# Can airdrop be utilized as a means of promoting zero-footprint logistics for the resupply of the Canadian Forces?

by

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**Abstract**

This thesis examines the suitability of airdrop as a means of resupply for the Canadian Forces (CF) in an attempt to reduce forward supply inventories and promote "zero-footprint" logistics. Research methods involved both quantitative and qualitative techniques, consulting CF manuals and subject matter experts. Based on performance, airdrop staged from rear locations or outside the theatre of operations can meet resupply requirements. Although airdrop has longer assembly and loading times than ground based delivery, flight speed and direct routes can make up the difference. However based on interviews with CF personnel, it appears that due to limited availability of aircraft, drop zone requirements, delivery vehicle vulnerability, and the need for backhaul logistics, airdrop could not be used as a sole means of resupply.

**Acknowledgments**

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**Establishing Research Problem**

In developing a research problem for his MSc thesis, the researcher contacted Canadian Operational Support Command (replaced by Canadian Joint Operations Command) and applied for a research topic. His application reached the Canadian Forces Aerospace Warfare Centre (CFAWC), where it was suggested that he examine the topic of "Zero-Footprint Logistics".

**Zero-Footprint Logistics**

The term "zero-footprint logistics" may suggest an environmental theme, based on topics such as "carbon footprint", "zero emission", etc. In explaining the concept of Zero-Footprint Logistics to the researcher, the question was posed, *"What are the technological, human, informatics and other elements that would need to come together or be developed to enable a sizeable land force to be deployed and sustained in mobile operations without a logistics base on the ground in the area of operations?"*

Although environmental subject areas (carbon footprint, emissions, etc.) have applications towards "zero-footprint" logistics, i.e. reducing the Canadian Forces (CF) physical presence, "zero-footprint" is more closely related to "focused logistics", "agile logistics", "reduced footprint", and "adequate footprint". These terms have been used to describe the move towards reducing the inventories and supply footprints of operational units. Similar movements were implemented in the commercial logistics sector with the development of concepts such as "lean" logistics and "just-in-time" (JIT). As there is no formal definition of "zero-footprint" logistics, a working definition was developed for the purpose of this research.

Zero-Footprint Logistics: *The ability to maintain adequate supply without a fixed (permanent/semi-permanent) warehouse or depot in the forward area of operations."*

The removal of logistics bases/depots from the forward area of operations raises many of the benefits proponents of lean logistics raise in describing minimal inventories, such as reducing:

- The capital cost(s) of the inventory
- The storage cost(s) of the inventory
- Management, handling and tracking challenges

Military based logistics offer additional arguments for a minimal inventory model. A report produced by the Rand Arroyo Center, examining the U.S. Army Velocity Management System, raised additional considerations and limitations regarding a "mass" based supply system versus an agile "velocity" based system (Dumond, 2001, p.2):

- Establishing forward inventories consumes transportation resources
- Large inventories limit speed and mobility of operational forces
- Large stockpiles in fixed locations provide attractive targets to enemy forces

In addition to these considerations,

- Unused equipment and inventory creates a backhaul requirement for forces leaving an area of operations

General Nathaniel Green, quartermaster of the American Revolutionary Army, has been widely credited with the following observation: "Logistics is the stuff that if you don't have enough of, the war will not be won as soon as". Countless examples of armies running out of supplies can be found through history. Although forward inventories can consume resources and create logistical challenges, there is no comparison to the risk of stock outs.

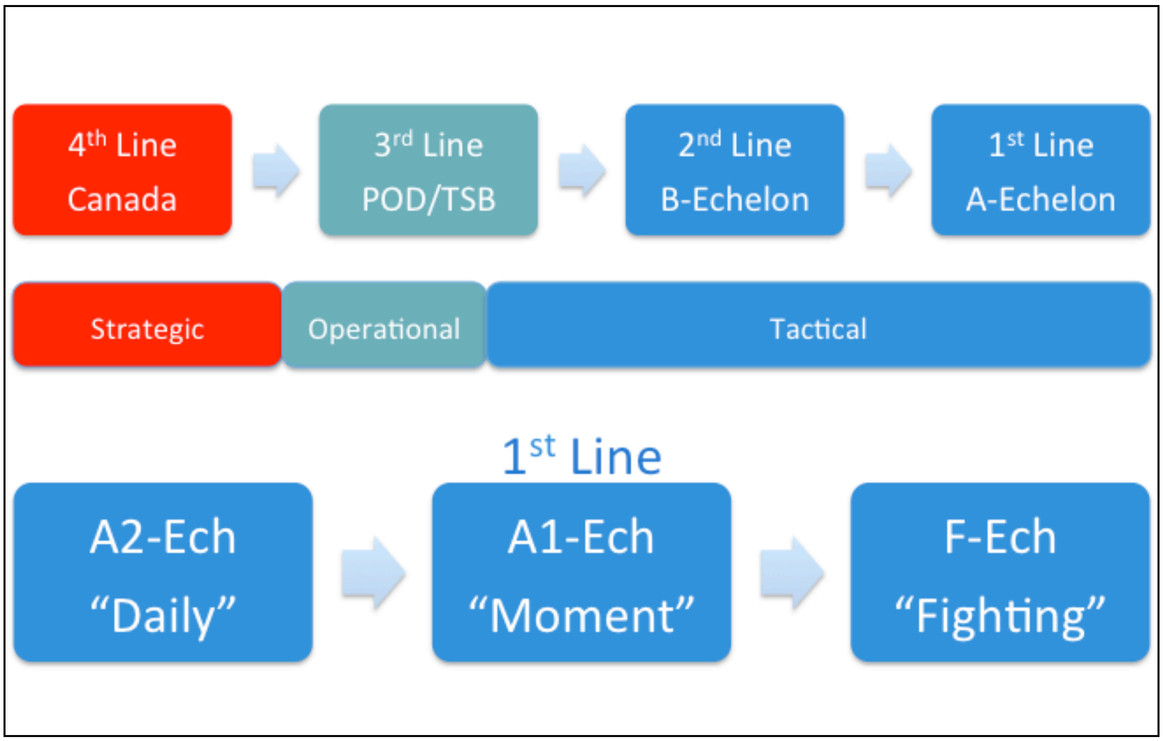
**Canadian Forces Logistics and Supply**

Doctrinally, the supply and sustainment of the Canadian Forces is distributed through an "Echelon" based system carried out over four "lines". The supply chain for the military originates at the "strategic" level located at the "4th Line" in Canada. From here, equipment, supplies, and personnel are moved through the supply chain. From Canada the supply chain moves to the "3rd Line", generally defined as either the "Port of Disembarkation" (POD) or "Theatre Support Base" (TSB). The 3rd Line focuses on "operational" level sustainment. The operational level begins at the POD and extends to the rear boundary of the brigade group, thus serving as a bridge between the strategic and tactical levels (Canada, 1999).

The "2nd Line" is found at the Brigade Administration Area (or Brigade Support Area). This area serves as headquarters and administration, and houses the "B-Echelon," which provides routine support and services that are not required during combat (Canada, 1999, p.26).

The final level is the "1st Line," which provides support to the "F" (Fighting) Echelon. This sustainment is carried out by the "A-Echelon" which is split into an A1 and an A2 Echelon. The A1 Echelon is used to directly resupply the immediate "minute to minute" needs of the F-Echelon. In order to "push" critical items (e.g. fuel, ammunition, etc.), the A1 is generally located relatively close to the F-Echelon. The A2 Echelon is used to reinforce the A1 and also resupply the daily sustainment demands of the F-Echelon (Canada, 1999, p.26). In general, 72 hours of combat supplies are kept in the 1st Line, with approximately 24 hours of supplies distributed between the F, A1, and A2 Echelons. The echelon system is designed for both "push" and "pull" replenishment, with high demand and frequently used items (e.g. fuel, food/water, ammunition, etc.) being prepared and automatically "pushed" to units, while other items can be "pulled" from supply by unit request (Canada, 1999 p. 31). The system is meant to be responsive between the lines and echelons. If supply demands cannot be met, requests will go through the system and supplies (if possible) will be moved forward. This system is designed to accommodate the Army's doctrine of "maneuver warfare" and promote speed and flexibility, while providing unit self-sufficiency.

**Figure 1: Canadian Forces Echelon System**




The Echelon system was developed during the Cold War when it was believed that the conflicts where Canada would operate would involve the Soviet Union on a linear battlefield with distinct zones and lines. Circumstances in Afghanistan required the Canadian military to modify and adapt the echelon system for their operations. The 3rd Line, TSB was based out of Camp Mirage (until 2010) and provided an air-bridge to Afghanistan. The 2nd Line Brigade Administration Area was designated the "National

Support Element" (NSE), based at Kandahar Air Field (KAF). In his memoir, "What the Thunder Said", Lt-Col John Conrad outlined the development of the NSE (Conrad, 2009). In establishing the personnel requirements for operations in Kandahar, Conrad consulted the "Army Managed Readiness Model" which outlines the support structure needs of Canadian military operations. Although initial modeling recommended a support system of 283 soldiers, the operational theatre and number of personnel required began to increase (Task Force Orion grew from an initial estimate of nearly 700 to 1,500 personnel). Despite this increase, the NSE was capped at 300 personnel (Conrad, 2009).

KAF and NSE served multiple supply and support functions. Due to short delivery distances, some A2 were based at KAF. Alternatively, some A2 were removed from the supply system and the NSE provided direct delivery to the A1. In contrast to the mobility provided by manoeuver warfare, static positions such as forward operating bases (FOB) and combat outposts (COP) were established. These locations served as supply depots and A1 echelons. To supply these locations, Canada developed "Combat Logistics Patrols", using delivery vehicles that were escorted by a force protection group.
As one CF driver described resupplying though the "non-contiguous" or "non-linear" battle-space in Afghanistan, "There's no such thing as a front line here. There's no such thing as a rear area either. It's dramatically changed the way we do business. Out here, pretty much everybody is a solider first" (Peebles, 2006) .

**Moving Towards Zero Footprint**

The development of a zero footprint can take many forms. It might involve reducing the supply demand by improving system efficiencies (e.g. fuel efficient systems, alternative energy forms, etc.) or adopting alternative scheduling/ordering systems. With the idea of removing the logistics base from the area of operations, the researcher thought of the "hub and spoke" model used for routing. In this model, the "hub" represents a central "node" and the "spokes" represent routes. By using multiple "hubs", cargo/passengers can reach destinations that are not directly connected. In this case, one of the "nodes" would be removed, resulting in more "spokes" that would be longer in length. In order to compensate for the longer distances, either longer lead times would need to be built into the resupply system or faster delivery methods would be required. Based on this reasoning, a general search into military logistics and delivery literature was conducted. An article written by Peterman, Narowski, Litynski, and Clouse in *Infantry Magazine* (Sept-Oct 2007) entitled "An Innovative Approach to Combat Logistics", which outlined the development of the Low Cost, Low Altitude (LCLA) aerial delivery system and its use in Afghanistan, was discovered. This introduced the researcher to the use of airdrop as a means of resupply.

