

eBird – control of marine seismic streamers

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Dr.ing. Ola Erik Fjellstad



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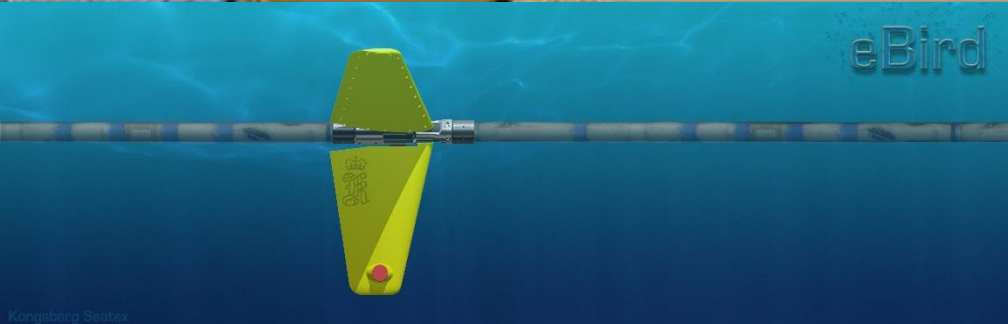
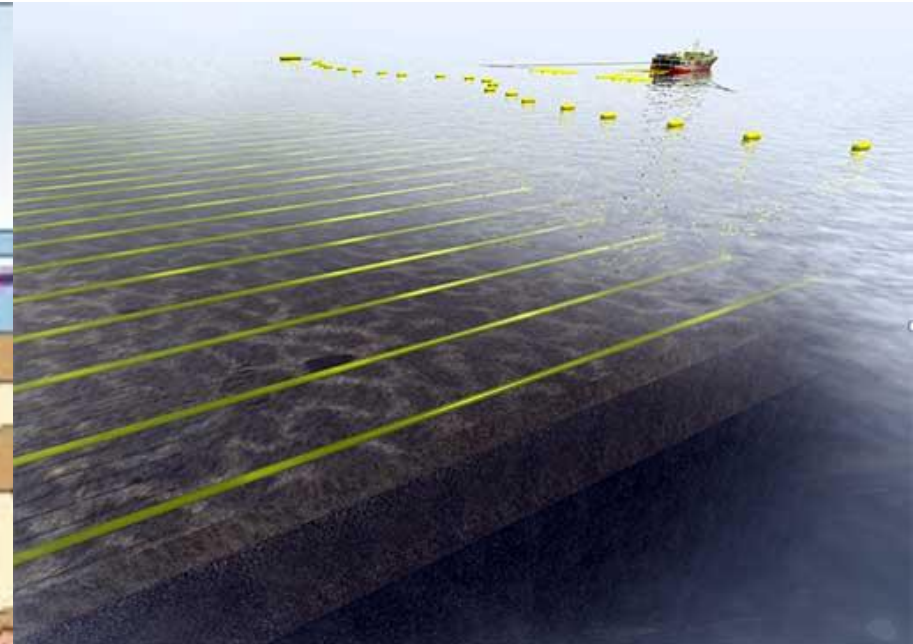
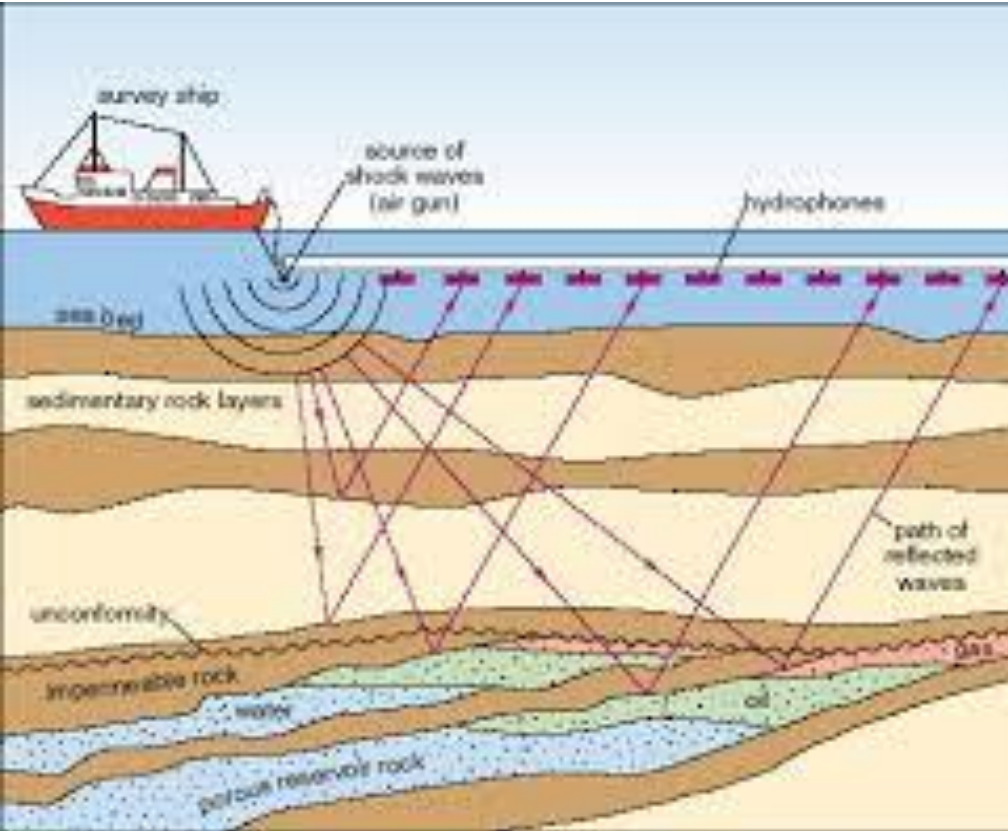
Ola Erik Fjellstad, PhD IPR Manager Kongsberg Seatex AS

- PhD Engineering cybernetics, NTH 1994
 - 6 DOF control of autonomus underwater vehicles
 - Professor dr.ing. Thor Inge Fossen supervisor
 - Professor dr.h.c. Jens Glad Balchen advisor
- Principal Engineer R&D, Kongsberg Seatex 1994 - 2013
 - Seapath - Integrated GNSS/IMU navigation system for pos/vel estimation
 - MRU - Inertial sensor system for motion measurement and RPH estimation
 - eBird – Steering device system for positioning of towed streamer spread
- IPR Manager, Kongsberg Seatex 2014 – today
 - Coordination of and participation in all IPR activities

