Turning Imagery Into Awareness

Defense Applications in Geospatial Imaging

30 May 2006
Agenda

- IMAGINE
- Defense Software Applications
- Production Solutions
- Special Projects in Defense
Defense Customer Base - Functional Areas

Imagery
Intelligence

Terrain Analysis

National Mapping

Target Analysis

Data Visualization
National Mapping Programs

National Geospatial-Intelligence Agency (NGA)
- Currently has 3500 + Licenses
- Softcopy Search Program
- Integrated Exploitation Capability - IEC (Lockheed Martin)
- Front End Processing Environment – FPE (BAE)
- Partnership for Peace Program (PFP)
- NGA College and Defense Mapping School

UK DGIA Project P (Raytheon)
Survey of India’s Data Production & CartoSat
Swiss Topo National Mapping Feature Capture & Editing
Multi-national Geospatial Co-production Program (MGCP)
Algeria Ground Station (Indian National Remote Sensing Agency)
Thailand’s THEOS Project (EADS)
Colombian Air Force (FAC) ADS-40 Recce
Tactical Mapping Solutions

MiSIPS
Spectral processing for terrain categorization

Combat Terrain Information System (CTIS)
Performs terrain analysis, elevation extraction, special mapping, and terrain visualization for the U.S. Army. Soon to be fielded to the Brigade level

TPC
Marine Corps rapid response mapping

RGSS
Rapid Geospatial Support System
Keys to Effective Geospatial Intelligence Production

- Accuracy
  - Rigorous sensor models
  - Assessment
- Automation
  - Replace repetitive and mundane tasks
  - Analysts handle the complex
- Integration
  - Internal
  - External
- Versatility
  - Offer extensive suite of tools for changing situations
  - SDK
- Training
  - Varying skills
  - Consistency
IMAGINE is the Foundation

Numerous imagery and data formats
Extensive image processing, analysis and intelligence extraction tools
Rigorous sensor models
IMAGINE Data Ingest

- 150 Ingest Formats
- 60 Export Formats
- NITF 2.0/2.1
- TFRD 1.29, 2.3, 4.3
- CADRG, CIB, ADRG, ADRI
- We Manufacture the Leading Photogrammetric Scanner Leica DSW700
- NGA Imagery Archive

Ingest
- National Technical Means (NTM) e.g.,
  - NITF (2.0, 2.1)
  - TFRD 1.29, 2.3, 4.3
- Mensuration Support Data Block (MSDB)
- Rapid Positioning Capability Data Block (RPCDB)

Commercial e.g.,
- IKONOS
- Landsat
- SPOT
- Other, current & future

Geospatial e.g.,
- DTED (All levels)
- USGS Digital Elevation Models (DEM)
- ADRG/CADRG Maps
- Vector
- Shape

Other
- Hardcopy scanning (all types)
- Airborne
- MSI/HSI

JPEG 2000 NGA Ready
The IMAGINE Geospatial Light Table

Simplified all IMAGINE tools

Multiple image exploitation

Up front functionality

All layers all the time

Imagery exploitation and GIS in a single interface
The New Imagery Standard
NITF 2.1 JPEG 2000

• Read/Write NITF & NSIF 2.0, 2.1
• JPEG 2000 encoder
• Original: 210MB
• JPEG 2000: 11MB
• Variable compression

IKONOS image of Kuala Lumpur, Malaysia courtesy Space Imaging

• JITC L 6/7 certification
• Support for TREs
• Advanced model support
• Adaptive quality roam
• Decoding on the fly
NITF XML TRE Tree View
RADAR Sensor Support

RADAR Mapping Suite and RADAR Interpreter improvements are driven by defense client requirements. These clients are moving to IMAGINE for Ground Station Processing Segments.
Hyper-Spectral Workspace

Select tasks

Select pre-processing

Hierarchical signature library structure

Current signatures in use for processing

Multiple linked viewers for zoom and overview

Signature plots... Select bands for display

Display results
Thermal Imagery Exploitation

Intelligence from thermal imagery

MTFC
Radiometric correction
Research and Negation Tools

- Multiple simultaneous roaming viewers
- Tree view for controlling image layering
- Unlimited layer swipe
- Change detection algorithm
Metric Accuracy Assessment (MAA) Tool

The MAA tool provides a means of calculating the accuracy of mono or stereo pair imagery using photo-identifiable ground control points.

