New Approaches to Protecting Critical Infrastructure from Cyber Attack

Linton Wells II
Centre of Excellence for National Security (CENS)
Distinguished Visitor Program (DVP) Lecture
September 2, 2016

Topics

- Types of Critical Infrastructures
- Observations from black hat and DEF CON
- Malicious Cyberspace Activities vs. Infrastructure Controls
- Characteristics of Smart Cities, Smart Nation Singapore
- Cyberspace Concerns in Smart City environments
- New Cybersecurity Approaches
- Opportunities and Risks for Singapore

Critical Infrastructures

Responsibilities typically assigned to ministries/ departments

In US, DHS's National Protection & Programs Directorate's (NPPD) Office of Infrastructure Protection (IP) leads coordinated national efforts to build resilience

Singapore Sectors (10)	US Sectors (16)
Economics	Commercial Facilities
Information	Communications
	Critical Manufacturing
	Dams
Security & Emergency	Defense Industrial Base
	Emergency Services
Energy	Energy
Banking and Finance	Financial Services
	Food and Agriculture
Government	Government Facilities
Health Care	Healthcare & Public Health
	Information Technology
	Nuclear Reactors, Material, Waste
Environment	Sector-Specific Agencies
Transportation	Transportation Systems
Water	Water & Wastewater Systems

Interconnections

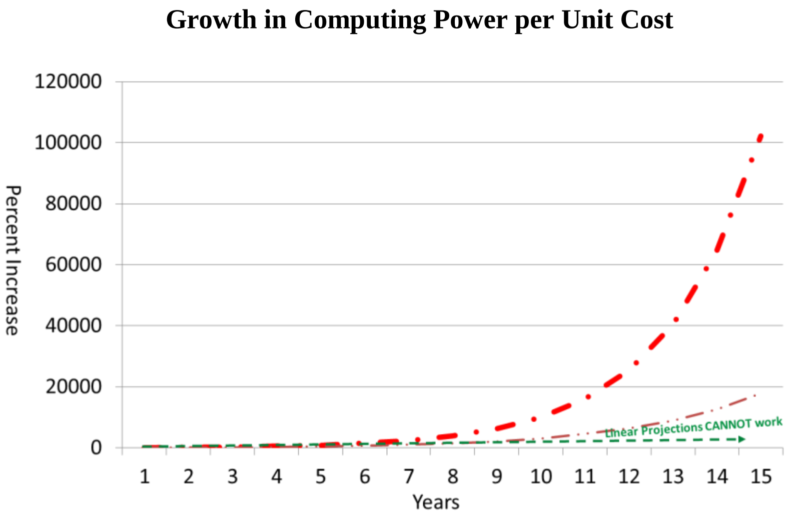
Superstorm Sandy example (2012)

- power, fuel and comms

- Some stations had fuel but no power to pump
- Some had power, but no fuel
- Decision-support systems didn’t integrate
- Comms often disrupted

Velocity of Tech Change

If a factor, e.g. computing power/unit cost, doubles every 18 mo, 5 yr increase is 900%, 10 yr 10,000%, by 2030 ~100,000%



Growth in Computing Power per Unit Cost

Capability doubles every 18 months▬ · ▬ Capability doubles every 24 months —··—

Biotech even faster, robotics ubiquitous, nano poised breakout, energy impacts are global

- Think BRINE (bio-robo-info-nano-energy) + Additive Manufacturing

Interactions complicate things

Linear projections CAN'T work

Planning and Engineering for Resilience

- Take **whole-of-society** approach:
  - Public-private, whole-of-government, transnational
- Address all dimensions: Physical, Cyber, Human, Temporal
- Consider scenarios (set in context)
  - Include threats, resources, tech change, political will, etc.—look ahead
- Analyze risk—consider:
  - Dependencies, including cross-sector vulnerabilities
  - Pathways to risk exposure (e.g. safety vs. security)
  - Cascading casualties
  - Overall risk across all dimensions
- Examine stakeholder perceptions
  - Including mental models
- Combine training, exercises, education and incentives to **change behavior**
  - Remember that **no lesson is ever learned until behavior changes**
- ACT EARLY
  - Designing in is ALMOST ALWAYS better than adding on afterwards

