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EVALUATION OF TENDER SOLUTIONS FOR AVIATION TRAINING USING DISCRETE EVENT SIMULATION AND BEST PERFORMANCE CRITERIA

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ABSTRACT

This paper describes a novel discrete event simulation (DES) methodology for the evaluation of aviation training tenders where performance is measured against "best performance" criteria. The objective was to assess and compare multiple aviation training schedules and their resource allocation plans against predetermined training objectives. This research originated from the need to evaluate tender proposals for the Australian Defence Aviation Training School that is currently undergoing aviation training consolidation and helicopter rationalization. We show how DES is an ideal platform for evaluating resource plans and schedules, and discuss metric selection to objectively encapsulate performance and permit an unbiased comparison. DES allows feasibility studies for each tender proposal to assure they satisfy system and policy constraints. Consequently, to create an objective and fair environment to compare tendered solutions, what-if scenarios have been strategically examined to consider improved implementations of the proposed solutions.

1 INTRODUCTION

The Australian Defence Aviation Training School is currently undergoing aviation training consolidation and helicopter rationalization, with the objective to design and develop a more efficient, lean and robust future training continuum. As part of this process, a new Helicopter Aviation Training System (HATS) has been designed, which will combine all basic helicopter flight training components in one location, including army and navy pilots', air-crewmen's, observers' and instructor trainees' curricula. The new training solution will include an increased simulation activity, with synthetic training devices taking pressure off live training.

The Australian Government uses a tendering process to invite service providers or companies to make competitive bids when acquiring a capability. During the tender process three companies were selected to submit a refined HATS training solution. The Defence Science and Technology Organisation (DSTO) was tasked to conduct an analysis of the tendered solutions to determine whether the level of resources were adequate and the overall training solutions feasible.

This paper presents a discrete event simulation (DES)-based methodology to evaluate and compare the candidate training solutions, including training schedules and allocated aircraft, simulator and supplementary workforce resources. DES can represent physical aspects of the system including resources and the environment and is routinely used at an operational and tactical level to answer specific questions, such as resource allocation and scheduling problems. It is the most appropriate method to model stochastic, queuing systems (Brailsford and Hilton 2001; Johnstone et al. 2009; Le et al. 2012; Zhang et al. 2012; Johnstone et al. 2015), which is the system described herein.

The paper is organized as follows. Section 2 presents related work, while Section 3 describes the modeling rationale, covering model assumptions, critical metrics, model input and output, and experimental methodology. Results are presented in Section 4, and the paper concludes in Section 5.

2 RELATED LITERATURE

Previous research into the utilization of DES in the tender process has investigated how DES could be employed to model the process of awarding the tender (Padhi and Mohapatra 2007), where the goal was to provide insight into the high turnaround time. In this paper, the focus is on evaluating tendered solutions.

Davenport et al. (2007) used DES to assess options for improving waiting times at a Marine Corps training school. Two models were developed for running classes, one followed a schedule and the other used an on-demand method that commenced classes once starting conditions were satisfied. Simulation results, some of which influence the experimental methodology taken in this paper, indicated reductions in waiting times were possible from using the on-demand approach, increasing class size and increasing instructor levels.

Kádár et al. (2004) showed that DES can be used as both a schedule evaluator and simulation-based scheduler. They argue that deterministic methods do not consider important issues such as resource and raw material availability, variable processing times and conditional operations. When DES is used to evaluate a schedule, the non-determinist aspects of the real system were tested against multiple simulation runs, providing a thorough evaluation of schedules. To assist planners, Le et al. (2015) implemented a hybrid discrete event and continuous simulation method to evaluate the feasibility and risk of production schedules. DES was employed in a feedback loop to evaluate schedule robustness and facilitate schedule generation. Kempf et al. (2000) defines good schedules as ‘feasible’ in that they do not violate system constraints and ‘acceptable’ in that they cannot be improved trivially. Once both conditions are met, a range of metrics are required to assess one schedule over another. Also relevant is Kempf et al.’s method of comparing schedules relative to one another. However this raises the problems of deciding on metrics and evaluating each schedule’s performance against these (Melnyk et al. 2004; De Snoo et al. 2011). We consider rationale for selecting modeling metrics suitable for objective and fair comparison, as discussed in section 3.

