TerraMatch

Introduction

Why TerraMatch?

- Error sources

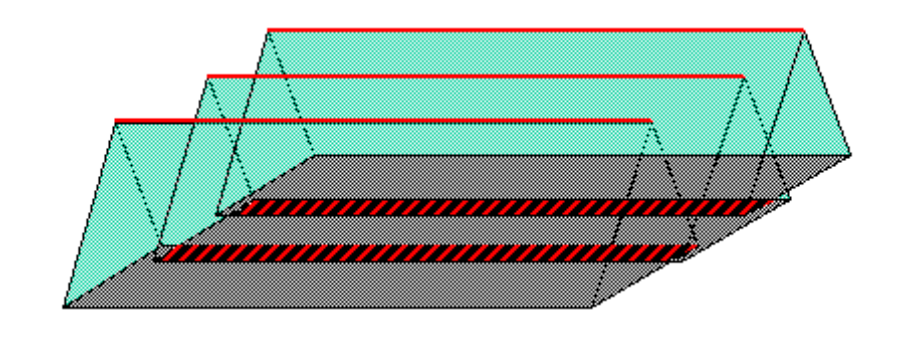
  Interior in LRF

  – Errors in laser distance measurement
  – Scanning mirror errors

  Exterior in trajectories

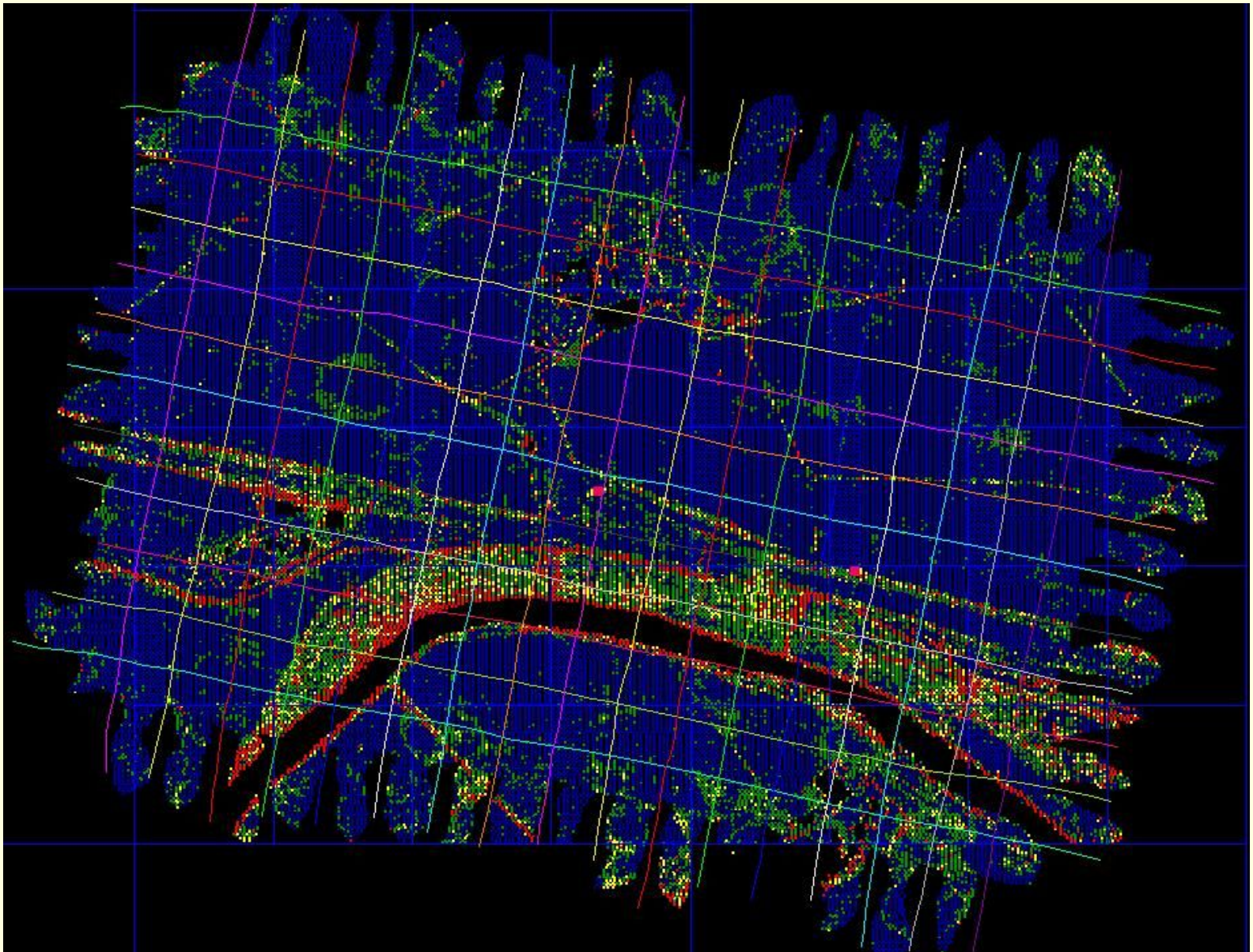
  – Errors in position (GPS)
  – Errors in orientation (INS)
  – Errors in boresight calibration (misalignment between IMU and laser)
- TerraMatch solves systematic errors in position, orientation or mirror scale

Requirements

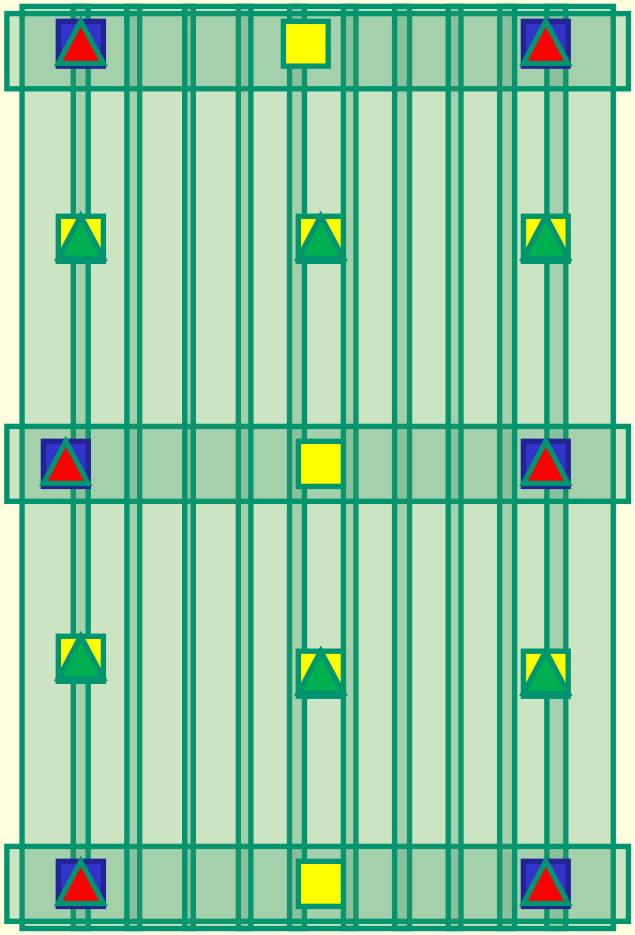


- Multiple flightlines with overlap
- Time stamped trajectory information
  - time x y z heading roll pitch
- Laser points linked to trajectory position
  - flightline number matching trajectory number
  - time stamp

RMS plot (Blue 2cm – Red 5 cm)



