Recent Positioning Techniques for Efficient Port Operations and Development of Suez Canal Corridor

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- RTK/VRS applications in port operations
- Applications of CORS/VRS in Development of Suez Canal Corridor.
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The current developments in positioning techniques and communication technology have great impact on both construction and operations of ports. The majority of positioning systems for marine traffic are satellite based such as GPS. Virtual Reference Station (VRS) is one of the recent high precision techniques for GNSS positioning which can be used for smart and efficient port.

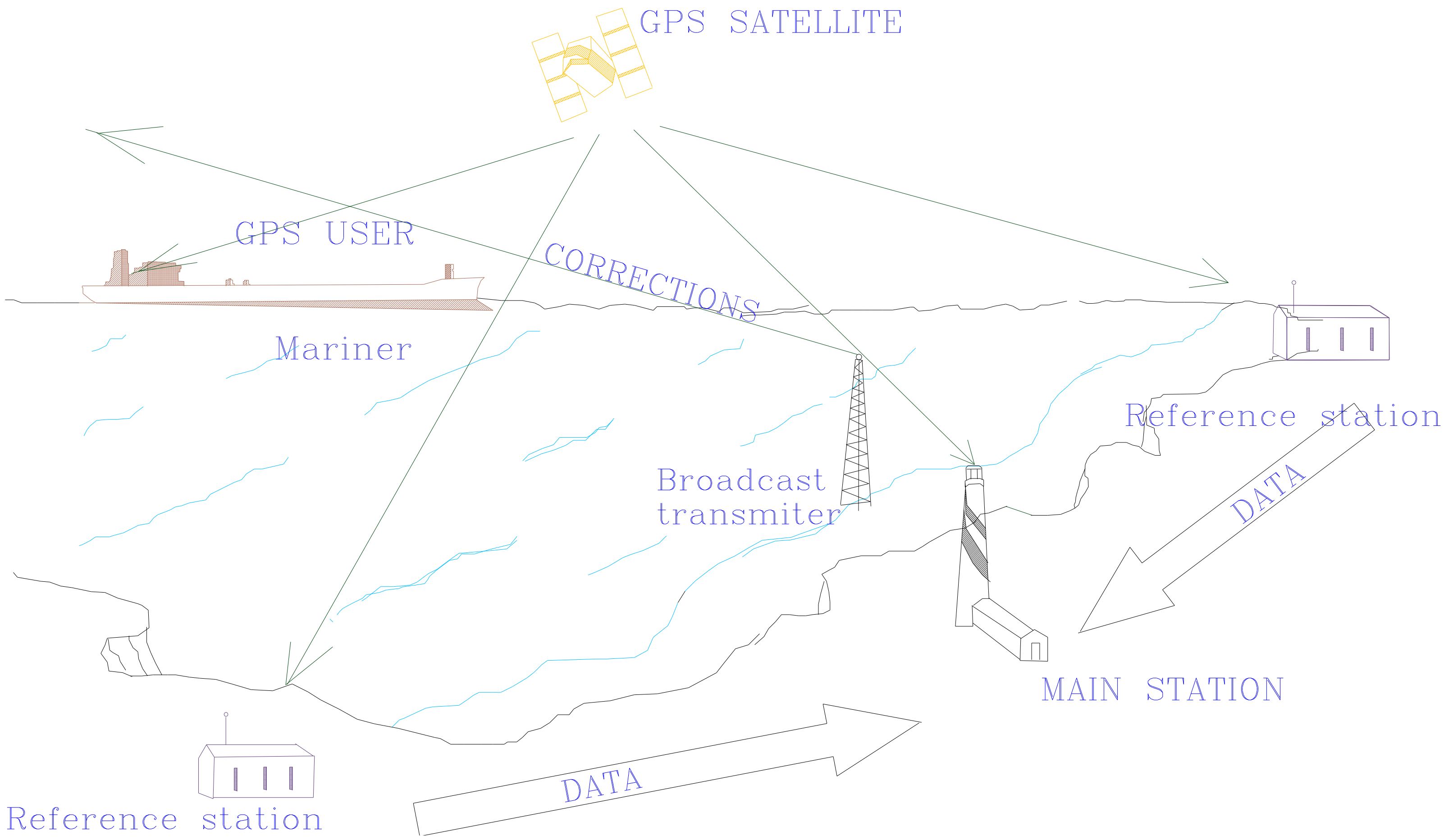
Satellite positioning systems in ports and waterways

