Improved Usability in DP Tracking Operations

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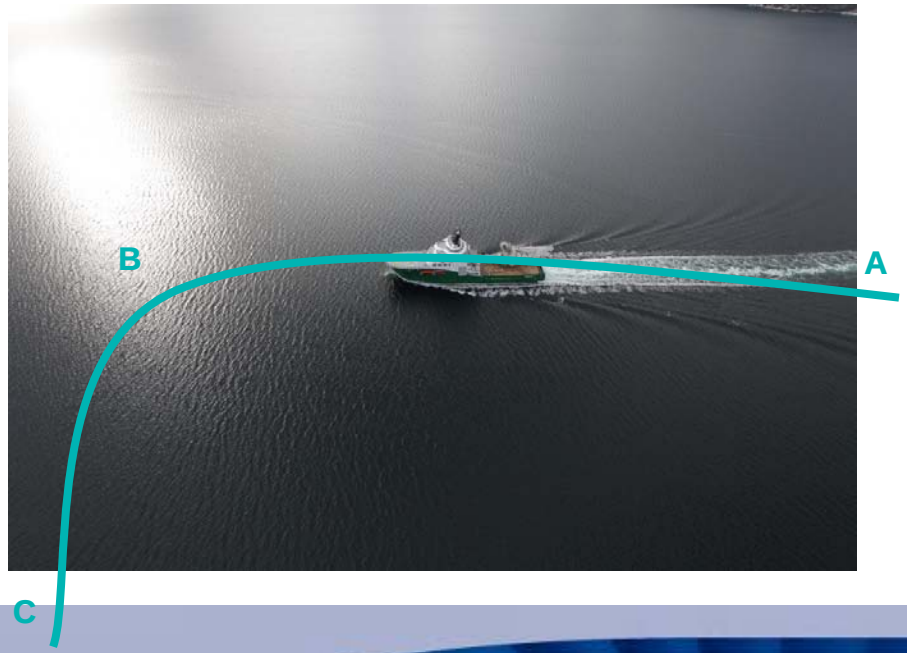
Waypoint Tracking

- **Natural extension to ordinary DP functionality**
- **Controls the vessel along a track of predefined waypoints**
- **Different heading and speed control modes available**



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Usability

- **Some definitions:**
  - “The degree to which an object, device, software application, etc. is easy to use with no specific training ”
  - “The study of the ease with which people can employ a particular tool or other human-made object in order to achieve a particular goal. ”
- **Associated with product functionality *and* as a user interface characteristic**
- **More than just**
  - User-friendly, accessibility
  - Ergonomics/human factors

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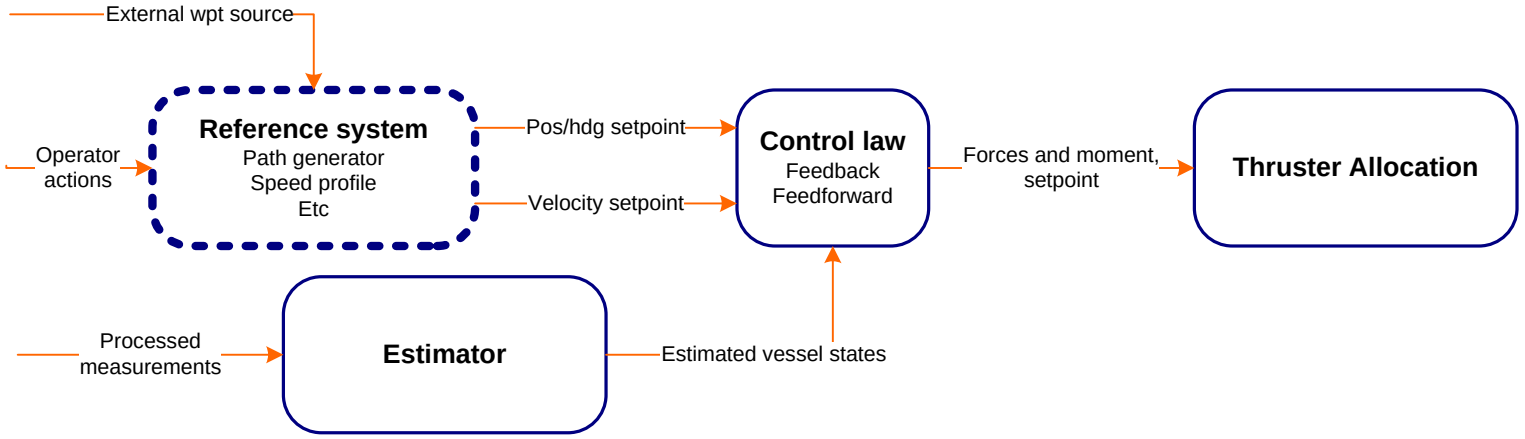
Introduction

- **Reference model in the control loop:**



- **Low-speed waypoint tracking implementation**

- **Applicable (in parts) to high-speed tracking schemes**

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DP applications

- **Tracking: Enabler for DP applications**

- **Offshore survey support**
- **Pipelay, cable lay**
- **Trenching, dredging, rock dumping**

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Path Construction and Analysis

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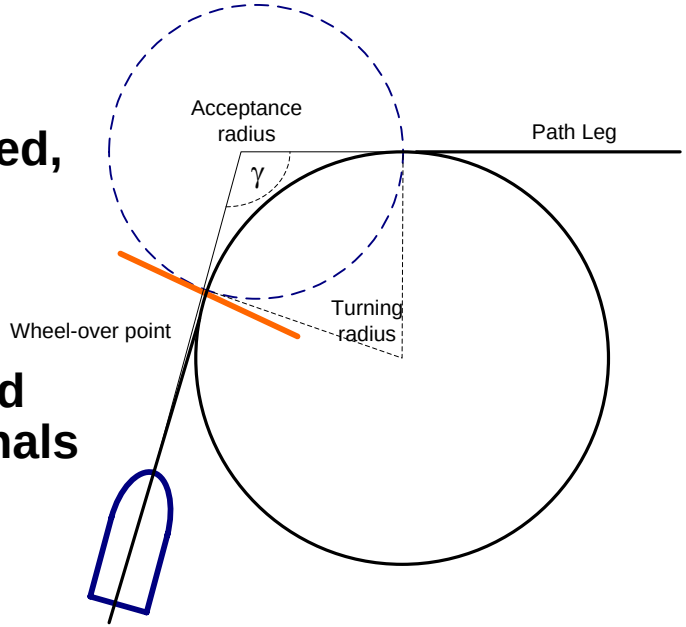
Points and paths

