Colloques swisstopo

Augmentation de la résolution des images aériennes, besoins et possibilités

Erhöhte Auflösung der Lufbilddaten, Bedürfnisse und Möglichkeiten

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Wabern, 9th December 2016

Agenda

- **Rückblick**
  - 1858 - 2016
- **Heute**
  - Was haben wir gelernt
- **Ausblick**
  - Perspektiven
  - Mögliche Evolution
  - Fragen & Antworten

1858

«NADAR élevant la Photographie à la hauteur de l'Art»

Schöne Luftbilder aufnehmen ist eine Aktivität 150 Jahre alt. Man kann mehr und besser machen…

1858

1908

1858

Wild C2
1925

f = 165 mm,
Glassplaten
10 x 15 cm

Machen wir vorwärts…

1858

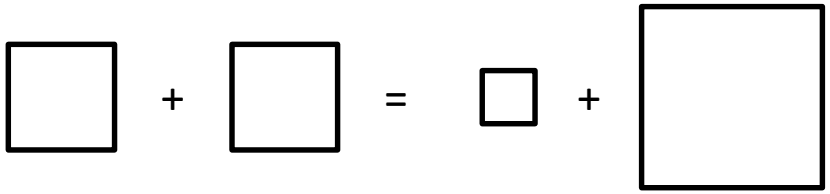
1908

1925

Und plötzlich…

- **2009: erste autonome Drachenflieger für photographische Anwendungen**

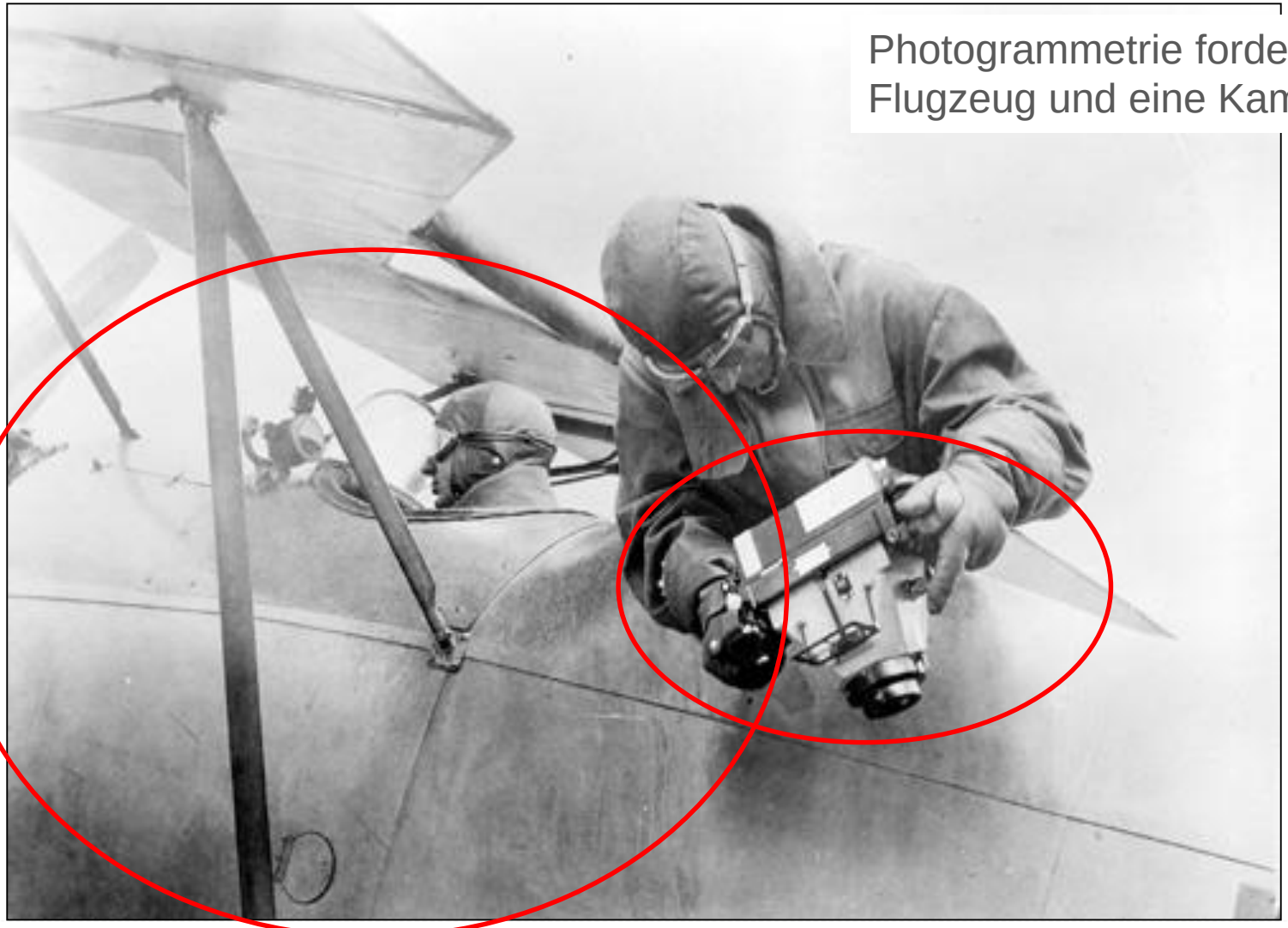
Paradigmawechsel



Schlusswörter von Dr. Ismael Colomina bei 2. UAV-g Konferenz (09.2013):

