


Wondering about the future of work? Look to innovations of the past

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We Row into the Future: Looking back to the past



www.prospectmagazine.co.uk/



Why we need a good work environment (WE)

- 2.78 million annual deaths from work (ILO, 2019)
- 20% of working population suffering from some kind of musculoskeletal disorder (Vézina et al., 2011)
- Costly outcomes
 - 3.94 percent of world GDP (ILO, 2019)
 - On par with all cancers combined (Leigh, 2011)
 - Detracts from companies' performance and profitability (Rose et al., 2013)
 - Poor WE causes quality problems (Kolus et al, 2018)

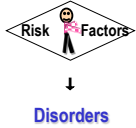




TECHNOCENTRIC DESIGN EXAMPLE

-> Sources of Risk are Deep in Design

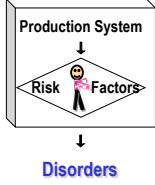
What is the problem?







(Neumann et al., 2006, IJOPM)

What is the Problem?





(Neumann et al., 2006, IJOPM)



**WHO IS RESPONSIBLE?
NO ONE!**


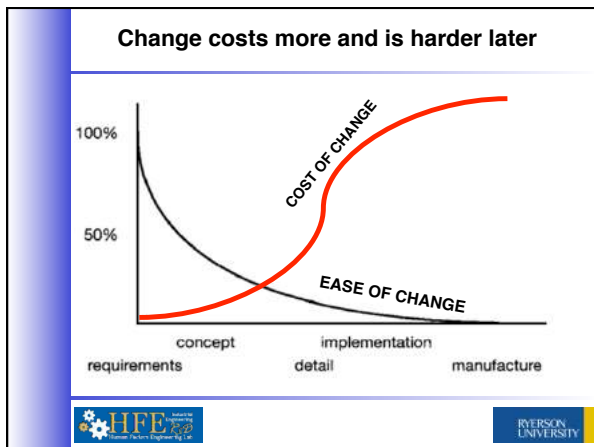
Workplace is an EMERGENT
Characteristic of design

```


    graph TD
      SD[System Design] --> PS[Production System]
      PS --> RF{Risk Factors}
      RF --> D[Disorders]
  
```

(Neumann et al., 2006, IJOPM)

Problem: Engineered systems are largely immune from change

'Side Car' OHS Structure?



Ergonomist

**“the irony of ergonomics”
Health focus opens doors, but limits its application**

(Theberge & Neumann, 2013, IR/RI)

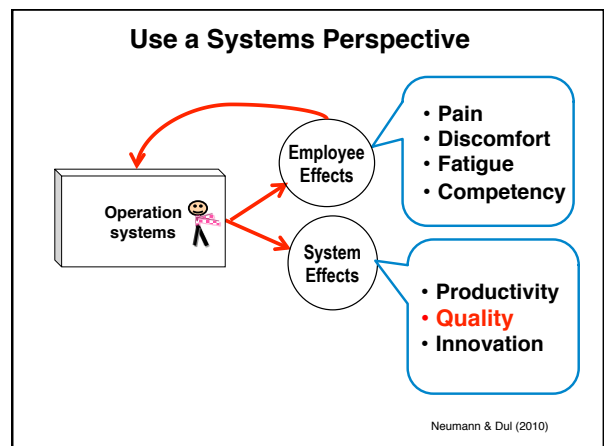
**Whack-a-mole is not effective strategy:
max cost, max constraints**

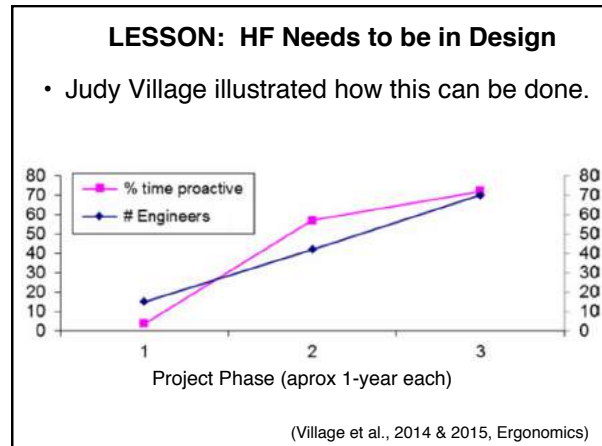
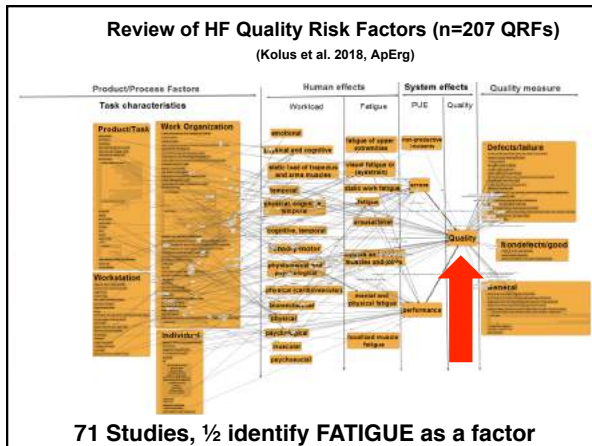


