CANADIAN INTERAGENCY FOREST FIRE CENTRE INC.
CENTRE INTERSERVICES DES FEUX DE FORÊT DU CANADA INC.

Canadian Wildland Fire

Aviation Challenges

Introduction

Aviation work within wildfire management is a specialized area that has a unique set of challenges. The work area is characterized by a high level of tacit and expert knowledge held by a few specialists in each wildfire organization. Wildfire aviation faces several challenges, such as an aging fleet, aircrew and aviation maintenance engineer (AME) shortages, increased costs and budgetary pressures, a fire load expected to increase with climate change, and staff recruitment, retention, and training issues. To help address these challenges, the Canadian Interagency Forest Fire Centre (CIFFC) convened a workshop bringing together subject matter experts (SMEs) and wildfire aviation researchers. The workshop outcomes are presented in this report, which aims to give researchers, aviation specialists, and senior managers insights into challenges and possible solutions for addressing them.

Collaboration and Focus in the 2023 Wildfire Aviation Workshop

The March 2023 workshop on wildfire aviation was a successful collaboration between the CIFFC Fire Science Committee (FSC), Aviation Working Group (AWG), and researchers with expertise in wildfire or aviation. This workshop was intended to fulfill the FSC's goal of hosting focused 'Issues to Research' workshops. Before the workshop, the AWG members completed a survey to identify and prioritize discussion topics. Survey results were shared with the participants, who were invited to contribute to the workshop's discussion. Several scoping discussions were held online with the FSC, AWG Co-Chairs, FSC Chair, RMC Chair, and project consultant Wally Born to ensure the workshop's success.

The workshop brought together aviation SMEs and a focused group of researchers with wildfire or aviation expertise. During the workshop, participants examined the survey result topics and listened to three brief presentations by Melanie Wheatly (University of Toronto), Brandon MacKinnon (FPInnovations), and Colin McFayden (Natural Resources Canada). The workshop aimed to identify the challenges in wildfire aviation, approaches to meet these challenges, and potential sources of data or intelligence to assist researchers who study these challenges. Furthermore, the workshop served as an opportunity for networking, as agency aviation representatives and researchers were introduced to each other, and they could build their respective awareness.

Overall, the workshop successfully fulfilled its goals of bringing together experts in the field and identifying ways to address the challenges facing wildfire aviation.

Workshop participants were as follows:

CIFFC Staff
Heather Simpson, FSC Chair
Leah Coulombe, AWG Co-Chair
Dave Bokovay, RMC Chair

Facilitator
Wally Born, Country View Consulting

FSC Members
Dave Schroder, AB
Colleen George, ON
Gregg Walker, PC
Steve Taylor, NrCan

IMIT Member
Emma Zerr, PC

AWG Members and SMEs
Jason Robinson, ON Co-Chair
Chris Boland, YK
Duane Sinclair, NT
Eric Antifaeff, BC
Brian Loposhinsky, AB
Shawn Legasse, AB
Bob Spracklin, SK
Ethan Goldak, SK
Travis Smelski, MB
Brady Holliday, SOPFEU
Mathieu Payette, SOPFEU
Marc Dionne, NB
Ian Moore, NS
Reuben Solomon, NS
Dion Geange, NL
Steve Michelin, NL
Kent Baylis, PC

Presenters
Melanie Wheatly, UofT
Brandon MacKinnon, FPI
Colin McFayden, NrCan

Researchers
Den Boychuk, ON
Emily Hope, NrCan
Gabrelia Ifimov, NRC
George Leblanc, NRC
Katia Davi-Digui, UofA
Ilbin Lee, UofA
Jen Beverly, UofA
Nima Karimi, UofA
Mike Wotton, UofT
Matt Plucinski, CISRO, AUS

Report Structure

We collated information gathered before and during our workshop and organized it into tables based on three main themes from our discussions. Each theme is accompanied by a list of challenges, possible approaches, and potential data or information sources. These challenges represent the questions the wildfire aviation community is seeking answers to in the near and mid-term. Solutions to these challenges may include tools for better resource allocation, improved effectiveness, efficiency, and safety. Examples of resource questions include human resource retention and recruitment, aircraft, and fire chemicals. While this paper does not define specific research questions, our aim is to narrow the focus of practitioners and researchers to define manageable-sized research projects. The themes and associated challenges are as follows:

Aerial Capability and Capacity

Future Fleet
- Airtanker/Birddog
- Other

RPAS (Drones)
Long-term Fire Retardants

Human Capacity and Capabilities

Air Attack Officer Recruitment and Retention
Aircrew and AME Shortages
Simulator Use

Resource Demand, Allocation, and Utilization

Future Demand in a Changing Environment
Decision Support Tools
Response Zones
Drop Effectiveness
Aircraft Procurement and Resource Sharing
Night Helitanker Operations

We identified immediate solutions for two discussion items: Fatigue Management Regulations and Fire Chemical Qualification. Information to address these challenges has been conveyed to the AWG Co-Chairs and is presented in Appendix A. Appendix B offers more detailed or supplementary information to the future fleet challenge. Finally, Appendix C lists other contributors who were not workshop attendees.

