

Biomechanics and Assistive Technologies Research Group



**University of Defence**  
Military Faculty  
of Medicine



**FACULTY  
OF BIOMEDICAL  
ENGINEERING  
CTU IN PRAGUE**

# Current State and Design Recommendations of Wearable Systems in Military Applications

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# Who we are

A multidisciplinary team focused on research, design and development:



**Methodologies**

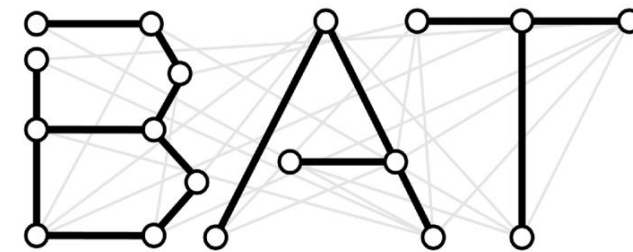


**Software**

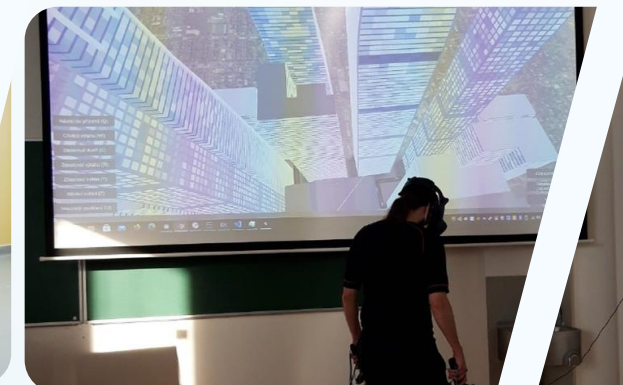


**Electronic systems**

for measuring and evaluating physiological, motion and image data.



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# Research challenges



**Operating in  
hazardous environments**



**Real vs. simulated  
environments (VR, AR, ...)**



**Screening and assessing  
individuals and teams**



**Training planning  
and readiness assessment**



**Optimizing the  
working environment**



**Optimizing individual  
wearable equipment**

# Introduction and motivation

Military operations involve high physical and mental demands in unpredictable environments.



