Defence Workforce Transition Simulation and Analysis*

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Abstract: Simulation plays a key role in the workforce planning of defence workforces, with their strictly hierachical nature, and complex interactions and interdependencies. In this paper, the Athena tool suite, containing Athena Lite and Athena Pro, is introduced. The Athena tool suite is the official workforce planning tool of the Australian Defence Force (ADF), and uses Discrete Event Simulation and hybrid Agent-Based Discrete Event Simulation to simulate the highly complex ADF workforce. These are web-based, scalable tools that have been specifically designed to be used by Defence workforce planners. Their use in the analysis of the Australian Army Aviation's planned transition from the Tiger Armed Reconnaissance Helicopter to the Apache helicopter demonstrates their capability in identifying workforce shortfalls and risks, bottlenecks, and potential solutions through optimisation.

1 INTRODUCTION

The Australian Defence Force (ADF) workforce is a large, highly complex system with many constraints, interdependencies and complex interactions among people, resources, schools and units. The system is closed and strictly hierachical, meaning external personnel cannot be easily brought into the workforce and the system relies on personnel progressing through their career and achieving particular proficiencies and skills in order to fill critical roles. Training and career progression of Defence personnel can take many years, be very expensive and require large amounts of resources (both platforms and people). On top of this, changes in governance, capability requirements and operational platforms also regularly occur. Robust workforce planning is therefore required to ensure that the right amount of people at the right time with the right skills are trained and ready to provide ADF capability.

To assist in this planning Athena was created. Athena consists of two simulation tools, Athena Lite and Athena Pro. These are scalable, web-based decision-support tools that provide the ADF with the ability to simulate, analyse and forecast workforce surplus or shortage against workforce requirements, and determine recruitment, training and promotion requirements to meet future demands.

*None of the values and charts used in this paper are representative of ADF capability, and have been created in order to demonstrate the use of Athena.

Athena Lite and Athena Pro are complementary tools that simulate the ADF workforce to different fidelities. Athena Lite is a discrete event simulation (DES) engine, that is less data intensive, computationally faster, and has specific optimisation algorithms capable of optimising inflow and promotion numbers for the workforce. Athena Pro, an Agent-Based Discrete Event Simulation (AB-DES) engine, provides a more detailed analysis on the complex structure of the ADF workforce, and how requirements for training and career courses, and specific prerequisites and proficiencies effect the workforce. Athena Lite and Athena Pro are available on the Australian Defence network, and are in active use by ADF workforce planners from the Royal Australian Navy (RAN), the Australian Army, and the Royal Australian Air Force (RAAF).

The Australian Army Aviation (AAvn) are a critical capability in the Australian Army, and the wider ADF. This capability contains three separate helicopters - the Tiger Armed Reconnaissance Helicopter (ARH), the MRH90 helicopter, and the Chinook CH47F helicopter - that provide specific roles. Each of these helicopters requires many different highly trained personnel in specialist areas, including engineers, technicians, pilots, and aircrew. Training these personnel can be an expensive, time-consuming process that requires many resources. Competing needs between services and between different helicopter types within AAvn, as well as unforeseen circumstances such as particularly high and variable train-

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ing failure rates, workforce separation or low recruitment numbers, means it is necessary for pilot workforce scheduling to be resilient enough to withstand these variations. Added stress occurs when AAvn undergo complex workforce strains as they transition their ARH capability from the Tiger ARH to the Apache Guardian helicopters. This transition is occurring over the period of several years from 2025 and requires retraining of the current Tiger-trained personnel to the new Apache helicopter while, at the same time, requiring Australia's ARH capability to be maintained. To ensure that the workforce transition occurs in this time-frame, with as little disruption to the capability as possible, a robust workforce transition plan is necessary.

Athena Lite and Athena Pro were used in a complementary way in the analysis of the AAvn workforce, and the ARH to Apache workforce transition. The career pipelines of the AAvn operators were modelled in both Athena Lite and Athena Pro. These pipelines were simulated over 20 years, analysing the health of the workforce, including personnel shortages, bottlenecks, and high-risk positions, with and without the platform transition.

2 RELATED LITERATURE

Athena Lite and Athena Pro are specifically designed for simulating Defence workforces. Defence workforces are closed systems with a hierachical structure. They are reliant on personnel progressing through their career, meeting particular milestones before being able to fill certain positions.

