UK PERSPECTIVE ON COST-BENEFIT ASSESSMENT OF INTELLIGENT TRANSPORT SYSTEMS

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SUMMARY

In 1996 the results of a major government funded study into the costs and benefits of Intelligent Transport Systems in the UK was published. This paper outlines the results of that study and discusses the extent to which the most beneficial applications have been promoted and deployed. Progress is explained with reference to development in technology and in government policy. Institutional and deployment issues that need to be considered in parallel with costs and benefits are highlighted.

INTRODUCTION

During the mid 1990s, the UK Department of Transport funded a major study into the costs and benefits of Intelligent Transport Systems (ITS) in the UK (Perrett and Stevens, 1996). The aim of the study was to develop a methodology to provide broad strategic advice on the likely costs and benefits of ITS applications to assist with decisions regarding transport policy, resource allocation and research funding.

The aims of the assessment project were:

- To promote discussion within DoT and between DoT and industry
- Consistency of approach across applications
- Transparency of method
- Completeness
- Robustness

The study did not focus on specific implementation of a technology, or on specific schemes. Instead it developed implementation scenarios appropriate to each generic application of ITS and then estimated the costs and benefits accruing to society as a whole from the implementation, following a standard approach to investment appraisal. Of course, estimation of costs and benefits was based on knowledge of specific scheme implementations and the capabilities of relevant technologies, but this had to be generalised for application, where appropriate, across the whole country.

STRATEGIC COST-BENEFIT ASSESSMENT

Methodology

The assessment methodology was based largely on that developed during a previous European Community supported project (EVA, 1991). Apart from the conventional Cost-Benefit modelling, EVA also recognised the need for other types of analysis. In particular, Multi-Criteria Analysis was recommended for situations where money values were not available, and Cost Effectiveness Analysis was recommended for situations where costs are available, but there are no equivalent monetary values for the benefits. EVA produced detailed guidelines for the Socio-Economic Evaluation of a particular system. It also identified quantifiable criteria, such as construction and operating costs, travel time savings, vehicle operating costs, passenger comfort, accidents, air quality etc, in a similar manner to the traditional approach as used in the UK for highway scheme evaluation (COBA, 1998).

It must be emphasised that, unlike the EVA approach, the focus of this study was not a particular system or implementation but on the national benefits of different ITS applications. The 36 different ITS applications considered were categorised into six main classes:

- Inter-urban
- Urban
- Monitoring and Enforcement
- Driver Information, navigation and guidance
- Freight and Fleet
- Automatic Vehicle applications

The type of assessment designed to provide broad strategic advice to justify the allocation of public resources is normally referred to as Technology (or Strategy) Assessment, as shown in the third column of Table 1. However, the techniques used in the study were more closely related to conventional cost-benefit analysis, or Socio-Economic Evaluation, as indicated by the second column in the Table. The techniques are based on welfare theory and the principle of consumer sovereignty. They use estimates of the monetary value of costs and benefits over time to provide an indication of social worth and support for decisions on resource allocation. The assessment could therefore be considered as a combination of the Socio-Economic Evaluation and Technology Assessment.

The overall methodology that was applied is summarised in Table 2. This process is standard practice; the novelty in this work was applying it to ITS for the first time. A key part of the assessment process was to define suitable scenarios for evaluation. This involved making a large number of assumptions regarding system characteristics, the scale of implementation and the nature and scale of impacts.

To calculate the Benefit/Cost ratio, the discounted value of any disbenefits was subtracted from the discounted value of the positive benefits, and this total net benefit then divided by the total discounted cost. Thus, the net social benefit is compared with the cash cost (investment and running cost). Financial values were estimated for each of the criteria with costs and benefits normally being calculated over a 10 year period, but varied where this was appropriate. All the costs and benefits were discounted at 8%. This is lower than the discount rate that would be used for commercial decisions, but is accepted as a suitable rate for public sector evaluation in the area of new technology. A sensitivity analysis was performed for each application and in some cases more than one variation was tested. The results are presented in detain in the project report.

Results

At the outset, two fairly distinct but overlapping markets for ITS were distinguished – "commercial" and "policy related". Commercial markets were those in which supply and purchase of ITS systems was likely to be achieved through normal commercial transactions (such as in the case of personal driver information systems and fleet location and management systems). Of more strategic interest to Governments were the "policy related" markets where the public sector was the major purchaser or there were substantial social benefits that were unlikely to be realised through normal commercial markets.

