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Cost Forecasting and Programme Management Study

Task 11 Value Engineering : Guidance on Value Engineering Techniques

July 2010

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1 Introduction - What is Value Engineering

1.1 Definition

Value Engineering (VE) is a structured and disciplined, team-centred problem solving technique to ensure the optimum balance between performance, cost and time.

The VE process can help in any situation where choices must be made. It is of greatest benefit for important or "difficult" decisions where improvement and innovation are sought, where there are several stakeholders, each with their own goals and priorities, and where the best value decisions must be made and demonstrated.

1.2 Origins and Evolution of Value Engineering

Value Engineering Techniques, like many major inventions, originated as a result of a crisis - the shortage of materials and production capacity in USA in the face of sudden demands to support the allied efforts in World War II. In 1947, Larry Miles was given the full-time role of applying his techniques throughout General Electric's product portfolio and developing what he called his Value Analysis (VA) procedure. In 1954 Larry introduced the techniques to the US Navy - saving $35 million in the first year. To fit into the Navy rankings, the process was re-named Value Engineering (VE).

The European Governing Board (EGB) of Value for Europe manages the European Value Management Training & Certification system. Current EU practice is described in Appendix A.

1.3 The Difference between VA, VE and VM

There is no universal standard terminology for the Value Methodology (VM). The following descriptions may help - but it is important to remain alert to possible misunderstandings in the use of these expressions.

Value Analysis (VA) is the name Larry Miles used for his procedure, from which all value techniques have evolved. The term VA is still used today, particularly in USA and for work on an existing subject in current use, where real data is available for analysis. Value Engineering (VE) is the 'umbrella' term used by most American and Japanese practitioners today. Value Management (VM) is the 'umbrella' term used in Europe and Australia.

1.3.1 Common usage in Europe

VM can refer to any stage through a project's lifecycle, but it is also used specifically for work on the early stages of concept definition and strategy development. VE usually refers to the stages of design development and construction, after VM has defined the concept. The following table shows the common usage within Europe.

Project Stage		Issue addressed
Prepare	VM VM	Stakeholder needs & wants Detailed Objectives / Brief Optional Concepts for Feasibility
Design	VE VE	Selection of best value Concept Best functionality for least cost. Procurement planning Removal of unnecessary cost. Optimise construction plans
Construct	VE	Refine Design & Construction Team Building, Problem Resolution
Use	VM VA	Confirm Objectives Met Lessons Learned Analysis of Operations

1.4 When to Apply the VE process

Figure 1 below shows how value engineering maybe applied to the project lifecycle.

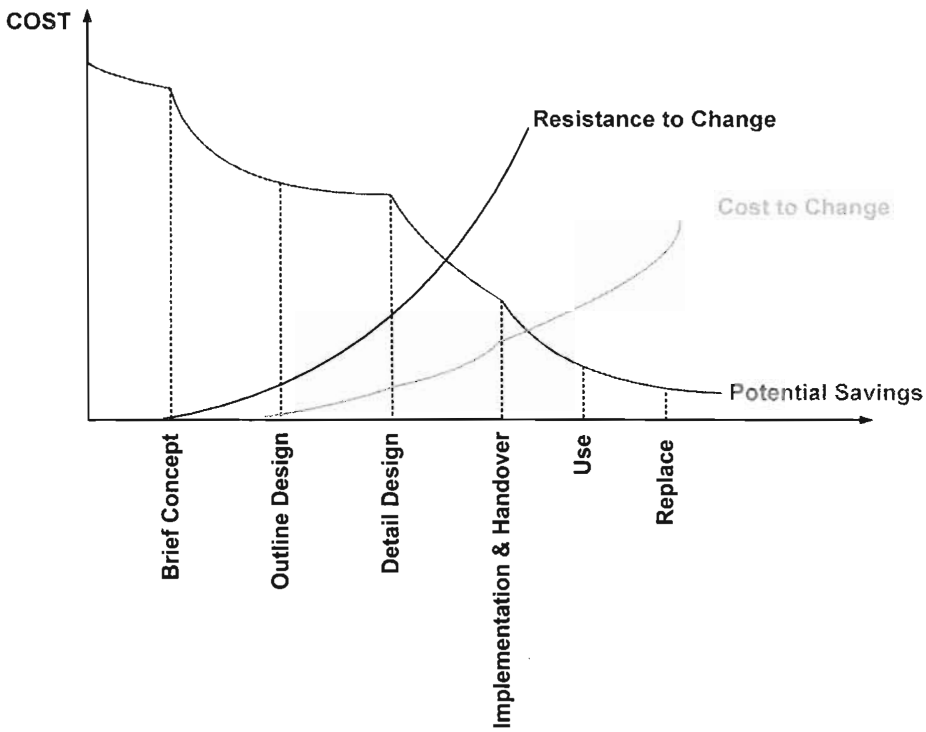


Figure 1: Where to apply the VE process

Figure 1 depicts the following important messages;

1. Potential Savings are at their greatest early in the life of the project - at the Prepare stage.
2. The cost of change is lowest at this early stage.
3. During the Design phase, significant savings are still available - and implementation costs are relatively low, utilising resources already budgeted for the purpose.
4. Even as late as the Construction Phase the potential can exist for beneficial change - though some throw-away cost may be incurred in work done to date.
5. At implementation, VE remains a powerful tool for rapid, consensus problem resolution.
6. "Resistance to Change" builds in the design team. Examples exist of major strategic change as late as detailed design, with VE team realisation that change is necessary (despite natural resistance and the negative impact on cost and programme) to avoid building "the wrong project."
7. "Hard VE" has the advantage of established design and cost assumptions for the team to work on - giving them "the benefit of hindsight."
8. "Soft VM" is often more vague, starting from a clean sheet and requiring more creativity.

1.5 Multi-disciplined Teams

The principles of VE can help any individual to develop a new, objective view of the issues faced, giving a basis from which to consider alternative solutions and on which to make decisions. These benefits are far more effective when used in a team setting.

1.6 The VE Process

The Value Engineering is structured and disciplined process. People dismiss it as unnecessary or they fail to recognise the importance of following, disciplined steps in their rush to find rapid answers.

1.6.1 The Logical Sequence of THE STUDY PLAN:

1.6.1.1 Initiate the VE Study

Within the initiation phase, it is important to both identify and understand the specific issues to be addressed or decisions to be made, which in turn will then confirm the need for a VE study and its scope and objectives. A preliminary assessment should determine the information available and the team membership required. The VE Study Facilitator shall be appointed and briefed.

1.6.1.2 Preparation Meeting

Within this phase, the initial group of project stakeholders shall be assembled. The initial assumptions shall be clarified along with the scope and objectives. Finalisation of the format & logistics for the VE Workshop, including: information gathering and workshop presentation assignments to team members shall be conducted.

1.6.1.3 VE Workshop

For a dedicated time, away from the daily office environment, a facilitator guides the team through each step in the VE Job Plan to achieve their declared objectives.

1.6.1.4 Workshop Reports

A diary of activities and decisions, and a statement of conclusions and post-workshop actions is compiled into a report and agreed between team members.

1.6.1.5 Implementation

Implementation begins as the last step of the VE Workshop Job Plan when the team members commit to their own parts in the post-workshop action plan.

1.7 The WORKSHOP JOB PLAN - Design Stage VE

The VE Workshop follows a disciplined "Job Plan" tailored for each specific case. The Job Plan forms the structure for the Workshop and ensures systematic and disciplined adherence to the logical steps of a mature and well proven process.

1.7.1.1 Information Phase:

All "Customers" of the project and their needs and wants are identified. These are mapped into a diagram of Project Objectives and then prioritised to establish criteria against which workshop proposals will be judged later.

1.7.1.2 Function Phase:

This involves intense, structured examination of each project element in simple non-technical language, focused on what it DOES, not what it IS. This builds a clear, shared understanding between the team and highlights any cost contributing little or no function.

1.7.1.3 VALUE and VALUE MIS-MATCH

In evaluating any function or objective, three factors matter;

a. How **important** is this function (to the customers)?

b. How **effectively** is this function delivered with our current proposals?

c. How much does this one function **cost** us?

1.7.1.4 Creative Phase

Many, many ideas for value improvement and project advantage are generated by the team, targeting the value mismatches (important functions not delivered, high cost for items of lesser importance etc), seeking improved performance and/or reduced cost, time or risk.

1.7.1.5 Evaluation Phase

A series of filters strip out the duplicate or unworkable ideas, and 'bank' the minor ideas for post-workshop use by the team. Ideas with particular merit, but which are unusable in the immediate project circumstances, are recorded for potential future use. This leaves a short list of ideas with greatest potential in relation to the prioritised objectives of the project.

1.7.1.6 Development Phase

The team then assess the short-list of most promising ideas for practicality, benefit, disadvantage, cost, timing and risk through;

- Additional dedicated sufficient workshop time
- Send the team away for a period of development.

1.7.1.7 Decision Phase

The team build a consensus on which ideas to adopt. Some ideas will compete with each other. They may be mutually exclusive (doing one would physically prohibit doing others), or perhaps limited time or resource prevent the team adopting more than one or two ideas, especially if VE has been left too late. Matrix selection techniques enable the team to rank competing ideas in terms of value, judged against criteria established in the Function Phase.

1.7.1.8 Implementation Phase:

The team agree the steps needed to implement their proposals. Tasks are assigned to individual team members, with due dates and estimates of required resource. These tasks are compiled into an overall Action Plan to which the team all commit.

1.8 Senior Management Participation.

Maximum benefit is derived from a full, uninhibited and encouraged team. The team members should be empowered individually to represent their organisations and to make decisions, and as a team to represent the whole project in striving to optimise value to both client and customer.

In many organisations with an accepted VE culture, Senior Management proactively encourage the VE process, participating in selection of VE study projects and attending the final afternoon of the VE Workshop to hear the team's recommendations.

Senior Management have a significant part to play by;

- Giving visible support to the VE process, acknowledging the team members' efforts
- Being open to appropriate innovation,
- Empowering the team to make decisions,
- Giving immediate approval to team recommendations (when suitable and required),
- Approving the team's Action Plans and the allocation of any necessary resources - enabling the team to maintain the momentum generated in the workshop as they begin the process of implementation.

- Celebrating and publicising success
- Encouraging a VE culture.

1.9 Where is the VE Process applicable?

1.9.1 Costly Projects

These have greatest potential for Value Improvement, through cost savings and cost avoidance as well as functional enhancement. The Pareto principle suggests concentrating on the 20% of subjects responsible for 80% of total cost, giving greatest potential pay-off and team satisfaction.

1.9.2 Complex Projects

These have great potential for misunderstanding and the adverse effects of late changes. VE brings clearly understood objectives, agreed by all stakeholders, and consensus on the developing design and construction plans. The result is better value, with more control and less disruption throughout project delivery.

1.9.3 Uncompetitive Products/Services

VE has helped several organisations to survive and then to excel.

1.9.4 Repetitive Projects

Manufacturing sector benefits of high pay-off from small change can apply to infrastructure projects.

1.10 Benefits of the VE Process

1.10.1 Project Confidence

This is given by;

- Highly structured, auditable consensus decision-making
- Time taken to do the job properly and once only,
  "to Get it Right First Time"
- Widest range of solutions (and risks) considered, gives confidence in the chosen solution.

1.10.2 Value optimised

This is given by;

- Correct focus on Customer needs & wants the detailed project objectives.
- Functional enhancement as well as cost reduction
- Savings can be 10% to 30% of project value.

1.10.3 Improved

This is given by;

- Projects properly planned, costed and controlled.

1.10.4 Implementation

This is given by;

- Committed and recorded action plans.
- Team building, common understanding and consensus

1.10.5 A Culture Change

This is given by;

- All team members sensitive to cost, value, time, the customer, each other and the business as a whole.
- Job satisfaction and pride, through personal contribution and team achievement.

