



Centre of Research Expertise
for the Prevention of
Musculoskeletal Disorders

Improving HFE applicability in organizations - connecting with business processes and using relevant metrics

Michael Greig

*Human Factors Engineering Lab
Toronto Metropolitan University*

How can others not see the benefit of HFE?

- Potential of human factors and ergonomics (HFE) well known

Dual objectives: 1) Wellbeing 2) System Performance (IEA, 2000)

- Why is uptake limited?
- What are challenges with making a connection to organisations and individuals?
- Can HFE be better communicated and connected?

Benefit and potential cost of historical HFE success

Perhaps too much success in one component?

The HFE specialist “...is a tables and chairs guy....”

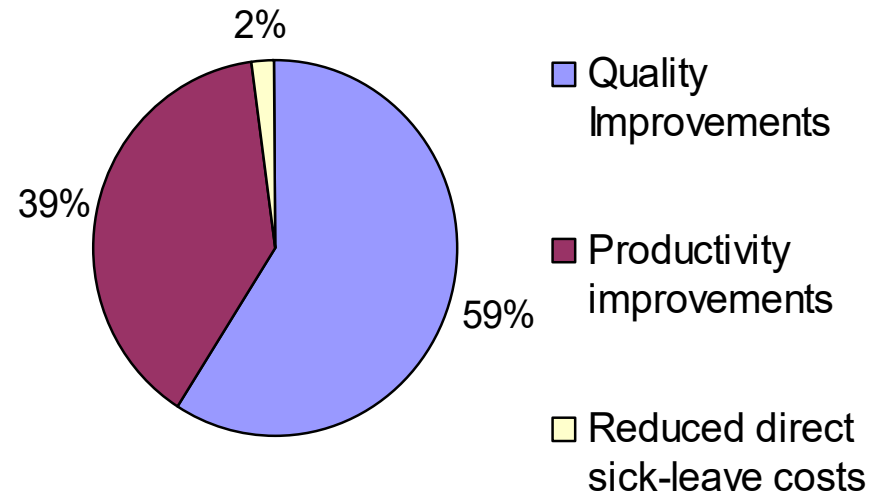
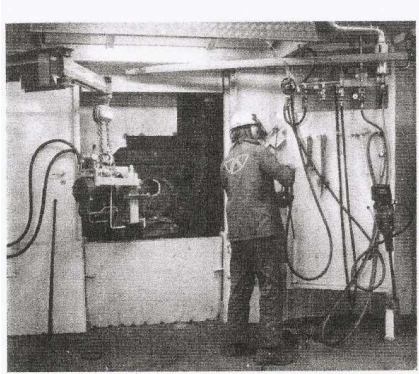
“...most [in the organisation] don’t see ergonomics beyond desks and chairs and injury prevention” (Greig et al, Ergonomics, 2023)

“An irony of the dominant understanding of ergonomics as oriented to safety is that this provides the main basis for its growing presence in workplaces but also limits its applications” (Theberge and Neumann, Relations industrielles / Industrial relations, 2013)

Human effects and system effects converge

		Human effects # papers (%)	
		-	+
System effects	-	3 (8%)	1 (2.6%)
	+	1 (2.6%)	33 (87%)

Benefit to quality and productivity can greatly exceed sick-leave



Investment 11.3 million SEK
"Saving" 5.14 million SEK/
year

(Abrahamsson, 2000)

Quality risk factor effects

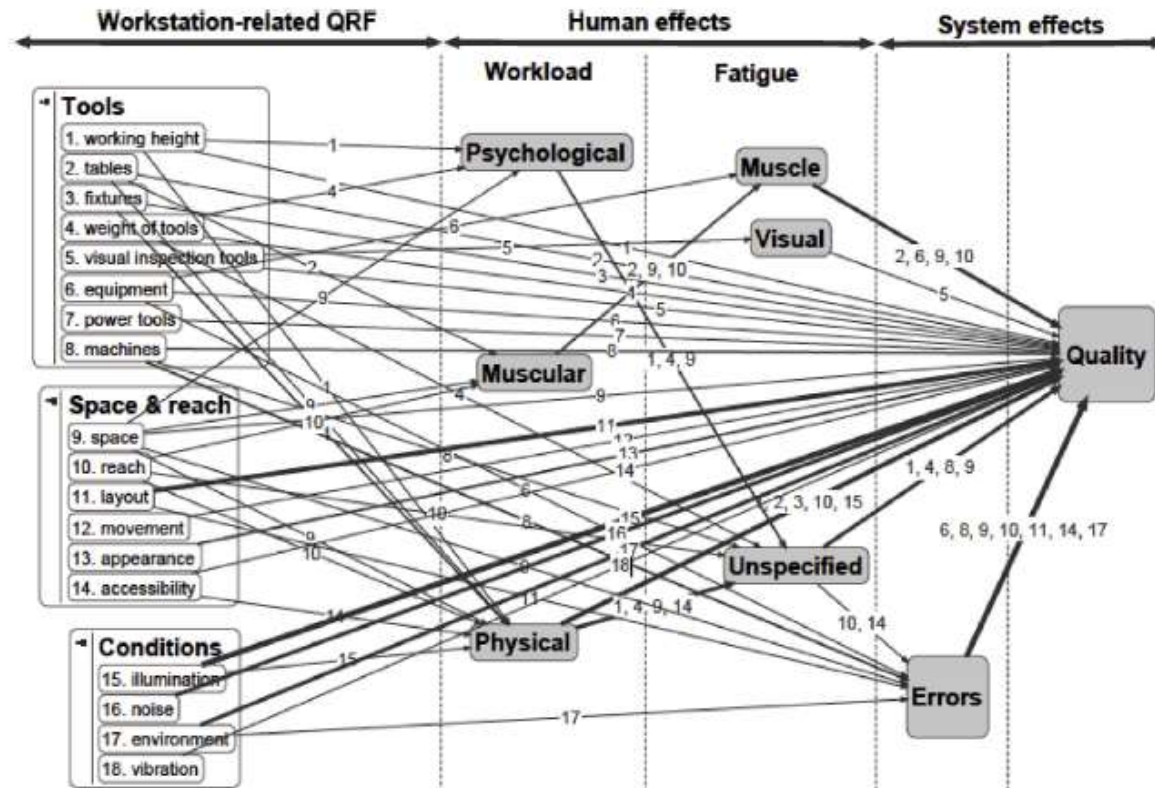
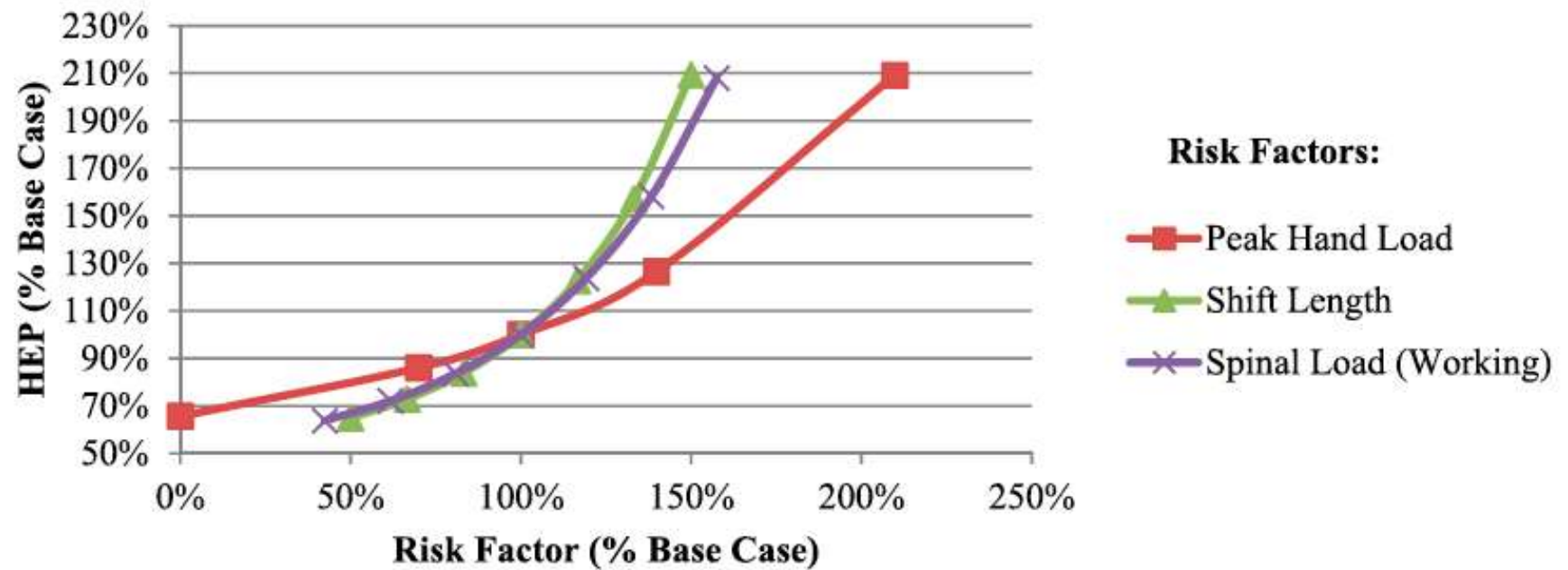


