Maritime Integrity Requirements

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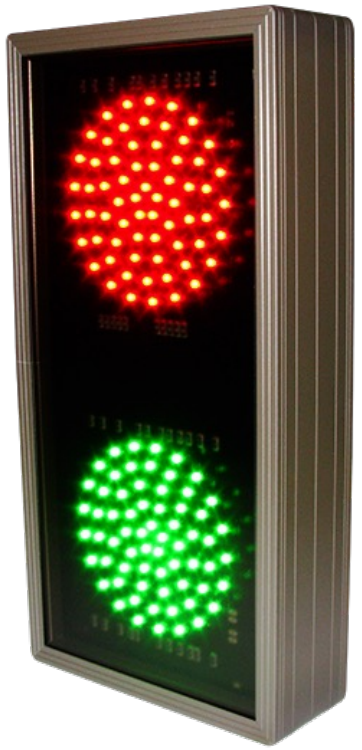
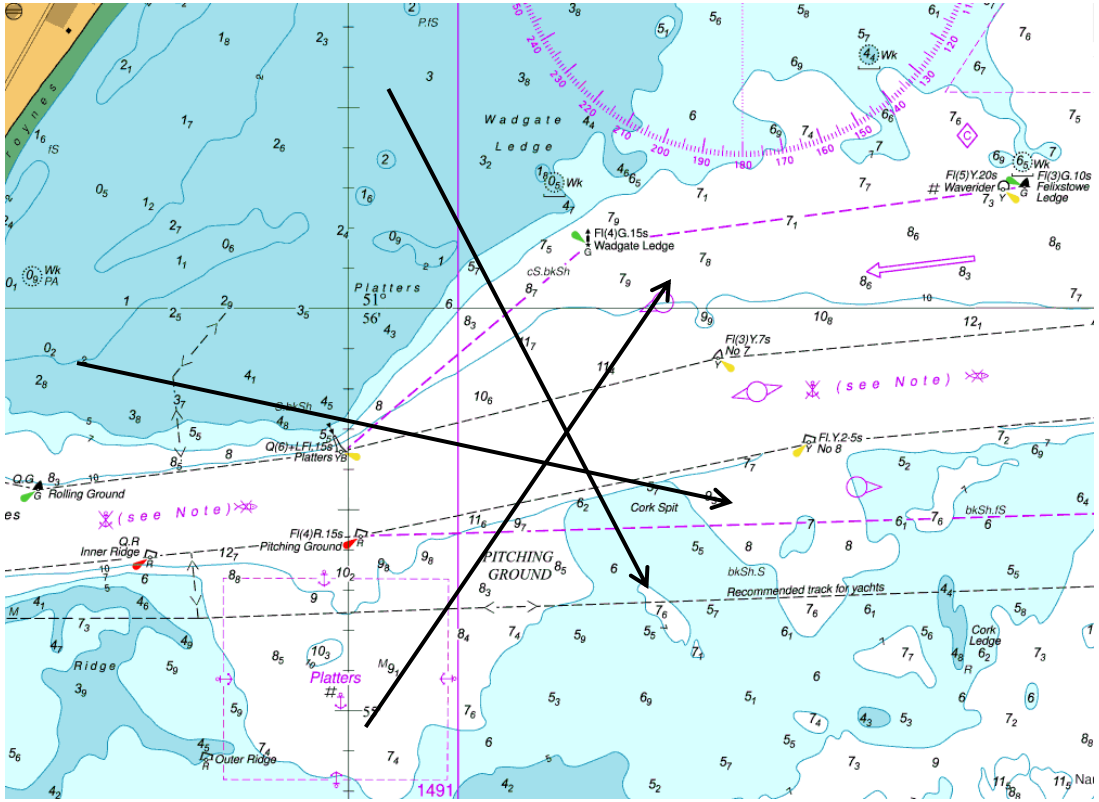
What is Integrity ?

- The ability to trust a navigation system
- The ability to **detect problems** and issue **warnings**
- Traffic Light
  - Green = All is OK = Go
  - Red = Warning! = Stop



Receiver Integrity (RAIM)

