The GTP-System – Efficient computer-aided Planning as a Basis for Rapid Mine Development

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ABSTRACT

In order to achieve an increase in the mining performance and productivity in the sense of "Rapid Mine Developments", one needs comprehensive planning heeding the most varied aspects. The computer-aided Geometric Technical Planning System (GTP System) of Deutsche Steinkohle AG is a suitable aid to live up to this requirement. The system designed in modules offers an effective support both thanks to its professionally oriented applications as well as to the data and information exchange between the specialised departments involved in mining planning. The concept of the GTP System may be hailed as a new milestone with regard to the homogenisation of professional applications, an improved information management and the bridge to SAP. The terms of "horizontal integration" and "vertical integration", introduced with this system, represent efficient planning and an exchange of information within a homogenous environment and a purposeful exchange of data with external systems such as SAP.

ZUSAMMENFASSUNG

Um in den Bergwerksbetrieben eine Leistungs- und Produktivitätssteigerung im Sinne des "Rapid Mine Developments" zu erzielen, bedarf es im Vorfeld einer umfassenden, die verschiedensten Aspekte berücksichtigende Planung. Das rechnerunterstützte Geometrisch-Technische Planungssystem (GTP-System) der Deutschen Steinkohle AG ist ein geeignetes Hilfsmittel, diesem Bedarf gerecht zu werden. Das modular aufgebaute System bietet mittels seiner fachspezifischen Applikationen nicht nur wirkungsvolle Unterstützung bei der Bearbeitung fachspezifischer Aufgabenstellungen, sondern auch hinsichtlich des Daten- und Informationsaustausches zwischen den an der Bergwerksplanung beteiligten Fachabteilungen. Mit der Konzeption des GTP-Systems wurde hinsichtlich der Homogenisierung fachspezifischer Applikationen, einem verbesserten

Informationsmanagement und dem Brückenschlag zu SAP ein neuer Meilenstein geschaffen. Die Begriffe "Horizontale Integration" und "Vertikale Integration", die für effiziente Planung und Informationsaustausch in einer homogenen Umgebung und für einen zielgerichteten Datenaustausch mit externen Systemen wie SAP stehen, wurden geprägt.

TECHNICAL PLANNING IN MINING - EFFICIENT INTERDISCIPLINARY PLANNING FOR THE COST-EFFECTIVE FURTHER DEVELOPMENT OF THE MINE

The high degree of working point concentration of DSK mining operations over the past years did not only require significant investment into operating equipment but at the same time posed high demands on the technical planning. The number of working points in German hard coal mining dropped from 146.6 in 1990 to 33.9 in the year 2001. Whereas the overall output decreased by some 46 million tons in the above mentioned period, the output per working point rose from 1,803 t/d to 3,130 t/d, constituting an increase of 74 %.

These figures make clear just how important the working point planning is – ranging from the layout planning to the technical design of the operating equipment – for such a concentrated working point production. The few remaining operations have to provide their output securely and thus need to be processed comprehensively from an engineering point of view already from an early stage of the planning on.

It is this backdrop and the SAP integral software system introduced at DSK as of 1999 that rendered necessary the new design of the technical system environment. The aim of this new design was the integrative, computer-aided processing of technical planning processes as well as the link with the SAP system.

The concentration on a few working points and the connected expenditure in infrastructure and preparatory work increase the risk potential of achieving a secure output of any mine. In order to reduce this risk potential, it is necessary, on the one hand, to increase the planning security and to establish the best technical option, on the other hand.

The planning security can be achieved by rendering more transparent the complex interdisciplinary technical planning procedures. Every member of staff involved in the planning must be able to access the latest stage of planning at any time. All amendments of the planning and their impact must be made available to the parties involved immediately and to the full extent.

The identification of the best technical option can be facilitated considerably by using simple, standardised methods and procedures in the technical planning. Furthermore, an integrated, standardised catalogue of working equipment for fitting out the working points should be available for such planning systems.

I am going to introduce the structure and the scope of function of the individual modules of the Geometric Technical Planning System (GTP) in the following and subsequently present a planning example to explain the possibilities of use and benefit with regard to ”Rapid Mine Developments”.

