CRE-MSD Fatigue Conference, Dec. 4, 2012

Designing Jobs in Manufacturing: Rest Allowances

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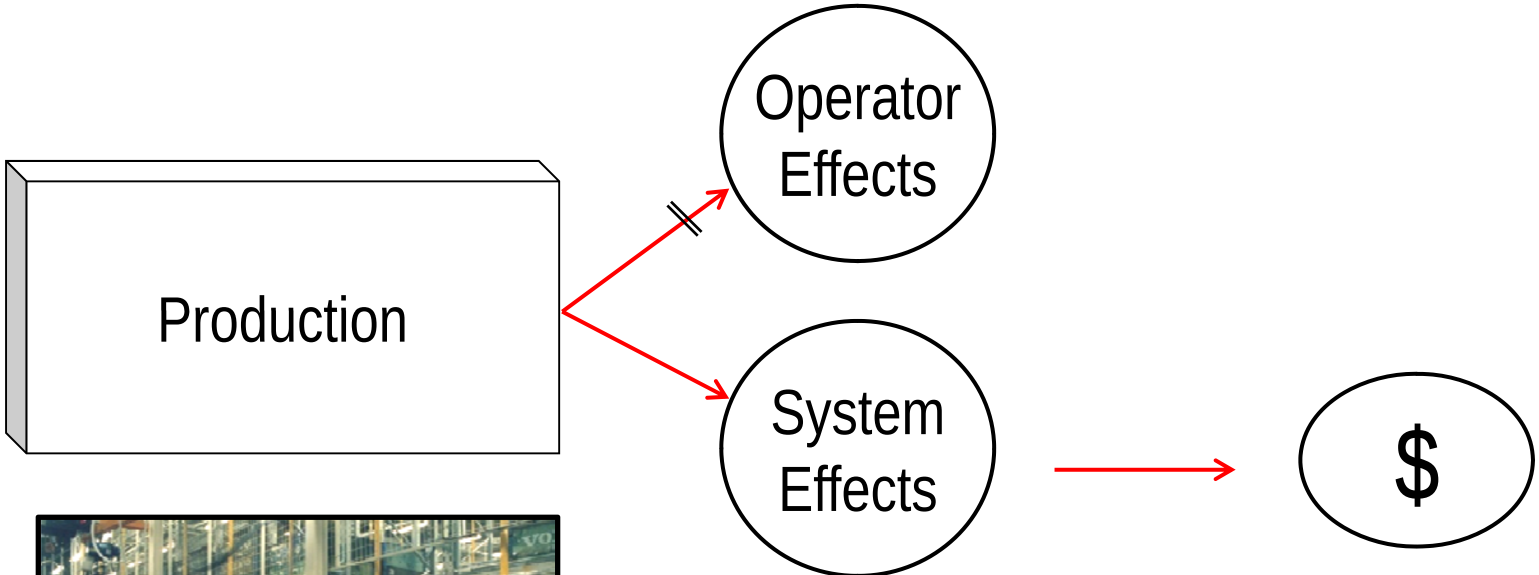
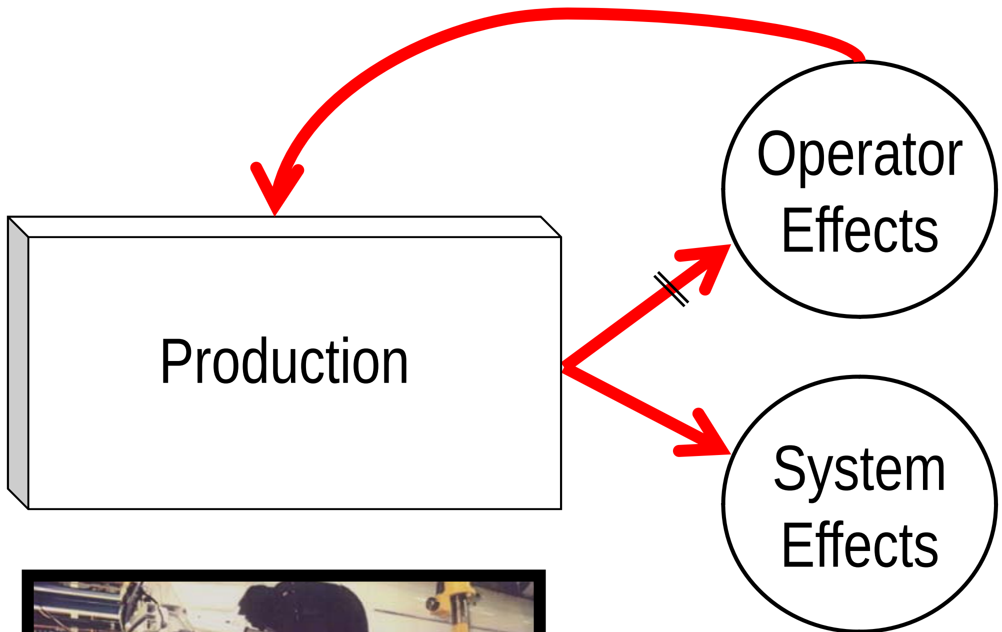
Ergonomics contributes to company strategies...



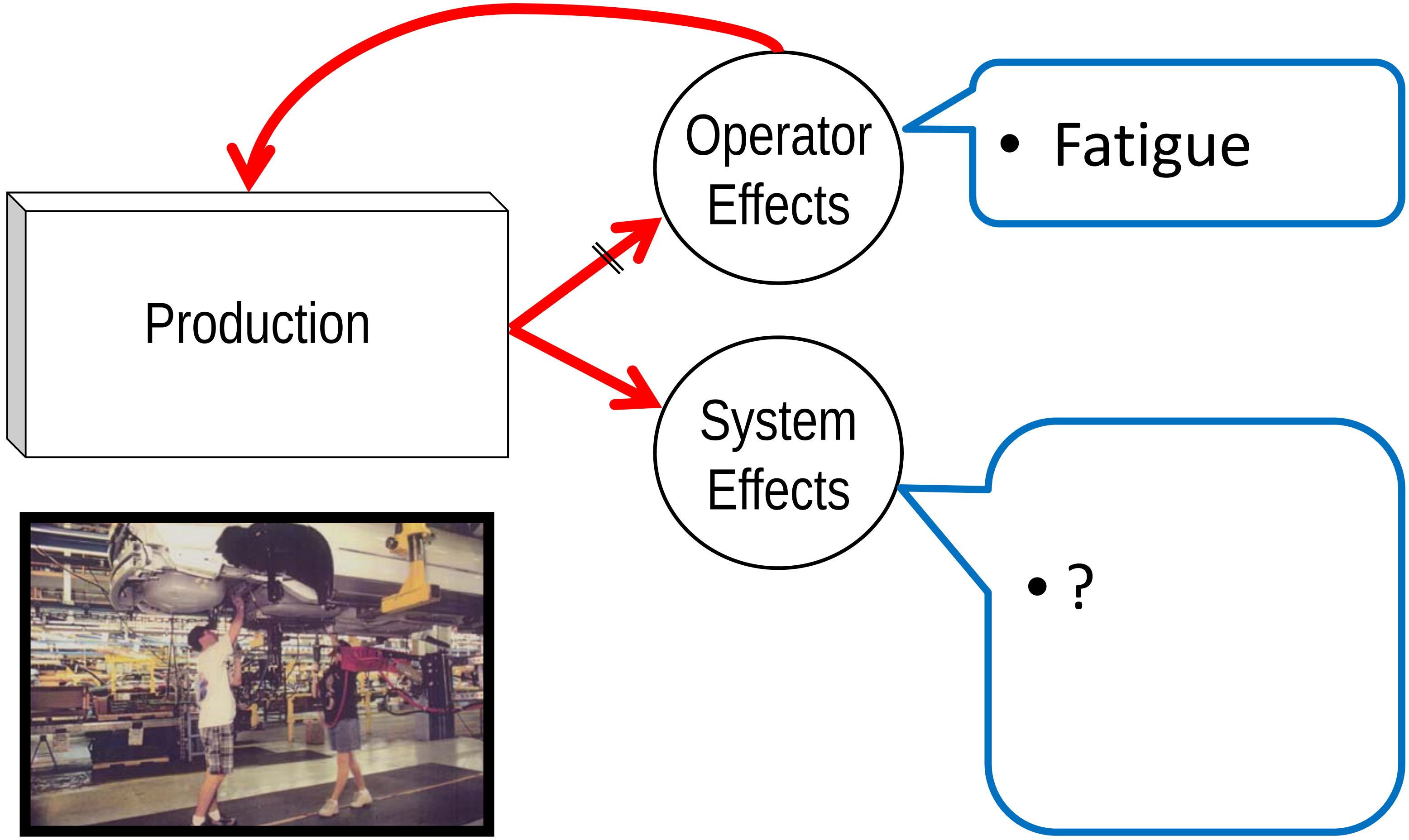
Dul, J. and Neumann, W.P., 2009. Ergonomics Contributions to Company Strategies. Applied Ergonomics, 40(4): 745-752.

