Systems Engineering for the ED Simulation Session

Part 1: The View from the ED

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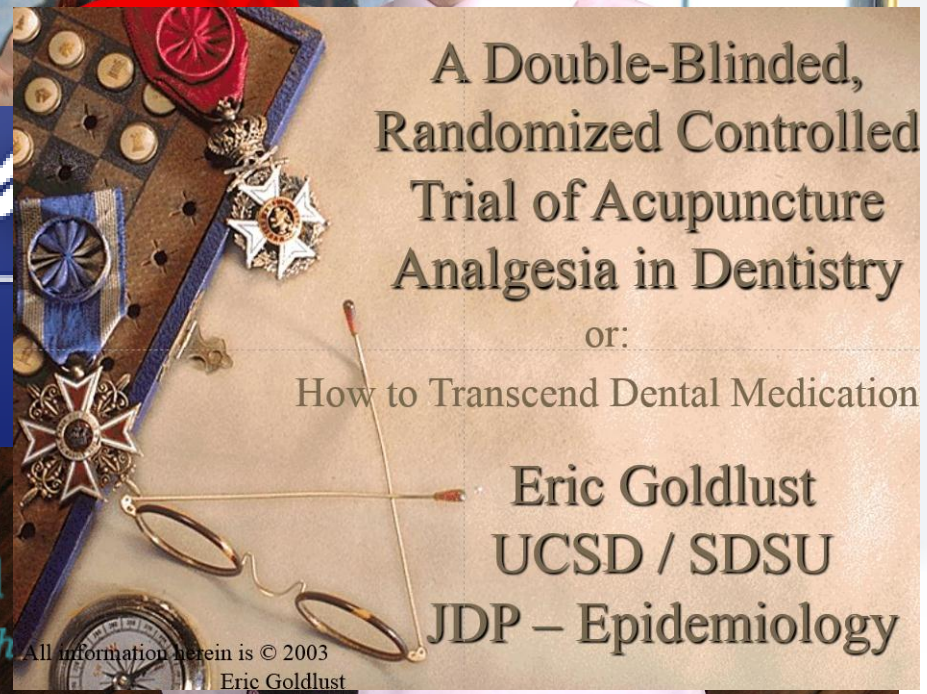
Emergency Physician, TPMG, Kaiser Permanente – Santa Clara, CA

January 31, 2016 – Healthcare Working Group, INCOSE International Workshop; Torrance, CA

What to expect for the next 30 minutes:

- My background
- Perspectives on SE / M&S from the healthcare industry
  - Clinicians
  - Medical administrators
  - Medical researchers
- The disconnect
- The reconnect

Consider the source:



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My view on MBSE

MBSE

How does our healthcare system actually WORK?

What am I DOING?

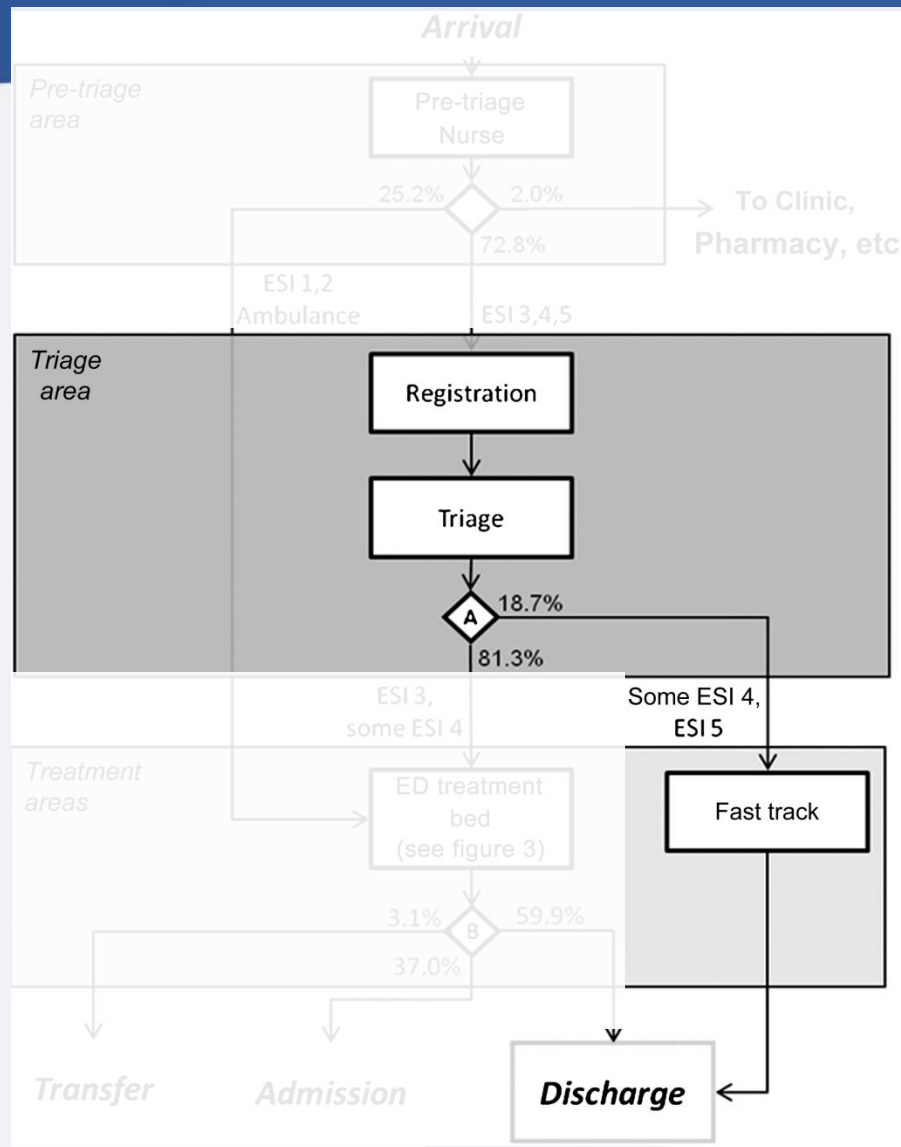
How do we do it BETTER?

