

Avalanche Rescue Beacon with Smartphones

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DECLARATION - This is a joint master thesis project

Academia / Project

- ! Master Thesis at ETH Zürich

Student:

- ! Matthias Mock

Academic Supervision

- ! Prof. Dr. Bernhard Plattner (Head of Communication Systems Group)
- ! Bernhard Distl (ETH Zürich)

Industrial Supervision

- ! Dr. Franck Legendre (CTO - Uepaa AG)
- ! Mathias Haussmann (CEO - Uepaa AG)



MOTIVATION - An unsolved problem

People ski unprepared

- ! too many risk takers don't use a rescue beacon
- ! however 69% own a smartphone

Power of smartphones

- ! Communication
- ! Variety of sensors
- ! Powerful processing possibilities

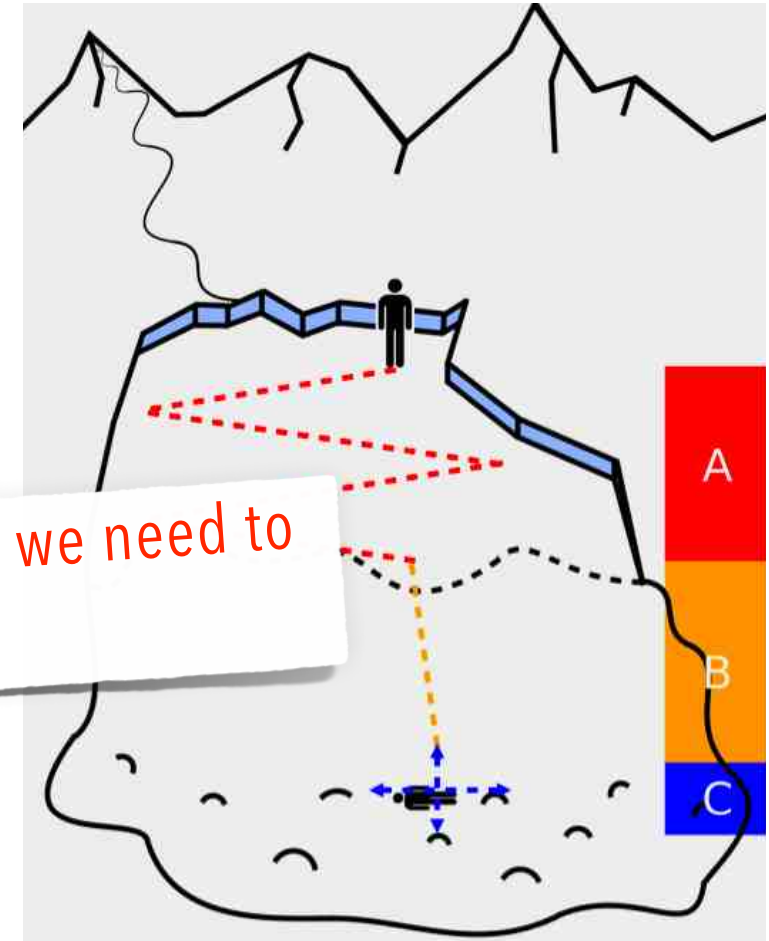


So we wanted to give that an **academic spin!**

SEARCH PROCEDURE - Existing apps focus on Phase C only

Search stages

- ! Phase A: Obtaining a signal
- ! Phase B: Coarse search
- ! Phase C: Refined search

