Dynamic Database

Efficiently convert massive quantities of sensor data into actionable information for tactical commanders

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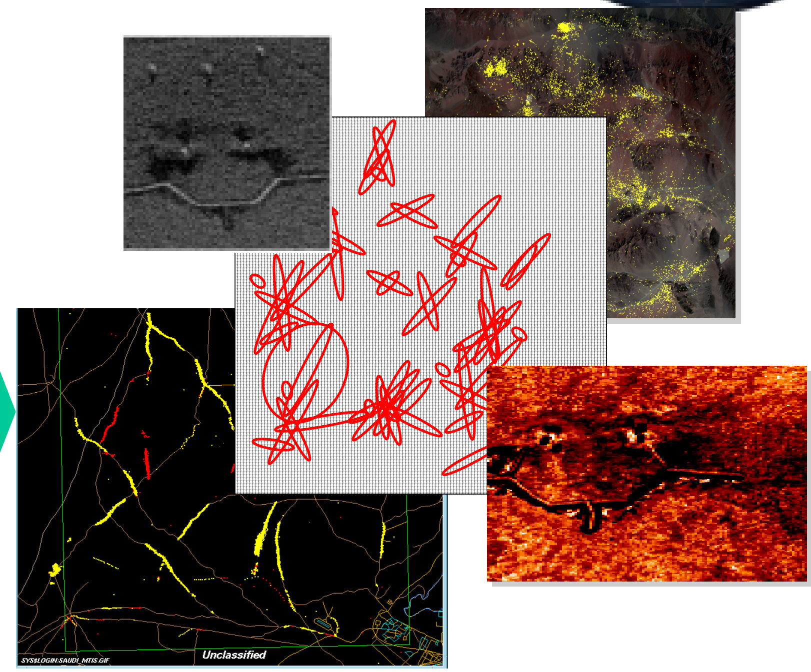
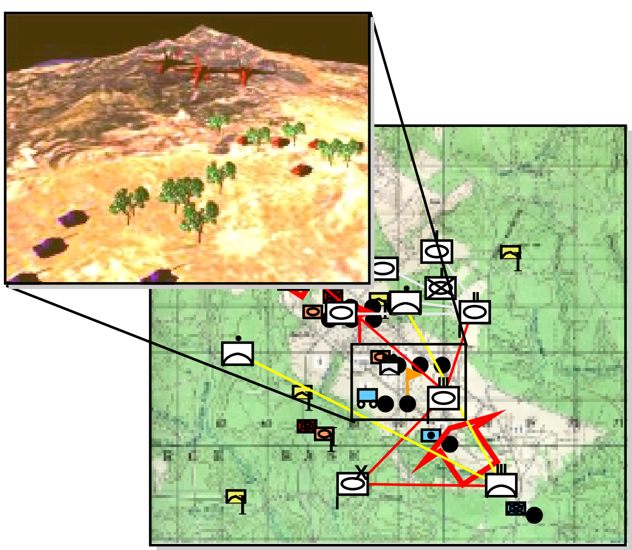
Motivation

- *What the Commanders get . . .*
  - Large numbers of partially overlapping sensors
  - 100s of reports; 1000s of images per minute
  - Unregistered, soda straw sensor observations
  - Very high false alarm rates
  - Signals - based

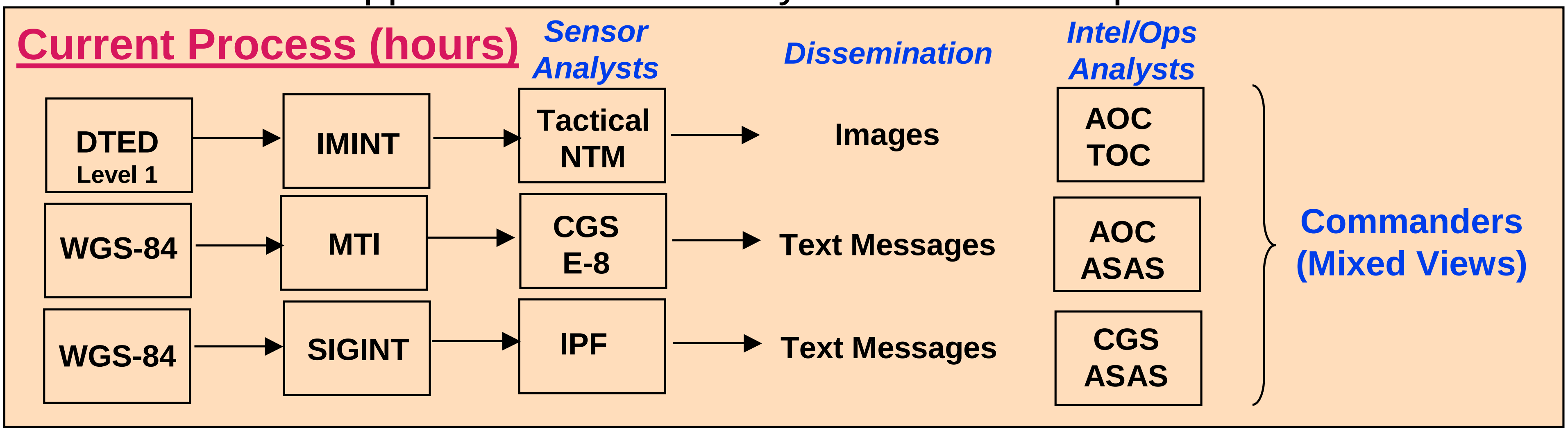




- *What the commanders want . . .*
  - Timely situation knowledge
  - Comprehensive coverage (>1000 targets over ~1000 Km^2)
  - Accurate target locations with small Circular Error Probabilities
  - Low burden, geo-referenced database

