SINERGISE

Uncertainty of LPIS data or how to interpret ETS results

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LPIS Quality

Often little is known of the input data quality, and far too much is assumed about the output quality

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Accuracy – inaccuracy

$$\sigma(\Delta) = \sqrt{\frac{1}{A_1^2}\sigma^2(A_2) + \frac{A_2^2}{A_1^4}\sigma^2(A_1)}$$

$$\int_{-\infty}^{\infty} \Delta x_i^{\,2}((y_{i+1} - y_{i-1})^2 + \Delta y_{i-1}^{\,2} + \Delta y_{i+1}^{\,2}) \frac{1}{\sqrt{2\pi}\sigma_{xi}} \exp\left(-\frac{\Delta x_i^{\,2}}{2\sigma_{xi}^{\,2}}\right) d\Delta x_i$$
$$= \sigma_{xi}^{\,2}((y_{i+1} - y_{i-1})^2 + \Delta y_{i-1}^{\,2} + \Delta y_{i+1}^{\,2})$$

$$\frac{\mathrm{d}P}{\mathrm{d}\left|\frac{A_1 - A_2}{A_1}\right|}$$

$$\sigma_A = \sigma_s \sqrt{l^2 + 3\,(N_{\text{out}} - N_{\text{in}})^2\,\pi^2\,\sigma_s^{\,2}}\,.$$

$$\int_{-\infty}^{\infty} (x_i + \Delta x_i)\,(y_{i-1} - y_{i+1}) \frac{1}{\sqrt{2\pi}\sigma_{xi}} \exp\left(-\frac{\Delta x_i^{\,2}}{2\sigma_{xi}^{\,2}}\right) d\Delta x_i = x_i\,(y_{i-1} - y_{i+1})$$

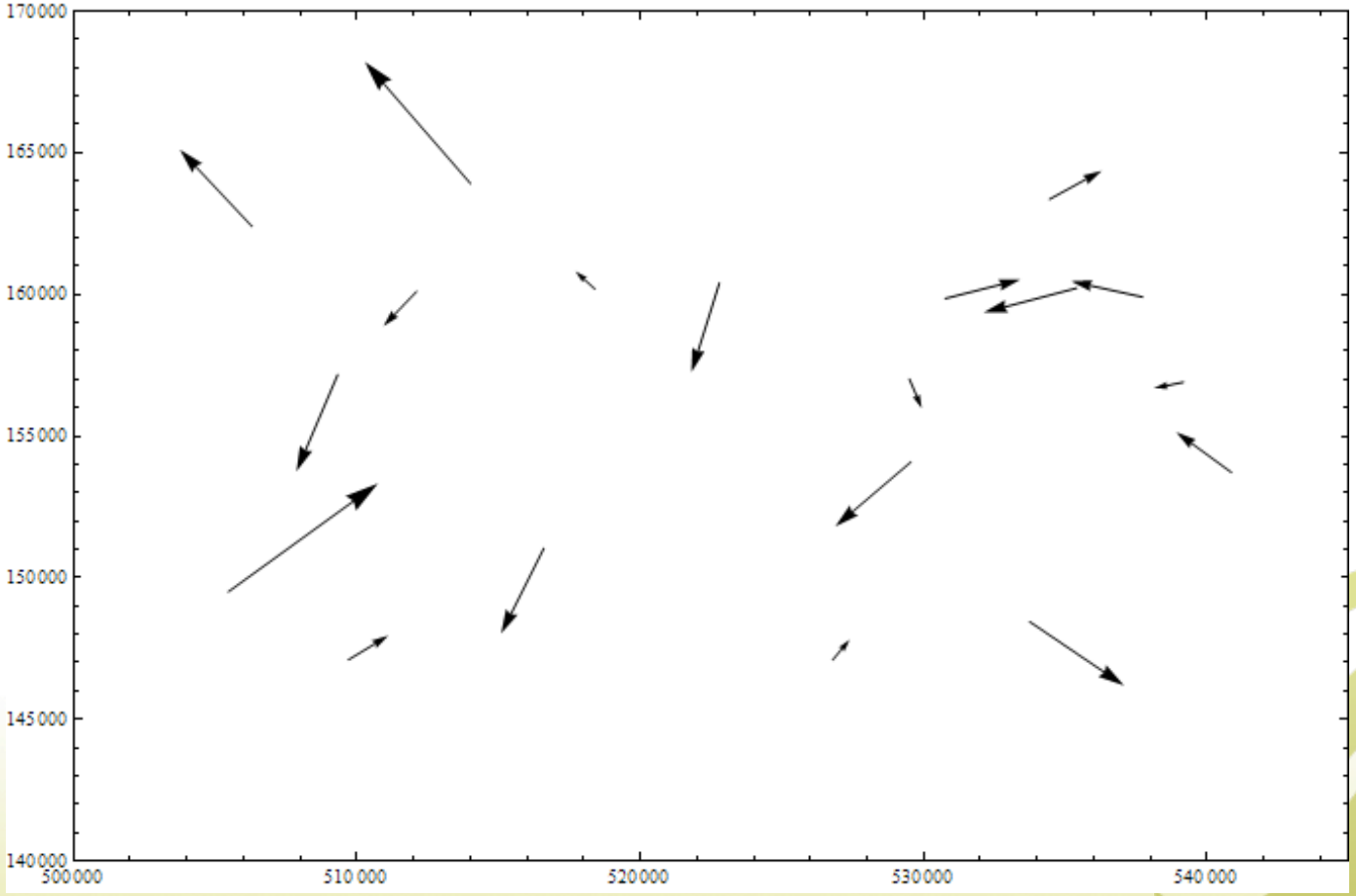
$$\sigma_A^{\,2} = \frac{1}{4}\sum_{i=1}^{N} \sigma_{xi}^{\,2}\left((y_{i+1} - y_{i-1})^2 + \frac{1}{2}(\sigma_{yi-1}^{\,2} + \sigma_{yi+1}^{\,2})\right)$$
$$+ \sigma_{yi}^{\,2}\left((x_{i+1} - x_{i-1})^2 + \frac{1}{2}(\sigma_{xi-1}^{\,2} + \sigma_{xi+1}^{\,2})\right)$$

Aerial imagery

Aerial imagery

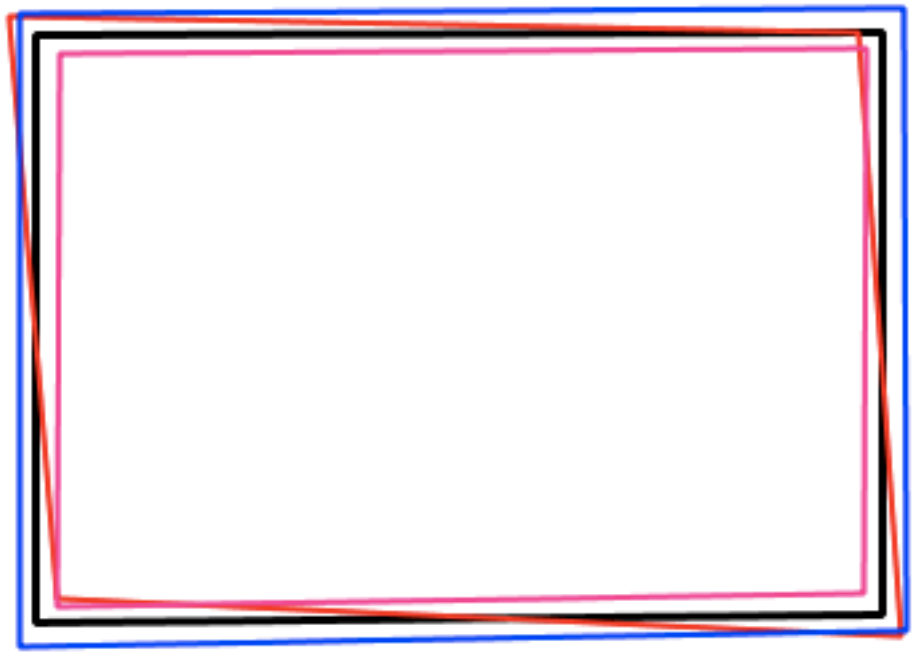
Aerial imagery

- Absolute position error – RMSE = 1 m
- Relative position error – RMSE = ???



