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Healthcare
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5th Annual Systems
Engineering in Healthcare
Conference

May 1-2, 2019
Minneapolis, MN

The Future of Healthcare Through a Systems Approach

Alan Ravitz PE, PhD

Chief Engineer, National Health Mission Area
Johns Hopkins University

Applied Physics Laboratory
alan.ravitz@jhuapl.edu

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The Challenge

- Lack of reliable safety, access, affordability, and outcomes → diminished **value**
  - Worldwide, hundreds of thousands of patients die from preventable harms
  - Significant healthcare costs are wasted
  - Hospital-based clinicians spend significant time documenting, hunting for supplies, and other nonproductive work
- Healthcare costs constrain investments in other social programs (e.g. education, etc.)

Health Care Spending as a Percentage of GDP, 1980–2012

Percent

- US (16.9%)
- NETH (12.1%)*
- FR (11.6%)
- SWIZ (11.4%)
- GER (11.3%)
- DEN (11.0%)
- CAN (10.9%)
- JPN (10.3%)
- NZ (10.0%)*
- SWE (9.6%)
- NOR (9.3%)
- UK (9.3%)
- AUS (9.1%)*
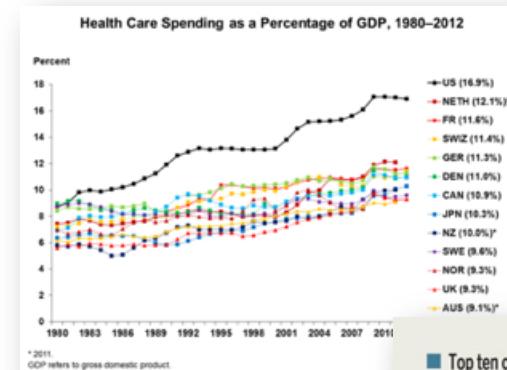
* 2011.
GDP refers to gross domestic product.
Source: OECD Health Data 2014.

https://www.commonwealthfund.org/chart/2014/health-care-spending-percentage-gdp

Top ten causes of death, 2013   *Estimate*

Cause	Deaths
Heart disease	611,105
Cancer	584,881
Medical error	251,454*
COPD	149,205
Unintentional injuries	130,557
Stroke	128,978
Alzheimer's disease	84,767
Diabetes	75,578
Influenza and pneumonia	56,979
Kidney disease	47,112
Suicide	41,149

*Authors' calculation

A new study estimates that **medical error** was the cause of 251,454 deaths in 2013, making it the third-most common cause of death in the U.S.

Sources: Centers for Disease Control and Prevention; BMJ Publishing group Ltd.

@sdutgraphics

http://www.sandiegouniontribune.com/news/health/sdut-medical-errors-3rd-leading-cause-death-2016may03-story.html

Symptoms of the problem

Current-state – in-patient
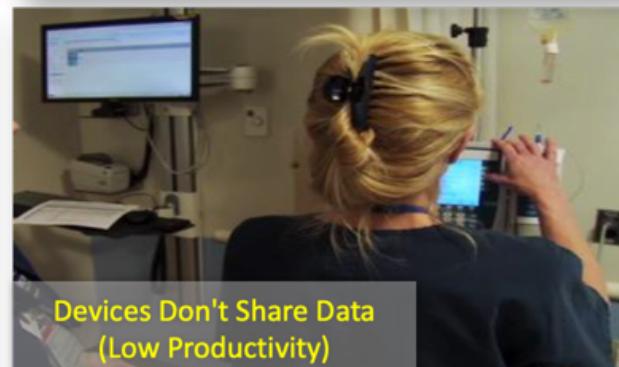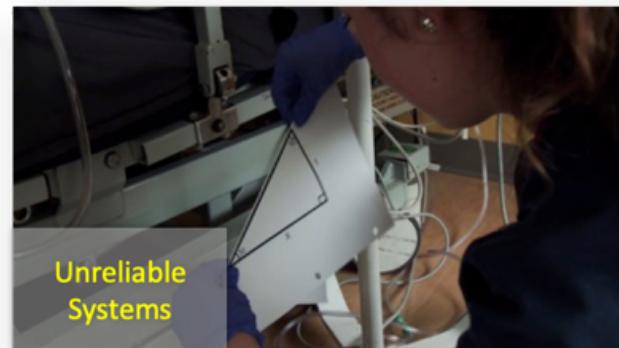
Hand Calculations

Unreliable Systems

Constant False Alarms

Devices Don't Share Data (Low Productivity)

System Evolution

Aviation

Legacy

Today

Healthcare

Legacy

Today

Recognition of the problem

Engineering approaches to resolve the challenges

NAE/IOM, 2005

BUILDING A BETTER DELIVERY SYSTEM
A New Engineering/Health Care Partnership

REPORT TO THE PRESIDENT
BETTER HEALTH CARE AND LOWER COSTS:
ACCELERATING IMPROVEMENT THROUGH
SYSTEMS ENGINEERING

Executive Office of the President,
President's Council of Advisors on
Science and Technology

May 2014

PCAST, 2014

Engineering better care
a systems approach to
health and care design and
continuous improvement

RAE, 2017

How Systems Engineering Can Help Fix Health Care
by Peter Pronovost, Alan Ravitz, and Conrad Grant
FEBRUARY 09, 2017

OPERATIONS MANAGEMENT
What Hospitals Can Learn from Airlines About Buying Equipment
by Peter Pronovost, Sezin Palmer, and Alan Ravitz
JUNE 13, 2017

JHM, APL, 2017

- **Rapid advances** have **outgrown the capacity** of any one individual or even a group of individuals to comprehensively absorb and apply new knowledge to the benefit of patient care

- **Cottage-industry** origins counter to today where healthcare is a **complex partially interconnected myriad of services** that relies heavily on technology, influenced by markets, and is implemented in any one of a number of different provisioning models subject to statutory laws, policies, licensing, and regulation

- **Persistent underinvestment** by the healthcare delivery sector in information/communication technology

Systems must be designed from the start to ensure seamless integration between culture, workflows, and technology

