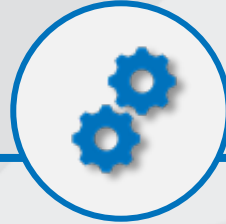# Dynamic Under Keel Clearance: Data & Modeling
Karsten Uil, PROTIDE by Charta Software
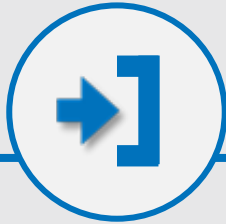
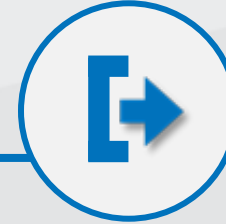## 2006

Charta Software

Rotterdam, The Netherlands Experts in math & computer science

Operations

Development, hosting and support

Domain specific optimization in maritime, logistics and resource planning.

Tailor-made

Standardization

Standard solutions with customization to address unique circumstances.

<u>Minimum dynamic under keel clearance</u>, air clearance; maximum currents or winds; other maneuverability issues.

Real time notification on changing circumstances: buoy data, <u>Go/No Go</u>, bail out with insight in ship motion.

<u>Plan a ship in 2 to 24 hours</u> or investigate options next week. Adjust to operational restrictions or conflicts with other ships.

Continuous evaluation <u>data quality</u>, ongoing <u>analysis of actual ship movements</u>: operational safety & efficiency.

Optimize <u>safety</u>, <u>increased draft</u>, use planning windows, decreased waiting times or fuel usage

<u>Share and discuss consistent information</u> with stakeholders.

PROTIDE by Charta Software

Charta Software
## PROTIDE
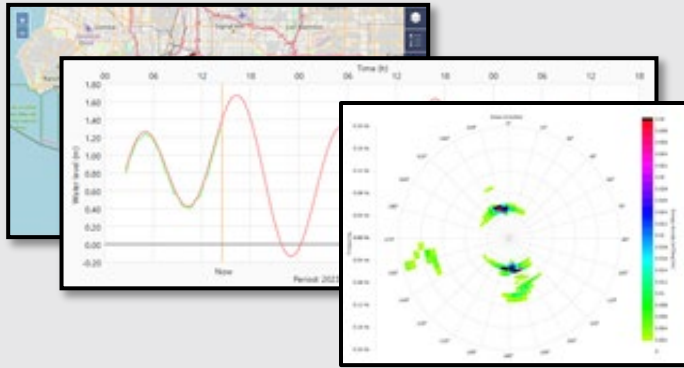
Input

- Port, <u>channel</u>, routes and berths.
- Best available data for <u>water levels</u>, <u>currents</u>, winds, <u>waves</u> and salinity.
- <u>Safety restrictions on UKC</u> / overhead clearance, currents and winds.
- <u>Ship dimensions</u>, <u>draft</u> and <u>loading conditions</u>.
- *Possible API integration*
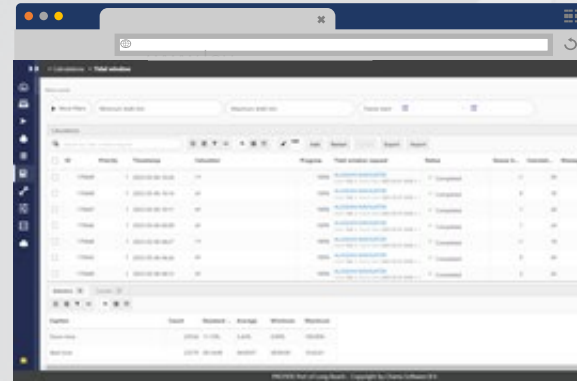
Calculation

- Consider passages of each transit at each relevant time and location.
- Ship behavior for given currents, winds, speeds and waves: drift, squat, roll, pitch and heave.
- Determine dynamic vertical clearance to create safe time intervals.
- Possible route options within valid time intervals: time windows.
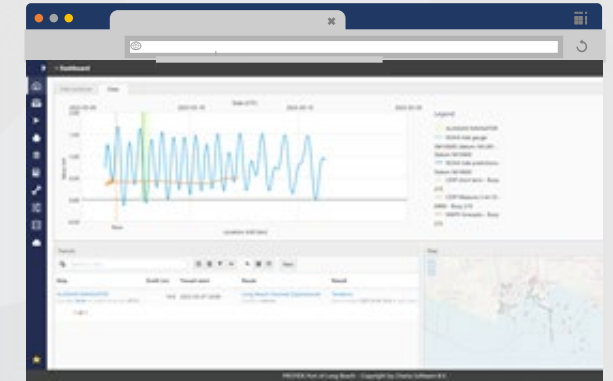
Results

- <u>Tidal windows</u> and <u>valid itineraries</u> within horizontal (currents) and vertical (UKC / overhead) restrictions.
- Detailed insight into expected squat, <u>roll</u>, <u>pitch</u>, heave, total vertical motions and <u>dynamic UKC</u>.
- <u>Go/No Go based on actual data</u>.
- Plan itinerary and monitor of transits via AIS.

## NOAA Tides and Currents

- Predicted tides

- Comparison of predictions and tide gauge.