Control points



Planimetric control

Height control

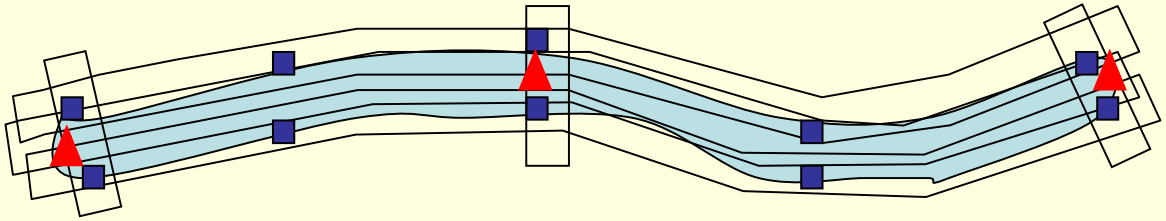
Planimetric check

Height check

Corridor projects

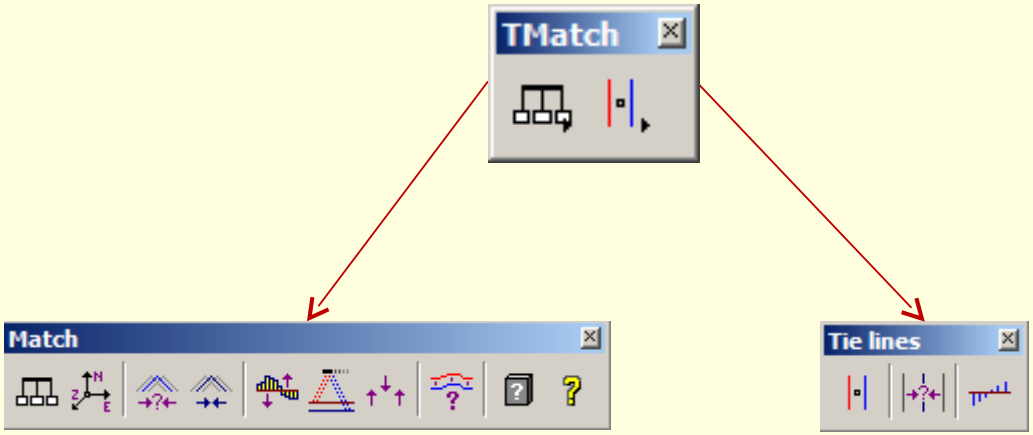
Planimetric control

Height control



TerraMatch Tools

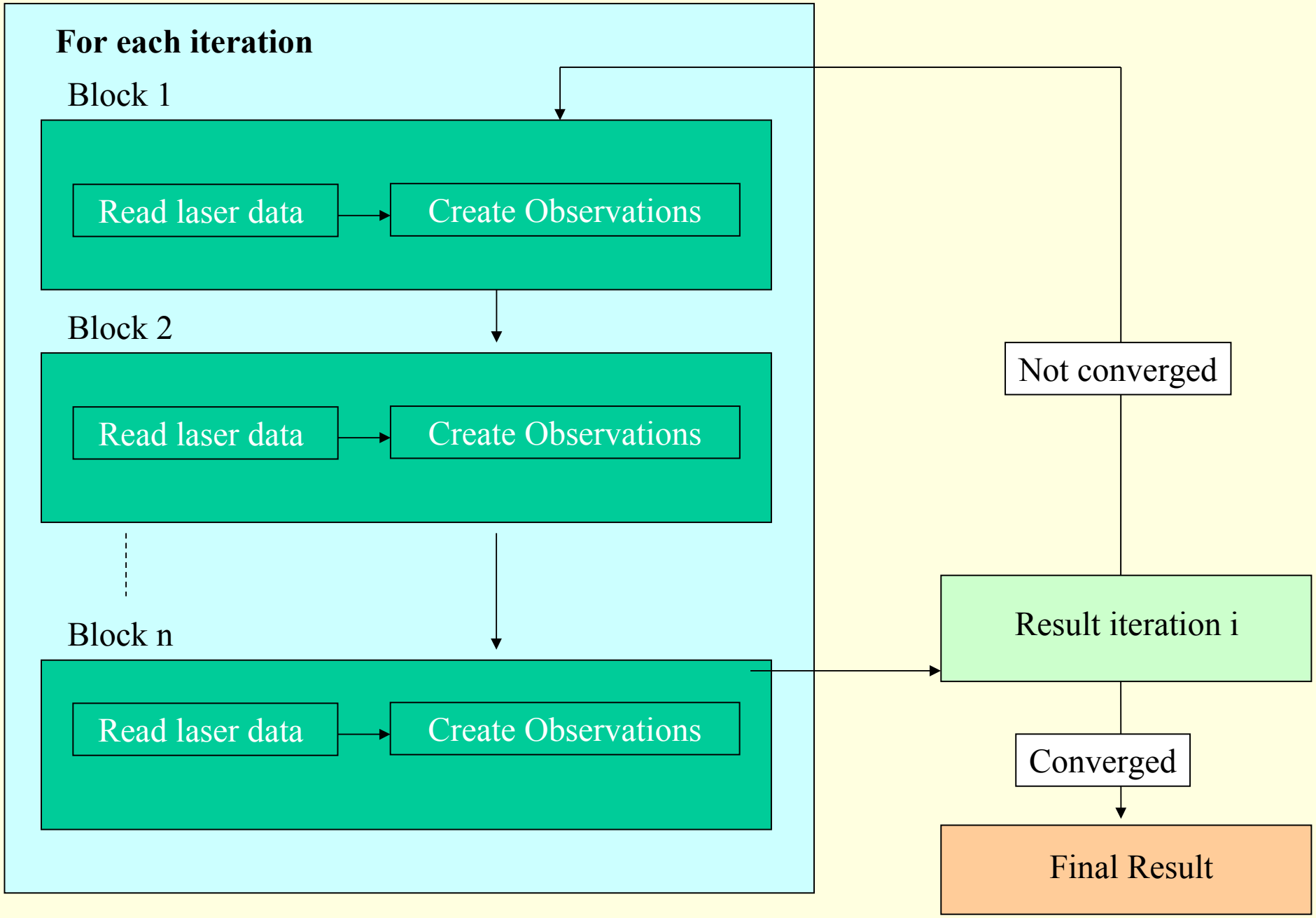
TerraMatch Toolbar



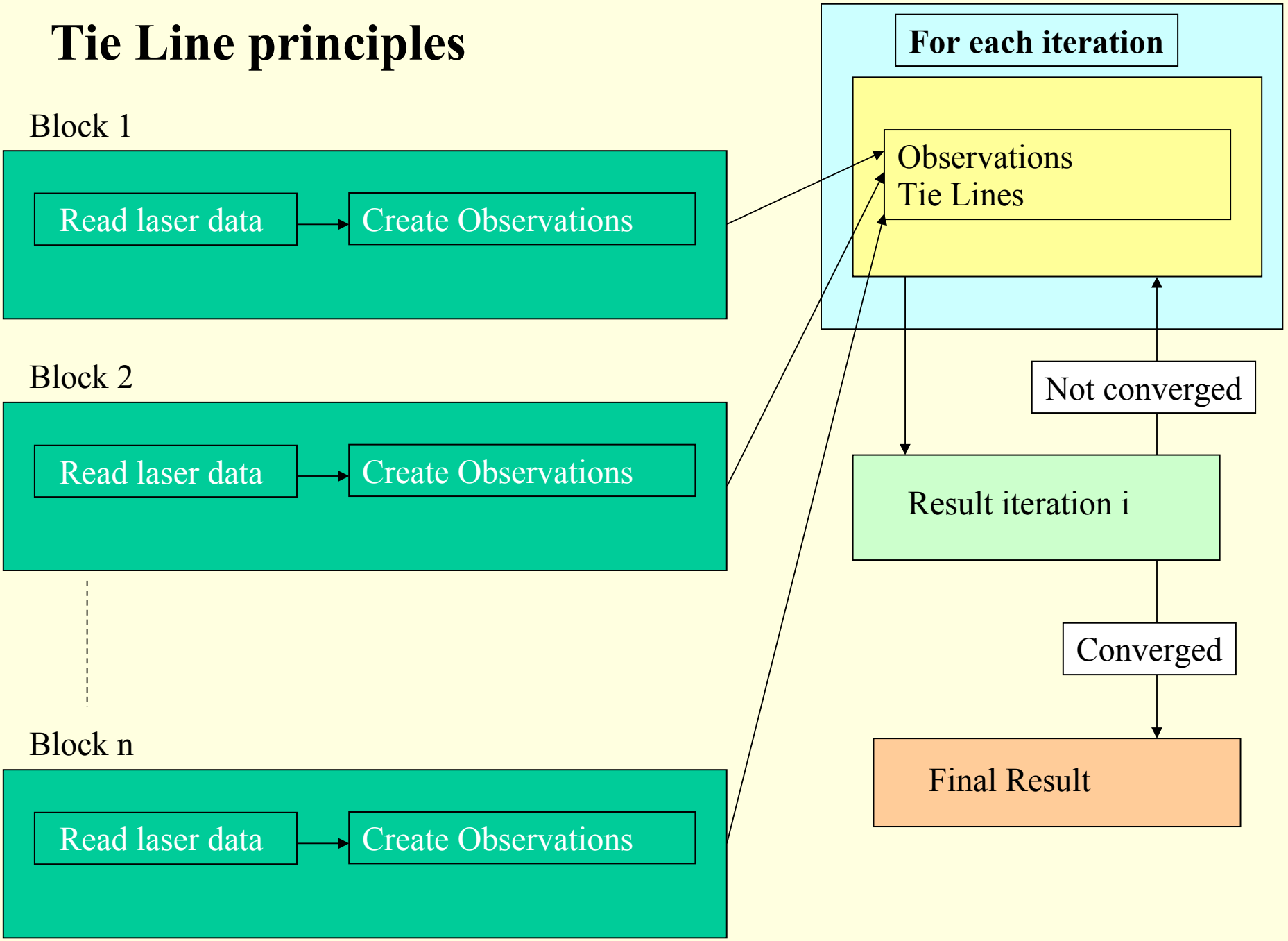
Find Match:
Surface to surface matching

TieLine Matching:
Surface to surface,
Line to line,
Point to point matching

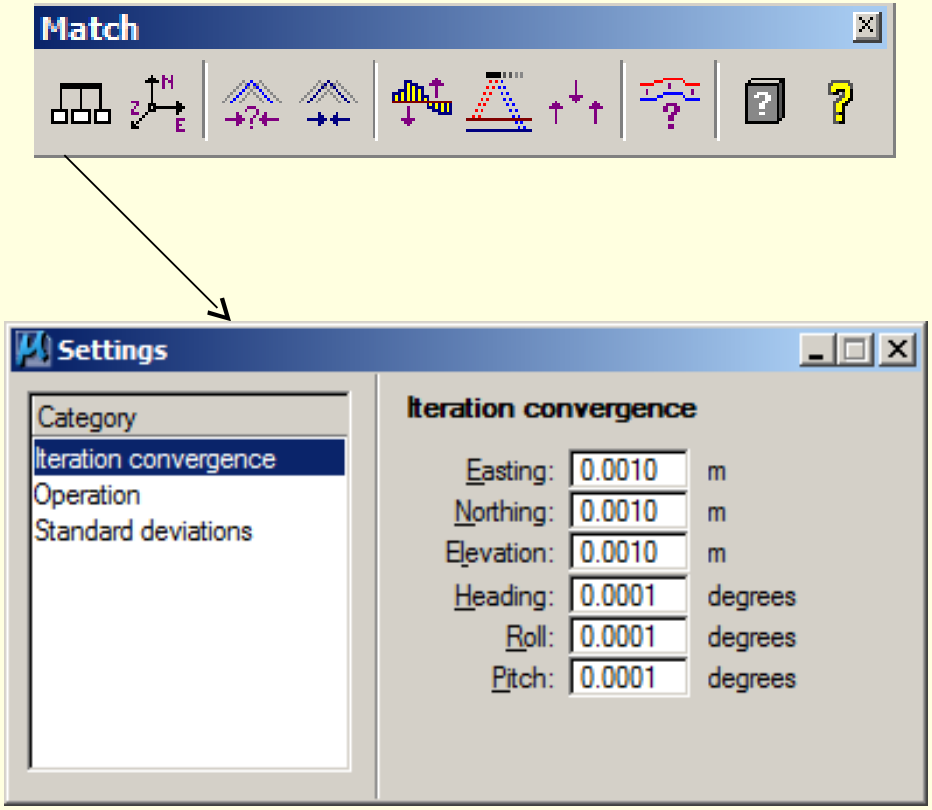
Find Match principles



Tie Line principles

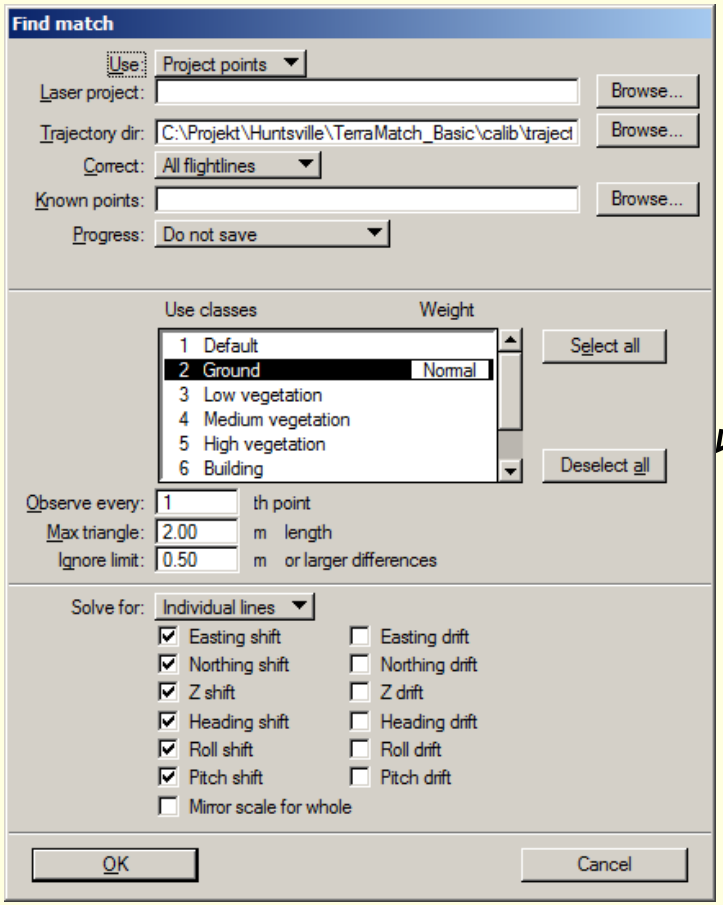


Find Match Settings



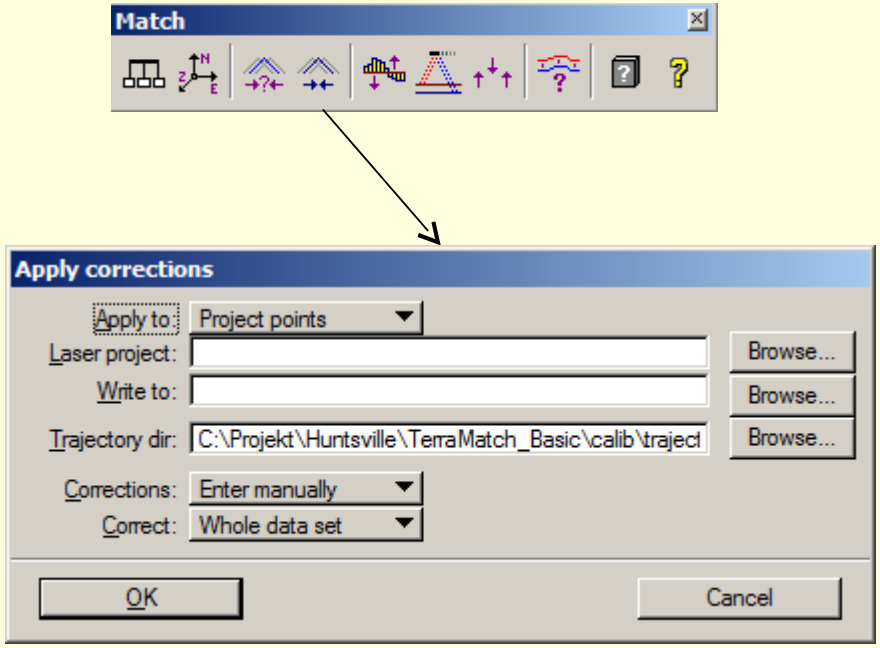
Find Match

Calculate corrections to flightlines



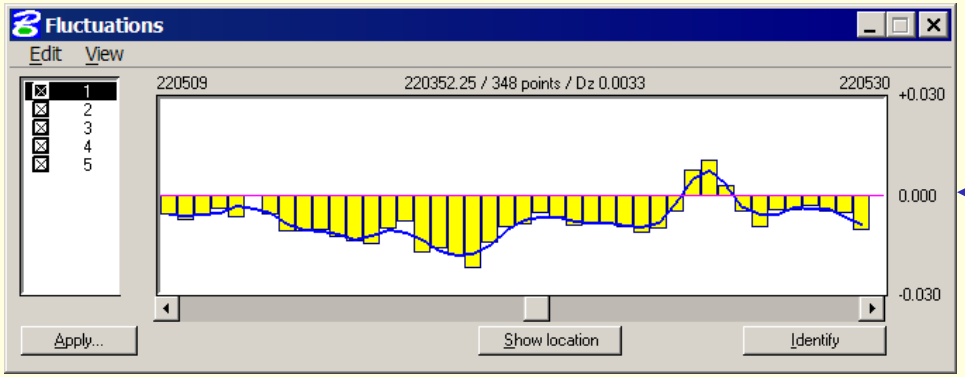
Apply Match

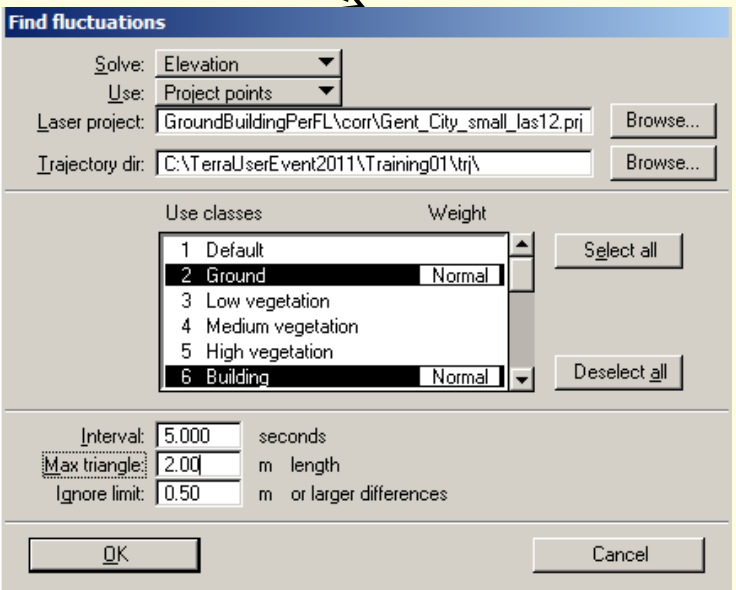
Apply corrections to flightlines



Find Fluctuations

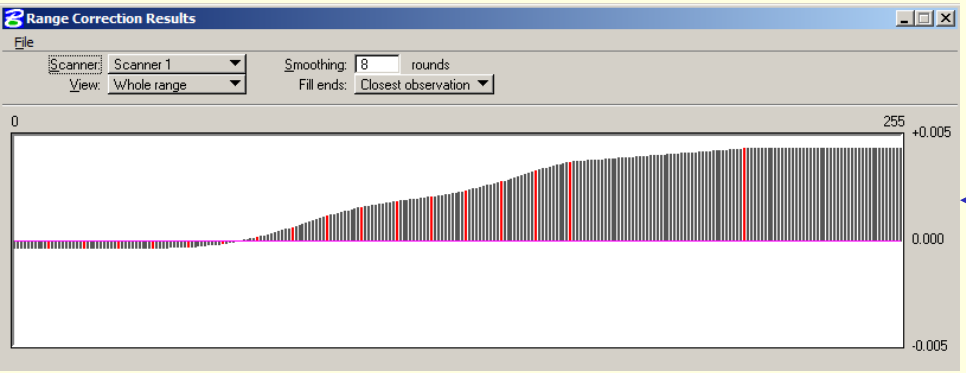
Find fluctuating corrections to flightlines