<https://www.youtube.com/watch?v=D0n8N98mpes>

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HUMAN FACTORS ENGINEERING

RYERSON UNIVERSITY





Why Engineers Don't Consider Ergo

TABLE I. Ranking of Constraints to the Integration of Work Environment (WE) Considerations Into Engineering (n = 441) (Three Marks).

Type of constraint	%
Lack of time	44
Lack of work environment	44
Lack of methods and tools	40
Customers do not demand	28
Management does not appreciate	17
It is difficult to use the available resources	17
Management is not committed	15
There is no tradition for design	13
It is troublesome	11
It is not required by the authorities	7
The safety organization does not ask for it	6
The subject does not have my interest	5

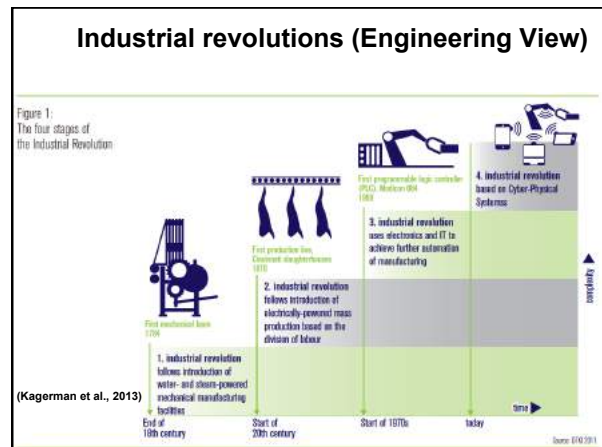
1. Lack Time
2. Lack Knowledge
3. Lack Tools
4. Lack Mandate

(Broberg, 1997, IJIE)

- ### Design problems
- Techno-centric design
 - "leftover" allocation to humans
 - HF not in the design process
 - A management problem
 - A design problem
 - Resistance to fixing problems
 - > sub-optimal designs
 - Drift to unsafe states
 - Ineffective technology designs

INDUSTRY 4.0

(Did I mention the Industry 4.0 Workshop?)





Division of Labour

"The greatest improvement in the productive powers of labour... seem to have been the effects of the division of labour"



-ADAM SMITH (1776)
Chapter 1: 'The Wealth of Nations'

✓ **The Pin Factory Example**

And the race was on...

- Taylor (1911) – *Scientific management*
- FORD (1920's)
- Demming (1950s +) – *Continuous Improvement*
- TOYOTA (1970 +)
- Womack (1994) – 'Lean'
- 2000+ "Lean Sigma": "Waste" Elimination
- 2010 -> "Industry 4.0"






I4.0 Elements

1. Big Data
2. Internet of things
3. Cyber-Physical Systems
4. Cobotics
5. Artificial Intelligence
6. Exoskeletons
7. Other?

-> Need HF to make this work!

(Badri et al., 2018)

Drone Inventory Checks



<http://www.dronescan.co>

Augmented Reality – Order Picking: A new headache?



https://quantum-software.com/blog/index.php/magazynewanie/pick-by-vision-rozszerzona-rzeczywistosc-w-magazyne

Robotic Order Picking



“COBOTS”: Like your old colleague, but quieter?



Enhancing the “Operator”... or Designing Work?



