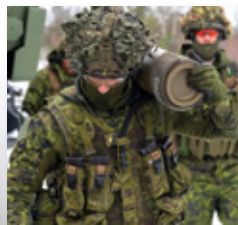


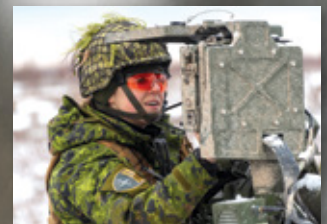
STRATEGIC REPLENISHMENT OF AMMUNITION :

A PROPOSAL TO ACHIEVE OPERATIONAL READINESS

Lieutenant-Colonel G. Olivier



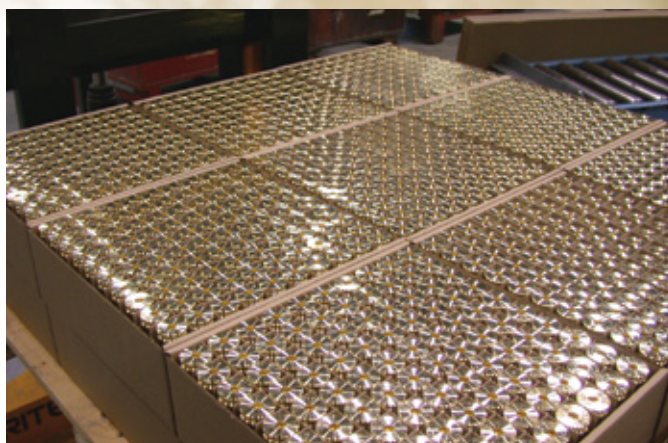
Source: Combat Camera



As Canada offers military aid (including ammunition) to Ukraine amid the ongoing war in Europe, the issue of ammunition replenishment has become more pressing.¹ In September 2022, Canada's Minister of National Defence, Anita Anand, met with the Munitions Supply Program (MSP) partners to discuss readiness and the necessary provisioning of ammunition.² Given the growing importance of the broader subject, it is pertinent to pose a crucial question: Do we have enough ammunition and explosives (A&E) in the Canadian Armed Forces (CAF)?

The most commonly assumed answer to this question is "Yes!" However, from a strategic/operational perspective, and for those concerned with "true" operational readiness, a more appropriate response should be "We are not sure." Needless to say, this is a troubling answer that deserves greater attention from scholars and policy makers. The A&E issue examined in this article is complex and, unfortunately, efforts to resolve it have not gained much momentum beyond good intentions. However, in recent years, there has been a growing impetus to address the issues and weaknesses in the current trajectory of A&E development.

A degree of "strategic impasse" exists due to inefficient handling of the ammunition (ammo) requirement, insufficient funding and complex procurement. The ongoing issues are exacerbated by the opacity created within and between headquarters, which precludes the organization from seeing clearly and acting with conviction to sustain the defence strategy and manage the risks associated with insufficient stockpiles of ammunition. In the current context, the operational readiness of the CAF is jeopardized. As noted by the Auditor General of Canada, "National Defence should review its materiel forecasting and positioning to ensure that sufficient stocks are maintained...[and] also review its materiel availability measures at the warehouse and national levels and use these measures to monitor whether stock levels are met."³



Source: GD-OTS-C

Fuze and high explosive insertion of the 40mm LV 6b at the General Dynamics-Ordnance Tactical Systems-Canada (GD-OTS-C) facility in Repentigny, Quebec. GD-OTS-C is an important strategic source of supply for Canada.

This article presents a replenishment model for establishing strategic/operational control limits and, by extension, A&E stockpiling, which ultimately seeks to empower the CAF to ensure its operational readiness.

BACKGROUND

Stocks and Control

The Strategic Joint Staff (SJS) is responsible for identifying the CAF's stock requirement. The needs and larger management of A&E are divided into two categories: free stock (FS) and reserve stock (RS).⁴ FS is used for lower-intensity operations and training, including the training conducted during named operations.⁵ CAF demand for FS is determined via feedback loops at various staff levels of the organization. Quantities are then rolled up to SJS, which allocates the FS yearly to environmental commands (EC) and other Level 1 (L1) organizations. RS is held in the Defence Supply Chain⁶ as a risk or contingency measure for the potential escalation of conflict during domestic and/or deployed operations turned to the highest intensity.⁷

The release of RS requires approvals at the highest level, and it is used only for the direst of circumstances. However, RS quantities in the CAF are determined with a less standardized approach than that required for FS. Although the FS–RS categorization is widely used in the A&E community, there is no clear outline of what it means in terms of the strategic requirement and corresponding control limits or how to establish a pertinent common understanding of the demand signal and its commensurate supply chain management.⁸

Procurement Oversight

In theory, pan-departmental standing committees⁹ oversee and steer the identification of the A&E requirement, its funding and procurement. In practice, it is the funding that frames the demand, making the resource dependence theory (RDT) the conceptual foundation of any program oversight. The RDT “is premised on the notion that all organizations critically depend on other organizations for the provision of vital resources and that this dependence is often reciprocal.”¹⁰ Notably, the annual funding allocated to the Director Ammunition and Explosives Management and Engineering (DAEME) for the procurement of A&E barely fluctuates, remaining close to \$150 million from year to year.¹¹ Usually, requests for more funding are met with bureaucratic resistance.

Overall, the combination of resource dependency and the lack of a solid approach to determining the demand signal makes it challenging to effect any change or adjustment to the ongoing ammo situation. Even forecasting lower spending is met with similar caution, reinforcing the incentive to “spend it or lose it.” This is reflective of inertia and departmental stasis, which often resist demand changes from year to year, even when those changes are deemed essential. Therefore, even when the right stakeholders are gathered by standing committees, procurement oversight tends to remain concerned with stability and predictability as the most “important dimension of its operation.”¹² Hence, it would not be wrong to argue that operational readiness becomes a secondary determinant, as do the A&E demand and the risks associated with insufficient FS and RS for the CAF.

Mitchell, Agle and Wood argue that within an organization there are many stakeholders that can be divided into various categories, including a group based on economic interests.¹³ They also note that these types of stakeholders or communities are “based on the practical reality of limited resources, limited time and attention” and are “defined in terms of their direct relevance to the firm’s economic interests.”¹⁴ The A&E governance structure in the CAF is akin to stakeholders that prioritize economic considerations, which is expected given the limited availability of resources at hand. However, for medium- and long-term effectiveness, there is a growing need to prioritize the operator community,

i.e. the clients’ demand and the corresponding value creation that is needed. The focus should be on the right A&E, in the right quantity, at the right time, coupled with greater attention to the assessment and management of the capability risk.

