National Defence Défense nationale

Canadian Forces College

Collège des Forces Canadiennes

FIFTH-GENERATION COMMAND AND CONTROL

MAJOR NAKUL NAYYAR

JCSP 46

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 46

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 46 – PCEMI 46
2019 – 2020

SERVICE PAPER - ÉTUDE MILITAIRE

FIFTH-GENERATION COMMAND AND CONTROL

Major Nakul Nayyar

Word Count: 2,555

Nombre de mots : 2.555

FIFTH-GENERATION COMMAND AND CONTROL

AIM

1. The intended audience of this paper is BGen I. S. Huddleston, Deputy Commander 1 Canadian Air Division (1 CAD). The aim of this paper is to recommend to the leadership of the 1 CAD to evolve RCAF's traditional Command and Control (C2) doctrine that governs the conduct of air operations for two chief reasons- first, in order to fully utilize the potential of the fifth generation jet fighter expected to arrive in 2025 and second, to retain decision superiority at the tactical level in future conflicts where RCAF should expect to operate in cyber contested domains. To affect that change, the paper recommends that the RCAF transform its Centralized Control and Decentralized Execution (CCDE) doctrine[1] to one of Centralized Command-Distributed Control-Decentralized Execution (CCDCDE).

INTRODUCTION

2. The Government of Canada (GC) released the official Request for Proposal (RFP) for its future fighter program on 23 July 2019 [2]. This is the next step in achievin one of the objectives of 'Strong, Secure, Engaged', specifically the procurement of a next generation fleet of 88 fighter jets to replace the CF-188 Super Hornets (SSE #44).[3]

---

[1] Department of National Defence, B-GA-402-001/FP-001, *Canadian forces Aerospace Command Doctrine (*Ottawa: DND Canada, 2012*)*, 19.
[2] Public Services and Procurement Canada, "Future Fighter Capability Project," last accessed 23 Oct 2019, https://www.tpsgc-pwgsc.gc.ca/app-acq/amd-dp/air/snac-nfps/CF-18-eng.html
[3] Department of National Defence, *Strong, Secure, Engaged:Canada's Defence Policy* (Canada Comunications Group, 2017), 38.

Considering that the F-35 Lightning II Joint Strike Fighter remains a strong contender to be picked as GoC's choice for the RCAF, this paper will utilize F-35's information age capabilities to make the case for transformational change required in existing C2 doctrine in the RCAF. The same conditions that will support the employment of the F-35 are also applicable for other fifth-generation platforms.

3. This paper will make its case by first illustrating how the RCAF presently employs traditional C2 methodology in the planning and execution of air operations that are heavily centered on the Combined Air Operations Center (CAOC). The paper will then illustrate how traditional C2 methodology utilized at present will be incompatible with the realities of the emerging 21st century battle-space. That is followed by an examination of the F-35's fifth generation capabilities and how they can be leveraged to transform the traditional C2 doctrine from CCDE to CCDCDE. Finally, the paper will recommend the corresponding evolution of pilot training required to support the evolution of the C2 doctrine proposed.

DISCUSSION

Traditional C2 (CCDE)

4. Centralized Control and Decentralized Execution (CCDE) is considered "the overarching tenet of airpower"[4]. It stems from a need to optimize and prioritize limited air assets. CCDE also allows the speed and range of air power to be diverted from tactical to strategic operations in response to the Commander's priorities. The RCAF employed

[4] Department of National Defence, B-GA-402-001/FP-001, *Canadian forces Aerospace Command Doctrine (*Ottawa: DND Canada, 2012*)*, 19.

CCDE successfully in support of UN Resolution 1973 during its air bombing campaign in Libya (Op Mobile) with virtually unlimited access to cyberspace. However, the rise of Chinese and Russian offensive expertise in cyber-space presents new risks in future conflicts for Canada and its allies. Moreover, the network centric warfare of tomorrow also presents an opportunity for smaller nations to neutralize the western military advantage with relatively inexpensive cyber weapons.

5. An example of the prevalence of a CCDE-driven methodology is how the RCAF conducts air operations. The CAOC remains the nexus from which Joint Forces Air Component Commander (JFACC) commands, coordinates and monitors air assets and executes missions. According to CAF doctrine, the purpose of ISR is to "enable the commander to have situational awareness and acquire an advantage over the adversary through understanding and potential decision superiority"[5]. The process-driven CAOC emphasizes reliance on centralized collection and analysis of ISR data and sequential ATO generation.

