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Remote Digital ATC: A Step-Function Upgrade to a Capability Critical for Air Power

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REMOTE DIGITAL ATC:
A STEP-FUNCTION UPGRADE TO A CAPABILITY CRITICAL FOR AIR POWER

The air traffic control (ATC) tower is an iconic and commanding presence that serves as a reassuring perch from which ATC Officers enable both force generation and employment of the Royal Canadian Air Force's (RCAF) air power, deconflicting users in the air or on the ground while balancing safety with efficiency. ATC is complex, requiring assessment of aircraft speeds and headings, using radars or visually fixing aircraft locations relative to their destination, applying separation standards and other regulations, sequencing and prioritizing missions, and communicating with pilots and other ATC Officers throughout the entire process.[1]

Stewardship of ATC capabilities has required ongoing costly sustainment of infrastructure and equipment that drain already tight budgets, despite the reality that alternative and less expensive options exist. Recently, the RCAF has financed replacement of aging towers and radar control centres, with completion of the CFB Comox tower in 2000, CFB Trenton in 2010, and CFB Greenwood in 2021, and a crumbling CFB Shearwater yet to gain funding despite being in desperate need of replacement. From planning to delivery, the latest tower replacement at CFB Greenwood took more than 10 years, with total costs for construction, furniture, and equipment projected to exceed $34M, and the tower itself $15.5M.[2] However, new regulations and technology are already in use at major airports throughout the world which permit the provision of remote digital air traffic control services without costly tower

[1] Murillo Pagnotta et al., "Task Difficulty and Physiological Measures of Mental Workload in Air Traffic Control: A Scoping Review," *Ergonomics*, December 14, 2021, Intro, doi:10.1080/00140139.2021.2016998.
[2] Department of National Defence, "Budget 2016: Highlights of Federal Infrastructure Investments at 14 Wing Greenwood and Detachment Aldershot" (Canada, September 8, 2016), https://www.canada.ca/en/department-national-defence/news/2016/09/highlights-federal-infrastructure-investments-14-wing-greenwood-detachment-aldershot.html; Canada, Department of National Defence, "Replace Control Tower - 14 Wing Greenwood," Defence Capabilies Blueprint - Defence Investment Plan 2018, January 9, 2020, http://dgpaapp.forces.gc.ca/en/defence-capabilities-blueprint/project-details.asp?id=1852.

infrastructure that make for lengthy project management and costs related to personnel hours, all while enhancing services both in terms of safety, efficacy, and capability for deployment.

Air power's tight coupling to technology can present opportunities, but only if we practice the ability to look beyond "presentism."[3] This paper will argue that remote digital air traffic control capabilities should be immediately adopted by the RCAF to evolve both domestic and expeditionary ATC capabilities. Using the CAF Force Development analysis tools of Measures of Capability (MoC) and the Personnel and Infrastructure aspects of PRICIE analysis, this paper will show that remote digital ATC not only represents an evolution in the ATC capability, but also presents opportunities to enhance member engagement, retention, and readiness, as well as save significant costs that also improve procurement timeframes. Essentially, the digital control technology should be the future of the RCAF.

Force Development Models

Capability-based planning (CBP) is a process for identifying and recommending capability and force options to meet government priorities, expected tasks and the operating environment in the context of an economic framework that requires tough decisions.[4] Within CBP, CAF Force Development doctrine directs inquiry around the Conceive, Design, Build and Manage model for validation and sustainment of existing capability, including present to future capability evolution in the future.[5] Measures of Capability (MoC) and PRICIE analysis models

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[3] John Andreas Olsen, *Routledge Handbook of Air Power* (Abingdon, Oxon: Routledge, 2018), 374, https://search.ebscohost.com/login.aspx?direct=true&db=nlebk&AN=1714916&site=ehost-live&scope=site.
[4] The Technical Cooperation Program (TTCP), "Guide to Capability-Based Planning" (Defence Research and Development Canada, June 2013), 6, https://cradpdf.drdc-rddc.gc.ca/PDFS/unc194/p801995_A1b.pdf.
[5] Canada, Department of National Defence, "Evaluation of Defence Capability Development Program (Audit)" (Ottawa, November 2017), 2, https://www.canada.ca/en/department-national-defence/corporate/reports-publications/audit-evaluation/evaluation-defence-capability-development-program.html.

are used to guide that capability assessment. MoCs are functional abilities that contribute to mission achievement and include lethality, survivability, environmental resilience, range, adaptation, technical, deployability and sustainability, and other factors.[6] PRICIE is a framework that describes the institutional costs of a capability around the following dimensions: Personnel, leadership and individual training; Research and development and operational research; Infrastructure and environment; Concepts, doctrine and collective training; Information management and information technology; and Equipment, support and sustainability.[7] Combined, the output from this analysis can fuel organizational decisions on investment, divestment or sustainment of core capabilities, which would include divestment of legacy approaches to capability delivery in favour of improved models, such as remote digital ATS.[8] It is through these two lenses that remote digital ATC will be considered.

