National Defence Défense nationale

Canadian Forces College

Collège des Forces Canadiennes

AN AEROSPACE HARD DECK FOR AEROSPACE ENGINEERS

Lieutenant-Colonel Trevor J. Cadeau

JCSP 47

Service Paper

Disclaimer

Opinions expressed remain those of the author and do not represent Department of National Defence or Canadian Forces policy. This paper may not be used without written permission.

PCEMI 47

Étude militaire

Avertissement

Les opinons exprimées n'engagent que leurs auteurs et ne reflètent aucunement des politiques du Ministère de la Défense nationale ou des Forces canadiennes. Ce papier ne peut être reproduit sans autorisation écrite.

Canada

CANADIAN FORCES COLLEGE - COLLÈGE DES FORCES CANADIENNES

JCSP 47 - PCEMI 47
2020 - 2021

SERVICE PAPER – ÉTUDE MILITAIRE

AN AEROSPACE HARD DECK FOR AEROSPACE ENGINEERS

By Lieutenant-Colonel Trevor J. Cadeau

Word Count: 2,596

Nombre de mots : 2.596

AN AEROSPACE HARD DECK FOR AEROSPACE ENGINEERS

AIM

1. This paper intends to inform the Aerospace Engineering (AERE) Occupation Advisor (OA) of a locally observed deficiency in some junior Aerospace Engineering (AERE) officer's aircraft knowledge and proficiency. Further, it advocates for a baseline knowledge level that must be attained by all junior AERE officers prior to the attainment of the Occupational Function Point (OFP).

INTRODUCTION

2. AERE officers fulfill integral roles in enabling aircraft operations. Junior officers are employed in a variety of roles: within Royal Canadian Air Force (RCAF) squadrons directly overseeing and managing aircraft maintenance operations, within Weapon Systems Management (WSM) offices responsible for the stewardship of the maintenance program and provision of engineering support, as well as several other occupational and technical support roles.[1]

3. There are a very limited number of support roles that do not require AERE officers to possess and apply both engineering and technical competencies in support of sustaining (directly or indirectly) aircraft operations during their first tour of employment. This is reflected in the entry standards for the occupation, requiring entrants to possess

[1] Department of National Defence, A-PD-055-002/PP-001, *The Canadian Forces Military Employment Structure, Volume 2 Part 1, Officer Job Based Specification for the Aerospace Engineering 00185* (Ottawa: DND Canada, 2019), 7-8.

either a Bachelor of Engineering (BEng) or a Baccalaureate Science (BSc) degree.[2] There are two entry streams available to serving Non-Commissioned Members (NCMs) that do not require degrees, but they draw exclusively from the RCAF's aviation support occupations. One of the most significant challenges an AERE officer confronts in transitioning from an academic to a work environment, pertains to a shift from the significance of mathematical solutions, toward a capacity to distil complex technical problems and provide ingenious practical recommendations. To conceptualize the nature and breadth of aircraft specific technical problems, one must appreciate the aircraft as a system and the principles by which they sustain flight.

4. To adequately set graduates up for success and to maintain the technical engineering management excellence demanded of the AERE occupation, this paper proposes the establishment of an aircraft knowledge and proficiency baseline conditional to the officer's achievement of OFP and posting into a Trained Effective Establishment (TEE) position.[3]

DISCUSSION

5. The prerequisites to be authorized to exercise airworthiness functions are outlined within what is commonly referred to within the aircraft maintenance community as the P-Series.[4] Attaining these authorizations can be considered the pinnacle of recognition for a junior AERE officer posted to a first-line maintenance organization. Far more important

[2] Department of National Defence, A-PD-055-002/PP-002, *Annex D - Entry Standards Aerospace Engineer (AERE 00185)* (Ottawa: DND Canada, 2019), 1-3.
[3] Department of National Defence, A-PD-055-002/PP-001, *The Canadian Forces Military Employment . . .*, 6.
[4] Department of National Defence, C-05-005-P03/AM-001, *Maintenance Policy – Aircraft Weapon System Maintenance – Maintenance Activity Authorizations and Training Standards* (Ottawa: DND Canada, 2021), 1-23.