- **Differential GPS Positioning (DGPS)**

- **Real Time Kinematic GPS positioning (RTK GPS)**

- **Network RTK / Virtual Reference Station (VRS)**

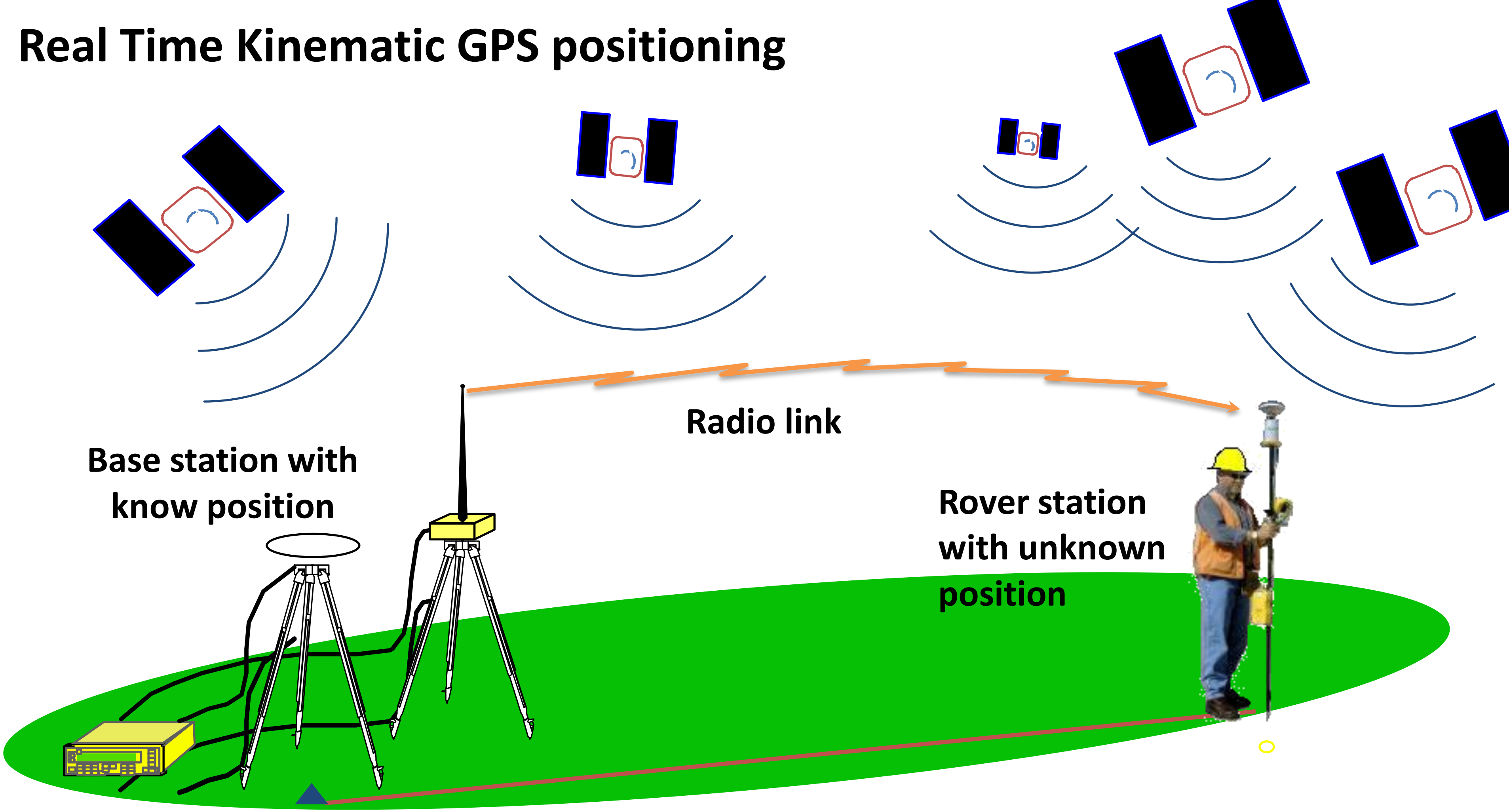
- **Differential GPS Positioning (DGPS)**



DGPS uses a network of fixed, ground-based reference stations to broadcast the difference between the positions determined by the GPS and the known fixed positions of the stations. These differences are received by the users as corrections which can be applied to improve the accuracy of their GPS positions.

The DGPS network in Egypt consists of six control stations, each has one reference station and radio beacon broadcast site with integrity monitoring and communications links.

Real Time Kinematic GPS positioning



*Both Base and Rover station receive GPS data form at least 5 satellite.

