datum electronics

Digital Ship
ATHENS SPRING CONFERENCE
DIVANI APOLLON PALACE & THALASSO HOTEL
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Datum Hawk: The Future of Intelligent Engine Diagnostics

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Outline

1. Introduction to DATUM Electronics
2. Datum Hawk concept
3. Datum Hawk Ready Marine Shaft Power Meter (SPM)
4. Crankshaft Dynamics Digital Twin
5. Thermodynamics Digital Twin
6. Case Study
7. The Bigger Picture

1. Introduction to Datum Electronics

Who are we?

- Located on the Isle of Wight, UK
- Produce & sell innovative torque & shaft power measurement solutions (30 years)

Core Business Part

- Forefront in research and development of torque and strain measurement technologies

Our Network

- Extensive network of re-sellers & suppliers in more than 30 countries

Industries

- Involved in over 9 different industries


MARINE & SHIPPING


AUTOMOTIVE

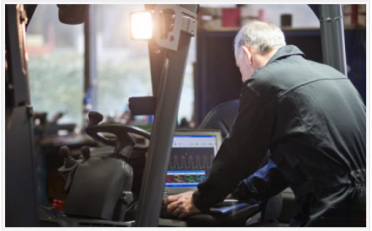

AEROSPACE & DEFENSE


PUMP, VALVE, MOTOR & ENGINE TESTING


MIXERS & MIXING


CIVIL ENGINEERING


GOVERNMENT


TEST RIG SENSORS


GREEN & RENEWABLES

2. Datum Hawk Concept

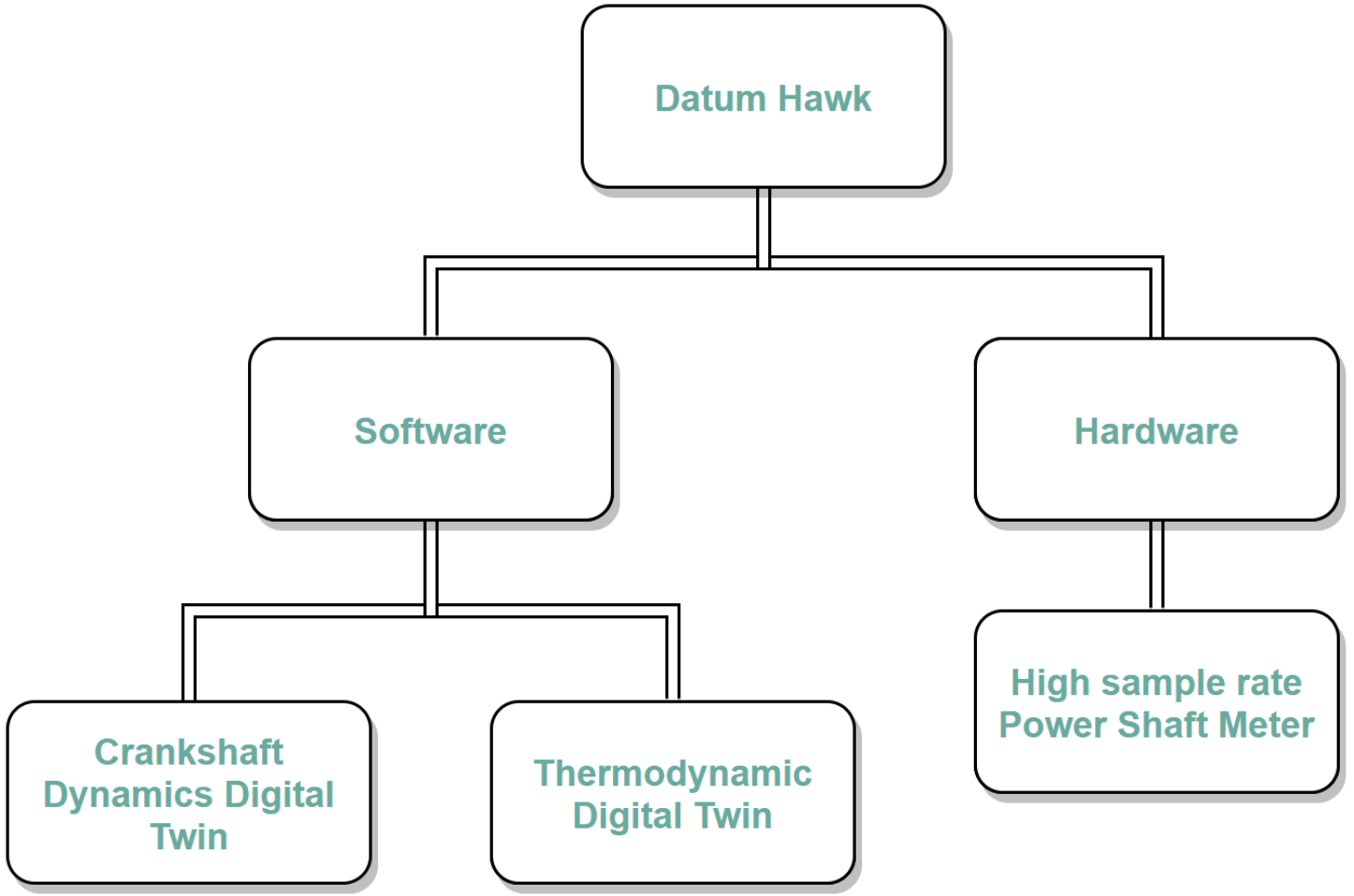
What is Datum Hawk?

