TNO innovation for life

VR AND XR PLATFORMS TO MEASURE THE EFFECT OF COGNITIVE AND PHYSICAL ENHANCEMENT TECHNOLOGIES

| DR. OLAF BINSCH

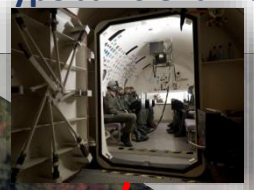
TNO HUMAN FACTORS @ SOESTERBERG

- Research groups
  - Human Performance (HP)
  - Human Machine Teaming (HMT)
  - Human Behaviour & Training (HBT)
- ≈ 140 scientists

Human Tech Campus @ Soesterberg

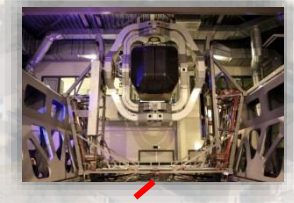
F-35 Pilot Readiness Center

Hypobaric Chambers



Human Centrifuge

NVG Training



DESDEMONA

RNLAF / CML

IBL

HAT-lab

ICL

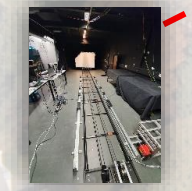
Game lab

TNO
Human Factors

CTC
> F35 simulator
> O2 simulator
> MICE

Audio Hall

ASD

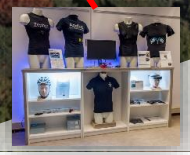


LIMOSINE

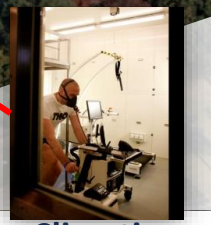
Visual Experiment Hall

Concurrent
Design Facility

3D Rotation
Chair

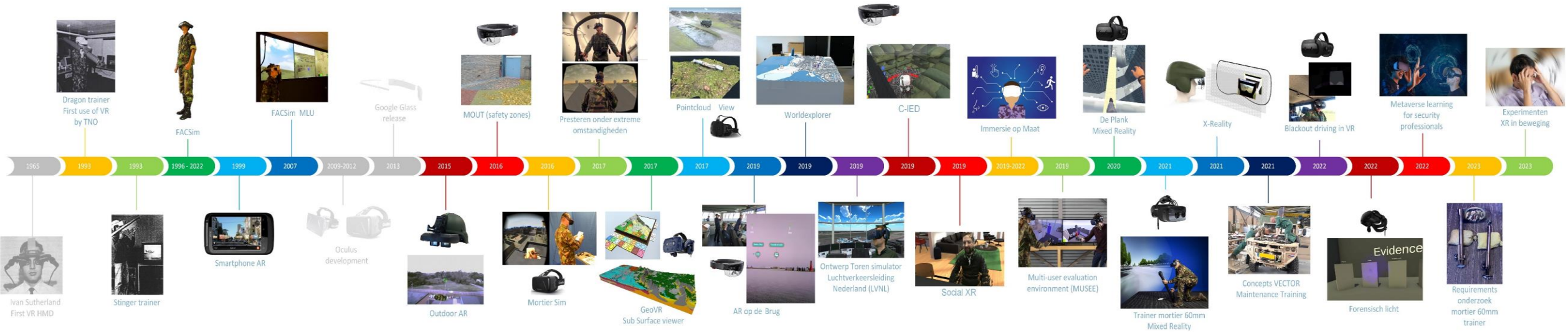


Wearable Tech
Lab



Climatic
Chambers

ROADMAP


1965
Ivan Sutherland
First VR HMD
1993
Dragon trainer
First use of VR
by TNO
1993
Stinger trainer
1996 - 2022
FACSim
1999
Smartphone AR
2007
FACSim MLU
2009-2012
Oculus
development
2013
Google Glass
release
2015
Outdoor AR
2016
MOUT (safety zones)
2016
Mortier Sim
2017
Presteren onder extreme
omstandigheden
2017
GeoVR
Sub Surface viewer
2017
Pointcloud View
2019
AR op de Brug
2019
Worldexplorer
2019
Ontwerp Toren simulator
Luchtverkeersleiding
Nederland (LVNL)
2019
C-IED
2019
Social XR
2019-2022
Immersie op Maat
2019
Multi-user evaluation
environment (MUSEE)
2020
De Plank
Mixed Reality
2021
Trainer mortier 60mm
Mixed Reality
2021
X-Reality
2021
Concepts VECTOR
Maintenance Training
2022
Blackout driving in VR
2022
Evidence
Forensisch licht
2022
Metaverse learning
for security
professionals
2023
Requirements
onderzoek
mortier 60mm
trainer
2023
Experimenten
XR in beweging

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PERSONALIZED IMMERSION AND PRESENCE RESEARCH (FOR F-35 PILOTS)

TNO SOCIAL XR

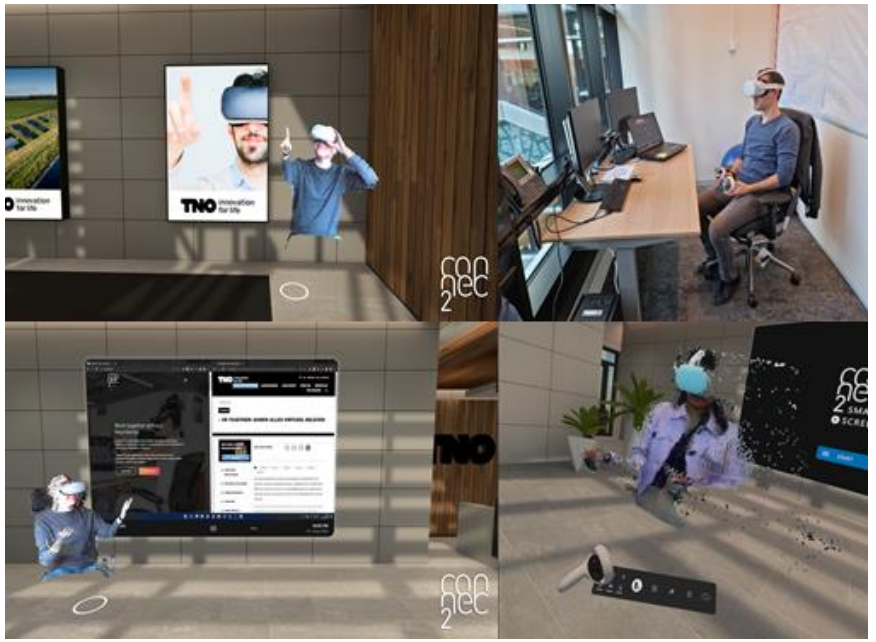
MULTI-USER MULTI-MODAL IMMERSIVE EXPERIENCE

Reality-Virtuality continuum

Real environment		Augmented Reality (AR)	Augmented Virtuality	Virtual environment