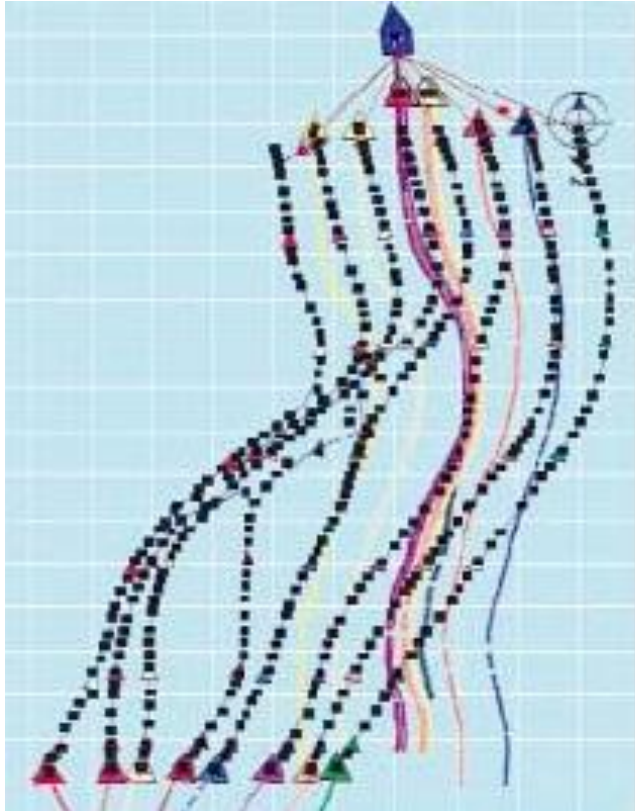
Marine seismic survey



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Streamers need steering



Conventional operation



Worlds biggest controlled structure



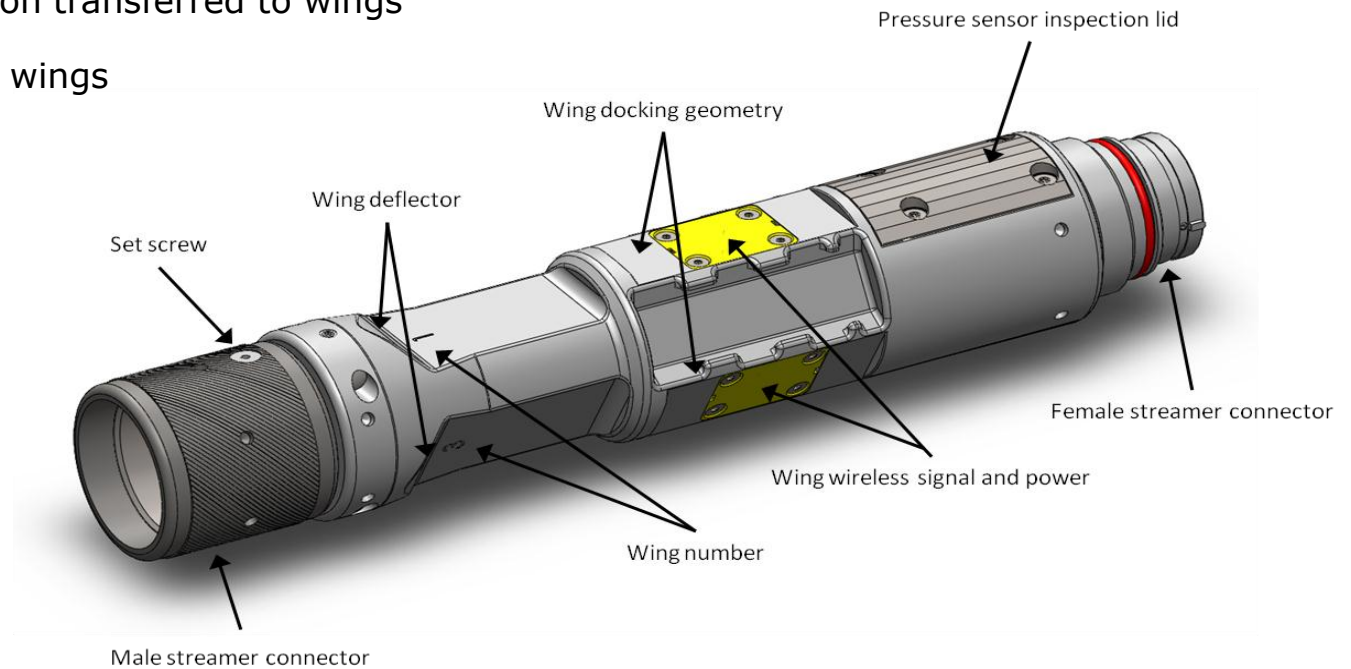
eBird - Streamer steering device

- Mounted inline, low vibration noise
- Typically 300m separation
- Power and communication through streamer
- Wing profile optimized for maximum lift and minimum acoustic noise
- Batteries in wings → autonomous operation for several days
- 3 wings independently rotatable
- Decoupled roll, depth and lateral control
- Provides ~400 N at 4.5 kt through water
- 3 degrees feather angle



