



Cartography M.Sc.

Towards an automatic UAS-based Mapping Tool for First Responders: Defibrillator Missions in Alpine Regions

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Cooperation with:



- Problem Statement
- Research Objectives
- Innovation & Contribution
- Literature Review
- Methodology
- Experimental Setup
- Results
- Conclusions



Keywords

Emergency Drone
Service Network

Alpine Regions

Automatic External
Defibrillators (AED)

Unmanned Aircraft
Systems (UAS)

Cartographic
Workflow

Optimal Flight
Paths

UAS-AED Missions

Problem Statement

Heart Attacks cause **23% Fatalities**
in Alpine Mountains

TIME IS CRUCIAL

to Increase Probability of Survival

Drones are Efficient to Deliver Defibrillators
Especially in Rural Areas

Standardize Drone Operations for the **U-Space**

Improvements Required

- **Suitable Locations**
- **Optimal Routes**

Cartographic Approach

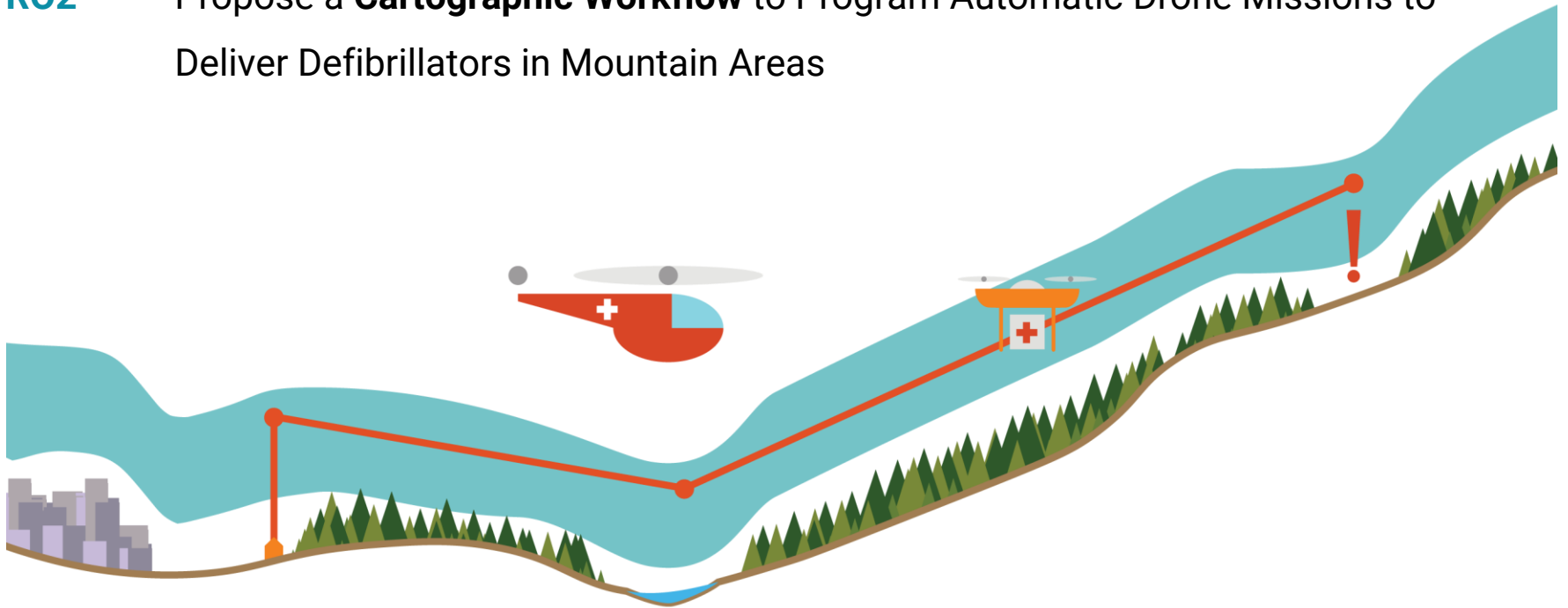
to Support First Responders



Design a Map-Driven Distributed Emergency Drone Service Network

R01 Identify **Suitable Areas** to Deploy Drone-Defibrillator Missions in Alpine Regions

R02 Propose a **Cartographic Workflow** to Program Automatic Drone Missions to Deliver Defibrillators in Mountain Areas

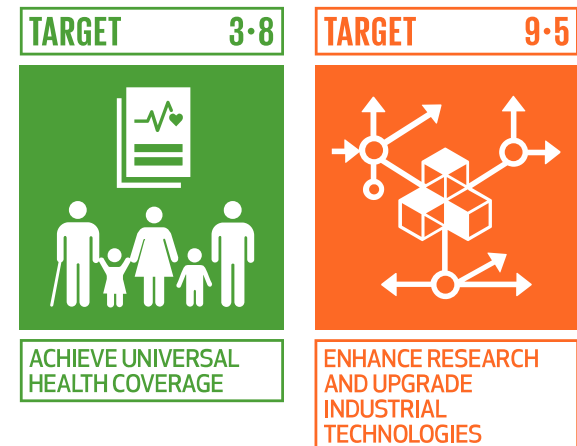


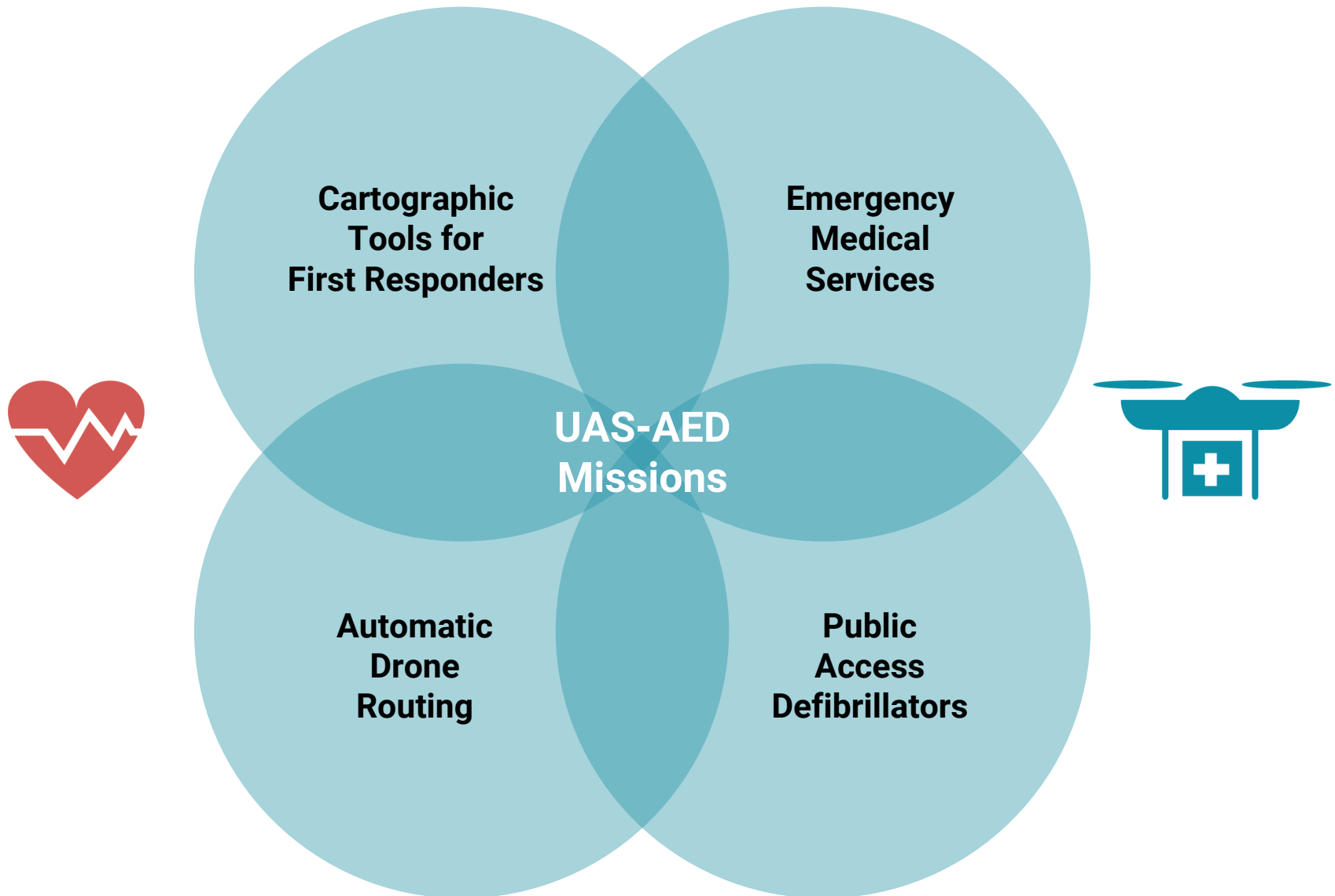
- **Cartographic Approach** Applied in Cross Disciplinary Studies Related to Drone Automation and Mountain Rescue
- Emergency Drone Routing for the U-Space



