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LTA-UAV: The Future of Disaster Response and Surveillance

Shattri MANSOR, Ahmad Salahuddin Mohd Harithuddin, Syaril Azrad Md Ali, Bahareh Kalantar, Azman Abd Ghani

Presentation Outline

Background and why UAV

Object Tracking

LAT-UAV

Surveillance phase and service description

Future

The rational behind drone (in border surveillance)

Smuggle diesel at Malaysia Thai border

Thai authorities in the border towns have detected a rise in the smuggling of petrol and diesel from Malaysia following a sharp increase in domestic fuel prices in Thailand.

Ops Titik berjaya tangani penyelewengan diesel

KUALA PILAH – Menteri Perdagangan Dalam Negeri, Koperasi dan Kepenggunaan, Datuk Seri Hasan Malek (**gambar**) menegaskan Ops Titik yang dilaksanakan bagi menangani penyelewengan diesel mula membuahkan hasil dengan 151 kes dicatat membabitkan sitaan bernilai RM8.05 juta sejak dilancar pada 15 Mei lalu.

Katanya, operasi bersepadu itu menyasarkan semua pihak, bukan setakat individu tertentu tetapi juga syarikat dan kawasan panas yang dikenal pasti menerusi risikan.

"Semalam sahaja, dua kes dilapor di Selangor dengan nilai sitaan berjumlah RM116,006, manakala pada Jumaat lalu sebanyak lapan kes iaitu empat di Kelantan, dua di Negeri Sembilan dan satu kes masing-masing di Sabah dan Sarawak dengan nilai sitaan RM186,560," katanya kepada pemberita di sini semalam.

Menurut Hasan sepanjang Ops Titik, Johor dan Putrajaya mencatatkan kes tertinggi iaitu enam kes, namun dari segi nilai sitaan, Johor mencatat jumlah tertinggi dengan jumlah RM2.166 juta, manakala Putrajaya RM1.592 juta.

Selain itu, beliau berkata, dang menambah baik perun-tukan undang-undang sedia

Border Surveillance

- Some months ago, Malaysia found ‘migrant’ mass graves near

The several mass graves thought to contain bodies of migrants have been found in Malaysia, the graves were found in 17 abandoned trafficking camps near the Thai border. Every year thousands of people are trafficked through Thailand into Malaysia.

NEW STRAITS TIMES ONLINE

Human trafficking: Kg Puyu, Satun believed to be main entry point

SATUN (Thailand) : Kampung Puyu here or known as Kampung Puju by Malaysians is believed to be one of the main entry points for human trafficking syndicates bringing Rohingya and Bangladeshi immigrants into the country.

This village is located next to Kampung Syed Omar and Bukit Bintang in Perlis and separated by the dense forest at Gunung Perlis, which is also along the Malaysia-Thailand border.

The Muslim majority village can only be accessed by sea, a one-and-a-half hour journey from Kuala Perlis, Malaysia and 30 minutes from the Tammalang jetty in Satun.

Bernama learnt that the village is believed to have been used as the first location to house victims of human trafficking syndicates right after boats carrying refugees reached the Andaman Sea shore on the Thai side.

The route starts from Kawthaung (Myanmar) to Ranong (Thailand)-Phuket-Phang Nga-Krabi-Trang to the final destination at Satun before the migrants are smuggled into Malaysia.

Many people are wondering how the Rohingya refugees and Bangladeshi immigrants are able to enter Malaysia and where they were housed before being 'sold' in the black market.

The writers met a tour guide in Satun who only wanted to be known as Lan to find the answer. However, he asked us to pose as university students to avoid untoward incidents.

Lan, who agreed to take us to the hot spots for human trafficking boats to transit, said Kampung Puyu, although bordered by the dense forest, it was still considered as a strategic location because it has many small villages as well as rat trails to enter Malaysia.

Cuba masuk melalui sempadan Malaysia-Thailand selepas naik bot dari Ankara

PGA tahan 62 pendatang Turki

Oleh MEGAT LUTFI MEGAT RAHIM

PADANG BESAR - Keinginan untuk menikmati hidup senang dengan gaji lumayan seperti diceritakan rakan-rakan yang telah menetap di Malaysia menjadi punca 62 warga Turki bertekad menyelinap masuk ke negara ini secara haram melalui sempadan Thailand semalam.

Bagaimanapun kesemua mereka termasuk 24 orang kanak-kanak ditahan anggota Pasukan Gerakan Am (PGA) yang menjalankan rondaan rutin berdekatan pagar sempadan Malaysia-Thailand di Pos Padang Besar 16 dan 17 di sini pada pukul 6 pagi.

Penolong Pegawai Pemerintah Batalion Tiga PGA Bidor, Deputi Superintendan S. Sivam berkata, kehadiran PATI terbabit disedari anggota PGA yang berkawal di pos berkenaan yang terlibat pemerakan manusia.

"Semasa ditemui, mereka dalam keadaan keletihan dan kelaparan kerana berjalan kaki dari Thailand ke sempadan di sini. Hasil pemeriksaan mendapati mereka tidak memiliki sebarang dokumen perjalanan yang sah.

"Mereka mendakwa menaiki bot dari Ankara, Turki ke Thailand dan menetap selama dua hari di negara tersebut sebelum cuba masuk ke negara ini pagi ini (semalam)," katanya ketika ditemui di Kem PGA Padang Besar di sini semalam.

Jarak di antara Ankara, Turki ke Padang Besar di sini adalah kira-kira 10,650 kilometer.

Katanya, warga Turki terbabit terdiri daripada 23 lelaki dan 15 wanita berumur antara 19 hingga 40 tahun manakala 24 kanak-kanak yang ditahan pula berusia lima bulan hingga 11 tahun.

Jelas Sivam, salah seorang daripada warga Turki terbabit yang boleh berbahasa Inggeris, Abdullah Zaid, 20, memberitahu, mereka merupakan anggota keluarga, suami dan isteri serta kenalan rapat.

"Abdullah memberitahu sahabat-sahabat mereka di sini memaklumkan kehidupan di Malaysia sangat aman dan makmur tanpa komlik peperangan selain mudah mendapatkan pekerjaan yang dibayar gaji lumayan.

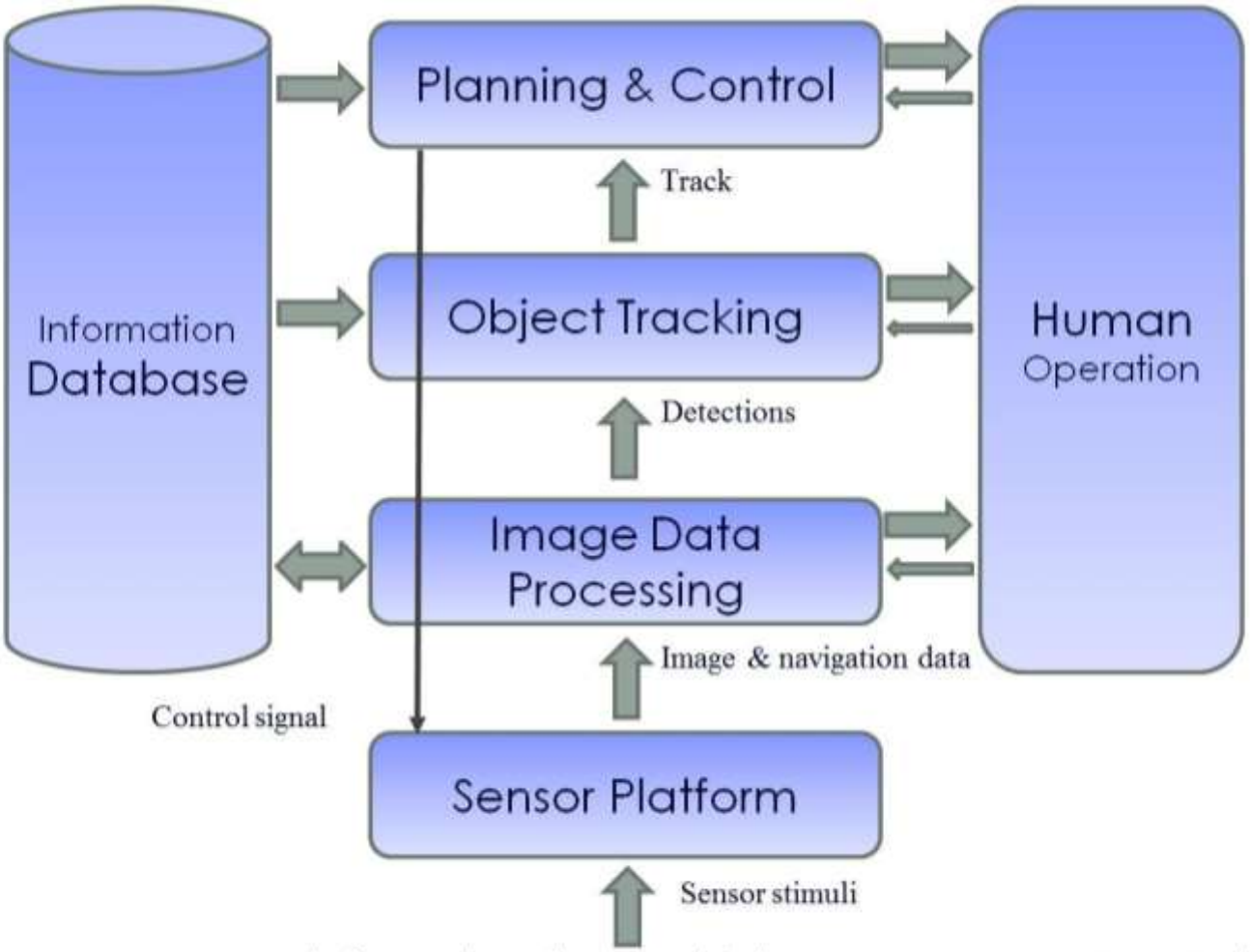
"Oleh kerana itu, mereka bertekad mengambil risiko dengan cuba memasuki negara ini secara haram. Kita turut menemui wang tunai berupa dolar Amerika Syarikat sebanyak AS$6,500 (RM20,659.58) daripada mereka," katanya.

