ANALYSIS OF A METHODOLOGY TO OBTAIN A WORK BREAKDOWN STRUCTURE BUILT UP FROM INTERDEPENDENT KEY PROJECT DELIVERABLE PACKAGES

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Abstract

The work breakdown structure (WBS) forms the base for most project management processes. A well-defined and comprehensive WBS that fits the organisational structure and the project system profile is important to increase the probability of project success by ensuring that the best resources are applied to the correct selection of projects suiting the particular company. Many different bases for the WBS are found in the literature, but most WBSs only repeat the functional breakdown of the project organisational structure. A method of building the WBS up from identified interdependent key project deliverables has a distinct advantage in increasing the probability of a successful project. The importance of the WBS lies not only in the hierarchical diagram that forms the backbone for the project planning, but also in the process of developing it and in the correct phasing of the WBS development through the project life cycle.

This paper proposes a method for the development of a deliverable-based WBS and analyses the possible effect it could have on the success of a project by doing a qualitative and quantitative analysis of different WBSs developed for a specific project. The analysis is done by answering a number of WBS-related project success questions developed from WBS-related project success measures. The project success measures that might be influenced by the WBS were formulated from project success measures found in the literature.

A case project was used to develop a deliverable-based WBS. This WBS was compared with the original discipline-orientated WBS used to manage the project. The objective of the project was to design, build and commission a 1-MWth pilot scale pulverised coal combustion test facility with the necessary options to evaluate the fuel performance of South African coal in Eskom power stations at Eskom’s TSI facility in Rosherville.

The paper concludes that the method of developing a deliverable-based WBS from a functional analysis of the project’s ultimate deliverable has shown that it has a positive effect on some project success measures.

Keywords: Work Breakdown Structure, System Thinking, System Engineering, Deliverable-based, Project Success Measures

1 INTRODUCTION

The WBS forms the bases for the planning, estimation, scheduling, monitoring, management and control of all project activities. A well-defined and comprehensive WBS that fits the organisational structure and the project system profile is important to increase the probability of project success by ensuring that the best resources are applied to the correct selection of projects suiting the particular company. Robert Buttrick (1) refers to a method of building up the WBS from identified interdependent key project deliverables. This is different from the traditional method of progressively breaking down the scope of work into less complex levels (Nicholas (2), Department of Defence (3), Project Management Institute (PMI) (4)), which is based on engineering disciplines, products, schedule, resource requirements or cost items.
The process of developing the WBS from the key deliverables of projects shows parallelism to system thinking and system engineering (Blanchard and Fabrycky (5), Kerzner (6)).

Throughout the literature the WBS is seen as an independent input to the planning process, but the importance of the WBS lies not only in the hierarchical diagram that forms the backbone for the project planning, but also in the process of developing it and in the correct phasing of the WBS development through the project life cycle.

The approaches followed by project teams in the development of a WBS range from the re-use of a previous WBS with slight changes, to the progressive breakdown of the work required for the project, to the development of a deliverable-based WBS with the focus on the ultimate functionality of the end product (Fig 1). The width of the arrow in Fig 1 depicts the frequency of use of the approach, the effort of developing the WBS increasing from left to right.

A number of organisational factors also influence the structure of the WBS development approach, including:

- the project management maturity of the organisation in the field of application;
- the experience of the project management team with the type of project;
- the availability and accessibility of relevant project history;
- the number of times similar projects have been successfully completed;
- the familiarity of the project environment to the project team.

Fig 1. Approaches and their frequency of use by project teams in developing a WBS

Fig 2 graphically combines the familiarity of the organisation with the specific project and the complexity and novelty of the project. Fig 2 can be used to gauge the approach of the project team to the development of the WBS as depicted in Fig 1, and indicates the area of interest for the proposed deliverable-based WBS development method.

WBS-related literature is discussed in the next section. This is followed by literature on system engineering and system thinking that can possibly be used in the realisation of a new WBS development method. WBS-related project success measures found in the literature are given in
Section 4. Section 5 proposes a WBS development method, while Section 6 gives an example project used to analyse the method. The WBS-related project success measures are formulated as questions, and the answers are discussed in terms of the new WBS development method in Section 7. The paper concludes with Section 8.

2 THE WBS-RELATED LITERATURE

Globerson (7), as well as Bachy and Hameri (8), stresses that there is a lack of available information and references in the literature, and that insufficient importance is attached to the WBS. The PMI is re-emphasising the importance of the WBS in the draft Practice and Standards for the WBS (4), and provides some clarity in the definition of terms and functions related to the development of the WBS.