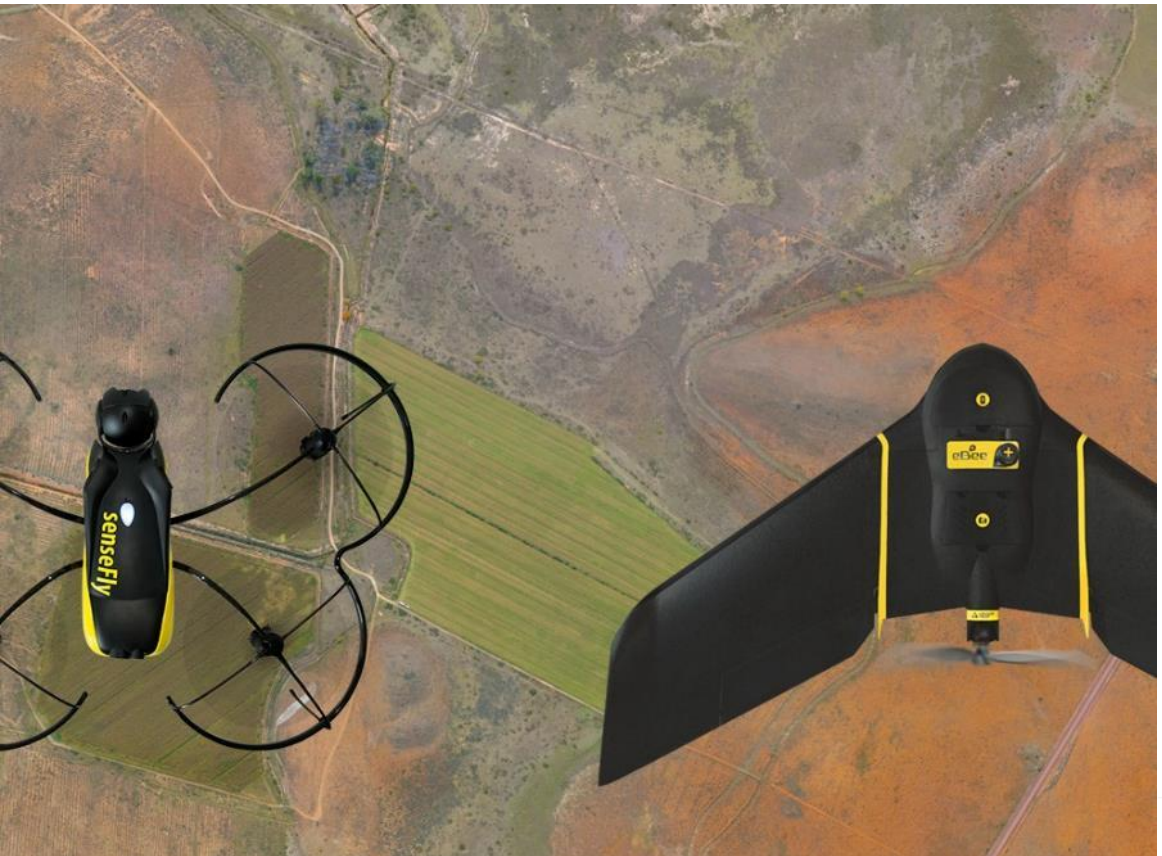
«Before, we had HW and SW that were performing equivalently; now, SW compensates for the low cost HW»

Was haben wir gelernt?



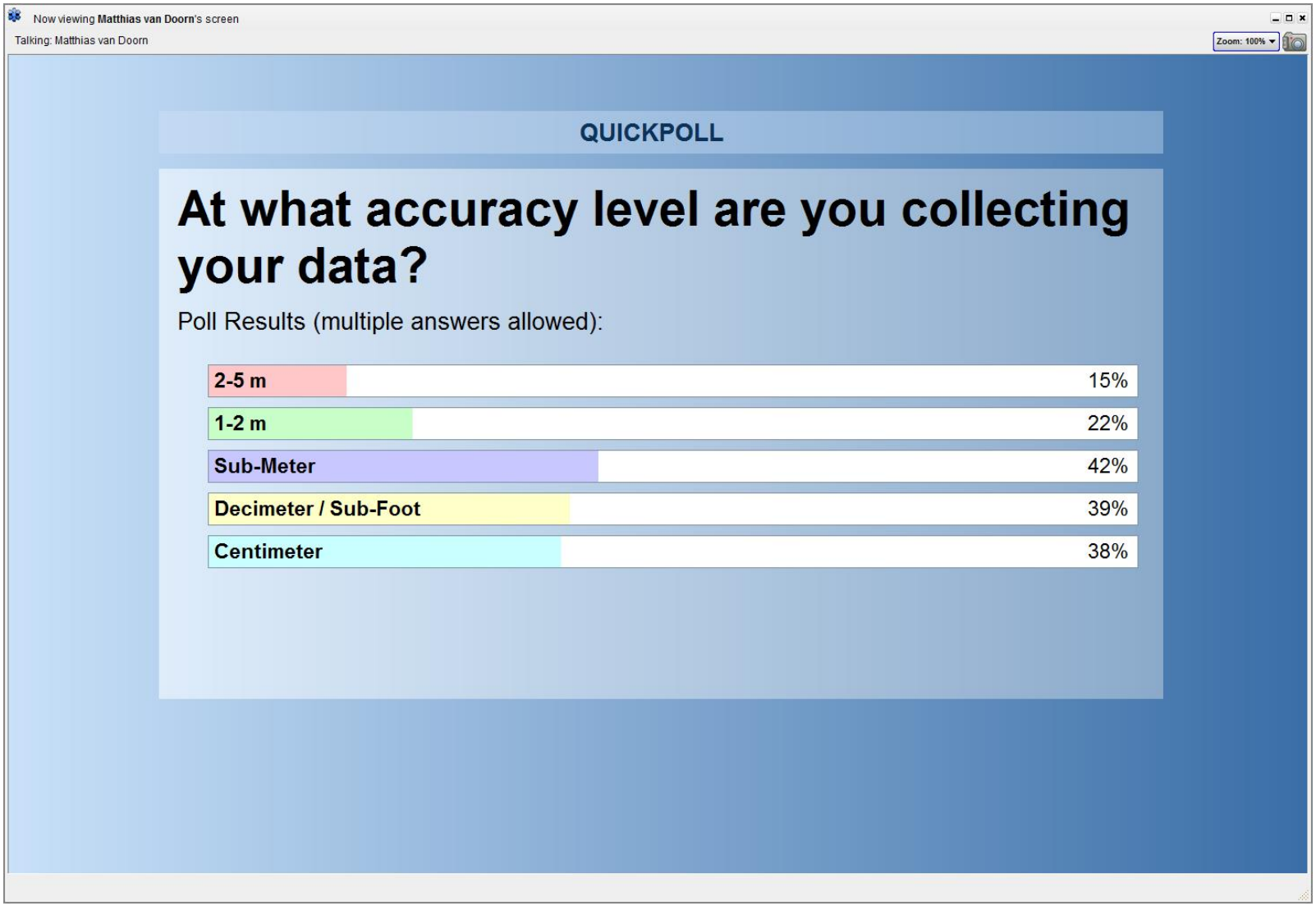
Photogrammetrie fordert einen Flugzeug und eine Kamera

