2018 Annual INCOSE
Great Lakes Regional Conference
SYSTEMS AT THE CROSSROADS
17 - 20 October 2018 | Indianapolis, Indiana

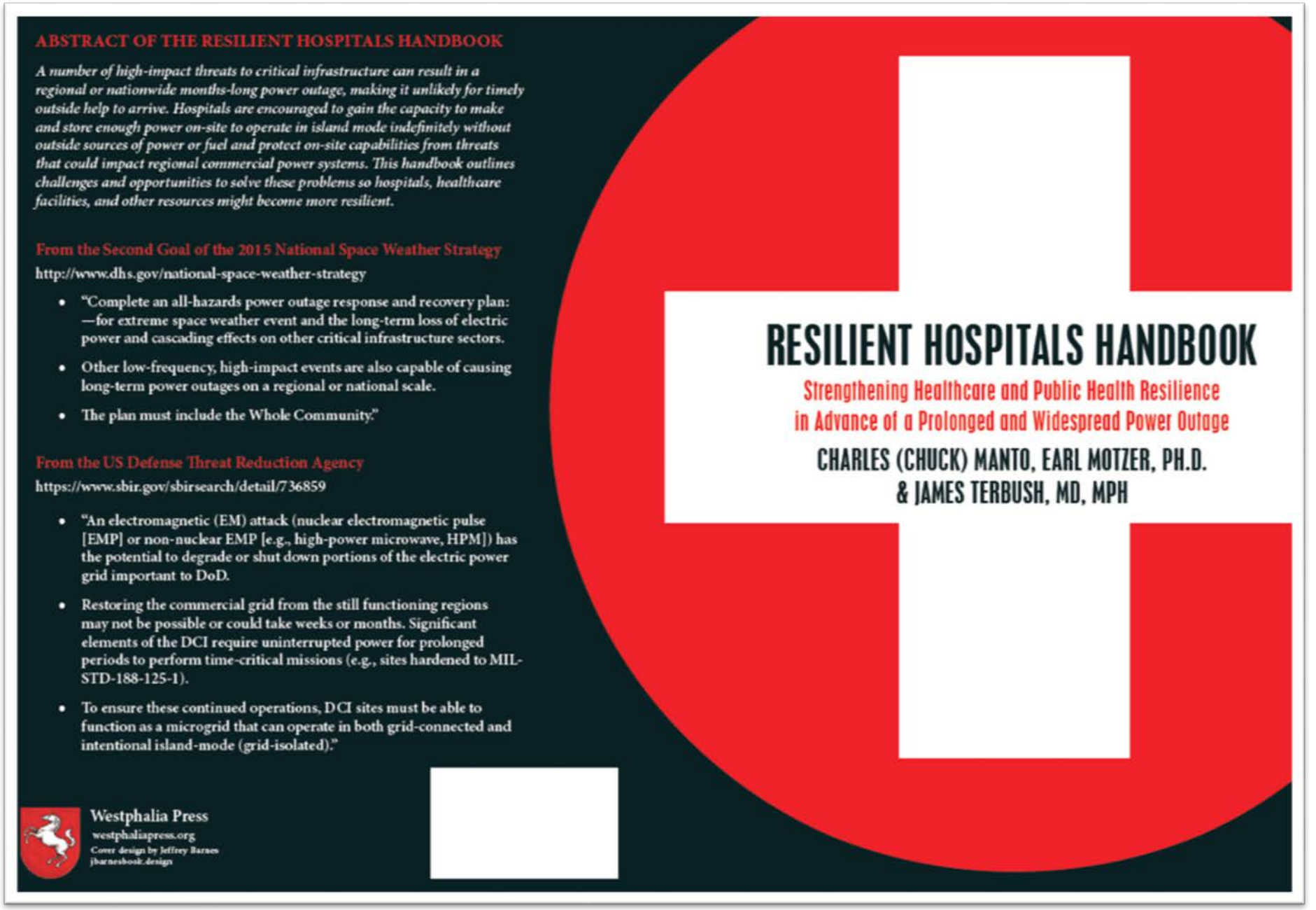
A Panel Session with Mike Pafford, Steve Pappas and Ajay Thukral