Aircraft Capacity and Capability

Challenge	Description of Challenge	Questions & Potential Approach(s)	Potential Resources
Future Fleet Airtanker and Birddog	A review and modelling of current aviation usage are needed as a baseline or benchmark in future fleet considerations. With few exceptions, the Canadian airtanker fleet is aging, with some platforms reaching the end of operational life and others with aging components that will require significant upgrades, most commonly the avionics equipment required to fly, navigate, and communicate. In the past, agencies have increased, altered, or decreased airtanker fleets or long-term contracted helicopters based on past fleet modernization, budget requirements, or new funding coming from major fire events. These choices may have been made without a robust resource selection/needs model to guide decision making. A robust current usage model would set a defendable baseline as agencies look to the future. The models developed would also assist in outlining parameters for future fleet considerations.	There are several questions and opportunities to explore: 1) What other aircraft are the providers (Conair, FPL, Air Spray, Buffalo Airways and Coulson) looking at? Answers to this may require a Non-Disclosure Agreement (NDA) with results available to a limited audience. 2) Are there options for the avionics upgrade of the De Havilland CL series of aircraft? Will the original equipment manufacturer (OEM) support 3rd party packages with engineering, drawings, etc.? 3) What is the status of the 1002? Is there interest in the Canadian market for a “bigger 802,” with the impacts on climate change top of mind? 4) What is the realistic timeline for delivery of the new 515 skimmers from the date of order? What is the cost? 5) What is the appropriate Birddog to be used in combination with any proposed airtanker that can match speeds and flight profiles? 6) What infrastructure is needed to support the aircraft? Consideration should be given to runway length and strength, taxiway width, apron size and load bearing, and associated loading pits for retardant tankers. Review the historic resource demands of each agency and filled and unfilled air tanker request via CIFFC agreement, and agency use of resource sharing Compact Agreements with individual US states.	Agencies have relationships with Canadian and international operators that can be surveyed for information. **Canadian Operators** Conair / Aero Flite USA Air Spray / Air Spray USA Buffalo Airways Forest Protection Limited (NB) Coulson Aviation Babcock Canada **US Operators** Neptune Aviation (BAE 146) Minden Air (Bae 146) 10 Tanker Company (DC 10) Erikson Aero Tanker (MD87) Bridger Aerospace **Australia** National Aerial Firefighting Centre (NAFC) Pays Aviation Agencies filled and unfilled air tanker request data CIFFC ‘unable to fill’ Air Tanker Exchange request (2012-2022)

Challenge	Description of Challenge	Questions & Potential Approach(s)	Potential Resources
Future Fleet Other	There are concerns about the need for more mid-sized transport aircraft (20-100 passengers) in Canada. Canadian agencies are heavily reliant on medium utility use rotary wing aircraft. The fleet is aging; the newest Canadian Bell 212 was built in 1972. New aircraft development is focused mainly on commercial airlines, medical and military sectors. The aircraft industry faces fuel changes, referred to as "the decarbonization of aviation" by industry insiders. There is pressure to move from traditional aviation gas and jet fuel-powered engines to electric and hydrogen-powered aircraft. There are numerous online articles about the potential for electric, hydrogen, or hybrid engines in the rotary-wing (RW) and fixed-wing (FW) sectors. Harbour Air has electric-powered seaplanes for commuters between Vancouver and the Islands. Diamond Aircraft has a purpose-built small electric airplane. Airbus has worked on electric and hybrid aircraft (FW and RW) since at least 2010.	Complete and inventory of national FW fleet in the 20-100 passenger capacity. What are they, where are they based, and what availability do they have from April to September? Are there opportunities for contracts to secure availability? Do provinces have similar aircraft in their fleets? What are the competing industries for these aircraft, and their projected future needs (e.g. fly-in work camps in the resource extraction sectors)? What is being done for 'utility' RW aircraft that have multi-function roles? Airbus has an EC130/H130. What about other Intermediate helicopters? According to a Honeywell Aerospace article, about 215 electric-powered aircraft are in development. Fuel changes will impact agency infrastructure and supply contracts. For example, instead of drum/bulk fueling, will hydrogen fuel or large output generators be needed on extended attack fires? How close is the industry to making the fuel transitions? What is a timeline projection for 10%, 25%, 50%, and 75% of today's typical commercial aircraft being converted or replaced? What is needed to support these aircraft: 1) At an established base or airport 2) On an active fire or other emergency response incident. What is the cost of transitioning to these new infrastructure needs?	The National Research Council (NRC) is conducting research into Hybrid powered aircraft The following is a list of contacts/operators who could be surveyed for information: Diamond Aircraft - Honeywell engine (Bell 205/204) - Harbour Air electric seaplane conversion – DHC-2 De Havilland Beaver - Pratt and Whitney Canada - Airbus (RACER and H130 aka EC130 T2) - Viking / De Havilland - Eagle Helicopter, an overhaul and leasing facility for Bell helicopters in Calgary, AB **Australia** NAFC