black hat/DEF CON 2016 Observations

- **No** reason for complacency about cybersecurity
- Speed: Reducing Time to Detect (TTD) of malware, remediate flaws faster, and aggressively update code
- Infrastructure remains vulnerable, complicated by exploding weaknesses in the Internet of Things (IoT)
- Software Defined Radios (SDR) and Software Defined Networks (SDN) can be secured, but
  - they require people who can integrate hardware and software fixes, and very skilled systems administrators
- DARPA's Cyber Grand Challenge (CGC) offered something new with Artificial Intelligence & Machine Learning (but far off)

black hat briefs re Smart Grid/ Industrial Security

- Drone Attacks on Industrial Wireless: A New front in Cyber Security [electronic attacks via drone]
- The Risk from Power Line Communications [G3 PLC sniffing]
- What's the DFIRrence for ICS? [Digital Forensics and Incident Response] for embedded devices
- Advanced CAN Injection Techniques for Vehicle Networks
- Understanding HL7 2.x Standards, Pen Testing, and Defending HL7 3.x Messages [health care messaging]
- The Tao of Hardware, the Te of Implants [Hardware hacking]
- PLC Blaster: A Worm Living Solely in the PLC [Siemens Simatic]

black hat briefings are at: https://www.blackhat.com/us-16/briefings.html

DEF CON Infrastructure-Related Events

Many of the DEF CON briefings are at: https://media.defcon.org/DEF%20CON%2024/DEF%20CON%2024%20presentations/

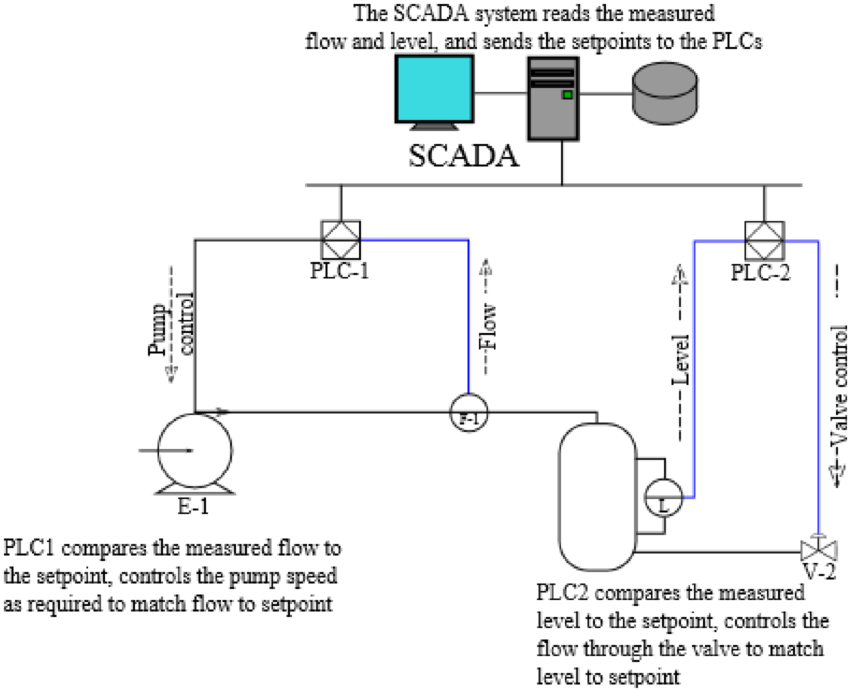
- **Villages**
  - Car Hacking
  - Hardware Hacking
  - IoT
  - Lockpick
  - Social Engineering
  - Wireless (including Software-Define Radios-SDR)
  - Packet Hacking
- **Workshops**
  - Pentesting Industrial Control Systems (ICS) 101
  - Applied Physical Attacks on Embedded Systems
- **Presentations**
  - How to Remote Control an Airliner: Security Flaws in Avionics
  - Picking Bluetooth Low Energy Locks from a Quarter Mile Away
  - Hacker-Machine Interfaces: The State of the Union for SCADA HMI Vulnerabilities
  - All Your Solar Panels Are Belong to Me
  - Hacking Hotel Keys and Point-of-Sale Systems
  - Attacking Base Stations—An Odyssey Through a Telco's Network [via eNodeB]
  - Network Attacks Against Physical Security Systems
  - Can You Trust Autonomous Vehicles: Contactless Attacks Against Sensors of Self-Driving Vehicles

Malicious Cyberspace Actions

- Deny
- Disrupt
- Degrade
- Destroy
- Deceive
- Combine with Information Operations
- Combine with kinetic actions