**Airdrop**

The first air supply operation was conducted in April 1916 by the RAF, during the British Defence of Kut Al Amara (Iraq) during World War I. During a two-week operation, 30 Squadron, flying BE2, MF.11, and MF.7, delivered 13 tons of food and ammunition. (Despite these efforts, the British surrendered the garrison to the Ottoman Army) (Royal Air Force, 2013).

Although airdrop was employed as a method of resupply during World War II and the Korean War, its application during two separate conflicts in Vietnam serve as the primary case studies regarding the use of aerial delivery as a primary means of resupply.

Dien Bien Phu

The Battle of Dien Bien Phu was fought March-May 1954, during the First Indochina War between the French Military and Vietminh communist forces. Although several strategic errors led to the defeat of the French forces, one of the major issues was the dependence on aerial resupply. In an attempt to mount offensive operations to improve the position of France in an effort to negotiate for peace, the hamlet of Dien Bien Phu (already equipped with a landing strip) was selected to serve as a forward operating base. Dien Bien Phu was located in a valley, approximately 200 miles by air from the French supply base in Hanoi and 300 miles by a mountainous road controlled by the Vietminh (Miser, 2001). In November 1953, a French airborne force (that eventually amounted to over 16,000 soldiers) parachuted into Dien Bien Phu and began establishing the airhead (Operation Castor) (Ireland, 2006). The logistics deficit was visible during the fortification of Dien Bien Phu as only 3,300 of the required 36,000 tons of needed construction materials arrived at the base (approximately 2,200 tons of materials were locally "sourced" from the village and surrounding jungle, leaving a shortage of 33,800 tons) (Miser, 2001). The minimum daily supply requirements of Dien Bien Phu totaled 200 tons (Miser, 2001). Airlift was carried out by 100 C-47 and 20 C-119 aircraft, though maintenance issues limited the number of available aircraft to 100 (Miser, 2001). Unlike the C-119 "Flying Boxcar", the C-47 Skytrain, a World War II era (considered dated by 1954) cargo plane, did not possess a rear tailgate, limiting load size to that of the side door and slowing unloading operations on the ground (Thompson, 1991). Based on the fleet of available aircraft, the daily resupply averaged 123 tons (100 tons of which were useable due to damage). During this period, French forces were losing ground to the Vietminh, who began to establish artillery positions in the hills surrounding Dien Bien

Phu (Tokar, 1998). On March 13 (1954) the Vietminh attacked the camp, damaging the airstrip and destroying the control tower and directional beacon (in addition to 14 aircraft and 2 helicopters) (Ireland, 2006). Several days later (March 17), the dirt airstrip was rendered completely inoperable by monsoon rains (Ireland, 2006). The resupply of Dien Bien Phu was now limited to airdrop (versus aircraft landing and offloading, "air-land"). Vietminh anti-aircraft artillery (AAA) greatly reduced the accuracy of the airdrops as aircrews (ordinarily dropping from 500-1000 ft.) began flying higher to avoid ground fire (increasing 2,500-8,500 ft.) (Thompson, 1991). This, coupled with declining number of available drop zones (DZ) due to approaching Vietminh forces, created significant supply shortages for French forces. In addition to the shortages the French experienced, the Vietminh were able to recover wayward supplies, including thousands of pounds of rounds that matched the size of Vietminh artillery (Ireland, 2006). Attacks on French air bases (resulting in the damage and destruction of 78 aircraft) and poor weather (fog, heavy rain, low ceilings) further limited the aerial resupply efforts of Dien Bien Phu (Ireland, 2006). On May 7, following a 56-day siege, the French surrendered to the Vietminh.

Khe Sanh

Fourteen years following the French defeat at Dien Bien Phu (1968), 6,000 American (USMC) and ARVN forces faced 40,000 NVA troops during a siege lasting 77-days at the Khe Sanh Combat Base (Thompson, 1991). Much like Dien Bien Phu, Khe Sanh was an isolated base/airstrip, located on a plateau surrounded by higher terrain and peaks (Tokar, 1998). This is where the similarities end. Although Khe Sanh relied on aerial resupply, it was located next to a surfaced highway (Route 9), which permitted access to a supply network (though this route was vulnerable to attack) (Tokar, 1998). Although "isolated" Khe Sanh could receive field artillery support from Camp Carroll, a U.S. Army firebase located 20 kilometers away (Ireland, 2006). In addition, Khe Sanh received considerable close air support (fighter, attack, and bomber) from air-wings based in Vietnam and Thailand, which reduced the AAA threat American aircrews faced (which had hindered French resupply efforts at Dien Bien Phu) (Ireland, 2006).

During the initial assault of Khe Sanh (January 21, 1968), NVA artillery damaged the runway and destroyed 98% of the ammunition stored at the base (Ireland, 2006). Within a day, Navy construction crews (Seabees) had repaired the runway to allow the operation of USAF C-123 aircraft, which resupplied 130 tons of ammunition through 26 deliveries (Ireland, 2006).

Although further repairs to the runway allowed for the use of C-130 aircraft to land and off-load, the destruction of an aircraft on the ground by enemy fire resulted in the adoption of 2 "rapid extraction" techniques, *Low Altitude Parachute Extraction System* (LAPES)[1,2] and *Ground Proximity Extraction System* (GPES)[3 4] by C-130 crews, in addition to landing and off-loading (Air-Land) C-7A, C-123, and helicopters(Ireland, 2006) Due to weather challenges (monsoon, reduced visibility, low cloud), which limited the use of LAPES and GPES, the majority of C-130 deliveries were carried out using airdrop (Thompson, 1991). The accuracy in the airdrops (compared to those of Dien Bien Phu) was due in part to improvements in technique and several navigational aids,

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[1] During delivery, cargo pallets are pulled from low flying aircraft by drogue parachutes.
[2] The RCAF discontinued LAPES following a training accident that destroyed a CC-130 and killed several aircrew.
[3] Cargo pallets are fitted with hooks and arresting cables are strung across the runway. Aircrews attempt to "catch" the hooks on the wire, much like the arrested landings used by naval aircraft.
[4] Later due to delivery hazards and equipment requirements, GPES was discontinued in favour of LAPES (Johnson, 1990).

including ground radar, Doppler, and a Marine Air Traffic Control Unit stationed at Khe Sanh (Thompson, 1991; Tokar, 1998).

During the siege, approximately 12,430 tons of supplies were delivered by the USAF, of which approximately 8,120 tons (65%) were delivered via LAPES (52 deliveries), GPES (15 deliveries), and conventional Container Delivery System (CDS) airdrop (601 deliveries) (Tokar, 1998). During this period, daily deliveries ranged between 250-350 tons, exceeding the (approximate) 235 tons needed daily to sustain Khe Sanh (Miser, 2001).

Case Comparison

Although Dien Bien Phu and Khe Sahn were similar with regard to terrain and the need for aerial resupply, the two serve as very different cases. Historians and military scholars generally attribute the failure of the French (Dien Bien Phu) and the success of the Americans (Khe Sahn) primarily to the following factors:

- Demand/Delivery Capacity; the French daily resupply requirements (200 tons) could not be met by the available airlift capacity (100-123 tons), while the American aircrews could meet (and beat) supply needs (delivering 250-350 tons for a daily requirement of 235 tons).
- Fire Support; Khe Sahn received artillery support from a nearby fire-base, while Dien Bien Phu had little to no support beyond the base. As a result, aircrews, supplies, and recovery teams were at risk during the recovery of the deliveries. In addition, infrastructure (runways) was targeted, reducing the delivery capacity.
- Aerial Support; American aircrews were able to draw from a variety of squadrons and bases throughout Vietnam and Thailand, while the French were limited by airframe, location, and total number of aircraft. In addition, due to the distance

and aircraft used, French aircrews could only provide limited close air support before being required to return to the airbase, while American forces maintained air superiority throughout the battle.

- Delivery Mode; Although aerial delivery served as the sole means of resupply in Dien Bien Phu, Khe Sahn did offer a highway as an alternative means of delivery. In addition, following the destruction of the runway at Dien Bien Phu, the French were limited to airdrop, while American forces relied on a variety of means of resupply including aerial delivery (airdrop, LAPES, GPES) and air-land, which permitted the recovery and backhaul of personnel and equipment.

Wars in Afghanistan and Iraq created new demands for aerial delivery that differ from those found in Vietnam. Similar to Vietnam, coalition forces have limited infrastructure (e.g. roads and highways) available for transport. However the conditions, supply demands, and types of operations, differ from those found in the historic airdrop cases of Dien Bien Phu and Khe Sahn. Although the French began with offensive operations, by the end of the conflict at Dien Bien Phu, they were required to adopt a purely defensive posture from North Vietnamese attacks. Similarly, the Americans were forced to defend Khe Sahn from the NVA. In Afghanistan and Iraq, coalition forces were largely facing insurgents that could not mount a sizeable attacking force. As a result, coalition forces required resupply while mounting offensive (rather than defensive) operations.

As it appeared that airdrop (based on the speed and range of aircraft) could make up the distance between rear supply depots and forward locations, the researcher began to examine whether its application could be used in a move towards zero-footprint logistics. This initially began with the examination of LCLA parachutes as this system would not require a backhaul move (due to low cost and disposable design). In discovering that the CF already had "low cost" airdrop systems in its inventory (e.g. Unicross), the research was expanded to examine whether airdrop (using disposable delivery systems) could be used as a means of promoting zero-footprint logistics during Canadian Forces operations.