Zo werkt een Augmented Reality (AR) belsysteem

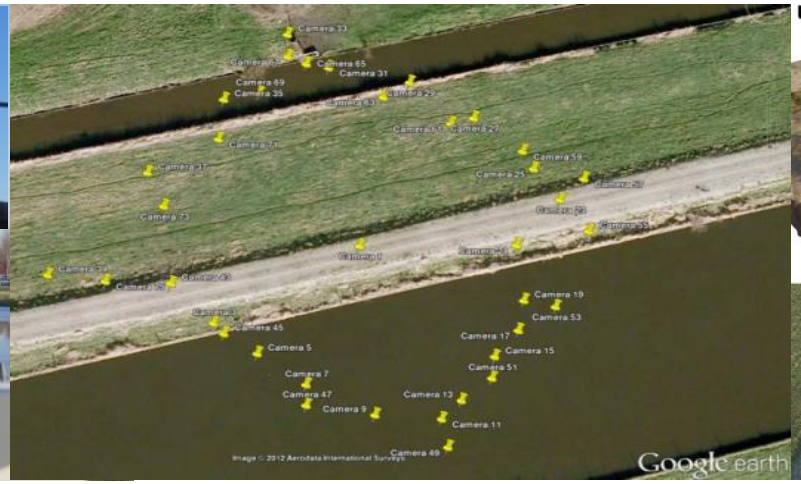
- 3D capture and rendering
- Social Touch
- Real time communication
- Tailored end-to-end transmission chain

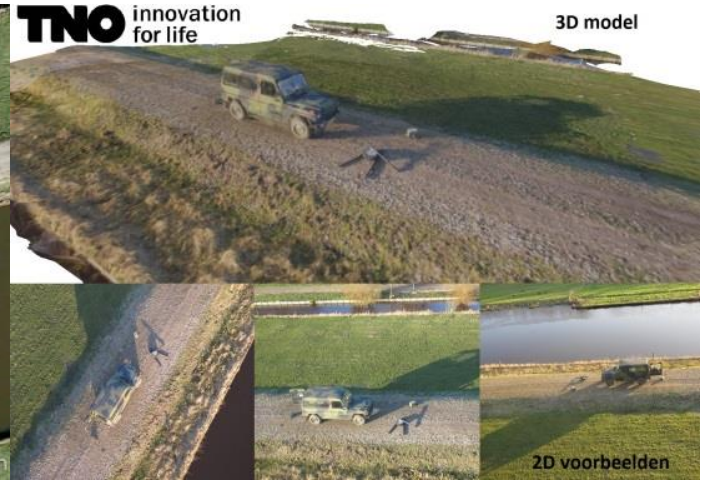


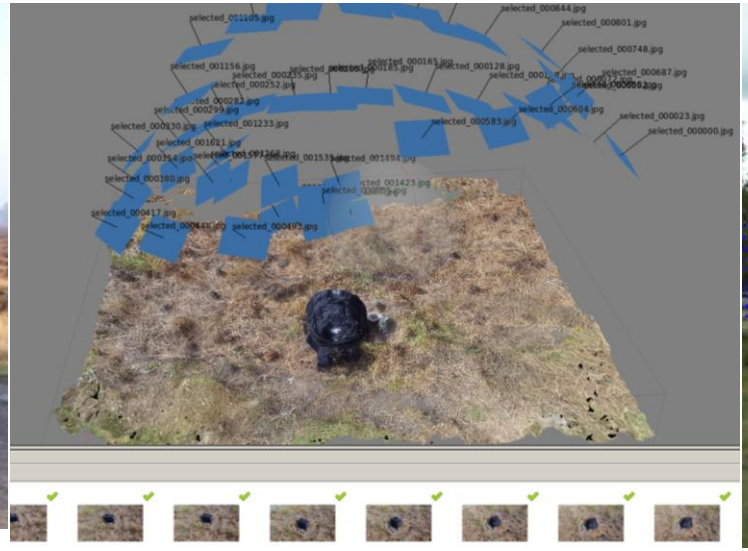
METHODS & TOOLS TO MEASURE SITUATION AWARENESS

