How to teach a machine kitesurfing – and why

Blue Intelligence

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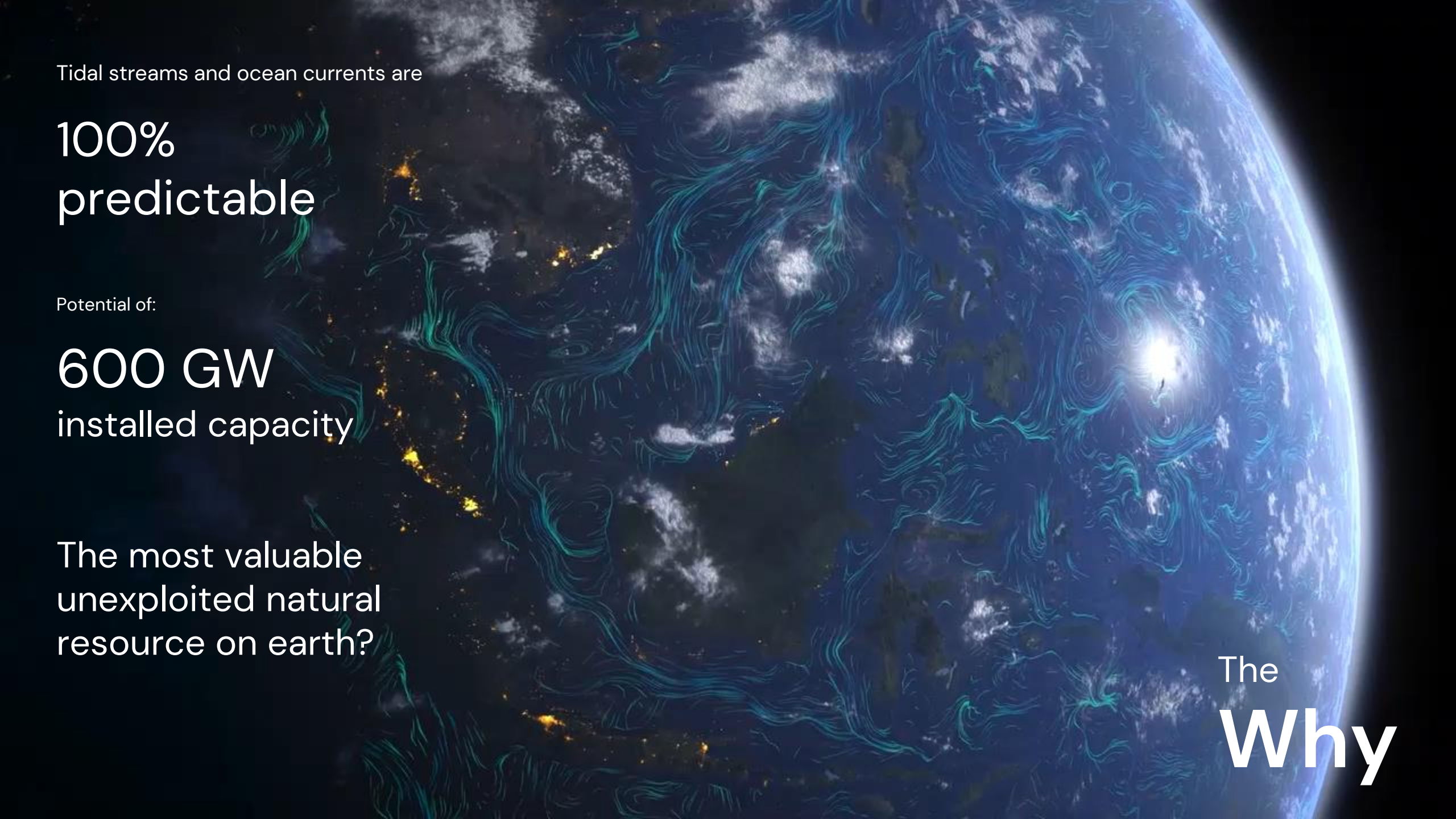
A high-tech impact company

