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TABLE OF CONTENTS

REVISION CHART AND HISTORY LOG	2
TABLE OF CONTENTS	3
LIST OF TABLES	4
LIST OF FIGURES	4
LIST OF ABBREVIATIONS	5
EXECUTIVE SUMMARY	6
1. INTRODUCTION	10
2. TEST CRITERIA OF IMPLEMENTATION CONCEPTS	13
3. IMPLEMENTATION CONCEPTS	14
4. MOBILE PHONE-BASED NAVIGATION	15
5. ASSESSMENTS: MOBILE PHONE-BASED NAVIGATION SYSTEMS	18
6. MOBILE NAVIGATION SYSTEMS	26
7. INDIVIDUAL ASSESSMENTS: MOBILE NAVIGATION SYSTEMS	28
8. AFTERMARKET IN-DASH NAVIGATION SYSTEMS	37
9. ASSESSMENTS: AFTERMARKET IN-DASH NAVIGATION SYSTEMS	40
10. IN-DASH OEM NAVIGATION SYSTEMS	44
11. ASSESSMENT OF IN-VEHICLE OEM NAVIGATION SYSTEMS	46
12. FINDING TEST CRITERIA	52
13. CONSUMER TEST RECOMMENDATIONS	55
14. TEST CRITERIA	55
CONCLUSIONS	58
REFERENCES	59
ANNEXES	60

LIST OF TABLES

- [Table 1: Overview of results](#)
[Table 2: ADAC rating key](#)
[Table 3: Results of mobile phone-based navigation systems](#)
[Table 4: Results of mobile navigation systems](#)
[Table 5: Results of aftermarket in-dash navigation systems](#)
[Table 6: Results of in-vehicle OEM navigation systems](#)

LIST OF FIGURES

Mobile phone-based navigation systems:

- [Figure 1: Navigon navigator on iPhone 4](#)
[Figure 2: TomTom navigator on iPhone 4](#)
[Figure 3: Navigon navigator on Samsung Galaxy S](#)
[Figure 4: Falk navigator Europe on iPhone 4](#)
[Figure 5: Google maps on Samsung Galaxy S](#)
[Figure 6: Nokia maps 3.0 on Nokia E72](#)
[Figure 7: Skobbler on iPhone 4](#)

Handset-based navigation systems:

- [Figure 8: TomTom GO Live 1000](#)
[Figure 9: Navigon 70 Premium Live](#)
[Figure 10: Becker Traffic Assist Z 215](#)
[Figure 11: Medion X4545](#)
[Figure 12: Falk Vision 700](#)
[Figure 13: Garmin Nüvi 3790T](#)
[Figure 14: NavGear RS-50-3D](#)

After-market in-dash navigation systems:

- [Figure 15: Pioneer AVIC-F930BT](#)
[Figure 16: Zenec EGO 2012](#)
[Figure 17: Parrot ASTEROID](#)

In-vehicle OEM navigation systems

- [Figure 19: RNS 510 in the VW Touran](#)
[Figure 20: Carminat TomTom in Renault Mègane](#)

[Figure21: Professional navigation system in the BMW 730D](#)

[Figure 22: COMAND APS in Mercedes](#)

LIST OF ABBREVIATIONS

ABBREVIATION	DESCRIPTION
PDA	Personal Digital Assistant
OEM	Original equipment manufacturer
BMW	Bayerische Motoren Werke
V	Volt
D	Diesel
VW	Volkswagen

EXECUTIVE SUMMARY

Navigation systems influence driving behaviour. To what extent depends on the type of system (mobile/integrated) or type of device. Among the different factors, the type of mount plays an important role. Optimum conditions are provided when the system is fitted at eye-level since here the driver may read all necessary information with a minimum of distraction from the traffic. The head-up display system (tested in the BMW 740D) turned out to be the ideal solution as it projects all important information onto the windscreen. Directional instructions, indication of street names and distance to the next change in direction of travel enable motorists to drive their car without being distracted by the navigation device. The system also has very agreeable voice guidance giving timely instructions in an unobtrusive and clear voice from the vehicle's speakers. In addition, the display in the top section of the dashboard provides orientation as to the current position on the map.

All suction-mount systems attached to the windscreen have potential for improvement. This hinges on the size of the devices and the extent to which they block visibility as well as on awkward mounting systems and cable routings. Cabling is particularly problematic if the antenna is not integrated in the 12V power supply and where an external wire antenna is required for optimal reception of traffic information. This may present an impediment and enhance the risk of distraction in the driver's action radius.

The operation of the system or navigation device must be self-explanatory, i.e. intuitive. To meet this requirement, symbols/graphics/texts must be clear, menu navigation coherent and information at minimum level. Good examples are popular brands on the navigation system market such as Garmin, Navigon and TomTom which have a very user-friendly and easy-to-follow menu navigation concept.

Touchscreen displays proved to be the best for operating the devices. Smartphones are in the lead in this sector with their sensitive surfaces, capacitive screens and very short response times. Among the factory-fitted navigation devices tested, only the VW system has a touchscreen display. All other systems are operated using a joystick or the iDrive system (BMW) placed in the centre console. This input option can be quite tedious and slow but it allows users to enter their data while seated comfortably.

There are great differences in the output quality and quantity of the information provided. Good navigation will influence the driver as little as possible, with the amount of instructions from the voice guidance kept to a minimum. Drivers should not feel irritated by massive amounts of information on the display. Conditions are ideal if the driver is able to take in all the information required at a glance. Here, a 4.3 inch screen is minimum and the key data should be displayed in adequate size.

Moreover, wrong navigation instructions or information have a potential to distract. With systems drawing their information exclusively from the maps provided, the information shown on the display and the current road situation often do not match. In the worst case, wrong or delayed information may give rise to dangerous situations. Drivers may feel doubly insecure if, on top of this, they receive incorrect speed limits. Supporting systems such as traffic sign recognition may help to prevent this. BMW's OEM navigation solution "Professional" proved a good example, since it even recognised temporary speed limits. Only one mobile navigation systems manufacturer tried to provide this function by integrating a camera, but its functionality and reliability were inadequate.

Drivers should not operate the navigation device while driving. All the same, access to various functions ought to be available (e.g. looking for the next petrol station while driving on the motorway with the voice output deactivated) which is why quick access options must be easy and quick to find and operate. Some vehicles provide additional on-board service elements (e.g. mute button or separate key for the search of near-by petrol stations). In mobile navigation devices such items are mostly located at second or third sub-menu level.

A device's or system's route selection is not only based on the underlying algorithm but includes further computation data. Some manufacturers of mobile navigation devices offer different routes depending on the time and hour of the day. This enables motorists to avoid time-related congestion, i.e. the rush hour, if necessary. We did not come across many modifications in the navigation instructions based on changed weather conditions, i.e. the systems did not adjust the time of arrival at the destination to the weather conditions en-route (reduced speed due to wet road).

There is no great difference in navigation systems when it comes to their key task namely navigation itself. They all guide you from A to B! However, good navigation performance mostly depends on considering daytime-relevant traffic density and using traffic information from various platforms. In dynamic route planning, the information

used and the details provided are decisive for being able to drive the distance without any traffic hold-ups or major detours. In this context, the TomTom system continues to be in the fore. TomTom uses traffic information e.g. from mobile network operators to ensure that traffic jams get captured more quickly and precisely even if on small by-roads. It is also essential how the user receives the information. Route changes are not necessarily less stressful. If congestion is imminent on the proposed route, taking the alternative route may not be the wiser decision. The voice message "You are still on the quickest route" has a calming effect. The transmission of traffic information and dynamic route planning are undergoing an important evolution. This is why the results in this category are valid for the TeleFOT project period only. Winners are the mobile navigation devices and the in-vehicle OEM systems. There is potential for improvement as regards the scope and quality of the display in aftermarket in-dash devices. Not all software solutions had live services for all countries and therefore this type of system did not go beyond an average rating.

