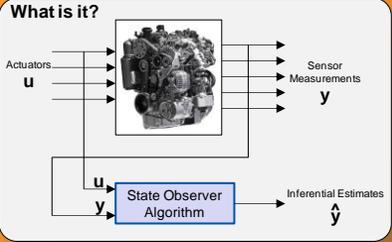


NEW OPPORTUNITIES THROUGH  
TURBOCHARGER SPEED MEASUREMENT

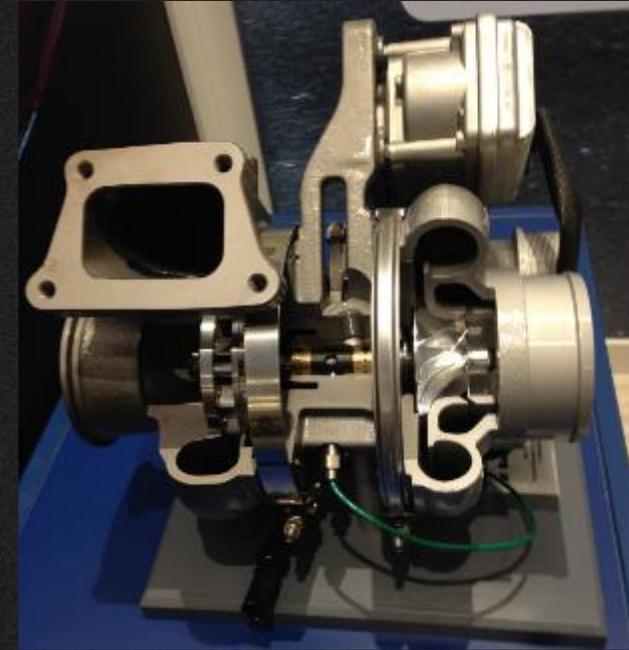


INCREASED PERFORMANCE  
IMPROVED RELIABILITY  
HIGHER EFFICIENCY

	Look-Up Table Based Estimator	Physics Based Virtual Sensor	Physical Sensor
			
<b>Cost / Engine</b>	\$-\$\$ (inhouse)	\$	\$\$
<b>Development Time</b>	Dyno Mapping (~1 month)	Fitting (~1 week)	Plug & Play
<b>Power Margin</b>	O	+	++
<b>Altitude Margin</b>	O	+	+
<b>Time to Boost</b>	O	+	++
<b>Bi-Turbo Balance</b>	O	+	+
<b>Overspeed Protection</b>	+	++	++
<b>Diagnostics</b>	-	O	++
<b>Installation / Mounting</b>	+	+	O
<b>Reliability</b>	O	O	+
<b>ECU Impact</b>	Table	Model	Customizable
<b>Safety Margin Range</b>	10-20%	5-15%	1-2%

