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Conference Presentations 2022

UK National Earth Observation Conference 2022

Venue: National Space Centre, Leicester, UK

Date: 7th September 2022

Session: 6C - Emergency Management and Disaster Risk Reduction

Title: *Experiments to determine optimal effectiveness of drones for post-disaster search and rescue*

Authors: Dr Ian Greatbatch, Toby Meredith

Abstract: A central and fundamental component of disaster response is the use of technology or human teams to locate and assess vulnerable people potentially trapped or injured. This set of assessment activities are generally termed Assessment Search & Rescue, or “ASR Level 1” based on the International Search and Rescue Advisory Group (INSARAG) protocols.

ASR activity has traditionally been carried out by teams on foot, with search dogs or from the air using fixed wing or rotary aircraft. However, the advent of unpiloted aerial systems has opened an opportunity for a faster response with fewer logistical overheads, potentially leading to a more effective ASR Level 1.

During two sets of fieldwork, over 60 drone missions were flown, capturing data that was organised by the visibility of target, the environment, the altitude of the aircraft and the sensor type and sensor angle. The imagery collected during these missions was presented to many human observers who were given the task of determining whether each image contains a human target or not.

These observation results were analysed using a modified SAR effectiveness formula. This enabled us to compare the effectiveness of different flight parameters leading to an evidence-based Standard Operating Procedure for drone operations in Search and Rescue post-disaster.

Presentation slides:

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Assessing the effectiveness of drones for post-disaster search and rescue

School of the Environment, Geography and Geosciences

Dr. Ian Greatbatch ian.greatbatch@port.ac.uk
Toby Meredith toby.meredith@port.ac.uk

Introduction

- 2021 World wide: 432 disastrous natural hazards 10,492 deaths, affected 101.8 million people (Emergency Event Database - https://reliefweb.int/report/world/2021-disasters-numbers))
  - 223 flood occurrences; aprox 12, 000 deaths
- Survival stats
  - Drones: 509 rescue incidents; 883 total number of people saved (https://enterprise.dji.com/drone-rescue-map/)
- INSARAG Guidelines - Wide Area Assessment (ASR1)
- In country LEMA restrictions
  - ASR1 undertaken by incoming ISAR teams.
  - Documented issues with teams arriving in country - delays due to runways etc

INSARAG Preparedness Response | 30 YEARS

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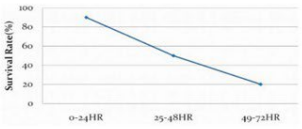
Research questions



- Could we develop a system that gets us ASR1 quicker?
- How do we know how effective our options are?
- Options:
  - Equipment;
  - Search techniques/parametres;
  - Image interpretation (human v machine learning)

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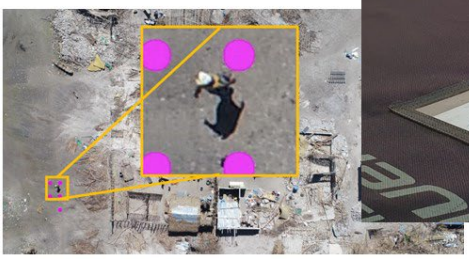
More background

- UNWFP
  - Cyclone Idai - 154 flights; 54 KM^2 mapped; 2,772 minutes of flight
- Dourtchev et al 2017
- Machine learning
- ECHO & other partners



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Research method

- Assumption of a super light team, deployed to collect ASR1
- Create a set of images, that reflect a controlled set of parameters for us to assess
- Create a workshop environment (whilst collecting that data) to build a stronger and more connected community of responders

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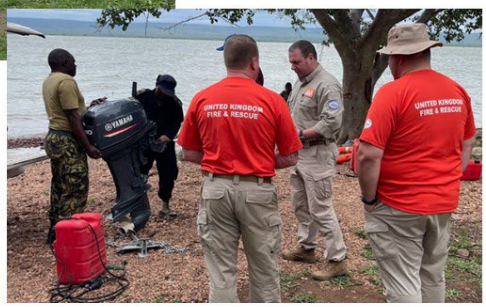
Methods 1