Methods to compare alternate tenderer bids often focus on the problem of criteria selection and the importance of incorporating qualitative factors (Fortune and White 2006; Zwikael and Globerson 2006; Park 2009; Meland et al. 2011). The importance of each factor is usually defined by a weight scoring criterion computed by combining a score with a defined weighted value. The computation results are then normalized and ranked in order of their contribution importance.

There are numerous techniques to support the criteria selection problem. Oladapo (2011) used Analytic Hierarchy Process (AHP) to show the benefit of using more than just the lowest cost in evaluating bids, and how more favorable project outcomes result. Meland et al. (2011) used an Equivalent Tender Price model where simulation was shown to make selection criteria transparent and quantifiable. El-Abbasy et al. (2013) combined Analytic Network Process (ANP) with Monte Carlo simulation to identify and prioritize selection criteria, finding that multiple selection criteria provided better results than using cost alone. Nassar and Hosny (2013) utilized Fuzzy-C clustering to categorize bids into performance groups to enable comparison.

Typically these methods add multiple selection criteria as opposed to only cost to evaluate bids. This study looks at the effectiveness of each bid over the solution life cycle, both temporally and spatially, to provide an understanding of resource capacity requirement, resource bottlenecks and student waiting times and allow for stochastic events such as weather, resource availability and student availability, which are critical to the underlying problem in this study.

3 MODELING RATIONALE

The training school in question proposes a combination of live and synthetic training devices to support a training program for helicopter aircrew. Over the year, multiple courses of varying size will run for each student type, with each course defined by daily training event sequences (TES). Each training event is defined by a duration, instructor requirement and resource requirement, thus a daily static picture of utilization across resources can be established.

The design, construction and operation of the system was put to tender. The resultant question asked of received bids was "Is the level of resource proposed by the tenderer sufficient to support their proposed training solution?".

To address this question appropriately, an analytic approach, supported by modeling and simulation, was used to assess the capacity of proposed resources. The modeling objective was to facilitate the analysis of the dynamic allocation and release of resources on a daily basis. Simultaneously, the model had to identify where bottlenecks might occur through a lack of available training or instructional resources, providing an indication of potential problems in system capacity. DES was selected as the preferred modeling approach to satisfy these objectives. Additionally, its ability to animate the modeled system's internal processes facilitated communication with the clients, to both validate the model, and explain the potential issues and gaps between tendered and sufficient resources for a given schedule.

The challenge remained in determining whether to design a scheduler to evaluate the tendered schedules, or to simply construct a dispatcher that would mimic various tenderer solutions. Designing a scheduler would require defining a set of priority sequencing rules based on scheduling objectives. However, this modeling approach is prone to the risk of favoring a solution that used similar rules to those encoded in the "assessing scheduler". Thus to avoid such bias and adhere to a philosophy of fair and critical assessment, a dispatcher in the DES environment was designed and combined with respective tenderer schedule and resource allocations.

3.1 Model Input

The primary input that underpinned the model, which was developed in ARENA®, was the Training Event Sequence (TES) developed from the Life Cycle Cost model for each tenderer. The TES was an array variable that provided both a chronological sequence of events as well as a means of allocating appropriate aircraft, mission system resources and instructors to each training event, along with their respective duration. The basic structure of the TES is outlined in Table 1. For example, the first event *"Hovering and Circuits Simulation"* requires 1.3 hours on the Simulator and one instructor of type 1.

Table 1: Structure of the training event sequence input with sequence and resource requirements.

Event Number	Event	Training Resource				Instructor Resource		
		Aircraft	Simulator	…	Mission System x	Instructor Type 1	…	Instructor Type x
1	Hovering and Circuits: Simulation	0	1.3		0	1		0
2	Hovering and Circuits: Aircraft	1.3	0		0	1		0
3	Performance Margins	0	0		1	0		1
...	…	…	…	…	…	…	…	…
x	*Training Event x.x*			…			…	

Resource capacity, as shown in Table 2, serves as additional input into the model, where the instructor resources represent only the additional contracted workforce, not including the military personnel. In the model, instructors were treated as a set of military and civilian trainers with respective availability rates and constraints.

Table 2: Structure of the resource counts used as a model input.

Resource Capacity			
Mission System		**Instructor Staff**	
Aircraft	#	Instructor Type 1	#
Simulator	#	…	…
…	…	…	…
Mission System x	#	Instructor Type x	#

3.2 Assumptions and Constraints

The assumptions and constraints, and their source, identified during the modeling process are detailed in Table 3.