- **Waypoint: position (turning radius, speed, heading setpoint)**



- **Waypoints are converted into a path and used to generate smooth reference signals to the control law**

- **Path creation methods**
  - Straight-lines and circle arcs
  - Interpolation techniques
  - Optimization:
    - shortest route through a set of points
    - minimum time and energy
    - vessel speed and acceleration constraints

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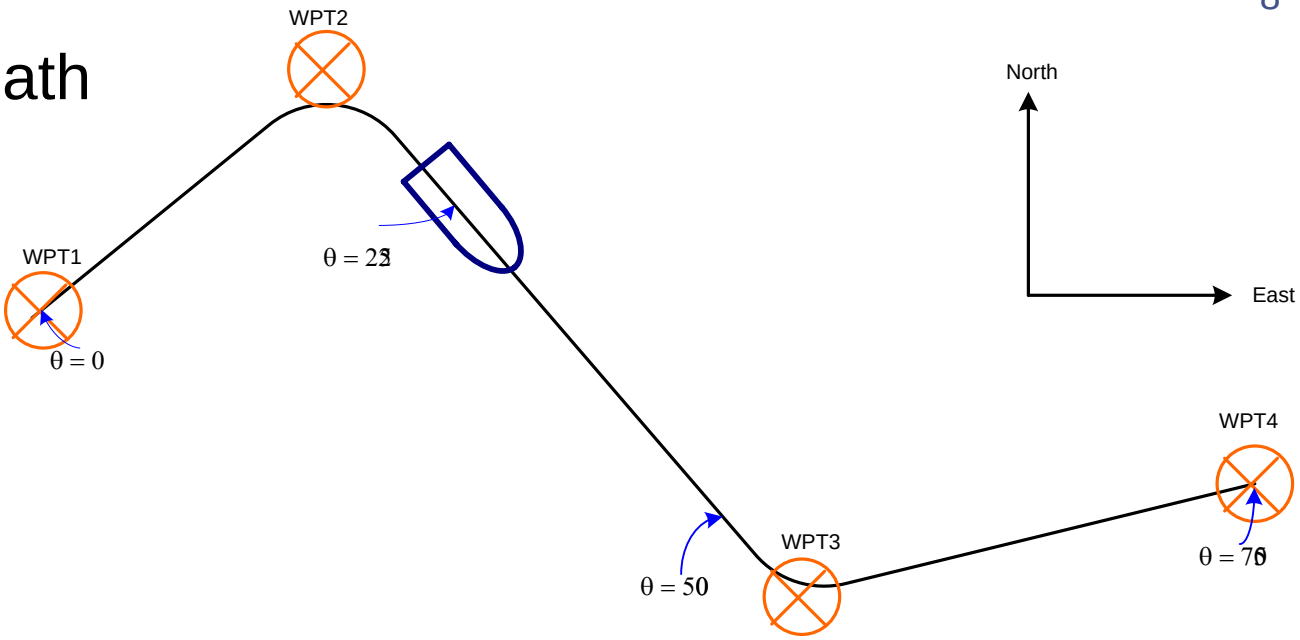
Parameterized path



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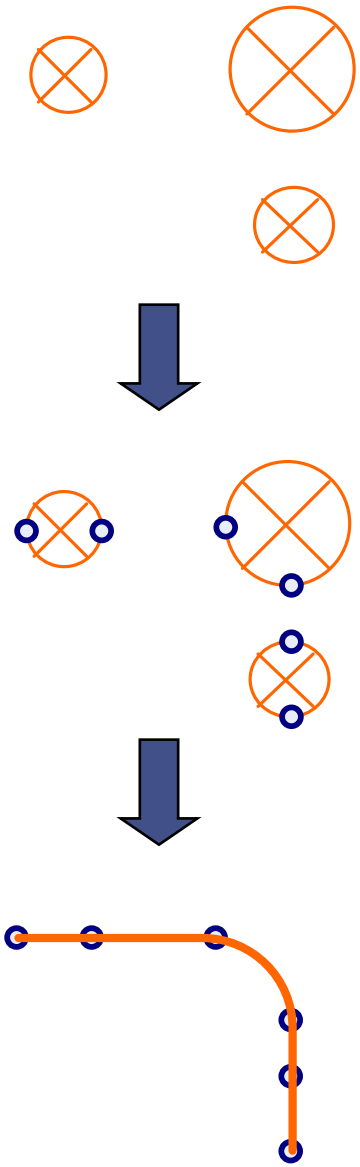
Path construction algorithm

1. **Find suitable path segment endpoints based on a list of waypoint location and acceptance radius.**

2. **Determine endpoint derivatives. Smoothness of the entire path follows by using similar endpoint values for path segments before and after endpoint.**

3. **Find polynomial representation for path segment using a suitable parameterization length.**