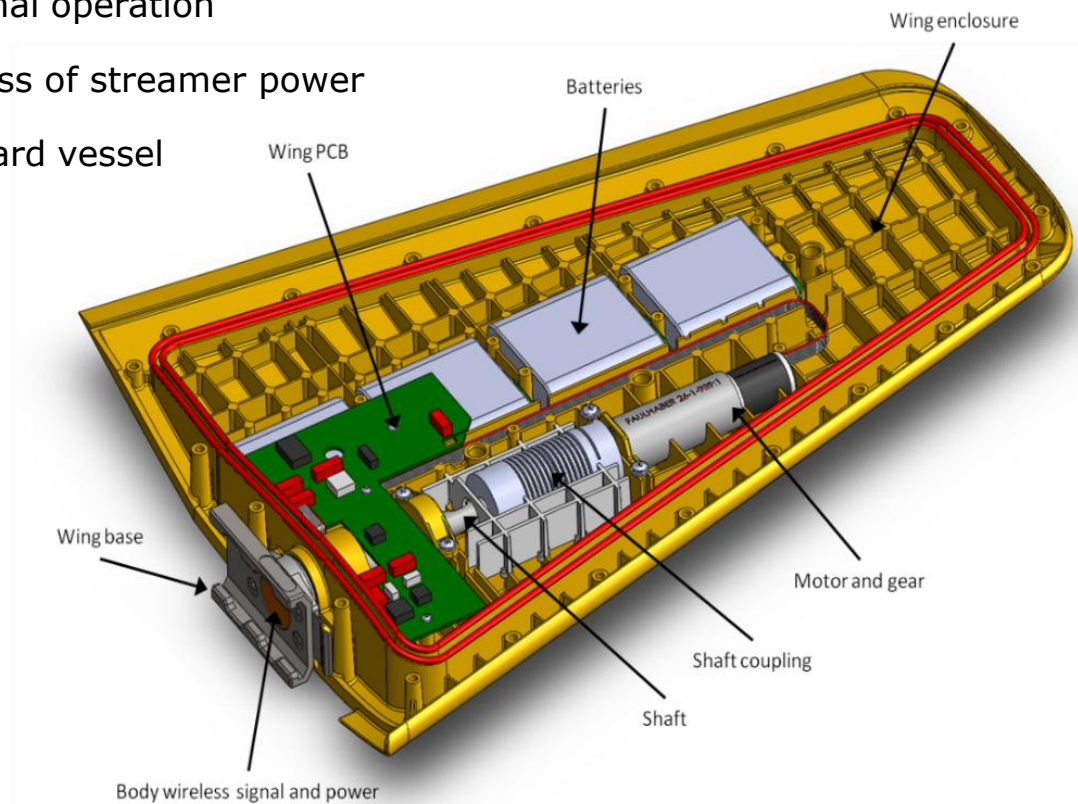
eBird body

- Length 370 mm Ø 74 mm titanium tube
- Inline mounting – stored on reel
- Sensors for roll angle and depth estimation
- CPU running bird local motion control loops
- Calculated wing deflection transferred to wings
- Wireless connections to wings
- 3 wing docking slots



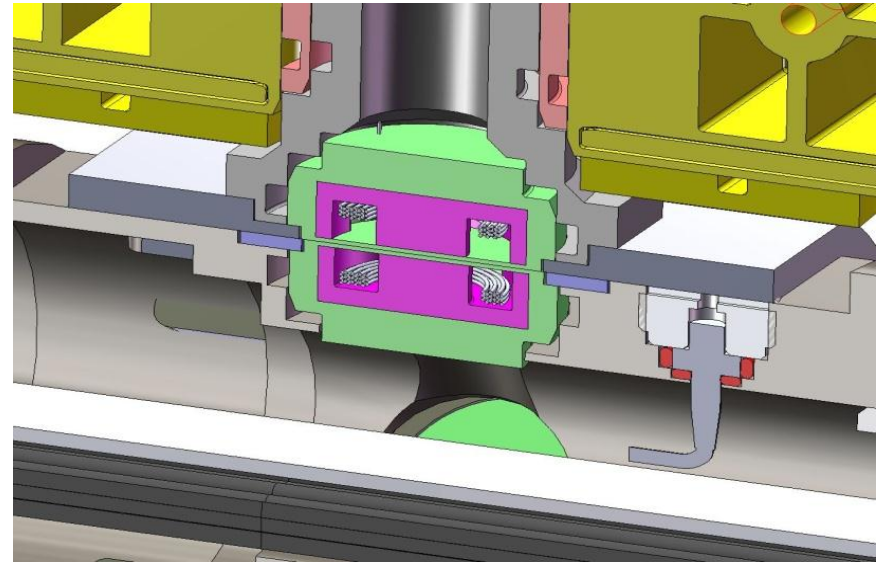
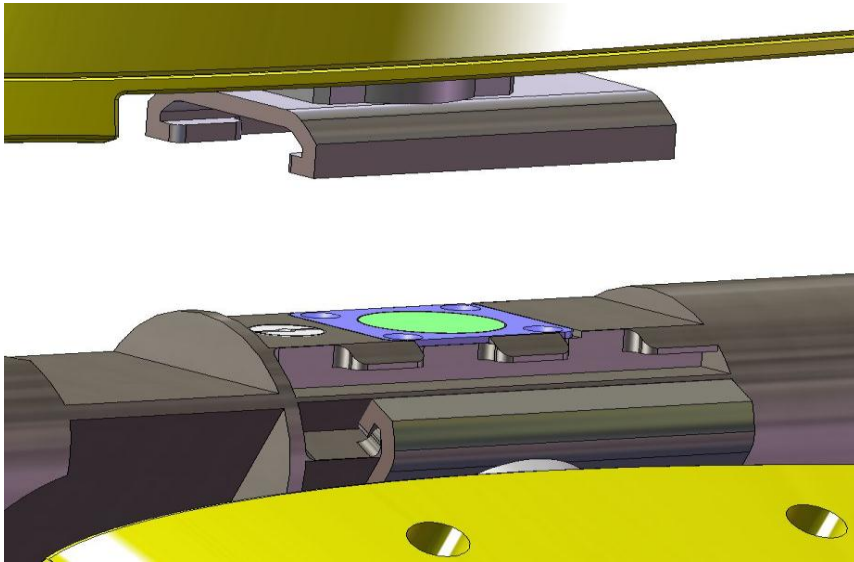
eBird wing

- Attached/detached at deployment/retrieval
- Contains CPU, motor/gear and batteries
- Shaft coupling for motor/gear protection
- Wireless power/comms
- Batteries charged in sea in normal operation
- Provides power to body when loss of streamer power
- Stored in charging station onboard vessel