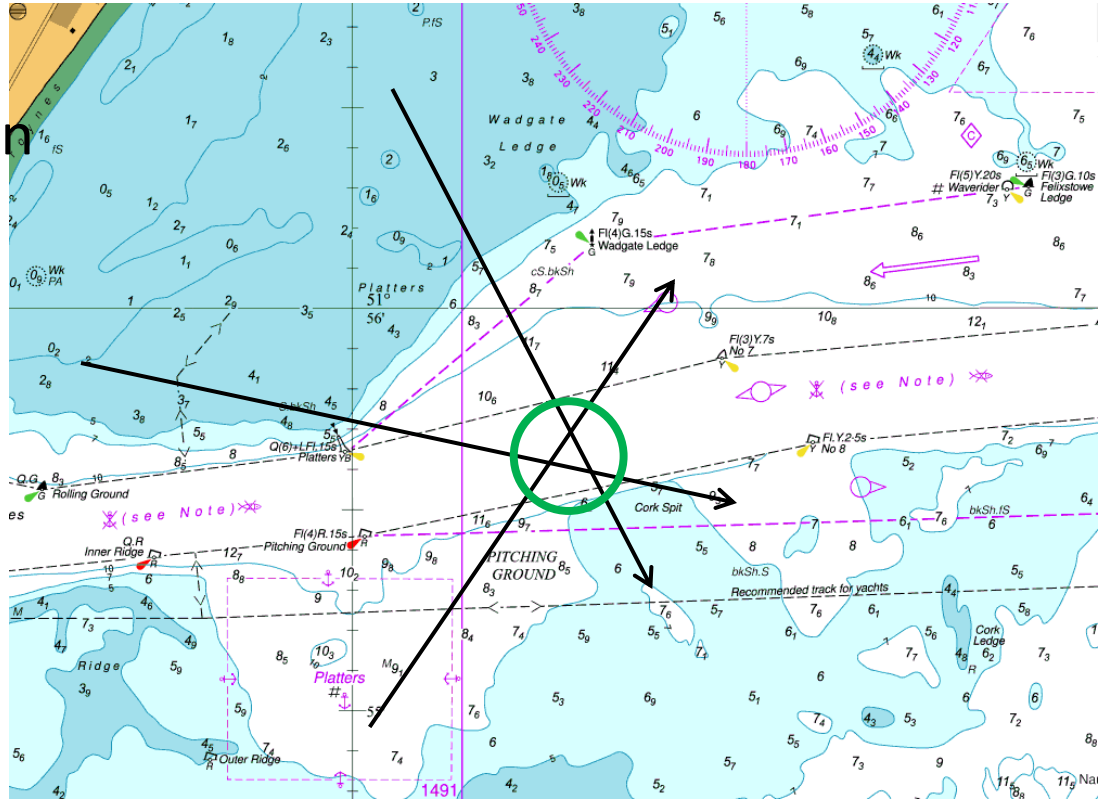
- E.g. 3 Visual Bearings
- Triangular “cocked hat”
- Use the size of the hat to determine **integrity**



Detection Threshold

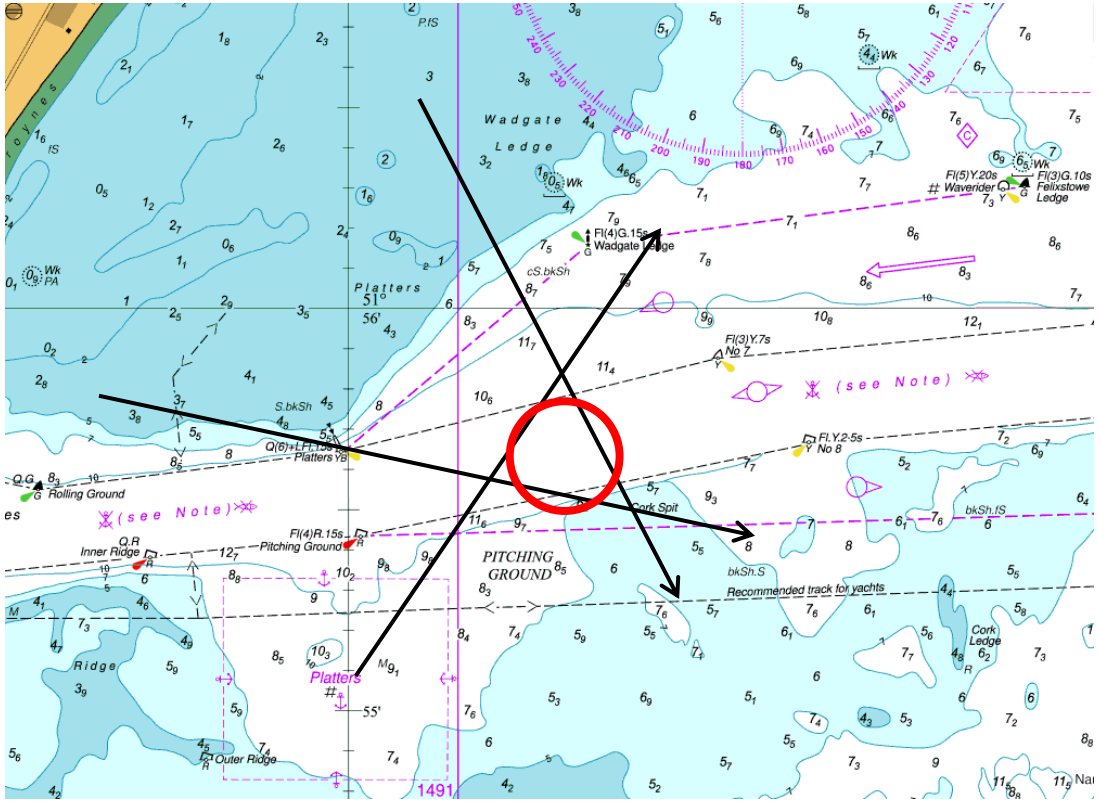
- Detection Threshold is the circle.

