ArcGIS Geometric Accuracy Evaluation

Mohamed MR Mostafa*

Gerald Kinn**

31 Mar 2011

JACIE

*Navmatica, 9040 Leslie Street, Richmond Hill, Ontario, Canada Mostafa@Navmatica.com
**ESRI, 8615 Westwood Center Drive Vienna, VA, USA 22182-2218 GKinn@esri.com

Objectives for this talk

- Inform JACIE of activities to validate software and workflows associated with ArcGIS
- Present results on initial work
- Stimulate discussion on industry practices

Background

GIS users need better tools

- GIS Users are not all photogrammetrists
- On the fly processing and imagery services
  - Provide new possibilities
  - Are sometimes unbounded by expectations
  - Are often set up by non-traditional practitioners
  - Serve very wide audiences
  - Enables rapid delivery of imagery
- Software and workflows need to be easy and robust
- Users need to understand the “authority” of the data
- Navmatica has been working with Esri

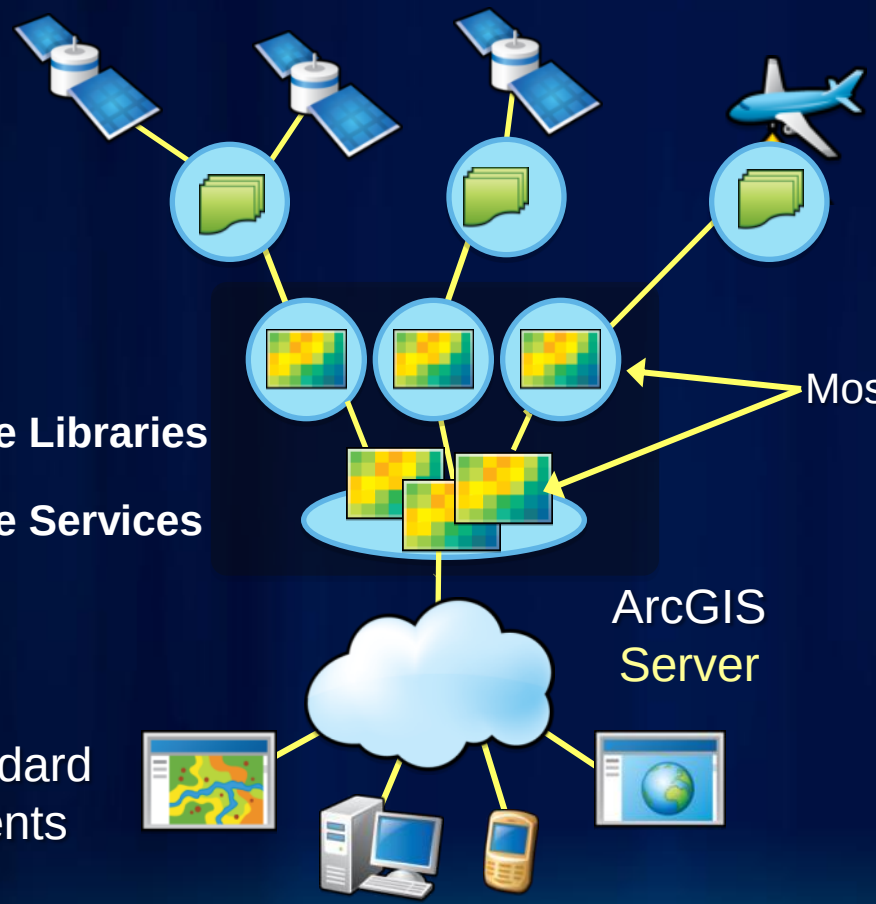
Study Objectives

Validating software and best practices for our users

- Verify and validate
  - Software
  - Best Practices
  - Specific to classes of sensors
- Determine Accuracy
  - Consistent with industry standards
  - Develop error propagation models
  - Set user expectations

Imagery Dynamically Processed and Served

Using Image Server Technology



- **Image Libraries**
- **Image Services**

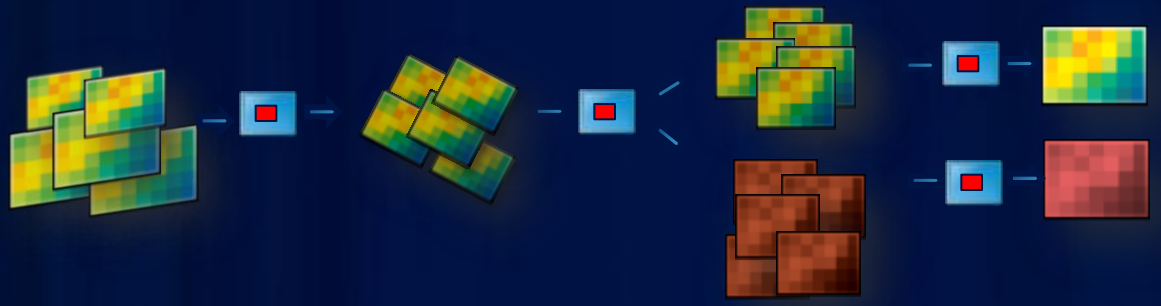
Benefits

- Simpler access
- Image Integration
- Fast Visualization
- Lowers Cost
- Dynamic Analysis