- Error margin of 5cm - 30cm (mostly underestimations).
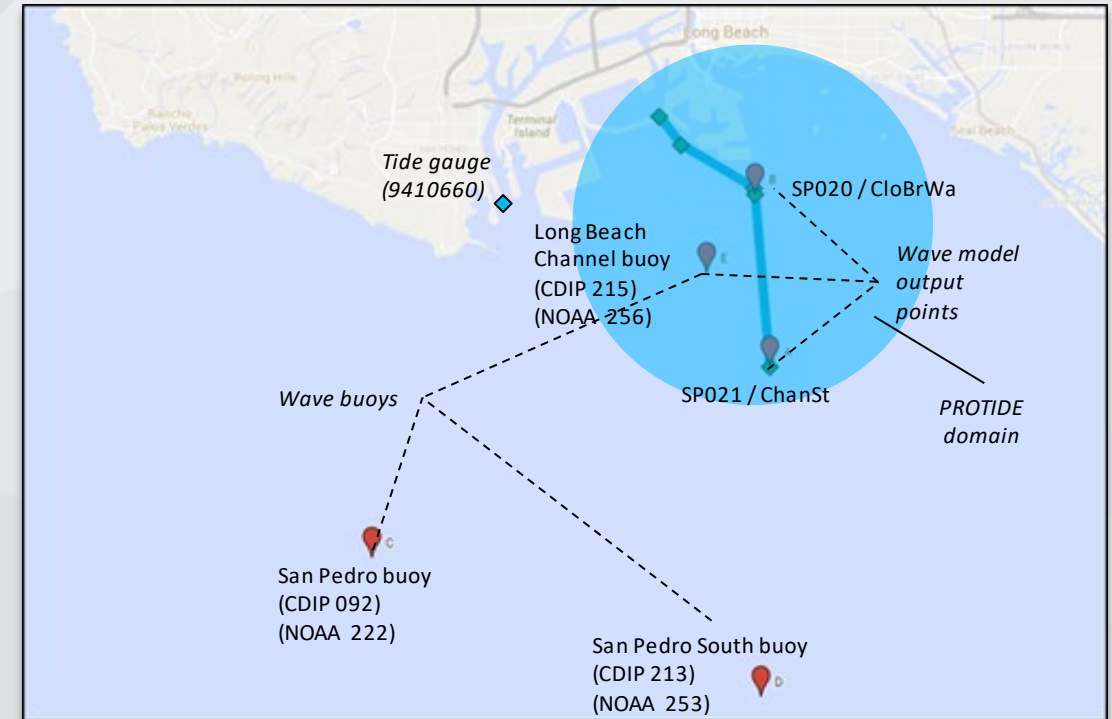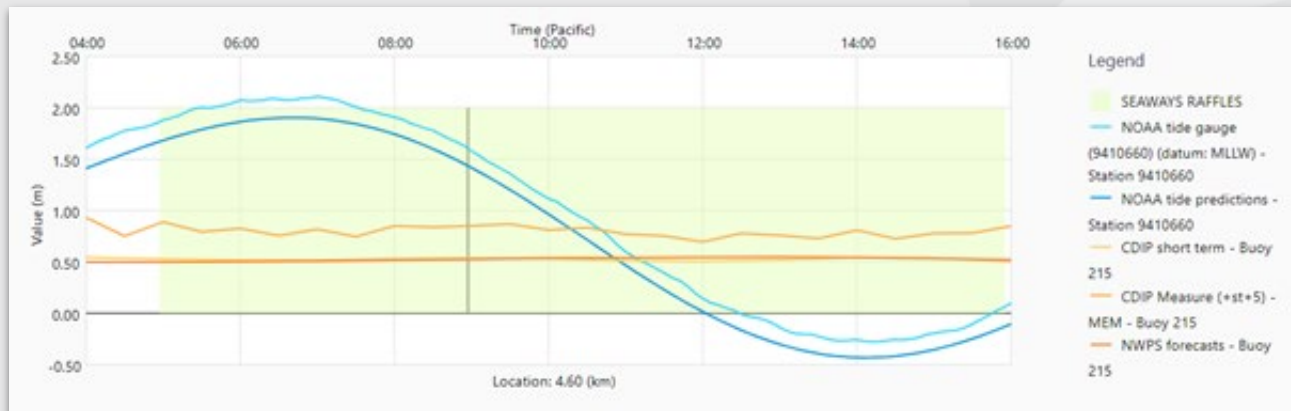
Left: Tide and swell heights during a transit. Right: PROTIDE domain of imported data sources.

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PROTIDE Port of Long Beach

NOAA Tides and Currents

- Continuous correction based on difference predictions and measurements + evaluation to monitor errors in predictions.

- Error margin decreases to 2cm - 10cm

- Standard deviation of 15cm is used for uncertainties.