The Problem

- Sensor data increasing exponentially
  - FIA, Global Hawk, etc.
- Single source analysts decreasing at high rate
  - No multi-sensor analysts
- Targeting decision cycle delayed by manual processing
- Missed opportunities caused by too much un-exploited data



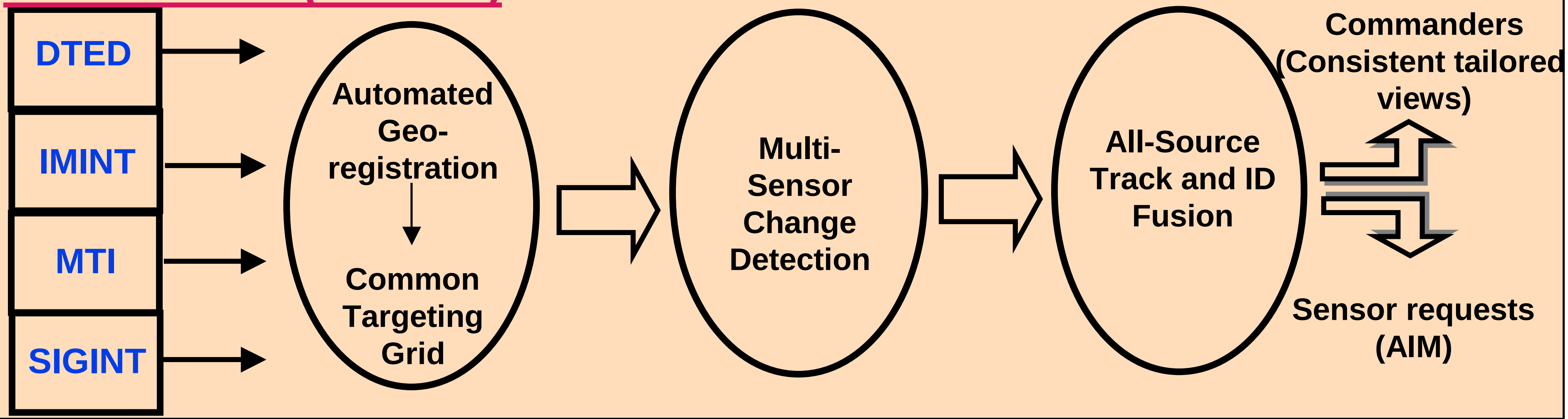
- Example - Image centric surveillance - Kosovo
  - Pixel by pixel "eyeball change detection"
  - Single sensor at a time("stovepipe analysis")
  - Manual exploitation - hours to days for product
  - No automatic multi-sensor geo-registration

Consequence: *Failure to find / identify targets*

DDB Solution

- **Common geo-registered database**
  – Common grid tied to wide area terrain data (DTED, CIB, FFD)
  – Multi-sensor observations (SAR, EO, IR, GMTI and SIGINT)
- **Fusion across sensors**
  – Model based evidence accumulation
- **Track targets and features at object level**
  – Wide area coverage, large numbers of targets
- **Dynamic closed loop tasking overcomes missing/ambiguous data**
  – Self evaluation of database and task requests to AIM

DDB Solution (minutes)

