INTERNATIONAL SCHOOL ON LIDAR TECHNOLOGY

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Indian Institute of Technology Kanpur, INDIA

Lecture 11: GNSS/IMU data workflow and LAS file creation

Yuji Kuwano, Lead ALS Support Engineer

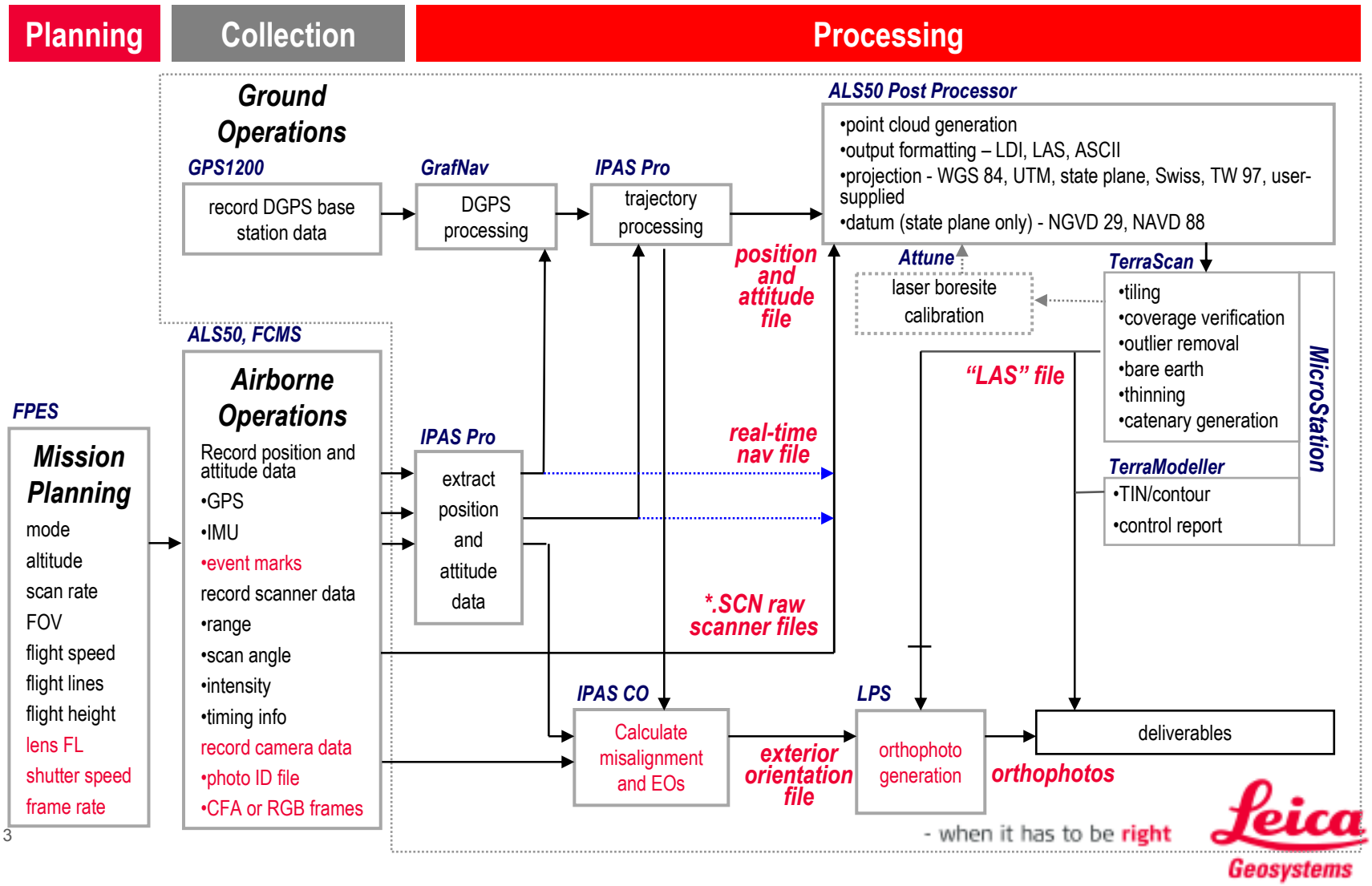
Leica Geosystems AG

- when it has to be right

Presentation outline

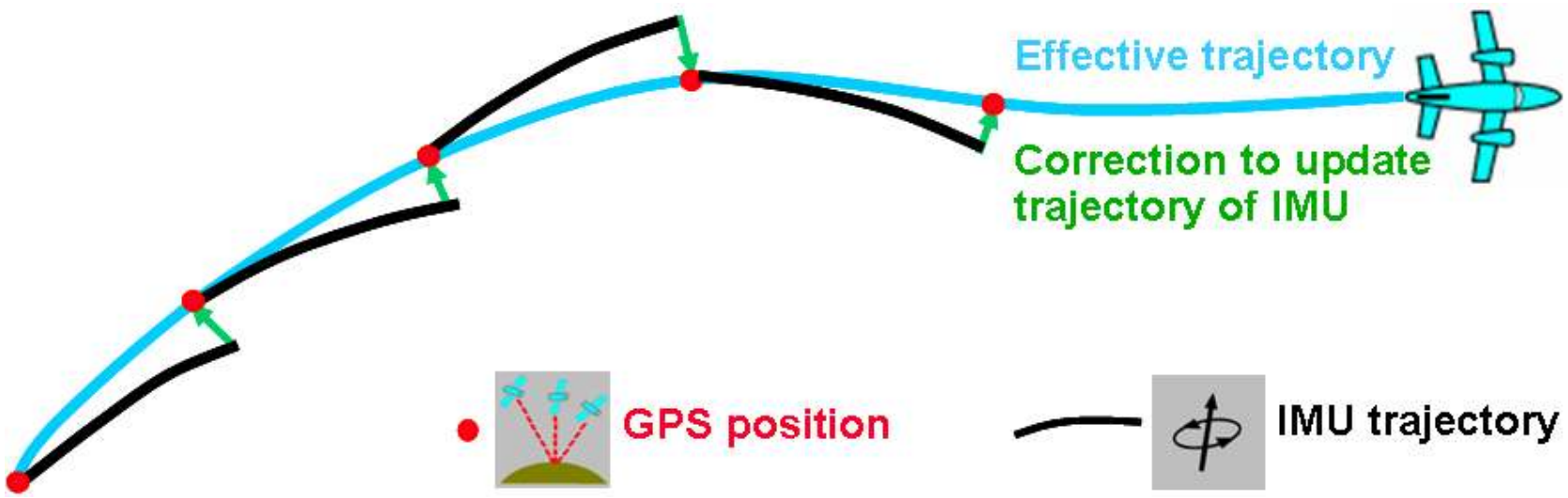
1. Introduction of Leica Geosystems IPAS solution
2. LAS generation workflow with Leica Geosystems software
3. Lidar Point cloud data handling options

Leica Geosystems ALS50 process workflow



GNSS-IMU trajectory for ALS50 - the principle

The GNSS sensor generates an absolute position at 1 Hz.
The IMU sensor generates a relative position and a precise orientation of pitch, roll and drift at 200 Hz.
Trajectory given by IMU is updated with absolute position given by GNSS.



Leica Geosystems IPAS10

Leica Geosystems strengths

Airborne components

- Leica Geosystems experience in designing and manufacturing airborne hardware
- Hardware designed according to DO-160E and complies with EMV standards Cat. M
- Powerful processor board and better designed electronics support high data rate
- Large number of external interfaces including four IMU types

GNSS/IMU post processing Software

- Straight forward and intuitive

General

- IPAS10 and IPAS Pro and IPAS CO is based on years of experience and testing
- All airborne sensing components from one supplier
- One point of contact for support of all components

Leica Geosystems IPAS10
Systems

System	IPAS10-NUS4	IPAS10-DUS5	IPAS10-NUS5	IPAS10-CUS6
Equivalent	POS 410	POS 510	POS 510	POS 610
IMU type	**FSAS**	**LN200**	**33BM61**	**uIRS**
IMU Manufacturer	**iMAR**	**Northrop Grumman**	**SAGEM**	**Honeywell**
Availablility for ALS50	**Yes**	**Yes**	**Yes**	**Yes**
Standalone IPAS10 for RC30/PAV30	**Yes**	**Yes**	**Yes**	**Not recommended IMU too heavy**

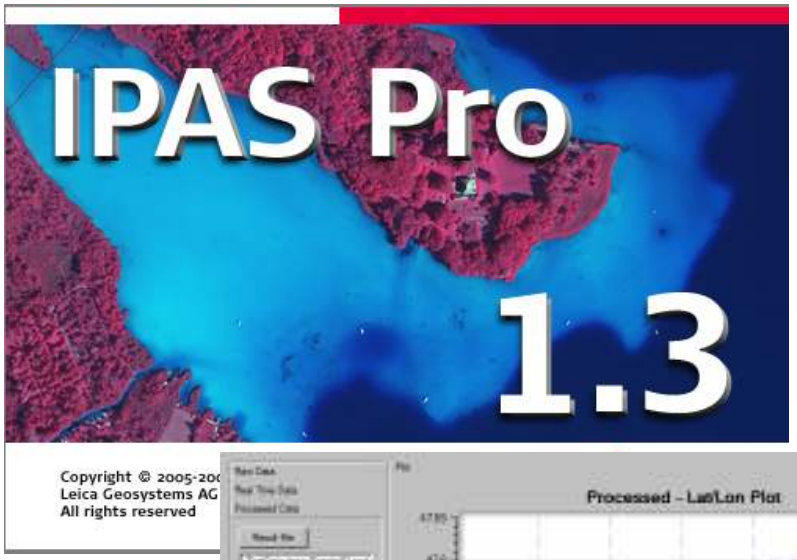
GNSS-IMU for ALS50-II and RCD105

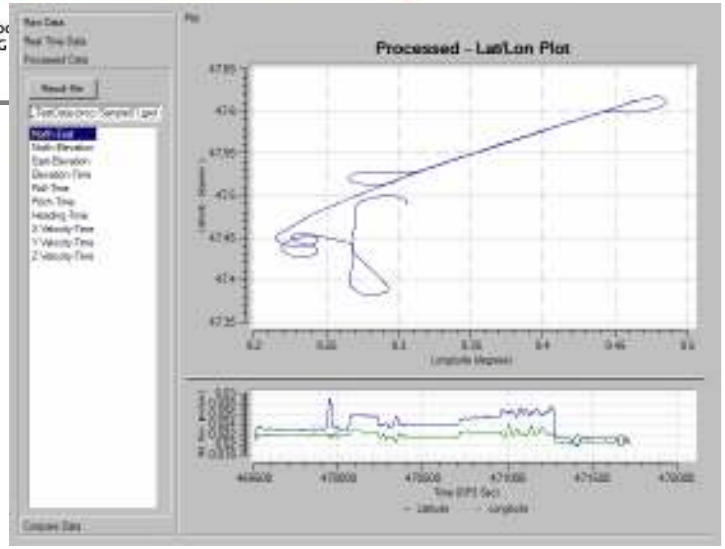
- IMU - integrated in Laser Scanner LS50-II
- IPAS Position and Attitude computer with GNSS engine - integrated in System Controller SC50

- GNSS post - processing software:
  - GrafNav
  - IPAS Pro
  - IPAS CO – for systems with RCD105

Leica Geosystems IPAS Pro

- Perform post processing of GPS/IMU data based on proven error modeling principle,
- Simplified and refined Windows-based user interface to make the GPS/IMU processing more reliable and less challenging,
- Automatically checking GPS, IMU and mount data integrity,
- Forward processing, backward processing and optimal smoothing to produce optimal integrated georeferencing solution,
- Use faimilar Waypoint GrafNav to process GPS data,
- Provides competitive georeferencing accuracy as current systems on the market.