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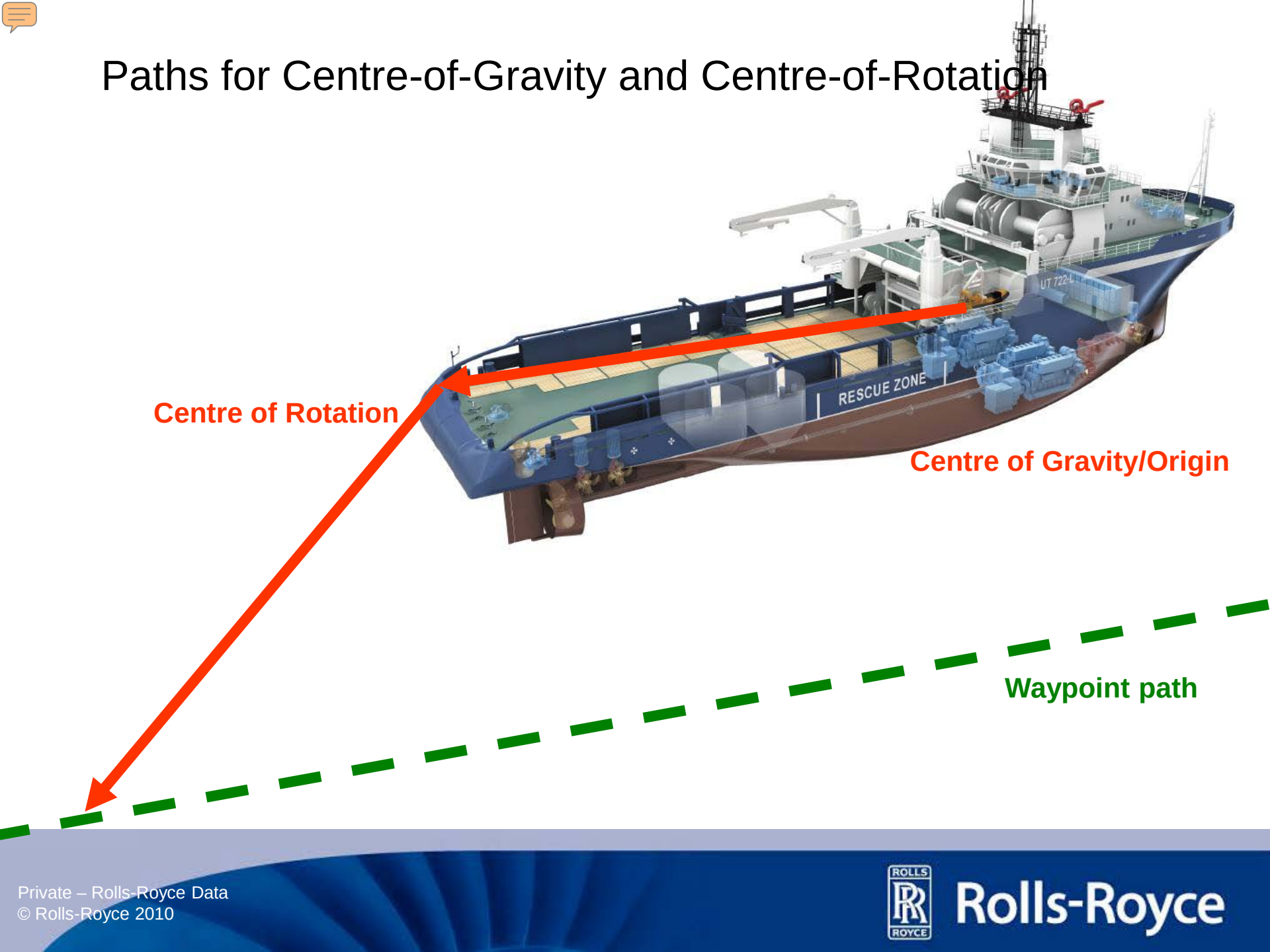
Paths for Centre-of-Gravity and Centre-of-Rotation



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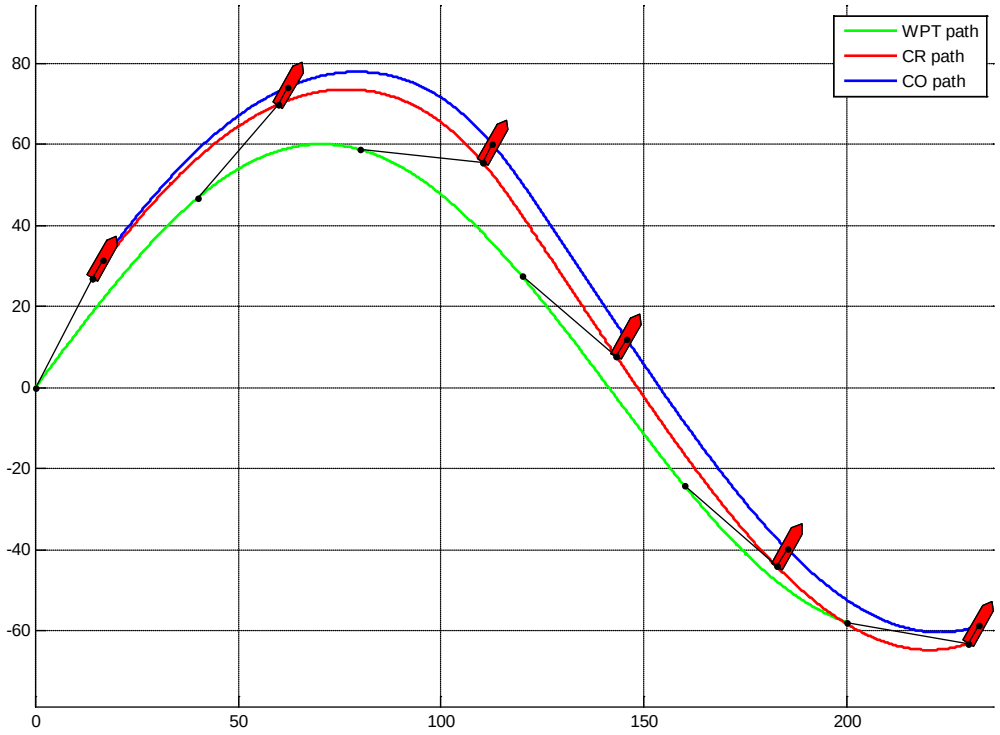
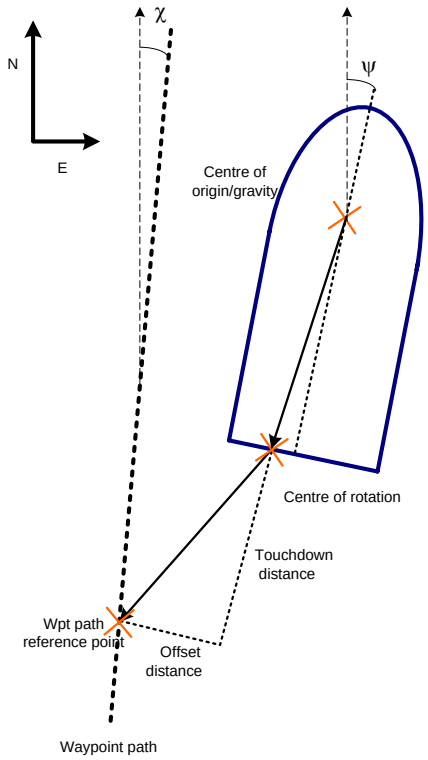
Paths for CG and CR