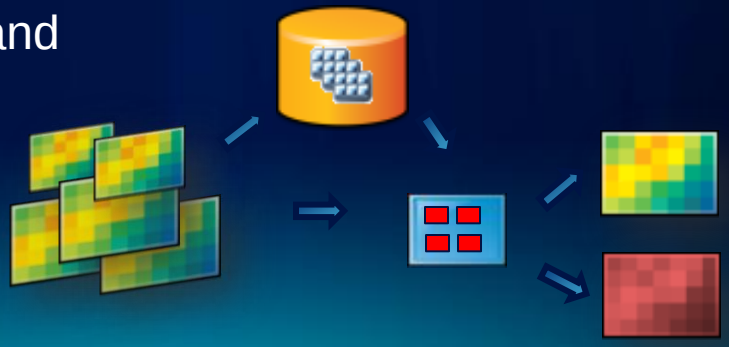
Shorten the time from sensor to use

Enhancing Processing Methodologies

- Conventional Image Processing Workflows
  - Multiple processes create intermediate results
  - Products created as static mosaic



- Mosaic Datasets Enable Transactional Workflows
  - Processes applied on demand
  - Products created on demand



Navmatica Effort

Independent view

- Work within the roll of an ArcGIS user
- Provide rigorous evaluation of software and workflows
  - Use actual, well characterized data
  - Compare with other software in the industry
  - Begin to evolve an evaluation process and data set

Digital Sensor System (DSS)

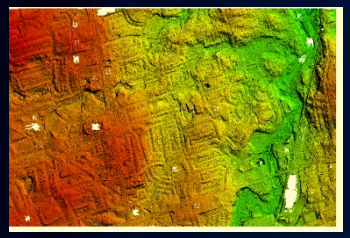
- **USGS-certified Medium Format Fully Digital System:**
  - **Digital camera**
  - **Applanix POS AV**
  - **Azimuth Mount**
  - **Flight Management System**
- **Tested and accepted by USGS and NASA**
- **Over 100 systems sold and operational around the world**

Task 1: Data Compilation and Documentation

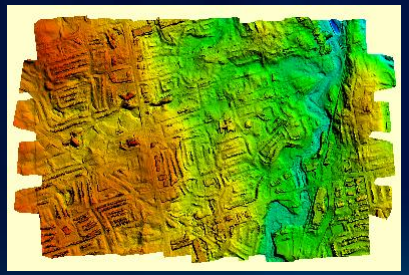
- **Airborne DSS Data**
  1. DSS 439 flown over Newmarket in 2009 (GSD = 11 cm)
  2. DSS 322 flown over Newmarket in 2006 (GSD = 15 cm)
- Data Configuration
  1. Raw DSS images
  2. Image georeferencing (Exterior Orientation) file generated from SBET file and calibrated boresights
  3. Updated camera calibration including:
     - **Focal length**
     - **Principal Point Offsets (PPA x and PPA y)**
     - **Lens distortion profile**

Task 1: Data Compilation and Documentation

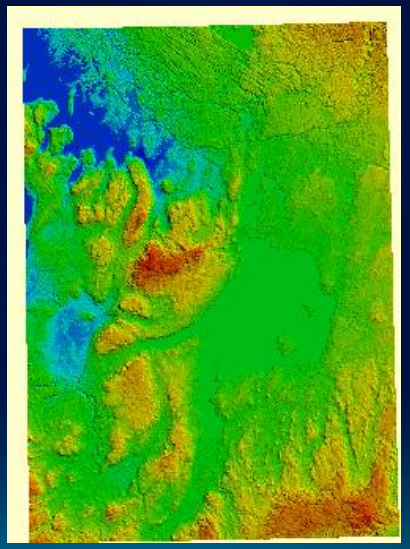
- **DEM data:**
  - LiDAR DEM: processed from raw LiDAR data
  - DSS DEM: extracted from the DSS images
  - SRTM DEM: downloaded from http://edcsns17.cr.usgs.gov/EarthExplorer/
  - ASTER DEM: downloaded from https://wist.echo.nasa.gov/api/



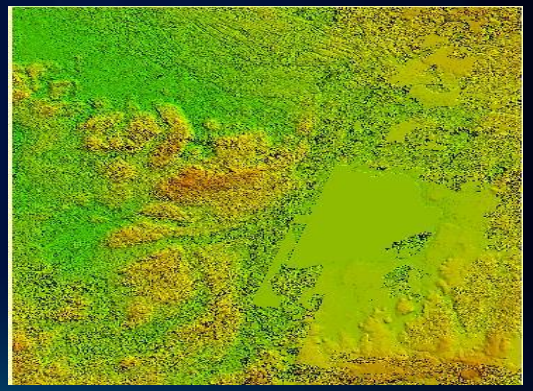
LiDAR DEM



DSS DEM



SRTM DEM



ASTER DEM

DEM Accuracy Evaluations

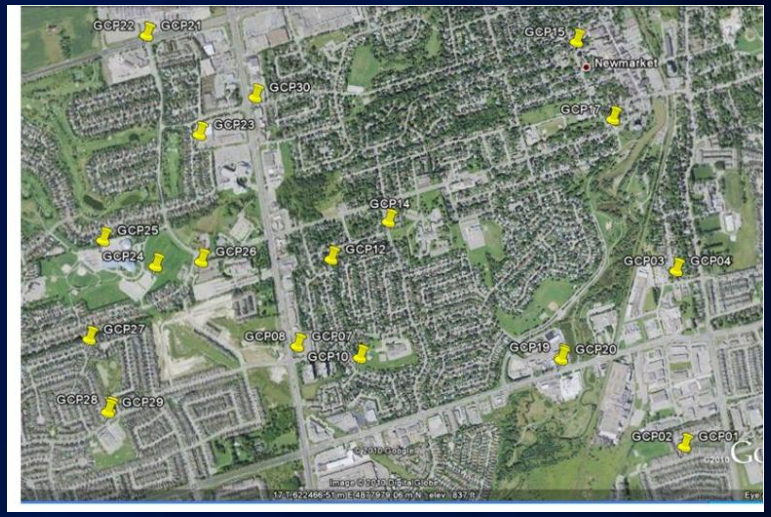
- **Accuracy assessment results**

Newmarket Digital Elevation Models				
Statistics	**SRTM**	**ASTER**	**DSS**	**LiDAR**
Min	-3.47	**-130**	-1.52	-0.17
Max	4.18	**120**	0.43	0.16
Mean	0.80	7	-0.50	-0.03
STD	1.84	38	0.54	0.07
RMS	**2.00**	**39.00**	**0.70**	**0.08**