Industrial Control Systems (ICS) & SCADA Systems (Supervisory Control and Data Acquisition)

ICS/SCADAs are ubiquitous, but HIGHLY insecure


The SCADA system reads the measured flow and level, and sends the setpoints to the PLCs
SCADA
PLC-1
PLC-2
Pump control
Flow
Level
Valve control
F-1
L
E-1
V-2
PLC1 compares the measured flow to the setpoint, controls the pump speed as required to match flow to setpoint
PLC2 compares the measured level to the setpoint, controls the flow through the valve to match level to setpoint

- Most architectures not designed for security
- Multiple entry and attack paths
- Default settings weak—vulnerable on reboot
- Often old, hard to fix
- IoT (Cloud of Everything) will dramatically increase "attack surface"

Types of Attacks Against ICS/SCADA

- Human Machine Interface (HMI)—200+ vulnerabilities discovered
- Distributed Denial of Service (DDOS)
- Remote penetration
- Hardware/firmware modification
- Supply chain vulnerability
- Social engineering
- Cleared insider
- Targets
  - Pressure/temperature/voltage modification
  - Set point modification
  - Programmable Logic Controllers (PLCs)
- Examples: Hospital and production line modification

Internet of Things (IoT)

- Should be "Cloud of Everything"—human body becoming a platform, apps interact
- Growing attack surface
  - IHS projects 53 billion IoT devices by 2020, 3x 2013*
  - More than 300 kinds of IoT have been hacked
  - 26% of cyber attacks in Japan in 2015 targeted IoT devices

- Almost **NO** market demand for security
  - Functionality and speed-to-market dominate priorities
- Be careful not to build "Smart Nation" on a foundation of sand
  - Internet Engineering Task Force (IETF) began work on IoT in 2006—use them
- Educate people in cyber security
  - Lou Gerstner story
  - Singapore could do this better than most

* *Japan News* Aug 24, 2016, p. 1

Characteristics of Smart Cities

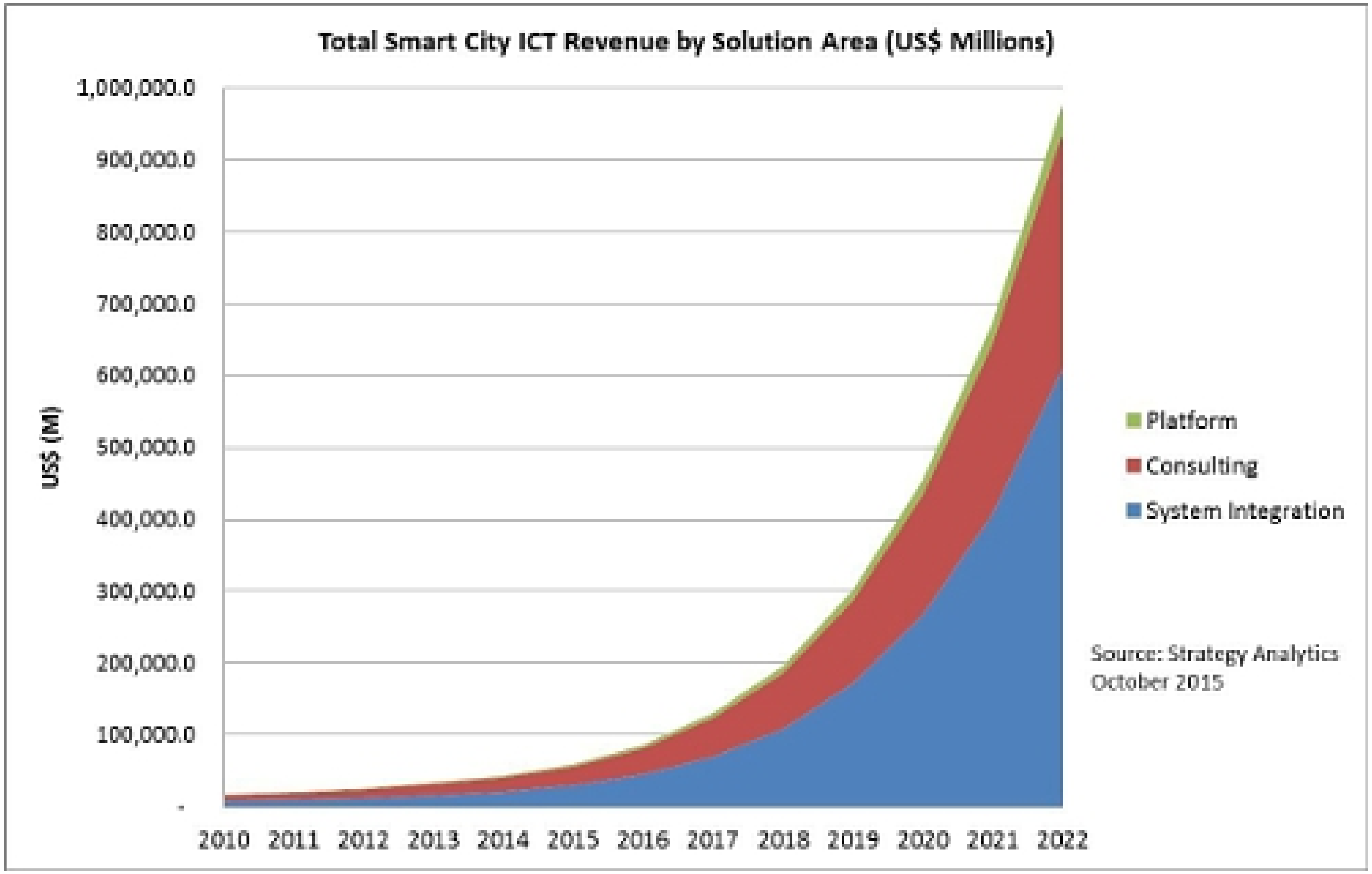
A **smart city** uses digital technologies or information and communication technologies (ICT) to