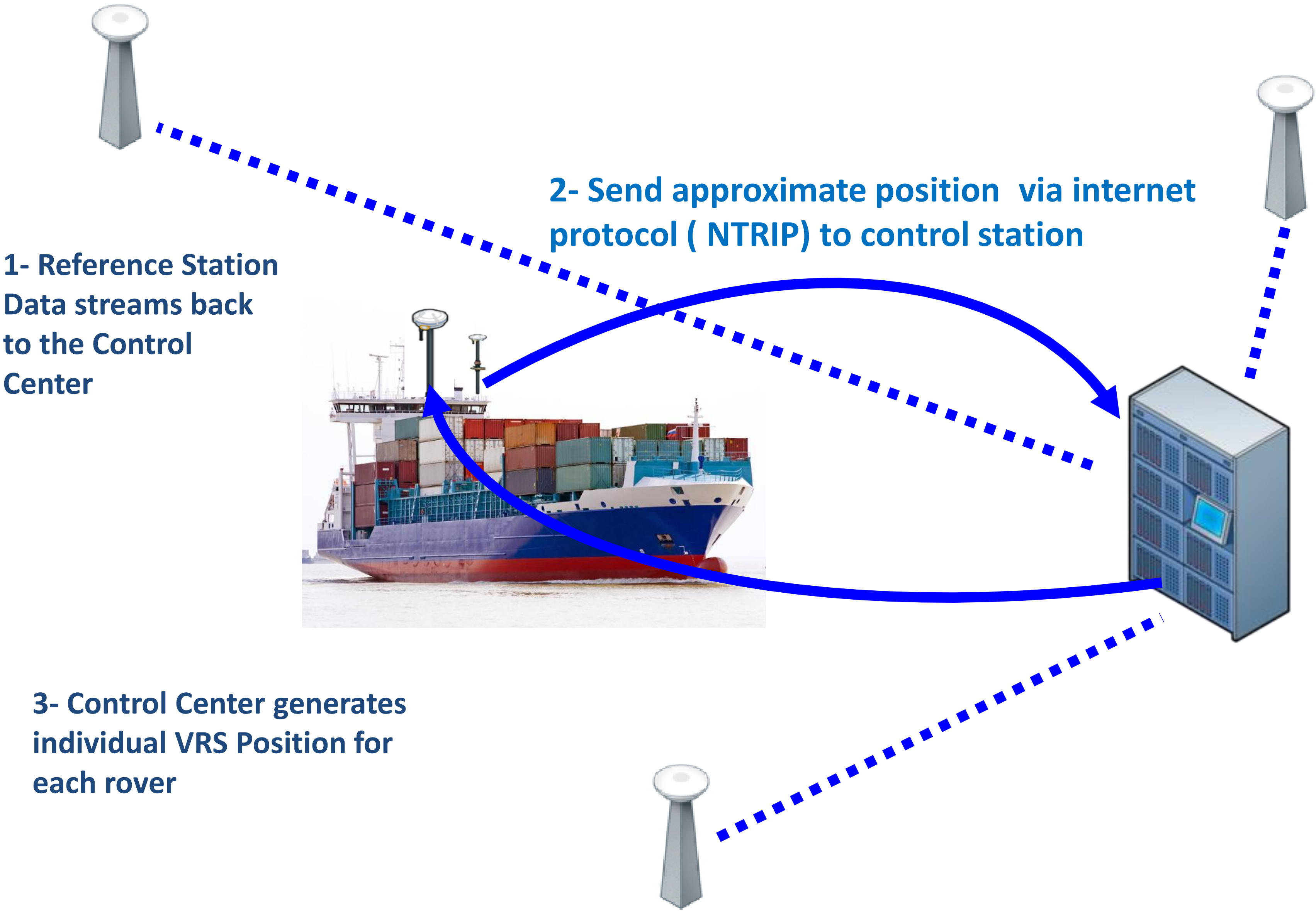
* Base station sends the received GPS data to the rover stations as corrections.

* The data are processed at the rover station and the unknown ambiguities are resolved. The coordinates of the rover position can be determined with high accuracy relative to the base station.

Limitations of Classical RTK

- Two receivers for each job
- Communication (radio)
- Potential gross error in establishing ref. stn.
- Productivity loss
- Power supply

Network RTK / Virtual Reference Station (VRS)

