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**Abstract**: This final report presents an overview of the results of the ActMAP project. It is a consolidated report on the requirements, specifications, implementation and validation of the ActMAP framework. A section on methodology and problems encountered is also included. This overview has been intentionally shortened to give a first insight on the ActMAP framework. The reader is invited to refer to the specific deliverables for further detailed information about the project results.

**Keyword list:** ActMAP, incremental update, online update, digital map, location referencing, ADAS, navigation, map partition, map layer, version control, map consistency, update exchange format, permanent and unique map identifier, XML, XML Schema, GDF

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# ActMAP
# Final Report

**Version 1.0**

**24 June 2005**

Produced by:

**ERTICO (project co-ordinator)**
**Tele Atlas N.V.**
**Siemens VDO Trading B.V.**
**BMW Forschung und Technik GmbH**
**DaimlerChrysler AG**
**NAVIGON GmbH**
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**NAVTEQ B.V.**

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# EXECUTIVE SUMMARY

Based on current in-vehicle system market conditions and requirements of future applications such as advanced driver assistant systems (ADAS) and advanced navigation applications, it has been shown that in-vehicle applications will significantly benefit from up-to-date maps. With this perspective, the ActMAP project developed a standard solution for incremental updates of in-vehicle map databases The project includes the investigation of requirements, the development of the technical specifications, and a proof of concept via a test implementation and validation of the concept.

The ActMAP project identified several issues being relevant for implementing online updating such as the existence of many proprietary physical storage formats, the limited bandwidth of the transmission channels, the timing constraints for dynamic updates, and the importance of the quality of the distributed updates.

This final report presents an overview of the results of the ActMAP project. It is a consolidated report on the requirements, specifications, implementation and validation of the ActMAP framework. A section on methodology and problems encountered is also included.

The ActMAP specification is a major output of the ActMAP project. It specifies the strategies and the technical specifications for online incremental updating of in-vehicle digital map databases resulting from the prototyping and validation.

Furthermore, the ActMAP project proposed a reference architecture as an example for the implementation of the ActMAP framework. This reference architecture has been implemented, tested and validated during the project, strengthening at the same time the relevance of the ActMAP framework, the update distribution strategies, and the ActMAP exchange format.

This overview has been intentionally shortened to give a first insight on the ActMAP framework. The reader is invited to refer to the specific deliverables for further detailed information about the project results.

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# 1. General project information and contact details

## 1.1. Purpose of the document

This final report presents an overview of the results of the ActMAP project. It is a consolidated report on the requirements, specifications, implementation and validation of the ActMAP framework. In addition, a section on methodology and problems encountered is included.

This overview has been intentionally shortened to give a first insight on the ActMAP framework. The reader is invited to refer to the specific deliverables for further detailed information about the project results.

## 1.2. Project abstract

Project Title: **Act**ual and dynamic **MAP** for transport telematic applications
Research Area: Systems for intelligent vehicles

Up-to-date map data are a must for current and future in-vehicle ITS applications, mainly Advanced Driver Assistance Systems (ADAS) and navigation applications. Today there are more than 4 million in-vehicle navigation systems in Europe that are using a digital road map on a CD or DVD. As the real world changes every day, an important challenge is to keep these onboard maps as up-to-date and as accurate as possible. Today a typical map update takes place via the distribution of a new map CD once every 6-12 months.

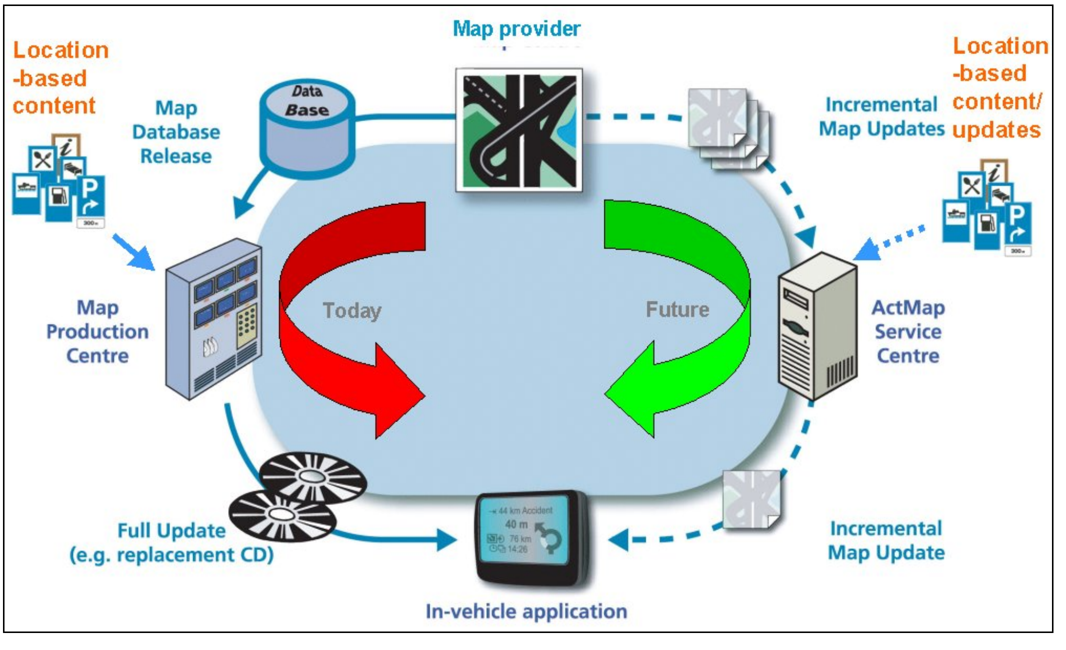


**Figure 1: ActMAP chain of incremental map updates**

The EC-funded ActMAP project (Apr. 2002 – Nov. 2004) has developed strategies and mechanisms for the dynamic update of digital map databases. This represents an important milestone for the quality of the map databases for future in-vehicle applications. The project has built a test environment to validate the mechanisms. The test sites include advanced navigation applications and ADAS applications (curve speed assistance and Predictive Cruise Control with speed adaptation).

ActMAP developed a solution to increase the frequency of the updating cycle and improve its content by using technologies already available today (See Figure 1).

It is our vision that future navigation and advanced driver assistance systems will require an on-board map database much more up-to-date and dynamic than what is available today. This will improve the navigation experience and enable new applications in the area of driver safety. As the number of safety systems is expected to significantly increase over the next years, there is a strong need for a standardised process to update the onboard maps.

## 1.3. Project objectives

The aim of ActMAP was to investigate and develop strategies for the dynamic update of digital map databases. Up-to-date map components should be integrated and/or attached to the in-vehicle digital map. This mechanism represents an important milestone for the ubiquitous availability of future location-based information and the quality of the map databases for future in-vehicle applications.

The project has built a test environment to validate the mechanism(s) shown in Figure 2. The test sites included advanced navigation applications and ADAS applications (curve speed control and Predictive Cruise Control (PCC) with speed adaptation). After validation, the proposed mechanisms were submitted to the relevant standardisation body (ISO TC204/WG3).

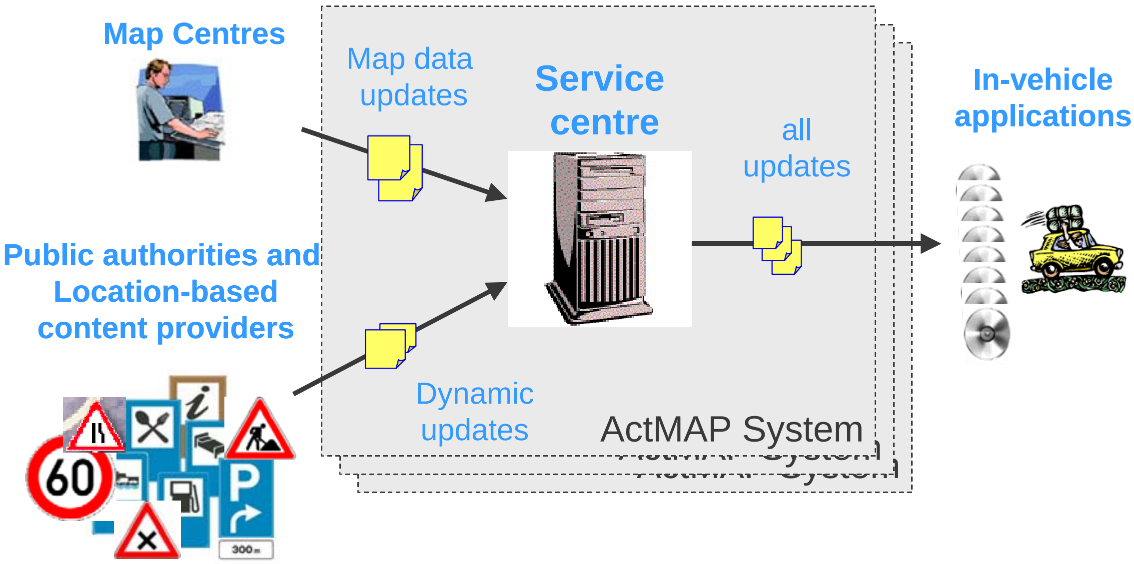


**Figure 2: ActMAP standard architecture**

Besides the multiple links to standardisation and other EC-funded projects, ActMAP has created a Forum opened to anyone willing to implement or use dynamic map actualisation in their applications/services. The received feedback will be used to consolidate the specified actualisation method. Organisations having an interest in the ActMAP approach are invited to contact the ActMAP coordinator and join the forum.

## 1.4. Important project milestones

11 / 2002, [M 8] List of preliminary map actualisation requirements and first User Forum Workshop to consolidate the preliminary map actualisation requirements

05 / 2003, [M 14] Validation plan

07 / 2003, [M 16] Specification of actualisation strategies, map components version control and interfaces (Deliverable 3.1)
09 / 2003, [M 18] Preliminary specification of the test environment
09 / 2003, [M 19] Final version of validation plan based on results of M16 and M18
04 / 2004, ActMAP workshop on location-based content providers
05 / 2004, [M 26] Test environment specification, including test scenario description (Deliverable 4). Test environment implemented and ready for performing the validation
09 / 2004, [M 30] Validation results, final map actualisation requirements, ActMAP specifications, implementation and integration report
10 / 2004, [M 31] Final ActMAP forum workshop and demonstration
11 / 2004, [M 32] Submission to ISO
01 / 2005, [M 34] Final Report

## 1.5. Project data

| | |
|---|---|
| Starting date: | 01-April-2002 |
| End date: | 30-November-2004 |
| Duration: | 32 months |
| Total Cost: | 3,755,948 EURO |
| EC Contribution: | 1,877,973 EURO |

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## 1.8. Project URL

http://www.ertico.com/en/subprojects/actmap/

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# 2. Methodology, Work performed and problems encountered

The work in the ActMAP project has been divided into seven work packages (WP) as represented in the following table:

| WP # | Title and short description |
|---|---|
| WP 1 | **Project management** |
| WP 2 | **Requirements for map actualisation (user needs):**<br>to investigate the need of in-vehicle applications for map actualisation to be classified in safety categories and type of update. |
| WP 3 | **Specification and design of the actualisation process:**<br>to define and develop an architecture with the corresponding APIs, strategies, methods and corresponding algorithms for actualising in-vehicle digital map databases. Results of the WP3 have be then submitted to ISO as a standardization proposal. |
| WP 4 | **Specification of the test environment:**<br>to specify the test environment to be used to validate the proposed actualisation methods, which will be integrated into a full service environment (service centre to the vehicle). |
| WP 5 | **Implementation and integration of test environment:**<br>to define and implement the proposed actualisation mechanisms to be used by in-vehicle systems. In particular the following applications will be considered: navigation application, PDA-based application and curve speed control application. |
| WP 6 | **Validation**<br>to validate the developed actualisation methods implemented in WP5. |
| WP 7 | **Liaison and dissemination**<br>to link with other project, to build European consensus and submit consolidated actualization method for digital map databases to standardisation (CEN or ISO). |

The structure and relations between these WPs are shown in Figure 3.

This structure reflects the organisation of the project with respect to the logical phases of a project's life cycle when considering that:

- WP2 corresponds to a user needs phase
- WP3 corresponds to a system specification phase
- WP4 and WP5 correspond to an implementation and a testing phase
- WP6 corresponds to a validation phase
- WP7 corresponds to an exploitation phase

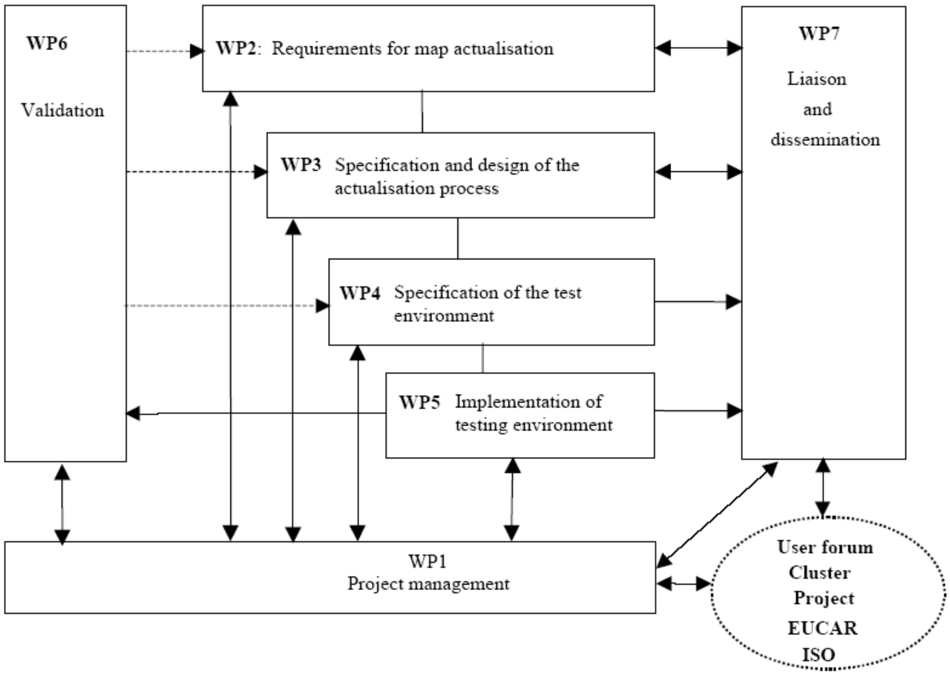


**Figure 3: ActMAP workpackage structure and relations**

The project was executed in an iterative manner in order to achieve consolidated mechanisms for map actualisation at the end of the project. The methodology and the approach used in ActMAP to achieve its objectives are presented hereafter following the logical phase of the project mentioned above. The following sections present also the work done WP by WP, as well as the problems encountered and the solutions implemented to meet the project objectives.

## 2.1. WP 2 Requirements for map actualization

**WP2** started at the beginning of the project with the goal to establish the needs and requirements of in-vehicle applications for map actualisation. This was achieved by internal project meetings in an iterative process, including the consultation of the user group created by **WP7**. The identified data or map components to be actualised were classified in safety categories, type of updates (typically what belongs to map update and what belongs to attaching information to a map), actualization rates, lifetime and dynamic update of information. Simultaneously, WP2 derived a tentative roadmap to envision the necessary prerequisites to mid/long term dynamic digital map products (e.g. 10 years).