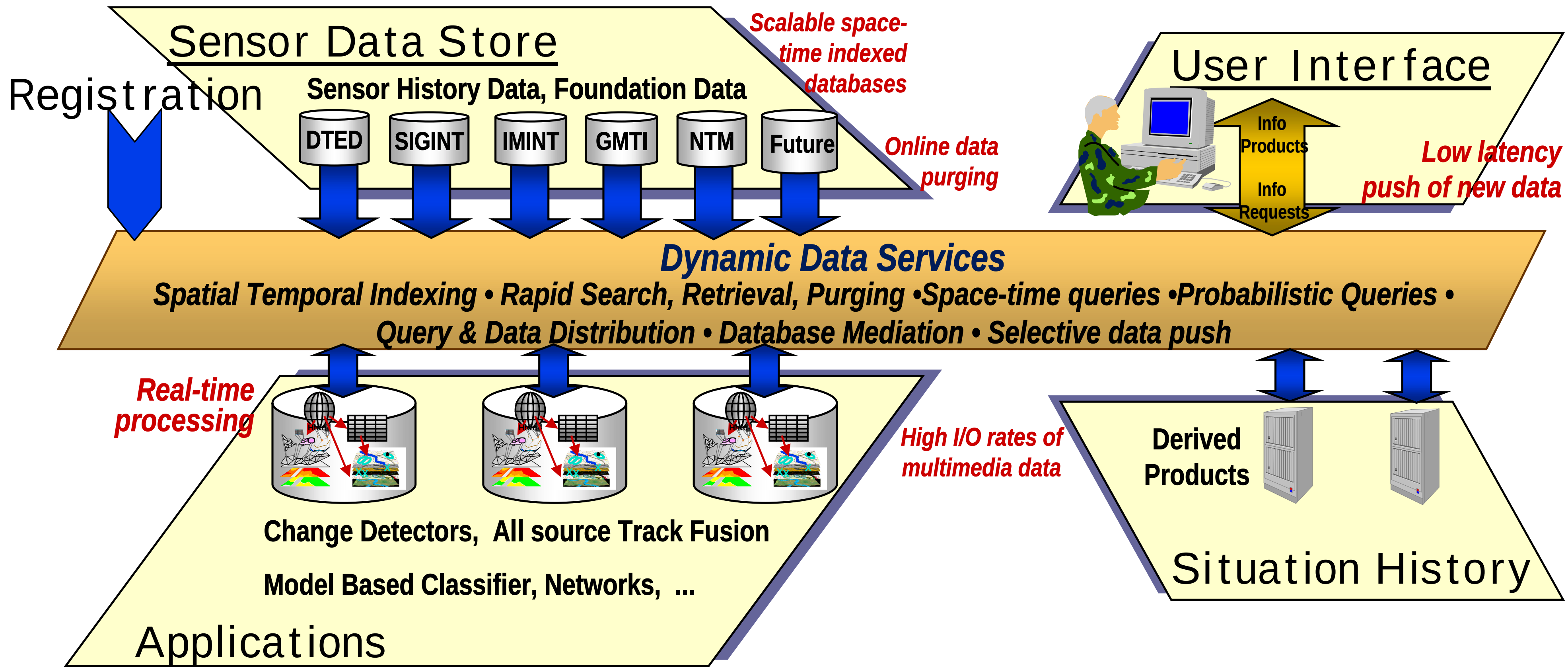


Dynamic Multi-sensor ISR Database

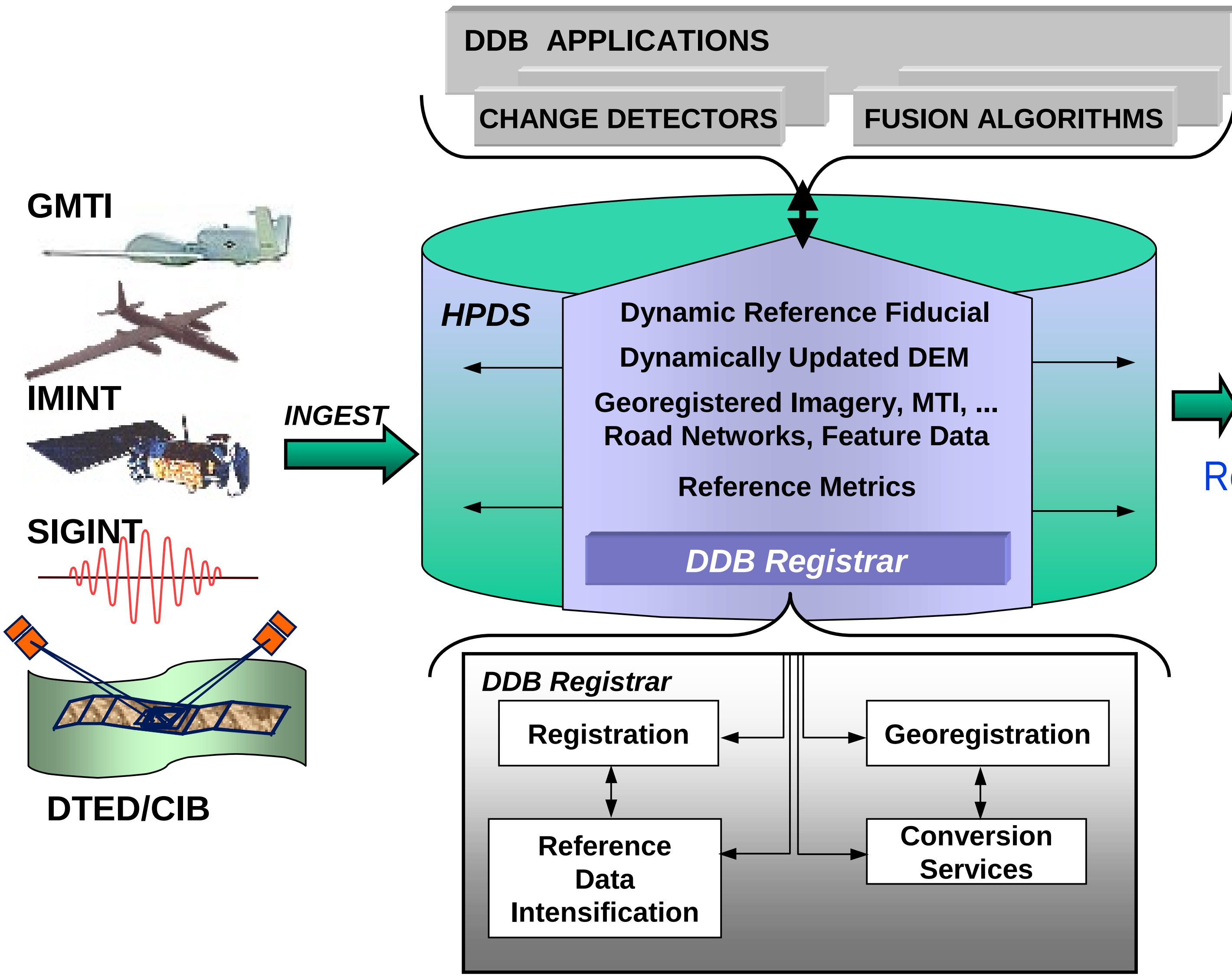
DDB Architecture

Enables Sensor Data Access and Technology Growth

- Database architecture overcomes limitations of data ownership
- Enhances:
  - Data sharing, interoperability
  - Technological growth - applications and visualization
- Leverages COTS thrusts in “open systems” & “object oriented databases”
  - Explore military needs which exceed likely commercial interests