- **Conclusion**
  - **LiDAR DEM has the best accuracy as expected. It will be used for most of the accuracy tests.**
  - **ASTER DEM is not a good reference, corrupted in Newmarket region**

Task 1: Data Compilation and Documentation

- **Ground Control Points (GCPs)**
  - GCPs:
    - 30 GCPs
    - accuracy of 2 cm horizontally and 3 cm vertically
  - Densified GCPs:
    - 112 GCPs created using Semi-automatic Tie point Generation (STG) technology
    - accuracy of 20 cm in X, Y, and Z, respectively



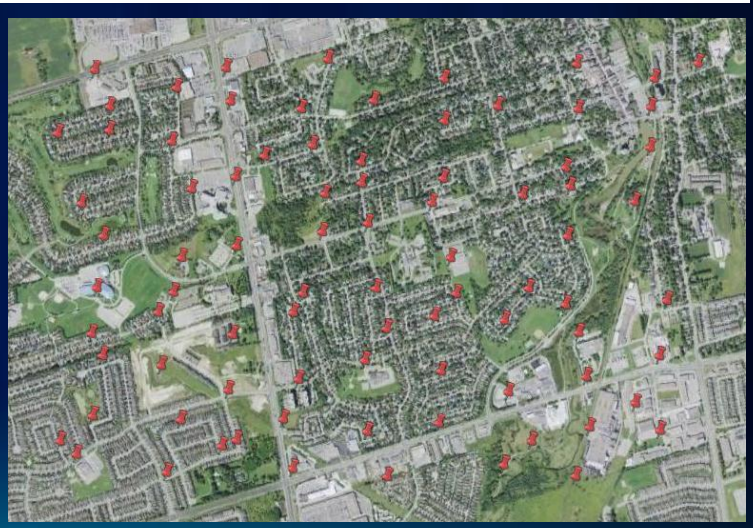


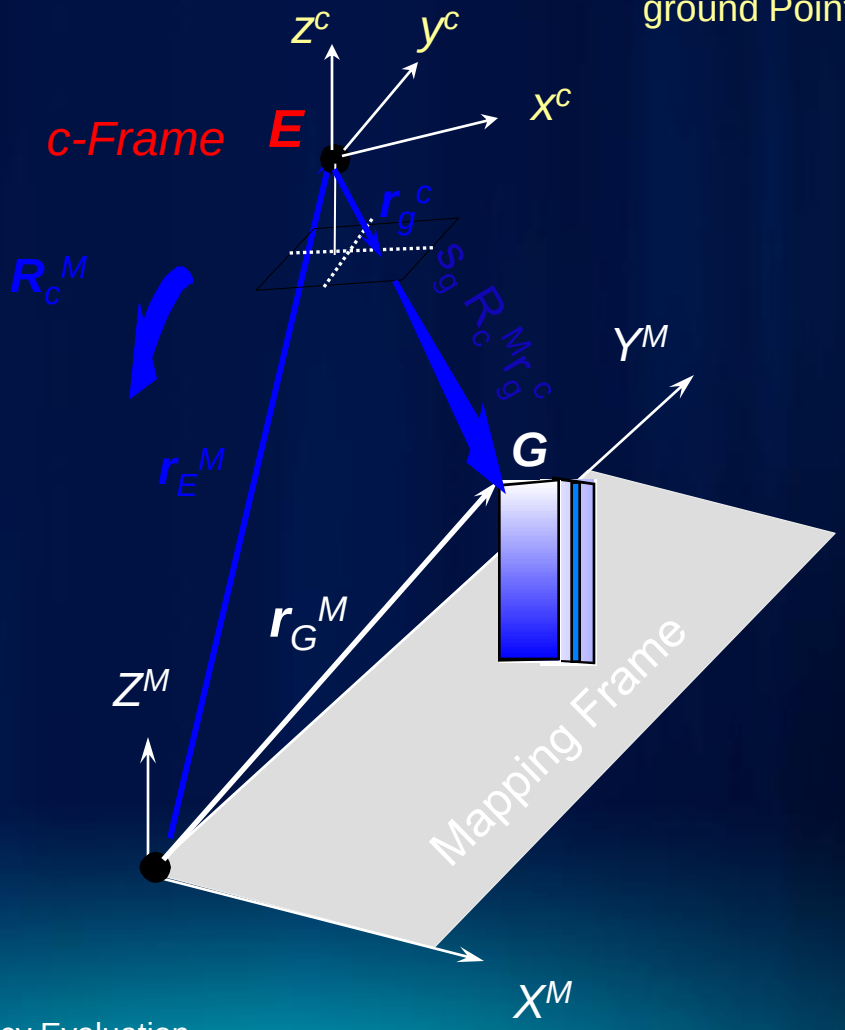
Image Georeferencing

Indirect Georeferencing

1. Survey GCPs
2. Measure image points
3. Compute translation and rotation using AT
4. Produce 3D Coordinates of ground Points

