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Towards a Proposed Process to Manage Assumptions during the In-Service Phase of the Product Lifecycle

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Abstract. Assumptions affect our everyday life and more specifically in business they can have a profound effect on an organisation's support services delivery performance if they prove to be wrong. The literature shows the need to identify assumptions and expose any implicit assumptions that may have a major impact on the business objectives. There are also examples of methodologies that suggest there are advantages in managing assumptions for strategic decision making. However, there is little research dealing with the ongoing assessment or review of assumptions when delivering support services during the In-Service phase of a product's lifecycle. The outputs of various government audit reports and independent enquiries suggest that erroneous assumptions are a potential cause of death or serious injury and substantial increases in costs or reductions in capability of major capital systems. This suggests that a method for the ongoing review and management of assumptions would be beneficial as an aid to the successful delivery of support services. An industry project was observed to gain an insight into how projects deal with assumptions. A number of methods from the strategic planning, risk management and reliability engineering domains are compared and these form the basis for a proposed process to manage assumptions in the In-service phase of a system's lifecycle.

Keywords. assumptions management, In-Service Support, Product Life-Cycle

1. Introduction

Nova Systems (Nova) is a Professional Service Provider specialising in the provision of engineering and management services that provides industry and government with independent expertise in delivering complex projects and solving technologically challenging problems. Nova has recently started working on two projects that are significantly higher value and duration than any other work carried out in the past. Both operate under a performance based contracting construct that puts an element of Nova's future profit at risk. Consequently Nova is keen to reduce and manage the uncertainty that goes with long term projects. One element of uncertainty could be linked to the assumptions that underpin a project's execution and their likelihood of proving false during the lifetime of the project. Potentially this could be addressed through a formal

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method that reduces the possible impact of assumptions that prove to be false when delivering support services to enduring systems. This, in turn, may improve Nova's service delivery and reduce the risk of losing the profit at risk.

The lifecycles of enduring systems (e.g. rail, ships, process plants, aircraft, lighthouses, nuclear power stations) are generally measured in the tens of years and in some instances the lifecycle could be over 100 years. These systems bring with them the need for ongoing support that can cost much more than their original purchase price [1]. Effective planning is required to gain the maximum utility from these systems during their in-service or operational phase that meets the organisation's desired outcomes. Although the physical attributes of the system may be known today humans are sadly lacking in their ability to predict the future and hence the conditions the system may encounter during its lifetime. This leads to a level of uncertainty during the planning activity and consequently assumptions are made about future states that may or may not prove to be accurate. The time horizon for these assumptions could be short term or long term and their potential impact could range from no effect to catastrophic. This naturally leads to the concept that some assumptions are more important than others and should warrant an increased level of scrutiny [2][3].

Assumptions are a part of our everyday life. Without them the decision making process would grind to a halt and nothing would get done. This extends into engineering where engineers are expected to use assumptions in their application of engineering methods when solving complex problems or applying appropriate techniques [4]. All business plans (whether they be strategic plans, project management plans, integrated logistics support plans, support services management plans, asset management plans or similar) are based to some extent on assumptions, either explicitly stated or implied. Typical assumptions may include availability of appropriately qualified personnel, equipment operating periods and rates of effort, availability of support equipment, and potential changes (or lack thereof) to relevant legislation. If the assumptions are not challenged or tested during the planning process or as the business context changes then it is probable that business outcomes could be impacted to the detriment of the business and the customer. Peter Drucker (1994) writing about what he termed "The Theory of the Business" highlights the potential impact of not reviewing and possibly changing assumptions as changes to the operating environment evolve [3]. What may have been sound assumptions in the beginning of an enterprise's or system's life may no longer hold true and, if this is not recognised, can lead to significant loss of revenue or even collapse [3].