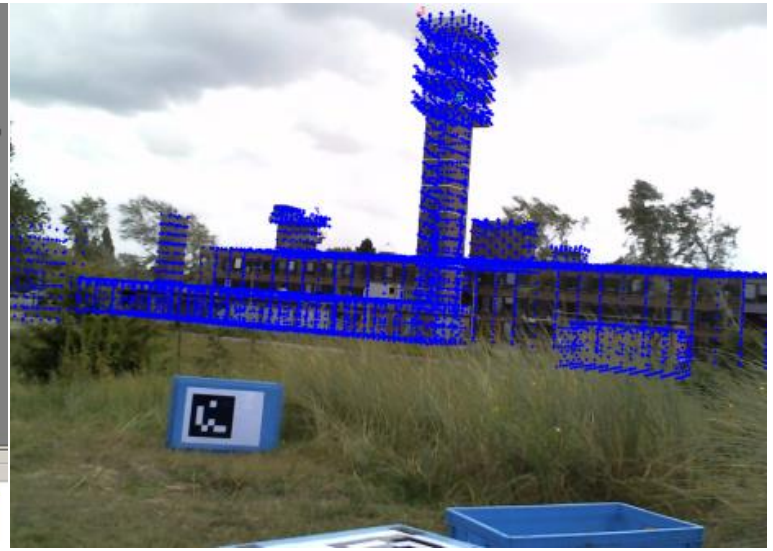
FIRE BRIGADE AMSTERDAM

FROM 3D IMAGING TO VR/AR







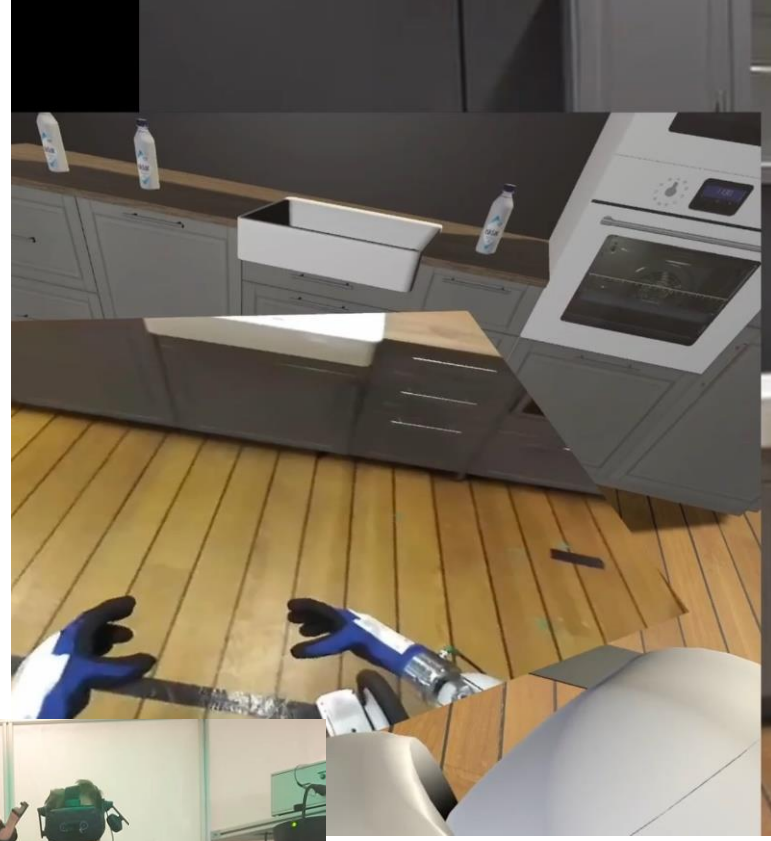


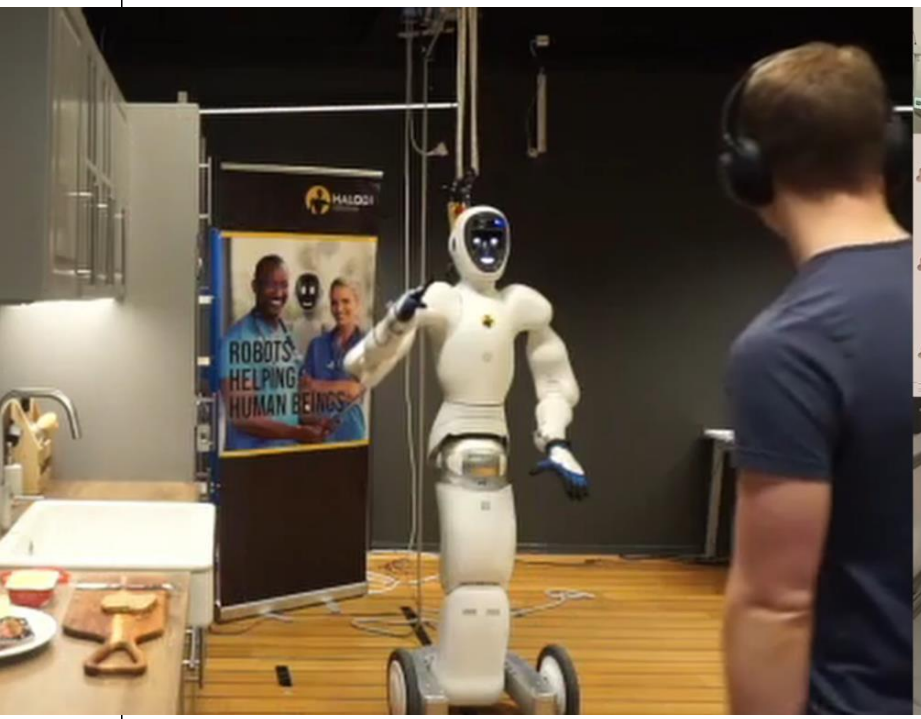
CAPTURE, RECONSTRUCT, AND REVISIT IED EVENT IN VR

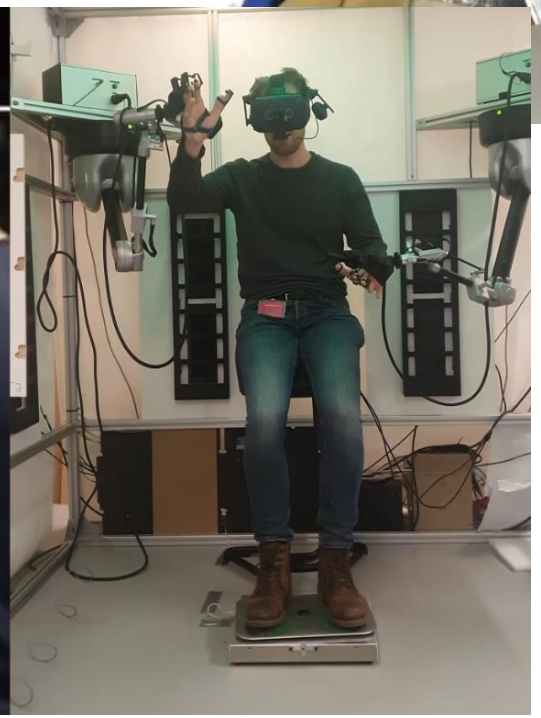
- Clockwork Orange
- DEC C-IED - Bureau Attack the Network
- Innovation in Defense
- Video

I-BOTICS XPRIZE 2022

- VR-mediated intuitive robot control
- Goal: tele-operation without robot-control training
- Video
- Live demo at Soesterberg







VR ASSET INSPECTION AND ROV CONTROL

- Train the diver how to capture underwater assets for 3D recontruction and inspection
- + SA for autonomous ROV operation
- Video (or live demo)