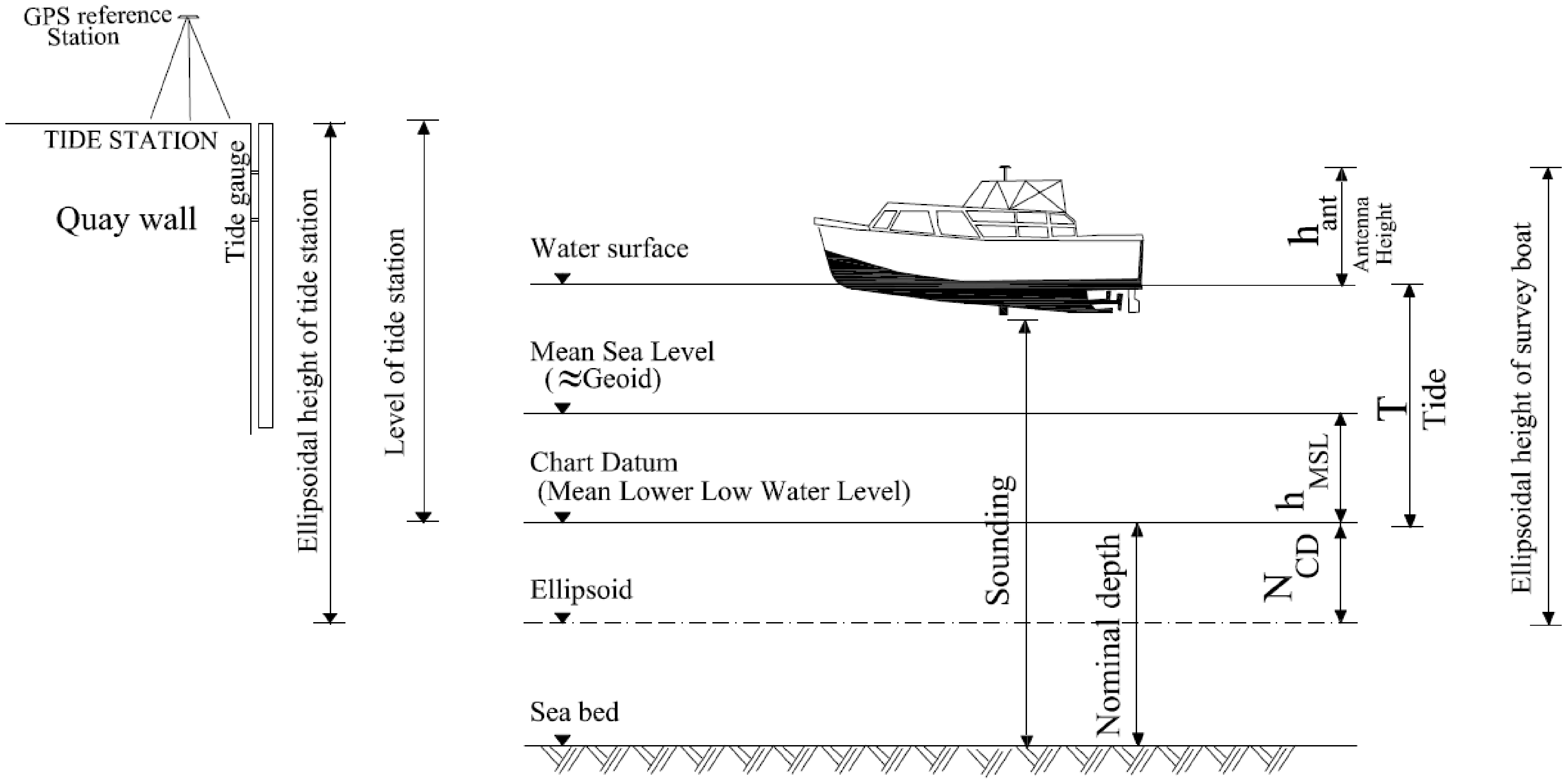


General Advantages RTK Networking

- Cost and labor reduction, as there is no need to set up a base reference station for each user

