

## **Development of a Naval Reserve Training and Career Progression Analysis Application**

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**Abstract:** Within the Canadian Armed Forces (CAF) Naval Reserve (NAVRES), attrition has outpaced recruitment since 2010. In the current fiscal environment, resources for recruiting are limited; this further increases the pressure to improve retention to ensure a sufficiently large workforce. For some years now, there has been concern that personnel tend to leave the organization when they are unable to commit the time required to complete the training necessary for career advancement. This concern is particularly applicable to part-time personnel, who are more likely to have demanding personal or professional commitments outside of the NAVRES (e.g. a full-time civilian job). A stronger understanding of members' career progression patterns and challenges, such as major barriers in completing training, would help the NAVRES to identify key target areas for improving the efficiency of the system such that personnel would be more likely to remain in the NAVRES and advance further in their careers.

A user-friendly, flexible application was developed to enable NAVRES planners to investigate personnel management questions. The application enables the user to conduct a cohort analysis to trace the career path of each person in a population of interest, from the time of joining the population to the time of leaving (or up to the time that the analysis is carried out). In doing so, the user is able to address questions such as: What percentage of personnel achieves a particular qualification? How long does it take for personnel to achieve that qualification? After a certain number of months or years of service, how many of the key training courses have personnel completed? Among those who left the population of interest within a certain period of time, how many remained in a different element of the CAF, and how many left the CAF entirely? Further, the answers to these questions can be compared across different subgroups of the overall population; e.g. for full-time vs. part-time personnel, or across personnel serving in different occupations.

This paper will provide an overview of the application, and will address some of the challenges that were encountered, such as dealing with incomplete or inconsistent data. An example focusing on a specific occupation will also be provided as a demonstration of the breadth of results that can be obtained using the tool.

**Keywords:** workforce modelling; cohort analysis; training; career progression

### **1. Introduction**

#### **1.1 Rationale**

Within the Canadian Armed Forces (CAF) Naval Reserve (NAVRES), attrition has outpaced recruitment since 2010. In the current fiscal environment, resources for recruiting are limited; this further increases the pressure to improve retention to ensure a sufficiently large workforce. In recent years, there has been concern within the NAVRES that personnel tend to leave the organization when they are unable to commit the time required to complete the training necessary for career advancement.

This concern is particularly applicable to part-time personnel, who are more likely to have demanding personal or professional commitments outside of the NAVRES (e.g. a full-time civilian job). Indeed, several previous studies have found that part-time reservists have limited availability to undergo full-time training (Jenkins 2005a; Mehmood 2007); and further, that outside commitments discourage some personnel from pursuing full-time service (Jenkins 2005b). A stronger understanding of members' career progression patterns and challenges, such as major barriers in the training system, would help the NAVRES to identify key target areas for improving the efficiency of the system such that personnel may be more likely to remain in the NAVRES and advance further in their careers.

#### **1.2 Previous Research**

Unlike most civilian organizations, in military organizations, personnel generally join at the entry level having little or no experience in the military domain, and progress to higher ranks as they gain knowledge and experience (Boileau 2012). A consequence of this type of system is that decisions (e.g. changes to training systems, policy changes, etc.) can have long-term consequences. Thus, to ensure an adequate supply of

trained personnel, military organizations must conduct workforce planning activities on an ongoing basis (Wang 2005), whether through data analysis, modelling and simulation, or other techniques. A large volume of research has been done in this area, covering a wide variety of techniques and subjects. While only very little published research has pertained to the NAVRES in particular (e.g. the systems dynamics model developed by Mehmood (2007)), if we look beyond the NAVRES, we find that some previous work has elements in common with this study.

Training is an important element of a military member's career development, so workforce planning activities in this area are of great interest to decisionmakers. Within the Canadian military context, workforce planning research pertaining to training often examines the early stages of one's career (Christopher 2009; Latchman and Michaud 2010; Straver et al. 2009), but can also focus on training at more advanced levels (Moorhead 2006; Straver 2012a; Woodill 2005).

Focusing on analysis techniques, while cohort analyses are very common in the medical field, this approach also has workforce planning applications. Within the CAF, it has been used to examine issues such as calculating early-career attrition (Latchman and Michaud 2010), measuring the time to completion of basic occupation training (Straver 2012b), and estimating the cost of implementing a change to promotion policy (Straver, Latchman, and Tabbenor 2013).