2 Preparing for a VE Study

2.1 Defining the Problem, the Need and the VE Study Objectives

A VE study will be ineffective unless accurately focussed with clear scope and objectives. This may be development of an all new strategy. Or it may be simply confirmation of established plans, while there is still time for change, if needed. This is only valid if existing decisions are thoroughly challenged in a genuine search for improvement. Failure to find a better alternative after such a search will greatly improve team confidence and focus.

The VE Study objectives will be reviewed and refined in broader and broader debate among an increasing number of team members as the study progresses through Initiation, Preparation and Workshop.

Value Engineering at the Design Stage usually means that the project objectives are already clearly defined and a concept has been developed and confirmed as meeting those objectives. Sometimes several concepts were explored through feasibility studies and the best value scheme has been selected for design development. Now in Design Stage VE, after reviewing and if necessary revising and re-prioritising established objectives, the team challenge the design, construction or operational plans in the search for advantage. If the scheme proposed for design development has not yet been validated and optimised as the best value concept, then this is undertaken at the start of the Design Stage, before significant resource is spent.
This is done firstly by confirming and prioritising the detailed project objectives, then by evaluating the scheme (or optional schemes) against these objectives by matrix evaluation. In general, the Objectives of the VE study are;

- To bring together the key project stakeholders, including design and construction specialists.
- To confirm or revise the statement of detailed Project Objectives and their relative priorities (or to create this as a decision framework if it does not yet exist)
- To optimise design and construction plans, seeking the best combination of highly effective delivery of the prioritised objectives versus lowest possible cost - and within any defined constraints.

2.2 Appointing an Independent Facilitator for the Study.

An independent Facilitator must be arranged, seen to be external to the team and the project, although the facilitator does not need to be independent of the business, if an in-house facilitator, suitably experienced in VE is available.

2.3 Key Stakeholders

Key Stakeholders are those with specific responsibility for the development, the design, construction and management of the project and, once complete and in service, for the ownership, use, operation and maintenance of the asset. It is important that the ultimate owners and users participate, or are well represented, in defining the project objectives. It is equally important that construction expertise is represented in the Value Engineering stages so that buildability is fully considered in the development of high value design solutions.

2.4 Selecting the Team.

The team (usually a maximum of 12 people) is chosen not to make the process easy, but to make it effective. All areas with a critical interest in the Workshop decisions should be represented and team members should be empowered to make decisions.

2.5 Scope Setting and Timetabling

The Scope of the VE Study must be defined during the Preparation Meetings. It must be understood and agreed by all team members at the start of the Workshop so that effort is focused on the real target with no misunderstandings.

The Timetable must be set to accommodate the diaries of all participants - their full-time attendance at the Workshop is essential. Sufficient time must also be allowed before the workshop for Information Gathering assignments.

The Workshop duration depends on the scale of the project, the timing of the Study, the complexity of issues faced, the need for team-building and the required output.

2.6 Information Gathering

Information Gathering tasks are assigned to individual team members at the Preparation Meeting for presentation at the workshop and are fundamental to the success of the VE study. Information requirements might include:

- Background data defining the Problem
- Detail of identified Critical Issues
- Needs & Wants of Client and key Users
- Detail of all proposed schemes/designs (drawings)
- Programme for design and construction
- Bills of Quantities / specification
- Capital and Operating Cost breakdown by element
- Procurement methodology/Supply Chain Management

Other data needed for reference may include:

- Drawings, Maps and Photographs
- Data on Specifications / Regulation / Standards
- Environmental and Safety factors
- Usage & loading of current and proposed facilities
- Performance data
- Relevant recent technological developments
- Data on Competitors or projects in other industries

3 The VE Workshop - Function Phase

3.1 Introduction

The workshop starts with the Information Phase (short presentations by team members of the data gathered beforehand) then moves on to the Function Phase. Most of the VE processes involve simply the disciplined application of common sense, using techniques in common usage. The Function Phase is unique to VE and is essential to the process.

Focus is on simple expressions of what things DO, not what they ARE.

3.2 Identifying Function

Functions can be identified at different levels for different purposes at different stages.

Firstly, to validate project direction, project objectives are examined. "Minimise Congestion" might be a key project goal and help to guide and select the choice of design concept.

Secondly, once the concept is chosen, functions of the design elements are determined. For example, an embankment must '*Support Weight,*' '*Stabilise Foundations.*' '*Maintain Levels*' plus supporting functions such as '*Enhance Appearance*' and '*Protect Environment.*'

3.3 Function Diagrams

In order for the team to develop a shared understanding of the functions of the project and of the design elements under examination, these are mapped onto a diagram which follows a How?/Why? logic. Functions are formed into a tree in which, reading from Root to Twig, each successive function answers the question How Is the previous function performed? For example, if '*Maintain Levels*' above was a main stem, then '*Support Weight*' and '*Stabilise Foundations*' might be side branches off it. Reading in the opposite direction answers the Why question. Why do we '*Support Weight*' and '*Stabilise Foundations*'? If the team agree that the answer is to '*Maintain Levels*' they confirm this part of the diagram. Team discussion in creating this diagram is as important as the finished diagram.

Two examples of Function Diagrams are show in Appendix C, One shows the Project Objectives for a programme of earthworks renewals (Cuttings, Embankments etc), the other shows the functions required of a protection barrier system to stop people falling into the gaps between train carriages. Both led to successful project outcomes.

3.4 Function Costing

Information available at the start of the VE workshop showed the design elements and their costs. We now know the Functions performed by those design elements. This next step asks very approximately how much of that cost is spent achieving each individual function.

For example, a concrete bridge performs the fundamental function of '*Support Weight,*' but some of its cost is there to '*Enhance Appearance*' and '*Minimise Maintenance.*'

The purpose is to gain a broad understanding of where money is being spent.

3.5 Value Mis-matches

Value Miss-matches are now identified - as the examples below:-

- Important Functions not well achieved - Targets for improved performance.
- Lesser Functions on which high cost is expended - Targets for Cost Reduction
- High Cost Functions - The most gold to be mined, again targets for cost reduction

The Function Phase helps to understand the problem. Creativity starts to solve it.

4 Creativity

4.1 Introduction

Creativity is the generation of ideas that are new to the individual, although they may not be new to someone else. In VE we are asked to be creative. Creativity generates the ideas for change which enable improved value.

4.2 Mental Processes in Creativity

Many people have an "Honest Wrong Belief" that they are not creative – that this is an attribute of a privileged few, perhaps the specialist designers and architects. But no one has the monopoly on good ideas, they can come from anyone, we all have the ability to be creative.

4.3 Blocks to Creativity

There are many, many factors which naturally keep us constrained within our comfort zone and stand in the way of creativity. These factors must be overcome to maximise our productivity.

4.3.1 Perception

Individuals perceive things in different ways according to past experience. VE benefits from a multi-disciplinary team from all the different stakeholder areas. Each team member has a different way of looking at the situation – sometimes very different.

4.3.2 Habits

We are all creatures of habit. We feel comfortable doing things the way we've always done them before – and more importantly, uncomfortable if we attempt different ways.

4.3.3 Attitudes

These are our instinctive ways of thinking of things. They are as powerful and useful to us as habits at the right time, but they are also as constraining as habits if our goal requires innovation.

4.3.4 Fear

Fear, whether fear of failure or fear of criticism and shame, is a powerful incentive for us to play it safe and not to take the risks and challenges of innovation. Criticism can easily be avoided by saying nothing and doing nothing!

4.3.5 Resistance to Change

This is very common, very powerful and by definition an inhibitor to creativity and innovation.

4.4 Role of the VE Facilitator during the Creative Phase

4.4.1 Guidance in Creative Thinking Techniques

The VE Facilitator must select appropriate Creative Thinking Techniques and provide team members with guidance in their application. This requires the facilitator to be thoroughly knowledgeable about the techniques available and the circumstances under which they should be applied. Often the facilitator must get the ball rolling, stimulating the team by proposing a few wild ideas or drawing ideas out from individuals. Team members will differ in their willingness to propose ideas, it is up to the facilitator to stimulate shy members and encourage the more enthusiastic to allow others to join in.

4.4.2 Recording of Ideas

Different techniques to record the ideas can help here. The simplest way is for team members to announce their ideas for the facilitator to record on a flipchart. This has the primary requirement that all can see and hear the ideas. The down-side is that the team can think much faster than the facilitator can write. Having team members write down their ideas, either on lined paper for a secretary to record or on cards piled up on the table, removes this restriction. Again the ideas must be announced to stimulate ideas in others. However, anyone uncertain and nervous of a particular idea can still add it to the pile without having to announce it or declare ownership.

4.4.3 Structuring the Process

Brainstorms must be uninhibited but not unstructured. Ideas must be recorded whenever identified – but the flow is helped by addressing a list of agreed targets one by one. This list of idea prompts may include Value Mis-matches, high-cost functions, key elements (eg. Programme bottlenecks, Procurement plans), Critical Issues, Major Risks, etc. By moving from one heading prompt to another, the flow of ideas is maintained as attention shifts to a new subject, a new problem, a new area of opportunity. Ideas are welcome at any stage, even "out of sequence" and must be recorded immediately or they will be forgotten.

4.4.4 Enforcing the Rules

The facilitator's role is to make the "rules" clear and then to help the team to stick to them. Key amongst these is to squash any negative message which arises either from words or actions and attitudes. No judgement of ideas must take place. Equally any effort to develop and explore a particularly interesting idea must only be allowed to go far enough to stimulate alternative ideas and variations – it must not be allowed to halt the flow of ideas.

5 Making Decisions

5.1 General

The team may have developed a very large number of ideas for potential project advantage in the creative phase. These need to be reduced to a short list of major opportunities in evaluation. These major opportunities are then explored in some detail and reduced further in the development phase (some may have been shown impractical or not beneficial during the development).

The team are now left with a shorter list of key opportunities which they support, having assessed them for benefit and ease of implementation.

5.2 Option Selection

When choices between competing ideas or option groups are required, it is usual that several criteria must be considered in making the choice. The Results are tabulated to omit decision making. Achieving team consensus on the judgement of several competing proposals against a number of criteria is impossible without a step-by-step process recorded for all to see.

5.3 Complex Weighted Criteria Evaluation

This technique shows how the decision is built up using decision criteria which are those objectives achieved to a greater of lesser extent depending on which option is selected. If the option chosen will influence achievement of certain objectives – then these objectives are clearly the correct Decision Criteria.

5.3.1 Relative Importance

Different criteria have different importance. It is essential that the decision takes greatest note of the most important criteria - hence the criteria must be weighted for relative importance. Often this weighting can be simply allocated for each of the criteria by the team, out of a maximum of 10. In theory all could score 10 or all could score 1, if that was the team's judgement. Sometimes weighting of the criteria is more critical and 100% must be subdivided between them.

5.3.2 Paired Comparison

This is a method of evaluating all criteria against each other, one by one – and thereby building up a score for each, as a relative importance weighting.

5.4 Decision Recording

After the decision, implementation is the pay-off, without which the VE study would be a waste of time. Fundamental to successful implementation is the active support and participation of the team.
For these reasons, it is essential that all team members understand and agree the decision taken.

6 Implementation

6.1 Action Plan

The final stage of the workshop is to develop the Action Plans. The workshop decision has been recorded. It is now broken back down again into individual proposals - and Action Plans are drawn up for each. For each proposal, the Action Plan will include;

- What needs to be done short term
- What needs to be done longer term
- Timing for completion of these actions

The Overall Action Plan will contain many assignments for the team members, and is not complete until all have agreed to these commitments.