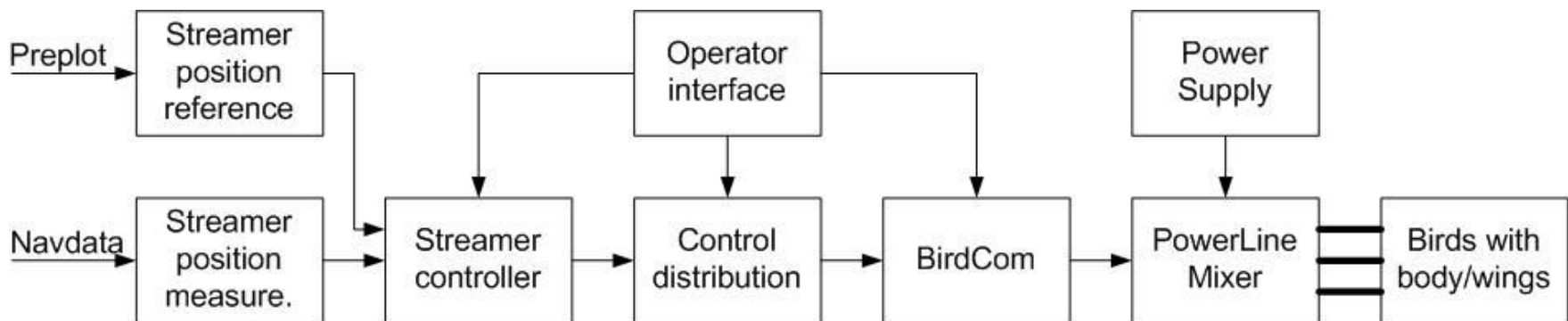
Wireless connection body-wing

- Wireless connection between body and wing
- No electrical parts exposed to water
- Easy snap on/off mechanism
- Identical iron cores surrounded by coils in body and wing
- Inductive energy transfer utilizing electro-magnetic resonance
- Radio communication: connector = antennae
- Two-way power and communication
- Back-deck operations: body and wing operated using hand-held radio-unit

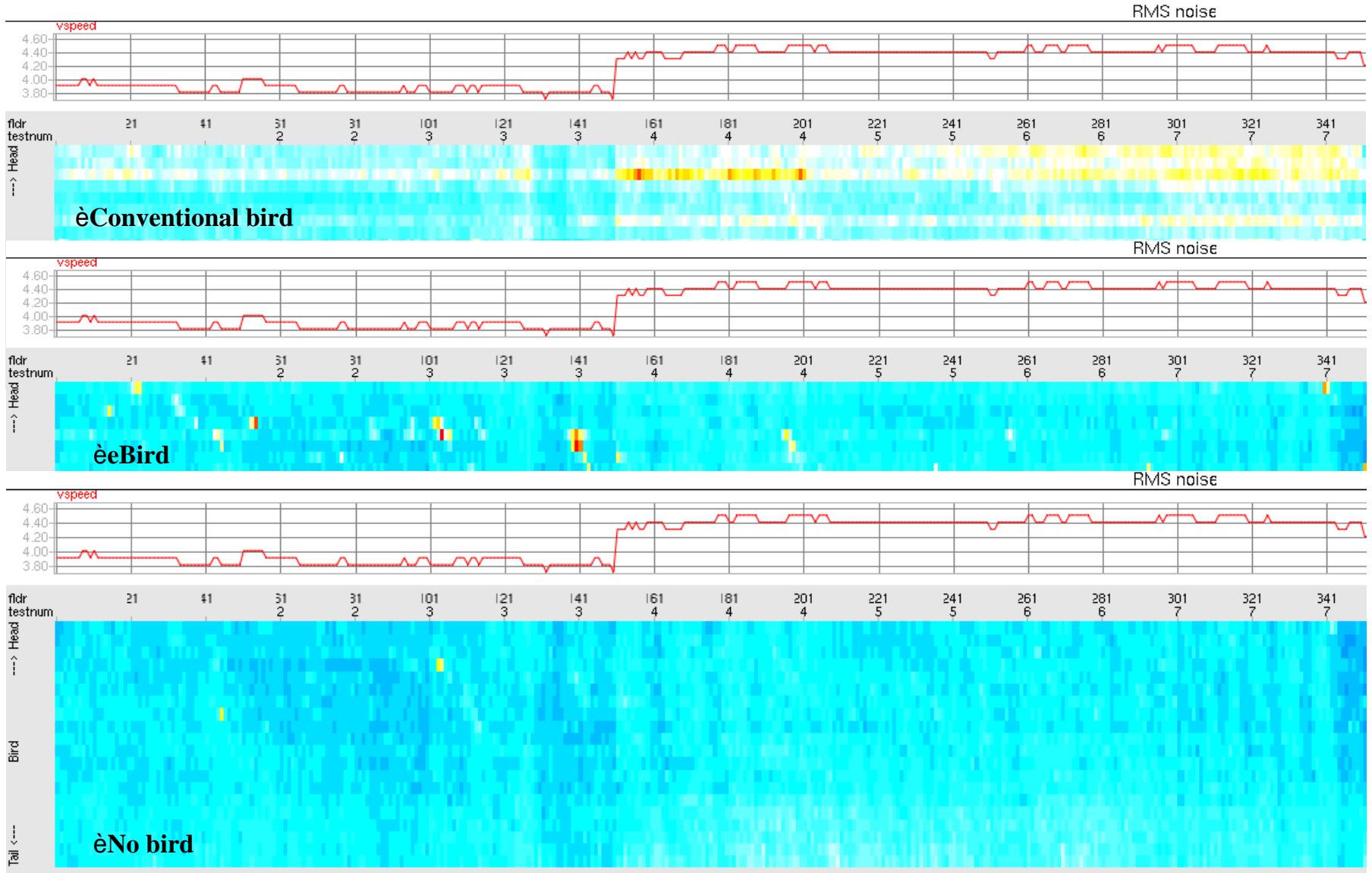


Challenges

- Robust control - sea current, waves, objects in sea
- Low acoustic noise – wing profile
- Power distribution over 10 km – voltage drop
- Noise free power – constant load
- Noise free communication – modem
- Loss of power/comms – autonomous operation
- Multicomponent interactions



Hydrophone RMS noise



How many eBirds in one flock?