6. Figure 1 below describes how ISR data is collected, analyzed and actioned during the Air Tasking cycle at the CAOC[6]. The Strategy Division (SRD) is responsible for developing and disseminating the ACC's strategy and the production of the Joint Integrated Prioritized Collection List (JIPCL). The Combat Plans Division (CPD) uses the planning guidance provided by SRD to produce a Master Air Operations Plan (MAOP) that matches ACC assets to collection targets and synchronize ISR collection,

[5] Department of National Defence, B-GA-401-002/FP-001, *Royal Canadian Air Force Doctrine: Intelligence, Surveillance and Reconnaissance (*Ottawa: DND Canada, 2017*)*, 9.
[6] Ibid., 13

processing and dissemination. Finally, the Combat operations Division (COD) directs the execution of the Air Tasking Order (ATO) and manage time-critical requirements. An ISR annex termed the Reconnaissance, Surveillance and Target Acquisition (RSTA) is published as part of the ATO that contains detailed taskings of ISR platforms and sensors.

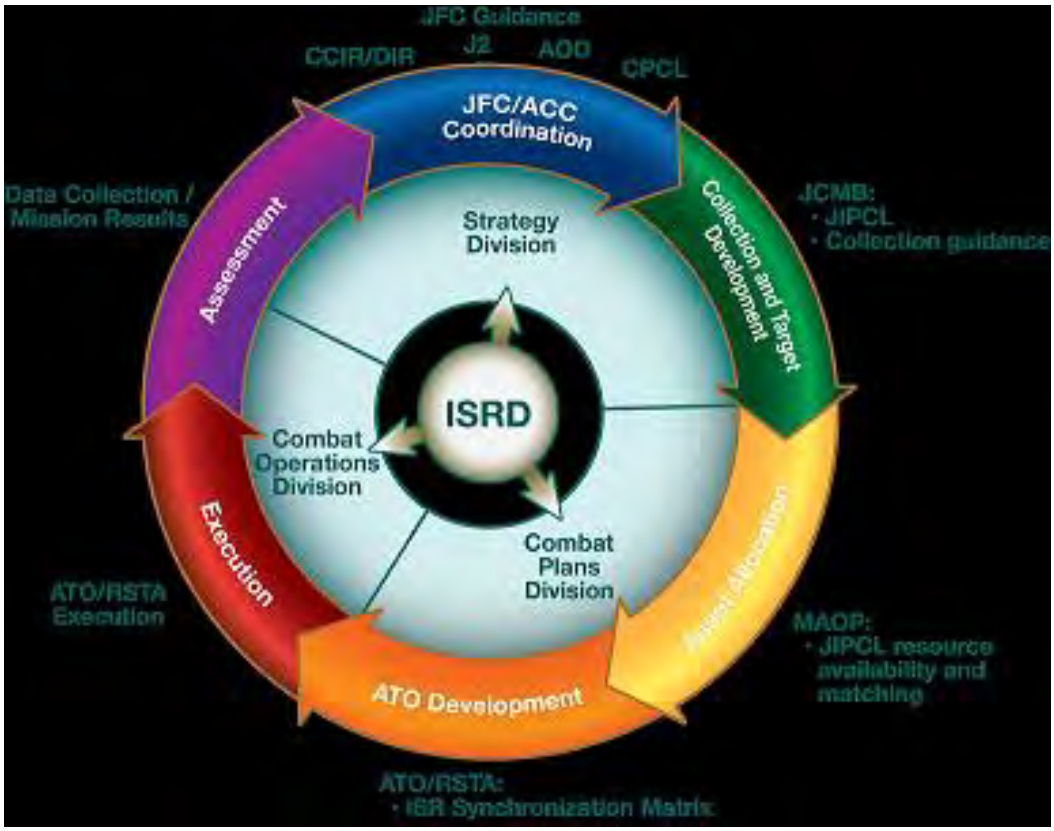

Figure 1: RCAF AOC ISR processes in the Air Tasking Cycle

Source: B-GA-401-002/FP-001:ISR

7. According to the RCAF Future air Operating Concept,[7] the RCAF must "consider the development of flatter, collaborative and agile organizations with vertical and horizontal feedback loops to eliminate information stovepipes". The rigid CAOC and

[7] Department of National Defence, *Royal Canadian Air Force Future Concepts Directive Part 2: Future Air Operating Concept (*Ottawa: DND Canada, 2016*)*, 27.

JIPCL-centered ISR planning, deployment and resultant ATO execution process discussed above is none of that. In fact, it is an example of traditional C2 approaches described by Albert and Hayes[8].