How Human and System Effects are connected



Neumann, W.P. and Dul, J., 2010. Human Factors: Spanning the Gap between OM & HRM. International journal of operations & production management, 30(9): 923-950.

How Human and System Effects are connected



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Workshop

How can employee fatigue affect your operational goals?

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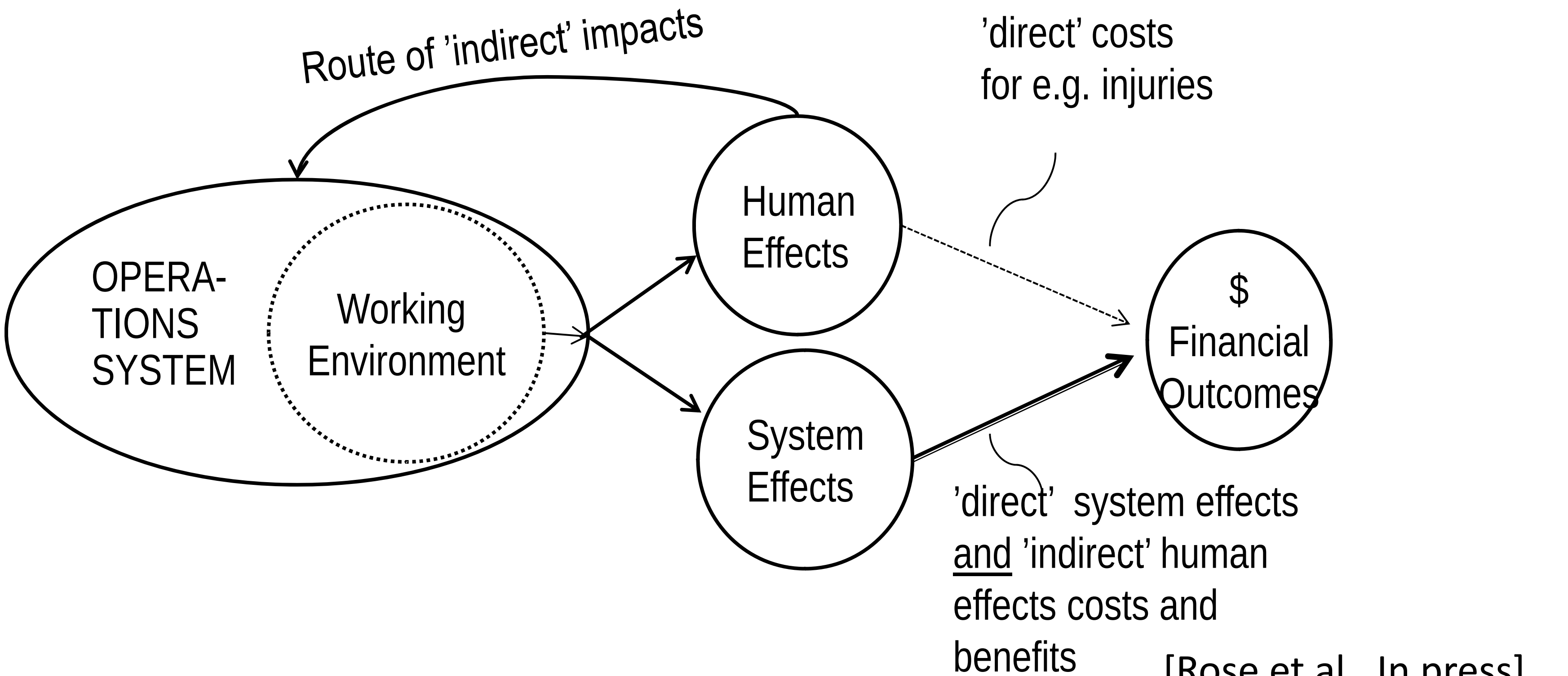
Effects of the working environment - visible and hidden effects



[Rose et al., In press]