Challenge	Description of Challenge	Questions & Potential Approach(s)	Potential Resources
Remotely Piloted Airborne Systems (RPAS), aka Drones	The use and integration of RPAS have been an ongoing challenge for the wildfire community for nearly 20 years. Questions around safety have been prominent, from operator qualification and competency, aircraft avoidance, regulations, battery life, inability to operate beyond the visual line of sight (BVLOS) with the aircraft, and the frequency of inflight failures. These challenges continue to mature through regulatory additions and changes, product evolution, development, and increased capabilities. There are two distinct aspects to using RPAS. 1) The operation of the aircraft, performance constraints and regulatory limitations. 2) The payload, challenges to data management and the size and weight of the payload. Each requires different expertise and development. The National Research Council of Canada (NRC) is conducting ongoing research in drone development and capabilities, including onboard sensor capabilities directed at wildfire activities. These activities support objectives such as intelligence gathering from thermal and hyperspectral imagers and LiDAR-based biomass before and after burn analysis. While the sector continues to evolve, there are enough foundational pieces, such as pilot licensing and aircraft with payload capacity and mission duration, to understand how to incorporate appropriate use into wildfire operations. Some agencies are already engaged in the space; for example, AB uses a LiDAR sensor on an RPAS to build a 3D map for point-of-origin investigations or the aerial ignition evaluation underway in BC. One challenge is that the agency aviation sections need to be more consistently engaged during explorative endeavours. There may be a need for standardized protocols for fuel assessment using RPAS. This was applied to airborne LiDAR data collections a	The RPAS sector continues to develop quickly. A regular (24-month cycle) RPAS workshop could bring together regulators, operators, product developers, manufacturers, users, and researchers such as NRC. The aim would be to share information and establish a common understanding of needs, potential uses, existing platforms and sensors, regulatory rules, and opportunities. An existing model is the FPInnovations “Wildfire Detection Workshop,” held five times over the last 12 years. Some objectives for the workshop: 1) Knowledge sharing and awareness of regulatory processes 2) Skills development to allow for the safe and systematic inclusion of RPAS use in wildfire management 3) Identification of service providers and RPAS manufacturers to better understand the needs of the wildfire community 4) To lobby for service needs, safety features, or regulatory changes 5) To collate a summary of regulatory compliance 6) Summarize the various platform and sensor performance factors to consider for different wildfire mission profiles Conduct a structured evaluation on current and future RPAS use (LiDAR, Thermal Imaging, Aerial Ignition, a supplementary tool for fixed detection lookouts or ground-based detection patrols, launch and return for aerial patrols). Develop shared best practices and provide feedback to RPAS providers for continuous improvement of mission development and quality of deliverables needed and desired by agencies. Maintain annual dialogue with NRC on current research and outcomes that may complement wildfire use. Develop a standing Community of Practice.	Canada Wildfire or FPInnovations as a workshop facilitator o Panel topic on pilot qualifications and competency o Panel topic on needs (pilot, platform company) to operate “Beyond Visual Line of Sight” (BVLOS) with other aircraft o Limitations and logistical support needed to support the RPAS unit and support resources Workshop attendees/presenters may include the following o Transport Canada (TC) on regulation updates and what is being proposed or worked on for the future o Agency presentations on current use- LiDAR mapping, aerial ignition, surveillance, and thermal imaging o Current and potential providers such as Hummingbird Drones o Aerial Evolution Association of Canada o NRC and industry associations who are researching RPAS DARPA is testing drones it can launch from a plane—then collect mid-air, By Charlotte Jee - January 31, 2020 MIT Technology Review NASA workshop on RPAS and fire support www.nasa.gov/aeroresearch/wildfire-workshop-accelerates-nasa-firefighting-solutions

Remotely Piloted Airborne Systems (RPAS), aka Drones *(Cont.)*	number of years ago (via ASPRS – American Society for Photogrammetry and Remote Sensing). Different technologies and acquisition methods can result in variable point clouds (from RPAS-based LiDAR systems and SfM) and different levels of fuel attribute differentiation. LiDAR onboard RPAS can acquire much more information than photogrammetric SfM because optical-based photogrammetry suffers from occlusion.	Consider adding thermal/ LiDAR for mapping fire behaviour associated with prescribed burns. For example, if there is a prescribed burn, it would be useful to have a pre-burn survey of fuels and the fire ROS using optical and thermal imagery.	

Challenge	Description of Challenge	Questions & Potential Approach(s)	Potential Resources
Long-term Fire Retardants and Qualification	Retardants from different manufacturers are incompatible and cannot be mixed, even with residual volumes. When mixed, precipitate forms and damage to actuator arms and tank components has been noted. If an airtanker carries one product and reloads with a different product, pre-loading tank cleaning is required. If these precipitates damage components in aircraft tanks, the damage will likely occur in agency blending and loading equipment. Agencies face several challenges when considering changes in suppliers. When converting an Air Tanker Base, a thorough flush of the entire storage, mixing, and loading system must be done before onboarding the new product. Some agencies have operated with two suppliers while transitioning or split supply contracts to different agency bases. This may no longer be feasible. Simultaneous conversion could result in the disposal of significant volumes of concentrate or the costly return of the product to the provider.	Can the list of non-compatible products be narrowed or defined? - It is unclear if this condition exists when the Fortress FRS product is mixed with any PHOS-CHEK® product or only select PHOS-CHEK® products (has been noted with LC95a). Is there an additive that can be used at the loading point to prevent the precipitate formation that does not compromise the integrity and effectiveness? What degree of “flushing” or cleaning is required of airtanker tanks to avoid the development of damaging precipitates? - A simple “fill and flush” with water is inadequate. Given the sensitivity of tank systems, proper cleaning standards of different companies, and liability exposures, this work may need to be done by AME staff and not traditional ATB staff or contract loading personnel. What is the proper and environmentally compliant method to dispose of different long-term fire-retardant concentrates? The assumption is, that the load would “drop” in a matter of hours. If not, the load may have to be aborted at the base or in a designated abort zone.	USDA Lab – Missoula and online publications Conair Air Spray Buffalo Airways Air Tractor De Havilland Kelowna Flight Craft FireBoss LLC Performance Solutions – PHOS-CHEK® Fortress FRS

