THE IMPACT OF A GLOBAL SATELLITE NAVIGATION SYSTEM – GNSS – ON THE PUBLIC SECTOR

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Short Version

on behalf of the Federal Ministry of Transport, Building and Urban Development
THE IMPACT OF A GLOBAL NAVIGATION SATELLITE SYSTEM -GNSS - ON THE PUBLIC SECTOR

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1. Introduction (Original Pages 7–9)

The satellite navigation system Galileo is currently being developed in Europe. It ensures independence for its users from military controlled systems such as GPS and GLONASS. In addition, it provides an increased accuracy and it is intended to help European enterprises gain a greater share of the world satellite navigation market.

The satellite navigation market has developed very successfully in recent years. However, despite a predicted billion Euro market, the necessary commercial applications and sustainable business concepts are still lacking for the full implementation of Galileo.

Considering this situation, the German Federal Ministry of Transport, Building and Urban Development (BMVBS) has appointed MICUS Management Consulting to examine the present and future use of Global Navigation Satellite Systems (GNSS) in the public sector. The objective of this study is firstly to identify how GNSS applications may create financial savings for public bodies, secondly to calculate the potential public demand, andthirdly to identify possible future developments. Finally, based on these results, the effects of public demand on the satellite navigation market are assessed.

In order to identify local GNSS applications, a survey of several public bodies at local level, federal state level and state level, as well as enterprises in the public sector, was conducted. In the course of a number of workshops at the BMVBS in Bonn, the various possibilities at local, federal state and state level were discussed.

This final report gives an overview of Galileo’s services, and describes selected GNSS applications that are particularly promising and effective. It evaluates the effects of public demand on the satellite navigation market and details the current obstacles and barriers to an intensification of GNSS use. Finally, it provides recommendations that should lead to both an increased use of the new technology by the authorities, and a positive market return.
2. GNSS TECHNOLOGIES (ORIGINAL PAGES 10–12)

- **Global Navigation Satellite Systems**

In 2000 the US Ministry of Defense opened their satellite navigation system Global Positioning System (GPS) for civil use. Since then, GPS has become the standard for civil satellite positioning. The GPS infrastructure consists of about 30 satellites which will be renewed continuously in the near future.

The Russian system GLONASS, which is so far mainly used for military purposes, will be released for civil and commercial use until 2012 and is also expected to rely on 30 satellites.

In contrast to these systems, the European project Galileo is intended to be independent of military-controlled systems. Galileo is expected to bring an increased availability and a higher accuracy of positioning signals, which will improve further after 2014 through compatibility with GPS III, the new generation of American satellites. Galileo is also expected to help European enterprises gain a greater influence on the world market.

- **Galileo Services**

Galileo will have one freely available signal (Open Service), and four extended services which will be provided partly for a fee. These services are adjusted to the requirements of the different user groups. They are the basis for numerous professional applications of satellite-based positioning and navigation with Galileo. For some services (Safety of Life), a guaranteed availability of and legal liability for the positioning information, as well as information about the integrity of the signal, will be provided.

<table>
<thead>
<tr>
<th>Frequency(ies)</th>
<th>Open Service</th>
<th>Commercial Service</th>
<th>Safety of Life Service</th>
<th>Public Regulated Service</th>
<th>Search and Rescue Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integrity</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Availability</td>
<td>worldwide</td>
<td>worldwide</td>
<td>worldwide</td>
<td>worldwide</td>
<td>-</td>
</tr>
<tr>
<td>Coverage</td>
<td>99%-99.9%</td>
<td>99%-99.9%</td>
<td>99%-99.9%</td>
<td>99%-99.9%</td>
<td>99%-99.9%</td>
</tr>
<tr>
<td>Accuracy</td>
<td>H: 15m</td>
<td>H: 4m</td>
<td>H: 4m</td>
<td>H: 15m</td>
<td>H: 4m</td>
</tr>
<tr>
<td></td>
<td>V: 35m</td>
<td>V: 8m</td>
<td>V: 8m</td>
<td>V: 35m</td>
<td>V: 8m</td>
</tr>
</tbody>
</table>

Figure 1: Overview of GALILEO services
3. GNSS APPLICATIONS (ORIGINAL PAGES 15–47)

- **GNSS application in Winter Services**

More and more winter service vehicles are equipped with GNSS-based on-board units, which allow full computerization of fleet pull-outs. The system records the work performed during the journey. Data concerning the routes driven and the location of the clearance, and the equipment used for and width of the clearance as well as the type and quantity of the grit dispensed, is stored in the on-board computer, updated every second. In addition, the vehicle’s operational state and performance characteristics are recorded. Consequently, the administration for each vehicle is considerably simplified.

