

DIRECT ON-SITE QUANTITY SURVEY FOR CONSTRUCTION WORK AND CUSTOMER QUOTATIONS WITH THE HELP OF HANDHELD COMPUTERS

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The development and use of mobile data acquisition devices to prepare site measurements required for construction projects and process quotations for power supply connections could provide field staff with a highly effective tool.

The introduction of such facilities would obviate the need for some of the steps previously involved and thereby significantly accelerate the entire procedure. Technical specialists on site will benefit from plausibility checks and graphic displays. Particular emphasis has been placed during development on simple user guidance specifically aimed at non-computer specialists.

GENERAL

The Hessische Elektrizitäts-AG (HEAG), Darmstadt, is the regional electricity supply company serving the South Hessen area. Together with its subsidiary, the Versorgungs-AG, it supplies electrical energy to approx. 750,000 residents in 66 communities. The area served of around 2,000 km² is divided into four Centres, in order to ensure optimum customer service. In the interests of providing reliable and environmentally-friendly power supplies, numerous medium-voltage and low-voltage construction works are undertaken each year within the area served. Besides installing overhead lines and replacing defective cables, connections are provided for newly developed areas, transformer stations are built and each year some 2,000 domestic properties are connected. Work on building and operating the supply grid is carried out each year at a total of approx. 3,400 construction sites, for which outside contractors are employed.

The term "measurement" may be defined as: "determining the extent of works on site in accordance with the dimensions, numbers and weights to be paid for". In practice, this means that the works carried out by outside contractors are inspected and documented in the course of a joint site visit. On-site documentation is supported by the use of handheld-computers, which in turn significantly simplify the entire measurement and billing procedure.

In addition, with the aid of such a handheld-computer a quotation for the connection of a domestic property can be prepared for the customer on the spot. Once the necessary works to be carried out at the construction site have been coordinated in the course of a consultation meeting, the

quotation can be issued directly. The customer receives exact information regarding the cost and can place the appropriate order immediately. Expensive correspondence is thus avoided, the customer receives more comprehensive advice and customer satisfaction is increased. Direct on-site processing improves communication with the customer and prevents misunderstandings.

Site measurement procedure for construction works

Within the area it supplies, HEAG regularly works with over 50 local and supra-regional outside contractors. Billing is calculated on the basis of a detailed schedule of works. The schedule drawn up by the HEAG Versorgungs-AG includes around 900 items relating to civil engineering and installation works.

Joint site measurements are prepared on site by a representative of the outside contractor and an authorised official from HEAG. It is essential to have the technical knowledge not only to evaluate the finished product, but also to appreciate the sequence of works, including any difficulties and special works which might be involved. That is why the authorised official from HEAG is also responsible for supervising the construction project and monitoring the entire construction process.

HEAG employs a total of some 50 officers authorised to carry out such measurements, and they in turn look after the 3,400 construction project sites dealt with each year. This entails preparing around 7,800 measurements covering a total of over 100,000 individual items for which settlement must be made. This procedure generates an annual turnover in the region of approx. 30 million DM during the last years, representing a significant proportion of HEAG's investment.

As part of the system for processing construction projects, a procedure has been in use at HEAG since 1977 under which payments for performances by outside contractors are processed by computer. On the basis of jointly prepared measurement calculations, invoices are generated via the HEAG data processing system. Under this procedure, all stages from estimating for works via cost monitoring through to invoicing are processed by computer. The only exception thus far has been the preparation of site measurements on the site itself.

Quotations for the connection of electricity supplies

The procedure thus far for connecting new customers to HEAG's supply network has entailed the customer registering his requirements with HEAG via an electrical contractor. Following an on-site inspection, the customer subsequently received a written quotation. A written order was then placed by the customer. Once the supply had been connected by an outside contractor on behalf of HEAG, site measurements were then prepared in respect of the works performed (for sequence, see Figure 1).

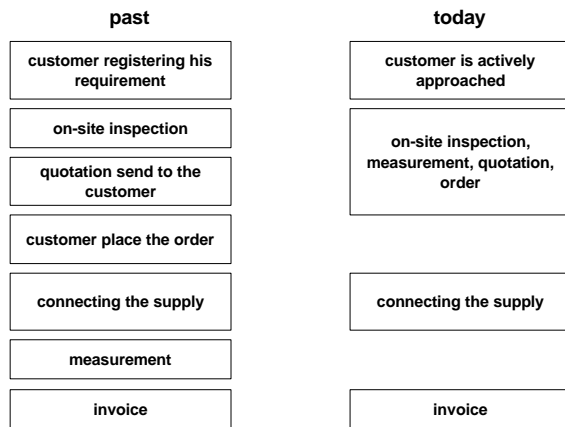


Figure 1

Objective

The objective was to formulate a continuous computer technology-based concept which embraces both processes, from measuring up for construction works on site through to paying the contractor as well as for generating quotations for our customers. The essence of the matter lay in integrating on-site data acquisition into the existing flow of computerised data currently being processed as part of the measurement and billing procedure. In addition, the preparation of quotations for the connection of power supplies was to be more closely oriented towards the customer.