- Rural and water environments
- Mozambique, Maputo
- UK, Chilmark



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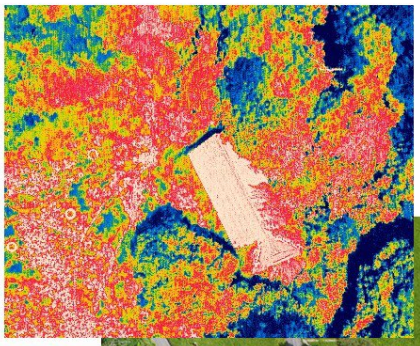
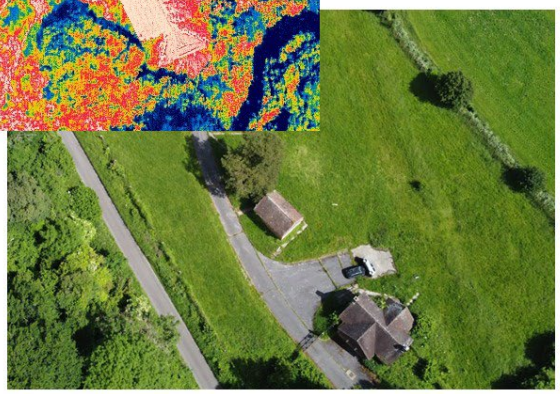
Methods 2

Parameters:

- Altitudes - 60m, 90m and 120m
- Azimuth - Nadir 90° ; Oblique 45
- Sensor - RGB & Thermal
- Target visibility - hi-viz; camo; clothes





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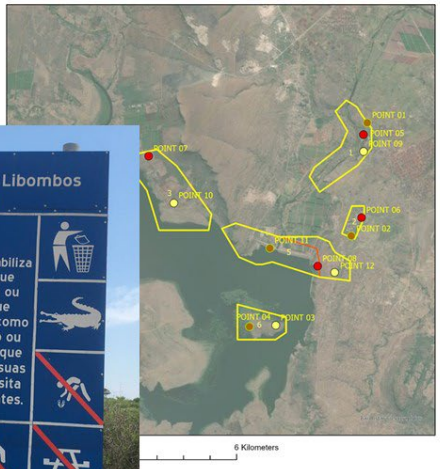
Fieldwork 1 - Mozambique

- 7km x7 km lake
- Surrounding land
- Soldiers as targets

UKISAR / International Agencies



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Fieldwork 2 - Wiltshire

- Repeat Mozambique parameters (VLOS)
- Area X x Z; rural and water
- Volunteers as targets (Lowland SAR, ServeOn)

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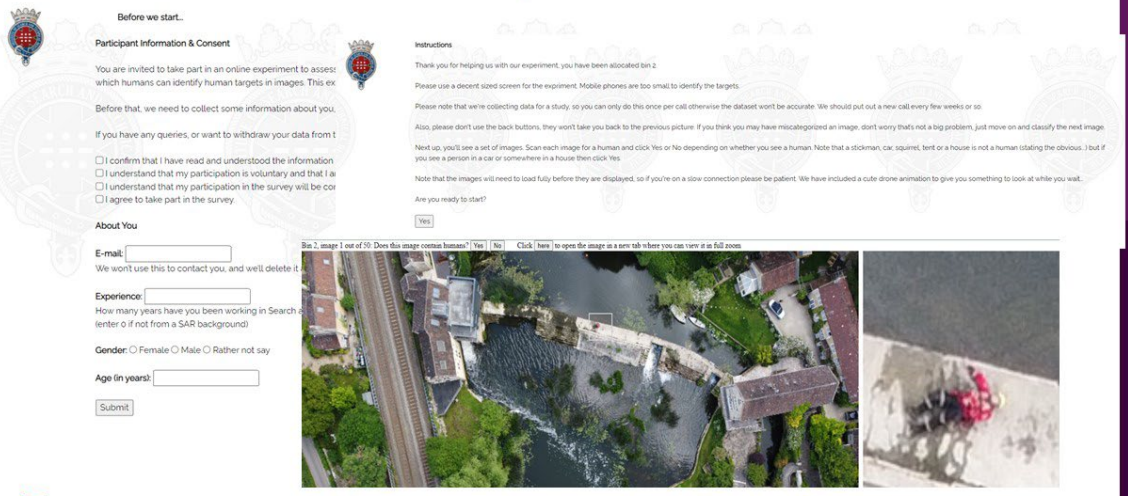
Methods 3: Web Analysis



