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Safety-Guided Design: Integrating STPA into the Systems Engineering Process for the Safety of Remote Health Workers

(Imperial College & NT Health)

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2021 MIT STAMP Workshop (Virtual)

23 June 2021

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Remote Health Worker Safety (Imperial College & NT Health)

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Background

- Based at Centre for Transport Studies, Imperial College London
- Collaborative projects drawing on range of expertise (technical & human factors)
- Interested in exploring/solving real-world problems
- Societal engagement for betterment of society
- Gravity Challenge - Northern Territory Government, Department of Health (‘NT Health’)

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Main Challenge

"How can space technologies assist in providing safety and security to people working in remote locations?"

- Outback doctors/nurses driving long distances in remote, isolated areas

- Separated from the systems and support in larger towns and hospitals

- Critical to track and communicate with employees during periods of duress and initiate timely emergency responses

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Northern Territory, AU

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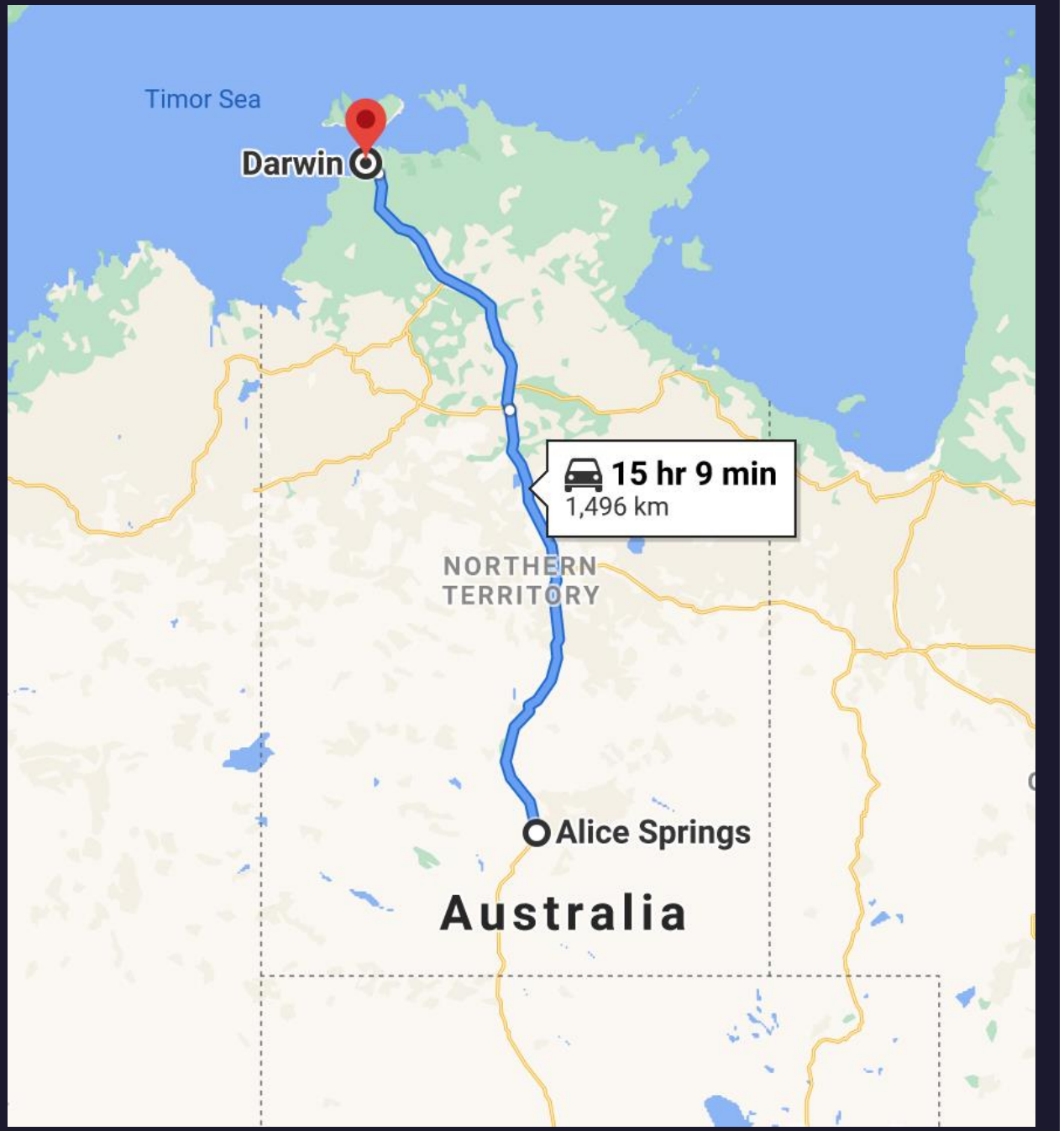
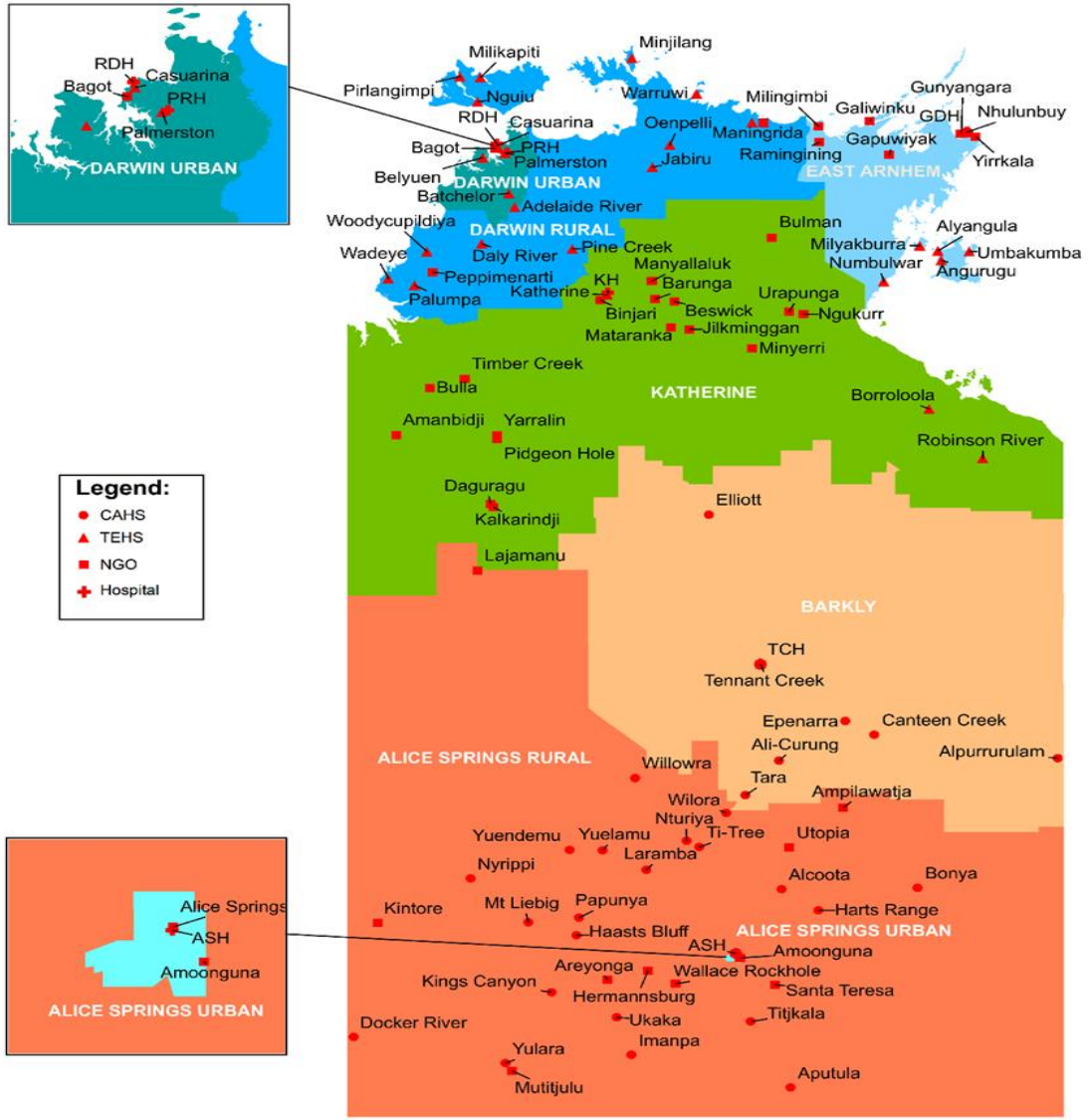