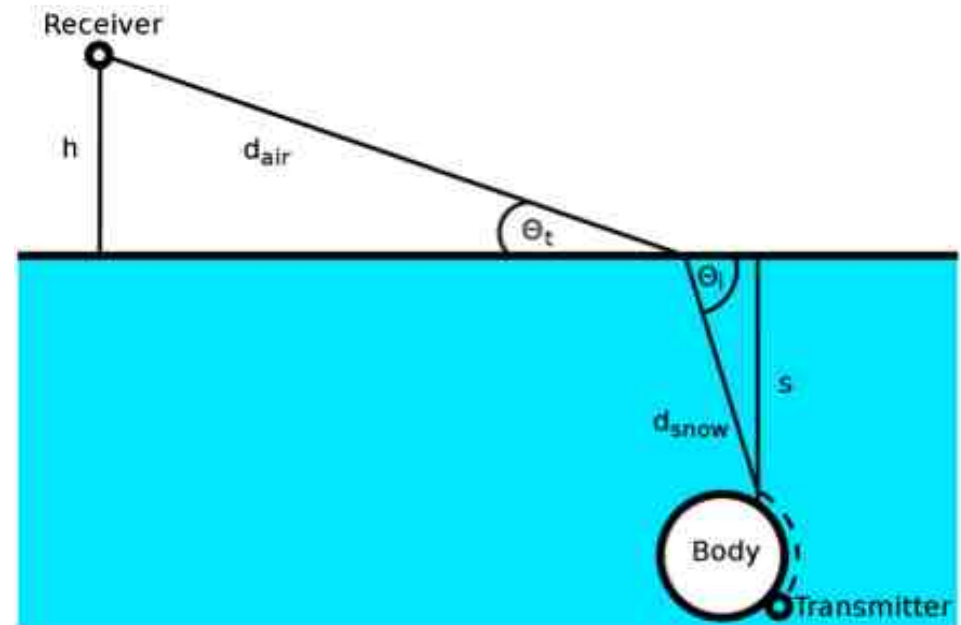


For an intuitive and effective search procedure we need to solve Phase B

THE THEORY - Problem definition and related work

Current localization approaches can be divided into three main fields

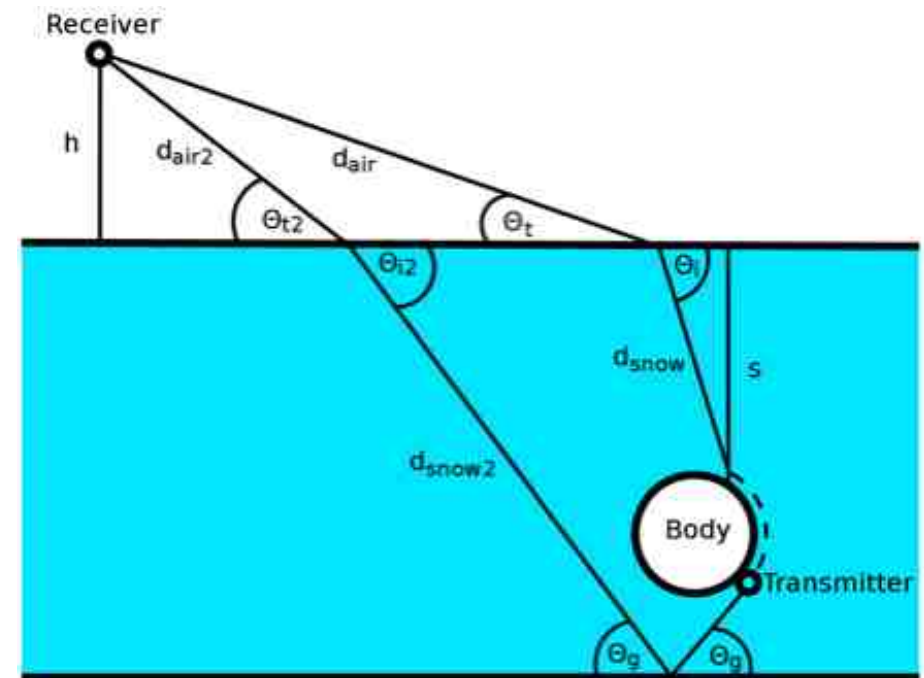
- ! Time of Arrival (ToA) / Time Difference of Arrival (TDoA)
- ! Angle of Arrival (AoA)
- ! Received Signal Strength Indicator (RSSI)



THE REALITY - It's far more complex!

Factors that influence WiFi and Bluetooth Signal (link budget)

- ! Free space loss
- ! Snow attenuation (reflection loss, loss due to propagation speed change & transmission loss)
- ! Body attenuation (victim and searcher)
- ! Ground reflection (multi-path model)
- ! Sloped terrain
- ! snow type
- ! ...