Minesto in short

- Founded 2007 – SAAB Group spinoff
- 60 employees – operations in Sweden, UK, Taiwan, Faroe Islands
- €115m invested in & awarded to the Deep Green technology to date
- First electricity to grid with commercial-scale unit 2020
- Listed on Nasdaq First North GM
- Market cap: c. €240m
- Main owners: BGA Invest and Corespring New Technology

As seen on



Tidal streams and ocean currents are

100% predictable

Potential of:

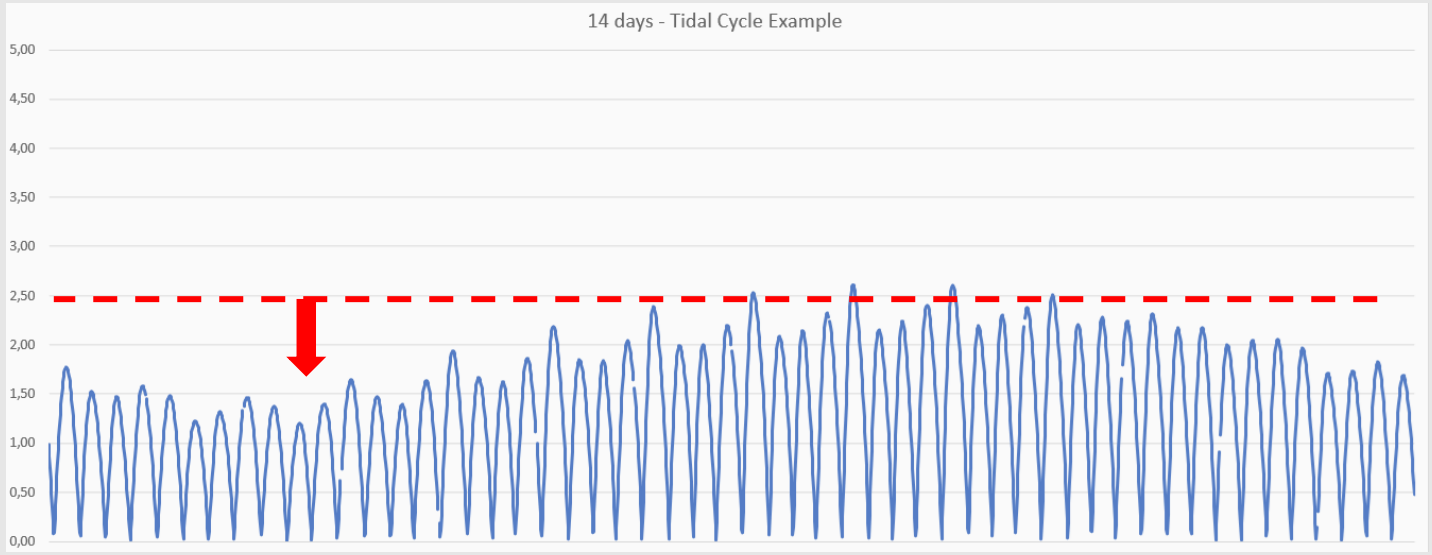
600 GW
installed capacity

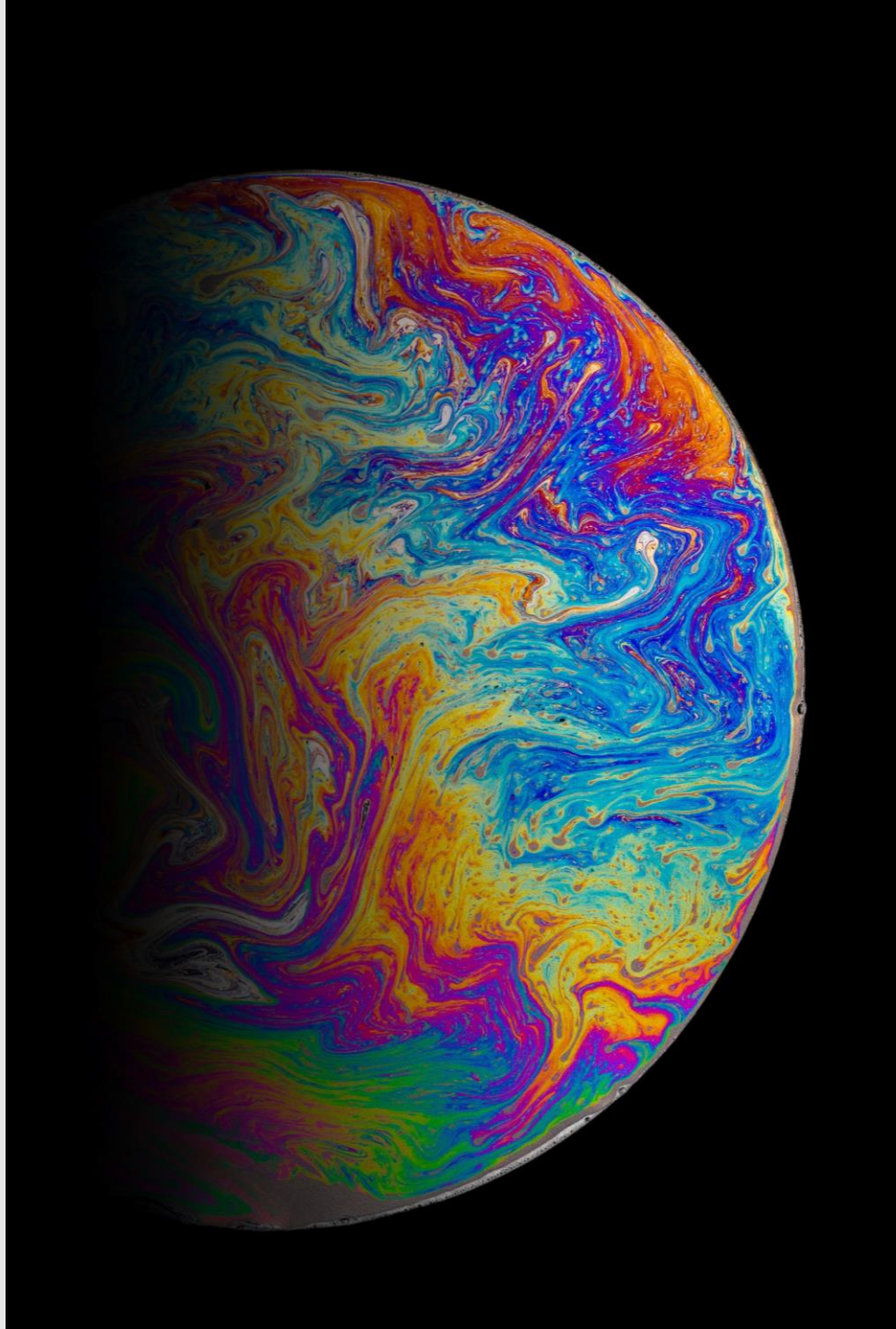
