

Exoskeletons in the Industrial Use – a Balancing Act between Expectations and practical Demands

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Classification: PUBLIC

General Situation and Expectations

Exoskeletons – a Trend

General situation until 2018

- ❖ Exoskeletons perceived as an innovative technology
- ❖ Manufacturers using offensive marketing strategies, leading to uncontrolled procurement.
- ❖ Exoskeletons „spilling“ into plants (worldwide 125), difficulty to maintain overview.
- ❖ „Work in progress“ regarding technology and scientific research.
- ❖ Insufficient information about level of maturity of equipment and effects on users.
- ❖ No clarity regarding statutory framework, resulting in legal and financial risks.

Expectations of Management in Planning and on Shopfloor

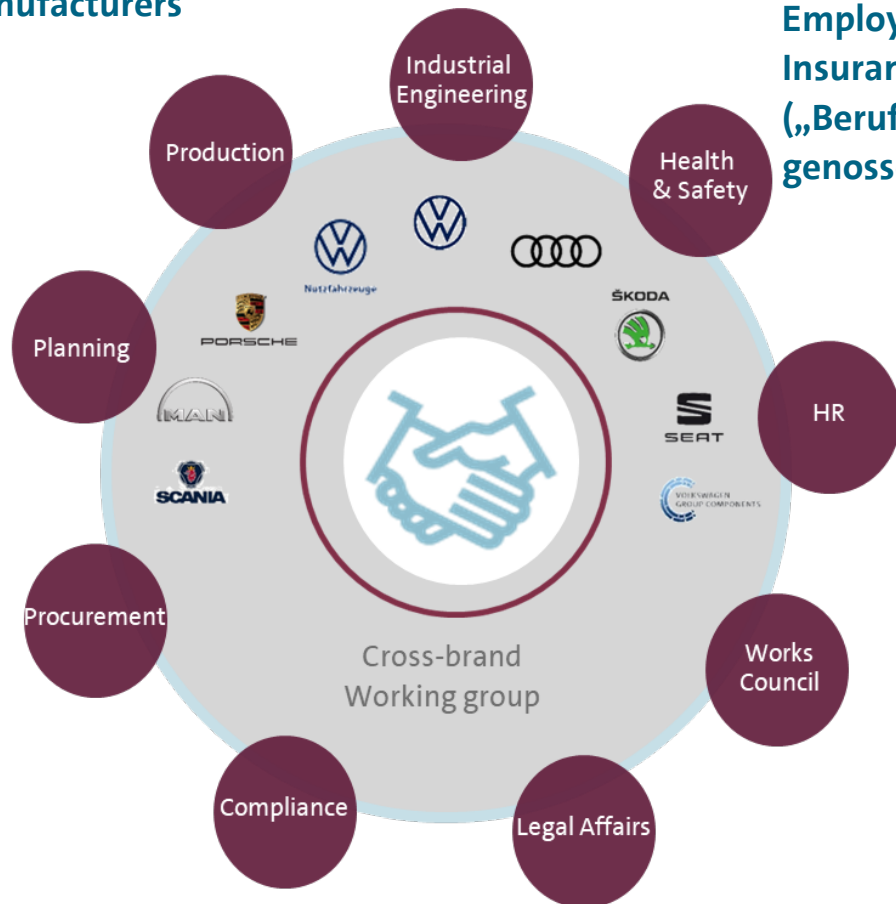
- ❖ Decrease of health-related absence
- ❖ (Re-)Integration of employees with reduced abilities
- ❖ Reduction of investment

Expectations of the **Employees**

- ❖ Physical Relief

Practical Testing Interdisziplinärer Dialog

Manufacturers



Employers' Liability Insurance Association („Berufsgenossenschaft“)

Volkswagen Group installed a interdisciplinary working group across all brands to coordinate the activities

Our objective

- ❖ Focusing human-centered application of exoskeletons
- ❖ Provide practical tools to monitor implications of use
- ❖ Standardize procedures to ensure quality and comparability
- ❖ Gain efficiency through synergies between brands and plants

Research Institutes

Practical Testing

Activities within the Volkswagen Group

Upper Limbs

Ekso Vest



PaExo



Airframe



SkelEx



PaExo Thumb



Exo-Jacket



Ironhand



MATE



PaExo Neck



PaExo Wrist



Carbon-hand



active exoskeletons

Back Whole body

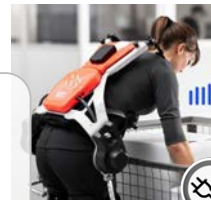
BackX



Laevo



Cray X



Lower Limbs

Chairless Chair



Practical Testing

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Laevo



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Lower Limbs

Chairless
Chair



Practical Testing

Evaluation of Laevo in a Combined Field and Lab Study

Subjective Evaluation: Field Study at Audi

Sample Workplaces:

