IMPLEMENTATION OF PERFORMANCE BASED SYSTEM ASSESSMENT OF MILITARY MULTI-MISSION PLATFORMS

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Abstract

In an effort to lower the overall cost of defence war-fighter acquisitions, the Commonwealth Government of Australia is imposing performance based contracting methods [1] upon contractors for acquisition and through life support. Whilst being relatively new to Australian Defence [1-3], performance based contracting is not a new concept to other industries around the world [4]. Demanding military aerospace acquisition and sustainment requirements however, present the defence industry with a significant challenge. This is inherent to the design of defence performance based contracts and each military performance based contract being different [4]. Considering these different requirements, the awarded prime contractor is presented with a variety of complex management and technical issues, particularly if that prime contractor is also responsible for multiple platforms and corresponding contracts.

This paper presents the, design and implementation of a Data Warehouse System for the management and analysis of performance based contracts which are specific to multi-platform military, rotary and fixed wing systems. The implementation encompasses a unique yet mandated [1],[3-4] group of Key Result Areas which were identified for a successful implementation of a performance based contract [3-4]. The Key Result Areas; Availability, Maintainability and Supportability are implemented as integrated Data Marts together with an abstracted Extraction Transformation and Loading (ETL) layer. The ETL layer provides the system with the unique capability of managing independent scoring requirements of multiple performance based contracts across multiple platforms. A role based, customizable Reporting and Analysis System is also integrated and implemented with the Data Warehouse, providing the capability to develop reporting specific to contract requirements and allow various data mining techniques for further analysis.

It is anticipated that this system will allow Australian Defence and subsequent prime contractors to minimize the resources required for metric analysis across a variety of data sources, track and monitor the progress of their respective performance based contracts, provide the foundation for simulation scenarios, data mining techniques, predictive analysis and decision support. The system provides the ability to measure an implementation of a PBC, and subsequently its level of applicability and subsequent optimization against the desired outcomes.

1 Introduction

Unlike the more conventional or traditional approach of purchasing a product or service, the strategy behind Performance Based Contracts/Logistics is for the purchase of outcomes [1],[3-4]. The outcomes are defined as Availability, Reliability, Maintainability and Supportability and each is associated with integrated Key Performance Indicators (KPI). These outcomes are common to both the United States Department of Defense and Australia's Aerospace System Division [3-4], however as the KPIs and in some cases the Outcomes are negotiated during the tender phase and the

award contract negotiation phase, each Military Aerospace PBC/PBL becomes unique [4].

The objective of this project is to implement three Data Marts, an example Extraction Transformation Loading layer and an example reporting system. This formulates the foundation for a generic Data Warehouse System design for management and analysis of PBC/PBL contracts which are specific to multi-platform Military, rotary and fixed-wing systems. Additionally, the system provides the capability to carry out simulation scenarios, undertake predictive analysis and utilize efficient data mining techniques.
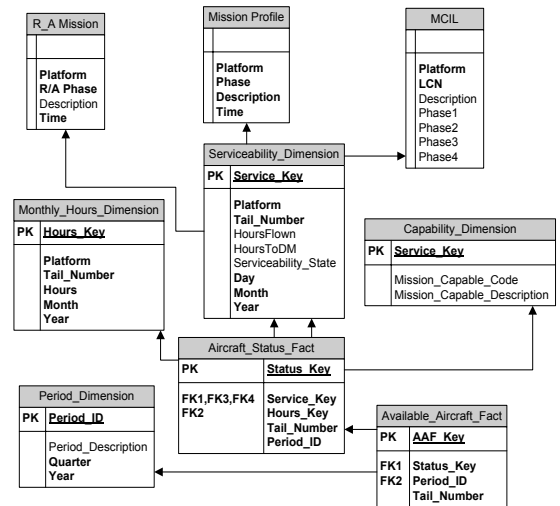
2 System Design

The system design, developed by Pozzetti et al (2010), is based on the ASD PBC framework.