Katanya, kesemua mereka telah dibawa ke Depoh Tahanan PATI di Kangar dan kes disiasat mengikut Seksyen 6(1)(c) Akta Imigresen 1959/63.

SIVAM (kanan) memeriksa dokumen perjalanan 62 rakyat Turki yang ditahan di sempadan Malaysia-Thailand, Padang Besar, Perlis semalam.

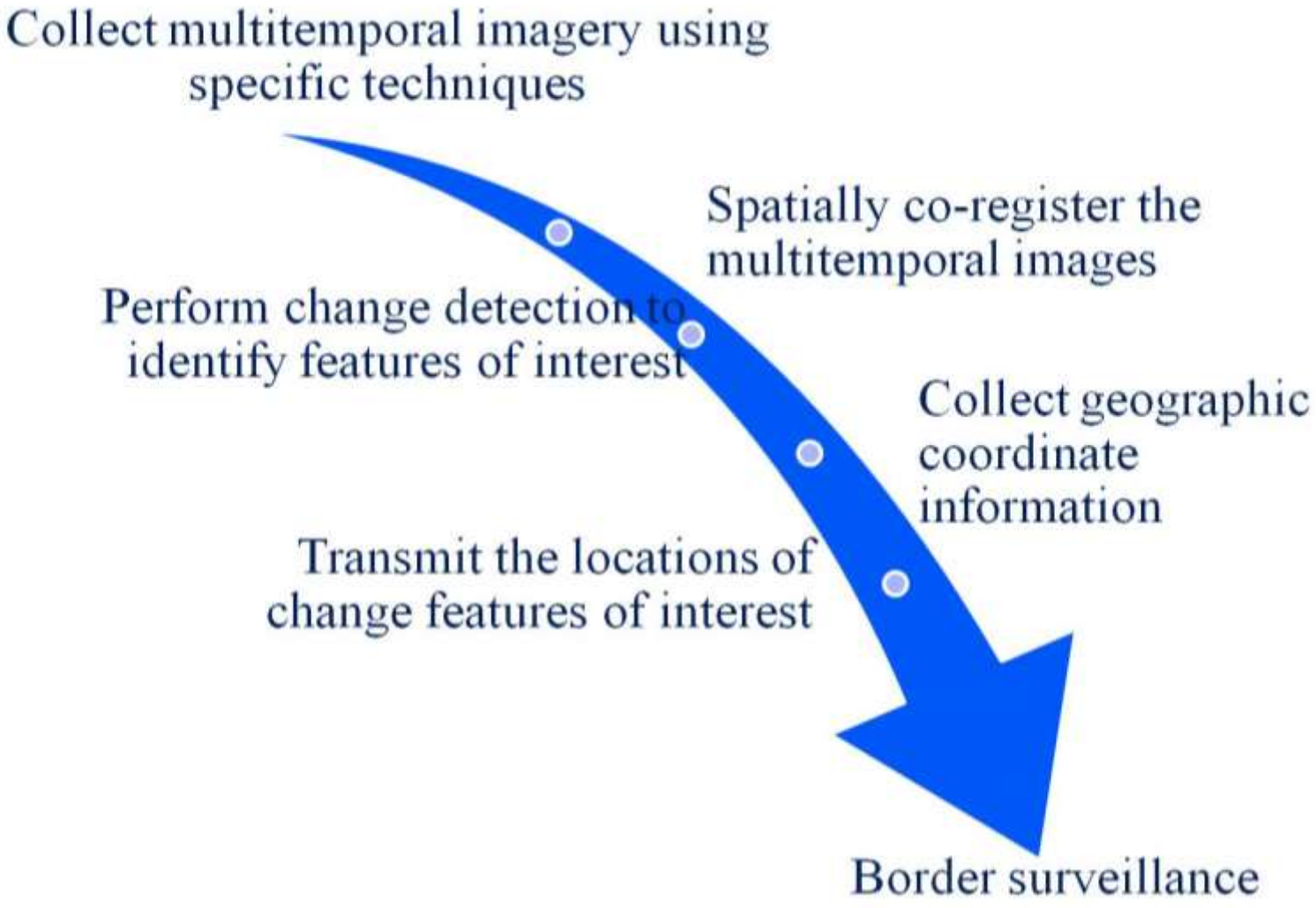
Why do we need an Malaysia Costal Patrol & Border Surveillance system?

Border Surveillance Framework



Thick arrows represent sensor or information data, and thin arrows represent control signals.

Five basic steps for Border Surveillance



Surveillance phases and service description

- Depending on the area (maritime/land) the surveillance activities can be grouped in distinct progressive phases based on the following three levels:

	Strategic level	Operational level	Tactical level
What is it	Pertaining to the planning of sequences of operations, the resources needed for the operations, and the collection and analysis of information needed to make that planning.	Pertaining to the planning and running of operations. An operation is a sequence of actions in a pre- planned framework of assets, personnel and time.	Pertaining to executing the elements of an operation, choosing the elementary actions and reactions in (almost) real time – or as close to real time as possible.
Typical timescale for planning ahead	Months to years	Weeks to months	Hours to days

Surveillance phases and service description

	Strategic level	Operational level	Tactical level
Shortest timescale to change plans	Weeks. E.g., decision to start collecting information from a certain area.	Days. E.g., the decision to call off a planned operation, or to substitute one available asset by another.	Seconds (immediate). E.g., decision to apprehend persons, or save people from a boat in immediate danger.
Maximum allowed delay of information	A month. E.g. statistics of arrivals and analysis of methods used by illegal immigrants.	Days. E.g. information on the appearance of new tracks in the land border region, or information on boat arrivals in a new area.	Fraction of an hour. E.g. information about last sighting of a truck or a group of people, or locations of unknown boats.
Radius of interest	Semi-global	Region / basin	< several 10 km

The same products may be used in each level, but in a different way. The level is primarily a property of the service, not of the product.

Land Phases

Phase 1 Strategic Level	Phase 2 Strategic/ Operational level	Phase 3 Operational/ tactical level
Static – reference maps (prerequisite for Phase 2)	Low-time critical – background changes	Punctual monitoring – volume/flux of actual crossings

Land Surveillance- Phase 1 & 2

a) This service include following functionalities:

- Obtain a reference situational picture on the topography, transport infrastructure, routes, hubs/nexus points, stopovers etc.

- Conduct change analysis by comparison to the reference picture on a regular basis to detect any changes;

- Detect or verify the routes potentially used by illegal migrants and smugglers of contraband and to adapt border control measures (patrols, deployment of surveillance infrastructure) accordingly;

- Gather further information expanding on intelligence (e.g. on gathering points; in situation of urgent and exceptional pressure at certain external land border sections as result of a political crisis, natural catastrophes);

Land Surveillance- Phase 1 & 2

b) Requirements:

Static:

- Enable mapping of terrain, including topography, land cover, buildings, roads, tracks, demarcations, etc., by virtue of adequate spatial resolution (horizontal and vertical), spectral power, etc.;
- Product must be ortho-rectified and terrain geo-coded, which implies that also a DEM at the proper resolution must be available;
- Geographic features should be in vector form in order to facilitate their automatic identification, selection and query;
- Data must be in such a form that they can be combined with existing maps used by the authorities (projection, datum, format, standards).

Indicative Performance Requirements

Attribute	Optical	Radar	Remarks
Resolution	50 cm – 5 m	1 m – 50 m	Higher resolutions are classified. Lower resolutions are not used for surveillance.
Image Size	For the highest resolution, 10 x 10 km. For lower resolutions, up to 60 x 60 km.	For the highest resolution, 10x10 km. For lower resolutions, up to 400x400 km.	The higher the resolution, the smaller the image.
Tasking Time	Normal: 12h to days before overpass. Fast: asap to 12h before overpass.	Normal: several days ahead. Fast: 6 to 24 h ahead	Precise times vary per satellite operator. Orders at short notice are (much) more expensive.

