

# Joint Capability Technology Demonstration (JCTD)

## *Operational 3-Dimension (Op3D) Next Generation 3D PDF Production*

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# Op3D JCTD - The Problem

- **C**ollection, **P**rocessing, **E**xploitation, and **D**issemination (CPED) of high-resolution 3D products has historically been too time consuming and costly.
- The warfighter has limited means to request, produce, acquire 3D products and is equipped with only limited capability software to fully exploit available 3D products.
- Importing, processing, conversion, and fusion of 3D products is often ad hoc.
- 3D product offerings are generally focused on niche applications and customers.
- 3D product dissemination is typically not available or too bandwidth intense
- There is no centralized storage for DoD produced 3D data
- The result is that we often fail in delivering fully useable and accurate 3D products in time to satisfy the warfighter's urgent needs.





# Operational 3D (Op3D) JCTD Overview

Objective of the Op3D JCTD is to develop and transition capabilities to enhance the **C**ollection, **P**rocessing, **E**xploitation, and **D**issemination of 3D and 3D Derivative GEOINT Products in OCONUS theaters of operation and CONUS geospatial production facilities.

- Started in Spring 2010
- Op3D JCTD is currently in the third, and final, spiral of the JCTD
  - Our individual projects will be completed this fall
- Op3D has invested in sixteen individual tasks
  - Op3D often invested in making improvements to COTS software that was already in use for 3D GEOINT production and had been certified for use on existing DoD systems
  - COTS improvements are available to the entire DoD, and often, commercial GEOINT users



# Next Generation 3D PDF Production Overview

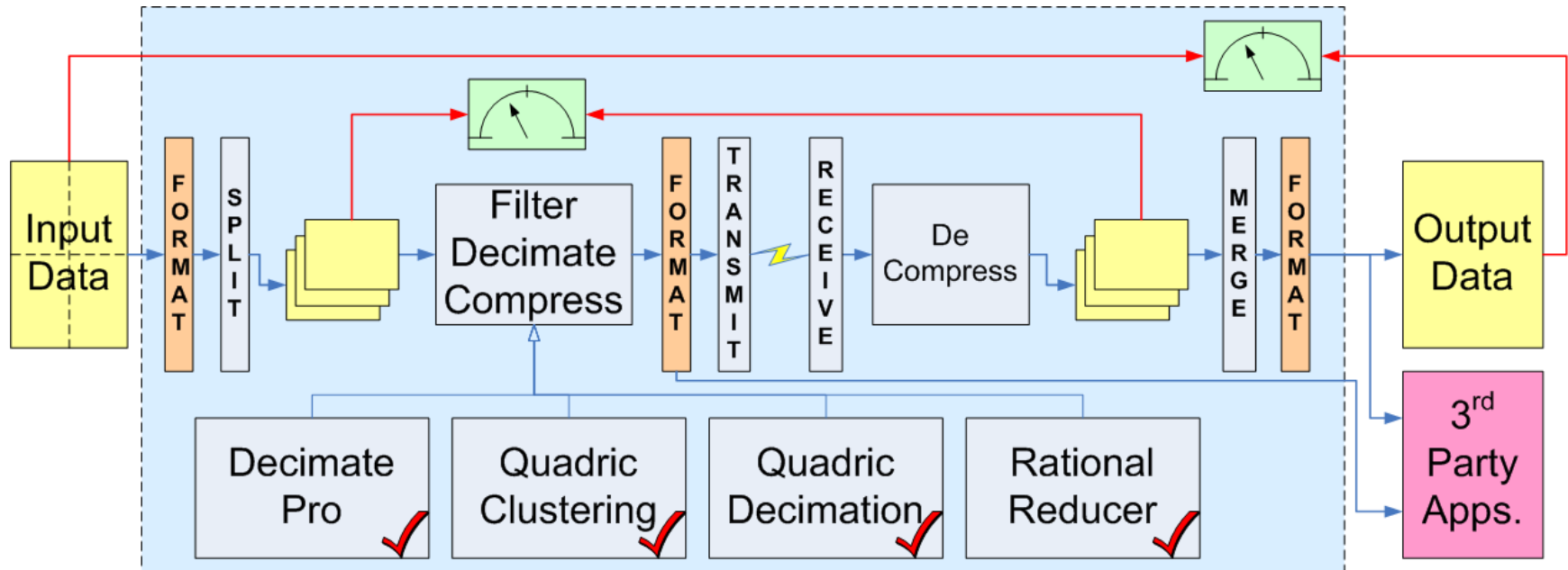
- **Problem:** Currently the exploitation and dissemination of 3D GEOINT imagery and Digital Elevation Models (DEM) requires specialized tools, training, and multiple data formats. 3D GeoPDF® are Adobe Acrobat PDF files containing georeferenced imagery, 3D digital elevation models, and exploitation tools within a single easy to use file with compression for transmission across limited bandwidth communications.
- **Objective:**
  - Create Improved 3D GeoPDF® generation process
  - Integrate and transition 3D GeoPDF® process into 3D Composer
- **Vendors: SAIC and TerraGo**
  - SAIC – provides 3D Meshing, Decimation, and Compression and expertise in 3D geospatial processing software
  - TerraGo's 3D GeoPDF® – COTS software application developer with existing tools installed at NGA, DCGS-A, and other Government Agencies
- **Technical Approach**
  - Merge TerraGo's 3D GeoPDF® COTS application with SAIC's 3D Meshing, Decimation, and Compression for digital elevation data
  - Provide one step, easy-to-use, user interface for application