6.2 Presentation to Senior Management

Some organisations with a successful VE culture demonstrate support for the efforts of their teams by arranging for senior management to attend the final afternoon of the Workshop. The team make a presentation of their proposals, recommendations and action plans – identifying the benefits to be gained and seeking approval of any key decisions or additional resource requirements.

Management approval at this stage encourages the team members to make immediate progress on their action plans, maintaining the momentum generated during the workshop.

6.3 VE Study Reports

Immediately following the Workshop, the Facilitator prepares a draft report which contains as a minimum a statement and quantification of benefits achieved. It may also include:

- A record of the series of meetings from Initiation and Preparation to Workshop that make up the study.
- Identification of all participants
- A record of the agreed objectives of the project and the scope and objectives of the Workshop
- A summary of the Information Presentations made
- A record of the Function Analysis, SMART or FAST Diagrams, identified Value Miss-Matches and targets
- A complete list of all ideas generated
- A record of all minor ideas 'banked' by the team for post-workshop use
- A record of any ideas inappropriate to the study in hand but of potential value to future projects
- Detail of those ideas developed at the workshop, with benefits identified
- The Decision and the team's rationale (eg. Matrix)
- Action Plans, including anticipated roadblocks and plans to overcome them, names and dates
- An opening Executive summary can help to stress the key purposes and achievements of the study.

7 Workshops with Beneficiaries

7.1 Introduction

Workshops were held with the beneficiaries on 19th May in Bucharest (with attendees from Romania) and on 26th May in Riga (with attendees from Latvia and Lithuania).

The workshops were intended to provide an overview of the latest methods, tools and processes available to the Highways and Railway industry sectors. They were one day in duration and included interactive case studies and provided delegates with an up to date overview of the current EU best practice relating to Value Engineering.

Details of the attendees at the workshops and their feedback are given in the Attendance and Feedback Report.

7.2 Workshop materials

The materials used in the workshops were the case studies as detailed in section 8 below and a Value Engineering manual comprising Chapters 1-6 and 9 of this report.

7.3 Trainers' feedback

The trainers provided the following observations following the workshops.

In Bucharest, the general feeling was that they would not be able to make use of VM or VE in their work. This was due to decision making being taken at very senior levels in their organisations, and they could therefore see little opportunity for cross functional VE teams to develop improved value solutions and influence the decision making.

Therefore in order to introduce VM to optimise value for money and to assist decision making there will bee a need first to address the political and cultural nature of the government and business processes in Romania.

The feeling in the Riga workshop was different, with many of the attendees believing that they could make good use of the VM and VE techniques which they had learnt during the course.

8 Case Studies Selected for VE Review

8.1 Background

The initial intention of this sub-task was to obtain case studies from the participating countries to review at the VE workshops held with the beneficiaries in Bucharest and Riga in May 2010. However, it was not possible to obtain suitable designs for review. The consultant therefore produced a number of case studies for discussion at the workshops.

8.2 Case Studies

The case studies, presented in Appendix B, were as follows. Case studies B1, B2 and B3 were used for a full VE review in the workshops. The other three case studies were used in the workshops to highlight a specific feature of VE and therefore do not go into as much detail.

B1. Workshop Case Study - Train Inter-Car Barriers
This was the first test case selected for VE review - as a workshop team exercise. It showed how a safety-critical decision was structured and justified.

B2. Workshop Case Study - Rail Embankment Repair
This was an alternative test case selected for VE review, also a structured decision, and was demonstrated to the workshop team.

B3. Workshop Case Study - Station Enhancement
This was the second test case selected for VE review which was undertaken as a workshop team exercise.
This was a proposed Railway Station Enhancement with multiple stakeholders. The established design had been approved by the local Planning Authority, but was unaffordable. This exercise therefore had Cost Reduction as its primary purpose - in consensus between all stakeholders.

B4. Rail Function Diagram - Earthworks Renewal Programme
This was used during the early workshop stages as an example Function Diagram.

B5. Road Case Study - VE Later versus Earlier
This was used during the early stages of the workshop to demonstrate the different effects of using VM early in the project lifetime versus using VE later on.

B6. Rail Case Study - Not “Savings” but “Cost Avoidance”
This was used early in the workshop to show that although VE is often considered a “Cost Reduction” method - it can provide even greater Cost Avoidance, although this is often difficult to measure.

9 Conclusions

9.1 Using VE positively

VE can be used for problem solving and relationship building through a well organised and managed workshop. If used early on in the project lifecycle, beneficial changes may be identified and implemented.

VE should be recognised as a constructive management tool and therefore an overarching project objective. It should draw upon a set of baseline assumptions that are ready to be challenged and tested in meeting this objective.

Careful thought shall be given to choosing the right team participants and a facilitator should be utilised, who is external to the delivery team. All team members are empowered to make decisions, being at a sufficiently responsible, senior level. Try to use a neutral venue away from daily distractions, with a positive ambience, ample space and all required facilities. With the facilitator, ensure that this is not just another team meeting. A different way of thinking is essential.

Always ensure the team have ownership of the decisions and are committed to a comprehensive but concise action plan.

9.2 Dispelling the VE Myths

It is important to recognise that using VE implies you did it wrong before. VE never criticises what was done. if in doubt, seek a second opinion on how VE may or may not help in any application. VE will not change just for the sake of it, it will avoid such risk. VE will lead to change only when the team agree that benefit outweighs risk - and it will learn lessons for the next project.

Appendix A

Review of EU VE Practice

A1 Applicable Standards

a) The initial standards in Value Engineering were developed in USA by the Society of American Value Engineers (SAVE), evolving since the 1950's. During the early 1990's SAVE changed its name to SAVE International as more and more countries adopted their methodologies and standards, including Japan, Korea, Taiwan, Hong Kong, China, Saudi Arabia, India, Kuwait, Australia, Brazil, Canada, Hungary, Italy, Germany and UK.

The formal certification standard for practitioners awarded by SAVE International is the **CVS (Certified Value Specialist)**.

Japan, Korea and Hungary remain closely tied to SAVE International methods, but Australia, Hong Kong and Europe have created their own developments based on those methods but generally placing more emphasis on the early project planning stages.

All these countries remain associated with SAVE International, regularly presenting papers on their pioneering developments at the SAVE International annual conferences.

b) A "**Value for Europe Training and Certification**" system was developed in 1997, sponsored by SPRINT and led by Michael Dallas on behalf of the UK Institute of Value Management, with the active participation of representatives of the national value societies in Germany, France, Spain, Portugal, Italy and Belgium. Other interested parties participating as observers included Netherlands, Ireland, Greece, Denmark and Austria.

These countries formed a **European Governing Board** (EGB) to coordinate and maintain the European training and certification system.

The European certification standard for practitioners, awarded by the national value societies on behalf of the collective "**Value for Europe**" and the EGB is the **PVM (Professional in Value Management)** - the first was awarded in 1997.

TVM (Trainer in Value Management) is a further certification standard which qualifies professionals to develop and deliver VM training courses. The courses themselves must also be certified and attendance is an essential pre-requisite for any new PVM.

A Reciprocity Agreement is now in place under which PVMs can become CVSs on demonstration of rigorous application of Function Analysis methods. CVSs become PVMs by demonstrating training in the softer skills of team and people management.

TERMINOLOGY: With this European emphasis on the early project planning stages, the generic expression for the value disciplines in Europe became Value Management. Frustratingly, there is much confusion and inconsistency in the use of terminology around the world, even within individual countries, but the best guidance for Europe is as follows:-

Value Management is the generic name for use of the value disciplines.

Value Management is also the name for applications in early project planning

Value Engineering is the name for applications during later Design and Construction.

A2 European Country Practice

As part of this Cost Forecasting and Programme Management Study on behalf of the European Investment Bank, a survey was undertaken of current use of VE on Road and Rail projects throughout Europe. Indeed it was Michael Dallas himself who emailed to the national representatives of all members of Value for Europe asking for their input.

Countries approached included Belgium, Hungary, Norway, Portugal, France, Austria, Spain, Italy, Netherlands and Germany, plus our own experience in UK.

Despite a number of follow-up requests, there were disappointingly few responses. The survey was therefore extended by seeking inputs from business contacts and this contributed to the overall survey results below.

Austria are now seeking to expand the use of VM/VE but little is done currently, with none reported on road and rail projects.

Netherlands make significant use of VM/VE on Rail projects, much as Value Engineering at the Design stages, but also Value Management in the early Prepare and Planning stages.

UK Rail: Network Rail are extensive users of VM, which is written into their GRIP procedures (Guidance to Railway Investment Projects). Again much is Value Engineering at the Design stage, but up to around 20% is Value Management in the earlier Prepare and Planning stages.

London Underground have also used VM in both Design stage Value Engineering, but also in the earlier stages which they have called Value Planning.

UK Road: The Highways Agency, responsible for all UK Road infrastructure development, also make extensive use of VM/VE. Their catch-phrase of "*doing the right things the right way*" covers both their use of early VM in the planning stages (doing the right things) and also the use of later VE (doing them the right way).
Their Project Control Framework mandates VM studies at key stages of projects.

Irish Rail: Project Start-up and Management Procedures for the Infrastructure Division specify the use of Value Management on larger projects. They place at least as much emphasis on early Value Management as later Value Engineering. Their VM1 study explores and defines the project objectives from the outset, then agrees ways in which those might be delivered. This often leads to a number of optional schemes which are investigated in feasibility studies.
Later, their VM2 studies examine, challenge and refine the results of those feasibility studies before agreeing on the scheme to be developed through the design stages.
Where several optional schemes were studied for feasibility, VM2 compares them in terms of both performance of objectives and cost, in order to choose the best-value scheme to proceed into design. (*Appendix B contains two examples of the Decision process*).

All of these road and rail companies in Netherlands, UK (Underground and Mainline) and Ireland broadly follow the Value for Europe VM guidelines. In fact the UK Highways Agency stated that they had brought their procedures into line with the European Standard in 2008/2009 - and found this "helped greatly."

Appendix B

Selected Case Studies

B1 Workshop Case Study - Inter-Car Barriers

BACKGROUND

The Metro rail company of a major European capital city handled 2 billion boarding and alighting passenger movements per year.

3 fatalities had occurred in the last 3 years associated with boarding or alighting.

The Safety Regulator body (SR) requested action to reduce the risks associated with these fatalities and four separate measures were considered.

Inter-Car Barriers (ICBs) were one of the safety measures under development. Their purpose was to stop people falling into the gaps between train carriages / cars - including people with poor eyesight who might mistake these gaps for doorways, especially when rushing onto the platform for a train about to shut its doors.

Many different methods had been considered for blocking the gaps between adjacent cars. These had been reviewed with SR and a short-list of 4 were selected which would be subjected to a VM/VE Decision study with the following objectives:-

- To select the Highest Value option (*best relation between Function & Cost*)
- Then to seek improvements to the chosen scheme
- Then to justify that choice to the SR.

INFORMATION 1 / FUNCTION 1:

Before looking at the potential solutions, the team first re-examined the reasons for doing this project, the project objectives, and also functional requirements which must be delivered by the chosen ICB scheme.

Once identified, these functions were debated, related and mapped onto the Function Diagram on the following page.

(The workshop team were asked to identify Functions themselves, before seeing the diagram overleaf).

INFORMATION 2:

Now the four schemes under consideration were reviewed, as follows:-

1. Rubber Fairings.

Different shape/size fairings on facing corners would overlap and allow movement.

2. Balls on Springs

Two on one car overlapping with 3 on the other to allow movement.

