An autonomous time dependent swarm routing system for real time investigation

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Autonomy

- Fully autonomous systems?
- Cognitive autonomy
- Computer vision
- System on Chips (NVIDIA, Intel)
- Open Source (Dronecode, Tango, CUDA, OpenCV)

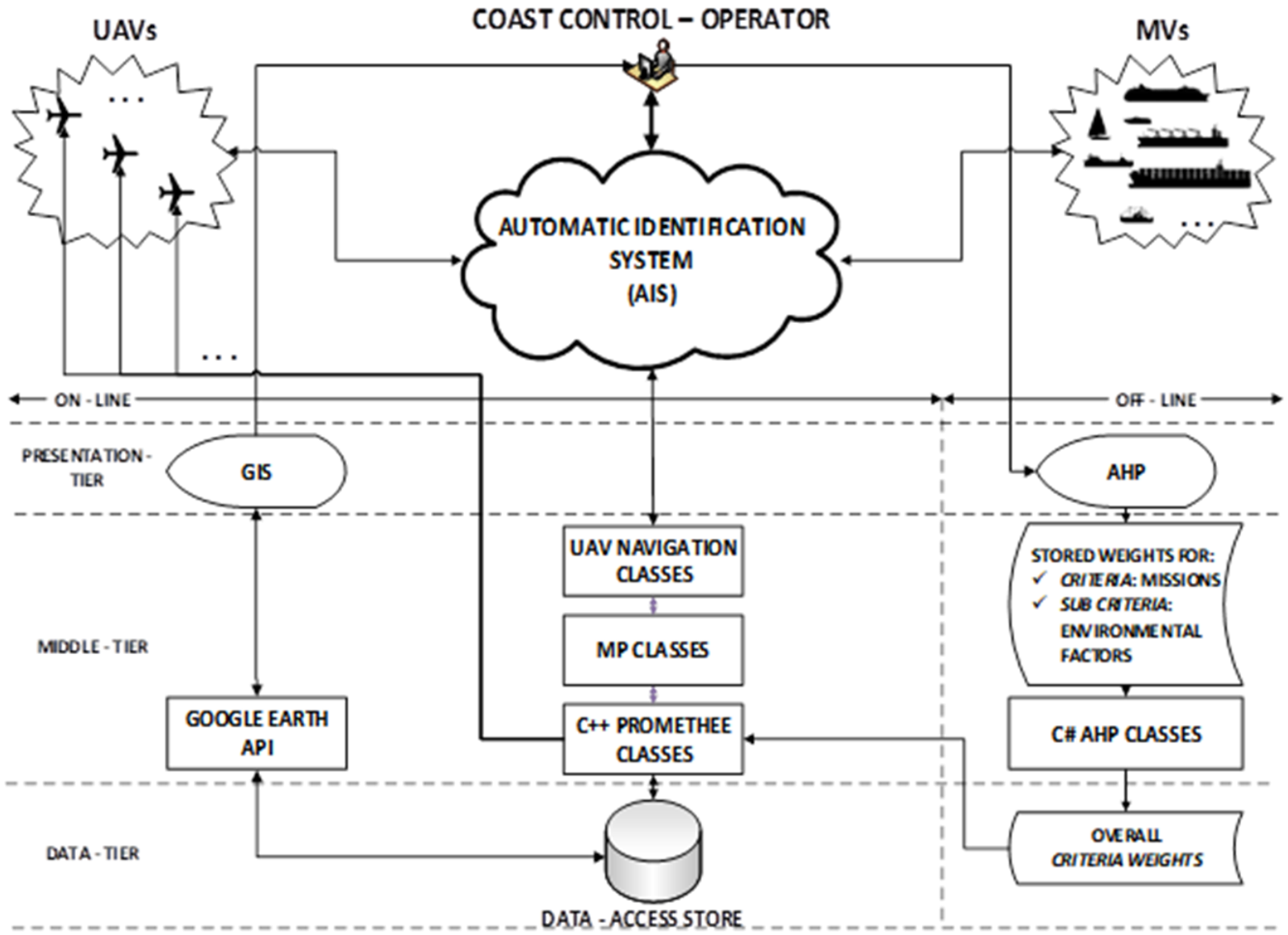
Vehicle Routing Problem

- TSP
- VRP taxonomies (Dynamic Deterministic)
- Moving target TSP
- Genetic algorithms
- Ant colony algorithms
- Objective optimization
- Multi criteria decision analysis (MCDA) methodologies
- MCDA routing
- MCDA integration

