NAVIGATION OF BIG SHIPS IN PORTS AND WATERWAYS

– A CHALLENGE FOR NUMERICAL MODELLING –

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Introduction. 30 years have passed since the maritime world copied the idea of simulation from the aircraft industry to train navigators but it is only in the last few years that the power of this tool for serving port and waterway planning has been fully understood. However there are some shortcomings to be compensated for in order to enhance simulation of complex human – machine –environment systems in shipping. programs established in engineering are the product of a marriage between science and mathematics. Ship traffic infrastructure, i.e. ports and waterways, cannot become adequately adapted to the ever increasing ship sizes, thus maneuvering has become a true challenge. However, the potential hazards from ships colliding with other ships or infrastructures, or from grounding, do not allow for any kind of gambling. Port and waterway access policy by maritime administrations needs to be based on reliable assumptions of opportunities and risks. This is also in the interest of the shipping companies who accept neither excessive risks for their ships nor delays in the ships' extremely tight schedules. Whereas expanding existing ports requires lots of effort, new ports can more easily become adapted to current and future ship sizes. However the luxury of too spacious ports is extremely expensive and investors there-fore just want tailor-made ports fulfilling minimum requirements. Thus those minimum requirements must be determined.
Maneuvering of ships can be simulated by

- Scaled models, remote controlled, towed or manned
- Numerical fast time simulation
- Numerical real-time simulation.

Only real-time simulation allows for the complete human-machine-environment system. Manned scaled models are useful to elucidate hydro-dynamic effects but because the time constants are very different from real operations these models are not adequate to develop sophisticated maneuvering strategies. State of the art ship simulators provide a realistic, controlled environment, the ship's bridge, displaying computer-generated information on off the shelf equipment. Also the visible environment is computer-generated and projected to large screens surrounding the ship's bridge. Such simulators are used for investigation and training, however their suitability depends on the ability of the mathematical model to mirror ship motion characteristics. Usually this is achieved by parameterised model-ling of reality. To allow real-time behaviour even under highly dynamic conditions, not all forces are calculated numerically, just the influence of governing scalar parameters. Each degree of freedom of ship motion is covered by a differential equation where coefficients provide the particularities of an individual ship. Surge, sway and heave describe the motions along the three main axes (x, y, z) and roll, pitch and yaw the rotation around these axes. The degrees of freedom required for simulation depend on the complexity of simulation. For simple simulation tasks surge and sway as linear motions and yaw as rotation is sufficient. This approach works fine for deep water conditions at quasi-stationary speeds. It also allows some conclusions for port design or maneuvering strategies at unsteady speeds and within a restricted environment like a waterway or a port. There the ship's behavior is dependent on

- under keel clearance
- distance to banks
- presence of other ships to become overtaken or encountered
- propeller thrust
- rudder
- other propulsion or steering devices like podded (azimuth) drives or bow and stern thrusters
- dynamics of engine
- current pattern
- wind forces

to only list the most prominent ones.
The most advanced ship simulators provide plug-ins to replace an inherent mathematical model or sub-set by a more sophisticated one computed by an external processing unit.
The smaller margins of safety in maneuvering mean that simulation must mirror reality to allow its application as a reliable tool for port design. Current conditions for big ships in tight ports no longer allow for significant uncertainties.