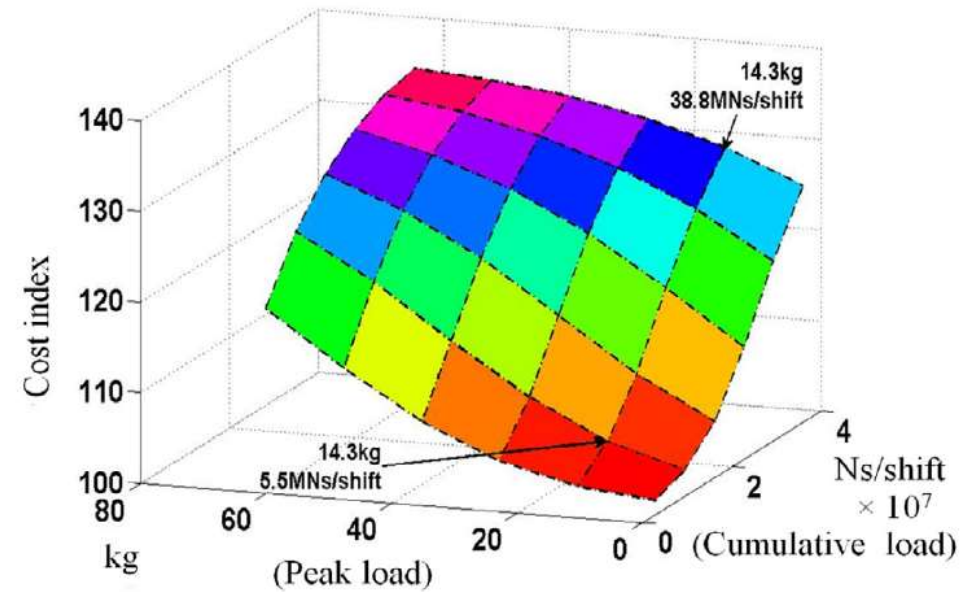
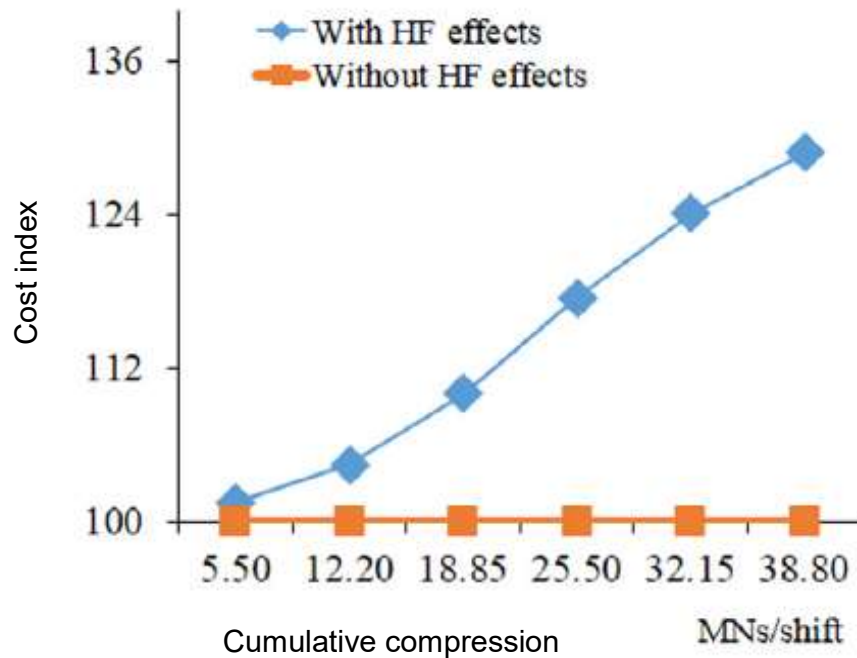
Fig. 6. Workstation-related QRF and their effects on human operators and subsequently on system quality (Numbers on the arrows are associated with the numbers of workstation-related QRF on the left).

(Kolus et al, Applied Ergonomics, 2018)

Error probability and workload



Workload connection to production costs



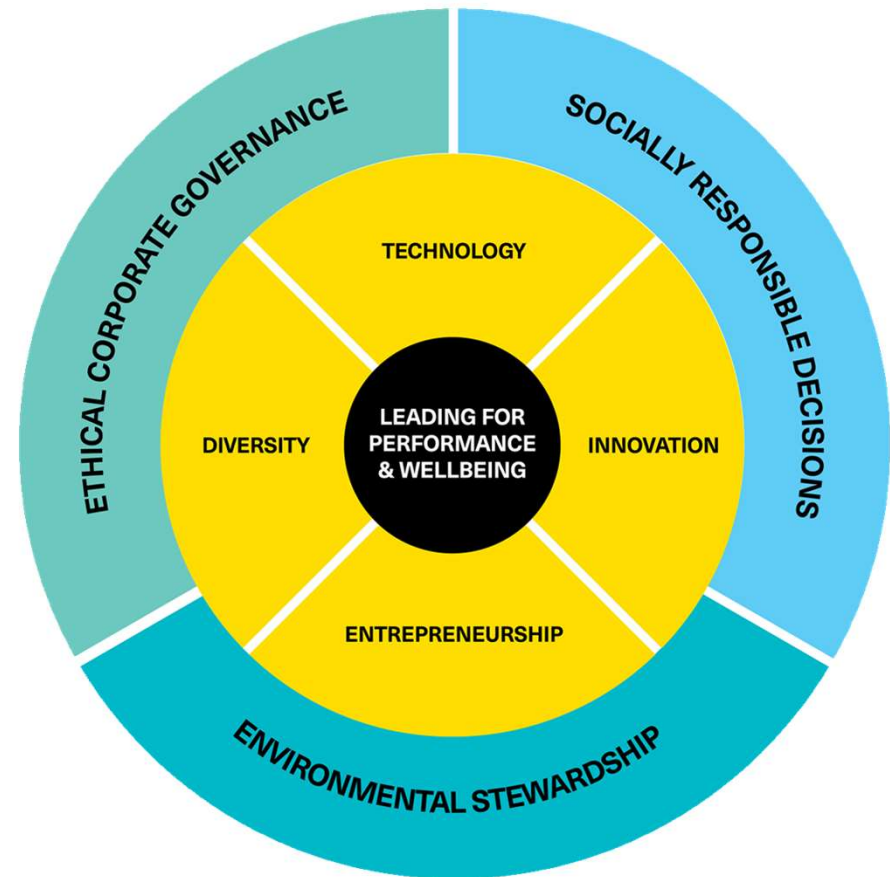
With evidence of HFE-performance connection why could there still be challenges with buy-in?

- What is the background of key personnel?

Ted Rogers MBA at TMU

Leading for Performance and Well-Being

- “Leading for performance and wellbeing is central to the new MBA curriculum. It is driven by four themes: **diversity, technology, innovation and entrepreneurship**. Our Ted Rogers MBA graduates will lead for performance and wellbeing guided by ethical corporate governance, socially responsible decision-making and stewardship of the environment.”



TMU MBA Courses

- Two of 36 courses list performance and/or wellbeing in the title
 - 1) Core Course
 - Leading for Performance and Well-Being
 - 2) Elective Course
 - one of six course choices in Human Resources
 - Mental Health and Wellbeing in the Workplace

Leading for Performance and Well-Being

“...key theories of leadership, central debates about the obligations of leadership, the role of leaders in modern organizations, and the importance of self-awareness for effective leadership and social well-being.

...encourage you to think critically about leadership as both a practice and a field of study.

...help you develop your abilities to lead and follow with resilience.”

TMU MBA Courses

- Mental Health and Wellbeing in the Workplace
 - “The focus of this (half credit) course is on **how to flourish in the workplace**. It is **based on Positive Psychology**, which is a field of study that encompasses six broad areas of research: positive emotions, engagement, relationships, meaning, achievement, and vitality (PERMA-V). **Resilience, as a foundation to flourishing, will be explored and resilience skills and strategies will be taught.**”

Education of engineers lacks HFE content

- How many HFE courses are there in engineering?
- How many are required?

Most common in industrial engineering; 86% of programs no HFE keywords in required courses; 66% no HFE in elective course content

(Black et al, 2023, CEEA Conference; see also the poster of Nancy Black and colleagues at ACE)

- Practicing engineers do not consider the work environment because they lack:
 - Time
 - Knowledge
 - Tools
 - Mandate

(Broberg, 1997, IJIE)

Education of engineers lacks HFE content

- How many HFE courses are there in engineering?
- How many are required?

Most common in industrial engineering; 86% of programs no HFE keywords in required courses; 66% no HFE in elective course content

(Black et al, 2023, CEEA Conference; see also the poster of Nancy Black and colleagues at ACE)

- Practicing engineers do not consider the work environment because they lack:
 - Time
 - Knowledge
 - Tools
 - Mandate

What might be their
yearly/project/personal goals
and objectives?

(Broberg, 1997, IJIE)

What about guidance and standards?

Corporate social responsibility (CSR)

- Work environment (WE) reporting content in CSR reporting is inconsistent
- No consistent definition of WE
 - Working definition “all aspects of the design and management of the work system that affect the employee’s interactions with the workplace”
- 12 WE dimensions developed from literature
- Compared to WE reporting guidance of 14 WE standards on 0 to 4 scale

Table 1

Review criteria to score the quality of work environment dimension reporting included within a standard (from Greig et al. (2019)).

Criteria	Score
Work environment in standard addresses issue related to standard scope; no connection to external reporting of work environment	0
Work environment in standard is related to external reporting is purely descriptive, generic, and without specifics for work environment reporting	1
Work environment in standard is related to external reporting that is either numerical OR qualitative explanation; purely qualitative (L) OR purely quantitative (T)	2 L or T
Work environment in standard is related to external reporting that has numerical and qualitative explanations; qualitative and quantitative	3
Work environment in standard is related to external reporting that is numerical, with qualitative explanations, and a referent allowing comparison in time (year to year) or to a threshold or target; qualitative, quantitative, and comparable	4

More comprehensive reporting guidance needed

Dimension	GRI	<IR>	ISO	ISO	CAN/CSA		CSA	BNQ	CAN/CS	ANSI/ASSE	SA8000:	CAN/CSA	CSA	CSA	CSA
			30414	45001	Z1000-14	Z1004	-12	9700-803/2013	A-ISO 26000:16	Z490.1 -2016	2014	-Z1001-18	Z1002-12 (R2017)	Z1005 -17	Z412 -17
Job demands	0	-	-	-	-	0	1	0	-	-	-	0	0	0	
Health and wellbeing management and outcomes	3	1	2T	0	0	1	1	0	0	0	0	0	1	0	
Work environment design and maintenance	0	-	-	0	-	1	-	0	-	-	0	0	-	0	
Learning and development	3	1	2T	0	-	0	1	0	0	0	0	0	0	-	
Work control	-	-	-	-	-	-	-	0	-	-	-	0	-	-	
Leadership structure, support, and worker participation	0	-	2T	0	0	1	1	0	-	-	-	0	0	0	
Work structure and stability	3	-	2T	1	0	1	1	0	-	0	-	-	-	-	
Work-life balance and work experience/performance	3	-	1	-	0	0	1	0	-	0	-	0	-	0	
Respect and inclusion	3	-	2T	-	-	-	1	0	-	0	-	0	-	-	
Recognition and benefits	2T	-	2T	-	-	-	0	0	-	0	-	0	-	-	
Work type and location	3	-	2T	-	-	-	-	0	-	-	-	0	0	-	
External factors of influence	0	1	-	-	-	-	-	1	-	1	-	-	-	-	



(Greig et al., Journal of Cleaner Production, 2021)

Are expectations of others to come to HFE fair?

