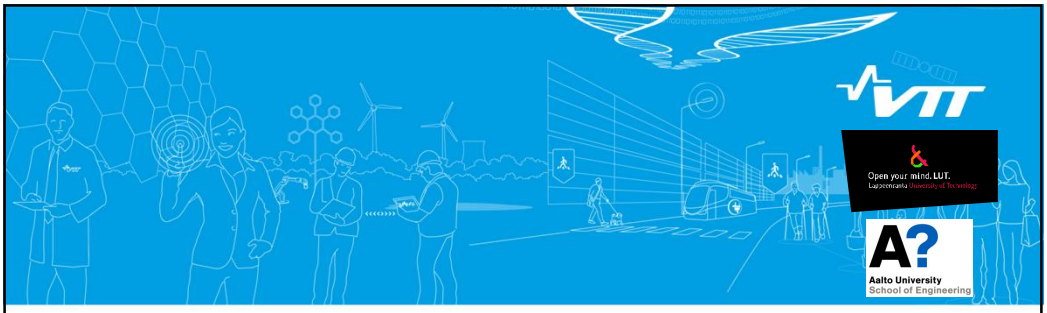

Tubridi road map ver. 2015

FIMA seminar 29.1.2015
Panu Sainio, Tatiana Minav, Antti Lajunen / Aalto
Lasse Laurila, Juha Pyrhönen / LUT
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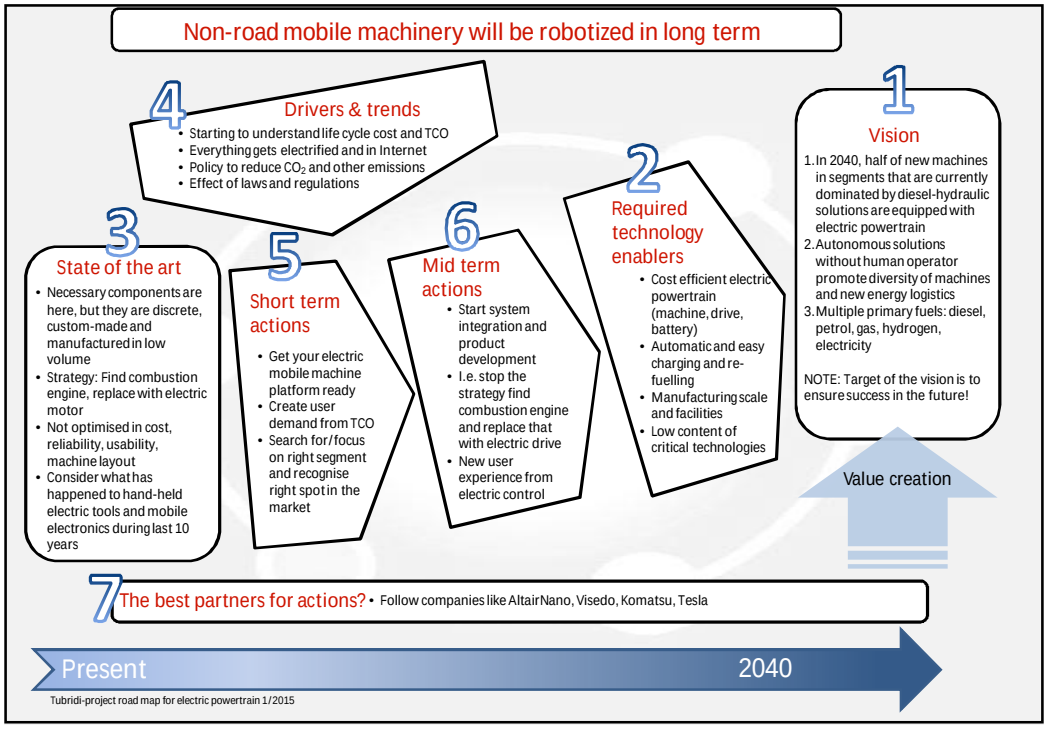
About the road map

- Follow the boxes in numerical order i.e. from 1 to 7
- **Vision** is in the first box – it is something that we believe the world is going to
- The next boxes are steps to be considered if someone wants to be prepared for that kind of future
- There will be, of course, major variance between machine groups
  - Think about today's automated guided vehicles (AGVs) in warehouse logistics or how the electrification and automation on rails are developing.



