Scaling ISE in Healthcare: National Initiatives

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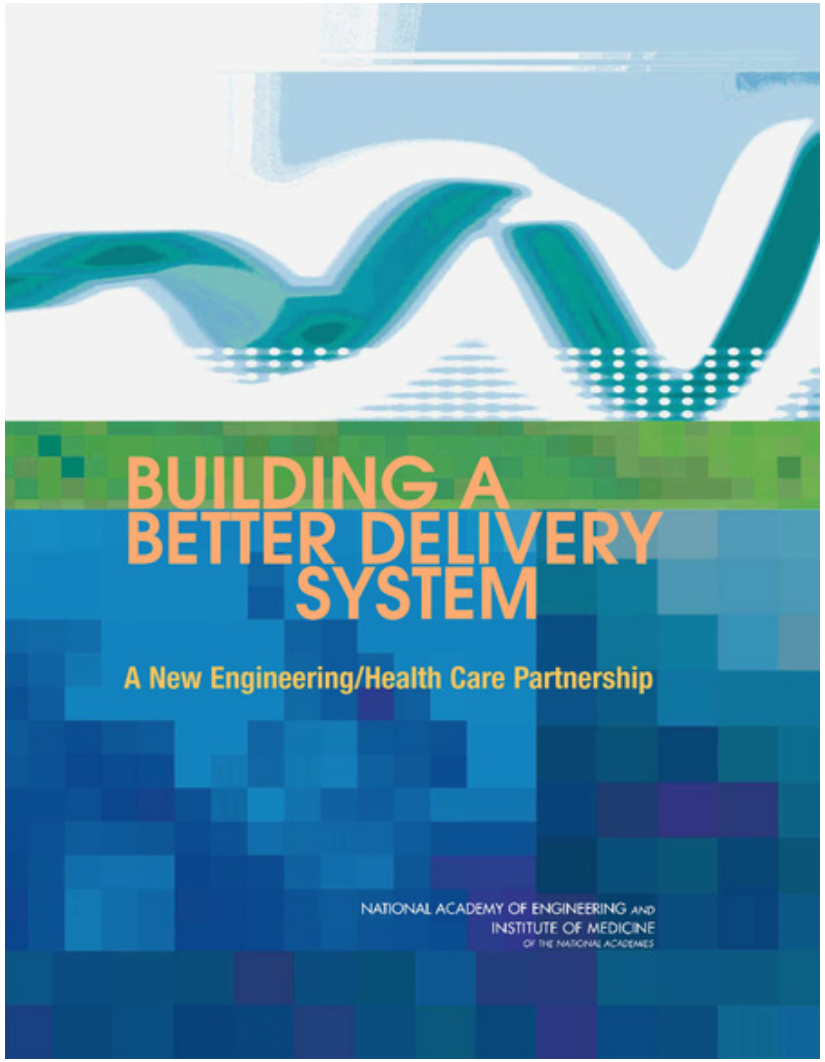
Improving **P**rimary **C**are **T**hrough **I**ndustrial and **S**ystems **E**ngineering
June 3, 2019

Outline

1. Motivation and need
2. Summary of national healthcare ISE initiatives
3. Results, lessons, comparisons
4. Discussion



Motivation

Significant interest in quality & systems engineering methods

(IOM, NAE, AHRQ, NSF, NIH, PCAST)

'Time for science of health care to embrace science of systems engineering...' (JAMA, 2012)

'Greater use of... principles... widely used in manufacturing and aviation... small number health care organizations... not widespread in U.S. health care'

National Calls in Healthcare

IOM, NAE, AHRQ, NSF, NIH, PCAST, HBR, RAE, etc

Widely Used Elsewhere

Common recommended needs:

Broad scale application

Demonstrated impact

Workforce development

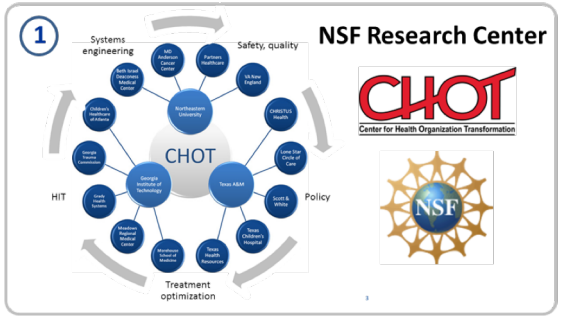
Clinician-engineer partnerships

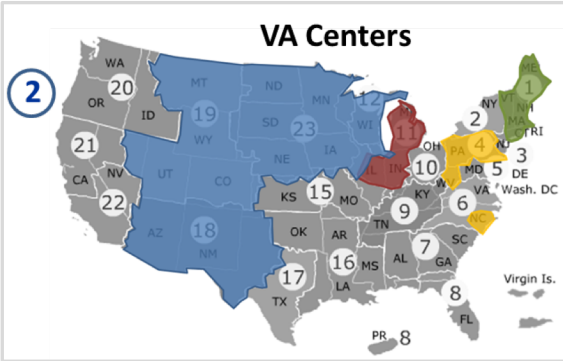
"By what method" (Deming)

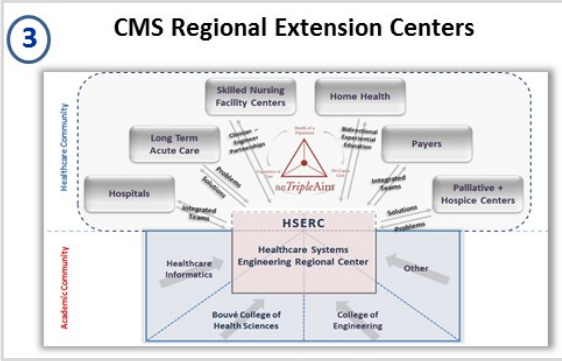
Item	Process/leading measure(s)	Outcome/lagging measure(s)
D1: Impacts of projects (on triple aim)	• Number health systems engaged • Number projects conducted, and balance across each aim • Survey of partners re: impact	• Number successful projects achieving goals, by aim • Total measured impact of projects across each aim
D2: Increase workforce	• New courses in health systems engineering x number times offered • Number faculty involved in this project as advisors or trainees	• Number trained BS and MS students graduated • Number training faculty now teaching elsewhere
D3: Increase demand, visibility, perceived value	• Publications and presentations • Case studies developed • Publications	• Requests for students, coops, interns, senior projects • Requests to join center • Media mentions
D4: Scalable, spreadable, standardized	• Project tool kits • Center launch and mgmt tools • Processes for syncing and sharing work across centers	• Replicated, spread projects • Tests of remote sites • Ability to coordinate work across locations
D5: Sustainable	• Number potential business models identified, vetted • New positions created	• Number retained and new academics and health systems • Continued ROI on 3 aims

National large-scale initiatives (5)

1. **NSF collaborative research center**
   - ~40 health systems, ~7 universities [‘B/B-’]
2. **VA VERC engineering centers**
   - 4 national SE centers serving VA++ [‘A-/C+’]
3. **CMS/CMMI regional extension center**
   - National healthcare IE demonstration [B+]
4. **Texas/UT systems engineering initiative**
   - State-wide initiative [A]
5. **AHRQ patient safety learning labs**
   - ~22 ‘clinician-engineer’ awards [IP]





