Continuous Assessment of Health to Prevent Injury and Optimize Performance: Wearables-Based Solutions for the Warfighter

Meghan Hegarty-Craver, Hope Davis-Wilson, Pooja Gaur, Howard Walls, David Dausch, Dorota Temple • **RTI International**

RTI International

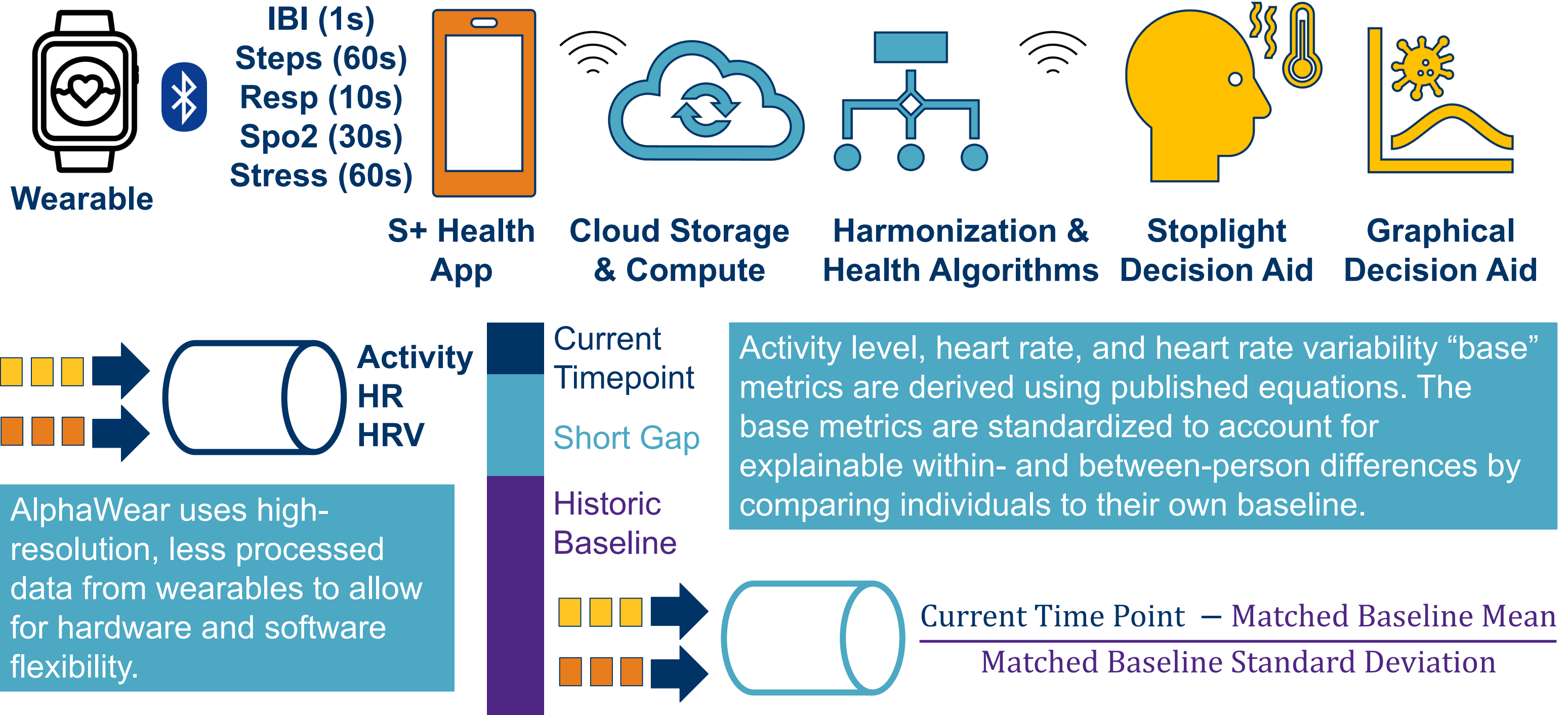**Non-traditional defense contractor**

Unique Expertise: Health and environmental modeling; Wearable device architecture for the DoD; AI/ML algorithms; Mobile app development

