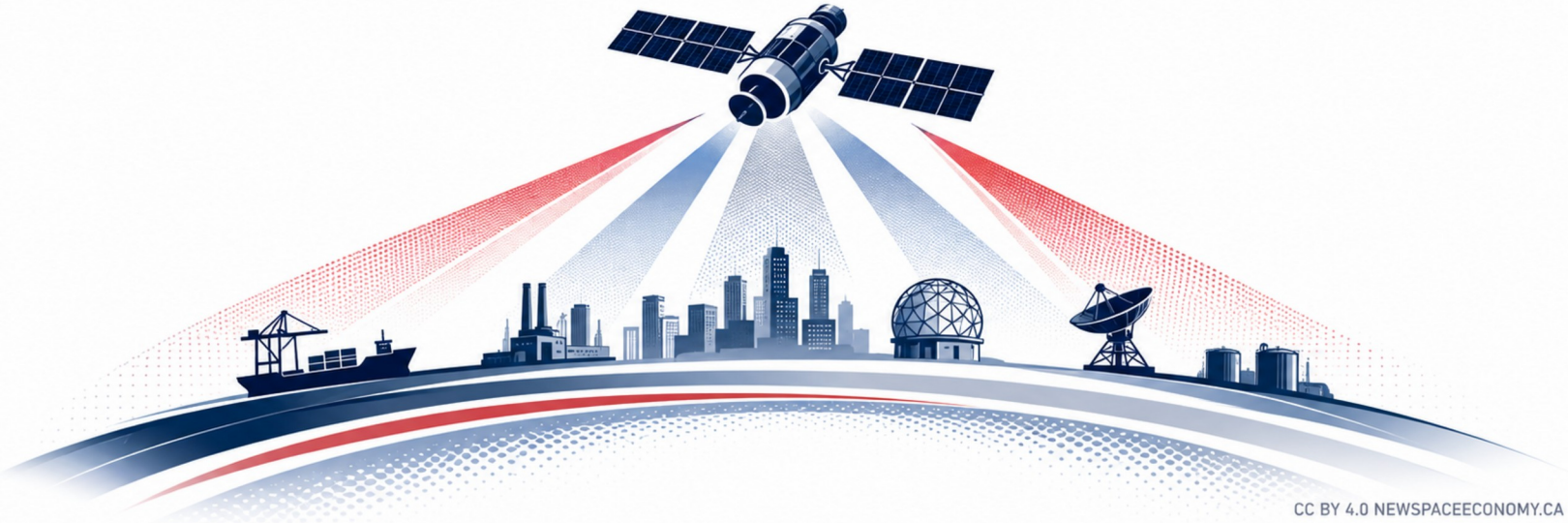


# MILITARY APPLICATIONS OF COMMERCIAL EARTH OBSERVATION SERVICES

HOW COMMERCIAL SATELLITE DATA SUPPORTS DEFENSE, SECURITY, AND ACCOUNTABILITY



# HOW CAN COMMERCIAL SATELLITES REVEAL MILITARY BUILDUPS?

EARTH OBSERVATION TURNS INFRASTRUCTURE CHANGES INTO OPEN-SOURCE EVIDENCE



## 1 WHAT CAN BE OBSERVED



NEW OR EXPANDED BUILDINGS AND FACILITIES



AIRCRAFT, SHIPS, AND VEHICLES



EQUIPMENT, MATERIALS, AND SUPPLIES



NEW ROADS, PARKING, AND STORAGE AREAS



PERIMETER ENHANCEMENTS AND SECURITY FEATURES

## 2 WHAT CHANGES MAY INDICATE



INCREASED CAPACITY AND THROUGHPUT



GROWING PERSONNEL PRESENCE



STOCKPILING AND SUSTAINMENT PREPARATION



EXPANDED OPERATIONS AND TRAINING



ENHANCED PROTECTION AND RESILIENCE

## 3 HOW ANALYSTS VERIFY



COMPARE MULTIPLE IMAGERY DATES AND SOURCES



ANALYZE PATTERNS, CONTEXT, AND BASE LAYOUT



USE VARIOUS CONDITIONS AND VIEWING ANGLES



CROSS-CHECK WITH OPEN SOURCES AND REPORTING



CONSULT SUBJECT-MATTER EXPERTS

## 4 LIMITATIONS



CLOUD COVER AND WEATHER CAN LIMIT VISIBILITY



NIGHTTIME OR SHADOWS REDUCE DETAIL



COVERED, CONCEALED, OR UNDERGROUND ACTIVITY MAY BE HIDDEN



IMAGERY SHOWS WHAT IS THERE, NOT WHY

**IMAGERY SHOWS ACTIVITY AND CHANGE — NOT INTENT**

# HOW DO COMMERCIAL SATELLITES TRACK NAVAL ACTIVITY?

MULTIPLE SENSORS HELP BUILD A PICTURE OF MARITIME MOVEMENT



**OPTICAL  
IMAGERY**



- PROVIDES HIGH-RESOLUTION VISIBLE IMAGES
- IDENTIFIES SHIPS, SIZE, ORIENTATION, AND PORT ACTIVITY
- USEFUL IN DAYLIGHT AND CLEAR CONDITIONS



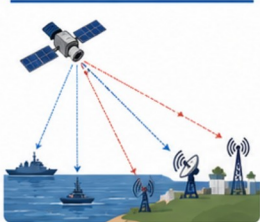
**SYNTHETIC-APERTURE  
RADAR (SAR)**



- IMAGES DAY OR NIGHT AND THROUGH CLOUDS
- DETECTS SHIPS VIA RADAR REFLECTIONS
- PROVIDES FREQUENT COVERAGE AND DETECTS MOVEMENT



