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Michael Palocz-Andresen

Decreasing Fuel Consumption and Exhaust Gas Emissions in Transportation

Sensing, Control and Reduction
of Emissions

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Preface

Since 1998, the introduction of the first Directive with On-Board Measurement in the EU, many parameters in transport have changed. Both the population of the world and the demand for transportation have been continuously increasing. Transport has become the basic foundation of the economy in all countries. In the course of this process, the environment and the climate have been changing in a remarkable way and in turn have influenced transport.

Environmental legislation with Directives such as 98/69/EU, 99/96/EU, and finally 582/2011/EC with amendments, is already reducing emissions of individual vehicles. However, the number of motor vehicles, ships, and airplanes is rapidly rising, especially in fast developing countries. Parallel to this, the amount of oil products consumed and the mass of pollutants emitted are intensively increasing.

A new, sustainable path is required, which focuses on reasonable mass transport at a reasonable price, short travel times with optimal connections, positive impacts in safety, and improvements in sustainability. Good examples are needed worldwide.

Transportation could be improved with the introduction of carbon taxes, higher fuel efficiency standards and the use of new kinds of fuels. It is not enough to produce biogenic and synthetic fuels, although they can be optimally used in road vehicles, airplanes and ships, because they have their own additional problems. On the one side, their utilization lowers the consumption of fossil fuels, but on the other side, their exaggerated use could contribute to the destruction of agriculture and the landscape.

Transport burns most of the petroleum of the world and emits the most air pollution, including unburned hydrocarbons, carbon monoxide, nitrous oxides, and particles. It is the fastest growing consumption and emission sector on Earth. This leads to significant environmental and health problems especially in large cities and is a major contributor to global warming because of emissions of carbon dioxide. New urban infrastructure needs to primarily foster environmentally friendly modes and better management of transportation.

Vehicles, airplanes and ships are becoming more and more efficient, i.e., lighter and more intelligent, with improved aerodynamics, optimized design, and higher

performance. But can technology reduce fuel consumption and emissions effectively?

While technological development has created many problems, such as climate change and loss of resources, at the same time it is part of the solution. The higher demand for transportation could be fulfilled with the assistance of new technologies, new materials and highly intelligent hardware and software systems. Additionally, navigation and active communication systems can optimally and safely regulate the increasing traffic.

The higher comfort level and safety of new vehicles, airplanes and ships also contributes to more sustainability in transportation. However, improved infrastructure is often combined with increased traffic density and higher emissions. That is the reason why research and technological development have to survey alternative technologies and pilot projects to provide sustainable urban development and improve the potentials of mass transportation.

Regarding fuel consumption and emission characteristics, regulations have been intensively expanded in the last 20 years. Energy use and emissions vary greatly between several modes of transportation. Electrification and energy efficiency of transport must be increased in the next decades. However, the introduction of new technology will not happen suddenly but only gradually.

Less than optimal measures to order intensive fuel saving could cause major economic losses. Fuel substitution in transportation has high investment costs in comparison to other sectors of the economy. Therefore, besides technology, a sustainable strategy requires the increased use of renewable energy resources, worldwide intelligent navigation measures, common international regulations, and voluntary agreements between governments, civil, and international organizations limiting fuel consumption and exhaust gas emissions.

The topic of this book is the comprehensive consideration of all aspects of intelligent fuel consumption and exhaust gas emissions in transportation. It can be recommended as a source for the stimulation of further discussions to anyone interested in the field of sustainable transportation.

Acknowledgments

Three years ago, 2008, my first book concerning On-Board Measurement was published by the Expert Verlag in Renningen, Germany. In that book the basic fundamentals of direct measurement technology (OBM) were described. Since that time, the legislation and the technology have been intensively developed. It seems to be necessary, to continue the work. The next logical stage of On-Board Measurement is Self Diagnosis (SD) which is the centre of consideration in this book.

This is the result of three and a half years of work. Special thanks go to the researchers and teachers, scientists and professors of Leuphana University Lüneburg for the invaluable advice and support regarding sustainable transportation.

The consortium of the University of West-Hungary Sopron supported several application-oriented sections in research and presentation and also gave important assistance.