Areas of Research: Presymptomatic illness detection; Personal environmental exposure; Aerosol science; Mild traumatic brain injury; Mental health

Projects: DARPA SIGMA+ (2019-2022); JPEO/T2S Localized Data Collection from Wearables (2021-2023); JPEO-CBRND Wearables Pilot (2023-present), MTEC 22-10-ChemBio-009 (2023-present), MTEC MPAI 22-02 (2023-present)

RTI is a leading nonprofit institute dedicated to improving the human condition. Our staff of over 6,000 professions provide research and technical services to governments and businesses in over 75 countries.

Architecture for Localized Precision Health data Acquisition from Wearables

AlphaWear
powered by SIGMA+

Wearable

IBI (1s)
Steps (60s)
Resp (10s)
Spo2 (30s)
Stress (60s)

S+ Health App

Cloud Storage & Compute

Harmonization & Health Algorithms

Stoplight Decision Aid

Graphical Decision Aid

Activity
HR
HRV

Current Timepoint
Short Gap
Historic Baseline

AlphaWear uses high-resolution, less processed data from wearables to allow for hardware and software flexibility.

Activity level, heart rate, and heart rate variability "base" metrics are derived using published equations. The base metrics are standardized to account for explainable within- and between-person differences by comparing individuals to their own baseline.

$$\frac{\text{Current Time Point} - \text{Matched Baseline Mean}}{\text{Matched Baseline Standard Deviation}}$$

## Exposure Detection & Health Effects

Presymptomatic Illness

Previous Research: RTI has developed wearable sensor-based algorithms for identifying viral respiratory illness before symptom onset. The "health risk score" (SIGMA+ or S+ score) tracks with symptom severity. The S+ Health algorithm was tested with data from a flu challenge study and identified 94% of positive symptomatic and asymptomatic individuals an average of 23 hours before symptom onset with no false positives.

Value Added: The S+ Health algorithm accounts for predictable changes in physiology (e.g., from physical activity or circadian variation) and provides a continuous measure of exposure risk that can be used with active individuals. This algorithm has been implemented on the AlphaWear platform.

Future Research: RTI is seeking to validate its algorithms 1) for different types of chemical and biological threats and 2) using different sensors. We are working to optimize our algorithms to run on edge computing devices.

Relevant Publications: https://doi.org/10.1093/infdis/jiac262, https://preprints.jmir.org/preprint/53977
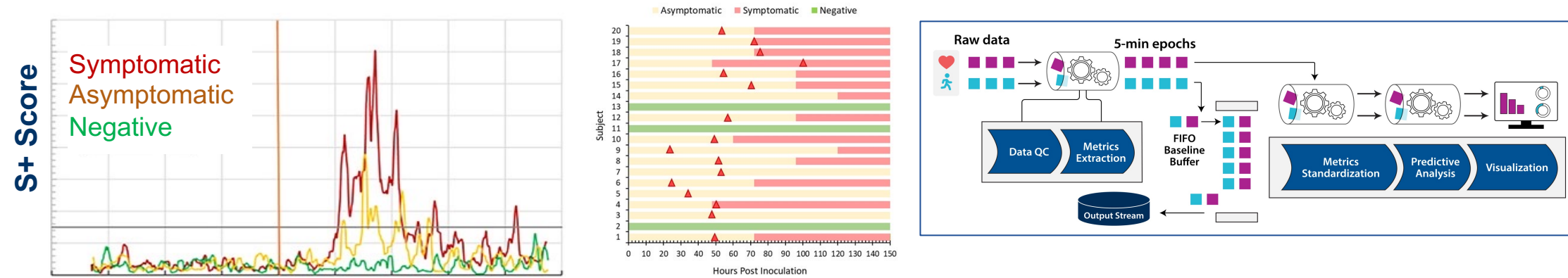
Environmental

Previous Research: RTI's MicroPEM™ and Enhanced Children's MicroPEM (ECM) have been used in research studies for over a decade to measure personal exposure to air pollution (real-time PM2.5, temperature, humidity, and acceleration; built-in filter for sample analysis).