Table 3 summarises the main findings. The results show strong benefits for many inter-urban applications and for urban traffic control. Dynamic fleet management also appears beneficial. Road user charging schemes that raise revenue but do not affect traffic movements do not generate benefits in a conventional sense. The situation is complex for higher road user charges that are used for demand management purposes. If demand management prices away travellers with the lowest value of time, then those remaining experience shorter journeys and this can result in increased overall benefits. There would appear to be particularly strong benefits from enforcement of speed and from automated speed control. In the area of "Driver assistance" systems, the only significant community benefits appear to come from fully automated (convoy) driving.

The strength of the study was the broadly similar treatment of costs and benefits across all applications with published assumptions. To the authors' knowledge, there have been no challenges to the report's main conclusions. However, as discussed below, illustration of a satisfactory cost-benefit is not a sufficient case for public sector investment.

REVIEW OF RECENT DEVELOPMENTS

In the five years since the strategic cost-benefit study was undertaken there have, of course, been ITS implementations from which lessons can be learnt and developments in technology that may change cost and benefit balances. Over this period there have been profound changes in the policy context within which local and national governments are operating. The effects of these factors are reviewed below.

Technology Developments

The strategic cost-benefit study was based on the generic functional capabilities of technology, rather than detailed specifications, and, at the outset, six technology areas were identified:

- Communication links
- Processors
- In-vehicle data storage devices
- Sensors
- Human Machine interface (HMI)
- Transponders

In each of the technology areas there have been developments in the last five years that would allow previous estimates of costs and benefits to be refined. Largely as expected, the costs of many components have fallen (particularly for sensors, storage devices and positioning systems) and processing power has continued to increase. The recent removal of selective availability on GPS signals has increased performance, and reduced costs where a differential positioning service would previously have been required.

In the area of communications, there is now widespread use of GSM digital cellular telephones in Europe, although this is yet to become commercially available embedded within vehicles. In addition, "Bluetooth" promises to solve many short range communication problems, and developments in future mobile radio systems and the use of internet protocols offer the prospect of mitigating data transfer problems.

In the HMI area, it still seems likely that things will get worse before they get better. Despite initiatives such as the EC Statement of Principles, recommending that manufacturers develop easy to use interfaces, little seems to have changed. In-vehicle products that are rich in features are often seen by manufacturers (and, unfortunately, by many drivers) as providing enhanced value. However, using a product that is the main focus of attention, and using the product as a secondary task while driving require completely different design philosophies. In the future, dynamically re-configurable dashboards, speech input and increased automation may eventually simplify the driver's task.

Integration of applications and the provision of a common telematics infrastructure was recommended in the 1996 cost-benefit study. Growth of the internet and the availability of "Middleware", such as CORBA, have gone some way to realising such an infrastructure. The need for a telematics infrastructure developed for the exclusive use of the transport sector is therefore diminished. Within the EC the KAREN project has been very active in providing frameworks and building blocks for architecture. There have also been significant developments in the architecture for urban applications of ITS in the UK with the Urban Traffic Management and Control (UTMC) project and related standardisation work.

Overall, it is not anticipated that any of the applications previously identified as cost-beneficial would be de-selected following a review of recent technological developments. Rather, it is possible that net benefits may be enhanced and additional applications would become beneficial. Of course, since the original analysis was not specifically dependent on technologies, major changes would not be expected unless there had been really significant new scientific developments.

Experience of ITS implementations

Data to complete a strategic cost-benefit assessment is ideally obtained from experience of actual implementation. Such real data would include cost of implementation and maintenance and measures of the actual benefits achieved (when behavioural and other real-world factors are taken into account). However, particularly when an ITS system is new, such data is not available and has to be estimated from available evidence using expert judgement.

As ITS functions move into implementation, previous estimates of costs and benefits can be refined *as long as comprehensive assessment data is available*. It is often the case, however, that political, institutional, financial and timescale issues mean that assessments, if carried out at all, are lacking in detail. The costs of comprehensive assessment are significant and tend to provide data for future projects rather than being of benefit to projects that are already committed. The trend towards more integrated transport and the synergies between public policies are likely to make it even more difficult to isolate the impacts of any particular application.