Human Capacity and Capability

Challenge	Description of Challenge	Questions & Potential Approach(s)	Potential Resources
Air Attack Officer (AAO) Recruitment and Retention	Many agencies are struggling to attract and retain AAOs. It impacts the ability to "fill the seat" in some jurisdictions, and some rely on other agencies to help fill the needs. AAO availability also results in the inability to provide the Air Tactical Group Supervisor on complex extended attack fires, which can compromise the safety and effectiveness of airborne operations.	Social science research to understand human behaviour, including 1) the evolving desire for a different work-life balance, 2) the broader perspective of aviation-based positions within organizations, 3) A review of policy impacts on recruitment, career advancement, and retention, and the opportunity to alter policy to promote these elements. Cross-jurisdictional scan of factors that influence the initiation, retention, or reduction of available qualified personnel, such as program promotion, attitude toward the role and program, rate of retirements, lack of experience in junior staff, perception of the danger or lack of understanding of the controls in place to manage risk. What holds people back from entering the program? This could include lifestyle–work/life balance, safety, career path, seasonal vs. permanent employment, contractor vs. staff positions, and associated obstacles such as funding or union agreements. Current agency career paths have been relatively static. Are there different career paths to be explored as an option? What impact will Air Attack programs face if recruitment does not improve or worsens? Are there tools and opportunities to build competency? For example, mentorships (use of retired staff?), coaching – trained and structured, and use of technologies like simulators. Are other programs (Ignition Specialist) experiencing similar issues? Are there lessons learned to be shared? Can they benefit from a similar or inclusion in a survey?	Social science researchers: Colleen George, ON FSC Should surveys or one-on-one interviews be conducted: - Access to agency AAO and aviation staff - Potential AAO candidates Agency HR departments - Need to ensure awareness and compliance with legislation protecting any personal information AWG members

Challenge	Description of Challenge	Questions & Potential Approach(s)	Potential Resources
Aircrew and Aviation Maintenance Engineer (AME) Shortage	There are aircrew and AME shortages currently impacting both fixed-wing and rotary-wing aviation. This manifests itself in a variety of different ways: 1) Inability to crew aircraft or double crew aircraft for extended use 2) Increased wages in a competitive market drive up tariffs 3) Agencies that own and operate fleets may have trouble recruiting 4) Request by the industry to utilize lower-time pilots The current shortages are expected to persist or worsen. There is a renewed focus on mineral exploration and mining, traditionally big aircraft users in the summer. The Government of Canada has announced that it aims to reduce mine approval time by 30% to help meet these needs. Has the focus/perceived focus by the regulatory body (TC) on the Airline sector viability caused a lack of accommodation of needs or awareness of the impacts on the Aerial Work and Air Taxi sectors for FW and RW?	Although there is little the agencies can do to impact the hiring and retention of pilots and AMEs directly, there may be opportunities for "customer of choice" beyond paying higher tariffs. A survey of operators and crews is one option. Operators could be grouped as local (one or two bases), medium (operating in one or two provinces/territories), and large (operating in more than two provinces). Research into what makes worksites or projects desirable from the viewpoint of these roles (job function, accommodation, camp amenities, remote locations) can provide insight into how to become a customer of choice in an increasingly competitive market. Could a social media campaign thanking the various contractors through the fire season have an effect? Establish a survey with standard social media monitoring (likes, retweets, shares) for effectiveness. Invariably this shortage will drive tariffs up, possibly beyond the inflation rate. Given the percentage of wildfire expenditures for aviation resources, what is the potential budget impact? Opportunity to engage a research economist for future forecasting. Is there a forecast of the current and future needs and critical shortages? Review with the industry the CIFFC/HAC document "Wildfire Helicopter Pilot Competency." Are there opportunities to reconsider the minimum pilot hours if supplemented with additional training such as a simulator?	Agency aviation sections AWG members Canadian Operators: Conair / Aero Flite USA Air Spray / Air Spray USA Buffalo Airways Forest Protection Limited (NB) Coulson Aviation Babcock Canada

Challenge	Description of Challenge	Questions & Potential Approach(s)	Potential Resources
Simulator Use	Several agencies have implemented simulators for AAO and other position training. Other agencies see this tool as potentially making training more cost-effective and efficient. Simulator use can be quantified in terms of: 1) Cost-effectiveness 2) Return on investment (ROI) 3) Training timeline measurable development thresholds 4) Mentoring/coaching and progression 5) Annual proficiency and pre-season refresher needs	A comprehensive review and report of those agencies using simulators for the AAO and other position training and development. Aviation SMEs may be able to answer some of the following questions, but their answers have yet to be quantified in an explicit and sharable format. 1) What minimum hardware (stations) and software are required to deliver a basic simulation? What is the cost of such a setup? What are the typical annual maintenance and update (hardware and software) costs? 2) How long does it take to see a return on investment? 3) What are the tangible cost benefits vs. traditional airborne training? What effort (hours/cost) is required to develop and deliver a simulation? Has the training time of new AAO candidates been compressed? How has simulator use assisted in coaching and mentoring candidates? 4) 'Washing out' a candidate is expensive, especially after airborne training has started. Has simulator used reduced or eliminated this occurrance? 5) At least one agency (BC) developed a regimented training syllabus with measurable development benchmarks to be met as candidates proceed. How does it (they) work? What are the tangible benefits or outcomes? 6) Some of the airtanker providers also use simulators for pilot training. What are the advantages of joint training scenarios? 7) Are simulators used in the spring as part of returning AAO refresher training? What are the outcomes? Include observational feedback from company pilots on the readiness of simulator training/exposure AAOs vs. those not exposed to simulators as part of their training. 8) What other positions use the simulator for training (Heli-tack leader)?	BC Wildfire Service AB Wildfire OMNR CIFFC reviews and reports Conair Air Spray