Value Added: Wearable sensors provide the ability to accurately measure peak and cumulative exposure levels as compared to ambient sources. In addition to air pollution, AlphaWear implements USARIEM's ECTemp™ algorithm for estimating core body temperature to assess risk for heat strain.

Future Research: RTI is seeking to combine real-time exposure and health monitoring using wearables to better understand risk factors for developing new or worsening chronic respiratory conditions.

Mental Health Applications

Stellate Ganglion Block Therapy
[Kristine Rae Olmstead: krolmstead@rti.org]

Previous Research: RTI has collected extensive data characterizing before/after treatment effects via survey instruments and clinical interviews.

Value Added: RTI is using AlphaWear to track treatment effects of SGB on sleep, stress, and other measures of health.

Future Research: RTI is developing algorithms using data from wearables to digitally phenotype individuals with PTSD to better deliver treatment.
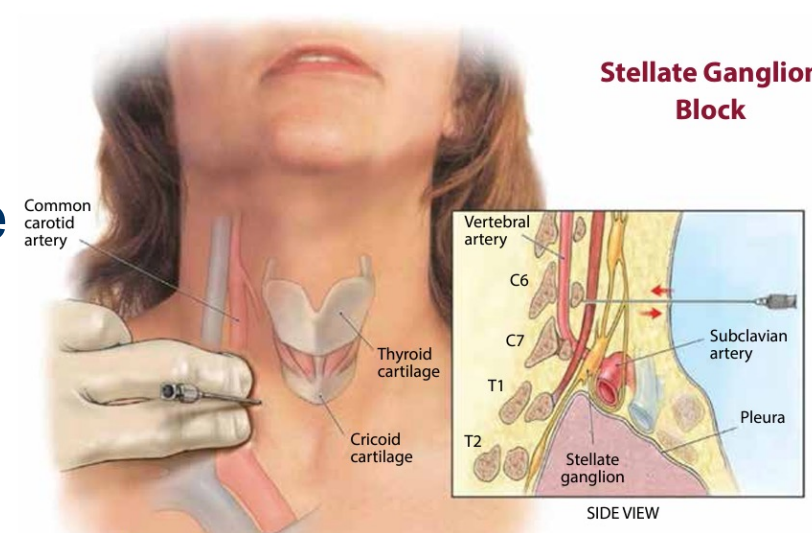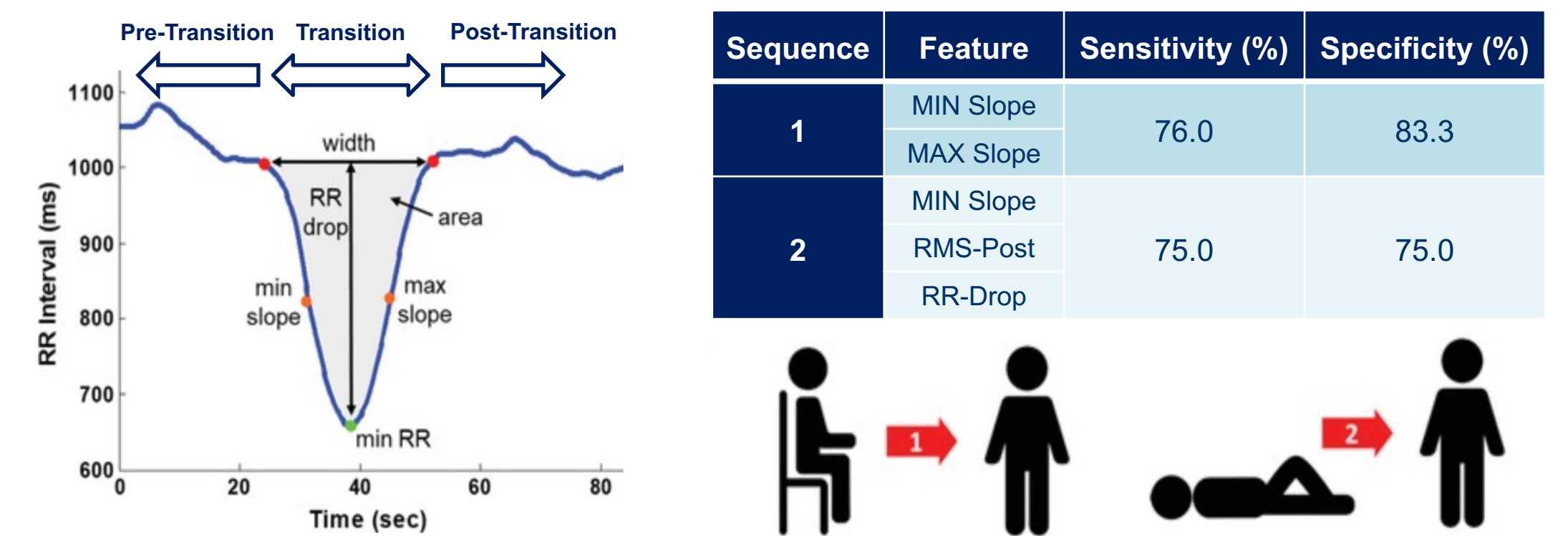
Injury Prevention & Recovery