### 2.1.1. Preliminary requirements

During the first phase of the project, the preliminary requirements for map updating have been collected. In December 2002, the preliminary map actualisation requirements have been defined and described in the Deliverable D2.1 available on the website.

The main results have been presented at the ActMAP forum workshop, but there were not very many specific comments on the requirements. ActMAP presented the preliminary requirements at the ITS world Congress in Madrid in October 2003 to collect more comments.

In general, the preliminary requirements took more time than planned: 87% of the planned resources for WP2 were spent. Therefore a shift of resources from other workpackages to WP2 for the final requirements was planned.

### 2.1.2. Revision of the requirements

In March 2004, the consortium started working on the final map actualisation requirements (Del 2.2) due at the end of September. 110 hours were left for completion of the final requirements deliverable D2.2. This was too low as all partners needed to contribute to this final deliverable.

During the final requirement phase, the project defined extensively the structure and the final content of the D2.2 containing the final ActMAP requirements. At the term of the period 9, the WP2 had already distributed its 2$^{nd}$ draft of the document requesting additional contribution from the consortium. During the period 10, the consortium has been revising the requirement of the ActMAP framework.

Several contributions from the lessons learnt during implementation, tests and validation were added to the original requirements. Also, the conclusions of the workshop for Location-Based Content (LBC) providers organised in April was included in the document.

The project completed the final version of the D2.2 containing the final ActMAP requirements in September 2004 (in time). The deliverables D2.2 was distributed publicly at the final workshop and is available on the ActMAP website. [2]

## 2.2. WP 3 Specification and design of the actualisation process:

After formulation of the map actualisation requirements, the first step of developing conceptual solutions was done in **WP3**. The key players in the actualisation service chain, being map providers, service centre operators and in-vehicle application developers, defined strategies for actualising the map components identified in **WP2**. Together with an actualisation architecture and interface definition, this allows to eventually design and specify processing algorithms, including version control mechanisms and certification. Overall this enabled the implementation of the information flow from the update provision interface (either from a so-called map centre or from other sources) through actualisation service operation to integration into the in-vehicle applications. In an effort to maximise synergies with related technical developments, **WP3** assessed the relevance of existing standardised methods as well as work in progress in the field of map updating and location referencing including AGORA and ISO TC204/WG3. The WP determined the potential to exploit elements of the ActMAP specifications for ISO submission.

### 2.2.1. Initial specifications

WP 3 started in November 2002. During the first phase of the project, a large part of the work in WP 2 (Requirements) was strongly related to **WP 3** (update strategies).

The **WP 3** milestone M10 on the specification of the ActMAP strategies (January 2003) was postponed to May 2003 (M14), due to the complexity and a lot of open questions. It was decided that Deliverable 3.1 would describe the preliminary holistic ActMAP concept.

The main conceptual issues were related to the interaction between the service centre and the in-vehicle application, because of the great diversity of applications. Additionally, it became necessary to define in details the key underlying aspects of the ActMAP framework such as partitioning, version control, clustering / filtering as fundamental concepts. This created an important amount of discussions between partners and a specific 1-day consortium workshop on this workpackage was organised in February 2004.

As a result, the incremental map update exchange format became relatively complex and necessitated specific technical expertise during the specifications. Deliverable 3.1 describing the ActMAP concept, was finally submitted at the end of August 2003 with a month delay.

### 2.2.2. LBC issues

As the ActMAP consortium did not have any partners representing the location-based content (LBC) providers called third party data (TPD) during the beginning of the project, a standard interface was difficult to realise due to the large variety of LBC providers. It was planned to validate in the Forum the proposal for this interface, using the same data model.

However, we identified that specific attention needed to be given given to attract the relevant Pan-European LBC-providers in the Forum, reason for which a special workshop on LBC providers was organised, see WP 7.

### 2.2.3. Second iteration of the specifications

In March 2004, the consortium started working on the Deliverable 3.2 'Revised specifications for actualisation strategies, map components, version control and interfaces' based on the forthcoming results of the tests and validations in WP6. In order to separate the core of the ActMAP concept and its extensions, the consortium decided to make a clear distinction between short/medium term implementation options and long-term implementation of ActMAP and create a roadmap for the ActMAP implementation. The consortium decided to propose for ISO standardization only the core of the ActMAP concept without its extensions.

The consortium reviewed all the ActMAP specifications according to new contributions from the implementation, tests and validation phases and comments from the ActMAP forum. New contributions from the implementation, tests and validation were added.

At the end of September, the consortium completed and peer-reviewed the revision of the D3.2 “ActMAP specification” [5]. The deliverables D3.2 has also been distributed publicly at the final workshop and is available on the ActMAP website.

In addition, the standardisation proposal to ISO (D3.3) was written with focus on the core of the ActMAP concept. D3.3 was published by mid of October. This is one of the reasons for which has been extended by two months. [6]

### 2.2.4. IPR issues

Regarding the standardisation and IPR, the use and future implementation of the relevant IPRs were investigated for relevance before making any standardisation proposal. A series of IPR were identified and necessary measures were taken in order to solve any potential issues. For companies outside the consortium, the discussions lasted until the end of the project and were to be continued during the standardisation negotiations.

## 2.3. WP 4 Specification of the test environment

In **WP 4**, the most relevant applications and actualisation methods were defined. Test environments were specified in detail: the concrete definitions of test scenarios, interfaces, and message formats were created in this work package. Sample applications to be considered were route guidance as well as ADAS applications like curve speed control and ACC with speed adaptation. The selected applications could show the efficacy of the proposed version control mechanism by demonstrating repeated actualisation of map components reflecting repeated changes for the same real-world location.

### 2.3.1. Definition of the test environment

Multiple and detailed discussions took place at the beginning of the test site environment specifications. All partners presented their plans at the steering committee in September 2003. A detailed planning was made on the test site development coordination. It was decided that the test environment would include 1 x PDA application, 2 x ADAS application and 2 x navigation application. Sample applications to be considered are route guidance as well as ADAS applications like curve speed control and ACC with speed adaptation.

The main issues during the test specification were related to the effective use of indicators described in the validation plan. The application of indicators for validation of the main ActMAP components had to be well coordinated through the different test sites.

NAVIGON specified the test environments in details with concrete definitions of test scenarios, interfaces, and message formats. The main focus was on addressing the definition of sample applications and test areas for different test scenarios including presentation of the results in the application. The draft specification document was ready in November 2004. This corresponds to Milestone M 18: Preliminary specification of the test Environment. Detailed planning on the test site development coordination was included in this document.

During this time, BMW, DaimlerChrysler and NAVIGON investigated potential participation of Third Party Data Provider to participate in their respective test sites. Finally, OBB, the road administration of Bavaria and, MERIAN, the commercial POI provider, were selected to represent the LBC providers during the tests.

The consortium published the deliverable D4 "Test environment specifications" in June 2004 with a delay of half a month. This marked the completion of the work package WP4.

The consortium consumed more resources than expected probably because there is no clear borderline between WP4 and WP5. [3]

## 2.4. WP 5 Implementation and integration of test environment

In **WP 5**, the sample applications, the service centre, and the map centre were implemented as specified in **WP4**, including testing. Activities comprise of data preparation, software development, and systems integration (including the necessary infrastructure for information collection for validation purposes). One single service centre was implemented to provide actualised map components in a harmonized format for use by all specified in-vehicle applications.

### 2.4.1. Implementation

The implementation of the test sites started as planned in November 2003. A precise timeline with all milestones for each of the test sites was presented by NAVIGON. First test at the ActMAP service centre (ASC) started in January 2004.

Practically, the implementation work was focussed on the preparation of the test environment for each test site. The ActMAP service centre was developed by NAVIGON beside their demonstrator for PDA navigation system. BMW Forschung und Technik prepared his demonstrator for curve speed assistance and variable message signs. CRF developed the module for downloading dynamic data to the ADAS functions in their project vehicle. Siemens VDO developed the route recommendation and warning demonstrator. And finally, DaimlerChrysler prepared the test site for route guidance with automatic updates of the surrounding point of interest. NAVTEQ and TeleAtlas contributed to the incremental map updates available at the ActMAP service centre.

### 2.4.2. Testing

In June 2004, the project consortium finished the implementation of most of the test sites. The project started the final tests on each test environment in June before the validation planned end of June and beginning of July. The project consortium finished the testing of most of the test sites before their validation. Consequently, most of the validation could be performed already in July with some exceptional extra-work in August.

Even if the milestone was reached with minor delays, the publication of deliverable D5.1 (other/report) was delayed until all test sites were implemented and tested. Also, as the consortium set a higher priority on the validation before the vacation period, this intermediate deliverable was given a lower priority and delayed until the mid of august. The deliverable D5.1 was published August 15, 2004.

### 2.4.3. Final reporting on the implementation and testing

At the end of the project, the consortium completed successfully most of the work of WP5.

Additional resources were planned in order to finalize the writing of the deliverable D5.2 "implementation and integration report" published at the end of September. [4]

### 2.4.4. Final demonstration version for workshop

Further implementation work has been done on the demonstration versions of the test sites that were displayed at the final forum workshop on October 6, 2004.

After completion of the WP tasks, the combined amount of resource consumption for WP4 and WP5 is slightly higher than expected (400 hours). Minor amount of resources were planned in October (Period 11) in order to complete the demonstration versions of the test sites before the workshop (about 25 hours total).

## 2.5. WP 6 Validation

**WP6** performs the validation, which is the key for exploitable project results and assess the proposed actualisation method.

At the beginning of the project, a validation plan was developed which created the basis for all specification and implementation work. The validation plan set measurable parameters and reference values to define the threshold for success of the ActMAP actualisation process for different applications. To set the quality parameters of ActMAP the state-of-the-art of map updating was taken into account as a reference case. The test scenarios were designed to enable conclusions about e.g. the reliability of the process, latency time, usability and technical constraints of possible transmission channels.

At the end of the project, a validation measuring phase was carried out for each test application. The validation results were presented in a detailed validation report including conclusions for technical assessment and possibilities for future improvements. The validation focussed mainly on the technical feasibility of the actualisation process and did not include end-user tests and benefit evaluation.

### 2.5.1. Validation planning

In 2003, the consortium worked on the plan for the validation of the ActMAP requirements and specifications.

Critical issues for validation and indicators were identified. As the actualisation strategies were not totally defined and the test environments still needed to be outlined, it was difficult to get a picture of the complete validation approach. It was therefore decided to publish a preliminary validation plan at the contractual date in May 2003 (M14).

In the second version of the Validation Plan (D6.1) the consortium restructured the document according to the CONVERGE guidelines. The Final validation plan was published at the end of September 2003. [1]

### 2.5.2. Validation phase

The project started its validation phase in June 2004 continuing until end of August 2004 for one test sites due to implementation and testing delays. All activities leaded to a successful validation of each test site and all the data was centralised at the WP leader to start writing the validation report.

The validation report was published in the middle of October. [7]

## 2.6. WP 7 Liaison and dissemination

The project has disseminated its results through different channels:

- Project website including both a public part for public dissemination of project results and a private part as a working platform for the partners.
- User Forum workshops were organised to consolidate the requirements for the actualisation of maps (WP2) and to disseminate the final results of the project.
- EC concertation meetings with the other ADASE projects and depending on the resources available, it is proposed to contribute to:
- Input to the ADASE web site and ADASE newsletter, in which all ADASE initiated projects should present their progress and next steps.
- Company specific dissemination channels: Each project partner also used its own dissemination channel in a co-ordinated way with the project management (a corporate image of the project was developed, e.g. logo, standard presentation, etc). Some partners propose to include project info on their web site, research CD, conference paper, etc. Most of this information is however on intranet, so in most of the cases the information is not public.
- ISO TC 204 WG 3 and ISO TC 204 WG 14:
  Presentation will be made to the ISO TC 204/WG3 in charge of the GDF standardisation, in order to inform about the progress of ActMAP as well as the proposed GDF change request to be delivered by WP3 (deliverable D3.3).
  Presentation will also be made to ISO TC 204/WG14 in charge of vehicle-roadside communications (For the ISO network, the project will make use of the existing company representatives in the respective workgroup. (for For WG 3.3: Tele Atlas, Navigation Technologies. For WG 14, DCAG, BMW)

In addition, the ActMAP partners have published their implementation plans consolidated in the Deliverable 7.5.

### 2.6.1. ActMAP Forum

The forum activities were one of the most important focus. The ActMAP user forum was created at the beginning of the project in order to promote and disseminate the results of the ActMAP project. The ActMAP forum is represented by many of the European and international key players for the next generation of maps including digital map makers, vehicle manufacturers and systems in-

tegrators (OEMs), in-vehicle equipment providers, commercial and public location-based content providers, and potential service centre operators.
The objectives of the ActMAP Forum are

- Provide access to preliminary results
- Obtain feedback, comments, advice
- Sharing ideas with experts and stakeholders
- Sensing the future market for ActMAP

There are three main keywords related to the forum activities.

1. **Awareness:** Create awareness of ActMAP framework and deeper contents. Attract/invite the relevant people to the project partners and website.
2. **Accessibility:** Make the project results accessible. Provide the information and results. Attract relevant stakeholders to User Forum.
3. **Interaction:** Interact and collect feedbacks through ActMAP Forum.

In December 2002, The ActMAP consortium organised the first ActMAP forum workshop where the preliminary map actualisation requirements were presented. The results presented at this workshop were mostly related to the interpretation of the area of dynamic actualisation of digital maps, and the requirements for realising a dynamic digital map.

In April 2004, the ActMAP consortium organised the workshop on Location-Based Content (LBC) providers and investigated the potential of attaching added-value dynamic information to the in-vehicle digital maps. The results of the discussions confirmed the viability of merging and attaching information from LBC providers to an incremental digital map database in service centres powered by ActMAP. This report contains the summary of this workshop.

In October 2004, the ActMAP consortium organised the final ActMAP forum workshop and demonstrations. The ActMAP project presented its final results and demonstrated the complete chain of map updates through its eight interconnected test sites. The workshop discussions showed a strong interest from both public and industrial key players for incremental map updating technologies

### 2.6.2. Participation to conferences and ActMAP papers

In total, four papers have been published at ITS congresses:

- "ActMAP: Real-time updates for advanced in-vehicle applications" was presented at the 2003 ITS World Congress in Madrid. The paper included the ActMAP concept, requirements, proposed map updating strategies and validation plan.
- “ActMAP – Incremental map updates for advanced in-vehicle applications” was presented at the ITS world congress 2004 in Nagoya. The paper focused on the first implementation results and validation plan.
- “The ActMAP approach – specifications of incremental map updates for advanced in-vehicle applications” will be presented at the ITS European congress 2005 in Hannover. The paper focuses on the specifications of the ActMAP framework proposed for standardization to the ISO TC204/WG3 in December 2004.
- “Results of implementation and validation of the ActMAP incremental map updates for advanced in-vehicle applications” was presented at the ITS European congress 2005 in

Hannover. The presentation focuses on the lessons learned from the implementation, and the results of the validation.

All documents are available on the ERTICO website.