### **1.3 Aim**

The aim of this study was to enable NAVRES planners to better understand training and career progression patterns and challenges within each NAVRES occupation. This was done by developing an application that would enable the user to obtain the answers to a variety of questions, including (but not limited to):

- What percentage of personnel achieves a particular qualification?
- How long does it take for personnel to achieve that qualification, and has this changed over time?
- After a certain number of months of service (MOS), how many of the key training courses have personnel completed?
- Among those who left the population of interest within a certain number of MOS, how many transferred to a different occupation in the NAVRES, how many transferred to the Regular Force or another element of the CAF, and how many left the CAF?

Further, the application would allow the user to compare the answers to these questions across different subgroups of the overall population; e.g. for full-time vs. part-time personnel, or across personnel serving in different occupations.

## **2. Methodology and Application Development**

This section outlines the overall approach used for the analysis, as well as details on the development of the application.

### **2.1 Cohort Analysis**

To answer the questions stated previously, it is necessary to trace individuals through their career from the point of joining the occupation to the point of leaving (or to the date of the most recent available data set). A cohort analysis was identified as the best way of solving the problem.

In a previous study (Straver, Latchman, and Tabbenor, 2013), the CAF population hired within a specific time period was tracked through 72 months of service (MOS) and separated according to whether they remained in the population or not; those who remained were further separated by rank. Here, a similar approach was taken, though at a higher level of detail.

### **2.2 Building the Application**

The decision was made to provide the NAVRES with an application that staff could use themselves. This approach has two main advantages over having DGMPRA conduct the analysis and provide the end results to NAVRES staff:

- NAVRES staff can use the application to answer a wider variety of questions, rather than having DGMPRA focus on answering only the highest-priority questions.
- With minimal support from DGMPRA, NAVRES staff will be able to re-use the application for years to come as newer data become available. This could be done to, for example, evaluate the impact of a change to the training system by comparing the results from before and after implementation.

These advantages came at only minor costs during the development of the application. First, additional time was required to implement rules-based solutions to account for data irregularities, rather than applying “band-aid” solutions (e.g. manual correction of errors). Additionally, it was necessary to take the time to design a user-friendly interface, and to provide supporting documentation. Importantly, the documentation needed not only to include instructions for use, but also to identify the application’s assumptions and limitations.

An additional constraint was that the application needed to be built in an environment that NAVRES staff would have access to, i.e. using commonly available software. Although some of the pre-processing of the data was done in an MS Access database, the majority of the analysis, along with the user interface itself, was implemented in MS Excel.

The remainder of this section will provide an overview of how the application was built, from a description of the necessary data to the user interface. Sample results will also be provided to demonstrate the key metrics that can be obtained.

### 2.2.1 Data Source

All data used for this study were taken from the Naval Reserve Information Management System (NRIMS), updated to 27 May 2013. This database contains information on each member of the NAVRES, going back to the 1990s. For this analysis, all of the required information was extracted from seven key tables:

- *MOS\_HIST*. This table contains data on the occupation(s) that each person served in (or is serving in), including start and end dates (if applicable) for each case.
- *ELEMENT\_HIST*. This table gives the time periods (i.e. start and end dates) during which each person served in an element of the CAF. In this study, the element of greatest interest is the NAVRES. However, personnel may have spent time in a different element before joining or after leaving the NAVRES, such as in another primary reserve element (e.g. the Air Reserve or the Militia), the Supplementary Reserve, or the Regular Force.
- *ENROLMENT\_RELEASE*. Although this table includes information on enrolments as its name suggests, only data on releases were used; most notably release dates, and to a lesser extent release items (i.e. release reasons, such as voluntary or medical). Of interest, a release date often (but not always) exists even in cases where an individual transferred from the NAVRES to a different element within the CAF.
- *EMP\_HIST*. This table was used to identify the time periods during which each member worked on a Class B or Class C contract. Reserve service falls into three classes. Class A service is considered part-time and is applicable when the member serves for periods of 12 consecutive days or less. Class B service is applicable when the individual is on full-time service of a temporary nature, for periods of 13 consecutive days or more. Class C service refers to full-time service that is not of a temporary nature (DSCS, 2006). Reservists will frequently move between the three classes. As will be discussed later, as an approximation for the purposes of this study, the time spent on Class B and Class C contracts is used to differentiate between part-time and full-time personnel.
- *QUAL\_HIST*, *QUAL\_VIEW*, and *CAREER\_PROG*. Personnel will complete a number of courses during their career, some of which will lead to the achievement of particular qualifications that are required for career progression. The *CAREER\_PROG* table specifies the normal sequence of qualifications applicable to each occupation; together with *QUAL\_HIST* and *QUAL\_VIEW*, the dates of achievement of these qualifications can be obtained for each person.