- **senseFly SA, seit 2009. In Cheseaux-sur-Lausanne, 120+ Leute**
- **Weltweit Markführer in Drachenflieger Drohnen**
- **Nach swinglet CAM und eBee, eBee Plus mit RTK/PPK on demand**
- **Erste «Sensor Optimised for Drone Application» (senseFly S.O.D.A.)**

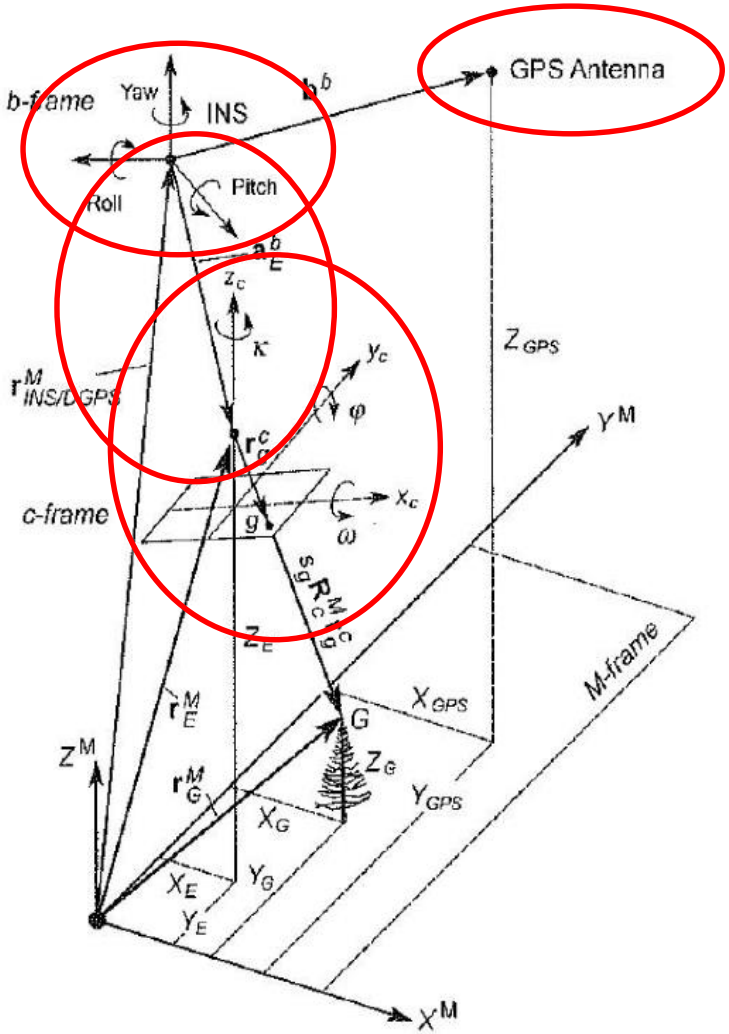


Was haben Vermesser und Drohnen gemeinsam?

Trimble Webinar, 7.12.16



Was ist für Genauigkeit nötig?