The complete logistics is optimized through the routing improvement and the automated analysis of the documentation through target-performance comparisons, as well as through the reduction of the lead time for both operator and driver.

However, acceptance of the new system by employees may be slow, due to the possibility of increased real time control over the performance and actual position of individual workers. This factor may in some cases be a significant obstacle to the introduction of GNSS-based systems for winter services. The startup costs of the system may also be a barrier for small companies: upgrading only becomes profitable for winter services with at least 20 to 30 vehicles.

- **GNSS application in Public Transport**

Public transport increasingly uses computerized operation control systems (ITCS – Intermodal Transport Control System). But transport control systems based on fixed beacons are considerably more maintenance-intensive and not as flexible as those based on GNSS-based ITCS. The use of GNSS-based ITCS optimizes the management of vehicles and staff: Public service operators can trace a vehicle’s position in real time, quickly react to delays in the schedule (accidents, obstacles, technical problems) and keep passengers informed. Furthermore, traffic light management can be prioritized for public transport vehicles, reducing runtimes and overall fleet size.

- **GNSS application in Rescue Services**

Rescue Services use GNSS technologies for the management of rescue equipment in emergencies. Emergency and rescue vehicles are managed by local control centers, which have the information relevant for the most effective choice of rescue equipment. With a GNSS-based fleet management, the precise position of any vehicle can be displayed on a map in real time.

The system identifies the appropriate rescue equipment, then the operator selects the vehicle and provides the driver with all the details required for the emergency drive. Then the navigation system guides the driver via the fastest route to the emergency. However, because of the specific requirements of an emergency drive (no speed limit, exclusive emergency routes and circulation privileges), efficient route optimization is still under development.
The most important criteria to enable the rescue services to utilize a GNSS-based system are stability and availability of the system as well as IT security and accuracy. The transmission and administration of the relevant data create high demands on the safety system (safe transmission channel, backup).

By optimizing the fleet management, the duration of the emergency rides or the hold-back time of the vehicles could be reduced and thus the costs for downtime could be minimized.

**GNSS application in Municipal Surveying**

Municipal surveying is carried out either by (private) land surveying offices, or (public) geo-information offices of the urban administrations, or the associated departments themselves. This study considers the possible use of GNSS systems for the surveying and localization of objects (manholes, urban trees, street furniture, etc.). Here, potential savings can be achieved mainly by the reduction in on-site staff made possible by the system.

The use of GNSS services for civil engineering requires a higher precision and availability of the signal in urban (so prone to being in ‘shadow’) areas than do other applications, even though delays of a few seconds between measurement and reception of information are more acceptable than in, for example, navigation. Regarding the development of Galileo, there is hope that the availability of GNSS signals in shadowed areas will increase. Detailed registration of such objects, however, will presumably only take place in municipalities with more than 100,000 inhabitants.

**GNSS application in Police Services**

It is generally recognized that the current technical achievements allow satellite-based navigation systems to support police services efficiently. However, currently available commercial systems do not provide enough of the functionalities required for, and suited to this kind of application. Thus far, the specific requirements for police operations and additional supporting functions have not been sufficiently taken into account by providers of either hardware or software (cf. Rescue Services, above).

Generally, the basic advantages of the use of GNSS in applications relevant to police and security are both the availability and the security of the signal. In order to increase accuracy, it is also possible for the system to incorporate the latest real-time information about, e.g., traffic jams and traffic flows, or corrective and referencing data.

The potential of a police-specific navigation system is promising. It is anticipated, therefore, that the use of specific GNSS systems and hence the development of a police-specific navigation system will be accelerated.

**GNSS application in German Railways (DB Netz AG)**
In order to locate a railway train, the German Railways currently use fixed transponders. Under certain technical conditions the transponders could prospectively be replaced by more competitive GNSS technologies. The availability and the integrity of the GNSS signal play a key role here.

