AI and Homeland Security

Fred S. Roberts

Director of
CCICADA
Rutgers University

Image credit: top: TheDigitalArtist, pixabay, bottom: DHS

CCICADA
Command, Control, and Interoperability Center for Advanced Data Analysis

My Background

- AB degree at Dartmouth in Math
  - Introduced to applications of math
- PhD at Stanford in Math
  - Interdisciplinary interests
- Postdoc position in Psychology at U. Penn.
- First real job: RAND Corporation
  - Think tank
  - Research on energy use, pollution, transportation
- Postdoc at Institute for Advanced Study, Princeton – School of Social Sciences
- Rutgers Math Professor since 1972

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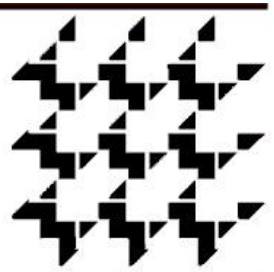
My Background: DIMACS

- 1988: nationwide competition for National Science Foundation science and technology centers.
- Rules: (1) cutting edge science (2) education/ tech transfer (3) partnership among academia, industry, government.
- >800 preproposals, >300 final proposals. We were one of 11 winners.
  - Partnership: Rutgers, Princeton, Bell Labs, Bellcore, NJ Commission on Science & Technology

DIMACS

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



My Background: DIMACS

- DIMACS = Center for Discrete Mathematics and Theoretical Computer Science
- I directed DIMACS for 16 years, then recently did it for another term as interim director.
- DIMACS original emphasis: math, CS, applications to communications and computing.
- Helped broaden emphasis to:
  - Molecular biology
  - Statistical physics
  - Social sciences
  - Data science
  - Artificial intelligence/ machine learning

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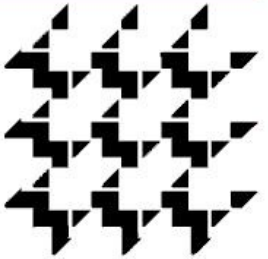

My Background: Transition to Homeland Security

- 2001: planned multiyear research on epidemiology.
- World Trade Center attacks/anthrax attacks
- NSF gathered help from those with projects that might be relevant.
- Ours on epidemiology was.
- Ended up working with intelligence community on natural language processing.

Photo credits: L: CDC Public Health Image Library, R: Flickr user Michael Foran, Wikimedia commons

My Background: Transition to Homeland Security

- 2002: DHS formed.
- DHS Office of University Programs created network of university centers of excellence (COEs)
- First competition for DHS COE
  - Joint proposal through NJ University Homeland Security Consortium (co-chair)
  - Failed
- Won our first DHS COE in 2006: Center for Dynamic Data Analysis (DyDAn)
- Won our second (and continuing) COE in 2009: CCICADA
- As of 2021, part of a new COE: SENTRY

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CCICADA

- Command, Control, and Interoperability Center for Advanced Data Analysis
- Multiple university and company partners
- Based at Rutgers
- City College a partner
- **Mission**: ***Provide powerful analytical tools for protection against natural and man-made threats.***
- ***Theme: CCICADA applies multidisciplinary methods of data extraction, analysis, modeling, and simulation to support information-driven decision making throughout the Homeland Security Enterprise.***

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Outline

1. Short introduction to some of the work of CCICADA
2. Detailed examples of some of the CCICADA work I've been involved in, with discussion of connections to Artificial Intelligence/Machine Learning
   - Stadium Security/Large Venue Security
   - Supply Chains
   - Disaster Preparedness and Response

Definitions

- Broad definition: ***Artificial Intelligence (AI)*** is the simulation of human intelligence processes by machines, especially computer systems
- ***Machine Learning (ML)*** is a class of AI algorithms that train a machine to learn and use training data and get tested on test data
- Many use these terms interchangeably
- More generally: My examples will involve:
  - Use of massive amounts of data/data analytics
  - "Intelligent" machines
  - Automated or semi-automated processes

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Stadium Security

- Stadium security – ***worked with all major sports leagues and many stadiums and arenas***
- **More on this later**

Photo credit: Phil Roeder, Creative Commons

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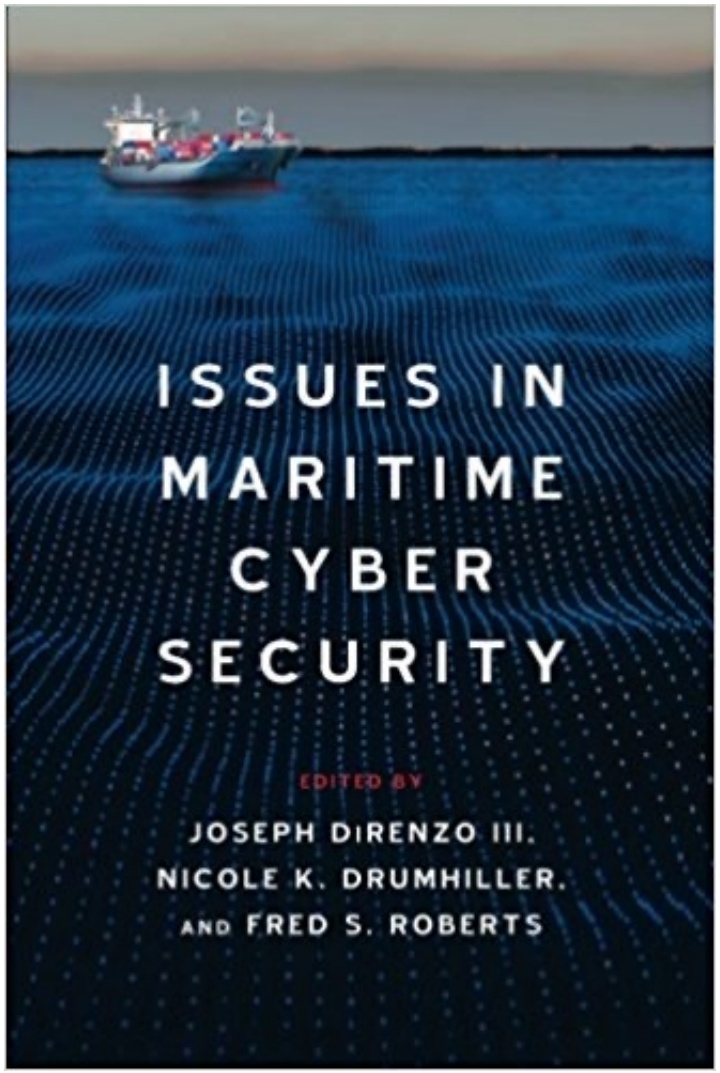
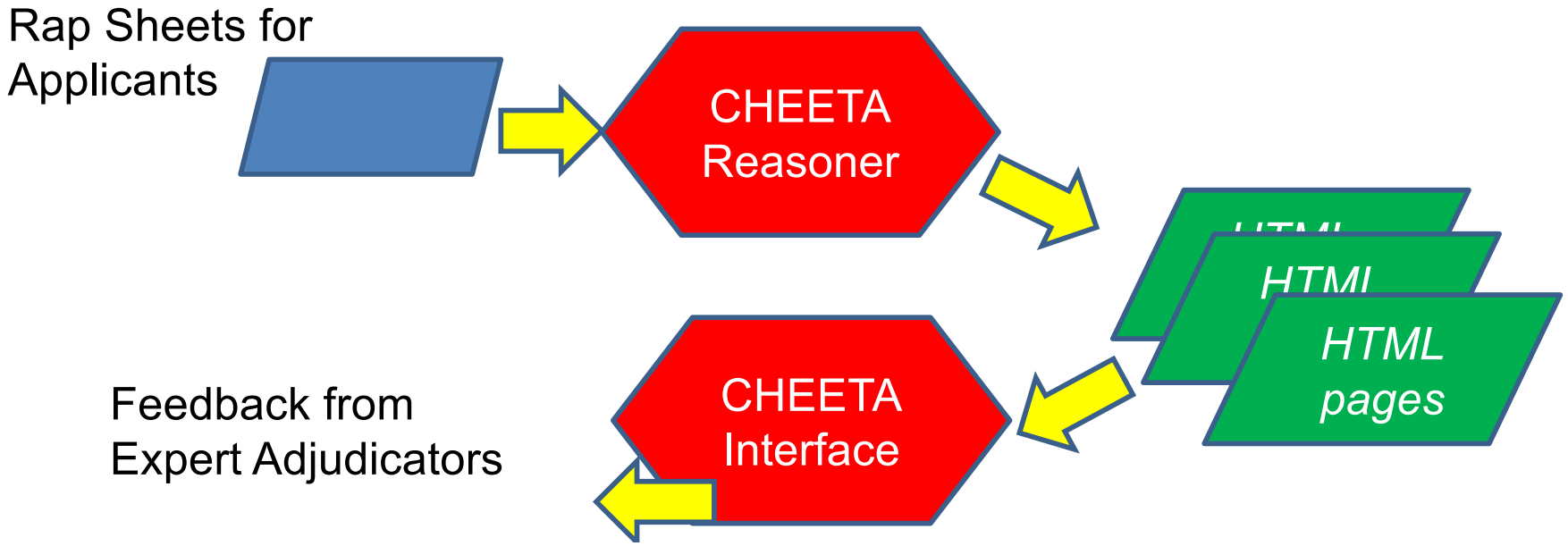
Maritime Cyber Security