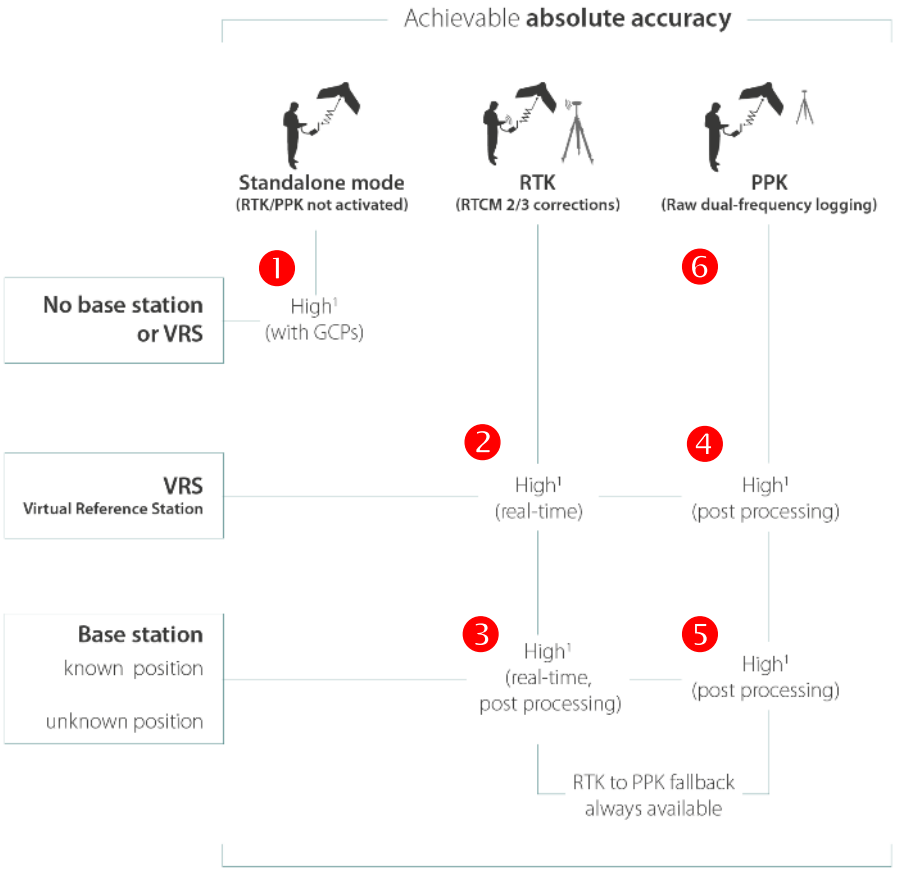


GNSS Antenne Position
+ Lage Winkel
+ Lever arms / boresight
+ Kamera
= Ausserorientierung

Position muss *gemessen* werden
Winkel können *gerechnet* werden

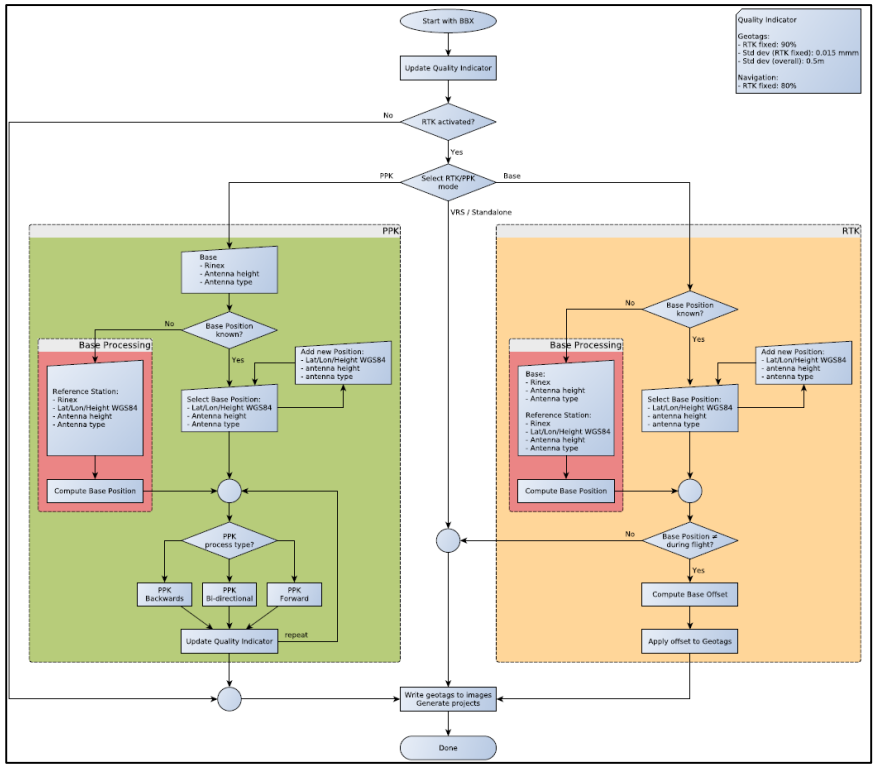
Hoch Genauigkeit GNSS (RTK & PPK)
+ Stabile Kamera
+ Winkel von CV/bundler gerechnet
= *Halbdirekt Georeferenzierung*

Mehrere Wege zur höhen Genauigkeit



1. **Standalone und Passpunkte**
   - Zeitkonsumierend, fordert spezielle Ausrüstung
2. **RTK – VRS**
   - Mehrere Datendienste (swipos.ch , Teria.fr, SAPOS.de, USGS.us, …)
   - Telefon mit 3G… und los!
3. **RTK – Basisstation**
   - Topcon, Leica, Trimble und mehr sind unterstützt
4. **PPK – VRS**
   - Gleich wie RTK-VRS, aber in Postprocessing und ohne Stress
5. **PPK – Basisstation**
   - Empfänger agnostisch (RINEX)
6. **PPK – CORS**
   - 10, 20, 30 km Entfernungen sind möglich

Komplex Workflow – einfach zu bedienen



- Alle Wege sind mit gleichem HW und SW (eMotion 3) unterstützt
- Kombinieren, vergleichen, rückfallen möglich
- Alle Situationen fähig
- Sehr oft, höhe Auflösung direkt aus der SD-Karte!

RTK/PPK

Results page

Project name: 119

Base station position (ARP)