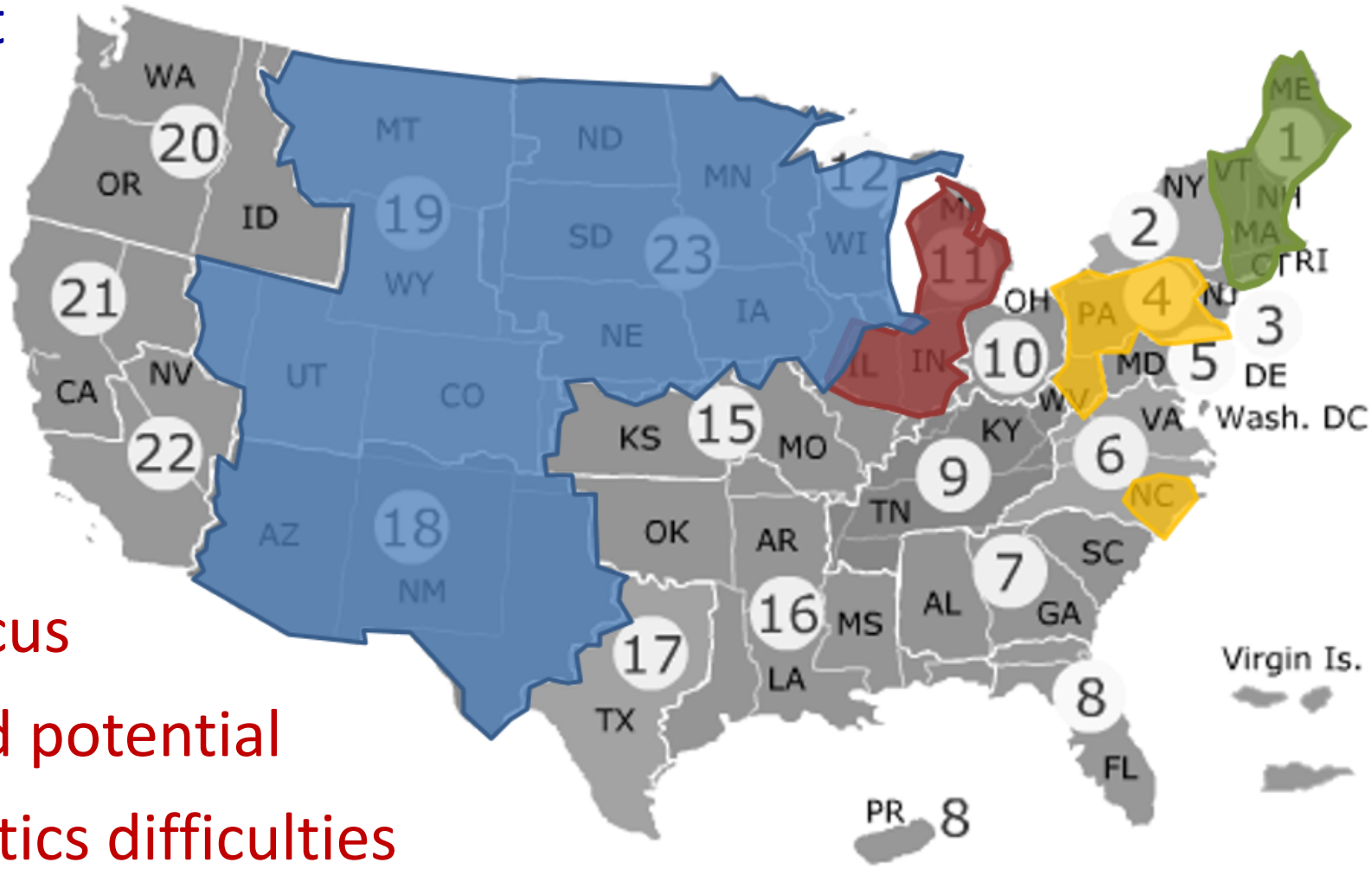


Representative projects

Applied / Basic Methods	More Technical	Advanced / Research
• Work process observation • CLABSI, pressure ulcer, HAI, etc reduction • Inventory improvement. RME standardized processes • Supply chain and purchasing optimization • PA staffing model • Same day waits and delays • Unnecessary referrals. Referral reliability	• ED and observation unit design and simulation • Readmissions reduction, predictive modeling • Care network capacity optimization • PTSD predictive modeling • Bed availability and patient flow prediction • Cognitive load analysis • Outside utilization (leakage)	• Primary care continuity resident scheduling • Adaptive appointment access control theory • Non-disruptive and robust optimization • Abx stewardship behavioral economics modeling • Complex surgery co-team scheduling • Advanced safety methods

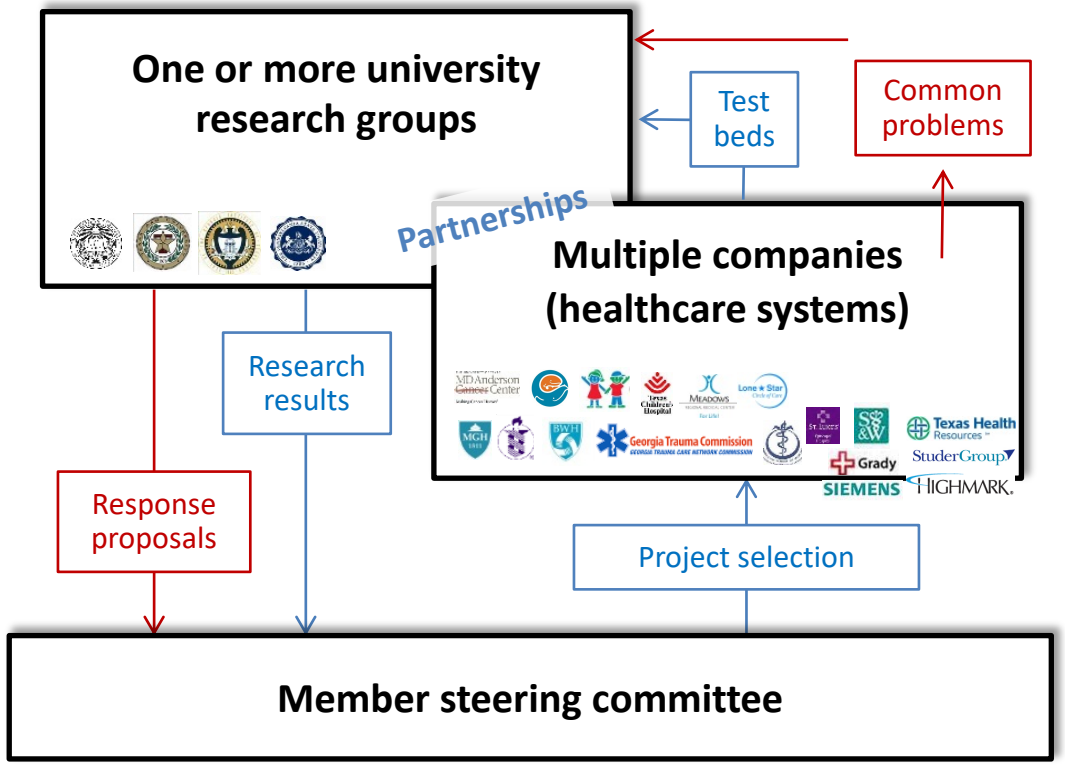
(1) Veterans Engineering ~~Research~~ Resource Centers

- Single largest & longest investment
- IE methods broadly
- Significant impact
- Primarily applied projects (vs. research)