- enhance quality and performance of urban services
- reduce costs and resource consumption
- engage more effectively and actively with its citizens

Source: SmartCitiesCouncil

Cyberspace is a key part of Smart Cities

Projected Smart City ICT Revenue



Source: Andrew Brown, Strategy-Analytics

One estimate is $977 billion by 2022

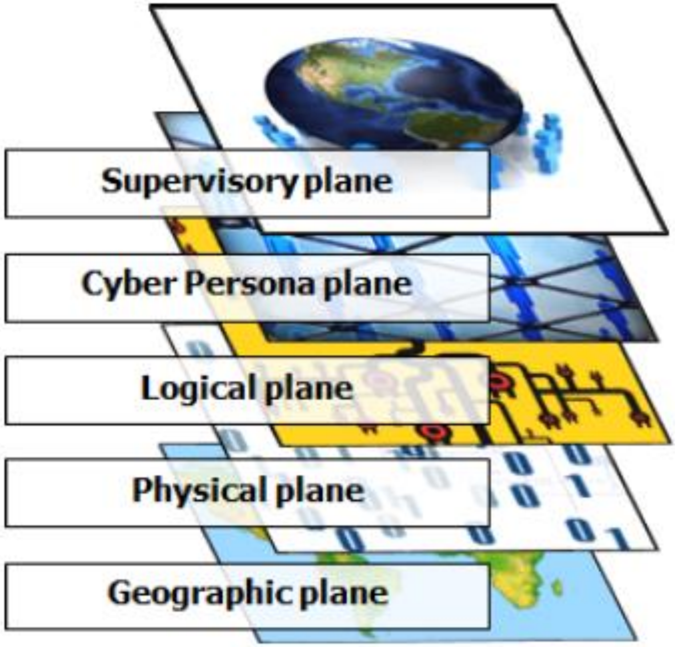
Smart Nation Singapore

- Smart Nation Platform (SNP): Connect, Collect & Comprehend→Create
  - Above-Ground (AG) Boxes
  - Heterogenous Network (HetNet)
- Benefits
  - Citizens: Greater citizen-centric services, empowerment
  - Businesses: Enable innovation
  - Public agencies: Greater efficiency, stronger inter-agency cooperation
- Steps: Sensor Mapping, Smart Traffic, Smart Homes

Cyberspace Concerns in Smart City Environments

- Organizations, People, Processes, Technology
- Many stakeholders, level of collaboration
- Skill sets, agendas
- Governance, whole-of-society approaches
- Control tech, underlying tech, rate of change

Cyberspace Planes



From: Greg Conti, et. al., PEN Testing a City Briefing presented at black hat Aug 2015

● **Supervisory** – Often siloed/ compartmentalized between sectors

● **Persona** - Relevant identities or accounts; do you know who to contact in other sectors?

● **Logical** - System compatibility; how do various networks and systems communicate?

● **Physical** - Redundancy; can connectivity be compromised?