The EC sponsored CONVERGE project provided an overview of evaluation work carried out by projects within the Transport sector of the Fourth Framework Programme (Maltby et al, 2000). It was concluded that cost-benefit assessment requires a rigorous approach on the part of those carrying out the assessment and a strong commitment from all those involved in planning implementing, operating and evaluating schemes. Results from the project generally show that most ITS applications that were demonstrated produced positive benefits, although a full economic assessment of monetary costs and benefits was carried out in only about a third of cases.

The companion paper to this (Brown, Miles & Stevens, 2000) contains a selection of ITS implementation projects in the UK and European programmes for which assessment results can be reported.

Policy developments

In contrast to the relatively predictable progress in technology, the strategic cost-benefit study was released at a time of significant political change. A new UK government and, more importantly, increased emphasis on sustainability and environmental issues, led to profound changes and developments in policy and the institutional context, particularly for urban and inter-urban applications of ITS.

a) Central Government

Transport policy

In parallel with publication of the cost-benefit study, the UK Department of Transport undertook a consultation exercise to examine future ITS policy (DoT, 1996). Comments were incorporated within Government thinking and ITS was accepted as one of the tools available to promote sustainable and integrated transport.

The subsequent White Paper on Transport by the newly formed Department of Environment, Transport and the Regions (DETR, 1998), recognised that to tackle the problems associated with growth in the use of the car, alternatives should be encouraged, thereby increasing personal choice and securing mobility that is sustainable in the long term. Although safety was still of paramount importance there was a change in emphasis from "Maximise capacity to minimise congestion" to "Manage demand and manage the environment", with the emphasis on promoting integration, achieving a shift from personal to public transport, and improving choice for users. Current ideas about innovation in transport – many of which are related to the goal of sustainable mobility – reflect general agreement that road building is not the solution to contemporary transport problems and many of the predicted innovations in transport over the next 20 years involve ITS.

In this context there is a search for ways to de-couple the growth in the demand for transport from growth in the economy. Consequently the emphasis of UK transport policies has shifted away from "predict and provide" towards goals of mobility management and making best use of the existing infrastructure. ITS has the potential to make a very significant contribution here, for example through demand management measures or by allowing road users to make more informed choices about their journeys at the planning stage and in real time.

The role of government

Many commentators argue that government has an allocative role, the purpose of which is to maximise the common interest of all members of the population being governed. Since transport greatly affects the quality of people's lives there is a general expectation that governments need to intervene. Further questions arise, however, regarding the nature of that intervention. From an economic perspective, government intervention may distort the market and create unforeseen inefficiencies. If efficient and inefficient markets can be identified, governments should then intervene only where the market is not working. Some government intervention, particularly if involving additional administrative procedures, may themselves create additional barriers to innovation.

Rather than seeing government as an external force, deploying financial levers and instruments in order to realise goals and overcome barriers, government can also be viewed as just one amongst a series of strategic actors creating systems and infrastructures and so influencing transport practices. Equally, other key players may influence the position of government. From this perspective, government's capacity for action depends not only upon the strength of public finances and the power of government to influence or call upon private investment. Policies and instruments have to be positioned within a network of existing interests and interact with the surrounding social and commercial context. Rather than imposing measures, the challenge for government may be better represented as one of identifying points of potential influence and of promoting and facilitating the actions of others.

b) Inter-urban

Management of the inter-urban motorway and trunk road network in England has been re-organised with responsibility vested in the Highways Agency (HA) by DETR. Further developments are expected as the Highways Agency subcontracts day to day strategic traffic management of the inter-urban network to a commercial consortium through the Traffic Control Centre project (Nicholson, 2000). This will include a substantial investment in the infrastructure for traffic monitoring and in electronic message signs to provide advice to the road users.

Another recent developments by the HA has been the "Travel Information Highway" (Yearworth et al, 2000) which provides an open architecture for the exchange of traffic and travel information between the different road management authorities and Value Added Providers. The availability of the TIH is likely to stimulate and increase the viability of a number of traveller related ITS functions in the inter-urban context.

c) Urban and Local

DETR has been promoting the use of ITS in urban areas by supporting projects such as "City Pioneers" (City Pioneers consortium, 1988). This was an EC supported project (funded from the Trans-European Network-Transport budget line) that developed guidelines and examples to highlight the most important deployment issues that may arise when introducing ITS. Figure 1 shows that assessment of costs, benefits and impacts was but one of 10 principal deployment issues.