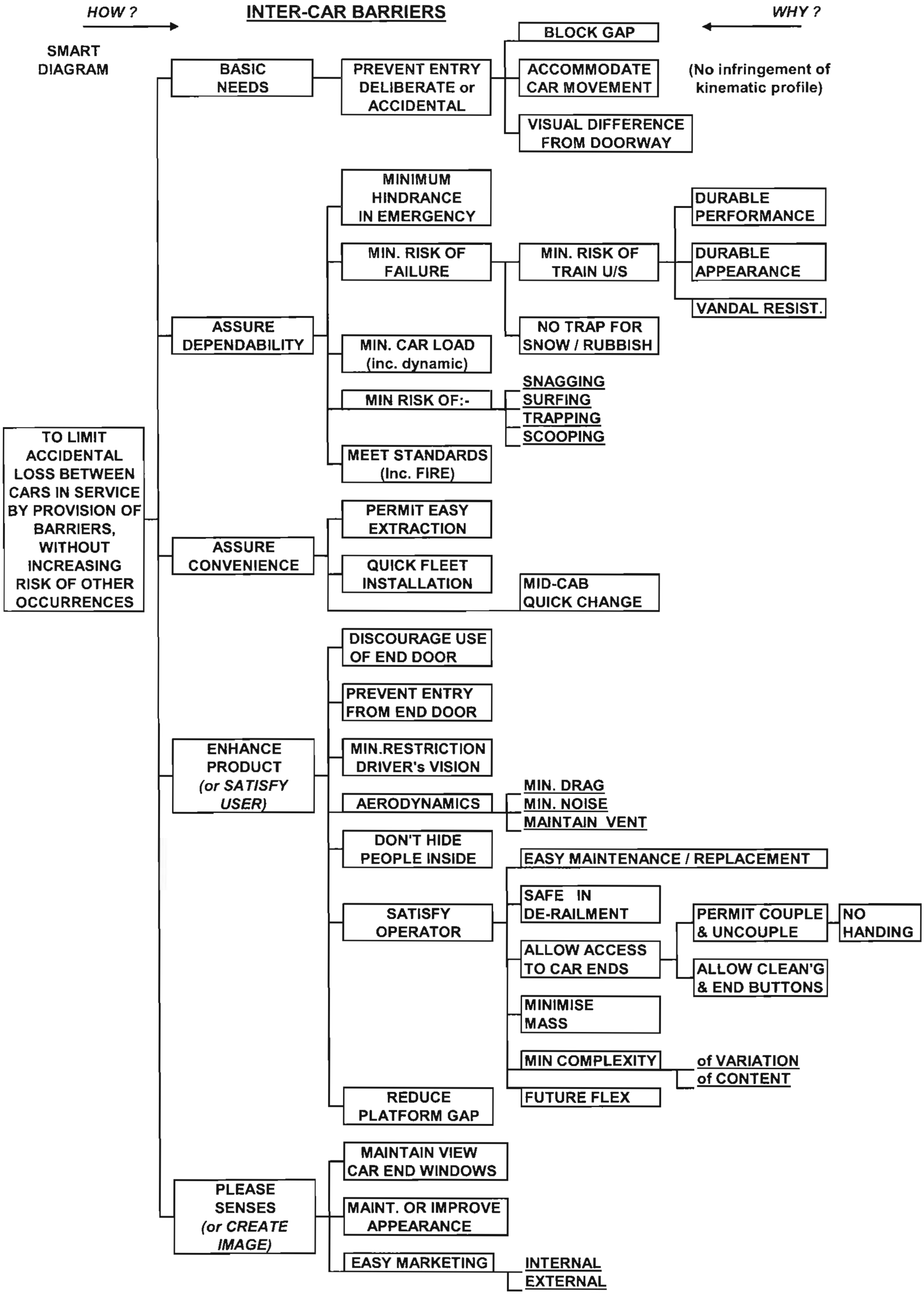
3. Rubber Bungees

These stretch from car to car, the elastic allowing movement between the cars.

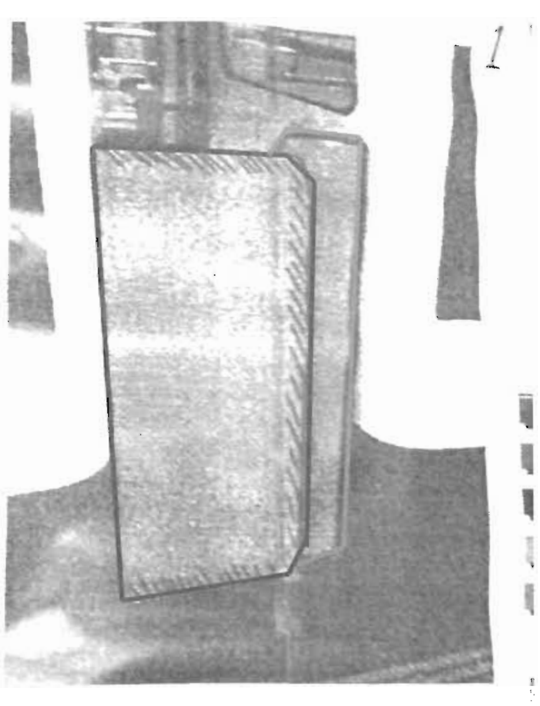
4. Inter-locking Rubber Pyramids

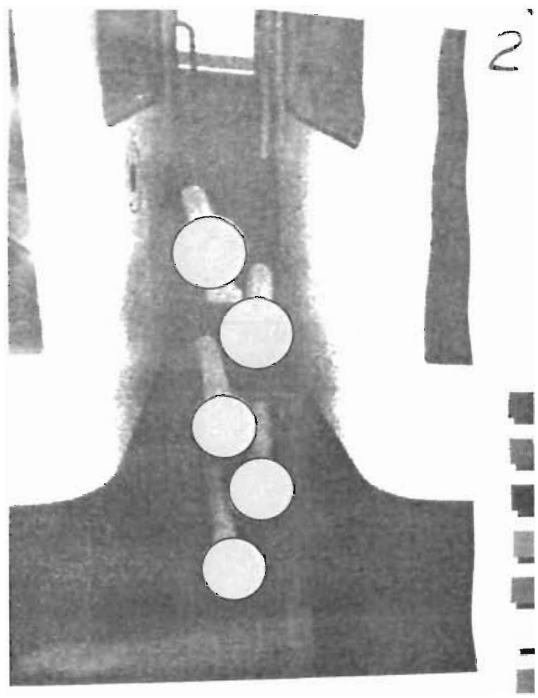
All four designs are shown in the picture on page B4.

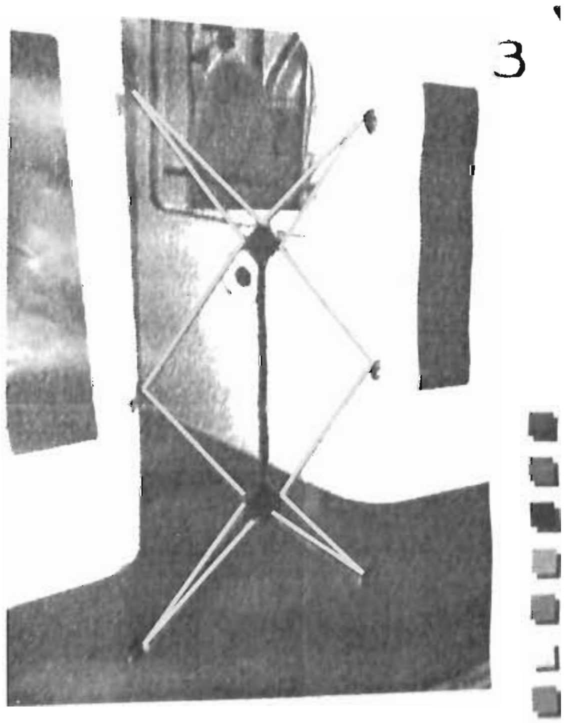
INTER-CAR BARRIERS

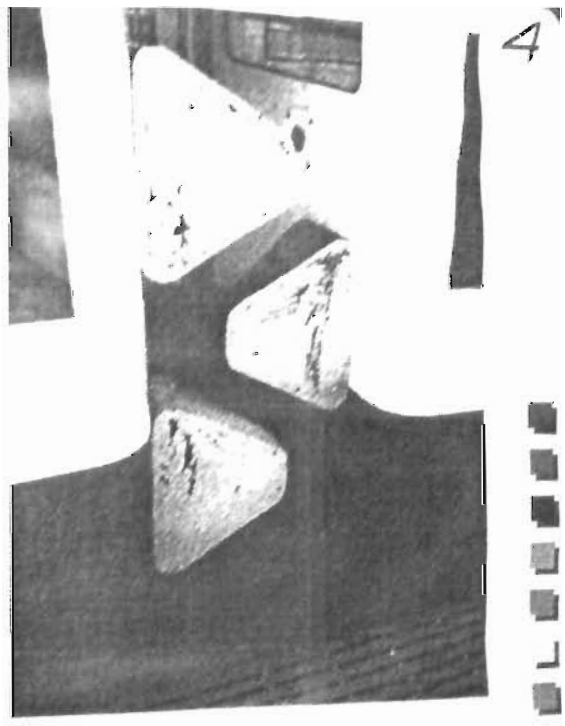


The Four Optional Inter-Car Barrier Schemes under review









Workshop Team Exercise 1 - Which Option represents Best Value?

How do we decide? Value is expressed simply as Function divided by Cost, although there can be complex detail under these two simple headings.

We have already identified the required functions on the Function Diagram and must now decide how the 4 optional schemes perform against these functions.

Note that some Functions will be (or must be) performed equally well regardless of which scheme we select - eg. Meet Standards, inc Fire - and Accommodate Car Movement (if they didn't do that, they wouldn't be on the list of possible options).

We must therefore choose those Functions which are achieved to a greater of lesser extent, depending on which scheme is selected.

Workshop Team Exercise 2 - Which are they? - these will become Decision Criteria.

IMPORTANCE: Next step recognises that some Functions are essential "Musts" and others may be "Wants" or "Nice to Have's." We must therefore prioritise the chosen Functions.

There are 4 ways in which this could be done:-

1. By classifying the functions as Must, Want or Nice-to-Have, as suggested above. These ratings are allocated in consensus by the team, after some discussion. It is usually necessary to include a "Strong Want" in order to limit the number of "Musts."
   This classification is often a useful starting point, but for the Matrix decision process it is necessary to assign numerical importance weightings to the objectives, as below.
2. By assigning an importance weighting out of 10 to each selected function. Again this is done in consensus after discussion. Several functions may have the same weighting.
   Such a process of function weighting is frequently sufficient - but occasionally more care must be taken over the relative weightings, as below.
3. By assigning percentage importance weightings to the selected functions. This forces more debate, because if one weighting needs to increase, others must reduce.
4. A process of Paired Comparison allows the importance of each individual function to be compared one-by-one with each other function. In this way a score is built up for each function - and the totals define the relative importance. This process takes time and is usually unnecessary unless development of a team consensus proves hard to achieve. Methods 2 or perhaps 3 above usually suffice, leaving time for the serious discussion over the matrix process which follows.

Workshop Team Exercise 3 - The Relative Importance of each chosen Function?

