Using Advanced Wearables and 3D Dynamic Biomechanical Modeling

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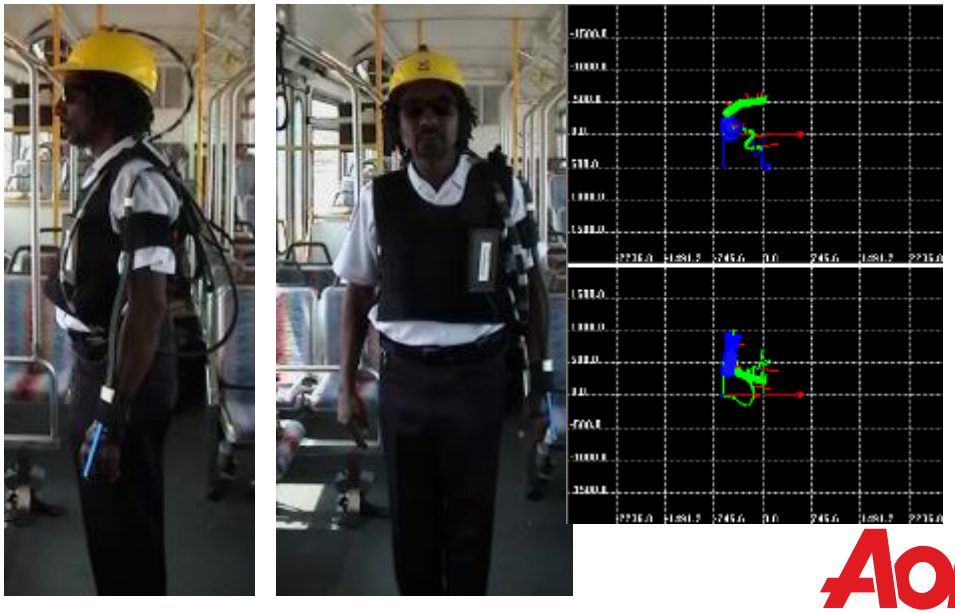
Agenda

- Types of Advanced Technology for Ergonomics
  - 3D Motion Capturing
  - Body and Segmental Pressure Mapping
  - Dynamic Muscle Force Data
  - 3D Dynamic Biomechanical Modeling
  - Case Study Examples of Wearable Technology:
  - Identifying risks
  - Support TCOR through WC cost reduction and productivity improvements
- Closing Comments

Wearables are Not New – Product Assessment and PDA – Circa 2003-04

- Used sEMG and Force Transducers to Measure:
  - Upper Body Forces Required to Turn Different Types of Bus Steering Wheels
  - Leg and Foot Forces Required to Activate Different Types of Bus Brake Foot Pedals
- Full Body Shape Tape to Measure Whole Body Posture to Operate a Bus

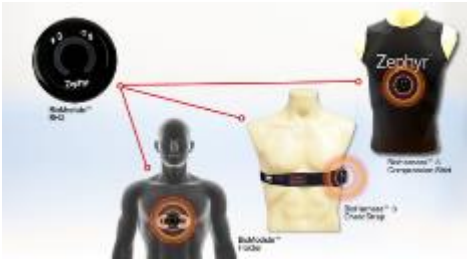


Spectrum of Wearable Technology - $79.00 to $30,000.00 and higher

Exemples of Posture, Muscle Force, Pressure, etc.

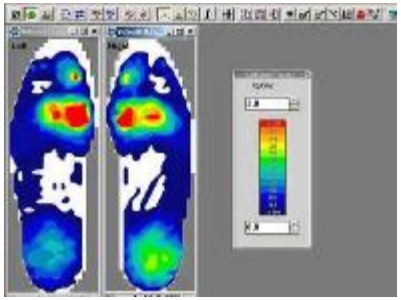
Lumo Lift

Somaxis Cricket



Zephyr Bioharness

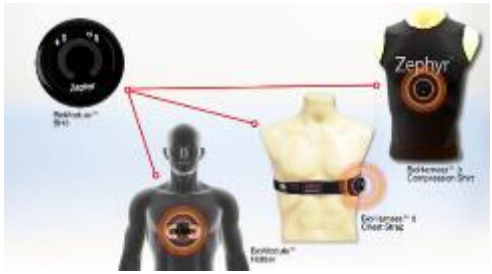
DataLink System



Tekscan

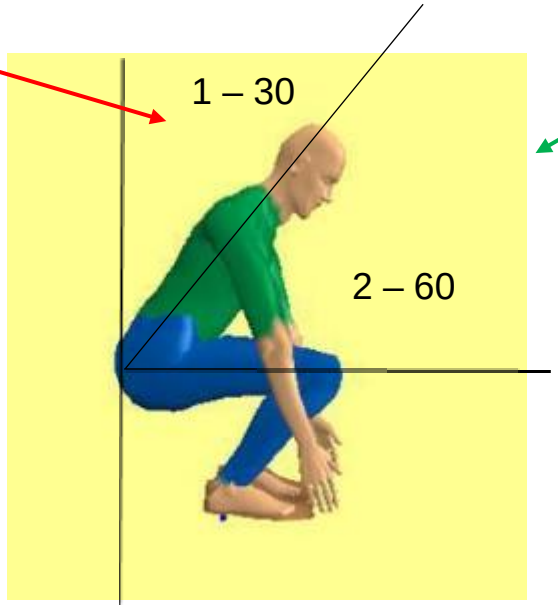
Xsens

Buyer Beware Though – Inclinometer vs Goniometer Example



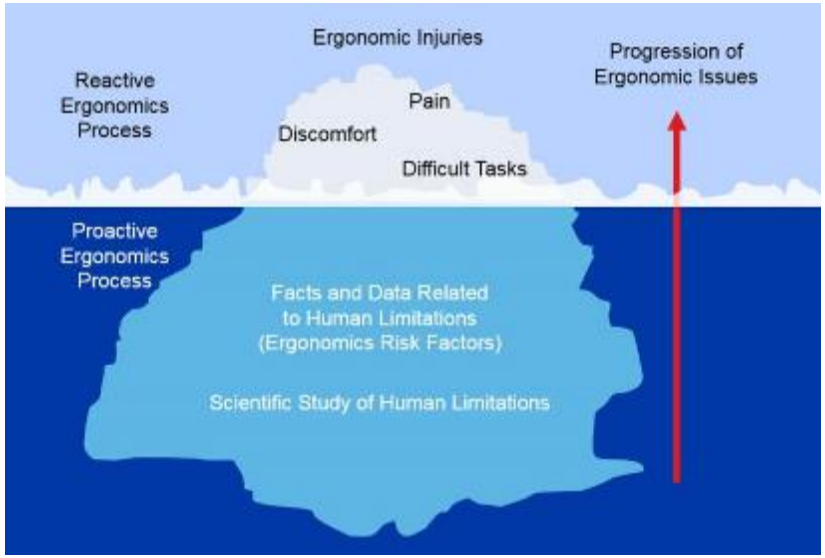
Inclinometer – Measures from Vertical

Goniometers – Measure Joint Axis

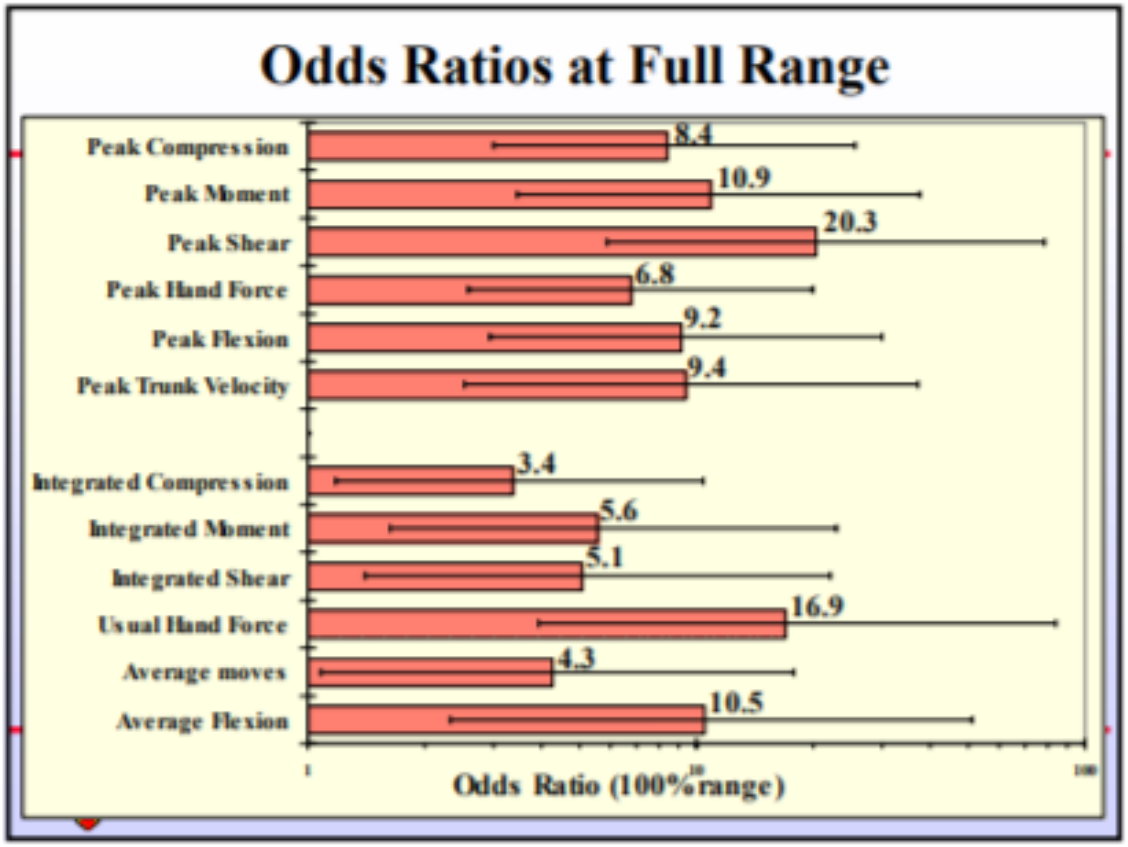


The Science of Ergonomics

- Ergonomics is the “scientific study of the interaction of people within their work environment”
- Much of what is know about human performance has been studied in labs and in the field and published to create the evidence of “work-relatedness”
- Facts and data must drive the process otherwise “opinion” can slow the process down and wrong decision can be made even if for the right reasons
- Traditional ergonomics approach typically review a job task as applies checklist or risk assessment method but does not measure the actual employee response to the work

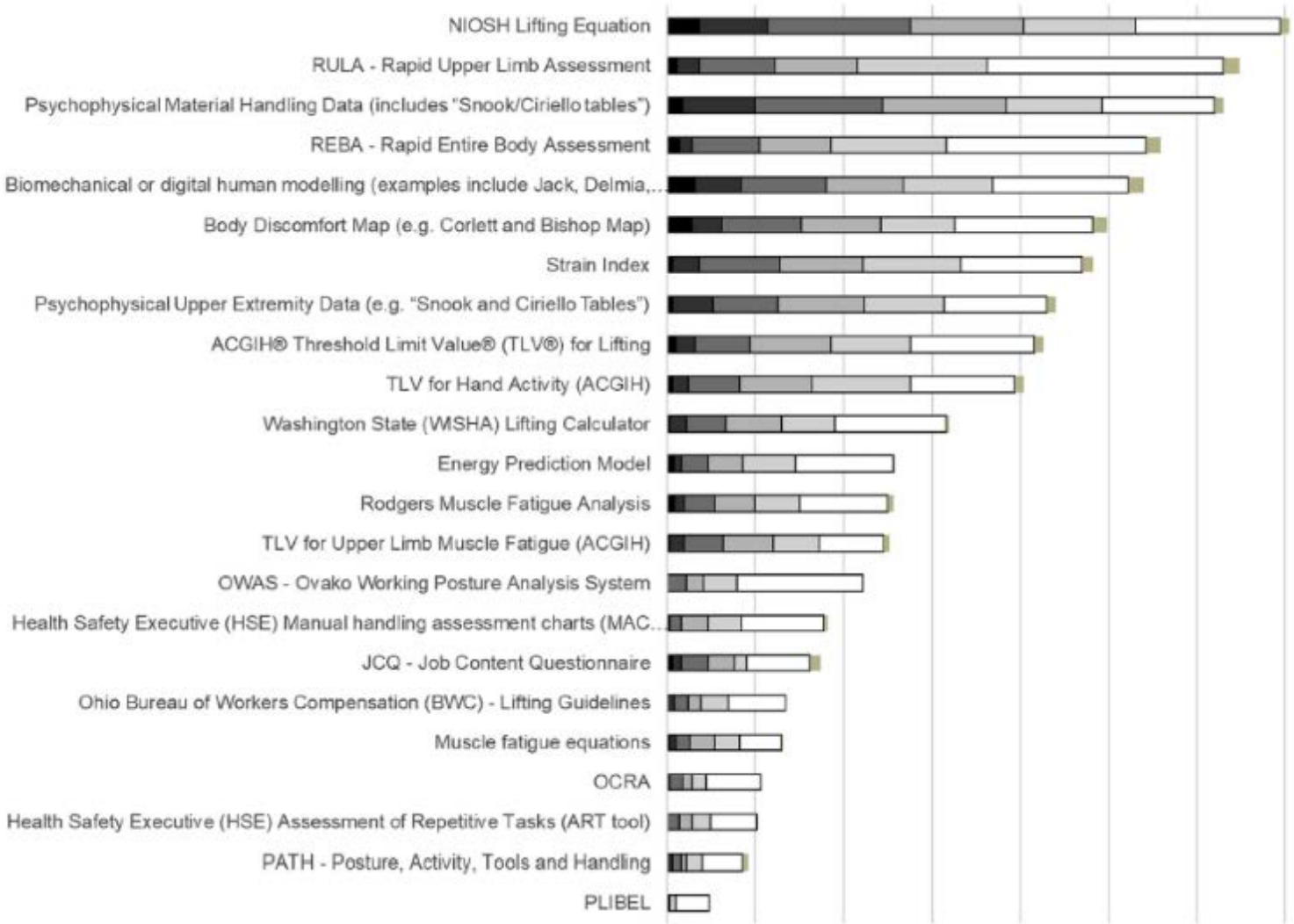


Scientific Studies Risk Factors Related to Low Back Pain



Ontario Universities Back Pain Study (OUBPS), 1998

Ergonomics Tools of the Trade - Study 2005 to 2019



Assessment Methods use in Ergonomics – Are They Really Working?

Musculoskeletal disorders rank second worldwide in curbing 'productive life': study

- WHO's Data from 2000 to 2015 from 183 Counties – "Years of Productive Life Lost Due to Disability":
  - In 2000 – 77.4 Million and now increased to 103.8 Million in 2015
  - Only heart disease and strokes ranked higher
- Tools are 15 to 30 years old but population is 15 to 30 years older
- Population BMI is also higher than 15 to 30 years ago
- Tools are still highly variable in results related to user experiences and at best "screening tools"
- More accurate systems are needed to actually measure the impact of work on employees' vs. a checklist or risk assessment screening tools

Why Use Wearable Technology?