- **Path for the centre of rotation**
- **Path for the centre of gravity**





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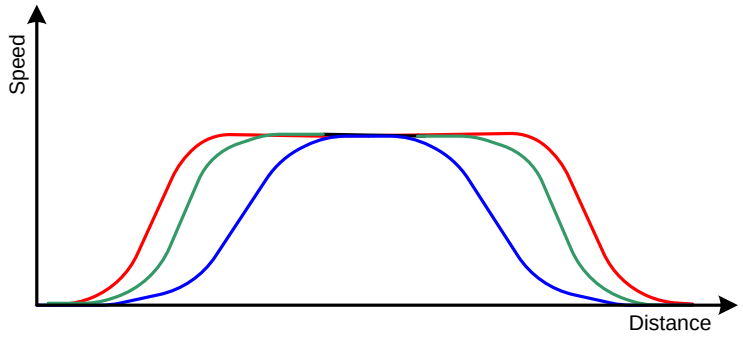
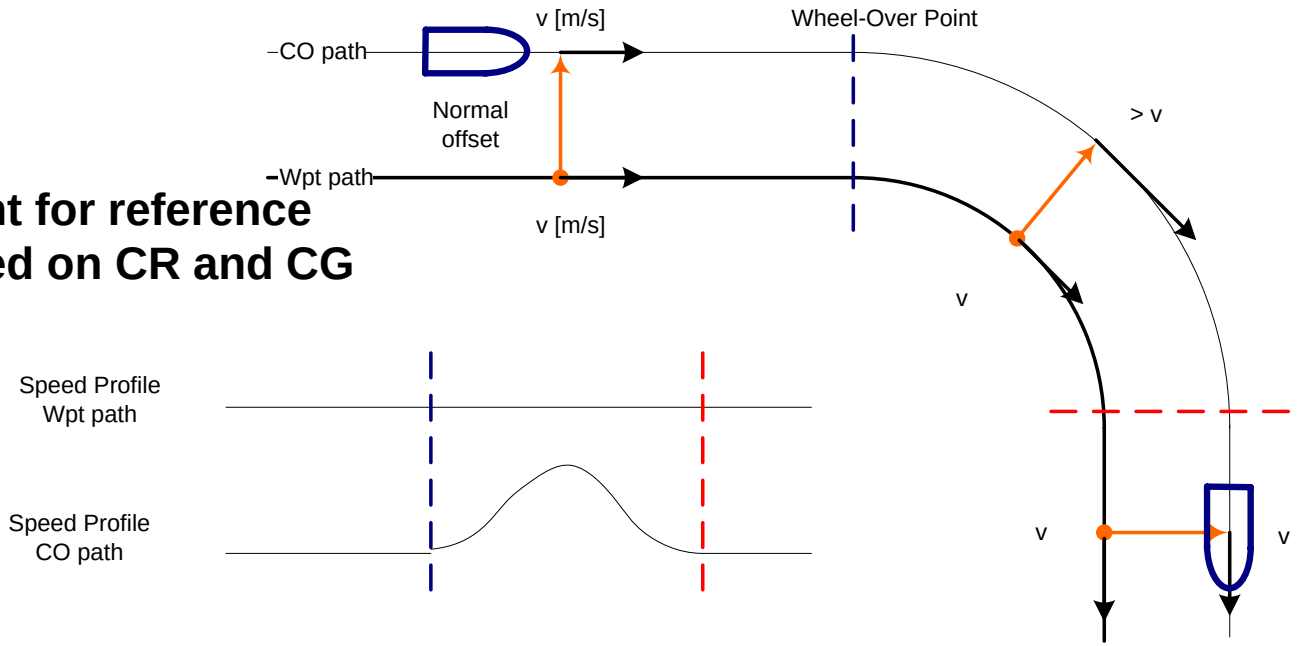
Path speed profile



- **Dynamic assignments on path:**
  - keep constant speed along path,
  - maintain a steady speed minutes
  - be at waypoint at time ,
  - complete track at minimum time, and
  - specified force for acceleration/braking

- **Speed assignment for reference point affects speed on CR and CG path**



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Combined path and speed profile information

- **New information enable us to:**
  - find speed and acceleration values on all paths
  - analyze path speed profile against limiting factors for entire waypoint, CR, and CO path.
  - detect conflicts between simultaneous operations
  - calculate new speed setpoints to eliminate conflicts

- **Some limiting factors**
  - vessel speed in turns,
  - rotation during heading change,
  - vessel speed/acceleration/rate limits,
  - reference point limits

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Example: Max speed vs vessel speed limits and heading change