- CCICADA organized the first-ever tutorial and symposium on Maritime Cyber Security - held at Rutgers
- ***Co-led University-Coast Guard Maritime Cyber Security Research Initiative***
- Led me to co-edit the first ever book on maritime cyber security
- Led me to give plenary talk at NATO maritime cyber security conference



TSA: Enhanced Adjudication

- Millions of applications for Pre-Check, Aviation worker, TWIC cards
- Disqualified for criminal records involving 27 specific crimes.
- TSA gets "rap sheet" from FBI covering criminal convictions.
- Manual adjudication.
- ***CCICADA developed a powerful automated system CHEETA that identifies and matches the 27 disqualifying crimes with state and federal databases and produces a recommended adjudication decision.***
- Vetted by adjudicator and TSA contractors. Delivered to TSA.
- ***Project involved an unusual mix of RU law students and CS students.***

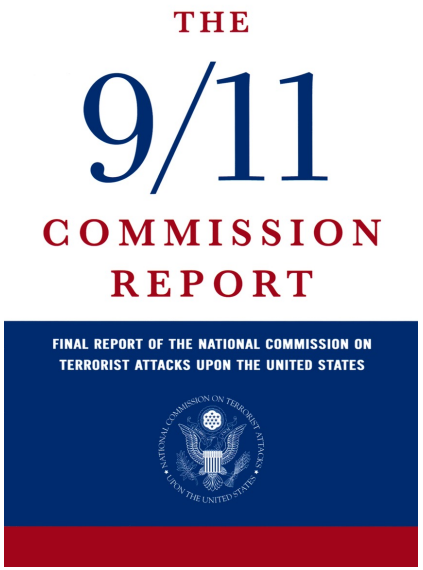


COE COVID-19 Supply Chain Initiative

- Supply chain disruption is a key homeland security challenge.
- ***CCICADA led a COE-wide initiative on supply chains, with emphasis on supply during COVID***
  - E.g., shortages of masks, ventilators, toilet paper, etc.
  - ***Major DHS involvement***: USCG, FEMA, CBP, ICE-HSI, CISA, DHS Chief Medical Officer
  - Captured attention of DHS Undersecretary for Science & Technology
  - Other government agencies: HHS, USDA, FDA, DOJ, DOD, state agencies
  - ***Major private sector involvement***: Deloitte, 3M, Merck, Pfizer, Moderna, Walgreens, Johnson & Johnson, …
- **More on supply chain work coming**

Photo credit: Wikimedia commons

Information Sharing



- ***9/11 Commission recommendation: Enhance information sharing*** to improve law enforcement and counterterrorism awareness and response
- ODNI project: develop properties of an effective information sharing environment (ISE)
- Project explored and formalized issues:
  - ***Interoperability***: Ability of two or more organizations to exchange data, information, material, and services and to use the information separately or collaboratively across multiple information technology systems
  - ***Trust***: Human and technical issue
    - ➢Participants trust each other
    - ➢Identity and access management

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Best Practices for Sharing Digital Evidence - FLETC

- ***More and more investigations involve digital evidence:***
  - Contained in smartphones, tablets, social media, apps, IOT devices, cloud storage
- Computer-enabled crimes evolving rapidly
  - New forms of identity theft, crypto-currency fraud
  - Court rulings on search and seizure, encryption are evolving
- ***Project: How to train and keep DHS investigators current***
- ***Close collaboration with Federal Law Enforcement Training Centers (FLETC)***
- ***Potential project to train NJ court workers***

Photo credit: Bubba73 (Jud McCranie), Wikimedia commons

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Fisheries Law Enforcement

- Coast Guard developed a scoring system (**OPTIDE**) to determine which commercial fishing vessels to board to look for violations
- Was having about 20% success rate in finding violations
- ***Can this be improved by use of ML?***
- **RIPTIDE** = Rule Induction OPTIDE
- ***Our best model for RIPTIDE uses some new features***, such as type of vessel (General, Trawler, Pot/Trap) and prior violations found per boarding
- Much experimentation.
- ***Best model for RIPTIDE found so far outperforms OPTIDE up to 87% in an experiment***

Photo credit: USCG

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HOAX CALLS

- US Coast Guard sends a small rescue boat and aircraft in response to every distress call it receives
- The Coast Guard receives well over 100 instances of phony distress calls a year – great expense
- CCICADA team pioneered in developing voice forensics
- The voice recording can reveal a great deal about the caller: their age, gender and ethnicity.
- ***Voice forensics is heavily influenced by AI and ML – with a caller's voice like a digital fingerprint.***
- ***Voice forensics combined with information about location of call has led to arrests of hoax callers***

Photo credit: USCG

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Disaster Preparedness and Response

- Studied use of social media for situational awareness.
  - ***ML shows that people follow typical sequences when communicating in emergency situations***
  - Understanding typical sequence allows crisis responders and others to identify "relapses"
- Used social media to develop real-time optimization of emergency response
  - Grouped messages by location
  - ***Determined top requests for help by location - using ML***
  - Developed algorithms for allocating aid based on integrated social media geolocations requests received
  - Applied ideas to social media data from 2010 Haitian Earthquake

US military provides relief in Haiti following the devastating 2010 earthquake. (Photo Credit: Expert Infantry, Creative Commons)

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CCICADA

- My work with CCICADA has gotten me to some amazing places:
  - 50-yard line at MetLife Stadium, day of game command center at Yankee Stadium and Citi Field
  - On a Coast Guard boat going under the Golden Gate Bridge
  - Meeting with Commandant of USCG