8. The present approach is process-driven and dependent on sequential planning spread over different teams. The collection of multi-spectrum sensor data is centralized at the CAOC. After the information is stove-piped and processed, the collective situational awareness is retained at the center with rigid controls over distribution of information. Only relevant information is then passed to the tactical units. Though this approach works for deliberate targeting in a largely static environment, it is a time intensive multi-step process that can slow down decision making and even lead to expired targeting sets. Figure 2 below illustrates how the classic C2 approach employed at the CAOC is incompatible with the realities of the 21st century conflicts battle-space[9].

[8] David S. Alberts and Richard E. Hayes, *Understanding Command and Control*. (Arlington:CCRP, 2011),2
[9] Ibid., 77

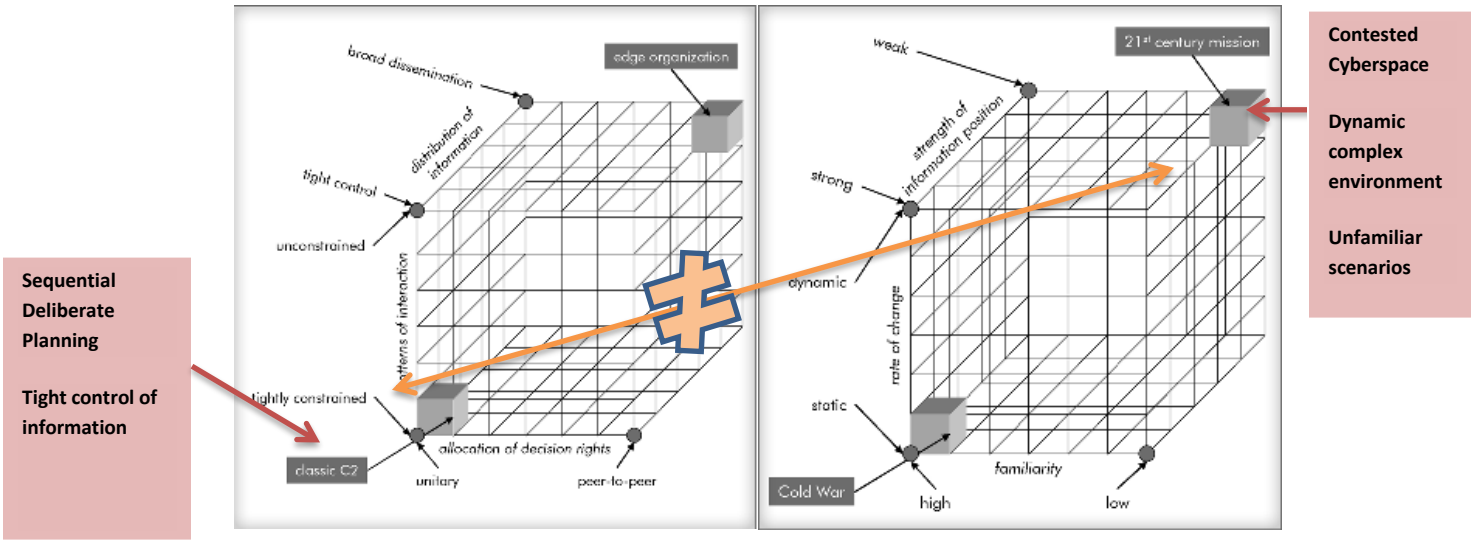

Figure 2: Incompatible C2 approach to problem space

Source: Alberts et all, Understanding Command and Control

9. Gilmary et all argue that "the simplicity of centralized control and decentralized execution renders it incomplete when applied to modern contested and denied operations."[10] Traditional C2 approaches borne out of experiences in recent one-sided conflicts will no longer be as effective in the future. As Hayes et all show in Figure 2, the 21st century battle-space will be low on familiarity, highly volatile and contestants can no longer rely on information superiority. Militaries organizations must evolve to remain relevant by adopting some of the features of an Edge organization. Though it's impractical for the RCAF to become a 'true' edge organization due to political constraints, it's important to recognize the need to take incremental steps in our doctrine towards the top right of the graph to ensure that it stays relevant and responsive.

[10] Gilmary Michael Hostage III and Larry R. Broadwell Jr., "Resilient Command and Control: The Need for Distributed Control," *Joint Force Quarterly* 74 (3rd Quarter, July 2014): 38, http://ndupress.ndu.edu/Portals/68/Documents/jfq/jfq-74/jfq-74.pdf.

