Vulnerabilities of Cyber-Physical Systems: From Football to Oil Rigs

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Image credits: wikipedia.org

DIMACS

Center for Discrete Mathematics & Theoretical Computer Science
Founded as a National Science Foundation Science and Technology Center

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Vulnerabilities of Cyber-Physical Systems: From Football to Oil Rigs

- Some of our nation’s most important critical infrastructure is increasingly controlled by computer networks.
  - Power systems (“smart grid”)
  - Transportation systems (“smart transportation”)
  - Water supply systems
  - Air traffic control
  - Building control systems (“smart buildings”)
- This infrastructure is potentially vulnerable to failures of computer systems or deliberate cyber attacks

Source: www.leesburgva.gov

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Super Bowl 47, New Orleans

- Was it terrorism?
- Was it cyber-terrorism?
- (Luckily just a relay device failing at Entergy Orleans)

Credit: businessinsider.com

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Super Bowl 48, New Jersey

Credit: new.mta.info

NJ State Police Regional Operations Intelligence Center pre-game assessment:

- ***Cyber attacks by "ideologically motivated and malicious" hackers, exploiting wireless systems, on stadium infrastructure or Super Bowl websites, is a serious possibility.***

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CCICADA Center

- Founded 2009 as a ***Dept. of Homeland Security University Center of Excellence***
- Based at Rutgers University in New Brunswick/ Piscataway, NJ
- We apply methods of mathematics, computer science, statistics and operations research to problems of homeland security.
- We partner with behavioral scientists, economists, biologists, epidemiologists, physicians, sociologists, industrial engineers, etc.
- We work with public and private agencies and organizations throughout the “homeland security enterprise”

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CCICADA and Stadium Security

- Numerous projects on patron inspection, employee credentialing, safety and security of infrastructure, etc.
- Working with all major sports leagues (MLB, NFL, NBA, NHL, MLS, etc.) + NCAA and minor leagues

Lambeau Field – Mike Roemer/AP

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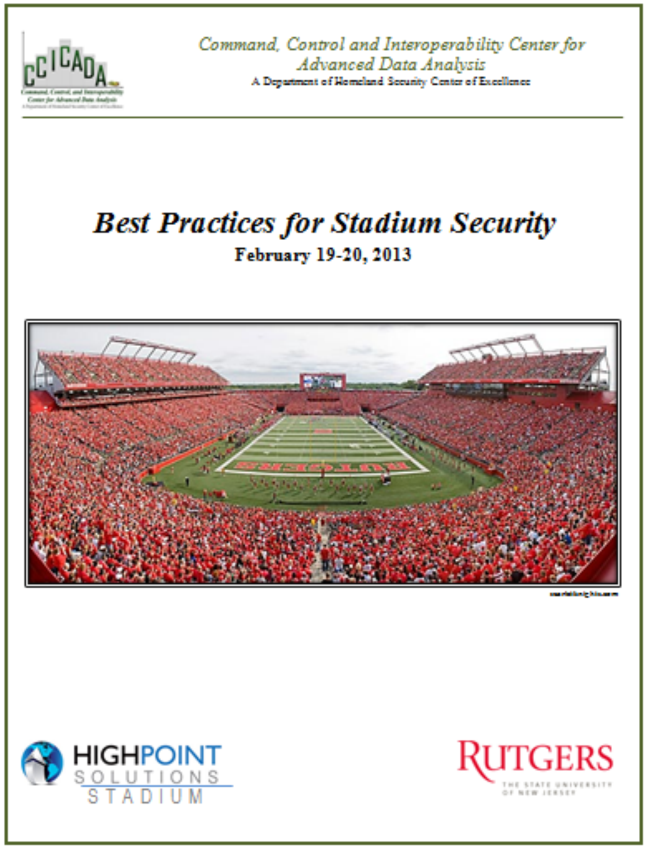
CCICADA Project: Best Practices for Stadium Security

Supported by DHS Office of SAFETY Act Implementation (OSAI)

CCICADA's Best Practices for Stadium Security Resource Guide can be found on the OSAI website

Widely used by all major leagues



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Best Practices for Stadium Security
February 19-20, 2013

HIGHPOINT SOLUTIONS STADIUM

RUTGERS THE STATE UNIVERSITY OF NEW JERSEY

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It’s not Just Sports Stadiums

- It’s any places where large crowds gather
  - Airports
  - Train stations, bus terminals
  - Concert halls
  - Amusement parks
  - Political conventions
  - Restaurants

Port Authority Bus Terminal, NYC
Credit: nj1015.com

Highlighted by recent events:

- Paris attacks Nov. 2015
- Ariana Grande Concert Manchester 2017
- Las Vegas Country Music Concert 2017

Cyber-Physical Systems

- ***Cyber-physical systems (CPS)***: Engineered systems that are built from and depend upon the synergy of computational and physical components.
- National Science Foundation (2013): “The CPS of tomorrow will need to far exceed the systems of today in capability, adaptability, resiliency, safety, security, and usability.”