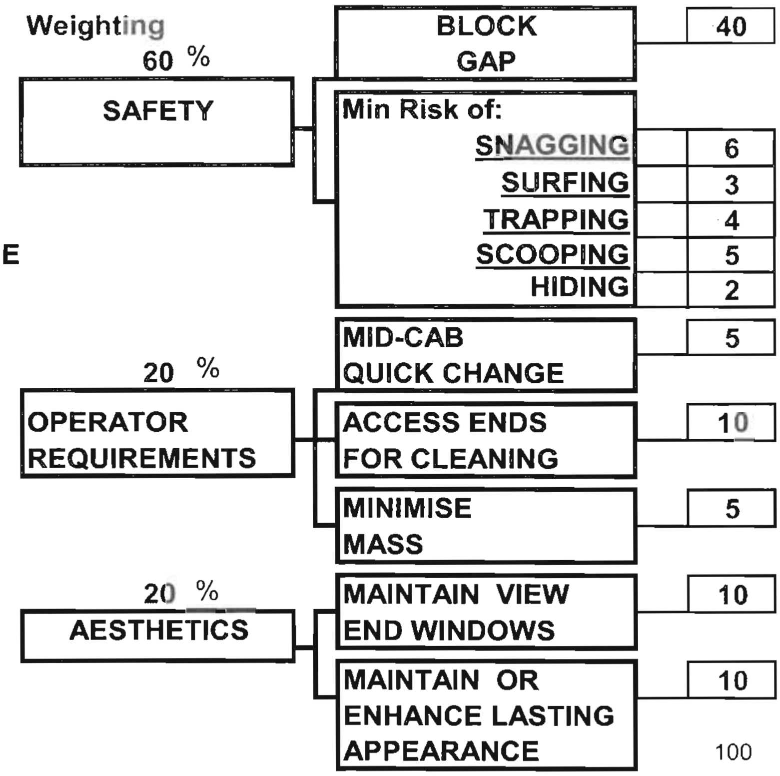
Method 3 was chosen for this particular study - largely because of the safety-critical issue faced and the need to satisfy the Safety Regulator body.

The result is shown overleaf.

The team established the functions which should form the Decision Criteria, but before they were weighted for Relative Importance, we agreed to regroup them under the 3 headings of Safety, Operator Requirements and Aesthetics. These three headings were allocated the importance of 60% for Safety, and 20% for each other group. This helped the task of allocating Relative Importance weightings to the detailed functions, as shown below.

INTER-CAR BARRIERS
CONDENSED
SMART DIAGRAM

DECISION CRITERIA & RELATIVE IMPORTANCE



Matrix Evaluation of the 4 Options against these Weighted Criteria.

Our goal is to choose the Best Value option - and this is most effectively done by creating a matrix in which all 4 options can be compared in terms of their Functional Performance against each of the 11 decision criteria.

The workshop team will undertake this process - a sample is shown overleaf.

*Note that Option 3 is called "**Rubber Bungees (enhanced)**" because the team had agreed that greater protection would be achieved with 3 vertical members between the bungee cords, not just the one central one shown on page B6.*

Matrix 1. Evaluation of Functional Performance of the 4 Options vs. Weighted Criteria.

Importance Weighting	Criteria chosen to compare the Competing Proposals	RUBBER FAIRINGS	BALL AND SPRING	RUBBER BUNGEES (ENHANCED)	RUBBER PYRAMIDS
40	BLOCK GAP (INC. CURVE)	70 / 2800	30 / 1200	90 / 3600	70 / 2800
6	MIN RISK OF SNAGGING	90 / 540	50 / 300	25 / 150	65 / 390
3	MIN RISK OF SURFING	10 / 30	20 / 60	60 / 180	20 / 60
2	MIN RISK OF HIDING	10 / 20	90 / 180	75 / 150	65 / 130
10	ACCESS ENDS FOR CLEANING	20 / 200	65 / 650	30 / 300	30 / 300
5	MINIMUM MASS	10 / 50	20 / 100	90 / 450	50 / 250
10	MAINTAIN/ENHANCE APPEAR'CE (LASTING)	20 / 200	10 / 100	80 / 800	45 / 450
	Weighted Function Rating	3840	2590	5630	4380

The 4 options are each scored by the team out of 10 for the extent to which they meet each of the decision criteria listed in the 2nd column (7 of the 11 shown here). Resulting scores are in the top left part of each square in the body of the matrix.

These scores are then multiplied by the Criteria Weighting (1st column) and the weighted scores for each option are in the lower right part of the matrix squares.

Weighted scores are then totalled to give a Relative Performance (Weighted Function) Rating, shown on the bottom row of the matrix.

These figures are meaningless in absolute terms, but relatively they express the team's collective judgement of the comparative performance of the options against the criteria judged to be important in choosing the best scheme.

What are the conclusions?

Best Performance (5630) is Option 3, the Bungees. This does best for the primary role of blocking the gap, and for Minimum Mass, the risk of Surfing, & Appearance.

This looked a clear winner, as the second place only beat it on one criteria.

Choosing by Value

Matrix 1 had assessed relative Functional Performance of the options, but to measure Value, Function must be divided by Cost.

Costs had already been determined for the 4 options -fleet installation costs plus anticipated maintenance & replacement over 7 years. Costs were then added to the Matrix to give Value, by dividing Functional Performance by Cost - as below.

Matrix 2. Evaluation of the 4 Options for VALUE.

Importance Weighting	Criteria chosen to compare the Competing Proposals	RUBBER FAIRINGS	BALL AND SPRING	RUBBER BUNGEES (ENHANCED)	RUBBER PYRAMIDS
40	BLOCK GAP (INC. CURVE)	70 / 2800	30 / 1200	90 / 3600	70 / 2800
6	MIN RISK OF SNAGGING	90 / 540	50 / 300	25 / 150	65 / 390
3	MIN RISK OF SURFING	10 / 30	20 / 60	60 / 180	20 / 60
2	MIN RISK OF HIDING	10 / 20	90 / 180	75 / 150	65 / 130
10	ACCESS ENDS FOR CLEANING	20 / 200	65 / 650	30 / 300	30 / 300
5	MINIMUM MASS	10 / 50	20 / 100	90 / 450	50 / 250
10	MAINTAIN/ENHANCE APPEAR'CE (LASTING)	20 / 200	10 / 100	80 / 800	45 / 450
	Weighted Function Rating	3840	2590	5630	4380
	Cost (Base +/- Change)	£2,387	£1,190	£600	£1,241
	Value (Function / Cost)	1.61	2.18	9.38	3.53

Conclusions from the full Matrix 2 - Value

a) The Bungees had offered best Functional Performance - it was now clear that at least cost of all the options, their Value was very much greater than all the other options.

b) In second place were the Rubber Pyramids.
In a Sensitivity Analysis, the team tried hard to make the Pyramids win by revising the scores allocated (or even the Criteria Weightings).
The fact that this effort was completely unsuccessful gave the team greater confidence that they had chosen the best value solution. This was critical to them, faced with the need to defend this decision to the Safety Regulators.

NEXT STEPS:

So what's the next step? Well - the team are all now geared up, have a much sharper focus on what matters to deliver this project and on the chosen option - a superb springboard from which to launch a search for improvement.

Improvements can be sought in very many areas, and no inhibitions should be placed on the team's imagination. However, there is one obvious prompt to start them off - and that is to seek improvements to any low scores in the matrix - where the Bungees did not perform to a high level.

The clear target is to improve the Bungees' risk of Snagging - where bags, clothing, even hands and arms could get caught on many of the points where the bungees join each other or the vertical members.

Improvement achieved: The 3 vertical members of the "Enhanced Bungees" were replaced by a single rubberised bag through which the bungees ran.

This 'Simplified Bungee' was not only a better performer but also lower cost, giving even greater advantage over the other options. The full final matrix is shown below. Note that "Do Nothing" suggests that 2 of the options did more harm than good!

Imp. Weight	CRITERIA Criteria to compare Competing Schemes	1 RUBBER FAIRINGS	2 BALL AND SPRING	3+ RUBBER BUNGEES (ENHANCED)	4 RUBBER PYRAMIDS	5 (3-) RUBBER BUNGEES (SIMPLER)	base DO NOTHING ie No ICB
40	BLOCK GAP (INC. CURVE)	70 / 2800	30 / 1200	90 / 3600	70 / 2800	80 / 3200	0 / 0
6	MIN RISK OF SNAGGING	90 / 540	50 / 300	25 / 150	65 / 390	35 / 210	100 / 600
3	MIN RISK OF SURFING	10 / 30	20 / 60	60 / 180	20 / 60	50 / 150	100 / 300
4	MIN RISK OF TRAPPING	10 / 40	80 / 320	40 / 160	80 / 320	60 / 240	100 / 400
5	MIN RISK OF SCOOPING	50 / 250	100 / 500	100 / 500	90 / 450	100 / 500	100 / 500
2	MIN RISK OF HIDING	10 / 20	90 / 180	75 / 150	65 / 130	90 / 180	100 / 200
5	MID CAB QUICK SPLIT/REFORM	20 / 100	20 / 100	75 / 375	50 / 250	75 / 375	100 / 500
10	ACCESS ENDS FOR CLEANING	20 / 200	65 / 650	30 / 300	30 / 300	65 / 650	100 / 1000
5	MINIMUM MASS	10 / 50	20 / 100	90 / 450	50 / 250	90 / 450	100 / 500
10	MAINTAIN VIEW END WINDOWS	100 / 1000	100 / 1000	90 / 900	100 / 1000	95 / 950	100 / 1000
10	MAINTAIN/ENHANCE APPEAR'CE (LASTING)	20 / 200	10 / 100	80 / 800	45 / 450	80 / 800	50 / 500
	Weighted Function Rating	5230	4510	7565	6400	**7705**	5500
	Cost (Base +/- Change)	£2,387	£1,190	£600	£1,241	**£482**	-
	Value (Function / Cost)	2.19	3.79	12.61	5.16	**15.99**	-

Benefits of this Matrix Evaluation Process

- All factors judged important by the team are made part of the decision.
- The most important factors have greatest influence
- The cleverest of individual brains cannot make a judgement based on so many factors without a means to record and build up the decision.
- Much harder for a team of brains - but the matrix focuses on one area at a time, structuring the discussion, recording the consensus and moving on. This avoids debates which go round in circles or back over old ground.
- Each team member can see that their own particular concerns are included on the matrix and taken into account as part of the total decision.
- Sensitivity analysis can take place - varying weightings or scores to show how robust is the decision, focussing further debate of specific areas.
- After such a review, the team have such an intense and shared understanding of the project's objectives, the solutions available and the winning scheme, that it is common for them to identify improvements through idea generation at this stage.
- One scheme was shown to be the winner - but some of its performance scores may be low against particular criteria. Improvements are often found by focussing on the weaker scores - as in this case study example.
- There is an auditable justification for the decision made.

B2 Workshop Case Study - Embankment Repair

BACKGROUND

An old railway embankment is in need of repair.

The first part is 800 m long and up to 4 metres high, with a slope of 40^{O} on the northern side. Movement and bulging, irregular alignment, depression of the track and loss of ballast has caused 40 km/hr speed restrictions. Excavations have indicated the various layers of material in the embankment, none of firm consistency. Not only must the Factor of Safety of the Embankment be raised to the required level, but also an increase in the width of the cess is required to achieve the 2.1 metres standard.

Four options (A to D) had been developed, as follows:-

A. Gabion Wall.

A Gabion Wall 2 to 3 metres high on the northern side of the embankment, backfilled with granular material.

B. Regrade the Slope

An engineered, granular-fill slope of 27^{O} (2:1), after removal of existing slope material.
This would create a larger embankment footprint, extending beyond current boundaries, necessitating the purchase of additional land.

C. Sheet Pile Wall

Installation of a Sheet Pile Wall around 2/3 of the way up the embankment, filled behind.

D. Reconstruct the upper 2 - 3m of the Embankment

Replace the upper 2 - 3 metres of the embankment with engineered (granular) fill.

It was then noted that the embankment was double-width on two levels. The southern half was lower, had originally contained a second track but this had been removed.

A further option was then suggested:-

E. Slew the track

Level the full embankment width and slew the track to the centre.

This alternative solution was agreed valid, although the objective of "Anticipating increases in speeds, axle loads & volumes - and Twin Track" would be jeopardised by this solution. Option F was therefore added, as below.