Fifth-Generation Fighters

10. The GoC is expected to receive competing bids from Saab's Gripen E, European consortium's 4 Eurofighter Typhoon, Boeing's F/A-18 Super Hornet or Lockheed Martin's F-35 Lightning II Joint Strike Fighter. One of these will likely be picked as the RCAF's next Fighter Jet to meet Canada's commitments to preserving peace and security alongside its NORAD and NATO security partners. Irrespective of which fighter jet is picked by the GoC in 2022, it will present a generational shift in jet fighter aircraft from the CF-188 Super Hornet[11].

11. This paper will utilize the F-35's information age capabilities to make the case for transformational change needed in existing C2 doctrine. It should be noted that similar information capabilities are common among the other fighters in contention. The F-35 provides a fifth-generation answer to the realities of today's complex and rapidly evolving battle-space. Though known mostly for its stealth and striking ability, what is lesser known about the F-35 is its futuristic suite of beyond line of sight ISR sensors and on-board capability to collate and fuse data into a 3-D rendering of the battle-space. It also has the ability to share its situational awareness with other fighters as well as other airborne, surface and sea-based platforms effectively making the F-35 a potential Battle-space manager[12]. In this manner, the F-35 presents a quantum technological leap from the CF-188.

---

[11] Air Power Development Center, "Five generations of Jet Fighter aircraft", *Pathfinder: Air Power Development Center Bulletin* (Issue 170, Jan 2012). http://airpower.airforce.gov.au/APDC/media/PDF-Files/Pathfinder/PF170-Five-Generations-of-Jet-Fighter-Aircraft.pdf

[12] F-35 Lightning II, "Capabilities", last accessed 23 Oct 2019, http://F35.com

12. The F-35's advanced airframe technology provides the pilot unprecedented situational awareness and battle-space management even when operating in a Denial-of-Service (DoS) attack scenario where the pilot has little time and reduced ability to communicate with the CAOC. With its ability to fuse its own sensors data with data available from other coalition platforms, the F-35 is able to self-synchronize independently of the CAOC to retain information superiority

Evolution to CCDCDE

> *Given the complexity of the 21st century security environment and the missions that 21st century militaries are and will be called upon to accomplish, C2 agility is perhaps the most important attribute of a C2 Approach.* [13]
>
> - David S. Alberts, Richard E. Hayes, Understanding Command and Control

13. Figure 3 illustrates Northrop Grumman's interpretation of the existing CCDE structure that illustrates the centralization of situational awareness and development of targets at the CAOC with only segmented targeting information made available to tactical units. This approach is highly dependent on network availability. The F-35's fifth-generation capabilities discussed earlier negate the reliance on the CAOC for the generation of targeting intelligence or fusion of sensor information.

[13] David S. Alberts and Richard E. Hayes, *Understanding Command and Control*. (Arlington: CCRP, 2011), 57.

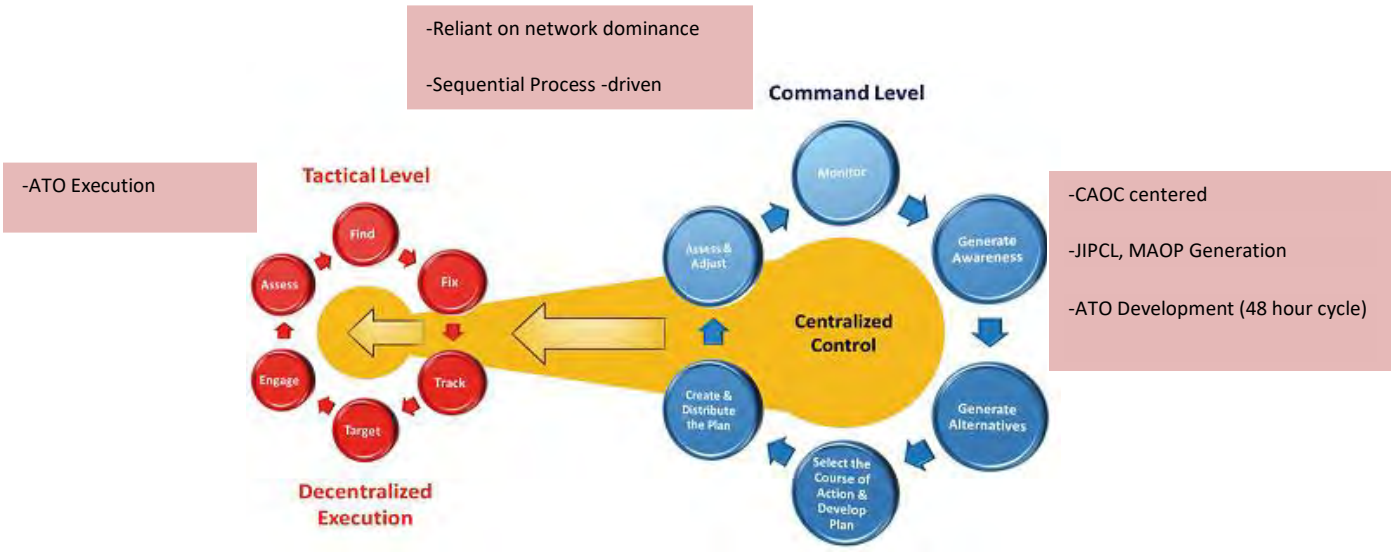

Figure 3: Legacy command and control (CCDE)