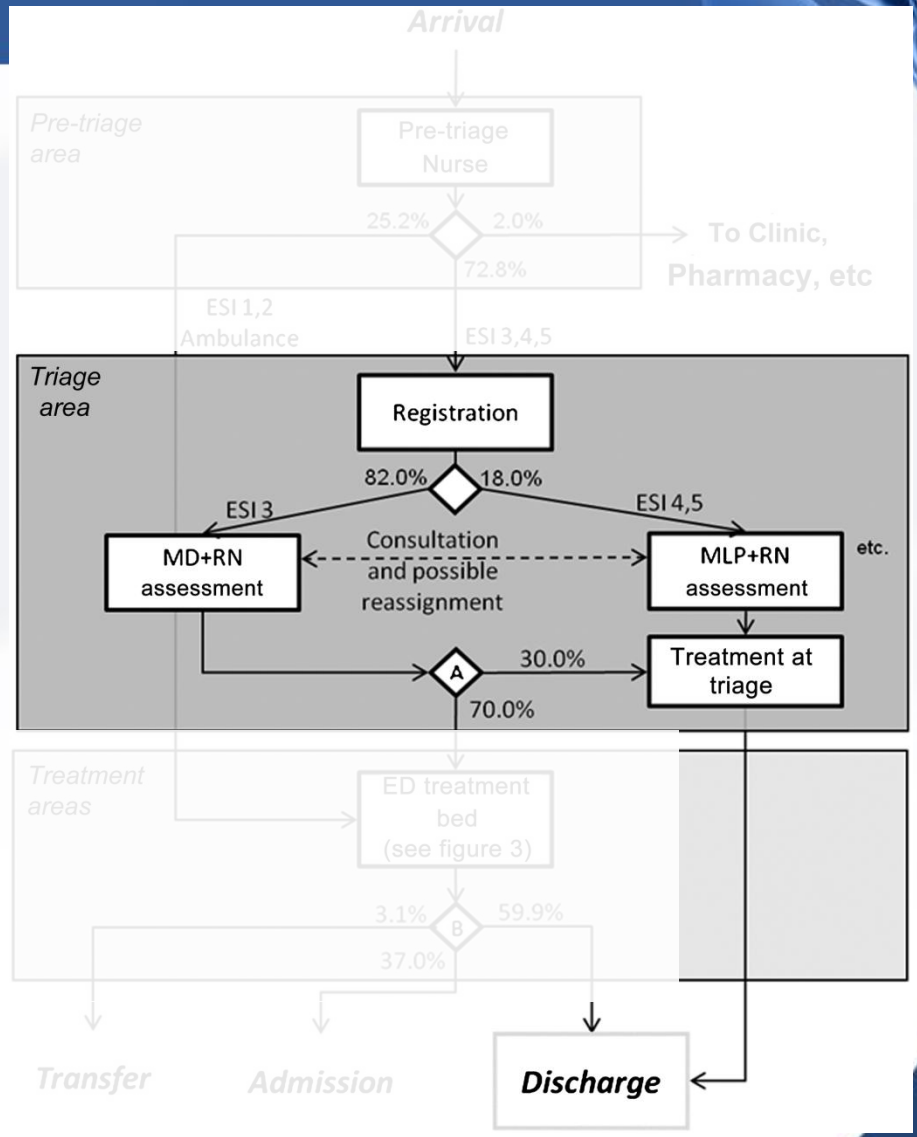
How do we STUDY these questions?

St. Louis (John Cochrane) VA Medical Center

- Quality Improvement Project
  - Objective: Decrease % of ED patients with length of stay (LOS) > 6 hrs
  - Compared real vs simulated results

And here's what I've done with it:





VA: Throughput Metrics

Mean Daily LOS:

- Simulation: 249’ ± 39.7’ → 200’ ± 19.0’
- Real World: 247’ ± 39.8’ → 210’ ± 16.6’

37 minutes (p <.0001)

% Patients with LOS > 6h:

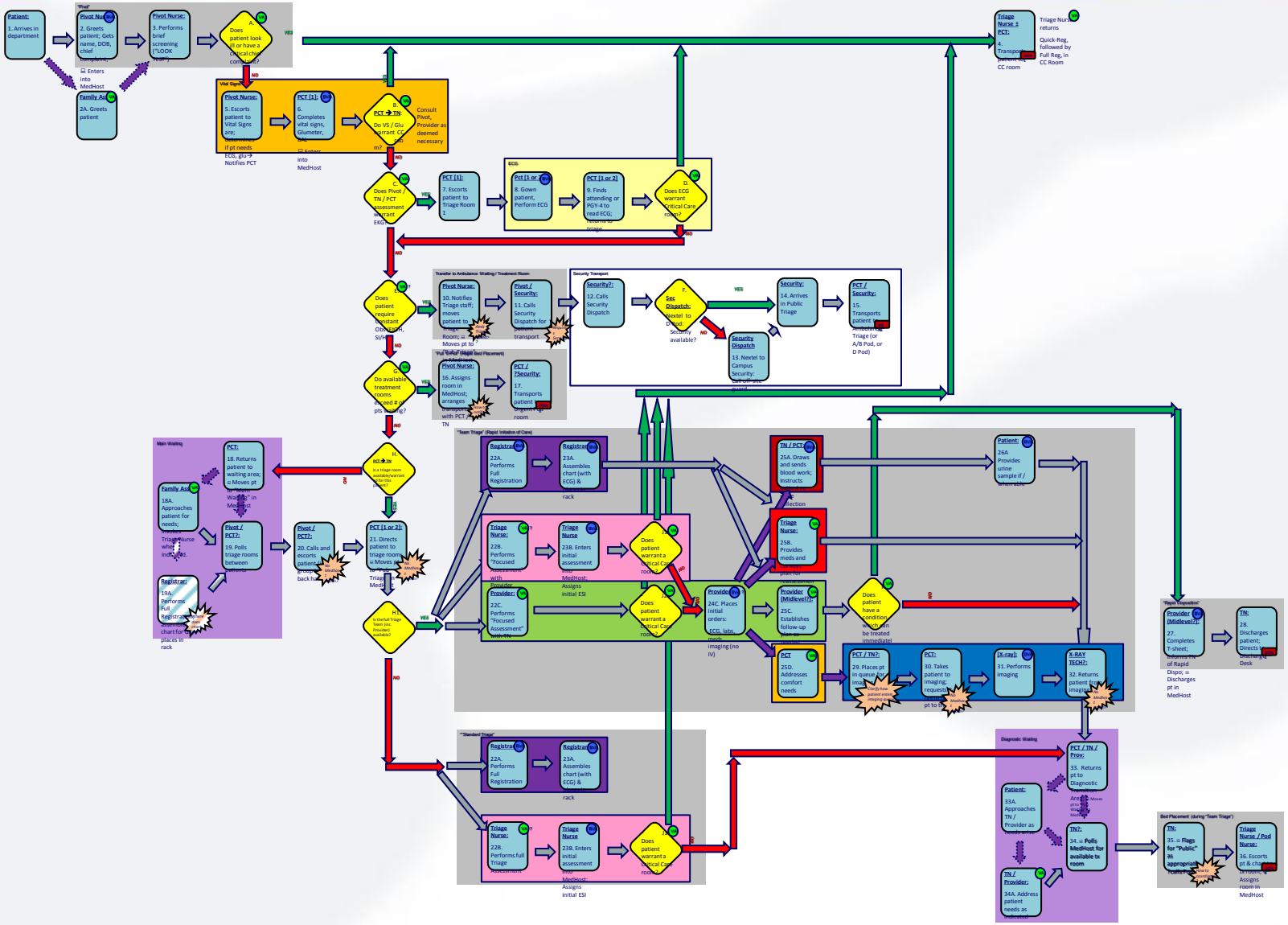
- Simulation: 19.0% → 13.1%
- Real World: 19.9% → 14.3%