### 2.2.2 Pre-processing of Data

The first step of the analysis was to pre-process the raw data from the NRIMS tables listed above to extract the required data elements required for each person in the data set, and to clean the data in doing so. Each data element is described below.

- *Occupation*. Within the CAF, changes are frequently made to occupation structures; occupations may merge, divide, or be renamed. All obsolete occupations were translated to their current equivalents.
- *Start Date*. For each combination of service number (SN) and occupation, the first instance of the start date in the occupation was identified, regardless of which CAF element the member was serving in at the time (e.g. NAVRES, Regular Force, etc). Next, these data were filtered to include only the cases where the member was in the NAVRES at the time. This approach ensured that only personnel who were joining the occupation for the first time would be included in the analysis. Otherwise, a bias

would be introduced by the inclusion of personnel who already had some qualifications in the occupation upon joining the NAVRES.

- *End Date.* For each instance of joining a NAVRES occupation as identified in the previous step, the time of leaving the occupation was determined. While this information was generally included in the MOS\_HIST table, there were a number of unexpected null values. For this reason, the end date was calculated as the minimum of the occupation end date (from MOS\_HIST), the element end date (from ELEMENT\_HIST), and the release date (from ENROLMENT\_RELEASE, filtered to capture the earliest instance that occurred after the date of joining the occupation). Some further validation was required. For example, cases were found where the MOS\_HIST table indicated that a person left an occupation on one day and restarted in the same occupation on the next day. In these cases, the data were modified such that a continuous period of service was reflected. Similarly, cases where an individual joined and left an occupation on the same day were excluded.
- *Destination.* Through manipulation of the MOS\_HIST, ELEMENT\_HIST, and ENROLMENT\_RELEASE tables, upon leaving an occupation, personnel were categorized according to whether they left the CAF and did not return, left the CAF but returned after a break in service, transferred to the Regular Force, transferred to another NAVRES occupation, or transferred to another CAF element. It is worth adding that information on the release type was also collected in case it would be required for future use; however, since the vast majority of releases were voluntary, this was not considered to be of great interest at this time.
- *Time on B/C Contract.* After obtaining the start and end dates of the time served in an occupation, the employment data from the EMP\_HIST table was used to determine how many of these days the person spent on a Class B or Class C contract, i.e. how many days were spent working on a full-time basis.

Once these data elements were obtained, they were filtered according to the occupation being analyzed, and exported into the application. Next, the qualifications associated with the occupation, along with the achievement dates, were exported for each person in the data set for further processing within the application.

### 2.2.3 Data Manipulation

The next steps of the analysis are done simultaneously from within the application as it is being used. Although this adds considerably to the file size, it has the advantage of transparency; this can help the user identify the reasons behind any counter-intuitive findings, and to correct for any remaining data anomalies that were not already removed in pre-processing.

After pre-processing, the data are structured as a table with each row representing a different person in the population. Each row contains the person's SN as well as the pertinent data elements. At this point, all data points are included in the data set, i.e. all personnel who joined the occupation for the first time since 1 January 1998. The data are then filtered according to the specifications set by the user (discussed later in this paper). An additional filter allows the user to exclude any rows that he/she does not wish to include; this is useful for excluding data anomalies.

Through the use of lookup tables to relate the qualification data to each person's dates of joining and leaving the occupation, the application calculates the MOS that each individual had at the time of achieving the qualifications required for career progression. In cases where the qualification was never achieved, or where the qualification was achieved after the time of leaving the occupation, data are excluded by setting the MOS to an arbitrary high value (9999).

Based on these calculations, the highest qualification achieved as of each MOS point is determined for each person in the filtered data set. These are then summed to enable the overall results to be obtained.

A similar approach is taken to evaluate, at each MOS point, how many personnel remain in population, and to separate the "leavers" according to the destination groups described previously.

### 2.2.4 User Interface and Sample Results

In this section, the user interface is described, along with key metrics of interest to NAVRES staff. All examples are taken from the analysis of the Maritime Surface and Subsurface (MARS) occupation.

The user interface for the MARS occupation is shown in Figure 1. Labelled items are discussed below.