- Innovative approach in engine condition monitoring

- In-house developed hardware:
  - ➢ High sample rate Power Shaft Meter (SPM)

- In-house developed software:
  - ➢ Crankshaft dynamics Digital Twin
  - ➢ Thermodynamics Digital Twin

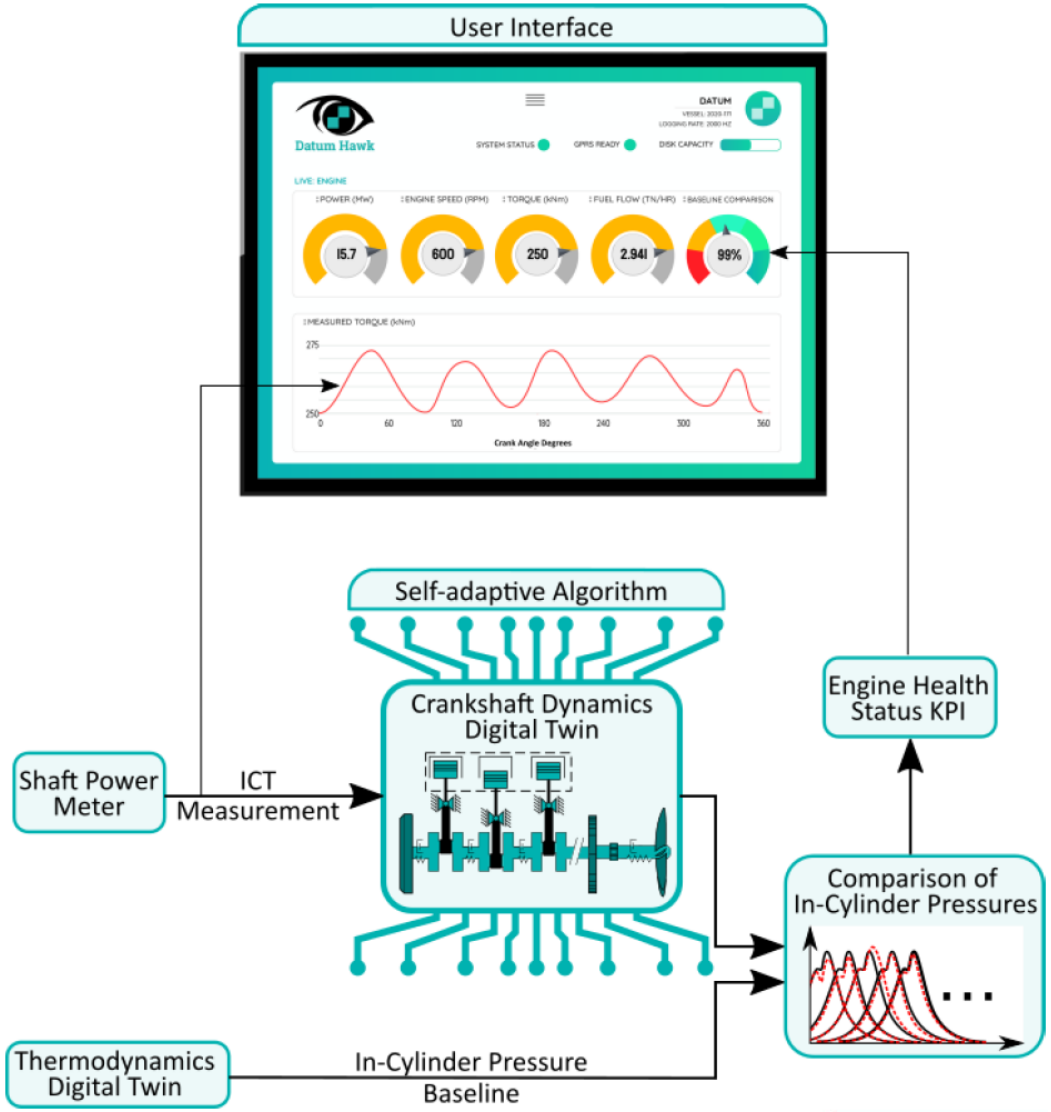
Datum Hawk



2. Datum Hawk Concept

How does it work?

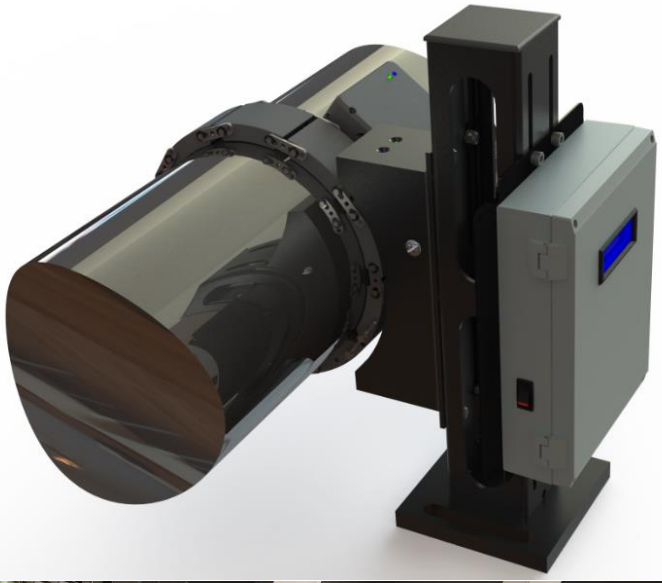
- Measurement of the engine's Instantaneous Crankshaft Torque (ICT) using the high sample-rate shaft power meter
- Torque measurements are employed in a self-adaptive algorithm containing the crankshaft dynamics digital twin
- The digital twin reconstructs the current in-cylinder pressures for each engine cycle