Registration of all Sensors to a Common Targeting Grid

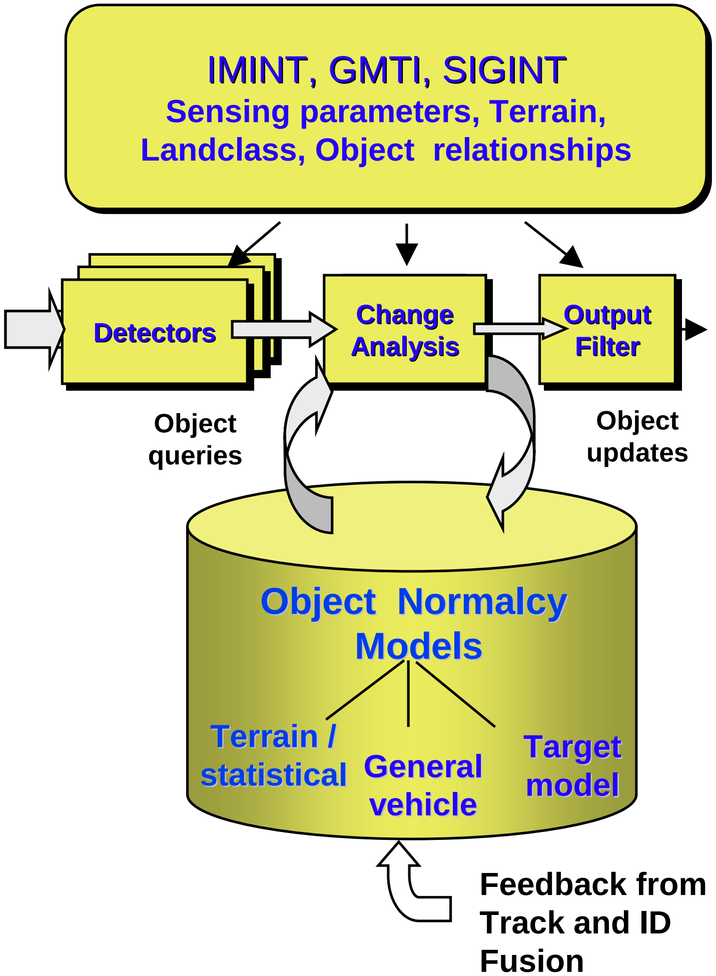


Absolute geospatial accuracy for targeting (~10 m.)

Relative georegistration for change detection (<1m.)

Dynamic update of reference data

Normalcy Models Enable Wide Area Change Detection



Normalcy models provide context for detection thresholds

- Is this a region of high clutter?
- Was it there on the last sensing pass?
- Has it changed state or shape?
- Is it emitting as expected?
- Is it moving in a new way, place, or time?

Combined multi-sensor data is required to derive normalcy

- Spatial, temporal, feature based representation of scene content, background, and behavior.

SIGINT Change Detection Approach

COMINT Intercepts (DF/TDOA/FDOA location measurements, extracted audio)

Target reports

Message Handler

ELINT Intercepts (DF/TDOA location measurements)