Table 3: Model assumptions and constraints.

Assumption / Constraint	**Description**
Number of mission systems	As per tender proposals.
Mission system availability and serviceability	Deterministic, as per Commonwealth advice.
Number of instructors	A base level of instructors provided by the Commonwealth. Additional workforce modeled as per respective tender proposals.
Turnaround time	The turnaround time indicates a period following a training activity for which the mission system will be unavailable for the next training activity. It has been modeled for all mission systems according to Commonwealth advice.
Prioritization	The resources are reserved by students as required according to the First-in-First-Out (FIFO) principle. However, priority is given to students that are not training to be instructors, as per Commonwealth advice.
Instructor availability	Instructor staff availability is not implemented as a constraint, but rather reported on. Instructor working hours are indirectly limited by the mission system operating hours. Instructor working hours, number of instructors busy, and the average instructor workload are output by the model on a daily basis. These are then used to determine whether the instructor average unavailability requirement is achieved.
Student unavailability	In order to assess the system's maximum capacity, student unavailability due to unplanned absences is not modeled.
Student failures	Student failures are not modeled as it relies on detailed knowledge of the interdependencies between training events and how normal training activity may progress while remedial sorties are accumulated and undertaken.
Spare days	As per tender proposals.
Weather assumptions	Modeled on hourly basis, based on data provided by the Nowra Meteorology and Oceanography station. The random weather generator provides time until the next

	"bad weather event" and its duration for life of type.
Night flying	Night flying has been modeled both for normal and extended flying hours during summer. Students undertaking a night flight are prevented from undertaking additional training activities for ten hours following the conclusion of the flight.
Formation flying	The requirement for more than one aircraft to participate in formation training events has not been explicitly modeled.
Secondary Missions	Aircraft tasking for secondary missions has not been modeled. It is assumed that aircraft tasking for secondary missions would be prioritized below that of training activities and therefore, the additional aircraft flight hours available will be determined through analysis of the mission system utilization outputs.

3.3 Objective Performance Assessment

An initial challenge in developing a model that allows for dynamic allocation of resources for the purpose of capacity analysis was the selection of an appropriate metric to quantify the resource capacity of the system as a whole. A number of options were plausible to contribute to an understanding of systems capacity, however each needed to be weighed against the capability and limitations of the modeling environment and approach.

The objective of the HATS capacity analysis was to determine whether tendered solutions were feasible and provided adequate resources to support their respective training schedule, in order to graduate the Commonwealth required number of students in a specified time frame. The DES model of the proposed virtual training school captured daily statistics for each mission system, aircraft and instructor resource, including maximum utilization for each resource type, queue length, number of successful training activities/hours, number of missed training activities and busy/idle states. The measure that proved most insightful, and the one we adopted as the "best performance" criteria for our study, was the *percentage of missed activities per year* for each mission system resource averaged over life-of-type, i.e. 30 simulation years. This measure is directly related to queue lengths and waiting times, but affected by additional model elements such as whether an activity was successfully completed.

The percentage of activities missed per year for each mission system was identified and compared across tenderers and this constituted the baseline scenario. Where this measure was minimal, it was considered that the adequate amount of that resource has been provided. However, where this was not the case, a program of exhaustive scenarios was run to isolate the cause of missed activities and inform the capacity analysis. Further details on these resource scenarios and findings are given in Section 0.

3.4 Experimental Methodology

A graphical representation of the experimental methodology applied to each tendered training system is presented in Figure 1.

To establish schedule *feasibility*, the model was run with unlimited resources and no weather effects simulated. This removes the possibility of any missed activities due to factors other than schedule conflicts and provides an insight into whether the training program is achievable within the working hours constraint imposed on students. Under such conditions, the student should never miss any training events unless the schedule is too ambitious in programming training events on a given day.

