Navigation at sea - Changes

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Navigating the changes ...

Mainly taking a look at how ships' navigation will change over the next 20 years

– the following 20 years is rather more difficult ...

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My interpretation of navigation

“The timely departure and arrival of vessels between specified locations at the lowest overall cost whilst meeting defined levels of safety and environmental protection”

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The main drivers

Increasing:

Safety

Environmental protection

Timeliness

Decreasing:

Costs

Total time

Primary responsibilities:

Industry

Governments

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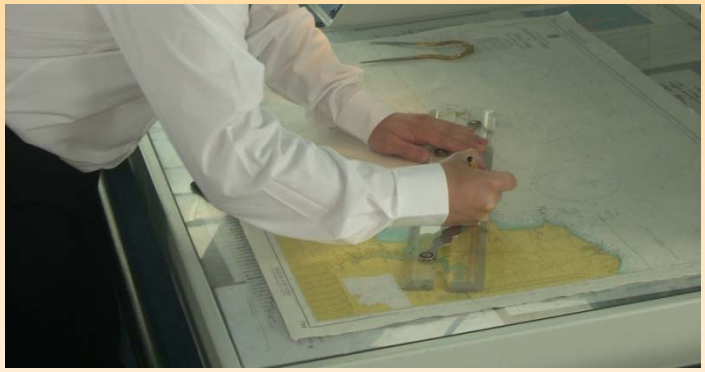
The situation 20 years ago

In 1993

- GNSS around – but no global coverage
- GMDSS in infancy
- No ECDIS
- No AIS



- No radar tracking on most vessels
- No track keeping autopilots
- Virtually no bridge computers

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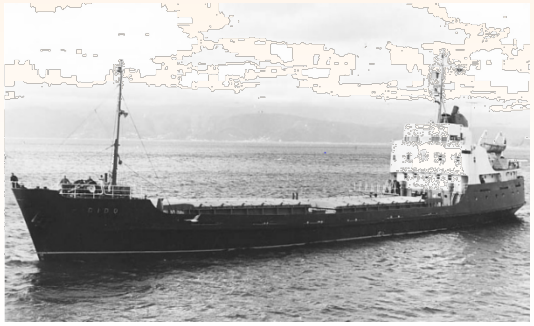
40 years ago - 1973

- Still under IMO's 'first' SOLAS (1960) ...
- Navigational requirements very limited, eg for:
  - Radiotelegraph station (Morse code)
  - Signalling lamps
  - Radiodirection finders
  - Weather charts mentioned – but not of navigational charts ...
  - Greater dominance of national regulations
- Available equipment included:
  - Logs, magnetic compasses, etc
  - Decca/Loran
  - Fairly primitive radar displays and processing,

40 years ago is a long time ...



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So what about the next 20 years?

Dominated by increases in integrity and efficiency

Integrity improvements

- Position & motion assessment of own and other vessels
- Onboard detection and depiction of uncharted dangers
- Automated receipt of up-to-date and timely navigational data
- Use of advice from automated assessment systems

Enabled by the e-navigation concept

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So what about the next 20 years? (2)

Dominated by increases in integrity and efficiency

Efficiency

- Aimed at better customer satisfaction and lower costs
- Intelligent real-time route and speed determination
- Firm links to integrated logistics data systems

Enabled by the e-navigation concept
– and investment in commercial systems

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Relevant mainstream developments

Include:

- Artificial intelligence
- System integrity
- Energy efficiency

Implies

- Increasing automation over all transport sectors
- Likely to change public perception to:

"Automation is the safe and green approach"