**RADIO-FREQUENCY  
DATA**



- CAPTURES SHIP COMMUNICATIONS AND ELECTRONIC EMISSIONS
- IDENTIFIES ACTIVITY, COORDINATION, AND INTENT
- USEFUL BEYOND LINE-OF-SIGHT AND IN ALL WEATHER

| SENSOR                                                                                                                 | STRENGTH                                                                                                                                                                                | LIMITATION                                                                                                                                                               |
|------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  <b>OPTICAL IMAGERY</b>                |  HIGH-RESOLUTION VISUAL DETAIL; IDENTIFIES SHIP TYPE, SIZE, ORIENTATION, AND PORT ACTIVITY             |  LIMITED BY CLOUD COVER, DARKNESS, AND LIGHTING CONDITIONS                            |
|  <b>SYNTHETIC-APERTURE RADAR (SAR)</b> |  ALL-WEATHER, DAY/NIGHT IMAGING; DETECTS SHIPS AND MOVEMENT; LESS AFFECTED BY ENVIRONMENT              |  LOWER VISUAL DETAIL THAN OPTICAL; REQUIRES INTERPRETATION OF RADAR SIGNALS           |
|  <b>RADIO-FREQUENCY DATA</b>           |  DETECTS COMMUNICATIONS AND EMISSIONS; INDICATES ACTIVITY AND COORDINATION; WORKS BEYOND LINE-OF-SIGHT |  DOES NOT SHOW PHYSICAL APPEARANCE; SIGNALS MAY BE ENCRYPTED, INTERMITTENT, OR ABSENT |

# WHAT CAN COMMERCIAL IMAGERY REVEAL ABOUT AIRFIELDS?

AIRFIELD ACTIVITY BECOMES VISIBLE THROUGH REPEATED OBSERVATION



## 1. OBSERVE

DETECT AIRCRAFT, VEHICLES, BUILDINGS, AND SURFACE CONDITIONS IN COMMERCIAL IMAGERY.



## 2. COMPARE

ANALYZE IMAGERY OVER TIME TO IDENTIFY PATTERNS, ACTIVITY LEVELS, AND PHYSICAL CHANGES.