- Green light if the hat is within threshold



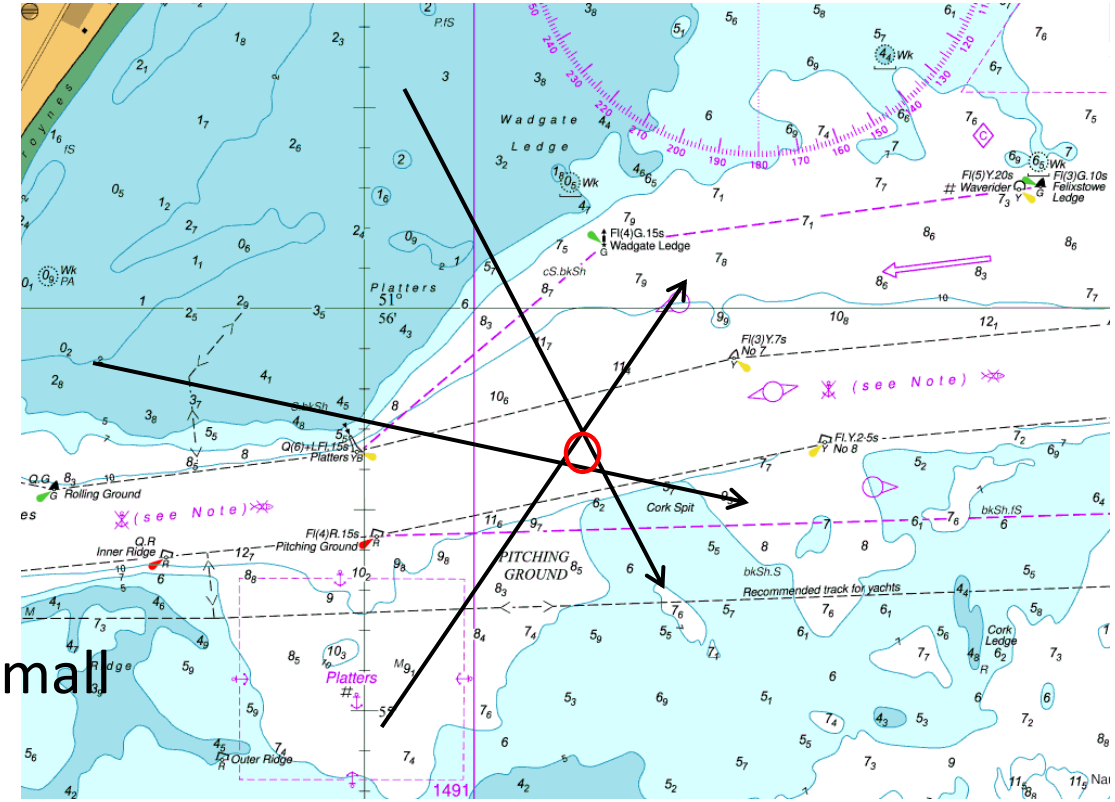
Detection Threshold

- Red light Alarm if hat exceeds threshold



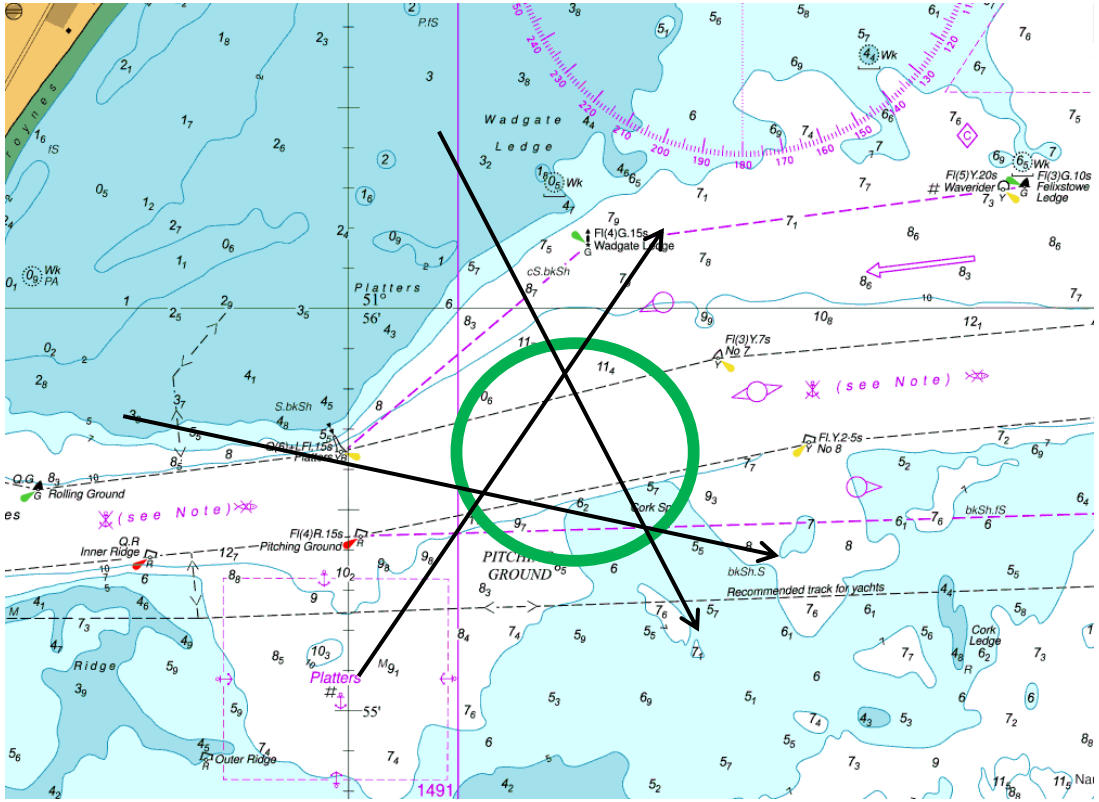
False Alarm

- Fix is Accurate
- Alarm is Raised
- Harms Continuity
  - Interrupts the Mariner
  - “Cry Wolf”
- Detection Threshold is too small



Missed Detection

- Fix is Inaccurate