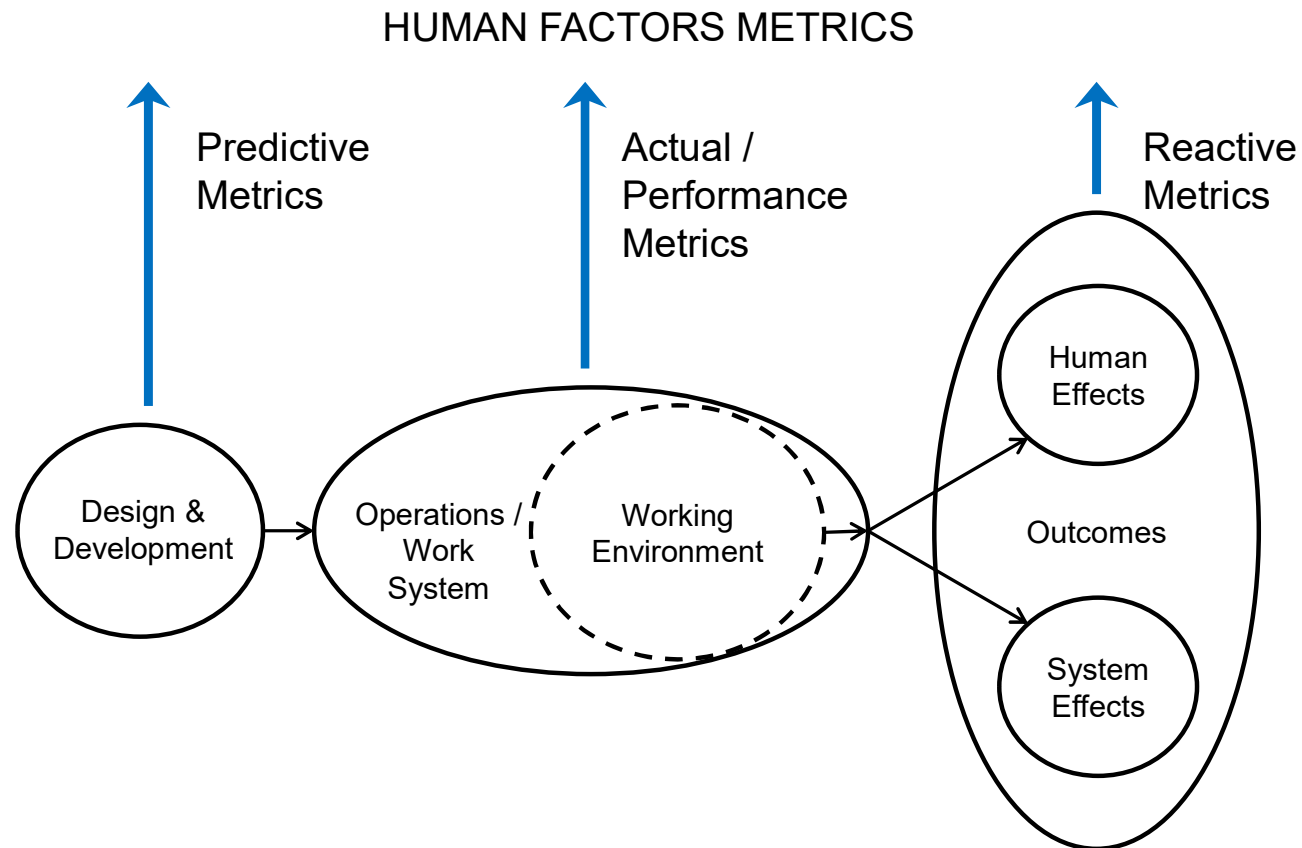
- Lack of knowledge and understanding of HFE contribution
“I didn’t understand how [HF/E] impacted our process” (Greig et al, Ergonomics, 2023)
- Is there an existing “language” in HFE that can start a conversation or contribute to existing conversations that have a business focus?

Metrics constructs and typology

- *Metric* consists of a specific measure, a standard for comparison, and a context of use
- Three constructs:
 - 1) Individual metrics; 2) Metrics sets; 3) Performance measurement system
- Metrics typology – consists of *Metrics Focus* and *Metrics Tense*
- *Focus* – Financial or Operational
- *Tense* – Outcome or Predictive

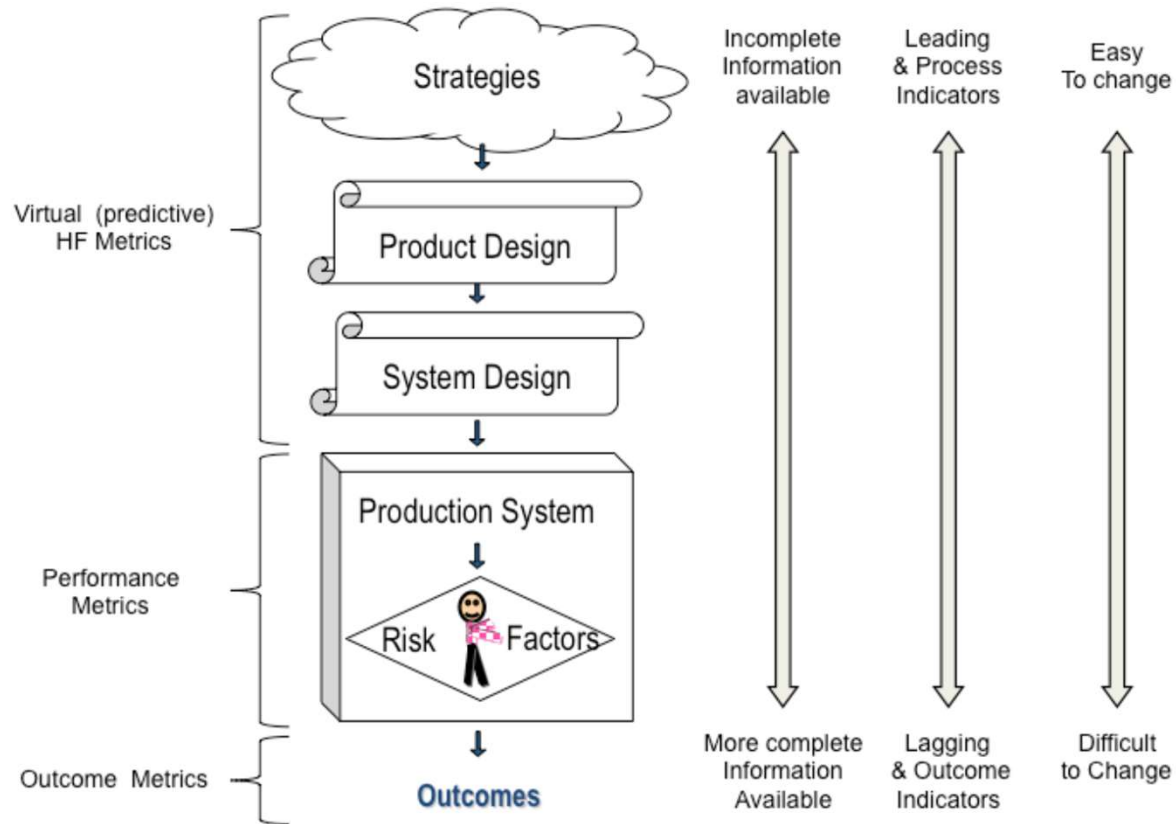
		<i>Metrics Tense</i>	
		<i>Outcome</i>	<i>Predictive</i>
<i>Metrics Focus</i>	<i>Financial</i>	Return on Assets	Overtime Dollars (predictive for budget overruns)
	<i>Operational</i>	Elapsed Lead Time	Number of process steps and setups (predictive for lead times)

HFE metrics connection



Adapted from Neumann and Dul (2010) and Rose et al. (2013)

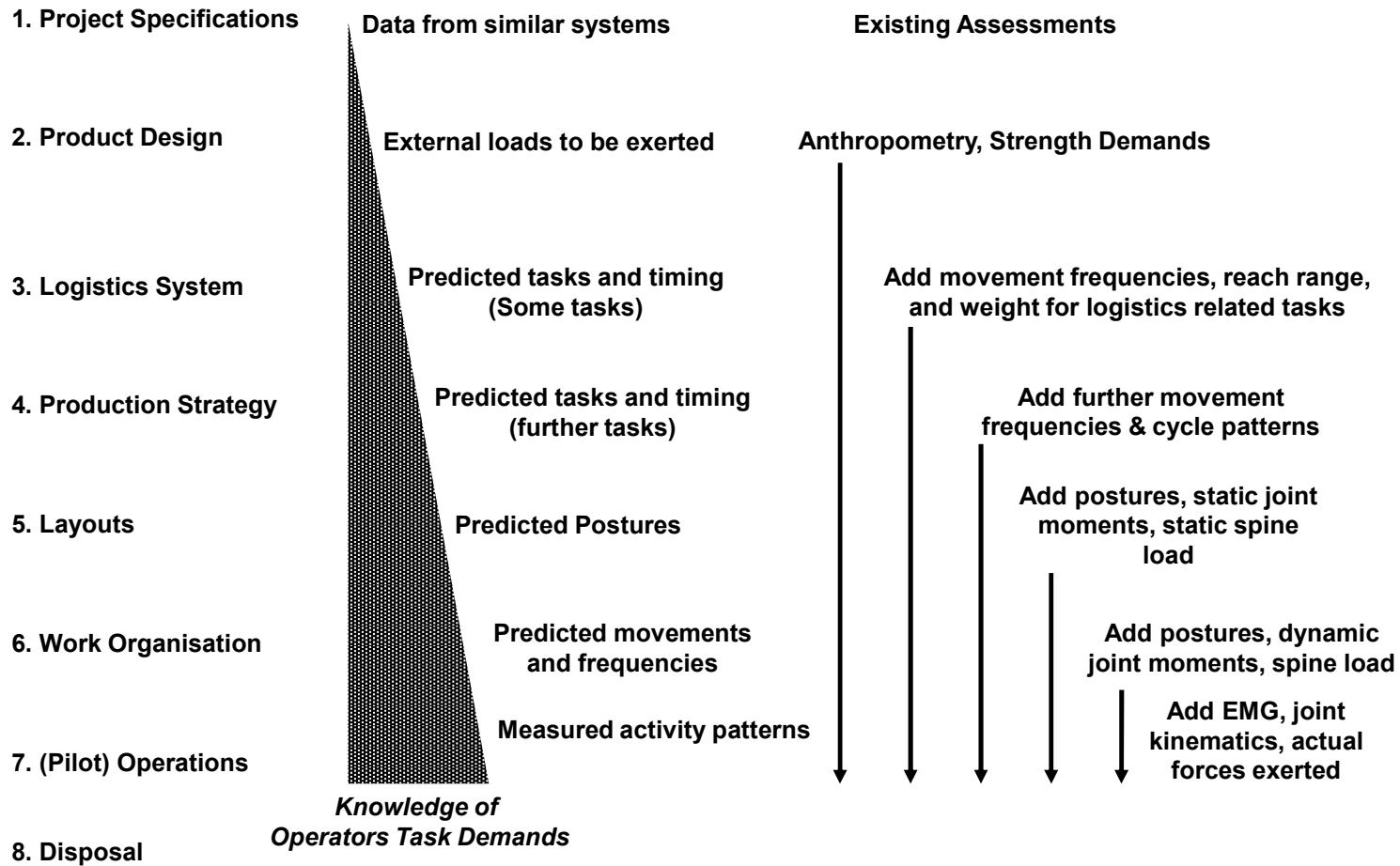
HF metrics issues and the development system



Design Stage

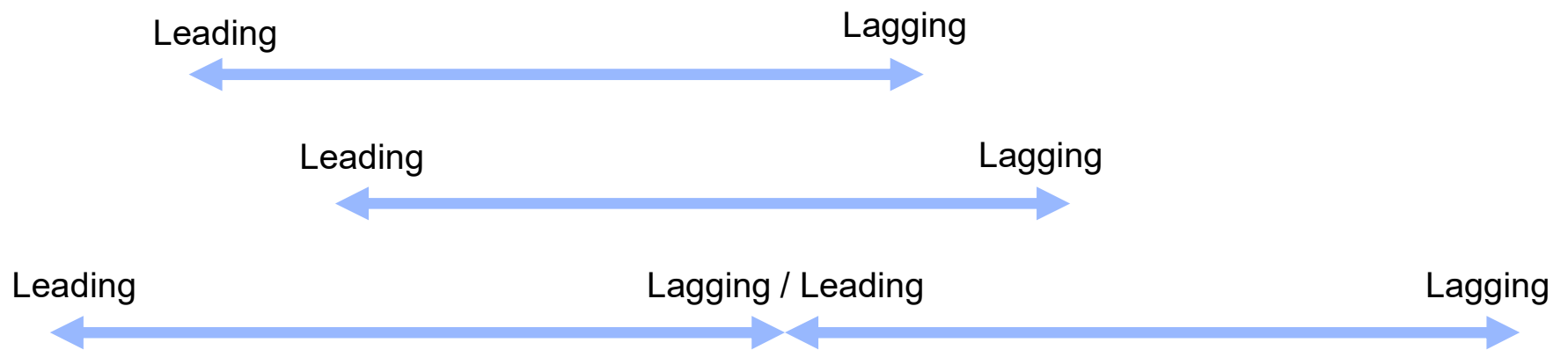
Available Data

Possible Biomechanical Indicators



(Neumann & Wells, 2006, CRC Press)

Leading and lagging indicators have a context dependency



Indicators for managing human centred manufacturing - Propositions on the need for:

1) Strategic HF metrics selection:

HF metrics must be carefully selected to be the most relevant to the particular operations in terms of injury risk, quality, and other strategic goals for the system.