## 3. INTERPRET

DERIVE MEANINGFUL INSIGHTS ABOUT OPERATIONS, CAPACITY, INTENT, AND AIRFIELD DEVELOPMENT.



## 4. VERIFY

CORROBORATE FINDINGS USING MULTIPLE IMAGERY SOURCES AND CONTEXT FOR GREATER CONFIDENCE.

## COMMERCIAL IMAGERY SUPPORTS AIRFIELD ASSESSMENT



### AIRCRAFT PRESENCE

DETECT AND MONITOR AIRCRAFT ON THE GROUND, INCLUDING TYPE AND QUANTITY TRENDS.



### RUNWAY ACTIVITY

OBSERVE TAKEOFF AND LANDING ACTIVITY BY IDENTIFYING AIRCRAFT POSITIONS AND MOVEMENTS.



### HANGAR USE

MONITOR HANGAR OCCUPANCY AND CHANGES IN STORAGE PATTERNS.



### CONSTRUCTION

TRACK NEW CONSTRUCTION, FACILITY EXPANSION, AND INFRASTRUCTURE IMPROVEMENTS.



### LAYOUT CHANGES

IDENTIFY MODIFICATION TO RUNWAYS, TAXIWAYS, APRONS, AND SUPPORT AREAS OVER TIME.

# HOW DOES COMMERCIAL IMAGERY SUPPORT BATTLE DAMAGE ASSESSMENT?

## BEFORE-AND-AFTER ANALYSIS CAN DOCUMENT CHANGE WITHOUT REVEALING INTENT

### THE ROLE OF COMMERCIAL EARTH OBSERVATION



**TIMELY, REPEATED OBSERVATIONS**  
Commercial satellites capture frequent imagery of the same areas, enabling rapid post-event assessment.



**BEFORE-AND-AFTER COMPARISON**  
Comparing imagery acquired before and after an event helps reveal changes to infrastructure and the environment.



**DAMAGE INDICATORS, NOT CERTAINTY**  
Imagery can show visible damage indicators, but it cannot confirm cause or provide intent.

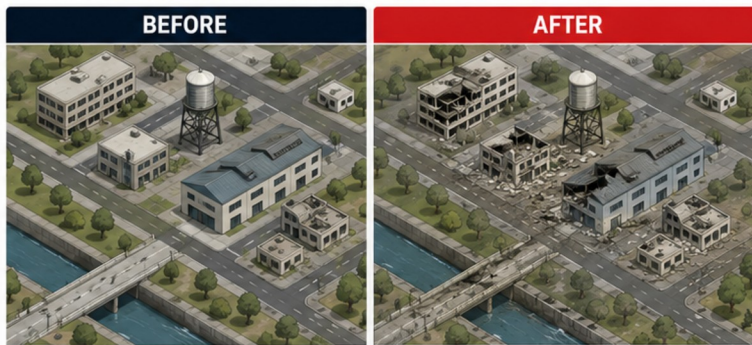


**INDEPENDENT AND OBJECTIVE**  
Commercial imagery provides an independent record that can support transparent, evidence-based analysis.



**INFORMS DECISIONS, NOT JUST REPORTS**  
Supports humanitarian response, infrastructure planning, risk assessment, and accountability efforts.

### BEFORE-AND-AFTER COMPARISON REVEALS CHANGE



### FROM IMAGERY TO ASSESSMENT: A CAUTIOUS PROCESS



**1. REVIEW**  
Examine before-and-after imagery systematically.



**2. IDENTIFY CHANGE**  
Flag potential damage indicators and changes in activity.



**3. ESTIMATE IMPACT**  
Estimate affected areas or extent cautiously. Use ranges, not exact figures.



**4. CROSS-CHECK**  
Validate findings with other information and context.

### EVIDENCE-CONFIDENCE LADDER

Assess the strength of evidence based on what the imagery shows.