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Effectiveness formula

Based on classic target detection - but with additional element for time taken..

$$success = \frac{finds}{targets}$$

Time penalty - adds between -1 and 2 to the denominator, based on quintiles of the full range of times..

$$new\ effectiveness = \frac{finds}{targets + false\ pos + timepenalty.}$$

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Preliminary results

Number of trials for prelim. results - 57

Average success - 0.78

Average classic effectiveness - 0.74

Average new effectiveness - 0.46

Average time per image (sec) - 28.06

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Next steps

Fuller results & analysis

ML version and comparison

Further fieldwork - with UN and other agencies

Publications - white paper / policy for UN & published paper

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Institute of Technical Search & Rescue Annual Conference, 2022

Venue: Union Jack Club, London, 2022

Session: Main Session

Title: *Assessing the effectiveness of drones for post-disaster search and rescue*

Authors: Dr Ian Greatbatch, Toby Meredith

Presentation Slides:

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Assessing the effectiveness of drones for post-disaster search and rescue

School of the Environment, Geography and Geosciences, University of Portsmouth &

Institute of Search and Technical Rescue

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Why are we here?

We are all here to help people

We help people when they are really in trouble

So what we do is important

So we should do it right, right?

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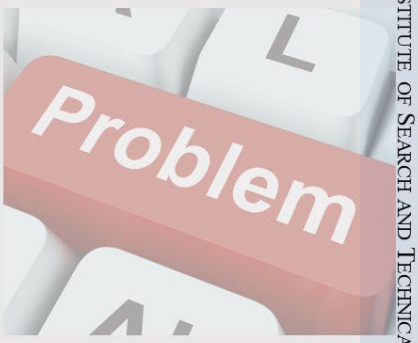
So what's the problem?

- Sometimes our evaluations *are* the problem
- Are we asking the right questions?
- Exercise, not experiment?
- Flying drones about is more fun than a boring rigorous baseline testbed



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"so what?"

- *"idols of the theatre"*
- Without baselines we don't really know the truth
- Established disciplines have an evidence base

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Introduction: So what's the problem?

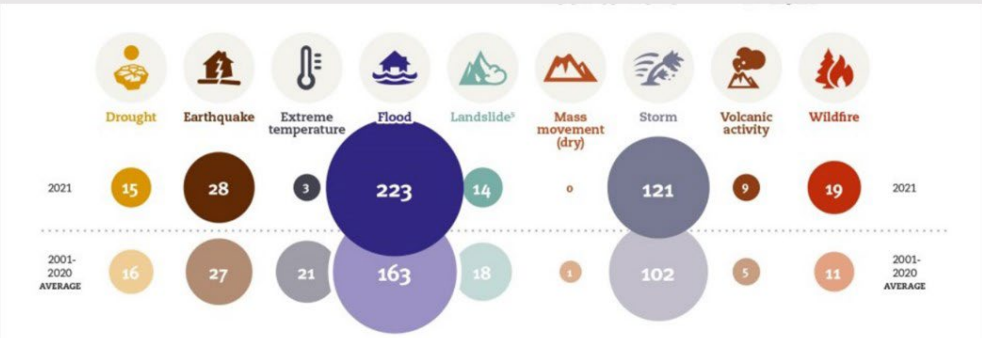

Figure 1: Occurrence by disaster type: 2021 compared to 2001-2020 annual average

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[1]Emergency Event Database - https://reliefweb.int/report/world/2021-disasters-numbers

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It's not getting better

The Intergovernmental Panel on Climate Change (IPCC) - extreme weather events and their impacts will increase throughout the 21st Century

(McGrath, 2021)

(Aljazeera, 2021)