Remote-Digital-ATC 101

Remote digital ATC replaces legacy "out-of-the-window" visual controlling so controllers can provide service for any location from any location by using technologies that include radar, infrared and other sensors, as well as high-resolution imagery. [9] The International Civil Aviation Organization, which standardizes air traffic control globally, paved the way for this evolution by allowing "visual observation [to] be achieved through direct out-of-the-window

[6] Chief of Force Development, "Capability Based Planning Handbook, V.9" (Department of National Defence, 2019), 30–31.
[7] Ibid., 33.
[8] Ibid., 45.
[9] Robert W Poole Jr, "Organization and Innovation in Air Traffic Control," *Reason.Org*, n.d., 6, https://reason.org/wp-content/uploads/files/air_traffic_control_organization_innovation.pdf.

observation, or through indirect observation utilising a visual surveillance system."[10] Digital ATC has been tested and successfully implemented in Sweden as early as 2015, as well as Hong Kong, Budapest, Germany, UK, and in 2021 at London Centre Airport (LHR), which services over 85,000 movements annually.[11, 12] In Ireland, a controller in a Dublin can simultaneously support three major airports using digital towers. In the United States, the FAA reported that a remote digital tower trial showed the system was operational viable after more than 75,000 movements.[13]

Many aviation technology companies have developed proprietary systems, including Searidge Technology, who has partnered with NAV Canada to test remote tower operations in Atlantic Canada, as well as Saab and Frequentis Technologies, who have signed contracts with the RAF and NATO, and USAF respectively to test and adopt these capabilities. The UK Military Aviation Authority, one of the world's foremost defence aviation safety bodies, has already issued regulatory approval for digital remote towers to be in full operational use. [14,15,16]

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[10] International Civil Aviation Organization, "DIGITISATION OF AERODROME AIR TRAFFIC SERVICES" (Thirteenth Air Navigation Conference, Montreal, Canada: ICAO, 2018), 2.1.1, https://www.icao.int/Meetings/anconf13/Documents/WP/wp_174_en.pdf.

[11] NATS: UK Based Air Traffic Service Provider, "London City Is First Major Airport Controlled by Remote Digital Tower," April 30, 2021, https://www.nats.aero/news/london-city-is-first-major-airport-controlled-by-remote-digital-tower/.

[12] "Saab Inks Deal for Digital Solution at Cranfield Airport," *Airline Industry Information*, October 11, 2017, https://www.proquest.com/trade-journals/saab-inks-deal-digital-solution-at-cranfield/docview/1949576571/se-2?accountid=9867.

[13] Chad Trautyetter, "FAA: Remote Tower at Leesburg 'Operationally Viable,'" November 10, 2021, https://www.ainonline.com/aviation-news/business-aviation/2021-11-10/faa-remote-tower-leesburg-operationally-viable.

[14] "Sweden : Saab Digital Tower Demonstrator Ordered by Royal Air Force," *MENA Report*, March 7, 2020, https://www.proquest.com/trade-journals/sweden-saab-digital-tower-demonstrator-ordered/docview/2373041067/se-2?accountid=9867.

[15] "Saab's Digital Tower Achieves UK MAA Approval: Saab Can Now Deliver and Maintain Digital Tower Air Traffic Management Equipment for the UK Armed Forces," *Defense Advancement Periodical*, April 14, 2022, https://www.defenseadvancement.com/news/saabs-digital-tower-achieves-uk-maa-approval/.

[16] "Digital Facilities: NAV CANADA and Searidge Gear up to Test Video Technology for Air Traffic Services" (Ottawa, ON: NAV CANADA, October 5, 2020), https://www.navcanada.ca/en/news/blog/digital-facilities-nav-canada-and-searidge-gear-up-to-test-video-technology-for-air-traffic-services.aspx.

