Car of Tomorrow

EUROPEAN COMMISSION

Task Force "Car of Tomorrow"

Car of Tomorrow

Plan of Action

EUROPEAN COMMISSION

CAR OF TOMORROW

ACTION PLAN

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FOREWORD

Established at the initiative of Commissioners Edith Cresson, Martin Bangemann and Neil Kinnock the Research-Industry Task Force *Car of Tomorrow* began its work in May 1995.

The Terms of Reference require :

* the preparation of an inventory of the current situation in the European Union identifying current actions - whether at the public, private, national or Community level - in this area;

* the definition of the research priorities and technological objectives while at the same time proposing a regrouping of projects selected in the framework of specific programmes which make up the Fourth RDT Framework Programme.

The problems resulting from increasing road traffic have a growing effect on our daily life and threaten the quality of life of us all. The provision of clean, safe, intelligent vehicles with an adequate performance is a legitimate demand of the European citizens. For the industry to respond with a vehicle competitive in price is a tremendous technological challenge, as well as an essential condition to maintain or rather reinforce its future competitivity.

This Action Plan results from the terms of reference for the Task Force (see Annex 1) and consultations with representatives of public and private organisations concerned with the use and production of vehicles (see Annex 3), together with a series of investigations conducted by the Task Force. The text was finalised following a meeting with all interested parties which took place in Brussels on 30 October 1995.

ACTION PLAN

1. Rationale

There is mounting public concern over the growth trends in road transport and the harmful externalities it generates. Increasing traffic congestion and unrestricted consumption of finite reserves of fossil fuels are unsustainable in the long term. Human health and safety are at risk from harmful emissions and road traffic accidents. In order to maintain a functionally effective transport system in the short to medium term, urgent solutions are required to alleviate urban transport pollution and congestion, where population exposure is greatest. The complexity of the transport system and the huge investments and long time constants to achieve significant change are such that a suitably measured response is required. This must consider the global consequences and likely acceptability of alternative technologies.

The challenge is to have industry and public authorities working together to advance new technological concepts which reflect changing European Union policies for transport, energy and the environment, whilst respecting social needs and contributing to industral competitivity. There is already a broad consensus on the performance and environmental targets which define a pathway to the *Car of Tomorrow*.

Recognizing the car's highly valued attributes of flexibility, privacy, security, comfort and amenity, it will evidently continue to be a vital element of mature societies. However it will need to operate with much reduced environmental impact, within a more integrated and controlled road transport system, fully exploiting telematics technologies and advanced information systems, ensuring its compatiblity with multimodal transport systems.

Accordingly the scope of the action, with its focus on RTD and demonstration on propulsion systems will, in addition to cars, also apply to buses, trucks, vans and motorised two-wheelers and the associated infrastructure for road, telematics, refuelling and recharging.

The process of setting a technological focus should be guided by comprehensive analysis and periodic review of the most promising technological options, set against agreed performance, emissions, safety, economic and social criteria. Technical progress should be continuously monitored to provide necessary inputs to the regulatory and standards making processes. To ensure a balanced approach to the introduction, acceptance and use of new vehicle concepts, it is necessary to ensure the cooperation of public authorities, the vehicle and component industries, other industries involved, and the providers of capital investment.

The Action Plan will be implemented as far as possible within the structure and constraints of the existing Framework Programme (FP4). Specialist working groups will coordinate and capitalise on synergies between RTD&D efforts at European, national and industrial levels. Opportunities for more focused activities under article 130 k,l,n of the Treaty on European Union will also be explored.

2. Need for Action at European Level

The White Paper on Growth, Competitiveness, and Employment identifies the need for new approaches to promoting growth in a sustainable way, whilst achieving higher employment and lower consumption of energy and natural resources, and improving the quality of life. This is reinforced in the Commission White Paper "The Future Development of the Common Transport Policy" which identifies major concerns as managing demand for road transport, reducing its social and environmental impact, alleviating congestion and improving road safety.

The EU energy policy aims to stabilize greenhouse gas (mainly CO_2) emissions at 1990 levels by 2000. Road transport currently accounts for 80% of energy consumed by transport - 30% of final energy demand in Europe. This is unsustainable in the face of dwindling fossil fuel reserves, the persistent threat to global energy security and growing concerns linking exhaust emissions with cancer and respiratory disease.

Harmful emissions attributed to road transport include lead, carbon-monoxide (CO), volatile organic compounds (VOC), including hydrocarbons (HC), oxides of nitrogen (NOx), oxides of sulphur (SOx), and particulates. The total external costs, in economic terms, of health problems attributed to transport emissions are estimated at 0.3-0.4% of GDP.

Mobility is essential to economic activity and the automotive industry is itself a major wealth creator. Vehicle production contributes 2% to the European GDP; 1.8 m employed represents 8.3% of all manufacturing jobs. A further 1.8m are employed in distribution and repair. The industry is critically dependent on its ability to produce world class products at fiercely competitive prices. It is vital that European RTD does not lag RTD effort in Japan and the US. The US government has been providing 375-450 MECU per year for automotive related technology in general. That compares with 135MECU per year in the EU Third Framework Programme (ie. excluding national programmes). In 1991 the "Big Three" US car makers and the government formed the four year, $262m, shared-cost United States Advanced Battery Consortium battery development project. The US Partnership for a New Generation Vehicle (PNGV) receives $933m for 1994-1996, and has three main goals - advanced manufacturing, improved efficiency, safety and emissions, and the 80mpg (3litres/100km) car. The Californian Low Emission Vehicle Programme effectively legislates EV sales from 1998. With five other states already following, cumulative sales of 1million EVs by 2003 are predicted.