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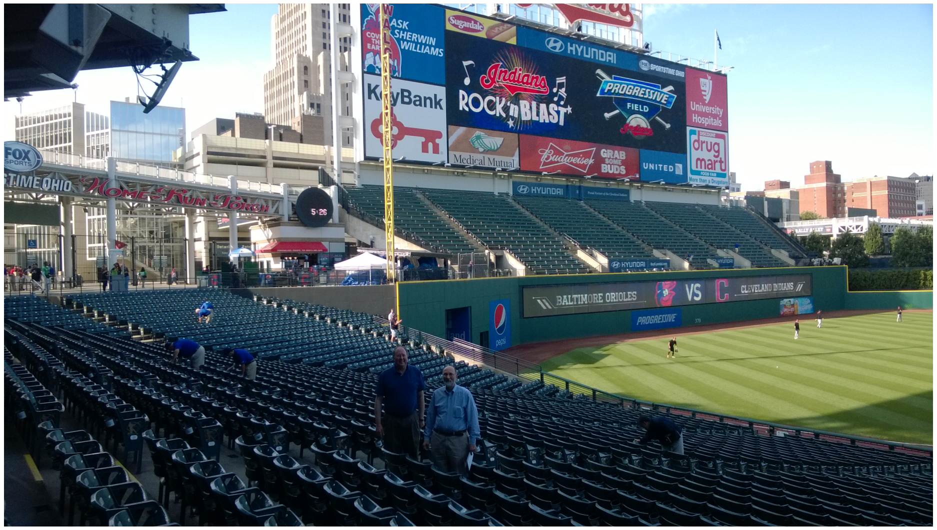
Cyber-physical Systems in Stadiums

- Access control systems
  - For patrons
  - For employees
- HVAC
- Communication systems
  - Electronic message boards
  - Public address systems
- Security cameras
- Elevators, escalators
- Lighting systems
- Power systems
- Traffic control in the parking lots



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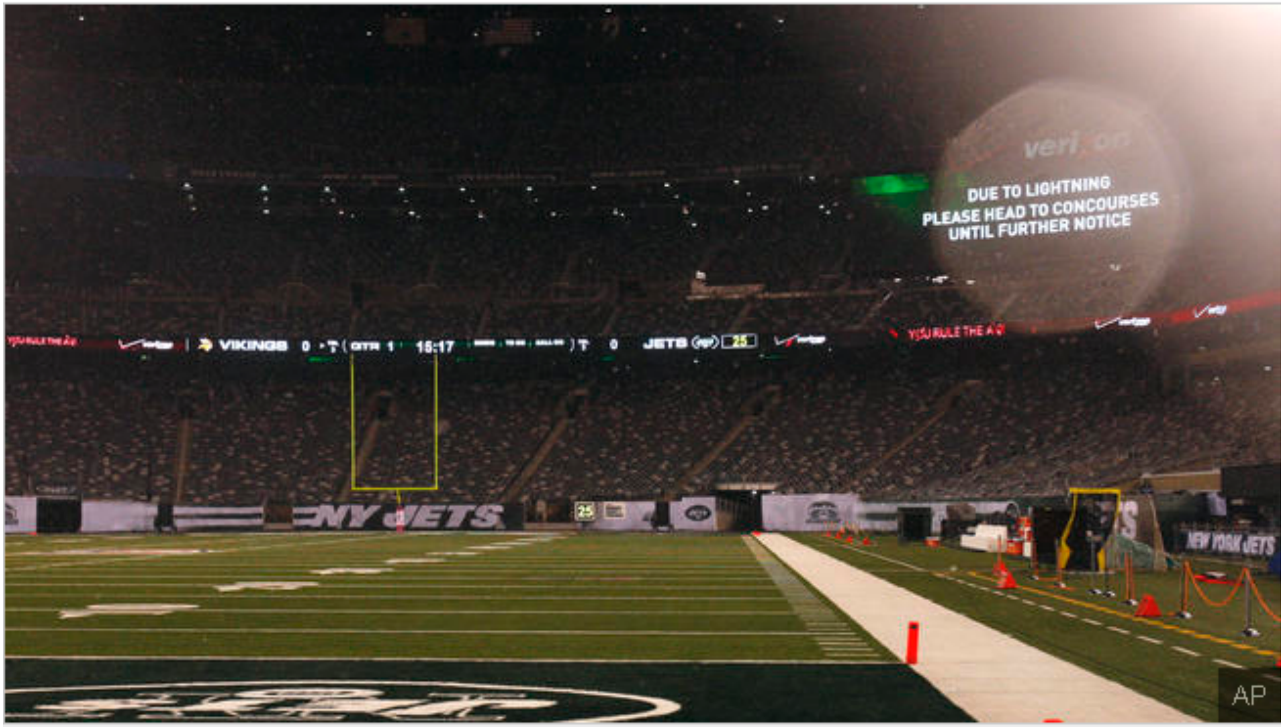
Example: Hacking into the Communications System

- This was a real emergency and a real message.
- But imagine what chaos a hacker could cause with a fake emergency message.



Stands are empty before an NFL football game between the Minnesota Vikings and the New York Jets on Monday, Oct. 11, 2010, in East Rutherford, N.J. The start of the game was delayed because of lightning and heavy rain; fans were cleared from the stands.

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Cyber-physical Systems in Stadiums

- Attack at Ariana Grande Concert in Manchester, UK – May 2017
- People attacked leaving the concert venue.
- Could a cyber attack on the message board directing people to leave be a prelude to a similar attack?

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Example: Drones over Stadiums

- A real concern of major sports leagues
- Recent NFL policy
- FAA setting rules
- Prof. Todd Humphreys of UT Austin has demonstrated how global positioning system (GPS) signals of an unmanned aerial vehicle can be commandeered by an outside source

Source: UT Austin Aerospace Engineering

Cyber-physical Systems in Stadiums

- Report by CNBC (Nov. 2013) names five large sports stadiums running a particular industrial control system software with known vulnerabilities.
- Include Bryant-Denny Stadium (University of Alabama) and Marlins Park (home of the Miami Marlins baseball team)
- Vulnerabilities supposedly addressed by now.

Bryant-Denny Stadium
Credit: wikipedia.org

So Why So Many Vulnerabilities?