According to Lieutenant-General M. Rouleau, Commander of Canadian Joint Operations Command (CJOC) at the time, writing in June 2020, “we, the CAF, do not treat ammunition as an operational capability. We have relegated the management to our sustainment community; however, they are not the ones who have the responsibility to establish the demand signal or consciously assess the risks of our procurement choices. This is a shared responsibility between the Services, Chief Force Development and SJS to identify our future requirements and ensure that our choices are informed and sustainable.”¹⁵

Force Posture and Readiness

Strong, Secure, Engaged: Canada’s Defence Policy (SSE) requires the CAF to fulfill eight core missions that encompass four concurrent operations, including six international peace and stability mission sets. Notably, there is a stipulated expectation for the CAF to be prepared to employ all its missions simultaneously. This is arguably an ambitious yet tangible component of the Canadian defence policy. The directive on force posture and readiness (FP&R) further defines such CAF outputs¹⁶ in the form of sustained and discrete mission sets with commitments for daily and contingent operations:¹⁷

- a. Daily operations – North American Aerospace Defense Command, Search and Rescue, and Special Operations Forces,
- b. Domestic operations – High readiness and immediate readiness,
- c. Air mobility,
- d. Other strategic and “reachback” capability/capacity, and
- e. Contingent operations are divided into minor and major operations and their force elements.

With regard to A&E, it was rightly decided that only the force generation and force employment (FE) of daily and contingent operations should determine the FP&R requirements and associated stock levels.¹⁸ This was largely in view of the limited scope of A&E expenditures for other daily and domestic purposes, such as recruit training. However, since the fall of 2017, when the FP&R planning commenced, the sustainment portion of readiness, including ammo, has evolved slowly. In light of SSE, the strategic/operational planners have struggled to advance



Source: Combat Camera

the FP&R and A&E. They have not extensively defined the FS–RS requirement or implemented a viable solution to the CAF’s provisioning and warehousing of A&E. There are sufficient supplies of some A&E natures; small arms ammo is a case in point. However, it should not be assumed that all natures have adequate quantities in stock, especially in terms of the increasingly complex and costly battle-decisive munitions, such as the ammo used in short-range anti-armour weaponry or precision-guided artillery.

Operation REASSURANCE – Latvia

While at the CJOC in 2017, the author¹⁹ co-led (with a colleague from SJS)²⁰ the development of an extensive A&E scale to provision the task force (TF) deploying to Latvia with the necessary ammo.²¹ It involved the active participation of other SJSs, the Canadian Army,²² and DAEME staff. The aim was to first understand the North Atlantic Treaty Organization (NATO) requirement²³ in terms of FS and RS for each force element and to then determine where Canadian A&E should be positioned: in Latvia or elsewhere in Europe, and/or kept in Canada (for RS only).²⁴ The team assessed the latter’s demand, the availability of national stocks and the feasibility of sending high quantities of ammo overseas. The team also factored in the CAF’s ongoing needs, the ability of DAEME to procure additional A&E to supplement/replace²⁵ the stocks moved to the theatre, and the operators’ willingness to accept alternatives to availability issues for a handful of items.

This operational planning lasted two months, with bi-weekly stakeholder engagements and ad-hoc interactions that always included the operator and sustainment communities working together.²⁶ While the stakeholder approach was broad, making it “bewilderingly complex for managers to apply,”²⁷ the underlying idea was to comply with the NATO requirement without compromising on the CAF’s needs. Notwithstanding the complexities involved, this stakeholder management paid off, and the whole enterprise proved to be a relative success. That noted, it was difficult to mitigate some availability issues for the TF and the CAF. Notably, the extensive planning exposed significant A&E availability issues at the national level.²⁸ For the first time, such deficiencies could be quantified and communicated internally to the organization and externally to NATO. Despite the identification of concerning national deficiency and related operational risk to CAF readiness, the issue was not adequately addressed at the strategic level, and the lessons learned from the exercise²⁹ did not generate sufficient attention.

How national procurement of free stock really works

Every fall, for the purpose of procurement planning, the SJS Strategic J4 Ammunition shares with DAEME the aggregate L1 requirement as a forecast of A&E usage for the next fiscal year. This requirement represents the overall L1 planning effort, not yet controlled or challenged by SJS.³⁰ In the following months, given the “unconstrained” character

A&E Replenishment

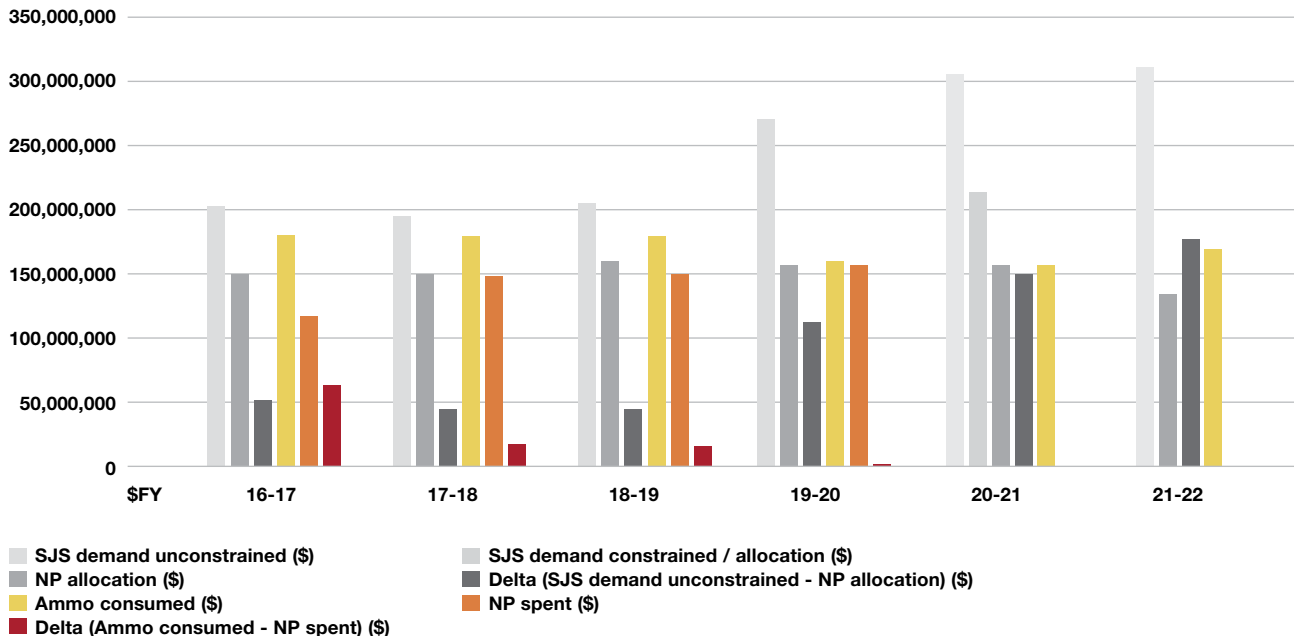


Figure 1: Reality check of the A&E replenishment cycle at the strategic level. Data extracted from DAEME National Procurement Briefing to Director General Land Equipment Program Management, 21 August 2020.