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# 3. The ActMAP Approach<br>Specifications of Incremental Map Updates

The ActMAP specification [5], described in some detail in this chapter, is a major output of the ActMAP project. It specifies the strategies and the technical specifications for online incremental updating of in-vehicle digital map databases resulting from the prototyping and validation.

An important part of the specification is the ActMAP update exchange format. It represents a standardised intermediate format based on XML designed for exchanging map updates between the proprietary formats of the map update suppliers and the map update users.

## 3.1. ActMAP framework and architecture

In-vehicle applications benefit from or need an up-to-date digital map. In the context of ActMAP this is done by combining map databases already available in the vehicle (from off-line full updates) with on-line updates. The assumption is that an on-line communication channel is available for receiving updates. Requirements for online updating are defined broadly [2]:

- There is no specific on-line communication channel specified. In fact it should support a whole range of channels, point-to-point and broadcast, with lower and higher bandwidth.
- It should support all parties that want to use the concept.
- No hard timing constraints are given.
- All known data elements should be supported, and it should be open for new data elements.

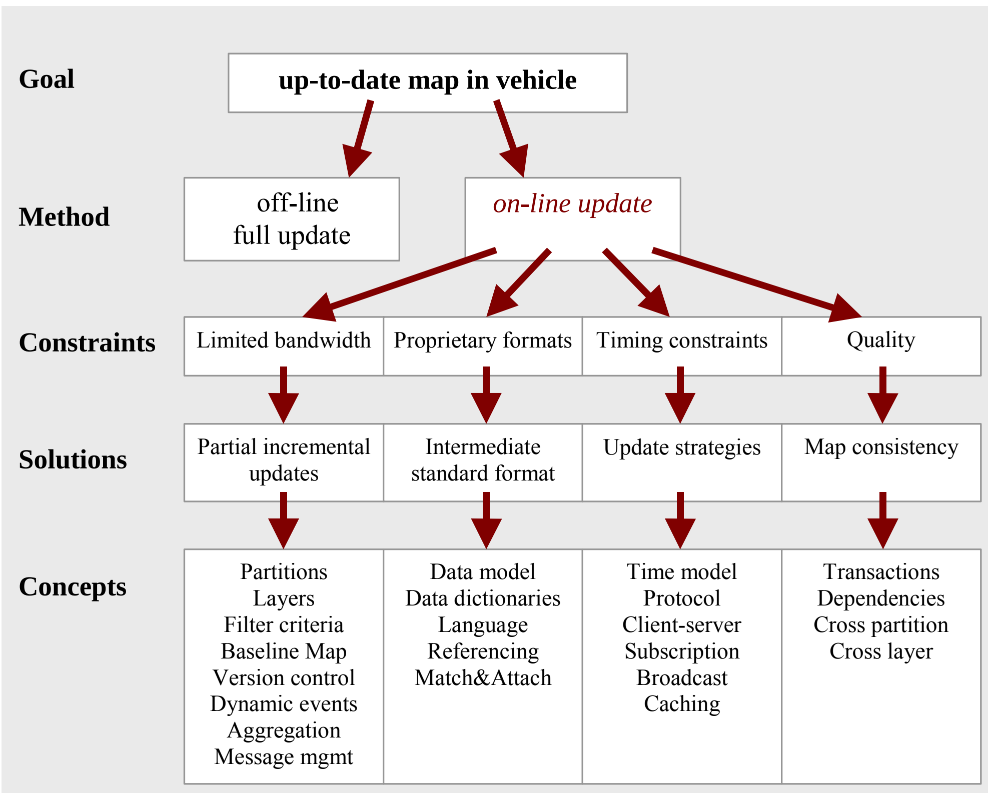


**Figure 4: ActMAP framework**

However, some generic constraints can be identified:

Communication channel bandwidth is an issue. A standard update approach should provide solutions to minimize the bandwidth usage.

- Every update supplier and update user has its own proprietary format to organize and store its map-related data. A standard update approach should take this into consideration.
- For an implementation of an update service, update users will have timing constraints. A standard update approach should provide solutions that can help reducing these delays.
- Update users will have quality constraints on the up-to-date map. A standard update approach should provide solutions to ensure the quality of the map.

### 3.1.1. Limited bandwidth => partial incremental updates

Map databases are becoming quite large, in the order of Gigabytes. An incremental update of a complete map with one month of changes may also grow in the order of Megabytes. This is quite a lot if compared to the bandwidth of a typical wireless communication channel. Size reduction is therefore of vital importance. One method for size reduction is to split a map in smaller pieces, which can be updated separately.

Since different applications need different data and have different criteria for requesting updates, it makes sense to split the map data in parts (layers) that are used by different applications. E.g., the map matching needs only detailed road information around the vehicle; the route planner needs a more global road network for a large area, whereas the map display needs land usage, waterways and railways. Much of the map data can be assigned to (more or less application specific) layers that can be updated separately. The feature themes as defined in GDF can be used as a starting point for defining the layers.

In most cases the in-vehicle applications only need an up-to-date map for a limited geographic area. Therefore it also makes sense to split the map data into geographic areas (so called partitions), e.g., based on administrative area (e.g., a municipality). Other filter criteria can be defined to reduce the size of updates even further, for instance the duration of a temporary update, the priority or importance of an update.

Another method to reduce the size of an update is to only transmit the changes with respect to a previous version. This way you get incremental updates. It is important to have the same starting point (baseline) for the off-line and the on-line updates. Version control for every piece of the map (by layer and by partition) is required to make sure all updates are applied, in the correct order.

Some map-related data can change very often, e.g., the current speed limit on a Variable Message Sign, or the current estimated delay on a stretch of road. For such dynamic information an event can be created when there is a deviation from the normal situation. The deviation from the normal situation can be described in an update, which gets assigned a unique identification of the event. If now the deviation is changing again, a subsequent update can refer to the event and only the differences with the previous version of the event need to be transmitted. If there are multiple updates for the same event, these updates can be aggregated, to create one update representing the latest status. When the situation is back to normal the event needs to be removed, by all parties in the update delivery chain.

### 3.1.2. Proprietary formats => standard intermediate format

If ‘n’ update suppliers directly communicate with ‘m’ (types of) update users, each with their own proprietary format, the number of required translation modules would be ‘n x m’. If an intermediate standard format is introduced, only ‘n + m’ translation modules are required.

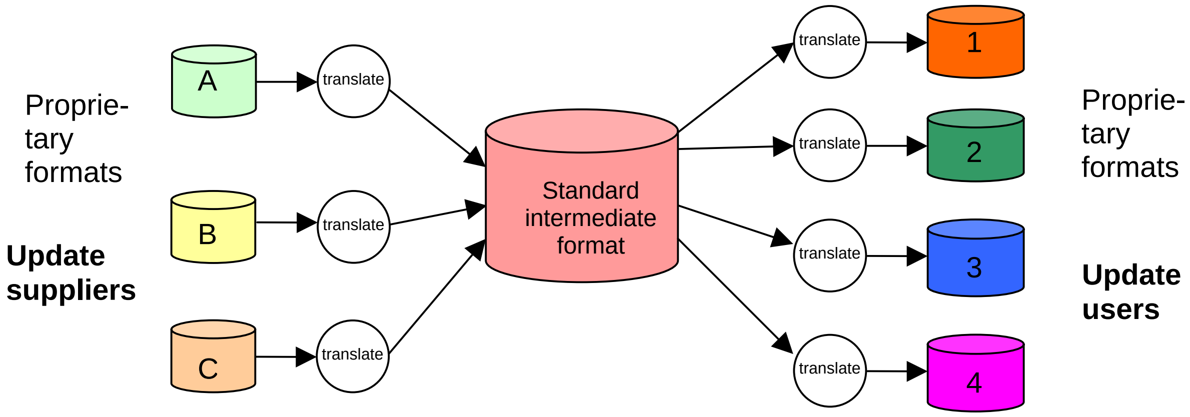


**Figure 5: Benefit of a standard intermediate format**

This is illustrated in Figure 5.

Without standard intermediate format, there are ‘3 x 4 = 12’ translations necessary, in order to deliver updates from each update supplier to each update user. With the standard intermediate format, only ‘3 + 4 = 7’ translations are needed.

The standard intermediate format needs to be powerful enough to describe all changes unambiguously, also for new update suppliers with yet unknown data. Translation between a proprietary format and the standard intermediate format should be feasible for proprietary formats. The difference between the proprietary format and the standard intermediate format may not be too large. Since proprietary formats are sometimes highly optimized this is not straightforward.

For off-line delivery of full mmap database updates is GDF a widely used standard. The data model of GDF is taken as the basis for the ActMAP data model, with Features, Attributes and Relationships. A language is required that can describe the changes to these data elements, with operations like add, remove, change.

To describe a change, it is necessary to identify which element of the map is changed (or deleted/added). A referencing method is needed. If identification is used in the off-line update it makes sense to re-use it for the on-line updates. In many cases a permanent unique ID is (or is coming) available for features in the map. This is an unambiguous and quite compact identification, and is used as the basis for referencing in ActMAP. An alternative is to use a generic referencing method, like AGORA [8], [9] or ROSA [10].

### 3.1.3. Timing constraints => update strategies

Different in-vehicle applications have different requirements with respect to the delay of updates. They will need an update within a certain time after they request for it (response delay) and within a certain time after the update supplier (availability delay) registers new information.

The delays experienced by the applications will very much depend on the characteristics of the on-line communication channel. Different strategies can be used for different types of data and different requirements on the delay. A subscription can be used to push new updates to interested users, either by broadcast or point-to-point. A client-server approach is possible for dedicated requests on a point-to-point connection.

If translation from one format to another is expensive, it makes sense to do this only once and store the result of the translation (in a cache) instead of the original information. If information is very dynamic and changes very often, it may be better to store it closer to or at the source, and do translations on the fly. An update user must be able to discover what update suppliers are available for the map it is using and what information they can provide. A protocol can be defined to exchange information, e.g., which update providers are available, to give selection criteria for a subscription, to start/stop a subscription.

### 3.1.4. Quality constraints => map consistency

It is important that, after processing of a set of updates, the in-vehicle map can be used again by the applications, that it is still consistent. If several update operations (e.g., split one road, add a new road, define the relationships of the new road) need to be processed all before the map is consistent again, they should be grouped into one update transaction. Updates must be assigned to a layer and a partition. However, there can be dependencies between layers or partitions that make it necessary to update more than one piece of the map to keep the whole map consistent.

### 3.1.5. Update delivery chain

Updates will go from many update suppliers to many update users. For every update supplier and update user an update delivery chain can be identified. What can be said about this chain?

- Somewhere in the chain the updates must be translated from a proprietary format of the update supplier to the standard intermediate format and from the standard intermediate format to the proprietary format of the update user.

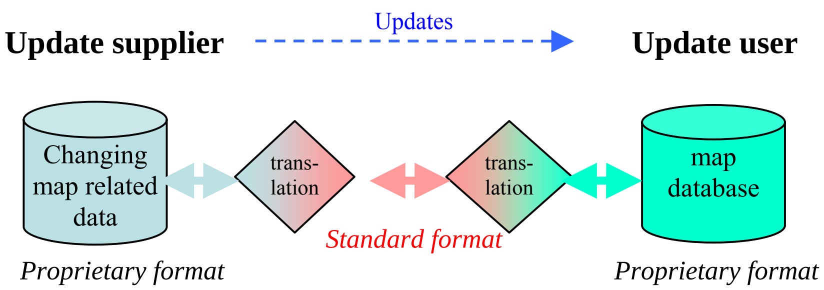


**Figure 6: Translation of updates in the delivery chain**

- Somewhere in the chain there will be a (wireless) on-line communication channel to transfer updates to the vehicle. Typically this is the bottleneck of the bandwidth and reduction of the size of updates is most necessary here.

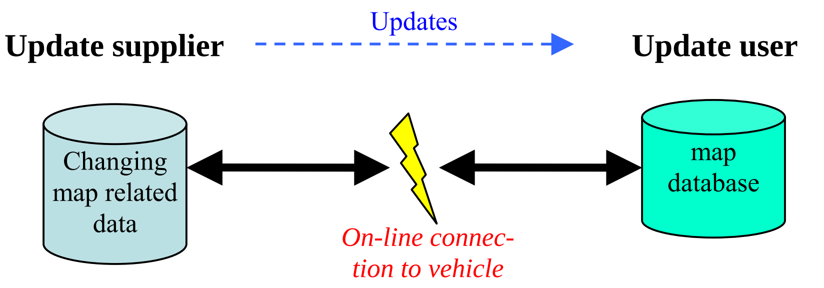


**Figure 7: Online delivery of updates in the delivery chain**

- o Somewhere in the chain there can be a cache for the updates, e.g., to store results of translations. Typically when an update supplier has a new update available it will be forwarded automatically to the cache (i.e. push). Typically an update user will request specific updates from the cache, using selection criteria (i.e. pull).

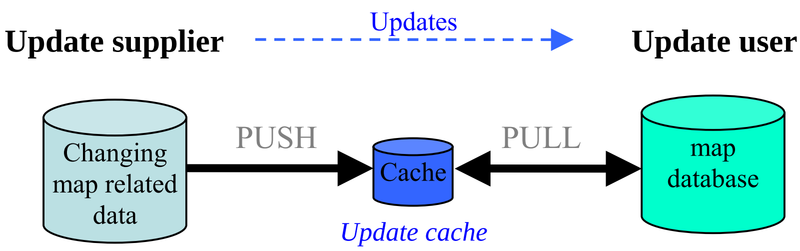


**Figure 8: Caching of updates in the delivery chain**

- o If an update has not been attached to a map, somewhere in the chain the match & attach process needs to take place. There are two main options:
  - o During the translation to the standard intermediate format the update is attached directly to a specific (baseline) map (using e.g., permanent ID's).
  - o During the translation to the standard intermediate format a generic reference is created (e.g., AGORA, ROSA), and during translation to the proprietary format of the update user it is attached to the specific update user map.

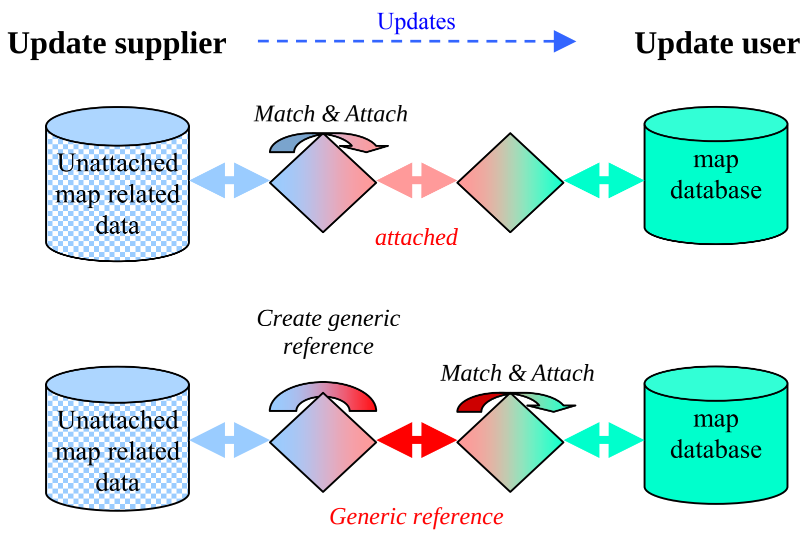


**Figure 9: Options for Match & Attach in the delivery chain**

### 3.1.6. Baseline maps

An ActMAP update user has a map database that is based on a Baseline map, typically a navigable map from a map vendor. The update user will not be able to process updates for a different Baseline map (cross vendor updates are not supported).