Local Authorities in the UK now have responsibility, through their Local Transport Plans, for long term planning of transportation issues including the use of ITS by road network managers. Reflecting national policy changes, there is now increased emphasis at local level on sustainability and a multi-modal approach to transport. Guidance has been provided (DETR, 2000) and the "New Approach to Appraisal" of multi-modal schemes explicitly introduces qualitative factors in addition to more quantitative cost benefit considerations. Including qualitative factors represents the most significant change introduced by the new approach; for example there is not yet an agreed method for quantifying environmental factors but they are now to be included, but treated in a qualitative way. Table 4 shows the range of quantitative and qualitative factors now required to be considered including:

- Distribution and equity
- Environmental factors
- Affordability and financial sustainability
- Practicality and public acceptability

Arguably one of the greatest policy levers that the government now has is the application of this new appraisal process in transport decision making.

d) The specific issue of road user charging

Road user charging provides a specific example illustrating the impact of policy changes on ITS cost benefit calculations. On the assumption of widespread inter-urban charging, the deployment of a beacon-based architecture was hypothesised and that deployment also had synergies with other ITS systems, particularly if some of the communications infrastructure could be shared. However, Government policy is now concentrating on the provision of charging powers for Local Authorities. The geographical scale, timescale (and possibly the appropriate technology) are now such that the assumptions upon which previous cost-benefit estimates were made are seriously questionable. The impact of this fundamental change may also have implications for the viability of other inter-urban and urban ITS applications.

ITS DEPLOYMENT

The application of new technology to transport is an ongoing process and "ITS" is just the latest label or acronym. However, it is interesting to review the extent to which progress has been made at a strategic level in identifying and promoting those applications that appeared to offer the greatest benefit to society in previous analyses.

In the 1996 study, Driver Information and Fleet management was considered as "commercial" market applications that are steadily growing. They have been stimulated, particularly by the availability of good digital maps and by the falling cost of communications. Government still has an interest in further stimulating the availability of multi-modal transport information and in ensuring that the Traffic Message Channel (TMC) reaches its full potential after an on-going process (Burton et al, 1998).

Deployment of inter-urban applications in England is now largely the responsibility of the Highways Agency (and their commercial contractors). Scotland and Wales are developing their own arrangements in parallel. The Travel Information Highway may develop as a very useful conduit for a number of commercial services. Incident control is being undertaken through wider investment in traffic management systems such as speed controlled motorways and motorway incident detection systems, but there has not been widespread development of ramp control that was estimated to have a good benefit to cost ratio.

In urban areas, central government has provided advice and leadership (through projects such as City Pioneers) and has exercised policy levers by issuing detailed guidance on Local Transport Plans through the process of approving them. All of the urban applications with significant benefits appear to be being implemented with the speed of deployment depending on financial affordability.

Speed detection was highlighted as a particularly beneficial application within the Enforcement area because of the proven potential for accident savings. This has received increasing attention and is a major policy issue. Technology developments (e.g. digital cameras) are available but there are still institutional issues (e.g. evidential requirement, public acceptability) that need to be addressed before more widespread deployment of speed detection systems.

In the area of Automatic Vehicle Applications, only automated external speed control and integrated automated driving ("road-train" or convoys) were identified as being of strategic interest. Speed control from outside the vehicle is now being researched in the UK by DETR and by the Highways Agency, although no specific policies have been formulated other than an extension to mandatory variable speed limits on motorways. This is a significant and increasing area for debate and development of policy, but one that is likely to require a significant timescale; there are major legal and institutional issues that need to be resolved.

No dedicated national infrastructure has been deployed for inter-urban road user charging that could act as a catalyst for other ITS applications. However, the development of real-time travel information services and wider developments in mobile communications and internet access will provide potential alternative platforms for ITS deployment.

One might ask why all the apparently beneficial applications have not been implemented: The explanation is not that the costs and benefits have been wrongly estimated, but that cost-benefit assessment is not the only issue. Recent guidelines for the evaluation of ITS projects in Finland (MOTC, 1999), and depicted in Figure 2, use additional stages of filtering following economic feasibility. Here, issues such as compatibility with policy objectives, acceptability, technical and financial risk and legal and institutional issues are highlighted. Similarly, in the new UK Local Authority appraisal framework such issues need to be explicitly considered before applying for public funds. At a European level, City Pioneers (figure 1) identified 10 deployment issues, with cost-benefit assessment being just one. Current European work on strategic analysis of driver assistance systems (ADVISORS, 1999) is considering both cost-benefit assessment and deployment issues in parallel.

