New techniques in Building Surveying

H. Bartels[1], A. Reutter[1], D. Donath [2], U. Weferling[3], F. Petzold[2],
Bauhaus University Weimar, 99421 Weimar, Germany

1 Faculty of Art & Design (heiko.bartels| andre.reutter @gestaltung.uni-weimar.de)
2. Faculty of Architecture (donath|petzold@archit.uni-weimar.de)
3. HTWK Leipzig - Department of Civil Engineering and Architecture (weferling@fbb.htwk-leipzig.de)

Summary

Building activities in the construction industry in Germany increasingly concentrate on building measures in or involving the existing built environment. Before planning can begin, buildings must be surveyed in whole or in part with the surveying of geometric data playing a dominant role. The geometric survey is typically undertaken using geodetic or photogrammetric measuring techniques and equipment that have been adapted for use in building surveying. Accordingly appropriate technical knowledge is required in order to be able to operate them as well as a considerable financial investment. Such equipment and surveying methods are usually adaptations from other disciplines.

The paper discusses and presents approaches to developing “new” equipment for building surveying, devised with the needs of building surveying in mind – redesigns or new designs for surveying tools.

The designs are the result of an inter-disciplinary project between the Faculty of Architecture and the Faculty of Product Design at the Bauhaus Universität Weimar.

1 Introduction

The ever more complex requirements which buildings are expected to fulfil are mirrored by an increasingly complex design process. This applies equally for the planning of new buildings as well as conversion and renovation work. The unknown quantities in existing buildings often present particular difficulties during planning. To tackle more complex planning tasks, the planner employs digital tools and systems. Systems specially developed for the needs of planners are seldom and usually insufficient.

The computer-aided support of planning processes is a primary research and development topic at the chair for computer science in architecture (InfAR) at the Bauhaus-Universität Weimar. Since 1998 the research has been integrated as a sub-project (D2) within the special research area 524 “Tools and Constructions for the Renovation of Buildings.” The establishment of a new “junior professor” for architectural computer science in 2002 has added extra impetus to the theoretical and practical research.

The following paper discusses ONE aspect of the research area “Planning and Building in Existing Built Environments”.

In most cases the term “building survey” is understood to mean a geometric survey of a construction’s physical dimensions translated into architectural plans, sections and elevations. For more comprehensive planning documentation further supplementary information is required, and typically the amount of information required, geometric or otherwise, increases as the project planning progresses (see also F. Petzold et al. "The building as a container of information the starting point for project development and design formulation " in this publication).

The building survey is usually undertaken "… by architects and building engineers. They lack perhaps the necessary education with regard to geodetic surveying, however their knowledge of building construction and history makes them obviously well suited to building surveying. As a result the surveying methods and equipment is typically described as basic." /Kehne89/

This reflects the current situation fairly accurately. The geometric building survey is, however, often undertaken using geodetic or photogrammetric surveying techniques which have been adapted to the needs of building surveying. In general a degree of specialised knowledge is required and the equipment is typically expensive.

2 Traditional measuring techniques

Building surveying traditionally uses conventional measuring techniques which lead to the production of analogue results in the form of plans, sections and elevations. Conventional equipment and surveying methods usually involve the measuring stick/folding rule, (reflectorless) tacheometry and photogrammetry. They have been developed within their specific fields and then later adapted for use in building surveying. /Donath et al., 2002/.

a) Computer-aided manual surveying methods

Computer-aided manual surveying using an electronic distancing meter is a simple and cost-effective means of quickly measuring simple geometric dimensions. The following characteristics apply:

- Measurements are taken in direct contact with the building.
- The dimensions are typically measured between two surfaces (wall length, room height, door width etc.) against which the measuring device is held.
- Measurements can only be taken between two points which can be seen from one another.

Fig.1 DLE 150 Connect – Bosch

Fig.2 DISTO™ classic[5] - Leica

b) Reflectorless Tacheometry

Reflectorless Tacheometry is also often employed as a further means of measuring geometric dimensions. Despite its adaptation to the needs of building surveying, tacheometry does have some disadvantages:

- The direct contact with the building is lost.
- The point being measured must be visible from the total station.
- Tacheometry requires special skills and is therefore usually undertaken by those with specialist surveying skills.