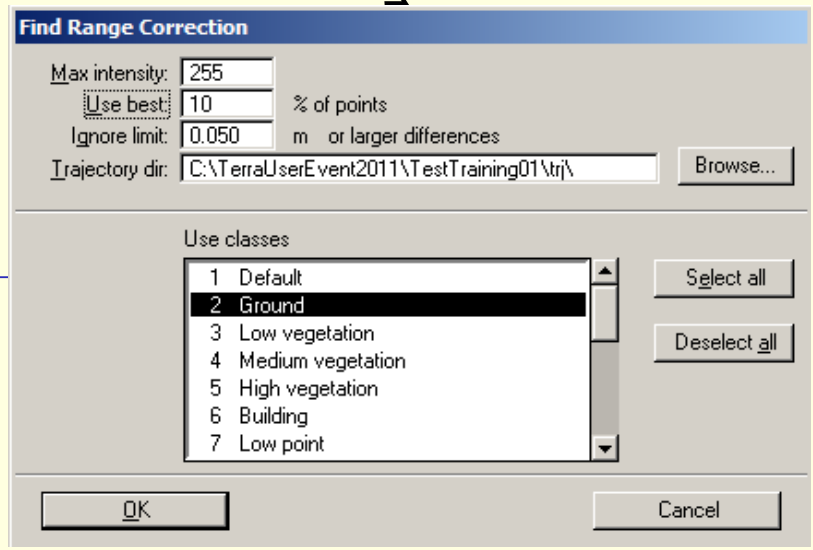




Find Intensity Range Corrections

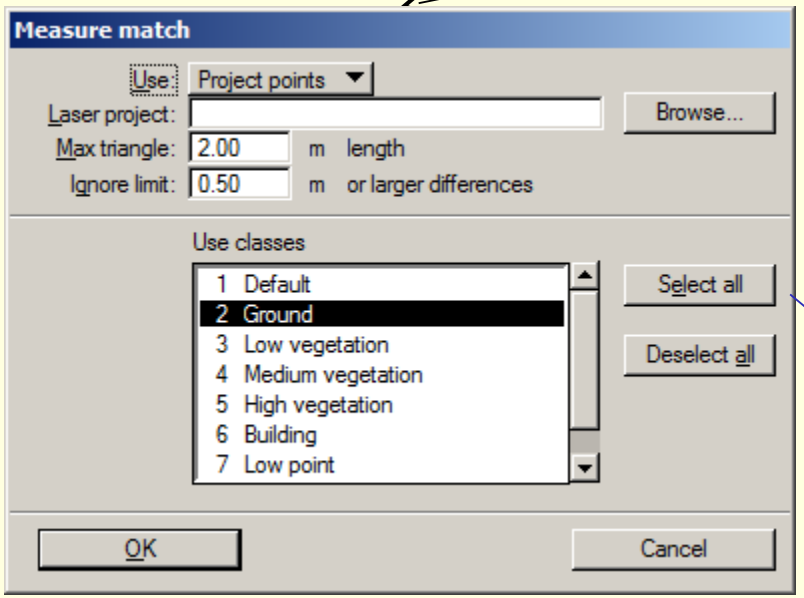
Find intensity range corrections to flightlines