This digitization presents opportunities to fuse elements of information from multiple sources on one screen to augment controller decision making. Controllers can now view digital data tags, receive information that provides predictive separation, and be made aware of alerts to flight safety issues. This additional information can serve to "reduce the mental computation" load for air traffic controllers and lead to better decision making, especially in higher tempo environments or increased operations. [17]

Delivering Enhanced Capability Effects

Currently, increasingly in the future, Canada is facing a defence and operational environment that requires "simplicity, greater agility and timely delivery" of capability, both at home and abroad.[18] "Strong, Secure and Engaged," Canada's most recent defence policy, articulates a focus on modernizing the Canadian Armed Forces, and seizing technological advancements to keep pace with allies and ahead of adversaries in the context of meeting adversaries on their home turf.[19] This requirement necessitates the CAF to be ready to deploy to austere environments with high levels of readiness. As a capability, ATC is a combination of practitioner experts, physical assets, and organizational resources used to procure and sustain the capability, [20] which makes it especially unique in terms of providing ATS overseas or in difficult domestic locations. Remote digital technology would improve several measures of capability.

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[17] Fitri Trapsilawati et al., "Integration of Conflict Resolution Automation and Vertical Situation Display for On-Ground Air Traffic Control Operations," *Journal of Navigation* 74, no. 3 (2021): 625, doi:10.1017/S0373463320000703.

[18] Ross Fetterly, "Funding Defence for the Age of Acceleration" (Canadian Global Affairs Institute, April 2019), 23, https://www.cgai.ca/funding_defence_for_the_age_of_accelerations.

[19] Canada and Department of National Defence, *Strong Secure Engaged: Canada's Defence Policy.* (Ottawa: Minister of National Defence, 2017), 50, 55, 63.

[20] Alfred E. Jr. Thal and David E. Shahady, "Is Your Organization Ready for Innovation?," in *Defense Innovation Handbook : Guidelines, Strategies, and Techniques*, ed. Adedeji B. Badiru and Cassie Barlow (Milton, UNITED KINGDOM: Taylor & Francis Group, 2018), 192.

With remote digital technology, ATC capability would be enhanced through improved controller situational awareness and flight safety. Furthermore, the potential for miniaturization of the systems that enhance deployability for remote control from safe locations would improve ATC capability to better meet the vision articulated in defense policy.

Remote digital ATC capabilities provide improvement across multiple MoCs, including lethality, survivability, preparedness, environmental resilience, endurance, fidelity, deployability, and sustainment.[21] Firstly, multiple high definition cameras replicate a controller's 'out of the window' tower view, and can be further magnified up to 30 times. As a particular boon, these images are at a far higher definition than human faculties or binoculars.[22] Secondly, those cameras can be augmented by infrared and other sensors that significantly improve night operations or visibility in poor weather conditions.[23] Thirdly, cameras can track moving objects, with the potential to overlay additional data—such as altitude, speed, type, route details, and weather readings—to provide an enhanced reality view to the controller in real time.[24] Traditional tower control requires much of this additional information to be collected from multiple displays or tools that can be both distracting or cognitively inaccessible during emergencies or higher tempo. [25] The remote digital tower capability reimagines a capability

[21] Chief of Force Development, "Capability Based Planning Handbook, V.9," 30–31.
[22] "Aviation Policy News: Remote Towers Are Going Mainstream in Europe," *Reason Foundation*, February 25, 2022.
[23] "TINKER CENTER OF NEW ATC TESTING," *US Fed News Service, Including US State News*, July 26, 2019, 2264946128, Military Database, https://www.proquest.com/newspapers/tinker-center-new-atc-testing/docview/2264946128/se-2?accountid=10524.
[24] Philip Georgiadis, "London City Airport Replaces Control Tower with Virtual System," *FT.Com*, April 29, 2021, https://www.proquest.com/trade-journals/london-city-airport-replaces-control-tower-with/docview/2533671779/se-2?accountid=9867.
[25] Trapsilawati et al., "Integration of Conflict Resolution Automation and Vertical Situation Display for On-Ground Air Traffic Control Operations," 625.

blueprint that has not changed since WW II, providing additional new tools that make for safer and more effective service capability.[26]

Many military organizations see remote digital towers as a potential dual-use system and this capability can be used domestically and also to deploy air traffic control to austere fields, in potentially contested operating zones. Expeditionary ATC is human centric, and requires significant sustainment, thus this capability is able to be delivered while keeping operational experts out of harm's way and reducing force protection requirements.[27] Canada's current Expeditionary Air Traffic Management capability is shepherded by 8 ACCS and consists of a cramped, purpose-built late model trailer with windows, poor environmental controls, and requires auxiliary sensors and systems to support communications. Also, ATC towers are often high value and high priority targets both as a highly visual command and control node, but also because ATC facilitate air power; as shown in the Iraq war, towers are often shot at or shelled, but remote digital ATC can reduce this risk. [28] The US Air Force has acquired two deployable remote digital towers capable of deployment in the back of a Humvee, to be set up within hours.[29] When the cameras and sensor suite are attached to a tall structure, such as a building or mast that allows full view of the airfield, visuals are fed to a safer location control room where controllers can remain outside the war zone, thereby protecting their expertise.[30] Importantly, adoption of this new technology enhances ATC as a command and control node, both because the quality and quantity of data increases, and the RCAF will still require controllers who can