## **VARIABLE RELUCTANCE (VR)**

VARIABLE MAGNETIC RESISTANCE USED ON FERROMAGNETIC TARGETS SUCH AS THE CARTRIDGE SHAFT



## **PASSIVE/ACTIVE EDDY CURRENT (PEC)**

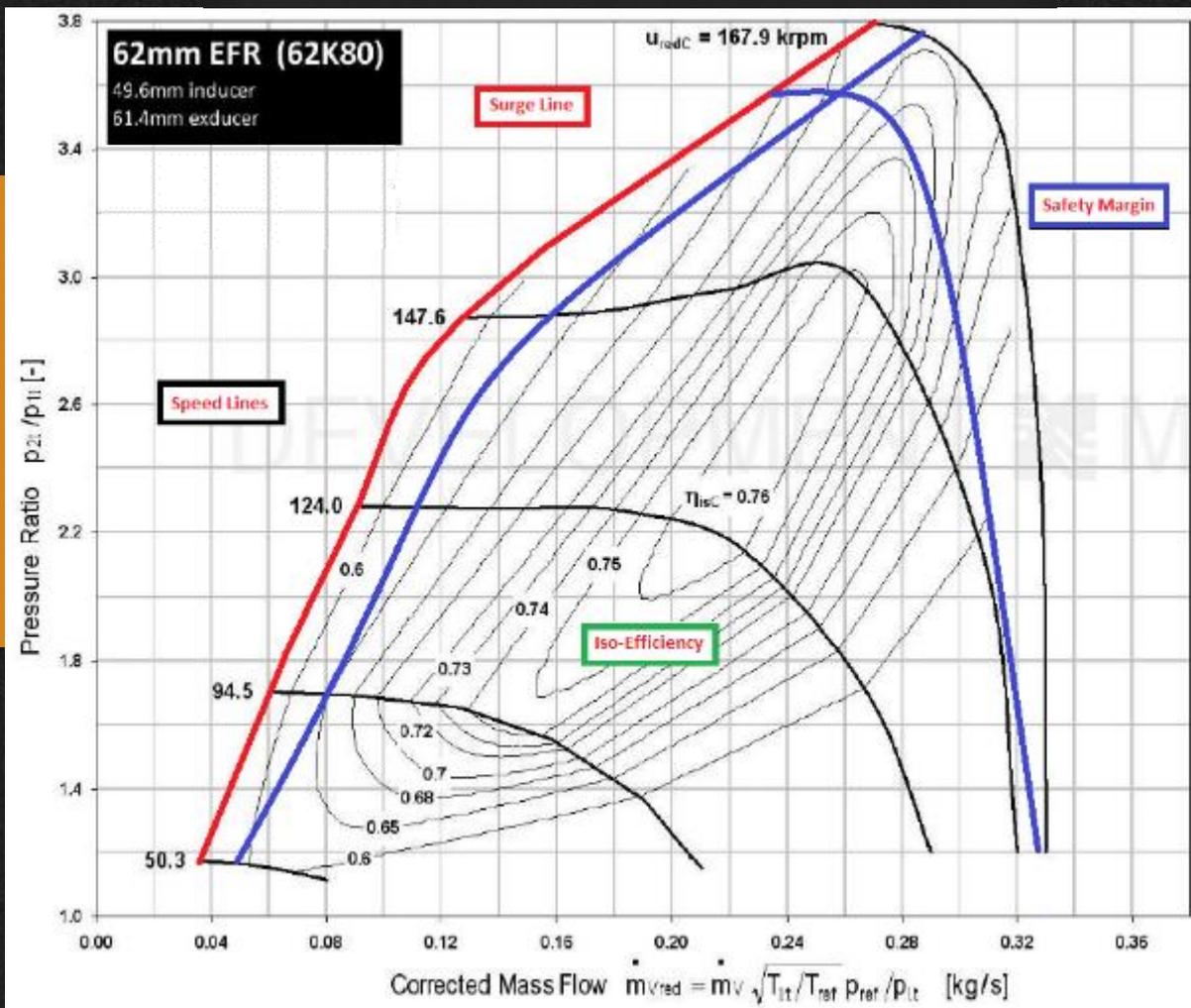
CURRENT INDUCED IN AN ELECTRICAL CONDUCTING TARGET AS THE COMPRESSOR WHEEL





**INCREASED PERFORMANCE**  
IMPROVED RELIABILITY  
HIGHER EFFICIENCY

# INCREASED PERFORMANCE



INCREASED  
**PERFORMANCE**

SAFETY MARGIN  