In combination with other technologies GNSS is also used for surveying tracks and for civil engineering. For the examination of the rail profiles and overhead lines the vertical and horizontal clearances are linked by laser scanners, geo-referencing video measuring systems and a number of sensors. As surveying in this field requires a higher degree of accuracy, normally within centimeters, it is essential to use corrective and referencing data in addition to the satellite signal.

German Railways also use GNSS technologies for the control of spraying trains. In 2009 trains were used for the first time in order to support the spraying of herbicides. Paramount here was the documentation of the spraying, taking protected areas into account.

- **GNSS application in German Air Traffic Control (Deutsche Flugsicherung)**

Aviation uses a range of systems and technologies to support pilot skills. Numerous aircrafts have now been equipped with GPS systems, but because of their limitations these systems can only be used for en-route navigation and landing, without providing vertical guidance. The current GNSS systems alone are unable to meet the demanding requirements of vertical guidance for a landing: Basically, the accuracy and integrity of the signal is lacking here.

In order to increase their integrity and accuracy in Europe, GNSS signals are complemented and improved by EGNOS, which has 34 measuring stations that generate corrective data and transmit the information to the user via satellite. German Air Traffic Control (Deutsche Flugsicherung – DFS), together with six European air navigation service providers, is involved in the development and operation of EGNOS.

Because of the combined use of GNSS with systems that have already been established in aviation, it is the interoperability of the signal that is of key interest to the DFS. In order to enhance GNSS use in aviation, the most important criteria, as in all safety-critical applications, are the availability, the integrity and the safety of the signals. A significant obstacle to the takeup of Galileo by the DFS is the unanswered question concerning the liability of providers and operators of its services.

- **GNSS application in Forest Services**

Thus far, the management of timber transport routes in forests has been very time-consuming: Approximately one third of running time has had to be spent in locating destinations within the forest. Currently, the forestry commissions compile navigable data records in which every forest road that is open for trucks is digitally filed, and then classified according to its practicability. In this way the optimal conditions for wood logistics in the forest are achieved.
Financial savings can be realized by avoiding unnecessary detours, and by reducing the maintenance costs of the forest roads as well as reducing time-consuming briefings of drivers who are not familiar with navigating in a particular forest. It is envisaged that these potential advantages can currently be achieved in approximately 30% of the forests. Further advantages could be achieved in connection with, e.g., harvest management or the Federal Forest Inventory.

The systems which are used on site must be compact and robust. An accuracy within a range of 10m is sufficient. Problems of availability of the signals could occur in woods with a dense canopy.

- **GNSS application in Administrative Surveying**

In Germany, administrative surveying is predominantly carried out by the surveying administrations and by publicly appointed surveyors (Öffentlich bestellte Vermessungsingenieure (ÖbVI)).

As administrative surveying usually requires an accuracy within a range of centimeters, the GNSS signal must be revised by corrective data from reference stations (SAPOS). With Galileo, quality improvements can be expected, particularly in densely populated areas. The use of GNSS-based methods can yield financial savings of approximately 20% for property surveys and 10% for real estate surveys. In addition, the maintenance effort required for position benchmarks could be reduced by 90% and for height benchmarks by 50%. These savings potentials have already largely been realized.

- **GNSS application in Federal Waterways and Shipping Administration**

The Federal Waterways and Shipping Administration (WSV) is responsible for the administration of the federal waterways and the management of shipping traffic. Its supervision ensures that shipping traffic and the use of waterways do not cause damage to people or the environment. The WSV has seven reference stations that send correction data and thus contribute to increasing the accuracy of GNSS measurements.

There is a wide range of operations for the WSV for GNSS applications, e.g. for the surveying of bodies of water or the management of navigation marks. With the introduction of GNSS-based measurements, the outlay on personnel required for surveys could be reduced considerably. Furthermore, maintenance-intensive equipment could be replaced by systems that are less so. The WSV has already shifted workflows comprehensively to GNSS-based systems and has realized financial savings of several million Euros.