Physical exertion and fatigue



Psychological stress



Time pressure

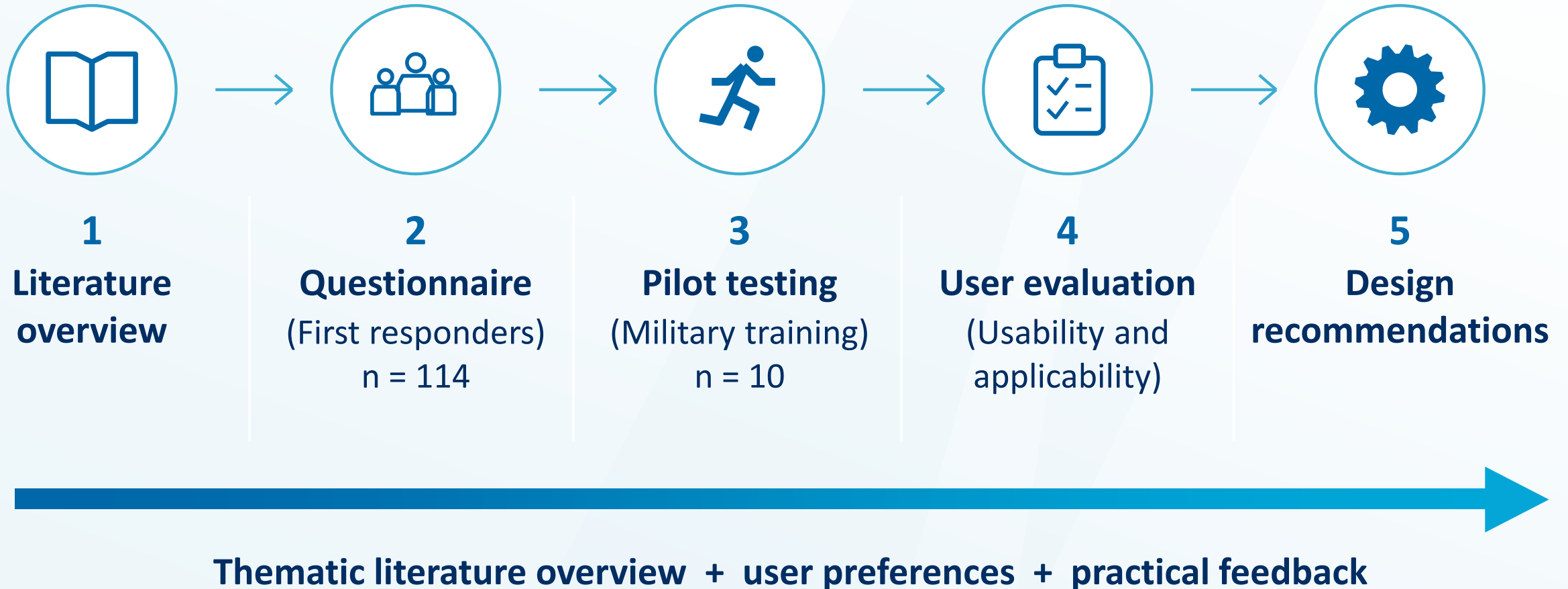


Unpredictable conditions (hazards, terrain, weather)

**Continuous physiological monitoring can support safer and more effective military operations.**

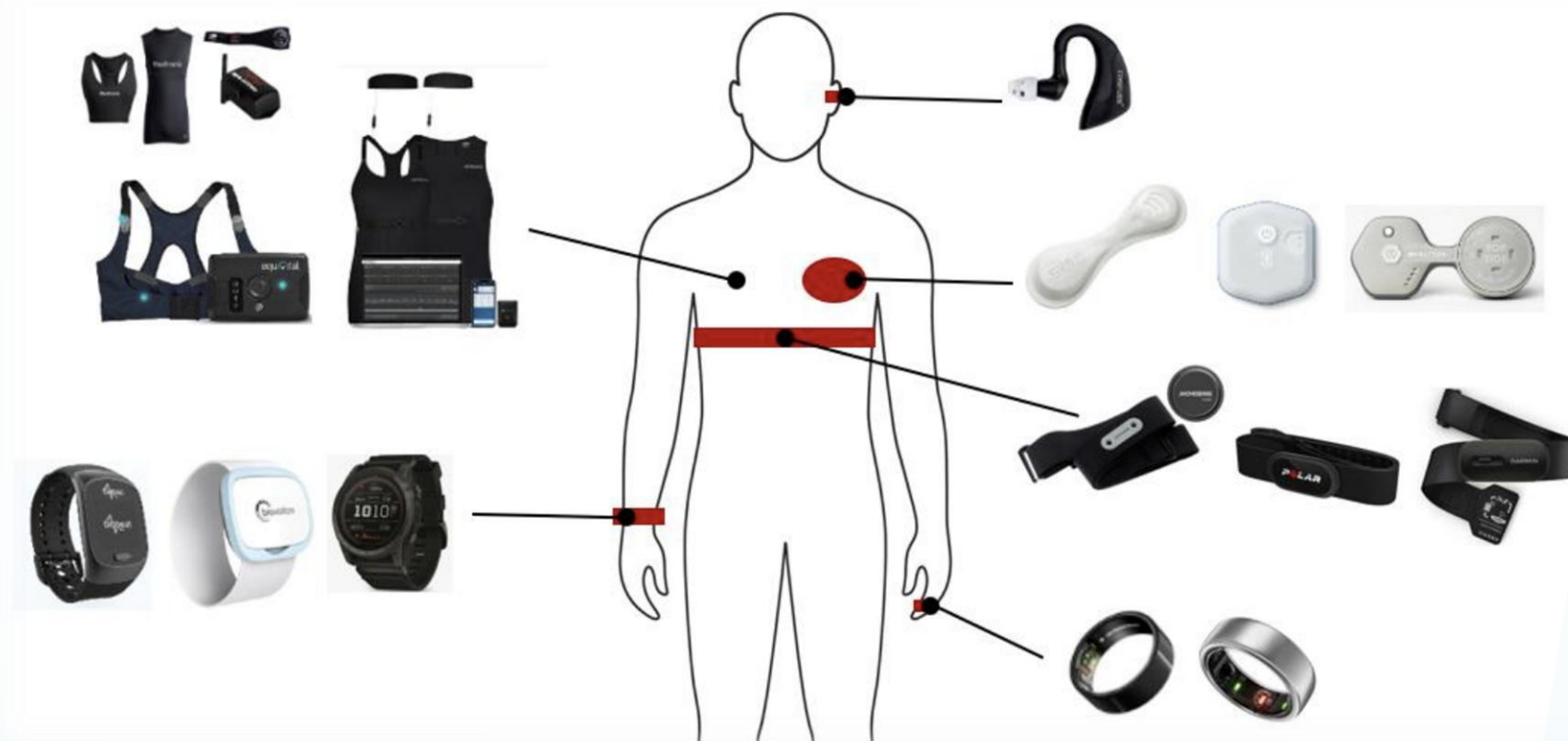
# Research design

From literature to user requirements and practical evaluation.



