As the UK's HM Customs & Excise formally announces the start of its procurement for packages to implement a Lorry Road User Charging (LRUC) scheme the author looks at current policies and projects elsewhere. How do emerging national schemes fit into a European-wide solution for the charging of heavy vehicles? And which technologies best fit Europe's emerging policies for LRUC?

Lorry Road User Charging
Part 1: Europe Wakes Up

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POLICY VERSUS TECHNOLOGY

Lorry Road User Charging (LRUC) is now on the policy map of Europe. A few countries only but with more to follow. The national contexts of the early adopters that have implemented LRUC are not comparable, operating models or delivery mechanisms are complex and economic models are often difficult to analyse. This may be an overly pessimistic starting point to describe LRUC as a viable taxation policy instrument, but, as Europe wakes up to a future of Road User Charging (RUC), the few examples that exist for heavy trucks can provide useful precedence to future scheme design.

LRUC: Enforcement

The scope, procurement, delivery and operation of systems and technologies for RUC in general, are defined by the interplay between transportation, environmental and taxation planning at the level of the Member State and EU itself. The impact of charging policy on charging and enforcement technology development, demand, adoption and evolution cannot be overlooked although it is often the easy, and in many cases misleading, option to focus

only on the 'box in the cab' and its underlying technologies in isolation from these policies. Whether 'technology leads policy' or 'policy leads technology' is academic. Technology enables policies to be implemented. The reverse is also true: technology development responds to policy demands. Anyway, as a useful starting point the functional requirements can be defined generally, and for this we will refer to a well-understood related market: electronic toll collection or ETC.

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FUNCTIONAL REQUIREMENTS

Since 1987, when the first generation ETC systems were used commercially, the technologies that were used to trigger the payment of fees (or identify the account to which the charges should be made) captured the interest of highway operators, financiers, media, politicians and, of course, road users themselves.

Common System Functions

Registration	Users (locally or through inter-service provider contractual relationship), frequent / occasional use
Distribution and Installation	In vehicle equipment (if required)
Charging	Based on declaration / determination of user and vehicle-related information to allow the correct charge to be determined at the point of provisions of road user (e.g. OBU-based declarations);
Enforcement	If the correct charge cannot be applied (e.g. lack of or incorrect user declarations) by capturing evidential information relating to the vehicle passage and its context;
Collection and management of records	Relating to user and vehicle-related charging and enforcement events; and
Settlement	Charges, rebates and penalties

Fig 1 Common System Functions

The capability and cost structure of systems based on Dedicated Short Range Communication (DSRC) for ETC met the commercial and business case needs well and led to the dominance of this technology for ETC worldwide. However, alternative

technical approaches are being currently presented to public and private road operators for RUC, initially for application to heavy goods vehicles for LRUC. So avoiding any technology comparison for LRUC at this stage what are the functional requirements for a generic road user charging system?

Based on a study of operating and planned ETC and LRUC schemes in Europe (including Italy, France, UK, Norway, Austria, Switzerland, Spain, Portugal, Germany, Turkey and Greece) several common end-to-end operational functional requirements emerged (Fig. 1).

The limited number of LRUC schemes currently planned, or in operation, base the charging levels on distance travelled on defined categories of road both for regular and occasional users. A means of accurately determining the distance travelled and identifying the class of road is a fundamental requirement of the system, whether pre-paid or not. Similarly, an effective, credible enforcement process is needed to ensure that the primary charging policy is properly executed. Typically enforcement requires accurate vehicle discrimination, vehicle detection, the capture of an image of the vehicle license plate and a record of other contextual information. The need for an enforcement infrastructure is common to all road user charging systems – independent of charging policy or the approach used for charging. Other requirements matched to feasible technologies are listed in Fig 2.

TECHNOLOGY OPTIONS

There are several components available to scheme operators, including GPS and DSRC. These technologies have evolved in parallel from very different origins. Both have passed through several generations, both are now available in mass-market products and both are well-supported by an internationally competitive industry. Nevertheless, although GPS and DSRC perform completely different functions this has not stopped frequent direct comparison and often misleading claims by the apparently competing camps.

