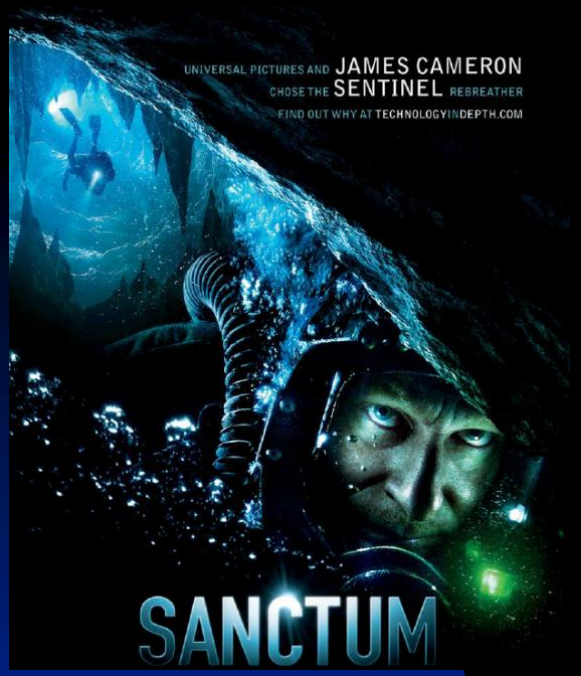
diver position
dead reckoning
inertial navigation

nick bushell

VR Technology Ltd

the solution



vr technology and me

- 25 years designing and manufacturing diving electronic stuff
- practical product, engineered with ingenuity
- patents in diving equipment
- world leaders
- We make cool stuff – James Cameron used our equipment in his film Sanctum

diver position dead reckoning

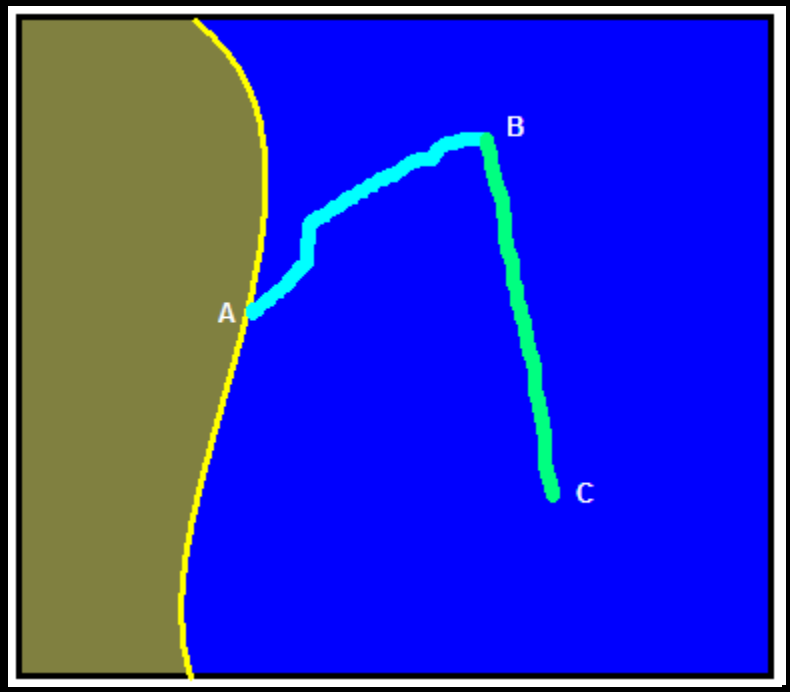
- Divers need a product that gives the equivalent of a Surface GPS system
- BUT - They need to rely on no one else but themselves to achieve this
  - Equipment worn only on the diver
- It must be the same price as a consumer hand held GPS
- Diver Navigation Assistant - DNA

sensors

- Easy
  - Depth
  - Time
  - Compass
  - Gyro
  - Accelerometer
    - +-2g @ 0.001g sensitivity ish…
    - 0.0001g /√Hz noise
- Tricky
  - Flow – current / tide
  - Sonar – velocity over bottom?
  - Tide tables
- Impossible
  - GPS, except for initial surface reference

