Performance Analysis of the QDaedalus Astrogeodetic Measurement System by CODIAC parallel Observations at the Zimmerwald Observatory in Switzerland

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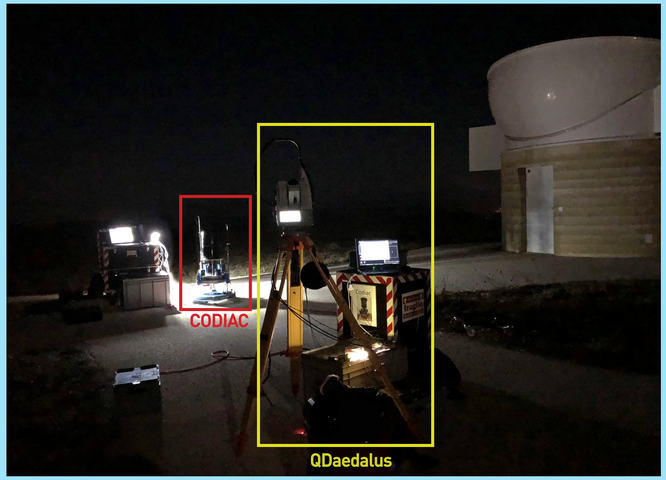
G45C-0421

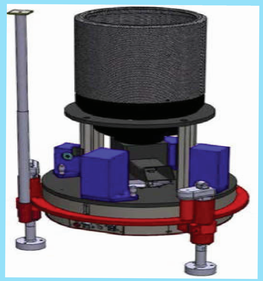
1 Parallel Observations at the Zimmerwald Observatory



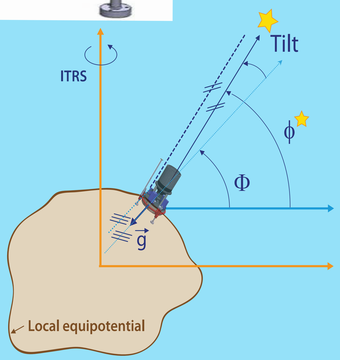
Set up for astrogeodetic observations of the zenith telescope-based CODIAC and the Leica Nova MultiStation (MS) 60-based QDaedalus astrogeodetic systems at the Zimmerwald Observatory near Bern, Switzerland.

- We used the ETH Zurich-developed CODIAC (accuracy of 0.05″) and MS60-based QDaedalus (precision of 0.1″) systems to conduct parallel observations over two nights.
- The parallel observations were designed to establish the accuracy of MS60-based QDaedalus.

2 The CODIAC System



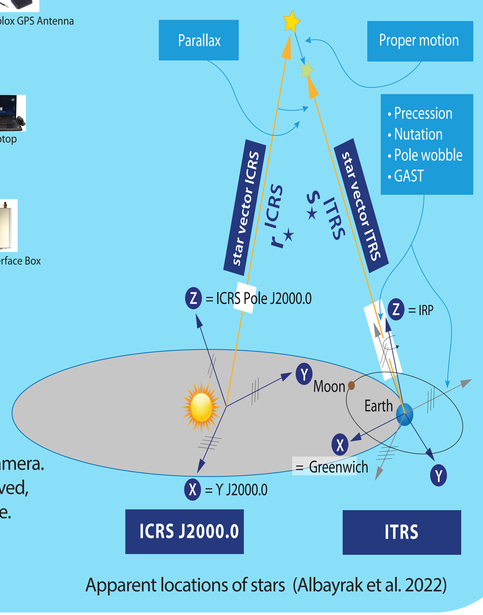
- CODIAC has the standard Digital Zenith Camera System (DZCS) components: Telescope, CCD camera, tiltmeters, focuser, single frequency GNSS receiver and antenna, laptop, and substructure.
- While each DZCS has a unique design, CODIAC has upgraded hardware components (four tiltmeters—two Wyler and two Lippmann) as well as advanced software and processing technology.
- Star catalogue: UCAC4.