#### DIRECTLY VISIBLE

Damage or change is clearly visible in the imagery.  
High confidence.



#### CONSISTENT WITH

Imagery shows changes that are consistent with possible damage or impact.  
Medium confidence.



#### REQUIRES CORROBORATION

Imagery alone is insufficient to confirm damage or impact.  
Low confidence.  
Seek additional evidence.



**IMAGERY SHOWS WHAT CHANGED.**  
IT DOES NOT DETERMINE WHY.



**CAREFUL ANALYSIS.**  
CONTEXT MATTERS.



**INDEPENDENT EVIDENCE.**  
BETTER DECISIONS.



**TRANSPARENCY BUILDS TRUST.**  
EVIDENCE DRIVES ACCOUNTABILITY.

# HOW DOES COMMERCIAL EARTH OBSERVATION MONITOR CONFLICT ZONES?

REPEATED IMAGERY CREATES A TIME-STAMPED RECORD OF CHANGE

## REPEATED IMAGERY REVEALS CHANGE OVER TIME



COMMERCIAL SATELLITES COLLECT IMAGERY



IMAGERY IS PROCESSED AND STANDARDIZED



OBSERVATIONS ARE TIME-STAMPED



IMAGERY IS ANALYZED AND COMPARED



1

### INFRASTRUCTURE DAMAGE



- Destroyed or damaged buildings
- Impacted facilities
- Debris and burn marks

2

### ROAD CHANGES



- New roads or tracks
- Road blockages
- Cratered or destroyed sections

3

### DISPLACEMENT PATTERNS



- New or expanding settlements
- Temporary shelters
- Concentrations of people and vehicles

4

### MILITARY ACTIVITY INDICATORS



- Vehicle concentrations
- Field fortifications
- Staging areas
- Support activity

5

### CHANGING LINES OF CONTROL



- Shifts in boundaries
- New defensive positions
- Interspersation on opposing sides



## DOCUMENT CHANGE

- Objective, repeatable observations
- Wide-area coverage
- Persistent record over time
- Supports situational awareness



## SUPPORT VERIFICATION

- Compare multiple dates and sources
- Corroborate with other information
- Establish patterns, not just events
- Strengthen evidence and reporting



## PROTECT SOURCES

- Commercial data reduces risk to people on the ground
- Responsible tasking and data handling
- Limit detail to what is necessary
- Respect privacy and confidentiality



## RECOGNIZE LIMITS

- Clouds, smoke, and darkness reduce visibility
- Resolution has limits
- Interpretation requires context
- Does not show intent or motives
- All findings need context and corroboration



IMAGERY SHOWS WHAT WE CAN SEE. UNDERSTANDING WHAT IT MEANS REQUIRES CONTEXT AND CORROBORATION. RESPONSIBLE USE, CRITICAL ANALYSIS, AND MULTIPLE SOURCES ARE ESSENTIAL.

# WHY IS SYNTHETIC-APERTURE RADAR IMPORTANT?

RADAR OBSERVATION EXTENDS MONITORING WHEN LIGHT AND WEATHER LIMIT OPTICAL IMAGERY

## WHY SAR CAN SEE WHEN OPTICAL SENSORS CANNOT



**PENETRATES CLOUD, SMOKE, AND HAZE**  
RADAR WAVES PASS THROUGH CLOUD COVER, SMOKE, AND HAZE THAT BLOCK OR SCATTER VISIBLE LIGHT.