Moderator: Jack Stein

MBSE and Resilient Hospitals

Agenda

• Opening Remarks	J. Stein	5m
• Need for Resilient Hospitals	S. Pappas	15m
• Current Activities / Concepts	M. Pafford	15m
• Healthcare and Modeling	A. Thukral	15m
• Open Discussion and Q&A	All	30m
• Wrap-Up Final Remarks	Panelists	5m



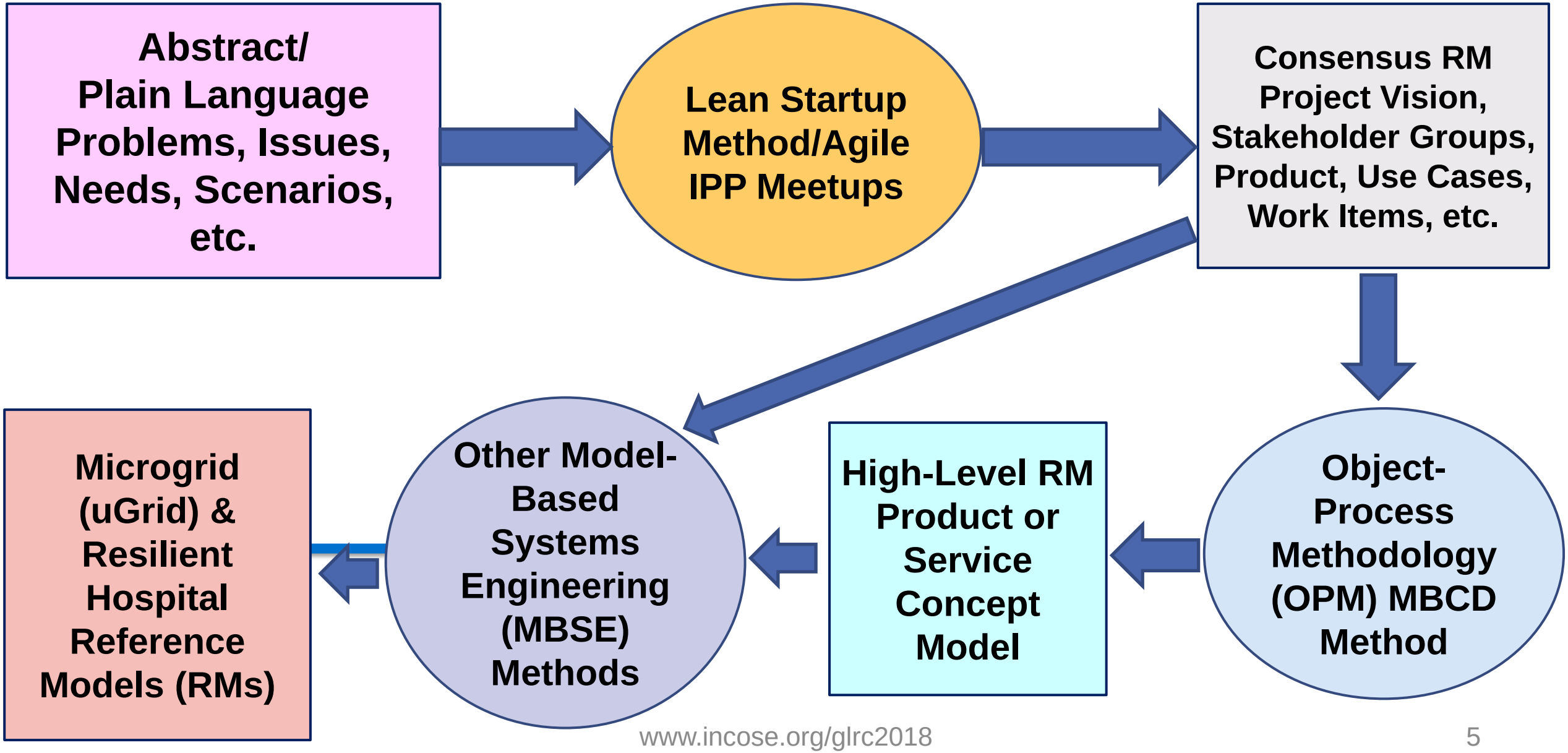
Available on Amazon

www.amazon.com/Resilient-Hospitals-Handbook-Strengthening-Healthcare/dp/1633916006