(Abdul Majeed, 2022)

Pakistan: 1730 deaths; 33,000,000 affected people
India: 2035 deaths; 1300000 affected people
Nigeria: 603 deaths; 2,504,000 people

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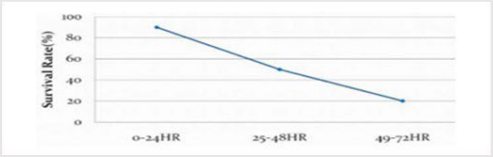
Introduction: Current Practice

- INSARAG Guidelines "*sudden-onset disaster causing large-scale structural collapse*"
- ASR1 – *Speed is of the essence*



(Hakami et al., 2013)

- In country LEMA restrictions
  - Reduced local capacity for ASR1
  - ASR1 undertaken by incoming ISAR teams.
  - Documented issues with teams arriving in country - delays due to runways etc
- ISAR Teams - Optimise methods and technology to increase effectiveness and efficiency

DRONES!

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Drones for SAR

- Drones used for SAR nationally and internationally

- Drones: 546 rescue incidents;
  - 933 total number of people saved
- UK - Buxton Mountain Rescue
- Internationally - WFP (Mozambique, cyclones Idai and Kenneth)

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Barriers

- Regulatory Frameworks
- Safety and security
- Privacy/Ethical Implications
- Lack of resources
- SOPs!

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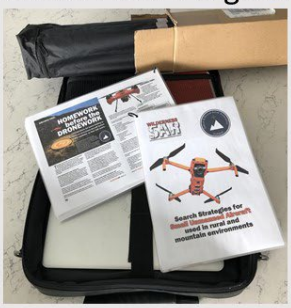
SOPs

- INSARAG Guidelines 2020 - 2 mentions of drones
- IACO - UAS for Hum Aid and Emergency Response
- SARRA - Search and Rescue Aerial Association - Scotland
- World Food Programme - https://drones.wfp.org/



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Project Origins

UNWFP - Funding by ECHO

Requirement to demonstrate academic evaluation

Establishment by InSTR of Research Coalition

Establishment of research question

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Research questions

Broader

- Can ASR1 be quicker?
- How do we integrate UAS ops into UN response work?

Narrower

- How do we evaluate SAR activities?
- What are the benefits of various platforms / aircraft / software?
- Can we create usable SOPs at this stage?
- How can a coalition of rescue teams, academics and technicians work together with drones in a post-disaster scenario?

Specific

- What does an effectiveness formula look like?
- How do human operators compare to Machine Learning?

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Research method

- Dourtchev et al 2017
- Assumption of a super light team, deployed to collect WAS ASR1
- Create a set of images, that reflect a controlled set of parameters for us to assess
- Create a workshop environment (whilst collecting that data) to build a stronger and more connected community of responders

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WFP World Food Programme

Funded by the European Union

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GLOBALMEDIC

LFB LONDON FIRE BRIGADE

Methods 1

- Rural and water environments
- Mozambique, Maputo
- UK, Chilmark

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Methods 2

Parameters:

- Altitudes - 60m, 90m and 120m
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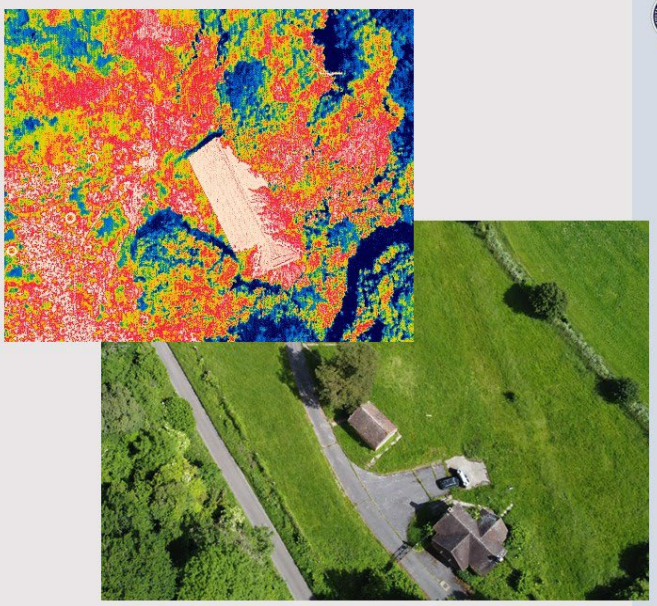