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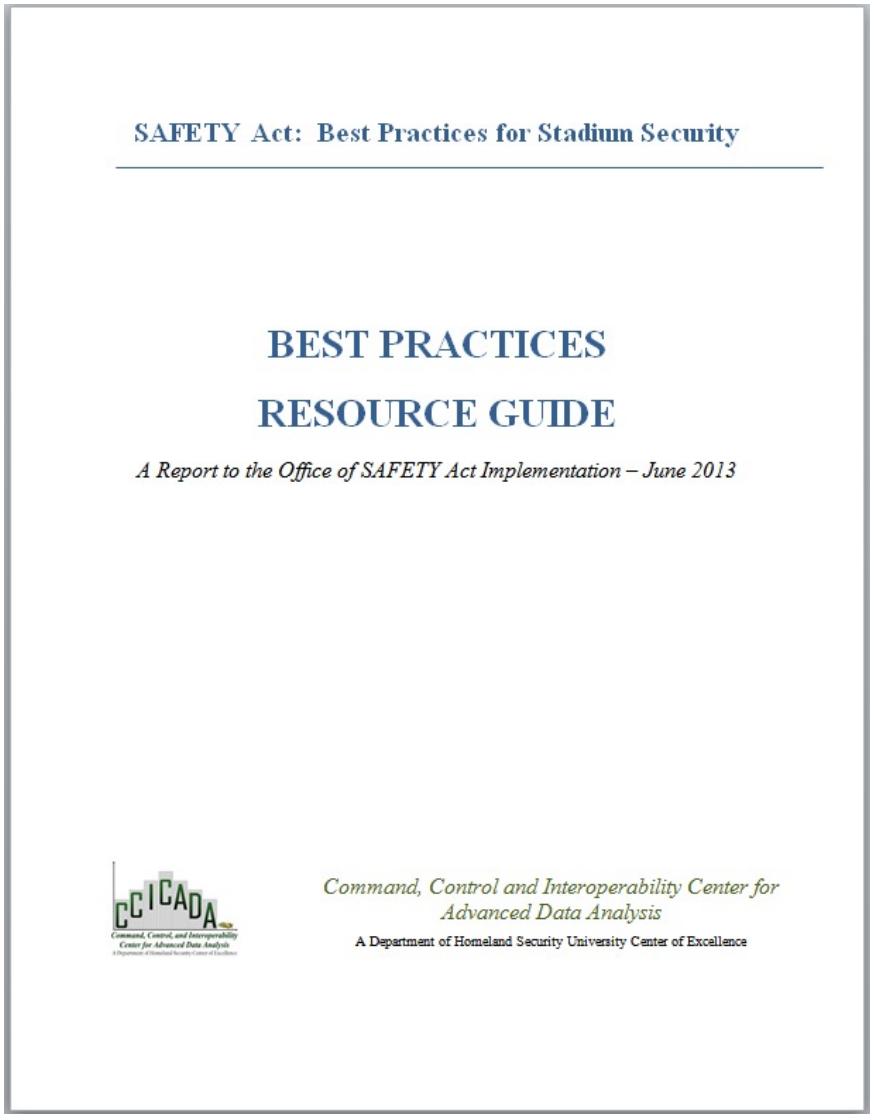
Stadium Security/Large Venue Security

Image credit: Phil Roeder, Creative Commons

Best Practices for Stadium Security



Best Practices Resource Guide

- On DHS website
- ***Used by all major sports leagues: NFL, NBA, MLB, NHL, MLS, NASCAR***
- Used to design new sports arenas
- Applied to other venues (e.g., convention centers)

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Latest Project on Stadium Security: Economics of Security & Randomization

1. Economic costs and benefits of security at stadiums
2. Randomization designs
3. Practical implementation of simple randomization for patron screening
4. Recommendations also on DHS website

Rutgers Stadium, photo credit commons.Wikimedia.org

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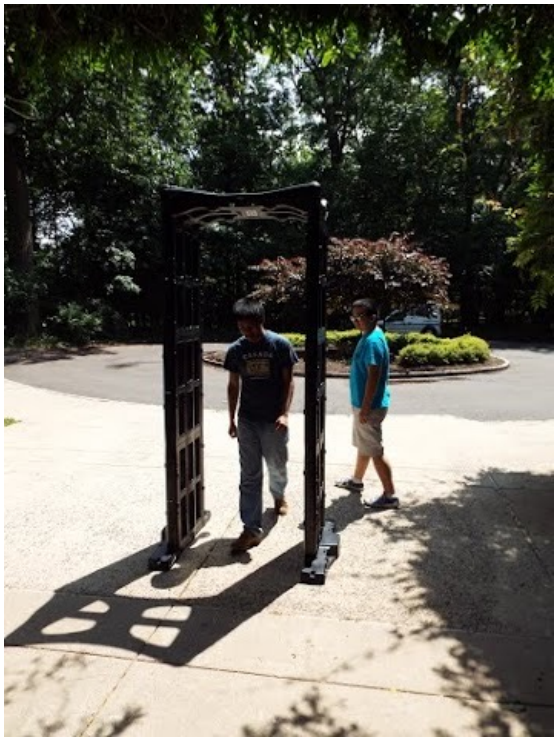
Performance of Walkthrough Metal Detectors

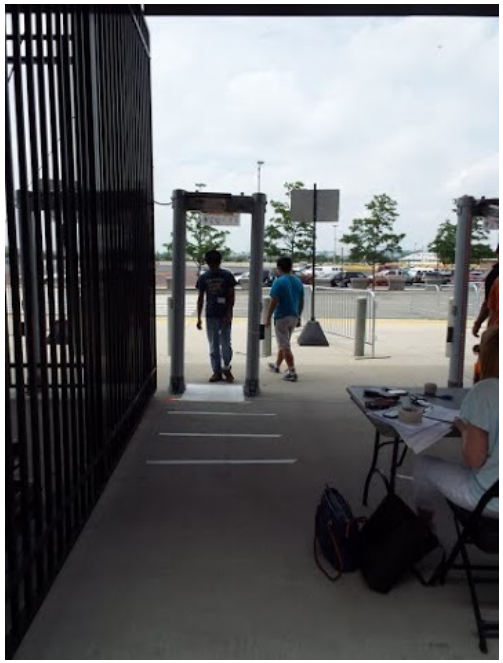
- ***When NFL required stadiums to use WTMDs, CCICADA helped MetLife Stadium determine number needed and how they work in real stadium conditions***
- Many different settings; not clear which is best
- Performance varies with weather, location, vibration, etc.