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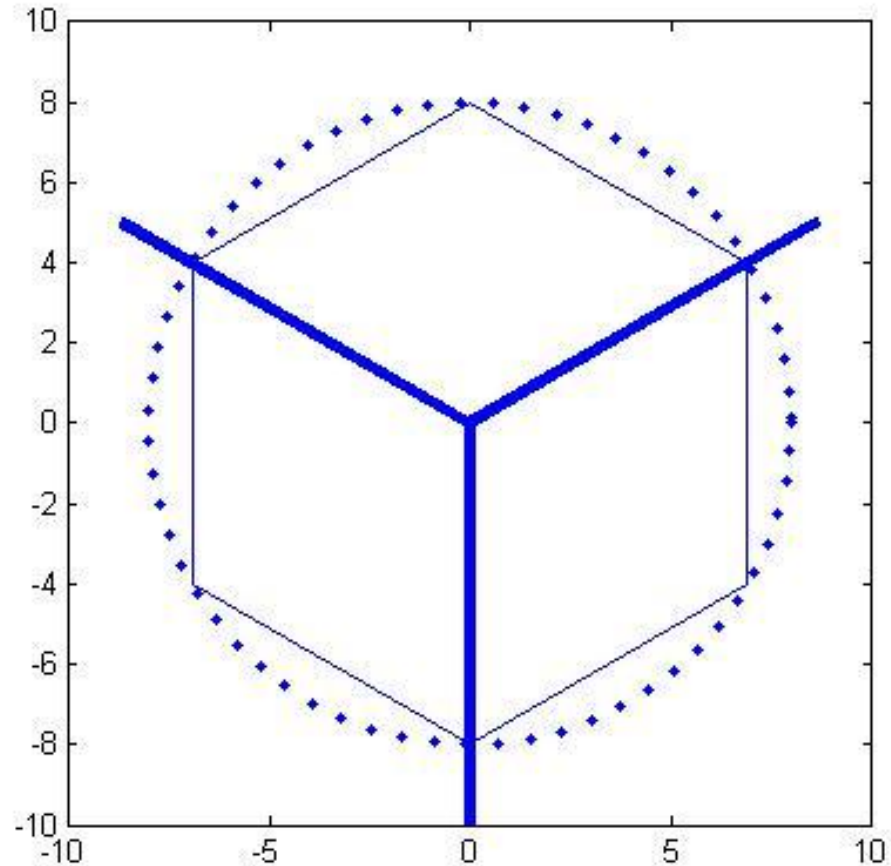
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There have been issues..