- Green light: no Alarm is Raised
- Harms Integrity
  - Gives the OK to poor fixes
  - Danger to the Mariner
- Detection Threshold is too large

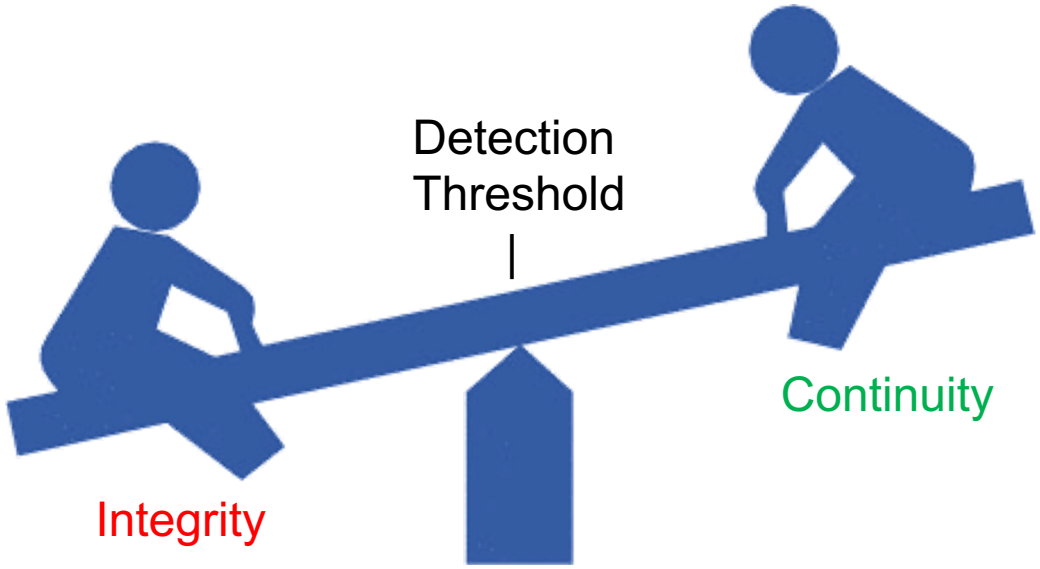


Integrity vs. Continuity

- Balancing Act: Where to set the Detection Threshold

- Too Small:
  - “Cry Wolf”
  - Poor Continuity

- Too Large:
  - Poor Integrity
  - Danger!



