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Real-Time Kinematic (RTK) Technology for Safer and Smarter Port Operations

-A detailed study –

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Port Operations Team

(Marine Operations Group)

Kuwait Oil Company (KOC)-Mina Al Zour terminals

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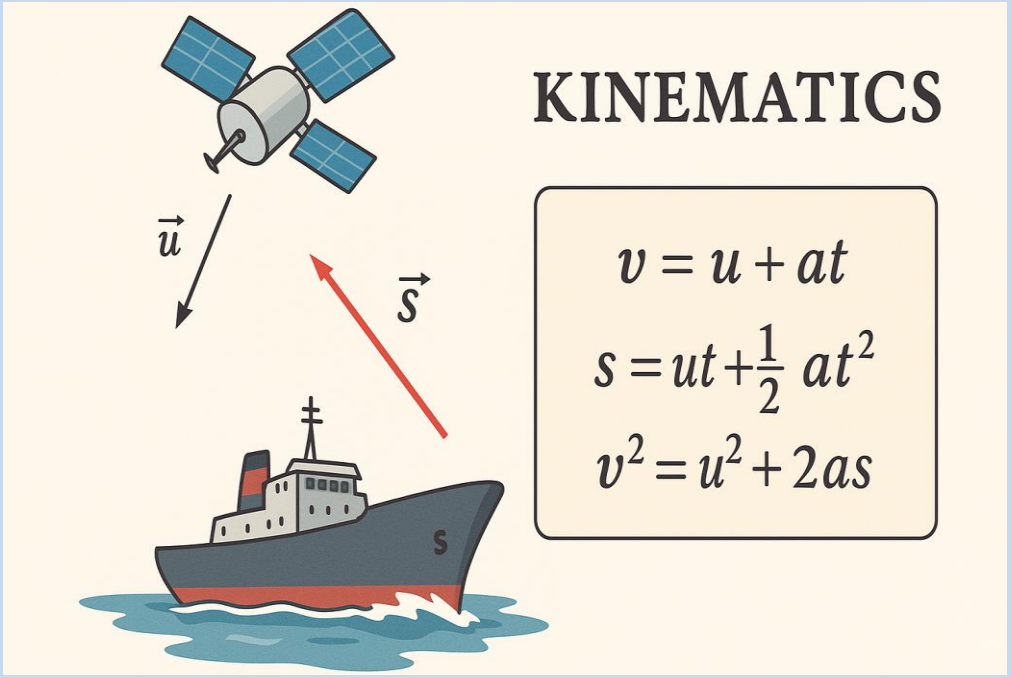
What is RTK technology (Real Time Kinematics)?

The word "Kinematics" comes from physics in Mechanics. It means the study of motion. (movement of objects without considering the forces causing them).



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Why RTK is needed ?

Resilience Against GNSS Errors

Protects against GPS signal jamming and distortions.

Precise Navigation

Provides CM-level positioning, critical for port navigation.

Operational Safety

Enhances pilotage and mooring accuracy, minimizing risks of grounding or collision.

Efficiency Gains

Enables real-time UKC monitoring and faster vessel turnaround.

Multi-Use Benefits

- Drilling
- Dredging
- Hydro Surveys
- VTS management

Channel Navigation

Critical for narrow channels

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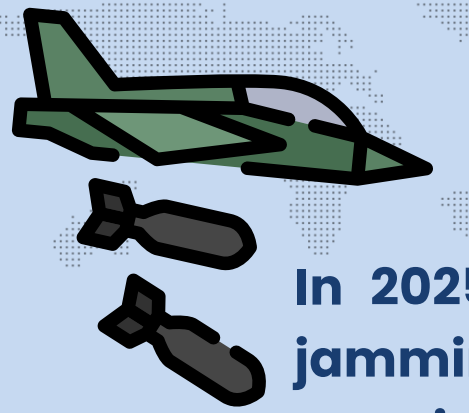

Immediate cause: Arabian Gulf incidents- jamming & spoofing

In 2025, vessels in the Strait of Hormuz and Arabian Gulf faced GPS signals jamming and spoofing, showing false positions outside safe channels and creating serious navigation hazards.

GPS Signals Spoofed – Vessel positions falsely shown outside the approach channel.

