matrics
CONSULT • LTD

A Universal and Unique Expert System for the International Tunnelling and Civil Construction Industry

based on the Integrated Coding System ICS

Issued by
Martin Smith B.Sc MICE CEng SIA Dipl Baumeister BSI Lead Auditor
FIDIC-ITA Emerald Book Lead Author

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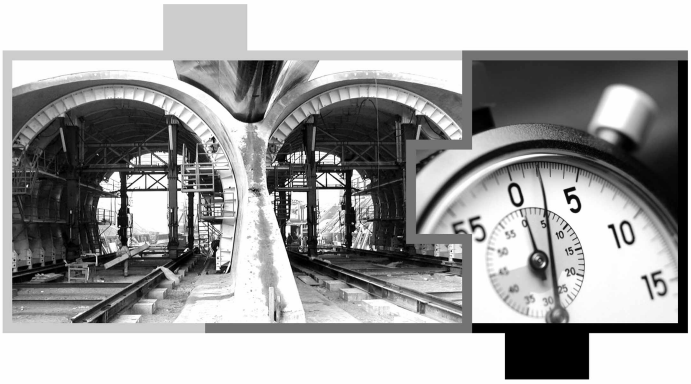

we give you the time to improve it.

management of
activities, time & resources
for international construction solutions

www.matricsconsult.com

MATRICS Consult Ltd

Registered in England and Wales
Company No. 4165597

Arrowsmith Court
Station Approach
Broadstone
Dorset BH18 8AT UK

www.matricsconsult.com

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Management Overview

MATRICS Consult Ltd is a solution provider for the international construction industry specialising in the provision of integrated solutions for the tunnelling and civil engineering market.

This is provided by a transparent project model which includes the use of a common database, technical dictionary and library for all construction information.
The model is structured into a series of inter-related matrices so as to enable all parties to a construction project independent of language, location, organisation or activity to access and apply information with the minimum of effort.

This has been achieved by a long term approach to the issue of construction information management so that the end result now provides the user with a single point of access to all relevant library or project information. The ICS model covers all aspects and phases of construction from initial feasibility study, through design, procurement and operation, and in turn, provides the ability for the user to develop project information management as new or revised information becomes available during the life of the project.

The probable outcome of the project can be continuously re-analysed in real time as the latest information is received without the need for re-entering information into different software packages through the use of the intelligent coding system ICS which can be adapted, amended and expanded to suit prevailing conditions.

Decision making is made easy by using the computer to analyse the variances whilst the project manager assesses the impact and possible risks of the ever increasing volume of information.

The futuristic approach of combining all data, whether it be of a technical, commercial or general nature, provides the user with a ready made construction model with integrated planning and costing for easy development and monitoring including standard model conditions of contract, Q.A. documents, specifications, bills of quantities, resource checklists, auditing tools and filing system each of which has a distinct and common relationship to other documents through the standard code.

MATRICS Consult Ltd provides the link to an even more productive and profitable project.

1 Synopsis

The management of both small or large tunnelling and civil construction projects world-wide calls for an ever increasing capability of all parties to a construction investment to collect and effectively filter and disseminate relevant information as quickly and as accurately as possible within the restraints and demands for increased quality, tighter schedules and overall lower budgets.

ICS provides the solution for real time construction information management

The ICS Integrated Coding System Logic

The ICS is a decision tree method of presenting information from feasibility study stage through to commissioning and maintenance of a construction project, enabling the consequences of ever changing impulses to be integrated into the existing systems with the minimum of effort by the user. The information is structured so that material facts and periodic variances can be absorbed or exchanged without destroying the overall picture. The concept of information presentation imitates the topdown generic relational database philosophy to a degree of detail that has not been achieved to date.

ICS provides the user with a project orientated controlled filter

Transparency through a uniform data structure

The method of achieving fast, clear, accurate and economic analyses can be realised by adopting and exploiting the following logical criteria:

Standardised Project Dependencies using the ICS Model
Sequencing of Operations

Maximising Computer Power and Speed
Iteration of Decision Cycles

Providing Precious Time for User Creativity
Freedom of Selection

Conclusion

Input: ***Absolute minimum entries***
Output: ***Only essential consequences***

This report outlines the features and presents an extract of the principles involved as well as a few short worked examples of the power of the ICS Concept

2 *Introduction to the Concept*

Often the costs of preparing and supervising tunnelling and civil engineering projects represent a large proportion of the overall costs of production at the construction sites.
Whoever the party is to a construction contract, be it a government body, private client, consultant, contractor, sub-contractor or supplier, the amount of paperwork can often be self generating to the point of being meaningless. The ability of companies to operate across national borders world-wide is developing a new set of problems.
Contracts are faced with a confusion of local laws, building regulations, varying standards, besides different cultural interpretations of the written word.
The tunnelling and civil construction industry is very reliant on experience which is frequently lost when the site team changes and people move onto different projects. This however could be counteracted by establishing an expert system into, or from which, members of the team at any point in time can enter relevant information or request existing data from a common database on a project-, company-, national- or international-wide level. Experience has shown that there is a case for an

Integrated Coding System - ICS

which can provide the basis of a universal expert system for the tunnelling and civil construction industry
based on determining the objectives of the parties to produce an effective project by structuring the information into an
international, tunnelling or construction specific, comprehensive and transparent relational database

Objective
The concept must be simple and enable the user to

Intuitively Manage the Project and Supporting Data quickly and effectively

and independently of location, language, law, project size, complexity or specification criteria using a comprehensive Master System. Any change in any one of the criteria can then be continuously monitored and adapted with time.
The objective in establishing this integrated concept is to produce a minimum no. of ***Standard Logical Variables*** in which the sequence of events can be arranged so that the minimum effort is required in applying the system, by establishing the principles of a relational database adaptable to any aspect within a construction administration situation.
Information has been gathered from numerous different national systems world-wide and brought under one common denominator to ensure international acceptance.

3 *Key to the Concept*

The following properties are required for an effective solution.
It shall be:
self learning
flexible
transparent
multilingual
multidimensional
topdown in approach

It shall also:
maximise the decimal system
utilise a multi-layered matrix
provide a filter
cover all disciplines
be suitable for all parties involved

for all phases of a project from:
design
procurement
construction
operation

and financing of tunnelling and large civil engineering projects

where the digits, positions of the digits and numbers have a specific meaning which can be related to the information content. The path to the information follows the principles of mind mapping techniques or directory and sub-directory.

However, ***each level of detail*** can be cross-related throughout the various layers and sub-directories of the code structure both ***vertically*** and ***horizontally*** in ***multi-directions*** and from the ***general*** to the ***specific point of view*** or ***vice-versa***.

The advantage of this concept is self-evident when operating projects in different countries and languages, as numbers are independent of national codes and customs. Information management and estimating time can be reduced drastically.

This is becoming more evident with the development of the Internet where there will be an ever increasing demand to instantly access information world-wide.

