Smart campus tools
Executive Summary

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Executive Summary

The 'Smart campus tools' research started because of a problem that is familiar to both users and campus managers alike: space that is reserved, but only partly in use. Users are often looking for a place to study, to work or to have a meeting, but all the space on campus seems to be in use: education spaces are booked for a lecture and desks are claimed by books on the table or a coat on the chair. However, for large parts of the day they are not in use. The analogy with the 'towel problem' that occurs at the swimming pools during holidays (figure M.1) is made quickly: "reserved but not in use" is a major irritation when space is scarce. This leads to a paradox: whilst students and professors demand more space on campus, campus managers know that the available spaces are not used to their full capacity.

Figure M.1: "reserved but not in use" als problem statement – smart tools als possible solution

It seems that smart tools can deliver an important contribution to solve this problem, and in doing so they can be an added value for different stakeholder groups on campus. By helping users with booking or finding available spaces they can make better use of space in the current situation. By providing facility managers and real estate managers with (real-time) data on the actual use of the different space types on campus, they are aided in the decision making on future campus investment. The main research question is: Which smart tools are in demand by the universities and which smart tools are available?

A smart tool is a service or product which collects (real-time) information on space use to improve the space use on the current campus on the one hand, whilst supporting decision making on the future space use on the other hand. A smart tool is described in three components:

1. Why this tool? - objectives - the reasons why the smart tool is implemented
2. What does this tool measure? - space use information - the type(s) of data collected
3. How does this tool measure? - measurement methods - the sensor, system or method used to determine space use

Each of these components are explained briefly with examples.

Objectives of smart tools - "Why this tool?"

In order to determine in which way the smart tools can be of added value to the organisation the research team has used the objectives for campus management, based on previous research by Den Heijer (2011). These objectives are assigned to the most important stakeholders within universities and their perspectives on the campus (figure M.2): policy makers (strategic), users (functional), controllers (financial) and technical managers (physical). Examples of objectives are increasing the user satisfaction, increasing flexibility (of space use) and reducing the m2 footprint.

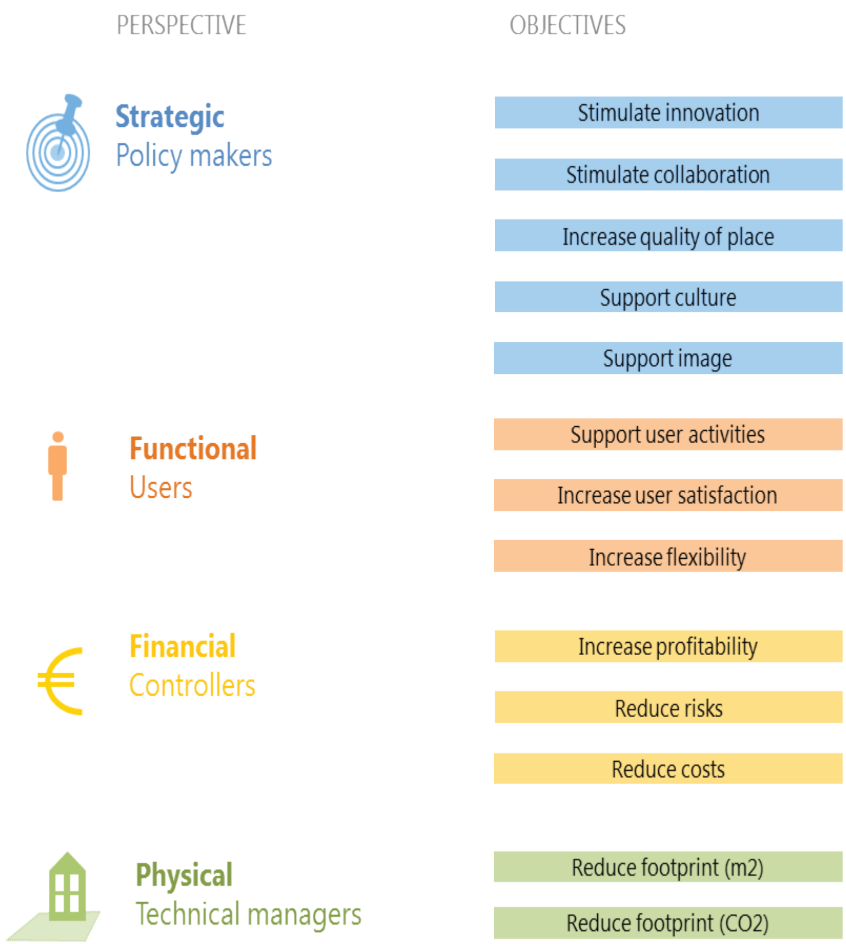


Figure M.2: Objectives of "campus management" (adapted from Den Heijer 2011), used in this research to structure the 'why' of smart tools

