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## **Application of Standard Software in Construction Management**

Application de logiciels standard dans la gestion de la construction

Anwendung von Standardprogrammen in Bauplanung und Baubetrieb

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### **SUMMARY**

Standard software are programmes that a user can apply to solve specific practical problems on his personal computer. Most of these programmes refer to word processing, financial accounting, data base systems and spread sheets. Some of the numerous special applications available nowadays are presented in this paper.

### **RÉSUMÉ**

L'auteur définit le logiciel standard comme un programme que l'utilisateur peut appliquer sur son micro-ordinateur pour résoudre un problème spécifique. La plupart de ces programmes concernent le traitement de texte, la comptabilité financière, les systèmes de bases de données et des calculs en tableaux. Quelques-unes des nombreuses applications spéciales disponibles sur le marché sont présentées dans cet article.

### **ZUSAMMENFASSUNG**

Unter Standard Software versteht man Programme zur Bearbeitung von speziellen Problemen, die vom Benutzer auf Personal Computer eingesetzt werden können. Die Hauptanwendungen dieser Programme liegen im Bereich der Textverarbeitung, der Finanzbuchhaltung, der Datenbanksysteme und der Tabellenkalkulation. Schon heute gibt es eine Vielzahl von speziellen Anwendungen. Einige davon werden in diesem Beitrag vorgestellt.



### Development of Hard- and Software as regards PCs

In the late 70's there were only a few manufacturers of micro-computers. In consequence, there were only a few models of personal computers, as they are called nowadays. Nevertheless, names like APPLE, TANDY or PET still have a good reputation because they started a revolution in computers. It is of interest that up to now, more than 1 million Apple II computers have been sold.

These computers were 8-bit calculators with a main memory up to 64k-byte. One unit including an external floppy disk drive, a screen and a simple printer was available for less than 10.000 dollar.

The essential progress of this new computer generation was - besides its price - an operating system that was easy to handle. The whole system was a real desk top computer. Specially adopted basic languages enable the user to write simple programs for his needs.

In the beginning there were indications that, among others, due to restrictions of the main memory, each application required a tailor-made program. Programmers aspired to have their programmes run on different hardware. Nevertheless, this used to be restricted to only a few applications.

However, the unexpected proliferation of PCs during the early 80's led to the establishment of numbers of software firms, which offered not only tailor-made programs, but also standard PC software the latter with an astonishing sales record. This success can be explained by the inexperienced buyers and new applications. Unlike the professionals in data processing centres, these people were newcomers in computer use.

These standard programs had already predecessors in the main frame market, in particular for data base-, information-, simulation-, and word processing programs. This kind of data processing permitted automatic execution by computers, depending on the input of specific commands.

As a PC user operates his machine himself and enters not only data but also commands, the door was open for the development of standard software. Already by the end of the 70's, most of the now famous software houses were founded in the US - such as MicroPro, MicroSoft, Digital Research, Lotus, or Ashton Tate - just to mention a few examples. Operating systems like - C/PM and later C/PM86 and MS-DOS - and standard programs like - Wordstar, Visicalc, Multiplan, Calcstar - were put on the market at that time and are still valid today.

Nowadays, the main applications are programs for **word processing, accounting, data base management and general spreadsheet programs**. They enable the user to solve specific problems without referring to tailor-made programs. The main advantage is the broad application potential of these programs, the versatility to handle them (e.g. layout of printed reports or graphics), and the possibility of frequently needed subroutines (like data sorting) which are integrated parts of the programs.

On the other hand - and this also has its advantages - the user cannot alter the program by himself. The built-in functions in all standard programs have to be sufficient for the intended solution of a specific problem. The user therefore

has to have profound knowledge of all essential functions, in the program, and their use. It is also important that the user has rather clear ideas on how to solve his problem with a standard program, before he selects a specific program and uses it. Each standard program has its own possibilities and restrictions and, of course its own macro language.