Figure 1: Operator 4.0 Typology (Romero et al., 2016)

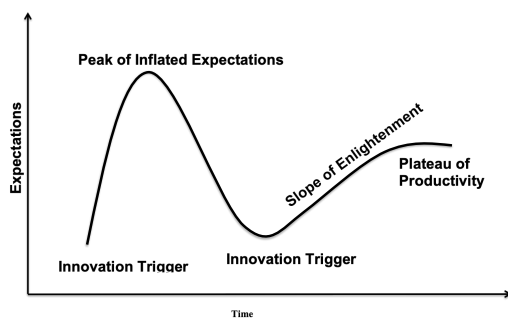


Manufacturing FADs Come and Go

- | | |
|---------|--------------------------------------|
| 1. TQM | Total quality management |
| 2. JIT | Jut in time production |
| 3. MC | Manufacturing cells |
| 4. ICBT | Integrated computer based technology |
| 5. CE | Concurrent engineering |
| 6. TPM | Total productive maintenance |
| 7. TBW | Team-based working |
| 8. EMP | Empowerment |
| 9. LC | learning culture |
| 10 OS | Outsourcing |
| 11 SCP | Supply-chain partnering |
| 12. BPR | Business process reengineering |



Innovation Hype Curve (Gartner Inc.)

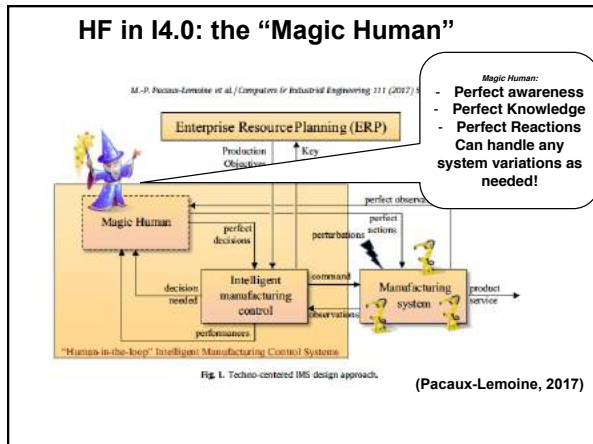


Stated I4.0 NEEDS: Where is HF?

(Kagerman et al. 2013)

1. Standardization of architecture
2. Managing complex systems
3. Broadband Infrastructure
4. Safety & Security
5. Work Organisation & Design
6. Training & development
7. Regulatory Framework
8. Resource Efficiency (Euro, Enviro)





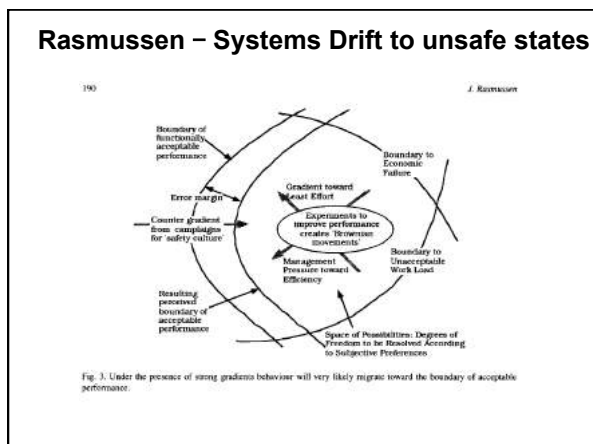
- ### Who is Affected by Innovation?
1. Front Line Employees
 2. Engineers
 3. IT specialists
 4. Maintenance Person
 5. Managers & Supervisors
 6. More...
- Innovation affects all of these PEOPLE

Kagerman et al. 2013 – Unsubstantiated Claims

“Employees should have greater freedom to make their own decisions, become more actively engaged and regulate their own workload.”

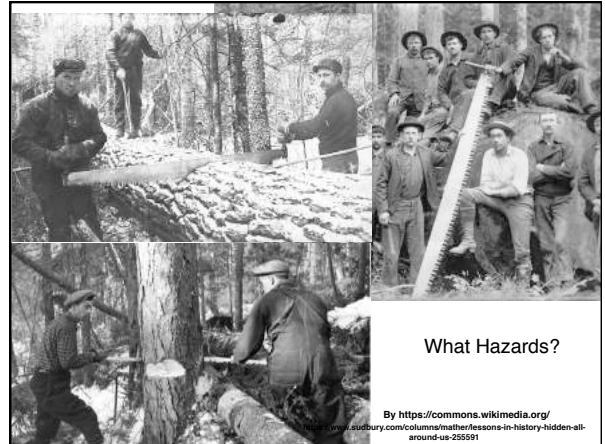
“Seriously?”
- Neumann (2019)

- ### Potential Problems without HF
- Drift to unsafe states effect
 - Worker Monitoring & surveillance
 - Inappropriate pace control
 - Fewer jobs = more unemployed ...?
 - New tools – new dangers (emergent risk)
 - Unmet Goals, quality problems



- ### Potential Benefits
- More interesting high skill jobs
 - Training & skills development
 - Industrial Efficiency (maybe)

LOOKING TO PAST INNOVATIONS



What Hazards?