- ❖ Assembly
- ❖ Logistics
- ❖ Press Shop



Questionnaire Survey:

- ❖ Physical Discomfort, Wearing Comfort
- ❖ Usability
- ❖ User Acceptance

Perceived Relief of Workload

- ❖ support rather for static work tasks (working bent forward) than for dynamic work tasks (such as in logistics)

Wearing Comfort

- ❖ increased wearing discomfort (pressure perception in chest area, especially in case of manual material handling in logistics)

Usability

- ❖ easy to use: operating the system, fast donning and doffing

User Acceptance (52 participants, 30 finishing the test)

- ❖ Wearing discomfort (esp. in chest area) outweighs the perceived workload relief, what leads to rejection of the system by the users

Practical Testing

Evaluation of Laevo in a Combined Field and Lab Study

Objective Evaluation in a Lab Study at University in Tübingen

Physiological Assessment:

- ❖ Muscle Load Measurement (Surface - electromyography)
- ❖ Assessment of Body Postures and Joint Angles
- ❖ Compressive Load Measurement



Objective Workload Relief

- ❖ up to 60% load relief of intervertebral discs
- ❖ no deconditioning of the back muscles to be expected

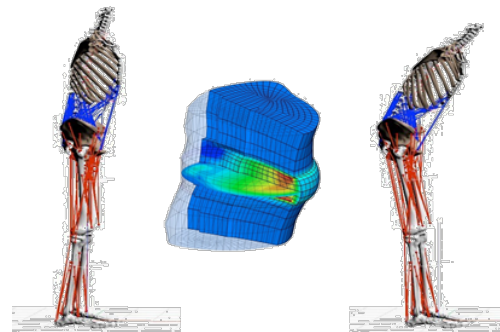
Load Redistribution

- ❖ increased pressure load in the chest area of up to 10 daN leading to severe discomfort
- ❖ slight pressure load in the knee joint



Human Model Simulation:

- ❖ Load on Muscles
- ❖ Load on Tendons
- ❖ Load on Vertebrae
- ❖ Load on Intervertebral Discs



Findings

Experience gained from Testing



Benefit

Perceived decrease of stress at tasks such as

- ❖ working overhead
- ❖ handling load
- ❖ in bend posture



Requirements

Acceptance by the employees depends upon

- ❖ wearing comfort
- ❖ individualisation
- ❖ short time for donning/ doffing
- ❖ freedom of movement
- ❖ hygiene

A **support** not only of simple, but rather **complex work actions** is relevant to prevent monotonous work routines.

Findings

State of Knowledge



Effectiveness

- ❖ No evidence of a preventive or therapeutic effect

Safety

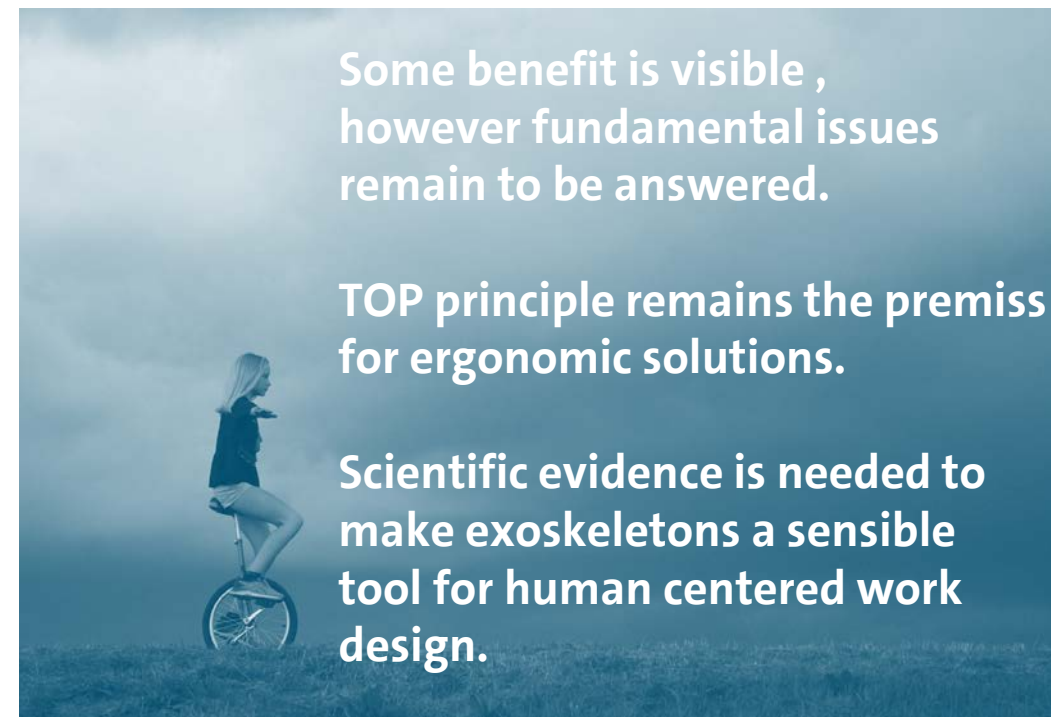
- ❖ Long –term consequences & side effects unknown
- ❖ Legal situation unclear