- Building management systems have many parties involved
  - Selling
  - Implementing
  - Maintaining
- Need systems for large, complex facilities
- CPS are of great complexity and are often engineered for environments not engineered from scratch (as in the power grid)
- Cyber security neglected
- Management doesn't want to pay for cyber security (security in general)
- Public/private communication needs improvement

Another Scenario: Car Hacking in the Stadium Parking Lot

- Terror attacks using vehicles on the rise:
  - Berlin, Nice, London
- But terrorists ended up dying in the process.
- What if they could control a car remotely and not risk dying and use it in a crowded stadium parking lot?

Christmas Market Vehicle Attack, Berlin, Dec. 2016
Credit: wikipedia.org

Another Scenario: Car Hacking in the Stadium Parking Lot

- Car hacking: criminals remotely take control of your car
- Imagine the damage a hacker could do in a stadium parking lot.

Credit: ctvnews.ca

Another Scenario: Car Hacking in the Stadium Parking Lot

- Car hacking: criminals remotely take control of your car
- A serious challenge as in-car technology becomes more sophisticated
- Already thousands of semi-autonomous cars
  - In-car computer systems
  - Electronic control units
- Coming: fully autonomous cars
  - Self-driving cars

Credit: wikipedia.org

Another Scenario: Car Hacking in the Stadium Parking Lot

- 2013: Miller (Twitter) and Valasek (IOActive) demonstrated take control of Toyota Prius and Ford Escape from a laptop.
- They were able to remotely control:
  - Smart steering
  - Braking
  - Displays
  - Acceleration
  - Engines
  - Horns
  - Lights

Credit: npr.org

Another Scenario: Car Hacking in the Stadium Parking Lot

- What about self-driving cars?
- Could we hack into them?

Tesla
Credit: en.wikipedia.org

Why Vulnerabilities in Cars?

- Vehicle control system depends on system components manufactured by different vendors
- Each vendor uses their own software and hardware
- Manufacturers like to develop components that will work for different kinds of vehicles (cheaper) – spreading the vulnerabilities
- Increasing complexity of components like sensors, actuators, wireless communication, multicore processors

Credit: Baheti and Gill (2011)

Why Vulnerabilities in Cars?

- Development of control system may be independent of system implementation
- Challenge of integrating various subsystems while keeping them functional
- Research missing on understanding interactions between vehicle control systems and other subsystems:
  - Engine, transmission, steering, wheel, brake, suspension

Credit: Baheti and Gill (2011)

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From Cars to Ships

- Vulnerabilities in CPS for cars have been highly publicized.
- Much less well known: vulnerabilities in CPS of the maritime transportation system.
- CCICADA has numerous projects in collaboration with the US Coast Guard, Customs and Border Protection, and other agencies on safety and security of the maritime transportation system.

Hacking into a Ship

- A recent demonstration by a UT Austin team showed how a potential adversary could remotely take control of a vessel by manipulating its GPS.
- The yacht “White Rose of Drax” was successfully spoofed while sailing on the Mediterranean.
- The team’s counterfeit signals slowly overpowered the authentic GPS signals until they ultimately obtained control of the ship’s navigation system.
- “The ship actually turned and we could all feel it, but the chart display and the crew saw only a straight line.”

Source: UT Austin “Know”

Hacking into a Ship

- The maritime transportation system is critical to the world’s economy.
- 95% of goods in international trade are still transported by sea.
- Disruption of global supply chain for commodities such as oil or food could cause dramatic problems for the world-wide economy.
- Disruption of the maritime transportation system could cause billions of dollars in damage to the economy.
- During January 2015, ports on US West Coast were closed due to a labor stoppage – with dramatic impact on the economy.

Maritime Cyber: Modern Ship CPS

- For modern ships: dependence on a proliferation of sophisticated technology – that is subject to cyber attack
  - ECDIS (Electronic Chart Display and Information System)
  - AIS (Automatic Identification System)
  - Radar/ARPA (Radio Direction and Ranging) (Automatic Radar Plotting Aid)
  - Compass (Gyro, Fluxgate, GPS and others)
  - Steering (Computerized Automatic Steering System)
  - VDR (Voyage Data Recorder –"Black Box")
  - GMDSS (Global Maritime Distress and Safety System)
  - Numerous other advanced units and systems

Thanks to Capt David Moskoff, US Merchant Marine Academy, for many of the following Examples. Also thanks to Dana Goward and Joe DiRenzo.

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Electronic Chart Display & Info System

- Electronic Chart Display and Information System (ECDIS):
  - Computer-based navigation system
  - Can be used as an alternative to paper navigation charts
  - Integrates a variety of real-time information
  - Automated decision aid - continuously determining ship's position in relation to land, charted objects, navigation aids and unseen hazards
  - Includes electronic navigational charts and integrates position information from the Global Positioning System (GPS) and other navigational sensors, such as radar, fathometer and automatic identification systems (AIS).
  - May also display additional navigation-related information, such as sailing directions.

Electronic Chart Display & Info System

- Electronic Chart Display and Information System enables solo watchstanding

Electronic Chart Display & Info System

- World’s largest container ship: Triple E Maersk under construction
  - 18,000 containers
  - 400 meters long!
  - Crew size: Can operate with 13 crew members!!
    - ➢Thanks to ECDIS & other such systems.

Credit: http://www.worldslargestship.com/

Electronic Chart Display & Info System

- The Royal Caribbean’s Allure of the Seas cruise ship, launched in 2010, is not far behind in size.
- 360 meters long
- Capacity of 6360 passengers

Credit: royalcaribbean.com/

Electronic Chart Display & Info System

- ECDIS flaws might would allow an attacker to access and modify files and charts on board or on shore; could cause serious environmental and financial damage, even loss of life.
- In Jan. 2014, the NCC Group tried to penetrate an ECDIS product from a major manufacturer.
- Several security weaknesses were found: ability to read, download, replace or delete any file stored on the machine hosting ECDIS, etc.
- Once such unauthorized access is obtained, attackers could be able to interact with the shipboard network and everything to which it is connected.
- Attack could be made through something as basic as insertion of USB key or download from Internet.

