



Simulating Health Care Value Streams

Hugh McManus
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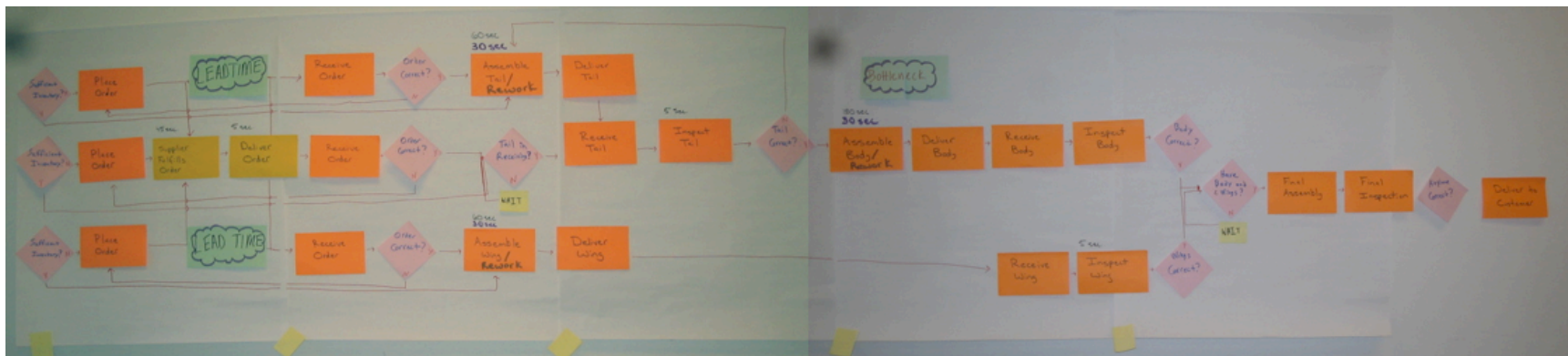
Why use simulations?

- **Increased comprehension of the curriculum**
 - Controlled studies show increased comprehension using “games” vs. lectures or static web-based learning
 - Controlled studies also show improved outcomes measured by behavior
- **Better understanding of context and holistic, system-spanning nature of lean changes**
- **Learning through experience - a practice field for lean change**
 - Supported as *goals*, improved outcomes unproven
- **Increase student involvement and excitement**
 - Observed!

Teaching lean is hard – simulations help

Simulating Processes

- **Lean works on Processes**
 - So this is what we need to simulate
- **Processes have**
 - Material and Information they operate on
 - Times, rates, and/or capacities
 - Variations, branching flow, rework
 - Interactions





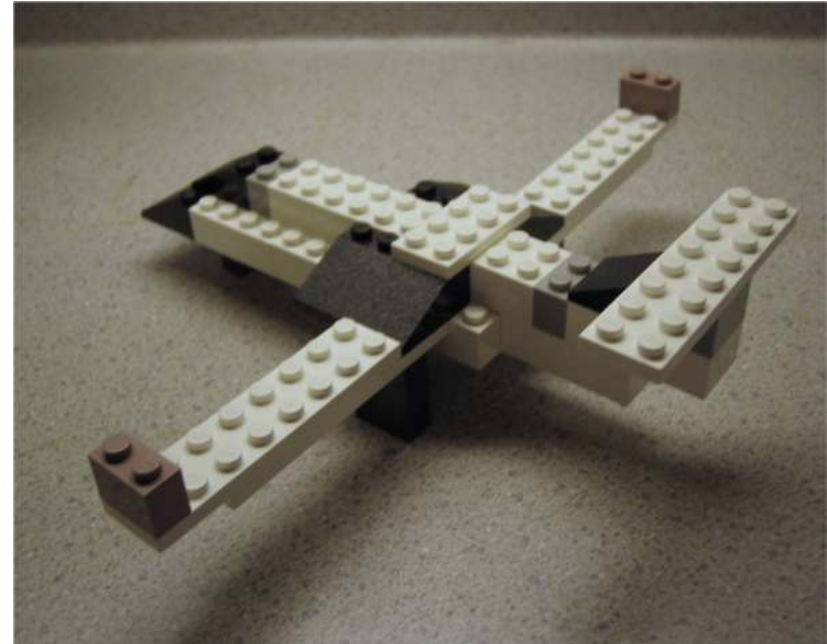
Understood Value Streams and associated lessons