Within my own team, I would like to express my gratitude to Mr. János Székely (Budapest), Mr. Balázs Szegedi, Ms. Luca Héjja, and Mr. Gergely Krizbai (Sopron) for their efforts in the area of design, Mrs. Dóra Szalay (Sopron) for her support in the construction and checking of units and conversions in the book, and Dr. Hartmut Mädler and Mr. Ulrich Gross (Hamburg) in the translation of subtexts in the international literature and creation of subject indices.

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Hamburg, winter 2011

Prof. Dr.-Ing. habil. Michael Palocz-Andresen

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Abbreviations

| | |
|------|---|
| AAC | Alaska Marine Vessel Visible Emission Standard |
| ACNS | Airborne computer-based navigation system |
| AFDS | Autopilot Flight Director System |
| ADC | Analogue-digital converter |
| AFL | Airplane flight log |
| AFP | Alloy ferritic-pearlitic |
| AIP | Aeronautical information publication |
| AIS | Automatic identification system |
| ALU | Arithmetic logic unit |
| AMOC | Area Meteorological and Oceanographic Coordinator |
| APU | Auxiliary power unit |
| ARO | Air Traffic Services Reporting Office |
| ASTM | American Society for Testing and Material |
| AT | Auto throttle system |
| ATC | Air traffic control |
| ATM | Air traffic management |
| ATS | Air traffic service |
| BEV | Battery driven electric motor vehicle |
| BPR | Bypass pressure ratio |
| BSFC | Best specific fuel consumption |
| BTL | Biomass to liquid |
| CAA | Civil Aviation Authority |
| CAC | Charging air cooling |
| CAD | Computer-aided dispatch |
| CAEP | Committee on Aviation Environmental Protection |
| CAFÉ | Corporate average fuel economy |
| CAI | Controlled auto ignition |
| CAN | Controller area network |
| CARB | Californian Air Resources Board |
| CCNR | Central Commission for Navigation on the Rhine |
| CDA | Continuous descent approach |

| | |
|--------|---|
| CDU | Control display unit |
| CDL | Configuration deviation list |
| CEV | Combustion engine vehicle |
| CFC | Carbon fibre composite |
| CFD | Computational fluid dynamics |
| CLD | Chemo luminescence detector |
| CM | Condition monitoring |
| CN | Cetane number |
| CNG | Compressed natural gas |
| CNS | Communication, navigation and surveillance |
| COP | Compliance of production |
| CPU | Central Processor Unit |
| CRT | Cathode ray tube |
| CSR | Common structural rules |
| CVS | Constant volume sampling |
| DAC | Digital-analogue converter |
| DGPS | Digital global positioning system |
| DME | Distance measuring equipment |
| DOC | Direct operation cost |
| DPNR | Diesel particulate NO _x reduction |
| DWT | Deadweight tonnage |
| EASA | European Aviation Safety Agency |
| EC | European Commission |
| ECAC | European Civil Aviation Conference, Regional body of ICAO for European regions |
| ECD | Electronic chart display |
| ECDIS | Electronic chart display and information system |
| EDC | Electronic diesel control |
| EEC | European Economic Community |
| EEDI | Energy efficiency design index |
| EEP | Engine enhancement package |
| EEPROM | Electrically erasable programmable read-only memory |
| EFIS | Electronic flight instrument system |
| EGAS | Electronic accelerator gas |
| EGT | Exhaust gas temperature |
| EPROM | Electronic programmable read only memory |
| ERAA | European Regions Airline Association |
| ETC | Exhaust turbo charger |
| ETP | Equal-time point |
| ETSO | European technical standard orders |
| ETOPS | Extended-range twin-engine operation performance standards |
| EU-OPS | European operation performance standard |
| FAA | Federal Aviation Administration |
| FADEC | Full authority digital engine control |
| FAME | Fatty acid methyl ester |