- The old saying goes, “what you don’t know won’t hurt you.” In reality, what you don’t will hurt you and your people!

- Leverage wearable technology to be a predictor of potential injury vs. waiting for an injury claim to happen.

Why Use Wearable Technology? Some Research Findings

- Article published in 2008 but Merryweather, Bloswick and Sesek – University of Utah Department of Mechanical Engineering Ergonomics and Occupational Biomechanics Department
  - Initial review of literature review indicated that peak low back forces may be under reported in static biomechanical models by 19 to 200%
  - Static models don't account for acceleration and velocity of movement
  - Findings found that fast movement were 42% higher forces than static forces
- Additionally, Koblauch (2015 - Low Back Disorders in Airport Baggage Handlers), found lighter bags posed more of a risk related to "throwing" than heavier bags using a dynamic biomechanical model

Wearable Sensors, Systems and Applications for Ergonomics

IMU Motion Tracking

Goniometers

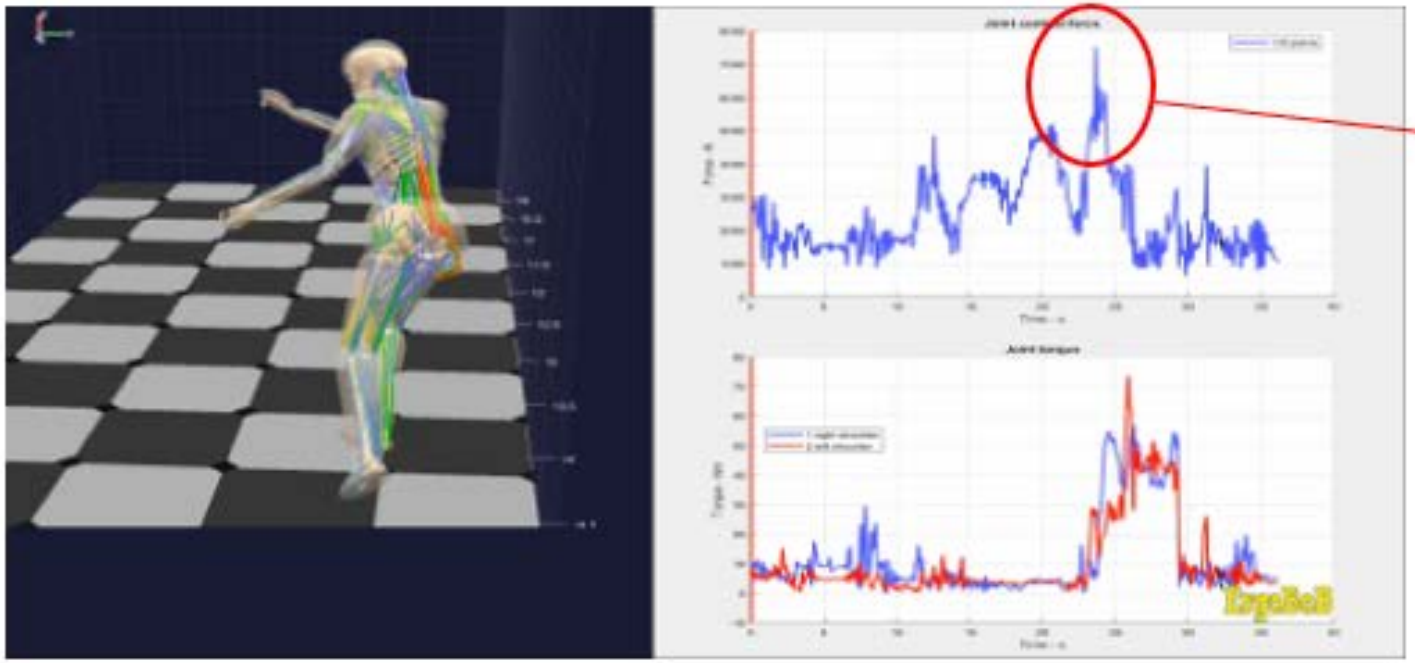
EMG Sensors

Force Sensor

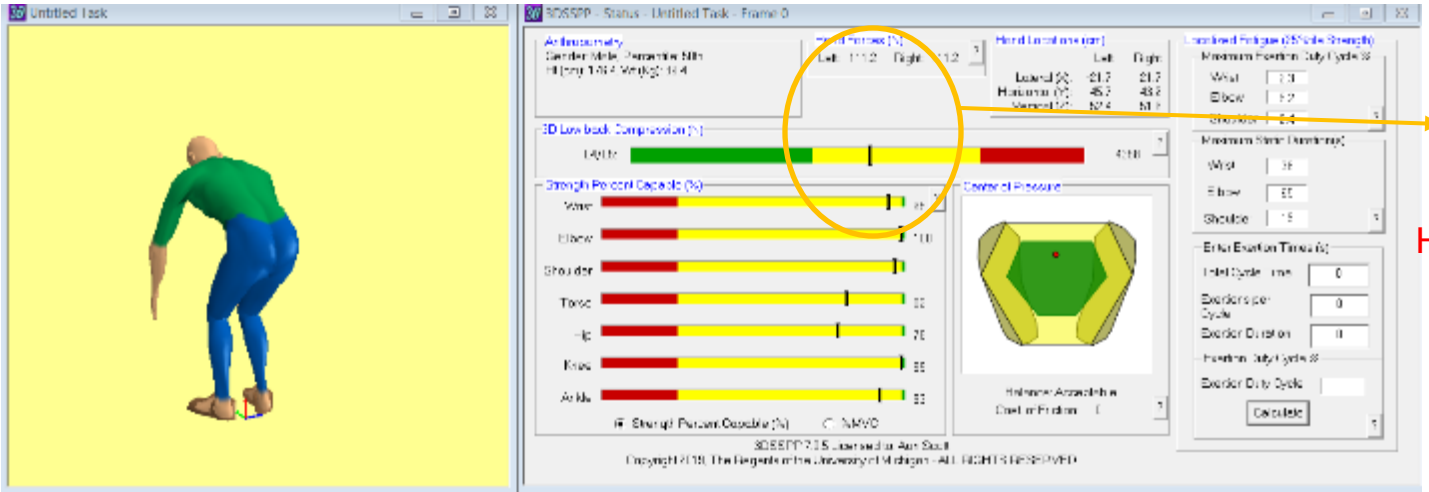
IMU Sensors & Biomechanics of Body (BoB)

- Biomechanics of Bodies (BoB) is a biomechanical modelling package that contains a human musculoskeletal model with 600 muscles.
- BoB enables the calculation of muscle forces, joint contact loads, joint torques, whole-body dynamic posture assessments using data collected from 16 IMU sensors.
- Enables ergonomist or ergonomics practitioner's to perform dynamic comparisons of risk vs. observation alone.
- Allows an evaluator to peel back the other layer and assess the impact of work internally vs. an observational screening tool or checklist.
- ErgoBoB has specific ergonomics assessments related to biomechanical outputs for joint forces, joint torques and muscle effort levels.
- Can assist in identifying root cause issues through an entire cycle vs. a tradition ergonomics assessment methods.

Dynamic vs. Static Biomechanical Modeling Sample



7,480 N of Force
High Risk with 50 lbs.



4,358 N of Force
Moderate Risk with 50 lbs.

Authors Note:
High Risk Occurs at 114 lbs.

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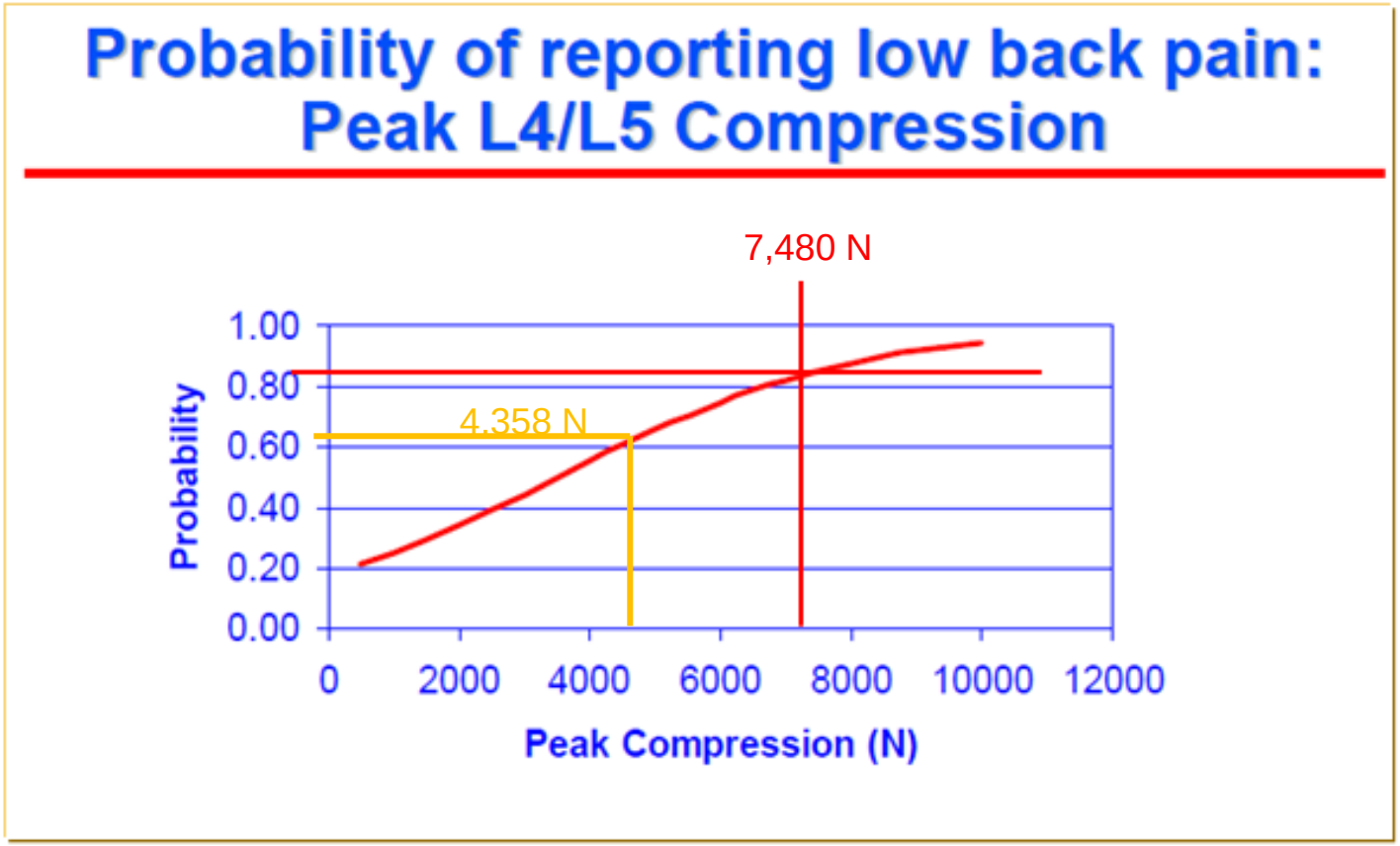
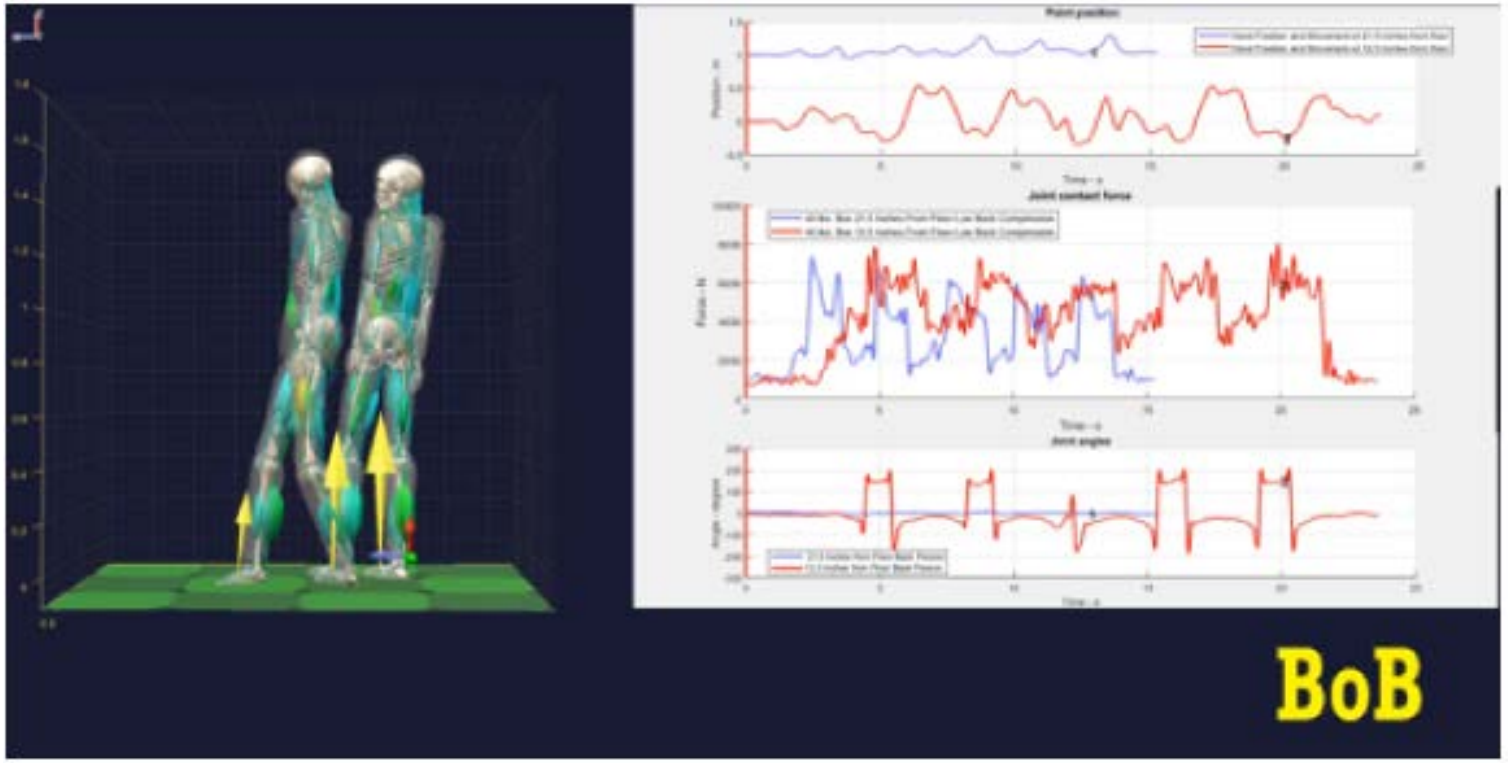
Leading Indicators and What They Mean