MARS (MOSID 00207)					Enter MOS point to be analyzed: 96			
Range for Occupation Start Date		1	01-Jan-98	31-Dec-04	(min = 1 Jan 1998, max = 27 May 2013)			
Range of Class B/C Days Worked / Days in Occ			0%	20%	Suggest 0%-20% to capture part-time personnel; 70%-100% to capture full-time personnel.			
Date of NRIMS Extract			27-May-13	3				
Latest Valid MOS Point			100					
2					4	5	6	7
Qualification	Order	BTL	Rank	Include in Graphs	Average Time to Completion (if achieved by 96 MOS) (Excludes those who had qual upon entry into occupation)	% Achieved Qualification (if achieved by 96 MOS) (Includes those who had qual upon entry into occupation)	% Achieved Qualification (if achieved by 96 MOS) (Includes those who had qual upon entry)	For Selected Qualifications: Completion Rate by 96 MOS
BMOQ	1	1	A-SLT	1	4.4	69%	100%	69%
NETPO DL	2	1	A-SLT		8.6	60%	100%	
NETPO F2F	3	1	A-SLT	1	8.3	58%	100%	84%
MARS 3	4	1	A-SLT	1	22.6	34%	100%	59%
MARS 4 PT1	5	1	A-SLT		29.2	32%	96%	
OOD DL	6	1	A-SLT		32.9	26%	100%	
MARS 4	7	1	A-SLT	1	37.5	22%	96%	63%
OOD AFLOAT	8	1	A-SLT	1	40.0	21%	96%	95%
BWK	9	1	LT(N)	1	41.2	21%	96%	100%
BOC MOD 1	10	0	LT(N)		50.2	12%	58%	
BOC MOD 2	11	0	LT(N)	1	50.4	12%	58%	58%
MWBC	12	0	LCDR		61.0	8%	46%	
COPS MOD1	13	0	LCDR					
COPS MOD2	14	0	LCDR	1				
JCSF DL	15	0	CDR	1				
AEDP	16							
AEFG	17							

Figure 1: User Interface

In Item 1, the user specifies the range of occupation start dates that should be included in the cohort analysis; that is, personnel who joined the occupation outside of these dates are excluded. The dates may range from 1 January 1998 to the date of the NRIMS update. It is necessary for the user to select a wide enough range such that the data set is sufficiently large to be able to extract valid results; however, the user must also take into consideration the latest valid MOS point that will result. The latest valid MOS point is based on the difference between the upper end of the selected date range and the date of the NRIMS update; thus, it refers to the MOS served by those who joined the occupation on the last day of the selected range. Results can be shown only up to this MOS point. If, for example, the user selects a date range from 1 January 1998 to 31 December 2012, only data up to 4 MOS can be analyzed, since those hired on 31 December 2012 would only have 4 complete MOS as of 27 May 2013.

Also in Item 1, the user selects the range of the ratio of Class B or Class C days worked to the total number of days in the occupation. As noted previously, Class B and Class C reservists are considered full-time. As an approximation, a range of low ratios (e.g. 0% to 20%) will capture part-time personnel, whereas a range of high ratios (e.g. 70% to 100%) will capture full-time personnel.

Item 2 shows the sequence of qualifications in the career progression for the occupation, along with the rank associated with each qualification. The Basic Training List (BTL) column indicates whether the qualification is part of basic occupation training or more advanced training that would taken after an individual is considered qualified in his/her occupation. All of these are specified in the NRIMS; note that the application can accommodate up to 40 different qualifications. The user can then select which of these qualifications he/she wishes to be shown in the results. It may not be desirable to select all qualifications; rather, the user may wish to focus on the qualifications that involve lengthy training courses, or to ignore the initial phases of training, or to focus on a specific rank, etc.

In Item 3, the user specifies the MOS point that is to be analyzed. This can be any MOS point up to the latest valid MOS point identified in Item 1.

Items 4 to 7 give some of the key metrics. Of note, all of these metrics pertain to qualifications achieved by the MOS point being analyzed, as specified by the user.

Item 4 gives the average time to completion of each qualification, which is based only on the personnel who did not have the qualification upon entry into the occupation. As noted above, no personnel in the data set should have any of the qualifications that are exclusive to the occupation being analyzed; however, some may

have qualifications that are shared with other occupations, such as the Basic Military Officer Qualification (BMOQ).