Sources: templarexecs.com 2014, CyberKeel 2014

Electronic Chart Display & Info System

- Special concern for cruise ships.
- Passengers want to be connected while on board.
- Shipboard control systems could be vulnerable as a result.
- Modern cruise ships keeping passenger internet access firewalled from shipboard systems, ECDIS for example.

Credit: commons.wikimedia.org

Automatic Identification System

- Automatic Identification System (AIS) transceivers on over 1.000,000 ships worldwide.
- Installation is mandatory for all passenger ships and commercial (non-fishing) ships over 300 metric tons per International Maritime Union agreement.
- Tracks ships automatically by electronically exchanging data with other ships, AIS base stations, and satellites.

Source: Help Net Security

Credit: wikipedia.org

Automatic Identification System

- AIS enables ships to communicate with other ships, plot a course and follow it, and avoid collisions with other ships, reefs, floating objects, etc.
- An attacker with a $100 VHF radio could exploit weaknesses in Automatic Identification System which transmits data (e.g. vessels' identity, type, position, heading and speed to shore stations).
- The attacker could also tamper with the data, impersonate port authorities, communicate with the ship or effectively shut down communications between ships and with ports.

Source: templarexecs.com 2014, Help Net Security net-security.org

Automatic Identification System

- In Oct. 2013 Trend Micro demonstrated how easy it is to penetrate a ship's AIS.
- Plausible scenarios (CyberKeel 2014):
  - Modification of all ship details, position, course, cargo, speed, name
  - Creation of "ghost" vessels at any global location, which would be recognized by receivers as genuine vessels
  - Trigger a false collision warning alert, resulting in a course adjustment

Attack 3: CPA Alerting [1/2]

- Fake a CPA alert (Closest Point of Approach) and trigger a collision warning alert.

Dr. Marco Balduzzi of Trend Micro discussing potential scenario
Credit: Help Net Security

Automatic Identification System

- In Oct. 2013 Trend Micro demonstrated how easy it is to penetrate a ship's AIS.
- Plausible scenarios continued (CyberKeel 2014):
  - Send false weather information to a vessel to have them divert around a non-existent storm
  - The ability to impersonate marine authorities to trick the vessel crew into disabling their AIS transmitter, rendering them invisible to anyone but the attackers themselves
  - Cause vessels to increase the frequency with which they transmit AIS data, resulting in all vessels and marine authorities being flooded by data. Essentially a "denial-of-service attack"

Automatic Identification System

- Somali pirates help choose their targets by viewing navigational data online, prompting ships to either turn off their navigational devices, or fake the data so it looks like they're somewhere else. (Reuters 4/23/14)

Credit: wikipedia.org

Automatic Identification System

- How it could work: “Frequency Hopping Attack” (Balduzzi & Pasta)
  - Every vessel is tuned in on a range of frequencies where they can interact with port authorities, as well as other vessels.
  - There is a specific set of instructions that only port authorities can issue that make the vessel's automatic identification system transponder work on a specific frequency.
  - A malicious attacker can spoof this type of "command" and practically switch the target's frequency to another one which will be blank. This will cause the vessel to stop transmitting and receiving messages on the right frequency, effectively making it "disappear" and unable to communicate.
- How it could work: Timing Attack (Replay Attack):
  - Attacker spoofs command to delay transmission time and repeat this over and over
  - Effectively causes vessel to disappear.

Automatic Identification System

- In Oct. 2013 Trend Micro demonstrated how easy it is to penetrate a ship's AIS.
- Why? (CyberKeel 2014):
  - The key problem with AIS is that it has no built-in security. All information is automatically assumed as being genuine and hence treated as correct piece of information.
  - Additionally, AIS messages are not encrypted and therefore very easy for outsiders to tap into and manipulate.

Automatic Identification System

- Potential Countermeasures to AIS Vulnerability:
  - Addition of authentication in order to ensure that the transmitter is the owner of the vessel
  - Creating a way to check AIS messages for tampering
  - Making it impossible to enact replay attacks by adding time checking
  - Adding a validity check for the data contained in the messages (e.g. geographical information)

Source: Help Net Security

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GPS Jamming

- GPS Jamming can wreak havoc with modern ships.
- This was demonstrated by the spoofing attack on the White Rose of Drax.
- Civil GNSS (global navigation satellite systems) in use are much more vulnerable to attack than military GPS.
- Such systems are unencrypted and unathenticated.
- Loran-C had been a widespread backup to GNSS but was “abandoned” by the US Coast Guard in 2010.

Source: Bhatti and Humphreys

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GPS Jamming

- In 2008, the UK & Irish General Lighthouse Authority directed GPS jamming equipment at a specific patch of ocean to demonstrate the effect of jamming.
- When the MN Pole Star entered the jamming zone, a range of services failed: the AIS transponder, the dynamic positioning system, the ship's gyro calibration system and the digital selective calling system.
- ECDIS was not updated due to GPS failure, so the screen remained static.

Source: CyberKeel 2014

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GPS Jamming

- In this case, because the crew was expecting this, it was able to cope with multiple alarms.
- However, on a modern vessel the bridge might in some cases be single-manned at night, causing significant problems should such a situation occur – imagine this if it were the Emma Maersk.
- A similar problem could arise if jamming attack took place during a highly complex maneuver requiring high concentration, such as docking under very low visibility.

Source: CyberKeel 2014; Grant, Williams, Ward, Basker

GPS Jamming

- GPS jamming is possible with low cost jammers available over the Internet (though illegal).
- Many devices are battery-operated or can be plugged into a cigarette lighter and cost as little as $20.