Research on the contemporary context of the Dutch university (Campus NL, 2016) shows that the (more) effective and efficient use of scarce and expensive resources - such as space, energy and personnel - has a high priority amongst policy makers. Smart tools can deliver a positive contribution to this, direct or indirect via a number of objectives.

Information on space use – "What do smart tools measure?"

In order to achieve the aforementioned objectives, smart tools are used to collect data on space use. When space use is measured real-time the data can be collected on different levels of detail: so-called 'resolutions' (figure M.3). Examples of resolutions: it can be determined if someone is present in a space at a given time (frequency), how many people are present in that space (occupancy), who are present in the space (identity) and what they are doing (activity). Activity can either be defined in movements or behaviour.

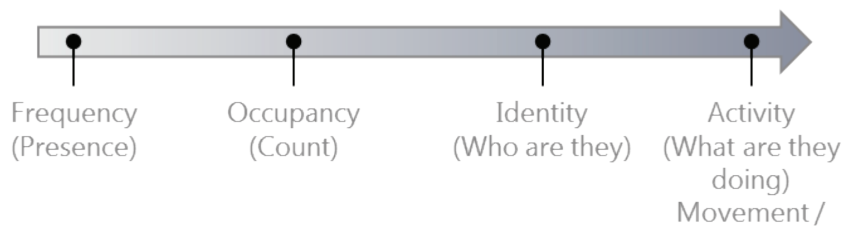


Figure M.3: Occupancy -space use- resolutions (adapted from Christensen et al. 2014), used in this research to structure the 'what' of smart tools: what is measured.

In the measurement of space use it is common to make a distinction in frequency and occupancy. Frequency indicates the use of a space in relation to the available time (e.g. opening hours of the building) whilst occupancy indicates the use of a space in relation to the available capacity (e.g. the amount of seats). In addition a distinction can be made for education spaces and classrooms in what the space use is according to the timetable or booking system and what the space use is in reality.

For the smart tools four types of space use information have been discerned:
(1) frequency as stated in the timetable;
(2) occupancy as stated in the timetable;
(3) frequency as measured in reality; and
(4) occupancy as measured in reality.

This is displayed in a four-quadrant matrix in figure M.4a. When measuring frequency it is important to know which time interval is used as maximum - the opening hours of the building or only the education hours. When measuring occupancy it is important to know how many people can study or work in a space - usually measured via the amount of seats or desks in the room.

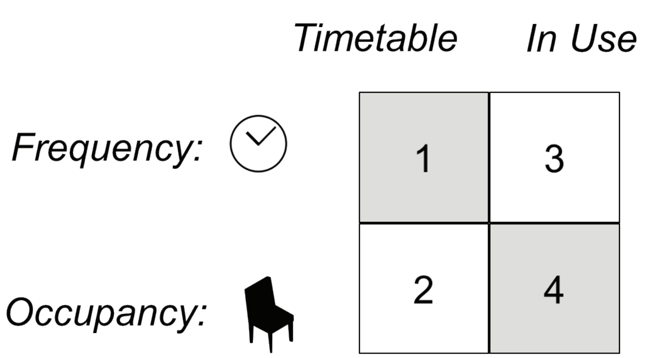
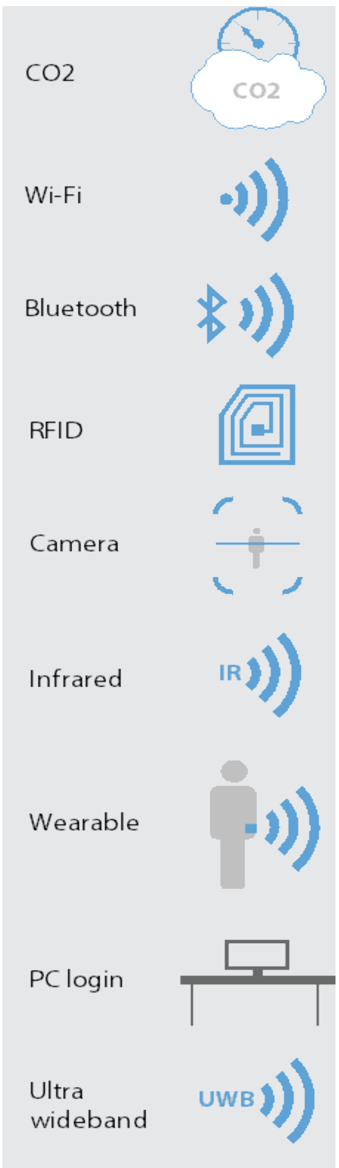