ICS provides a universal standard for information exchange within the tunnelling and construction industry

ICS provides the universal structure to manage all relevant construction project information in a simple and easy to use manner

ICS provides a concept independent of national language and local customs or standards

Visualisation

The model can be best understood by placing the relationships in a three dimensional pyramid. Each of these relationships is in turn dependent on the overall objective of the project under review.

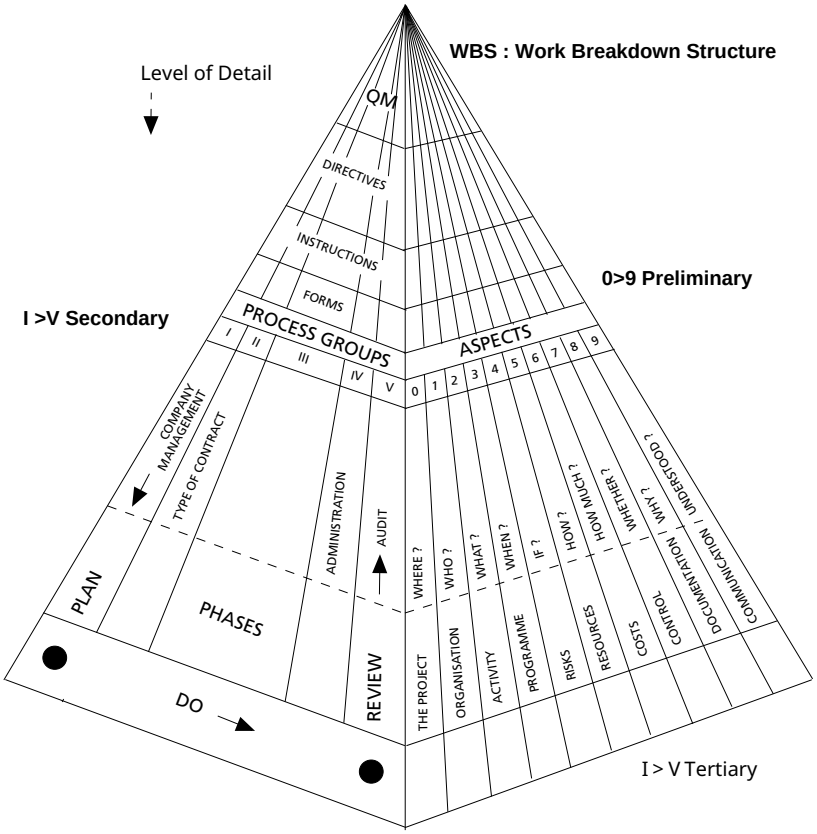


Figure 1 - ICS Pyramid

Legend:

QM = Quality Manual

The three axes are:

Level of Detail

e.g. Project Organisation > Owner, Client, Consultant, Contractor, ...

The Quality Loop

e.g. Plan > Organise > Do > Check > Review

The Key Aspect

Where?, Who?, What?, When?, If?, How?, How Much?, ...

This provides the skeleton for combining all further details at lower levels such as **Project Phases**

e.g. Environment, Design, Procure, Build, Operate, ...

4 *The Preliminary Breakdown*

A preliminary breakdown is achieved by establishing further dependencies or ***terms of reference to the overall matrix***.

This approach enables the basic sequence for even further detail to be established so that all information can be cross related, whether in ***the form of standard or non-standard parameters***.

Example of the Standard Parameter [K] Key Aspect:
(further details are shown later)

No	General	Content
0	Where ?	Geographical Location
1	Who ?	Legal or Organisational Framework
2	What ?	Activity (Provision of Goods and / or Services)
3	When ?	Time
4	If ?	Risk
5	How ?	Resources
6	How Much ?	Cost and Value
7	Whether ?	Control
8	Why ?	Documentation
9	Understood ?	Communication

Table 1 – ICS Key Aspects – Standard Parameters

Example of a Non-standard Parameter is:

No	General	Content
0	Where ?	Place Name
1	Who ?	Name of Organisation
2	What ?	Excavation
3	When ?	2003
4	If ?	Water Ingress
5	How ?	Excavators
6	How Much ?	2 Million
7	Whether ?	Design Review
8	Why ?	Audit Report no 10
9	Understood ?	Fax dated today

Table 2 – ICS Key Aspects – Non-Standard Parameters

4.1 Organisational Structure

Standard parameters are shown in brackets as follows: [....]

[O] Organisation Levels relate to the overall position of the parties to a contract within a project, e.g.. local authority, client organisation, planner, contractor, sub-contractor, supplier etc. as shown below:

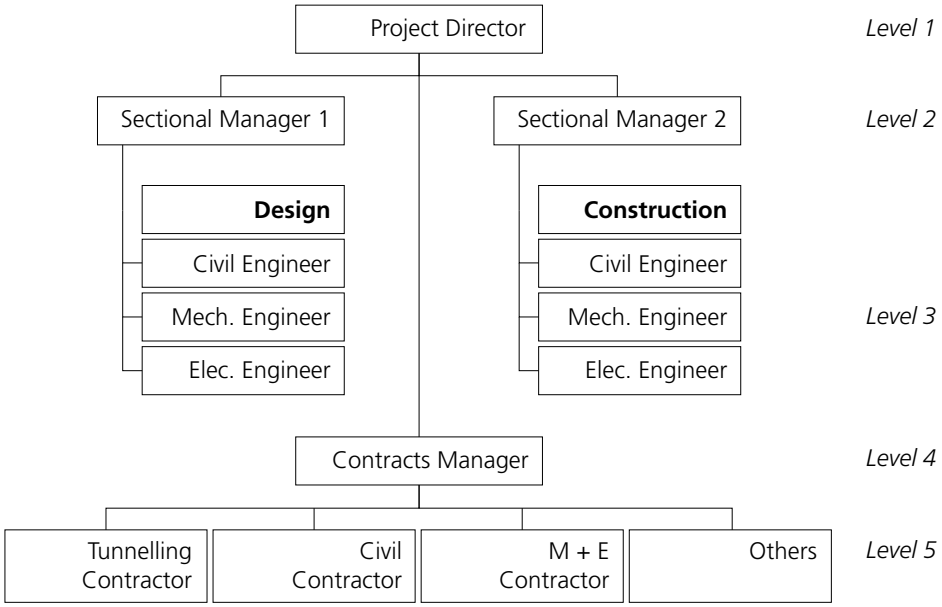


Figure 2 – Typical Project Organisation Chart

The ICS Model can accommodate all types of organisation structures

4.2 Activity Processes

The variables are linked by a series of process groups and sub-processes related to the objective of the project which can be further expanded, at will, as shown in the next figure:

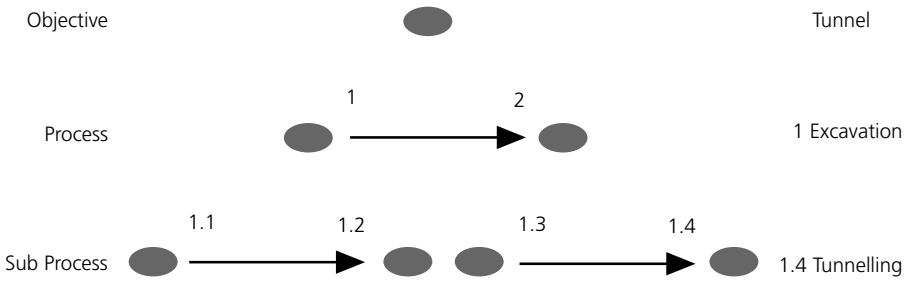


Figure 3 – Activity Processes: Objectives, Process and Process Sub-Groups

These processes or sub-processes can be linked by the user at any point to the overall project objectives on a simple or complex basis as required each interlinked through the standard variables such as resource or cost as shown below.
The ***ICS Model*** allows all associations to be made on either a ***one to one or one to n basis by the user to his definition as and when he requires***.

