National Defence Défense nationale

Canadian Forces College

Collège des Forces Canadiennes

THE CHANGING LANDSCAPE OF OPERATION SUSTAINMENT

Major Douglas McCarthy

JCSP 45

Exercise *Solo Flight*

Disclaimer

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

PCEMI 45

Exercice *Solo Flight*

Avertissement

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

Canada

CANADIAN FORCES COLLEGE – COLLÈGE DES FORCES CANADIENNES

JCSP 45 – PCEMI 45
MAY 2019 – MAI 2019

EXERCISE *SOLO FLIGHT* – EXERCICE *SOLO FLIGHT*

THE CHANGING LANDSCAPE OF OPERATION SUSTAINMENT

Major Douglas McCarthy

Introduction

Militaries around the world historically lead industrial advancement and set the standard for best practices but over the past 30 years the private sector has far outstripped the militaries innovativeness and quickly reversed these roles. The Canadian Armed Forces (CAF) is in a situation where its existing support structures and concepts are quickly becoming marginalized by the speed at which operations are expected to occur. As a result of budget limitations and the cost of modern support technologies, decisions rendered today regarding what future support systems will be pursued, will undoubtedly have effects lasting decades. These effects will directly impact the credibility and operational capability of the CAF as it seeks to deploy domestically and globally.

In order to determine the most effective support infrastructure that will elevate how the CAF conducts support to operations, it first has to decide how its capabilities will be employed throughout the world. Will these deployments be in a contributory role? Will it rely on a high degree of support from allied countries (ie USA)? Or will it look to retain operational independence and to what capacity? Once these questions have been clearly answered by the government and adopted by the CAF, then the problem question of how best to support operations can be answered by looking at the best practices industry has to offer. The days are gone where "doing everything, everywhere" is an option.

This paper aims to discuss the current trends that exist within Supply Chain Management (SCM) and how some of these changes could benefit the CAF and the potential integration into how logistics are executed and how it sustains/supports operations. This will be achieved by looking at the best practices industry has to offer to include cutting edge advancements in Additive Manufacturing (AM) and how it can improve supply chains, Radio

Frequency Identification (RFID) and how it can provide overall improvement in efficiency, Enterprise Resource Planning (ERP) and the adoption of Systems, Application and Products (SAP) interconnected software and finally the proven applications of bar code scanning technology. Any advantages that can be leveraged to reallocate resources in an operationally sound manner, while improving the overall defence support system should be actively pursued.

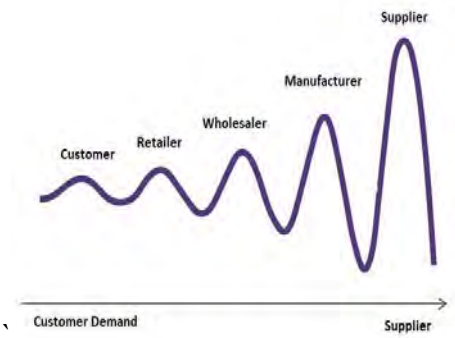
Accountability and Visibility

Accountability and visibility are the critical components of efficient logistical planning. The development of the Just-In-Time (JIT) model of material management was instituted to reduce the large quantities of materials pushed forward in support of operations and to reduce the holding costs associated with maintaining large quantities of stock within warehouses unnecessarily. Material management is more than just having demanded items on-hand, at its core it is about minimizing the overhead necessary to provide the demanded item. Having outdated spare parts and material sitting in the Montreal CAF supply depot is a prime example of inefficiencies in the disposal process. Contributing to these issues are a lack of personnel to preform the task, which could be linked to inefficient and time consuming warehousing practices, and misunderstanding of the cost associate with maintaining stock in a heated facility over the course of its lifecycle and beyond.