Panel: MBSE and Resilient Hospitals

Current Activities / Concepts

Roadmap: uGrid & Resilient Hospital Reference Models Projects



MBSE and Resilient Hospitals

…what if infrastructure is compromised/challenged

Ajay Thukral
Cientive Group Incorporated
Oct 17-20
Indianapolis

MODEL BASED SYSTEMS ENGINEERING

Healthcare Working Group - Vision

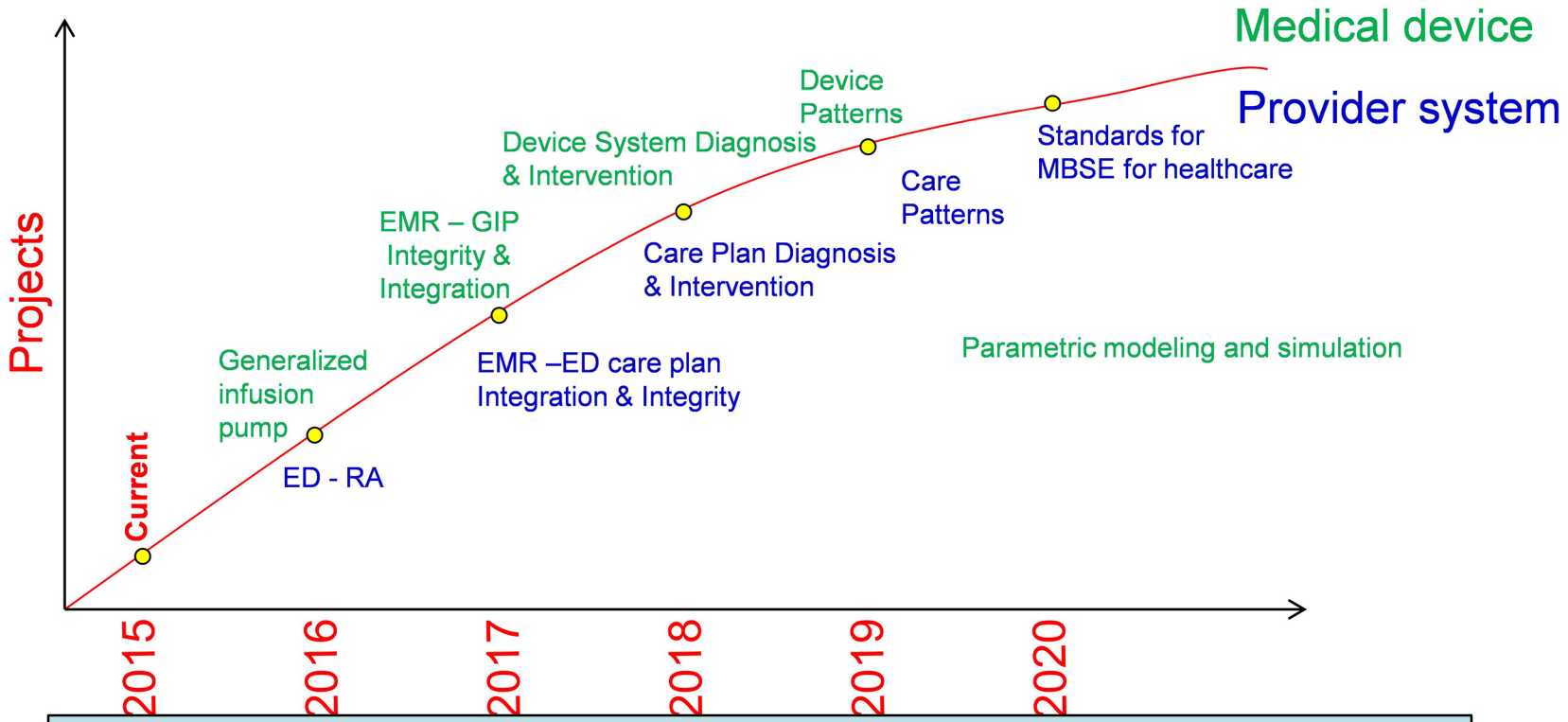
- **Engage** medical practitioners, hospital managers and device manufacturers create an integrated care delivery system that operates seamlessly and flawlessly.
- Goal is to **develop**, **build** and **advance** SE capabilities through **case studies** the application of systems methods within healthcare and medical device industry.
- Using model based system tools to engage health care professionals and medical device developers to create **best practices**, **forum for collaboration** and **resource for system modelers**.