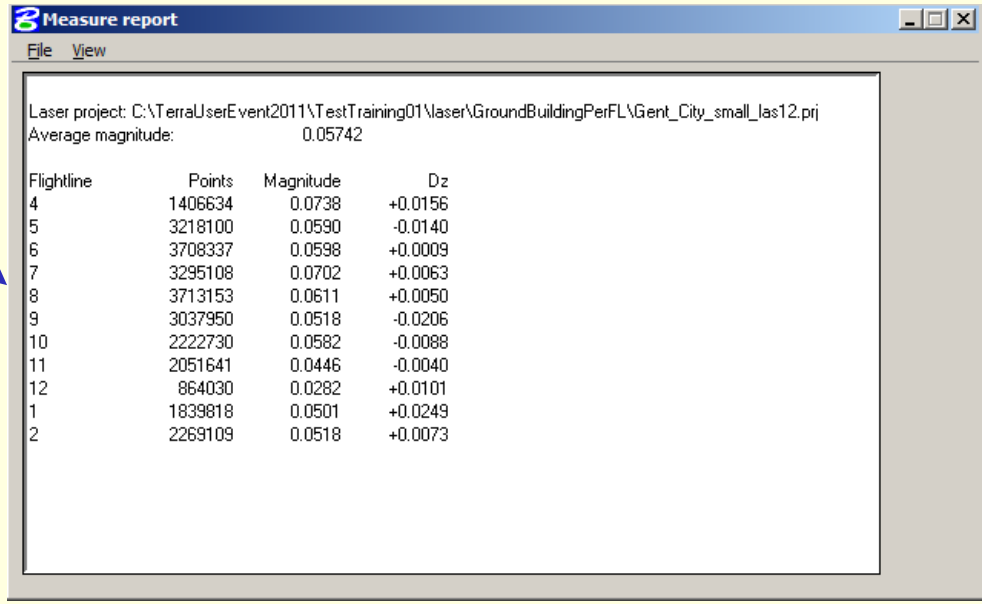




Measure Match

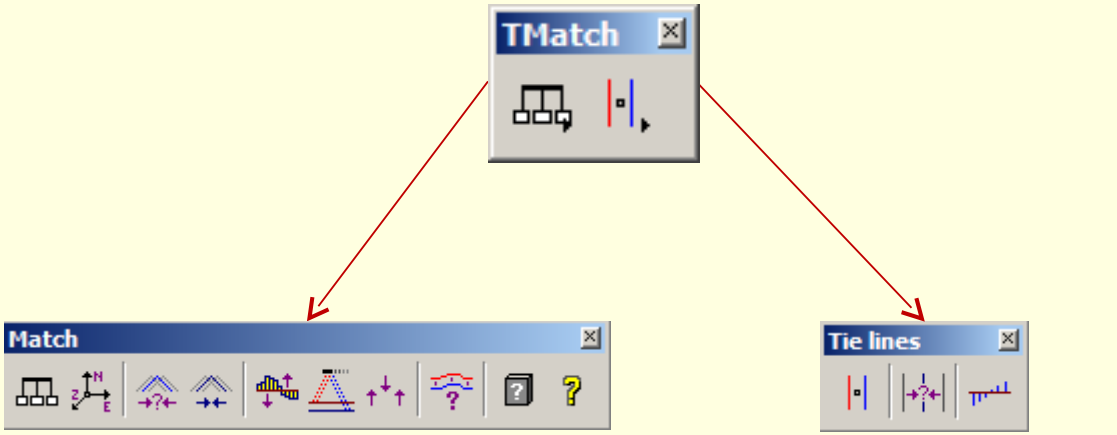
Calculates statistics of overlap areas





TerraMatch Tools

TerraMatch Toolbar

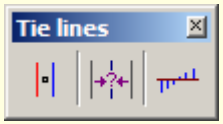


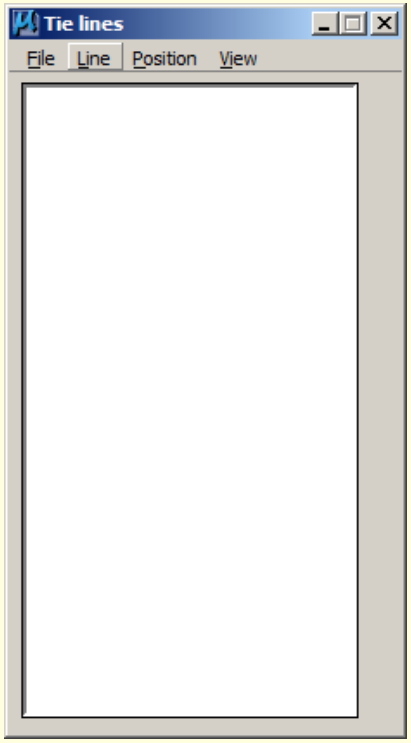
Surface to surface matching

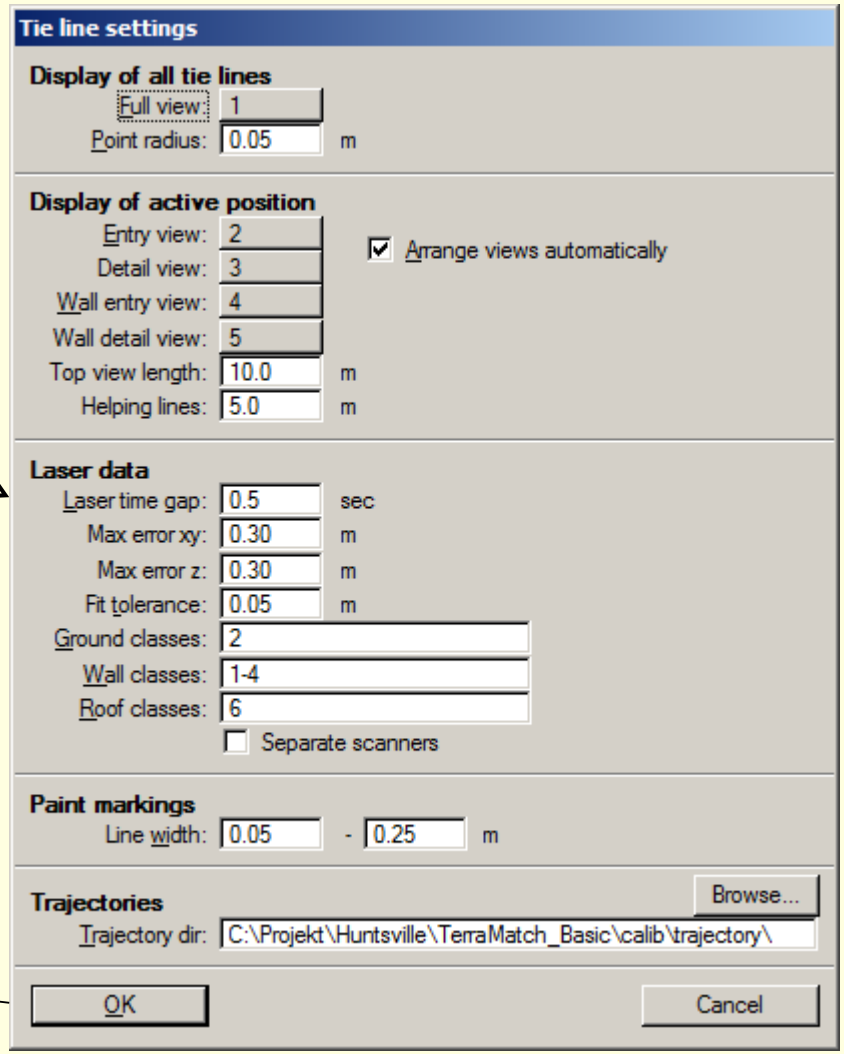
TieLine Matching

Find Tie Lines for Matching

Find features suitable for matching

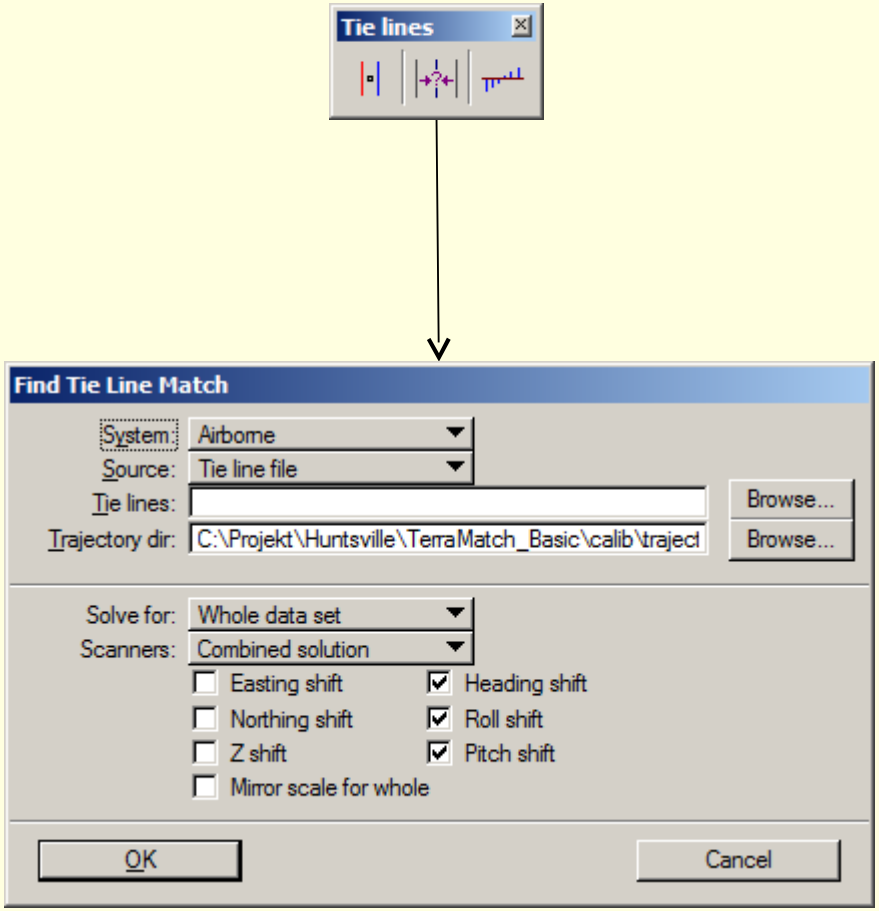






Find Tie Line Match

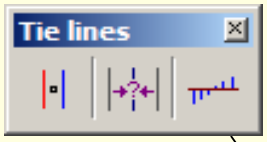
Calculate corrections to flightlines

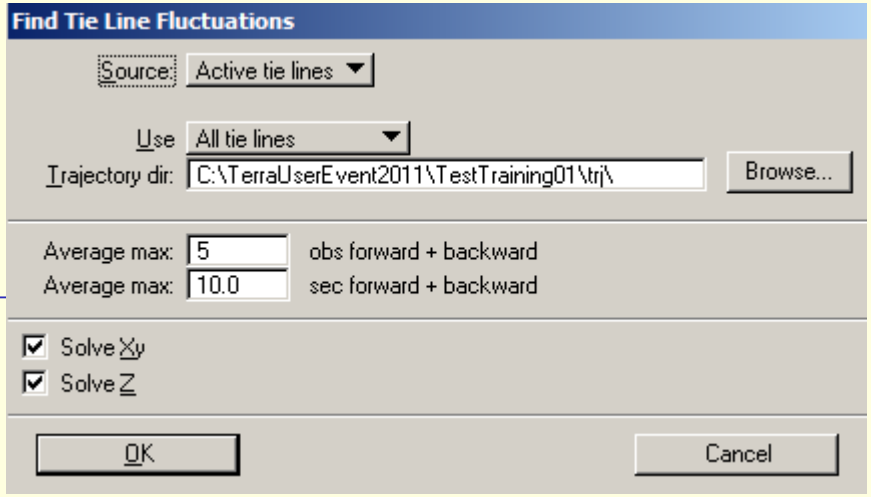


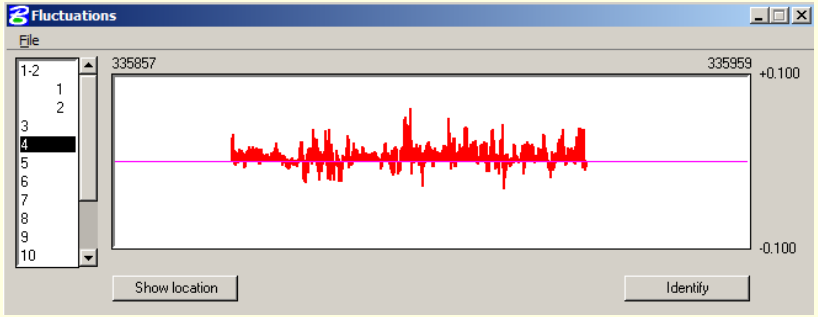
- For the whole dataset
- Per group
- Per flightline

Find Fluctuations from Tielines

Calculate fluctuating corrections to flightlines







Find Match

- Surface to surface matching
- Only one type of observation
- More time consuming adjustment
- New (better) observations for each iteration
- No manual observations

Tie Lines

- Feature to feature matching
- Several types of observations
- Less time consuming adjustment
- Old observations for each iteration
- Manual observations possible

Find Match- Input data

- Trajectories with time tag
- Laser points
  - linked to trajectories through time tag
  - Classified for ground (buildings)
- Optional known points

Tie Line Match- Input data

- Trajectories with time tag
- Tie Lines – derived from laser points
  - linked to trajectories through time tag
- Optional known points

Find Match- Solvable parameters

- Easting shift
- Northing shift
- Elevation shift
- Heading shift
- Roll shift
- Pitch shift
- Mirror scale

- Easting drift
- Northing drift
- Elevation drift
- Heading drift
- Roll drift
- Pitch drift

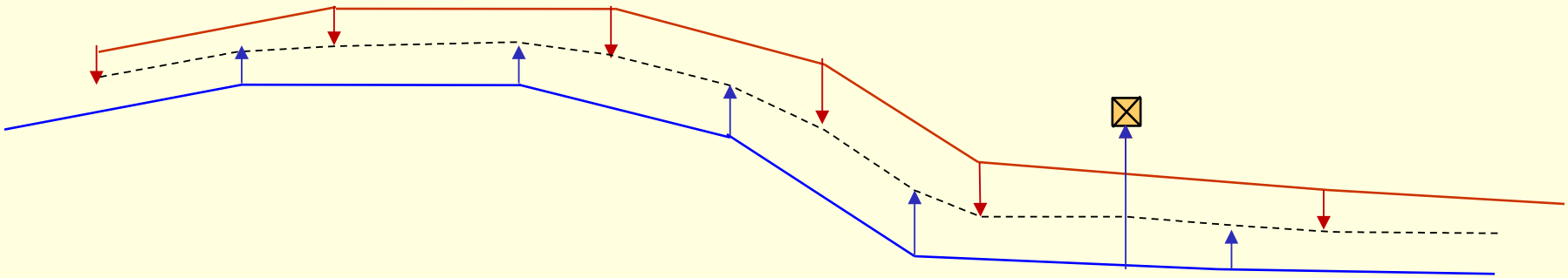
- Fluctuations

Tie Line Match- Solvable parameters

- Easting shift
- Northing shift
- Elevation shift
- Heading shift
- Roll shift
- Pitch shift
- Mirror scale
- Fluctuations

Find Match - Observations

- Builds a triangulated model of each flightline surface
- Compares overlapping laser points and known points against that surface
- Translates observed difference and gradient to heading/roll/pitch/dz



Find Match - Observations

- Builds a triangulated model of each flightline surface
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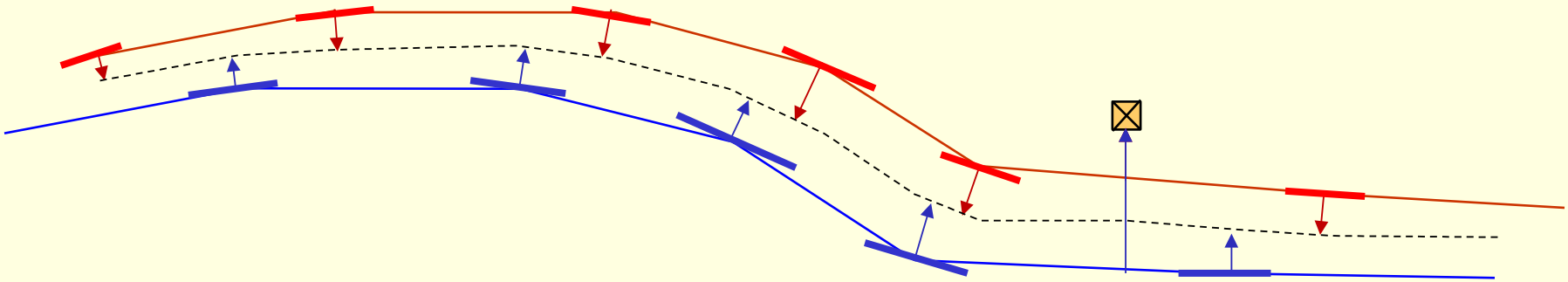
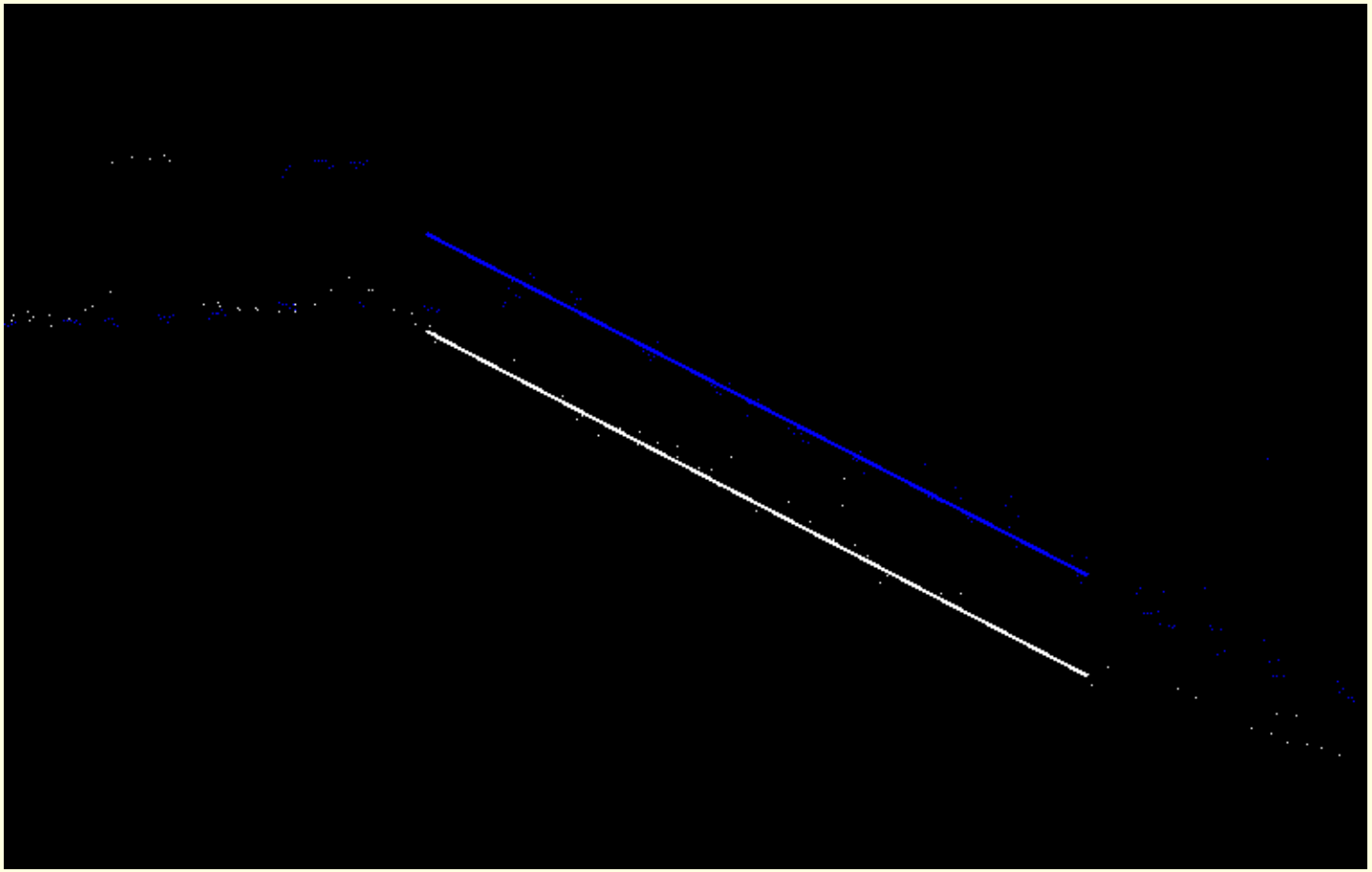


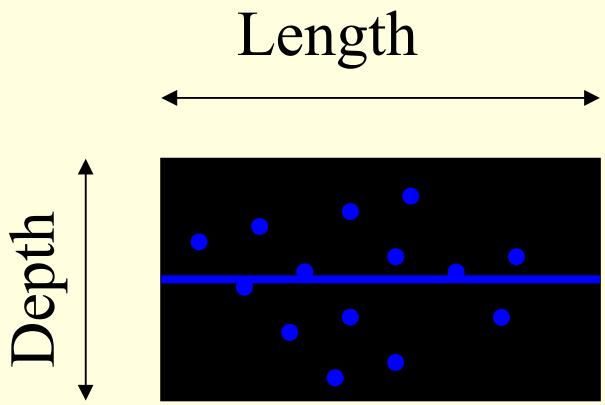
Tie Line Observations

- Ground Surface Line
  - Automatic search
  - Follows direction of surface
- Section Line
  - Manual measurement
- Ground Line
  - Manual measurement
- Roof Intersection Line
  - Automatic search
- Known Line
  - Manual measurement