28% reduction (p = .045)

No indication of negative effects on patient health or satisfaction
Allows 3,500 more visits/year (17.5%) without adding staff or space

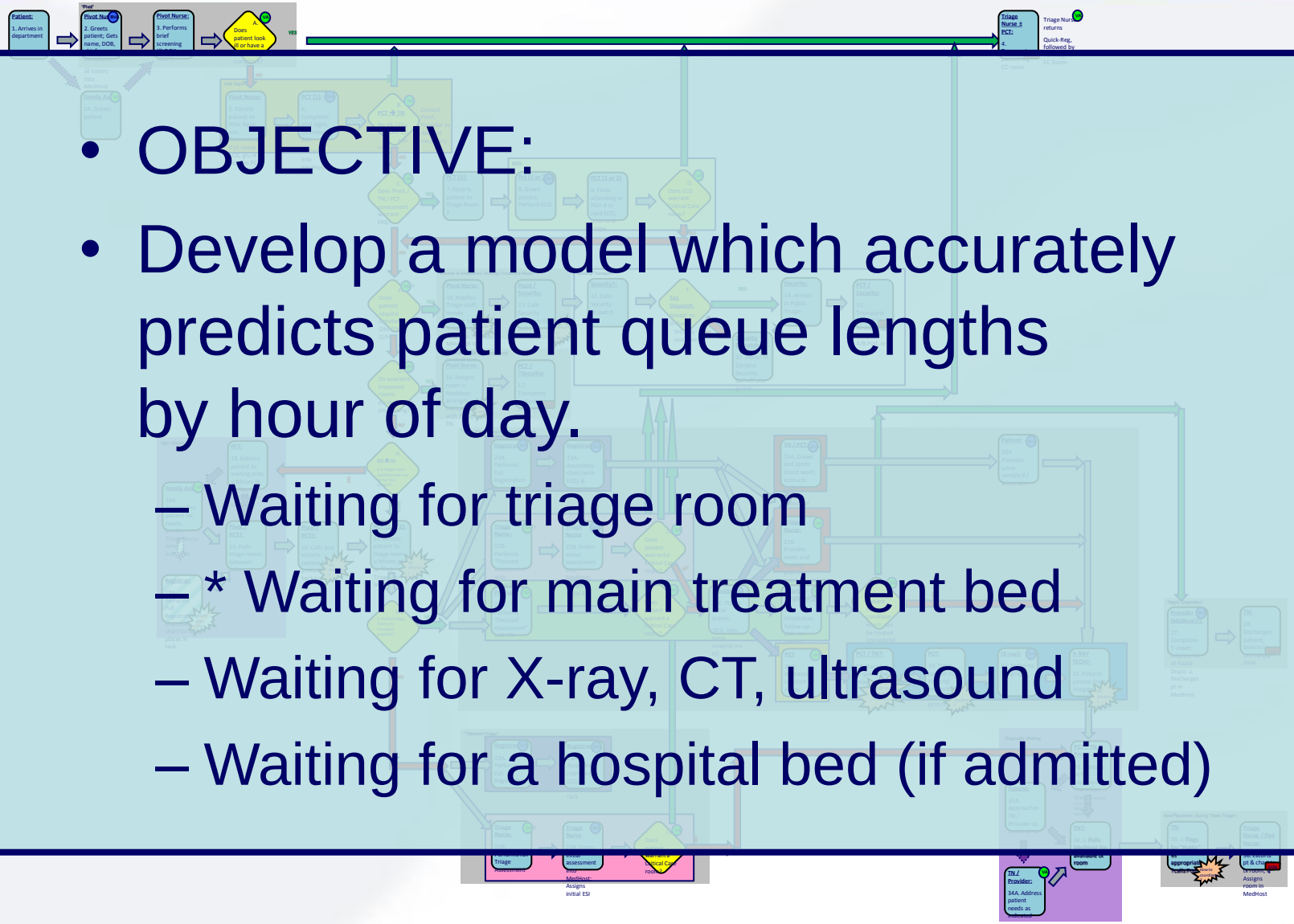
Rhode Island Hospital

AEC: Process Flow Map (2010)



- Yikes.