COMINT Multi-Platform Association

COMINT Radio/Platform Pairing

ELINT Multi-Platform Association

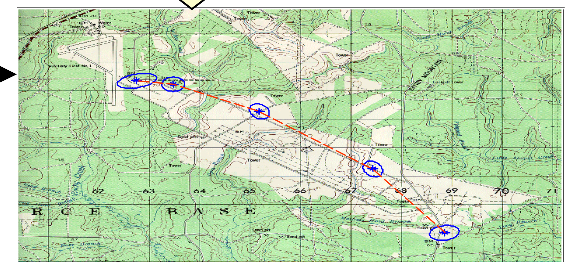
EOB / Weapon System Pairing

COMINT Tracking & ID Features

COMINT / ELINT Correlation

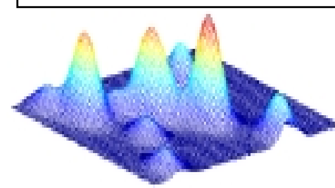
ELINT Tracking & ID Features

Alerts for tactically significant events

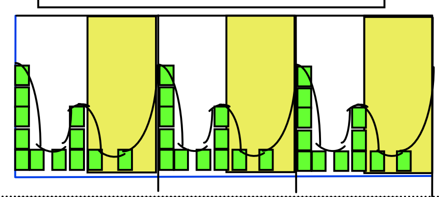


SIGINT Tracks, ID

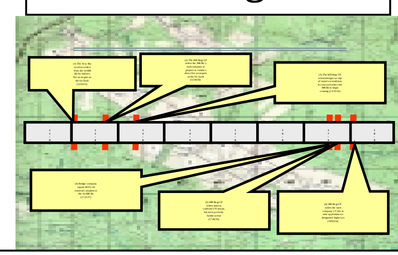
Emission Density



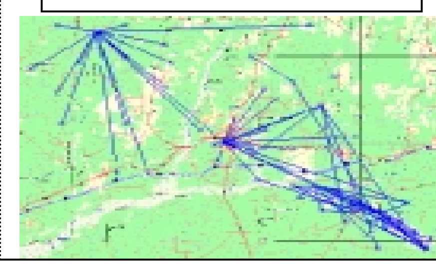
Emission Profile



Event Recognition

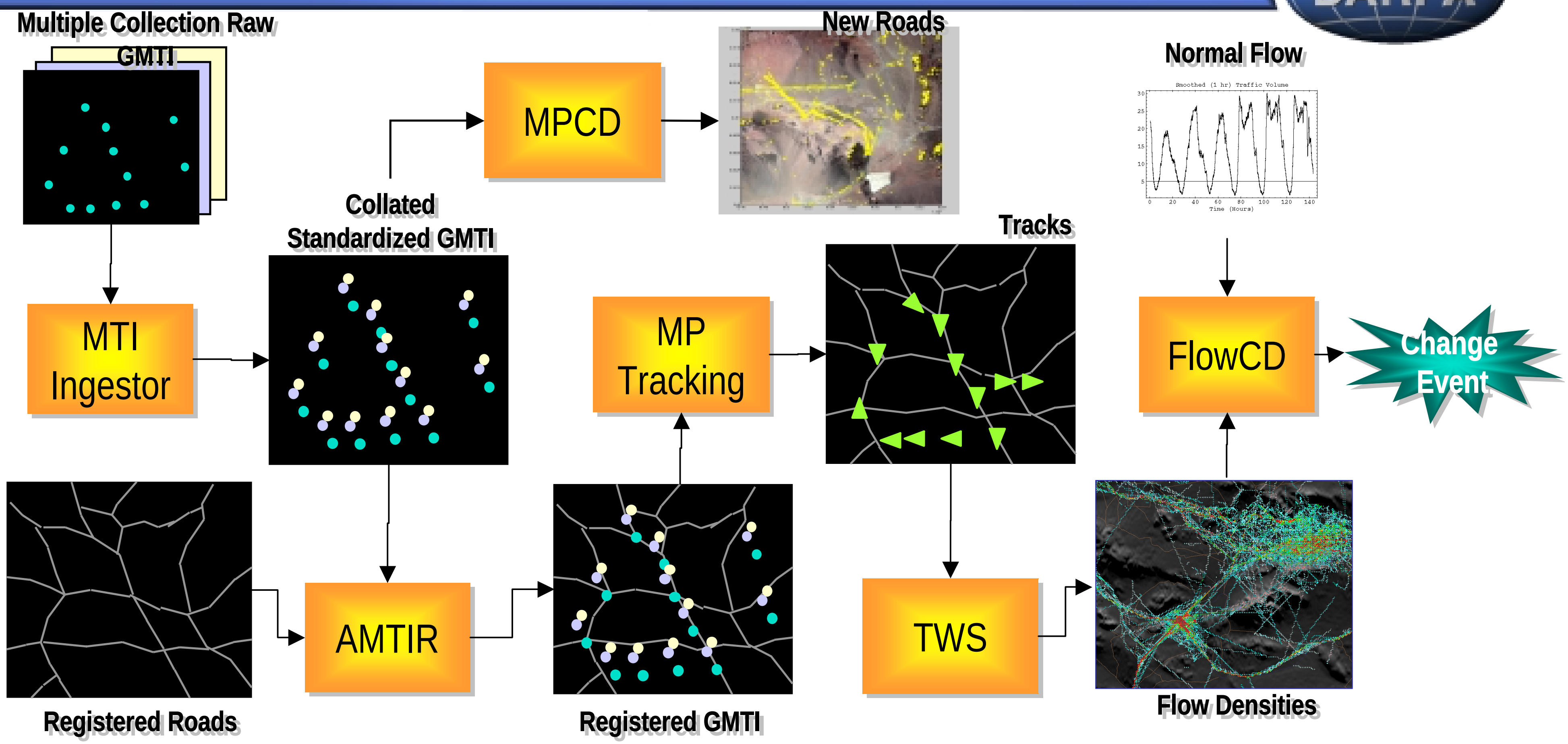


Comm Network



- **Analysis of spatio-temporal structure of RF activity:**
  - **Emission Density** - Exploits spatial features of the battlefield
  - **Emission Profile** - Exploits periodic activity of the battle space
  - **Communication Network** - Maps lines of communication between entities and echelon levels

GMTI Change Detection Approach



Ingest

- Common representation
- Sensor History Database
- Spatial-temporal indexing

Register

- Improved position accuracy
- Improves multi-source fusion

Multi-Platform Tracking

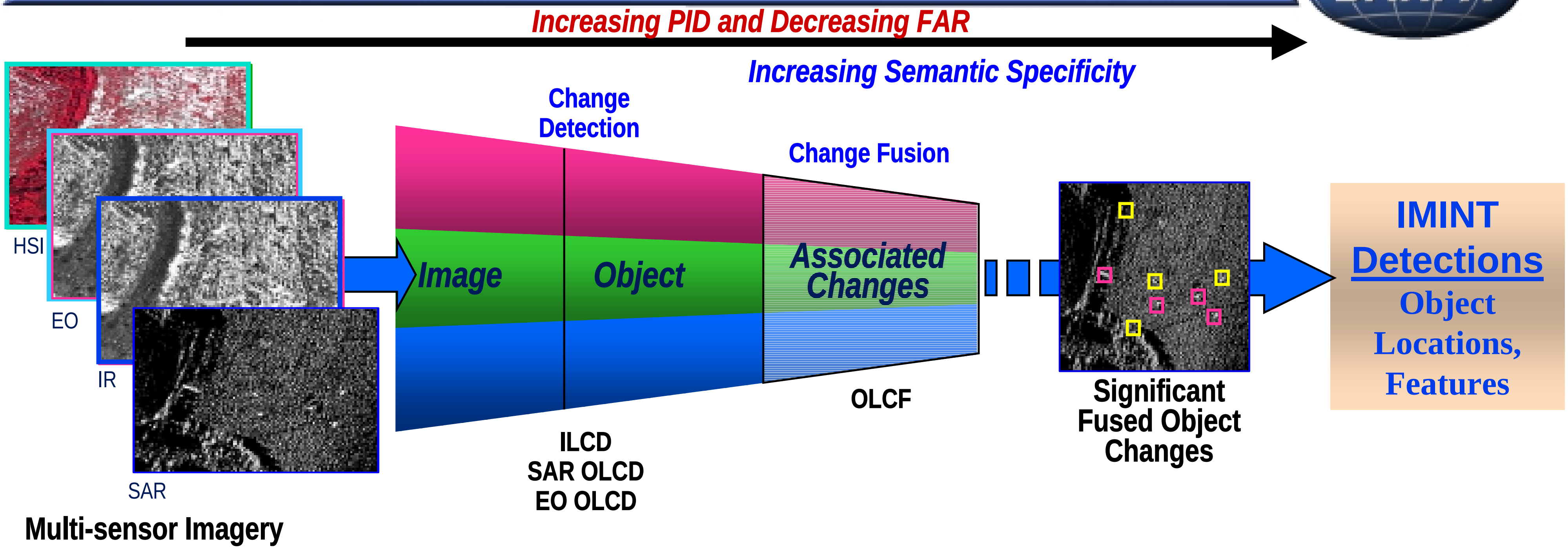
- Improved track continuity, purity, position and velocity accuracy