Resource Demand/Allocation/Utilization

Challenge	Description of Challenge	Questions & Potential Approach(s)	Potential Resources
Future Demands in a Changing Environment	Climate change effects are changing the frequency and severity of fires. Given the current forecasted impact of climate change, how do agencies sustain their existing performance measure over 10, 25, 50, and 70 years? Planning and procurement need to start very soon to be ready for any change by year 10. Population growth coupled with expanding activities (municipal, industrial, infrastructure, and recreation) into suppression areas. This is the expansion of the Wildland Urban Interface or WUI. In 2016 Lynn Johnson prepared a series of maps indicating the distribution of the WUI (defined as industrial, infrastructure, and community) across Canada and explanations of the data. The data used for the thesis is about 20 years old, and the analysis is being updated with new data at the U of A. The new analysis will once again give wildfire agencies and community leaders a picture of a more "current state" of the WUI and values at risk of wildfire. But what about the future? Using the 20-year data differential in these two analyses, can a model be built to forecast the WUI in another 20 or 40 years? The scope and impact of this are beyond just the aviation sector and impact an array of wildfire specialties and senior management of the agencies. It will take broad research skills and capabilities, extending beyond the traditional wildfire groups/centres. Policy specialists, economists, and a variety of other research talents will be needed.	What is the future fuel complex? 1) When will the transition start? 2) Has the transition started already? 3) How long with the transition take? Can the future resource demand (fire load and season length) be modeled using today's performance measures (PMs) as the benchmark? 1) Can these PMs be sustained? 2) What do new PMs look like, and how does that impact the risk to communities, critical infrastructure, and critical wildlife habitat? Are water sources used to model placement or even procurement of skimmer airtankers going to exist? What is the impact of the thawing permafrost on fire ignition potential in those areas? Build a WUI and climate change forecasting model. The model should be built to include known influences. 1) Increased power line transmission and distribution networks 2) Increase in mining activity for resource extraction 3) Community growth, increased critical infrastructure, and recreation use demands, both formal and informal 4) What is that impact on resource needs? 5) Is protection required of new or expanded critical wildlife habitat (implication of the Species at Risk Act, or SARA?)	A variety of academic research bodies ECCC–climate scientists and climate change models, weather, changes in plant communities, speed and progression of changes U of A student work Population growth and trends – Statistics Canada and provincial/territorial census data Natural Resources Canada – climate specialists, wildfire researchers, remote sensing specialists NRC – Atmospheric and terrestrial remote sensing specialists, research aircraft, RPAS, climate change and ecology specialists.

Challenge	Description of Challenge	Questions & Potential Approach(s)	Potential Resources
Response Zones	There are a variety of response "circles" portraying effective response zones for different airtanker types. Aircraft manufacturers or providers create some, and agencies make some for use in business cases and public information. Many of these portray the perfect dispatch with optimal loading times, little or no taxi time from the base to the runway threshold, optimal airspeed to the fire, and optimal orientation and direction upon arrival to complete the first drop. Conditions that seldom, if ever, exist in the real world. Many companies proclaim airtanker or Birddog airspeeds more than 250 knots. The Canadian Air Regulations (CARS) prohibits air speeds more than 250 knots below 10,000 ft ASL. Only above this altitude and most commonly with instrument flight rules (IFR) clearance can they exceed 250 knots. Given the traditionally short dispatch distance that most agencies there are limited dispatches to get to that altitude and file for IFR clearance.	What do real-world scenarios need to account for? For example: 1) Real loading times 2) Taxi times including taxi to the other end of the runway for take-off, taking off, and then having to do a 180 after departure to head in the direction of the fire 3) Take-off delays due to landing aircraft or other aircraft taking off 4) Communications challenges over the fire to ensure ground crew safety 5) Air traffic coordination delays over the fire Using AAO drop reports and GPS location of fires or tracking data, build a series of response circles (maximum distance in 30 minutes to first drop from time of dispatch) by airtanker type for each base. Criteria may include: 1) Group on base for Red Alert 2) Initial attack dispatches only 3) Maximum of 30 minutes (performance indicator) time-lapse from dispatch notification to first drop Once the new/real response circle is created, they can be inputted back into a model used for optimizing base locations or used to alter the response effectiveness areas and resource allocations.	Air Attack Drop reports Fire Reports GIS or spatial data sets, fires, base locations.

Challenge	Description of Challenge	Questions & Potential Approach(s)	Potential Resources
Drop Effectiveness	Since 2018, ON with partners from QC, and MB have been working with researchers from the University of Toronto, NRC, and CFS to measure the effectiveness of CL215/215T, CL415, Twin Otter, AT802F, and the Bell 212 equipped with a Simplex 302 tank drops. The final report in both French and English is expected in the near future. This important information can be leveraged to build several decision support systems. 1) Target selection/prioritization 2) Input to stop action decision and justification 3) The number of resources required at dispatch This foundation methodology can be expanded to include land-based airtanker and the evaluation of new platforms and tank designs as they come online. The study has incorporated the use of airborne thermal imaging to map the coverage levels of drops with different suppressants.	Share and expand the methodology to evaluate the land-based fleet. For each airtanker type model, the effectiveness of different drops at different HFI or BUI/ISI fuel combinations. A new model can then be developed to forecast the amount of retardant/suppressant required, mission longevity, and the need for enhanced dispatches (multi-group/planes, automatic, etc.). 1) Can this information be used in wildfire growth models like Prometheus to model the impact of the application of fire retardants and suppressants on different wildfires? 2) The next step would be measuring the effectiveness when coupled with additional support. 3) Hand crews could indicate when reapplication would be required to hold the line or on extended attack fires allow better sequencing of air attack operations (airtanker, helitanker, or buckets) with ground crews. Aerial Ignition and heavy equipment (dozer line)	Reference Guide to the Drop Effectiveness of Skimmer and Rotary Wing Airtankers, Canadian Forest Service, Great Lakes Forestry Centre, Information Report, GLC-X-35