A number of papers advocating the use of deliverables as the base for the WBS (Bachy and Hameri (8), Turner (9), Davies (10) and Rad (11)) indicate a move back to the original definition of the WBS as a product breakdown, but for different reasons. There is no clear definition of a deliverable, or consensus on the level to which deliverables should be used as the bases for the WBS, the effect such a WBS will have on the management and control of the project, the effects on the organisation structure, and the effect of the project and product life cycle on the actual deliverables to be defined.

A solution to the above might be found in the PMI Practice Standard for WBS (4). It sees the WBS as defining the project’s work in terms of activities that create a tangible result, ie deliverables are defined as products or services, and the project management process is defined in terms of the project life cycle appropriate for that project and organisation. The PMI also gives a clear definition of a deliverable, namely: “Any measurable, tangible, verifiable outcome, result or item that must be produced to complete a project or part of a project”. The WBS design process is also defined as “decomposes (or disassemblies) the overall project scope into deliverables, and supports the definition of the work effort required for effective management”.

What is still lacking is the process of defining the variables in relation to the project and product life cycle and the ultimate deliverable (outcome) of the project, where the deliverable is much more than a tangible product; it is a solution to the needs of the stakeholders.

An approach that might be able to assist in the process of defining the deliverables, from which the WBS can be built, is system thinking and its advancement into system engineering. In the next section the concepts of system thinking and system engineering, as found in the literature, with their possible application to the development of the WBS, are introduced.

3 SYSTEM THINKING AND ENGINEERING

3.1 System thinking

A system is an assemblage or combination of elements or parts forming a complex or unitary whole. Unity, functional relationships and a useful purpose (a common goal) must be present to distinguish between a random group of items and a system (Blanchard and Fabrycky (5)). System thinking professes the abandonment of linear causal thinking for circular causal thinking (12). Linear thinking sees everything as cause and effect, whereas circular or system thinking sees everything as a continuous loop.

3.2 System engineering

A number of processes and the product life cycle approach followed in system engineering show similarities to the process of the WBS development. A number of concepts from the system engineering discipline given by Blanchard and Fabrycky (5) can be utilised, as is or in adapted form, to enhance the WBS development process.
The process of functional analysis, allocation and synthesis is analogous to the proposed process of breaking up the end deliverable into smaller subdeliverables with their interdependencies and using these to build up the WBS.

The process starts with the identification of the “need” and a preliminary high-level feasibility analysis. A detailed system requirement analysis follows the need identification, focusing on the requirements throughout the total product life cycle, including operational, maintenance and support requirements, each with its technical performance measures. System requirements represent the “whats” the system must be capable of, which, together with its technical performance measures, are then used to define the system in functional terms. System requirements are translated into detailed design criteria through the functional analysis. Functions still represent the “whats” (what is needed to accomplish) and the words in each functional block are “action-orientated”.

Synthesising the functions and allocating deliverables to the functions constitute the next step in the process. This is done by combining and grouping similar functions together into logical subdivisions and identifying the major subsystems, and can be seen as the development of a functional packaging scheme for the system. Synthesising the functions means that the “whats” are converted into “hows” (how it should be done) and the system is broken down into components.

4 WBS-RELATED PROJECT SUCCESS MEASURES

Belassi and Tukel (13) state that since the early days of project management, focus has been placed on the scheduling of projects. Later the main success or failure criteria were related to the three pillars of project management (schedule, cost and performance) as per Nicholas (2). Belassi and Tukel (13) further state that it is today realised that determining whether a project is successful is far more complex. Projects that overrun in schedule and budget can still be classified as successful by the clients in terms of quality and specification. A project perceived as a success by the project management team in terms of budget and schedule can be seen as a failure by the client if it does not meet his requirements (Belassi and Tukel (13)).

A list of project success measures found in the literature (Gioia (14), Davis and Zweig (15), Pinto and Slevin (16), Belassi and Tukel (13), Tukel and Rom (17)) that can be influenced by the WBS is presented in Table 1. These project success measures are translated into six questions that can be used to analyse the effect a WBS might have on the outcome of a project. The six WBS-related project success questions are presented in Section 7.