Timor Sea
Darwin
15 hr 9 min
1,496 km
NORTHERN TERRITORY
Alice Springs
Australia


RDH
Casuarina
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Palmerston
DARWIN URBAN
Milikapiti
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Gunyangara
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Oenpelli
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EAST ARNHEM
Belyuen
Batchelor
Adelaide River
DARWIN RURAL
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Wadeye
Daly River
Pine Creek
Bulman
Alyangula
Milyakburra
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Umbakumba
Angurugu
Peppimenarti
Manyallaluk
Barunga
KH
Katherine
Palumpa
Binjari
Beswick
Urapunga
Ngukurr
Mataranka
Jilkminggan
Minyerri
Timber Creek
Bulla
KATHERINE
Borroloola
Amanbidji
Yarralin
Pidgeon Hole
Robinson River
Daguragu
Kalkarindji
Elliott
Lajamanu
BARKLY
TCH
Tennant Creek
Epenarra
Canteen Creek
Ali-Curung
Alpurrurulam
ALICE SPRINGS RURAL
Willowra
Tara
Ampilawatja
Wilora
Nturiya
Ti-Tree
Utopia
Yuendemu
Yuelamu
Laramba
Nyrippi
Alcoota
Bonya
Kintore
Mt Liebig
Papunya
Harts Range
Haasts Bluff
ALICE SPRINGS URBAN
ASH
Amoonguna
Areyonga
Wallace Rockhole
Kings Canyon
Hermannsburg
Santa Teresa
Ukaka
Titjkala
Docker River
Imanpa
Yulara
Aputula
Mutitjulu
Legend:
CAHS
TEHS
NGO
Hospital
Alice Springs
ASH
Amoonguna
ALICE SPRINGS URBAN