Figure M.4a: Matrix with four types of space use information: frequency (use in time) and occupancy (use in capacity), as stated in the timetable or as measured in reality.

Figure M.5: Possible sensors in smart tools – used as basis in this research



As a part of this research the universities have also been asked if they have this information on space use for certain space types, such as education spaces. From measurements of four Dutch universities (figure M.4b) the following results are reported: in the timetable the average frequency is 67 percent whilst in reality the frequency is 58 percent - a difference of 9 percentage points. The occupancy in reality is 56 percent - this is only compared to the occupancy in the timetable at one university, and therefore not included in this figure.

In the United Kingdom the term 'utilisation' is also commonly used in space use audits: this number is obtained by multiplying the frequency and occupancy rates. Space use information is also used to express reduction opportunities: how many space, energy and costs can be saved by using space more effectively and efficiently? This relates to the aforementioned objectives. Naturally no university has the ambition to achieve a 100 percent frequency or occupancy - they do however aim to improve their space use.

Sensors and measurement methods – "How do the smart tools measure?"

In the application of smart tools sensors and other measurement methods are used to collect information on space use. In the past space use was often measured by counting manually. Examples of sensors that are used in smart tools to measure space use are cameras, bluetooth, infrared sensors and Wi-Fi - see figure M.5.

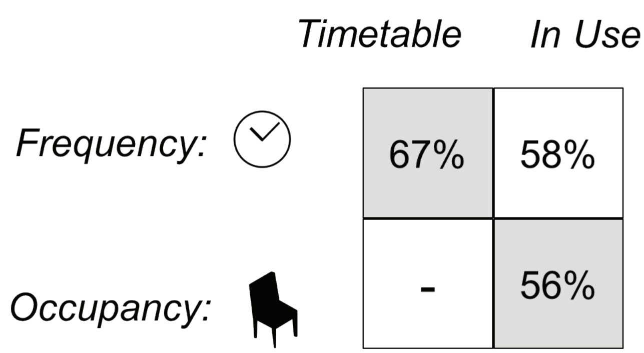


Figure M.4b: information on space use - average percentages based on space use measurements at four Dutch universities (education spaces).

Research Methods

The research consists of three parts. First a literature study has been done in which the goal was to create an overview of the current smart tools in literature and the use of these smart tools in real estate management. Thereafter an assessment is done at the Dutch universities, consisting of a questionnaire and two interviews. In this assessment data is collected about the tools currently in use at the universities and their future demand for tools. Finally, an exploratory study is done in the market, which consisted of interviews and desk research. For a part of this exploratory study interviews have been held with end users of real estate in other sectors, in order to get a perspective on the smart tools that they use in their practice. For the other part of the exploratory study interviews were conducted with consultants, engineering firms and suppliers in order to get a better view on the sensors used in smart tools and their performance.

Results

The Dutch universities are currently using 26 different smart tools for a number of different purposes.

> **Conclusion:** The Dutch universities have 26 different smart tools in the current situation; these tools are predominantly aimed at using the campus more effectively.

Objectives: Facilitating the student, in self-study and collaboration with fellow students, is the largest driver for the implementation of current tools. These support functional goals (52 times) and strategic goals (27 times) in particular and are thus mainly aimed at using space on campus more effectively. In many cases reducing m2 or costs are not objectives of the existing tools. Furthermore, for example financial and/or sustainability goals are not always the objectives named first, although they are objectives that can be achieved indirectly via more effective and efficient space use.