This means it can receive updates from an update supplier that is using the same Baseline map, or update suppliers whose updates are Matched & Attached to the Baseline map.

As it has been described in the previous section, there are two different ways to do Match & Attach. In general you can say that all updates in the standard intermediate format are either meant for a specific Baseline map, or they are generic, with a generic reference that needs to be Matched & Attached to a Baseline map.

So the updates in standard intermediate format can be grouped according to the Baseline map they are meant for, and a group for generic updates.

In Figure 10 update users 1, 2 and 3 are using the same Baseline map X and Update user 4 is using Baseline map Y. Update supplier A is supplying updates directly for Baseline map X. Update supplier B has unattached map related data that is not related to any Baseline map. His updates are matched & attached to Baseline map X during the translation to the standard intermediate format. The updates from Update suppliers A and B are grouped, as updates for Baseline map X. Although not explicitly indicated by an arrow, update user may get updates from update suppliers A and B, because he is also using baseline map X.

Update suppliers C and D also have unattached map related data. Its updates are also translated to the standard intermediate format, however, without attaching it to a Baseline map. Instead, a generic reference is created. So the updates in standard format from Update suppliers C and D are put in the group of Generic updates. These updates can be used both by Update user 3 that is using Baseline map X and Update user 4 that is using Baseline map Y.

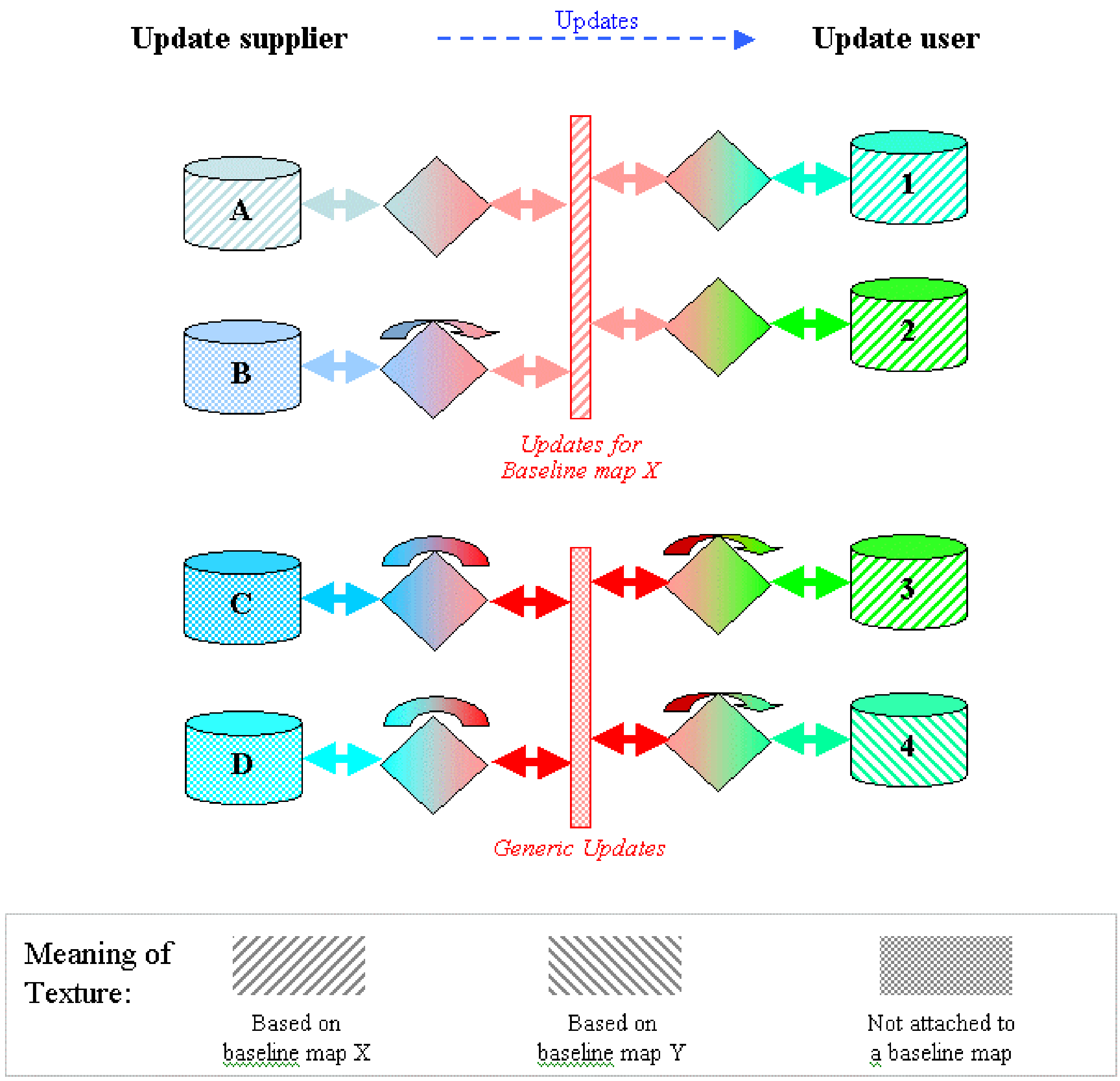


**Figure 10: Updates for a specific baseline map and generic updates**

## 3.2. Update strategies

The ActMAP framework supports two basic strategies for delivering incremental updates.

### 3.2.1. (Notify)-request-response

With this strategy, the in-vehicle application requests the delivery of updates from the ActMAP system. Consequently, a bi-directional communication channel is mandatory for this strategy. In the most cases this will be a point-to-point connection between the ActMAP system and an individual in-vehicle application. However, for the communication from the ActMAP system to the in-vehicle application also a broadcast channel might be used but extended with an addressing mechanism to indicate the receiver. There is always an initial request from the in-vehicle application, before the first update information is sent. With the request, the in-vehicle application may inform the ActMAP system about details of the update(s) to be requested, e.g., which baseline map, release, version, update types etc. In addition the in-vehicle application may specify certain priorities for individual entities to be updated, e.g., for time- and safety-critical data. The consequence will be a faster delivery of the corresponding updates and/or error-redundant transmission. In addition ActMAP system may decide to immediately deliver high priority updates from update suppliers. For subsequent deliveries of updates two possibilities will be supported:

1. The in-vehicle application has to make another request to check if new updates are available
2. The in-vehicle application will receive an automatic notification from the ActMAP system when new updates are available and can decide what to do

### 3.2.2. Publish-subscribe-distribute

This strategy requires that the ActMAP system initiates the delivery of updates to the in-vehicle application. The in-vehicle application has no possibility to make any individual request and can just use the updates as they are provided. For realising such strategy only a unidirectional communication channel from the ActMAP system towards the in-vehicle application is needed, e.g., a broadcast channel. Updates will typically be sent according to a certain schedule. The ActMAP system may (optionally) provide this schedule in advance when and how often updates of certain data entities are sent to allow the in-vehicle application a better function, e.g., broadcast the schedule at fixed dates + times. If a bi-directional link is available, the back channel towards the ActMAP system is only used for un-/subscribing an update stream.

## 3.3. ActMAP update exchange format

Currently there are many proprietary physical data formats on the in-vehicle application side (i.e., the user of updates), a few map database formats at map centre side, and many proprietary formats at LBC centre side (i.e., the update suppliers). To avoid having proprietary translation software for every connection between update supplier and update user ActMAP defines an ‘intermediate format' for the description and delivery of map updates. This means that every party involved needs to write translation software just once, to translate between its own format and the intermediate format. A new party can connect by providing software that translates between the party’s proprietary and the intermediate format, allowing a rapid growth of the map update business. ActMAP has developed an Update Exchange Format specified in XML using the conceptual data model of GDF as basis.

Below there is an example of an incremental map update in ActMAP Update Exchange Format. The metadata section provides details of the baseline map, i.e. baseline map ‘DEU_03.10_MN’ from map provider ‘Tele Atlas’, who is also the update supplier. The example includes one update collection for the partition with the ID = 51001182, which will have after the update the new version ‘2004-04-07T12:00:00’, i.e. the time stamp when the update has been created at the map supplier. The update collection includes for a first road element (feature code = ‘4110’) a change of the attribute functional road class (attribute code = FC) to the value = ‘4’. In addition there is a new composite attribute direction of traffic flow (attribute code = ‘DF’) and vehicle type (attribute code = ‘VT’) with values ‘4’ and ‘0’, which closes this road element for any type of vehicle. The next two update operations are each adding a new official name (attribute code = ‘ON’) with the value = ‘GERSchmiding’ (language code = ‘GER’ for German) to a road element. And finally, the last update concerns the change of the functional road class of another road element to the value = 7.

```
<?xml version="1.0" encoding="ISO-8859-1"?>
<ActMap version="1.0">
    <MetaData>
        <BaselineMap>
            <MapName>DEU_03.10_MN</MapName>
            <Release>03.10</Release>
            <MapProvider>Tele Atlas</MapProvider>
            <UpdateSupplier>Tele Atlas</UpdateSupplier>
            <DataDictionaryID>Multinet 3.x</DataDictionaryID>
        </BaselineMap>
        <Generic>
            <MeasureUnit>DEGREE</MeasureUnit>
            <GeoSystem>WGS84</GeoSystem>
        </Generic>
    </MetaData>
    <UpdateCollection Operation="CHANGE" PartitionId="51001182" Version="2004-04-07T12:00:00">
        <TimeZone>MET</TimeZone>
        <Accuracy>'1</Accuracy>
        <Transaction>
            <UpdateOperation Operation="CHANGE">
                <LineFeature FeatCode="4110" FeatId="31958">
                    <SingleAttribute AttrCode="FC" Operation="CHANGE">
                        <Value>4</Value>
                    </SingleAttribute>
                    <CompositeAttribute Operation="NEW">
                        <SingleAttribute AttrCode="DF" Operation="NEW">
                            <Value>4</Value>
                        </SingleAttribute>
                        <SingleAttribute AttrCode="VT" Operation="NEW">
                            <Value>0</Value>
                        </SingleAttribute>
                    </CompositeAttribute>
                </LineFeature>
                <LineFeature FeatCode="4110" FeatId="32212">
                    <SingleAttribute AttrCode="ON" Operation="NEW">
                        <Value>GERSchmiding</Value>
                    </SingleAttribute>
                </LineFeature>
                <LineFeature FeatCode="4110" FeatId="32214">
                    <SingleAttribute AttrCode="ON" Operation="NEW">
                        <Value>GERSchmiding</Value>
                    </SingleAttribute>
                </LineFeature>
                <LineFeature FeatCode="4110" FeatId="32639">
                    <SingleAttribute AttrCode="FC" Operation="CHANGE">
                        <Value>7</Value>
                    </SingleAttribute>
                </LineFeature>
            </UpdateOperation>
        </Transaction>
    </UpdateCollection>
</ActMap>
```

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# 4. Results of implementation and validation of ActMAP

In order to validate the ActMAP framework, the project has built a test environment, covering the whole service chain from update suppliers to update users. The test sites include advanced navigation applications and ADAS applications (curve speed assistance and Predictive Cruise Control with speed adaptation). Each test site has selected complementary aspects of the ActMAP framework (Table 1), which were examined and assessed jointly. In order to verify the feasibility of the framework, a set of indicators was set up and each test site evaluated a subset of these indicators. The validation results are described in the ActMAP validation report (D6.2 [7]).

| | Daimler Chrysler (NAV) | Siemens VDO (NAV) | Navigon (NAV) | BMW (ADAS) | C.R.F. (ADAS) |
|---|---|---|---|---|---|
| **Navigation and ADAS applications** | Route guidance application capable of POI (point of interest) actualisation | Route recommendations and warnings for road construction and travel conditions | PDA-based navigation application | Curve speed control adapting actual speed and geometry changes | Cruise control application based on dynamic information, e.g. road-works |
| **Tested map updates** | Focus on updating point information | Focus on changes of geometry and speed | Focus on routing and navigation relevant map changes | Focus on actual speed and geometry changes | Focus on updating actual speed |

**Table 1: Navigation- and ADAS applications tested in the ActMAP test implementation**

The ActMAP results presented here consist of two main items: the test implementation and the validation results of the ActMAP framework. This chapter is an overview of the results of three work packages of the ActMAP project: the test environment specifications [3], the implementation and testing [4], and the validation results [7].

The following sections describe the implementation setup, the lessons learned from testing, the validation results and the foreseen benefits of the ActMAP framework.

## 4.1. ActMAP Test Implementation

The ActMAP test implementation shown in Figure 11 contains three types of components:

- the content provider centres, (Maps and Location-Based Content)
- the ActMAP Service centre (ASC),
- the in-vehicle applications (navigation and ADAS applications).

Map or LBC centres hosted by content providers deliver incremental updates towards an ActMAP service centre. An incremental update includes only the parts of the map database that really have changed since the last update. This allows the delivery of updates in a significant higher frequency. The ActMAP service centre is managing the updates from the different update suppliers and distributes them towards the corresponding in-vehicle applications.

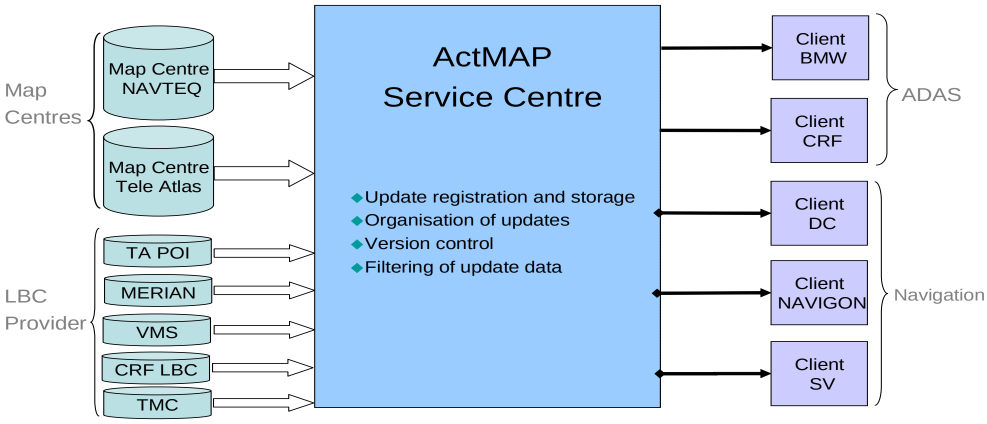


**Figure 11: Overview of ActMAP test implementation**

The test environment comprises eight test sites: two test sites for map centres, one test site for a service centre, and five test sites for in-vehicle clients. Additionally, there are five location based content (LBC) providers. These LBC providers are not test sites. They are simulated by the ActMAP partners.