Previously Markov chain models have been used to model Defence workforces, as in Škulj et al. (2008) and Filinkov et al. (2011). However, an important feature in Defence workforce planning is the ability to run 'what-if' scenarios, testing different workforce and training policies, recruitment, wastage and promotion changes, and capability transitions. Markov chain approaches are not easily adapted for these analyses.

System Dynamics (SD) modelling has been used for this purpose, where the workforce is represented as a set of stocks and flows. In Thomas et al. (1997) a SD model is built to analyse the effect of policy decisions on personnel strength in the United States Army. An SD model was also used to model the pilot occupation in the Royal Canadian Air Force, and determine the impact of increased production and reduced budget on the occupation (Séguin, 2015).

DES models a system as a sequence of discrete events in time. DES models are very flexible, and can model a high level of detail. As such, discrete event simulations have been previously used to model Marine training (Davenport et al., 2007), the Royal Canadian Navy (Henderson and Bryce, 2019), and in various industries, such as in healthcare (Gunal and Pidd, 2010), and call centres (Mathew and Nambiar, 2013).

Heath et al. (2011) compares different simulation paradigms, including SD and DES. They argue that while SD models have much fewer data requirements, they do not provide the flexibility and detail of a DES. Heath et al. (2011) also compares combinations of simulation paradigms, such as SD-DES, AB-DES, and SD-AB, and argues that AB-DES is a good choice when resources perform activities and human interactions where individual behaviours effect how these activities proceed. As such, AB-DES has been used to assist in disaster planning and evacuation (Na and Banerjee, 2014) and in modelling emergency medical services (Anagnostou et al., 2013), as they are capable of incorporating the complex interactions between agents. In the Defence context, AB-DES has previously been used by the authors (Nguyen et al., 2017) to model the ADF aircrew supply problem.

Athena Lite and Athena Pro both employ DES. However, to properly simulate the complexity included in the higher fidelity Athena Pro, an AB-DES engine was used. This is necessary in Athena Pro, as it models the inter-dependencies in the workforce, where positions and training can be shared across levels and careers, and to model complex personnel careers, where many possible paths may be available. A key difference between Athena Lite and Pro and other simulation tools available is that they are web-based tools, specifically designed to allow Defence workforce planners with little experience in modelling and simulation to make use of them. They are scalable, and capable of simulating the entire ADF. They have intuitive user interfaces, and detailed results analysis, allowing users to create, use and validate their own workforce simulations, while still maintaining the complexity of modelling and simulation required for the Defence context.

3 ATHENA

Athena Lite and Athena Pro are two separate simulation engines that were used in the AAvn workforce transition analysis. Both simulation engines are capable of completing detailed modelling of Defence workforces, analysing individuals' progression throughout their career and detailing unit, posting, and rank readiness. These simulation engines were employed in a complementary manner to provide extensive what-if analysis of the workforce transition, and to provide detailed modelling of the effects of the complex training and prerequisite requirements present the highly trained AAvn workforce.

In this section, the logic behind these engines will be explained, as well as the web-based user interface that allows Defence workforce planners with little modelling experience to interact with these simulation engines.

3.1 Simulation

Athena Lite and Pro are designed to be detailed enough to accurately model the complexities of careers in a Defence workforce, however generic enough to be able to model many different operator types to any required fidelity. Both simulation engines employ Monte-Carlo methods to simulate the randomness is workforce wastage, promotions, and allocations. Athena Lite is a DES, that simulates individuals as they progress through their career and complete postings. Personnel attributes, such as current posting, platform endorsement, level and current time in posting and level, are used to determine personnel eligibility to be promoted to the next level or fill a particular posting. In this case platform endorsement refers to any platform specific training or proficiencies that a posting may require. Athena Lite is used to answer workforce questions such as:

- can the workforce requirement be met?
- what is the risk of not meeting workforce requirements?
- what are the optimal recruitment and promotion targets in order to meet demand?

Athena Pro uses an AB-DES engine to simulate the Defence workforce. Athena Pro is capable of simulating the workforce at a much higher fidelity than Athena Lite, modelling training and career courses, complex prerequisite structures in the workforce, and more detailed modelling of the workforce's skills progression. This allows the user to understand not just where the personnel shortages are, but exactly which skills are missing from the workforce and trace it back to particular bottlenecks. Athena Pro is used to answer questions such as:

- which skills and proficiencies are missing from the workforce?
- what are the bottlenecks slowing progression of personnel through the workforce?
- what is the effect of dependencies and interactions between different ranks and careers on the workforce?
- how do course timings, session sizes and pass rates effect the progression of personnel?