Indicative Performance Requirements

Attribute	Optical	Radar	Remarks
Delivery Time (after image acquisition)	Normal: 1 day. Fast: few hours	Normal: up to 1 day. Fast: up to 30 min	Precise times vary per satellite operator. Very fast times can be obtained only for a few images, not for all. VHR data may be intentionally delayed on national security laws. Faster delivery is more expensive.
Processing and analysis time	Over land: Fast analysis: 1-3 hr. Full analysis: 1 day. Ship detection at sea: Fast analysis: 1 hr. Full analysis: 6 hr.	Over land: Fast analysis: 1-3 hr. Full analysis: 1 day. Ship detection at sea: Fast analysis: 30 min. Full analysis: 1h – 1h30 min.	The time depends on the area of interest within the image that needs to be analysed, the density of objects, the exact nature of the analysis, etc.

Static Reference Data

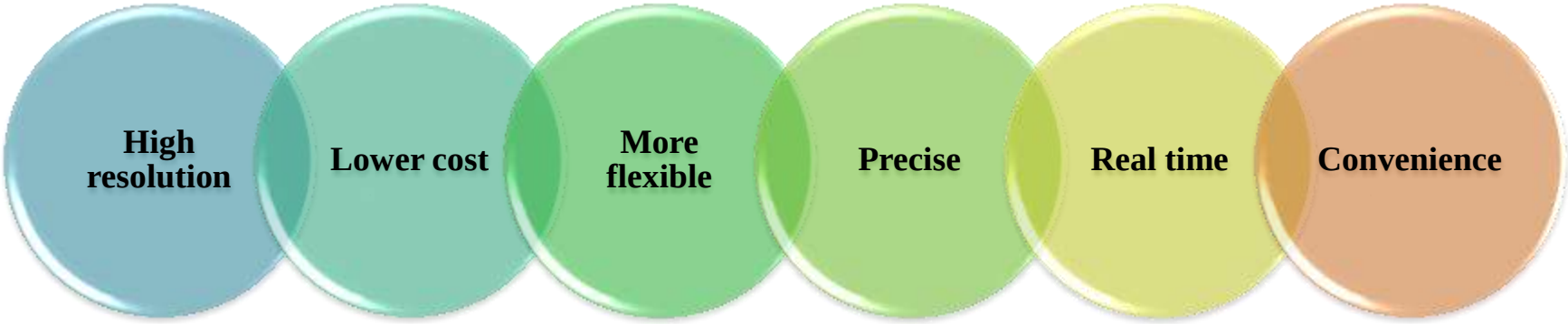
1. Satellite imagery (ortho-rectified and ortho-photo datasets)
2. Land-use datasets at medium (1:25 000) scale
3. Topographic Map at medium (1:25 000) scale
4. Digital Elevation Model (DEM)
5. Nautical Charts
6. Weather data
7. Reference Maps (geo-coded databases)

- Geo-referenced demographic profiles of populations,
- Geo-referenced database of socio-economic variables (databases containing information on migration push or pull factors such as unemployment, poverty, health, economic development,
- Geo-referenced database of population ethnicities/languages/religion etc.,
- Geo-referenced information on illicit activities (hotspots), smuggling routes and human-terrain analysis (including administrative info/jurisdictions).

Optical Satellites

Satellites	Spatial resolution (after pan-sharpening)	Frequency	Equator Crossing Time
Worldview-4	0.31 m	< 1.0 day	10.30 am
Worldview-3	0.31 m	<1.0 day	10.30 am
Worldview-2	0.46 m	1.1 days	10.30 am
Worldview-1	0.46 m	1.7 days	10:30 am
GeoEye-1	0.46 m	2.1 days	10:30 am
Pleiades-1A	0.5 m	Daily	10.30 am
KOMPSAT-3A	0.55 m	Daily	10.30 am
KOMPSAT-3	0.7 m		10.30 am
QuickBird	0.65 m	1-3.5 days	10:30 am
Gaofen-2	0.8 m		10.30 am
TripleSat	0.8 m	daily	10:30 am local time
IKONOS	0.82 m	3 days	10:30 am solar time
SkySat-1	0.9 m		10.30 am
SkySat-2	0.9 m		10.30 am
SPOT-6	1.5 m		10.30 am
SPOT-7	1.5 m		10.30 am
Other Satellites	2 m-20 m		

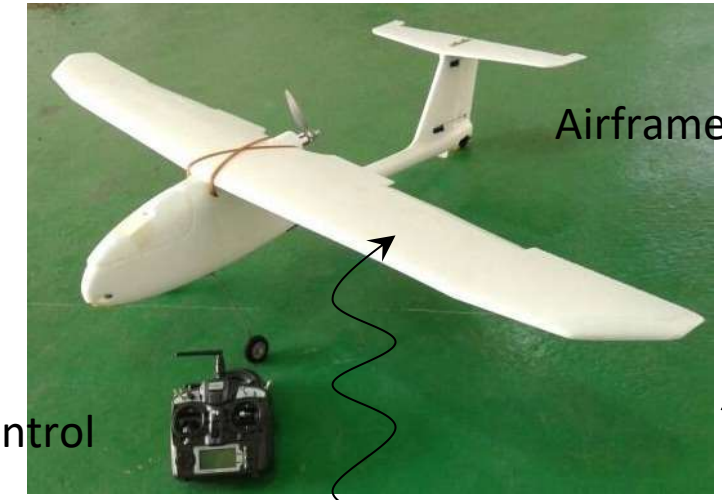
UAV for filling the Gap



The rationale behind drones (in border surveillance)

- Costs: cheaper (?), calculated per h/flight (?)
- Autonomy (or remoteness) > rationalizing human resources
- High endurance (Nomad: > 10 h)
- Information/intelligence (ISTAR: intelligence, surveillance, target acquisition, reconnaissance)
- Increased surveillance > situational awareness > humanitarian
- Dimension: saving human lives at sea (political discourse, Commission)

UAS- Platform 1: Fixed Wing System



Airframe / Autopilot

Camera

Radio Control

Telemetry system

Ground Control

Post Processing

Platform 2: Multirotor System

Radio Control

Airframe / Autopilot

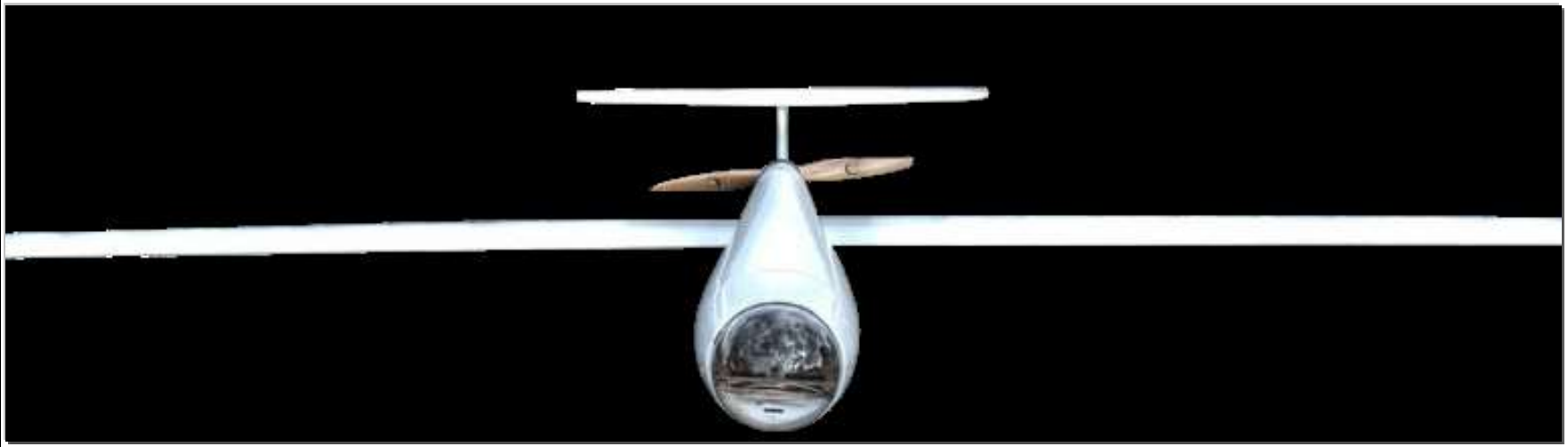
Camera

Telemetry system

Ground Control

Post Processing

Platform 3: (NOMAD-X)



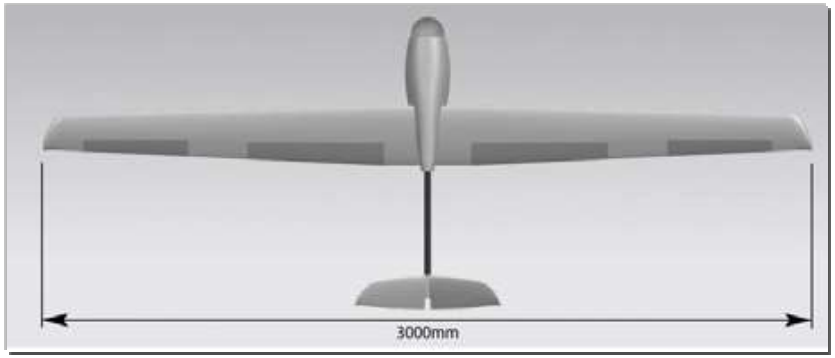
NOMAD-X is a complete airborne multi-mission unmanned aircraft measuring 3 metres tip to tip. Designed with a large internal bay enabling it to carry up to 6 kg of payload. Having an extended endurance of 4 hours makes this UAV unmatched in its class.