Challenge	Description of Challenge	Questions & Potential Approach(s)	Potential Resources
Decision Support Tools	1) Target Prioritization 2) Pre-Determined Dispatch 3) Hire and Release Parameters 4) Aircraft Optimization a. daily preparedness placement b. base Location optimization – i. primary staging, ii. secondary staging, iii. day bases iv. primary air tanker v. secondary air tanker	There are many opportunities for Decision Support Systems (DSS) 1) Using the information derived from the joint MNRF/NRCan/NRC drop effectiveness research to be conducted in ON in 2023, build DSS or a set of criteria to aid AAO on target prioritization to maintain IA effectiveness. 2) Alberta implemented an "automatic dispatch" SOP in the early 2000s; although it has been modified somewhat over the years, it still exists. Review this historical data and evaluate the effectiveness of meeting the IA objectives. Can the information be used to build a more precise set of criteria to aid dispatching and alert settings? Can the data be evaluated to be used in decisions to support the objectives of extended attack fires? 3) Study aircraft use relative to fire hazard, fire conditions, and fire load to build a model to forecast appropriate hiring and timely release. The objective would be to target potential cost saving while maintaining appropriate resourcing levels to meet performance objectives. If possible, include resource availability as an input. 4) Using information like the drop effectiveness research, develop a resource needs and deployment DSS based on meeting performance measures or indicators. Using real response time circles coupled with WUI spatial information, fuels, and historical fire occurrence to determine optimum areas for Air Tanker Bases. Primary base location (crew staging or 'home base'), secondary bases, and day base locations. Other influences for final site selections include potable water availability, air or ground access, power supply, communication coverage – agency radio network, and different utility needs.	Reference Guide to the Drop Effectiveness of Skimmer and Rotary Wing Airtankers, Canadian Forest Service, Great Lakes Forestry Centre, Information Report, GLC-X-35 The research outcomes of the ON drop effectiveness study and any future additional as different platforms are evaluated GIS data on WUI and values at risk, critical infrastructure Researchers for data analysis and model development Subject matter experts from the agencies to advise and provide specialized insight/ knowledge to developers Airtanker Management Analytics, a recent (14/04/2023) webinar delivered by Dave Martell and hosted by Canada Wildfire, provides an overview https://www.canadawildfire.org/webinarsandcourses.

Challenge	Description of Challenge	Questions & Potential Approach(s)	Potential Resources
Aircraft Procurement Resource Sharing	Other than the CIFFC 737 transport contract aircraft, all aviation contracts are specific to an agency. This results in parallel procurements for the same or similar resources. This is not limited to aircraft but includes aviation safety consultants, fire pumps, hoses, and fire chemicals. 1) Modeling for better decision-making on procurement or contract timing and aircraft type 2) Options for collaboration–shared or split contracts between agencies or between nations (CAN/AUS) 3) Models used elsewhere, e.g. NAFC national contracts that include rotary-wing and air tankers 4) Support the national availability of "All Hazard Response" aircraft capability – like the Conair CARE proposal – multi-role Q400 that others can also support Urban Search and Rescue 5) Are there opportunities to do more resource sharing of critical resources? Several airtankers and helicopters move seasonally between the northern and southern hemispheres. Is this practice sustainable if the northern and southern hemispheres' fire seasons get longer?	Are there other procurement options available that would result in agency cost savings (or cost neutral) and provide for better utilization of unique or limited resources? 1) Are there other resource-sharing models or practices in the emergency management theatre to consider? 2) A search of different procurement-sharing models 3) Standing offers–how could they be used? Would CIFFC have a role in establishing National Standing offers? What are the financial and legal impacts on CIFFC? 4) Can element 3 in the DSS section be leveraged into a broader procurement model, maybe beyond just aircraft to heavy equipment, sustained action crews etc.? The model serves a broader part of the wildfire community. Would the use of a national Dispatch platform (all agency active fire and resource data be shared and viewable by all? At the senior decision-making, it could provide situational awareness of the broader fire loads, potential demands, and resource locations and needs. Would it enable CIFFC to be more responsive or better anticipate the need to access international resource-sharing agreements? Could it eliminate the need for the daily "sitrep" or at least automate some of it?	NAFC – Arena Database Agency or Department staff knowledgeable in procurement rules and restrictions governed by the Agreement on Internal Trade (AIT), New West Trade and Partnership Agreement, CANUSMX agreement NRC is undergoing fleet renewal and is procuring new research aircraft. While quite different, government procurement lessons learned and defining roles of aircraft may be of interest.