- **Static vs. Dynamics Peak Compression Probability Difference**



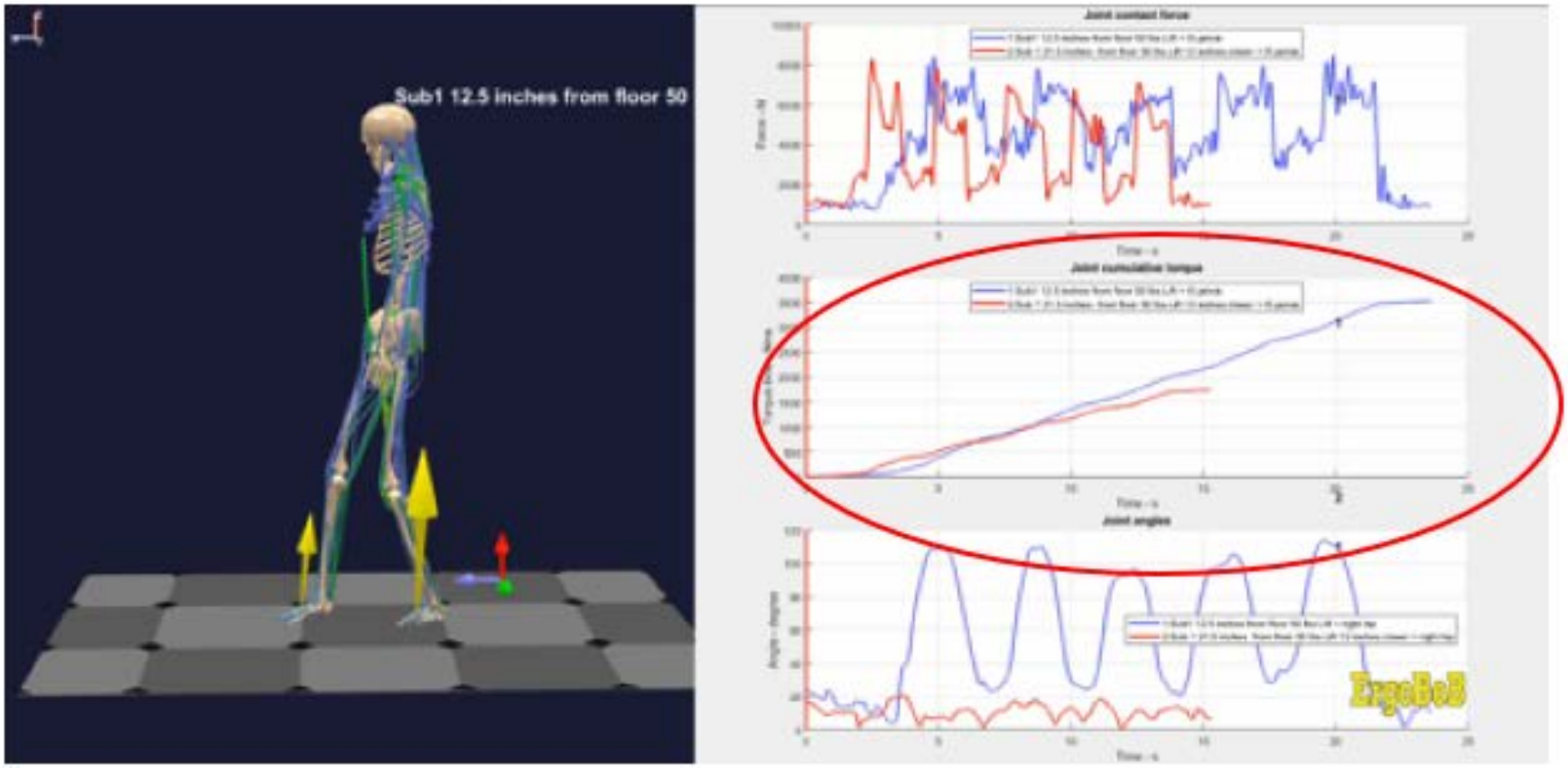
Solution Assessment - Measuring Impact of Future Change

Lifting from 12” vs 21” off the ground Peaks



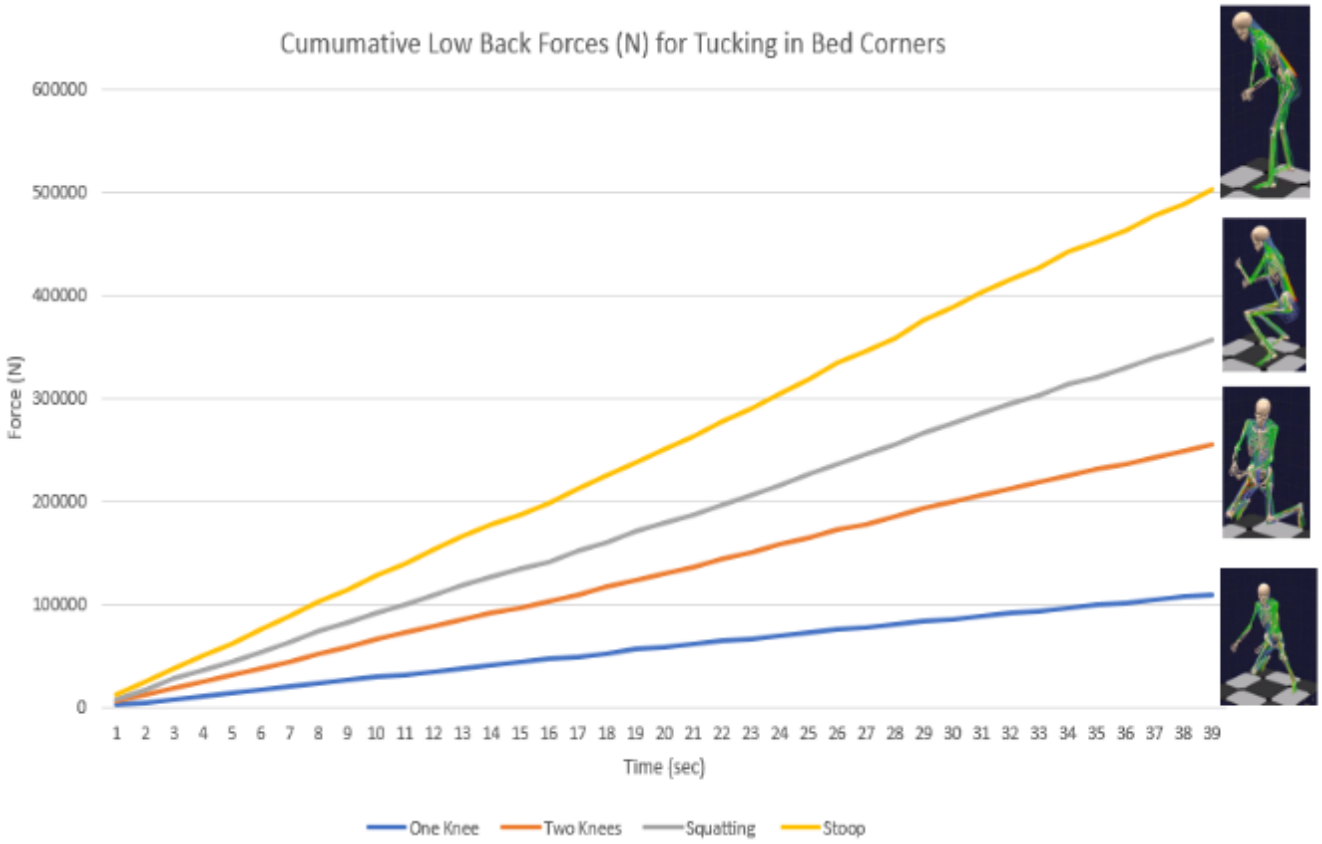
Work Smarter, Not Harder - Analysis Related to Changes Over Time

40% Reduction in Cumulative Load and a 20% Reduction in Cycle Time to Lift Same Five Items



Not knowing will hurt your People!
Better Data, Better Decisions, Happier and More Productive Employees

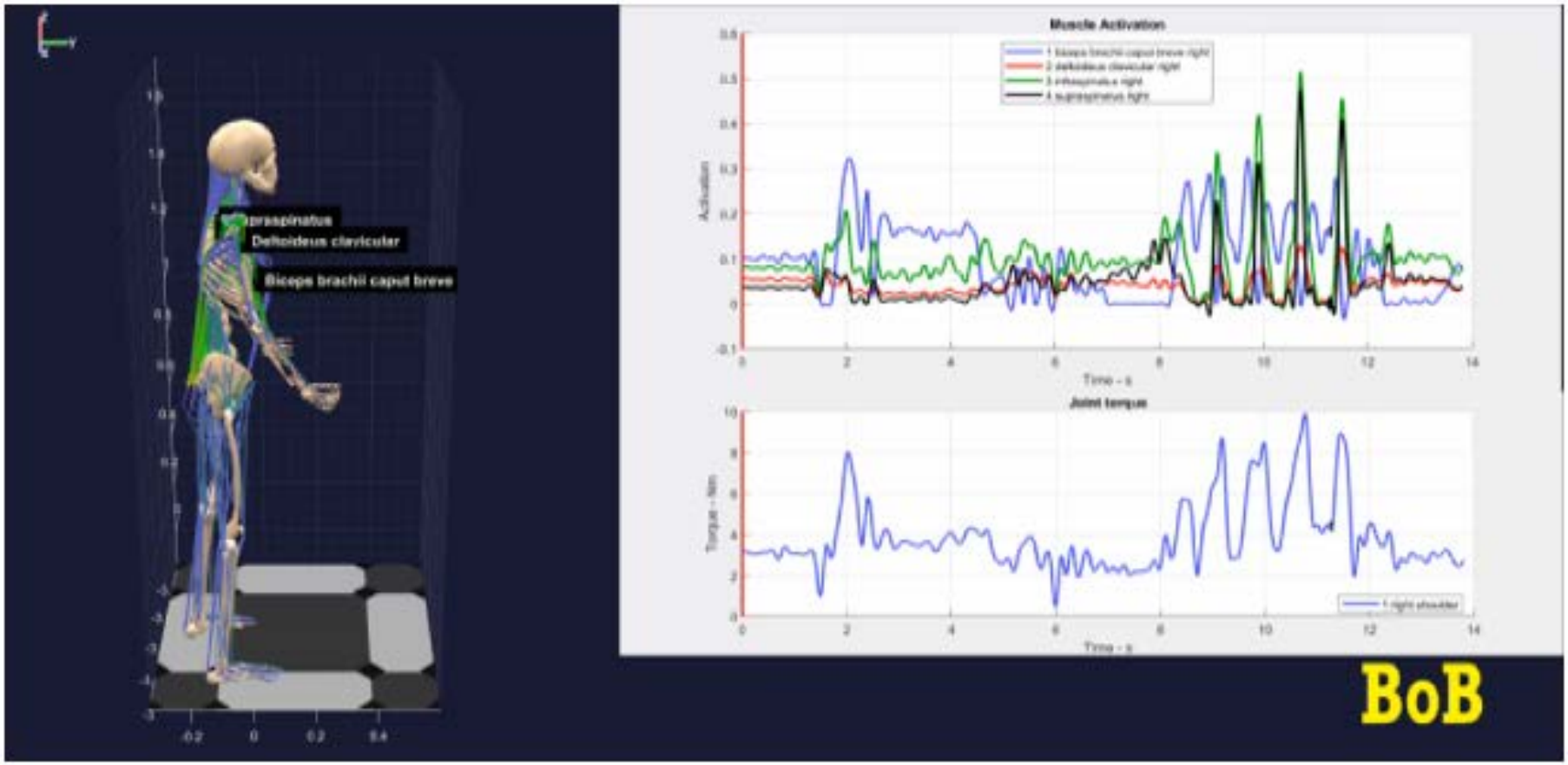
Low Back Cumulative Force Analysis – All Conditions