● **Geographic** - Physical location can be important!

Also have Cross-Cutting Vulnerabilities among Infrastructures

Risks for Singapore

- Single impactful events
  - – Disrupt services
  - – Damage infrastructure
  - – Injure people
- Persistent disruptions, e.g. rolling blackouts
  - – Political pressure, job action
- Multi-domain campaign like RU is mounting against Ukraine
  - – Undercut people's confidence in government
  - – Influence political actions

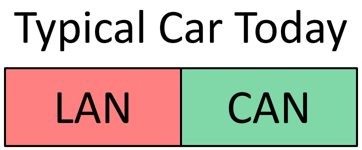
New Cybersecurity Approaches Opportunities for Singapore

- Boundary control points and segmented enclaves
- Cyber Secure Microgrids--SPIDERS
- Secure Codes/Components
- NRT anomaly detection and response
  - Hawaii Electric Company (HECO)
  - Supervisory Phasors
- Educated Population
- AI & ML and binaries

Opportunities for Singapore (1)

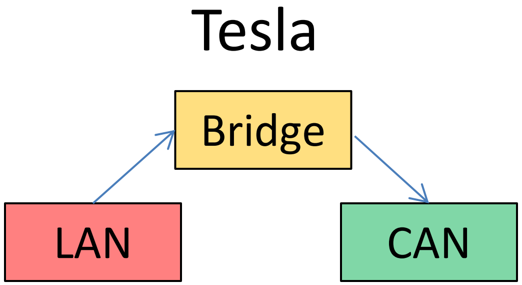
Boundary Control Points & Segmented Enclaves

Tesla security architecture shows there IS a secure alternative



Typical Car Today

LAN CAN



Tesla

Bridge

LAN

CAN

Typical car today

- Mixes Infotainment LAN and vehicle control CAN (Controller Area Network)
- Multiple RF paths into LAN
- Hard to patch

Tesla

- Separates LAN & CAN
- Crypto-secure bridge
- Over-the-air fixes

Can Tesla-like “wrapper” be applied to traditional SCADA systems in Singapore’s systems?