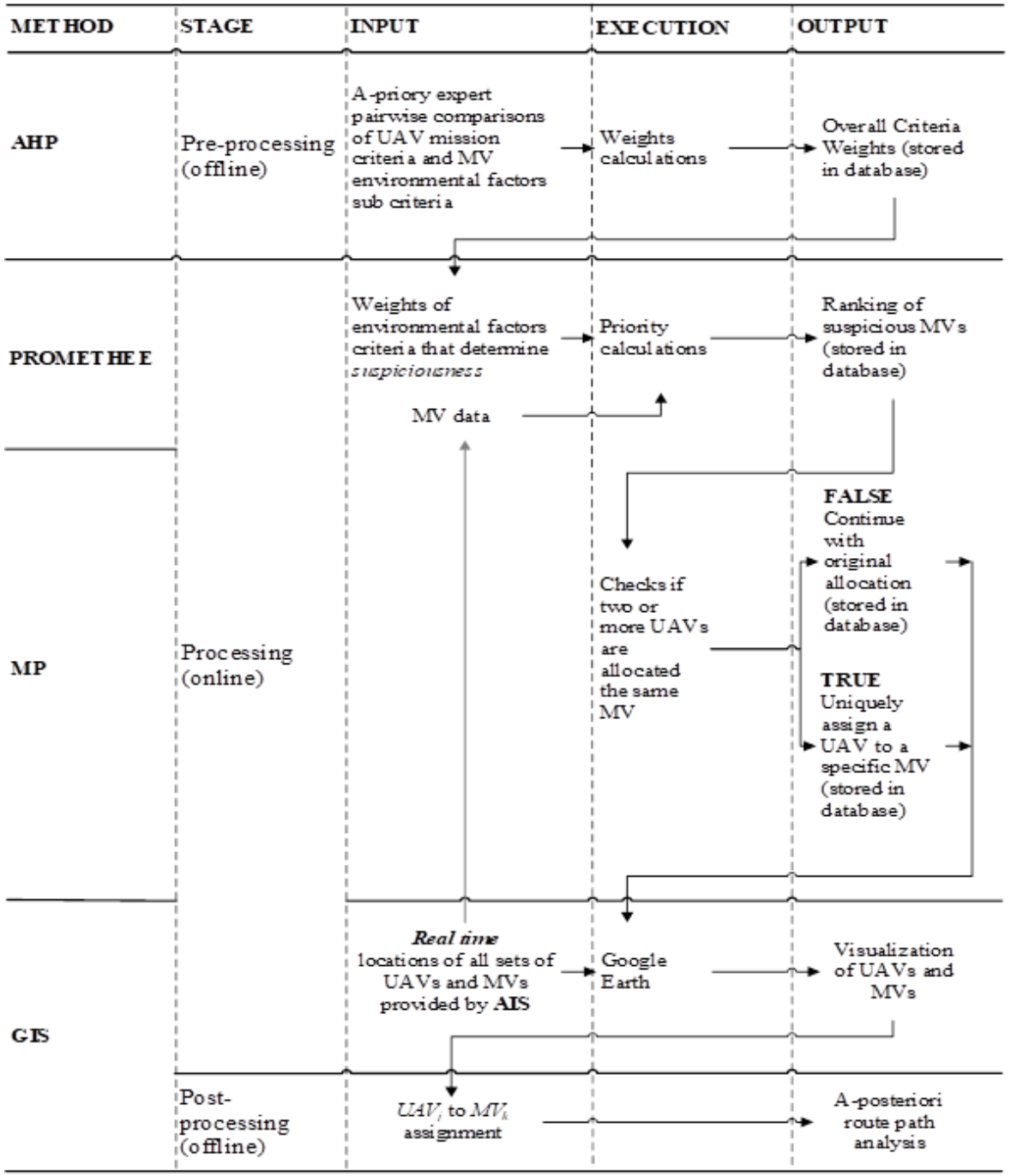
- AHP
- PROMETHEE
- MP
- GIS

Time dependent MCDA

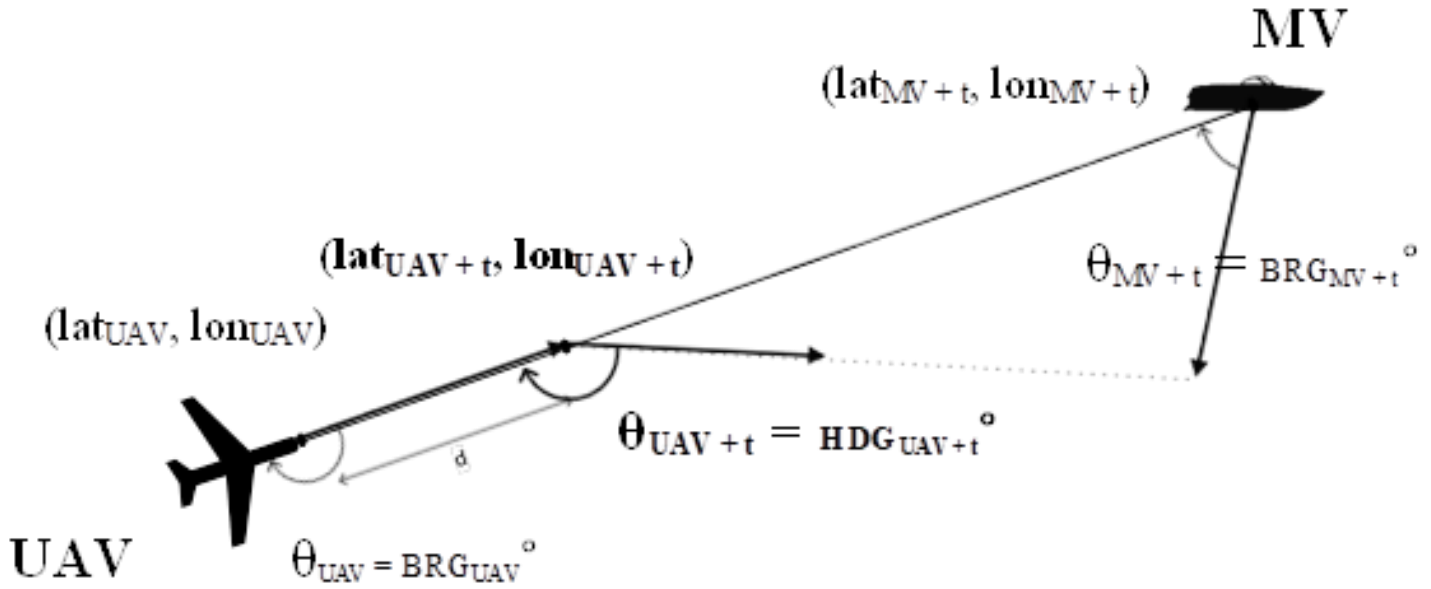
Overview


UAVs
COAST CONTROL – OPERATOR
MVs
AUTOMATIC IDENTIFICATION SYSTEM (AIS)
ON - LINE
OFF - LINE
PRESENTATION - TIER
GIS
AHP
UAV NAVIGATION CLASSES
STORED WEIGHTS FOR:
✓ CRITERIA: MISSIONS
✓ SUB CRITERIA: ENVIRONMENTAL FACTORS
MIDDLE - TIER
MP CLASSES
GOOGLE EARTH API
C++ PROMETHEE CLASSES
C# AHP CLASSES
DATA - TIER
OVERALL CRITERIA WEIGHTS
DATA - ACCESS STORE