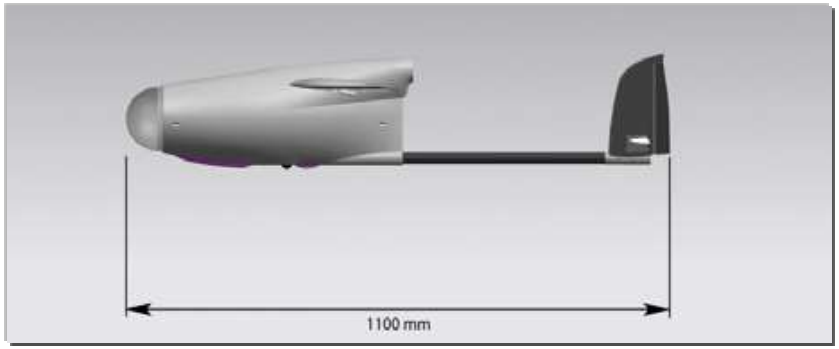
NOMAD-X

- The unique design of the NOMAD-X allows for fast setup and mission start in the field. Coupled with a generous payload carrying capacity, extended endurance and reliability makes this system truly a multi-mission UAS.
- Take-off is easily accomplished by hand or catapult launcher. Landing is autonomous and can be a belly landing or flown into an erected landing net for use in confined areas.

NOMAD-X

Platform Characteristics:





Airframe material : Composite (CF/FG)
Propulsion: Electric
Maximum take off weight: 8 kg
Empty weight: 2 kg
Wingspan: 3000 mm
Fuselage length: 1100 mm
Cruise speed: 15 m/s (29 kts)
Dash speed: 34 m/s (66 kts)
Maximum wind penetration: 18 m/s (35 kts)
Command & Control range: 40 km (900 Mhz)
Data-link range : 20 km (1.3Ghz)
Long range communications : 3G / 4G / LTE / IRIDIUM

Platform 4: Lighter-than-Air Unmanned Aerial Vehicle (LTA-UAV)

Refers to aerial vehicle that

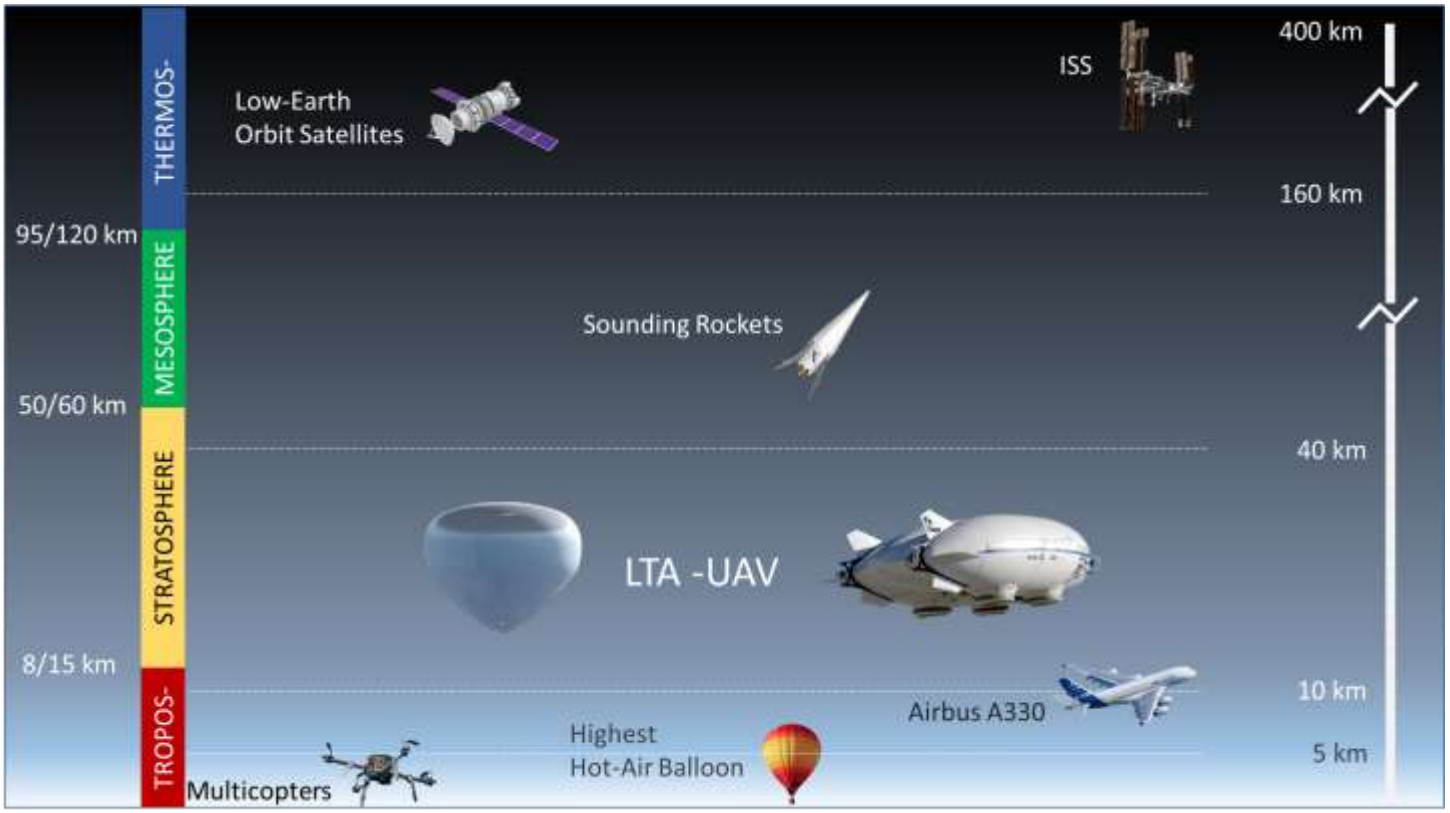
- Generates all or a fraction of its lift using gases e.g. helium or hydrogen
- Operates without pilot, either under remote control or full-autonomously by an onboard computer
- Examples: airship, hybrid airship, high-altitude balloon

Potentials of LTA-UAV

- Maneuver and remain in a desired geographic location for days/weeks ("**station-keeping**")
- Operates in **higher altitudes** (10-40 km)
- Provide surveillance over **large areas**
- A fraction of the cost of a **satellite**

A platform for **persistent**, **hi-resolution**, **local- to regional-scale** observation

LTA-UAV Operating Altitude Capability



Station-Keeping and High-Altitude Observation Free-floating Balloon vs HTA (Glider) vs LTA