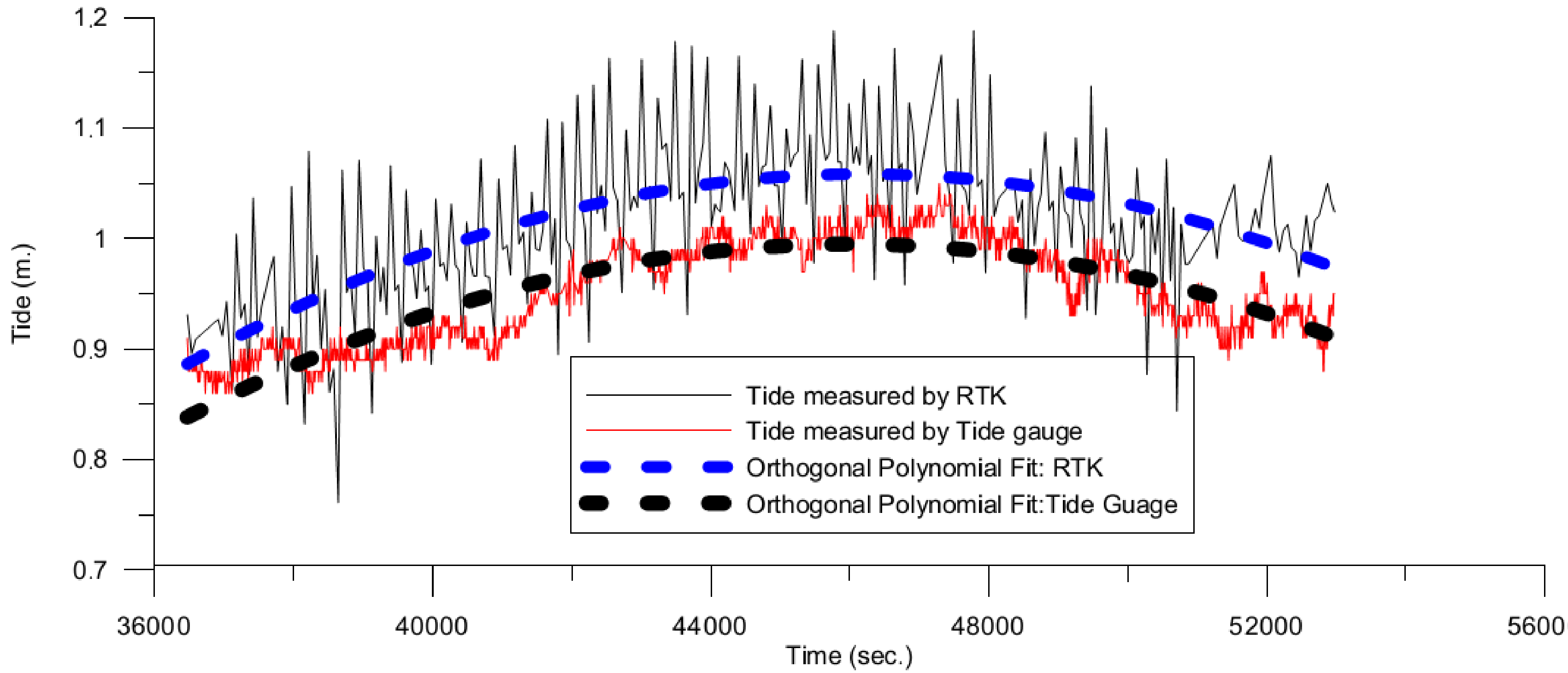
RTK/VRS applications in port operations

Advantages of using VRS in hydrographic surveying



This figure shows vertical datums in hydrography where the tide can be calculated using RTK/VRS techniques

This figure shows the tide values measured by both the tide gauge and RTK/VRS for an area about 10 km away from the tide gauge. Data obtained during a maintenance dredging project in Port Said East Port were utilized .It is noticed that, there is nearly a 10 cm gap between the measured values in each case. Tide measurements at the location of tide gauge deviate from the tide values at the project site due to the change in the sea state conditions



The limitation of using RTK/VRS for measuring tide is the assumption that the separation between ellipsoid and CD for the project area is constant where the gradient of chart datum is considered zeros.

Many errors associated with GPS positioning can be eliminated through careful calibration procedures prior to each survey. The remained errors affect the measured coordinates depending on the type of equipment and measurements technique. The following figure illustrate an example of effect of error in horizontal position of survey vessel on the measured depth and consequently on the calculated dredged volume. In areas with flat bottom, this effect may not be significant.