When comparing the results of the main criteria it became obvious that the equipment components & diversity criterion requires improvement. The devices hardly ever come with user instructions or DVDs and there is no information about the dates of the maps. This is astonishing since the up-to-dateness of maps greatly impacts user satisfaction (cf WP 4.8.2 "Report on consumer survey"). Three systems scored good and very good results in route calculation and calculation times. Only mobile navigation devices are at a disadvantage which is mostly due to the fact that the satellite takes too long to locate the current position. In their key task, i.e. navigating the vehicle, all systems achieved a good rating with the exception of aftermarket in-dash navigation systems whose performance was only satisfactory due to their use of outdated maps. All systems or manufacturers have their own operation philosophy. No matter how different the devices are, their functions become quite easy to remember after using them for some time. All testers found operating the devices straightforward. Some mounting solutions impaired operating and reaching the device. Moreover, if the sun stood unfavourably, this could produce severe reflections on the display and considerably restrict visibility. In the driver distraction category, the OEM navigation devices performed well and came out best. Good view of screen, unequivocal and clear voice guidance from the vehicle-specific speakers as well as few cases of misguidance or incorrect announcements resulted in a good overall rating of the factory-fitted navigation systems. Mobile navigation systems and smartphones are on a similar level but have potential for improvement. This is

definitely the case with aftermarket in-dash navigation systems. Here, driver attention is taken up too much with incorrect announcements and texts/instructions which are too small. Often, unfavourable mounting solutions and insensitive menu navigation are added to these drawbacks.

Listed below is an overview of the results:

Table 1: Overview of results

Equipment components

Mobile phone-based navigation					
Handset-based navigation					
Aftermarket in-dash-navigation					
In-vehicle OEM navigation					
	poor	acceptable	satisfactory	good	very good

Route calculation

Mobile phone-based navigation					
Handset-based navigation					
Aftermarket in-dash-navigation					
In-vehicle OEM navigation					
	poor	acceptable	satisfactory	good	very good

Navigation

Mobile phone-based navigation					
Handset-based navigation					
Aftermarket in-dash-navigation					
In-vehicle OEM navigation					
	poor	acceptable	satisfactory	good	very good

Fittings / usability

Mobile phone-based navigation					
Handset-based navigation					
Aftermarket in-dash-navigation					
In-vehicle OEM navigation					
	poor	acceptable	satisfactory	good	very good

Driver distraction

Mobile phone-based navigation					
Handset-based navigation					
Aftermarket in-dash-navigation					
In-vehicle OEM navigation					
	poor	acceptable	satisfactory	good	very good

1. INTRODUCTION

TeleFOT is a large-scale collaborative project under the Seventh Framework Programme, co-funded by the European Commission, DG Information Society and Media within the strategic objective "ICT for Cooperative Systems".

Officially started on June 1st 2008, TeleFOT aims to test the impacts of driver support functions on the driving task with large fleets of test drivers in real-life driving conditions.

On the basis of field operational tests, TeleFOT primarily assesses the impact of functions provided by aftermarket and nomadic devices, including future interactive traffic services that will become part of our automotive environment within the next five years.

Field Operational Tests developed in TeleFOT aim at a comprehensive assessment of the efficiency, quality, robustness and user-friendliness of in-vehicle systems, such as ICT, for smarter, safer and cleaner driving.

The European market for nomadic devices has grown rapidly over the past few years. A huge variety of different technologies is available. Existing standards relate to the design and development of nomadic devices, but there is no uniform definition of any minimum requirements.

For consumers, this situation is very confusing. This is why organisations all over Europe have conducted tests of navigation systems to obtain an overview of all systems offered on the market. On the basis of these tests, the organisations inform consumers about the different navigation devices available and also about their quality. This will help consumers with their buying decisions and it will also help prevent buying mistakes.

First of all, the aim was to identify the types of devices under review as well as the test frequency and the basic test criteria, highlighting all overlaps in the scope of testing and the assessment criteria applied by the different organisations in Europe. As a result, we established a list of recommended test criteria for the evaluation of nomadic devices.

When selecting the test devices we aimed at including one test field in each system group that partly reflected the market at European level. As far as the OEM solutions are concerned, we tried to include as many integration options as possible. We developed a test device proposal and submitted it to the Consortium in SP4.

This report aims to give an overview of the systems revealing disadvantages compared with other systems while subjected to the same requirements. It also highlights the strengths and weaknesses of the individual devices.

The present 4.8.3 deliverable is the third of three deliverables within SP 4.8. The two other reports, (D 4.8.1 "Review of consumer tests and standards" and D 4.8.2 "Report on consumer survey") were delivered in months 18 and 24. Part of D 4.8.3 was delivered in early November 2009. D 1.3 "Crash test of fitting systems" examined various mounting systems and their crash behaviour in terms of safety. The report was approved to the Commission.

Deliverable D 4.8.3 contains a comparative test of different driver assistance systems. In general, the market for aftermarket systems is a single European market. In the framework of the TeleFOT project, it was decided that the products selected for testing should not only be available in Germany but also in all other European countries.

The tests will not be restricted to a comparison of different brands, but it will also include a comparison of different implementation concepts.

For example:

- i) Handset-based navigation (mobile navigation)
- ii) PDA-based navigation
- iii) Mobile phone-based navigation
- iv) Aftermarket in-dash navigation
- v) In-vehicle OEM navigation (for comparison purposes).

Note:

Today, the market share of navigation systems operated on PDAs or Pocket PCs, e.g. palm devices continues to decrease. Smartphones have taken over this share which is why these two categories (PDA-based navigation and mobile phone navigation) have been merged to one category. Moreover, functions doing justice to green driving aspects can hardly or not at all be found in the navigation systems. Since comparing the different models is not the issue here, we did not include green driving as a test category.

User experience benchmarking included long-term (2-4 weeks) field evaluation with around 10 users. First of all, the user experience benchmarking focused on navigation

systems. Later on, benchmarking also covered other driver assistance systems such as weather forecast services, traffic information services and roadside service information, as far as this function is available in the equipment.

2. TEST CRITERIA OF IMPLEMENTATION CONCEPTS

As established in SP 4.8.1 "Review of earlier consumer tests", automobile clubs, consumer organisations have conducted tests of navigation systems across Europe helping consumers to make informed choices. 31 organisations in 14 different countries conducted or published tests of nomadic devices.

Most tests cover mobile navigation devices in general. Some tests are collaborative projects. For example, the ADAC test of mobile navigation devices is supported by ÖAMTC and also published by TCS and other partners all over Europe.

The results are based on test criteria which were found to be the same with all organisations. These include:

- Equipment components & diversity
- Operation
- Installation
- Route calculation
- Navigation functions
- Other features and functions, e.g. driver distraction

Consumer tests have the purpose of providing purchase advice to potential buyers. Before testing nomadic devices in the framework of the TeleFOT project, the aim was to subject the devices to comprehensive testing according to consumer test criteria. This would allow stakeholders to identify and evaluate aspects of safety and ease of operation in advance. Elements from the ADAC consumer tests of mobile navigation devices in combination with the criteria applied by the various testing organisations serve as a basis to define benchmarks that will help compare and evaluate nomadic devices from the consumers' point of view.

The test criteria collected by ADAC will be used in the TeleFOT WP 4.8.3 "Benchmark of different navigation systems" work plan.

3. IMPLEMENTATION CONCEPTS

Looking at the different types of navigation systems, it seemed reasonable to divide them into four main groups. The number of test devices per group depended on the number of different model variants available on the market. The largest number of devices was found among the group of smartphones. This is a trend also evident in the vast variety of navigation software that has been launched over the past two years. The popular mobile navigation devices are followed by the group of aftermarket double DIN cage navigation systems which are, however, on a downward trend. In the group of OEM navigation devices, we compared four different systems of different price bands.

The test programme was established on the basis of the test criteria compiled in D 4.8.1. All groups were subjected to the same conditions to ensure that they were comparable in the individual assessment criteria of the various groups.

Table 2 shows the rating key for the relevant test criteria.

Table 2: ADAC rating key

ADAC rating key														
++		very good	+		good	O		satisfactory	⊖		acceptable	–		poor
		(0.6 - 1.5)			(1.6 - 2.5)			(2.6 - 3.5)			(3.6 - 4.5)			(4.6 - 5.5)

4. MOBILE PHONE-BASED NAVIGATION

In the group of smartphones, we compared software solutions used on the IOS, Android, Windows and Symbian platforms. When selecting the navigation software, we took care to compile a broad range of top-selling software compatible with the relevant hardware (smartphones). If the smartphone was sold with its own mounting system, we also tested mounting and stability. For all other smartphones we used a universal mount. Due to the vast amount of models and vehicle types, we were unable to consider special dashboard-integrated mounts. We used the test criteria **equipment components & diversity, route calculation, navigation, fitting & usability** as well as **driver distraction** for assessing the navigation software.

Table 3 shows the overall result of the seven different software solutions tested on the IOS, Android, Windows and Symbian platforms for the aforementioned test criteria.