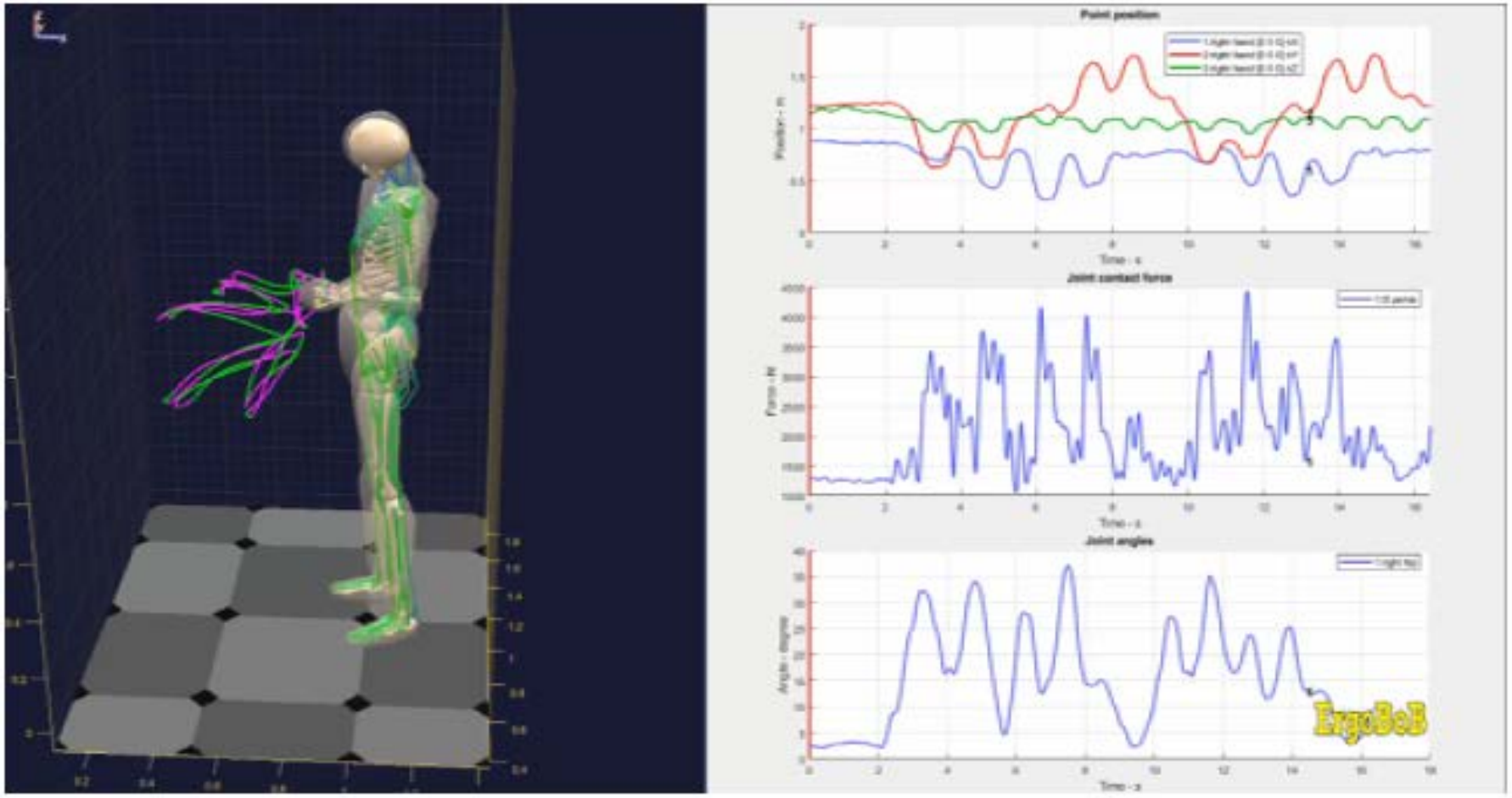
Analysis of Compression Over Time

Lowest Forces – One Knee Posture
Highest Forces – Stooping

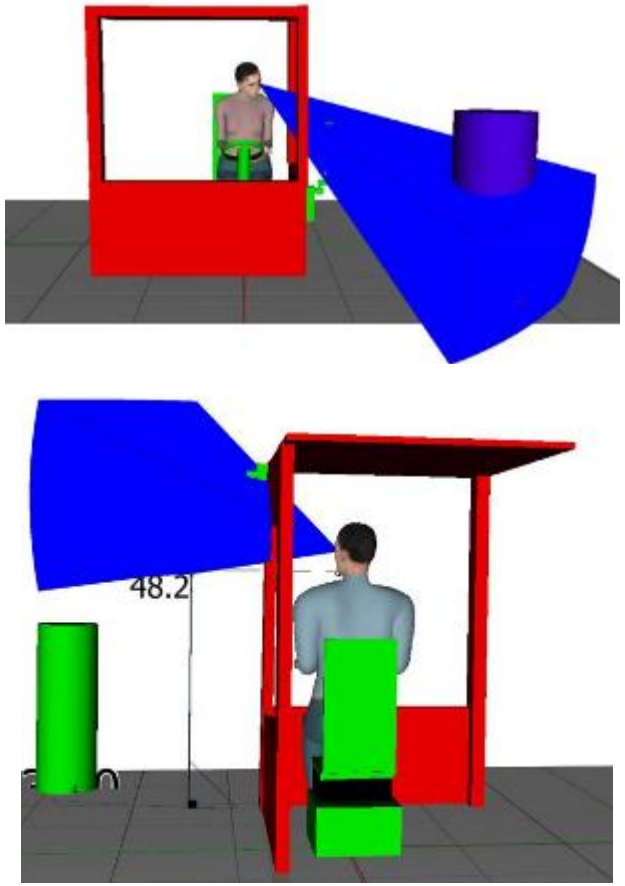
Product Assessment - Measuring Impact on Specific Muscles



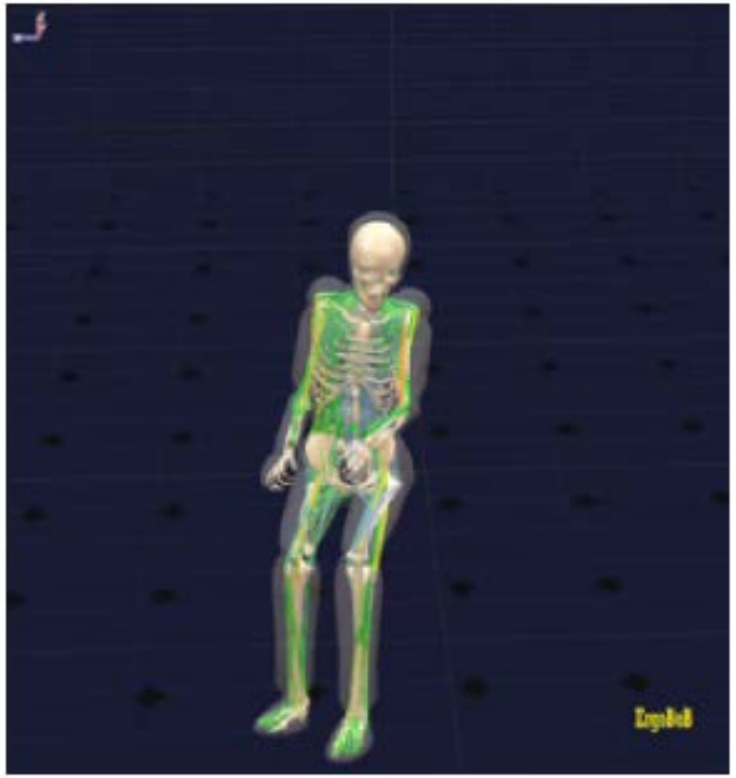
Dynamic Reaching Distances of an Assembly Task



Driver Ergonomics and Cab Design – Static vs. Dynamics Analysis



Static

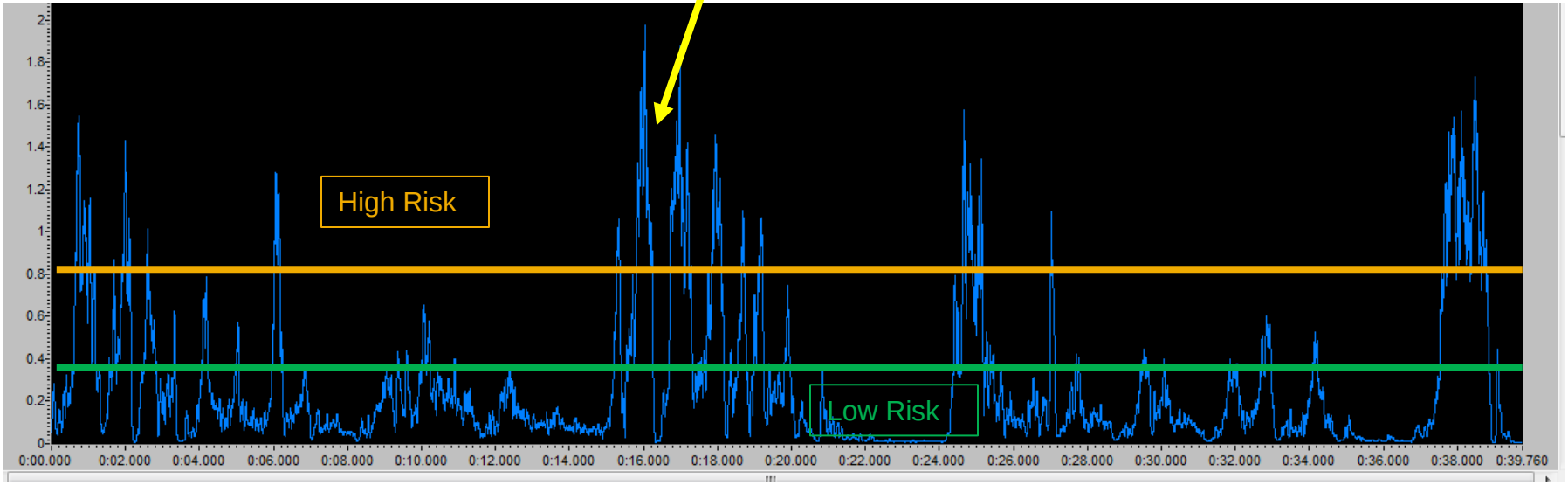


Dynamic Analysis

Product Assessment and Solution Development

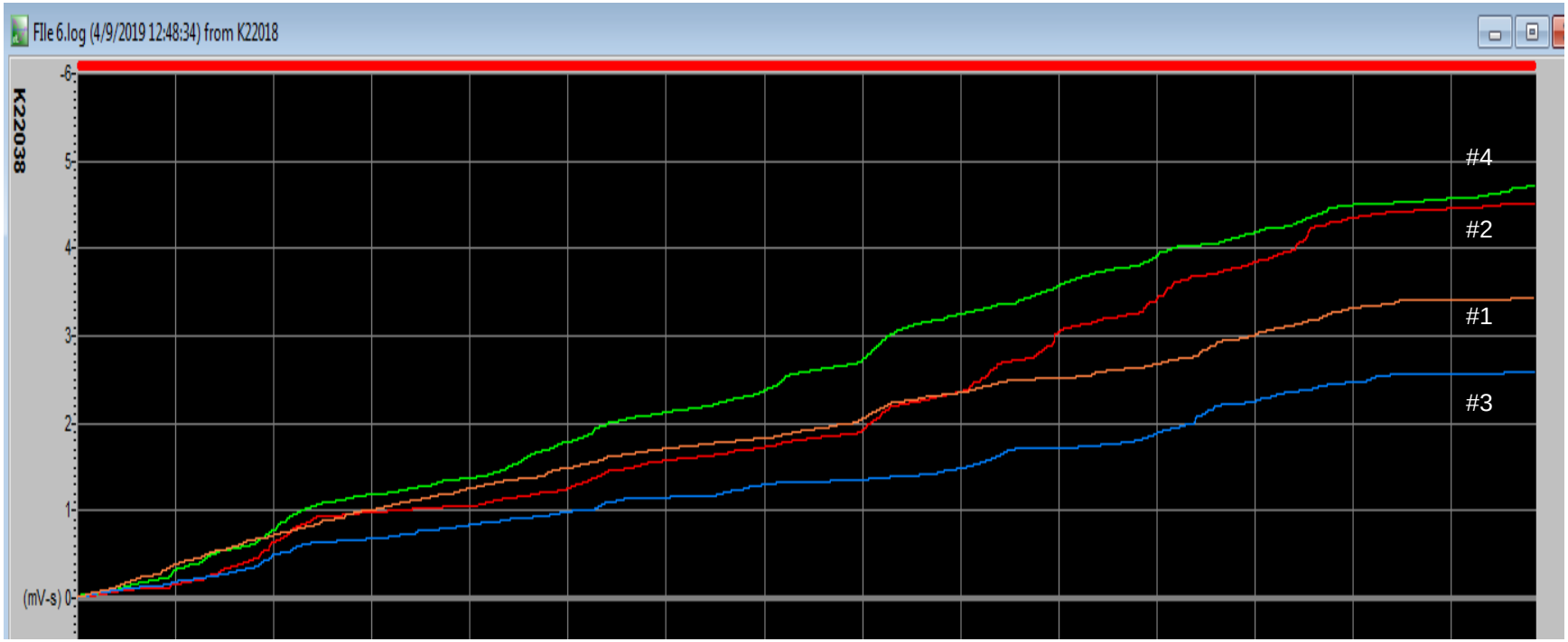
Identifying High Hand Forces During Pipetting Tasks:

- Used sEMG to evaluate 3 different pipettes to determine average and peak hand forces as well as repetition of tasks



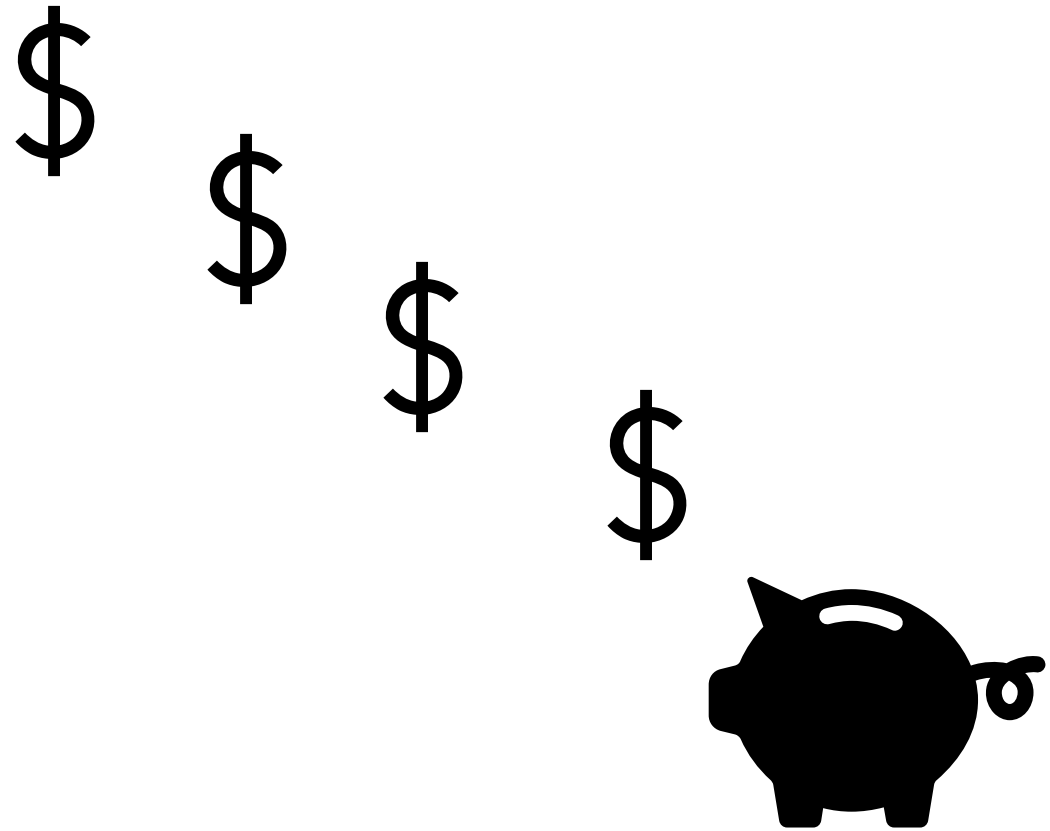
Example – Analysis of Forearm and Thumb Activity Levels

- Can also use data to identify which solution has the biggest impact (lower muscle activity) over the length of a task
- Pipette #3 requires 41% less muscle effort as compared to #4 over the same time period



Ergonomics Assessment - Finger Force Analysis vs. Actual Requirements

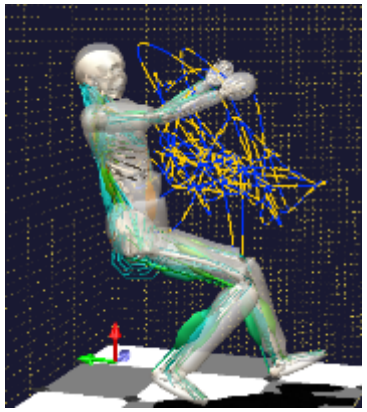
Cost Savings Opportunities



Predicting Productivity Opportunities Potential Cost Savings

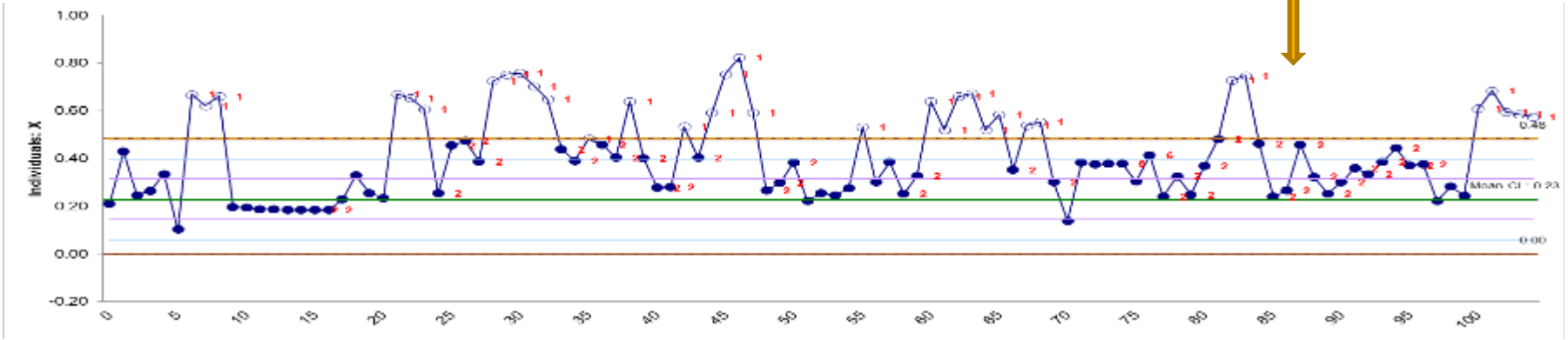
Real People/Real Work

Xsens MVN & IMUs



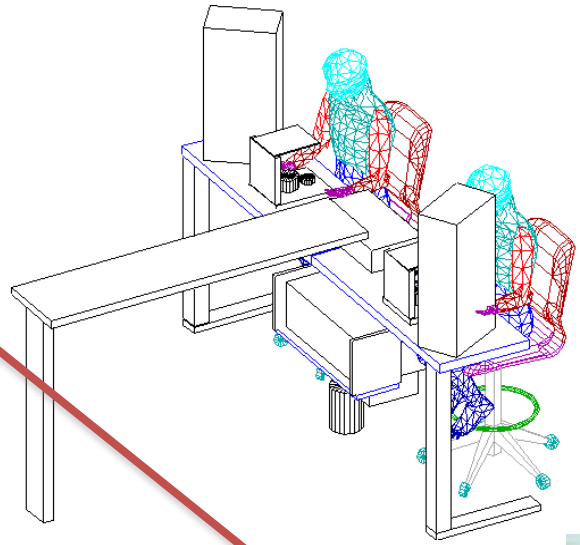
- Analysis of time and motion savings to reduce MFG cycle times
- 12.38% spent <9” – Low Risk Reaches
- 44.76% spent between 9 and 19“ – Moderate Risk
- 32.38% time spent in >19” – High Risk