- *Future*
  - *Output points close to the route / channel.*
  - *(OFS) Hydrodynamic model.*
  - *Data assimilation to correct close to the channel.*
  - *Introduce profile currents.*
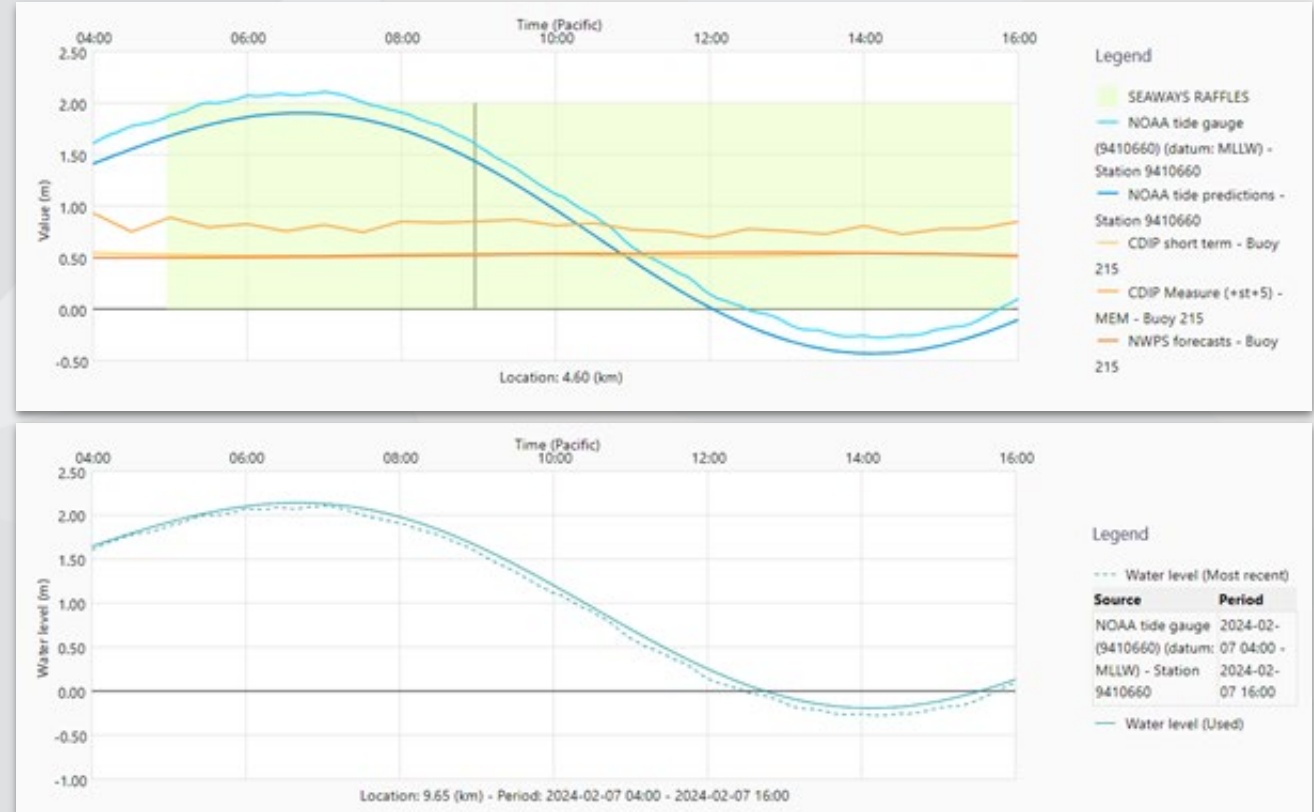
*Top: Tide and swell heights during a transit. Bottom: PROTIDE used tide 4 to 5 hours hours before transit.*

NOAA NWPS Waves + CDIP Buoy driven + Observations

- 6-144h before transit: NWPS wave 2D forecast with hourly output points.

- 1-3h before transit: CDIP buoy-driven forecast converted to 2D.

