Ortho-rectification and Precision Terrain Correction with OSSIM

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Overview

Intelligence Data Systems provides software and support as a service to various agencies in the Intelligence Community. This paper specifically addresses recommendations to provide a phased approach to providing and enhancing high volume commercial precision terrain corrected imagery and mosaics controlled to National Technical Means (NTM) reference. OSSIM can provide high volume parallel processing to geometrically accurate imagery with precision terrain correction to DTED. The proposed approach consists of the following phases:

- ***Initial installation and capability demonstration on government Beowulf cluster***
- ***Integrate into existing process, use MET front end to provide updated geometry files as input. Resampling and product generation on OSSIM based cluster***
- ***Replace MET front end with optimized stagers and OSSIM based registration capabilities***

The Open Source Software Image Map (OSSIM) technology was developed by key personnel at Intelligence Data Systems with an open source software development model. This technology provides high performance remote sensing, image processing, and geo-spatial capabilities for both commercial and government data sets. OSSIM has been funded and deployed since 1997 by numerous defense and intelligence agencies in the Federal government and been favorably evaluated in a number of government studies. Configuration Management, software development, documentation and support is provided through Intelligence Data Systems via various contracting vehicles. This paper specifically covers the ortho-rectification and precision terrain correction capabilities of the OSSIM technology suite.

Background

Remotely sensed images are acquired through various types of sensors typically resulting in a detected image and associated metadata being provided to the user. Typically this results in a two dimensional image that was acquired from a three dimensional environment. The associated metadata typically describes the acquisition parameters and relevant calibration information about the sensor. The acquired data is relative to the sensor and not accurately geo-referenced to a desired map projection or projected back into three dimensional space to provide elevation information. For the data to be useful it needs to be processed through a sensor model, transformed to a map projection, and intersected with elevation data to remove geometric and topographic distortions. The OSSIM software baseline provides these capabilities for a number of supported sensor models.

This paper specifically reviews the current capabilities of the OSSIM baseline with respect to the task of precision correction of high resolution satellite data for subsequent use with National Technical Means (NTM) data. Often, for this application, the geodetic accuracy of the commercial data sets needs to be adjusted to remove residual errors and achieve pixel alignment with NTM. Historically, this function has been performed with government funded tool sets such as the Multi-Image Exploitation Tools (MET) currently being commercialized by Harris Corporation. The OSSIM open source baseline supports ingest of MET file formats and geometries allowing a phased approach to be planned for implementing complete capabilities within the OSSIM baseline.

OSSIM Orthorectification and Precision Terrain Correction

Orthorectification and Precision Terrain correction is performed to resample and reproject input pixels from a sensor's output into geographically accurate locations in a desired map projection adjusting for topographic displacements and layovers due to the sensor acquisition geometry and the underlying elevation surface. Brute force attempts using polynomial warping ignore the three dimensional nature of the problem and tend to create artifacts and anomalies. The correct photogrammetric approach is to model the physics involved in the acquisition process and reproject the pixels through a reverse ray tracing algorithm intersecting with a separately supplied elevation model. OSSIM performs these functions by default when data is ingested through a sensor model and elevation data is available on the system.

Sensor Models

OSSIM supports and implements several types of rigorous sensor models including frame, pushbroom, scanline, and synthetic aperture radar. Specific instances of these model classes have been implemented for Landsat, SPOT, Ikonos, Quickbird and aerial frame cameras. The Universal Sensor Model using Residual Polynomial Coefficients (RPCs) is also implemented for both commercial and national sensors. Implemented sensor models ingest the imagery and associated metadata with specialized formatters and parsers. Vehicle and acquisition metadata is loaded and processed in the sensor model for sensor position, attitude, focal length to provide the initial sensor orientation and view plane projection in three dimensional space. The image plane is then projected onto a three dimensional mathematical model of the earth using the appropriate ellipsoid and available digital terrain elevation data. The default format for OSSIM is DTED and the software will automatically prioritize and retrieve the relevant DTED for the projection area. OSSIM already supports arbitrary Map Projection, Datum, Resampling, and File conversions within its core capabilities.