System of Systems

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Transportation

Healthcare

Representative, not exhaustive, compilation of subsystems
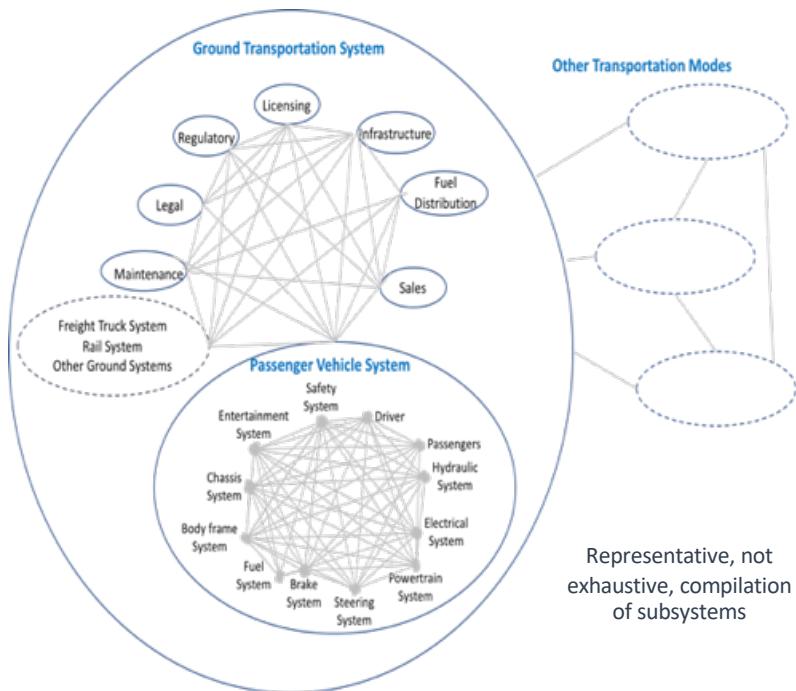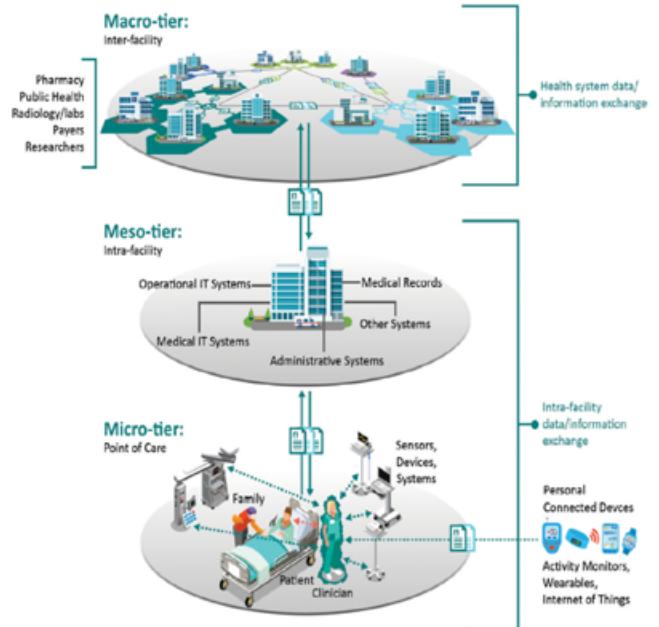
"Procuring Interoperability – Achieving high-quality, connected, and person-centered care", National Academy of Medicine, October 2018

Systems Approach
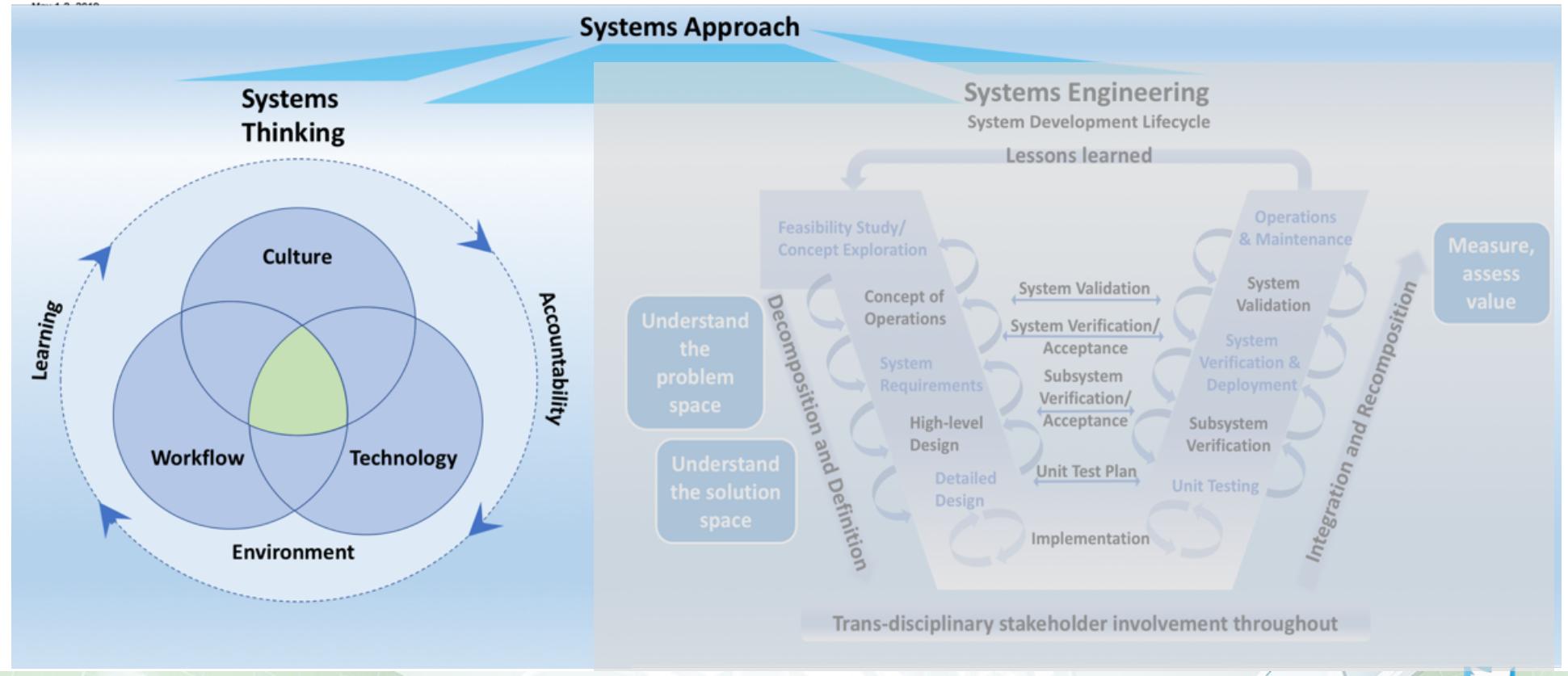
Healthcare System Costs Causal Effects

