THE IPTS REPORT

Produced by IPTS and issued in Cooperation with the European S&T Observatories Network

Environment

- Clean production technologies: figuring out key issues for the future
- Is Europe marketing the recyclability of its products?

Transport

- Combining the wheel with the flywheel?

Biotechnology

- Epic-making advances in genome analysis and their potential impact

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- European and US trends in ATM use: are regulations delaying the introduction of multimedia in Europe?
- Electronic Cash: two sides to the coin
- Rethinking telecommunications infrastructure competition

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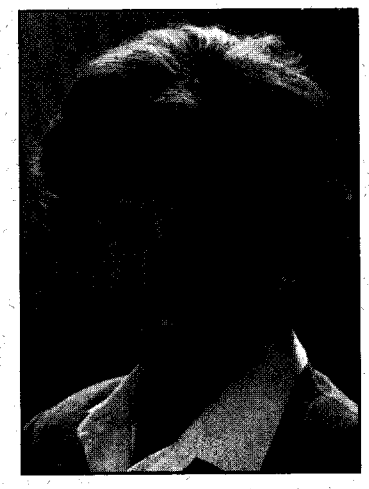
PREFACE



I welcome this first issue of the monthly IPTS Report on technology watch as a major event in several respects.

First there is the satisfaction of seeing a long-cherished project come to fruition; successive responsibilities have confirmed my belief that information is better shared than guarded.

But there is also the fact that the lack of any real technology watch activity is one of the major weaknesses of European research, in particular since the practice is highly developed among some of our main competitors, such as Japan. Europe urgently needs an effective early warning and rapid response mechanism. That was one of the main aims in setting up the Seville institute. Its function is to collect, process and disseminate among European policy-makers information on recent technological advances and the way in which they are taken into account in Europe and elsewhere, particularly among our major industrial competitors.

The IPTS Report has a crucial contribution to make to this process. It is the first highly visible initiative of the new institute set up under the umbrella of the Joint Research Centre, which in so doing takes up the challenge of dedicating its scientists and engineers to reconnaissance, networking and reporting on the cutting edge of technology.

The monthly frequency of publication will also stimulate internal collaboration.

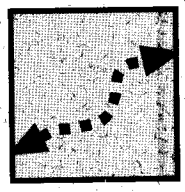
Above all, the Report is a means of achieving a high enough public profile and sufficiently broad scope, to encourage our fellow readers to take part in the exchange of concise, rapid and strategic information.

This networking of intelligence so ardently desired by all policy-makers will not happen overnight. I urged IPTS director H. J. Allgeier to disseminate the Report from the outset in four languages to a readership which, albeit diverse[1], is vital to the day-to-day conduct of our Community activity. In doing so my aim is to ensure that, in a context of ever faster technological change, we all come to depend on it to fire the imagination, alert us to change and keep our activities in perspective.

Ehrenson

1 Including not only decision-makers at the Commission, but also the Council, the European Parliament, expert committees such as IRDAC and CREST, the scientific consultants to the permanent representations, the industry and research ministers of the Member States, and European industrial associations and federations - in all, a readership of nearly 3,000 (?) from January 1996.

Combining the Wheel with the Flywheel?



Zero-emission vehicles such as electric vehicles powered by electrochemical batteries, do not at present offer a completely satisfactory performance in terms of range and acceleration, and therefore might not be fully embraced by the consumer. Modern flywheels can be considered as an alternative/complementary electromechanical energy storage device. Recent developments using modern composite materials have resulted in devices that may outperform batteries in certain ways, and offer a particularly high power density which is comparable to - or even better than - that of the internal combustion engine. Thus flywheel powering should help greatly consumer acceptance of the electric car. Even though the performance of flywheels has been proven in laboratory tests, their commercial exploitation may require greater focus on, and support for R&D effort in this field.

At present the growth of individual transport is overwhelmingly dominated by vehicles powered by the internal combustion engine (ICE), and this is causing increasing environmental concern. In the future, zero emission or ultra low emission vehicles (ZEV or ULEV, respectively), such as battery-powered electric or hybrid vehicles (in the sense of multi-source power generation), are projected to replace standard internal combustion engine cars as far as possible, at least in urban areas. Previous pilot experiments have demonstrated that acceptance of this new type of vehicle (ZEV or ULEV) will depend largely on the extent to which it can meet those customer needs that the ICE-powered car presently satisfies. These are related in particular to range and acceleration - which themselves are a factor of the energy and power density - as well as to the cost of the alternative power source.