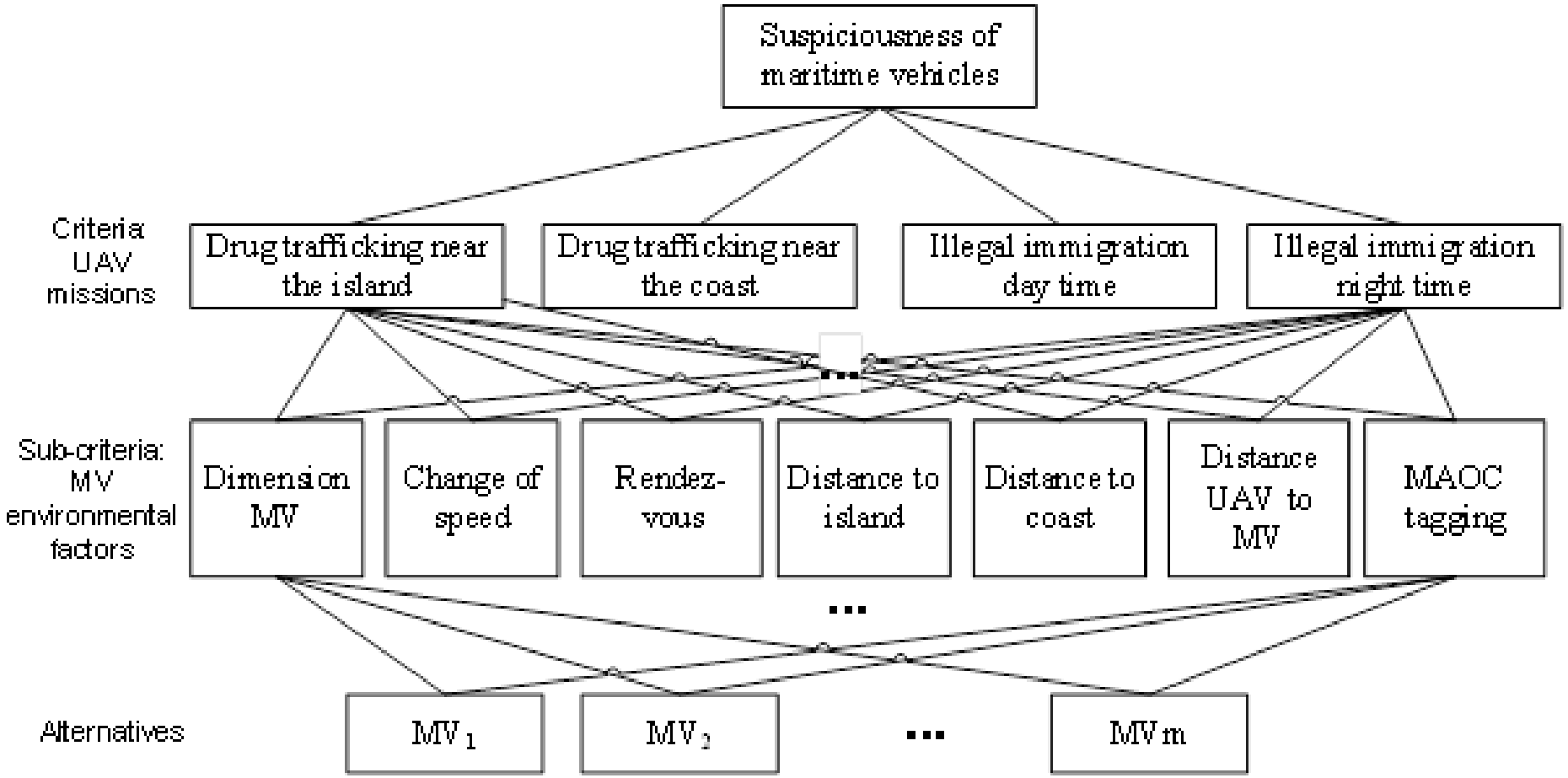
Autonomy algorithm



Autonomous navigation based on suspiciousness



Mission – Envir. factors modelling



Mission priorities

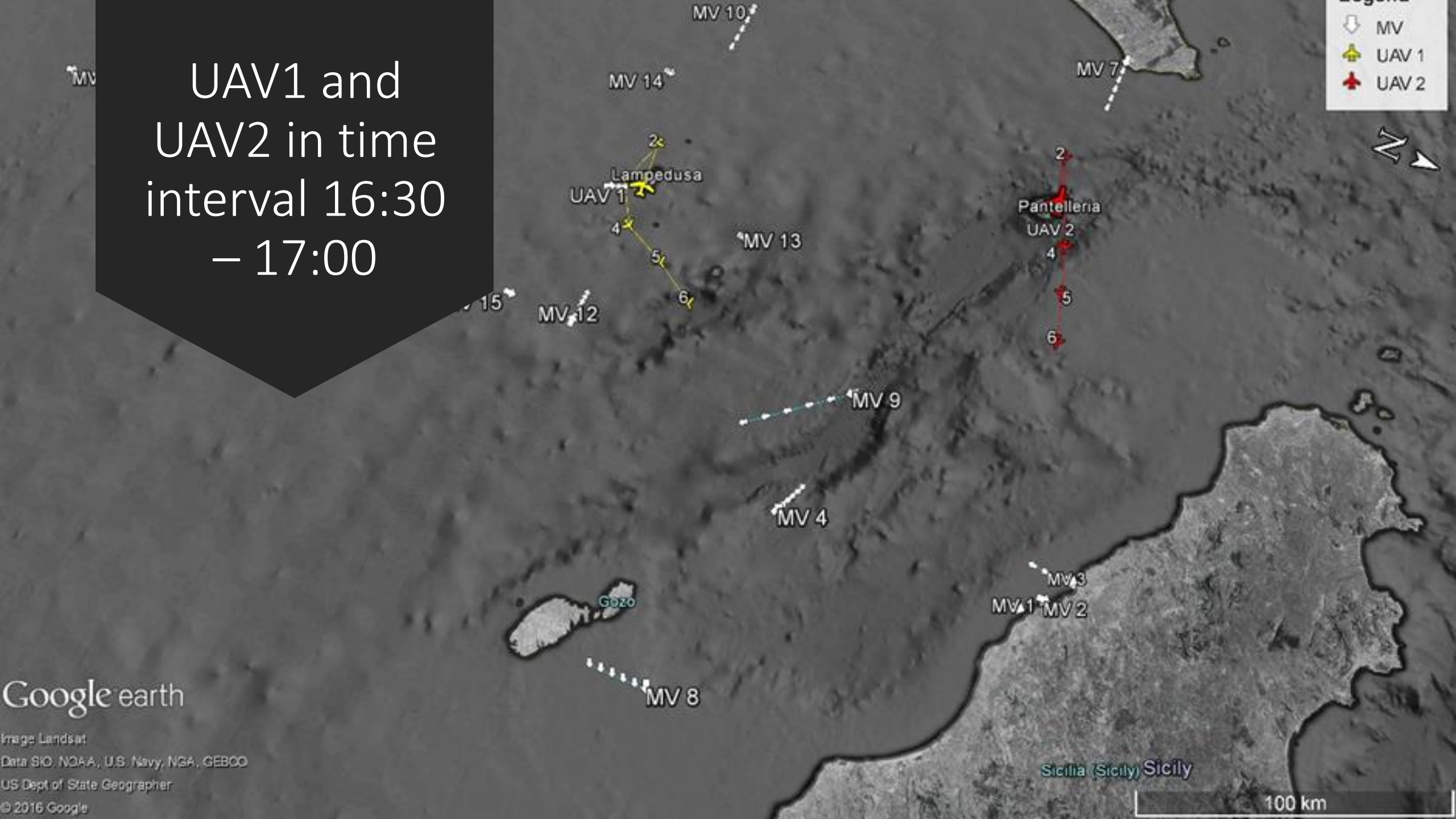
Priorities	UAV_1	UAV_2
Drug trafficking near the island	0.1307	0.1249
Drug trafficking near the coast	0.0488	0.6925
Illegal immigration during the day	0.2259	0.0995
Illegal immigration during the night	0.5946	0.0831
Consistency ratio	0.043	0.0001

Target criteria weights

Criteria	Drug coast	Drug sea	Immigration day	Immigration night
Dimension	0.171	0.103	0.092	0.165
Change of Speed	0.039	0.023	0.031	0.144
Rendezvous	0.040	0.321	0.025	0.020
Distance to island	0.034	0.020	0.155	0.063
Distance to coast	0.319	0.033	0.150	0.221
Distance UAV to MV	0.034	0.166	0.030	0.083
MAOC tagging	0.426	0.334	0.518	0.304
Consistency Ratio (CR)	0.06	0.09	0.07	0.09

Overall suspiciousness criteria

	Criteria	***UAV₁***	***UAV₂***
C_1	Dimension	0.139	0.111
C_2	Change of Speed	0.104	0.047
C_3	Rendezvous	0.062	0.079
C_4	Distance to island	0.069	0.044
C_5	Distance to coast	0.184	0.252
C_6	Distance UAV to MV	0.084	0.059
C_7	MAOC tagging	0.358	0.408