Driven directly from the exploitation viewer

Control (or Test & Evaluation – T&E) points can be manually entered or read from file

Global error statistics
Individual point error and statistics
Error report
Traditional IMAGINE Decision Aids

- Corridor Analysis
- Trafficability Analysis
- Image Maps
- 3D Threat Analysis
- Point Analysis

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IMAGINE 9.0 for the Enterprise

- Imagine GLT
- Real Time Vector Editing
- HTML Client
- Clients: Handheld Devices

Query, retrieve and fully exploit Arc SDE Raster & ORACLE 10g GeoRaster

Data Editor

RDBMS
Future Database Directions

Spatial Query

Imagery Tables

Processing Tables

Contrast Filter Projection

A powerful foundation for server side image processing
Defense Software Applications

Softcopy Search Imagery Analysis Solution
Mission Data Production System
Commercial Joint Mapping Tool Kit Software
The Softcopy Search Imagery Use Case

Define Search Task

Gather Imagery & Support Data

Build Image Mosaic

Exploit Area Imagery

Track Status & Re-Task Imagery

Produce Reports
Softcopy Search System Design

Oracle
Arc SDE
SYBASE
MS Access
ODBC Connectivity
HTTP Servlet Connectivity

Imagine Professional
Global Retriever (GRV)
Geospatial Light Table (GLT)
NITF Module
Stereo Analyst
Softcopy Search (GEOINT) Solution

Global Retriever (GRV)

Geospatial Light Table (GLT)

- Exploit Imagery Call From GRV
- Exploit Imagery (FTP Call)
- User Selected images from Thumbnails and Footprints
- Metadata Filters
  - Sensor Type
  - Cloud Cover
  - NITF
  - GSD
  - DateTime
  - BNE Number
  - Boolean Operators
- The Discovery Viewer
- Project Workspace Viewer
- GRV SQL Builder
- GRV Mapped View
- Thumbnails
- Support Data
- Raw Imagery
- External Data Server
- Relational Database Manager

Overview
Exploitation
Stereo
Softcopy Search Workstation
Local Data Storage
- Exploitation Imagery
- Snail Trail Files
- Extracted Features

GLT Software Components
- Professional
- NITF
- Vector
- Stereo Analyst
- Defense
- Productivity Module

Exploitation Capabilities
- Roam & Zoom
- Auto Roam
- DRA
- Ruler
- MTF
- Snail Trail
- Virtual Mosaic
- Annotation
- Vector Overlay
- Slope Analysis
- Line of Sight
- MS/HSLI
- Change Detect
- Ortho Correct
- Sensor Merge
- Magnifier
- Linked Viewers

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Gather Imagery: The Global Retriever Viewer

**Discovery View**

- Discover image files located on various imagery libraries located throughout the community.
- Support both geospatial queries and metadata filters to select required images.
- Allows user defined map backdrops to support detailed geospatial data queries.
- Display footprints and thumbnails to aid in the selection process.