Table 3: Results of mobile phone-based navigation systems

Equipment components					
Route calculation					
Navigation					
Fittings / Usability					
Driver distraction					
	poor	acceptable	satisfactory	good	very good

Equipment components & diversity:

Using navigation software on a smartphone requires the download of the software onto the device. This may be a first source of problems. If the download is successful right away (which was not always the case in the test), the software can be installed on the smartphone. This process is not without surprises either! The tested iPhone 4 software solutions had to be bought in an Apple Store. You need to make sufficient time for software updates since they may take up to one hour depending on the scope and size of the update. You have to be aware that downloads do not come with a software manual. Mounting systems or a power supply for using the smartphone as a navigation device in the vehicle are rarely included in the equipment components.

Route calculation:

In this category, the smartphone benefits from the mobile network. Positioning via satellite contact is established within a very short time. The powerful processor typical of smartphones is an asset in the route calculation.

Navigation:

The minimum requirements of navigation devices are to guide users quickly and easily from A to B. Ideally, the device also recognises any congestion ahead and recommends a better route. Features such as the clear announcement of street names (text to speech), a lane assist or the display of traffic information were so far mainly associated with mobile navigation devices. These functions increasingly come with software solutions and are mostly rather reliable. Today's smartphone generation is on a par with the performance of mobile navigation devices. In some cases smartphones are even better. Potential for improvement is a voice guidance system using the in-vehicle speakers.

Fittings/usability:

Not all smartphones are equipped with a mounting system and a vehicle charging cable as is the Nokia E72 navigation device. In general, you have to make additional investments to be able to use the software solution in the vehicle. We tested the iPhone 4 with a TomTom fitting system at an extra cost of €99.99. It has an integrated speaker for improved acoustics and a GPS receiver for faster satellite reception. With their large displays and touchscreens, the smartphones can keep up with the mobile navigation devices in terms of operability. The displays are responsive and the ergonomics of equally good standard. A docking station which could be used both as a smartphone mount and as a charging station would be an advantage.

Driver distraction:

Small screens combined with small buttons impede the entering and reading of information. If, in addition, maps contain mistakes, wrong guiding instructions may quickly give rise to confusion and lead to distraction. Short and precise voice guidance together with a first-rate illustration of the driving situation on screen, as is the case with Navigon systems, will have a positive effect on the driving behaviour. Lane instructions need to be clear and given on time. The time required for taking in the necessary information must be minimal. Moreover, the glass touchscreen surfaces should be anti-glare. The more often drivers take their eyes off the road, the more they get distracted.

To minimise this, the mount position should be near the driver. If fitted by suction mount this is not always possible (vehicle with low-edged windscreen). In the test, all smartphones were suction mount.

Other functions (e.g. traffic information):

At the time of testing, not all software solutions included country-wide live traffic updates and traffic incidents were not always transmitted with the desired accuracy. This is why the systems achieved no better than a satisfactory rating. Essential for the assessment were the update frequency and the quality of the messages and how these were displayed and processed. Navigon's software showed good results but most systems could not cope on ancillary roads or in urban areas. In the test phase, only TomTom had an adequate software solution. Today, more and more manufacturers offer live traffic updates at affordable prices. Only Navigon and TomTom software solutions gave out weather information such as heavy snow, gales etc., but information updates were restricted to the calculated time of arrival.

5. ASSESSMENTS: MOBILE PHONE-BASED NAVIGATION SYSTEMS

Navigon Navigator on iPhone 4

Figure 1: Navigon Navigator auf iPhone 4



+	Equipment components
++	Route calculation
+	Navigation
+	Fittings / Usability
0	Driver distraction

Overall impression:

Good iPhone-compatible software providing all necessary navigation functions. Optional traffic information is recommended (€19.99). In-car use of the phone requires the purchase of a specific mount.

Purchase price of the software (mid September 2010): €89.99 plus €19.99 for Navigon Traffic, €99.99 TomTom in-car mount

Software/maps:

Navigon 1.6.0 / Navteq 2009

Area of coverage:

Europe

Additional functions:

Reality view, lane assist, text to speech, emergency call shortcut

Options:

€19.99 traffic information

€99.99 in-car mount with integrated GPS receiver and speaker

Manufacturer of navigation software:

Navigon AG
Schottmüllerstr. 20A
D-20251 Hamburg

Plus:

- good graphic display
- good voice instructions
- very good lane assist
- very responsive and sensitive display
- traffic information

Minus:

- no anti-glare display
- no voice input

- in-car mount only optional
- traffic information not always up-to-date

TomTom Navigator 7 on iPhone 4

Figure 2: TomTom Navigator 7 auf iPhone 4



O	Equipment components
++	Route calculation
+	Navigation
+	Fittings / Usability
+	Driver distraction

Overall impression:

Good and low-cost software. Optional traffic information annual subscription is quite expensive (€29.99) but recommended. In-car use of the phone requires the purchase of a specific mount. The tested TomTom fitting system increased voice guidance volume and enabled faster satellite connection.

Purchase price of the software (mid September 2010): €59.99 plus €29.99 for Navigon Traffic, €99.99 TomTom in-car mount

Software/maps:

TomTom v1.4.1 / Tele Atlas 8.300

Area of coverage:

Western Europe

Additional functions:

IQ Routes (route calculation taking Sunday/holiday or weekday into account), Help me! emergency menu, MapShare (update platform from users for users), lane assist, Reality View, text to speech

Options:

€29.99 traffic information (for 1 year)

€4.99 traffic information (for 1month)

€99.99 in-car mount with integrated GPS receiver and speaker

Manufacturer of navigation software:

TomTom Mobility Solutions

Rembrandtplein 35

NL-1017 CT Amsterdam

E-mail: info.mobility@tomtom.com

Plus:

- route planning using "via" function
- good screen layout
- lane assist
- good display of traffic information also on secondary roads

Minus:

- rough map display
- rather complex menu structure
- in-car mount only optional
- traffic information not always up-to-date

Navigon Navigator on Samsung Galaxy S

Figure 3: Navigon MN7 auf Samsung Galaxy S



O	Equipment components
++	Route calculation
+	Navigation
+	Fittings / Usability
O	Driver distraction

Overall impression:

Software slimmed down for the Samsung (compared to the iPhone). Traffic information is included. In-car use of the phone requires the purchase of a specific mount.

Purchase price of the software (mid September 2010): €89.95, €12.99 in-car mount for the Samsung Galaxy S i9000

Software/maps:

Navigon 3.5.1 / Navteq Q1/2010

Area of coverage:

Europe

Additional functions:

-

Manufacturer of navigation software:

Navigon AG
Schottmüllerstr. 20A
D-20251 Hamburg

Plus:

- good graphic display
- good voice instructions
- very good lane assist
- traffic information
- supports alternative routes

Minus:

- temporary system instability (several crashes during test)
- no voice instructions if battery is running low
- in-car mount only optional
- traffic information not always up-to-date
- to obtain traffic information, users must register with Google
- traffic information is supplied by Android users only

Falk Navigator Europe auf iPhone 4

Figure 4: Falk Navigator Europe auf iPhone 4



O	Equipment components
++	Route calculation
+	Navigation
+	Fittings / Usability
O	Driver distraction

Overall impression:

Low-cost software with extendable functionality (Falk travel guide).
Text to speech only optional.

Purchase price of the software (mid September 2010): €49.99
plus €19.99 for Live Traffic, €99.99 TomTom in-car mount

Software/maps:

Falk / Navteq 2010

Area of coverage:

Europe

Additional functions:

Lane assist, accident black spot warning, Reality View,

Optional accessories:

€19.99 traffic information (for 1 year)

€3.99 text to speech

€1.59 Falk travel guide (several guides)

€99.99 in-car mount with integrated GPS receiver and speaker

Manufacturer of navigation software:

United Navigation GmbH

Marco-Polo-Straße 1

D-73760 Osterfilden

www.falk-navigation.de

Plus:

- lane assist
- accident black spot warning
- optional Falk travel guide
- test winner with regard to positioning and route calculation time

Minus:

- text to speech only optional (€3.99)
- rather complex menu structure
- in-car mount only optional
- traffic information not always up-to-date

Google Maps on Samsung Galaxy S

Figure 5: Google Maps auf Samsung Galaxy S



+	Equipment component
++	Route calculation
0	Navigation
0	Fittings / Usability
0	Driver distraction

Overall impression:

Less-than-perfect but free navigation solution. Data transfer may incur high additional costs (data flat rate required). Traffic information only based on information supplied by Google users.

Purchase price of the software (mid September 2010): €0, €12.99 in-car mount for the Samsung Galaxy S i9000

Software/maps:

Google 4.5.1/ Google Maps

Area of coverage:

World-wide. Routing functionality is, however, likely to be limited.

Additional functions (Software):

Traffic information based on information by registered Google users (data transfer!)