> ***The ICS Model has the ability to adapt to local, national or international standards and still track activities against resources and costs.***

Code	Description
2	**Activity**
23	Specifications
23.1	Excavation
23.14	Tunnel Excavation
5	**Resource**
52	Equipment
52.1	Excavation Equipment
52.14	Tunnel Excavation Equipment
6	**Cost**
61	Cost Estimate
61.1	Cost of Excavation
61.14	Cost of Tunnel Excavation

Table 3 – Coding Example: Tunnelling Specification, Resource & Cost

4.3 Project Phases

Standardising the various phases enables repetitive decision making to be simplified enormously. The end result of one phase becomes the starting point of the next phase and so the individual phase reviewed during the development of the project can be back traced with clarity and precision. Equally the same codes as shown above are used for all activities in the various levels of programme detail ensuring absolute clarity and minimising mistakes.
[P] Phase relates to the state of development of the project within the commonly known definitions of feasibility study, design, procurement, construction, supervision, operation and maintenance etc.

The ICS model can be used for all stages of a construction project

The output of one phase is the input for the next phase

4.4 Risk Management

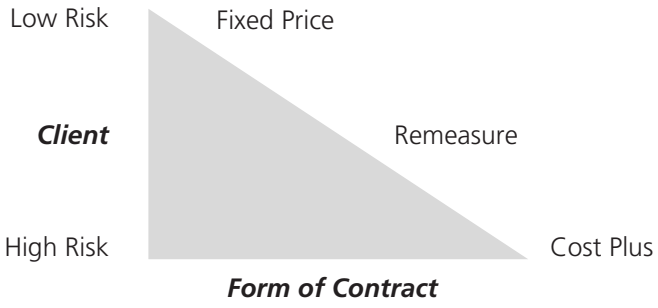


Figure 4 – The Types of Contract vs Risk

The Form of Contract can be re-organised into the following main chapters which can readily be associated with the ***Key Aspects***.
Research into the cross-relationship between these elements shows that the risk varies considerably with
the form of the contract
the activity required
the time allocated
the resources provided

The ICS model can adapt to different forms and language of contract

ICS provides a standard form of comparison to evaluate the risk variance of each of the designated criteria with the minimum of effort

4.5 Resources

Each activity requires resources to achieve the overall objective. Ideally resources are chosen to fit the activity under scrutiny and be appropriately qualified and/or experienced.

ICS provides a standard activity orientated resource base

Tunnelling Activity: Description of Method of Excavation can be related directly to the machine employed for that purpose. The following icons illustrate the types of tunnelling excavating machines that can be found under the heading
5. resource
2. plant
1. excavation
4. underground
i.e. 5.2.1.4 tunnelling excavating machines

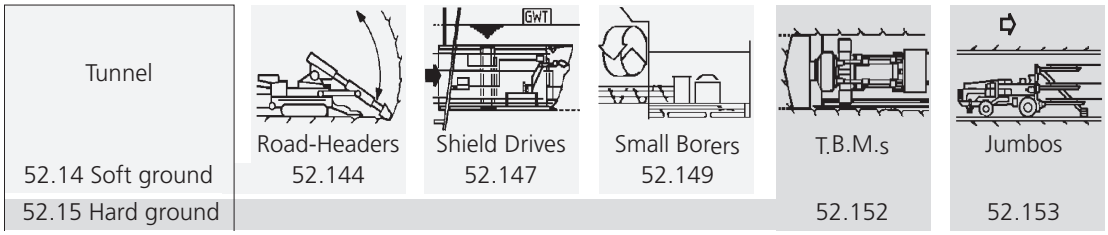


Figure 5 – The Types of Tunnelling Excavation Equipment

4.6 The Primary Business Relationship

The simple principle of the three criteria: ***Input, Time, Output*** can equally be used in establishing the business relationship, i.e. a commercial contract or joint venture agreement between any of the following parties:
Project Client, Design Consultant, Main Contractor, Sub-Contractor, Main Supplier, etc.
This can be integrated into a general business relationship as shown in the next figure.

Figure 6 – The Primary Business Relationship

Any two parties, I Seller (supplier) + II Buyer (customer) are tied into a legal framework where party I supplies goods and services at a value in a given time with some form of guarantee from party I to party II. However, the risk in transferring the goods and services is deeply rooted in the documentation of the project which is subject to continually changing events in time through various communications.

ICS provides the analysis for the basic Business Plan Requirements

4.7 Management Decision Making Cycles I – V

It is important to integrate the decision making process at each level and phase of the project so that all further decisions can be interlinked. This can be shown in the form of a Management Decision Making Cycle with the following key elements:

I Plan > II Organise > III Do > IV Check > V Review

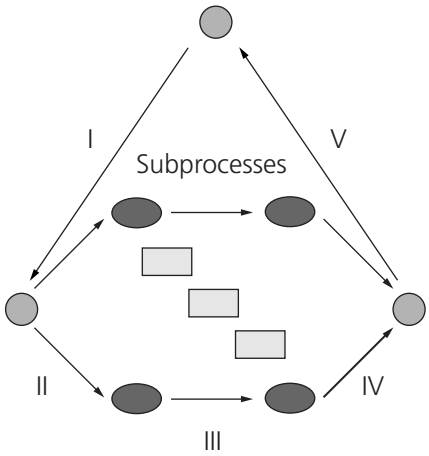


Figure 7 – Management Decision Making Cycles I – V

These cycles represent the basic thought processes necessary in analysing and commercially evaluating the relationship between the mass of ***Technical Information*** required or available but not always easily accessible. The model has a built-in code structure that reflects the nature of the project and the corresponding QA procedures uses the same code structure.
i.e. no burdensome volumes of complex QA texts

The various levels of detail mirror the organisation and activities in the design and construction programme.

ICS provides a repetitive and systematic framework which can be employed for all management decisions

ICS provides a direct link to the Quality Assurance Requirements of ISO 9001

4.8 Documentation

Each transaction shall, ideally, be properly documented without additional editing so that in turn it provides the input for the next decision in the continuous change of project development. All documentation that can be related to any stage or part of a project should be instantly accessible and valid for that instant in time independent of who in the project team enters the latest changes.