Photo credit: Oakland Raiders

WTMD Experiments

- Performed experiments with WTMDs obtained from MetLife and from RUPD
- Found that performance varies per
  - Brand
  - Height & Orientation
  - Proximity of outside sources
  - Human gait
  - Speed





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WTMDS

- WTMD standards were not written the way that WTMDs are used in the field
- They are based on lab experiments with robot testers
- ***Gold standard of WTMDs are used in prisons. Use ML to learn to identify which prisoner is going through***
- When WTMDs at a stadium are networked, can gather huge amounts of data
  - ***ML can help learn arrival patterns – help in planning allocation of security personnel***

Robot testing WTMD

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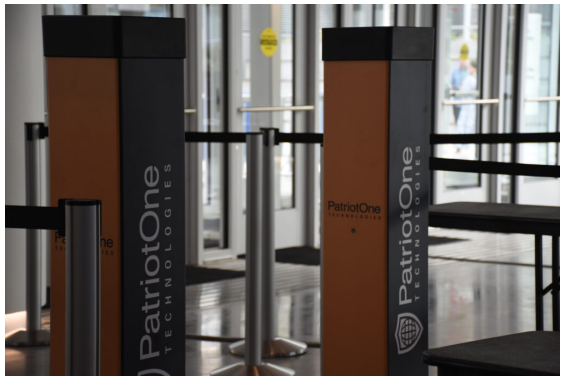
Next Generation Crowd Screening Tools

- The next generation of crowd screening tools is already being deployed in some venues, though jury is still out on how well they work.
- Claim to spot weapons while not worrying about keys, cellphones, etc.
- ***These tools use AI and ML to:***
  - ***Speed throughput***
  - ***Give venue security teams tools to adjust their screening settings and screener assignments based on data gathered in real-time***
- ***Move ticket scanning before screening to take advantage of information about who is coming into the venue***

Evolv Screening System at Six Flags; PatriotOne Multi-sensor Gateway

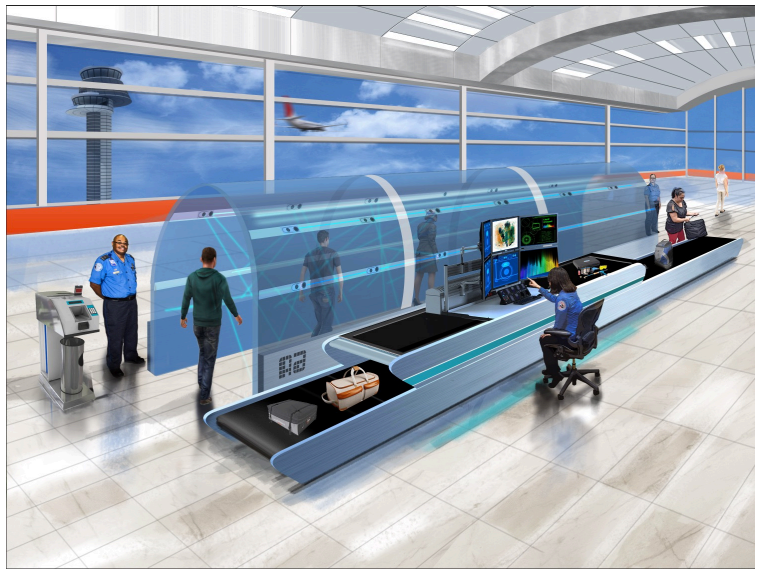
Credit: Evolv Technology, PatriotOne Technology



Next Generation Crowd Screening Tools: Screening at Speed

- ***DHS futuristic goal: "Screening at speed"***
  - ***Goal: Use AI/ML to make screening so unobtrusive that person being screened is only vaguely aware that it is happening***
  - ***By the time a traveler reaches a checkpoint, the screener will understand the risk the customer poses, which will allow informed decisions as to what level of inspection, if any, is required***

Credit:
DHS



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Port Authority Bus Terminal

A prototypical transportation hub

- Largest terminal in the United States
- Busiest in the world by volume or traffic
  - It has reached peak hour capacity

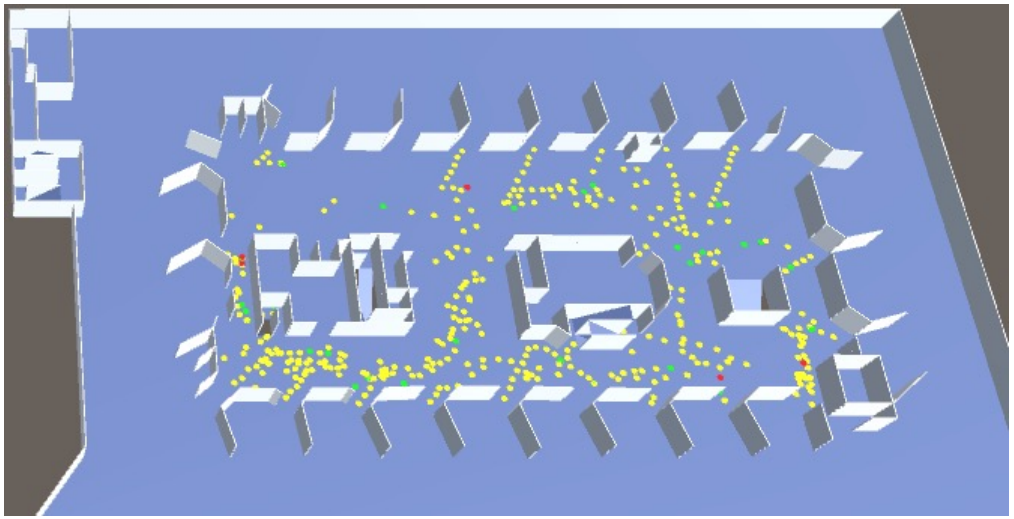
8,000 buses - 225,000 people on ordinary weekday - 65,000,000 people per year - 223 different departure gates - 1,250 parking spots - commercial and retail space

(2013 statistics)

Photo credits: Wikimedia commons, L: Roger Rowlett, R: Transitsylveonkpop

Port Authority Bus Terminal

- ***Developed simulation of crowd movement***
- ***Based on "learning" crowd behavior from lots of observations***
- Uses:
  - Evaluate surveillance and inspection strategies
  - Develop evacuation scenarios and extreme conditions
  - Study queuing and crowd management strategies
  - Understand impact of structural changes, construction and gate reassignment



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New DHS COE: SENTRY

- 2021: CCICADA joined with 2 other COEs to form a new DHS COE concerned with protection of soft targets and crowded places (STCPs)
  - Stadiums, schools, places of worship, etc.
  - Hundreds of thousands of STCPs across the country visited by millions of people each day
- ***SENTRY's theme: You can't protect everything with human beings, and humans can't react fast enough to all threats. So automated responses are central; "intelligent machines" needed***
- Will include experimentation with dynamic digital twins and in the Rutgers "living laboratory"
- SENTRY = Soft target Engineering to Neutralize the Threat RealitY

Supply Chains

Image credit: Wikimedia commons MAERSK MC KINNEY MÖLLER & MARSEILLE MAERSK

Remember March 2020?

- When COVID-19 hit, we saw shortages of Personal Protective Equipment (PPE)
  - Masks
  - Gowns
  - Ventilators

Credit: Wikimedia commons, James Heilman, MD

Credit: Wikimedia commons, Timely Medical Innovations, LLC

Remember March 2020?

- When COVID-19 hit, store shelves were empty.
- We couldn't get important items:
  - Hand sanitizer
  - Disinfectant wipes
  - Toilet paper

Credit: :Laurie Kolano

Hoarding Toilet Paper

Credit: Wikimedia commons, Mwinog2777

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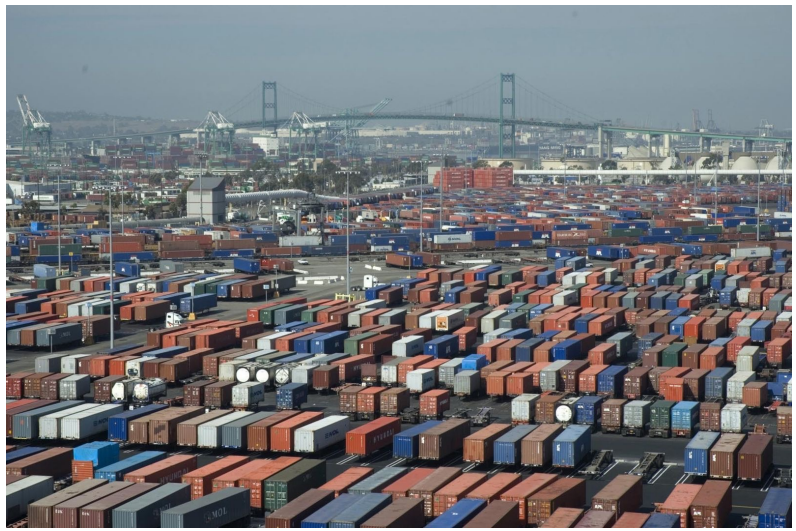
Remember March 2020?