Aalto University
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1 Vision (1/2)

- In 2040, half of new machines in segments that are currently dominated by diesel-hydraulic solutions are equipped with electric powertrain
  - Even though the powertrain is electric, the primary energy source will be fossil fuel in 2040
  - In some machines electric powertrain is already today the solution – in small ones, very big ones and on rails
  - Hydraulics will be used still but perhaps not always controlled by valves but instead by electric motor pumps
- Multiple primary fuels: diesel, petrol, gas, hydrogen, electricity

1 Vision (2/2)

- Autonomous machines without human operator may **promote diversity of using electric energy** in machines and new energy logistics
  - Transportation and recharging
  - Local and global energy production
  - Storing of electric energy
  - **Energy security**
- Machines will operate 24/7 (logistics, mines, shift work)
  - People do not work 24/7 but machines could
  - Less noise from electric vehicles, enabler for 24/7
- New earning models will be there for sure
  - Leasing machines or purchasing tons to be moved (i.e. services) instead of having a machine and employees

2 Required technology enablers (1/2)

- Automatic and easy charging and re-fuelling
  - Technology
  - Infrastructure
- Cost efficient electric powertrain (electric machine, drive, energy storage)
  - Modularity is the key for coping with the lower volumes, standardised interfacing of components to promote and ensure the modularity, components should mix and match
- Manufacturing scale & facilities
  - Consumer market is very different, actually just the opposite from the “A la Carte”-style machine manufacturing. Cost efficient means for manufacturing of customised solutions are needed also in the future.

2 Required technology enablers (2/2)

- Low content of critical technologies
  - The material demand of non-road mobile machineries is not the challenge, the challenge is the demand of mass produced products, i.e. components like in cars etc.
  - If components needed are available only by one source or they are tailor-made how to ensure even spare parts matters

3 State of the art (1/2)

- Necessary components are here, but they are discrete, manufactured in low volume and custom-made
  - Situation will remain more or less like this for some time. There is a lot of software and product protection, for instance, the battery management systems or real performance measures do vary a lot
  - Mechanical designs have been developed during 100 years and are partly standardised
  - More flexibility, why is it hard for traditional electric machines manufacturers to produce components for vehicles? Dialogue between machine producers and electric component manufacturers needed

3 State of the art (2/2)

- Strategy “Find combustion engine, replace with electric motor” is, perhaps, not the way to go
  - What is, in fact, the machine manufacturer’s strategy: the **key aim is to find a cost effective solution**
  - You do not want to fail, the expectation is that the performance has to be the same or better, yet would be enough to be **equal**; new technology always better -idealism
  - Over-dimensioning everything → astronomical costs
- Please consider what has happened to hand-held electric tools and mobile electronics during last 10 years – evolution per year but revolution in a decade?
- New emission classes will be there 2019 – remember the Tier IV time tables and do not forget lessons learned

4 Drivers & trends (1/2)

- Global policy to reduce CO_2 and other emissions
- Everything gets electrified and in Internet
  - Internet of Things
- What is the current driver for the electrification of non-road mobile vehicles
  - Most of the companies are working on electrification in order to gain understanding, to have the knowledge and the readiness to act when the time is right; PR, marketing are listening carefully
- Major trend: to find a cost effective solution
- Starting to understand life cycle cost (total cost of ownership)
  - Business models etc., business to business

4 Drivers & trends (2/2)

- Upcoming Tier V regulation will impose new limitations on the particle mass and particle number emissions of non-road diesel engines in the power range up to 560 kW
  - Alternative fuels, e.g. biofuels are seen as one solution and are associated with the need for restricting of methane emissions and other non-regulated emissions such as aldehyde emissions
  - Change from Tier IV to Tier V is not cosmetic. Instead, it is almost certain that the particle filters have to be widely applied in working machine engines in the power range of 19–560 kW.
- Regulations of Tier V do not concern the fuel consumption, i.e. no limitations are imposed

5 Short term actions

- Get your electric mobile machine **platform** ready i.e. prototypes now, we are late
- Create user demand from TCO, not only the price of the product but the energy consumption, the emissions etc. affect too
- Focus on right segment and recognise the right spot in the market
- Follow standards, regulations and emission limits, the most boring job in engineering but essential
- Waiting for one more year is so easy, but the cost of consequences is unknown

6 Mid term actions, ~10 years

- Start system integration and product development
  - I.e. stop strategy find combustion engine, replace with electric motor.
- New user experience by electric control
- New layouts to machine and powertrain, having the new layouts ready that are enabled by electricity – electric platform
- Retrofitting? Should the machines sold at the moment and within five years be suitable for retrofitting electric later on? Easy replacement of mechanical components in some point of the machine's life cycle if customer demand begins
  - Hard to accomplish, of course, but an option