- Current in-cylinder pressures are compared against baseline pressures via a thermodynamics digital twin
- Quantification of differences and engine health status through a Key Performance Indicator (KPI)



3. Datum Hawk Ready Marine Shaft Power Meter (SPM)

Class Approvals

- Development of smart and environmentally friendly shaft power meter solution
- In the process of gaining SPM certification and class approval

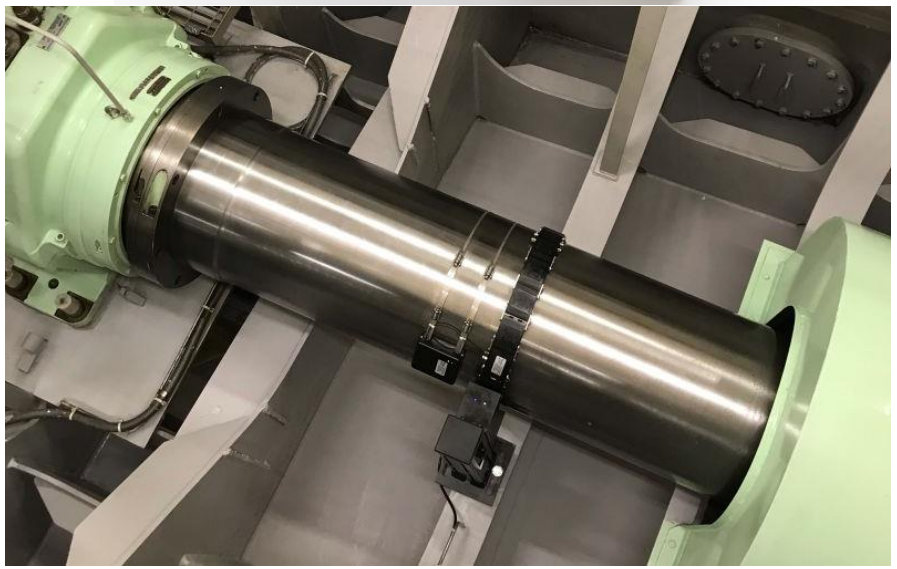


One-fits-all

- Modular design
- Can be easily retrofitted to existing vessels
- Can be recycled between vessels with different shaft diameters