Source: Northrop Grumman Integrating 5th Generation systems requires 5th Generation C2

14. Northrop Grumman proposes that air forces transform their CCDE doctrine to one of CCDCDE to get the maximum utility of the F-35 and enable decision superiority in the battle-space of the future.[14] The change is two-fold; transform centralized control to centralized command and the addition of distributed control. Changing to centralized command vice centralized control is required to enable faster decision making at the tactical edge by giving them freedom of action. According to Albert[15], the more complex and dynamic the situation, there is a greater need for more allocation of decision rights to the edge (Figure 2). Centralized command establishes common intent that guides the actions at the tactical edge. Once common intent is established, it reduces the need for centralized control and enhances decentralized execution.

[14] Northrop Grumman, "Integrating 5th Generation systems requires 5th Generation C2". *NIDV Magazine*, no. 3-2015 (2015), <https://www.nidv.eu/wp-content/uploads/2015/07/NIDV_magazine_2015-3_LR.pdf>

[15] David S. Alberts, *Information age Transformations*. (Arlington: CCRP, 2002), 43.

15. The addition of Distributed Control (DC) allows the subordinate units (F-35 in our example) to carry out its mission set in support of the Commander's intent albeit with freedom to self-synchronize and make real-time decisions. Gilmary et all define Distributed Control (DC) as "the conditional, adaptive delegation or assumption of control activities through orders or protocols to synchronize operations, maintain initiative, and achieve commander's intent."[16] DC does not imply the delegation of command authority away from the Air Component Commander (ACC). DC can be implemented in a deliberate manner for certain duration or when faced with an unanticipated communications break-down. DC can also be used to temporarily alleviate the workload of the CAOC during intense periods.[17]

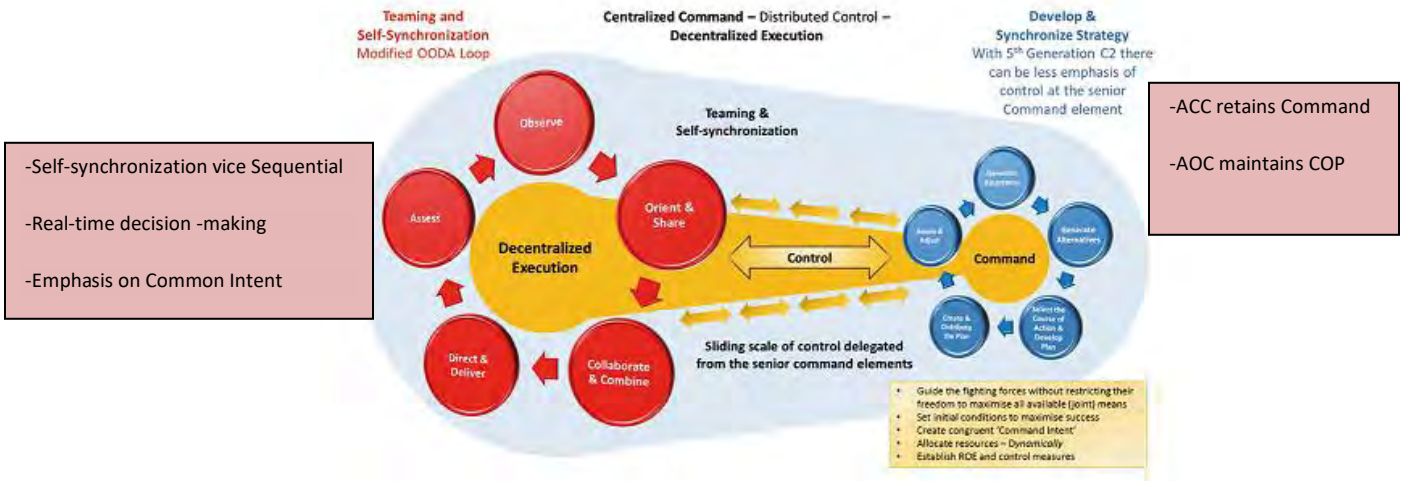

Figure 4:5th Generation C2 (CCDCDE)

[16] Gilmary Michael Hostage III and Larry R. Broadwell Jr., "Resilient Command and Control: The Need for Distributed Control," *Joint Force Quarterly* 74 (3rd Quarter, July 2014): 38, http://ndupress.ndu.edu/Portals/68/Documents/jfq/jfq-74/jfq-74.pdf.