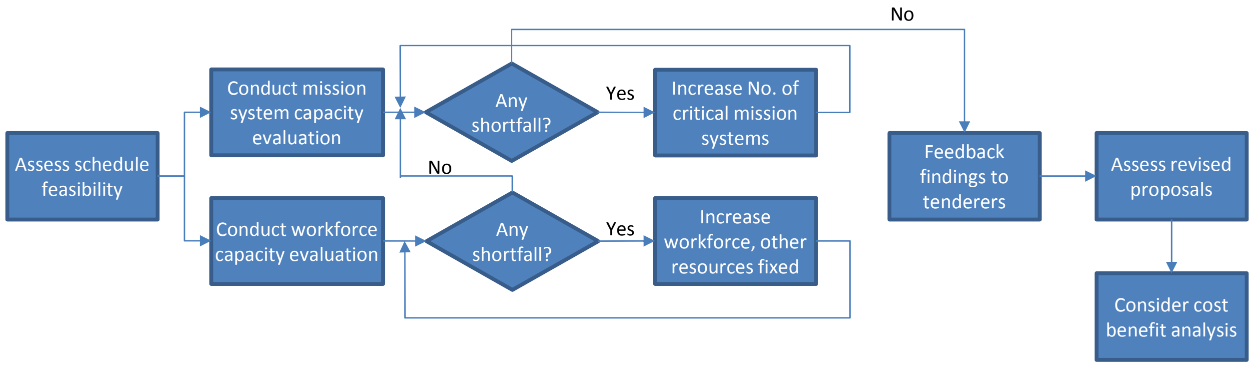


Figure 1: Graphical representation of the proposed methodology.

The second assessment for each tendered solution is a *mission systems capacity evaluation*. The model is run with the levels of mission system and instructor workforce as specified by the tenderer, including the effects of weather on the flight program. This test provides a baseline scenario, and establishes whether the tendered solutions have the capacity to achieve the training schedule as provided, and if not identify which mission systems or aircraft are experiencing a shortfall. Next, a workforce capacity evaluation is undertaken to determine the workload of each instructor type. This assessment provides an indication of whether instructors are able to support the training program within the working hours limitations, and if not it identifies which instructor type is lacking in workforce numbers. This now concludes the baseline diagnosis as visualized in the dashboard controller, see Figure 2.

Figure 2: A snapshot of the scenario dashboard showing the resource utilization of instructors and mission systems for a single simulation replication.

Critically important to the proposed methodology, following the establishment of the baseline and identification of the resource deficits, was to identify the gaps between tendered and sufficient resource allocations, measured against the respective proposed schedules. In order to achieve this, an appropriate *set of scenarios were constructed to examine the reasons behind resource shortfalls* and their magnitude relative to cost. These scenarios essentially involve considering all combinatory variations of additional resources previously identified as critical and the ones that may influence them indirectly. In the case where both instructor workforce and mission systems were limiting, the scenarios were developed to hold mission systems constant and increase the number of critical instructors. The rationale for this approach lies in the fact that increasing the number of instructors is less costly than increasing the number of mission systems. In order for a student to complete a given training activity it requires both the appropriate mission system and instructor type. If one is lacking, the shortfall will be seen on both. Therefore, in this example, resolving the instructor shortfall first will simultaneously lift the burden from the coupled resource.

In the case of missed aircraft sorties, the schedule is also reviewed for flights during months where "bad" weather is more likely. If there is a large proportion of such flights, the schedule start and end dates are adjusted in the favorable position and resources reviewed again as before. The outcome of the scenario analysis as well as the feasibility study is fed back to the tenderers to inform and, as required, subsequently improve their individual solutions.

The revised solutions are reanalyzed and the capacity analysis presented along with time and risk penalties associated. In some instances, the shortfall of the resources can be resolved by accepting the extended curriculum length, at other times the risk is assessed against the financial cost of the resources at stake. Finally, the solutions were used to facilitate a cost benefit analysis.

3.5 Model Output

Model outputs were collected for each tendered training solution and included the statistics presented in Table 4. These statistics were used for verification of the stochastic components in the model and to collect information on resource behavior that would instruct the capacity analysis and the comparison of the tendered solutions.

Table 4 Model outputs.

Model Output	Description
Mission system utilization	The utilization of each of the mission systems specified by the tender responses, providing the daily number of events for each type of mission system and duration in hours. It also provides a figure for the maximum number of each mission system that was required simultaneously on each day.
Mission system rate of effort	Rate of effort for each mission system, providing the number of hours on each day that each of the mission system types was required.
Workforce statistics	Daily workforce statistics, providing data on the hours each instructor type is required to support training events and the number of instructors used on a daily basis.
Missed training events	Daily missed training events, providing the number of training events missed on any given day. The missed activities are one of the key indicators of insufficient capacity of the training resources against the tendered solutions. As such, this output is used, in reference to other outputs to inform where, how, and why capacity shortfalls are occurring.
Student course size	Each course, for a given student type, is run multiple times a year. The course sizes vary throughout the year and between student types, adding to the annual Commonwealth requirement.
Daily flight permitting weather	The cumulative daily hours where flying was permitted due to rain and wind conditions deemed unsafe for flying.