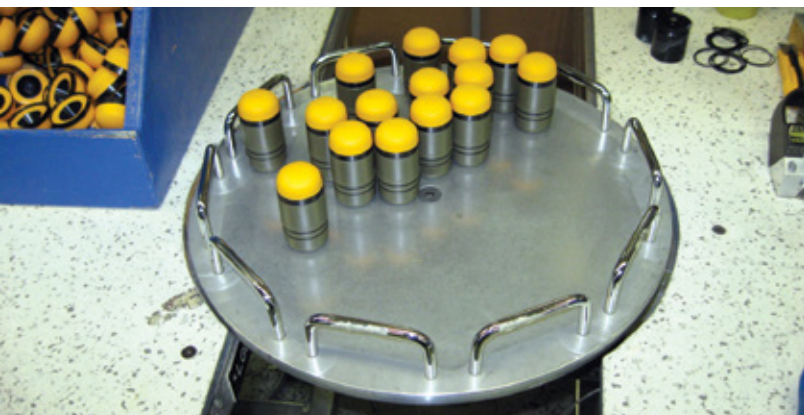
of the demand signal, quantities are further scrutinized exclusively by the sustainment community. Significant L1 variances from the previous year trigger SJS to ask for justifications. One can assume that the unconstrained CAF demand, known as the “CAF demand,” is considered malleable from the very start. The CAF demand can be viewed as a starting point for discussing and determining the constrained CAF demand, known as the “CAF allocation,” as both are driven by the RDT logic and economic considerations noted previously.

Further, primarily based on the DAEME staff advice, some A&E natures and their problematic availability are considered by SJS, which lowers the CAF allocation for the next fiscal year accordingly. Although the CAF allocation is decided for the next fiscal year, SJS considers the whole length of an availability issue, often spanning multiple years, to ensure that all activities (training) continue unabated. It is crucial to understand that availability issues or significant fluctuations of the CAF allocation can seldom be accommodated by DAEME in under two years.³¹ This is because the procurement cycle of in-service A&E is a rigid process with corresponding lead times and is often affected by delays. So, from the CAF demand, the CAF allocation is produced, focusing solely on FS for the next fiscal year. From a departmental standpoint, the provision of A&E is understood as a matter to address yearly, but DAEME must cope with its own procurement cycle and thus consider outer years.

From the explanation above, one can surmise that the yearly CAF demand and CAF allocation of FS are essentially created from multiple and often confusing correspondences within and between higher headquarters and various levels of logistics/ammo staff. Adding to this complex mix is the fact that CAF demand vs CAF allocation vs what is funded to DAEME for procurement initiation vs what is actually expended or consumed are all generally different from one another.

There were concerted attempts in 2019³² and 2020³³ to better define the CAF demand, including the identification of future FS needs beyond the next year (so as to justify the commensurate procurement of A&E in replacement value). However, these attempts did little to resolve the issue but ended up exposing the existing problems further and highlighting the volatility of the CAF operational readiness post-SSE.

In essence, DAEME is expected to decide what to procure annually (or not) based on similar yearly budgets, a lengthy procurement cycle, past consumptions, unreliable external feedback loops and difficult internal predictions. The risk associated with misunderstanding the pan-CAF A&E stocks that are needed in inventory, FS and RS alike, are inadequately considered by those who should be the most concerned: the operator community at the strategic/operational level – SJS, the ECs, and CJOC. Figure 1 reveals the extent of the FS issue.



Source: GD-OTS-C

Last but not least, the National Procurement (NP) funding, also termed the NP allocation, is constantly and at times markedly less than the CAF consumption. This difference emphasizes the current replenishment of A&E at the strategic level failing to sustain the FS reality in the longer term—a situation or deficit that simply grows and gets worse every year. As for the CAF demand, it is repeatedly higher than the constrained CAF allocation, with the actual yearly CAF consumption constantly lower than what was initially allocated. Unfortunately, the data pertaining to the difference between the CAF demand and the CAF allocation (as pictured in the bar graph in Figure 1) is available only for 2020/2021, as it was not captured by SJS for previous years.³⁴ Consequently, given the data presented, the author posits that L1 methodologies to forecast requirements and arrive at reliable quantities are not producing the intended effect. The main reason for this is that the CAF allocation is systematically below what is initially demanded without a commensurate impact being qualified—for example, it does not prompt ECs to signal their corresponding training risk. Adding to the problem, the ammo expenditure is systematically below the CAF allocation, which implies that the Canadian Army is unable to consume what it is constrained to in any given year. It is difficult to grasp the increase in the CAF demand, which started in 2019/2020 and has continued since then (see Figure 1). So far, these increases have been met by DAEME with skepticism and a reluctance to follow this FS trend, given its discrepancies. The consumption for 2019/2020 remained nearly the

same as the previous year, despite a higher CAF demand, which has, in essence, validated DAEME's careful approach. Therefore, despite the periodic invoking of SSE to support the CAF demand for outer years, this sudden excitement cannot be considered a game-changer, as the FP&R planning has yet to solve the FS-RS problem.

Way forward

The CAF-wide issue was exposed in 2017 by the scaling and provisioning of Operation REASSURANCE (Latvia), which deserves greater attention. The accurate SSE demand is still unknown for FS and RS. Additionally, there are irreconcilable tensions and laborious staff efforts³⁵ at the departmental level to properly integrate the ammo program activities. Given the realization that the current availability of ammo is insufficient, continued strategic neglect of the issue jeopardizes the CAF's ability to fulfill its mandate. Above all, a workable framework is imperative to care for the sustenance of FP&R and A&E.

The author proposes a replenishment model based on the establishment and periodic review of strategic control limits and ordering levels,³⁶ commonly known as re-order points (ROP).³⁷ This proposal stems from the granular interpretation of what the FP&R signifies in terms of the requisite FS-RS stocks versus funding and procurement. Fundamentally, such scheme is meant to portray the overall CAF impact and risk associated with insufficient stocks. And for this conceptual framework to work,

CAF Outputs

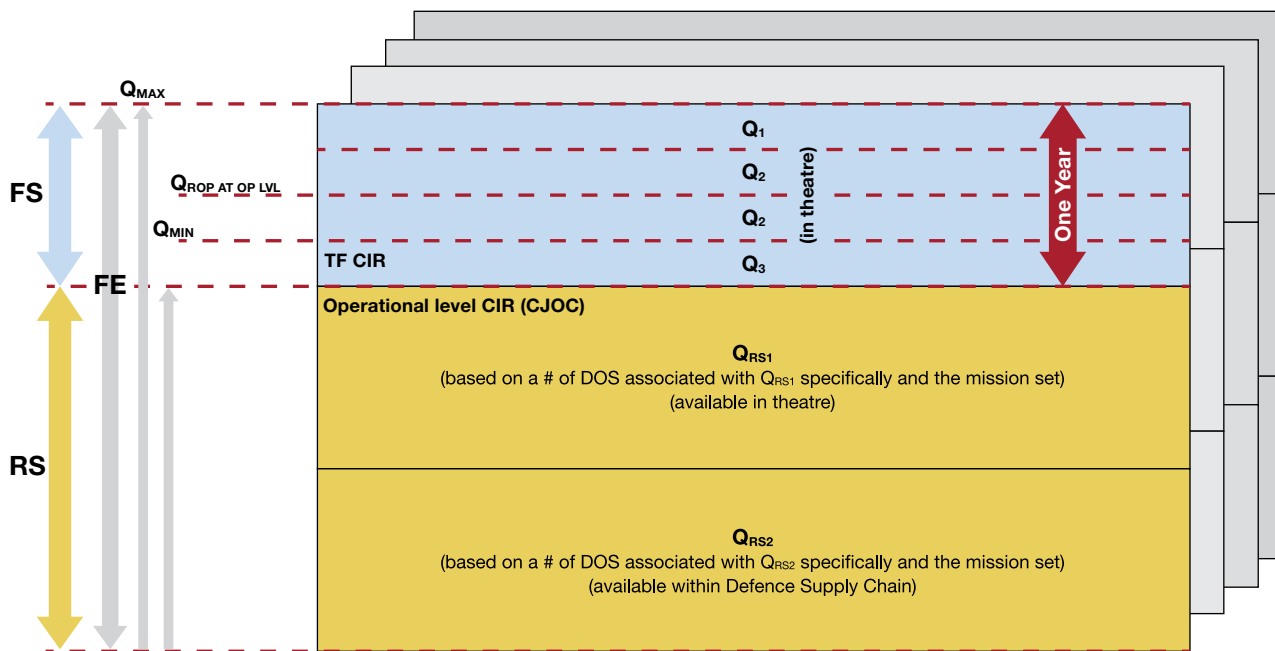


Figure 2: Force employment free stock and reserve stock requirements.