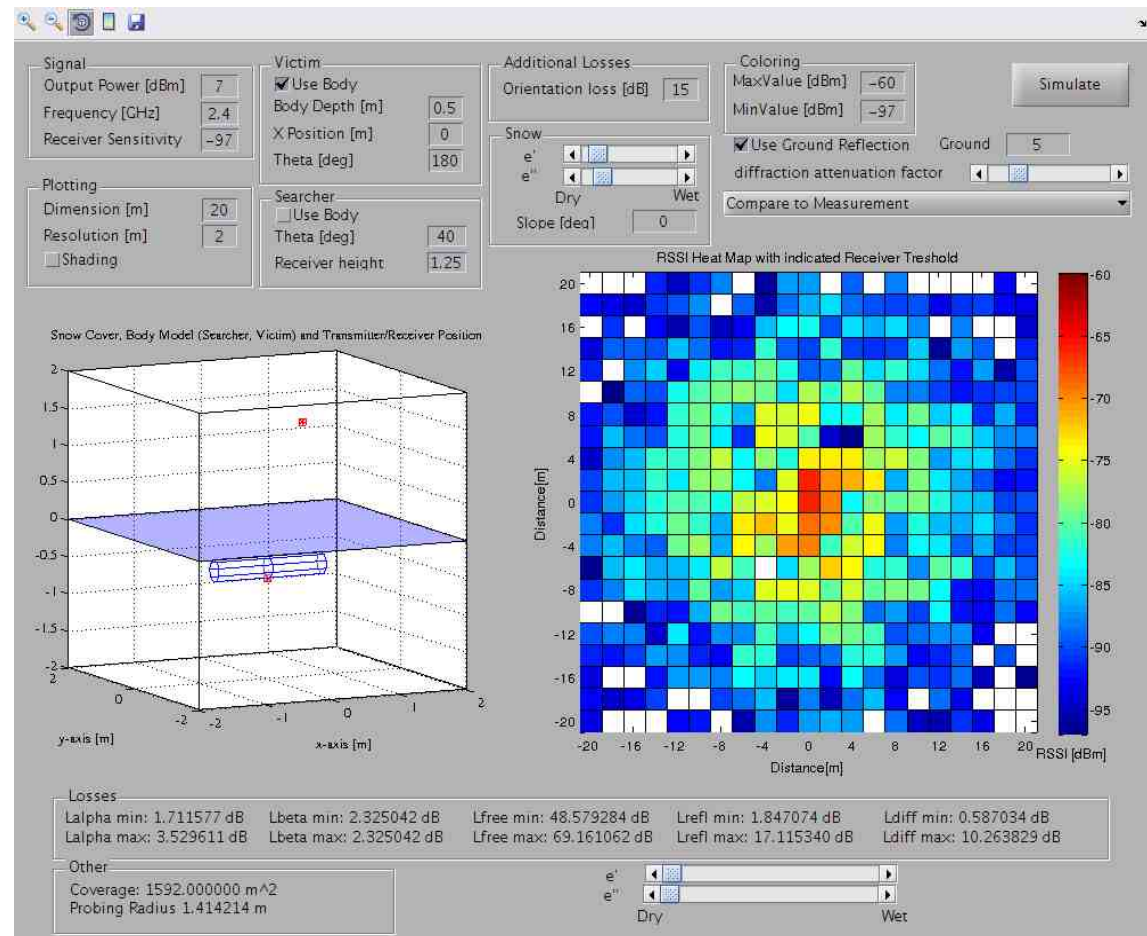
THE SIMULATOR - Reality can be modeled

The simulator is able to model

- ! Any kind of radio signal (incl. WIFI, Bluetooth and „old“ 457kHz technology)
- ! Any kind of burial location
- ! Any kind of searcher location & their own impact
- ! Any kind of snow condition

Other effects assessed

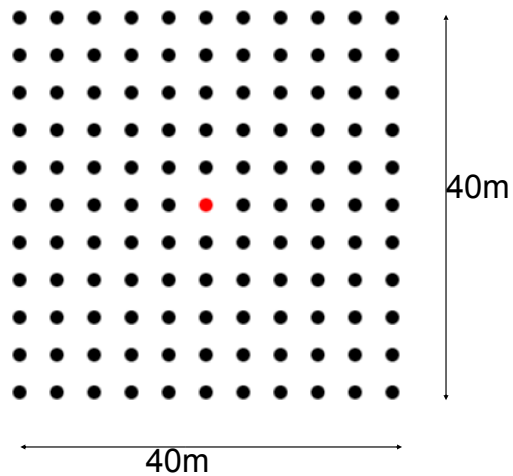
- ! GPS error under snow
- ! GSM reception under snow



THE SIMULATOR - Does it tell the truth?

We calibrated the simulator in snow

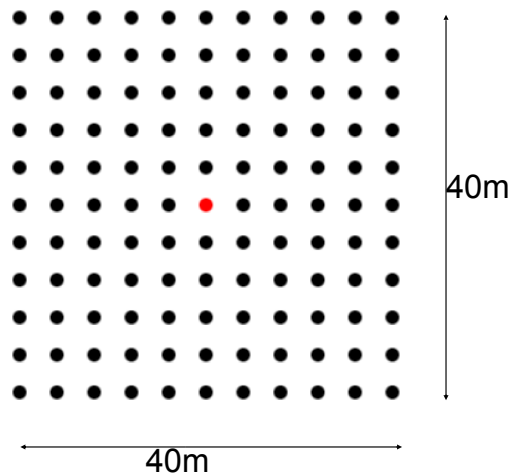
- ! 121 measurement points
- ! 10 measurements / point
- ! 2 setups without body
- ! 3 setups with body



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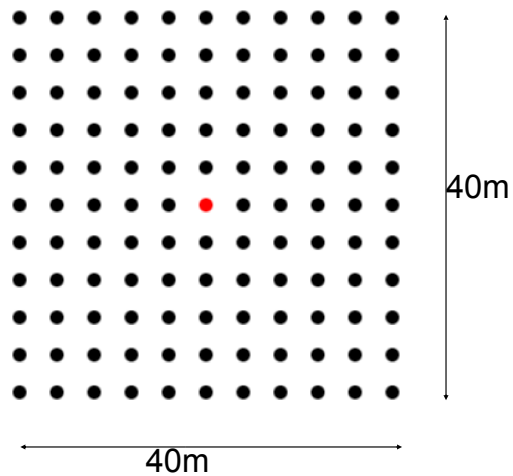
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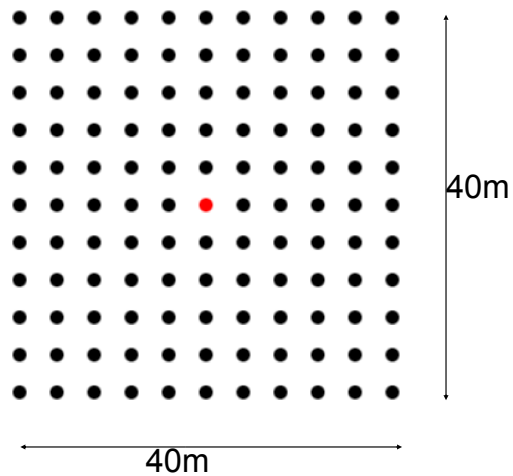
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THE SIMULATOR - Does it tell the truth?