Technical Features

- Maintenance free
- Uses strain gauge technology
- Tested up to 3,000 RPM
- Up to 4000 samples per second



4. Crankshaft Dynamics Digital Twin

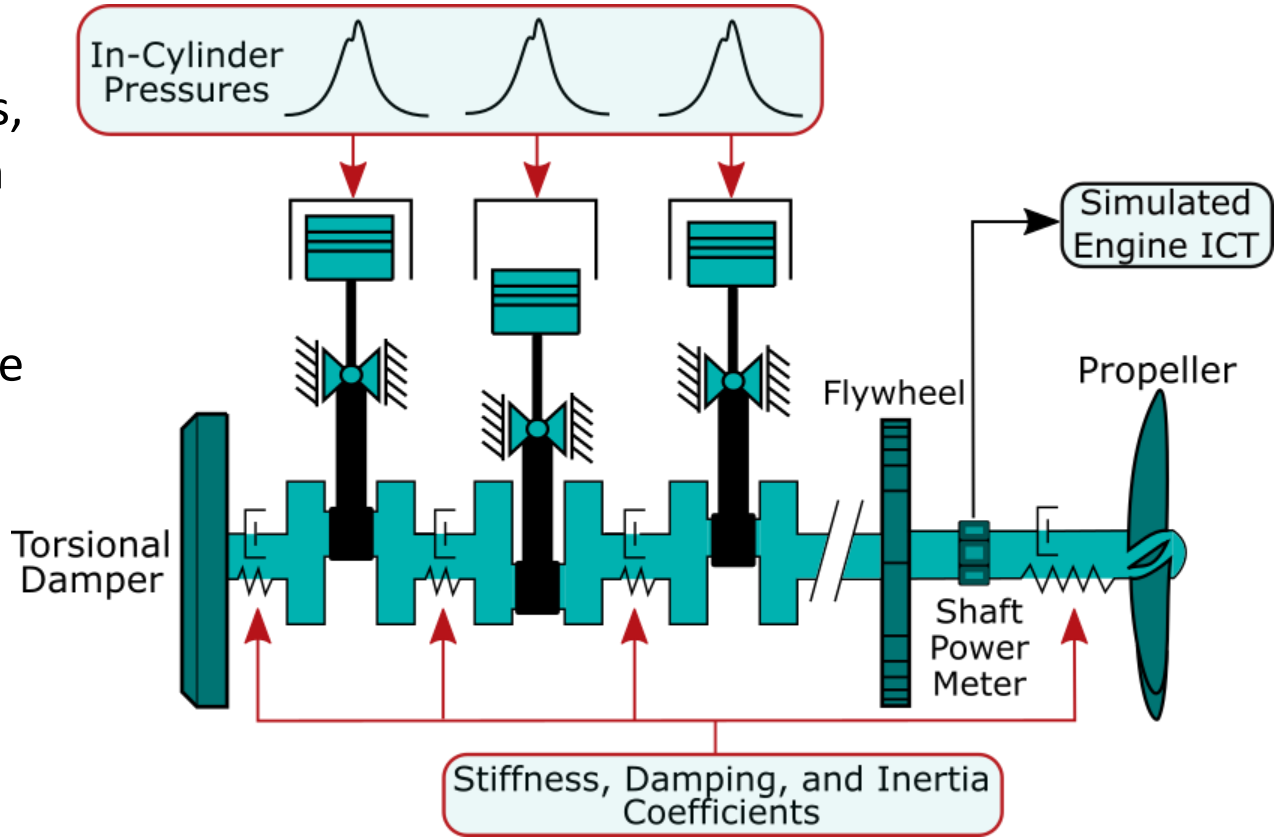
Characteristics

- Employs a torsional model to simulate the crankshaft's stiffness and damping characteristics

Calibration

- Uses as input the in-cylinder pressure for all cylinders, and information from the engine's torsional vibration study (stiffness, damping, inertia coefficients etc.)