Information on Japanese RTD expenditure is much harder to find. Since 1971 the MITI has been supporting EV-related RTD. In 1991 NEDO launched the 10year, 14bY (=120MECU) LIBES programme for developing lithium batteries with very high performance and reliability targets. The Japanese are also pursuing a fuel cell development programme. The Japanese launched a market expansion programme in 1991 with targets for cumulative EV sales of 200.000 by 2000, and production of 100.000 per year, although these targets are understood to have been relaxed somewhat.

Applied to the *Car of Tomorrow* the issues identified reinforce the need for Europe to produce world class vehicles which are efficient, clean, and safe and fully integrated with future transport systems. The negative impacts of road transport - environmental pollution, the risk of irreversible global climatic changes, traffic accidents and congestion - are global problems requiring a global response. Atmospheric pollution and greenhouse gas emissions do not respect national frontiers. However these harmful externalities must be put in balance with the wealth and employment opportunities created by the automotive and component industries as well as with the need for mobility of EU citizens. There is always substantial financial and technical risk in advancing new technologies - beyond the resource of any single company or country. Common measures should be adopted throughout the EU to secure a single market for the exploitation of appropriate new technologies.

Accordingly, the Action Plan aims to support development of a number of propulsion technology options, against defined targets and timescales for harmful emissions reduction, energy efficiency and fleet average energy consumption. These options must be subject to regular review and rigorous comparison, with a view to defining the most cost-effective and consumer acceptable future development strategy. Emphasis is placed on stimulating the development of inherently clean propulsion technologies for operation in areas of high population density, and which can eventually act as a vector for renewable energy sources. These include fuel cell, battery electric and hybrid electric vehicles and emissions reducing technologies for ICEs. The work will be set within a common perspective for the Car of Tomorrow which reflects EU policies for transport, energy, environment and industry, maximising social benefits and creating opportunities for employment and training.

For a more extensive analysis of the justification for European action see Annex 2.

3. *Car of Tomorrow* Action Plan Objectives

The Terms of Reference which provide the basis for this Action Plan have as their objective to contribute to the research and demonstration efforts necessary to realise the *Car of Tomorrow* which will be clean, safe, energy efficient and "intelligent". Accordingly the Action Plan has been prepared in close consultation with all the actors concerned including those from automobile, electronics, materials, and energy related industries and public authorities. Starting from an assessment of the current situation, the essential RTD needs to achieve the objective have been identified. By mapping these onto current activities, the additional RTD priorities for European action have been established. Recognising that a flexible approach is essential to leave room for rapidly emerging and promising technologies identified by industry, the basis for future action is set in terms of the following deliverables :

3.1. Short to Medium Term :

- energy efficient, competitive ultra low and near zero emission vehicles (ULEV) vehicles for both urban and regional use, incorporating ultra-low emission combustion engines and cleaner fuels;

- radically new, competitive, safe, intelligent, energy efficient, zero emission vehicle (ZEV) concepts, such as ultra compact electric vehicles (EV) for urban use;

3.2 Long Term :

- radical, fully sustainable, negligible or zero emission propulsion systems (for example fuel cells), which have the prospect of exploiting renewable primary energy sources;

4. Overview of Scientific and Technological Content

The technological emphasis of the Action Plan is the radical reduction of the environmental impact of the *Car of Tomorrow*, compatible with commercial acceptability of the product. Essentially that means coordination of RTD&D effort at Union, member state, and industrial level on technologies capable of yielding substantial improvements in vehicle concepts and technologies leading to sub-ULEV and ZEV. Although much has been achieved since the 1966 Californian Clean Air Act (which was an initial stimulus to European effort on emissions reduction), reductions in absolute emissions levels have been offset by growth in road transport demand and customer demands for higher performance, more fully equipped vehicles.

Considering RTD&D on propulsion technologies, Otto (gasoline) and Diesel internal combustion engines (ICEs) set very high standards for performance and cost, as the data for typical 4-seater European small electric and ICE cars in Table 1 show. The Hybrid Electric Vehicle (HEV) is an opportunity to combine optional zero emission electric traction with the performance advantage of ICEs. Because of the ICE's vital role in powering HEVs some RDT&D effort on integration of cleaner, more efficient ICEs in HEV, is foreseen. There are also spin-off benefits for conventional vehicles.

Table 1: Current Typical European Small 4-Seater Car Performance

Propulsion	Fuel Cons.* litres/100km	Range (km)	Refuel time (min)	Acceler. 0-100km/h (s)	Top Speed km/h	Cost ECU/kW **
Otto (petrol)	8.1/5.7	450-700	3-4	15	140-150	200
Otto (CNG)	8.1/5.7	250-300	3-4		140-150	
Diesel	6.1/4.7	650-850	3-4	17	135-145	225
EV Conv.***	-	80-100	480	-	90-100	1000

* overall/touring fuel consumption

** Cost based on whole car, including batteries in case of EV

*** Electric car "conversion design" - converted from equivalent ICE model.

Alternative propulsion systems (eg. battery, fuel-cell, hybrid) offer the best prospect for negligible point of use and global emissions. However consumers' reasonable expectations for replacement technologies are that they should be at least as good as ICE vehicles in terms of performance, cost and convenience. Detailed Performance Targets and RTD&D priorities for technological action at European level will be given in a separate document, reflecting discussions with the actors concerned.