Terrain Correction

The OSSIM library and associated tools supports automated loading of DTED. When spatial data sets are loaded into the software the geographic footprints are automatically calculated and elevation data sets are loaded into the system based on the settings in the OSSIM preference files. Multiple elevation tree structures can be prioritized and traversed to provide loaded elevation over the project area. Once the elevation cells are loaded they are automatically used to provide precision terrain correction for any displayed or processed imagery. This feature can optionally be disabled in cases where elevation correction is not desired.

Image data is projected on to the elevation surfaces as the area of interest is processed through the image processing chain. Typically, the flow begins with native sensor data on disk, processed through file formatters into the associated sensor model. The sensor model provides calibration and correction services and projects an image plane in three dimensional space referenced in geodetic coordinates. Similar to many traditional ray tracing algorithms, the sensor pixels are projected along a ray from the platform position through the image plane and intersected with the three dimensional surface established by the appropriate ellipsoid and elevation surface. This process establishes the pixels coordinates in geodetic ground space.

OSSIM can arbitrarily resample to any desired spatial resolution and map projection. This re-sampling is performed on demand to fill the required output area whether that output is to a viewport, display, printer, or file. Data access and processing is optimized with an underlying image tile structure that provides efficient spatial and spectral access to the data sets. Pre-processed reduced resolution data sets and histogram files reduce the number of redundant calculations in the overall workflow. A tile based scheduler provides high performance parallel processing capabilities.

Geometry Adjustments

The current OSSIM baseline has methods for adjusting sensor parameters. The Visual Chain Editor tool has dialogs and controls for directly manipulating parameter values. This would be tedious and impractical for large volume production. One of the design goals is to fully implement autonomous image registration and automated parameter adjustment based on feature correlation in overlapping areas. Until then, it is possible to perform the geometry adjustments externally and apply the adjusted parameters within OSSIM to take advantage of cluster processing and enhanced product generation.

Mosaicking

One of the strengths of the OSSIM baseline is the ability to rapidly create cross sensor mosaics and output arbitrary areas of interest within the coverages. A number of functions exist for histogram matching, tonal balancing, and layering of data. Various combiner methods are provided for compositing imagery in mosaic overlap areas.

A Phased Approach to High Volume Commercial Imagery Mosaics

It is assumed that the current process is MET based and similar to the diagram shown below:

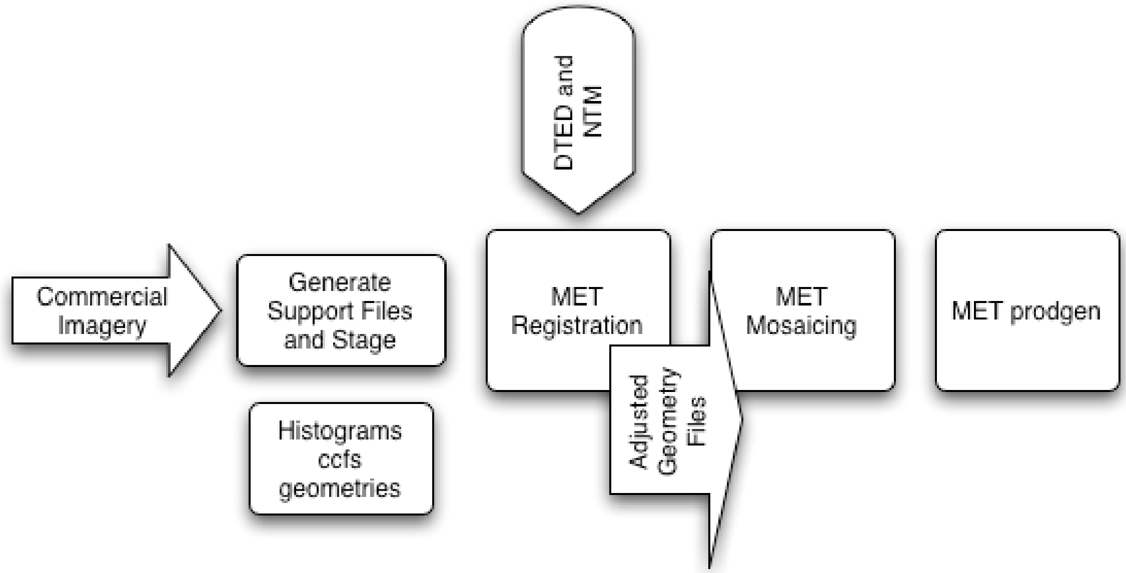

Figure 1 Assumed current process with MET

Commercial imagery will need to be loaded into the sensor models and the corresponding geometry, histogram, and ccf files will need to be generated in the staging process. With NTM and DTED used for control, the commercial imagery is registered updating the MET geometry files. Those adjusted files are subsequently used to define the mosaics and product is output through the generation of a spec file and prodgen.