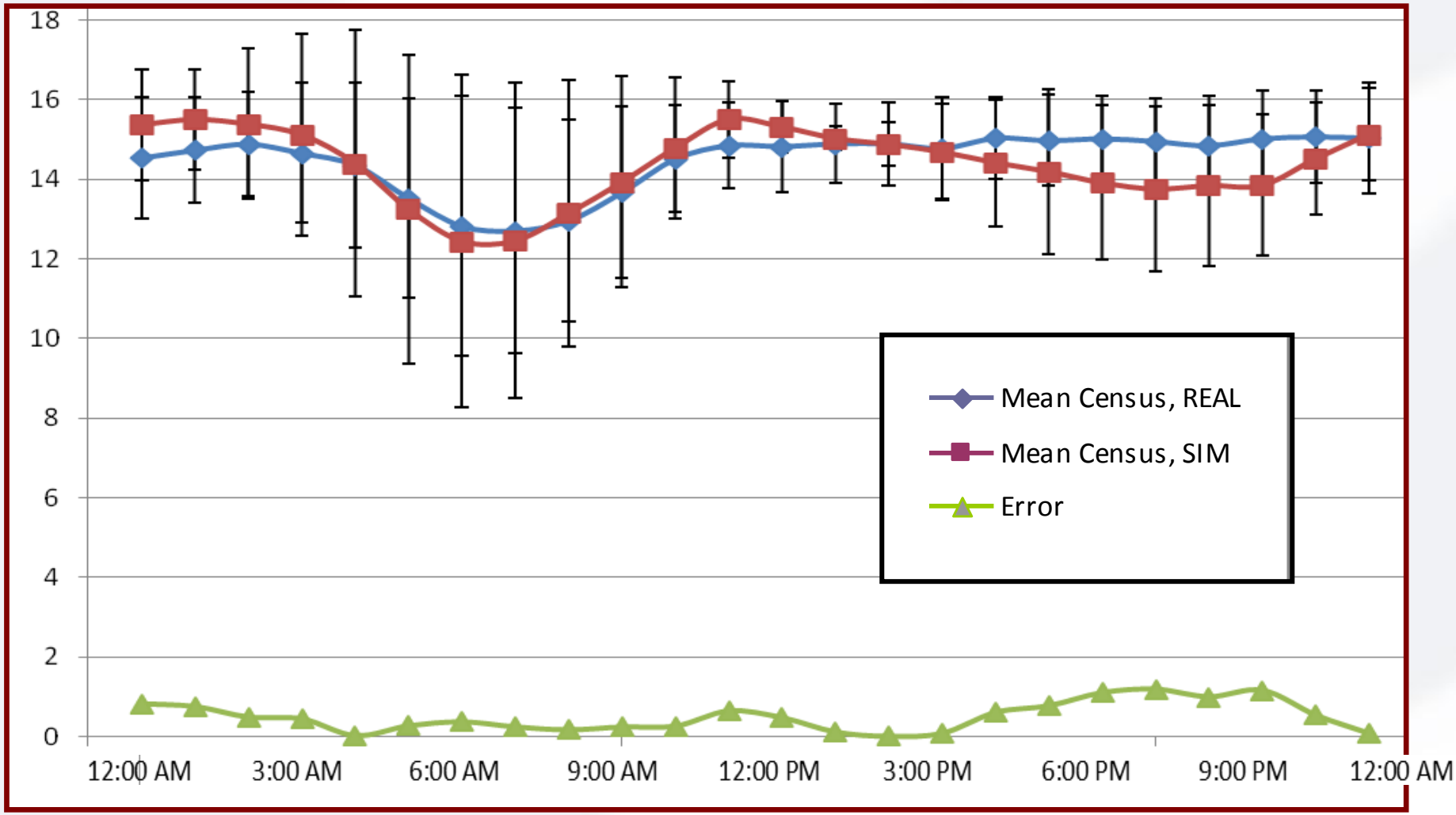
AEC: Process Flow Map (2010)



- OBJECTIVE:
- Develop a model which accurately predicts patient queue lengths by hour of day.
  - Waiting for triage room
  - * Waiting for main treatment bed
  - Waiting for X-ray, CT, ultrasound
  - Waiting for a hospital bed (if admitted)

- Yikes.

Census: “A” Pod


18
16
14
12
10
8
6
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0
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Mean Census, REAL
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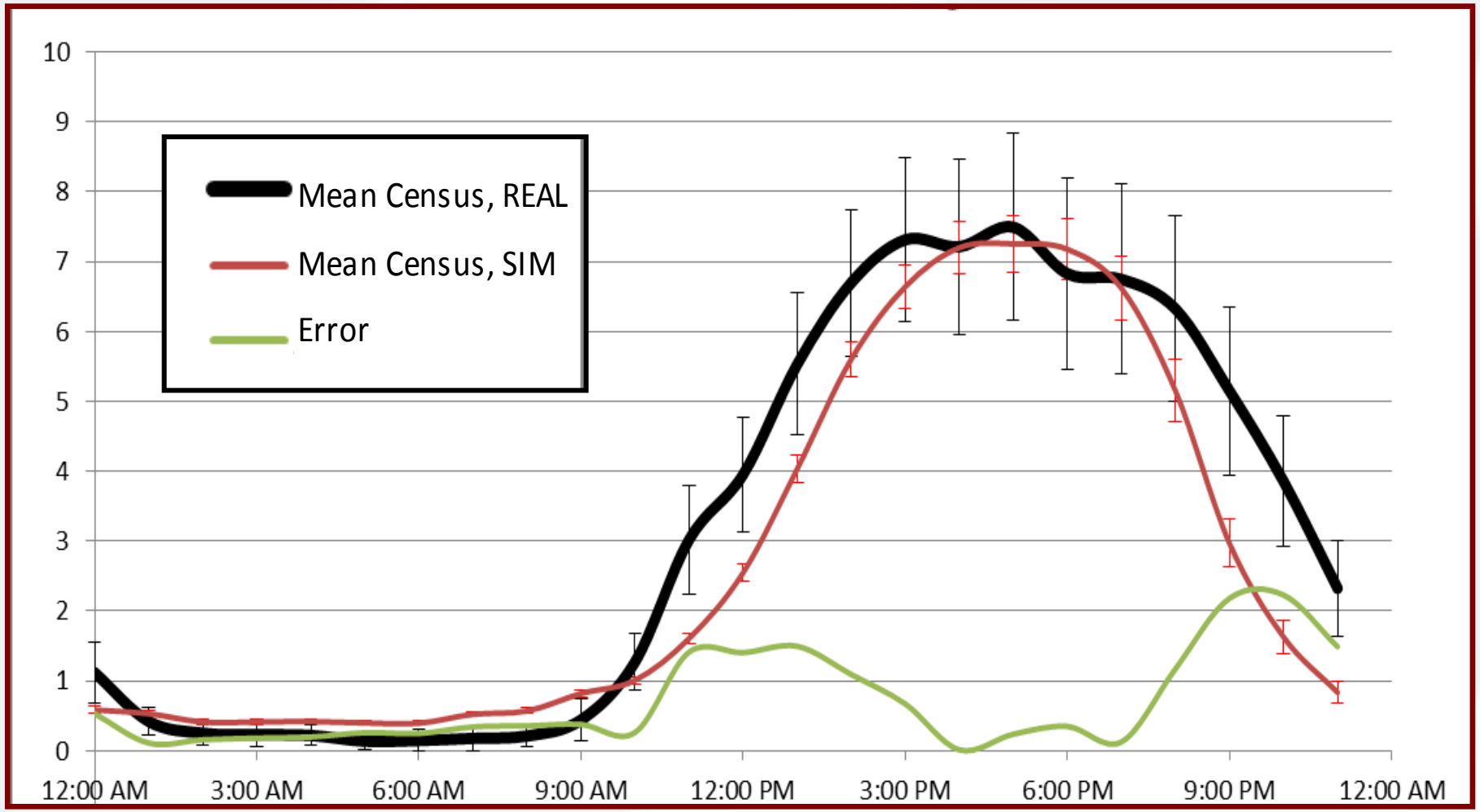
Queue for Service: “Main Waiting” Area



My colleagues' view on SE:

Operations Researchers

Clinicians

Administrators

Although there are some good examples..