than meeting the prerequisites, their awarding of these authorizations is recognition that they have demonstrated an ability and earned the confidence of the Senior Maintenance Manager (SMM), to exercise sound judgement concerning decisions that have a direct impact on airworthiness and the safety of aircraft. The Maritime Helicopter (MH) fleet has a unique approach to the training of its junior AERE officers in that the fleet has imposed an additional prerequisite to these authorizations. This community has incorporated the Maintenance and Engineering Officer Certificate of Competency program.[5]

6. The program culminates with an oral board exam to validate the candidate's safe, effective and reasoned airworthiness decision making. Positions with airworthiness authorities ". . . are high visibility roles that require the ability to distil complex problems into tangible solutions within a stressful environment."[6] Further, the candidate must prove themselves capable of providing ". . . defensible recommendations and articulation of technical risk to their operational command. They shall be able to justify and mitigate the level of risk being accepted, taking full account of the operational circumstances."[7] To achieve the level of proficiency required to pass the board, the trainee is assigned a mentor who among other things, validates and builds their system engineering knowledge through written and practical exercises. In both the mentor's preparation of trainees and the conduct of these boards, it has been noted that some candidate's aircraft specific knowledge is weak. This conclusion is consistent with this author's experience and confirmed through consultation with current and past incumbents in direct support of the

[5] Department of National Defence, A-PD-050-148/PA-000, *CH148 Fleet Employment & Training Plan* (Ottawa: DND Canada, 2020), 72.
[6] *Ibid.*, 73.
[7] *Ibid*.

program.[8] This shortcoming impedes the candidate's ability to fully appreciate the breadth of technical issues, which in turn hampers their ability to conceptualize appropriate risk mitigation strategies. The knowledge deficiencies include topics such as the theory of flight, aircraft design, systems, components, performance and instrumentation. While the training to prepare candidates for the board is quite comprehensive, it does not include academic instruction in these subject areas.

7. To illustrate the type of difficulties observed, an example of a proposed aircraft modification will be utilized. Candidates arrive at their first units familiar with the aircraft modification approval process and the supporting checklist, of which the requirement to perform a weight and balance is stipulated.[9] In candidates whose aircraft knowledge is weak, what they may not fully appreciate for instance is how the increased weight affects the aircraft as a system due to the interdependencies of the four forces of flight (lift, weight, thrust and drag). An increase in weight reduces the aircraft's payload capacity, increases the takeoff distance, increases drag, reduces the aircraft's range and cruise speed. For those sufficiently exposed to the principles of flight, these conclusions are logical. However, they are not so logical for someone who has insufficient familiarity with these principles. When lacking a theoretical framework, it is natural to refer to something that one is familiar with to hypothesize the answer. In the case of this example, one may refer to their experience in placing heavy cargo in the trunk of their vehicle, which results in the rear of the vehicle riding low. Whilst this may help the candidate appreciate the importance of where within the aircraft the weight is located, it

[8] Email, "Service Paper – Technical Engineering Competency," received 4 February 2021.
[9] Department of National Defence, EMT04.001 Modification Process for Approved Aerospace Equipment and Products (Ottawa: DND Canada, 2016), B-8/30.

will not aid in their full appreciation of the effect the increased weight has upon an aircraft. This often leads to false assumptions and conclusions.