- **Heading change (270 CW) during 90 turn**
- **Objectives:**
  - Follow WPT/CR path with a given speed
  - CO path speed within limits
  - Finish heading change before end of turn

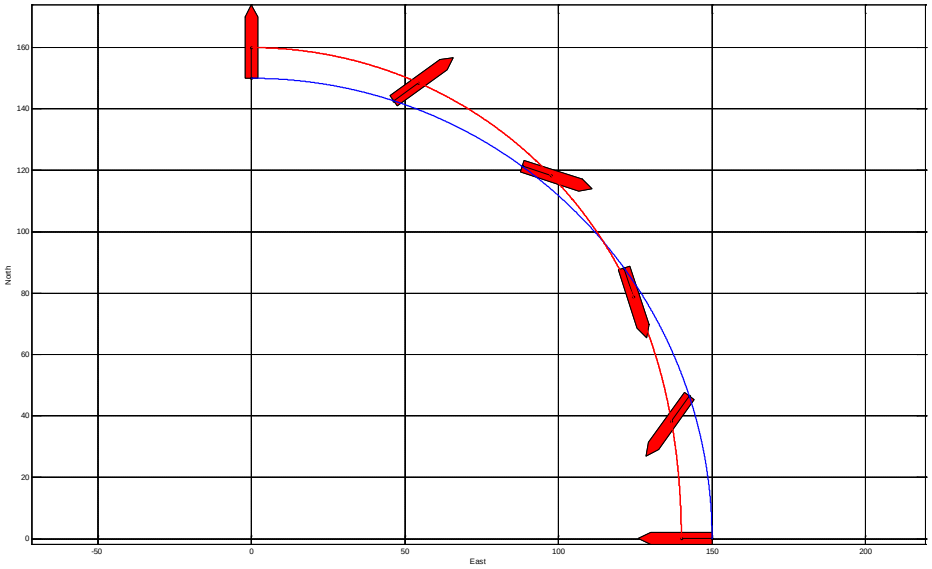
CR speed vs vessel speed limits:

Relate CO-CR path speed

Relate vessel speed and CR path speed

Use surge and sway limits

Find max path speed



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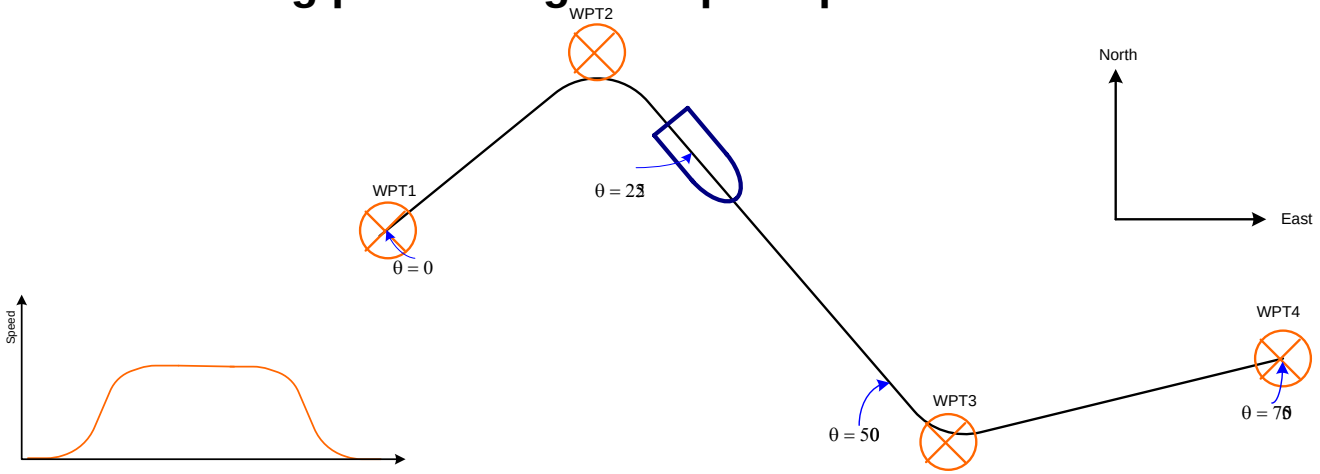
Path parameter update law

- **Steer reference model along path with given speed profile**



- **Reference model is inaccurate compared to real-life**
  - Vessel state feedback needed
  - Design mechanisms that ensures path parameter progress keeps up with vessel

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Operator Interaction

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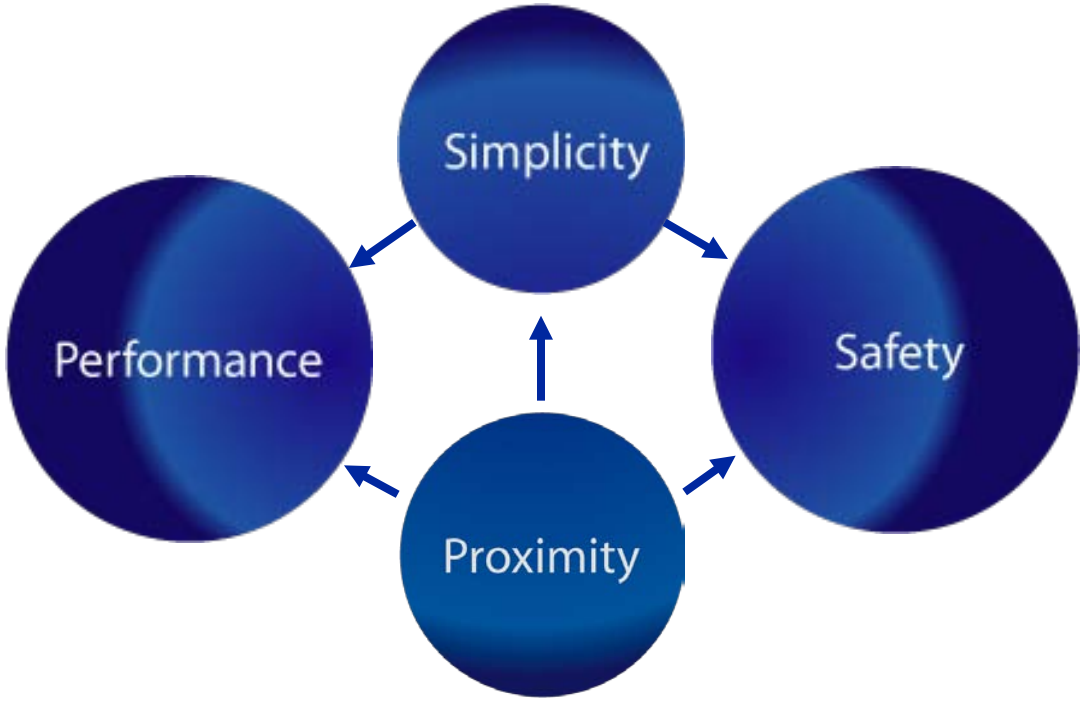
Design principles