<table>
<thead>
<tr>
<th>WBS-RELATED PROJECT FAILURE FACTORS</th>
<th>REFERENCES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Underestimating the program/project complexity</td>
<td>Gioia, Kerzner</td>
</tr>
<tr>
<td>2 Poor requirement management, miscommunication of project scope; goal clarity</td>
<td>Gioia, Davis &amp; Zweig, Pinto &amp; Slevin</td>
</tr>
<tr>
<td>3 Inadequate estimations</td>
<td>Tukel &amp; Rom, Belassi &amp; Tukel, Nicholas</td>
</tr>
<tr>
<td>4 Inadequate project planning and scheduling</td>
<td>Pinto &amp; Slevin, Belassi &amp; Tukel, Nicholas</td>
</tr>
<tr>
<td>5 Correct resource availability</td>
<td>Tukel &amp; Rom, Belassi &amp; Tukel, Nicholas</td>
</tr>
<tr>
<td>6 Availability of required technology and expertise</td>
<td>Pinto &amp; Slevin, Belassi &amp; Tukel</td>
</tr>
<tr>
<td>7 Ignoring the systemic nature of projects</td>
<td>Nicholas</td>
</tr>
<tr>
<td>8 Inadequately defined tasks</td>
<td>Kerzner</td>
</tr>
</tbody>
</table>

Table 1. Project success factors related to the WBS
5 THE PROPOSED WBS DEVELOPMENT METHOD

The proposed new WBS development methodology utilising the system thinking and system engineering principles to develop a deliverable-based WBS for projects in the area of interest as given in Fig 2, is graphically presented in Fig 3. Although the process as depicted in Fig 3 is iterative, the discussion will be split into the functional analysis and the deliverable allocation processes in the next two paragraphs.

Fig 3. Proposed WBS development methodology

5.1 Functional analysis
The methodology proposes the development of a statement of work (SOW) from an extensive stakeholder needs analysis, to be followed by a functional analysis of the project SOW whereby the ultimate functionality required of the product is broken down into manageable functions. A graphical representation of the functional requirements of the product, namely the functional WBS, is generated through the functional analysis process. Resources required to be responsible for achieving each of the functions are identified and the functional required resource breakdown structure (RRBS) is developed. The functional RRBS is compared with the available resource breakdown structure (ARBS) and the responsibilities and accountabilities for realising all the functions are assigned to the resources through the functional resource allocation table (RAT). Fig 4 graphically depicts the process of identifying the required resources and matching these with the available resources, and the identification of responsibilities/accountabilities of the resources. Fig 4 stresses the possibility that the required resources will not be available to the project as indicated by assigning resources J and G to the required E and F respectively.

The responsibilities of the functional level resources are very important, because the person responsible for a functional package in the WBS has to act as the system integrator of that particular package. He/she must ensure that all the relevant role-players are involved in the deliverable assignment, planning and estimation of the work package. Each of the disciplines that is involved in the development of the deliverable needs to be integrated, because the WBS will no longer be discipline-orientated (which usually ensures representation for each discipline), but deliverable-orientated.
5.2 Deliverable allocation
Deliverables that will fulfil the functional requirements of the projects, as given in the functional WBS, are then allocated to form the deliverable-based WBS. Conceptual designs, feasibility studies and even experimental work might be required for this process. Required resources are identified in the RRBS and compared with the available resources in the ARBS. The responsibilities and accountabilities of the resources for realising the deliverables are assigned in the deliverable RAT.

Assigning deliverables to functions is not necessarily done one to one. A deliverable can be assigned to a group of functions, or more than one deliverable can be assigned to one function. Different iterations between functional analysis and deliverable assignment are required.

5.3 The iterative nature of the WBS development method
The nature of the deliverable-based WBS development process is iterative; resulting in some lower-level functions only being identified after deliverables are assigned to the higher-level functions. The comprehensiveness of the WBS will therefore increase with every iteration of the process. Fig 5 graphically depicts the iterative process of functional analysis and deliverable assignment. Fig 5 indicates that packages 1.1.1 and 1.1.2 can be grouped together and assigned to deliverable b. Package 1.2.3 needs to be split into two and assigned to deliverables g and h. The next iteration in the process indicates that deliverable d has two functional requirements, namely d1 and d2, which are assigned deliverables i and j respectively.

In order to test the proposed WBS development method described in this section, an example project, described in the following section, was used for comparing a functional WBS with a deliverable-based WBS.

6 THE EXAMPLE PROJECT
An example project was used to develop a deliverable-based WBS, which was compared with the original discipline-orientated WBS used to manage the project.