Aerial imagery – effect on area uncertainty

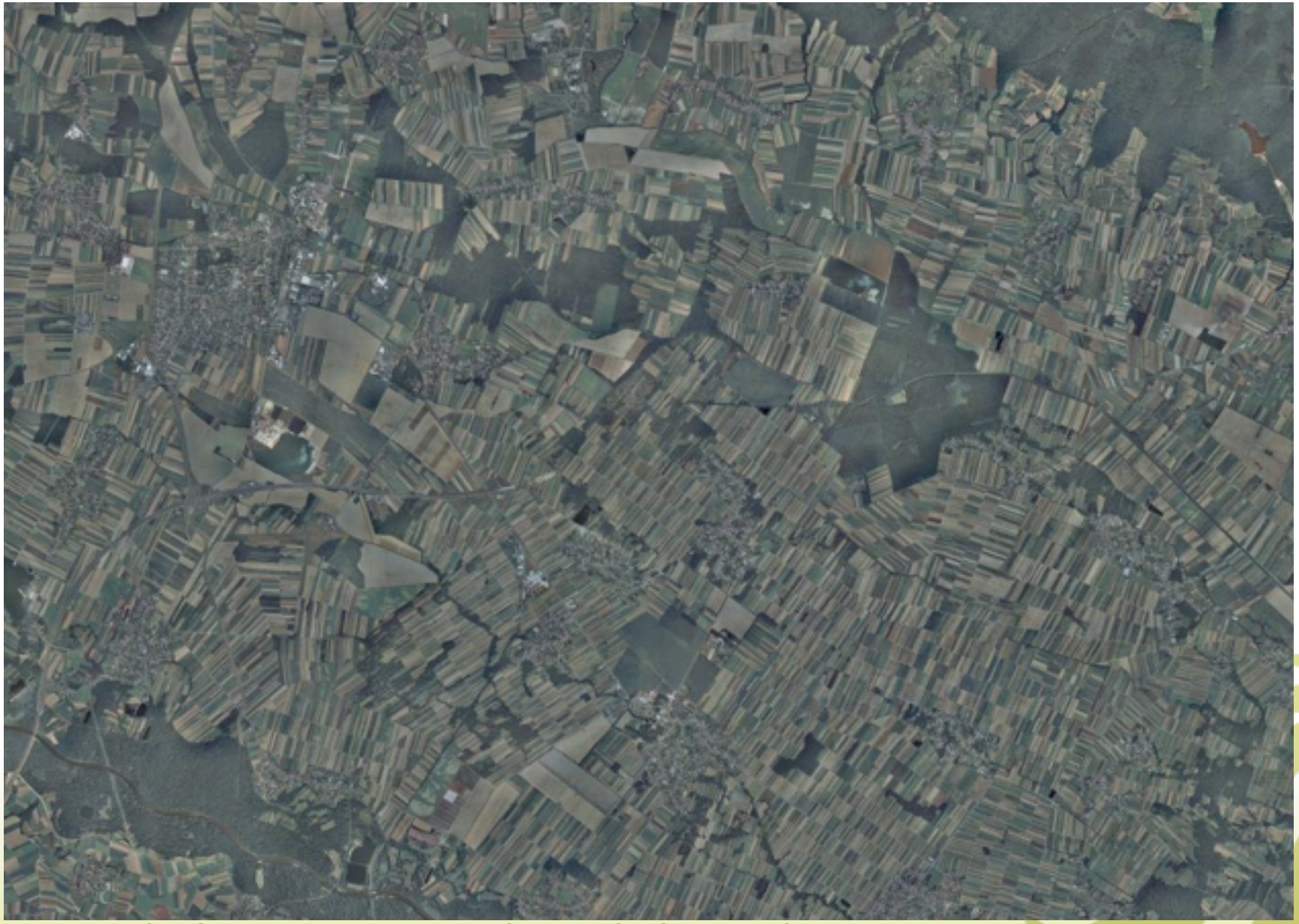
- Any point on DOP might not actually be there – it can be anywhere in the distance of RMSE away!



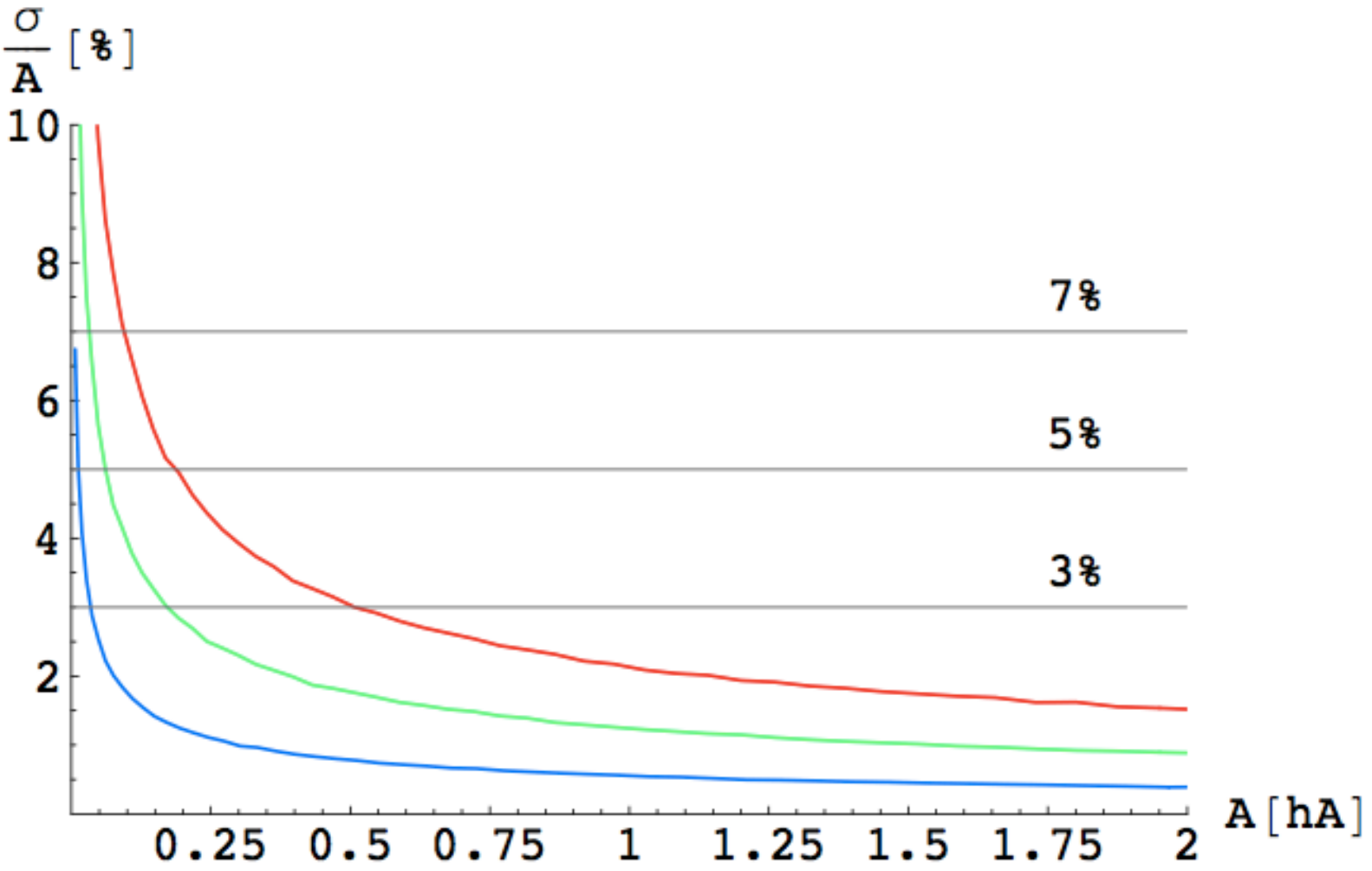
Aerial imagery – effect on area uncertainty

- Parameters related to inaccuracy
  - relative position accuracy
  - size of the polygon (area)
  - elongated polygons
    - ratio width/height = 1:1 (square), 1:10, 1:30

Aerial imagery – effect on area uncertainty



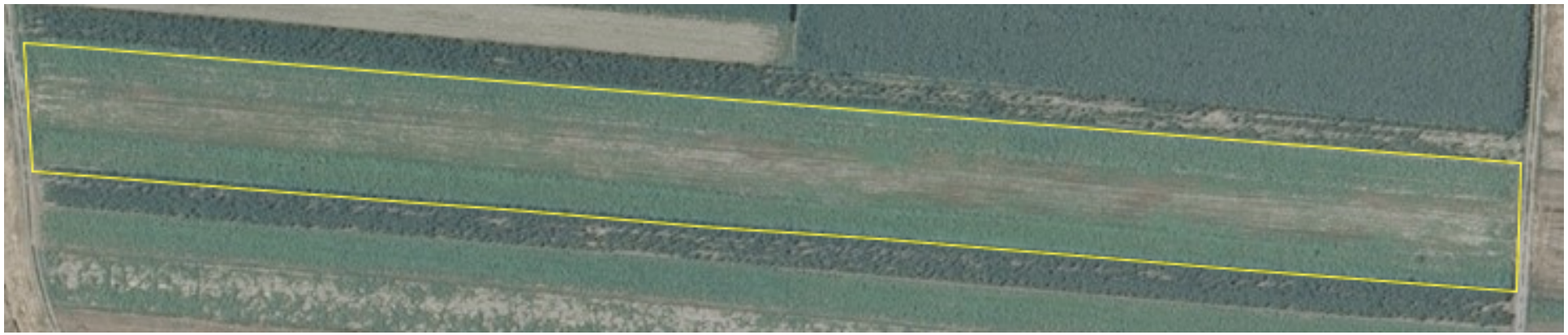
Aerial imagery – effect on area uncertainty