Phase 1 – Initial Installation and capability demonstration on government Beowulf computer

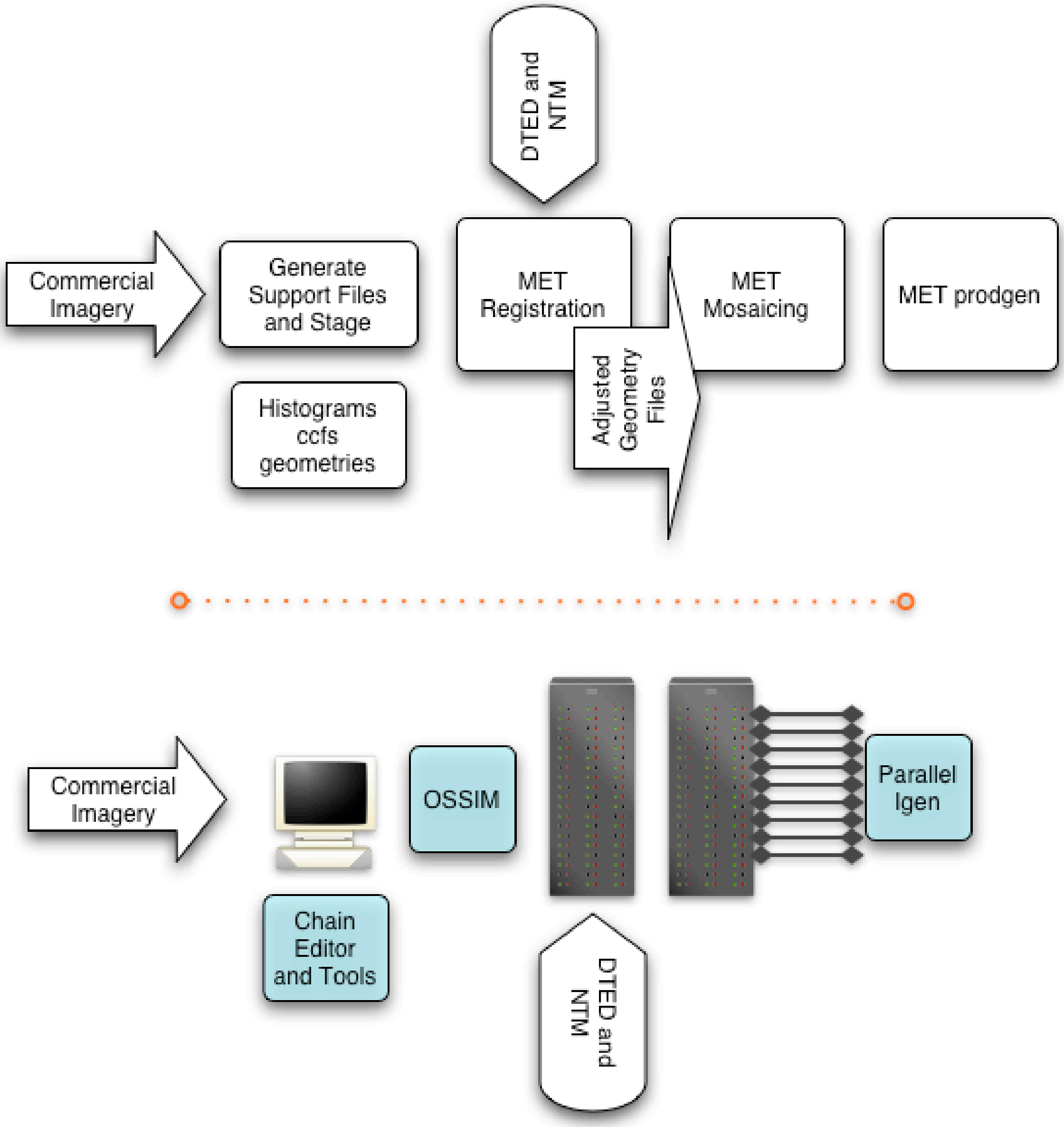

Figure 2 Initial Installation and Demonstration

During Phase 1 the software will be installed and demonstrated on the Beowulf cluster. OSSIM based tools will be installed on attached workstations. The OSSIM baseline will be able to take advantage of the same reference data sets and be able to ingest and manipulate commercial imagery sets. Parallel processing with the mpi libraries and a scheduler will be available. Operations will remain unchanged with the existing process.