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[26] Georgiadis, "London City Airport Replaces Control Tower with Virtual System."
[27] "Sweden : Saab Digital Air Traffic Solutions Receives NATO Air Base Order," *MENA Report*, June 29, 2019, https://www.proquest.com/trade-journals/sweden-saab-digital-air-traffic-solutions/docview/2249326113/se-2?accountid=9867.
[28] Stew Magnuson, "Air Force Tests Remote Air Traffic Control Towers," *National Defense* 103, no. 785 (April 2019): 12.
[29] Ibid.
[30] "TINKER CENTER OF NEW ATC TESTING."

"understand, interpret and contextualize this information."[31] Royal Navy commander Mick Gladwin has stated that the "development and exploitation of remote system technology to enhance the way air traffic services are delivered, [is] improving controller efficiency and providing a safe operating environment for air systems."[32]

The Personnel Factors in Favour of Remote Digital ATC

Remote digital air traffic control holds the potential to ameliorate issues surrounding recruiting, force generation, and retention of air traffic controllers, as well as superior flexibility and efficiency in providing control services domestic and abroad. These benefits are encapsulated in the "Personnel and Leadership" aspect of the PRICIE framework used in CAF Force Development doctrine to classify and contextualize the necessary components to deliver a capability.[33] Adoption of digital tower technology will open the potential for increased operational efficiency through centralization, safety enhancements, and increased flexibility, while setting the stage for embracing future technology in delivery of ATC services.[34]

Much of this benefit derives from a movement to a centralized digital ATC control centre, where controllers provide services from a single, safe location that can be outside of the war zone or locations of increased risk.[35] This will allow the RCAF to maintain 24/7 operations at core flying wings, while increasing flexibility in flying hours at smaller aerodromes or for

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[31] Stephanie Carvin, "Canadian Defence and New Technologies," in *Canadian Defence Policy in Theory and Practice*, ed. Thomas Juneau, Philippe Lagassé, and Srdjan Vucetic (Cham: Springer International Publishing, 2020), 391, doi:10.1007/978-3-030-26403-1_22.
[32] "Saab's Digital Tower Achieves UK MAA Approval: Saab Can Now Deliver and Maintain Digital Tower Air Traffic Management Equipment for the UK Armed Forces."
[33] Emile Pelletier, "Operational Research and Analysis Supporting Canadian Army PRICIE + G Analyses" (DEFENCE RESEARCH AND DEVELOPMENT CANADA OTTAWA, October 2016), 26–27.
[34] William Richardson et al., "Toward Agile Procurement for National Defence: Matching the Pace of Technological Change," *CGAI*, 2020, 5, https://www.cgai.ca/on_toward_agile_procurement_for_national_defence.
[35] Poole Jr, "Organization and Innovation in Air Traffic Control," 25.

deployed operations and emergency response.[36] A European Union study found that a consolidated control centre allows for flexibility of staffing and service delivery that is impossible with a decentralized in-location model.[37] As an example, current RCAF ATC employment models employ 10 or more controllers on a normal night shift, all while providing service to only a handful of aircraft that could be easily be handled by one or two controllers remotely.[38] Consolidating controllers in a centralized location provides a larger staffing pool that allows ATC to focus service delivery for specific exercises or night flying operations, or to easily pivot when required to support unexpected air power operations. With some wings struggling to check out controllers still in the training phase of their employment and therefore not yet operational, fewer controllers on night shift would allow for greater personnel recovery and training and professional development across the occupation.

Given the demographic shift to a younger, less experienced workforce, and stiff competition with civilian control agencies that is affecting ATC staff retention, a centralized control centre concentrates professional experience to more effectively provide services, but also to support force generation. Operational Training Units (OTUs) are currently decentralized, and a digital control centre would consolidate training efficiency and ensure controllers can benefit from the air traffic densities and complexities that are unique to each wing, further enhancing and broadening each controller's skills. Finally, a centralized ATC community nexus could

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[36] "Skyguide Expands Collaboration with FREQUENTIS to Advance Its Virtual Centre Strategy," *Contify Telecom News* (New Delhi: Athena Information Solutions Pvt. Ltd., February 19, 2021), 2491543712, Advanced Technologies & Aerospace Collection; ProQuest Central, https://www.proquest.com/magazines/skyguide-expands-collaboration-with-frequentis/docview/2491543712/se-2?accountid=9867.