Credit: CAPT David Moskoff

GPS Jamming

- One goal of the UK and Irish General Lighthouse Authority study: Investigate effectiveness of alternative sources of position, navigation, and timing for ships that are complementary to GPS.
- Especially important in light of the “abandonment” of Loran-C by USCG.
- Enhanced Loran (eLoran) has different failure modes than GPS, so could serve as backup.
- This was demonstrated in this study.
- Justifies effort to introduce eLoran in the UK.

Source: Grant, Williams, Ward, Basker

Oil Rigs

- Not just ships – ***vulnerabilities extend to the entire maritime transportation system.***
- Hackers recently shut down a floating oil rig off the coast of Africa by tilting it. It took a week to identify and fix the problem. (Reuters 4/23/14)
- In 2010: drilling rig being moved at sea from South Korea to South America was infected by malicious software so its critical control systems couldn't operate. Took 19 days to fix matters. (Reuters 4/23/14)

Credit: www.peakoil.net

Oil Rigs

- In the Korean example: the computers controlling the blowout preventer were infected.
- If this had happened while the rig was engaged in drilling operations, there could have been a well blowout with possible explosion and oil spill.
- The blowout preventer failed during the Deepwater Horizon oil spill in the Gulf of Mexico in 2010.
- The malware involved might not have caused a problem for a smartphone, but that has much better security than an oil rig.

Credit: wikipedia.org, Shauk 2013

Oil Rigs

- The system that keeps an oil rig in position also has vulnerabilities.
- Dynamic positioning (DP) is a computer-controlled system to automatically maintain the position (and heading) of a vessel, in particular an oil rig.
- In DP, knowledge of the oil rig's position and angle, sensor information, wind direction, and speed feed into a computer program that contributes to the oil rig's stability.
- Disabling the DP of an oil rig by jamming its GPS could conceivably have a serious effect on the rig.
- In addition to safety and environmental impacts, large cost: Oil rigs are contracted for at close to $1M a day.

Shauk 2013

Cargo

- Cargo is also affected.
- Modern port operations are heavily dependent on complex, networked logistics
- Management systems track maritime cargo from overseas until it reaches a retailer
- Yet, these systems are subject to cyber attacks that can cause significant problems.

Credit: VADM Chuck Michel

Cargo

- Port of Antwerp is one of the world's biggest.
- 2011-2013: Hackers infiltrated computers connected to the Port of Antwerp, located specific containers, made off with their smuggled drugs and deleted the records.
- Attackers obtained remote access to the terminal systems; released containers to their own truckers without knowledge of the port or the shipping line.
- Access to port systems was used to delete information as to the existence of the container after the fact.

Source: Reuters 4/23/14, CyberKeel

Credit: wikipedia.org

Cargo

- The hackers began by emailing malware to the port authorities and/or shipping companies.
- After the infection was discovered and a firewall installed to prevent further infections, the criminals broke into the facility housing cargo-handling computers and fitted devices allowing wireless access to keystrokes and screen shots of computer screens.

Source: Bell 2013, Mulrenan 2014, Woodland Group

Cargo

- In 2012 it was revealed that crime syndicates had penetrated the cargo systems operated by the Australian Customs and Border protection.
- The penetration of the systems allowed the criminals to check whether their shipping containers were regarded as suspicious by the police or customs authorities.
- The consequence was that containers with contraband were abandoned whenever such attention was identified by the criminals.
- Others could be handled without worrying about the police.

Credit: CyberKeel

Credit: commons.wikipedia.org

Cargo

- The Iranian shipping line IRISL suffered from a successful cyber attack in 2011.
- The attacks damaged all the data related to rates, loading, cargo number, date and place.
- This meant that no one knew where containers were, whether they had been loaded or not, which boxes were onboard the ships or onshore.
- Even though the data was eventually recovered, it led to significant disruptions in operations and resulted in sending cargo to wrong destinations causing severe financial losses.
- Additionally, a considerable amount of cargo was lost.

Credit: CyberKeel

Cargo

- The FBI has advised private industry that GPS jammers are a common tool for cargo theft by organized crime.
- July 2014 FBI Advisory: report 46 instances of jammer use transporting stolen cars to China, and one instance of theft of a trailer of refrigerated pharmaceuticals.

Port Operations

- Today, ports rely as much on computer networks as on human stevedores.
- Complex networked logistics management systems track maritime cargo from overseas until reaching a U.S. retailer.
- Networked control systems are also often involved in the loading and unloading of these goods.
- Modern gantry cranes and other systems use optical recognition and other technologies to locate, scan, and manage all facets of port terminal operations.
- Automated container terminal systems use GPS to facilitate the automatic placement and movement of containers.

Source: CDR Joe Kramek, Brookings Report 2013

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Port Operations

- Self-driving trucks move cargo from place to place.
- They even determine if their batteries are running low and drive to a robot to have them charged.
- Could a terrorist hack into one and wreak havoc?

Source: wikipedia.org

Source: porttechnology.org

Port Operations

- Trucks that haul cargo away from the port are also heavily dependent on GPS.
- This modern port operating system makes the entire port vulnerable.
- In 2014, to give just one example, two cranes at a major East Coast port in the US were idled for 76 hours when they were unable to receive GPS signals.

Sources: CDR Joe Kramek, Brookings Report 2013, Resilient Navigation and Timing Foundation

Michael @ NW Lens via Flickr

Port Operations

- The entire port is vulnerable – from cargo handling to truck and crane movement.
- Easily available GPS jammers could close down a port at cost of more than $1B per day (more counting effect on GDP regionally and nationally).
- GPS jamming is possible with low cost jammers available over the Internet (though illegal).
- Many devices are battery-operated or can be plugged into a cigarette lighter and cost as little as $20.