Overcoming range and acceleration limitations

Present electric vehicles (EVs), are mostly powered by electrochemical batteries and suffer from low range and limited acceleration because of the limited energy and power densities offered by today's batteries. Even a future generation of batteries, whose goals are defined by the (perhaps over-optimistic) long term objectives of the US ABC-programme, would not result in a vehicle with performance similar to present ICE cars (Figure 1).

In order to overcome this difficulty, present efforts are aimed at developing a hybrid vehicle, which is an electric vehicle combined with a small internal combustion engine. While the range (energy density related) problem would clearly be eased, lack of acceleration, due to the low power density of the chemical batteries, would still pose a major problem with regard to user acceptance.

Urgent need for low emission vehicles ...

... but in acceleration and range internal combustion engines are hard to beat

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even the internal combustion engine.
Other flywheel characteristics also appear very attractive. The charging time can be as low as 15 minutes, which can be compared to the many hours required to charge a battery. In addition, its charge / discharge efficiency is greater than 0.9, instead of 0.6 - 0.8 with batteries, and the self-discharge losses are close to 1% per day while battery losses can peak at several percentage points per day.

Safety and costs: surmountable issues

A further advantage is the fact that most of the know-how needed to design and engineer flywheels is already available. Yet some development is needed for production of cost-effective, stronger fibres for the composite materials. In addition to this, further improvements in magnetic bearings, which would lead to better rotor balance, and high performance motor / generators are required.

There are two main drawbacks associated with flywheels: safety and cost. The safety issue is indeed of particular concern, with uncontrolled energy release occurring in cases of accidental rotor failure. Yet this problem is greatly reduced if there is adequate engineering of the rotor and the containment vessel. Setting several small flywheel units in place of a single large one should improve safety as well.

At first glance, the cost issue is dominated by the expensive composite materials (particularly carbon fibre composites) and the flywheel production process itself. Yet this needs to be qualified. Firstly, less expensive high-strength glass fibres are now available, and even the price of carbon fibres is coming down. Furthermore, even though it appears that the production price of flywheels is considerably higher than that of lead acid batteries, the lifetime and the charge / discharge efficiency advantage should result in a price advantage over the battery.

The main vehicular applications that can be imagined for flywheels depend very much on their actual performance. First, because of their strong performance compared with other power sources, flywheels could be used in pure electric vehicles. Due to their higher energy density and efficiency, the projected range for such vehicles could be substantially greater than that of battery powered cars. In addition, user acceptance should be higher because of better acceleration and convenience, due to their large power density and quick recharging time. It is also worth emphasising the importance of the higher charge / discharge efficiency of flywheels compared to that of batteries. Given that it is likely that all electric vehicles will recover braking energy in order to combat the low range problem, simulations have shown that the efficiency advantage alone of a flywheel-powered electric vehicle would achieve double the range of a battery-powered electric vehicle during urban driving.

Safety (like cost) is a concern but is not an insuperable problem

Second, if the energy stored in the vehicle is still too low to provide sufficient range, then flywheels can be employed favourably as the buffer energy and power source for a hybrid vehicle (Figure 2). In this concept, they would be recharged when needed by a small on-board internal combustion engine, allowing large power peaks to be delivered by the flywheels. This would make the vehicle similar, in terms of range, acceleration and pleasure of driving, to the traditional internal combustion engine car. **Finally, the use of flywheels as a buffer source for battery powered electric vehicles, i.e. for satisfying peak power demand, would substantially improve battery durability** and also would allow for efficient braking energy recovery.

Flywheel cost is coming down rapidly due to advances in glass and carbon fibres

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substantial advantages over alternative power sources, they deserve serious consideration.
- Among the features offered by the flywheel, the very high power density (and hence higher acceleration) should strongly boost user acceptance of alternative vehicles, and this should help make the mass diffusion of clean cars more likely.
- Today's flywheels need development - rather than basic research - which focuses on taking them out of the laboratory and applying them in the real world.

Keywords

Flywheel, electromechanical battery, energy storage, future car, zero emission vehicle (ZEV), ultra low emission vehicle (ULEV), electric vehicle (EV), hybrid vehicle, market acceptance of EVs, composite materials, defence industry conversion.