3.1.1 Athena Lite

Athena Lite creates a workforce structure, using generic concepts: careers, levels, and units. In a Defence workforce levels generally represent ranks, while careers represent operator types. Units are defined as groupings of positions and may include operational squadrons, regiments, training schools or headquarters positions. Positions are grouped as postings, which are defined as a particular combination of career, level and unit. Postings have a requirement or target value, as well as a priority value which defines the order in which the postings are filled.

Individuals will attend postings or be promoted based on their eligibility. To determine their eligibility, the simulator records and updates a number of personnel attributes, including current posting, time in posting, platform endorsement, current level, and time in level. Personnel may be promoted to a higher level if they have reached the minimum time in rank constraint and there is an available posting at the next level. Wastage is applied stochastically based on a particular career's survival profile, where personnel have a certain probability of leaving the workforce based on their length of service, as described by Bartholomew (1971). To fill some postings, personnel must have the required platform endorsement. Personnel will either join the workforce as trained inflow with a particular platform endorsement or must attend a transition course to gain a new endorsement.

3.1.2 Athena Pro

Athena Pro is an AB-DES. Personnel are modelled as individual person agents. They progress through career pipelines, made up of building blocks: intake points, buffers, courses, milestones, and position groups. These blocks are connected to form levels, which in Defence workforce modelling generally represent ranks. A typical career pipeline can be seen in Figure 1.

A key part of these pipelines is the buffer agent. Each level in a career pipeline will have one buffer, that allocates personnel based on position vacancies and priorities, career progression requirements, and course vacancies. Upon completion of a course, position group, or milestone, personnel will return to the buffer to be re-allocated. Attendance at position groups, courses, and milestones may give personnel 'proficiencies'. These proficiencies can be used in determining whether personnel are eligible to fill vacancies in blocks, using prerequisites. All blocks may

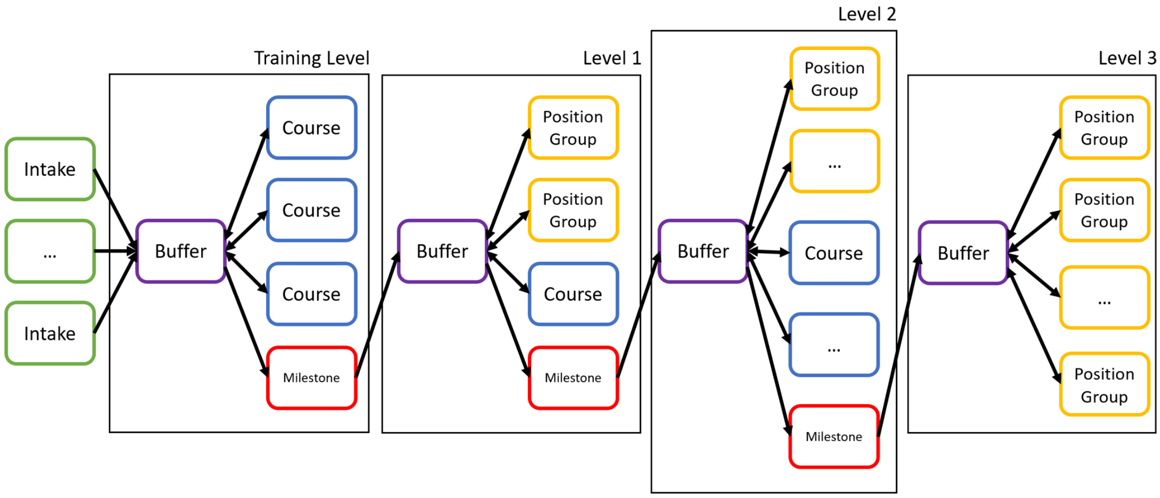

Figure 1: An example of a typical career pipeline in Athena Pro. In this pipeline, personnel enter the system as new recruits, before attending courses in a training level. They then flow through the pipeline, filling positions and completing courses.

have prerequisites, which will restrict the flow of personnel from the buffer. These prerequisites include:

- Time-based prerequisites: These prerequisites take the form of 'time since X', or 'time spent in X'.
- Entity and proficiency prerequisites: These prerequisites can be mandatory completion of one or more particular entities or proficiencies, a minimum number of particular entities or proficiencies, or one or more particular entities or proficiencies having not been completed.