The task was to develop a high-performance system which was easy to operate and which would enable construction work data to be acquired directly on the construction site by computer. Embracing as it does some 900 items, the comprehensive schedule of works offers a highly accurate basis on which to make settlement for the works involved and has proven to be an excellent resource. The aim therefore was to find a procedure under which the requisite entries could be reduced to a minimum without incurring any loss of accuracy in documenting the outside performances delivered.

Developing the new procedure

The starting point was the requirement that the new system should be comprehensively capable of documenting all possible kinds of outside performances on site - whether in the field of installation works or of civil engineering. In addition, a facility was to be created to enable detailed quotations to be prepared for power supply connections of all kinds.

Particular attention was devoted during development to the ease and clarity of operation of the handheld-computer. The majority of site measurement officers are not familiar with using computers, as a result of which the system had to be so designed that it could equally be operated by a computer layman. This goal was achieved by dispensing with the keyboard which non-computer specialist find difficult to comprehend. Data is entered directly via the touch-sensitive screen of the input device. Moreover, at each step in the measurement process, the information displayed on the computer screen is restricted to that which the user requires at the present moment to enter his data. A further important consideration was to employ plausibility checks and graphic displays to prevent possible errors in direct on-site data acquisition.

The device

The device selected was the "EHT 30 handheld computer" from EPSON. This acquisition device is specifically designed for use in the field. It is intended for all-weather use at ambient temperatures ranging from -10°C to +50°C and comes equipped with an exceptionally high-performance lithium-ion rechargeable battery which is capable of up to 14 hours of continuous operation. Further plus points include the high-resolution sensor screen with graphics capability and the low weight and handy size (length: 176 mm, width: 89 mm; height: 36 mm).

Integration into the existing measurement and billing procedure

Designing a suitable method of documenting construction works on site was only part of the overall project, however. The other aspect of the project involved developing a suitable interface to the main central computer system. A rational work sequence, which will after all increase on-site productivity, can only be achieved by implementing a fully integrated procedure. This interface took the form of PC's located at the decentralised offices.

Data is transmitted between the main central computer system (HOST) and the decentrally located PC's at the operations management offices via HEAG's own long-range communications network. This facilitates direct access to centrally held contract and ordering data. These data inventories - which are managed by the specialist commercial departments - are accepted onto the PC's using a file transfer procedure. The PC's represent the link between the handheld-computers and the HOST and offer a convenient management platform to control the construction works. Site data is fed from the PC to the handheld-computer via an S-RAM card. When measurement has been completed on-site, the content of the S-RAM card is read via a drive at the PC. Once the measurement data has been released, it is passed to the main central computer system and entered into the internal order billing system. An invoice is then generated automatically.

Preparation of models

Data is generally entered with the aid of so-called models. The model comprises items from the schedule of works which frequently occur together. With the aid of these models, it has been possible to reduce the entries required to a minimum, without entailing any loss of measurement accuracy.

Taking as an example the entries required for a 20 metre long trench, the simplification achieved by using models in conjunction with computer-aided data acquisition becomes clear. In the past, eight items had to be selected from the schedule of 900 items and a total of 16 data entries made for length, breadth and depth as required for each item. Today, all that is needed is to select the model and enter just four different details - length: 20m; surface width: 1.20m; and depth: 0.60m. The principle of once-only data acquisition has been optimised to the extent that the program determines all entries which can be calculated from other data and inserts them at the appropriate points. It has thus been possible to reduce the number of data entries required by over 70%.

Whilst under the previous measurement procedure it was necessary to enter individual measurements for each item, in future it will be sufficient to input just a few determinant values in order to produce a site measurement which is every bit as accurate. Besides reducing the cost of data acquisition at the construction site, by minimising the number of entries and introducing plausibility checks, the number of potential errors has been significantly reduced.

Only by using these models can measurements be so rapidly and clearly entered on site. Taking the above example, it is clear how vast the rationalisation effect can be. For the user, the clarity of the procedure is increased, since by introducing models it has been possible to

significantly reduce the range of possible items to be selected in standard cases. Overall, some 60 different models have been assembled for various activities.

The new procedure

A total of 35 handheld-computers are in use at HEAG. Prior to taking the site measurements, the site-specific initial data records are loaded onto the computer. Data such as e.g. category, contract and order number, name of outside contractor and construction site description are transferred from the PC to the S-RAM card. In addition, HEAG's complete schedule of works and all of the models are loaded. The storage capacity of the S-RAM card is adequate for a large number of construction sites. Every measurement officer is provided with the data for the sites to be dealt with.