- There were shortages of food
- Yet, farmers were burying crops and pouring out milk
- Our supply chains were thrown into chaos

Despite shortages in grocery stores, some farmers had to destroy crops.
Photo Credit: Wikimedia Commons

And Starting in Fall 2021

- We started seeing a repeat of many of these things.
- Stores shelves again empty.
- Long delays in obtaining supplies.
- Chip shortages affecting manufacture of everything from cars to iPhones.
- Long lines of ships waiting to dock at ports.
- And large backlogs of containers waiting to be unpacked.
- How did this happen?



Port of Long Beach
Photo credit: Wikimedia commons, CBP

How Did This Happen?

- Combination of disruptions
- Continuing impact of COVID-19 supply chain disruptions
- Labor issues: trucker shortages
- Labor issues: differing rules for workers boarding or leaving vessels at different ports due to COVID
- Malaysian chip plant shutdown
- Changing spending patterns – after lockdowns and quarantines, people spending more on goods rather than on services

Credit: Wikimedia commons: New Zealand Defence Force

Data-driven Supply Chains

- Supply chains have been dramatically changed in the digital age
- ***Artificial intelligence and machine learning have allowed the private sector and governments to minimize inventories***
  - Due to extremely accurate knowledge of demand for goods or components
  - Allowing for ***"just-in-time" delivery***
- COVID has demonstrated the problems with this approach
- AI/ML-driven supply chains worked great until a ***"Black Swan" event*** – an anomalous event, one that was totally unexpected.
  - Terminology stems from (Western) view that all swans are white
- ***AI/ML may be part of the problem, but it is also part of the solution***
  - Track transactions
  - Rapidly vet new vendors/suppliers
  - Early warnings of anomalies

Credit: Wikimedia commons, Josephus37

Supply Chains are Not Always Flexible

- Why did farmers plow under food and pour out milk when COVID hit and consumers couldn't get these products in the stores?
- ***Supply chains are not that flexible***
- There was more demand – people started hoarding. The supply chain didn't foresee this
- Workers at different stages of the supply chain were out sick or in lockdown
- It was difficult to change packaging, transportation routes, and contracts
  - If you are used to delivering 25 Kg bags of potatoes to institutions such as schools or restaurants, you can't suddenly shift to 2 Kg bags
  - Packaging is different. Transportation is different. New contracts have to be signed

Credit: Wikimedia commons, Ahoek

Why are Supply Chains a DHS Issue?

- Daniel Gerstein (former DHS Under Secretary (Acting) and Deputy Under Secretary in the Science & Technology Directorate): ***We need to treat supply chains as a national security issue and need to develop a strategic national supply chain approach***
- Gerstein: Our "just in time" delivery systems have been designed to optimize costs through prediction and minimizing inventories, but they lack resiliency in times of crisis
  - 95% of companies will be impacted by COVID-19 and only 56% had a plan to address supply disruption from China, a source of many of the key active pharmaceutical ingredients

Daniel Gerstein

Homeland Security

Why are Supply Chains a DHS Issue?

- *Gerstein calls for the development of a methodology to:*
  - Improve current supply chain visibility
  - Determine appropriate balance between efficiency and resilience
  - Develop principles, strategies, policies, and regulations for supply chains
  - ***Establish and validate the algorithms that will guide the supply chains***
  - Model new risks and costs (network flow models or time series forecasting)
  - Improve situational awareness through use of advanced capabilities
  - ***Use technology: Internet of Things, artificial intelligence. robotics, and 5G***

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Challenges for the ICT Supply Chain

- All aspects of our lives are intertwined with ***information and communications technology (ICT)***:
  - Smartphones and tablets
  - Laptops
  - Servers running our power grid and our financial transactions
- Threats include:
  - Counterfeit components
  - Cyber attacks
  - Introduction of malicious software
  - Ransomware
- ***The counterfeit components might be introduced early in the supply chain and not noticed for years***
  - ***Can AI/ML help speed up detection of counterfeit?***

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Why are Supply Chains a DHS Issue? CISA

- DHS Cybersecurity and Infrastructure Security Agency (CISA) is heavily involved with supply chains
- Specifically, CISA's National Risk Management Center (NRMC)
- Example: CISA efforts in Information and Communications Technology (ICT) supply chain risk management
- They have a series of ICT Supply Chain Risk Management Task Force Working Groups
  - You can find their reports online
  - These reports describe different supply chain disruption scenarios and identify useful countermeasures.
  - ***Can we tell which threats present the greatest risk and which countermeasures are most effective at reducing risk from disruptions?***

ICT SCRM TASK FORCE: THREAT SCENARIOS REPORT

Threat Assessment for the ICT Supply Chain: Recently Completed CCICADA Project

- Goal: develop a risk-based methodology that will allow us to:
  - Make quantitative comparisons of relative risk of different information and communications technology (ICT) Supply Chain threat scenarios
  - Identify potentially useful countermeasures for different scenarios
  - ***Make quantitative comparisons of relative risk reduction of the countermeasures for a particular scenario***

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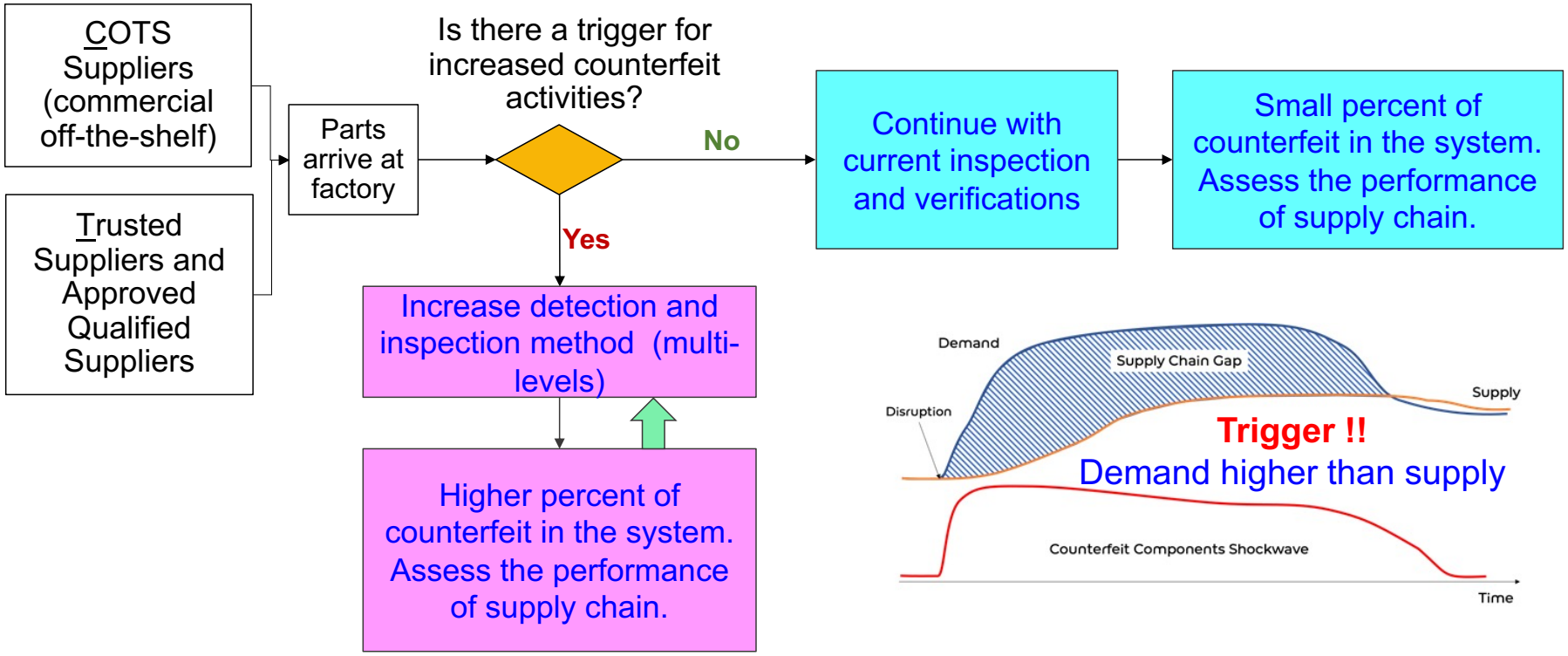
Sample ICT Supply Chain Disruption Scenario We Studied