**Workspace View**

- Stores the various files/images of a project as determined by the analyst.
- Allows instant access to all the images of a saved project.
- Image files can be added and subtracted as needed.
- Pushes selected images directly into the GLT for immediate exploitation.
Imagery Management – Global Retriever Functionality

Geospatial Queries
NGA Gazetteer

Imagery Footprints
Image “Flipper”

Imagery Management – Global Retriever Functionality
Highly automated CIB / CADRG production

Mission Data Production System (MDPS)

Significant speed-up of the IMAGINE RPF exporter (5X)

Map Production Timeline

<table>
<thead>
<tr>
<th>Activity</th>
<th>Minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Search and Retrieve Data</td>
<td>30</td>
</tr>
<tr>
<td>Geo-registration</td>
<td>30</td>
</tr>
<tr>
<td>Raster Mosaicking</td>
<td>60</td>
</tr>
<tr>
<td>Image Enhancements (Fuse Data)</td>
<td>60</td>
</tr>
<tr>
<td>Write to CADRG at ONC 1:1000000 with 150m pixels (allocated, *=measured on less capable hardware)</td>
<td>60 45*</td>
</tr>
<tr>
<td>Total for one map (allocated)</td>
<td>240 (4 hrs)</td>
</tr>
</tbody>
</table>

External Source Data
- Maps and Charts
- Raster Scanning
- Digital Imagery Data
- Digital Elevation Data

DATABASE Sources
- Geospatial Data Catalog (GDC)
- DATABASE Product Archive

Global Retriever (GRV)
- View & Verify Feature Data
- Geo-Register
- Ortho-Rectify
- Imagery Mosaic

ERDAS IMAGINE Software
- Export CIB
- Export CADRG
- Fuse Data
- Raster Mosaic
- Add, modify, & delete Feature Info

Mission Data Production System (MDPS)

To JMPS

DCHUM Overlays

Write to CADRG at ONC 1:1000000 with 150m pixels (allocated, *=measured on less capable hardware)

Optima Professional Graphics Workstation

OPTIMA Professional Graphics Workstation

Contex MAGNUM Scanner

Media Adapter, as Required

Contex MAGNUM Scanner

470 45*

60 Image Enhancements (Fuse Data)

60 Raster Mosaicking

30 Geo-registration

30 Search and Retrieve Data

130 External Source Data

240 (4 hrs)

240 (4 hrs)

Maps and Charts

Raster Scanning

Digital Imagery Data

Digital Elevation Data

Contex MAGNUM Scanner

Media Adapter, as Required

Contex MAGNUM Scanner

Media Adapter, as Required

Contex MAGNUM Scanner

Media Adapter, as Required

470 45*

60 Image Enhancements (Fuse Data)

60 Raster Mosaicking

30 Geo-registration

30 Search and Retrieve Data

130 External Source Data

240 (4 hrs)

240 (4 hrs)
GRV Modified for Production Management

- Radio buttons choose the workflow; CADRG or CIB
- Red & Green cells indicate where you are in the workflow
- ENHANCE indicates if color adjustments were made
- DTED indicates corresponding elevation information is available
- ORTHO indicates the image has been orthocorrected
- CIB indicates if the RPF frames have been created
Auto-locating DTED

Because Orthorectification requires terrain data, RPF WS will automatically find the imagery for which there is corresponding elevation data.
<table>
<thead>
<tr>
<th>ENHANCE</th>
<th>CHUM</th>
<th>CADRG</th>
</tr>
</thead>
</table>

- Enhance
- Edit CHUM
- Output CADRG
MDPS Controlled Image Base (CIB) Production Workflow

<table>
<thead>
<tr>
<th>ENHANCE</th>
<th>DTED</th>
<th>ORTHO</th>
<th>CIB</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Improved CIB/CADRG Export Time 5X
Operate in Complex Terrain

All Source Imagery

Imagery Provided by TEC

Understand Threat Changes

Geospatial Accuracy
**IMAGINE C/JMTK Example Application**

**PURPOSE:**
Provide a valid image processing application client designed to use various ERDAS IMAGINE Objects integrated into ARC Server

**Auto Warping Engine (AWE)**
This application takes raw sources of imagery and creates oriented images either geographically or stereo referenced.

**Change Mapper**
This application provides both visual and automatic tools used to locate and analyze changes between two images.