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# DARPA GRID Seedling



- Op3D was approached to participate in the DARPA GRID program
- Seedling funding was provided to create a framework for the insertion and evaluation of 3D Meshing, Decimation, and Compression algorithms
- The framework supports large file sizes, parallel processing, and has multiple compression algorithms along with API to integrate new algorithms

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# Qualitative Evaluation of GRID Lossy Compression using LIDAR Feature Extraction



Identify from: <Top-most layer>

Bldgs\_from\_Original Points  
Complex

Location: 527,042.863 3,900,798.067 Unknown Units

Field	Value
FID	50
Shape	Polygon ZM
CLASS_ID	0
Roof_Type	Complex
Avg_Ht_AGL	3.81452
Min_Ht_AGL	-0.196228
Max_Ht_AGL	6.478149
Dev_Ht	6.674377
Area	437.733024
Perimeter	103.871031
Length	30.523563
Width	25.666644
Orient_Ang	25.124242
Ground_Elv	770.881934

Identified 1 feature

Original 40cm LIDAR (23.8MB)

Identify from: <Top-most layer>

Bldgs\_Decimate\_Pro (80% File Size Reduction)  
Pitched

Location: 527,047.416 3,900,801.762 Unknown Units

Field	Value
FID	52
Shape	Polygon ZM
CLASS_ID	0
Roof_Type	Pitched
Avg_Ht_AGL	3.722175
Min_Ht_AGL	-0.143616
Max_Ht_AGL	6.464294
Dev_Ht	6.60791
Area	425.802387
Perimeter	90.400793
Length	29.248676
Width	19.922726
Orient_Ang	33.437209
Ground_Elv	770.897659

Identified 1 feature

Decimate Pro (90) – 5.0MB

Identify from: <Top-most layer>

Bldgs\_Quadric\_Decimate (90% File Size Reduction)  
Pitched

Location: 527,045.440 3,900,799.356 Unknown Units

Field	Value
FID	53
Shape	Polygon ZM
CLASS_ID	0
Roof_Type	Pitched
Avg_Ht_AGL	3.741563
Min_Ht_AGL	-0.127014
Max_Ht_AGL	6.588013
Dev_Ht	6.715027
Area	429.968073
Perimeter	90.616828
Length	28.784522
Width	19.023087
Orient_Ang	33.745037
Ground_Elv	770.768361

Identified 1 feature

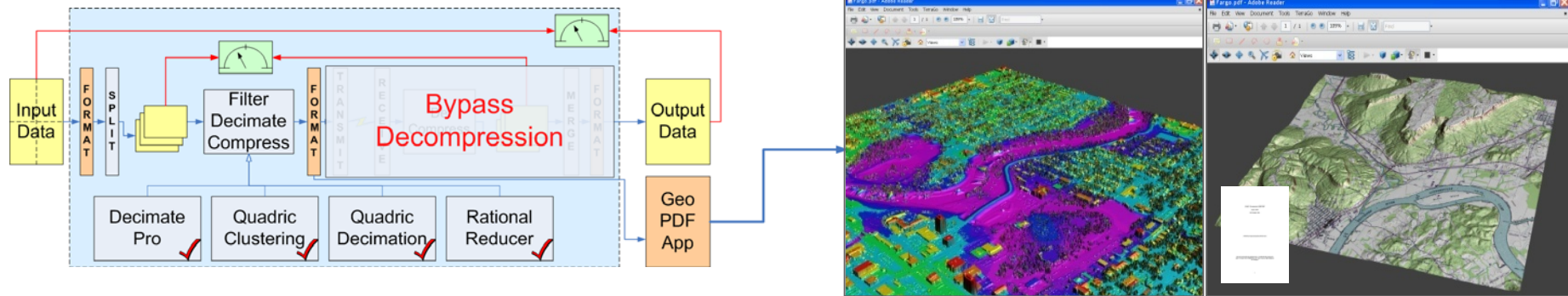
Quadratic (90) – 2.3MB

- The impact of the lossy compression on the utility of the data was evaluated using automated feature extraction algorithms with LIDAR and determined to be acceptable even at 90% decimation

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# Task: Next Generation 3D GeoPDF® Technical Approach



Sample 3D GeoPDF Files

- **SAIC creates software for geospatial data compression and conflation**
  - Geospatial data compression for DEM, image texturing
  - Research incorporation of shapefile/vector and 3D model integration
  - SAIC outputs compressed and conflated data in U3D format
- **TerraGo integrates software into their software baseline**
  - TerraGo ingest U3D software into their GeoPDF creation process
  - SAIC delivers software to TerraGo repository
- **TerraGo creates user interface with one-step creation process**
  - Current process is a multi-step, multi-tool process requiring manual file editing and three licensed tools
  - New interface will be a single tool requiring no manual file editing