2.1 Schema Design

During the system design, the following three facts associated with the Available Aircraft Outcome were identified; Available Aircraft, Aircraft Status and Aircraft Configuration. Considering Aircraft Configuration is controlled through 'Government Process' [3], and that Government processes need to be eliminated from the system, the potential for Aircraft Configuration to be hosted in an Entity Relationship format is considered.

Therefore, we are now left with Available Aircraft and Aircraft Status as our Fact Tables, with Serviceability, Time and Capability as the corresponding Dimension Tables, resulting in the Snow Flake schema shown in Fig. 1.

Fig. 1. Available Aircraft Star Schema

The logical model for the Demand Satisfaction Rate (DSR) Outcome identified DSR, Logistics 0 and Maintenance 0 as the three Fact Tables in addition to Logistics 1, Maintenance 1, Time, Demands, District, Stock and Warehouse as the supporting Dimension Tables and results in the slightly more complex Constellation Schema shown below in Fig. 2.
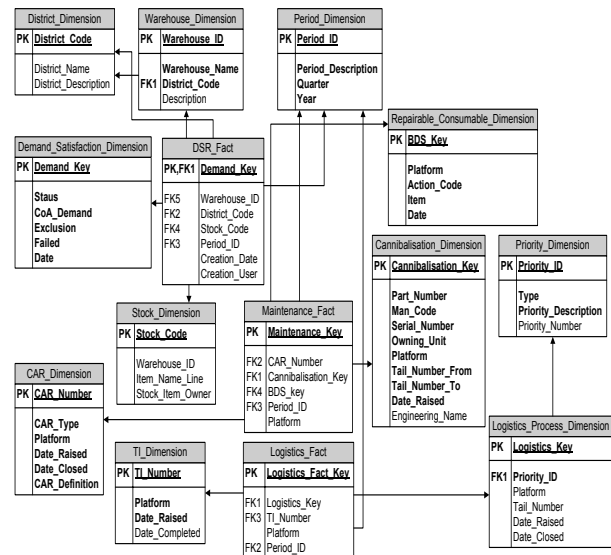

Fig. 2. Demand Satisfaction Rate Constellation Schema

The logical model for Outcome Mission Reliability identified Mission Reliability and Mission Abort as the Fact tables, with Failure, Mission Details, Environment and Time for supporting Dimension Tables and incorporating R/A Mission, Mission Profile and Mission Critical Item List as Entity Relationship Tables.

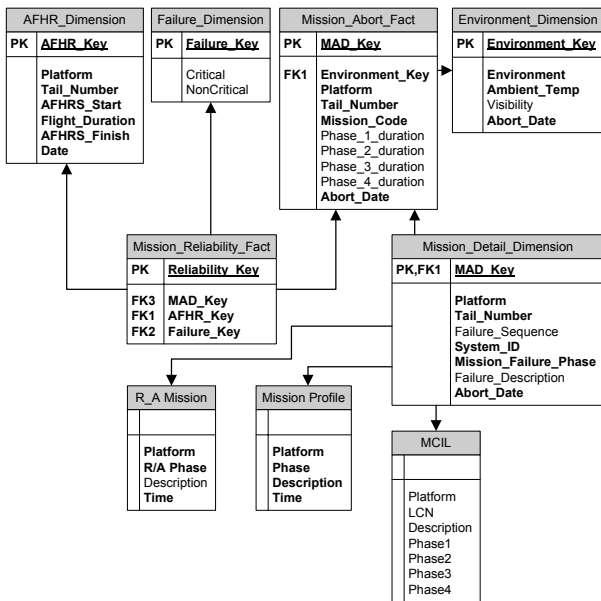This results in the Snow flake Schema shown in Fig. 3.

Fig. 3. Mission Reliability Snow Flake Schema

2.2 Extraction Transformation and Loading

Data Warehouses collect and store integrated sets of historical data from multiple systems, which becomes one prime source for all shared data. [5] A number of common tools are utilized in industry to extract data from data sources, and perform transformations for loading into the target Data Warehouse [5-6]. These tools are called Data Extraction, Transformation and Load (ETL) tools.

