PRODUCTION FLOWCHARTING FOR MAPPING ORGANISATIONS: A GUIDE FOR BOTH LECTURERS AND PRODUCTION MANAGERS

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KEY WORDS: Flow Diagram, Workflows, Process Analysis, Process Management, Flow Diagram Functionality.

ABSTRACT.

The introduction of digital mapping processes is a fact in a part of the world. In other regions developments are going on at the stage of carefully starting the conversion from traditional to digital mapping. Inevitably, the changes are rapidly taking place. Without an appropriate organisation of workflows it is impossible to have access to the control of new digital processes running for mapping organisations.
'Cartographic flow charting for production processes' has already been presented at the International Cartographic congresses in Cologne and Barcelona. But since evaluations and improvements in the application of flow chart symbols have taken place and since digital mapping has been introduced the time is now ripe to introduce flow charts for entire mapping processes, supporting educational introduction and managerial functioning for production organisations. Investigations, studies and experiences in the use of and new developments in the application of flow management and the software for flow charting enable a wider and easier use of flow diagrams for a digital mapping environment than ever before. The example as indicated in the paper deals with process flow charts on the entire mapping platform.
The basis for production flow diagram (PFD) is determined within the cartographic process, but since we require consistency in other fields, as well, a larger impact has been reserved for wider flow chart use. The main benefits of flow-charting are therefore seen at the level of operations and management, in both Spatial Data Handling and Cartographic context and includes an education component.
In the paper principles and symbolisation of flow chart items for digital mapping are explained and displayed. A brief description of subsequent tasks for the flow chart construction indicates the activities to come to the drawing of such a diagram.
Further, the practical use and the relations between the processes and products visualise the dependency of various processes and their results, the products.
As a main example the production of a part of a general map production acts as a clarification of the process flow diagram model.

1. THE PROCESS OF FLOW-CHART DESIGN.

Flow chart construction requires a thorough study and knowledge of any process. The designer of the flow chart requires adequate and sufficient information with respect to all individual parts of a large geoinformation process. The designer has therefore to make use of other people's knowledge and experience. Moreover, information is required from the agencies that deliver software to be applied for the processes.

Further it is essential that we know of which level of process flow chart we speak. In our case we have adopted the 'top down' approach [Paresi, 1998]. In his lecture note Paresi particularly deals with Data Flow Diagrams (DFD), while we mainly concentrate on Process Flow Diagrams (PFD).
In the set up of such an approach first the boundaries of the entire process have to be defined. In the geoinformation mapping environment the context process flow diagram (CPFD) displays just general processes from the perspective of fields, such as Spatial Data Acquisition, Remote Sensing or Cartography.
The predetermining of the boundaries of the CPFD depends on the field of the process. As an example one can determine the cartographic process as a CPFD, but any main process can be seen as a Context Process.

But also if applying GIS the GIS process can be displayed in the context process flow chart. In our case we have considered that the CPFD comprises the entire geoinformatics process (*see figure 1*).
It should be clear that the users of the CPFD do not distil much detail out the chart. Managers, lecturers and trainees and operators require much more information for their execution of tasks. However, for **overview** of the main processes and considering the CPFD being the start for further detailing this type of diagram is very valuable.