Information on space use: In all of the current smart tools that collect information on space use data is collected on the resolution of frequency and/or occupancy. There is no case in which information is collected on the resolution of identity or activity. The frequency as measured in reality is determined in a large amount of tools via a self-booking system which allows short-term bookings. The shorter the time is between making a booking and using the booking, the more accurate the booking system displays reality.

Measurement methods: The most used sources to collect information on the actual space use are self-booking systems and login data of desktop PCs. A number of other sensors are used in a few cases to determine the frequency or occupancy in reality: Wi-Fi, cameras and infrared sensors.

Objectives	Tools – current and desired functionality	Current	Desired
	Tools for campus management		
	Manual space use measurements education spaces	13	0
	→ Real-time space use measurements	1	3
	Space use measurement for offices		1
	User flows in inside and outside environments		3
	Tools for students		
	Available PC study places	9	
	Available non-PC study places	1	
	Self-booking system for project rooms	6	
	Facilitating studying in classrooms and meeting rooms	3	
	Self-booking system based on amenities in rooms		1
	Tools for employees		
	Availability of meeting rooms	2	
	Self-booking system for workplaces and meeting rooms	1	
	Tools for students and employees		
	Indoor navigation	2	
	Displaying emergency routes in emergency situations		1
	Tools for the sustainable campus		
	Linking timetabling system & building management system	2	
	Tools for sharing campus facilities		
	Booking system for third parties (meeting rooms)		2

Figuur M.6: Overview of functionalities, universities and tools.
With 'Current' the amount of universities that have implemented tools is shown for each functionality. With 'Desired' the amount of times a university has expressed interest in smart tools is shown for each functionality.

Conclusion: The current supply of smart tools is well aligned to the current demand for information, according to the Dutch universities - the additional demand is predominantly for tools that enable a more efficient use of space.

The current smart tools have fifteen different functionalities. These functionalities are more specific than the generic objectives that they support. Figure M.6 displays the amount of tools currently implemented per functionality. The tools which are most in demand by the universities are space use measurements - for education spaces, offices and as user flows. With the implementation of Lone Rooftop Wageningen University has a tool that collects real-time information on frequency and occupancy of education spaces. Other universities can make use of the experience of Wageningen University. The other functionalities are only desired in a few cases.

Conclusion: The supply of smart tools at the Dutch universities is currently in full development.

In addition to the 26 different smart tools approximately half of the universities is working on the further development of their smart tools. This is done in different ways: by developing existing tools further, by starting pilot projects with market players or by developing new tools themselves. The further developments are displayed in figure M.7.

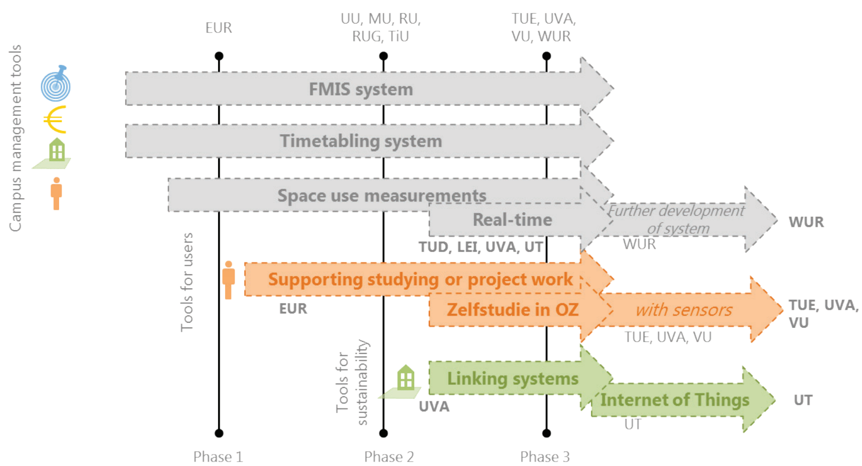


Figure M.7: Overview of the development of smart tools. The current implementation is displayed in a regular font, the ongoing projects are displayed in a bold font.

Conclusion: Also at Universities of Applied Sciences and parties in other sectors smart tools are used that are comparable to those of universities, or which can be relevant for them.

The findings from the market study reveal that both the Universities of Applied Sciences and organisations in other industries have implemented smart tools, which have different functionalities.