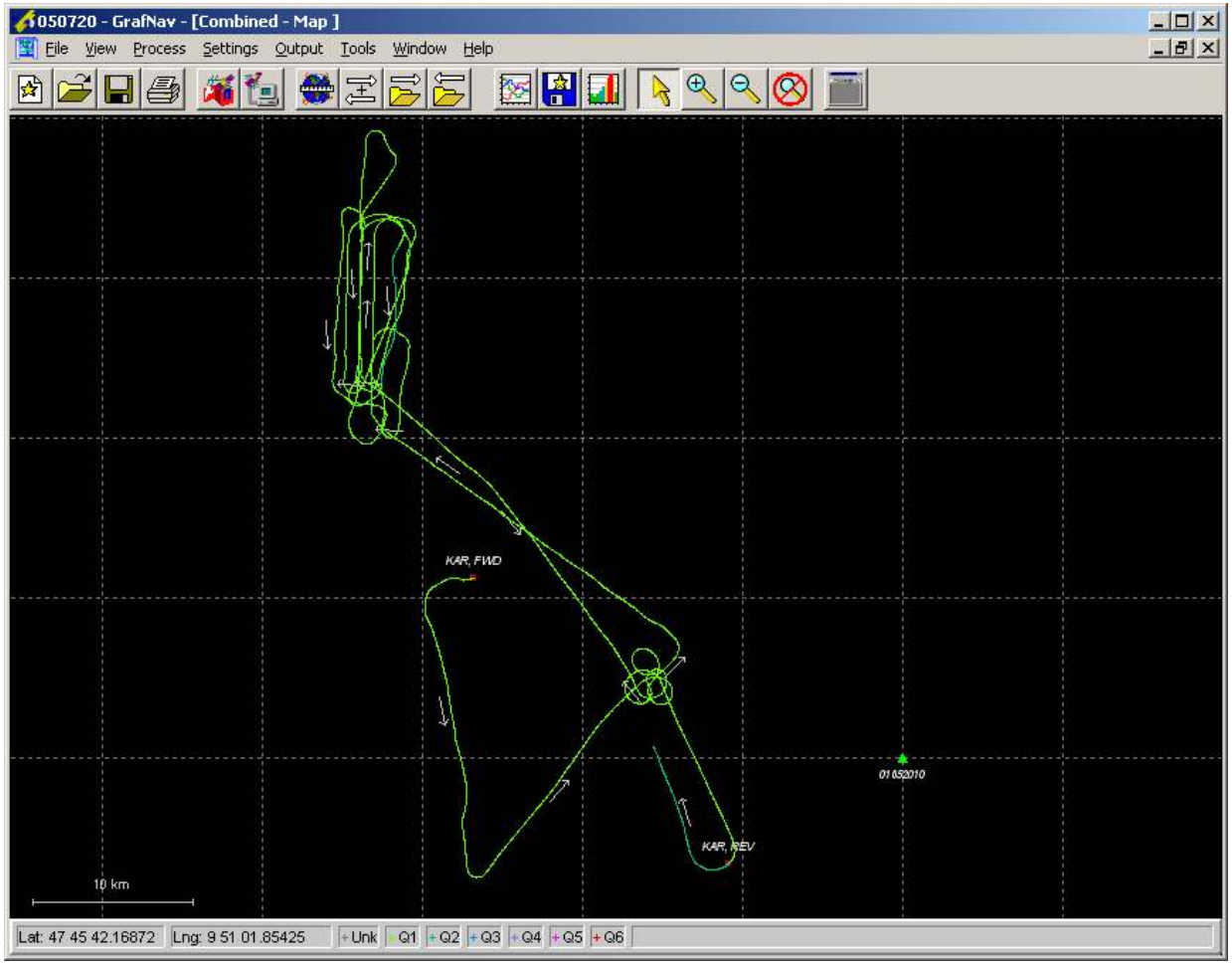




- when it has to be right

Leica Geosystems

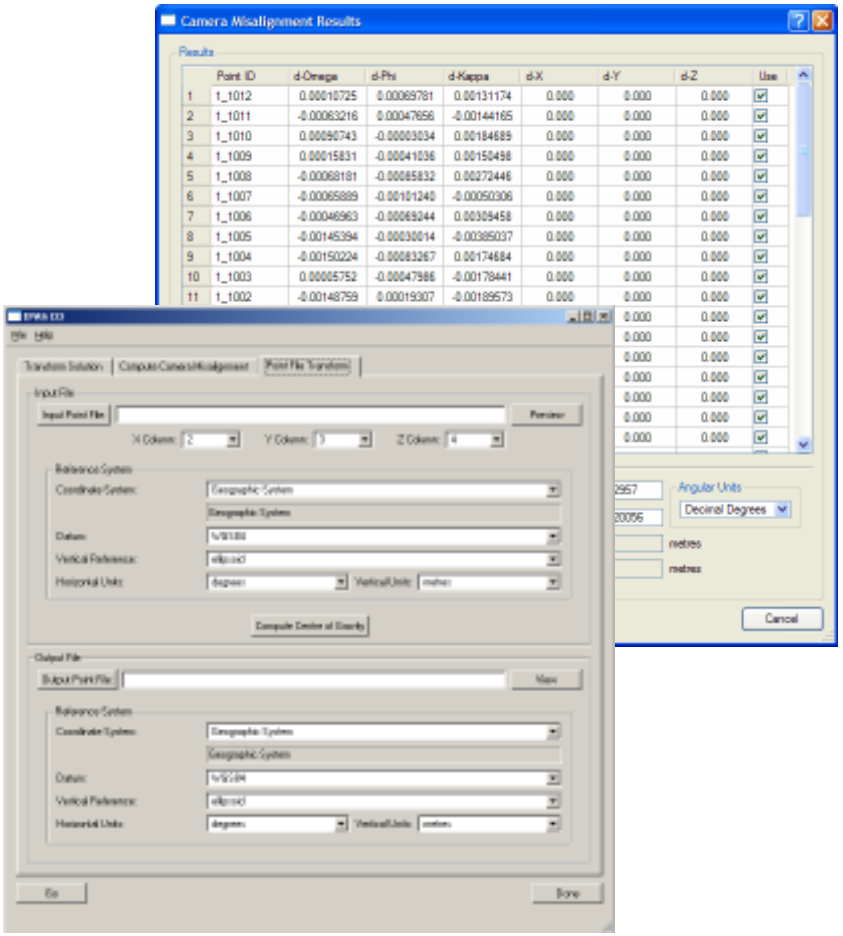
Differential GNSS trajectory calculation - GrafNav



Leica IPAS CO

Camera Orientation Software for frame camera flow

- Transformation of IPAS Pro solution and camera events for further use in various photogrammetric software
- Computation of misalignment angles between IPAS reference frame and camera frame
- Transformation of points



- when it has to be right

Leica Geosystems

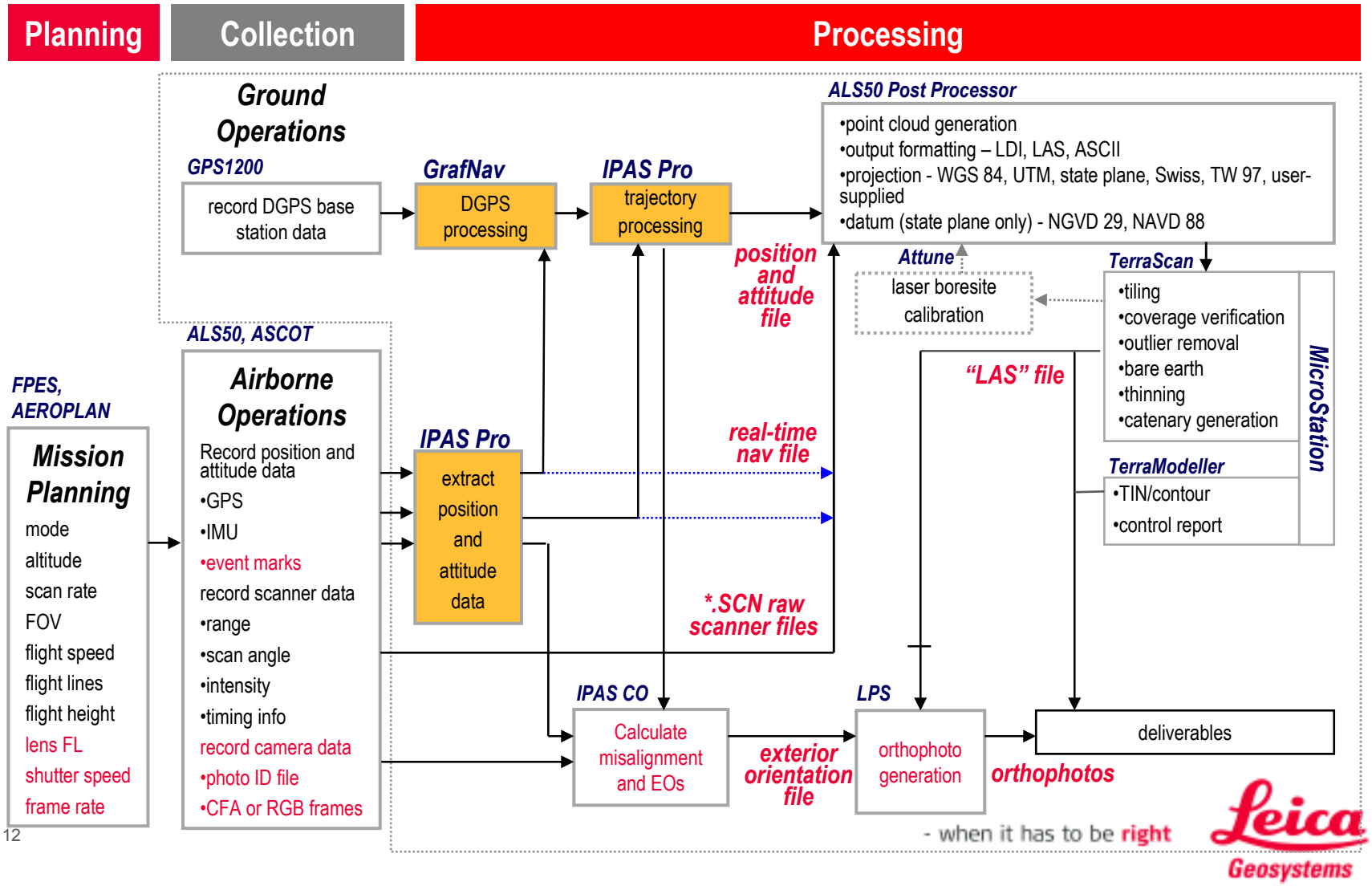
IPAS Pro

Aircraft trajectory computation

- when it has to be right

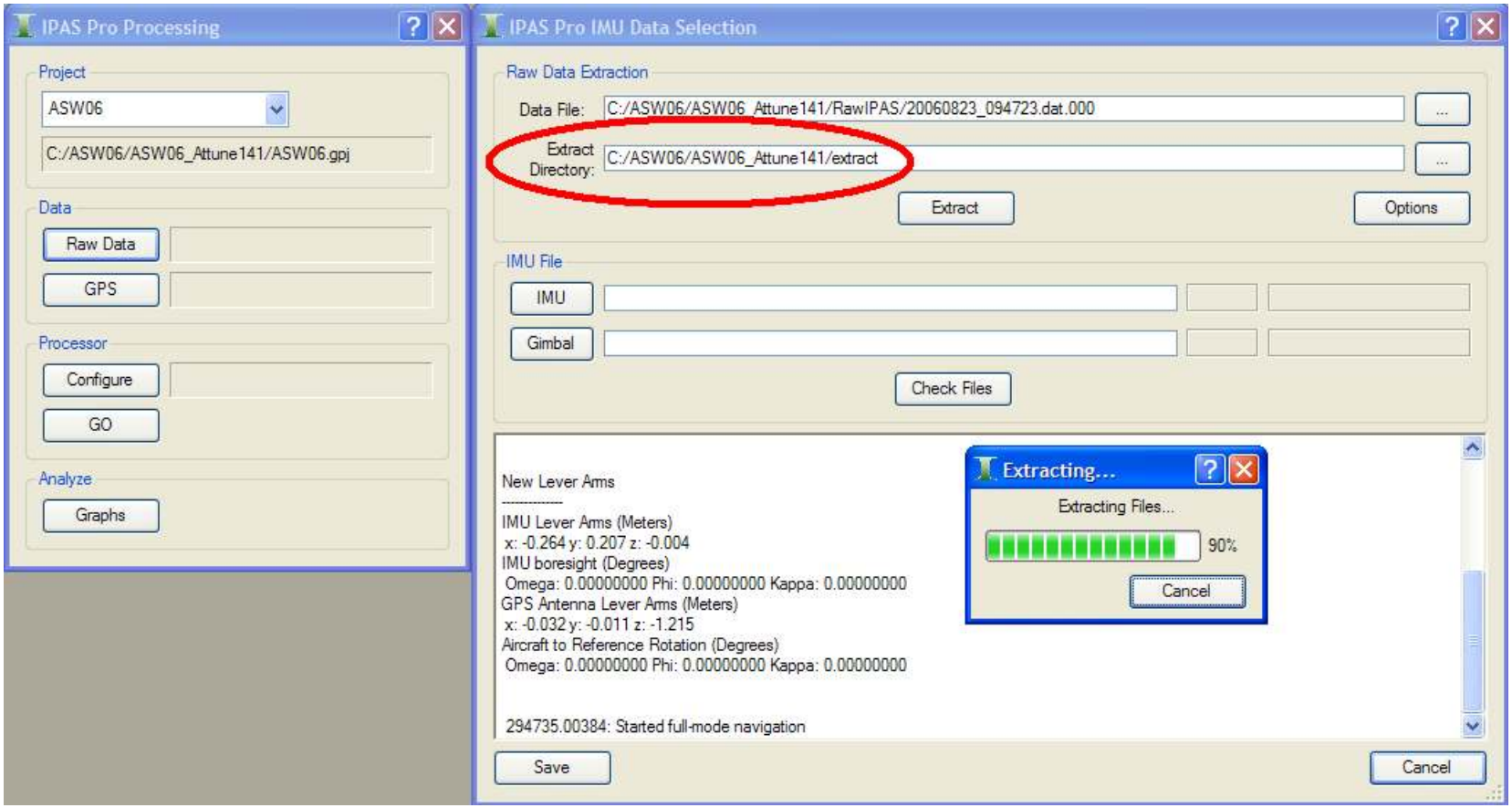
Leica Geosystems

Aircraft trajectory workflow overview
in context of LIDAR workflow



IPAS Pro

extract directory automatically created



IPAS Pro

step 1 - data written to extract directory

Address C:\ASW06\ASW06_Attune141\extract

File and Folder Tasks

Other Places

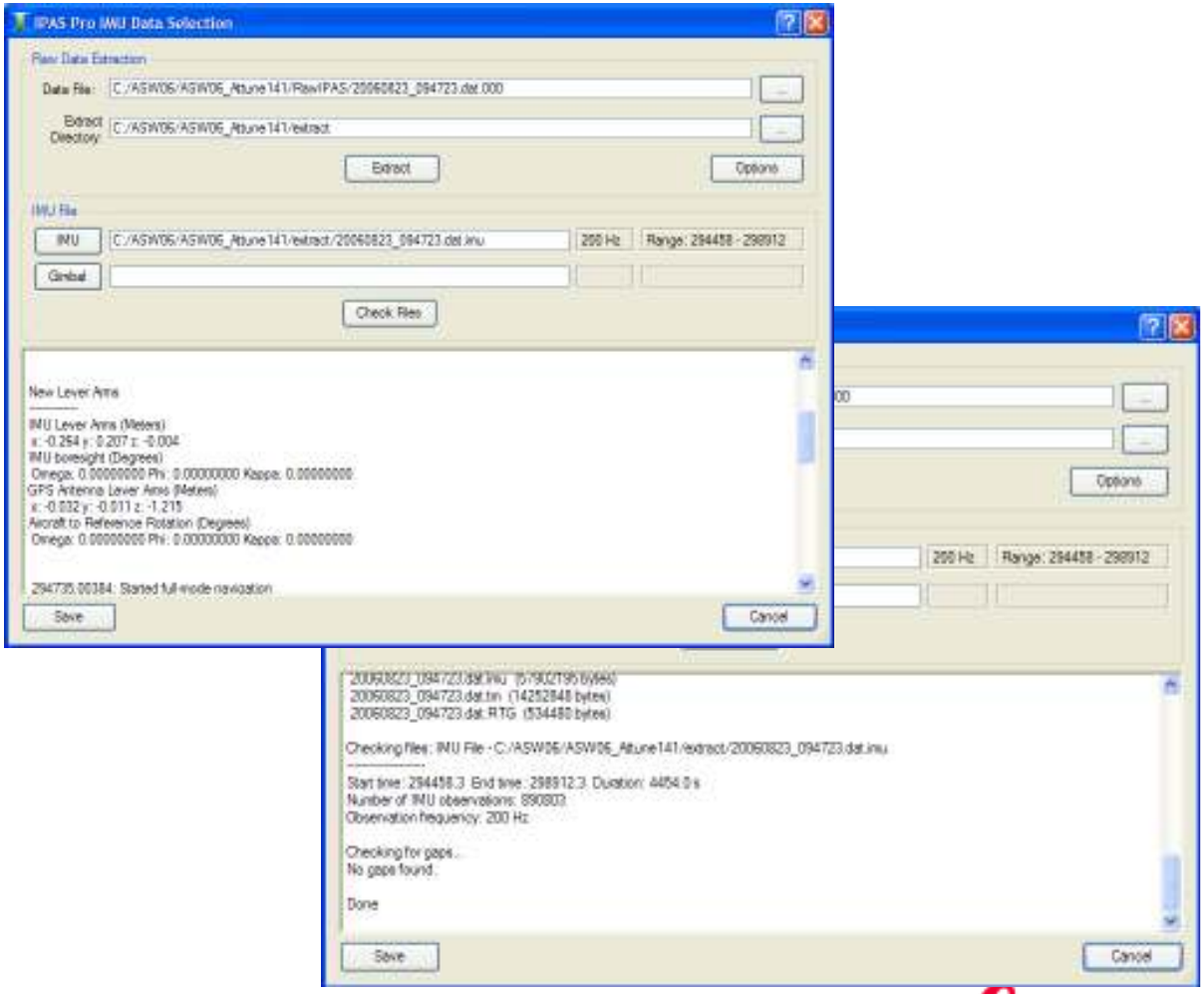
Details

Name	Size	Type
20060823_094723.dat.GPS	10,747 KB	GPS File
20060823_094723.dat.IMU	56,546 KB	IMU File
20060823_094723.dat.RTG	522 KB	RTG File
20060823_094723.dat.TM	13,919 KB	TM File
20060823_094723_0.EVT	2 KB	EVT File
ASW06_extractLog.txt	3 KB	Text Document
ASW06_RTMsg.txt	1 KB	Text Document

