FINDING FAILURE FAST IN A RAPID DEVELOPMENT ENVIRONMENT USING AHP

Sam Sharp*
Numerix Pty Ltd
Sydney, NSW, Australia
Email: sam.sharp@numerix.com.au

Peter Hall
Numerix Pty Ltd
Sydney, NSW, Australia
Email: phall01@bigpond.com

ABSTRACT

In a rapid development environment, the very identification of viable solutions forms part of the project, in addition to its implementation. The pressures to "find failure fast" require that candidate solutions must be evaluated on the run, requiring at least a preliminary and partial implementation whose chief purpose is to identify, assess and suitably control associated risks. This renders the traditional linear planning and control methodologies unsuitable for such work.

In this paper, we developed a process which systematically analyses and prioritizes a series of previously selected candidate solutions using an AHP- based approach in which time, cost and quality criteria typically dominate. A quantitative risk assessment is performed on the highest rated candidate, leading either to its rejection, (and the initiation of a similar investigation into the next most preferred option), or the identification of a refinement believed to reduce the risk to acceptable levels. Since these refinements usually affect either cost, time or both, a re-calculation of the AHP is necessary, leading to an iterative "prioritize – plan – implement – test – reprioritize" process which provides a non-linear identification and implementation of the most promising solution from a cost/schedule/quality and risk perspective.

The method highlights the use of Work Breakdown Structure fragments, the appropriate aggregation of risk, dynamic decision-making and flexible change management protocols. It also relies critically on the effective communication and cooperation between planners and decision-makers operating at the commercial / technical interface.

Keywords: rapid development, project selection, risk aggregation, risk decision, prototyping

1. Introduction

The Analytic Hierarchy Process (AHP) has been used (Saaty, 2007) to optimise project selection in a static manner, that is, applied once to find the most suitable project relative to specified criteria. In this paper, we introduce its use as a vehicle for optimising selection in a Rapid Application Development (RAD) environment.

RAD was introduced by James Martin (Martin, 1990) during the early 1990s in an attempt to reduce software development cycle times. Since then it has gone through several refinements, the most recent being Agile Modelling (Ambler, 2002). The general approach seeks to embrace change and uncertainty and encourage flexibility, often by developing parallel models or plans and by producing a series of prototypes which are modified as a result of continual testing and feedback.

It is highly suitable to 'eXtreme' (Decarlo, 2004) project environments, where often simultaneous pressures of time, budget, risk, quality demands and the need to innovate require that planning and implementation activities blur, with one leading to the other in a cycle of continual refinement. Indeed, these become activities of discovery rather than the orderly linear processes that characterise the traditional approach.

Since a series of selection decisions is clearly required throughout the process, AHP can help ensure that in this context of evolving or radical change, the current selection remains the most preferred. If not, due perhaps to the potential increase in development cost and duration resulting from the need to mitigate against newly found risks or design problems, the next most preferred strategic approach offered up by AHP is embraced and the process continues.

The general schema is shown in Figure 1.

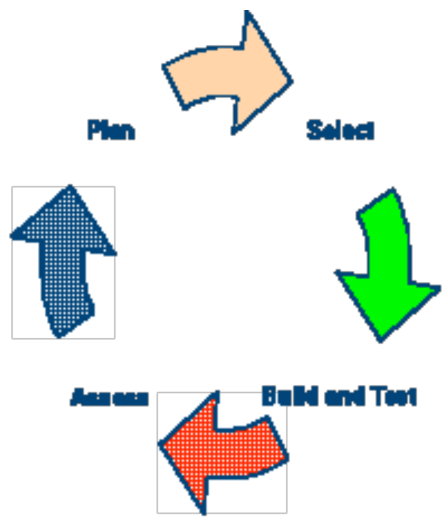

Figure 1

2. The Tools

In this section we describe the basic tools required to support the agile environment.