Options:

-

Manufacturer of navigation software:

Google Germany GmbH
ABC-Strasse 19
D-20354 Hamburg
Phone: +49 40-80-81-79-000
Fax: +49 40-4921-9194

Plus:

- easy installation
- easy destination entry with Google search
- high-definition satellite view
- maps are always up-to-date

Minus:

- no reliable traffic information
- no lane assist
- does not support stopover entry
- does not support route planning with several stopovers
- no user instructions available

Nokia Maps 3.0 on Nokia E72

Figure 6: Nokia Maps 3.0 auf Nokia E72



O	Equipment components
++	Route calculation
O	Navigation
O	Fittings / Usability
⊖	Driver distraction

Overall impression:

Good navigation software suitable also for pedestrians. Longest rechargeable battery life among all devices tested. Automatic map updates incur additional mobile phone costs. Layout less clear, operation not as easy as with touchscreen smartphones; more distraction.

Purchase price/lowest price (mid September 2010): €305.00

Software/maps:

Nokia Ovi 3.0/ Navteq

Area of coverage:

Pre-installed maps of D, A, CH (free maps of a total of 180 countries available)

Additional functions:

Integrated compass, A-GPS (very fast but high data transfer cost)

Accessories included:

In-car mount

Manufacturer/seller:

Nokia GmbH
Balcke-Dürr-Allee 2
D-40882 Ratingen

Plus:

- good pedestrian navigation
- test winner in rechargeable battery life category
- many country maps available
- Navigation Edition includes mount and car charger cable

Minus:

- traffic information and POI search incur additional mobile phone costs
- maps and voice instructions must be loaded separately
- it may take somewhat long to establish first satellite connection
- no text to speech
- no automatic daytime/night mode
- rather difficult data input (small keys)
- tiny display
- traffic information not always up-to-date
- no lane assist

Skobbler on iPhone 4

Figure 7: Skobbler auf iPhone 4



O	Equipment components
++	Route calculation
O	Navigation
+	Fittings / Usability
+	Driver distraction

Overall impression:

Less-than perfect but low-cost navigation solution. Data transfer may incur high additional costs (data flat rate required). The only navigation software that supports Openstreet Map. Very spartan device.

Purchase price/current price (mid September 2010): €1.59, €99.99 for TomTom in-car mount

Software/maps:

Skobbler 3.0.1 / OpenStreetMap 2010

Area of coverage:

Maps available on the Internet

Additional functions (software):

No information

Options:

€99.99 in-car mount with integrated GPS receiver and speaker

Manufacturer of navigation software:

skobbler GmbH
Luisenstr. 41
D-10117 Berlin
info@skobbler.de

Plus:

- low-cost navigation solution (provided users have a data flat rate)
- simple display

- easy handling

Minus:

- maps not always verified
- no traffic information
- no lane assist
- no text to speech
- does not support stopover entry
- no automatic daytime/night mode
- does not support route planning with several stopovers
- indicated journey times may be unrealistic
- no user instructions available

6. MOBILE NAVIGATION SYSTEMS

Our comparison of mobile navigation systems category included devices in the middle and high-end price segment of reputable manufacturers. These price segments were necessary, because many of the basic devices did not provide additional features such as traffic information, speed alert systems and text to speech for street names. All mobile navigation devices are suction mount and were assessed in the following test criteria: **equipment components & diversity, route calculation, navigation, fittings & usability** and **driver distraction**.

The seven different mobile navigation devices achieved the following ratings in the different assessment criteria:

Table 4: Results of mobile navigation systems

Equipment components					
Route calculation					
Navigation					
Fittings / Usability					
Driver distraction					
	poor	acceptable	satisfactory	good	very good

Equipment components:

The equipment of mobile navigation systems always includes suction mounts for windcreens as well as chargers for the 12V connection in the vehicle. In most cases, it does not include a comprehensive operation manual, service notices and pre-purchase information e.g. about the area covered on the map. Some manufacturers offer vouchers for alternative dashboard mounts. This is a first step towards preventing vision impairment which is likely to occur with windscreen mount mobile devices. Some software or map updates take several hours.

Route calculation:

There are huge differences in route calculation. While some mobile navigation devices have SIM cards which enable satellite connections within seconds to receive traffic information, others take a few minutes. Processor generations in mobile navigation

devices do not compare with processors in smartphones. This is why the average time needed to calculate a suitable route from A to B is longer. This may result in minor odysseys in urban traffic.

Navigation:

Navigation results are generally good. Service features such as giving street names, lane assist, speed alert, indication of direction of travel are standard in this price segment.

Fittings / Usability:

Suction mounts are the standard fitting system for mobile navigation systems. This reduces visibility through the windscreen which is not tolerated in certain countries (example: Zurich in Switzerland). The 12V power supply wiring is not exactly a pretty sight but it may also turn out to be an obstruction to the driver. If the windscreen edges are low it becomes very difficult to reach the device. Often extension mounts are used but this may cause vibrations as soon as there is any resonance. Since all this contributes towards driver distraction, it seems reasonable to integrate the device and the power supply in the dashboard near the driver. Ideally, vehicle facilities may be exploited for better functionality (e.g. use of on-board speakers).

Driver distraction:

The focus is on maps and potential mistakes. Wrong instructions may quickly cause confusion and distract the driver. Short and clear voice guidance and a clear illustration of the road situation on screen as is the case with Navigon systems, will have a positive effect on the driving behaviour. Lane instructions need to be clear and timely. The time required for taking in the necessary information must be minimal. Moreover, glass surfaces must be anti-glare. The more often drivers take their eyes off the road, the more they get distracted from the traffic scene. The aim must be to use clearly discernable symbols and unequivocal instructions (image and audio).

Other functions (e.g. traffic information):

Traffic information was of good quality and up-to-date in most mobile navigation devices, many of which were equipped with TMC or TMCpro (now Navteq Traffic). The TomTom device even displayed good quality and up-to-date traffic incidents in large cities and on by-roads, also using information provided by mobile phone users. Only the TomTom device displayed weather information such as heavy snowfall, gales etc. but updates were restricted to the calculated time of arrival.

7. INDIVIDUAL ASSESSMENTS: MOBILE NAVIGATION SYSTEMS

TomTom GO Live 1000

Figure 8: TomTom GO Live 1000



O	Equipment components
+	Route calculation
+	Navigation
+	Fittings / Usability
O	Driver distraction

Overall impression:

Good navigation device. Good routing and traffic information. 2-year LIVE services included; optionally available afterwards:

Purchase price/lowest price (mid October 2010): €299.00

Type of device/operation:

PNA/4.3" touchscreen

Software/maps:

TomTom/Tele Atlas

Area of coverage:

Europe

Additional functions:

LIVE services, help funktions, voice input

Accessories included:

Navigation device, suction mount incl. car charger, USB cable, quick reference guide

Manufacturer/distributor:

TomTomTom Mobility Solutions

RemRembrandtplein 35

NL-NL-1017 CT Amsterdam

Phone: +31 (0) 20 850 0800

Fax: +31 (0) 20 850 1099, E-mail: info.mobility@tomtom.com

Plus:

- good mount: compact, no vibration
- quick positioning
- very good routing: route selection based on time of day and day of week
- most up-to-date traffic information through HD Traffic (LIVE service)
- voice input
- supports destination entry based on coordinates and Google search
- "via" function

Minus:

- LIVE service not available in all countries
- LIVE service is a must for traffic information reception
- incomplete maps
- sometimes strange routing

Navigon 70 Premium Live

Figure 9: Navigon 70 Premium Live



O	Equipment components
O	Route calculation
+	Navigation
+	Fittings / Usability
O	Driver distraction

Overall impression:

Easy-to-use elegant device offering good navigation. Outstanding voice output and quality of route display. Supports traffic information.

Purchase price (early October 2010): €349.00

Type of device/operation:

PNA/5" touchscreen

Software/maps:

Navigon PR70 Live Version 7.7.1 (build-338) / Navteq 3Q 2010

Area of coverage:

44 European countries

Additional functions:

Premium Live Services, Reality View, lane assist, Bluetooth hands-free kit, text to speech, voice input, Navigon Fresh Internet service, Curve Warner, emergency assistance function

Accessories included:

Navigation device incl. suction mount, quick installation guide, USB cable, car charger, Live Service brochure

Manufacturer:

Navigon AG
Schottmüllerstr. 20A
20251 Hamburg

Plus:

- very good graphic display with terrain modelling
- clear voice instruction

- good voice input
- low-cost map update (2 years)
- excellent lane assist
- emergency assistance function
- intelligent route selection
- motion sensor for device operation

- Minus:**
- relatively slow response when shifting from one menu level to another
 - dims very late
 - incomplete user instructions
 - takes rather long to establish satellite connection
 - traffic information not always up-to-date

Becker Z215

Figure 10: Becker Z 215



O	Equipment component
+	Route calculation
O	Navigation
+	Fittings / Usability
+	Driver distraction

Overall impression:

Well-equipped device enabling single-sentence voice input (destinations). Outdated maps (>1 year old).