The use of the ICS model library provides a direct link to external library sources of information and uses the same code structure for the documents as well the contents of the documents. E.g. The internal structure of a bill of quantities and/or estimate takes the activity and resource codes and directly sorts and summarises them according to the criteria defined in the contract specifications. This relationship enables changes e.g. site instructions, unexpected occurrences (either physical or with respect to time) to the contract to be monitored precisely against time and cost in real time, a concept much sort but not yet found elsewhere.

In addition, associations can be made with various sections of already accepted standards or technical articles with little effort. ***ICS International Classification of Standards*** 1999 or the ***Dewy Library Classification System*** (with which ICS has a direct link) and other similar documents. The ICS Model can frequently detect defects in the original document due to its ***self learning techniques***. Information comparison is independent of language and culture.

> ***The ICS Model has a comprehensive set of indices to link to external libraries***

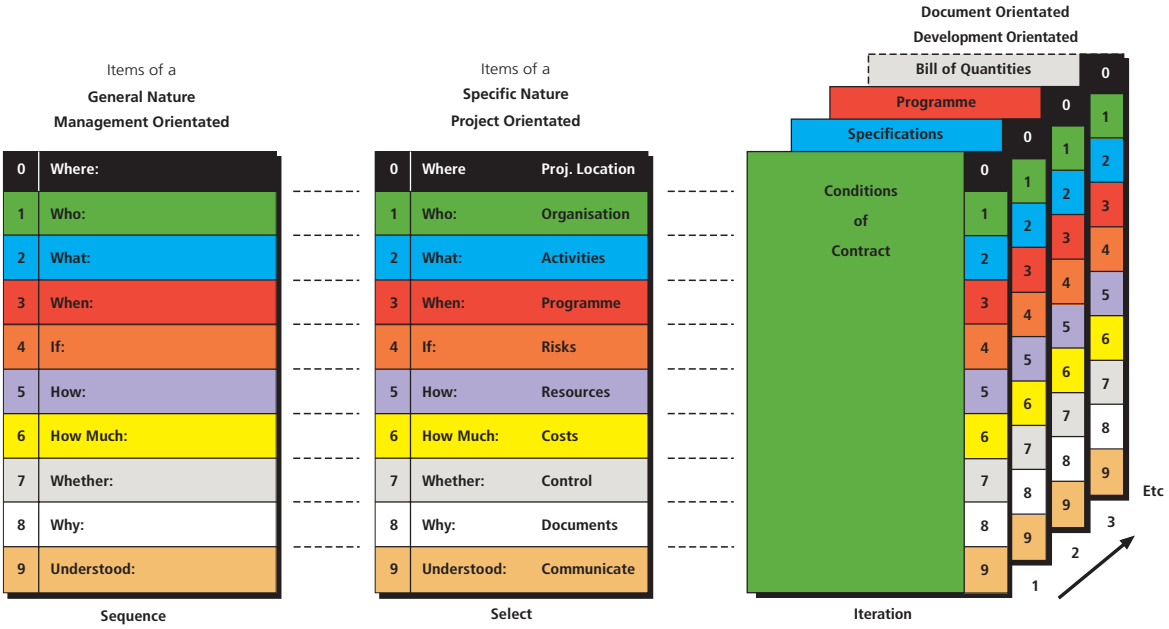


Figure 8 – Structured Library

5 The Secondary Breakdown

The preliminary breakdown provides the ***basic general structure*** for managing information so that situations can be both analysed and synthesised quickly.
The ***secondary breakdown*** provides the ***specific details*** within a tunnelling and construction environment. Note the similarities.

Items of a General versus Specific Nature:

General	Specific
Geographical Location	The Actual Site Environment
GIS Systems	Survey Data
Forms of Contract, FIDIC, NEC	The Specific Parties to the Contract
Pertinent Ruling Law and Language	Local Applicable Law
Dictionary of Definitions	Multilingual Dictionaries
Precontract Prequalifications etc.	Tender Procedures
General Rights and Obligations	Specific Conditions of Contract
Operational Procedures	Quality Systems and Programmes
Settlement of Disputes, DRB etc.	Seat of Arbitration
International & National Standards	Particular Project Design Specifications
General Specifications	Schedules of Activities or Quantities
Particular Conditions of Contract	List of Deliverables
Drawing Registers	Actual Drawings
Activity Descriptions	Tender Documents
Trade Descriptions	Productivity Cycles
Bills of Quantities	List of actual materials required
Milestone Events	Interim Stage Events
Project Programmes	Design and Construction Programmes
Calendars	Status of Project at Specific Dates
Project Diaries	... through the various Phases
Special Risks	Project Specific Risk Evaluations
Insurance Situations	Insurance Policies
Resources Standardised Data	Materials, Plant, Labour, Sub-contractors
Product Quality Standards	Supplier's Recommendations
Payment Conditions	Payment Events and Conditions
Statutory Commercial Requirements	Costing: Estimates, Budgets, Financing
ISO 9001 Quality Assurance Audits	Quality Management Programme
Documentation System	Filing Systems, Memos, Minutes of Meetings and the content of the specific information

Table 4 – Comparison of General and Specific Items within a Project

6 The Tertiary Breakdown

The ICS Concept exploits the principle of the Corner Stone, which inter-relates Input, Time and Output or in Terms of Key Aspects [R] Resource, Time and [A] Activity in a 3-D Model.