4.1 Table 1 clearly demonstrates the relatively poor range, speed, performance, cost and recharge time for current battery-electric "conversion" designs. Battery cost, performance, durability and recyclability remain the principle RTD challenge for pure EVs, with direct spin-off benefits to HEVs. Battery concepts such as lithium carbon, sodium nickel chloride and metal-air, variously offer real potential to achieve substantial gains in range (threefold) and performance and, subject to series production, also cost reductions. Comprehensive fleet demonstration of existing EV technology is envisaged, to prove EV capability (eg winter performance, reliability, fleet management), customer acceptability, and to obtain energy and emissions performance comparisons with comparable ICE vehicles

Key technological barriers for Battery-Electric Vehicle development:

- ***high specific energy, rapidly rechargeable batteries with long cycle life,***
- ***low-cost functional battery materials and production and recycling processes,***
- ***low-cost battery energy management and control systems,***
- ***energy efficient vehicle auxiliary power systems, e.g. heating and air conditioning,***
- ***low cost peak power devices for battery load levelling.***

4.2 Fuel cells generate electrical power by chemical combustion, have no moving parts, and are silent in themselves, though they normally require air compressors. The most promising technology is the Solid Polymer Fuel Cell (SPFC) running on H_2 and air. The SPFC, which emits only water, could be classed as a ZEV over the whole energy pathway, provided the H_2 is produced from renewable energy sources. Fuel efficiencies approaching 60% are in principle possible. To avoid the complexity and expense of an H_2 refuelling infrastructure, and the controversial issue of H_2 safety, it is also possible to reform H_2 from methanol or NG on board the vehicle, or oxidise methanol directly in a special fuel cell. Extended range (>500km) operation depends on the vehicle fuel storage capacity. Refuelling time is comparable to an ICE vehicle. Fuel cells therefore are potentially the most efficient and cleanest long term propulsion technology, provided costs and volumetric energy density can be very substantially reduced.

Key technological barriers for fuel cells:

- ***low cost membranes and bipolar plates with improved current density and reduced catalyst loading,***
- ***compact, low cost reformer and gas clean-up systems,***
- ***electronic energy management and control systems,***
- ***lightweight, safe, and energy efficient compressed and liquified gas storage tanks.***

4.3 Various HEV configurations are possible. "Parallel" hybrids generally consist of a conventional ICE drive train which can be "assisted" by a battery powered motor/generator. This allows down-sizing of the ICE, with peak accelerative power and energy recovery being provided by the motor/generator, as well as optional zero emission mode operation. The "series" hybrid is primarily battery - electric propulsion, but with a (usually) small ICE/generator running at its optimum efficiency, as a range extender. Peak power devices, such as a flywheel or supercapacitor may provide additional battery load levelling. Substantial reductions (20-30%) in vehicle energy consumption (and hence emissions) are reported for hybrids, but the dual technology introduces high cost penalties, and there is a complex, variable trade-off possible between vehicle and power station emissions.

Key technological barriers for HEV development:

- ***low-cost, high energy batteries, optimised for hybrid applications,***
- ***energy management and control systems integrating alternative energy storage and power devices for optimised hybrid vehicle operation***
- ***variable rate transmission and peak power buffer devices.***

4.4 The further improvement of ICEs to realise higher fuel efficiency and ultra-low (or lower) emissions is recognised as a matter of continuing priority, both for conventional and hybrid vehicles. Cost and infrastructure considerations are likely to favour Otto and Diesel engined vehicles for a considerable time to come. Stabilising the global impact of vehicle emissions will require cost-competitive ICE technologies for enhanced fuel efficiency and emissions reduction. Whilst the Diesel engine has inherent efficiency advantages, major obstacles to its greater utilisation include harmful particulate and noise emissions, which must be reduced to comparable levels for Otto engines. The conflict between improving fuel efficiency and reducing the emissions of ozone producing components, viz NOx and unburnt hydrocarbons must also be resolved. For Otto engines, charge stratification and lean burn offer scope for efficiency improvement, particularly at part load, although combustion stability is then difficult to control. Very precise fuel charging and mixing will be required, through a combination of : controlled, sequential direct fuel injection, variable valve timing, and turbocharging to improve volumetric efficiency and control the effective compression ratio. Improved exhaust gas after treatments will be needed, including low light-off temperature de-NOx catalysts (to reduce HCs on cold start), and particulate traps for Diesels. The down-sizing of Otto and Diesel engines introduces proportionately greater heat (and hence efficiency) loss through wetting of the cylinder walls. Improved computer simulation of the fluid dynamics of induction, spray formation, heat transfer, and chemical kinetics of combustion can further reduce these losses, as well as improve the noise refinement of small capacity, direct injection Diesels. In addition to the use of physico-chemical means, the application of advanced sensors, and powerful on-board real-time diagnostics with feedback, offer the possibility of developing the Intelligent Thermal Engine (ITE) - propulsion units which are highly flexible and self-optimising under a variety of load conditions. The precompetitive RTD&D for the ITE will focus on those technologies which hold the prospect for radical improvements in emissions reduction in so far as the development phase relates to the first introduction of genuinely innovative products or processes at European level.

Key technological barriers for radical improvements in ICE emissions reduction :

- **sequential direct injection systems, optimised for Otto and Diesel combustion;**
- **real-time electronic engine control, incorporating variable valve timing, exhaust gas analysis, and optimised control algorithms for varying load ;**
- **low-light-off temperature de-NOx catalysts, and Diesel particulate traps;**
- **integrated thermo/fluid/structure simulation techniques, including combustion modelling;**

4.5 Natural gas (NG), hydrogen (H_2) and methanol are inherently cleaner fuels for Otto engines. Methanol, being a liquid, has a consequential infrastructure advantage, but this is substantially undermined because of its toxicity and the need for protective handling measures. Of the gaseous fuels, NG emerges as a strong candidate in the short/medium term, in view of its very high octane number, allowing much higher compression ratios and hence fuel efficiency. Although methane is emitted from NG fuelled ICEs, it has a negligible effect on ozone formation, though it is a strong greenhouse gas. Being lighter than air, it is considered safer than Liquid Petroleum Gas (LPG). Combustion of H_2 generates water, with low levels of NOx and HCs (from lubricating oil). However the production of H_2 and methanol fuels themselves, may add significantly to the overall harmful emissions. All these fuels have lower calorific value than gasoline and, for comparable vehicle range, the gaseous fuels introduce non-trivial problems of in-vehicle storage by compression or liquifaction. Equally the provision of inherently safe, energy efficient, competitively priced, vehicle-compatible stationary refuelling infrastructure has to be addressed for gaseous fuels. Although dual fuel gasoline/NG and H_2 fuelled Otto engines are currently being demonstrated, further combustion optimisation is required, especially through improved direct fuel injection systems. A consistent pan-European NG fuel quality may be needed to minimise engine variations. H_2 is seen as a longer term clean fuel option, being a vector for renewable sources for electricity generation.