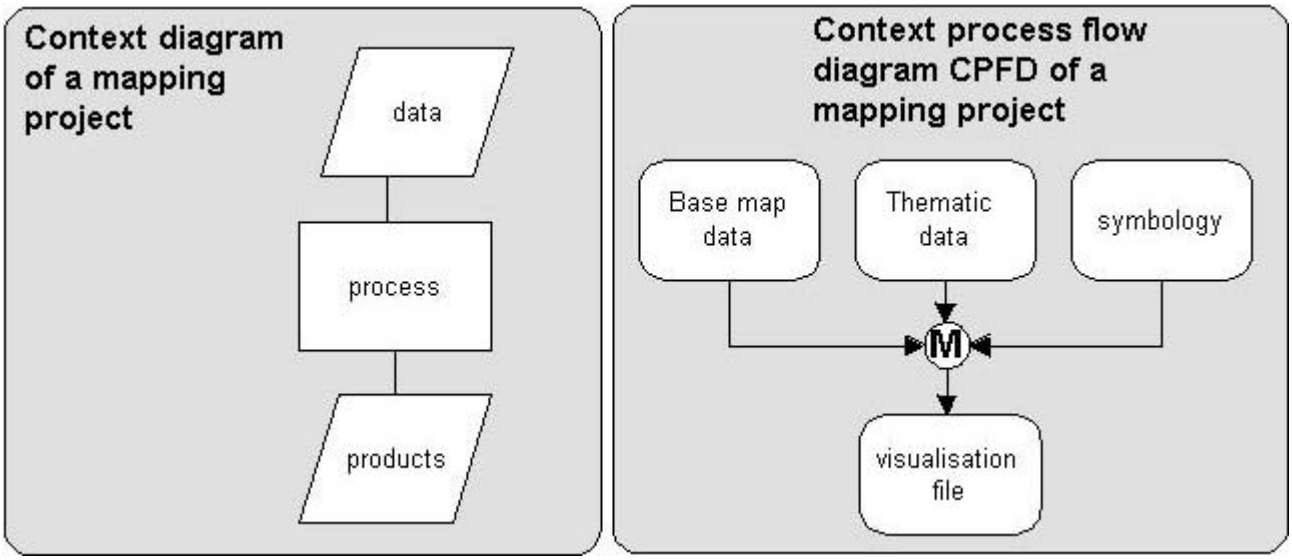


Figure 1. On the left side a general context diagram. The right illustration displays a Context Process Flow Diagram of a mapping process project, like has been discussed.

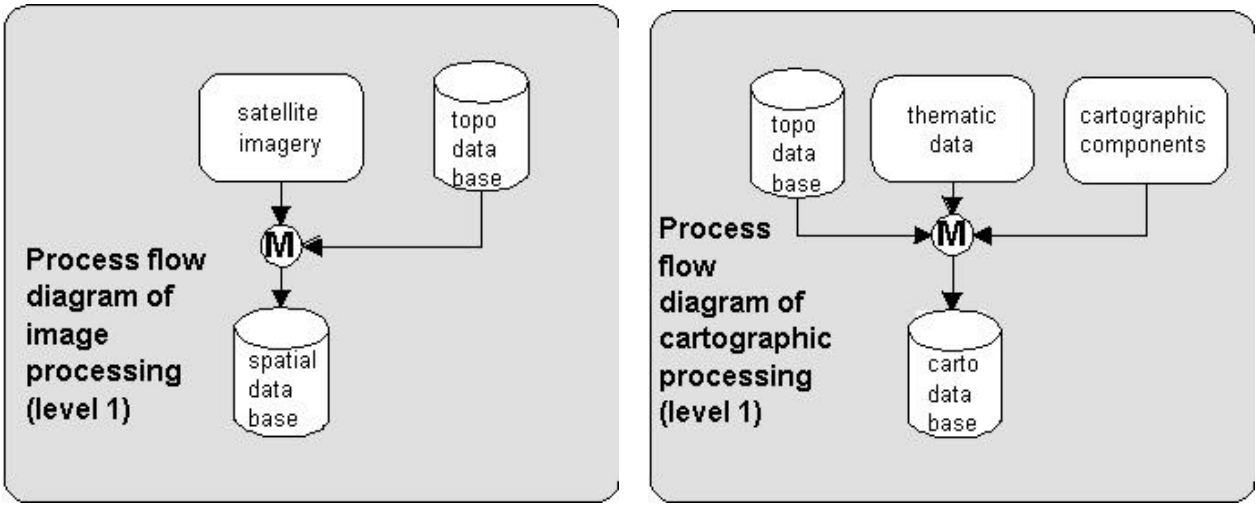


Figure 2. Two samples of a Top Level PFD (level 1) of a main process in a mapping project.

As told, the CPFD is detailed to lower level diagrams. The entire CPFD is broken down into main processes symbolised as separate PFDs. In this diagram a level 1 or top-level diagram one just distinguishes separate processes (*see image in figure 2*). The top-level PFD does not display detailed activities and results of the processes, but is a useful start for further refining the diagram to the logic continuation to PFD level 2, in which every little process is symbolised. Besides, products resulted out of processes are visualised. Due to the complexity of some main processes it is, however, possible that a further detailing to PFD level 3 has to be established particularly in case databases are involved.
For extensive detailing one might make use of the so-called work breakdown structure (WBS). Work breakdown is often applied for large projects. WBS facilitates managers with details of complex projects, amongst which mapping is such a extended and complex process. With the use of WBS it is possible to find the smallest manageable unit to be distilled from a large process analysis.
As told PFD level 2 and 3 visualise a process with all its important elements. The diagram displays the important activities, and input and output of the activities. Further, details such as reference numbers, file formats, file names and software or software modules facilitate the process flow diagram user with the most essential elements for his/her tasks. The following page shows a PFD level 2. Activities and results of activities are symbolised including the input-activity-output relation. A legend comprising the symbols explains the important issues of the diagram.