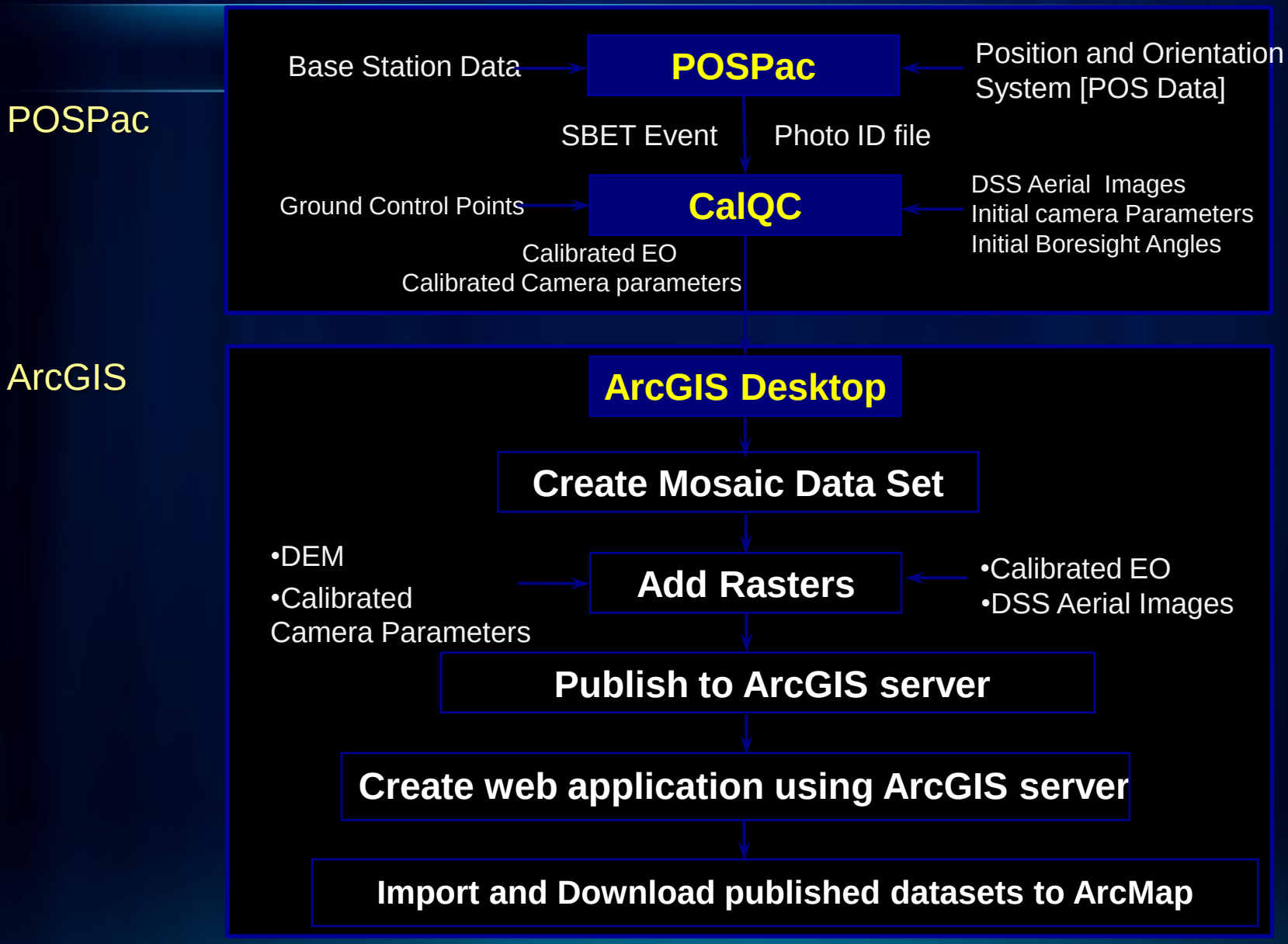
Direct Georeferencing

1. **Measure translation and rotation (EO) using Navigation Sensors**
2. **Produce Orthophoto or collect features on stereopairs**
3. **No GCP needed**
4. **QC is needed**



item	Accuracy
Roll, Pitch	20”
Heading	40”
STD Error	~ 1 pixel

Task 2: DSS Workflow



Task 3: Establish Accuracy Assessment

Mosaic Analysis Overview

Methods

1. **Resampling**
   - **Bilinear**
   - **Cubic**
2. **Mosaic**
   - **Seamline**
   - **Closet to Nadir**
   - **Closest to Center**
3. **Operator**
   - **First**
   - **Blend**