Systems Thinking Perspective (Notional)

Streamline Administrative costs
- Shift to electronic transactions
- Implement common terms, approaches for insurance billing
- Standardize claims forms and review processes

Prevent Avoidable Hospital Admissions
- Improve care coordination
- Better manage chronic diseases
- Provide palliative and hospice care

Prevent Medical Errors
- Full reporting of medical errors
- Provide tools to hospital leaders

Improve Hospital Efficiency
- Find and eliminate sources of waste
- Promote cooperation among units/departments

Improve targeting of costly services
- Decrease Costs of Episodes of Care
- Increase Shared Decision Making

Improve Hospital Efficiency
- Find and eliminate sources of waste
- Promote cooperation among units/departments

Prevent Avoidable Hospital Readmissions
- Provide community and support services to patients leaving hospital
- Create a culture of continuous improvement
- Provide economic incentives to providers, hospitals

Source: http://www.emeraldinsight.com/content_images/fig/0240221103003.png

Systems Approach
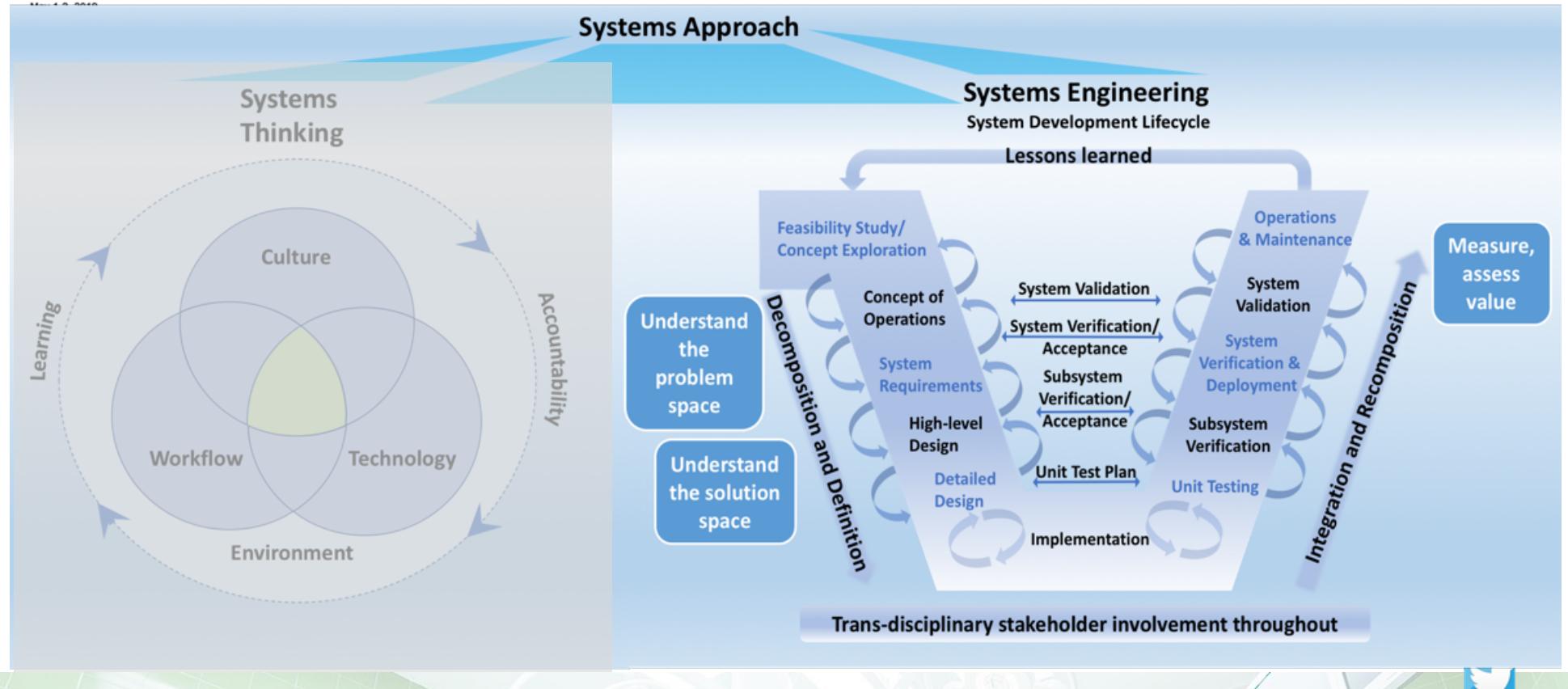
Culture, Lexicon, Transdisciplinary Teams

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Hexagon diagram labeled "Integrated Team" surrounded by: Systems Eng., Patients, Clinicians, Informatics, Computer Science, Palliative Care, Business/Economics, Psychology, Law, Physical Therapy, Pastoral Care, Ethics, Anthropology, Human Factors Eng.