Contribution

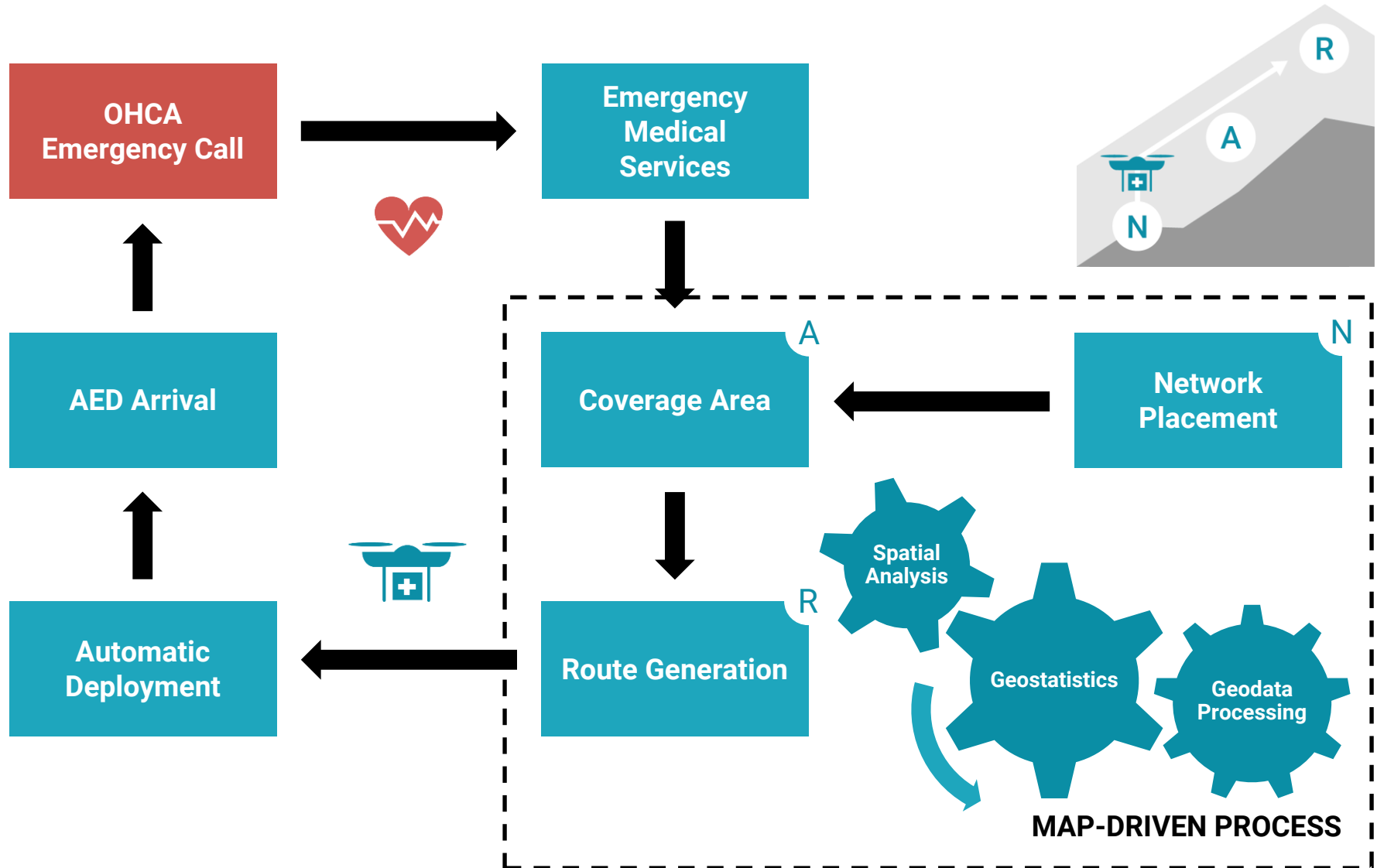
- Healthcare Services Coverage Improvement
- Local Companies Technological Development





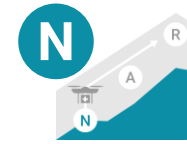
Methodology

General UAS-AED Mission Workflow

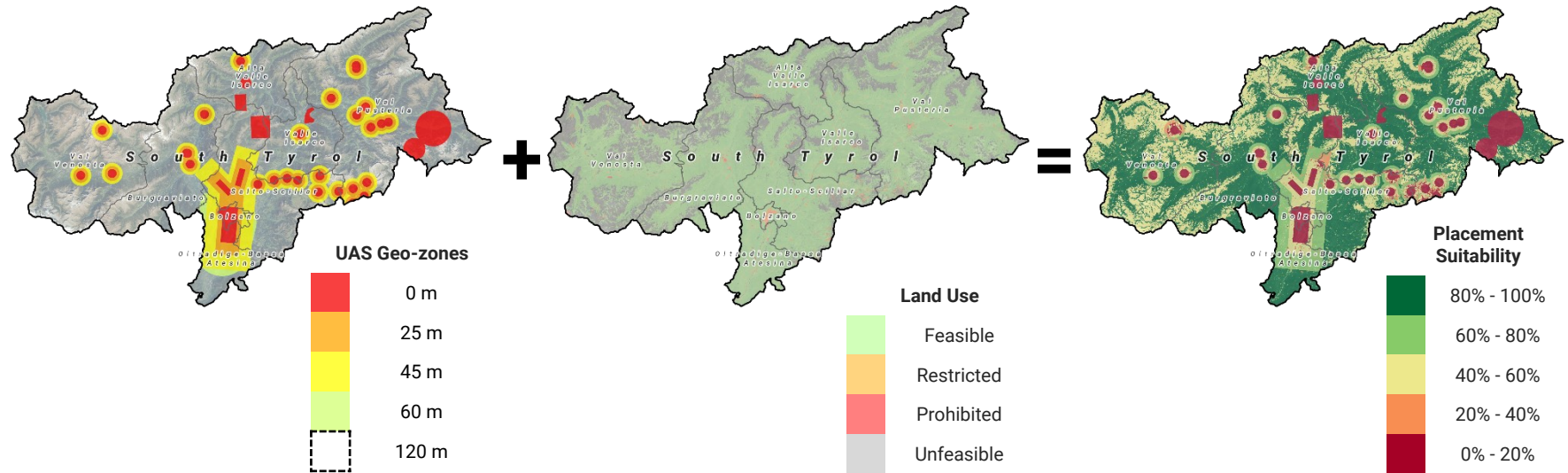


Methodology

UAS-AED Network Placement



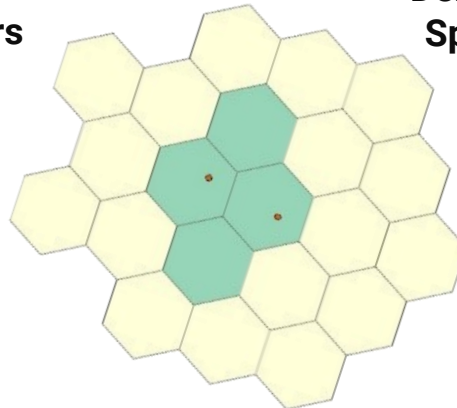
Weighted Overlay



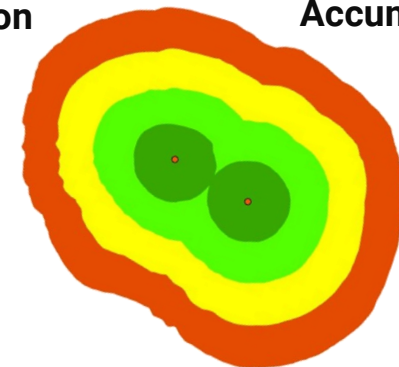
Suitable Locations Query & Nearest Neighbor Clusters



Density Analysis & Spatial Selection

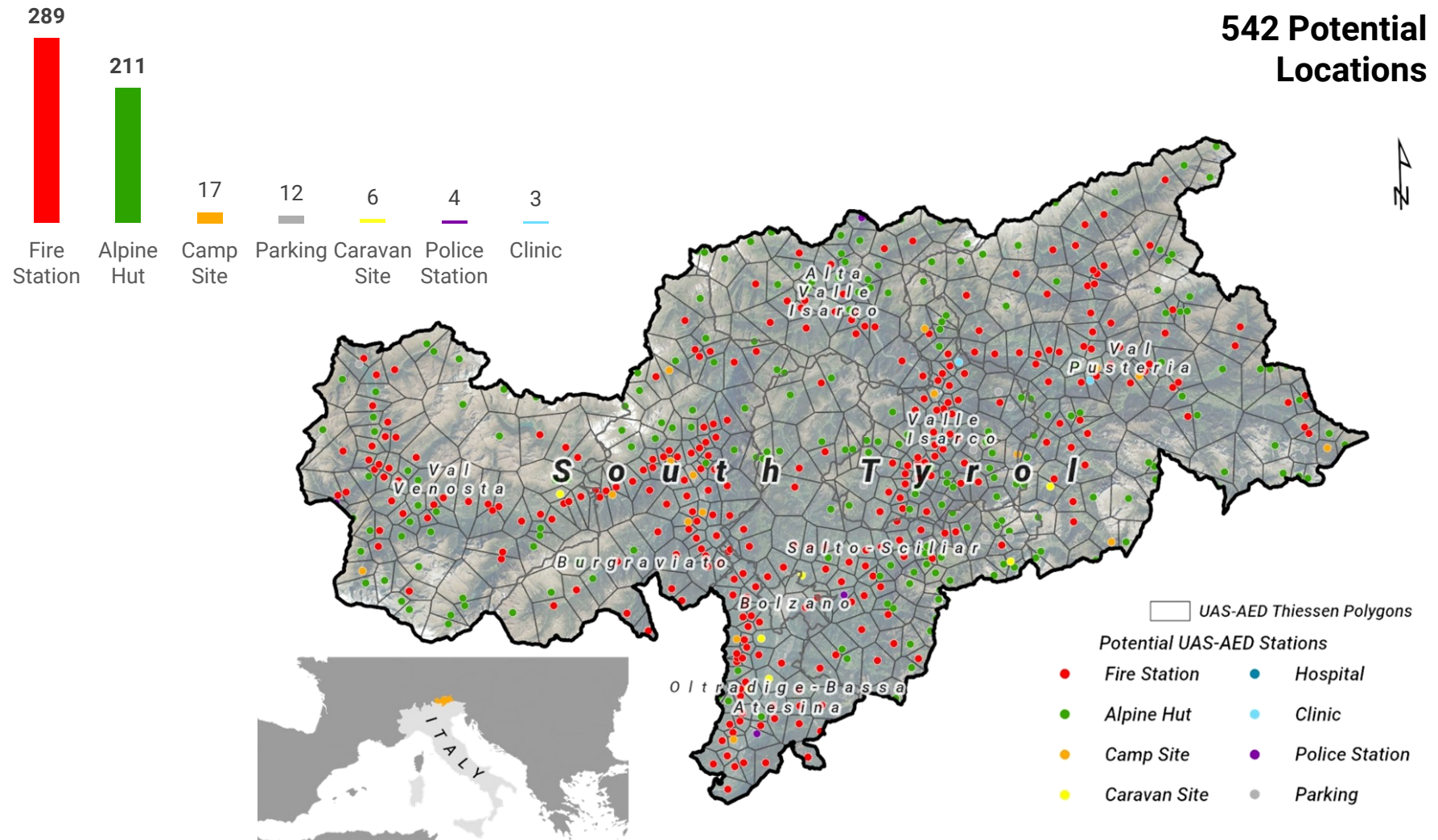
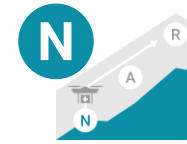