Configurations

1. Given GCP coordinates.
2. Low flight altitude.
3. LiDAR DEM.

Flight Alt

- **Low alt (650 m)**
- **High alt (1,000 m)**
- **Hybrid**

Configurations

1. Given GCP coordinates.
2. LiDAR DEM.
3. Mosaicking Parameters (Cubic ,Closet to Nadir and Blend)

DEM Files

1. **DSS DEM**
2. **LiDAR DEM**
3. **SRTM DEM**
4. **ASTER DEM**

Configurations

1. Given GCP coordinates.
2. Mosaicking Parameters (Cubic ,Closet to Nadir and Blend)
3. Low Flight altitude.

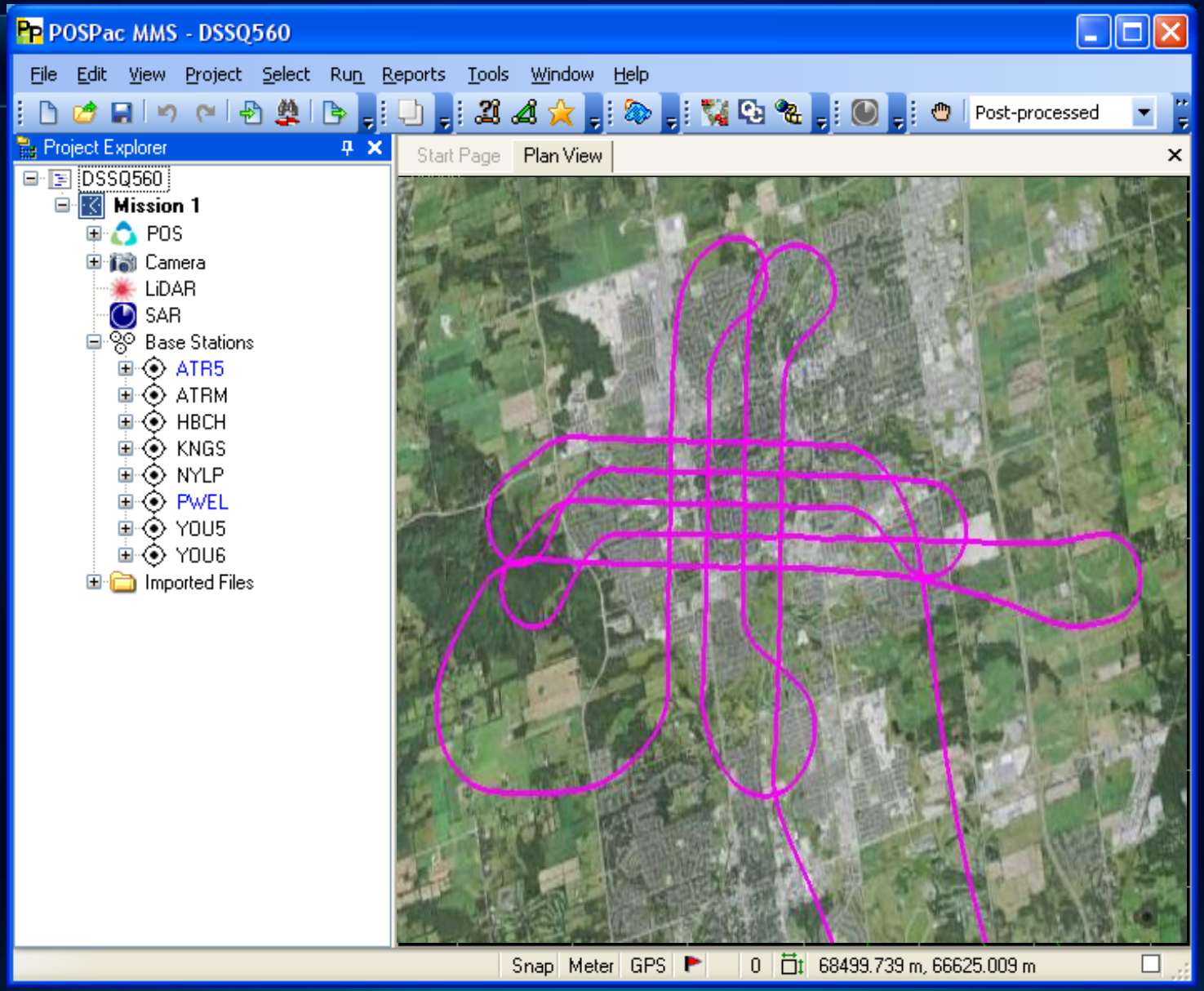
GCP type

- GCPs
- Densified GCPs

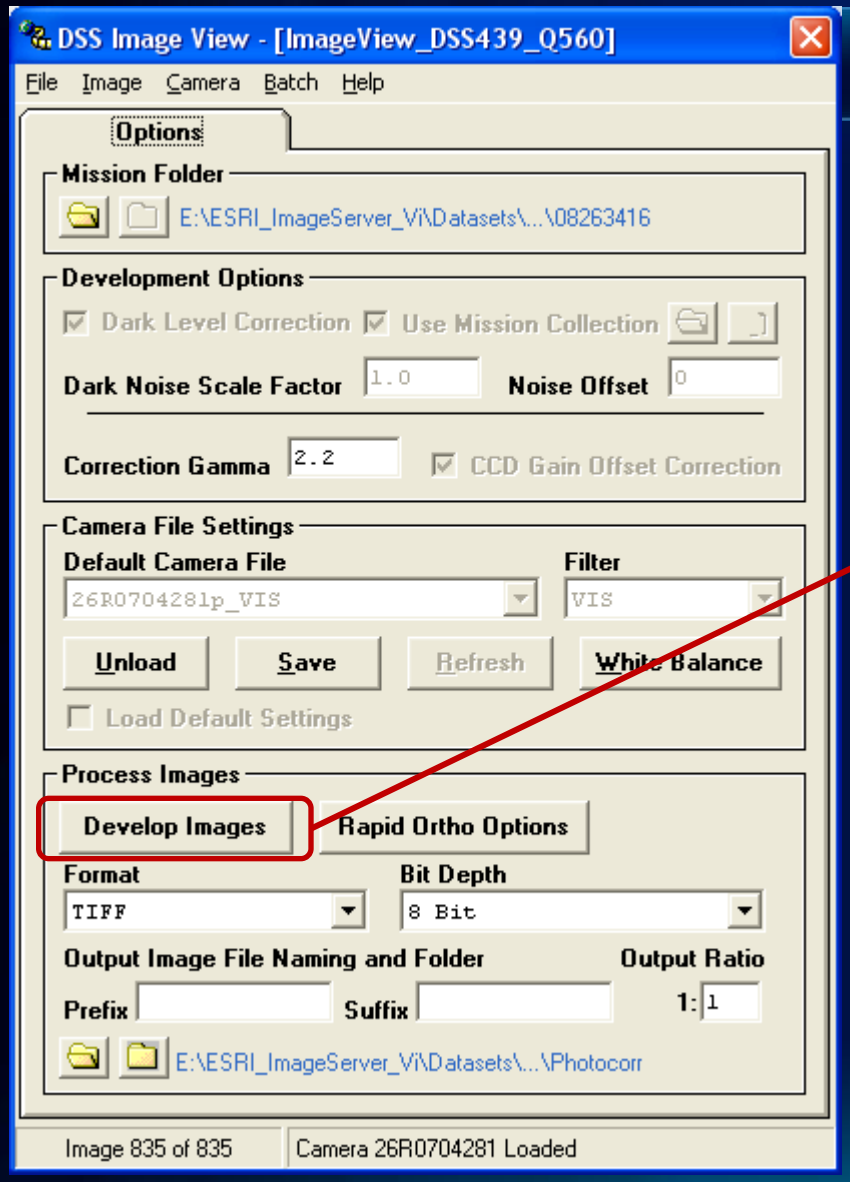
Configurations

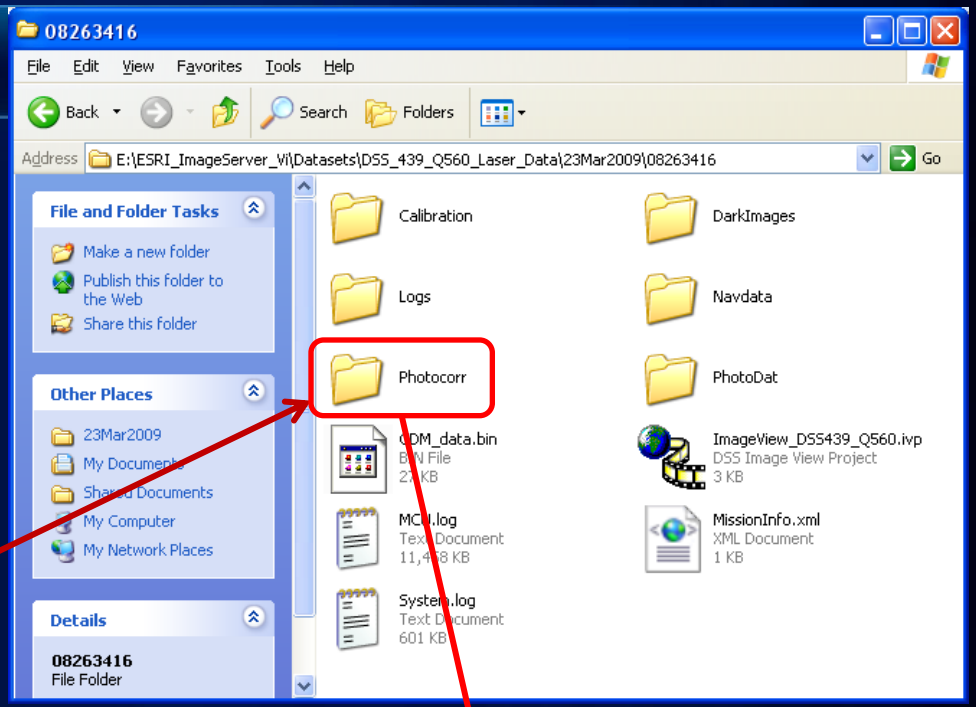
1. Low flight altitude.
2. Mosaicking Parameters (Cubic ,Closet to Nadir and Blend)
3. LiDAR DEM.