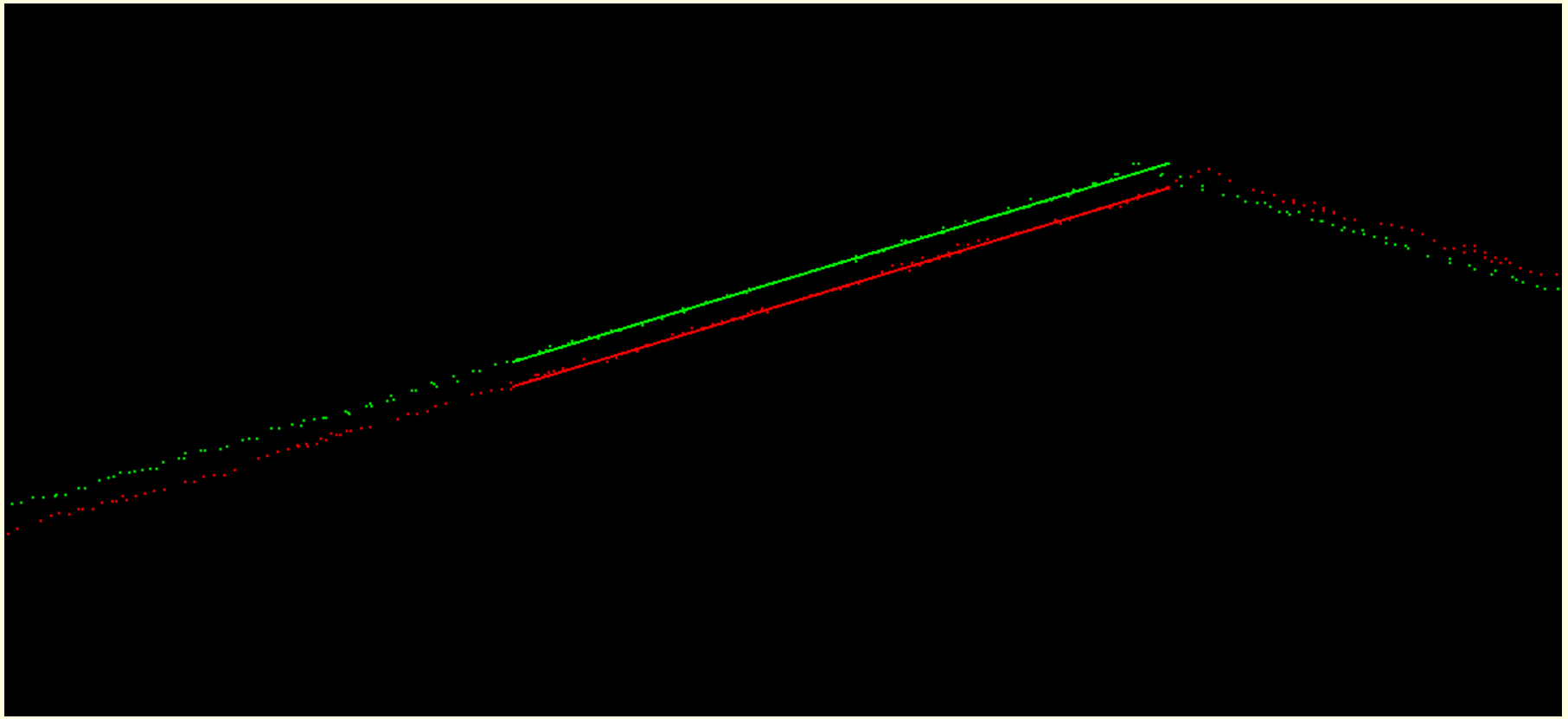
Ground Surface - automatic



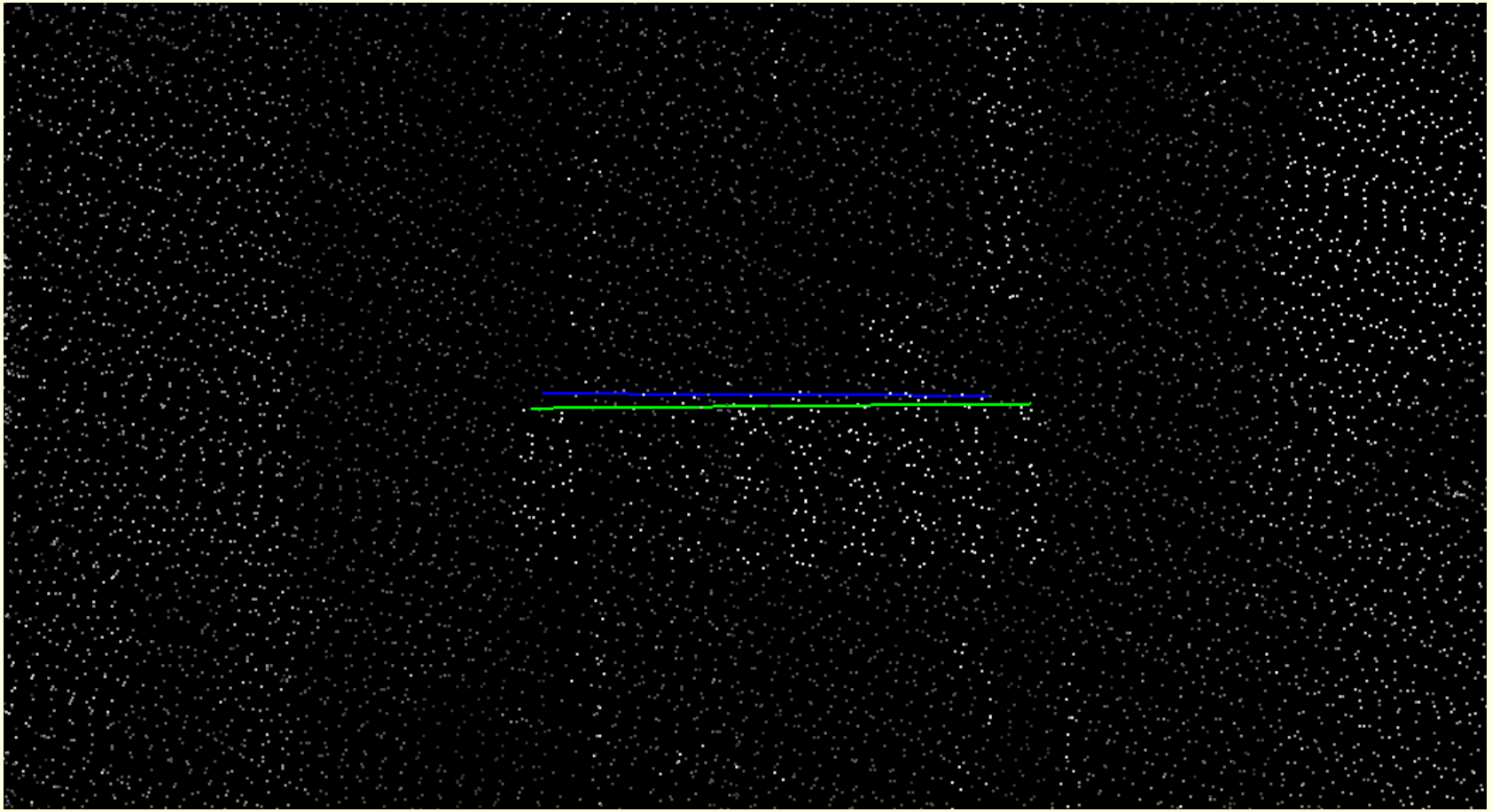
Ground Surface - Settings



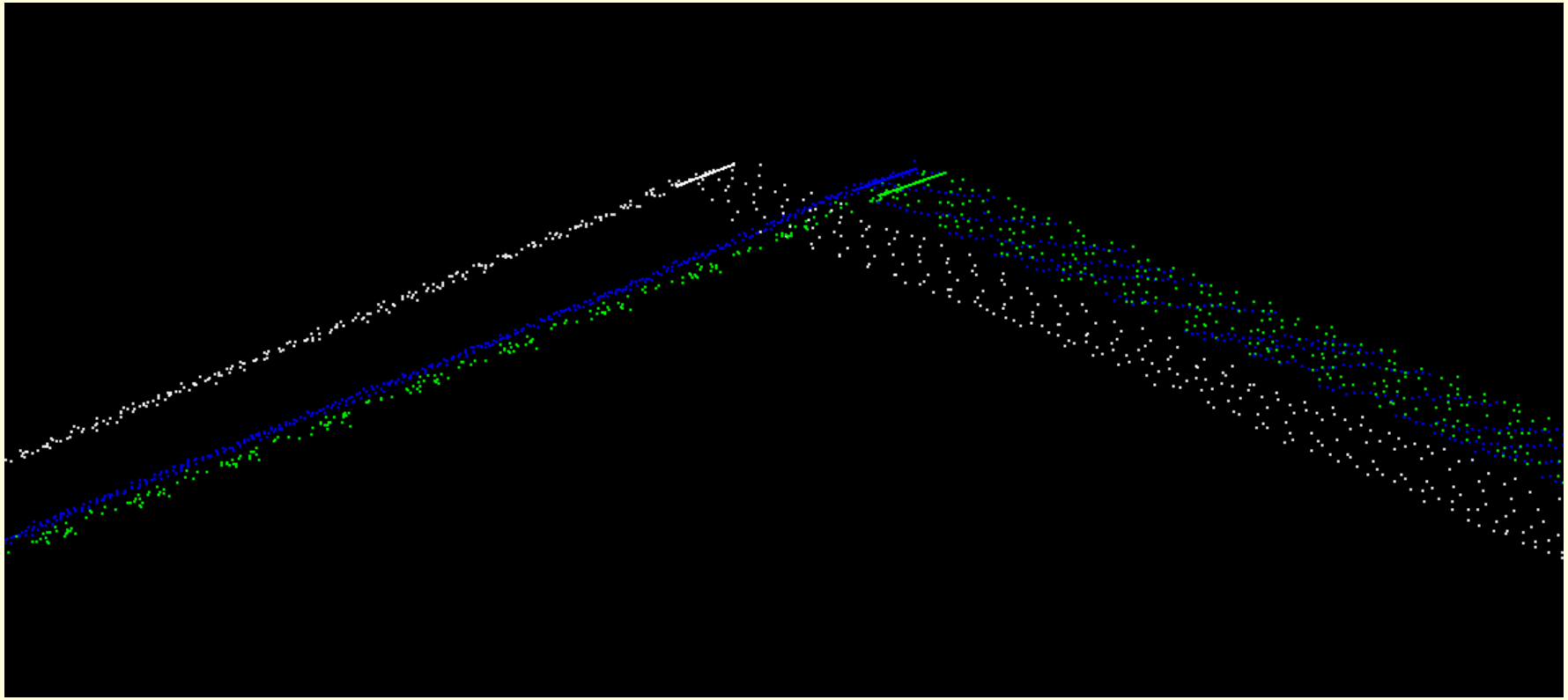
Section Line - manual



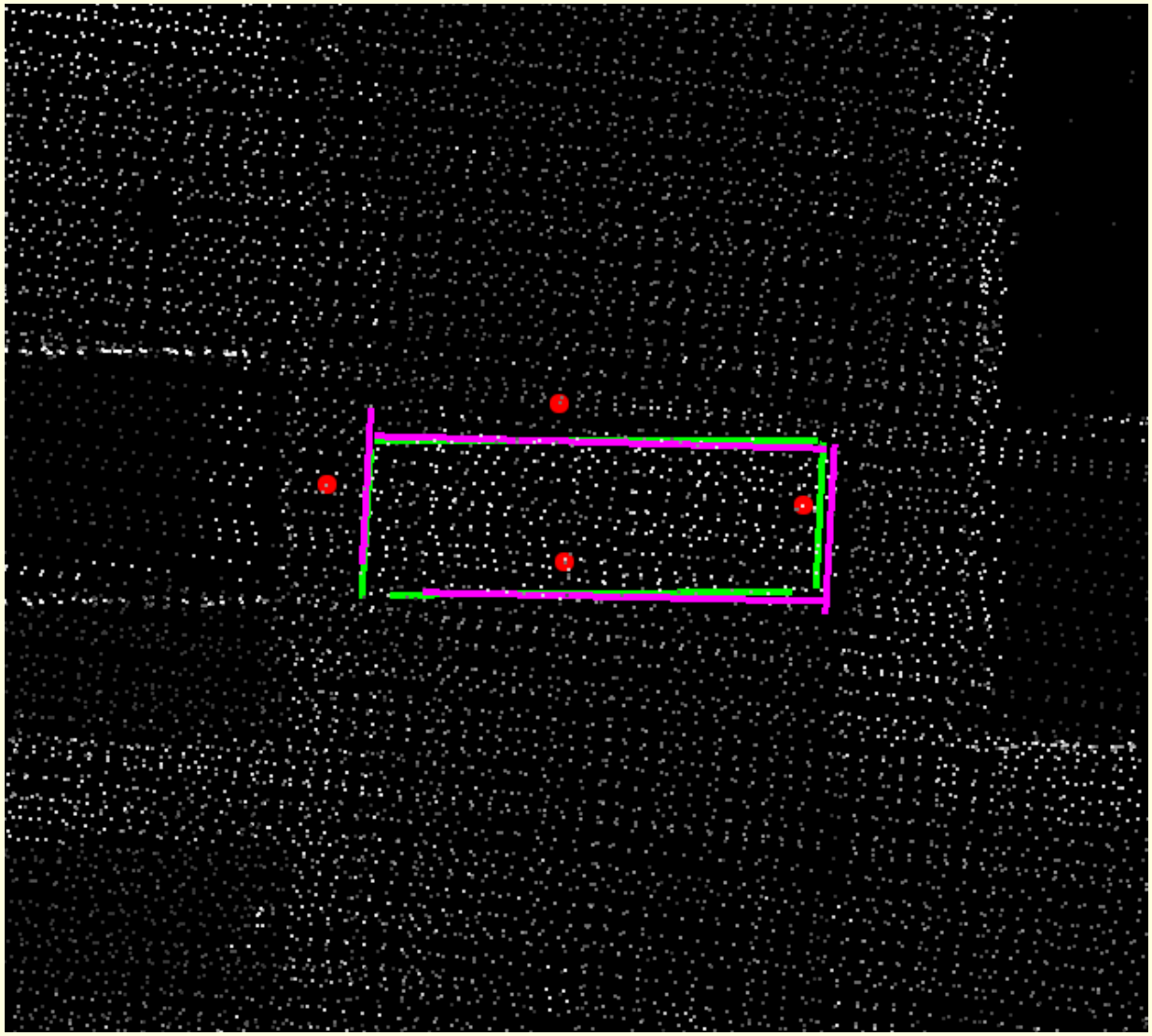
Ground Line - manual



Roof Intersection Line - automatic

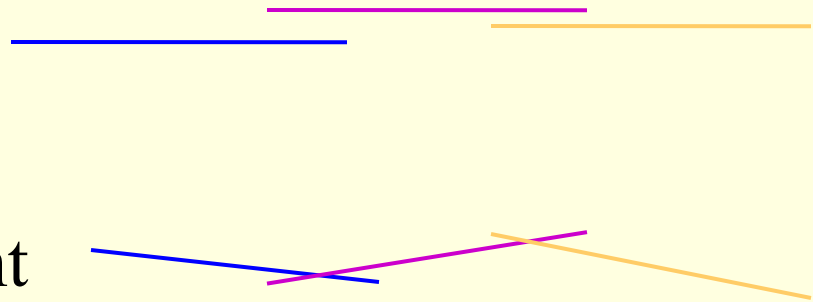


Known Line - manual



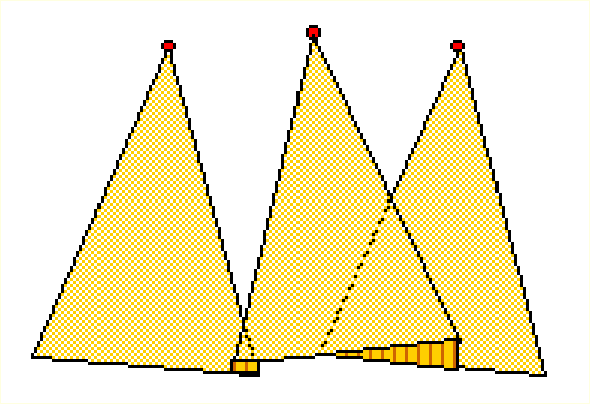
Find Match - Parameter difficulty

- dZ easiest
- dRoll easy
  - flat surfaces are sufficient
- dPitch more difficult
  - requires slopes in flight direction
- dHeading most difficult
  - requires slopes on both sides of flightline