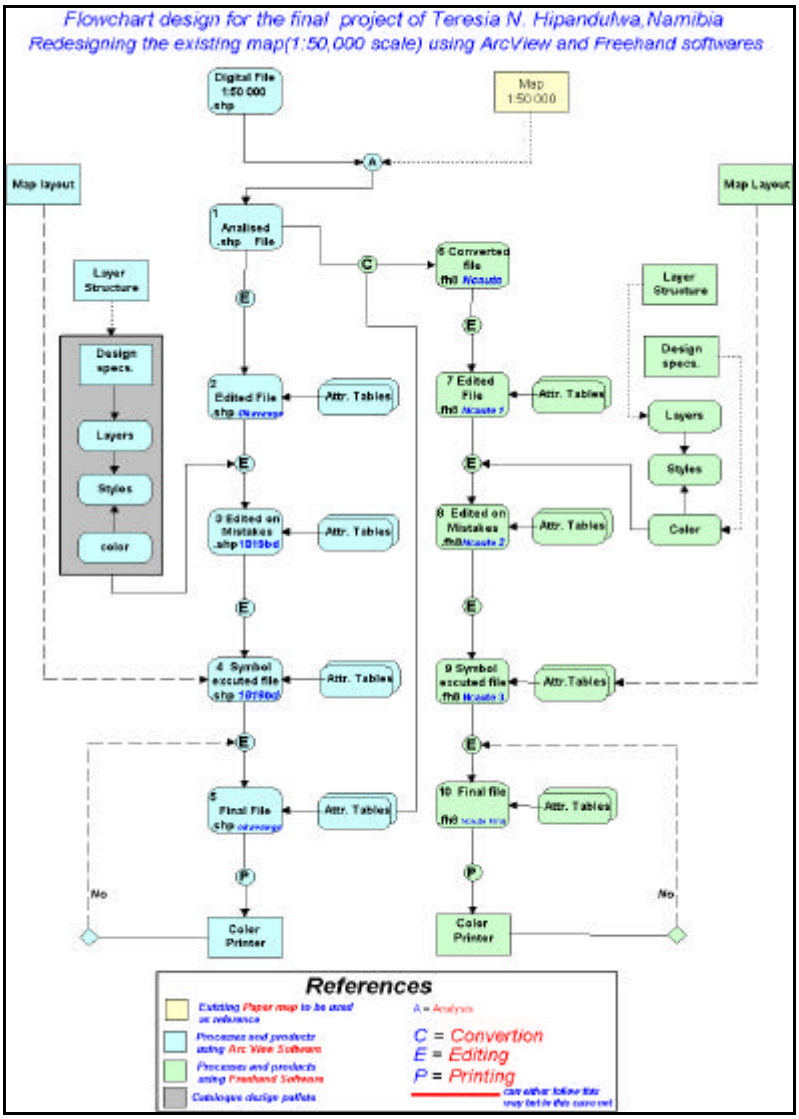


Figure 3. The design of a scaled Process Flow Diagram. (level 2)

2. THE FUNDAMENTALS AND THE SYMBOLISATION

Dealing with process flow charts the fundamentals have to be established primarily. It is inevitable that the designer of the diagram must make a thorough analysis of main processes and decomposed smaller processes and activities, because in a process flow diagram we wish to display the symbolisation of many processes to be extracted from a large context process.
If one deals with a process analysis he/she discovers that every single process consists of similar and common elements. The basic elements of such an individual process in PFD can be classified as:

- the input element,
- the activity element and
- the output element.

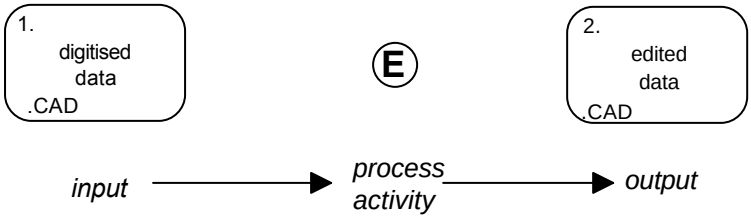


Figure 4. A drawing of the three elements of one individual process.

In this case the diagram displays the symbology of CAD data files and the editive correction activity. Due to consistency with earlier standardisation the symbolisation could not be established with examples like displayed in Managing Geographic Information System Projects.
Those basic elements have a close relation with each other and for clarification the items have been described.