Purchase price: €247.27

Type of device/operation:

PNA/4.3" touchscreen/key

Software/maps:

Becker 8.5.3.129065 / Navteq 2009 Q2

Area of coverage:

41 European countries

Additional functions:

Speech dialogue system, text to speech, Bluetooth, time-dependent navigation (D-F-UK), economic routing, alternative routing, TMCpro, lane assist, Reality View, 3D landmarks, traffic sign display, country-specific information, trip computer

Accessories included:

Navigation device, active mount, car charger incl. TMC antenna, 2 small suction cups, USB cable, CD-supplied software and maps, quick reference guide, 45-day map update guarantee.

Manufacturer/distributor:

United Navigation GmbH
Marco-Polo-Str. 1
D-73760 Ostfildern
<http://www.united-navigation.com>

Plus:

- very clearly laid-out graphic display
- split screen
- traffic sign display
- time and weekday-dependent routing
- good voice output
- innovative single-sentence voice input (addresses only)
- supports coordinate-based destination entry

Minus:

- outdated maps (>1 year old)
- no "via" function
- no external volume control (key, wheel)
- voice input not for all functions (e.g. POI search and other functions)
- no low emission zone information (POI and routing)
- no information about seasonal road closures (e.g. winter)
- partly inappropriate traffic sign display

Medion Gopal X4545

Figure 11: Medion GoPal X4545



O	Equipment components
+	Route calculation
+	Navigation
⊖	Fittings / Usability
O	Driver distraction

Overall impression:

Well-equipped navigation device. Mount and TMC antenna impair device operation.

Purchase price: €294.95

Type of device/operation:

PNA/4.7" touchscreen

Software/maps:

Medion PE 5.5/Navteq 2009/Q4

Area of coverage:

Europe

Additional functions:

tunnel assist, travel guide, text to speech, voice input, Bluetooth, FM transmitter, mp3 player, photo viewer, alarm clock, first-aid advice, contact manager, sudoku, PIN-protected anti-theft protection, fingerprint sensor

Accessories included:

navigation device, active mount with integrated TMC antenna, USB cable, car charger, separate TMC antenna, user manual, steering wheel remote control, Gopal Navigator maps and support on CD, PIN Lock sticker, €10 voucher for integrated system

Manufacturer:

Medion AG
D-45307 Essen
www.mediongopal.de

Plus:

- clear display: map, arrow display, or voice guidance only
- good display of junctions and exits
- quick recalculation
- good voice output using text to speech
- standard remote control

Minus:

- device is difficult to remove from mount
- no "via" function
- dims very late in the evening
- very long, separate TMC antenna
- relatively slow response when shifting from one menu level to another
- too bright in night mode
- mount takes up space and vibrates

Falk VISION 700

Figure 12: Falk VISION 700



+	Equipment components
⊖	Route calculation
+	Navigation
+	Fittings / Usability
0	Driver distraction

Overall impression:

Satisfactory luxury device offering a wide range of functions. StadtAktiv function is an asset. Responds

rather slowly to device operation and takes rather long to establish first satellite connection.

Purchase price €329.00

Type of device/operation:

PNA/4.3" touchscreen

Software/maps:

Falk 11.0/Navteq 2010-2

Area of coverage:

Europe

Additional functions:

Travel guide, text to speech, voice guidance, TMCpro, intelligent navigation, StadtAktiv city travel information, mobile phone Bluetooth connection, multi-media pack, games, anti-theft protection.

Accessories included:

Navigation device, suction mount, car charger, USB cable, quick reference guide, DVD-supplied software and maps, voucher code for a 2-year map subscription, €10 voucher for installation of a vehicle-specific mount.

Manufacturer/distributor:

United Navigation GmbH
Marco-Polo-Str. 1
D-73760 Ostfildern
<http://www.united-navigation.com>

Plus:

- high adjustability
- voice address input
- good graphic display incl. satellite view
- good routing
- public transport information for many cities (StadtAktiv)
- travel guide function, guided routes
- good voice output
- good magnetic mount: compact and vibration-free
- supports coordinate-based destination entry

Minus:

- takes long to establish first satellite connection
- no "via" function
- no active mount
- rather slow response to device operation

Garmin Nüvi 3790T

Figure 13: Garmin Nüvi 3790T



⊖	Equipment components
⊖	Route calculation
+	Navigation
+	Fittings / Usability
○	Driver distraction

Overall impression:

Design-oriented and practical Navigation device with minor weaknesses. The extremely flat design

and the optional CityXplorer maps make it an ideal travel companion.

Purchase price: €309.00

Type of device/operation:

PNA/4.3" touchscreen

Software/maps:

Garmin 2.30 / Navteq

Area of coverage:

Europe

Additional functions:

Text to speech, voice input, PIN Lock, ecoRoute, picture viewer, world travel clock, alarm clock, calculator, currency & unit converter

Accessories included:

Navigation device, suction mount, car charger, TMC antenna, dashboard disc, quick reference guide (several languages), 60-day NüMaps guarantee

Manufacturer:

GPS GmbH
Lochhamer Schlag 5a
D-82166 Gräfelfing
www.garmin.de

Plus:

- very flat and compact device
- device can be used either horizontally or vertically
- good graphic display
- vibration-free mount
- easy operation
- clear menu structure
- supports coordinate-based destination entry

Minus:

- no "via" function
- route planning with several stopovers complicated
- Reality View inadequate (displayed too early and too short)
- slow information display
- bad grammar
- partly poor TMC reception

NavGear RS 50-3D

Figure 14: NavGear RS 50-3D



⊖	Equipment components
⊖	Route calculation
+	Navigation
○	Fittings / Usability
○	Driver distraction

Overall impression:

Low-cost device with minor weaknesses (e.g. low-contrast display). Also available for recreational vehicles and trucks. Slow-responding and insensitive display.

Purchase price: €169.90

Type of device/operation:

PNA/5" touchscreen

Software/maps:

NNG Global Services/ Navteq 2010-Q1

Area of coverage:

Europe

Additional functions:

text to speech, eco trip, TMC, lane assist, traffic sign display, Bluetooth, FM transmitter, video player, multi-media player, on-screen instructions, picture viewer

Accessories included:

Navigation device, suction mount, car charger, TMC antenna, AC charger, user instructions, USB cable, maps on SD card and DVD

Manufacturer/distributor:

PEARL Agency Allgemeine Vermittlungsgesellschaft mbH
PEARL-Straße 1-3
D-79426 Buggingen
www.pearl.de

Plus:

- large, very slim device
- good graphic display
- traffic sign display

-
- supports coordinate-based destination entry
 - good TMC reception

Minus:

- low-contrast display difficult to read in bright light
- poor readability when looking at display from an angle
- device rather difficult to remove from mount
- TMC antenna
- rather slow response to device operation
- takes long to establish first satellite connection

8. AFTERMARKET IN-DASH NAVIGATION SYSTEMS

Aftermarket in-dash navigation devices are single or double DIN cage systems integrated into the centre console. Usually, the OEM integrated radio has to go for such a navigation system solution. This shows that navigation is not the only service facility of such a device. However, within the framework of this project, we only assessed the navigation performance, including the test criteria equipment & diversity, route calculation, navigation, fitting & usability and driver distraction. Noteworthy is the higher price required for such integrated systems. Although the price is not on the same level as OEM integrated navigation devices, it is still three times as expensive as the average mobile navigation system. We examined if in-dash systems are a better alternative or provide additional information.

General result of aftermarket in-dash navigation devices (single and double DIN devices):

Table 5: Results of aftermarket in-dash navigation systems

Equipment components					
Route calculation					
Navigation					
Fittings / Usability					
Driver distraction					
	poor	acceptable	satisfactory	good	very good

Equipment components:

An expert is almost indispensable for integrating a single or double DIN navigation device. Most user manuals do not make it clear that additional cables are required (depending on the vehicle model) which are not included in the standard equipment. Example: To ensure that radio reception quality remains unchanged, it is recommended to install a pre-amplifier which, however, is not included in the equipment. None of the devices included any information about the date of the maps. Obviously, it is suboptimal when updates are necessary before you start. Moreover, this requires PC knowledge and time. Also, most manufacturers of aftermarket in-dash navigation systems do not offer map updates on a regular basis.