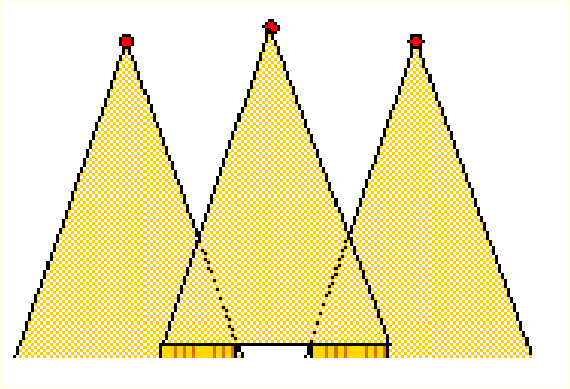


Algorithm - Parameter difficulty

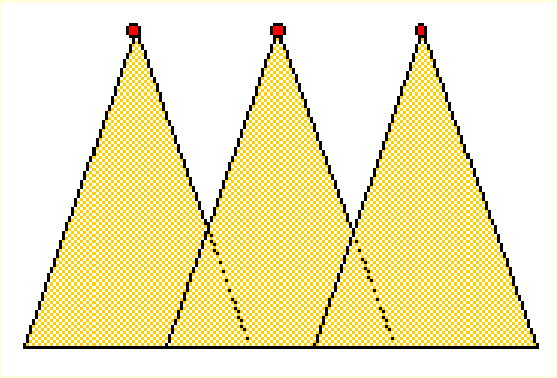
- **dRoll** and **dZ** can be solved even in flat terrain



Original data



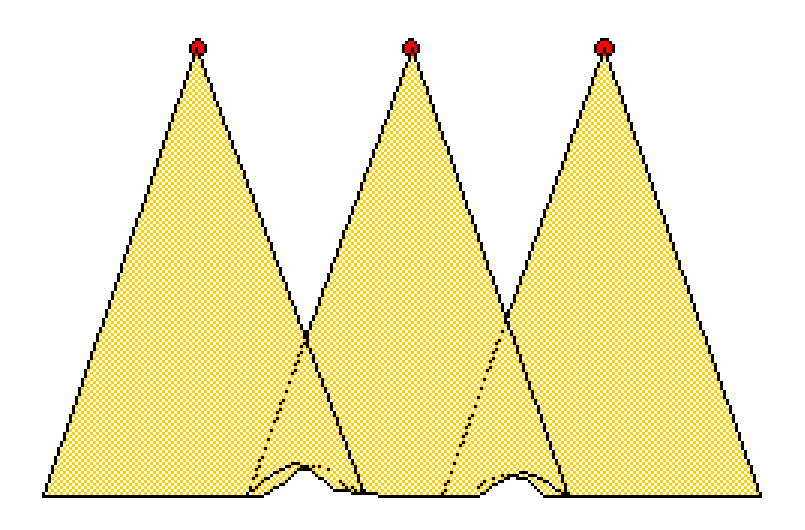
Corrected for roll



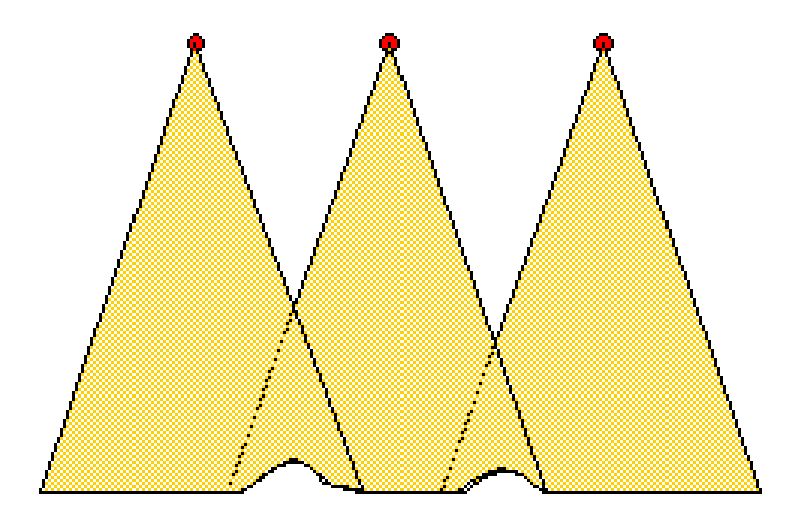
Corrected for dZ

Algorithm - Parameter difficulty

- **dPitch, dHeading, dEasting and dNorthing** require slopes



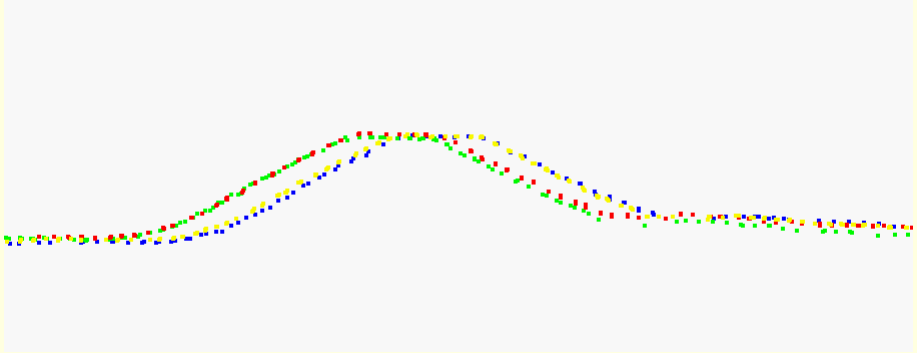
Original data



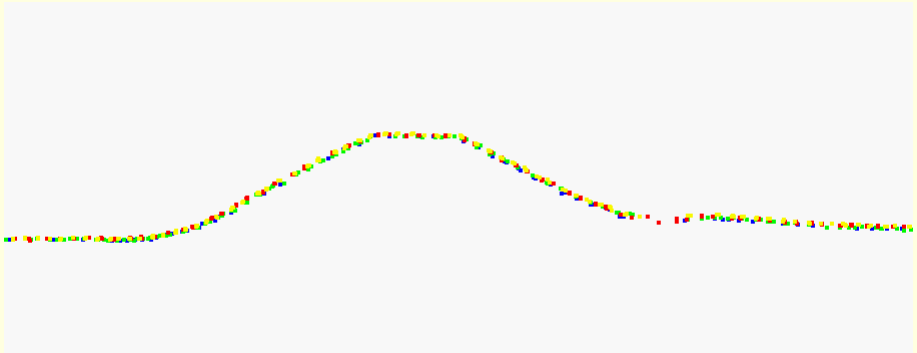
Corrected for dEasting and dNorthing

Task

- Solve laser scanner calibration parameters
  - scanner / IMU misalignment (hrp)
  - mirror scale
- Solve mismatches between different flightlines
  - roll and dz correction for each flightline



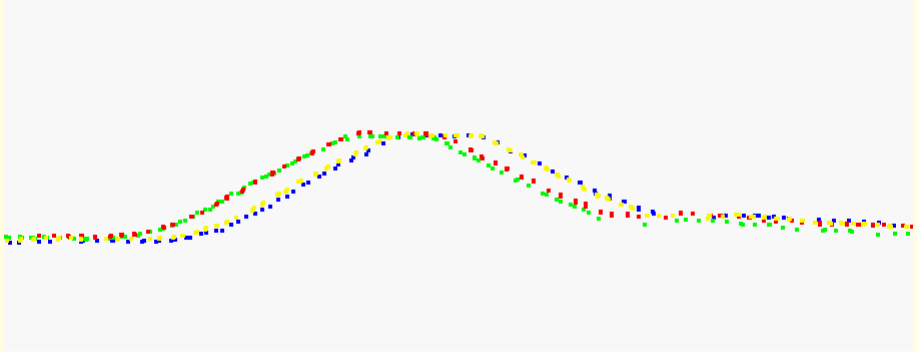
Before



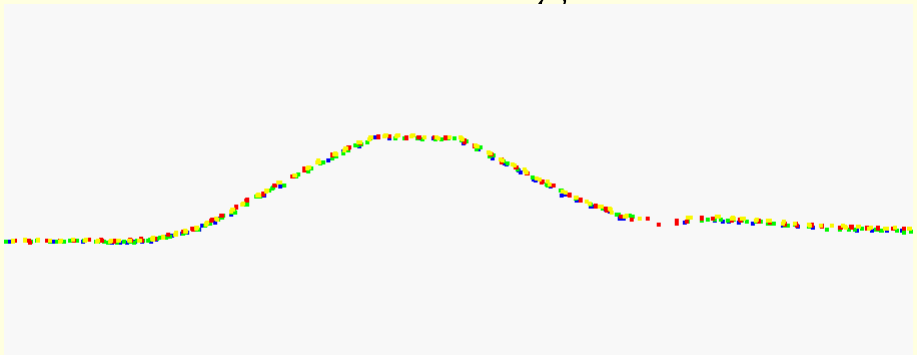
After

Task

- Solve laser scanner **calibration** parameters with **Tie Lines**
  - scanner / IMU misalignment (hrp)
  - mirror scale
- Solve mismatches in **project data** with **Find Match**
  - heading, roll, pitch, mirror scale correction for whole data set
  - heading, roll, pitch and Z correction for each flightline
- Solve mismatches in **project data** with **Tie Lines**
  - heading, roll, pitch, mirror scale correction for each group
  - heading, roll, pitch and dz correction for each flightline



Before



After

Preprocessing

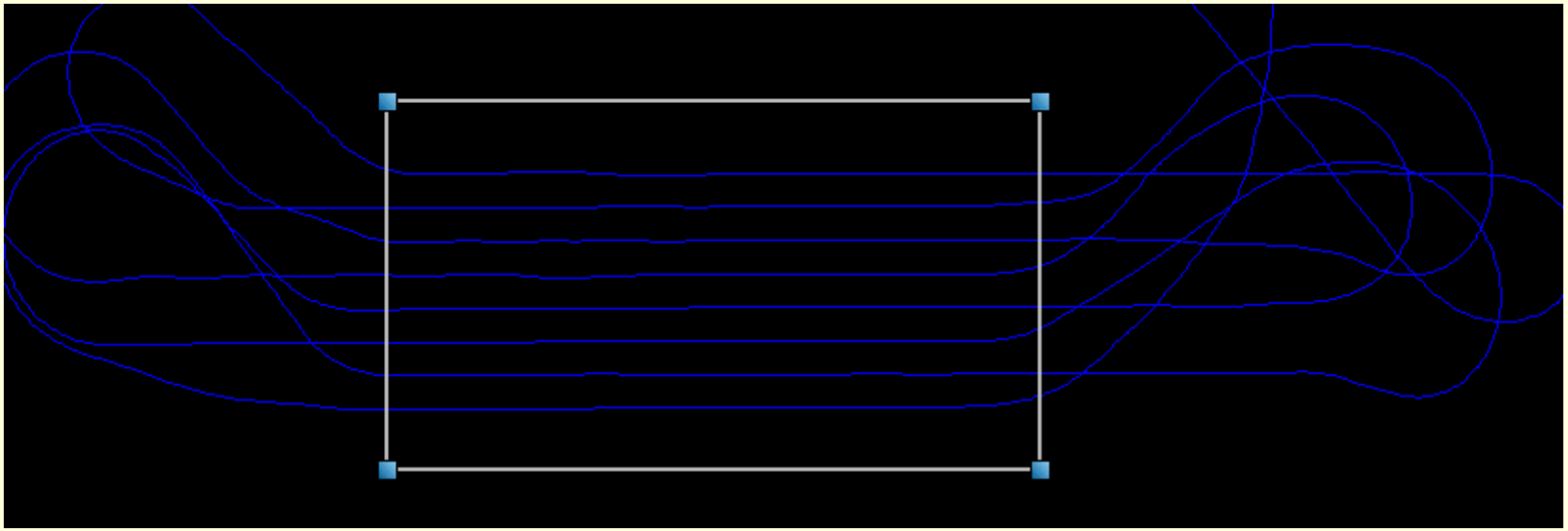
- Import trajectories into TerraScan
- Import laser points
- Assign flightline numbers to laser points
- Classify low points below ground
- Classify ground in each flightline