2) Metrics application throughout the development process:

The metric system should allow the identification and evaluation of potential HF issues at the earliest possible stage of development where the costs of change are lowest and solution constraints are minimal.

3) Predictive 'virtual' HF metrics approaches

Predictive tools are required to provide metrics at early design stages and, based on current development, these tools may need to be customised for the particular production context.

Indicators for managing human centred manufacturing - Propositions on the need for:

4) Metrics based design guidelines

Design guidelines should be applied in the form of a metric by which guideline compliance can be quantified and tracked.

5) Connecting metrics with design choices and strategies

Metrics and underlying design criteria need to be designed in ways that span the perspective clash between the technical design aspects and the HF relevant to performance.

6) Integrating HF metrics within existing approaches

Adapting existing metrics approaches (tools) to include HF may be more effective than trying to develop and adopt separate methods.

Indicators for managing human centred manufacturing - Propositions on the need for...

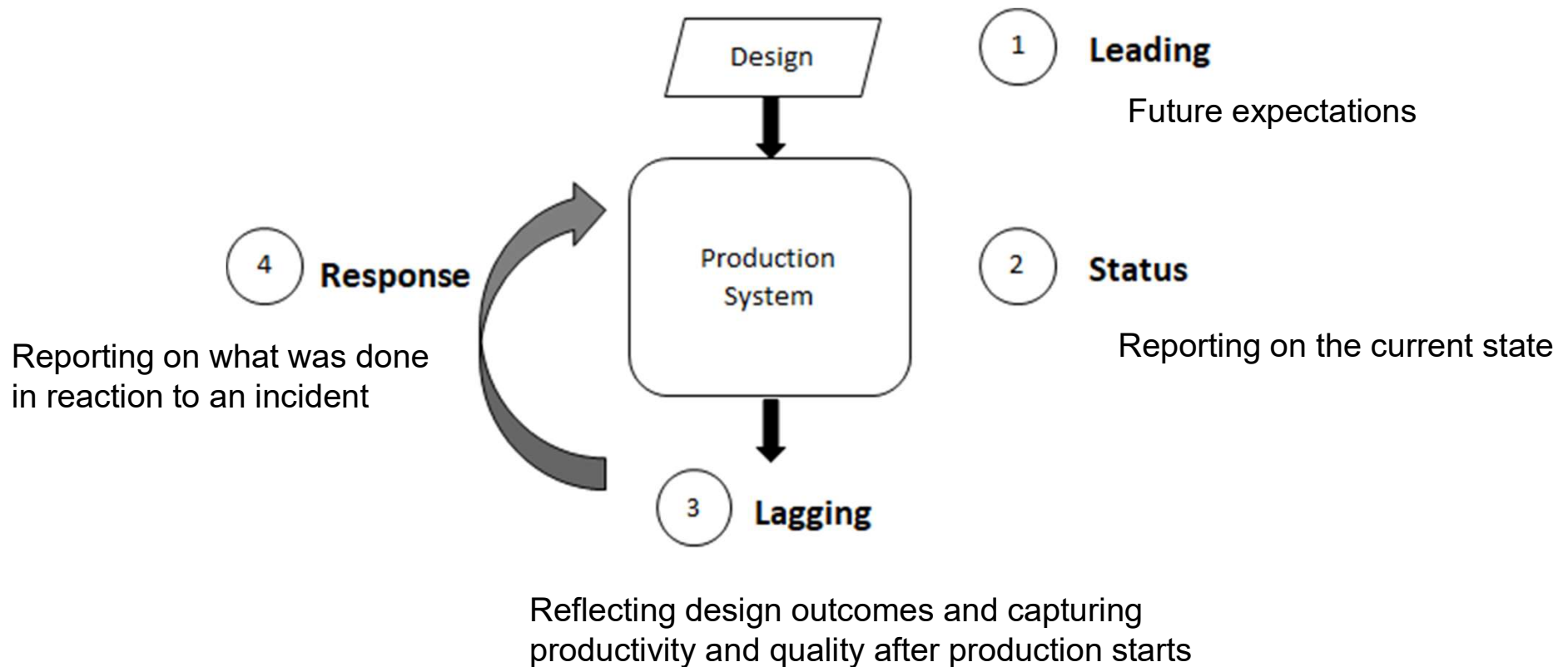
7) Continuous improvement of the metrics system

The metrics system needs to have a mechanism to periodically check if the right HF are being captured, and to adapt the metrics prediction approach to better match the actual HF demands experienced in real production.

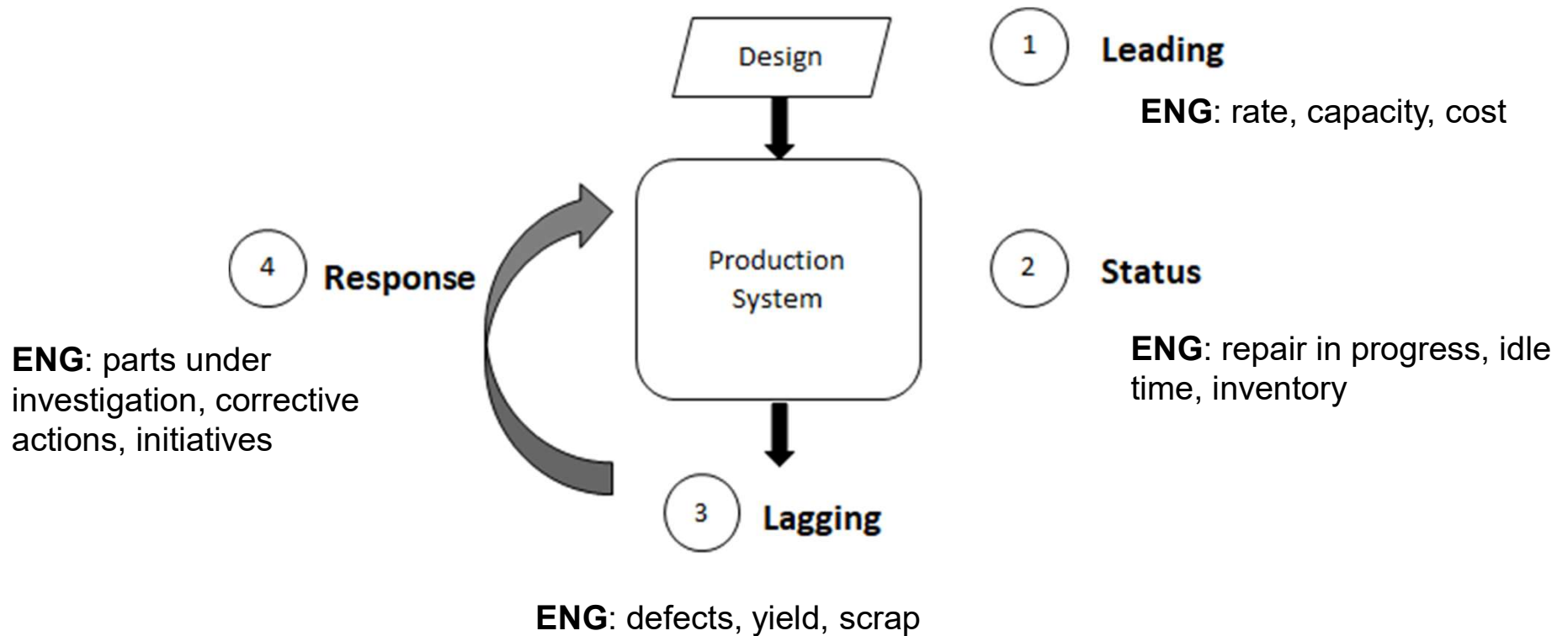
8) The need to evaluate metrics system quality

There is a need for an approach to evaluating the completeness of a company's approach to managing and capitalising on HF aspects in their production system; an approach to scoring a metrics system's quality.

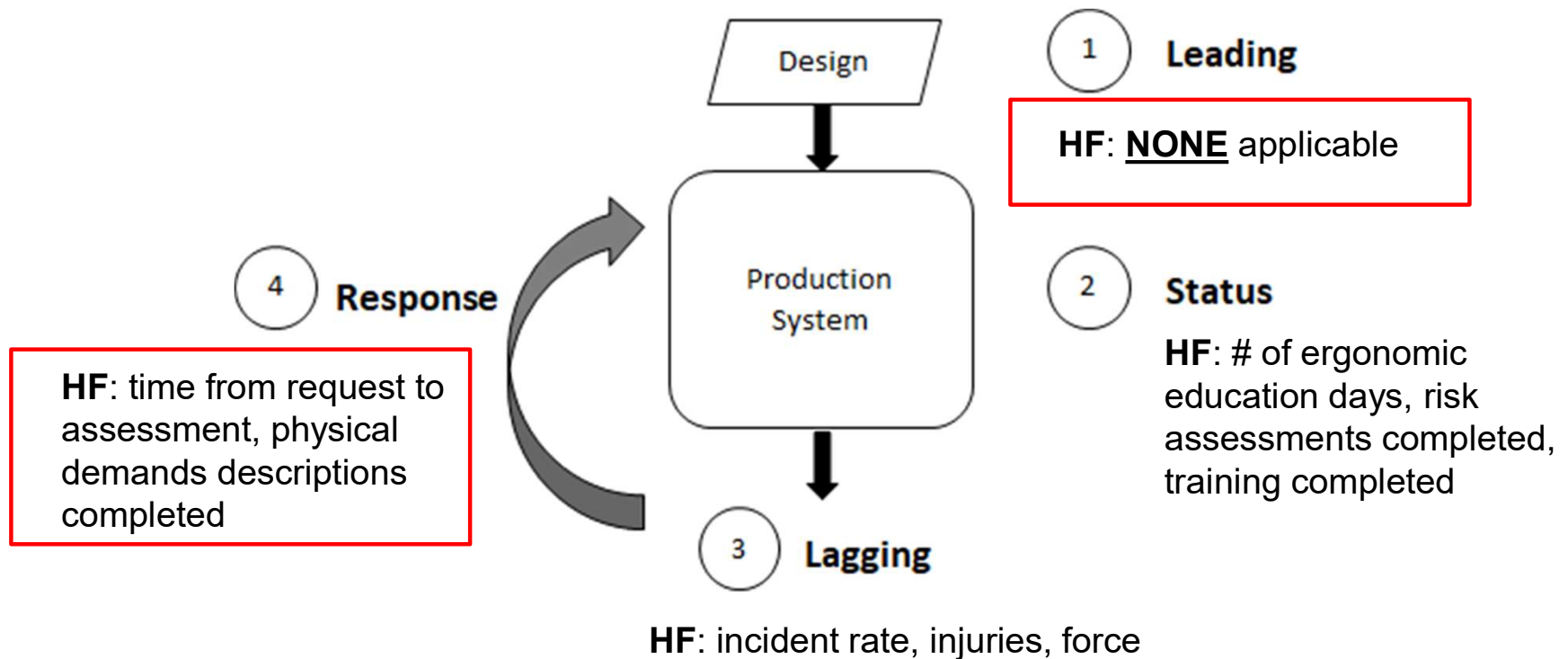
Identified engineering metrics categories in a case company