Having improved visibility on material in a warehouse allows the entire supply chain to react in an informed manner and reduces fluctuations in the provision of material.[1] The negative effects of an inefficient supply system are well documented causing a "Bullwhip" effect that resonates throughout the entire supply chain.[2] This can be associated with the CAF

[1] Lapide, L., "RFID: What's In It For The Forecaster?". Journal of Business Forecasting, Summer 2004,17.
[2] Supply Chain Management. "Bullwhip in the Supply Chain". Bizskinny, 21 January 2019.

through the lens of a base that has been requested to support an activity, which submits demands higher to address shortfalls that cause greater reactions as you move up the subsequent levels. As the demand triggers additional forecasting at each subsequent level, the magnitude of the forecast increases. Once this demand reaches the strategic level the demands have been amplified dramatically causing reason for concern and demonstrating inefficiency in the provision and management of material.



The **bullwhip effect** is a distribution channel phenomenon in which forecasts yield supply chain inefficiencies. It refers to increasing swings in inventory in response to shifts in customer demand as one moves further up the supply chain.

Supply Chain Management. "Bullwhip in the Supply Chain". Bizskinny, 21 January 2019. https://www.bizskinny.com/Supply-Chain-Management/bullwhip-effect.php

Each of the following areas for consideration will directly speak to the improvement of both accountability and visibility and how the CAF can benefit from leveraging technological improvements to enhance support to operations.

Additive Manufacturing (AM)

It can be said that AM will be the supply chain revolution of tomorrow. AM is defined as a process that creates an object by joining material from the bottom-up, rendering a three dimensional object.[3] Having the capability to produce spare parts and disposable items in location will affect every aspect of the manufacturing industry. Additionally this ability will provide the CAF with distinct advantages when operating in austere and remote

---

https://www.bizskinny.com/Supply-Chain-Management/bullwhip-effect.php

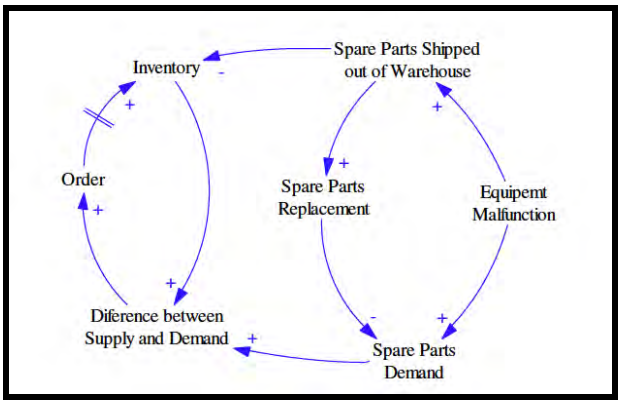
[3] A. Busach, J. Erkoyuncu, P. Colegrove, R. Drake, C. Watts, and S. Wilding. "Additive Manufacturing applications in Defence Support Services: Current Practices and Framework for Implications." *International Journal of System Assurance Engineering and Management, Vol 9, Issue 3*, (June 2018).

locations. Reducing budgetary overhead and employing forces in as lean a logistics posture as possible is the goal of every commander. The vision of the AM process in the context of the military is that it would allow for greater kinetic forces to be projected forward while minimalizing the vulnerability of the support elements.

As the CAF looks to construct multiple Operational Support Hubs (OSH) around the world the question that remains unanswered is what material, if any, is required to be staged out of OSHs for each region? It is obvious that staging equipment in seven locations around the world, capable of supporting every manner of deployment is not feasible or a prudent use of public resources. So how do you decide? The benefits of AM, if used in the context of Canada's recent Mali deployment in support of MINUSMA, could have dramatically reduced the spare parts requirement from 100 Sea Containers (SC) of helicopter parts to a fraction of what was actually deployed. There is of course concerns regarding the safety of the parts used and the process of validating the airworthiness of the components but as technology advances so to will the quality of the products generated. Lending credibility to the AM processing movement, notable companies are investing into AM including; GE, NASA, Lockheed Martin, Boeing and Aurora Flight Sciences (unmanned aerial vehicles).[4]

[4] Timothy A. Moore, Timothy, "Evaluating the Augmentation of Army Resupply with Additive Manufacturing in a Deployed Environment." *North Carolina State University Graduate Thesis*, 2018.