Likely to have significant impact on maritime within 20 years

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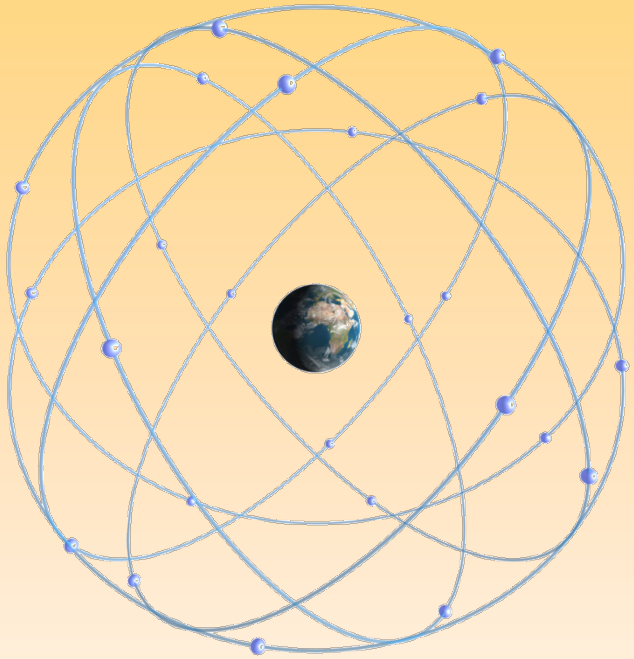
High integrity positioning

Protection required from:

- On board equipment failures
- External system failures
- Unusual natural conditions
- Unintentional interference
- Jamming
- Spoofing



All RF-based positioning systems can suffer from these

Must [continue to] use parallel methods of positioning
– and utilise the benefits of using appropriate non-RF systems

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RF positioning systems

GNSS:

- GPS, GLONASS, Galileo, BeiDou
- All capable of being enhanced by Satellite Based Augmentation Systems, eg WAAS, EGNOS
- SBAS is likely to replace ground based systems (eg DGPS)

Terrestrial station-based systems:

- eLoran (VLF)
- Systems based on use of existing communications transmissions
  (‘Sort of’ automatic radio position fixing on transmitters of opportunity)

Fixes on radar-identified charted objects

- Now - human operator
- In the future - automated systems, perhaps based on ‘active’ targets

Non-RF positioning systems

Fixes on visually-identified charted and celestial objects

- Now - conventional visual sights by humans
- Into the future - automated systems?

DR/EP based systems

- Mainly now based on human calculation
- DR/EP functionality already exists as a little known feature of ECDIS – enables automated use of inputs from log, gyro, etc
- Inertial systems based on micro-electromechanical (MEM) and micro-fabrication technology. Favoured by the military as the future solution to GNSS backup

Positioning in the next 20 year? (1)

- Main source will be multi-system GNSS receivers, with at least two separate multi-system receivers being fitted to every ship

– with automatic comparison and jamming/interference detection

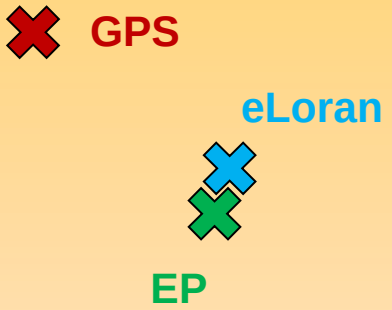
- SBAS will inevitably become available over a wider area and will probably become favoured for maritime
- The jamming of GNSS by individuals is likely to become a major crime if it ever truly threatens maritime and aircraft safety
- There will be some regional uptake of eLoran – a good solution but needs multi-government funding and good regional cooperation

Positioning in the next 20 year? (2)

- Advanced inertial sensors will become the main backup to GNSS once they can affordably give ‘several hours’ of reasonable positional accuracy after a GNSS problem
- The ship’s integrated navigation system will sort out the best positioning from the available inputs
- Radar precise positioning possibilities requiring additional infrastructure are unlikely to be implemented

– but the automatic correlation of the radar image with ECDIS data may become commonly used to alert for positional offsets

Keep in mind...