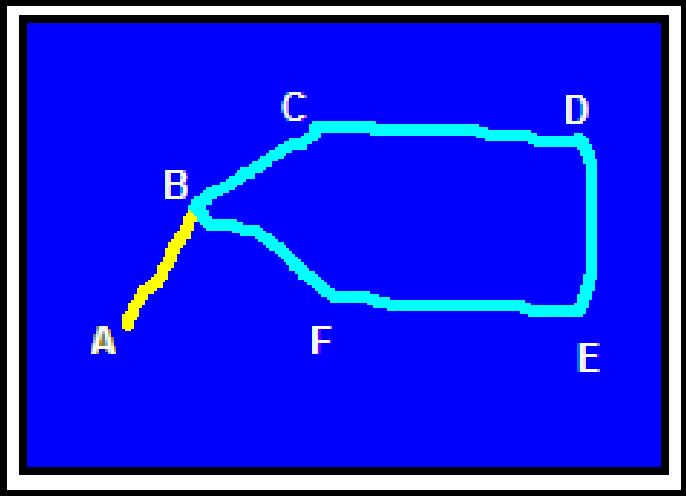
real life

- Diver gets in water on a beach at position A
- Swims underwater to position B using a compass heading
- Swims underwater to position C following an interesting feature.
- Diver wants to return to position A
- Easiest to follow a ‘track graphic’ than use compass alone



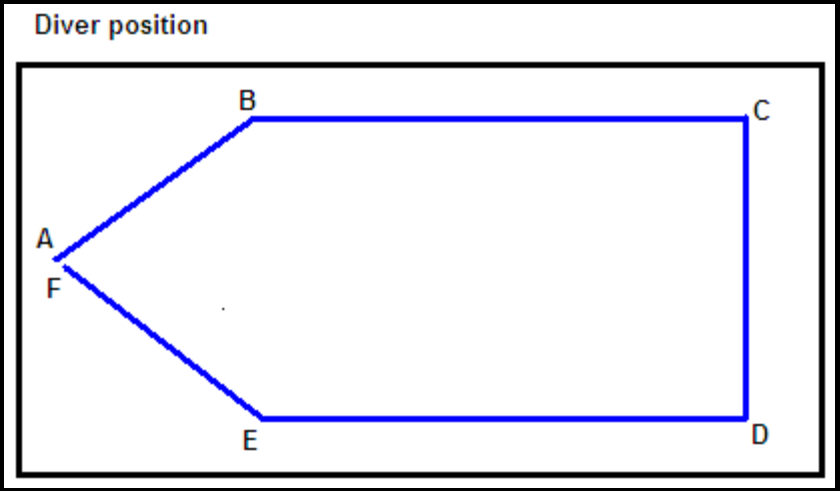
real life - archaeology

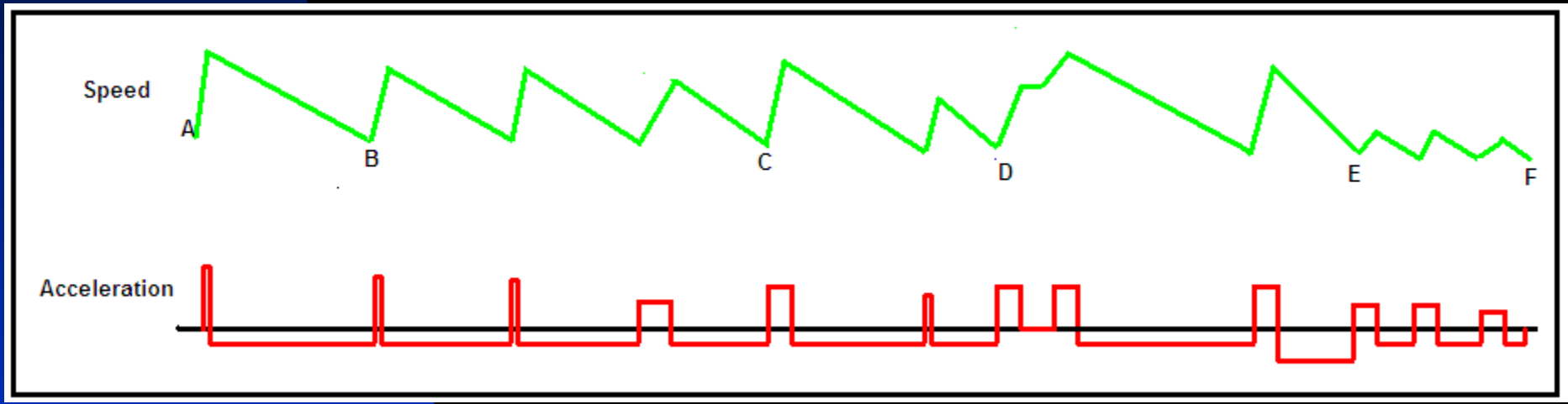
- Diver starts from position A
- Swims to position B and marks this as a relevant archaeological point
- Swims to position C, D, E, F and marks positions as relevant archaeological points
- Diver wants to download track reference onto PC



example…

- Aside: The diver deceleration and the diver finning look viable for characterisation, should this be useful…