Information Sources

• *"Electromechanical battery program at the Lawrence Livermore National Laboratory"*, Post R. F. , Bender D. A. and Meritt B. T., Proceedings of the 29th Intersociety Energy Conversion Engineering Conference, Monterey, CA, USA, 7 - 12 August 1994.
• "*Technology assessments of advanced energy storage systems for electric and hybrid vehicles*", US Department of Energy Report, No. DOE/CE/50337-T1, 30 April 1993.
• "*Flywheel energy storage technology workshop*", Oak Ridge National Laboratory / DOE, Oak Ridge, TN, USA, 2 - 4 November 1993.
• "*Hybridantriebe mit Schwungradenergiespeicher*" - ("*Flywheel Hybrid Power Source*"), J. W. Biermann, ÖZE, Jg. 32, HEFT 9, pp 331 - 336, 1979.
• *"Flytech"*, BRITE EURAM III, proposal BE 95 - 1616, 1995

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An ATM network can support many types of service which may come into any of the four categories: (i) loss-sensitive, delay-sensitive, (ii) loss-insensitive, delay-sensitive, (iii) loss-sensitive, delay-insensitive, and (iv) loss-insensitive, delay-insensitive. It can further reserve and allocate a fixed bandwidth for a connection carrying a continuous bit stream for isochronous traffic (repeating in time such as 8khz voice samples), allocate a bandwidth range for a variable bit stream for plesiochronous traffic (i.e. variable frequency signals such as interactive compressed video), as well as allocate no specific amount of bandwidth and rely on statistical sharing among bursty sources. It may also provide multiple priorities in any of the above categories. The services can span the entire range from interactive - such as telephony and online data retrieval - to distributed - such as video and stereo hi-fi broadcasts and multicasts for conferencing and database updates. All specifications concerning ATM are to be found in the ATM user network interface specification (UNI) - version UNI 3.1.

represents a massive investment both in research and development, as well as deployment and integration. On the other hand, the software investment required to make the ATM network work is substantial. Considerable work is also required in developing new network management paradigms and protocols to control and manage effectively the bandwidth and services that the revolution in communication technology promises.

The market by segment

Having presented some of the ATM fundamentals, the next question is the degree to which the market has taken up ATM. The market for ATM-based products and services in business communication may be divided into three segments: Public Network Infrastructure, Local Area Networks (LAN) and Wide Area Networks (WAN). This segmentation is determined by existing market structures, by the rate of new technology deployment and by the regulatory environment.

The **Local Area Network** market segment includes workstations and other workgroup products, adaptors for client/server architectures and other technologies (Fiber Distributed Data Interface, token ring, ethernet, etc.) and backbone products (including those serving a university campus facility). **This market is characterised by a large number of players, many diverse technological solutions and rapid technology innovation.**

The **Wide Area Network** market segment includes enterprise networks operating over leased lines (or, less commonly, a privately-owned infrastructure such as optical fibre) and those provided as virtual private networks by a public network operator. It also includes interworking with other wide-area technologies such as Frame Relay and Packet Switching. This market is characterised by a variety of regulatory regimes which are moving at different speeds towards deregulation. **There are a relatively small number of service providers, with new entrants and the extension of geographic coverage of existing players.**

The **Public Network Infrastructure (PNI)** seg-

ATM market uptake in Europe depends on the market segment...

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considered as the first step in this direction. Moreover, data private networks play a large role in Europe and will heavily rely on what value added service providers can offer.

Time-lag of 6 to 18 months in ATM Local Area Networks

Finally, the main feature of any comparison between the European and US Local Area Network markets is their similarity. The major differentiating factor is the time-lag of 6 to 18 months displayed by the European market. But in terms of technology, applications, user demands and expectations the two markets track each other remarkably closely.

CONCLUSIONS

From a product point of view, apart from the physical interfaces, e.g. 1.5 Mbit/s and 45 Mbit/s in the US and 2 Mbit/s and 34 Mbit/s in Europe, there are no major differences between the US and Europe. **The competitive nature of the US market has led to the earlier availability, at lower cost, of ATM cell relay services.** The emergence of alternative service providers in Europe is likely to see the availability of a similar choice of services, although European tariffs may remain higher. However, the differences are related to timing, in many instances. This is particularly true of the LAN market **where the European market can be characterised as lagging behind the US market by 6 to 18 months. The differences in the WAN and Infrastructure markets are created by the differences in the regulatory environment.** As the European market becomes increasingly liberalised and alternatives and cross-border service providers appear, the differences may diminish. **In the short term, the most significant effect is the inflated cost of bandwidth in Europe compared with the US.** This may slow down the development of broadband services and applications in Europe compared with the US.