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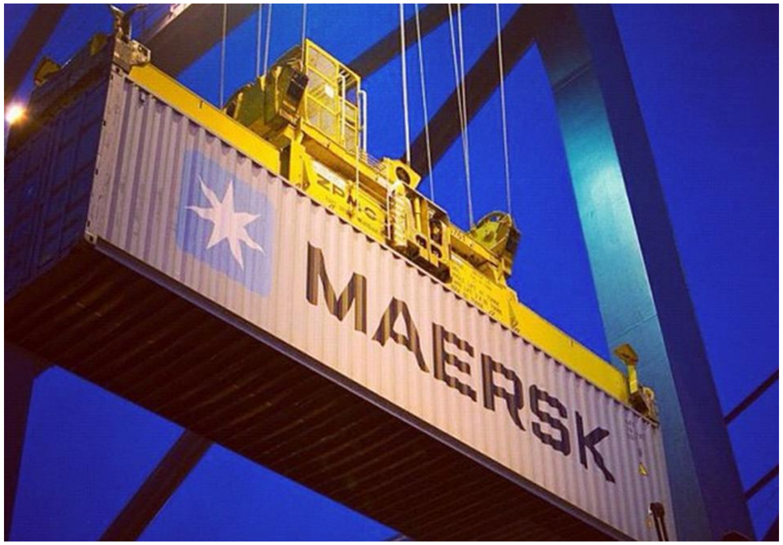
Port Operations

- June 2017 NotPetya ransomware attacks on various companies.
- Maersk moves about 20% of the world's freight.
- Operations at Maersk terminals in 4 countries affected.
  - Delays, disruptions for weeks.
- Cost estimated at $200M-$300M.
- NotPetya also hit Fedex, Merck, etc.



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Maritime Cyber Security

- The cyber threats to the maritime domain are serious.
- These threats not well known.
- In November 2011, the European Network and Information Security Agency (ENISA) reported that, “[t]he awareness on cybersecurity needs in the maritime sector is currently low to non-existent.”
- ENISA recommends:
  - maritime cyber security awareness training, cyber security training of shipping companies, port authorities, and national cyber security offices.
  - Updating regulations/policies from emphasis on physical security to cyber aspects.

Maritime Cyber Security

- 2013 Brookings Report found that of the six ports studied, only one had conducted a cyber security vulnerability assessment and not a single one had a cyber incident response plan.
- 2014 GAO report found that DHS needs to better address maritime cyber security (in particular port cyber security).
- GAO recommended that:
  - USCG assess cyber-related risks & use the assessment to inform maritime security guidance;
  - FEMA use the cyber risk assessment to inform its grant guidance.

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Maritime Cyber Security

- Is the maritime transportation system "special" in its cyber threats?
- In some ways, e.g.:
  - Dependence on long range communications systems due to distance from land, dependence on specialized instruments for position, navigation, and timing.
- But mostly the issues involve lack of awareness by management, lack of information about attacks and vulnerabilities, emphasis on physical security, lack of cyber security training of personnel – similar to many other sectors.
- The industry can and should learn from other industries.
- We need to spread awareness of the maritime cyber threat.

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Research Issues in Security of Cyber-Physical Systems

NSF CPS solicitation 2013:

- Develop the fundamental science needed to engineer systems of the complexity of cyber-physical systems that you can have high confidence in.
- Find ways to conceptualize and design for the deep interdependencies among engineered systems and the natural world.

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Research Issues in Security of Cyber-Physical Systems

- Need methods of verification and validation.
- How can you certify performance of such highly complex systems?
- Right now, overdesign may be only route to system certification.

Credit: collegepals.org

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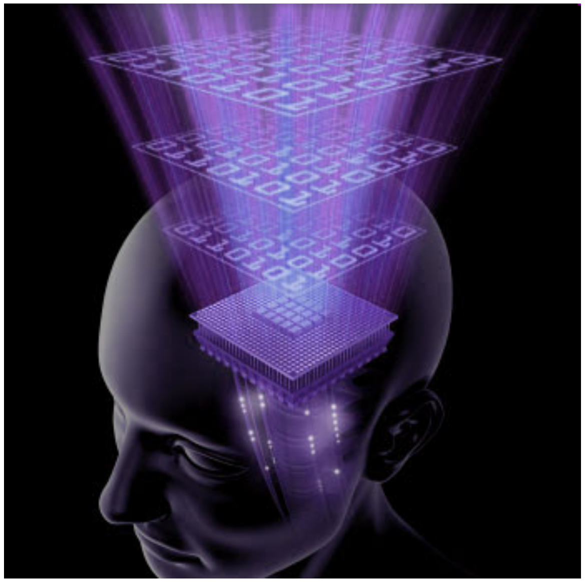
Research Issues in Security of Cyber-Physical Systems: Data

- Huge amounts of data available to describe CPS.
- Challenge: Find ways to utilize data to enhance safety and security of CPS.
- Data about state of the system can come to us so fast humans can't process it.
- Need tools for rapid system understanding.
- Need tools for rapid anomaly detection.