Main findings

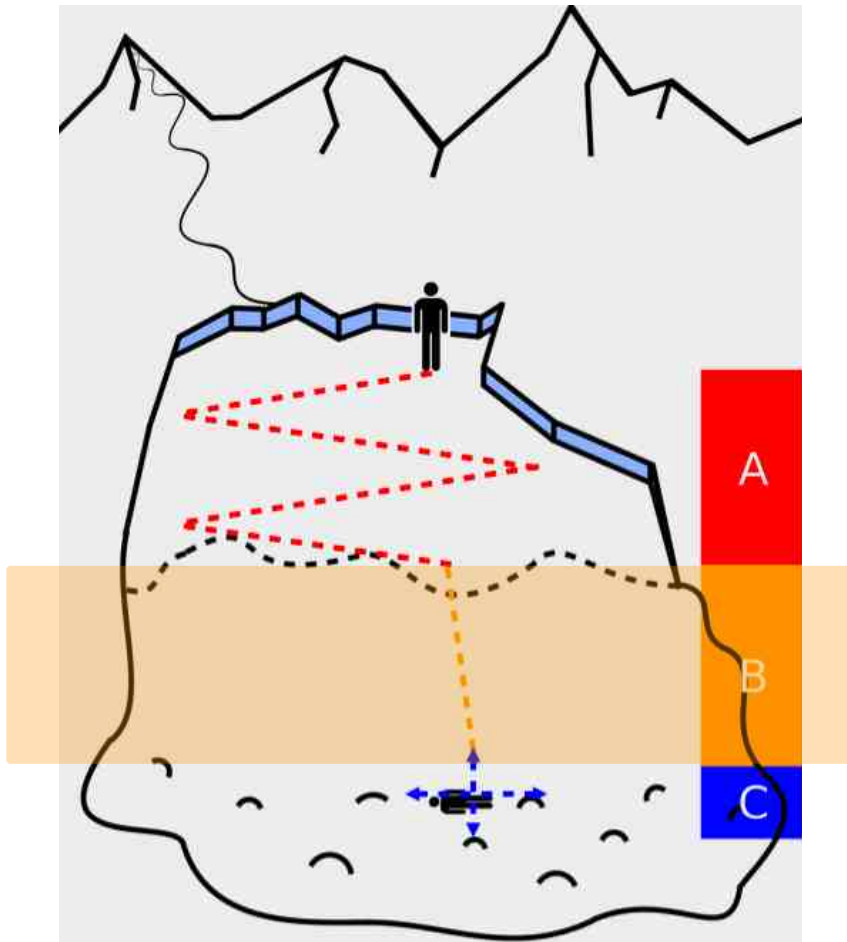
- ! 80 % average agreement between measured and modelled WiFi signal strength
- ! Predicted GSM signal strength showed only 1-2 dB difference compared to measurement
- ! Area of reception showed deviations of only 2-4m

YES, it's verified!

THE SIMULATOR - Now we don't have to wait for snow

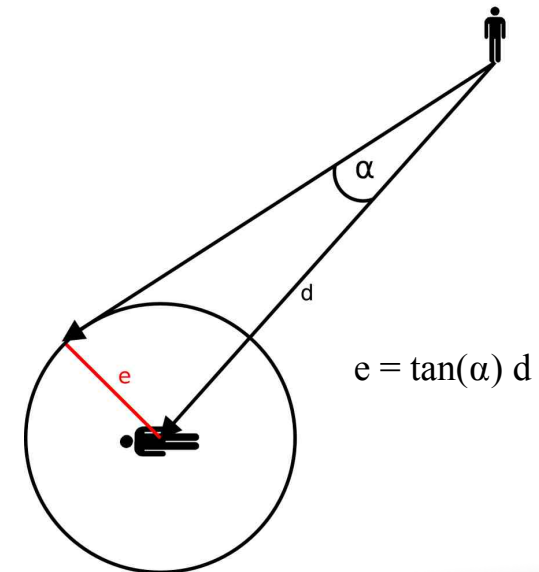


OUR PHASE B APPROACH - The requirements



Our goal

- ! Obtain an accurate direction towards the victim
- ! Get within **3m** of the victim when starting **30m** away



The orientation error should not exceed **5.7°**

OUR PHASE B APPROACH - The ingredients

TURN AROUND & RECORD WiFi SIGNAL

Find victim orientation by making use of body attenuation in a 360° turn



OUR PHASE B APPROACH - The ingredients

TURN AROUND & RECORD WiFi SIGNAL

Find victim orientation by making use of body attenuation in a 360° turn

Signal processing is necessary!