Challenges

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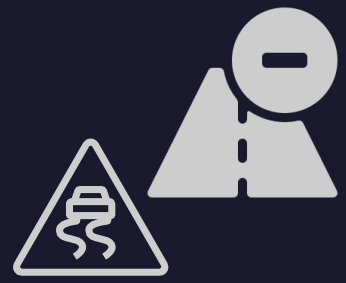
- False alarms

- Unsealed roads, poor road surfaces and livestock hazards



- Vehicle accidents

- Limited signal coverage

- Bullying and harassment of health workers

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Challenges

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Opportunities

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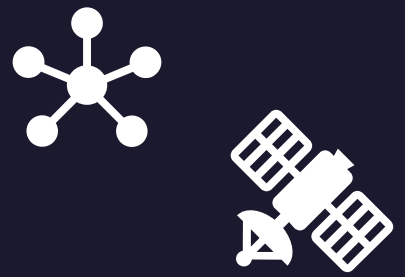
Monitoring heart rate variability

Dash cam accident detection

Provide connectivity using both:

- Geostationary Systems
- Low Earth Orbiting Systems



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Solution Summary

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Stream	Sensors	Location	Comms
Personal/Health Worker	Heart rate monitor	GNSS	Thuraya – Geostationary System
Vehicle	Camera, Inertial Measurement Unit (IMU), CAN Bus	GNSS	Iridium – Low Earth Orbiting (LEO) System

Innovative system with 2 complimentary solutions :

- enhances safety and security for remote workers
- automatic, reliable and improves on previous arrangements
- addresses key requirements following detailed discussions with stakeholders (NT Health, technology/service providers, etc.)

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Trial Aims – Early Development

- Improve Remote Area Worker Safety by creating an alert system that works both inside & outside the vehicle environment
- Increase safety by learning what will work and what won't work, as well as enhance and improve on what currently exists
- Phase 1 – Collect data for model development
- Phase 2 – Model development then testing

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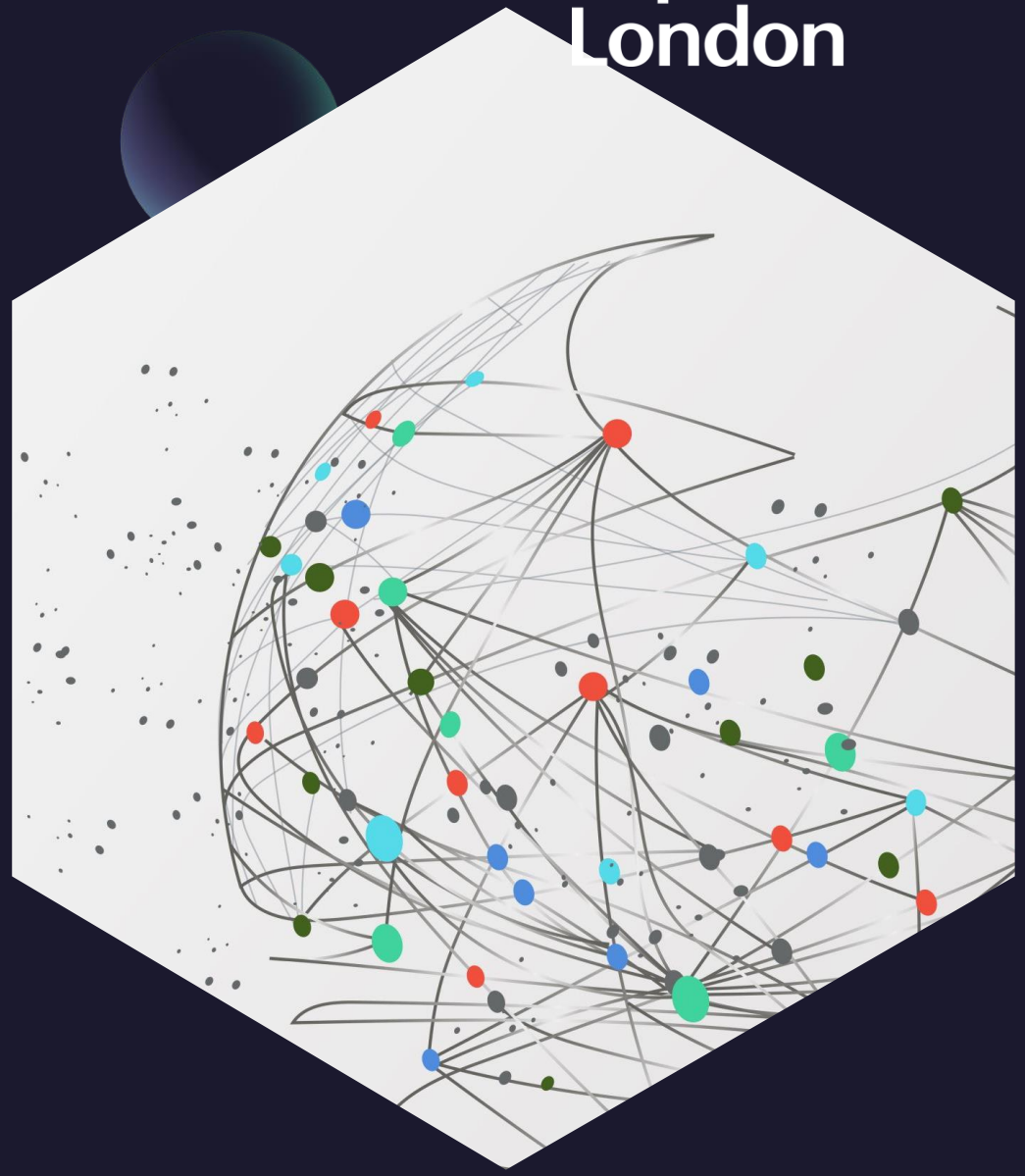
Personal Stream:

Background to the heart rate monitor for stress detection



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Scosche Rhythm 24

- 24-hour battery life
- Photoplethysmogram monitor so unaffected by external electrical interference
- Designed for triathlons so is more resistant to motion artifacts compared to similar devices
- We can access raw HR and we can derive HRV parameters from the data
- Samples above 100 Hz (Baseline for HRV measurements – Camm et al, 1996)

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Health Worker: Concept Visualization

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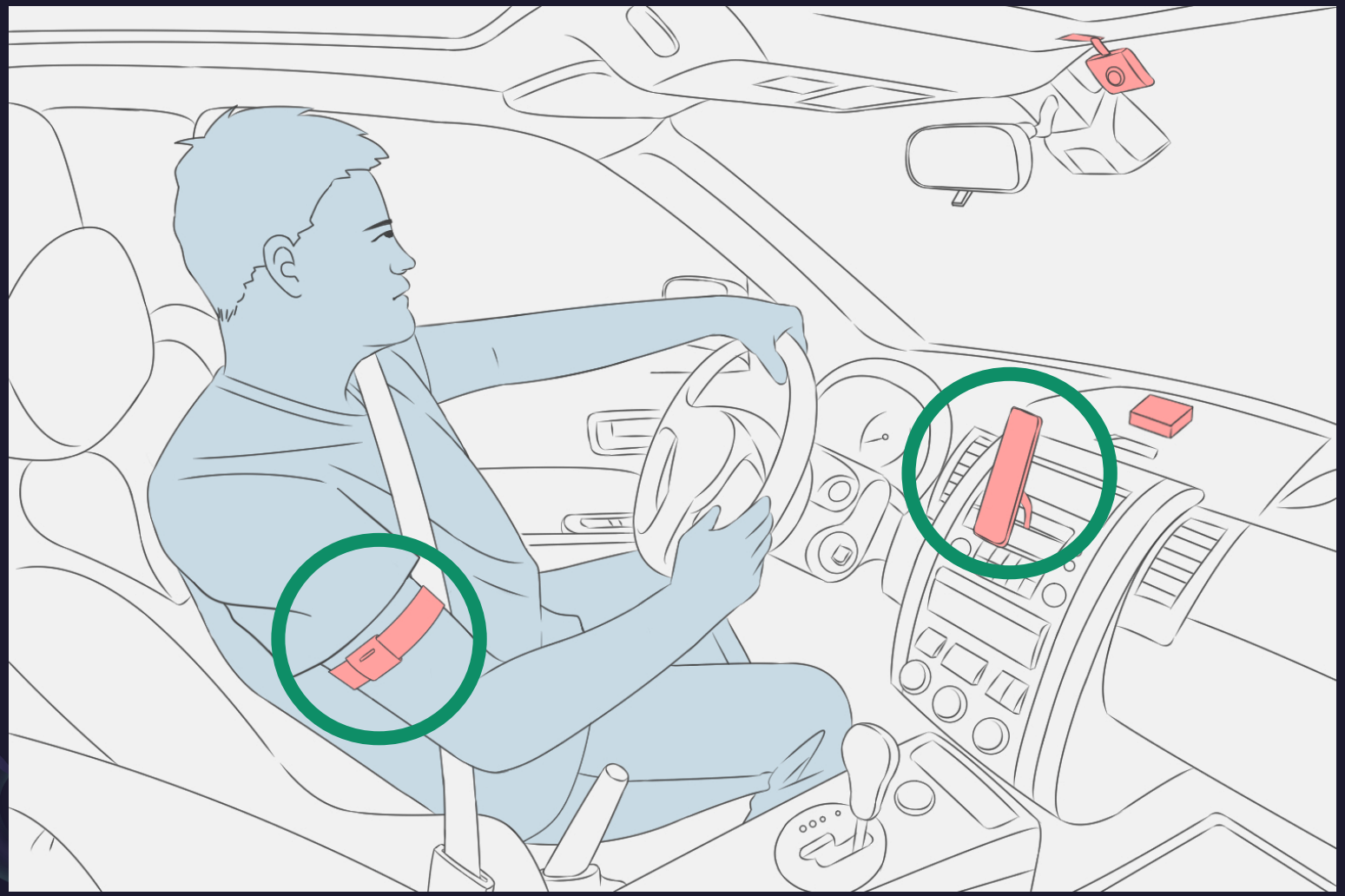

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Data we will collect

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Measure	Why?
Heart Rate	Calculate HRV which is a validated indicator of stress.
User experience Self-reports and Interviews	Understand how comfortable and easy the sensor is to use.
Fatigue Questionnaire	Understand the context of stress for NT remote workers in time and create a sensitive model that responds reliably.
Stress Questionnaire	
Driver Behaviour Questionnaire	
Temperature/Humidity	
Demographics (Age, Height, Weight, Drinking, Smoking, Medication)	Baseline of current health

- Any other data that you think would be useful?