4 RESULTS

The type of results produced through this methodology are described in the following sections. Example data has been generated to show the utility of the method.

Model Verification. The model was verified by comparing the utilization of equipment between the manually calculated utilization from each tenderer's TES and the model outputs. The difference between the two values provides an indication of whether the model is producing expected results, and thus contributes to confidence in the veracity of the model. Verification data have been collected for all scenarios presented here, to ensure that no scenarios caused unexpected or unexplainable behavior of the model. Differences between expected and observed output fell well within limits expected through normal input variations from year to year.

Schedule Feasibility. Schedule feasibility was assessed by running the model with unconstrained instructor and equipment resources. A schedule is deemed unfeasible if it breaks one of the Commonwealth constraints, such as school, or mission system operating hours. Tenders were given the opportunity to address any such errors to ensure a feasible schedule.

Mission Systems Capacity Evaluation. This test establishes the baseline scenario with the tenders, utilising the model inputs specified by each tenderer in terms of the number of instructors and mission systems. An example model output using these inputs is visualized in Figure 2. The missed aircraft and mission system events refer to all events missed due to either weather or unavailable resources. Running the model with the mission system and instructor resources as proposed but without weather effects enabled, shows the proportion of flights that are missed due to unavailable resources. The difference in missed flights between this scenario and the Baseline Scenario with the weather impacts, indicates the weather contribution and the remainder can be contributed to resource deficiency.

Workforce Capacity Evaluation. The initial workload assessment for instructor workforce has been conducted against the requirements for instructor workload distribution where each instructor is expected to spend no more than a percentage of their time on the HATS activities. The instructor utilisation presented in the dashboard of Figure 2 is able to be interrogated to provide additional detail as to the instructor workload over the year, see Figure 3. The red dotted line represents the Commonwealth upper limit for average instructor hours dedicated to HATS activities and the green dashed line is the average hours based on the tendered levels of resources. In this illustrated case, the green line is below the limit, which suggests that the number of Type 1 instructors is adequate.

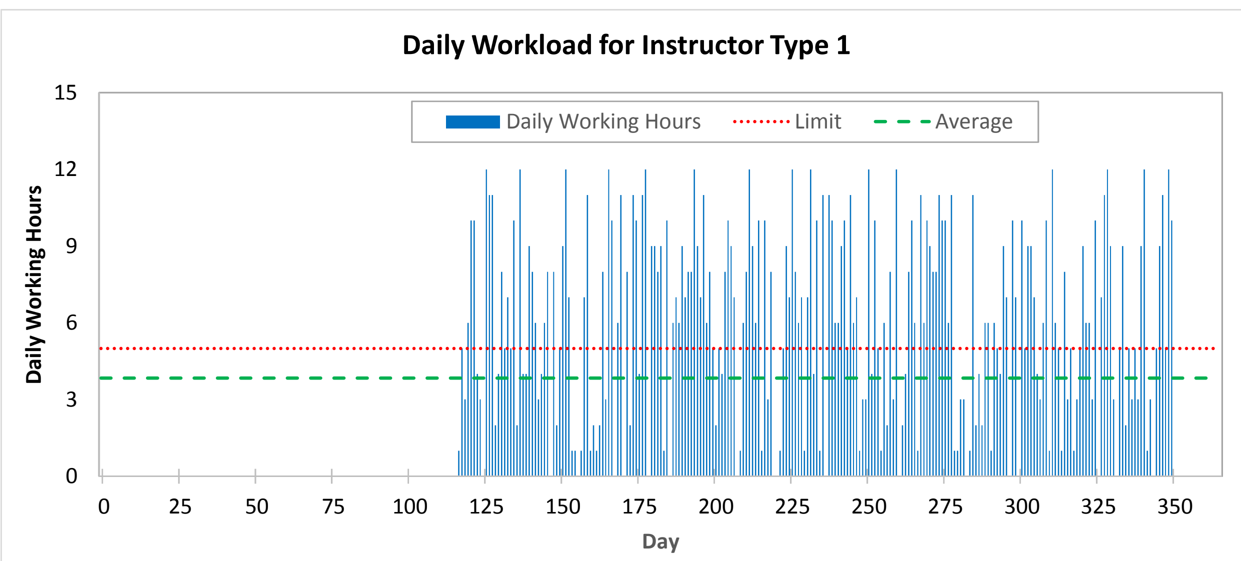
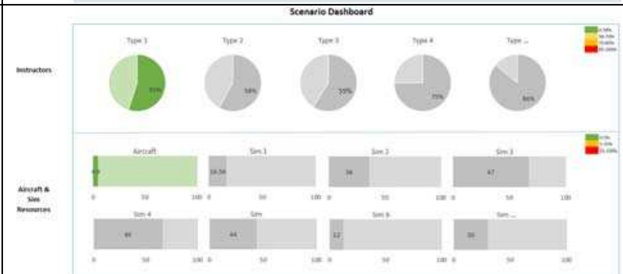
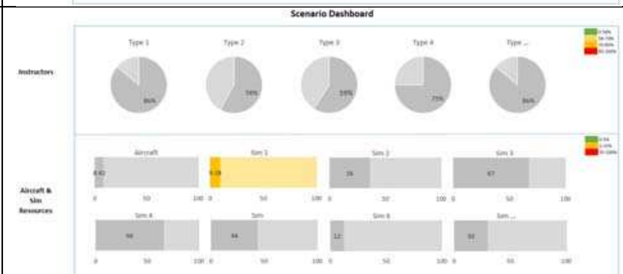
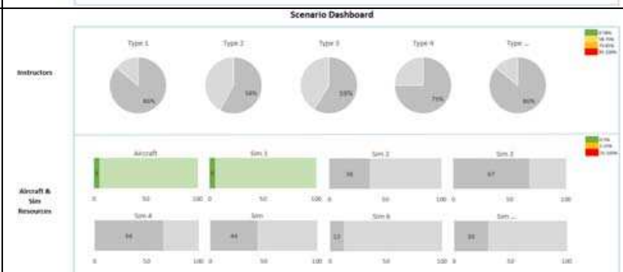