# Next Generation 3D PDF Production GeoPDF Bandwidth Reduction

- **Compression of BuckEye LAS and GeoTIFF image**

- LIDAR LAS format = 13 Mb
- EO Image uncompressed = 72 Mb

Terrain Compression (%)	JPEG Image Compression (%)	PDF File Size (Mb)
0	0	23.3
50	0	17.4
90	0	12.1
0	75	14.9
50	75	9.1
90	75	3.8
0	90	14.2
50	90	8.4
90	90	3.1

- Recommended terrain compression is 90%
- Based upon Spiral 1 evaluation of the impact of the lossy compression on feature extraction
- Less terrain facets also speeds up the display and exploitation of the GeoPDF ® on lower end laptop video cards
- Users can exploit data over limited bandwidth with compressed 3D GeoPDF ® products





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# Full View

## No Decimation, No JPEG Compression



**23.3 Mb PDF file size -- stand still movement on laptop**

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# Zoom View

## No Decimation, No JPEG Compression



**23.3 Mb PDF file size -- stand still movement on laptop**

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# Zoom View

## 90% Decimation, 90% JPEG Compression



**3.1 Mb PDF file size -- real-time performance on laptop for moving in 3D, no visible loss of 3D quality**

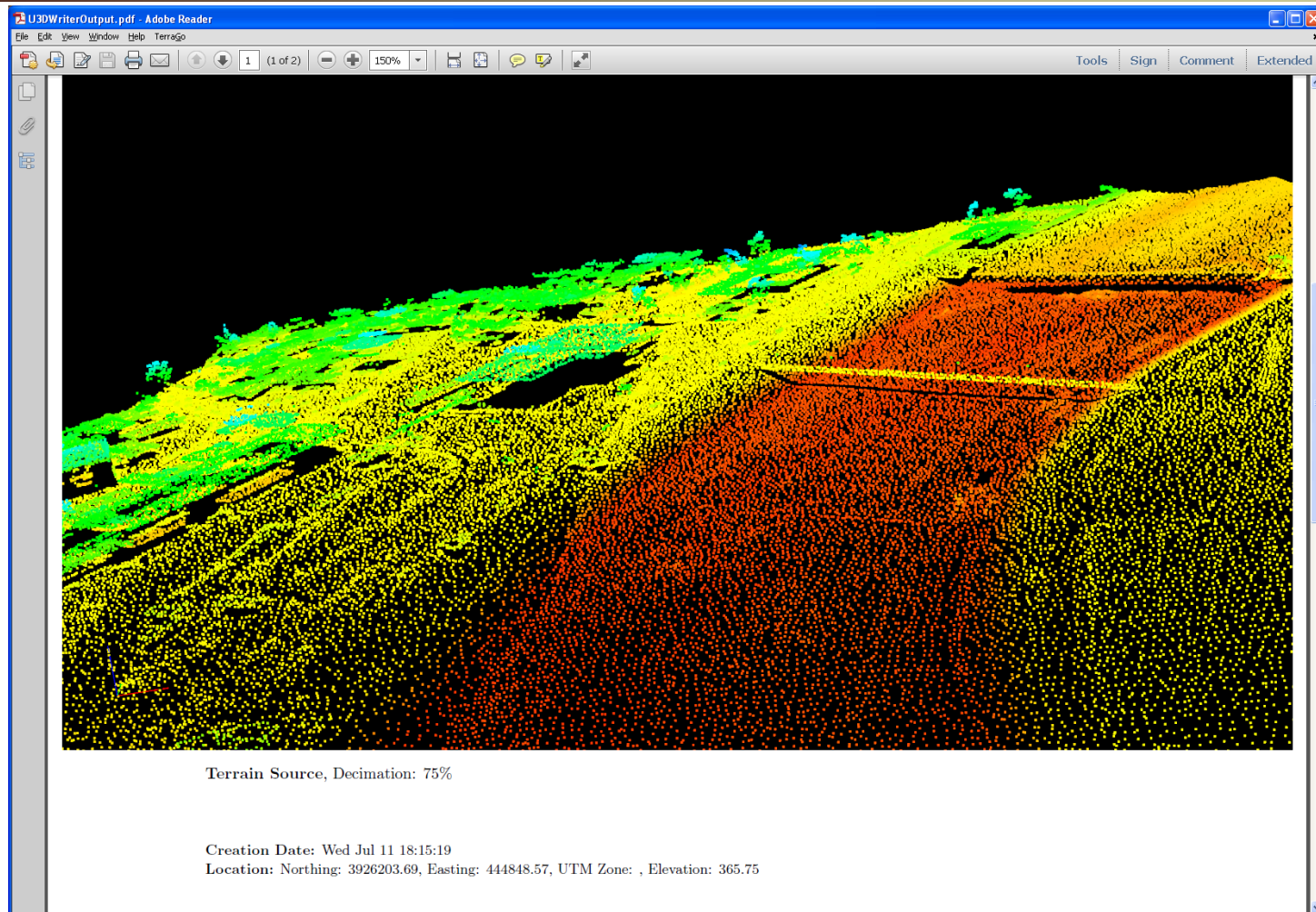




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# Zoom out view of LAS Point Cloud in PDF Colorized Point Cloud