The most valuable unexploited natural resource on earth?

The Why

The Tidal Resource

- 14 days shown
- 0 to “max” to 0 in about 6 hours
- 4 cycles every day
- Intensity follows Moon and Earth orbital patterns
- A vast majority globally is in the lower domains
- Minesto’s target velocities
- Highly predictable

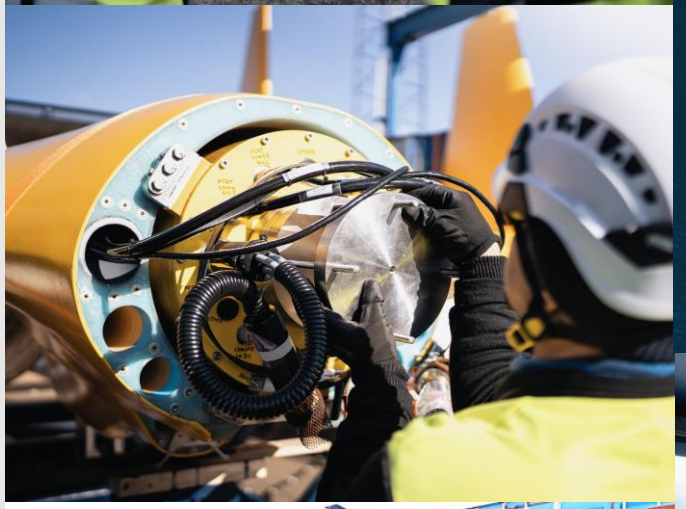





Minesto
The
What

Think: Product – not project

- Designed, and intended for, mass production
- Subsea technology – we need partners and suppliers with capacity, knowledge, experience and drive
- Global reach and potential