Figure 3: The daily, average and maximum workload of Instructor Type 1 over a year.

Resource Capacity Scenarios. Table 5 provides the results of the resource capacity scenario testing. The Baseline scenario results are included for comparison. Subsequent scenarios use colored outputs to highlight the significant differences from the baseline scenario, quickly providing a visual indication to the impact of changed resources on the training school. For example, in scenario 2 it can be seen that increasing the instructors of Type 1 has a positive effect on the utilisation of those instructors and on the aircraft resources.

Table 5: Example scenario output of resource capacity testing. The colored outputs show the significant changes between the scenario and the baseline.

Mission System Capacity Testing Scenario	Scenario Dashboard
Scenario 1: Baseline	
Scenario 2: Baseline + x instructors of type 1	
Scenario 3: Baseline + 1 Mission System 1	
Scenario 4: Baseline + 1Mission Sys 1 + x instructors of type 1	

5 CONCLUSION

This paper described a methodology used for assessing and comparing multiple, competing training schedules against their resource allocation plans for a set of given objectives. A DES model was developed, mimicking the actions of each proposed schedule to provide an indication of ability of each tendered solution to meet performance objectives in the presence of Commonwealth operating constraints, instructors' availability and additional tender resource constraints, as well as other influencing factors such as weather and variable class sizes. Scenarios were constructed to test and improve a given tender solution to maintain a fair and objective philosophy. In this paper, the evaluation of one example solution was presented and sample results are provided to demonstrate the method.

This approach was effective for the unbiased evaluation of alternate bids, delivering the ability to objectively evaluate each tendered schedule against its proposed level of resources and compare the tendered solutions against each other. A key component in this methodology is the use of the dashboard controller, which provides a means to diagnose problems within a tendered solution and suggest feedback to improve that solution. The overall effect of providing feedback to tenderers is to improve the quality of all bids, all the while checking that system and policy constraints were satisfied.

The methodology presented in this paper is of a generic nature and able to be applied to other military and civilian training and educational systems.

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REFERENCES

Brailsford, S., and N. Hilton. 2001. "A Comparison of Discrete Event Simulation and System Dynamics for Modelling Health Care Systems." In *Planning for the Future: Health Service Quality and Emergency Accessibility. Operational Research Applied to Health Services (ORAHS)* edited by J. Riley, 18-39.

