IOWA STATE UNIVERSITY
Department of Industrial and Manufacturing Systems Engineering

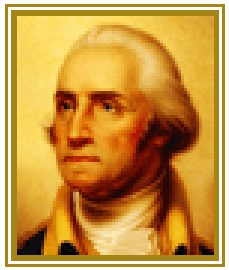
Industrial engineering solutions to non-industry problems:

How industrial engineering methods are being applied to healthcare, humanitarian aid, public policy, and sports

Cameron MacKenzie

March 7, 2016

My background



THE GEORGE WASHINGTON UNIVERSITY
WASHINGTON DC

Interesting questions

- How can mathematical models help us make better decisions?
- How can we apply industrial engineering methods to other applications (e.g., security and defense, healthcare, humanitarian aid)?
- How can we still use models and good analytics when we don't have a lot of data?

Focus on operations research and system engineering models

U.S. healthcare system

Descriptive statistics

- 17% of GDP for healthcare
- Expenses increasing at 4-10% annually
- Major pressure to become more efficient and provide higher quality care
- Shortage of skilled workers

Costs of poor quality

- Estimated 35% of all healthcare costs = waste
- Duplication, non-value add, redundancies
- Medical errors, adverse events, preventable deaths, process defects

IEs in healthcare

- Integrate people, equipment, facilities, and other resources to improve work results
- Perform cost-saving and quality improvement projects
- Analyze data, perform feasibility studies, analyze waiting times and scheduling, layout for space planning
- Optimize disease screening, optimize organ transplant schedule

IE projects in healthcare

- Productivity management
- Staffing and scheduling
- Process improvement
- Inventory management
- Simulation
- Benchmarking
- Facility design and capacity analysis
- Operations and systems analysis
- Quality improvement

Examples

- Determines how much to order and when to order for medical supplies
- Uses yellow tape to determine when to reorder

- Design optimal inventory policy for specially designed medical cabinets (includes medical supplies and medicine)

MD Anderson Cancer Center

Bryan Norman,
University of Pittsburgh

Public health example

- HIV prevention and treatment programs
- Programs to control spread of hepatitis B (vaccinate or not)
- Strategic national stockpiles to stop spread of pandemics

Margaret Brandeau, Stanford University

Humanitarian aid and disaster relief

Challenges in humanitarian aid

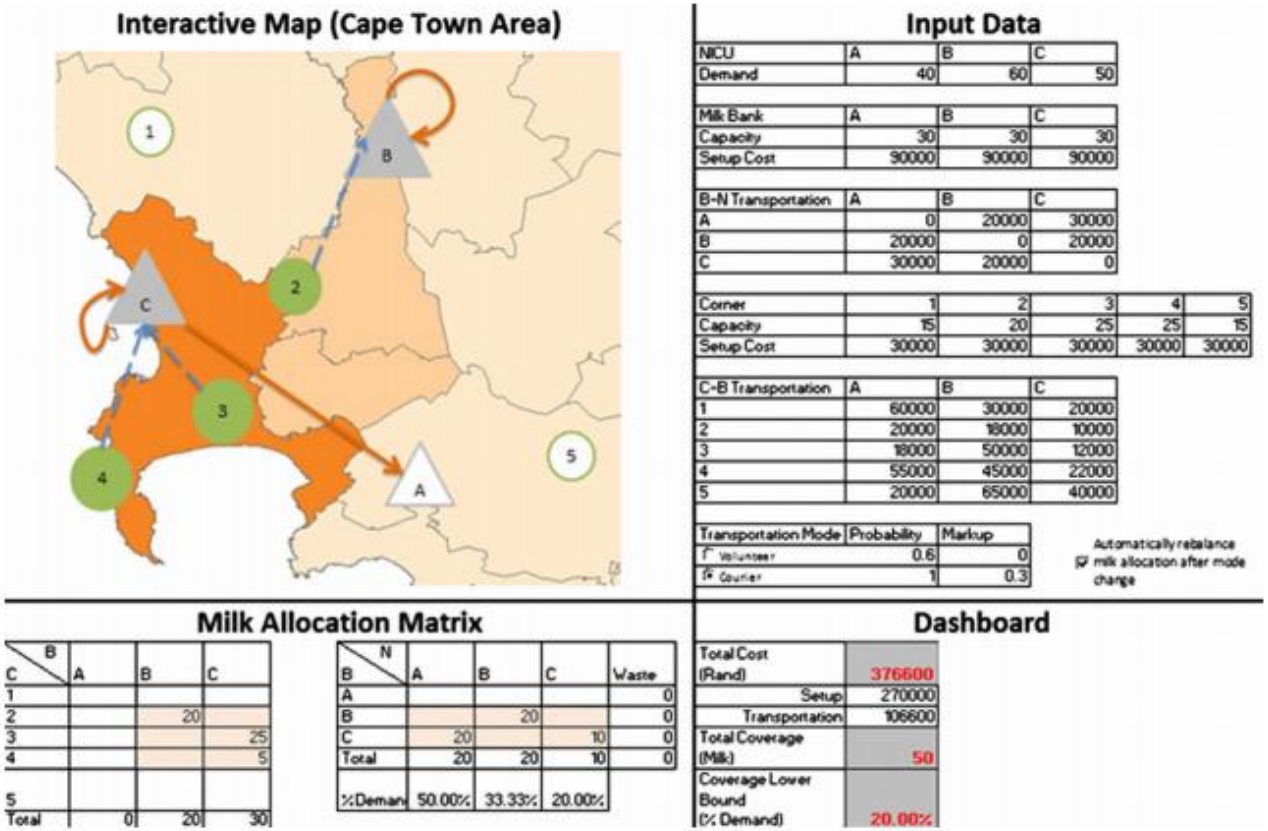
- Limited availability of resources
- Lack of infrastructure
- High uncertainty
- Multiple stakeholders with different objectives