DUDE – PROVIDING BASIC MINE SURVEYING DATA

The dude system (digital underground and deposit) provides the primary mine surveying data. With the help of dude, cavities and deposits can be depicted 2 or 3 dimensionally and be evaluated, either using the available surveying or geologic-tectonic data of the current situation or as planning alternatives. Apart from the official mine plan, the operational mine plan is added as a layout, cross-section or perspective.

By using the GTP-database as a common data platform, data does not need to be registered several times over in various application systems with a simultaneous reduction of the processing times and increase in the safety of data exchange.

GTP-PANEL-DESIGN

The pits represent the main point of reference for the inter-departmental coordination of mine planning activities. Two planning engineers will agree much faster in a discussion on what type of belt conveyor or which section of a panel they want to refer if they use a 3D view of a panel than mere words:

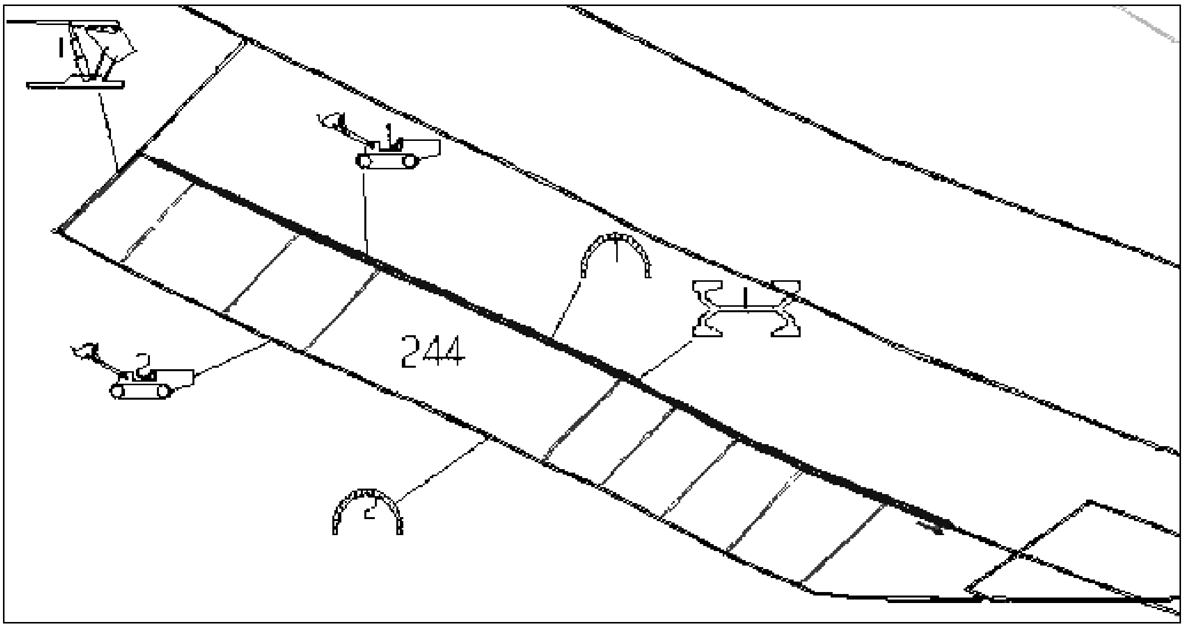

Figure 1: Typical panel design as visualized in the GTP system

The GTP M Part "Panel Design" module first generates a 3D-model from the mine surveying data of the above described dude system. This ensures that all further planning steps will always use the official planning stage of mine surveying. Subsequently, planning items such as dinting machines, shield supports or belt conveyor systems may be positioned graphically. Initially, such symbols represent empty carriers of information that can be detailed more precisely with the respective specialised departments as the work proceeds.

GTP-BELT-CONVEYOR-DESIGN

The technical design of a belt conveyor starts by importing the roadway geometry: the planner marks the course of the panel in the 3D-view and subsequently starts the calculation module. The engineering calculation basis for this module is taken from the DIN standard No 22101, applicable beyond the industry.