POWER & TORQUE  
SYNCHRONIZATION  
ALTITUDE

INCREASED  
**PERFORMANCE**

CONTROL  
MULTI-COMPRESSOR  
SYSTEMS

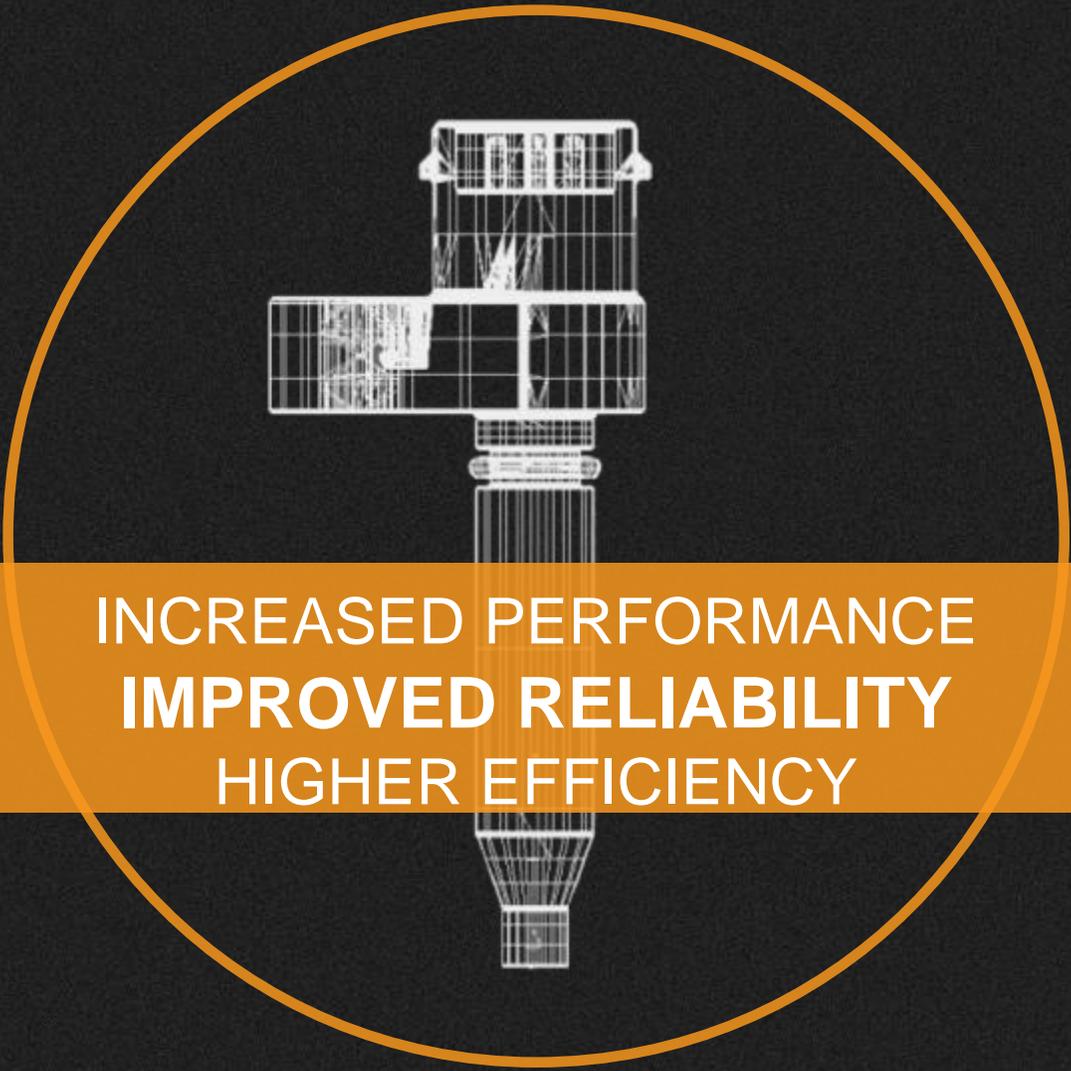
MINIMIZE HARMFUL  
OPERATION

ADAPT TO  
CHANGING  
ALTITUDES

**TURBO-  
CHARGER  
CONTROL**

MONITOR  
COMPRESSOR  
EFFICIENCY

INCREASE MAXIMUM  
OPERATING SPEED



INCREASED PERFORMANCE  
**IMPROVED RELIABILITY**  
HIGHER EFFICIENCY

# IMPROVED RELIABILITY

DIAGNOSE AIRPATH

