European Commission

This fiche is part of the wider roadmap for cross-cutting KETs activities

'Cross-cutting KETs' activities bring together and integrate different KETs and reflect the interdisciplinary nature of technological development. They have the potential to lead to unforeseen advances and new markets, and are important contributors to new technological components or products.

The complete roadmap for cross-cutting KETs activities can be downloaded from:

http://ec.europa.eu/growth/industry/key-enabling-technologies/eu-actions/ro-ckets

Potential areas of industrial interest relevant for cross-cutting KETs in the Transport and Mobility domain

This innovation field is part of the wider roadmap for cross-cutting KETs activities developed within the framework of the RO-cKETs study. The roadmap for cross-cutting KETs activities identifies the potential innovation fields of industrial interest relevant for cross-cutting KETs in a broad range of industrial sectors relevant for the European economy.

The roadmap has been developed starting from actual market needs and industrial challenges in a broad range of industrial sectors relevant for the European economy. The roadmapping activity has focused on exploring potential innovation areas in terms of products, processes or services with respect to which the cross-fertilization between KETs can provide an added value, taking into account the main market drivers for each of those innovation areas as well as the societal and economic context in which they locate.

Taking the demand side as a starting point, cross-cutting KETs activities will in general include activities closer to market and applications. The study focused on identifying potential innovation areas of industrial interest implying Technology Readiness Levels of between 4 and 8.

T.1.3: Eco-efficient Maintenance, Repair and Overhaul (MRO) strategies and systems

Scope:

To design vehicles and systems for maintainability, including regular, condition-based, predictive and preventive maintenance, based on eco-efficient Maintenance, Repair and Overhaul (MRO) systems, as non-destructive testing, robotic maintenance or advanced retrofit strategies.

Demand-side requirements (stemming from Societal Challenges) addressed:

- Tackle the "Smart, green and integrated transport" societal challenge
- Contribute to the achievement of the EU Transport 2050 strategy (COM/2011/0144 final) objective of a 60% reduction of CO_2 emissions from transports, at least 40% for shipping
- Support the Smart Vehicle initiative of the i2010 strategic framework on the innovation society (COM(2005) 229 final)
- Continuously enhance safety, resistance/resilience and security of vehicle operation all along end-to-end transport chains
- Increase recyclability of vehicles and systems and resource efficiency in the manufacturing processes and reduce dependency to rare or foreign controlled materials and components (as per the Raw Materials Initiative (COM(2008)699) and numerous waste management regulations)

Demand-side requirements (stemming from market needs) addressed:

- Reduce vehicle operation costs, including through increasing energy efficiency and reducing final vehicle energy bill, but also through optimising overall vehicle lifecycle cost of ownership, including maintenance, repair and overhaul
- Reduce or maintain numbers and rates of accidents in Europe at an acceptable number, whatever traffic growth
- Enable new transportation services dealing with changing mobility and transportation needs, changing trade patterns as well as citizen and logistic chains request for affordable, timely, comfortable, seamless and ubiquitous transport services
- Enable time to market reduction and production ramp up / adaptation so as to cope with European and global market requests on new vehicle supply

Specific technical / industrial challenges (mainly resulting from gaps in technological capacities):

- Development of low-operational impact maintenance and upgrades processes (through advanced monitoring, diagnostic and prognostic for all relevant vehicle systems), including predictive maintenance and non-intrusive inspection capabilities
- Development of smart materials and/or sensor networks for on-line structural health monitoring & load or temperature control capabilities to support preventive and condition-based maintenance
- Development of vehicles and systems taking into account integrated life cycle management concerns, including usage modularity and focus on easy retrofit and refurbishment
- Development of advanced monitoring and prevention strategies for normal usage corrosion, wear and fatigue
- Development of mobile, self-guiding, self-referring robotic maintenance and repair modules
- Design of systems for maintainability, including self-healing, modular architectures and automatic reconfiguration capabilities in case of failure (for hardware and software)
- Improvement of non-destructive testing capabilities (time-saving, materials-saving, maintenance optimization)
- Implementation of repair strategies adapted to high cost / high environmental impact elements

