LAI Healthcare Research

Prof. Debbie Nightingale

Jorge Oliveira and Jordan Peck

Massachusetts Institute of Technology

October 14, 2009

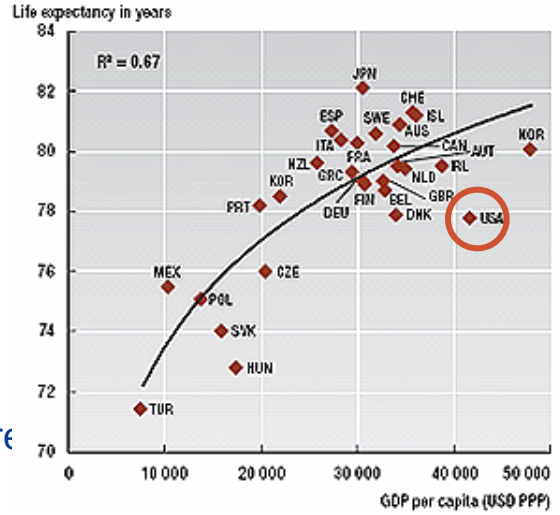
Agenda

- Research Motivation and LAI Alignment
- LAI Healthcare Research Pipeline
- Overview of Research Projects
- Final Comments

Research Motivation

Life Expectancy at Birth and GDP Per Capita

2005 OECD Data



Cost

- Over 16% of US GDP spent in healthcare expenses
- Hospital care represents 30.8% of total expenditure
- 49% of expenditure concentrated in only 5% of population
- Individuals over 65 years old expected to increase over 50% by 2020

Quality

- 98,000 deaths attributed to medical errors
- Adults on average only receive 55% of recommended care
- Emergency Departments are overcrowded nationwide
- Provider fragmentation unable of creating sufficient volume

Access

- 45 million Americans are uninsured
- Fragmented provider network, 75% being small or single practices
- Recent survey indicated 40% of Americans received uncoordinated care
- Fragmented payment systems, health plans, information systems, etc

Cross Industry Enterprise Challenges

Aerospace

- Overarching commitment to ensure global peace and security
- Incumbent higher, faster, farther mindset
- Declining defense dollars after Cold War (fewer military aircraft programs; industry consolidation)
- Inherently complex industry:
  - Multiple stakeholders with misaligned objectives and numerous constraints
  - Capital Intensive
  - Complex product development
- Uncertain outcome in contract awarding

Healthcare

- Overarching commitment to provide world class medical care
- Incumbent overuse, underuse, and misuse mindset
- Overburdened healthcare expenditure as a % of GDP (proliferation of fragmented disjointed providers)
- Inherently complex industry
  - Multiple stakeholders with misaligned objectives and numerous constraints
  - Capital Intensive
  - Complex service provision
- Uncertain outcome in value sharing

LAI - A Consortium Dedicated To Cross Industry Enterprise Performance

- Enable Enterprises to effectively, efficiently and reliably create value in a complex and dynamic environment
- Enable focused and accelerated transformation of complex enterprises
- Collaborative engagement of all stakeholders in Government, Industry and Academia
- Understand, develop, and institutionalize principles, processes, behaviors and tools

Parallel issues/needs in healthcare!

Agenda

- Healthcare Research Motivation and LAI Alignment
- LAI Healthcare Research Pipeline
- Overview of Research Projects (*JO,JP, and JM*)
- Final Comments

LAI Healthcare Research Pipeline

Ongoing Research

- High Performing Hospital Enterprise Architectures (*Jorge Oliveira)*
- New England Veteran Affairs (*Jordan Peck*)
- Multiple Class Projects from Integrating the Lean Enterprise and Enterprise Architecting
- NEWDIGS Drug Development ESAT (Judy Maro and Debbie Nightingale)
- Impact of Advanced DNA Sequencing Technologies on Clinical Microbiology Processes (Rob Nicol)

Existing Proposals in Enterprise Systems

- NEWDIGS Phase II
- PTSD Systems Study

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  - PTSD (Debbie Nightingale)
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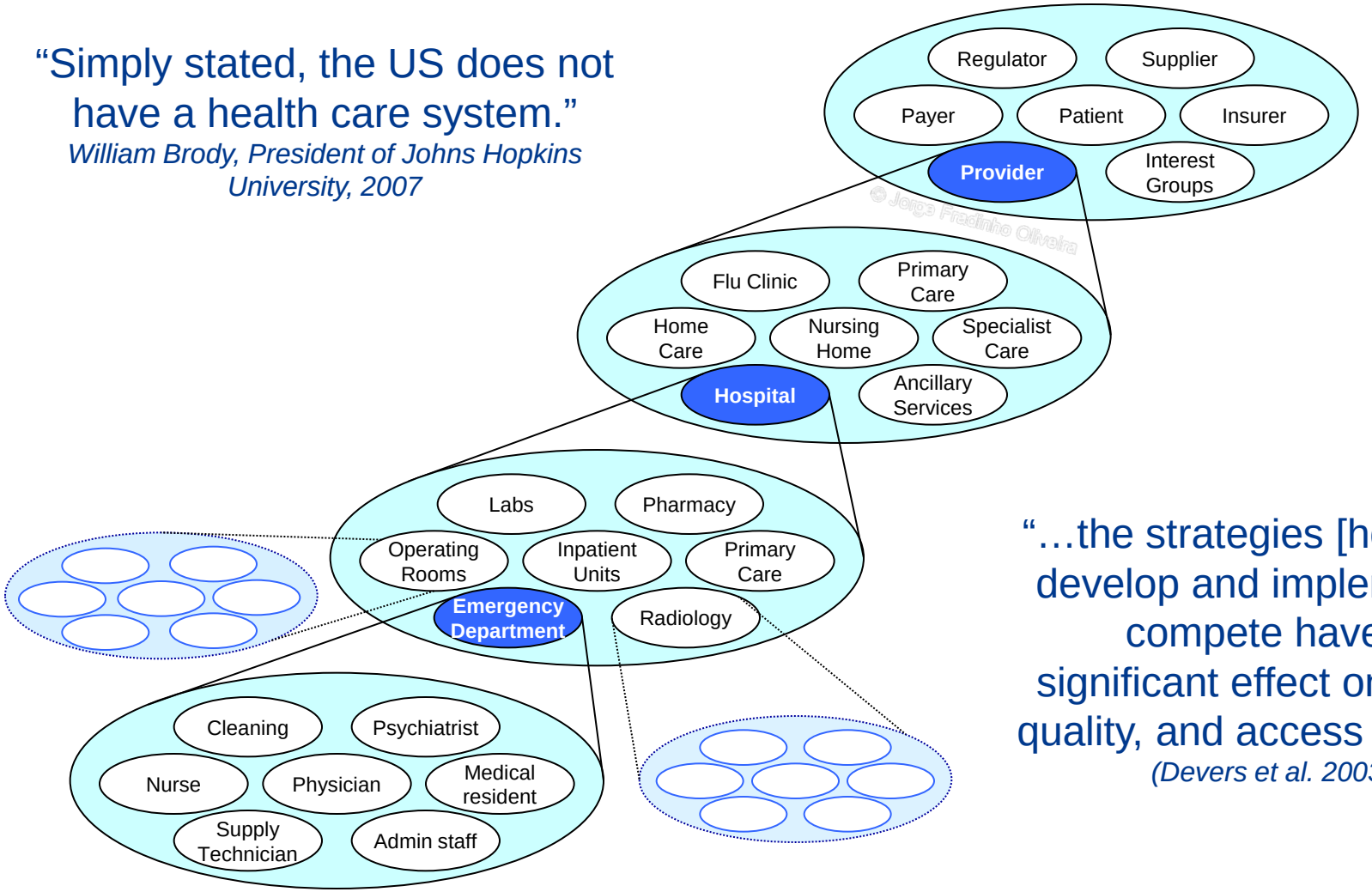
Health Care is a Complex Socio-Technical System

"Simply stated, the US does not have a health care system."
William Brody, President of Johns Hopkins University, 2007



"…the strategies [hospitals] develop and implement to compete have a significant effect on costs, quality, and access to care."
(Devers et al. 2003)

Greater Boston Hospital Case

- **Leading multi specialty physician led group practice with national and international recognition (i.e. neuro, liver, heart & vascular, etc)**

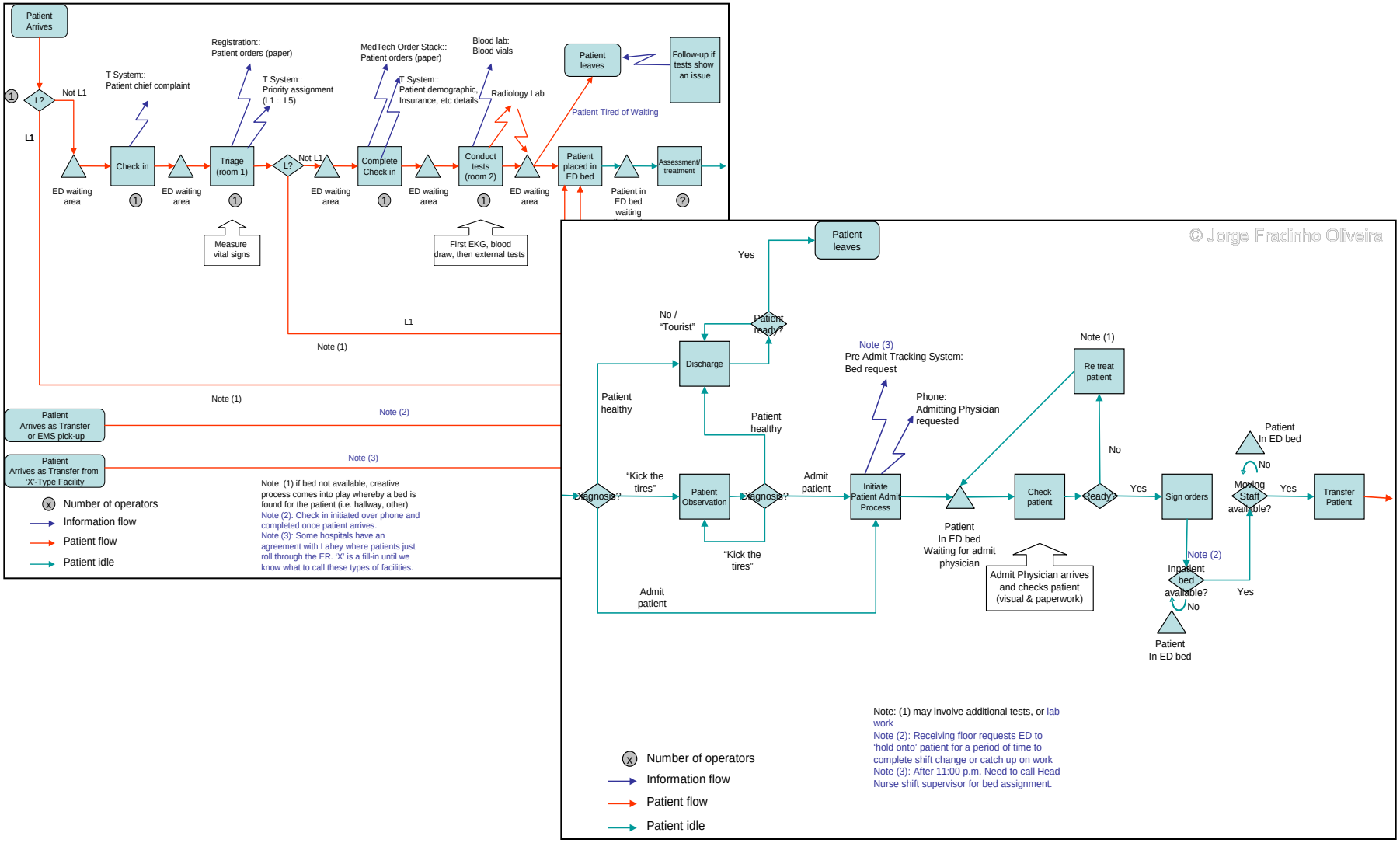
2006 Highlights	
• Emergency Visits:	38,631
• Total Beds:	293
• Total Staff:	4263
• Total Income:	$679,454,000
• Total Expenses:	$628,525,000
• Operating Income:	$50,929,000

Problem Statement

- Emergency Department (ED) struggling to keep up with demand
- Long wait times in the ED and patient leaving without being seen
- ED staff blame inpatient staff and vice versa
- ED staff churn levels significant

What can be done to speed patient flow in the ED?
Where should a process improvement initiative focus?

Emergency Department VSM



Emergency Department Analysis

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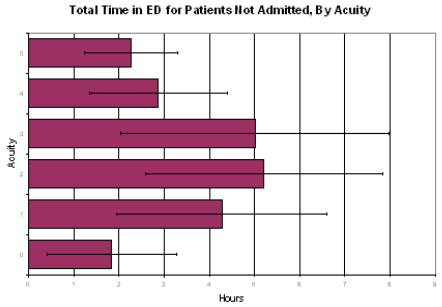
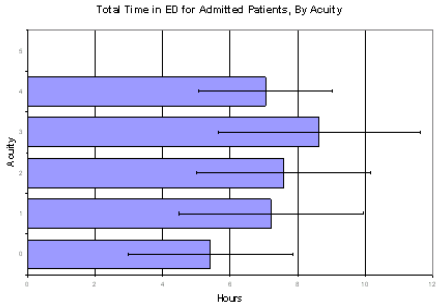
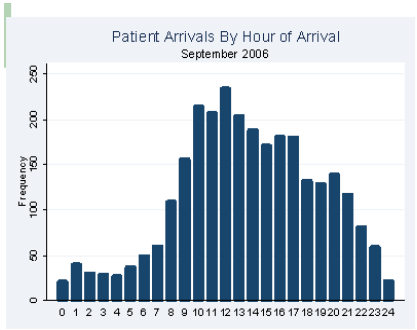
Description of patient time spent in ED

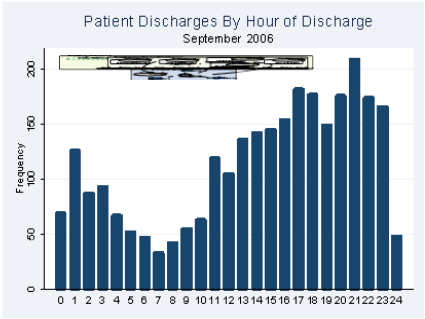
Average Total Time Spent in the ED	
Patients Not Admitted:	4.14 hrs
Patient Admitted:	7.85 hrs