8. One may conclude that the observations associated with the Certificate of Competency program are not relevant to the greater AERE community: the program is unique to the MH fleet, other fleets have not adopted similar prerequisites and only those MH officers posted to first-line maintenance organizations complete the program (these positions account for a small proportion of each fleet's overall positions). An examination of the AERE master task list is therefore appropriate to determine the relevance of the aircraft specific knowledge found to be lacking in some junior AERE officers.[10] An occupation's master task list provides the overall scope of jobs and tasks specific to each rank level. The AERE list provides four duty areas, each sub-divided with a variety of associated tasks particular to each duty. The four duty areas, including a sample of the tasks, are:

a. Maintenance operations – Lead, manage and advise off-aircraft second-level aerospace equipment maintenance, interpret aircraft weapon system maintenance policies and programs, and manage unit compliance to technical airworthiness and aircraft weapon system maintenance policies and programs;

b. Maintenance support – Lead, manage and advise on the airworthiness of a weapon system, interpret weapon system aerospace engineering and technical policies, and approve deviations from the approved maintenance program;

[10] Department of National Defence, A-PD-055-002/PP-001, *Annex A – Master Task List (AERE 00185)* (Ottawa: DND Canada, 2019).

c. Engineering support & project management – Recommend maintenance process manuals, recommend airworthiness policy and guidance material and lead technical airworthiness audits; and

d. General aerospace engineering staff and development – Advise on aerospace engineering aspects of the flight safety program and advise on technical and airworthiness aspects of aerospace contracts.

9. Many of the actions required of junior AERE officers involve advise, recommend, lead and approve, all of which are considerable responsibilities when dealing with aircraft safety. To fulfill tasks within each of the four duty areas, a junior AERE officer must be capable of facilitating solutions to aircraft-specific technical problems. A fulsome acquaintance of the problem requires the officer to have an appreciation for aircraft systems and theory. The importance of this knowledge to function as an AERE is corroborated by the entry standards into the occupation, which values aircraft knowledge so substantially, that select individuals who have supported aircraft operations as NCMs, are eligible to transfer to the AERE occupation without the prerequisite engineering or science degree. Therefore, given all four duty areas require a firm grasp of aircraft theory and only NCMs with aviation-specific experience are eligible to enter the occupation without a degree, it is clear that the AERE occupation is reliant upon a baseline knowledge of aviation-specific systems and theory.

10. In search of what accounts for the lack of aircraft specific knowledge, a review of the AERE occupation's basic rank qualification course (ADAM) is appropriate.[11] Given the AERE occupation draws upon students from a diverse range of degree programs (of

[11] Department of National Defence, A-PD-055-002/PP-001, *The Canadian Forces Military* . . ., 6.

which only a BEng in aerospace engineering is directly applicable), one role of the basic rank qualification must be to baseline the graduate's knowledge. In an initiative to better prepare AERE officers to fulfill their role and enable them to support business processes immediately upon graduation, the ADAM curriculum was overhauled in 2015 by applying a cognitive apprenticeship model to the training:

> Learners are challenged with tasks slightly more difficult than they can accomplish on their own and must rely on assistance from and collaboration with others to achieve these tasks. In other words, learners must work with more experienced others and with time move from a position of observation to one of active practice.[12]

This change to the curriculum has had a profound effect on the student's readiness to contribute, facilitating much of the learning that previously was relegated to the graduate's gaining unit. A side-by-side comparison of the curriculum is provided in Table 1:

[12] Vanessa P. Dennen and Kerry J. Burner, "The Cognitive Apprenticeship Model in Educational Practice," in *Handbook of Research on Education Communications and Technology*, ed. J. Michael Spector et al (New York: Lawrence Erlbaum Associates, 2008), 427.