Basic principle of a DZCS (Albayrak et al. 2022)

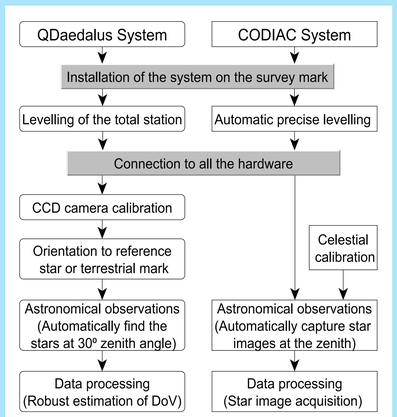
3 The QDaedalus System

- The key components of the QDaedalus which differ from the DZCS:
  - * Total station
  - * Interface box
  - * Meniscus lens
- The QDaedalus' CCD camera is quite small compared to the CODIAC's CCD camera.
- The eyepiece of the total station is removed, and the CCD camera attached in its place.
- Star catalogue: FK6.

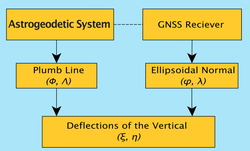


Apparent locations of stars (Albayrak et al. 2022)

4 QDaedalus and CODIAC observation steps



Obtaining the Deflection of the Vertical (DoV)



ξ: North-South component
η: East-West component

$\xi = \Phi - \varphi$

$\eta = (\Lambda - \lambda) \cos \varphi$

5 Method, Results and Discussion of Parallel Observations

Method

- MS60-based QDaedalus and the CODIAC systems were set up at a distance of ~5 meters on a flat area.
- QDaedalus observations executed at ~15 min. per series.
- CODIAC observations required 12 CCD shots in four azimuths per series (10 min. per session).
- Total of 41 (17+24) series of QDaedalus observations completed over the two nights (up to seven series observations per session).
- Data were collected over two nights:
  - * 10 sessions (4+6) using the QDaedalus
  - * 81 sessions (45+36) using the CODIAC
- Geodetic coordinates are ITRF2014 reference frame with reference epoch of 2021.67.

Discussion

We identified several possible sources of bias:

- CODIAC system contains errors, and a bias was observed during the observations.
  - * Bias possibly due to either large temperature variations in winter or an atmospheric signal.
- Bias in observed DoVs could be from the different star catalogues.
- Different results using QDaedalus could be found with the different observers or different total stations.

SDs of pooled single session: $s_i = \sqrt{\frac{\sum (SD)^2}{n}}$

Results

The nightly mean DoV values and standard deviations (SDs) of pooled single session for each night and system, and the differences between the QDaedalus and CODIAC systems [arcseconds]

System	Observation date (number of sessions)	SDs		Nightly mean		Diffs. between nights		System mean		System diffs.*	
		ξ	η	ξ	η	ξ	η	ξ	η	ξ	η
QDaedalus	24-02-2021 (4)	0.14	0.09	7.96	3.97	0.08	0.13	7.92	3.91	0.09	0.02
	01-03-2021 (6)	0.10	0.14	7.88	3.84						
CODIAC	24-02-2021 (45)	0.02	0.05	7.82	3.87	-0.03	-0.03	7.83	3.89		
	01-03-2021 (36)	0.02	0.03	7.85	3.90						

Diffs.*: Differences

6 Conclusions

- The precision of the Leica MS60-based QDaedalus system was found to be 0.1″ by repeated observations at the test station.
- The MS60-based QDaedalus system's accuracy was determined through simultaneous parallel observations with the CODIAC at the Zimmerwald Observatory.
- The differences between the two systems were found to be 0.09″ and 0.02″ for N-S and E-W components, respectively.
  - * These differences are similar to the nightly differences of the QDaedalus system.
  - * Therefore, the accuracies of the QDaedalus system's two components are 0.1″.
- As a result, the MS60-based QDaedalus system can be used safely in astrogeodetic applications that require high precision and accuracy.
- Astrogeodetic test observations can be conducted at the Zimmerwald Observatory stations to determine the precision of newly-installed QDaedalus systems.

Funding

This research is supported by the Scientific and Technological Research Council of Turkey (TUBITAK) 2219 international post-doctoral research fellowship programme (grant number 1059B192000149) in Turkey, the Haute Ecole d'Ingénierie et de Gestion du Canton de Vaud (HEIG-VD) and the Swiss Federal Office of Topography (Swisstopo) in Switzerland.

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Presented at AGU Fall Meeting, online, 13-17 December 2021, Session G45C