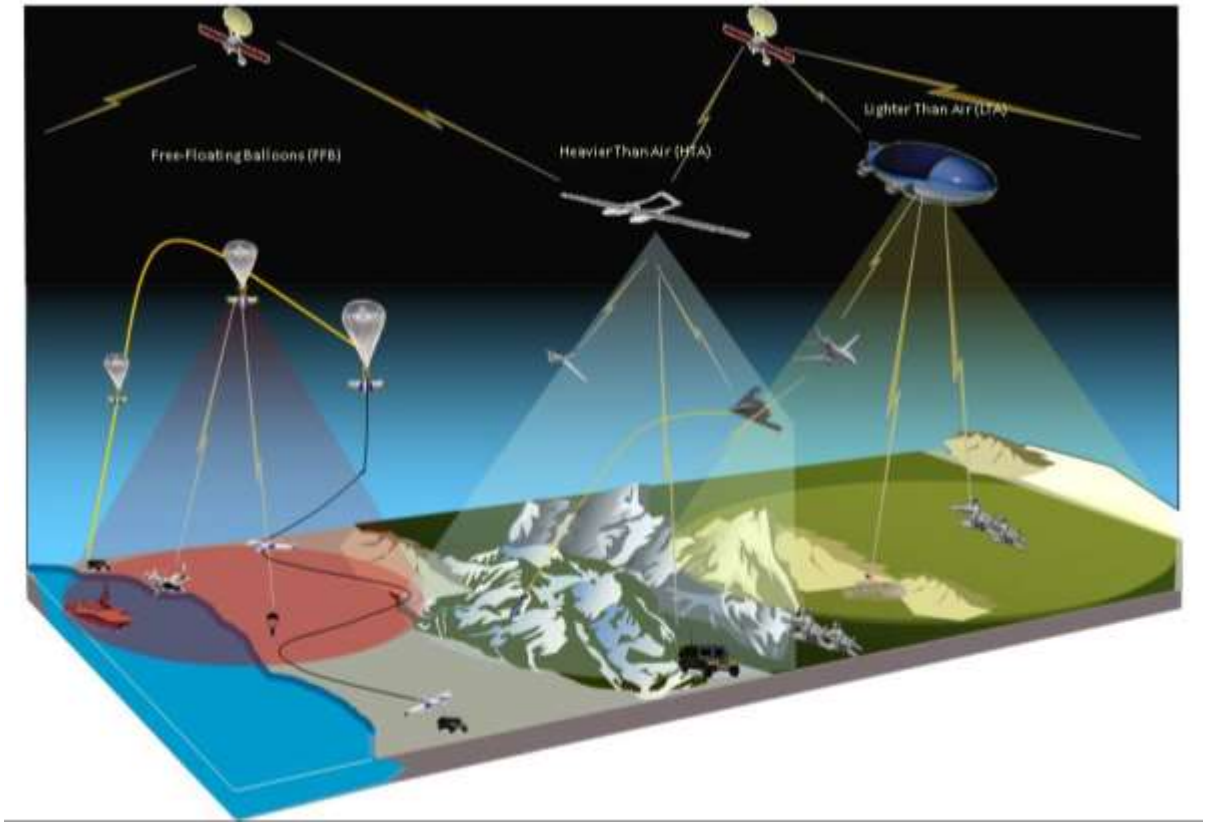
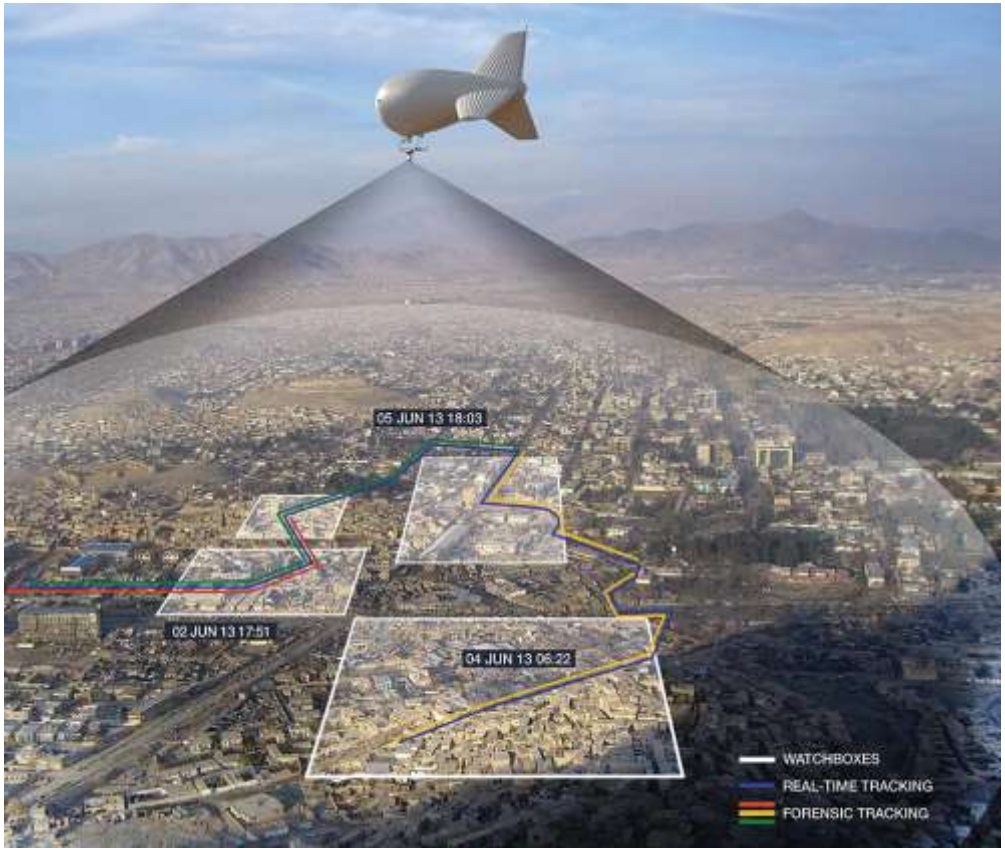


Photo credit: Courtesy graphic https://www.army.mil/article/62316

Persistent Surveillance & Wide-area Motion Imagery

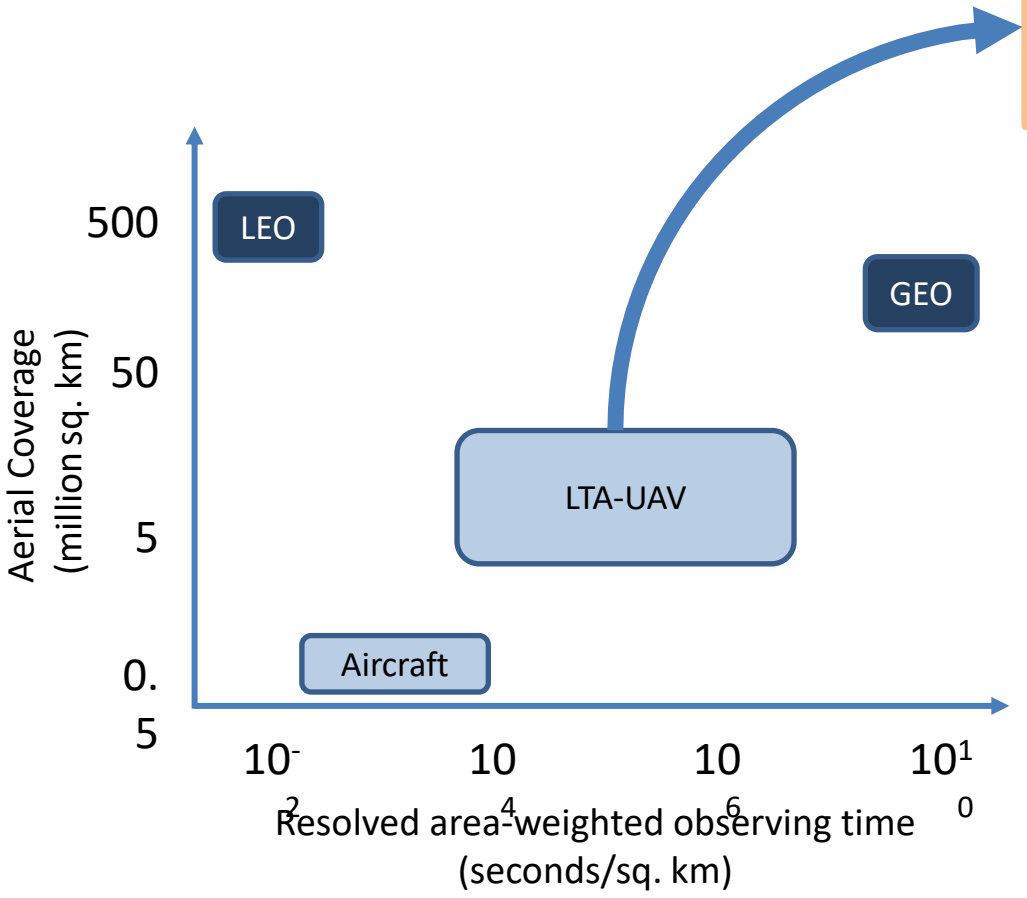


Graham Warwick, *Aviation Week & Space Technology,* Defense & Space Technologies to Watch in 2016

Comparison with other Surveillance Options

Multicopter	Balloon/Airship	Airplane/Heli	Satellite
Altitude: up to 700 m	**Altitude:** 10km-40km	**Altitude:** 50-3500 m	**Altitude:** 160- 500 km
Coverage: Small	**Coverage:** Large	**Coverage:** Large	**Coverage:** Very large, global
Cost: Low	**Cost & Usage :** Medium	**Cost & Usage :** High	**Cost & Usage :** High
Maneuver: Flexible & Narrow	**Maneuver:** Persistent	**Maneuver:** Flexible, semi-persistent	**Maneuver:** Fixed path, non-persistent
Concern: Battery, Weather	**Concern:** Helium, maneuverability (wind)	**Concern:** Fuel, High-risk (Manned)	**Concern:** Cloud, frequency of revisit