Cost efficient operations and handling

- Low-cost O&M procedures verified
- Proprietary unique (LARS) Launch and Recovery concept
- Small work-boat approach a key driver for flexibility and cost-efficiency

- Scalable, lightweight kite systems that are easy to transport and handle
- Dragon 4 fits in 20 ft container

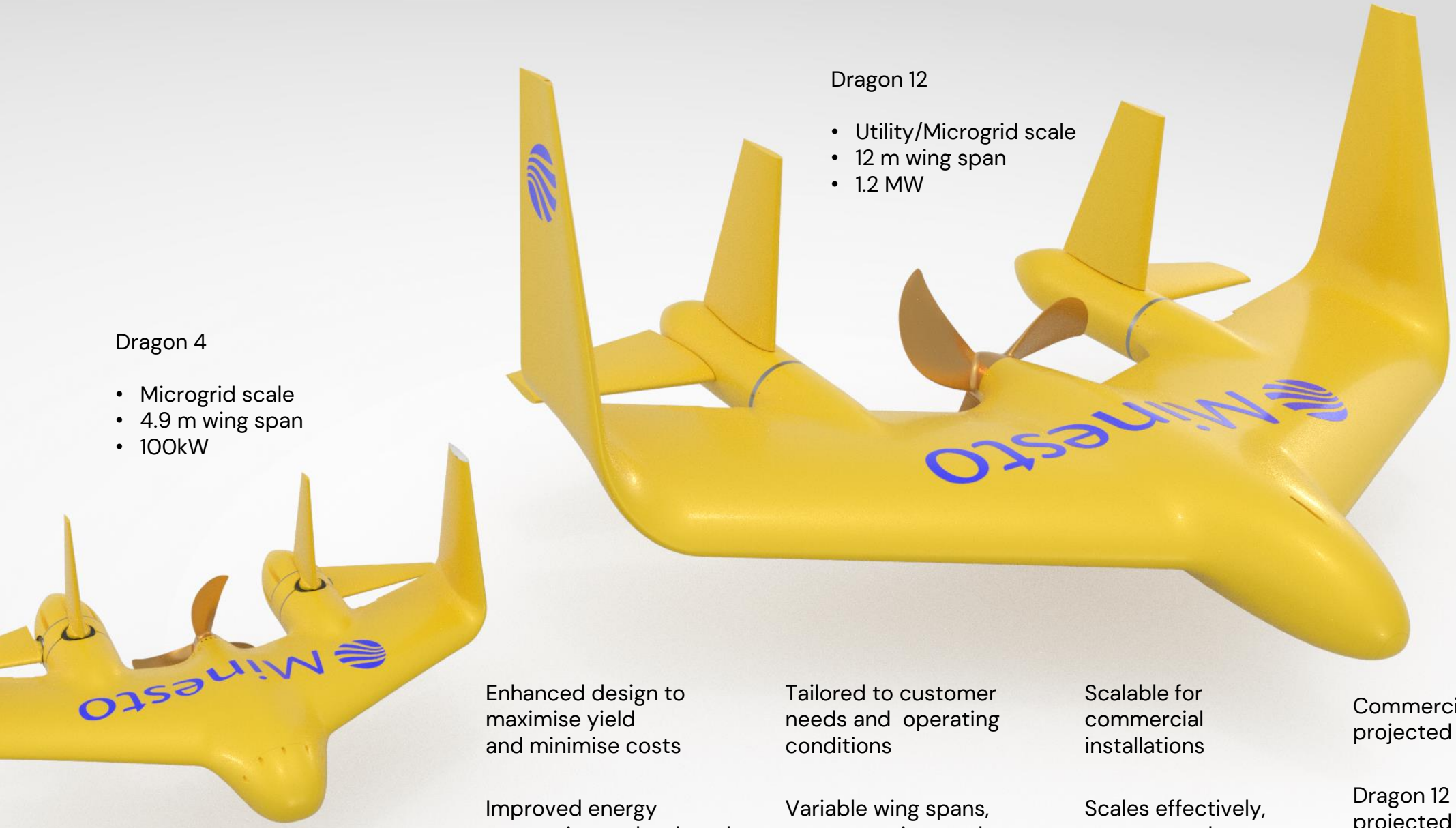
The How

Dragon 12

- Utility/Microgrid scale
- 12 m wing span
- 1.2 MW

Dragon 4

- Microgrid scale
- 4.9 m wing span
- 100kW



Enhanced design to maximise yield and minimise costs

Improved energy conversion and reduced number of subsystems and components

Tailored to customer needs and operating conditions

Variable wing spans, generator sizes and tether lengths are combined to optimise performance

