EnviGuard

Biosensors for Real-Time Monitoring of Biohazards and Disease in Aquaculture.

Dr Ian Johnston
Microfluidics & Microengineering Research Group
University of Hertfordshire

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Biosensors for Real-Time Monitoring of Biohazards and Disease in Aquaculture.

- Large end-user led consortium. 16 Partners, end user focused, 11 SMEs, 3 academic institutions.
- Aim is to develop reliable and cost-effective risk management tools for early detection of harmful algal blooms (HAB), chemical contaminants, bacteria, viruses and toxins.
- Early warning system for aquaculture enterprises, providing improved food security and reducing economic loss.
- Near real-time environmental monitoring.
- Autonomous operation and data distribution.

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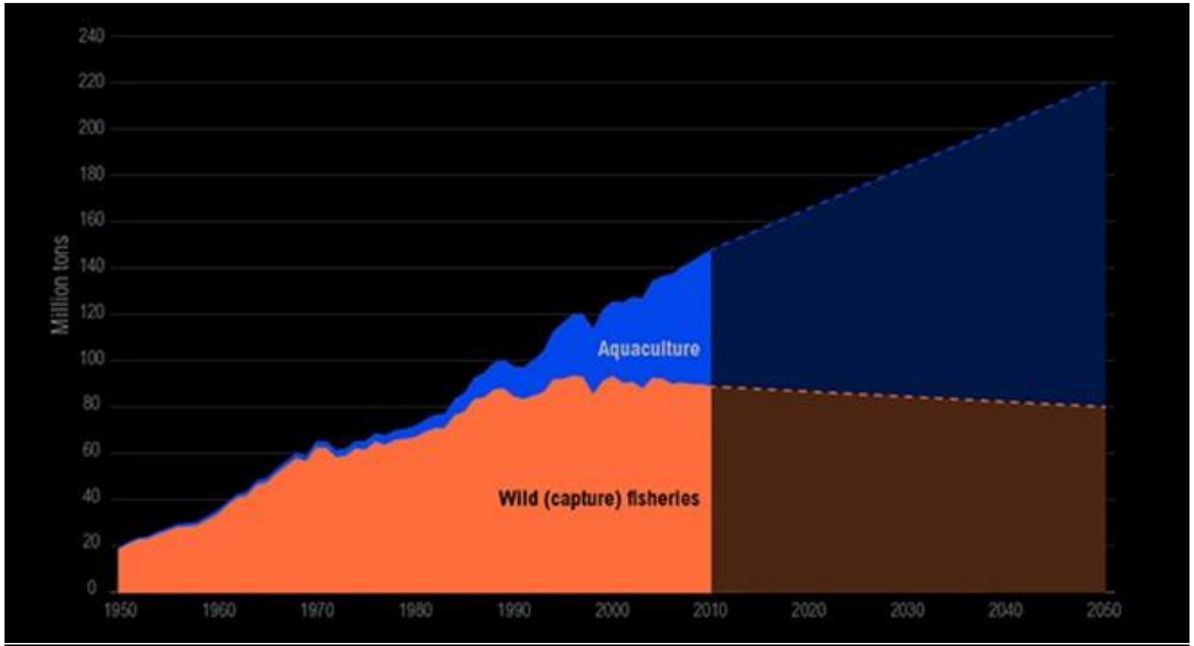
- Global fisheries and aquaculture production totalled 158 million tonnes in 2012.
- Combined this accounts for ~17% of global protein consumption.
- Aquaculture improves diet, especially in poor areas where essential nutrients are often scarce.



Source: Historical data 1950–2010: FAO. 2014. "FishStatJ." Rome: FAO. Projections 2011–2050: Calculated at WRI, assumes 10 percent reduction in wild fish catch between 2010 and 2050, and linear growth of aquaculture production at an additional 2 million tons per year between 2010 and 2050.