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Fieldwork 1 - Mozambique

- 7 km x7 km lake
- BVLOS
- Surrounding land
- Soldiers as targets
- UKISAR / International Agencies

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Fieldwork 2 - Wiltshire

- Repeat Mozambique parameters (VLOS)
- rural and water
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ISAR INTERGRATION

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Local SAR Integration

- Serve ON
- ALSAR

..future integrations…

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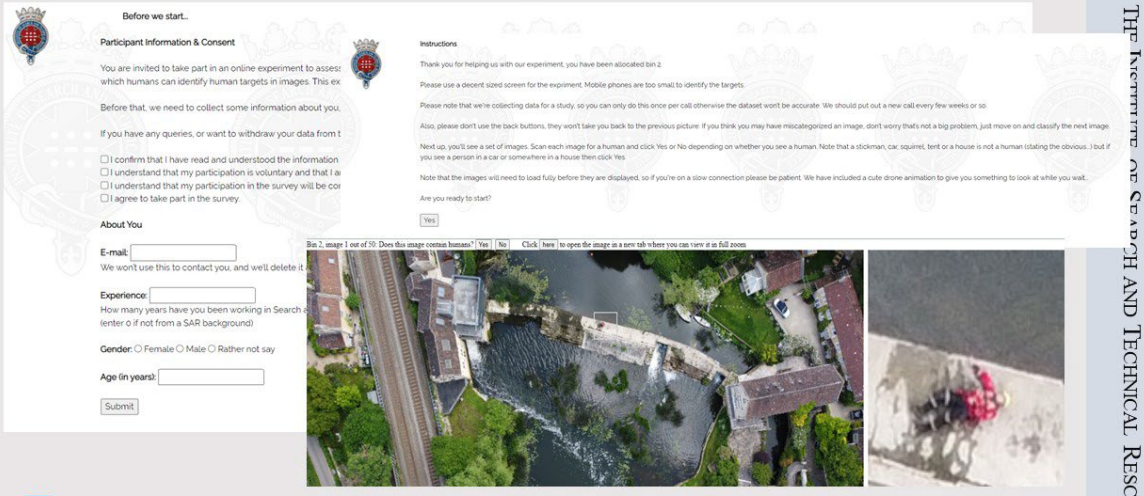
Methods 3: Web Analysis



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Effectiveness formula: Success

Based on classic target detection formula.

$$success = \frac{finds}{targets}$$

100 targets

Our sensor finds 80 of them

Success = 80%

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Effectiveness formula: Effectiveness 1

$$effectiveness = \frac{finds}{targets + false\ pos.}$$

100 targets
80 found
60 “alerts” for targets that were not there - “false positives”

(80 / 100+60) = 50%

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Effectiveness formula: New formula

$$new\ effectiveness = \frac{finds}{targets + false\ pos + timepenalty.}$$

100 targets	100 targets
100 found	80 found
No false positives	10 false positives
Time taken: 120 minutes	Time taken: 10 minutes
100/(100 + 0 + 120) = 46	**80/(100 + 10 - 5) = 76**

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Preliminary results

Number of trials for prelim. results - 57

Average success - 0.78

Average classic effectiveness - 0.74

Average new effectiveness - 0.46*

Average time per image (sec) - 28.06

*we're working on this

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Outreach / engagement

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Conclusions & Future Work

What we do is important…

…and it is important to know we are doing the right thing.

For InSTR this is has been an excellent piece of engagement, outreach and capacity building.

There has been 2 academic outputs so far, more to come.

There is a third phase to come next year.

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Next steps

Fuller results & analysis

Finalising Formula

ML version and comparison

Further fieldwork - with UN and other agencies

Publications - white paper / policy for UN & published paper

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