Key technologies for NG and H_2 fuelled Otto engined vehicles (in addition to those listed above for the ICE), include:

- **lightweight, safe, and energy efficient compressed or liquified gas in-vehicle storage tanks, their manufacture and compatible stationary infrastructure;**
- **development of gas injection systems and optimised combustion for NG and H_2;**

4.6 To meet the needs of a highly competitive market the best available vehicle design and telematics technologies must be integrated into future vehicle concepts.

Key technological barriers to effective integration :

- ***energy efficient, lightweight and low drag structures***
- ***inherently safe vehicle dynamics, crashworthy structures and components for vehicles equipped with alternative propulsion systems***
- ***telematic control systems for minimising environmental impact***

4.7 The market driven penetration of new technologies will be critically dependent on their safety, performance, functionality, operability, and maintainability and affordability. This can only be determined through an extensive programme of demonstration under diverse European conditions, extending from prototype technology demonstrators to establish proof of concept, right through to fleet scale testing to prove safety, and fitness for purpose. Extensive demonstration activities are envisaged, covering the above range of propulsion technologies, which will provide valuable input to the standards making process. A comprehensive programme on comparative assessment and test will be integrated with these technology and fleet demonstrations relevant to personal, public and goods transport. This will include objective energy and emissions performance measurements, under controlled laboratory and field test conditions, extending to more subjective assessment of customer acceptability and compatibility with the transport system. In order to ensure maximum benefit from fleet tests using alternative, clean propulsion vehicles these should normally be implemented as part of a package of measures designed to improve the urban - energy - environment - transport system.

Key demonstration actions include:

- ***prototype technology demonstration of advanced battery, fuel cell, and hybrid vehicles incorporating clean combustion engines and clean fuels;***
- ***fleet scale demonstrations integrating new generations of alternative propulsion technologies, with refuelling infrastructure, telematics for traffic control, safety and information***
- ***demonstration of validated methodologies for comparative assessment of safety, performance, environmental impact, affordability and social acceptability under diverse European climatic, geographic and urban conditions***
- ***global cost/benefit analysis of alternative technologies***
- ***establishment of a comprehensive European database for alternative propulsion vehicles to support dissemination of best practice***

5. Resources needed

Considerable resources are necessary to overcome the technological barriers identified. To minimise the demand on capital and human resources, a closely coordinated approach is essential. Within the Commission this implies a coordinated approach towards project management, including clustering of projects already selected within the first calls for proposals of FP4 and towards the additional work identified as necessary for action at the European level. The Commission will also coordinate the additional measures necessary to accelerate the diffusion of the results of the Task Force. With regard to the coordination between the European Union and Member State activities, whether RTD, demonstration or implementation measures, there is a need for a structured approach. Coordination within the research community and industry will build on the links already established during the elaboration of the Action Plan to extend into the implementation phase. Care will be taken to ensure that there is no conflict with rules on competition.

5.1 Timing.

The deferment of part of the priority RTD actions until a successor programme to FP4 would of course mean a substantial delay to the prototype technology demonstrators foreseen for the period (2000-2002). That would almost certainly adversely affect the competitiveness of the European industry in critical technology areas such as advanced batteries and fuel cells, where there is already a perceived technology lag and funding deficiency needed to meet the anticipated market requirements, compared with North American an Japanese competitors.

5.2 Linking Technology and Policy through a continuing dialogue within the Commission and with external bodies.

The preparation of the Action Plan has highlighted the difficulty in arriving at R&D actions at Union level without the support of all the actors working together in an informal though continuing dialogue. Through this dialogue the Commission is better able to appreciate the true situation, the impact of its actions and, where appropriate, to respond to new requirements. The setting up of a Consultative Committee made up of representatives of the automotive and component industries, the utilities, and public authorities responsible for transport, planning and the environment, will enable the Commission to receive the views of all the actors concerned in a way which can be taken into account in the realisation of the Action Plan for the *Car of Tomorrow* as well as in the definition of transport, energy, environment and industrial policies.

This Committee will be able to establish multi-disciplinary working groups to assure the necessary coherence of its work in :

- the development and implementation of methodologies and procedures for assessment and comparative testing;

- proposing performance, energy efficiency, particulate, atmospheric and noise emissions targets, for different categories and sizes of vehicles, together with the timescales for their implementation;

- scenarios analysis of financial and technical risks, and market prospects.

The Action Plan proposes to establish a Consultative Committee, comprising representatives from the automotive, component, electronics and materials industries, utilities, users and public authorities representing transport, planning and the environment. It will be possible to create a number of working groups, dealing respectively with comparative assessment of technologies, proposing vehicle efficiency and emissions targets, and investment and technical risk assessment. The Consultative Committee will advise on future technical priorities and strategy for RTD&D, maintaining a balance between the more commercially driven "bottom up" approach to technology acquisition and "top down" measures to implement policy.

6. Conclusion

As a result of the analysis and mapping exercise which has examined the current situation and identified the shortfalls, it is concluded that :

- additional RTD and demonstration is needed to address strategically important priorities and comparative assessment

- there is an urgent need to focus the efforts of collaborative research on technological breakthroughs which will permit the development of zero or ultra-low emission vehicles;

- improved coordination is necessary both inter-programme within the Commission, and between the Commission and the exterior

- amongst the accompanying measures, the establishment of a framework for a dialogue with the key actors is regarded as essential.