Geotags

Geotags in flight

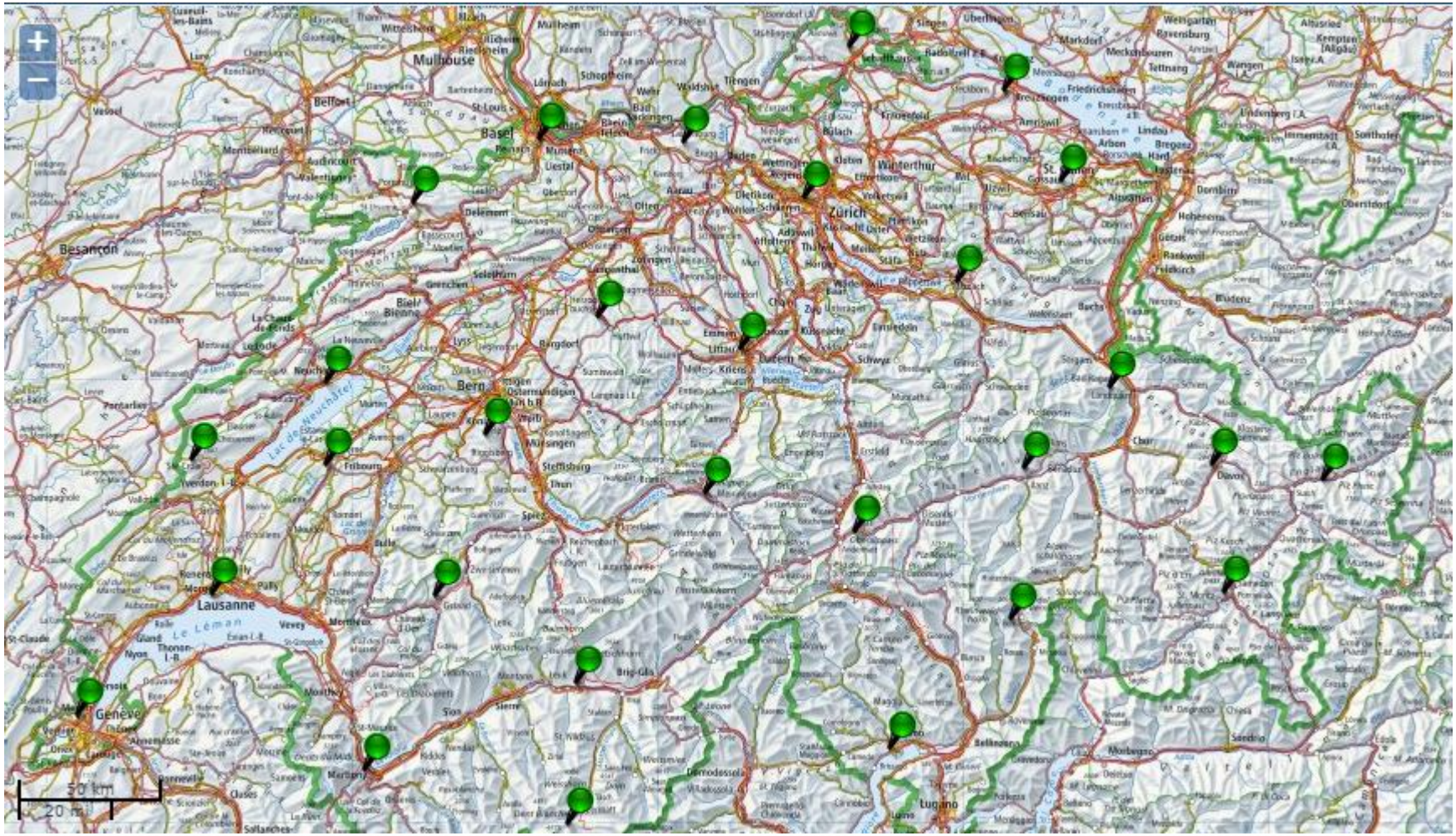
RTK fixed:	112	99 %	σ:	0.018 m
Standalone:	1	1 %	σ:	1.277 m
overall:	113	100 %	σ:	0.029 m

Geotags post-processed

RTK fixed:	112	99 %	σ:	0.040 m
Standalone:	1	1 %	σ:	0.402 m
overall:	113	100 %	σ:	0.043 m

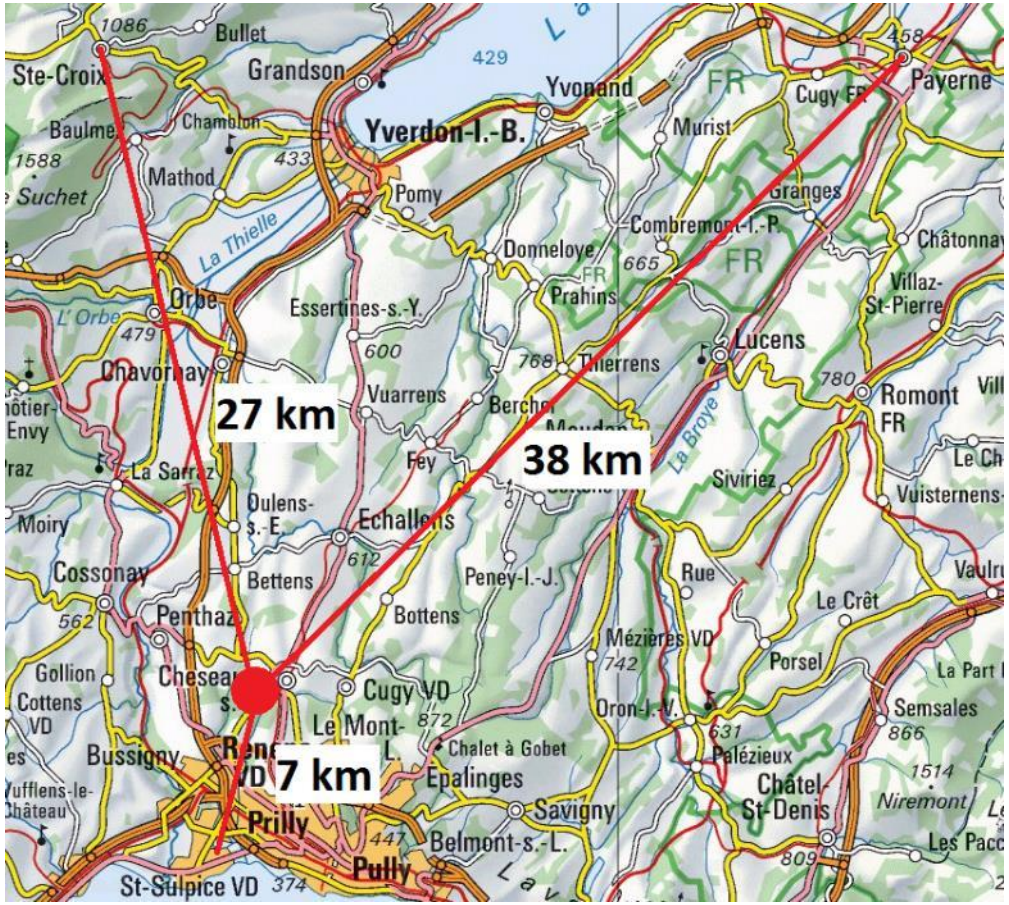
swipos CORS

- **30-80 km Dreiecke**



RTK-VRS, PPK-VRS, PPK-CORS

- **One flight, several georeferencing options:**
  - RTK with a Virtual Reference Station directly from the SD card (or via FDM with stats)
  - PPK with a Virtual Reference Station at the location
  - PPK with a (real) Continuously Operating Reference Station
    - Closest: 7 km
    - 2nd closest: 27 km
    - 3rd closest: 38 km