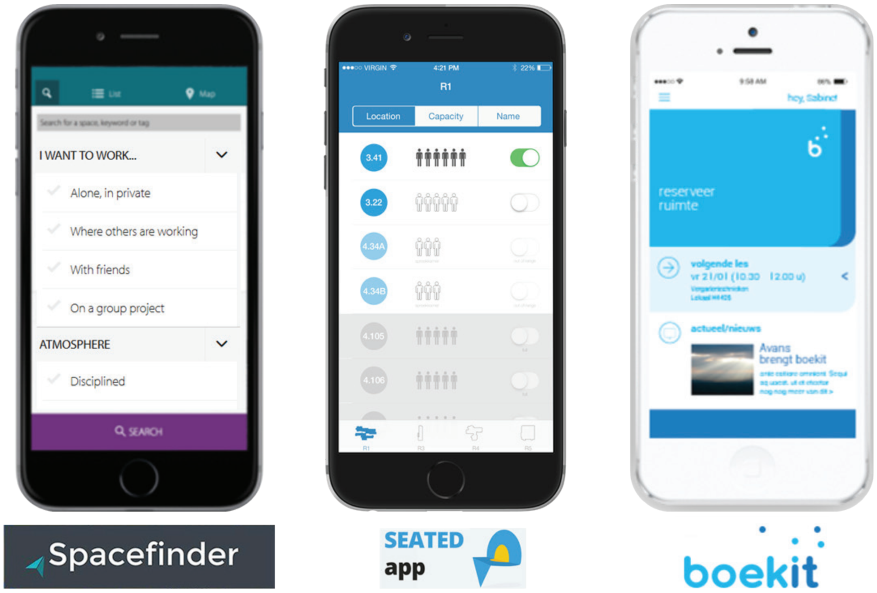


Figure M.8: Impressions of a few tools that emerged from the exploratory market study: Spacefinder, Seated, Boekit.

Conclusion: The development of tools at the Universities of Applied Sciences is comparable to the implementations at the Dutch universities - both examples from the UAS can give direction to the next step in the development of smart tools for users in higher education.

The current smart tools at the Universities of Applied Sciences are comparable with the smart tools at Dutch universities in terms of functionalities and objectives. The tools are mostly aimed at using space on campus more effectively. However, in both cases the tools have not yet been implemented - the implementation is in progress or the tool is still in development.

Although the tools found are comparable in terms of functionalities and objectives, the tools also have properties that are not observed in the tools that are used by the universities. Therefore they can give the universities direction when they develop their tools further, by serving as reference projects:

• The implementation of Boekit (Avans) will combine both the demand for user tools (effective space use) and the demand for space use data (efficient space use). This is a combination that is not yet existent at the universities.

• The development of Seated (Fontys) is an example of an interactive self-booking system. In this app, the act of making or deleting a booking is determined by the vicinity of the user to the space he/she wants to reserve.

• The implementation of Spacefinder (Cambridge University) shows an alternative for offering users information regarding the availability of spaces - instead, it displays information on the location of study places on campus in combination with information about the properties of the study place. This makes it possible for students to find a study place based on their requirements: e.g. daylight, atmosphere, noise levels, vicinity to coffee.

Conclusion: The smart tools in other sectors are more aimed at efficiency than effectiveness. From these tools lessons can be learned about the use of multiple data sources and combining them to gain insight in space use - however the implementability of these specific solutions at universities is limited.

The current smart tools at other organisations are much more aimed at more efficient space use than is the case at universities. Shell has developed their own smart tool, which is used to determine which locations have high and low occupancy levels, which is used to make investment or divestment decisions. At Dutch Railways smart tools are used to determine which areas of stations are used most frequently. This information is used for the (re)design of station areas, adaptations in the train schedule and ensuring the safety levels on platforms.

Both Shell and Dutch Railways use multiple data sources to determine space use. The universities can learn lessons from these parties with regard to how data from multiple sources can be combined. Directly implementing the solutions used at these organisations is not possible, because both systems rely on monitoring the access of the building. This is in contrast to the situation at universities, which have buildings that are mostly accessible to the public.

Conclusion: Wi-Fi as a sensor seems to be the most suitable to be applied in the context of campus management at universities.