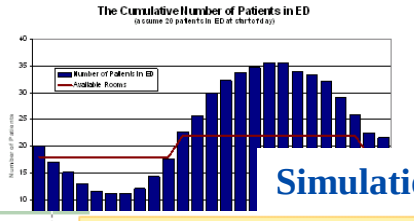


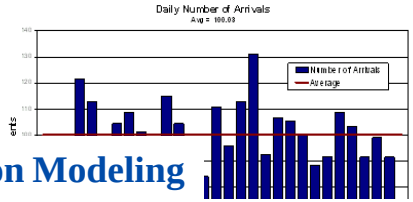


Description of patient arrivals and departures



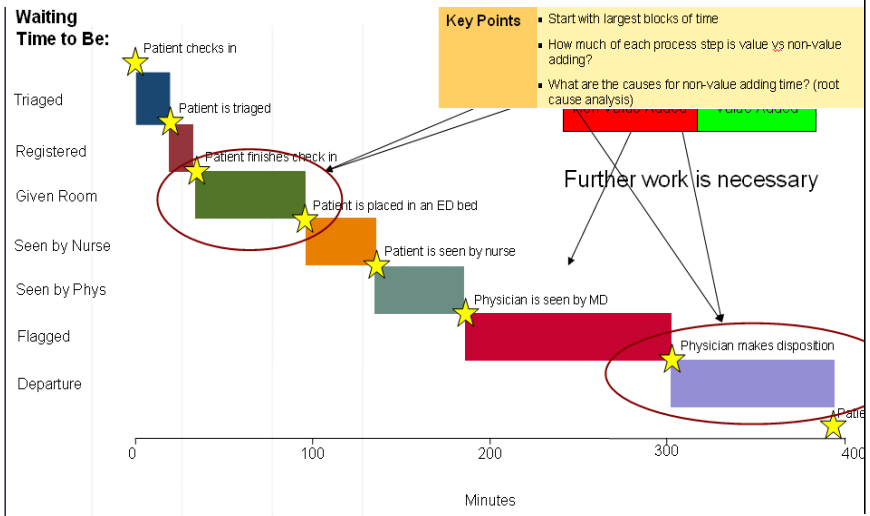




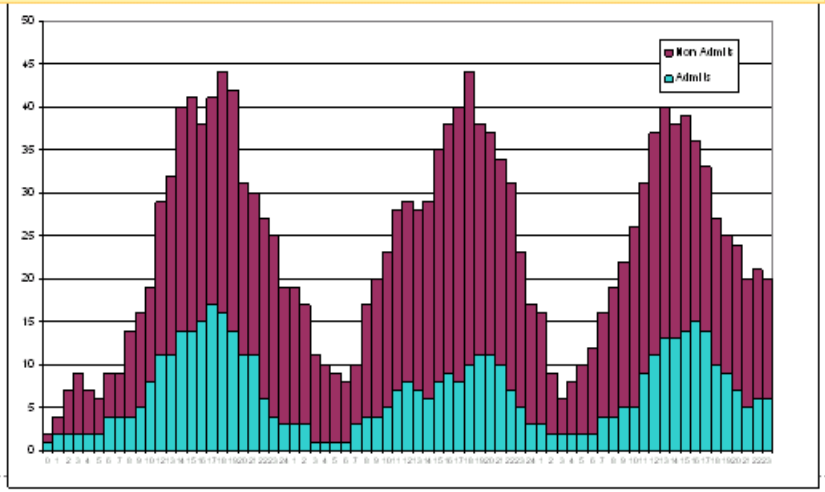


Simulation Modeling

Average time for each step of the patient process



Simulation patient levels in ED over three days



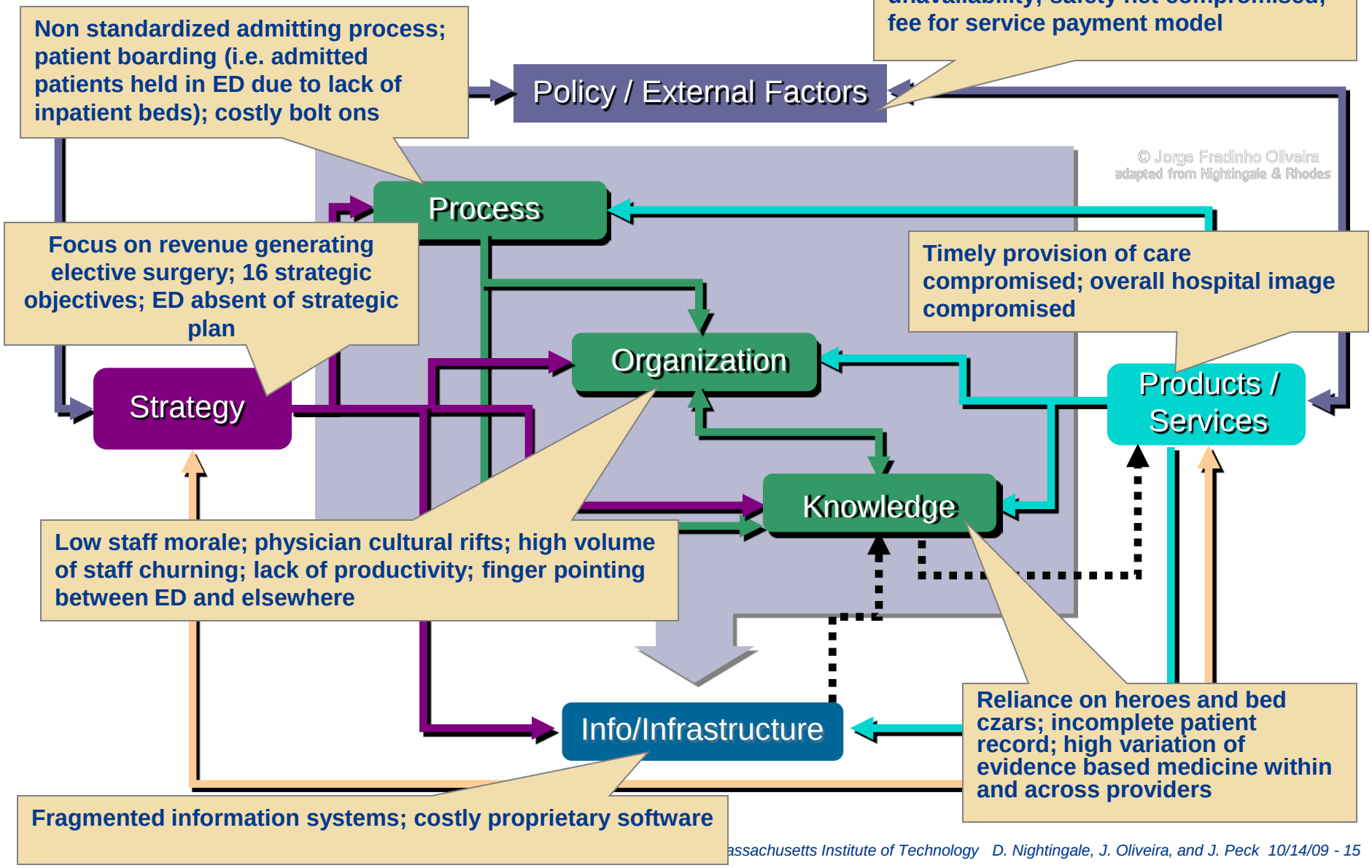
Preliminary Findings

Main Findings	ED average length of stay considered problematic, but non-admitted patients took 4 hours, whereas admitted patients took over 8 hours ED interacted well with some patient wards but not with others ED heroic employee efforts said to be common rather than sporadic ED metrics and strategic goals misaligned with overall hospital (X-Matrix)
Questions For Further Study	Why was the ED managed as a silo rather than end-to-end? Was the varying performance of ED interactions due to the payment model? Could it be that different observed EA configurations were directly related to the different observed performance levels?

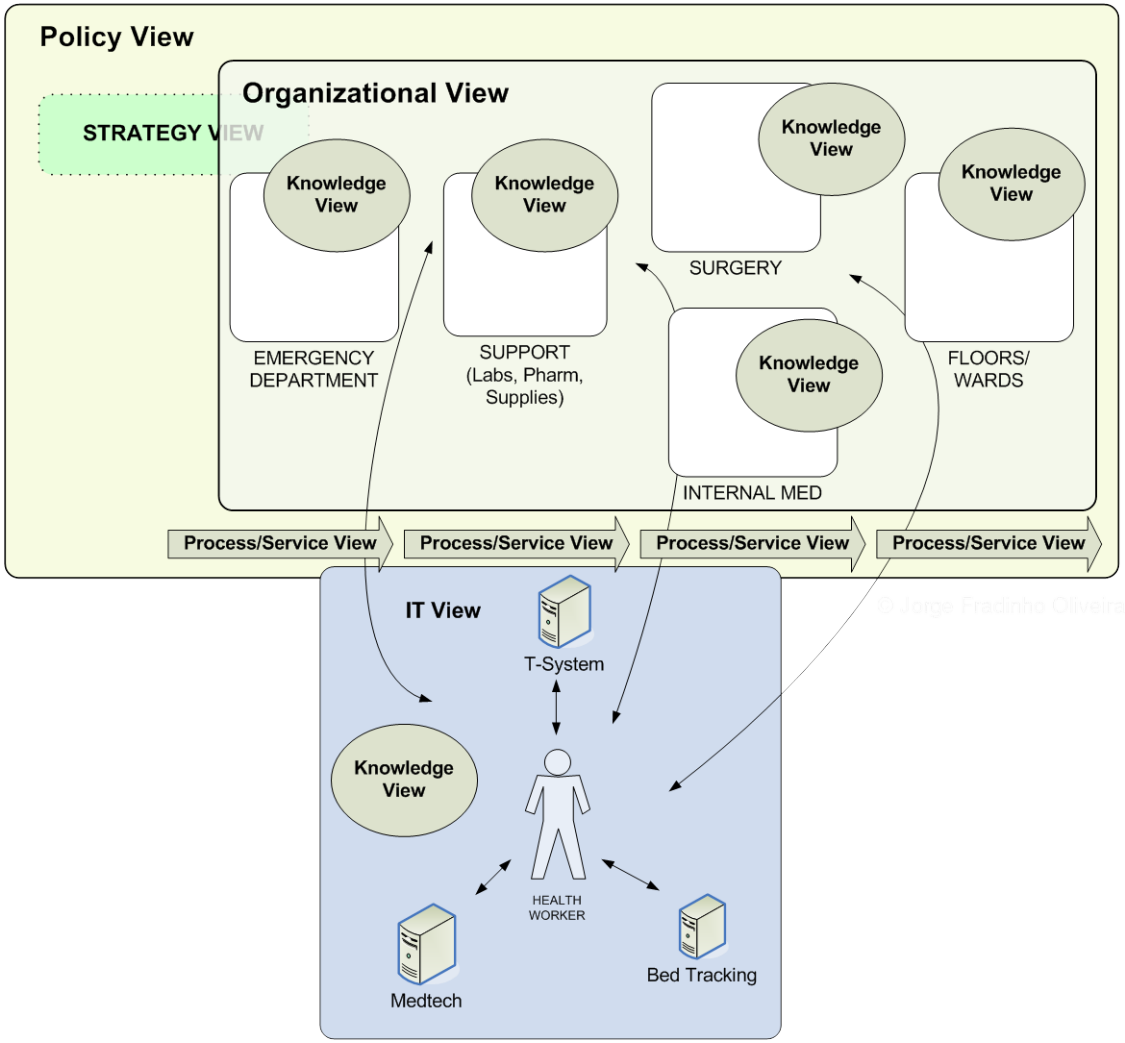
"The problem of redesign gets harder and the evidence weaker as one moves from the microsystem to the organization."

Donald Berwick, President of Institute for Healthcare Improvement, 2002

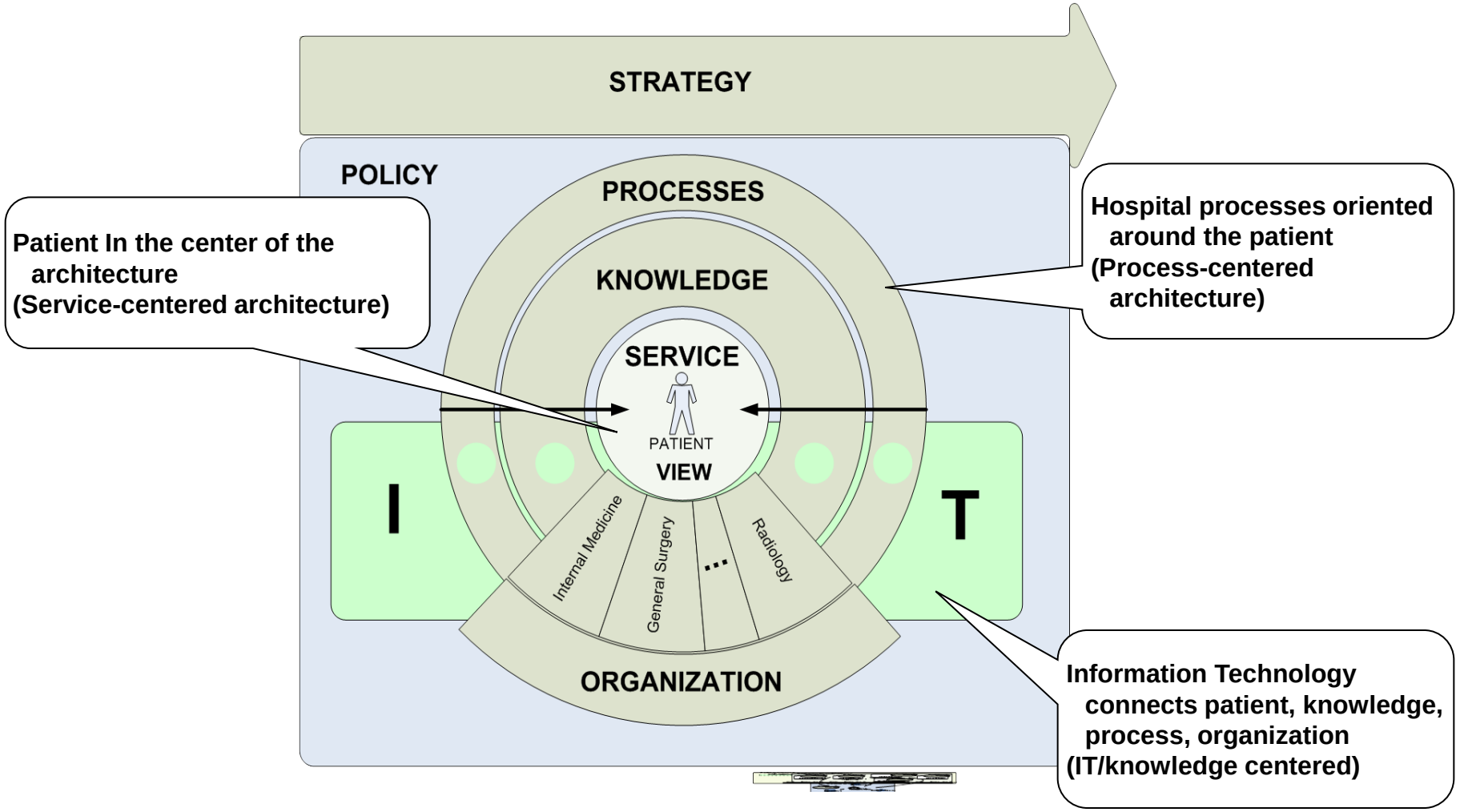
Hospital Enterprise Architecture Diagnostic