Position groups, courses, and milestones may be in multiple levels, or careers, so that the complex inter-dependencies in Defence workforces can be modelled.

3.2 Optimisation

The Athena Lite optimiser is designed to determine recruitment and promotion plans that help minimise shortfalls and excesses of personnel within different careers and levels over time. These shortfalls and excesses are costed (and can be costed differently for different workgroups and ranks) in generic units by the workforce planner, and the optimiser attempts to minimise the total cost over time.

The optimiser uses a customised heuristic which involves backpropagating personnel demand from combinations of level and time, and then using a Dijkstra-like pathfinding algorithm (Dijkstra, 1959) to find level-progression pathways for personnel (whether already in the system or recruited through inflows) to fill that demand whilst minimising the total cost. The pathfinding must consider several constraints such as time in rank limits and recruitment year-on-year change limits. Wastage is handled deterministically, where a person's supply is a decimal value between one and zero, and application of wastage reduces this value.

This algorithm has shown favourable solution quality and speed, when compared with a Linear Programming implementation. Further description and evaluation of the optimisation algorithm will be included in future work.

3.3 Web-Based User Interface

Athena Lite and Pro are web-based simulation tools, designed with intuitive user interfaces. These user interfaces are key components in ongoing Athena use, as they allow Defence workforce planners with little modelling and simulation experience to create, use, and validate the workforce models.

Athena Lite and Pro are currently in active use by ADF workforce planners, with feedback incorporated into new releases.

3.3.1 Building Workforce Models

As it is a requirement that users build their own models, effort has been put in to make this process as simple as possible. Data is entered via Microsoft Excel, or via the UI, to facilitate data transfer between personnel management databases and Athena. Career pipelines are built in Athena Pro using 'drag-and-drop', where users drag entities into the pipeline and drag connections between them based on the flow of personnel in the workforce. Extensive data validation with clear and understandable error messages is also completed.

3.3.2 Visualising Simulation Results

Athena Lite and Pro provide a variety of results visualisations. These visualisations are specifically created to highlight personnel shortages, workforce bottlenecks, and capability risks.

In both Athena Lite and Pro, charts can be created that show various statistics about the workforce, personnel and position fill. Some examples include:

- supply vs. demand statistics,
- frequency of observed undersupply,
- wastage and promotion statistics,
- personnel progressions statistics, such as time in level, time in posting, and time in service,
- course graduations, session sizes, and input queue statistics.

Some charts created using Athena Lite and Pro can be seen in Section 4.3.

The Sankey diagram in Athena Pro shows the flow of personnel through the career pipeline, at each simulation timestep. Each node and arc in the career pipeline, is represented in the Sankey diagram. The size of each arc represents the amount of personnel flowing through that arc, while the colour displays whether the secondary node is above, below, or at capacity. The bar above each node represents the fill level of that node, while the colour of the node represents the type of node. A timeline panel is displayed along the bottom of the Sankey diagram. This panel contains a vertical bar that represents the current timestep that the Sankey diagram is displayed at. This bar can be dragged along the timeline to set the timestep. The user can also use the 'play' button to automatically step through the simulation timesteps, with the Sankey diagram changing at each timestep, or the 'forward' and 'backward' buttons to click through the simulation timesteps.

3.3.3 What-if Scenarios

'What-if' scenarios can be quickly and easily run and analysed. A scenario in Athena is defined as a particular representation of a Defence workforce. This scenario has specific input parameters, careers, and events, resulting in specific simulated results. Scenarios are grouped in a study. From some 'baseline' scenario, child scenarios can be created, where all the contents of the 'baseline' scenario are copied into a new scenario. This child scenario can then be modified and compared to the baseline scenario to determine the effect of the modification on the workforce, thereby answering 'what-if' questions, related to workforce and training policy changes, recruitment, wastage and promotion changes, and capability transitions. An example of the scenario tree used in the analysis of the AAvn workforce transition is shown in Figure 3.