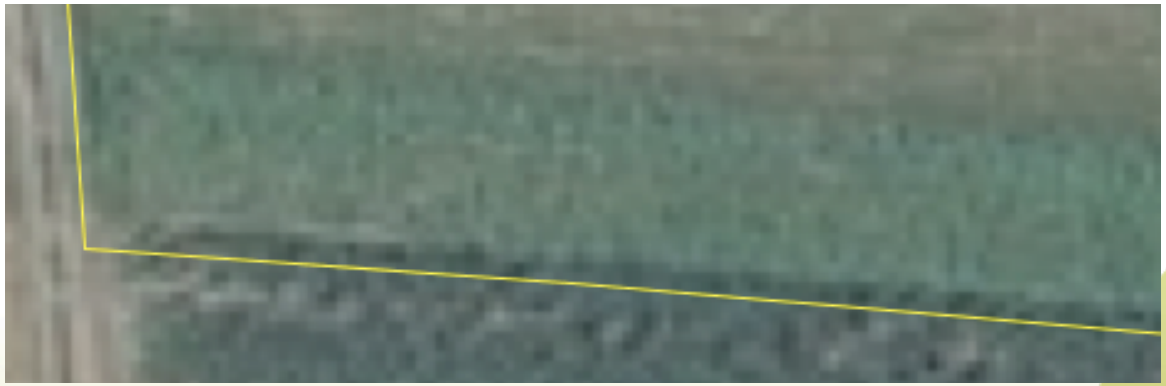
Relative position error = 0.2 m

Digitization

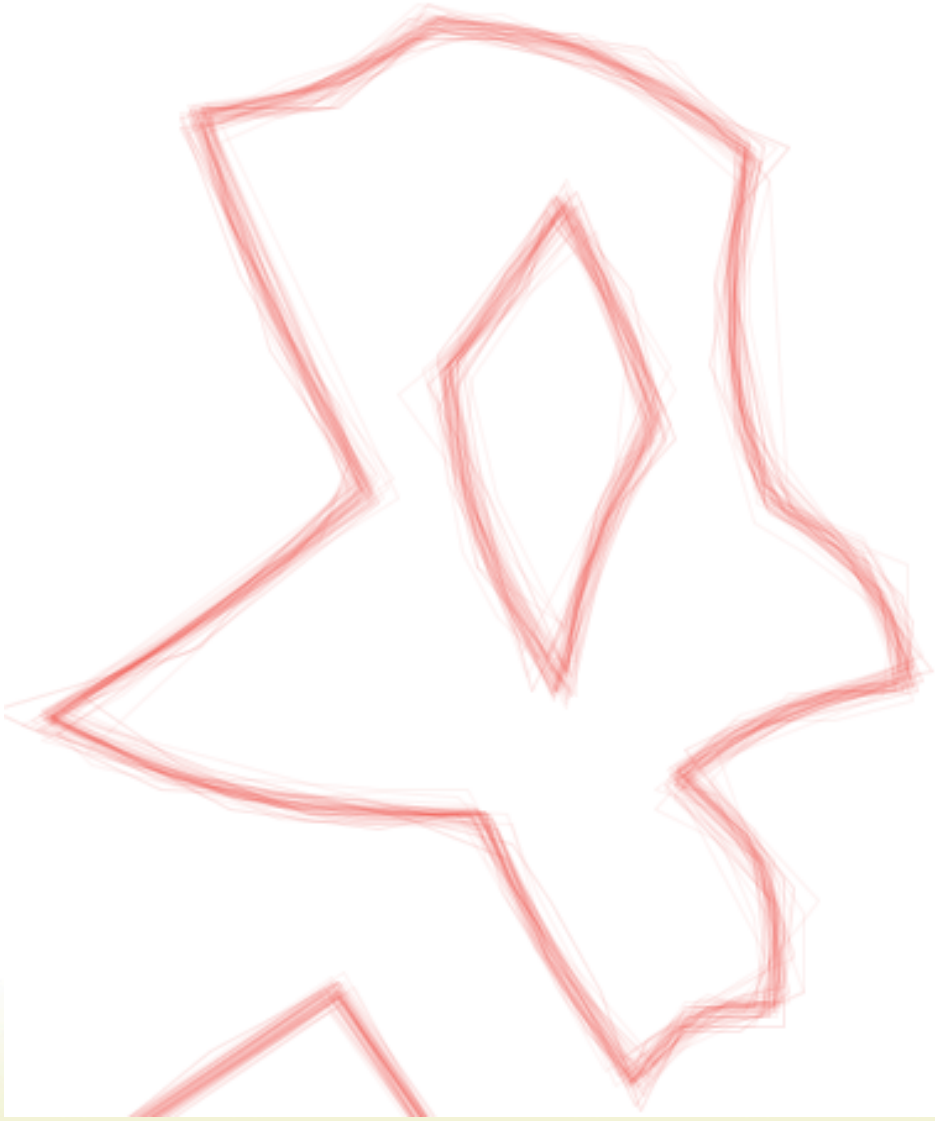
Scale 1:1.500



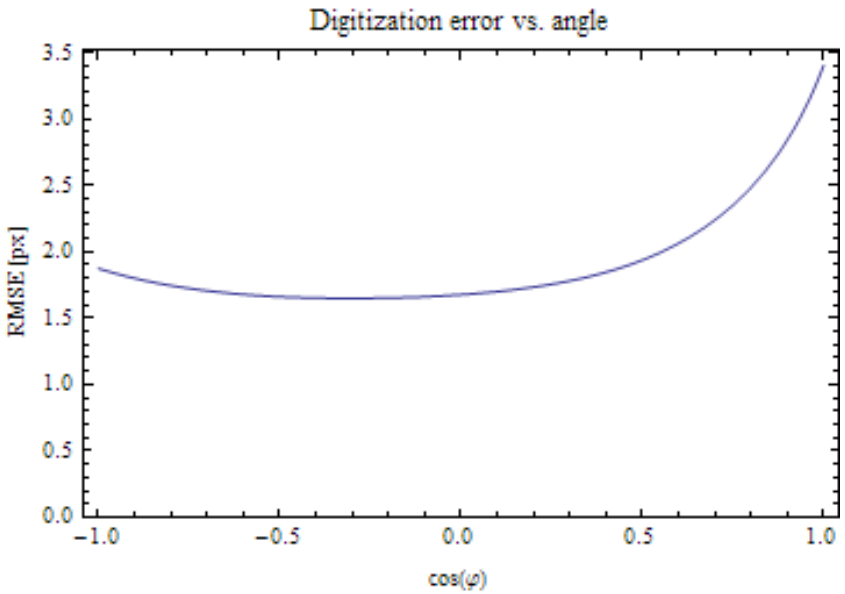
Scale 1:350



Digitization

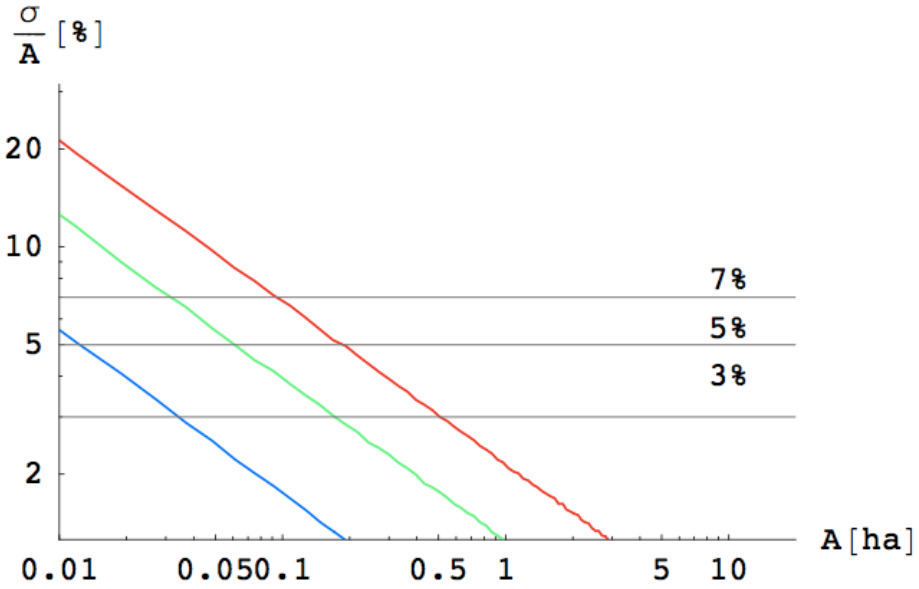


Digitization



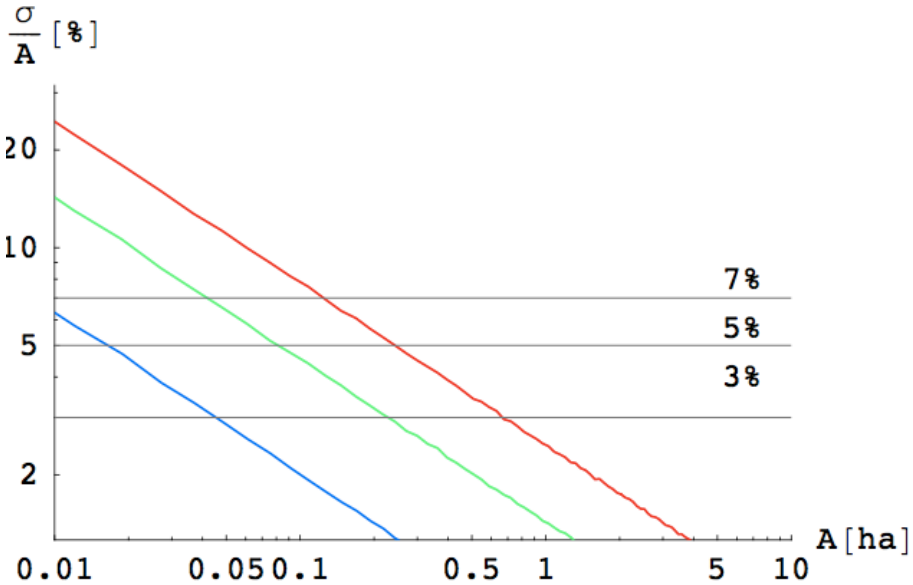
- RMSE – 1.58 px
  - depends on scale and monitor resolution
