
# THE GEOSPATIAL IMPERATIVE IN MULTI - DOMAIN OPERATIONS

# MULTI - DOMAIN OPERATIONS (MDO)

- **Modern Warfare**
  - Beyond the traditional, domain-centric approach of operations
- **MDO**
  - Simultaneous & integrated employment of all instruments of national power
  - Conducting converging & complementary operations across multiple domains
  - Creating, exploiting and achieving objectives faster than an adversary can respond

**Cyberspace & Electromagnetic Spectrum**

The networked information environment and the electromagnetic spectrum, which connects the four physical domains.


**Land**

The terrestrial surface, including subterranean & complex urban terrain, where forces manoeuvre, seize, hold ground, and where the population resides

**Space**

The orbital environment, which is simultaneously a contested war-fighting domain and the principal provider of PNT, satellite communications and space-based ISR.

**Air**

The atmospheric volume used for strike, air mobility, air defence, and control of the air

**Maritime**

The surface, sub-surface and littoral environment, including the seabed, used for sea control, sea denial, power projection and protection of sea lines of communication

# GEOSPATIAL DATA - *THE CONNECTIVE TISSUE* FOR MDO

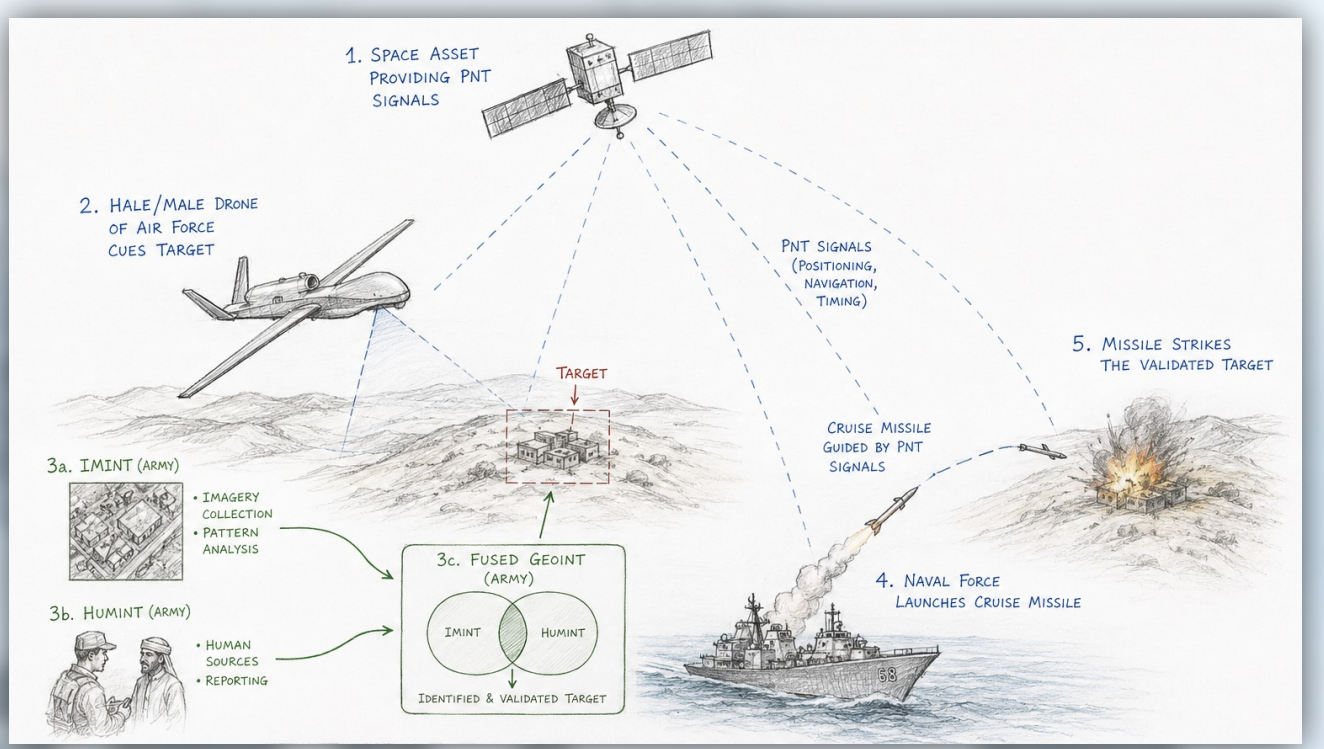
## Indispensability of Geospatial Data

- **Provides Common Spatial Reference**
  - Precisely measure, locate, and map features on Earth
  - Domains can describe the same point in the same way
- **Enables Fusion**
  - IMINT
  - HUMINT
  - SIGINT
  - OSINT
- **Facilitates Terrain Analysis & Prediction**
  - LoS
  - Mobility
  - Precision Targeting
  - Sensor Coverage Footprints
  - Weapon Coverage

- **Generates COP**
  - Location & Disposition
    - Friendly Forces
    - Adversary Forces
    - Neutral Entities
  - Infrastructure
  - Environmental Conditions

## *What Makes Geospatial Data so Critical to MDO?*

- Actions in one domain directly affect conditions in other domains
- Failure of any single geospatial data layer directly degrades overall operational tempo & accuracy of effect.



# RELEVANCE OF GEOSPATIAL DATA IN MDO

| Data Type | Description | Military Relevance |
|---|---|---|
| Electro-Optical (EO) Imagery | Panchromatic, colour and video imagery in the visible band from satellites, aircrafts and UAVs/ USVs. | Target identification, PSDA, mapping, ISR. |