it was designed to be simple in its application so that the operator and sustainer communities can fully understand the stakes and work together to strengthen, maintain and thereby maximize operational readiness, especially as it pertains to the neglected RS. As for DAEME, the above-mentioned control limits and ROPs indicate the need to implement longer-term contracts and phased deliveries. This constitutes a significant challenge, considering the funding, procedural and industrial constraints faced by the directorate, as well as the chief concern of the organization and procurement writ large for stability and predictability. The intent of this article is not to comprehensively expand on the procurement intricacies at DAEME, although addressed in relatively more details later in the text. Longer-term contracts and phased deliveries are not only feasible but crucial to the model's application and much-needed simplicity. It also reduces irreconcilable tensions at the departmental level and allows for the development of information requirements for the subsequent and effective control of the A&E inventory.

DISCUSSION

SSE's concurrent operations and force employment

The core of the following proposal is the establishment of strategic minimum (min) and maximum (max) stock levels. At the strategic level, they are referred to as lower control limits (LCL) and upper control limits (UCL). This replenishment method is not new; in fact, it is common for Class II³⁸ items. In short, when a stock reaches a pre-determined minimum level, it is requisitioned to its maximum. With TF LATVIA, which was

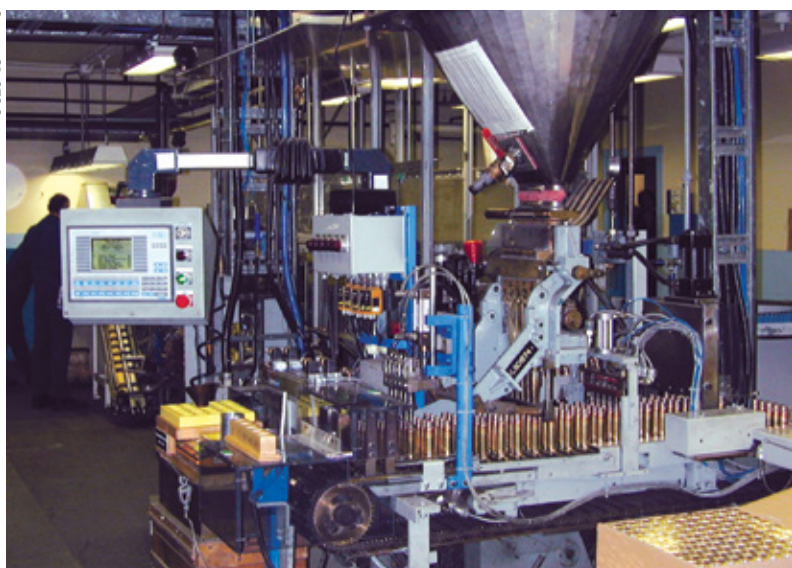
similar in many ways to a CAF output or mission set of the SSE-FP&R, such control limits and surrounding schemes were implemented at the operational level for the purpose of differentiating between strategic and operational limits. The "min" and "max" are the nomenclatures linked to the operational level, not the strategic LCL and UCL. So, in the case of TF LATVIA, A&E control limits in the form of min-max were part of the dual RS-FS scale, and the FS was associated with ordering levels or ROPs as well (see Figure 2 for details).³⁹

FS is measured in A&E quantity (Q) over time in year(s), whereas RS is measured in day(s) of supply (DOS), i.e. Q for a number of DOS. This *modus operandi* hinges on practicality, for example, FS that is allocated by SJS yearly. As illustrated in Figure 2, for the operational level, FS corresponds to the maximum quantity planned and authorized for an operation for the likely A&E usage spanning two rotations of personnel, precisely one year. In contrast, RS is linked to DOS,⁴⁰ as NATO has required it for TF LATVIA.⁴¹ Overall, the total quantity of A&E dedicated to the force employment of an FP&R mission set or CAF output comprises multiple force elements as the references to determine what are the requisite procurement and inventory of FS and RS. The five quantities (Q) are shown in Figure 2, which constitutes the pioneering method used for TF LATVIA:

- Q₁ – FS relief quantity to allow reasonable time after replenishment before an operational ROP is triggered (again).

- b. Q_2 – FS quantity that represents a CAF output consumption during the time required for the replenishment of an A&E nature, including stock sourcing and corresponding lead time. It is the quantity associated with the operational ROP for a given A&E nature and mission set, or $Q_{ROP\ AT\ Op\ LVL}$.
- c. Q_3 – FS risk mitigation quantity that reflects the organization's tolerance to risk at the operational level. It is the minimum FS quantity in theatre. In the case of TF LATVIA, the risk measures factored in included the volatility of current operations, deployment duration, the sustainment plan and the training plan, apart from other considerations and uncertainties.
- d. Q_{RS1} – RS quantity readily available⁴² to a CAF output as a contingency measure to the potential escalation of conflict turned to the highest intensity. As an example, for TF LATVIA and each of its force elements, this number⁴³ of DOS was mandated by NATO. Such A&E is located within or in the vicinity of the TF area of responsibility and therefore is assumed to be solely dedicated to such operational output. It is the maximum RS authorized in the theatre. Therefore, depending on the mission set and its purpose, Q_{RS1} can range from zero to a significant quantity. That being said, it is assumed that readily available RS quantities can be "shared" amongst mission sets and that, therefore, the overall quantity can be reduced accordingly. The additional risk engendered by this measure should first be assessed and then accepted to the extent that is tolerable by the operator community and SJS. Additionally, the required RS quantity readily available for each CAF output must be arrived at before the aggregate quantity is reduced, that is, for all FP&R sustained and discrete mission sets.
- e. Q_{RS2} – RS quantity remotely available⁴⁴ to a CAF output as a contingency measure to the potential escalation of conflict turned to the highest intensity. In the case of TF LATVIA, for instance, this number⁴⁵ of DOS was mandated by NATO. As opposed to Q_{RS1} , this type of RS remains in the Defence Supply Chain writ large, thereby remotely supplementing the FS–RS quantity that is readily available to the theatre. It is (still) warehoused in the Canadian Forces Ammunition Depots, possibly⁴⁶ in regional CJOC Operational Support Hubs, should additional proximity to areas of operations be needed. Like Q_{RS1} , depending on the mission set, Q_{RS2} ranges from zero to a significant quantity. It is also assumed that RS quantities remotely available can be "shared" amongst mission sets, and that the overall quantity in the Defence Supply Chain can be reduced accordingly. In short, it is a risk decision similar to what is required for Q_{RS1} .