6.3 Yokogawa Electric Corp. Counterfeit Equipment

- **Scenario:** Yokogawa Electric identified instances in which several customers received counterfeit high performance differential pressure transmitters used to measure liquid, gas, or steam pressure. The counterfeit products used the Yokogawa logo
- **Threats**:
  - Counterfeiting originated at integrator
  - At shipper
  - At third party
- Which presents higher risk?
- **Countermeasures**:
  - Does traceability/serialization (***using technologies such as blockchain***) to keep track of transactions reduce risk more than setting up product inspection and performance spot-testing processes with customers?
  - Does use of advanced techniques (e.g., ***machine learning***) to detect counterfeit packaging, labeling, and logos reduce risk more than placing engineers in a vendor's location on a regular basis?

Counterfeit Goods: Modeling & Simulation

- The CCICADA project developed network models of the supply chain for an ICT product
- ***It studied different countermeasures against counterfeit goods and simulated the performance of the supply chain under different CMs***



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Counterfeit Goods

- **CMs in a sample exercise:**
  - (CM1): Select 20% of all incoming parts and compare them to databases (GIDEP by DoD and ERAI High Risk and Suspect Counterfeit Parts)
  - (CM2): Database search as in CM1; trigger increased inspection and detection when fraction of undetected counterfeit parts among all counterfeit parts is above 10%; inspect 60% of parts from COTS suppliers and 50% of parts from trusted suppliers
  - (CM3) CM2 plus factories adjust production plan every day: increase production capacity to compensate for time lost in increased inspection and detection
- ***Sample result: CM3 increases proportion of "good" products received by 69%, CM1 by only 12%***

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New Supply Chain Project: Detecting Criminal Disruptions of Supply Chains

- ***Detecting Criminal Disruptions of Supply Chains***
  - Goal: detecting active, pending, or past criminal manipulation or disruption of a supply chain
  - Start with drugs and vaccines
  - Close collaboration with fraud units at Merck and Johnson & Johnson
  - Detailed models of pharmaceutical supply chains
  - Detailed models of criminal organization capabilities
  - ***Key: development of indicators and warnings***
  - ***AI/ML: Detecting anomalies in values of indicators and warnings***

Real and fake Lipitor; HSI. Credit: top: FDA; bottom: Brian Weinhaus, HSI

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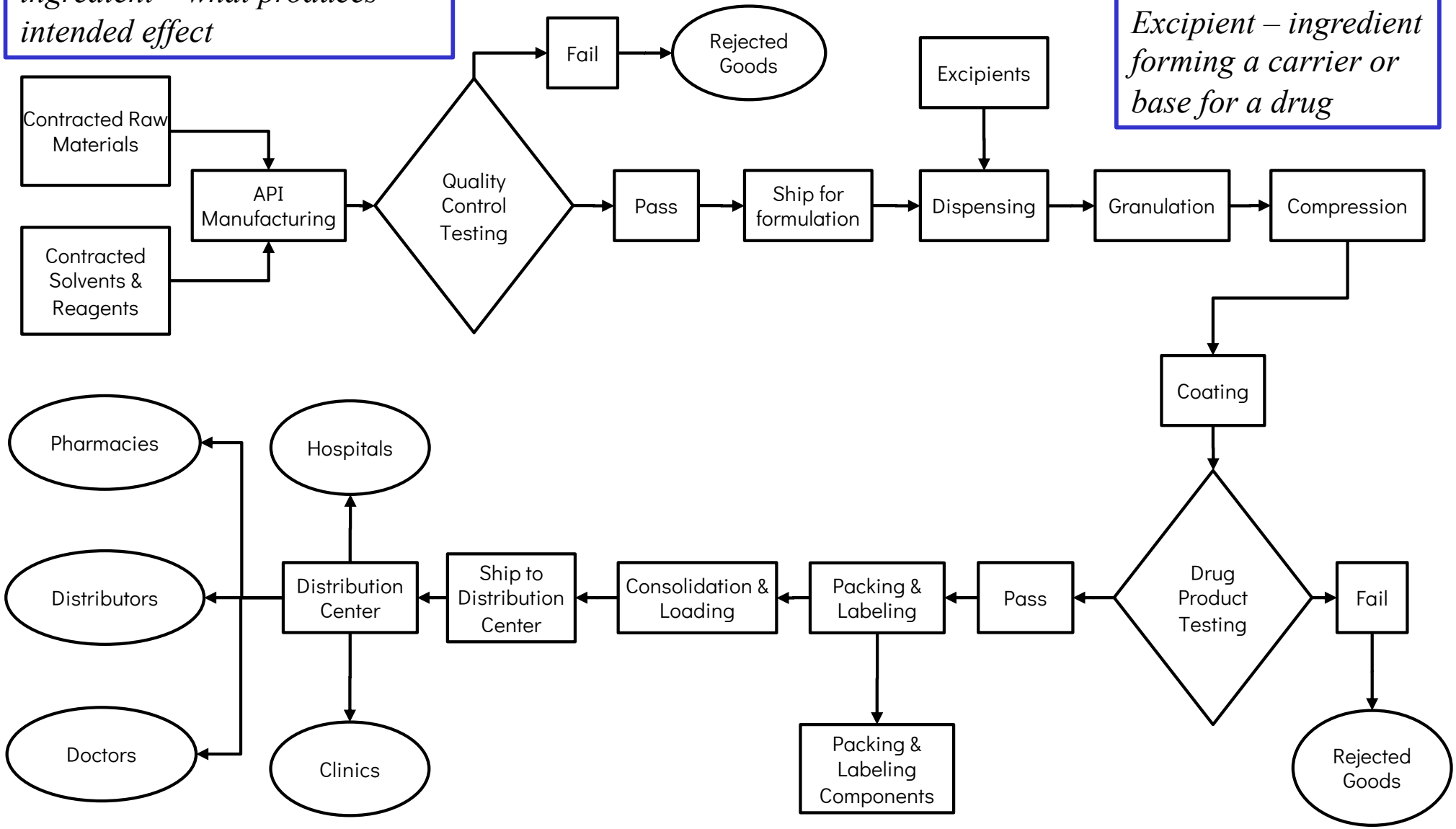
Challenges for the Pharmaceutical Supply Chain