As a result the building survey is usually delegated to experts with the respective surveying skills but who may lack sufficient knowledge of the ‘actual’ planning-relevant problem areas. This deficit is, for example, evident when it comes to surveying complex technical installations which are part of almost every construction and an important aspect for the future building planning.

Fig.3 TPS410C and TPS110C Builder Total Station - Leica

Fig.4 Trimble Totalstation 3300 DR

c) Laser-Scanning

Laser-scanning can be regarded as a special form of reflectorless tacheometry in which (part of) a building object is scanned in detail producing a high-resolution ‘cloud’ of points. The disadvantages of such systems are therefore similar to those of reflectorless tacheometry. In addition it should also be noted that the high-resolution surveying of such surface geometries necessitates a secondary post-processing stage in which the relevant building parameters are derived. This aspect of building modelling still requires considerable development before laser-scanning can be used in practice for planning-relevant building surveying. It is however well-suited to limited areas of detailed measurement.

Fig.5 Callidus

Fig.6 Cyrax 3D Laser Scanner – Leica

d) Photogrammetry

Stereo-photogrammetry or multiple image photogrammetry is, generally-speaking, not relevant for building surveying. It requires specialised skills, involves technical post-processing and is expensive. In principle it is suited to the surveying of irregularly structured building details.

In contrast, single-image photogrammetry is a good means of obtaining geometrically correct information at a high-resolution of reasonably even building surfaces. However distortion correction algorithms have difficulties dealing with irregularly formed building surfaces. Approaches which combine photogrammetry with laser-scanning are not yet sufficiently developed for market applications.

The equipment and processes described have been developed in various different specialised fields, for instance land surveying, land property surveying and engineering surveying. Each field imposes its own boundary conditions and form the basis from which the tools and approaches have been developed. Whereas in engineering surveying accuracy is of primary importance, in building surveying the contact to the building is of particular importance as is simple operation. As a result high-precision instruments are less useful than ‘straightforward’ cost-effective instruments.

3 The project “Daten(staub)sauger” (Data hoover)

The aim of the project is the development of practice-oriented mobile digitally supported equipment and system environments for the digital architectural surveying of buildings. The targeted user group is architects and engineers who require simple to use, ergonomically designed tools tailored to the needs of building surveying with a view to future planning needs.

The task included the development of a system which together with tools and equipment forms a working environment for architectural building surveying. The emphasis was laid on the development of optimised man-machine communication as well as ergonomic considerations.

A working environment for currently existing as well as possible future surveying equipment was developed and realised as a prototype. Special attention was also paid to product ergonomics: a contemporary design, functional and robust for use on site, with appropriate ergonomic form and choice of materials for optimal interaction between user and tool. A selection of project proposals are described here in more detail:

3.1 DISTANZO

This concept is based upon the idea of a limb extension with the additional advantage of a direct connection to a database as well as the ability to create and edit a CAD-model in real-time. After the technical feasibility had been established, detailed attention was given to the design of the tool and the ability to position a hand-held tool accurately for use in typical building surveying applications.

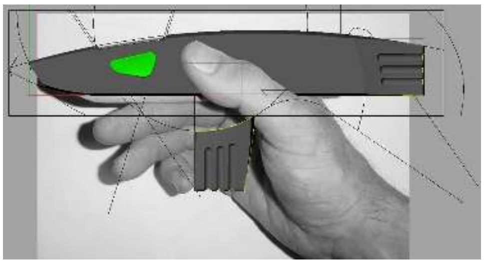


Fig.7 Design study

Fig.8 – Prototype model

The DISTANZO is a digital measuring device with notebook facility. Using the integral tracking system measurements can be taken by simply pointing with the finger. The device consists of a positioning device and a holder in which the device can be held. When connected to a laptop DISTANZO can be used to create a CAD-model on site. The software allows the system to be configured, the use of complex measuring operations (intersection surfaces) and comfortable data administration. The DISTANZO-system can be extended using a slimline tacheometry tool for indoor spaces, a digital camera and various different pointers for use in special situations such as stairs, columns, pilasters etc. The tool can be transported together with the tracking station in a robust case. The hand-held device can be stored in the box together with wearable PC or necessary accessories such as cables etc. Connection to a conventional laptop is via a second Systainer.