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What the data will NOT be used for

Possible misuse	Why?
Job performance	Data cannot infer whether someone is "good" or "bad at their job" All safety critical environments elicit stress/fatigue to some degree etc.
Clinical measurements	The device is not a clinical device and we cannot determine any cardiac health related parameters e.g. irregular heartbeat etc.
Privacy	Data collected stays between Imperial College and participants unless participants are happy for it to be shared with higher NT Health
Identify individuals	All data will be fully anonymized, participants will not be able to be identified from the data.

Procedure – Data Collection Phase

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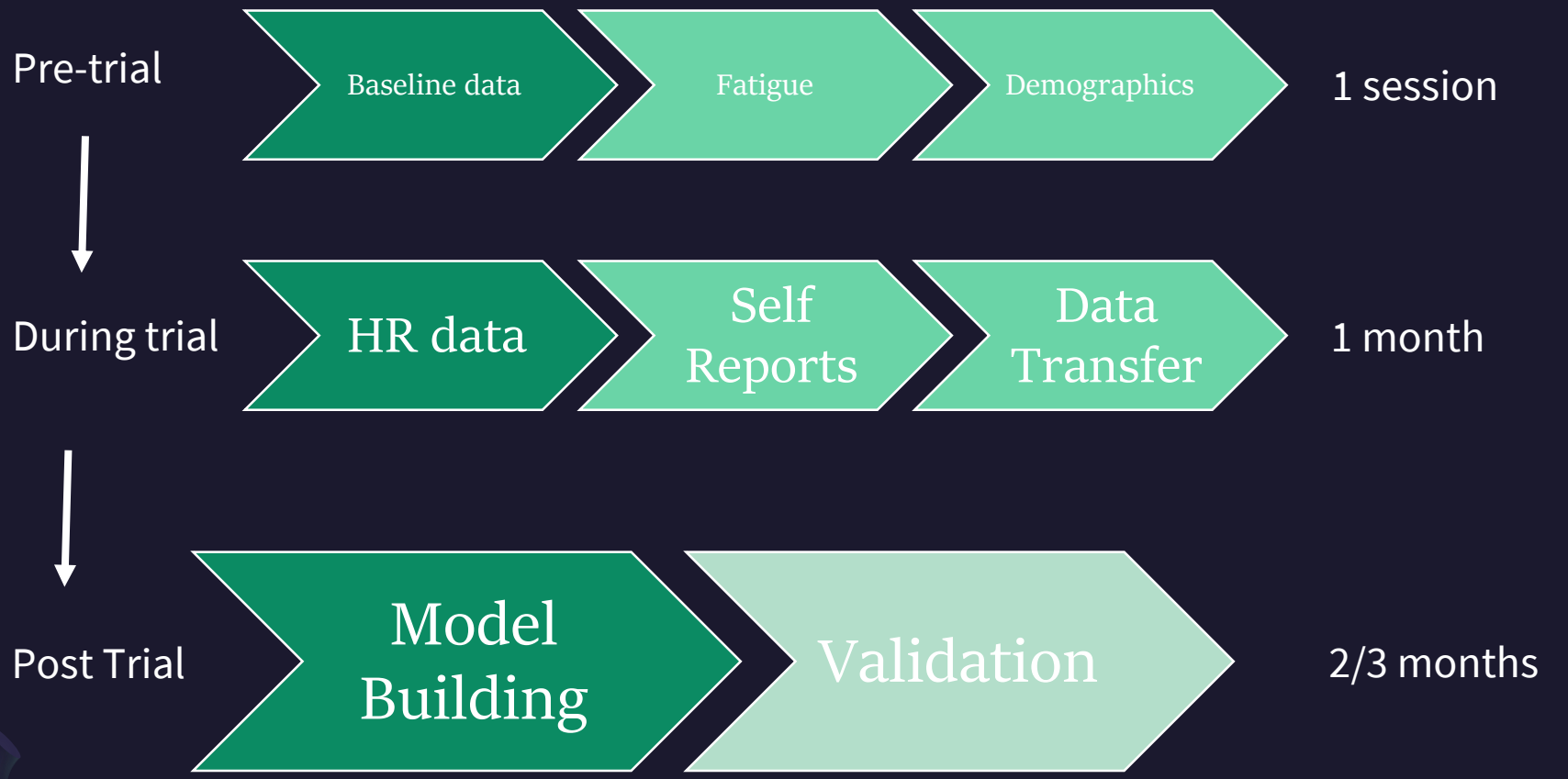