- One average diver fin motion accelerates the diver to 1m/sec in 1 sec.
  - Acceleration = 1m/s/s = 0.1g
- Drag decelerates the diver by 0.1m/sec in 1 sec
  - Deceleration = 0.1m/s/s = 0.01g
- These accelerations are detectable by an average game type 3 axis accelerometer – aren't they – surely – so why is there not app to do this?

we do know the z dimension

- Depth ‘z’ can be measured very accurately using an ambient pressure sensor. Can this help determine, in conjunction with a compass and gyro, exactly how much of the 3 axis acceleration components are acting in the non-depth directions?

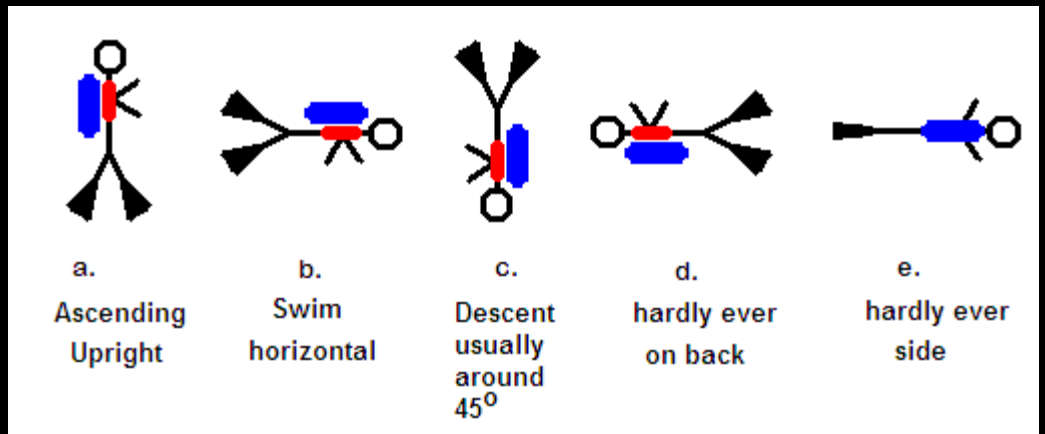
(The diver controls position in the water with finning and a buoyancy control device)

clear problems

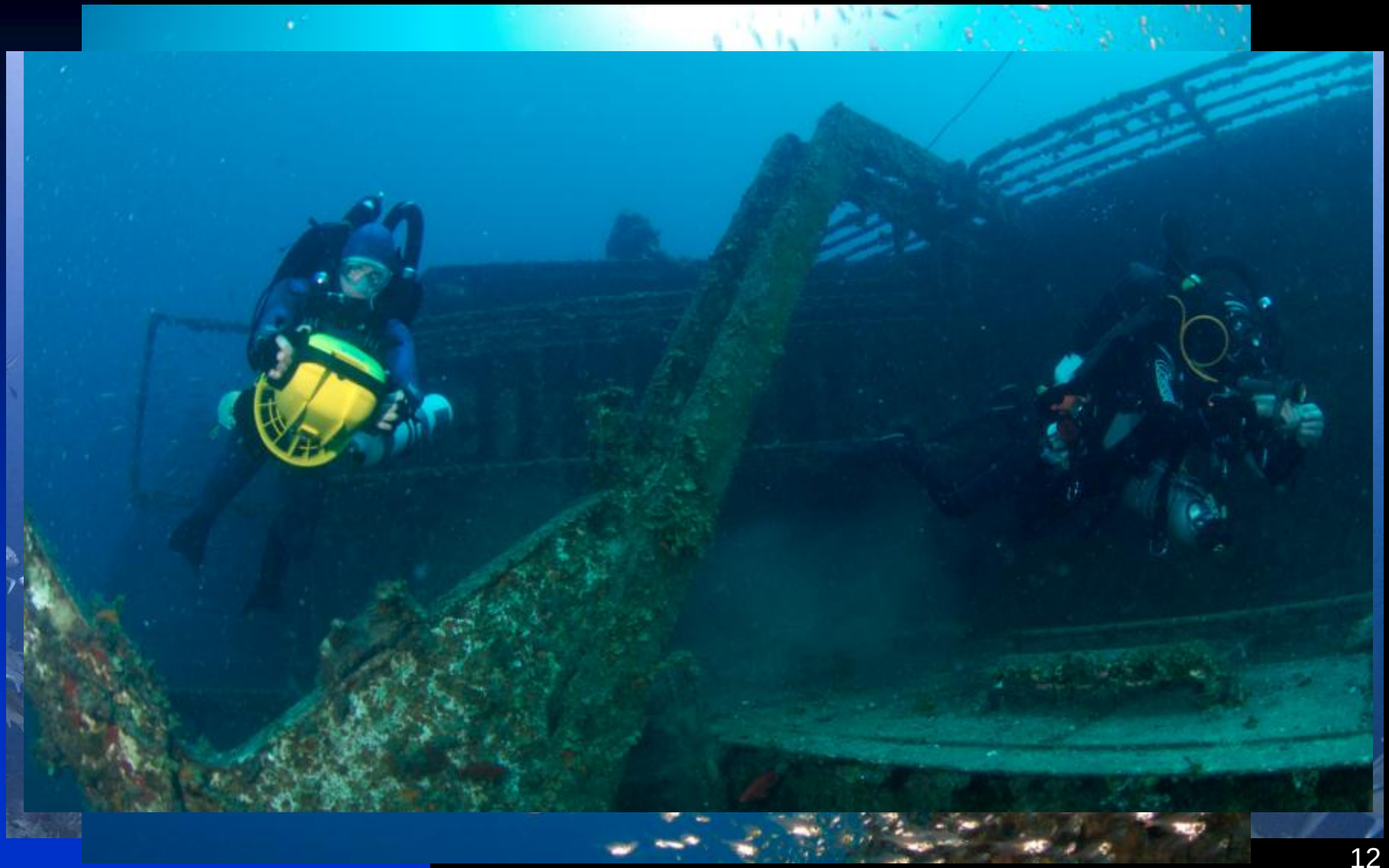
- Tides and currents
  - Constant velocity
  - Slow tide velocity changes
- Ship to diver motion
- Subtle diver finning techniques
  - could they be characterised and detected with sensors?
  - do they need to be?