[17] Bart A. Hoeben, "5th Generation C2 and ISR - Exploring new concepts for Air Command & Control and Intelligence, Surveillance & Reconnaissance related to F-35" (International Fellowship paper, Royal Australian Air Force Air Power Development Centre, 2017), 60.

Source: Northrop Grumman Integrating 5th Generation systems requires 5th Generation C2

16. Figure 4 shows how CCDCDE will transform the conduct of air operations. Though the CAOC will retain command and Common Operating Picture (COP), the F-35 (or other 5th Generation platform) pilot will experience a faster OODA loop as its loop is longer intersected by or dependent on the CAOC's control. Pilots can continue to execute ISR, air interdiction or attack missions in line with Commander's intent without a dependency on the CAOC especially when operating in a degraded communications environment. The evolution of CCDE to CCDCDE is also in line with the RCAF Future Air Concept[18] that states that "capabilities that enable freedom of action and continued operations in physical domains, in cyberspace and across the EMS when systems are compromised, degraded or denied in a contested environment should be strengthened."

Establishing Common Intent

17. Establishment of common intent is vital for the transformation of a CCDE centered approach to that of CCDCDE in the conduct of air operations. It is critical that commander's intent be bounded within the acceptable solution space. In other words, by making it explicitly clear what is unacceptable, Commanders can then allow subordinates freedom of action within the solution space for acceptable options as seen in Figure 5[19].

[18] Department of National Defence, *Royal Canadian Air Force Future Concepts Directive Part 2: Future Air Operating Concept (*Ottawa: DND Canada, 2016*)*, 30.
[19] Pigeau, R.A., C.A. McCann. "Establishing Common Intent: The Key to Co-ordinated Military Action." In *The Operational Art: Canadian Perspectives — Leadership and Command*. Kingston:(2006): 93

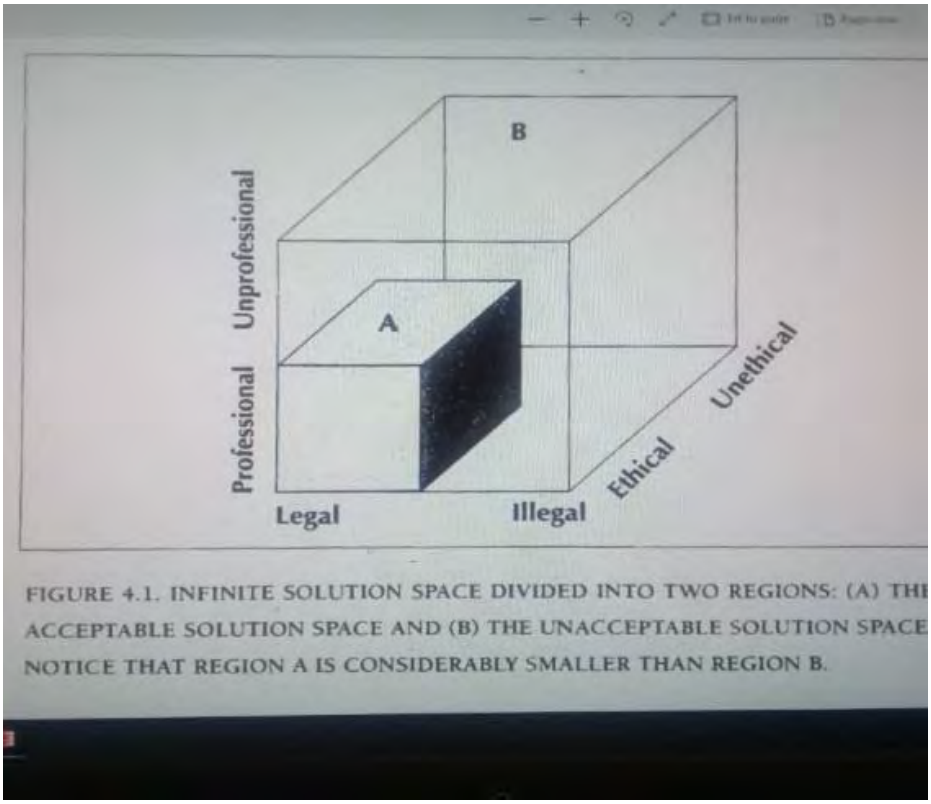

Figure 5: Bounded solution space

Source: Pigeau et all, Establishing Common Intent: The Key to Coordinated Military Action