Source: CDOTSC



As shown in Figure 2, Q_{MIN} is the minimum FS–RS quantity dedicated to force employment, i.e. $Q_{MIN} = Q_3 + Q_{RS1} + Q_{RS2}$.

Moreover, Q_{MIN} constitutes a control limit associated with a mission set/TF critical information requirement (CIR). As for $Q_{MAX} = Q_1 + 2Q_2 + Q_{MIN}$, it represents the maximum FS–RS quantity authorized for an FP&R CAF output and its force elements, the axioms upon which to build the case for the sustainment of the larger SSE context.

As discussed previously and for the purpose of this study, the maximum FS authorized in theatre ($Q_1 + 2Q_2 + Q_3$) is fixed at one year of stocks for ease of sustainment planning. Amongst mission sets, it is also assumed that the total FS authorized for each can be "shared," and thus the overall quantity needed in the Defence Supply Chain can be reduced accordingly. The bigger picture here is that the named operations are circumstantial and rarely match the FP&Rs completely. At this time, it is also difficult to envisage all CAF outputs being deployed simultaneously,

despite SSE's clear mandate in this regard. One must note that the same logic applies to Q_{RS1} and Q_{RS2} , as explained previously. Further, A&E for which FS in a TF area of responsibility is used completely constitutes a CIR at the operational level, as CJOC's readiness is *de facto* changing and worthy of commensurate attention, with only RS remaining in theatre at that time. The authority to spend RS in theatre, considering that it is used on a contingency basis and is therefore crucially significant, should be assigned to CJOC at the highest level, similar to the way it is currently set up for TF LATVIA.

To find the total A&E requirement Q_{MAX} or Q_{FE}^{47} as it relates to the force employment of all CAF outputs—all FP&R mission sets, including minor and major operations—one must add the FS–RS quantities associated with each.⁴⁸ This sum considers the maximum FS quantities authorized in the theatre. It also includes the RS quantities readily available in theatre and remotely available in the Defence Supply Chain that should be rationalized (reduced) and thus divided by constants A, B and C, respectively, all greater than or equal to one. This method yields the FS–RS requirement for an ammo type that pertains to the CAF's entire force employment, as shown in Equation 1:

CAF Outputs

For an A&E nature:

X: CAF output

Y: Force element

$$Q_{FE}(X, Y) = \frac{Q_1(X, Y) + 2Q_2(X, Y) + Q_3(X, Y)}{A} + \frac{Q_{RS1}(X, Y)}{B} + \frac{Q_{RS2}(X, Y)}{C}$$

$Q(X_i, Y_i)$ is a quantity associated with the i^{th} possibility of n possibilities. In other words this i^{th} possibility corresponds to a specific CAF output X and a specific force element Y for a given A&E type.

$$Q_{FE\ TOTAL} = \sum_{i=1}^n Q_{FE}(X_i, Y_i)$$

Equation 1: Force employment free stock (FS) and reserve stock (RS) requirements

Force generation training

In the current proposal and for practicality purposes, the force generation (FG) training stock and associated level of FS or Q_{FG} coincide with one year of pan-CAF training consumption. That does not include training during named operations, which was addressed previously. The "one year" is a strategic-level measure of risk mitigation. Q_{FG} can be more or less than a year (proposed here) and specific to individual ammo natures, as it depends on the risk of considerable fluctuations over a short period of time without national procurement being able to adjust it in a timely fashion. The need to stockpile Q_{FG} is a risk decision

as well, which remains a significant and recurrent theme of this article. Figure 3 shows how force employment and force generation mesh:

As a result, $Q_{FP\&R} = Q_{FE} + Q_{FG}$ is a control limit linked to a strategic-level CIR. Below this quantity, the CAF's operational readiness is affected. When that happens, it should be reported to the highest level of SJS and the Materiel Group. The added risk should be subsequently re-assessed and further managed⁴⁹ until national procurement can restore the baseline. This CIR, linked to an A&E nature, could also point to the need to re-assess $Q_{FP\&R}$ altogether in terms of FS for this ammo type specifically. There may be a need to re-assess whether the force elements—the references to determine what the FP&R means in terms of the requisite FS—truly indicate the FS reality. Indeed, $Q_{FP\&R}$'s validity should be re-assessed periodically,⁵⁰ not only on an as-needed basis.

Procurement cycle stock

As stated earlier, it is crucial to establish a strategic A&E stockpiling that matches LCLs, UCLs, and ROPs. The strategic level has unique factors and uncertainties to deal with, such as the RDT as the conceptual foundation of program and procurement oversight, the procedural and industrial constraints, and the procurement cycle of in-service A&E, which is a rigid process with corresponding lead times (2 years minimum) and often affected by delays. Figure 4 shows how the procurement cycle stock and $Q_{FP\&R}$ mesh:

- Q_4 – FS relief quantity to allow reasonable time after replenishment before a strategic ROP is triggered (again). For the purpose of this paper, it is set at two years of pan-CAF consumption of FS.
- Q_5 – FS quantity that represents the CAF consumption during the time it takes for the replenishment of an A&E nature, including stock sourcing and corresponding lead time. Q_5 must also consider Q_2 and the FS quantity expended at the operational level during that time. Q_5 is the quantity associated with the strategic ROP for a given A&E nature or $Q_{ROP\ AT\ STRAT\ LVL}$.
- Q_6 – FS risk mitigation quantity determined from a periodic risk assessment of national procurement, specifically its ability to sustain the FS reality. It is also representative of the organization's tolerance for risk at the strategic level. This risk measure also factors in funding and acquisition delays and other strategic considerations and uncertainties. For the purpose of this study, Q_6 is set at one year of pan-CAF consumption of FS.

As shown in Figure 4, Q_{LCL} is the minimum FS–RS quantity in the CAF, i.e. $Q_{LCL} = Q_6 + Q_{FP\&R}$. For each A&E nature, it is a control limit associated with a Director General Land Equipment Program Management (DGLPEPM) / DAEME and