2. Comparison of assumption identification and assessment methodologies

This chapter describes and discusses various methods found in the literature that consider assumptions and their potential impact as part of a business planning process. These methods will be compared to each other and to FMECA and risk management processes. The approaches or methods are:

2.1 Assumption-Based Planning

The aim of Assumption-Based Planning is to expose as many load-bearing assumptions as possible so that they can be appropriately treated in the planning process [2]. It is focused on improving an existing plan rather than the delivery of the planned activities.

It is important to note that the Assumption-Based Planning method is aimed at those assumptions that are affected by what the future holds and not those about how it is hoped the plan will perform [2]. This is a subtle distinction that appears to be a method for reducing the number of assumptions that need to be assessed and provides focus onto those assumptions associated with the way that the world may behave in the future. Although not particularly relevant to the Assumption-Based Planning process Dewar makes an important, albeit subtle, point that assumptions need not be explicit to everyone; just to the planners and decision makers in situations where exposure to a wider audience may put the organisation at a disadvantage [2].

The Assumption-Based Planning process is depicted in Figure 1 and comprises five steps:

- Step 1 is the analysis of these plans to identify the explicit and implicit assumptions on which they are based.
- Step 2 then identifies those assumptions on which the success of the plan rests (what Dewar calls the '*load-bearing assumptions*') and those that are most likely to be overturned by future events (the '*vulnerable assumptions*'). Assumptions that are both '*load-bearing*' and '*vulnerable*' are of particular interest as their impact could be significant if the assumption proves to be false.
- Step 3 identifies thresholds or events that when detected indicate that a vulnerable assumption has either failed or is about to fail. These thresholds or events are termed '*signposts*' and if a signpost event occurs then action is required.
- Step 4 considers actions that can be taken to support the success of the assumption i.e. reduce the possibility of it proving false. They are intended to deal with the vulnerability of load-bearing assumptions and are actions taken to reduce or eliminate any uncertainty in a vulnerable, load-bearing assumption. In the Assumption-Based Planning vocabulary these are called '*shaping*' actions.
- Step 5 determines the actions needed to prepare for the possibility of a load-bearing, vulnerable assumption failing. In Assumption-Based Planning vocabulary these are called '*hedging*' actions.

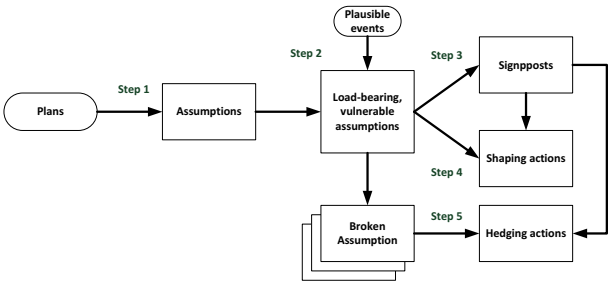

Figure 1. Assumption Based Planning [2].

The Assumption-Based Planning method provides a strong structure for identifying assumptions, assessing their impact should they prove false and approaches for determining appropriate actions to either eliminate or reduce the probability of an assumption proving false or actions to take in the event that it does fail. This appears to be similar to risk management methods. The weakness of the process is that there is no continuous review loop once the planning stage has been completed although it is quite

possible that the success or otherwise of the plan could be used as an input to future planning rounds.

2.2 Critical Assumption Planning

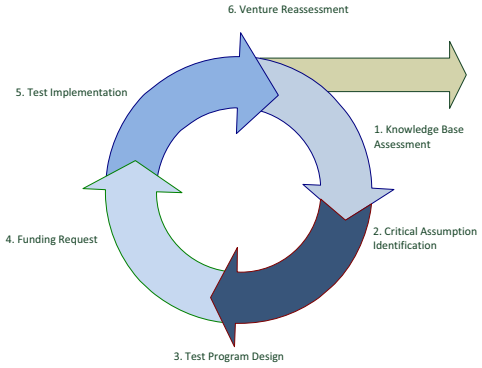

Figure 2. Critical Assumption Planning [5].