- Buoy observations
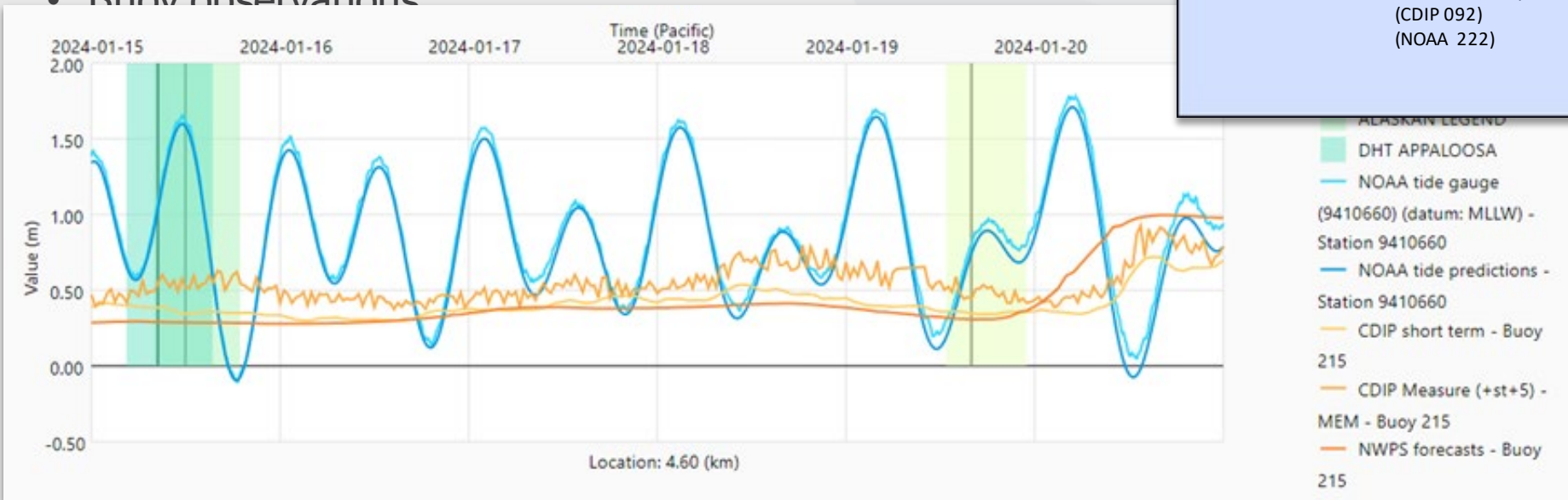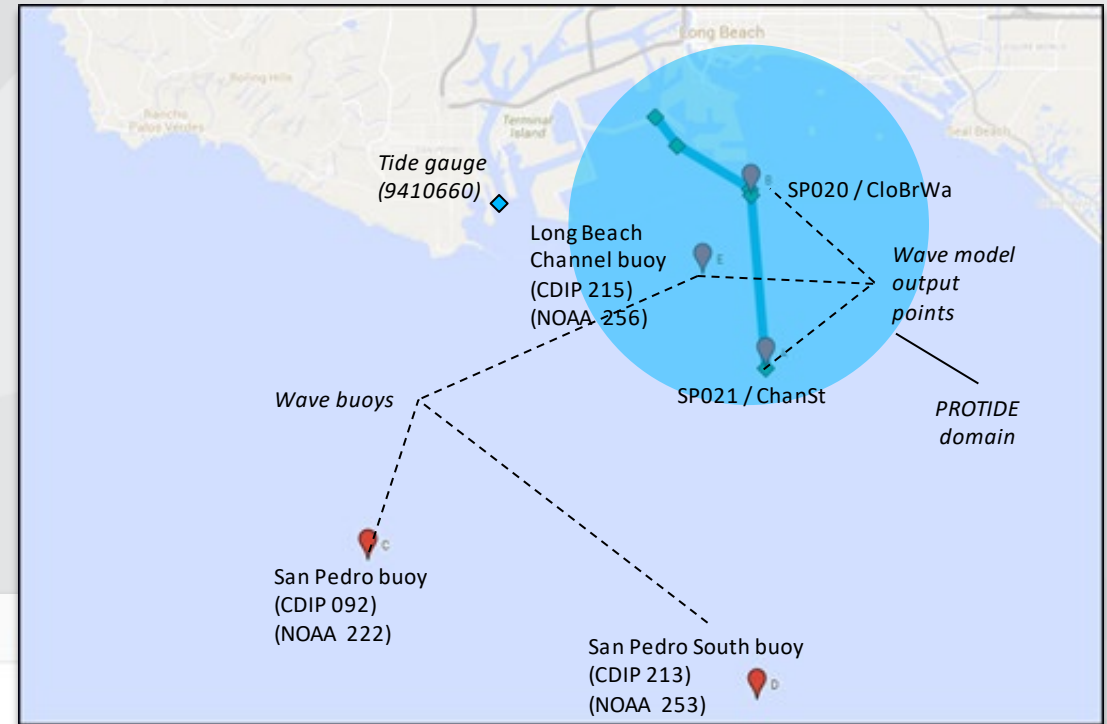
# NOAA NWPS Waves + CDIP Buoy driven + Observations: effect on ship motion

- Data evaluation + monitoring ship motion: *tune settings and error margins (>99% within error margins)*