Challenge	Description of Challenge	Questions & Potential Approach(s)	Potential Resources
Night Helitanker Operations	Night operations for rotary-wing-based suppressant delivery are being examined in several jurisdictions. California was the first to delve into this area; others include AUS, BC, and AB. AB is continuing a trial in the 2023 fire season. The evidence to date would suggest that it can be done. The underlying questions continue to be: 1) Cost-effectiveness 2) The efficiency of the operations and operating parameters, go-no-go criteria 3) What are the parameters for a safe water pick-up site? 4) Safety and risk management–risk vs. reward and by asking two fundamental aviation safety questions, "Is this flight necessary?" and "Just because we can, should we?" Are we doing this to provide the "CNN moment?" 5) What else needs to be in place, flight following, dispatching decisions, and need for rescue/extraction platforms? 6) Impact on daytime operations and aircraft maintenance downtime, assuming other daytime operational use. 7) How is effectiveness impacted when supported or not supported by ground crews – immediately or during the following burning period?	There are different components to reviewing and researching this topic. 1) In-depth cost analysis incorporating a review of drop accuracy and effectiveness 2) Review and summary of reports generated by those agencies and jurisdictions worldwide as to their findings and decision to proceed from a trial to a fully operational program or to cease moving forward from a trail phase. 3) In depth risk assessment and mitigation measures. Who audits or inspects for compliance? Is it Transport Canada or the Wildfire Agency? If it is the Wildfire Agency is there adequate expertise to conduct the audit or inspections? General questions: 1) Is nighttime operation more effective than daytime operation? 2) For what kind of fires is nighttime operation more effective than daytime one? 3) What data should we collect to answer these questions? 4) Is there a need for a national risk management study that reflects the Canadian operating and regulatory environments? 5) Is there an opportunity to introduce full-sized RPAS rotary-wing (Helitankers) in this role?	AB Wildfire, BCWS, Coulson, NAFC, Talon Helicopters (BC), and other providers **CalFire Night Flying Guidelines** https://wildfiretoday.com/documents/Night_Flying_Guidelines_FIRESCOPE_2018.pdf **Australia** New South Wales (NSW) Rural Fire Service (RFS) Night Flying Training https://www.airforce.gov.au/news-and-events/events/nsw-rfs-night-fire-bombing-trials-phase-3-day-and-night-time-training Emergency Management Victoria (EMV) Article on Recommencing Night Flying https://www.emv.vic.gov.au/news/night-fire-aviation-recommences-for-fire-season Alberta NVIS Operations Manual – Assessment(s) by FPInnovations

Appendix A – Immediate Solution Items

The following topics were raised as a concern by the AWG but did not require a workshop or substantive research approaches to be concluded or reach a resolution.

Pilot Fatigue Management Regulations and Flight Crew Accommodations

Transport Canada (TC) has recently established new fatigue management regulations for all aviation industry

sectors. Specifically, this concerns air carriers working under Canadian Air Regulations 702 (Aerial Work) and 703 (Air Taxi). There are concerns with a perceived one-size-fits-all approach, and some groups have lobbied TC for exemptions or changes. There are also efforts to define better the specific operations that qualify as 702 – Aerial work.

A solution is for the AWG to approach TC to provide a presentation before this year's fire season. The AWG could ask for a co-presentation by TC staff from two regions (Prairie and Northern, as the bulk of the Canadian RW operators and fleet are based in these regions) and the Assistant Director General – Andy Cook. Andy has indicated the definitions of aerial work in TC publication TP4711. As part of the discussion, TC could be asked to clarify their expectations or interpretation of suitable accommodations day basing and overnight/sleeping.

Note that TC requirements are the minimum. Operators may choose more restrictive actions for various reasons, including insurance, requirements from other clients/sectors such as oil and gas (O&G) companies, and contractual arrangements (union or otherwise) with pilots or AMEs—additional restrictions if in their Ops Manual etc., are non-negotiable.

Fire Chemical Qualification – Qualified Product List (QPL)

Canadians rely on the QPL developed by the USDA lab in Missoula. There are ongoing questions about or desire for a Canadian equivalent to the USDA QPL. This topic has been raised repeatedly for nearly 25 years, even before the AWG was resurrected in 1999. An immediate solution is for the AWG to invite Dave Bokovay, CIFFC, to review the history of a Canadian QPL and the AWG.

The Missoula lab has been viewed as the single source of truth for more than 40 years. The processes are well-defined and clearly published and have been defended several times, both contractually and environmentally. Four USDA QPLs are published, each for a different category of fire retardant, 1) long-term fire retardants, typically salt or fertilizer based and the only products tested in a burn, 2) pre-treatment retardants, 3) water enhancers, often referred to as Gels, and 4) Class A foams. Each category has its own set of published qualification standards. Companies must submit products to the USDA lab in Missoula for testing a qualification. This is a fee-for-service and costly process, especially for long-term fire retardants. Missoula has extended offers to test products or different blends (retardants with viscosities lower than the USFS contract requirements) to CIFFC and the CIFFC partners.

The downside to the USDA QPL process for new products is time and money. It is expensive to get admin approval which allows trials for field use and final approval. It takes 24 months to get to the admin approval stage. This process often is an obstacle for companies submitting products and has historically limited competition in the long-term retardant to one or two providers.

Can an alternate lab effectively compare or compete with Missoula? Past discussions indicated that no known entity in Canada has the capability to be the testing and certifying agent for these products. The primary testing parameters are aquatic toxicity, performance (reproducible burns in a calibrated burn chamber using two different fuels – pine needles and shredded aspen), corrosion, and over-winter storage (product stability through freeze-thaw cycles). The cost of setting up a similar testing facility and processes would be high and largely duplicate what is done in Missoula already. Additionally, the US Forest Service (USFS) is the largest single fire chemical procurement agent in the world. It is very unlikely that the USFS would entertain products "qualified" at different labs or using an alternate set of processes.