equipment configuration

- Equipment can be worn on the diver's back and data communicated to a wrist display. This reduces extraneous arm movements. (but there is still wobble…)
- Divers swim in different orientations



in action



compromises

- Consider only zero tide situation
- Only a better idea of location and track is required +- 50% accuracy could be enough

dead reckoning on land

- In environments where GPS has not been available, militaries have developed dead reckoning systems based on Kalman filters with pedometer / accelerometer sensors
- BUT – it was tuned to a human's step. It did not work in a car for example – why? Is this too difficult? Where do the accelerometer inaccuracies and noise cause problems of too large a scale? For underwater needs, can we get sufficient accuracy?

current diver perspective

- The diver does not really know where they are or where they have been.

  (unless a very good navigator or there is a bottom reference object – eg wreck)
- The diver could be completely disorientated and head off 180degrees in the wrong direction
- Anything that gives them some clue as to how to get back to where they started or how to move on to another place would/could be enough
  - Perfection is not required
  - can we provide enough to be useful

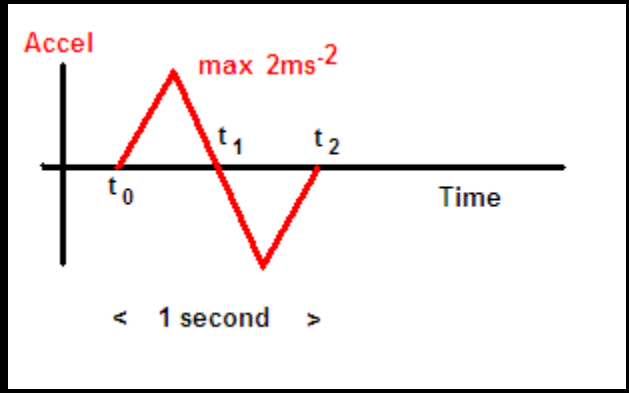
next steps

- Can the limited data accuracy from the available sensors be processed mathematically to give the diver positional accuracy of 20% or better over a 1 hour dive?
- Kalman filter plus more?
- Build one and test it on my android tablet by the end of the week…
- What am I missing that makes dead reckoning so tricky - Acceleration^4 ?

Diver Navigation Assistant - DNA

- My tablet has:
  - 3 axis accelerometer
  - Gyro
  - Compass
  - Android

- Simple App experiment showed $s=ut+\frac{1}{2}at^2$ still works – distance traveled was about 0.25m from the readings read off the app by eye…



- Land based dead reckoning app by the end of the study group?