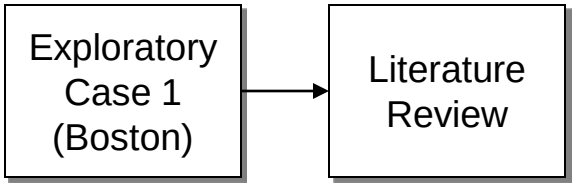
"As Is" Enterprise Architecture



“To Be” Enterprise Architecture



Overview of Research Methodology

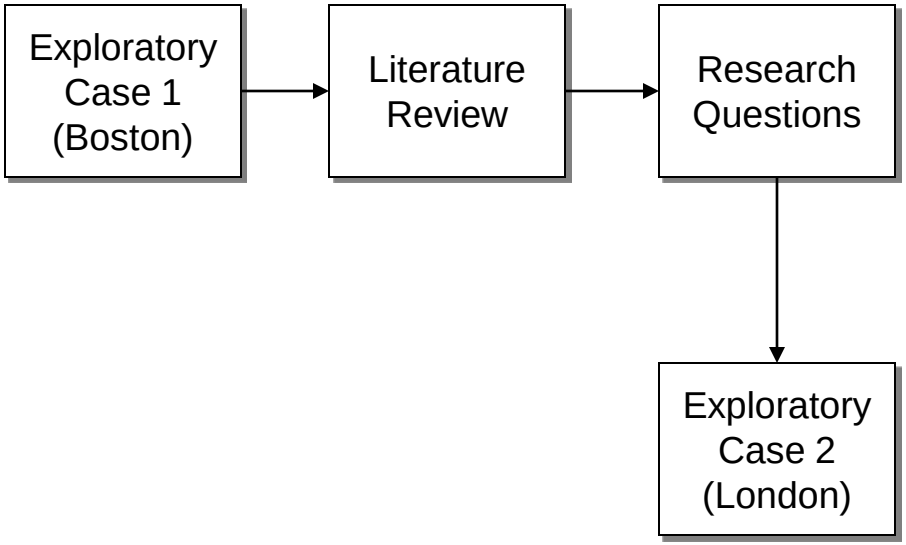


- **Literature Review**
  - Mostly health care
  - Healthcare payment model evolution (FFS, capitation, etc)
  - Hospital management (functional, DRG, service lines)
  - Institutional dimension (uninsured, cost, quality, access)
  - Lean best practice (Virginia Mason, Mayo Clinic, etc)

Overview of Research Methodology

- **Research Questions**
  - How should hospital enterprise performance be measured?
  - How does hospital enterprise architecture relate to hospital enterprise performance?

Overview of Research Methodology



- **Exploratory Case 2 (London)**
  - Multi specialty hospital: 872 beds, 43 wards, 18 operating rooms, ED, UK leader
  - Burning platform: meeting 18 Week target
  - Method: 1 month onsite; grounded theory methodology
  - Despite different contexts hospitals shared strategic and operational issues
  - Multiple configurations present with varying performance

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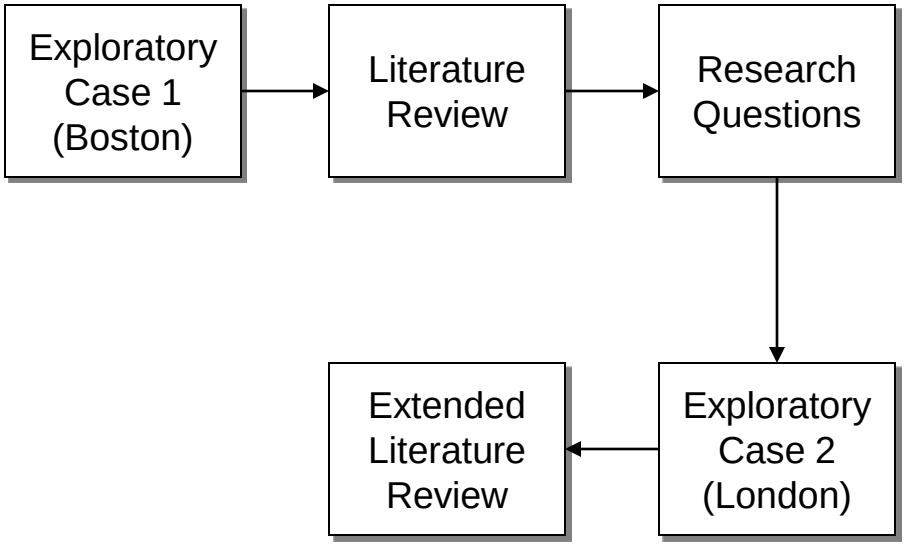

- **Extended Literature Review**
  - Multidisciplinary performance literature (categorical, process, systems)
  - Longitudinal in-depth study of Organizational theory literature (organizational effectiveness criteria; ideal and hybrid organization types; configurations; frameworks; proven relevant constructs; etc)
  - Healthcare literature (hospital typology for sampling, hospital internal structures for theoretical sampling, etc)
  - Research method refinement (multi-level analysis; embedded case studies; grounded theory; hybrid methods; theory maturity; etc)

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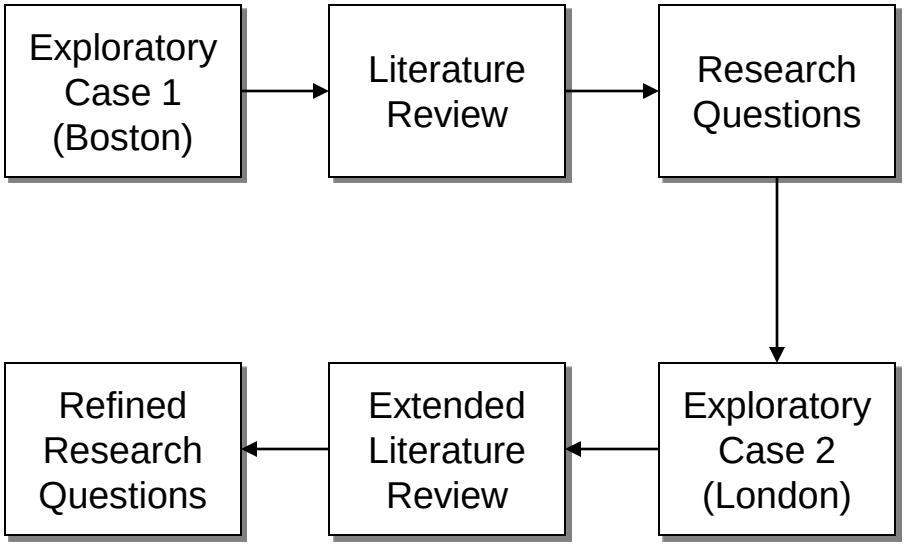

- **Refined Research Questions**

  Does hospital enterprise architecture relate to hospital enterprise performance? How?

  a) How is hospital enterprise performance currently measured?

  b) How could hospital enterprise performance measurement be improved using lean enterprise architecture principles?

  c) What are different internal organizational design configurations capable of supporting higher performance for different service complexity artifacts?

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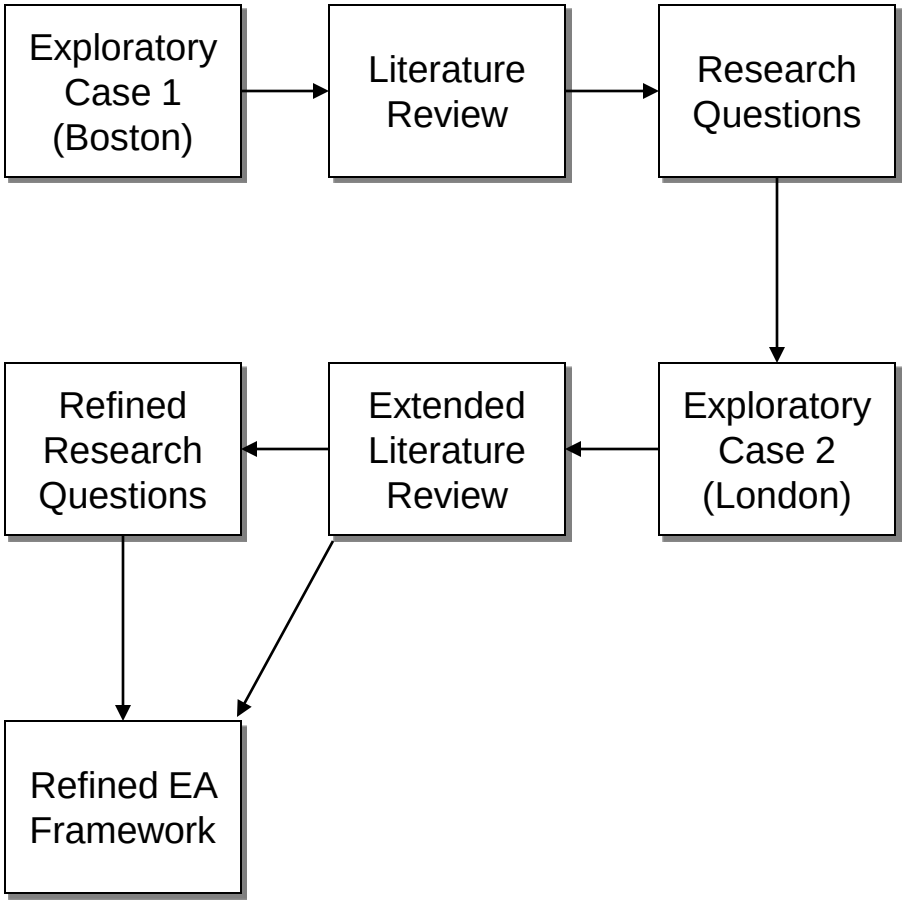
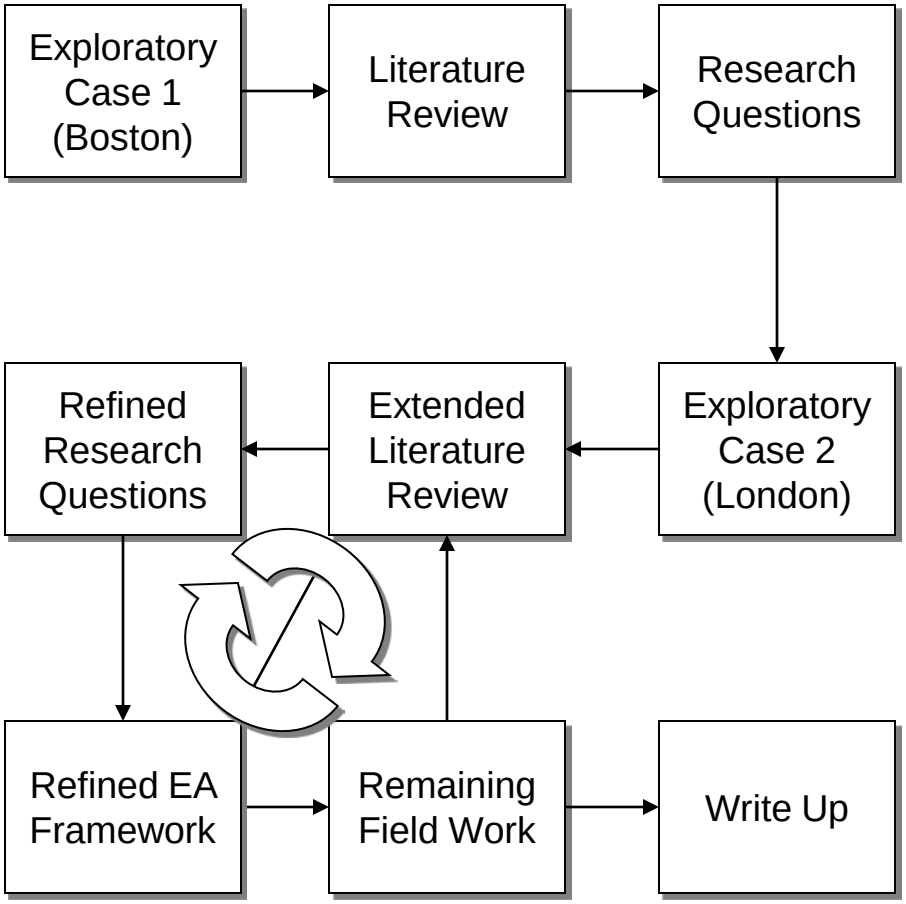


- **Refined EA Framework**
  - Augmented version of LAI EA Framework conveying theoretical richness, clear constructs, and guidelines to allow for subsequent empirical testing and refinement.
  - Enhanced knowledge of EA characterization.