UAV1 and UAV2 in time interval 16:30 – 17:00
MV 10
MV 14
MV 7
Lampedusa
UAV 1
Pantelleria
UAV 2
MV 13
MV 12
MV 9
MV 4
MV 3
MV 1
MV 2
Gozo
MV 8
Sicilia (Sicily)
Sicily
100 km
Google earth
Image Landsat
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
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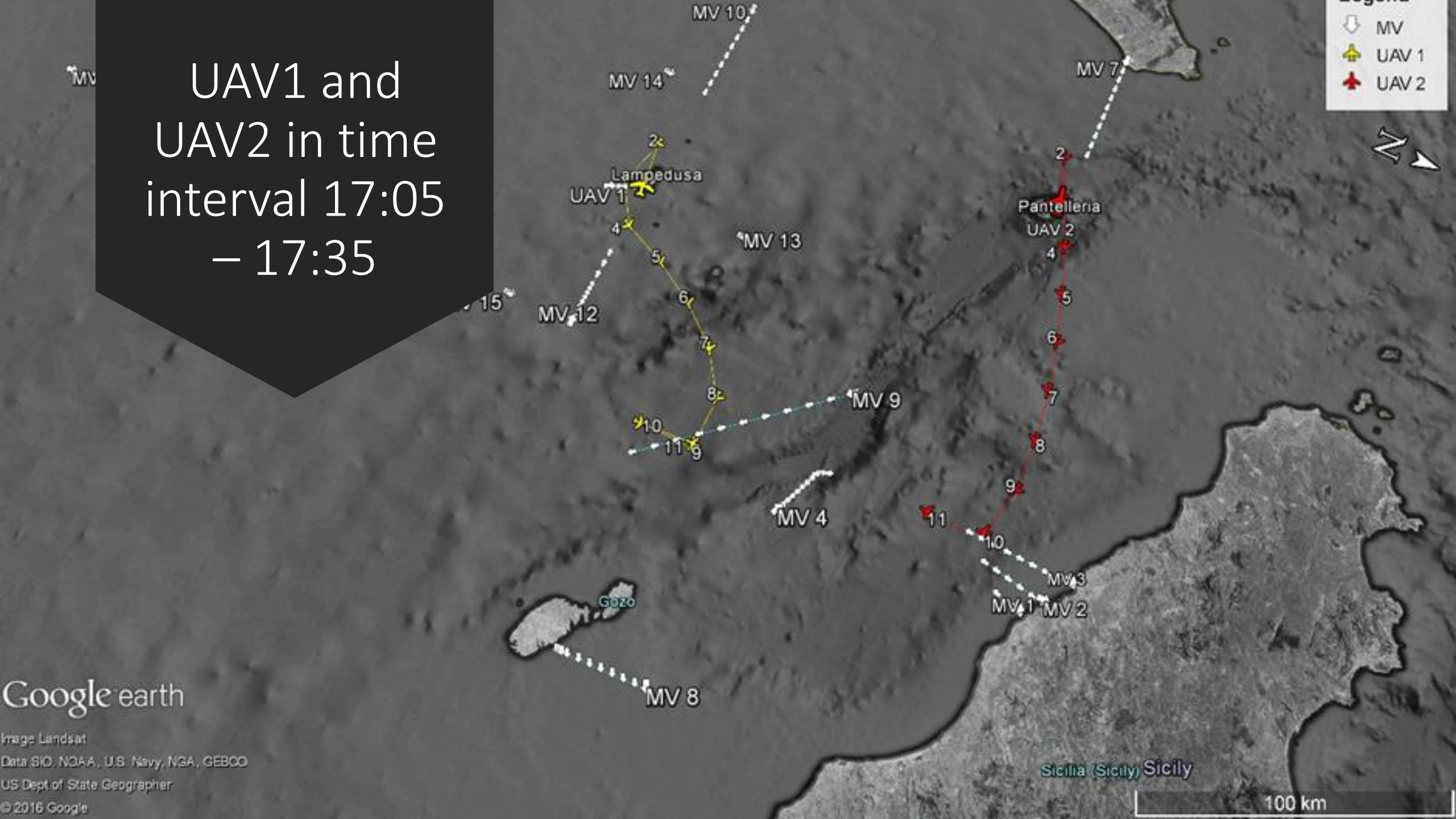
UAV1 and UAV2 in time interval 17:05 – 17:35
MV 10
MV 14
MV 7
Lampedusa
UAV 1
Pantelleria
UAV 2
MV 13
MV 12
MV 9
MV 4
MV 3
MV 1
MV 2
MV 8
Gozo
Sicily
Legend
MV
UAV 1
UAV 2
Google earth
Image Landsat
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
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100 km