By <https://commons.wikimedia.org/wiki/File:Logskid.jpg>
www.southbury.com/columns/mather/lessons-in-history-hidden-all-around-us-255591



What Hazards?



What Hazards?

<https://www.wideopenpaces.com/property-use-chainsaw-tree-cutting/>

Diagnosis?

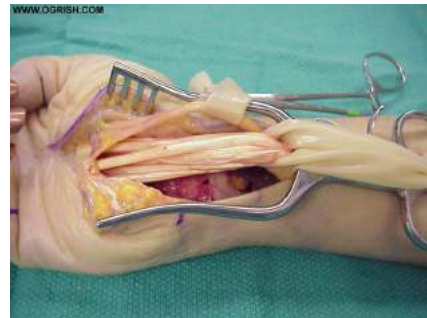


© MARIO ESPOSITO/ISTOCK/ALAMY. ALL RIGHTS RESERVED.
<https://www.mayoclinic.org/diseases-conditions/raynauds-disease/symptoms-causes/syc-20363571>

Forestry Harvester



What Hazards?



A First for Caterpillar – Remote Operated Logging Machines



Consequences? Fewer horses++

Will autonomous machines improve safety?

Agriculture? Same thing.



10:44 80%

2 of 6

The farm robots

Feeding and weeding

Arched legs to rise to exact height of plant

Laser range finder enables navigation to plant boundary

Scan to cut weeds with electric chains and also spray pesticide and fertilizer

Mapping and monitoring soil

GPS accurate to within 2cm

Smartphone for wireless communication

Laser range finder

Rear camera

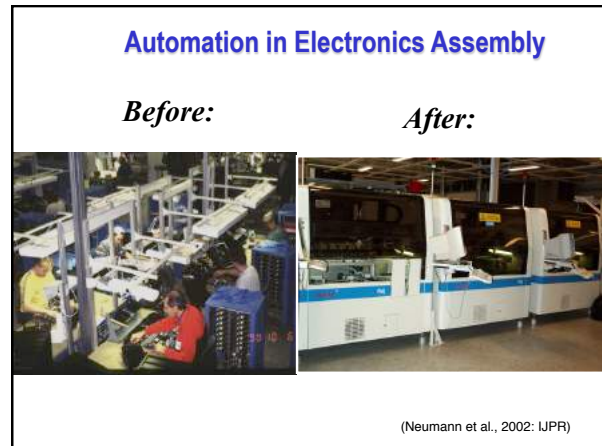
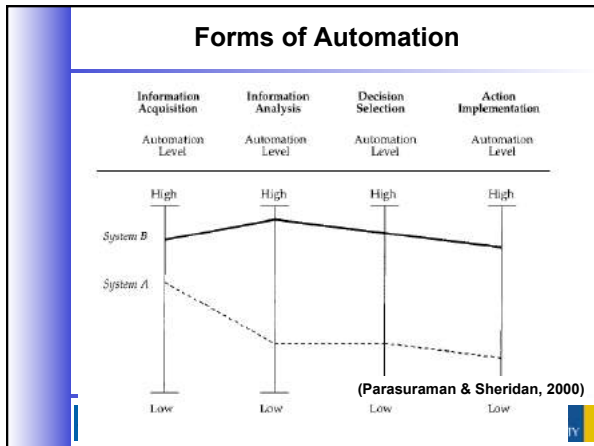
Front camera

Source: Small Robot Company

Farming robotics can use much less CO2 than conventional

AUTOMATION CASE EXAMPLE



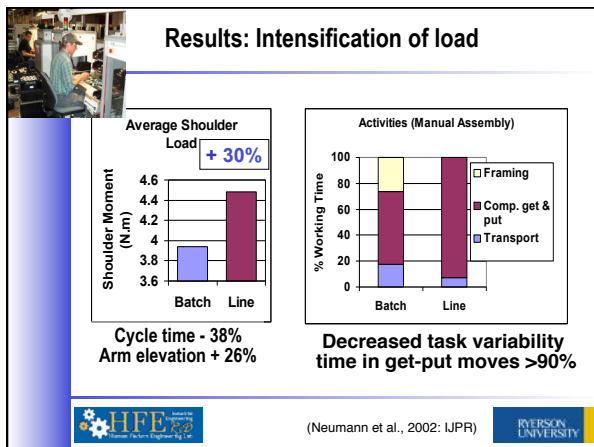
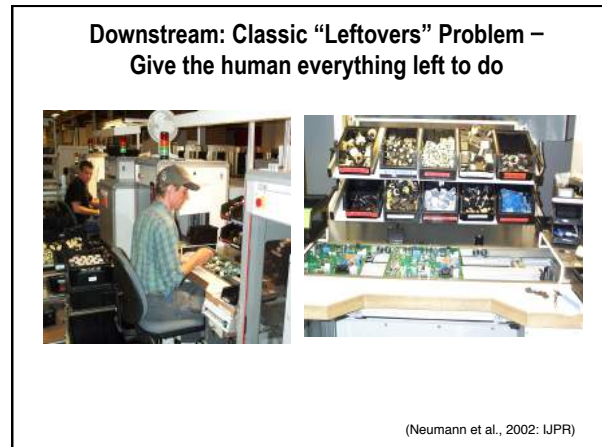