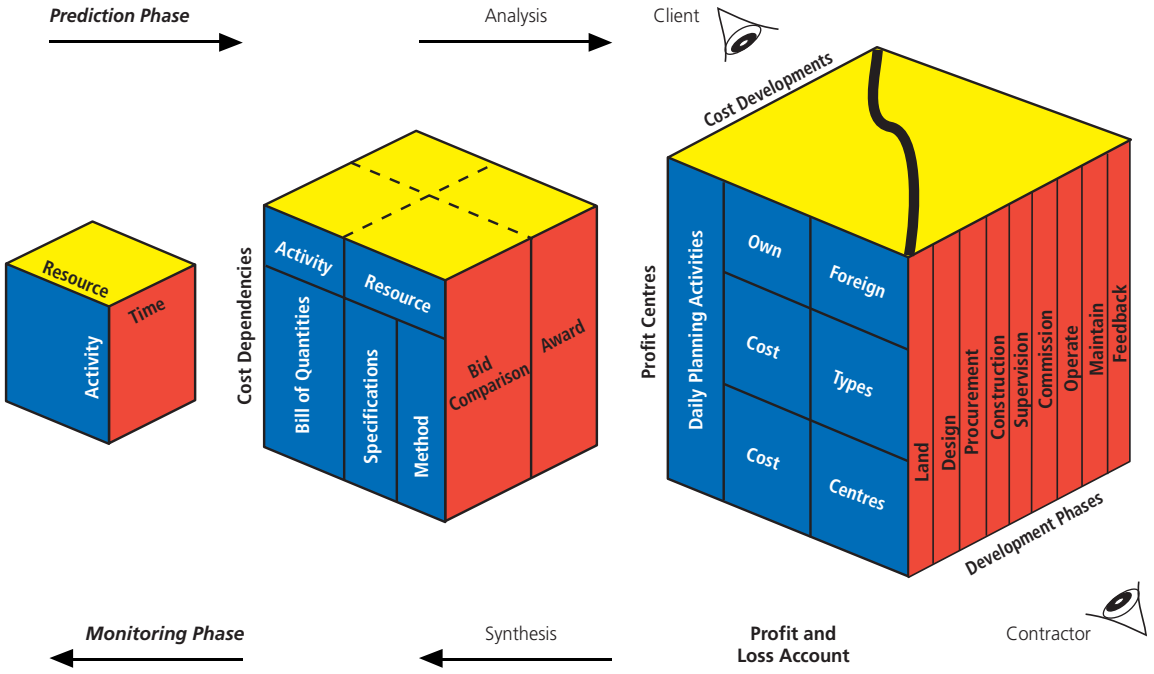


Figure 9 – The 3-D ICS Model: Levels 1, 2 and 3

6.1 Organisation of Cost Types and Cost Centres

The Aspect Activity can be conveniently subdivided into five major sub-layers which can be directly related to the cost types and cost centres for commercial planning and monitoring as follows:

[C]	Cost Centre Layer
A	The Client's Contingencies and Management
B	Site Orientated Activities
C	On-Site or Off-Site Contractor Infrastructure
D	Transport Facilities
E	The Contractor's Contingencies and Management

Table 5 – Cost Centre Layer

6.2 Activity Groups and Breakdown

Each activity group can be conveniently allocated directly to an individual layer or cost centre.

The activity groups have been defined to eliminate all duplication and as a consequence allow the user to make direct comparisons of conditions of contract, activity specification, bill of quantities, programme, resource and cost with a single code simply by superimposing the appropriate layer which in turn is used for the filing system.

[A]	Description of Activity Group	Layer				
		A	B	C	D	E
000	General Planning	X	X	X	X	X
100	Topographical Change		X	X	X	X
200	Geotechnical Improvements		X	X	X	X
300	Structural Elements		X	X	X	X
400	Environmental Finishes		X	X	X	X
500	Materials Preparation			X	X	X
600	Utility Supply and Distribution			X	X	X
700	Site Access and Accommodation			X	X	X
800	Site Supervision			X	X	X
900	Logistics				X	X
1000	General Organisation					X

Table 6 – Subdivision of Activity Layers A-E

Individual headings can be transposed within each layer A – E.

Layer A defines the overall planning services required
e.g. pre - & postcontract project management

Layer B defines the client's project specific activities required
e.g. final product as required at handover

Layer C defines the services the contractor is to provide
e.g. construction plant and site management

Layer D defines the relative logistics of the project
e.g. transport facilities to, from and on-site

Layer E defines the contract management techniques required
e.g. head office management and overheads

> ***ICS provides a direct link between Activities, Bills of Quantities, Programme, Resources and Costs with a single entry***

6.3 Programme

These construction activity groups can be used for all construction programme and administration summaries and are normally allocated serially in time.

However, Fast Track Projects require these groups to be overlapped in time and executed, as far as possible, in parallel.

The phases of activities can be sub-divided into recognisable routine construction activities which can take place in isolation or in parallel with other activities on the same construction project:

[P] Phase	Subdivision
Environment	Site Investigation and Property Purchase
Design	Preliminary, Provisional, Definitive, Final
Procurement	Prequalification, Estimating, Tendering, Contract
Construction	Adaption to Existing Works Provision of Temporary Works Provision of Permanent Works Provision of Repair Works
Supervision	Site Supervisory Services
Commissioning	Partially or Totally Completed Projects
Maintenance	Remedial Works
Research and Development	New Techniques & Systems

Table 7 – Construction Phases

These basic ***Phases*** are standardised and used as the basic structure for both project planning, design and construction modules for every aspect in project reporting, programming and costing etc. i.e. using the same activity codes as the specifications and bill of quantities thus making project tracking transparent.

6.4 Risk Analysis Breakdown

Risk factors have to be allocated individually against each variable for each item in the analysis. ICS provides the access tool to compare each variable against all others in turn and can then automatically run "what if" situations in real time e.g. risk profiles in graphic format.

6.5 Construction Resource Breakdown

The Activity Layers A - E can also be integrated with the major resources required to the extent that Productive Resources can be directly related to a specific construction activity by an intelligent coding system.

This enables specialised as well as global activities to be analysed against requisite resources.

This is the most important feature of the ICS relational database concept, as it transparently reflects the Input / Output model.

6.6 Cost Breakdown

The resources are further linked with accounts by the use of sub-groups as follows to enable fast track evaluation:

[R] RESOURCES BREAKDOWN		
Own Resources	Category	Foreign Resources
Own production Capitalised	**Materials**	Own manufactured or purchased
Own	**Plant**	Hire
	Energy	
Employed	**Personnel**	Hire
	Subcontract	Subcontract
Equity	**Capital**	Foreign
Risk Capital	**Contingencies**	

Table 8 – The Tertiary Breakdown of Construction Resource

The estimating and accounting systems use the same groups and sub-divisions derived from the activity / resource breakdown.

This feature is critical to the ICS Concept in providing the ability to cross relate internal contexts with no additional input from the user.

The decimal logic allows a simple but effective relationship to be established without any requirement on the user to be aquainted with modern accounting principles. However, the resources, once established, can then be directly used for project accounts.

6.7 Comparisons of Activity, Time and Resource

Integrating the 3 major elements into a similar order enables analysis of the information to reduce uncertainties to a minimum.

It is now possible to control the project and produce a comparison profile as we now have an interactive relationship between all the major components, a situation normally not available with systems to date.

Comparisons between the various components at each and every level can be made in a global or specific manner depending on the amount of detail entered or required by the user:

of Activity, Time and Resource.

The ICS concept gives a very quick relationship between activity, time and resource. If these are combined, we have a 3-D matrix which can be viewed from various angles to display the numerous relationships between the various parties involved:

For example the following documents can be generated with a

Single Combination of ICS Codes

from a common database independent of language of origin:
to assist the user in analysing the situation rapidly
and to compare the actual project documentation under review
against other standards or previous projects
and to any specified level of detail required simultaneously

In Short
A simple and ideal structure for international applications or instant management tool