Phase 2 - Integrate into existing process, use MET front end to provide updated geometry files as input. Resampling and product generation on OSSIM based cluster

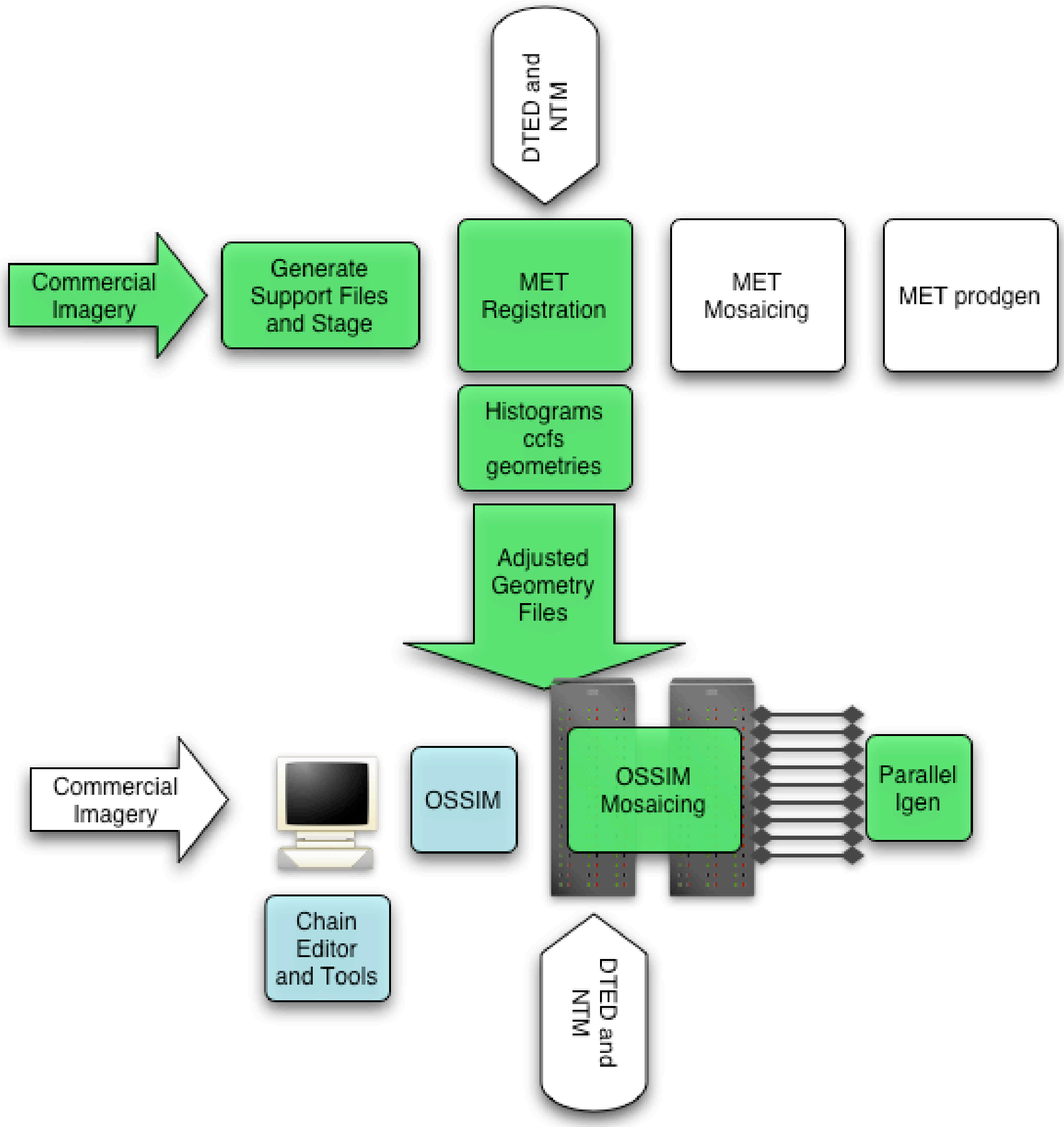

Figure 3 Ingesting MET files into OSSIM

Phase 2 will continue to use MET for staging and geometry corrections to commercial imagery with its autonomous image registration capabilities. The OSSIM system will ingest the updated geometries, histogram and ccf files and perform the computationally expensive resampling, precision terrain correction and product generation functions taking advantage of the parallelism in the OSSIM library on the Beowulf cluster. This phase can be demonstrated and implemented without disruption to the existing production chain.

Phase 3 - Replace MET front end with optimized stagers and OSSIM based registration capabilities

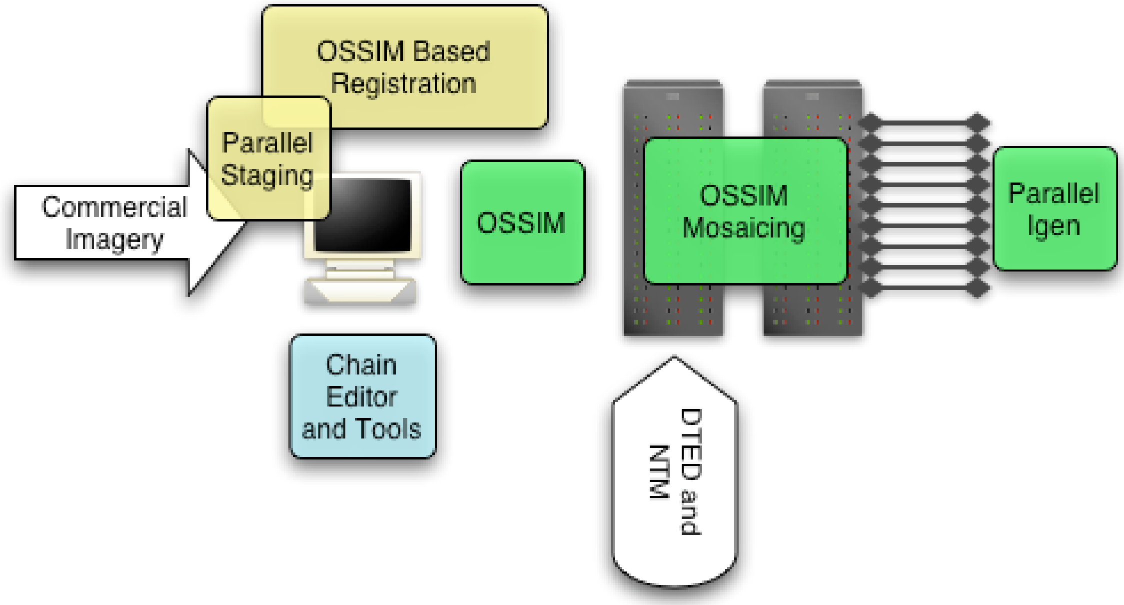

Figure 4 Optimizing Parallel Processes with OSSIM

Optimized Staging and Autonomous Image Registration are new capabilities that will be developed and integrated into the system in the third phase. This will allow parallel scheduling and staging of the ingest process and automate the geometry correction process to the extent possible to provide a highly leveraged and parallel commercial product generation capability.

Summary

The OSSIM baseline has the potential of providing a highly leveraged technology platform to meet mission requirements. Specifically, much of the capability to provide high volume and accurate commercial satellite imagery mosaics already exists. OSSIM already has support for MET ccf and geometry file ingest and the development team has a number of years experience with both systems.

As OSSIM is an open source software technology it continues to evolve and improve as more users and developers become involved with deploying the technology. Embedded support for parallel processing and the parameter based processing design make it well suited for high performance Beowulf computing solutions. OSSIM has been ported to a number of platforms including Linux, Windows, MacOSX, Solaris and AIX.

IDS is a subcontractor to SRA on the GRAAMI contract and is available to assist in implementing the OSSIM solution.