- That is takes three independent sources of position to decide which positional system has gone awry
- Two will just show that there is a discrepancy – not necessarily which one is correct – but nevertheless very useful to know
- Systems like eLoran significantly help but are not the complete solution
- Integrated Navigation Systems (INS) using multiple sources will increasingly be able to automatically determine potential problems and give a real-time estimation of positional accuracy

INS is needed for high positional integrity

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AIS – and high integrity positioning

- On the face of it – good for AIS
- BUT the AIS raw signal is of very low integrity
- Always been known but ignored by many
- Last week, at a conference sponsored by Microsoft, Facebook and others, it was announced that:

"We have been able to hijack and perform man-in-the-middle attacks on existing vessels, take over AIS communications, tamper with the major online tracking providers and eventually fake our own yacht!"

Dr Marco Balduzi, et al, HITB Security Conference

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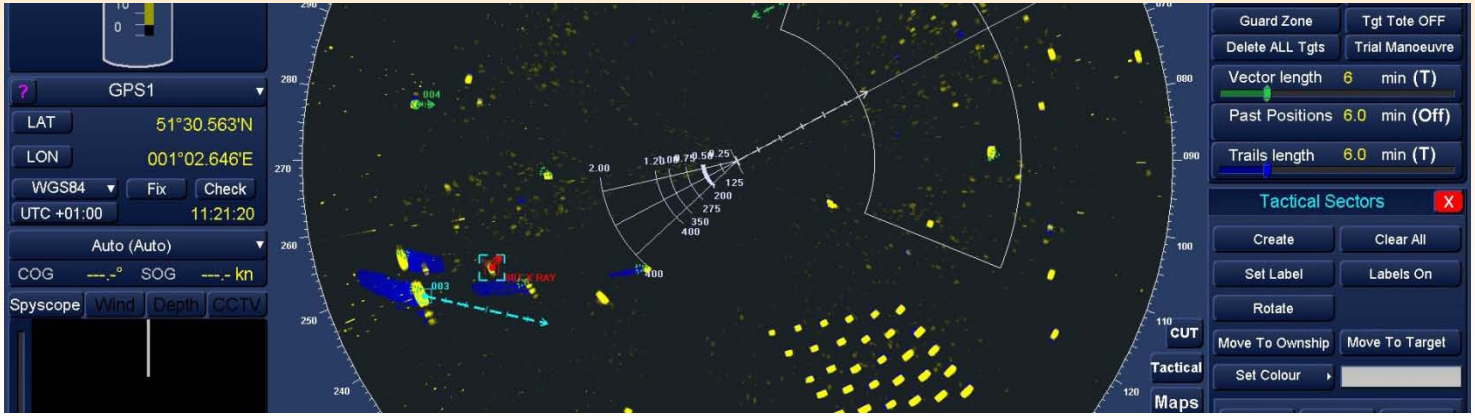
AIS and Radar

- Need to move to higher capacity, higher integrity AIS
- Implies better use of VHF (and other) radio bands
- High integrity AIS will then become the main system for collision avoidance
- Radar will be primarily used for the detection of other hazards
  - Vessels with non-fitted or non-working AIS
  - Floating debris and ice
  - and for automated assistance with enhancing positional integrity



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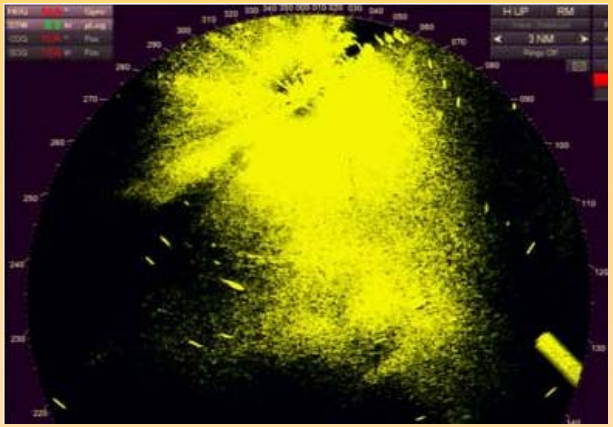
Future radar



- Existing marine radars meet users' expectations but not their needs
  - "You can't expect radars to detect small targets in rough seas and in heavy rain"
- BUT existing technology, can do a lot better, especially in sea clutter
- Users, companies and legislators will wake up to this in a few years time