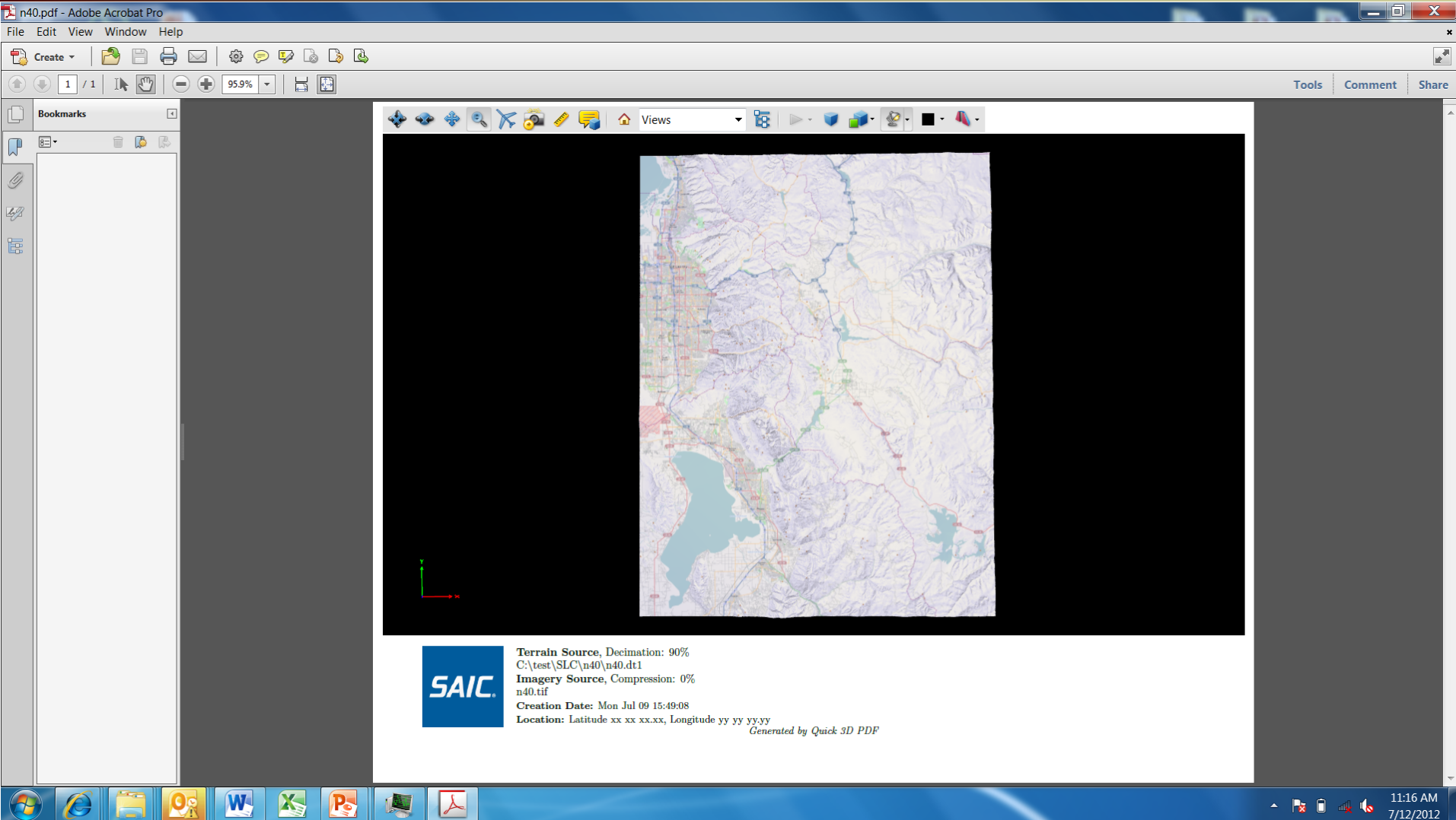
**75% decimation of point cloud enables transmission and 3D analysis of point cloud through 3D PDF**

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# Full View – DTED 1 overlaid with USGS Raster Graphic



## Top level 2D view of the fused product

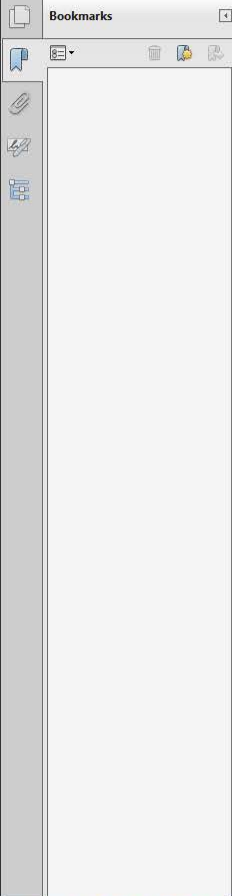


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# Zoom View – DTED 1 overlaid with USGS Raster Graphic

n40.pdf - Adobe Acrobat Pro  
File Edit View Window Help



Terrain Source, Decimation: 90%  
C:\test\SLC\n40\n40.dt1  
Imagery Source, Compression: 0%  
n40.tif  
Creation Date: Mon Jul 09 15:49:08  
Location: Latitude xx xx.xx, Longitude yy yy.yy  
*Generated by Quick 3D PDF*