- **Challenges**
  - Diverse educational background
  - Different value propositions
  - Varying terminology
  - Engineers who think they understand healthcare
  - Clinicians who think they knew systems engineering

- **Approaches**
  - Shadow healthcare professionals
  - Be less rigid in language used
  - Identify individuals who can "bridge the divide" between healthcare and engineering
  - Stay focused on addressing project objective(s)
  - Engineers know they have done their job when healthcare professionals actively speak as if the solution is theirs

Success, but not scalable
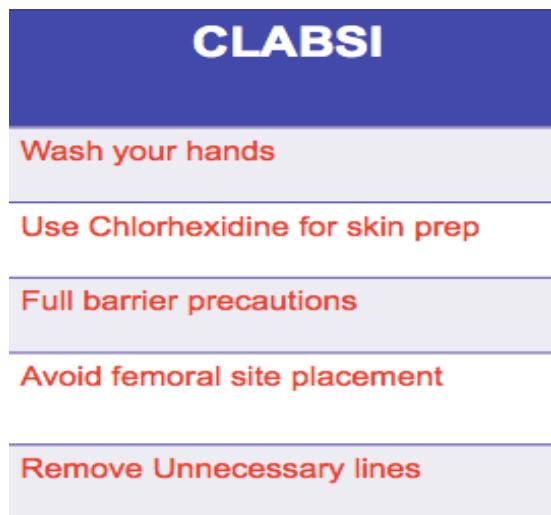
**ICU CLABSI Rates per 1000 catheter
days in US**

CLABSI

Wash your hands

Use Chlorhexidine for skin prep

Full barrier precautions

Avoid femoral site placement

Remove Unnecessary lines
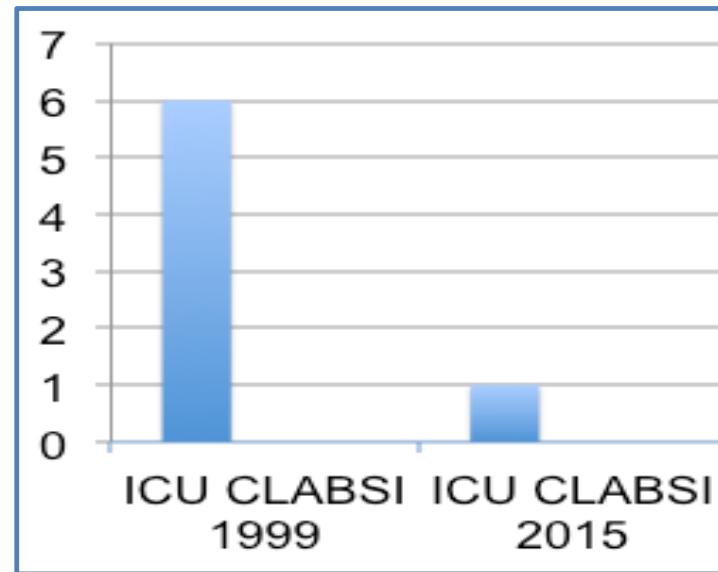
CLABSI Checklist: highly successful *but not scalable to multiple harms*

Current Approach to Manage the Challenge

Challenge: data and workload overload
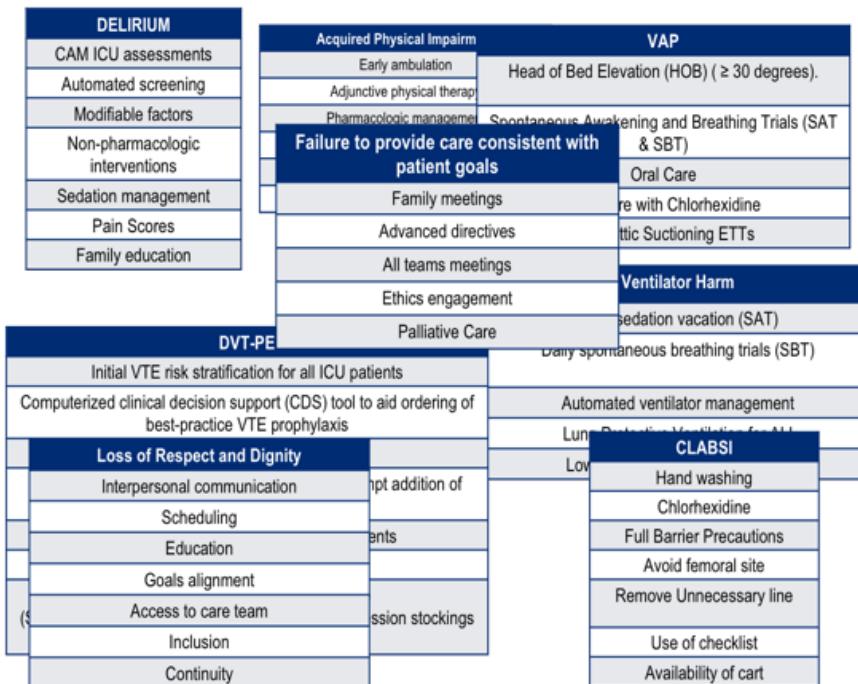
Current approach: culture, workflows, health IT

DELIRIUM
CAM ICU assessments
Automated screening
Modifiable factors
Non-pharmacologic interventions
Sedation management
Pain Scores
Family education

Acquired Physical Impairm	VAP
Early ambulation	Head of Bed Elevation (HOB) (≥ 30 degrees).
Adjunctive physical therap	
Pharmacologic managemen	Spontaneous Awakening and Breathing Trials (SAT & SBT)
	Oral Care
	re with Chlorhexidine
	ttic Suctioning ETTs

Failure to provide care consistent with patient goals
Family meetings
Advanced directives
All teams meetings
Ethics engagement
Palliative Care

Ventilator Harm
sedation vacation (SAT)
Daily spontaneous breathing trials (SBT)
Automated ventilator management
Lung
Lov

DVT-PE
Initial VTE risk stratification for all ICU patients
Computerized clinical decision support (CDS) tool to aid ordering of best-practice VTE prophylaxis

Loss of Respect and Dignity
Interpersonal communication
Scheduling
Education
Goals alignment
Access to care team
Inclusion
Continuity

| CLABSI |
|---|
| Hand washing |
| Chlorhexidine |
| Full Barrier Precautions |
| Avoid femoral site |
| Remove Unnecessary line |
| Use of checklist |
| Availability of cart |

The Emerge Vision

Project Emerge (Sponsor: Gordon and Betty Moore Foundation)

Partner with patients, their loved ones and others to eliminate preventable harm, optimize patient outcomes and experience, and reduce waste in health care delivery.