Figure 1.2: Spare parts supply chain casual diagram



Guozhu, Yao Li, Yang Cheng, and Yuchen Hu. " Additive Manufacturing Technology in Spare Parts Supply Chain: A Comparative Study." International Journal of Production Research, (2016).

Currently the CAF makes every effort to leverage a Just-In-Time (JIT) delivery model. However in the CAF context, this model is only applied in any degree of success when viewed through the lens of contracting services and consumables. When applied to the provision of spare parts and materiel, the model very much resembles traditional warehousing models dating back almost 70 years where materiel is stored in large warehouses for forecasted/potential future use. The overall goal of the JIT model is to reduce levels held within warehouses, but assumes increased risk as warehouses become operationally strained.[5] AM technology addresses these concerns and shifts the model to a JIT manufacturing model. This shift creates a leaner supply chain with lower costs and increased responsiveness.[6] Strategic Lines of Communications (SLOC) can now be established to provide material support in a more efficient and cost effective manner. The basic premise of AM is that you can produce a large quantity of required items in situ rather than shipping via costly air, slow

[5] Sellitto, C., S. Burgess, and P. Hawking. "Information quality attributes associated with RFID: Derived Benefits in the Retail Supply Chain". International Journal of Retail & Distribution Management, Vol 35, No. 1, 2007, 73.

[6] Timothy A. Moore, Timothy, "Evaluating the Augmentation of Army Resupply with Additive Manufacturing in a Deployed Environment." *North Carolina State University Graduate Thesis*, 2018.

moving sea lanes or massing large amounts of material projected to satisfy future demands. Once a blueprint has been developed for a particular item and the processing capability is moved into a support area, the ability to reproduce the item can be matched with the demand without maintaining large warehouse stocking levels, making the support organization more agile and responsive. Militaries who take measures today to position themselves as future users will possess a tactical advantage in the global battle spaces of tomorrow.

Radio Frequency Identification (RFID)

RFID technology has transformed industry and provided the accuracy and asset visibility required to reduce unnecessary warehousing and improve the efficiency of entire supply chains.[7] Inventory management plays a critical role in minimizing the operating cost of materiel management while maintaining the appropriate maximum and minimum stock levels within warehouses. RFID is a wireless automated system that allows the user to tag materiel and record its movement and stocking levels.[8] The benefits to implementation of this technology are that over 50-80% of logistics operating costs are sunk into labor costs which can be reduced by almost 36% for order picking and 90% for verification of stock.[9] In the case of the CAF these costs are likely higher as a result of not harnessing other industry adopted technologies similar to barcode scanning technology and forcing the CAF to rely on manual counting and verification processes that are labor intensive.

In the context of a deployed support construct, asset visibility can be monitored globally in real-time through the Global Positioning System (GPS) or internally within a warehouse and can provide decision-makers clarity on where support capabilities reside and

---

[7] Langer, N., Chris Forman, and S. Kekre. " Assessing the Impact of RFID on Return Centre Logistics". Interfaces Vol 37, No. 6, Nov-Dec 2007, 501.
[8] Lapide, L., "RFID: What's In It For The Forecaster?". Journal of Business Forecasting, Summer 2004.16.
[9] A. Ozdemir, M. Bayrak, & K. Kuvvetleri. "Assessment of RFID Investment in the Military Logistics Systems through the Life Cycle Cost Model". Journal of Military and Information Science, Vol 3 No. 4, 2015, 92.

where they should be moved for better support. The CAF is notoriously risk adverse when considering its logistics and routinely ships material forward with minimal logistical planning regarding requirement to mitigate risk. A clear example of poor materiel management can be seen with the placement of arctic toboggan groups in the Kandahar valley, which remained in country for the duration of the mission in Afghanistan. Providing further clarity of a need to increase material accuracy and visibility. An additional example of similar challenges faced by other militaries can be drawn from the following quote:

> The United States Air Force (USAF) General (ret.) Walter Kross, Director of Ops & Logistics of the U.S. Transportation Command during the first Gulf War, stated that: "*During the Gulf War, we simply did not have good information on anything. We did not have good tracking; we had no real asset visibility. Materiel would enter the logistics pipeline based on murky requirements, and then it could not really be tracked in the system.... We lacked the necessary priority flows to understand where and when things were moving. It was all done on the fly, on a daily basis... It truly was brute force. Generally speaking, if front-line commanders weren't sure of what they had or when it would get there, they ordered more...The result was the oft-referenced iron mountains of shipping containers. We had too much, and, worse yet, we did not know what was where.*"[10]

Accountability of materiel can be seen as a force multiplier when considering the assets taken out of battle to transport unnecessary material forward as a result of loss of visibility. A significant benefit of RFID implementation is the removal of human interaction into the support chain.[11] RFID identifies when the correct number of items have arrived and automatically adjusts stock levels accordingly. In the case of the CAF, this would allow for greater accountability of material and reduce the levels required to augment potential risk of shortages.

---

[10] A. Ozdemir, M. Bayrak, & K. Kuvvetleri. "Assessment of RFID Investment in the Military Logistics Systems through the Life Cycle Cost Model". Journal of Military and Information Science, Vol 3 No. 4, 2015, 89.
[11] Langer, N., Chris Forman, and S. Kekre. " Assessing the Impact of RFID on Return Centre Logistics". Interfaces Vol 37, No. 6, Nov-Dec 2007, 506.

These improvements are attained through a reduction in personnel, which can be reassigned to other MOSIDs, reallocated elsewhere in the supply chain or employed in other capacities. Deployed operations would be able to provide real-time data to commanders on the ground as well as allow for big data analytics to be transmitted higher for strategic level decisions. These benefits would be achieved while reducing the strain on the support system and when combined with other industry best practices the results can be profound.

Barcode Scanning Technology

Barcode scanning technology has been accepted by private industry as the cost effective replacement for RFID technology. Capable of producing inexpensive barcodes that can be printed at a moments notice and even read when they are damaged, barcode technology generates one error in every million characters.[12] Compared to the current CAF model utilizing manual transactions, which are time consuming, labour intensive and prone to human errors with more than one error for every 300 characters.[13] Under the current CAF system, Supply technicians are required to complete up to 34 steps to properly receipt and warehouse an item once it arrives at a particular location vice simply scanning the item, scanning the location where it will reside and then uploading the data into the system of record.

The benefits besides time savings and reduction of human error is that it provides a clear picture of what is in a particular warehouse and what is not.[14] "Barcode scanning technology helps material managers identify products that have low inventories and thus

[12] McCathie, L., and K. Micheal. "Is This The End of Barcodes in Supply Chain Management?" University of Wollongong Australia, Faculty of Infomatics, 2005, 4.
[13] Ibid, 5.
[14] Ibid, 9.

allows them to update inventory levels and replenish these products".[15] Inaccurate stock levels within the CAF as a result of human error, plague logistical support to activities and generate a climate of uncertainty, risk aversion and over compensation. Common issues such as over stocking a warehouse, duplicating orders and inaccurate stock levels create systemic problems that are costly, inefficient and time consuming. These issues may lay dormant and unchecked over a period if years until properly investigated giving a false periodic perception of accuracy.

Understanding the importance and benefits of accepting this technology has not been overlooked by the CAF. With limited capability, 3 Canadian Support Unit (CSU) is the sole unit that possesses this capability in a deployed setting and is able to leverage barcode scanning to conduct theatre activation, verifications and theatre closures. Considering the time saving benefits of the technology, the need to accurately maintain positive control over material in an operational theatre and its relative low cost when considering future benefits and comparison to other similar technologies, it is questionable why this widely accepted, commercially available, technology hasn't been further integrated. The CAF logistics branch has been attempting to integrate a wireless barcode scanning system into its support infrastructure for over 15 years. Obstacles to it implementation has included control and vulnerability of wireless networks, infrastructure upgrade costs, and overall support of the organization. The concerns regarding the transmission of a wireless signal that could be intercepted by adversarial information operations but this technology can also be utilized in the form of a docking station where the wireless option is not used.