F. Re-build and re-instate the Southern Track

Re-construct and reinstate the southern embankment and its track, while continuing to operate the existing (northern) track at restricted speed. Once complete, operate trains on the southern track only. Any future requirement to re-introduce two-track operation would then require re-enforcement of the northern slope of the embankment using one of the options A to D.

Workshop Team Exercise 1 - Which Option represents Best Value?

How do we decide? Value is expressed simply as Function divided by Cost, although there can be complex detail under these two simple headings.

Team Exercise - How do we assess Function?

1. What are the Objectives?
2. Which objectives are performed better or worse depending on choice of scheme (A-F)?
   (These become Decision Criteria)
3. How important is each objective (relative to the others)?

Sample Answers to Question 1 - *Note the workshop team decided on the day.*

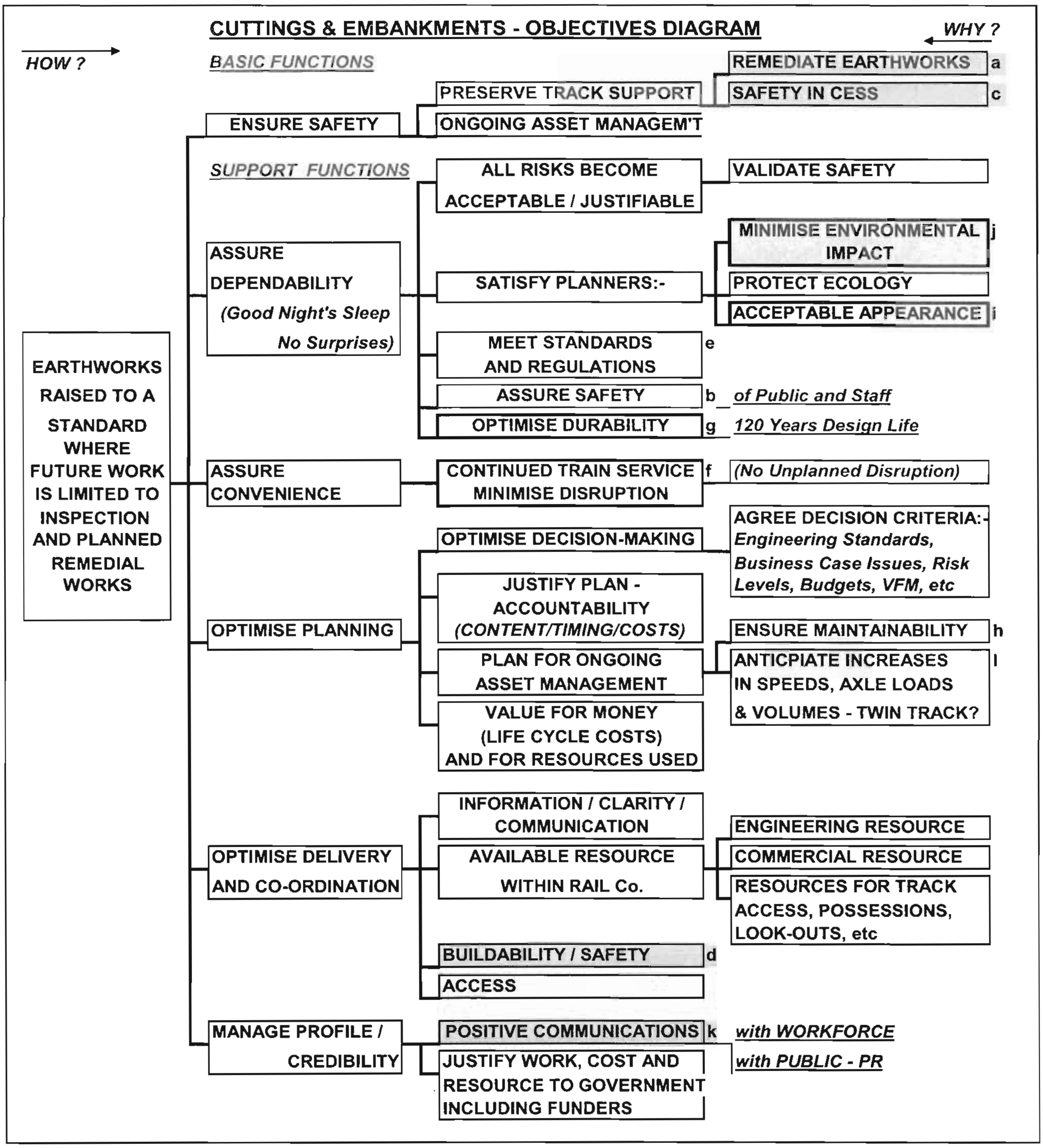
a) **Remediate Earthworks** - the primary project goal
b) **Assure Safety** - eliminate risk of sudden failure in operation.
c) **Safety for Operators** - ensure safe cess
d) **Safety in Construction** - ensure safe working on the operating railway
e) **Meet Standards & Regulations**
f) **Minimise Disruption** - to train service, customers & neighbours during works.
g) **Durability** - we want a long-term solution (*target - 120 year design life*)
h) **Ensure Maintainability**
i) **Enhance Appearance**
j) **Protect Environment**
k) **Positive Communications** - with public, rail customers and workforce
l) **Anticipate Requirements** - future need of increased speed, weight, volume?

Sample Answers to Question 2 A sample Objectives Diagram is shown on the next page. All of the 11 objectives listed above are included - they are valid and important (some are "Musts" others may be "Wants"). However, some objectives would be achieved to a greater of lesser extent depending on which option is chosen. These objectives must be considered in making that choice - and so they become Decision Criteria.

Any objectives which will (or must) be achieved similarly by all options need not be part of the decision process. These are objectives a, c, d, e & k above - shown yellow on the diagram overleaf. The other objectives (decision criteria) are highlighted green.

As a workshop exercise, the team are asked to identify the project objectives for themselves - and then choose those which become Decision Criteria,

Sample OBJECTIVES DIAGRAM (or Value Tree, or "SMART* Diagram")



* Note that "**SMART**" = **S**imple **M**ulti-**A**ttribute **R**ating **T**echnique. The process enables evaluation of options by matrix, against selected project objectives, weighted for relative importance, to facilitate project decision-making where critical choices must be made.

Sample Answers to Question 3 Relative Importance of the Objectives.
- Note that the workshop team will decide on the day.

Those objectives shown green in the SMART Diagram on the previous page must all be taken into account in the choice of Best Value Option. However, some objectives are more important than others - eg. Assure Safety could be classed a "Must," Enhance Appearance may be just a "Want," or even a "Nice to Have."

The objectives chosen as Decision Criteria must therefore be prioritised in terms of their relative importance. There are 4 ways in which this could be done:-

1. By classifying the objectives as Must, Want or Nice-to-Have, as suggested above. These ratings are allocated in consensus by the team, after some discussion. It is usually necessary to include a "Strong Want" in order to limit the number of "Musts."
   This classification is often a useful starting point, but for the "SMART" decision process it is necessary to assign numerical importance weightings to the objectives, as below.
2. By assigning an importance weighting out of 10 to each selected objective. Again this is done in consensus after discussion. Several objectives may have the same weighting.
   Such a process of objectives weighting is frequently sufficient - but occasionally more care must be taken over the relative weightings, as below.
3. By assigning percentage importance weightings to the selected objectives. This forces more debate: if one weighting needs to increase, others must reduce.
4. A process of Paired Comparison allows the importance of each objective to be compared one-by-one with each other objective. In this way a score is built up for each objective - and the totals define the relative importance.
   This process takes time and is usually unnecessary unless development of a team consensus proves difficult. Methods 2 or perhaps 3 above usually suffice, leaving time for the serious discussion over the matrix process which follows.

Sample Importance Weightings, using Method 2 above:-

b. Assure Safety	9
f. Minimise Disruption	7
g. Optimise Durability	6
h. Ensure Maintainability	6
i. Enhance Appearance	3
j. Protect Environment	3
l. Anticipate Requirements	4

Matrix Evaluation of Options A to F against these Weighted Criteria.

Our goal is to choose the Best Value option - and this is best done by creating a matrix in which all 6 options can be compared in terms of their Functional Performance against each of the 7 decision criteria.

The workshop team undertake this process - a sample is shown overleaf.

Matrix 1. Evaluating Functional Performance of Options A-F against Weighted Criteria.

Importance Weighting	CRITERIA Criteria chosen to compare the Competing Proposals	Competing Proposals Option A	Option B	Option C	Option D	Option E	Option F
9	MINIMISE RISK OF SUDDEN FAILURE	6 / 54	7 / 63	5 / 45	8 / 72	5 / 45	9 / 81
7	MINIMISE DISRUPTION	5 / 35	5 / 35	6 / 42	1 / 7	6 / 42	6 / 42
6	ENSURE DURABILITY	6 / 36	7 / 42	6 / 36	8 / 48	5 / 30	9 / 54
6	ENSURE MAINTAINABILITY	6 / 36	7 / 42	6 / 36	8 / 48	5 / 30	9 / 54
3	ENHANCE APPEARANCE	6 / 18	7 / 21	3 / 9	8 / 24	7 / 21	7 / 21
3	PROTECT ENVIRONMENT	6 / 18	5 / 15	6 / 18	7 / 21	8 / 24	6 / 18
4	ANTICIPATE FUTURE INCREASES	6 / 24	6 / 24	6 / 24	7 / 28	3 / 12	8 / 32
Total Weighted Rating		221	242	210	248	204	302

The 6 options, A to F, are each scored by the team out of 10 for the extent to which they meet each of the 7 decision criteria listed in the second column. Resulting scores are shown in the top left part of each square in the body of the matrix.

Scores are then multiplied by the Criteria Weighting (1st column) and the weighted scores for each option are shown in the lower right part of the matrix squares.

Weighted scores are then totalled to give a Relative Performance (Weighted Function) Rating, shown on the bottom row of the matrix.

These figures are meaningless in absolute terms, but relatively they express the team's collective judgement of the comparative performance of the options against the criteria judged to be important in choosing the best scheme.

What are the conclusions?

a) Best Performance (302) is Option F - re-instating the disused southern track. This does best for Future Increases (double track), but also performs best for Durability and Ongoing Maintenance because the embankment and track foundations can be rebuild to high standard while the existing track remains in operation, albeit at the restricted speeds. This also performs better in terms of Disruption during construction.

b) The opportunity to take time for a thorough reconstruction of the southern embankment, because train services continue on the northern side, will also minimise the Risk of Sudden Failure.

c) Option D, replace the upper 2-3m of the northern embankment, performs second best. It will achieve a durable solution for the existing track, performing well against all criteria - except for severe disruption during construction.

d) Option B is 3rd, re-grading the northern slope after removal of existing material.

c) However - the decision will be based on Value, not performance, so.....

Matrix 2. Evaluation of Options A to F for VALUE.

Matrix 1 had assessed relative Functional Performance of the options, but to measure Value, Function must be divided by Cost.

Costs had already been determined for Options A - D. First sight costs for the two new Options E and F were now estimated and the costs then added to the Matrix to give Value, by dividing Functional Performance by Cost - as shown below.