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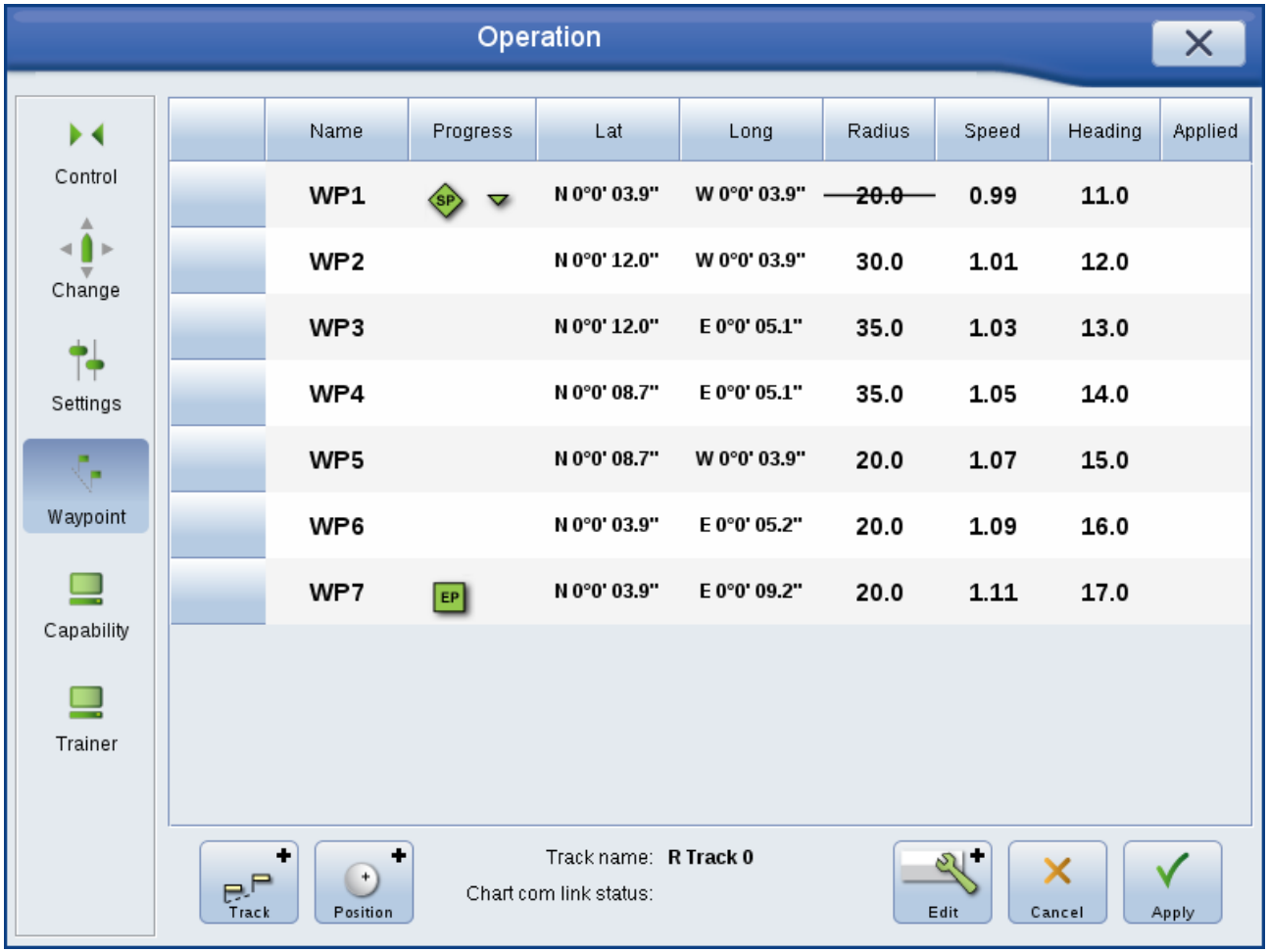
Waypoint Table