Apart from designing the panel according to the requirements, it is the aim of the planning to draw up lists of standardised machine components, such as electric motors, gears, drums, conveyor belts or support rollers. The program offers the user operating equipment standardised throughout the DSK, which is also obtainable via the SAP basket.

Now the calculation checks the technical feasibility of the design: Does the belt quality chosen offer sufficient safety against breaking? Are the drives dimensioned appropriately? Can the planned output be handled from a geometric point of view etc? The program provides the following calculation results - belt pull forces, drive and break forces required - and it points out existing technical deficiencies of the design, such as falling short of the required safety specs or unrealistic start-up factors for the drives.

Professional knowledge of the client as well as general handling hints are to be found in an HTML-Online-Help. This includes, for instance, the complete standards for choosing the operating equipment just as the bulk density of various types of materials or design recommendations of DSK experts. The design of the belt conveyor is completed with the following steps:

- The planner is able to leave any background information in a commentary box: contacts with phone numbers, information on planning alternatives, special values of optimisation etc.
- WORD documents, EXCEL files or AutoCAD drawings of operating equipment relevant for a certain layout may be linked directly with individual designs in the form of a hyperlink.
- With the help of the GTP "Equipment Management" module (see below), a list of operating equipment may be drawn up from the calculation. The automatic generation of lists saves time and avoids errors in the manual transfer of data.

GTP LONGWALL DESIGN

The machine and procedural design of the shearer- or plough-operated longwalls was implemented very closely to the above described belt conveyor design:

- import of the mine surveying data from dude
- access to standardised DSK operating equipment
- commentary file and user-defined hyperlinks
- automatic generation of equipment lists
- depositing DSK expert knowledge
- time and personalised stamp for every design

From a technical equipment point of view, the module for the longwall calculation is characterised, above all, by the integrated view of the mining equipment (plough or shearer loader) with the longwall conveyor. The program establishes all relevant operating conditions, depending on the seam properties. Critical aspects of the design are highlighted clearly in the depiction of the results.

An extension module to consider drives controlled by frequency converters is being developed at the moment. It is the aim to enable a simulation of a combination of ploughing and conveying speeds to be changed by the planner in any way as regards the time. This is to enable the assessment of the new possibilities emerging from the use of speed controlled drives before the design. Both the plough- and the shearer-operated longwalls may be visualised in an animated simulation after determining the design data.

GTP VENTILATION NETWORKS

Until the mid-1980ies, the physical models used for the computation of mine ventilation systems neglected the compressibility of air. With the average depth of mines nearing 1,000m, however, it became clear that errors due to the inaccuracy of the model became more and more difficult to deal with. Consequently, an algorithmic solution for the calculation of compressible airflow was implemented as a software application for the German hard coal industry. Its main features were the computation of compressible air flows and a graphical user interface based on a 3D-model of the mine. Today, GTP Ventilation Networks [2] [3] offers an integrated AutoCAD environment that provides both for the design of complex networks as well as the generation of plots.

In accordance with the overall concept of the GTP system, the geometry of the mine can be imported from the dude system thus supporting the idea of consistent planning data.

GTP PIPE DESIGN

The GTP Pipe Design [1]*[1] features many similarities with the Ventilation Network Design as regards the handling and the structure. Following the import of the 3D-pit from the GTP database, the pipe network may be defined and calculated using an AutoCAD-based user interface:

[1] *The numbers in angular brackets relate to the literature list at the end of the text.