Healthcare Working Group/Challenge Team

- Medical device developers
  - Promote and establish MBSE as the *key methodology for effective & efficient delivery* of medical devices
    - Provide device developers with opportunity to learn by **medical device specific development models** for medical devices
    - Benefit team members and collaborators by developing **best practices** for employing MBSE for risk analysis, risk management, compliance verification, etc.
- Healthcare administrators and providers
  - Lead/foster the development of MBSE applications to *healthcare provider process improvement*
    - Provide team members with the opportunity to **collaborate** with care provider organizations and SMEs
    - Lead the collaboration with stakeholders to define the **value proposition** of MBSE to care provider organizations
    - Provide collaborators with **case studies** that show the utility of MBSE for care provider **process improvement** and **patient outcome improvement**

HWG- High Level Strategic Path

- Parallel advancement of the MBSE state of practice for both stakeholders medical device and healthcare provider



A progression of increasingly sophisticated examples that enable team member learning and provide collaborators with improved understanding of MBSE methods and benefits

Accomplishments

Contact:
Chris Unger: Christopher.Unger@med.ge.com
Bob Malins: rjmalins@eaglesummittech.com
Ajay Thukal: ajay.thukral@cientivegroup.com

- Medical Device Developers
  - Pre-2014: demonstrate MBSE
    - Infusion pump MBSE reference model
  - 2014: use cases for MBSE in device development
    - Use MBSE to structure the risk management process
  - 2015: use case for MBSE in compliance
    - MBSE representation of compliance req'ts and verification
  - 2016: Generalized MBSE (device intended use environment)
    - General practice for device developers to employ MBSE for both device design and characterizing intended use environment
  - 2017: MBSE for device interoperability with EMR
    - Leverage care organization model to define approach for capturing interoperability req'ts at device level
- Healthcare administrators and providers
  - Pre-2015: assessment & brainstorming
    - Evaluation of PCAST report & it's significance
  - 2015: initial outreach to stakeholders & users
    - IW2015 workshop with stakeholders & potential partners
    - White papers and presentations (GLRC9)
  - 2016: focused efforts to get stakeholder needs
    - IW2016 workshop on SE/MBSE for emergency department
    - AAMI-INCOSE East workshop on operating room/acute care
  - 2017: demonstration of reference architecture (RA)
    - Lead/promote example reference architecture at the hospital department level

APPLIED MBSE – HOSPITAL RESILIENCE

Model Based Approach

- Purpose/utility of model has to be clear
  - All models are **wrong** but some are **useful** (Box 1978)
  - … models are about the real world **…and not real world**
  - Models should help support, analyze, conjecture real system possibilities
- Models represent, quantify, assess as a surrogate to the real system of interest
  - Utility ➔ predict, estimate, assess, analyze, conjecture
  - Construction ➔ Depth, fidelity, graphical, mathematical, prototype, scale
- **Modeling Continuum**
  - Reference Architecture: Construct domain, vocabulary, semantic representations/views and concepts that are used in synthesis and evolution of design & trade analysis
  - Transformation of Concepts: Physical laws, science, math, infrastructure (People, Process, Products) into analytical/computational models
  - Design & Analysis: explore what if's, decision basis…