Robot Operator

Less manual work
save 2.6 min / board
++ machine supervision
+ variety
++ Workstation cost

Unanticipated Consequences...

(Neumann et al., 2002: IJPR)



Workstation Design Strategy

Constraints from tech. team:
Conveyor pathway & space
Line rate & tasks
Number of parts (increased)

1st rack elevates parts above transport system (+ load)
2nd rack added for failed automation parts (+ load)



Adjustable 'Ergonomic' workstation (sit-stand capability):
- expensive & not used much
- does not change essential shoulder demands

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(Neumann et al., 2002: IJPR)

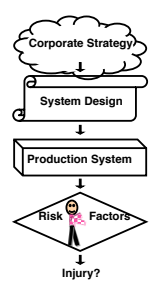
Lessons Learned

- Automation
 - Adds work
 - Removes Work
 - Changes work
- Watch out for problems downstream from Automation
- Can affect supply chain and other actors
 - programmers, engineers, maintenance

Consider the ODAM perspective...

Injury Pathway



Comment

1) Improve Performance with Automation
 2) Consider Ergonomics separately

1) Technology choices for line system
 2) Workstation design constrained by tech.

1) Increased rate, machine pacing elements
 2) Fewer tasks, less interaction potential


1) Reduced Work Variability (↑ intensity)
 2) Increased shoulder loading


59% report neck/shoulder pain or stress

(Neumann et al., 2006, IJPR)


A Shift in Industrialisation Level in Car Disassembly...

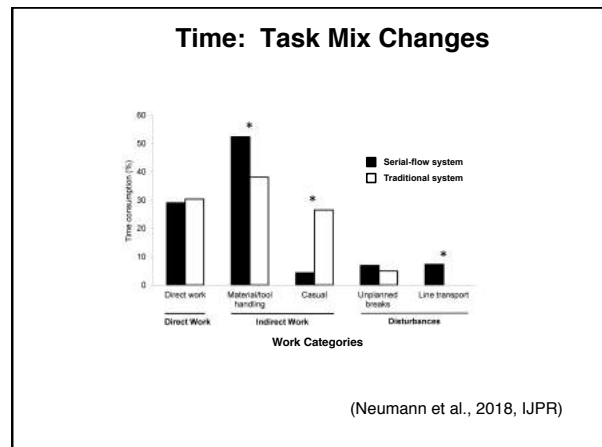
From “craft” parts recovery to line based full disassembly

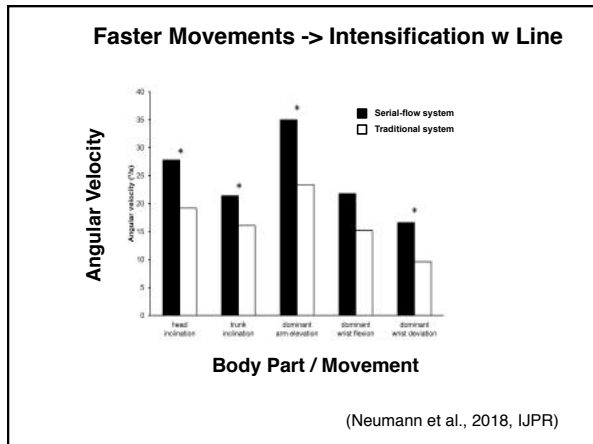




(Neumann et al., 2018, IJPR)