Distance Accumulation



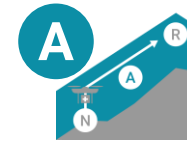
Methodology

UAS-AED Network Distribution



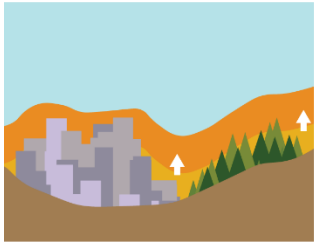
Methodology

Low-Altitude-Flight Elevation Model (LAFEM)

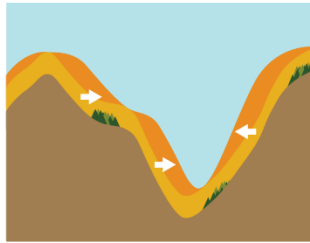


Elevation Surface Modifications

Vertical Modifications



Spatial Filters



Spatial Raster Filters Applied

Modified DEM

20	20	20	30	40	60
30	30	40	30	50	50
50	40	50	40	40	40
60	50	60	30	20	30
70	80	60	40	20	30
60	70	60	50	30	20

Maximum Filter

30	40	40	50	60	60
50	60	60	60	60	60
60	60	60	60	50	50
80	80	80	60	40	40
80	80	80	60	50	30
80	80	80	60	50	30

Mean Filter

45	47	52	55	58	60
50	51	54	56	57	57
65	66	64	59	53	50
73	73	69	60	49	43
80	80	73	62	47	40
80	80	73	63	47	40

Low-Altitude-Flight Elevation Model (LAFEM)

Adapted to elevation model to generate routes using a **safety threshold**

Contingency Volume

Up to 120 m over the terrain

Obstacles Modifier

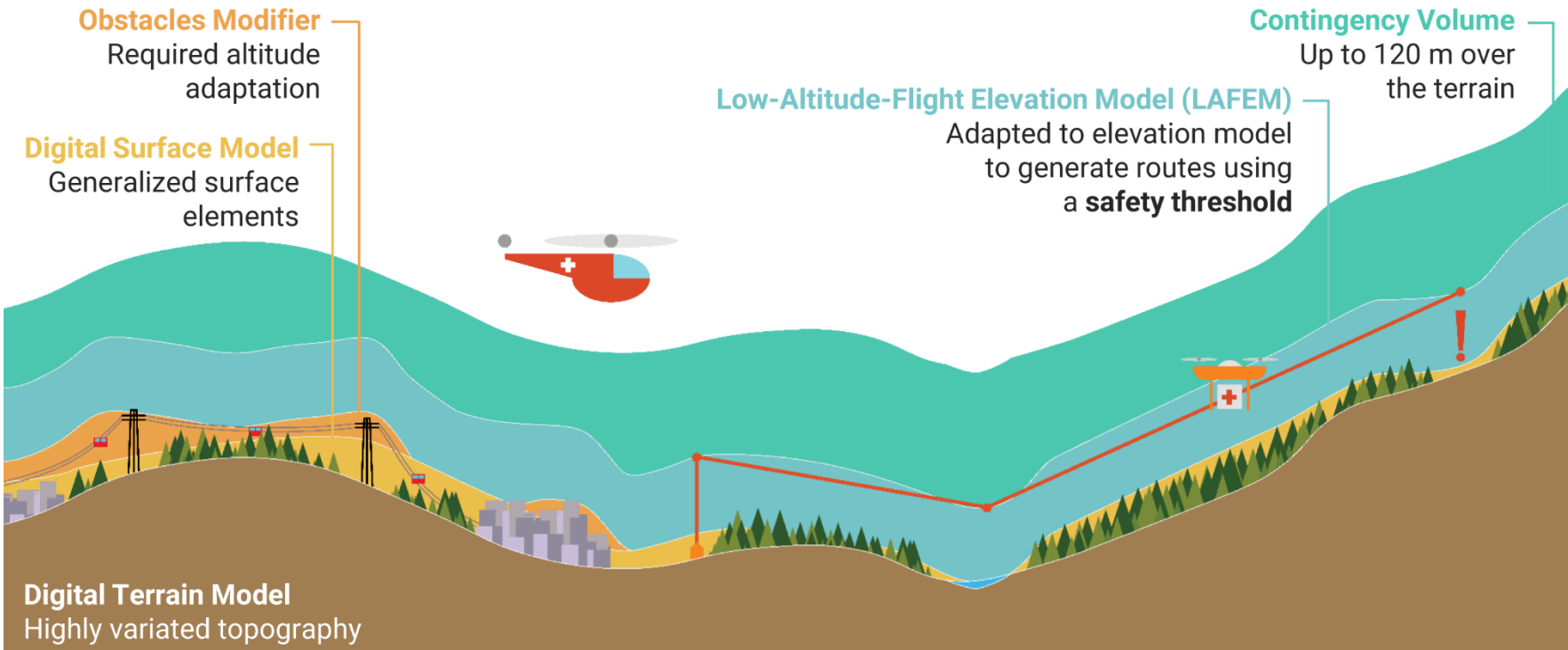
Required altitude adaptation

Digital Surface Model

Generalized surface elements

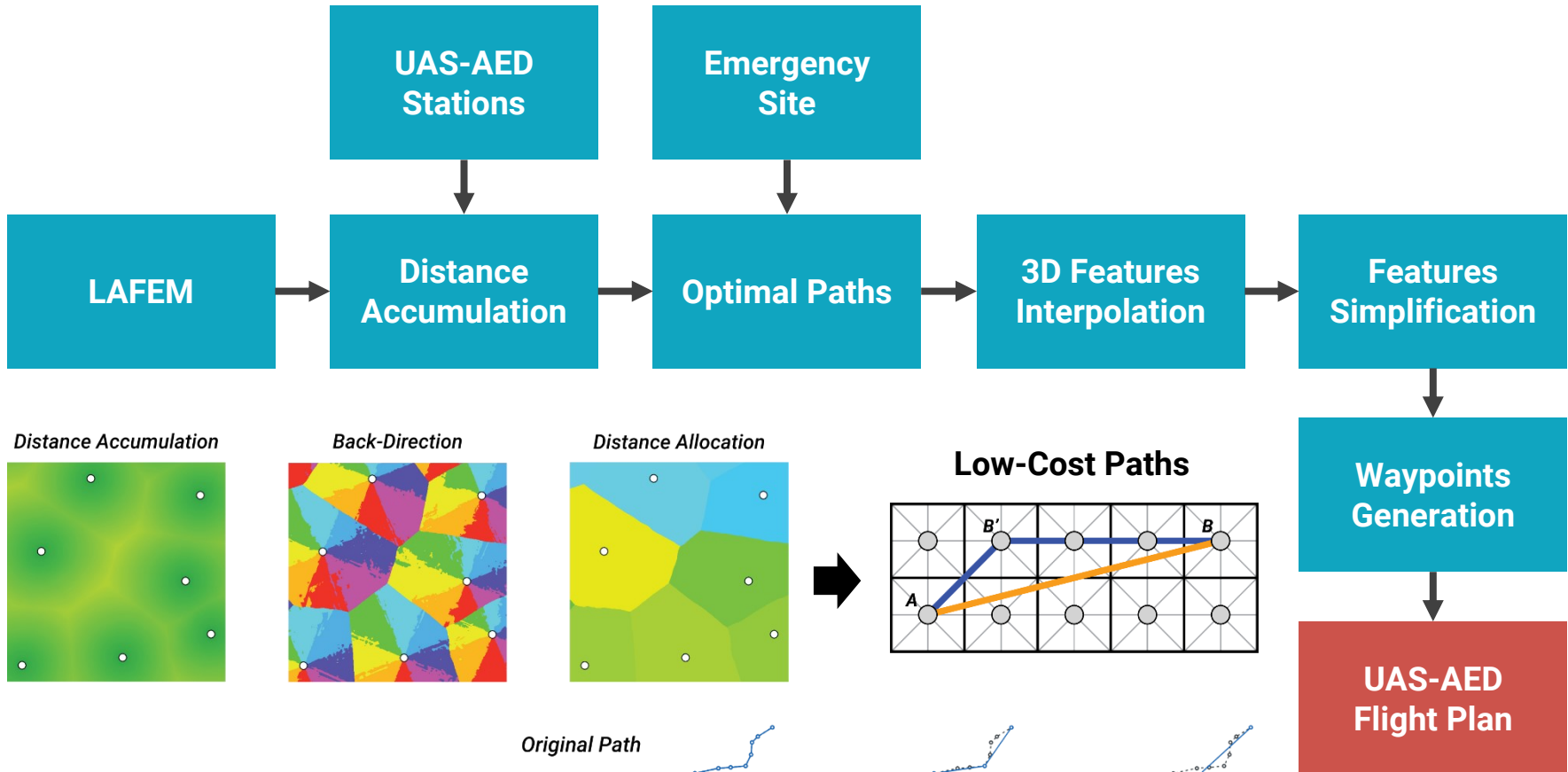
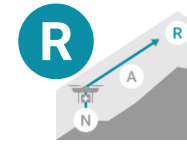
Digital Terrain Model

