OVERVIEW

The results of life cycle costing must, whatever the phase of the programme, contribute to the process by which managers can make the best decisions on options presented to them. These options can include evaluation of future expenditure, comparison between alternative solutions, management of existing budgets, options for procurement and evaluation of cost reduction opportunities. Life cycle costing is also used for affordability assessment and determining the cost drivers associated with the Key Performance Indicators or Key User Requirements. There are many methods and models available to conduct life cycle cost estimates. It is important to understand the applicability and boundaries of each method and model in order to use them appropriately.

The core objectives of the SAS-054 Task Group were to understand NATO and PfP Nations' methods and models and to promulgate best practice within the NATO Phased Armaments Programming System (PAPS) phases. In order to meet this aspiration the following objectives were defined in the Task Group terms of reference.

O.1 REVIEW OF COST FORECASTING METHODS

The report has captured all the key estimating methods and provided examples to demonstrate their applicability. For consistency, both the methods and models have been categorised as Optimisation, Simulation, Estimation and Decision Support. The findings confirmed that almost all nations used a similar process to develop life cycle cost estimates; that the quality of the available data nearly always determined the method to be employed; and, in addition, that the type of study also influenced the process and the selection of the appropriate method.

O.2 REVIEW OF COST FORECASTING MODELS

In developing life cycle cost estimates all the nations have in-house developed models that are based on a defined Cost Breakdown Structure. Data for these models is estimated either by empiric methods or parametric formulae (for completeness, sometimes both techniques are employed). The findings confirmed that there were many life cycle cost models in use and these are identified within the report. Generally speaking, the use of more than one model to produce a life cycle cost estimate is considered good practice. This would provide verification of the life cycle cost estimate. However, the use of multiple methods and models should always be balanced with the knowledge and understanding of how the estimate will be used. It is important to ensure that the life cycle costing activities are conducted in a cost-effective manner and balanced with what is realistically achievable at a specific stage in the programme. It is also important to ensure that every model used for acquisition and life cycle costing is subject to calibration, verification and validation. This will build confidence that the cost model is fit for purpose.

O.3 GUIDELINES FOR THE COLLECTION AND UNDERSTANDING OF COST RELATED DATA FOR NATIONAL AND MULTI-NATIONAL PROGRAMMES

In terms of time, effort, and resources consumed, collection of data is a major part of a life cycle cost study. Life cycle costing is a data driven process, as the amount, quality and other characteristics of the available data often define what methods and models can be applied, what analyses can be performed, and therefore determine the usefulness of the results that can be achieved. Unfortunately, because uncertainty, risks, and opportunities decrease as the life cycle progresses, the need for knowledge is greatest at the earliest stages. This means that more time and resources should be allocated to the data

collection effort during the earlier stages of the life cycle in order to develop an acceptable and auditable life cycle cost estimate.

O.4 TREATMENT OF UNCERTAINTY AND RISK

Life cycle cost estimates of defence programmes are inherently uncertain and risky. Estimates are often made when information and data is sparse. Estimates, in turn, are based on historical samples of data that are almost always messy, of limited size, and difficult and costly to obtain. And no matter what estimation tool or method is used, historical observations never perfectly fit a smooth line or surface, but instead fall above and below an estimated value. To complicate matters, the weapon system under study is often of sketchy design.

For all of these reasons, a life cycle cost estimate, when expressed as a single number, is merely one outcome or observation in a probability distribution of costs. To better support the decision making process it is recommended that three point estimating is always undertaken. This study has captured a wide variety of methods and models available for conducting risk and uncertainty analysis of life cycle cost estimates of weapons systems. Each, if used properly, can give scientifically sound results and provide a better yardstick for an accurate life cycle cost estimate.

O.5 GUIDELINE FOR MULTI-NATIONAL PROGRAMMES

Multi-national programmes involve at least two nations who have agreed upon the main principles of co-operation in a Memorandum of Understanding, or an equivalent arrangement, for one or several phases of the entire lifetime of that programme. It has been found that the life cycle cost studies for multi-national programmes follow the same principles as national life cycle cost requirements. However, there are some specifics that have to be taken into account in terms of organisation, currency issues, studies, model(s) and presentation of the life cycle cost results.

O.6 REVIEW AND POSSIBLE ENHANCEMENT OF THE NATO GENERIC COST BREAKDOWN STRUCTURE

The NATO generic cost breakdown structure developed by SAS-028 has been reviewed by participating nations and organisations. Within the report it is recommended that some changes to the NATO generic cost breakdown structure be made based on recent OCCAR experience in implementing it on multi-national programmes.