Advances in coherent radar technology will make this affordable

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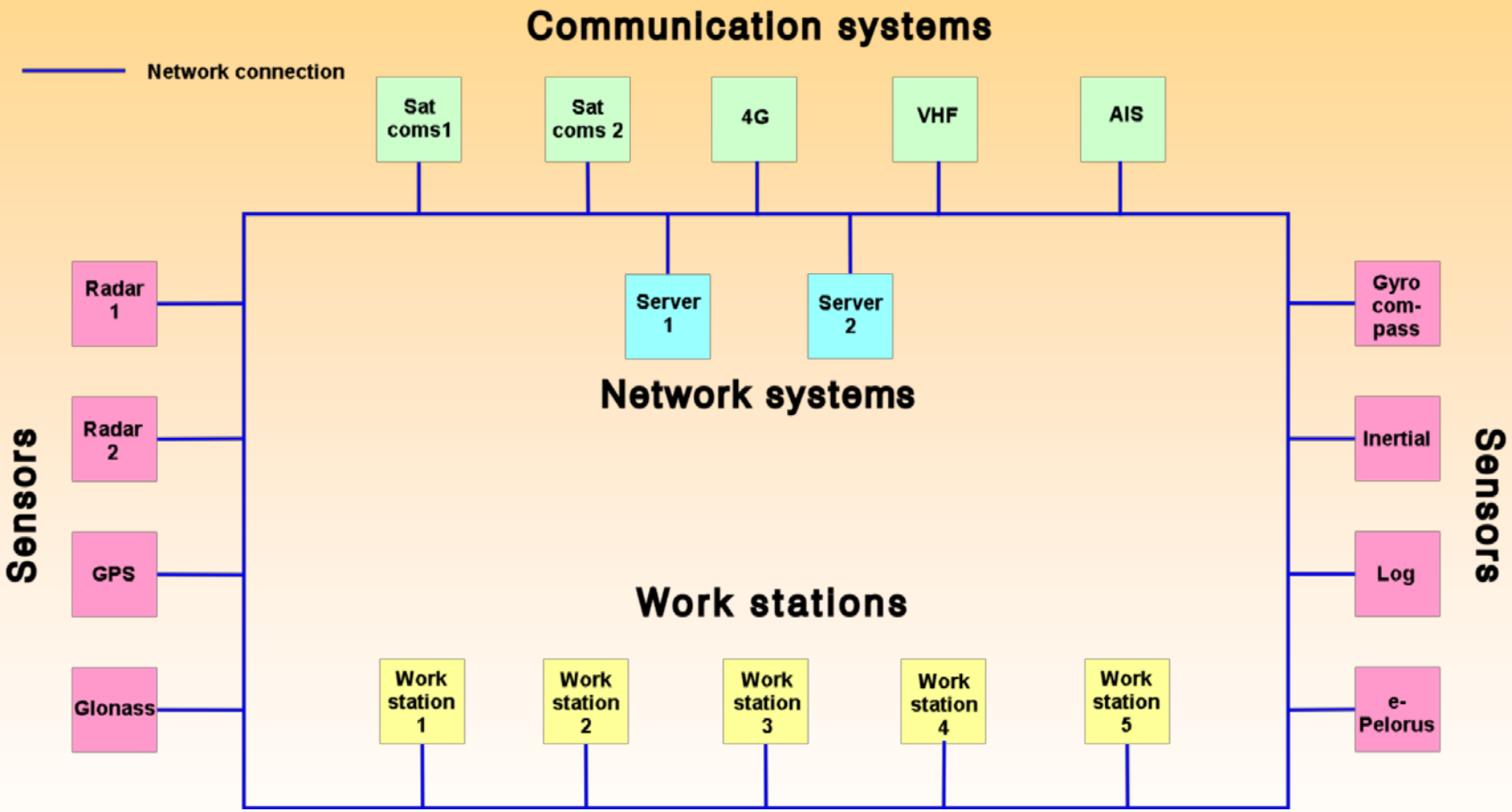
Communications