Resolution-Coverage Spatial-Temporal



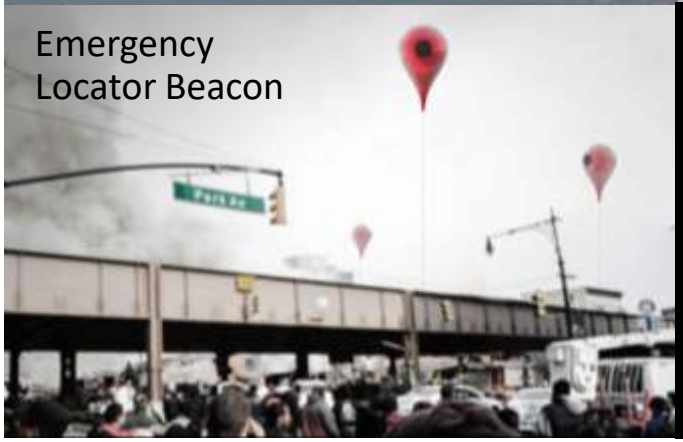
LTA-UAV	**RESOLUTION**	**COVERAGE**
SPATIAL	High	Local to regional
TEMPORAL	High	Diurnal to seasonal

Aircraft	**RESOLUTION**	**COVERAGE**
SPATIAL	Moderate	Global
TEMPORAL	Low	Weekly to inter annual

LEO Satellite	**RESOLUTION**	**COVERAGE**
SPATIAL	High	Regional to continental
TEMPORAL	Low	Seasonal to inter annual

GEO Satellite	**RESOLUTION**	**COVERAGE**
SPATIAL	Low	Continental to 3rd of sphere
TEMPORAL	High	Diurnal to inter annual

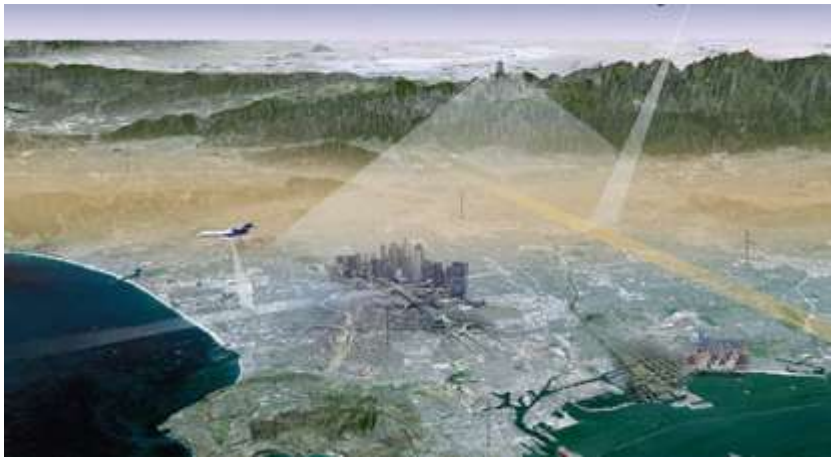
Most Promising Use Cases for LTA-UAV in Disaster Relief



Lighter-than-Air UAV Applications

LTA UAV or Platform Potential Missions

Megacity Carbon Emissions Observation
Duren and Miller (2012)



FOV
>10^5 km^2
Spatial resolution **<10 m**
Duration: **days**
Frequency: **monthly**

Coastal Ecosystem Monitoring

FOV
>10^5 km^2
Spatial resolution **<10 m**
Duration: **days**
Frequency: **monthly**

LTA UAV or Platform Potential Missions

Tropical wildlife monitoring

FOV
<10^2 km^2
Spatial resolution **<1 m**
Duration: **days**
Frequency: **seasonal**

Persistent Surveillance – Cities/Ports

FOV
<10^2 km^2
Spatial resolution **<1 m**
Duration: **hours**
Frequency: **daily**

LTA Vehicles : Current Development of Hybrid Airship

Nimbus EosXi
NIMBUS Srl
Italy

Hybrid Airship UAV
Dept. of Aerospace Engineering
UPM

P-791
Lockheed Martin

LTA Platforms : Stratospheric Sounding

Zero Pressure Balloon

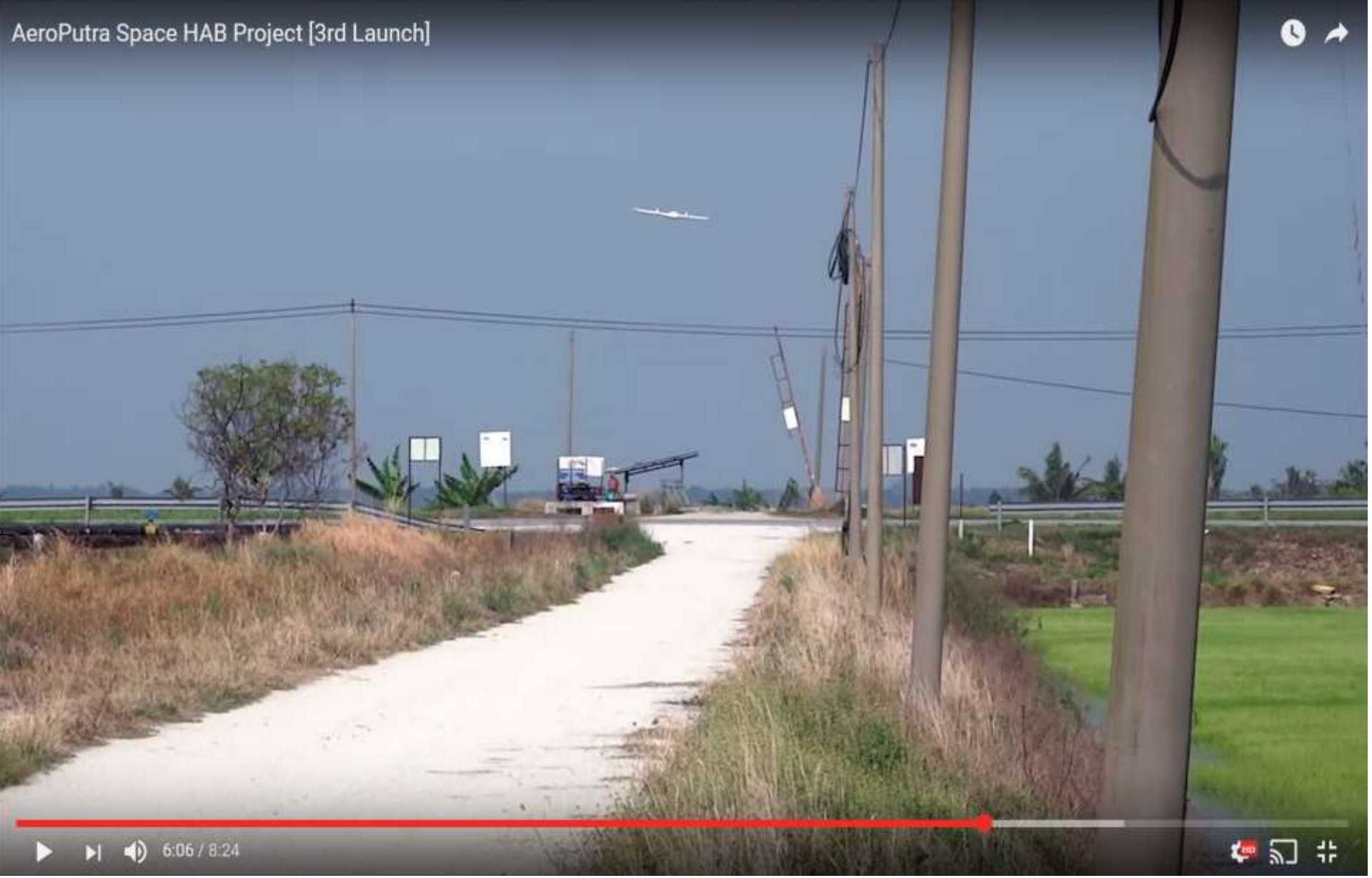
Space Balloon (@altitude 37 km)
Dept. of Aerospace Engineering
UPM

Super Pressure Balloon
NASA

AeroPutra Space HAB Project [3rd Launch]
3:12 / 8:24

AeroPutra Space HAB Project [3rd Launch]
5:39 / 8:24

AeroPutra Space HAB Project [3rd Launch]
5:23 / 8:24


AeroPutra Space HAB Project [3rd Launch]
6:06 / 8:24

Lighter-than-Air Unmanned Aerial Vehicle (LTA-UAV) Components:

Three (3) major systems are at the heart of every UAS and these are:

a) the Flight Management System (FMS),

b) the Power Plant (PP) and

c) the Data Acquisition System (DA).

Engineering Challenges

- **Aerospace Engineering -** flight control; LTA-UAVs are very susceptible to wind disturbances. Various ways of **tethering** are considered.
- **Structural & Manufacturing -** Manufacturing large rigid and semi-rigid airship
- Requires **large space** for storage, airport
- **Data Acquisition** : Sensors and real time data transmission
- **Data Processing and Machine Learning** : real time
- **Sustainability -** Helium is expensive and not renewable, while hydrogen storage and fueling is trickier.