Critical Assumption Planning is a cyclical planning method predominantly aimed at new business ventures with the intention of challenging and testing assumptions based on the premise that "*surfacing and testing assumptions is the essence of running and managing a new business venture*' [5]. The method essentially develops a plan to test the assumptions on which a business venture is based and to use the results to refine the business plan. The process is depicted in Figure 2 and comprises six steps of which Steps 1, 2 and 6 are relevant to the subject of assumption management in a support system environment. Step 3 includes an element of contingency planning that deals with alternative actions to take should an assumption prove false when it is tested.

2.3 Active Threat and Opportunity Management (ATOM)

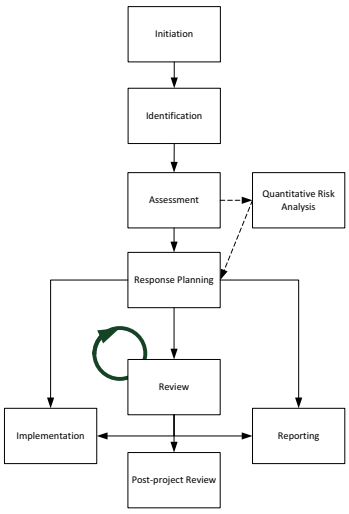

Figure 3. ATOM process [6].

ATOM is a process for the management of risk and opportunity throughout the whole project lifecycle from project initiation to closeout or handover. According to the authors it provides "*a simple method for effective risk management*". It includes an explicit analysis step to identify and assess assumptions during the 'Identification' stage of the process as part of .a risk workshop [6]. Figure 3 illustrates the ATOM process steps. It is noticeable that there are similarities between this process and the previous planning approaches or methods and that it includes a continuous review cycle.

The assumption identification process depicted in Figure 4 is as follows [6]:

- Examine the project's documentation, this could be bid documents, business plans or management plans. The expectation is that the documentation should contain all the assumptions and constraints that affect the project but this is not always the case and that implicit assumptions held by stakeholders have to be exposed [6].

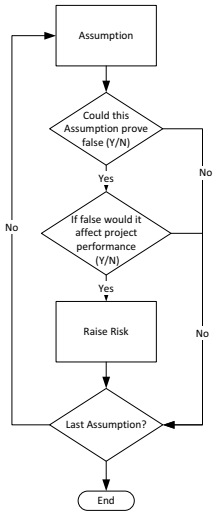

Figure 4. The assumption assessment process

- Identify and list the implicit assumptions through a facilitated discussion between all stakeholders based on work breakdown or risk breakdown structures.
- Continue the facilitated discussion to validate each assumption. This is likely to identify assumptions that can be considered safe i.e. unlikely to prove false and these can be excluded as potential risks. Note that the exclusion at this stage does not mean that the assumptions are ignored. They are revisited whenever a risk review is conducted.
- Determine the extent to which the remaining assumptions may affect the desired outcomes and then raise risks as necessary.

Although the ATOM methodology is applied to risk and opportunity management the assumption and constraints analysis could be adapted for the general management of assumptions throughout the In-service (operations) phase of a system's lifecycle [6]. This would entail replacing the 'raise risk' step with one that captures the way in which the assumption could be monitored, any mitigation or prevention actions and potential recovery plans should the assumption prove false. The ATOM methodology has strong similarities with the Risk Management process described in AS/NZS ISO 31000 [7].

2.4 Comparison with FMECA and Risk Management processes

Table 1 presents a comparison of the approaches described above with the FMECA and Risk Management processes for a number of factors that could be applicable to the management of assumptions during the In-service (operations) phase of a system's lifecycle. Because the ATOM methodology is similar to the Standards Australia Risk Management approach this has been excluded from the table. The factors and the questions they pose are:

- **Environment or System Boundary.** This sets the context for each of the methods. Although Assumption Based planning does not appear to have a stage that sets the environment or system boundary this may be because the starting point of assumption based planning is an already developed plan which in theory contains the context for that plan [8].
- **Identification.** Does the method have a step that identifies the analysis object? In the case of the approaches above this would be assumptions, in the FMECA the failure modes and in risk management identification of relevant risks.
- **Impact.** Are the potential impacts of a failure of the analysis object captured?
- **Causes.** Is the way in which a failure of the analysis object captured? In the case of an assumption this translates to identifying the possible reasons for it to prove false. According to Table 1 possible causes are only identified in the FMECA and Risk Management processes. This is a weakness of the other three approaches although it is possible that the signposts step of Assumption Based Planning is attempting to identify possible causes. If causes are not identified then it is difficult to see how treatment and mitigation strategies can be defined or implemented [8].

Table 1. Comparison of planning methods with FMECA and Risk Management.

Factor	Assumption Based Planning	Critical Assumption Planning	Scenario-based Strategic Planning	FMECA	Risk Management
Environment / System Boundary	No	Step 1 – Knowledge base assessment – strives to understand the business context and what is already known and unknown	Yes – the framing checklist used to create a common understanding of the scope of the project	System description and use	Yes – establishing the external context
Identification	Step1 – Identify the assumptions in the plan	Step 2 – Identify critical assumptions	Yes – 360° Stakeholder feedback process	Yes – list the potential failure modes	Yes – list the potential risks
Impact	Step 2 – Identify load bearing and vulnerable assumptions – determines those assumptions that are worthy of further analysis	Part of step 2 – use of business models to determine potential impact of assumptions on business outcomes	Yes – Impact / Uncertainty Grid	Yes – describe the effect on the system of the failure mode	Yes – describe the potential impact if the risk materialises
Causes	No explicit step	No explicit step	No explicit step	Yes	Yes
Likelihood of occurrence	Possibly part of Step 2 when determining vulnerability of an assumption in the plan's lifetime	No	Yes forms part of the Impact / Uncertainty Grid. Qualitative in the form of levels of uncertainty	Yes – failure rate or qualitative scale	Yes
Treatment or mitigation strategies	Steps 3, 4 and 5 – termed signposts, shaping actions and hedging actions. Signposts are warning signs that should result in management action. Shaping actions are intended to help the assumption hold true for the duration of the plan. Hedging actions prepare for the assumption to fail (what can be done now to mitigate the potential effect or what has to be in place should the assumption prove false).	Contingency planning element of Step 3 Assumption Test program	Yes – Strategy definition	Yes – through feedback into the engineering process. Also identifies existing control measures that may mitigate potential failures and their impact	Yes – action plans to remove the risk or deal with it when it materialises and becomes an issue
Review	No explicit step	Step 6 Venture reassessment.	Step 6 monitoring – although this is not an explicit monitoring of the assumptions but more to do with monitoring the plan's effectiveness.	Yes as part of the engineering management process	Yes – regular review as mandated by management plans and corporate instructions.

- **Likelihood of occurrence.** Within a timeframe of interest will an assumption fail or a risk event occur. In FMECA terminology this is the failure rate associated with the particular failure mode.
- **Treatment or mitigation strategies.** Does the method include a step to identify and document possible mitigation or treatments in the event that an assumption proves false or a risk event materialises. For failure modes this factor relates to existing controls that prevent a failure or its probability of occurring. Treatment beyond existing controls would require feedback into the overall engineering processes to effect a design change or implement new controls.
- **Review.** Are reviews a part of the methodology? Reviews may be one off events as is the case of a FMECA unless it is updated at some point in the future or regular events as is usually the case in a risk management regime. In the case of Scenario based strategic planning the monitoring process looks at the plan's overall effectiveness rather than specific assumptions. Should effectiveness drop off then assumptions would be revisited as part of the overall process [9].