Highly varied topography

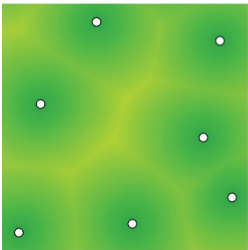


Methodology

UAS-AED Map-Driven Routing Workflow



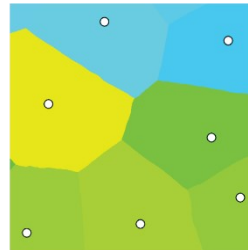
Distance Accumulation



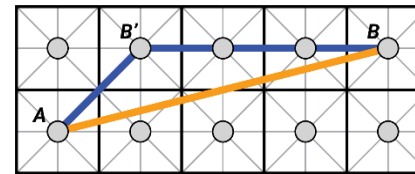
Back-Direction



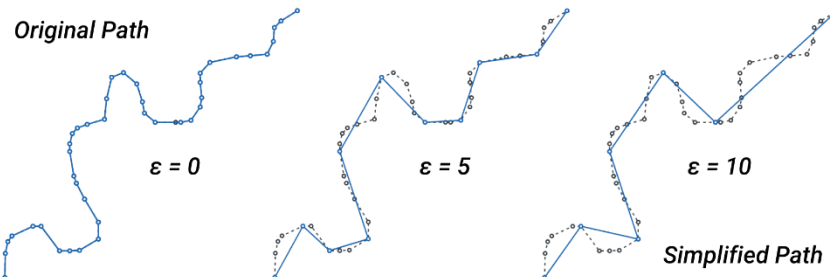
Distance Allocation



Low-Cost Paths

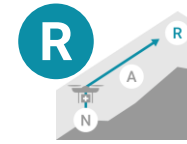


Vector Line Simplification
Douglas-Peucker Algorithm



Experimental Setup

Routing Approaches

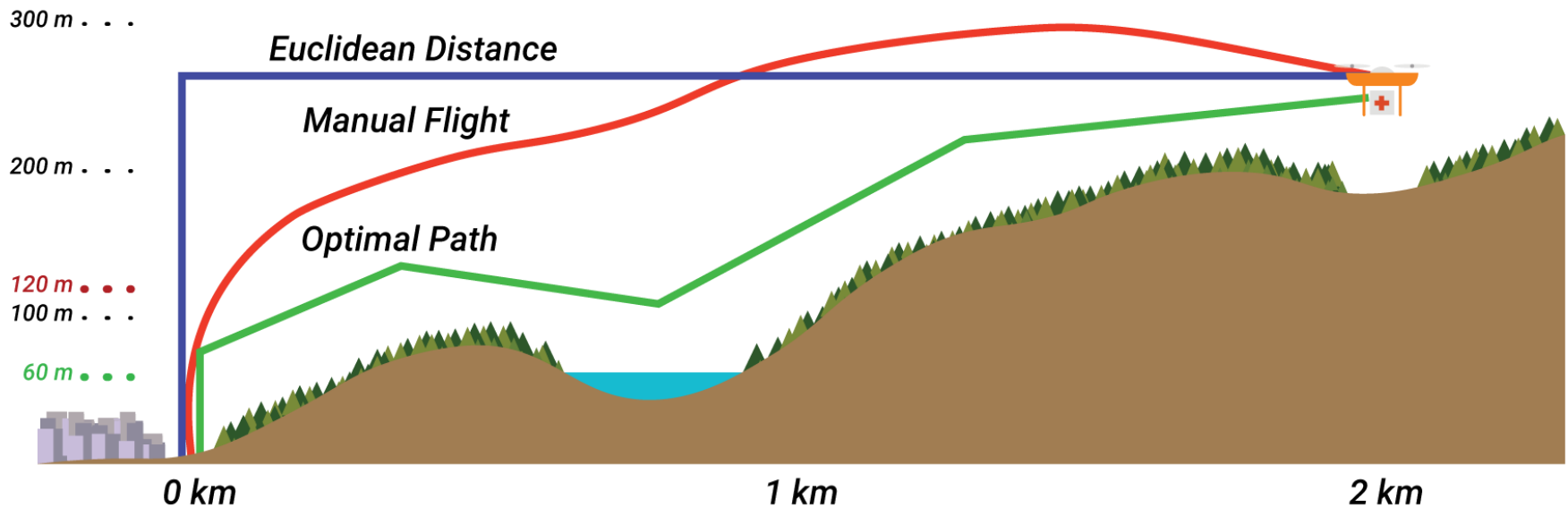


Soleon Octagon



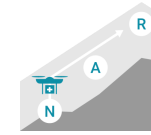
Provider	Eurac Research	MavTech
Brand	Soleon	MavTech
Model	Octagon	Q4X
Configuration	Octocopter	Quadcopter
Length	1260 mm	1200 mm
MTOM	7500 g	9000 g
Autonomy	25 min	32 min

MAvTech Q4X



Experimental Setup

Study Cases



Summer Scenario
Trail Running
Ritten

Field Test



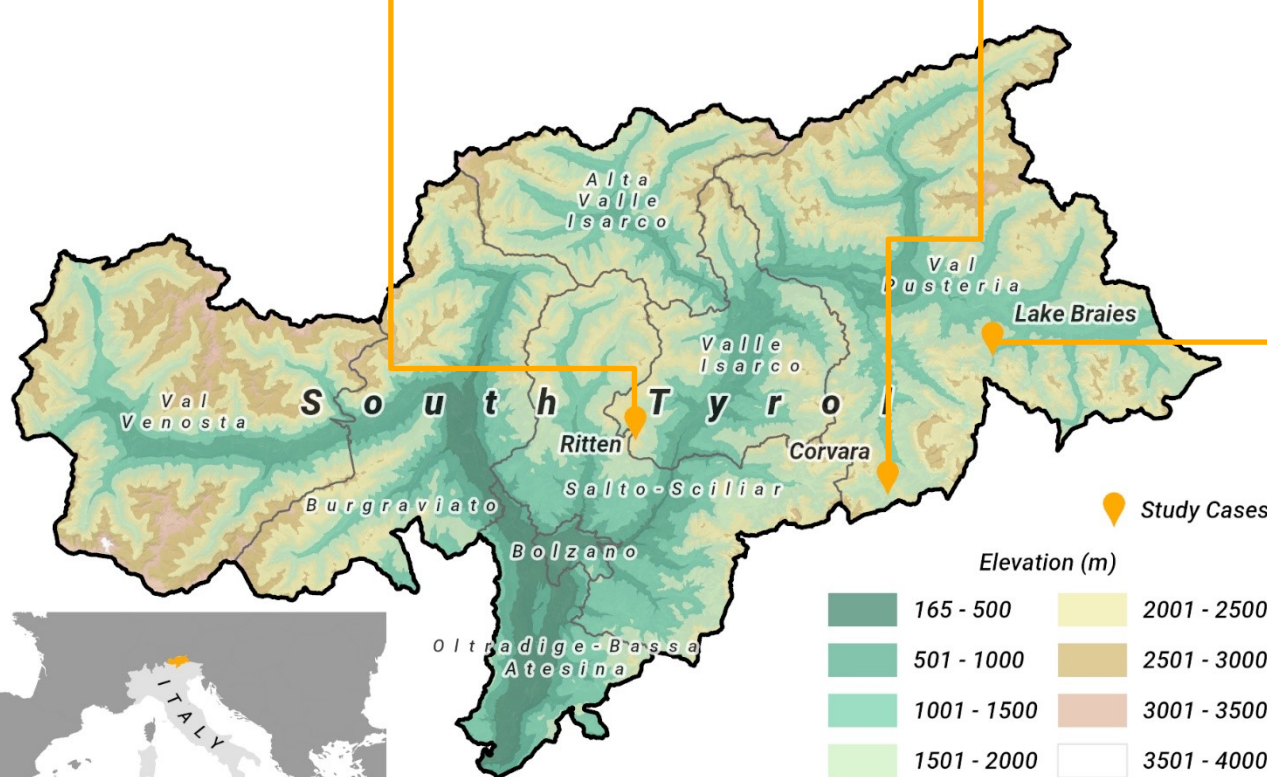
Winter Scenario
Recreational Ski
Corvara

Field Test



Route Testing
Mountain Hiking
Lake Braies

Simulation



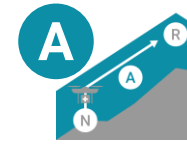
UAS-AED Network
Regional Model
Autonomous Province
of South Tyrol, Italy