Produce Smooth Best Estimate Trajectory



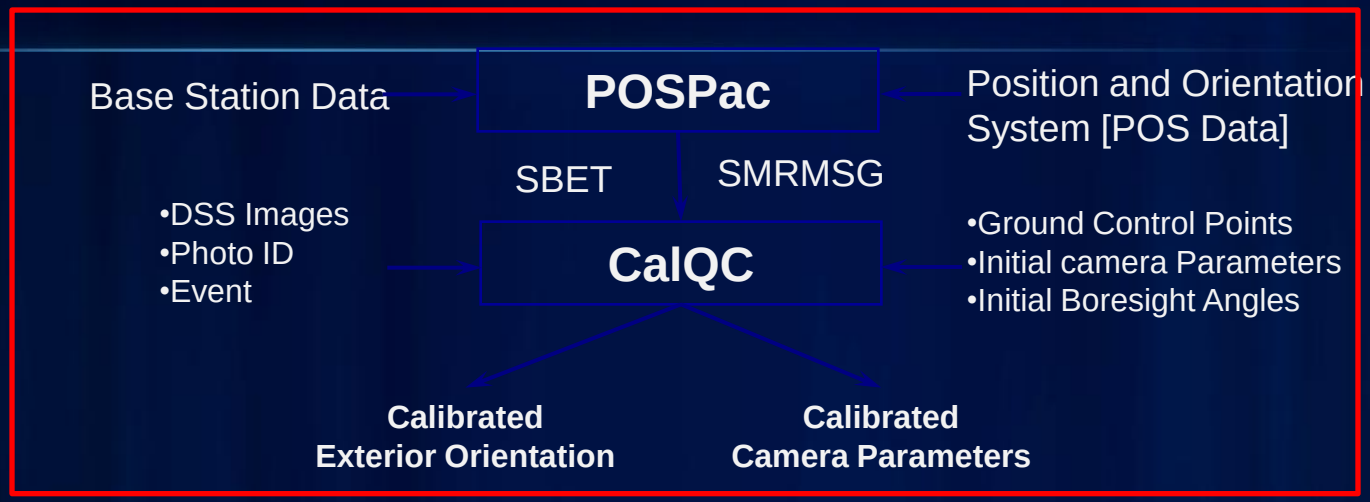
Produce DSS images

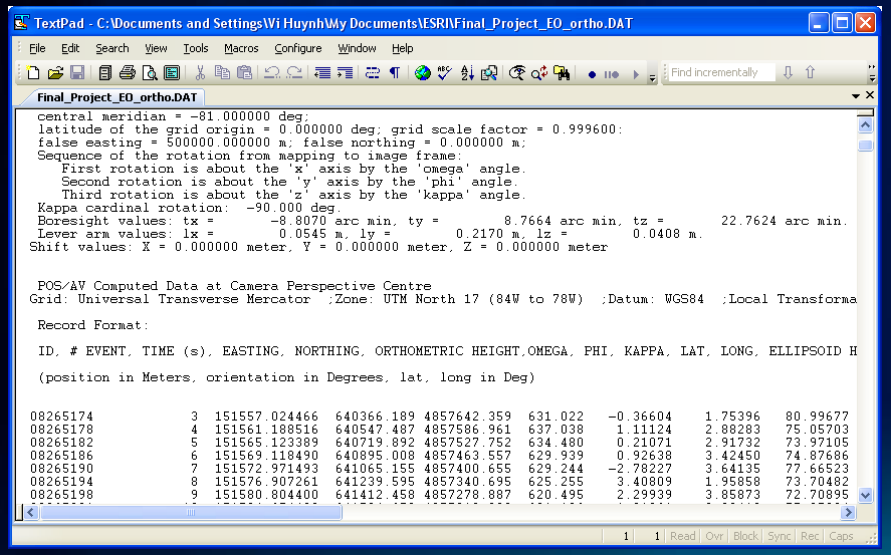




Produce EO and Calibrated Camera Parameters

Process





Camera Param	Value
F (mm)	40.843
Xpp (mm)	0.105
Ypp (mm)	-0.071

Boresight	Value	RMS
Tx (Arcmin)	-8.81	0.43
Ty (Arcmin)	8.77	0.50
Tz (Arcmin)	22.76	0.84

Datum Shift	Value
X (Meter)	0.00
Y (Meter)	0.03
Z (Meter)	-0.16

GCP RMS	Value
RX (Meter)	0.20
RY (Meter)	0.22
RZ (Meter)	0.17

Produce Densified GCPs

Process

Base Station Data → **POSPac** ← Position and Orientation System [POS Data]