Overall, it can be concluded that the 1996 strategic costs and benefits study is still relevant but needs to be reviewed following recent changes in the policy context as well as updated in the light of experience with developments in technology and ITS deployment. The scope of the study was restricted to costs and benefits but a strategic assessment of ITS applications, however, needs an approach that is broader such that costs and benefits are considered in parallel with the key deployment issues.

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Table 1 - Evaluation Categories (Based on EVA, 1991)

Categories-> Features	OPERATIONAL ANALYSIS	SOCIO-ECONOMIC EVALUATION	STRATEGY ASSESSMENT
Kind of evaluation	Technical assessment of operational effectiveness	Economic evaluation of social impacts	Long-term strategic assessment on a political level
Purpose	Determination of technically superior solution	Indication of social worth	Estimation of fundamental potentials and long-term risks
Alternatives to be evaluated	Individual, technical options	Concrete, public investment projects	Entire technologies
Perspectives	Control and optimise a technical solution	Optimal allocation of scarce resources	Provision of the basis for comprehensive progress
Result	Statements on technique specific operational performance	Identification of concrete social gains and losses	Appraisal of far-reaching consequences

Table 2. TRL Methodology (based on ERTICO guidelines; Zhang and Kompfner,1993)

DEFINE ASSESSMENT OBJECTIVES
- Intended effects of ITS
- Efficiency, safety, environment
- Timescale

DESCRIBE SYSTEM CHARACTERISTICS
- Technology components
- Performance
- Market penetration

DEFINE ASSUMPTIONS CONCERNING
THE POLICY AND TECHNOLOGICAL CONTEXT

IDENTIFY IMPACTS
- Expected in principle
- To be included in the assessment

SELECT APPROPRIATE INDICATORS
- e.g. travel time, injury accidents

ESTIMATE EFFECTS ON INDICATORS
- e.g. hours of travel time saved, number of accidents

APPLY "STANDARD" VALUES
- e.g. £79,560 per serious injury (COBA, 1994)

ANALYSIS AND RESULTS

Table 3. CBA Summary Table (adapted from Perrett and Stevens 1996)

Inter-urban applications	
Significant benefit (Benefit >1.5 x costs)	Ramp control Incident Control
Costs outweigh benefit	Area control Speed control Lane control Electronic tolling Demand management
Urban applications	
Significant benefits	Intersection control Area traffic control Incident detection Parking management
Costs outweigh benefit	Urban demand management Priority for emergency and public service vehicles
Monitoring and enforcement applications	
Significant benefits	Speeding detection
Net benefit	Weigh in motion
No analysis	Traffic monitoring Vehicle classification
Driver information, navigation & guidance	
Average user benefits less than expected cost	Driver information Navigation aids Autonomous route guidance Dynamic route guidance
Freight and fleet management	
Average user benefits greater than expected cost	Dynamic fleet management
No analysis	Vehicle location
Automatic vehicle applications	
Net benefit	Automated speed control Integrated automatic driving
Costs outweigh benefits	Adaptive cruise control Anti-collision systems Driver and vehicle monitoring Lane keeping Freight-only motorway

Table 4. Appraisal Summary Table (based on DETR Guidance on the Methodology for Multi-Modal Studies,2000)

OBJECTIVE	**Sub-Objective**	**Assessment**
Environment	Noise	Net properties win/lose
	Local Air quality	Concentrations weighted for exposure
	Greenhouse gases	Tonnes of CO_2
	Landscape	Score*
	Townscape	Score
	Heritage of historic resources	Score
	Biodiversity	Score
	Water environment	Score
	Physical fitness	Score
	Journey ambience	Score
Safety	Accidents	Present value of benefits £m
	Security	Score
Economy	Transport economic efficiency (Cost-benefit)	Net present value £m
	Reliability	Score
	Wider economic impacts	Score
Accessibility	Value of more transport choice	Present value of benefits £m
	Severance	Score
	Access to the transport system	Score
Integration	Transport interchange	Score
	Land-use policy	Score
	Other Government policies	Score
Supporting Analyses	Distribution and equity Affordability and financial sustainability Practicality and public acceptability	