11:18 AM  
7/12/2012

Zooming you begin to see terrain details that are not visible on the 2D USGS DRG

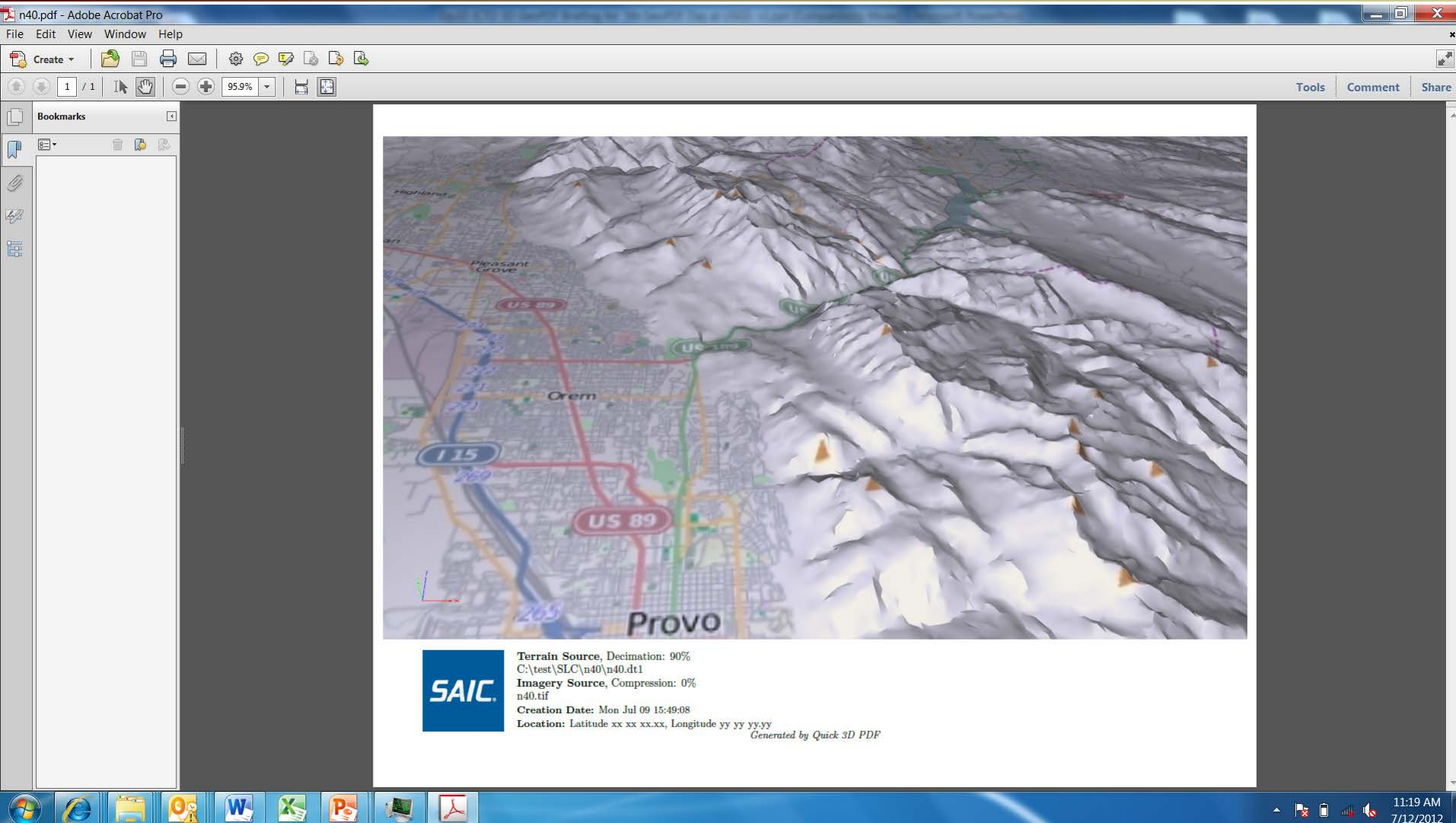
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# Off Nadir Zoom View – DTED 1 overlaid with USGS Raster Graphic



Off-nadir view of combined product enables 3D situation awareness for free  
within PDF document