... it closely tracks the US in the LAN market (6-18 month delay)

... but lags more seriously behind in the WAN market and public infrastructure market,

Keywords

ATM, LAN, WAN, Europe-USA

Information Sources

• Zahir Ebrahim (1992): *A Brief Tutorial on ATM.* A HTML document available at the **URL: http://av.avc.ucl.ac.uk/atm.htm**

• ATM-Forum: *Comparison of European and US Market. Trends in ATM Implementation.* An HTML document prepared by the ATM Forum, European Market Awareness Committee. see **URL: http://www.atmforum.com/atmforum/US_vs_Euro_Mkt_Trends.html**

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cash, through a collaborating bank. **This version of i-cash is a form of money-token consisting of strings of ones and zeros, including special 'anti-forgery', 'anti-duplication' substrings.** The absence of the latter activates an alerting mechanism in the 'issuer's' program, when a 'forgery' is encountered. What is crucially different about this scheme is the anonymity it offers. **The identity of the user of these tokens is untraceable - except when a 'forgery' is encountered, in which case the original user can be identified.**

Repercussions for the medium term...

Such developments have clear positive repercussions. They facilitate the growth of business on the Internet, and, more importantly, they **potentially could provide a strong overall boost to business activity**. Using i-cash and a good bookkeeping program anyone can launch a business on the Internet, with substantially fewer regulatory obstacles than in the real (as opposed to the virtual) marketplace. Furthermore, if accepted as a medium of exchange, i-cash could substantially reduce transaction costs by expediting instant settlement of often complex financial obligations.

On the other hand, policymakers need to be alerted not only to the positive effects, but also to the potential headaches which i-cash may cause. Since traffic of strings of digits on the Internet can be very fast, token money can move readily from computer to computer, from jurisdiction to jurisdiction, making it **very hard for tax authorities to assess and tax true taxable income.**

There may be justifiable worries for banks as well. I-cash will undoubtedly initially be regarded with considerable suspicion by many people - as were banknotes, checks and credit-cards when they first were introduced. With i-cash the long process of money abstraction (from banknotes to checks to credit-cards) reaches its purest abstract form. The facilitating effect of i-cash on commerce **may undermine the banks' importance** - and profits - in such transactions, by reducing the role they play and the commissions they charge.

...money abstraction ad extremum

...and the longer term

Money matters

If, furthermore, i-cash develops a good reputation it may start being used as a store of value and not only as a medium of exchange. To achieve this it would need to be convertible into real cash, through the issuer guaranteeing one-to-one correspondence between the amount of i-cash outstanding and real cash kept in the issuer's vaults. In such a scheme i-cash balances would earn no interest, because any interest they earned would have to be 'paid' towards the interest foregone by the 'frozen' real cash backing the outstanding i-cash. Since there could be no interest there could be no lending, and hence i-cash is not a particularly attractive source of income for the banks. In a competitive environment the commissions they could charge on the issuing or conversion of i-cash would have to be very low. It is also true that, due to the difficulty in converting across foreign currencies, i-cash may face limitations in international commerce (or conversely, it may prove an excellent means of conducting black-market operations in foreign exchange).

...for banks

Taking the analysis a step further, **just as the one-to-one correspondence with gold - originally used to back the new banknotes - was eventually interpreted more loosely and lending in cash flourished, so, too, lending in i-cash might develop.** Although this might be good news for the banks, it could

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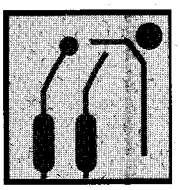
Rethinking Telecommunications Infrastructure Competition



Cost reductions due to technological developments and deregulation are leading to liberalisation of telecoms infrastructure provision - not just competition in the provision of telecoms services. It is the cost of infrastructure - which in turn depends on the state of technology - that will determine the best transitional strategy. The latter may justifiably include a pooling of effort and resources, followed by careful connection charge regulation. The key to the construction of the Multimedia Information Society (MIS) network is to make private enterprise pay for a broadband network (rather than a large number of inadequate narrowband ones) and then, if necessary, regulate interconnection charges during a transitional period, so that no-one is excluded from entering the service provision market. A further consideration may be that public telephone operators (PTOs) can gain from participation in such joint exercises.