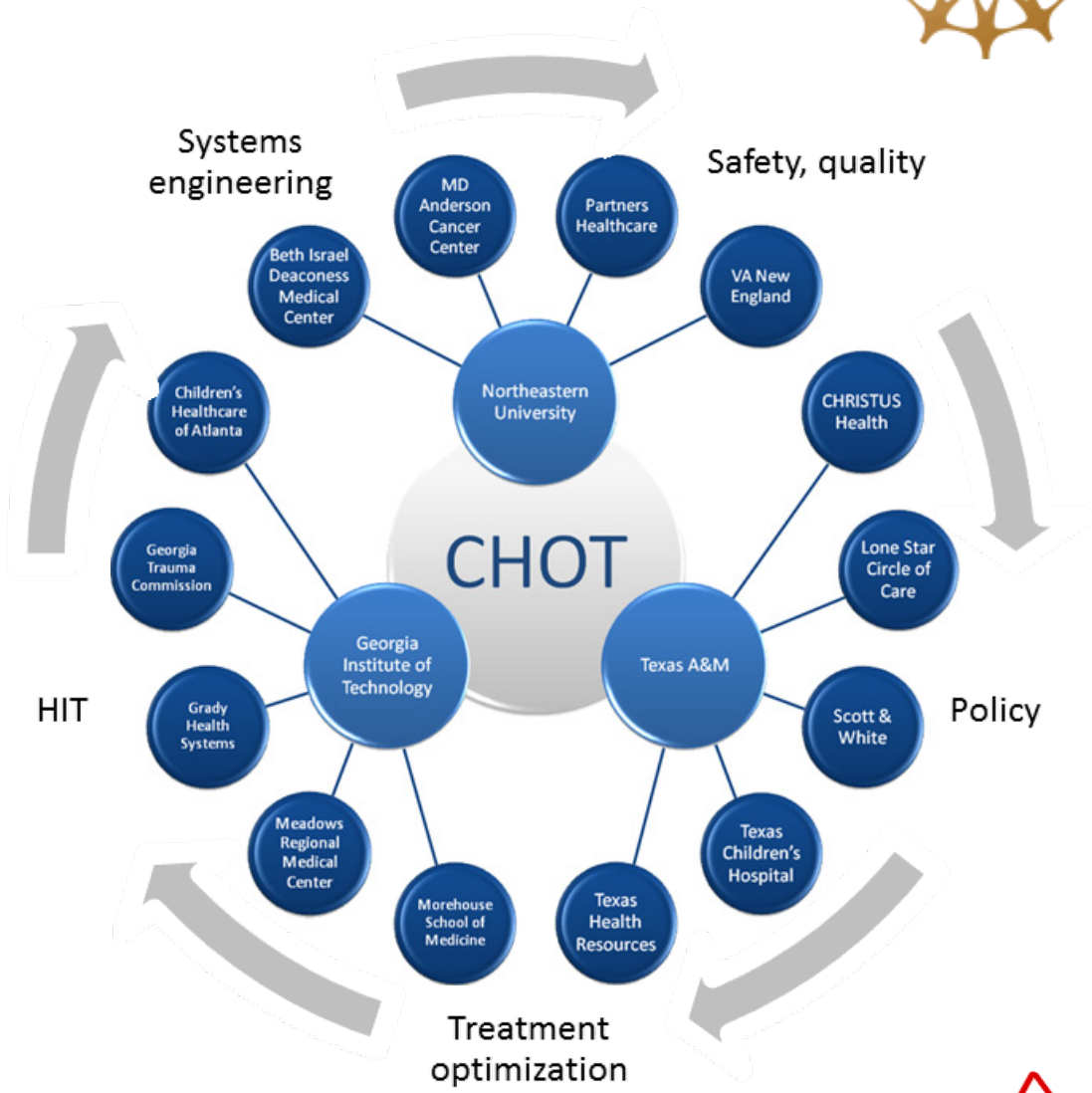


- Variable leadership, focus
- Realized and unrealized potential
- Collaboration and logistics difficulties

(2) Collaborative research center (NSF)

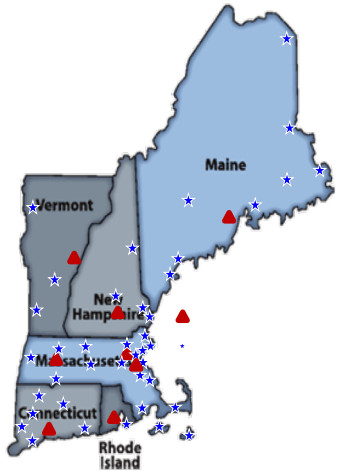


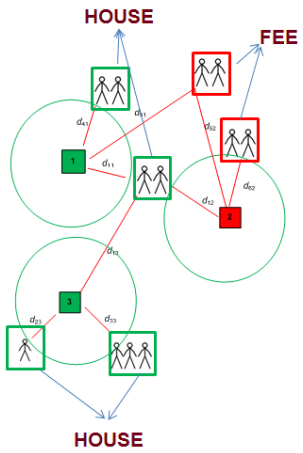
- Pooled resources on common projects, members as test beds, co-pursue funds
- Oscillating synergy & bureaucracy



Example projects

Network Design





$$\text{Minimize } N_1(4712 - \sum_i \sum_j C_{ij} Y_{ij} h_i) + (\sum_i \sum_j C_{ij} Y_{ij} h_i (d_{ij} * N_2 + N_3))$$

Subject to: $\sum_j X_j = P$,

$\sum_j Y_{ij} = 1$ for all i,

$Y_{ij} - X_j \le 0$ for all i, j,

$X_{j \in O} = 1$,

$N_2 = 0$ for all i, j if $d_{ij} \le 30$,

$X_j \in \{0, 1\}$ for all $j \notin O$,

$Y_{ij} \in \{0, 1\}$ for all i, j.

Savings

5 - 15% cost ↓
10 - 35% access ↑
15% in-house care ↑

Primary Care Continuity - Resident Team Scheduling

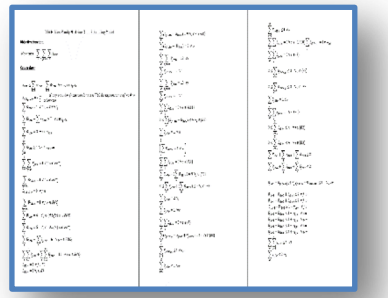
- Primary care resident complex schedule problem. Minimize visits not with familiar PCP team

Fragmented schedule

	MON	TUE	WED	THU	FRI
AM	R	R	R	R	R
	F	F	F	F	F
	R	R	R	R	R
	R	R	R	R	R
PM	F	F	F	F	F
	R	R	R	R	R
	F	F	F	F	F
	R	R	R	R	R

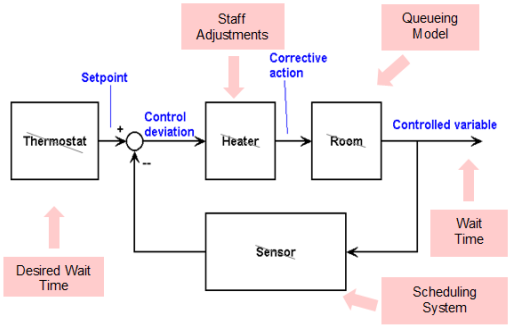
Patient-centered schedule

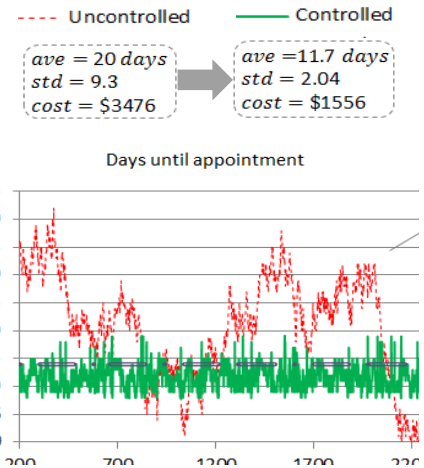
	MON	TUE	WED	THU	FRI
AM	R	F	R	R	R
	F	R	F	F	F
	R	R	R	R	R
	R	R	R	R	R
PM	F	R	R	R	F
	R	F	R	F	R
	F	F	F	R	F
	R	F	R	R	R



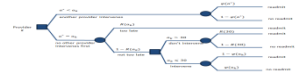
Appointment Access

- Long waits common problem
- Engineering control methods





Cooperative Competition



- **Competition** driven by economics
- **Cooperation** encouraged by social welfare

Game Theory in the Operating Room Environment

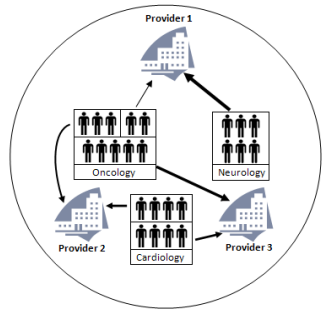
ALAN P. MARCO, M.D., M.M.M

From the Department of Anesthesiology, Medical College Hospital, Toledo, Ohio

PARTNERS HEALTHCARE

The Nash Equilibrium Breaks Down

Thomas H. Lee, MD, MSc.
Network President, Partners HealthCare System



Utility = Benefit − Cost

$$U_{ik} = b_{ik}\phi(a_i^*)\sum_{j=1}^{N} x_{ij} - c_{ik}x_{ik}$$

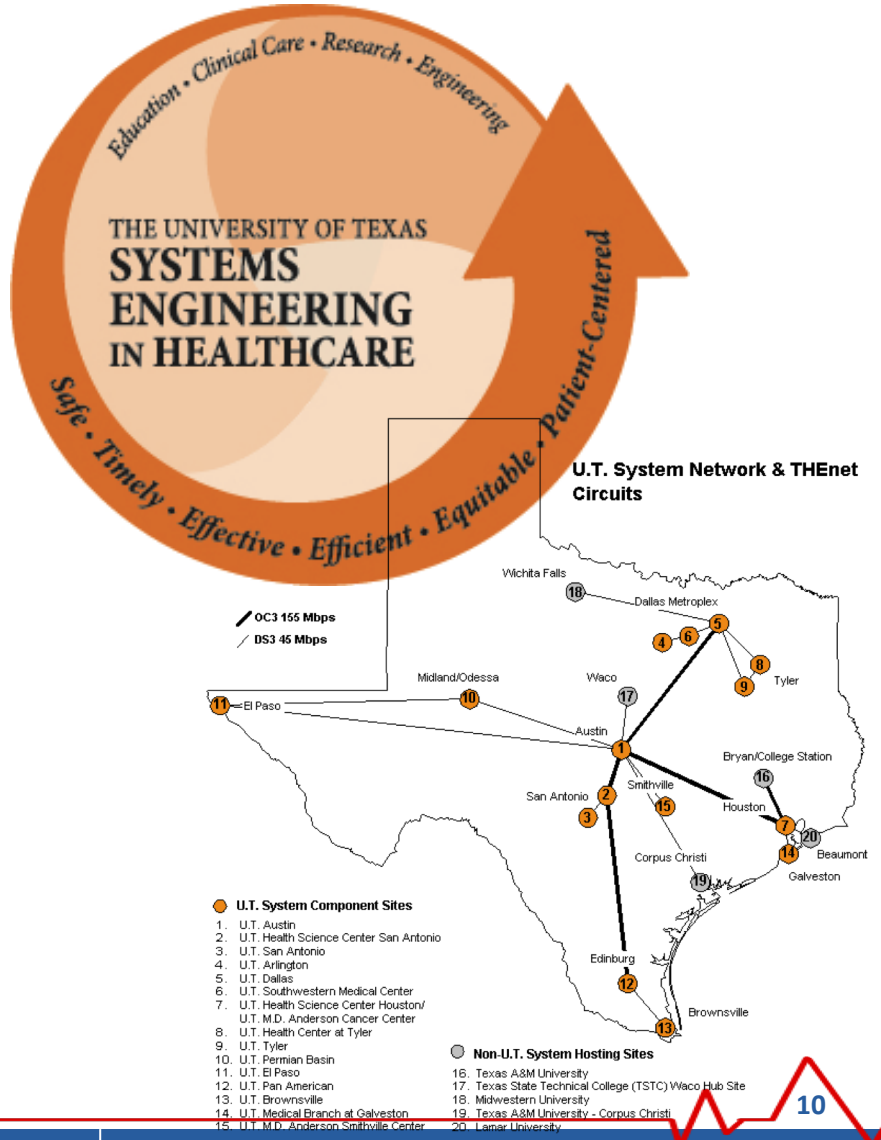
$$= b_{ik}E[\phi(a_i^*)\textstyle\sum_{j=1}^{N} x_{ij}] - c_{ik}E[x_{ik}]$$