Applications

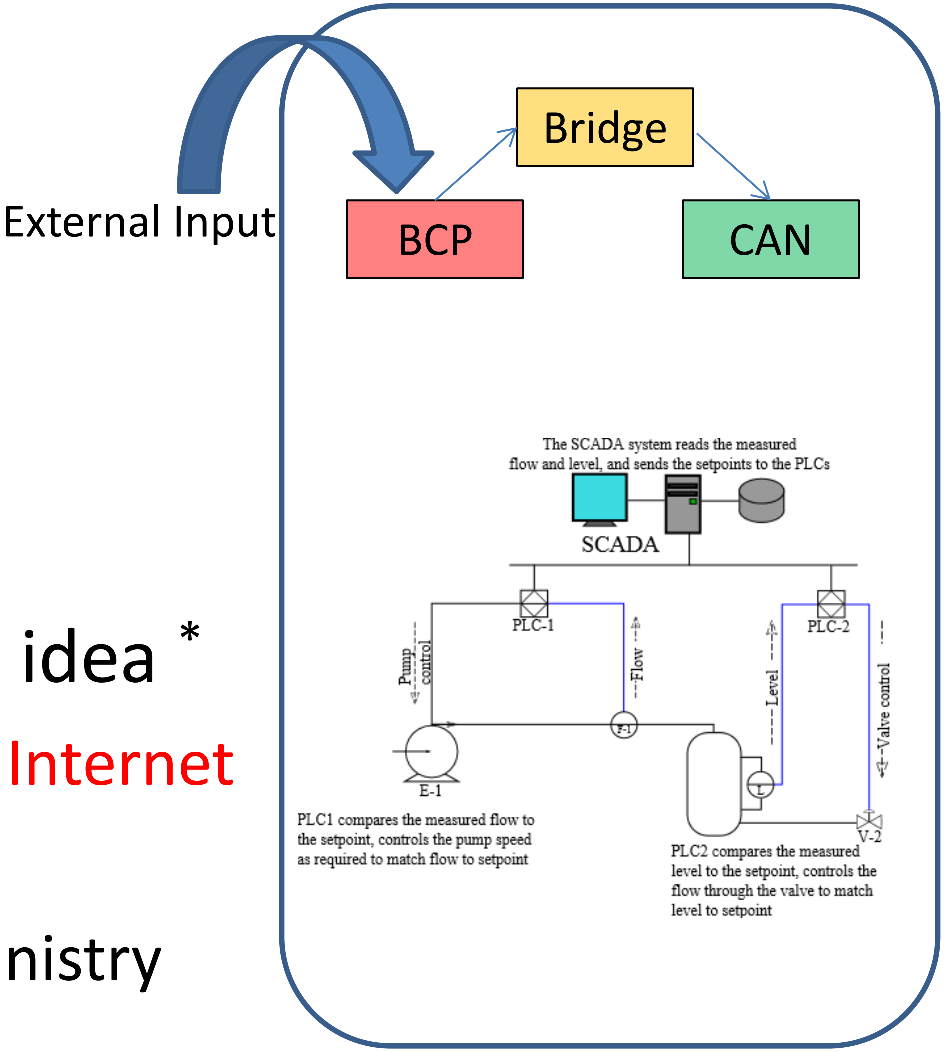
- Wrapper for ICS/SCADA

- USN “Cyber Resiliency”
  - Boundary Control Points/ Enclave Segregation
  - Design in Security
  - Muliti-level training

- Japanese “protective wall” idea *

IoT Devices at Home	Protective Wall (System)	Internet

Internal Affairs and Comms Ministry



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Opportunities for Singapore (2)

Cyber Secure Microgrid--SPIDERS

SPIDERS
(Smart Power Infrastructure Demonstration for Energy Reliability and Security)

Cyber-secure microgrid architecture:

- smart grid technologies
- distributed and renewable generation
- energy storage

on military installations to enhance mission assurance

Phase 1: Single circuit demo of cyber-secure microgrid for waste water treatment

Phase 2: Multi-building demo

- Integrated large solar PV array and microgrid connected electric trucks

Phase 3: DoD’s first installation-wide microgrid

Next step is project transition, possibly to private sector

Opportunities for Singapore (3)

Use More Secure Codes/Components

Cybersecurity liability costs likely to rise

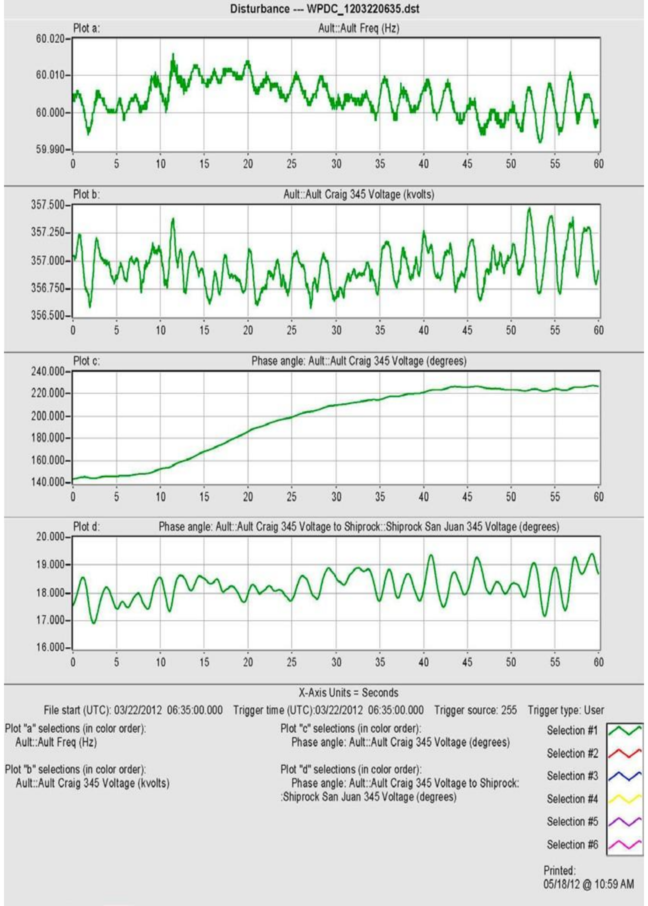
- Some project 25-30% of IT budgets will be for insurance in a few years
  - These funds not available for investment or innovation
  - Per Singtel, today's cyber insurance market is under developed
- Singapore could set codes requiring more secure components, and focus on more secure interoperability
- Build on reputation for quality
  - Lower insurance costs and liability risk
  - Consider how "Smart Buildings" can contribute to security of "Smart Cities"
  - Perhaps as part of secure microgrids

Opportunities for Singapore (4)