Agencies are not compelled to use the USDA QPLs, but the QPLs provide a clear and defendable selection criterion to declare what products are eligible to be offered in a competitive procurement process. From a contractual and procurement perspective using the QPL is simple. There is no need to try and compare with products that may have Underwriters Laboratory. Some certifications involve little to no testing. Manufacturers must declare that the product meets a published set of standards (e.g. American Society for Testing Materials or ASTM), and the certification can be granted with no independent check.

It should be noted that in the case of the CL series, historically, Bombardier approved products that could be used in this aircraft series. Other aircraft providers have left it open to the agencies to choose with the understanding that there was an approval or certification process for the products, the most important for them is corrosion protection.

Appendix B – Additional Future Fleet Challenge Information

Details of the Canadian Fleet

The Lockheed Electra was manufactured in the mid-1950s. These converted commercial aircraft are now approaching 70 years of age. With the current engine and propellor configuration, There is only one overhaul shop in North America, Pacific Propeller International (PPI) for the propellor. Every propellor must be overhauled every 5 years from the date it is put into service on an aircraft, regardless of the number of hours it is used.

The Convair 580 (CV580) was manufactured in the mid-1950s. Initially, as a piston-powered CV340 or 440 and later converted to a turbine-powered CV580, which uses the same engine and propellor combination. In addition, the original equipment manufacturer (OEM), Kelowna Flight Craft, is finding it increasingly difficult to source replacement parts for this aircraft and its sister, the Convair 580A, which has a different engine and propellor package as well as other upgrades.

The last of the original De Havilland CL215s are being converted, sold, or removed from service. The original CL215T (circa 1995) conversion aircraft are experiencing aging components, the same is happening with the first CL415s introduced in Canada. Some aircraft have already commenced upgrades provided by the new OEM Viking - De Havilland. These conversions are expensive, and the capacity of the OEM is limited. Are there additional avionics upgrade packages via a third party or in-house, if so equipped? Can these 3rd party upgrades provide a better-suited kit or package for the aircraft or a better price point? Does or will the OEM support an owner seeking other solutions?

De Haviland is currently offering a CL415EAF, essentially the latest version of the CL215 (series 3 and better) conversion. In addition, De Havilland has announced the construction of a new production facility east of Calgary. The De Havilland 515 is one of the aircraft that will be produced at this new facility. De Haviland indicated they have 22 orders for the aircraft. The production timeline needs to be clarified. If a Canadian operator signs an order today, they may not see the aircraft for seven years based on previous production by Bombardier. The estimated cost of a new 515 is between 35-40 million US dollars.

The Air Tractor AT 802 was first introduced in Canada in 2000. Wipaire produced the airframes for the FireBoss variant, and production continues by Air Tractor in the USA. The use of the aircraft continues to expand across the globe. All indications are that this aircraft production and support will be in place for the immediate future. In 2008-09 Air Tractor proposed the AT 1002, a larger aircraft with a 1000+ US Gallon retardant tank that would be a variant for firefighting. The project went into hiatus in 2013, and its status is unknown.

Conair recently introduced the RJ 85 and the De Havilland Dash 8- 400 or Q400 as land-based airtankers. The Q400 was previously used in France by Conair in a combi role (Passenger/cargo or Firebombing) and the RJ in the USA under its American company Aero Flite. The RJ 85 and its alternate, the BAE 146, are no longer in production, limiting the longevity of these aircraft as the OEMs may withdraw their support for this specialized role.

The Q400 is still a production aircraft and supported by the OEM. Due to its popularity for short-haul flights and its ability to operate from smaller runways (5000'), airframes suitable for conversion into the firembing role are difficult to procure. Conversion of a Q400 takes approximately ten months to complete.

Coulson introduced the 737 in the USA and Australia, but it still needs TC certification to fly in Canada. The US certification is a combination of the US Federal Aviation Administration (FAA) Restricted Category certification and the USFS certifications that have less stringent airworthiness/air maintenance implications (see the 2002 USDA Blue Ribbon Panel Report for a certification explanation). Coulson would have to undergo an extensive certification review by TC for approval.

Coulson has also introduced the C130 Hercules in the USA and Australia. In addition to the certification challenges of the 737, TC prohibits using ex-military aircraft for civil commercial use in Canada. Therefore, Coulsons C130s are not permitted to be used as airtankers in Canada. The last ex-military aircraft allowed was the S2F Tracker/Conair FireCat used in SK, YK, and BC. There are a few civilian C130s, but they are older models unsuitable for conversion.

This leaves limited options for airtanker selection, with serviceability time ticking on several current airframes. For the skimmer fleet, the choices for new are limited to the 515 with long delivery dates and the FireBoss. The choices for the land-based or retardant fleet are the Air Tractor 802 and the Q400, which currently have limited airframes available for conversion. What are the options, and what are the likely delivery dates? First conversions are highly engineered prototypes and are prone to delays due to engineering and certification (a 24–36-month window for a first conversion would not be unexpected).

Birddog aircraft require excellent front seat forward and side views to observe as much of the fire operating area as possible, observe and evaluate drops, and provide correction to bombing runs of airtankers. Many Birddog aircraft are aging and will not keep up with the new fleet. A parallel review of suitable birddog aircraft is also required. What is new and upcoming that fits the role for observation but is also compatible from an airspeed and flight profile perspective?

Appendix C - Additional Contributors

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