3. Proposed assumptions management process model

Complex enduring systems tend to have Support System solutions and associated support services with lifecycles that can be measured in the tens if not hundreds of years and may have multiple stakeholders. This sort of environment is intrisically uncertain and affected by unplannable events [10]. As Hillson points out "*no one knows the future with perfect certainty*" and that making assumptions is a way of dealing with uncertainty by simplifying matters [11]. The issue is that the assumptions made today may either fail or become irrelevant due to changing circumstances. Furthermore, successful delivery of support services is reliant on the various assumptions holding true. It is clear that assumptions are an endemic part of any system support solution or support service. Overtime as the situation changes it would be prudent to revisit and reassess the assumptions in the light of experience gained, current knowledge and future directions. At the moment there does not appear to be a formal process that routinely reviews the assumptions on which a support solution or its associated support services are based. This chapter will describe a proposed process based on the literature and from project observations that is intended to assist projects pay more attention to assumptions.

3.1 Characteristics of an assumption management process

The analysis of the various approaches to assumption identification, risk management and FMECA suggests that an assumption management process should include the following:

- The context within which the assumptions exist is defined. What are the circumstances that lead to the need for an assumption?
- Identification of all the assumptions affecting the service delivery.
- Analysis of the identified assumptions to determine their potential impact on service delivery.
- Judgement about the importance or otherwise of the impact of the assumptions should they prove false.

- Determination of the likelihood that the assumption will prove false.
- Identification of possible indicators that the assumption is heading towards proving false. These indicators should enable action to be taken before there is any significant impact on service delivery.
- Identification of possible actions that can be taken to reduce the possibility of an assumption proving false.
- Identification of possible actions to take if the assumption does prove to be false.
- Recording the results of the analysis outcomes.
- Updating plans with the outcomes of any assumption analysis activity
- Regular review including when changes to the external environment occur.
- The process is continuous.

3.2 The lifecycle view of assumption management

Assumptions come into being the moment that any planning activity commences. They are usually used to fill gaps in knowledge or uncertainty about the future. The lifecycle starts with the analysis of support services definitions and requirements and an understanding of the support system and contract requirements. The analysis of these artefacts will identify the known facts and the gaps in knowledge (certainty and uncertainty). The known facts will feed directly into the planning process whilst the gaps in knowledge will be treated as assumptions or risks and these will then be fed into the planning process. The planning process may turn the gaps in knowledge into known facts and this will lead to a revision of the assumptions or risks. Conversely the planning process may result in more gaps in knowledge and uncertainty and this will need to be put through the assumption and risk analysis processes before being included in any resultant plan. Once the plan is established and the support services are delivered, the plan will be reviewed and this may require the assumptions to be revised. This could be through adding new assumptions, revising existing assumptions or retiring assumptions because they are no longer relevant to the delivery of support services.

3.3 Proposed assumption management process

Figure 5 depicts the proposed assumption management process. For simplicity the context and continuous review steps are not included. The process starts with the identification of all assumptions contained in the plans or derived from the contract requirements, support services requirements, support system description, support services definition and any other relevant source of information used to plan support services. At this step it is important to identify as many of the explicit and implicit assumptions as possible. A technique such as '*Looking for wills and musts*' should be utilised to seek out the implicit assumptions [2]. Engagement with stakeholders is another good method for determining assumptions [9]. When listing the assumptions Hillson recommends writing them in the form of '*IF this assumption proved false, THEN the effect on the project would be…*' [11]. Using this approach assists the assessment stage with the 'IF' side addressing the likelihood of the assumption failing and the 'THEN' side the impact if the assumption did fail [11]. Once as many as possible assumptions are identified and listed, the next step is to analyse each assumption. Starting with the first assumption two questions are asked that reduce the

list of assumptions to those that could affect service delivery performance and should therefore be monitored and managed going forward. The first question deals with assumptions that are highly unlikely to fail during the lifetime of the project. The next then decides that if the assumption did prove false would there be a significant impact on the service delivery. In either case if the answer is "no" the details are recorded for future reference.