From the big picture to the specific detail with an absolute minimum of effort

Using a standard cross reference code throughout

Comparison	Detail
Contract Organisation	Work and Organisation Breakdown Schedules
	General and Particular Conditions of Contract
	List of Definitions
	Prequalification Formats
	Project Responsibility Matrices
	Environmental & Geological Reports
Activity only	List of Construction Standards
	Format for Particular Specifications
	Bill of Quantities
Activity vs Resource	Estimates and Project Budget Formats
	Management Accounts for Each Phase of the Project
	Cost Indices Analysis
Activity vs Time	Design and Construction Programmes and
	Dependencies
Resource only	Lists of Materials, Plant, Personnel, SC's, Overheads
	for Site Planning, Monthly Measurement & Dayworks
	Work Preparation Tables for Site Installations
	Resource Relevant Production Data Sheets & Graphics
	Site and Management Organisation Charts
	Comparisons for Analysing Resources: Own and Hiring or Sub-Contracting
	Contract and Subcontract Tender Evaluations
	Charts of Management and Financial Accounts
Resource vs Time	Histograms
	Cash Flow and Progress Evaluation Curves
	Profit and Loss Accounts, Balance Sheets
Overall Planning and Control	A Management Documentation System
	A Project History conforming to ISO 9001 Requirements
	A Standard Filing System
	A Protocol Format for Project Management Meetings
	A Direct Context Sensitive Reference to International Library Systems
	A Common International Information Standard for Construction Projects World-wide
	An on line Help by means of over 300 Full Colour Context Sensitive A4 Graphics

Table 9 – List of Management Reports

7 *Evaluation*

The result of the top-down analysis concept runs into every aspect of tunnelling design and construction management from concept to completion. The gathering of information by all parties has very distinct advantages for every level of management.

1. The use of the same information grouping enables different sectors of management to compare results.

2. The same consolidation concepts enables groups of information to be analysed in a similar fashion and variance in one aspect of the analysis will consequently show a comparable variance in other related aspects, e.g. any change in
   quantities
   cost
   methods
   progress
   geology
   design

3. The transparency enables action to be taken where it is most effective as any differences are more distinct.

4. The use of common coding minimises mistakes in identifying items.

5. The system can be adapted to any national or international system, independent of language.

6. The decimal classification codes used by the ICS concept permits the user to determine the degree of detail he wishes to have. This enables the concept to be used on both small and large complex projects and assists in the integration of information between all parties to a project, due to the same sequential logic. The longer the number the more detailed the level of information.

   In short

   Evaluation is relatively simple

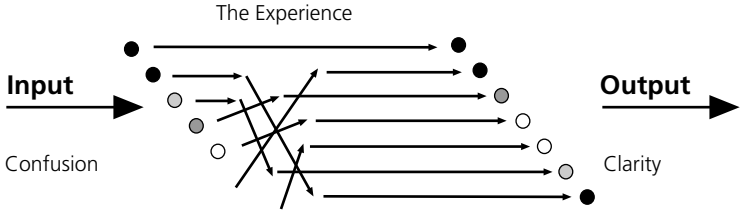


Figure 10 – From a confused organisation to a clear relationship

8 *The Consequences*

The consequences of the ICS System are manifold, but the key items can be best summarised as follows:

1. The system is computer and user friendly and compatible with conventional paper systems
2. Information can be retrieved instantly to any specified level of detail
3. Comparisons can be made of variances either globally or in specific detail
4. The manager decides which reports are required and which criteria are to be analysed
5. Information not required can be avoided
6. The amount of management time required is reduced considerably
7. The system is adaptable and can be supported by standard office and special applications software
8. The system can be managed by a portable computer
9. The net savings in overheads are considerable
10. The manager has more time for creative thinking for new solutions to every day problems
11. and the system can, if called for, provide an in-built dictionary of construction terms with definitions.

9 *Conclusions*

The management of information itself should not be a source of increasing overheads. The ICS system enables complex, as well as simple projects, to be managed with very little effort producing the maximum output, but allowing the manager to decide the amount of reporting he requires.

The effect of the time saved in producing the information can permit the manager to make immediate decisions to improve situations that he would not otherwise be in a position to do thus permitting even further savings to be effected.

The ICS model has the power to consolidate to any level required instantly, so that the executive summaries can be issued at short notice with the ability to back trace any specific detail at will to the criteria specified by the user.

The only problem that really remains is:
Is management prepared to change its established complex systems for a simple one that is based on a logical association of ideas?

The foundation mode in which man normally thinks:

THE SIMPLER THE CONCEPT
less paper
less time
less cost
THE BETTER THE RESULTS

10 Extracts from Completed Projects

The following examples have been simulated from actual projects but simplified to enable the reader to apply the principles of the ICS concept within the limited space provided.
It has been used on various parts of the following tunnelling projects:

Version No being used since	Reference Projects
Version 1: (1984-) Black and White 2-D Lotus Version	Palmiet Pumped Storage Scheme, Cape Town, RSA Inanda Wiggins Aqueduct, Durban, RSA Lesotho Highland Water Project, Lesotho Underground Oil Storage Farm, Middle East AlpTransit General Planning, Switzerland
Version 2: (1991-) Over 300 Colour Coded Slides & Specialist Software	Leuna Oil Refinery, Leipzig, Germany Arrisoule Motorway Tunnel, FR Switzerland Lonza Hydroelectric Supply Tunnel, VS, Switzerland New Gotthard Base Railway Tunnel, TI, Switzerland Many Minor Civil Projects, Germany and Switzerland Ghazi Barotha Hydroelectric Scheme, Pakistan
Version 3: (1997-)	Comprehensive Integrated 3-D Colour Coded Slides and Interactive Graphic Software - in preparation

Table 10 – Reference Projects

.....	London Underground Upgrade, Budapest Metro, Algiers Metro
Version 20: (2020-)	Fully Integrated Geomodel for GBR Contract Conditions

Operating Languages:
Basic Model in English, German, French, Italian and others

Numerous parts of the ICS Model have already been translated into French and Italian and used on various projects in Europe. It is also being used as a standard dictionary for the tunnelling industry in Europe.

It is hoped that the examples below are of sufficient detail to clearly illustrate the ICS Model which was developed from a simple concept on paper and now encompasses a wide range of uses.

Time is money, so saving time saves money

Coded Examples

The following figures and tables illustrate the coding relationships between the various aspects.

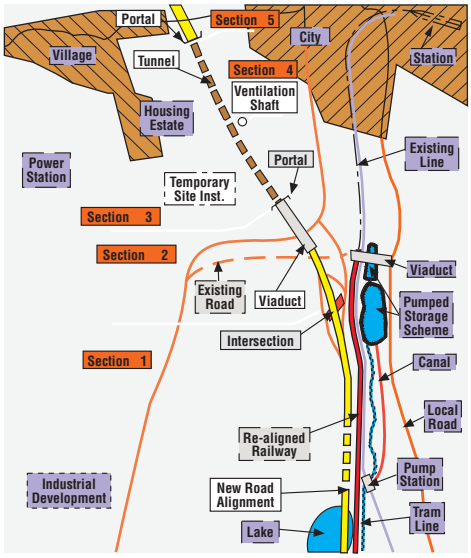
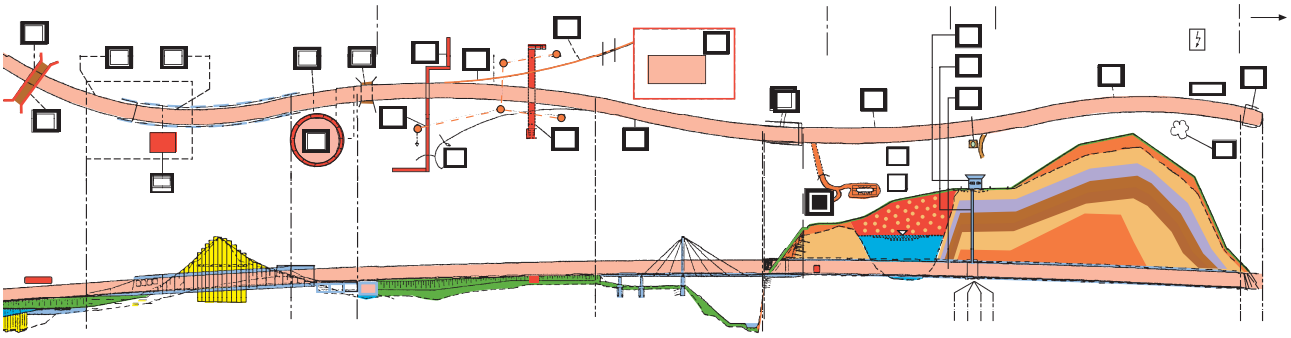