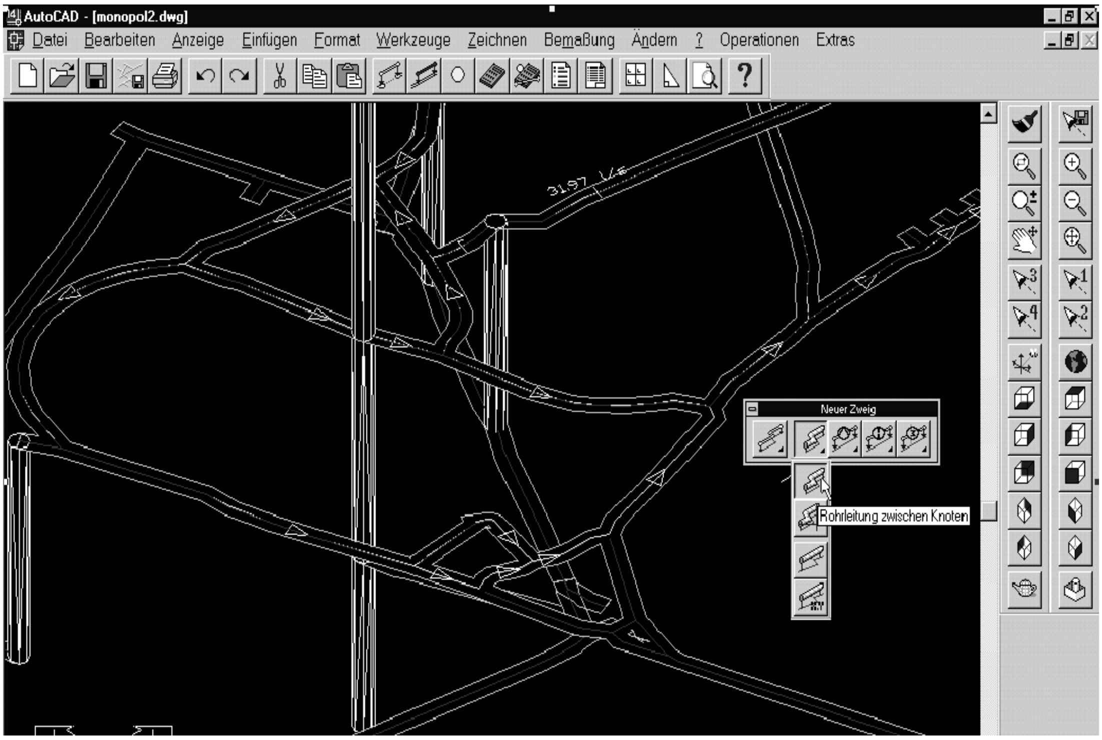

Figure 2: Typical pipe network design as visualized in an AutoCAD environment

This module serves the calculation of gaseous and fluid media. The core of the calculation is an iterative procedure for the calculation of flow networks by Hardy-Cross. The graphically defined network data is read in by the program and the results are fed back to the graphical application after the calculation. Here the calculation results may be depicted directly in the pits. Thus, plans may be derived on the computer as large-format plots for various purposes, using the AutoCAD functions to the full.

Further developments in the future are aimed, above all, at considering the user-defined feed of gas mixes.

GTP SUPPORT DESIGN: PLANNING AND DESIGNING GATES AND THEIR MONITORING DURING OPERATION

The cross-section of gate roads is of central, inter-disciplinary importance. For instance, it influences the air resistance, the possibility of installing technical equipment and the danger of methane gas accumulations and thus affects other planning operations, in turn. The prediction of the convergence is thus of great importance for designing the ventilation networks, the infrastructure, the longwall discharge and the installed output.

The independent GTP Support Design module enables the user to plan gate roads, heeding rock mechanics and geometrical parameters. In doing so, the impact of various mining methods typical for German hard coal mining are analysed in a differentiated manner and visualised along the road.

Furthermore, measurements registered during the life of the road can be related to one another for the purpose of a variance comparison, in order to be able to recognise the need of newly evaluating the former planning basis early enough.

GTP INFORMATION MANAGEMENT

The success of planning an underground mine depends both on individual and group performance. The one is not much worth without the other. The people involved, however, do not share the same background. A machine engineer is likely to have a far a more detailed interest in the intricacies of belt drives than, for example, a ventilation engineer. The latter is probably only interested in the heat production of the machinery. In order not to confront everybody with the totality of everybody else's information, GTP Information Management [4] supports the concept of sensible information reduction and adaptation. Via an easy-to-use, browser-like application, everybody can gain a quick overview of the planning results of his colleagues without having to start any of the specialized applications mentioned above. A few clicks will produce the width of a belt or the thickness of a seam:

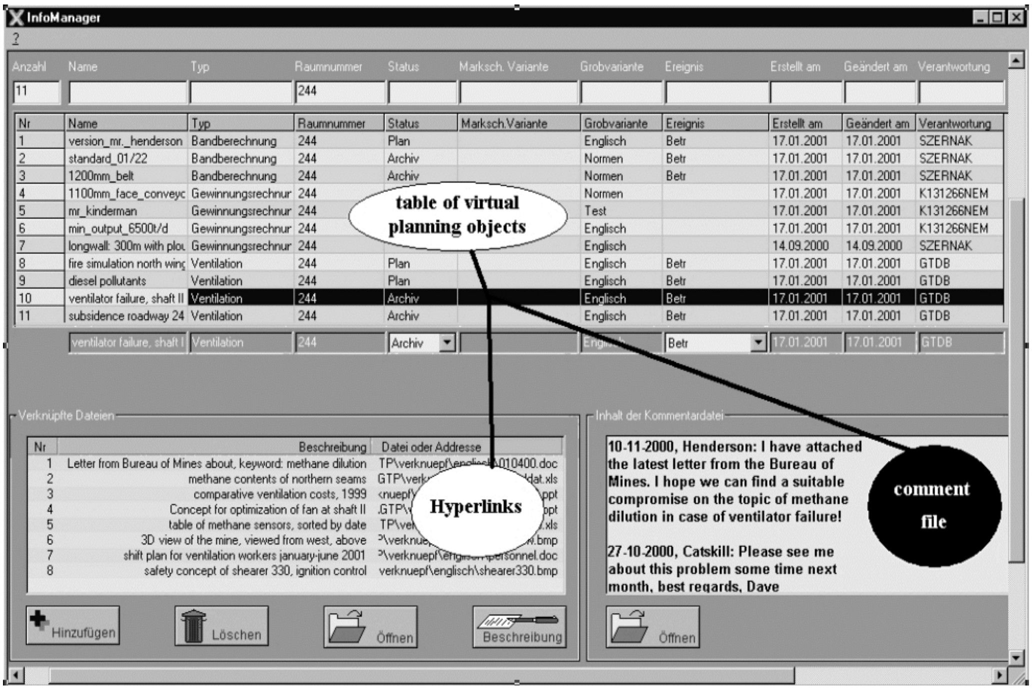

Figure 3: GTP Information Management: a technical browser for mine design

The screenshot above shows a typical view of the GTP Information Management system. The dark blue line represents a ventilation network. This specific layout is shown together with some commentary texts (bottom right) and attached hyperlinks (bottom centre). Without having to handle AutoCAD, anyone can gain a first impression of the planning activities going on. On top of that, the Information Management system offers some helpful filtering devices. It is thus possible to quickly select all planning activities edited within the last two weeks by a certain person and relating to a certain working.

But GTP Information Management means more than just providing a browser-like user-interface for technical information. It represents a standard for saving information in a homogeneous database that other software can easily accommodate. A recent example is ProNet [5], an intranet-based system for presenting process data from heterogeneous data sources via user interaction on a 3D-model of the mine. To sum it up, GTP stands for a philosophy of creating a uniform data structure across project or system boundaries, thereby encouraging horizontal information flow between technical planners.

GTP EQUIPMENT MANAGEMENT

Drawing up the operating equipment lists is a significant result of technical planning work. These are lists of technically specified components such as electric motors, conveyor belts, gears or conveyor chains that are available in SAP in the form of equipment lists. GTP supports the preparation of such operating equipment lists with the Equipment Management module [6]: technically specified equipment from applications, as for instance, GTP Longwall Design or GTP Belt Conveyor Design is automatically transferred into a table structure, which is close to MS-Excel in its handling and may be further processed by the planner. There is a standardised stock of some 10,000 items of technically relevant operating equipment at his disposal, complete with a great number of technical detail information.

The end result of the planning is a tabulated list comprising every individual item of equipment, with an SAP number attached.