Sensors

Object Tracking

Allows you to designated a region of interest on the video as a target. The gimbal automatically steers to keep the object center of frame throughout platform movements. The template matching algorithm allows you to track objects even if they are partially obscured.

Motion Detection

You can follow multiple cars travelling on a road-will automatically tag up to 5 moving object within its FOV

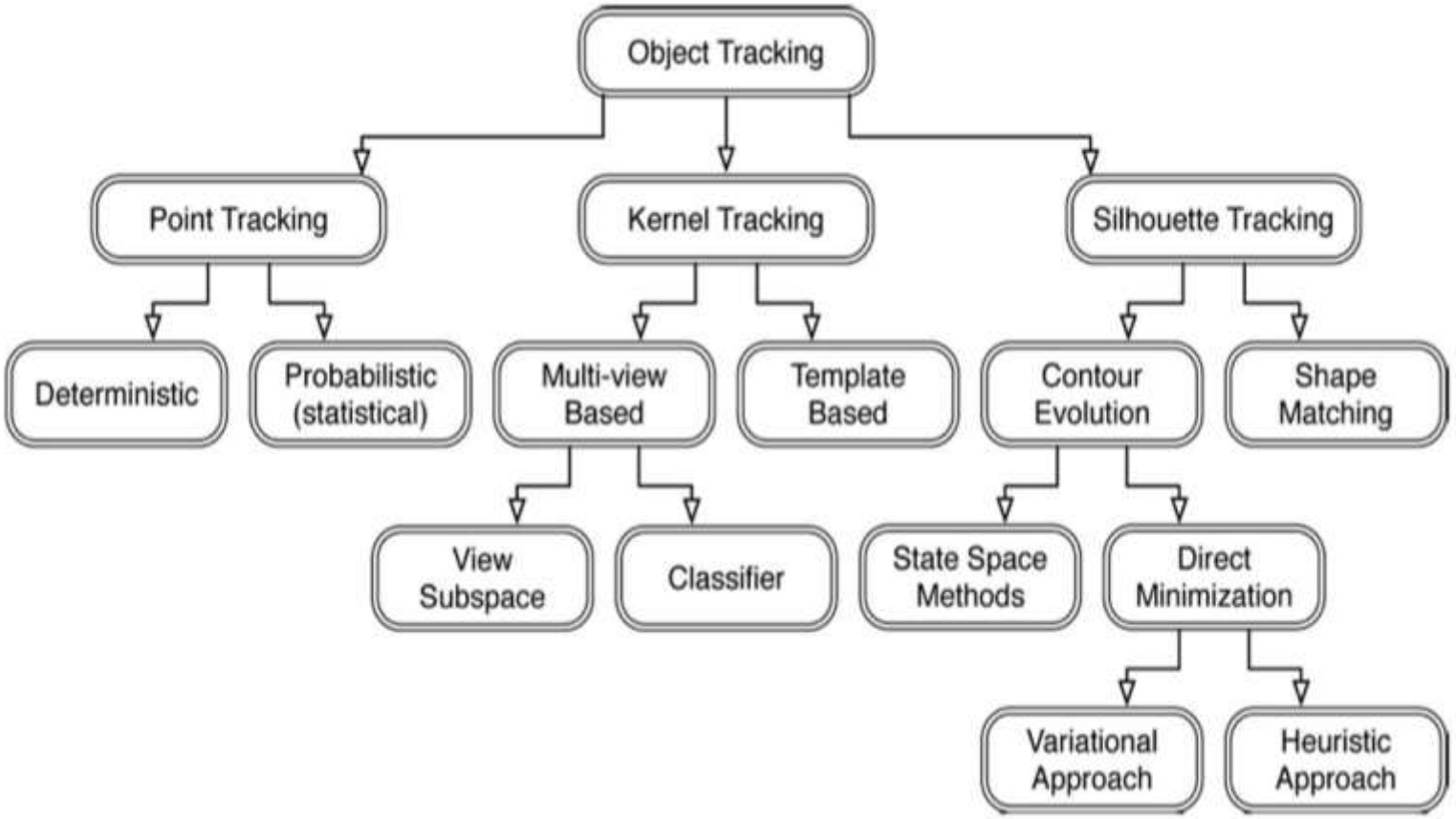
Object Tracking

- Track an object (or multiple objects) over a sequence of images.
- Tracking is usually performed in the context of higher-level applications that require the location and/or shape of the object in every frame.

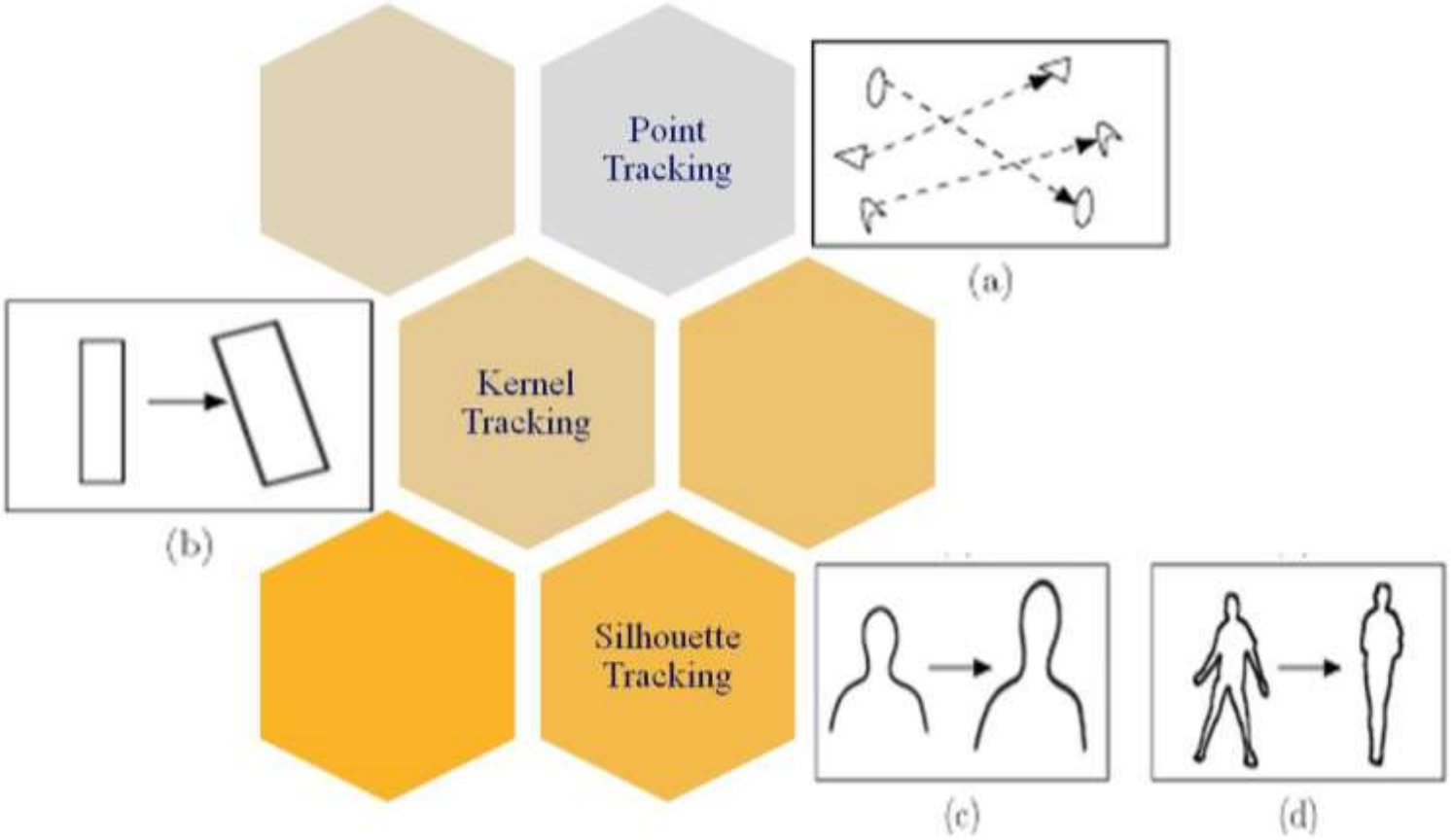
Common Algorithms for Object Detection

Object detection methods	Advantages	Disadvantages
Optical flow	✓ it can work even in the presence of camera motion	✓ sensitive to illumination changes and noise. ✓ often can only detect partial edge shapes of moving objects. ✓ computationally complex.
Temporal differencing	✓ The algorithm is simple and can quickly detect motion object while it appears. ✓ adaptive to dynamic environments	✓ unable to detect all relevant pixels and complete shapes of foreground objects. ✓ small changes in object movements or stopping objects can cause temporal differencing to fail
Background subtraction	✓ flexible and fast ✓ Low memory requirement ✓ its computational simplicity	✓ camera vibration and speckle noise also seriously affects the accuracy of detection ✓ background scenes need to be consistent while the camera should also be fixed.