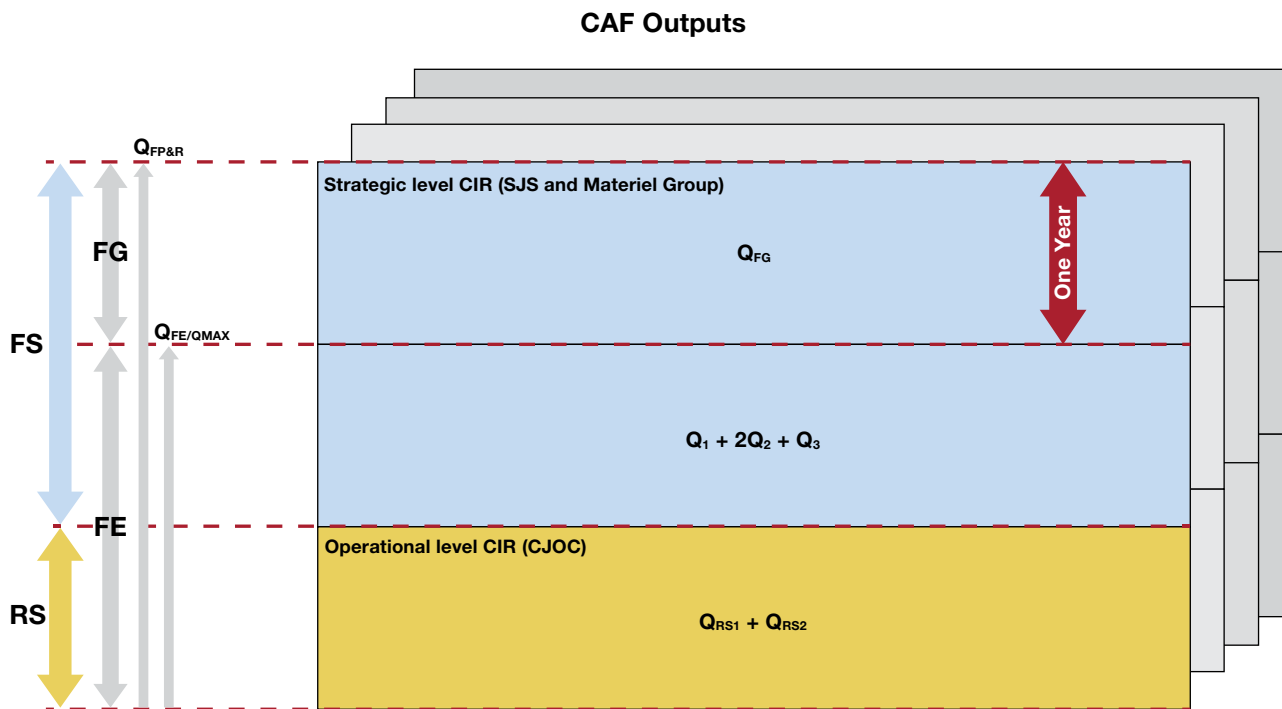


Figure 3: Force Posture and Readiness free stock and reserve stock requirements

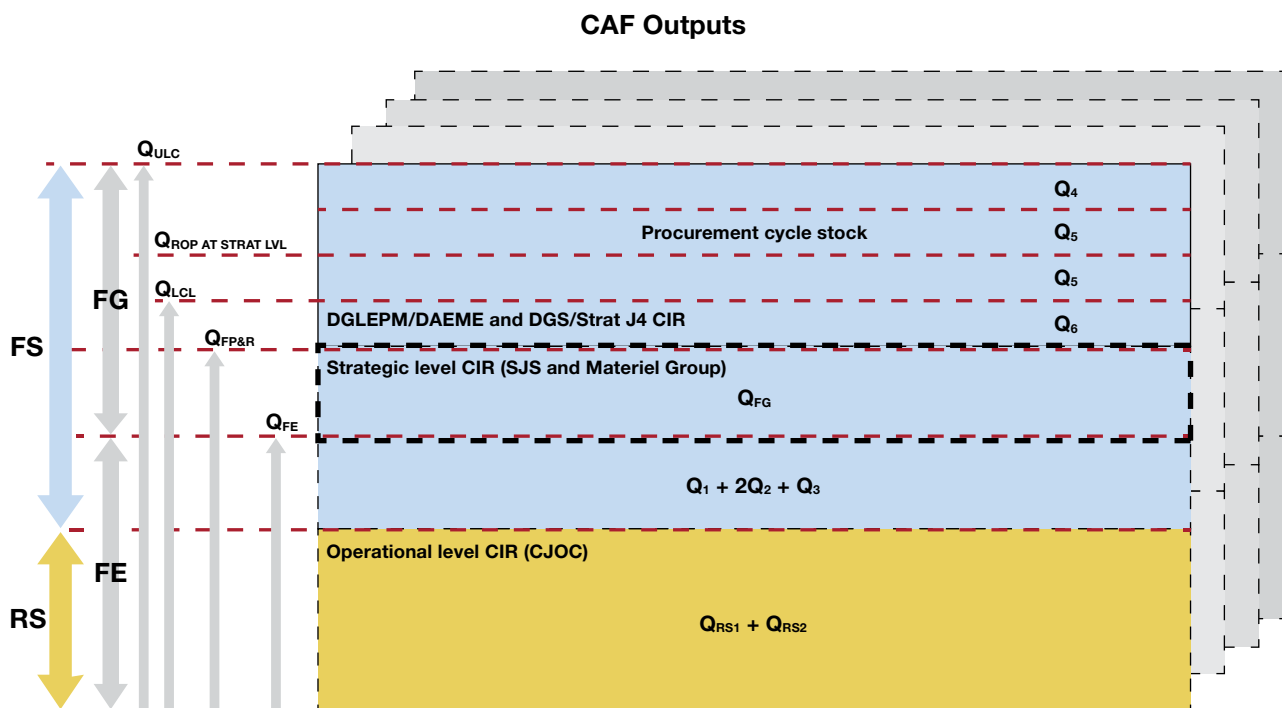


Figure 4: Canadian Armed Forces free stock and reserve stock requirements

Director General – Support / Strat J4 CIR. As the latter organization’s ability to provision the CAF with the requisite stock level ($Q_{FP\&R}$) within the desired timeframe was affected, it requires immediate attention. As for $Q_{UCL} = Q_4 + 2Q_5 + Q_6 + Q_{FP\&R}$, it is the maximum FS–RS quantity authorized in the CAF. And if national procurement adheres to the proposed model, such UCLs and related FS–RS levels should never be surpassed. Like Equation 1, Equation 2 illustrates how to arrive at the Q_{LCL} and Q_{UCL} for each type of ammo. Moreover, Equation 2 includes all sustained/discrete mission sets and other strategic concerns and risks:

CAF Outputs

For an A&E nature:

X: CAF output

Y: Force element

$$Q_{FP\&R}(X, Y) = Q_{FE}(X, Y) + Q_{FG}(X, Y)$$

$Q(X_i, Y_i)$ is a quantity associated with the i^{th} possibility of n possibilities. In other words this i^{th} possibility corresponds to a specific CAF output X and a specific force element Y for a given A&E type.

$$Q_{FP\&R\ TOTAL} = \sum_{i=1}^n Q_{FE}(X_i, Y_i) + Q_{FE\ TOTAL}$$

$$Q_{LCL} = Q_6 + Q_{FP\&R\ TOTAL}$$

$$Q_{UCL} = Q_4 + 2Q_5 + Q_6 + Q_{FP\&R\ TOTAL}$$

Equation 2: Minimum and maximum quantities authorized in CAF (Q_{LCL} & Q_{UCL}).

Considering the proposed procurement model, the total availability of FS, as it pertains to individual A&E natures in the Defence Supply Chain, will oscillate between about two and five years. Expectedly, this depends on the risk decisions associated with Q_3 , Q_{FG} , and Q_6 , the set relief quantities Q_1 and Q_4 , stock sourcing and corresponding lead time, usage rate, and how the replenishment cycle is executed for that type of ammo. Based on this logic, do we have enough A&E in the CAF? Most likely not.