- ***Input*** items are the product elements that deliver information for the follow up of the input: the process activity.
- The (*process)* ***activity*** element forms the dynamic of the entire process. This is the dynamic centre of a small process.
- The result of a single process is called the ***output*** element.

In fact each individual output element is the beginning point of a successive activity. What is output of a certain activity will be the input element for the successive activity.
Input and output elements are ***products***, elements that require a certain activity to become a result; another product.

As told, a main process is decomposed of separate processes, which are all dependent on each other. As a result of this and for clarification on relation a link has to be made between the various elements of the single processes.
Besides, since output elements form the start of a new process they are chained with the next process activity.
In the symbolisation relational lines might differ with respect to their function. Some relations imply permanent changes some temporary changes. In order to display the difference continuous lines and broken lines are the symbolisation of the two.

3. THE PROCESS FLOW DIAGRAM FUNCTIONALITY: A PERSPECTIVE VIEW FOR THE POTENTIAL USERS

The use of process flow diagrams varies with the structure of an institute or company. If these do not work with an appropriate management structure it does not make sense to adapt PFDs. However, if well organised production managers, operators, and trainees benefit from tools like a process flow diagrams.
In all cases, if applied the diagrams are provided for everybody dealing with map production. In order to clarify the benefits for potential users tables with classes of users and functionality have been listed.

One can discover four tables in perspective with:

- management matters prior to a production process
- keeping track on the various processes
- evaluation after having executed the process
- communication for data/file exchange

Each of the tables are explained.

4.1 Flow diagrams for use prior to the actual production

Regardless on the production management certain preparation activities have to be organised in order to fulfil the actual task of the relevant production.
Map production also reflects this statement. Below we give a small table and an explanation of its features relating to their function and their advantages for map production preparation.

Function item:		Particular useful for:
a. time consumption		Operator and manager
b. equipment utilisation		Manager
c. skills of employees		Operator and manager
d. cost pre-calculation		Manager, client
e. contracting		Manager, client

Table 1. Functionality for process flow-chart users. The table displays function item with the user

Explanation:
a. If the diagrams are applied for time estimation both operator and manager and other responsible employees have to check the amount of time to be spent for a particular step in the process.
b. A potential source of conflict is the availability of devices. In the digital environment particularly it may be a problem that digital production hardware is only temporarily available.
c. In order to meet the qualification to apply hardware and software, skills and knowledge of the operators suppose to be as updated as possible. Both manager and operator should be aware of the proper knowledge and skill level of the operator and if correct this must be realised prior to the actual production process represented by the flow diagram symbolisation
d. It is evident that the main goal of a successful management is a proper cost control. Cost calculation begins prior to production, but also during and after major geoinformation process cost control is essential. Applying the process flow diagrams the manager possesses a magnificent tool. The details of the production and their related symbols in the diagrams comprise the true elements to exactly know the steps to be followed.
e. If all elements of a PFD all well defined and established the flowchart could be applied as a predetermined piece of contract document. Nowadays elements of a production are executed outdoors. Consequently one requires useful documents for contracting and subcontracting. PFDs enable supporting a contract.

4.2 Flow diagrams as a tool for keeping track of production

One of the tasks of the manager is to follow the state of affairs of projects. A diagram is the ideal instrument to be applied. Each production step appears separately and if related to a time period it can therefore be an indication for keeping track in production.

Function item:		Particular useful for:
a. time consumption		operator and manager
b. process progress		operator and manager
c. quality check		operator and manager

Table 2. Functionality for process flow-chart users. This time the functions are valid during the process

Explanation:
a. Deals with keeping track of the time spent for each process step.
b. In principle this item relates to time control. However, here it will be of great advantage to know which is the condition of a particular process at a certain time. E.g. how much time it still takes to finish a certain production process. Maybe this function might initiate matters like decisions on overwork or so. This is an ongoing process for both operator and manager and is one of the most frequent uses of a flow diagram.

c. Assurance of quality becomes increasingly important. Decision steps have to be implemented in order to build in quality controls. The process flow diagram symbols are an ideal tool for showing indications on where the quality check should be taken into action.

4.3. Flow diagrams as a tool for evaluation.

A good habit for the continuity of production in general is the evaluation of a production project.
If properly applied evaluation gives very useful information on errors, shortcomings, difficulties, but also corrections and matters, which were successfully executed. The table indicates these advantages. For statistical information one should consistently and frequently make use of evaluations, which result in figures and situations delivering historical data that can be applied for planning of new processes.