The objective of the project is to design, build and commission a 1-MWth pilot scale pulverised coal combustion test facility with the necessary options to evaluate the fuel performance of South African coal in Eskom power stations at Eskom’s TSI facility at Rosherville. The furnace must consist of a single, wall-fired, variable-swirl, low-NOx 1-MWth burner capable of a turn-down ratio.
of 50%. A 3-second residence time in the radiant section and a 5-second residence time in the convection section of the coal particle with a heating value of 16 MJ/kg are required of the furnace. All water, air, coal, oil, heating transfer fluid and ash-handling systems must be designed to operate safely under the above conditions. The total budget for the project is R20m and the commissioning must take place before 31 December 1999.

7 ANALYSIS OF WBS-RELATED PROJECT SUCCESS MEASURES

Table 1 gives the project success measures that can be influenced by the WBS. These were translated into six questions that can be asked in order to analyse the effect of different WBSs on the success of a project. Table 2 gives the six questions.

<table>
<thead>
<tr>
<th>WBS MEASUREMENT QUESTION</th>
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<tbody>
<tr>
<td>1  Does the WBS facilitate the accurate identification of the project complexity?</td>
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<tr>
<td>2  Does the WBS accurately reflect the solution to the clients’ needs?</td>
</tr>
<tr>
<td>3  Does the WBS structure help to improve the estimation of the duration and cost of the project?</td>
</tr>
<tr>
<td>4  Does the WBS facilitate the more accurate identification of resources, technology and the expertise required for the project?</td>
</tr>
<tr>
<td>5  Is the WBS complete?</td>
</tr>
<tr>
<td>6  Do the WBS and the WBS development method reflect the systemic nature of the project?</td>
</tr>
</tbody>
</table>

Table 2. WBS-related project success questions
The highest level of the WBS developed using the traditional method used to manage the project is given in Fig 6. Fig 7 and Fig 8 give the high-level functional WBS and the first iteration deliverable WBS using the proposed new method for the example project. Fig 9 gives the expansion of the deliverable breakdown of the protection function.

Fig 6. Traditional WBS for level one of the example project

Fig 7. High-level functional WBS for the example project

Fig 8. High-level deliverable WBS for the example project

Fig 9. Deliverable-bases WBS for the example project (protection function)
A summary of the answers to the questions pertaining to the example project is given in the following paragraphs.

7.1 Does the WBS facilitate the accurate identification of the project complexity?
The complexity of a project lies in two different areas, namely the physical solutions required to realise the project’s functional requirements, and the ability to identify the clients’ needs (discussed in the next question).

The process of developing a functional WBS and then assigning deliverables to the functions assists in the identification of the complexity of realising the physical solutions to the functional requirements. Furthermore, it assists in finding better solutions, ie deliverables to satisfy the functional requirements.

7.1.1 Identifying the project complexity
The functional requirement related to the safety of the furnace (protection function, Fig 9) that requires the metal skin temperature to not exceed 80 °C sounds very simple to realise - just cool the gas and/or insulate the furnace. In reality the complexity of this task is only realised when looking at the full functional requirements of the project and assigning deliverables to the functions. Then it is seen that the gas cannot be cooled, because the radiant section outlet gas temperature has to be representative of the real furnace temperature at 1100 °C. The temperature therefore needs to be reduced from between 1600 °C and 1100 °C to 80 °C, and all heat losses must be measurable.

From this example it is clear that the new WBS development process helps in identifying the project complexity by following a specific process in which the functional requirements are converted into deliverables at an early stage of the project planning process.

The difference between a deliverable-based WBS and a discipline-based WBS is the approach used in the development of the higher level of WBS packages. In the discipline-based WBS (Fig 6) the responsibility for the higher levels of the WBS packages lies with the senior discipline managers or engineers and, in the absence of a system engineer overseeing the system integration of the project, they will have to form an opinion about the complexity of realising the project. In the case of the deliverable-orientated WBS the responsibility for the higher-level functional packages of the WBS will ensure a more system-orientated approach in realising the functional requirements with the deliverables. For instance, in the above example the realisation of the insulation method of the furnace was first discussed by the mechanical, civil, electrical and C&I engineers. The complexity of the task was identified by them and only then was it decided to hand the detail design over to an insulation expert. In the case of the deliverable-orientated WBS, the function of insulation can be identified early in the planning process and a suitable person can be identified to accept responsibility for the realisation of this function. This will ensure a more accurate identification of the complexity of realising this function.

An added advantage of the process described above is that it could result in the development of better solutions to the project needs.