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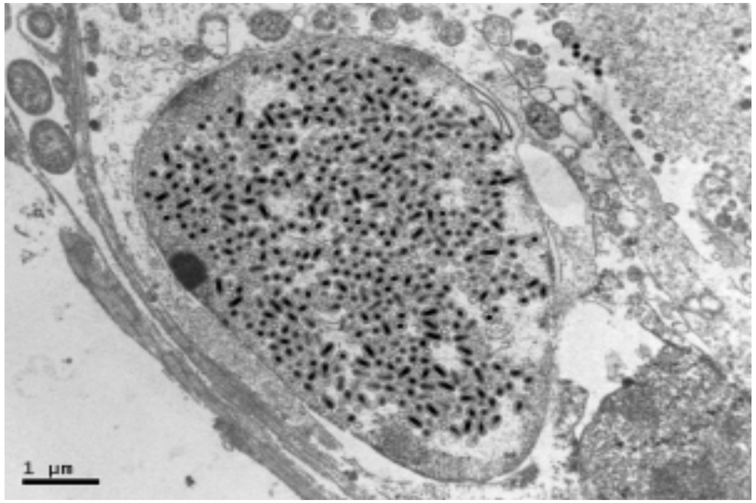
- Infectious microbial diseases limit yield.
- Global cost of these diseases exceed $6bn pa.
- In specific sectors disease losses may exceed 40% of global capacity.
- Disease is the major restricting factor for expansion of the aquaculture industry to 2050.
- White spot in shrimp. Devastation since 1990’s, accounting for at least $1bn in losses every year since its emergence.



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- In-situ early detection of Harmful Algae Blooms (HAB), chemical contaminants, viruses and toxins for aquaculture and environmental monitoring.
- Integration of 3 independent modular near real-time sensing systems.
- 3 independent sensing technologies and sensing bioassay systems.
- Potential for future integrated orthogonal detection.
- Integrated sample preprocessing.
- Integrated power supply and control systems.

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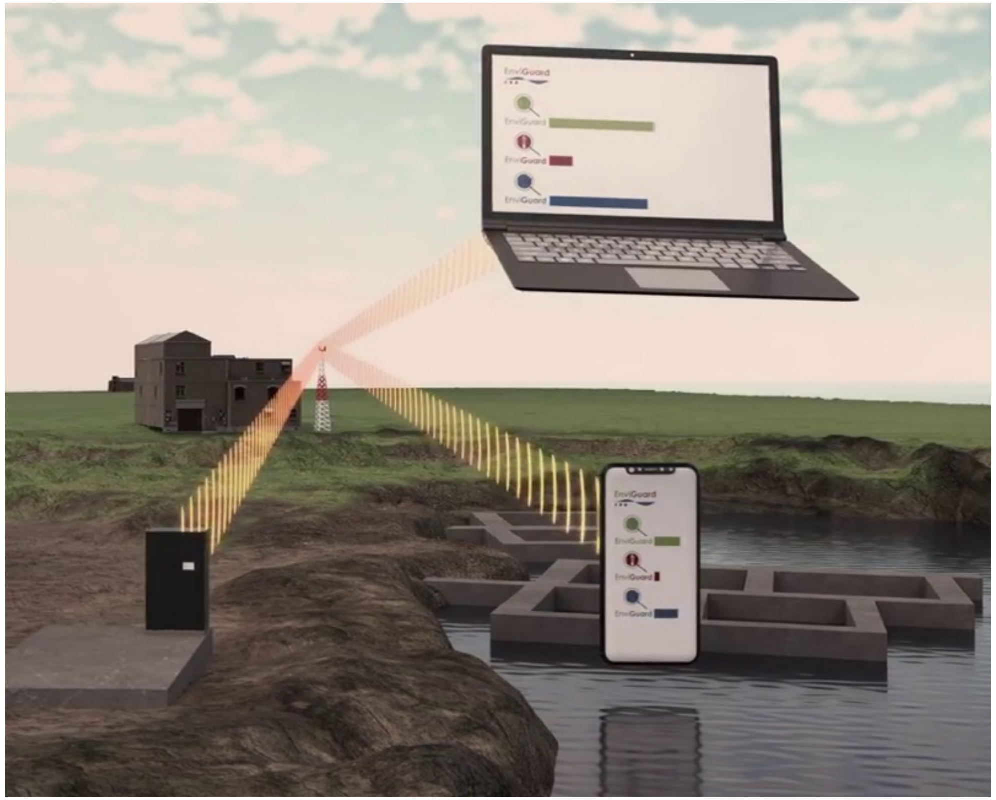
- Sensing systems integrated within a single EnviGuard Port platform.
- On-board data analysis.
- Cloud-based communication for system control and data transmission via a web interface.