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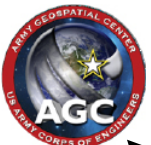
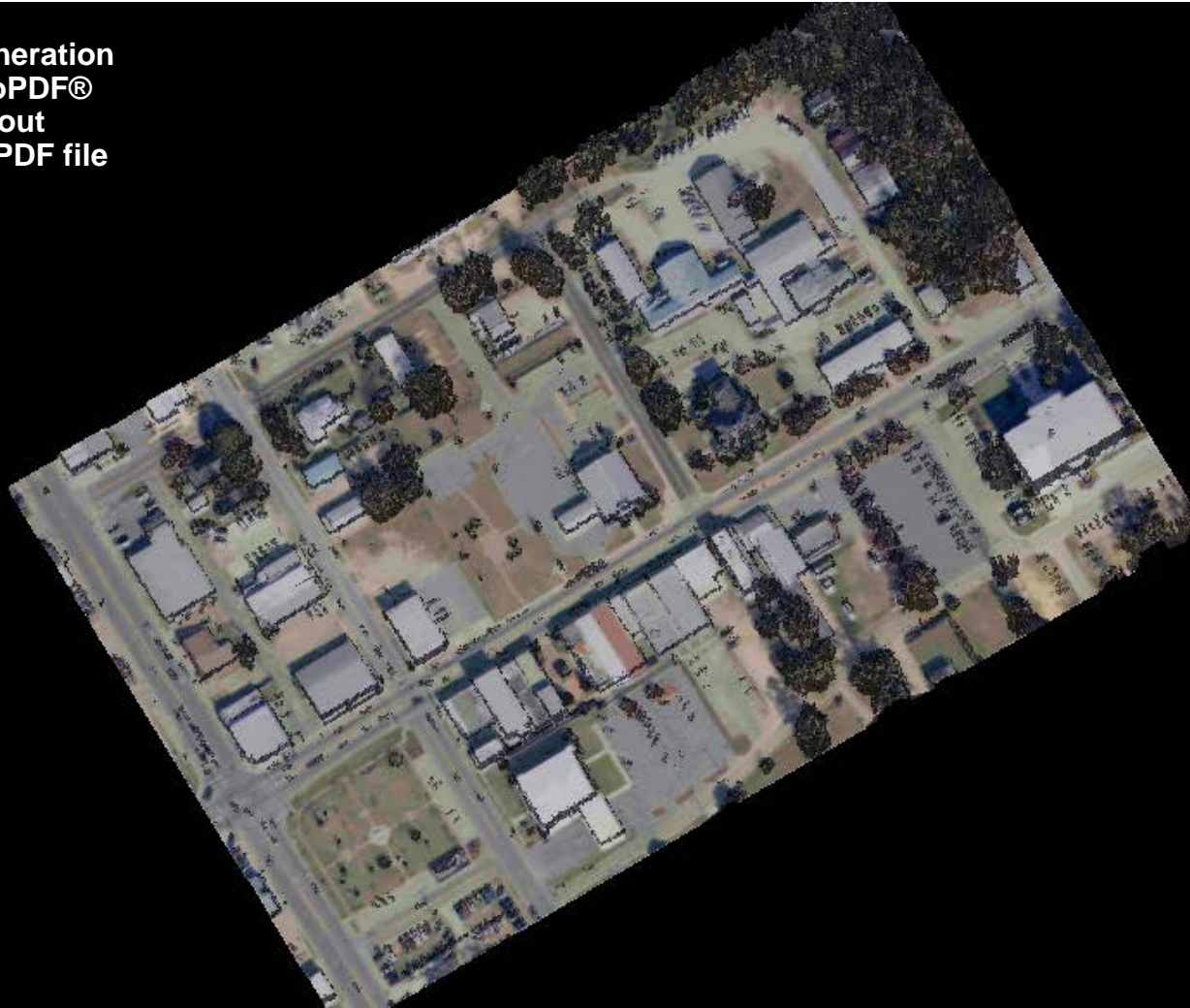


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TITLE

Title (Allow users to input their own Title)

Next Generation  
3D GeoPDF®  
Layout  
Output PDF file



Logo (Allow users to input their own logo)

**Terrain Source:** Blountstown\_LIDAR\_UTM.las; Decimation: 75%  
**Imagery Source:** Blountstown\_OrthoImage\_UTM.tif; Compression: 90%

**Creation Date:** 30 May 2012

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Auto Generated Text

*This data was collected  
for Emerald Warrior  
2012 as part of the  
Op3D JCTD*

Optional Description Text





# Next Generation 3D PDF Production Current Status

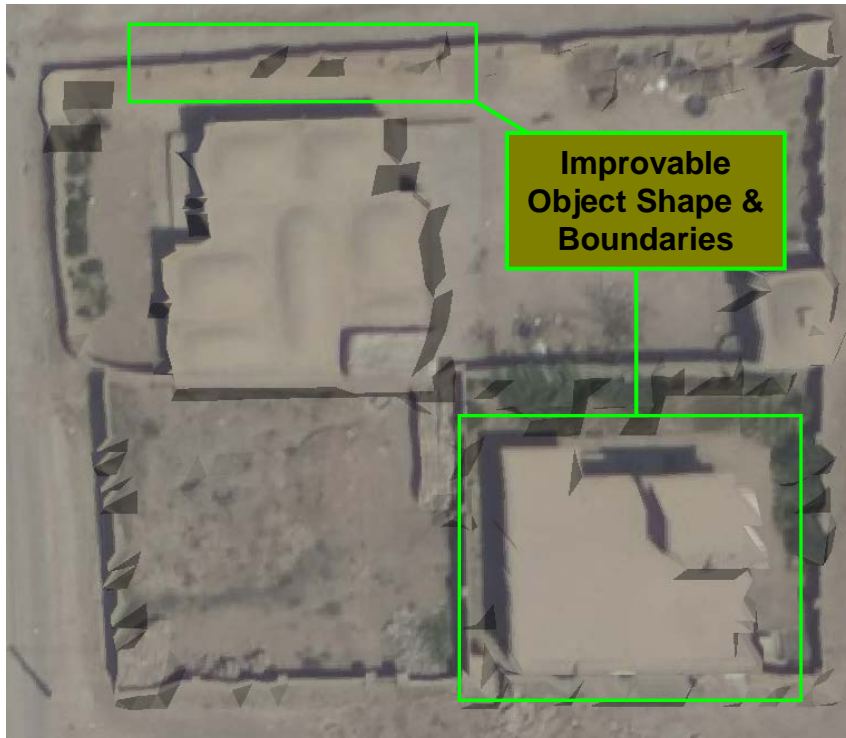
- SAIC has delivered the 3D Meshing, Decimation, and Compression source code to TerraGo's software repository
  - 3D Meshing, Decimation, and Compression of DTED and LIDAR
  - JPEG compression of imagery
- TerraGo and SAIC have been testing the software
- Spiral updates are made collaborative between TerraGo and SAIC
- Upcoming schedule milestones
  - Op3D Spiral 3 Demonstration – Sept 2012
  - Product release anticipated - 4<sup>th</sup> quarter 2012