Galileo is intended to achieve higher integrity, availability and accuracy as well as faster solutions, especially in areas with no sightline to the sky (shadowed areas). The use of GNSS on waterways is affected by obstacles such as vegetation and buildings, which may interrupt the signal or reduce its accuracy; under bridges and similar structures the connection breaks down completely. Although the use of Galileo might bring some improvement, its practical and technical benefits have yet to be assessed.
The calculation of the market returns achieved by the use of GNSS in public services (see section 4) is based on the benefits and saving potentials of GNSS applications for public bodies, as well as associated investment.
4. Market returns achieved through the introduction of GNSS technologies in the public sector (original pages 48–58)

Analysis shows that a potential of €93.7 m. savings per year could be achieved for the above-mentioned sectors. In order to realize these savings, an investment of approx. €590 m. is necessary.

The potential benefits of GNSS applications to police/fire and rescue services must be considered as qualitative and cannot be valued in merely monetary terms. For the Federal Waterways and Shipping Administration, German Air Traffic Control and the railways, the necessary investments were evaluated as a percentage of the total investment of GNSS deployment in public services. In each of these three cases, the necessary investment was set at 5% of the total required in public services. For police/fire services, we assumed that 50% of all rescue vehicles would be equipped with GNSS systems.

<table>
<thead>
<tr>
<th>Transportation/Logistics</th>
<th>Potential savings per year</th>
<th>Public Procurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter Services</td>
<td>24,977,000.00 €</td>
<td>105,105,000.00 €</td>
</tr>
<tr>
<td>Equipment of local winter services</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equipment of operation centres</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Public Transport</td>
<td>24,626,385.30 €</td>
<td>245,803,546.69 €</td>
</tr>
<tr>
<td>Police/Fire Services¹</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rescue Services</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waterways and Shipping Administration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air Traffic Control²</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Railways²</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Transportation/Logistics (100% implementation)</td>
<td>49,603,385.30 €</td>
<td>534,750,743.70 €</td>
</tr>
<tr>
<td>Total Transportation/Logistics (50% implementation)</td>
<td>24,801,692.65 €</td>
<td>267,375,371.85 €</td>
</tr>
</tbody>
</table>

| Surveying/LBS                                    |                            |                        |
| Municipal Surveying                              | 742,300.00 €               | 24,404,000.00 €        |
| Forest Services                                  | 19,853,000.00 €            | 4,410,000.00 €         |
| Sovereign Surveying                              | 23,506,000.00 €            | 26,988,000.00 €        |
| Acquisition of equipment, administration         |                            | 10,188,000.00 €         |
| Acquisition of equipment publicly appointed surveyors (ObVI) | 16,800,000.00 €          |
| Total Surveying/LBS (100% implementation)        | 44,101,300.00 €            | 55,802,000.00 €        |
| Total Surveying/LBS (95% implementation)         | 41,896,235.00 €            | 53,011,900.00 €        |

Total 93,704,685.30 € 590,552,743.70 €

¹ 50% of the vehicles equipped
² 5% of total requirements

Figure 2: Total Public Procurement / Euro

4.1. Base case scenario: The private market for GNSS technologies

A study on behalf of the GSA estimates the worldwide turnover with GNSS systems at approximately €170 bn. in 2010. For the year 2020, the study predicts
a market growth of 76%, to approximately €300 bn. According to calculations based on the GDP, the corresponding market volume for Germany will be approx. €11 bn. in 2010, and €18 bn. in 2020. Personal devices (e.g. GNSS-compatible mobile phones and navigation systems) have also been considered in these figures.

The study considers the following six market segments: Location-based services (LBS), logistics and transportation (i.e. air traffic, railway traffic, and waterway traffic) plus miscellaneous. The two larger market segments, LBS and transportation/logistics, hold 92% of the market share.

Currently, the range of location-based services is growing rapidly, due above all to the newest developments in the scope of mobile phones and the combination of GPS and the internet. Considering this high-speed market-driven development, it is not expected that public demand policies will make any significant impact on the private market. The introduction of new positioning systems such as Galileo and EGNOS, though, opens the door for new innovative products.

In recent years the marketing of applications for transportation and logistics has effectively focused on the consumer by offering navigation devices with datasets incorporated within them. The navigation market is increasingly put under pressure by the innovation strategies of new competitors (e.g. Google): A single piece of hardware can now be used for both telephoning and navigation. Navigation systems need no longer be attached to specific devices but are also offered as, e.g., software for smartphones. Furthermore, data does not need to be stored on local drives but can be downloaded.