2.1 The Workbreakdown Structure

The workbreakdown structure (WBS) is a hierarchically arranged list of tasks that constitute a project. The headings and sub-headings can represent any organisational framework imposed on the work such as temporal phases, locations, disciplines or work processes. It is the very heart of a project plan and includes task names, estimates of duration, resource requirements and dependency links to other elements within the structure. These data are sufficient to allow task and resource schedules and costing forecasts to be calculated. The great appeal of the WBS approach is its natural support of a top-down approach for planning. Initially, a brief list of broad tasks can be identified which provides early approximations of project durations and costs. In RAD, this can be done for all candidate strategies being pursued, with more promising versions elaborated upon and refined by adding levels and detail within levels as these become warranted.

2.2 The Analytical Hierarchy Process

AHP plays a central role in the scheme, assisting the project team to select the currently preferred option, using evaluations from the most recent versions of the WBS to update ratings against the decision criteria.

The process, invented by Thomas L. Saaty (Saaty, 1980), presents a hierarchical formulation of the decision, with each option rated against the criteria. When these criteria are sub-divisions of higher-level criteria, the relative preferability of the candidate options against the latter are computed, using weightings reflecting the relative importance of the former. The process is continued up the hierarchy where it delivers the relative attractiveness of all options against the entire set of criteria. The method therefore helps to formalise the decision, provide focus and structure for decision-makers and prioritise decision options even when their attributes are intangible or qualitative. A typical AHP tree is shown in Figure 2, representing a simple decision for selecting suppliers against the criteria of cost and quality.

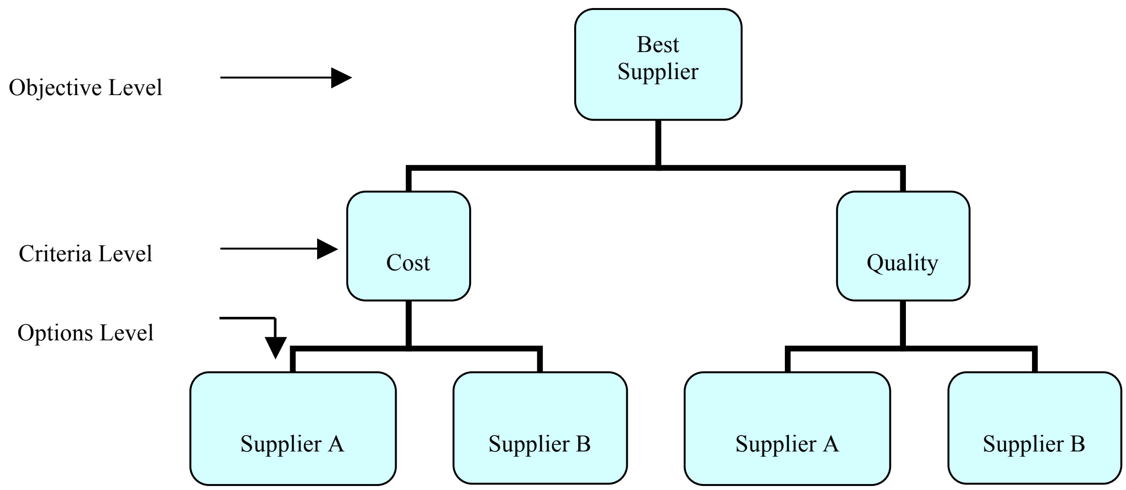

Figure 2

2.3 Risk Management

The control of risk is crucial in guiding eXtreme projects to a favourable conclusion. We distinguish between two types of risk here:

Product risk

This can be thought of as entrepreneurial risk, involving the likelihoods and impacts of severely unfavourable financial or commercial outcomes should the product fail to be developed or be developed and then fail.

Process risk

This relates to the potential for problems to arise during the development of the deliverables. They could include possible delays and cost overruns due to technical problems or errors.