| | |
|-------|---|
| FAR | Federal aviation regulation |
| FBP | Final boiling point |
| FC | Fuel cell |
| FCC | Flight Control Computer |
| FCY | Flight cycles |
| FID | Flame ionisation detector |
| FEW | Fuel–water emulsion |
| FHEV | Full hybrid engine vehicles |
| FM | Field monitoring |
| FMS | Flight management system |
| FTIR | Fourier transformation infra red |
| FTP | Federal test procedure |
| FAB | Functional airspace block |
| GAMA | General Aviation Manufacturers Association |
| GC | Green card |
| GDP | Gross Domestic Product |
| GHG | Green house gases |
| GMDSS | Global maritime distress and safety system |
| GPS | Global positioning system |
| GPU | Ground power unit |
| GSM | Global system for mobile telecommunication |
| GT | Gross tonnage |
| GTL | Gas to liquid |
| GVWR | Gross vehicle weight rating |
| HCCI | Homogenously charged compression ignition |
| HCO | Heavy cycle oil |
| HDDE | Heavy commercial diesel engine |
| HDT | Heavy commercial truck |
| HDV | Heavy commercial vehicle |
| HDC | Highway driving cycle |
| HFO | Heavy fuel oil |
| HSLA | High strength low alloy |
| HWFET | Highway fuel economy cycle |
| IACS | International Association of Classification Societies |
| IATA | International Air Transport Association |
| IC | International convention |
| ICAO | International Civil Aviation Organization |
| ICCT | International Council on Clean Transportation |
| ICT | Information and Communication Technology |
| IFO | Intermediate fuel oil |
| IFR | Instrument flight rules |
| ILO | International Labour Organization |
| IM | Inspection and maintenance |
| IMC | Instrument meteorological condition |
| IMO | International Maritime Organization |

| | |
|---------|---|
| IOSA | International operation safety audit |
| IRS | Inertial reference system |
| ISA | International standard atmosphere |
| ISM | International Safety Management |
| JAA | Joint Airworthiness Authority |
| JAA-OPS | Joint Airworthiness Authority-Operation Performance Standard |
| JAR | Joint airworthiness requirement |
| JTSO | Joint technical standard order |
| LCD | Liquid crystal display |
| LDT | Light duty truck |
| LDV | Light duty vehicle |
| LF | Low frequency |
| LNG | Liquid natural gas |
| MARPOL | International convention for the prevention of maritime pollution from ships |
| MDF | Marine destillate fuel |
| MDO | Marine diesel oil |
| MEL | Minimum equipment list |
| MEPC | Marine Environment Protection Committee |
| MF | Medium frequency |
| MGO | Marine gas oil |
| MMI | Man-machine interface |
| MOT | Ministry of Transport |
| MP | Maintenance Program |
| MSC | Maritime Safety Committee |
| MSG | Maintenance Steering Group |
| MSI | Maritime safety information |
| MTOW | Maximum takeoff weight |
| NAA | National aviation authority |
| NEDC | New European Driving Cycle |
| NOTAM | Notices to airman |
| OAT | Outside air temperature |
| OBD | On-Board diagnosis |
| OBM | On-Board measurement |
| OC | On condition |
| OCA | Oceanic control area |
| OFCA | Operational fuel consumption analysis |
| OPR | Overall pressure ratio |
| PCM | Phase changing material |
| PHEV | Plug-in hybrid engine vehicle |
| PO | Peak oil |
| PROM | Electronic Programmable Read-Only Memory |
| RAM | Random access memory |
| RBM | Risk-based Maintenance |
| RCM | Reliability centered maintenance |

| | |
|--------|--|
| RMF | Residual marine fuel |
| RNP | Required navigation performance |
| SAFC | Solid acid fuel cell |
| SC | Start control cycle |
| SCR | Selective catalytic reduction |
| SD | Self Diagnosis |
| SFC | Specific fuel consumption |
| SI | International System of Units (Système International d'Unités) |
| SN | Smoke number |
| SMS | Short message service |
| SOLAS | Safety of life at sea |
| SRAS | Shipboard routing assistance system |
| TA | Type approval |
| TC | Type certification |
| TMC | Traffic message channel |
| TEU | Twenty equivalent units (20 feet container) |
| Tier | Emission Standard in the USA |
| TOC | Top of climb |
| TSFC | Thrust specific fuel consumption |
| TSO | Technical standing order |
| TST | Total seaborne trade |
| TST | Type sample test |
| TÜV | Technischer Überwachungsverein |
| UDDS | Urban dynamometer driving schedule |
| UHB | Ultra high bypass |
| UNFCCC | United Nations Framework Connection on Climate Change |
| VFR | Visual flight rules |
| VHF | Very high frequency |
| VLA | Very large airplane |
| VTG | Variable turbine geometry |
| WAFS | World area forecast system |
| WHSC | World harmonized stationary cycle |
| WHTC | World harmonized transient cycle |