Computation in FDM: 641 geotags

	RTK VRS	PPK VRS	PPK 7 km	PPK 27 km	PPK 38 km
good	639	618	614	546	283
average	0	0	3	66	328
poor	0	15	16	21	22
not tagged	2	8	8	8	8
total	641	641	641	641	641

- ***Good* means better or equal to 5 cm in horizontal / 7.5 cm in vertical**
  - Can be used with high level of confidence, maximum weight
- ***Average* means between 5 and 10 cm in horizontal / 7.5 - 15 cm in vertical**
  - Can be used to “bridge” good geotags, limited weight
- ***Poor* means worse than 10 cm in horizontal / 15 cm in vertical**
  - Sufficient for an improved absolute georeference compare to standalone
- ***Not tagged* means that no info is available for this photo**
  - Reason: GNSS availability and/or synchronisation. Image exists though.

Validation in FDM: % of *good* geotags

	RTK VRS	PPK VRS	PPK 7 km	PPK 27 km	PPK 38 km
good	99.7%	96.4%	95.8%	85.2%	44.1%
average	0.0%	0.0%	0.5%	10.3%	51.2%
poor	0.0%	2.3%	2.5%	3.3%	3.4%
not tagged	0.3%	1.2%	1.2%	1.2%	1.2%
total	100.0%	100.0%	100.0%	100.0%	100.0%

- Not surprisingly, the closer the better in term of percentage
- Even at max distance, the percentage of poor geotags is limited
- Some images are not tagged, no alarm up to 5%. Are integrated during the photogrammetric process

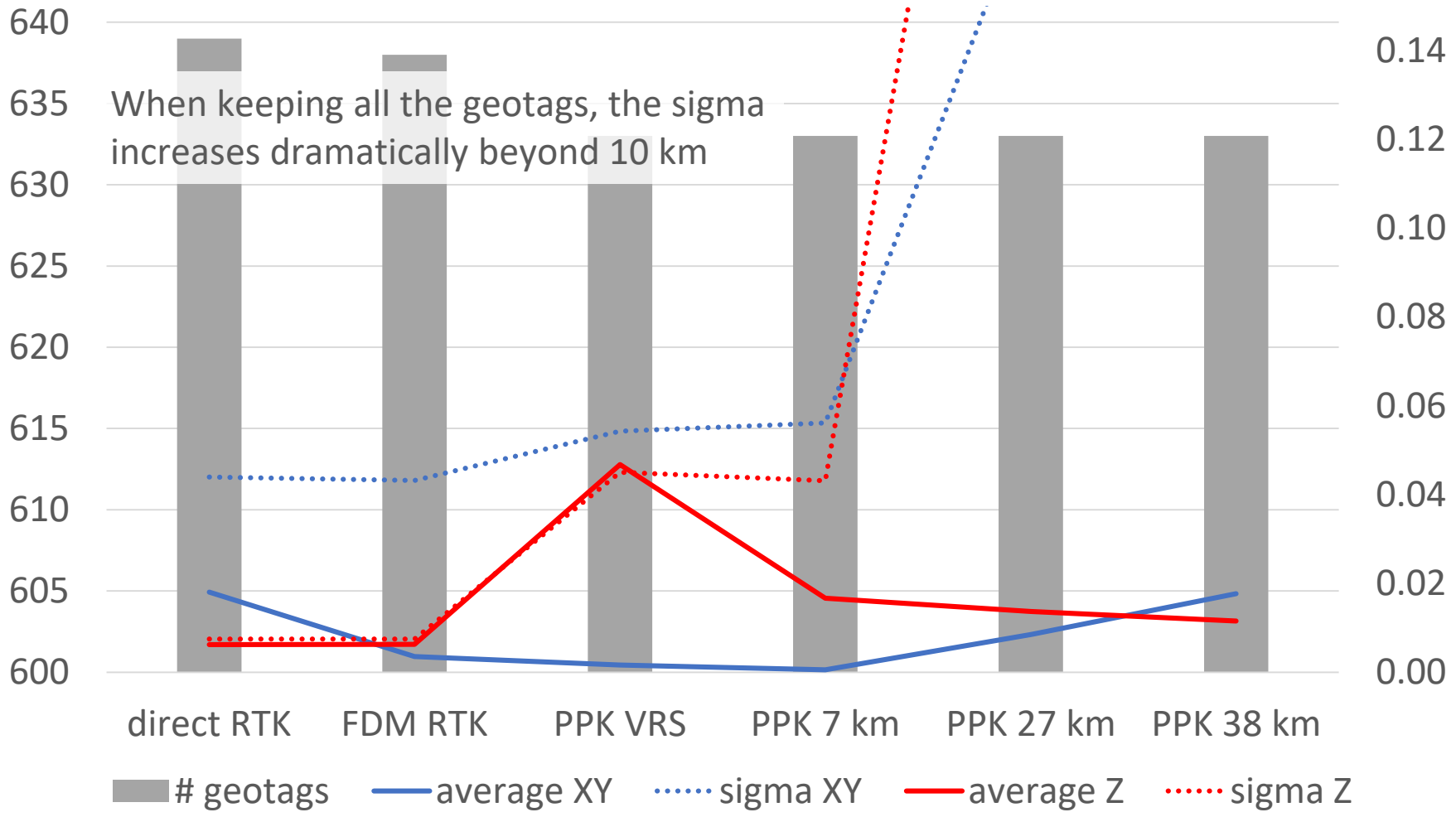
Differences to the mean weighted value

	RTK VRS	PPK VRS	PPK 7 km	PPK 27 km	PPK 38 km
# geotags	639	633	633	633	633
average XY	0.018	0.002	0.001	0.008	0.018
sigma XY	0.044	0.054	0.056	0.176	0.174
average Z	0.006	0.047	0.017	0.014	0.012
sigma Z	0.007	0.045	0.043	0.307	0.397