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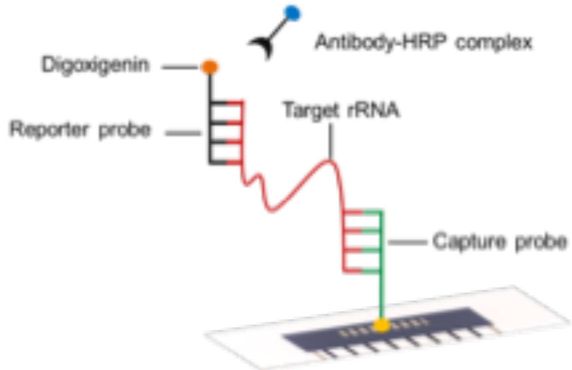
Algal Detection Unit

- A quantitative nucleic acid-based detection sensor for toxic algae in EU waters.
- Molecular detection and quantification uses a Sandwich Hybridisation Assay.
- The biosensor is calibrated for target species:
  - ➢ *Protoceratium reticulatum*
  - ➢ *Dinophysis sp.*
  - ➢ *Pseudonitzschia sp.*



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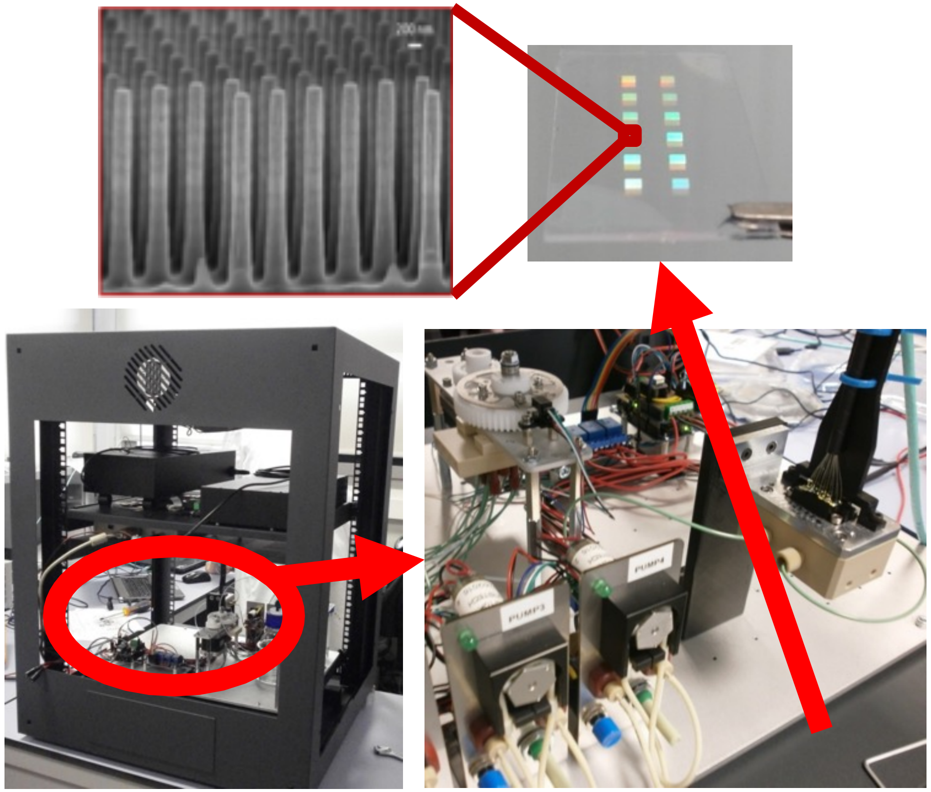
Chemical Detection Unit

- An optical nano-biosensing unit making use of antibodies for the detection of chemicals & toxins.
- Optical interrogation of biological antibody-based binding to arrays of nano-pillars.
- The biosensor is calibrated for target species:
  - PCBs
  - Okadaic Acid
  - Saxitoxin (ongoing)