4 USE IN THE SIMULATION OF THE AUSTRALIAN ARMY AVIATION

Seven careers were modelled to provide a complete analysis of the AAvn capability. These careers included engineers, technicians, ground and air support, pilots, and aircrew. Models were built in Athena Lite and Athena Pro. In this section, only the pilot model will be discussed. Three main scenarios were investigated. These were:

- Scenario 1: analysis of the 'as-is' workforce to find whole-of system health, workforce bottlenecks, and high-risk positions, assuming no changes to AAvn workforce capability and requirements.
- Scenario 2: Analysis of the workforce during and post Tiger to Apache platform transition to examine the impact of the transition on the workforce and the ability of AAvn to meet milestone capability dates. Various transition plans were modelled and analysed in Athena Lite, as in Figure 3. Those of particular interest to AAvn workforce planners were then modelled to a higher fidelity in Athena Pro.
- Scenario 3: Optimisation of recruitment and promotion numbers in order to meet AAvn workforce requirements, while undergoing the Tiger to Apache platform transition. This involved using the Athena Lite optimiser to optimise inflow and promotion numbers, and using these results as input to Athena Pro, in order to inform training requirements.

Athena Lite and Athena Pro were used together in a complementary manner to complete these analyses. The simulations were run over 10 years, with 30 Monte-Carlo trials per scenario. The number of Monte-Carlo trials can be chosen by users, and in choosing this the size of the workforce being modelled (and the corresponding simulation size), and the amount of available computation time should be considered. In this case 30 trials were chosen as this provides a reasonable error, while still facilitating computations. All models, and results discussed in this section are only to demonstrate the use of Athena, and

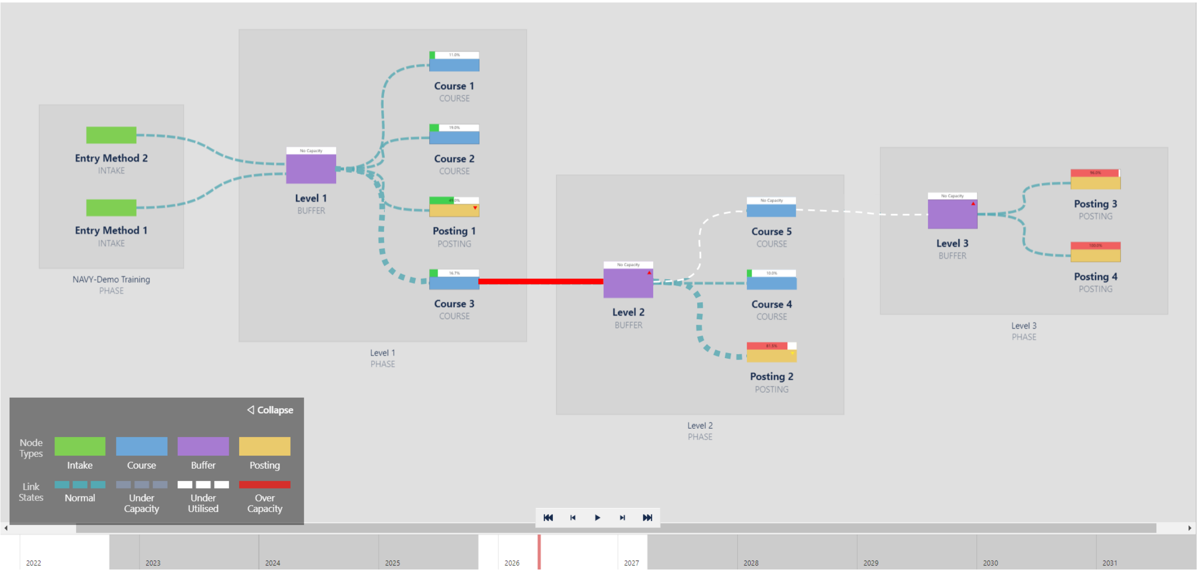

Figure 2: The Sankey visualisation in Athena Pro. This visualisation shows the flow of personnel at the timestep May 2026. The fill level of particular nodes can be seen by the bar on top, while the capacity size of flow, and capacity at the succeeding node are represented by the size and colour of the arcs. The colour of each node represents the type of node.

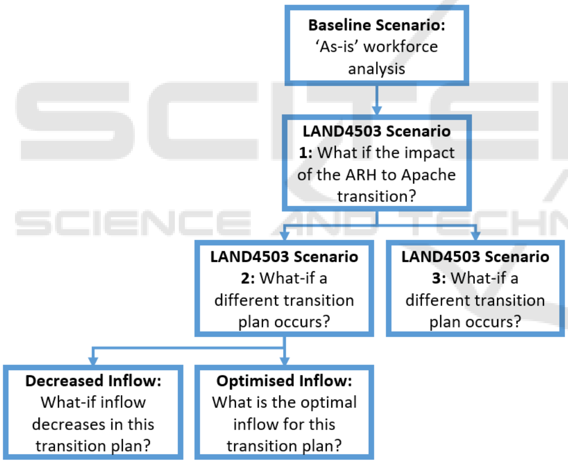

Figure 3: The scenario tree in the AAvn workforce transition analysis. A number of different transition plans, and inflows are investigated.

not representative of ADF capability. Chart sizes are notional.