---

[15] A. Ozdemir, Mustafa Bayrak, and K. Kuvvetleri. "Assessment of RFID Investment in the Military Logistics Systems through the Life Cycle Cost Model". Journal of Military and Information Science, Vol 3 No. 4, 2015, 88.

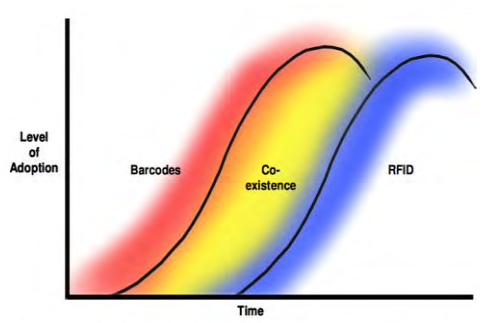


Figure 4. The Barcode and RFID Adoption Lifecycles

General integration process regarding implementation of improved material management technologies. Barcoding to RFID and the transition. The diagram clearly indicates that the introduction Barcode technology is the first of a three phase process to improve asset visibility.

Huber, Nicholas, Katina Michael, and Luke McCathie. "Barriers to RFID adoption in the supply chain." In *2007 1st Annual RFID Eurasia*, pp. 1-6. IEEE, 2007.

Enterprise Resource Planning (ERP) &

Systems, Application and Products (SAP) Based Software

In the wake of globalization, the ability for systems of record to interface on one-platform and leverage efficiencies provides a more responsive and lean material management system.[16] ERP was derived from the desire to have all systems of record operating on the same platform to enable users to have access to the same real-time information across the spectrum of operations. Forcht states, "*ERP allows an organization to gain competitive advantage by saving resources and responding to changing environments*".[17] With the introduction of DRMIS and the Guardian system within the CAF these systems are milestone advancements to sound and efficient management if information. CAF is in the process of moving the majority of its systems into the SAP based software systems to provide an all-encompassing system of record that spans the spectrum of management. This spectrum includes, personnel administration, medical care file management, maintenance, and of course transportation and supply. It must be noted that 50% of all ERP implementations fail as a

[16] Karen Forcht, Kiescnick, A. Albridge and J. Shorter. "Implementing Enterprise Resource Planning (ERP) for Strategic Competitive Advantage." *Journal of Issues in Information Systems* 8, no. 2 (2007): 425.
[17] Karen Forcht, Kiescnick, A. Albridge and J. Shorter. "Implementing Enterprise Resource Planning (ERP) for Strategic Competitive Advantage." *Journal of Issues in Information Systems* 8, no. 2 (2007): 425.

result of the organization being unable or unwilling to adopt the new operating procedures and certainly the CAF are no exceptions.[18]

ERP systems allow for greater information management within an organization and combining this capability with the new Defence Analytics Program will provide greater decision-making power. It is critical however to understand where and how the information is generated. Taking into consideration the value of the improvements above, procurement decisions rendered at higher levels may be ill informed as a result of inefficient processing, resulting in over-purchasing due to poor asset visibility. ERP is the foundation to which efficiency can be built upon within the logistics branch.

The implementation of an ERP system is a large step in the right direction however strong consideration needs to be made regarding why the decisions were made to move into this direction. ERP implementation is a knowledge-intensive process and the fate of the project generally resides in the hands of a group of knowledgeable employees and management's ability to move information into and through this small group.[19] In the case of the CAF the decision to develop DRMIS and move into a SAP based program, was made as a result of the Material Inventory Management System (MIMS) was no longer supported or being upgraded. Essentially the decision to change systems was forced upon the CAF rather than a decision chosen out of a desire to improve. This is important from an organizational perspective and its lead in to adopting a new comprehensive system of record and how the organizational users perceive the change.