- *Future: ongoing research in swell underestimations + notifications + dynamic corrections.*
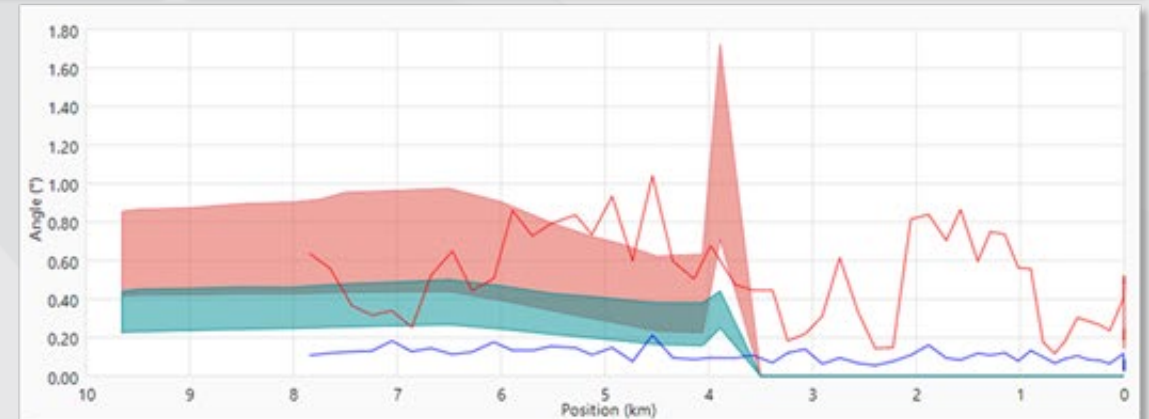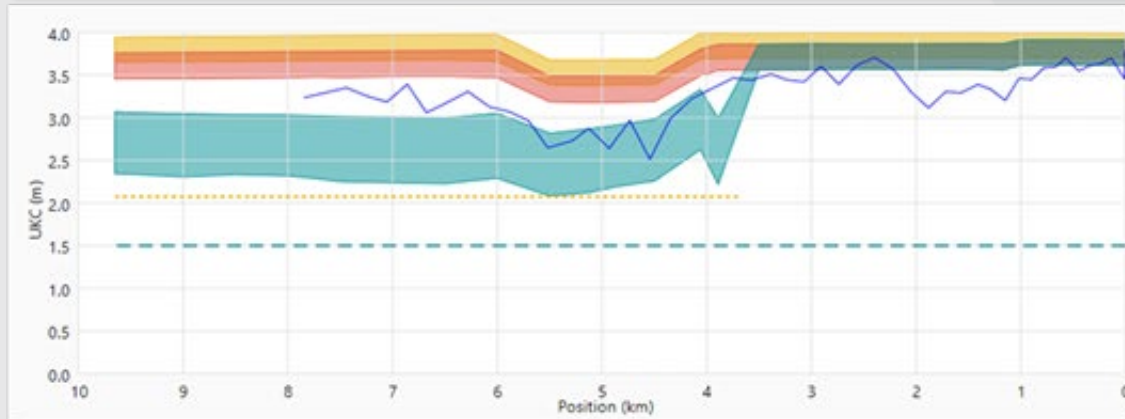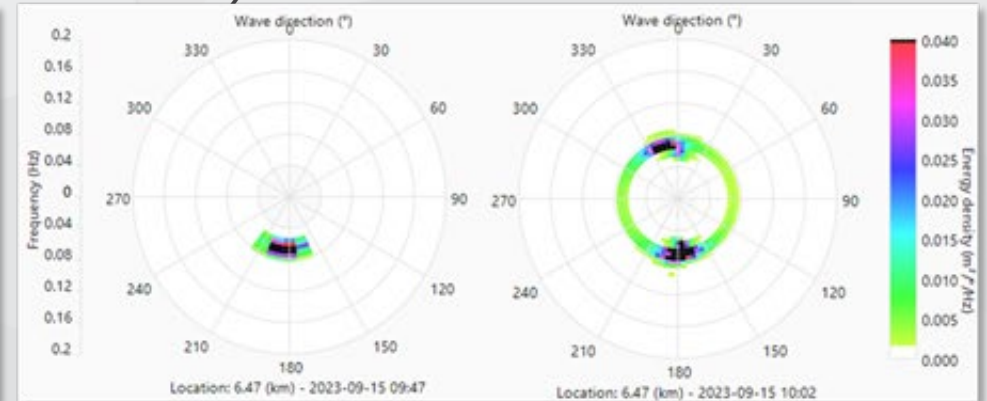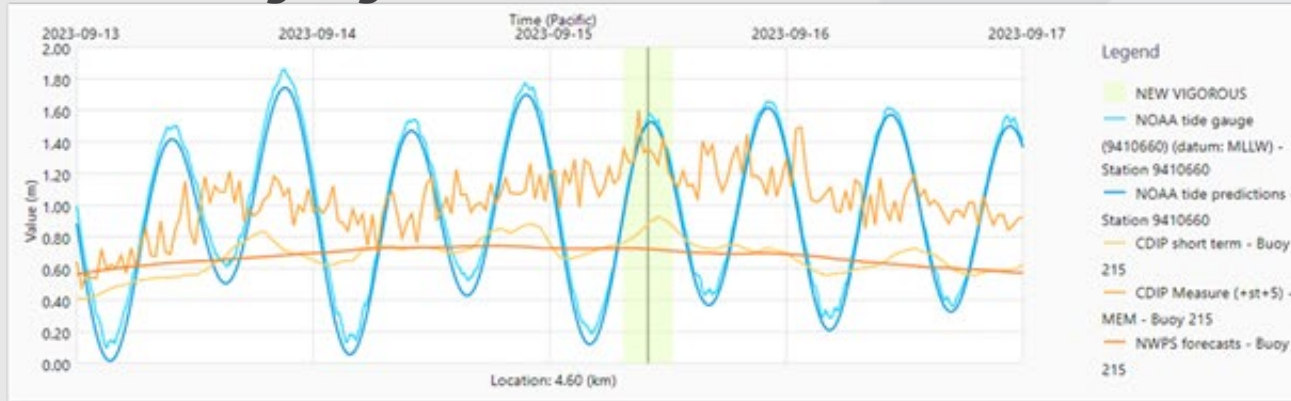
From left to right, up to bottom: Tide and swell conditions (km.pos 4.6), Wave spectrum before and after transit (km.pos 6.47, measured), Under keel clearance, Roll and pitch.

NOAA Office of Coast Survey

- Hydrographic surveys and high-resolution ENC overlays including S-102 standard.

- Determine depth with appropriate channel width:

  - Outside breakwater 300m: depth 79ft, 77ft, 76ft, 75ft

  - Inside breakwater and passing pilot station: 76ft

- *Future: automatic import and notification*
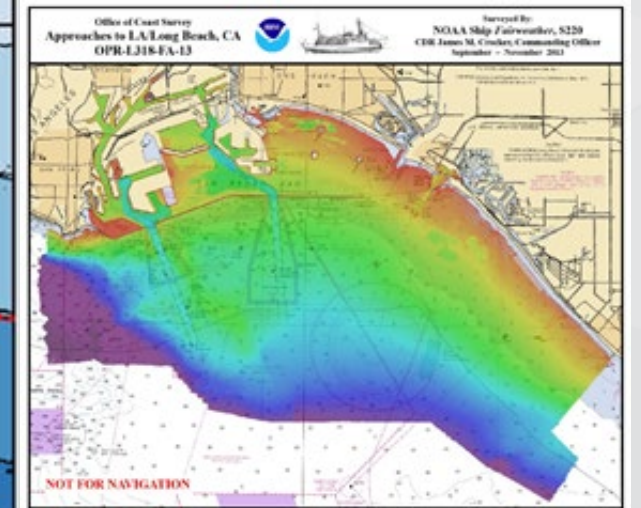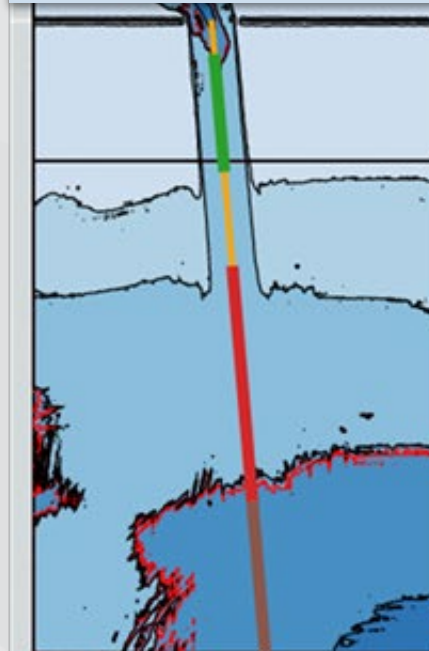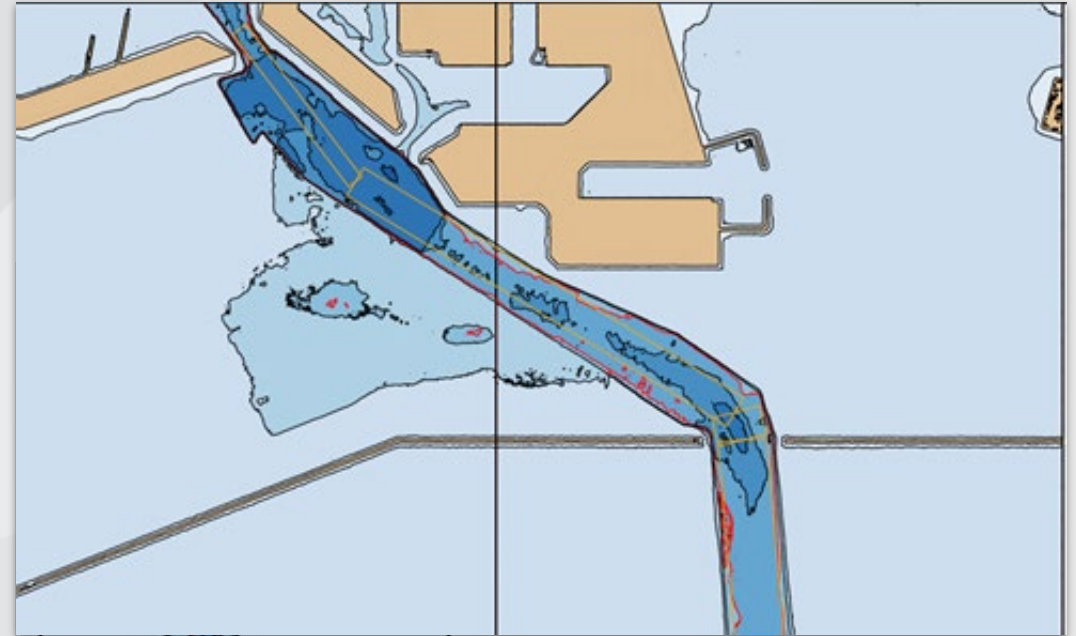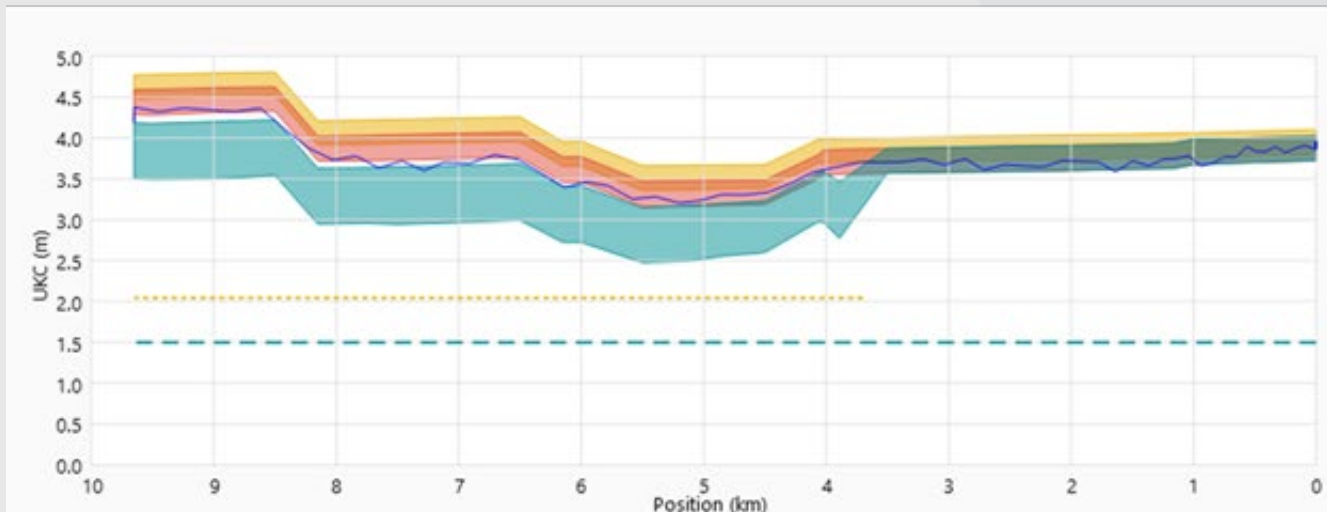
Transit: Ship type, dimensions, load, route and speed

- PROTIDE data sheet & snapshot loading computer.