Navigation Hazards – Created risk of grounding and collision in restricted waters.

Abnormal Berthing – Vessel berthing was done using 'Abnormal Berthing emergency procedures.

Operational Impact – Marine pilots reported loss of confidence in GPS-based navigation.

<u>Lesson Learnt</u> – Sole reliance on GPS is unsafe; RTK provides resilient, accurate positioning.

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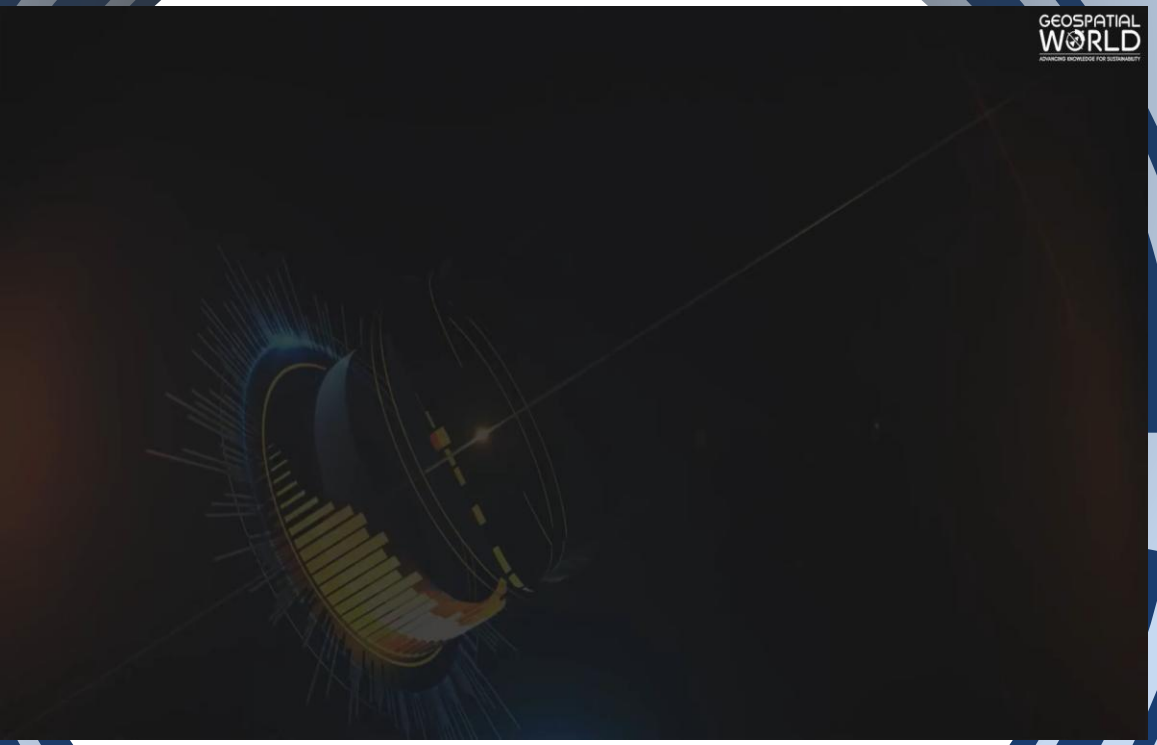
RTK Technology Overview



RTK is a satellite navigation technique that provides centimeter-level accuracy.

- Correction data from a fixed base station to enhance GNSS positioning.
- Accuracy: 2–5 cm vs 3~5 m (GPS)
- Base station sends corrections to rovers/PPUs
- Uses multi-GNSS (Global Navigation Satellite System viz. GPS(US), GLONASS(Russia), Galileo(EU), BeiDou(China))