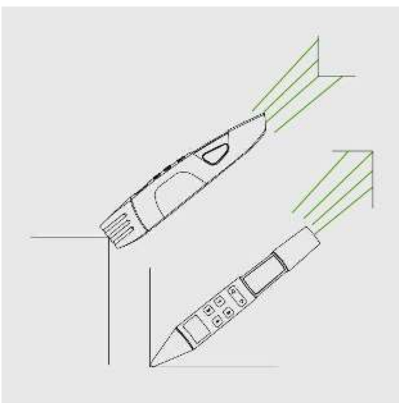


Fig.9 Distance measuring device – measuring technology

Fig.10 – Distance measuring device – prototype design

STICKIII is powered by Li-Ionen cells and uses infra-red or modified marker techniques. The data is transmitted from the tracking station to the PC via Bluetooth or WirelessLAN. /Brück 2003/

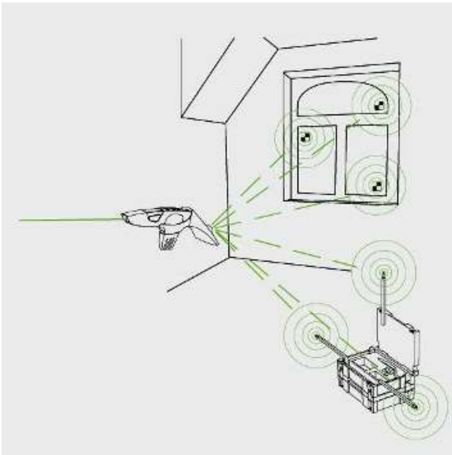


Fig.11 Tracking - principle

Fig.12 – Tracking module

3.2 : DT-SMART

DT-SMART is a modular device which combines the most essential functions required for data capture in existing buildings and relays other functions to remote equipment. DT-SMART also makes use of techniques not currently considered in the field and helps concentrate data capture in a central database. DT-Smart is based upon current technological possibilities and combines the functions of a distance-meter and a simple building tacheometer.

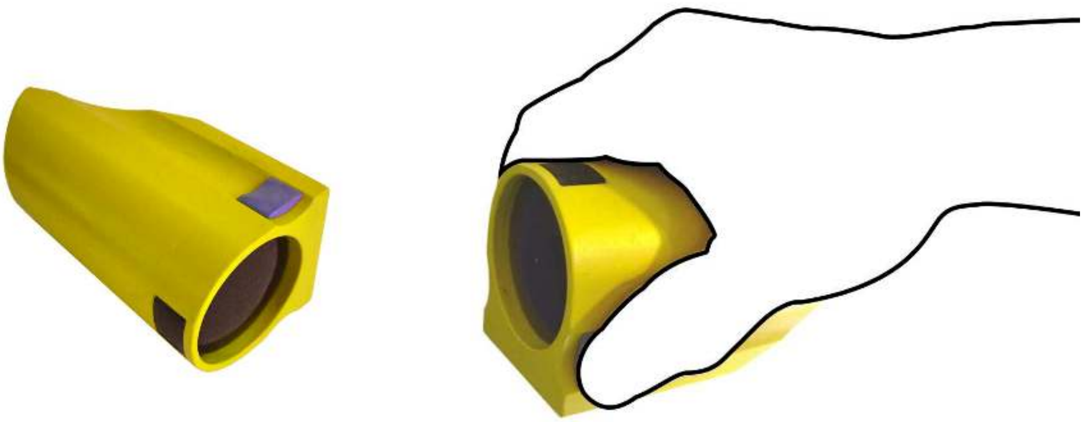


Fig.13 D-Smart – Prototype model

D-Smart has the equivalent functionality of current distance-meters. It does not include electronics for processing captured data, instead the data is transmitted via Bluetooth directly to a Tablet-PC with database. It does not therefore need complex display and button panels. As a result it is ergonomically simple with a buttons only needed to initiate measurements and a display to show the resulting measurement.