As everybody knows, requirements are increasing with available alternatives in using programs. For example, one might wish to combine word processing with classical spreadsheet functions and even with graphics and/or data base problems. But, such so-called program-packages already exist, which include all these operations or parts of them - like **dBase III**, **Symphony**, **Framework**, or **Open Access**.

#### Possibilities for Applications of Standard Software in CM

Construction Management deals mainly with numeric data. Whenever word processing is required, it rarely stands alone and frequently uses numeric data in a mixed mode.

Starting a computer program, words or values must be entered, updated or stored. Examples are: Tender documents, quantity surveying, basic data for cost estimation, basic data for construction machinery and equipment

If values are concerned, they will be subject to mathematical or logical operations.

Examples are: Bill of quantities, cost estimation and cost control, cost comparison, performance calculation of machinery and equipment

The result of these calculations have to be made visible on the screen or in a printed list.

Examples are: Price lists, quantity selections, schedule lists and reports, accounting tables

Very often, following these operations, the user might require a sorting operation or kind of chart.

Examples are: Price structure, ABC analysis, analysis of alternatives, sensitivity analysis, dispatch lists

Data processing in CM can also mean repetitive calculation or search operations.

Examples are: Documentation of interior equipment, what if analysis, cost comparison analysis, budget planning, control and forecasting

Existing standard software is not always geared to those complex needs. Nevertheless, a comprehensive system analysis might enable the solution of many of the above mentioned problems by carefully selected standard software.

#### Examples for Application

Members of our construction management institute have worked on several applications during the past years. I also know of examples from contractors or consultants. Some of our own application will be presented in the following.



## Life Cycle Cost

Life cycle cost includes primary investment cost and all following cost items, including cost of operation, repair, and so on, for a given project. Initial investment costs are one time expenditures; operation- and maintenance costs usually depend upon the total life of a project. Whenever alternatives concerning the technical layout and the utilization of an installation are analysed, not only the absolute cost of maintenance has to be considered, but also the net present value.

The example has used the Multiplan program. Initially a basic worksheet was set up (see Fig. 1), which comprised all basic data like wall- and floor-space, thermal transmittance, and also prices for constructural elements and technical equipment.

Based on this sheet, we developed calculations on seperate worksheets for:

- Heat balance and energy cost per year
- Cleaning cost per year (see Fig. 2)
- Annual cost for water, dewatering and electrical energy
- Maintenance cost for the whole life cycle (see Fig. 3).

These worksheets had to be consolidated into one final sheet for the total operation cost. By changing initial data, we could analyse alternatives their influences on total costs.

Multiplan has a lot of built-in commands and functions such as for net present value calculation with given interest rates and time horizons. However, the effective memory space of approximately 15 x 100 cells for one sheet is rather limited.

## Claims for additional Cost

Whenever there are deviations from the original schedule due to interruptions or hindrance in execution, the contractor is confronted with a loss of money. This loss is mainly an overrun of fixed cost, because fixed costs are related to periods of time and affected by changes of schedule. Other additional costs do not depend on elapsed time, such as lower efficiency or purchase prices for construction material. The underlying schema for calculations is in principle simple. There is, however, need for extensive explanatory parts by text.

The example was done with the Symphony program. We only used the SHEET and the DOC parts, because the problem only needed calculation and word processing. Word processing and calculation can be done in this program simultaneously in one procedure. Symphony also has much more memory space (suitable hardware provided) than Multiplan. Therefore, the whole procedure needed only one file and the attachments like the first example are obsolete.