If we focus on the 'front-end' (on-road or in-vehicle) charging technologies it is clear that distance travelled can be determined through direct measurement from the vehicle odometer although this does not identify the road type. On the other hand, a GPS module can be used to estimate the vehicle position. Therefore, continuous position measurement based on GPS could theoretically be used to determine distance travelled or, as in the Swiss LSVA scheme, to provide redundancy to an odometer-based distance measuring scheme. Alternatively, accurate GPS-based position estimates can be used to identify a road segment whose length and type is pre-loaded into a database of all chargeable road segments held in the OBU. Other, more complex variants attempt to improve on this.

A further option is to use DSRC as a highly localised, discrete positioning and communication system that can be deployed at the boundary points or interface between

road types differentiated by charging rates. The Austrian LKW scheme is based wholly on DSRC. All OBUs were installed by the road users themselves and road segments were identified by communication points located on each chargeable motorway section.

Terrestrial positioning based on cellular networks can reduce the ambiguity or augment other methods of positioning to the resolution of a cell or cell sector but however cannot be used to accurately measure distance by itself.

Technology Options	
Registration of Users	Frequent and occasional / 'per trip' registration permitted; call centre, internet or kiosk, occasional / regular: account, user and vehicle registration
Distribution	OBUs: by post or collection (for self-installed OBUs) or authorised fitting centre for externally powered, more complex units
Charging	DSRC for location identification, account/vehicle identification and localised communication; GPS for vehicle position estimation, W-LAN or GSM/UMTS for communication (digital maps, tariff tables etc.), odometer/tachograph for direct relative distance measurement, OBU application; on-board data collection / interpretation and tariff table management.
Enforcement	Physical (barriers), ANPR / contextual image capture, manual / road choke-point OBU and vehicle inspections, vehicle detection (non-contact overhead, in-ground sensors); on-road management of evidential enforcement records.
Communication, Collection and Management	Fixed communication links; fixed enforcement and physical charge points (if used), GSM/UMTS for generally location-independent communication with OBUs; multi-tiered, high availability, distributed IT network for charging and enforcement processes, O&M.
Settlement	Charges and penalties; direct (local) or indirect (cross-border) interface to vehicle registration databases; multi-tiered, high availability, distributed IT network (billing engines, CRM, etc.), clearing

Fig 2 Technology options that meet functional requirements

Overall, it can be seen that a mix of complementary technologies and processes is required for charging and to provide suitable enforcement schemes. This conclusion however, sits uncomfortably with the currently established position for adopting the '*Directive on the interoperability of electronic road toll systems in the Community*' that recommends the use of satellite positioning (i.e. GPS and Galileo via EGNOS) and mobile communication technology such as GSM (or UMTS). This technology 'couplet' is often referred to as 'Global Navigation Satellite Systems with Cellular Networks'

(GNSS/CN). However, the requirement for ensuring the minimum technical level of interoperability with the Swiss, Austrian, the planned German schemes and most existing ETC systems in Europe naturally points to DSRC – also conflicting with the recommendation. So, whilst EU policy attempts to provide guidance it does not specify how schemes will be built or will be inter-related.

Distant Cousins

GPS was conceived by the U.S. Department of Defense in 1973 leading to the launch of the first GPS satellite in 1978. Full 24-satellite capability was made available in 1993. However, 1973 was also the year that contactless electronic toll collection was first promoted by the operator of the Golden Gate Bridge although it was not until 1987 that the world's first commercial ETC solution commenced operations in Norway. In 1993 the European Commission mandated European standardisation bodies to create standards that would enable interoperability of products and services for electronic fee collection, dedicated short-range communication, automatic identification of vehicles and equipment. It was this mandate that ultimately triggered the formation of CEN Technical Committee (TC) 278 that led to pre-standard DSRC systems deployment from about 1995 and final adoption of the standards themselves in Spring 2004.