### 4.1.1. Map centres

The map centres are the suppliers of map database related updates in the ActMAP system. The tasks of the map centres are to continuously collect information about the changes happening in the real road network and deliver them to the service centre. The ActMAP approach requires that each map centre updates only their maps at the in-vehicle application side. Thus, cross-updating is not allowed, which guarantees reliability and consistency.

The NAVTEQ map centre provided incremental updates in the update exchange format for the test sites that are using the NAVTEQ baseline maps for Bavaria and Baden-Württemberg, i.e., the DaimlerChrysler, Siemens VDO, and NAVIGON test sites. The interface towards the ActMAP service centre was implemented via HTTPS protocol. The NAVTEQ map centre could foresee the delivery of real world updates and, when needed for testing, simulate updates. Simulated updates were necessary for validation purposes and for the proof of concept. The NAVTEQ map centre was also delivering Point of Interest (POI) information, which were used by the DaimlerChrysler test case.

The Tele Atlas Map Centre consisted of two main components: the update production server, and the Map centre server itself. The update production server gets data about changes in the production database located in India and generates incremental updates in the XML format of ActMAP. Then the updates are transferred to the Map Centre server, which is connected to the Internet. Upon arrival of new updates, an XML notification file is sent via HTTPS POST method to the ActMAP service centre, which downloads the update files via a secure copy protocol. All Tele Atlas updates were relative to a certain baseline map. For the ActMAP test implementation, the Tele Atlas Map Centre supported three baseline maps: Bavaria (version 2003.3), and Baden-Württemberg (version 2002.2 and 2003.3). For the version 2003.3 baseline maps the updates were coming directly from the "live" production of Tele Atlas located in India and were processed by the update production server. In addition, the older version v2002.2 of the baseline map of Baden-Württemberg was used. The updates were generated from comparing the "historical" GDF products of 2003. Tele Atlas was acting in this scenario as supplier of updates for Location-based Content, and delivers updates of POI features, geometry and attributes.

### 4.1.2. Location-based content centres

The ActMAP project further considered location-based content (LBC) centres. Providers of Location-Based Content enhance the data provided by a map centre, by ‘attaching’ value-added location-based information to the map database and store it in the ActMAP service centre database, where it can be accessed by a multitude of users. The information is integrated seamlessly to the in-vehicle map. One can identify a whole range of LBC providers going from traffic control centres and road operators to travel guides.

In the ActMAP project examples of LBC providers are tested in test sites from BMW, CRF, DaimlerChrysler, and Siemens VDO. As shown in Figure 12, there are five different LBC providers in the ActMAP test environment: POIs are provided by Tele Atlas and iPUBLISH. Speed limit information from variable message signs (VMS) is generated manually. CRF provides manually generated information about speed limits and blocked lanes. Traffic messages are received from the Traffic Message Channel (TMC). Though the LBC updates are originally in different formats, all of them are registered as updates in the ActMAP update exchange format.

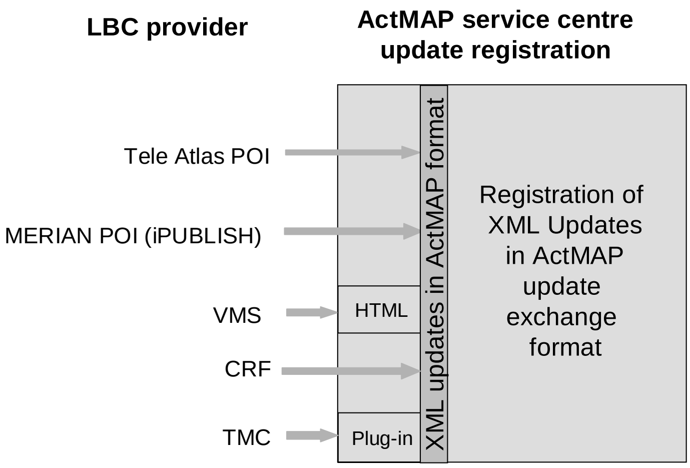


**Figure 12: Interfaces between LBC provider and ActMAP service centre**

An LBC may only add, delete and change features of its own data layer. There can be features in the LBC data layer matching a feature in the map vendor data layer (i.e., both features model the same real world object). In this case, the application decides whether the LBC data, map vendor data, or both are used. The LBC data layer can for example contain additional attributes such as opening hours of a restaurant that is not present in the map vendor data layer so that it can be merged easily. For LBC features that have no match to a map vendor feature, it is still possible that there is a map vendor feature representing the identical real-world object. It is left up to the application to decide how to handle such situations.

LBC providers can choose between “loose” and “tight” relationships between their LBC and the roadmap. Depending on the choice, the requirements are different. Loose relationships between LBC and the roadmap must be given via a location-referencing method. The LBC can then be used for roadmaps of any map vendor. Tight relationships between LBC and the roadmap must be given by referring to roadmap features with their map-vendor specific ID. In the latter case, separate update files must be provided for each supported map vendor or the ASC has to perform the map and attach process.

#### 4.1.3. ActMAP service centre (NAVIGON)

An ASC is one of the platforms forming an ActMAP system and links between the suppliers of map updates (Map and LBC centres) and the road users (in-vehicle applications). While many ASC can be interconnected, only one ASC was implemented in the ActMAP test environment. The main task of an ASC is to collect the updated data from the individual map and LBC centres, aggregate them by means of incremental updates and provide them to the in-vehicle applications.

The ASC validates all incoming update information with the defined XML schema. If the update is valid, the data is registered and locally stored in the update store linked to the relevant baseline maps. The ASC supports the partitioning and versioning concept of the ActMAP system (section 7.4 in [5]) using a relational database.

When in-vehicle clients request map updates using the selection criteria, the available updates at the ASC are checked against data and version required by the in-vehicle system. A filtering of the update data is performed to meet the selection criteria. The ActMAP service centre supports area filtering by rectangle.

All updates are supplied and delivered to the users in ActMAP standard exchange format or in a proprietary format. For updates in proprietary format plug-ins on update supplier side and update user side of the ASC are used. Inside the ASC, all updates are only processed in ActMAP standard exchange format.

#### 4.1.4. In-vehicle applications

The in-vehicle applications use the map database stored physically in the vehicle. This information and new information from LBC related to a defined area are automatically kept up-to-date thanks to the updates from the ActMAP service centre, thus improving the functionality and potential of the navigation and ADAS applications.

##### 4.1.4.1. PDA-based navigation application (NAVIGON)

NAVIGON has established consumer products for navigation purposes. These navigation solutions are running on Personal Digital Assistants (PDA). In the consumer product, a static map is stored locally on the device. The test client is based on NAVIGON’s consumer product and uses a map, which is updated by the ActMAP framework. Updates are downloaded on demand from the ASC using wireless connection through the PDA built-in mobile phone or cable connection through the PDA craddle. In order to save processing power and storage on the client device, the updates are converted into proprietary format by a plug-in running at the ASC. After new updates are received, the in-vehicle map database is updated

##### 4.1.4.2. Off-the-shelf navigation client (Siemens VDO)

The idea of the Siemens VDO test site is to implement and test incremental updates on a commercially available navigation system, to learn about the feasibility of the ActMAP framework in a realistic environment.

To receive on-line updates from the outside world the off-the-shelf navigation system has been extended with an Ethernet interface. The navigation system has limited processing power, limited storage space and is using a proprietary map format. These properties of the system make it a good test case for the feasibility of the framework presented in ActMAP.

When the navigation system is planning a route, it requests to the ASC static updates for selected areas. Static updates consist of changes to existing geometry. The requested area is translated at the ASC to a set of partitions to be updated. Version control has been implemented at the ASC.

Furthermore, the navigation system requests dynamic speed information available for the area between the current car position and the destination in order to make more accurate route calculations. The affected road elements are shown on the map display and eventually avoided automatically if there is a more suitable route. The dynamic updates are shown during their specific durations and disappear when they are expired or when the ASC sends a clearing message.

In this implementation, a plug-in is used to convert data from the standard ActMAP format to the proprietary SV format.

#### 4.1.4.3. Navigation application (DaimlerChrysler)

Based on the application's baseline map, updates from the map supplier to the ASC are delivered in the following way:

- Standard updates of all relevant map information (both POI and map topology) in the update exchange format
- POIs have an extra attribute "ROSA-Code" which is generated by the map supplier. The ROSA-Code describes a location code encoded with the method "ROSA" (proposed to ISO in July 2003).

The vehicle side is simulated by PC emulation. It receives the same data in the update exchange format, optionally with or without the ROSA-Code. A mobile communication channel is not used so that no real delay times are measurable. However, the amount of the transmitted data has been logged and used to derive an estimation of the delay times to be expected.

The following types of updates have been tested:

- POI-updates based on the standard ActMAP approach using permanent IDs without considering the ROSA-Code.
- POI-updates with ROSA, i.e., the map feature IDs transferred with the map update are ignored and referencing is done based on the ROSA-Code attribute.

The update qualities of both approaches have been compared. Additionally, map topology updates have been downloaded to analyse data volume, but were not processed.

#### 4.1.4.4. Curve Speed Assistant application (BMW)

Curve speed assistance informs the driver about the speed given by the VMS sign depending on the dynamical content attached to the map.

The main parameters for speed estimation are the curve radius, the change of direction of a turn and the roadway type. The estimated (safe) speed is compared with the current vehicle speed. If the speed of travel is too high a warning is issued. Concerning the ActMAP project the curve speed assistance system informs the driver about the current state of variable message signs.

#### 4.1.4.5. Predictive adaptive Cruise Control (PCC) Application (CRF)

The application realised in ActMAP project by Centro Ricerche Fiat deals with the integration between the PCC and a navigation system. The PCC application is setting the cruising speed according to the actual road geometry and dynamic information. The aim has been to build the scenario in front of the vehicle (electronic horizon), using updated information provided by digital maps and to adapt the cruise speed taking into account road geometric features (for example curves, particular intersections) and road attributes (for instance, speed limit) on the vehicle's way. The main advantage demonstrated by this application is the capability of the system to improve the safety, assuring comfortable driving without the necessity of any driver's intervention. On board map actualisation, following specific strategies singled out in ActMAP framework [5], represents an important source of improvement for the ACC application, in terms of cruise information related to an up to date road scenario. In the test application implemented in ActMAP, dynamic events (such as traffic work situation) were simulated along the test track in Orbassano.

## 4.2. Lessons learned during ActMAP Implementation

In this section, we present a series of observations taken during the ActMAP test implementation and integration [4]. These observations will eventually help implementing more efficiently other ActMAP frameworks using the proposed ISO standard.

### 4.2.1. Format of the Baseline maps at the ASC

No standard format is defined for the baseline map used at the ASC. When the ASC needs additional data from the baseline maps (e.g., for area filtering), the data has to be accessed according to the proprietary format. This considerably increased the processing complexity needed at the ASC.

### 4.2.2. Usefulness of map updates

The characteristics of the updates were investigated for the area of downtown Stuttgart in the Tele Atlas 2002.2 map. Surprisingly, almost all POIs received an update within a single year. Most of the updates were completing or correcting the map information, e.g. with street address and postal code. The amount of correction updates should be reduced in the future. However, other features not included in the maps, e.g. altitudes, speed limits, etc…, might keep this flow of new updates relatively high. In addition, updates are sometimes not important for navigation applications, e.g. spelling corrections of official names. It is however difficult to decide whether updates are useful or not for the user.

### 4.2.3. Conflict of Permanent unique ID

In some cases it was not easy to find a (permanent) unique ID to identify a feature. Different solutions were found:

- Combine the feature ID with the partition ID to make it unique
- Combine the partition ID with the section ID, to make the partition ID unique
- For a junction: identify the junction by the unique ID of one of the road elements leaving from it, plus a flag indicating whether it is the from- or to-junction.

These solutions increased the size of the reference/identification. An optimization would help saving bandwidth and storage space in the in-vehicle map. This was not considered in the ActMAP implementation.

### 4.2.4. Processing of geometry updates

In GDF, a junction gets one coordinate, and a road element has two bounding junctions (with a coordinate) and it gets zero or more intermediate coordinates. During implementation and testing of the update chain, it was discovered that some geometry updates used the same (GDF) strategy, but in other geometry updates all coordinates of a road element were given, also the coordinates of the junctions. This also means that processing the updates was difficult, because you don't know whether end coordinates are included. It was decided that road element geometry updates only include intermediate coordinates. Furthermore, such an update must include all intermediate coordinates of a road element, not just the ones that are changed.

### 4.2.5. Conversion issues due to wrong mapping of data elements

During the conversion of a GDF map to the proprietary Siemens VDO format, several optimizations are done. This happens typically with road elements. The role of the plug-in is to translate an update of an original feature to zero or more updates in the proprietary features.

An example is a geometry update of a road element. If this road element has been split into multiple proprietary 'chains', the updated coordinates have to be assigned to the individual chains, in the correct order. Also, in some cases, an update of the direction of traffic flow of a road element could lead to a wrong update. For this purpose, a sequence number was added in a look-aside table to complete the information on specific road elements.

The process of updating the map would be much easier if there were a one-to-one mapping between the features of the map supplier (as delivered in GDF) and the features in the proprietary map.

### 4.2.6. Update of long-distance route planning network

For long distance planning the route planner is using a 'high level network'. This is a subset of the road map created during conversion of the map. If the route planner is to take into account updates of roads that are part of the high level network, the updates have to be mapped to this network as well. For the test site, it was chosen to do this in the plug-in. An update (of the delay, direction of traffic flow) of a road element was transmitted multiple times to the vehicle. If the mapping to the higher level networks would be done in the navigation system, this would save bandwidth but require more processing.

### 4.2.7. Handling of correlated dynamic updates

If there is a traffic jam on a highway, several road elements might be affected. In this case, a notification of delay will create a considerable amount of updates. It would be more efficient to send, e.g., only the first and the last road element affected plus a total delay. The receiver can then determine all the road elements in between, and assign delays to individual road elements, if it wishes so.

In addition, an update may include a delay on a road element, which is taken into account by the route planner. In fact, on a two-way road, the delay may be different in the two directions. Therefore, it must be possible to assign a direction to a delay update. This was not supported in the current implementation of the test site.

### 4.2.8. Consistency of maps after process of updates

During the off-line conversion of a map to the proprietary format several quality and consistency checks are done. Only changing attributes of existing features introduces a potential problem. For examples, the direction of traffic flow is a vital attribute for navigation map consistency. It is dangerous to do this without further checking consistency after the processing of updates. It was suggested to perform all translation and checks as soon as an update is created at the ASC, then store the result, and make the translated result available to the user. This was not implemented in the implementation of the ASC, so application specific consistency checks had to be done in the in-vehicle client.

## 4.3. Validation of the ActMAP framework

The ActMAP framework should provide a significant improvement on the quality and usability of in-vehicle ADAS- and navigation applications. Today a typical map update takes place via the distribution of a new map CD once every 6-12 months. The comparison to the status quo provides a judgement of the technological step forward that is done by the ActMAP system by reducing this distribution time significantly and enabling new functionality by providing dynamic map related information.

### 4.3.1. Current map change rates

Due to the current map product delivery process, maps used in today's in-vehicle systems can not be completely up to date. Current systems are media-based and as described in the paragraph above this causes a delay of several months, leading to outdated information. However, an even larger effect on the ageing of the map is caused by the changes taking place in the "real world". On average 15-20 % of the information available in the map is changing in a year.