| Synthetic Aperture Radar (SAR) | Active microwave imaging that penetrates cloud, smoke and darkness; supports change detection. | All-weather ISR, change detection, maritime surveillance. |
| Multispectral / Hyperspectral | Imagery across many spectral bands revealing material composition. | Camouflage and decoy detection, locating dugouts, mine fields, terrain trafficability, chemical signatures. |
| Elevation / Terrain Data | DTM and DSM describing the height of the bare earth and surface features in DEM and DTED | Line-of-sight, mobility, terrain-following flight, viewshed analysis, mapping, flood modelling. |
| LiDAR / Point Clouds | Dense 3-D point measurements from laser scanning. | High-fidelity 3-D models, urban operations, obstacle data, DTM and DSMs |
| Vector / Feature Data | All topographic features in the form of points, lines and polygons | Mission planning, spatial analysis, network analysis infrastructure analysis, mapping, overlays |

| Data Type | Description | Military Relevance |
|---|---|---|
| Bathymetry / Hydrographic Data | Depth of water bodies and seabed characterisation; Electronic Navigational Charts. | Naval navigation, mine warfare, submarine and amphibious operations. |
| Aeronautical Data | Airspace structure, obstacles, navigation aids and airfield data. | Flight planning, airspace control, safety of flight. |
| Geodetic & Gravimetric Data | Reference frames, datums, geoid and gravity models. | Common datum, accurate heights, weapon accuracy, inertial navigation, geo-referencing. |
| Meteorology and Oceanography Data | Atmospheric, oceanographic, and space weather conditions; time-referenced and geo-referenced. | Sensor and weapon performance, mobility, sea state, flight conditions. |
| RF / EM Geolocation Data | Geo-referenced position of emitters and spectrum usage. | Electronic warfare, SIGINT cueing, spectrum management. |

**Geospatial Data - ~~A Planning Tool~~ An Operational Necessity**

- Enables decision advantage
- Synchronization/ integration across domains
- Freedom of movement
- Exploitation of opportunity

# GEOSPATIAL DATA - POWERING DOMAINS OF MDO

## Land

- **Every Tactical Decision - *Function of the Terrain***
- **Terrain Analysis**
  - *What forces can see*
  - *What can see them*
  - *Where cover exists*
- **Trafficability/ Going Analysis**
  - *Where vehicles can move*
  - *Which type of vehicle*
  - *At what speed*