The separate treatment of these risks is necessary since the assessment of product risk and, more importantly, of "acceptability" of that risk, is a subjective process and not amenable to the same treatment applied to process risk. For example, similarly sized commercial risk could be regarded differently by companies distinguished by their capital base or entrepreneurial outlook. On the other hand, process risks are quantifiable through the need for cost and duration contingencies, and can be dealt with adequately under an uncertainty criterion within AHP.

3. The Process

We now provide a detailed description of the process. This will be supported by references to figure 3 below which captures the general schema.

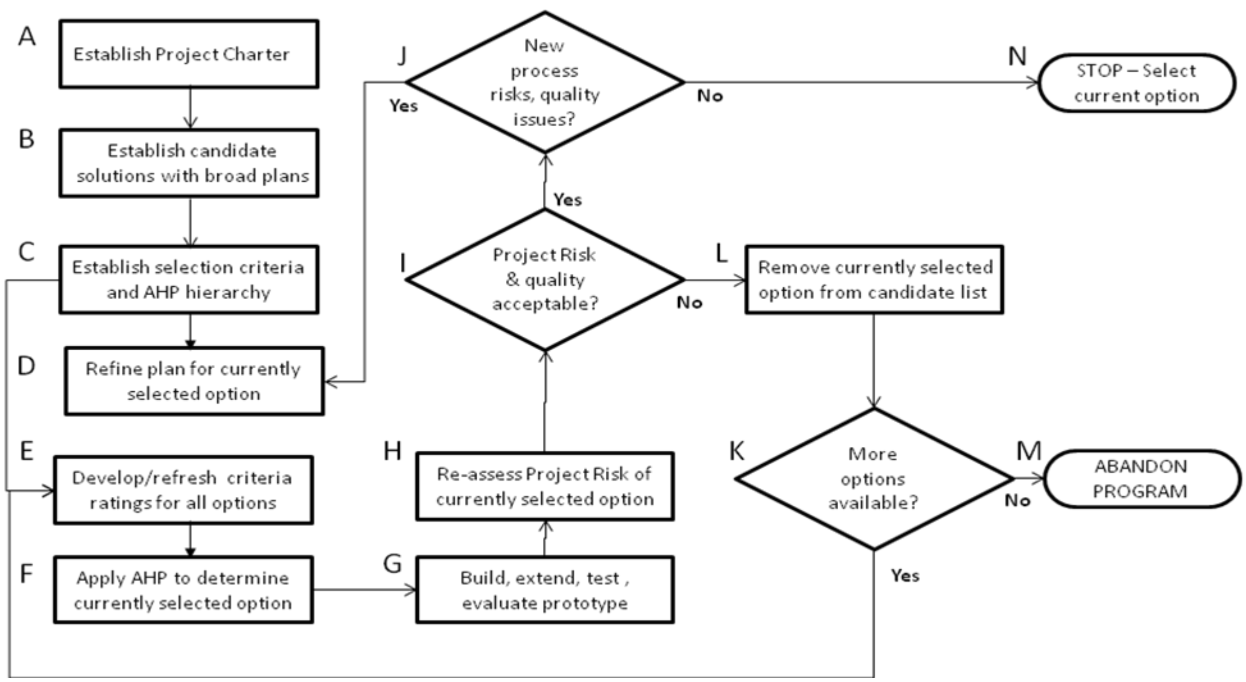

Figure 3

The Charter (A)

After user requirements have been absorbed, a charter document should be developed. This will comprise the statement of objective, constraints, risks, assumptions and stakeholder profiles. These will serve to provide an overarching context for all strategies to be pursued.

Identify Candidate Strategies (B)

The set of initial candidate strategies must be identified. These might vary in many aspects, including fundamental approach, development sequence or platform choice. An initial broad WBS should be developed for each option. The degree of detail should be sufficient to produce adequate approximations of cost, schedule, quality and risk profiles so that an initial selection can be made.

Establish the AHP model (C)

The selection criteria need to be established next. These might include cost and duration of development, uncertainty and also quality characteristics such as performance, reliability, stability and ease-of-use.