$$= b_{ik}[P(a_{ik})Q(a_{ik})\phi(a_{ik}) + (1 - P(a_{ik}))Q(a_i^*)\phi(a_{ij})] - c_{ik}P(a_{ik})Q(a_{ik})$$

$$= b_{ik}\left[P(a_{ik})Q(a_{ik})\phi(a_{ik}) + (1 - P(a_{ik}))\sum_{t=0}^{a_{ik}} p(t)Q(t)\phi(t)\right] - c_{ik}P(a_{ik})Q(a_{ik})$$

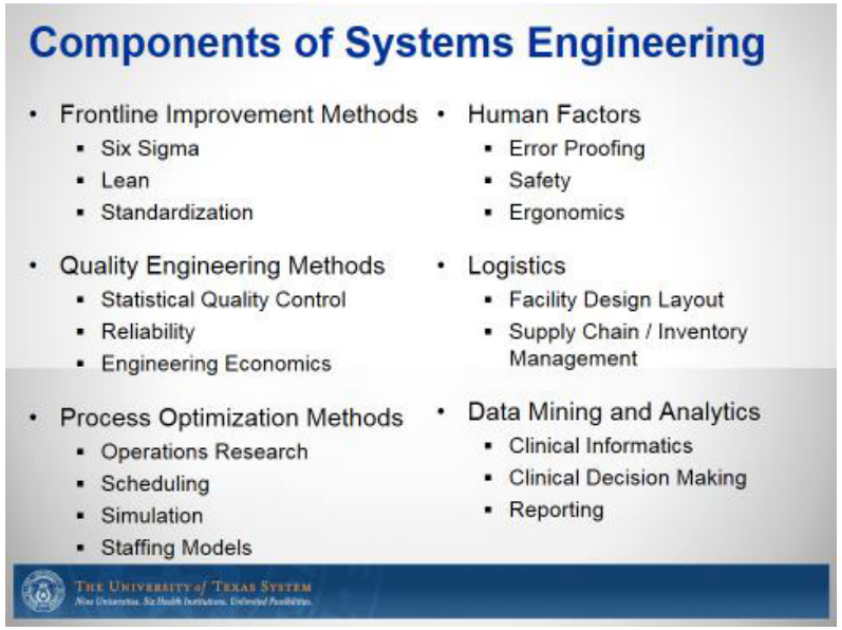
(3) UT systems engineering initiative

- Statewide initiative across UT campuses (Chancellor Ken Shine)
- Grant-based. Dual clinician-engineer PI required
- Experienced project leads, technical support, national expert oversight committee
- Strong measurement, project management, reporting requirements, selection criteria
- Projects varied by problem and method
- Poorly disseminated, 100% projects met aims, on time



Results

Examples of Methods Used



$13 million savings annually

(100% projects met their aims)

Setting	Impact /Methods
ICU	19% reduction in admission delays
Radiation oncology	36% reduction in waits, $700K annual savings
Diagnostic imaging	69% reduction in waits, $579K annual savings
Pharmacy mgmt.	$1m annual savings
COPD	13.4% decrease in readmissions
Elective surgery	23% lower LOS, 50% lower readmits, $360K
Labs	4x increase in lab TAT < 2 weeks
ED	Boarding 75% lower, LWBA 72% lower
Primary care	7% access increase, 8% wait reduction
Surgery	34%-69% reduction in first case delays
Device-related HAIs	81.5% HAI decrease, $110K annual savings

(5) AHRQ patient safety learning labs

- 3 (4) rounds, 21 (26) awards, $60-80m
- Very successful incentivizing partnerships
- Patient safety focus (vs broader problems)
- Mostly HFE (vs SE broadly)
- Loosely evaluated at best
- SE often secondary (research-as-usual with small SE consults, small SE budget)
- Clinician or HSR led/prime (1 exception)

Monday 12:25: PSLL panel (auditorium)

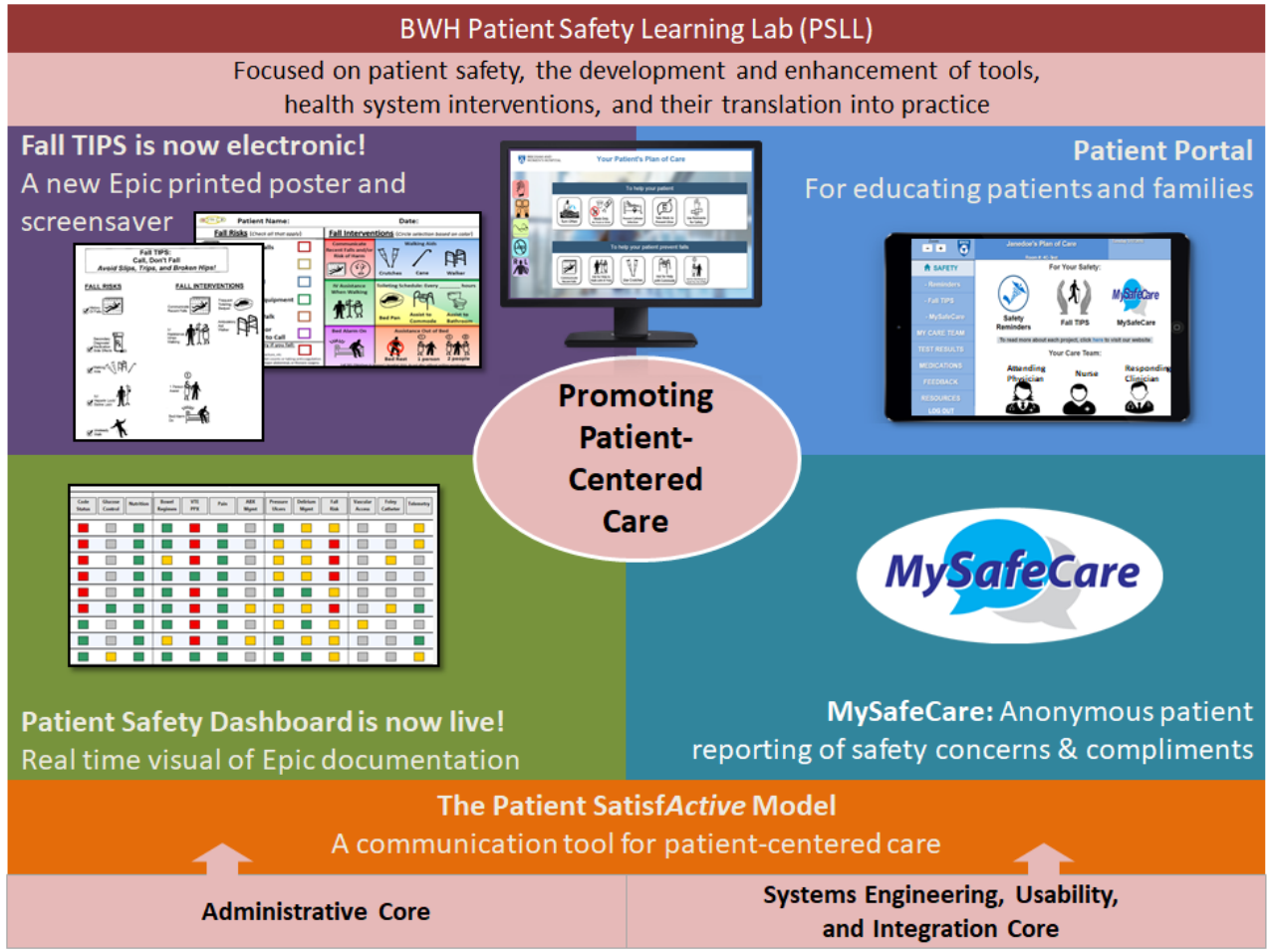
Monday 1:45: Three case studies (session C2)