Georgia Tech Health & Humanitarian Systems Interdisciplinary Research Center

Melih Celik, Ozlem Ergun, Ben Johnson, Pinar Keskinocak, Alvaro Lorca, Pelin Pekgun, Julie Swann, 2014. Humanitarian logistics. In INFORMS *Tutorials in Operations Research*, 18-49.

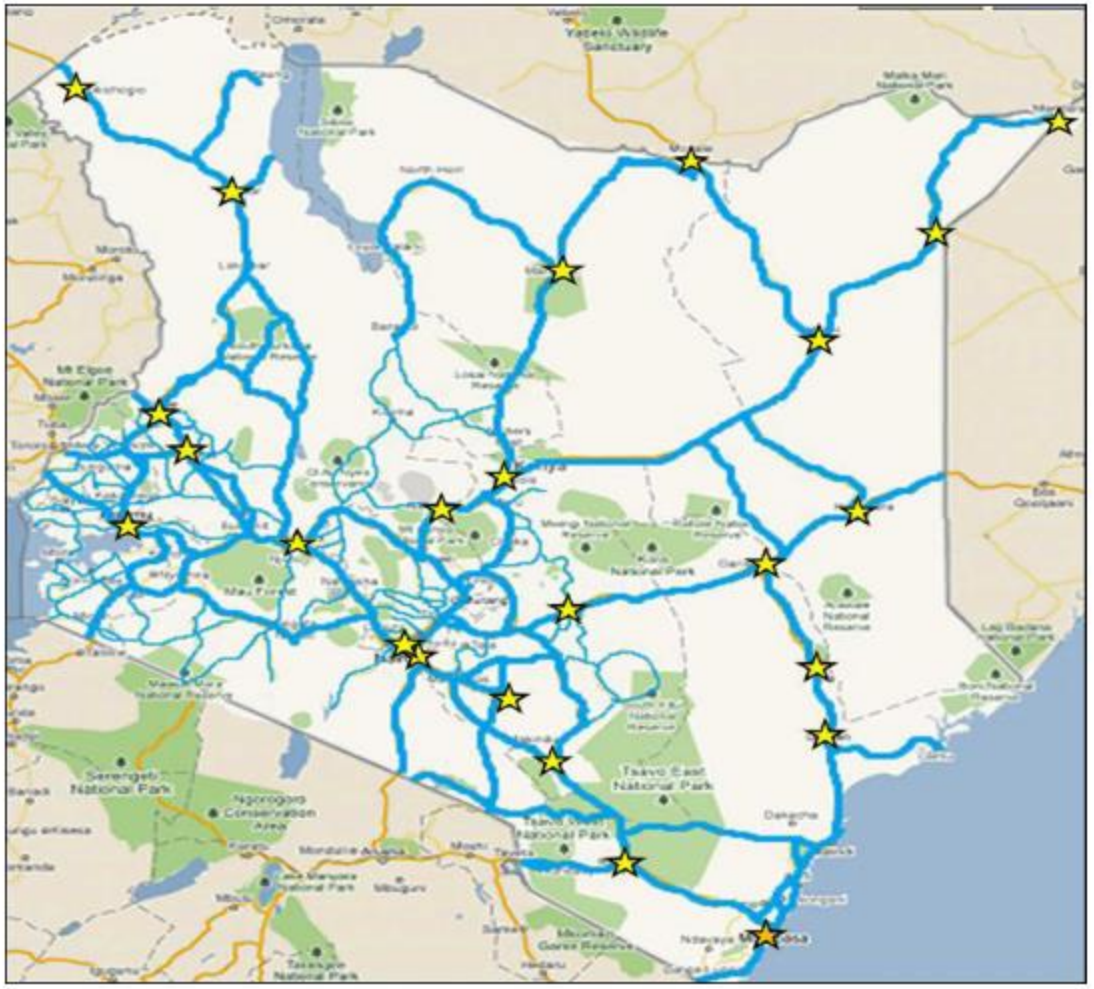
Breast milk delivery in South Africa

- Allocate donated breast milk in South Africa for newborns
- Determine how much milk to deliver to each facility based on equity considerations



Food aid distribution in Horn of Africa

- United Nations World Food Program
- Supply forecasting
- Inventory management
- Truck scheduling
- Port simulation



Demand estimation and procurement tool for CARE

- Use historical data to estimate numbers of affected populations for a disaster
- Procurement tool for what CARE should purchase once a disaster strikes (optimization model in Excel)

Postdisaster medical response

- Assess ability of medical resources to handle a disaster situation
- Model number of people that will seek aid following a disaster and where they will go
- Estimate amount of debris that needs to be cleared following disaster

Security and defense

- Operations research was initially developed to help the U.S. and U.K. win World War II
- Logistics models on optimal planning for purchasing, facility location, maintenance for military
- Multiple objective decision making: how to measure effectiveness in national security
- Simulation tools for analysis, planning, and war gaming

U.S. Marine Forces Reserve

Lt. Gen. Rex McMillian

Evacuate?

- 1,000 Marines on base