Results

Route Testing Simulation

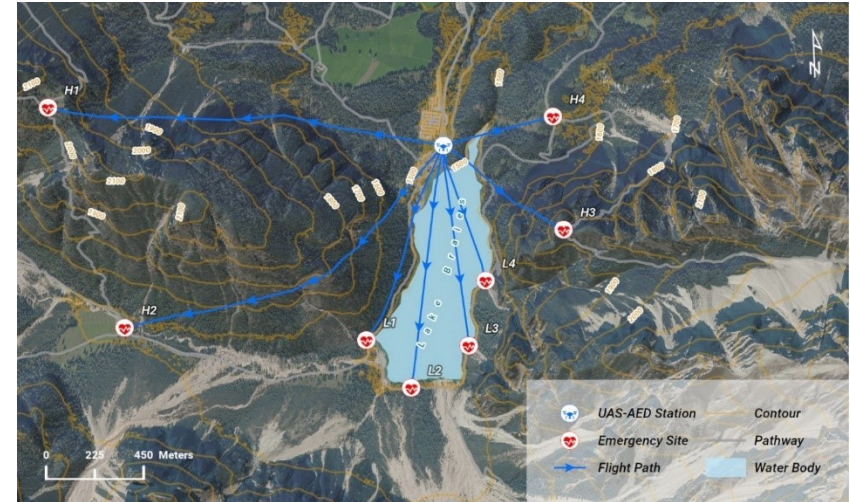
Mountain Hiking Lake Braies



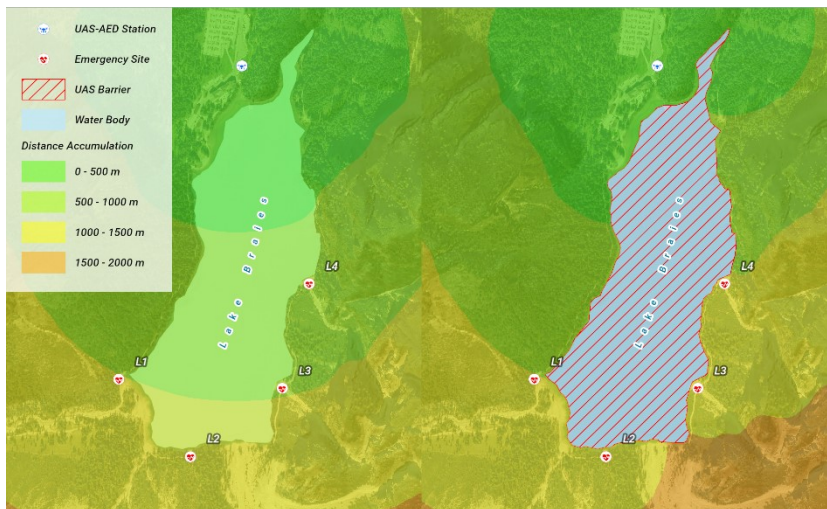
Lake Braies Aerial Perspective



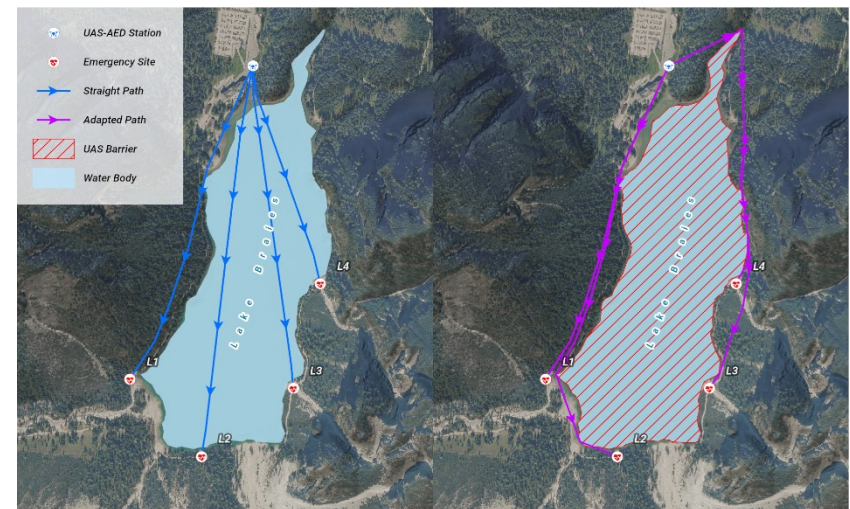
Simultaneous Drone Routing over Challenging Terrain

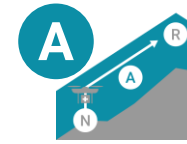


Distance Accumulation with/without Barriers



Optimal Drone Routes with/without Barriers



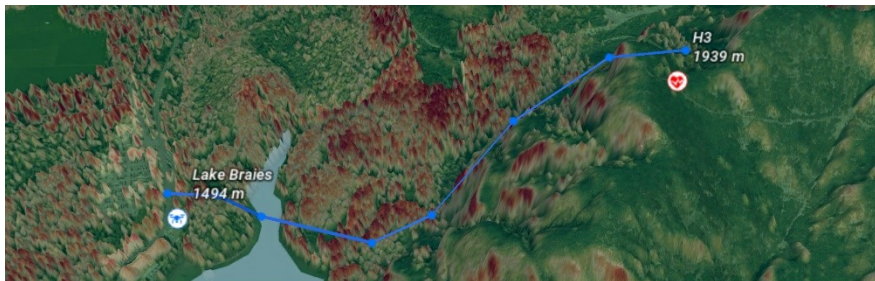


Drone Routing with Different Simplification Parameters

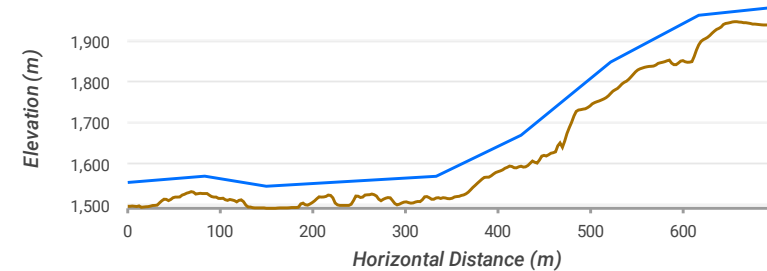


10 m Simplification Parameter

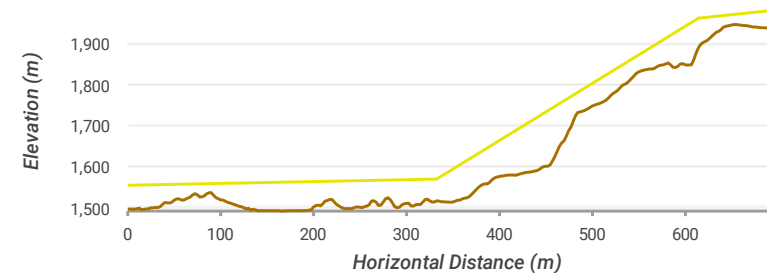
Suitable for Practical Tests



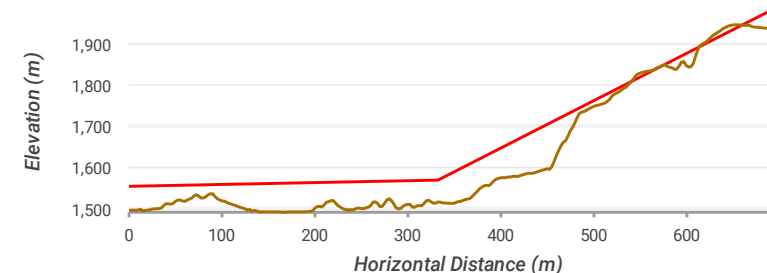
H3 Simplification Tolerance 10 m



H3 Simplification Tolerance 25 m

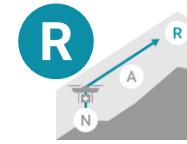


H3 Simplification Tolerance 50 m



Results

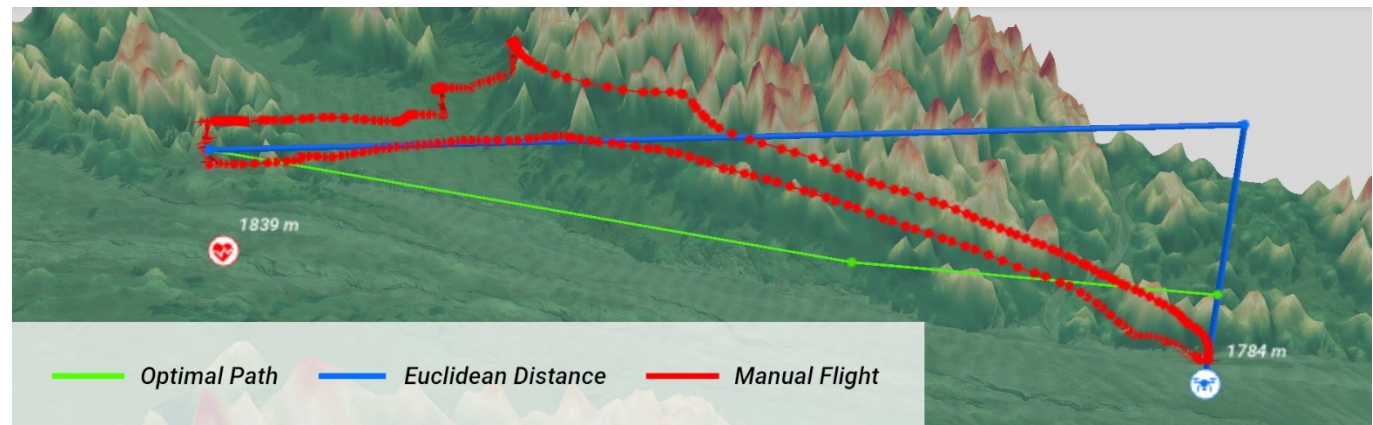
Winter Scenario Field Test Recreational Ski Corvara



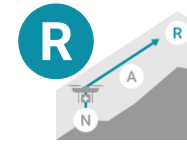
Optimal Paths estimate shorter delivery time and flight distance

Flight	Total Distance	Delivery Time	Return Time	Total Time
Optimal (E)	602.00 m	00:01:19	00:01:19	00:02:38
Euclidean (E)	763.89 m	00:01:32	00:01:32	00:03:04
Manual	718.72 m	00:02:30	00:01:40	00:04:10

Manual Flight
require on-flight
adjustments



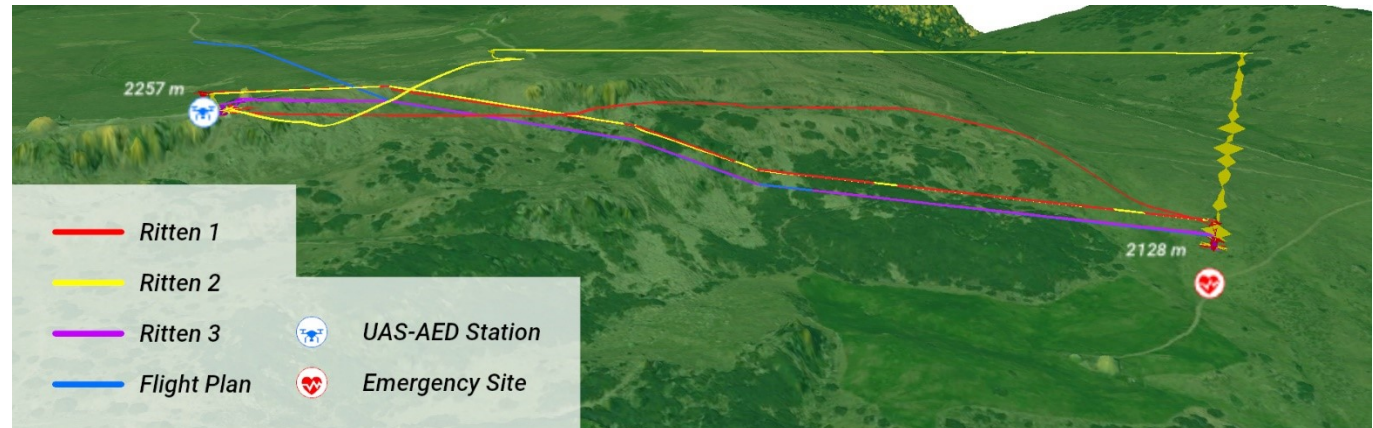
Results Summer Scenario Field Test Trail Running Ritten