# LIFE CYCLE COST DIN 18960

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## BASIC DATA:

Element	Unit price	Area	U-Value
Roof (upper part of thermal insulation)	228.00	3280.00	0.616
External walls (below ground)	220.00	1837.00	
External walls (above ground)	198.00	910.00	0.504
Windows	450.00	300.00	3.000
Doors	750.00	75.00	0.358
Floor space carpets	45.00	1300.00	
Ceilings	122.00	3180.00	
Interior walls	95.00	1950.00	
Floor (lower part of thermal insulation)	122.00	1060.00	0.747

Temperature differential	=	35.00 Degree Celsius
Temperature l. floor ceiling	=	20.00 Degree Celsius
Price of heating oil	=	0.80 DM/litre
Volume of heated areas	=	5830.00 m3
Usefull life of building	=	88.00 Years
Rate of interest	=	6.00 %
Annuity	=	0.0606
Capitalization	=	16.5091

Figure 1: Basic Data of the Life Cycle Project

# CLEANING COST PER YEAR

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## INTERIOR CLEANING CCI = A \* F \* 1/P \* C

	Area (m2)	Frequency (N/A)	Performance (M2/H)	Cost of labour (DM/H)	Total cost (DM)
	A	F	P	C	CCI
Floors	1300.00	50.00	50.00	19.50	25350.00
Rest rooms	215.00	50.00	25.00	19.50	8385.00
Second rooms	0.00	0.00			0.00
Stairs	930.00	24.00	30.00	19.50	14508.00
Entrance hall	80.00	50.00	30.00	19.50	2600.00
Cost of interior cleaning				DM	50843.00

## WINDOW-/ FRONT - CLEANING CCE = A \* F \* P

	Area (M2)	Frequency (N/A)	Price (DM/m2)	Total cost (DM)
	FEF	F	P	RKF
Outside window areas	300.00	6	0.60	1080.00
Inside window areas	300.00	12	0.60	2160.00
window frames		0		0.00
Blinds		0		0.00
Compact front	0.00			0.00

Cost of window-/ front - cleaning	DM	3240.00
Cost of interior cleaning	DM	54083.00
Net present value for cleaning	DM	892863.32
*****		*****

Figure 2: Cleaning Cost per Year and Net Present Value for Interior Rooms and Exterior Windows /Fronts



The calculation of additional cost consisted of:

- Cost of equipment (see Fig. 4)
- Site overhead (see Fig. 5)
- General overhead
- Labour cost
- Lost cost for lower efficiency
- Insurance
- Price increases for steel
- Inflation adjustment for wages and salaries
- Deductions of change orders

The assumed time extension of 10 month had some uncertainties. Therefore, additional costs were also calculated with an extension of 9 month and 11 month. This is a so-called "What If Analysis". In the present case, however, the built in function was not used. The margin of additional cost was calculated for each cost centre with the recalculation procedure (see Fig. 6).

### Cost Comparison of Earth Moving Processes

The cost of hauling by scrapers or truck with a given transport distance depends on equipment performance and equipment costs.

Knowing the technical data and the conditions of site and transportation engineering (see Fig. 7), the performance of equipment can be calculated with simple algorithms. The distance of transport is a decisive criteria: increasing the distance will result in lower performance rate per hour (see Fig. 8).

The production cost per unit is a function of hourly cost rates and hourly performance rates:

$$\text{Production cost (DM/m}^3\text{)} = \frac{\text{Hourly cost rate (DM/h)}}{\text{Hourly performance rate (m}^3\text{/h)}}$$

These costs were calculated for each element of equipment and for the whole operation unit with respect to the transportation distance. Longer distances result in higher costs (see Fig. 9). The different cost curves for the means of hauling from the break even point on, the truck alternative is favourable. The break even point may change, depending on the hourly cost of equipment e.g. hauling tariff.

This example was also done with Symphony. While the initial calculation assumed a distance of 1.000 m, the explained tables and graphs were the result of using the "What If" function.