- **Manufacturing**
 - Standardize path and eliminate rework and variations
 - Balance line and inventory to achieve Takt, flow and pull
- **Engineering and Product Development**
 - Eliminate *unplanned* rework and *avoidable* variation
 - Plan capacity to achieve “psuedo-Takt”, flow and pull
- **Supply chains**
 - Standardization, Communication and Coordination
- **Enterprise**
 - Synchronize many inhomogeneous value streams

All need to adapt to changing environments

Manufacturing Sim: Build Lego Airplane

- **Lego aircraft starts as a non-lean product**
 - Excessive part count
 - Too many part types
 - Weak tail
- **Built in a non-lean way**
 - Unbalanced production system (bottlenecks, unused capacity)
 - Long supply chain
 - Excessive paperwork
 - Unclear communication
- **Apply lean tools**
- **People issues key!**



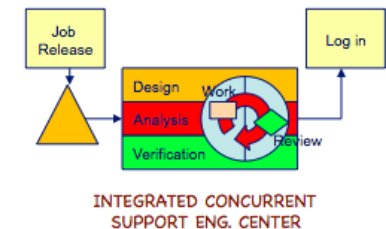
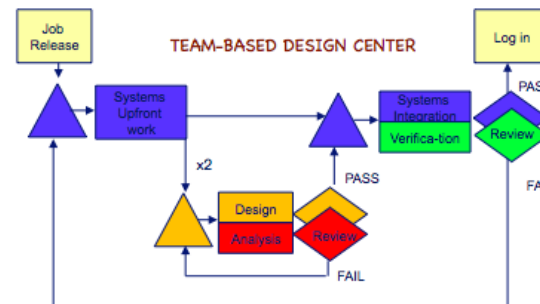
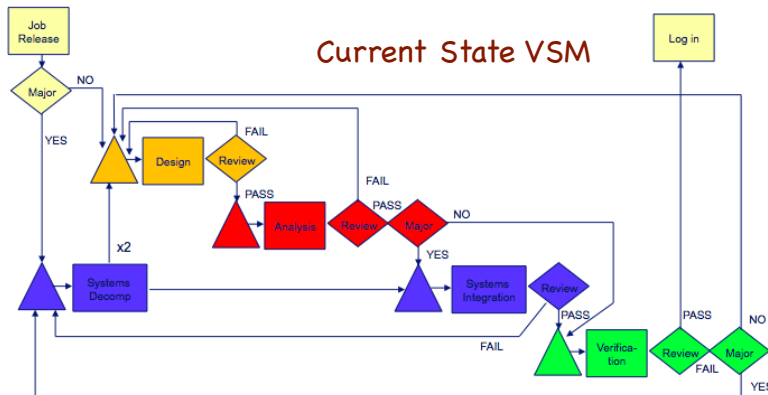
*Legos come together
to build aircraft*

Simulating PD Organizations: Passing paper “jobs”

- Complex VS must be uncovered; characterized by rework loops, branching paths, imbalances and variations
- Capacity matching, planned iterations, simplified flow illustrated
- Process design, humans-in-loop issues also explored