7. Proposed Actions

The following steps and actions are proposed to address the identified needs.

7.1 The Action Plan comprises four distinct steps respecting the objectives and management rules of Framework Programme IV.

Step I. coordination a posteriori : This will bring together projects selected through the different calls as Target Research Actions (groups of projects on key technologies, targeted on industrial objectives)

Step II. integration of activities : This foresees a single infopack bringing together R,D and D themes of the Action Plan, covered by the different specific programmes (associated with a targeted and coordinated call for proposals)

Step III. additional effort : This will assess the possible need to seek additional resources to reinforce the European action, notably on the most urgent themes identified by the Task Force in close cooperation with the Industry, and on demonstration with an ad hoc targeted call.

Step IV. planning recommendations : for the Fifth Framework Programme.

7.2 Implementing Actions.

1. To set up a Consultative Committee for consultation between industry, users, public authorities and the Commission's Task Force on technical and policy matters relating to the *Car of Tomorrow*;

2. To work together with the Consultative Committee in conjunction with appropriate working groups to provide a strategic approach to technology acquisition for the *Car of Tomorrow* and better definition of its performance targets, operating and regulatory environment;

3. To define functional, safety, energy, emissions performance and cost targets for research on ultra-low and zero emission vehicles, appropriate to the diverse economic, social, climatic, and geographical conditions in Europe;

4. To define priorities and implement focused research and technological development (RTD) to overcome all technology barriers which inhibit rapid realisation of ultra low and/or zero emission vehicles;

5. To develop methodologies for objective and subjective assessment (including marketability) of competing ultra-low and zero emission vehicle technologies,

and criteria for comparison and trade-off analyses which reflect EU policy objectives;

6. To define and implement a phased demonstration programme for evaluation and comparison of different technologies for ultra-low and zero emission vehicles, structured as follows:

   For short/medium term delivery (by 2000)

   - prototype technology demonstrator vehicles for evaluation of the most advanced energy efficient, ultra-low and zero emission propulsion technologies;

   - fleet tests based on current state of advancement of ultra-low and zero emission technologies;

   For longer term delivery (by 2005)

   - prototype technology demonstration based on output from focused RTD defined in item 4.

   - consolidation of the most promising advanced prototypes into fleet scale demonstration

7. To propose accompanying measures to facilitate the take up of results in the market. This will include an appropriate framework for promoting coordination of RTD&D efforts at Union, national and industrial level; education and training initiatives, dissemination and exploitation activities and issues relating to standardisation, certification and type approval.

8. To present an annual report to the Commission.

Annex 1.

TERMS OF REFERENCE FOR THE TASK FORCE

1. Objective

The objective is to contribute to the research and demonstration efforts necessary to realize the *Car of Tomorrow* which will be clean, safe, energy efficient and "intelligent". Such vehicles must be competitive and capable of meeting environmental constraints in the context of sustainable mobility. The work of the Task Force will be focused on vehicles with ultra low and/or zero emissions.

2. Tasks

Accordingly the Task Force *Car of Tomorrow* will in particular:

- establish an Action Plan in consultation with all the actors concerned. This will include the identification of all needs, priorities and actions to be addressed at European level in respect of RTD, demonstration and validation necessary for assuring acceptance in the market place of a new generation of competitive, ultra low and/or zero emission vehicles.

- define in the Action Plan the necessary steps, timescale, performance and energy-environment efficiency targets for a series of vehicle projects, demonstrating best available technologies.

- focus on all technological bottlenecks which limit the rapid realization of ultra low and/or zero emission vehicles. Efforts will:-

  ° be concerned with advanced propulsion technologies, notably those associated with batteries and fuels cells.

  ° be also concerned with associated critical technologies (electronics, light materials, etc)

  ° establish, in close concertation with the vehicle manufacturing sector, their integration into zero emission or hybrid vehicles together with the related infrastructure.

In the initial stage already existing vehicles could be used to test components of the future systems.

- provide a reference framework for benchmarking ultra low and zero emission vehicle technologies, enabling comparative assessment of alternative options for ultra low or zero emission vehicle technologies and related infrastructure. This reference framework will support the integration of best practice in vehicle and infrastructure technology, including operational aspects.

- provide a policy review framework to ensure compatibility between the developments in vehicle technology and the emerging Community policies on energy, environment, industry and transport.

- identify and develop, on the basis of proposals arising from the partners, particularly those from industry, the accompanying and support measures for accelerating the transfer of RTD results into the market. For research this may include synergy with EUREKA and national RTD programmes, national and Community funding and fiscal instruments, tools for comparative evaluation of different solutions, standardization, etc.

- report back, within three months of the approval of the Terms of Reference by the Commissioners concerned, with an Action Plan proposing measures to be taken and a timetable to achieve the objectives of the Task Force and which reflects the views of all the actors concerned.

3. **Organisation**

The Task Force will have a separate identity and a light structure. Its work will be limited in duration. It will be supported by a permanent secretariat and a group of officials having the knowledge and specific competence relevant to the sector and coming from the Directorate Generals principally concerned. It will consult all the public and private sector actors concerned.

The Task Force will be directed by DGXII in close collaboration with DGs III, VII, XI, XIII, XVII and XXII. European organizations, notably the European Parliament, the Programme Committees concerned, the Scientific and Technological Assembly and IRDAC will be consulted and informed over the progress of the Task Force activities.

Annex 2.

COMMENTARY ON JUSTIFICATION FOR ACTION AT EUROPEAN LEVEL

The White Paper on Growth, Competitiveness, and Employment identifies the need for new approaches to promoting growth in a sustainable way, whilst achieving higher employment and lower consumption of energy and natural resources, and improving the quality of life through the development of new, innovative products based on clean technologies. Applied to the *Car of Tomorrow* that implies world class vehicles which are efficient, clean, and safe and fully integrated with future transport systems, by means of advanced telematics and information systems.