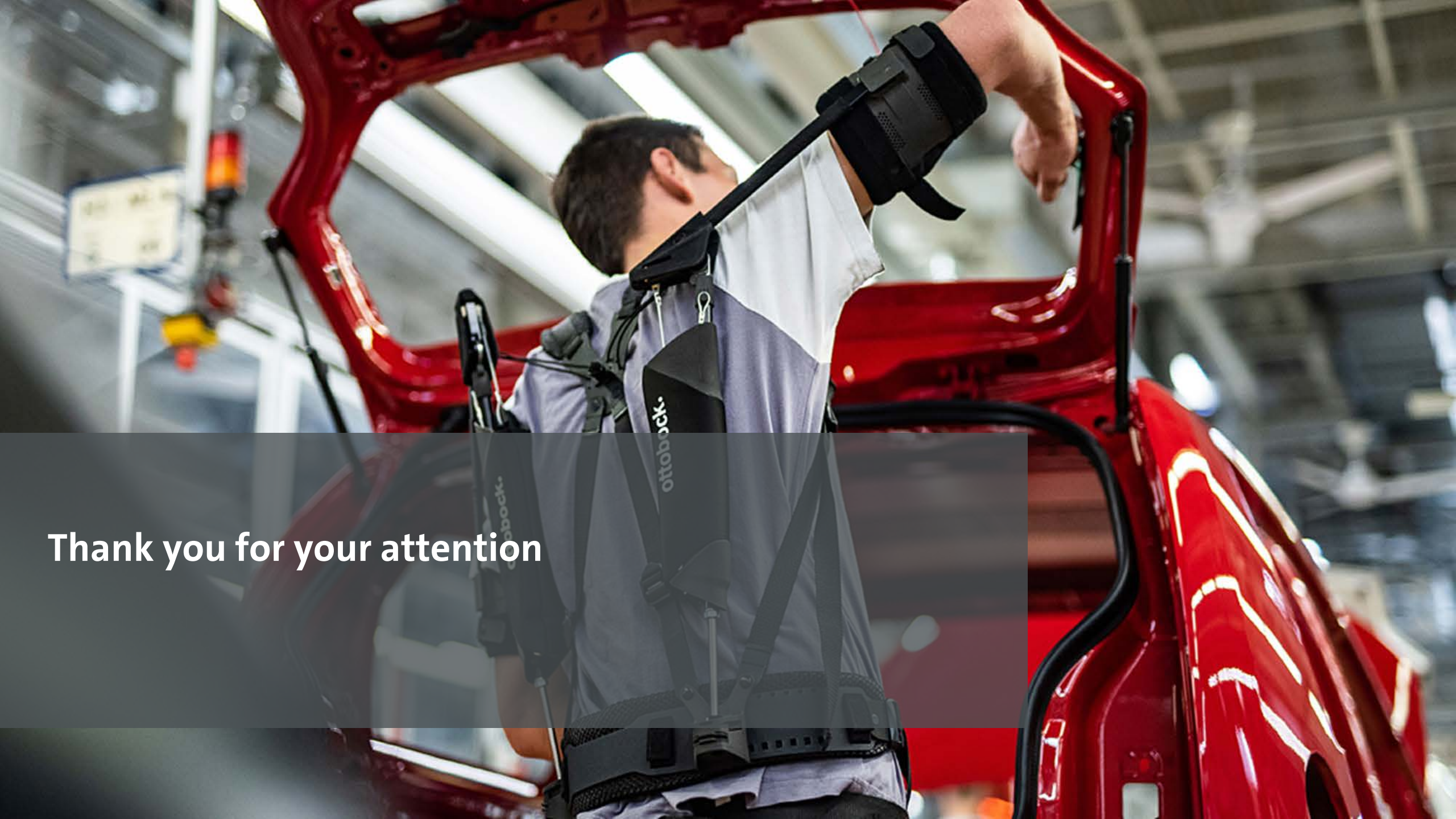
Suitability for employees with physical limitations or disabilities

- ❖ Currently not advisable

Economic effects

- ❖ Not proven as of yet





Thank you for your attention