Davenport, J., C. Neu, W. Smith, and S. Heath. 2007. "Using Discrete Event Simulation to Examine Marine Training at the Marine Corps Communication-Electronics School." In *Proceedings of the 2007 Winter Simulation Conference*, edited by S. G. Henderson, B. Biller, M.-H. Hsieh, J. Shortle, J. D. Tew, and R. R. Barton, 1387-1394. Piscataway, New Jersey: Institute of Electrical and Electronics Engineers, Inc.

De Snoo, C., W. Van Wezel, and R. J. Jorna. 2011. "An Empirical Investigation of Scheduling Performance Criteria." *Journal of Operations Management* 29 (3):181-193.

El-Abbasy, M. S., T. Zayed, M. Ahmed, H. Alzraiee, and M. Abouhamad. 2013. "Contractor Selection Model for Highway Projects Using Integrated Simulation and Analytic Network Process." *Journal of Construction Engineering and Management* 139 (7):755-767.

Fortune, J., and D. White. 2006. "Framing of Project Critical Success Factors by a Systems Model." *International Journal of Project Management* 24 (1):53-65.

Johnstone, M., D. Creighton, and S. Nahavandi. 2015. "Simulation-Based Baggage Handling System Merge Analysis." *Simulation Modelling Practice and Theory* 53:45-59.

Johnstone, M., V. Le, S. Nahavandi, and D. Creighton. 2009. "A Dynamic Architecture for Increased Passenger Queue Model Fidelity." In *Proceedings of the 2009 Winter Simulation Conference*, edited by M. D. Rossetti, R. R. Hill, B. Johansson, A. Dunkin, and R. G. Ingalls, 3129-3139. Piscataway, New Jersey: Institute of Electrical and Electronics Engineers, Inc.

Kádár, B., A. Pfeiffer, and L. Monostori. 2004. Discrete Event Simulation for Supporting Production Planning and Scheduling Decisions in Digital Factories. *37th CIRP international seminar on manufacturing systems*.

Kempf, K., R. Uzsoy, S. Smith, and K. Gary. 2000. "Evaluation and Comparison of Production Schedules." *Computers in Industry* 42 (2–3):203-220.

Le, V. T., M. Johnstone, J. Zhang, B. Khan, D. Creighton, S. Hanoun, and S. Nahavandi. 2015. "Complex Simulation of Stockyard Mining Operations." In *Advances in Global Optimization*, 529-537. Springer International Publishing.

Le, V. T., J. Zhang, M. Johnstone, S. Nahavandi, and D. Creighton. 2012. A Generalised Data Analysis Approach for Baggage Handling Systems Simulation. *2012 IEEE International Conference on Systems, Man, and Cybernetics (SMC)*.

Meland, O., K. Robertsen, and G. Hannas. 2011. Selection Criteria and Tender Evaluation: The Equivalent Tender Price Model (Etpm). *Management and Innovation for a Sustainable Built Environment MISBE 2011*, June 20-23, 2011, at Amsterdam, The Netherlands.

Melnyk, S. A., D. M. Stewart, and M. Swink. 2004. "Metrics and Performance Measurement in Operations Management: Dealing with the Metrics Maze." *Journal of Operations Management* 22 (3):209-218.

Nassar, K., and O. Hosny. 2013. "Fuzzy Clustering Validity for Contractor Performance Evaluation: Application to Uae Contractors." *Automation in Construction* 31:158-168.

Oladapo, A. 2011. "Multi-Criteria Contractor Selection–a Practical Application of Analytic Hierarchy Process." In *Proceedings of the ICE-Management, Procurement and Law* 164 (2):79-88.

Padhi, S. S., and P. K. Mohapatra. 2007. A Discrete Event Simulation Model for Awarding of Works Contract in the Government–a Case Study. *5th International Conference on E-Governence-2007*, 28-30th December 2007, at University of Hyderabad, India

Park, S. H. 2009. "Whole Life Performance Assessment: Critical Success Factors." *Journal of Construction Engineering and Management* 135 (11):16.

Zhang, J., V. Le, M. Johnstone, S. Nahavandi, and D. Creighton. 2012. Discrete Event Simulation Enabled High Level Emulation of a Distribution Centre. *2012 UKSim 14th International Conference on Modelling and Simulation*.

Zwikael, O., and S. Globerson. 2006. "From Critical Success Factors to Critical Success Processes." *International Journal of Production Research* 44 (17):3433-3449.

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