- Loading conditions and intact stability parameters.

- Database with ship types, hull shapes and dimensions.

- Route, speed and itinerary on input pilots.

  + Tuned error margins on: speed, currents, roll period.

Example:

- Tanker / lpp: 319m / w: 60m / dwt: 318325t
- Draft forward / middle / aft: 20.7m
- GM_0: 9.0m / GG': 2.7m / T: 13.7s (±1.8s) / Δ: 330617t
- 6kn - 5kn - 4.5kn - 3.5kn (±1kn)
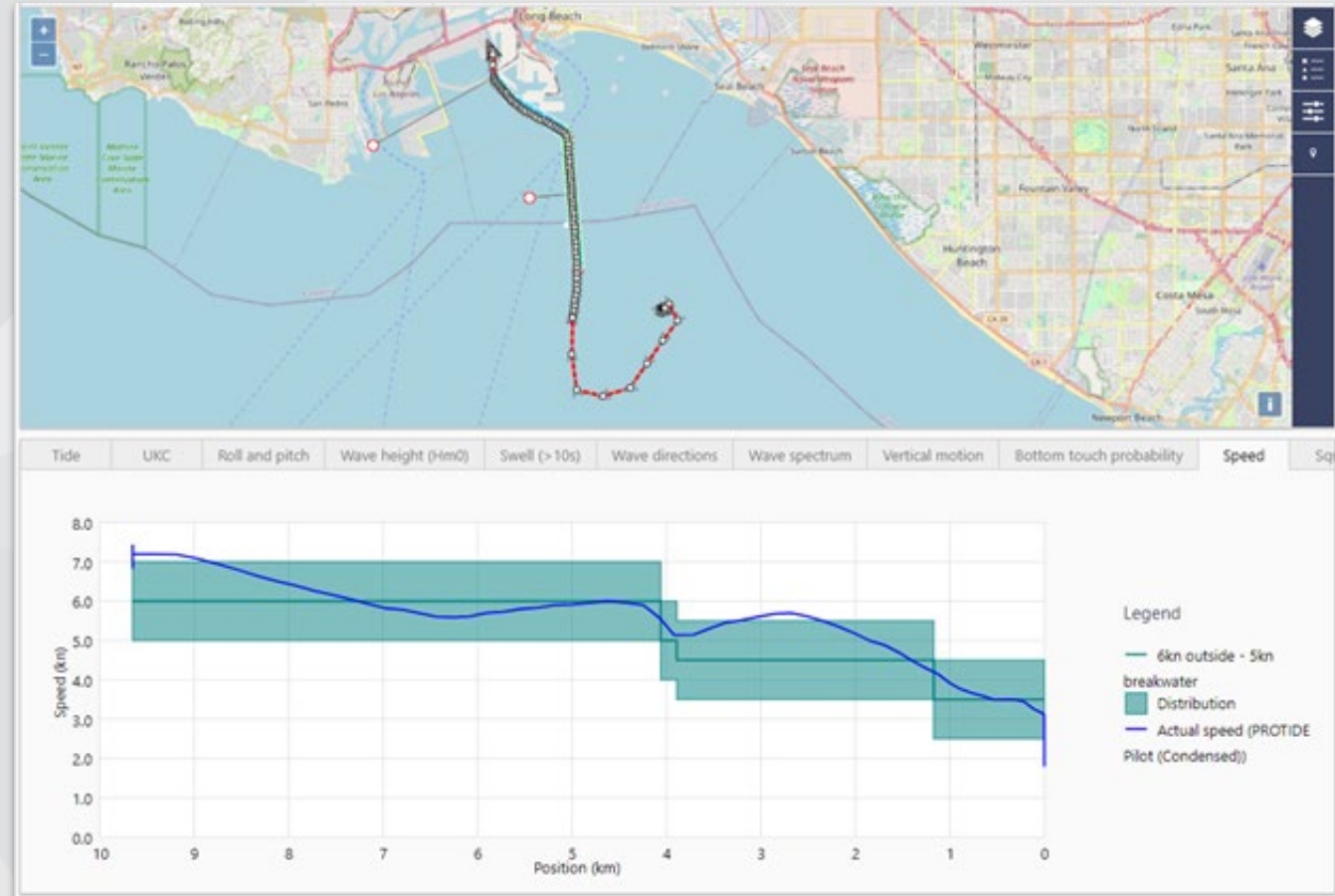
Real time tracking of track, timing, speed and course.

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On board validation: PROTIDE Pilot

- Sensor with minimal error margins: 0.03° RMS roll/pitch or 5cm heave.

- Real time insight in dynamic roll and pitch.

- After the fact analysis in PROTIDE:

  - Combine roll, pitch and heave motions into total vertical motion at extremes to obtain dynamic UKC.

  - Check: tides, waves, ship details, timing, motions.

  - Research anomalies and propose improvements.