IPAS Pro

Parameter check lever arms

- **Lever Arm check**
  - GNSS
  - IMU Lever Arm
- **Data Gap**
  - GNSS
  - IMU



IPAS Pro

output also stored in log file

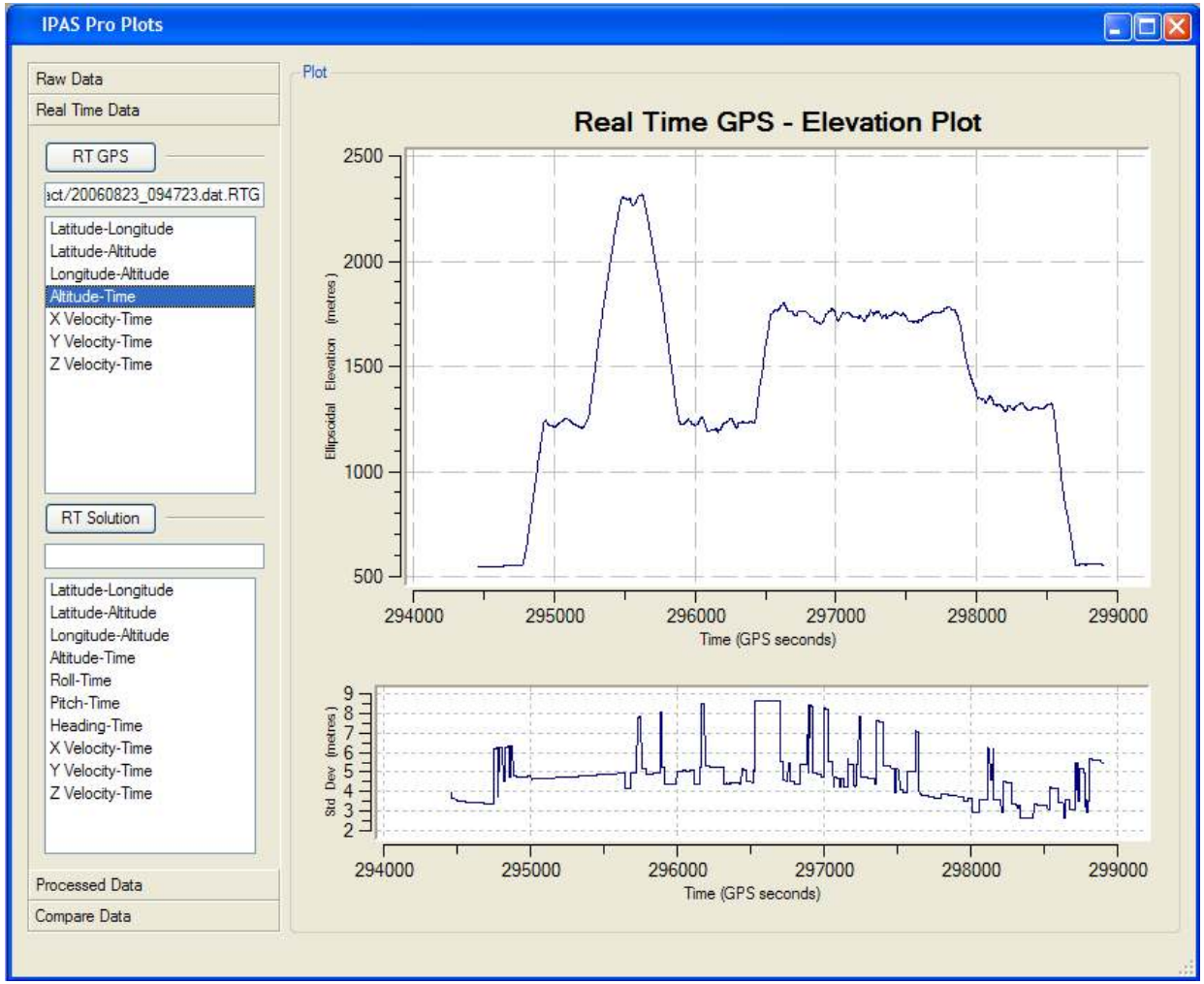
ASW06_extractLog.txt - Notepad

File Edit Format View Help

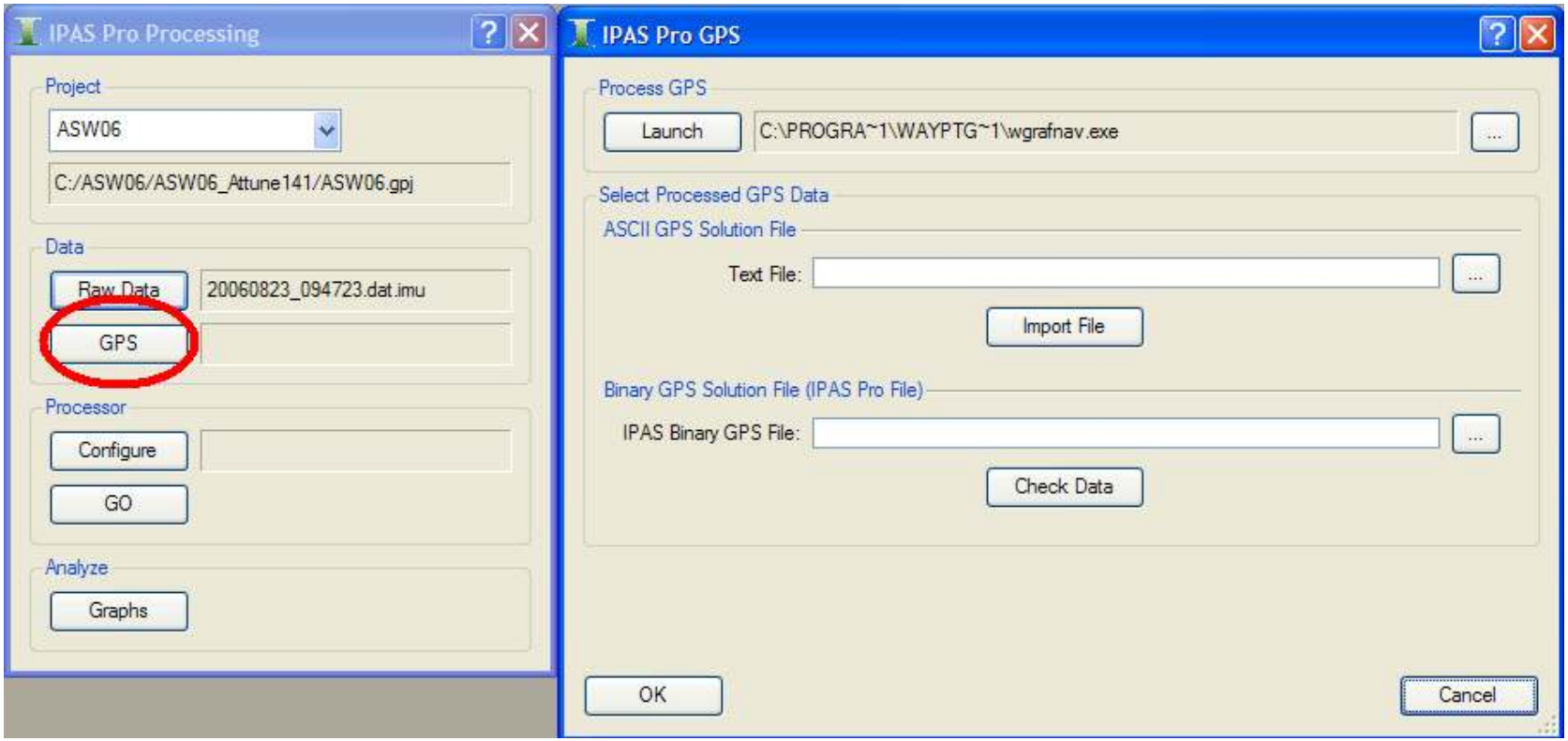
```
26.09.2006 05:37:10
26.09.2006 05:37:10
26.09.2006 05:37:11  Started Extraction
26.09.2006 05:37:11   Raw file: C:\ASW06\ASW06_Attune141\RawIPAS\20060823_094723.dat.000
26.09.2006 05:37:11   Extracting to: C:\ASW06\ASW06_Attune141\extract\
26.09.2006 05:37:11
26.09.2006 05:37:11  Imu Type: uIRS_200Hz
26.09.2006 05:37:11
26.09.2006 05:37:11
26.09.2006 05:37:11  New Lever Arms
26.09.2006 05:37:11  --------------
26.09.2006 05:37:11  IMU Lever Arms (Meters)
26.09.2006 05:37:11   x: -0.264 y: 0.207 z: -0.004
26.09.2006 05:37:11  IMU boresight (Degrees)
26.09.2006 05:37:11   Omega: 0.00000000 Phi: 0.00000000 Kappa: 0.00000000
26.09.2006 05:37:11  GPS Antenna Lever Arms (Meters)
26.09.2006 05:37:11   x: -0.032 y: -0.011 z: -1.215
26.09.2006 05:37:11  Aircraft to Reference Rotation (Degrees)
26.09.2006 05:37:11   Omega: 0.00000000 Phi: 0.00000000 Kappa: 0.00000000
26.09.2006 05:37:11
26.09.2006 05:37:20  Successfully read complete file!
26.09.2006 05:37:20
26.09.2006 05:37:20  Version Statistics
26.09.2006 05:37:20  -----------------
26.09.2006 05:37:20  Product Name: IPAS  Model: 10  SN: 4  Version: 1.0605
26.09.2006 05:37:20  OS Version: WINXPE  IMU Type: 3  IMU SN: n/a
26.09.2006 05:37:20  Primary GPS Type: 1  Model: L1L2  Firmware Version: 2.312  SN: SVG05070010
26.09.2006 05:37:20  Secondary GPS Type: 0  Model:   Firmware Version:   SN:
26.09.2006 05:37:20  Total Hours Used: 13.4  Number of Runs: 44  Current Run: 1.2
26.09.2006 05:37:20
26.09.2006 05:37:20
26.09.2006 05:37:20  Finished Extraction.  Extracted the following files:
26.09.2006 05:37:20   20060823_094723.dat.gps  (11004362 bytes)
26.09.2006 05:37:20   20060823_094723.dat.imu  (57902195 bytes)
26.09.2006 05:37:20   20060823_094723.dat.tm  (14252848 bytes)
26.09.2006 05:37:20   20060823_094723.dat.RTG  (534480 bytes)
26.09.2006 05:37:20
26.09.2006 05:37:20  Checking files: IMU File - C:/ASW06/ASW06_Attune141/extract/20060823_094723
26.09.2006 05:37:20  ---------------------
26.09.2006 05:37:20  Start time: 294458.3  End time: 298912.3  Duration: 4454.0 s
26.09.2006 05:37:20  Number of IMU observations: 890803
26.09.2006 05:37:20  Observation frequency: 200 Hz
26.09.2006 05:37:20  Checking for gaps...
26.09.2006 05:37:20  No gaps found.
```