**Research Question**

This study addresses the question,

*"Can airdrop be utilized as a means of promoting zero-footprint logistics for the resupply of the Canadian Forces"?*

**Research Methodology**

In constructing this thesis it was determined that both quantitative and qualitative research would be appropriate to develop and present the topic. Quantitative methods would be used to examine the capability of airdrop to meet the needs of the CF as a resupply method, while qualitative methods would be used to gain a better understanding of the feasibility of using airdrop as a resupply method from those that would be directly involved in the process. Early in the research process, CF manuals and publications were reviewed to gain an understanding of the CF methods and perspectives regarding logistics, resupply, and aerial delivery. Following this initial research, the researcher established the key positions and personnel required in the aerial resupply process as well as the personnel involved in alternate delivery methods (air-land, ground). Public Affairs offices with various CF schools, bases, departments, Wings/Squadrons, and Regiments/Battalions were contacted and assistance was requested in arranging contact with appropriate subject matter experts (SME). Frequently, Public Affairs would locate SMEs and then provide contact information (phone and/or email) for the researcher. In many cases the researcher conducted interviews (either in-person or remotely) with the SME. Interviews were the preferred method by the researcher as they provided the opportunity to clarify points of interest and delve into subjects that emerged during the interview process. Based on the (limited) number of SMEs consulted, the researcher had enough time to conduct interviews and analyze the data in greater detail. Alternatively, had it been determined that a larger number of SMEs would be consulted (e.g. an entire air-wing), the researcher would have likely used a survey or similar tool to gather information. Although a survey would be able to reach a larger number of personnel, the researcher would likely have difficulty in following up with individual subjects regarding specific points and might not generate the same level of detail. In some cases (due to time and scheduling) the SME would request that questions be submitted in writing and answered similarly at the SME's convenience. In some cases, combinations of these methods were used with an interview being conducted and written questions being submitted later for clarification (or vice-versa). Interviews were conducted in a "semi-standardized interview" structure as defined by Berg (1995). The "semi-standardized interview" is a combination of the "standardized interview", in which subjects are asked questions from a formalized list, and "unstandardized interview", during which the interviewer develops and adapts questions and follow-ups through the interview process (Berg, 1995). During the interviews, a set list of "standardized" questions were used which focused on the SME's position, function/role (s) in the delivery process, their opinions of the delivery process (e.g. strengths, weaknesses, "fundamentals of sustainment", appropriate application, etc.), and (when appropriate) establishing the inputs and multipliers needed for the quantitative modeling. Based on the answers provided, "unscheduled" follow-up questions and probes were asked in an effort to gain a greater understanding and appreciation of the subject matter.

The quantitative models used in this study were influenced by a study conducted by Maj. Christopher J. Ireland (USAF) in his School of Advanced Military Studies monograph "Why Not Airdrop? The utility of preplanned airdrop to resupply land forces in the contemporary operating environment". As part of his study, Ireland compared the "responsiveness" between airdrop and ground delivery using American delivery vehicles (e.g. C-130, HEMTT, HMMWV), based on various loads and distances. In addition, Ireland used the daily supply needs of a US Army field artillery battalion in Ar Ramadi, Iraq, and how they could be addressed using airdrop. A similar model, based on Ireland's, was developed for this thesis using Canadian delivery vehicles (e.g. CC-130J, CH-147, AHSVS) and escorts (e.g. CH-146, LAV III, RG-31) based on appropriate inputs established by CF SMEs. In addition to the comparison of delivery methods, scenarios were developed using Canadian based units in an operating environment simulating distances and conditions similar to those in Kandahar, Afghanistan, where Canadians operated during Operation Athena.

**Quantitative Analysis**

**Model**

To help examine the potential use of airdrop to reduce the logistics footprint, it needs to be compared to other CF delivery methods. A model has been developed to compare *Airdrop*[5] delivered by CC-130J, *Airland*[6] delivered by CH-147, and *Ground* delivered by AHSVS traveling either by "road" or "off-road" (see Appendix 1 for details). To create this model, CF technical guides, operations manuals, and SMEs were consulted to establish appropriate operating conditions and times. In developing the model, SMEs were asked to consider appropriate delivery/packaging "units" (e.g. containers, sling nets, etc.) and the time needed to assemble and load these onto delivery vehicles, based on a situation where a resupply shipment was being assembled at a fixed rear location (such as Kandahar Airfield) for delivery to a forward location. Using weight based inputs, the model can perform basic comparisons between the delivery methods.

The model focuses on three key factors[7]:

- Assembly, the time needed to assemble a load for delivery (e.g. rigging skid board, container, and parachute).
- Loading, the time required to inspect and load the assembled cargo onto the vehicle.
- Travel, the time needed to travel to the delivery destination.

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[5] The delivery of personnel or material from aircraft in flight (Canada, 2011A, P.64)

[6] The delivery of personnel or materiel after the aircraft has landed or while hovering (Canada, 2011A, P.64).

[7] The model is based on the weight of the load and does not adjust for other factors such as physical shape or item class (e.g. fuel, ammunition, etc.), which can affect the assembly of the loads. Similarly, the model focuses on delivery characteristics and does not adjust for factors such as the transportation from supply to the rigging area or flight line.

Based on these factors, various estimates can be developed. A summary of these estimates is presented below based on a load of 100 kg.

Total Time

The "Total Time" represents the total sum of the time needed to assemble, load, and travel to the delivery location. Based on this model, *Assembly* and *Travel* times are variable, based on the size of the load and the distance traveled. *Assembly* times are generally longer for aerial delivery (airdrop and helicopter sling loads) than for ground based loads. According to the SME's that were interviewed, the *Load* times needed to secure a package to the delivery vehicle is generally considered to be a fixed time[8]. The total sum of the time needed to assemble, load, and deliver 100 kg. of supplies is found below in Figure 2. When compared between the three delivery modes, airdrop takes the longest time to load (240 minutes). This is due to need to load, secure/rig, and inspect the loads, along with general pre-flight duties. Compared to a "strategic" load which uses a gauge of 180 minutes to prepare (on a CC-130J), a "tactical" load requires additional time due to inspecting the rigging for release.

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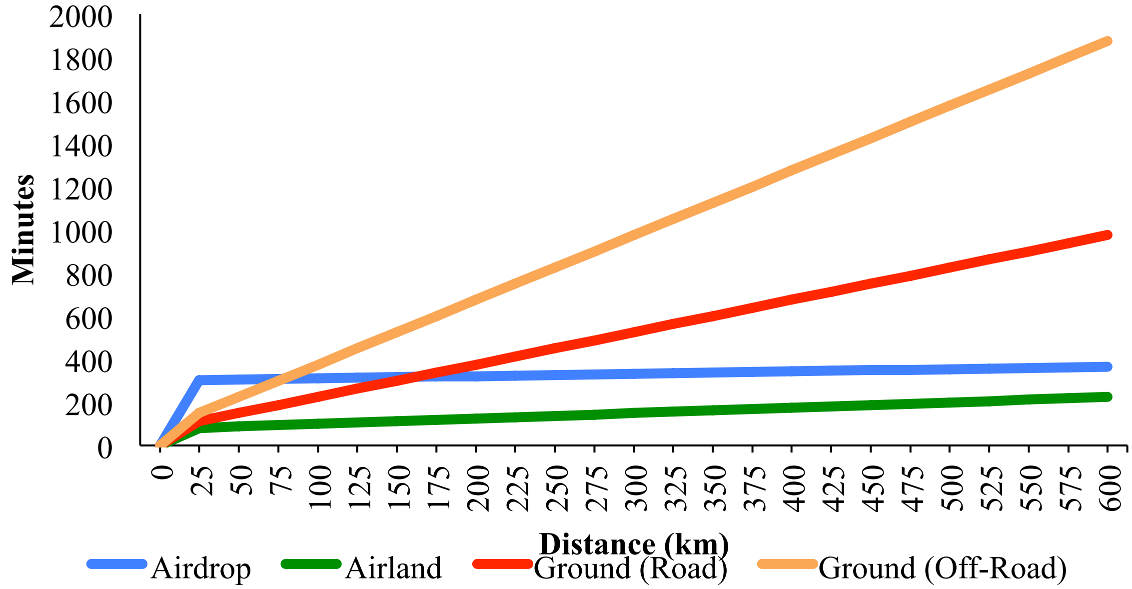
[8] Complete summaries of the models are found in the *Appendix*.

**Figure 2: Total Time (100 kg)**




Based on this model, ground and airland transports have nearly identical preparation (assembly and load) times. However, the delivery speed of the CH-147F is approximately six times that of the ASHVS. In traveling 100 km, the CH-147F will reach its destination in approximately 25 minutes, while the AHSVS will require approximately 2.5 hours (road) or 5.0 hours (off-road) to complete its delivery. Although the airdrop has a longer preparation time than the Ground load, the CC-130J operating speed is considerably faster (over twice that of the CH-147F). At a distance of 161 km, there is an intersection, in the *Total Time* needed to deliver 100 kg., between airdrop and ground (317 minutes). Due to the speed of the aircraft and scale of the graphs, the lines measuring the total time of airdrop and airland may appear horizontal. Following the initial slope indicating the combined assembly and load times (airdrop 300 mins, airland 75 mins), the travel times range from 3-65 minutes for airdrop and 6-150 minutes for airland, across distances of 25-600 km.

The following figures display the *Total Time* needed to assemble, load, and deliver various delivery loads.