OUR PHASE B APPROACH - The ingredients

TURN AROUND & RECORD WiFi SIGNAL

Find victim orientation by making use of body attenuation in a 360° turn

PROCESS SIGNAL & CALCULATE ORIENTATION

Apply sophisticated signal processing and filtering algorithms



Evaluated Algorithms

- Raw Minimum
- Moving Average Minimum
- Cubic Spline Minimum
- Raw Signal Degradation
- Moving Average Signal Degradation
- Cubic Spline Signal Degradation

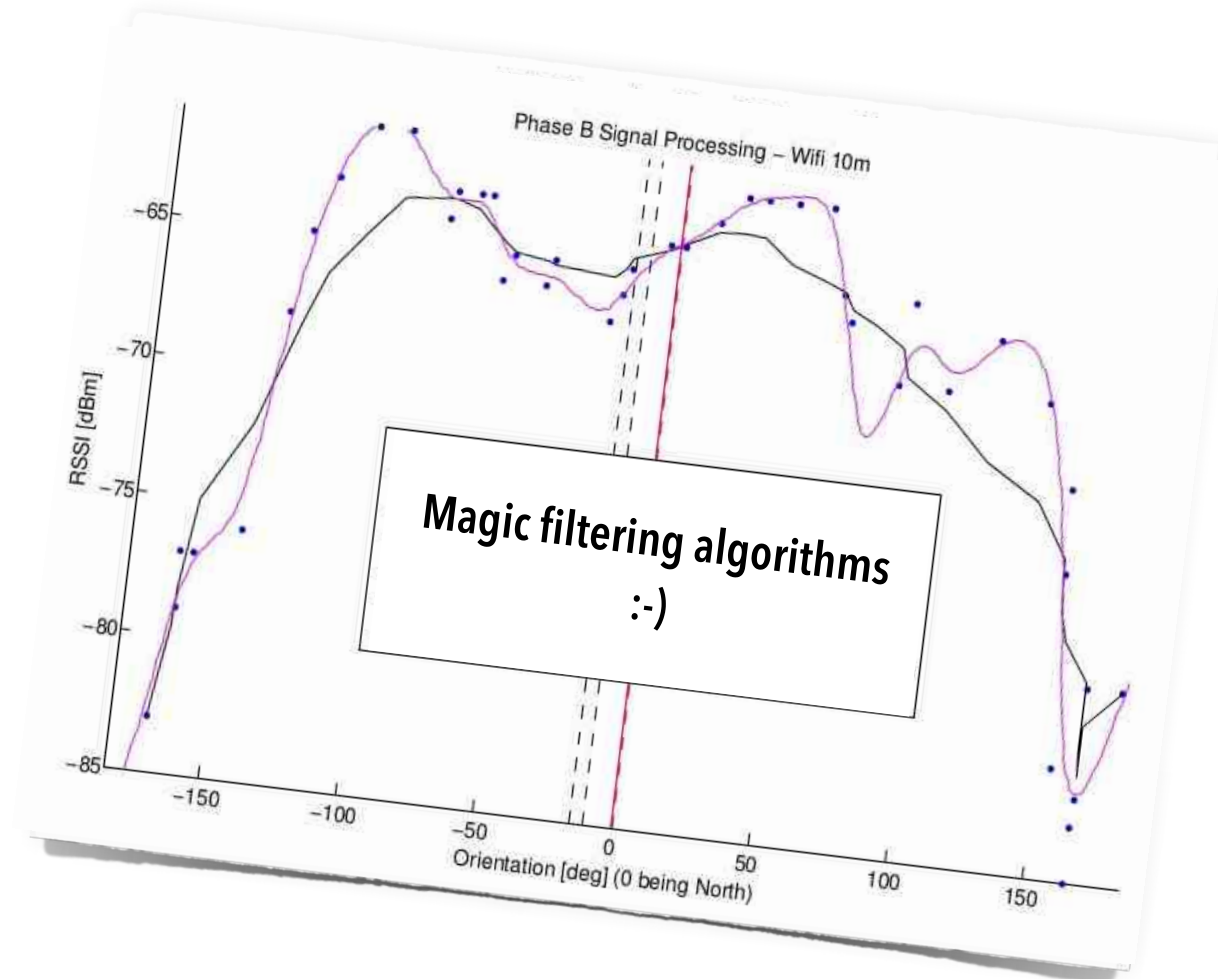
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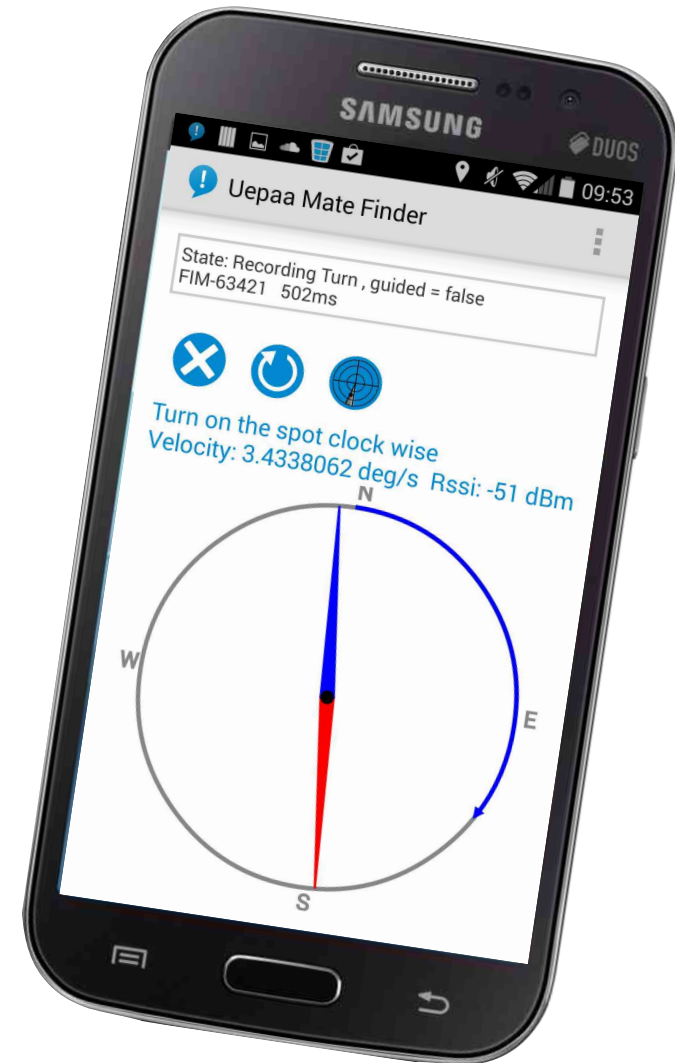
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OUR PHASE B APPROACH - The results