  - 1:1.000 – 0.45 m
  - 1:2.000 – 0.9 m

Digitization - effect on area



Aerial

RMSE Aerial = 0.2 m

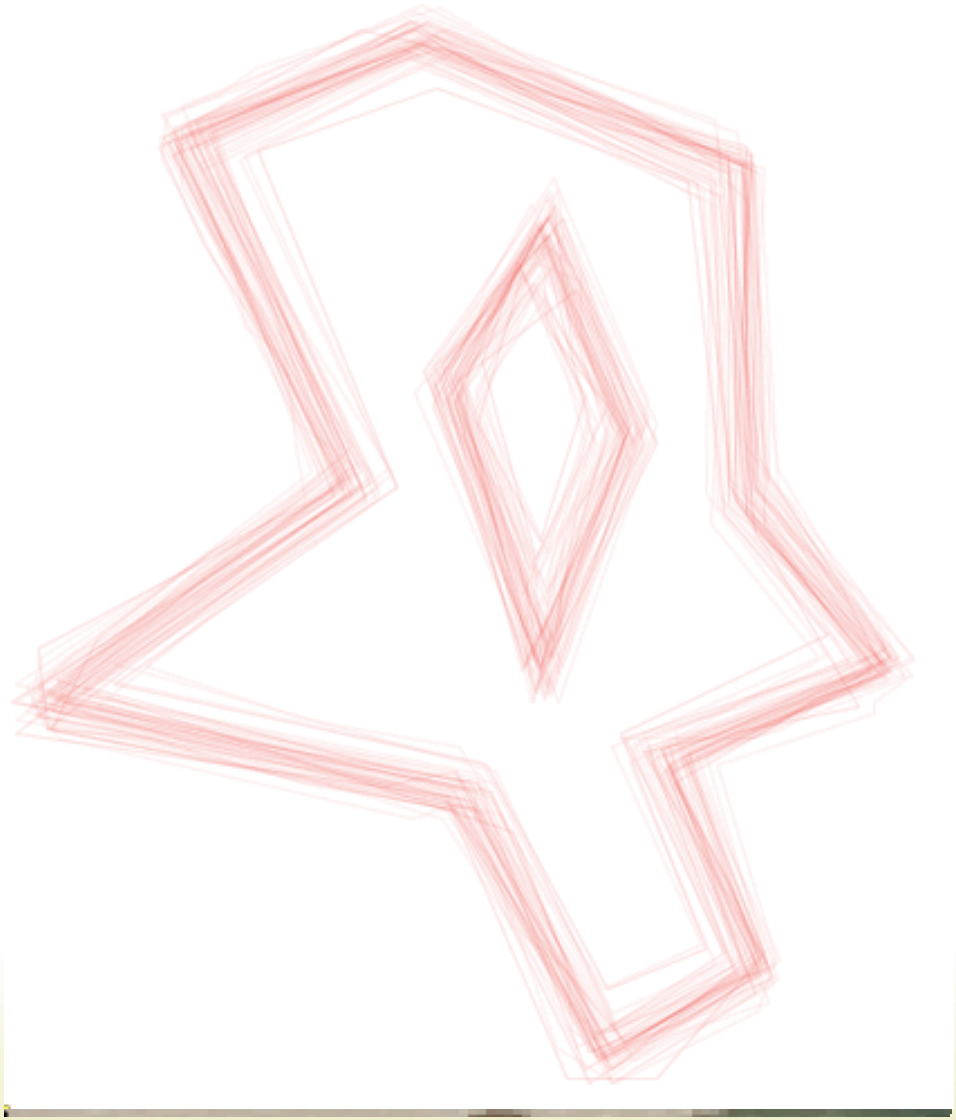


Aerial + Digitization

RMSE Aerial = 0.2 m

RMSE Dig = 0.4 m

Interpretation

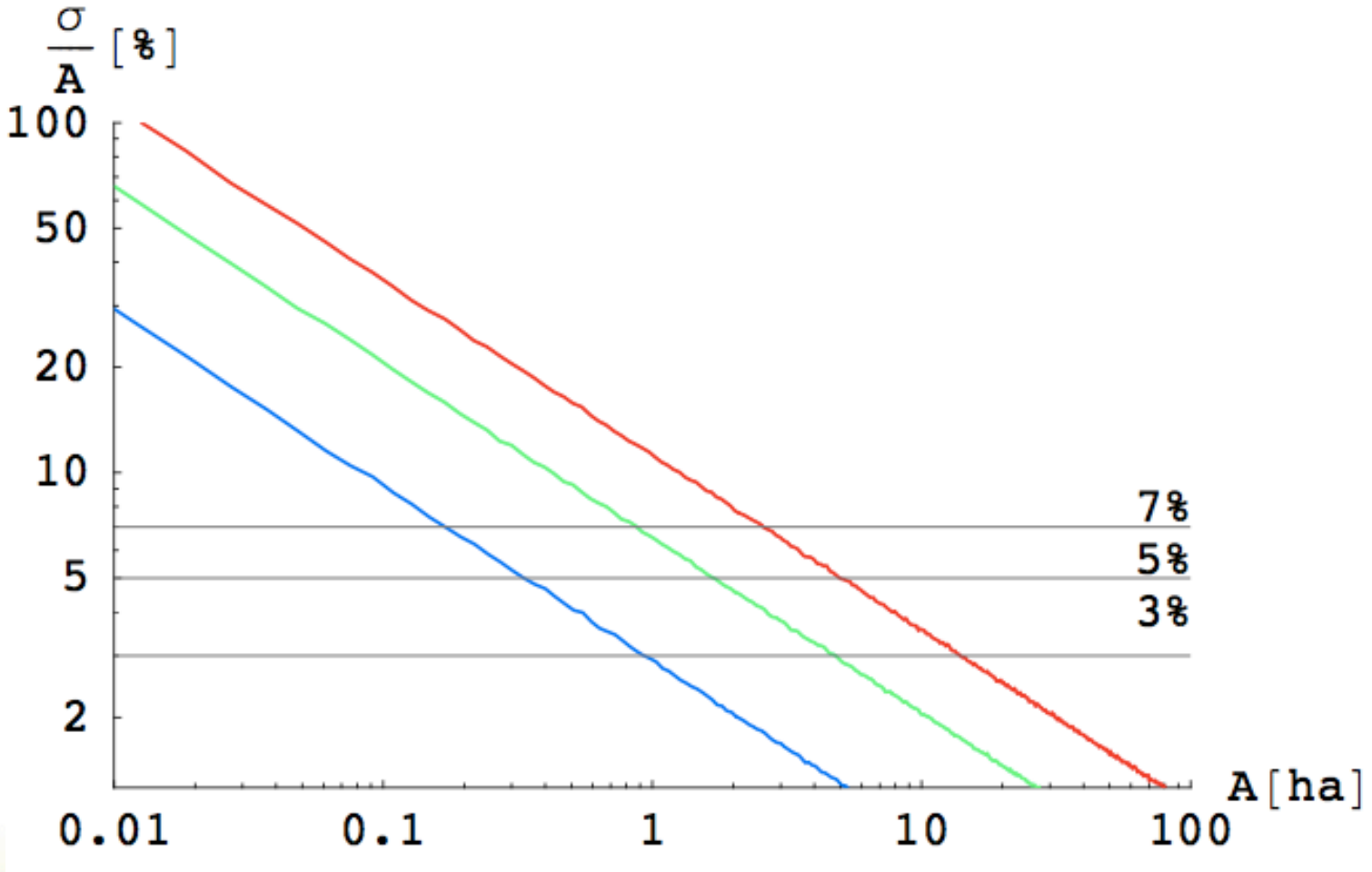


Interpretation

- subjective
  - correlated error
- depends on skills
- obstacles (trees, steep areas)