As the ActMAP system is looking for high update rates, it is relevant to know the amount of changes per year for a complete country. In the context of ActMAP validation, an analysis of change rates has been done by Tele Atlas. Over a period of half-a-year, the change rates of two different regions have been analysed:

a. Luxemburg: Region with full coverage with focus on map updating only.

b. Spain: Region with partial coverage with fast growing coverage.

The results in terms of change rates can found in the table below:

**Table 2: Change rates of two different regions**

| Region | Inserts | Delete | Changed | Total |
|---|---|---|---|---|
| Spain | 14% | 6% | 10% | 30% |
| Luxemburg | 5% | 4% | 6% | 15% |

The percentage values indicate how much database records have been inserted, deleted or changed relative to the total amount of database records. A first conclusion that can be drawn is that for areas with full coverage approximately half the number of update operations can be expected than for areas with partial coverage. A second conclusion is that in areas with partial coverage the majority of update operations are inserts (obviously). And finally, for fully covered areas there is still a significant amount of insert and delete operations to be considered.

### 4.3.2. ActMAP Service chain

The general concept of a service chain providing updates from a map centre or a LBC centre via a service centre to in-vehicle clients is the most important basis of the ActMAP framework.

Eleven update delivery chains in the ActMAP test environment incorporate a broad range of update types (map updates, LBC updates), time frames (from static to highly dynamic), update suppliers (2 map vendors, 5 LBC content provider simulations), and update users (3 navigation applications, 2 ADAS applications). Also different service centre functionalities are used, e.g., area filtering with clipping towards complete partitions and clipping towards complete transactions, aggregation of updates, and version control for in-vehicle maps.

All chains are based on updates in ActMAP standard exchange format. Two update suppliers (TMC, VMS) and two update users (Siemens VDO, NAVIGON) are using plug-ins to convert from proprietary format into ActMAP standard format or from ActMAP standard format into proprietary format.

This concept was been validated via a set of quantitative indicators described in the validation plan [1]. In this section, we refer extensively to these indicators.

4.3.2.1. Core result statements

- Updates are best processed if their size is below 1 MB. This is mostly a result of the interface and service centre implementation. The ActMAP interface is scaleable and should be able to handle bigger updates.
- Provision of data is application independent in the examined test applications
- It is possible to transfer updates from the data provider to the user via the ActMAP service centre in a standard way.
- Problems can occur if version information is done at the ASC because the vehicle does not acknowledge the reception of data. → Recommend acknowledgement message.
- The ActMAP update interfaces are generic and independent from data supplier and applications.

4.3.2.2. Indicator summary

State in summary: we tested approx. 7000 Tele Atlas map updates + 6000 NAVTEQ map updates + 20 static LBC updates over 10000 dynamic LBC updates, giving the following results.

Concerning the complete ActMAP chain, it was found that generally no data is lost in the ActMAP system (Chain-Ind. 1). All loss of data during validation could be accounted to communication and implementation problems. Communication problems can be detected with standard mechanisms like TCP. Implementation problems are detected in the software verification.

The ActMAP interface has proven to be scaleable (Chain-Ind. 2). The size of the updates, processed in the test environment is in the range from kilobytes to several megabytes. Limitations in processing updates with sizes of several tens of megabytes are due to implementation limitations of the test environment. The interface should allow bigger updates.

The updating interfaces are generic (Chain-Ind. 3). The provision of data is application independent (Chain-Ind. 5).

From a general point of view it should be observed that it was possible to collect the new information to be delivered, to pack them in a standard format, and to send them to the ASC as a new update.

### 4.3.3. Push/Pull strategy

The ActMAP framework includes several ideas about strategies where a map actualisation can be either initiated by a server ("push") or by a client ("pull").

4.3.3.1. Core result statements

- Pull strategy was demonstrated to be more reliable than push approach.

- Push strategy may encounter problems regarding provisioning of updates, because the vehicle does not acknowledge the correct reception of data.
- Push strategy has a provision delay which is on average about 1 second. Compared to update frequencies typically used for the pull approach, this is much faster.

4.3.3.2. Indicator summary

Both push and pull strategies have been proved to work with high reliability in the different test sites in which one or both approaches were implemented. As in the pull strategy the vehicle (i.e., a single user) is calling the ActMAP Service Provider, there are some advantages on the side of connection establishing resulting in time saving during download request. However in both implementation approaches where it was applied (BMW and CRF test sites), the push technique appears to be a feasible way to keep a moving car up-to-date, so that the car itself can receive (for example while moving) the latest map features' updates, as soon as these arrive to the Service centre.

### 4.3.4. Plug-in concept

The plug-in concept is introduced, as not all systems are capable or willing to convert real-time updates from a standard format into a proprietary representation. It allows such systems another way of using online updates from the ActMAP system. The plug-in concept describes the idea, that certain data conversion routines that would be normally run in the vehicle client could also be moved to the service centre. The focus of the validation of the plug-in concept is based on compatibility with different up-date strategies, on one side, and interoperability between the service centre and the proprietary application.

4.3.4.1. Core result statements

- A plug-in can be used to deal with differences between the map format of the map supplier and the (often highly optimized) map format of the in-vehicle system. Depending on the type of differences this can be easy or (very) hard to do.
- A plug-in can be used to check if an update does not break (proprietary) consistency constraints of the proprietary map.
- If a plug-in needs a lot of resources (processing, memory, database access) for the translation and checking of updates, it makes sense to do this translation in the service centre (once) as soon as an update becomes available, and store the result in a proprietary format.
- When using the service centre based plug-in translation the interface between the plug-in and the in-vehicle system is proprietary. On the other hand, the plug-in exchange format can be highly optimized.

4.3.4.2. Indicator summary

Most existing proprietary map formats have been designed for compactness, fast access and optimized for the navigation functions. If the capability to incorporate on-line map updates was not taken into account from the start, the full processing of update information, both in a plug-in and in the in-vehicle system, will cost a lot of effort, if possible at all. To fully benefit from on-line map updates, the format of the in-vehicle map needs to be (re)designed with this feature in mind. Adding (dynamic) attachments to the existing road network is feasible now.

### 4.3.5. Selection criteria

The functional requirements [2] specify that updates shall be selectable according to: a selected area, a specific type of information, a specific accuracy, a specific priority or a combination of them. According to the current specification, this selection is performed by the service centre.

#### 4.3.5.1. Core result statements

- Selection criteria are useful for all update types if baseline map and update come from the service centre.
- Filtering is one of the most difficult challenges for an ActMAP system
- Update records do not always contain all the information needed for selection
- Additional transactions have to be transferred to insure map consistency

#### 4.3.5.2. Indicator summary:

At a first glance, filtering updates seems to be a simple task. During the implementation and validation phase of the project, however, filtering was found to be one of the most difficult challenges for an ActMAP system. When receiving an update request containing filter criteria, the ASC first has to select those transactions that fulfil the criteria. As a consequence, it might have to select additional transactions that the in-vehicle application needs to maintain map consistency.

The first selection can be done easily if the selection criteria are attributes of the update records themselves such as feature class or update type. Other filter criteria like area (e.g., polygon) or road class are not necessarily part of the update records. Those attributes have to be made available to the ASC by other means. One option is to look up the attributes in a map database, however also considering the change history of the attributes.

The selection of additional transactions for map consistency can either be done by clipping towards complete partitions or implementing transaction dependencies. With clipping towards complete partitions, the whole update for a partition must be transferred as soon as a single feature in the partition fulfils the selection criteria. In many cases, the same amount of updates will be transferred, as would be the case when selecting only by partition without update filtering. More filtering functionalities are described in D3.2 [5] but not all are implemented.

### 4.3.6. Partitioning

The idea of partitioning could be considered as a subset of the selection criteria but in a more restrictive way. Partitioning in the definition of the ActMAP framework means that updates are only made available in certain geographic partitions, i.e., that if an update for a certain geographic point is requested, it will be provided with an update of the whole surrounding region.

#### 4.3.6.1. Core result statements

- Partitioning based on administrative area order 8 is a convenient way to support data reduction for online delivery
- Partitioning size is a trade-off between ease of geographic definition and size
- Partitions based on GDF administrative order 8 areas change more frequently in areas under development. Partitioning in fully covered areas is more stable but not permanent as administrative areas may change over time.

- Having partitions not based on administrative areas is difficult for map providers and will lead to individual proprietary solutions
- Location based service providers are not always organising the data according to predefined partitions

4.3.6.2. Indicator summary

Dividing the database and update delivery into predefined areas is a useful way in making a pre-selection. Some database updates cross partition boundaries and therefore adjacent partitions have to be downloaded from the client in order to keep a consistent map database. Updates crossing partition boundaries result in fragmented updates. The amount of fragmented updates is however limited and does not lead to large problems. By analysing the size of the different partitions and using compressing techniques an acceptable definition of the different partitions can be identified. Both map suppliers have identified GDF order 8 areas or a combination of several GDF order 8 areas as an acceptable definition. Additional testing should occur in the areas of third party data suppliers and LBC suppliers as they are not very aware of the partitioning concept.

### 4.3.7. Permanent IDs / location referencing

An important aspect for incremental updating of map databases as well as attaching of (dynamic) information to a map is the way how a map entity or attachment is identified and how the relation between an update and/or attachment and the corresponding map database entities is established. There are two basic solutions: permanent and unique identifiers of the database entities or map-based location referencing.

4.3.7.1. Core result statements

- Permanent identifiers can be used for referencing incremental updates to the baseline map
- Permanent IDs did not change during the time frame of the project

4.3.7.2. Indicator summary

Based on a discussion of the pros and cons of both methods, the ActMAP consortium has decided to use permanent IDs to reference incremental updates to the baseline map [5]. Three test sites have analysed the use of permanent ID's and none has detected changes or re-use of permanent IDs.

For third-party data or POI information ActMAP allows both methods, where usage of permanent IDs is the preferred method to be used in the service centre for versioning of the updates. Location referencing is foreseen for attaching information to the map (either on the server or on the client side) when permanent IDs are not available in the centre or in the vehicle database.

The third-party POI Data used in the project contains permanent IDs. No change in those IDs has been detected.

### 4.3.8. Location referencing

Map-based on-the-fly location referencing creates a location reference that can be decoded relative to the receiver's digital map using certain map characteristics, e.g., geometry, connectivity, classification. Unlike table-based location referencing, it is not necessary to store additional IDs in a digital map. In the ActMAP system, new location referencing technologies, e.g. AGORA, ROSA, are used to attach updates without IDs to the in-vehicle map database.

4.3.8.1. Core result statements

- Location referencing is useful for all update types if baseline map and update come from the same provider and permanent IDs are not available.
- ROSA location referencing codes alone are reasonably compact, occupying 8% of POI update data, with XML-Tag: 50% of the data
- If updates come from a different provider than the baseline map, location referencing is useful for data where duplicate entries due to matching errors are acceptable (e.g., POIs).

4.3.8.2. Indicator summary

For the tested Tele Atlas POI data updates for the Tele Atlas baseline map, location referencing codes were a perfect substitute for permanent IDs. The ROSA code alone occupies 61 bytes out of an average 757 bytes per POI update (8%). With the XML-tags around the ROSA-code, it makes up almost 50% of the uncompressed data.

### 4.3.9. Update exchange format

A major part of the ActMAP framework is the delivery of map and LBC updates in an open standard format that is based on XML (see deliverable D 3.2 [5]). The underlying data model of this update exchange format is derived from the GDF (see ISO GDF) data model.

4.3.9.1. Core result statements

- The neutral, XML-based Update Exchange Format has been proven as appropriate for update delivery in conjunction with compression techniques.
- In combination with state of the art compression techniques the update files can be delivered in a very efficient way (worst case observed was a few less than 4 kBytes for Tele Atlas only).
- The average compression ratio observed for the baseline map DEU_2003.10_MN is 70 % (minimum compression rate 52%, maximum 99%).
- The number of update per KByte in the update exchange format is proportional to the number of individual updates in an update delivery.
- Processing of XML files is feasible on today's navigation systems and PDAs, if their size matches the available system resources.
- Violations of the ActMAP XML schema can be effectively prevented by integrating a standard XML parser into the update delivery process after any component, that is either creating or modifying an update delivery.
- Necessary change in the ActMAP XML schema: the schema should allow update deliveries that includes no update collections as a result of a client request to the service centre for an area that does not contain any updates.
- For countries such as Germany that are already fully captured by map vendors, the majority of tested updates for existing roads concern attribute changes.

4.3.9.2. Indicator summary

The validation of the update exchange format has been performed by measuring and calculating statistics about the update deliveries between map centres, service centre and test sites. The underlying ActMAP XML schema has been proven as feasible and efficient way for update deliveries throughout the ActMAP service chain. At the client side there are some special cases, for which minor modifications of the ActMAP schema are to be done. In combination with state of the art compression techniques the update exchange format provides an efficient way to exchange updates. The number of updates per KByte increases with the number of individual updates in a particular update file. An analysis of the compression ratio of the update files delivered has shown that the average compression ratio is 70% (observed for the baseline map DEU_2003.10_MN, minimum compression rate 52%, maximum 99%).

It has also been proven that the processing of XML files is even feasible on today's navigation systems and PDA's, provided the file size matches the available system resources. In order to prevent effectively violations against the ActMAP schema, it is strongly recommended to include a standard XML parser into the ActMAP delivery chain. The parser validates each update delivery against the ActMAP schema and can be used as output quality check after each component, which is creating or modifying update deliveries.

Another finding is that in countries that are fully captured by the map vendors, the majority of updates were in average related to attributes of existing road features.

### 4.3.10. Dynamic aspects

An in-vehicle application should only receive information that is (still) useful. Furthermore, a dynamic update may be overruled by a new update (an adaptation). An adaptation may include a change of the (expected) duration of the update, a change of an attribute inside the update, and even a change of the features involved in the update. In any case, it is likely that an adaptation contains a lot of redundant information if the original update would still be available. Since bandwidth usage is an important issue, adaptations are good candidates for data size reduction.

4.3.10.1. Core result statements

- The ActMAP framework allows dynamic updates of different durations. For highly dynamic updates a push strategy is preferred to reduce delays.
- Message management (e.g., deleting old updates) needs some special attention.
- The concept of adapting existing updates (with aggregation and version information) reduces the size of updates, but also puts a high demand on the whole update chain. Extra processing is required at the service centre, and it works best if the updates from the update supplier are really up-to-date. Improvements to the concept of adaptations are possible.

4.3.10.2. Indicator summary

Dynamic updates were tested in several test sites of the ActMAP test implementation, both with the push and the pull update strategy. In all cases the received updates were still useful at the time of reception, provided the filter criteria for the duration were set correctly. Using the ActMAP update exchange format, it appeared to be possible to generate several types of dynamic updates

- Temporary updates, with a typical duration of days or more.
- Dynamic updates, with a typical duration of 15 minutes and more
- Highly dynamic updates, with less than 15 minutes duration.

Partitioning for dynamic updates was not implemented in the test sites. That means that all dynamic updates of one update provider are part of one partition.