Traffic Flow

- Wide area movement estimates
- Indications and warnings of significant movements

AMTIR - Absolute MTI Registrar	MP - Multiple Platform	MPCD - MTI Pattern Change Det.	TWS - Trip Wire Sentry	FlowCD - Flow Change Det.

IMINT Change Detection Approach

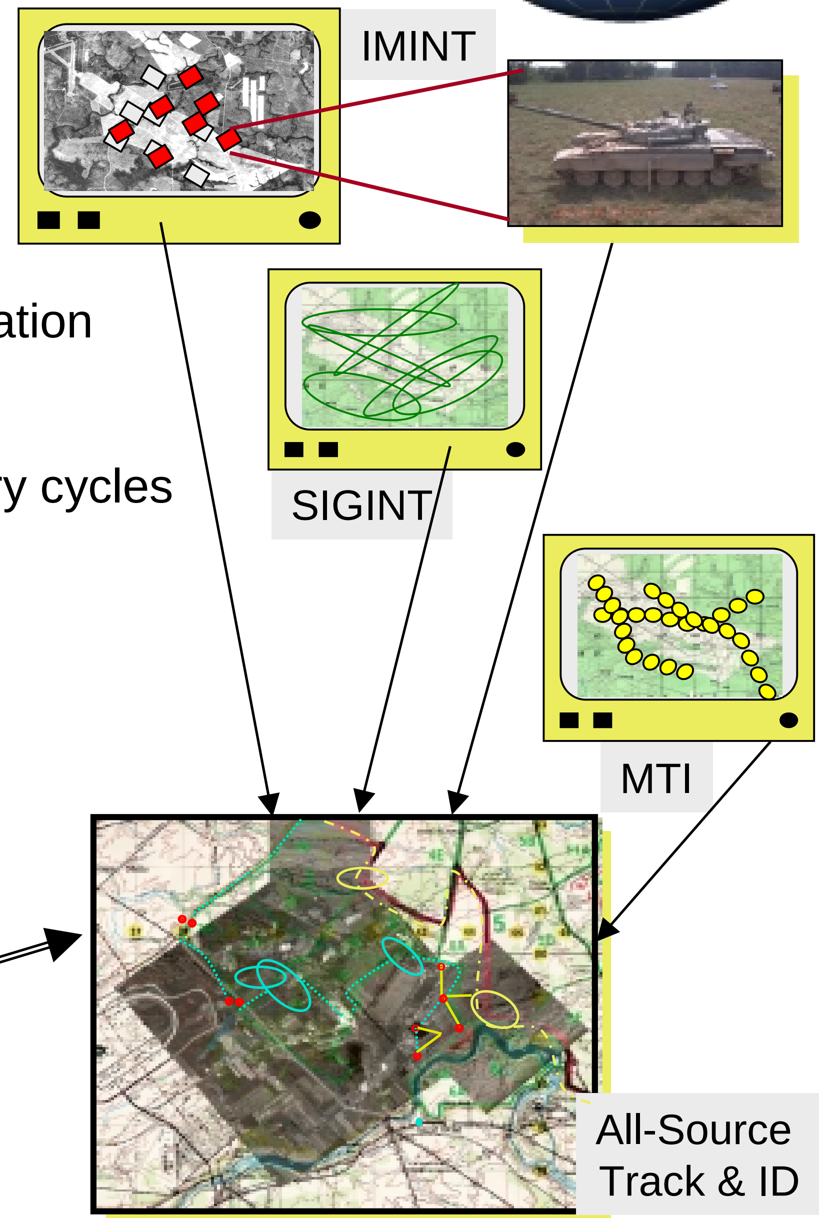


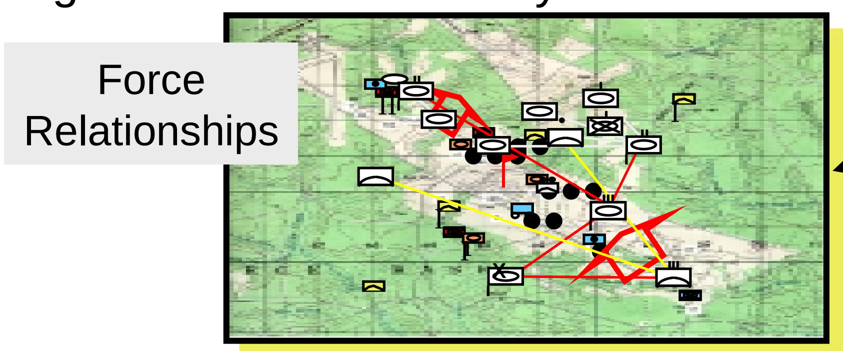
- Sensor history enables “modeling” of image response under various conditions
  - Image-level
  - Object-level
- Object Level Change Fusion enables decorrelation of false alarms
- Change fusion provides high confidence discovery of objects for simultaneous track & ID

