Building Value in ITS Services

Pekka Leviäkangas
Chief Research Scientist
pekka.leviakangas@vtt.fi

ITS services need to be developed and there is potential for new business opportunities and investors, but the value of information must be assessed properly. This paper presents a framework of attributes that contribute to information value; the list is derived from the literature on information value and valuation. The attributes are discussed from the viewpoint of stakeholders in the service supply chain. A value asymmetry proposition is formulated and strategies to mitigate the asymmetry problem are discussed, giving three basic strategies to tackle the problem.

Keywords: Value, Services, ITS

1. Introduction

ITS services are multiple and range across modes and users. The service repertoire today is impressive. For example, Karvonen et al. [1], focusing on European services alone and primarily on the most typical ones and road transport, are nonetheless able to identify dozens. Many other studies list various services and cases of use, such as those by Li et al. [2], Ng et al. [3], Toledo and Beinhaker [4] among others. ITS services do not function without information, which is actually the core “produce” delivered to users. This produce is used to enhance safety, increase efficiency of operations and productivity of the transport system as a whole. In other words, information will generate added value, the magnitude of which will then depend on who values the information and what is the magnitude and volume of impact. Leviäkangas [5] lists two relevant angles: 1) the value of information to the decision maker, 2) value realised through the impact.

The decision making value, which can also be regarded as the normative value can according to Ahituv [6] be regarded as the perceived value that reflects the expectations of the second angle, the realistic value. Perceived and normative values are hence always speculative in nature, while the realistic value is empirical and observable.

![Figure 1. Perceived and realistic value [6]](image)

The outcomes, i.e. the impacts, of information on the decisions and actions of users are mostly uncertain or at least stochastic: the impacts so not always manifest in exactly the same ways, and different users react differently even in identical situations with the same information. Leviäkangas and Hautala [7] list five types of impact assessment models: analytical, validated empirical, unvalidated empirical, logical-descriptive and heuristic. Analytical models are the strictest type of impact models requiring only known input variables. At the other end, heuristic models appeal to common sense and reasoning. (In fact, as we assess the impacts of ITS, we probably have very few impact assessment models that meet the criteria of analytical models.)

As we approach the question of value of information, we must do battle on several fronts. First we enter the science and theories of information economics; fundamental material is available e.g. in the reports by Lawrence [8] and Mudge [9]. Next we also must utilise the tools of value engineering [10], which help to increase the value and quality of products and services. Finally, we must base the valuation process and methods on the principles of modern micro-economics. As always with applied fields of science, we need to operate at the intersection of several disciplines.

Value is not a one-lump concept, however. It consists of several attributes that partly overlap and probably also in some cases leave some gaps to be filled by more refined attributes. Herrala et al. [27] created such an attribute list with ITS in particular in mind. The list was constructed on the basis of several prior studies and research, which were integrated into a rather exhaustive list of value attributes. Prior research included that by Ahituv et al. [11], Ahituv [6], Anderson et al. [12], Bates et al. [13], Brownstone and Small [14], Cykana et al. [15], Feltham et al. [16], Freiden et al. [17], Hilton [18], O’Reilly [19], Strong et al. [20], and Wand and Wang [21].

Then there is the question of actually putting the price tag on the value, i.e. how to monetise the utility perceived or realised value in each particular valuation case. We could also speak about pricing of impacts, as
done by Leviäkangas [5]. Typically we face the pricing problem when performing cost-benefit analysis where each benefit and cost item must be priced in order to reach the single key figure, the benefit-cost ratio. Based on previous works [e.g. [22], [23] and [24]], Leviäkangas [5] finds at least five methods of quantitative pricing and two methods of qualitative or relative pricing:

1. Historical cost (quantitative, based on recorded prices or costs; example: past procurement cost of a produce)
2. Cost of damage (quantitative, based on avoided damage or repurchase costs; example: avoided accident or time costs, avoided material damage)
3. Market prices (quantitative, based on market information and the balance of supply and demand; examples: mobile phones from the shelf)
4. Shadow pricing (quantitative, based on pricing which differs from the market prices because of market inefficiencies and asymmetric information; examples: accident costs, environmental costs)
5. Willingness-to-pay (quantitative, based on stated willingness to pay for produce or avoid damages or undesirable outcomes; examples: interviewees’ stated willingness to pay for information that is not yet there to be offered)
6. Analytical hierarchy process (relative, based on preferences that some objects or outcomes are more desirable than others and on the ranking of these; example: ITS investment is more preferable than road infrastructure improvement because it is cheaper)
7. Multicriteria analysis (qualitative, based on integration and synthesis of non-comparable or non-uniform objects or outcomes; example: calculating a goodness index for comparing different IT systems).