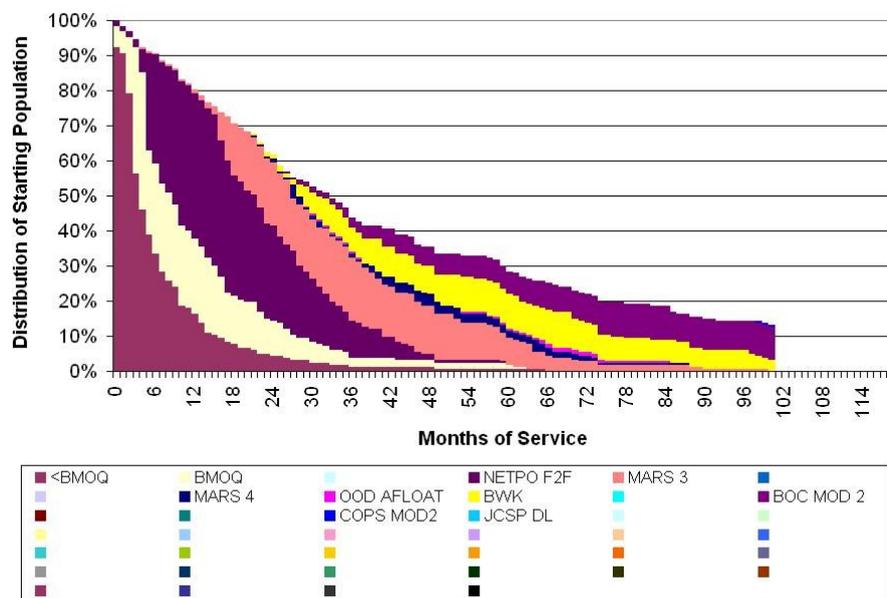
Item 5 gives the percentage of the starting population that achieved each qualification. Item 6 is similar, but gives the percentage of the *remaining* population (i.e. of those who did not leave the occupation before the specified MOS point) that achieved each qualification.

Item 7 gives what is perhaps the most interesting of this set of metrics: the percentage of those who achieved the qualification, *measured out of those who achieved the previous qualification*. This is particularly useful for identifying common “off ramps” in the training system. From Figure 1, we can see relatively low completion rates for MARS 3 (out of those who completed NETPO F2F); for MARS 4 (out of those who completed MARS 3); and BOC MOD 2 (out of those who achieved BWK).

Even more useful results can be obtained by comparing these results with those of a different population. For example, if we change the parameters to capture full-time personnel rather than part-time personnel (by changing the range of the Class B/C ratios in Item 1 from 0%-20% to 70%-100%), we obtain the following results: 92% of those who completed NETPO F2F also completed MARS 3 (vs. 59% of part-time personnel); 97% of those who completed MARS 3 also completed MARS 4 (vs. 63% of part-time personnel); and 94% of those who achieved the BWK also completed BOC MOD 2 (vs. 58% for part-time personnel). Results like this can help NAVRES planners determine which training courses are the most problematic for part-time personnel to complete.

Although the user can obtain the above metrics for any MOS point, certain metrics are better presented in graphical form. Two examples are given below.

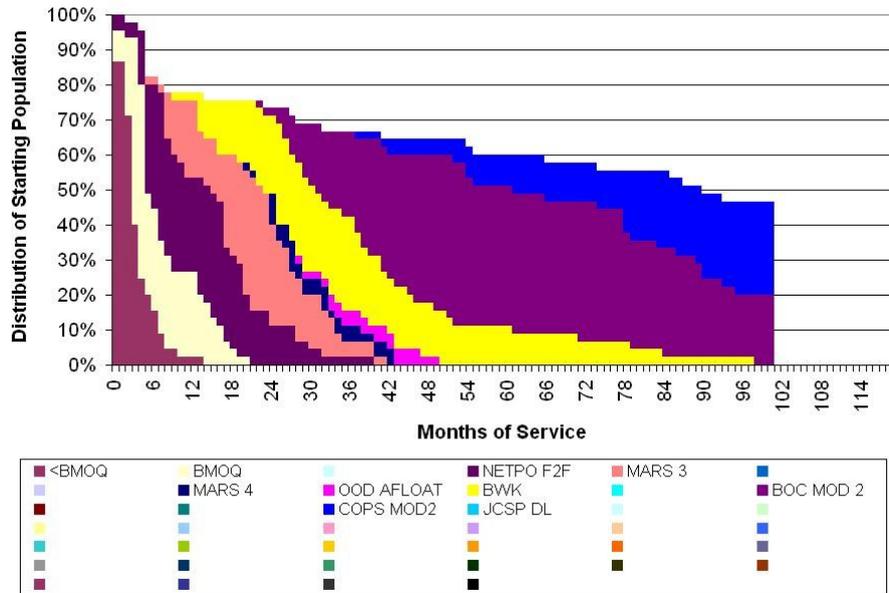
For each MOS point up to the maximum valid value (100 in this example), Figure 2 shows the distribution of the starting population according to the highest qualification achieved. Only the qualifications selected by the user are included; blank series are a consequence of this flexibility.