Table 1 – Legacy and Current ADAM Curriculum

Legacy Course		Current Course	
EO (Number/Title)	**Minutes of Instruction**	**EO (Number/Title)**	**Minutes of Instuction**
PO 406 - Predict Aircraft Behavior	3920	PO 401 - Conduct unit business planning	1340
PO 407 - Explain aircraft structure and electro mechanical systems	4190	PO 402 - Apply mandated programs	3400
PO 408 - Explain functions and operating principals of avionics	2850	PO 403 - Direct air maintenance operation activities	3060
PO 409 - Use basic mgmt tools in aircraft maint	3060	PO 404 - Direct deployed aircraft maint operations	1350
PO 410 - Verbally communicate concepts and facts to an audience	1250	PO 405 - Conduct engineering support activities	1210
PO 411 - Communicate concepts and facts through military correspondence	1160	PO 406 - Provide leadership to personnel	7310
PO 412 - Lead aircraft maintenance personnel	5565	PO 407 - Manage technical airworthiness processes	5420
PO 413 - Use personnel counselling techniques	1200	PO 408 - Manage projects	3990
PO 414 - Explain the aim and principles of safety and security programs relevant to aircraft maint	2225	PO 409 - Conduct contract mgmt activities	2370
PO 415 - Demonstrate and understanding of Nat'l Defence Headquarters functions	2860	PO 410 - Conduct life-cycle material mgmt activities	660
PO 416 - Manage aircraft maint for routine and contingency operations	5050	PO 411 - Prepare military correspondence	0
		End Stage Exercises (x4)	5950
Total Minutes of Instruction	33330	Total Minutes of Instruction	36060

Source: Department of National Defence, *Aerospace Engineer Basic Occupation Qualification Training Plan* (Ottawa: DND Canada, 2018), Chapter 4.

11. The change in curriculum is in keeping with the apprenticeship philosophy of advancing the student from a position of observation to one of active practice. The PO's each reflect the action that each is intended to enable the student to perform: conduct, provide, prepare or manage. There is little theoretical information within the new curriculum. Students must arrive with it and the focus is on the application of their knowledge to business processes that support each PO knowledge area.

12. Three factors are important to consider with respect to the reduction of the theoretical curriculum on the ADAM course. First, there exist two preparatory phases of training that are prerequisites to attendance on the ADAM course. Some aircraft

theoretical knowledge was incorporated within the preparatory training to accomplish the legacy training objectives. Second, the Royal Military College (RMC) established an aerospace engineering degree program in 2009.[13] Given the direct applicability of the degree program to the AERE occupation, combined with a large proportion of intake coming historically through the Regular Officer Training Plan (ROTP) at RMC, it was assumed most ADAM students would be graduates of the Aeronautical Engineering program. It is believed that the choice of degree program assumption has proven to be accurate with the greatest number of AERE selecting this program, although an analysis/study to validate this is beyond the scope of this paper. Finally, the Annual Military Occupation Review (AMOR) identifies a change to the historical dominance of AERE entrants inducted through the ROTP stream (Figure 1):

	DEO	ROTP	CEOTP	CEOTP	UTPNCM	CFR	SCP	In-Svc	0	0	0	SRCP	DEO CT (T)	DEO (Re-Enrl)	CEOTP (Re-Enrl)	Total Skilled	Total
18/19	5	32	0	0	1	3	1	2	0	0	0	0	0	0	0	0	44
19/20	25	15	0	0	2	6	1	2	0	0	0	0	0	1	0	1	52
20/21	11	15	0	0	1	4	1	1	0	0	0	0	0	1	0	1	34
21/22	21	15	0	0	1	4	1	2	0	0	0	0	0	1	0	1	45
22/23	29	15	0	0	1	1	1	2	0	0	0	0	0	1	0	1	50
23/24	26	15	0	0	1	1	1	1	0	0	0	0	0	1	0	1	46
24/25	26	15	0	0	1	1	1	1	0	0	0	0	0	1	0	1	46
25/26	26	15	0	0	1	1	1	1	0	0	0	0	0	1	0	1	46
26/27	26	15	0	0	1	1	1	1	0	0	0	0	0	1	0	1	46
27/28	0	15	0	0	1	1	1	1	0	0	0	0	0	1	0	1	20
28/29	0	15	0	0	1	1	1	1	0	0	0	0	0	1	0	1	20

Figure 1 – Forward-Looking Intake and Production (FLIP) Model, 00185 AERE
Source: RCAF D Air Pers Strat, "AMOR Record of Discussion," accessed 30 January 2021. http://rcaf.mil.ca/en/d-air-pers-strat/amor-rod-2018.page