**Figure 3: Total Time (1,000 kg)**

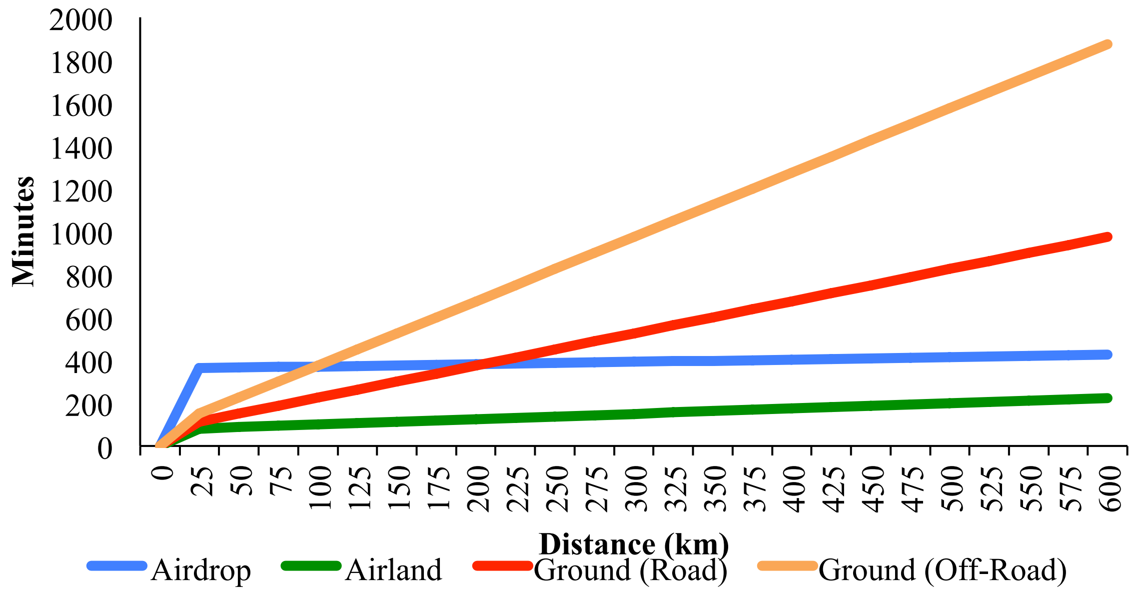
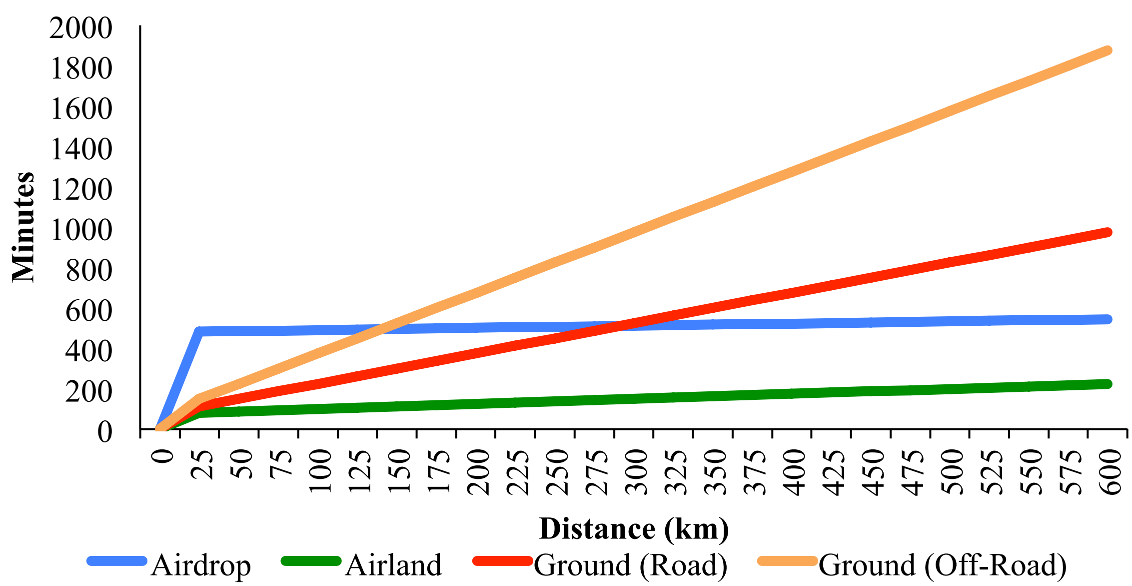



**Figure 4: Total Time (2,000 kg)**

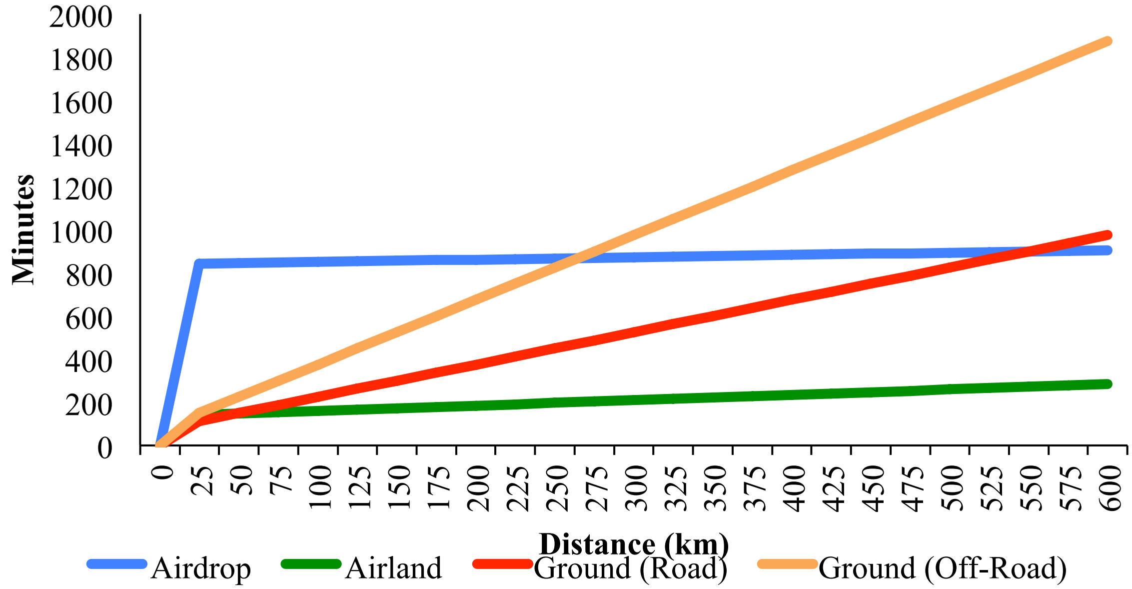


The times displayed in Figure 2 (100 kg.) provide somewhat of a baseline for the time requirements of various modes. Due to the capacity of the "containers" used by the airland and ground (see Appendix 2), there is no change in the delivery times displayed in Figures 2-4 for these modes. Although the *Load* and *Travel* times for airdrop remain constant in these figures, more time is required for *Assembly* as in Figure 3, a larger parachute would/could be used, and in Figure 5, multiple delivery containers would be assembled. Based on these models, the convergence between airdrop and ground transport extends. Based on a load of 1,000 kg (Figure 3), these points are found at a distance of 99 km. (371 minutes) traveling off-road, or 205 km. (382 minutes) traveling by road. For a load of 2,000 kg (Figure 4), these points are found at a distance of 140 km (495 minutes) traveling off-road, or 291 km (511 minutes) traveling by road.

In Figure 5, the number of "nets" used by the airland load is doubled from the previous models, increasing the *Assembly* time from 60 to 120 minutes. Despite this increase the speed of the CH-147F makes up the difference between it and the AHSVS, with airland overtaking ground transport at distances of 22 km (140 minutes, off-road) and 48 km (147 minutes, road). Due to the increased *Assembly* time[9], the airdrop still intersects with the ground *Total* delivery time, though at greater distances, 265 km (869 minutes, off-road) and 549 km (899 minutes, road).

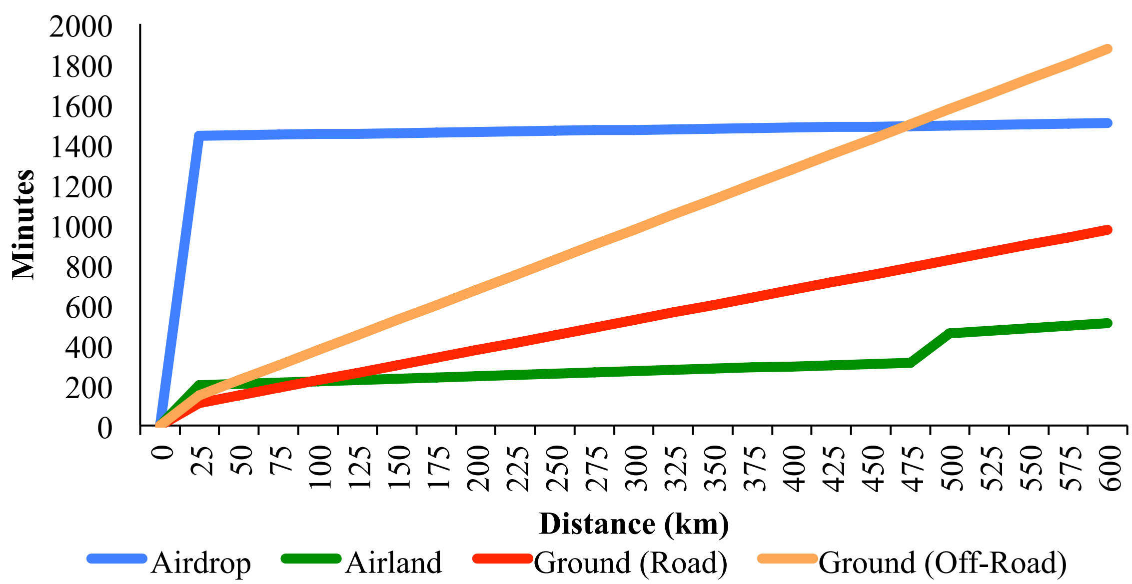
[9] The parameters of the model show a team of 4 members assembling these loads. For larger deliveries, it would not be unreasonable to assume that more personnel would be assigned to assemble the load.

**Figure 5: Total Time (5,000 kg)**




The containers used to transport goods by ground via the AHSVS have capacities greater then 10,000 kg. (see Appendix 2). As a result, the lines depicting the *Total* time required to transport loads in Figures 2-6 are identical. In Figure 6, additional time is again needed to assemble the containers required by the airdrop and airland delivery modes. In this case (10,000 kg.), the time needed for a CC-130J to match an AHSVS travelling off-road is 472 km (1,491 minutes), while the point of intersect for a delivery by road is beyond the range of the graph (approximately 980 km or 1,546 minutes). The delivery times of the airland and ground transports intersect at 44 km (206 minutes, off-road) and 96 km (219 minutes, road). Based on the operating guidelines of the model, 2 CH-147F's would be required to complete any deliveries beyond a distance of 482 km. Alternatively, a single helicopter could be used however refueling would be required.[10]