Measurements are then taken on site. Models are referred to for each section of the task and the necessary data entered. With the aid of a graphic display, the data entered can be rapidly checked directly at the construction site. All measurement items are also displayed in a list at the end of the program, and can where necessary be altered or amended before leaving the site.

Thanks to the use of mobile data acquisition, it is now possible to combine some of the steps involved in preparing a quotation (see Figure 1). Customers are also actively approached regarding the connection of their electricity supply, at the latest once their construction plans have been approved. A quotation for connecting the supply is generated directly on the spot when the site is inspected. In the course of a detailed consultation meeting the customer can be offered various alternatives, thus enabling him to place the order directly. Misunderstandings are minimised and time-consuming correspondence is done away with.

Example of site measurement for laying cable to connect a residential property to the supply

The following outlines the principle on which the program sequence is based:

The screen is divided into a selection area and a bar containing the on-screen buttons. Data is entered by selecting a term in the selection area and then activating the desired screen button.

The appropriate surface model is first roughly selected via the screen form in Figure 2. The second step is then to define the exact model. The "Asphalt" model for example is subdivided into eight individual models which contain various items from the schedule of works, dependent on the thickness of the bitumen-coated gravel layer and the number of subsequent workstages required.

X	Baumassnahme : HEINRICHSTRABE
MODELLE Oberfläche grob	
Asphalt Straße	
Asphalt Gehweg	
Verbundpflaster	
Platten	
Großpfl, Rasen, Kies, Ges. Gehweg	
Ohne Oberfläche	
Unterschied Aufbruch/Wiederherstellung	
<input type="button" value="Freie Eingabe"/> <input type="button" value="WEITER"/> <input type="button" value="ZURÜCK"/>	

Figure 2

The requisite measurements are entered with the aid of a numeric editor as illustrated in Figure 3. When the term "surface length" is selected, the editor automatically

X	Baumassnahme : HEINRICHSTRABE
Asphalt Straße, 4cm	Oberflächenlänge
Oberflächenlänge	12,52 m
Oberflächenbreite	7 8 9
Unterbaubreite	4 5 6
Unterbau Tiefe (Aufb)	1 2 3
Unterbau Tiefe (Hers)	0 , L ö
mehr	OK ← → Ab

Figure 3

appears and the length data can be entered. The procedure is the same for all further measurement information.

After the data have been entered in the section regarding the cables laid, there is an opportunity to include additional individual items from the overall schedule of works which have not so far been covered by the various models. The graphic in Figure 4 provides a quick check on the trench dimensions measured. The number and type of cable laid is also shown here.

X	Baumassnahme : HEINRICHSTRABE
GRAPHIK	
OF 0,24	
UB 0,20	
VZ 0,16	
LZ 0,20	
Pos.-Liste	

Figure 4

Finally the measurement officer is offered a display showing the complete list of measured items for the relevant section. This allows him the opportunity to check all items directly on site and if necessary to alter them. Site measurement for the outside contractor is then concluded.

The quotation for the customer is generated on the basis of the measurement data recorded for the outside contractor. Customer-specific data are supplemented and the customer is offered various alternatives. The customer then chooses one option and places the order.

Conclusion

Mobile acquisition of site measurement data was introduced in 1996 and has been in use throughout HEAG since the beginning of 1997. In 1998 the facility was added to prepare supply connection quotations for our customers directly on site. Experiences thus far have been highly positive. Thanks to the easily understood guidance given to users and the clarity with which data is entered via the sensor screen of the handheld-computer, the equipment has proven simple to operate and has found wide acceptance even among non-computer specialists.

The measurement and billing procedure outlined represents an important element in the processing of construction works at HEAG. Thanks to computer-aided site measurement data acquisition it is now possible to close the gap in the flow of computerised data and process the entire sequence by computer from estimating for works via preparation of site measurements and current cost monitoring through to invoicing.

By accepting ordering and contract data from the main central computer, simply acquiring construction work data on site with handheld-computers and automatically transmitting this data back to the main computer, we have succeeded in developing a fully integrated procedure which relieves the burden on both technical and commercial departments, thus leading to a more rational work sequence and not least to an increase in productivity in processing construction works. The principle of once-only data acquisition has been optimised and the number of data entries required has been reduced by over 70%.

In terms of providing our customers with supply connection quotations, direct on-site processing has led to improved customer communication. Costly and anonymous written correspondence has been replaced by a personal consultation. Customers receive more comprehensive advice and are informed immediately of the cost and extent of works. Misunderstandings are thus avoided and customer satisfaction is increased.