**Figure 2:** Highest Qualifications Achieved by MOS for Part-Time MARS Personnel

This display allows the user to draw several conclusions. First, since the distribution is based on the starting population, the sum of the series tells the user how many remain in the population at a given MOS point. The width of each coloured band can also provide insights on the length of time required to achieve a certain qualification (either overall, or in comparison to a previously-earned qualification).

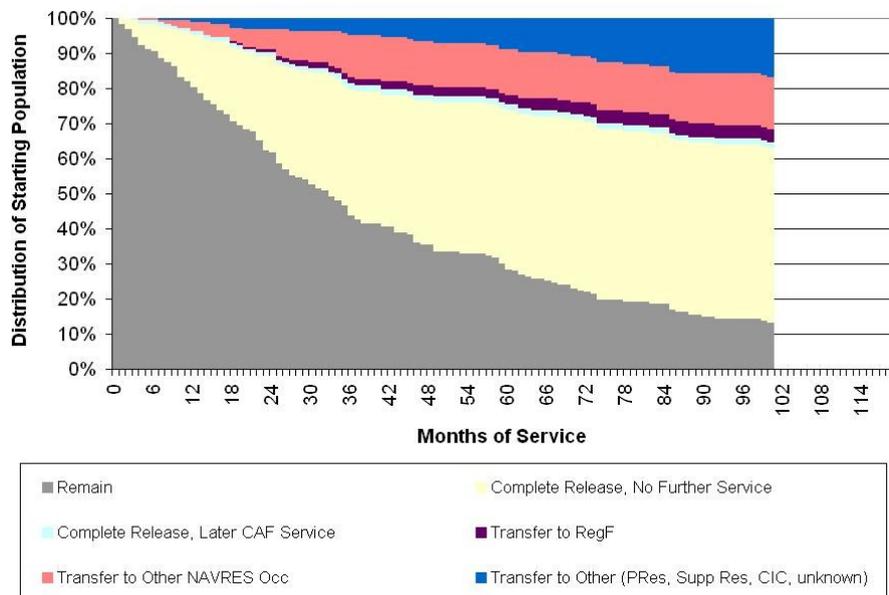
Again, more interesting results can be obtained by comparing the results for different populations. Continuing from our previous example, Figure 3 shows the same graph for the full-time group of MARS officers.



**Figure 3: Highest Qualifications Achieved by MOS for Full-Time MARS Personnel**

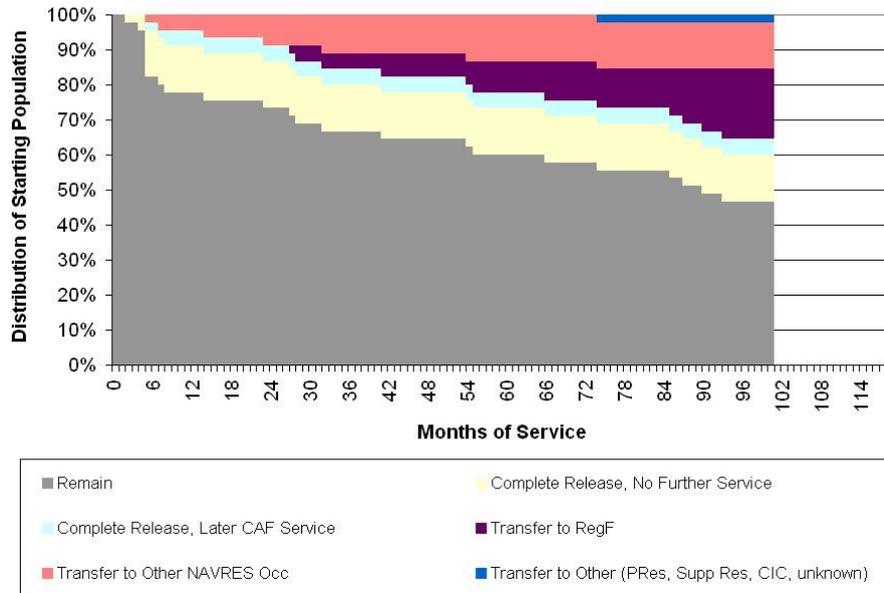
By comparing Figures 2 and 3, several conclusions can be drawn. For example, retention is generally higher for part-time personnel over the first 6 MOS, but lower thereafter. Also, not surprisingly, full-time personnel achieve qualifications in a shorter period of time than do part-time personnel; consequently, for a given MOS point, full-time personnel will tend to have more qualifications.