Function item:		**Particular useful for:**
a. time consumption		Manager
b. difficulties/errors/shortcomings		Manager and operator
c. skills/knowledge		Manager

Table 3. Functionality for process flow-chart users after production execution.

Explanation:
a. For appropriate management time consumption, which has been spent for certain processes should be measured and analysed for future processes. Whether this leads to changes in processes or reconsiderations in time estimation depends on various matters and will not be discussed.
b. Difficulties, errors or serious shortcomings of a certain product or in a certain process are to be reported. If well analysed and corrected this definitely leads to fewer problems next time.
c. If employees seem to possess lack of basic skills and/or knowledge for the proper execution of tasks one should consider either to improve by study/development if all becomes a constraint for the production continuation. A similar problem occurs to the manager if he fails to know important details of the process. Therefore a close corporation should be provided for production planning, progress watching and evaluation. Process steps could be compared with employees' qualifications. Incompatibility between process and incorrect qualification requires upgrading/studying of staff.

4.4 Flow diagrams as communication for data exchange

Survey of current geoinformation production processes learns that all production is not necessarily executed within one institute or organisation. Nowadays complete sub-processes are sometimes externally executed. For instance, due to the high salary costs it is often cheaper to have done the conversion of the analogue mapping products to digital files and databases in other companies dealing with lower salary costs. Another very common example is the purchase of GIS data for further processing.
Exchanging data files involves a well-defined agreement on formats and standards. To avoid confusion very detailed contracts will be specifically written. Since in the flow diagram issues like the file formats are indicated within the diagram symbols they can explicitly be applied for data exchange.

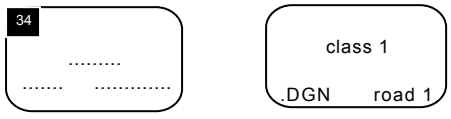
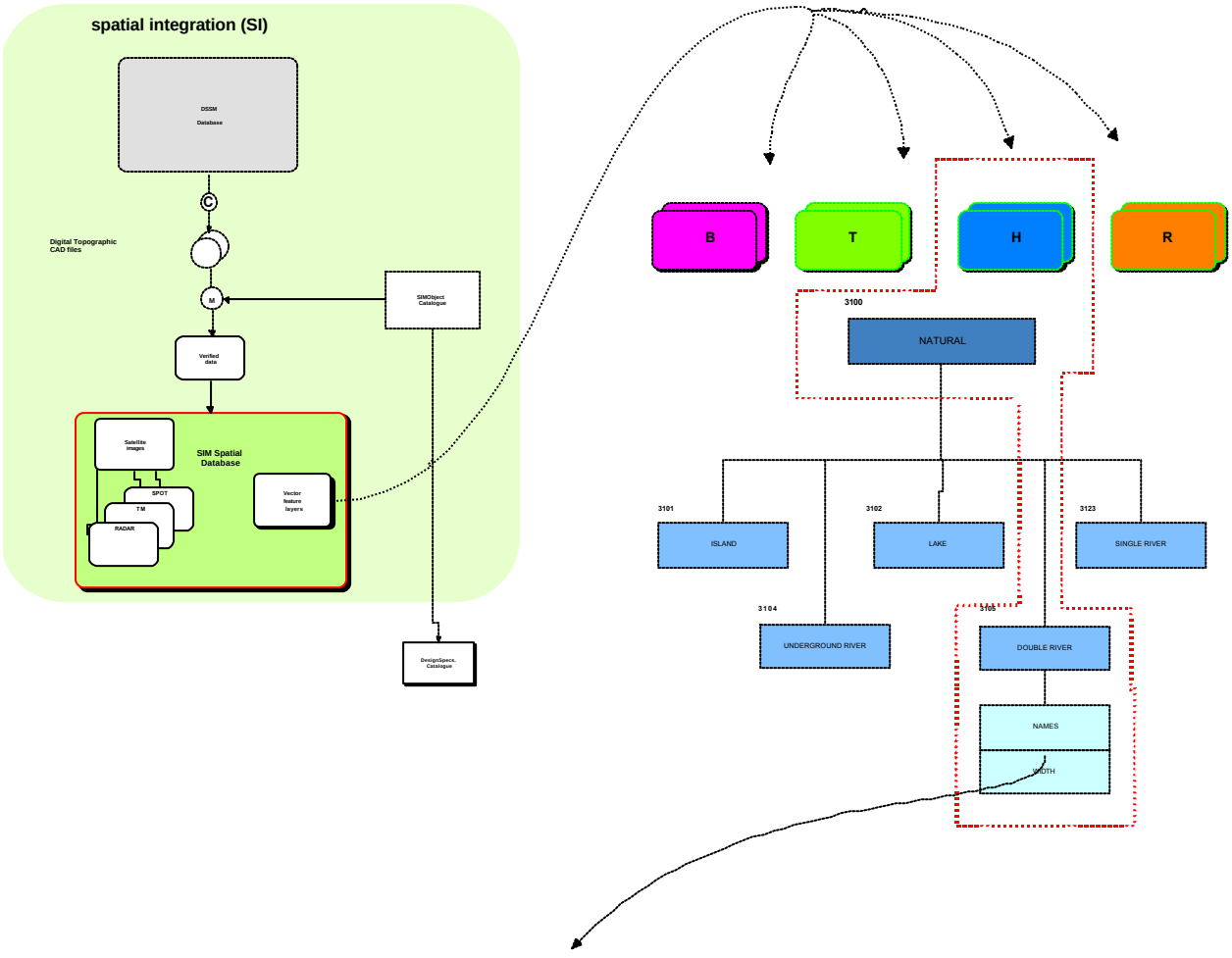