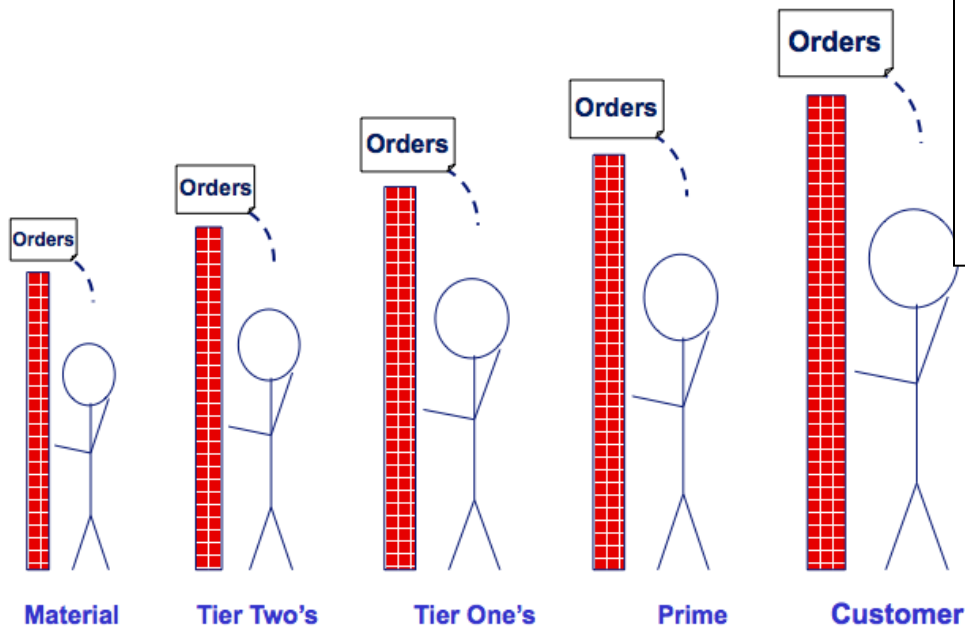
Major Job Func. B		Required to Return to Systems At least one Yellow Dot Followed by at least one Red Dot*		
Complexity	Serial Number	Time Released by Systems		
Major Job Func. A		Required to Return to Systems At least one Yellow Dot		
Major Job Systems Engineering		Required to Complete: Both Function Jobs done On this sheet At least one Blue Dot Followed by at least one Green Dot		
Minor Change Job		Required to finish: At least one Yellow Dot Followed by at least one Red Dot Followed by at least one Green Dot		
System De	Complexity	Serial Number	Time Issued	
Sign in Time RoundMin	2	4	1/3	
Sign in Time RoundMin	1/3	Process Dot	Pass Review? Y/N	Sign Out Time RoundMin
	1/3	●	y	1/5
System Int				Signature
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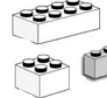


New Technology -2
Subtract two from dot count when doing reviews



Simulating Supply Chains


- Long, uncoordinated chain to supply lego parts
- Standardize, forecast, communicate, develop relations
- Kanban, JIT, Lego inventory management



Parts Order Form			Deliver to: A
Part Description			Quantity
Type	Color	Size	
	Light Grey	1x2	3
	Brown	1x2	2
	Sand Red	1x2	
	White	2x2	
	White	2x4	
	White	2x8	
	White	1x6	
	White	2x4	4
	White	2x8	
	Black	2x3	
	Black	4x3	

To be completed by supplier when order is fulfilled:

Total number of parts shipped:	9
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Fulfillment Receipt	
Delivered to:	A
Invoice amount: 45	Fulfilled by: J

Simulating Enterprises

Suppliers

Manufacturing

Customer Acceptance

- Link inhomogeneous parts
- Coordination, communication, relationships key
- Silo solutions don't work!

2nd Tier

1st Tier

Plant C

Plant B

Final Assembly

Design Change Request

Design

Analysis

Engineering

Verification

Service & Support

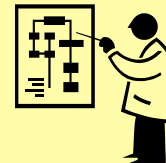
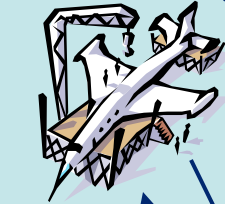
Design