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1 The GNSS opportunity: key market facts and figures, L.E.K. Consulting on behalf of the European GNSS Supervisory Authority, presented at the Conference Growing Galileo in January 2009
Figure 4: The combination of several technologies as important market drivers

Due to the lack of development of suitable systems, the technical potential of business process optimization based on GNSS has barely been realized so far, particularly in small and medium-sized businesses (SMEs). Increased involvement by the public authorities in Germany could have a considerable impact on the development of widely accepted applications for the transportation and logistics industry.

Even cities and regions that become involved in the progress of intelligent transportation systems can support the growth of key skills in their region. Thus they contribute to the competitiveness of local enterprises that have access to these services.

4.2. **BASE CASE SCENARIO: INTRODUCTION OF GNSS TECHNOLOGIES IN THE PUBLIC SECTOR**

Relating to the LBS and transportation/logistics market segments, the following applications are used in the public sector:

<table>
<thead>
<tr>
<th>Private Market</th>
<th>Public Sector</th>
</tr>
</thead>
<tbody>
<tr>
<td>LBS (location based services)</td>
<td>Municipal Surveying</td>
</tr>
<tr>
<td></td>
<td>Sovereign Surveying</td>
</tr>
<tr>
<td></td>
<td>Forest Services</td>
</tr>
<tr>
<td>Transportation/Logistics (mobile services)</td>
<td>Winter Services</td>
</tr>
<tr>
<td></td>
<td>Public Transport</td>
</tr>
<tr>
<td></td>
<td>Police/ Rescue Services</td>
</tr>
<tr>
<td></td>
<td>Waterways and Shipping Administration</td>
</tr>
<tr>
<td></td>
<td>Air Traffic Control</td>
</tr>
<tr>
<td></td>
<td>Railways</td>
</tr>
</tbody>
</table>
All in all, in order to achieve 100% implementation, a total investment of approximately €590 m. must be realized in the LBS and transportation/logistics sectors. (cf. Figure 2):

- LBS: €56 m.
- Transportation and logistics: €535 m.

Location based services (LBS) are already well established in administration (especially in the surveying sector). But it is different with regard to the transportation/logistics sector: much research and development work on intelligent transportation systems is required before mature, flexible systems can be introduced into the commercial market.

![Rate of implementation - Base Case](image)

Observing the progress of the LBS sector in recent years, it is envisaged that approximately 70% of the remaining implementation will be realized in 2015, and that this will increase to 95% in 2020. With regard to the current situation, the transportation and logistics sector will probably have a slower rate of implementation, of approximately 15%, in the year 2015, increasing to 50% in 2020.

In order to compare the progress of the LBS and transportation/logistics sectors and to take into account the different initial situations, the rate of implementation for both sectors is standardized on the base year 2010. Thus, only future investments are considered.

In the base case, the public authority investments are completely different for the two sectors. Due to the investments that have already been made in the surveying/LBS sector, investment needs in this sector are declining. On the other hand, the development of GNSS applications for transportation/logistics requires
much greater, and rising, investment in order to achieve the anticipated implementation rates.

As a result, on the one hand, the annual investment volumes in the surveying/LBS sector are predicted to decrease from approximately €10 m. in the year 2010 to approximately €280,000 in 2020. On the other hand, volumes in the transportation/logistics sector are likely to rise continuously from approximately €2.7 m. in 2010 to €46 m. in 2020.

![Graph showing investment volumes by year for surveying/LBS and transportation/logistics sectors.]

**Figure 6:** Base case scenario: Investments made by the public authorities (per year, per sector)

### 4.3. Market returns achieved through the introduction of GNSS-based systems in the public sector

Innovation processes must be considered within a global context. First of all, the earlier an investment is made, the more significant its impact. If competitors have already established similar solutions in the market, it is too late to apply innovation strategies.

A positive impact generally involves a time lag. If investments in intelligent transportation systems are made today, medium-term market returns of 1:2 can be expected: every €1 invested by the public authorities generates €2 for the free economy. In the long term, market returns of 1:10 and more are possible. These figures are based on previous analysis and experience of innovation policies.

The later an investment is made, the greater its impact on the regional economy. If innovation does not take place, the potential benefits we see today could become competitive disadvantages, as in, for example, the late introduction of intelligent transportation systems.
• **Market returns in the base case scenario**

The base case assumes that in the years 2010 to 2020, public procurement expenses in the transportation/logistics sector amount to €267 m. in order to achieve an implementation of 50%. It is assumed that public investment will be as low as €2.7 m. in the first year, and increase continuously until €46 m. in 2020.