Overview of Research Methodology



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VA Mental Health – Boston

ESD.62J/16.852J: Integrating the Lean Enterprise

Ellen Czaika
Clayton Kopp
Orietta Verdugo
Zakiya Tomlinson
Jordan Peck, Facilitator

X-Matrix

Metrics vs. Objectives

- ■ Very strong alignment with most metrics on target
- ❑ Goals are not formal or documented
- ❑ Research is a goal but not measured locally

Values vs. Goals

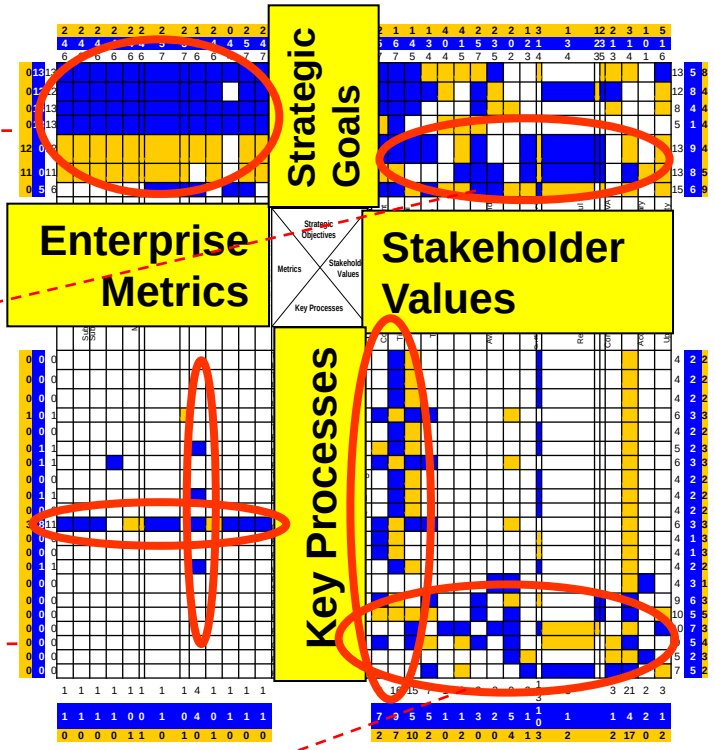
- ■ Strong alignment with areas in service, care, & research
- ❑ Gap lies in aligning goals to values such as:
  - – Operating within budget
  - – Well-documented monetary transactions

Metrics vs. Processes

- ■ Strong alignment with outpatient treatment and clinic wait times
- ❑ Missing metrics for key processes
  - – Transfers to inpatient
  - – Program referrals

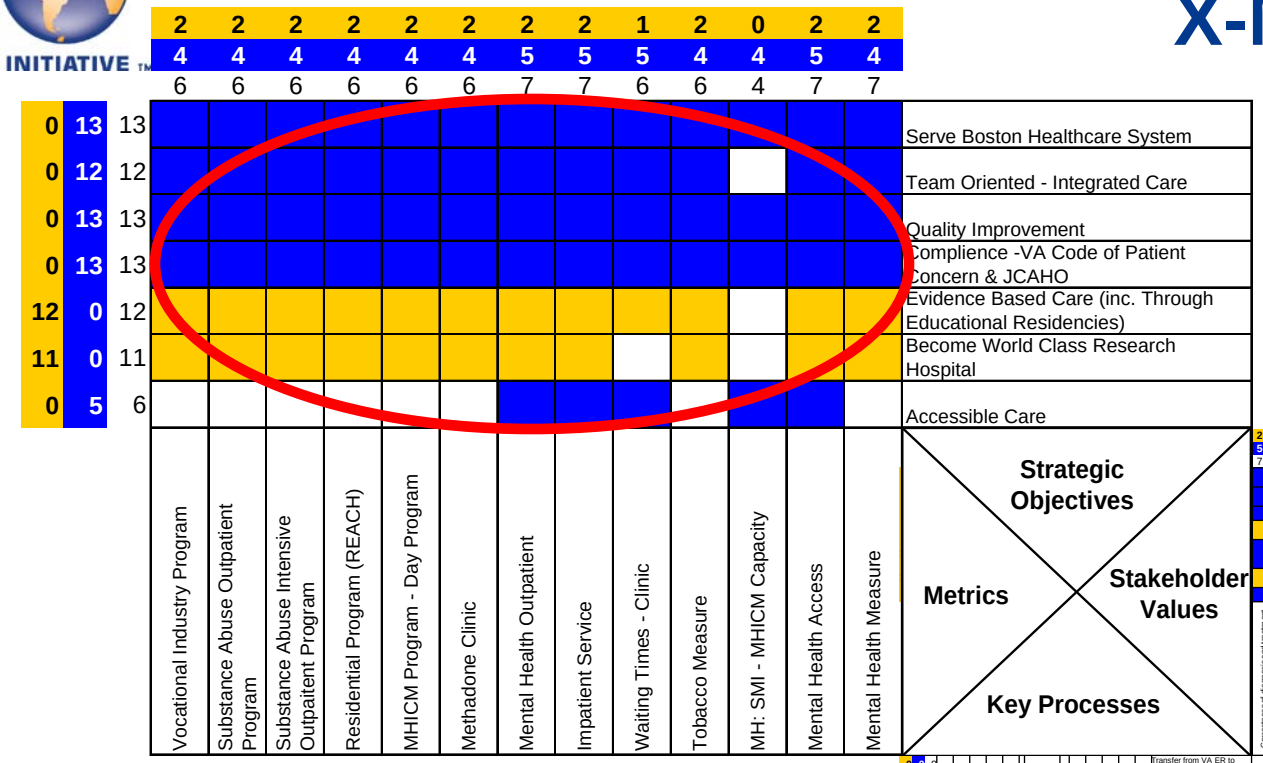
Processes vs. Values

- ■ Strong alignment in areas of service, research, & quality
- ❑ Processes addressing the least stakeholder values are primarily patient movement



■ Strong Alignment
❑ Weak Alignment

X-Matrix



Metrics vs. Strategic Objectives

- **Very Strong Alignment Between Strategic Goals and Metrics**
- **Indicative of a Strong Top Level**
- **Metrics are chosen by national and reported regularly**

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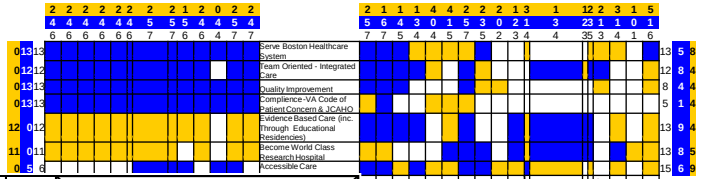
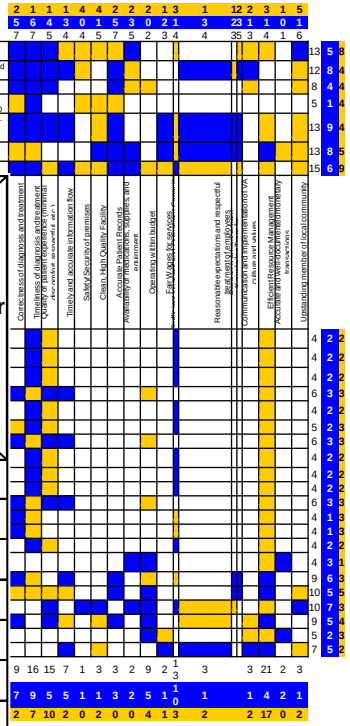
X-Matrix





			Vocational Industry Program	Substance Abuse Outpatient Program	Substance Abuse Intensive Outpatient Program	Residential Program (REACH)	MHICM Program - Day Program	Methadone Clinic	Mental Health Outpatient	Inpatient Service	Waiting Times - Clinic	Tobacco Measure	MH: SMI - MHICM Capacity	Mental Health Access	Mental Health Measure	Strategic Objectives / Metrics / Stakeholder Values / Key Processes
0	0	0														Transfer from VA ER to Inpatient
0	0	0														Transfer from Urgent Care to Inpatient
0	0	0														Transfer from Outside ER to Inpatient
1	0	1								■						Inpatient Treatment
0	0	0														Transfer from Inpatient to Residential
0	1	1									■					Discharge from Inpatient
0	1	1				■										Residential Treatment
0	0	0														Transfer from Residential to Inpatient
0	1	1									■					Discharge from Residential
0	0	0														Transfer to Outside Facility
3	8	11	■	■	■		■	■	■		■	■	■	■	■	Outpatient Treatment
0	0	0														Referral to Inpatient
0	0	0														Referral to Residential
0	1	1									■					Walk-in to Outpatient
0	0	0														Purchasing (Supplies & Services)
0	0	0														Patient Data Management
0	0	0														Research
0	0	0														Facilities and Maintance
0	0	0														Quality Assurance
0	0	0														Payroll
0	0	0														Human Resources
			1	1	1	1	1	1	1	1	4	1	1	1	1	
			1	1	1	1	0	0	1	0	4	0	1	1	1	
			0	0	0	0	1	1	0	1	0	1	0	0	0	

Metrics vs. Key Processes

- **Week alignment between key processes and metrics.**
- **Metrics seem to be measuring secondary results rather than directly measuring process outcomes.**

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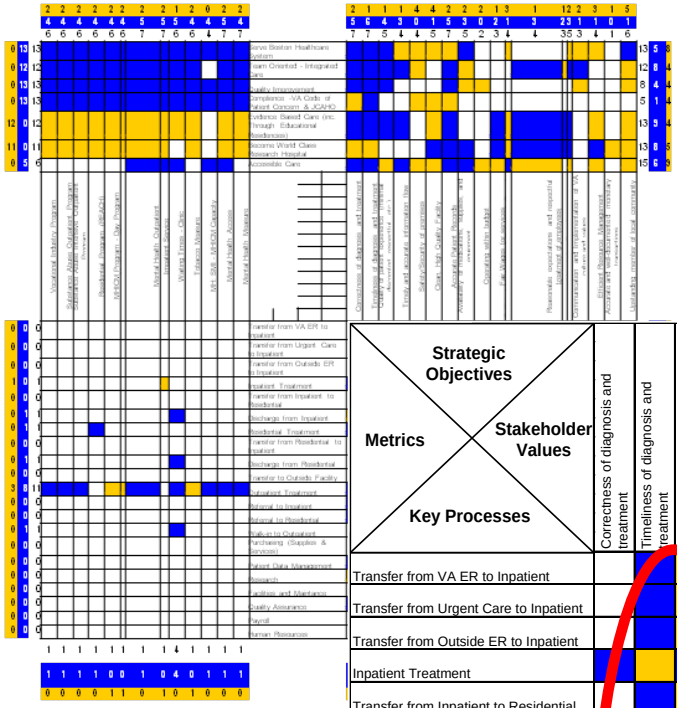
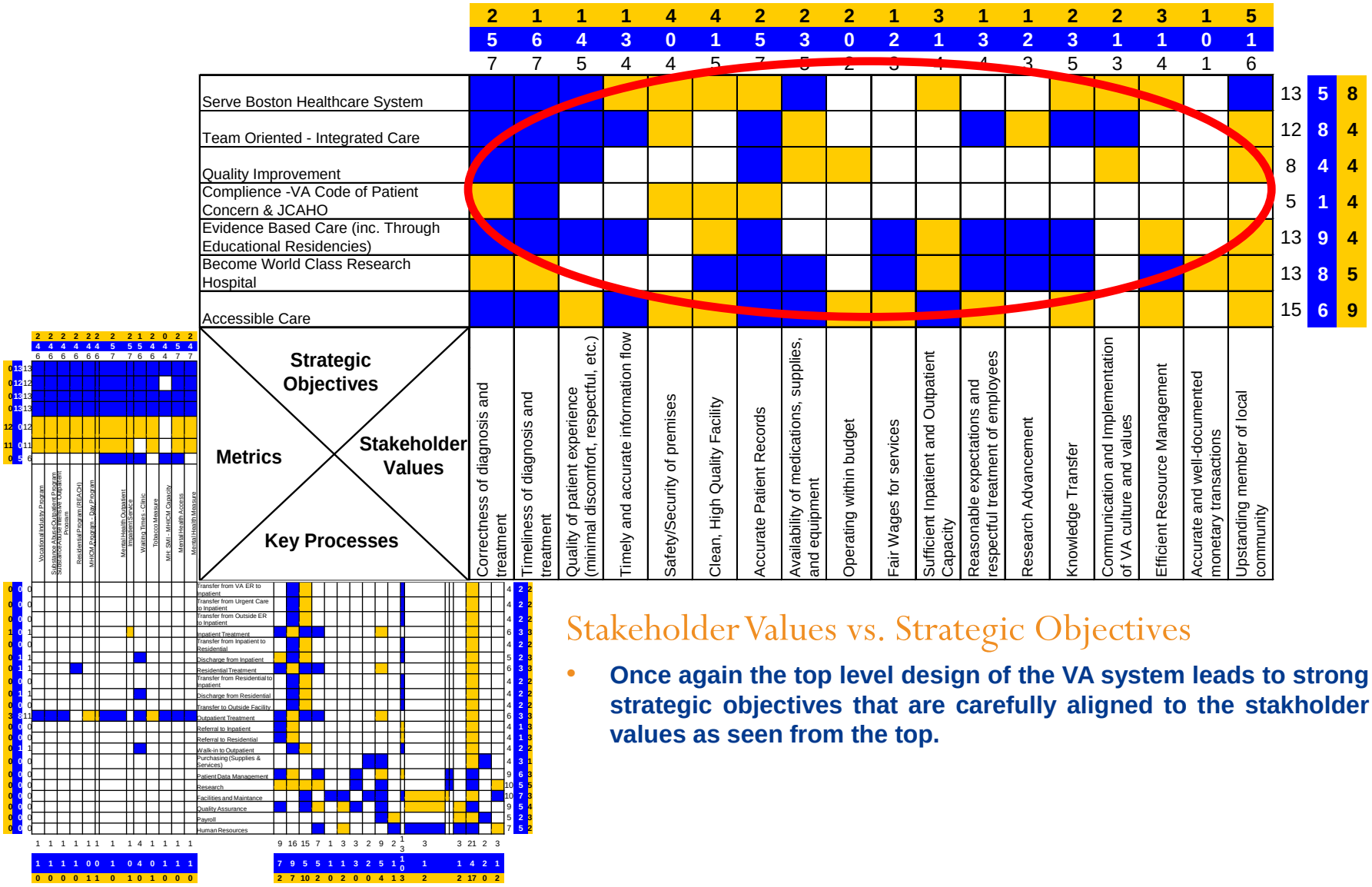
X-Matrix



Key Processes vs. Stakeholder Values

- **Key Processes are primarily focused on satisfying specific stakeholders however all are taken into account.**

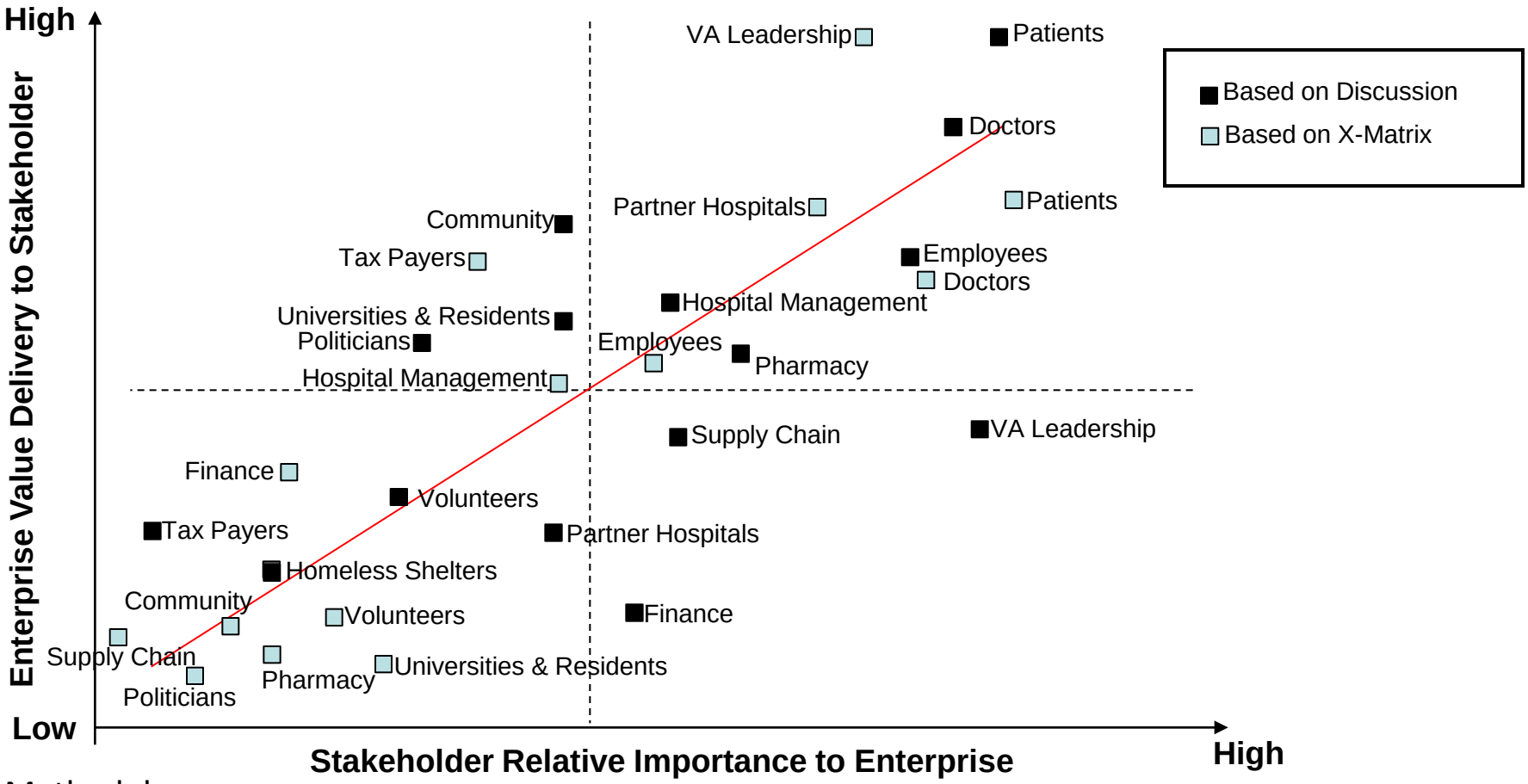
X-Matrix



Stakeholder Values vs. Strategic Objectives

- **Once again the top level design of the VA system leads to strong strategic objectives that are carefully aligned to the stakholder values as seen from the top.**