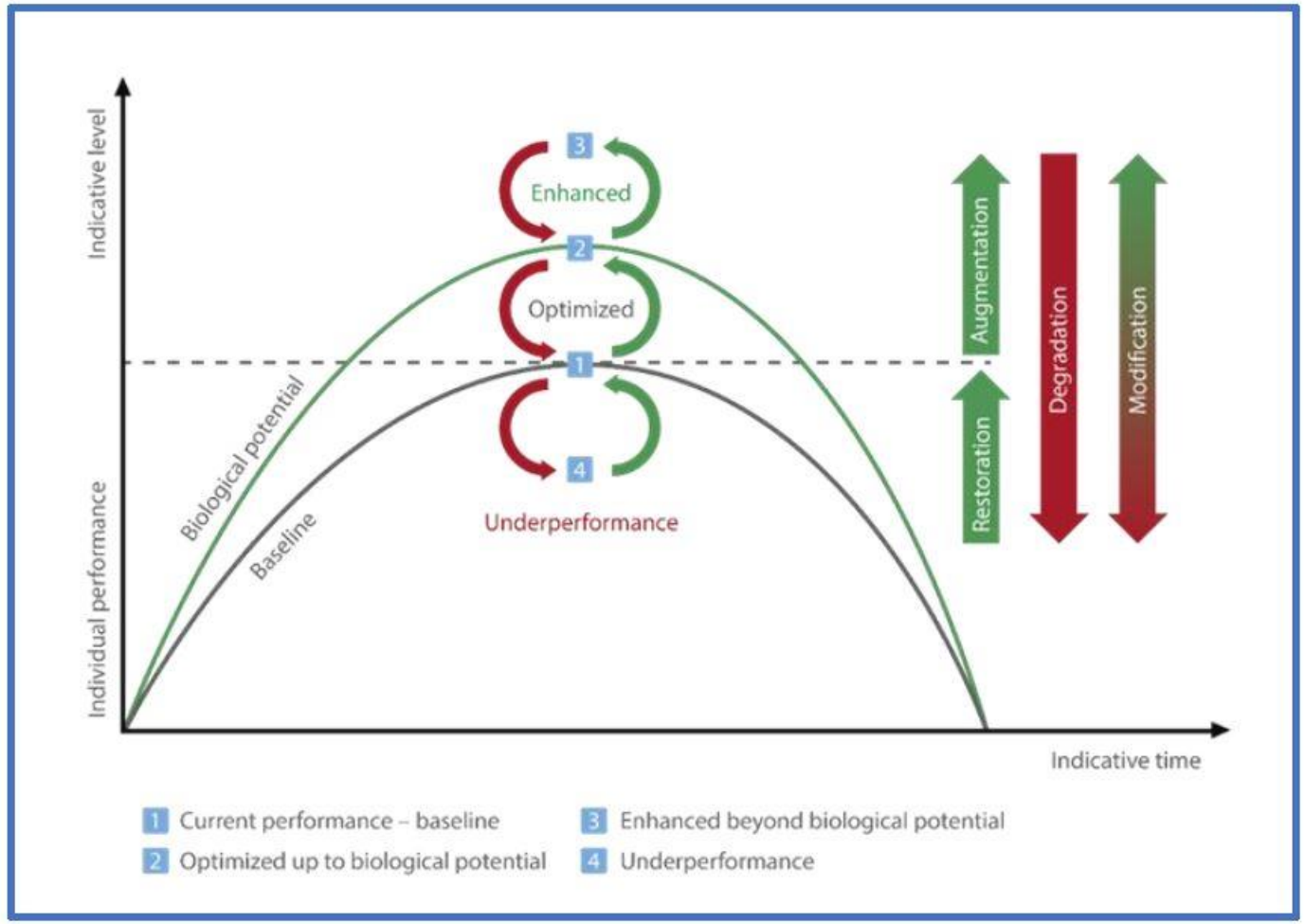
V2208 RESEARCH PROGRAM

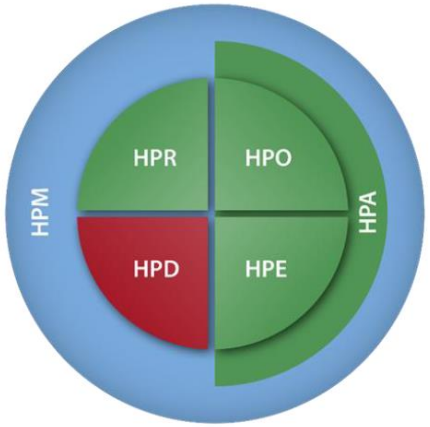
HUMAN CAPABILITY & SURVIVABILITY ENHANCEMENT (HCSE) |

DR. OLAF BINSCH

HUMAN ENHANCEMENT

FUNDED (3 M€; 2022-2025)





HPM	Human Performance Modification
HPA	Human Performance Augmentation
HPO	Human Performance Optimization
HPE	Human Performance Enhancement
HPD	Human Performance Degradation
HPR	Human Performance Restoration

Figure 1 Relation between different notions of performances.
HPM is the umbrella term that includes all other terms. HPA includes HPO as well as HPE, which are both positive developments of the performance of an individual, therefore shown in green. HPR is also a subset of HPM but has no intersections with HPA and shows a positive performance development, therefore shown in green, too. HPD is also a subset of HPM without intersections with the other subsets and is a negative performance development, represented by the red colour.
Source: own development

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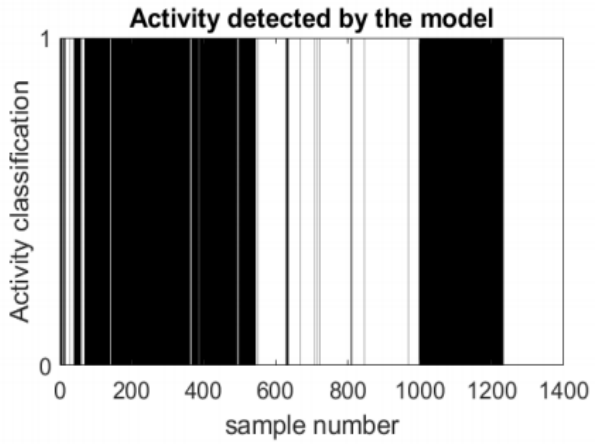
Binsch, O., Bottenheft C., Landman, A., Roijendijk, L., & Vermetten, H.G.J.M. (2021). Testing the applicability of a virtual reality simulation platform for stress training of first responders. Military Psychology, DOI: 10.1080/08995605.2021.1897494

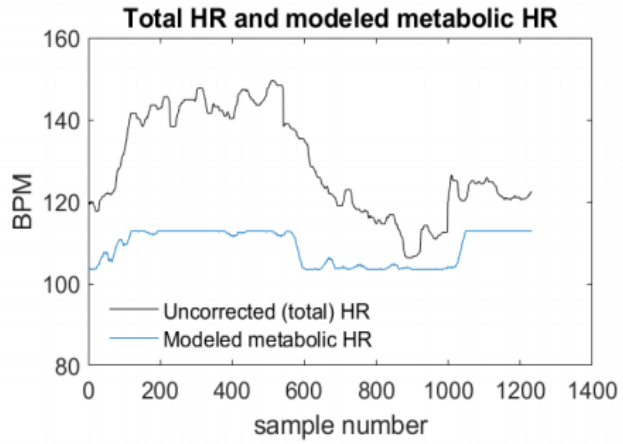
Linssen, L., Landman, A., Baardewijk, J.-U., Bottenheft, C., & Binsch, O. (2022). Using accelerometery and heart rate data for real-time monitoring of soldiers' stress in a dynamic military virtual reality scenario. *Journal of Multimedia Tools & Applications, 81,* 24739–24756. DOI: 10.1007/s11042-022-12705-6

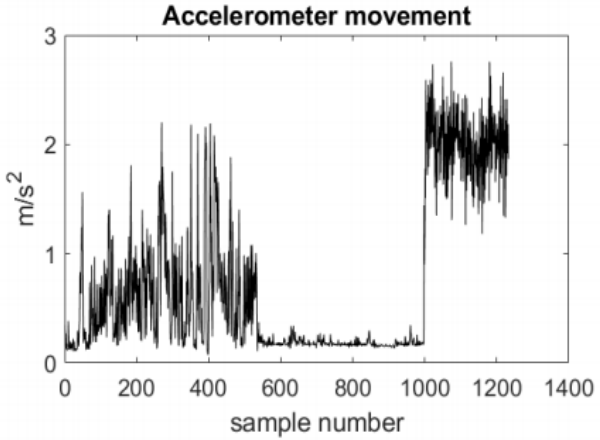
MEASUREMENT AND CLASSIFICATION OF PERFORMANCE AND STRESS LEVELS IN DYNAMIC SCENARIO'S