- ***Potential Opportunity to Address Moderate and High Risk Reaching and Reduce Cycle Time by 77.14%***



Example - Measuring Productivity and TCoR Impact

Current State



Virtual Testing State

Future State

Enables Predicting Productivity Opportunities Potential Cost Savings

- Reducing cycle time from 50 seconds to 42.5 (7.5 secs) enables the operator to go from 72 pieces per hour to 84.7 per hour without any extra internal effort.
- Profit per unit is $100
- Potential throughput increase on the bottle neck operation:
  - 12.7 units per hour * $100 profit per unit = $1,270/hour
  - 95 units per day * $100 profit per unit = $9,500 per shift
  - This is a two shift operation: 2 shifts * $9,500 per shift $19,000/day
  - $95,000 per week (5 day a week operation)
  - **$4,750,000 per year (50 week period)**
  - **Payback Period 0.003 years**
  - **Cash Flow Return on Investment = 35,190% per year**

- Movements of long reaches and seated back bending were eliminated completely.

Example – Predicted Probability of Future Injury

Current Probability of Low Back Disorder - (LBD) Near Bottom of Pallet

Liftrate (lifts/hour)	Moment (Nm)	Sagittal Position Max (degrees)	Average Twisting Velocity (deg/sec)	Maxiumum Lateral Velocity (deg/sec)	LBD Probability
55	213	88.2	0.08	2.5	96.26%

Future Probability of Low Back Disorder (LBD) - Top of Pallet

Liftrate (lifts/hour)	Moment (Nm)	Sagittal Position Max (degrees)	Average Twisting Velocity (deg/sec)	Maxiumum Lateral Velocity (deg/sec)	LBD Probability
55	110	10	0.08	2.5	31.26%

Improvement Percentage
68%

- Risk benchmarks
  - "High Risk" - LBD Risk values greater than 60%
  - "Moderate Risk" – LBD Risk between 30% and 60%
  - "Low Risk" - LBD Risk values below 30%

Heat Map of Lagging and Leading Indicators

	Lag	Leading	Lag	Leading	Leading
Job	Incurred Losses	EQuIP Risk Score	Loss Work Days	Low Back Disc Compression (lbs.force)	Low Back Disc Probability of Injury
Loader/Unloader	$136,696.62	115	900	1400	94%
Split	$63,499.18	100	434	1245	83%
Marking	$112,417.09	80	553	660	34%
Unpack	$62,030.22	75	510	770	45%
Stockroom Assoc	$5,000.00	65	0	550	33%
Stager	$1,569.70	60	0	500	29%
Receiving	$3,924.38	45	0	504	34%
Maintenance	$1,721.35	45	0	360	23%
Other	49,869.47	0	422	NA	NA

TCoR - Predicting the Future Using Analytics Data

- Regression Modeling to Predict Future Incurrent Costs based on Leading Risk Indicators
  - **Multiple Regression Model: Incurred Losses = (-8628.8) + (879.29) * Disc Compression**

Current Future State

Job	Incurred Losses	Current EQuIP Risk Score	Loss Work Days	Low Back Disc Compression (lbs. Force)	Low Back Disc Probability of Injury
Loader/Unloader	$136,696.62	115	900	1400	94%

Predicted Future State

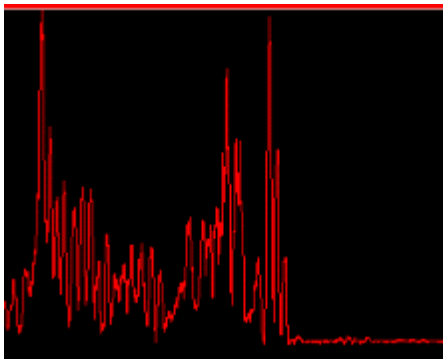
Predicted Response Calculator:

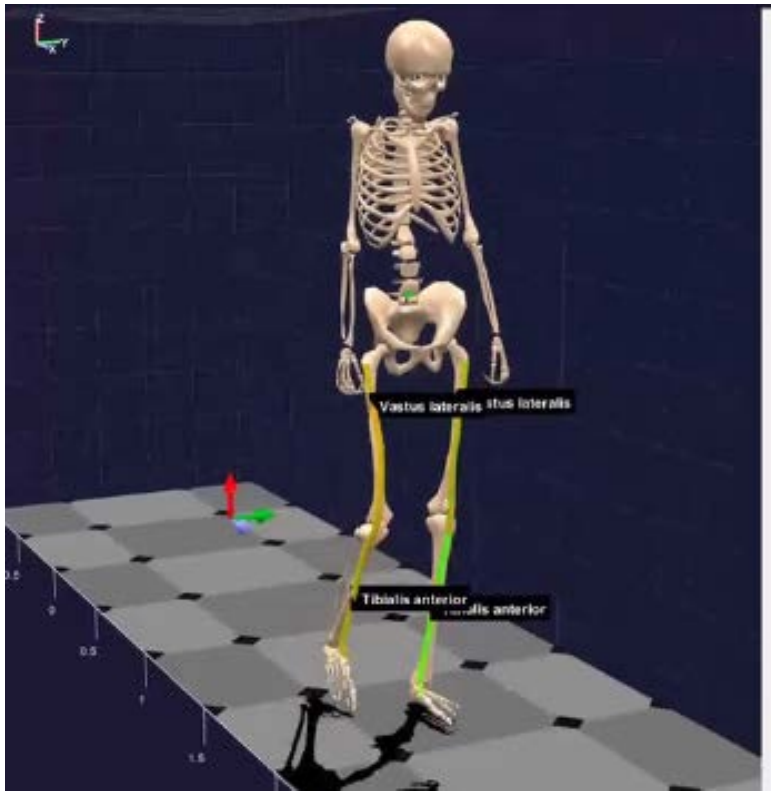
Predictors	Enter Settings:	Predicted Response	Lower 95% CI	Upper 95% CI	Lower 95% PI	Upper 95% PI
Future Low Back Disc Compression (lbs.	550	$ 26,531.23	$ (11,019.83)	$ 64,082.29	-73299.32015	126361.7869

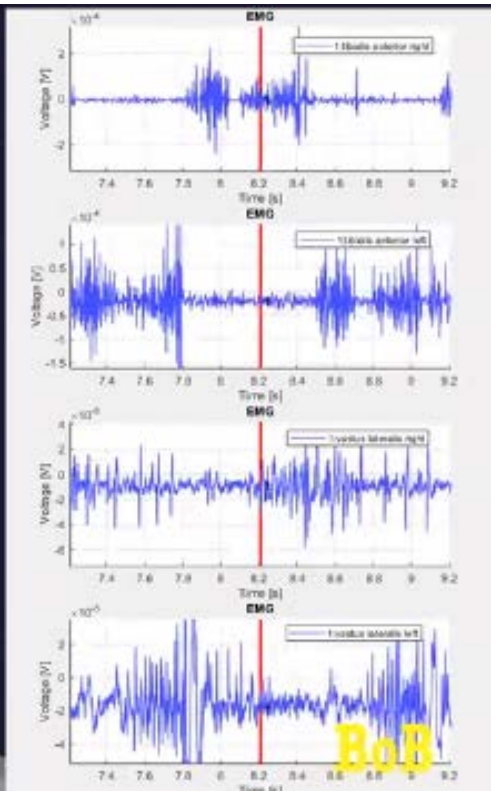
TCoR and Risk Impact:

- **Low Back Compression Reduction: Current 1,400 lbs. to Future 550 lbs. = 61% Reduction**
- **Probability of Future Low back Pain: Current of 94% to Future of 33% = 65% Reduction**
- **Predicted TCoR: Current $136,696.62 to Future $26,531.23 = 80.5% Reduction in Future Cost**

Direct Measurement to Validate Models and Muscle Effort Level Predictions

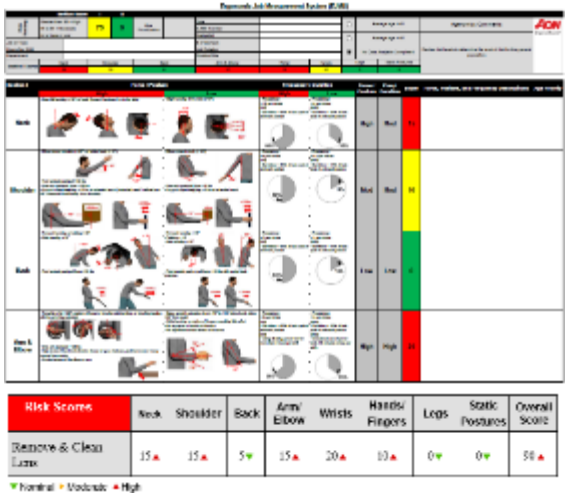






Wearable Data Supports All Types of Assessments

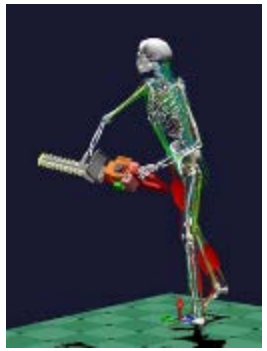
Product Design and Product Testing

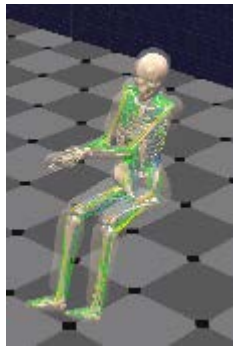


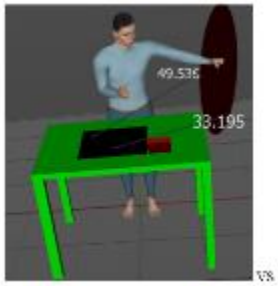
Risk Scores	Neck	Shoulder	Back	Arm/ Elbow	Wrists	Hands/ Fingers	Legs	Static Postures	Overall Score
Remove & Clean Lens	15▲	15▲	5▼	15▲	20▲	10▲	0▼	0▼	58▲

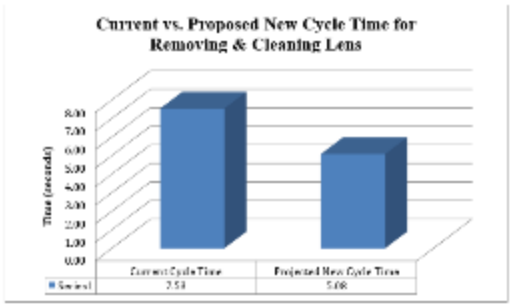
▼ Nominal ▪ Moderate ▲ High

Increased speed and accuracy of completing risk assessment methods

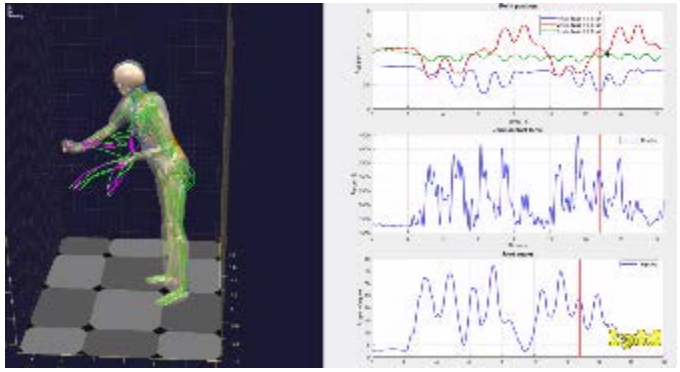


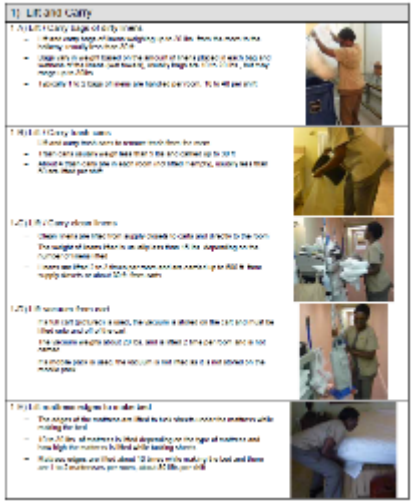






Accurate prediction of cycle time impacts





Increased accuracy of Actual Physical Demands and Functional Capacity Assessments

Work-relatedness assessment and Litigation Support Related to Specific Injury Diagnosis

Empower Results®

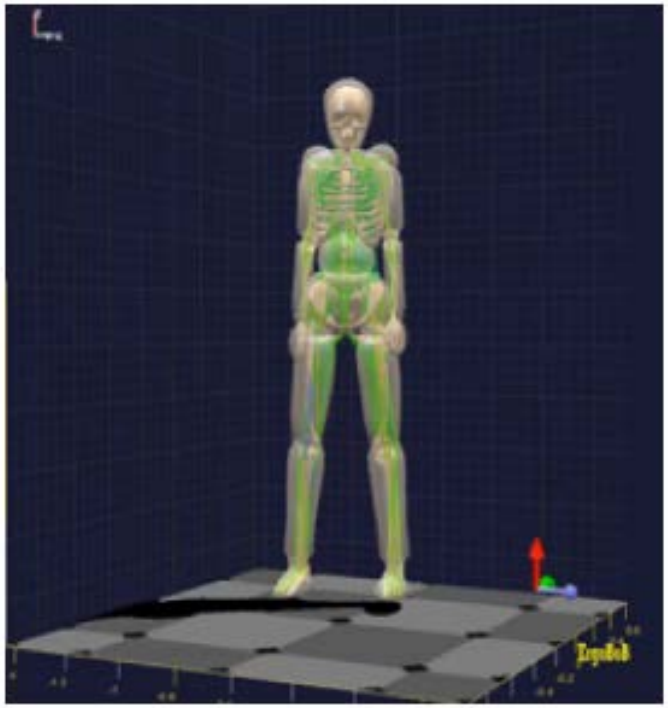
Closing Comments

1) Technology is improving along with lower costs for wearables

2) Data is used to objectively assess the likelihood of injuries and predicting impacts to risk and productivity through improving the workplace or work methods

3) Proactively measuring the how employees' respond to work vs. waiting for injuries to occur which can reduce costs associated with time off work (productivity and efficiency) as well as employee retention

4) Future AI will combine WC's analytics data with employee specifics measurements and risk to predict the impact of solutions on future losses



Thank You for Participating

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NATIONAL ERGONOMICS Conference & ErgoExpo®

How Data From Workforce Wearables Is Impacting Worker Safety Today!