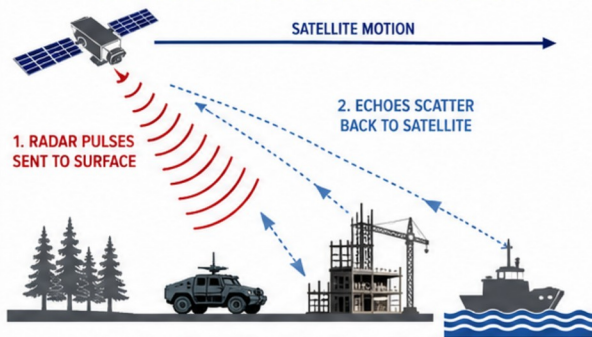


**OPERATES DAY AND NIGHT**  
RADAR IS AN ACTIVE SENSOR THAT EMITS ITS OWN ENERGY, SO IT DOES NOT RELY ON SUNLIGHT.



**ALL-WEATHER, ALL-LIGHT CAPABILITY**  
SAR PROVIDES CONSISTENT OBSERVATION THROUGH RAIN, CLOUD, AND DARKNESS, ENABLING CONTINUOUS MONITORING.

## HOW SYNTHETIC-APERTURE RADAR (SAR) WORKS



**3. MOTION CREATES A SYNTHETIC APERTURE**  
AS THE SATELLITE MOVES, MANY ECHOES ARE COMBINED TO BUILD A HIGH-RESOLUTION IMAGE REVEALING THE SHAPE, TEXTURE, AND STRUCTURE OF SURFACE FEATURES.

## WHAT SAR CAN REVEAL



**SURFACE STRUCTURE**  
REVEALS SHAPE, ROUGHNESS, AND PATTERNS OF NATURAL AND MANMADE FEATURES.



**VEHICLES AND EQUIPMENT**  
DETECTS AND DISCRIMINATES VEHICLES, AIRCRAFT, AND OTHER EQUIPMENT.



**SHIPS AND MARITIME ACTIVITY**  
DETECTS SHIPS AT SEA AND IN PORTS, INCLUDING SIZE AND ORIENTATION.



**FLOODING AND WATER EXTENT**  
MAPPING STANDING WATER AND MONITORING CHANGES OVER TIME.



**CONSTRUCTION AND INFRASTRUCTURE**  
MONITORS BUILDING PROGRESS, SITE ACTIVITY, AND INFRASTRUCTURE DEVELOPMENTS.



**CHANGE DETECTION**  
IDENTIFIES NEW ACTIVITY, DAMAGE, AND OTHER CHANGES BY COMPARING IMAGES OVER TIME.

## SENSING APPROACHES COMPARED

|                  | OPTICAL                                       | RADAR (SAR)                                         | RADIO-FREQUENCY (PASSIVE)                                  |
|------------------|-----------------------------------------------|-----------------------------------------------------|------------------------------------------------------------|
| HOW IT WORKS     | DETECTS REFLECTED SUNLIGHT                    | EMITS MICROWAVES AND MEASURES RETURNED ECHOES       | DETECTS NATURAL RADIO EMISSIONS FROM THE EARTH             |
| LIGHT DEPENDENCE | REQUIRES DAYLIGHT                             | DAY AND NIGHT CAPABLE                               | DAY AND NIGHT CAPABLE                                      |
| WEATHER IMPACT   | BLOCKED BY CLOUD, RAIN, SMOKE, AND HAZE       | CAN SEE THROUGH CLOUD, RAIN, SMOKE, AND HAZE        | SOMEWHAT AFFECTED BY HEAVY RAIN AND IONOSPHERIC CONDITIONS |
| WHAT IT MEASURES | VISIBLE LIGHT REFLECTION (COLOUR, BRIGHTNESS) | SURFACE CHARACTERISTICS (SHAPE, TEXTURE, STRUCTURE) | NATURAL RADIO SIGNAL STRENGTH AND PATTERNS                 |
| BEST USES        | VISUAL DETAIL, COLOUR, HUMAN OBSERVATION      | ALL-WEATHER MONITORING, STRUCTURE, CHANGE DETECTION | BROAD AREA MONITORING, ENVIRONMENTAL INDICATORS            |

# HOW CAN SATELLITE IMAGERY REVEAL MILITARY LOGISTICS?

## INFRASTRUCTURE AND ACTIVITY PATTERNS HELP ANALYSTS STUDY SUPPLY NETWORKS

### THE POWER OF REPEATED COMMERCIAL IMAGERY



#### FREQUENT COVERAGE

Regular collections build a timeline of activity.