[37] Transport and Mobility Section, "Remote Airport-Tower Concept Proven and Ready for Deployment: PJ05 Remote Tower Project Overview" (European Union - Community Research and Development Information Service, May 5, 2020), https://cordis.europa.eu/article/id/415953-remote-airport-tower-concept-proven-and-ready-for-deployment.

[38] "Aviation Policy News: Remote Towers Are Going Mainstream in Europe."

address well-known issues that affect attrition, including geographic stability and the impact off military life on spouses and families.[39] A centralized nexus also provides an opportunity for the community to enhance group and occupational affiliation, which is often lauded as a core principle and benefit of military life.

It must be acknowledged that the transition to a centralized digital ATC control centre may face some challenges from a personnel perspective. Depending on the wing, some communities would lose 40 or more highly skilled, high-paying jobs. There may also be resistance from civic leadership, as was found in Scotland where regional governments highlighted the loss of those jobs and buying power in the community when the region's ATC agency communicated an intent to adopt this technology.[40] In addition, some controllers have already established a connection with their current posting location, or communicated an intent to release for family or lifestyle reasons should a future posting be required. However, these issues would be minimal given the staffing size of ATC units relative to the wing as a whole, and could be further mitigated by careful selection of the location of the future control centres with an eye to balancing quality of life and cost of living. Further, a switch to a digital tower model would be a deliberate process undertaken over time as towers neared retirement age, and would involve planning to mitigate these issues.

Ultimately, choosing digital towers allows for the centralization of air traffic services, enhancing staffing efficiencies and flexibility in re-tasking expertise to meet the demands of the

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[39] Vanessa Myers, Evanya Musolino, and Emrah Eren, "The 2019 CAF Regular Force Retention Survey: Qualitative Analysis" (DEFENCE RESEARCH AND DEVELOPMENT CANADA OTTAWA, 2019), 61; Edward Yeung, Evanya Musolino, and Emrah Eren, "The 2019 CAF Regular Force Retention Survey: Descriptive Analysis" (DEFENCE RESEARCH AND DEVELOPMENT CANADA OTTAWA, 2019), 21.

[40] Andrew Tunnicliffe, "Remote ATC Towers: Why Not Everyone Is on Board," *Airport Industry Review*, January 2021, Issue 63 edition, https://airport.nridigital.com/air_jan21/remote_air_traffic_control.

flying community at any aerodrome.[41] Since the RCAF is struggling to attract and retain expertise, and attrition through ATC training exceeds 60 per cent, efficiency and flexibility in meeting domestic demands could allow for better support of the Expeditionary Air Traffic Management capability that is so critical to operations abroad.[42]

The Infrastructure Factors in Favour of Remote Digital ATC

In the PRICIE model, remote digital ATC presents significant advantages from the perspective of infrastructure and equipment sustainment. The service has always faced the challenge of "how to get the most capability for the money they spend."[43] Defence funding must balance "personnel, operations and maintenance, and capital or equipment,"[44] and costly construction and maintenance of DND infrastructure is a significant portion of those costs. With a legacy control tower bill starting at $20M—on top of additional fees in furniture, environmental concerns with new builds, and increased cost of supplies—tower construction falls within the major projects category, with an average project life exceeding 10 years due to file processing times and funding competition. [45, 46] The financial and administrative hurdle in replacing a tower is evident in the aging Shearwater tower still yet to receive funding.[47] On the

[41] Stew Magnuson, "U.S. Military Experiments With Remote Digital Air Traffic Control," *National Defense* 105, no. 808 (March 2021): 11.
[42] Steven Maj Buckley, Occupation Manager Update Brief, delivered at Aerospace Capability Advisory Group 22-01 in Cornwall, ON, Conference, 21 Apr 22.
[43] Alain C Enthoven and K Wayne Smith, *How Much Is Enough?: Shaping the Defense Program, 1961-1969* (Rand Corporation, 2005), 327.
[44] Fetterly, "Funding Defence for the Age of Acceleration," 42.
[45] Canada, "Defence Investment Plan 2018 - Defence Capabilities Blueprint," 2018, 41, http://dgpaapp.forces.gc.ca/en/defence-capabilities-blueprint/index.asp.
[46] Canada, Department of National Defence, "Project Approval Directive" (Canada Communication Group, 2019), 35.
[47] ACAG Membership, "Aerospace Capability Advisory Group (ACAG) 22-01 Discussions" (ACAG 22-01, Cornwall, ON, 21-22 APR 22).

other hand, remote digital control tower systems cost $2-3M for a medium-sized aerodrome, allowing these projects to fall within the minor projects regime, manageable by the CAF and RCAF directly.[48] The FAA has estimated that remote towers result in a savings of over 50% relative to the replacement of a traditional tower, and these savings are amplified as additional towers are replaced with remote digital systems.[49] In fact, Britain's ATC service provider has projected an additional 30% savings due to improved efficiency across multiple airports.[50] Further, remote systems are simpler to install, with significantly less sustainment requirements, which only heightens their benefits. Remote digital ATC capability presents an opportunity to shed the old paradigm of major projects and platform-based capability that will be used for decades in favour of more agile and flexible systems that can provide the same or better operational effect.