Types of Applications

Inpatient safety HIT	Cognition and communication	
Diverse populations	Failure to rescue	
Maternal and neonatology	Imaging	
ICU harm	Primary care transitions	
Radiology	User-centered design of ORs	
Aging brain	Built environments	

Example: Acute care patient-centered PSLL

Patient Safety Dashboard



ARHQ Lifecycle

Analysis → Design → Develop → Implement → Evaluate

Methods Application

Year 1	• Individual tool focus • Usability & interface design • Human factors
Year 2	• System of systems focus • Pilot data, failure analysis • SoS simulation model
Year 3	• Macro ergonomic, SEIPS view • Workflow, contextual, failure, cognitive burden analysis
Year 4	• Prospective view • Automated reporting, control charts, risky states detection

(4) CMS/CMII HSyE demonstration project (RECs)

- CMS/CMMI $8m innovation HCIA award: “Scalable Healthcare Systems Engineering Regional Extension Centers”
- Agricultural/manufacturing extension center model
- H_0: Demonstrate ISyE REC can measurably impact ‘triple aim’ in manner that can scale nationally, create demand and workforce

Science and workforce components

Sub-Aims

- Study ISyE utility in health care (*by system types, problems, methods*)
- Solution repeatability (by type)
- Biggest impact for next time.
- How best scale SE in health care
- Barriers and effective strategies

Workforce Development

For engineers (~825)

- Model curricula, minor, prof MS
- Experiential education (coop, internship, postdoc programs)

For healthcare (~1,450)

- Seminars, workshops, symposia

Experiential Learning

Undergraduate Co-op Program
- Assist with 2+ projects in health systems
- Sophomores through seniors eligible
- 6 month duration

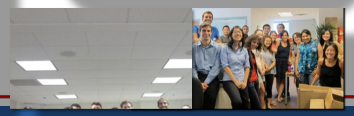
Graduate Research Internships
- Work 3-6 months in healthcare system
- Combined applied project(s) and in-system work on thesis research or topic discovery
- Continued work in following semester

Summer Fellows Program
- Experience on applied and research problems in our centers and health system partners
- Supervised by academic & healthcare mentors
- 8-12 week duration, undergraduate and graduate students eligible

In Development
- Online tutorials ("HSyE for dummies")
- Summer faculty mini-sabaticals

Formal Education
- Undergraduate healthcare IE minor
- Graduate health systems engineering MS and PhD concentrations within IE
- Engineering leadership program in health systems engineering MS & PhD
- Short courses and webinar series (practitioner focused)

In development
- Professional MS, healthcare improvement science
- HSyE MS engineering degree



"This was the best learning event I've attended in 10 years on new but practical ways to improve broken healthcare processes."

"I never imagined one summer could so powerfully influence and prepare me for what I'm now certain I want my career focus to be."

"The impact HSyE's postdoctoral training program and coursework had on my early career and ability to lead effective healthcare engineering work as an applied scientist is extraordinary."


HSyE
Healthcare Systems Engineering
Northeastern University

Seminar Series
Healthcare Systems Engineering Institute

All events are free and open to anyone in the healthcare community interested in process improvement.

Healthcare Systems Engineering as an Improvement Strategy
1-hour seminar
Monday, March 10, 2014
5-6 pm Reception / 6-7 pm Seminar
Hartwieg Medical Center
300 6th Avenue

A general introduction and overview of healthcare systems engineering methods and how they complement other improvement efforts - including common methods, examples of applications, and available resources and assistance for getting started. Preceded by an informal networking reception. More details.

Using Computer Simulation to Improve Healthcare
1-day workshop
Week of April 28, 2014
9-4 pm Workshop / 4-5 pm Reception
Date and location to be announced.

Computer simulation is one of the most common systems engineering methods used to improve healthcare processes. This workshop provides an introduction to using simulation models to make a variety of healthcare decisions, using several exercises to teach basic concepts and provide experience in the basic steps of effective simulation studies. More details.

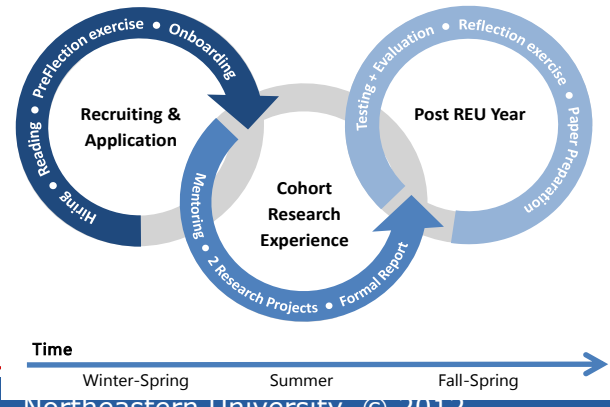
Using Quality Control Charts in Healthcare
1-day workshop
June 23, 2014
9-4 pm Workshop / 4-5 pm Reception
Northeastern University Seattle
401 Terry Avenue North, Suite 103

An introduction to using statistical process control in healthcare, including selection, construction, and interpretation of the most common types of control charts. The morning will cover general concepts and basic methods and the afternoon will cover more advanced control charts, including for rare events and risk adjusted data. More details.

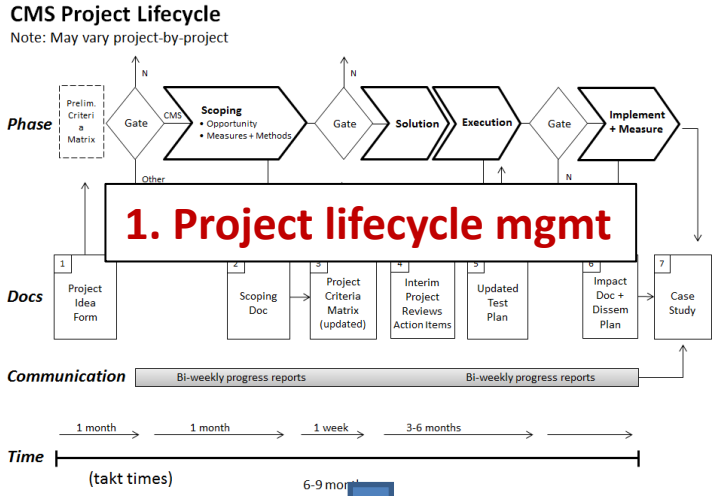
>> Click here to register.

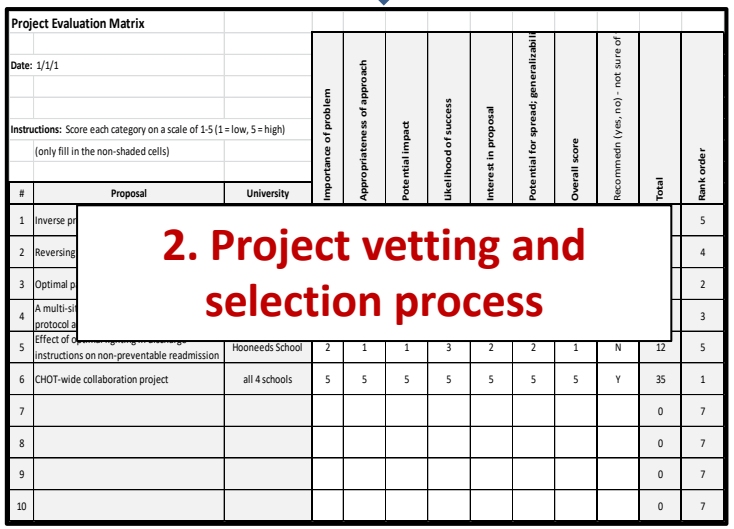
Faculty

James C. Benneyan, Ph.D., Director
Northeastern University, Boston, MA
Colleges of Engineering and Health Sciences
Healthcare Systems Engineering Institute
CMS/CMMI Healthcare Systems Engineering Center
NSF Center for Health Organization Transformation
VA Engineering Resource Centers