- *Future: Real time dynamic UKC + machine learning*
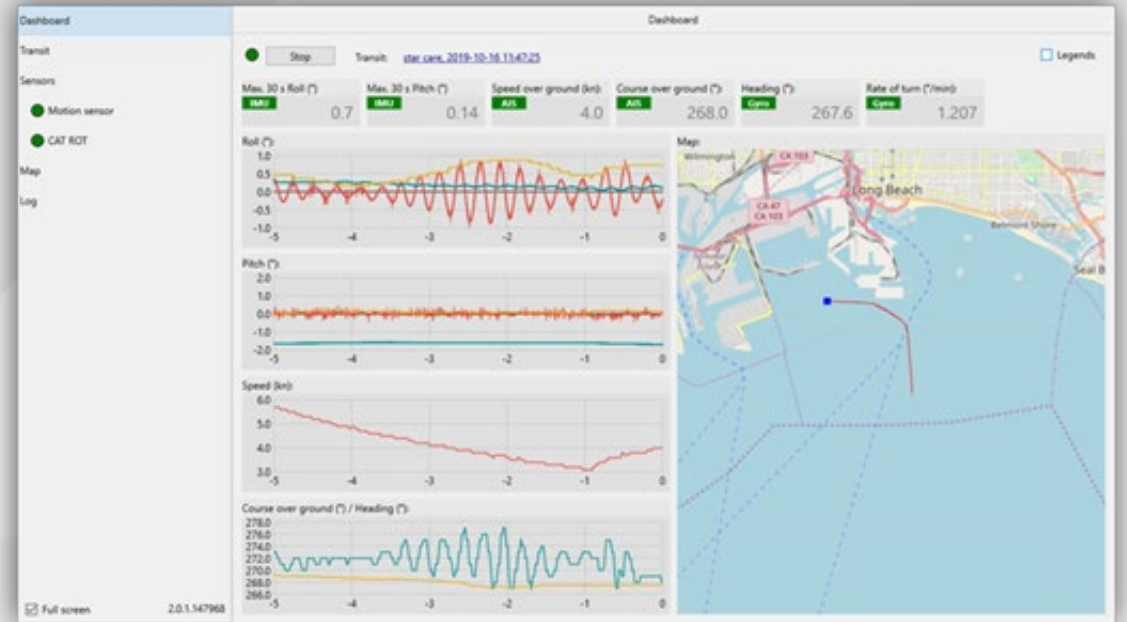
PROTIDE Pilot registers dynamic motion from SMC motion sensor and navigational data from SafePilot CAT ROT.
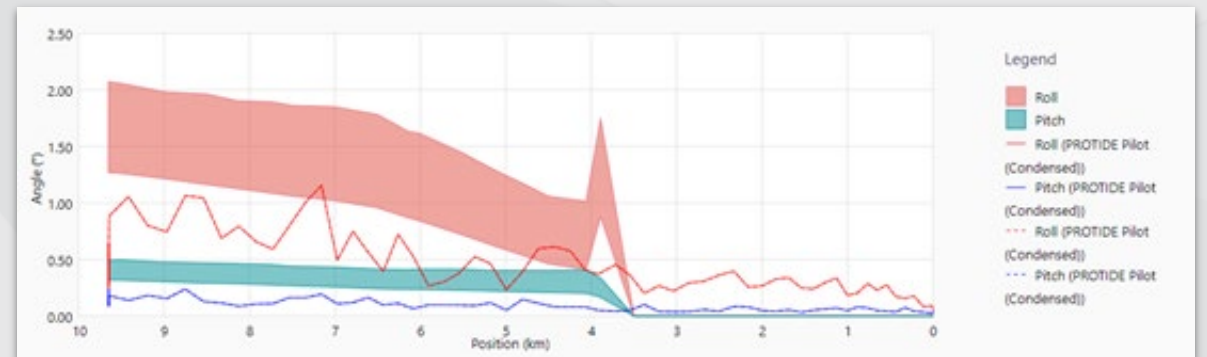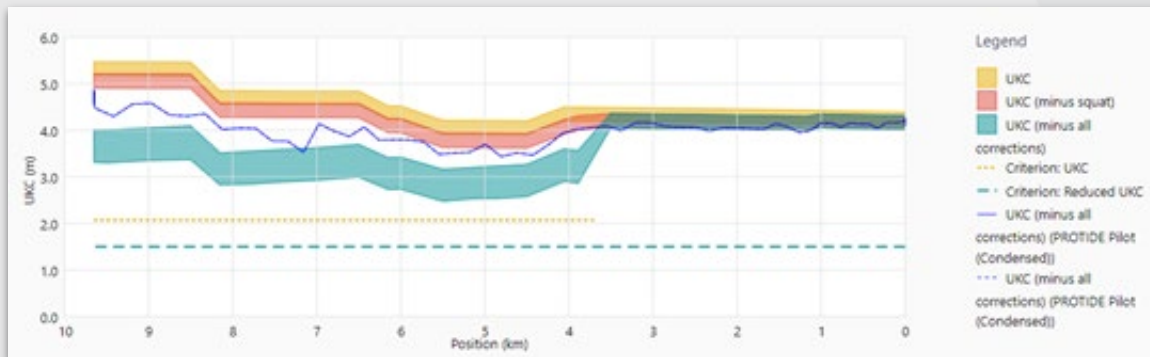
On board measurements are analyzed in PROTIDE to get insight in maximum dynamic roll/pitch motions (right) and resulting dynamic UKC (left).

Lessons learned

- Using data and modeling in an operational setup is possible to increase safety and improve operations.

- Combination of expertise and commitment is invaluable.

- Input models & data need constant validation and possibly corrections to be applicable in the field.

- Improvements in models take time.

- Operations depend on constant availability and reliable input and output.

Opportunity

- Collaboration in Port of Long Beach is an example for other regions.

- Commitment by all parties on the local circumstances make it work.

- Data and models available in a standardized format with consistent quality.

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PROTIDE

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Utilize data

Increase safety

Optimize resources

Improve planning and processes