- Simulates the engine instantaneous crankshaft torque (ICT) at the point on the shaft where the real shaft power meter would be installed



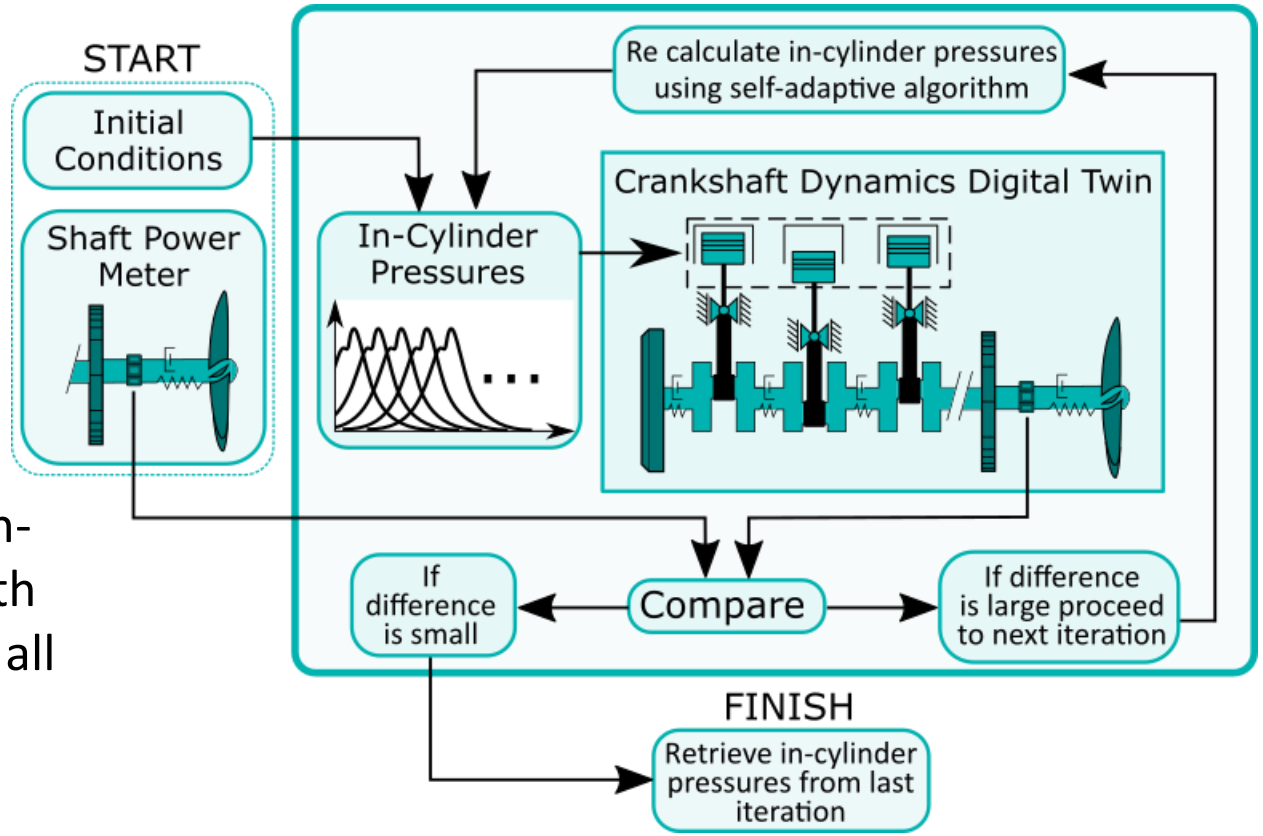
4. Crankshaft Dynamics Digital Twin

Capture of in-cylinder pressure

- The digital twin is utilised within the self-adaptive algorithm
- Uses as inputs the high-sample rate torque measurements from the shaft power meter
- Reconstructs the in-cylinder pressure for all cylinders

Highlights

- The crankshaft dynamics digital twin along with a high-sample rate shaft power meter, provide the ability with just one sensor to retrieve the in-cylinder pressure of all engine cylinders



5. Thermodynamics Digital Twin

Characteristics

- Employs a multi-zone model approach to simulate the combustion inside the cylinders
- Reproduces the engine's performance in healthy conditions and at any operating point
- Can be used to simulate the engine performance under different malfunctioning conditions (e.g., blowby, clogged injectors and engine de-tunning)

Calibration

- The digital twin is calibrated for the engine operating points available in the shop tests
- Minimum inputs required include the engine fuel flowrate, engine rotational speed, engine room ambient temperature, cooling water inlet temperatures