IPAS Pro

check graphs – real time data



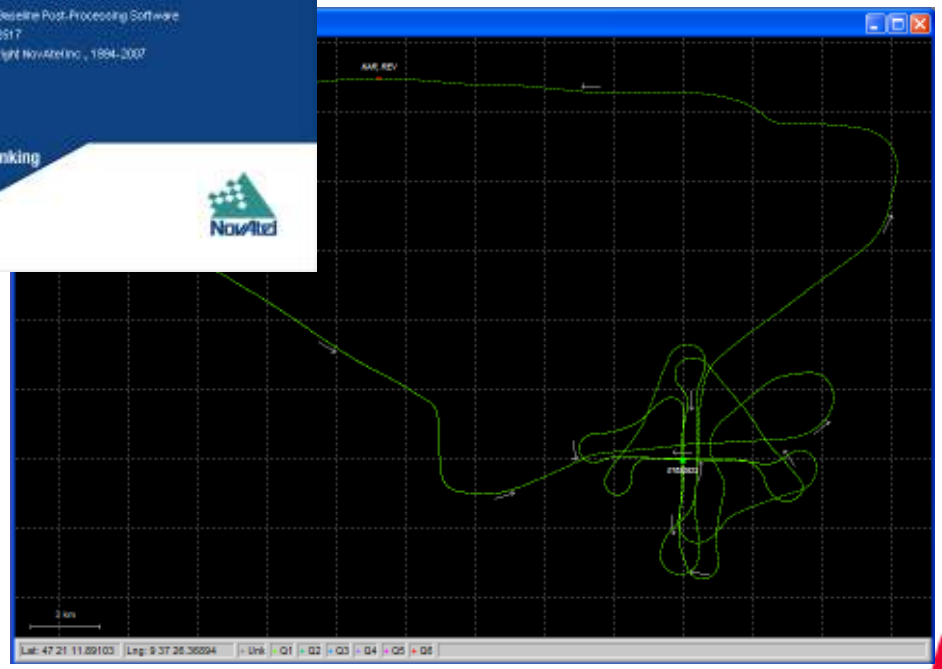
IPAS Pro
launch GNSS processor



IPAS Pro
process differential GNSS

GrafNav

- Differential GNSS processing

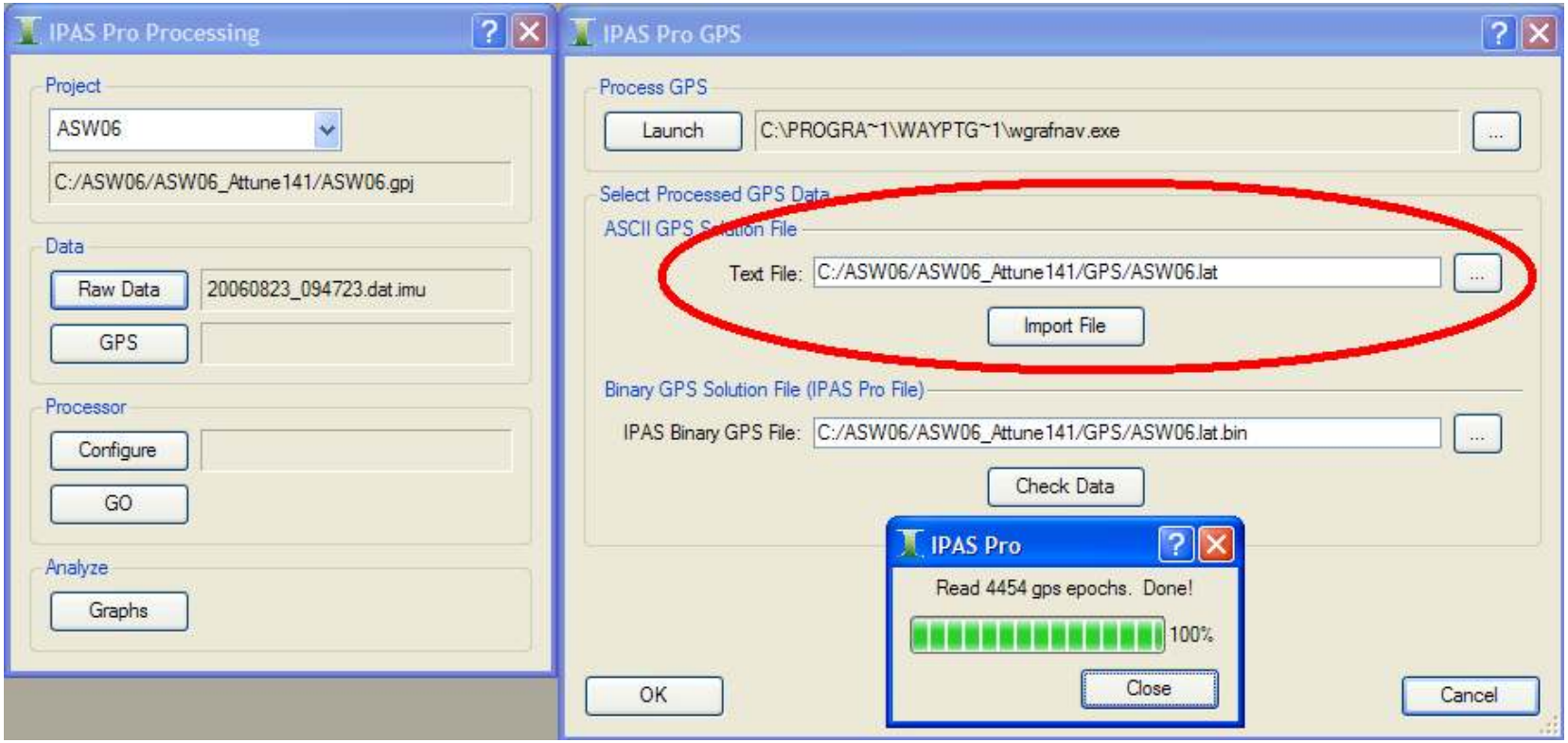


IPAS Pro
output GPS solution in IPAS Pro format

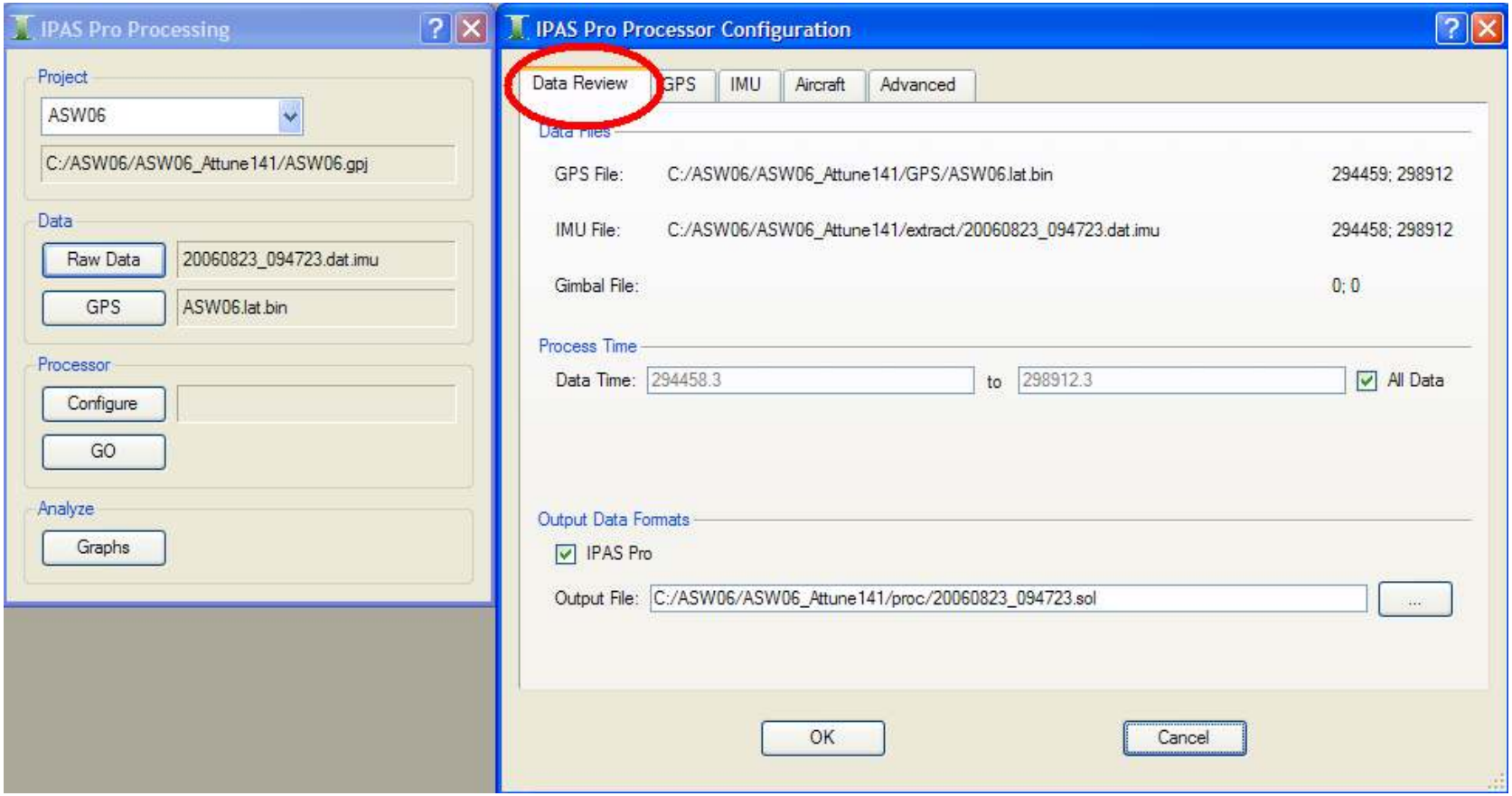
IPAS Pro requires an ASCII post-processed GPS solution file. The file format is defined as following:

- **GPSTime** - GPS Time (Seconds of the week)
- **Latitude** - Latitude (Decimal Degrees)
- **Longitude** - Longitude (Decimal Degrees)
- **H-Ell** - Ellipsoidal Height (meters)
- **Q** - Quality Number, an integer number
- **SDNorth** - Latitude Standard Deviation (meters)
- **SDEast** - Longitude Standard Deviation (meters)
- **SDHeight** - Height Standard Deviation (meters)
- **VNorth** - North Velocity (meters/second)
- **VEast** - East Velocity (meters/second)
- **VUp** - Up Velocity (meters/second)
- **SD-VN** - North Velocity Standard Deviation (meters/second)
- **SD-VE** - East Velocity Standard Deviation (meters/second)
- **SD-VH** - Height Velocity Standard Deviation (meters/second)