Resilient Healthcare Features

- **Resilient Healthcare & Public Health Sector**: Ability to provide and maintain life critical care for sustained period of time under failed/imminent failure of key support infrastructure
- Features of Resilient Health system
  - Protect life
  - Sustain life
  - Maintain habitable state
  - Provide fail safe/alternate solutions for critical infrastructure
- HILF events

http://www.sjgeneral.org/servicesnicumain.html

Report –Resilient Hospitals Handb

Infrastructure

water

medicine

power

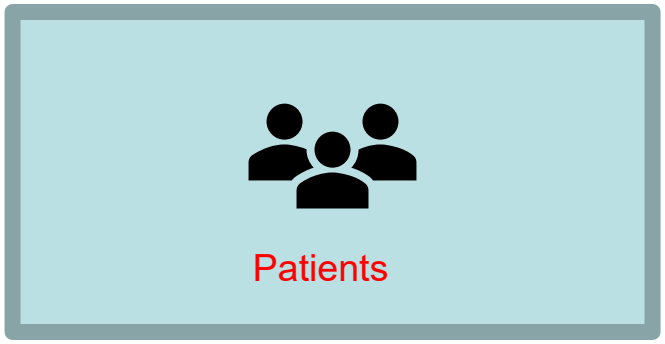
Access to hospital

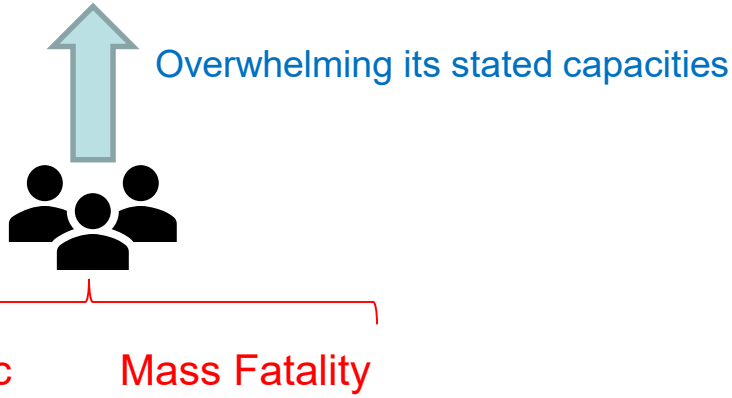
Internet/intranet

Care provider/Professionals

Data repositories

Critical to delivering care and ensuring patient health





System operates under sub optimal conditions

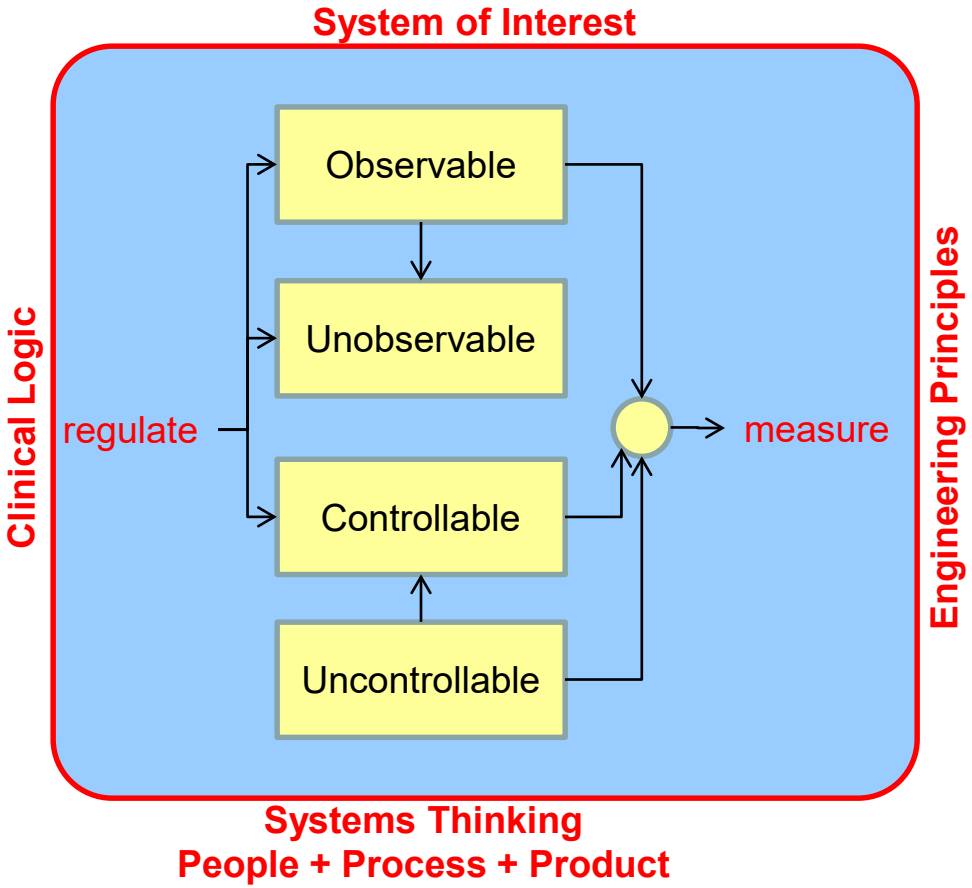
cientivegroup
Digital Intelligence for a Data-Filled World

Model Resilience - 1

- Stability: Restoring forces to regain equilibrium; maintenance and regulation of the stability and constancy needed to function properly, regulate a desired state of function