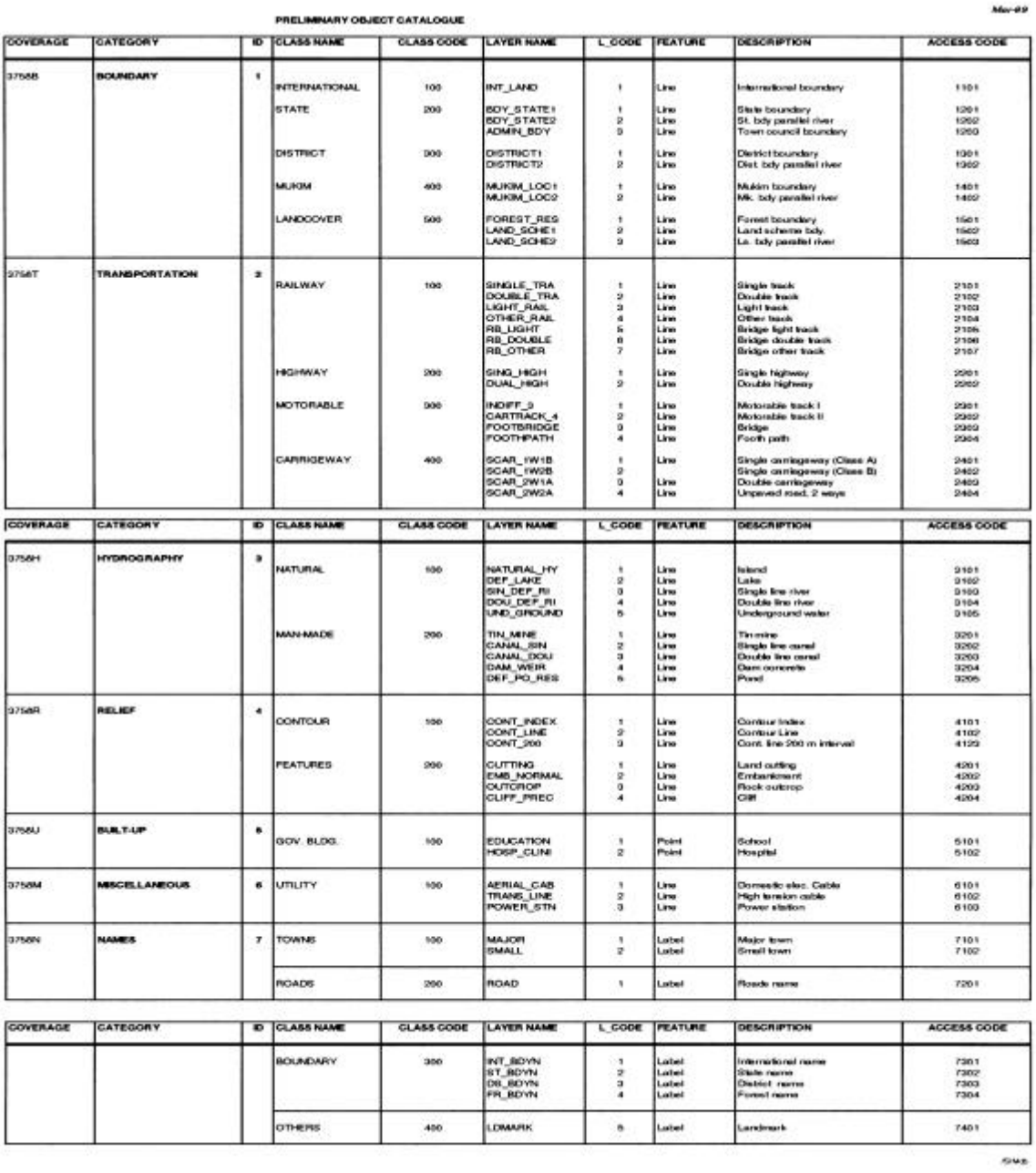
Figure 4. Symbols require more detail information.
They might include a reference number, contents, file name and file format

