Technology Implications for Marine Pilotage

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ClearSeas

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Challenges facing pilotage service delivery

- Safety of pilot transfers
- Aging workforce
- Long training
- Challenging working conditions
- Extreme weather
- Changing bathymetry and landscapes
- Bigger ships
- More traffic
- Increasing environmental protection measures
- More data

- *Technology (challenge and solution)*

Our Research Project

Understanding the Impacts of Technology on the Safety and Efficiency of Pilotage Service Delivery

The Research Objectives:

1. Characterizing progress in navigational safety technology over the past 50 years
2. Identifying advancements in pilotage technology and examples of best practices
3. Discovering emerging technologies that could be beneficial to a technology-enhanced pilotage service

The Research Team:

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Safety = safety of the pilots, safety of the ship, safety of the environment, safety of the public

Evolution of Navigational Technology

Image: Bochaca & Moal,
Le Grande Routier

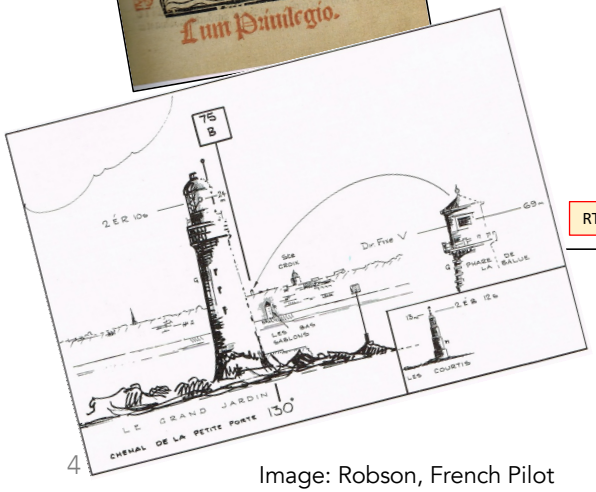
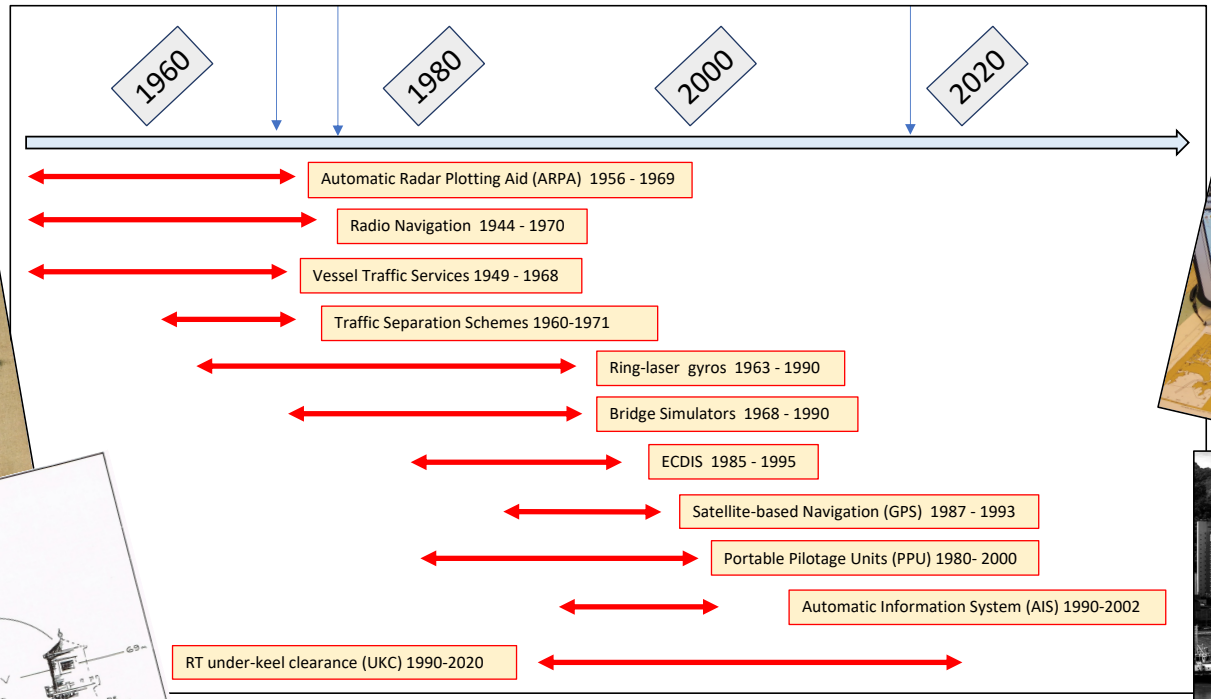
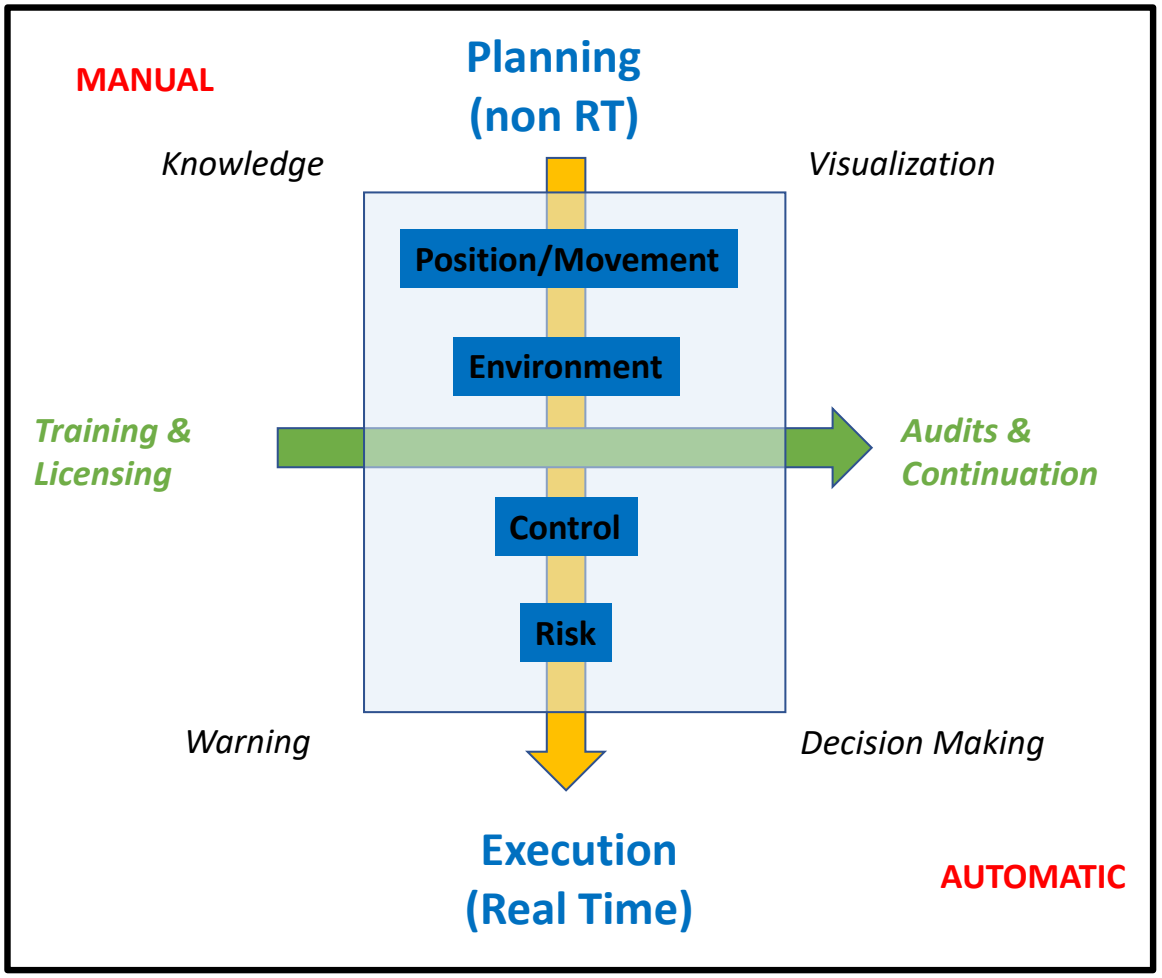


Image: Robson, French Pilot



Images: Navicomdynamics.com

Pilots' ***current*** techniques and tools range from ancient/traditional skills to cutting-edge technology



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Different perspectives on pilotage technology:

- Purpose
- Function
- Sequence
- Time domain
- Interface
- Automation

Jurisdictions Investigated:

- Canada (4 pilotage regions)
- Australia
- United States
- Chile
- Denmark
- Norway
- Finland