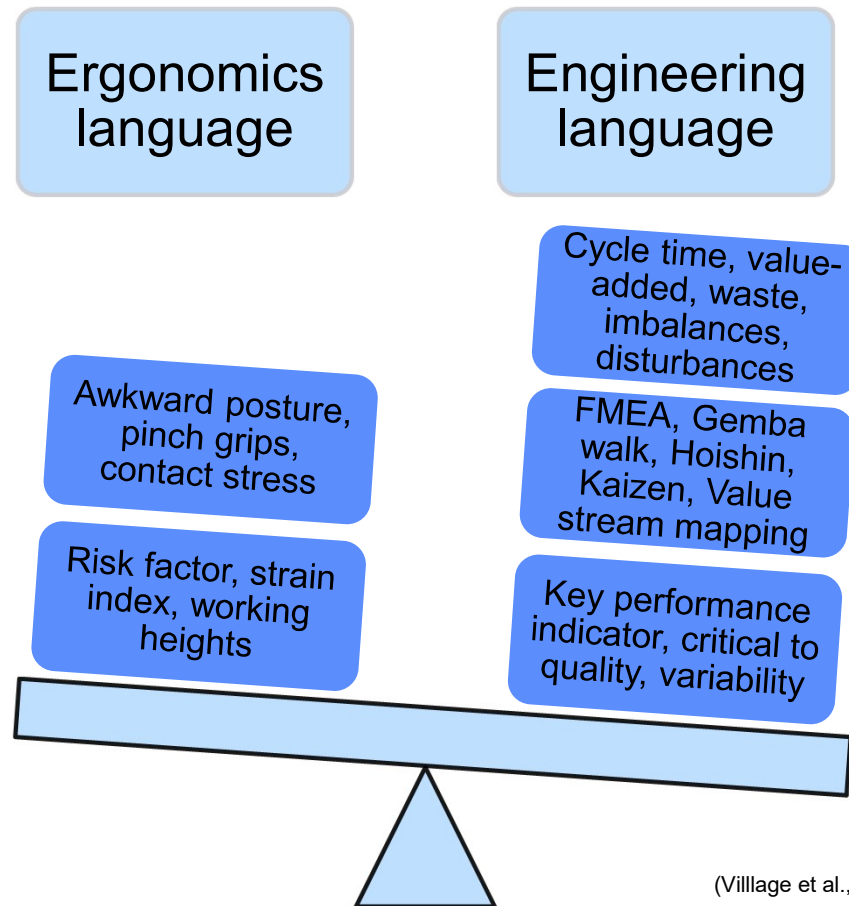
Identified engineering metrics categories



How HF metrics related to engineering metrics



Learn to talk to Engineers



(Village et al., 2015, Ergonomics)

Considerations for metrics in healthcare

- Workload measures “associated with direct care delivery in tertiary healthcare settings”
- Measures from electronic records to “inform operationalization of workload measurement”
- In 30 papers - task-level metrics (9); patient-level metrics (14); clinician-level metrics (7); unit-level metrics (20)
- Objective, workload measures included:
 - patient turnover (9), volume of patients (6), acuity (6), nurse-to-patient ratios (5) and direct care time (5).

Recommendations for developing HFE metrics

“Metric’ refers to qualitative or quantitative information that can be related to a referent for comparison”.

1. Look for gaps that exist between the metrics and indicator information that you communicate and the scope of the information communicated by the group you are looking to work with.
2. Determine the motivation for metrics and indicators – for the organisation and the individual, and make sure that you have information to be impactful at the different levels in the system.
3. Connect to strategic goals and/or individual goals in the organisation to move HF/E beyond a health and safety focus and gain key stakeholder support.

Recommendations for developing HFE metrics

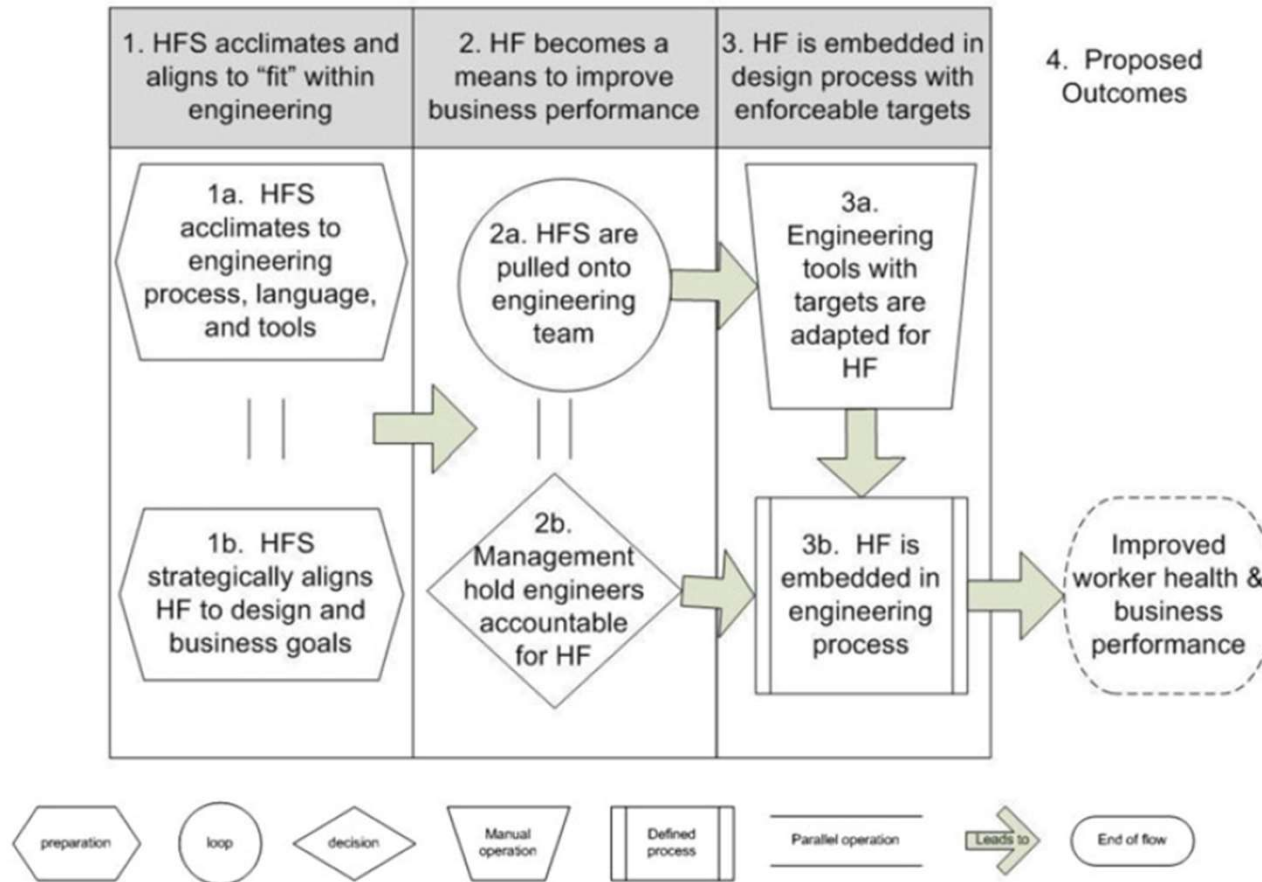
4. Appreciate the background knowledge of the target audience. Educate as required and adapt your communication to their strengths and organisation context.
5. Create information in a style that is familiar to the audience and with an appropriate amount of detail.
6. Be mindful of perceptions of the credibility of the data and data gathering processes.
7. Create processes that integrate with existing workflow or add minimal work. Identify appropriate timing to introduce new concepts and demonstrate the importance to their role or the organisation.

Some key comments

- *‘if [a] production manager’s boss [is] not asking [for] it, [it’s] less likely it will work’.*
- *‘Whatever my manager likes, I’m fascinated about’*
- Need to determine which *‘measures can make their [managers]’ jobs better’*

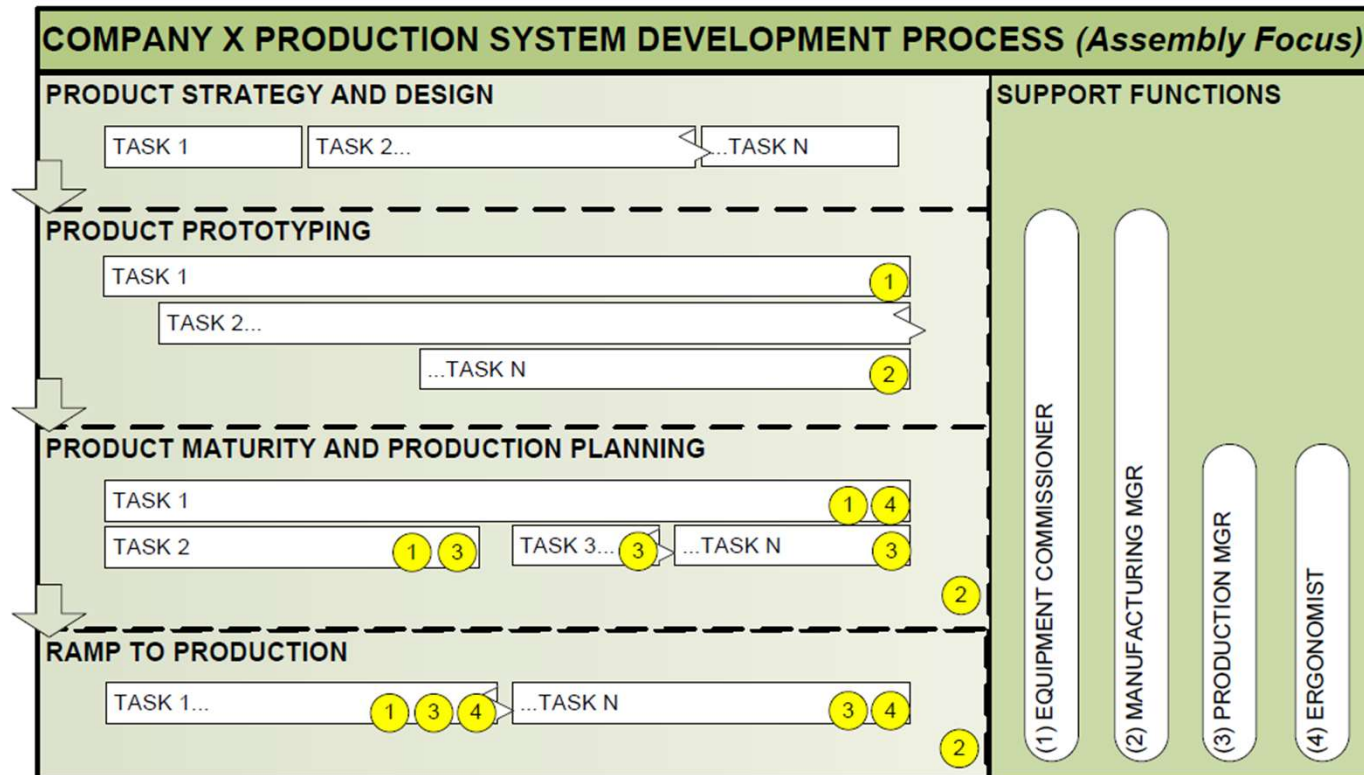
What are some approaches and tools to identify connection points and develop relevant metrics?