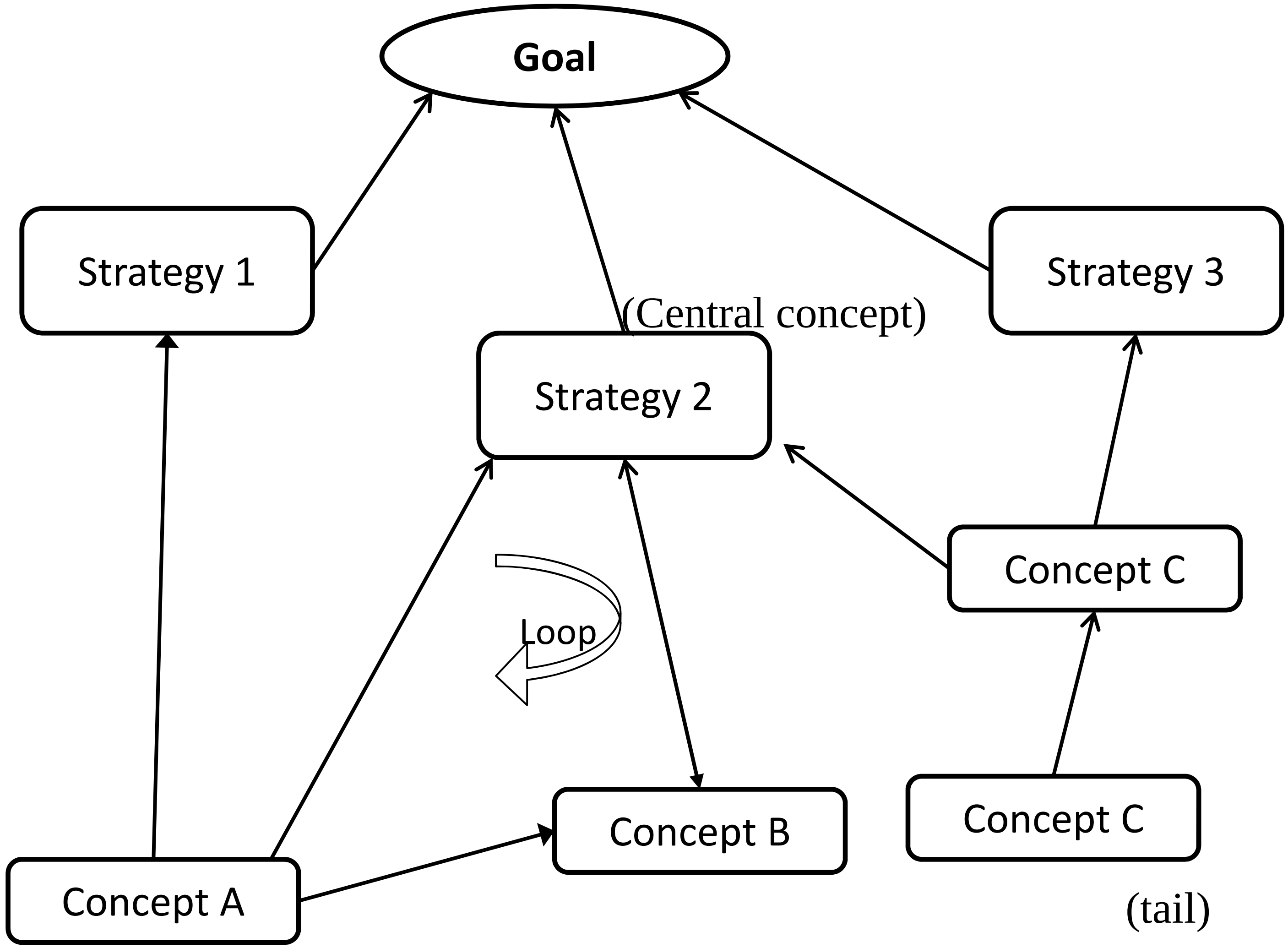
Concept Mapping

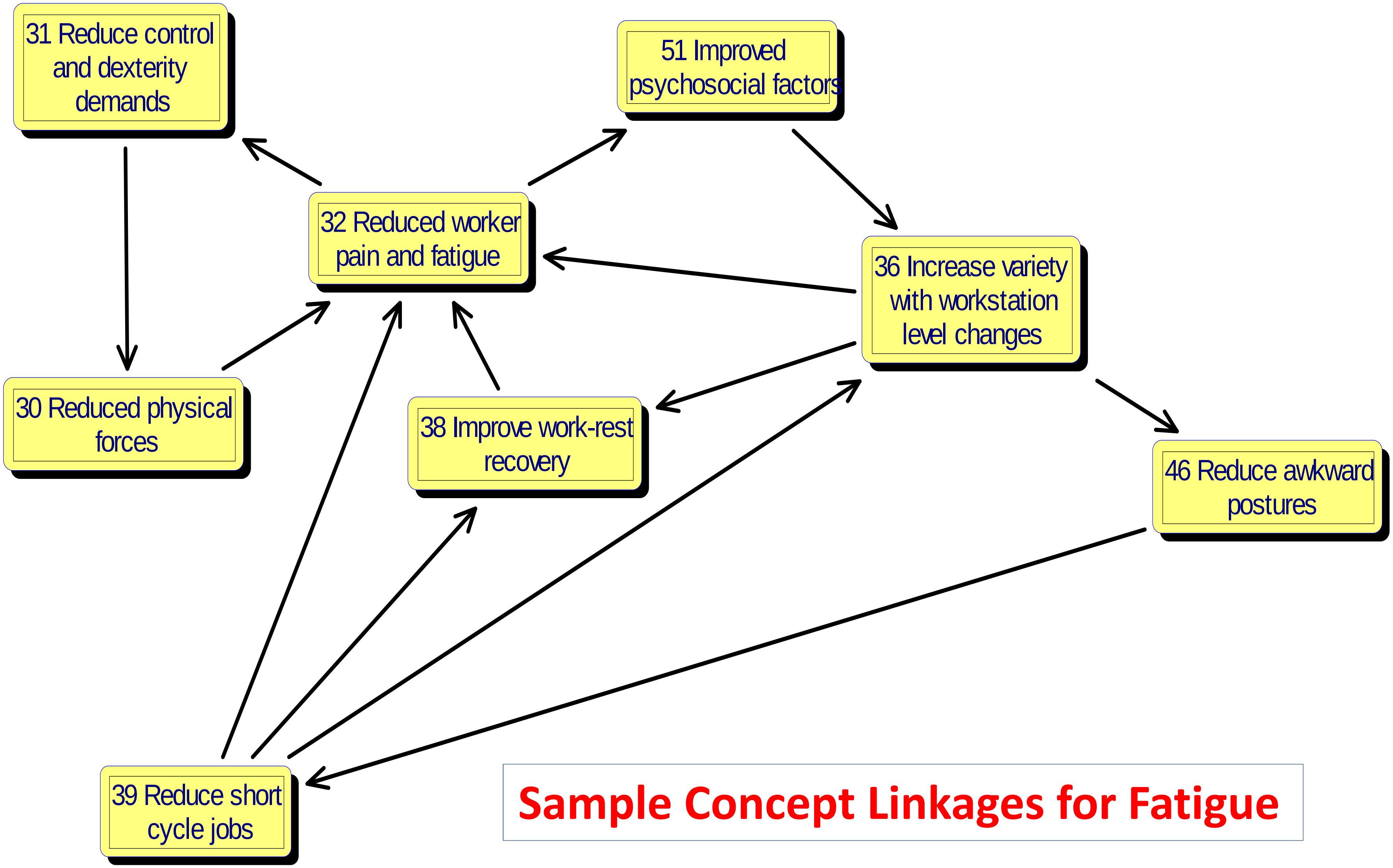
- Used to tap into Executives strategic thinking

- An interview process
- Concepts are linked by hand on a ’map’
- Maps are then combined for an Exec. Team (n=7)
- Results are analysed for trends and linkages

- Technique applied to a team of Engineering Managers in electronics manufacturing

- Focus on: How can HF help you reach your strategic goals?


Goal
Strategy 1
(Central concept)
Strategy 3
Strategy 2
Concept C
Loop
Concept B
Concept C
Concept A
(tail)



Sample Concept Linkages for Fatigue

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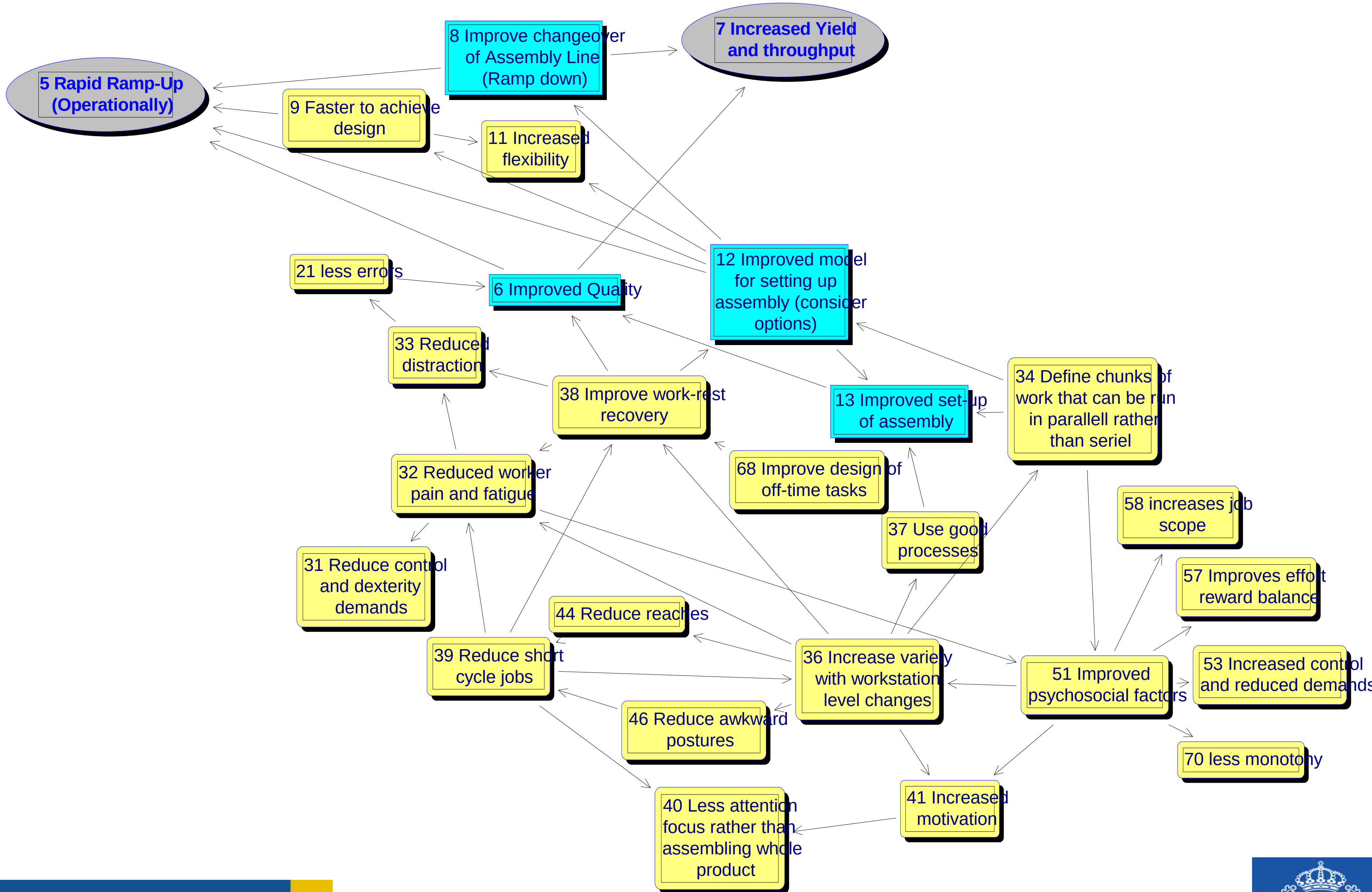