**Stereo Client**
This light client provides for the exploitation of stereo imagery via a web based application.
C/JMTK Client

Geospatial Imagery Agent

C/JMTK Funded project for web based imagery applications

- LGGI image analysis technology including Auto Warp, GRV and Stereo Analyst
- Built upon ESRI Server Technology
- Global Retriever Search functions to the Web
C/JMTK “Auto-sync”
C/JMTK Compare
C/JMTK Change Mapper
Production Solutions

Multinational Geospatial Co-Production
LPS Triangulation
MGCP

- Multi-national Geospatial Co-producer Program
  - VMAP2-type (1:50K and 1:100K attributed 2-D vector data) production
  - 28 nations with 11 lead are participating
  - 2714 one degree cells from now to 2011, many North of 60 degrees
  - Production requirements vary, but source is primarily commercial satellite imagery, with some supplemental DPPDB for control, and maps/DTED
  - Ortho production may be required to be returned to US if NGA pays for data
  - Data will be shared among all who meet a minimum production requirement
MGCP LPS Imagery Preparation

MGCP is designed for nations to share co-produced image based feature data using Geodatabase technology.
MGCP LPS Imagery Preparation

- Triangulate
- Vector Features
- 3D Vector Feature Extraction
- Vector Feature Extraction into Arc GIS w/SAfA
MGCP is designed for nations to share co-produced image based feature data using Geodatabase technology.
MGCP IMAGINE Imagery Preparation

Mosaic Orthos

Vector Features

Database

Image Based Vector Feature Extraction
LPS for Defense Triangulation

• Two QuickBird 2A images with about 15% overlap
• Ground control on one image
• Images from CSIL tiled into 4 non-overlapping pieces each
• Update positional accuracy of both images
Combine Chips

- CSIL images that are chipped must be recombined with the Unchip Tool
- Assembled file stored as .img with RPC, with pyramid layers
- Unchip Tool may be found under Data Prep
MAA Tool
MAA Tool

- MAA Tool allows accuracy check before adjustment
- Launch from GLT viewer Utility menu
- Graphical display can aid point measurement in LPS
- See MAA Tool Help file for workflow

- Pre-adjustment results ->

- MAA Report for 77574
  - Mean latitude error: 4.639773
  - Mean longitude error: 23.695586
  - Mean horizontal error (average HE): 24.152368
  - Standard deviation latitude error: 0.551383
  - Standard deviation longitude error: 0.549356
  - Standard deviation horizontal error: 0.526512
  - 90% Circular Error (against T&E): 24.827093
  - 90% Circular Error (T&E and mensuration error included): 24.832128
Block Setup

• Start LPS and enter a block name
• Model Setup
• Block Property Setup – use defaults
• Ignore warning about vertical reference mismatch
Block Setup
Control Point Import

- Launch point measurement tool (classical)
- Create ASCII text file with points, one per line
- Select Import/Export Points Icon
- Use format definition to assign fields to file entries (see next slide)
Set and Measure Control

- Select all points in the Cell Array and click the link icon in the point measurement tool palette to compute image coordinates for ground points.
- Use link boxes and windows to locate points and measure.
Measure Tie Points
Refine RPC polynomials

- Open Triangulation Properties and select polynomial refinement with order 0
- Click Run, then Review results
- Check control and pass points with high residuals (typically greater than 2 pixels) for proper measurement and coordinate entry.
- Rerun, and Accept when satisfied with the results
Polynomial Refinement

- Order 0 is a lat and lon shift – need at least 1 GCP (should have 2)
- Order 1 is an affine transformation in lat and lon – need at least 3 GCP (should have 4)
- Start with Order 0 and try Order 1 to see if results improve
- Avoid higher orders unless you have significant control
- May be best to solve image with control first, then add image with only tie points
- Need at least 2 tie points for Order 0 and 6 for Order 1
Calibrate Images
Check with MAA Tool