A relative rating of the options against these benchmarks or their sub-criteria can now be established. These can be arrived at by means of pair-wise comparisons, expert judgement and in some cases by means of parameters emanating from the project plans as discussed in (E) below.

Rating the Options (E)

Calculating Weights

After WBS-based schedule and cost estimates have been determined for each of the candidate strategies in step D (see below), the relative attractiveness of these options can be rated against the criteria. This too can be achieved by pair-wise comparison methods and expert consensus. Some ratings can be achieved directly by computing the contributions from each strategy emerging from the WBS formulations. For measures where higher values are more desirable, 'raw' scores from each strategy can be divided by the sum of all raw scores to provide a rating for the appropriate criterion. That is, if $Pref_{it}$ is the preference rating for option i at time t, with i = 1 …N, and N the number of candidates, then we have that

$$Pref_{it} = a_{it} / \sum_{j}^{N} a_{jt}$$

where a_{it} is the raw score for option i at time t. For measures where higher values are less desirable, such as cost or duration the normalized values must be reversed by means of:

$$Pref'_{it} = (1 - Pref_{it})/(N-1)$$

Aggregating Process Risk for the Project

In order to produce relative ratings for uncertainty relating to process risk, we need to aggregate this risk for each strategy. There are many ways to accomplish this and the specific method chosen does not affect the overall iterative process. However, if we wish to make use of the formulae above for computing preferences in relation to the uncertainty of the strategy, the following approach can be used.

The aggregate process risk $R(A_i)$ for strategy A_i can be found by assuming that all contributing risks r_{ik} k = 1 to m_i, (where m_i is the number of tasks in the plan for strategy i, i = 1 to N), are independent with behaviour that can be approximated by Normal and Beta[1] distributions for cost and duration respectively. If we regard the cost estimate c_{ik} and $\sigma^c{}_{ik}$ as the mean and standard deviation respectively of the distribution for task t_{ik}, then the total cost of option A_i can be described by the normal distribution $N(C_i, \sigma^c{}_i)$ where

$$C_i = \sum_k c_{ik}$$

and

$$\sigma^c{}_i = [\sum_k (\sigma^c{}_{ik})^2]^{1/2}$$

To find the standard deviation $\sigma^c{}_{ik}$ for the cost of each task, we identify the maximum assessed risk, that is, the lowest probability $p^c{}_{ik}$ that an additional cost Δc_{ik} will be required to cover contingencies. If we define N_s (p) as the Standard Normal distribution, then we have that

$$\sigma^c{}_{ik} = \Delta cc_{ik} / N_s(p^c{}_{ik})$$

In the case of duration required for the respective strategies, by appeal to the Central Limit Theorem, their probability distributions can be assumed to be $N(D_i,\sigma^d{}_i)$ where the strategy duration D_i is simply the sum of contributing duration estimates along the critical path, i.e.,

$D_i = \sum_k d_{ik}$ where d_{ik} are estimated durations of critical tasks and,

$$\sigma^d{}_i = [\sum_k \sigma^d{}_{ik}]^{1/2}$$

and where, according to the PERT approximations, we have:

$d_{ik} = (pd_{ik} + 4* ld_{ik} + od_{ik})/6$, with pd_{ik}, ld_{ik} an od_{ik} representing respectively the pessimistic, most likely and optimistic estimates of duration for the task and

$$\sigma^d{}_{ik} = (pd_{ik} - od_{ik})/6$$

The Selection Process (F)

Once the relative weightings are in place, the AHP can be exercised to produce the current most favoured selection. Borrowing from the WBS terminology, the hierarchy can be represented by what we might call

[1] This is the traditional choice, approximated in the Program Evaluation and Review Technique (PERT) (Kerzner, 1989)

the decision breakdown structure (DBS), with a code to show the relative positions of the criteria and sub-criteria. A typical example of the structure is shown in Table 1 below, with the outer level representing the high-level criteria, and the indented items their sub-criteria.