13. While relying upon student's independent selection of aeronautical engineering as a degree program provides no collective assurance of aircraft specific expertise, further exacerbating the knowledge concern, is the fact that a declining proportion of the intake into the occupation, becoming the minority in 21/22 (Fig 1), will be comprised of

[13] Royal Military College, "A Short History of Mechanical Engineering at RMC," accessed 4 February 2021. https://www.rmc-cmr.ca/en/mechanical-and-aerospace-engineering/short-history-mechanical-engineering-rmc#:~:text=This%20long%20term%20interest%20in,standing%20program%20in%20Aeronautical%20Engineering.

graduates from RMC (ROTP). Therefore, the probability that some junior AERE officers will lack sufficient or have very limited familiarity with the principles of aviation, is increasing.

14. The enhancements in readiness of officers to assume a functional role immediately following graduation is a tremendous success that should be celebrated, shared and pursued by other training establishments. However, the occupation must not lose sight of the foundation that underpins the aerospace engineering occupation. When officers arrive at their first unit, they do so under substantial expectation given the importance of their role in maintaining the operational safety of their assigned fleet. These expectations extend beyond their immediate AERE chain of command; they include the aircraft technicians and aircrew. While technicians do play a critical role in the development of a junior officer's knowledge of a specific aircraft type, technicians can begin to withdraw when it becomes arduous to explain basic concepts, including the principles of aviation. The RCAF sets these expectations by branding the junior officer as an aerospace engineer. Given this title, it is not unreasonable for there to exist an expectation that the officer has an elementary understanding of the principles of flight and aircraft systems. Similarly, from an aircrew perspective, motivated predominantly by their desire to have confidence in the airworthiness of the aircraft they operate, they have fundamental expectations of the most junior AERE officers also. Senior AERE officers continue to advocate to push *power to the edge* concerning airworthiness authorities.[14] As a competent profession, AERE should pursue such increases in responsibility. However,

[14] Mathew Maxwell, "Putting the Engineer Back in Aerospace Engineer: Increasing the Senior Maintenance Manager's Scope of Authority" (Joint Command and Staff Program Paper, Canadian Forces College, 2020), 4.

in pursuit of further airworthiness autonomy, the occupation must validate its cadre's professional development, knowledge and expertise, to assure a sturdy theoretical footing.

15. The expectation for graduates to possess discipline-specific knowledge is not unique to the military.[15] While educational institutions continue to struggle with developing the skills desired in graduates by workplaces, the AERE occupation's ADAM curriculum has made significant strides in this regard.[16] The continued struggle of post-secondary institutions reflects the fact that different forms of knowledge and skills are more conducive to be conferred in certain environments. While teaching business processes post-graduation is inefficient for a graduate's gaining unit, a workplace is better suited to augmenting skills rather than theoretical knowledge. Foundational theoretical principles must be established before a student can learn to apply them and are optimally taught in an academic environment. Additionally, establishing a solid theoretical foundation will enable them to confidently meet the expertise and knowledge expectations upon arrival at their first unit.

CONCLUSION

16. The AERE occupation requires an aircraft knowledge benchmark to set all graduates up for success and to deliver the aircraft specific technical engineering excellence demanded of the AERE occupation. The MH Certificate of Competency program has identified a concern that some junior AERE officers lack sufficient aircraft

[15] Gili Marbach-Ad, Carly Hunt and Katerina V. Thompson, "Exploring the Values Undergraduate Students Attribute to Cross-disciplinary Skills Needed for the Workplace: an Analysis of Five STEM Disciplines," *Journal of Science Education and Technology* 28, no. 5 (October 2019): 452.
[16] *Ibid*.

theoretical knowledge to articulate the risks and propose defensible solutions to unfamiliar technical problems. Given the occupation draws on graduates across a broad range of disciplines, there is a requirement to baseline entrant's aerospace knowledge. This paper's review of the ADAM course should not be interpreted as a critique of the significant progress made with the curriculum; these successes should be heralded. While many post-secondary institutions continue to struggle with delivering some of the skills sought by the Science, Technology, Engineering and Mathematics (STEM) field (such as collaboration and professional writing), the ADAM course successfully fosters these skillsets. However, given the observations of the Certificate of Competency program, it is apparent that a gap exists within the development system. The AERE occupation prides itself in the technical and engineering competency it provides the RCAF and the quality of its junior officer cadre is first-rate. However, the occupation must equip its graduates with a common degree of aircraft theoretical knowledge commensurate with their vital role in airworthiness and the sustainment of unparalleled levels of aviation safety.