All these can be, and have been, applied to ITS investments and ITS services. For example, Leviäkangas and Lähesmaa [25] used an analytical hierarchy process when assessing the profitability of ITS investments. Shadow pricing is used widely across public sector investments when performing cost-benefit analysis of transport investments, including ITS.

In this paper the value of information is discussed and the concept of value is disaggregated into value attributes, summarising some of the preceding studies and research on the subject. Then the valuation methods and techniques are briefly listed and discussed: we should be able to distinguish between applicable methods along the value chain and phases of the decision making. The value attributes are spread across the service supply chain and a simple mapping system is demonstrated. With the aid of this, practitioners and researchers should be able to build and analyse service supply chains more analytically. This is one of the contributions of this paper. Another contribution is the introduction of the value asymmetry proposition, which is claimed to cause many of the problems and challenges faced when building up ITS services. Thirdly, the strategies for overcoming the value asymmetry problem are drawn from a standard corporate strategy framework.

Practitioners can exploit the results in the value build-up of novel or re-engineered service delivery processes. Thus the results of this paper should also be of help in the design of commercially and socially sustainable business models. Previous research results (in particular [5], [7], [26] and [27]) are synthesised and further developed in this paper.

2. Attributes of information value

Based on an extensive review of prior research [26], a list can be drawn of the value attributes of information. The attributes are not independent, but very much associated with each other and there are conceptual and semantic challenges in treating them separately. However, the dependence does not diminish their usability, since applications and use cases are obviously so numerous. It goes without saying that attribute dependencies are very contingent and may vary significantly between contexts. These attributes are presented in Figure 2 and discussed below.

![Figure 2. Information value attributes](image-url)

**Cost** of information is an unambiguous attribute in the sense that it is always expressed in monetary terms. Cost in itself may, however, be determined using different pricing techniques as discussed earlier. Hence, only the unit of cost is unambiguous, but the amount may vary depending on the pricing principle. Cost is associated with effectiveness, especially in the case where the cost of the output is measured. **Effectiveness** describes the change of behaviour or output when information is provided and this change might result in additional costs or decrease them. Cost effectiveness describes how much change can be achieved with the cost of input or output. Information that costs more than the perceived value will not be purchased.
Timeliness indicates how up to date information is, and how well it meets the demand for information in a particular time and space. Information given too late becomes worthless, or even harmful, and the same applies to information received too late. Timeliness is one aspect of relevance, though not the only one. Information that is not rightly timed is hardly relevant either. Relevance has also other dimensions, and is very much related to contents and completeness. If the content is not right or information is incomplete, it cannot be regarded as very relevant. The form must also be right for the information to be understandable and effective.

Objectivity might in some cases be crucial, especially when the information has impacts on third parties. For example, recommending the use of alternative transport modes must be based on objective information so as not to interfere with market efficiency. Objectivity is also loosely associated with reliability, since subjective information could not really be accepted as reliable. Reliability of information in turn has links to accuracy and consistency. Accuracy means that there is little deviation between the information and reality that it is supposed to reflect. Consistent information is logical and coherent and also reflects the real world situation.

Validity means that information is what it is supposed to be, and nothing else. Validity is described as an independent value attribute, but one might be tempted to associate it with relevance, for example. The other independent attribute is uniqueness. Unique information will certainly have a competitive advantage over information that is offered from multiple sources as substitutes. It is most likely that information that has a good reputation is more valuable that equally "good" information that for some reason or the other has a poorer image. Certainly reputation is built on attributes such as reliability and accuracy, at least.

Last, but definitely not least, we have accessibility to and availability of information, which are in fact rather similar attributes. Easily accessible and available information has greater value especially from the user point of view.

These attributes can be summed, multiplied, indexed, ranked, etc. in order to capture the value of information – or actually service, to be more concrete. The application possibilities are innumerable and attributes can easily be combined or divided into sub-components as needed. The literature that is behind the list covers such a range that the attribute list can be regarded as fairly extensive, but never exhaustive. The attributes’ relative importance varies with time, place and context.

3. ITS service supply chain: accounting for risky and uncertain values

The service supply chain consists of multiple stakeholders from data providers to service suppliers and system vendors, and of course the end-users. Figure 3 illustrates the generic information service supply chain. First, there needs to be a physical observation network that is usually hosted by public entities. Then, the data must be provided, content for the service must be created and packaged, information must be transmitted and routed, and finally the service must be disseminated via different information channels to end users. System and device suppliers are needed to facilitate the dissemination. Even with this simplified figure, the complexity of the service supply chain is easily observed. There are significant transaction costs related to such a service chain and each stakeholder values differently the information that flows through the chain.