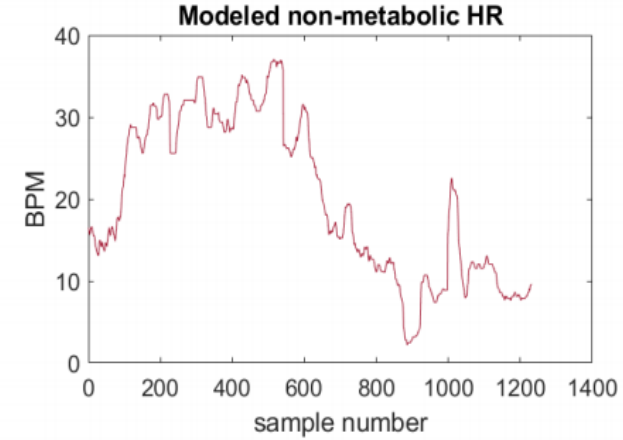
MODEL

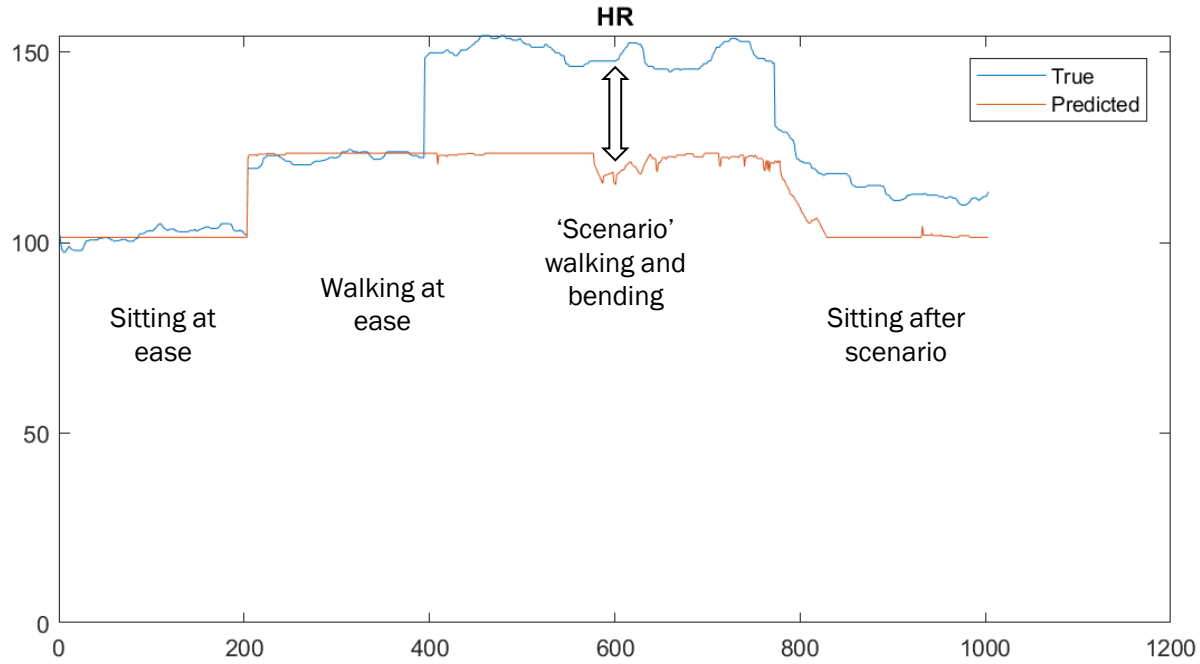
DATA EXAMPLE FOR MODEL





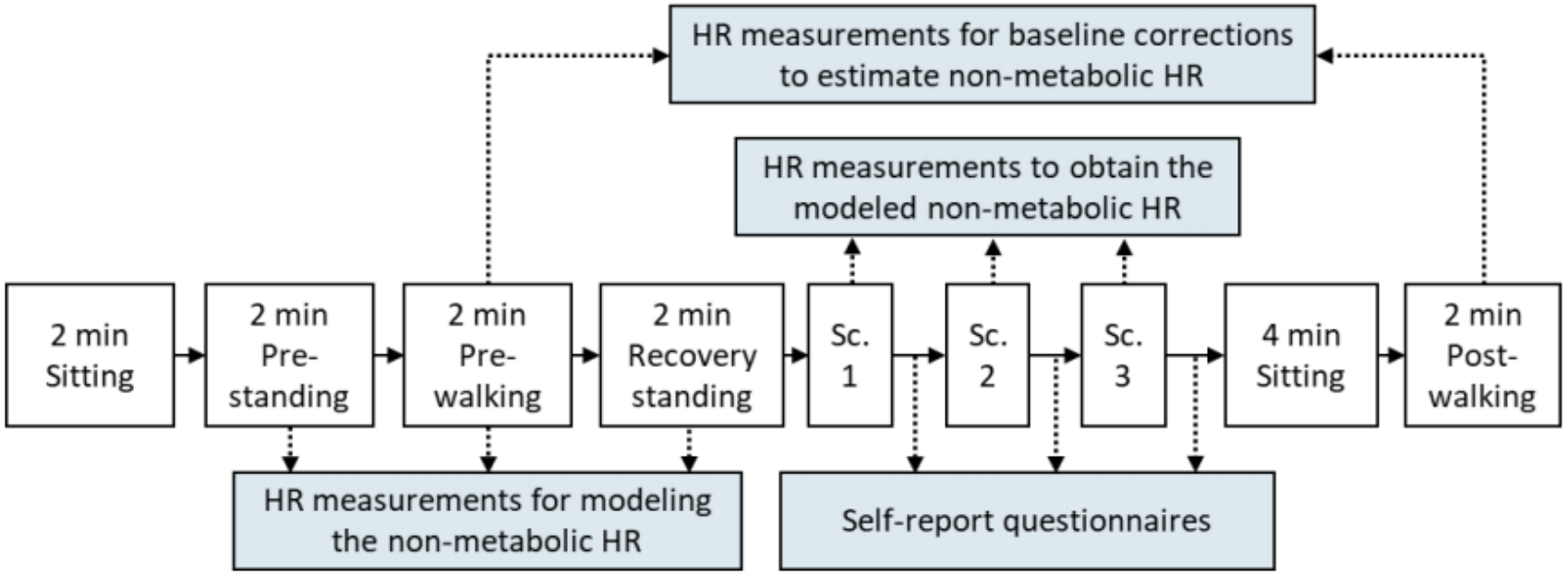






METHOD

PROCEDURE



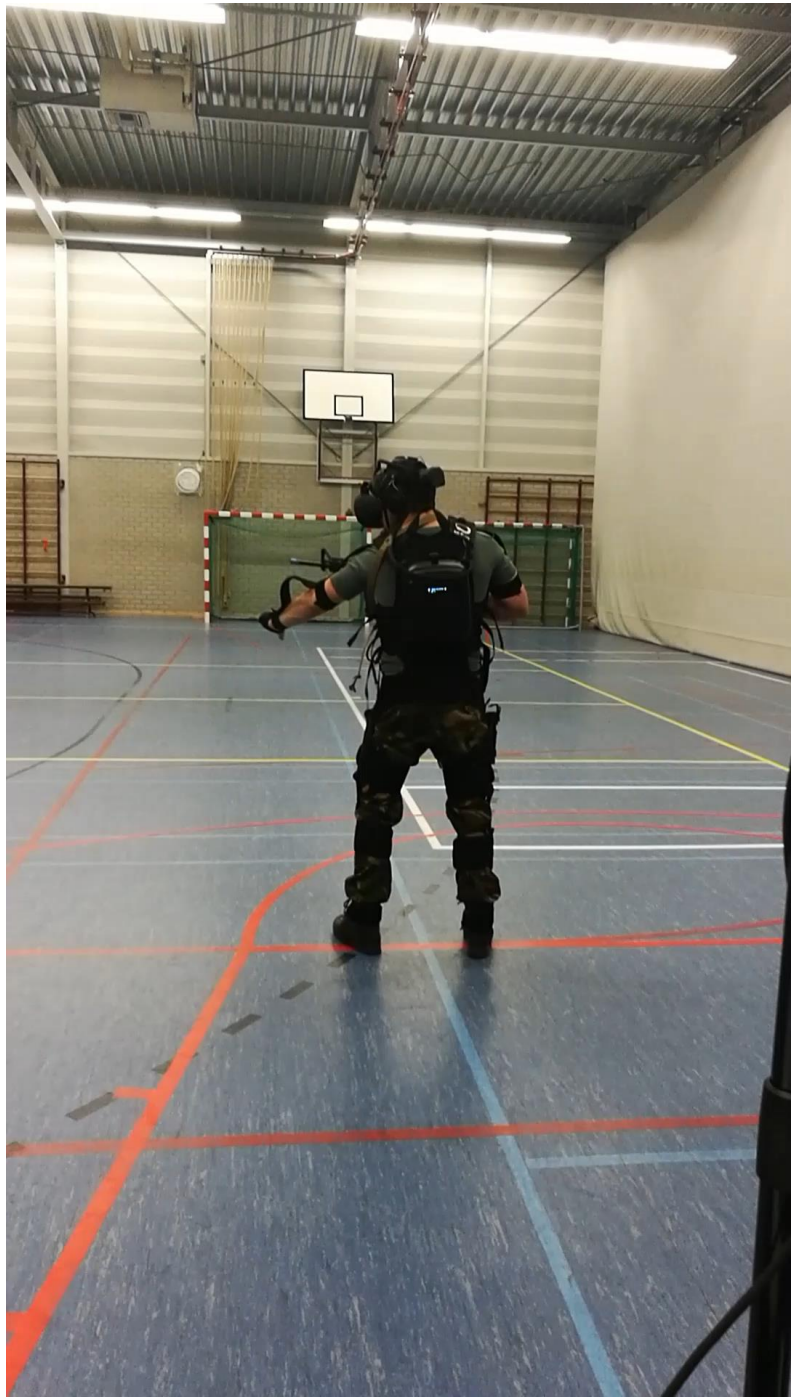
HR methodes:

1) Modelled non-metabolic HR
2) HR corrected pre-walking
3) HR corrected post-walking
4) Uncorrected HR

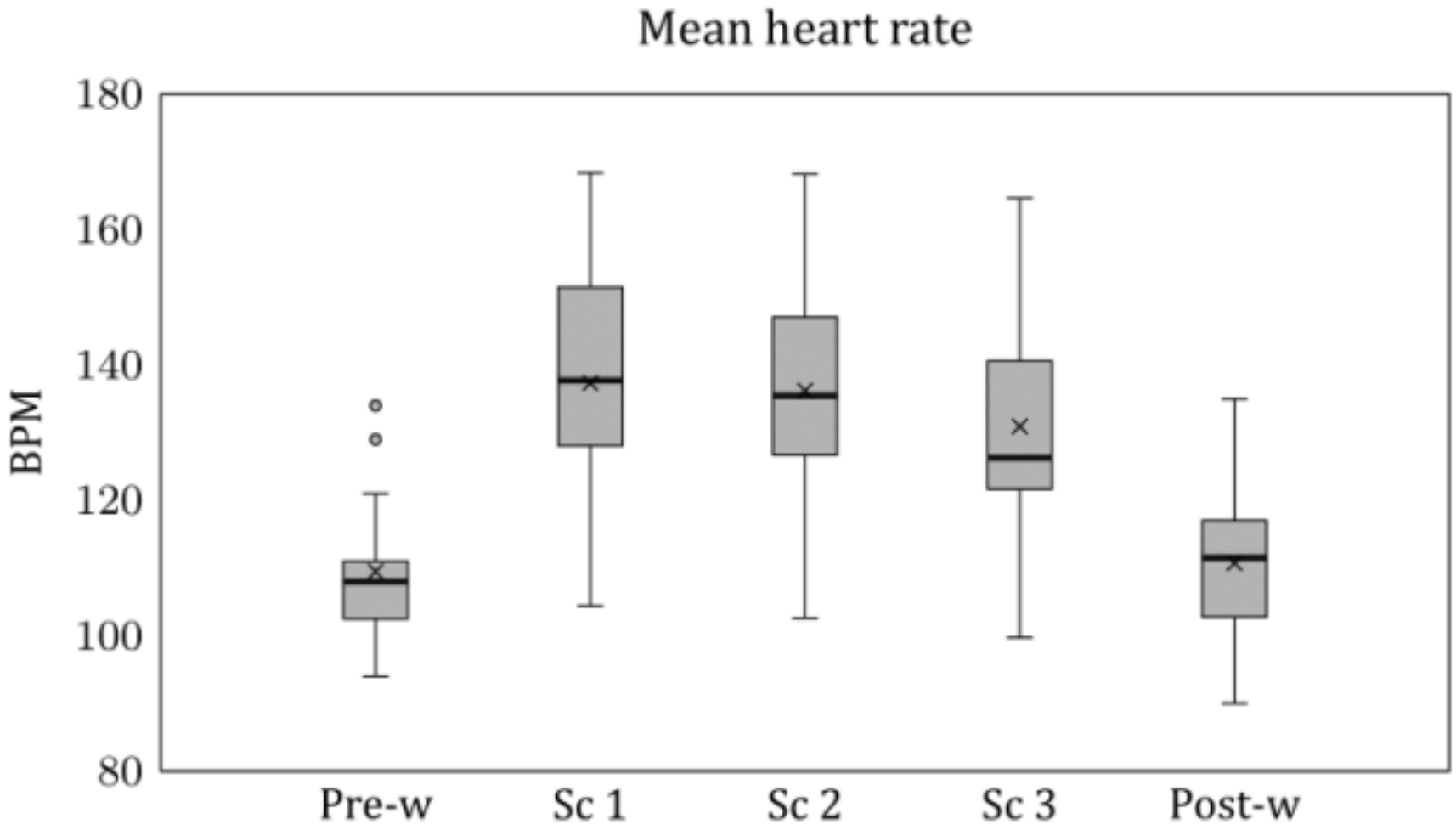
Self-reported questionnaires:

1) RMSE
2) Stress likert scale
3) Physical demand (uit nasa-tlx)