Route calculation:

Compared with the mobile navigation device average, route calculation is good, but it is not as fast as with in-vehicle OEM systems or smartphones with navigation software. It is important to install the external GPS antenna at the right position, since steamed-up windows or the vehicle's own A pillar may considerably influence its functioning.

Navigation:

One must not expect too much from the devices' navigation. Once the system is properly integrated, it seems to be on a par with OEM fitted systems. It will therefore perfectly satisfy users unless they also expect vehicle-specific data and functions. Some do not have a display control connection for day/night-time control. Also, the in-vehicle speakers are hardly exploited at all. Steering sensors would be useful to facilitate improved positioning even without satellite connection (e.g. in an underground car park or in inner cities with high buildings). Obsolete maps further contributed to a mere satisfactory rating of aftermarket in-dash navigation devices.

Fittings/usability:

The device's integration is a great advantage, since there are no irritating cables for the power supply or for receiving traffic information. A suitable position in the vehicle also ensures good reachability. The only critical aspect might be the device's display angle as it may cause reflections or if the distance to the device is too big and therefore likely to distract the driver. Menu navigation is not always intuitive. Different menu levels for setting up the general system functions and the specific navigation functions are

confusing. A potential for improvement is the option to operate the device using a multi-function steering wheel.

Driver distraction:

Even before setting off on the road, the device is likely to distract the driver if the place of installation is suboptimal. If it is difficult to reach the keys or if the touchscreen lacks responsiveness signalling delayed input acceptance, the driver will easily be distracted and not pay sufficient attention to the traffic. Moreover, the shiny surface may cause strong reflections and the device's display may not be in the direct vision of the driver adding further to his/her distraction from the road. In the worst case, poor contrast quality will make reading the information on the display almost impossible when the sun is out. In such cases, screen-based navigation is impracticable. Also, incorrect voice input or wrong positions on the map display possibly due to poor GPS reception (see navigation above) have a negative impact on driver attention. Conclusively, a combination of a suitable mounting position, in-vehicle access to comprehensive information and an intuitive menu structure are not given for all in-dash devices.

Other functions (e.g. traffic information):

Concerning traffic information, aftermarket in-dash navigation systems have a bit of catching up to do. Scope and quality of the information correspond to that of an older mobile navigation device. Quality and up-to-dateness of the information is equivalent to the messages broadcast as TMC or TMCpro (now Navteq). This also means that the devices are unable to display any incidents occurring in urban areas or on by-roads and that they do not provide weather updates.

9. ASSESSMENTS: AFTERMARKET IN-DASH NAVIGATION SYSTEMS

O	Equipment components
++	Route calculation
+	Navigation
+	Fittings / Usability
⊖	Driver distraction



Zenec ZE-NE2010 EGO

Figure 15: Zenec ZE-NE2010 EGO

Overall impression:

Device is way behind state-of-the-art mobile navigation systems: obsolete maps, few input options and disrupted navigation in the tunnel. Operation sometimes sluggish. Poor reception of some radio stations.

Purchase price: €999.00

Type of device/operation:

6.5" (double DIN) aftermarket integration, key controls, touchscreen

Software/maps:

Nav N Go

Area of coverage:

43 countries in Eastern and Western Europe

Additional functions:

Text to speech, bluetooth, TMC+TMCpro, lane assist, iPod and iPhone compatible, Bluetooth, CAN Bus Interface, MFA connection (e.g. display of turn-off signs), 3D display of buildings, DVD/CD/mp3/WMA Player, USB connection

Accessories included:

Vehicle-specific mount instructions, user instructions, Quick Start Guide, remote controls, different cables

Distributor:

ZENEC by ACR AG
Bohrturmweg 1
CH-5330 Bad Zurzach

Plus:

- no disturbing cables, vibrations and reflections
- speed limit display (depending on the alert setup)
- good fast access
- external volume control (scroll wheel)
- supports coordinate-based destination entry

Minus:

- navigates into pedestrian precincts (map error)
- obsolete maps (new B17 missing)
- annoying voice output "recalculation of route"
- sunlight from the side causes reflections on display
- traffic information not always up-to-date
- few control options (brightness, contrast)
- no input about environmental zones (POI and route guidance)
- no seasonal road closures (winter closures)

Pioneer AVIC F930BT

⊖	Equipment components
++	Route calculation
○	Navigation
+	Fittings / Usability
⊖	Driver distraction



Figure 16: Pioneer AVIC F930BT

Overall impression:

High price, low performance. Input options and navigation performance are way behind those of state-of-the-art mobile navigation systems. Without accessory, poor reception of some radio stations.

Purchase price: €889.00

Type of device/operation:

6.1" (double DIN) aftermarket integration, key controls, touchscreen

Software/maps:

Pioneer/TeleAtlas 06/2010

Area of coverage:

44 countries in Europe

Additional functions:

Bluetooth, TMC, lane assist, iPod and iPhone compatible, DVD/CD/mp3/WMA player, USB connection

Accessories included:

Installation manual, user information, Quick Start Guide, CD with user instructions and text-to-speech elements

Distributor:

Pioneer Europe NV
Haven 1087, Keetberglaan 1
B-9120 Melsele

Plus:

- no disturbing cables, vibrations and reflections
- extra SD card slot
- iPod and iPhone compatible
- speed limit display
- involves vehicle sensors to display direction changes even without satellite connection
- supports coordinate-based destination entry
- connector option for reversing camera
- good fast access

Minus:

- switching off ignition switches off navigation
- obsolete maps (new B17, opened in September 2009, not included)
- poor control options (map colours, brightness)
- no external volume control (keys, scroll wheel)
- no input about environmental zones (POI and route guidance)
- no seasonal road closures (winter closures)

Parrot ASTEROID

⊖	Equipment component
-	Route calculation
-	Navigation
○	Fittings / Usability
⊖	Driver distraction



Figure 17: Parrot ASTEROID

Overall impression:

Anything but navigation! Instruction display requires pressing of arrow keys no matter where the car is located. Does not support address input. Data transfer may incur high additional costs (data flat rate required).

Purchase price: €260.00

Type of device/operation:

Single DIN aftermarket integration; 3.2" TFT colour display; key controls

Software/maps:

1.02/ Google Maps

Area of coverage:

Worldwide; route guidance option may be restricted

Additional functions (software):

Orange Liveradio, discounts on refuelling, voice input, iPod and iPhone compatible, Bluetooth

Manufacturer of navigation software:

Google Germany GmbH
ABC-Strasse 19
D-20354 Hamburg
Phone: +49 40-80-81-79-000
Fax: +49 40-4921-9194

Plus:

- high-resolution satellite view

Minus:

- additional adapter plug for antenna and radio plug are required (extra cost!)
- very poor FM radio reception
- return button slightly jammed: frequent radio station switch back
- very reflective display
- no proper navigation; instructions are displayed by pressing arrow keys no matter where vehicle is located
- map display requires Internet connection (via phone or 3G stick)
- does not support address input
- no voice guidance
- no lane assist
- no input of stop-over
- no multi-stop route planning

10. IN-DASH OEM NAVIGATION SYSTEMS

Integrated OEM navigation solutions are far more expensive than mobile navigation devices but they ideally fit into the vehicle. The device is usually operated by joystick or a scroll wheel in the centre console. Input takes some time to get used but is simple enough. Interface to on-board electronics enables information using light control (day/night), steering movements (navigation supported in tunnels) and is integrated into the vehicle's sound system. Information can also be obtained using the steering wheel or sometimes the speedometer area. With in-dash OEM navigation devices we also assessed the test criteria equipment & diversity, route calculation, navigation, fitting & usability and driver distraction.

Table 6 shows the overall result in the group of in-vehicle OEM navigation systems:

Table 6: Results of in-vehicle OEM navigation

Equipment components					
Route calculation					
Navigation					
Fittings / Usability					
Driver distraction					
	poor	acceptable	satisfactory	good	very good

Equipment components:

Perfectly integrated into the vehicle design, the aftermarket OEM navigation devices provide optimum access for users who make their entries using a joystick or a scroll wheel located in the centre console. There are helpful user instructions about the functions. However, the equipment does not usually include a DVD with the navigation software, meaning that in the event of errors the software cannot be re-installed. In fact, users would buy it when needing a map update, which is quite an investment and does not even guarantee up-to-date material. The integrated device is connected to on-board electronics (steering sensors, light, speed etc.) but does not allow access to travel guide functions or speed alert activation.