18. As Pigeau and McCann[20] have pointed out, three factors affect the establishment of common intent are level of motivation and commitment, level of shared explicit and tacit knowledge and reasoning ability. The pilot's reduced competency in any of these factors can then affect his or her ability to comprehend the acceptable solution space in a CCDCDE scenario where decisions must be made in the absence of the Commander (CAOC). Therefore, training of the F-35 or other fifth-generation fighter jet pilots must

[20] Pigeau, Ross, and Carol McCann. "Re-conceptualizing Command and Control." *Canadian Military Journal* 3, no. 1 (2002): 53-63.

go beyond technical competency. The pilots should be selected and tested on their level of motivation and commitment as well as reasoning ability.

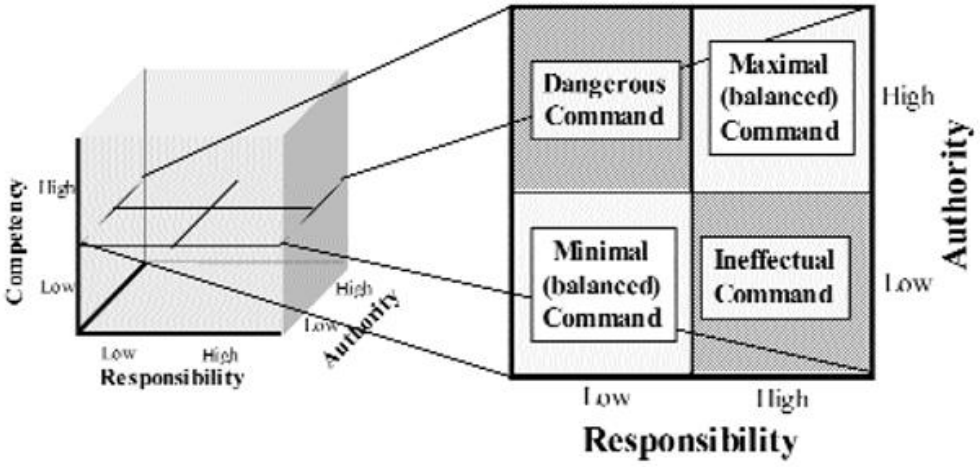

Figure 6: Competency-Authority-Responsibility Interplay

Source: Pigeau et all, Establishing Common Intent: The Key to Coordinated Military Action

19. Existing RCAF training continues to produce highly competent and motivated pilots that excel in their craft. However, under the CCDCDE construct, they will be granted additional authorities and freedom of action. As Pigeau & McCann's CAR model shows (Figure 6), a significant level of authority without commensurate sense of responsibility can lead to a situation of Dangerous Command. Therefore, the pilots must accept the legal and moral liability of such a responsibility[21]. Otherwise, there is a high risk that the pilots can take actions out of line with the Commander's intent. The RCAF needs to make concerted efforts in changing its CCDE centric training doctrine to permit the development of CCDCDE-driven training programs that develop the fifth-generation

[21] R. Murphy and K. Doherty, "The Triangle Model of Responsibility," *Psychological Bulletin*, Vol. 101, No. 4 (1994):640.

jet fighter pilots of tomorrow. Such training will include the evolution of training and exercises that train pilots for Distributed Control in a cyber-contested battle-space. Otherwise, they will be ill-prepared for executing mission command when faced with unanticipated problem sets in a degraded communications environment where reach-back is unavailable.

RECOMMENDATION

20. It is recommended that the Commander RCAF task the RCAF Aerospace Warfare Center (RAWC)[22] to update the Canadian Forces Aerospace Command Doctrine (B-GA-401-000/FP-00) to render it more relevant to the employment of the fifth-generation fighters in the 21st century battle-space. To enable this change, the RAWC, in its capacity as the change driver and enabler for the RCAF, should modify Chapter 2 (Command in the Aerospace domain) to introduce the concept of CCDCDE as the next iteration of CCDE. This will then be the catalyst required to overhaul the training and development programs for fifth-generation fighter pilots to reflect the evolution of C2. Next, the RAWC must modify Chapter 3 (Elements of Command and Control) in order to reflect the CCDCDE transformation required in the existing processes that govern the planning and execution of air power. This will specifically overhaul how air power is controlled and coordinated by the CAOC to reflect fifth-generation C2 principles of distributed control and self-synchronization.