# Current state of wearable systems

Classification depends on function, body placement and architecture.



## Body placement



Head



Torso



Upper limbs (e.g. wrist)



Lower limbs (e.g. ankle)

## Architecture



On-body systems



In-body systems

## Function



Monitoring



Medical support



Communication



Alerts

# Three implementation approaches

From standalone devices to fully integrated solutions.

## 1 Commercial devices



Smart T-shirt, chest straps, smartwatches, etc.

## 2 Multimodal Systems



Combination of multiple sensors (e.g., ECG, EMG, PA, etc.)

## 3 Integrated into equipment



Smart vests and uniforms.

# Application areas in military environments

Six application domains identified in the literature review.



## External risk detection

Hazards and exposure



## Passive health protection

Physiological status



## Localization and tracking

Position and activity



## Treatment and rehabilitation

Recovery and biofeedback



## Personnel preselection

Response to workload

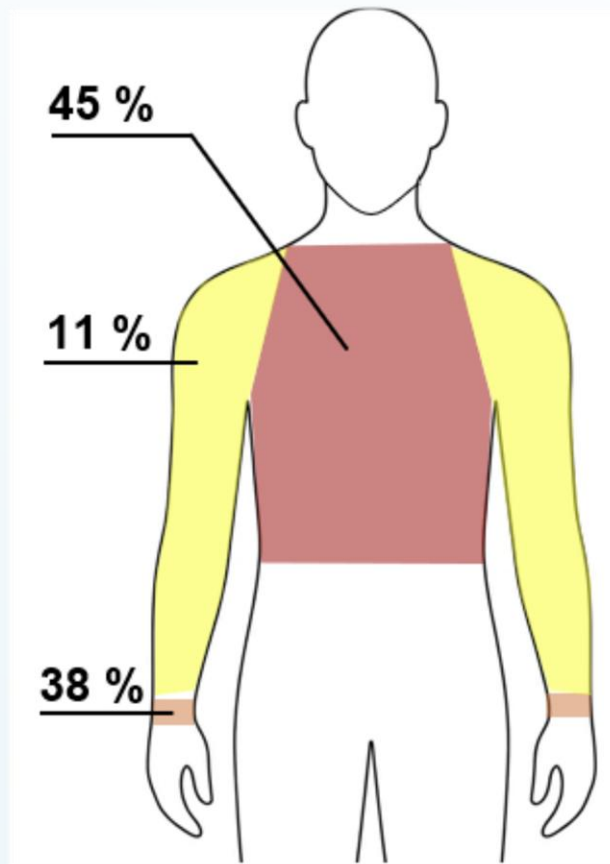


## Training and education

Performance assessment

# Questionnaire survey – first responders

n = 114 respondents (military, police, fire and rescue, emergency services)



**Preferred placement  
on the body**

## Most preferred monitored parameters



Heart rate **31 %**



Respiration **26%**



Other **23%**



**≤ 150 g**

Preferred device weight  
(majority of respondents)

# Pilot testing in tactical training

Testing of a CTU-developed wearable system.



## Participants

10 students  
(University of Defence)