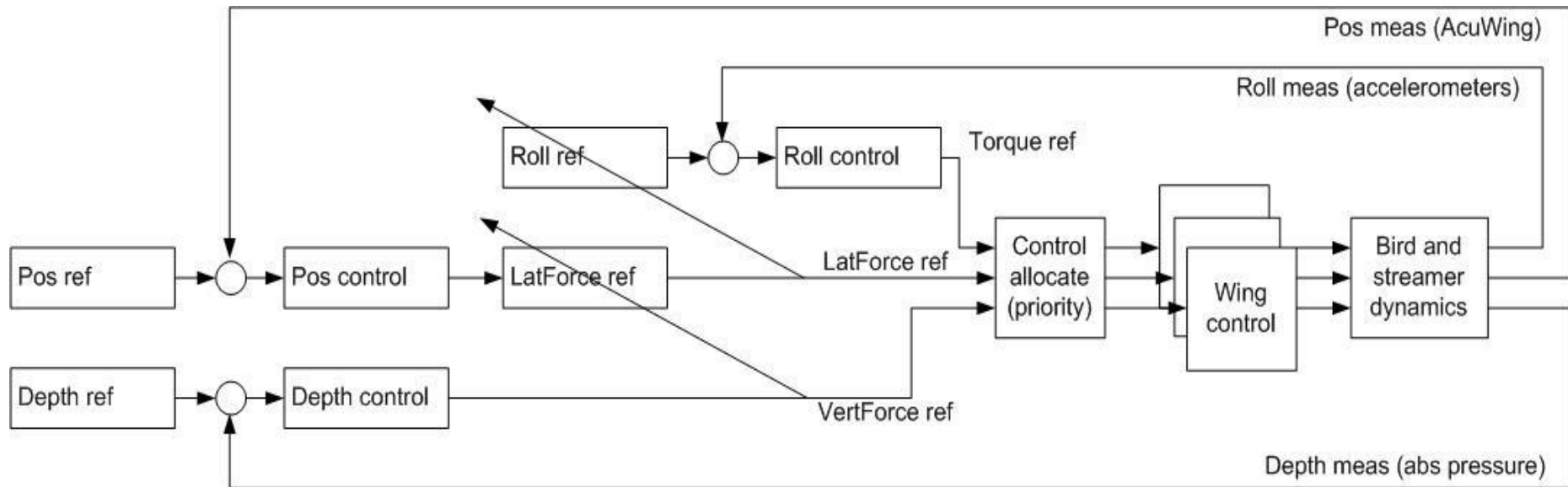


Lift envelope



Clever choice of roll angle reference will enhance stability capacity

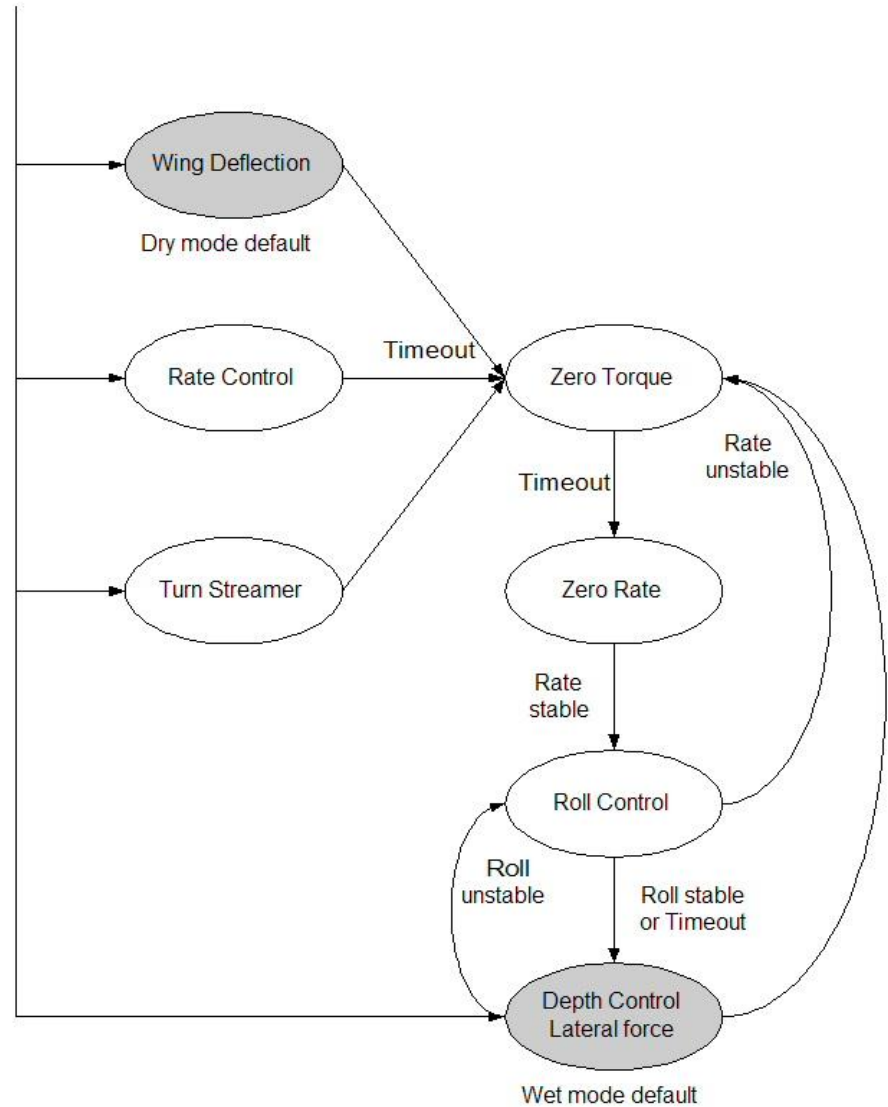
Control system



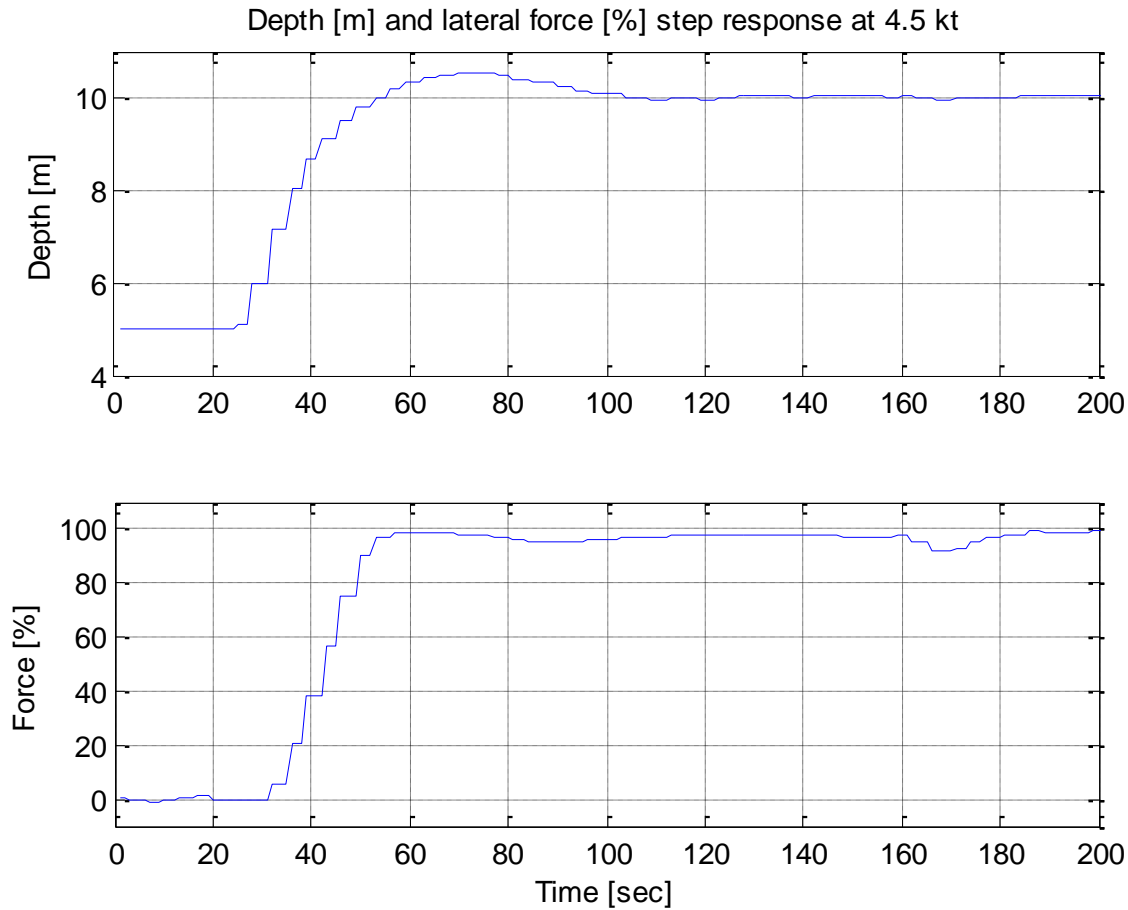
Robust control



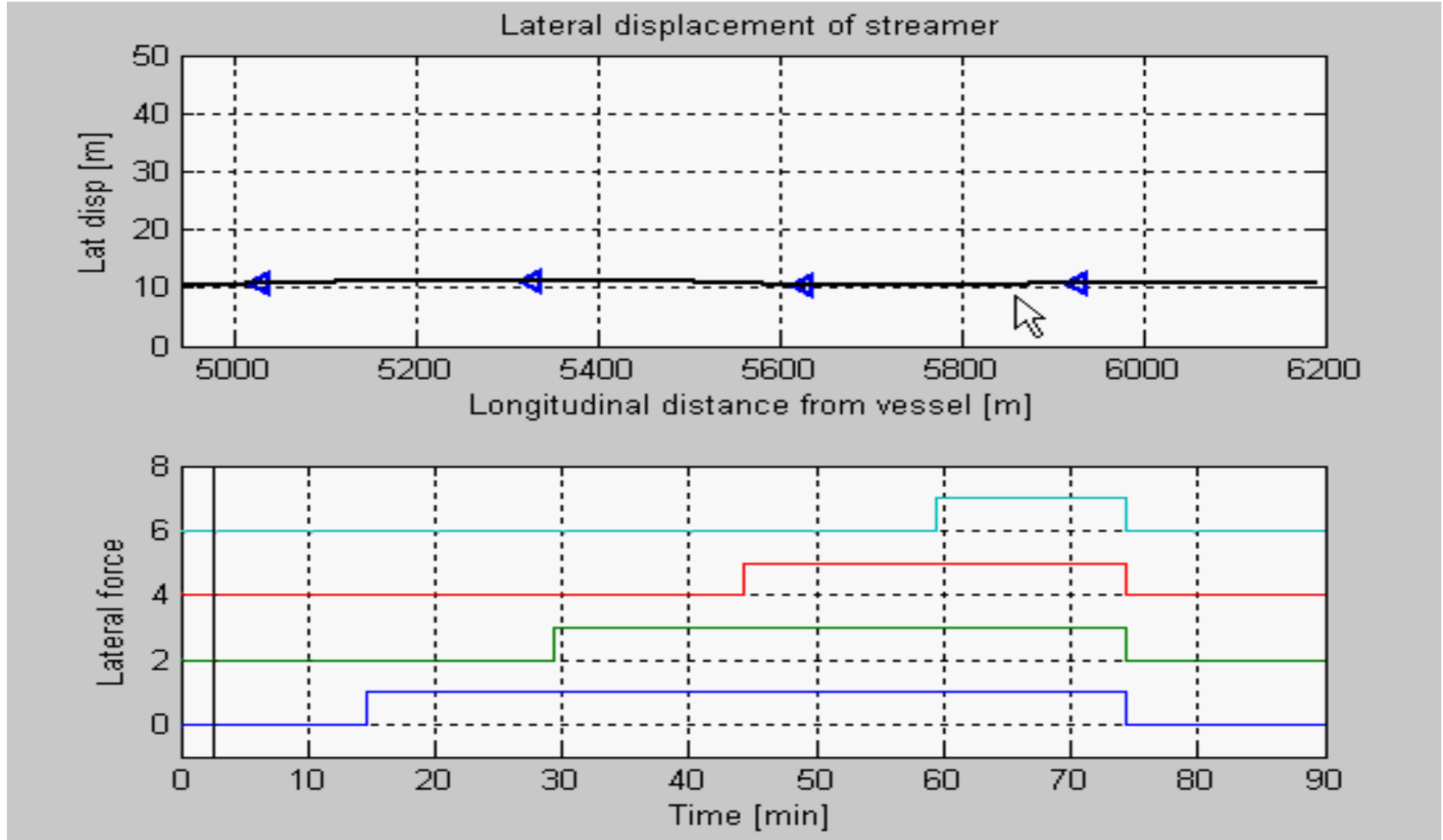
Command from
Guidance and Control



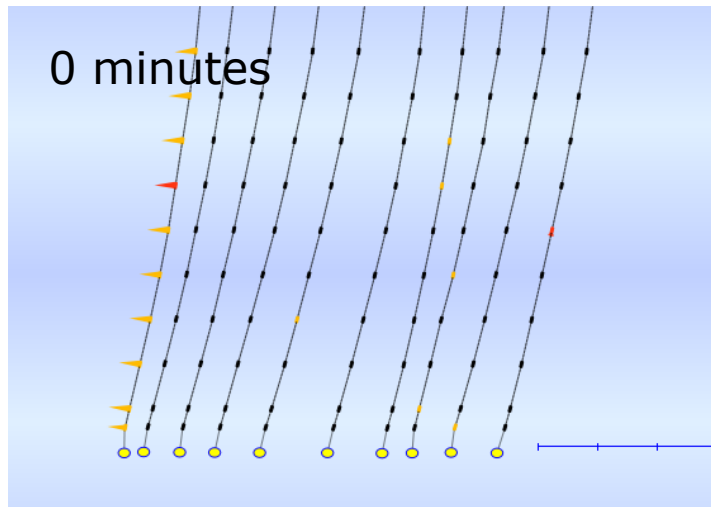
Rapid depth change



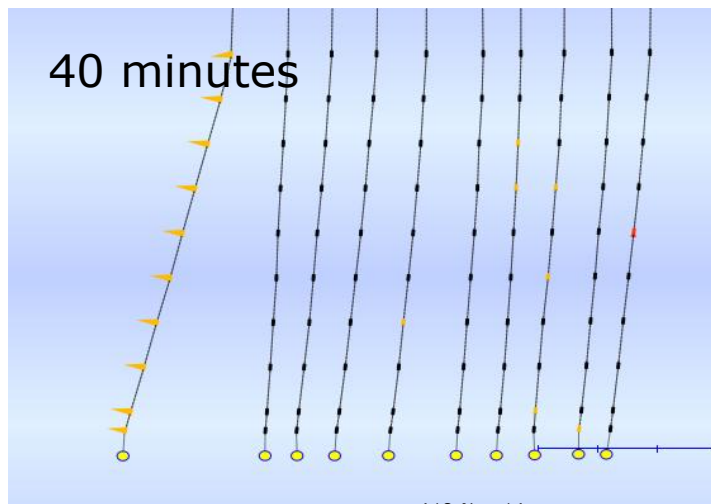
Lateral control



Feather angle capability: $>3^\circ$



100% lateral force portside
300 m inline separation

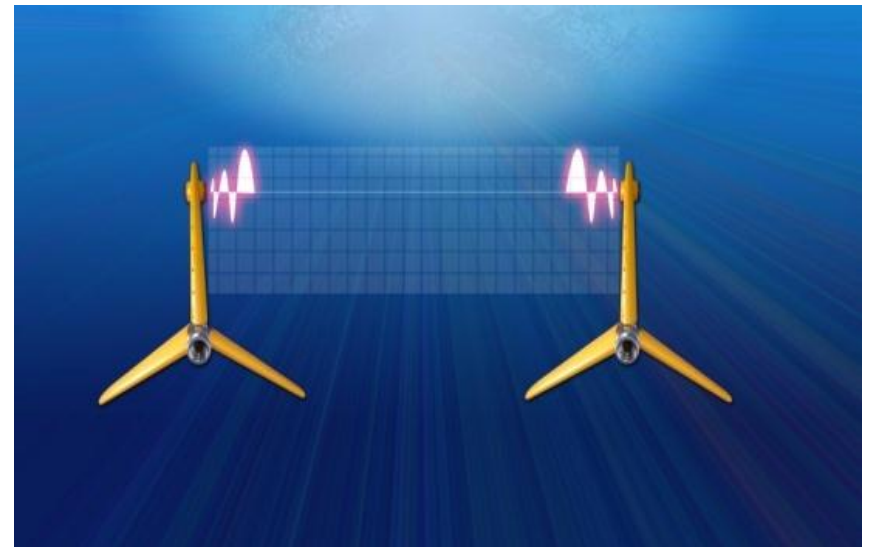