7.1.2 Finding better solutions to functional requirements
Doing a functional analysis of the project, or at least enforcing the development of a functional WBS, before assigning deliverables to the functions, ensures that different solutions to the functional needs are evaluated. In many cases where there is no form of functional analysis the solution to a function (deliverable) or the “how it will be done” is confused with the function or “what must be done”. For instance, when it comes to controlling air flow, a control valve, which is just one method (how) of changing air flow, is seen as the function (what) of flow control. In a functional analysis the function of air flow control would first be identified, and only then would the questions be asked as to how the control was to be done. This could, for example, lead to using a variable-speed drive motor on the fan as the deliverable to realise the function of flow control, instead of a fixed-speed fan with a control valve.
Another advantage of the new proposed WBS development method is that by using a functional approach in the development of the higher-level WBS packages, a better understanding of the realisation of the functions is achieved than would have been the case with a discipline-based WBS. A better deliverable assigned to realise the functional requirements of the project could be achieved by the above process.

7.2 Does the WBS accurately reflect the solution to the clients’ needs?
The WBS as such cannot increase the accuracy with which the clients’ needs are reflected - this has to be done through extensive stakeholder needs analysis and communication with the stakeholders. Its structure and development methodology can, however, assist in the process of stakeholder needs analysis by providing an environment in which the best possible resources for the task are identified and by ensuring that certain steps are taken, such as the functional analysis and the assignment of functional package responsibilities. The accuracy of the functional solution to the client’s needs can be addressed by involving the client in the process of its development and ultimately having him sign it off before deliverables are assigned to the functions.

7.3 Does the WBS structure help in improving the estimation of duration and cost of the project?
Two very important factors that can have an impact on the accuracy of the time and cost estimation are the completeness of the WBS and the ability of the responsible people to do the estimates. Firstly, the completeness of the WBS ensures that all the possible deliverables and tasks are catered for in the estimates. Secondly, the ability of the new WBS development method to ensure completeness is addressed in the next question.

The best person to do the cost and time estimate of a WBS package is the person that will actually be doing the work (Nicholas (2)). Ensuring that the person that will be doing the work is identified early enough and that he/she is the best available person is facilitated by the development of the functional WBS and the assignment of deliverables to the functions. The same principle that applies to the responsibility for the higher-level functional WBS packages applies to the responsibilities for the lower-level deliverables. Ensuring that the responsibility is assigned to a person knowledgeable in the realisation of the functional requirements through the assigned deliverable down to the lowest level of the WBS will contribute to the development of more accurate estimates of the deliverables.

From the above it is evident that the new WBS development method could have an advantage over the traditional method in helping to develop more accurate cost and time estimates.

7.4 Is the WBS comprehensive?
The comprehensiveness or completeness of the WBS can be divided into two aspects - firstly ensuring that the end product has all the functionality that will satisfy the client’s needs, and secondly ensuring that all the different activities from the different disciplines required to successfully develop the deliverables are planned for. As seen previously, the newly proposed WBS development process is iterative and the first couple of passes through the process will not lead to a comprehensive WBS. Instead, the different WBS packages must be identified in time to be included in the time and cost estimation.

7.4.1 Functional completeness of the WBS
The aim of a functionally complete WBS is to plan the project in such a way as to ensure that the end product has all the functionality required to meet or exceed the client’s needs. The proposed new WBS development method helps to increase the completeness of the product’s functionality by developing the functional WBS before assigning deliverables to the functions, thereby ensuring some form of functional analysis.

7.4.2 Work package completeness of the WBS
To ensure that all the actions from the different engineering disciplines required to realise the project deliverables are planned, estimated and scheduled, the completeness of the WBS needs to be addressed. Structurally the proposed new WBS is no longer discipline-orientated, but deliverable-
orientated, increasing the responsibility of the person responsible for the functional WBS package. Traditionally the persons responsible for the separate disciplines in a discipline-orientated WBS were responsible for ensuring that their disciplines were represented in all the relevant WBS work packages. With the deliverable-based WBS the responsibility for integrating the different disciplines, ensuring that all the disciplines are present in the further expansion of the functional WBS, and assigning the deliverables to the functions lie with the person responsible for the functional WBS packages. This person will act as the system integrator for the functional work package.

The structure of the deliverable-orientated WBS therefore does not necessarily lend itself to ensuring the completeness of all the different discipline actions related to a deliverable, but the process of assigning deliverables to the product’s functions, together with the system integration responsibilities of the persons responsible for the functional WBS, will increase the probability of the comprehensiveness of the WBS.