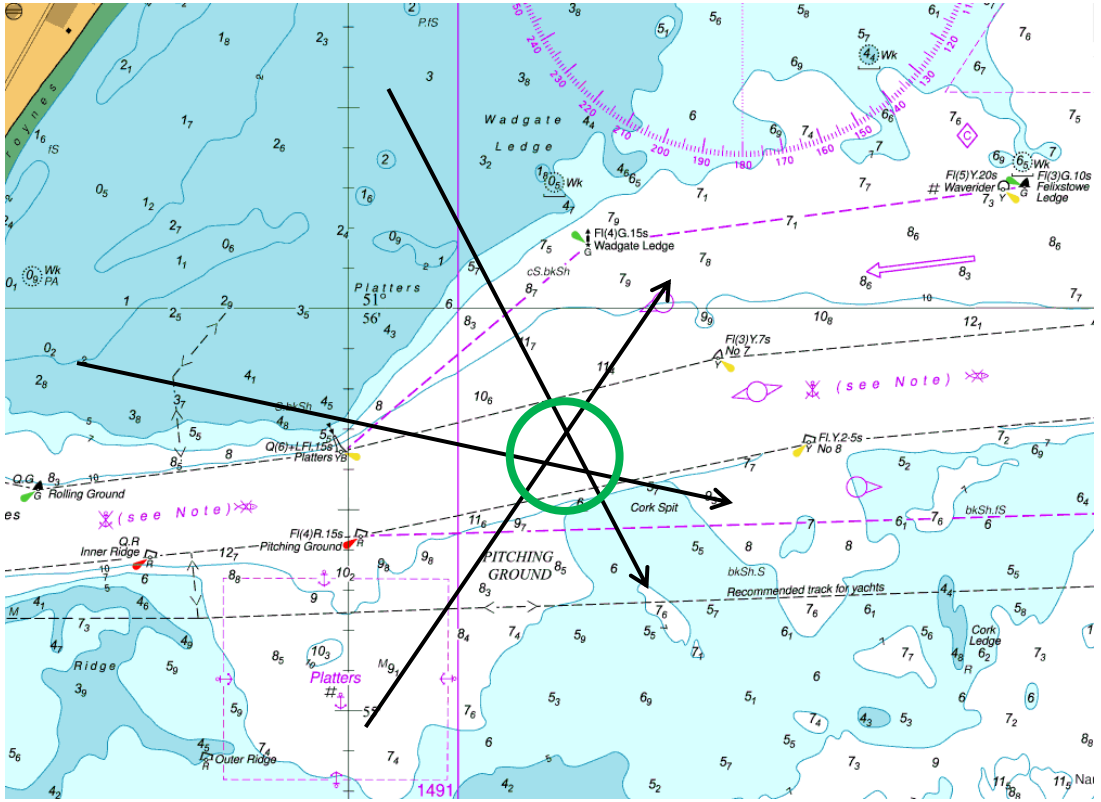
User Requirements

- IMO Resolution A.1046
  - Continuity: >99.97% per 15 minutes
  - “Do not Cry Wolf” more than once per 35 days.
  - Requirement is very clear

- What constitutes a Missed Detection?
  - Unknown!
  - No missed detection requirements in A.1046
  - Question: How to define User Integrity Requirements?