Figure 4 is opposite to Figure 2 in that the information is focused on the personnel who have left the occupation rather than the remaining personnel. It shows the distribution of these personnel according to the destination groups noted in Section 4.1.



**Figure 4: Destination Groups by MOS for Part-Time MARS Personnel**

Figure 5 provides similar information for the full-time population.



**Figure 5:** Destination Groups by MOS for Full-Time MARS Personnel

Continuing with our previous example, by comparing Figures 4 and 5, it can be observed that upon leaving the MARS occupation, full-time personnel are much more likely to transfer to the Regular Force, whereas part-time personnel are much more likely to transfer to another element of the CAF or to be released from the CAF altogether.

### 3. Notes of Interpretation

The key point that must be understood by the user when interpreting the results is that the data set only includes personnel who had no prior experience in the occupation. For this reason, results cannot be extended to the overall population. As an example, looking at Figure 3, the user might be inclined to conclude that, among full-time MARS personnel, approximately 18% have achieved BWK, 67% have achieved BOC MOD 2, and 15% have achieved COPS MOD 2 by the 60 MOS point. However, this is not the case. Rather, it is likely that the overall population is more qualified as a result of personnel who enrol in the NAVRES with prior Regular Force or NAVRES experience (and by extension, qualifications) in the occupation. Similarly, the patterns observed in the destination groups that personnel go to upon leaving their NAVRES occupation could be different if personnel with prior service were to be included in the data set.

The user must also be careful when choosing the range of start dates that define the cohort to be analyzed. For example, a user may wish to assess the impact of a change to a course that was implemented in January 2010. It would be incorrect to define the pre-change (“before”) cohort as the personnel who joined the occupation up to and including December 2009. This is because, although the selected personnel will have joined the occupation prior to the implementation of the change, they may not have taken the course until some time later. Instead, the user would need to select an earlier range of start dates, and examine the results to ensure that all (or at least most) of the personnel in the cohort had completed the course prior to the implementation date of the change.

### 4. Conclusion

This paper outlined the development of a user-friendly, flexible analysis application that is intended for use by NAVRES planners to investigate personnel management questions. In total, 15 versions of the application were built, each pertaining to a different NAVRES occupation.

Developing an application for NAVRES planners to use themselves had several advantages over the alternative of providing only end results: first, NAVRES staff will now have the capability of reusing the application as newer data become available; secondly, NAVRES staff will be able to answer unanticipated questions as they arise. These advantages came at only minor costs during the development process.

The overall process of building the application involved several steps to extract and pre-process the NRIMS data into a form that could be exported and used within the application. However, much of the analysis is done within the application itself, based on user inputs.

The example given in this paper demonstrated that NAVRES planners can use the application to answer questions on the subject of training and career progression; most notably, pertaining to the achievement of qualifications. In doing so, it can help planners to identify target areas for improving the efficiency of the training system. For example, it was found that only 59% of part-time personnel who achieved the NETPO F2F qualification also achieved MARS 3; in contrast, 92% of full-time personnel did so. This suggests that the MARS 3 course is problematic for part-time personnel, and would be a suitable place to start when seeking to increase the efficiency of the system.

The application is also useful for supporting or disproving certain hypotheses about training and career progression. Indeed, NAVRES planners were able to confirm that the average time to completion of basic occupation training for the MARS occupation was within their standard of 36 months (for part-time and full-time personnel together).

Finally, it is of interest to note that this work could have applications beyond the military context. Although the application is set up to suit the structure of the NRIMS database, the general approach could be adapted for use in other organizations. For example, it could help to identify common exit points and/or systemic barriers along a lengthy training system, such as an undergraduate university program, training systems for medical or legal professionals, etc.

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