- **Pre-adjustment**
  - Mean latitude error: 4.639773
  - Mean longitude error: 23.695586
  - 90% Circular Error (T&E and mensuration error included): 24.832128

- **Post Adjustment**
  - Mean latitude error: 1.076928
  - Mean longitude error: 0.232564
  - 90% Circular Error (T&E and mensuration error included): 1.808512
SRTM Holes
Terrain Editor - Collect Polygon
Terrain Editor – Surface Fill
Terrain Editor - Cleanup
Terrain Editor – Contour Check
Special Projects in Defense

Smart Editing Tools (SET)
Target identification and tracking
Vertical obstruction identification
Buckeye
Problem: Automatic feature extraction techniques often result in building blobs and wobbly roads:
- Integrate a Bayesian Network Classifier into IMAGINE
- Works by assigning confidence from multiple extraction processes (buildings, shadows, vegetation)
Smart Editing Tools Use Case
SET Manual Assistance
Target Identification and Tracking

- Exploit Information for identification
- Input observed parameters
- Explicit representation of observation errors
- Statistics returns identification probability

\[
\begin{align*}
F-16 &= 0.87 \\
F-18 &= 0.05
\end{align*}
\]
Target Identification and Tracking

Problem: Use a Bayesian Network to perform Target Identification
- Integrate measurement tools with a Bays Net
- Build a database of potential targets
- Process Multiple Sightings Into a Mobility Prediction Model
Vertical Obstruction Detection

- Calculate Sun Angles...
- Locate Shadow Edges...
- Threshold Shadow Edges...
- Convert Shadow Edges to Polylines...
- Combine Polyline Shapefiles...
- Calculate Polyline Attributes...
- Delete Polylines at Wrong Angles...
- Connect Shadow Edge Pieces...
- Delete Short Polylines...
- Match Shadow Edges...
- Find Obstruction Locations...
- Calculate Obstruction Confidence...

Close Help
Sun Angle Information

![Vertical Obstructions](image1)

- Calculate Sun Angles
- Locate Shadow Edges
- Threshold Shadow Edges
- Convert Shadow Edges to Polylines
- Combine Polyline Shapefiles
- Calculate Polyline Attributes
- Delete Polylines at Wrong Angles
- Connect Shadow Edge Pieces
- Delete Short Polylines
- Match Shadow Edges
- Find Obstruction Locations
- Calculate Obstruction Confidence

![Calculate Sun Angles](image2)

- Select Image: 05jan22103911-p1bs-000000185076_01_p0
- Acquisition Date and Time:
  - Month (MM): 01
  - Day (DD): 22
  - Year (YYYY): 2005
  - Time (HHMM): 1028
- Azimuth: 153.8
- Elevation: 40.4
- Calculate
- Close
- Help

- when it has to be right

Leica Geosystems

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Locate Shadow Edges
Threshold Shadow Edges

- Locate Shadow Edges...
- Threshold Shadow Edges...

Input Image: shadow_edges.img
Threshold: 327
Output Image: threshold_shadow_edges.img

Viewer #1: edges_rotated_back_clipped.png (Layer 1)
- when it has to be right
Convert Shadow Edges to Polylines
Combine Polyline Shapefiles
Calculate Polyline Attributes
Delete Polylines at Wrong Angles
Connect Shadow Edge Pieces
Delete Short (or too long) Polylines
Match Shadow Edges
Find Obstruction Locations
Multi-Temporal Analysis
Verify Obstruction Locations – Muti-Temporarily
Locations from Date 1
Locations from Date 2
Verified Locations
Calculate Obstruction Confidence

Vertical Obstructions
- Calculate Sun Angles...
- Locate Shadow Edges...
- Threshold Shadow Edges...
- Convert Shadow Edges to Polylines...
- Combine Polyline Shapefiles...
- Calculate Polyline Attributes...
- Delete Polylines at Wrong Angles...
- Connect Shadow Edge Pieces...
- Delete Short Polylines...
- Match Shadow Edges...
- Find Obstruction Locations...
- Calculate Obstruction Confidence...