Nevertheless, we can already see the benefits of 'learning' - the adoption of ETC was initially driven by highly localised needs and it took almost 10 years from the first use of ETC until cross-border interoperability found its way onto the agenda. The directives already enshrined in law at a national level that enable LRUC and the modified directive relating to interoperability have served to elevate industry debate, national technology preferences and expose positive support for cross-border interoperability. This process took only 5 years. This was also the time taken for Switzerland and Austria to plan, deploy and launch national schemes.

DON'T FORGET THE OCCASIONAL USERS

An occasional user is (paradoxically) usually defined by the vehicle and not the user. Depending on the charging policy adopted, a vehicle that does not meet the distance and or total annual duration thresholds that warrant the use of the regular road user charging scheme can be defined as 'occasional'. For example, a scheme threshold could be set at 12,000km. Driving less than this annually on chargeable roads would permit a driver to use an alternative method of trip registration rather than having to fit an OBU. The currently defined German LKW scheme requires transiting truck drivers or despatchers to pre-register a route manually, for example at roadside terminals, by contacting a call centre or through the scheme operator's Internet site. Changes to the route can only be accommodated by re-registering. Alternatively, the planned UK scheme defines a Low Use OBU (LOBU) that can accommodate route changes dynamically and be able to distinguish road types differentiated by charging rates by means of roadside infrastructure. However, the Austrian scheme has no occasional user provision and all

users must have a mandatory OBU although, due to its relatively low cost, this appears to be considered as disposable by some drivers (!)

INTEROPERABILITY

Ensuring cross-border interoperability of manual trip registrations could reduce operating costs. For example, a trip could easily span two or more Member States, although operationally, this would require apportionment of pre-paid fees paid between member states. Drivers that change their route (intentionally or not) would still need to re-register with the scheme operator and, extrapolating the manual trip registration for a journey across national borders, this would multiply the effort required for the user to keep the trip updated. However, an OBU that meets minimum interoperability requirements for automatic trip recording is not be affected by a variation in route. Furthermore, fees could be reconciled at the exit from every charging policy area (i.e. the borders of each EU member state), periodically or on reaching charge thresholds. This would ensure OBU roaming, trip flexibility, continuous service provision and a single bill – as GSM service providers routinely deliver today.

The status of a road user is likely to differ depending on where they registered as 'occasional' in one state and 'regular' in the road user's home country – with the same OBU. Practically, this would mean that such an OBU issued by one member state would (or rather, should) meet the minimum requirements for interoperability (technically and contractually) with another. The same arguments must also apply to evidential enforcement records (i.e. as studied by VERA 2).

Once the OBU complies with technical interoperability requirements, cross-border usage of OBUs, is dependent simply on the principles of contractual interoperability as evident between Austria and Switzerland (currently only one-way), Denmark and Sweden, Spain and Portugal and between other pairs of EU and EEA member states. The Road Charging Interoperability Pilot Project (RCIPP), led by Ertico, seeks to validate an RCIPP-compliant open interoperability platform at 5 sites: Austria, France, Germany, Italy and Switzerland based on inputs from the earlier CESARE, CARDME and INITIATIVE projects. The RCIPP focuses on creating and validating an Open Minimum Interoperability Specification (OMIS) that would be adopted as part of the charging policy by any member state to enable pan-European cross-border interoperability.

FUTURE TRENDS

The practical implementation of '*Directive 1999/62/EC Of the European Parliament and of the Council on the charging of heavy goods vehicles for the use of certain infrastructures (17 June 1999)*' and its future revisions will need to take account of national pressures: compatibility with existing toll collection schemes, policy preferences for differential charging (road types, vehicle attributes, congestion, time of day, etc.), compensation mechanisms (e.g. fuel duty rebates, offsets for tolls incurred), preferences of existing road user associations, timing of introduction, and relationship

with other EU wide initiatives such as the introduction of the electronic tachograph and introduction of mass market road user charging in different countries at different times.