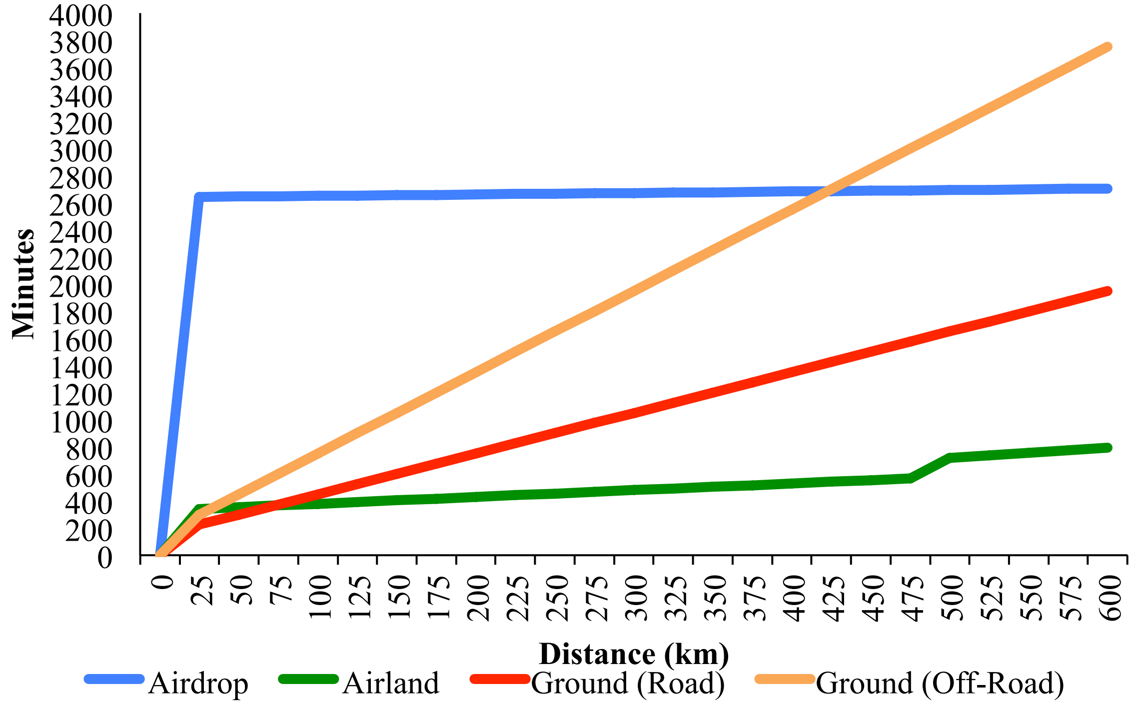
**Figure 6: Total Time (10,000 kg)**




For a load of 20,000 kg. (Figure 7), 2 AHSVS, 2 CH-147F, or 1 CC-130J (20 bundles) would be required. With longer *Assembly* times, the intersection between ground and airland occurs at distances of 33 km (346 minutes, off-road) and 72 km (366 minutes, road). The intersection between ground (off-road) and airdrop occurs at 423 km (2,686 minutes). Much like the previous model, the intersection between ground (road) and airdrop is beyond the scope of the chart, occurring at 861 km (approximately 2,733 minutes).

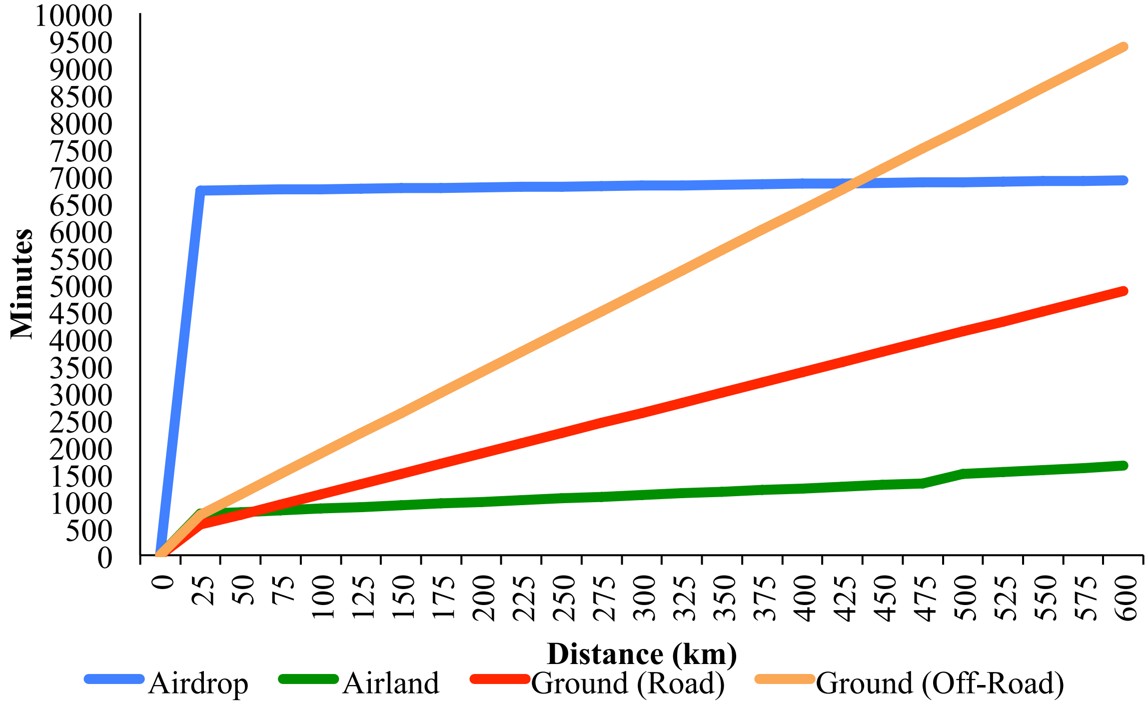
[10] Refueling would be conducted at a Forward Operating Base (FOB) or Forward Arming and Refueling Point (FARP). The refueling process and extra distance travelled would add additional time to the delivery.

**Figure 7: Total Time (20,000 kgs)**




Loads of 50,000 kg. would require 3 CC-130J (50 bundles), a minimum of 5 CH-147F (6 for loads traveling further then 480 km or a refueling at a FOB/FARP), or 5 AHSVS. Much like the other models, although the airland delivery mode has an assembly time of more then twice that of the ground mode, the aircraft's speed allows it to make up the difference occurring after 26 km (767 minutes, off-road) and 57 km (806 minutes, road). The intersection between airdrop and ground occurs after 432 km (6,860 minutes, off-road) and 884 km (7,006 minutes, road).

**Figure 8: Total Time (50,000 kgs)**



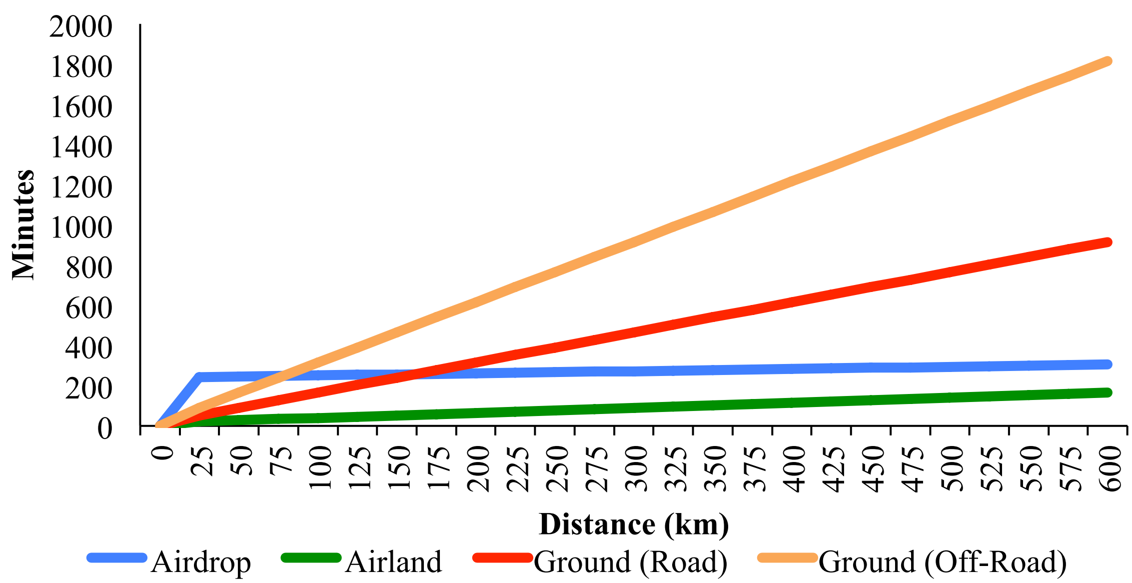

<u>Operational Time</u>

As previously displayed, one of the major factors in the "Total Time" for delivery is the time required to assemble the load. However, due to the need to maximize the usage of available aircraft (as aircraft are in great demand with limited supply), loads will likely be assembled ahead of time. Based on this, an additional measurement of "Operational Time" has been calculated. Operational Time is based on the use of the vehicle, which is the sum of the *Load* and *Travel* times.

The Load times for the model parameters are fixed and the Travel times are variable based on the distance. As a result, the variance between Operational Times does not fluctuate as widely between the weights of delivery loads (e.g. 1,000 kg vs. 2,000 kg). Rather, Load times increase with the number of vehicles required.

Figure 9 compares the Operational Times of each of the delivery vehicles used in the model.

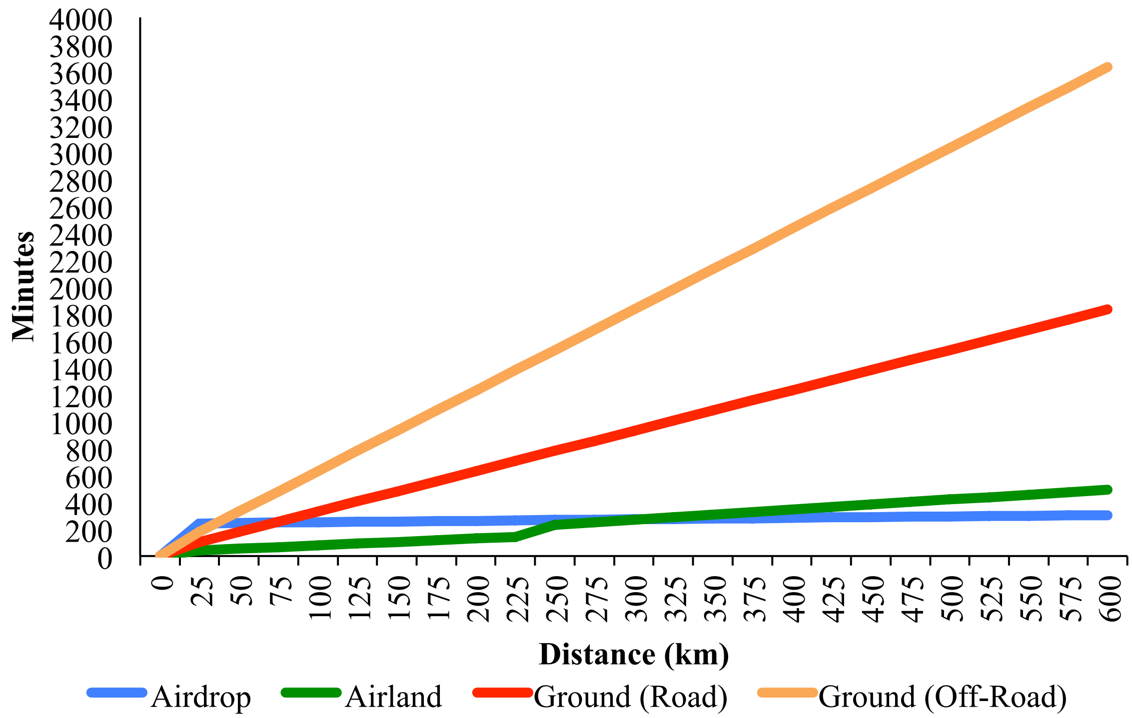
**Figure 9: Operational Time (Single Vehicle)**




Based on the parameters of this model, an airdrop would operate more quickly than ground based delivery at 78 km (248 minutes, off-road) and 161 km (257 minutes, road)). In this model, a CC-130J requires 240 minutes to load, secure, and inspect the load. Despite the length of time needed to Load, the operational speed of the CC-130J is faster compared to the other delivery methods.