CONCLUSION

Just because we've always done it "that" way, doesn't mean it's still the best way. Military procurement and capability advisors must keep abreast of advances, advocate for their adoption to evolve capabilities, and in this case, save significant costs. The CAF is experiencing a technological revolution that both creates challenges in maintaining a technological edge over our adversaries, yet equally opens opportunities to use autonomous and digital systems as "solutions to deal with declining budgets, demographic change and the evolving nature of

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[48] Canada, Department of National Defence, "Project Approval Directive," 41; Magnuson, "Air Force Tests Remote Air Traffic Control Towers."

[49] "What Are 'Virtual' Air-Traffic Control Towers?: The Economist Explains," *The Economist (Online)* (London: The Economist Newspaper NA, Inc., May 29, 2017), 1904293604, ProQuest Central, https://www.proquest.com/magazines/what-are-virtual-air-traffic-control-towers/docview/1904293604/se-2?accountid=9867.

[50] Georgiadis, "London City Airport Replaces Control Tower with Virtual System."

warfare."[51] As Rittle and Webber asserted in their seminal paper on wicked problems, we need to move from questions about what the system or capability is made of (the legacy ATC tower) to what do the systems do, which allows us to challenge established processes, assumptions and expectations and be open to new paradigms.[52, 53] Remote digital towers represent not only a step-function improvement in the ATC capability, but also minimize procurement funding and timeline challenges. By enhancing air traffic controller situational awareness, both the quality of control services provided and the safety of flight are improved. Remote digital tower technology allows for the consolidation of ATC facilities and controllers that would enable more efficient and less labour-intensive delivery of capability, and create economies of scale that make for eased domestic and deployed capabilities.[54] Centralized ATC control centres could solve recruiting, training, and retention by creating geographic stability to better support military spouses and families, consolidating OTU activities, and create flexibility in meeting the demands of the Forces domestically and abroad. It has been said that the "availability of current strategic choices is a reflection of past strategic choices," and the procurement of remote digital ATC could be the seed for future success for the RCAF.[55]

There are two immediate opportunities to seize the occasion of advancing ATC in the RCAF through the procurement of a remote digital systems: CFB Shearwater Tower replacement project and modernizing EATM ATC capability. The former has struggled to obtain funding for a number of years despite crumbling and leaking tower infrastructure, while the latter is built

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[51] Carvin, "Canadian Defence and New Technologies," 383.
[52] Horst W J Rittel and Melvin M Webber, "Dilemmas in a General Theory of Planning," *Policy Sciences* 4, no. 2 (June 1, 1973): 157.
[53] Nicola Sayers, "A Guide to Scenario Planning in Higher Education," Leadership Foundations for Higher Education — Research and Development Series 2, no. 4 (January 2010): 2.
[54] Poole Jr, "Organization and Innovation in Air Traffic Control," 6.
[55] Thal and Shahady, "Is Your Organization Ready for Innovation?," 193.

upon a legacy containerized deployable tower. These would present an opportunity to validate remote digital ATC for the RCAF in both a domestic and deployable context. Germany's national ATC service provider has already suggested that remote digital technology is a paradigm shift that will likely see no new traditional towers in the future, while the RAF's Chief of Staff Capability believes it is the key to "operating safety, securely and efficiently for decades to come."[56, 57]

[56] "Sweden : Saab Digital Tower Demonstrator Ordered by Royal Air Force."
[57] "Aviation Policy News: Remote Towers Are Going Mainstream in Europe."

BIBLIOGRAPHY

ACAG Membership. "Aerospace Capability Advisory Group (ACAG) 22-01 Discussions." Presented at the ACAG 22-01, Cornwall, ON, 21-22 APR 22.

Reason Foundation. "Aviation Policy News: Remote Towers Are Going Mainstream in Europe," February 25, 2022.

Canada. "Defence Investment Plan 2018 - Defence Capabilities Blueprint," 2018. http://dgpaapp.forces.gc.ca/en/defence-capabilities-blueprint/index.asp.

Canada, and Department of National Defence. *Strong Secure Engaged: Canada's Defence Policy.* Ottawa: Minister of National Defence, 2017.