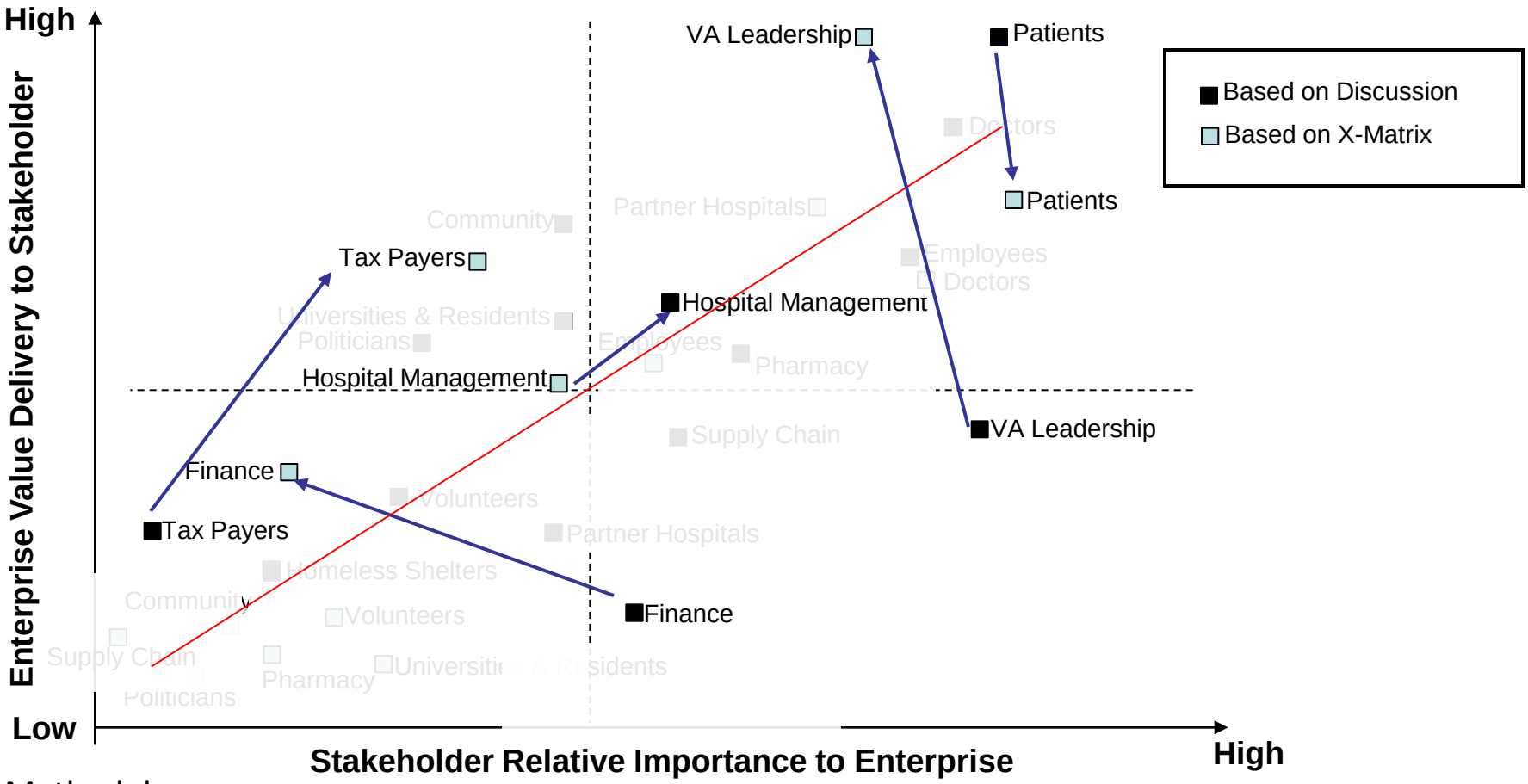
Stakeholder Value Comparison



Methodology

- Inferred Stakeholder Importance from Strategic Objects & Value Delivery from the Key Processes
- Used weighting algorithm to calculate positions
- More research & data needed on weights, and to validate results.

Stakeholder Value Comparison



Methodology

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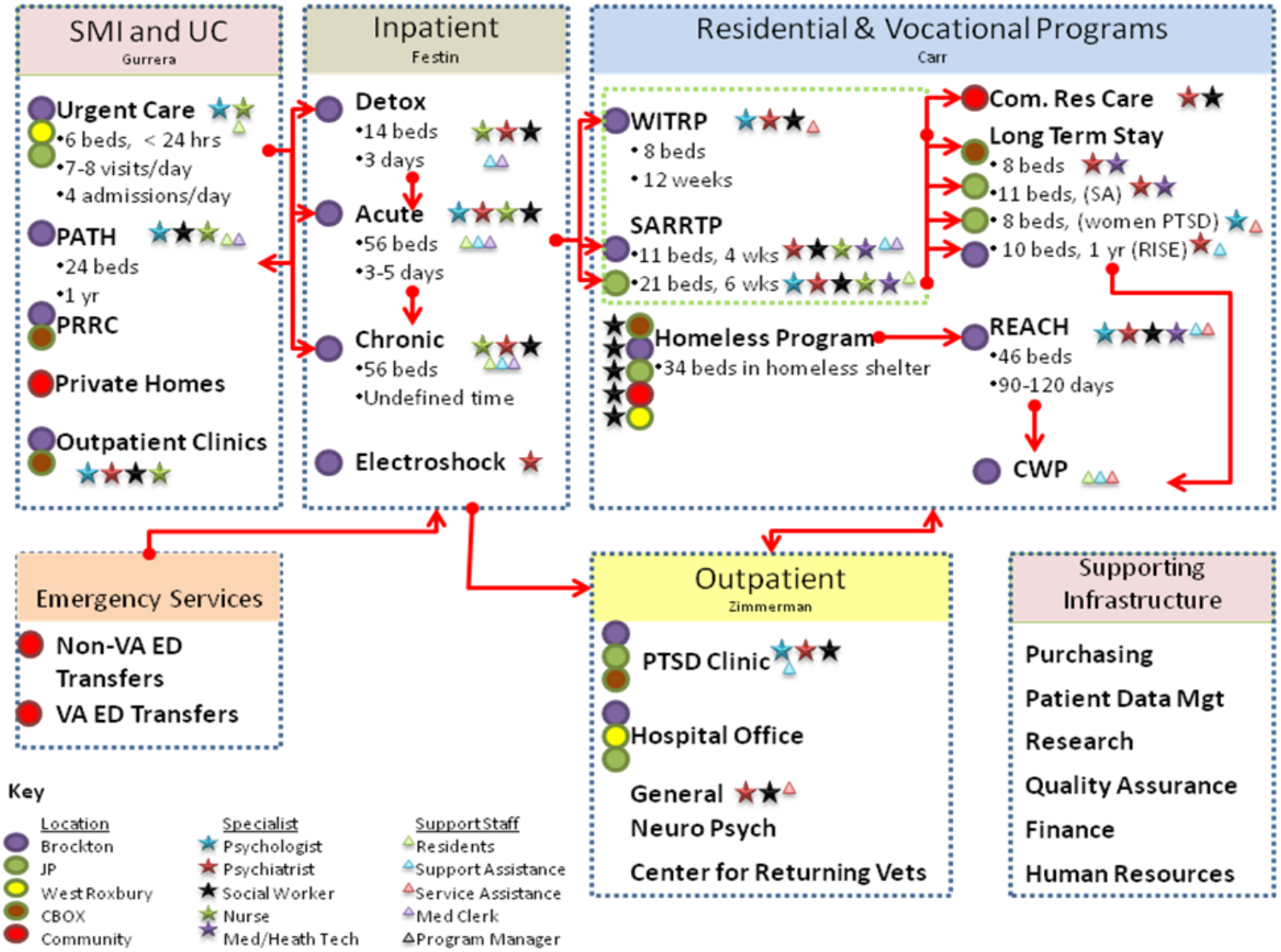
Veteran Affairs
Boston Mental Health

Enterprise Architecting

May 13, 2009

Team:
Oladapo Bakare
Jordan Peck
Orietta Verdugo

Current Architecture



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Candidate Architectures

Candidate Architectures

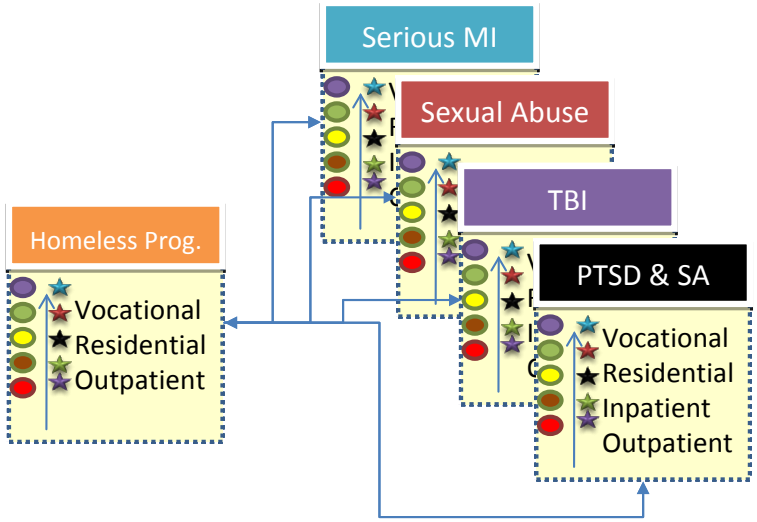
Illness Based

Pros:

- Continuous care in a given category can be easily tracked and traced
- Flexible if new mental disorders, programs, or illnesses arise in the future

Cons:

- Many patients fall into more than one category
- Wasted resources on programs that have low volume or excess capacity



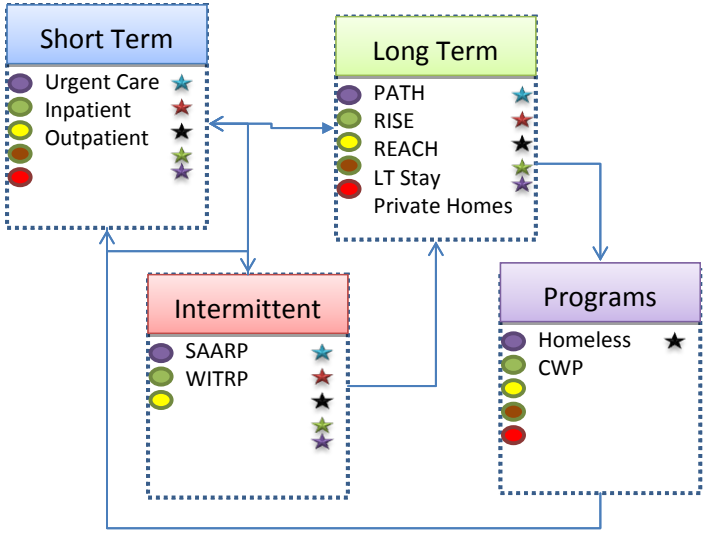
Patient Length of Stay

Pros:

- Resources can be maximized through each department

Cons:

- Unbalanced system with excess capacity in some units and overflow in others
- Patients currently transition between some or all of the programs
- Metrics will be focused on local maximization rather than focusing on optimal flow across the organization



Candidate Architectures

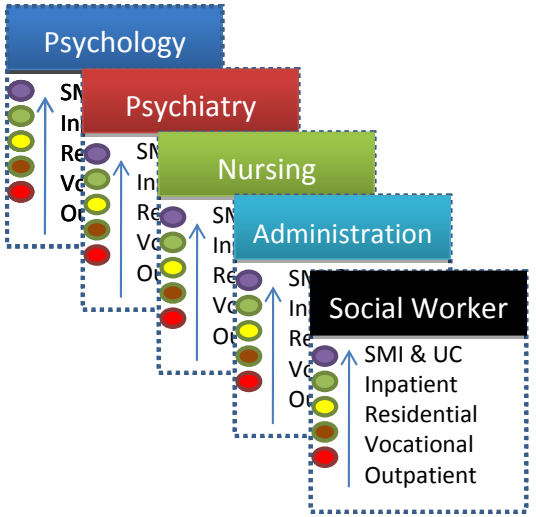
Profession Expertise

Pros:

- Allows medical staff to create optimal treatment plans by working within their specialty
- There is a direct connection with leadership team and employees

Cons:

- Difficult to collaborate with other specialties
- Supervisors will not be capable of treating specific illnesses



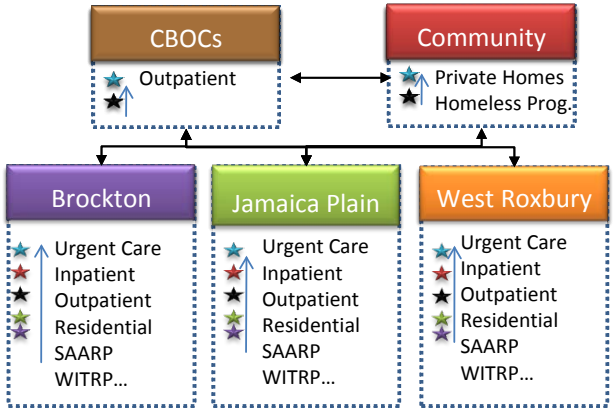
Area Based

Pros:

- Leadership oversight is more direct and site specific
- Initiating change in each location is more manageable

Cons:

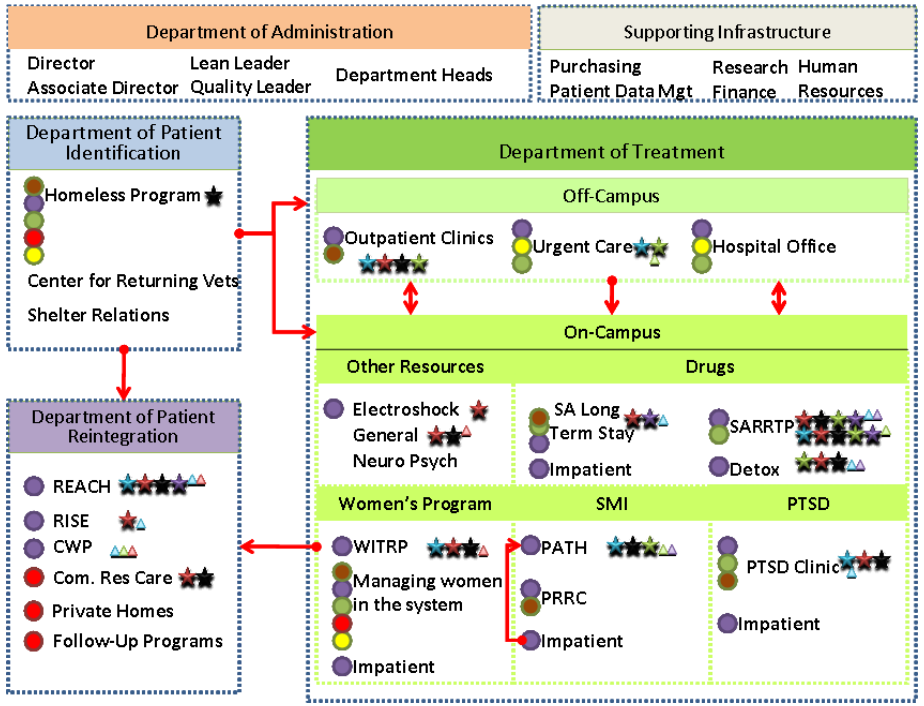
- Scalability of any one location is limited to capacity constraints
- Quality of treatment programs may vary across locations



Candidate Architectures

Functional Requirements	VA BMH	Patient Identification & Community Relations	Treatment Programs	Patient Re-Integration
Maximize Veteran Quality of Life	X			
Identify Patietns with Mental Illness		X		
Treat Cause and Effect of Mental Illness			X	
Integrate Patient Back into Community			X	X

Axiomatic



Pros:

- Director responsibilities are clear and aligned
- Connection between leadership and treatment professionals are more transparent

Cons:

- Departmental imbalance due to program sizes and patient needs
- Requires significant re-organization of the enterprise

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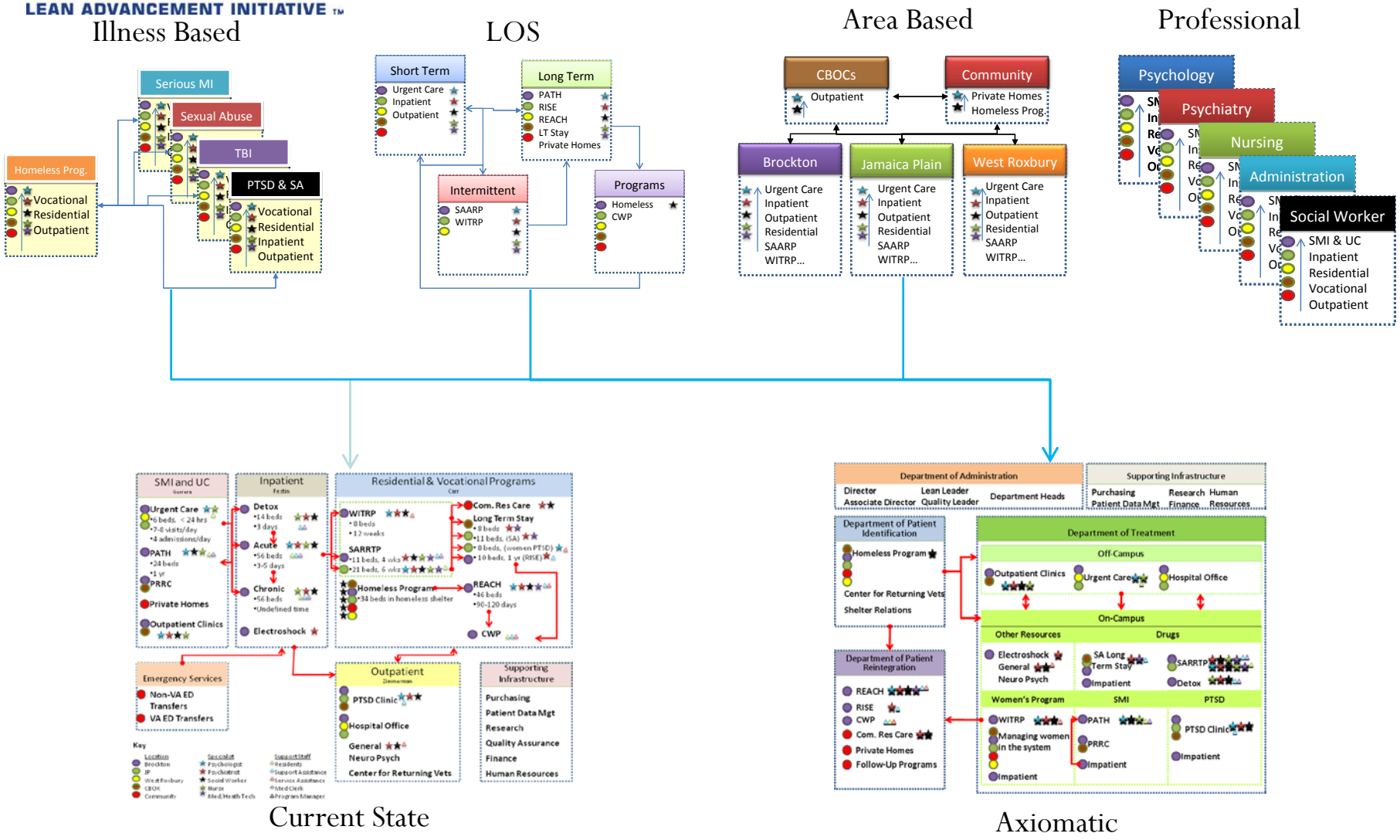
Architecture Evaluation

Architectures at a Glance



Concept Scoring Matrix

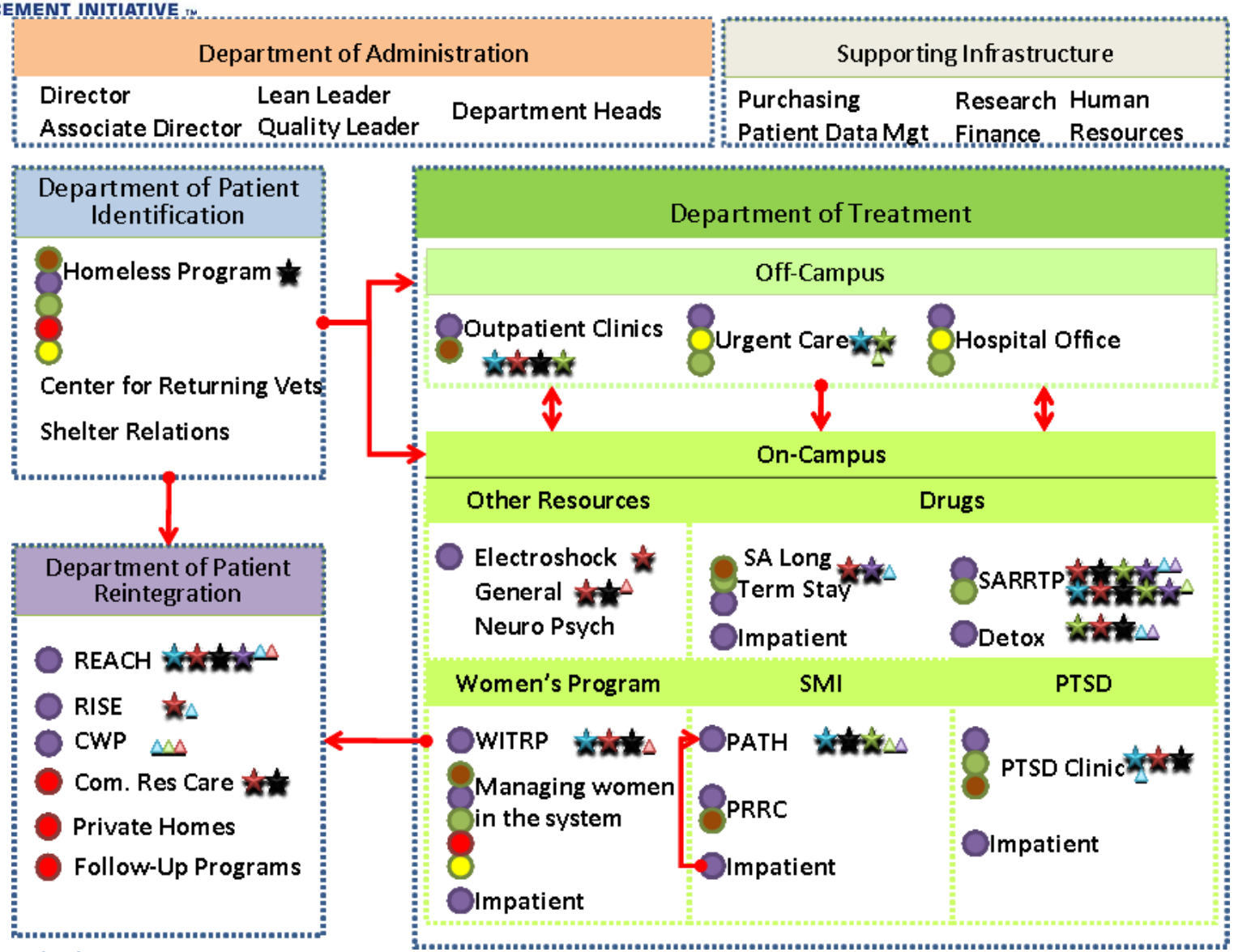
Architecture Evaluation

		Enterprise Architecture Concepts											
		Current State						Illness		Area		Axiom	
Selection Criteria	Weights	Rating	Weighted Score				ghted ore	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score
Agility	9.00%	3	0.27				18	1	0.09	3	0.27	5	0.45
Scalability	3.25%	3	0.10				07	2	0.07	1	0.03	3	0.10
Quality	15.00%	3	0.45	3	0.45	2	0.30	4	0.60	2	0.30	4	0.60
Accessibility	9.00%	3	0.27	3	0.27	3	0.27	3	0.27	4	0.36	3	0.27
Standards Compliance	3.25%	3	0.10	3	0.10	3	0.10	3	0.10	3	0.10	3	0.10
Customizability	15.00%	3	0.45	2	0.30	2	0.30	2	0.30	1	0.15	5	0.75
Demonstrability	15.00%	3	0.45	1	0.15	3	0.45	3	0.45	2	0.30	4	0.60
Safety	3.25%	3	0.10	2	0.07	3	0.10	4	0.13	3	0.10	4	0.13
Responsiveness	15.00%	3	0.45	1	0.15	2	0.30	2	0.30	3	0.45	4	0.60
Serviceability	9.00%	3	0.27	4	0.36	3	0.27	3	0.27	1	0.09	3	0.27
Survivability	3.25%	3	0.10	5	0.16	2	0.07	1	0.03	4	0.13	3	0.10
Total Score		3.00		2.16		2.40		2.61		2.28		3.96	
Rank		2		6		4		3		5		1	
Continue		No		No		No		No		No		Develop	