Figure 9 displays a comparison between each of the delivery vehicles. Although the airland and ground each have (relatively) shorter loading times (compared to airdrop), the vehicles used for these deliveries also have smaller capacities for cargo. As a result, larger loads require multiple vehicles. Figure 10 compare the Operational Times of the delivery vehicles needed for the capacity of a single CC-130J.

**Figure 10: Operational Time (CC-130 J Capacity, 21,319 kg)**




The delivery of a 21,319 kg. load requires either a single CC-130J, 2 AHSVS, or 2 CH-147F (3 for distances greater than 240 km). Based on this delivery weight, the airdrop would operate faster than a ground based delivery at distances greater than 35km (off-road) and 75 km (road). The CC-130J would match the operational time (273 minutes) of 3 CH-147 at a distance of 305 km.

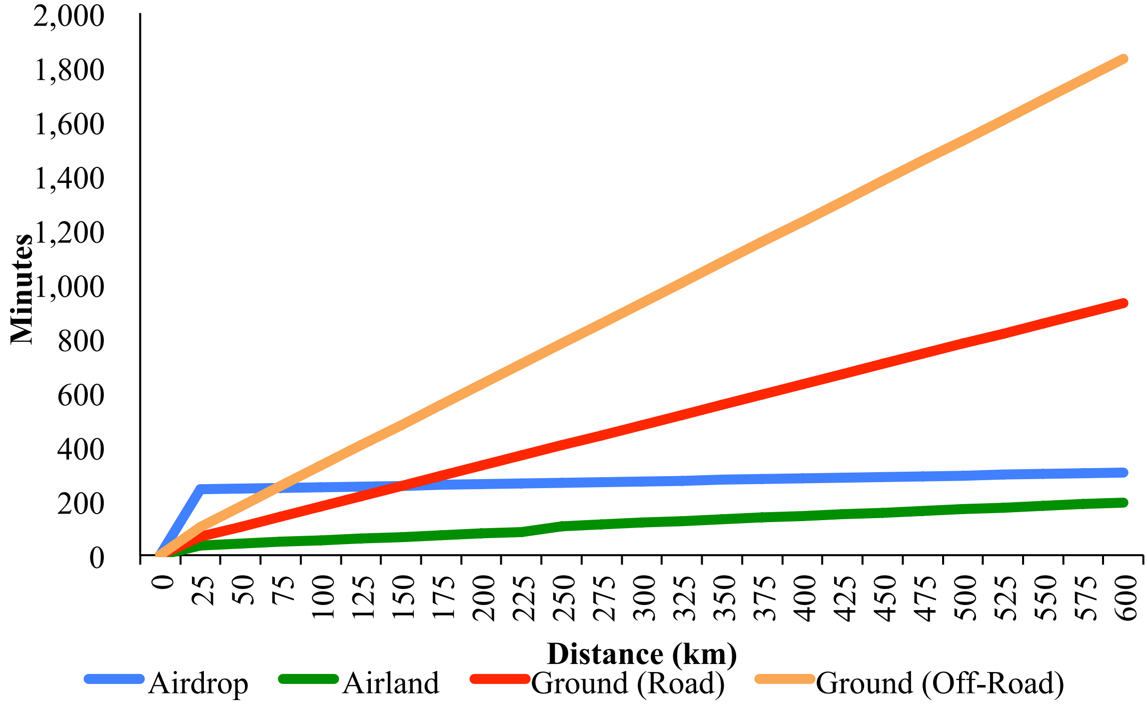
Elapsed Time

The calculation of Total and Operational Time(s) measure the personnel and equipment hours needed to complete a delivery (assembly, loading, and travel). However, there is additional measure that should be considered. Measuring the personnel and equipment hours is beneficial in considering asset utilization, however it provides a somewhat less than accurate perspective regarding the final delivery time. In measuring the Total and Operational Times, the actions in the delivery process are measured sequentially.

However by measuring the vehicle hours used during the travel process, it does not provide an accurate measure as to how the vehicles would operate. Based on the current method of measure, vehicles do not begin traveling until the prior vehicle has reached the final destination (e.g. 1 hour travel time x 3 vehicles = 3 hours travel). However, for safety during travel and to minimize exposure at the final delivery location, delivery vehicles would travel close together (e.g. convoys). To provide an alternative perspective, the measure of "Elapsed Time" has been calculated. Elapsed Time is similar to Operational Time as it measures the use of the delivery vehicle based on the Load and Travel times. Although it would depend on the available personnel, a sequential system would seem appropriate in the assembly and loading processes (e.g. one vehicle would be loaded, then the crew(s) would start on the next) with the exception of the CC-130J. The measure used for the loading of the CC-130J includes the loading and inspection of the cargo, in addition to the preflight checks performed by the loadmasters (who budget 240 minutes for tactical deliveries). Although the cargo may be loaded onto the aircraft sequentially, the loading of additional aircraft would begin well before the completion of the loading process by the previous aircrew. Based on this, an "Elapsed Loading Time" of 240 minutes will be used in cases where multiple CC-130Js are required. Travel times are calculated to reflect the vehicles moving closely together with aircraft arriving at the same time and ground vehicles traveling in a convoy. As a result, the Elapsed Time is the same as the Operational Time in cases where only a single vehicle is used.

Figure 11 compares the Elapsed delivery times of a load weighing 21,319 kg (a fully loaded CC-130J) between the various delivery methods.

**Figure 11: Elapsed Time (CC-130 J Capacity, 21,319 kg)**

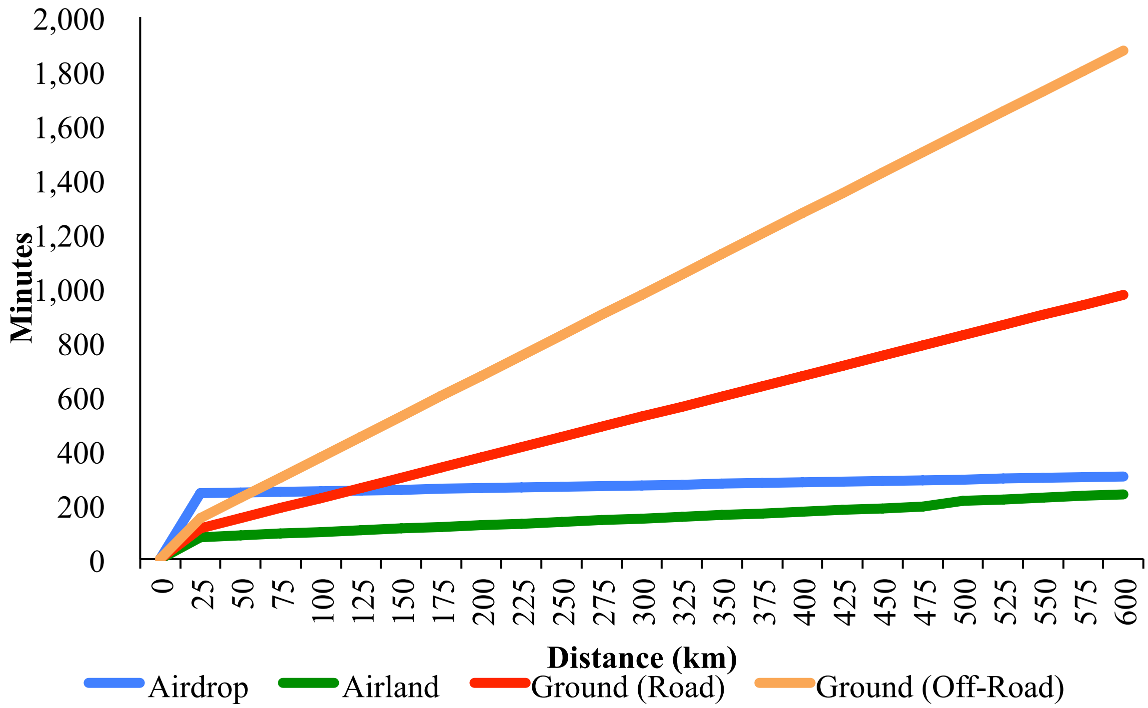



Based on the Elapsed times, an airdrop and ground (off-road) based delivery would take the same amount of time at 73 km (248 minutes). The intersect point between airdrop and ground (road) delivery would occur after 150 km (256 minutes). The intersection of the

Elapsed time between airdrop and airland occurs beyond the scope of the model at a distance of 2,975 km (801 minutes) though this does not take into account the time required to refuel the flight of CH-147F (as this distance is beyond the range of the aircraft).

As described earlier, an elapsed loading measure will be used in cases where multiple CC-130J aircraft are used. Figure 12 displays the elapsed time of a delivery of cargo weighing 50,000 kg.

**Figure 12: Elapsed Time (50,000 kg)**




As described earlier (Figure 8), the delivery of this load would require either 3 CC-130J, 4-6 CH-147F (depending on the distance), or 5 AHSVS. Based on the elapsed time, a delivery delivered by airdrop would overtake an off-road ground convoy at a distance of 57 km (246 minutes), and a ground convoy traveling by road at a distance of 119 km (253 minutes). The elapsed time of airdrop and airland is equal at a distance of 950 km (343 minutes).

Escorts

The previous models have compared each of the delivery vehicles separately, operating individually. However, this would depend greatly on the operating environment. In a combat environment (such as Afghanistan), the CH-147F and the AHSVS would travel with escorts.

When Canada began operating the CH-47D in Afghanistan, the RCAF modified 8 CH-146 "Griffon" helicopters as "gunships" to escort and provide protection to the Chinooks (the rotary-wing aircraft were designated Task Force FAUCON). A "section" of 2 CH-146 may be used to provide protection to the CH-147F (Lewchuk, 2012). In addition, the CH-146 may also be used to provide cover to a unit on the ground.