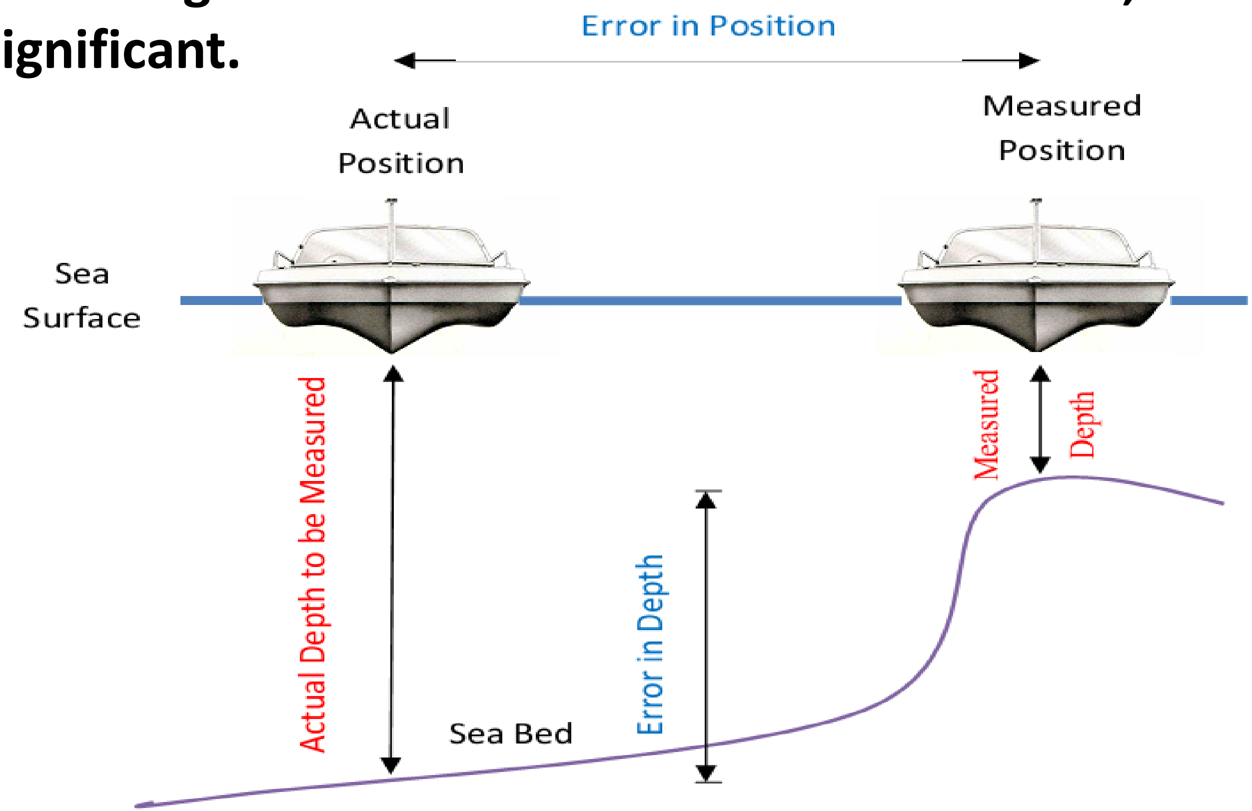


Figure 7. Example of effect of errors in position on the measured depths

Precise and economic dredging and construction

- **Using the VRS network provides improved accuracy for both horizontal positioning and depth. Therefore, and the possibilities of missing spot shoals are decreased. Also, knowing the exact draft of the vessel enables increased accuracy for dredge cuts. Plus the improved accuracy makes dredging around piers and pilings easier**

- **To inspect the effect of the used positioning equipment on the estimated dredged volume, an experiment has been carried out in Arish Port. Hydrographic survey has been performed using two different positioning equipment RTK and DGPS model.**

- **The difference in dredging volume to level (-13 m) using DGPS and RTK GPS is about 3000 cubic meters. Considering the average cost of dredging is 7$ per cubic meters, the direct difference in cost is about 21000 $ which nearly the difference between purchasing cost of RTK GPS and DGPS.**