---

[18] Ibid, 428.
[19] Vandaie, R. "Knowledge Based Systems: The Role of Organizational Knowledge Management in successful ERP Implementation Projects." Elsevier, DeGroote School of Business, 2006.

Chandana. "Enterprise Resource Planning and ERP Systems" SimpliLearn, 10 December 2015.

https://www.simplilearn.com/erp-planning-and-erp-systems-rar102-article

Counter-argument (236)

With all new developing technologies there is an inherent gamble when choosing which one best suits your needs and which technology will become an industry standard and allow maximum benefit from the system selected. The most obvious downside to upgrading and selecting/enhancing logistical capabilities to support tomorrows CAF is cost. Technologies like RFID inventory management systems carry significant initial investment that in some cases could be prohibitive.[20] Viable alternatives to RFID selection would be the barcode scanning technology but given that this technology has been widely adopted by the industry, has the opportunity to gain maximum benefit already been lost?

Aside from the obvious restrictions of trying to do more with less in a restrictive budgetary climate, the periphery costs relate to the retraining of your users. Militaries today cannot afford to retrain their staff at the same rate of technological advancements. As seen with the implementation of the SAP based project, involving many of CAFs software systems, there are periods of inefficiency while competence adapts. The adaption period depends on the user base and their desire, and ability to embrace the new technology.

---

[20] Langer, N., Chris Forman, and S. Kekre. " Assessing the Impact of RFID on Return Centre Logistics". Interfaces Vol 37, No. 6, Nov-Dec 2007, 501.

Finally, given the financial commitment required to make a fundamental improvement to support systems the projects for development and implementation take years to acquire approval and construct and again years to implement the training and execution. By the end of the cycle the technology has already lost a large portion total life cycle of the program. The project cycle, when dealing with technologies, needs to assume increased risk to permit greater yield from the product before it becomes obsolete.

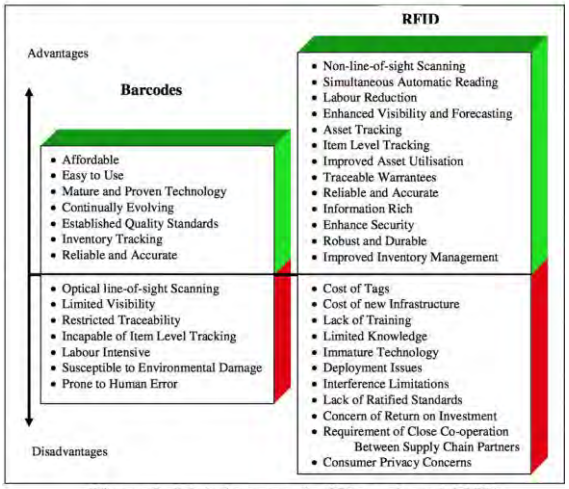


Figure 3. Dis(advantages) of Barcode and RFID

Advantages and disadvantages of RFID and Barcode technologies.

Huber, Nicholas, Katina Michael, and Luke McCathie. "Barriers to RFID adoption in the supply chain." In *2007 1st Annual RFID Eurasia*, pp. 1-6. IEEE, 2007.

Conclusion (270)

Developing a capability that is robust enough to operate in both static and remote austere environments, capable of providing institutional level support while generating the necessary analytics to make strategic decisions is no small task. Combine this requirement in a period of time where technology is changing at a rate that has never been seen before in history and you quickly understand the daunting task the Canadian Armed Forces are facing to adopt large Supply Chain Management (SCM) upgrades. Understanding that the decisions made for improvement impact not only over 80% of all Federal materiel holdings but the deployment capability of Canada's military and it quickly demonstrates the scope and scale of the issue at hand.

As the CAF looks to the future it is critical that a holistic approach be taken of the entire supply chain and how Canada intends to deploy its forces around the world. As a major consumer, material manager and employer, it is paramount that large-scale leading edge technology be reviewed and considered for implementation. Too often operators overlook the importance and the complexity of regulating and managing the CAF sustainment requirements. Software improvements such as DRMIS has only marginally improved the system

CAFs ability to manage resources has continually been under scrutiny by the Federal Government. As identified by the Auditor General "National Defence did not adequately manage the resources used to support military equipment in a cost-effective manner, to meet operational and training requirements."[21] These findings can be directly tied to the challenges that are inherent within the existing supply system and its struggle to meet the operational demands of the military.