Although the AHSVS is heavily armored and provides protection for its crew, in Afghanistan, additional protection was provided by escorts using LAV III and RG-31 fighting vehicles.[11] Although the number of escort vehicles is somewhat variable and guarded, sources suggested the following for modeling purposes:

-1 "lead" escort vehicle
-1 "rear" escort vehicle[12]
-1 protective escort vehicle for every 5 logistics vehicles[13]

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[11] As this model is "weight" based, it does not take into account cargo size or class. As a result, the model may calculate fewer logistics vehicles then those found in functional convoys.

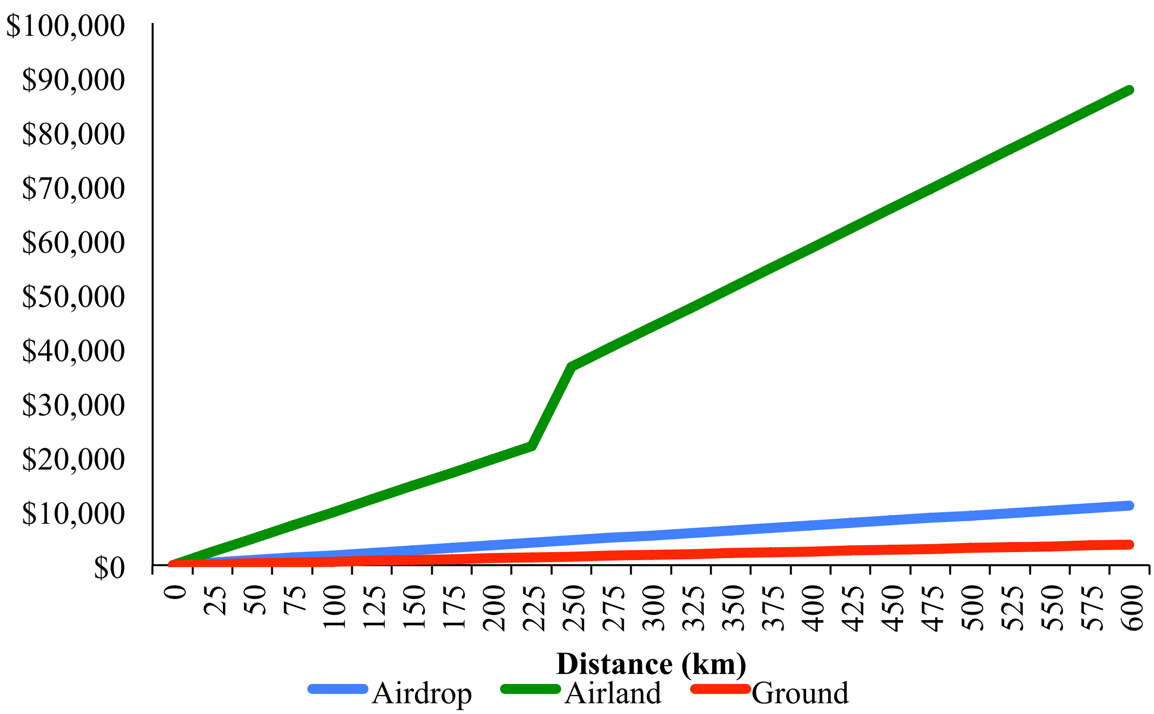
[12] For the purposes of the model, the LAV III will be used as the lead and rear escort vehicles, though this is not based on any formal rule or doctrine.

[13] For the purposes of the model, the RG-31 will be used as the protective escort vehicle, though this is not based on any formal rule or doctrine.

Cost

Determining the cost of delivery is not difficult; however, the value of such a measurement for this analysis is questionable. The Department of National Defence (DND) produces an annual "Cost Factors Manual" that provides the operating costs of DND/CF personnel, equipment, and bases. In the case of transportation, an hourly cost has been determined for aircraft and a mileage rate (per/km) has been calculated for ground transportation. Based on these figures, operating costs can be applied to the delivery models.

**Figure 13: Operating Cost (CC-130 J Capacity, 21,319 kg)**



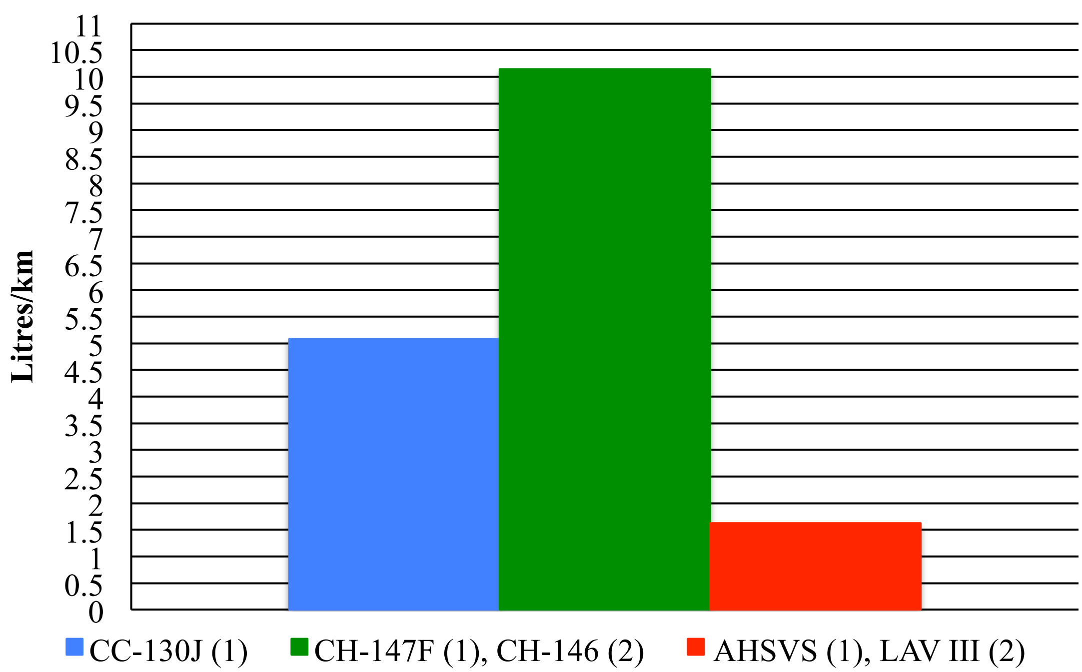

In the 2011-12 Cost Factors Manual, the hourly operating expense of a CC-130 was approximately $10,172 (p.39) (2010-11 flight hours were valued at $5,878 (Canada 2010, 3-1-1)). Based on the operating speed of the CC-130J, traveling 100 km would cost $1,831. Alternatively, during 2011-12 the AHSVS listed a mileage cost of $3.15 /km (p.51). Based on an operating speed of 40 km, an hourly cost of $126 per vehicle can be calculated. In the figure above, a 100 km trip would cost $630 due to the use of 2 vehicles. Although the CF was operating CH-147D in Afghanistan during this period, an operating expense was not available. Available CF rotary aircraft hourly expenses include CH-124 Sea King ($9,913), CH-149 Cormorant ($21,327), and CH-146 Griffon ($1,943) (Canada, 2011B). Alternatively, the American DOD provided an hourly operating rate of $11,727 for the CH-47F, which was used in this calculation (United States Army Financial Management, 2011). Flying 100 km would cost approximately $9,742 based on the use of 2 CH-147F. The hourly rate for this model would increase from $23,455 to $35,182, for distances greater than 240 km due to fuel constraints.

During interviews several subjects noted that planners generally do not think of equipment cost/expense in “financial” terms (e.g. operating cost). Rather, planners consider other factors such as available flight hours (see *Operational Time*). Another possible measure is fuel or POL (Petroleum, Oil, Lubricants). In Afghanistan, fuel was not locally sourced; rather, it was transported over land from Pakistan using civilian contracted “Jingle-Trucks”. Given the difficulty and demand for POL in the field, it may represent a better gauge of “cost” rather than financial operational expense.

Based on mileage (litres per kilometer), the AHSVS operates the most efficiently, consuming 0.82 L/km. The CH-147F has the highest consumption rate (6.3 L/km), while the CC-130J is somewhat more efficient (5.1 L/km).[14]

As described earlier, in a combat environment the AHSVS and CH-147F would travel with protective escorts. Based on the model, a load of 5,000 kg would require either 1 CC-130J, 1 CH-147F with 2 CH-146 escorts, or 1 AHSVS with 2 LAV III escorts. The fuel economy of these vehicle and escort configurations is displayed in Figure 14.

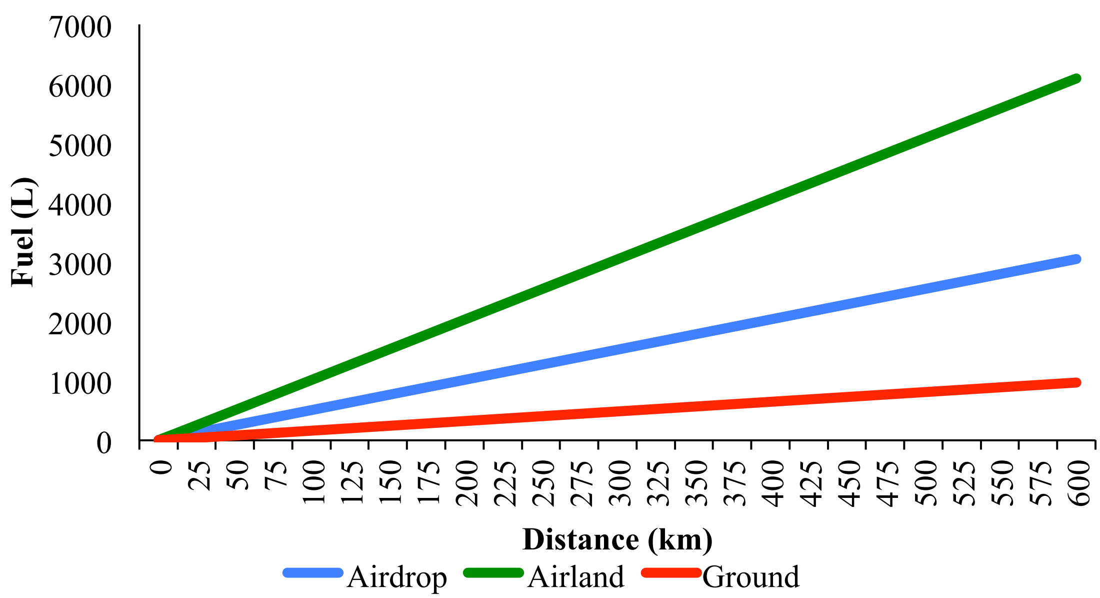
**Figure 14: Fuel Economy (5,000 kg)**




[14] For these models, fuel economy is constant (based on mileage) and does not fluctuate with speed.