Calculate Obstruction Confidence

Obstruction Shapefile: obstructions.shp

Form View for c:/data/testlocation...

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>ID</td>
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<td>46.4414</td>
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<tr>
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<tr>
<td>B_CENTERY</td>
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</tr>
</tbody>
</table>

Drive to in Viewer   Close   Help
Final Results
Buckeye

Sensor
- Integrate metric digital sensor and LIDAR
- GPS/INS
- Improved mounting platform (stability and portability)

Software
- A near real-time airborne ortho processing capability
- Advanced change detection with hi-res DEM
- Improved 3D feature extraction and modeling
- Processing system fully CTIS compatible

Integrated solution supports both IED Detection and Urban Visualization

Development potentially leads to a standardized off-the-shelf solution
Enhanced Multi-Sensor Workflow

**Ground Operations**

1-2 Hours

**Airborne Operations**

2-3 Hours

**Ground Operations**

2-3 Hours

### Planning

**Digital Camera Mission Planning**
- Altitude
- Camera Firing
- Sensor Selection
- Flight Speed

**LIDAR Mission Planning**
- Mode
- Altitude
- Scan rate
- FOV
- Flight speed
- Flight lines

### Collection

**LIDAR Operations**
- Record POS Data (GPS, IMU)
- Record Scanner Data (Range, Scan angle, Intensity, Timing info)

**Modulis**
- Digital Camera Operations
  - Record POS Data (GPS, IMU)
  - Record Image’s

**ALS50**

### Processing

**Image Post Processor**
- Research and Negation
  - Visual Analysis
- Advanced Change Detection Processing
  - Create Image Change Pairs
  - Create DEM Change Pairs

**Airborne Processing**
- Launch Rectification Service
  - Process Ortho’s
  - Pre Loaded DEM’s

**ALS50 LIDAR Post Processor**
- DEM Generation
  - Output Formatting – LDI, LAS, ASCII

**Record POS Data**
- GPS
- IMU

**Record Scanner Data**
- Range
- Scan angle
- Intensity
- Timing info

**Record Image’s**
- Digital Camera

**DGPS Processing**

**Off Load Data**
Defense Applications Training Courses

Custom Courses Available:
• Photo Interpretation
• Imagery Intelligence
• Radar Imagery Exploitation
• Thermal Imagery Exploitation
• Sensor Fusion Techniques
• Data Production

Standard Courses:
• Geospatial Analysis for Defense
• GLT & IMAGINE for Defense

Tradition of Excellence
Upcoming defense features 9.1/9.2

- CSM support
- Emerging commercial sensor models
- Enhanced TIN and raster terrain handling in LPS
- Improved NITF chipping and coring capabilities and support for many new tags
- Improved NITF exporter with full control over metadata
- Support for NextView imagery
- RPF/MDPS Workstation
- Viewer performance improvements
- Expanded Oracle capabilities
- Map Composer improvements
- 64-bit OS compatibility
- Currency with ArcGIS
- Enhanced intelligence reporting capability
- Radar Mapping Suite enhancements to math models and SAR/IFSAR processing
We have come a long way
Providing Solutions for the Future...

ERDAS IMAGINE software combines image processing, photogrammetry, visualization, and light table functionality into a complete solution.

The introduction of Enterprise Database connectivity allows users to fuse multi-source data with imagery for greater efficiency & effectiveness.

Our 30 years of image exploitation expertise provides the foundation for our expanding multi source data fusion capabilities.

The Map of the Future is an Intelligent Image
Contact

• Dr. Tom Lobonc
• Director, Defense Markets
• 1-404-229-8014
• tom.lobonc@gi.leica-geosystems.com
• Website: http://www.gi.leica-geosystems.com/