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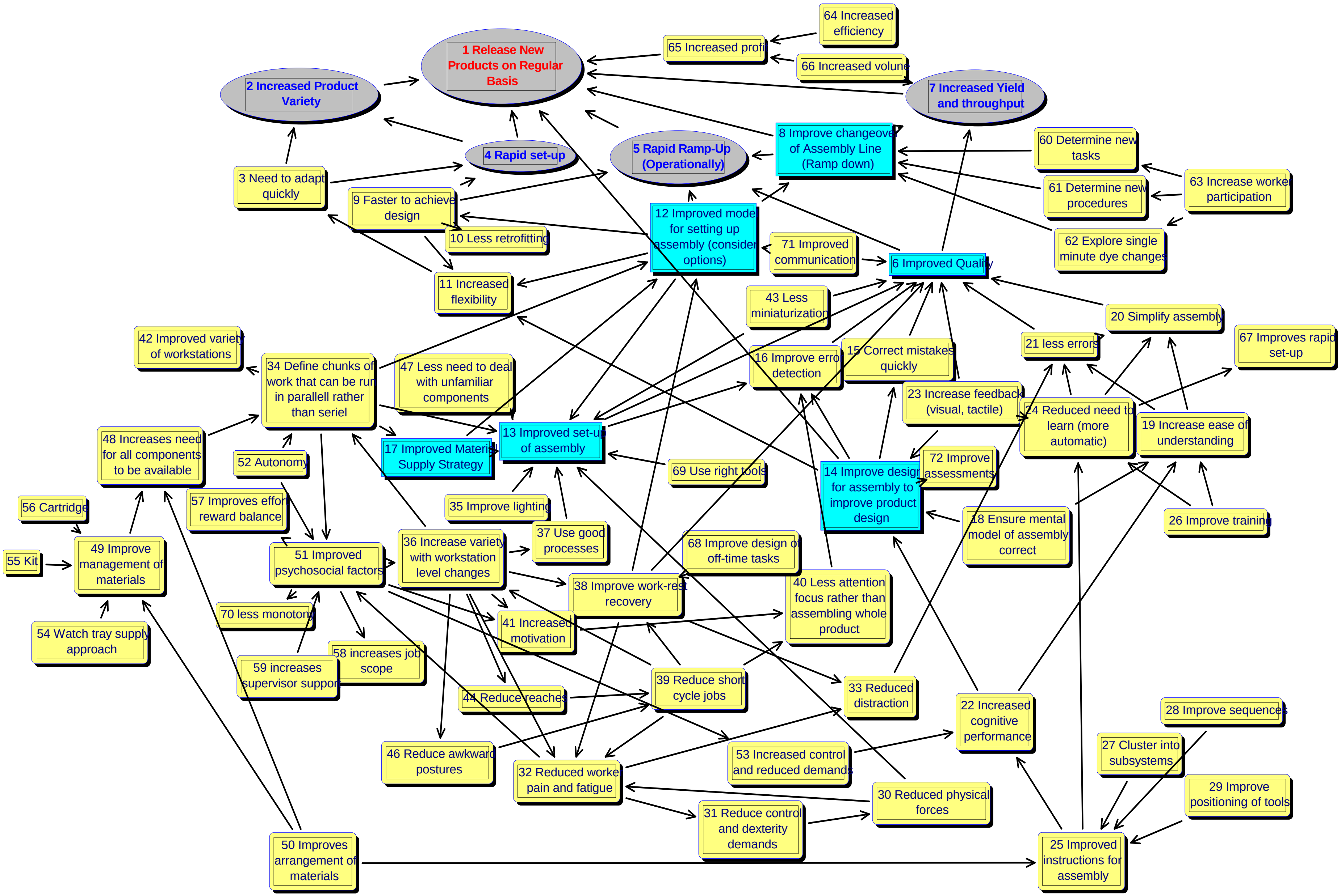

1 Release New Products on Regular Basis
2 Increased Product Variety
3 Need to adapt quickly
4 Rapid set-up
5 Rapid Ramp-Up (Operationally)
6 Improved Quality
7 Increased Yield and throughput
8 Improve changeover of Assembly Line (Ramp down)
9 Faster to achieve design
10 Less retrofitting
11 Increased flexibility
12 Improved model for setting up assembly (consider options)
13 Improved set-up of assembly
14 Improve design for assembly to improve product design
15 Correct mistakes quickly
16 Improve error detection
17 Improved Material Supply Strategy
18 Ensure mental model of assembly correct
19 Increase ease of understanding
20 Simplify assembly
21 less errors
22 Increased cognitive performance
23 Increase feedback (visual, tactile)
24 Reduced need to learn (more automatic)
25 Improved instructions for assembly
26 Improve training
27 Cluster into subsystems
28 Improve sequences
29 Improve positioning of tools
30 Reduced physical forces
31 Reduce control and dexterity demands
32 Reduced worker pain and fatigue
33 Reduced distraction
34 Define chunks of work that can be run in parallell rather than seriel
35 Improve lighting
36 Increase variety with workstation level changes
37 Use good processes
38 Improve work-rest recovery
39 Reduce short cycle jobs
40 Less attention focus rather than assembling whole product
41 Increased motivation
42 Improved variety of workstations
43 Less miniaturization
44 Reduce reaches
46 Reduce awkward postures
47 Less need to deal with unfamiliar components
48 Increases need for all components to be available
49 Improve management of materials
50 Improves arrangement of materials
51 Improved psychosocial factors
52 Autonomy
53 Increased control and reduced demands
54 Watch tray supply approach
55 Kit
56 Cartridge
57 Improves effort reward balance
58 increases job scope
59 increases supervisor support
60 Determine new tasks
61 Determine new procedures
62 Explore single minute dye changes
63 Increase worker participation
64 Increased efficiency
65 Increased profit
66 Increased volume
67 Improves rapid set-up
68 Improve design of off-time tasks
69 Use right tools
70 less monotony
71 Improved communication
72 Improve assessments

RESULT: Engineering Management Team Concepts

Merged Map on Quality: Central Concepts	Score	#Concepts
Increase quality	110	198
Improve systems design	100	191
Reduce injury and/or fatigue	91	186
Increase understanding of how to do the task	87	186
Improve service to design teams	83	188
Reduce repetitive activities	78	166
Increase motivation	77	178
Improve repeatability	77	184
Improve layout of process on mfg floor	75	175
Build process from point of view of operator	74	160
Improve lessons learned (quality)	71	169

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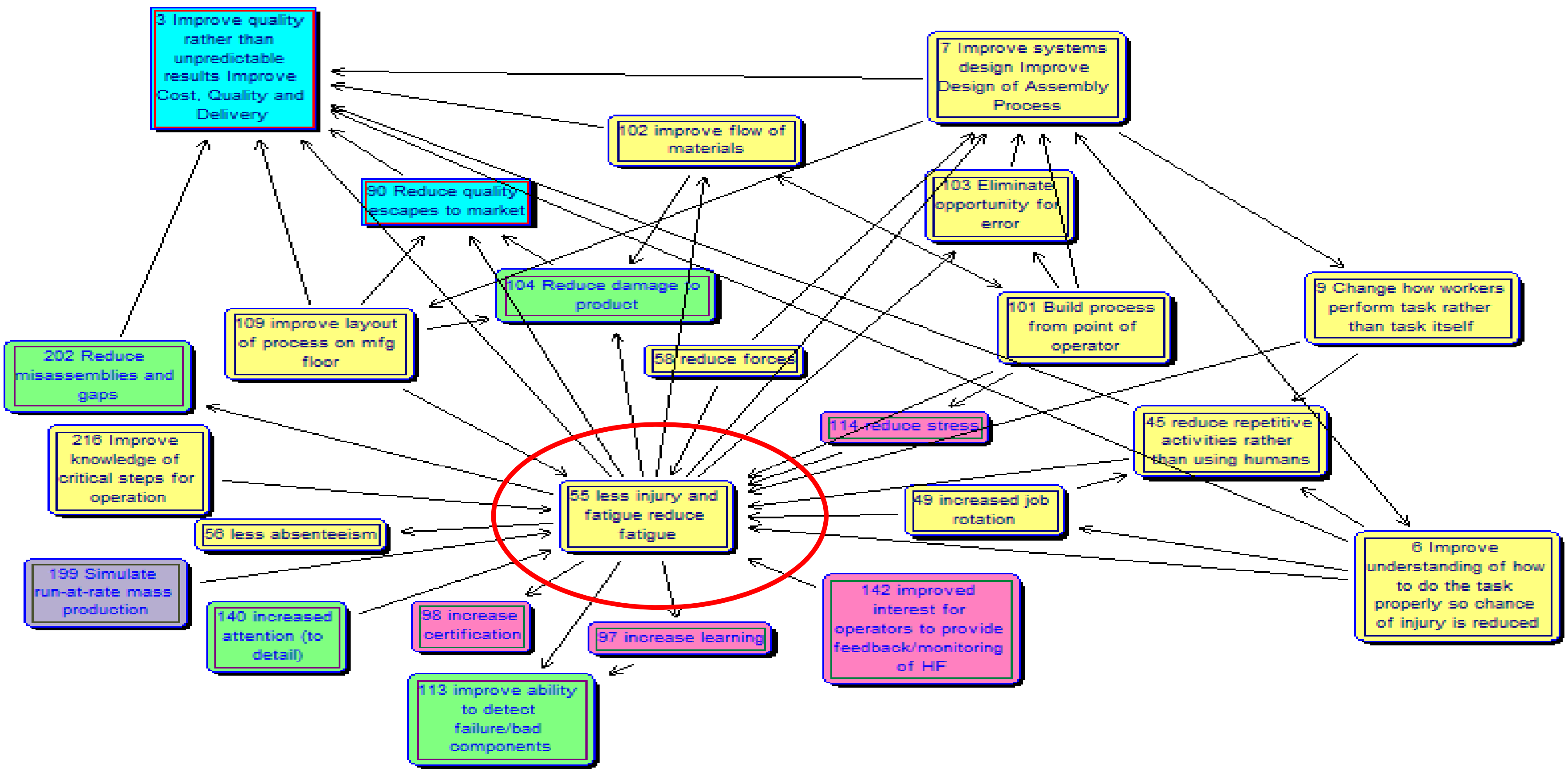
Reduce Injury and/or Fatigue