- RMSE > 1m

Interpretation – effect on area uncertainty

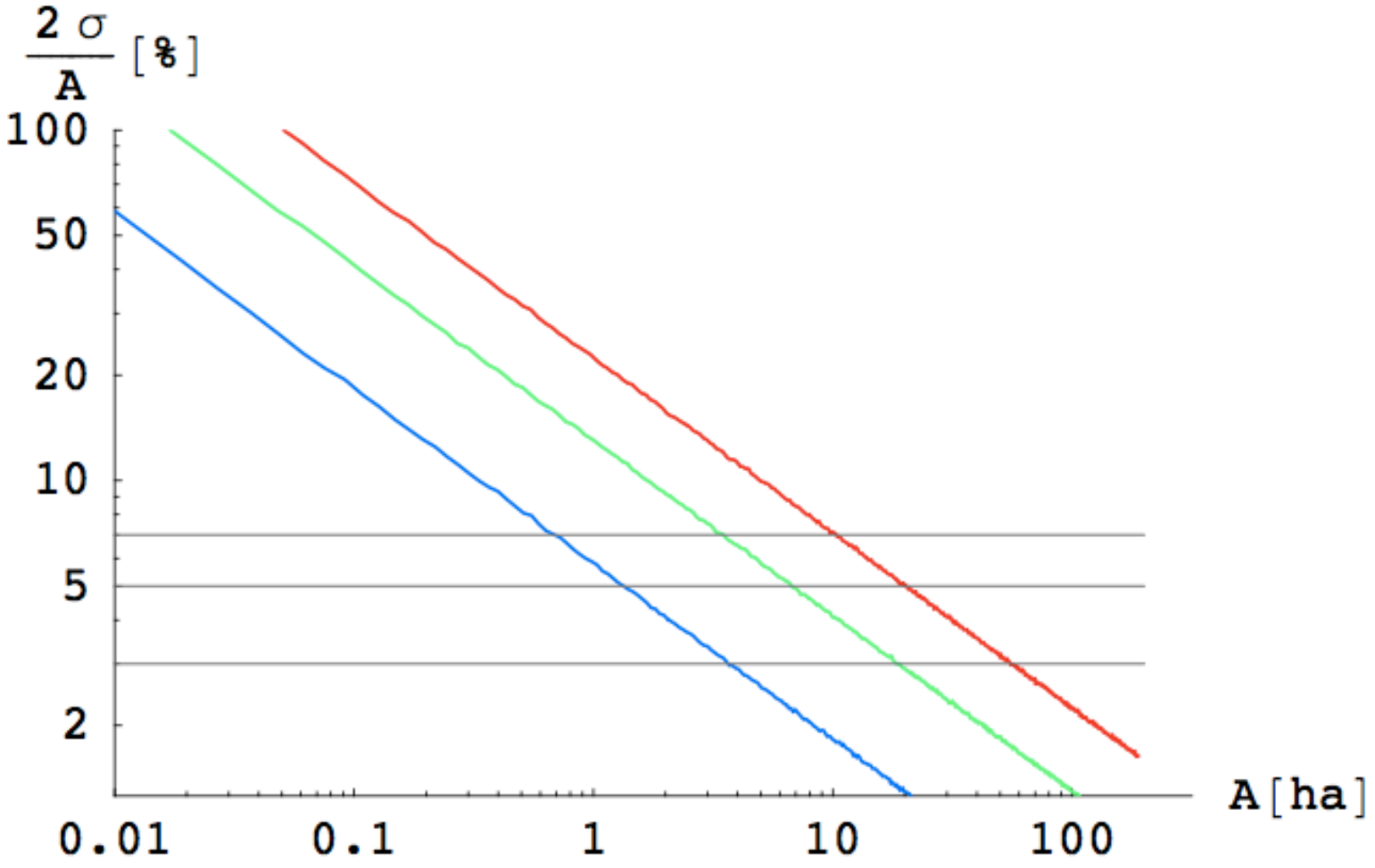


Aerial (0.2m)+ digitization (0.4m) + interpretation (1m)

ETS (and CwRS)

- repeating the same procedure
  - producing the same set of errors
- parameters
  - imagery – RMSE = 0.4 m
  - digitization – RMSE = 0.4 m
  - interpretation – RMSE = 0

ETS – effect on area uncertainty



ETS/CwRS testing (95%)

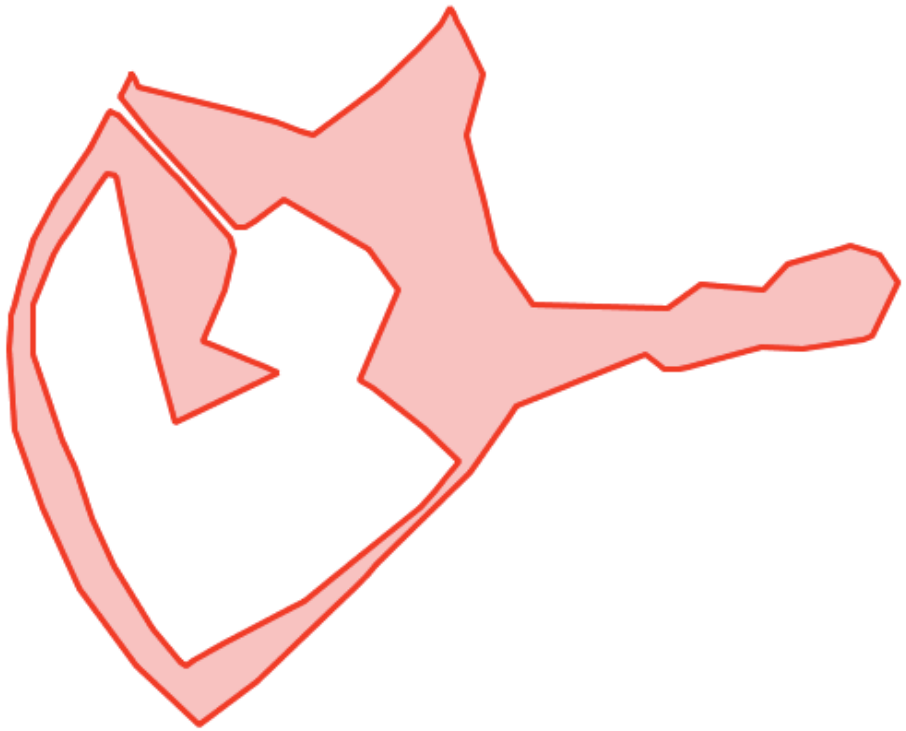
ETS – effect on area uncertainty

		area uncertainty (%)			diff (%)
ha	shape	DOP	DOP+DIG	DOP+DIG +INT	ETS
2	Square	0.39	0.87	3.9	4.02
	Middle	0.88	1.96	8.9	9.11
	Long	1.51	3.41	15.25	15.53
0.5	Square	0.78	1.73	8.0	8.08
	Middle	1.76	3.93	18.1	18.43
	Long	3.00	6.71	31.0	31.48