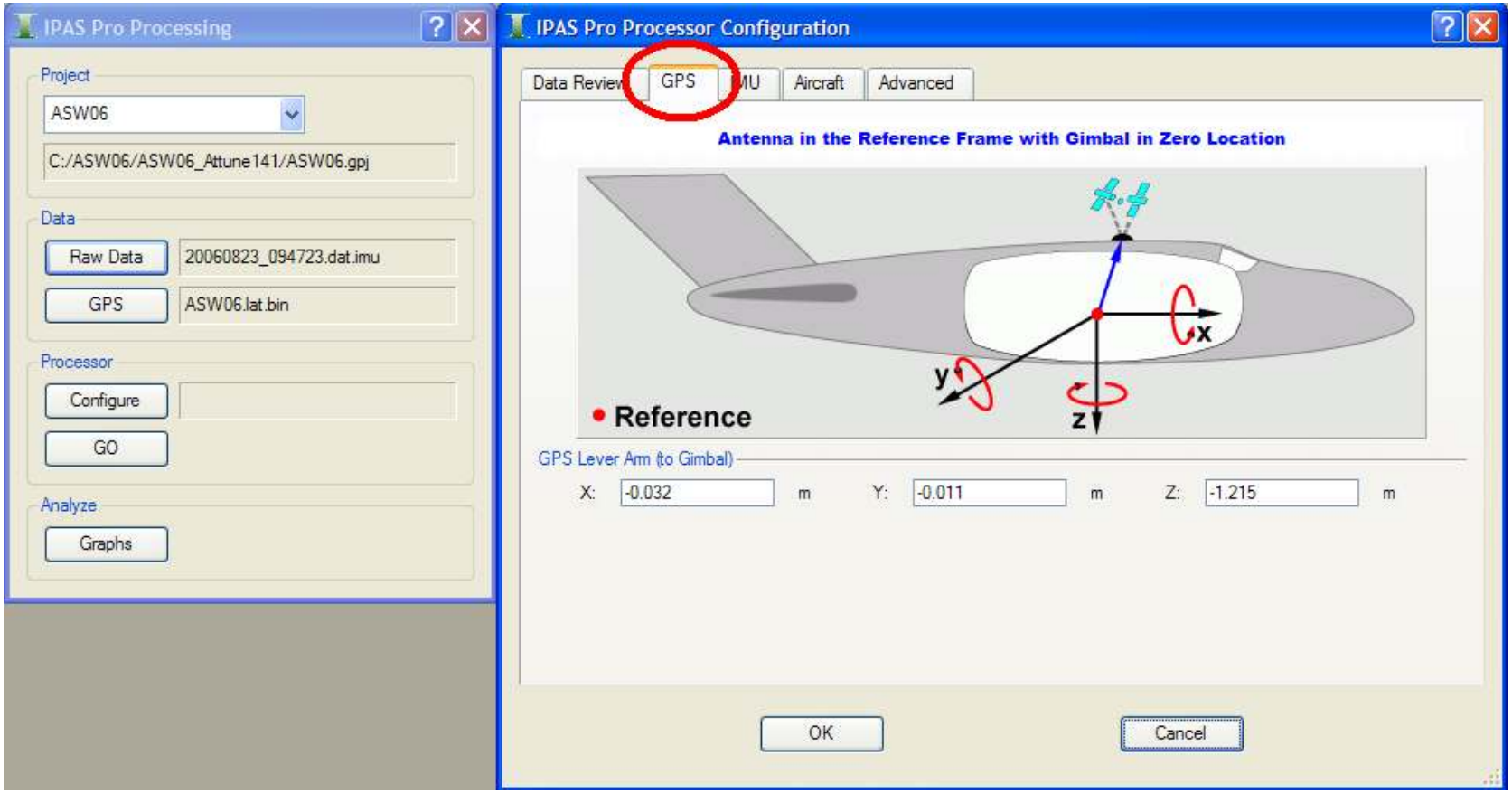
IPAS Pro
step 2 - import GNSS solution



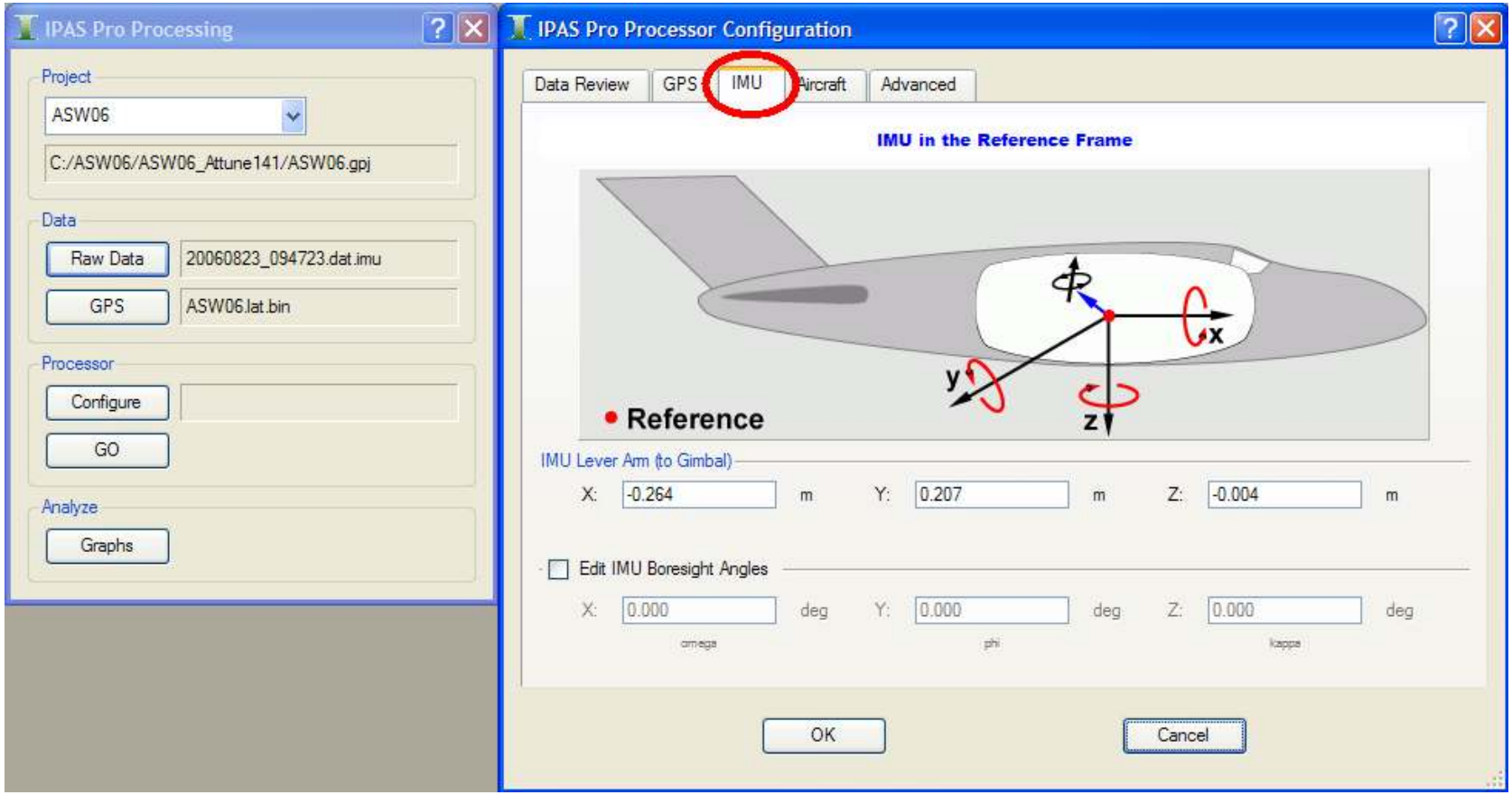
IPAS Pro
review data import



IPAS Pro
check GNSS lever arms

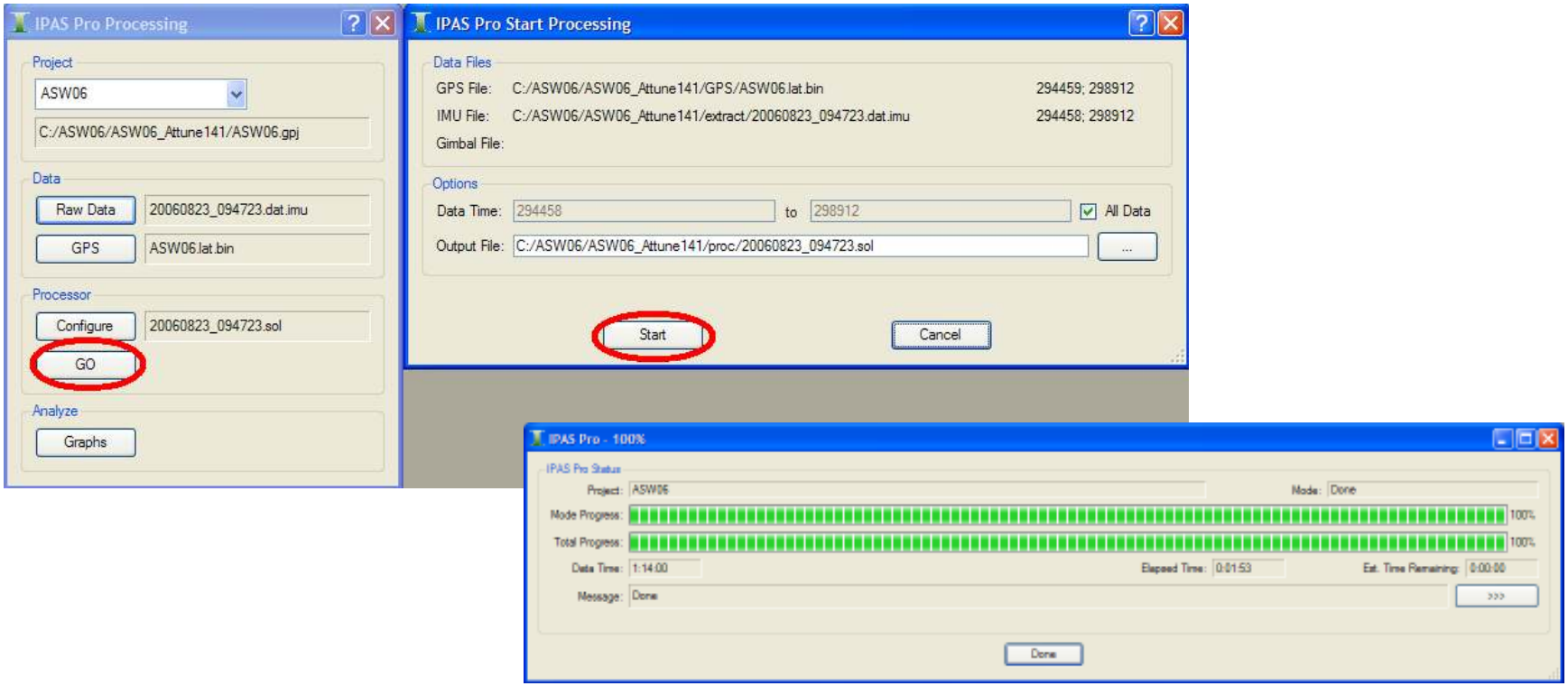


IPAS Pro
check IMU lever arms

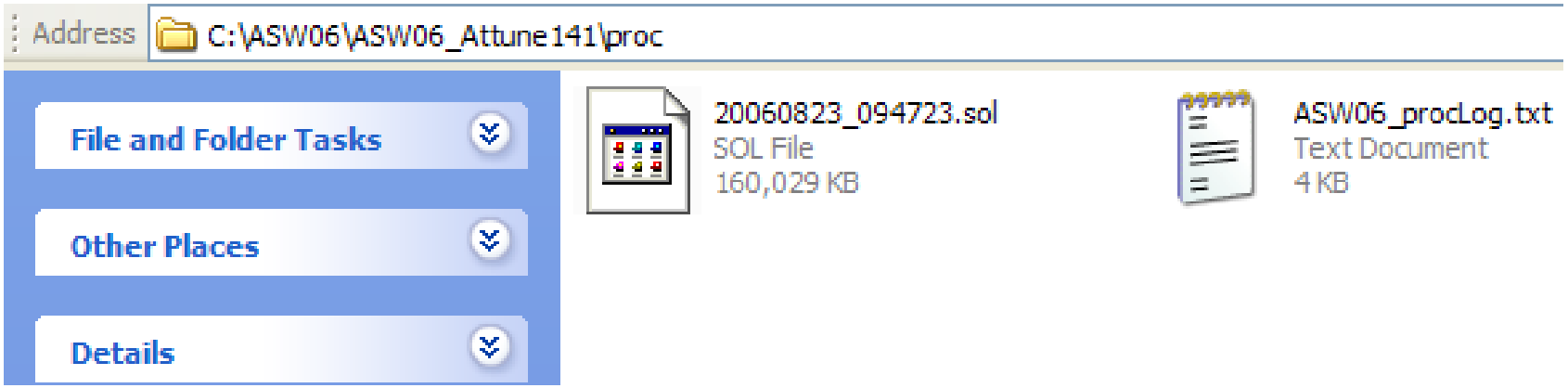


IPAS Pro
start trajectory processor

Process forward , backwords for smoothing

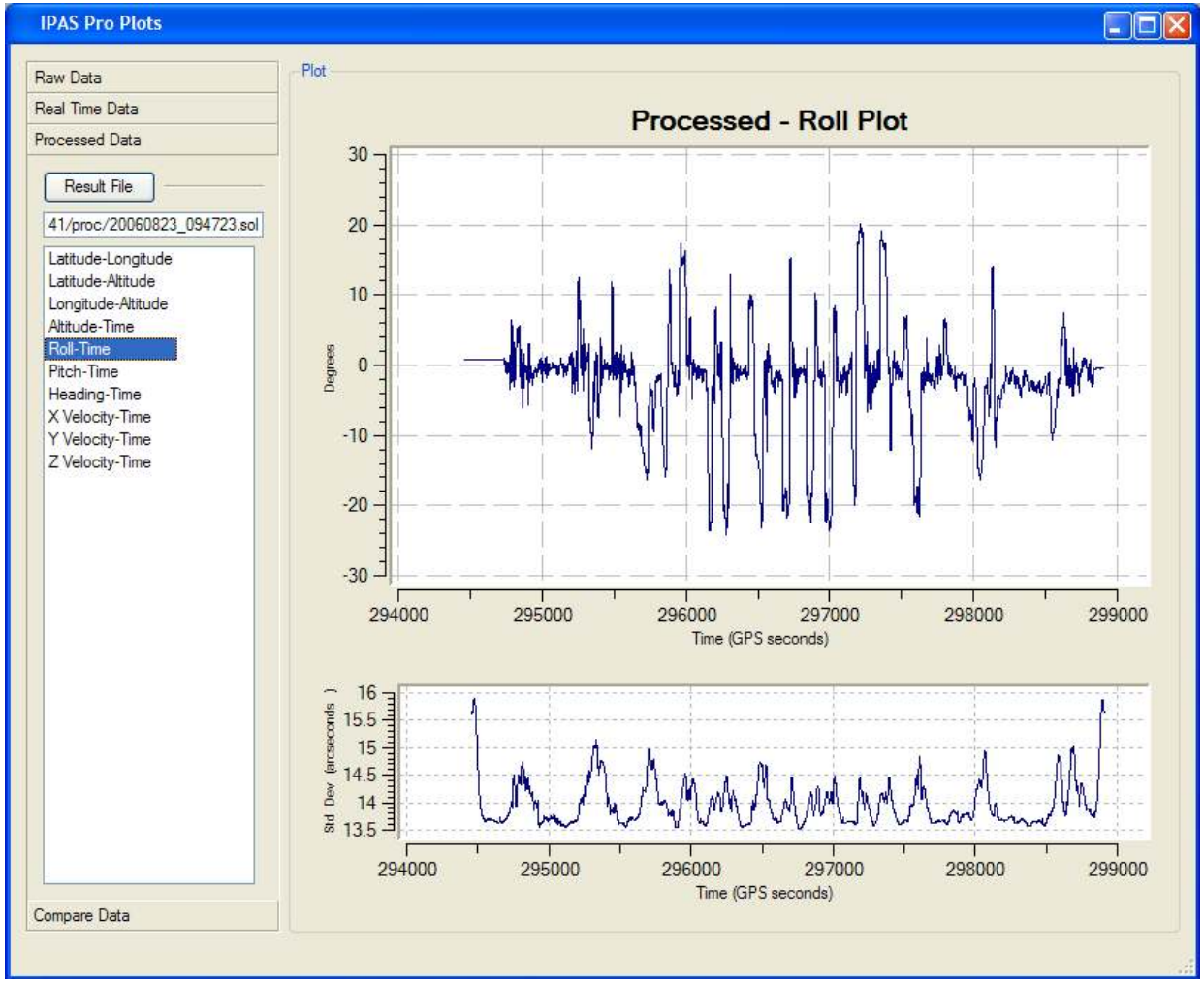


IPAS Pro
data written to proc directory



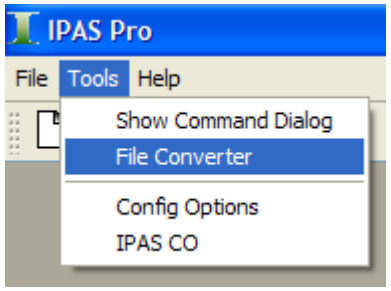
IPAS Pro

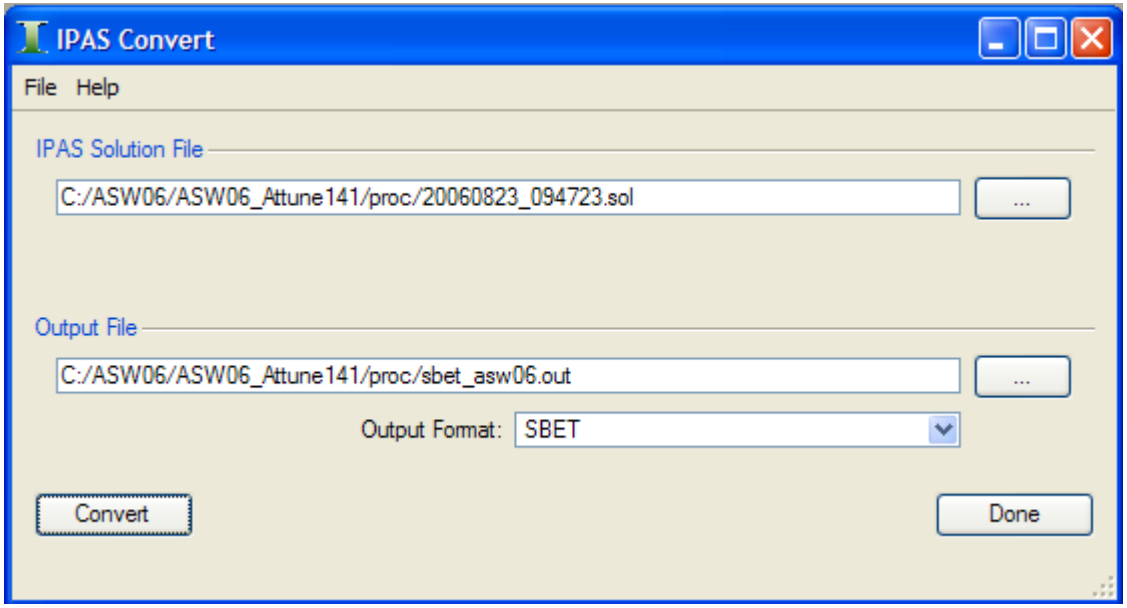
check graphs – processed data



IPAS Pro
Data handling flexibility

File format conversion feature,,,export to SBET format & ASCII





IPAS Pro

step 3 - data written to proc directory

Address C:\ASW06\ASW06_Attune141\proc

File and Folder Tasks

Other Places

Details

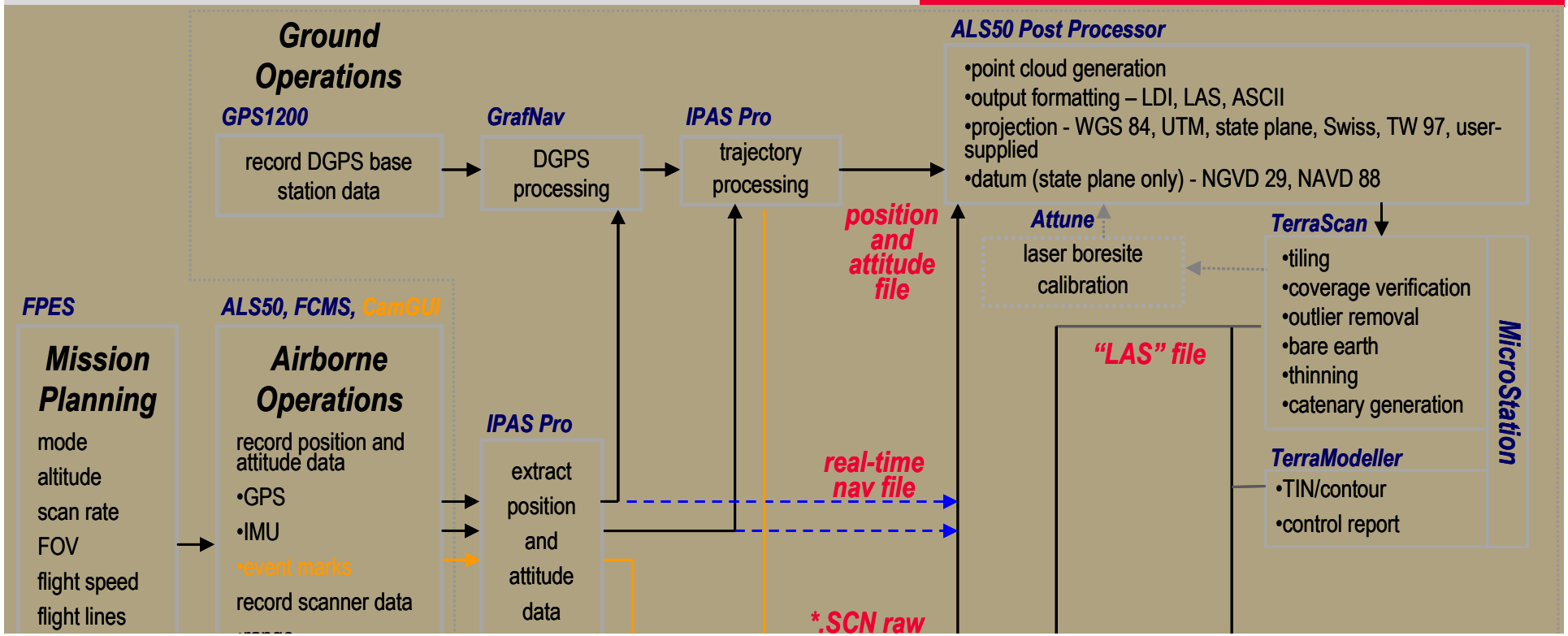
Name	Size	Type	Date Modified
20060823_094723.sol	160,029 KB	SOL File	9/27/2006 7:34 PM
ASW06_procLog.txt	4 KB	Text Document	9/27/2006 7:34 PM
sbet_asw06.out	118,283 KB	OUT File	9/27/2006 7:46 PM
smrmsg_sbet_asw06.out	348 KB	OUT File	9/27/2006 7:46 PM

Conclusions

IPAS Pro is used to calculate the aircraft trajectory.

There are 3 processing steps:

- **Extract, where input data is separated into IMU and GPS files**
- **GrafNav, where a differential GNSS solution is calculated**
- **Processor, where the IMU data is blended with the differential GPS solution**