Analysis

Design In/
Out Box

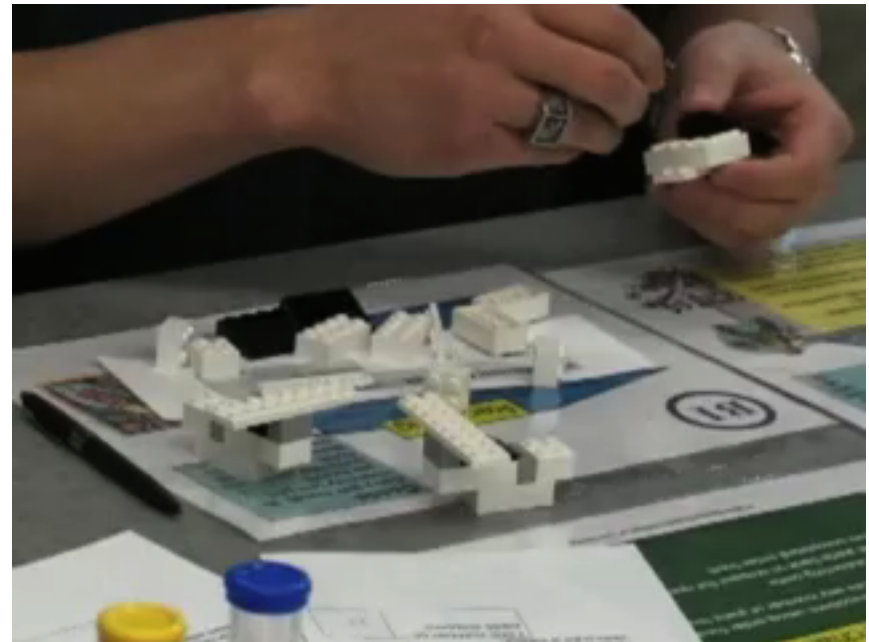
Systems Engineering

Full Enterprise



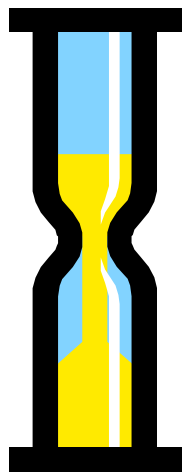
Simulation Toolkit






- **Build Lego airplanes**
 - **Treat Lego patients**
 - **Process paper orders**
 - **Complete paper “jobs”**
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- **Modular “process boxes” specify inputs, outputs, and transformation rules at each station**
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- **Paper “mats” are an easy and versatile way of specifying processes**



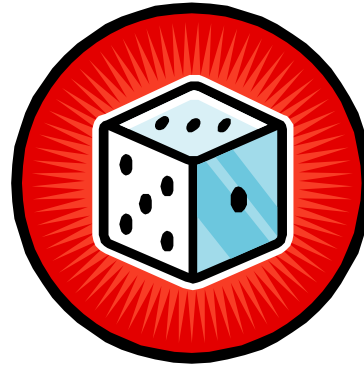
Timers Represent Process Times and Capacity

- Process proceeds by the pace of an hourglass (e.g. time depends on Lego part count)
- Prevents racing, dexterity contests
- Focuses attention on the *process*



Process Time			
Part Count	Hourglass		Sec
2-3			30
4-7			60
8-13			120
14-21			180

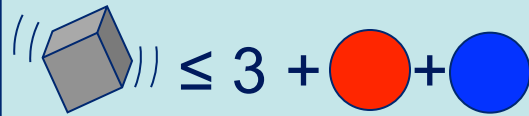
Dice Represent Process Variability



Variability can affect:





- **Process Quality (failure at review)**
- **Process Capacity (amount of work done)**
- **Process Time (which hourglass to use)**
- **Process Path (where does the work go next)**

Review



To pass, roll one die and score $\leq 3 + \text{number of red and blue dots on job}$

Process Time

Roll	Hourglass	Sec
1-2		30
3-4		60
5		120
6		180

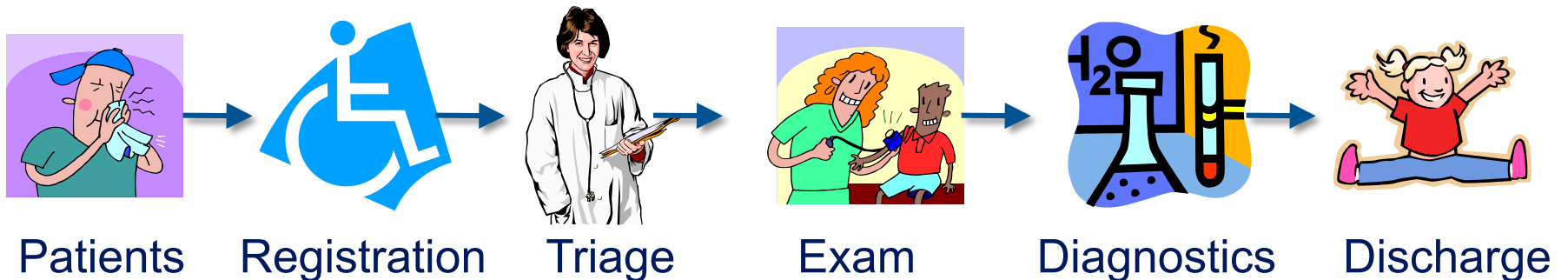
Example: Learning About Variation

- **The impact of variation on processes is a good subject for simulation**
 - Non-intuitive but simple
- **Simple dice game for experiential lesson in effects of variation on waiting times**
 - Computer simulation to rapidly show impact of process changes