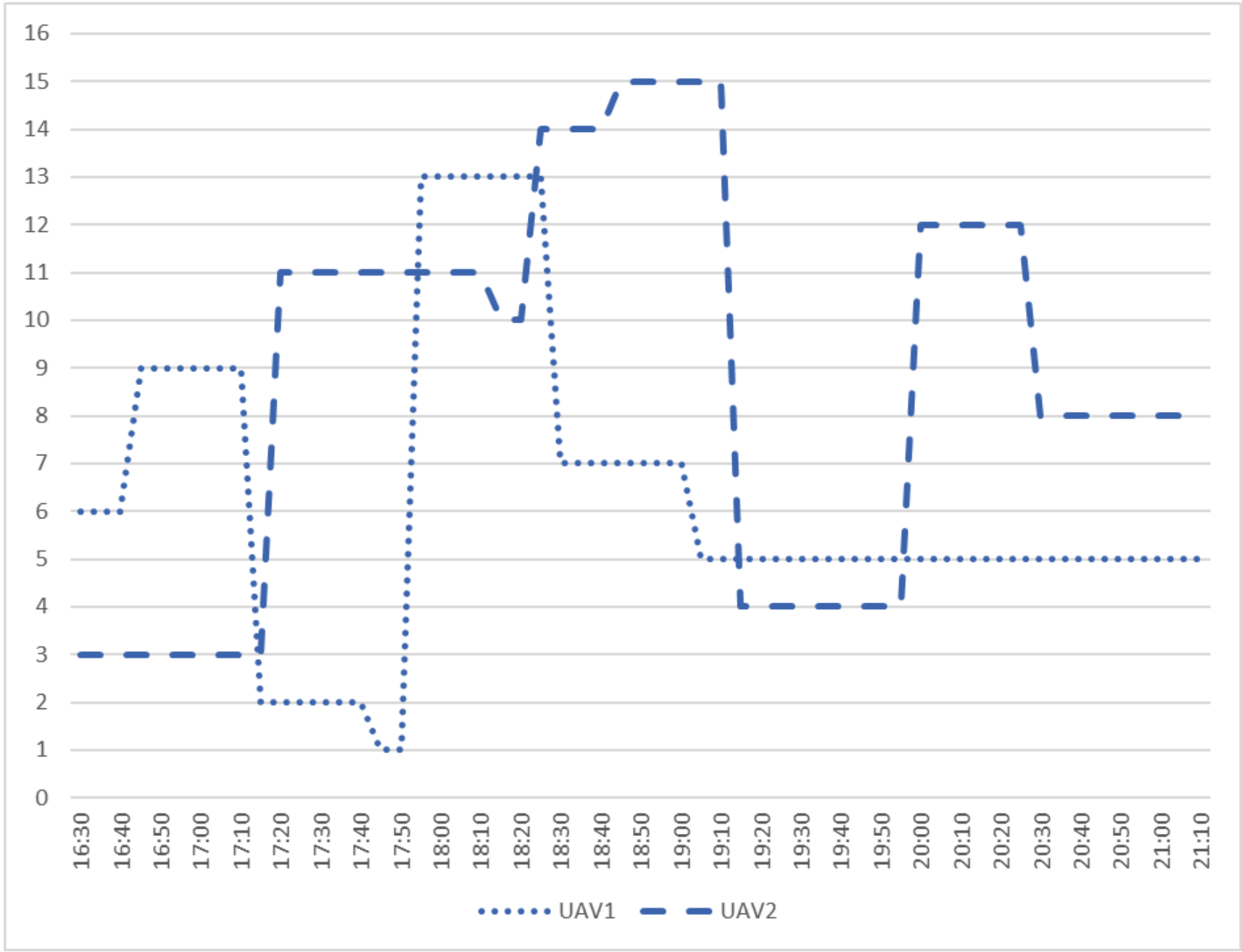
UAV 1: 16:30

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	
Min/Max	**MIN**	**MAX**	**MIN**	**MAX**	**MAX**	**MIN**	**MAX**	
Pref. fn	Linear	Linear	Linear	Linear	Linear	Linear	Linear	
Preference	20	0.001	20	1	1	40	1	
Indifference	8	0	2	0	0	10	0	
Inflection	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
Weight	**0.139**	**0.104**	**0.062**	**0.069**	**0.184**	**0.084**	**0.358**	***MV***
								Ranking
MV 1	12	0	9.043	0.691	0.685	207.041	1	0.008
MV 2	8	0	9.043	0.973	0.551	210.297	1	0.023
MV 3	20	0	11.64	0.985	0.908	212.091	1	0.122
MV 4	60	0	46.416	0.919	0.843	135.964	1	-0.236
MV 5	12	0	108.862	0.805	0.914	131.736	1	0.017
MV 6	**8**	**0**	**55.751**	**0.707**	**0.941**	**12.785**	**1**	**0.323**
MV 7	20	0	151.582	0.704	0.577	201.144	1	-0.329
MV 8	60	0	78.064	0.661	0.768	188.331	1	-0.485
MV 9	12	0	46.416	0.675	0.818	114.486	1	0.082
MV 10	8	0	46.231	0.977	0.95	95.321	1	0.260
MV 11	20	0	108.862	0.974	0.729	240.577	1	-0.251
MV 12	60	0	25.359	0.959	0.819	61.459	1	-0.032
MV 13	12	0	55.751	0.728	0.772	44.697	1	0.164
MV 14	8	0	46.231	0.66	0.806	53.966	1	0.214
MV 15	20	0	25.359	0.678	0.579	66.141	1	0.12