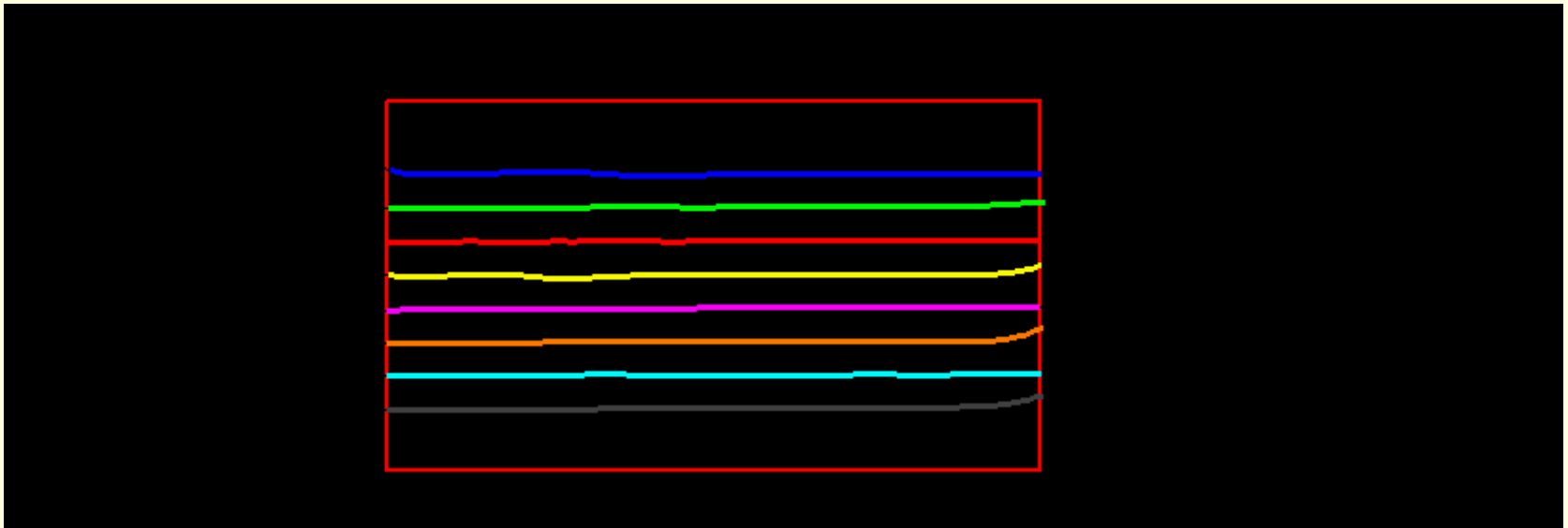
Preprocessing

- Import trajectories into TerraScan
- Thin trajectories to reduce data
- Split each trajectory which overlaps itself
- Import laser points
- Assign flightline numbers to laser points
- Classify low points below ground
- Classify ground in each flightline
- Optionally classify some buildings

Cut outside polygons

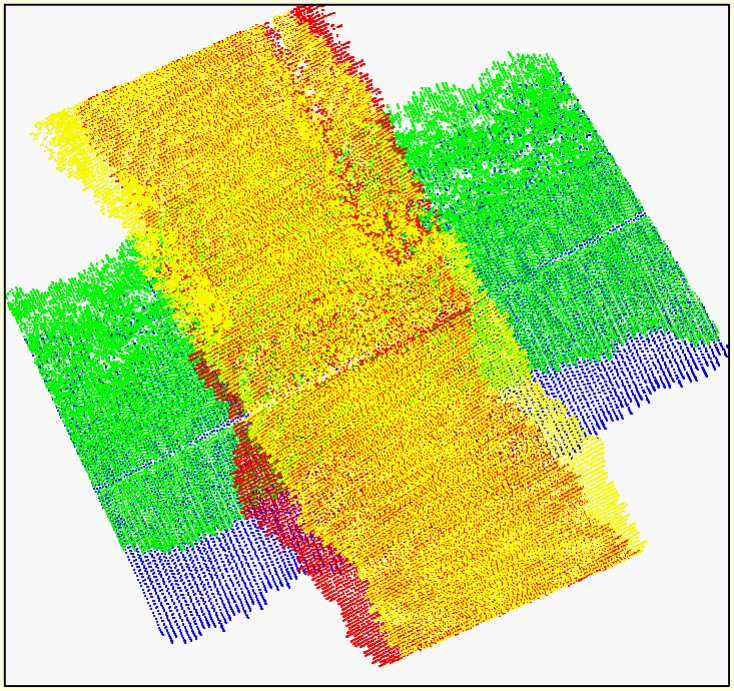
- Splits trajectories using bounding polygons



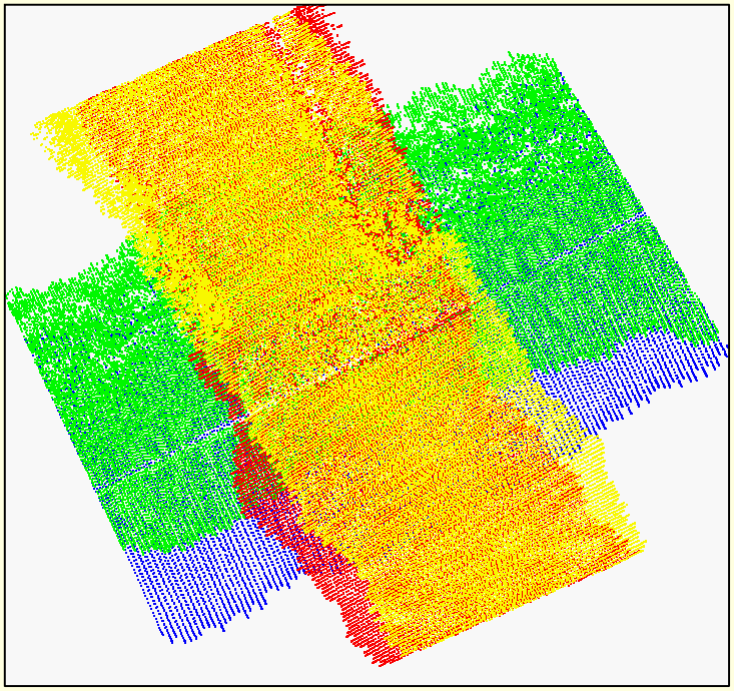


Find Match - Calibration workflow

- Fly a site with flat and sloped surfaces in at least four directions
- Classify ground (+buildings) for each flightline
- Solve heading, roll, pitch and mirror scale corrections for whole data set



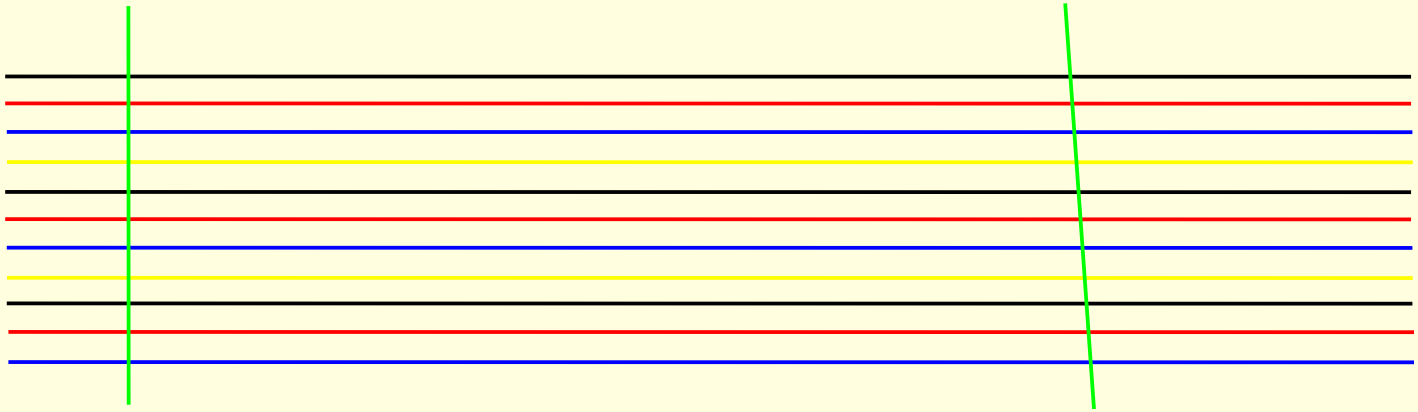
Tie Line Match - Calibration workflow



- Fly a site with flat and sloped surfaces in at least four directions
- Classify ground (+buildings) for each flightline
- Smoothen ground surface (if most is asphalt)
- Solve heading, roll, pitch and mirror scale corrections for whole data set

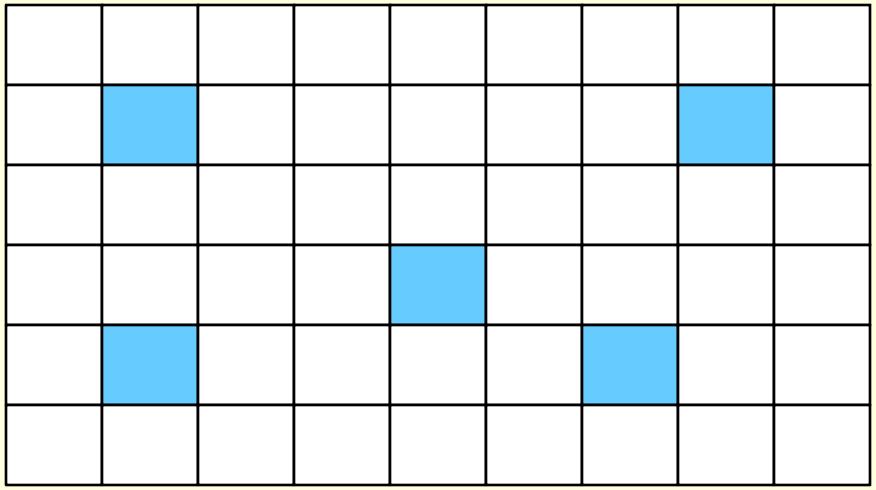
Project workflow

- Fly crossing flightlines over sloped surfaces
- Classify low points
- Compare flightlines visually in cross sections
- Classify ground for each flightline
- Solve corrections:
  - solve hrp + mirror scale for whole data set
  - solve dz or roll+dz for individual flightlines
  - find elevation fluctuations



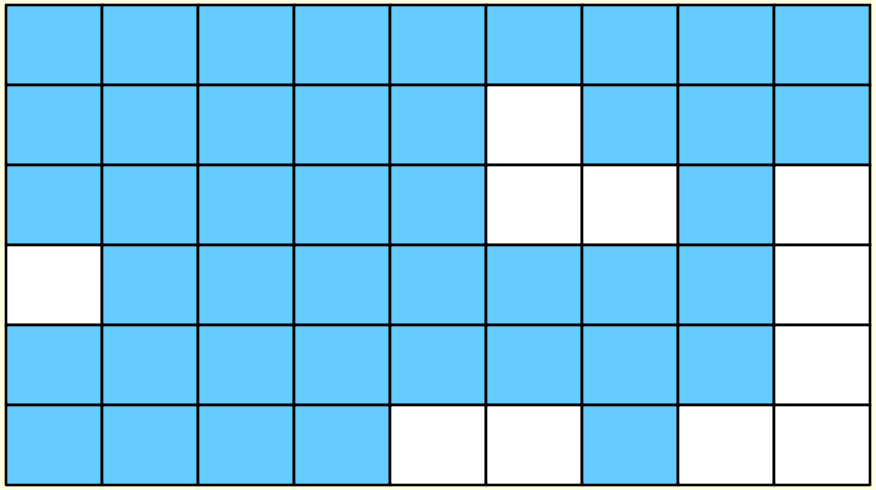
Solving for whole project

- Select blocks most suited for matching:
  - crossing flightlines
  - visible, clean, sloped surfaces
- Create project file with only those blocks
- Solve hrp (+mirror scale) for whole project using ground



Solving per flightline

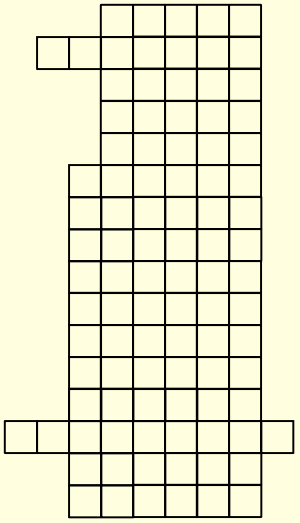
- Create project file with all usable blocks
  - take out forest only blocks if all lines cover better terrain as well
- Solve dz (+roll) per flightline



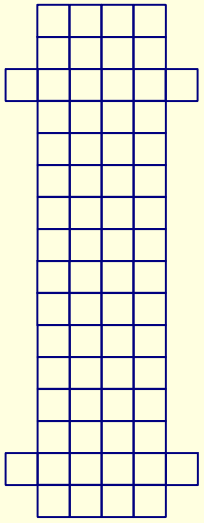
Large projects

- Check each flight session on its own first
  - misalignment & mirror scale
  - dz per flightline