Find where fit to improve business performance

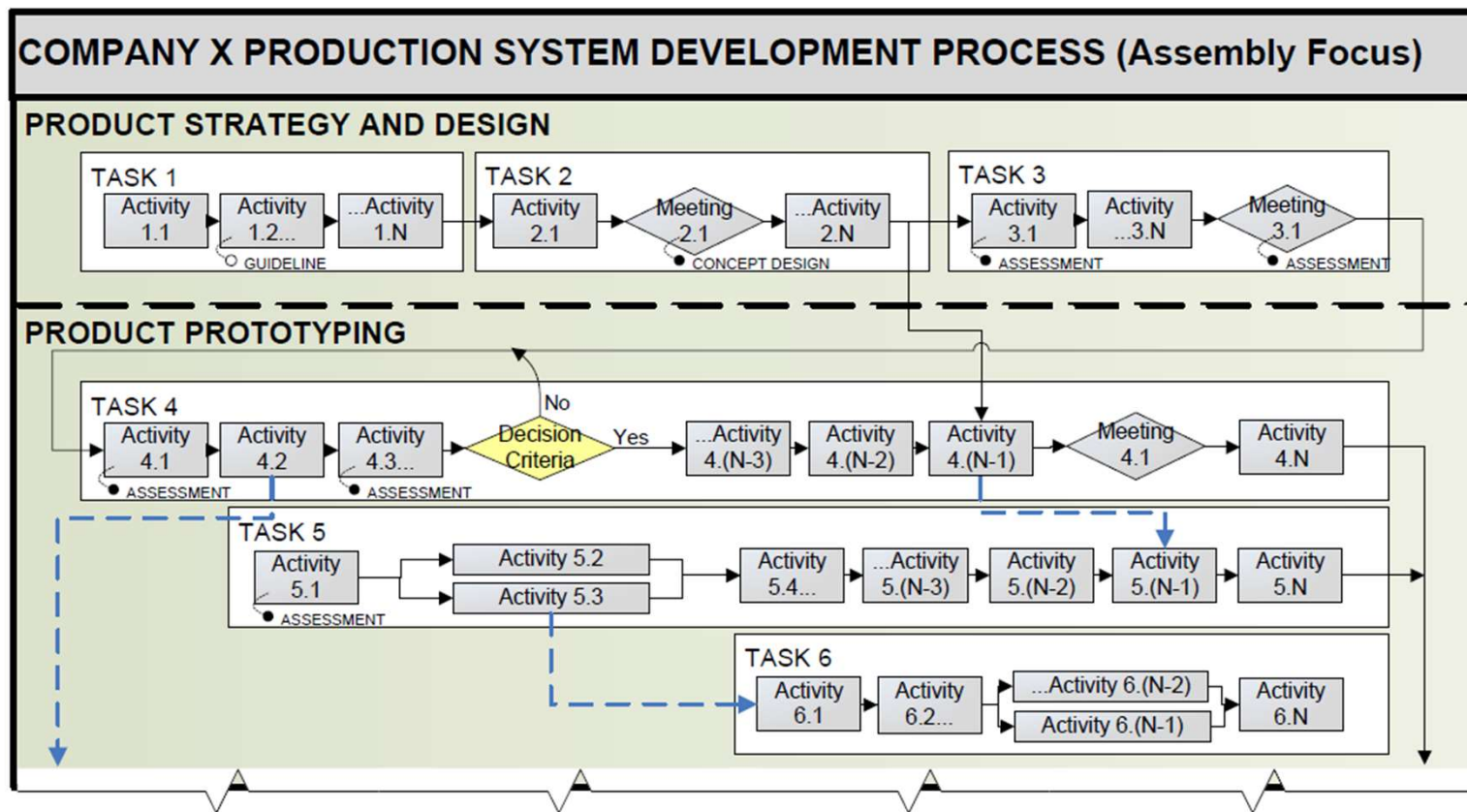


(Village et al, Ergonomics, 2015)

Process mapping to guide integration and information needs



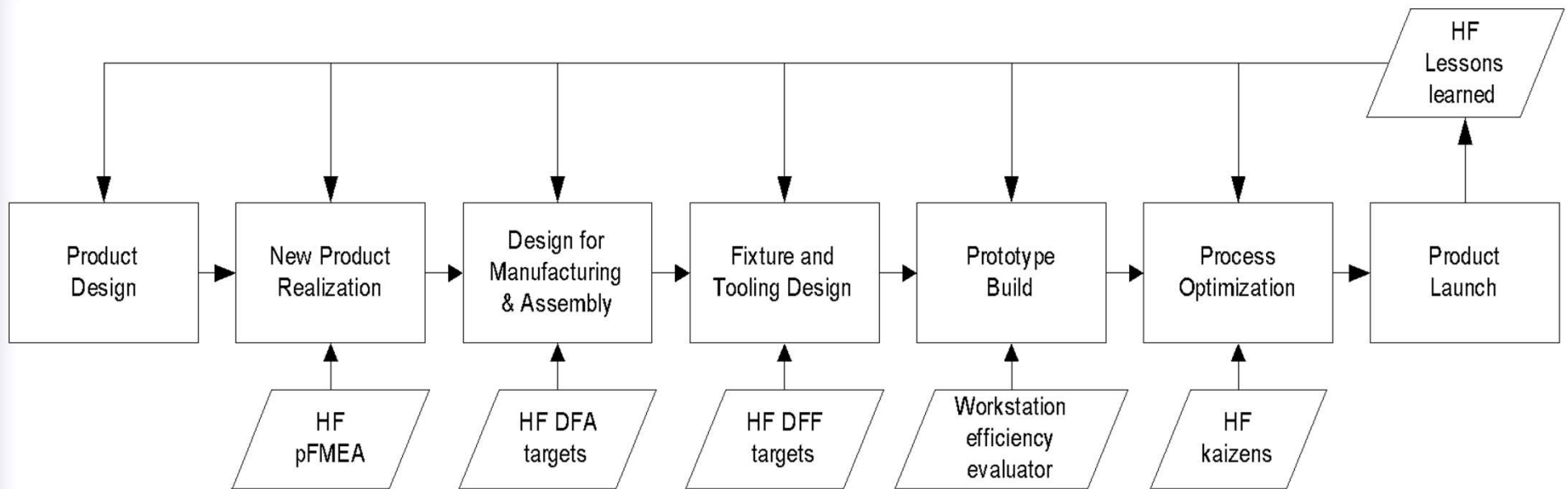
Process mapping to guide integration and information needs



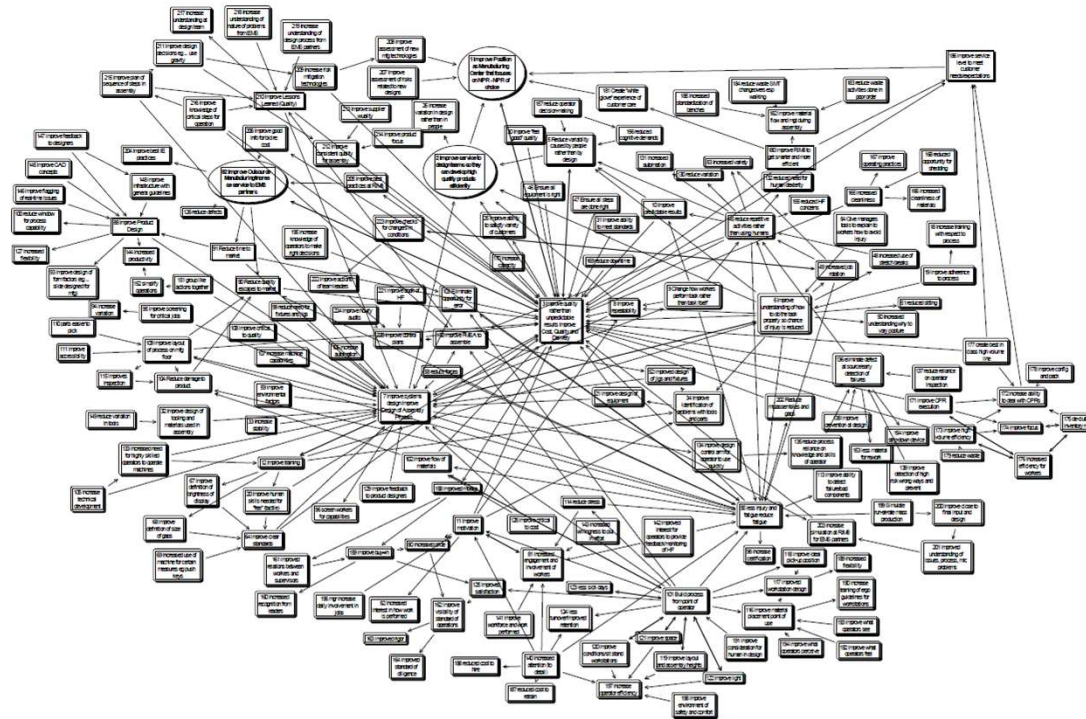
Process mapping to guide integration and information needs