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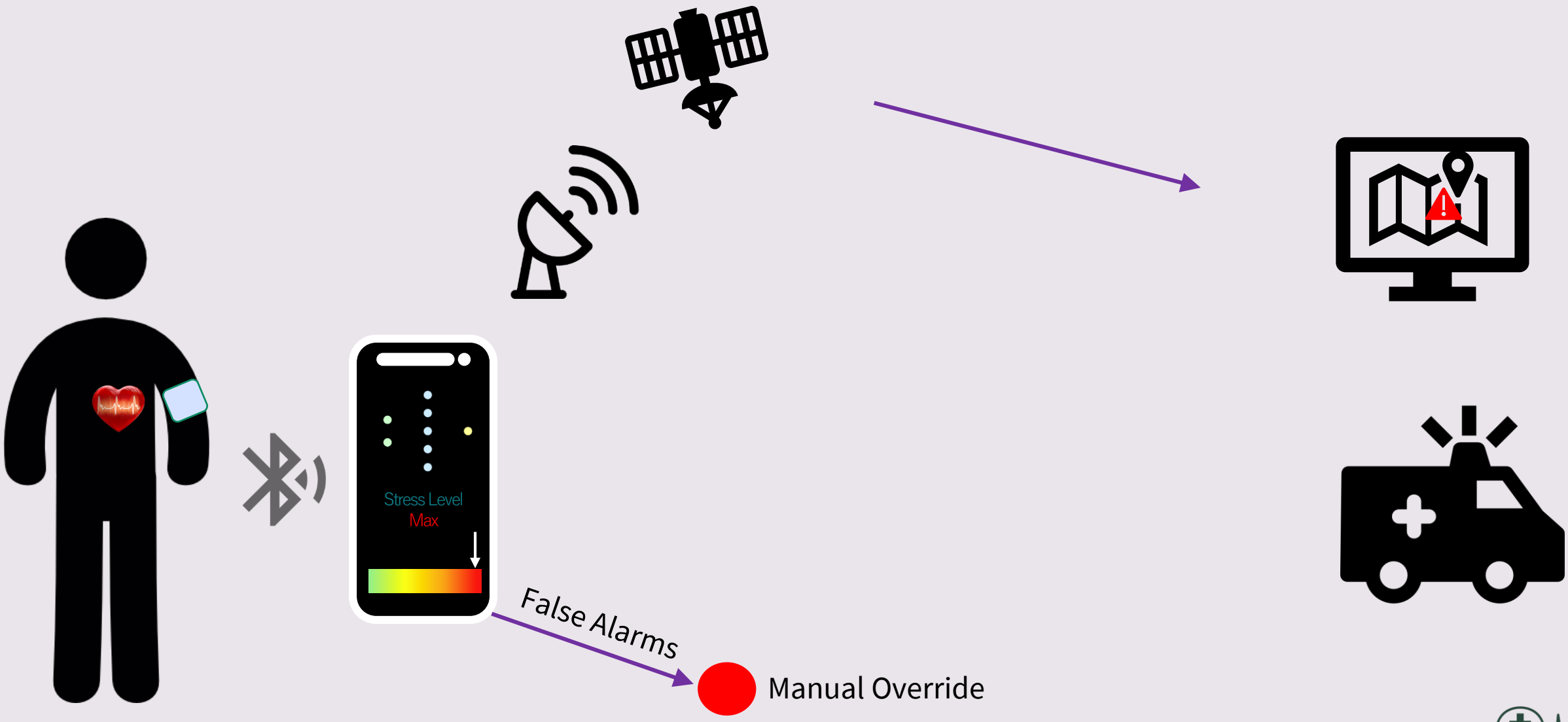

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Vehicle Stream

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Dashboard Camera

- Installed in the vehicle to observe vehicle's surrounding
- Does not obstruct the driver's view
- Collected data used to train the algorithm for accident detection.

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Vehicle: Concept Visualization