Figure 11 – Project General Layout



			Amendment				
	Structure No.....		A	B	C	D	
0	SUPERIOR CRITERIA:	Local Road Junction, see Community Report No..... Date.....					
1	BOUNDARY CONDITIONS:	Contract Nos: 1,2,3,4...../Geographical GBS 1.234/Responsibility County Engineer					
2	WORKS DESCRIPTION:	Overbridge over New Railway LIne incl. Utilities					
3	PROGRAMME CONSTRAINTS:	1.1.90 - 31.12.91	X		X		
4	RISKS:	Traffic Congestion, Groundwater Reserves, Environmental Interference					
5	RESOURCES:	Consultants...../Contractor...../Suppliers.....					
6	COSTS:	CHF 12,000.000	X				
7	CONTROL:	Municipal Engineer: Area Office ...../Mr M.Smith					X
8	DOCUMENTATION:	Report Nos. 1.234:/12, 45, 67, Drawings Dossier No.....	X		X		
9	SUBORDINATE CRITERIA:	Political differences at community level, Contractor behind schedule					

Figure 12 – Project Profile Overview Report

Example of Tunnel Approach and Tunnel / Shaft to Highway A101

In the case of Surface Works: viz: Cutting
Where: Excavation is the activity "100"
Road tunnel approach is the structure "1234"
The technical unit is "cutting"

Subject: Excavate 1000m3 through hillside with bulldozer

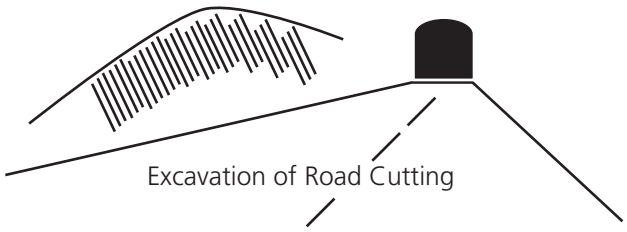


Figure 13 – Example: Excavation of Road Cutting

[O] = 0	means Organisation NOT defined
[K] = [G]	means Key Aspect is geographical definition of project
[G] = ABCD \ A101 \ 1234 \ PW \ 100 i.e. Location	means ABCD County, Highway A101, Structure 1234, Permanent Works, Open Cutting - Excavations

10.1 Typical Organisation Codes and Description

Code	Project Organisation
2	National Authorities
2.1	National Highways Dept.
3	Local Authorities
3.1	Local Traffic Management Office
4	Client Organisation
4.1	XYZ Property Developers
5	Project Managers
5.1	ABC Organisation
6	Functional Management
6.2	ABC Engineering Dept.
7	Location
7.1	Head Office, London
8	Contract Managers
8.1	DEF Environmental Planners
8.2	GHI Road Designers
8.4	JKL Civil Contractors
9	Suppliers
9.1.3	MNO Ready Mix Suppliers
9.1.6	PQR Steel Suppliers

Table 11 – Typical Organisation Codes and Description

10.2 Typical Activity Codes and Description

Code	Activity Description
100	Excavation general
140	Underground excav. soft ground
142	Tunnelling excavation
142.1	Tunnelling excavation: Scope, Definitions
142.2	Tunnelling excavation: Methods
142.3	Tunnelling excavation: Sequencing
142.4	Tunnelling excavation: Tolerances
142.5	Tunnelling excavation: Resources
142.6	Tunnelling excavation: Measurement
142.7	Tunnelling excavation: Testing
142.8	Tunnelling excavation: Records
142.9	Tunnelling excavation: Communications

Table 12 – e.g. 2-3 Specifications: Tunnelling Excavation

Code	Activity Description
0140	Underground excavation
0141.*	Shaft sinking
0142.*	Tunnel excavation
0142.*.04	Tunnel excavation class IV
0142.*.04.6	Tunnel excavation class IV 6m dia.
0142.*.04.67	Tunnel excavation class IV 6m/TBM

Table 13 – Typical Activity Codes and Description: e.g. Bill of Quantities

Re:	Code	Description	Resultant Code
Element	0310	Floor slabs	0310
Element	0340	Arch lining	0340
Development	.3	Supply	0310.3
Development	.4	Fixing	0340.4
Material	e	Mesh reinft	0310.2.e
Material	f	Prestressing	0340.5.f

51.xxx = Materials
51.6xx = Metal
51.62x = Reinforcement
51.624 = Mesh i.e. "e"

Table 14 – Typical Activity Codes and Description: e.g. Lining

Notes:
1. The star (*) in the activity section is a standard symbol to include all that follows.
2. The word "development" has been used to simplify the coding structure (e.g. .3 = supply).
3. Resource "e" is an alphabetical abbreviation of the resource code 1624. The ***most common positions*** use an abbreviation, which is convenient for use in bills of quantities to reduce the number of digits required and for ease of reading.

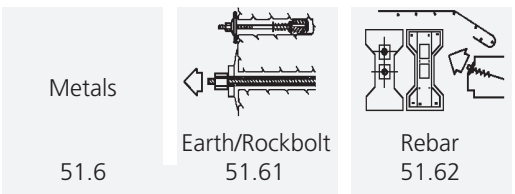
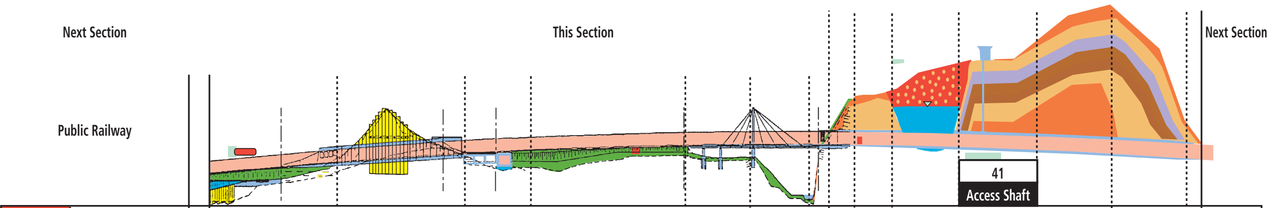


Figure 14 – Types of Materials - e.g. Reinforcing Steel (Rebar)

The same combination of activity and material codes can be used for such items as drawing register or trade descriptions and consequently the final no. of codes required is relatively small as they are a combination of the varying parameters in various sort orders.