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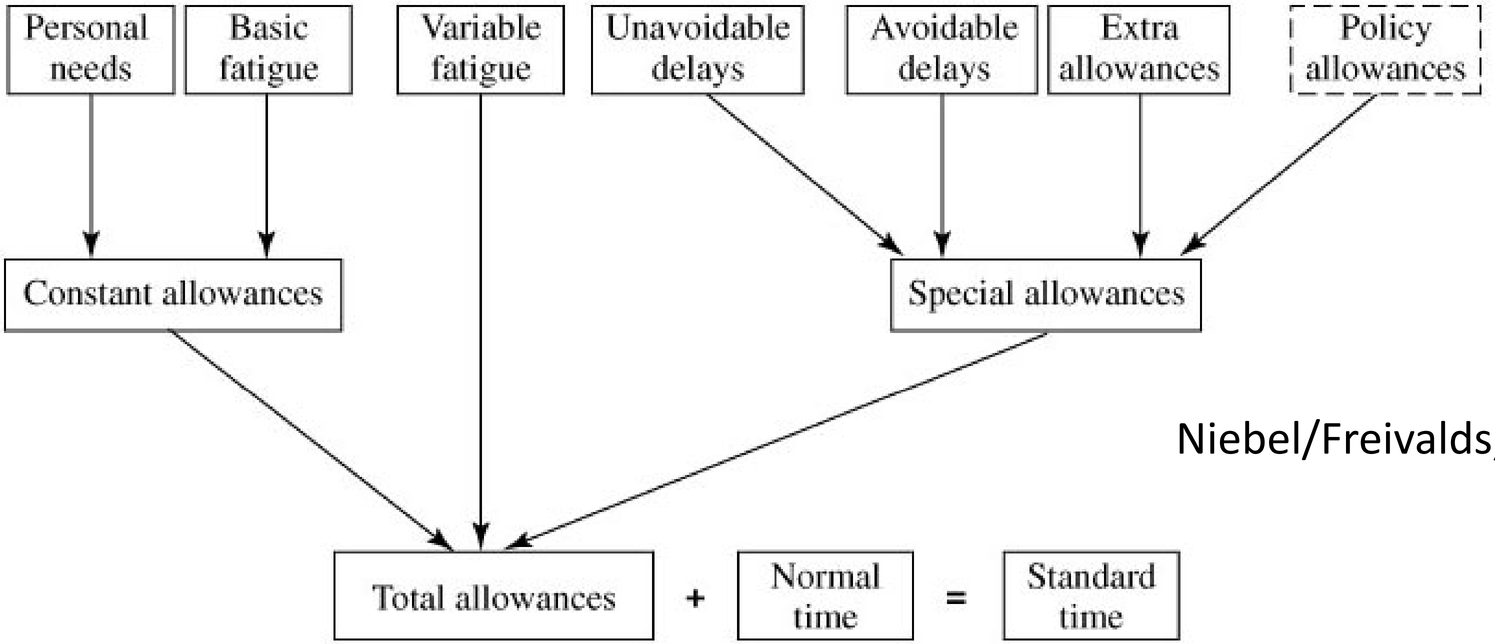
Quotes from Engineering Managers

- *"fatigue and quality seem to go hand-in-hand, and that fatigue is not only the root cause of our quality problems, but one of the biggest factors"*

- *"fatigue seems to sum it up"*

IE's are used to thinking about Allowances

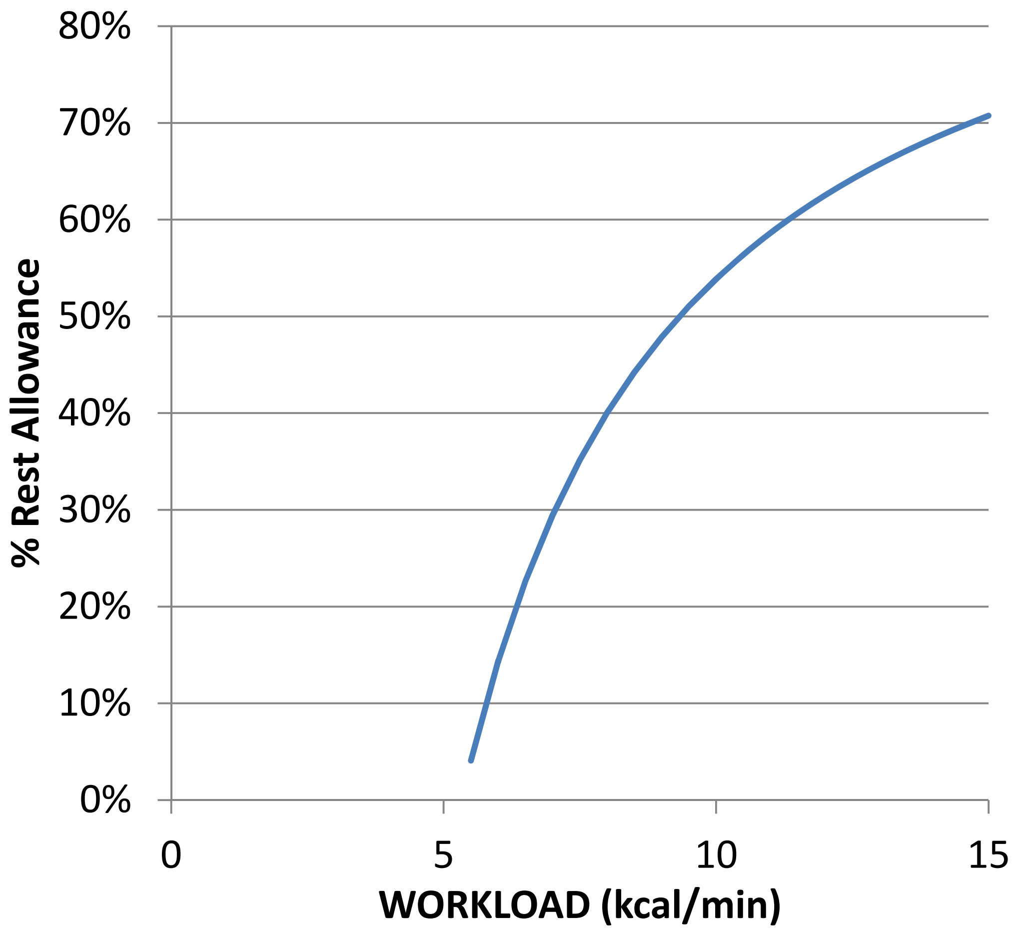


Niebel/Freivalds, 2009

- Allowances account for unavoidable (normal) delays
- Allowable delays may depend on company policy

- Table 11.8

% REST =(W-5.33)/(W-1.33)



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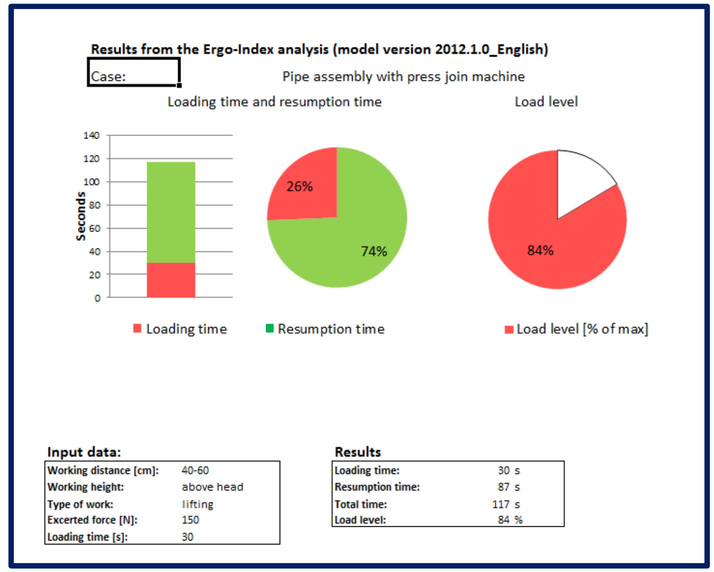
Ergo-Index:
Assessing recovery need in manual work