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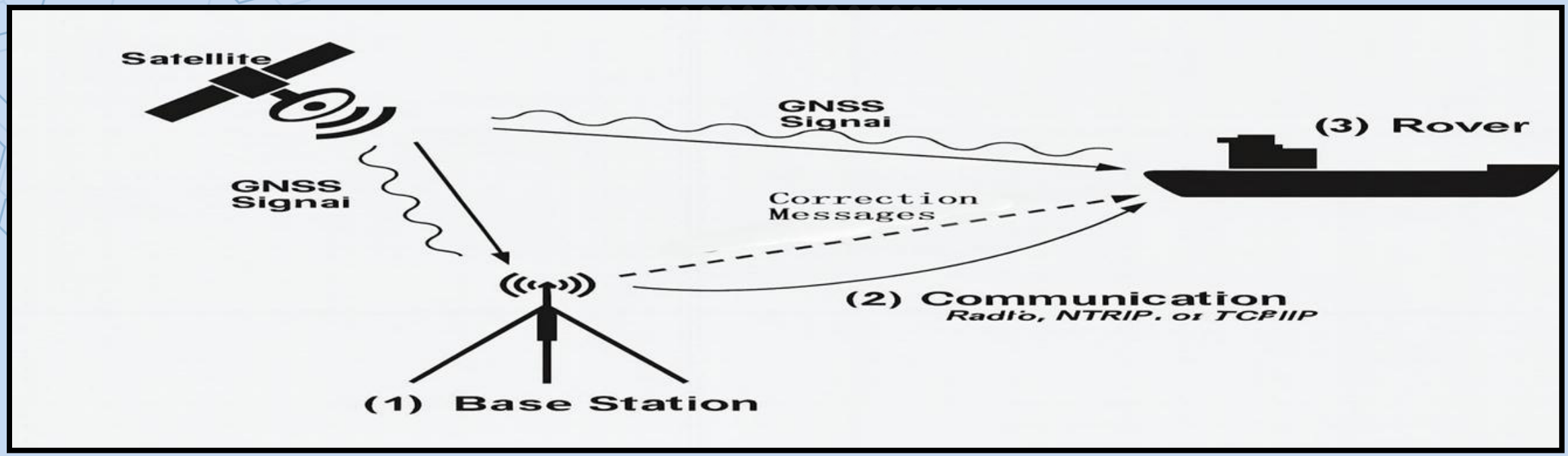
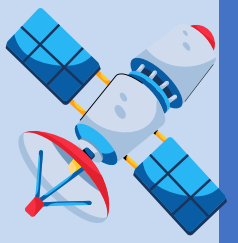
RTK System Components



How it works:

- Pilot boards the ship with a RTK enabled PPU.
- The PPU receives GNSS signals and RTK corrections from the base station.
- Provides real-time, high-accuracy positioning for safe navigation and docking.



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IMO Resolution A.915(22): Required Accuracy ?

- IMO defines minimum accuracy & integrity standards for navigation.
- Un-Augmented GPS falls short in port approaches and restricted waters.
- Augmentation (DGPS / RTK) is required to meet safety standards.

Area of Operation	Required Accuracy (95%)
Ocean / Coastal / Approaches	10 m (Horizontal)
Port Operations	1 m (Horizontal)
Automatic Docking	0.1 m (Horizontal)
Hydrography / Dredging	0.1–1 m (H/V)

⚓ Lessons:

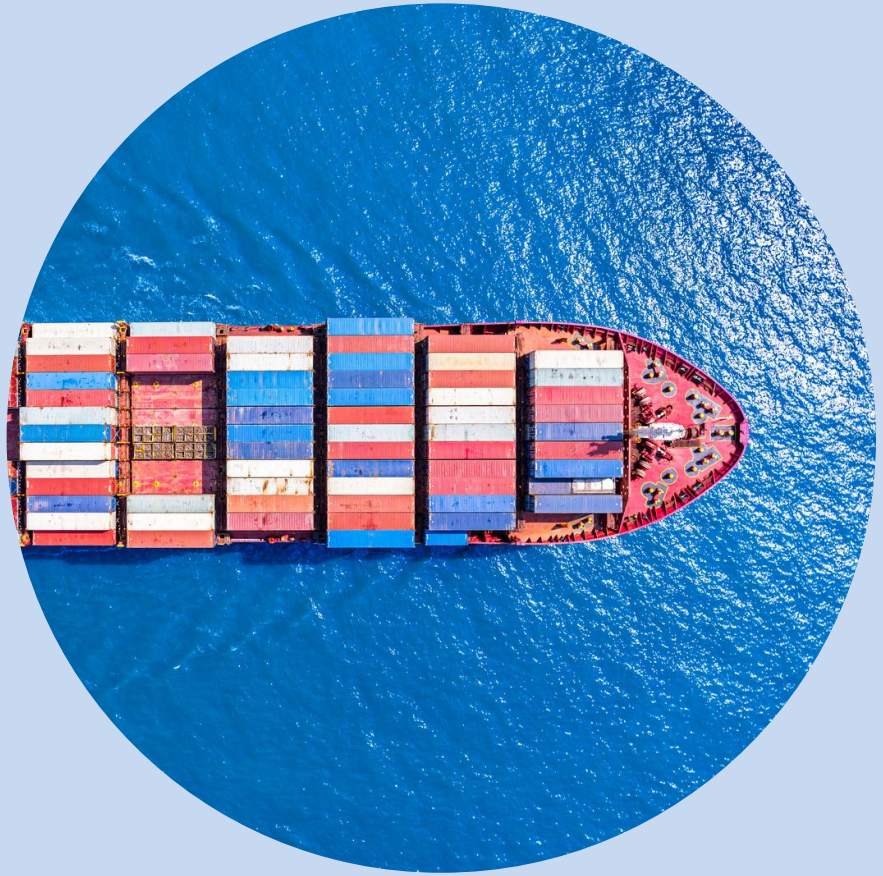
GPS alone cannot meet IMO port requirements.