#### CHANGE DETECTION

Identify new construction, movements, and changes over time.



#### WIDE AREA VISIBILITY

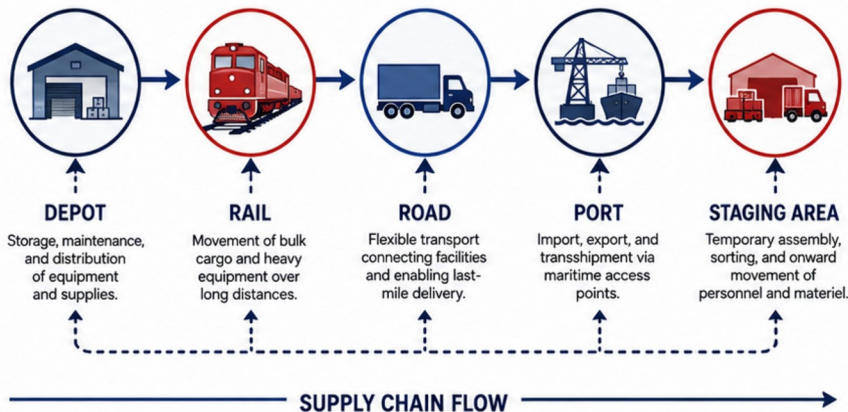
Monitor multiple sites across large regions consistently.



#### ALL-WEATHER CAPABILITY

Modern imagery collects in a variety of conditions.

### SATELLITE IMAGERY SUPPORTS ANALYSIS OF LOGISTICS NODES AND THE LINKS THAT CONNECT THEM



### WHAT ANALYSTS CAN LEARN



#### ACTIVITY LEVELS

Assess how busy a site is and how it changes.



#### FREQUENCY AND TIMING

Understand how often movements occur and their timing.



#### VOLUMES AND SCALE

Estimate the scale of assets and throughput.



#### INFRASTRUCTURE CHANGES

Track construction, expansion, or modifications.



#### RESILIENCE AND REDUNDANCY

Identify alternate nodes and potential workarounds.

### WHAT SATELLITE IMAGERY CAN REVEAL



EQUIPMENT AND VEHICLES



STORAGE AND MATERIALS



PERSONNEL CONCENTRATIONS



CONSTRUCTION AND EXPANSION



MOVEMENTS BETWEEN FACILITIES



FUEL AND SUPPLY STOCKPILING



**PATTERNS ARE INDICATORS, NOT PROOF**

# HOW DO COMMERCIAL SATELLITES SUPPORT MARITIME SECURITY?

EARTH OBSERVATION HELPS TURN DISCONNECTED VESSEL SIGNALS INTO CONTEXT

## MULTI-DOMAIN OBSERVATIONS



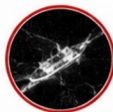
### OPTICAL IMAGERY

High-resolution images reveal vessels, activity, and changes over time.