Develop a solution that eliminates (7) harms using a systems approach:

1. Loss of respect and dignity
2. Failure to provide care consistent with patient goals
3. Delirium
4. Acquired physical impairment
5. Ventilator-associated infections and harms
6. VTE
7. CLABSI
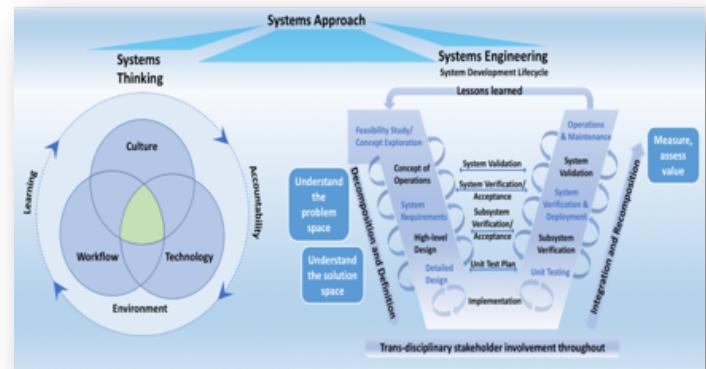
Original Conceptual Discussions

Concept of Operations (CONOPS)

- **Understand the as-is current state**
  - **What works well with our capabilities today?**
  - **What gaps exist in our capabilities today?**
  - **Who is affected by these gaps that exist today?**
  - **How may we <u>retain the capabilities that work well while addressing the gaps that exist</u>?**

CONOPS
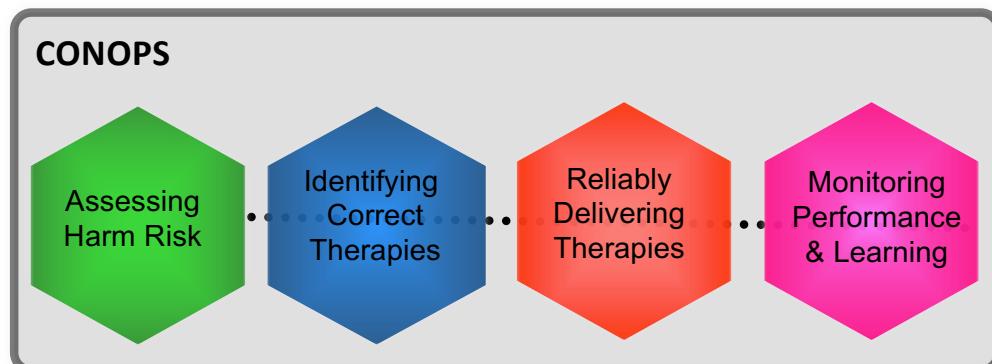
- **Start with the end in mind – independent of a specific implementation:**
  - **Why: do we lack what the system will ultimately provide?**
  - **Who: are the stakeholders involved with the system?**
  - **What: are the known elements and high-level capabilities of the system?**
  - **What: are physical, technical, policy, financial, etc. constraints bound the system?**
  - **When: is the system needed?**
  - **How: will we design, build, and test the system?**

  o Forces problem definition and project objectives
  o Clear vision of the current and future states
  o Team's "north star"
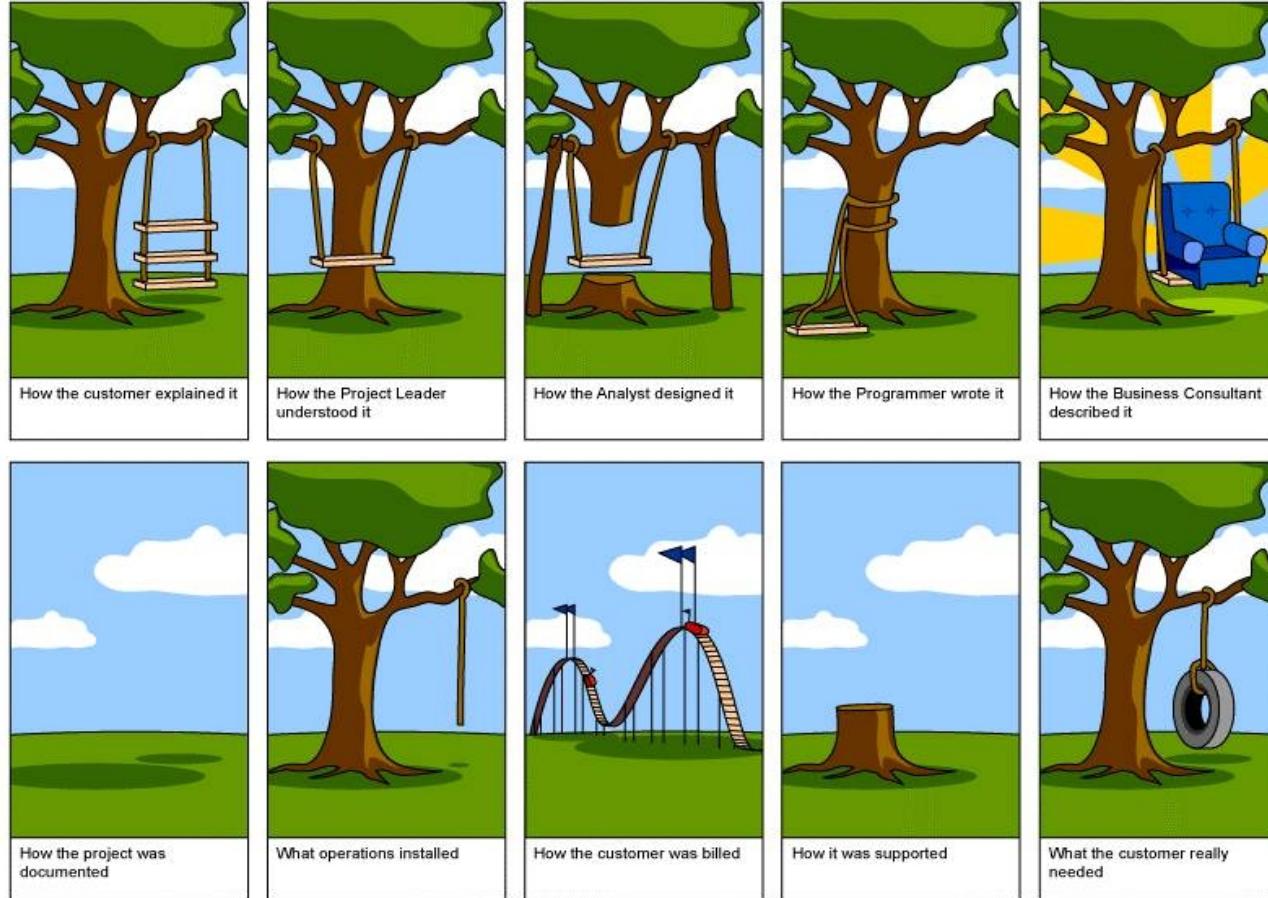
Engineering Discipline Applied to Care Delivery