In the base case scenario, the market returns that can be achieved by public procurement of GNSS systems and applications for the transportation and logistics sector could amount to a total of approximately €860 m. in the following 10 years.

• **Market returns in the best case scenario**

The impacts of a greater involvement by the public authorities in the sector that incorporates intelligent transportation systems for public transport and rescue services will be detailed as follows.

![Figure 7: The investment policy of base case and best case scenarios](image)

In order to show the importance of the innovation policy, the best case is a scenario in which the total investment of the public authorities of €267 m. is the same as in the base case scenario, with the same final implementation rate of 50%. In the best case scenario, however, the investments are made earlier than in the base case scenario.
The best case scenario shows that earlier investments lead to greater sustainable market returns than do late investments. In the best case scenario, market returns of approximately €1,427 m. altogether can be achieved between 2010 and 2020. The total market returns in the best case scenario are almost twice as much as those in the base case scenario. This again demonstrates the significance of early total investment in intelligent transportation systems.
The impacts of early investment lead to faster implementation and increasing market returns. In the year 2015, the 30% implementation rate in the best case scenario is twice that of the base case scenario, at 15%.

Without the involvement of the public authorities, the development of the national GNSS market would take place only in open competition on the world market. Experience has shown, however, that appropriate public strategies can support the high innovation potential of the dense network of high-tech SMEs in Germany very efficiently. Focused public demand policies could ease the financial burden of innovative development and allow the German economy to gain substantial market shares on the worldwide market for GNSS applications. This highlights the great importance of public investment in innovative GNSS technologies.

The timing of the investment is crucial: The earlier the investment is made, the higher the anticipated market return for the German economy.

5. **Barriers and Obstacles to the Use of GNSS Technologies (Original Pages 59–63)**

Given the above-mentioned cases of GNSS use and the market evaluations, the following barriers and obstacles to a use of GNSS technologies by the public sector can be identified.

**Barrier 1: Lack of Technological Convergence and Standards**

The potential for an increased and efficient use of GNSS can develop only with the combination of several technologies, e.g. geo information systems (GIS), remote sensing and Radio Frequency Identification (RFID). Public administrations, even when financing research programs, rarely take an active part in research projects applied in these sectors. Thus they miss the opportunity of having expert systems tailored to their specific needs.

Initiatives like INSPIRE aim at high degree of standardization, but internationally authoritative technological standards have not as yet been established. Existing applications currently work only with local solutions discouraging the use of existing products on alternative systems. Thus, efficient usage is not achieved and acquisition of the systems is less appealing.

**Barrier 2: Due to a Lack of Knowledge, the Potential is Insufficiently Exploited**

GNSS solutions are usually not at the core of investment strategies, but are considered luxury, bonus technologies. For example, commercially available navigation systems, instead of being part of integrated systems for control centers and service centers, are used for simple routing or point-to-point navigation. Thus, due to lack of knowledge, the potential of the technology is insufficiently exploited.
In particular, municipal authorities have to cope with great challenges due to the combination of low budgets, scarce personnel resources and a high workload rate (80%) for mandatory tasks. So innovation and development projects are accorded low priority, and their requirements and the necessary strategic concepts have to be specifically promoted.

**Barrier 3: Small and fragmented administrative units**

The use of GNSS is only profitable for public services that are over a certain size (relating the number of vehicles/machines or a minimum size of the application area). Particularly in municipal authorities, the administrative units are often too small and fragmented to allow the total potential of the technologies to be implemented. In addition, intercommunal cooperation schemes involving differing authorities present the parties involved with overwhelming organizational and legal problems. Synergies cannot be employed.

The European guideline INSPIRE points the way to a consistent pan-European infrastructure for geo-information that can considerably simplify data exchange between authorities. Satellite data provided by Federal authorities will form an indispensable basis for future information services; and the mapping of additional cartographic and socio-economic data for planning and political decisions can be executed by the municipal authorities.