In addition, in the market study an exploration was done that was aimed at the different kinds of sensors and their performance. Almost all sensors can be used for real-time applications, but especially in the spatial resolution (campus-bulding-floor-room-desk) there is a large variation in the extent to which sensors can give accurate results. In the application of a few methods the spatial resolution depends on the density and/or placement of the sensor, which also has a large impact on the costs. At the moment the use of Wi-Fi as a sensing method seems to be very suitable for application in the context of universities, for a number of reasons:

• Wi-Fi is applicable for many of the universities' (desired) functionalities, although it is less precise than a number of other methods;

• Because it used existing infrastructure the costs are relatively low when compared to methods that require investment in new infrastructure.

• The use of Wi-Fi for smart tools applications is more flexible than many other sensing technologies; when a new or other functionality is desired, it is relatively easy to adapt whereas other technologies would require alterations in the amount of sensors placed or the replacement of existing sensors.

Dashboard: individual advice specific to each university

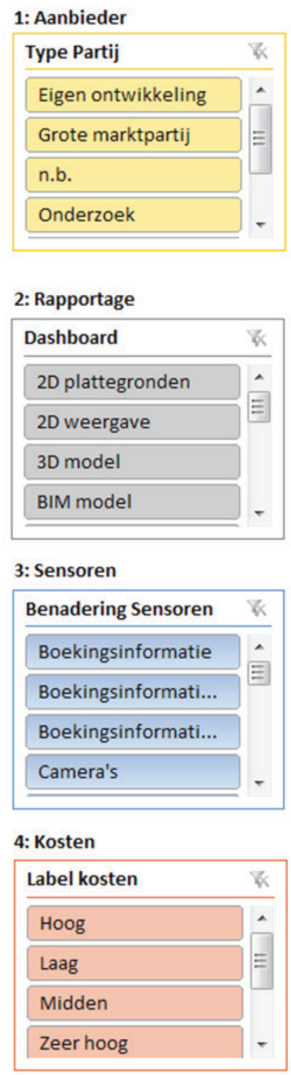
At the outset of the research the ambition has been stated to advise the universities about the smart tools that best fit their specific objectives. In light of the many different objectives and types of smart tools, finding an individual advice (per university) in a research report is a challenge. The match between demand and supply in smart tools is dependent on a multitude of interconnected variables: e.g. the functionalities of the smart tool, the space type for which it is used, the supplier of the smart tool, the privacy issues with the sensor used.

In order to navigate in this complexity a dashboard is made in addition to the report. The dashboard and its figures, which are shown on this page, are in Dutch. The dashboard gives each university access to a database filled with the tools found in the reseach, and enables the user to apply filters to achieve the desired overview. The dashboard gives an alternative route to all the information that has been collected in this research and offers the universities the opportunity to find their own way in the available information.

The most important filters that can be applied are:

Filters based on the application of the smart tool (Figure M.9a)
- Filter on case or supplier – the dashboard only displays examples of tools that are implemented (e.g. at Universities of Applied Sciences) or also displays which tools a supplier can potentially deliver
- Filter on space type – the dashboard displays smart tools based on the space type for which the user requires a smart tool (e.g. education spaces or offices)
- Filter on user – the dashboard displays smart tools based on the user for which the tool is developed (e.g. students, employees or facility managers).
- Filter on functionality - the dashboard displays the desired functionalities (e.g. measuring space use, self-booking tools)

Filters based on the properties of the smart tool (Figure M.9b)
- The supplier of the smart tool - Is the tool supplied by a large party, a start-up or is it developed by the organisation itself?
- The selection of sensors - This filter is added because universities have indicated that they prefer the use of proven technology. The options are all sensor technologies found in this research: e.g. Wi-Fi, iBeacons, infrared.
- Costs and benefits - In the end the costs of each solution and the (perceived) benefits decide if it is desirable to move from the current solution(s) to other solutions. Insight into the costs and benefits of each tool is complex: the costs are often based on the m2 or buildings to which they are implemented, and the benefits can often not be determined yet, because they are achieved over a longer timespan.



Figuur M.9b: Filters based on the properties of smart tools (in Dutch)

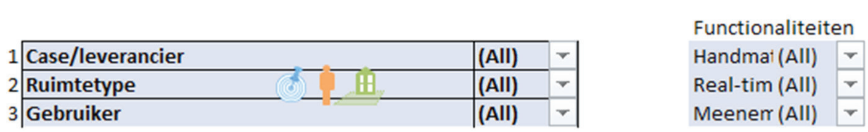


Figure M.9a: Filters based on the use of smart tools (in Dutch)