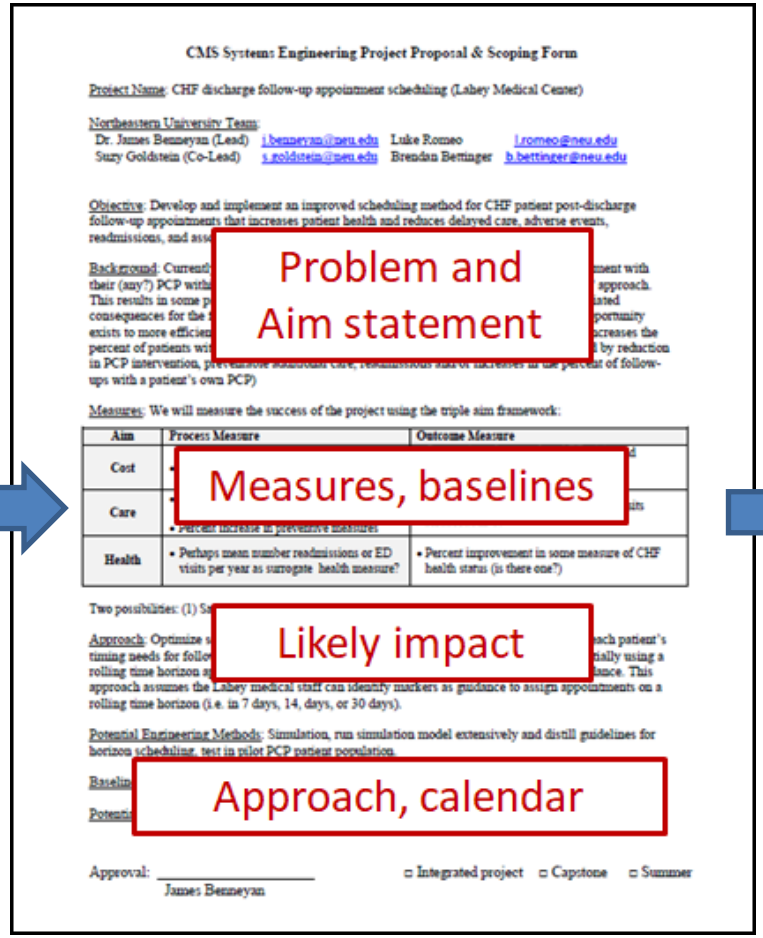


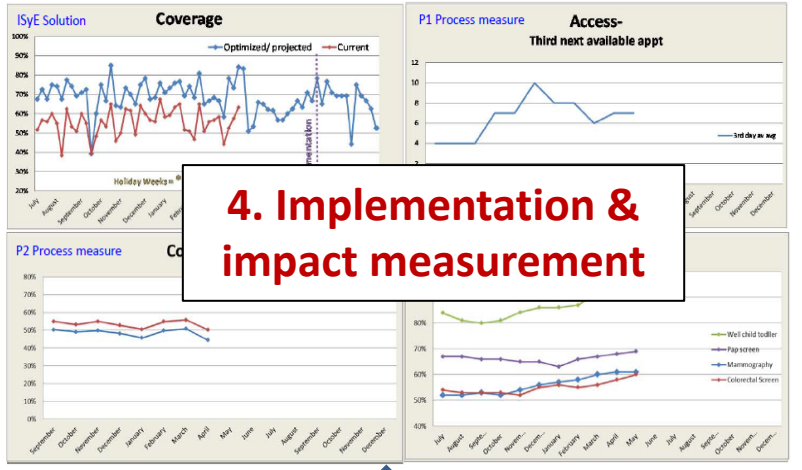
Operational processes





Disciplined project management
(gates, measures, milestones, etc)



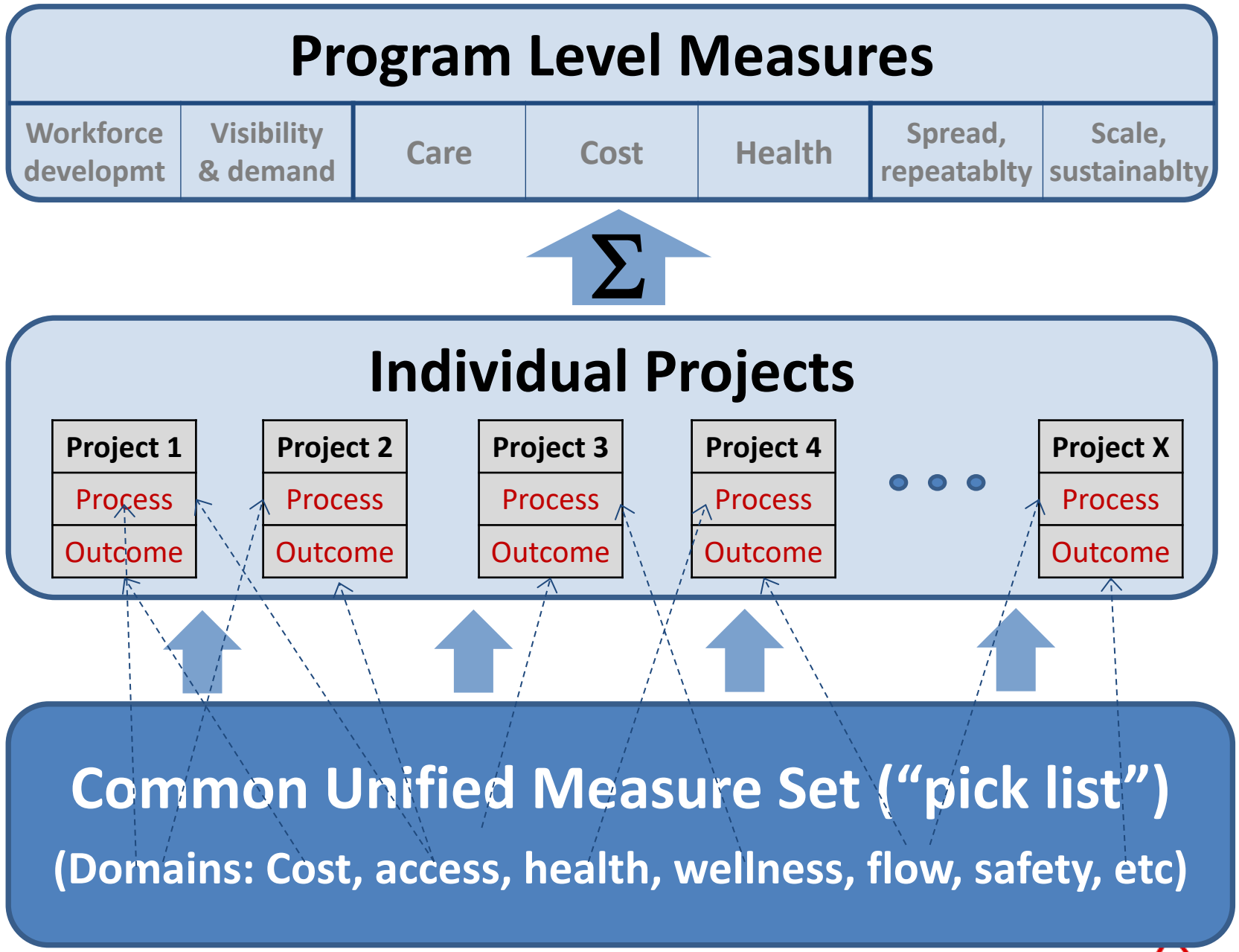


Type	When	Purpose	Disposition
SDR (scope)	M1	Scoping, appropriate project, potential, measures, approve for production	• Action items, tech review • Continue, redirect, cancel
PDR (prelimi			
CDR (critical)		issues, action items and tasks,	
FDR (final)	M6	Review of action items, technical details, needs, resource allocation	
IDR (implement)	M8	Review of implementation, testing, and evaluation plan/progress	