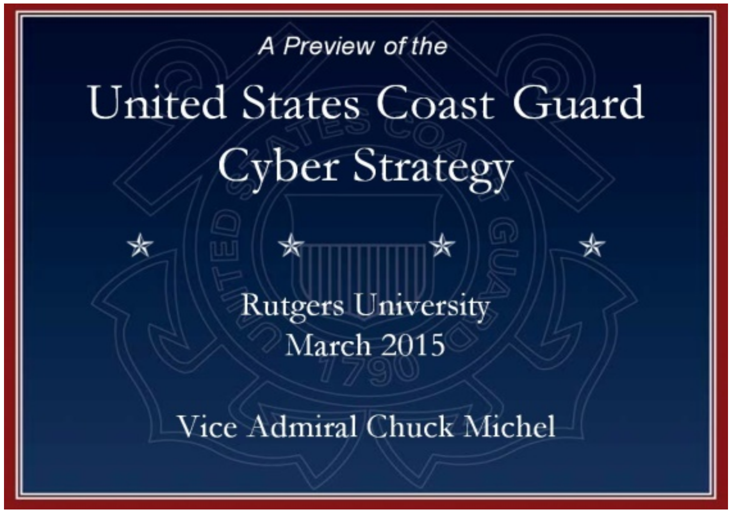


Specific Research Issues for Maritime Cyber Security

- Understand the possibilities for eLoran as a promising solution to problems arising from GP jamming.
- Explore methods of proper authentication and validation as part of the solution to problems arising from vulnerability of Automatic Identification Systems.

Maritime Cyber Security

- March 2-3, 2015: CCICADA organized the first-ever tutorial and symposium on Maritime Cyber Security at Rutgers
- Keynote by Admiral Chuck Michel, US Coast Guard Deputy Commandant
- Admiral Michel used the occasion to roll out the USCG's cyber security strategy.


A Preview of the

United States Coast Guard
Cyber Strategy

★ ★ ★ ★

Rutgers University
March 2015

Vice Admiral Chuck Michel

Admiral Michel’s Initial Research Challenges

- Analysis to identify greatest vulnerabilities in maritime domain
- Identify best options for operational and system cyber resilience
- Analysis and tools to map and predict dynamic maritime cyber threats
- Impact analysis for the maritime transportation system and cascading consequences to nation and economy
- Nodal and system analysis to identify single-points of failure in MTS
- Networking analysis solutions to support optimal information sharing with partners

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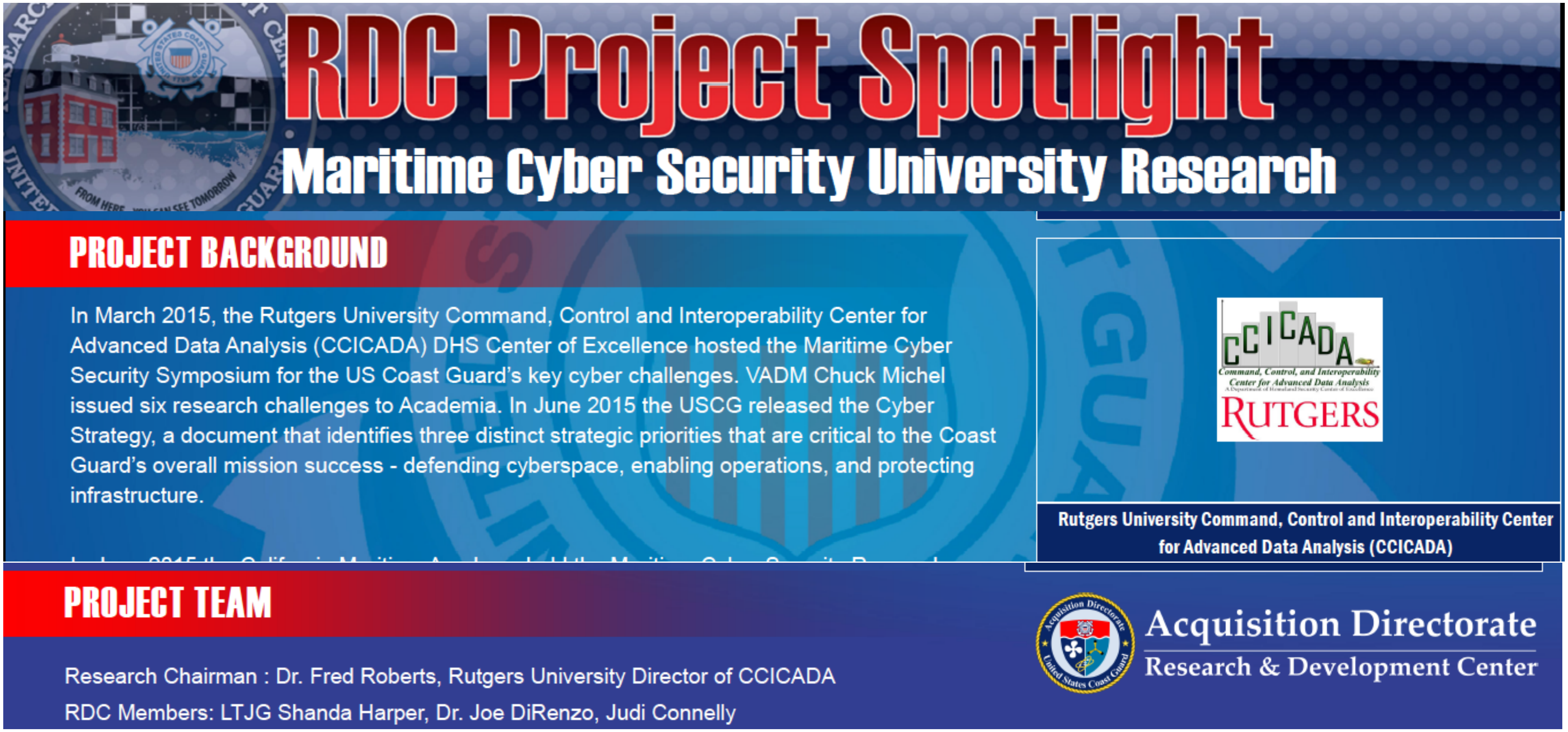
CCICADA and USCG



RDC Project Spotlight

Maritime Cyber Security University Research

PROJECT BACKGROUND

In March 2015, the Rutgers University Command, Control and Interoperability Center for Advanced Data Analysis (CCICADA) DHS Center of Excellence hosted the Maritime Cyber Security Symposium for the US Coast Guard's key cyber challenges. VADM Chuck Michel issued six research challenges to Academia. In June 2015 the USCG released the Cyber Strategy, a document that identifies three distinct strategic priorities that are critical to the Coast Guard's overall mission success - defending cyberspace, enabling operations, and protecting infrastructure.