POSPac → SBET, SMRMSG → **CalQC**

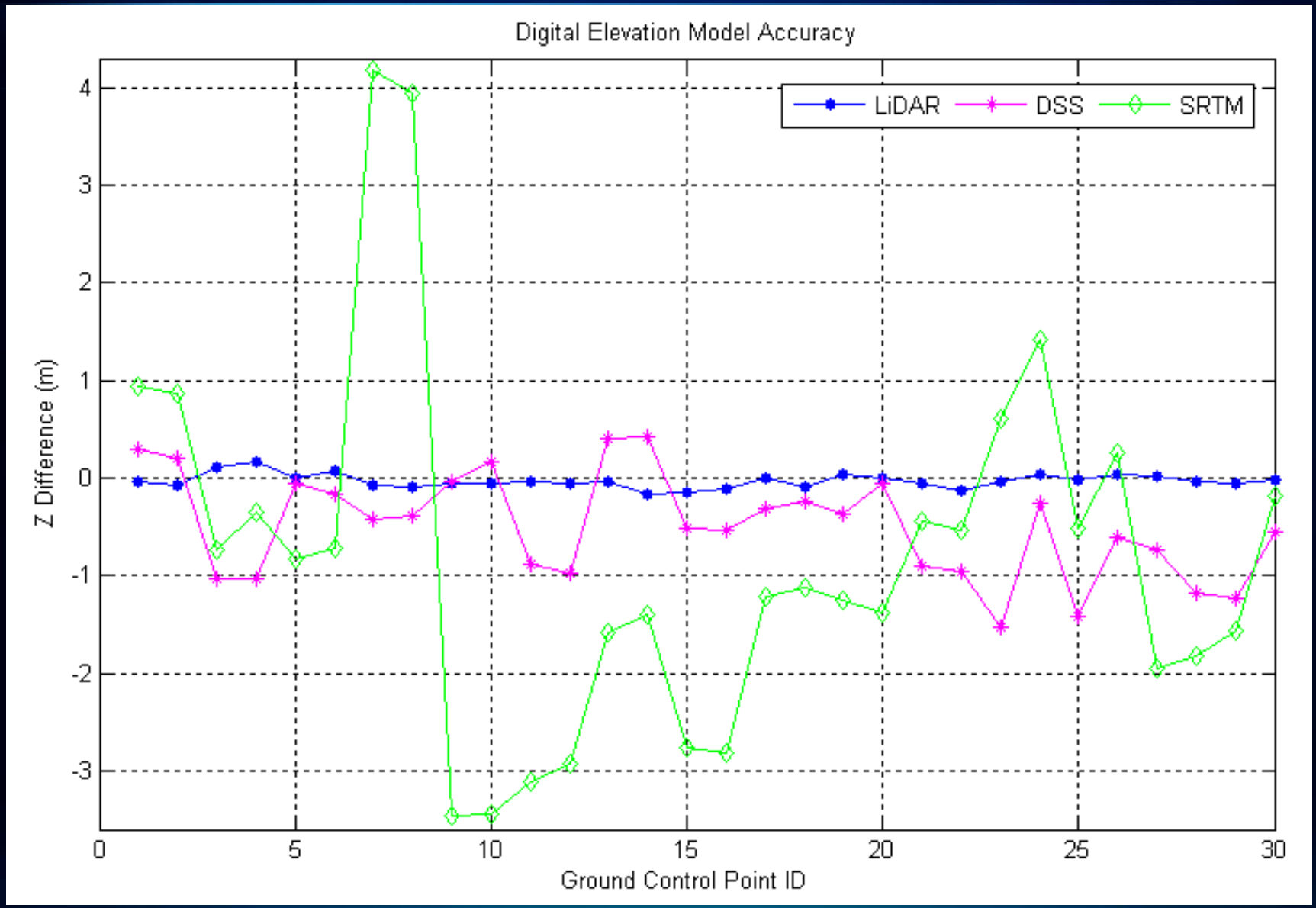
- DSS Images
- Photo ID
- Event

→ **CalQC** ←

- Ground Control Points
- Initial camera Parameters
- Initial Boresight Angles

CalQC → **Densified Ground Control Points**

DEM Accuracy Evaluations



Mosaic Accuracy Assessment

- **DSS datasets**

➢ ***DSS439 dataset properties:***

- **Year: 2009**
- **Coverage area: Newmarket**
- **Mapping Frame: UTM North 17**
- **Camera properties:**
  - **Pixel size: 6.8 micron**
  - **Focal length: 40 mm**
- **Two flight heights: 650m and 1000m**
- **GSD: 11cm and 15cm, respectively**
- **LiDAR data available**

➢ ***DSS322 dataset properties:***

- **Year: 2006**
- **Coverage area: Newmarket**
- **Mapping Frame: UTM North 17**
- **Camera properties:**
  - **Pixel size: 9 micron**
  - **Focal length: 60 mm**
- **One flight height: 1000m**
- **GSD: 15 cm**

❑ DSS 439 dataset was first selected for the analysis

❑ DSS322 dataset was added subsequently

Results

- **DSS439 in ArcGIS 10 (Preliminary)**
  - **Images at different flight heights produce different results when they shouldn't. This needs to be further analyzed.**
  - **DEM accuracy directly affects the accuracy of the mosaic as expected**
  - **Could be tightened up ~ 0.5 GSD**

GCPs	Densified GCPs	
Mean X = -0.05 m ~ 0.5 x GSD	Mean X = -0.10 m ~ 1 x GSD	GSD = 0.11 m
Mean Y = 0.08 m < 1 x GSD	Mean Y = 0.04 m < 1 x GSD	
RMS X = 0.23 m ~ 2 x GSD	RMS X = 0.34 m ~ 3 x GSD	
RMS Y = 0.18 m ~ 2 x GSD	RMS Y = 0.25 m ~ 2.5 x GSD	

Results

- **DSS322**
  - **The best achievable accuracy in DSS 322 is about 2-3 pixels per X and per Y. Accuracy could be improved by up to 0.5-1 GSD.**

GCPs	Densified GCPs	
Mean X = -0.12 m ~ GSD	Mean X = -0.04 m < 1 GSD	GSD = 0.15 m
Mean Y = -0.05 m ~ 1/3 x GSD	Mean Y = 0.04 m < 1 GSD	
RMS X = 0.37 m ~ 2.5 x GSD	RMS X = 0.29 m ~ 2 x GSD	
RMS Y = 0.25 m ~ 2 x GSD	RMS Y = 0.24 m ~ 2 x GSD	

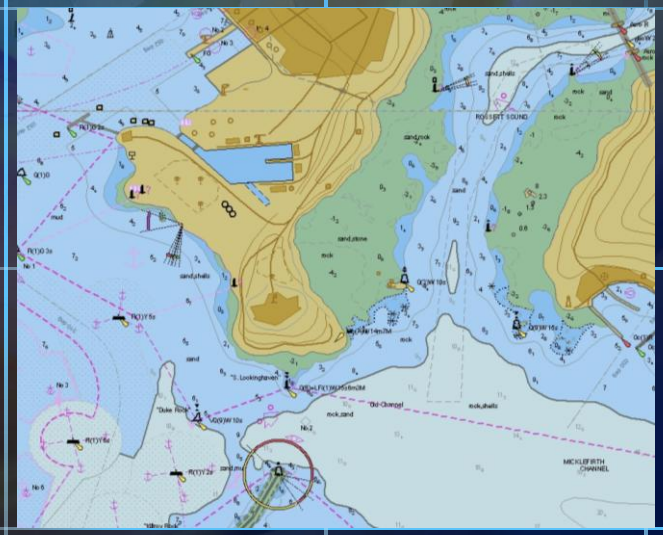
Summary

Work in progress

- Initial evaluation was completed for frame camera geometry with the DSS
- The software is consistent with other industry standards
- Workflows and best practices are being completed
- Other sensors are being investigated and best practices are being developed

Questions

Thank You

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