The negative impacts of road transport - environmental pollution, the risk of irreversible global climatic changes, traffic accidents and congestion - are global problems requiring a global response. Atmospheric pollution and greenhouse gas emissions do not respect national frontiers. However these harmful externalities must be put in balance with the wealth and employment opportunities created by the automotive and component industries. There is always substantial financial and technical risk in advancing new technologies - beyond the resource of any single company or country. Common measures should be adopted throughout the EU to secure a single market for the exploitation of appropriate new technologies.

The Action Plan aims to develop a common perspective for the Car of Tomorrow which reflects EU policies for transport, energy, environment and industry, maximising social benefits and creating opportunities for employment and training.

1. The Car of Tomorrow and Sustainable Mobility

Amongst the major concerns in the Commission White Paper "The Future Development of the Common Transport Policy" are managing demand for road transport, reducing its social and environmental impact, alleviating congestion and improving road safety.

The total number of cars is expected to increase by more than 25% between 1992 and 2005 (Energy in Europe - A View to the Future, 1992). Road haulage is forecast to increase 42% from 1990 to 2010 (COM(92)46). By comparison, the US total vehicle fleet is forecast to increase by 80% in the same period. Predicted future trends in absolute levels of CO_2 and noxious emissions depend on the economic scenario used to forecast road transport demand. In the UK, various scenarios have been used by ETSU to predict demand for car transport (ETSU: An Appraisal of UK Energy RDD&D, 1994). The Composite Scenario (CSS) - business as usual, no radical policy changes - predicts a 50% increase in passenger car-kilometres between 1990 and 2005. In the CSS, ETSU has selected oil price trends in line with the European Commission's "Conventional Wisdom" scenario. Rather surprisingly, ETSU's Low Oil Price (LOP) scenario predicts a 20% reduction, following a shift to rail because of intolerable traffic congestion! Actual experience 1990-1995 seems more to follow the CSS scenario.

The alleviation of congestion calls for a basket of technical and fiscal measures - introduction of telematics technologies to improve traffic flow, and to optimise available capacity of the road network and parking, improved links for intermodal transport, and measures to encourage multiple car occupancy and greater use of public transport and other environmentally friendly transport modes.

The Action Plan technology programme envisages inter alia, the development and demonstration of ultra compact commuter cars, which meet normal car safety standards, and which may be private, or self-drive, individual public transport systems; they will exploit telematics technologies to provide traffic control, route guidance, active safety control, and links with public transport and information systems.

2. Energy Consumption, CO2 Emissions and Energy Security

The EU energy policy aim to stabilize greenhouse gas (mainly CO_2) emissions at 1990 levels by the year 2000 will require substantial RTD effort to improve overall vehicle energy efficiency to compensate for increased transport demand.

Road transport currently accounts for 80% of energy consumed by transport, which itself represents 30% of final energy demand in Europe. Of this, 98% is oil based fuels. Furthermore, demand for road transport is growing - as fast as 6% per annum in some European cities. In 1990, transport accounted for 25% of total European CO_2 emisssions, with nearly 14% from cars alone (Energy in Europe- A View to the Future, 1992 and COM(92)46). CO_2 emissions are proportional to consumption of fossil fuels. These trends cannot be permitted to continue in the face of dwindling fossil fuel reserves, the persistent threat to global energy security and amidst growing concerns linking exhaust emissions with cancer and respiratory disease. Moreover, advanced societies have a burden of responsibility to reduce per capita energy consumption and emissions. By 2050, energy consumption in developing countries (from mainly fossil sources) is predicted to grow from around 25% at present, to 70% of total world energy demand (ETSU study).

Whilst alternative fuel and propulsion systems offer possibilities for energy consumption and emissions reductions to varying degrees, extensive recent consultation with the automotive industry has revealed great uncertainty as to their marketability. The industry maintains that there is still significant scope for improvement of fossil fuelled Otto and Diesel engines. Industry points to the substantial % reductions in engine harmful emissions and fuel consumption achieved since the introduction of the California Clean Air Act in 1966, the full benefits of which have not yet had time to work through the aging vehicle fleet. The US Reason Foundation Study (No 189, 1995) refers to a study which estimates that 50% of harmful tailpipe emissions come from 10% of the vehicle fleet, noting that incentives to scrap aging vehicles is a very cost effective way to reduce emissions.

However, despite technical improvements to engines, aerodynamics and lighter bodies, customer demand for larger, higher performance cars with higher levels of equipment has, to a significant extent, offset the improvement in fleet average energy consumption. There is considerable debate on the energy efficiency and consumption of alternative propulsion technologies. Aggregated estimates of the energy efficiency over the whole energy pathway are given in Table 1, based on current technology.

The high efficiency of fuel cells running on methane reformed from natural gas is noteworthy. Fuel cell electric vehicles have an inherent energy efficiency advantage, not being limited by the thermodynamic Carnot efficiency. The efficiency of battery vehicles depends on the primary energy source but, for the West European mix, it is some 23% better than gasoline ICE. It is emphasised in the study that the figures are first estimates; large variations are possible depending on the size and type of ICE, battery technology, and primary energy source for electricity generation assumed.