		MAINTENANCE COST =====				
Element		Area	Mainte- nance/ year	Useful Life	Net present V/year	Total cost 80 years
Roof	Covering	3280.00	96.00	30	64369.18	629760.00
External Walls below ground		1837.00	0.00	80	0.00	0.00
External Walls above ground	Plastering	910.00	32.00	30	5952.84	29120.00
	Painting	910.00	9.00	10	10180.68	57330.00
Windows	Renovation	300.00	450.00	20	59311.07	405000.00
	Painting	300.00	20.00	5	17515.25	90000.00
	Fittings	300.00	55.00	10	20510.52	115500.00
	Sealing	300.00	45.00	10	16781.34	94500.00
Doors	Panelling	75.00	80.00	20	2636.05	18000.00
	Painting	75.00	9.00	5	1970.47	10125.00
Floor	Carpet	1300.00	45.00	10	72719.12	409500.00
Ceilings	Plastering	3180.00	25.00	40	7729.16	79500.00
	Painting	3180.00	7.50	10	29647.03	166950.00
Interior walls	Plastering	13330.00	24.00	40	31103.32	319920.00
	Painting	13330.00	7.00	10	115990.10	653170.00
	Panelling	805	65.00	40	5087.15	52325.00
	Painting	805	7.00	10	7004.65	39445.00
	Tile	770	95.00	20	32137.81	219450.00
Heating system	Renovation	1.00	350000.00	40	34027.77	350000.00
Electrical inst.	Renovation	1.00	434000.00	40	42194.43	434000.00
Sanitary facilit.	Renovation	1.00	533000.00	40	51819.43	533000.00
Total cost for maintenance during life cycle						4706595.00
Net present value for maintenance					DM	628687.36
*****					*****	

Figure 3: Maintenance Cost for the Life Cycle and Net Present Value

CLAIMS FOR ADDITIONAL COST (EXTRA EXPENSE)		
Construction period (as planned)	DO	= 12.0 Month
Extension of time for completion	D1	= 10.0 Month

#### 1. COST OF EQUIPMENT DURING TIME EXTENSION

##### A. Monthly rate

Equipment unit	Depreciation(DM/Mo)	Monthly rate Reinstatement(DM/Mo)
Concrete mixer	1,118.00	854.00
Crane	12,299.00	7,040.00
Drilling & blasting	1,074.00	743.00
Power production	502.00	332.00
Miscel. Equipment	439.00	294.00
Site installation	1,886.00	1,495.00
Falsework	1,542.00	768.00
Total	18,860.00	11,526.00

##### B. Commissioning cost

Burden to wages of reinstatement works			
Reinstatement	Wages	Factor	
11,526.00	0.45	0.69	3,578.82 DM/Mo
Entire cost per month			33,964.82 DM/Mo
Commissioning time			30 d/Mo
Commissioning cost per day			1,131.16 DM/Mo

##### C. Reduced Commissioning cost during downtime

First 10 days (100%)	10*1,132.16	=	11,321.61 DM
From the 11. day on (83%)	(300-10)*1,132.16*0.83	=	151,320.07 DM
Burden to wages of reinstatement works			
15,320.07*0.08*0.9*0.69		=	7,517.58 DM

Cost of Equipment during time/extension	170,159.26 DM
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Figure 4: Cost of Equipment for 10 Month Time Extension



1. Scraper CAT 619			
Horsepower	N =	225 kW	
Stuck capacity	J0 =	13.8 m <sup>3</sup>	
Shell factor	U =	1.22	
Payload (m <sup>3</sup> compact): Jn = J0 * u	=	16.80 m <sup>3</sup>	

Figure 7: Technical Data of Equipment (Scraper)

### ABC-Analysys of Work Items

The bill of quantity is usually the owner's instrument in order to describe and quantify the work items of the job to be done. The contractor uses the bill of quantity for his pricing. It is a common base for both to settle the accounts for construction work, and to check the contractual performance. Each work item supports information for the above mentioned objectives. Normally a work item specification consists of:

1- Work item number	2- Description
3- Quantity of work	4- Dimension
5- Unit price	6- Total price

The first four elements are specified by the owner in the tender documents. The last two elements are the result of the contractor's pricing. Total price is unit price multiplied by quantity. In case of contract award the unit price is subject to the contract. The payment for the construction work will be settled of payable quantity multiplied by the unit price.