[22] Royal Canadian Air Force, "RCAF Aerospace Warfare Center", last accessed 23 Oct 2019, http://www.rcaf-arc.forces.gc.ca/en/cf-aerospace-warfare-centre/index.page

CONCLUSION

21. The battle-space of the near future promises to be a lot more complex and dynamic than what RCAF has encountered in the past. The RCAF cannot assume unfettered access to C2 networks for granted in planning and executing operations as enshrined in the existing CAOC centered approach. The addition of the fifth-generation fighter jet to RCAF presents a great opportunity for RCAF to gain an airframe that represents a quantum technological leap in military technology. However, employing the F-35 with the same doctrine used to employ the F-188's will squander that advantage. It is imperative that the RCAF transform its CCDE doctrine to CCDCDE in order to employ the F-35 to its full potential and enable decision superiority at the tactical edge. This change will enable the fifth-generation fighter pilots to better handle unanticipated situations in a degraded communications environment with zero or minimal contact with the CAOC. Vital to the CCDCDE approach is the establishment of common intent. Enabling this change will require pilot selection and training that goes beyond technical proficiency. The training must emphasize reasoning ability and instil a sense of moral and legal responsibility commensurate with the authority. CAF must strive to create a dialogue with the NATO militaries and especially the Americans on the new doctrinal approaches required to get the most out of the fifth-generation fighters and remain relevant in the future battle-space.

BIBLIOGRAPHY

Air Power Development Center, "Five generations of Jet Fighter aircraft", *Pathfinder: Air Power Development Center Bulletin* (Issue 170, Jan 2012). http://airpower.airforce.gov.au/APDC/media/PDF-Files/Pathfinder/PF170-Five-Generations-of-Jet-Fighter-Aircraft.pdf

Bart A. Hoeben, "5th Generation C2 and ISR - Exploring new concepts for Air Command & Control and Intelligence, Surveillance & Reconnaissance related to F-35" (International Fellowship paper, Royal Australian Air Force Air Power Development Centre, 2017).

Canada. Department of National Defence, *Strong, Secure, Engaged: Canada's Defence Policy* Canada Comunications Group, 2017.

Canada. Department of National Defence, B-GA-402-001/FP-001, *Canadian forces Aerospace Command Doctrine.* Ottawa: DND Canada, 2012.

David S. Alberts, *Information age Transformations*. Arlington: CCRP, 2002.

David S. Alberts and Richard E. Hayes, Power to the Edge: *Command and Control in the Information Age*. Arlington: CCRP, 2005

David S. Alberts and Richard E. Hayes, *Understanding Command and Control*. Arlington: CCRP, 2011

Department of National Defence, B-GA-401-002/FP-001, *Royal Canadian Air Force Doctrine: Intelligence, Surveillance and Reconnaissance.* Ottawa: DND Canada, 2017.

Department of National Defence, *Royal Canadian Air Force Future Concepts Directive Part 2: Future Air Operating Concept.* Ottawa: DND Canada, 2016.

Gilmary Michael Hostage III and Larry R. Broadwell Jr., "Resilient Command and Control:The Need for Distributed Control," *Joint Force Quarterly* 74 (3rd Quarter, July 2014): 38, http://ndupress.ndu.edu/Portals/68/Documents/jfq/jfq-74/jfq-74.pdf.

F-35 Lightning II, "Capabilities", last accessed 23 Oct 2019, http://F35.com

Northrop Grumman, "Integrating 5th Generation systems requires 5th Generation C2".*NIDV Magazine*, no. 3-2015 (2015), <https://www.nidv.eu/wp-content/uploads/2015/07/NIDV_magazine_2015-3_LR.pdf>

Public Services and Procurement Canada. “Futue Fighter Capability Project.” Last accessed 23 Oct 2019, https://www.tpsgc-pwgsc.gc.ca/app-acq/amd-dp/air/snac-nfps/CF-18-eng.html

Pigeau, R.A., and C.A. McCann. “Establishing Common Intent: The Key to Co-ordinated Military Action.” In *The Operational Art: Canadian Perspectives — Leadership and Command*. Kingston, 2006.

Pigeau, Ross, and Carol McCann. “Re-conceptualizing Command and Control.” *Canadian Military Journal* 3, no. 1 (2002): 53-63.

R. Murphy and K. Doherty, “The Triangle Model of Responsibility” *Psychological Bulletin*, Vol. 101, No. 4 (1994): 632-652.