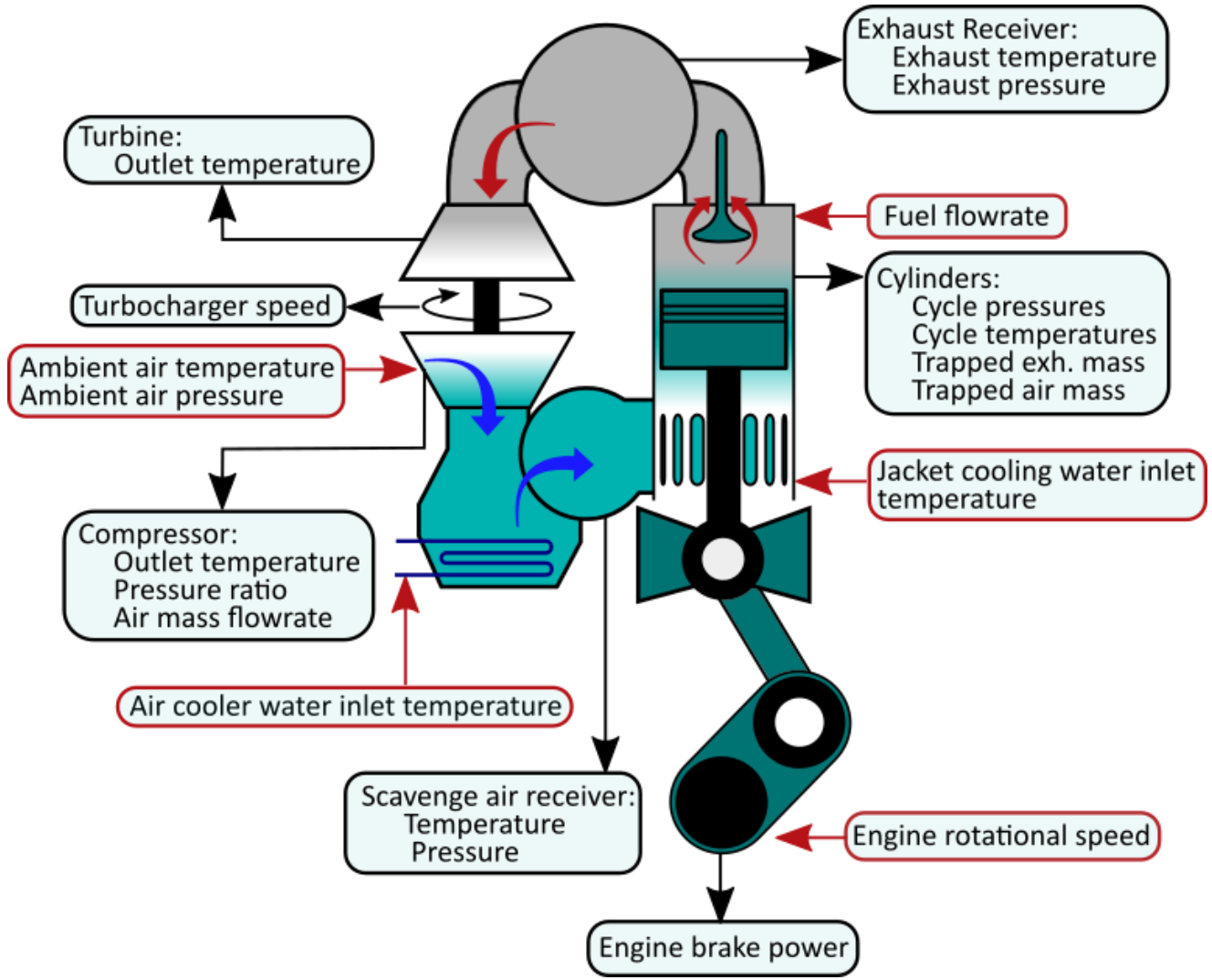
5. Thermodynamics Digital Twin

Outputs

- The outputs of the thermodynamics digital twin include vital information such as:
  - Exhaust gas temperatures
  - Turbocharger speed
  - In-cylinder pressure
  - In-cylinder temperature

Highlights

- Multitude of outputs can be generated
- Can be utilized as a baseline to compare with a variety of measurements
- Can be employed in tandem with the crankshaft dynamics digital twin to evaluate the engine's health status