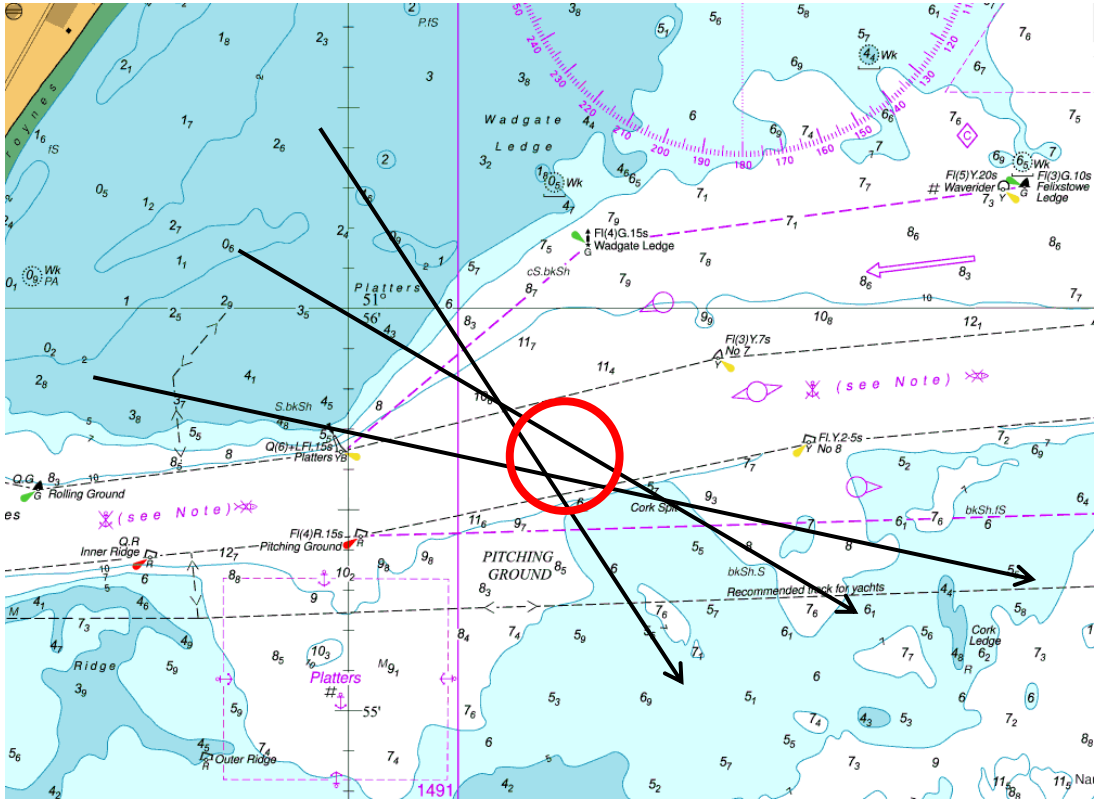
Geometry

- Good geometry
- Accurate fix
- Small cocked hat



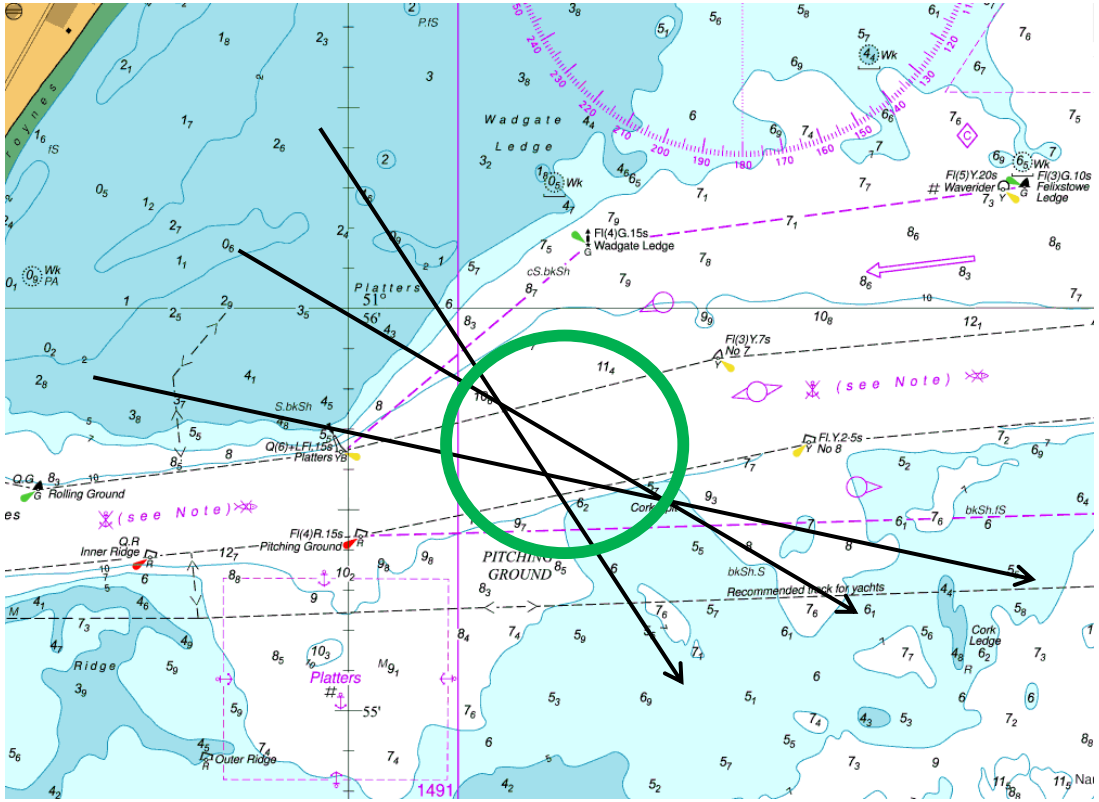
Geometry

- Poor geometry
- Inaccurate fix
- Fixed detection threshold
  - False Alarm??