Whenever a bill of quantity consists of a large number of items - frequently hundreds or thousands -, it will be useful for both the owner and the contractor, to identify those items, which are highly decisive for the total contract price. It is of common knowledge that usually 10 to 15% of the items (by number) are responsible for approximately 75% of the contract volume (by value). The next 15 to 20% of items correspond to a 20% share of contract volume. In the so-called ABC-analysis the first group is named the A-range of work items, the second group is named the B-range. The C-range contains all other items amounting to approximately 70% of the number of items, but only to 5% of total value. Evidently one can use data processing in order to compose the three groups. The required program can be a standard data base program.

In the present case, we used the Symphony program and specified in an entry form work item numbers, brief description, quantity, dimension and unit price. The total price per item was to be calculated automatically. When all items were entered, by means of the SORT-command the work items were brought in descending order (by values) and cumulated. The result were corresponding lists (see Fig. 10) and graphs (see Fig. 11).

## 2. Time related field overhead costs during extension

Salary	175,300.00 DM
Construction camp	26,600.00 DM
Wages office	19,449.00 DM
Miscellaneous	11,000.00 DM
Time related site overheads	232,394.00 DM
Construction period (as planned)	12 Mo
Site overhead during time extension =	193,624.17 DM

Figure 5: Site overhead for 10

### Table of Additional Costs and Reductions

Due to time extension	9.0	10.0	11.0 Mo
1: Cost of equipment	153,728	179,159	186,591
2: Field overhead	174,262	193,624	212,987
3: General overhead	204,795	227,550	250,305
4: Labor cost	346,988	361,562	376,135
5: Cost during idel time	264,770	264,771	264,770
6: Insurance	8,028	8,920	9,812
7: Price of reinforcement	41,235	41,235	41,235
8: Increase of wages	44,273	45,607	46,940
9: Reductions	(199,691)	(199,691)	(199,691)
Additional costs (DM)	1,038,388	1,113,737	1,189,084

Figure 6: Total Additional Costs for 9/10/11/ Month Time Extension

Scraper		Loader + Truck	
Distance	Hourly production	Distance	Hourly production
400 m	110.0 m <sup>3</sup> /h	400 m	52.2 m <sup>3</sup> /h
500	99.8 m <sup>3</sup> /h	500	49.6 m <sup>3</sup> /h
600	90.8 m <sup>3</sup> /h	600	47.4 m <sup>3</sup> /h
700	83.0 m <sup>3</sup> /h	700	45.2 m <sup>3</sup> /h
800	76.8 m <sup>3</sup> /h	800	43.0 m <sup>3</sup> /h
900	71.5 m <sup>3</sup> /h	900	39.6 m <sup>3</sup> /h
1000	67.3 m <sup>3</sup> /h	1000	38.2 m <sup>3</sup> /h
1100	63.5 m <sup>3</sup> /h	1100	36.9 m <sup>3</sup> /h
1200	60.3 m <sup>3</sup> /h	1200	35.7 m <sup>3</sup> /h
1300	57.1 m <sup>3</sup> /h	1300	34.6 m <sup>3</sup> /h
1400	54.3 m <sup>3</sup> /h	1400	33.5 m <sup>3</sup> /h
1500	51.7 m <sup>3</sup> /h	1500	32.4 m <sup>3</sup> /h
1600	49.5 m <sup>3</sup> /h	1600	31.5 m <sup>3</sup> /h
1700	47.5 m <sup>3</sup> /h	1700	30.6 m <sup>3</sup> /h
1800	45.6 m <sup>3</sup> /h	1800	29.8 m <sup>3</sup> /h
1900	44.6 m <sup>3</sup> /h	1900	29.1 m <sup>3</sup> /h
2000	42.2 m <sup>3</sup> /h	2000	28.2 m <sup>3</sup> /h