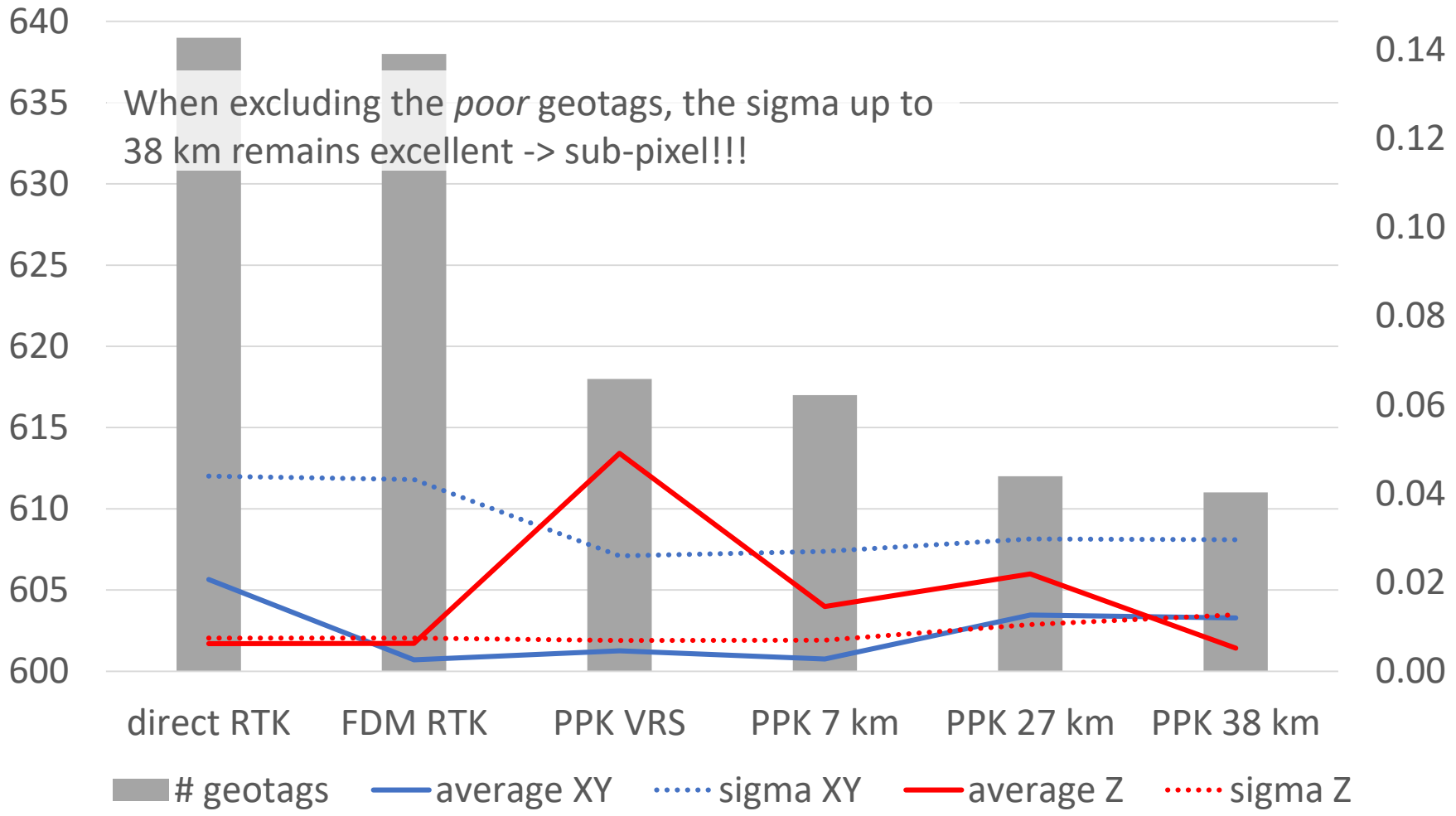
	RTK VRS	PPK VRS	PPK 7 km	PPK 27 km	PPK 38 km
# geotags	639	618	617	612	611
average XY	0.021	0.005	0.003	0.013	0.012
sigma XY	0.044	0.026	0.027	0.030	0.030
average Z	0.006	0.049	0.015	0.022	0.005
sigma Z	0.007	0.007	0.007	0.011	0.013

Poor geotags are filtered

Average and sigma with *poor* geotags



Average and sigma without *poor* geotags



Enough of geotags! What about GCP?

- **If the accuracy is trustable, then you're able to remove the filter the bad geotags from the good one**
- **Ignoring 30 out of 641 geotags (5%) provides great results… even at 38 km!**
- **For the first time *ever* (in my drone's experience), a sub-pixel accuracy is achieved in horizontal and vertical, in bias and noise.**

Check Point Name	Accuracy XY/Z [m]	Error X [m]	Error Y [m]	Error Z [m]	Projection Error [pixel]	Verified/Marked
43	0.010/0.020	0.016	-0.003	-0.025	0.790	12 / 12
45	0.010/0.020	0.011	0.008	-0.044	0.885	17 / 17
39	0.010/0.010	0.019	-0.001	-0.029	0.716	15 / 15
41	0.010/0.010	0.017	0.014	-0.013	0.763	13 / 13
184	0.010/0.020	0.026	0.009	-0.009	0.784	10 / 10
59	0.010/0.020	0.005	0.001	0.017	0.618	14 / 14
36	0.010/0.010	-0.020	0.033	0.003	0.646	4 / 4
34	0.010/0.020	0.037	0.004	-0.014	0.921	11 / 11
Mean [m]		0.013915	0.008197	-0.014256		
Sigma [m]		0.015713	0.010907	0.017776		
RMS Error [m]		0.020989	0.013644	0.022787		

senseFly S.O.D.A.