Transformation of data is traditionally performed during the preparation phase and before any data is loaded [5]. An understanding of the business usage and what business questions require analysis are both critical to determine the type of transformations necessary to develop the Data Mart [5]. This gives rise to the hypothesis formulated during the system design: the ability of using the ETL layer to cater for the requirements of each individual PBC, with the assumption that it is developed within the boundaries of a PBC Framework.

The PBC ETL Model will reflect a high level Data Flow Diagram, as shown in Fig. 4. below, then will be decomposed into specific ETL models with emphasis place on the

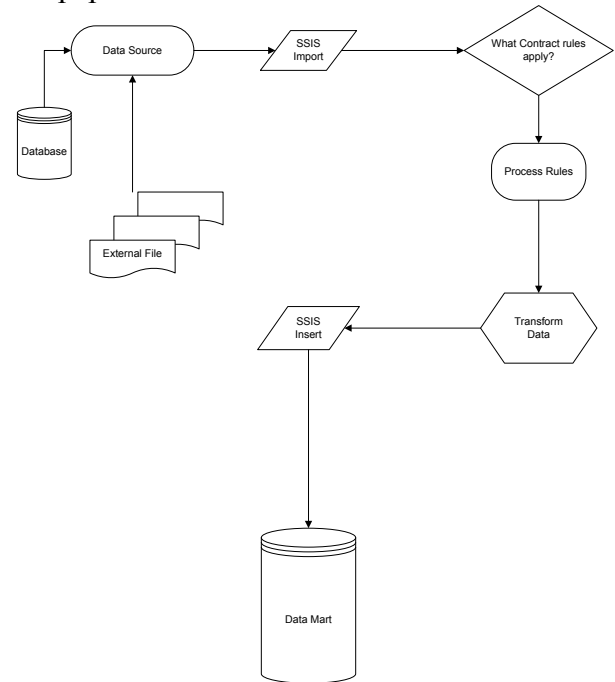Available Aircraft outcome for the purpose of this paper.

Fig. 4. High Level ETL Process

The logic of the above DFD can be described as:

➢ External Data Source, then
➢ Identification of applicable Platform and therefore,
➢ Identification of specific contract rules, then
➢ Calculation of applicable rules and formula, and finally
➢ Population of appropriate fact tables with calculated contract specific measures.

2.2.1 Available Aircraft ETL Process Model

The Level 0 diagram, as shown in Fig. 5, is used to segregate and determine appropriate scoring processes for each level of Aircraft Status; i.e. Fully Mission Capable (FMC), Partially Mission Capable (PMC) and Non Mission Capable (NMC). As stated earlier, the scoring process can be different for each individual contract [3-4], however as each contract is specific to a particular platform, we can allocate appropriate contract rules using the platform as the identifier. This Level 0 Process Model

identifies the Aircraft Platform, and the Aircraft Status. It then executes the Level 1 Process Model (Fig. 6) to import and distribute the data along with the appropriate score in accordance with the ASD PBC Framework. Once the Level 1 process is successfully completed, Status Calculation, Dimension and Fact inserts are then successively performed.
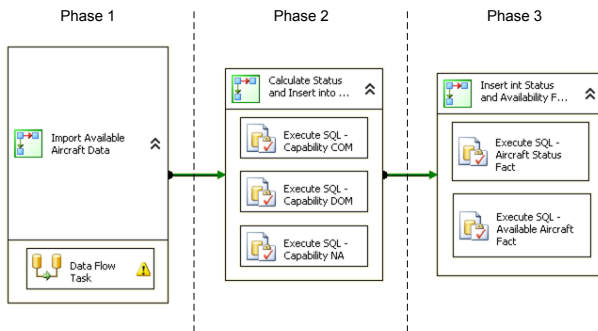