Used Current State as benchmark

1-5 Success Ranking for Architectures
5=high, 1 = low

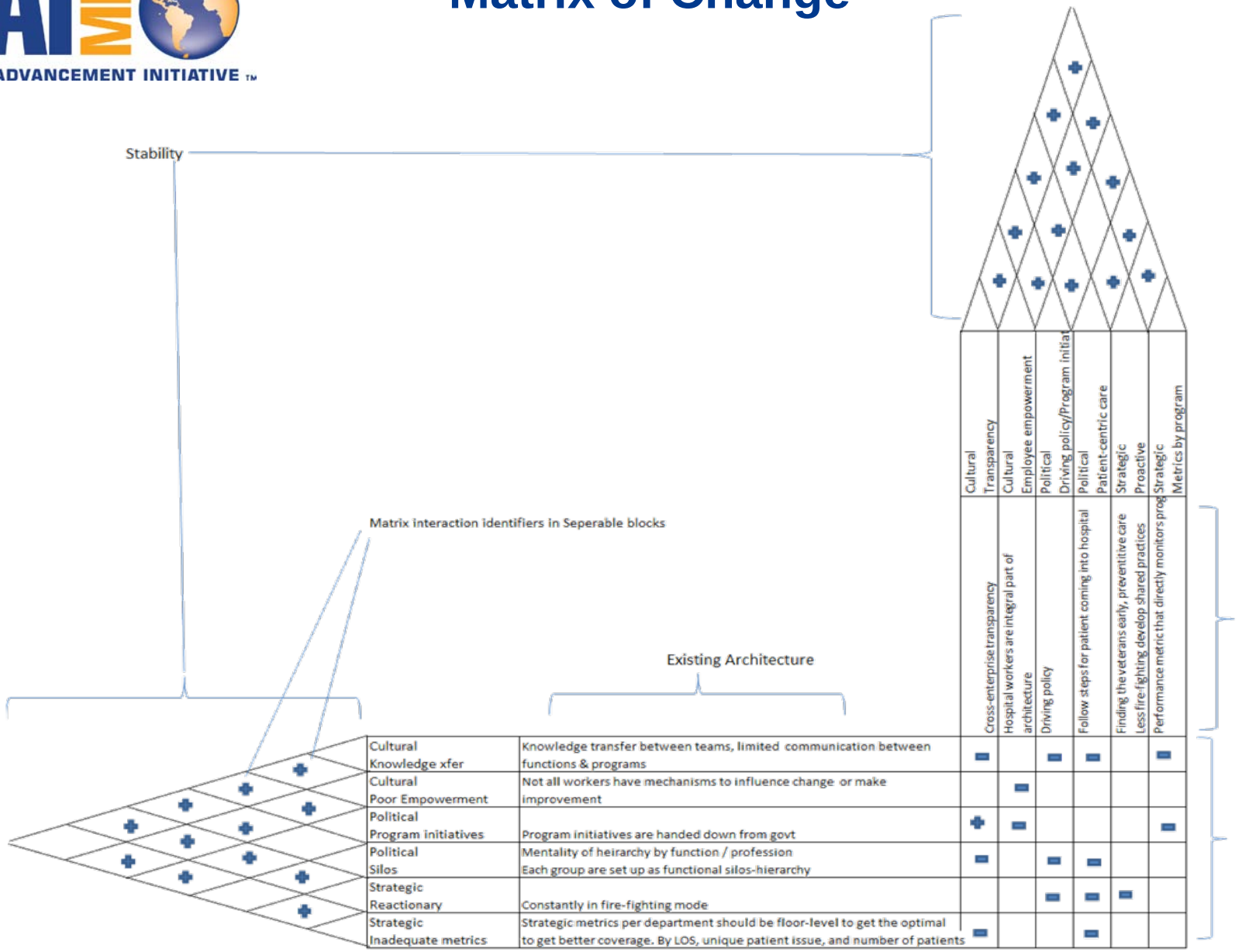
Proposed Architecture



LEAN ADVANCEMENT INITIATIVE ™

Transformation Plan

Matrix of Change



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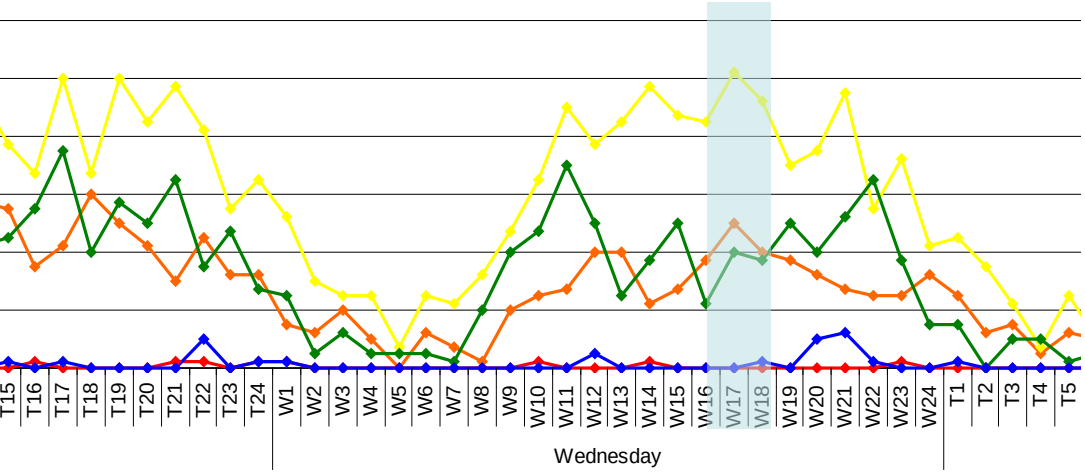
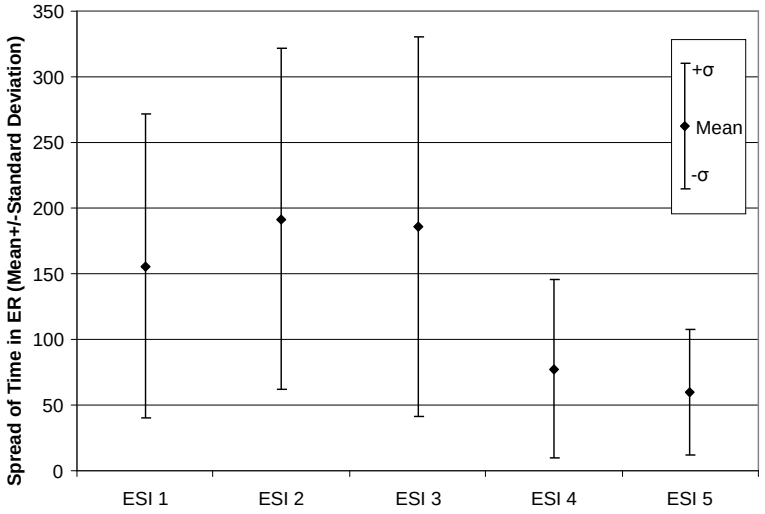
PhD Focus

Predictability = Control

Health Care Professionals are starting to recognize predictability



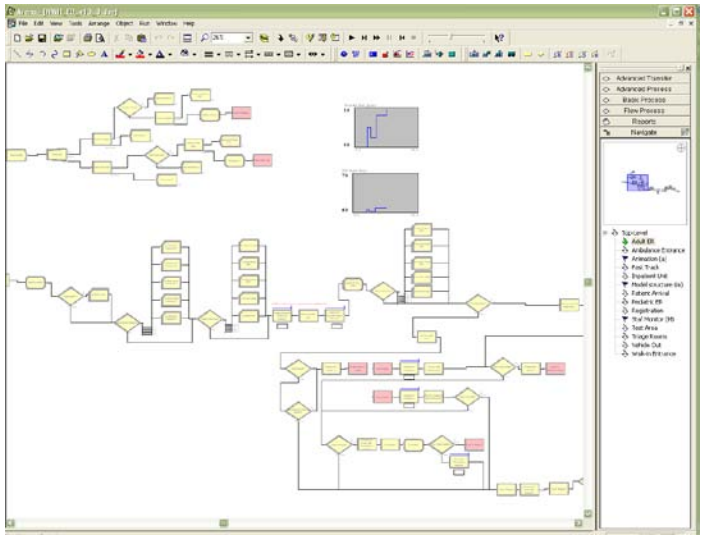


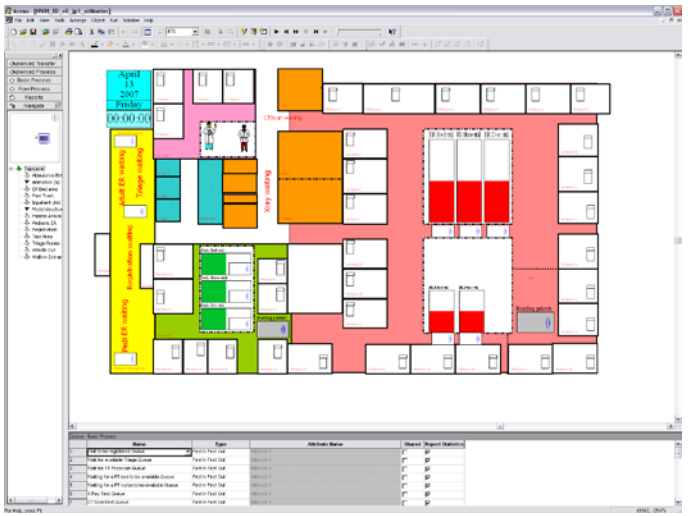
1 2 3 4 5

- Emergency Severity Index (ESI)—a five-level emergency department triage algorithm that provides clinically relevant stratification of patients into five groups from 1 (most urgent) to 5 (least urgent) on the basis of acuity and resource needs.

Simulation and Modeling

How can we model Control Options and Interventions





How do the people fit in?

How well can solutions cross between hospitals?

VA Boston, MA

VA Togus, ME

VA Manchester, NH

Source: www.VA.gov

Agenda

- Research Motivation and LAI Alignment
- LAI Healthcare Research Pipeline
- Overview of Research Projects
  - Jorge Oliveira
  - Jordan Peck
  - **NEWDIGS (Debbie Nightingale/Judy Maro)**
  - PTSD (Debbie Nightingale)
  - DNA Sequencing
- Final Comments

CBI's NEW Drug Development ParadIGmS (NEWDIGS)

Mission – Objective - Measures

Mission:

To improve therapeutic product innovation in healthcare.

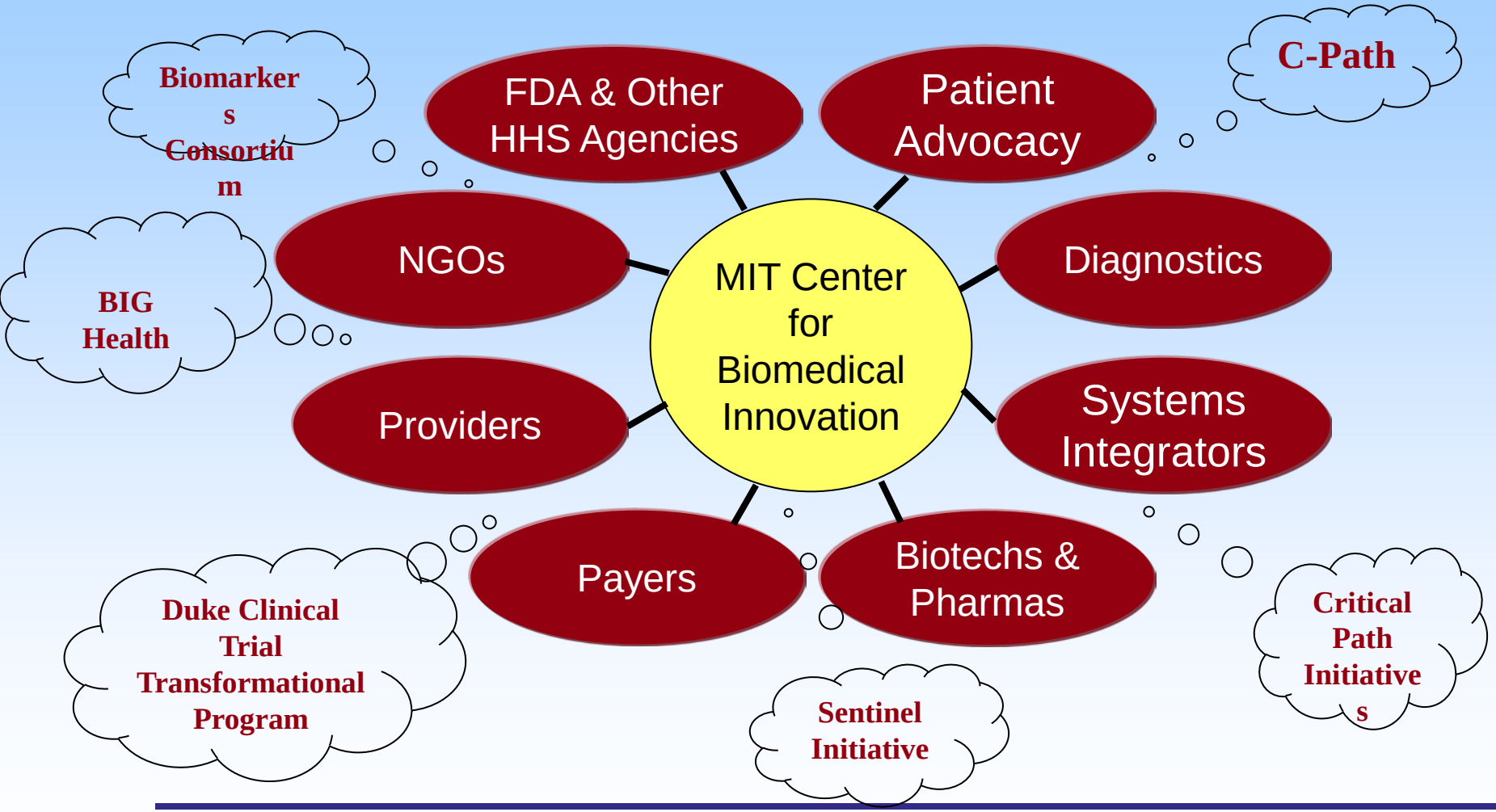
Objective:

Involving all stakeholders, catalyze true transformational change across the product development spectrum globally.

Measures:

Reduced cost and time-to-market for genuinely innovative products that significantly improve health and provide enhanced value for healthcare.

Consortium of Stakeholders



Core Issues - Driving Forces

- Changes in definition of “product”
- Changes in definition of “stakeholder/customer” needs
- Changes in appreciation of the complexity of the science & the multimodal nature of the solution
- Primacy of investor optics
- Changes in both internal and public perception of risk
- Conservative culture of industry and antique assumptions – e.g., competition & infrastructure

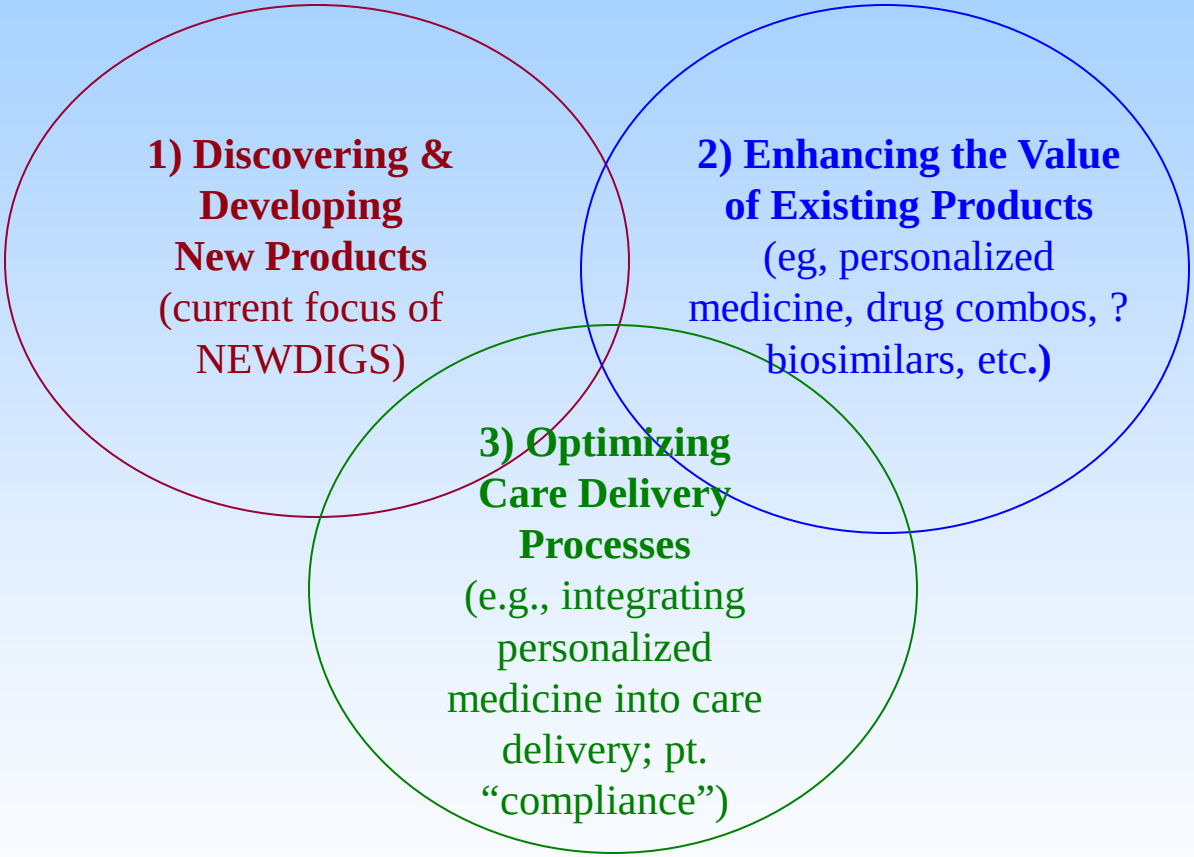
Key Organizational Attributes

- Delivers dramatically increased value over the current approach (faster, more efficient, reduced resource expenditure without compromise in outcomes).
- Is integrated with an outcomes-based reimbursement environment, finding solutions focused on patient outcomes driven by patient and payor value as well as scientific/medical community value
- Understands market and customer(s) health needs
- Focuses on integrated healthcare solutions and is not tied to developing one particular product (i.e., responsive to market need, flexible, adaptive)

Key Organizational Attributes

- Designs solutions that intervene earlier in the disease continuum including prevention.
- Lean and highly collaborative with all stakeholders from across the entire value chain.
- Informed by knowledge generated internally and externally (through pre-competitive, cross-stakeholder data sharing/collaboration) and processes that enable rapid-cycle learning (e.g., Learning Healthcare System).
- Has relationships with best-in-class providers of solution components (industry, academia, non-profits), and collaborates effectively with them to develop solutions.