Scalable for commercial installations

Scales effectively, current product range in development spans from 100kW to 1.2 MW

Commercial power projected

Dragon 12 (1.2 MW) projected to produce 3.5 GWh/y at site (Hestfjord)

The Need for Speed

Sea water is 832 times heavier than air
Substantially higher kinetic energy content than air

+

Power generation is proportional to the water speed cubed (v^3).
The flying kite multiplies the water current flow through the on-board turbine

=

Cost-effective exploitation of a so far untapped energy source.
Commercially viable electricity generation with compact, fast and lightweight systems

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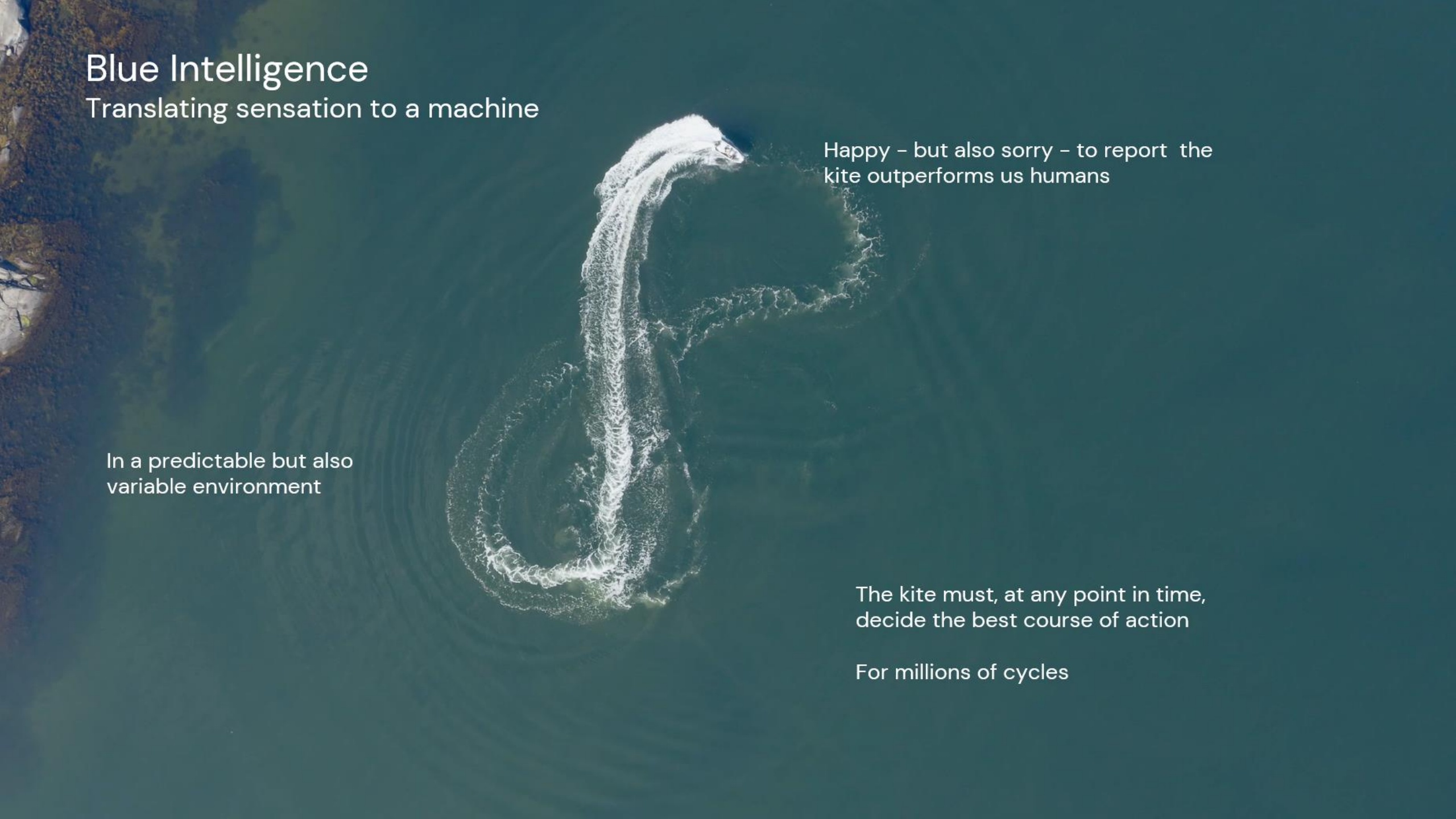
Translating sensation to a machine