O.7 AWARENESS OF NEW DEVELOPMENTS IN METHODS AND MODELS

A number of new developments have been identified that will impact on life cycle costing and analysis activities. Some appear to stem from changes in the types of studies being conducted (e.g. capability estimating, system of systems estimating, etc.). This will not change the way life cycle costing is conducted, but it has changed the interpretation of the costing boundary of the estimates.

In addition, to more effectively manage scarce defence resources, several NATO and PfP nations are initiating efforts to analyse the costs, capabilities, and risks within an entire portfolio of assets in a joint war-fighting environment. Viewing capabilities across the entire portfolio of assets enables the decision makers to make better informed choices about how to reallocate resources with the ultimate goal of delivering needed capabilities to the joint force more rapidly and efficiently. Capability portfolios are intended to serve as a basis for strategic level trade studies by senior decision makers.

It is recommended that further studies be conducted to better understand the life cycle costing requirements and benefits to the decision making process that these new developments may bring.

O.8 CONCLUSION

The report provides details on the findings of the Task Group into the methods and models being used for life cycle costing. In addition, it has examined data collection, the measurement of risk and uncertainty, new developments and other related life cycle cost issues. The report concludes with a number of recommendations to improve the use and understanding of life cycle costing in the decision making process. The most important recommendation is to implement this work as NATO policy.

O.9 KEY RECOMMENDATIONS

The following key recommendations are made with regard to the development and improvement in life cycle costing for multi-national programmes.

O.9.1 Life Cycle Costing Methods

1) Life cycle cost estimates should be fully documented (Sub-section 2.3.2)

- A cost analyst should be able to re-create the complete estimate working from the documentation alone.
- All assumptions and data related to the study should be captured in an MDAL or CARD or similar document.
- Assumptions recorded in an assumptions list such as the MDAL or CARD should be questioned by an independent technical team.

2) All life cycle cost estimates should be prepared by suitably experienced personnel (Sub-section 5.2.3.1)

- Decisions such as budget setting and options analysis studies are often conducted when data to support cost forecasting and life cycle costing is very sparse. It is therefore essential that experienced personnel are used to conduct the life cycle cost estimates to support the decision process at these key stages.

3) The life cycle cost analysis should include an affordability analysis (Sub-section 2.9)

- Affordability plays an important part in programme decisions throughout the life cycle. Even before a programme is formally approved for initiation, affordability plays a key role in the identification of capability needs. This aspect is part of the process which balances cost versus performance and in establishing key performance parameters. Although this is not common practice in all nations the assessment of affordability is one that we recommend should be conducted by all nations.

4) Life cycle cost estimates, where possible, should use two independent methods for each cost breakdown structure element (Sub-section 4.4)

- The use of two independent methods to develop the life cycle cost estimates will improve the confidence in the results and help to validate the outputs. It is accepted that this may be tempered by the constraints imposed by a financial threshold (see Sub-section 2.6) or by a simple consideration of what the estimate will be used for (e.g. rough cost for initial views or detailed costs for decision making).

O.9.2 Life Cycle Cost Models

5) All life cycle cost models should be validated (Sub-section 5.5)

- It is essential that all life cycle cost models implemented through spreadsheets or more advanced programming techniques be validated by using recognised testing processes. This will increase confidence that the model is fit for purpose and that the input data and results can be assessed through a clear audit trail and mathematical reasoning of any cost estimating relationships.

O.9.3 Data for Life Cycle Costing

6) Investments should be made to increase the accuracy, visibility, and availability of cost, programmatic, technical, and performance data within the NATO/PfP cost analysis community (Chapter 6).

- Data collection forms a large part of the life cycle costing activity and significant effort is expended to gather and analyse the data so that it is suitable for use in life cycle cost analysis studies. Improvements in data exchange standards or even the development of a NATO costing database would:
  - Improve the quality of the life cycle cost estimate;
  - Reduce the effort needed to conduct the life cycle cost estimate; and
  - Reduce the time schedule to conduct the life cycle cost estimate.

O.9.4 Multi-National Programmes

7) For multi-national programmes the participating nations should agree on a common LCC framework (Sub-section 2.10.6)

- The life cycle cost studies for multi-national programmes follow the same principles as those required by a national study. However, there are some specifics that must be taken into account in terms of organisation, models and the presentation of results. It is essential that all parties in a multi-national programme agree on a common life cycle cost framework. This framework is determined by the costing boundary and the tools that will be employed to populate the framework. A common framework will provide consistency, comprehensiveness, traceability and audit. All are essential to achieve life cycle cost estimates in a timely and responsive manner.