Importance Weighting	CRITERIA Criteria chosen to compare the Competing Proposals	Competing Proposals						
		Option A	Option B	Option C	Option D	Option E	Option F	Option G (E+)
9	MINIMISE RISK OF SUDDEN FAILURE	6 / 54	7 / 63	5 / 45	8 / 72	5 / 45	9 / 81	5 / 45
7	MINIMISE DISRUPTION	5 / 35	5 / 35	6 / 42	1 / 7	6 / 42	6 / 42	6 / 42
6	ENSURE DURABILITY	6 / 36	7 / 42	6 / 36	8 / 48	5 / 30	9 / 54	5 / 30
6	ENSURE MAINTAINABILITY	6 / 36	7 / 42	6 / 36	8 / 48	5 / 30	9 / 54	5 / 30
3	ENHANCE APPEARANCE	6 / 18	7 / 21	3 / 9	8 / 24	7 / 21	7 / 21	7 / 21
3	PROTECT ENVIRONMENT	6 / 18	5 / 15	6 / 18	7 / 21	8 / 24	6 / 18	8 / 24
4	ANTICIPATE FUTURE INCREASES	6 / 24	6 / 24	6 / 24	7 / 28	3 / 12	8 / 32	6 / 24
	Total Weighted Rating	221	242	210	248	204	302	216
	Total Costs	866.2	480.6	851.8	600.0	260.0	480.0	260.0
	Value (Function / Cost)	25.5	50.4	24.7	41.3	78.5	62.9	83.1
	Percentage of Best	30.7	60.6	29.7	49.7	94.4	75.7	100.0

Conclusions from the full Matrix 2 - Value

c) Option E, Slewing the track to the centre of a levelled full-width embankment offered the best value from A to F - as its cost is much less than other options, based on first-sight costs discussed at the workshop, which must be confirmed. However, Option E's performance is the lowest for durability, ongoing maintenance, risk of sudden failure and for provision for future increases (double-tracking).

d) Second best Value is Option F, rebuilding the southern embankment and re-instating the second track. This option was shown to be the best for performance and was no more costly than the other options, except the low-cost Option E.

e) This led to development of an 8th Option G, a variation and improvement on Option E, to slew the track by only around 1 metre, enough to achieve the required factor of safety without major reinforcement of the northern embankment - while retaining the flexibility to reconstruct and reinstate the southern track in the future, if and when needed, avoiding Option E's weakest performance rating.

Options E, F & G required validation in the port-workshop action plan, after which Option G was confirmed the best value option - and adopted.

Benefits of this Matrix Evaluation Process

- All factors judged important by the team are made part of the decision.
- The most important factors have greatest influence
- The cleverest of individual brains cannot make a judgement based on so many factors without a means to record and build up the decision in such a manner.
- Much harder for a team of many brains - but the matrix focuses discussion on one area at a time, structuring the discussion, recording the consensus and moving on. This avoids debates which go round in circles or back over old ground.
- Each team member can see that their own particular concerns are included on the matrix and taken into account as part of the total decision.
- Sensitivity analysis can take place - varying weightings or scores to show how robust is the decision, focussing further debate of specific areas.
- After such a review, the team have such an intense and shared understanding of the project's objectives, the solutions available and the winning scheme, that it is common for them to identify improvements through idea generation at this stage.
- One scheme has been shown to be the winner - but some of its performance scores may be low against particular criteria. Improvements are often found by focussing on those weaker scores - as was so in this case study example.
- There is an auditable justification for the decision made.

B3 Workshop Case Study - Station Enhancement

BACKGROUND

A major international Airport Operating Company (AOC) intended to increase its capacity.

In order to improve public transport access to the airport and to minimise traffic growth, plans were developed to modernise an existing railway station and to introduce a dedicated bus link direct to the airport.

The station was owned by the national Rail Infrastructure Company (RIC) and operated by a specific Train Operating Company (TOC). Much of the required capital cost would be paid by the RIC, in return for increased lease costs paid by the TOC, who expected this to be more than paid back by the increasing passenger numbers and ticket sales. A contribution to the capital cost was to be paid by the AOC.

Designs were developed which widened the platforms to allow for increased passenger numbers, created a new Station Building on the opposite side of the tracks from the original one, in order to create an easy interface with the new bus stopping point.

This is shown on the picture on the next page.

The sections shown pink are the original station platforms, with the station office building on the right hand side at the top of the picture. A footbridge can also be seen.

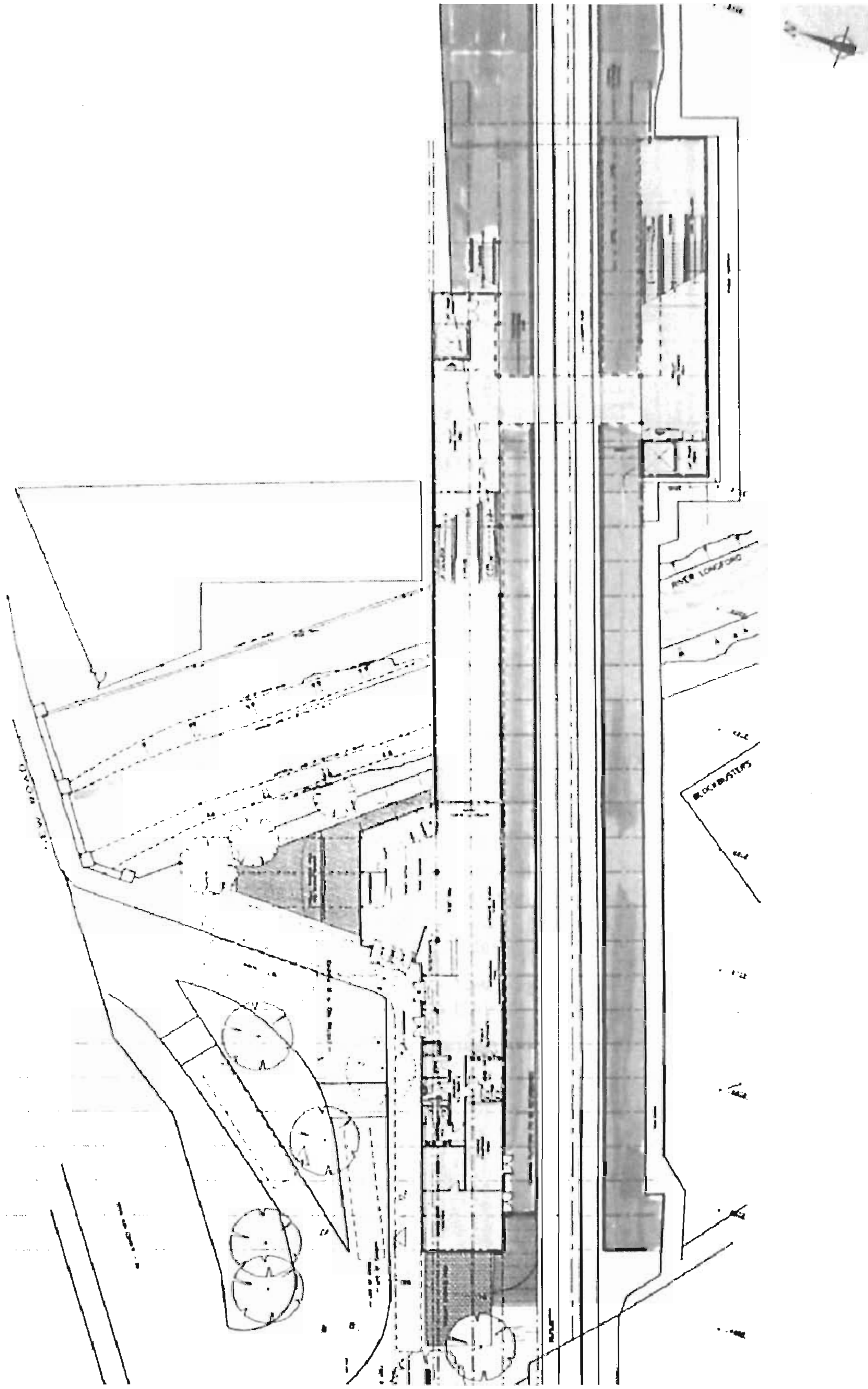
The yellow sections were the proposed new elements, including the new, enlarged and modernised station building, including staff offices, on the lower left of the picture. Outside of this can be seen the newly created bus interchange area.

Running under the tracks is a small river, shown blue. The new, widened platform on the left forms a bridge over this river.

The vision was to encourage use of this route to the airport by making the journey not only easy, but to create an "airport" environment at the station, as if passengers had already arrived into the airport infrastructure. This was to have been achieved by the layout and atmosphere of the main station building, then by the covered walkway along the platform, into a bank of escalators and a fully enclosed footbridge over to the opposite platform escalators. Lifts were also planned, for disabled access between the platforms.

After designs were developed and Local Authority Planning Permission granted, it became evident that the costs were unaffordable.

A Value Engineering workshop was therefore arranged, attended by all parties.


RIVER LONGFORD
BLOCKBUSTERS

INFORMATION: The following key elements of the project were examined.

New Platform on Left side (inc. River Bridge)	€ 100 k
Enclosed Footbridge	€ 225 k
Stairs on both platforms	€ 40 k
Lifts on both platforms	€ 150 k
Escalators on both platforms	€ 250 k
Platform Canopies	€ 75 k
Scope under examination:	€ 840 k

FUNCTION IDENTIFICATION:
The Functions of each element were identified by the team, as follows:-

New Platform on Left side (inc. River Bridge)

Functions:- Increase Capacity
Bridge River
Enhance ambiance

Enclosed Footbridge

Functions:- Increase Capacity
Cross Tracks
Resist Weather
Enhance ambiance

Stairs (x 2) Change Levels

Lifts (x 2) Change Levels
Enable Mobility-Impaired

Escalators Change Levels
Increase Capacity
Enhance ambiance
Speed Flow

Canopies Resist Weather
Enhance ambiance

FUNCTION COSTING:

The Cost of each element was known at the start. Now the team also knew the Functions of each element. The next stage was to establish the cost of each function.

This is not an exact science, but an approximation, enough to give the team an all-new perspective on how their funding is being spent - as shown in the matrix overleaf.

VM Cost versus Function Analysis

		Function (Two Words Only - Active Verb / Measurable Noun)									
		A	B	C	D	E	F	G	H	I	J
Part / Operation	Total Cost	Increase Capacity	Bridge River	Enhance Ambiance	Cross Tracks	Resist Weather	Change Levels	Enable Mobility	Speed Flow		
		Must		Want	Must	Must	Must	Must	Want		
New Platform	€100k	€60k	0	€40k							
(on left over river)											
Footbridge	€225k	€65k		€125k	€35k	0					
Stairs (2)	€40k						€40k				
Lifts (2)	€150k						€40k	€110k			
Escalator(2)	€250k	€40k		€40k			€40k		€130k		
Canopy(2)	€75k			€50k		€25k					
	100%	20%		30%	4%	3%	14%	13%	15%		
Page Total	€840k	€165k		€255k	€35k	€25k	€120k	€110k	€130k		

The cost of each element is broken down by Function in the matrix.

Taking the Footbridge, which is wide, fully enclosed, well lit to create the "airport" feel, the total cost of € 225k is broken down between the functions as follows.

Enclosed Footbridge € 225 k

Functions:-	Cross Tracks	*This could be a simple bridge = € 35 k*
	Increase Capacity	*This would need to be wider, add € 65 k*
	Enhance ambiance	*The enhancements cost the extra = €125k*
	Resist Weather	*Ambiance was all-important and fully enclosed the footbridge. So no added cost was needed to Resist Weather. = € 0*

Note that rather than leaving this cell blank, a Zero is added. This ensures that if changes are made and Ambiance is down-graded - then the team may have to add something extra to ensure that this required function is still achieved.

Note that a significant proportion of the cost of the new wider platform was not for capacity, which would have been satisfied with less widening. This wider platform continued the profile of the roof of the station building, along as a platform canopy and it continued up as a cover over the escalators.

Extra widening cost was not for capacity, but Enhanced Ambiance & Appearance.

'Bridge River' shows Zero cost, because it is not an independent function, you cannot decide not to do it and still perform the others. If you map these onto a Function Diagram, you could ask "How" do you Increase Capacity? Answer - Bridge River. "Why" do you Bridge River? Answer - to Increase Capacity. These are effectively the same function (or perhaps Bridge River is the technical solution to achieve the function of Increase Capacity).