1975: First proposed… in the economics literature (Hannan 1975)

1989: First published simulation of ED flow (Saunders 1989)

2001: Second article, proof-of-concept model (Coats 2001)

2001 – 2015: Discrete Event Simulation to:

- Optimize physician and staff scheduling
  Hung '07, Brenner '10, Day '15*
- Analyze & visualize patient flow
  *Codrington-Virtue '05, *Mes '12, Batarseh ''*
- Optimize unit bed capacity
  Zhu '12, Santos '13
- Forecast near-future operating status
  Hoot '08, Hoot '09
- Assist in ancillary service design (e.g., pharmacy)
  Reynolds '11
- Compare alternative triage processes
  Connelly '04, Day '13, Ward '14
- Assist in pharmaceutical allocation and trial design
  Barrett '12
- Decrease inpatient boarding
  Levin '08, Hung '09, Khare '09
- Evaluate ED/EMS interventions
  Stahl '03, Chase '06
- Study interactions between providers
  Genuis '13, Lim '13
- Identify bottlenecks in a continuum of care
  ** Noonan '09, Santos '13*

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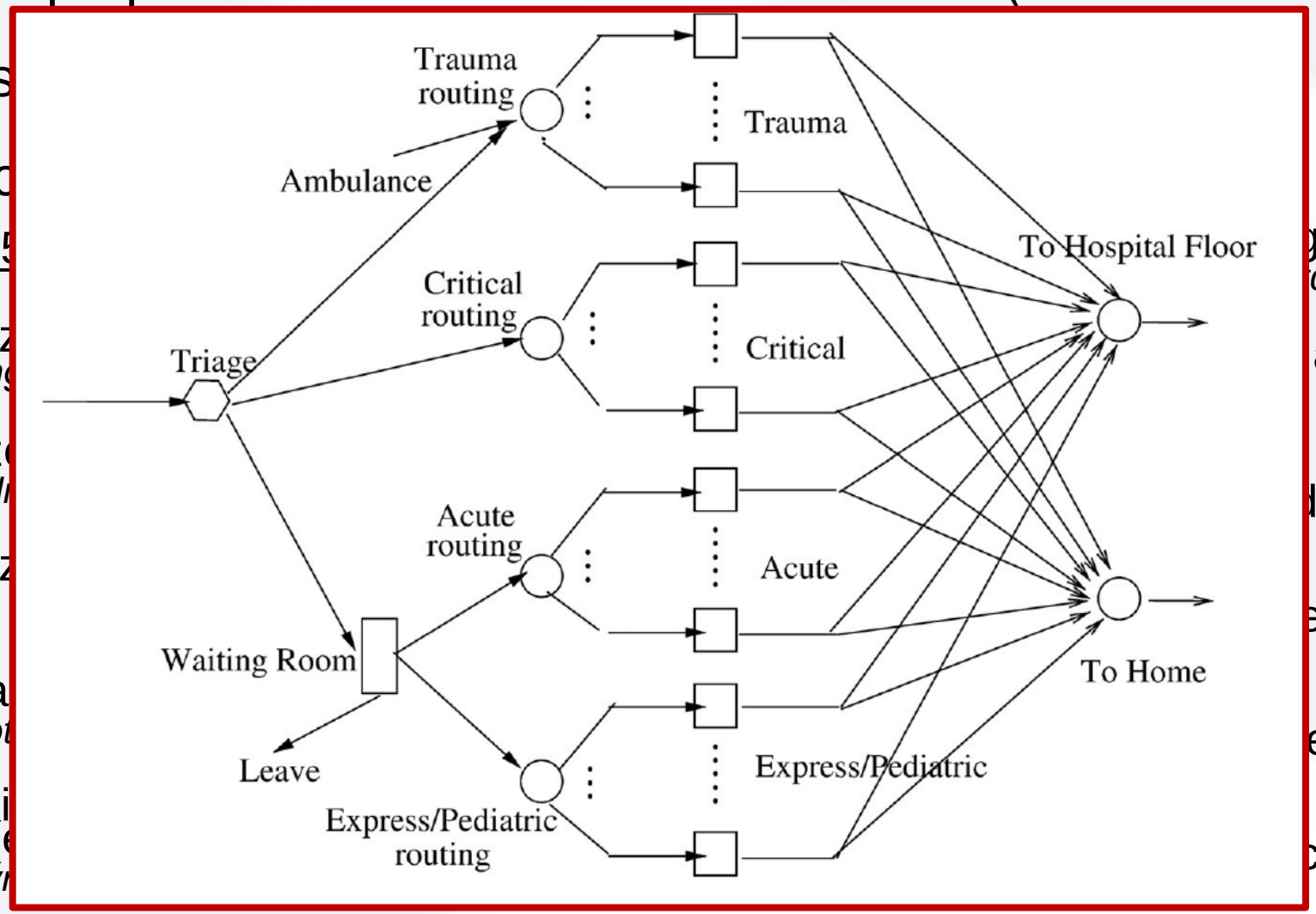