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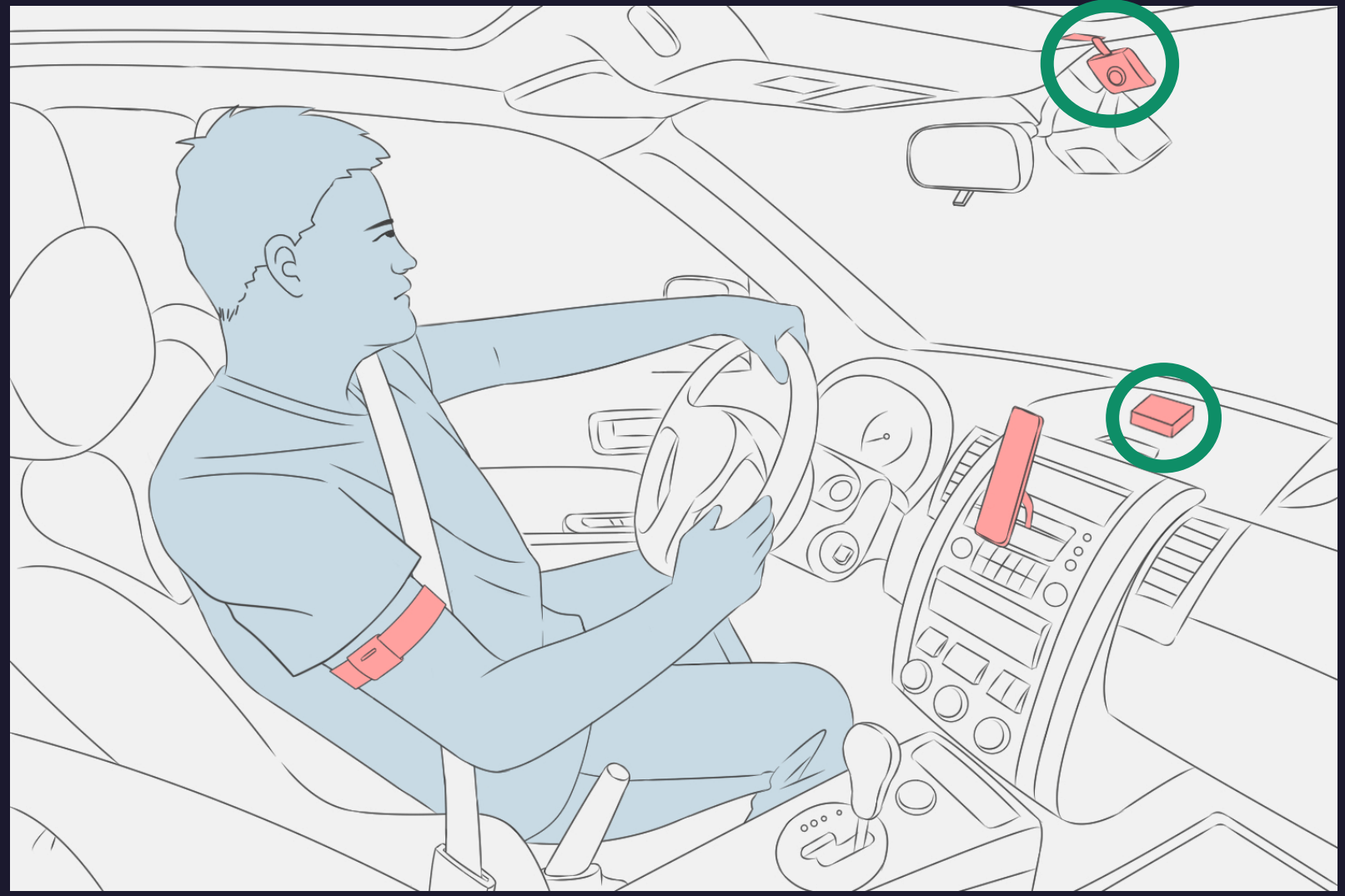

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Vehicle - Functional Architecture

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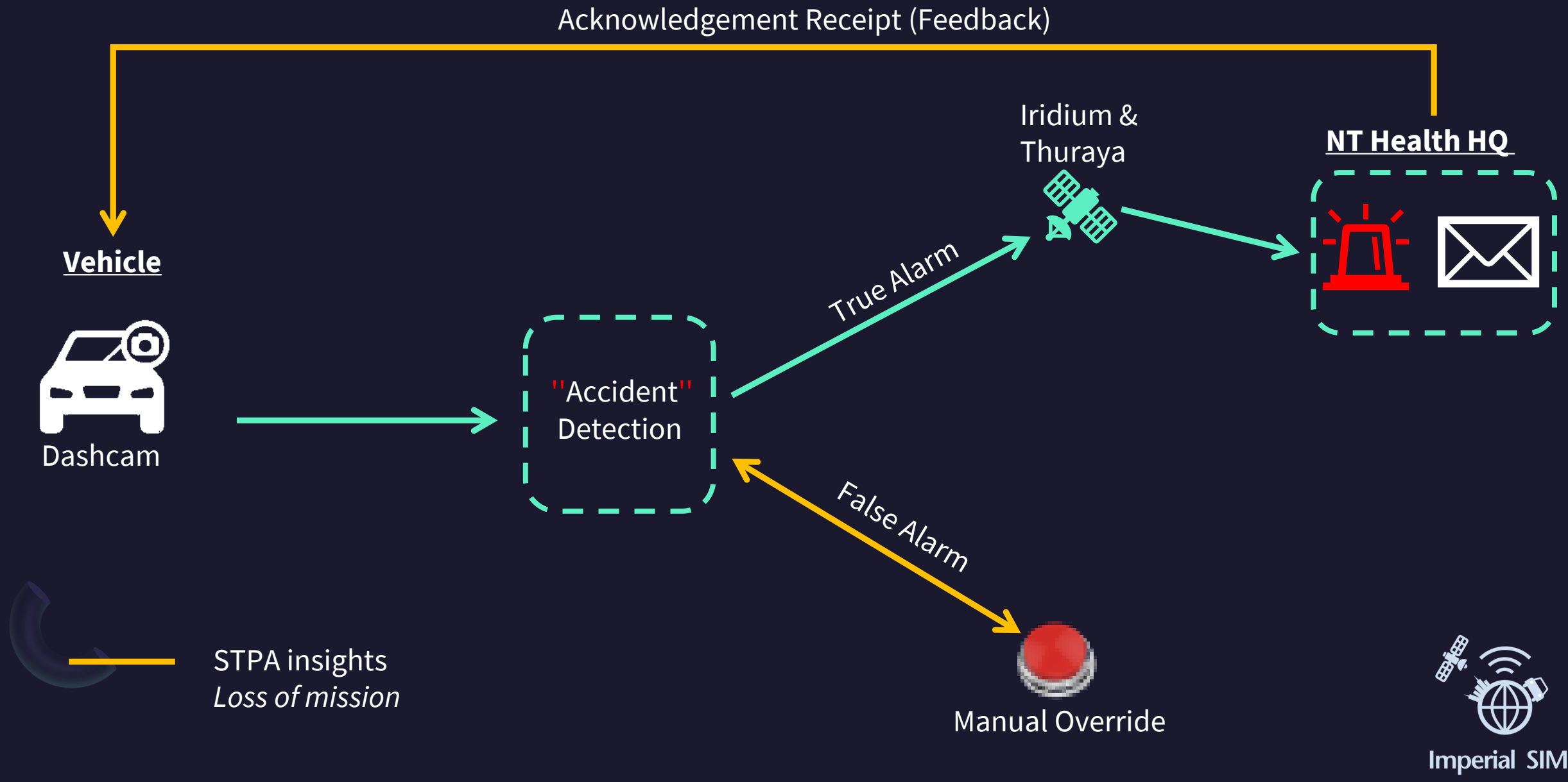