Presented by: Tom West, SPHR, SHRM-SCP

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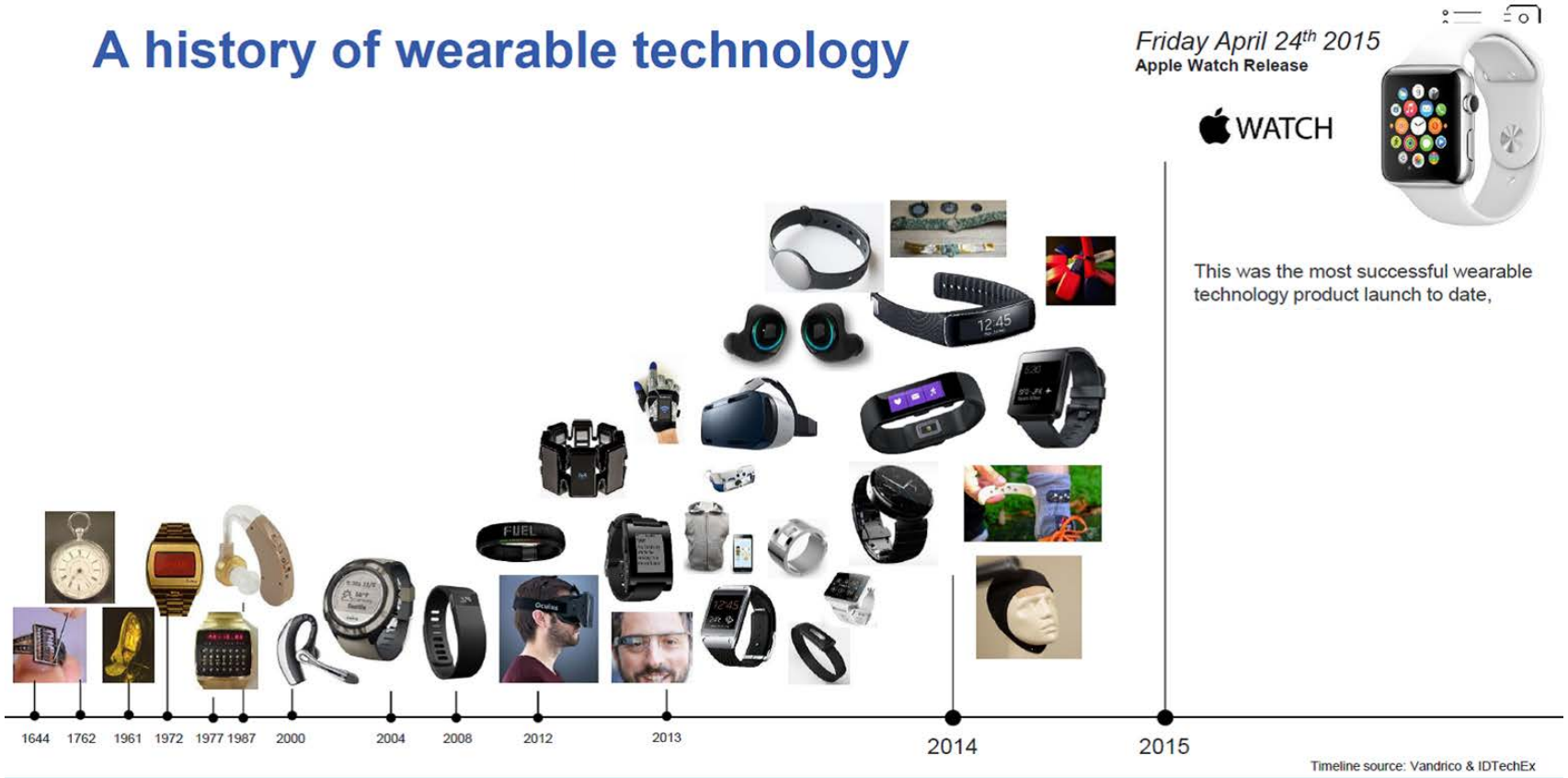
Agenda

- **Key Takeaways**
  - Use of wearables in the workplace
  - Growth in wearable tech market
  - MākuSafe technology overview & approach
  - Summary of pilot findings
  - 4 Case studies from field deployments
    - Wearables contributing to engagement
    - T.R.U.E. Leading Indicator Characteristics
  - Q&A

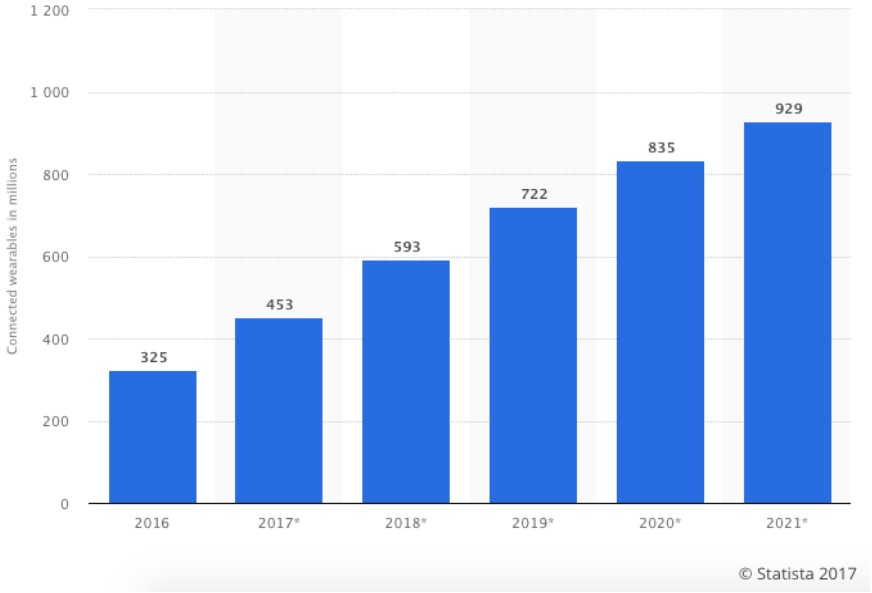

MÄKUSAFE

A history of wearable technology



https://www.statista.com/statistics/487291/global-connected-wearable-devices/

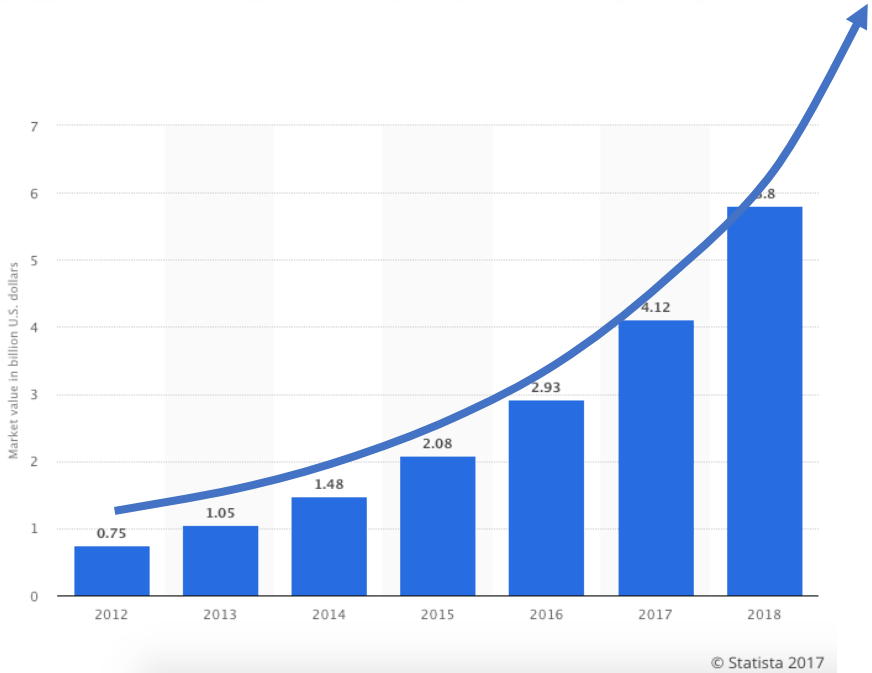
Wearable Market



Nearly 1 billion connected wearable devices in 2021

https://www.statista.com/statistics/487291/global-connected-wearable-devices/

Wearable Market



Non-linear growth of wearable spending

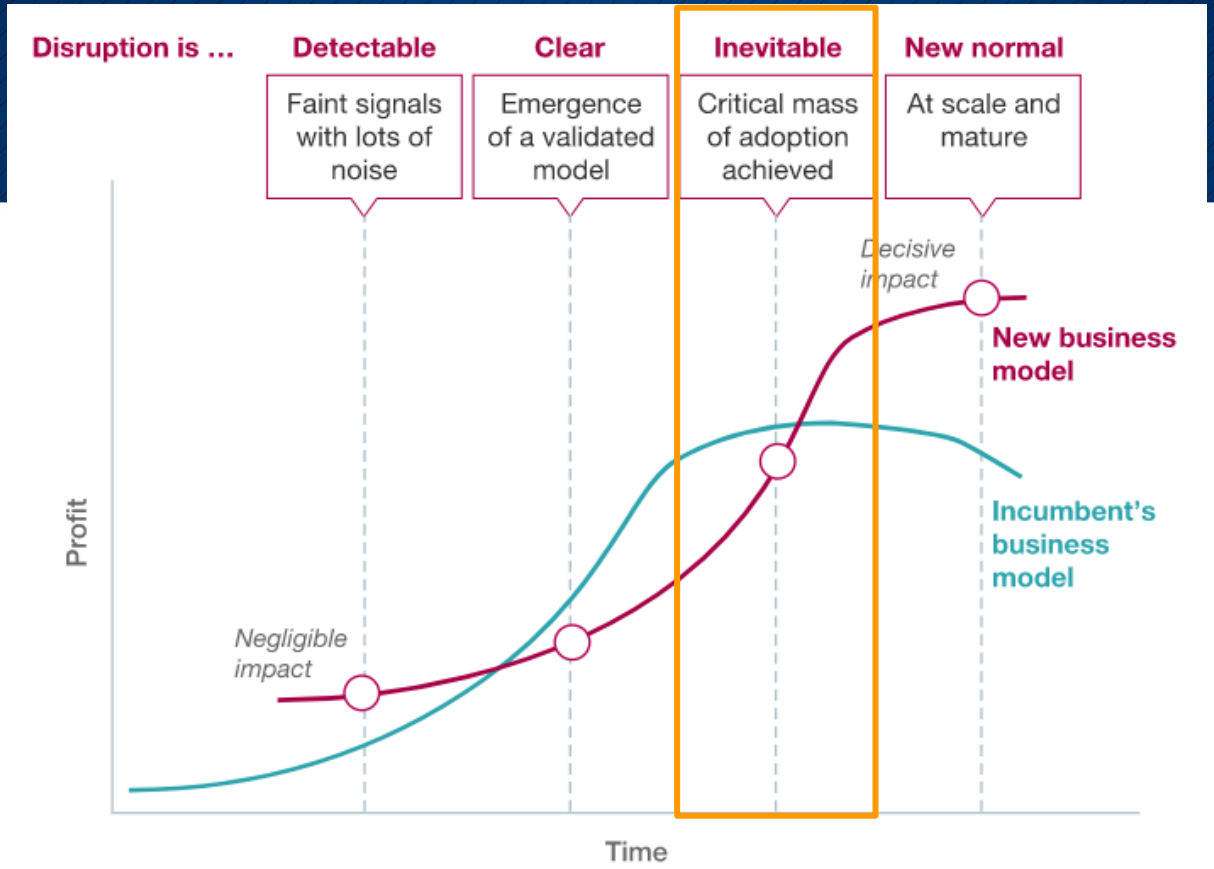
https://www.statista.com/statistics/302482/wearable-device-market-value/

Wearable Market

- Employees equipped with wearable technology reported a 8.5% increase in productivity and a 3.5% increase in job satisfaction.
- One in six consumers owned and used wearable technology in 2016.
- 71% of 16 to 24 year olds want wearable tech.
- More than 50 billion internet-connected devices will exist worldwide by 2021.

https://www.forbes.com/sites/bernardmarr/2016/03/18/15-mind-boggling-facts-about-wearables-in-2016/#6bc0880e2732

Wearables in the Workplace



https://www.mckinsey.com/business-functions/strategy-and-corporate-finance/our-insights/an-incumbents-guide-to-digital-disruption

Wearable Market

Companies are beginning to test wearables
in basic use cases like:
workplace security access (23%),
employee time management (20%),
and real-time employee communication (20%).