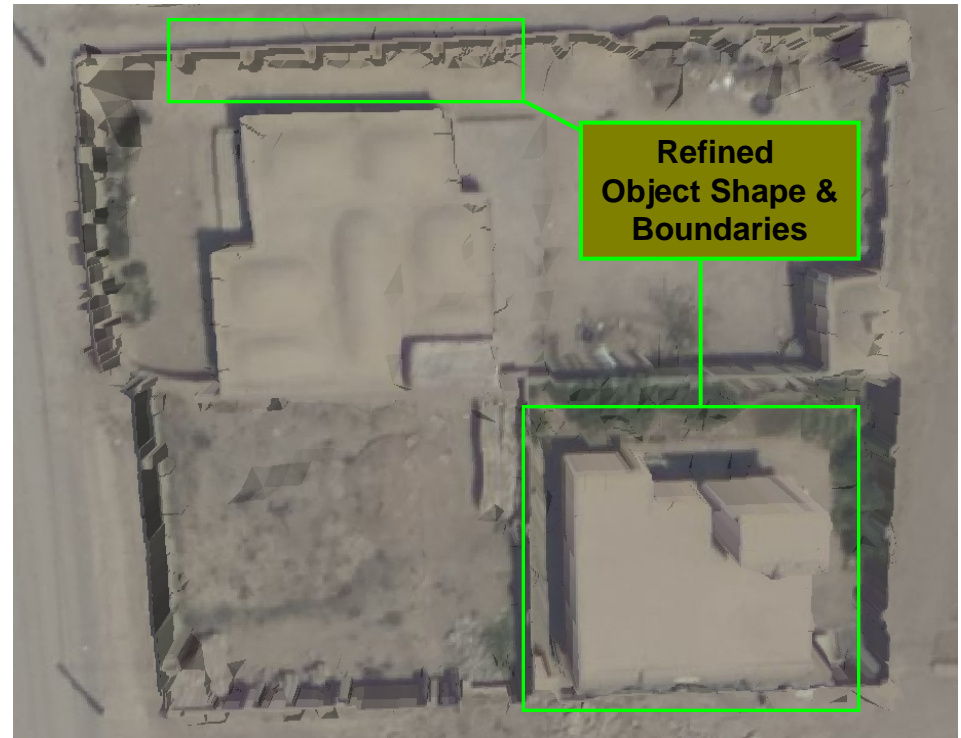
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# Related Op3D Project Sensor Resolution Fusion



Before



After

- SAIC is researching methods to automatically fuse EO and LIDAR
  - LAS – 1m resolution
  - EO – 10cm color resolution
- Output of the sensor fusion is an augmented LIDAR LAS file which can be exploited by any COTS tool

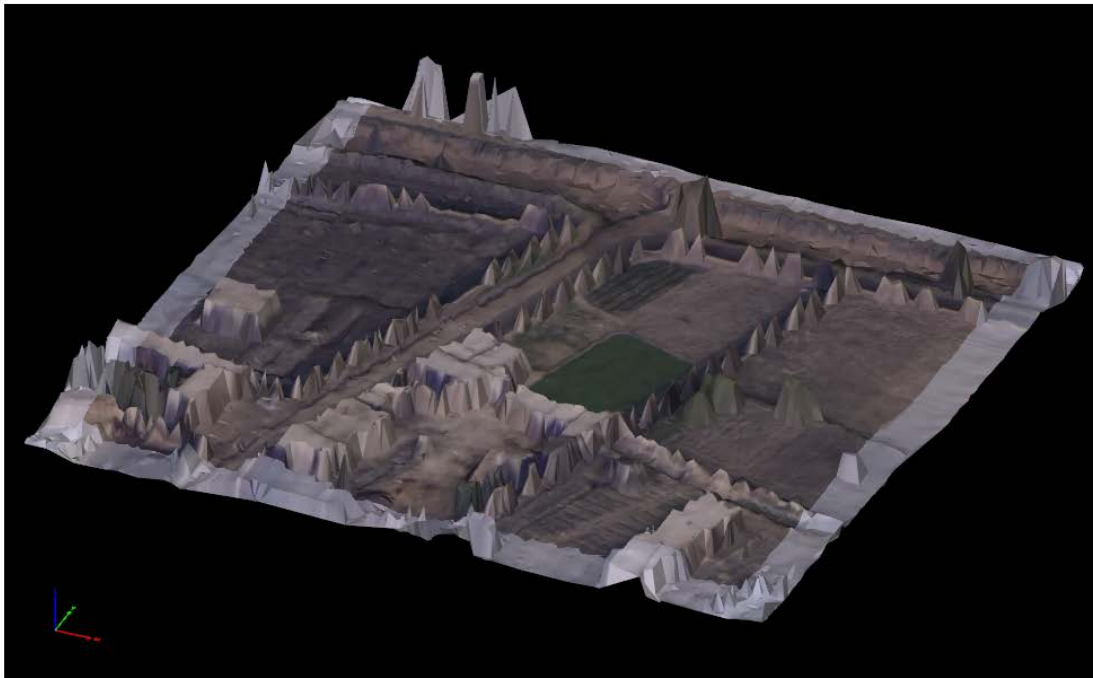
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# Related Op3D Project Sensor Resolution Fusion