In case the pull strategy is used, a typical scenario is that an in-vehicle system will request a full dynamic update after switching on, and then with regular or irregular intervals ask for incremental updates, only providing the differences with the previous situation. During testing the average size of an incremental update was one fourth of a full update, without losing information.

The response time for a full TMC LBC Provider update was quite long (15 seconds, compared to 3 seconds for an incremental update). For a full update, the ASC needed to go through all stored updates.

To relate different updates to each other, a unique event ID needs to be assigned to each update transaction. The TMC LBC Provider is using the TMC Problem Location as the event ID. To be really unique, probable more needs to be added, at least the direction.

The mechanism of aggregating update transactions with the same event ID in subsequent updates was working.

Every event contains a duration start, duration stop and expiration time. Usually events have a duration that starts just before the time of the update. In that case adding the duration start costs bandwidth, but does not give much information. It is more efficient to only include a duration start time if it is in the future.

The duration end was in all cases the same as the expiration time. If used in this way it does not add information. It should indicate when the dynamic update is expected to end. If unknown, it seems better not to provide it and only give an expiration time.

To have some continuity in the dynamic updates, a refresh should occur before the updates expire. In case of a broadcast or subscription, the service centre is responsible that a refresh is sent to the in-vehicle system in time. In case of client-server, the in-vehicle system is responsible to send a request for an incremental update. The system may choose to do this just before one of the updates expires, or when it would need new information.

Finally, explicit cancelling of events was not implemented. They can be used to delete events before they expire, which will improve the flexibility of the dynamic updates.

### 4.3.11. Summary of the validation results

The test implementations realised by the ActMAP partners have proven the technical feasibility of a complete ActMAP system for the distribution of map updates. The systems showed good performance and good reliability. As in most software development projects, minor problems like data loss have been detected in the validation phase and have been mentioned in this report. Most errors could be traced down to implementation errors and solved during the validation phase.

There was also a highly positive feedback from the user forum. Today, providers of location-based content have to convert their data into many formats for the various navigation systems on the market. From their point of view, a standard ActMAP format for the distribution of their data to many different systems could substantially reduce their cost and improve their distribution strategies. The use of a standard exchange format also opens the door to the public authorities' databases especially knowing that European-wide initiatives, such as EuroRoadS, are developing harmonised public database for their infrastructure.

The usage of an update exchange format based on XML together with standard compression techniques resulted in data sizes that can be transferred via mobile phone networks within an acceptable time, e.g., updating speed information via GPRS from the ASC to the in-vehicle application could be done in real time. The ActMAP mechanism and exchange format was developed assuming that an off-line physical support or a TCP/IP connection was available. This allowed the consortium working at a higher layer and therefore independently of the type of communication link available. While off-line physical supports already exist, one can expect that, in the future, mobile data communication will be widely available at a lower cost.

The amount of updates that were created by the map suppliers was surprisingly high. One of the reasons is “normalization” works on the map databases that implement, for example, new naming conventions. Another reason is that additional information, not due to a real-world change, is added to existing map entities. Tele Atlas, for example, added the street address and postal code to virtually all points of interest in the Stuttgart area. ActMAP is therefore contributing to the completeness of the maps as much as its up-to-dateness. This trend is expected to continue as map suppliers and location-based content providers are adding new attributes to the existing features. As a result, the database design in an ActMAP service centre has to be scaleable. In addition, solutions are proposed to prioritise critical map updates as compared to other “normalization” updates due, for example, to new naming conventions and therefore use more efficiently the limited capacity of the communication link and its related cost for the end-users. New filter criteria are considered to only select the information needed for a specific application.

Filtering was found to be one of the most difficult challenges for an ActMAP system. Some filter criteria like area or road class are not necessarily part of the update records and have to be made available by other means. Moreover, additional transactions that do not fulfil the filter criteria must be sent to the in-vehicle application to maintain map consistency. Different solutions have been identified in order to mitigate this issue, but none of them was tested during the project. This is an important item considered for future research. Another challenge for future research is the optimization of in-vehicle physical storage formats (PSF) to enable an efficient map update. An important initiative originating from the German car manufacturer industry aims to solve this problem by evaluating a new harmonised PSF by the end of 2008.

# 5. Beyond the ActMAP project – an outlook

The ActMAP project, carried out by an industry consortium of car manufacturers, navigation system suppliers and digital map providers, has investigated the technical feasibility of online delivery of incremental map updates to in-vehicle applications. The main conclusions based on extensive prototyping and validation are [7]:

i. Current map-based in-vehicle applications such as navigation will significantly benefit from online incremental updating their digital map databases.
ii. The availability of online up-to-date map databases in the vehicle is seen as a necessary condition for the successful implementation of map-based ADAS.
iii. Incremental updates of in-vehicle map databases in general and the ActMAP approach in particular are feasible from a technical point of view.
iv. The ActMAP approach is also feasible for attaching a variety of location-based contents to in-vehicle maps. These can be static or dynamic information.
v. The update delivery using a standardised XML format in conjunction with state of the art compression techniques results in reasonable amounts of data to be transferred.
vi. Current Physical Storage Formats (PSF) have been optimised for compactness and fast access, while not considering requirements for online incremental. Depending on the proprietary PSF used by the system provider, the processing of incremental updates can be very complex, if possible at all.

## 5.1. Identifying the enablers

Based on these findings the conclusion is drawn that the industry can start using the ActMAP mechanisms for online delivery of incremental updates to in-vehicle map databases. The market acceptance of the concept will not happen in one-step, but most likely progressively, as it was the case for other ITS technologies. As the need for up-to-date maps increase, car manufacturers and equipment providers will have to agree on a harmonised solution for map updating. The ActMAP approach will be one contender among other proprietary standards and the standardisation of the concept should facilitate its acceptance. Moreover, the need for map updates will be strengthened by increasing innovation demands and the steady development of the navigation and ADAS market. On the one hand, successful deployment furthermore is dependent upon the availability of several enablers, which will significantly lower technical and commercial barriers that still exist today:

a. An open and sound industry standard for the delivery of incremental updates from source to destination will ensure a mature market
b. Viable business models for incremental updating
c. Delivery of incremental updates by map vendors
d. Delivery of safety related information at low costs or for free by government and other location based content providers with a reliable method to attach the information to a map
e. Infrastructure for high volume (or low latency) update delivery
f. Sufficient read/write storage available at the in-vehicle system to store and process updates
g. Physical Storage Format(s) for in-vehicle maps that are designed for incremental updates
h. A standard physical storage format for all in-vehicle maps

## 5.2. The road to better maps

How can these enablers be realised? Concerning (a), upon the completion of the ActMAP project, the results will be made public to the whole industry. In parallel they will be submitted to ISO TC 204 working group 3 as proposal for a new standard. Finally, the ActMAP consortium will continue to work on this subject, to fine-tune the ActMAP approach and bring it on a commercial stage. This also includes the development of business models, which will address enabler (b).

In parallel, all players in the service chain for incremental updating have to prepare their technology. The map vendors representing enabler (c), have to change the way they produce and update digital maps today from a fixed schedule of four times a year delivering full maps towards a more and more continuous delivery of individual map information. This will not happen in one step, but starting with updates for most important database information only (e.g., road attributes) and will gradually be extended to the full scope as demanded by the market.

If in addition to the mapping industry, safety related information such as weather, traffic information, construction sites, dynamic speed limits is available from government and other location-based content providers, the pressure will increase to make this available to in-vehicle systems, in particular ADAS applications (d). Incremental updating is one way of doing it.

Also the necessary infrastructure for update delivery (e) will not be available in the near-future. Instead, it will most likely start with delivery of updates via physical media such as CD, DVD, memory stick maybe in conjunction with downloading via Internet, or cables being installed at garages to perform updates during maintenance etc. Only in a second step the wireless technologies such as UMTS, WiFi, Bluetooth, DSRC, DAB and sattelite broadcasting will be adopted on a medium to large-scale, also enabling dynamic updates. As ActMAP is communication link independent, any of these technologies could be used to receive updates.

The issue of read/write storage for in-vehicle systems as mentioned by (f) is being solved with the introduction of Hard Disc Drive (HDD) navigation systems in the vehicle. This has already been adopted in Japan and will soon be followed by Europe. For personal navigation devices this problem is not relevant, as the state of the art storage medium is a read/write memory card.

Enabler (g) seems to be a very challenging enabler for adoption of incremental updates. A logical consequence of HDD based in-vehicle systems is the desire for new update concepts, which has definitely an impact on current physical storage formats. Many system suppliers already seem to work on such update concepts and are discussing incremental updating for future systems. It is expected that, during market introduction, the second generation of HDD systems will include minimum capabilities for incremental updating at in-vehicle system side.

Finally, the achievement of a standard physical storage format for all in-vehicle maps (h) in conjunction with (g) would be the ultimate enabler for incremental updating. It would allow to deliver one standard update format to be directly processed by the in-vehicle application without the need to translate updates back to a proprietary representation. The German automotive industry has recently launched a new initiative to achieve such a standard PSF and it can be expected that it will have a successful outcome around the end of this decade.

From a realistic point of view, it can be expected that online incremental updating will be introduced in several stages:

1. Updates of whole in-vehicle map at least once per year (is being introduced now, e.g., C-IQ from Siemens VDO)
2. Region-wise full updates several times per year
3. Add additional new content to in-vehicle maps several times per year
4. Dynamic updates and map attachments via a wireless communication channel (e.g., safety related)
5. Frequent incremental updates of important map features only (change existing attributes and geometry, no NEW or DELETED features)
6. Incremental updates to full extent necessary in high frequency (for all database features being demanded by the Industry)

On the other hand, it can be expected that online incremental updating will be introduced in several stages. This is illustrated by Figure 13, presenting as such a likely roadmap for online incremental updating. The intensity of the colours indicates the degree of introduction, from first implementations (light colour) to fully established market (dark colour) for both the enablers and introduction steps.

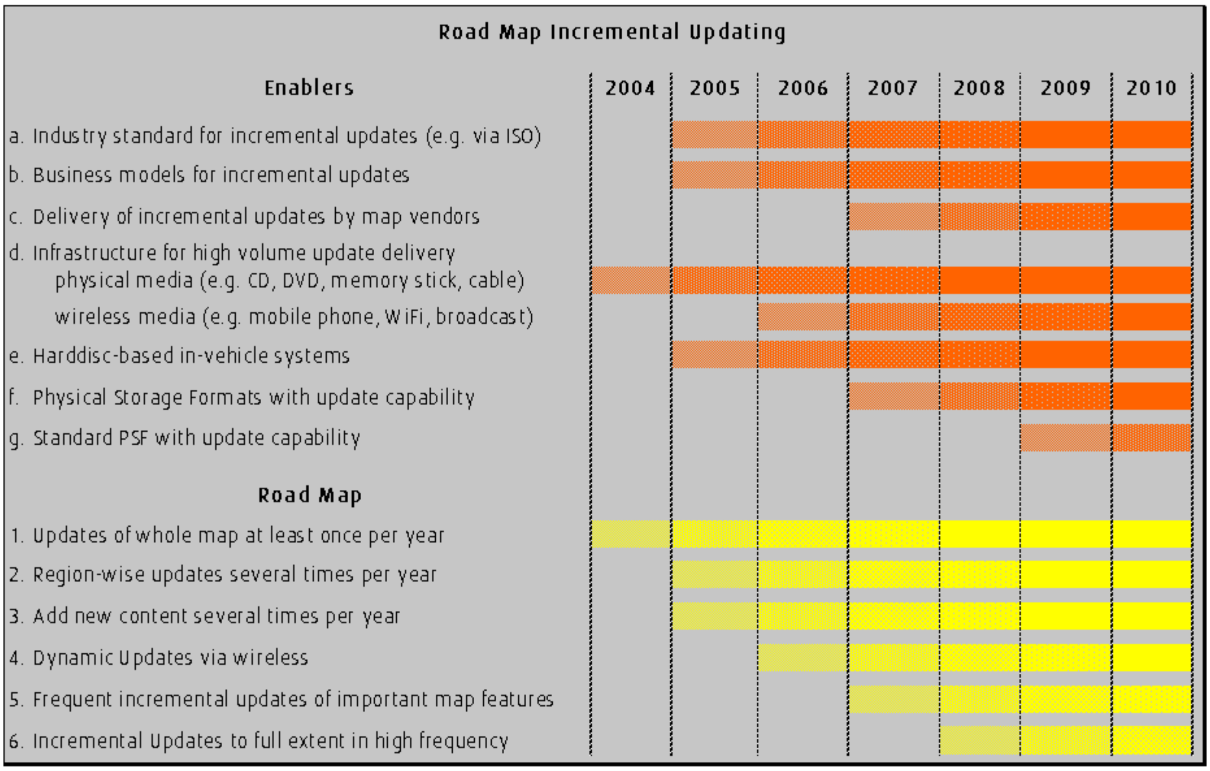


**Figure 13: Enablers and roadmap for incremental updates**

As mentioned earlier, online incremental updates are an important prerequisite for the successful introduction of new in-vehicle systems, in particular, ADAS. The introduction of them will however go hand in hand with the development of the corresponding databases having higher accuracy and new content such as slope, altitude, curvature, and traffic signs. With both prerequisites in place, new in-vehicle systems will grow up. In other words, new applications using more accurate and dynamic maps will benefit from increased system functionalities and robustness and will enable road users in the future to drive more safely, comfortably and economically.

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# Conclusions

During the ActMAP project, the consortium has gained an extensive knowledge on the implementation of a standardized solution for the publication and distribution of map updates and its integration on the in-vehicle digital map database for navigation and ADAS applications.

The main goal was to develop a standardized exchange format for facilitating the interaction between different parties in the whole map updating chain, i.e., map providers, location-based content providers, service centres, and in-vehicle map database. By doing so, the consortium hopes to build a wider market for the provision of map updates opening the doors to location-based content providers and their dynamic or static added-value data. This will increase the potential of the emerging applications for in-vehicle end-users.

The standardization process of ActMAP core specifications has now started. The consortium believes that an open standard will ease the way the maps are distributed as compared to today's time- and resource- demanding process. As a major consequence for the end-users, the price of maintaining an up-to-date map database in the vehicle will decrease dramatically. On the other hand, the baseline maps published by the map providers do not need to be published at the same rate as today, i.e., every 6-12 months. Instead end-users will be able to access the latest updates on-line. The ActMAP framework will allow incremental updates related to layers and partitions, which means that only updates related to the visited regions will update.

A special role in the context of open standard is played by the providers of location-based content (LBC). One benefit of the ActMAP process specification is the integration of third-party content to the whole system. So the implementation of a data interface and the integration of non-map-vendor data can be much easier for the user of the system. As there was no LBC supplier in the ActMAP consortium, an intensive validation of LBC related issues was problematic. Nevertheless the consortium implemented "pseudo" LBC centres to simulate this part of the system and to validate the impact and benefit of the LBC integration. The consortium hopes that the work performed and the dissemination of the concept will convince or allow more location-based content providers to adopt this common standard and to contribute to the improvement of the digital map market in quality and competitiveness.