UAV 1: 16:45

	C1	C_2	C_3	C_4	C_5	C_6	C_7	
Min/Max	**MIN**	**MAX**	**MIN**	**MAX**	**MAX**	**MIN**	**MAX**	
Pref. fn	Linear	Linear	Linear	Linear	Linear	Linear	Linear	
Preference	20	0.001	20	1	1	40	1	
Indifference	8	0	2	0	0	10	0	
Inflection	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
Weight	**0.139**	**0.104**	**0.062**	**0.069**	**0.184**	**0.084**	**0.358**	***MV Ranking***
MV_1	12	0	9.043	0.691	0.685	197.567	1	-0.085
MV_2	8	0	9.043	0.973	0.551	201.404	1	-0.073
MV_3	20	0.037	11.01	0.977	0.578	195.009	1	0.073
MV_4	60	0.041	30.397	0.939	0.657	122.15	1	-0.129
MV_5	12	0	74.324	0.825	0.856	137.187	1	-0.072
MV_7	20	0	150.365	0.899	0.638	200.435	1	-0.361
MV_8	60	0	86.26	0.994	0.659	167.196	1	-0.554
MV_9	**12**	**0.045**	**30.397**	**0.663**	**0.829**	**95.352**	**1**	**0.324**
MV_{10}	8	0	36.624	0.975	0.699	101.887	1	0.059
MV_{11}	20	3.022	74.324	0.966	0.961	211.033	1	0.143
MV_{12}	60	0	26.623	0.949	0.821	37.293	1	-0.120
MV_{13}	12	0	47.851	0.728	0.77	43.98	1	0.086
MV_{14}	8	0	36.624	0.661	0.806	71.302	1	0.110
MV_{15}	20	0	26.623	0.678	0.579	52.574	1	0.024

Investigation of 15 MVs by 2 UAVs



Time dependent autonomous / swarm autonomous systems

- The swarm autonomous simulation for a multicriteria (investigate and forget) system, can be seen on:
- https://www.youtube.com/watch?v=WBrX-iQ9Uao
- For a single autonomous simulation for a multicriteria (only investigate):
- https://www.youtube.com/watch?v=AS4_8Ej0otc
- An independent autonomous simulation for a multicriteria (only investigate) with mathematical programming:
- https://www.youtube.com/watch?v=OUlg24xKsXI
- The swarm autonomous simulation for a single criterion as minimum distance of UAV to MV (investigate and forget) system, can be seen on:
- https://www.youtube.com/watch?v=QDSFMPYZdsc
- An independent autonomous simulation for a single criterion as minimum distance of UAV to MV (only investigate):
- https://www.youtube.com/watch?v=g9nVJTFwnx8
- An independent autonomous simulation for a single criterion as minimum distance of UAV to MV (only investigate) with mathematical programming:
- https://www.youtube.com/watch?v=tD_EjGqe93w


10/4/2012 12:55 am
Tunisia
Gulf of Tunis
Skerki Bank
Nabeul
Gulf of Hammamet
Sfax
MV 7
Sfax
Gulf of Gabes
Drepano Seamount
Medenine
MV 10
UAV 2
Pantelleria Shoal
Ustica Trough
Charles Quint
MV 14
Pantelleria Trough
Palermo
MV 13
Pinne Marine Patch
UAV 1
MV 6
MV 9
MV 3
MV 2
Eolo Seamount
MV 1
Sicily
MV 5
MV 12
MV 15
MV 4
Sicilia (Sicily)
Isola Lipari
MV 11
Tripoli
Tripolitanian Valley
Gozo
Malta
MV 8
Catania
Messina
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Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Malta Rise
Google Earth
Imagery Date: 12/14/2015 36°09'58.19" N 12°35'14.86" E elev -683 m eye alt 685.30 km