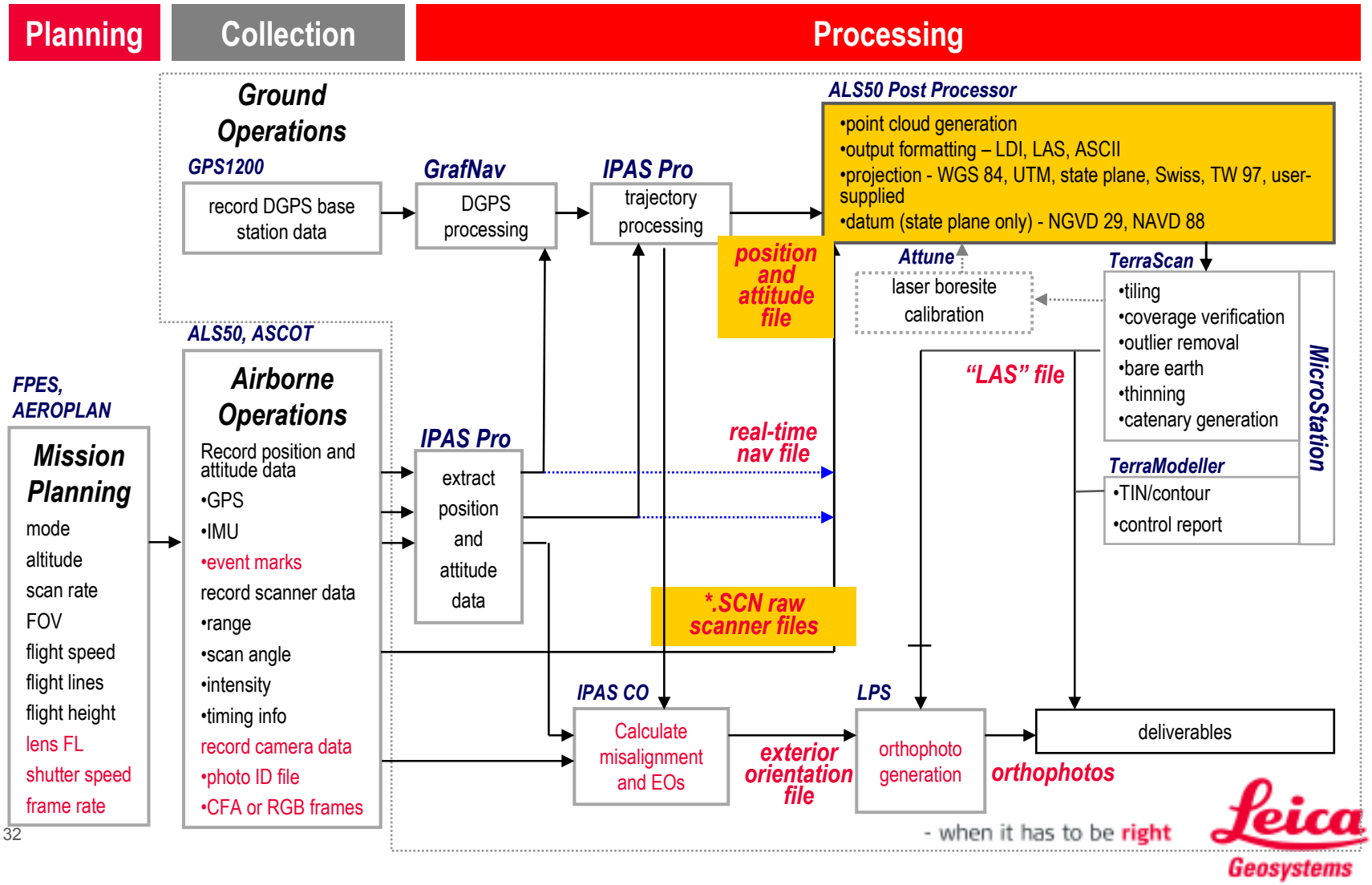
ALS50 workflow

ALS Post Processor

- when it has to be right

Leica Geosystems

Aircraft trajectory workflow overview
in context of LIDAR workflow

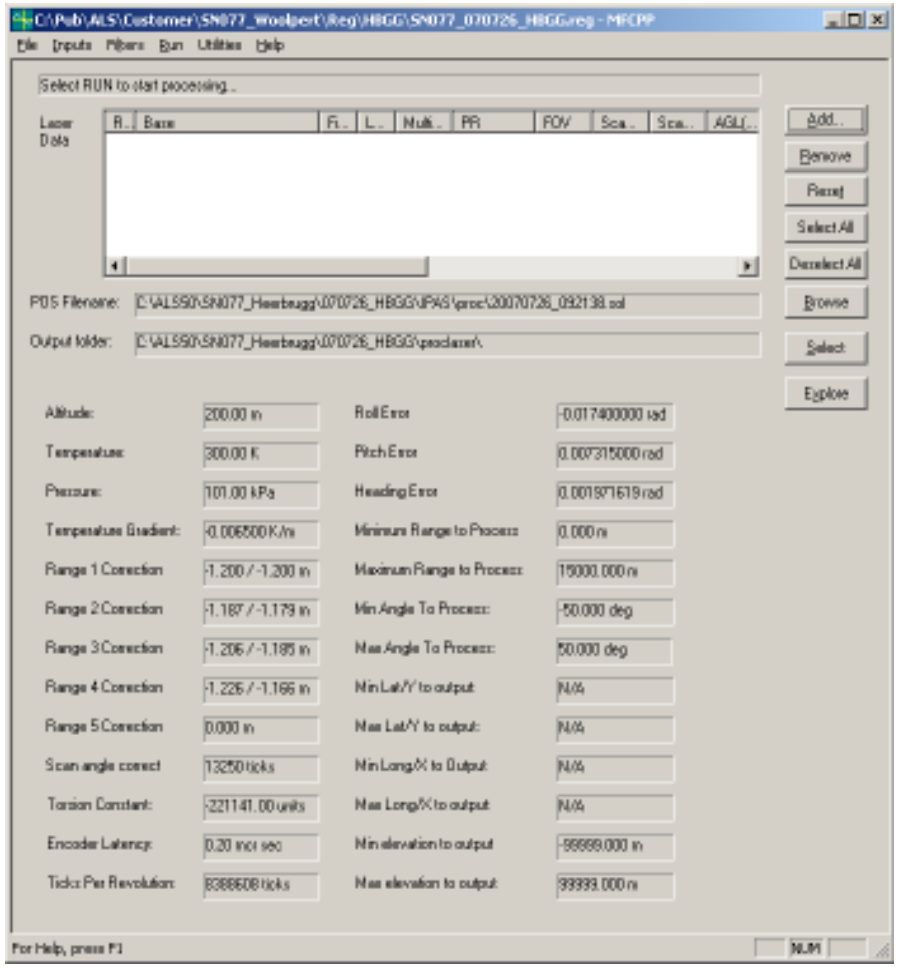


ALS Post Processor

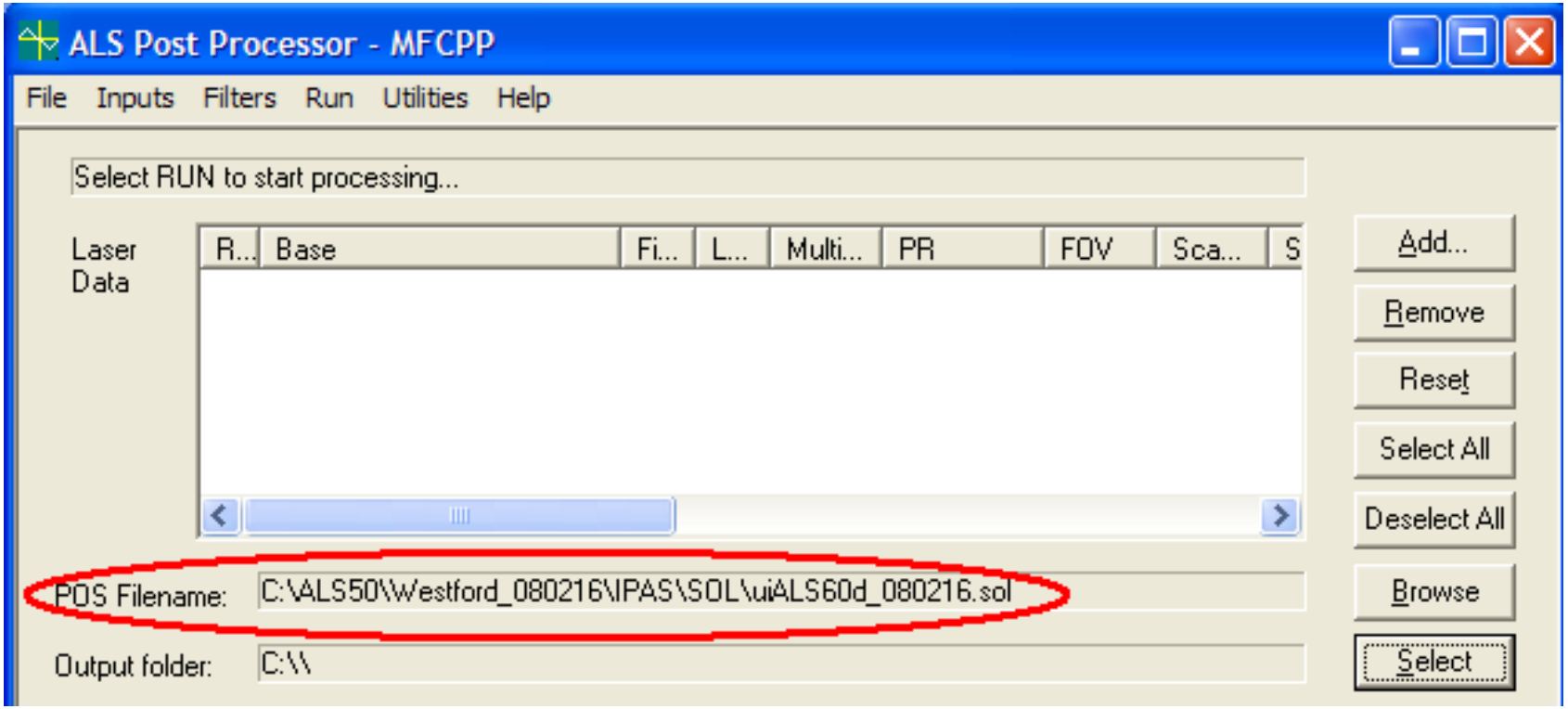
Marge AB trajectory & range finding data

ALSPP main feature

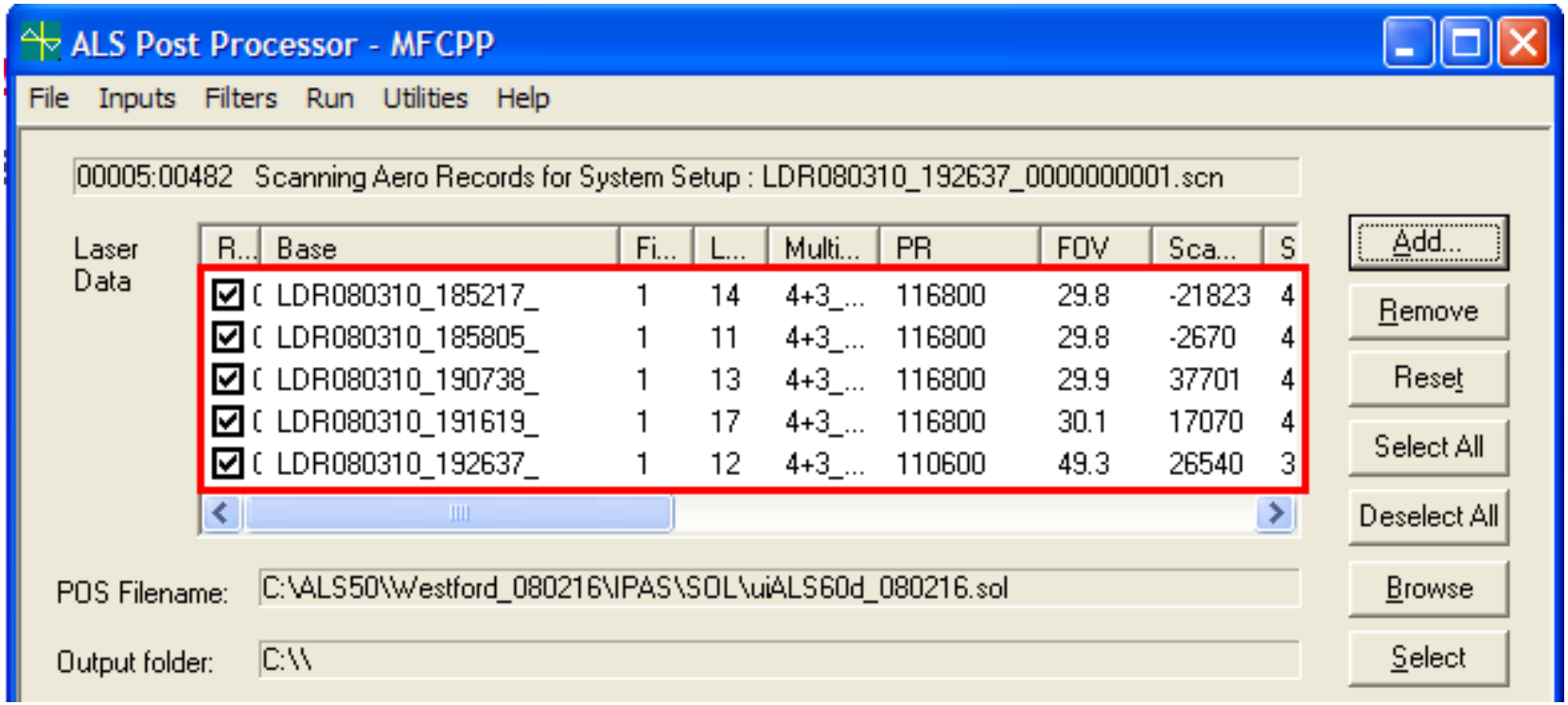
- Store system dependent calibration parameter
  - Factory calibration data
  - User calibration data
    - IMU Misalignment
    - Range offset
- Marge Trajectory & Range data
  - Leica IPAS(*.sol) / Applanix POS(*.sbet)
  - Range data (*.scn) file
- Apply user selected projection