Fig. 5. Level 0 Available Aircraft ETL Process Model

The input into this process can come from numerous data sources, such as a host of existing databases or various file formats. The source data is checked for errors, such as missing or incorrect line items and invalid formatting. Depending upon the conditions of the data, the Level 1 ETL Process Model may be terminated at the input phase and corresponding invalid data may be written out to an error log for further investigation, in addition, and any changes made to the database will be rolled back and thus ensuring data integrity. The Data Process phase performs various data type format conversions, if required, to guarantee compatibility with the corresponding mapped data types in the host Data Mart. In the event of a problem with the conversions, error trapping can be used. Next is the Script Component, which is where we programmatically define and process any specific contractual requirements for the Aircraft Status.

Finally, the Output phase covers the configuration and insertion of data into the Data Mart destination. Error trapping can also be applied here in the event that the data insertion fails.
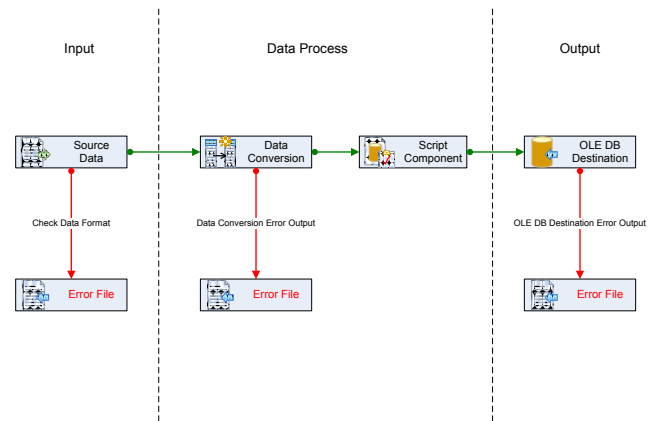

Fig. 6. Level 1 Available Aircraft ETL Data Flow Task Process Model

2.3 Reporting Layer

The reporting layer is designed to present data in a legible format to the user. For the purpose of this paper, we use Microsoft SQL Server 2005 Reporting Services, of which the system layout is displayed in Fig. 7 below.
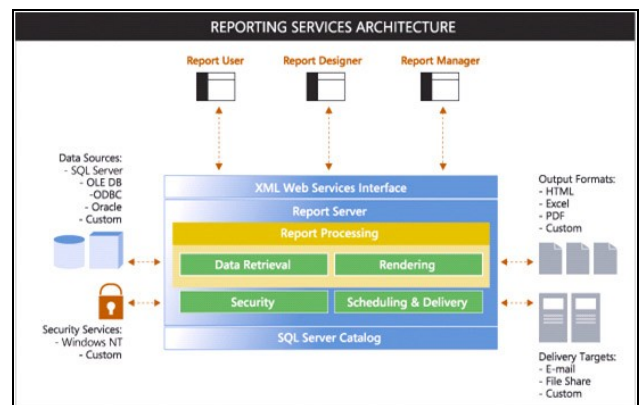

Fig. 7. Reporting Services Architecture (Source: Microsoft)

Microsoft SQL Server 2005 Reporting Services provide two built-in tools for report design; Report Builder and Report Designer. Report builder is a client-side web application which is used to build reports based on a published report model [7-8], whilst the Report Designer is a tool for creating and publishing report definitions [9].

3 Implementation

3.1 Introduction

This implementation is a proof of concept with heavy focus on the Available Aircraft Data Mart. As stated earlier, it is implemented using Microsoft SQL Server 2005 as the supporting DBMS. The ETL layer is implemented using a simple SQL Server Integration Services (SSIS) package, which is programmed to input test data from an excel spreadsheet, but is flexible enough to incorporate data from a variety of sources. Results were confirmed through the addition of a reporting layer.