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CONOPS: understating the as-is state & envisioning the future state independent of a specific solution

For Each Harm:

| Delirium | DVT/PE | VAIH | API | CLABSI | Loss of Respect/Dignity | Failure to Provide Care Consistent w. Goals |

Specify:

| Who | What | When | Where | How you do it today | How do we ensure you are competent to perform this? | How do you want to do it in the new system? | Compliance Criteria | Data |
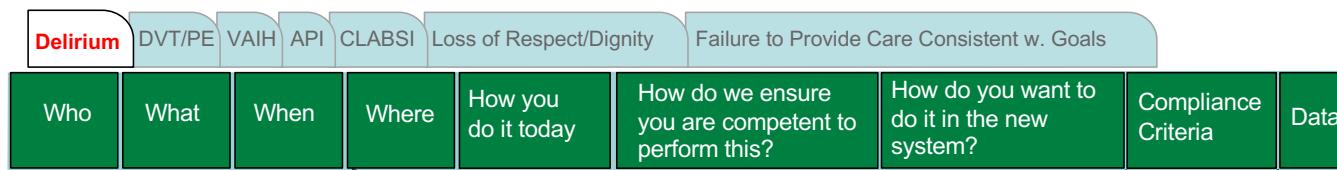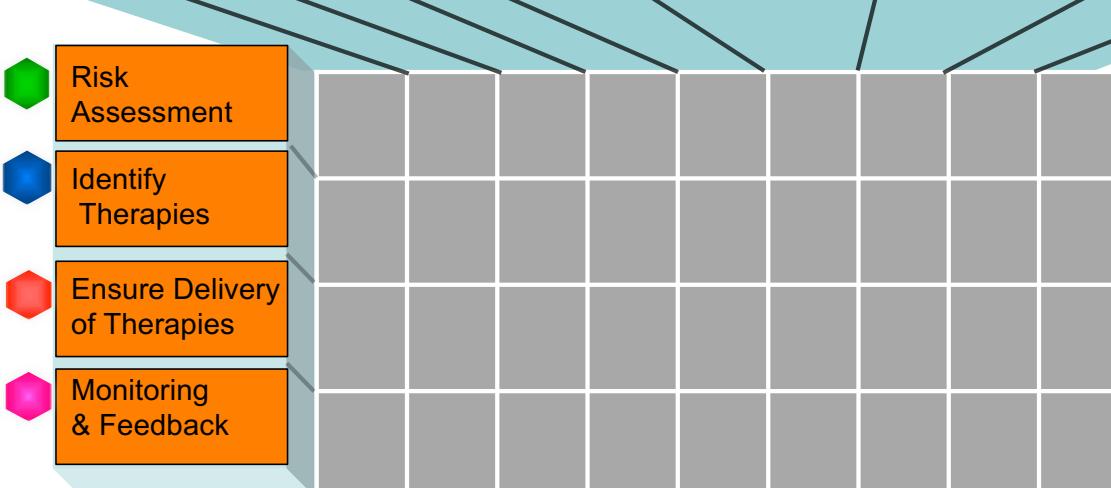
Across each stage of the CONOPS model:

- Risk Assessment
- Identify Therapies
- Ensure Delivery of Therapies
- Monitoring & Feedback

Emerge Operational View

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- Structured and methodical means for **capturing knowledge** to be **shared** among the team

- Research prototype

- Data sources:
  - Electronic medical record
  - Patient, family
  - Clinical team

- If required data isn't readily available, implement solution that doesn't require additional work
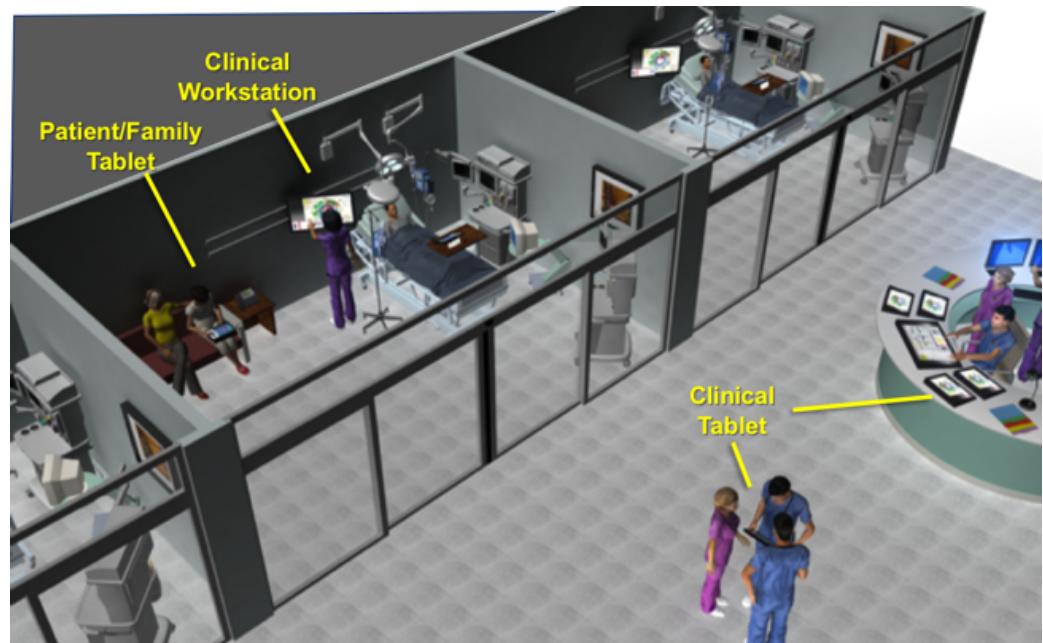
Using technology to decrease the distance between providers and patients, and improve the quality of care.