In June 2015 the California Maritime Academy held the Maritime Cyber Security Research

Rutgers University Command, Control and Interoperability Center for Advanced Data Analysis (CCICADA)

PROJECT TEAM

Research Chairman : Dr. Fred Roberts, Rutgers University Director of CCICADA

RDC Members: LTJG Shanda Harper, Dr. Joe DiRenzo, Judi Connelly

Acquisition Directorate
Research & Development Center

CCICADA has led the USCG-university research effort in maritime cyber security in collaboration with the USCG Research & Development Center (RDC)

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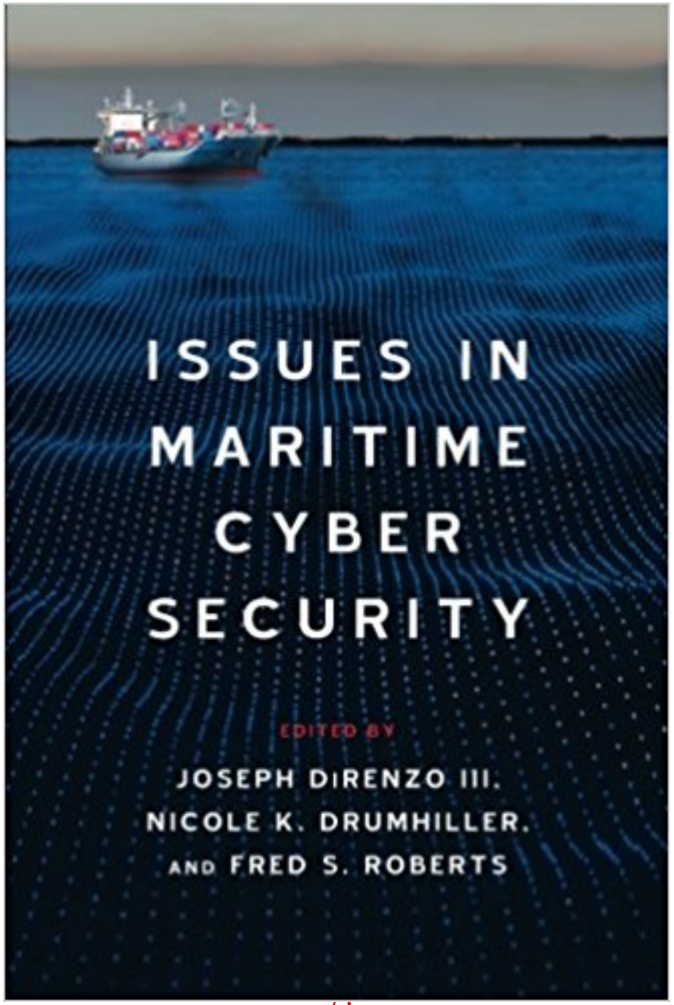
Maritime Cyber Security: The Research Continues

- Information sharing is key: but what are the incentives for sharing information?
  - In some domains (auto, aviation, financial services) there is a great deal of sharing
  - Maritime transportation system is harder
- How do we assess the cyber readiness of your company? Will you let us into your network to do it?
- What about coordinated cyber & physical attacks?
- What are the single points of failure in the maritime cyber system?
- What are the best ways to educate/train the workforce on proper cyber behavior – A CCICADA Report for DHS

Maritime Cyber Security: The Research Continues

- Recent book summarizing current research topics.



ISSUES IN MARITIME CYBER SECURITY

EDITED BY

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Maritime Cyber Security: The Future

- There is a growing demand for cyber security experts.
- A June 2017 report projects that by 2022, there will be ***a shortage of 1.8 million cyber security experts world-wide***
  - (ISC^2: Global Information Security Workforce Study)
- But the problem is not just a shortage of cyber security experts.
- Most cyber security problems arise from “poor cyber hygiene.”
- Educating/training the workforce in good cyber practice is central.

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Maritime Cyber Security: The Future

- Special problems in the maritime domain
  - Many players: government agencies, commercial shipping, cruise lines, onboard captains and crew, ports, cargo handling systems, drill rigs; *lots of small companies*
  - Most small players:
    - ➢ don’t have the resources or expertise to understand or deal with cyber threats − even if given the information
    - ➢ don’t have the funds to hire employees with sufficient background to understand anything beyond the most rudimentary aspects of good cyber security hygiene
    - ➢ don’t have the resources to understand information about evolving cyber attacks, cyber vulnerabilities, cyber defense
  - Even big companies in maritime haven’t paid much attention to cyber security − until recently

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Maritime Cyber Security: The Future

- Special problems in the maritime domain: A key is going to be to educate the wider maritime workforce.
  - That is not technical training.
- Similar issues in the stadium world:
  - Few cyber security experts
  - Until recently, little attention paid to cyber
  - Large part-time workforce; little time to train them

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Cyber Security: The Future

- Cyber security education/training challenges in general:
  - How do we educate people to deal with threats and defenses that don’t exist yet?
  - To deal with an environment that is changing so rapidly?
- Cyber security is not just a technical problem.
  - Relevance of legal issues, social sciences, political science, economics
- Also need to educate the general public.
  - When should we start?
  - Middle School?
  - Kindergarten? Pre-K?

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Vulnerabilities of Cyber-Physical Systems: From Football to Oil Rigs

For More Information:

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CCICADA Center
www.ccicada.org

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