Near-Real Time Anomaly Detection

Hawaiian Electric
Maui Electric
Hawaiʻi Electric Light

- Supervisory Phasors
  - – Collect data across grid
- Big Data Analytics
  - – Near-Real Time (NRT) anomaly detection
  - – Irrespective of source
  - – Address problems directly



Disturbance --- WPDC_1203220635.dst

X-Axis Units = Seconds

File start (UTC): 03/22/2012 06:35:00.000 Trigger time (UTC):03/22/2012 06:35:00.000 Trigger source: 255 Trigger type: User

Plot "a" selections (in color order):
Ault::Ault Freq (Hz)

Plot "b" selections (in color order):
Ault::Ault Craig 345 Voltage (kvolts)

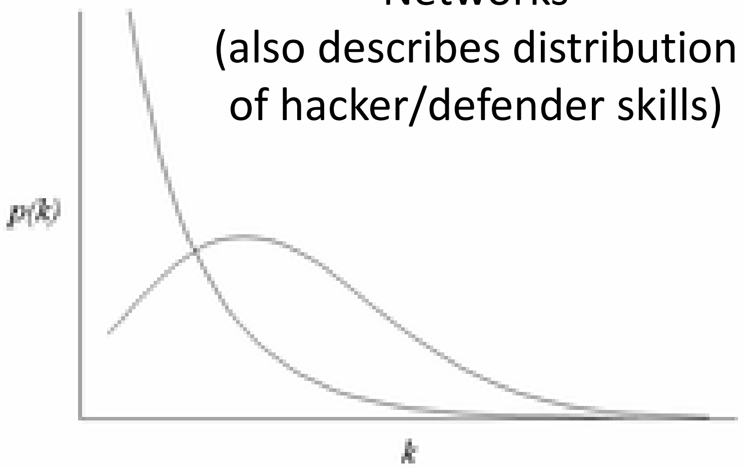
Plot "c" selections (in color order):
Phase angle: Ault::Ault Craig 345 Voltage (degrees)

Plot "d" selections (in color order):
Phase angle: Ault::Ault Craig 345 Voltage to Shiprock:
:Shiprock San Juan 345 Voltage (degrees)

Printed:
05/18/12 @ 10:59 AM

Opportunities for Singapore (5)
Educated Population

- Teach on many levels
  - Executives/Commanders
  - Managers
  - Cyber
- Life-long learning
- Develop elite skills



Random vs Scale-Free Networks
(also describes distribution of hacker/defender skills)

Source: Wikipedia

Opportunities for Singapore (6)

Artificial Intelligence (AI) & Machine Learning (ML)

- DARPA’s Cyber Grand Challenge (CGC) offered something new:
  - Artificial Intelligence (AI), Machine Learning (ML), and Big Data Analytics, plus
  - Focus on security operations at the binary level and
  - “formal verification” of code, offer ways to
  - **“imagine a future with some likelihood of cybersecurity”***
- Long term project, but it offers a way ahead
  - But ML algorithms also can be hacked

*DARPA Director Dr. Arati Prabhakar, at DEF CON Aug 5, 2016

Opportunities for Singapore (7)

Sept 14, 2015 US “Smart Cities” Initiative

- $160M in Federal research & leverage over 25 tech collaborations
- Help local communities reduce traffic congestion, foster economic growth, manage climate change impacts, improve service delivery
- Four strategies
  - Test beds for IoT apps & multi-sector collaborative models
  - Collaborate with civic tech movement, inter-city collaboration
  - Leverage existing Federal activity
  - Pursue international collaboration
- Singapore-related areas:
  - $10M Cyber-Physical Systems Program, includes smart buildings
  - $2.5M Global City Teams Challenge: integrate networks & physical
  - $2.5M for research to improve interdependent infrastructures
  - $3M from DoE to advance smart building technologies

Ways that Companies can Contribute

- Rethink Public-Private Partnerships for Smart Nation
- Commit to “Smarter & Greener” Construction
  - Smart buildings
  - Use reliable components
  - Energy management
  - Green energy
- All contribute to:
  - Enhanced quality and performance of urban services
  - Reduced costs and resource consumption
- Corporate Social Responsibility (CSR)
  - Smart City projects

Summary

- These are big issues
- Can’t be taken for granted
- The “smarter” the city, the bigger the “attack surface”
  - Consider “thin line” fallback
- But lots of opportunities

QUESTIONS?

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