4.1 Simulating AAvn in Athena Lite

In all three scenarios, the career and level structure remained the same. Pilots in ranks Lieutenant (LT), Captain (CAPT), Major, (MAJ) and Lieutenant Colonel (LTCOL) were modelled and move through the workforce as in Figure 4. Pilots were promoted through the ranks when they reached specific minimum time in rank requirements, and there was an unfilled position they were eligible for at the higher level. As Athena Lite does not model training courses, the training phase of a pilot pipeline was modelled as a training (TRN) level. Wastage was modelled using survival curves based on historical data.

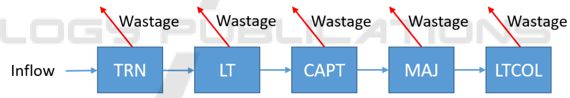

Figure 4: Progression of pilots throughout their career, with the application of inflow and wastage shown.

All AAvn positions were modelled, including those in AAvn operational units, 1 AVN REGT, 5 AVN REGT, and 6 AVN REGT, and those in generic school or headquarters units. Personnel entered the system as inflow with a singular platform endorsement, that will define which units they can fill positions in.

The model had initial states, based on current personnel data, and position requirements that changed over time, based on planned establishment changes. In scenarios 2 and 3, when the platform transition occurred, 1 AVN REGT was modelled as two separate units, with different platform endorsement requirements. This changing requirement was modelled as in Figure 5, where the requirement for Tiger trained personnel was reduced, as personnel were sent to conversion training. However to ensure no loss of capability, the requirement for Apache trained personnel increased at the same rate.

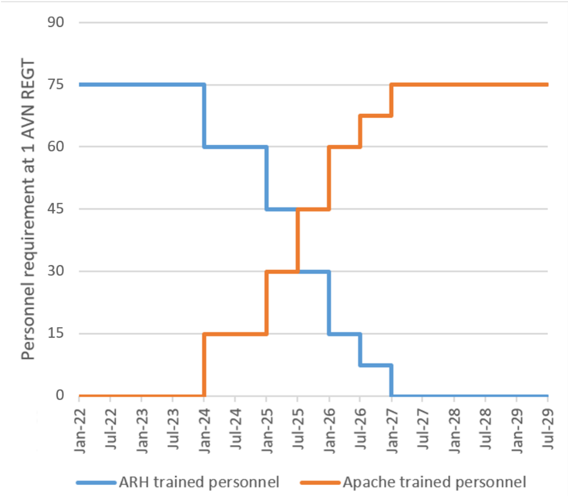

Figure 5: The changing requirement at 1 AVN REGT during the transition period. The requirement for ARH trained personnel reduced, while personnel were sent to conversion training. At the same time, the personnel requirement for Apache trained personnel increased.

In scenario 2, a number of ‘what-if’ scenarios relating to transition timing, and personnel inflow were completed. These ‘what-if’ scenarios are fast, and simple to run using Athena Lite due to its relatively low fidelity compared to Athena Pro. As such, the majority of these scenarios were investigated using Athena Lite. Scenarios of particular interest to AAvn workforce planners were then modelled in more detail in Athena Pro. In scenario 3, optimisation for inflow and promotion was completed.

4.2 Simulating AAvn in Athena Pro

Career pipelines of the AAvn workforce were built, based on career category management requirements and Defence workforce planner expertise. In this pipeline, personnel entered the career and become ARMY-PILOT-TRN, representing the training level. During this level they complete a number of flying courses. The flow of personnel to these courses was restricted by prerequisites.

Flow of personnel is also restricted by the number of positions in each position group, and the session sizes and timings in each course. Extra personnel are stored as overflow in the buffer. Positions in position groups had start and end dates to represent changing requirement. This changing requirement for scenarios 2 and 3 was as in Figure 5. Similarly session timings and sizes changed over time, as school scheduling changes were made, and platform transitions occurred. These sessions also had pass rates based on historical data. These pass rates were particularly relevant for courses in the ‘ARMY-PILOT-TRN’ level, as upon failure of these courses pilots do not continue through the career pipeline.