Happy - but also sorry - to report the kite outperforms us humans

In a predictable but also variable environment

The kite must, at any point in time, decide the best course of action

For millions of cycles

“All it takes”

- Main duty of the control system is to set position and speed of four control surfaces
- Control trajectory and force in tether
- Sounds easy, right?

From manual to autonomous

SeaKite – Basin Testing (2010)
First version – manual control

Dragon 2 – Barge Testing
Common controls platform

Setup

Fiber communication

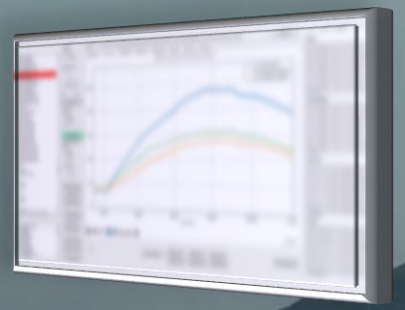
Kite
Embedded System

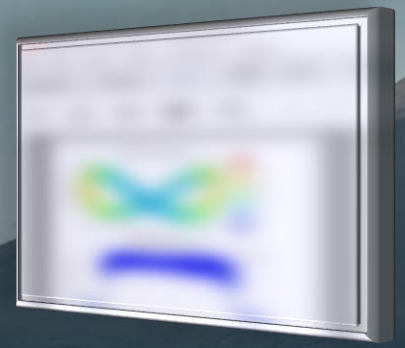
- All signals are logged in 250 Hz
- Adjustments can be made “on the fly”
- Adjustments to code/datasets:
  - Simulated (CFD)
  - Code Simulator
  - Scale Model Testing
- Datasets and software upgrades can and is being uploaded remotely
- Can be pushed to any kite, anywhere

HMI – SCADA
Operator Interface

KitePilot
Expert Interface

- Logs and Reports automatically produced
- Manual and Automatic Posting





General ground rules

1. Any component onboard: undesirable
   - However, some are required of course
2. Objects subject to flow are to be avoided
   - Preferably remove, if not possible: internal or hidden
3. Move as much as possible to software
4. Do not compensate weakness by adding a new system

Example “Speed sensors”:
- Notoriously unreliable and/or expensive
- Shift ability to software
- Speed is now an output, not an input

Example “Twist Detection”:
- Original concept: sensor (in tether subsystem)
- Compass function in control unit developed *(keep in mind it is a flying magnet)*
- No additional hardware required

Some Key Elements

- It moves
- It moves with, against and parallel with flow during a lap
- It moves quite fast
- Small adjustments have significant impact
- Hydrodynamically efficient
- We cannot see it, but neither can anybody else

Some Benefits

- Environment is known, all loads are self-induced
- It moves within a known and set domain
- It is subsea, and is slightly buoyant
- Pressure variances are easy to detect
- It is light and responsive

This image shows the Vestmannasund site with Dragon 4 in operation


Thank You! Questions?
Minesto