Canada, Department of National Defence. "Evaluation of Defence Capability Development Program (Audit)." Ottawa, November 2017. https://www.canada.ca/en/department-national-defence/corporate/reports-publications/audit-evaluation/evaluation-defence-capability-development-program.html.

———. "Project Approval Directive." Canada Communication Group, 2019.

———. "Replace Control Tower - 14 Wing Greenwood." Defence Capabilities Blueprint - Defence Investment Plan 2018, January 9, 2020. http://dgpaapp.forces.gc.ca/en/defence-capabilities-blueprint/project-details.asp?id=1852.

Carvin, Stephanie. "Canadian Defence and New Technologies." In *Canadian Defence Policy in Theory and Practice*, edited by Thomas Juneau, Philippe Lagassé, and Srdjan Vucetic, 383–97. Cham: Springer International Publishing, 2020. doi:10.1007/978-3-030-26403-1_22.

Chief of Force Development. "Capability Based Planning Handbook, V.9." Department of National Defence, 2019.

Department of National Defence. "Budget 2016: Highlights of Federal Infrastructure Investments at 14 Wing Greenwood and Detachment Aldershot." Canada, September 8, 2016. https://www.canada.ca/en/department-national-defence/news/2016/09/highlights-federal-infrastructure-investments-14-wing-greenwood-detachment-aldershot.html.

"Digital Facilities: NAV CANADA and Searidge Gear up to Test Video Technology for Air Traffic Services." Ottawa, ON: NAV CANADA, October 5, 2020. https://www.navcanada.ca/en/news/blog/digital-facilities-nav-canada-and-searidge-gear-up-to-test-video-technology-for-air-traffic-services.aspx.

Enthoven, Alain C, and K Wayne Smith. *How Much Is Enough?: Shaping the Defense Program, 1961-1969*. Rand Corporation, 2005.

Fetterly, Ross. “Funding Defence for the Age of Acceleration.” Canadian Global Affairs Institute, April 2019. https://www.cgai.ca/funding_defence_for_the_age_of_accelerations.

Georgiadis, Philip. “London City Airport Replaces Control Tower with Virtual System.” *FT.Com*, April 29, 2021. https://www.proquest.com/trade-journals/london-city-airport-replaces-control-tower-with/docview/2533671779/se-2?accountid=9867.

International Civil Aviation Organization. “DIGITISATION OF AERODROME AIR TRAFFIC SERVICES.” Montreal, Canada: ICAO, 2018. https://www.icao.int/Meetings/anconf13/Documents/WP/wp_174_en.pdf.

John Andreas Olsen. *Routledge Handbook of Air Power*. Abingdon, Oxon: Routledge, 2018. https://search.ebscohost.com/login.aspx?direct=true&db=nlebk&AN=1714916&site=ehost-live&scope=site.

Magnuson, Stew. “Air Force Tests Remote Air Traffic Control Towers.” *National Defense* 103, no. 785 (April 2019): 12.

———. “U.S. Military Experiments With Remote Digital Air Traffic Control.” *National Defense* 105, no. 808 (March 2021): 11.

Maj Buckley, Steven. Occupation Manager Update Brief, delivered at Aerospace Capability Advisory Group 22-01 in Cornwall, ON. Conference, 21 Apr 22.

Myers, Vanessa, Evanya Musolino, and Emrah Eren. “The 2019 CAF Regular Force Retention Survey: Qualitative Analysis.” DEFENCE RESEARCH AND DEVELOPMENT CANADA OTTAWA, 2019.

NATS: UK Based Air Traffic Service Provider. “London City Is First Major Airport Controlled by Remote Digital Tower,” April 30, 2021. https://www.nats.aero/news/london-city-is-first-major-airport-controlled-by-remote-digital-tower/.

Pagnotta, Murillo, David M. Jacobs, Patricia L. de Frutos, Ruben Rodríguez, Jorge Ibáñez-Gijón, and David Travieso. “Task Difficulty and Physiological Measures of Mental Workload in Air Traffic Control: A Scoping Review.” *Ergonomics*, December 14, 2021, 1–24. doi:10.1080/00140139.2021.2016998.

Pelletier, Emile. “Operational Research and Analysis Supporting Canadian Army PRICIE + G Analyses.” DEFENCE RESEARCH AND DEVELOPMENT CANADA OTTAWA, October 2016.

Poole Jr, Robert W. “Organization and Innovation in Air Traffic Control.” *Reason.Org*, n.d. https://reason.org/wp-content/uploads/files/air_traffic_control_organization_innovation.pdf.

Richardson, William, Kalen Bennet, Douglas Dempster, Philippe Dumas, Caroline Leprince, Kim Nossal, David Perry, Elinor Sloan, and Craig Stone. "Toward Agile Procurement for National Defence: Matching the Pace of Technological Change." *CGAI*, 2020. https://www.cgai.ca/on_toward_agile_procurement_for_national_defence.