## Measured signals

Heart activity (ECG)  
Respiratory activity  
Physical activity

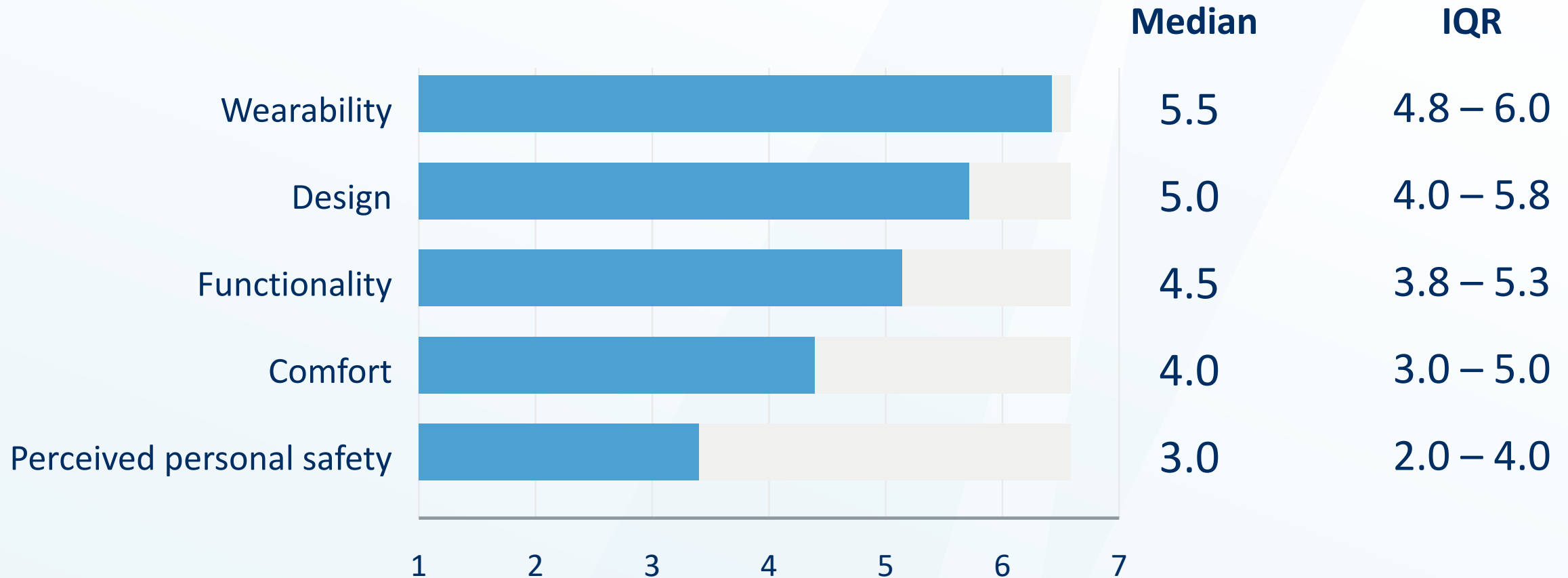


## Practical setting

Tactical training activities  
Equipment worn during  
real movement

# User evaluation – applicability and usability

Assessment of the wearable system during military training.



Pilot evaluation, n = 10; descriptive statistics.

# Practical limitations and user feedback

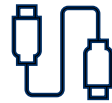
Technical functionality does not automatically guarantee operational usability.



Discomfort during wear



Impractical placement of recording unit



Restrictive cabling



Ergonomic limitations during movement



Need for better integration with equipment

# Design recommendations

Based on literature review, user preferences and pilot evaluation.



## Technical reliability



Resistance to water, dust, shock



Operational temperature  
-40 to +40 °C



Reliable skin contact



Battery autonomy  $\geq 24$  h



## Data and communication



Data encryption



Local data recording



Suitable interfaces



Communication  
requirements



## Human factors



Low weight ( $\leq 150$  g)



Comfort and ergonomics



Minimal restriction  
of movement



Compatibility with equipment



Easy maintenance

# Conclusions



## Significant potential

Wearable systems can support physiological monitoring in military applications.



## Operational requirements

Technical design must reflect real deployment conditions.



## End-user validation

Practical testing is essential to identify ergonomic and usability limitations.



Further validation with larger samples and in different operational conditions is required.

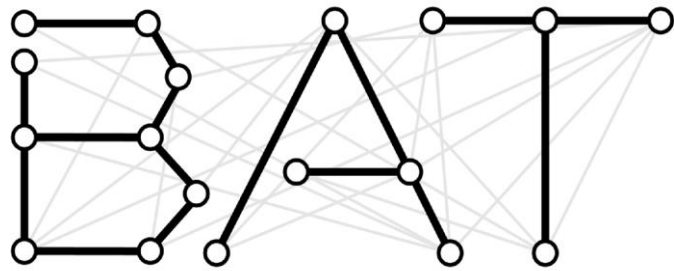
# Thank you for your attention



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