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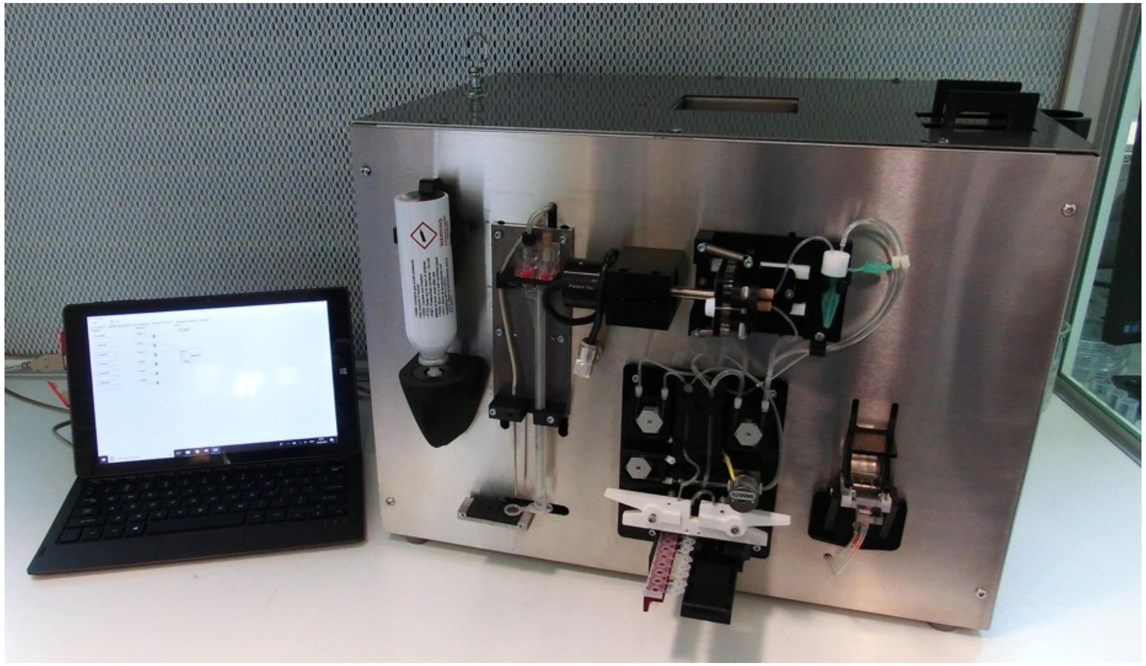
- Application of UHs extensive expertise in the field of biological sample processing and system integration.
- Filter-based pathogen concentration, hydrodynamic separation, ultrasonic disruption.
- Numerous end-user driven prototype automated biological sample processing systems have been developed.
- Physical delivery of systems for further extended evaluation.



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Pathogen Detection Unit

- UH have developed a prototype sample processing and analysis system for pathogen detection.
- Laser illumination and PMT-based optical fluorescence detection with a large stokes shift.
- Partners ttz Breherhaven have developed a sandwich assay employing both binding aptamer and antibody labelling stages, for target species:
  - E.coli
  - Betanodavirus

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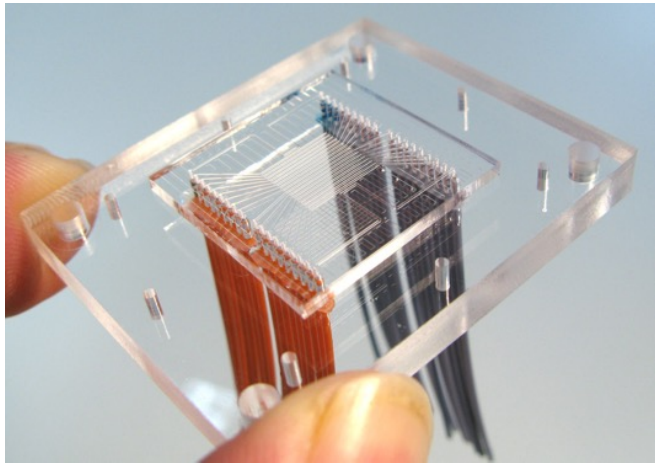
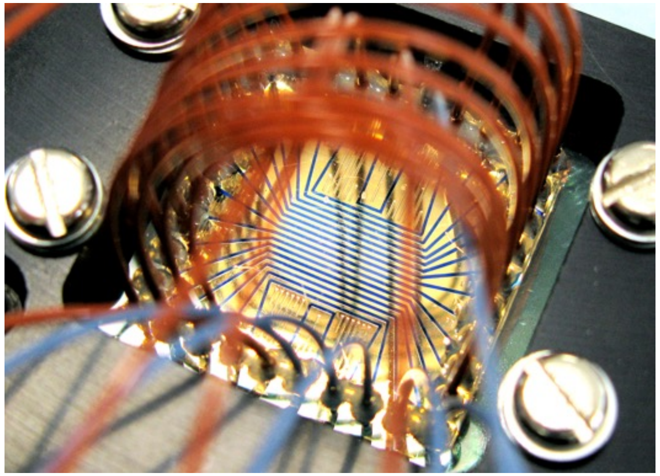
- UH have significant expertise in development of complex microfluidic devices and systems.
- For higher TRL application with real-world samples strategic decisions were made to make trade-offs between state of the art technology and in-field usability.
- Ease of use, reliability and performance.