DAEME constraints

To implement LCLs, UCLs and ROPs at the strategic level, the key stakeholder, DAEME, must overcome a significant constraint. It must provide the industry, specifically the MSP partners or strategic sources of supply,⁵¹ with steady production and cash flow. The DAEME must continuously ensure that the MSP stays alive and well and prospers. In view of the proposed model and given the latter constraint, it becomes apparent that longer-term contracts are necessary, as are phased deliveries. As indicated previously in the article, for larger volumes, less frequent

procurement is needed, given that following aspects are considered: the relief quantity Q_4 to allow reasonable time after replenishment before the strategic ROP is triggered (again), and stock sourcing and the corresponding lead time Q_5 set at two years minimum. Given the model, DAEME’s current way of initiating procurement needs to be reformed. By adjusting contracts and deliveries over the longer period of time associated with the consumption over Q_4 and Q_5 added, the MSP constraint of DAEME is eliminated (see the appendix for details). It is also a practical explanation of how the organization and procurement writ large can maintain the stability and predictability of expenditures. In the context of the replenishment model proposed, one of the most important factors to consider is the RDT as the conceptual foundation of program and procurement oversight.

That noted, the DAEME procurement, including the management of the various authorities⁵² and stakeholders, departments and industries involved, is a convoluted business, which signifies procedural constraints, adding to time and effort. Longer-term contracts and phased deliveries are the game changer that the current procedure needs. Such contracts are essential to the implementation of a strategic replenishment model. Although it initially appears complex, the procurement scheme is rather simple and is essential for enabling the institution to resolve the A&E conundrum.

CONCLUSION

The proposed replenishment model is based on the CAF’s need to revisit its genuine requirement and involve the operator and sustainment communities in a broader stakeholder approach. The model incorporates all FP&R sustained/discrete mission sets and their force elements as references to determine the requisite FS and RS for force generation and employment alike. Planning-wise, the model appears complex and front-end heavy. Additionally, once implemented, such scheme necessitate periodic assessments of the numerous $Q_{FP\&R}$. Despite the complexities involved, after the status quo is reached, the overall application is simple, and the potential for realizing benefits is too significant to ignore.

This larger framework proposes to overcome the irreconcilable tensions at the strategic level and address the need for national procurement to remain stable and predictable. It also allows funding and procurement to follow a logical, coherent, and fully justified plan. Most notably, it makes it easier to find offsets so that the corresponding risks are managed accordingly, especially if availability issues arise. Lastly, from the A&E standpoint, the model overcomes the “strategic impasse” and empowers the CAF to reach “true” operational readiness to match the SSE and to have a relevant FP&R beyond good intentions.⁵³ 🍁

APPENDIX – PRACTICAL APPLICATION OF THE MODEL PROPOSED CONSIDERING LONGER-TERM CONTRACTS AND PHASED DELIVERIES

PROCUREMENT MODEL WITHOUT A LONGER-TERM CONTRACT AND PHASED DELIVERIES

Year	0 to 1	1 to 2	2 to 3	3 to 4	4 to 5	5 to 6	6 to 7	7 to 8	8 to 9	9 to 10	10 to 11
Quantity in inventory	30	20	10	40	30	20	10	40	30	20	10
Dues in	0	40	40	0	0	40	40	0	0	40	40
Quantity in inventory + dues in	30	60	50	40	30	60	50	40	30	60	50
Procurement initiated in Dec.	Yes	No	No	No	Yes	No	No	No	Yes	No	No
Deliveries in Jan–Feb.	0	0	40	0	0	0	40	0	0	0	40
Procurement initiated every 4 years ($Q_4 + Q_5$) when ROP triggered	Yearly consumption = 10	$Q_6 = 10 \geq 1$ year	$Q_5 = 20 \geq 2$ years lead time	$Q_4 = 20 \geq 2$ years	$Q_{UCL} = 70$	$Q_{LCL} = 10$	$Q_{ROP} = 30$				

PROCUREMENT MODEL WITH A LONGER-TERM CONTRACT, I.E. PHASED AND EQUAL DELIVERIES OVER 4 YEARS ($Q_4 + Q_5$)

Year	0 to 1	1 to 2	2 to 3	3 to 4	4 to 5	5 to 6	6 to 7	7 to 8	8 to 9	9 to 10	10 to 11
Quantity in inventory	30	20	10	10	10	10	10	10	10	10	10
Dues in	0	40	40	30	20	50	40	30	20	50	40
Quantity in inventory + dues in	0	60	50	40	30	60	50	40	30	60	50
Procurement initiated in Dec	Yes	No	No	No	Yes	No	No	No	Yes	No	No
Deliveries in Jan–Feb.	0	0	10	10	10	10	10	10	10	10	10
Procurement initiated every 4 years ($Q_4 + Q_5$) when ROP triggered	Yearly consumption = 10	$Q_6 = 10 \geq 1$ year	$Q_5 = 20 \geq 2$ years lead time	$Q_4 = 20 \geq 2$ years	$Q_{UCL} = 70$	$Q_{LCL} = 10$	$Q_{ROP} = 30$				

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ENDNOTES

1. The author would like to thank the GD-OTS-C for graciously offering the pictures that are included in the article. The pictures remain the property of GD-OTS-C.
2. Anita Anand (@AnitaAnandMP), "Last week, I met with Munitions Supply Program partners for a meeting of the Munitions Industry Roundtable. As the war in Ukraine carries on, we must continue to work with the defence industry to ensure the readiness of our @CanadianForces and support for our partners." *Twitter*, 3 October 2022, <https://twitter.com/AnitaAnandMP/status/1576972218629640203>.
3. 2020 Spring Reports of the Auditor General of Canada to the Parliament of Canada, Report 3 – Supplying the Canadian Armed Forces – National Defence, tabled 8 July 2020, retrieved 4 September 2020 from https://www.oag-bvg.gc.ca/internet/English/mr_20200708_e_43596.html.