Society of course includes all the stakeholders. Society’s interest lies in the simple fact that if all the stakeholders in the chain benefit from the service supply, the society will benefit too, unless the service results in negative effects elsewhere. In the relatively novel field of ITS this re-distribution of wealth seldom occurs, and we can state with reasonable certainty that in most cases of new ITS services the added value for society is real and with few, if any, stakeholders who will be worse off.

Society’s valuation comes mainly from the socio-economic cost-benefit analysis that includes externalities. In short, if the information service cuts travel times, reduces accidents, reduces emissions and puts travellers and transport sector operators better off one way or the other, the service is profitable for the society. To price externalities, the society, represented typically by some central authority such as road administration, adopts shadow pricing. To determine the impacts of the information service, the society must choose from the impact assessment models that are available. Unfortunately, here is where the first difficulty often lies, as such available models are usually logical-descriptive or heuristic and might not convince the public decision maker. Perceived value is recognised, but realistic value too uncertain.
The society’s valuation formula is in its simplest form as follows:

+ benefits of users
+ benefits of service suppliers less the payments from users
+ benefits of externals
- public and private net investments
- public and private net operating costs
- public (and private) subsidies

\[ \text{Net benefits for the society} = \text{Benefits} - \text{Costs} \]

Prepare for cautious revenue projection and high costs in addition to risk premiums on required returns (i.e. discount rates). Then there will possibly, or even likely, be double risk accounting. When this practice is repeated by every actor in the service chain, the future of the service might start to look bleak. When this prospect is combined with natural managerial risk aversion and with the efforts related to contractual and legal arrangement, we can well understand why the ITS market has so far been perhaps more passive than we expected. The situation is illustrated in Figure 4.

4. Value attributes in the service supply chain – the value asymmetry proposition

Stakeholders along the service supply chain will look into all attributes depending on their business case, but perhaps the emphasis could be on cost, uniqueness, availability and accessibility. If these are required and yet they fail the test, it is hard to see that the stakeholders would be willing to put effort into building up the service. All other attributes must also pass the test, certainly, but some attributes might be improved more easily, e.g. by technical means.

The end-users will be the ones who mostly look at all the attributes too, but their attribute preferences are surely more balanced. This does not make the situation any easier for the service supply chain, since now all the attributes must pass critical thresholds. Failing in accessibility, reliability, relevance, form, etc. can all be lethal in the end-user marketplace. This means that all the actors in the chain must first be ensured that the attributes are there at an acceptable level for the end users, since otherwise being along in the chain cannot be sustainable for long – if there is no business, there is little reason to build up the chain.

The above discussion is summarised in Table 1. It somewhat simplifies the real world situation, but is done to emphasise the relevant issues and value building.

---

**Figure 3. Service supply chain; revised** [28]

The increased tax revenues have been consciously disregarded, since their net impact is zero – somebody in the society always pays the taxes due! In a fiscal sense, the society might also want to check the tax revenue potential. Obviously when new business is created, the society benefits also in the fiscal sense. In the decision making situation (to invest or not to invest), the society will have to rely on perceived value and realisation of value will be witnessed only later. The value attributes that are of particular interest to the society are costs and effectiveness. All other attributes are only intermediates from the society’s perspective. If the effectiveness is regarded as sufficient, meaning lower emissions, time savings, more comfort, less accidents, etc., the service must be “good”, provided that it does not cost too much in the form of investments, operating costs and/or subsidies.

Companies, both as users and along the supply chain, will value the information services on a cash basis. When investments are made, perceived value dominates and the actual cash flow generated by the investment will result in a realistic value. The companies in the supply chain must rely first on estimates of willingness-to-pay, knowledge on today’s market values and past historical costs. The estimate on willingness-to-pay dominates, however, since each stakeholder will look upstream along the value chain and has to assess how much the information is worth to them – this will result in revenue projection. The cost side is then based on historical or today’s market information, likely a combination of both. In both cases, the situation is most uncertain and will lead to risk premiums that could be rather high. It is likely, that companies would rather
aspects for different stakeholders. Table 1 follows the role division set in Figure 3. Each and every case of ITS service needs to make its own assessment, depending on the situation and context, but even with a quick subjective exercise it is easy to identify the end-user’s critical role at the extreme downstream, as well as the critical attributes in the upstream parts of the supply chain. The table might explain partly why public-driven information services are so slow to take off, since in many cases information providers could be public, e.g. providing traffic data. The information perhaps simply was not available and accessible.