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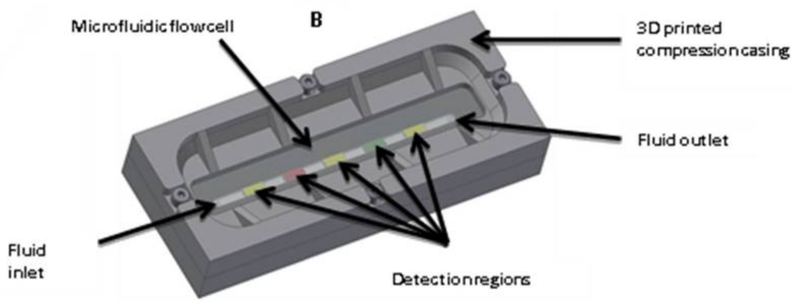
- Robust and fluidically simple microfluidic consumable design.
- Developed primarily for system development with mass manufacture capability.
- Simple easy to pattern the bioassay and manually assemble.
- Plug and play packaging for end user operation.



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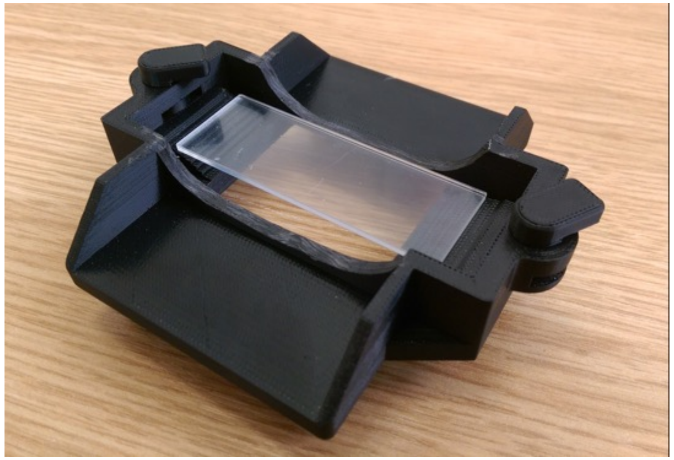
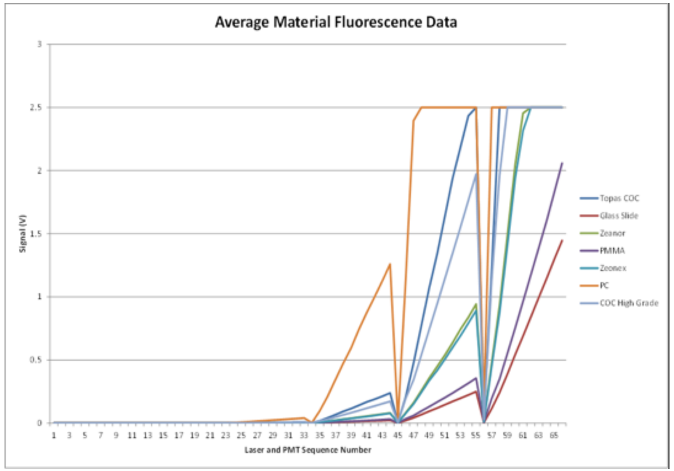
- Polymer material selection based on in system autofluorescence testing.

- Fluorophore selected with large stokes shift to minimize non specific background signal. Dynomics DY-521XL, 523 nm / 668 nm.

- PMMA was selected as the optical flow cell material due to ease of fabrication and low autofluorescence.