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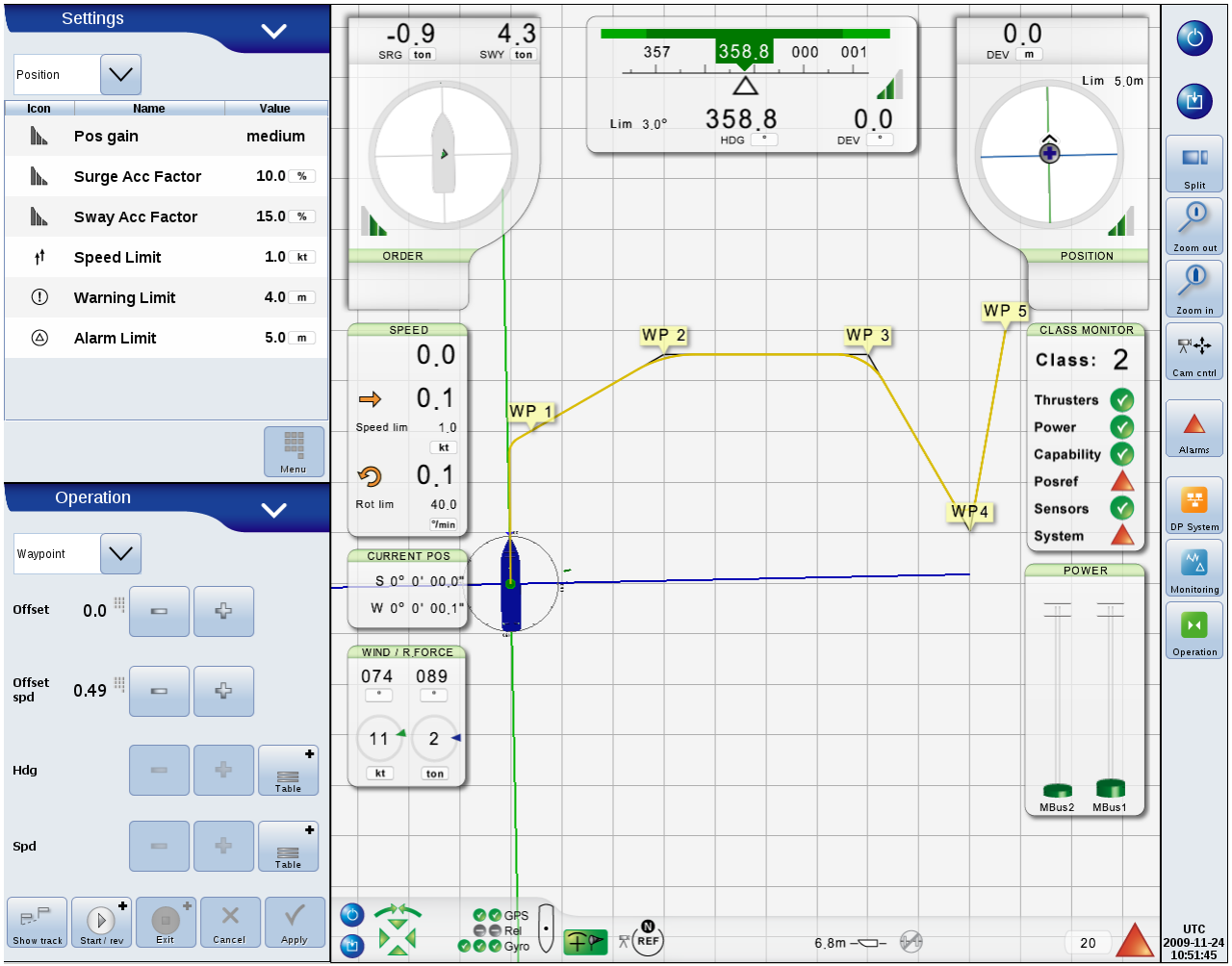
3D scene



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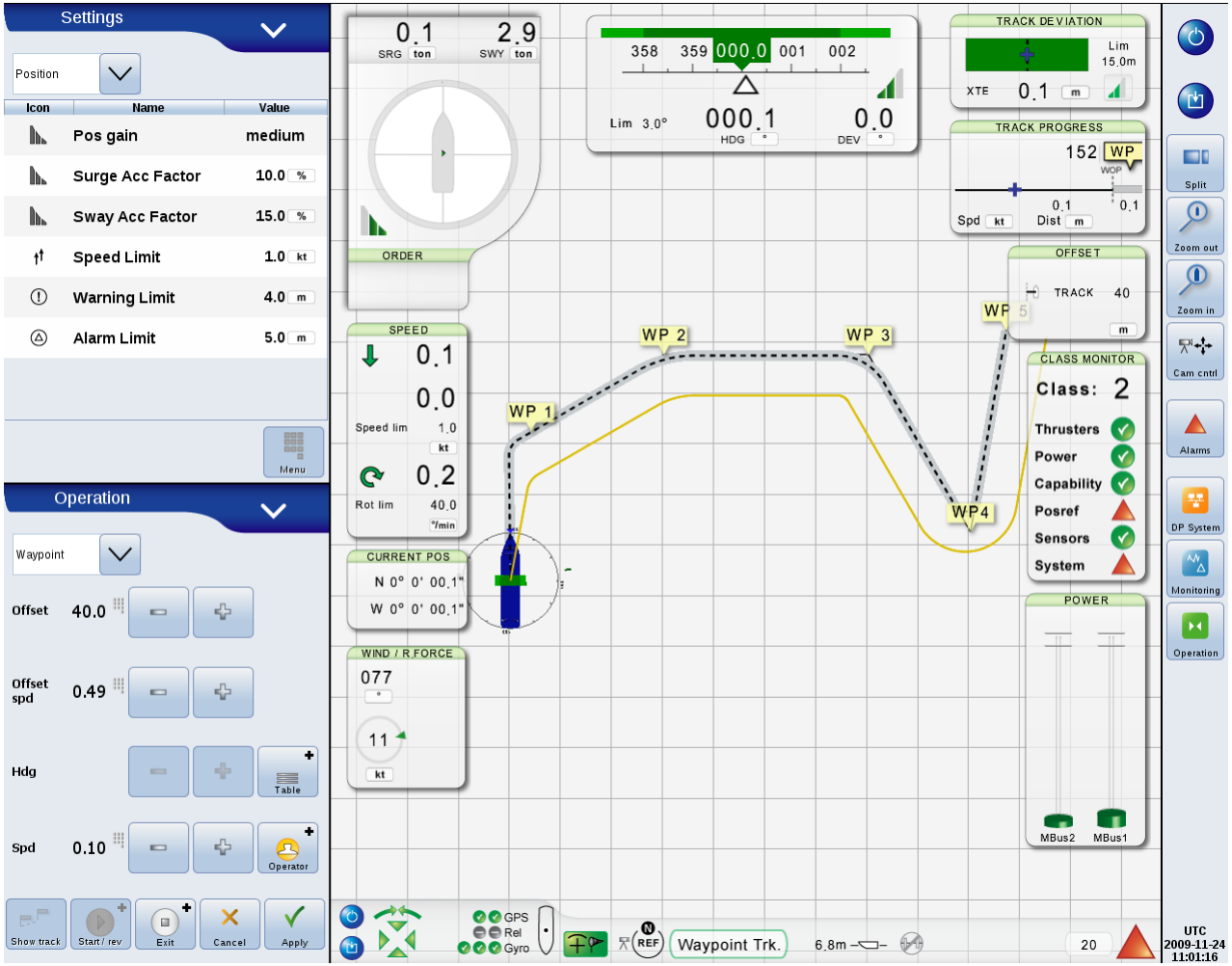
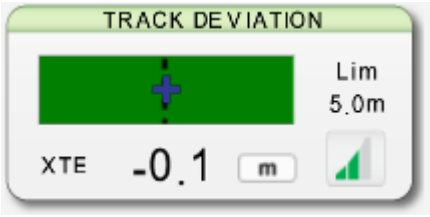
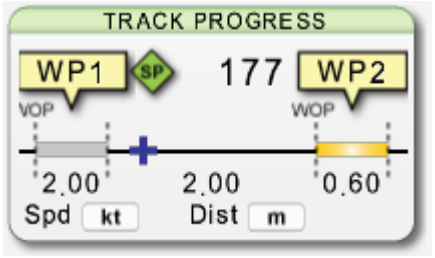
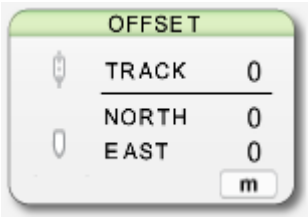
Operation-specific User Interface