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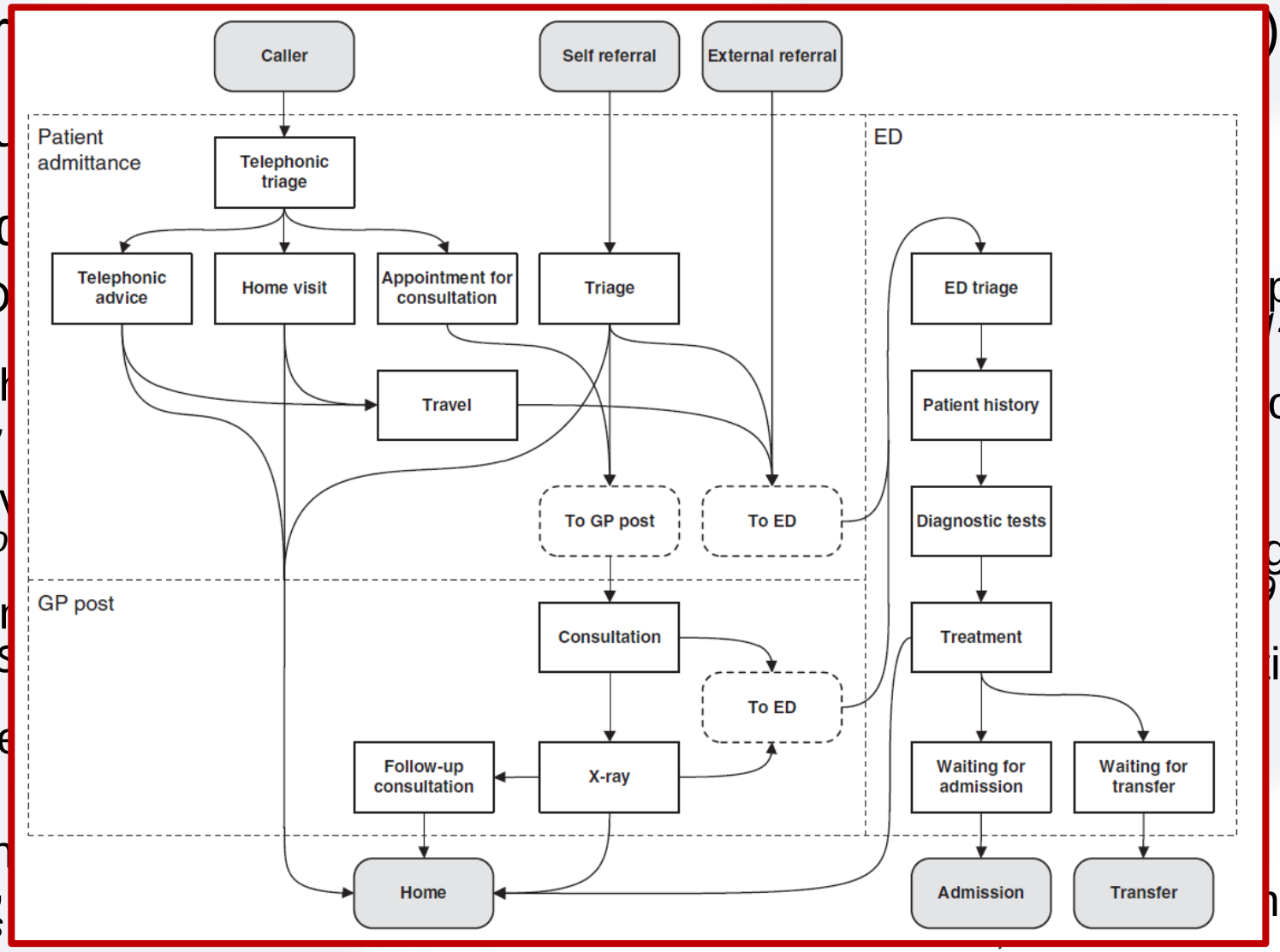

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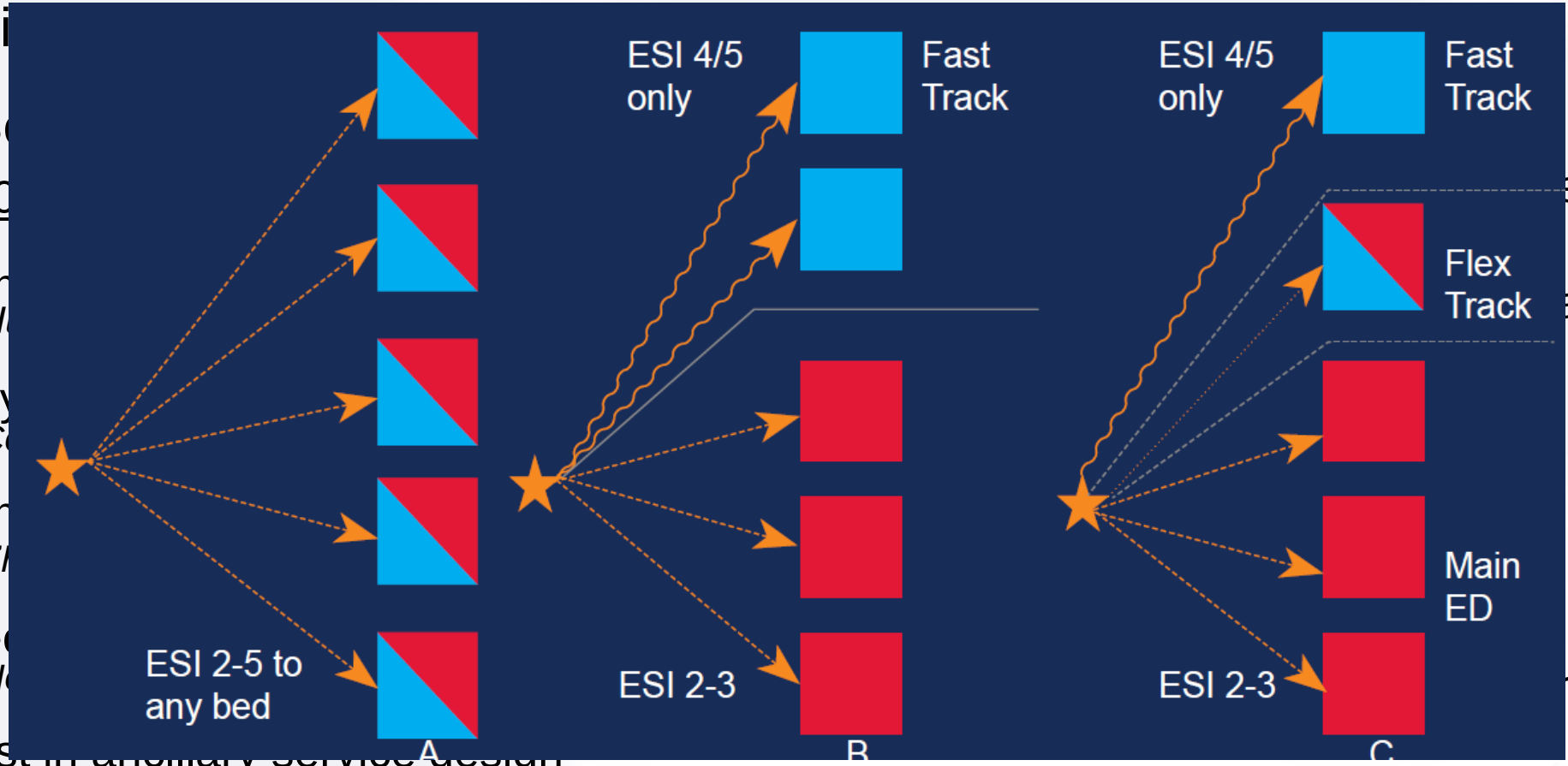