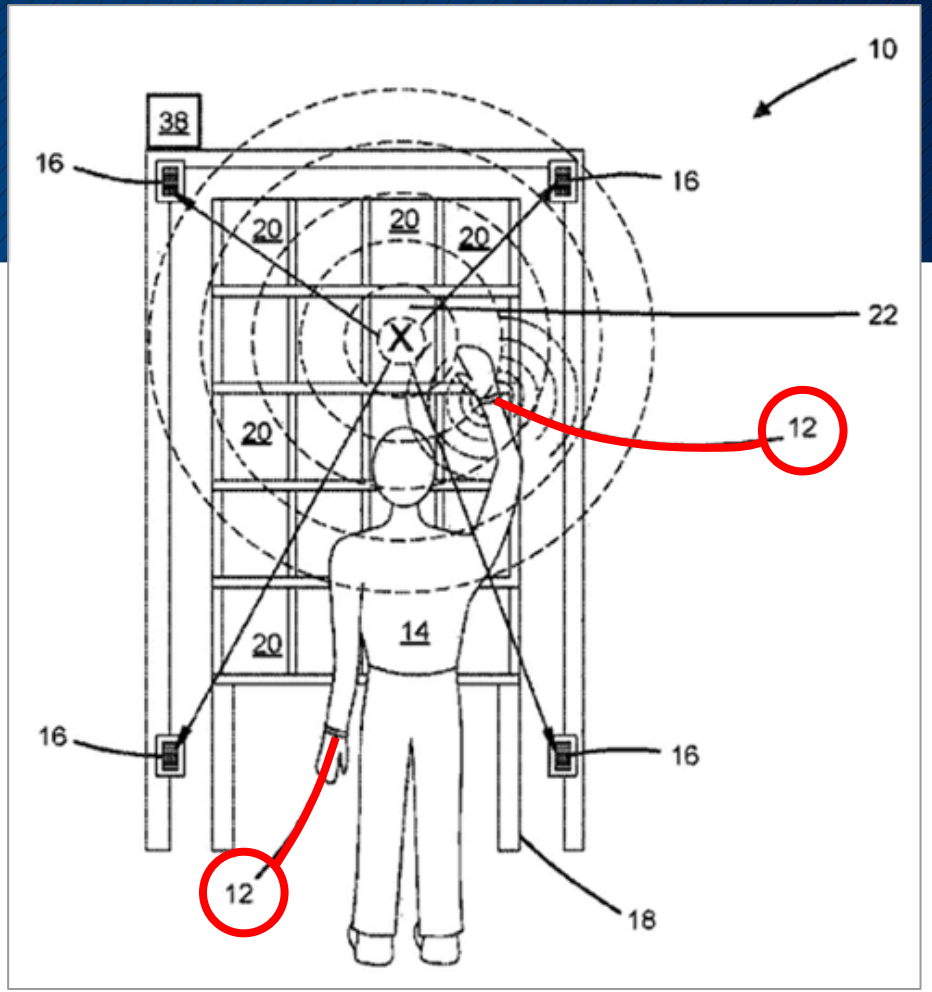
AND EHSQ!

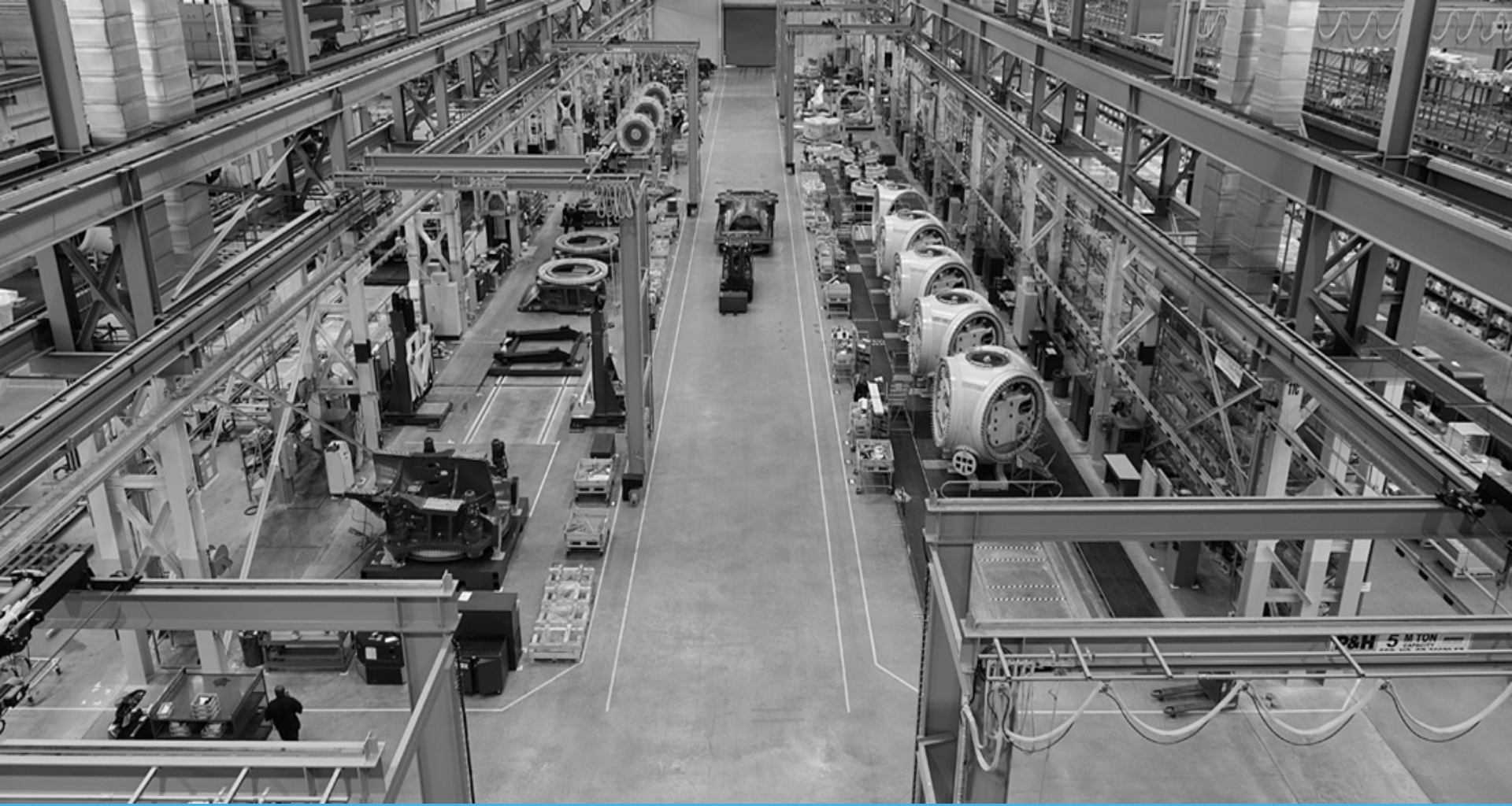
https://www.salesforce.com/form/other/wearables-in-the-enterprise.jsp?d=70130000000iGBD&nc=70130000000iGB8

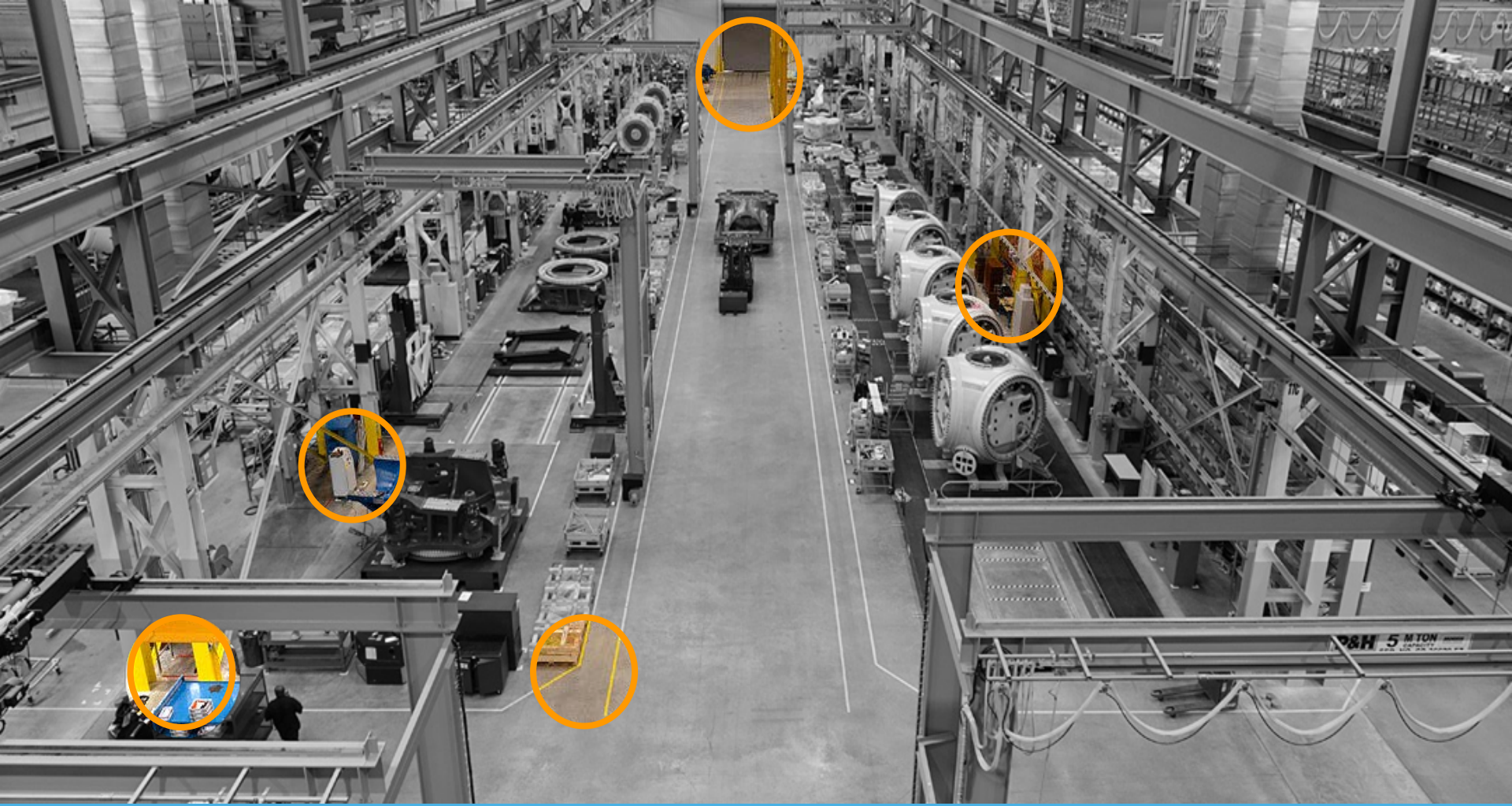
Wearable Market

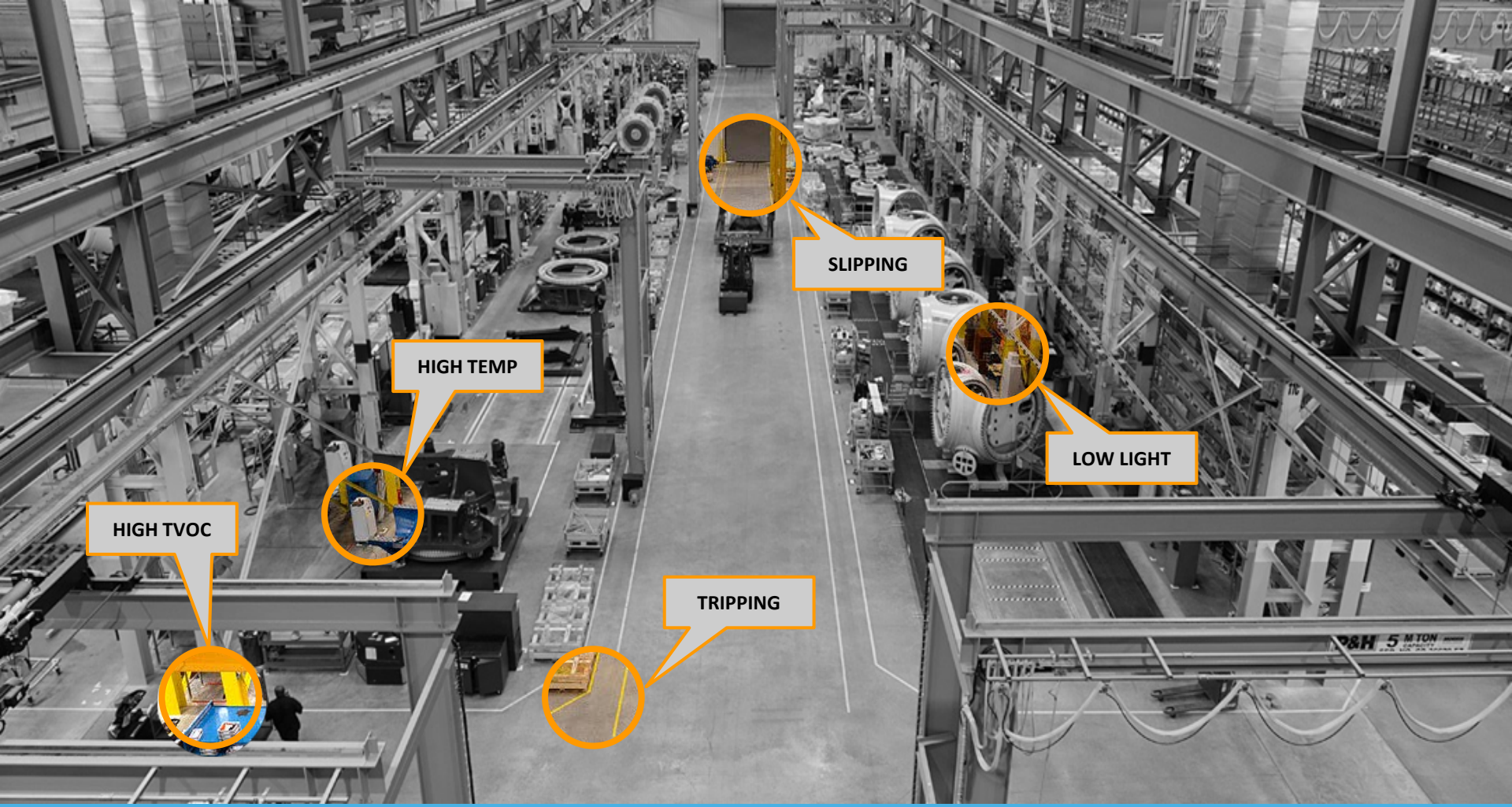
Available at amazon

https://www.theguardian.com/technology/2018/jan/31/amazon- warehouse-wristband-tracking