4. In the *Supply Administration Manual (SAM)* [A-LM-007-100/AG-001, *Supply Administration Manual*, release date 18 December 2019], Allocation Management, 2.4, A&E is divided into three categories: training, operational and contingency. Those definitions are not complied with, but are used differently for the purpose of this article.
5. A “lower-intensity operation” has an operational tempo that can be sustained indefinitely. However, it is up to the operator community to further define it for the purpose of this study and proposal.
6. Defined as “The end-to-end system of interdependent activities that function horizontally across, and are housed within, National Defence organizations, other government departments and industry to deliver materiel requirements to the Canadian Armed Forces both domestically and overseas.” From “Decision brief to MGMC, MA&S Transformation Campaign Plan Strategic Initiative #20 – Improve Supply Chain Performance,” by R. Cormier, 12 May 2020.
7. A “highest-intensity operation” is to be determined by the operator community for the purpose of this study and proposal. It should essentially mean “break the glass in the event of a war” to access RS.
8. “Supply chain management is the management of the interconnection of organizations that relate to each other through upstream and downstream linkages between the processes that produce value to the ultimate consumer in the form of products and services.” From N. Slack, A. Brandon-Jones, and Robert Johnston, *Operations Management*, 7th ed. (Harlow, United Kingdom: Pearson, 2013), 406. For A&E, the many activities that “supply chain management” entails include provisioning, inventory control, continued safety and suitability for service, warehousing, transportation and more.
9. Such oversight committees are the Ammunition Program Steering Committee at L3, which feeds the Ammunition Program Oversight Committee (APOC), chaired by the SJS J5 and Materiel Group Deputy Chief of Staff, which in turn feeds the Programme Management Board (PMB). The APOC Terms of Reference were endorsed by the PMB 14/07 on 4 April 2014.
10. Johannes M. Drees, and Pursey P.M.A.R. Heugens, “Synthesizing and extending resource dependence theory: A meta-analysis.” *Journal of Management* 39, no. 6 (2013): 1667.
11. DAEME National Procurement Briefing to the Director General Land Equipment Program Management, 21 August 2020.
12. J. Pfeffer and Gerald R. Salancik, *The External Control of Organizations: A Resource Dependence Theory*, New York: Harper & Row, 1978, 47.
13. Ronald K. Mitchell, Bradley R. Agle, and Donna J. Wood, “Toward a Theory of Stakeholder Identification and Salience: Defining the Principle of Who and What Really Counts.” *The Academy of Management Review* 22, no. 4 (1997): 853–86. <https://doi.org/10.2307/259247>.
14. Ibid.
15. 3350-1 (Comd) June 2020, State of the CAF Ammo Program.
16. FP&R “CAF outputs” and “mission sets,” which include minor and major operations, mean the same thing and are used interchangeably in the text.
17. CDS Directive for CAF FP&R 18-19, 2 March 2018.
18. SJS presentation on ammunition requirements, January 2018.
19. The author was the CJOC J4 Ops from 2016 to 2018.
20. Lieutenant-Colonel S. Pellicano (SJS, Director General Support [DGS], Directorate of Sustainment Operations Coordination, Sustainment Plans), whose leadership was instrumental in gathering and influencing the necessary stakeholders during the planning effort.
21. The first comprehensive scale ever developed, at least during my tenure at CJOC, indicative of how ammo is a second-order item on the agenda, rarely discussed beyond generalities.
22. TF LATVIA is land-centric. Canadian Army Headquarters was represented by the G35.
23. From SACEUR’s Strategic Directive for the Implementation and Operation of Enhanced Forward Presence (eFP), 16 Dec 2016; CDS Directive 003 for Op REASSURANCE, 1 February 2017; 3350 – Op REASSURANCE eFP (J4 Ops), June 2018, OPORD Annex R (Logistics); and Placemat on the eFP Ammo Requirements & Provisioning (Class V) v12, 8 June 2017.
24. To this extent, the CJOC J3 and staff were involved.
25. During the planning and initial force employment of TF LATVIA, it was wrongly assumed that deployed RS should trigger a commensurate re-supply at the national level. That was a misunderstanding, indicative once more of how the TF LATVIA experience has helped with and is key to the understanding of A&E scaling, including how requirements should be determined at the operational level.
26. At the time, the CJOC J3 was Colonel R. Ritchie. His firm grasp of the joint effort needed by both the operator and sustainer communities with regard to scaling and provisioning operations with the necessary A&E was exemplary. His leadership and support proved key to provisioning TF LATVIA with the right FS and RS.

27. Mitchell, Agle and Wood, "Toward a Theory of Stakeholder Identification and Salience," 849.
28. These availability issues are not discussed in this article, as the information is classified.
29. The DAEME Chief of Staff briefed the SJS FP&R cell and subsequently the AP MA&S WG specifically on such lessons identified. From FP&R A&E Framework Proposal, 21 November 2018.
30. In reality, the challenge or control function of SJS Strategic J4 Ammo is limited, given this section's lack of in-depth knowledge about how ECs arrive at their quantities.
31. There may be one or many reasons for this, such as funding, safety and suitability for service; engineering/technical problem(s); and procedural and industrial constraints.
32. 2184J-11300-01 (DAEME) 23 May 2019, Yearly Call for the Identification of the CAF Forecasted A&E Usage Requirement.
33. 11300-1 (SJS Ammo 5) March 2020, CAF Ammunition Training Allocation FY 20/21.
34. As it should be, for it is an important metric.
35. Really meaning a significant waste, an effort that so far has proven extremely difficult, even impossible, given the current norms in place.
36. Defined in the SAM, Establishing Maximum and Minimum Levels, 2.37 to 2.42.
37. "The point in time at which more items are ordered, usually calculated to ensure that inventory does not run out before the next batch of inventory arrives," from Slack, Brandon-Jones and Johnson, *Operations Management*, 7th ed., 709. The SAM defines such points as the "ordering levels."
38. In the SAM, Class II items are general and technical stores, including spare parts. See Canadian Classes of Supply, Annex C.
39. For FS only, as RS remained "fenced in" and therefore accounted for separately, its release characterized as non-routine and the related authority kept at the highest level.
40. In and of itself, determining what a DOS is for a given force element and level of operational intensity can prove a difficult task, one that should factor in heuristics, operator and staff experience, and pre-determined formulas and scales. During the planning for TF LATVIA, "What is a DOS?" led to animated discussions.
41. SACEUR's Strategic Directive for the Implementation and Operation of Enhanced Forward Presence (eFP), 16 December 2016.
42. In the range of 10–30 days for an FP&R minor or major operation.
43. The exact number of DOS is not disclosed, as that is classified information.
44. In the range of 10–30 days for an FP&R minor or major operation.
45. The exact number of DOS is not disclosed, as that is classified information.
46. Unlikely, however, given the nature of RS2.
47. Q_{FE} is used in Equation 1 instead of Q_{MAX} , since Q_{FE} better illustrates what the quantity represents at the strategic level, whereas Q_{MAX} is linked to an operational-level measure. That said, I reiterate that Q_{MAX} and Q_{FE} are the same quantity and have the same value.
48. Some FP&R mission sets, for instance as they relate to domestic operations and reachback capability/capacity, seldom if ever need force employment FS and RS or Q_{FE} ; the latter stocks essentially pertain to contingency operations.
49. Mitigate, accept and/or transfer externally to the CAF.
50. Suggested to be approximately every five years.
51. The MSP and the industrial partners / strategic sources of supply therein enable the Government of Canada (GC) to maintain autonomy with regard to the production of A&E, in order to ensure timely and adequate provisioning of the CAF with ammunition; therefore, the MSP contributes significantly to the sustainment of Canada's defence interests. However, despite the MSP being a success, long procurement lead times are the norm, given procedural (mostly internal to the GC) and industrial constraints.
52. Requirement, Technical, Procurement and Contracting Authorities, the latter authority being Public Services and Procurement Canada for most contracts.
53. Due to the scholarly nature of this article, it falls short of recommending specific actions. That said, the main recommendation emerging from it should be that a Major Crown Project be sponsored by SJS/DGP in order for the stockpiling of A&E to comply with SSE and FP&R, given the strategic replenishment model proposed for FS and RS alike and given the likely complexity, risk and cost of this project, which should include additional HR structure and personnel, warehousing infrastructure and other supporting equipment if necessary. Truly complying with the FP&R will undoubtedly require a significant financial investment beyond the capacity of the current NP *modus operandi*.