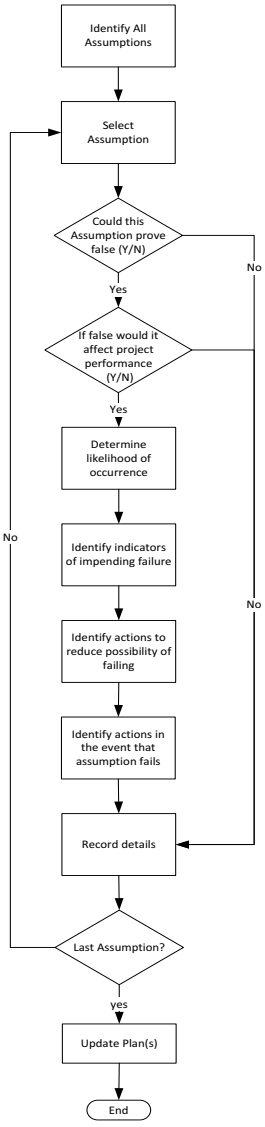

Figure 5. Proposed assumptions management process

If an assumption is likely to prove false and have an impact on the performance of the support services the next steps in the process assess the likelihood of occurrence and determine possible actions that either eliminate or reduce the likelihood of occurrence, give advance warning of impending failure or actions to take if the assumption does fail. The process is then repeated for the remaining assumptions until there are no more to be assessed at which point the results of the analysis are incorporated into the relevant plans.

One aspect of the assessment process is the decision about whether an assumption could prove false. There are two aspects to this question worthy of further discussion. These are the level of confidence that can be afforded to the assumption and how vulnerable the assumption is to a change in environmental circumstances. When the timeframe is relatively short, there is likely to be a high confidence that the assumption will hold true and less likely to be vulnerable to unforeseen changes in the operating environment. However, the opposite is true when the timeframe is relatively long such that confidence would be low and vulnerability would be high. Hence when determining if an assumption could prove false, then the planning timeframe must be taken into consideration.

4 Conclusions

Assumptions underpin most, if not all, In-service support plans and the delivery of support services. Once the plan is established and being executed the assumptions are rarely, if ever, revisited until either the contract is renewed or an incident occurs that affects support services performance. If assumptions are managed to the same degree as risk and opportunity then it is possible that there will be fewer surprises during the In-service phase of a system's lifecycle. Assumptions that prove false can have catastrophic consequences and for this reason alone it would be prudent to ensure that all significant assumptions are explicitly identified and recorded. Many assumptions go unnoticed because they are implicit and they are the most difficult to identify and bring into the open. Some implicit assumptions are the result of the organisations culture and are treated as fact without challenge. This has led to the

situation outlined in the Rizzo Report [12] where the RAN assumed a ship was 'safe to sail' unless proven otherwise or the Nimrod aircraft crash where it was dangerously assumed that because there had been no accidents that the aircraft was therefore intrinsically safe [13].

Various methodologies that identify, assess and treat assumptions were compared with each other and with risk management and reliability engineering. They show common themes between the various approaches including setting the context, identify the assumptions, assess their impact on the project and likelihood of occurrence and then determine an appropriate treatment. Not all methods included a review step but in the context of support services delivery over a long period this would be a sensible step to ensure that the assumptions are still relevant or are becoming vulnerable to the possibility of proving false.

A technique that identifies implicit assumptions contained in a plan was trialled in an industry project environment. The results were quite interesting and the exercise did reveal a number of assumptions that if they prove false could have a significant impact on the project's success.

A structured process for assessing, categorising and managing assumptions in a support services context is proposed to improve overall service delivery by potentially reducing the adverse impact of an assumption proving to be false. This is based on the methods outlined in the risk management and strategic planning literature. The proposed process could benefit to Nova Systems as it continues to provide engineering services to its many clients and moves into longer term contracts involving the Integrated Support Contractor construct. In the wider Support Systems community a thorough understanding of the potential impact of assumptions that prove to be false and putting more effort into the identification of implicit assumptions would benefit the design of Support Systems and the associated delivery of support services.

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