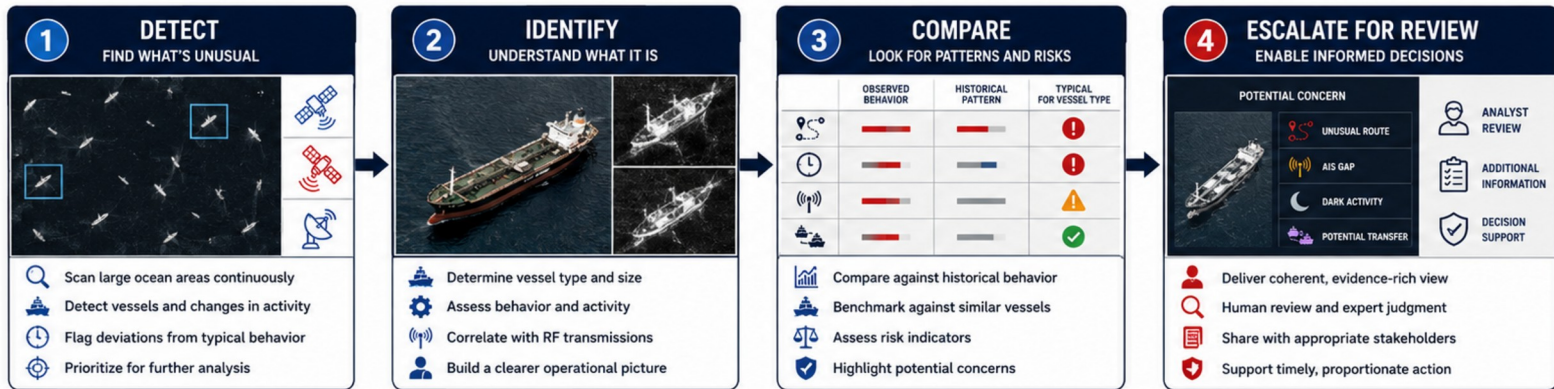
### SAR (RADAR) IMAGERY

Sees through clouds and darkness to detect vessels and activity day or night.



### RF SIGNAL INTELLIGENCE

Captures vessel transmissions (AIS and other signals) to understand behavior.



## MARITIME SECURITY USE CASES



### IDENTIFY UNUSUAL ACTIVITY

Spot deviations such as loitering, route changes, and AIS gaps.



### DETECT SANCTIONS EVASION

Find deceptive practices like ship-to-ship transfers and false identities.



### COMBAT ILLEGAL FISHING

Detect incursions, dark vessels, and suspicious behaviors.



### REDUCE SAFETY RISKS

Support search and rescue and monitor hazardous situations.



### PERSISTENT GLOBAL COVERAGE

Monitor vast ocean areas consistently.



### ALL-WEATHER, DAY AND NIGHT

SAR and RF provide coverage when others can't.



### MULTI-DOMAIN FUSION

Stronger insights through combined data sources.



### ACTIONABLE INTELLIGENCE

From raw data to context and decisions.