- Identify bottlenecks in a continuum of care
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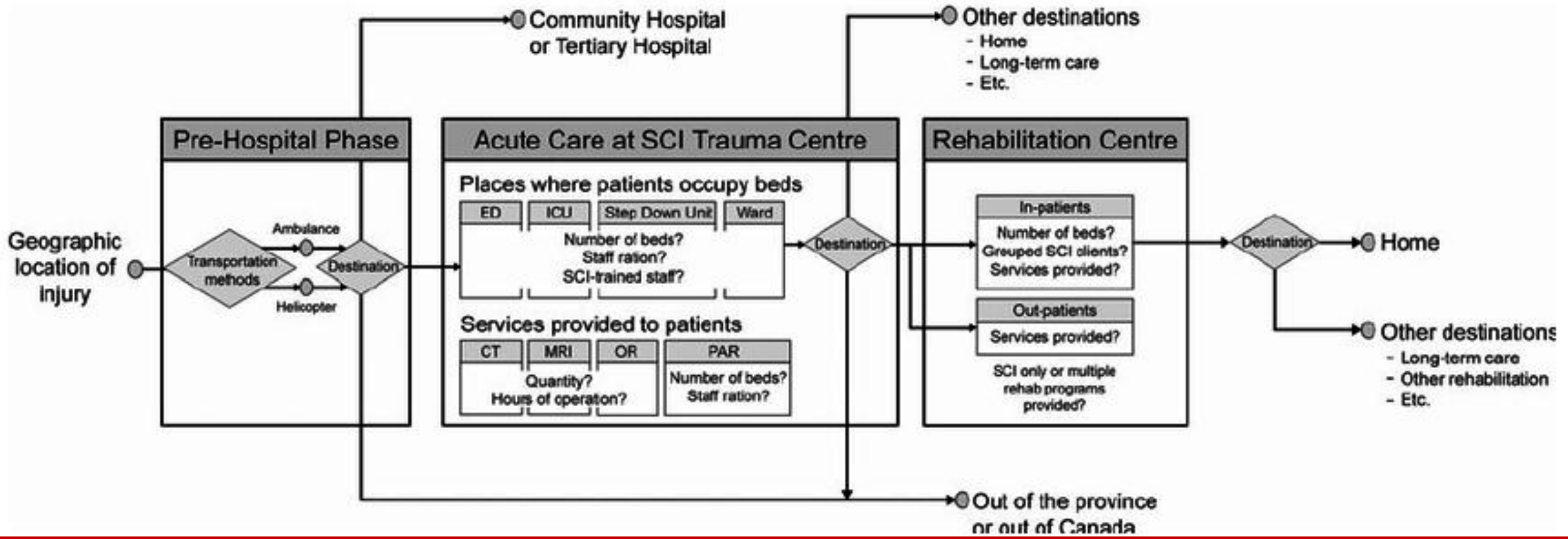

- (drugs, pharmacy)

Reynolds '11

- Identify bottlenecks in a continuum of care

** Noonan '09, Santos '13*

… and a few who champion SE in healthcare…

Modeling and Analysis of the Emergency Department at University of Kentucky Chandler Hospital Using Simulations

Authors: Stuart Brenner, MS, Zhen Zeng, MS, Yang Liu, MS, Junwen Wang, MS, Jingshan Li, PhD, and Patricia K. Howard, PhD, RN, CEN, FAEN, Lexington, KY

Discrete Event Simulation of Emergency Department Activity: A Platform for System-level Operations Research

Lloyd G. Connelly, PhD, Aaron E. Bair, MD

Computer Modeling of Patient Flow in a Pediatric Emergency Department Using Discrete Event Simulation

Geoffrey R. Hung, MD, FRCP(C) FAAP, Sandra R. Whitehouse, MD, FRCP(C),* Craig O'Neill, BComm, MMOR,† Andrew P. Gray, BSc,† and Niranjan Kissoon, MD, FRCP(C) FAAP, FCCM‡*

Journal of Simulation (2010) 4, 42–51 1747-7778/10

Discrete event simulation for performance modelling in health care: a review of the literature

MM Günal* and M Pidd

Lancaster University Management School, Lancaster, UK

Incorporating Discrete Event Simulation Into Quality Improvement Efforts in Health Care Systems

American Journal of Medical Quality
201X, Vol XX(X) 1–5

DOI: 10.1177/1062860613512863
ajmq.sagepub.com
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Matthew Harris Rutberg, MBA,[1] Sharon Wenczel, MSN, RN,[1] John Devaney, BA,[1] Eric Jonathan Goldlust, MD, PhD,[2,3] and Theodore Eugene Day, DSc[1]

Forecasting Emergency Department Crowding: A Discrete Event Simulation

Nathan R. Hoot, PhD
Larry J. LeBlanc, PhD
Ian Jones, MD
Scott R. Levin, PhD
Chuan Zhou, PhD
Cynthia S. Gadd, PhD, MBA
Dominik Aronsky, MD, PhD

From the Department of Biomedical Informatics (Hoot, Jones, Gadd, Aronsky), the Owen Graduate School of Management (LeBlanc), the Department of Emergency Medicine (Jones, Aronsky), the Department of Biomedical Engineering (Levin), and the Department of Biostatistics (Zhou), Vanderbilt University Medical Center, Nashville, TN.

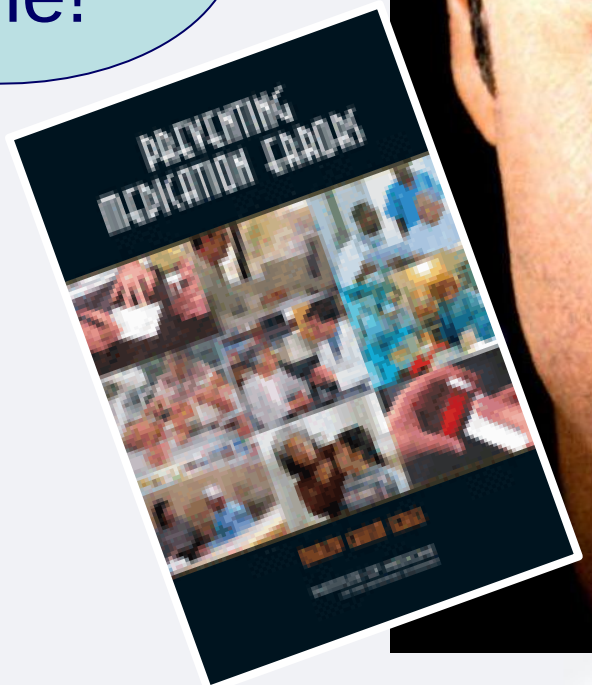
…so Why the disconnect?