*Table 1: Comparison of Energy Efficiency over Complete Energy Pathway for Alternative Propulsion Technologies**

Energy Source	Propulsion System Overall Efficiency (%)			
Secondary /Primary	ICE	Battery	Hybrid ICE	Fuel Cell
Gasoline/Crude Oil	10.2	-	12.3	27.5
Methane/Natural Gas	11.8	-	14.2	31.7
Electricity/Hydroelectric	-	47.6	-	-
Electricity/W.Europe Mix**	-	33.2	-	-
Methanol/Natural Gas	8.2	-	9.8	21.9
Hydrogen/Hydroelectric	5.8	-	-	16.4

* Source: Final Report, Joule Contract JOU2-CT92-0255, May 1993
** 34% Nuclear, 19% Hydro, 34% Coal, Hydrocarbons 13%

A more useful basis for comparison is the primary energy consumption per kilometre (or 100km), although this is difficult to normalise for driving cycle and driving behaviour. Another study <TUV Rheinland> estimates the primary energy consumption over the same ECE standard cycle for the VW Golf City Stromer (electric car with lead acid battery) and the equivalent Golf gasoline model. Primary energy consumption is reported to be virtually identical for both. An OECD study, reported in <GAO Electric Vehicles 1994>, attempts to give upper and lower bounds on battery electric vehicle overall energy consumption compared to gasoline ICEVs. The worst EV case cited is for a 'low performance' EV, consuming 40.6kWh/100km from electricity generated from natural gas, compared to a high economy ICE consuming 28 mpg. The assumed best case is an EV with advanced Li battery consuming 25.6kWh/100km generated from natural gas with 53% efficiency, against an ICEV consuming 21mpg. In the worst case, the EV consumes 126% more primary energy; in the best case 59.8% less! Clearly, with such large divergence, more effort is needed on comparitive assesment and test, but as old, inefficient power stations are gradually phased out, and battery technology matures, EV operation should become increasingly attractive.

There is currently no propulsion technology which emerges as the most energy efficient in all circumstances. This depends on national circumstances and the uncertain development potential of the different technologies. Fuel cells do seem to have inherent efficiency advantages, but are a long term solution.

The Action Plan aims to support development of a number of propulsion technology options, against defined targets and timescales for energy efficiency and fleet average energy consumption, subject to regular review and rigorous comparison, with a view to defining the most cost-effective future development strategy.

3. Environmental Impact

Harmful emissions attributed to road transport include lead, carbon-monoxide (CO), volatile organic compounds (VOC), including hydrocarbons (HC), oxides of nitrogen (NOx), oxides of sulphur (SOx), and particulates. Some VOC components are carcinogenic. Of the volatile aromatics, benzene is well known to be carcinogenic. Studies show that in heavy traffic in city centres, benzene levels can be considerably higher than that shown to carry unacceptable risk in occupations where workers are especially exposed to benzine. The total external costs, in economic terms, of health problems attributed to transport emissions is estimated at 0.3-0.4% of GDP(COM(92)46); a German study is reported to assign 91% of these costs to road transport.

The NOx and VOC contribute to ozone formation in the presence of sunlight and high daytime temperatures. Tropospheric ozone is a particularly aggressive toxicant with respect to lungs, respiratory tract and eyes, and may be carcinogenic. Ozone also contributes more than methane to the greenouse effect, and causes vegetation damage as well as reducing crop yields. A recent study of forestry in Europe reports that 1 in 4 trees suffer defoliation (25% loss of leaves). Together with SO_2, it contributes to acid rain and aerosol formation. Both SO_2 and NOx form acids in air which cause lung inflammation. Studies have linked high levels of particulates with higher incidence of cancer, though no causal link has been established. It is now thought that the very small PM 2.5 particles are most injurious to health as they can penetrate the alveoli. Table 2 shows the estimated contribution of road transport to total emissions of the various components in Europe.

Table 2: Road Transport Emissions as a % of Total Emissions

Category	NOx	VOC	SO2	CO	PM
Europe	53.6*	27.1*	2.9*	74**	13-22**
USA+	29	27	na	50	na

* CORINAIR (1985) figures cited in COM(92)46
** Figures for Germany and Netherlands cited in COM(92)46
\+ Reported EPA figures(1991), considered low by a factor of 2 by some investigators

An EU Directive setting ozone thresholds for public notification and alert was introduced in 1994. In June/July of that same year, 3100 notifiable excedances were recorded in 11 of the 12 member states. The big contribution of road transport to ozone formation is a problem of European dimension.

The results of a TUV Rheinland study for DG XVII on the effectiveness of EVs to reduce harmful emissions are listed in Table 3 for the 'reference year' 1990 for a VW Golf in Otto, Diesel, and electric variants for the ECE city cycle. A 2010 equivalent scenario is also listed, based on a ICE car with 3litre/100km fuel consumption. The results in Table 3 indicate that, even with current, immature EV technology, total NOx and CO_2 emissions are substantially less than for the ICEs. The prognosis for 2010, taking account of the development potential of both ICEs and EVs, is even more favourable to the EV as far as ozone forming constituents VOC and NOx are concerned, but relatively worse for SO_2. However the present advantage to EVs in terms of global CO_2 emissions is likely to be substantially reduced. There is no contest, however, for (direct) point of use emissions.

Table 3: Emissions Comparison (g/km) for VW Golf Otto, Diesel and Electric Cars

Propulsion System	SO_2	NOx	CO_2	CO	HC
1990					
Diesel(indirect)[1]	0.046	0.063	17.154	-	-
Diesel(direct)	0.239	0.827	186.690	-	-
Diesel(total)	0.284	0.890	204.204	-	-
Otto(indirect)[2]	0.054	0.074	20.534	-	-
Otto(direct)	0.035	0.470	206.853	-	-
Otto(total)	0.088	0.544	227.387	-	-
Electric(indirect)[3]	1.253	0.345	130.498	-	-
Electric(direct)	0.001	0.003	6.9	-	-
Electric(total)	1.254	0.348	137.398	-	-
2010 (% reduction c.f. 1990 reference, asuming fleet 15%diesel, 85% Otto)					
Electric(total)**	-45	-95	-75	-100	-97
ICE (total)**	-65	-38	-62	-95	-95

** TUV Study " Electric Vehicles Chance for Environment and Quality of life" - approximate figures calculated from histogram

[1] VW Golf Diesel (40kW, 7.6litres/100km)

[2] VW Golf Otto (40kW, 3-way cat, 9 litres/100km)

[3] VW Golf City Stromer (lead-acid, 15kW, 26kWh/100km, 0.3litre/100km cabin heating, W Europe generating mix)

Studies (ref France) have also established that high traffic noise levels contribute to mental stress. The TUV study presents results of noise emissions for the electric VW Golf City Stromer and Otto engined Golf. In the critical accelerating range 0-50km/h, corresponding to city driving, the electric car is 8dB (4 to 8 times) quieter and is, of course, totally silent at idle.