Optimal Paths adapted to the terrain considering a **30 m Safety Threshold**

Flight	Total Distance	Delivery Time	Return Time	Total Time
Optimal (E)	1,582.88 m	00:03:11	00:03:11	00:06:21
Ritten 1	1,638.50 m	00:03:36	00:06:35	00:10:11
Ritten 2	1,736.63 m	00:03:06	00:03:39	00:06:45
Ritten 3	1,532.17 m	00:02:59	00:02:30	00:05:29

Flights required **take-off and land manually** due to high obstacles



Conclusions

Suitable Zones to Place Drones Identified in South Tyrol
Extended in **Mountainous Areas**

542 Potential Locations Selected to Place UAS-AED Stations

Proposed **Cartographic Workflow** Generate
Optimal Flight Paths Adapted to Challenging Terrain

Proposed Paths Showed **Significant Improvements**
Against Other Routing Approaches

Tests and Automation Required for Implementation
with Rescue Operations



Thanks
Danke
Grazie
Gracias



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Technical
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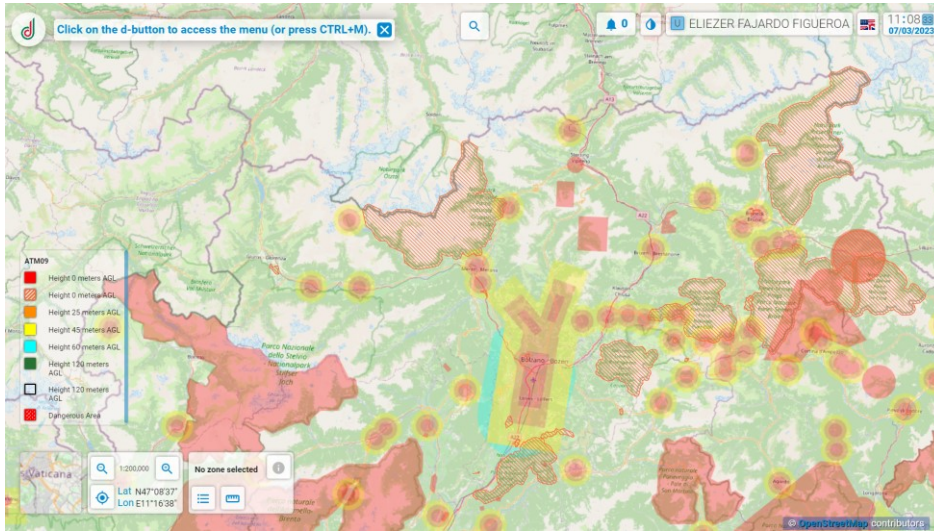
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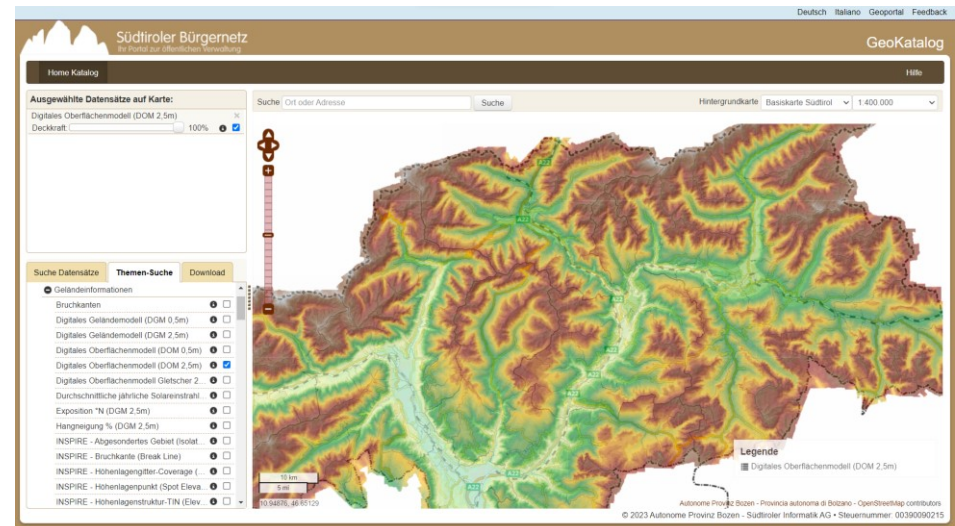
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Data Sources