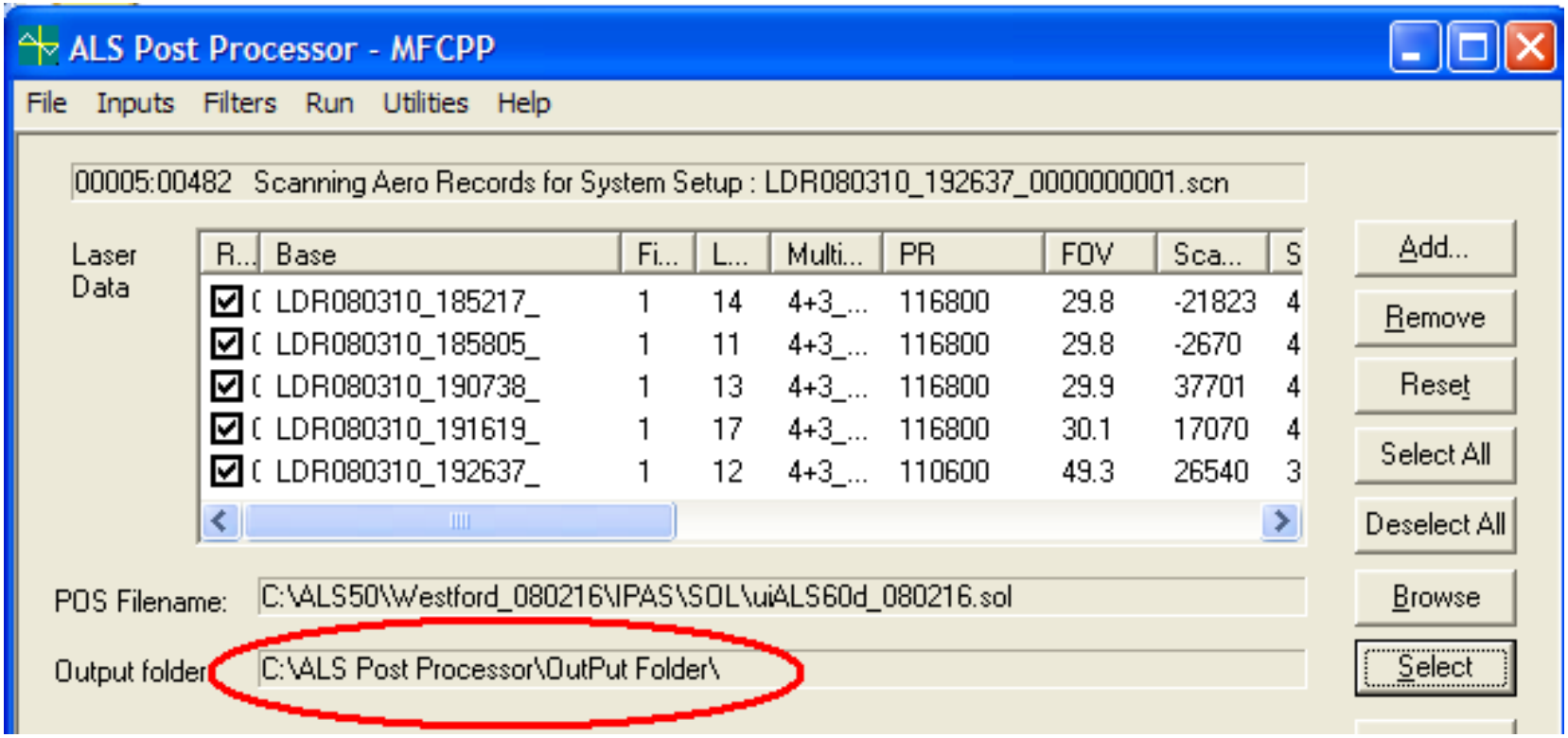
ALS PP
select trajectory file



ALS PP
select rawlaser input files

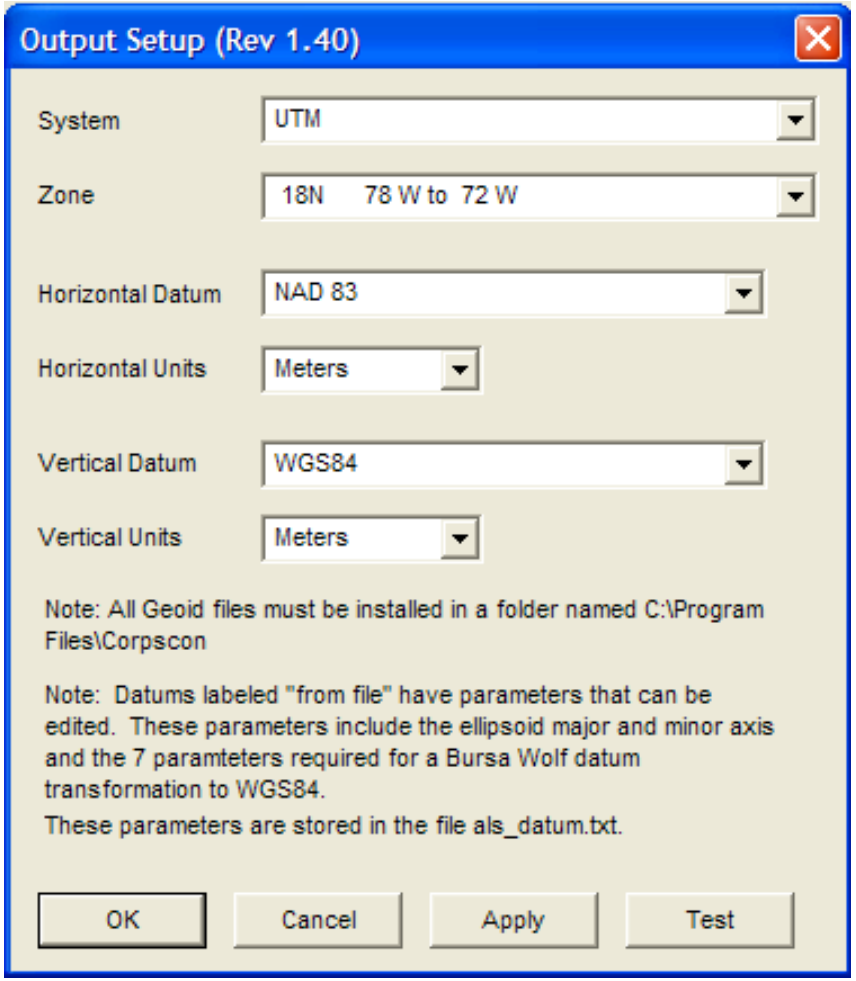


ALS PP
specify output folder



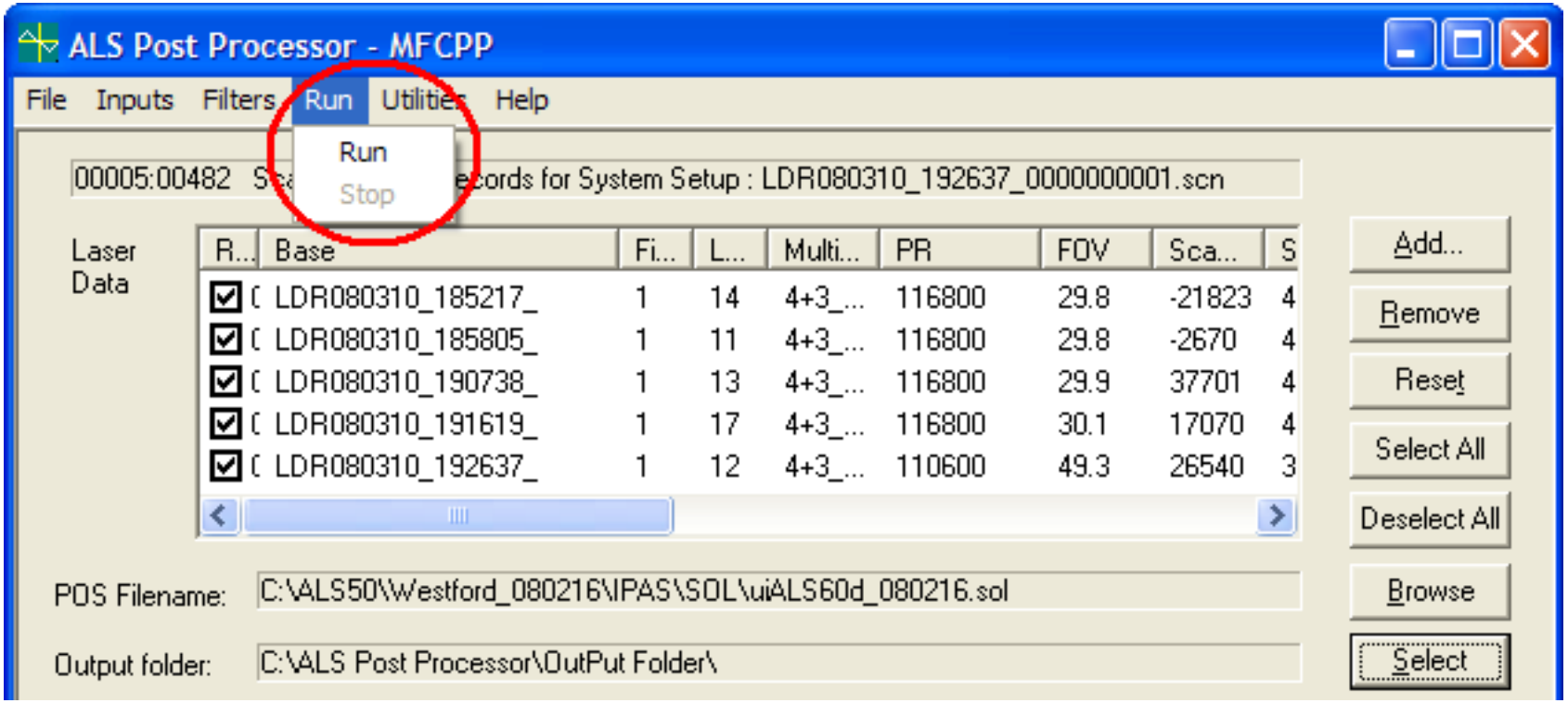
ALS PP

select datum and projection



ALS PP

run



Conclusions

ALS Post Processor is used to calculate the point cloud. Inputs required are:

- **Aircraft Trajectory file**
- **Rawlaser files**
- **Selection of datum and projection**

Emerging alternatives in airborne LIDAR processing

- when it has to be right

Leica Geosystems

Caveats

Leica Geosystems is a reseller of both TIN-based and grid-based processing software:

- **ALS Post-Processor (point cloud generator for ALS LIDAR systems)**
- **IMAGINE (image processing software)**
- **LPS (photogrammetry software)**
- **TerraScan/TerraModeler (point cloud & TIN based visualization, filtering and feature collection software for LIDAR data)**
- **LIDAR Analyst (grid based visualization, filtering and feature collection software for LIDAR data)**

Trends affecting LIDAR processing

Pressure to increase accuracy of end data product

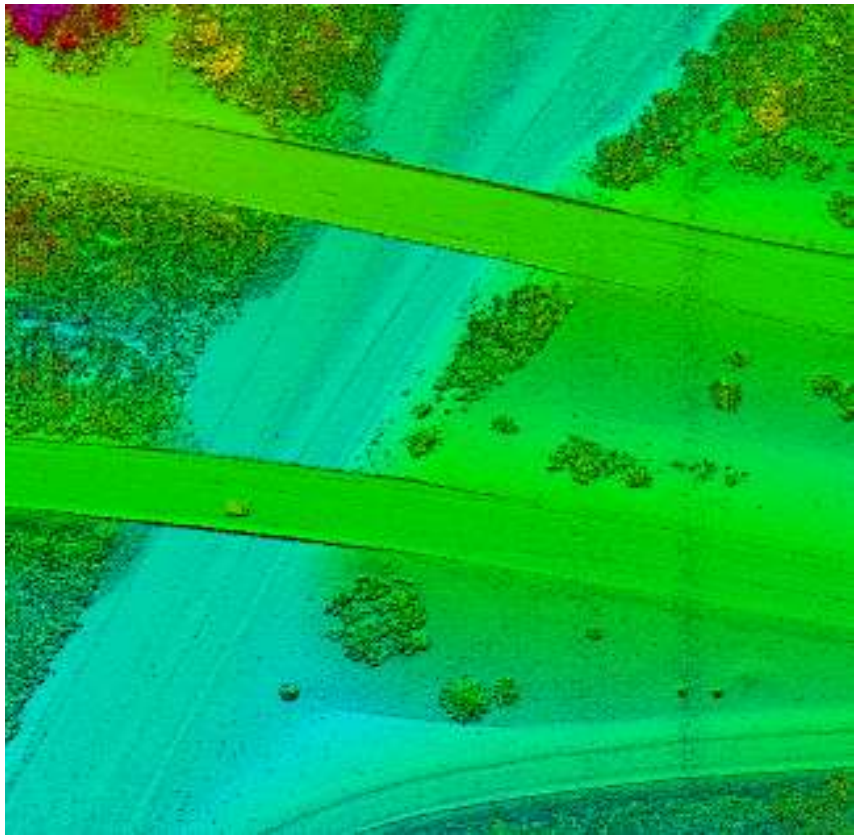
- 15 cm accuracy is commonplace
- New product releases target 5 cm accuracy

Increasing point density available

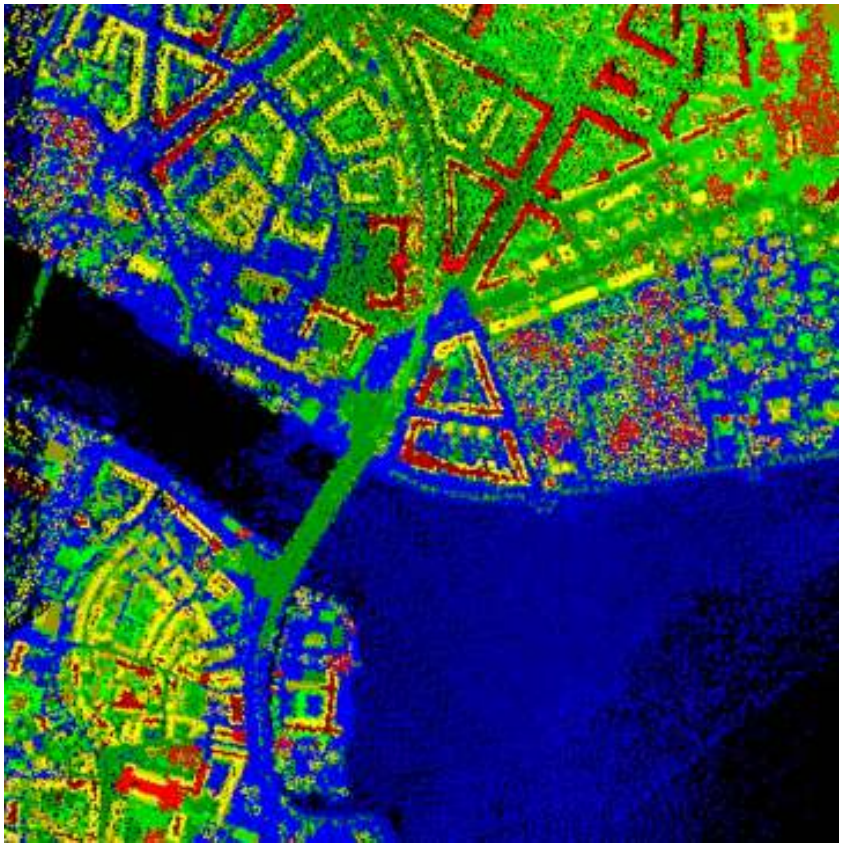
- 105 m swath @ 125 knots = 42 points/m^2
- 15 cm average post spacing
- Facilitates feature extraction

Emerging applications for geospatial data

- Microsoft Virtual Earth, Google Earth
- Not hosting LIDAR data…yet
- Price/pixel, latency will be big drivers