Figure 8: Performance Rate per Hour by increasing Distances

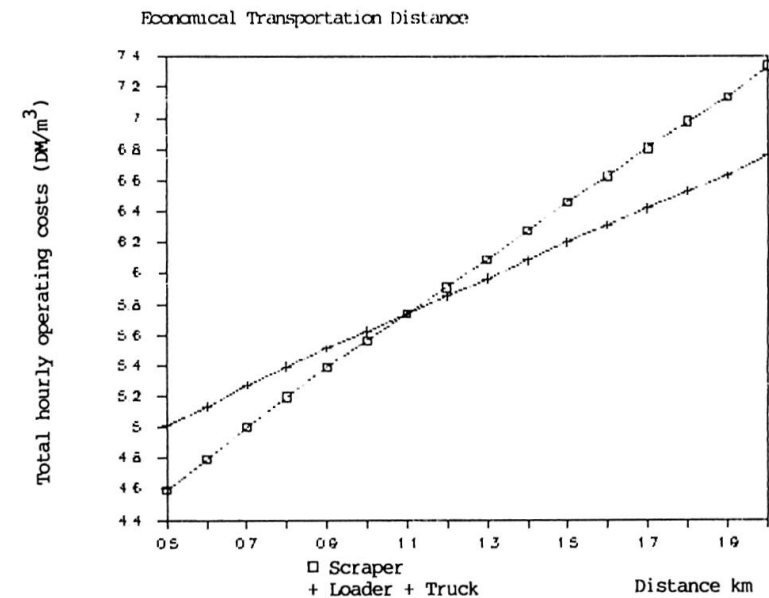


Figure 9: Economical Transportation Distance for Scraper and Truck



## Documentation of Interior Equipment

Architects and engineers use special form-sheets for documentation of design data and information. This form contains all relevant construction elements and their rough specifications - qualitative and quantitative. A possibility for updating must be provided in case of changes in requirements or conditions. Another purpose of the form is the concentration of data by certain criteria.

As compared to the ABC-analysis the form-sheet is much more complex. The interlink between the elements is much more complicated. All detailed information must be considered all kind of evaluations. The mass of data is far too big for spreadsheet programs. The only possibility is the use of a genuine data base program. Standard data base programs may be limited in the amount of fields per record and processing time but practically unlimited in the number of records.

In the present case, we used the dBase III program. It is like all other today's standard software programs rather user friendly. The user can specify his own entry forms, he is also free as to sorts and listings. On the other hand, this freedom requires a profound systems analysis prior to processing and a complex macro language. Therefore we had to develop an auxiliary program for the needs of the site engineer. This program defines a simple menu for data entry and various kinds of analysis. It is close to a tailor-made program but much easier to write because it can depend on the standard program for all data base functions.

Our form-sheet can process up to 9 general, and 30 detailed elements, each element with up to 5 specifications per room (see Fig. 12 for the first 5 general elements). The amount of data is decisive for the processing speed. A rather high performing PC needs approximately one hour for the sorting of 2.000 rooms. Even one of the faster printers requires approximately one minute for two pages of the document (= 1 room). Special attention therefore, has to be given to economic and reasonable scope of data requirements.