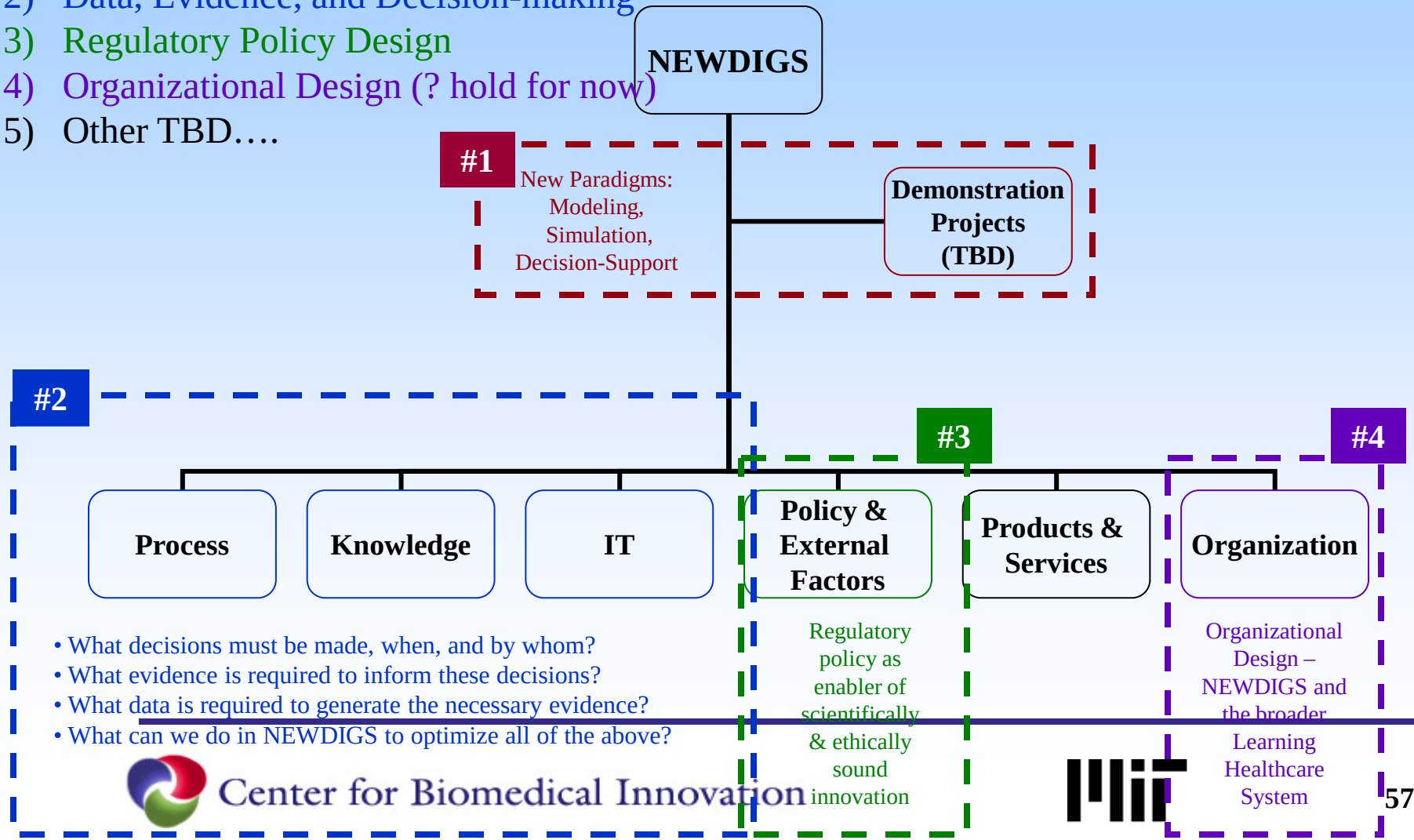
10-15 Year Vision (?): NEWDIGS Innovation Spheres



Proposed Initial Workstreams

Workstreams

1) New Paradigms: Modeling, Simulation, & Decision Support
2) Data, Evidence, and Decision-making
3) Regulatory Policy Design
4) Organizational Design (? hold for now)
5) Other TBD….



Center for Biomedical Innovation

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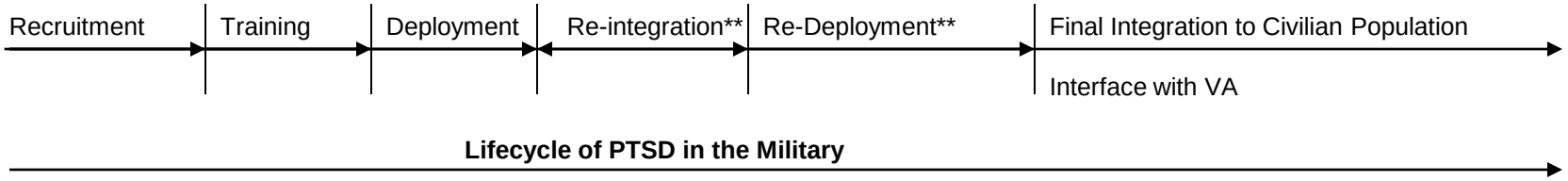
Systems based approach to PTSD

Warrior - Centric



Phase I - **Current State Analysis**: Descriptive Research designed to understand the system

- Model each phase of the lifecycle ("system") of PTSD and the interfaces between each phase
- Multi-scale: Top down/ Bottom up
- **Outcome**: **Define Problem**

Phase II - Model Creation and Validation: Descriptive Research designed to represent the system

- Drill down into identified gaps to develop possible solutions
- Outcome: Recommendations

Phase III - Implementation

** Will take into account multiple deployments.

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Motivation for Application to PTSD

- Rising suicide rates among returning veterans and the potential PTSD precursors
- PTSD impact on health and well-being of servicemembers and their families
- PTSD impact on health services utilization within the military and in affected communities
- PTSD impact on national priorities for DoD

LEAN ADVANCEMENT INITIATIVE ™

Potential Outputs

- **Generate <u>models</u> as tools so that policymakers can:**
  - **Develop Insight on PTSD's systemic impacts**
  - **Identify Missed Opportunities and Misalignment among current PTSD-related functions**
  - **Inform Resource Allocation for PTSD-related functions**
  - **Direct R&D Funding to Needed Areas**
  - **Reshape PTSD-related metrics to Monitor System Performance**

Starting Points for Research

- Resource Allocation among Functions
- Capacity Utilization and Demand Modeling for Services
- At-Risk Subpopulations
- Active v. Reserve v. Guard Health Dynamics on Return
- Effects of Changing Suicide Policies
- Effects on Family and Community

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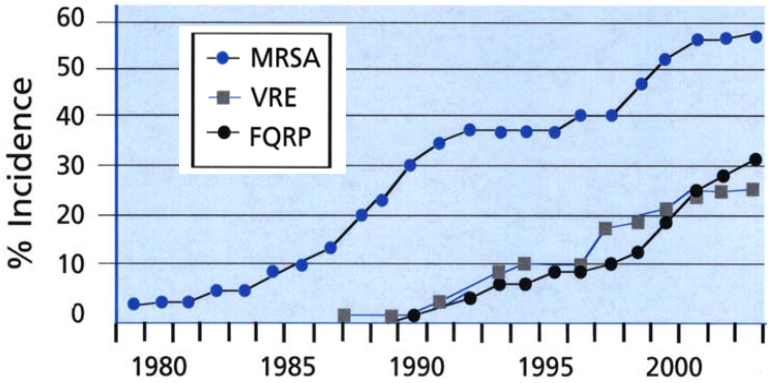
Motivation / Problem

> Antibiotic Resistance Surveillance: Key Healthcare Problem

- Rapidly increasing resistance
- Few effective antibiotics remain
- Limited system level surveillance
- Process improvement difficult



Source: CDC; MRSA=methicillin-resistant *Staphylococcus aureus*; **VRE**=Vancomycin-resistant *enteroccoci*; **FQRP**=Fluoroquinolone-resistant *Pseudomonas aeruginosa*

> Complex Healthcare Processes

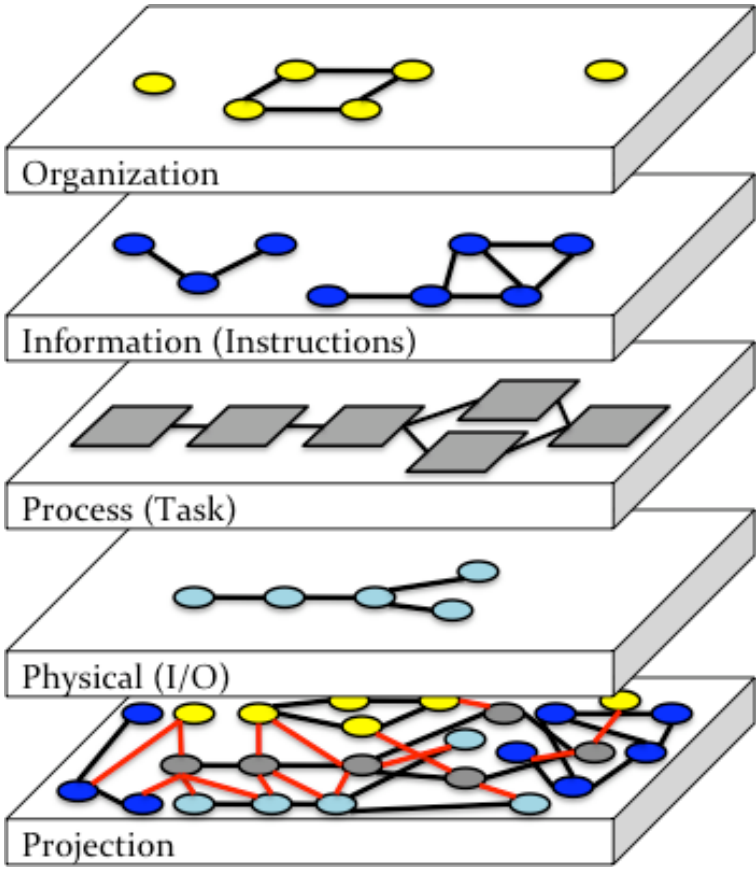
- Large number of tasks and rapidly changing technology
- Numerous disconnected stakeholders
- Vast technical design space
- Highly distributed information (tacit and explicit)

> Severe Health and Cost Impacts

- 2 Million hospital acquired infections per year
- $5 Billion (est.) and over 90,000 deaths per year (source: IDSA)

Key Questions

- How can the true system level complexity of healthcare processes be modeled and measured?
- How does this system level process model and complexity measures work on a real world healthcare process design and implementation effort?
- How does process complexity impact change and adoption in healthcare?



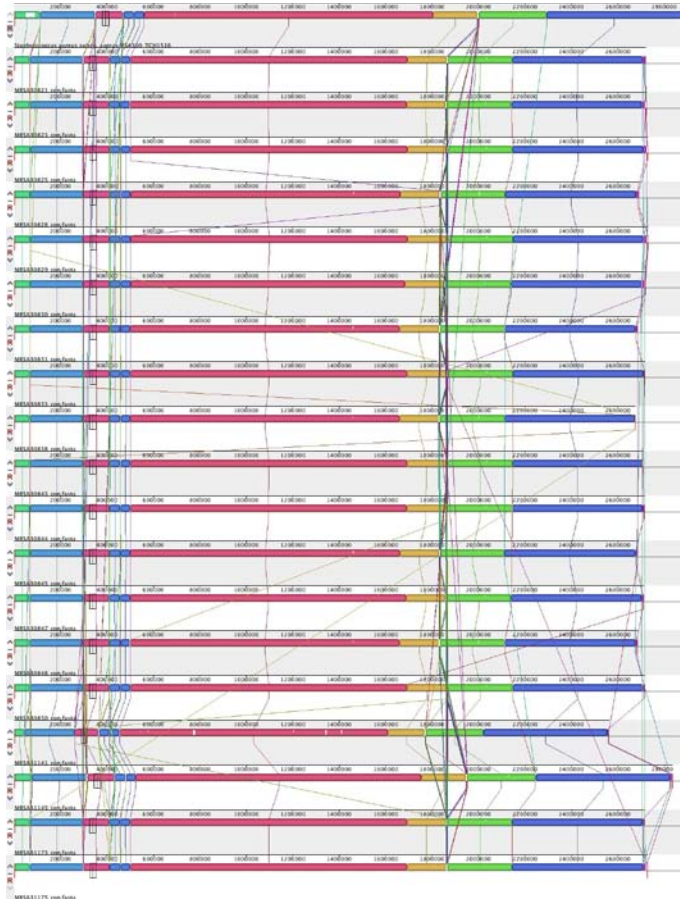
Contributions

- Novel Network Based Process Representation and Complexity Analysis Methodology **(model)**
- Novel Theory for Process Innovation Adoption as a Function of Process Complexity **(model observations)**
- First Specification of a Whole Genome Clinical Microbiology Process for MRSA Surveillance **(test case for model)**
- First Operational Demonstration of a Whole Genome Clinical Microbiology Process for MRSA Surveillance **(test case for model and complexity measures)**
- First Whole Genome MRSA Diversity Study **(real biological results showing policy change needed)**

Contributions (Significant Biology Too...)

MRSA Surveillance Process designed and implemented as part of thesis yielded significant insight into MRSA biology which in turn suggests system policy changes needed

Reference (should all be the same as this)



Multiple Genome Alignment of BWH Samples Compared to Reference at the Top

- >50 Genomes Sequenced (<15 existed previously)
- > All Supposed to be identical based on current hospital diagnostics
- > Significantly different! (look at length)
- > Highlights need for surveillance and policy changes

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