* Scores are generally on a seven point scale: slight, moderate or large beneficial/adverse or neutral

Figure 1. Deployment of ITS (based on City Pioneers ITS planning handbook, 1998)

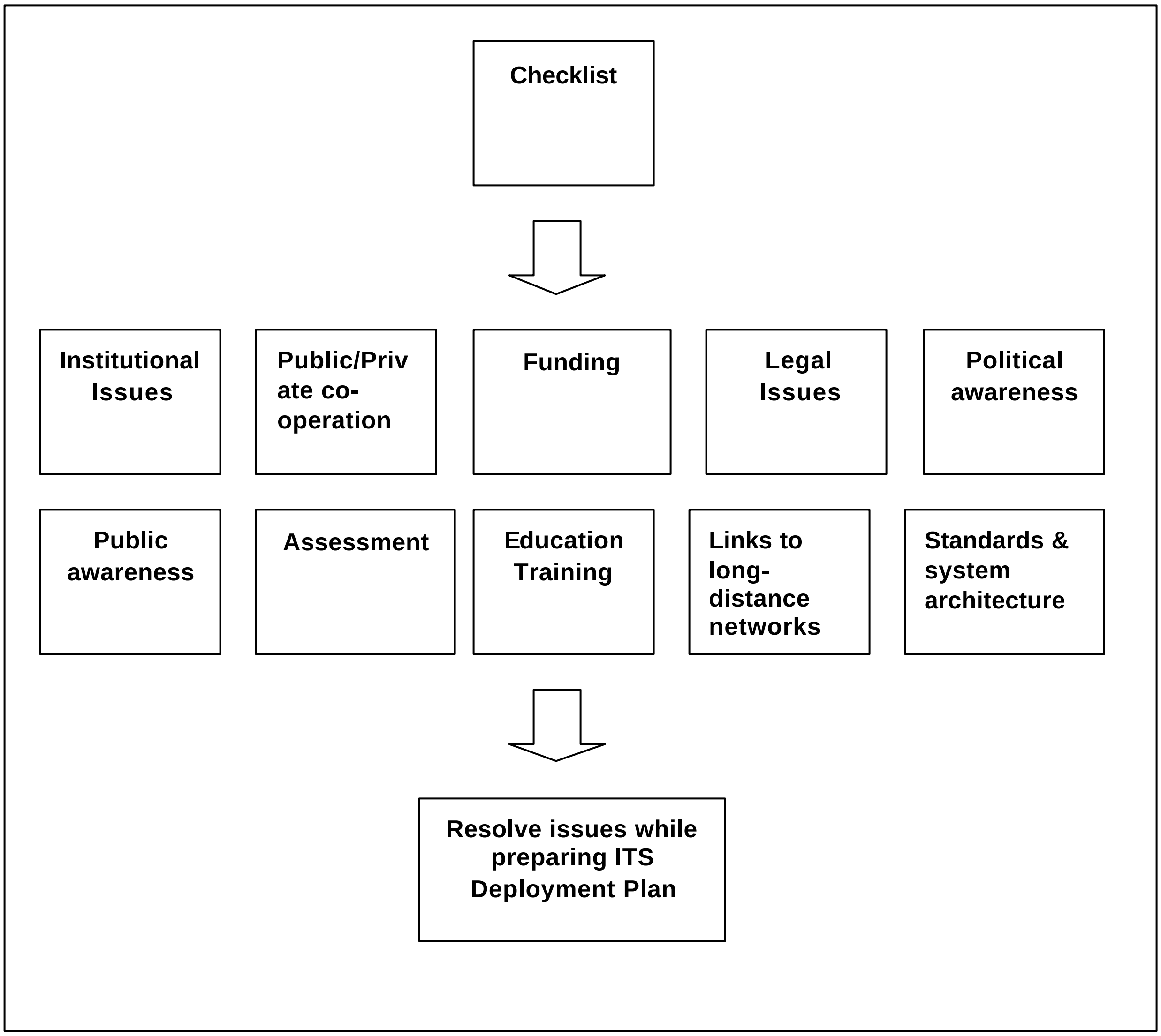

Figure 2 Evaluation Framework for ITS Projects (Adapted from Finnish Guidelines MOTC, 1999)