Route calculation:

Thanks to a very fast processor, route calculation is really quick. Wheel sensors and in some cases Internet communication cards enable positioning even within buildings or in tunnels.

Navigation:

Integrated OEM navigation systems provide high-level navigating. Example: they have lane assist and support street name input for which the volume is coordinated with the running radio and the current speed. The traffic information is so up-to-date as to even allow drivers to avoid urban road sections where there is minor congestion.

Fittings/usability:

Operating the device by scroll wheel or joystick located in the centre console takes some getting-used-to and is somewhat awkward but it is done sitting in a relaxed position. Information should never be input when driving, since the distraction involved presents a serious safety risk. Some systems do not allow drivers to operate the controls when the vehicle has exceeded a certain speed.

Driver distraction:

This navigation system category distracts drivers least, due to a combination of screen position, unobtrusive and clear voice guidance and excellent visibility despite sunshine. Particularly impressive was the BMW head-up display with directional instructions projected onto the windscreen, directly helping drivers not to take their eyes off the road while getting oriented.

Other functions (e.g. traffic information):

The comparative test showed that the quality and up-to-dateness of in-vehicle OEM navigation systems were unrivalled. However, since these devices did not display any traffic incidents on by-roads either, this system category does not stand out in the overall result.

11. ASSESSMENT OF IN-VEHICLE OEM NAVIGATION SYSTEMS

RNS 510 in the VW Sharan

O	Equipment components
++	Route calculation
+	Navigation
+	Fittings / Usability
O	Driver distraction



Figure 18: RNS 510 in the VW Sharan

Overall impression:

The RNS 510 is a bit sluggish. Menu navigation, input options and processor speed are restricted compared with mobile navigation solutions. Traffic information is up-to-date, but its presentation could be better.

Purchase price: €2170.00

Type of device/operation:

6.5" in-vehicle integration, touchscreen

Software/maps:

Volkswagen Navigation CY RNS 510 / Navtec Europe West V6.1

Area of coverage:

Western Europe

Additional functions:

Text to speech, Bluetooth, time-specific navigation, alternative routes, TMC, lane assist

Accessories included:

User instructions RNS 510, short virtual user information and maps on CD

Distributor:

Volkswagen Zubehör
An der Trift 67
D-63303 Dreieich

Plus:

- choice of several routes
- pre-selection of entertainment volume reduction for voice guidance
- continued navigation without satellite connection through vehicle sensors
- no disturbing cables, vibrations and reflections
- additional display in on-board display
- displays traffic signs
- supports destination entry based on coordinates
- very clear graphic display
- split screen

- good voice output
- No "via" function

Minus:

- long response times between menu levels
- uncomfortable posture when input takes longer
- no external volume control (keys, scroll wheel)
- no input about environmental zones (POI and route guidance)
- no seasonal road closures (winter closures)
- provides arrows as lane assist only

Carminat TomTom in the Renault Mégane

O	Equipment components
++	Route calculation
+	Navigation
+	Fittings / Usability
O	Driver distraction



Figure 19: Carminat TomTom in the Renault Mégane

Overall impression:

Low-cost integration with minor weaknesses. Device provides all necessary functions for good navigation. Maps are one year old!

Purchase price: €490.00

Type of device/operation:

5.8" in-vehicle integration with operation elements in the centre console (scroll wheel/keys)

Software/maps:

TomTom 8.841/TeleAtlas

Area of coverage:

D, A, CH

Additional functions:

Text to speech, Bluetooth, time-specific navigation (IQ routes), alternative routes, TMC, lane assist, 3D landmarks, display of traffic signs

Accessories included:

SD card with maps for D, A, CH, user information

Distributor:

TomTom Mobility Solutions
Rembrandtplein 35
NL-1017 CT Amsterdam
E-mail: info.mobility@tomtom.com

Plus:

- low-cost in-vehicle integration
- no disturbing cables, vibrations and reflections
- displays traffic signs
- continued navigation without satellite connection through vehicle sensors
- supports route selection by time of day and day of the week
- supports destination entry based on coordinates
- good fast access options
- good display of traffic information (can be read out loud)
- "via" function

Minus:

- D, A, CH on the included SD card only
- complex vehicle user elements
- slow route calculation times
- only some navigation menus are translated (Dutch)
- display is reflected in windscreen at night
- inconsistent display/output, e.g. voice guidance: "turn left after 80m", display: "70m"
- maps one year old
- no external volume control (keys, scroll wheel)
- other system on mute during voice output
- no input about environmental zones (POI and route guidance)
- no seasonal road closures (winter closures)
- some of the displayed traffic signs are incorrect
- 2GB storage space for SD card allows only small area of coverage

BMW Professional navigation system

O	Equipment components
++	Route calculation
+	Navigation
+	Fittings / Usability
+	Driver distraction



Figure 20: BMW Professional navigation system

Overall impression:

Nearly perfect navigation thanks to combination of head-up display, monitor and absolutely clear voice guidance. Connected to vehicle sensors, positioning is very fast & precise. The awkward and time-consuming iDrive system operation is the only drawback.

BMW price list: €3850.00

Type of device/operation:

12" in-vehicle integration with head-up display and iDrive operation system

Software/maps:

ECE BMW Group 101094.0.19 / Road Map Europe PREMIUM 2011

Area of coverage:

Europe

Additional functions:

Head-up display, text to speech, Bluetooth, alternative route, TMC, lane assist, telematics compatible (for using the services of BMW Connected Drive such as BMW Assist (includes eCall, enhanced traffic information (RTTI), comfortable information services) or BMW Online (information and news portal including geo-coded address transfer into navigation system) and Internet access). Includes Business mobile phone preparation based on Bluetooth interface, voice input system

Accessories included:

User instructions

Distributor:

Bayerische Motoren Werke AG
D-80788 München
Phone: +49 89 3 82-0
www.bmw.de

- Plus:**
- head-up display
 - agreeable voice output via speakers
 - choice of alternative routes
 - agreeable reduction of entertainment volume during voice guidance
 - precise navigation through vehicle sensors

- no disturbing cables, vibrations and reflections
- displays traffic signs
- very clear graphic display
- split screen

- Minus::**
- iDrive system input somewhat awkward and time-consuming
 - slightly long booting
 - no touchscreen
 - no automatic zoom
 - does not support destination entry based on coordinates
 - no input about environmental zones (POI and route guidance)
 - no seasonal road closures (winter closures)

Mercedes COMAND APS

⊖	Equipment component
++	Route calculation
+	Navigation
+	Fittings / Usability
+	Driver distraction



Figure 21: Mercedes COMAND APS

Overall impression:

Good navigation with drawbacks. Additional display not always consistent with vehicle's display. Input of e.g. a route is awkward. Connected to vehicle sensors, positioning is very fast and precise. Operation of scroll wheel at centre console is slightly awkward and time-consuming (e.g. route programming).

Mercedes price list: €3070.20

Type of device/operation:

Diagonal integration (17.8cm), operation by scroll wheel at centre console

Software/maps:

No information

Area of coverage:

Europe

Additional functions:

Text to speech, time-specific navigation, alternative route, TMC, lane assist, USB interface, Bluetooth interface to hands-free kit and audio streaming for music transmission, TMCpro, slot for SD cards, speed alert, DVD video and LINGUATRONIC audio voice control system, free navigation updates for maps for 3 years

Accessories included:

No information

Distributor:

Daimler AG
Mercedesstraße 137
D-70327 Stuttgart
Customer phone: 00800 1 777 7777
www.mercedes-benz.de

Plus:

- agreeable voice output via speakers
- choice of alternative routes
- complete reduction of entertainment volume during voice guidance
- precise navigation through vehicle sensors
- no disturbing cables, vibrations and reflections
- supports destination entry based on coordinates
- supports route planning
- split screen

Minus:

- scroll wheel in centre console somewhat awkward and time-consuming
- no touchscreen
- no automatic zoom
- no input about environmental zones (POI and route guidance)
- no seasonal road closures (winter closures)

12. FINDING TEST CRITERIA

All over Europe, automobile clubs, consumer organisations and communication magazines carry out comparative studies helping consumers to make informed choices.

Organisations in 26 countries all over Europe have been contacted to provide information about of nomadic device tests. Altogether, 31 organisations in 14 different countries conducted or published tests of nomadic devices (see WP 4.8.1 "Review of earlier consumer tests and standards")

Most tests cover mobile navigation devices in general. Some tests are collaborative projects. For example, the ADAC test of mobile navigation devices is supported by ÖAMTC and also published by TCS and RACC.