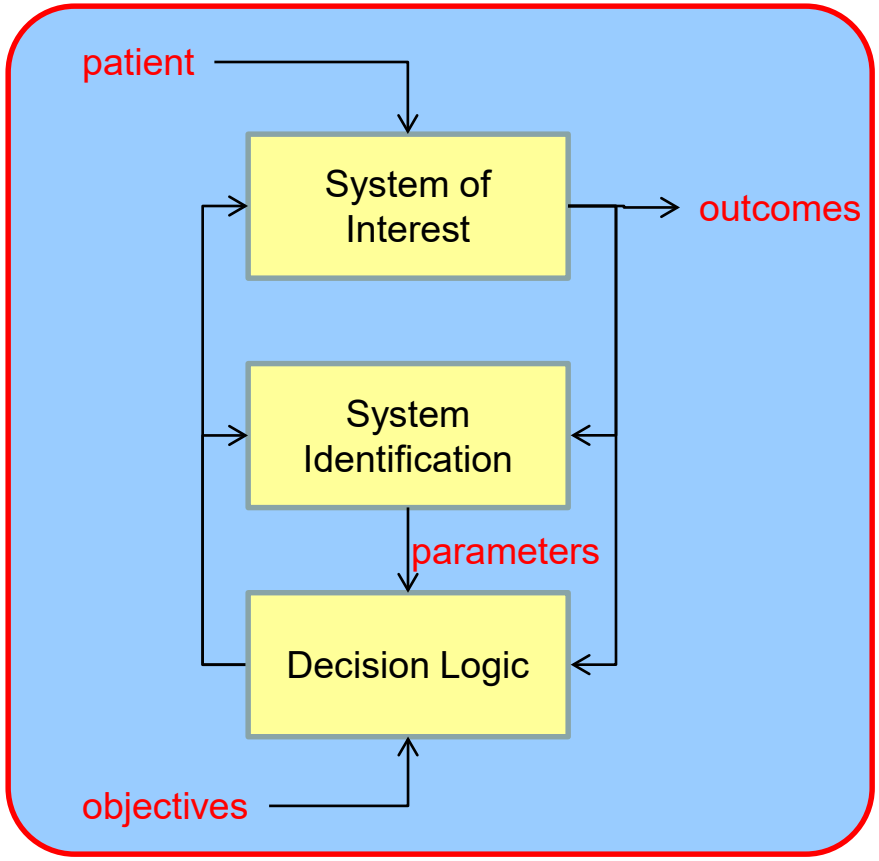
Model Resilience - 2

- Measure & Regulate
  - Need to **appreciate** that there are components within the system that cannot be controlled and cannot be observed
    - To address resilience ➔ Need to Manage the unobservable & uncontrollable when it occurs
  - To regulate
    - Measurement
    - Decision
    - Actuate/Dispense Care



Model Resilience - 3

- Model Utility
  - Represent
  - Quantify
  - Assess
  - Predict
  - Estimate



Dependency of Health Support System

- Collapse of critical infrastructure & its impact
- Model the impact on a patient if the sophisticated care environment functionality were interrupted for unknown duration of time

Room weather control system
- Air-condition unit
- air, ambient temp, humidity
- Positive air flow, filters – cross contamination