$$WaitTime = \frac{u}{1-u} \cdot \left(CV_i^2 + CV_p^2 \right) / 2$$

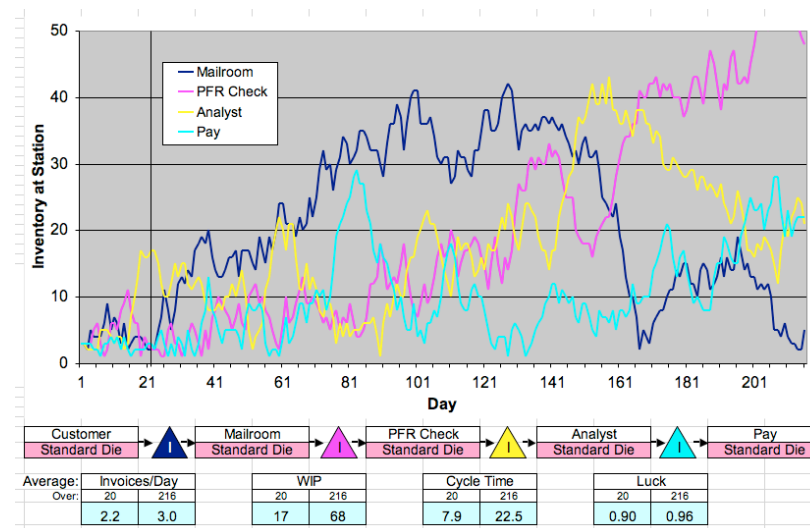
Simple Dice Game

- **5-step clinic value stream**
- **Dice (provides variation) and a Lego patients (flowing value)**
- **Everyone, simultaneously,**
 - Rolls die
 - Passes that many patients (or all in the waiting room, whichever is smaller) to the next step
 - Record number of patients in the waiting room
- **Repeat for 20 “shifts”**



Collect Data

- How many patients entered the system?
- How many came out?
- How crowded did the waiting rooms get?



- Computer simulation can be used to do many more “runs,” but credibility is established by physical simulation