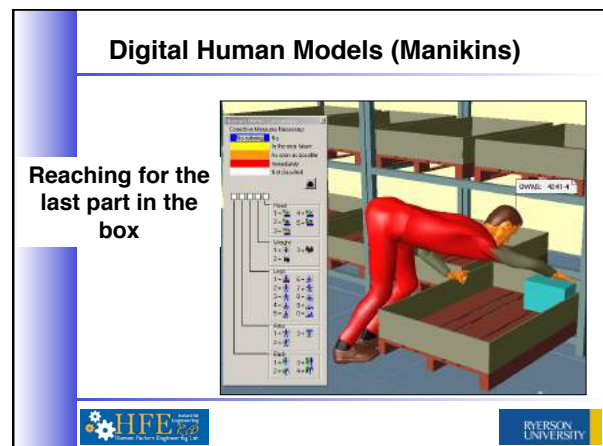
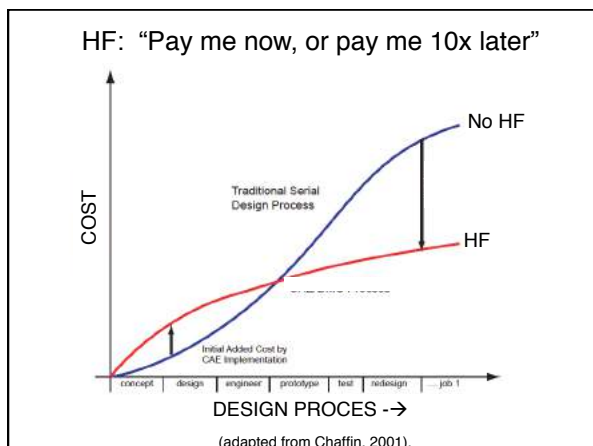




- ### So What Happened?
- Innovation:
 - Removed work (data entry, filing)
 - Added Work (full disassembly)
 - Changed work (Line System)
 - Without an HF mandate engineers won't see this.
 - Pace Control needed

SIMULATION

- ### SIMULATION – A Design Tool
- Main Types:
 - Digital Human Models
 - Math models, optimisation
 - Discrete Event Simulation
 - Agent Based Simulation
 - System Dynamics Modelling
 - Mock-Up Simulations
 - Integrates evidence to see the future(s)



Examples of analysis situations - Buss

50%ile male mounting air pipe under crossbeam

Eye view

Sundin 2000, IEA

DIGITAL HUMAN MODELS

- Most common
- Good for examining Layouts/Postures
- Workload oriented
- Less good with time

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System Level: Cost Optimization Model

$$\sum_{j=1}^4 \sum_{r=1}^{12} \sum_h c_{j,r}^n \pi_{j,r}^h P_{j,r}^{n,r} + \sum_{j=1}^4 \sum_{r=1}^{12} \sum_h c_{j,r}^o \pi_{j,r}^h P_{j,r}^{o,r}$$

MIN E (Production cost in regular time) + **E** (production cost in over time)

+
E (Insurance cost) + **E** (Indirect OHS cost) + Inventory cost
 + Subcontract cost+ **E** (Wage loss cost)

$$\sum_{j=1}^4 \sum_{r=1}^{12} \sum_h c_{j,r}^i \pi_{j,r}^h p_{j,r}^{i,r} P_{j,r}^{i,r} + \sum_{j=1}^4 \sum_{r=1}^{12} \sum_h c_{j,r}^o \pi_{j,r}^h p_{j,r}^{o,r} P_{j,r}^{o,r}$$

$$\sum_{j=1}^4 \sum_{r=1}^{12} \sum_h c_{j,r}^s \pi_{j,r}^h P_{j,r}^{s,r} + \sum_{j=1}^4 \sum_{r=1}^{12} \sum_h c_{j,r}^w \pi_{j,r}^h p_{j,r}^{w,r} P_{j,r}^{w,r}$$

(Sobhani, 2014)

Production Costs w. Psychosocial Risks

Price (% Baseline)