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Procedure – Data Collection Phase

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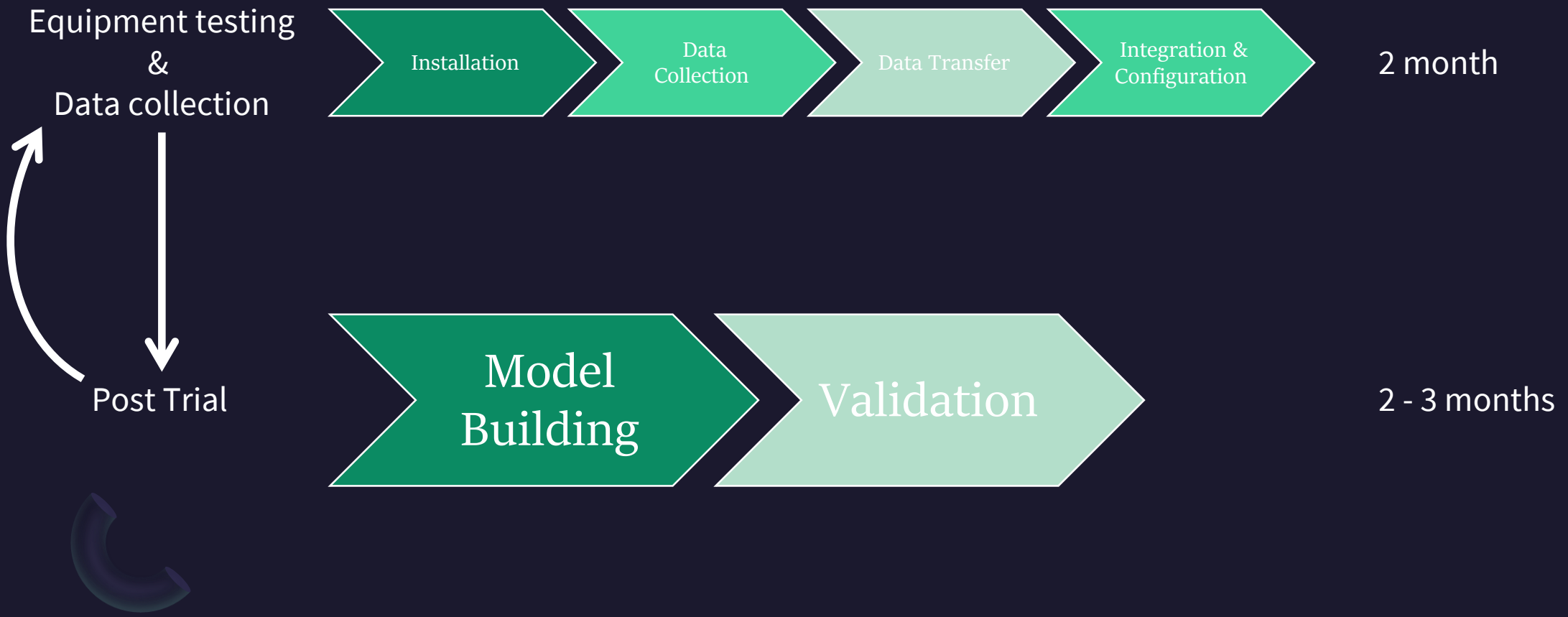

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Summary

- 2 solution streams – targeting health worker and vehicle
- Working with NT Health – **safety-guided, user-centered** design
- NT Health open to (new) system safety approach
- Identify system/safety goals early on
- STPA helpful in identifying UCAs / scenarios early on
- Reliable, secure system – improve health worker safety and well-being

GOAL: holistic solution that makes remote health workers safer!

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Safety Track Record at Imperial

- Transport Risk Management Centre at Centre for Transport Studies, Imperial College London
- Lloyds Register Foundation charitable support
- Mission "make the world a better place"
- New York airspace redesign to save airlines US $ millions led to a start up www.vianair.com
- Currently working with Transport Canada to make general aviation safer

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Remote Health Worker Safety

Please do get in touch!

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