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Use Index 5 & 4: Technologies in almost universal use by pilots

Technology Item	Brief Description	Use Index	Implement-ation Level	Primary Functional Area	Secondary Functional Area	Specific Function
Navigation Software	Custom solutions for pilotage	5	Pilots	Execution	Planning	Pos/Mov
Automatic Info Systems (AIS)	A system for exchanging ship identities and navigational details through automated VHF radio messages	5	Ships	Execution	Planning	Envir
Portable digital VHF Radios	Hand-held units for communication with tugs	5	Pilots	Execution	Execution	Control
Tractor/tethered tugs	Modern tugs for ship-assist in harbour and tethered escort	5	Ports/PAuth	Execution	Training	Control
Improved pilot ladders	The most common pilot boarding method	5	Ships	Execution	Execution	Control
Portable Pilotage Unit (PPU)	Portable electronic navigation system with ENC	5	Pilots	Execution	Planning	Pos/Mov
ECDIS	Electronic Charting and Display System	5	Ships	Execution	Planning	Pos/Mov
Bridge Dials	Visual readouts of critical control indicators	5	Ships	Execution	Execution	Control
Radar	Radio Detection and Ranging	5	Ships	Execution	Planning	Risk
ARPA	Automated Radar Plotting Assistance	5	Ships	Execution	Planning	Risk
GPS/GNSS	Global Positioning System	5	State	Execution	Planning	Pos/Mov
S-57 ENC	IHO Standard for Electronic Nautical Charts	5	IMO	Execution	Planning	Envir
Pilot Plug	Connection to ship's AIS or VDR feed for positional, attitude or contact information	5	Pilots	Execution	Execution	Pos/Mov
Echo Sounders	Sounds the depth below keel immediately beneath the ship	5	Ships	Execution	Planning	Risk
Full Mission Bridge Simulators	Simulators for training and continuing certification of pilots.	5	Ports/PAuth	Training	Certification	Control
Internet connectivity	Wireless connectivity to the WWW	5	Ports/PAuth	Execution	Planning	Envir
Autopilots	Automated steering assists in ships	5	Ships	Execution	Execution	Control
Real Time Kinematic (RTK) Positioning	Independent pilotage unit provides refined positional info.	4	Pilots	Execution	Execution	Pos/Mov
Virtual AtoN	Uses AIS to mark dangers with or without physical marks	4	Ports/PAuth	Execution	Planning	Envir
Rate of Turn (ROT) Generator	This function of the pilot plug determines change of heading rate	4	Pilots	Execution	Training	Pos/Mov
RT UKC	Real-time sensors and squat calculation give actual/forecast draft	4	Ships	Execution	Planning	Risk
VTMS	Integrated surveillance, tracking and communications systems for marine traffic control	4	Ports/PAuth	Execution	Planning	Envir
Scale model vessels	Use of manned models for training pilots	4	Ports/PAuth	Training	Certification	Control
Pilot assignment software	Software to help schedule pilots for maximum efficiency	4	Ports/PAuth	Planning	Execution	Control
Voyage data recorder	Automatically logs critical voyage parameters for post-voyage analysis	4	Ships	Execution	Planning	Control
e-Navigation portals	One-stop shopping for information relevant to navigation	4	Ports/PAuth	Planning	Execution	Envir
Optimum ship routing	Routing advice to ships to minimize weather delays/damage	4	Ships	Planning	Planning	Envir

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Use Index 3-1: Enhancing and/or Emerging Technologies not in widespread or common use