MONITOR LIFETIME

DIAGNOSTICS

IMPROVE ZERO-FUEL  
CALIBRATION

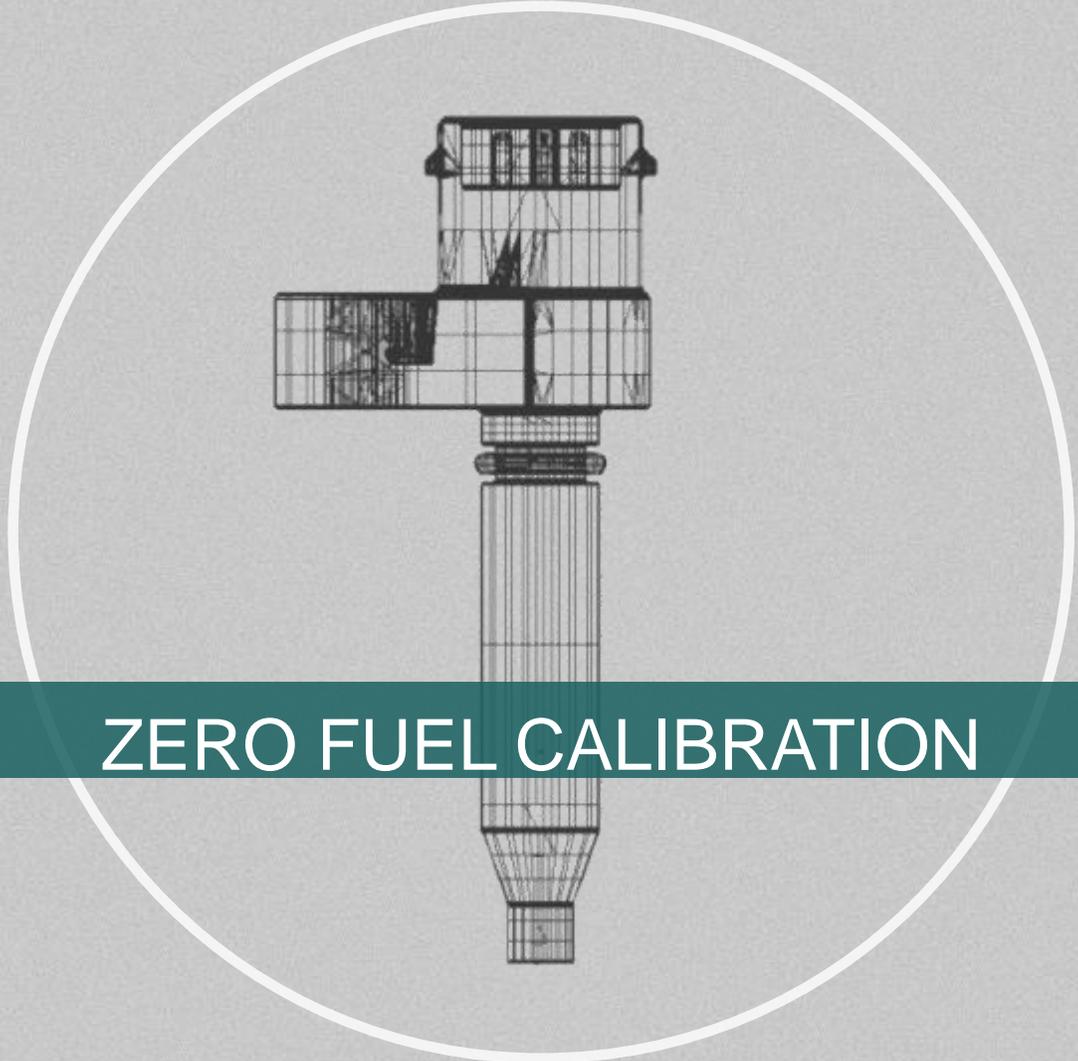
OPTIMIZE  
COLD START



DIAGNOSE AIRPATH



LEAKAGE  
COLD START  
CLOGGED AIR FILTER



**ZERO FUEL CALIBRATION**



EXHAUST AIR ENTHALPY



INCREASED PERFORMANCE  
IMPROVED RELIABILITY  
**HIGHER EFFICIENCY**

# HIGHER EFFICIENCY

EXHAUST  
GAS PRESSURE

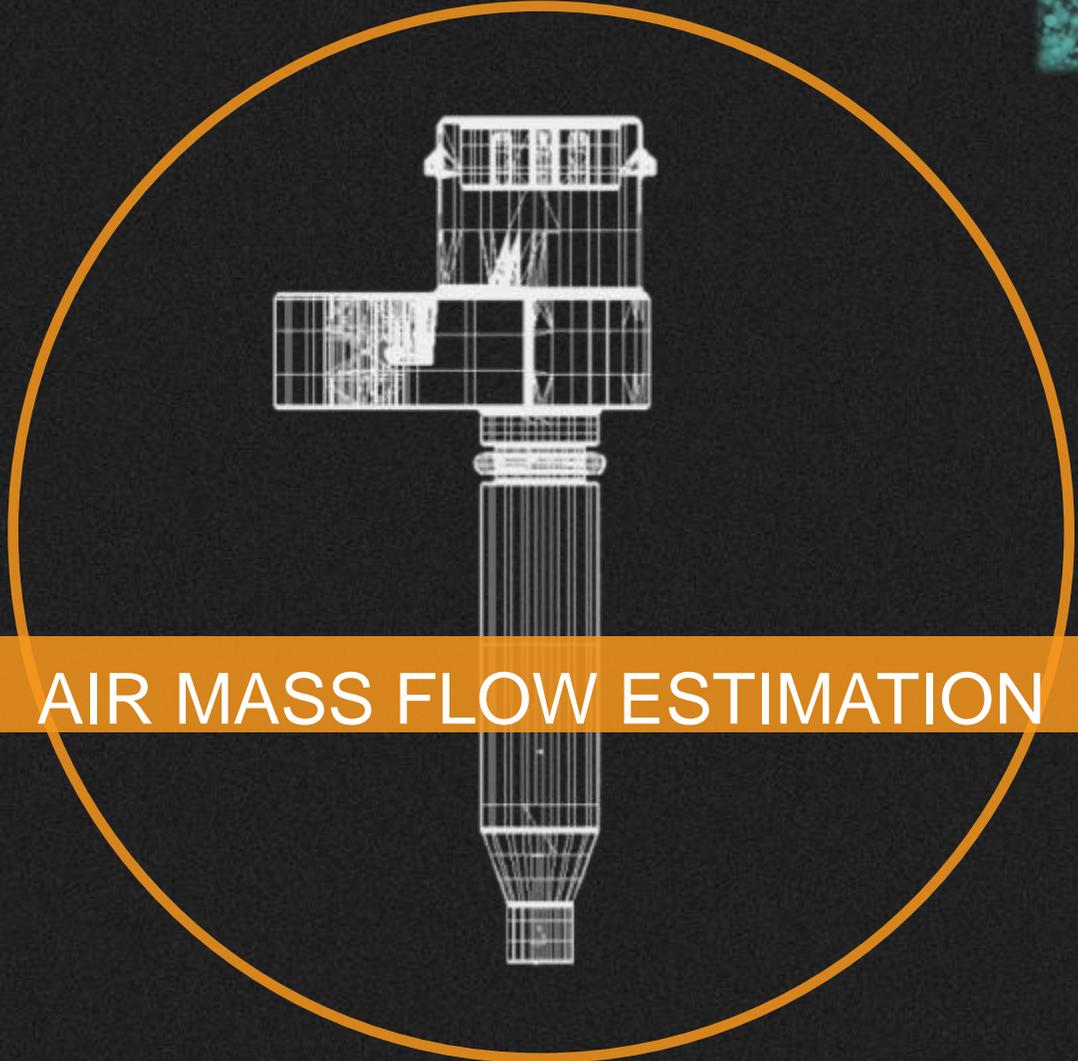
EXHAUST GAS  