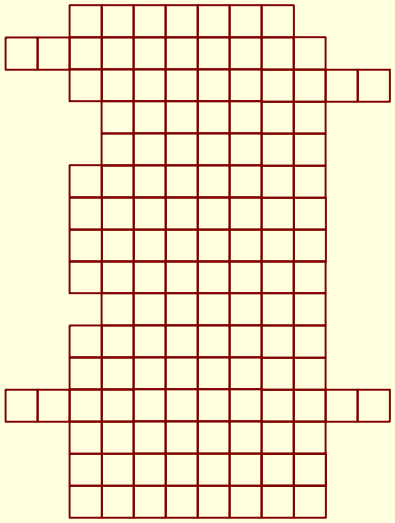
Day 1
Lines 10xx



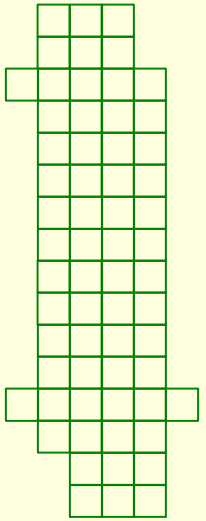
Day 2
Lines 20xx



Day 3
Lines 30xx



Day 4
Lines 40xx



Calibration is easy

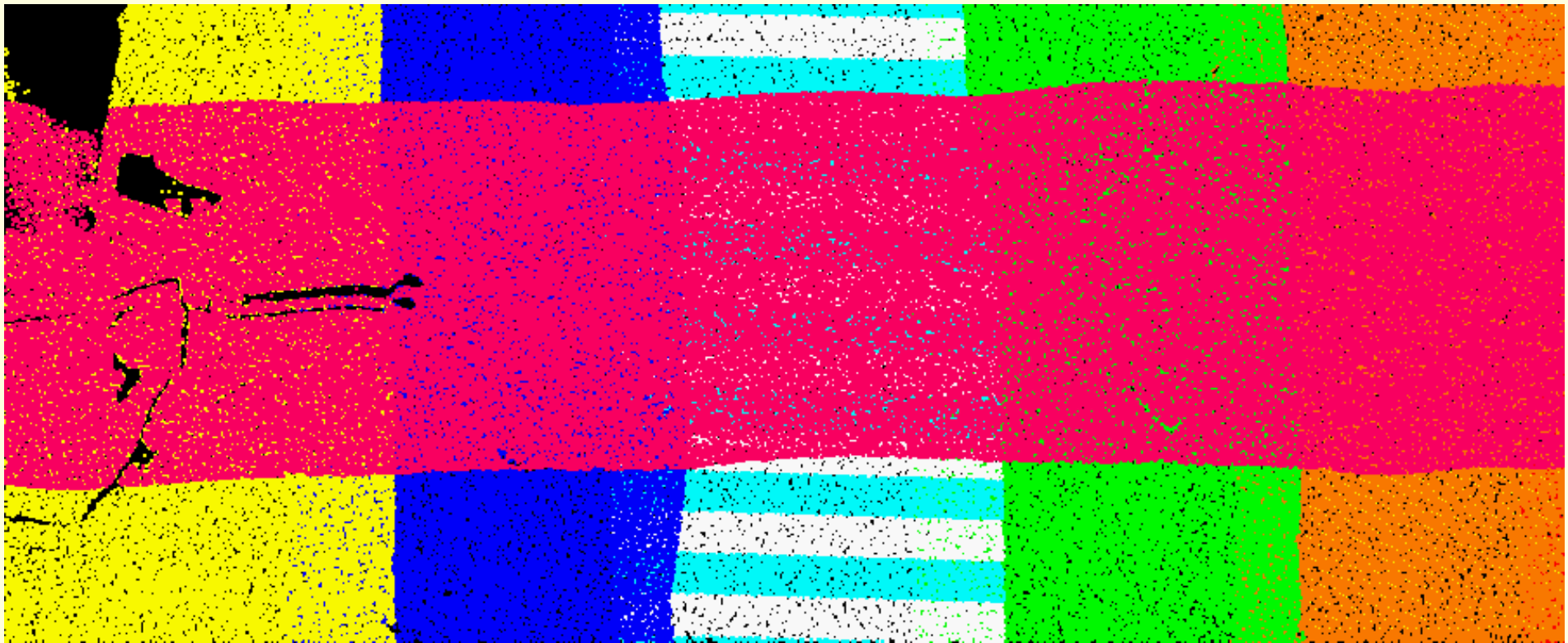
- Site is suitable for task
- Flight pattern is optimal
- We know what to solve
- Data volume is small

Project is difficult

- Site is not optimal
- Flight pattern is not optimal
- Error source may be unknown
- Data volume is large

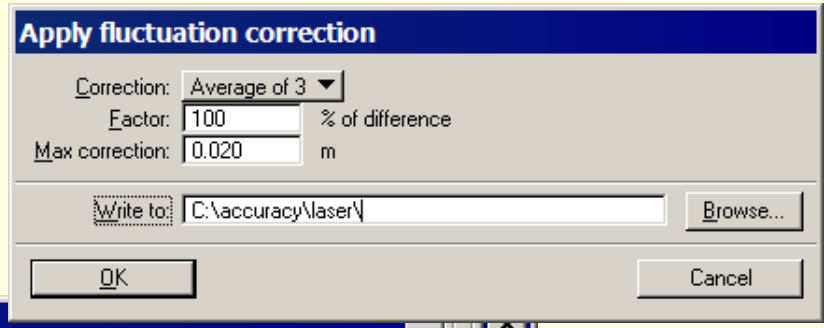
Find Fluctuations

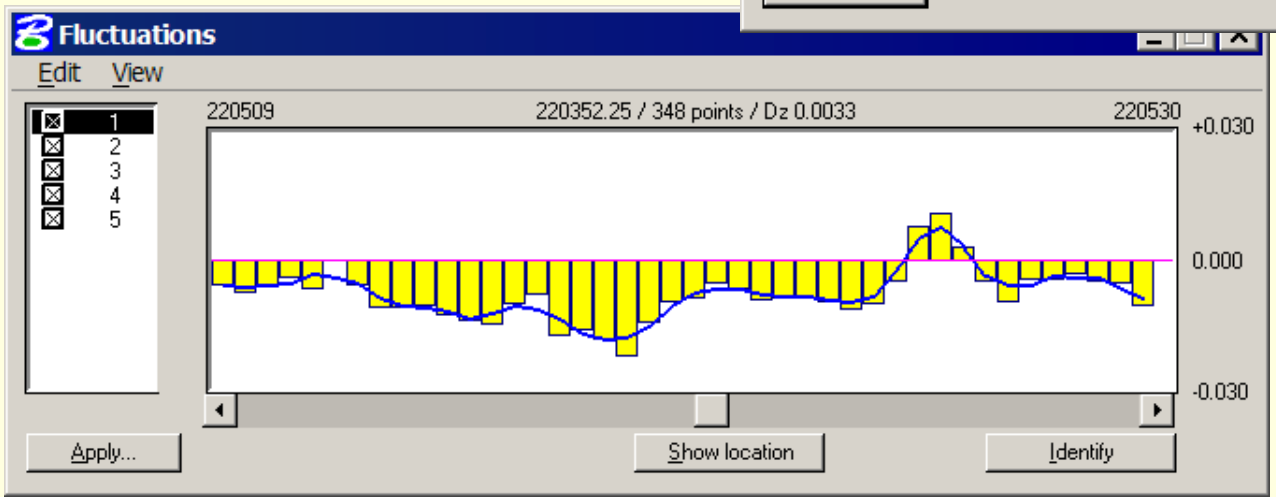
- Corrects for inaccuracy of trajectory elevations
- Requires surfaces classified per flightline
- TerraMatch computes elevation difference of each flightline to others at user specified intervals (~ 0.5 sec)



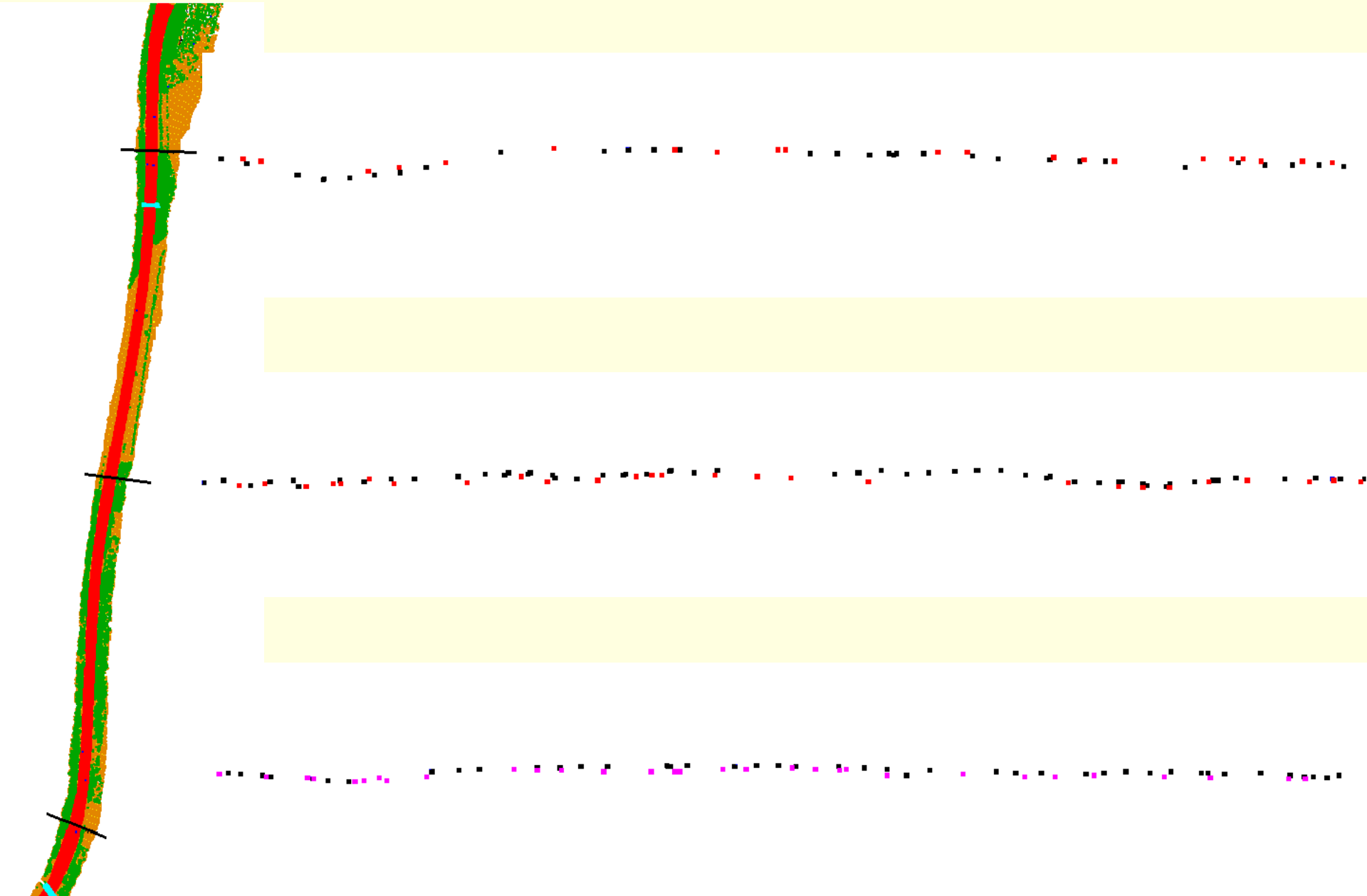
Find Fluctuations

- Correction will modify laser points of each interval with a unique dz correction
- User can select:
  - how correction curve is averaged from consecutive intervals
  - what is the maximum correction to apply

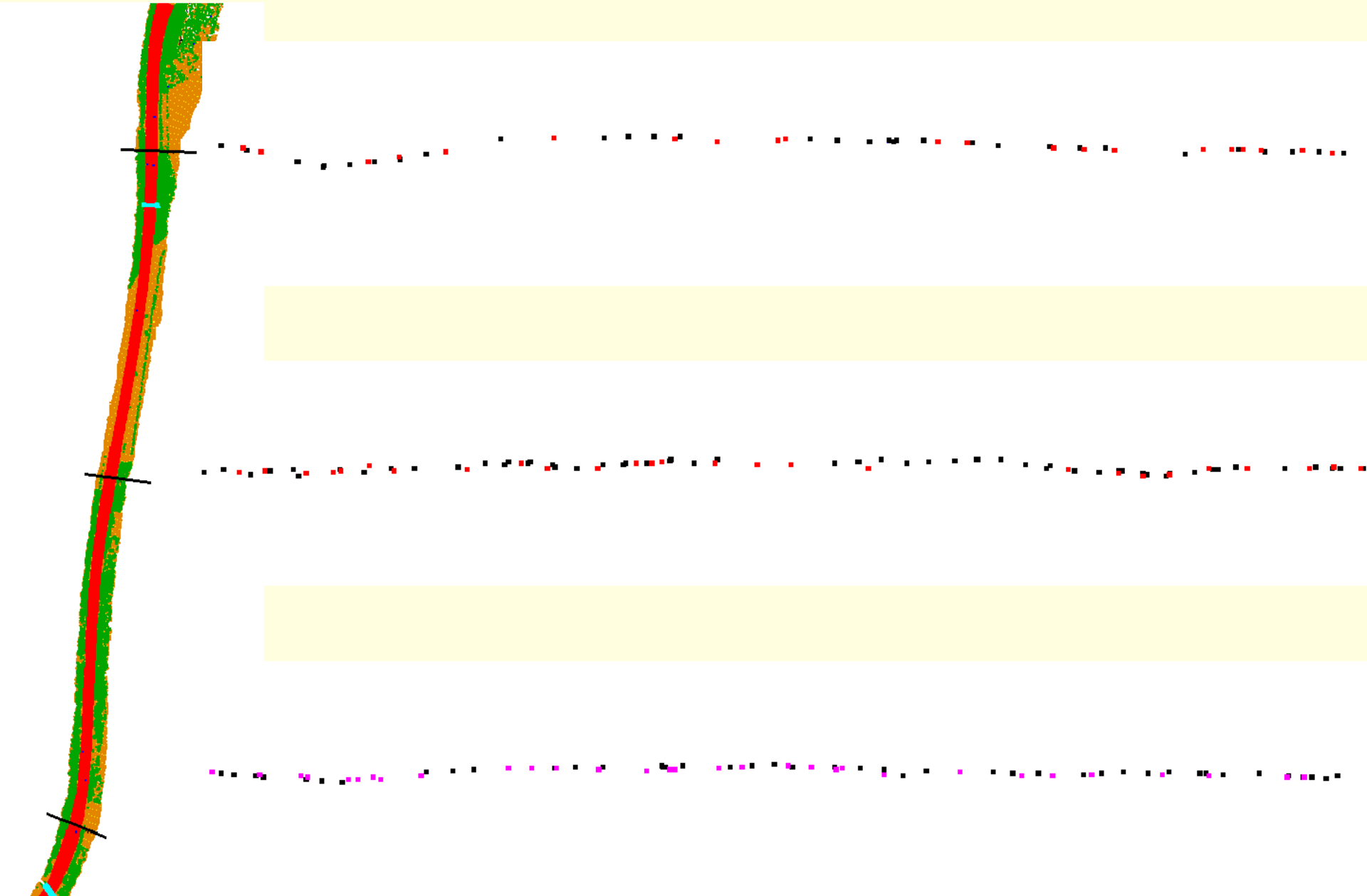




Find Fluctuations - Before



Find Fluctuations - After



TerraMatch benefits

- Quick misalignment & mirror scale calibration
  - choose a good site with sloped, visible, clean ground
- Flexibility in calibration strategy
  - ongoing calibration using each project data set
  - fewer separate flights for calibration
- Improve accuracy of project data sets