- Maritime communications are generally far behind the times – except the newer satellite systems
- A digitally connected maritime world is essential to lower costs and raise safety, environmental protection and business efficiency
- The present use of the maritime VHF FM band is inefficient and generally inconsistent with the needs of digital services
- Expect to see:
  - Steady increase in use of satcoms
  - Permitted use of satcoms for ‘statutory’ communications
  - Permitted use of commercial networks eg 4G, in coastal waters
  - Phased revamp of VHF into a fully digital band
  - Phased move to the ‘maritime cloud’

The emerging bridge concept



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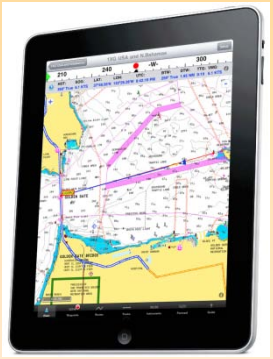
The user interface (1)

- A continued move in the direction of multifunction displays
- The use of portable displays for information when on bridge wings, etc
- Growth in specialised ‘apps’ for more efficient navigation
- Greater standardisation of the ‘basic building blocks’ of the user interface for navigation and communication (S Mode)



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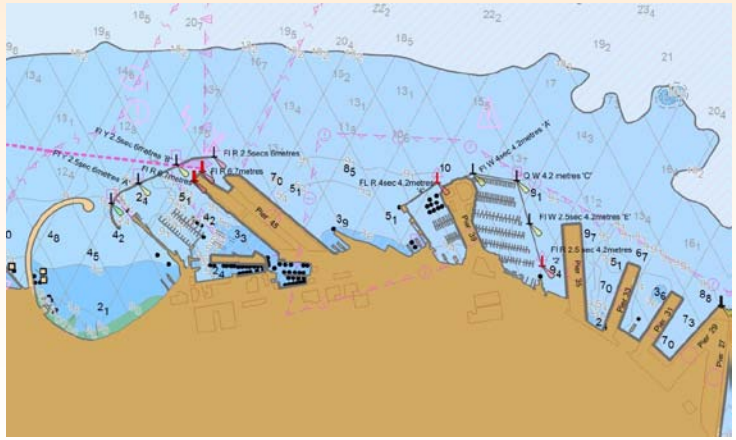
The user interface (2)

- Use of displays and associated systems to enhance the visual and underwater view of the current situation, including direct comparison with charted information
- Huge improvements in providing necessary information to mariners, including the prevention of distracting information – expert systems
- An inevitable but gradual move away from the ‘navigating’ navigator to the ‘monitoring’ navigator



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The building blocks

The next 20 years will be dominated by base technology and knowledge available now, eg:

- Digital communications
- Sophisticated antenna technology
- Advanced artificial satellite capability
- High definition flat panels
- Advanced HMI concepts
- High integrity web infrastructures
- Advanced digital processing
- High integrity design & manufacture of systems and software
- Complex database design

The notable lack of required base technology is in affordable and accurate inertial sensors

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Maritime coordination for change

Primarily through:

- IMO's enavigation programme
- IALA's enavigation thinking
- National/regional programmes supporting enavigation
- IHO's S-100 and S-101 'advanced database' structures
- ITU's radiocommunications coordination

However, gaining international coordination of highly detailed concepts is the difficult part – the way forward is fraught ...

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Conclusions ...

- Change will be inevitable because of external pressures on the industry
  - Just part of the growing integrated logistics chain
  - Electoral pressure of safety and ‘greenness’ on governments
  - Non-availability or excessive cost of the old technology for doing things
- The cost of retraining bridge staff for the digital world is considerable
  - If not tackled or possible it will just bring forward the inevitable move to the ‘monitoring navigator’ – the step before full automation
- Company and end user groups should contribute to ensuring that the maritime digital world is aligned with safe and efficient navigation – it will not go away ...

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