TEMPERATURE

MODELLED  
DATA

AIR MASS  
FLOW

INJECTOR  
TIMING

HIGHER  
**EFFICIENCY**



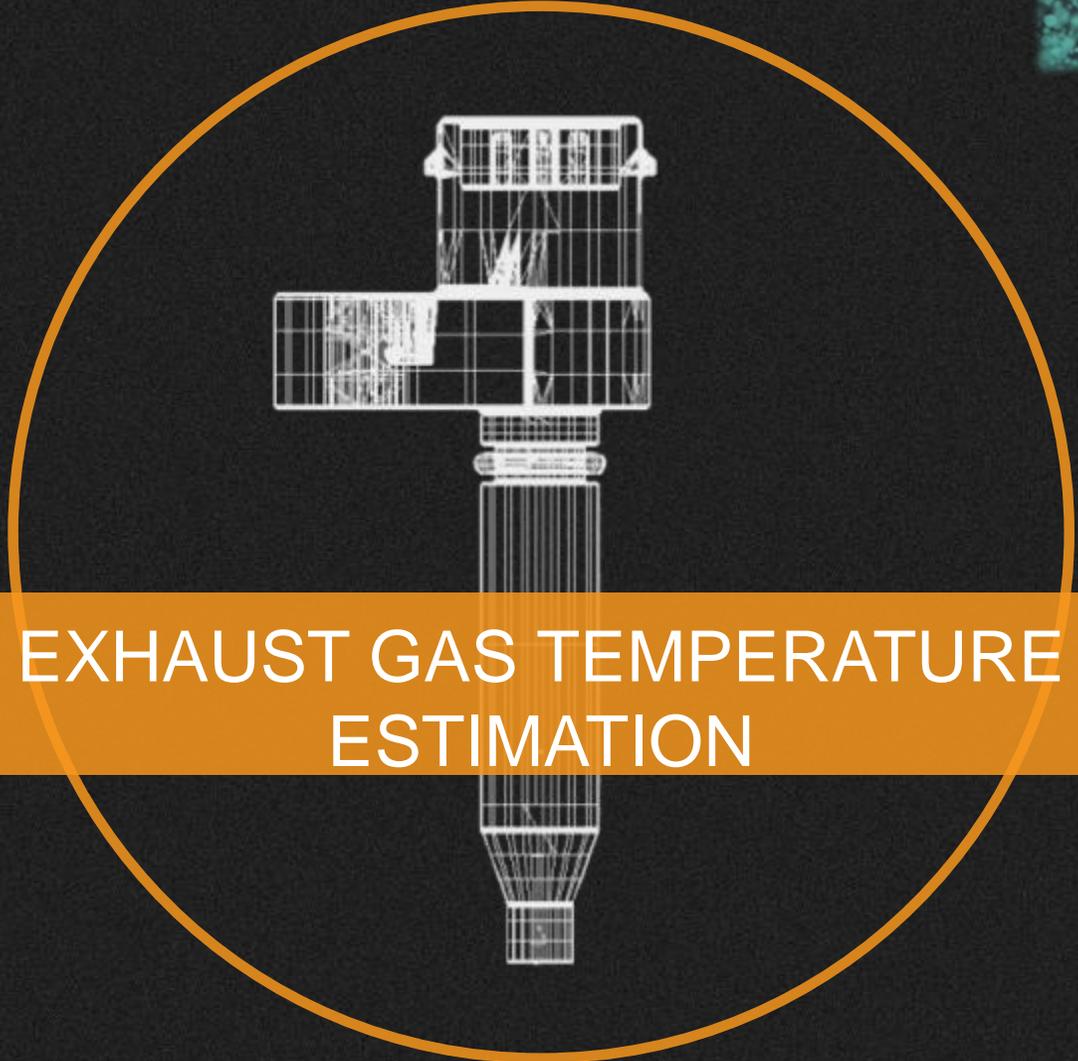
**AIR MASS FLOW ESTIMATION**

HIGHER  
**EFFICIENCY**



**STRENGTHEN THE MAF**  
**ROBUST AND RELIABLE**  
**NO CALIBRATION**  
**NO DELAY**  
**COST SAVINGS**

HIGHER  
**EFFICIENCY**



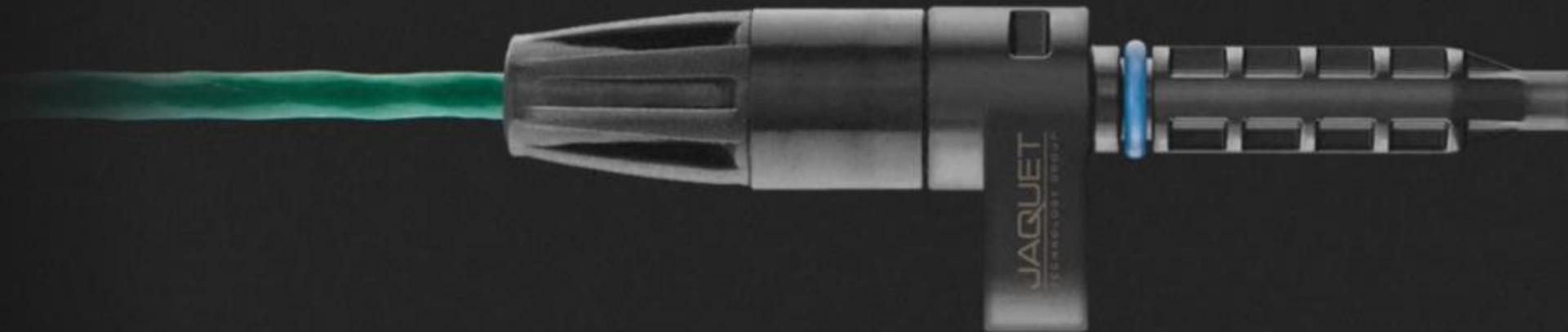
**EXHAUST GAS TEMPERATURE  
ESTIMATION**

HIGHER  
**EFFICIENCY**



**STRENGTHEN THE T4**  
REAL TIME  
FASTER CONTROL ON COMBUSTION PROCESS  
IMPROVED EMISSIONS CONTROL

**LESS IS MORE**



**APOLLO**

ONE SENSOR  
TWELVE OPPORTUNITIES

LEADER IN  
TURBOCHARGER  
SPEED SENSING

OVER 10 MILLION TURBO  
SPEED SENSORS IN TRAFFIC

SERVING ALL MAJOR  
MANUFACTURERS



FIVE  
TECHNOLOGY  
PLATFORMS

116 PROGRAM  
LAUNCHES

95% MARKET SHARE





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