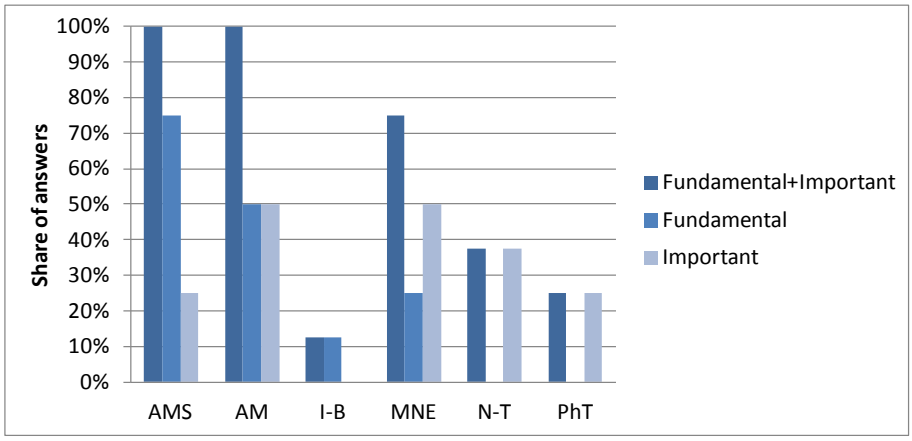
Contribution by cross-cutting Key Enabling Technologies:

In respect to this Innovation Field, the integration of KETs could contribute to the development of condition-based, predictive and preventive maintenance strategies based on solutions such as smart materials, sensor networks for on-line monitoring of structural health, load, temperature, corrosion, wear and fatigue, or self-

guiding, self-referring robotic maintenance and repair modules. Solutions may also include self-healing architectures that would automatically reconfigure in case of failure (for hardware and software).

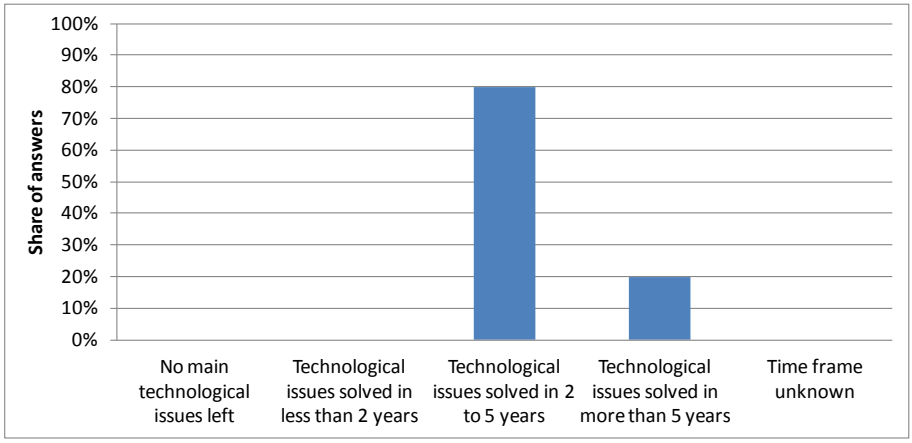
To this aim, the combination of KETs experts' opinions collected through the dedicated survey (whose result is depicted in the below bar chart), the examination of KETs-related patenting activity in respect to this Innovation Field, and desk research activities, have allowed identifying a rather strong interaction of KETs with respect to this Innovation Field, with either fundamental or important contribution mainly by the following KETs:

- Advanced Manufacturing Systems (AMS)
- Advanced Materials (AM)
- Micro- and Nano-Electronics (MNE)



Timing for implementation:

According to the majority of KETs experts' opinions (whose result is depicted in the below bar chart), desk research, and in line with the KETs-related patenting activity in this field, it is considered that the main technological issues holding back the achievement of cross-cutting KETs based products related to this Innovation Field could be solved in a time frame of 2 to 5 years:



Hence, depending on the specific technical and/or industrial challenges holding back the achievement of cross-cutting KETs based products related to this Innovation Field, the provision of support in the short term should be taken into consideration within this framework.

Additional information according to results of assessment:

➢ ***Impact assessment:***

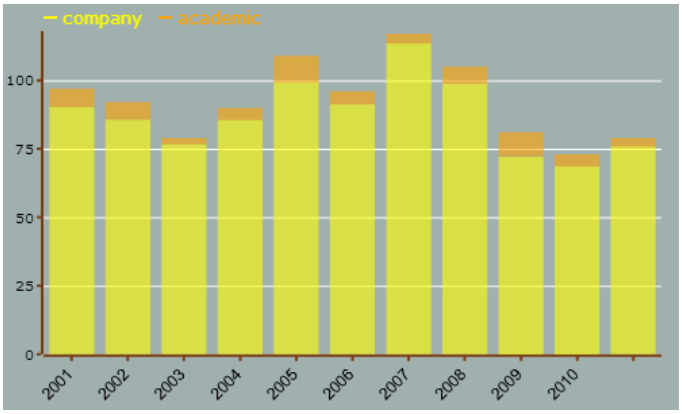
- Considering vehicles' campaign life, the impact of a vehicle being stopped in a fleet and the special care needed for ensuring passenger and crew safety, maintenance costs usually account for a significant part

of overall ownership costs. Improving vehicle maintainability or maintenance processes can support a major progress in competitiveness of transport services.