# HOW CAN COMMERCIAL IMAGERY DOCUMENT CIVILIAN IMPACTS?

SATELLITE OBSERVATION SUPPORTS INDEPENDENT ASSESSMENT WHEN ACCESS IS LIMITED



HEALTH



ASSESS DAMAGE TO HOSPITALS, CLINICS, AND HEALTH FACILITIES



EDUCATION



IDENTIFY DAMAGE TO SCHOOLS, UNIVERSITIES, AND LEARNING SPACES



WATER



MONITOR WATER FACILITIES, PIPES, AND TREATMENT PLANTS



ENERGY



DETECT DAMAGE TO POWER PLANTS, SUBSTATIONS, AND GRID ASSETS



HOUSING



EVALUATE DAMAGE TO HOMES AND RESIDENTIAL AREAS



ROADS & OTHER INFRASTRUCTURE



ASSESS ROADS, BRIDGES, PORTS, AIRPORTS, AND OTHER ASSETS



## HOW IMAGERY HELPS



PROVIDES INDEPENDENT, OBJECTIVE EVIDENCE FROM ABOVE



ENABLES REPEATED OBSERVATION OVER TIME TO TRACK CHANGE



SUPPORTS HUMANITARIAN RESPONSE, SITUATIONAL AWARENESS, AND ACCOUNTABILITY



COMPLEMENTS FIELD REPORTS AND LOCAL INFORMATION



## WHAT IMAGERY CAN REVEAL



VISIBLE STRUCTURAL DAMAGE AND DESTRUCTION



DEBRIS AND SIGNS OF IMPACT OR BURN DAMAGE



CRATERS, BLAST MARKS, AND SCORCHING



BLOCKED ROADS AND DISRUPTED ACCESS



FIRES AND SMOKE PLUMES



SERVICE DISRUPTION INDICATORS



MILITARY ACTIVITY NEAR CIVILIAN INFRASTRUCTURE



PATTERNS OF DAMAGE AND IMPACT OVER TIME



## LIMITATIONS TO CONSIDER



CLOUD COVER, DAY/NIGHT, AND IMAGE TASKING CAN LIMIT AVAILABILITY



IMAGERY SHOWS WHEN DAMAGE OCCURRED, NOT WHO OR HOW



INTERPRETATION REQUIRES CONTEXT AND EXPERTISE; RISK OF MISINTERPRETATION



PRIVACY AND SENSITIVE INFORMATION MUST BE PROTECTED



RESPONSIBLE USE, DATA PROTECTION, AND RESPECT FOR AFFECTED POPULATIONS ARE ESSENTIAL. IMAGERY IS A TOOL TO INFORM DECISIONS—NOT A SUBSTITUTE FOR HUMAN JUDGMENT.

# HOW IS COMMERCIAL SATELLITE INTELLIGENCE CHANGING MILITARY POWER?

WIDELY AVAILABLE OBSERVATION IS ALTERING THE BALANCE BETWEEN SECRECY AND TRANSPARENCY

## 01 ACCESS

WIDER AVAILABILITY LOWERS BARRIERS TO HIGH-QUALITY OBSERVATION.

- MORE ACTORS CAN OBSERVE MILITARY ACTIVITY
- REDUCES INFORMATION ASYMMETRY
- CHALLENGES THE ADVANTAGE OF SECRECY

## 06 ESCALATION RISK

GREATER VISIBILITY CAN INCREASE SUSPICION AND MISPERCEPTION.

- ROUTINE ACTIVITY MAY BE MISREAD
- SIGNALS CAN BE MISINTERPRETED
- HIGHER RISK OF REACTION AND COUNTERACTION

## 05 PRIVACY

PERSISTENT OBSERVATION REDUCES THE ABILITY TO OPERATE UNNOTICED.

- PATTERN-OF-LIFE ANALYSIS REVEALS INTENT
- SENSITIVE SITES AND MOVEMENTS AT RISK
- PROTECTING PERSONNEL AND OPERATIONS BECOMES MORE DIFFICULT

01



02



02

## SPEED

FREQUENT REVISITS AND RAPID DELIVERY COMPRESS THE DECISION CYCLE.

- FASTER DETECTION OF DEVELOPMENTS
- SHORTER TIME FOR ASSESSMENT
- FIRST-MOVER ADVANTAGE TO THE BETTER INFORMED

03

## TRANSPARENCY

VISIBLE ACTIVITY CREATES PRESSURE AND ENABLES SCRUTINY.

- EXPOSURE OF MILITARY BUILD-UPS AND ACTIONS
- SUPPORTS DIPLOMATIC VERIFICATION
- PUBLIC AND ALLIED OVERSIGHT INCREASES

03



04

## RESILIENCE

DIVERSE SOURCES IMPROVE AWARENESS AND REDUCE SINGLE POINTS OF FAILURE.

- MULTIPLE PROVIDERS AND PLATFORMS
- HARDER TO DENY OR DECEIVE CONSISTENTLY
- STRONGER CONTINUITY IN CONTESTED ENVIRONMENTS

04



05



06



BROAD ACCESS TO  
COMMERCIAL IMAGERY  
RESHAPES STRATEGIC  
DYNAMICS



### KEY TAKEAWAY:

COMMERCIAL SATELLITE INTELLIGENCE DOES NOT GUARANTEE OUTCOMES, BUT IT IS SHIFTING THE STRATEGIC ENVIRONMENT. POWER INCREASINGLY DEPENDS ON HOW NATIONS MANAGE INFORMATION, ADAPT, AND MAINTAIN LEGITIMACY.

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