**Barrier 4: The maintenance of legacy systems is not prescribed by law or administrative regulations**

In some administrations the maintenance of legacy systems is prescribed by law or at least by administrative regulations. If legacy systems have to be maintained, the concurrent use of GNSS technologies is not appealing. A reformation of the regulations or even of the basic laws can potentially take years. The surveying administrations of some Federal states call for the use and maintenance of terrestrial triangulation stations; this, again, restricts the economic use of GNSS-based surveying technologies.

Public authorities in general feature high inertia in their systems. This is the reason why technology changes often cannot be achieved either quickly or comprehensively. So Galileo’s positive features would have to be communicated to all administrations concerned, and would have to be coherent and transferable.

**Barrier 5: Employees’ fear of performance monitoring**

The use of GNSS allows the precise localization of particular vehicles matched to individual employees and, in some cases, a positioning of individual people. Personnel officers fear that the automatic handling of personnel data would allow monitoring of employees’ behavior and
performance. So, with the rights of codetermination, involvement and hearing, they tend to discard the new methods.

A balance needs to be achieved between, on the one hand, the functional, factual and legal betterment of the individual employee and the authority he represents, and, on the other, the employee's privacy rights. This process could require a long period of time.

**Barrier 6: Insufficient information about Galileo’s services**

The currently available information about Galileo's services, its characteristics and, above all, its future costs, are not sufficient for a coherent, reliable and sustainable evaluation of the technology. This involves a risk, especially for the developers of solutions and systems, because future costs for its development and use are thus unpredictable. The particular example of the public regulated services (PRS) illustrates how unsolved questions concerning liabilities and service guarantees create enduring barriers against market developments. Market evaluations of the development of individual applications or devices are not possible.

The positive experience with navigation systems shows that GPS is very accessible and easy to implement in various devices. Users will likely not be easily moved from the existing free system to a new, more accurate non-free system: the added value of the paid service should be clear and well demonstrated. Concerning public users, no central decision can be taken but every administrative level is responsible for its own decision whether or not to use the new system. This process may take time and result into very disparate results.

**Barrier 7: No regulations concerning access to PRS services**

It has not yet been clearly concluded who will be permitted to use PRS services, who will be the service provider and what costs will be associated with its use. Thus, the number of users who will book this service cannot be evaluated. But in a commercial setting, every provider will have to cover the costs of operation with service fees. High costs per user may be an obstacle for organizations which should use PRS and want to use it, but are not mandated to do so.

**Barrier 8: Unclear situation concerning the liability of Galileo service guarantees**

The legal situation concerning the liability of Galileo service guarantees is unclear. In order to offer potential providers some protection for their investment, authoritative regulations must be generated in the near future (→ liability rules). Concrete concepts have already been stated for EGNOS
and Galileo, but the implementation of these concepts is currently in the early stages.

For several reasons the implementation of authoritative regulations concerning liability is difficult. Here, uncharted judicial terrain will be ventured into and liability rules will have to be applied globally. Thus, both national and international laws will have to be taken into consideration.

Unless there are no clear universal regulations concerning liability, the risks for providers and developers are unforeseeable, meaning that innovation will be avoided.

6. **Recommendations (Original Pages 64–69)**

**Recommendation 1: Support research and development**

Very extensive GNSS applications combined with other technologies require additional basic research as well as the establishment of standards and rules. Public administrations should get actively involved in this process and propose their requirements to the relevant boards.

**Recommendation 2: Bundle the acquisition of basic data**

The logistics sector, in particular, requires the acquisition of basic data, e.g. the accessibility of forest tracks to vehicles, routes for oversized loads, or the transportation of substances harmful to the environment. Generally, single authorities cannot afford these investments from their own budgets. Coordination of the parties involved as well as financial support for the acquisition and update of basic data is necessary.

**Recommendation 3: Support innovative projects**

In order to increasingly exploit the potential of the GNSS technology, a combination of several methods and technologies is essential. The use of GNSS by police and fire services demonstrates that positioning and navigation can be used as a single technology – but the combination of GNSS with special systems for the control centers and with coordination of emergency drives provides a much greater extra benefit. Moreover, both services have similar requirements, so significant potential synergies can be applied regarding the development of new systems.