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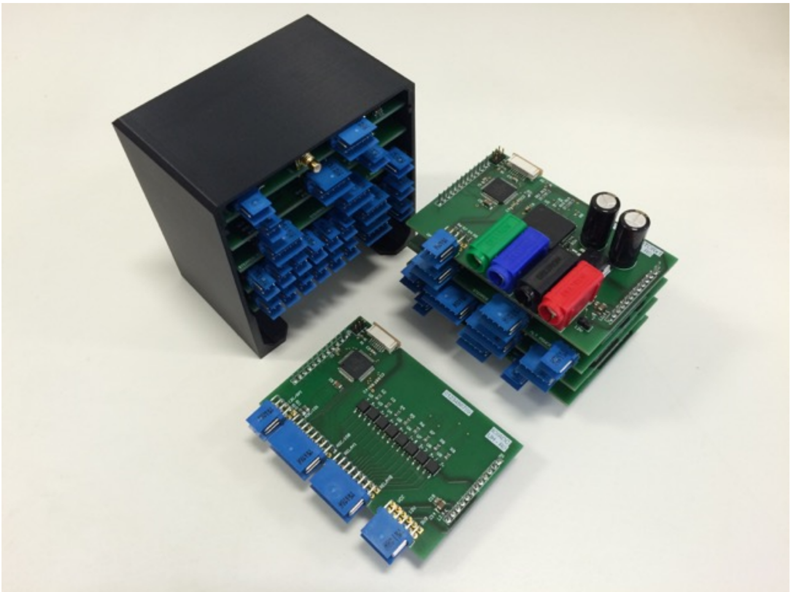
- Holistic approach to system design.
- In-group development of all core aspects of system design and manufacture.
- Electronics, software, custom fluid devices, packaging etc…
- Working with OEM manufacturers when there are specific requirements to use emerging commercial technologies.



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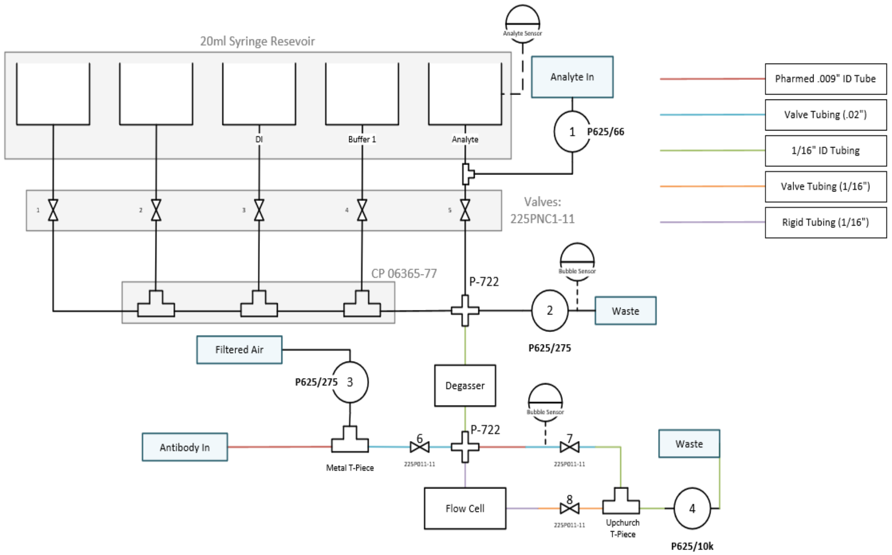
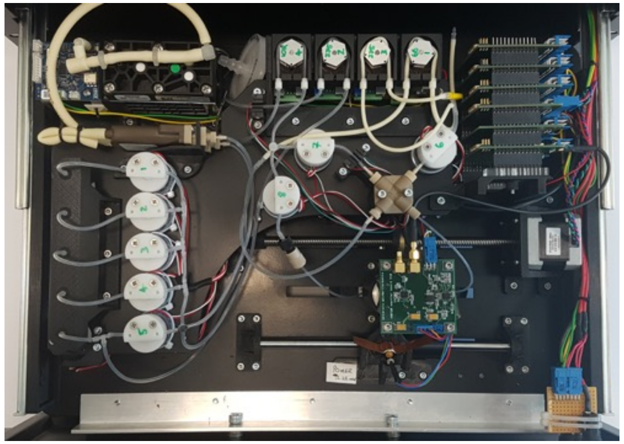
- System complexity.
- Multi analyte processes and analyte carry over.
- Sample manipulation for optimized delivery of target pathogens within collected samples.
- Sample specific requirements eg. outgassing of liquid samples.