- If you wait to order evacuation until 30-40 hours before hurricane, Marines could be stuck in traffic as the rest of New Orleans tries to evacuate
- If no evacuation and hurricane strikes
  - Potential loss of life
  - Potential of city infrastructure disabled
- $300,000 for each day that Marines have evacuated

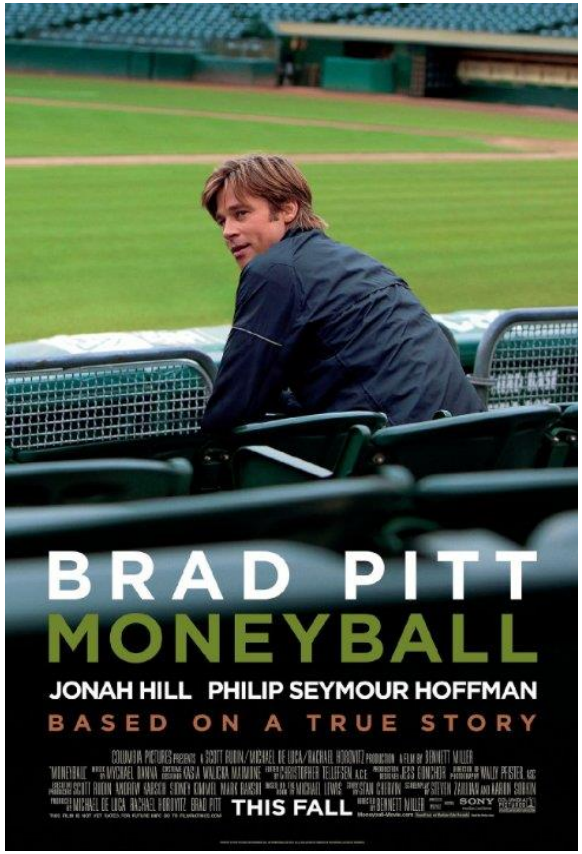
Homeland security

- Best practices for screening passengers in Transportation Security Administration (eg, precheck)
- Preparation for nuclear, biological, chemical attack
- Pandemic outbreaks
- Risk quantification and budget allocation based on risk assessment

Homeland security

- Psychological perception and reactions to events
- Protection of ports
- Police security at airports
- Economic consequences of terrorist attacks and natural disasters
- Infrastructure protection
- Resilience

Sports analytics



FiveThirtyEight

What inefficiencies exist in sports evaluation and strategy that can be exploited?

Sports analytics

- Statistics-based research: new statistics to evaluate players and referees
- Decision-making models
  - When should you go for it on fourth down?
  - When should baseball teams shift defense?
- Predictions
  - Winning your NCAA bracket
  - Forecasting player and team performance (computer simulation)

Wayne Winston,
University of Houston

Skills

- Good mathematical, modeling, and statistics skills
- Applications in these areas in human factors and manufacturing
- Interest in these types of problems, ask good questions that need to be solved
- Ability to communicate technical detail to non-technical decision makers