Healthcare Value Streams

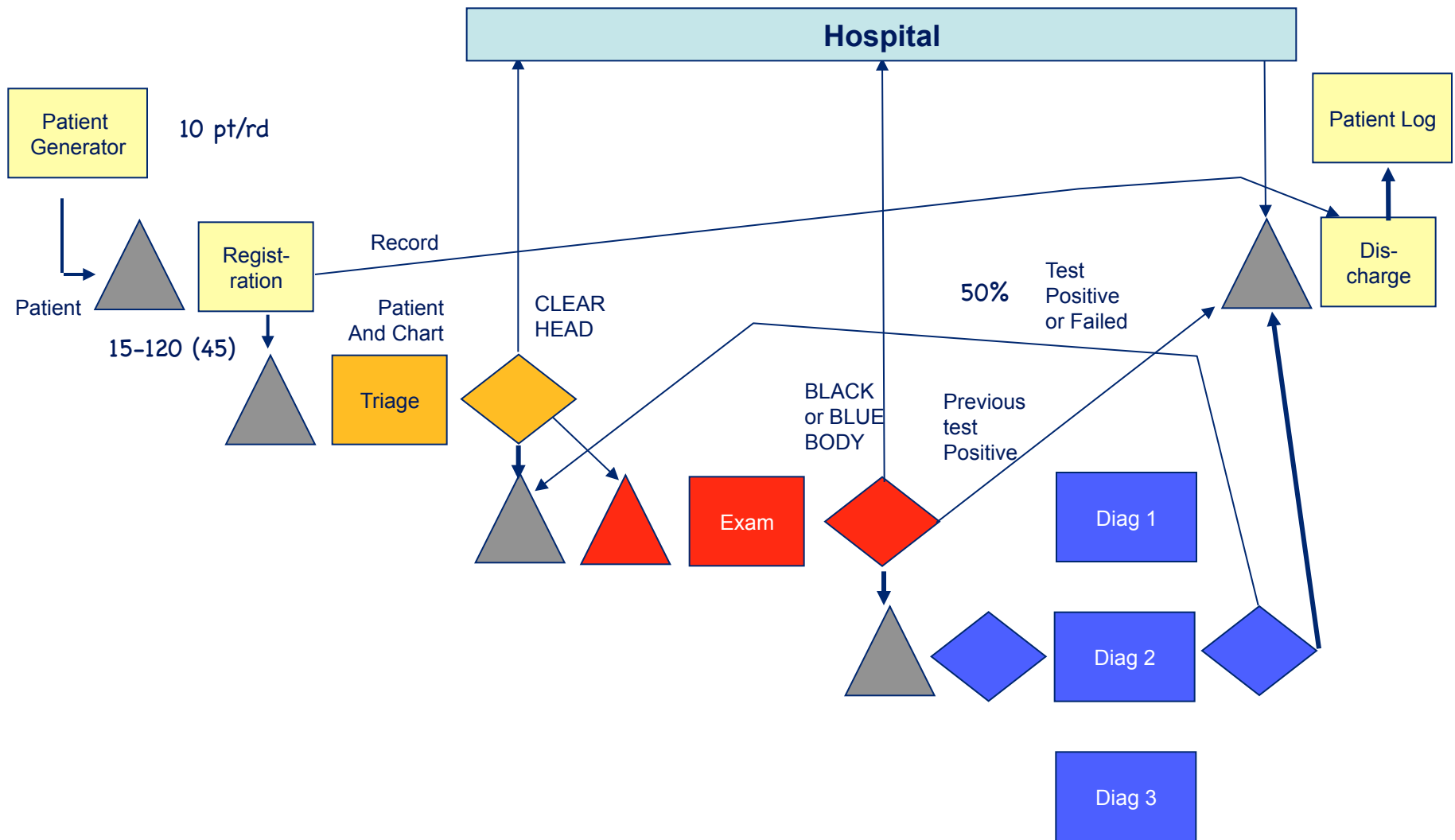
- **New to us!**
- **Lean Healthcare team members and cooperating medical personnel at University of Indiana and the VA in Bedford MA provided subject matter knowledge**
- **Existing toolkit used to develop simulations**
- **Iterative development though live testing at University of Indiana and VA Bedford (first Lean Healthcare Academy)**