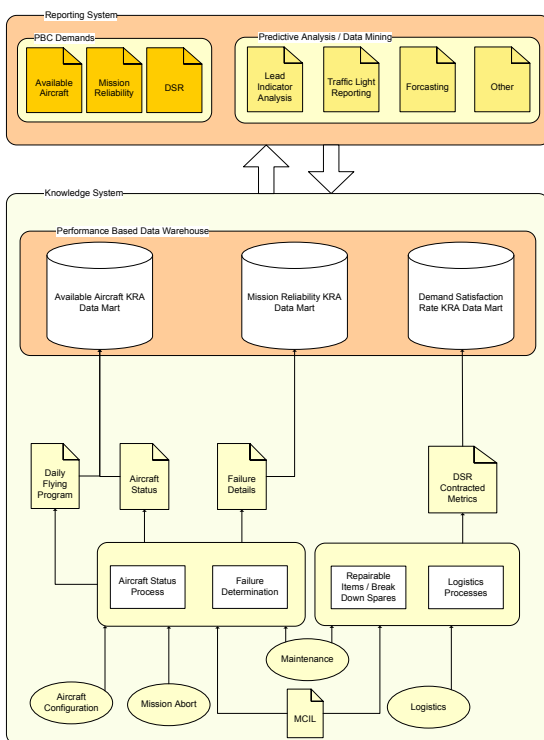The overall system design is represented in Fig. 8 below.

Fig. 8. High Level System Design

3.2 Data Warehouse

Each Data Mart was created, as per the schema design, using the Enterprise Management Console as supported by Microsoft's SQL Server 2005.

3.3 ETL Layer

The ETL layer was implemented with Microsoft's SQL Server supporting ETL toolset; SSIS packages developed with Business Intelligence Development Studio (BIDS).

As discussed in section 2.2, each PBC will be different [ref] and therefore the test system requires an example set of rules for implementation. For the purpose of generating sample data sets we have assigned the following scenarios and formats:

➢ MCIL is a once off load per platform and hence, per contract.

➢ The Period Dimension is a once off load, pre-populated upon Data Mart creation.

➢ The Daily Flying Program and Aircraft Status are Government Controlled processes [3] and therefore resulting data is required to be imported via ETL process on a regular basis. In this specific example, we are using a simple Microsoft Excel spreadsheet containing the required information.

3.3.1 Import Available Aircraft Data

The first of the three ETL phases under the level 0 process model, Import Available Aircraft Data initializes a container prior to carry out the Excel spreadsheet data import. A container in SSIS is used to group tasks which must succeed or fail as a unit and hence either commit or roll back all transactions made to the database [7],[10]. This ensures a 'clean' Data Mart independent of an import success or failure. The data import process, as shown in Fig. 6, contains Excel connection configuration, Data Conversion, Script Component, Data Insertion and Error Logging tasks.

The serviceability test data covers all aircraft scenarios for two tail numbers of the same platform, repeated at random to give a range of 245 unique records for all columns in the Serviceability Dimension. A snapshot of the test data is displayed in Table 1 below.

Table. 1. Serviceability Sample Data Set

NH	40002	NULL	NULL		7	Dec	2008
NH	40002	NULL	NULL		8	Dec	2008
NH	40002	NULL	NULL		9	Dec	2008
NH	40003	NULL	NULL	DOM	16	Feb	2009
NH	40003	NULL	NULL	COM	22	Jan	2009
NH	40003	NULL	NULL	A	18	Dec	2008
NH	40003	NULL	NULL	A	19	Dec	2008
NH	40003	NULL	NULL	A	1	Jan	2009
NH	40003	NULL	NULL	A	20	Dec	2008

Considering that both the Connection Configuration and Error Logging is relatively self explanatory, we will move directly into the Data Conversion. The Data Conversion Task is necessary to ensure that the sample dataset is in a format compatible with the corresponding records in the mapped Data Mart tables [5-6],[11]. For example, we found that string lengths required correction and other non-integer fields required conversion to an integer format. The Script Component was developed to eliminate leading and trailing whitespaces, which we discovered to be a problem when importing data from an Excel spreadsheet.