METHOD
EXECUTION



RESULTS


Mean heart rate
BPM
180
160
140
120
100
80
Pre-w
Sc 1
Sc 2
Sc 3
Post-w

RESULTS

Predictions	Stress perception (Q)	Mental effort (NASAtlx)	Physical demand (NASAtlx)
Modeled non-metabolic heart rate	*B*=0.60 ΔR^2 = 0.11	*B*=0.89 ΔR^2 = 0.36	
heart rate corrected pre-walking		*B*=1.01 ΔR^2 = 0.24	
heart rate corrected post-walking		*B*=1.12 ΔR^2 = 0.24	
Uncorrected heart rate		*B*=0.84 ΔR^2 = 0.42	*B*=0.07 ΔR^2 = 0.09

- ΔR^2 indicates explained variance

- Dynamic VR environment (developed via VR BlackSUIT) can significantly induce mental workload/stress
- Initial model is able to predict non-metabolic stress/workload heart rate component
- This component can already predict mental workload/stress better compared to normal heart rate components

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PILOT: TOWARDS VALIDATED EVALUATION OF DISMOUNTED SOLDIERS' PERFORMANCE DURING MOUT

COGNITIVE PERFORMANCE

Micro cognition

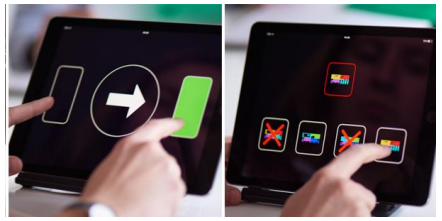
memory, long vs short

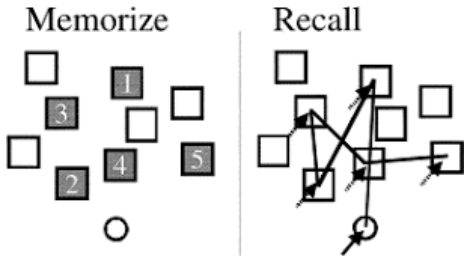
vigilance, reaction speed,

Inhibition, multitasking, attention control

and deviation

Lab tasks
Many times examined





relation

but:

≠

Macro cognition

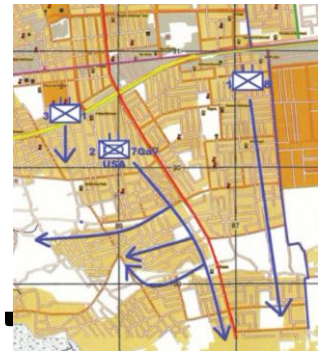
Decision making, SA, anticipation

uncertainty/stress/complexity

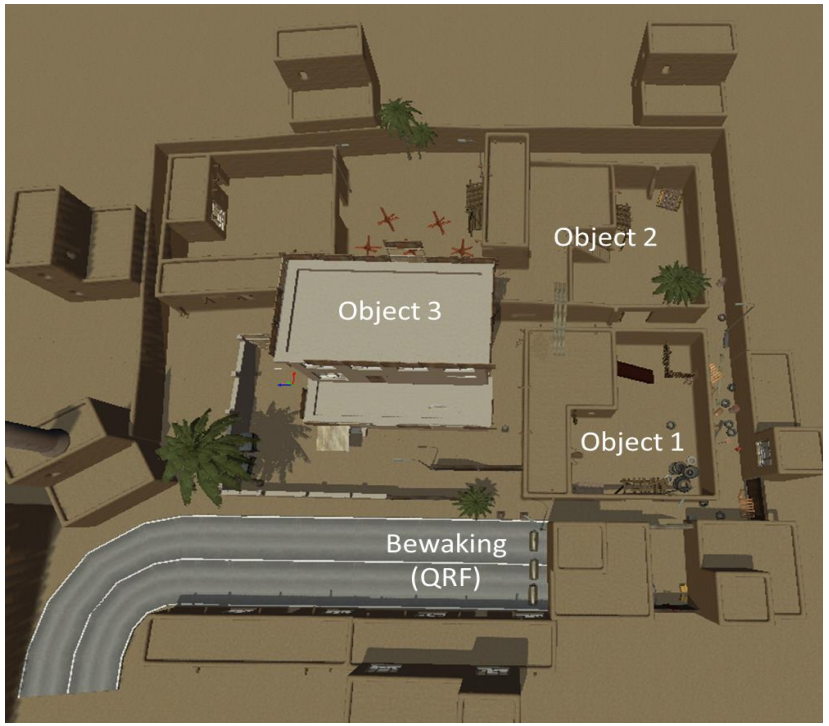
planning, adaptive task execution

team coordination

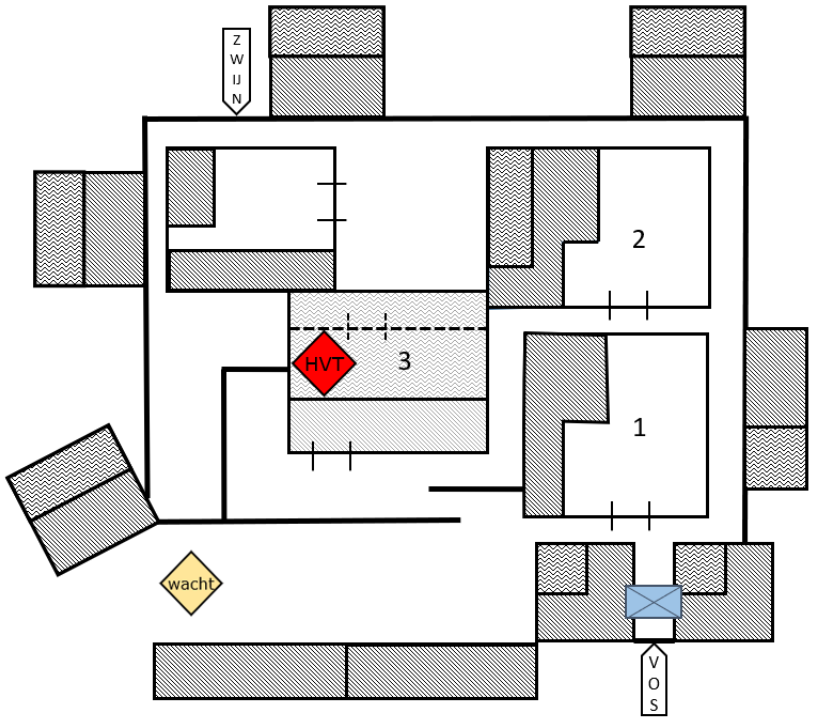
Operations
Difficult to examine

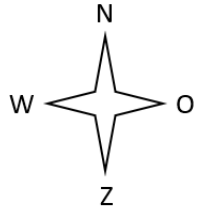


METHOD



Stadsdeel Ras El Kef, Gafsa, Tunesië





HVT

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UITVOERING

Observation

Interviews

UITVOERING

Tijdens het scenario klinkt een luid en repetitief
moskeegeluid om de deelnemers te storen. Dit
kon helaas niet uit de video gefilterd worden.