PLANNING EXAMPLE

Planning a longwall operation is far from being a well defined sequence of actions that could easily be implemented within a classical work-flow management system. Instead, the overall activity consists in a host of interdependent and semi-autonomous processes. It involves people from underground operations, from various technical departments, from headquarters etc. It affects data stored in data-bases, file archives and on hard disks but also in classical paper folders, on plotted charts and maps and – not to forget - in the brains of the people involved.

As mentioned before, it is of vital importance to detect and assess any changes made to any critical datum. The example below does not try to support the illusion that any IT-system or any organizational routine can reliably guarantee the accuracy and consistency of all mine planning data. The software components described in this paper rather assist human beings in noticing changes and then evaluating their effects.

The working in question is planned to produce about 4,500 tons of coal per day. The worked seam has an average thickness of 1.6m. The length of the longwall is 350m. The coal is worked using a drum shearer. The haulage road has an initial length of 1,000m. There is a single belt conveyor covering that distance and operating at a speed of 2.9 m/s.

We are now talking about a time some two years before operations are due to start, when, quite unexpectedly, the target output is raised from 4,500 to 6,000 tons of coal per day in order to further reduce the number of working points. It has been decided not to increase the speed of the belt conveyor but to chose a wider belt instead. This raises a number of questions that must be dealt with speedily:

- ⇨ In how far does a wider belt of a possibly higher quality affect investment costs as envisaged and fixed for the coming year? Who will have to be informed?
- ⇨ In how far will the belt drives have to be redesigned to satisfy the increased demand for mechanical power? In how far is the electrical power supply affected?
- ⇨ Will it be necessary to redesign the anchorage of the belt drives? If so, will there be enough space to do so?
- ⇨ Are there any changes to be made within the current SAP system as to the pieces of machinery already ordered? If so, who is authorised to do so?
- ⇨ Is it possible to reduce the belt width slightly and thereby save a lot of money by reducing the peak output of the longwall sensibly? Who would have to give his consent?
- ⇨ In how far is air-conditioning affected by the increase in warm bulk material flow and the increase in installed electrical power? What will the Bureau of Mines say?
- ⇨ In how far is methane monitoring affected by an increase in longwall output?
- ⇨ Is road support affected by a possibly greater cross-section of the roadway and the increased longwall advance?
- ⇨ Which documents concerning the Bureau of Mines may be affected and who will have to be contacted?
- ⇨ Are there any ongoing planning activities that must be stopped or any documents that must be labelled as obsolete now?

To answer these questions in time, the changes must be made known to everybody concerned. Such information is usually circulated via group meetings or the use of e-mails. Then, however, people will begin to look at their own planning results and those of their colleagues trying to find newly arisen inconsistencies.

This is where the GTP concept of meaningful correlation and contextual embedding of information helps. By using the GTP Information Management system anybody can quickly scan over the ongoing planning activities and see who did what, when and why: this can be done by filtering all data for the colliery number in question, eg 123. The result will be a list of all ventilation networks, longwall layouts conveyor belt designs etc. If the planner is now interested in getting more information about a certain conveyor belt design, he can "zoom" into the information.

It is possible to go into further detail by reading commentary files and viewing related documents attached to the planning results and thereby identify those aspects of the overall layouts that must be reconsidered. For instance, any changes to the belt conveyor layout may affect certain standards:

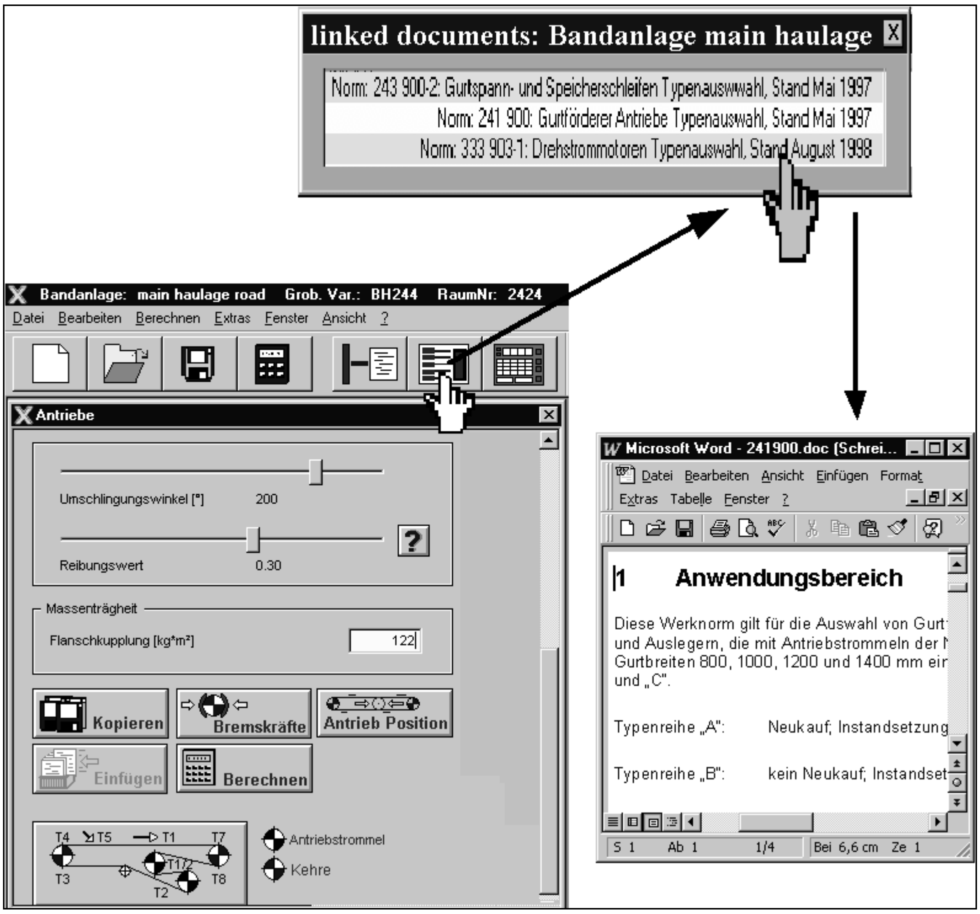

Figure 4: Background information attached to a belt conveyor design

The picture shows that a certain standard No 241900 has been used for the choice of belt drives. Obviously, any changes to the conveyor design may address that standard and its relevance must consequently be reassessed. Likewise, a letter from the Bureau of Mines concerning safety devices may have been attached to the layout and must not be omitted. If the original planner has attached all such relevant information to his files, much time and confusion can be saved when adjusting results to new planning targets or facts.

It is up to your imagination to find out more examples of how easily relevant information can be neglected and to appreciate the usefulness of the concept of hyperlinks and intelligent information filtering as implemented throughout the GTP system.

The basic message of this paper is that much time in daily work is consumed by running after bits and pieces of information that may be somewhere but nobody really knows who to ask or where to look. It is a first step towards speeding up the generation of technically consistent longwall layouts by correlating intelligently hitherto isolated pieces of information into a meaningful entity.

LITERATURE

[1] LANGEFELD, Dr. O. et. al., GTP-R Rohrleitungsplanungsmodul: Glückauf 137 (2001), No 7/8, p. 385-388

[2] AGUILAR, C. et. al., GRUBE-V: A Specialists` Software in a Groupware Environment, Proceedings of the 7th International Mine Ventilation Congress June, Cracow, Poland, 2001, ISBN: 83-913109-1-4

[3] LANGEFELD, Dr. O. et. al., GTP-W Das wettertechnische Planungsmodul des GTP-Systems: Glückauf 137 (2001), p. 640-643

[4] HEIM, G. et. al., GTP information management, Mining Magazine, Volume 182 (2000), No 5, S. 264-266.

[5] HÜNEFELD, Dr. R. et. al., Pronet - ein internetbasiertes 3D-Informationssystem, Proceedings of the 14th International Conference on Automation in Mining, Tampere, Finland, 3.-5. September 2001, p 37-45

[6] LANGEFELD, Dr. O. et. al., GTP - Das Materialmanagement, die Schnittstelle zur technischen Planung von Bauhöhen, Glückauf 137 (2001), No 5, p 274-277