Multi-look -- Multi-temporal -- Multi-sensor -- Multi-algorithm Fusion

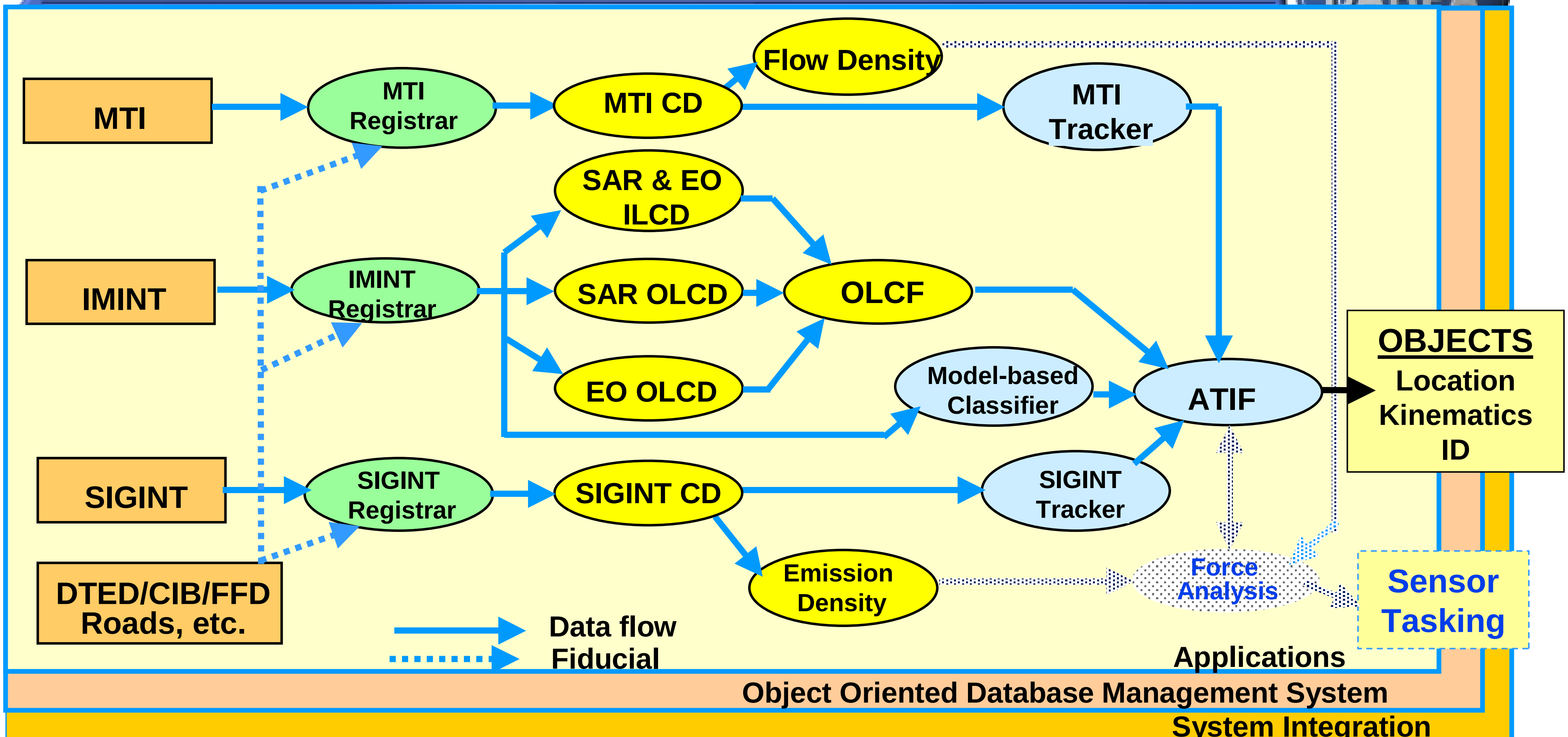
All-Source Track & ID Fusion Approach

- **Fuses Change Detector Outputs**
  - Detections, tracks, identifications, features
  - MHT (Multiple Hypothesis Tracker)
  - Support sensor tasking
- **Target Identification**
  - Fuse and maintain SIGINT/ IMINT identity information
  - Model based classifier
    - EO and SAR classification of vehicles
  - SIGINT ID features link with moving and stationary cycles
- **Target Track Continuity Through Move-stop-move Cycles**
  - Fuse GMTI and SIGINT when moving
  - Fuse IMINT and SIGINT when stopped
  - Increase track length relative to MTI alone
  - Recognize force level activity and relationships