Item discription	Quantity	Unit price	Total price	Sum	Rank	Range
170 Reinforcement mat	to 196.00	2,050.00	401,800.00	401,800.00	1	A
101 Wall formwork	m2 11,020.00	28.50	340,070.00	715,870.00	2	A
52 Wall concrete	m3 1,150.00	179.00	205,850.00	921,720.00	3	A
160 Reinforcing steelbars	m3 98.50	1,980.00	195,030.00	1,116,750.00	4	A
1110 Floor concrete	to 990.00	180.00	178,200.00	1,294,950.00	5	A
21 Foundation concrete	m3 940.00	141.00	132,540.00	1,427,490.00	6	A
3010 Site installations	% 100.00	1,250.00	125,000.00	1,552,490.00	7	A
1170 Floor formwork	m2 3,375.00	34.50	116,437.50	1,668,927.50	8	A
90 Foundation formwork	m2 2,770.00	41.60	115,232.00	1,784,159.50	9	A
130 Floor formwork	m2 3,045.00	33.50	102,007.50	1,886,167.00	10	A
3030 Site clearance	% 100.00	650.00	65,000.00	1,951,167.00	11	B
1190 Face formwork	m2 675.00	77.00	51,975.00	2,003,142.00	12	B
230 Air shafts	St 164.00	300.00	49,200.00	2,052,342.00	13	B
22 Foundation concrete	m3 266.50	146.50	39,042.25	2,091,384.25	14	B
2040 Floor slab	m2 3,000.00	12.20	36,600.00	2,127,984.25	15	B
1071 Wall concrete	m3 125.00	236.00	29,500.00	2,157,484.25	16	B
1360 crushed rock course	m2 3,800.00	7.00	26,600.00	2,184,084.25	17	B
53 Wall concrete	m3 150.00	173.00	25,950.00	2,210,034.25	18	B
1240 Face formwork	m2 265.00	86.00	22,790.00	2,232,824.25	19	B

Figure 10: List of Work Items and Total Price in Descending Order

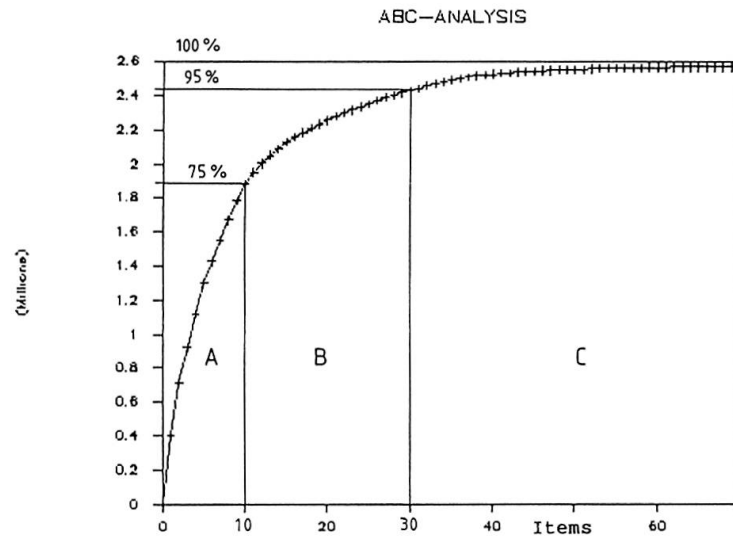


Figure 11: ABC-Analysis of Work Items

***** Interior Equipment * *****					
***** Room number 03090 *					
Page 1 - Material for interior work Date 17.3.1986 *					
***** Manager EDP/ 1.Floor *					
1.00 General *****					
1.10 Living area	*	30.20 m2			
1.20 Clear hight	*	3.00 m			
1.30 Circumference	*	22.01 m			
1.40 Finished floor level	*	0.00 m			
***** Building material * Tye Deskription Quantity BQ-Item Drawing *****					
2.00 Exterior windows and doors *					
2.10 Window element	*	A59 C Aluminium window	3		
2.20 Window glazing	*	K19 C Thermo glazing	3		
2.30 Parapet glazing	*	K19 C Thermo glazing	3		
3.00 Walls and column *					
3.10 Exterior wall finishes	*	Plaster & painting			
3.20 Interior wall finishes	*				
3.30 Partition walls	*	TRMO2 Stud Partition			
4.00 Interior doors					
4.10 Doors in load bearing walls	*				
4.20 Doors in non bearing walls	*	TMAO4 Metal doors/ painting	2		
5.00 Floor covering *					
5.10 Insulation	*	Cement floor			
5.20 Barrier	*				
5.30 Flooring	*	Carpeted floor			
6.00 Ceiling *					
6.10 Plaster ceiling	*				
6.20 Suspendet ceiling	*	DBM01 Metal plates			

Figure 12: Document Sheet 1 of 2