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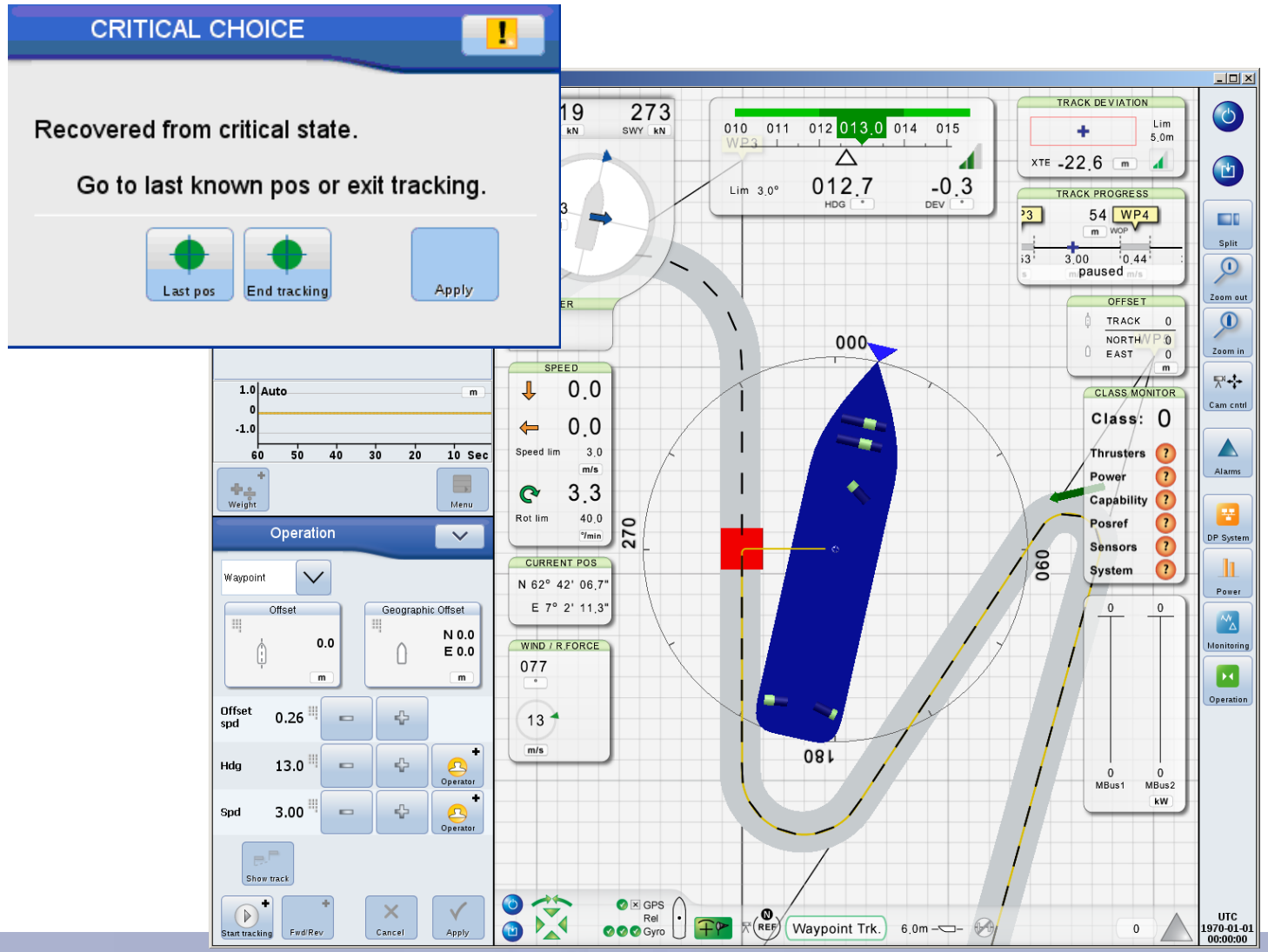
Error Handling



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