RECOMMENDATIONS

17. An occupation baseline should be established for theoretical aircraft knowledge. This should not comprise detailed engineering mathematical problem solving, rather it should focus on developing an integrated understanding of the principles, concepts and systems, fundamental to aviation. The appropriate knowledge is akin to that which aircrew and technicians require to function and succeed in their respective roles.

18. A working group comprising representatives from 1 Cdn Air Div A4 Maintenance, CFSATE, WSM staff, DTAES and members from various fleets, should be

convened to determine how to achieve this baseline as part of pre-OFP professional development. Achieving this knowledge baseline may be accomplished by other means than the ADAM course. While every effort should be made to preclude the dilution of the new ADAM curriculum, aviation-specific knowledge and competencies are the bedrock of the AERE profession. Should prioritization be necessary, aviation-specific competencies must be prioritized ahead of skillsets more conducive to development within the workplace.

BIBLIOGRAPHY

Canada. Department of National Defence. *Aerospace Engineer Basic Occupation Qualification Training Plan*. Ottawa: DND Canada, 2018.

Canada. Department of National Defence. A-PD-050-148/PA-000, *CH148 Fleet Employment & Training Plan*. Ottawa: DND Canada, 2020.

Canada. Department of National Defence. A-PD-055-002/PP-001, *Annex A – Master Task List (AERE 00185)*. Ottawa: DND Canada, 2019.

Canada. Department of National Defence. A-PD-055-002/PP-001, *The Canadian Forces Military Employment Structure, Volume 2 Part 1, Officer Job Based Specification for the Aerospace Engineering 00185*. Ottawa: DND Canada, 2019.

Canada. Department of National Defence. A-PD-055-002/PP-002, *Annex D - Entry Standards Aerospace Engineer (AERE 00185)*. Ottawa: DND Canada, 2019.

Canada. Department of National Defence. C-05-005-P03/AM-001, *Maintenance Policy – Aircraft Weapon System Maintenance – Maintenance Activity Authorizations and Training Standards*. Ottawa: DND Canada, 2021.

Canada. Department of National Defence. *EMT04.001 Modification Process for Approved Aerospace Equipment and Products*. Ottawa: DND Canada, 2016.

Dennan, Vanessa P., and Kerry J. Burner. "The Cognitive Apprenticeship Model in Educational Practice." in *Handbook of Research on Education Communications and Technology*, edited by J. Micheal Spector et al. New York: Lawrence Erlbaum Associates, 2008.

Marbach-Ad, Gili., Carly Hunt, and Katerina V. Thompson. "Exploring the Values Undergraduate Students Attribute to Cross-disciplinary Skills Needed for the Workplace: an Analysis of Five STEM Disciplines." *Journal of Science Education and Technology* 28, no. 5 (October 2019): 452 469.

Maxwell, Mathew. "Putting the Engineer Back in Aerospace Engineer: Increasing the Senior Maintenance Manager's Scope of Authority." Joint Command and Staff Program Paper, Canadian Forces College, 2020.

RCAF D Air Pers Strat. "AMOR Record of Discussion." accessed 30 January 2021. http://rcaf.mil.ca/en/d-air-pers-strat/amor-rod-2018.page

Royal Military College. “A Short History of Mechanical Engineering at RMC.” accessed 4 February 2021. https://www.rmc-cmr.ca/en/mechanical-and-aerospace-engineering/short-history-mechanical-engineering-rmc