Once these tasks are successfully completed, the process then executes the Data Insertion task which distributes data according to the configured table mappings. Successful completion of this task concludes the first phase and triggers the second phase, "Calculate Status and Insert into Dimension"

3.3.2 Calculate Status and Dimension Import

Using Structured Query Language (SQL), the second phase queries the serviceability data from the first phase and calculates the Capability according to the test dataset in Table 2, and adds a row to the Capability Dimension.

Table. 2. Serviceability Capability Definition

Serviceability State	Capability
A or DOM	FMC
CDM or COM	NMC
'null'	NA

3.3.3 Fact Table Import

The third phase is responsible for populating the Fact tables and like the second phase, it is triggered on successful completion of the previous phase.

The Aircraft Status Fact Task generates a key record for each daily serviceability state inserted with the Data Flow Task. Each row calculated is unique by platform, tail number and date. Then finally, the Available Aircraft Fact Task inserts a separate row for each tail number confirmed to be fully mission capable.

These fact tables, like in other Data Warehouse systems [5-6], allow the user to generate summary reports, drill through reports and formulate the basis for performing analysis and data mining.

3.4 Reporting

As stated in section 2.3, the Reporting layer was configured using Microsoft SQL Server 2005 Reporting Services and reports developed with Report Builder. Standard Microsoft guidelines [9],[12] were followed for the initial setup and configuration of Reporting Services. Whilst, Report Models for each Data Mart were generated and published to the inbuilt Reporting Services website.

Individual reports themselves are then developed from the Report Builder using standard Microsoft guidelines and help [13]. An example of a developed and deployed report displaying cumulative results of mission capability is shown in Fig. 9. This example report provides a simple breakdown of serviceability per tail number across a set time period and is presented in two formats, a bar graph and matrix table.
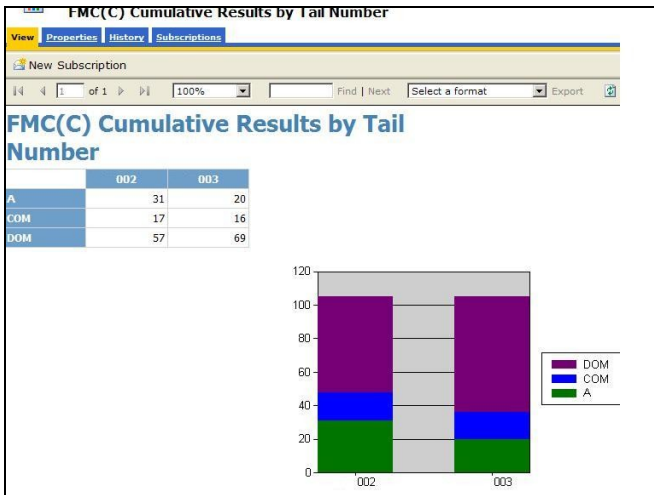
Fig. 9. Example Report Developed with Report Builder

4 Results and Discussion

Building upon the design developed by Pozzetti et al (2010), and through utilizing one of the more common [14] supporting DBMS platforms, we have shown how it is possible to manage and report on multiple Performance Based Contracts through categorization within the ETL layer. The system then manages and distributes PBC data according to specific embedded contract rules, providing the user with the ability to produce reports independent of supporting technology [15-17].

This system lays the foundation for a number of possible analysis options. Data Cubes can be generated from a combination of Fact, Dimension and Measurement tables, upon which data mining and predictive analysis can be performed [5-6],[18-20]. Additionally, contractual KPI/KRA target values can be configured against the appropriate Data Cube to present the user with an automated dash board of information [21]. Another analysis option is, the ability closely investigate the inter-relationships of targeted KPIs and avenues for optimization given a set of scenarios. Granting the user with the ability to predict and simulate the impact of a proposed PBC during the tender bid phase.

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