7.5 Does the WBS facilitate the more accurate identification of the resources, technology and expertise required for the project?

Resources are identified from the WBS for each package. The correct choice of resources therefore relies heavily on the accuracy and completeness of the identified WBS packages. Developing the functional WBS and assigning responsibilities and accountabilities for realising the functional requirements helps in identifying the resources by means of functional capabilities and experience rather than specific discipline experience.

7.6 Do the WBS and the WBS development method reflect the systematic nature of the project?

The new WBS development method definitely helps in the development of a deliverable-based WBS that reflects the systemic nature of projects, especially projects that are complex and/or not familiar to the company executing the project. Even in the absence of system engineering, the process of developing a functional WBS and assigning deliverables to the functions has all the basic elements to help ensure the functional integration of the project.

7.7 Summary

To relate the qualitative analysis of the project success measures to a quantitative result, the author gave each standard answer a quantitative score related to its importance to the success of a project. For instance, a distinction is made between a parameter that only assists in improving the possible success of a project and a parameter that will improve the possible success of a project. Some parameters require added effort and/or responsibilities; they were therefore given a score reduced by 0.5. Parameters deemed not to assist in the possible success of a project or to only indirectly influence the project success, depending on the use of the parameter, were allocated a score of zero. Higher scores indicate a bigger possibility of a successful project.

<table>
<thead>
<tr>
<th>SUMMARY ANSWER</th>
<th>QUANTITATIVE SCORE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assist (A)</td>
<td>1</td>
</tr>
<tr>
<td>Assist with added effort (A+)</td>
<td>½</td>
</tr>
<tr>
<td>Not assist (NA)</td>
<td>0</td>
</tr>
<tr>
<td>Improve (I)</td>
<td>2</td>
</tr>
<tr>
<td>Improve with added effort (I+)</td>
<td>1½</td>
</tr>
<tr>
<td>Dependent on its usage (D)</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 3 Summary answers and quantitative score
The summary answers and quantitative scores for three different WBS scenarios for the example project are given in Table 4. The three scenarios include:

- the WBS developed using the traditional approach (discipline-orientated);
- a deliverable-based WBS not using the proposed new method;
- a deliverable-based WBS developed using the proposed method given in Section 5.

<table>
<thead>
<tr>
<th>WBS MEASUREMENT QUESTION</th>
<th>ANSWER</th>
<th>SCORE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does the WBS facilitate the accurate identification of the project complexity?</td>
<td>NA</td>
<td>A</td>
</tr>
<tr>
<td>Does the WBS accurately reflect the solution to the client’s needs?</td>
<td>NA</td>
<td>A</td>
</tr>
<tr>
<td>Does the WBS structure help in improving the estimation of duration and cost of the project?</td>
<td>D</td>
<td>A</td>
</tr>
<tr>
<td>Is the WBS functionally complete?</td>
<td>A</td>
<td>I</td>
</tr>
<tr>
<td>Does the WBS include all work packages?</td>
<td>A</td>
<td>I</td>
</tr>
<tr>
<td>Does the WBS facilitate the more accurate identification of the resources, technology and expertise required for the project?</td>
<td>A</td>
<td>I</td>
</tr>
<tr>
<td>Do the WBS and the WBS development method reflect the systemic nature of the project?</td>
<td>A</td>
<td>I</td>
</tr>
<tr>
<td>TOTAL</td>
<td>6 1/2</td>
<td>2 1/2</td>
</tr>
</tbody>
</table>

Table 4. Quantitative analysis of WBS-related project success measures

Table 4 shows that using a deliverable-based WBS will improve the possible success of a project considerably. Using the proposed deliverable-based WBS development method discussed in Section 5 further increases the possibility of a successful project.

8 CONCLUSION

The importance of the WBS in the project management process is clear. Any method that increases the quality of the WBS will therefore have a positive effect on the possible success of the project. Developing a deliverable-based WBS from a functional analysis of the project’s ultimate deliverable has shown that it has a positive effect on some project success measures. These measures include the identification of the project complexity, the completeness of the deliverables making up the total project, better time and cost estimation, better analysis of the clients’ needs, and the facilitation of the accurate identification of required resources and technology.
The analysis of the possible effect the proposed new WBS development method could have on the success of the project presented in this paper is hypothetical. More research is required where the method is used to develop the WBS for projects in the area of interest as given in Fig 2 and is used in the management of the projects. The actual success of projects could then be measured using the WBS-related project success measures.

More research work is also needed to relate the iterative WBS development process to the project life cycle phases.

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