TNO innovation for life

PILOT STUDY: COGNITIVE ASPECTS OF ACTION-INTELLIGENCE

MEASUREING ACTION-INTELLIGENCE WITH VR

- Action-intelligence: The capacity to quickly choose and execute an appropriate action in response to unpredictable circumstances

Function of:

- Knowledge, practice, experience
- Talent, personality, stress resistance
- State: fatigue, emotional/physiological readiness
- Team composition

VR AS MEASURING PLATFORM FOR A-I

- Relatively low-cost, quick to set up
- Performance can be analyzed accurately

Reliability and validation:

- Testing for relationships between performance measures
- Feedback operators, subjective experience, stress

OVERVIEW EXPERIMENT

Real-life scenarios

A-I scoring instructor 1
↕?
A-I scoring instructor 2

Stress, Mental effort, heart rate

VR scenarios

A-I checklist with performance measures

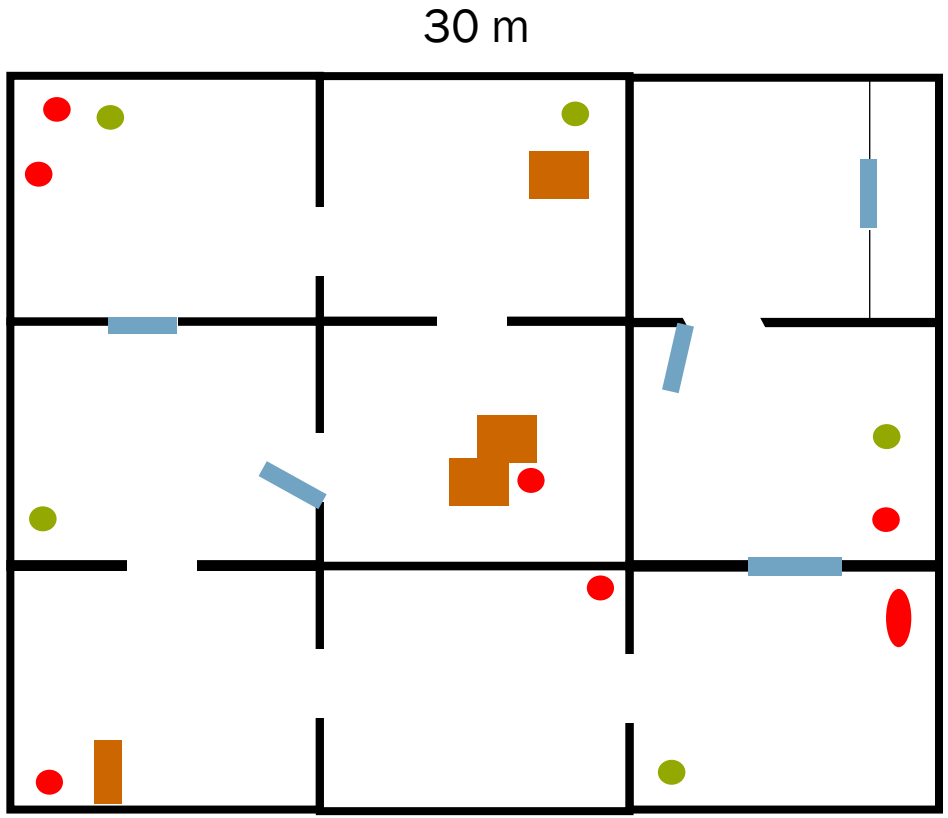
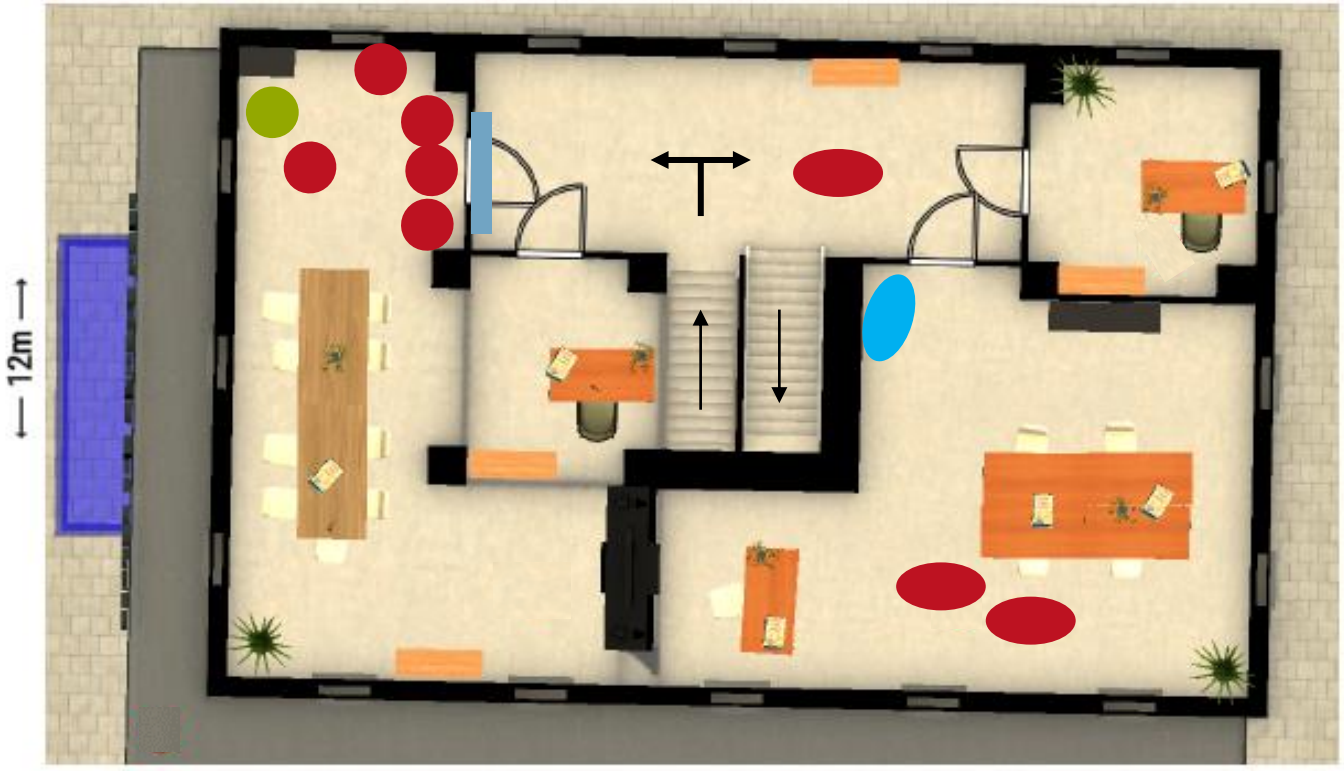
A-I scoring instructor 1
↕?
A-I scoring instructor 2

Stress, mental effort, heart rate, feedback

Validated cognitive computer tasks (30 min)

Ravens progressive matrices, divergent thinking

Questinonaire (20 min)

Work experience
Training experience
Function

EXAMPLES OF SCENARIOS