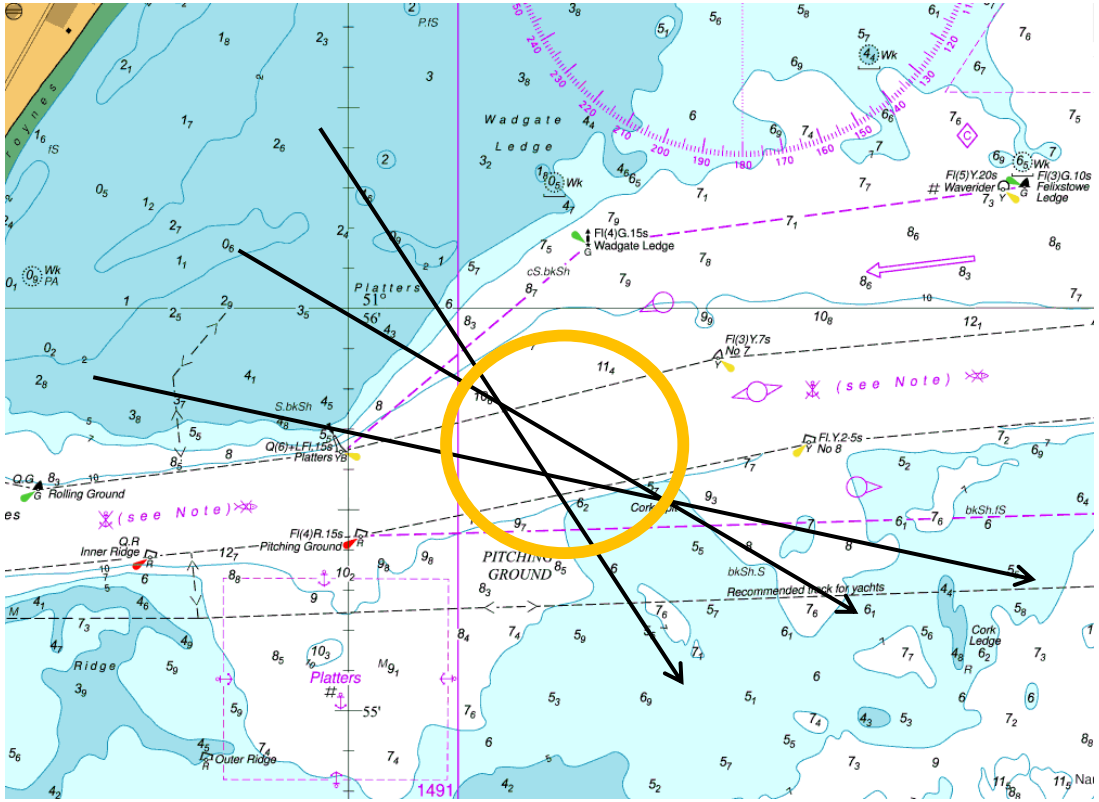
Geometry

- Variable detection threshold
  - Missed Detection??



Geometry Screening

- “Amber Light” condition
- Warns of poor geometry
- Screens out bad geometries



User Requirements

- How to specify Geometry Screening
  - Horizontal Alert Limit (HAL)
  - Geometric rules e.g. DOP
  - Others… ?

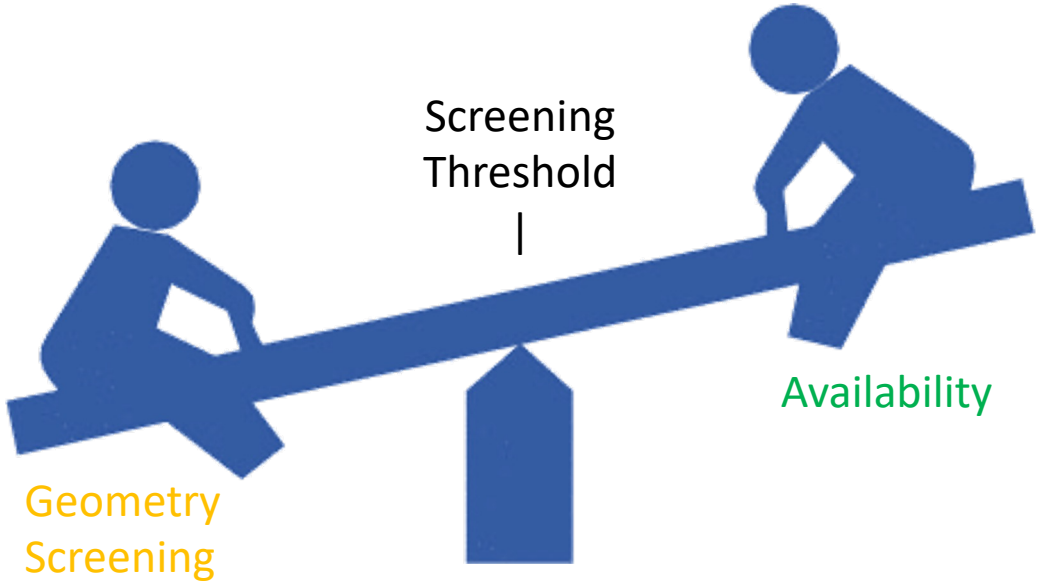
- Needs careful thought
  - Allow bad geometry = poor safety
  - Disallow good geometry = no availability