Only RTK-class solutions meet critical tasks.

RTK provides the required Cm-level accuracy.

RTK Benefits in Navigation

- High-precision (±2–5 cm)
- All-weather, anti-spoofing navigation safety
- Critical For Use In Narrow Channel
- Accurate & Safer Docking



- Reduced UKC & side clearance risks
- Improved tug assistance
- Real-time data to VTS and recording
- Aids in Incident Investigations

RTK Benefits in Mooring

Monitoring of Abeam Speed (~0.05 knots) & Bow Swing (~ 0.1 deg/sec)

Reduced Fender Impact Force by 1.8 times

Better Tug Coordination

Predictive Berthing Calculations

Optimized Fender Design → Cost Savings

Reduced Risk of Quay or Vessel Damage

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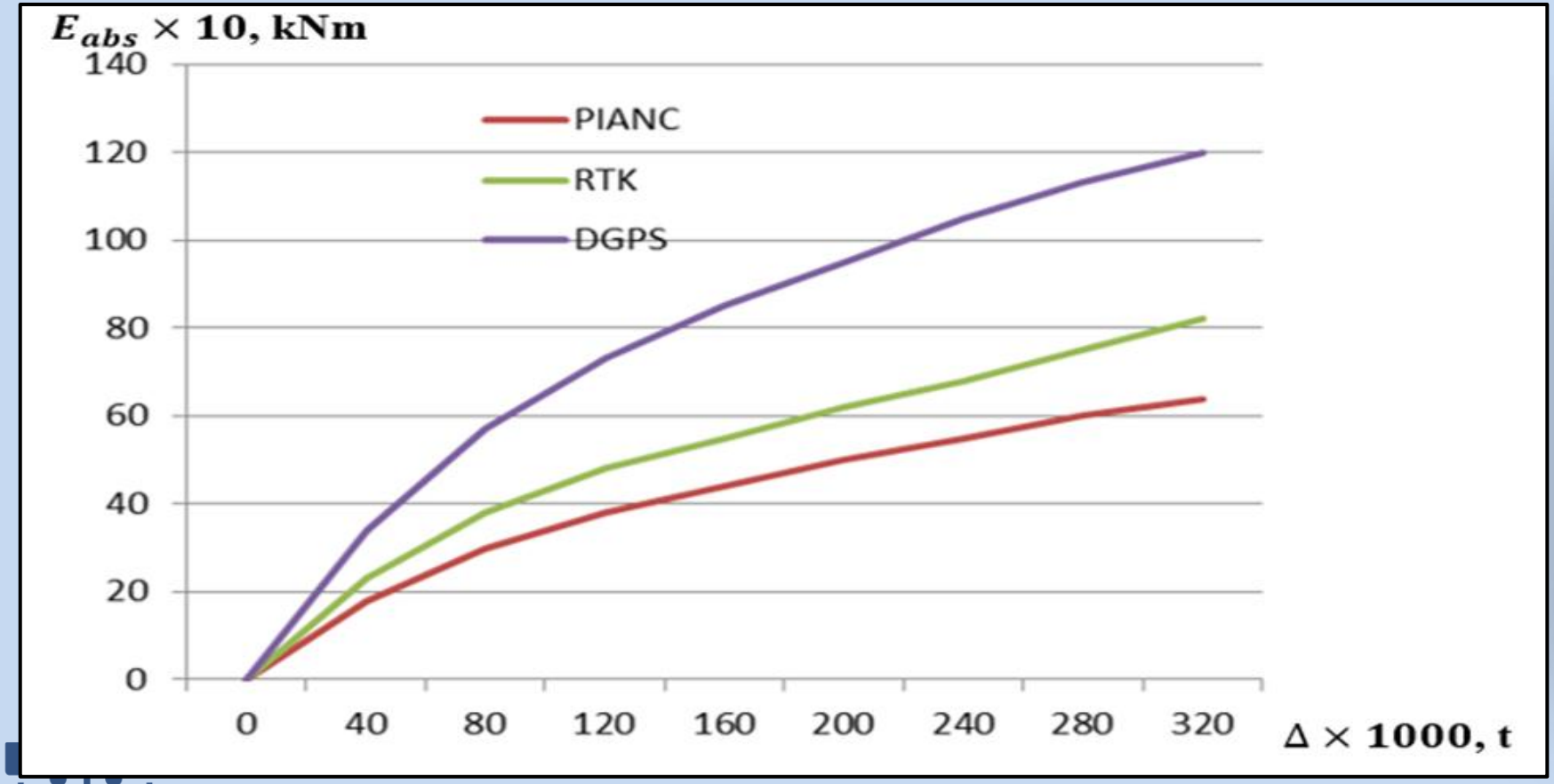
Mooring Energy Safety Margins