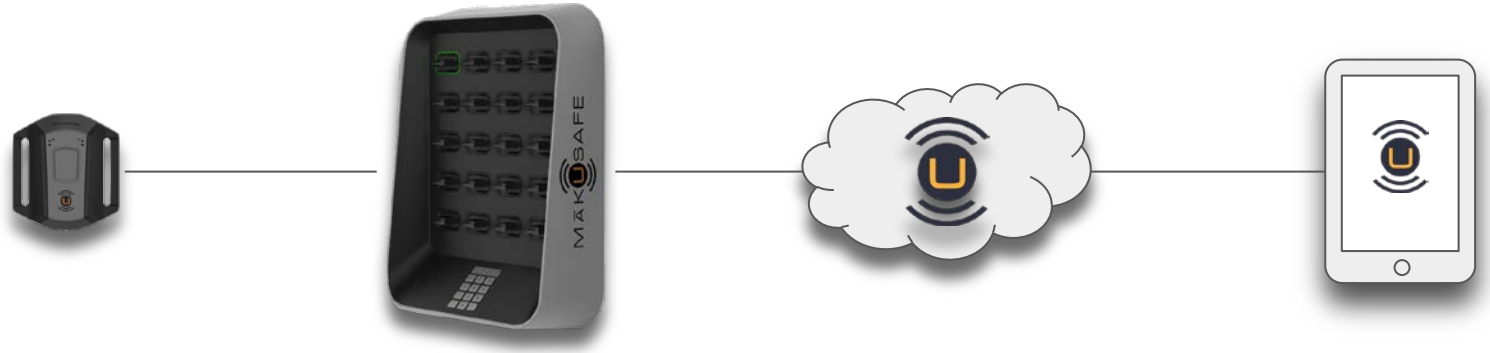



P&H 5 M TON


5 M TON


SLIPPING
HIGH TEMP
LOW LIGHT
HIGH TVOC
TRIPPING

MākuSafe Technology Overview



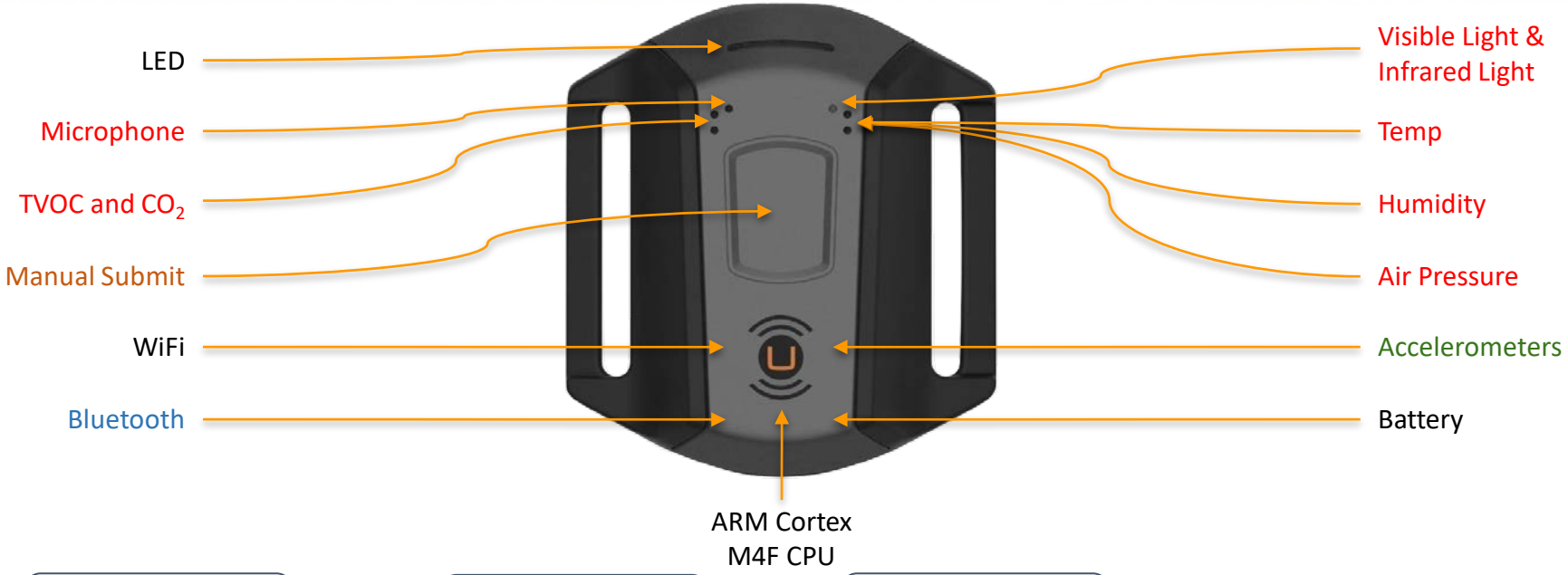
Wearable

Base Station

MākuSmart Cloud

MākuSmart Application

MākuSafe Wearable Device Sensors



Environmental Conditions

Forceful Motion

Location

Voice Memos/Near Misses

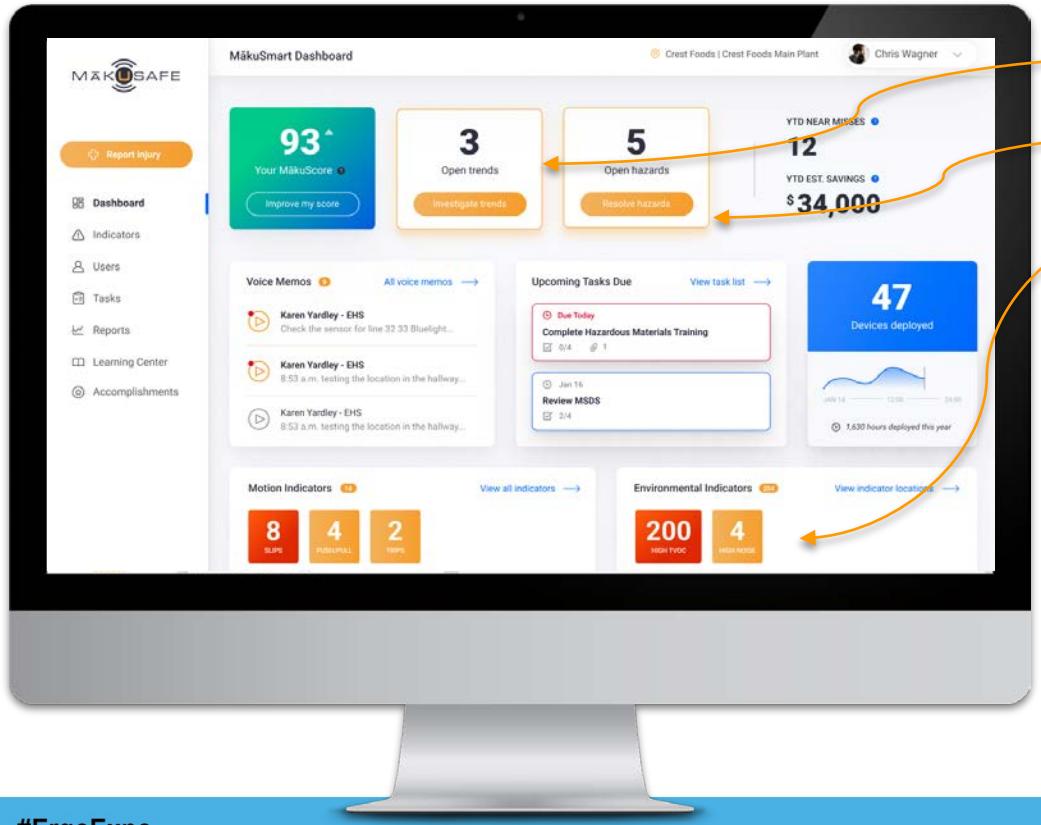
MākuSafe Respect for Worker Privacy

- No haptic feedback
- Not continuously tracking
- Nothing personal or HIPAA covered

COVID related concerns

- No personal devices
- Sanitizable
- Contact Tracing and Density Mapping

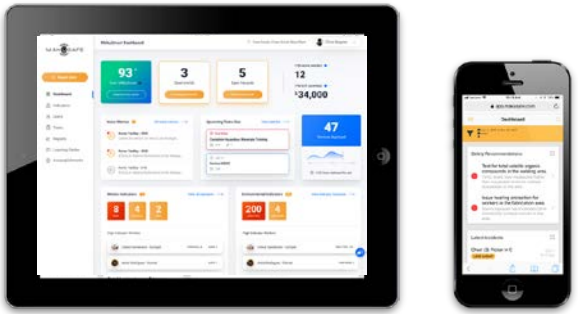
MākuSmart 2.0 Platform Dashboards



Safety Analytics

Risk Intelligence

Discovery



Support for Multiple Devices

MākuSafe 2019 Pilot Summary: Aggregate Results

- Paid Pilots with Strategic Partners in Varied Environments
- Both End User Industrials & WC Insurer Policyholder Sites
- 3 Organized Labor Union Sites
- Running concurrently in 6 States
- 140 Workers. 75,000 Wearable Hours
- Over 20 Million Data Points Gathered
- 300,000+ Indicators Detected
- Small Number of Investigated, Confirmed & Documented Near Misses
- $600,000+ in potential losses avoided

- Over 1000% ROI* (As determined by users, no further value for remaining 9 mos.)

Pilot Case 1: Commercial Laundry

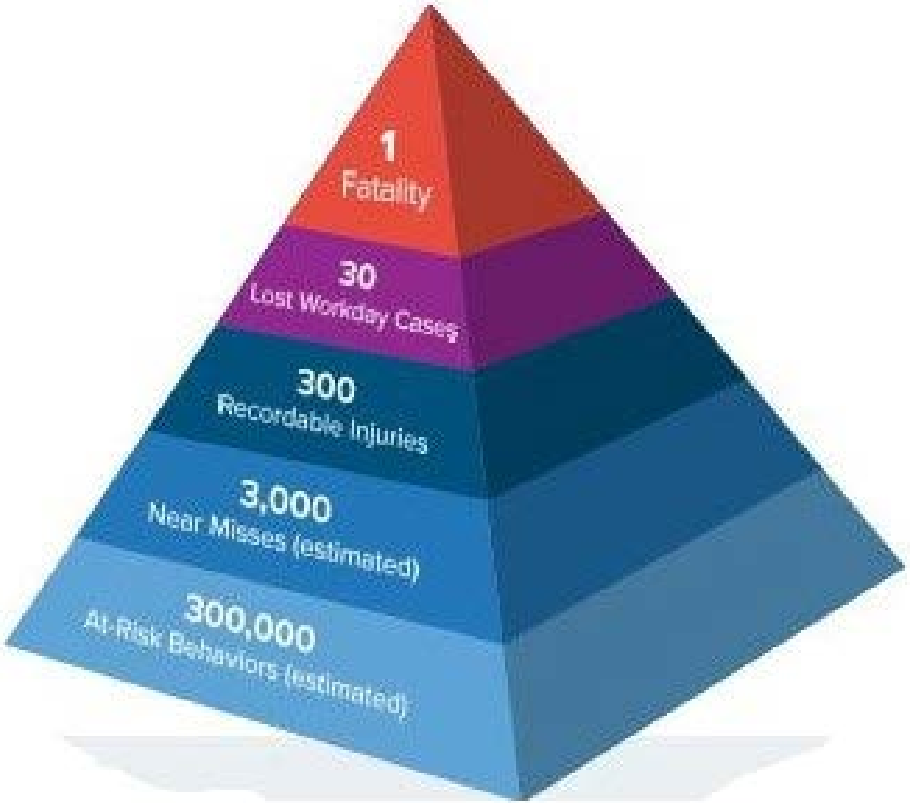
Indicator Detected: Multiple employees wearing the devices showed indicators of forceful repetitive motion in one particular area of the facility.

Issue Identified: Management was notified, upon observation it was discovered that material was repeatedly jammed in a machine and workers were using a large amount of force to pull while bent over to dislodge the material when this occurred. It was also discovered during the hazardous motion investigation that the employee was using the safety light curtain to shut down the machine instead of following the proper procedure.

Action Taken: Leadership considering a process change or machinery modification to keep workers from having to perform this motion and retraining on proper shutdown.

Risk: Repetitive motion injuries to the shoulder or back. Worse?

Potential Impact: $50,000+ ???


1
Fatality
30
Lost Workday Cases
300
Recordable Injuries
3,000
Near Misses (estimated)
300,000
At-Risk Behaviors (estimated)

Pilot Case 2: Consumer Product Manufacturer

Indicator Detected: MakuSafe wearable was picking up excessive repetitive force to one specific employee, which became more dramatic later in each week.

Issue Identified: MakuSafe reviewed and determined that other workers in the same area were not having similar indicators. When asked, this long term worker revealed that he was seeking chiropractic care on Saturdays for his sore shoulder, which the leadership team was unaware of. Early in the week he felt fine, but as the week progressed he became more and more bothered.

Action Taken: Interviewed employee, consulted with safety director and leadership team who then considered job rotation to lessen impact on shoulder for this worker.

Risk: Repetitive motion injuries to the shoulder/rotator cuff or back.

Potential Impact: $50,000+???

The ROI of safety

Safety+Health

Knowing how much an injury costs is vital to determining the ROI of safety.

How much?

Here are some of the more expensive injury types by average cost per workers' compensation claim from 2015 to 2016.

BY CAUSE OF INJURY:

Cost of occupational injuries and deaths, 2016

Total cost to society:

$151.1 billion

From Jan 2019 National Safety Council Report

Pilot Case 3: Heavy Mfg/Metal Fabrication

Indicator Detected: High Noise Levels

Issue Identified: One individual user who is responsible for running an industrial power washer was repeatedly experiencing 200%+ of his allowable sound dosage within the first couple of hours of his shift. This is a mandatory hearing protection environment, however none of the other workers were achieving anything near the dosage of this worker.

Action Taken: Higher rated hearing protection being investigated by safety leaders, but time allowed at that work station has been decreased by job rotation. Management is considering a work process change to minimize exposure.

Risk: Potential Hearing Impairment or Loss

Potential Impact: $30,000+???

Pilot Case 4: Steel Foundry

Indicator Detected: MakuSafe wearable detected motion, identified in MakuSmart as a Slip.

Issue Identified: MakuSafe and shift supervisor were notified via MakuSmart dashboard. Supervisor and Safety Director went to the work area within 30 minutes and met with the employee. The 3 discussed the incident and it was determined that the incident was actually more of a trip rather than a slip, over an ergonomic pad.

Action Taken: Safety manager was able to easily reclassify indicator in MakuSmart platform from his cell phone and leave a note that detailed the change and what was done to fix the hazard. Operator confirmed Ergonomic pad was replaced with an option that fit the space better. Mgmt. team indicated they were re-evaluating fit of mats in other locations as well.

Risk: Trip leading to sprain or broken bone.

Potential Impact: $46,000+???

The Conversation

Gallup SOAW Engagement Study

- **Only about a third are highly engaged.**
- **Those highly engaged contribute…**
  - 70% fewer safety incidents
  - 40% higher quality
  - 58% fewer patient safety incidents
  - 41% reduced absenteeism
  - 24 to 59% reduced turnover
  - 21% higher profitability
  - 17% higher productivity
- **Active disengagement costs $500-$700 Billion annually.**

T.R.U.E. Leading Indicators of Hazards & Risk

T – Timely
R – Relevant
U – Unique / Useful
E – Easy / Economical

Thanks

SMART. SAFE. MĀKUSAFE.

makusafe.com/pilot

makusafe.com/nearmiss

Tom West, Vice President, tom@makusafe.com, 515-490-6202

SMART. SAFE. MĀKUSAFE®

MAKING THE WORLD SAFER THROUGH TECHNOLOGY AND DATA

MākuSafe® is a Safety Data & Analytics company focused on improving workplace safety and reducing workers' compensation claims. MākuSafe® gathers real-time environmental, motion, and near-miss data from connected devices, including their proprietary ***wearable armband*** technology.

The data is then sent to their cloud platform MākuSmart®, which uses machine learning & AI to identify high-risk trends in a facility, and generate alerts to safety leaders. The portal auto-records near-misses, proactively targets resources to specific conditions & occurrences, and streamlines compliance reporting. MākuSafe® improves organizational culture and strengthens safety mindset while respecting employee privacy.

FEATURES

- Intuitive analytics & reporting dashboards are easy to understand and provide actionable intelligence
- Alerts to high impact trends with suggested action steps at the moment of need
- Real-time automatic collection of leading indicators to potential hazards and risk
- Monitoring of environmental conditions and harmful human motion, including slips & trips, with location identification
- Easy voice reporting of near-misses and observations from the wearable device

MĀKUSAFE®

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