The goal

Get within **3m** of the victim => The orientation error should not exceed **5.7°**

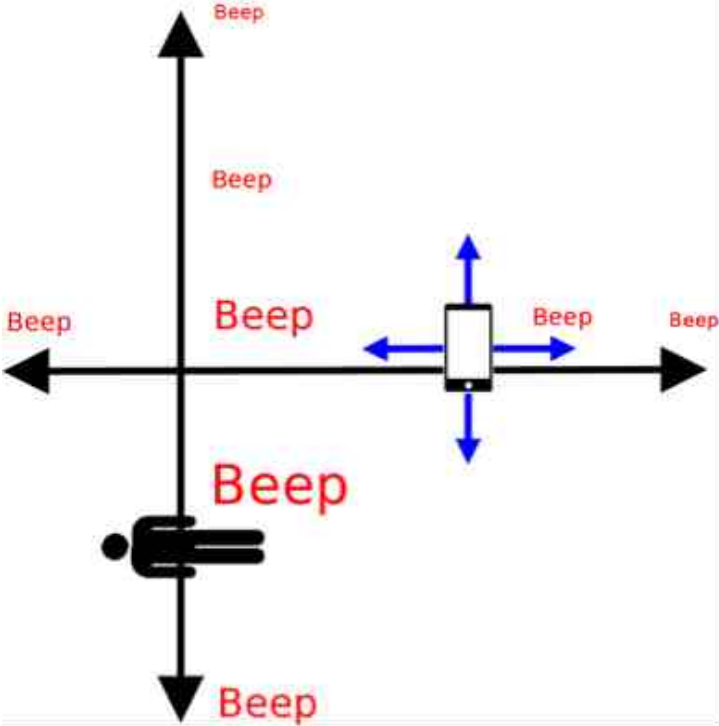
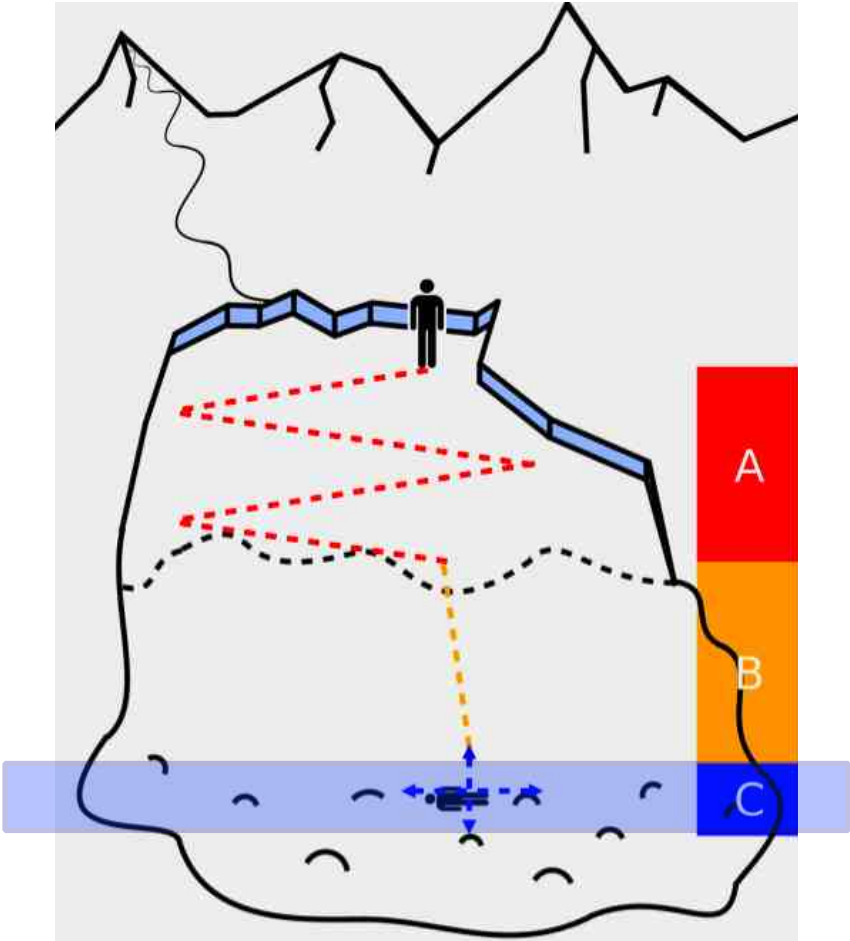
Preliminary results