During development of the ActMAP standardized exchange format, the consortium has been confronted to issues related to version information, layering and partitioning, format compatibility, filtering, permanent IDs and dynamic aspects of updates. This work has resulted in a series of key aspects of ActMAP system answering most of the issues encountered by the consortium. Thus, the new concept is built on a series of validated key aspects presented in this paper. The consortium has therefore built the basis for further development within each of the companies involved in the project and hopefully other key players. The few additional aspects not validated, as well as the definition of the services and business models supporting the ActMAP system have been left for further investigation.

The standardization of information exchange between different parties has been relatively delicate since major map providers and equipment providers have developed proprietary solutions. ActMAP exchange format translators, called plug-ins, are essential for the future acceptance of the open standard. In some cases, it has been difficult to achieve a one-to-one relationship between ActMAP updates and proprietary updates. Some of the translations need a considerable amount of computing resources. It has been therefore considered to use caching of proprietary updates at the ActMAP service centre. This kind of solutions is hopefully temporary until the proprietary physical storage format is adapted to the new standardized format, which seems to be a next joint step for the main actors in Europe.

On the data acquisition side, the issue that the key players are facing is the costly acquisition and collection of data and its maintenance. Indeed, the number of attributes on the maps and their accuracy has increased dramatically in order to answer the needs of new ADAS and navigation applications (number of lanes, sign posts, speed limits, etc…). This increases the importance of finding novel and cost-effective ways to realise map data acquisition. The ActMAP consortium is now focussing on a cooperative environment between road users and map providers collecting, analysing and distributing in-vehicle digital map incremental updates. Using this combination, the road users will enhance the map updates process for all the other road users using intelligently the communication infrastructure and the in-vehicle map database and sensors available.

# References


[1] Bracht, A. et al: Validation plan, IST-2001-34141 ActMAP Project, Deliverable 6.1, Brussels, July 2003.

[2] Löwenau, J. et al: Final map actualisation requirements, IST-2001-34141 ActMAP Project, Deliverable 2.2, Brussels, September 2004.

[3] Meier, J. et al: Test environment description, IST-2001-34141 ActMAP Project, Deliverable 4, Brussels, June 2004.

[4] Meier, J. et al: Implementation and integration report, IST-2001-34141 ActMAP Project, Deliverable 5.2, Brussels, October 2004.

[5] Otto, H.-U. et al: ActMAP specification, IST-2001-34141 ActMAP Project, Deliverable 3.2, Brussels, September 2004.

[6] Otto, H.-U. et al: ActMAP ISO input, IST-2001-34141 ActMAP Project, Deliverable 3.3, Brussels, October 2004.

[7] Aleksić, M. et al: Validation report, IST-2001-34141 ActMAP Project, Deliverable 6.2, Brussels, September 2004

[8] Hummelsheim, K.: Location referencing change requests for ISO, IST 20457 – AGORA Project, Deliverable 6.4, Brussels, February 2003. http://www.ertico.com/activiti/projects/agora/agora.htm.

[9] Otto, H.-U. et al: Validation Report, IST 20457 – AGORA Project, Deliverable 5.2., Brussels, December 2002.

[10] Demir, C.: 9th World Congress on ITS, "A New Location Referencing Method for Unique Reconstruction of an Object on a Second Map", technical paper 2175, Chicago, October 2002.

[11] ISO14825:2004 , Intelligent Transport Systems - Geographic Data Files - Overall Data Specification (GDF4.0), ISO , 2004-02-15.

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# Appendix A – Deliverables and other outputs

This list provides all the deliverables published by the ActMAP consortium in a chronological order. In bold, the reader can find the most relevant outputs of the ActMAP project:

- D2.2 Final map actualisation requirements
- D3.2 The ActMAP approach (Final specifications)
- D5.2 Implementation and integration report
- D6.2 Validation results

Finally, this report (D1.2 Final report) includes summarised information about the results of the project extracted mainly from the 4 publications mentioned above.

| *Deliverable Code & Name* | | *Contractual delivery date* | *Actual delivery date* |
|---|---|---|---|
| D1.1 | Quality Manual | 06/2002 | 16/07/2002 |
| D7.1 | Project presentation (project summary) | 07/2002 | 30/07/2002 |
| D7.2 | ActMAP project web site<br>Update | 07/2002 | 01/08/2002 |
| D7.3 | Dissemination and Use plan | 09/2002 | 20/09/2002 |
| D7.4.1 | First User group workshop proceedings | 11/2002 | 17/01/2003 |
| D2.1 | Preliminary map actualisation requirements | 11/2002 | 12/01/2002 |
| D6.1-A | Preliminary Validation plan | 05/2003 | 26/6/2003 |
| D6.1 | Validation plan | 5/2003 | 22/9/2003 |
| D3.1 | Specification of actualisation strategies, map components version control and interfaces | 07/2003 | 31/08/2003 |
| D4 | Test environment specification, including test scenario description. | 05/2004 | 18/06/2004 |
| D5.1 | Test environment | 05/2004 | 12/08/2004 |
| **D2.2** | **Final map actualisation requirements** | **09/2004** | **01/10/2004** |
| **D3.2** | **Revised specifications of actualisation strategies, map components version control and interfaces** | **09/2004** | **01/10/2004** |
| **D5.2** | **Implementation and integration report** | **09/2004** | **01/10/2004** |
| **D6.2** | **Validation results** | **09/2004** | **22/10/2004** |
| D7.4.2 | Second User group workshop proceedings ”Final ActMAP user forum workshop” | 07/2004 | 15/11/2004 |
| D3.3 | Standardisation proposal to ISO | 09/2004 | 15/11/2004 |
| D7.5 | Technological Implementation Plan | 09/2004 | 15/11/2004 |
| **D1.2** | **Final report** | **11/2004** | **10/06/2005** |

In addition, four conference papers have been published:

- "ActMAP: Real-time updates for advanced in-vehicle applications" was presented at the 2003 ITS World Congress in Madrid. The paper included the ActMAP concept, requirements, proposed map updating strategies and validation plan.

- "ActMAP – Incremental map updates for advanced in-vehicle applications" was presented at the ITS world congress 2004 in Nagoya. The paper focused on the first implementation results and validation plan.
- "The ActMAP approach – specifications of incremental map updates for advanced in-vehicle applications" will be presented at the ITS European congress 2005 in Hannover. The paper focuses on the specifications of the ActMAP framework proposed for standardization to the ISO TC204/WG3 in December 2004.
- "Results of implementation and validation of the ActMAP incremental map updates for advanced in-vehicle applications" was presented at the ITS European congress 2005 in Hannover. The presentation focuses on the lessons learned from the implementation, and the results of the validation.

All Deliverables are public and available on the website of ERTICO: www.ertico.com

# ANNEX B - Project Management data

The Project has been completed after 32 months. The Consortium has published its final reports for the requirements, the specifications, the implementation and the validation of the ActMAP concept.

**Table 3: ActMAP project budget (€)**

| Participant short name | Personnel | Durable Equipment | Subcontracting | Travel and subsistence | Consumables | Other specific costs | Overheads | Estimated costs |
|---|---|---|---|---|---|---|---|---|
| ERTICO | €236.412 | €0 | €0 | €18.000 | €0 | €8.650 | €141.988 | €254.412 |
| BMW Forschung und Technik GMBH | €281.108 | €0 | €0 | €17.907 | €0 | €8.000 | €201.399 | €299.015 |
| CRF | €179.795 | €16.250 | €0 | €18.000 | €3.500 | €13.619 | €143.836 | €217.545 |
| DCAG | €129.786 | €17.333 | €0 | €16.160 | €0 | €8.000 | €216.309 | €163.279 |
| NAVTEQ | €196.000 | €0 | €0 | €18.000 | €0 | €8.000 | €196.000 | €214.000 |
| Tele Atlas | €281.532 | €8.967 | €0 | €22.951 | €0 | €8.000 | €134.663 | €313.450 |
| NAVIGON GmbH | €400.523 | €8.591 | €19.767 | €18.000 | €0 | €16.000 | €394.802 | €446.881 |
| Siemens VDO Trading B.V. | €199.665 | €3.000 | €0 | €18.000 | €0 | €8.000 | €119.435 | €220.665 |
| **Total** | **€1.904.821** | **€54.141** | **€19.767** | **€147.018** | **€3.500** | **€78.269** | **€1.548.432** | **€2.129.247** |

The total budget shown in Table 3 was underspent by approximately 200 k€.

**Table 4: Resources (hours) spent compared to total resource budget**

| PARTNER | WP1 | | WP2 | | WP3 | | WP4 | | WP5 | | WP6 | | WP7 | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Budget | Actual | Budget | Actual | Budget | Actual | Budget | Actual | Budget | Actual | Budget | Actual | Budget | Actual | Budget | actual |
| ERTICO S.C. | 3229 | 2983 | 0 | | 0 | | 0 | | 0 | | 0 | | 833 | 1086 | *4061* | 4069 |
| BMW AG | | | 771 | 660 | 1349 | 1047 | 578 | 630 | 1542 | 1058 | 578 | 325 | 386 | 410 | *5204* | 4130 |
| C.R.F. Societa Consortile per Azioni | | | 437 | 453 | 1166 | 970 | 437 | 380 | 1822 | 1628 | 437 | 599 | 219 | 495 | *4518* | 4525 |
| DaimlerChrysler AG | | | 346 | 613 | 807 | 690 | 346 | 320 | 923 | 976 | 461 | 690 | 231 | 280 | *3114* | 3569 |
| Navteq B.V. | | | 437 | 399 | 1310 | 889 | 437 | 392 | 1164 | 1075 | 437 | 661 | 291 | 167 | *4075* | 3583 |
| Tele Atlas N.V. | | | 362 | 323 | 1450 | 1444 | 362 | 278 | 1341 | 1445 | 362 | 359 | 242 | 224 | *4120* | 4072 |
| NAVIGON GmbH. | | | 403 | 277 | 1209 | 675 | 537 | 762 | 4312 | 4879 | 403 | 409 | 269 | 235 | *7132* | 7237 |
| Siemens VDO Automotive | | | 426 | 447 | 995 | 803 | 426 | 447 | 1137 | 1308 | 426 | 429 | 284 | 285 | *3695* | 3719 |
| **Total** | 3229 | 2983 | 3183 | 3172 | 8286 | 6518 | 3124 | 3209 | 12241 | 12369 | 3105 | 3472 | 2753 | 3182 | **35920** | **34904** |
| | 92,39% | | 99,67% | | 78,66% | | 102,70% | | 101,05% | | 111,81% | | 115,58% | | **97,17%** | |

The total amount of resources used for the project was around 3% lower than expected. However, beside the WP 3 on specifications and WP1 on management, most of the WPs have overused their resources (See Figure 14).

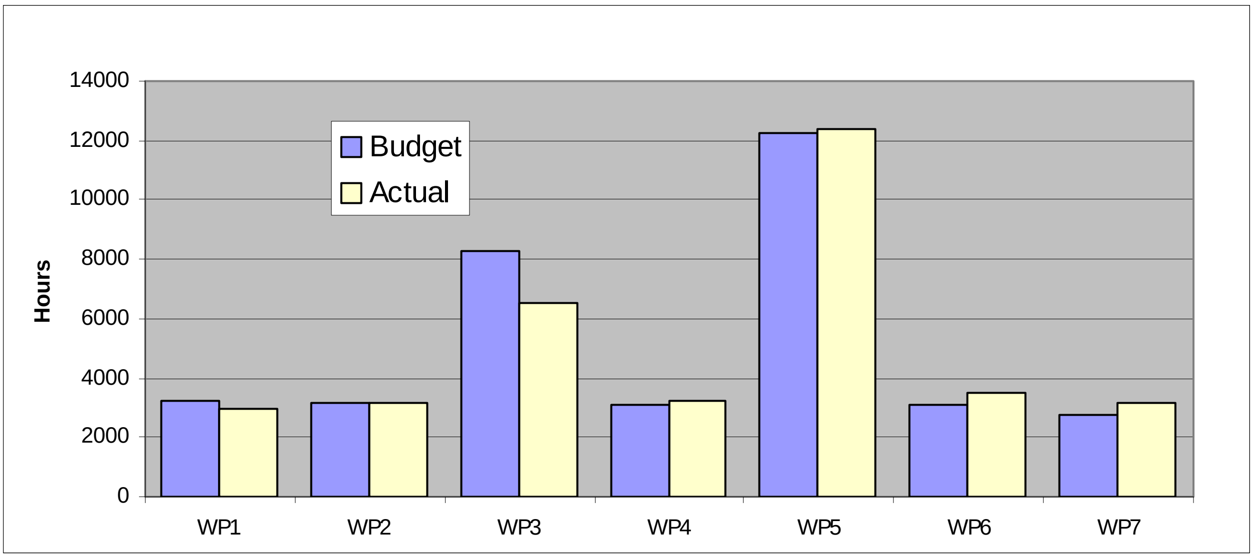


**Figure 14: Hours per workpackages used compared to total budgeted resources**

The same comment holds for the partners (see Figure 15).

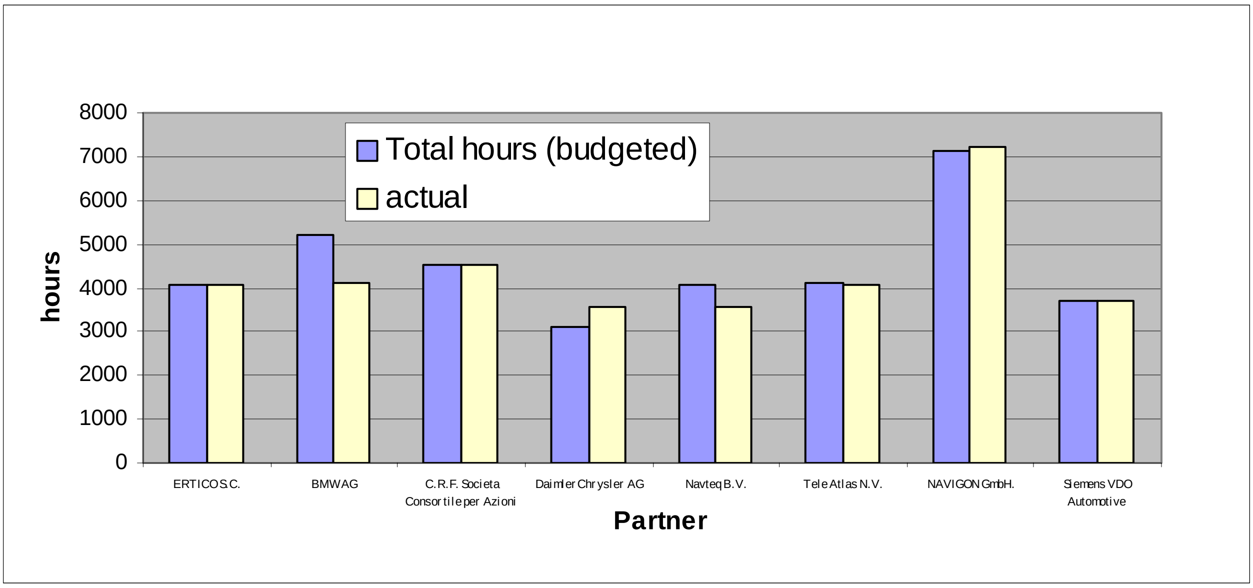


**Figure 15: Hours per partner used compared to total budgeted resources**

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