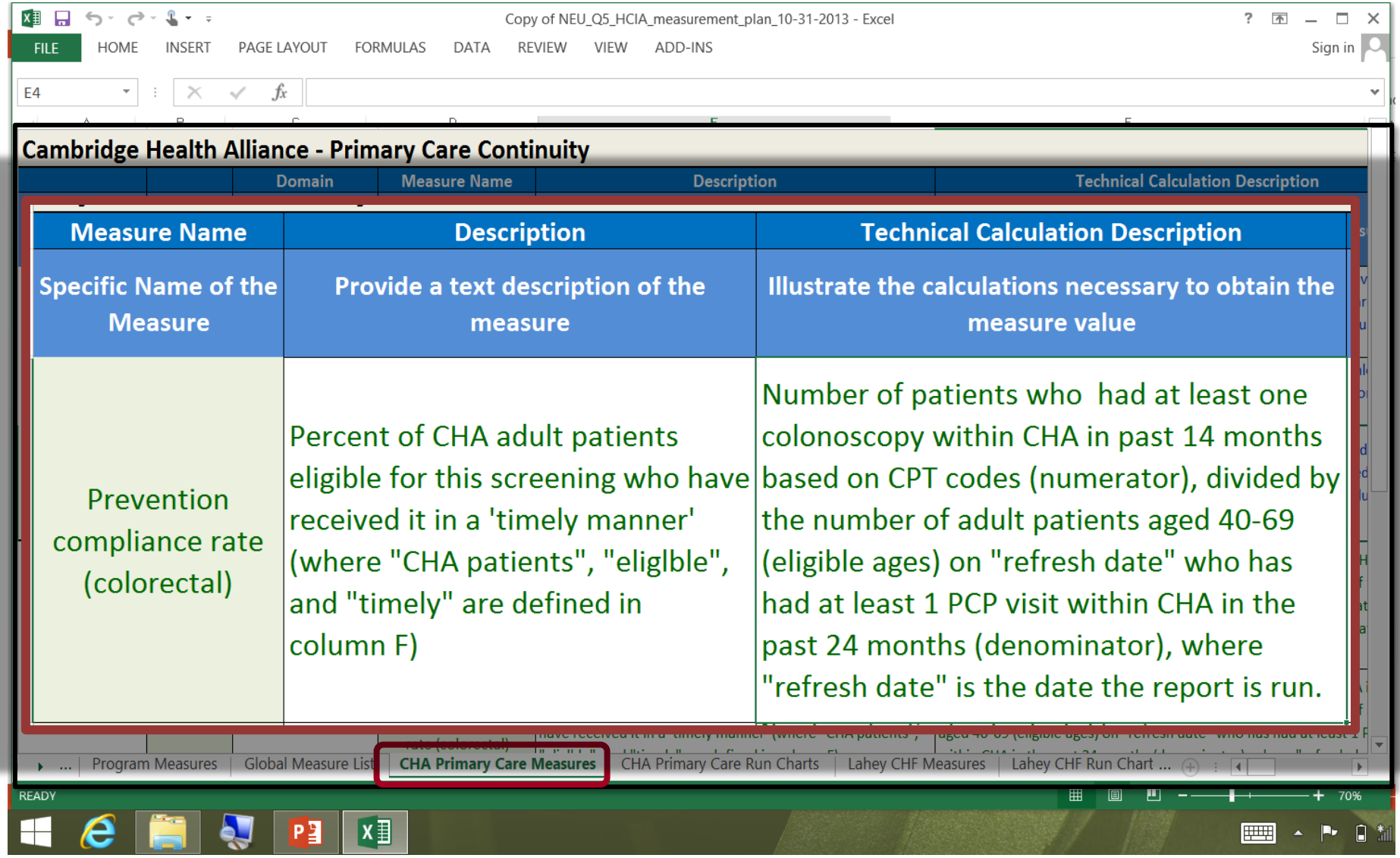
3. Project management and formal design reviews

Measurement

- Unified measure set
- Aggregation mapping process
- Program level (aims) measure categories
- Big spreadsheet
- Identified in project approval process
- Lot of work

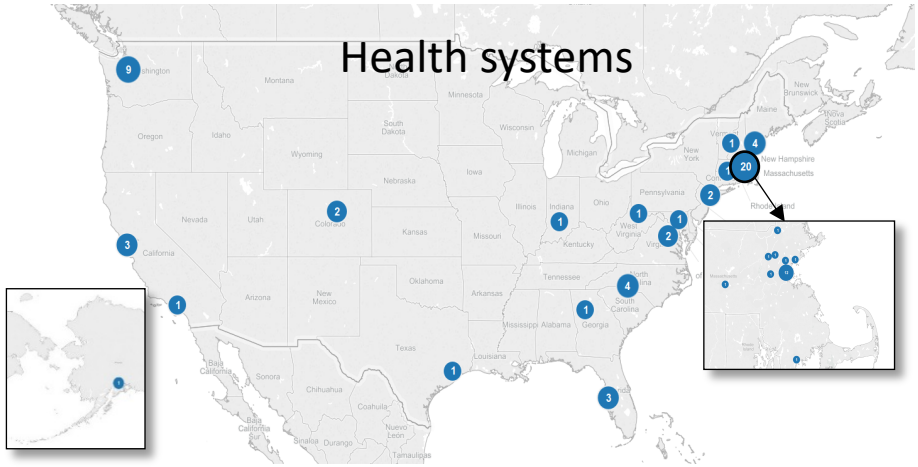


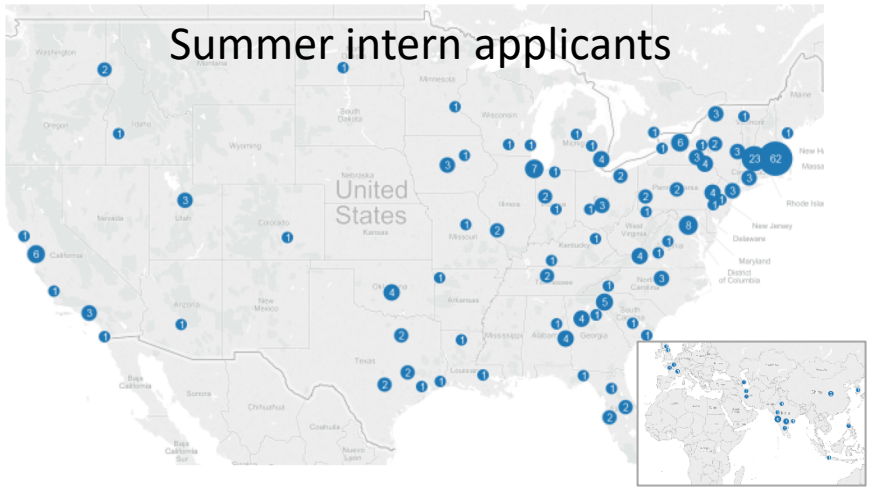
Project measures - example



Results (high level, many detailed slides)