Projects with a high convergence within user groups and value chains on horizontal and vertical levels should be supported specifically. An important criterion for the future implementation in the municipalities is that suitability for daily use needs to be verified!
**Recommendation 4:** Use experimentation clauses to provide more flexibility for administrative actions

Innovative administrations should have the opportunity to test new technologies via pilot studies, and then provide other administrations with their experience. Experimenting clauses in special laws could yield an essential legal tolerance e.g. by granting administrative discretion regarding the scale of fees or by temporarily waiving implementation rules. If the procedure is manageable, any essential amendments to the laws and regulations can then be made.

**Recommendation 5:** Promote co-operation between different administrations

Generally, a critical mass for a more efficient introduction of new GNSS systems is required. A single administration unit, however, cannot attain this critical mass. Thus, co-operation between different administrations should be encouraged which could also include corporate tendering for end-devices and systems.

More promising, though, are forms of co-operation that apply to the corporate use or operation of the systems, e.g. control centers that are operated corporately.

**Recommendation 6:** Develop new business concepts for the public sector

Private companies should develop further new business concepts that take advantage of co-operation between different administrations and generate economies of scale for both companies and public services.

**Recommendation 7:** Only results-oriented guidelines

Basically, only results-oriented laws and guidelines – not technical and methodical ones – should be drafted, as this could require a simultaneous maintenance of legacy systems, as in the surveying sector (see barrier 4). The focus on results would facilitate the introduction of new technologies and would stimulate the substitution of legacy systems by new and more effective systems.

**Recommendation 8:** Detailed service specification

More explicit service specifications need to be delivered in the near future. Enterprises and organizations which are planning the potential use of Galileo, or intend to develop new applications and services, require precise information about the different services, especially regarding special technical and financial conditions as well as the liability of guaranteed availabilities. The public documentation that is available now is, however,
often obsolete and provides no information about costs to be expected in connection with the use of commercial services.

**Recommendation 9: Stabilization of the German attitude regarding the PRS services**

A clear statement concerning the PRS services, their potential user groups and, not least, user costs, is absolutely essential.

It has not yet been fixed which private-sector users should have access to PRS services. Private sector users could expand the potential range of users significantly and, thus, have a positive impact on the user costs („costs-per-user“). With regulations and guidelines the state can push or even block the diffusion rate of this robust and trouble-free service.

In addition, user fees could be reduced, if the PRS service is co-financed by other European states or if individual users are supported by, for example, grant funding.

**Recommendation 10: Comprehensively provide all information concerning Galileo, and setting Galileo as standard**

It is essential to provide comprehensive information about the stage of development, the prospects, positive experience of administration (publication of field reports) and potential forms of co-operation. A nationwide image and information campaign is required in order to communicate the advantages of the system’s reliability, accuracy, value-added services and independence in comparison to – or, in particular, as a complement to – existing systems.

Identification of Galileo as a significant European system with a secure infrastructure is essential. If investments for new equipment will have to be made, the authorities should appeal to a compatibility with Galileo.

Competition between the three systems (Galileo, GPS and GLONASS) will stimulate the market.

**Recommendation 11: Consider GNSS solutions as a service to citizens and to the economy**

Information technology was, with its implementation, accepted into the German constitution as an infrastructure service (§ 91c GG). Services for citizens, customers and visitors shift more and more into virtuality. Those who are involved in the promotion of trade and industry (choosing a suitable location for a company, etc.), the promotion of tourism (points of interest, cycle trails, guided city tours, etc.) and citizen services are interested in innovative and modern ways to disseminate information.
The EU services directive establishing points of single contact, the D115 project for a direct line to public administrations and the INSPIRE guideline are already leading the way into a pan-European future.

**Recommendation 12: Stimulate investments by the public sector in innovative GNSS technologies**

The timing of investment by the public sector is essential, because it is only if an early investment into GNSS systems is made that the market returns for the German economy will be high.

Without the involvement of the public authorities, the development of the national GNSS market would take place only in open competition on the world market. Experience has shown that appropriate public strategies can support the high innovation potential of the dense network of high-tech SMEs in Germany very efficiently.

Together with the previous recommendations, several complementary tools have been provided in order, by overlapping different departments, to stimulate investment in GNSS systems.

If the challenges of the GNSS service have been accepted and the importance of basic innovation of satellite-based services has been identified by the public sector, then Germany has the opportunity to gain a market-leading position for the development and production of GNSS applications and devices in the years leading up to 2020.

The above-mentioned recommendations are intended to provide a course to steer in order to achieve this goal.