Job Control Index

←-- Industry 4.0? --→

A. Sobhani et al. / European Journal of Operational Research 241 (2015)

Cumulative Spine Load: QUALITY DRIVES Financial effects

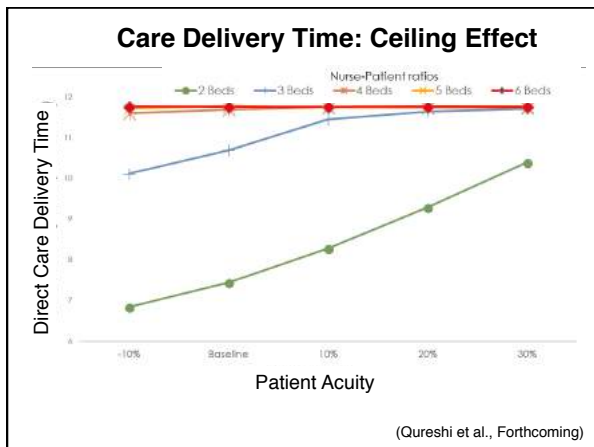
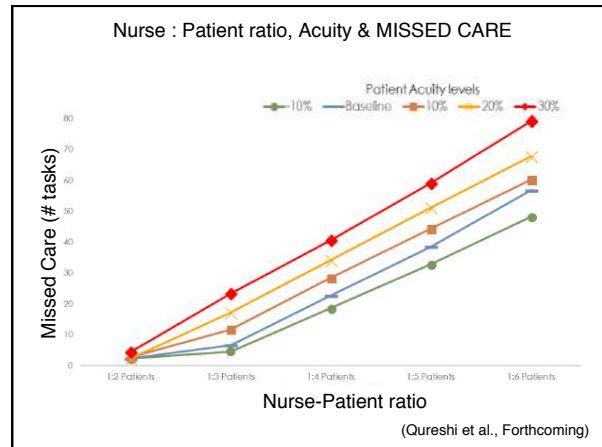
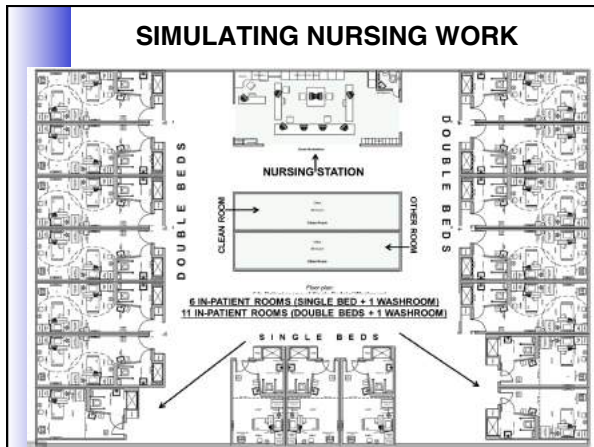
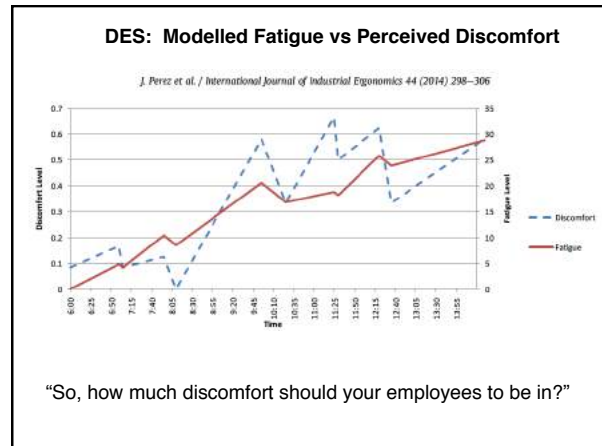
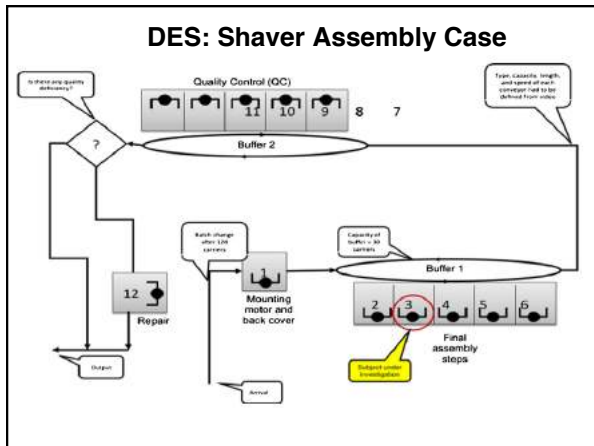
Cost growth (%)

Operator error rate (%)