Rittel, Horst W J, and Melvin M Webber. "Dilemmas in a General Theory of Planning." *Policy Sciences* 4, no. 2 (June 1, 1973): 155.

"Saab Inks Deal for Digital Solution at Cranfield Airport." *Airline Industry Information*, October 11, 2017. https://www.proquest.com/trade-journals/saab-inks-deal-digital-solution-at-cranfield/docview/1949576571/se-2?accountid=9867.

Defense Advancement Periodical. "Saab's Digital Tower Achieves UK MAA Approval: Saab Can Now Deliver and Maintain Digital Tower Air Traffic Management Equipment for the UK Armed Forces," April 14, 2022. https://www.defenseadvancement.com/news/saabs-digital-tower-achieves-uk-maa-approval/.

Sayers, Nicola. "A Guide to Scenario Planning in Higher Education," Leadership Foundations for Higher Education — Research and Development Series 2, no. 4 (January 2010): 1–32.

Contify Telecom News. "Skyguide Expands Collaboration with FREQUENTIS to Advance Its Virtual Centre Strategy." New Delhi: Athena Information Solutions Pvt. Ltd., February 19, 2021. 2491543712. Advanced Technologies & Aerospace Collection; ProQuest Central. https://www.proquest.com/magazines/skyguide-expands-collaboration-with-frequentis/docview/2491543712/se-2?accountid=9867.

"Sweden : Saab Digital Air Traffic Solutions Receives NATO Air Base Order." *MENA Report*, June 29, 2019. https://www.proquest.com/trade-journals/sweden-saab-digital-air-traffic-solutions/docview/2249326113/se-2?accountid=9867.

"Sweden : Saab Digital Tower Demonstrator Ordered by Royal Air Force." *MENA Report*, March 7, 2020. https://www.proquest.com/trade-journals/sweden-saab-digital-tower-demonstrator-ordered/docview/2373041067/se-2?accountid=9867.

Thal, Alfred E. Jr., and David E. Shahady. "Is Your Organization Ready for Innovation?" In *Defense Innovation Handbook : Guidelines, Strategies, and Techniques*, edited by Adedeji B. Badiru and Cassie Barlow, 189–207. Milton, UNITED KINGDOM: Taylor & Francis Group, 2018.

The Technical Cooperation Program (TTCP). "Guide to Capability-Based Planning." Defence Research and Development Canada, June 2013. https://cradpdf.drdc-rddc.gc.ca/PDFS/unc194/p801995_A1b.pdf.

US Fed News Service, Including US State News. "TINKER CENTER OF NEW ATC TESTING." July 26, 2019. 2264946128. Military Database.

https://www.proquest.com/newspapers/tinker-center-new-atc-testing/docview/2264946128/se-2?accountid=10524.

Transport and Mobility Section. “Remote Airport-Tower Concept Proven and Ready for Deployment: PJ05 Remote Tower Project Overview.” European Union - Community Research and Development Information Service, May 5, 2020. https://cordis.europa.eu/article/id/415953-remote-airport-tower-concept-proven-and-ready-for-deployment.

Trapsilawati, Fitri, Chun-Hsien Chen, Chris D. Wickens, and Xingda Qu. “Integration of Conflict Resolution Automation and Vertical Situation Display for On-Ground Air Traffic Control Operations.” *Journal of Navigation* 74, no. 3 (2021): 619–32. doi:10.1017/S0373463320000703.

Trautyetter, Chad. “FAA: Remote Tower at Leesburg ‘Operationally Viable,’” November 10, 2021. https://www.ainonline.com/aviation-news/business-aviation/2021-11-10/faa-remote-tower-leesburg-operationally-viable.

Tunnicliffe, Andrew. “Remote ATC Towers: Why Not Everyone Is on Board.” *Airport Industry Review*, January 2021, Issue 63 edition. https://airport.nridigital.com/air_jan21/remote_air_traffic_control.

The Economist (Online). “What Are ‘Virtual’ Air-Traffic Control Towers?: The Economist Explains.” London: The Economist Newspaper NA, Inc., May 29, 2017. 1904293604. ProQuest Central. https://www.proquest.com/magazines/what-are-virtual-air-traffic-control-towers/docview/1904293604/se-2?accountid=9867.

Yeung, Edward, Evanya Musolino, and Emrah Eren. “The 2019 CAF Regular Force Retention Survey: Descriptive Analysis.” DEFENCE RESEARCH AND DEVELOPMENT CANADA OTTAWA, 2019.