Screening vs. Availability

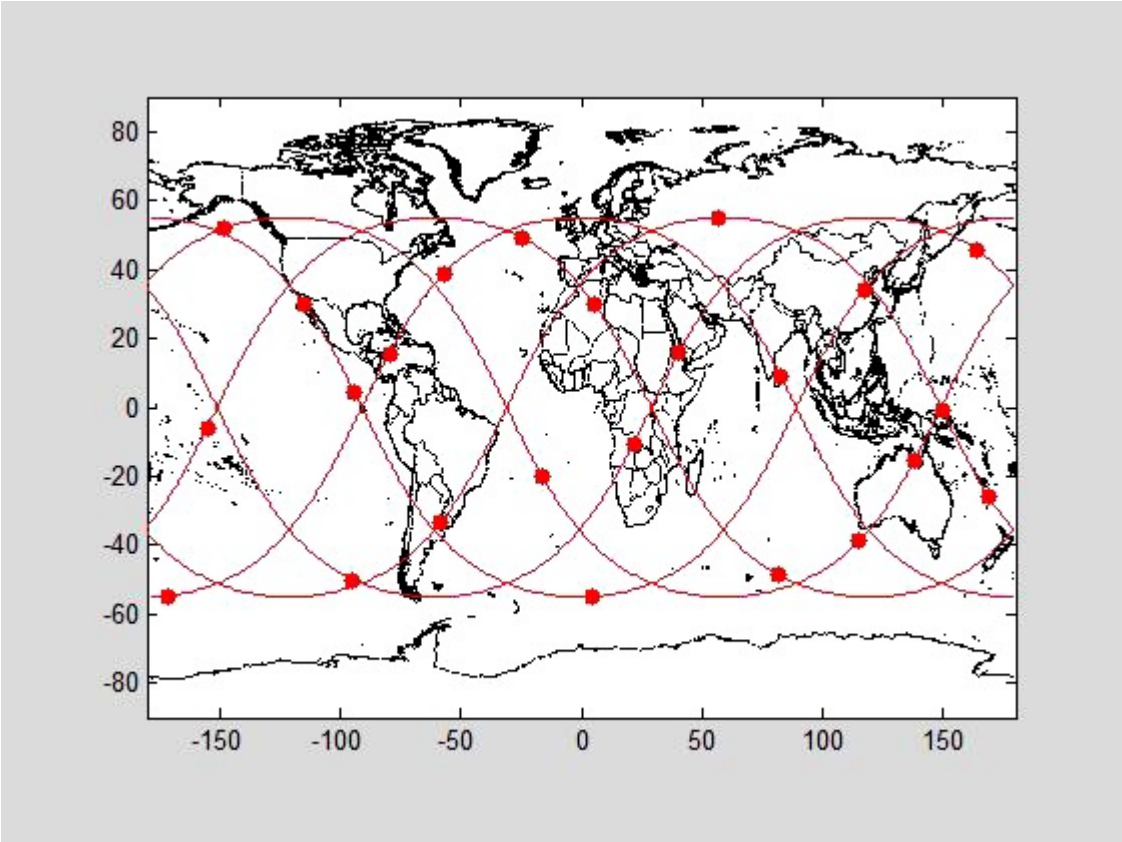
- Balancing Act: Where to set the Screening Threshold

- Too Small:
  - Amber light warning
  - Poor Availability

- Too Large:
  - Allows bad geometry
  - Danger!

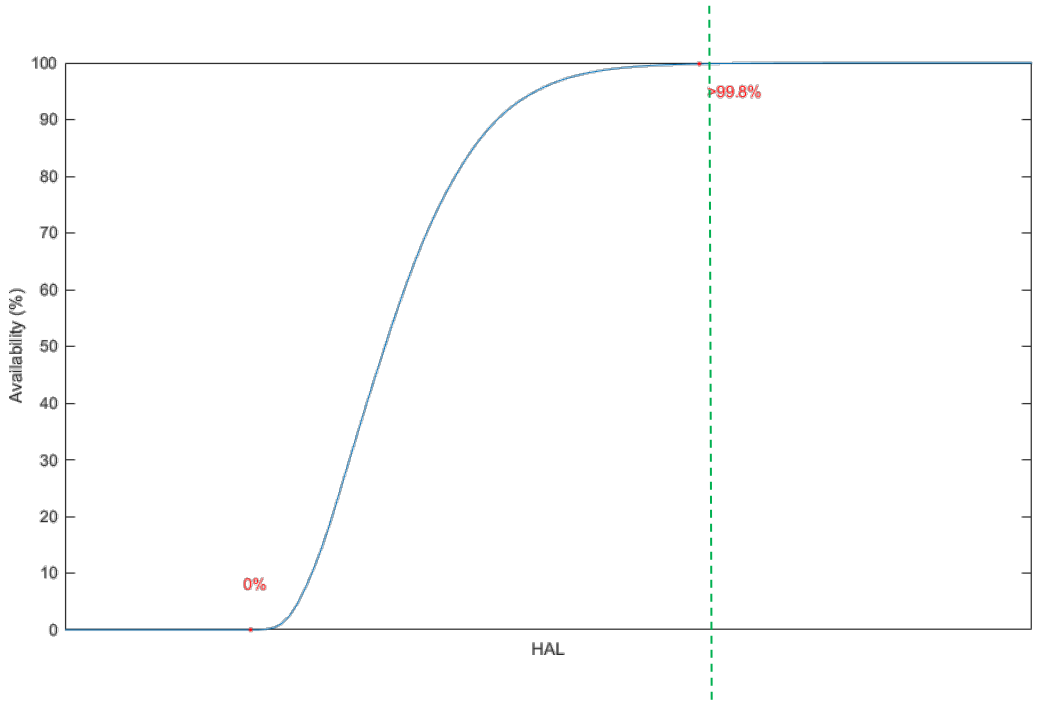


GPS Satellite Motion



Availability vs. Integrity

- Geometry simulation
- IMO Requirements (A.1046)
  - Availability: >99.8%
- No scale on x-axis
  - Achievable integrity at sea not yet known!



Summary

- RAIM Performance (setting a Detection Threshold)
  - Too strict = poor Continuity
  - Too lax = poor Integrity
- User requirements (setting a Screening Threshold)
  - Too strict = poor Availability
  - Too lax = poor Integrity
- What can actually be achieved in the real world?
  - The user “gets what they get”
  - Test against real data (define the Art of the Possible)

Any Questions?

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