[21] Kevin Sorenson, " Report 7, Operating and Maintenance Support for Military Equipment – National Defence, of the Fall 2016 Reports of the Auditor General of Canada." *Canada, House of Commons*, (June 2017). http://publications.gc.ca/collections/collection_2017/parl/xc16-1/XC16-1-1-421-29-eng.pdf

BIBLIOGRAPHY

Additive Manufacturing

Busachi, A., J. Erkoyuncu, P. Colegrove, R. Drake, C. Watts, and S. Wilding. "Additive Manufacturing applications in Defence Support Services: Current Practices and Framework for Implications." *International Journal of System Assurance Engineering and Management, Vol 9, Issue 3*, June 2018.

Moore, Timothy A. "Evaluating the Augmentation of Army Resupply with Additive Manufacturing in a Deployed Environment." *North Carolina State University Graduate Thesis*, 2018.

Crean, Ryan. "Benchmarking DoD Use of Additive Manufacturing and Quantifying Costs." *Air Force Institute of Technology AFIT Scholar*, 2017.

Sorenson, Kevin. " Report 7, Operating and Maintenance Support for Military Equipment – National Defence, of the Fall 2016 Reports of the Auditor General of Canada." *Canada, House of Commons*, June 2017. http://publications.gc.ca/collections/collection_2017/parl/xc16-1/XC16-1-1-421-29-eng.pdf

Birtchnell Thomas, and John Urry. "A new Industrial Future?: 3D Printing and the Reconfiguring of Production, Distribution, and Consumption." *Routledge,* 2016.

Knofius, N., M.C. van der Heijden, and W.H.M. Zijm. "Selecting parts for Additive Manufacturing in Service Logistics. (working paper)." *University of Twente*, September 2016.

Guozhu, Yao Li, Yang Cheng, and Yuchen Hu. " Additive Manufacturing Technology in Spare Parts Supply Chain: A Comparative Study." *International Journal of Production Research*, 2016.

Bogers, M., Hadar, R., and Billberg, A. "Additive Manufacturing for Consumer-centric business Models: Implications for Supply Chains in the Consumer Goods Market." *Technological Forecasting and Social Change*, 225-239.

Thomas, David S., and Stanley W. Gilbert. "Costs and Cost Effectiveness of Additive Manufacturing." *Department of Commerce,* Dec 2014.

Maj Brock A Zimmerman, and CPT Ellis E. Allen III. "Analysis of the Potential Impact of Additive Manufacturing on Army Logistics." *Calhoun NPS Institutional Archive*, 2013.

Dr Hartmut Stahl. "3D Printing – Risks and Opportunities." *Oko-Institut e.V.*, December 2013.

Col J. Drushal. "Additive Manufacturing: Implications to the Army Organic Industrial Base in 2030." *United States War College*, 2013.

McNultry, Connor M., Neyla Arnas, and Thomas A. Campbell. “Toward the Printed World: Additive Manufacturing and Implications for National Securtiy.” *Defense Horizons*, Journal No. 73, 2012.

Cazmei, Catalina, and Florentin Caloian. “Additive Manufacturing flickering at the Beginning of Existance.” *Procedia: Economics and Finance: Elsevier Ltd*, 2012.

Erkoyuncu, J.A., R. Roy, E. Shehab, and P. Wardle. “Uncertainty challenges in service cost estimation for product-service systems in the aerospace and defence industries”*Cransfield University*. 2009.

Stock Levels and Supply Chain Management Performance

Singh, Rakesh, and Vaidy Jayraman. “Supply Chain Integration and Information Technology.” *International Journal of Economics Business and Management Studies*, Vol 2, No. 2, May 2013, 62-74.