API – active pharmaceutical ingredient – what produces intended effect

Challenges at each step

Excipient – ingredient forming a carrier or base for a drug



Slide courtesy of Bill McLaury

Toward Solving Some Supply Chain Challenges: Identifying Counterfeit

Ingredients Found In Counterfeit Medicines

Slide courtesy of Viswanath Narayan

Toward Solving Some Supply Chain Challenges: Identifying Counterfeit

- ***Consider packaging***
- Compare to an authentic sample for:
  - Print quality
  - Spacing and spelling
  - Differences in font style
  - Correct colors in the artwork
  - Correct size and shape of the packaging
  - Quality of packaging material
- ***Similarly with labeling on the pills themselves***
- ***Now, moving to machine learning to be able to spot irregularities in packaging and pill labeling***

Courtesy of Viswanath Narayan

Toward Solving Some Supply Chain Challenges: Identifying Counterfeit

- The authentic capsule is on the right.
  - Packaging on the left is wrong shade
  - No print on capsule body on counterfeit one
  - Font is of a different type

Courtesy of Viswanath Narayan

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New Supply Chain Project: Modeling the Impact of Complex, Multi-vector Disruptions to the Marine Transportation System

- The grounding of the container ship Ever Given in the Suez Canal on March 23, 2021 led to significant short-term supply chain impacts and aggravated other existing supply chain issues.
- When the incident occurred, the global supply chain was already impacted by COVID-19. How did that make impacts of the incident worse?
- This new project: ***How do multiple, interconnecting disruptions of global supply chains produce outcomes that are much more complicated and challenging than those of single disruptions? How can we best prevent, prepare for, respond and recover from these incidents?***
- ***Close collaboration with Coast Guard***

Credit: Wikimedia commons, Contains modified Copernicus Sentinel data [2021], processed by Pierre Markuse

Toward Solving Some Supply Chain Challenges: Stockpiles

- One way to prepare for an emergency or a shortage is to stockpile goods or components you might need
- FEMA has an emergency stockpile of goods for emergencies:
  - Water, food, fuel, chainsaws
- There is a national strategic stockpile for medicines
- Should companies have stockpiles too?
- There are many challenging research questions about stockpiles.

Credit: Wikimedia commons, Nick Gray,

Credit: cdc.,gov

Strategic Stockpile for Medicines

Toward Solving Some Supply Chain Challenges: Stockpiles

- Stockpile Questions
  - How big should they be?
  - What should be in them?
  - Where do you locate them?
  - Things spoil – how often do you replenish them?
  - ***Can AI/ML guide us in deciding when to restock?***
  - Distribution strategies
    - What triggers distribution?
    - How do you prioritize who gets what in case of shortages?
  - ***How best to share information about what is in stockpiles***
    - Between federal government agencies
    - Between federal and state government
    - Incentives for information sharing
  - Government incentives for private sector stockpiling?

Shipment of PPE from Strategic National Stockpile

Image credit: National Guard, flickr

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Disaster Preparedness and Response

Image credit: Bureau of Land Management

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Many kinds of Disasters

- ***For example, no part of the world is impervious to natural disasters***
  - Epidemics
  - Earthquakes
  - Floods
  - Hurricanes
  - Tornadoes
  - Wildfires
  - Tsunamis
  - Extreme temperatures
  - Drought
  - Oil spills

Photo credit: Wikimedia commons

- ***AI/ML can help in predicting, monitoring, and responding to such events, and mitigating their effects***

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Intelligent Machines in Emergency Management

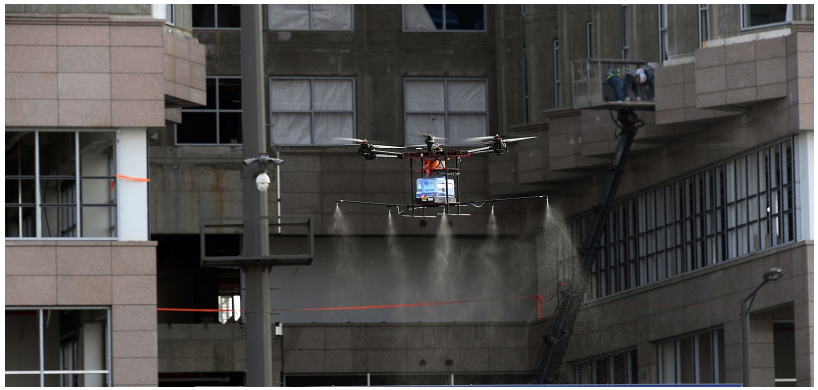
- ***"Intelligent machines" are increasingly used in emergency management***
  - Robots go into dangerous situations – earthquake rubble or radioactive environments – to move objects and rescue people
  - Robots clear debris after accidents and detonate bombs
  - Robots deliver medical supplies in COVID-19 contagion areas

credit: Commons.wikimedia.org, US Defense Advanced Research Projects Agency

Intelligent Machines in Emergency Management

- "Intelligent machines" are increasingly used in emergency management
  - Drones are increasingly used for situational awareness for law enforcement, e.g., in fires or gas leaks
  - Drones are used in COVID-19 surveillance for social distancing and mask wearing; and to spray disinfectant
  - Drones deliver supplies to officers in dangerous situations

credit: commons.wikimedia.com, Mollyrose89



credit: Commons.wikimedia.org, www.seongnam.go.kr

Intelligent Machines in Emergency Management

- "Intelligent" machines are increasingly used in emergency management
  - Unmanned vehicles can deliver equipment, supplies, food, etc. to a dangerous site
  - They have already been used that way in China during COVID
  - Unmanned vehicles can also help clear debris, do excavations, fight fires, etc.

Robotic firefighting vehicle

Credit: Commons.wikimedia.org, Branko Radovanović (no changes)

Intelligent Machines in Emergency Management

- This is not totally new
- Unmanned robotic machines were used during the Chernobyl disaster in 1986
- Radiation was too high for humans to enter

- This vehicle is at the Chernobyl Remote Controlled Vehicle Park
- Radiation levels prevented humans from working longer than 40 seconds
- Robots were developed to do it but mostly didn't succeed as high radiation destroyed electronic parts
- Most of the robots are still very radioactive

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Example: Oil Spills

- With climate change, more vessel traffic in the Arctic and possibility of offshore oil drilling
- Increased risk of spills
- *"The lack of infrastructure and oil spill response equipment in the U.S. Arctic is a significant liability in the event of a large oil spill"* *(National Academies, 2014).*
- Arctic challenges: resource allocation in advance in case of oil spill
  - Necessary because of long transit times, lack of infrastructure, remote locations, lack of roads, distant airlift
- CCICADA Research project with US Coast Guard: Dynamic Modeling for Arctic Resource Allocation (DMARA)

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Example: Oil Spills

- DMARA: formulated the oil spill resource allocation problem as a large optimization problem
- ***Model has two million variables and almost as many constraints***
- It developed
  - Algorithmic approaches to improve solvability
  - Heuristic programming techniques as possible solution procedures