Relative error of area at 95% confidence interval

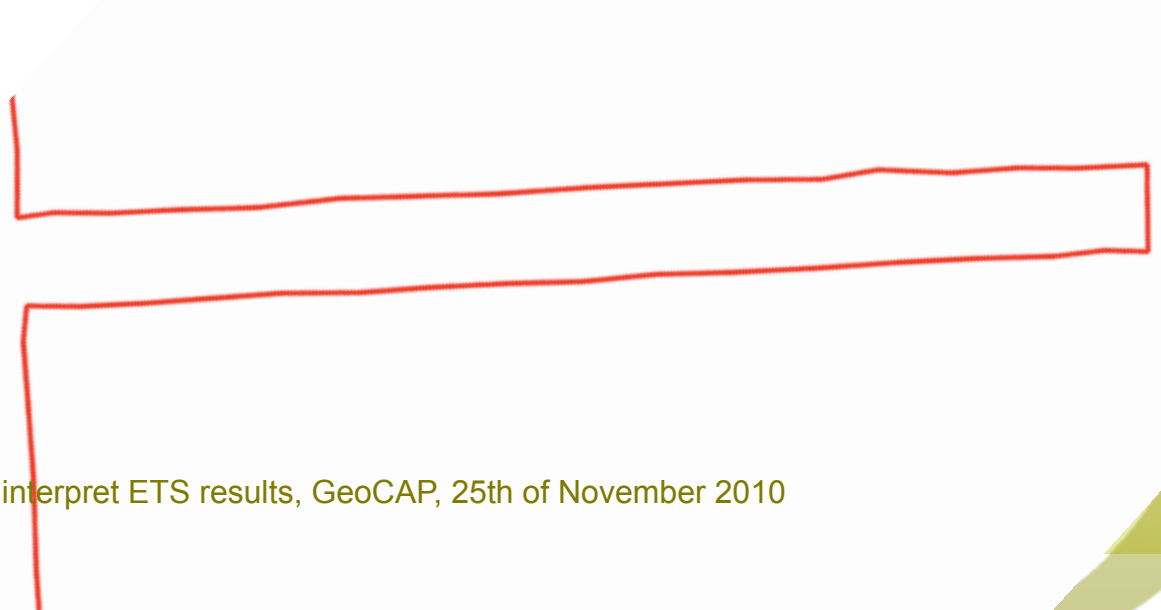
Lessons learned

- Analyze relative positional error, not only absolute
- Problematic are not only small parcels but also long parcels of all sizes
  - exclusions also matter!



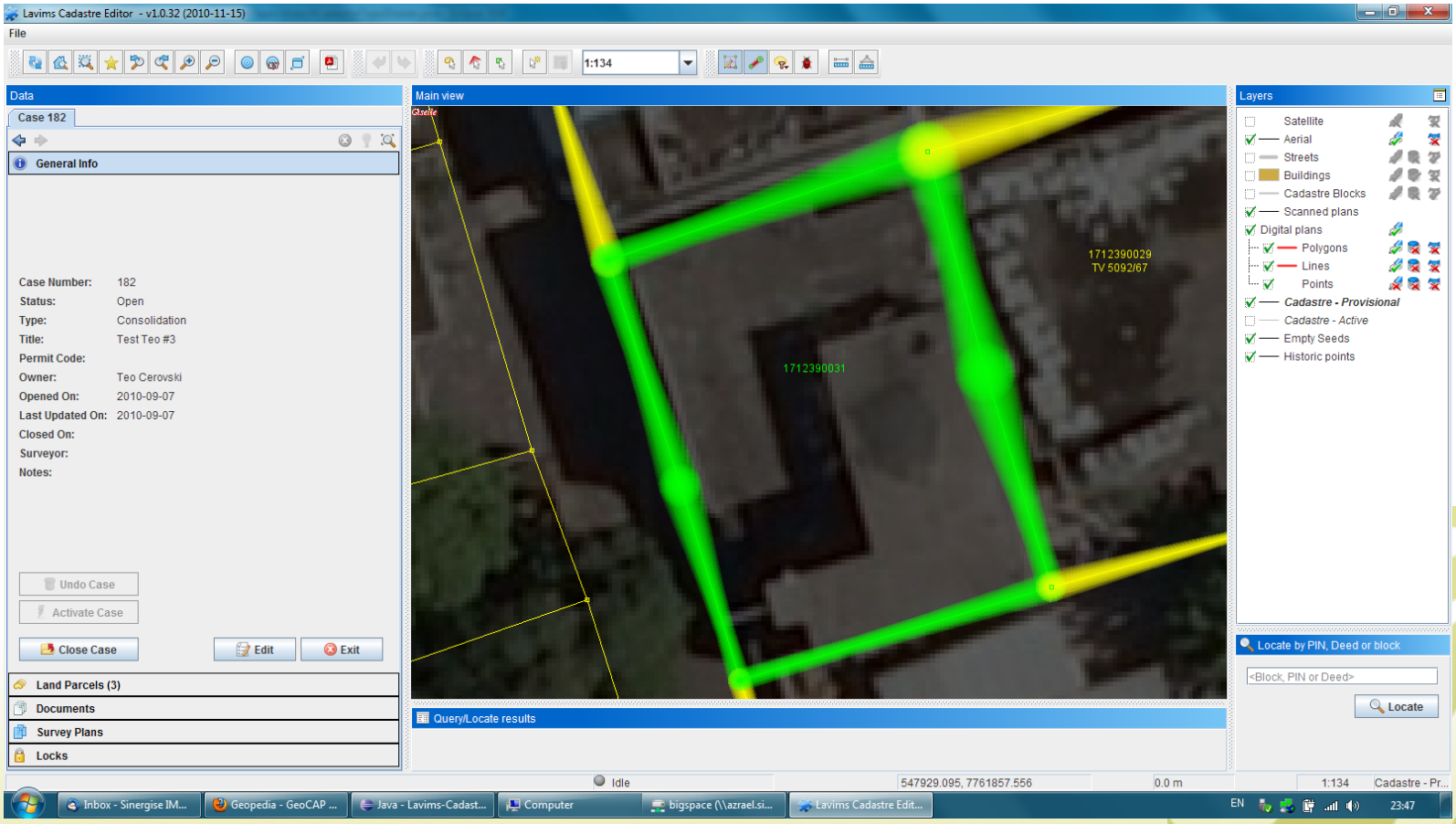
Lessons learned

- Digitize more points at the line, not only borders
  - relevant also for on-the-spot check
  - digitize on larger scales
  - we could use image recognition to fine-tune the digitized polygon (e.g. snap line to a “border” one px away)



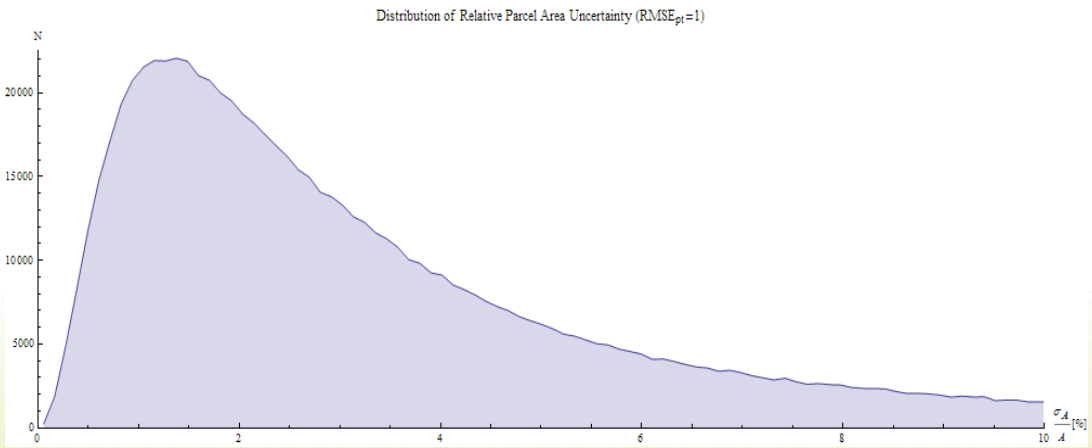
Lessons learned

- Be aware of the inaccuracy of the geometry
  - precision based styling



Lessons learned

- Hard threshold are problematic
  - both for ETS and for penalizing farmers
  - compare total sum of errors not only for one specific parcel



19.6% : no. of parcels with uncertainty above 3/5/7%

0.002%: the effect of combined uncertainty on total area

Conclusions

- only a model, but showing the problems
  - only technical ones (there are also “content” ones)
- parameters/assumptions/errors are not analyzed properly
- by performing ETS we are almost doubling (*1.41) the error
- relative errors are alarming, but what is their consequence? (absolute numbers are better)
- only a model, but real-life showcases available