In this example, four high-level criteria are used, these being Cost, Schedule, Quality and Uncertainty. Each of these is decomposed into sub-criteria to enable a sharper and more realistic evaluation of the candidate projects' performance. The ratings at each level are also shown and these must sum to unity.

Table 1.

DBS code	Criteria
D1	Cost
D1.1	Primary Costs
D1.1.1	Material Cost
D1.1.2	Labour Cost
D1.2	External Dependence
D2	Schedule
D2.1	Project Duration
D2.2	Schedule Complexity
D3	Quality
D3.1	Reliability
D3.2	Performance
D4	Uncertainty
D4.1	Cost Uncertainty
D4.2	Duration Uncertainty

The power and flexibility that AHP brings to this process is in evidence by the fact that it can be modified at each iteration if necessary. That is, not only can the judgements about the performance of the various options be changed, but options themselves can be added or removed. Further, it is possible to add new criteria, or modify the perceived relative importance that each has in the overall structure in order to reflect evolving or emerging concerns.

Note again that the uncertainty criteria relates to the development process and not to the ultimate commercial viability of the product. This is handled in item G in the process, to be discussed below.

The Build and Test Process (G)

New designs and features that emerge during the most recent round of planning for the current selection delivered by AHP must be implemented and tested. This activity might involve physical construction, model building, simulations or prototyping in order to flush out any flaws which could jeopardise ultimate performance.

Of course if there has been a recent demotion of a once promising selection, the state of construction on the new choice may be well behind that reached on the demoted item. This is a natural outcome of a 'find failure fast' approach, jettisoning selections whose partial development revealed it to be too costly, long, risky or flawed.

The Assessment Process (H)

This step involves a careful examination of the test results. In particular, a subjective assessment will need to be made of the product risk carried by the current selection in relation to the fulfilment of ultimate viability.

This assessment may be based performance or uncertainty issues which are reflected in the decision structure, but which cannot stand-out sufficiently in that calculation, given the presence of other criteria. For this reason, the process requires the potential for human intervention. If the current selection survives this intervention, the assessment may then focus on fixable issues

Screening Product risk and Defects (I)

If the product risks or quality issues relating to longer-term functionality or commercial impact appear to be excessive, the current selection could be disqualified (process L), and the project removed from the candidate list. In this case the next most preferred selection will be further developed before being submitted to AHP. If the list of projects is exhausted (K), the conclusion is that no viable solution can be identified and the entire program is abandoned (M).

Identification of New Risks or Quality Concerns (J)

If no catastrophic risk or quality issues were identified from the risk screening process (I), we need to determine whether any fixable process risks were identified in the Assessment process (J). If this was the case, responses need to be identified, converted into tasks and introduced into the WBS for the selected project.

If no new risks or quality concerns arose, and in the judgement of the team the project plan is sufficiently well developed, the entire process can terminate at exit point (N) and attention can turn exclusively to full project implementation. Alternatively, if there is confidence that no new options need to be tested, but that further plan refinements are needed, the iterations can continue, but with the omission or only occasional use of steps (D) and (E).

Refining the Plan (D)

The assessments might have led to additional tasks, some perhaps mitigative or preventative risk responses, others relating to quality or performance enhancement, but all likely to incur additional costs and time. These tasks will be integrated into the WBS of the current project in the next planning activity, along with other refinements and expansions, with AHP the arbiter as to whether these changes jeopardise the most preferred status of the strategy.

4. A Sample Calculation

The case study is implemented using Microsoft Excel™ and Microsoft Project™. Microsoft Project is used to develop and maintain successive versions of the alternative strategies. The PERT analysis feature within the software can be used to calculate the mean and standard deviation approximations while the risk aggregation is performed by means of customised formulae and some background code using Visual Basic for Applications™.

The AHP is represented with the Microsoft Excel spreadsheet. Customised functions are developed to allow the DBS number to control the weighted aggregations so that changes to the weights or structure can be introduced flexibly. An automatic routine is used to import the current values from each of the participating project schedules and feeds a project summary worksheet. From here, preference values are computed and used in the AHP tables.