Abs mean error = **2.6°**

Std deviation = **3.0°**

Desired orientation accuracy
achieved (first tests)

OUR PHASE C APPROACH - Standard search procedure

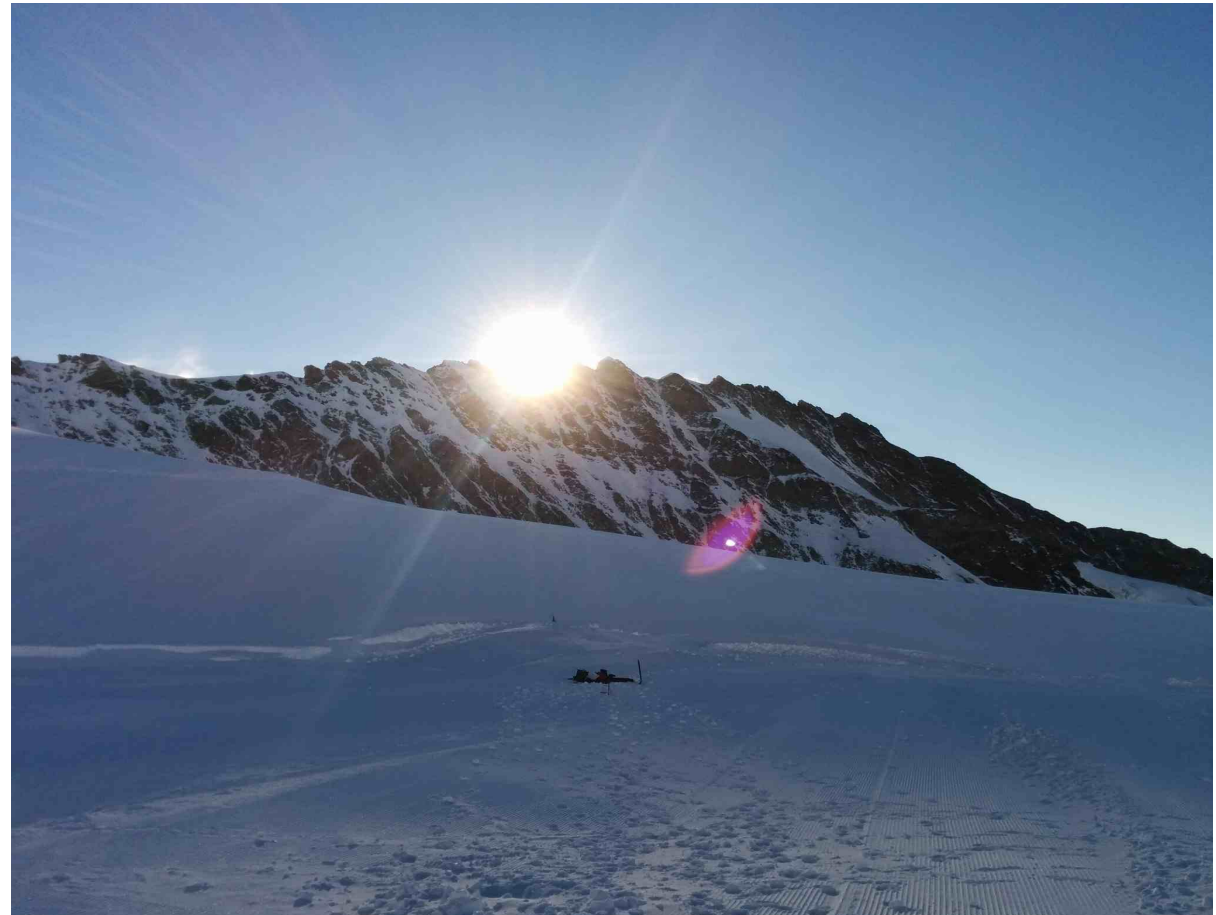


THE VERDICT - Does it work in the field?