eBird – The movie



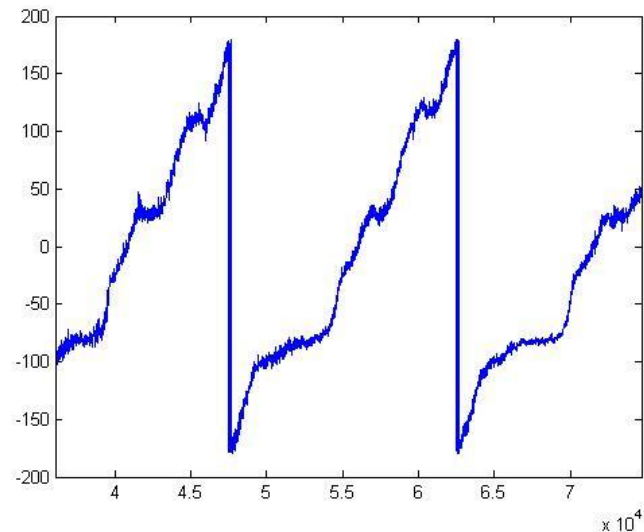
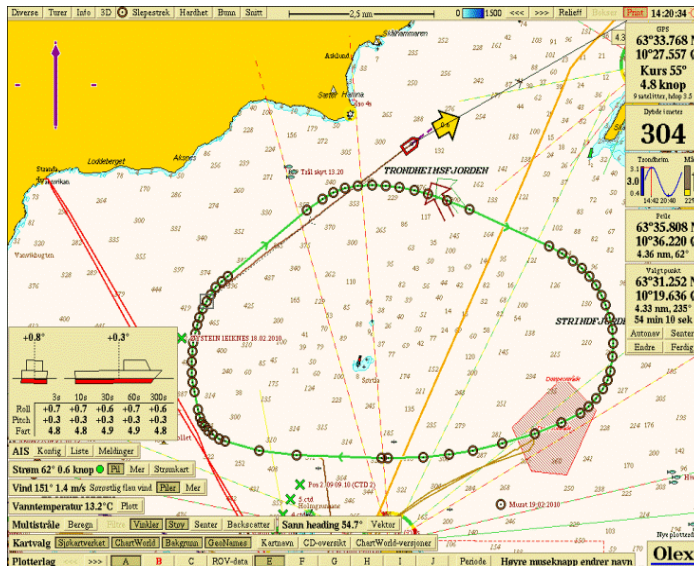
AcuWing

- Acoustics integrated in eBird wing = AcuWing
- Bi-directional acoustic transducers in wing tip
- Acoustic source attached to stabilized platform
- Cross-line and in-line range measurements



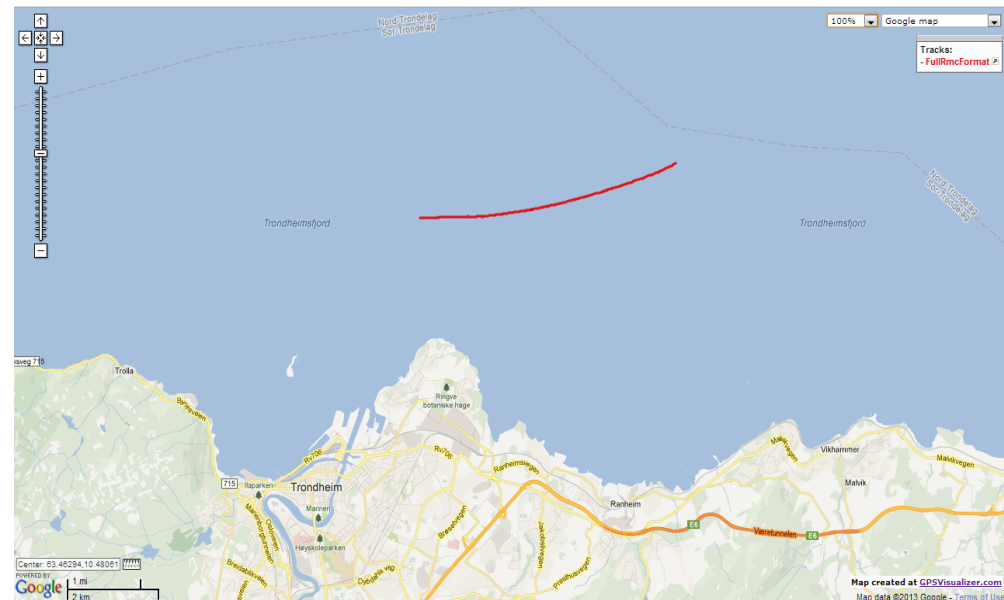
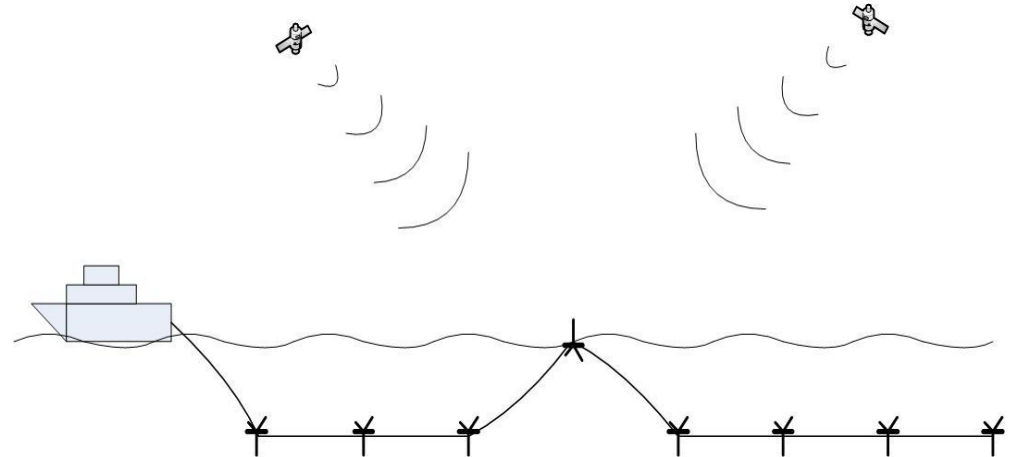
Magnetic compass

- Heading estimation from 3-axis magnetometer
- Located in wing tip - redundancy
- Magnetic field compensation:
 - wing angle
 - wing slot position
 - roll and pitch
- Calibration in 3-axis Helmholtz coil
- Algorithms for bird magnetic signature estimation



PosWing

- GNSS receiver and antenna in wing
- GNSS-wing pointing up in surface mode
- Ephemerides and clock aiding for fast acquisition (5-10 seconds)
- In combination with
 - AcuWing → sound speed calibration
 - Compass → streamer shape
 - Inertial sensors → integrated filter
 - Radio → aiding data or differential corrections
- No need for tail buoy, fully submerged streamer spread
- Easy to find from work-boat





Thank you for your attention!