Table 1. Service supply chain stakeholders and value attributes; author’s subjective assessment on the relative importance to actors across the chain (0 = less important, x = important, xx = very important, xxx = critical, I = intermediate role)

<table>
<thead>
<tr>
<th>Value attribute</th>
<th>upstream</th>
<th>&lt;= Actor =&gt; downstream</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accessibility</td>
<td>xxx</td>
<td>xxx xxx x x I xxx xxx</td>
</tr>
<tr>
<td>Accuracy</td>
<td>xx</td>
<td>xx x x x I x x</td>
</tr>
<tr>
<td>Availability</td>
<td>xxx</td>
<td>xxx x x I xxx xxx</td>
</tr>
<tr>
<td>Completeness</td>
<td>xxx</td>
<td>xx x 0 I xx x</td>
</tr>
<tr>
<td>Contents</td>
<td>x</td>
<td>xxx x 0 I xx xx</td>
</tr>
<tr>
<td>Consistency</td>
<td>xxx</td>
<td>xx x 0 I x x</td>
</tr>
<tr>
<td>Cost</td>
<td>x</td>
<td>xx xx xx xx I 0 xxx</td>
</tr>
<tr>
<td>Effectiveness</td>
<td>x</td>
<td>x 0 0 I 0 x</td>
</tr>
<tr>
<td>Form</td>
<td>x</td>
<td>x x xx I x xx</td>
</tr>
<tr>
<td>Objectivity</td>
<td>x</td>
<td>xx 0 0 I 0 x</td>
</tr>
<tr>
<td>Relevance</td>
<td>x</td>
<td>xxx x xx I x xx</td>
</tr>
<tr>
<td>Reliability</td>
<td>xx</td>
<td>xx x xx I x xx</td>
</tr>
<tr>
<td>Reputation</td>
<td>0</td>
<td>0 xx xx xx I x xx</td>
</tr>
<tr>
<td>Timeliness</td>
<td>x</td>
<td>0 xx x I xx xxx</td>
</tr>
<tr>
<td>Uniqueness</td>
<td>x</td>
<td>xx xx xx I xx x</td>
</tr>
<tr>
<td>Validity</td>
<td>xx</td>
<td>xx xx xx xx I x x</td>
</tr>
<tr>
<td>‘Sum’ of relative importance</td>
<td>26x</td>
<td>30x 19x 18x Intermediating role 21x 29x</td>
</tr>
</tbody>
</table>

Needless to point out, none of the attributes are incapable of failing the test, even if their relative importance is not the highest. If one attribute does not have the characteristics it is supposed to, the supply chain collapses or does not justify build-up. What could also be deduced from the mapping exercise is the criticality of both ends of the supply chain, not really the players in between. This is in fact self-evident: if there is a genuine user need downstream and the data is made available and accessible upstream, the intermediate actors will start looking for business opportunities. If this conclusion is correct, one might be tempted to draw some policy conclusions as well: make the data available and accessible; the rest will take care of itself! This is of course a crude generalisation but might be worth consideration as a policy measure if we want to boost ITS services and industry.

In addition to information asymmetry (which leads to inefficient market and market disturbances) we can speak about value asymmetry, since all network stakeholders have differing valuation logic. The author proposes that the value asymmetry is at least as important a challenge when building ITS services as any of the usual suspects: technical, organisational, regulatory and institutional issues. As far as the author knows, the ITS research community has so far placed little, if any, weight on the value asymmetry problem in the economics of ITS. This is to say placed weight explicitly, however – implicitly, the problem has always been there and has been recognised.

5. How should we tackle value asymmetry?

To tackle the value asymmetry problem, the management of different functions of the service supply chain must work together in order to achieve the total value at the end that meets the end-users’ needs. Horizontal integration strategy and strong quality management of the whole service process is hence the first obvious answer — integrating the service supply chain under the same strategic management will undoubtedly mitigate the value asymmetry problem.
Different functions of the service supply chain have their own management incentives, which sometimes conflict with each other and even with the end-user value. The risk with horizontal integration is rigid management of the supply chain and lack of efficiency incentives and management accountability along the chain.

Another approach is based on partnerships, alliances and profit sharing between service chain suppliers in a way that motivates all suppliers to work not only for their own but also for the common and shared good of all suppliers. The inevitable risk with this approach is that since it must be based on strong contractual commitments between suppliers, it reduces the suppliers’ room for manoeuvrability and strategic options. Hence, the different premiums set for these risks might increase the costs of the service beyond the accepted level from the end users’ point of view.