Mild Traumatic Brain Injury

Previous Research: RTI conducted a pilot study demonstrating that heart rate and heart rate variability during posture changes could be used to differentiate between individuals who had recently suffered an mTBI and uninjured controls.

Value Added: Wearable sensors (e.g., polar chest strap) can be fielded to provide an objective indicators of injury and recovery. AlphaWear provides a solution for wearables and survey data collection.

Future Research: RTI is seeking to combine expertise in identifying acute injuries using heart rate, heart rate variability, balance/sway, and gait data with our ability to monitor individuals longitudinally and detect changes from baseline health to 1) understand the health impact of repeated, sub-acute injuries from blast and 2) monitor treatment progress and return-to-duty status.

Relevant Publications: DOI: 10.1097/HTR.0000000000000582

Sequence	Feature	Sensitivity (%)	Specificity (%)
1	MIN Slope MAX Slope	76.0	83.3
2	MIN Slope RMS-Post RR-Drop	75.0	75.0

Musculoskeletal Injury

Previous Research: RTI has used wearable sensors to detect and characterize abnormal movement patterns. RTI researchers have experience conducting and analyzing results dual-task gait and balance protocols.

Value Added: AlphaWear provides a solution for using wearables during training and in operational contexts to understand activity and joint loading patterns that contribute to injury. Laboratory measurements are misleading because other stressors (e.g., environmental and cognitive) modify injury risk.

Future Research: RTI is seeking to leverage smartwatches and other wearables to determine how best to characterize cumulative loading and other contributors to injury risk during training, especially for female Soldiers.

Operational & Training Readiness

Future Research: RTI is developing the S+ Stress and S+ Sleep algorithms for the AlphaWear platform to provide indicators of mental stress, cognitive fatigue, total sleep time, number of awakenings, and circadian parameters.

Value Added: RTI's algorithms are traceable (versus blackbox vendor algorithms) and can be tailored to the military population to provide accurate assessments for unique use cases (e.g., intermittent activity during field training and operations).
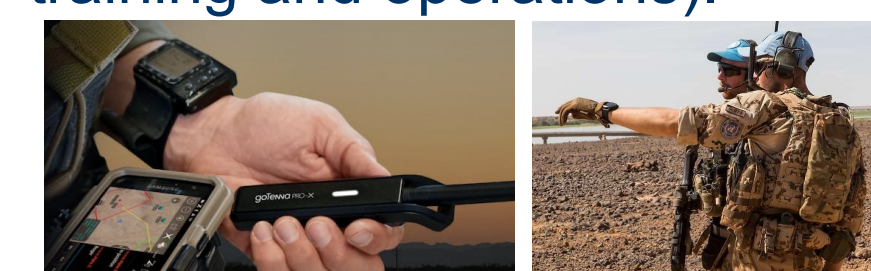
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