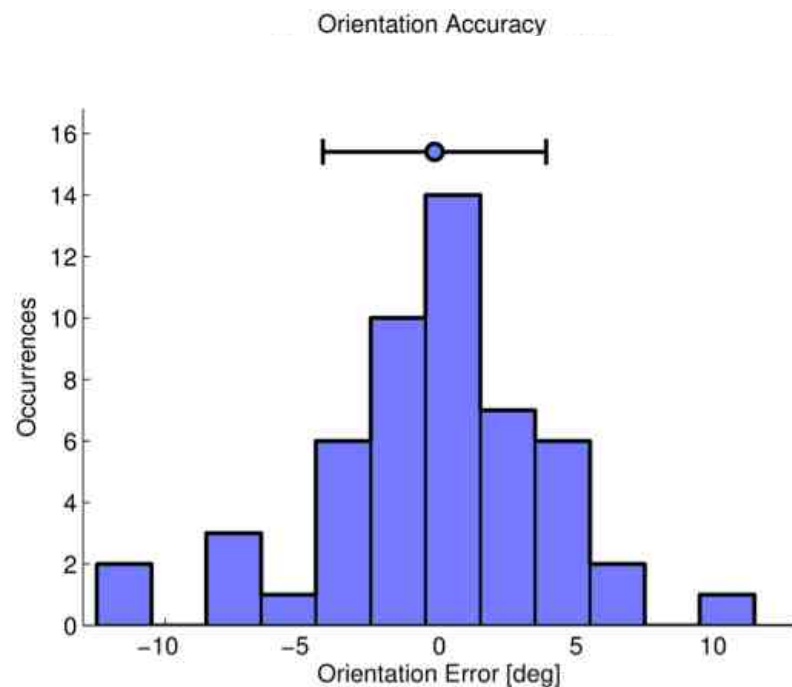
September 2014 @ High Altitude Research

Station Jungfrauoch (3454m)

- ! In 3 days of testing, over 200 search procedures
- ! Verified turn accuracy (Phase B)
- ! Measured search time and search accuracy (Phase B + C)
- ! Compared with an Avalanche Beacon System (ABS)
- ! Evaluated influence of other people on the field

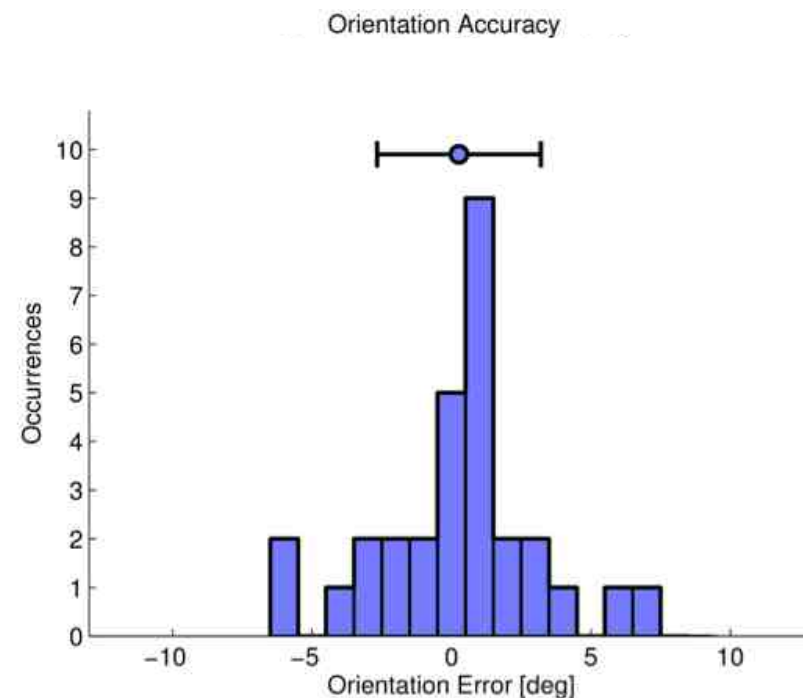


THE VERDICT - Phase B orientation accuracy



Single Victim (50 measurements)
Distances: 30, 20, 15, 10, 5 m

Abs mean error = 2.87° / Std deviation = 4.08°



3 Victims (30 measurements)
Distance: 15 m

Abs mean error = 2.13° / Std deviation = 2.94°

THE VERDICT - Overall search time and localization error

Single Victim (20 measurements)

Distances: 20, 10 m





	Search time		Localization Error	
	Absolute Mean	Std	Absolute Mean	Std
Smartphone	120.5 s	28.7 s	0.12 m	0.10 m
ABS	105.5 s	17.9 s	0.12 m	0.08 m

16 % relative increase
compared to classical ABS

Same precision
compared to ABS

CONCLUSION - We are ready for the pocket

Conclusion

- ! Orientation accuracy 
- ! Search time +16% 
- ! Search accuracy 
- ! Enhanced audible feedback 

Additional contributions

- ! Evaluation of current localization schemes
- ! Evaluation of multi searcher approach (triangulation)



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 - ! Team from Uepaa
 - ! University of Bern (i.e. High Altitude Research Station)
 - ! Jungfrauoch Bergbahn
 - ! Andermatt Bergbahn
-
- ! IKAR for having me here



HFSJG High Altitude Research Stations
Jungfrauoch & Gornergrat

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Swiss Federal Institute of Technology Zurich





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