4. Practical experiences with the latest developments.

Parent appropriate process flow charting software enables elements to be drawn from libraries but new symbols can also be designed, as well. This is the case for map making. A special set of symbols has been designed and placed in a new library. On request the library can easily be extended.
Our case deals with flow charting applications such as FlowCharter®. FlowCharter® allows a hyperlinking functionality, which is extremely useful for the purpose of process flow diagrams we require. It is possible to make a link between the drawn symbols and a file, a directory or even programs. FlowCharter® enables linking opportunities to referring information. Consequently, the addition of this function has increased process charts' effectiveness tremendously. Links to databases, spreadsheets or files comprising process results can immediately be recalled or displayed on request.
If in a PFD, for example, a database has been symbolised the chart element can be chained to the actual database saved in another folder or on another disk drive. After having established the connection the symbols on the chart can be double-clicked and after a little while the user can regard the database. On request the database can be justified, because the database software has also been activated. Other advantages of such a system imply the connection from a hyperlinked diagram to a lower or higher level chart clicking the single element and watching the required level diagram.

In addition it is possible to make a link to a spreadsheet. Each relevant chart element can be linked and acts e.g. in this case as a cost dialogue table to be filled with information such as cost for material, labour or equipment.
This way many combinations of software enable fine-tuning tools for appropriate management on many levels of work. One might think of setting up contracts for budgeting, quality specification and etceteras.





PRELIMINARY OBJECT CATALOGUE

COVERAGE	CATEGORY	ID	CLASS NAME	CLASS CODE	LAYER NAME	L_CODE	FEATURE	DESCRIPTION	ACCESS CODE
3756B	BOUNDARY	1	INTERNATIONAL	100	INT_LAND	1	Line	International boundary	1101
			STATE	200	BDY_STATE1	1	Line	State boundary	1201
					BDY_STATE2	2	Line	St. bdy parallel river	1202
					ADMIN_BDY	3	Line	Town council boundary	1203
			DISTRICT	300	DISTRICT1	1	Line	District boundary	1301
					DISTRICT2	2	Line	Dist. bdy parallel river	1302
			MUKIM	400	MUKIM_LOC1	1	Line	Mukim boundary	1401
					MUKIM_LOC2	2	Line	Mk. bdy parallel river	1402
			LANDCOVER	500	FOREST_RES	1	Line	Forest boundary	1501
					LAND_SCHE1	2	Line	Land scheme bdy.	1502
					LAND_SCHE2	3	Line	La. bdy parallel river	1503
3756T	TRANSPORTATION	2	RAILWAY	100	SINGLE_TRA	1	Line	Single track	2101
					DOUBLE_TRA	2	Line	Double track	2102
					LIGHT_RAIL	3	Line	Light track	2103
					OTHER_RAIL	4	Line	Other track	2104
					RB_LIGHT	5	Line	Bridge light track	2105
					RB_DOUBLE	6	Line	Bridge double track	2106
					RB_OTHER	7	Line	Bridge other track	2107
			HIGHWAY	200	SING_HIGH	1	Line	Single highway	2201
					DUAL_HIGH	2	Line	Double highway	2202
			MOTORABLE	300	INDIFF_3	1	Line	Motorable track I	2301
					CARTRACK_4	2	Line	Motorable track II	2302
					FOOTBRIDGE	3	Line	Bridge	2303
					FOOTHPATH	4	Line	Footh path	2304
			CARRIGEWAY	400	SCAR_1W1B	1	Line	Single carriageway (Class A)	2401
					SCAR_1W2B	2		Single carriageway (Class B)	2402
					SCAR_2W1A	3	Line	Double carriageway	2403
					SCAR_2W2A	4	Line	Unpaved road, 2 ways	2404