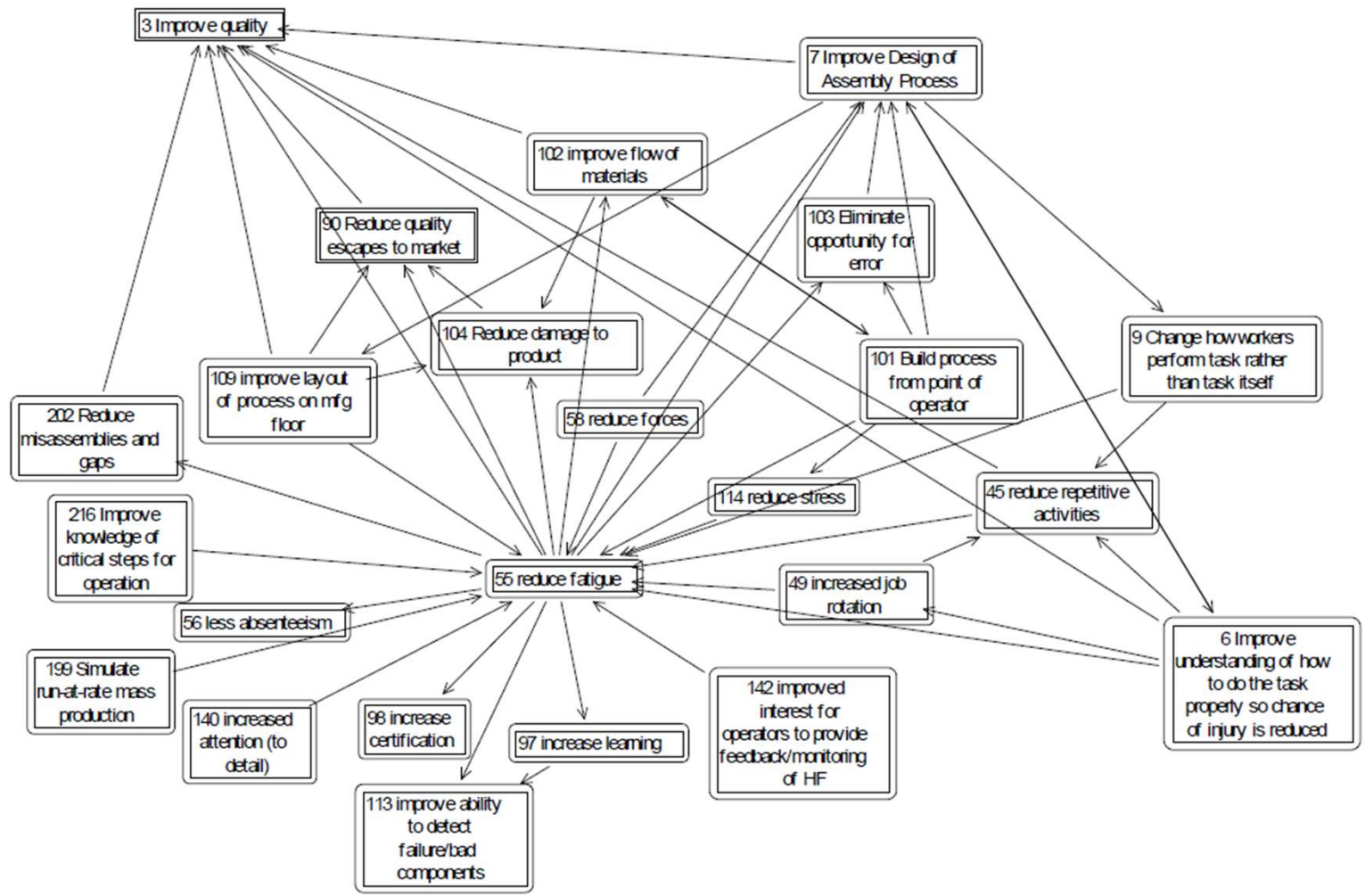


Look for strategic information points in processes



Cognitive mapping as a tool to form connections of logic

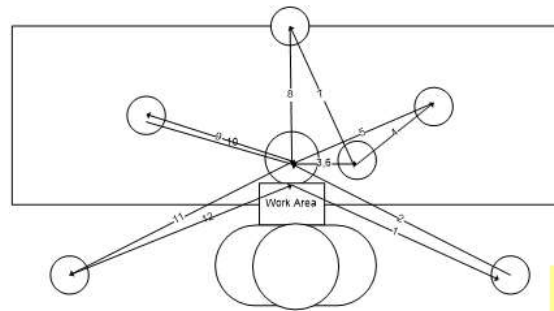




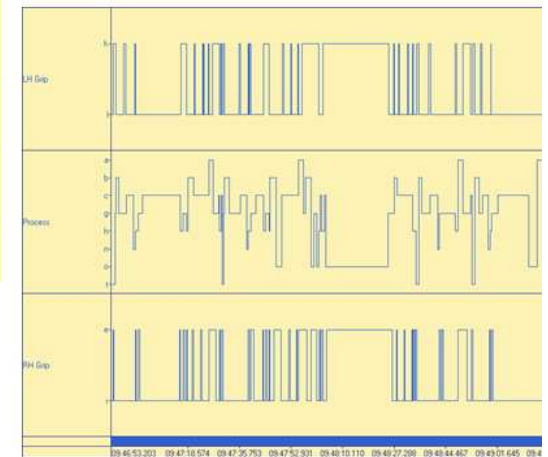
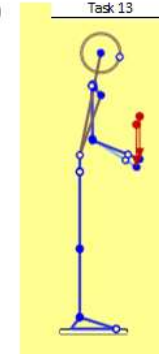
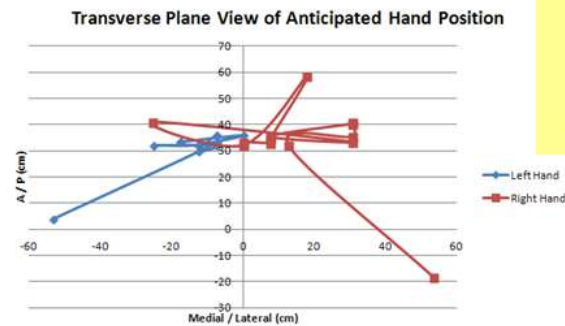
(Village et al., European J. Industrial Engineering, 2016)

Develop tools and approaches using HFE

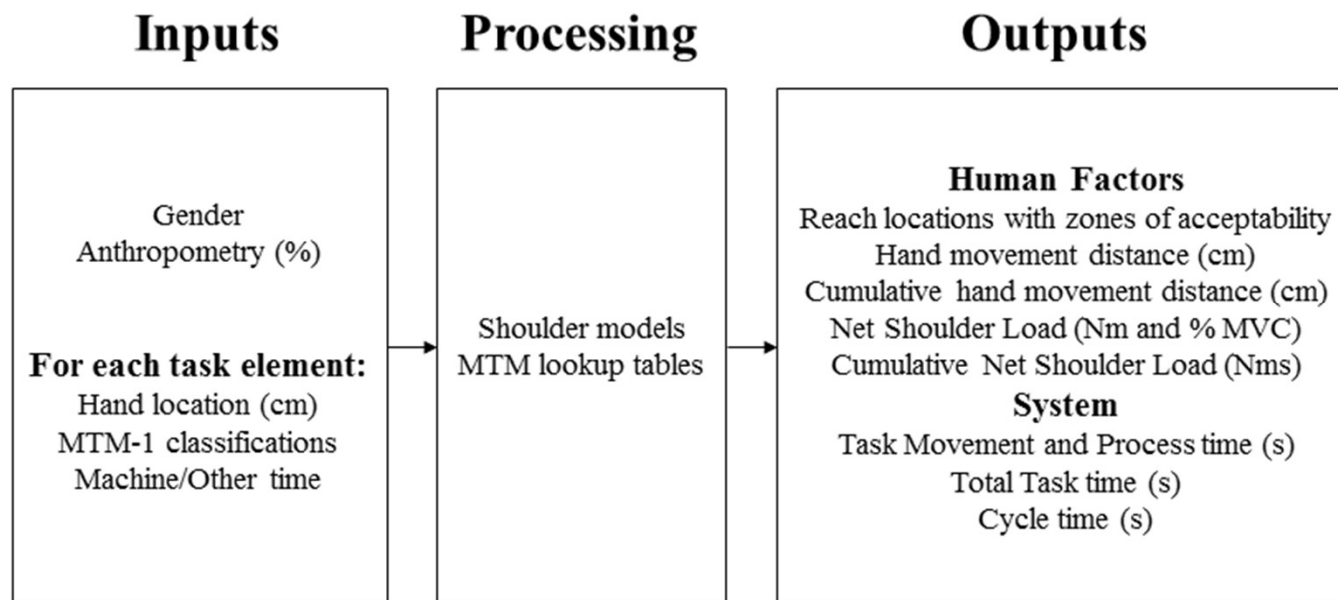
- Example – Workstation Efficiency Evaluator (WEE) Tool
- <https://doi.org/10.329/20/24194820.v1>



Description	Left				Right			
	A-P	Height	Lat (cm)	Load (N)	A-P	Height	Lat (cm)	Load (N)
Task 1	33.4	96.9	-17.78	0	-18.5	87.8	53.34	0.981
Task 2	33.4	96.9	-17.78	0	32.1	94.3	12.7	0.981
Task 3	33.4	96.9	-17.78	0	35.4	102.4	30.48	0.4905
Task 4	35.9	97	0	0	40.8	97.9	30.48	4.905
Task 5	32.1	94.3	-12.7	0	40.3	102.8	30.48	1.962
Task 6	33.4	96.9	-7.62	0	35.4	102.4	7.62	1.962
Task 7	32.1	94.3	-12.7	0	33.4	96.9	30.48	0.4905
Task 8	32.1	94.3	-25.4	0	41	91.2	-25.4	0.1962
Task 9	32.1	94.3	-7.62	0.981 (up)	32.1	94.3	0	0.981 (down)
Task 10	29.8	92.3	-12.7	0	58.3	121.4	17.78	0.4905
Task 11	35.9	97	-7.62	0.981	34.6	99.6	7.62	4.905
Task 12	33	92	-7.62	0.4985	33	92	7.62	0.4985
Task 13	4	94.4	-53.34	0.981	33.4	96.9	0	0



WEE Tool: Information flow



WEE Tool: User informed output

Work Assignment Summary - Domesheet

Analysis and Element Information:

Anthropometry 5%ile female
Number of Elements 35

Continuous Improvement Prioritization:

Top 3 Elements	Element #	Score (max=16)
Move Part	31	6
Place Part to Holder	34	6
Get new part	9	5

Note: There are 2 elements with score = 5. Listing only the first 1 occurring. See full element list below for other:

Hand Travel:

3D Cumulative Hand Travel (cm) Left 630.6 Right 697.2

Hand Location Scores:

Horizontal Zone Review		Count	% of Elements	Count	% of Elements
Zone 2 Count	2	5.7	2	5.7	
Zone 1 Count	7	20.0	6	17.1	
Zone 0 Count	26	74.3	27	77.1	
Sum (Max = 70)	11		10		
Vertical Zone Review		Count	% of Elements	Count	% of Elements
Zone 2 Count	0	0.0	0	0.0	
Zone 1 Count	6	17.1	6	17.1	
Zone 0 Count	29	82.9	29	82.9	
Sum (Max = 70)	6		6		

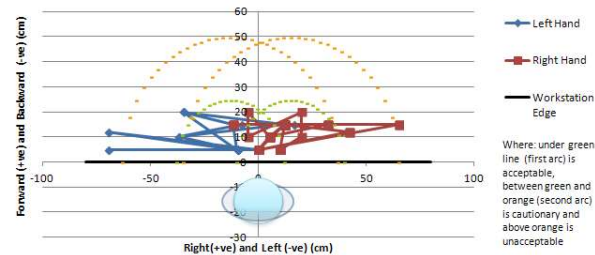
Where: Green is an Acceptable zone, Yellow is a Cautionary zone and Red is an Unacceptable Reach.