Specialized Simulation needed to establish credibility with intended audience

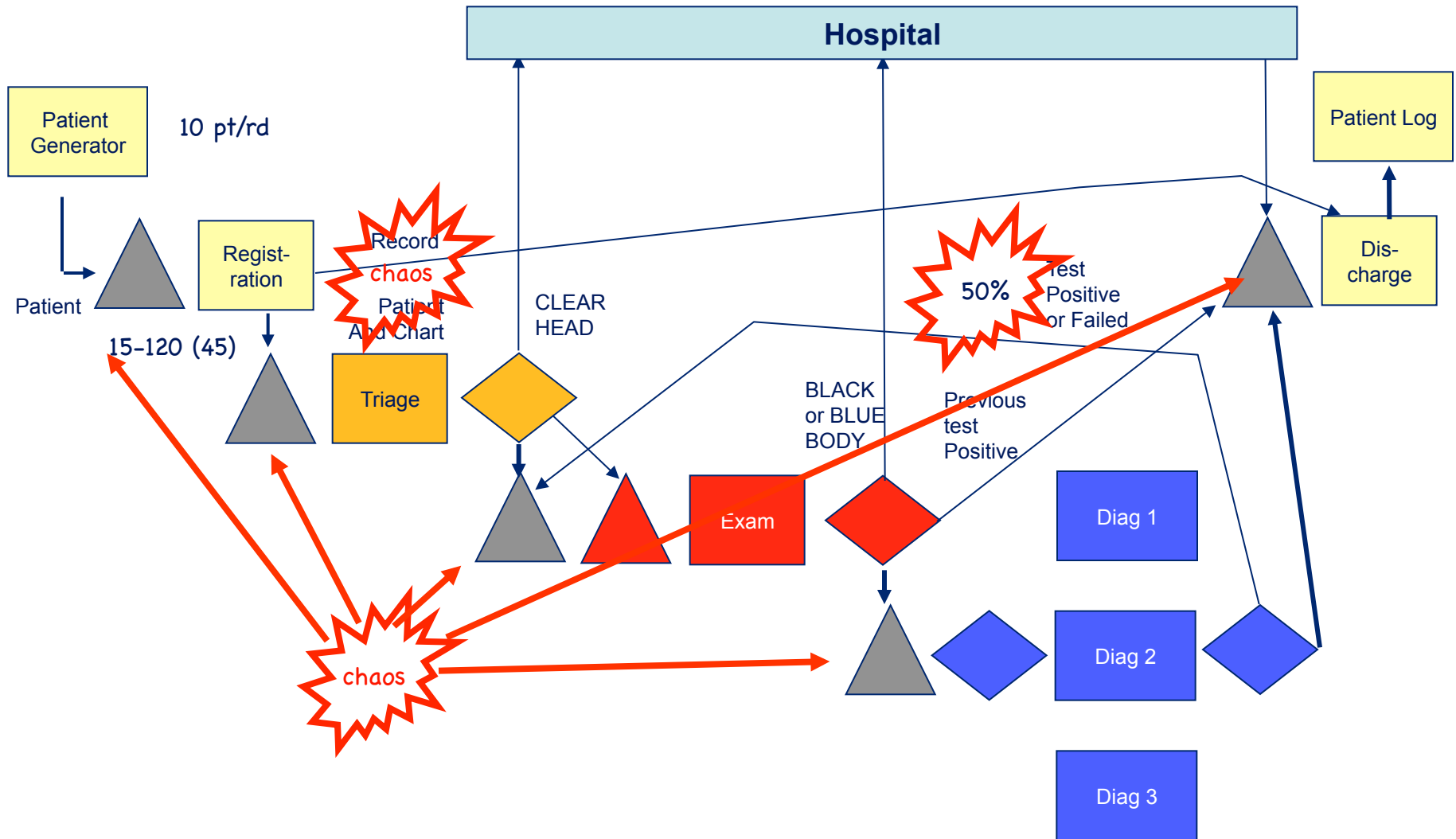
“Clinic” Simulation

- **Typical outpatient clinic – primary care, treatment**
- **Steps representative; not meant to be accurate depiction of any one process**
- **Same steps as simple sim, but more complex flow**
- **Lego people used: Different color legs, bodies and head denote condition of patients**
- **High variation, non-normal distributions, and strong correlations – some patients are “difficult” all the way through process**
- **Burdensome “chart” and “insurance record” paperwork**

Simulated Clinic VSM



Simulated Clinic VSM



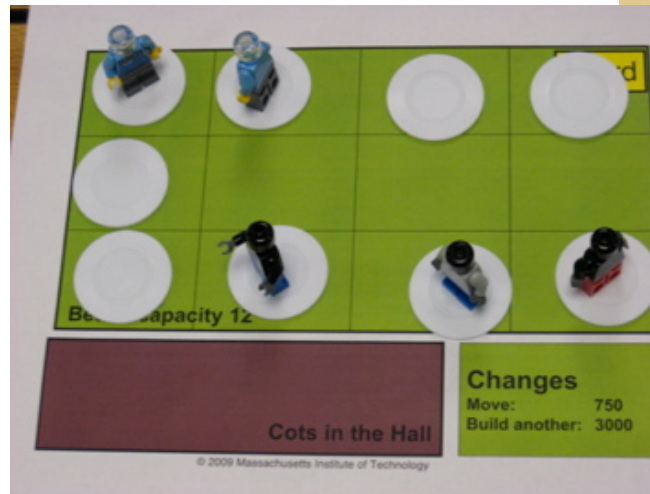
Lean Improvements

- **Standard work – chaos reduction**
 - No change in simulation, only actions of participants
- **Elimination of unneeded steps**
 - i.e. examinations for patients with known diagnosis
- **Simplification of flow paths**
 - separate waiting rooms
- **Balancing of resources**
 - Purchase “machines,” hire “people”
- **“Local Lean”**
 - Make individual processes run better
- **Global cooperation**
 - Coordinate with other clinics, hospitals