Although there is virtually full agreement that telecoms service provision should - and will be - liberalised, the case for telecom infrastructure provision is not as clear, especially with regard to the transitional process during which competing infrastructures will be constructed. "Free-riding behaviour" and incomplete appropriability of profits, as well as uncertainty about project profitability (at least in the short to medium term) do not bode well for fiber optics, ATM (asynchronous transfer mode, advanced switching technologies), and broadbanding. It may be the case that some wealthy firm sees an opportunity to make a certain and timely profit by building the broadband backbone of the Multimedia Information Society (MIS) network. It would then, however, want to operate not as a service retailer but as an infrastructure subletter. It is unclear how the issues of universal service provision, security and prevention of collusion between the service-providing and infrastructure-providing parts of a firm will be resolved.

Crucial observations setting the stage...

It may be that the above scenario is too hypothetical. The time scale for recouping the investment in building the infrastructure may be too long, especially in light of the need for the price of the new 'broadband' service not to be much higher than the tariff for its currently available, more primitive, version (a rule of thumb is that it should be no more than c. 1.5 times higher). Recent empirical evidence from the UK shows that rival newcomers do not set up their own full networks. They may lay certain lines, but they also use those of the existing, established provider, which in most cases cover the entire country.

It can be stated from the very outset that distribution is suffering from falling profit margins, and hence there is pressure to provide new, value-added services. On the other hand, local calls cannot be exploited as a source of revenue, not just for political reasons but also be-

Technology drives costs down but... ... the transition phase in liberalisation is critical

Reluctance to undertake possibly unprofitable investment...

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ABOUT IPTS

The IPTS is one of the eight institutes of the Joint Research Centre. Its specificity is the observation and follow up of technological change in the broad sense, in order to get a better understanding of its links with economy and society. IPTS develops methodology to carry out this task with scientific rigor starting with technologies in the fields of energy, environment, information technology, biotechnologies and materials, and gradually covering all technology fields. At the same time the institute carries out research to improve the understanding of the impact of new technologies and their benefits and more generally the relationship between technology, economy and society.

The IPTS' competitive edge is to be neutral while being totally pervaded by the EU philosophy and fully aware of EU policies and actions. This allows for the creation of bridges between the different fields of EU action and to contribute to the creation of a common knowledge base at the disposal of all stakeholders.

The purpose of this work is not scientific pursuit in itself. The Institute aims to support the decision-maker in the management of change whenever science and technology have an important role to play.

The main client for IPTS' work is the Commission. First, the Commissioner for Science and Technology, but more generally the Commission as a whole. The Commission and the Commissioners are to be seen as the strategic nerve centre of the European decision making process, as a centre of management of change, not of problems of subsidiary interests, but of problems of key importance to our society as a whole, problems that call for decisions which have to be taken at a European level, complementing those to be taken a national level.

Hence, indirectly, the clients of the IPTS are those concerned with preparing the initiatives to manage change - the Commission services - those concerned with the decision process itself - the Member States and Parliament- all those concerned by the consequences of any decisions or initiatives and, finally, again those concerned with the management, that is the implementation of such decisions, such as the Commission services, and other agencies and institutions in the Member States.

It is therefore in close cooperation with the decision-maker, that the missions of the institute have been defined as follows:

1. **Technology watch.** This mission should allow for a quick and reliable access to existing technological information, its processing and its diffusion in view of alerting the European decision maker about major events and trends with significant social, economic or political consequences. The Institute will also aim at satisfying the much broader function of a truly European Science and Technology Observatory by means of a network of similar organisations operating at national level. All the interested partners share the responsibility of carrying out technological watch as a "joint venture" in order to be aware of all relevant, significant and outstanding scientific and technological events.

2. **Technology, employment, competitiveness.** Given that employment is one of the major preoccupations of EU institutions and society, the driving force for all IPTS'activities is the compound Technology - Employment - Competitiveness. This entails the identification of promising technologies, and the analysis of their potentials in view of job creation, economic growth and social welfare. Regular synthesis of real experiences and analyses will be produced, highlighting the pros and cons of every option in view of facing needs and problems of the EU. IPTS will therefore undertake prospective studies in specific subjets

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