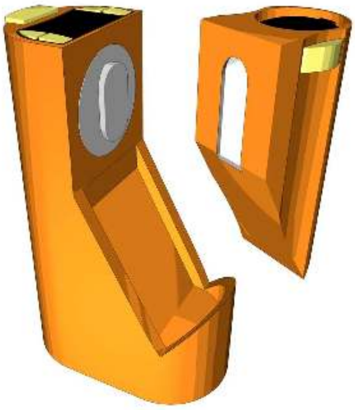
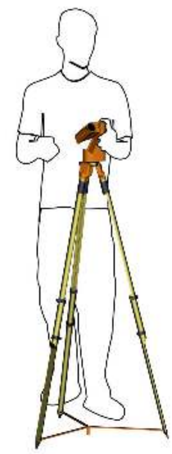


Fig.14 T-Smart Docking Station – Computer model and prototype

The docking station T-Smart extends the functionality of the hand-held device D-smart to that of a tacheometer. By attaching the hand-held D-Smart to the docking station T-smart, the device can be panned and inclined and as a result the direction and position can be determined. The T-smart display is protected by the surrounding buttons and displays measured data as well as analogue and digital levelling information. The data is communicated via contacts to the hand-held device and from there via Bluetooth to the Tablet-PC. /K. Guth 2004/



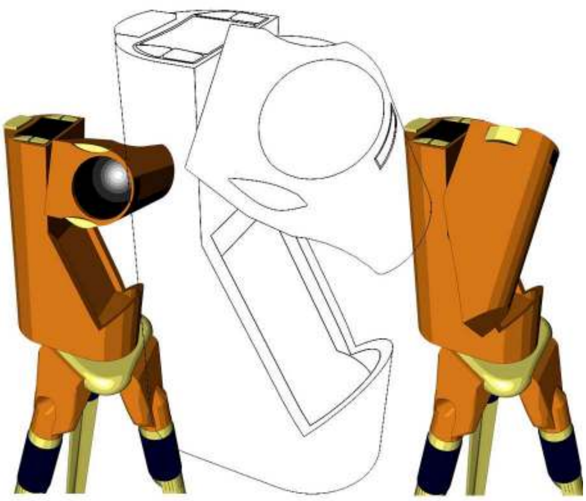


Fig.15 TD-Smart – Computer model of work situation

3.3 Tachycam

Tachycam combines the advantages of reflectorless tacheometry (high precision and flexible application possibilities during the survey and building process) with the advantages of digital photogrammetry (subsequent measuring of data and photographic documentation).

Tachycam takes a conventional computer-aided surveying system using a total station, and augments it with a variety of conceptual improvements:

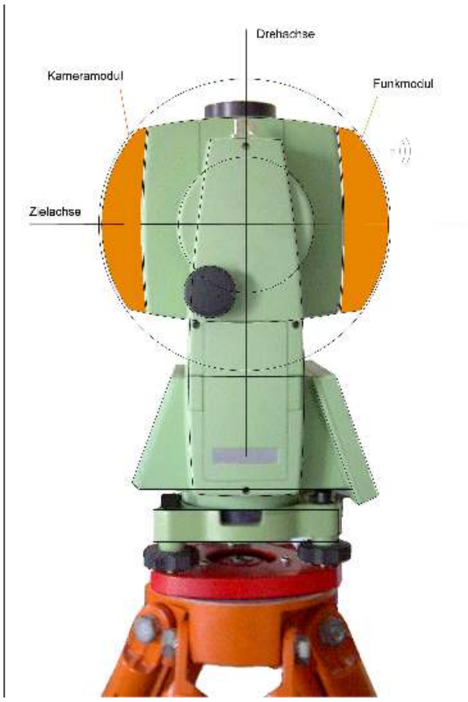


Fig.16 Tachycam - Principle

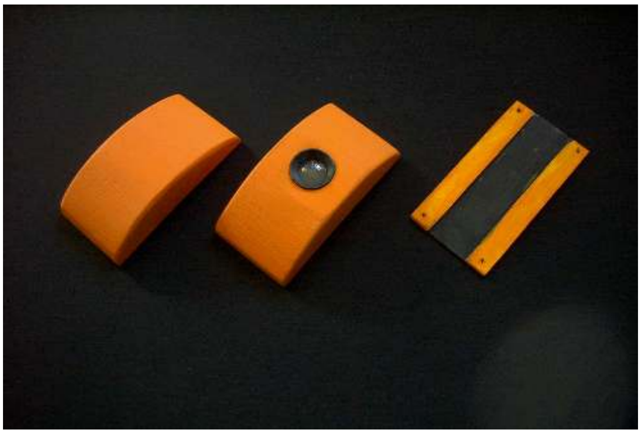


Fig.17 – Tachycam – Model photos

1. Addition of a digital image capture module to the motorised total station. In combination with the total stations precise panning ability, the module can be used to take panoramic photographic images.

2. Wireless link between the measuring equipment and a mobile CAD station for remote control of the equipment as well as data transfer.

3. Combined CAD control and recording system allowing remote control and data capture and modelling from the same system.

The configuration allows both tacheometric as well as photogrammetric data capture. The existing functionality of the tacheometer is maintained. The combination of both surveying methods allows both a considerable improvement in the quality of data captured as well as a restructuring of the working method.

The existing ergonomically poor conventional working method (manual measurement and separate appraisal of many points on site) is improved through the use of remote control and photogrammetric image processing. This results in both a quicker surveying process and more comfortable post-processing of the data.

In comparison to conventional photo documentation log books, the image data captured is both more comprehensive and, more importantly, its location and dimensions are known so that it can be automatically linked to the individual building element surfaces. /Donauer 2004/

3.4 Visions : Air-sistent

The Air-sistent is a system for the computer-aided semi-autonomous building survey. It consists of a remote controlled gas balloon and a basis station. The balloon is unfolded on site and filled with helium and can immediately begin capturing data as soon as a connection to the mobile computer has been established.

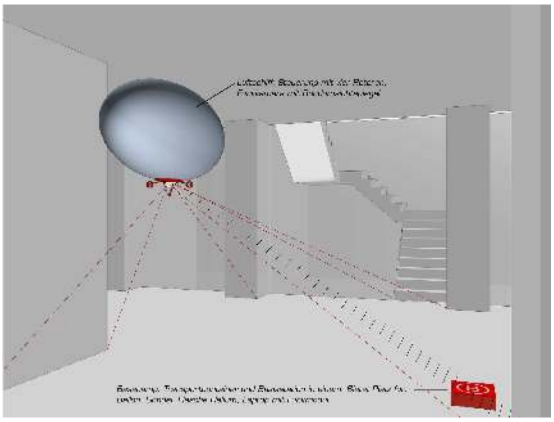


Fig.18 : Air-sistent – principle

Fig.19 – Air-sistent – model trials

Using a panoramic camera the Air-sistent begins to collect data from the surrounding environment which can be transmitted per wireless link to the mobile computer. The subsequent digital processing of collected image data allows the room geometry to be reconstructed in a 3D CAD model. Power cells can be recharged at the basis station. Through the use of internet-based remote control it would theoretically be possible to control the entire system from an entirely different geographic location. An architect could, for instance, be able to collect incomplete survey data without having to visit the site. The system is also suited for the surveying of locations and objects which are difficult or dangerous to reach, for instance wells or chimneys. /Spenling 2003/

4 Conclusion

The concepts presented here for computer-aided digital building surveying equipment and environments close the gap between specialist equipment adapted for use in building surveying and the need for simple straightforward surveying equipment for architects and engineers. A variety of different prototypes have resulted which make use of modern technology and take into consideration the specific ergonomic requirements of building surveyors.

A current interdisciplinary project takes these investigations one step further and examines the development of a concept for a practical mobile digital configuration and system environment for “planning on-site in the year 2010”, i.e. surveying and planning on-site within existing buildings.

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