Inflow is controlled by the intake points and was set by the users. Upon inflow into the ‘ARMY-PILOT-TRN’ level personnel may become overflow in the buffer, if the planned sessions were not frequent or large enough. This occurs similarly for promotion between levels. This is displayed as a bottleneck in the Sankey diagram, as well as in the chart statistics.

Detailed initial personnel, position, and proficiency history was used as input to the simulations. This data was collected using personnel management systems, cleaned and converted to the required format.

4.3 Discussion and Comparison of Results

These models were validated by AAvn personnel, and the results were used to inform the workforce transition plan throughout the acquisition process. Due to the high fidelity modelling in both Athena Lite and Pro, there was a large number of interesting results that came from this investigation. Some key observations found were:

- Multiple transition plans were tested and analysed in Athena Lite. The variables altered in these ‘what-if’ scenarios were the transition course length, transition course numbers and transition course delay. A comparison of the supply vs. demand at 1 AVN REGT, throughout these transition plans can be seen in Figure 6. It can be seen that the plan that leads to the lowest risk of undersupply in 1 AVN REGT is transition plan 2.
- As Athena Lite simulates all positions in AAvn, the impact of the transition on the entire workforce could be seen, and not just the direct impact on the unit where the transition is occurring. For example, as an increased number of ARH pilots are required to fill ARH positions in 1 AVN REGT, attend transition training to Apache, and fill Apache position in 1 AVN REGT, less are available to fill school and headquarters positions. This leads to a shortage in these units in comparison to when no transition occurs.
- Using the results from scenario 2 in Athena Lite, transition plan 2 was modelled in Athena Pro. A comparison of the results between Athena Lite and Athena Pro highlighted a number of things. First, while the overall number of personnel in the workforce was approximately the same in both tools, there were differences in the number of personnel per rank. This is because, in Athena

Pro promotion eligibility is more restricted than in Athena Lite, with the additional prerequisites of proficiencies and courses. Figure 7 shows the number of personnel waiting to attend the CAPT Careers Course, a prerequisite to being promoted from 'ARMY-PILOT-LT' to 'ARMY-PILOT-CAPT'. It can be seen that this course is unable to meet the student demand, leading to less people being eligible for promotion to the following rank.

- The cost-based optimiser is also used to optimise the inflow and promotion numbers for this scenario. The resulting supply vs demand results in Athena Lite can be seen in Figure 8. In this example, it can be seen that even with optimal results there is still some undersupply and oversupply, especially in the first few years. This is because progression of personnel through the ranks is restricted by a minimum time in rank constraint, and as the ranks start undersupplied, in order to meet the requirements at higher levels, the LT and CAPT ranks need to be oversupplied and undersupplied, respectively.
- The optimisation results in Athena Lite show the required number of inflow and promotion numbers, however does not detail the course requirements to meet these numbers. To calculate the required number of graduations per year in pilot training courses and in pilot promotion courses to meet this optimal inflow and promotion, Athena Pro was used. Intake points in the pilot pipeline were set to match the optimal inflow, and all courses were set to 'on-demand'. This means that the set sessions for these courses were ignored, and they were instead allowed to run when the minimum session size was met. An example of the results from this are seen in Figure 9 where the required number of graduates from the 'Rotary Wing Training' course at particular times to meet the required optimal inflow is shown. These results inform the scheduling of courses in order to meet the personnel requirement.

5 CONCLUSIONS

Athena Lite and Pro represent large improvements in the ability of Defence workforce planners to accurately represent and simulate the ADF workforce. Together they provide a capability that is able to forecast personnel shortages, identify bottlenecks in the system, and optimise recruitment and promotion targets.

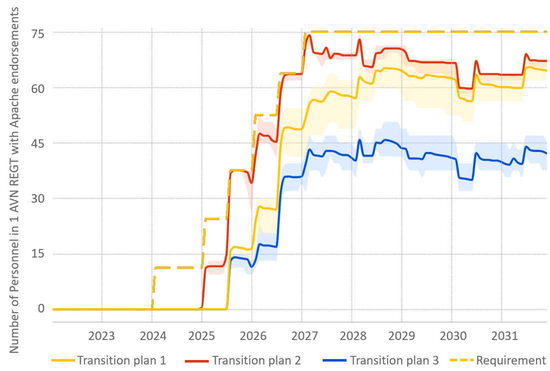

Figure 6: The supply vs demand of pilots at 1 AVN REGT with Apache platform endorsements, under different transition plans.