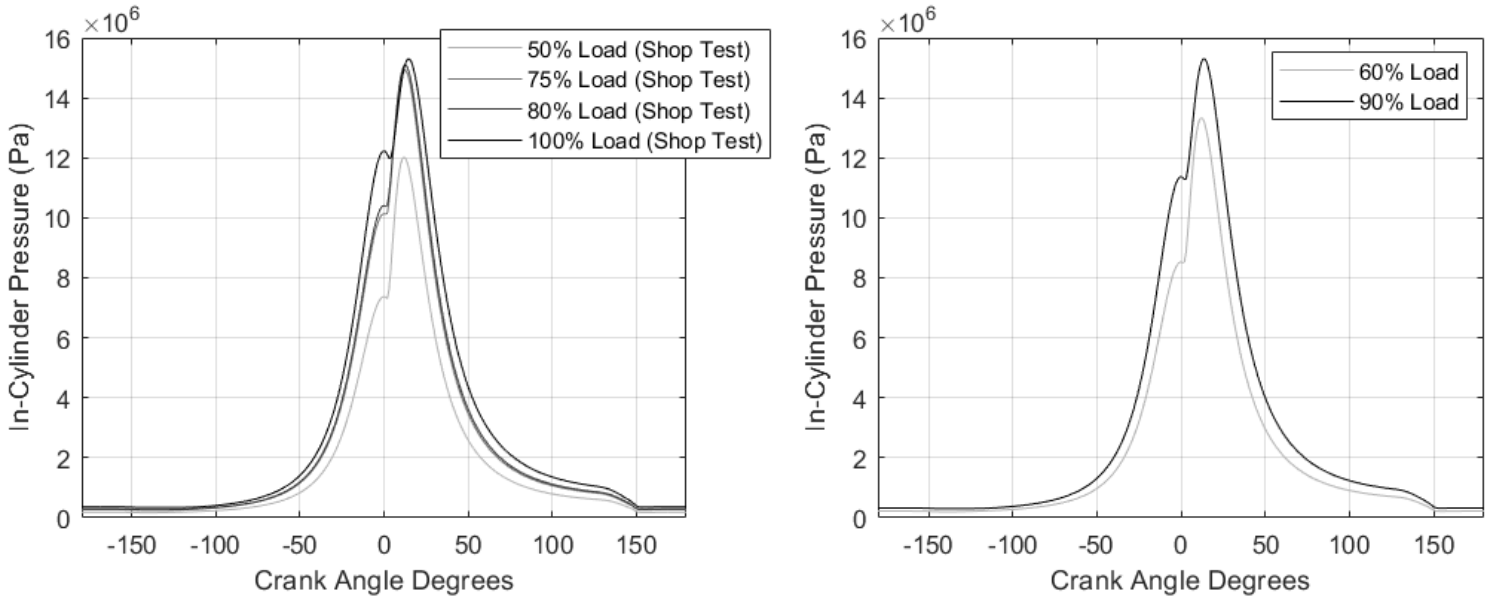
7. Case Study

System Details

- Configuration: Single screw, fixed pitch propeller
- Main engine: RT-flex50-D, MCR 8,890kW @116 RPM