Required absorption energy of quay fenders depending on vessel displacement and contact speed, comparing PIANC recommendations with results obtained from DGPS and RTK measurements (adapted from Filina-Dawidowicz et al., 2024).

PIANC = *Permanent International Association of Navigation Congresses* (now just called *PIANC – The World Association for Waterborne Transport Infrastructure*).

ADDITIONAL PORT APPLICATIONS

01

Offshore Rig Movement -

Precise Positioning During Tow & Anchoring

02

Hydrographic Surveying -

Eliminates Tide Gauge Dependency

03

Dredging -

Higher Accuracy & Cost Savings

04

UKC

Real -Time Under-Keel Clearance Monitoring

05

Terminal Safety & Efficiency

Comparing GPS vs DGPS vs RTK

FEATURE	GPS	DGPS	RTK
ACCURACY	❌ ~3–5 m (Worldwide coverage)	⚠️ ~1–2 m (Upto 450 kms)	✅ ~2–5 cm (Upto about 12 kms)
SPD & BOW SWING ACCURACY	❌ 0.5 Kt ~5-10 Deg/sec	⚠️ 0.2 kt ~ 1 Deg/sec	✅ 0.05 Kt ~ 0.1 Deg/sec
CORRECTION SOURCE	❌ None (satellite only)	⚠️ Ground stations **(Govt. controlled)**	✅ Base station **(Port/private owned)**
RELIABILITY	❌ Low (errors common)	⚠️ Moderate	✅ Very high
IMO SUITABILITY	❌ Not for restricted waters	⚠️ Acceptable	✅ Fully compliant & best

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Case Study Insights and Global Trend

01

Suez Canal Corridor- Research and study

(By: Dr Ahmed I Elhattab- Port Said University)

02

Panama Canal- Mandatory RTK Implementation.