MNs/shift

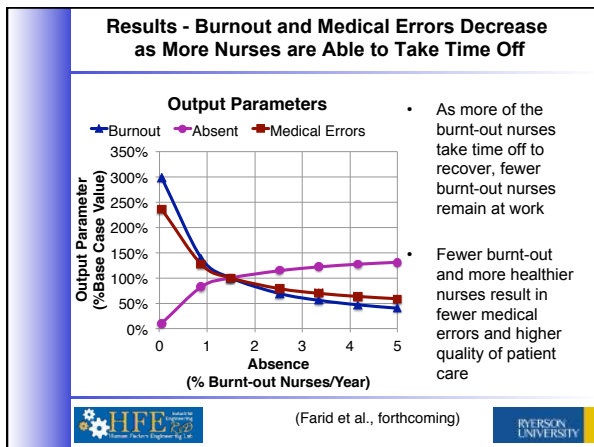
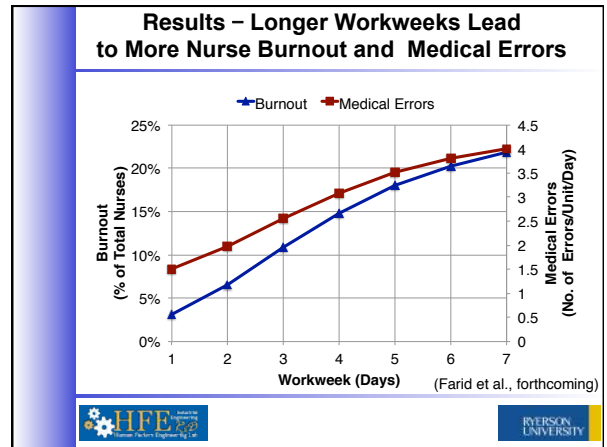
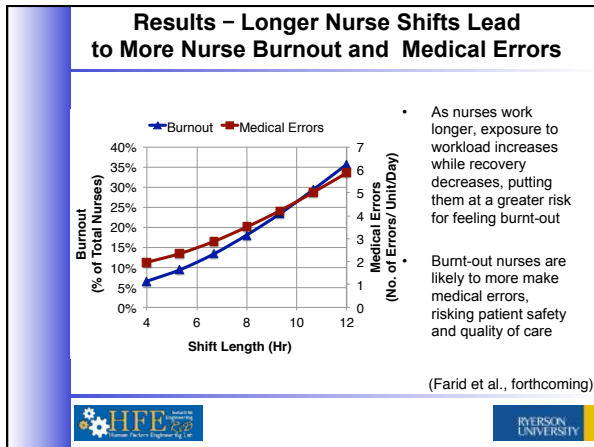
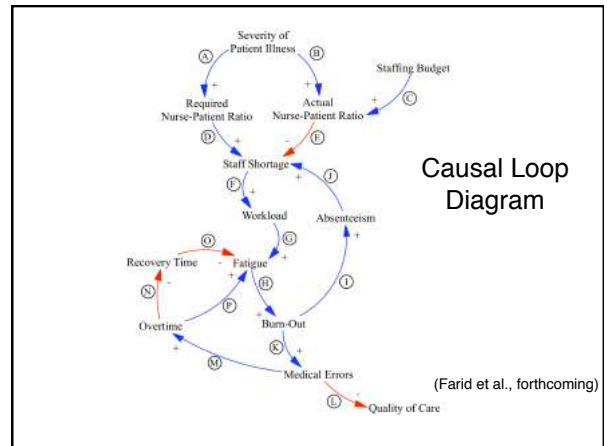
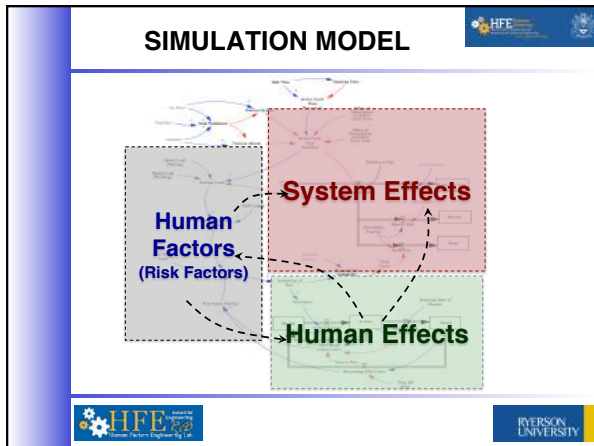
(Sobhani et al., 2017)

DISCRETE EVENT SIMULATION



SYSTEM DYNAMICS

The slide features the title "SYSTEM DYNAMICS" in large, bold, black letters. At the bottom, there are logos for HFE (Human Factors Engineering) and RYERSON UNIVERSITY.



- ### SIMULATION
- Integrates Information
 - Can provide system level analysis
 - Good for examining work-pace
 - Can include wellbeing and performance
 - Lets you peer into the future.

Messages

- Don't believe the Hype
- Engage in Design
- Focus also on performance aspects
- Consider: new tasks & work remaining
- Simulation: A window into the future(s)

- Join IEA 2021!



Main Message:



We Row into the Future: So think about the past



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2021

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JUNE 13-18,
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