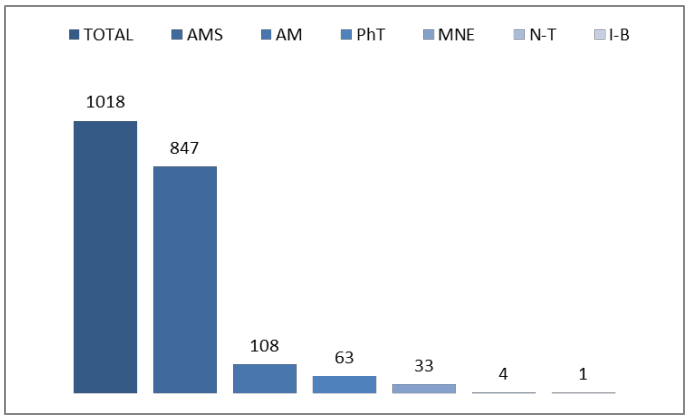
- Major approaches for improving maintenance are in health monitoring, non-destructive testing, predictive and preventive maintenance, self-healing structures, all solutions with a potential benefit to be expected from KET technologies.
- Traditional maintenance operations use much chemicals, produce much scrap and waste, and expend significant amounts of energy. New processes and strategies have a real potential for environmental impact minimization.
- The defence sector reached a high level of performance in Maintenance, Repair and Overhaul (MRO) in the past years, which had an important effect on the availability of the equipment: in many armed forces, one-third to half of the total capability of key assets is out of action for maintenance at any time. Furthermore, Maintenance, Repair and Overhaul (MRO) accounts for more than 10% of the total defence budget and as much as 70% of all aircraft related costs. This shows how the level of knowledge in this field in the defence sector has reached a high standard which could therefore be applied into the civil segment, thus showing its duality.

➢ ***Results of patents scenario analysis:***

- 1018 exclusively KETs-related patents identified in the period 2001-2011 for the specific Innovation Field
- Stable trend curve (number of patents per year)
- Highest share of industrial applicants, with main applicants being mainly from large aerospace or automotive industries, illustrating the technological advance of these sectors compared to other transport sectors:



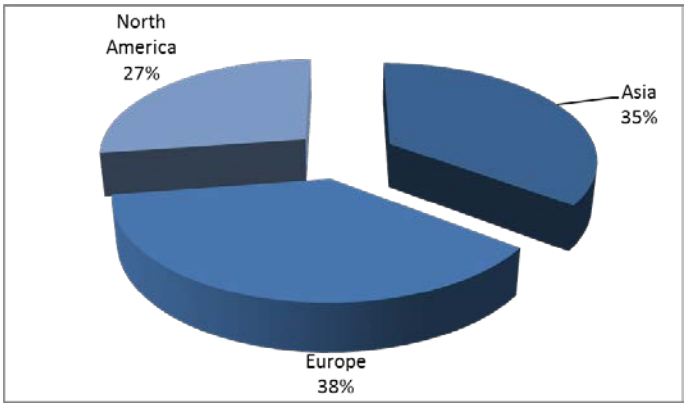
- Patents by KET(s):



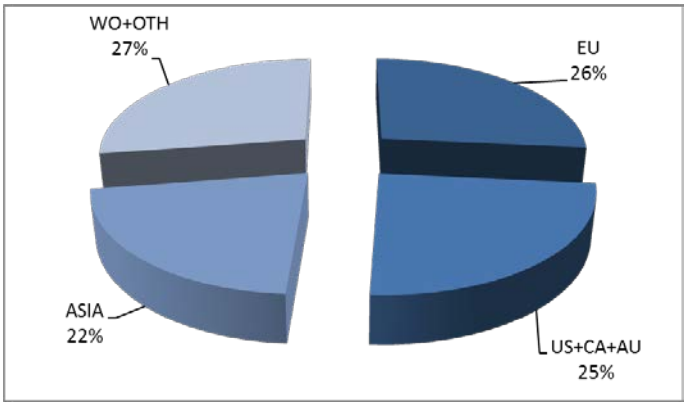
- Patents by KET(s) and relevant combinations of KETs:

KET(s)	*Number of patents*
AM	108
AM / N-T	2
AM / PhT	5
AMS	847
AMS / AM	6
AMS / AM / N-T	1
AMS / MNE	9
AMS / MNE / PhT	3
AMS / N-T	1
AMS / PhT	6
IBT	1
MNE	33
MNE / N-T	2
MNE / PhT	11
N-T	4
PhT	63

- Patent distribution by (Applicant) organization geographical zone:



- Patent distribution by geographical zone of priority protection:



- Europe is ahead in the patent race, as the 1st region of origin of applicants as well as a priority region of protection. Asia – mainly Japan – and the USA are nevertheless not so far behind. This is visible also through main applicants' list, Japan and Germany coming first, then USA and France