The particulates and emissions which form acids in air, are causing corrosion and erosion of Europe's historic buildings.The European Federation for Transport and the Environment puts these costs at between 1.8 and 13.7 bECU.

In view of the above, and the carcinogenic potential of certain VOCs and possibly particulates, the Action Plan places considerable emphasis on stimulating the development of inherently clean propulsion technologies for operation in areas of high population density, and which can eventually act as a vector for renewable energy sources. These include fuel cell, battery electric and hybrid electric vehicles with switchable ZEV mode operation.

4. Industrial Competitivity

Mobility is essential to economic activity and the European automotive industry is itself a major wealth creator. Vehicle production contributes 2% to the total European GDP; 1.8 m employed represents 8.3% of all manufacturing jobs (COM(94) 49, EUCAR). A further 1.8m are employed in distribution and repair. The vehicle industry has recently undergone traumatic restructuring to achieve "lean production", with the consequential loss of more than 100.000 jobs in the last two years. The component industry includes a very large number of totally dependent

SMEs. The trend in export earnings since 1989 is monotonic decline. For the first time in 1991, the EU became a net importer in terms of car numbers (though not value). The growing trade deficit with Japan is particularly worrying. In advancing new vehicle concepts, cost effective solutions are required, which reconcile the potentially conflicting demands of sustainable mobility with industrial prosperity and competitivity.

The industry is critically dependent on its ability to produce world class products at fiercely competitive prices. The White Paper on Growth, Competitiveness, and Employment acknowledges the importance of RTD to secure future competitiveness. Total RTD expenditure by the European industry is estimated as 4bECU per year (COM(94)49). It is vital that European RTD does not lag RTD effort in Japan and the US. Both these countries provide substantial indirect support to their automotive industries by means of basic research.

The US government has been providing 375-450 MECU per year for automotive related technology in general. That compares with 135MECU per year in the EU Third Framework Programme (COM(94)49). A considerable amount is allocated to alternative propulsion technologies. In 1991 the big three US car makers formed the United States Advanced Battery consortium (USABC) and announced a four year, $262m (=200MECU) shared-cost, government funded battery development project (compared to 15MECU in FP3 for the EU). The US Partnership for a New Generation Vehicle (PNGV) draws funds from eight Federal government agencies amounting to $933 (=700MECU) for 1994-1996. This govenrment -industry initiative involving the big three US car makers has three main goals -(i) advanced manufacturing, (ii) improved efficiency, safety and emissions, and (iii) an 80mpg (3litres/100km) car. The US DoE also has an ongoing (since 1976) Electric and Hybrid Vehicles Programme which contributes to the USABC battery development project and to the PNGV objectives. The budget for 1994-5 is listed in Table 4 The 84% increase in requested budget for the fuel cell development in 1996 is noteworthy. It is three times that of the EU fuel cell RTD budget.

Table 4: US DoE Electric and Hybrid Propulsion Development Programme Budget in Millions of US Dollars

	1994	1995	1996[1]
Battery Development	36	29	32
Fuel Cell Development (part of PNGV)	19	23	42
Hybrid Systems Development	19	38	56
Total $m (MECU)	74(56)	90(68)	130(98)

[1] 1996 figures are requested amounts, not yet enacted

The US government offers a 3.000ECU tax credit on EV purchase. The Californian Low Emission Vehicle Programme effectively legislates EV sales from 1998 onwards. With 5 other states already following, cumulative sales of 1million EVs by 2003 are predicted, although the "Big Three" are vigorously opposing the ZEV mandate.

Information on Japanese RTD expenditure is much harder to find. Since 1971 the MITI has been supporting EV-related RTD. In 1991, the New Energy and Industrial Technology Development Organisation(NEDO) launched the 10year, 14bY (=120MECU) LIBES programme - part of the "New Sunshine Project" - for developing lithium batteries with very high performance and reliability targets. The Japanese are also said to be pursuing a "very aggressive" fuel cell development programme, at 1mY funding per kW, but information on total funding is sparse.

The Japanese Electric Vehicle Council (adviser to MITI) launched an EV market expansion programme in 1991 with targets for cumulative EV sales of 200.000 units by 2000, and production levels of 100.000per year. In the early phase the aim is to introduce EVs into fleets run by public authorities and then utilities and other private delivery and service companies, providing charging infrastructure and promoting public awareness. The MITI is reported to subsidize EV purchase by 50%, limited by an annual budget of 700kECU. The Japanese Electric Vehicle Association, established by MITI in 1976, comprises 110 companies, automobile manufacturers, battery companies, public utilities, has an annual budget in the order of 260kECU, and leases around 300EVs. (US General Accounting Office, Annual Report 1994, Electric Vehicles).

Faced with strong international commitment to develop and promote ULEV and especially ZEV technologies, yet uncertainty as to their marketability, the Action Plan proposes that a common approach to quantifying and predicting the relative external costs of conventional and alternatively propelled vehicles should be developed jointly by industry and the public authorities. This would provide a rational, agreed basis for implementing fiscal measures, performance and emissions targets which properly reflect technological capability and the diversity of European demographic, climatic and geographical conditions. Corrective actions have to be weighed carefully to safeguard the competitiveness of Europe's automotive industry and the immense capital invested in today's production capability and refuelling and maintenance infrastructure. SME's are particularly vulnerable to changing circumstances and need clear targets and timescales to work to.

Annex 3

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