Three candidate strategies are considered. Preferred options are identified iteratively using performance measures emerging from the successive versions of WBS, rated against the selection criteria and weights shown in Table 2.

Table 2.

DBS code	Criteria and sub-criteria	Weights		
		Level 1	Level 2	Level 3
D1	Cost	.2		
D1.1	Primary Costs		.5	
D1.1.1	Material Cost			0.5
D1.1.2	Labour Cost			0.5
D1.2	External Dependence		.5	
D2	Schedule	.2		
D2.1	Project Duration		0.8	
D2.2	Continuity		0.2	
D3	Quality	.3		
D3.1	Reliability		0.3	
D3.2	Performance		0.7	
D4	Uncertainty	.3		
D4.1	Cost Uncertainty		0.6	
D4.2	Duration Uncertainty		0.4	

Iteration 1

The initial selection was based upon a broad representation of the three strategies. The relevant measures are shown in Table 3. The performance and quality ratings would be made by the team and have been normalised here.

Table 3.

	Dur	Labour Costs	Material Costs	Cost Spread	Dur Spread	Performance	Reliability
Strategy A	19d	25000	15000	38102	1.16	.3	.4
Strategy B	23d	50000	20000	12475	1.66	.4	.3
Strategy C	34d	20000	20000	25181	2.5	.3	.3

The resulting AHP tree appears as follows in Table 4:

Table 4.

	Strategy B Indicated	**Strategy A**	**Strategy B**	**Strategy C**
D		0.336	0.356	0.307
D1	Cost	0.348	0.304	0.343
D1.1	Primary Costs	0.366	0.278	0.356
D1.1.1	Material Cost	0.364	0.318	0.318
D1.1.2	Labour Cost	0.368	0.237	0.395
D1.2	External Dependence	0.330	0.330	0.330
D2	Schedule	0.380	0.337	0.283
D2.1	Project Duration	0.376	0.346	0.278
D2.2	Continuity	0.400	0.300	0.300
D3	Quality	0.330	0.370	0.300
D3.1	Reliability	0.400	0.300	0.300
D3.2	Performance	0.300	0.400	0.300
D4	Uncertainty	0.305	0.388	0.307
D4.1	Cost	0.249	0.418	0.334
D4.2	Duration	0.391	0.344	0.266

Option B appears to shade the others as the most promising line of approach. This is due to its perceived superiority in the areas of Quality and Uncertainty.

Iteration 2

As a result, the WBS for Option B was expanded, resulting in a downward revision of material and contingency cost estimates, a reduction in performance and reliability expectations and an increase in labour costs. These are shown in Table 5. The new AHP decision is shown in Table 6.

Table 5.

	Dur	Labour Costs	Material Costs	Cost Spread	Dur Spread	Performance	Reliability
Strategy A	19d	25000	15000	38102	1.66	0.4	0.444
Strategy B	25d	48960	18000	9161	1.45	0.2	0.222
Strategy C	34d	20000	20000	25181	2.5	0.4	0.333

Table 6.

	Strategy A Indicated	**Strategy A**	**Strategy B**	**Strategy C**
D		0.359	0.311	0.329
D1	Cost	0.346	0.307	0.341
D1.1	Primary Costs	0.363	0.285	0.352
D1.1.1	Material Cost	0.358	0.330	0.311
D1.1.2	Labour Cost	0.367	0.239	0.394
D1.2	External Dependence	0.330	0.330	0.330
D2	Schedule	0.383	0.331	0.286
D2.1	Project Duration	0.378	0.339	0.283
D2.2	Continuity	0.400	0.300	0.300
D3	Quality	0.413	0.207	0.380
D3.1	Reliability	0.444	0.222	0.333
D3.2	Performance	0.400	0.200	0.400
D4	Uncertainty	0.297	0.405	0.298
D4.1	Cost	0.237	0.437	0.326
D4.2	Duration	0.386	0.358	0.256

In light of these changes, Strategy B now dominates only under the Uncertainty criterion. Overall, the selection of Strategy A is indicated, requiring a more detailed version of its plan to be developed. However, if subsequent testing were to reveal intrinsic product risks in relation perhaps to ultimate ease-of-use issues, and if, in the judgment of the project leaders, the commercial viability of the product under this development strategy were to be in jeopardy, Strategy A would be abandoned. This is in spite of its continued good showing in the AHP calculations.