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- Redesign and repackaging for system integration.
- Designed to minimise interfacing and complexity for end-users.
- Disposable fluid reservoir consumables.
- Automated cleaning procedures.
- But with ease of access for required system maintenance.

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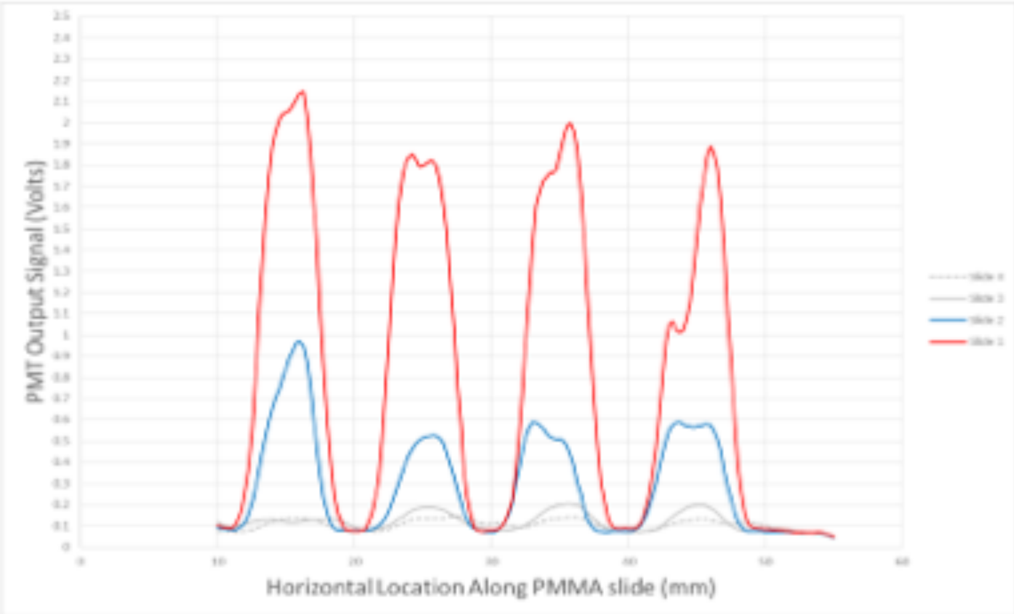
- *Early example of PDU output signals along the horizontal length of the patterned PMMA slides.*
- *Slide1 (red) - spotted regions represent exposure to 10^7 killed E.coli cells per ml.*
- *Slide 2 (blue) - spotted regions represent exposure to 10^6 killed E.coli cells per ml.*
- *Slides 3 and 4 (grey) - spotted regions are negative controls without E.coli cells, and with 10^7 E.coli cells per ml without antibody.*



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- Simple to install and get operational.
- Remote operation and data transmission processes all validated.
- Includes custom designed components for:
  - Precision antibody introduction and dispensing.
  - Bubble free operation.
  - Fluid level monitoring.

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- System testing and field trials are comencing on Orkney now at Orkney Shellfish Hatchery.
- EnviGuard Training Workshops are planned for:
  - August 1st Orkney Islands, UK.
  - November 7th Bremerhaven Germany (+ Final project conference).

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Acknowledgements

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1 University of Hertfordshire, College Lane, Hatfield, Herts., UK.

2 ttz Bremerhaven, Am Lunedeich 12, 27572 Bremerhaven, Germany.

3 Cemitec, ADItech, Polígono Mocholí, Plaza Cein 4, 31110 Noain, Spain.

4 Biotem, Parc d'Activités Bièvre Dauphine, Alphonse Gourju 885, Apprieu, France.

5 Center for Biological Technology, Technical University of Madrid, 28223 Pozuelo, Spain.

6 LioniX BV, PO Box 456, 7500 AL Enschede, The Netherlands.

7 Multitel a.s.b.l., 2 Rue Pierre et Marie Curie, BE-7000 Mons, Belgium.

8 Bio Optical Detection S.L., Technical University of Madrid, 28223 Pozuelo, Spain.

9 Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, Am Handelshafen 12, 27570 Bremerhaven, Germany.

10 iSiTEC GmbH, Bussestraße 27, 27570 Bremerhaven, Germany.

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