Working distance [cm]:	40-60
Working height:	above head
Type of work:	lifting
Excerted force [N]:	150
Loading time [s]:	30

Loading time:	30	s
Resumption time:	87	s
Total time:	117	s
Load level:	84	%

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Background

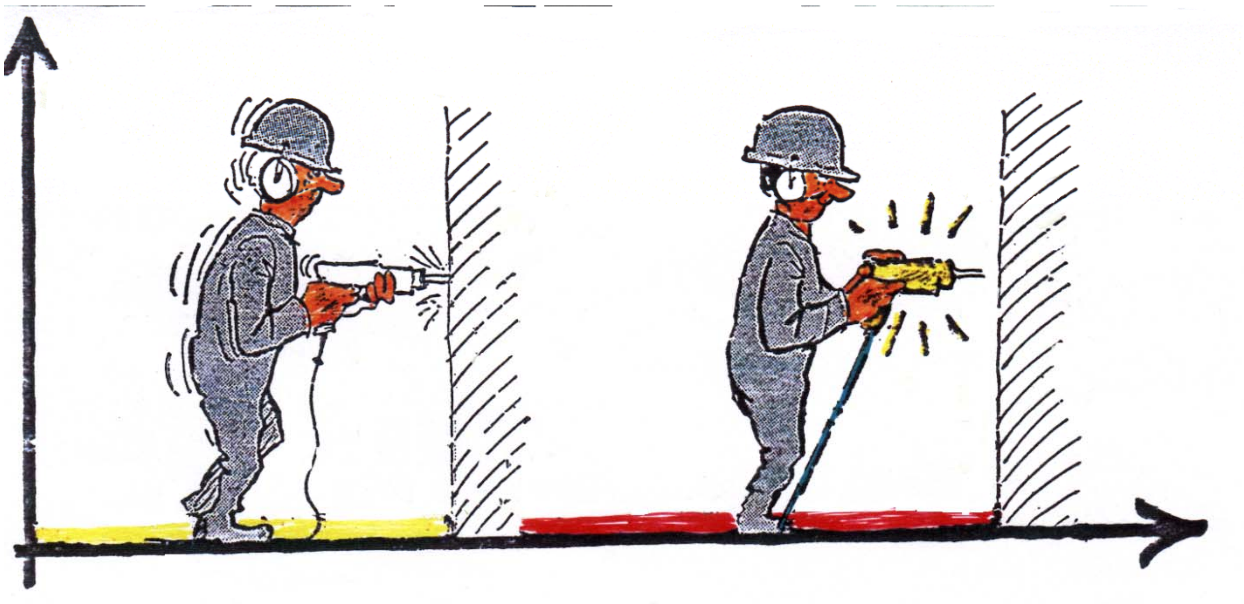
- Fatigue and Injury compromise strategic goals

- MSDs
  - Recovery
    - Load level
      - Performance

- Possible to combine assessment of 'ergonomics' and production economics?

Different ways to analyse work

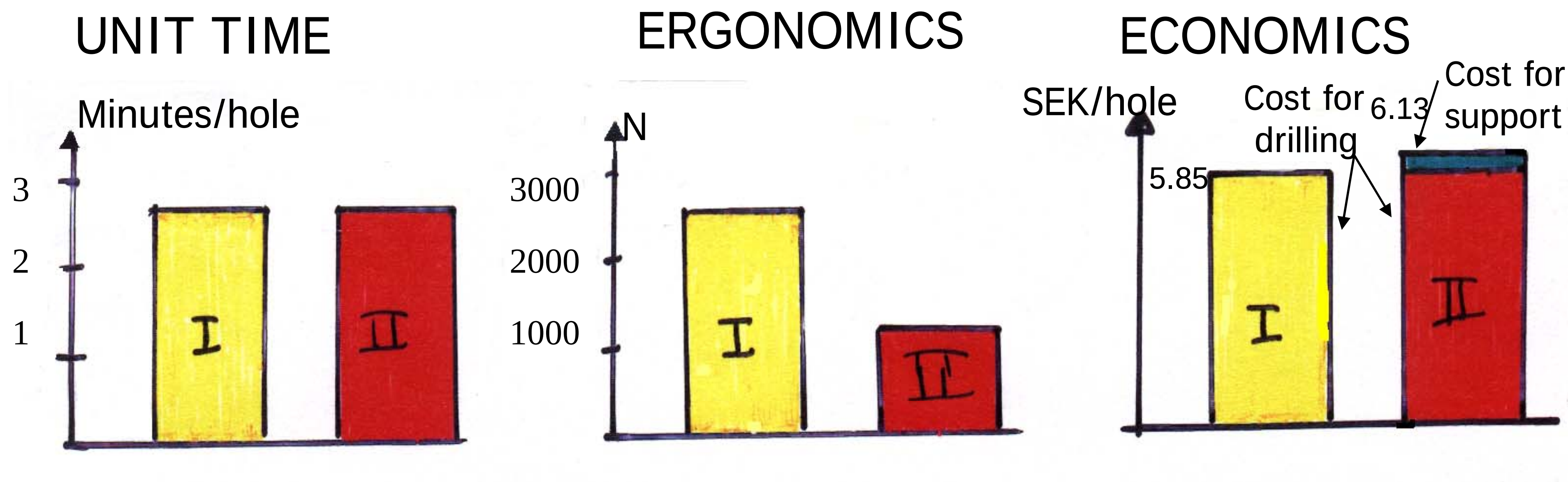
Chiselling/drilling in concrete wall



I: No support II: With support

[Glimskär et al.]

Traditional comparison



[Glimskär et al.]

Would you invest in alternative II?

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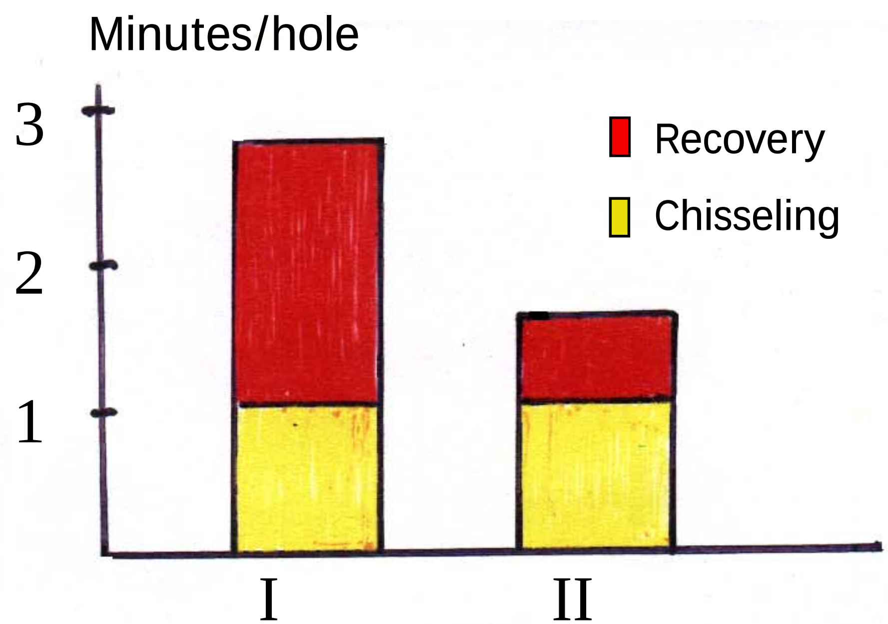
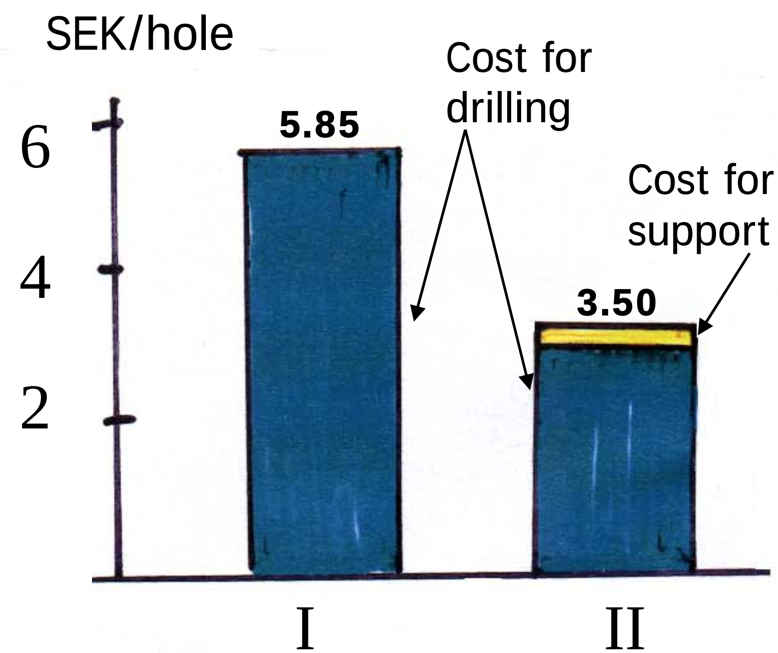
Ergo-Index rationale