Starting point
point cloud block loaded



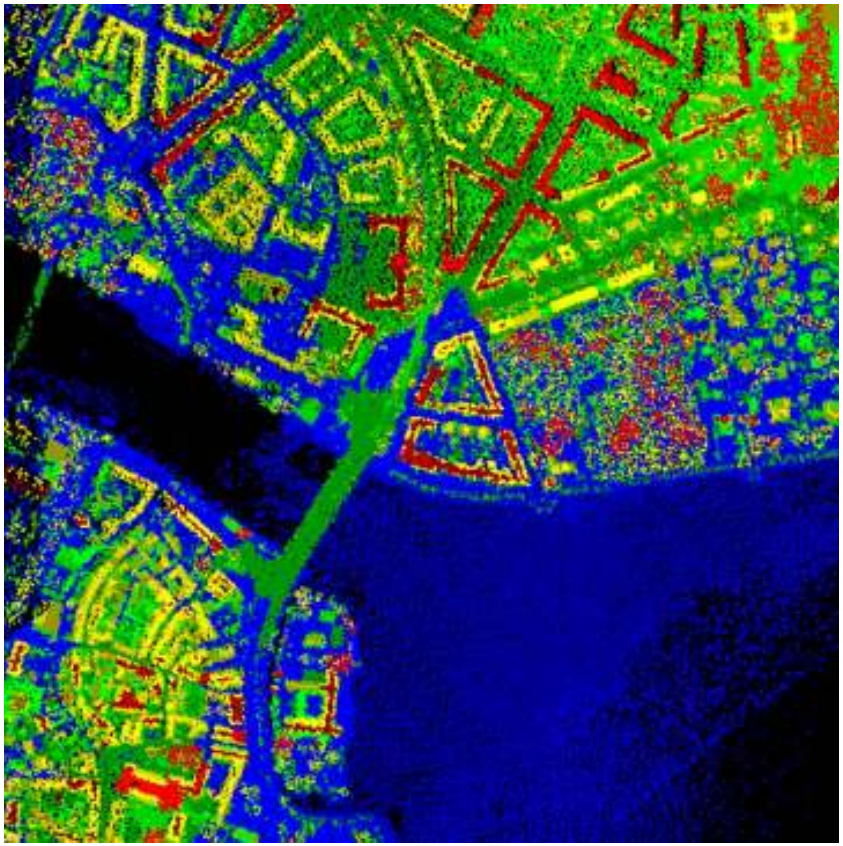
All returns shown

Ortho point cloud view

Color coded by elevation

Comparison of rendered 1st returns to point cloud

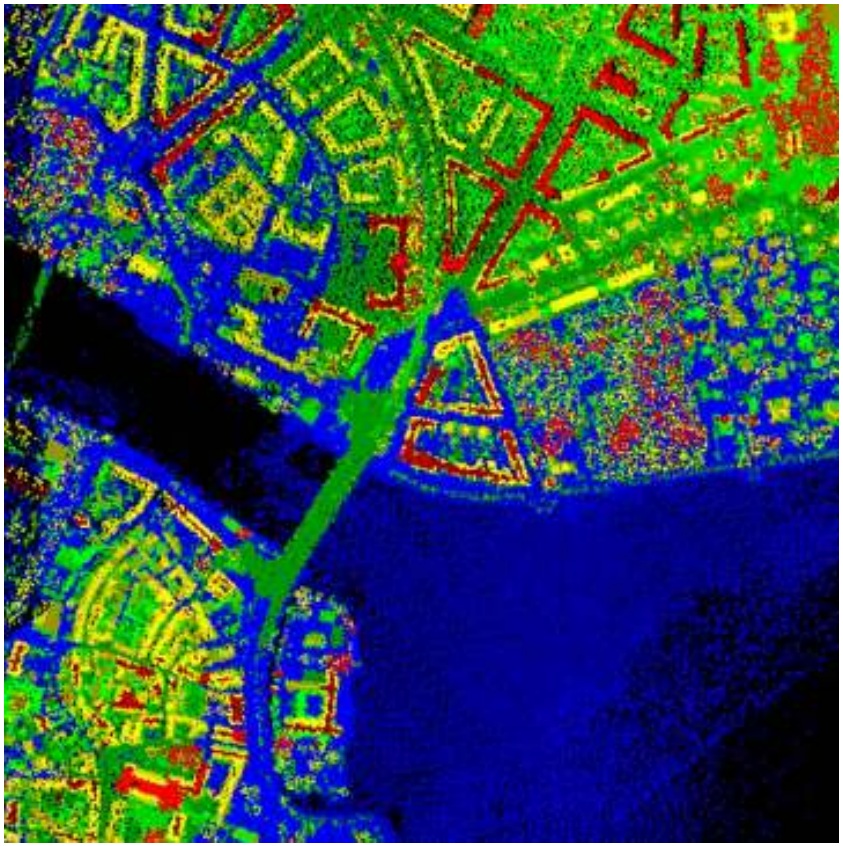
point cloud



gridded

Comparison of rendered last returns to point cloud

point cloud

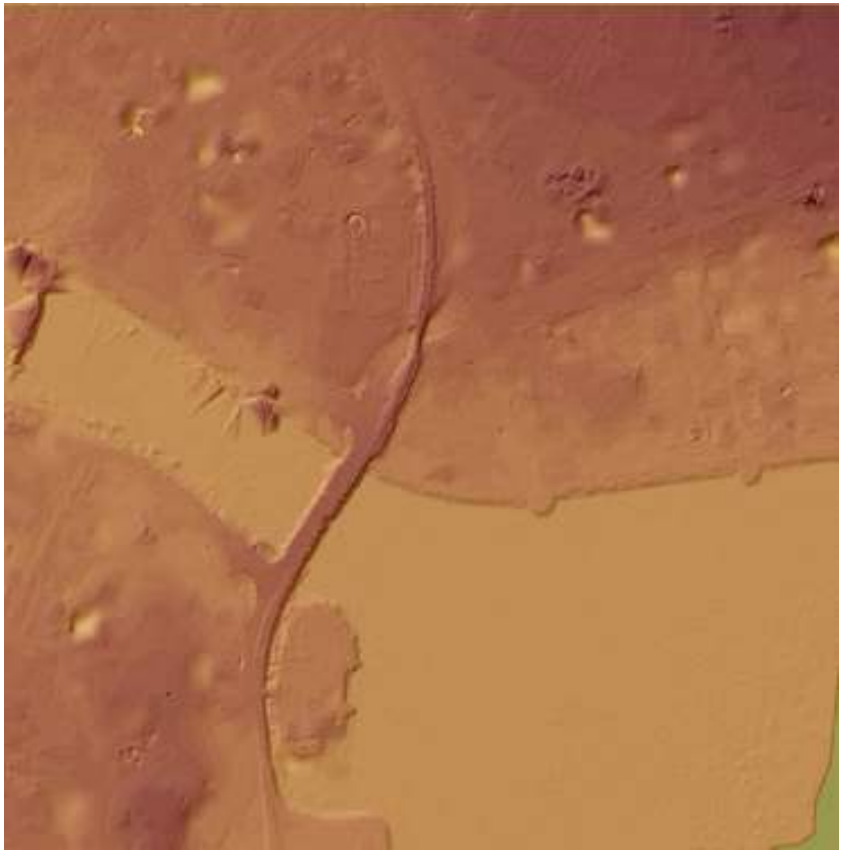


gridded

Bare earth extraction

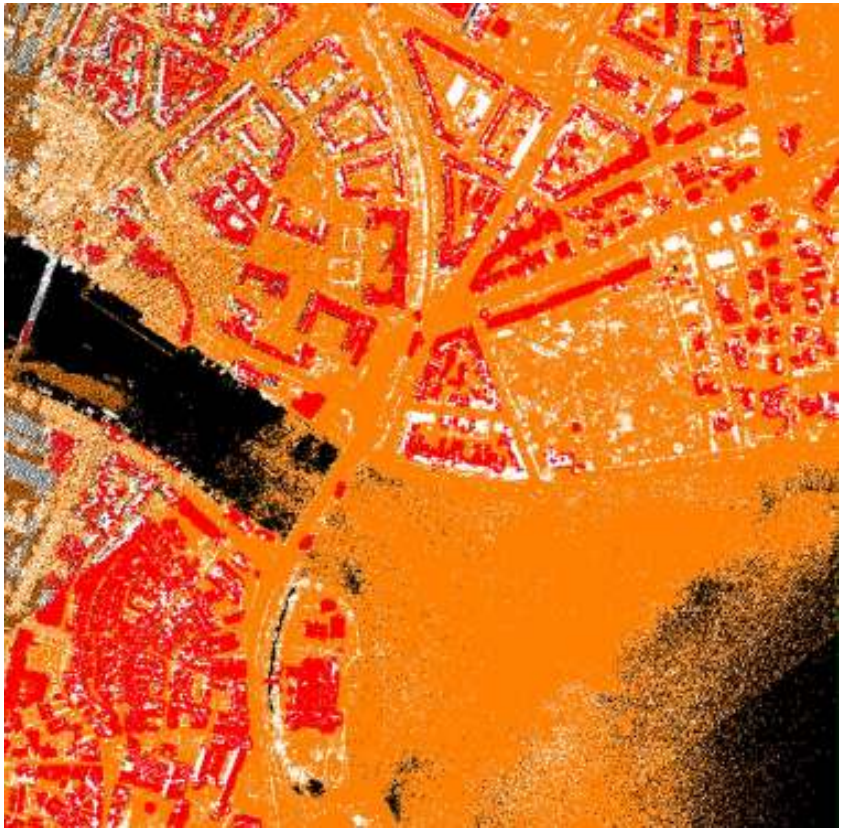
point cloud

gridded

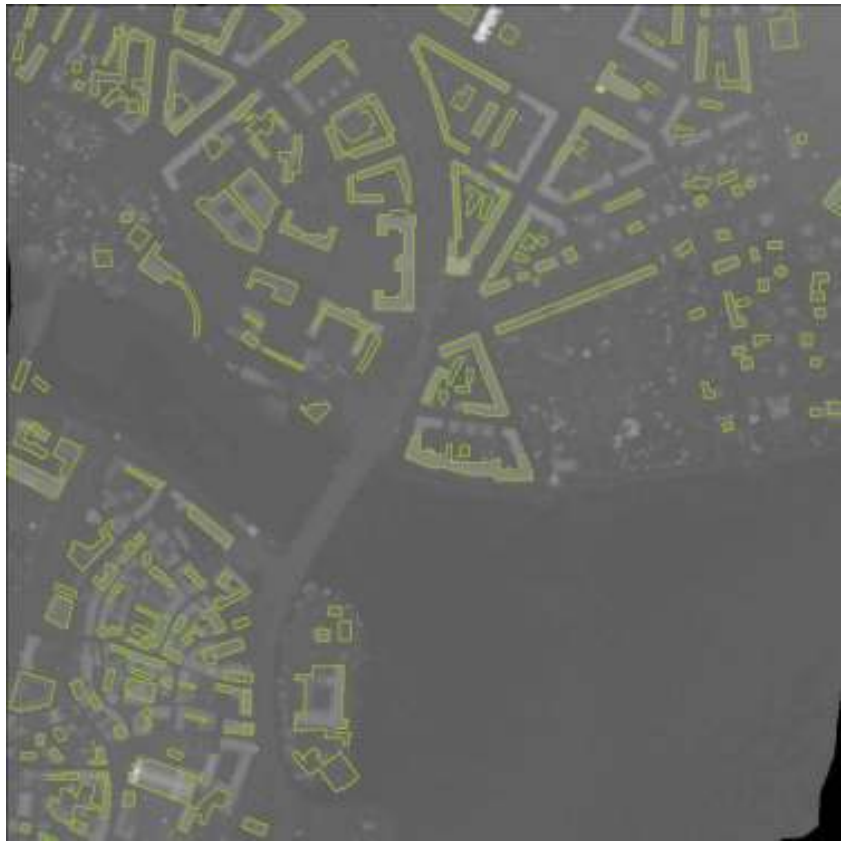


Building extraction

point cloud

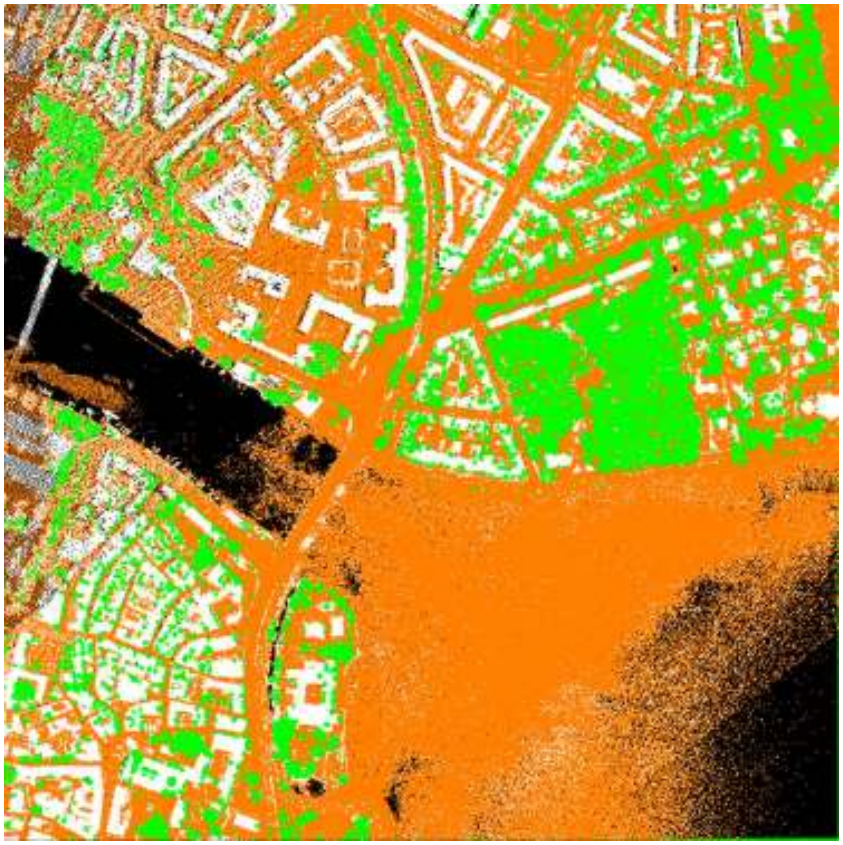


gridded



Tree extraction

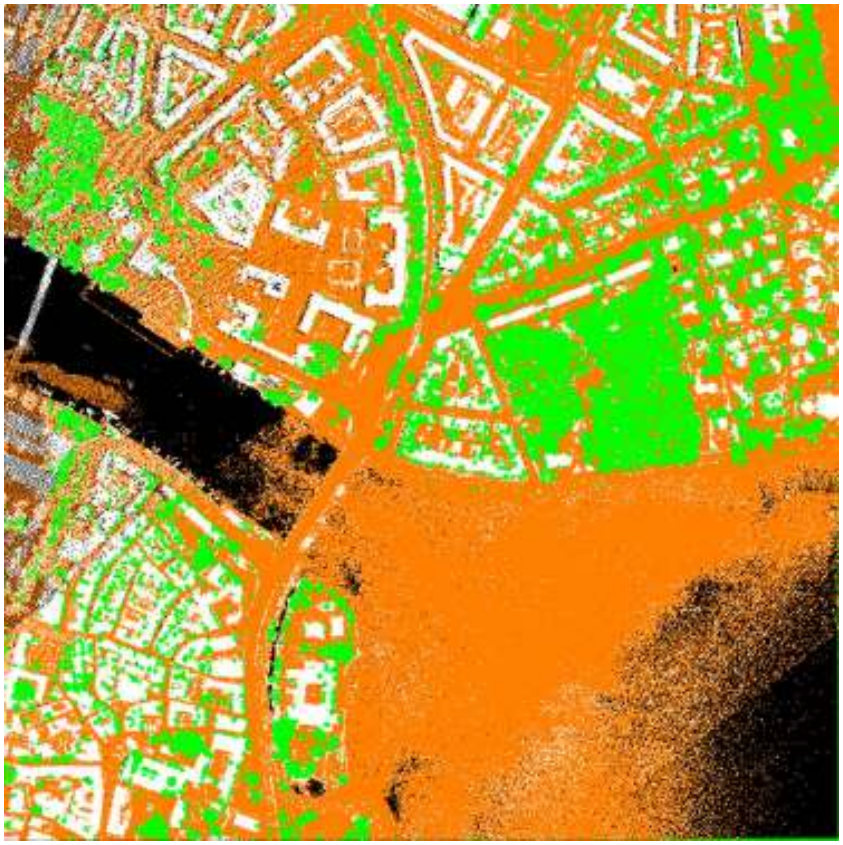
point cloud



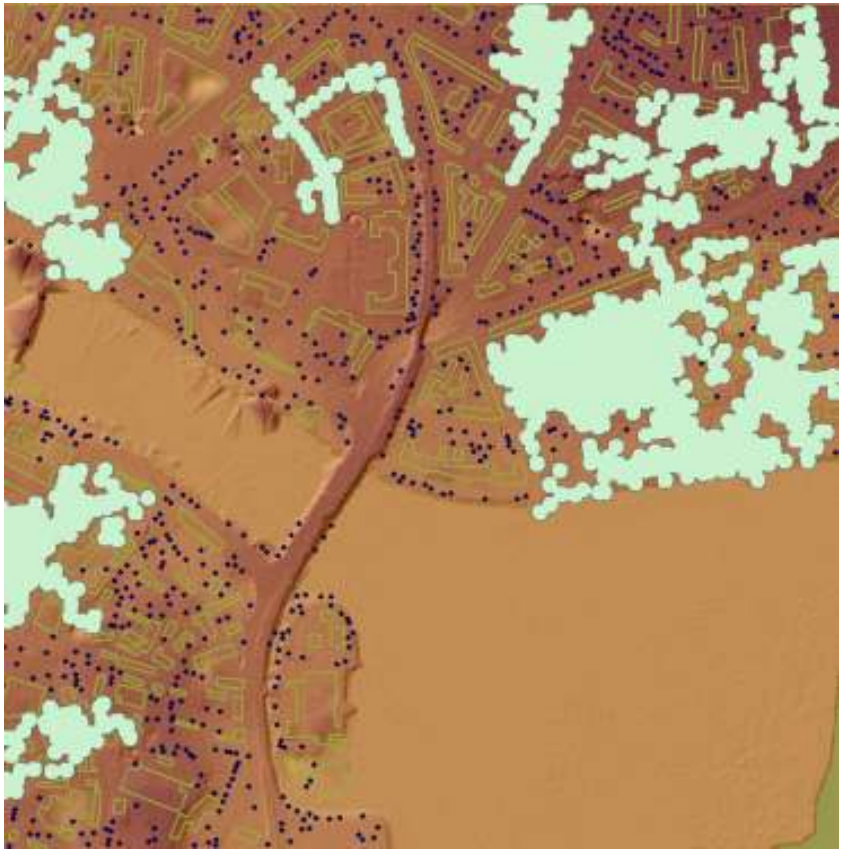
gridded

Forest extraction

point cloud



gridded



Conclusions
generally speaking

Gridded workflows are optimized for high-density LIDAR data

Gridded workflows have the potential to reduce processing costs through the reduction of manual intervention, especially in the area of feature collection

Gridded workflows provide a good starting point for feature collection, but significant manual clean-up is still required

Accuracy degradation is minimal when using gridded workflows, as long as the point density is high

Point-cloud-based workflows are still optimal for cases where point density is low (less than ~4 points/m^2), or in cluttered environments

Users will have to decide on which workflow to use based on primarily on required accuracy thresholds and availability of editing functions.

Thank you
questions?

Yuji.Kuwano@leica-geosystems.com

Leica Geosystems AG

Heinrich-Wild-Strasse

CH-9435 Heerbrugg ,Switzerland

Tell+41 71 727 4262

Fax+41 71 727 4674

- when it has to be right