The third strategy of tackling asymmetry is the introduction of a service integrator. The service integrator is familiar particularly from logistics and supply chain management, which both have essentially the same paradigms as the service supply chain. Supplying information, service or goods is not that different in many respects. The service integrator builds the service supply chain by finding the suppliers for different functions, parts of the chain, and assuming responsibility for the service to the end users.

The service integrator could be public, private or a PPP-type solution. All roles fit, depending on the context. A public service integrator might be called for where the service supply chain must be built to produce a socio-economically profitable but financially challenging supply chain. Also subsidised service supply chains might require a public service integrator. An example of this is the San Francisco Bay Area 511 service, where the public service integrator mainly contributes the required finance. A private service integrator could be a working solution in situations where the dominant suppliers take the leading role and build the chain. For example, large mobile phone manufacturers might be interested in building service supply chains to increase equipment sales. The recent example of Nokia offering free navigation services is a typical one [29].

The contingent nature of a service integrator makes it perhaps the most lucrative and flexible strategy to operationalise service supply chains and has in fact been widely used. Probably in most countries with relatively advanced ITS, service integrator examples can be found when looking closely at different service supply chains. The first two mentioned examples, horizontal integration and partnership models, are perhaps not that common but clearly in existence. The partnership model is found e.g. in Finland, where the state-owned Destia Ltd and the Finnish Meteorological Institute together with other suppliers deliver a local, pinpointed road weather warning service. Most European railways still manage real time passenger information in a horizontally integrated manner.

Strategies for tackling the asymmetry problem are listed in Table 2. The service integrator strategy fits most situations, whereas other strategies are more restricted and conditional or even unsuitable. The horizontal integration strategy by definition excludes PPPs. Partnerships in turn are the essence of PPP-type services. Partnerships often involve risks and uncertainties in terms of either efficiency (public partnerships can easily be bureaucratic) or sustainability (private partnerships are often unstable as the market environment changes). These risks set conditions for partnership strategy applicability. Service integrators can be used in all cases, with no foreseeable greater risk or uncertainty, as a solution to build up the service supply chain and create value for all suppliers and end-users. It is the service integrator that probably suffers most if the integration fails.

However, it is important to note that the asymmetry problem itself is essentially inherent in all strategies and types of services; in the best-case scenario it can only be reduced to a level that enables a working chain.

<table>
<thead>
<tr>
<th>Type of Service</th>
<th>Asymmetry tackling strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public</td>
<td>PPP</td>
</tr>
<tr>
<td>PPP</td>
<td>Private</td>
</tr>
<tr>
<td>PPP</td>
<td>PPP</td>
</tr>
</tbody>
</table>

6. Discussion and sum-up

Whenever ITS services are delivered, a value chain is needed. In this paper, the concept of service supply chain is introduced as an analogous term to supply chain in general. Each supplier, or stakeholder if that term is preferred, looks at the value of the information differently. The value attributes are listed and briefly discussed. The attributes are many, and each supplier weighs them differently both upstream and downstream of the service supply chain. Therefore, there is a value asymmetry between the suppliers and this asymmetry is claimed to result in many of the difficulties when attempting to build up the service supply chain. Much of the asymmetry problem is dealt with by creating various business models, but the models are usually looked at from the single supplier’s viewpoint, hence not fully resolving the asymmetry problem. Business models that
take the full view of the supply chain can be successful, but then they must be a composite of several subsequent and interoperable business models of the individual suppliers.

The strategies for overcoming the asymmetry problem are traditional, drawn from the standard business strategy options. It is concluded that the service integrator strategy is probably the most versatile to enable the build-up of service supply chains in contingent situations. Both public and private Integrators are possible and found as examples in numerous cases.

This paper would not be complete without an attempt to condense the message. Hence, the value asymmetry proposition is stated as a conclusion. This proposition statement is of course but a draft. The value asymmetry proposition could be stated, for example, something like this:

“In a value chain where information flow is the object of utilisation and processing, the information quality and value is perceived differently by each stakeholder and/or operator in the chain. The same information has a different value and different set of critical value attributes in different parts of the chain - the value and its attributes are contingent as are the methods and techniques to measure the value. The value of information is not by definition necessarily added as information flows downstream towards the end-user.”

The proposition ends with its most critical notification – the value is not necessarily increased as it moves forward in the value chain. It could also be reduced unless the value build-up is carefully nourished.

7. References


Pekka Leviäkangas has worked in multiple positions in transport sector as an expert, executive and researcher. He holds PhD in industrial engineering and management from the University of Oulu. He is an adjunct professor of business analysis in University of Oulu and adjunct professor of transportation in Tampere University of Technology. At present, his current employment as Chief Research Scientist in VTT includes research topics on service engineering, ITS, logistics, PPPs, finance and governance of transportation system entities.