RT Air Draft	Real-time sensors measure and transmit actual bridge height above water	3	Ports/PAuth	Execution	Planning	Envir
RT Tidal Current Info	Real Time sensors provide actual current data	3	Ports/PAuth	Execution	Planning	Envir
RT Wind and Sea data	Real-time sensors provide actual wind and sea state	3	Ports/PAuth	Execution	Planning	Envir
RT Water Levels	Sensors monitor and broadcast reference water levels	3	Ports/PAuth	Execution	Planning	Envir
Dynamic positioning, joystick control	Single-point manoeuvring controls for ships	3				
Helicopter pilot delivery	Helicopters transfer pilots onboard by landing or hoist	3	P			
Improved pier/fender systems	Advances in materials and sensing	3	P			
Fwd looking E/S	Transducers trainable in elevation and azimuth to read water depths other than beneath the ship	2				
Ergonomic Bridge design	Design of bridges for optimum visibility, mobility and bridge resource management	2				
Independent Advanced Positioning	Integrated systems provide redundant hi-accuracy position and orientation	2				
Millimeter wave radar	Use of EHF radar for short-range, high accuracy detction and ranging	2				
Automatic electro-optical detection of hazards	Use of FLIR or LLTV units to detect possible small contacts of concern	2				
RT Bathymetry	Real time sensors provide actual bottom profiles	2	Po			
Automatic berthing systems	Automatic ship-control for hands-off berthing	2				
Wave Analyzer Display	Use of advanced processing to analyse and display wave patterns	2				
RT MM detection	Systems to detect, track and alert ships to the presence of whales	2	Po			
3-D Display of Bathymetry	bottom topography imaged as a full-colour 3-D display	2				
Crowd-sourced bathymetry	The collection of unverified depth data from vessels of opportunity to compile a comprehesive database of safely executed tracks	2	State	Planning	Execution	Envir
ENC - S100 series layers	IHO's new schemes of layers for advanced data input to ECDIS	1	IMO	Execution	Planning	Envir
GIS for ice risk assessment	Software calculates POLARIS risk assessment using ice charts	1	Pilots	Planning	Execution	Risk
AI solutions for collision avoidance	AI-enabled decision aids	1	Ships	Execution	Training	Risk
VSTOL Pilot Transfer Arrangements	Physical/operational means of getting pilots on and off ships	1	Ships	Execution	Execution	Control
Mobile (AI) application assessment of ice	App uses AI to visually observe ice, analyse and calculate POLARIS risk assessment	1	Pilots	Execution	Training	Risk
Heads-up displays	Use of presentation technologies to combine situational information with navigational/control data to facilitate the tasks of navigation	1	Ships	Execution	Training	Pos/Mov
AI-driven ship scheduling	Use of AI and remote monitoring to accruately forecast and schedule berthing times	1	Ports/PAuth	Execution	Planning	Pos/Mov
Control for MASS/ Remote Pilotage	Shore-side operations centres provide terminal control for arriving/departing autonomous vessels	1	Ports/PAuth	Execution	Training	Control
Comprehensive risk assessment	Use of comprehensive databases to be able to look at risks as statistical averages	1	State	Planning	Execution	Risk

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Implentation Level		Functional Area			
		Pos/Mov	Envir	Control	Risk
	Pilot	2. Portable Pilotage Units		31. Portable Digital VHF	51. GIS for Ice Risk Assessment
		3. Navigation Software			52. Mobile AI App for Ice
		4. Pilot Plug			
		6. ROT Generator			
		7. RTK Positioning			
	Ship	5. ECDIS	12. AIS	35. Autopilots	47. Radar
		8. Indep. Advanced Position	17. Optimum Ship Routing	36. Bridge Dials	48. ARPA
		9. Heads-up/AR Display	23. Wave Analyzer Display	38. Voyage Data Recorder	50. RT UKC
			26. Forward-looking E/S	40. Dynamic Positioning	53. AI Collision Avoidance
			27. 3-D Display of Bathymetry	41. Improved Pilot Ladders	49. Echo Sounders
			28. mm Wave Radar	44. Ergonomic Bridges	
			29. E/O Detection of Hazards	45. Automatic Berthing	
	Port	10. AI Ship Scheduling	13. VAtoN	32. Tractor/Tethered Tugs	
			14. VTMS	33. FMB Simulators	
			15. Internet Connectivity	34. Manned Model Training	
			16. e-Navigation Portals	37. Pilot Assignment Software	
			18. RT Water Levels	39. Pier/Fender Systems	
			19. RT Air Draft	42. Helicopter Pilot Delivery	
			21. RT Bathymetry	43. VSTOL Pilot Vehicles	
			20. RT Tidal Current	46. Control Ctr for MASS/RP	
			22. RT Wind and Sea		
			24. RT Marine Mammal Detect		
	State	1. GPS/GNSS (DGPS)	25. Crowd-sourced Bathymetry		54. Comprehensive Risk Assess.
	IMO		11. S-57 ENC		
			30. S-100 Series ENC		

What Technology can be implemented,

By Whom,

For what Purpose?