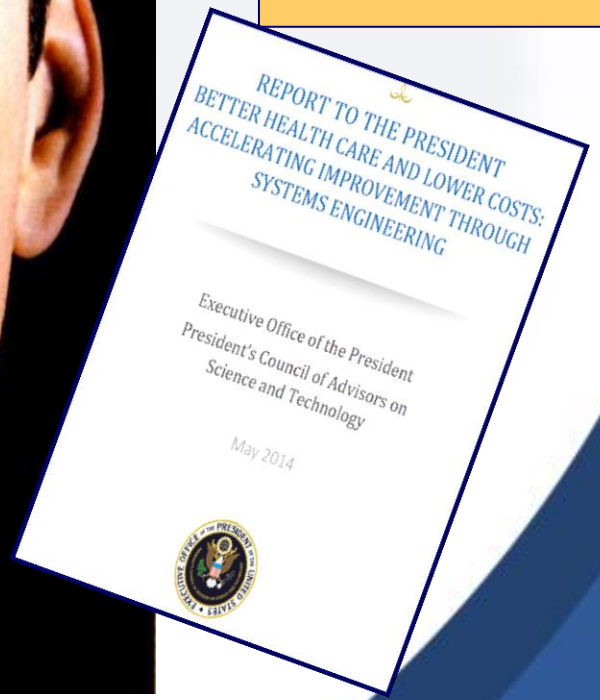
? ? ?

Bottom Line!

$$\chi^2 = \Sigma \left[\frac{(O - E)^2}{E} \right]$$

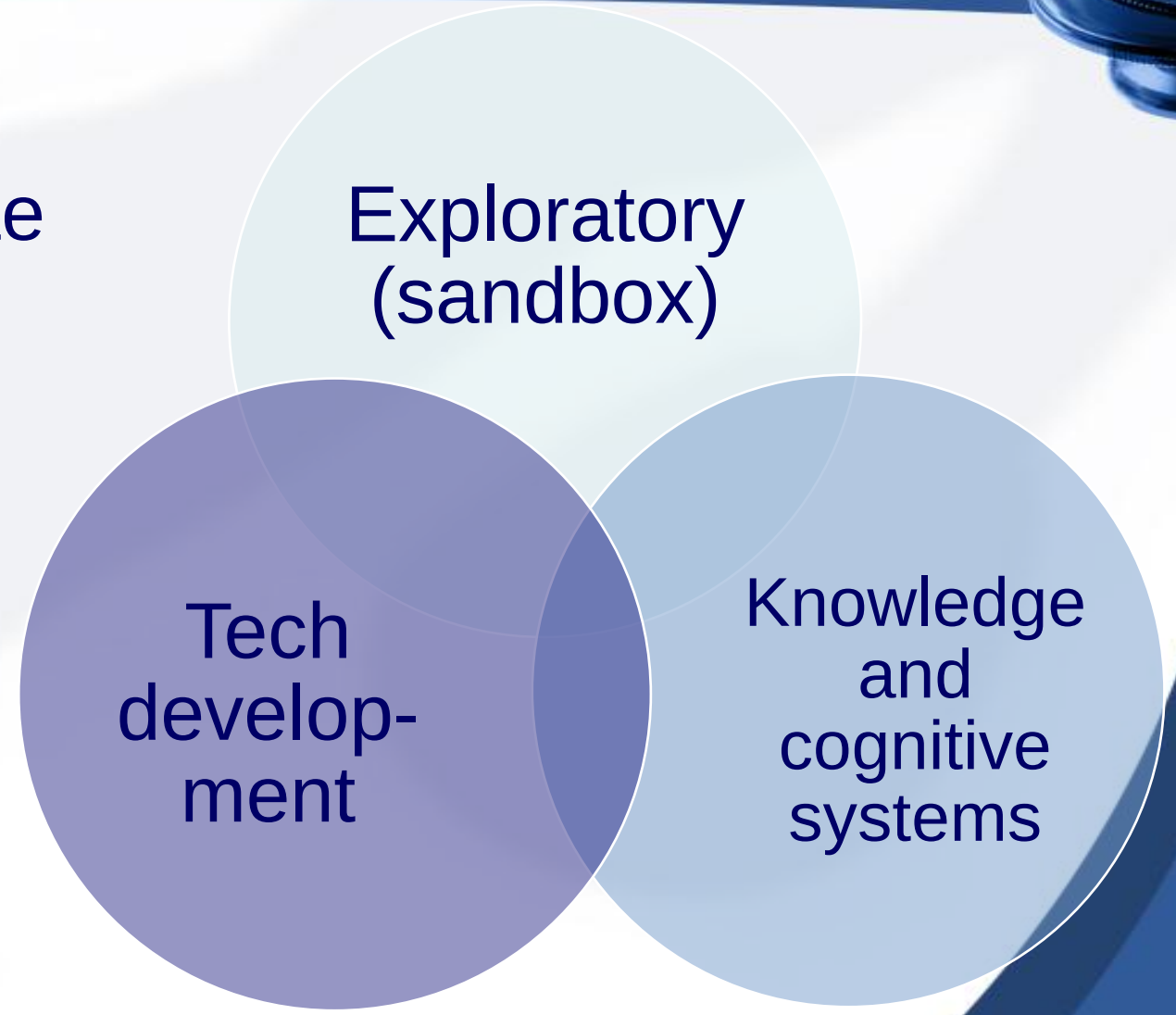
Best Methods!





How do we link SE and healthcare (in the minds of physicians)?

- STEP 0: Change the approach, to accommodate
  - Low engineering literacy
  - Physician egos
  - Reluctance to change
  - Need for visceral impact



How do we link SE and healthcare (in the minds of physicians)?

- STEP 1: Approach (the right groups) with caution.
- STEP 2: Frame systems problems in clinical terms.
- STEP 3: Slowly translate into SE terms.
- STEP 4: …
- STEP 5: Profit.

Thank you one and all.

- Especially:
  - Bob Malins
  - Ajay Thukral
  - Chris Unger
  - Anyone still awake
  - Ola Batarseh
  - Eugene Day
  - Nathan Hoot
  - Mike Ward