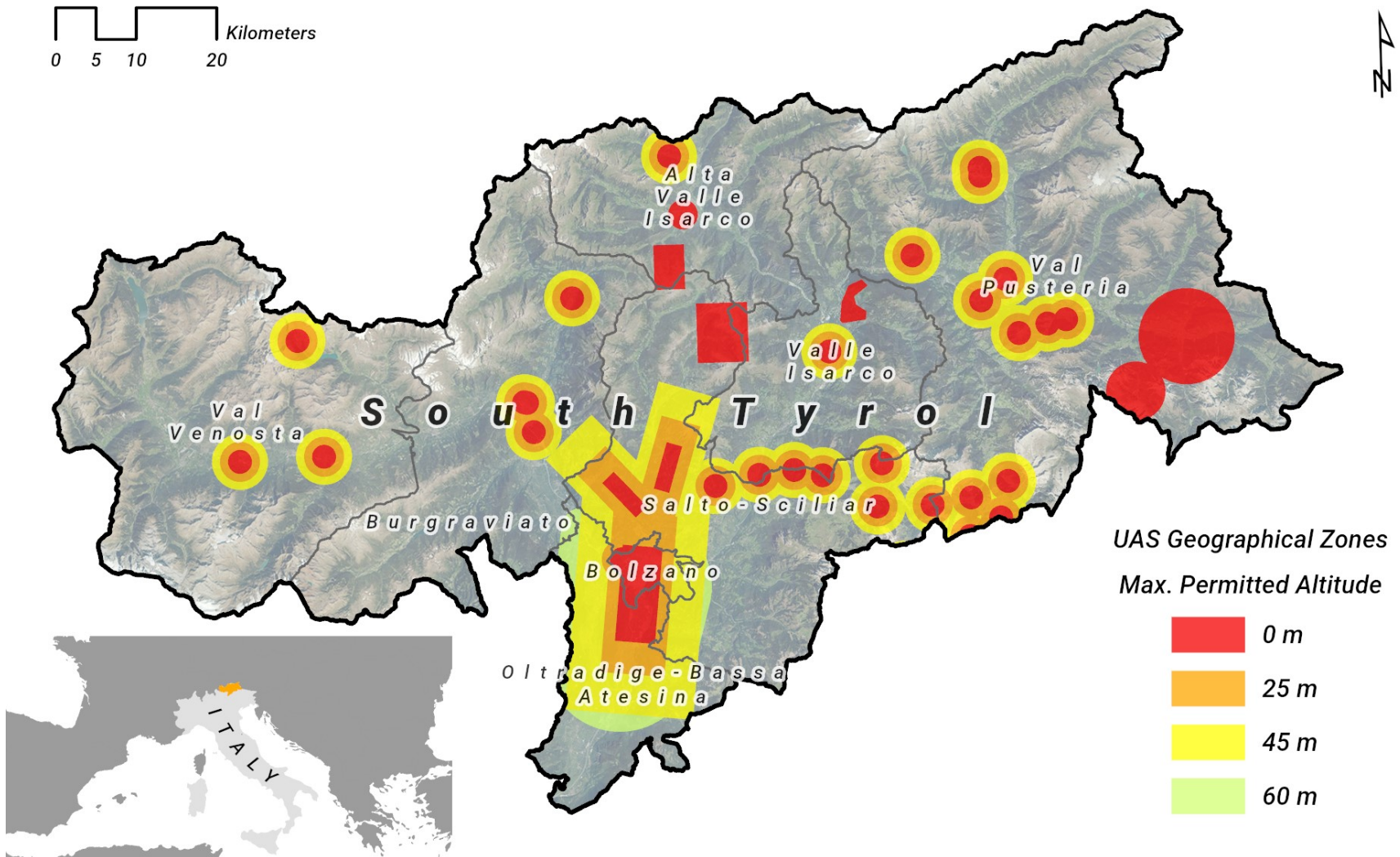
d-flight
ENAC

South Tyrol
Geoportal



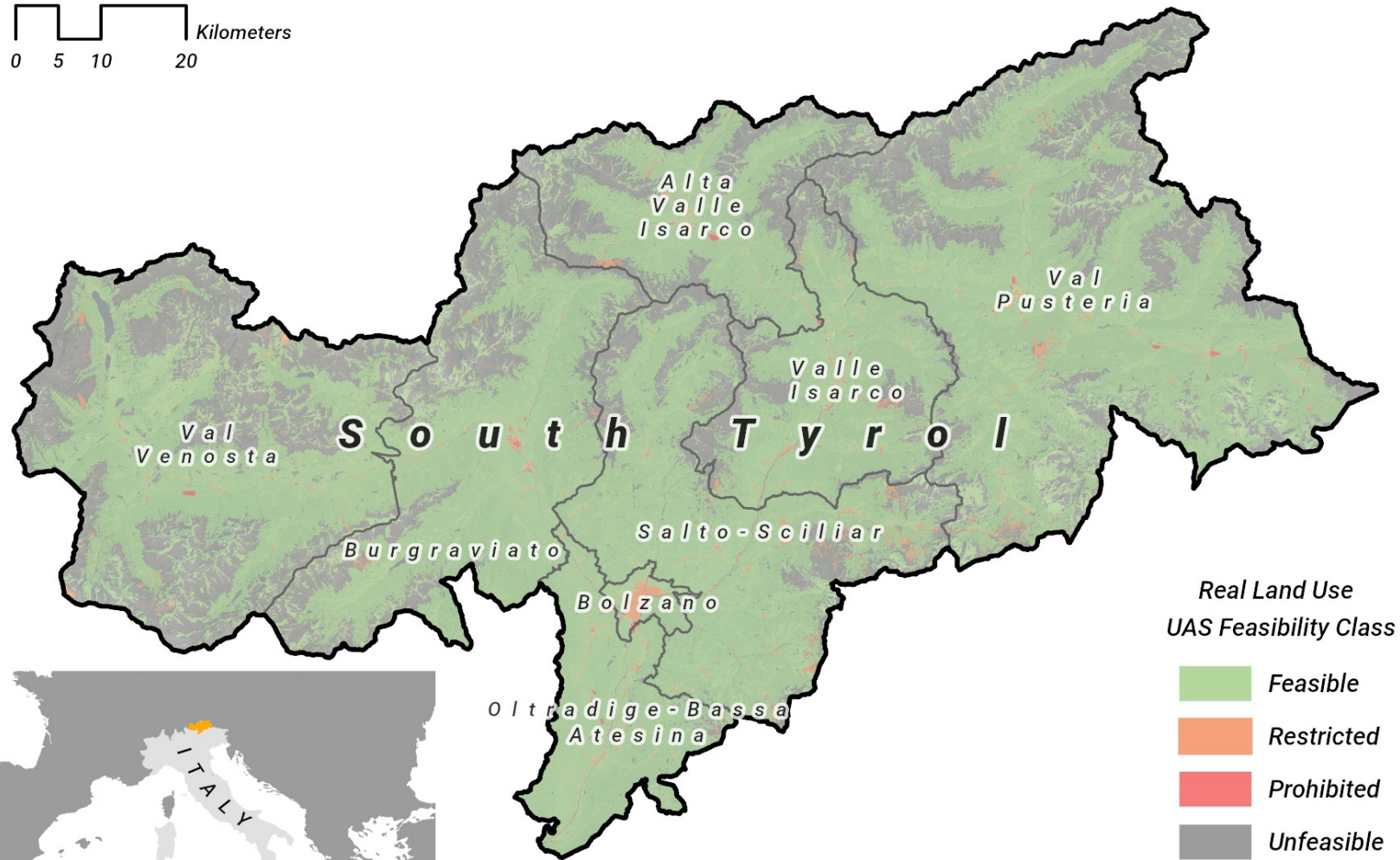
UAS Geographical Zones

Max. Permitted Altitude

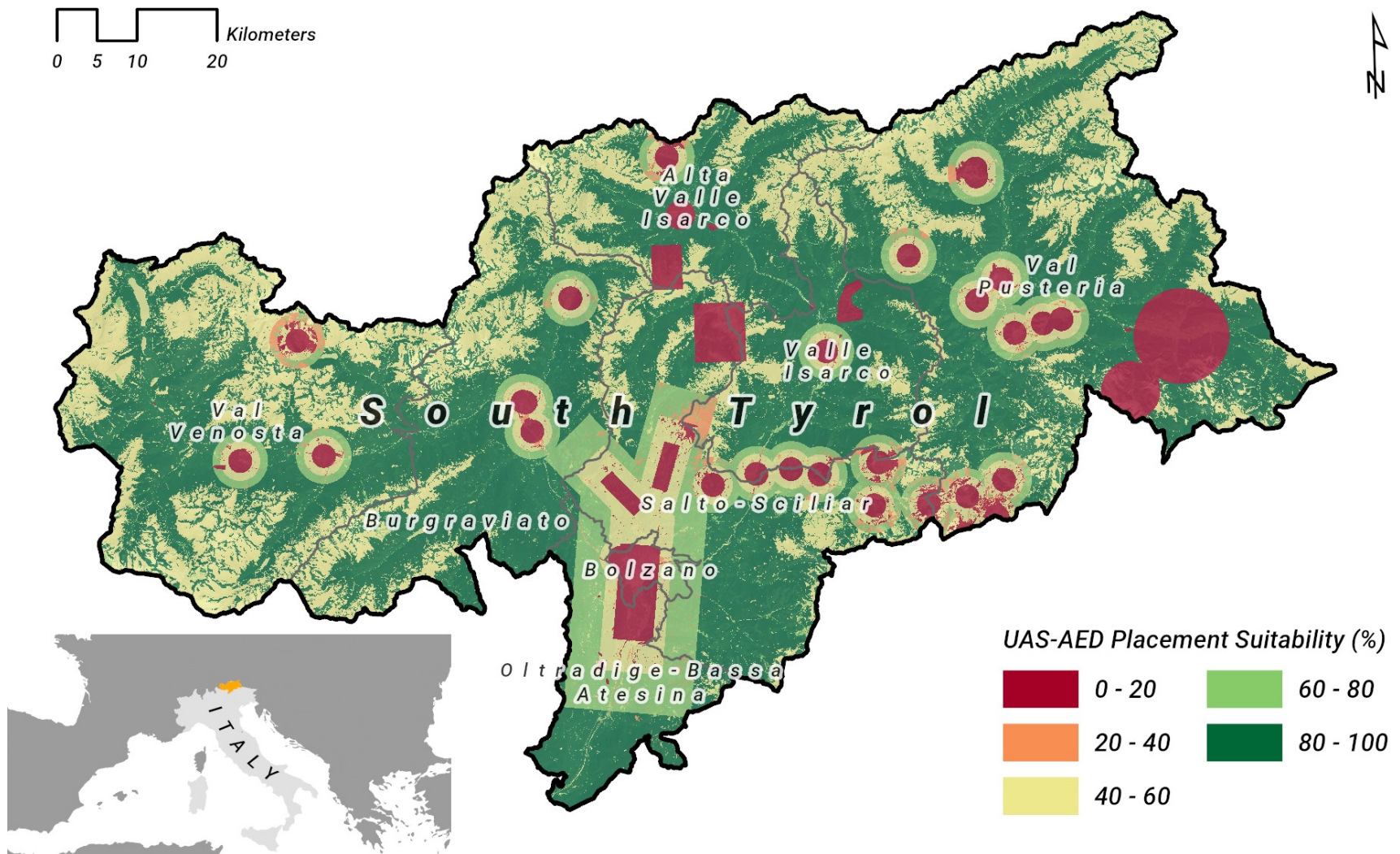


Real Land Use UAS Feasibility

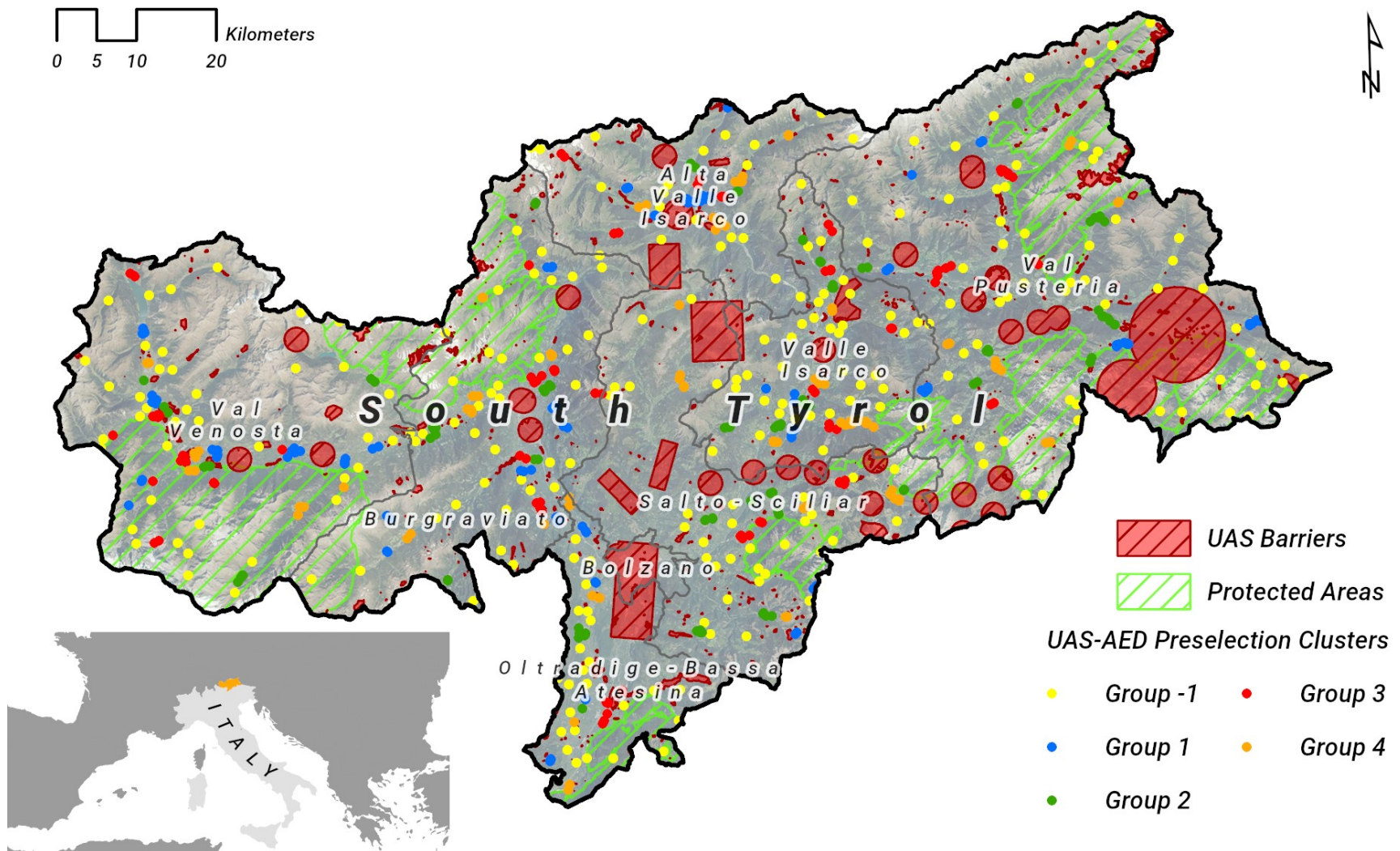
Kilometers
0 5 10 20



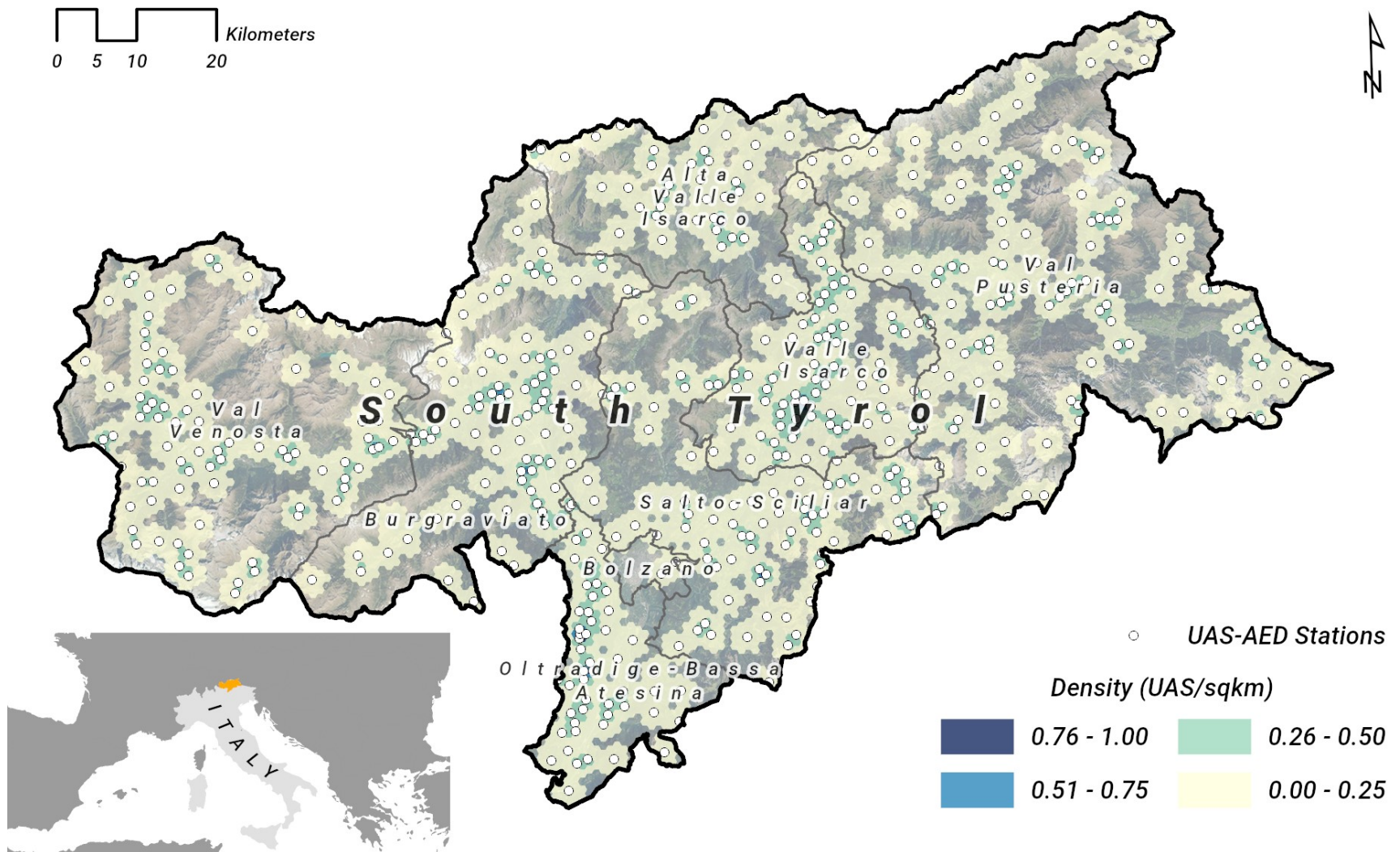
UAS-AED Placement Suitability



Feasible UAS-AED Station Clusters

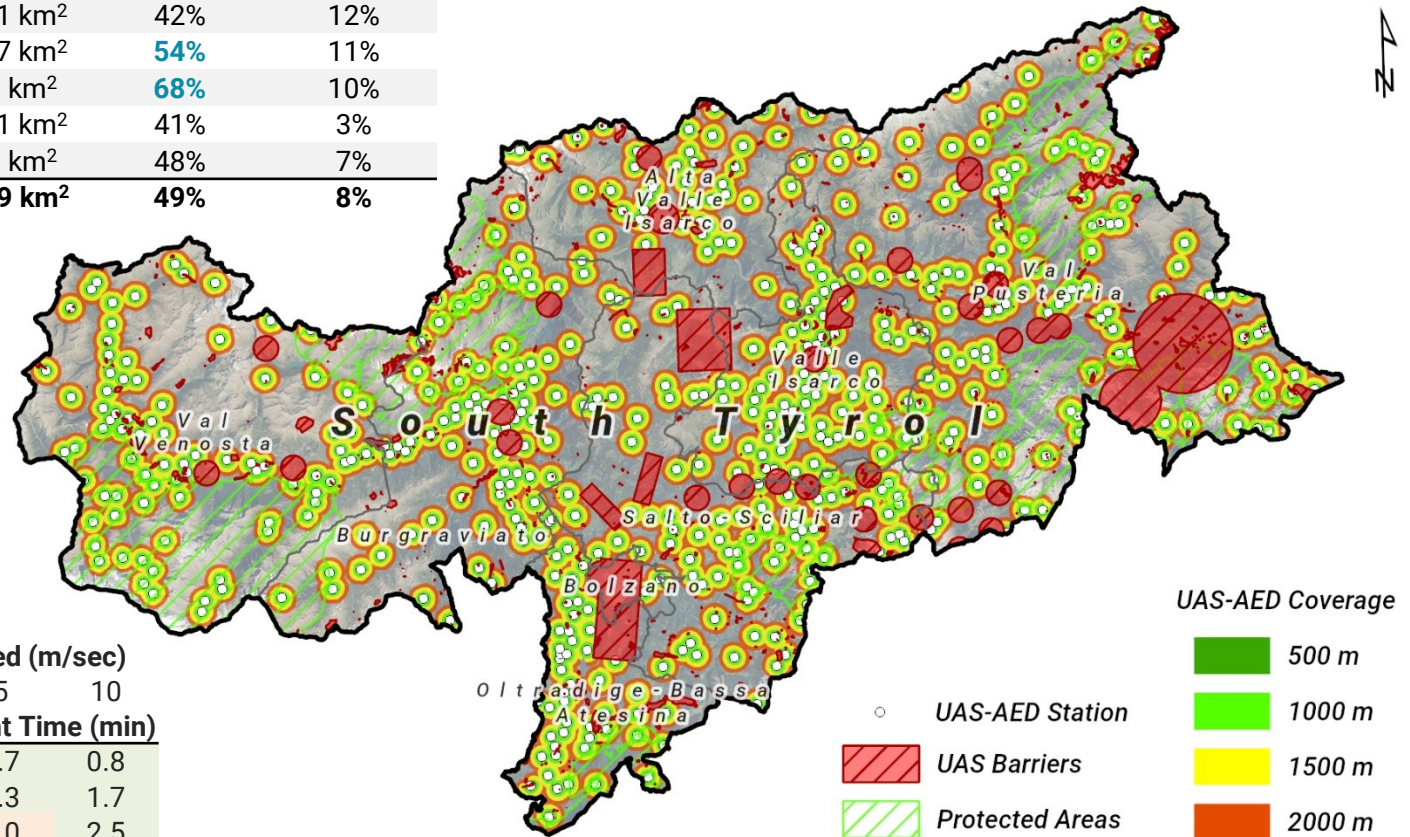


UAS-AED Stations Density



UAS-AED Network Coverage

District	Surface	UAS-AED Coverage	UAS Barriers
Bolzano	52 km ²	28%	58%
Burgraviato	1,100 km ²	52%	3%
Valle Isarco	624 km ²	68%	7%
Val Pusteria	2,071 km ²	42%	12%
Salto-Sciliar	1,037 km ²	54%	11%