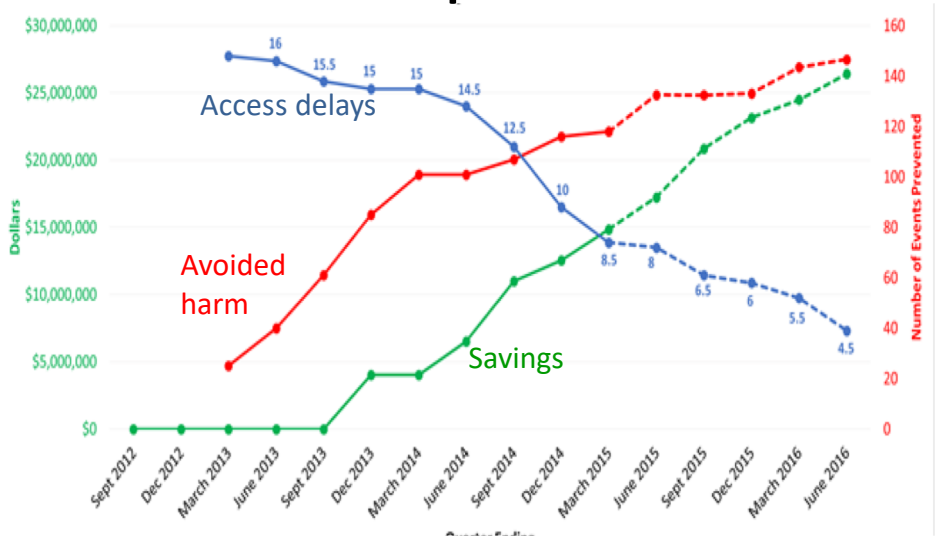
Participants / Outreach

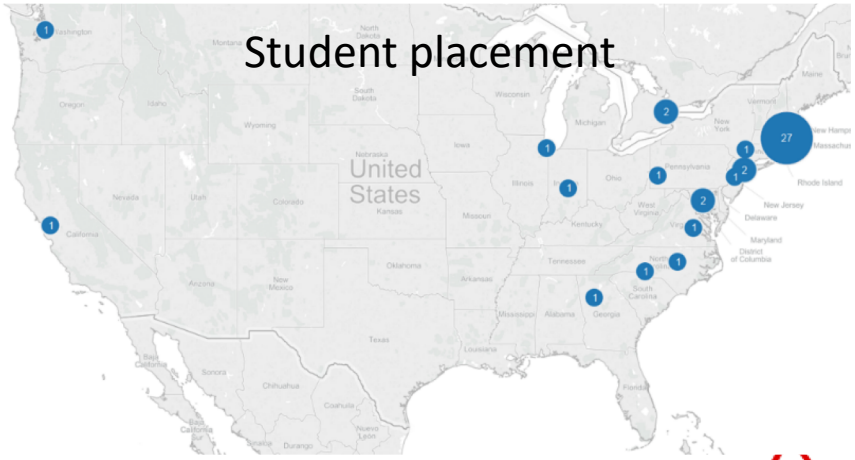




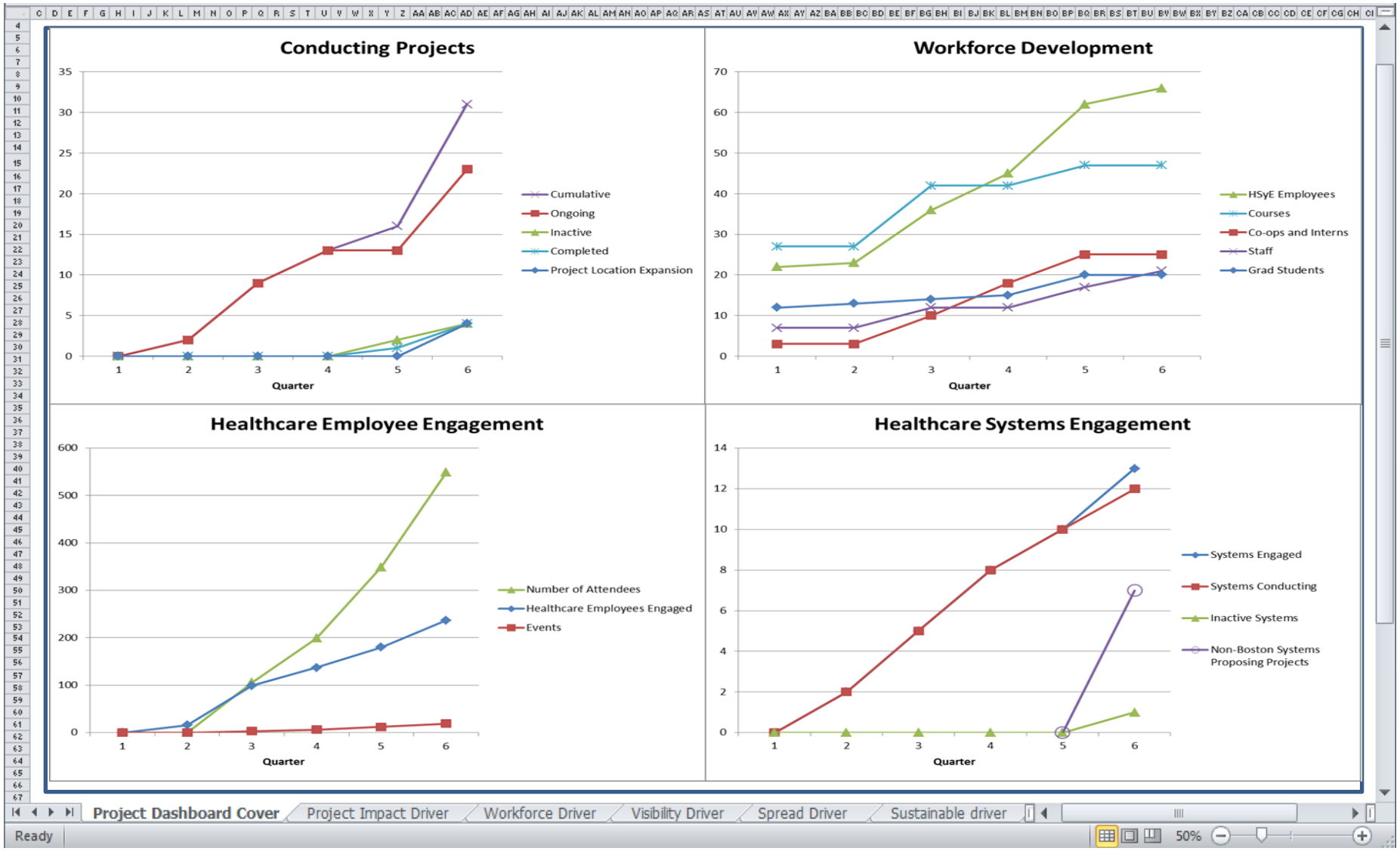
- 87 projects
- 39 health systems
- 8 states
- $25.6m savings ($85m 5-year)
- 147 harms avoided (non-trivial)
- 25% improved access
- ~32,000 patients
- ~825 students and ~1,450 clinicians

Impact



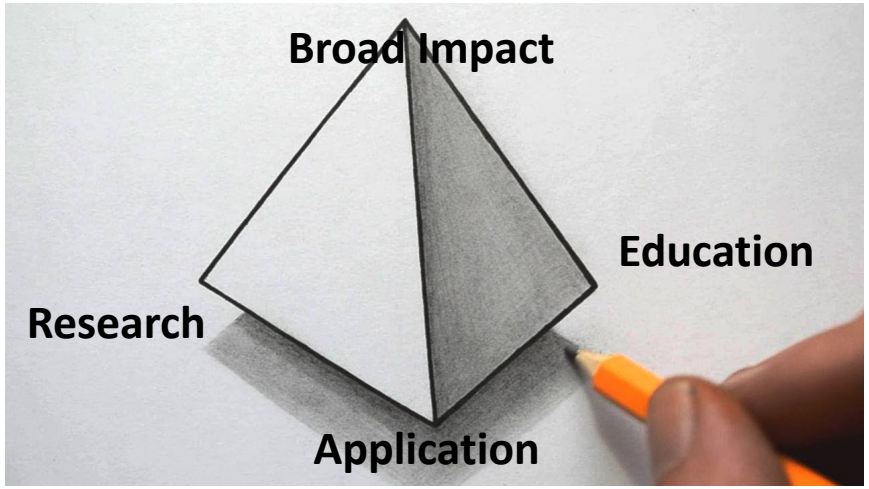


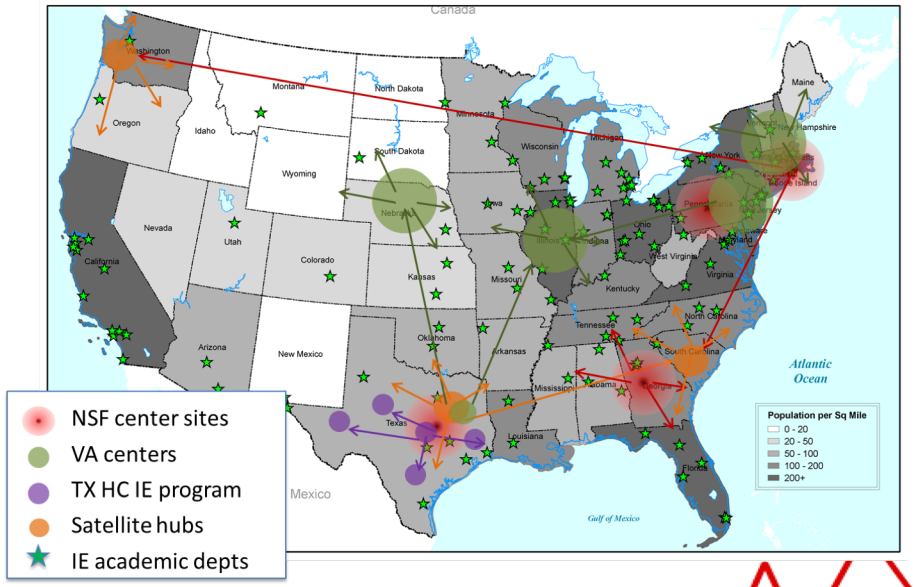
Operations measures



Summary

1. Systems engineering can effectively help improve healthcare
   - If applied well, significant impact
   - Also can be ineffective (if not)
2. Many approaches, none perfect
   - REC model, grant based, system driven, grass roots, federally run, others
3. Common challenges
   - Collaborative partnerships
   - Oversight (technical & project management)
   - Knowing what to do, not just how to do it





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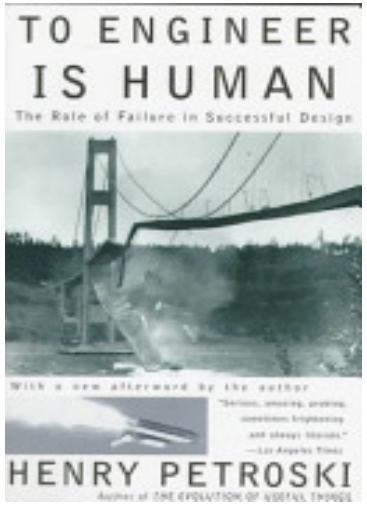

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