Further reading

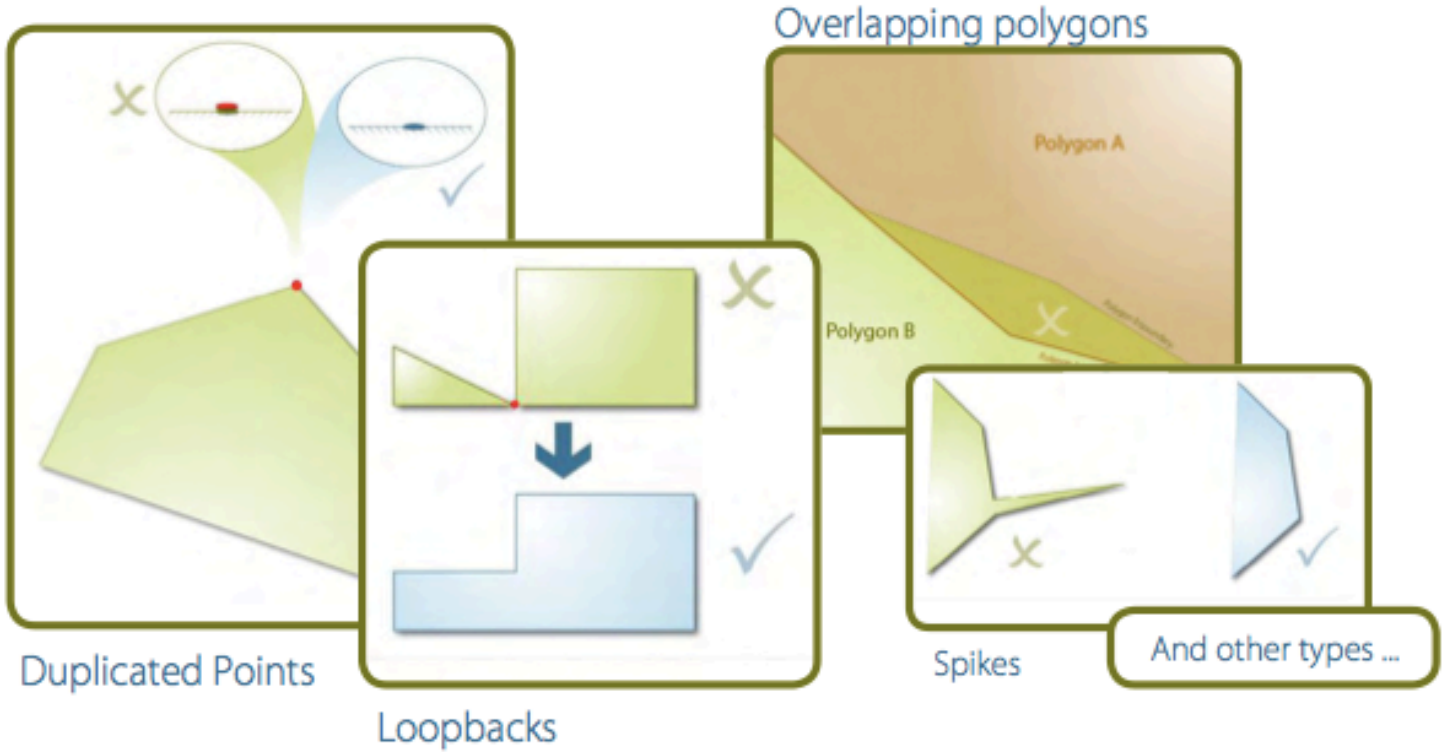
- supplementary material to this article
  - http://www.sinergise.com/en/articles.html
- Hejmanowska, B.: Validation of methods for measurment of land parcel areas, 2005
- Hejmanovksa, B.: Reliability of polygon area measurments for LPIS QA, 2010
- Chrisman N. R. and Yandell, B. S.: Effects of point error on area calculations: A statistical model, Surveying and Mapping, 241 - 246, 1988
- Wu, H,, Liu Z. and Lin, L.: Positional uncertainty of manual digitization vertex based on simlulation test (Geoninformatics 2008 and Joint conference on GIS and Built Enviroment, 2008).
- Shi, W.: Principles od modeling uncertainties in spatial data and spatial analyses, 2010, CRC Press.

Additional slides

TopoCheck

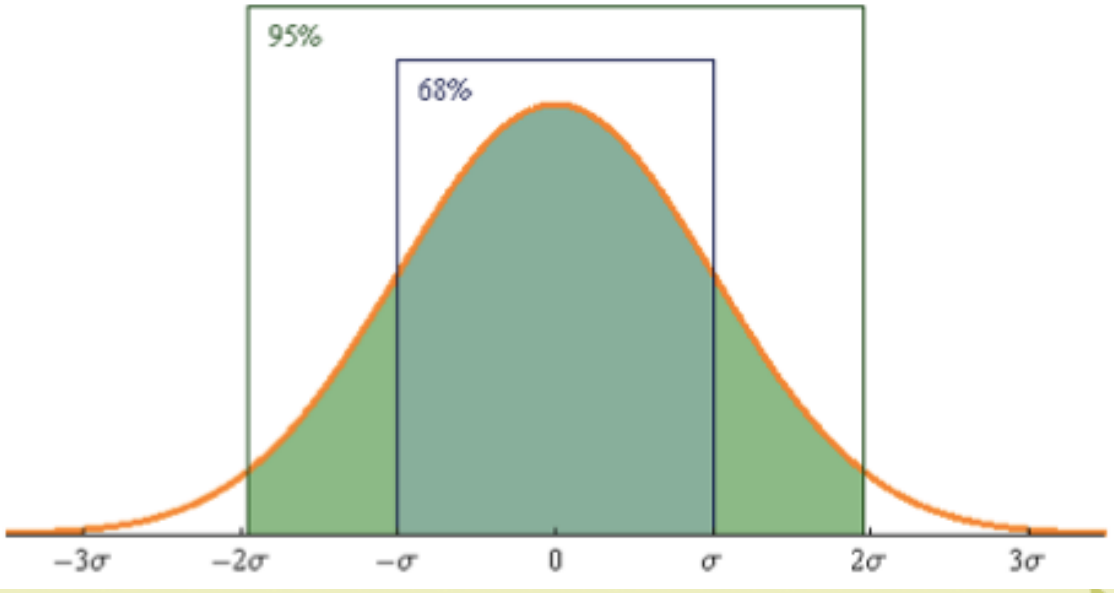
- Tool for calculation of parcel's uncertainty
  - http://www.topocheck.com

Identification of several types topological anomalies

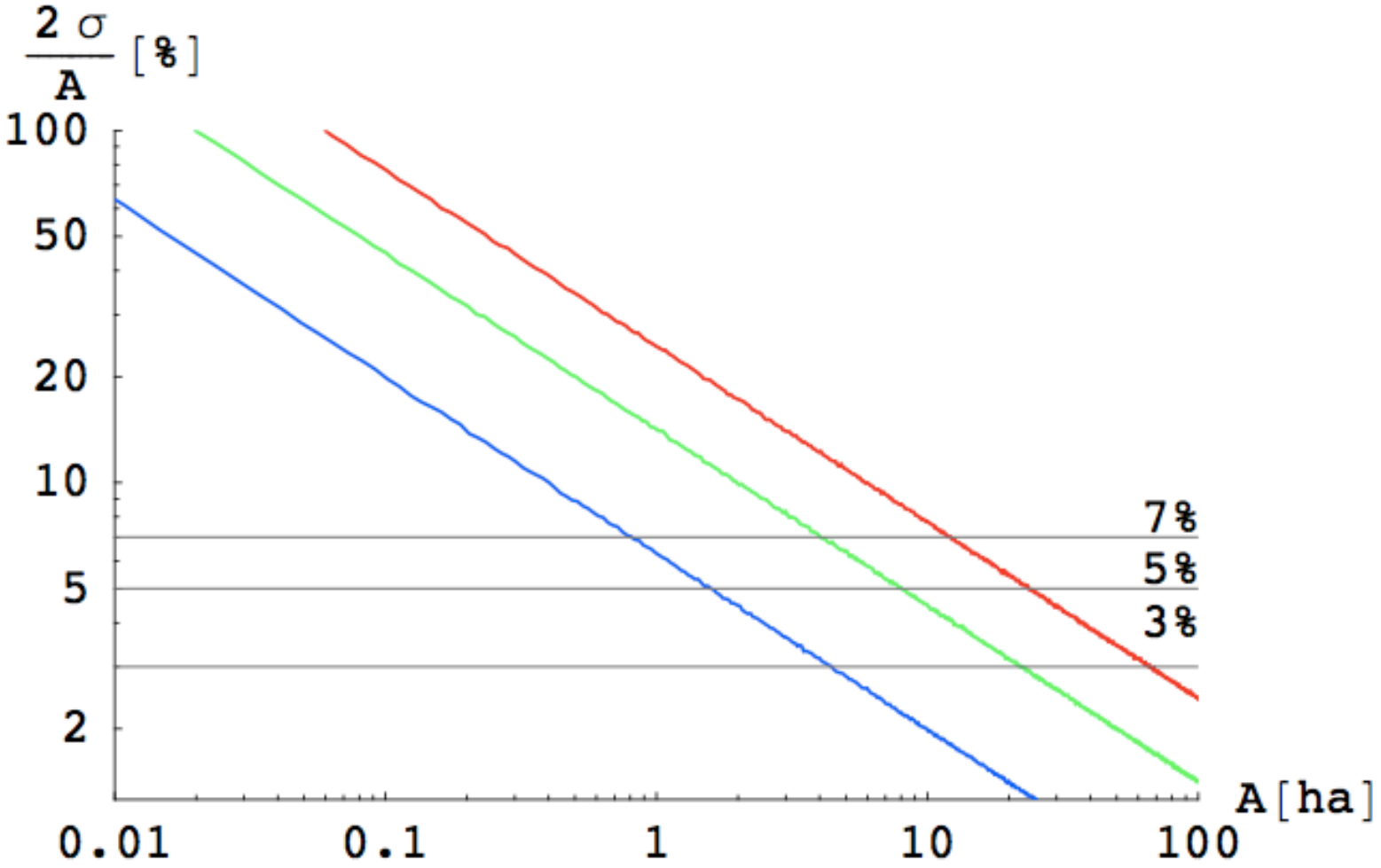


RMSE vs CI

- RMSE = root mean square error
  - 67 % of all measurements should fall within RMSE
- confidentiality interval = 1.96 * RMSE
  - 95 % of all measurements should fall within it