All done in the context of a continuous improvement process

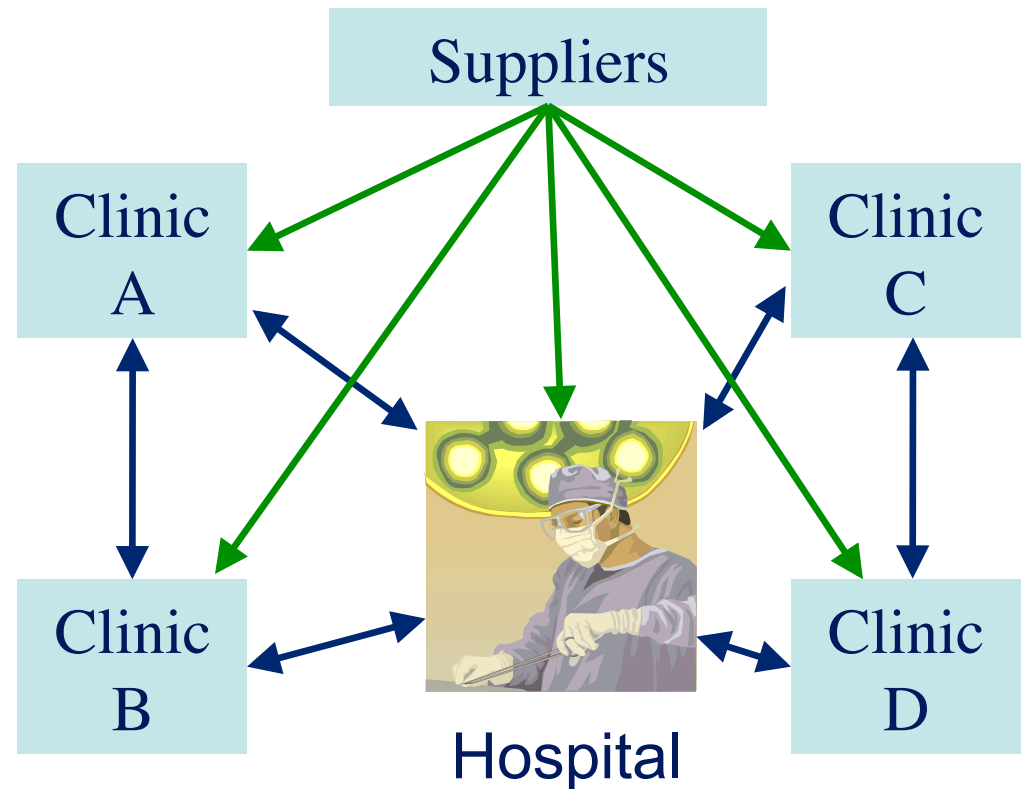
Other Health Care Value Streams Simulated

- **Hospital**
 - Registration, Triage, Beds, Surgery
 - Problems dominated by resource limits (beds, specialist time)
- **Supply Chain**
 - Supply of drugs, disposables, and equipment
 - Coordination issues, minor “until it isn’t”
- **Lower fidelity than clinics**
 - Less effort, but also less knowledge
- **Some local improvements modeled**



Health Care *Enterprise Simulated*

- **Four Clinics**
 - different capabilities and patient mixes
- **Hospital**
- **Supply Chain**
- **Local improvements did not fix systematic issues!**



Dramatic ah-ha's for health care professionals

Enterprise Lean Improvements

- **“Electronic Records” – visual patient status**
- **Use of cross disciplinary IPTs**
 - Visual Control team - maintain visual patient record
 - Error free process team - standard work for patient flow in clinics; visual control and triggers
 - Diagnostic team - Enterprise wide resource audit and sharing plan
 - Hospital Transport Team - Priority and transport; hospital check in/out with EMR
 - Supply team - Seamless pull system (paperless, but captures all information)
 - Hospital Team - revisit / error-proof hospital process
- **Actual improvements often easy; a few local lean improvements needed to align with enterprise**



Assessment

“Exercises seemed to be valuable – good active participation.”

We learned a lot

Credibility established with professionals

Ah-ha’s at both local and enterprise level