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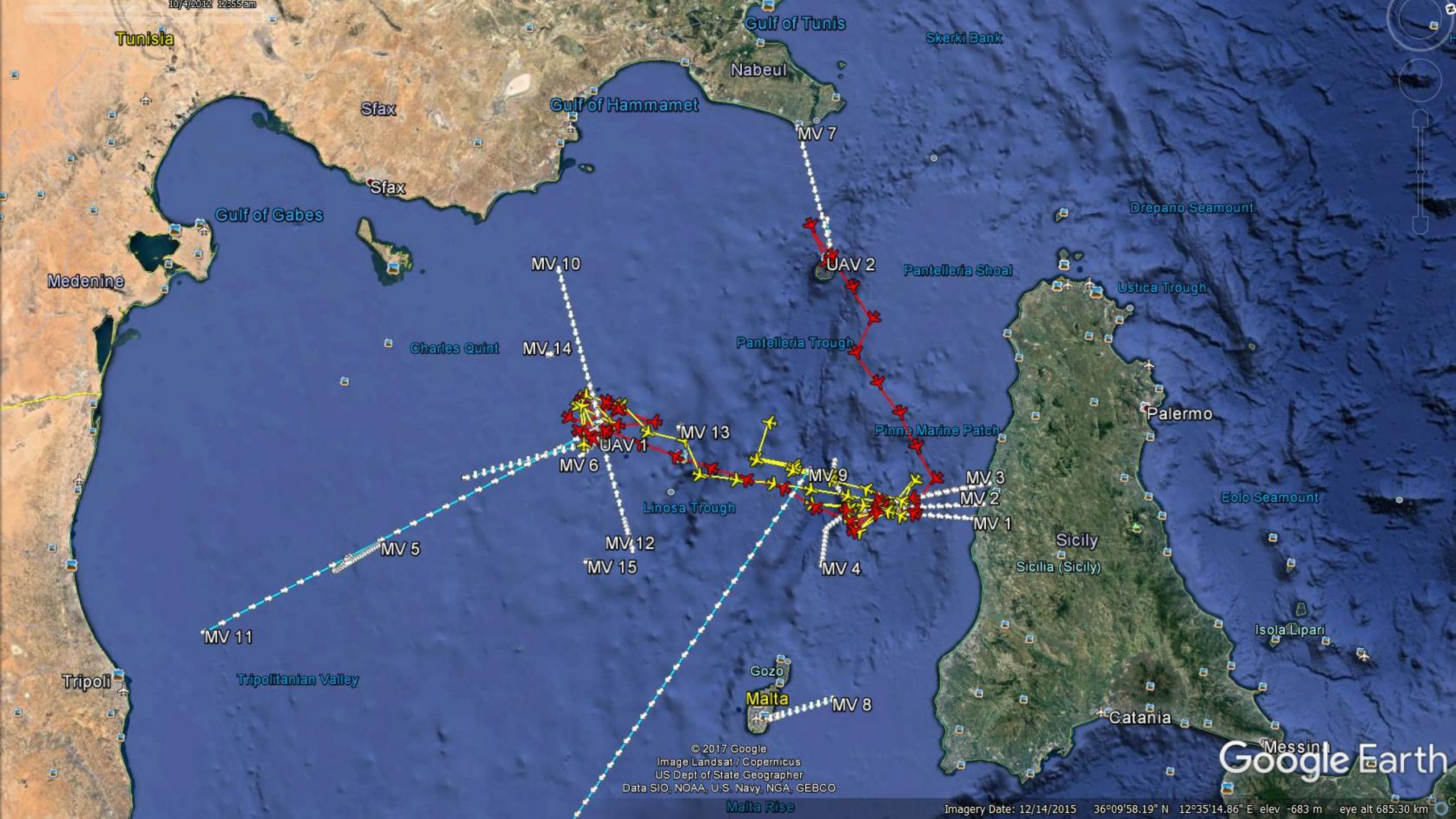
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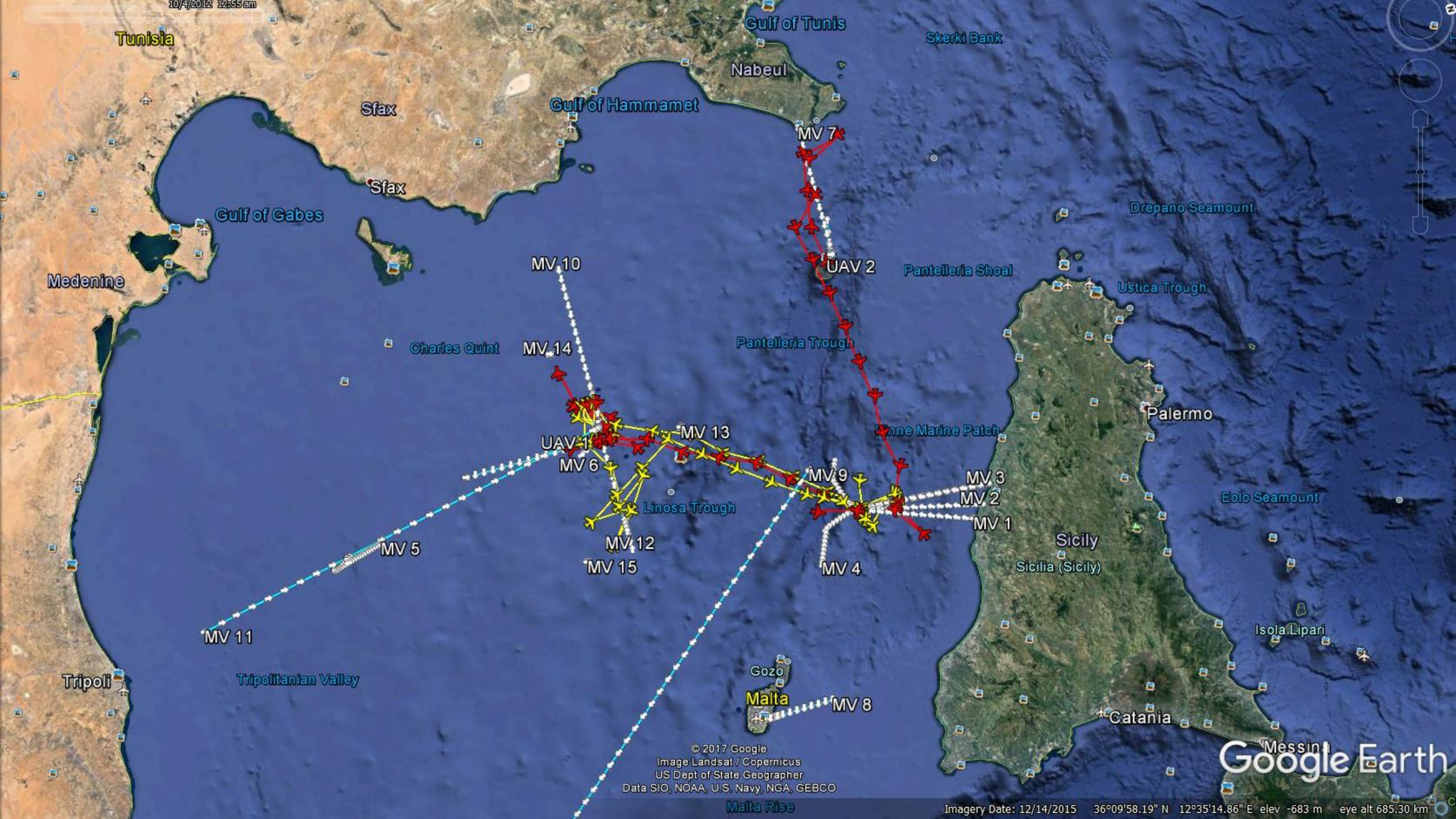
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Applications

- Hazardous scene assessment
- Last mile resupply
- Aviation security

Questions?