This would require the resumption of the development of planning for Strategies B and C. Their results are shown in Table 7.

Table 7.

	Dur	Labour Costs	Material Costs	Cost Spread	Dur Spread	Performance	Reliability
Strategy B	33d	64533	18000	$12,844	2	0.4	0.333
Strategy C	29d	60678	18000	$7,544	3.1	0.6	0.666

The corresponding AHP calculations are show in Table 8.

Table 8.

Strategy C Indicated		**Strategy B**	**Strategy C**
D		0.462	0.538
D1	Cost	0.497	0.503
D1.1	Primary Costs	0.495	0.505
D1.1.1	Material Cost	0.500	0.500
D1.1.2	Labour Cost	0.489	0.511
D1.2	External Dependence	0.500	0.500
D2	Schedule	0.485	0.515
D2.1	Project Duration	0.479	0.521
D2.2	Continuity	0.500	0.500
D3	Quality	0.380	0.620
D3.1	Reliability	0.333	0.667
D3.2	Performance	0.400	0.600
D4	Uncertainty	0.505	0.495
D4.1	Cost	0.473	0.527
D4.2	Duration	0.574	0.426

Option C is now the preferred strategy, winning on all fronts except for duration uncertainty.

5. Logistical Considerations

In practice, the process requires a great deal of flexibility on the part of the development team, with a willingness to cease and resume activities at short notice. Good document and version control are necessary to keep this organised and functional.

In order to make selection decisions effectively, analysts must have confidence that there are no gems buried beneath rejected options, nor flaws hidden in the selected one. Consequently, judgment must be exercised on the degree of detail required for both plan and prototype development in order that meaningful comparisons between competing strategies can be conducted.

Careful resource management will also be required. For example, it may be necessary for teams to split and work simultaneously on different strategies, in order to minimise overall development time. Effective communication between project leadership and team members will be vital to ensure smooth implementation of the process.

The program leader must be committed to the 'eXtreme' project management philosophy, and needs to communicate the challenges inherent in this type of environment to all stakeholders. Considerable skill is needed to manage the competing forces of expectations, quality, uncertainty, deadlines and budget. Equally, a well developed sensitivity to the needs of team members must be in evidence.

Summary and Conclusions

While by definition, the RAD approach can imply volatility, high risk, innovation and quick decision-making, along with frequent failure, we have shown that the frenzy and occasional chaos can be managed by means of a systematic approach. The hybrid WBS/AHP tools, bound within an iterative process and combined with the potential for appropriate human intervention, provide a valuable guiding hand for this important area of development.

References

J.D. Kendrick & D Saaty (August 2007), Use Analytic Hierarchy Process for Project Selection. Six Sigma Forum Magazine.

Scott Ambler (2002) Agile Modeling: Effective Practices for eXtreme Programming and the Unified Process.

James Martin (1990) RAD, Rapid Application Development, MacMillan Publishing Co, New York.

Doug Decarlo (2004) Using Leadership, Principles, and Tools to Deliver Value in the Face of Volatility eXtreme Project Management. Wiley 1st edition.

Thomas L. Saaty, (1980) The Analytic Hierarchy Process: Planning, Priority Setting, Resource Allocation. ISBN 0-07-054371-2, McGraw-Hill

Harold Kerzner (1989) Project Management A Systems Approach to Planning, Scheduling and Controlling, Van Nostrand Reinhold