Baseline
Enhancing
Emerging

Technology Matrix

New Ser #	Technology Item	Brief Description	Use Index	Implement-ation Level	Primary Functional Area	Secondary Functional Area	Specific Function	Maturity	Cost	Benefit to safe pilotage	Benefit/ Cost	Ease of Use	Implementation Risk	Remarks
1	GPS/GNSS	Global Positioning System	5	State	Execution	Planning	Pos/Mov	5	1	5	1.0	5	5	Is pervasive for martime, air and terrestrial navigation. GPS is single source (US) and GNSS is multiple source receivers (US, EU, Rus, PRC satellite systems)
2	Portable Pilotage Unit (PPU)	Portable electronic navigation system with ENC	5	Pilots	Execution	Planning	Pos/Mov	5	4	5	2.5	4	5	Uses common commerically-available computer tablet technology, married with navigational software, independent positioning and ship-attitude inputs
3	Navigation Software	Custom solutions for pilotage	5	Pilots	Execution	Planning	Pos/Mov	5	5	5	5.0	4	5	Commercially provided by companies such as Wartsila, Trelleborg, TRANSAS, NAVSIM, SEAiq …

Drop-down List Choices

Use Index	Implement-ation Level	Primary Functional Area	Secondary Functional Area	Specific Function	Maturity	Cost	Benefit to safe pilotage	Benefit/ Cost	Ease of Use	Implementation Risk
1	Pilots	Training	Training	Pos/Mov	1	1	1	1	1	1
2	Ships	Certification	Certification	Envir	2	2	2	2	2	2
3	Ports/PAuth	Planning	Planning	Control	3	3	3	3	3	3
4	State	Execution	Execution	Risk	4	4	4	4	4	4
5	IMO				5	5	5	5	5	5

Subjective/Relative Criteria of Comparison

Score	Short	Use Index	Maturity	Cost	Benefit to safe pilotage	Efficiency (Effect/Cost)	Ease of Use	Implementation Risk
1	VL	Rare	Basic Principles - Tech Concept	>$10M	Marginal benefit	0.2	Difficult, complex	Major change, difficult, indeterminate, doubtful
2	L	Occasional	Proof of Concept - Validation	>$1M	Some improvement	0.6	Significant training reqd	Involved, complex, lengthy, uncertain
3	M	Frequent	Laboratory Protoype Demo	>$100K	Modest improvement	1	Moderate training reqd	Progressive, careful, medium, confident
4	H	Common	Operational Prototype Demo	>$10k	Significant improvement	3	Some training reqd	Incremental, natural, quick, likely
5	VH	Universal	Technology Deployed	<$10k	Key technological improvement	5	Intuitive, natural	Straight forward, easy, immediate, certain

Note: all comparison criteria are subjective, ROM estimates/judgements in order to provide a rough "sort" of data

Best Opportunities for Improvement

What has least current usage and best prospective benefit?

Use Index	Benefit 1	2	3	4	5	Grand Total
1	1	4	3	1		9
2	2	2	5	1	1	11
3			1	1	5	7
4	1		3	4	2	10
5	1		1	3	12	17
Grand Total	5	6	13	10	20	54

AI solutions for collision avoidance
ENC - S100 series layers
GIS for ice risk assessment
VSTOL Pilot Transfer Arrangements

Automatic berthing systems
Automatic electro-optical detection of hazards
Ergonomic Bridge design
Fwd looking E/S
Independent Advanced Positioning
Millimeter wave radar
RT Bathymetry

Dynamic positioning, joystick control
Helicopter pilot delivery
Improved pier/fender systems
RT Air Draft
RT Tidal Current Info
RT Water Levels
RT Wind and Sea data

Note: all comparison criteria are subjective, ROM estimates/judgements in order to provide a rough "sort" of data

Systems of Systems Technology

Augmented Reality Bridge

Source: Wollebaek

- Safe conduct of the ship
- Ship-based investment

Maritime Autonomous Surface Ships (MASS)

Image: infomaritime.eu

- Economic goods movement
- Ship & Shore -based investment

Shore-Based Pilotage

- Safe and efficient conduct of the ship
- Ship & Shore-based investment

Advanced Vessel Traffic Management

Image: Kongsberg

- Efficient and safe flow of traffic
- Shore-based investment

Conclusions:

- Technology is advancing rapidly
- Not all technology will be present in all ships
- More technology is not necessarily better
- Pilots continue to use traditional skills alongside advanced technology
- Perfect confluence of technologies will enable/is enabling Shore Based Pilotage and Autonomous Ships
- This will not eliminate the need for skilled and experienced marine pilots

In systems of systems, even with automation, interface with operators ashore will remain critical for safe marine pilotage

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Questions?

Read the research report

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