PRODUCTION TIME



ECONOMICS



[Glimskär et al.]

Would you invest in alternative II?

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Ergo-Index

A model to evaluate job tasks regarding load level, time aspects and risk of injury, to be able to choose the "best" alternative from both ergonomic and production economics aspects.

1980s: Model based on literature and experimental studies

1990-2001: Further developed

2004: Call from industry
GM in North America among the users

Current project: Focus on:
1. Endurance time and Resumption time modelling
2. Repeated loading situations
3. Rating of Perceived Discomfort

Subjective assessment of recovery need

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Quotes about use of the Ergo-Index

- “It is used both proactively (design) and reactively “
- “It is used to make determinations about recovery time in jobs and if there is insufficient recovery time then the job is changed. “

[GM]

An applied example

Assembling windows at a construction site

Manually:

With robot:

At first glance:

“Heavier, but faster”

“Easier, but slower”

Patrick Neumann & Linda Rose, 2012

Manual window transportation 1(2)

Ergo-Index input data sheet (model version 2012.1.0_English)

Working distance: ◉ 0-40 cm ○ 40-60 cm ○ 60-80 cm

Working height: ○ foot-knuckle ◉ knuckle-shoulder ○ shoulder-head ○ above head

Type of work: ◉ lifting ○ pulling ○ pushing

Excerted force [N]: 375

Loading time [s] 15

Give a name to this case: Manual window transportation

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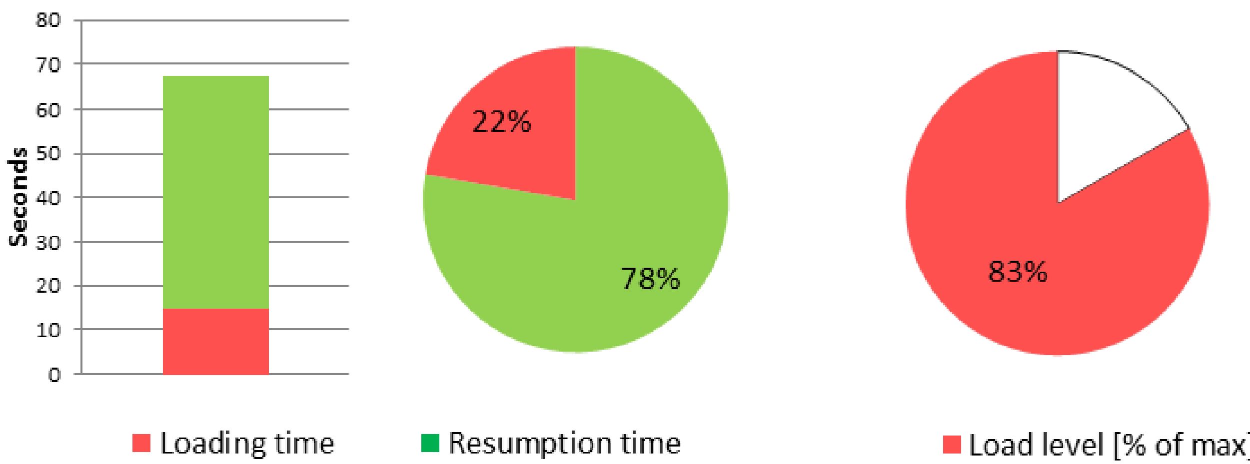
Manual window transportation 2(2)

Results from the Ergo-Index analysis (model version 2012.1.0_English)

Case: Manual window transportation

Loading time and resumption time

Load level



This load level is assessed to lead to a high risk of MSD-problems!

Input data:

Working distance [cm]:	0-40
Working height:	knuckle-shoulder
Type of work:	lifting
Excerted force [N]:	375
Loading time [s]:	15

Results

Loading time:	15 s
Resumption time:	52 s
Total time:	67 s
Load level:	83 %

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Robot window transportation 1(2)

Ergo-Index input data sheet (model version 2012.1.0_English)

Working distance:	○ 0-40 cm ○ 40-60 cm ◉ 60-80 cm
Working height:	○ foot-knuckle ◉ knuckle-shoulder ○ shoulder-head ○ above head
Type of work:	○ lifting ○ pulling ◉ pushing
Excerted force [N]:	80
Loading time [s]	20
Give a name to this case:	Robot window transportation

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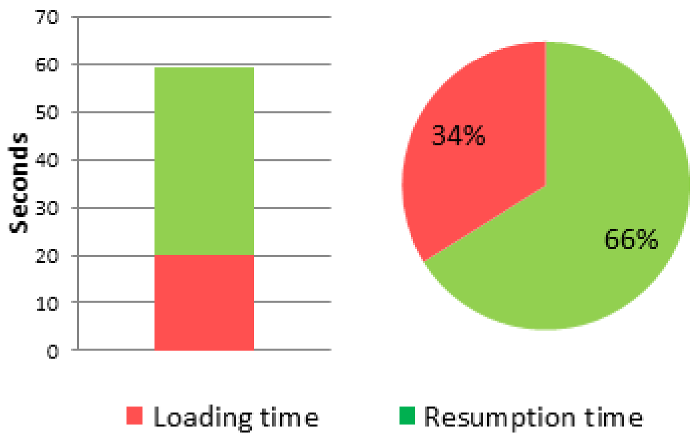
Robot window transportation 2(2)

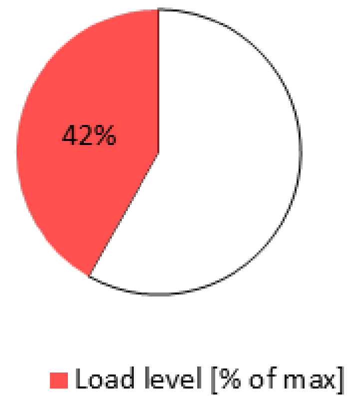
Results from the Ergo-Index analysis (model version 2012.1.0_English)

Case: Robot window transportation

Loading time and resumption time



Load level



Input data:

Working distance [cm]:	60-80
Working height:	knuckle-shoulder
Type of work:	pushing
Excerted force [N]:	80
Loading time [s]:	20