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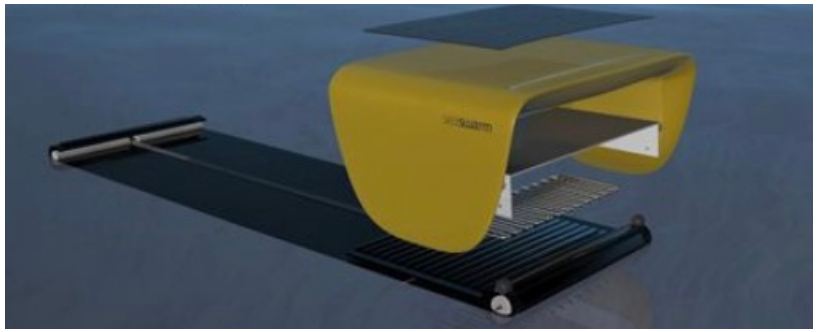
Example: Oil Spills

- ***Could intelligent machines help with oil spills?***
- ***Researchers in MIT's Senseable City Lab created a prototype robot for a system they call Seaswarm***
  - This is a fleet of vehicles that could make cleaning up future oil spills less expensive and more efficient than current skimming methods



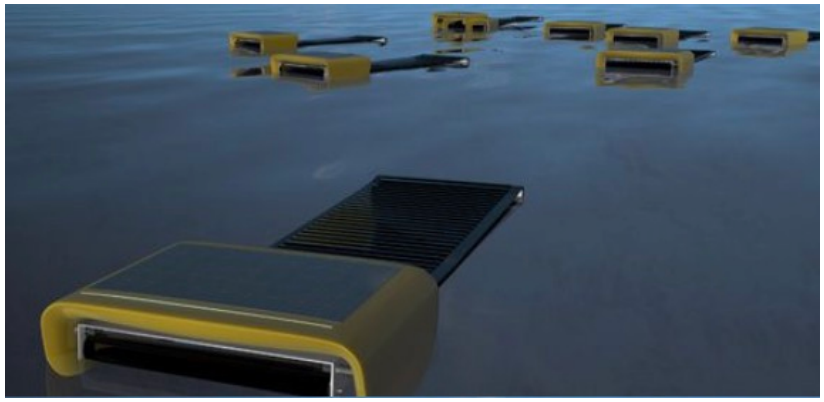


Photo credits: MIT Senseable Lab
https://sap.mit.edu/article/standard/swarm-robots-clean-oil-spills

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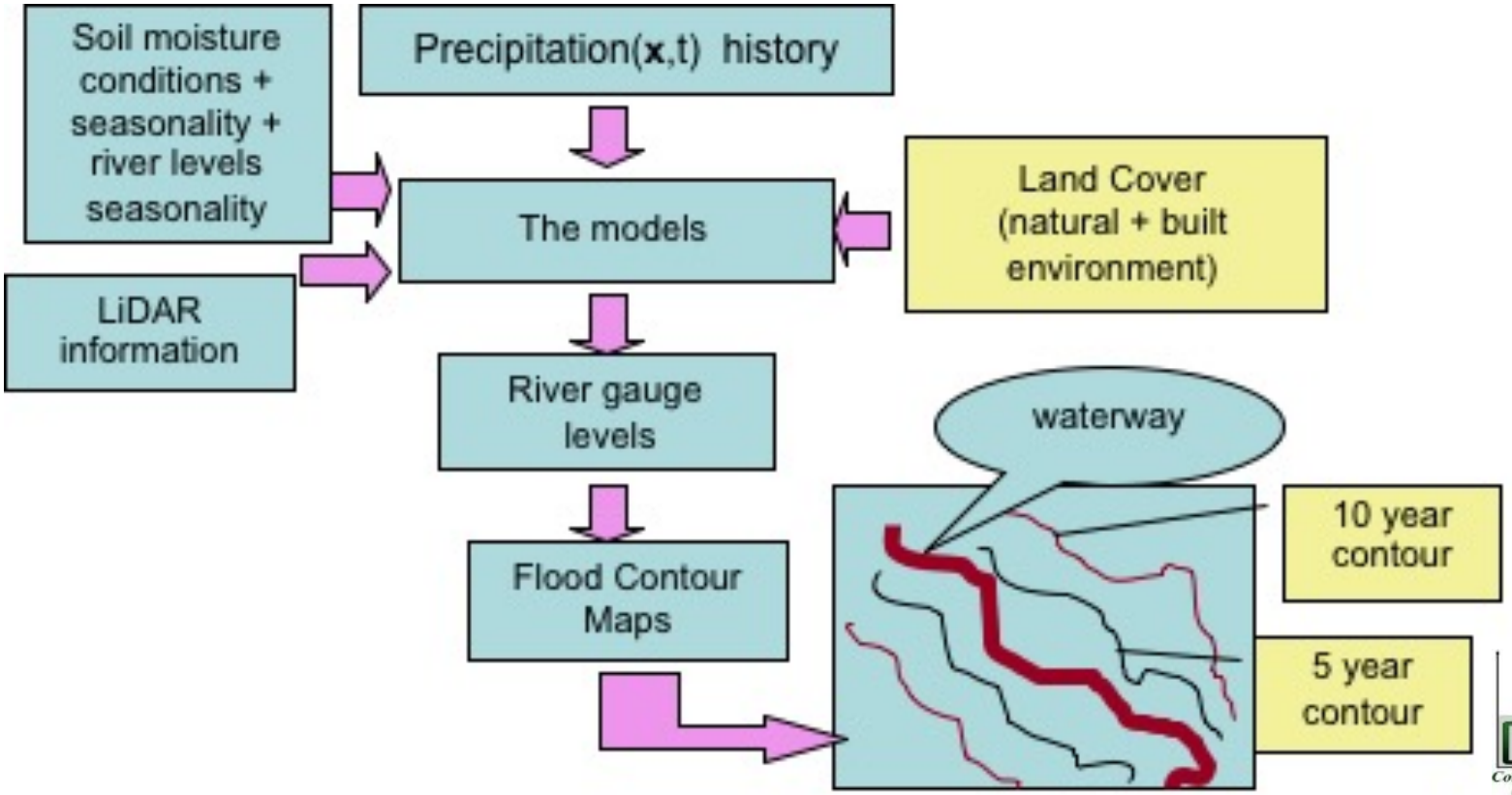
Example: Flood Mitigation

- ***FEMA problem: what mitigation projects to invest in***
- ***Need: New information-driven tools to make investment decisions***
- Project focused on Raritan River basin in NJ
- Data driven project. Assemble data about:
  - Precipitation (duration, amount)
  - Antecedent conditions (soil moisture content, ground cover, seasonality)
  - River gage levels
  - Flood maps
  - Property damage data – FEMA payouts

Image credit: Voice of America

Example: Flood Mitigation

- ***Developed models of meteorological activity, hydrological models, and models of economic impact***
  - A hydrological model relating flood mitigation strategies to water levels
  - A nonlinear econometric model relating several water-level-related variables to FEMA insurance payouts



Example: Flood Mitigation

- ***Combined the models to develop a general tool for flood mitigation investment decision support***
- Tool to understand the long-term flood damage reduction benefits of different flood mitigation strategies
- ***Next generation of such tools should build on the massive amounts of data and use ML to predict impact of different strategies***
- Results delivered to FEMA

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I Could Go On and On

- Intelligent machines to control the spread of disease – e.g., identification and capture of disease-carrying mosquitoes
- AI/ML to fight against invasive species (US Coast Guard has first line of responsibility)
- Robot screeners at border crossings (already under test in the European Union)
- AI/ML to find anomalies in data about goods in a shipping container – searching for weapons of mass destruction or counterfeit
- AI/ML to gain early identification of candidates for violent extremism or school shooting
- Predictive policing – identifying areas to police
- AI/ML from body cams to learn how to de-escalate conflict situations with police
- AI/ML to counter disinformation

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Questions?

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