Figure (7a) RTK contour

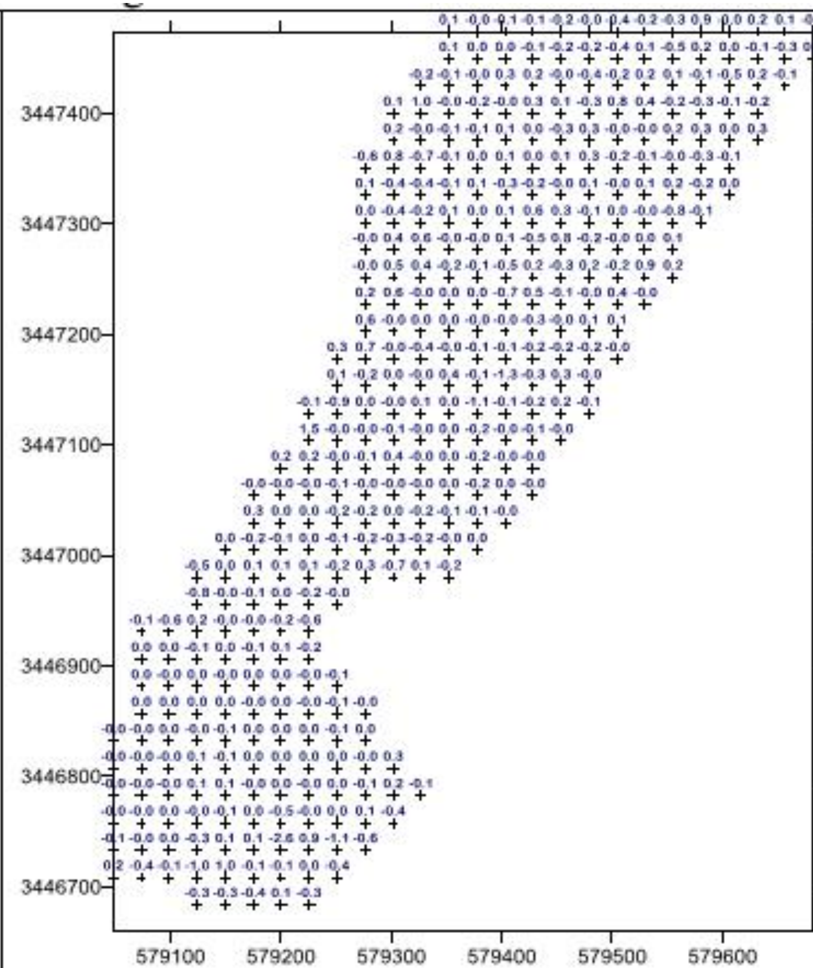
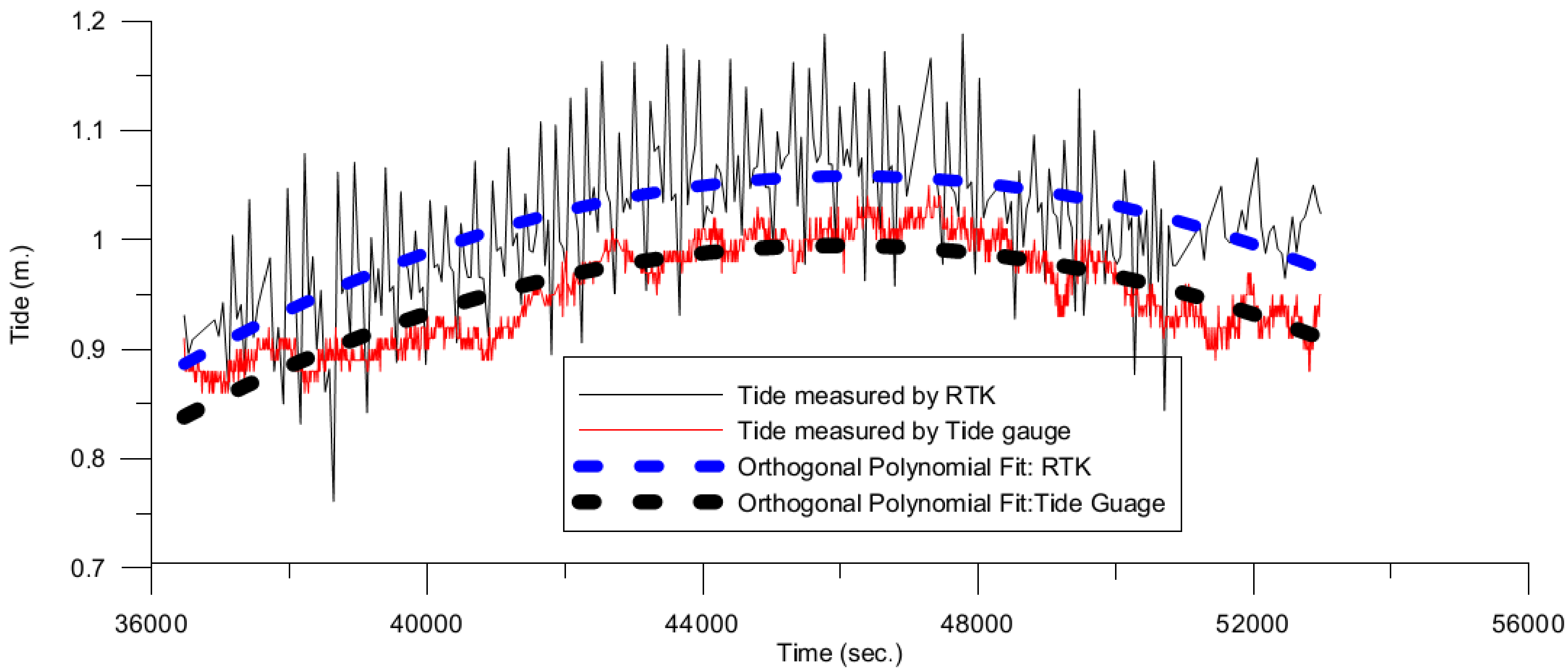


Figure (7b) Spot heights differences

Figure (8) Contour maps and differences in hydrographic survey results [**5**] using DGPS and RTK.

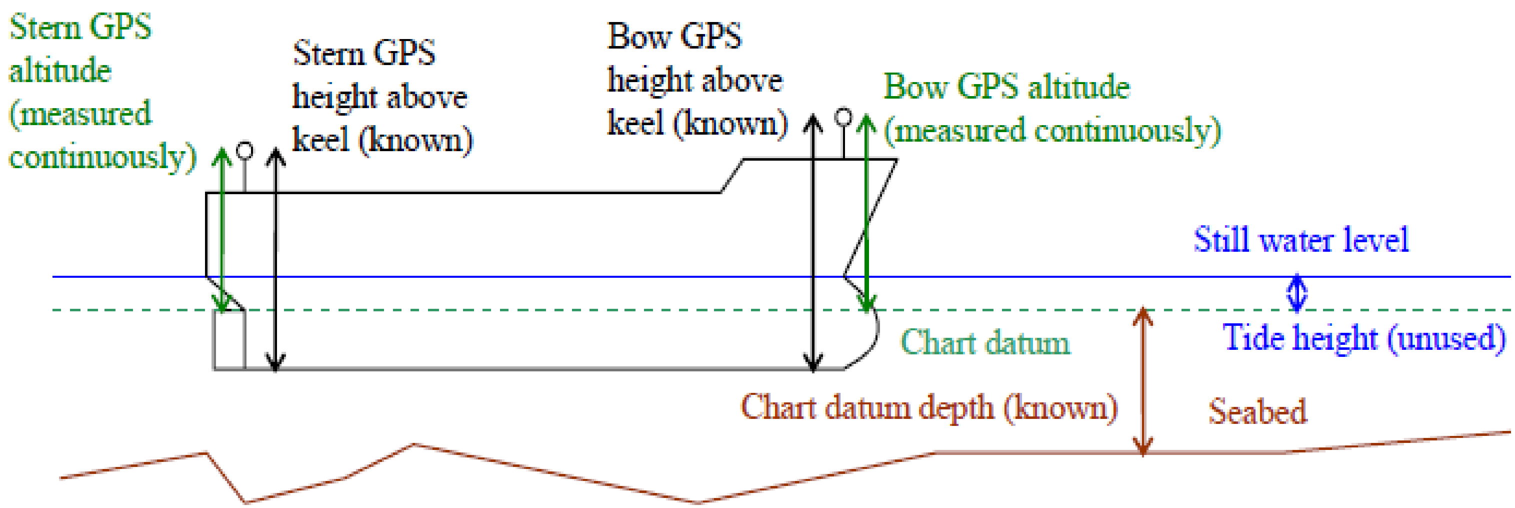
To investigate the effect of using RTK/VRS GPS in tide measurements the volume of the dredged materials of Port Said East Port maintenance dredging project has be calculated. The difference in volume is more the 200000 cubic meters . The difference in volumes is considerable amount and has significant impact on the project cost.