10097\_Lb6015



- SAIC is researching methods to automatically fuse EO and LIDAR
  - LAS – 1m resolution
  - EO – 10cm color resolution
- At 1m resolution LIDAR might only obtain 1-2 hits on a small object such as a wall but an accurate height is obtained
- Output of the sensor fusion is an augmented LIDAR LAS file which can be exploited by any COTS tool

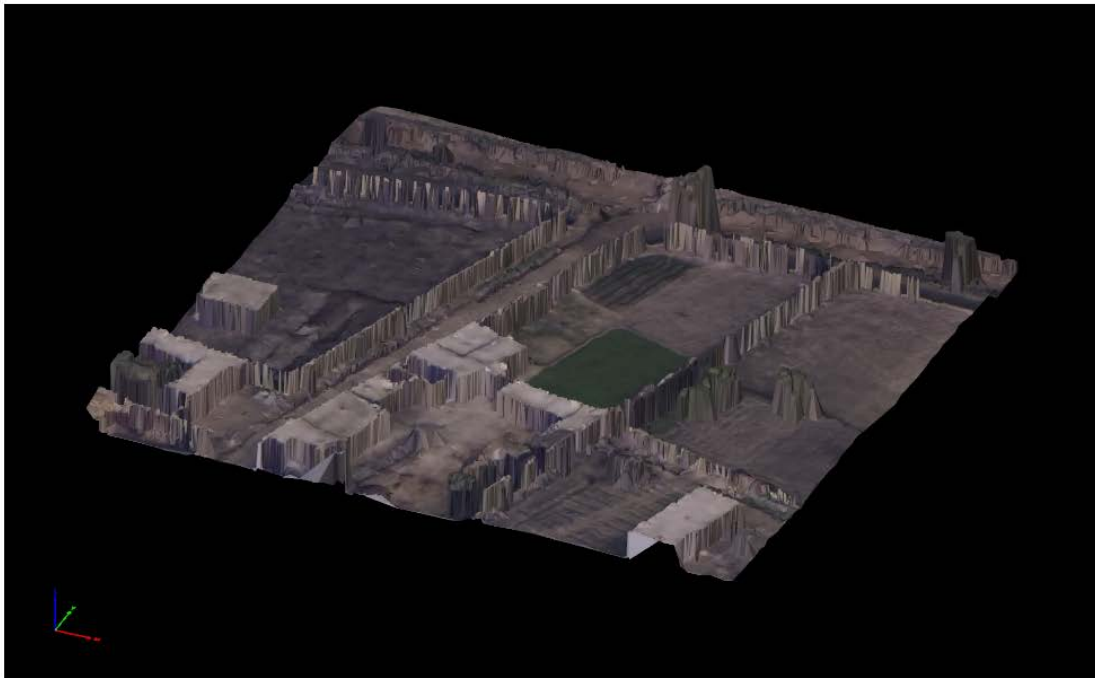
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# Related Op3D Project Sensor Resolution Fusion



Lb6015\_Refined



- At 1m resolution LIDAR might only obtain 1-2 hits on a small object such as a wall but an accurate height is obtained
- Higher resolution EO fills in the missing information from the sparse DEM
- The fused EO/LIDAR result provides a 10cm 3D view of the urban environment
- The result to the right has both fusion and 3D compression applied to it
- Op3D is investing to improve this technology to smooth out feature outlines in the output LIDAR LAS file

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# Next Generation 3D PDF Production Summary

- Op3D JCTD is focused on the development and transition of technologies to improve the Collection, Processing, Exploitation, and Dissemination of 3D GEOINT to the Warfighter
  - Make investments to improve COTS technologies which are already installed and available to Government and Commercial users
- Next Generation 3D PDF Production is a collaboration between SAIC and TerraGo to improve the Warfighter's ability to exploit and disseminate 3D GEOINT
  - TerraGo's 3D GeoPDF® product is easy to use, everyone is familiar with sending and receiving a PDF file
  - TerraGo's applications are deployed across NGA, US ARMY, and other organizations
  - Partnership with SAIC and TerraGo combines new compression technology and 3D composer implementation to enable the warfighter with relevant 3D products in low bandwidth environments
  - On-going development into automated EO/LIDAR fusion technology will improve the Warfighter's situational awareness
- Anticipate the first release of this product in 4<sup>th</sup> quarter 2012