Olt.-Bassa Atesina	423 km ²	68%	10%
Val Venosta	1,441 km ²	41%	3%
Alta Valle Isarco	650 km ²	48%	7%
South Tyrol	7,399 km²	49%	8%



Distance (m)	Flight Speed (m/sec)		
	3	5	10
500	2.8	1.7	0.8
1000	5.6	3.3	1.7
1500	8.3	5.0	2.5
2000	11.1	6.7	3.3

Process Automation

Low-Altitude-Flight Elevation Model

Model Builder

ArcGIS Pro 3.1

Geoprocessing

Low-Altitude-Flight Elevation Model

Parameters Environments

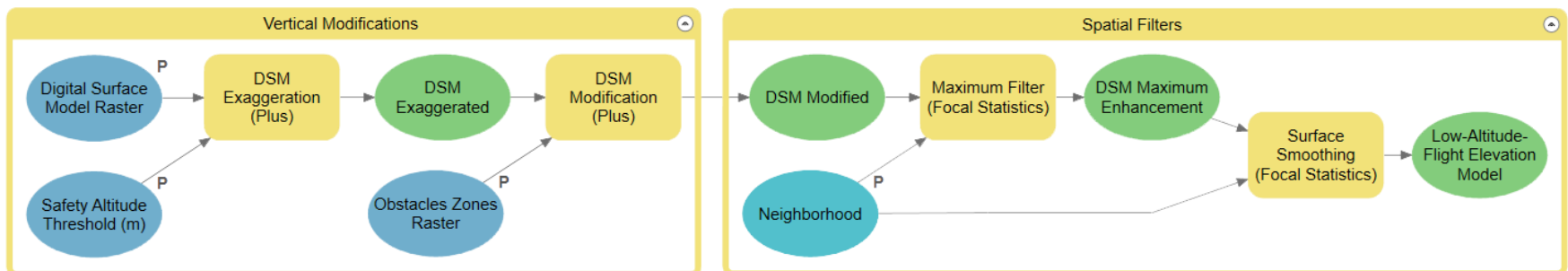
Digital Surface Model Raster
DSM

Safety Altitude Threshold (m)
30

Obstacles Zones Raster
Obstacle Zones

Neighborhood
Circle
Radius 10
Units type Cell

Run



Process Automation UAS-AED Routing

Model Builder

ArcGIS Pro 3.1