Clinical View

Detailed Patient Specific View →

← Aggregated Unit View

*Unit views*   *Harms monitor*   *Condition specific displays*

- Visual signals & data help care teams assess & respond to care needs

- Links to the patient/family tablet spark point-of-care dialogs

- Part of a suite of tools, including sensor integration

Condition Specific Display
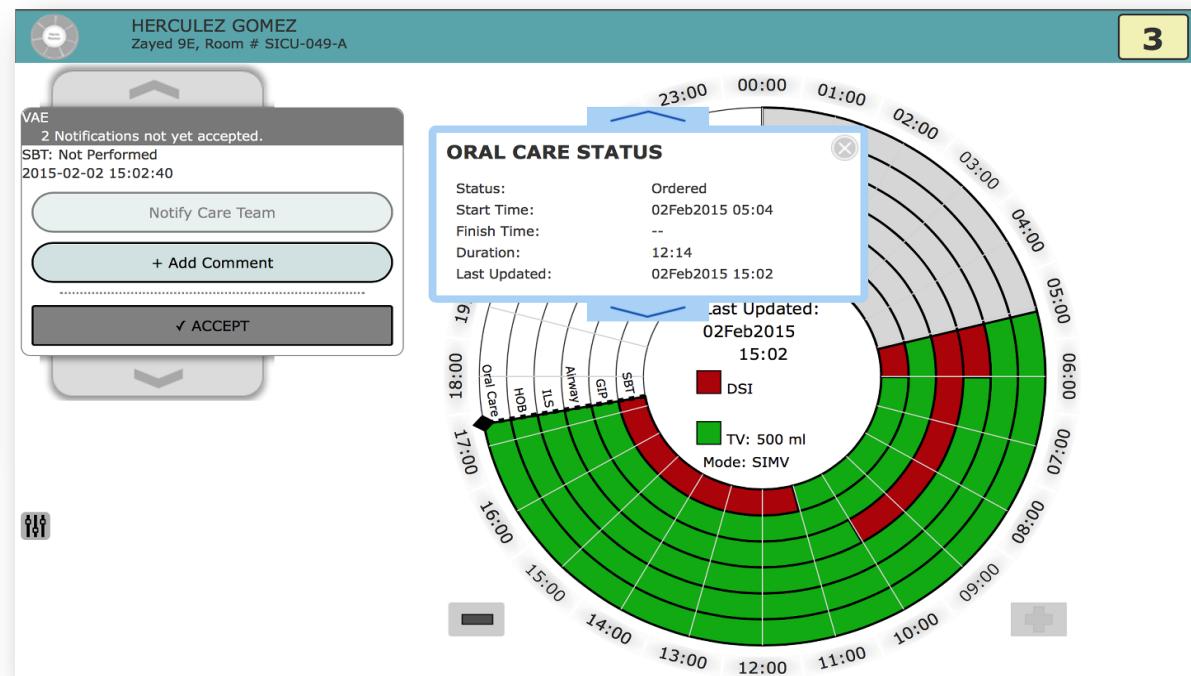
Patient/Family View
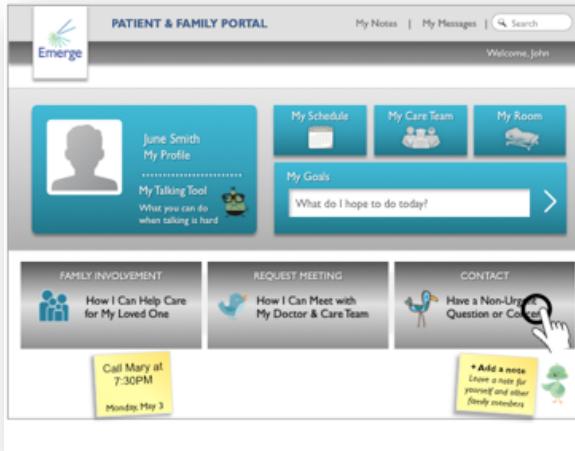
- Personalization options
- Education tools
- Scheduling tools
- Family Involvement Menu
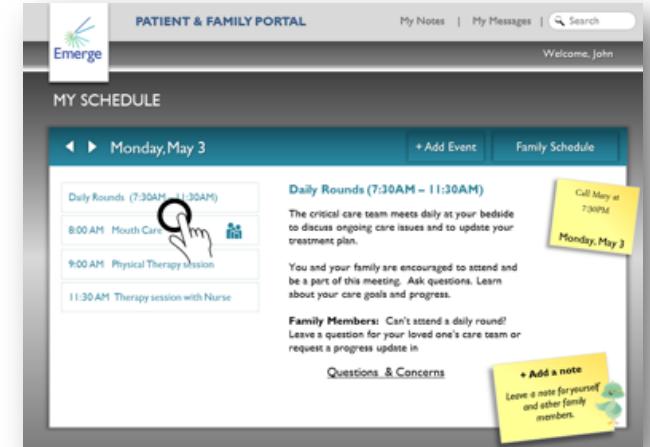
Sensor Integration

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Ambulation
sensor added
to wheel
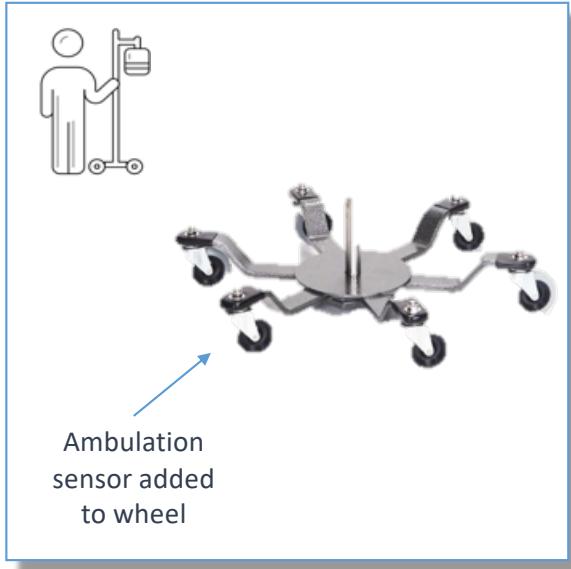
- ❑ Types
  - ❑ Ambulation sensor
  - ❑ Cyclometer
  - ❑ Hand grip dynamometer
  - ❑ Angle of the head-of-the-bed sensor
- ❑ Constraints
  - ❑ Limited/no additional data entry
- ❑ Challenges
  - ❑ Patient condition
  - ❑ Proprietary data

Tools of Systems Engineering Applied to Healthcare

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- Numerous approaches – never one size fits all and often more than one approach needed
    - Systems Thinking tools (Design Thinking, Soft Systems Methodology, etc.) and Systems Engineering tools (e.g. QFD, N-squared, etc.)