- **«Sensor Optimised for Drone Applications»**
- **1-inch sensor category (13.2 x 8.8 mm = 116 mm^2)**
- **20 MP, pixel pitch 2.4 um**
- **Focal length 10.5 mm (eq. 28 mm)**
  - FOV 64° lateral, 45° longitudinal, 74° diagonal
- **2.8 cm @ 122 m / 400 ft**
  - 150 m x 100 m on the ground
- **Global shutter**
- **Ultra-compact and light (76 g)**
- **Dust & shock protection**
- **Fully configurable in eM3 (settings, naming, geotagging, feedback)**
- **Standard with eBee Plus, available for eBee and eBee RTK**

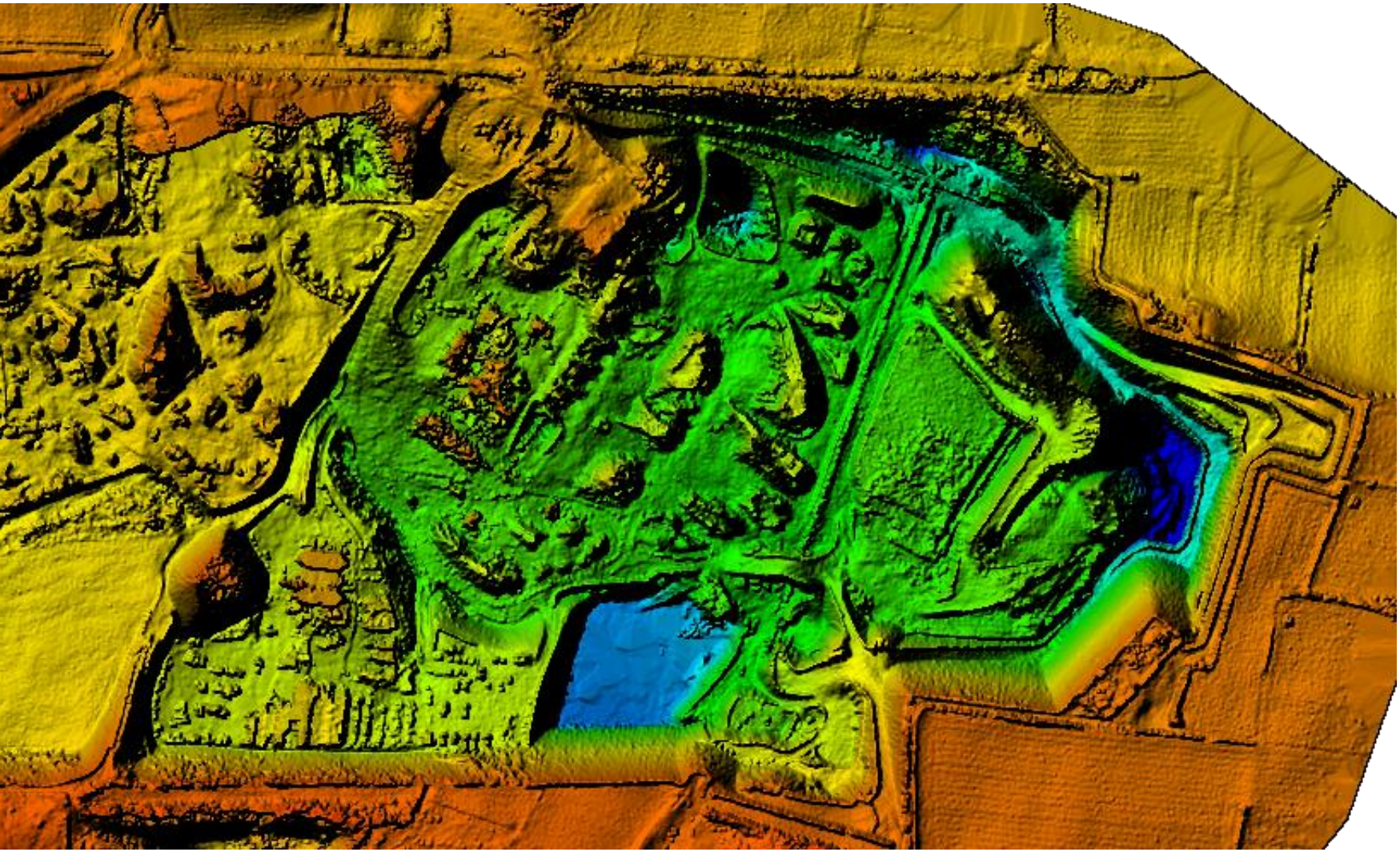
Challenge 1: Aletschwald

Die Bäume wechseln,
die Genauigkeit bleibt…

Challenge 2: Sénégal

Challenge 3: Kiesgrube

Challenge 3: Kiesgrube



Zukunft

- **Bessere Integration/Kontrolle von Flugzeug und Kamera**
- **Elektronisch weniger empfindlich, mehr robust**
- **Cloud Integration -> Drohne als «connected object» und Teil des Luftverkehrs**

- **Aus ca. 1000 Drohne pro Jahr**
  - Wachstum 2014 und 2015 war generell
  - Wachstum 2016 ist in RTK (ohne PPK!)
- **Trends:**
  - Mehr Auflösung (2 cm und besser) -> Multikopter
  - Weniger Feldarbeit, besonders Vorbereitung
  - Reine Fernerkundung
  - BVLOS