Real -time ship under-keel clearance monitoring

Under-Keel Clearance is the most important factor which determines the possibility of ships hull touching the bottom, therefore it is one of the basic elements which decide of navigation safety in restricted waters. The basic navigator’s responsibility is to keep safe under-keel clearance in any conditions. It has been recommended to reduce UKC without compromising safety for less cost and reduce possible environmental impact of dredging

The ability of RTK/VRS GPS receivers to determine the altitude of fixed points on the vessel relative to a known vertical datum means that the potential exists to bypass the measurement of tide heights, ship drafts and local sinkage in determining the elevation of a ship’s keel relative to chart datum. When combined with charted bathymetry, the under-keel clearance can then be obtained.



Real-time UKC at bow = (chart datum depth at bow at that instant)
+ (measured bow GPS altitude above chart datum at that instant)
– (bow GPS antenna height above keel)............................(1)

Overseas operational experience confirmed that applying a real-time UKC monitoring systems give greater understanding of the margin of navigational safety and increase the potential for economic benefit to the users by permitting increased cargo uplift

Applications of CORS/VRS in Development of Suez Canal Corridor

The Suez Canal Corridor Project is a mega project in Egypt. The project's goal is to increase the role of the Suez Canal region in international trading and to develop the three canal cities: Suez, Ismailia, and Port Said.

Such a mega and promising project could benefit from the advantages of GPS networks during the construction and operation phases. There are endless number of potential applications that might benefit by VRS and GNSS networks.


CORS Station
Baseline

Time savings	• Negates the need to set up control points when starting a new project – 0.5-1 day saved per project • Reduces time spent doing manual calculations • Reduces time spent in the office – from 40% to around 10% per project • Time savings of up to 75% for large projects and 60% for small projects are possible
Labour savings	• Reduces the number of surveyors required for a project from 50 to about 10 for large projects • Allows for the use of non-survey staff to do simple mapping tasks that would otherwise require a qualified surveyor
Infrastructure savings	• Reduces the need for traffic disruptions, such as lane closures, and associated risk to survey and road workers
Safety improvements	Reduces the need for maintenance of ground marks

Benefits of CORS/VRS in land surveying

EARTHMOVING IN CONSTRUCTION	
Time savings	• Reduces project time significantly – savings of between 30 and 80% are possible • Negates the need for surveyors to physically stake out routes • Negates the need to navigate machines around stakes and pegs • Reduces the frequency with which dirt is moved around a site by up to 60% • Reduces the time spent conducting as-built surveys
Capital savings	• Productivity of bulldozers, excavators and graders is significantly increased • Reduces the amount of re-work by up to 70% • Reduced need for support machines • Reduced downtime
Labour savings	Fewer workers are required for a project
Safety improvements	• Reduces the number of workers on a site and in close proximity to machines, particularly workers with grade stakes and string lines
Quality improvements	• Work is generally more accurate – e.g. grader trimming

Benefits of CORS/VRS in earthmoving in construction

Benefits of COR/VRS in SCCA during operation stage

The proposed CORS network could improve navigation through the Suez Canal and help vessels to transit in all weather condition which keeping the Canal open all times for ship transits. Using VRS technique through Suez Canal will provide real-time 3D monitoring of the vessel position and UKC improving navigational safety. The proposed network will keep controlled piloting and berthing, therefore minimal damage to infrastructure and ships occurs.

CORS/VRS have endless benefits and applications in operation of SCCA projects such as container terminals management, intelligent transport systems, assets management, etc.

Conclusions