	Count	% of Elements	Count	% of Elements
Value Added Count	0	0.0	0	0.0
Non-Value Added Count	0	0.0	0	0.0

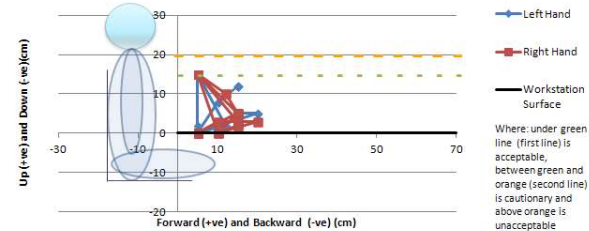
Predicted Times and Rest Allowance:

	Left	Right
Total Value Added Time (s)	0.0	0.0
Total Non-Value Added Time (s)	0.0	0.0
Total Movement Time (s)	10.8	13.2
Total Process Time (s)	1.8	10.3
Machine/Other Time (s)	25.0	
Est. Total Combined Time (s)	57.0	
Rest Allowance Req'd (s)	0.0	
Cycle Rest Allowance %	0.0	

Horizontal Plane (Above) View with Acceptability Ranges



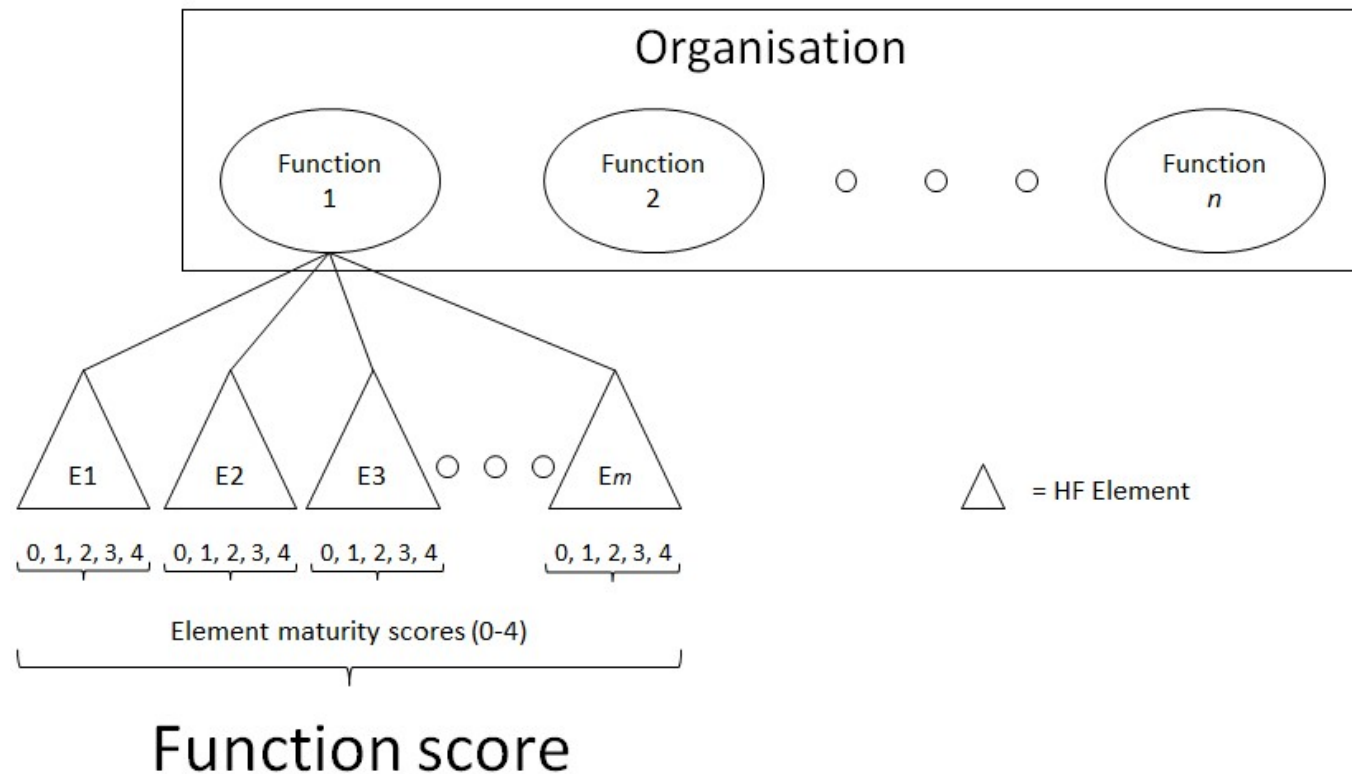
Vertical Plane (Side) View with Acceptability Ranges



Anthropometry used:		5%ile female			
		Pre-info	Post-info	Delta %	Considerations
Number of Elements		27	27	100.0	
Prioritization	First	7	6	85.7	
	Second	5	4	80.0	
	Third	4	4	100.0	
Cumulative Hand Travel (cm)	Left	589.4	561.5	95.3	
	Right	625.4	581.1	92.9	
Cumulative Shoulder Load (Nms)	Left	59.7	55.7	93.4	
	Right	88.2	84.5	95.8	
Horizontal Reach Count:					
Left	Zone 2	2	1	50.0	
	Zone 1	4	5	125.0	
	Zone 0	21	21	100.0	
Right	Zone 2	2	1	50.0	
	Zone 1	5	5	100.0	
	Zone 0	20	21	105.0	
Vertical Reach Count:					
Left	Zone 2	1	1	100.0	
	Zone 1	4	4	100.0	
	Zone 0	22	22	100.0	
Right	Zone 2	4	4	100.0	
	Zone 1	7	7	100.0	
	Zone 0	16	16	100.0	
Value Added / Non-Value Added:					
Value/Non-Value Total	Left	28.7276	28.6052		
	Right	27	27		
Value Added Count	Left	4	4	100.0	
	Right	6	6	100.0	
Non-Value Added Count	Left	23	23	100.0	
	Right	21	21	100.0	
Value Added Time (s)	Left	5.7	5.6	97.9	Check effect of Number of Elements
	Right	11.0	10.6	96.1	Check effect of Number of Elements
Non-Value Added Time (s)	Left	8.8	8.7	98.3	
	Right	10.1	10.0	99.4	
Times:					
Movement Time (s)	Left	9.1	8.8	97.0	
	Right	10.7	10.2	95.5	
Process Time (s)	Left	5.5	5.5	100.0	
	Right	10.3	10.3	100.0	
Machine Time (s)		0.0	0.0		
Estimated Cycle Time (s)		31.2	30.5	97.6	
Rest Allowance Required (s)		0.0	0.0	56.7	

Capture the quality of HFE in the organisation

- Example – Human Factors Integration Toolset (HFIT)
- <https://doi.org/10.32920/14669013.v1>



Capture the quality of HFE in the organisation

HF Elements	Organization Functions															
	Environmental, Health & Safety	Training	Human Resource Management (Hiring and Retention, Employee and Labour Relations and Internal Communications)	Medical Services & Claims Management	Marketing/External Communications/Advertising/Retail/Sales	Finance	Maintenance	Tooling	Construction and Fabrication	Logistics (Shipping/Receiving/Material Handling/Warehousing/Storage)	Product/Service Design	System Engineering / Design	Operations/Supervision	Scheduling/Operations Planning	Quality	Organizational Strategy Development (Board of Directors/Senior Management)
HF for performance not only injury prevention	x	x	x							x						x
Cost of injuries/problem related to source				x		x				x	x	x	x	x	x	x
Total HF cost considered (direct and indirect)		x	x			x										x
Application reason (e.g. legislated or culture)	x	x			x	x	x	x	x	x	x	x	x	x	x	x
Justification for change	x	x		x			x	x	x	x	x	x	x	x	x	x
HF Guidelines	x	x					x	x	x	x	x	x	x	x	x	x
HF specific training	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
HF training timeline and repetition		x	x				x	x	x	x	x	x	x	x	x	x
Employee development	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
HF in experience delivery (employee's work deliverables)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
HF includes physical and psychosocial (employee's workplace)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Control and adjustability of work environment	x												x	x	x	
Maintenance for HF problem prevention				x			x	x	x	x			x			
Feedback questionnaires that investigate HF	x	x	x		x		x	x	x	x	x	x	x	x	x	x
HF review process (for HF specific improvement)	x			x			x	x	x	x	x	x	x	x	x	x
HF review process applied (outcome measure)	x			x			x	x	x	x	x	x	x	x	x	x
Continuous review of process	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Review as early as possible	x			x			x	x	x	x	x	x	x	x	x	
Multiple people input							x	x	x	x	x	x	x	x	x	x
Level of subject matter expert need	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x
HF two-way communication			x							x	x	x				
Reactive results tracking	x			x						x	x	x	x	x	x	x
Lessons learned are logged and acted upon	x						x	x	x	x	x	x	x	x	x	x
Feed forward of information			x	x			x				x	x	x	x		
HF relevant metrics	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
HF connection to traditional metrics understood											x	x	x	x	x	x
Strategy integration		x			x									x		x
HF culture	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
HF as value promotion			x		x											
Celebrated - project promotion and ideal			x		x											
HF considerate hiring and development package			x		x											

Capture the quality of HFE in the organisation

HF Guidelines (#6):

Level of Human Factors Maturity	Score
HF training does not include HF guidelines.	0
HF training occasionally includes generic HF guidelines.	1
HF training frequently includes generic HF guidelines.	2
HF training occasionally includes organization specific HF guidelines.	3
HF training frequently includes organization specific HF guidelines.	4

Comments:

Capture the quality of HFE in the organisation

Human Factors Element	Score	Human Factors Element	Score
HF for performance not only injury prevention	0	Continuous review of process	0
Cost of injuries/problem related to source	N/A	Review as early as possible	N/A
Total HF cost considered (direct and indirect)	0	Multiple people input	N/A
Application reason (e.g. legislated or culture)	0	Level of subject matter expert need	0
Justification for change	0	HF two-way communication	N/A
HF Guidelines	0	Reactive results tracking	N/A
HF specific training	0	Lessons learned are logged and acted upon	N/A
HF training timeline and repetition	0	Feed forward of information	N/A
Employee development	0	HF relevant metrics	0
HF in experience delivery (employee's work deliverables)	0	HF connection to traditional metrics understood	N/A
HF includes physical and psychosocial (employee's workplace)	0	Strategy integration	0
Control and adjustability of work environment	N/A	HF culture	0
Maintenance for HF problem prevention	N/A	HF as value promotion	N/A
Feedback questionnaires that investigate HF	0	Celebrated - project promotion and ideal	N/A
HF review process (for HF specific improvement)	N/A	HF considerate hiring and development package	N/A
HF review process applied (outcome measure)	N/A		
Column Total	0	Column Total	0
		Grand Total	0
		% Ideal HF (100 * Grand Total / 64)	0.0%



Centre of Research Expertise
for the Prevention of
Musculoskeletal Disorders

So, what do you think?

Michael Greig
m2greig@torontomu.ca