Interconnected Software (SAP) & Enterprise Resource Planning (ERP)

Kumar Sameer, “Connective Technologies in the Supply Chain” *Auerbach Publications Taylor and Francis Group*, 2007.

Apiyo, Rosemary and Dr David Kiarie. “Role of Information Communication Technology in Supply Chain Performance.” *International Journal of Supply Chain Management*,Vol 3, Issue 1, No 2, 2018, 17-26.

Ibach, Peter, Vladimir Stantchev, Florian Lederer, Andreas Weiß, Thomas Herbst, and Torsten Kunze. "WLAN-based asset tracking for warehouse management." In *IADIS International Conference e-Commerce, Porto, Portugal*, pp. 15-17. 2005.

Fosser, E, Henrik Leister, C. Moe, and M. Newman. “Organizations and Vanilla Software: What do we know about ERP systems and Competitive Advantage?” In *ECIS*, pp. 2460-2471. 2008.

Johansson, B, Mike Newman. “Competitive Advantage in the ERP Systems value Chain and its influence on Future Development.” ECIS pp 1-15, 2009.

Forcht, K, E. Kiescnick, A. Albridge and J. Shorter. “Implementing Enterprise Resource Planning (ERP) for Strategic Competitive Advantage.” *Journal of Issues in Information Systems* 8, no. 2 (2007): 425-429.

Vandaie, R. “Knowledge Based Systems: The Role of Organizational Knowledge Management in successful ERP Implementation Projects.” Elsevier, DeGroote School of Business, 2006.

Kull, T, S. Chae and T. Choi. “The Future of Supply Chain Management”. 24 April 2017. https://www.supplychain247.com/article/the_future_of_supply_chain_management

Ostdick, N. “5 Important Supply Chain Advancements in the Last Decade.” 9 May 2017. https://blog.flexis.com/5-important-supply-chain-advancements-in-the-last-decade

Chandana. “Enterprise Resource Planning and ERP Systems” SimpliLearn, 10 December 2015. https://www.simplilearn.com/erp-planning-and-erp-systems-rar102-article

Barcoding and Scanning Technology

McCathie, L., and K. Micheal. “Is This The End of Barcodes in Supply Chain Management?” University of Wollongong Australia, Faculty of Infomatics, 2005.

Radio Frequency Identification (RFID)

Karkkainen, Mikko. “Increasing Efficiency in the Supply Chain for Short Shelf Life Goods using RFID Tagging”. International Journal of Retail & Distribution Management, Vol 31 No.10, 2003, 529-536.

Ozdemir, A., Mustafa Bayrak, and K. Kuvvetleri. “Assessment of RFID Investment in the Military Logistics Systems through the Life Cycle Cost Model”. Journal of Military and Information Science, Vol 3 No. 4, 2015, 88-102.

Lapide, L., “RFID: What’s In It For The Forecaster?”. Journal of Business Forecasting, Summer 2004.16-19.

Langer, N., Chris Forman, and S. Kekre. “ Assessing the Impact of RFID on Return Centre Logistics”. Interfaces Vol 37, No. 6, Nov-Dec 2007, 501-514.

Dr. S. Abdul Rehman Khan, D. Qianli, and Y. Zhang. “ Usage of RFID Technology in Supply Chain: Benefits and Challenges”. International Journal of Applied Engineering Research, Vol 11 No. 5, 2016, 3720-3727.

Dr. R. Wilding and T. Delgado. “RFID: Applications within the Supply Chain”. Supply Chain Practice Vol 6 No. 2, 2004, 30-43.

Sellitto, C., S. Burgess, and P. Hawking. “Information quality attributes associated with RFID: Derived Benefits in the Retail Supply Chain”. International Journal of Retail & Distribution Management, Vol 35, No. 1, 2007, 69-87.

Huber, Nicholas, Katina Michael, and Luke McCathie. "Barriers to RFID adoption in the supply chain." In *2007 1st Annual RFID Eurasia*, pp. 1-6. IEEE, 2007