## Maritime

- **Inverse of Land Problem**
  - Largely uniform surface
  - Medium itself shapes operations
- **Operating Environment**
  - 3Dimensional & dynamic
  - Largely invisible to conventional sensors
- **Terrain Analysis**
  - Bathymetric & Hydrographic Data
    - *Terrain data of sea*
  - Sound Velocity Profile Data
    - ASW - Acoustic Shadow Zones, Sonar Detection Ranges
- **Positioning & Navigation**
  - Featureless Blue Water - Drift

## Air

- **Geospatial Data - Critical in All Phases**
  - Mission planning to PSDA
  - Extreme data latency Vs positional accuracy
  - Target coordinate mensuration
- **Terrain Analysis**
  - Radar coverage modelling
  - Plan low-level ingress and egress
  - Execute auto terrain masking
  - Terrain referenced navigation

# GEOSPATIAL DATA - POWERING DOMAINS OF MDO

## Space

- **Paradoxical Position - *Generates Data; Still Requires Data***
  - EO + GNSS Vs SSA
  - SSA - *Terrain map of space*
    - Precise satellite manoeuvre
- **Datasets for Space Operations**
  - Orbital parameters
  - Sensor Field of Regard (SFR)

## Cyber & Electromagnetic Spectrum

- **Cyberspace Appears Non-geographic**
  - Physical layers anchored to real world
  - Georeferenced infrastructure
    -Understanding dependencies & effects
- **RF - Dependant on Terrain & Distance**
  - Elevation - Emitter location analysis
  - Planning of communication

### Convergence of Domains

When analysis & outcome using a consistent & accurate geospatial data from one domain is seamlessly used for actionable results in another, the domains are said to have converged, achieving MDO interoperability

# CHALLENGES IN ACHIEVING COP IN MDO

## Volume & Velocity

- Large volume of data
- Data collection speed
- Inadequate network infrastructure
- Extracting relevant information
- Auto exploitation - GeoAI
- Moving processing closer to the sensor

## Latency

- Links in Sensor-to-Effects chain - Adds to delay
- Cumulative delay Vs Window of opportunity
- Edge processing
- Transmission of compact, decision-ready results

## Interoperability

- Mil Hardwares - Varying generations, origins, & security levels
- Differences in formats, datums, data standards, and metadata conventions
- interoperability is not a one-time fix; but a continuous process
- Key to convergence in MDO

## Denied/ Degraded PNT

- MDO assumes reliable access to satellite PNT
- Adversaries will contest precisely this assumption
- Loss will degrade PNT and data fusion
- Degradation - Single point of failure with system-wide consequences
- Need - Layered Alt-PNT & Assured PNT technologies

## Data Fusion

- Combining multiple imperfect observations - Better estimate than any single source
- Geospatial accuracy directly bounds fusion quality
- Accuracy, currency & uncertainty of data - Key to data fusion

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## Data Integrity

- Geospatial data -Unifying enabler data in MDO
- Makes it an attractive target for manipulation
- Contaminated data degrades MDO into a set of disconnected actions
- Ensuring integrity controls, provenance tracking, and cross-checks
- Data should be authentic, unaltered, & from trusted source

# CONCLUDING THOUGHTS

- Geospatial data is the foundational operational substrate upon which all military actions are conducted
- The side that holds the most accurate, current, and resilient geospatial data, and can shares it fast; holds the operational advantage
- Difference between success and failure of operations hinges on availability of geospatial data
- Investment in geospatial accuracy, currency, interoperability, and resilience is an inescapable necessity in MDO


SPACE
AIR
LAND
MARITIME
Jai Hind
CYBER
COLLECT
PROCESS
ANALYZE
DISSEMINATE
DECIDE
ACT
INFORMATION DOMAIN