For LRUC, at least, it is no surprise that transit nations such as Switzerland, Austria and Germany were the first movers closely followed by the UK and the Czech Republic amongst others whilst France and Italy already charge heavy goods vehicles as part of existing ETC schemes on their existing widespread network of tolled roads.

Scenario 'Integrated'

- Development of hybrid OBUs supporting GNSS/CN and DSRC where DSRC is the lowest common denominator for complex and monolithic OBUs to ensure interoperability in EU/EEA, including newly joined EU member states.
- Continued but increasingly routine use of DSRC technologies for highly focused, mass-market applications such as ETC.
- Continued development of contractual interoperability to ensure co-existence with other forms of EFC such as CN/GNSS and ANPR (already introduced as nationally or locally optimal).
- Evolution of charging policies from motorways only towards 'all roads' with local differentiation based on emissions class, classification, axle weight, time of day and measured congestion.
- Emergence of cross-border charge clearing services and service providers driven by economies of scale.
- Further development of EU-and EEA-wide contractual roaming agreements for 'simple' OBUs (e.g. DSRC-based) and 'complex' (e.g. hybrid).
- Broad acceptance of road user charging policies driving adoption within vehicle and transport services supply chains (e.g. retrofit outlets, vehicle manufacturer options, etc.).
- The development of multi-mode, flexible OBUs capable of adapting to local RUC service requirements.
- Further development of pan-EU cross-border enforcement processes (e.g. based on VERA2-type tools and equipment approvals), initially on a bilateral basis.
- Continued emergence of OBU-only vendors.
- Scheme overlap will trigger separation of the roles of OBU issuing, account management and RUC service provision.

Source: Transport Technology Consultants developed several internally consistent and feasible scenarios based on current policies and technology trends, to help describe the possible future shape of LRUC in Europe in 2010. The scenario' Integrated' was extracted from this work.

Fig 3. Future Trends 1

The UK's 'all roads' scheme is founded on three principles: a main, fully automated

scheme for regular road users, an occasional user scheme (OUS) for road use below an annual distance threshold and scheme for offsetting the fuel duty (rebate). The scheme breakdown for the purposes of procurement does not specify any technology approach but instead describes the primary functions of charging enforcement and central services. Compliance to prevailing interoperability requirements and standards will be necessary. The Czech Republic's scheme is being defined around a core policy of charging for the use of motorways and selected linked roads. To implement directive 1999/62/EC fully, France's scheme is expected to focus on (tolled) autoroutes and possibly selected additional roads. Different contexts. Different solutions. Emerging common trends.

One large force that cannot be ignored is the relationship between national schemes for lorry road user charging and mass-market (all vehicles) road user charging. Only time will tell how these schemes will be incorporated alongside LRUC, ETC, Urban Road User Charging and mass-market RUC but since a single user may eventually participate in many schemes on a single journey, interoperability for heavy goods vehicles will be important to ensure economic efficiency and sustained user acceptance.

Whether one has a GPS-centric view or DSRC-centric view, the 'best' mix will probably be determined by the closest fit with national charging policies for LRUC, whilst meeting minimum interoperability requirements for pan-European cross-border charging, enforcement and ETC. As Europe continues with the current phase of 'fast learning' to implement LRUC – a pragmatic objective view of existing examples of road user charging schemes of all forms will help reduce the risks of implementing new schemes - on the road to the universal pricing of road use and not only for heavy goods vehicles.

Further information on RCIPP, including the Part B report is available at www.etsi.org, the original '*Directive 1999/62/EC of the European Parliament and of the Council of 17 June 1999 On the Charging of Heavy Goods Vehicles for the Use of Certain Infrastructures*' is available at europa.eu.int/comm/transport/infr-charging/library/directive1999-62.pdf (under revision), the public portal to the Swiss LSVA can be accessed at Switzerland at www.zoll.admin.ch/e/firmen/steuern/lsva/ausland.php, the VERA site at www.enforcement-research.org.uk, and the HMC&E procurement document pack at www.hmce.gov.uk/business/othertaxes/lruc.htm. The author Andrew Pickford can be reached at andrew.pickford@dial.pipex.com.