COVERAGE	CATEGORY	ID	CLASS NAME	CLASS CODE	LAYER NAME	L_CODE	FEATURE	DESCRIPTION	ACCESS CODE
3756H	HYDROGRAPHY	3	NATURAL	100	NATURAL_HY	1	Line	Island	3101
					DEF_LAKE	2	Line	Lake	3102
					SIN_DEF_RI	3	Line	Single line river	3103
					DOU_DEF_RI	4	Line	Double line river	3104
					UND_GROUND	5	Line	Underground water	3105
			MAN-MADE	200	TIN_MINE	1	Line	Tin mine	3201
					CANAL_SIN	2	Line	Single line canal	3202
					CANAL_DOU	3	Line	Double line canal	3203
					DAM_WEIR	4	Line	Dam, concrete	3204
					DEF_PO_RES	5	Line	Pond	3205
3756R	RELIEF	4	CONTOUR	100	CONT_INDEX	1	Line	Contour Index	4101
					CONT_LINE	2	Line	Contour Line	4102
					CONT_200	3	Line	Cont. line 200 m interval	4122
			FEATURES	200	CUTTING	1	Line	Land cutting	4201
					EMB_NORMAL	2	Line	Embankment	4202
					OUTCROP	3	Line	Rock outcrop	4203
					CLIFF_PREC	4	Line	Cliff	4204
3756U	BUILT-UP	5	GOV. BLDG.	100	EDUCATION	1	Point	School	5101
					HOSP_CLINI	2	Point	Hospital	5102
3756M	MISCELLANEOUS	6	UTILITY	100	AERIAL_CAB	1	Line	Domestic elec. Cable	6101
					TRANS_LINE	2	Line	High tension cable	6102
					POWER_STN	3	Line	Power station	6103
3756N	NAMES	7	TOWNS	100	MAJOR	1	Label	Major town	7101
					SMALL	2	Label	Small town	7102
			ROADS	200	ROAD	1	Label	Roads name	7201

COVERAGE	CATEGORY	ID	CLASS NAME	CLASS CODE	LAYER NAME	L_CODE	FEATURE	DESCRIPTION	ACCESS CODE
			BOUNDARY	300	INT_BDYN	1	Label	International name	7301
					ST_BDYN	2	Label	State name	7302
					DI_BDYN	3	Label	District name	7303
					FR_BDYN	4	Label	Forest name	7304
			OTHERS	400	LDMARK	5	Label	Landmark	7401

Figure 5. Linking facilities increase functionality of modern flow charting software. In the figure that begins on the previous page and continuous above the different levels of diagram details have been linked.

5. CONCLUSIONS

Today we experience an increasingly complex world around us. Whether we experience our bills coming in from companies, government and banks or we work with the software and the data files coming from our clients in all cases it seems we require an increasing management grade in order to execute our activities. Too much time is lost due to repeating actions as a reason of bad process management.

With the introduction of process flow diagrams and their hyperlinking opportunities we facilitate better production management. We can firstly study the analysis of processes and we are then able to separate the processes into small units in order to make them legible for maintaining. With respect to the existing spatial data-handling environment comprising complex GIS analyses and decision-making we particularly take benefit from the management of systems and

sub-systems if we really know processes within all their details. Moreover, we want to know the consequences of processes and decisions we should know all the process principles and elements, at least.
Hyperlinked PFDs enable access to control and manage processes and products and particularly the disaggregating of process flow diagrams gives users availability to modern management. Not only the production manager, but also the operator, lecturer and trainee benefit from the explained PFD methodology. Disaggregating the diagram to both a process context and details of processes and other elements equip the potential user with additional functional support.
Process flow-charting and applying linking functionality might result into substantially lowering production costs by less repetitious work, by increased structural activities and more adequate decision-making. Further, additional filing with diagram symbol links enables easier recording of information and calculation of costs.
We definitely have more opportunity of managing the processes with this type of flow charting software and having access to a set of different programs. The users are provided with the diagram tools that have formerly been neglected.

With the presentation of this paper the author wants to stress that, nowadays, it is a prerequisite for the adequate execution of processes to apply an appropriate management of processes at **all working levels** and **anyone** who deals with mapping processes. One of the most useful management assistant tools for production processes is process flowcharting. PFDs allow for multi-functionality of management tools in all kinds of sections, departments and organisations.
Since mapping processes are getting increasingly complex we can consider a well-defined role for the process flow diagrams with a full functionality.
Concerning management-education for all mapping process' aspects it implies full awareness of educating people dealing with a certain grade of map production management. These days, in order to be aware of mapping, one does not need to be a professional manager, but one should be able to manage him/herself at least.

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