O.9.5 NATO Generic Cost Breakdown Structure

8) Enhancements to the GCBS (generic cost breakdown structure) to improve its use (Chapter 10)

- It has been found that most nations have not adopted the generic cost breakdown structure reported in RTO-TR-058 as their national life cycle cost breakdown structure. However, the NATO generic cost breakdown structure has been applied on specific multi-national programmes and some areas of enhancement are recommended.

  The current structure does not allow the identification of the life cycle cost results over the time phasing for national financial and programme contributions. Therefore, it is recommended to include two dimensions in addition to the Activity, Product and Resource dimensions. These additional dimensions are:
  - Time phasing; and
  - National contribution.

  As the coding of the Generic Cost Breakdown is complex for non-experts, it is recommended to adopt a Generic Hierarchy for the GCBS.

O.9.6 Uncertainty and Risk

9) Risk and uncertainty analysis should be conducted at the same time as the life cycle cost estimate (Sub-section 7.9)

- Life cycle cost estimates of weapon system acquisition programmes are inherently uncertain and risky. To better support senior leadership, some sense of risk and uncertainty needs to be presented at the same time as developing the point estimate. This will present the decision maker with a comprehensive true view of the programme's likely eventual outcome.

10) The results of a life cycle cost estimate should be shown as a three point range of estimates (Sub-section 7.9)

- A life cycle cost estimate is not a single number, but rather a continuum or distribution of possible values.

O.9.7 Further Studies

The following paragraphs outline recommendations for further studies that would benefit the understanding and use of life cycle costing in NATO and multi-national environments.

- The next logical step would be to demonstrate the proof of concept (methods and models) described in the report by using a practical application of the guideline.
  - A typical example could be an existing NATO programme (but only using data that was available at the time) and/or any other multi-national programme (e.g. AWACS, AGS, JSF, NH-90, FREMM).
- Further research should be conducted in the area of capability portfolio analysis (see Chapter 9). This topic of joint NATO/PfP operational activities is becoming more important to NATO and, at present, there is insufficient information on how to evaluate the situation where a number of discrete assets share the information/data to provide a total capability solution.
  - An investigation into new methods and databases would support this requirement.
- Research into the life cycle costs of software. This report has not addressed software cost estimating as it was felt that this was a subject in its own right. Many academic studies are being conducted into open system architecture, modular construction and system behaviours that employ software intensive configurations.
  - Much is known about modern techniques in software development, but the issue of assessing software quality, reliability and support costs is still vague.
- Life cycle cost estimates are produced for a variety of reasons. It would benefit the NATO community to investigate how the cost estimates are being used in the decision making process.
  - This could avoid the situation where enormous effort may be spent in generating cost estimates when the answer could have been given in a more simplistic and effective manner.
- Estimating accuracy has been an issue for many years. An evaluation could be conducted that studied the delta between the original cost estimates and the actual costs.
  - This would provide a benefit by having a definitive document that could provide a view of estimating accuracy across a number of procurement processes.

- Research should be conducted continuously to enhance methods and models for life cycle costing (Sub-section 4.4).
  - Periodically, the US Department of Defense undertake an initiative to review the basis and techniques employed in cost estimating. This is supported by industry, a number of academic groups and learned societies. However, these initiatives purely examine techniques that will be employed within the US. It would be beneficial to conduct a similar continual review across NATO and PfP nations.

- The SAS-054 study gathered information on each nation's approach and use of models to generate life cycle costs. The study did not get a clear comprehension on the range of the functionality that could be provided by some of these models.
  - It would be of benefit to look in more detail on how these life cycle costing models generate cost for Research and Development, Production, Operating and Support.

- The issue of calibration, verification and validation of cost estimating models is of paramount importance. However, little or limited space is given in handbooks on the requirements and methods of validating cost models.
  - A study could be initiated to develop a common methodology for validating cost models, this would help to ensure cost estimating consistency across NATO and PfP nations on each nation's approach and use of models to generate life cycle costs.

- All life cycle cost estimates are only as good as the data that underpins the estimate. Much investment has been made in adopting ERP-systems to support financial and project reporting. The use of these systems in providing good quality data to support life cycle cost estimating is not clearly known.
  - A study should be conducted to evaluate the benefits or otherwise in adopting an ERP-system versus the investment in a bespoke system (e.g. VAMOSC) to assist the life cycle cost data collection process and improve cost estimating methods and accuracy.