- Judge how much non-engineers need to know about technical aspects of systems engineering – make the effort "approachable"

- Remaining agnostic to specific solution can be a challenge for many non-systems engineers
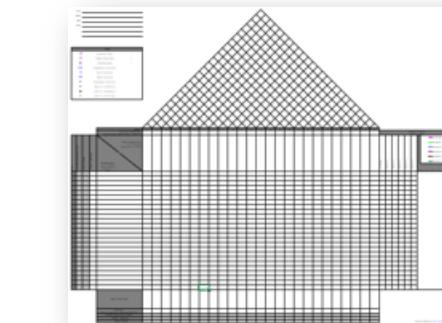
QFD
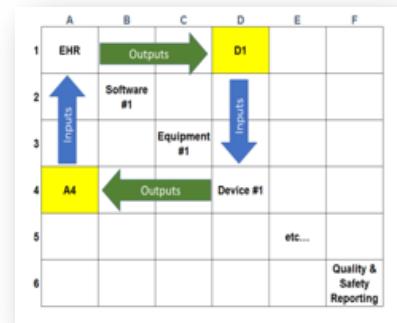
N-squared
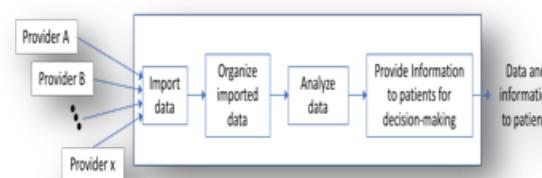
Context Diagram

Test & Evaluation

Tools keep focus on holistic, rather than reductionist perspectives

AHRQ P30 – Patient Safety Learning Lab

Developing Concept of Operations (CONOPS) for the Harm Free ICU

Demonstrating Potential for Clinical Improvement Through Device Interoperability

Measuring System Stress To Reduce Harm and Improve Performance in an ICU
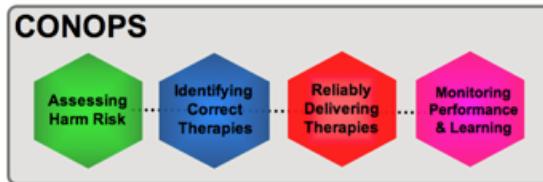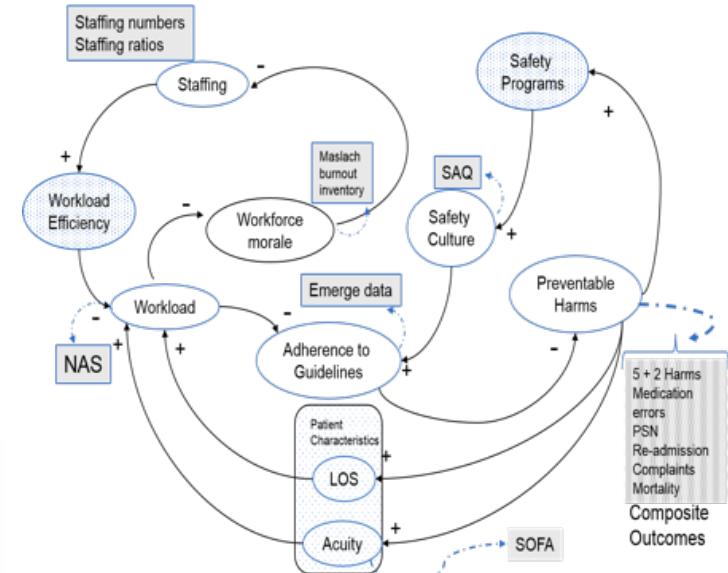
- **Scalable, modular, and generalizable model**
- **Design to eliminate harms, build to be usable**
- **Founded on sound engineering model yet based in language all disciplines can understand**

Some Lessons Learned

- Front-line provider & patient/family involvement early and throughout

- Language/communication

- Respective value propositions

- Scope control

- IT integration challenges

- Training roll out

- Transition from lab to operational setting

- Open interfaces to promote further innovation

- Timeline to achieve outcomes

Situational Awareness Tools
Visualization
Communication
Outcomes Analysis

Integrated Database
Business Logic
Data integration

Disparate Data Source Interfaces
Sensor Suite
Patient/Family Tools
Clinical Tools
Electronic Health Record

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Summary

- Healthcare approach to innovation stems from medicine's hypothesis-driven approach to discovery
  - Serves the field well for understanding first-principles associated determinants of health and illness
  - Does not translate well into the conception, design, development, and fielding of processes, workflow, or technology development that leverage understanding of those health determinants
  - Time for a different approach that can spur the transformation in health needed to yield improved safety, affordability, access, and value

- Critical to define (a) the problem to be solved or opportunity to capitalize upon and (b) the stakeholders involved
  - Human nature tends to leap toward solutions without fully understanding the objective

- Technology is not a panacea
  - Systems Engineers must be disciplined: do not prioritize technology over people

Create a new generation of engineers and healthcare professionals that understand enough of the culture, terminology, and disciplines of both systems engineering and healthcare to lead the way in bringing about revolutionary change

Acknowledgements

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[2]Johns Hopkins Medicine
[3]Greater Baltimore Medical Center
[4]Johns Hopkins Applied Physics Laboratory

Thank you for attending!
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