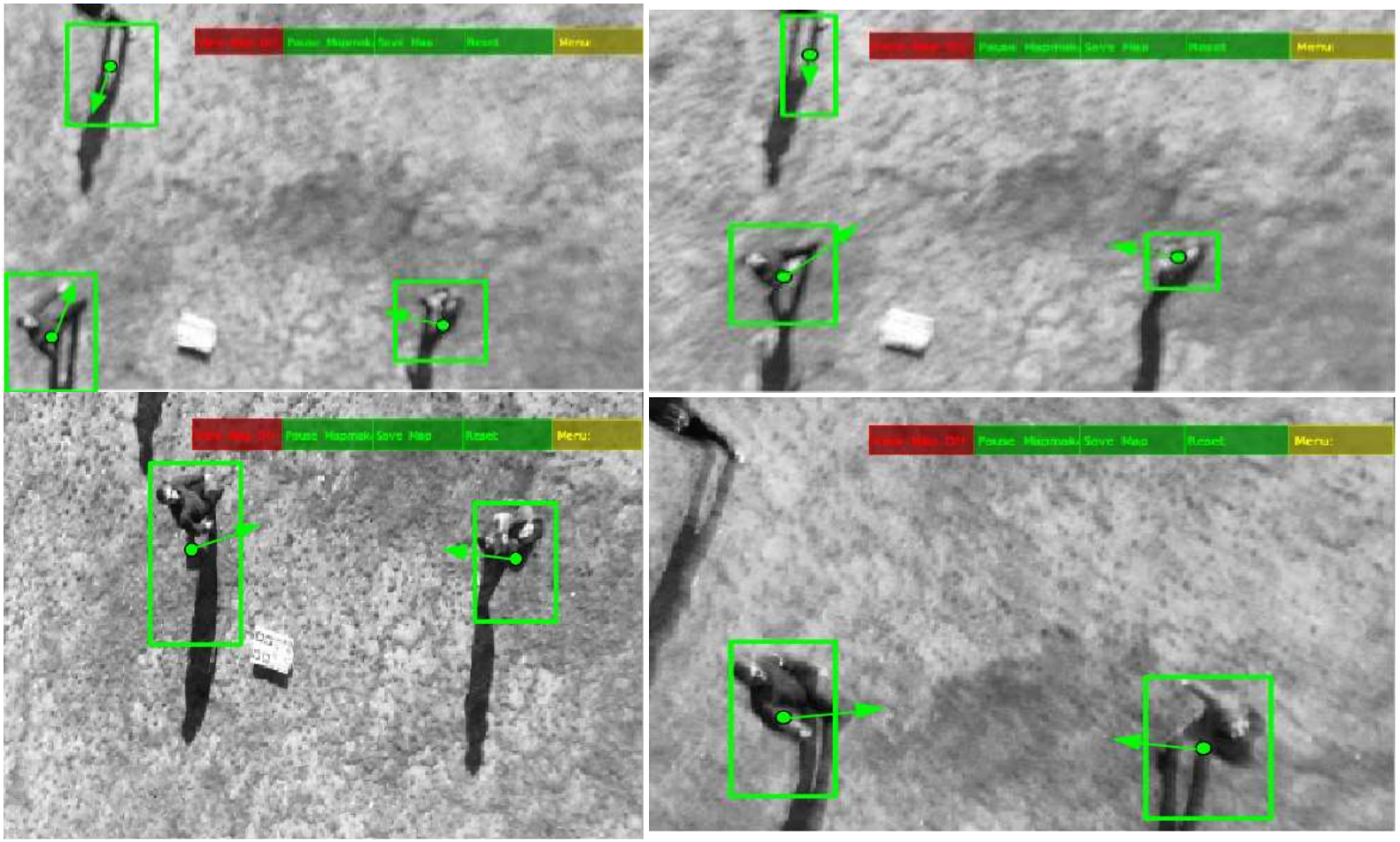
Method (Object tracking)



Method (Object tracking)

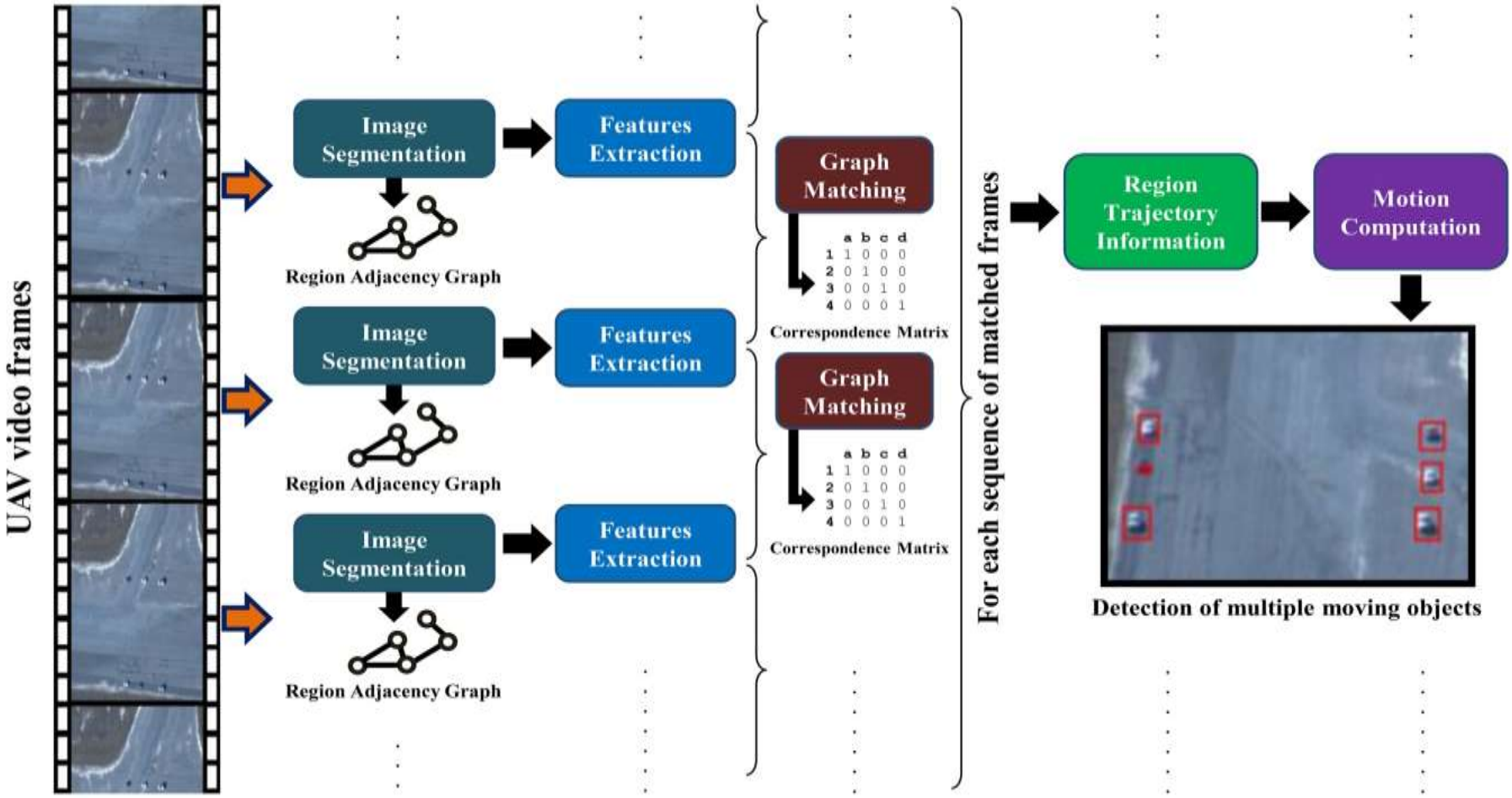


Results



Detection and tracking of a multiple dynamic object

Methodology (Moving Object Detection)



Results: Multiple moving object detection

Illustrative examples of the DARPA VIVID dataset. The represented images of EgTest01, EgTest02, and EgTest03 are depicted in the first, second, and third columns, respectively.

Final Observation

Costs: how cheap/expensive are drones?

Process: technology-driven (democracy replaced by technocracy?)

De-humanizing border surveillance, if unconnected from S.A.R. (vs: surveillance: epystemic bridging?)

Increased surveillance > increased control (duties?) and increased situational awareness >

Transparency: information will be partially classified.

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PROF. DATO' DR. SHATTRI MANSOR
GISRC, Faculty of Engineering, Universiti Putra Malaysia, 43400 Serdang
E-mail: shattri@upm.edu.my