In Europe, the most comprehensive consumer tests for nomadic devices were conducted by ADAC and Stiftung Warentest in Germany, Navigovat in the Czech Republic and Which? in the United Kingdom. ÖAMTC in Austria and TCS in Switzerland publish the ADAC test results. For competitive reasons, the testing organisations did not disclose further details about their tests which is why we are unable to provide a detailed description. Upon comparing the various tests, we found the following main differences:

- Type of devices, number of tests and publication frequency per year

We found that nomadic device testing mainly involved mobile navigation devices and smartphones. Which? is the only organisation that looked at all types of systems (mobile navigation devices, smartphones, PDAs, OEM devices). The number of models per test run ranged between 5 units (Tom's hardware) and 80 units (Which?). Between one test (Altro Consume, Quattroroute, TCS, Which? and Whatcar?) and 40 tests (Navigovat) were conducted annually.

- Equipment

The various organisations took different approaches in looking at what is included in the package. ADAC, Stiftung Warentest, Navigovat and Which? carefully checked the equipment and diversity. A detailed examination of all 13 organisations (excluding ÖAMTC and TCS, since they joined ADAC tests) revealed the following:

<u>Brand</u>	Only one third of the organisations examined the maps available on DVD
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<u>Navigation</u>	Only two organisations assessed the display reading angle
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Only one third of the organisations assessed the **display quality (number of pixels)**

UK organisations only (Which? and Whatcar) tested **traffic data (TMXpro)**

Only four organisations assessed **GSM traffic data**

Only Navi Magazin and Navigovat tested **compass mode**

Only five organisations assessed **congestion warning through the Internet**

Three organisations assessed the **arrow display/superimposed**

Destination input – intermediate destinations is no issue for nine organisations

Only two organisations assessed the **default destination memory**

Three testing organisations tested **speed alert**

Entertainment Only two organisations tested **CC/CD** functions

- Test criteria

Different aspects apply for the test criteria. Below are the results of detailed examinations carried out by all 13 organisations (excluding ÖAMTC and TCS, since they joined ADAC tests):

Operation Four organisations tested **user instructions**

Less than one third of the organisations assessed **route options**

Only one organisation tested the **battery charging time**

Only four organisations tested the **processing speed**

Navigation One in four of the testing organisations assessed **reaction to leaving the route**

Only three organisations tested **routing**

Route calculation

Only three organisations assessed the **stop-over function**

50% of the organisations tested **TMC**

Further criteria

ADAC and Tom's Hardware tested **driver distraction**

Only one organisation tested after-sales **service**

Only Navigovat tested **map updates** and **stability of functions**

Three organisations tested **value for money**

In some countries, no consumer tests for navigation devices were carried out at all. The reasons include:

- Not enough maps available for the relevant country
- Relevant country does not have a consumer organisation
- Consumer organisations buy test results from organisations in other countries

The purpose of consumer tests is to help potential buyers of nomadic devices make the right buying decision. Additional user requirements such as DVB-T are not part of the benchmark, since these functions have a potential risk of distracting drivers (the ADAC approach is based on ESoP system requirements).

13. CONSUMER TEST RECOMMENDATIONS

Comprehensive consumer tests enable buyers of nomadic devices to make informed choices. They are equally important for system developers of such devices and vehicle manufacturers and ensure due consideration of consumer requirements at an early stage.

All stakeholders should be familiar with the consumer tests and apply the same test criteria in their product tests.

This will allow manufacturers to identify and evaluate safety risks and ease of operation in advance. They should therefore ideally implement the ADAC consumer test procedure for mobile navigation devices combined with test criteria of other testing organisations.

14. TEST CRITERIA

1. Equipment components

- User instructions/manual (structure, intelligibility, errors, safety instructions, illustrations, language(s), hard-copy or CD/DVD format, short instructions, manufacturer contact information and update option)
- Components in delivery package
- Comprehensiveness and quality (updates) of the standard and optional digital maps; map provider
- Possibility to update the software
- Size of storage media
- Language versions (voice output/operation)
- Additional functions, e.g. Bluetooth, MP3, pictures, travel guides etc.

2. Route calculation

- Response time for vehicle positioning (time to establish first satellite connection) and start of route calculation
- Route calculation time from initial start-up (especially for long distances)
- Repositioning and/or re-routing time after interruption by GPS signal, if applicable (tunnel, underground parking, other failure in reception)
- Time until system starts re-routing after leaving initial route

- Accuracy of vehicle positioning by reference points (while stationary/moving, with/without routing)

3. Navigation

- Voice output (timeliness, lane change suggestions, intelligibility, clarity, adequate frequency, map consistency)
- Graphic display (accurate presentation of traffic situation, sensible instructions, no overcrowding with irrelevant symbols), real-time position consistent with map position
- Automatic zoom (speed-related) at intersections or when turning off (intersection zoom)
- Additional/exclusive arrow guidance
- Reaction to departure from initial route (timeliness, clarity of new route)
- Up-to-dateness and quality of map display
- Reaction to TMC messages and response time for detour routing (automatic re-routing, automatic re-routing with confirmation, manual re-routing only when entering new stop-over/destination?)
- Clarity of suggested route depending on route options (fastest, shortest or dynamic route)
- Display of driving time, ETA, length of route, speed, speed alert

4. Fittings/usability

- Installation (car, motorcycle, bicycle). visibility, wiring
- Controls (keys, touchscreen etc.)
- Intuitive operation
- Logical menu structure
- Size and accuracy of keys/key fields. Stylus necessary?
- Entry of destination; clarity and variability of entry mode; speed of entry (number of keys from start screen), "smart speller"
- Street number support, comparison with original map data (tour planner), localisation on map.
- Preview of suggested route (is function available, and if so, easy and quick?)
- Entry of stop-overs or special destinations [POI] before and during the trip
- Selection of POI without known address (e.g. airport)

-
- Selection of route options (fastest/shortest, dynamic, suppression of certain types of roads, avoiding turn-back instructions)
 - Manual/automatic congestion avoidance routing
 - Changing route options while driving
 - Specific settings (e.g. shortcuts to voice guidance volume, brightness, contrast, day/night graphics, 2D/3D display, colours, individual display settings)
 - Clarity of display in different daytime/night-time lighting conditions, glare
 - Battery capacity time when used outside vehicle
 - Adaptation to vehicle
 - Stability and adjustability of device holder/mounting
 - Stable installation in vehicle
 - Tendency to vibrate
 - TMC receiver integrated/connectivity
 - Obstructing driver's view

5. Driver distraction

- Distraction caused by routing mistakes, acoustic information or speed information while driving
- Distraction caused by excessive focus on device to grasp all information
- Distraction by attending to too many tasks at a time (different driving and traffic situations at a time)

With a view to traffic updates (TMC), even the above comprehensive test reached its limits, since it is not possible to evaluate the quality of alternative routes and the impact on traffic dynamics. The findings of the FOT could provide valuable input here. Other issues to be further explored by FOT include driver distraction, user friendliness, and in-vehicle installation.

CONCLUSION

The influence of navigation systems on road traffic depends on the respective system or navigation device. The fitting system, the directions display, the street name output as well as directional changes, all have an impact on driver concentration. Windscreen-fitted suction-mount systems impair the driver's visibility. Unsuitable fitting systems and cabling may further contribute to driver distraction. Moreover, operating the devices must be intuitive. To comply with these requirements, it is imperative to have clear indications, consistent menu guidance and an optimum of information.

Operating the touchscreen displays of smartphones is ideal because of their sensitive surface and short response times. The advantage of centre console fitting and operation is that it allows a comfortable sitting posture.

Good navigation should have little influence on the driver. The quality and frequency of the voice output and an abundance of information on the display can irritate the driver. A simple glance to take in all information seems ideal. Incorrect navigation instructions or information output have further distraction potential and may even give rise to dangerous situations if the information is given too late. This also applies to incorrect speed limits as they may confuse the driver at the given moment.

Route calculation also includes daytime-specific traffic information. Ideally, rush-hour jams can be circumnavigated or avoided. Within the test period, changed navigation instructions due to changed weather conditions were a rare feature: the times of arrival could not be adjusted to en-route weather conditions.

There are no major differences when it comes to the key function, namely navigation itself. The devices all take you from A to B! However, including daytime-relevant traffic scenarios and information from different platforms are decisive for the navigation performance. For dynamic route guidance, the information used and their scope are essential, i.e. whether the routes suggested can be covered without any disruptions or detours.

REFERENCES

- [1] Different publications of individual system groups within the navigation systems test conducted by ADAC and participating partners between 2008 and 2012 (Internet, ADAC Motorwelt)

ANNEXES