1st Step: Thermodynamics Model Calibration and Outputs

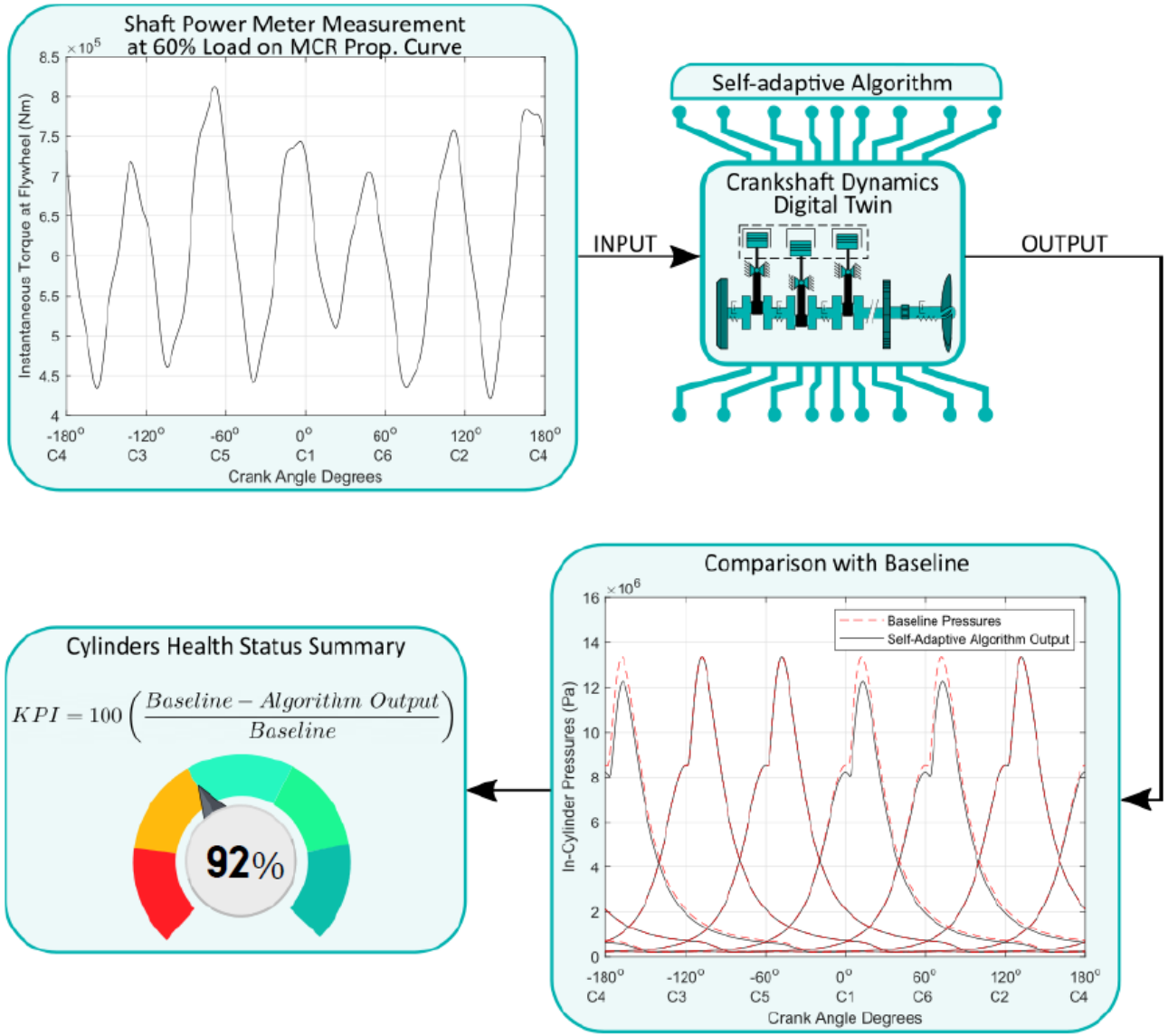
- The thermodynamics digital twin was calibrated using shop tests for one cylinder
- Baseline performance was derived for as-good-as-new conditions for every engine operating point
- Capture in-cylinder pressure curves for as good-as-new conditions for all cylinders



7. Case Study

Fault & Degradation Identification

- Obtain ICT measurements using Datum Hawk shaft power meter
- Torque measurements are used as inputs in the self-adapting algorithm
- Generate in-cylinder pressure data for every engine cylinder
- Comparison between the baseline in-cylinder pressures and the ones derived from the algorithm to obtain the engine's health status



8. The Bigger Picture

Summary

- Datum Hawk in its most basic version employs a high sample-rate shaft power meter with a crankshaft dynamics and thermodynamics digital twins to evaluate the engine health status

- The crankshaft dynamics digital twin allows for the interpretation of the complex patterns of the engine's instantaneous crankshaft torque to gain insight into the cylinder's condition

- The thermodynamics digital twin is a powerful tool, that can be utilised as a stand-alone module of Datum Hawk to evaluate the engine's health

Benefits

- Datum hawk does more with less; we can perform crucial set of diagnostics using our state-of-the-art torque meter (SPM)

- Quantify vessel and fleet performance with the ability to include custom KPIs as required by the client

8. The Bigger Picture

Benefits

- Extreme ease of installation; our Datum Hawk ready SPM is modular, adjustable on site and recyclable from vessel to vessel

- Ease of integration with existing sensors, if needed: we support all standardised protocols (e.g., any external sensor such as flow meters, temperature, pressure can be integrated into the Datum Hawk processing unit)

- Overall, this is an intelligent method of utilising crucial engine measurements to diagnose the ships powerplant from a physical perspective

- Identify the onset of degradations before they result to costly down time, and identity engine inefficiencies early on to save on fuel costs

Thank you for your attention!