Results

Loading time:	20	s
Resumption time:	39	s
Total time:	59	s
Load level:	42	%

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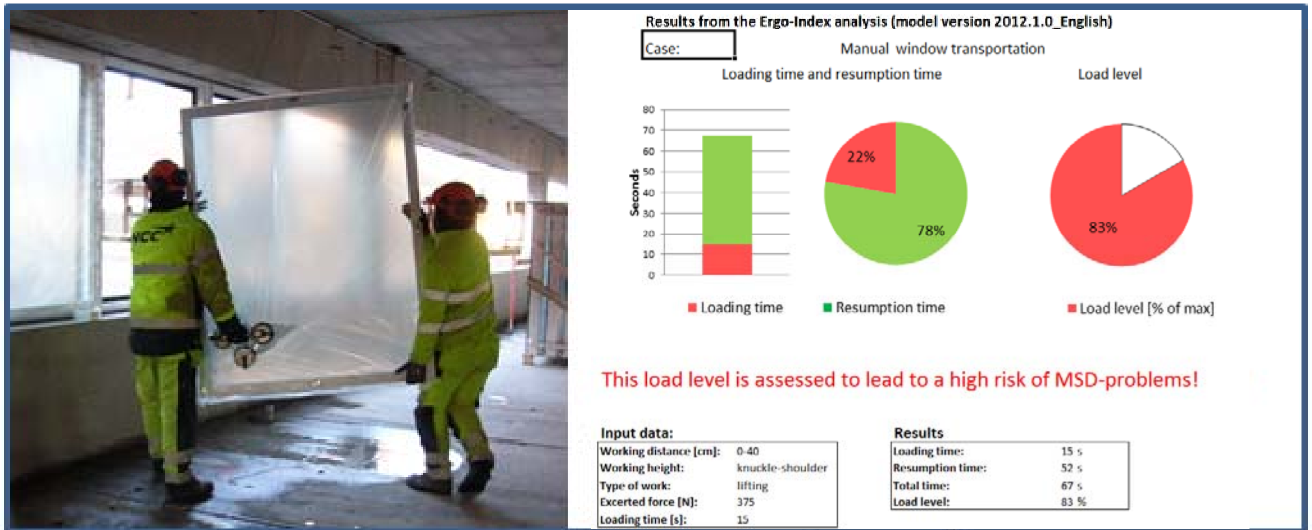
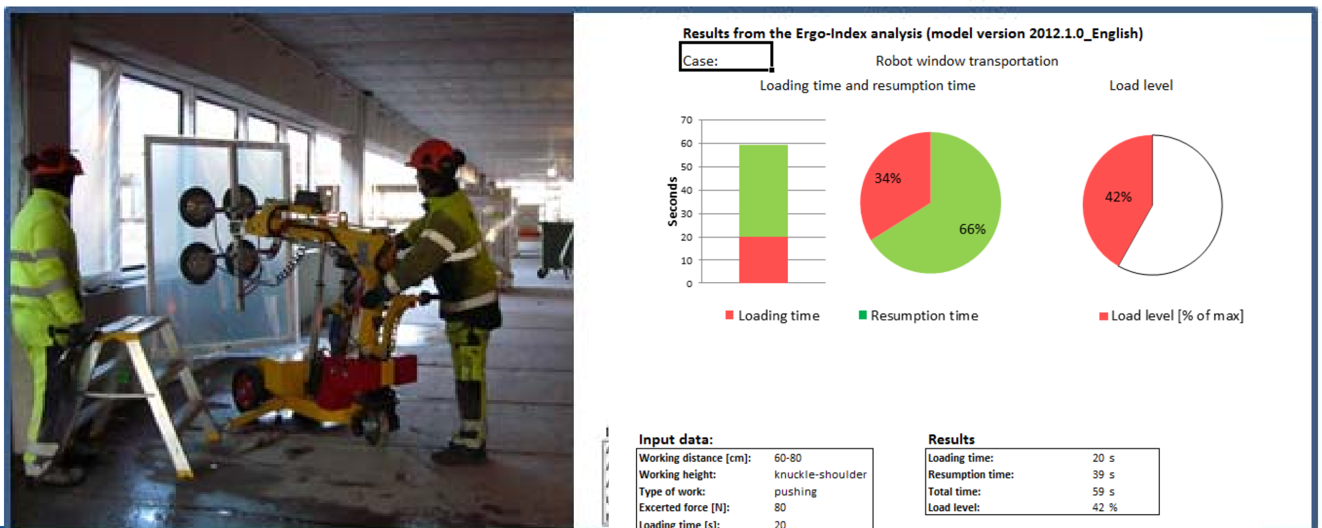
Ergo-Index summary





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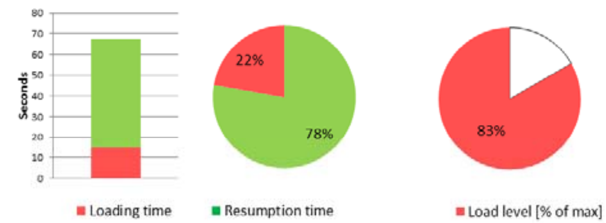
Ergo-Index summary

Results from the Ergo-Index analysis (model version 2012.1.0_English)

Case: Manual window transportation



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Results

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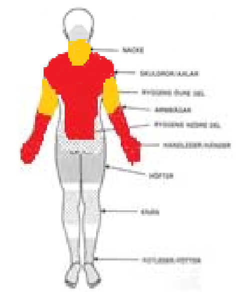
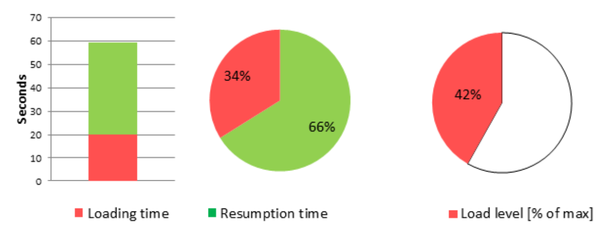
Borg's CR-10 & body map



Discomfort rating: 6

Results from the Ergo-Index analysis (model version 2012.1.0_English)

Case: Robot window transportation

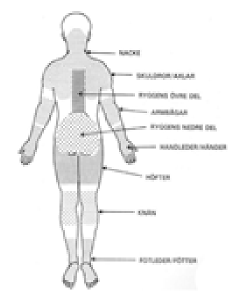


Input data:

Working distance [cm]:	60-80
Working height:	knuckle-shoulder
Type of work:	pushing
Excerted force [N]:	80
Loading time [s]:	20

Results

Loading time:	20 s
Resumption time:	39 s
Total time:	59 s
Load level:	42 %



Discomfort rating: 0.5

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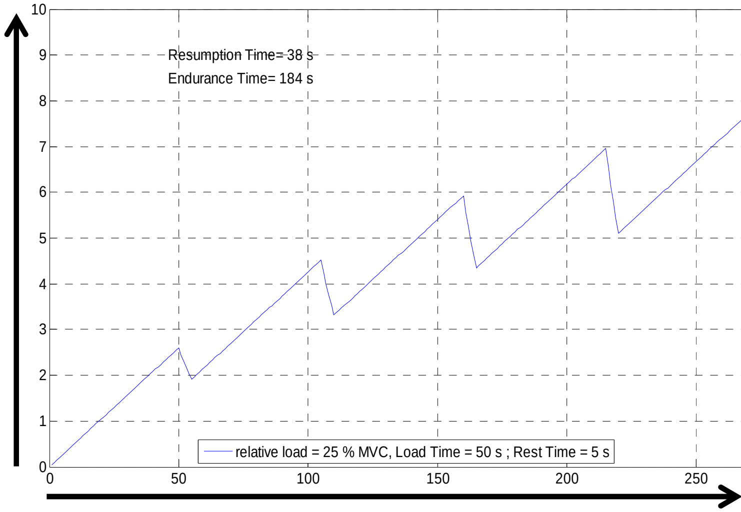
Perceived discomfort prediction model

Example: Same load level, same loading time

Short pause in work cycle:

- Rapid increase in discomfort
- Probably production & health issues

Discomfort

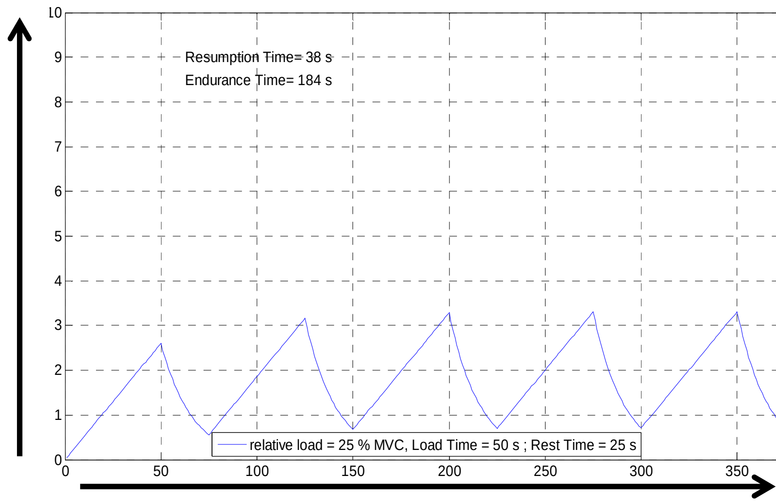


Time

Longer pause in work cycle:

- "Steady state" discomfort
- Probably less production & health issues

Discomfort



Time

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5 Key Points

1. Fatigue affects system performance
2. Engineering Managers ‘get’ that fatigue compromises quality etc.
3. Engineering Directors don’t think about 'ergonomics‘, but about fatigue
4. Higher loads need higher rest allowances
5. Rest allowance models allow you to balance fatigue & productivity concerns

Contact information

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