Illumination
Light -visibility

Water
- Hygiene
- Drinking water

Information system
- Who
- What
- When (time, duration)

Treatment:(Rx)
- Plan
- Drug
- Care services

Monitors

Diet
- Uncontaminated food
- Unperishable food

Care providers
- Physician
- nurse

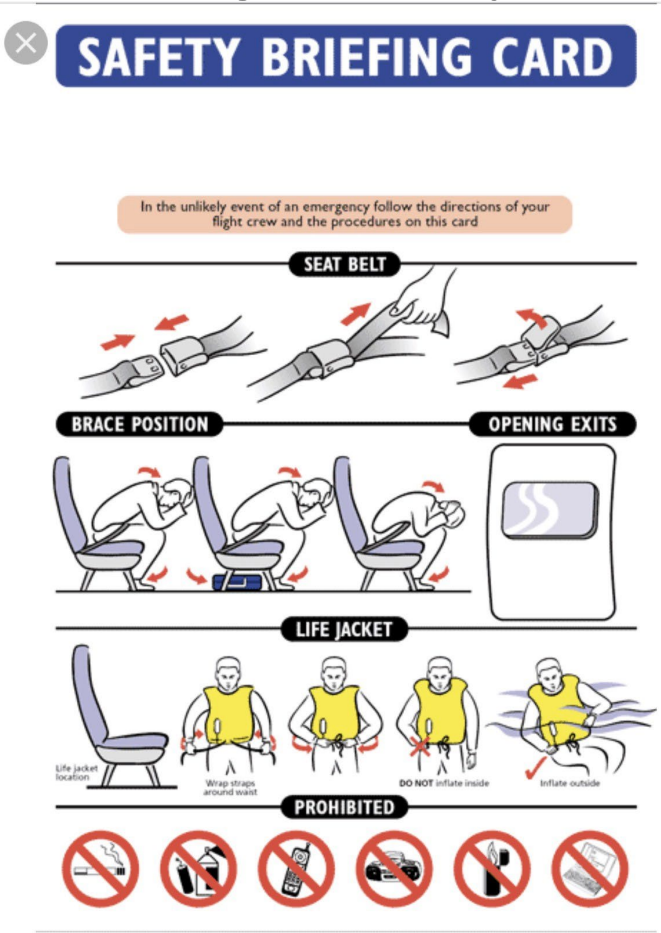
Power
- Life support system
- Automation

PA System & other auditory & visual alerts/warnings
- Will they work
- Will they assist
- Will they interfere

Hospital beds
- Care assist
- Automated devices in various state of operation

Empowering Patients/Local Public

- Passenger Safety



- If infrastructure is temporarily crippled – able patients can be part of safety net
  - Prescription format
  - Medication location
  - Prepare whom
    - First responders
    - Staff
    - Patient
  - Emergency route