(Panama Canal Authority Vice Presidency for Operations Advisory to Shipping No. A-32-2022): Mandatory for vsls > **109 Feet LOA)**

03

Global Ports Adoption

- **Rotterdam**
- **Singapore**
- **Hamburg**

(Emails and correspondences)

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Vendors and Equipment Options

Real-Time Kinematic (RTK) positioning for exceptional accuracy

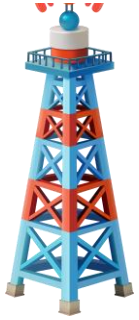
Trenz Sirius+

Navicom Dynamics

AD Navigation

Trelleborg

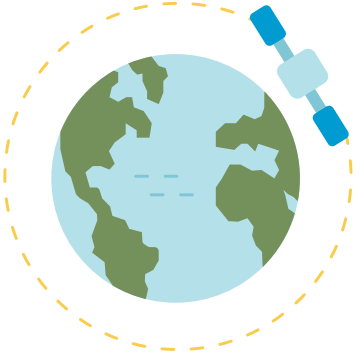
Proposed RTK System for port solutions



Single Base Station near terminal Structure

(Can use Sector light pole)

Pilot PPUs Fully Integrated with VTS



Dual Correction Channels (LTE + UHF)

Centralized Monitoring & Analytics

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RTK System – Cost Benefit and ROI Summary

💰 Investment Overview (Capex + Opex)

For one RTK base station + one RTK-enabled PPU

- Initial cost: USD 50,000 (RTK Base station: Appox 25000 USD, RTK-enabled PPU: Appox 15000 USD, Setup and Integration appox 10000 USD)
- Annual OPEX: ~USD 5,000 (maintenance & communications)
- Let's assume $50,000 initial and $5,000 recurring yearly.

📈 Quantifiable Annual Benefits

•↓ Fender and berth-impact repairs → USD 20,000
•↓ Tug time & fuel during berthing → USD 12,000
•↓ Demurrage & aborted approaches → USD 30,000
•↑ Offshore usage in Rig move and SBM maintenance etc → USD 30,000
•↑ Operational efficiency gains → USD 20,000
→ Total tangible savings ≈ USD 100,000 / year

📊 ROI Summary

ROI = (100,000 – 5,000) ÷ 50,000 = **≈ 190 % / year**

Payback period: ≈ 6 to 7 months

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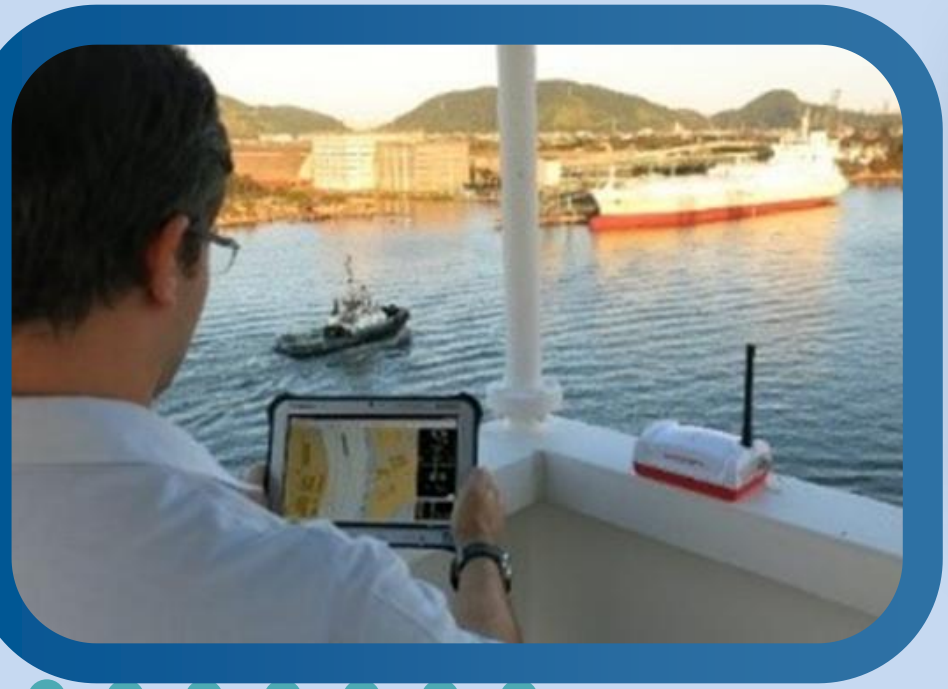
Conclusion

1. GPS alone is inadequate for restricted waters.
2. RTK provides a reliable safeguard against GPS spoofing.
3. Cost-effective and proven across leading global ports.
4. Enhances port safety, efficiency, and navigation accuracy.



Recommendations

- Initial Deployment with single system as pilot project.
- Later Expansion to all terminals in port.

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Thank you

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