10.3 Project Programme



	Section		11	12	13	14		21	31	32		33	34		35
	Main Facility		Embankment	Cutting	Bridge	Embankment		Bridge	P.	Main Drive		Cavern	Main Drive		P.
	Ancilliary Facility		A1 Over Bridge	A2	Access Road	A3 Under Pass		A4	Access Tunnel						
	Ground Conditions		Imported Fill	Gravel Marl		Imported Fill	Weathered Rock		Medium Rock		Soft Rock	Hard Rock	Hard Rock	Medium Rock	
	Plan View Revision														
0	1	Programme 6	6												
Prel. Study	1	No. Months													
10	1	20..30 3-12	12	12	6	12	12	10	3	6	6	6	6	6	3
Aquire Land	2														
20	1	10..20 6-15	10	15	6	10	9	15	1	15	15	18	15	15	1
Design	2														
30	1	5..15 3-6	5	6	3	5	6	5	2	6	6	6	6	6	2
Procure	2														
40	1	20..40 9-30	20	25	12	20	9	21	3	30	30	6/6	30	30	3
Construct	2														
50	1	20..40 9-30	20	25	12	20		20	3	30	30	12	30	30	3
Supervise	2														
60	1	2..3	3	3	2	3		3	1	3	3	3	3	3	1
Commission	2														

Figure 15 – Initial Project Programme in months per activity and section

This can be very quickly converted into the classical time line diagram commonly used for tunnel projects.

The matrix above can also be used for the following documents and data:

Geological Stratification	Location of rock, faults
Hydrological Information	Location of groundwater
Survey Information	Main and sub-axes
Construction Methods	Location of D&B, TBM
Line of Attack	Points of access
Progress Reports	Base for progress chart
Construction Profile Details	Location of different profiles, etc.
Site Organisation	Location of different teams

10.4 Risk Analysis

A risk analysis can now be undertaken for each section and strata against time and cost and the consequent effects analysed and reviewed.

10.5 Resource

Now that the initial elements have been defined it is quite a simple matter to analyse the resources required for each structure, activity and phase.

E.g. the Interaction Structure / Activity / Phase / Resource

Label	Title	Activity	Phase	Resource	Resultant code
Structure	Tunnel	0140			
Phase	Design		2		
Resource	Tunnelling			0.140	0140-2-0.140
Phase	Construction		4		
Resource	Plant Owned			52.000	
	Tunnel Boring Machine Soft			52.142	0140-4-52.142
	Plant Hire			55.000	
	Tunnel Excavator			55.140	
	Tunnel Excavator hydraulic			55.143	
	Tunnel Excav. hyd. Tracked			55.143.1	
	Tunnel Excav. hyd. Tracked diesel			55.143.11	0140-4-55.143.11

Table 15 – Example of Activity & Resource Codes

The Resource family is closely linked with the Activity family.

10.6 Costs

The cost can now be allocated in the form of unit costs or site installations against each particular facility, structure, activity or units of time.

Planning Costs	Cost Centre A
Unit Rates	Cost Centre B
Site Installations	Cost Centre C
Transport	Cost Centre D
Overheads	Cost Centre E

10.7 Auditing

In a similar fashion auditing becomes much easier – as shown below.

Selecting the activity code 140 "Tunnelling Excavation" would show which information is available against that code for each aspect from 0 Location to 8 Filing System.

Specific information entered against each of these lines of information will then be shown or printed as required by the user. The important factor is that all this is accessible with a single selection "140".

Alternatively entering the code

"1" would provide all information against "excavation"
"14" would provide all information against "underground excavation soft ground"
"141" would provide all information against "shaft excavation soft ground"
"142" would provide all information against "tunnel excavation soft ground"
"143" would provide all information against "cavern excavation soft ground"
"151" would provide all information against "shaft excavation hard ground" etc.

for the organisation and geographical section specified under the first table below

A common communication code throughout the Project

Organisation: Client [O] = 4

Preliminary Design [P] = 2.2

E.g. all information related to tunnel works in all documents and related references.

[O] [P] 1	[K]	KEY ASPECT ICS Optik Level >>>>	THEME	Key Aspect 2	Cost Centre 3	Activity Code 4	GROUP DESCRIPTION: **Bold: Activated Codes**
	0	GEOGRAPHY	Location				Structured to suit the spec. Project:
				01		ABCD	Political Unit: **County ABCD**
				02		A101	Geological Section: **Highway A101**
				05		1234	Structure No.: **1234**
				07		PW	Works Type: **Permanent Works**
				08		140	Technical Unit: **Tunnel**
				09		140	Technical Elements: **Tun. Excav.**

Table 16 – Coded Examples e.g. Tunnelling 140 and related Geography

[O] [P]	[K]	KEY ASPECT ICS Optik	THEME	Key Aspect	Cost Centre	Activity Code	GROUP DESCRIPTION:
1		Level >>>>		2	3	4	**Bold: Activated Codes**
	1	BOUNDARY	General	11			Parties:
			Conditions	13		^	Definitions:
							Procedures: **QM: XX/ 1 / 4 / 140**
	2	ACTIVITY	Specific	21			Design: Project Specification
			Activity			^	Design of Access Road:
				24			Construction:
					A	^	Works Planning: Site Activities
					B	140	**Excavation of Tunnel**
					C	140	Installations: **for Tunnel Works**
				26			Specifications:
						^	**Particular Conditions**
						140	**Tunnelling**
				27		^	Bill of Quantities
	3	PROGRAMME	Time				Project Time Elements
				31			Planned Programme
				32		^	Actual Programme
				33		140	Cycle Time: **Tun Excav.**
				37		^	Progress Measurement
				39			Project Calendar
	4	RISK	Included	41			Variations in Scope
			Excluded	42		^	Insurance
				46		140	Risk Prev. Measures: Tunnels
	5	RESOURCE	All facets	51	1		Material:
			linked to	52	2		Plant (own):
			Resource	54	4	^	Labour (own):
			management	55	5	140	Plant (hire): **Tunnelling Mach.**
				57	7	140	Subcontract: **Tunnelling**
				59		^	Contingency:
	6	VALUE	Unit costs	61		140	Estimate: **Tunnelling**
				62		^	Unit rates:
				69			Financial accounts:
	7	CONTROL	Q.A.	71		^	Guarantees: **Ground Settlement**
	8	DOCUMENT	Filing System	81		140	Minutes of Meeting: **Tunnelling**
						140	Technical Literature: **Tunnelling**
						^	Filing Code: **Tunnelling**

Table 17 – Coded Examples e.g. Tunnelling 140 – Management Aspects