MBSE & Resilient Hospitals

- How does the SOI operate in short-term and long term if a certain support system has failed/is functioning sub-normally
- System Driven Model based approach
  - Define Resilience
  - Understand unobservable and uncontrollable entities
  - Unravel system dependency/failures
  - Define what is achievable when a system fails
  - Remove or ensure when systems fail
  - Analyze solutions
  - Define outcomes
  - Simulate outcomes
  - Strategize solutions

Incorporating Resilience

- Technical products and solutions when they do not operate can hamper and pose risk to human well-being
- Technology X when it fails/stops functioning it shall do so gracefully (stable solution) :
  - Technology X solves Problem A
  - Non-availability of Technology X means Problem A reveals itself
- Employ models for life-critical system assessment, stability analysis, observability and controllability attributes
- Address the technology bias - At the end of the day technology is a tool while the real environment is what each living entity depends upon for its proper functioning and surviving.

Bio

- Dr. Ajay Thukral is currently working with Cientive Group as CTO. He has more than 16+ years of experience in diabetes developing a high performing and safe diabetes management product and health care delivery models. Dr. Thukral is also serving as an adjunct faculty at IUPUI, teaching at ME department. His main research interest is developing model driven solutions integrating tools across the products lifecycle. In conjunction with IPLI, Cientive is working to build an integrated modeling ecosystem for instruction and research.
- Dr. Thukral is a former R&D mathematical and modeling specialist at Roche. He had the opportunity of applying modeling and simulation skills in the diabetes area and provide several innovative ideas built around the use of models – such as prediction, safety assessment, risk assessment, fail safe features, and use of models during animal and clinical studies. He was the key designer and implementer of building a hybrid simulation environment for virtual testing of implemented system that was integrated with the actual clinical operations. Dr. Thukral has built hybrid simulation platform covering animal and clinical trial for developing and implementing fully closed and semi-closed glucose regulation, algorithm testing framework for demonstrating treatment performance and patient safety and systems approach. The modeling and analysis work includes physiological modeling, PK-PD modeling, and specification for monitoring and treating diabetes. Some of noteworthy analytical work includes predict surrogate marker for overall glucose management and modeling patient lifestyle. He is an inventor on many patents.
- On software application development side, Dr. Thukral has over 18 years of experience includes – software application development, modeling physiological and electro-mechanical systems, patient modeling, simulation and controller design.
- Additionally, his research work in Handing Qualities of aircraft and fundamental work in controlling highly maneuverable missile resulted in several journals and NATO-AGARD publications.

ajay.thukral@cientivegroup.com
(317) 258-8219

cientivegroup
Digital Intelligence for a Data-Filled World

MBSE and Resilient Hospitals

Panelists

Mike Pafford

Steve Pappas

Ajay Thukral

Moderator: Jack Stein

OPEN DISCUSSION

and

Q&A

MBSE and Resilient Hospitals

Panelists

Mike Pafford

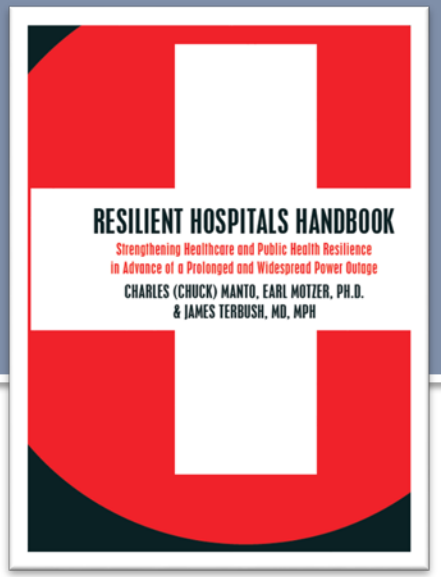
Steve Pappas

Ajay Thukral

Moderator: Jack Stein

THANK YOU !!

Handbooks:



2018 Annual INCOSE
Great Lakes Regional Conference
SYSTEMS AT THE CROSSROADS
17 - 20 October 2018 | Indianapolis, Indiana

www.incose.org/glrc2018