.

We will have free events for users who are so poor that they couldn't pay in 6 months.

How Do I Pay?

Payment is accepted in Bitcoin only. For more information, click <About bitcoin>.

Please check the current price of Bitcoin and buy some bitcoins. For more information, click <How to buy bitcoins>.

And send the correct amount to the address specified in this window.

After your payment, click <Check Payment>. Best time to check: 9:00am - 11:00am GMT from Monday to Friday.

Send $300 worth of bitcoin to this address:

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

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 **Relationships**
- **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’.

Questions? Comments?

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