The completed matrix is totalled for the cost of each function (bottom row) and these totals are indicated graphically by the simple highlighted histogram.

FUNCTION CONCLUSIONS:

The team now have an all-new view of how their money is spent.

Is it right that by far the highest function cost is for Enhance Ambiance?

Note that this is a Want, in fact a Strong Want, but not a Must.

"Speed Flow" is the 3rd highest cost and is a Want.

The team saw these a Value Mismatches - Function Cost out or step with Function Worth.

The modified chart on the following page gives a simple indication of the Value Miss-matches, where Function Cost (already shown on the previous chart) is now compared with Function Worth. The scale in the right hand side indicates worth in terms of "Want", "Strong Want" and "Must."
Costs which exceed Worth are bordered Red - and where Costs are below Worth, the surplus is shaded green. This is not an exact science, but does help to highlight the conclusions listed above - showing the excess of cost devoted to the functions of Enhance Ambiance and Speed Flow.

VM Cost versus Function Analysis

		Function (Two Words Only - Active Verb / Measurable Noun)									
		A	B	C	D	E	F	G	H	I	J
Part / Operation	Total Cost	Increase Capacity	Bridge River	Enhance Ambiance	Cross Tracks	Resist Weather	Change Levels	Enable Mobility	Speed Flow		
		M=3	*M=3*	*SW=2*	*M=3*	*M=3*	*M=3*	*M=3*	*W=1*		
New Platform	**€100k**	€60k	0	€40k							
(on left over river)											
Footbridge	**€225k**	€65k		€125k	€35k	0					
											Importance
Stairs (2)	**€40k**						€40k				
Lifts (2)	**€150k**						€40k	€110k			*Must*
Escalator(2)	**€250k**	€40k		€40k			€40k		€130k		
Canopy(2)	**€75k**			€50k		€25k					
											Strong Want
											Want
	100%	20%		30%	4%	3%	14%	13%	15%		
Page Total	**€840k**	€165k		€255k	€35k	€25k	€120k	€110k	€130k		

B6 VM STUDY CONCLUSION:

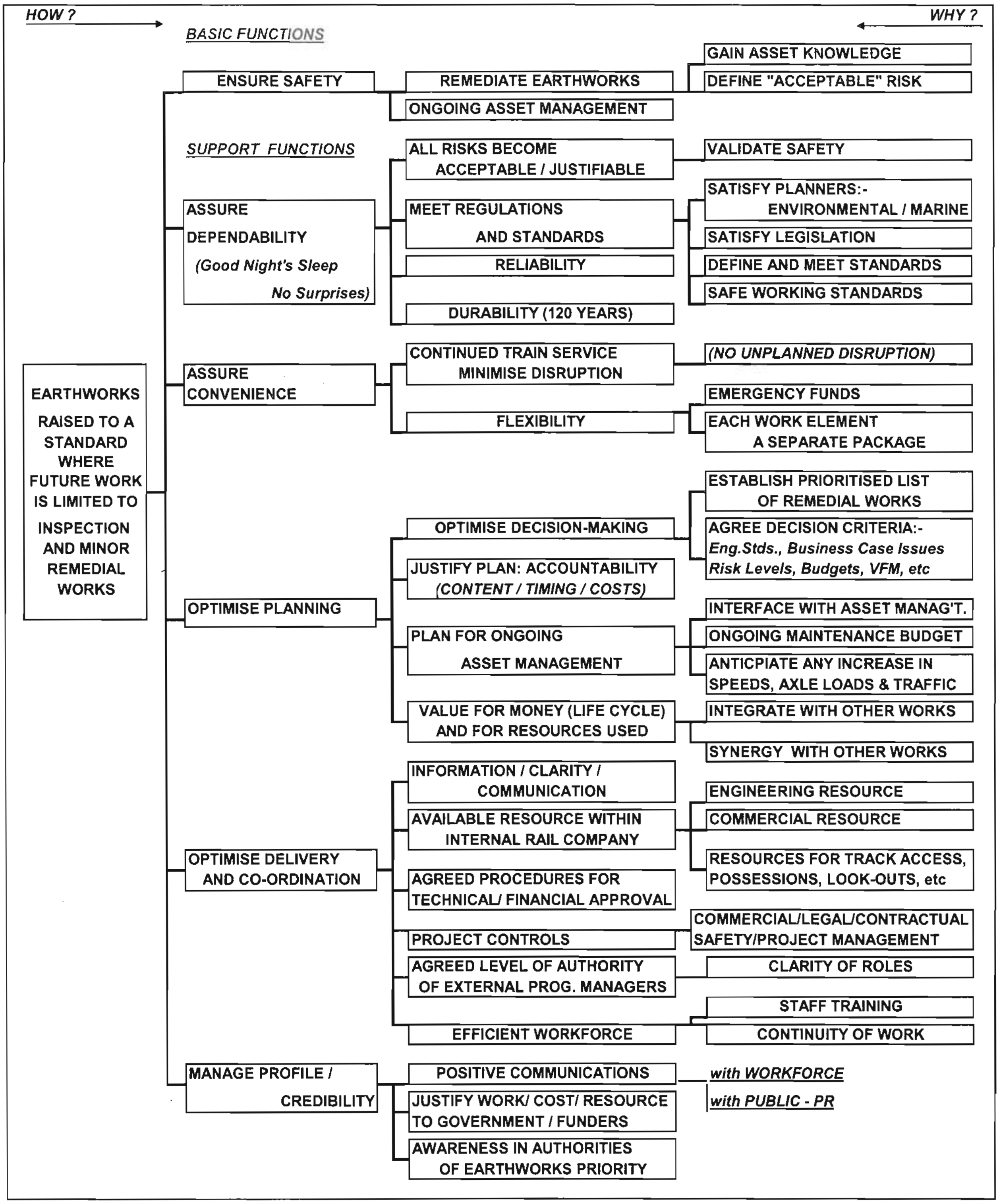
The outcome of this VM Study was as follows.

- "Speed Flow" was shown as taking excessive cost.
  Could the Escalators be deleted?
- Deleting the Escalators would reduce the "Enhance Ambiance" goal,
  However, this was shown as a clear Value Miss-match and a prime target for cost reduction.
- If the Escalators were deleted, then the architectural feature of extending the new station building Roof profile along as a Platform Canopy, continued up as a cover over the Escalators would be lost.
  However, again this would reduce the "Enhance Ambiance" helping to overcome this Value Miss-match, if the architects could devise an alternative scheme at lower cost.
- "Increase Capacity" was another identified Value Miss-match. A further consequence of deleting the Escalators would be to avoid the need for so much widening of the new platform leading to the new station building - a proportion of which was done merely to fit the Escalator width rather than for essential capacity.
  Some reduction in the Footbridge would also address excess indicated by the 2 Value Miss-matches of "Increase Capacity" and Enhance Ambiance."
- If Escalators were deleted, too much reduction in capacity was evident.
  Furthermore, the "Change Levels" function (a Must) would suffer.

Conclusion:

- The Escalators were deleted, the footbridge was simplified - and a second Lift was added on both platforms, considered better than Escalators for luggage.
- Lifts go in-line along the platform, not across - and this enabled a reduction in the platform widening.
- That destroyed the architectural feature of Roof → Canopy → Escalator,
  but the architects redesigned, obtained new planning permission - and the station and its dedicated bus service are now complete and in operation.

B4 Function Diagram - Earthworks Renewal Programme



B5 Case Study - VE Later versus Earlier

CASE STUDY 2-day VE Workshop - Highways

Subject: Upgrading an existing Motorway Interchange

Background: Project team estimate was € 20 m
Tenders came in at € 32 - 40 m - Hence this late VE Study

Study Results: Alternative 1 - Savings of € 6 m+ in the current project timing
Alternative 2 - Savings of € 16 m+ but timing delayed

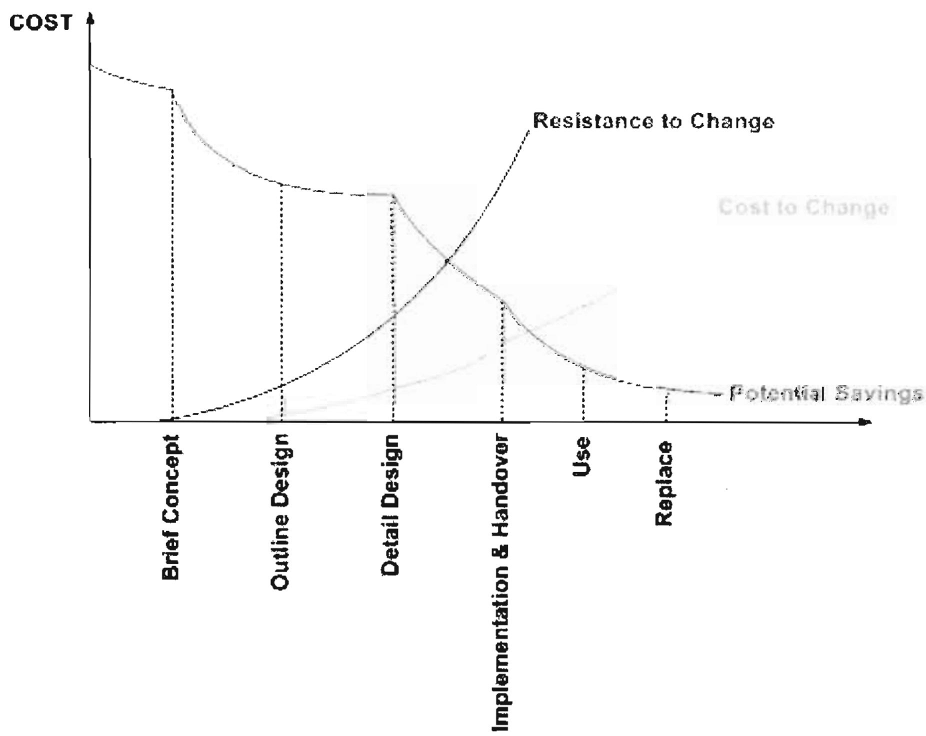
Client Decision: Public timing commitments had been made and the politicians did not want to reverse those,
So € 6 m savings was accepted and current timing held

Lessons Learned:

1. A clear example of 'Hard Value Engineering' VE very clear, instantly measurable results,
2. Also showed how much more an earlier 'Soft' VE study would have achieved - the € 16m saving
   i.e. this demonstrates the shape of the graph (copied below)
3. Paradoxically, the earlier study would not have recognised the savings made, because the € 16 m spending would not have been planned in the first place. The team will never know what would have transpired without their VM/VE effort.

ie. » Late VE feels good, the buzz of measurable achievement

» Early VE can give better results but, unaware of what was saved, does not always feel so satisfying to the team



B6 Case Study - Not "Savings" but "Cost Avoidance"

CASE STUDY 1-day Early VE Workshop - Railways

Subject: New Customer Information System (CIS) for major station upgrade, including track and platform remodelling and resignalling.

Background: New CCTV system already under development by same Contractor. Concern that CIS was too late, too far behind, hence this VE study with the Contractor, Station Operators, the different Train Operating Companies using the Station, the CIS Operators and the Project Delivery Team for the overall Station Upgrade Project.

Study Results: Consensus established between all users and operators on a clear and feasible Brief for development of the new CIS system.
i.e. a clear definition of Function - what the CIS must **do**.

Lessons Learned: One month later, the Contractor reported that CIS development was now well ahead of the CCTV, based on the clear understanding of Functional requirements agreed by the full team in the VE Study.

The Benefit: i.e. the primary benefit of this very worthwhile VE Study was not cost reduction but certainty and accelerated project delivery,
Not Cost Reduction - but significant **Cost Avoidance**.

COST AVOIDANCE: A regular and very real achievement of well performed VE, although it's often impossible to measure what would have been.