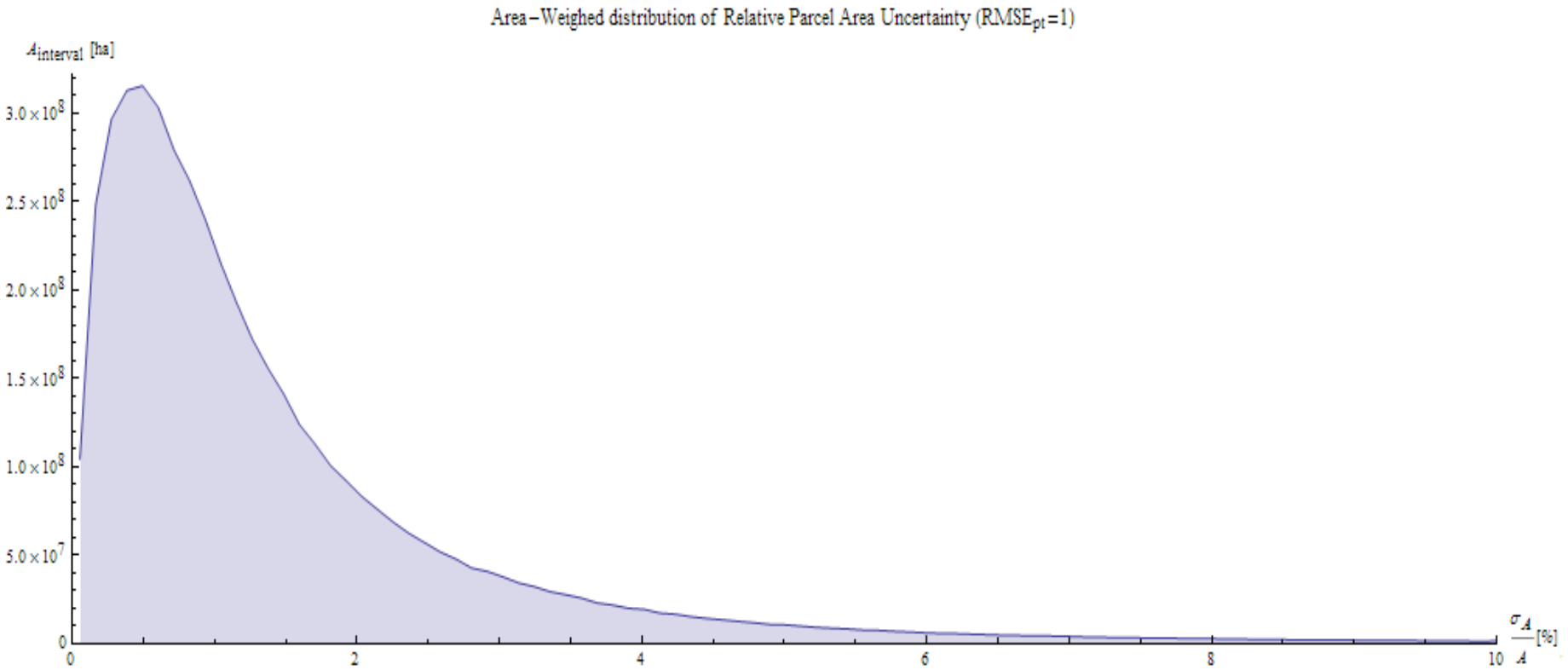


Basic error of the polygon (2 sigma)

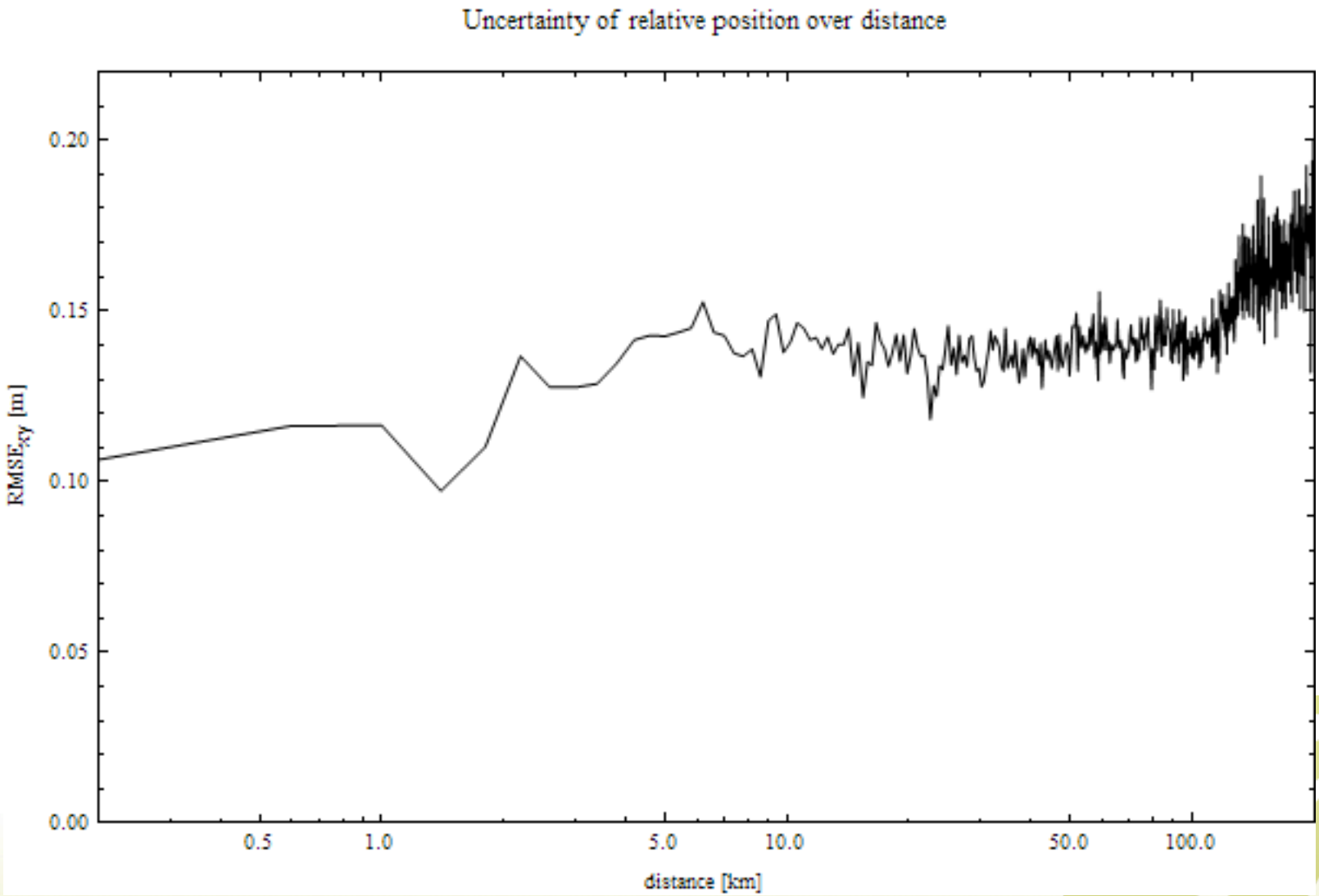


Aerial + digitization + interpretation (95%)

Relative parcel area uncertainty



DOP – error vectors - correlation



Not accounted errors

- steep areas (errors in digital elevation model + interpretation)
- round (non-straight) segments – approximation with straight lines

ETS – effect on area uncertainty

		diff (%)
ha	shape	ETS
2	Square	0.96
	Middle	2.16
	Long	3.75
0.5	Square	1.90
	Middle	4.31
	Long	7.37

Relative error of area at 95% confidence interval
DOP1 = 0.2, DIG = 0.4, INT = 0
DOP2 = 0.4, DIG = 0.4, INT = 0