DDB Algorithm Relationship



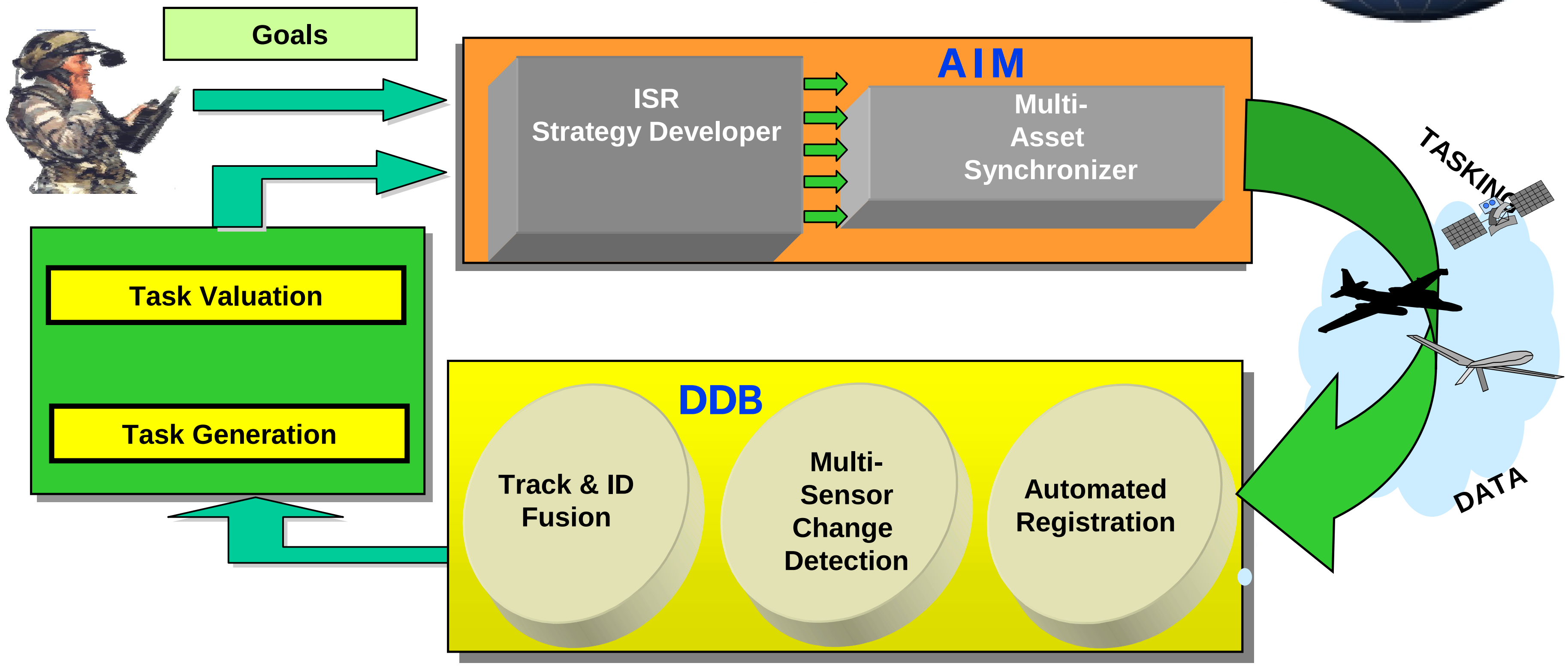
- **Registration:**
  - Shared multi-spectral fiducial
  - Salient feature matching
  - Iterative refinement

- **Change Detection:**
  - Adaptive background modeling (normalcy)
  - Spatial and temporal pattern analysis
  - Tripwires

- **All-Source Track & ID:**
  - Correlates detection features from sensors
  - Accumulate over time
  - Maintain through move/stop/move cycles

I LCD: Image Level Change Detection ◆ OLCD: Object Level Change Detection ◆ OLCF: Object Level Change Fusion ◆ ATIF: All-Source Track & ID Fusion

Data Driven Collection Management

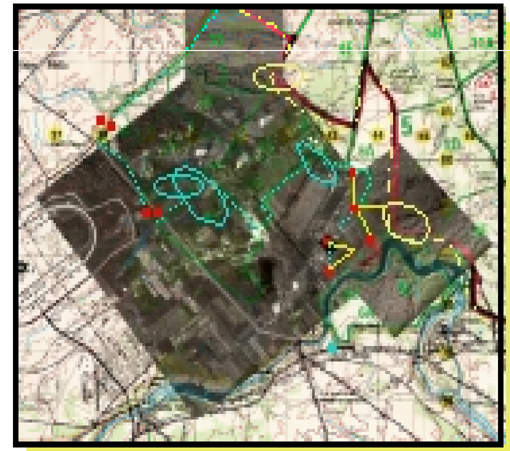


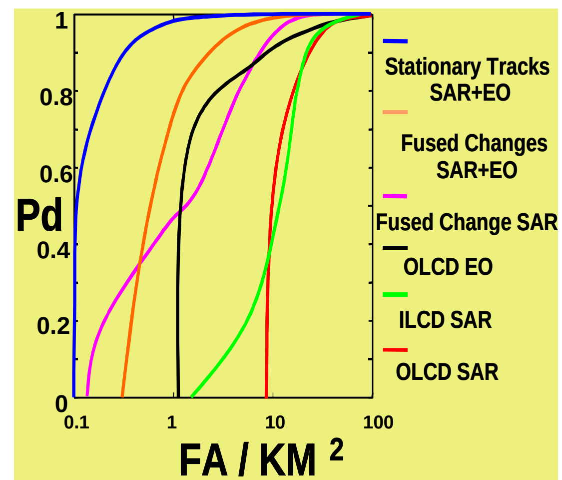
- **Goal: Close the Loop Between Collection Management and Situation Estimation**
  - Now: Manual coupling
    - Forces tasking focus to be on static targets
    - Limits use of uncertainty info in task valuation
  - Future: Automate process by developing
    - Task generation from ambiguities in fused product
    - Task valuation based on uncertainty estimate of the current situation

DDB Accomplishments

Demonstrated Benefit of Fusion Gain

- **Wide Area Change Detection (WACD)**
  - **IMINT**
    - **Statistical normalcy models to recognize change and reject false alarms**
    - **EO/SAR fusion reduced FAR ~4x in experiments**
  - **MTI**
    - **Increased track continuity by 27%**
    - **Reduced error in position by 37%**
  - **SIGINT**
    - **New emitter mapping and profiling capability**
    - **50% reduction in emitter location error through multi-platform fusion**
- **All-source track and ID Fusion (ATIF)**
  - **Developed new capability to maintain track through *move - stop - move* cycles**
  - **Association of mover/sitter tracks extends track continuity ~x4**
- **Dynamic Data Services**
  - **Common targeting grid**
  - **Registered sensor histories over space and time**





Foundation technologies to produce a timely, accurate estimate of the ground situation (kinematics, locations and IDs of objects)