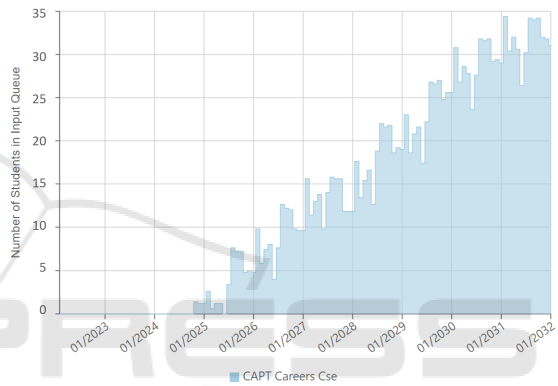

Figure 7: The input queue at the CAPT Careers Course, a prerequisite for promotion from ARMY-PILOT-LT to ARMY-PILOT-CAPT. These are the number of students waiting to complete this course. The increase in this queue indicates not enough sessions are being held to meet the demand.

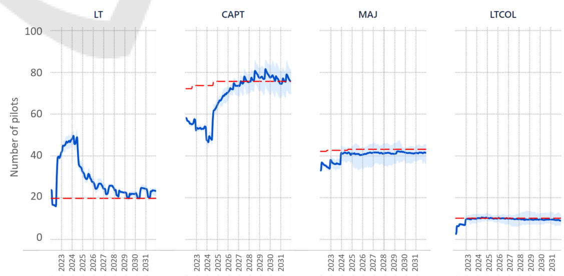

Figure 8: The supply vs demand for each pilot rank, after using the Athena Lite optimiser. Each graph shows the number of personnel in a particular rank throughout the simulation time. The requirement line can also be seen. It can be seen that in order to meet requirement at higher levels, MAJ and LTCOL, the LT and CAPT ranks must be oversupplied and undersupplied, respectively.

The relatively lower fidelity simulation tool, Athena Lite, allows Defence workforce planners to quickly explore their workforce risks, while still

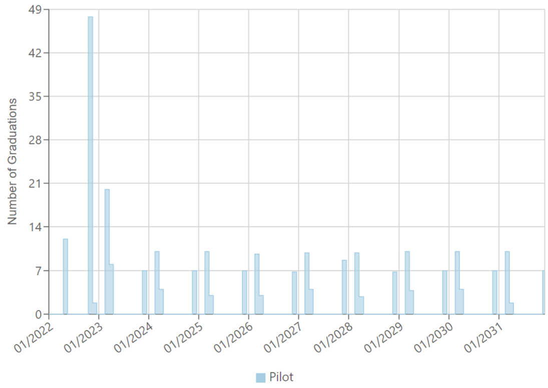

Figure 9: The number of pilot graduations from ‘Rotary Wing Training’ in order to meet the optimal inflow, as found using the Athena Lite optimiser.

maintaining enough detail to effectively analyse the readiness level down to the rank, unit, and career. Athena Pro is able to simulate the workforce to a higher fidelity, analysing the flow of personnel through the system as they complete courses, postings, and gain proficiencies.

These capabilities have been demonstrated in the analysis of the ARH to Apache workforce transition in the AAvn. In this analysis, various transition plans were investigated in Athena Lite, before those plans of particular interest to AAvn planners were modelled in more detail in Athena Pro. In Athena Pro, the effect of training courses, complex prerequisite structures, and more restricted flow through the career pipelines could be seen. The Athena Lite optimiser was then used to find the optimal recruitment and promotion strategies throughout this time, in order to meet requirement. Athena Pro was then used to inform the required training course schedules to meet this demand.

Besides AAvn, Athena Lite and Pro have also both been used to simulate the entirety of the RAN, including over 20,000 personnel, 100 vessels, and 66 careers. The Athena suite, including both Athena Lite and Pro, has been accepted as the official workforce planning tool for the entire Australian Defence Force.

Athena Lite and Pro are both still in active development, as ADF users use and request new features and changes. The future focus of the Athena tool suite is on automated diagnosis and reporting. This involves using machine learning, and data analytics techniques to analyse the workforce and understand the risks and vulnerabilities. Natural Language Generation is also being investigated as part of this process, to produce usable reports of interesting results, and provide an interface between the tool and the user. This will improve the interactions that users have with the Athena tool suite, and the insights that can be gained.

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