Based on these configurations, the ground convoy is still the most fuel-efficient, using 1.6 l/km, while the CC-130J and CH-147 flight use 5.1 l/km and 10.2 l/km respectively. Figure 15 applies the fuel economy rate to the distance travelled to show the total fuel consumed (based on a load of 5,000 kg).

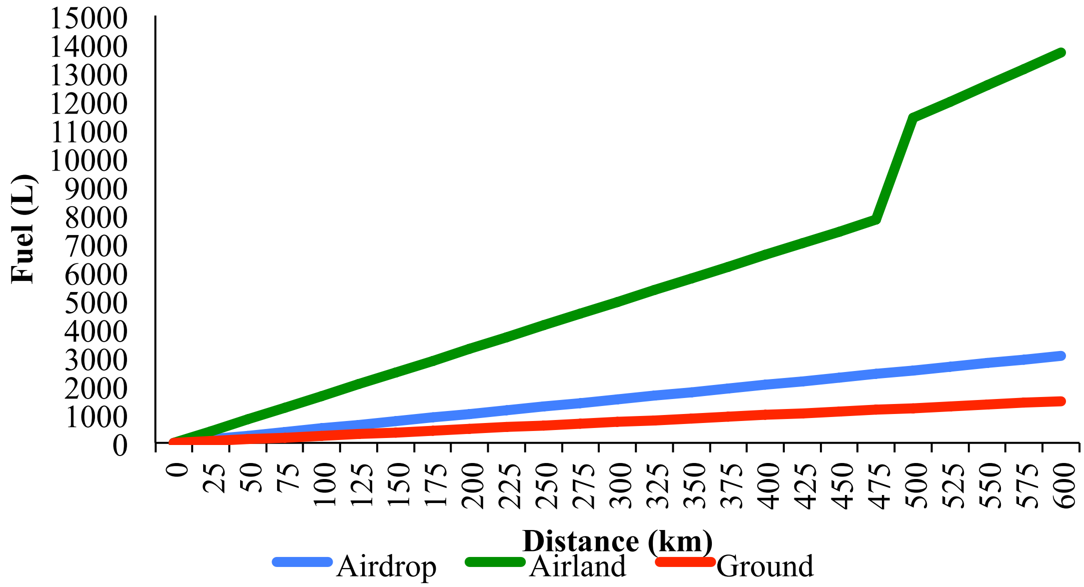
**Figure 15: Fuel Usage (5,000 kg)**




Based on the parameters of this model, only single delivery vehicles (i.e. 1 AHSVS, etc.) are required to transport this load. Although aircraft are able to travel faster, it comes at the expense of fuel economy. To travel 100 km the CC-130J requires 509 litres of fuel. To travel the same distance, the CH-147F burns 634 litres of fuel; while its CH-146 escort section uses 381 litres (combined total 1,015 L). The ground convoy consisting of 1 AHSVS (82 L) and 2 LAV III (80 L) escorts would use a combined 162 litres of fuel.

Figure 16 displays the fuel used to transport loads weighing 20,000 kg.

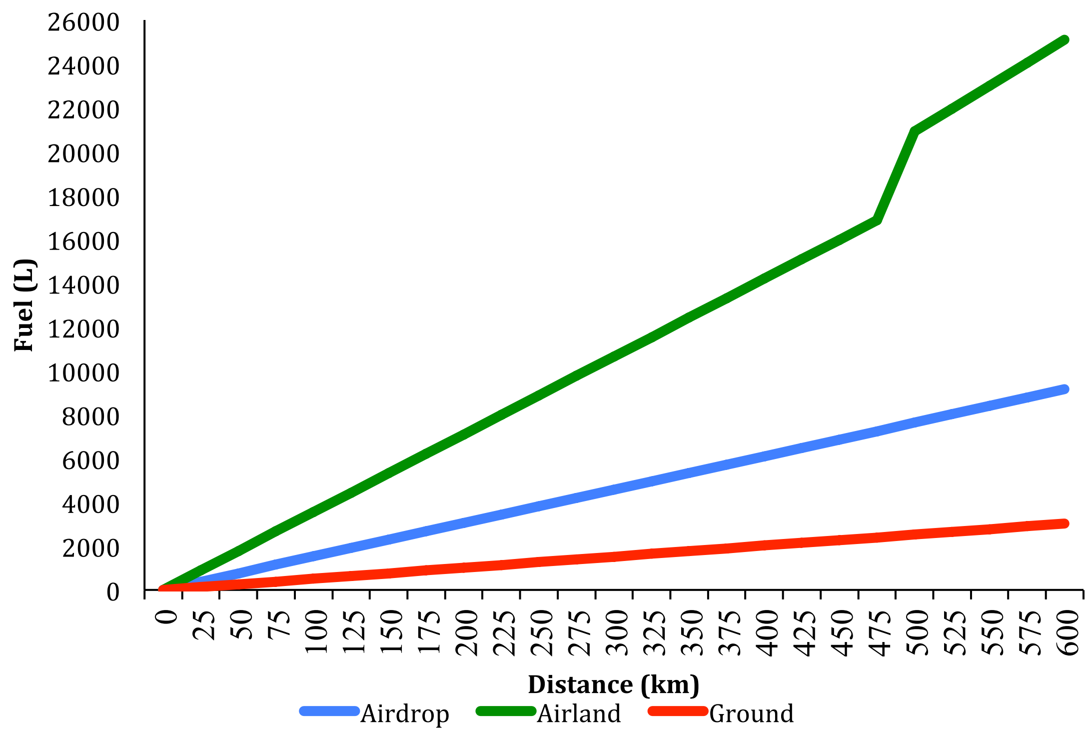
**Figure 16: Fuel Usage (20,000 kg)**




The transport of 20,000 kg a distance of 100 km requires either 1 CC-130 (509 L), 2 CH-147 (1,267 L) and a section of CH-146 escorts (38 L) (combined total 1,649 L), or a convoy of 2 AHSVS (82 L) and 2 LAV III (80 L). For distances greater than 481 km, either a refueling stop must be scheduled or a third CH-147 must be used (as displayed in the figure above). Based on this scenario, three CH-147s traveling 500 km would use 9,504 litres of fuel in addition to the escort section totaling 11,411 litres (with a refueling required by the CH-146 section).

Figure 17 displays the fuel required to transport loads weighing 50,000 kg.

**Figure 17: Fuel Usage (50,000 kg)**




Based on this model, the transportation of 50,000 kg requires an airdrop (3 CC-130J's), airland (5-6 CH-147's), or a ground convoy (5 AHSVS, 2 LAV III and 1 RG-31 escort). To travel 100 km, airdrop would require 1,525 litres of fuel, airland delivery requires 3,549 litres of fuel (CH-147: 3,168 L; CH-146[15]: 381 L), and a ground convoy requires 505 litres of fuel (AHSVS: 410 L; Escort: 95 L).

[15] Although this model uses an escort section of 2 CH-146s, for flight of CH-147's (in this scenario 5-6 aircraft) more escorts may be required.

DZ, LZ, Convoy Footprint

Based on current Drop Zone (DZ) protocol, airdrops can potentially create a large footprint. According to the Canadian Forces Drop Zone/Landing Zone Controller's Handbook (B-GL-322-006/FP-003), equipment dropped using CDS requires a DZ with a width of 200 m. and a minimum length of 400 m. for the first row of containers (P.21).[16] Each additional row of containers requires an additional 50 m. of length added to the DZ. Based on these guidelines, the DZ for a single container would require a minimum area of 80,000 $m^2$ (400 m. x 200 m.), while the delivery of a full CC-130J (24 containers) would require an area of at least 190,000 $m^2$ (950 m. x 200 m.), nearly a kilometer in length.

Alternatively, the footprint of a helicopter Landing Zone (LZ) is much smaller. The CH-147 requires an LZ 100 m. in diameter (a total area of 7,854 $m^2$).

Although ground vehicles can be organized into a small area to unload, during travel, the length of the convoy can vary based on situational requirements. Depending on the environmental conditions, the vehicle density (distance between vehicles) can typically range from 15-50 meters (Canada, 2003). Table 1 displays the convoy length based on the number of vehicles used (based on the model parameters).

[16] The CC-130J can carry approximately 24 CDS bundles, packed 12 rows deep by 2 columns.

**Table 1: Convoy Length**

| LAV III (Lead) | AHSVS | RG-31 (Escort) | LAV III (Rear) | Total Vehicles | Convoy Length (m) | Capacity (kg) |
|---|---|---|---|---|---|---|
| 1 | 1 | 0 | 1 | 3 | 125 | 12,000 |
| 1 | 2 | 0 | 1 | 4 | 186 | 24,000 |
| 1 | 3 | 0 | 1 | 5 | 246 | 36,000 |
| 1 | 5 | 1 | 1 | 8 | 424 | 60,000 |
| 1 | 10 | 2 | 1 | 14 | 785 | 120,000 |
| 1 | 15 | 3 | 1 | 20 | 1,145 | 180,000 |
| 1 | 20 | 4 | 1 | 26 | 1,505 | 240,000 |

Based on the model parameters, a fully loaded CC-130J (21,319 kg) would carry 22 "bundles" or 11 rows of cargo. This would require a DZ with a length of 900 meters and an overall area of 180,000 $m^2$. Depending on the distance of the delivery, the LZ required by the (1-3) CH-147(s) would measure between 100-300 meters in diameter (total area 7,854-23,562 $m^2$)[17]. The ground convoy would require 2 AHSVS and an escort of 2 LAV IIIs with a total length of 186 m.

**Scenarios**

The figures developed using the quantitative model in the previous sections measured the delivery distance between each of the vehicles equally. However, in real life, it is more likely that ground transportation would require longer routes due to infrastructure or obstacles that air transport can avoid.

To apply the delivery model to a "real-world" environment, a set of simulations have been developed.

[17] The minimal LZ could be used by the CH-147, however this may require the other aircraft in the flight to slow or hover. Depending on the environment, this may put the pilots and aircraft at risk.

Military supply requirements can differ greatly based on the unit type (e.g. infantry, armour, signals, etc.), size, and type of mission (e.g. combat vs. humanitarian relief). Methods of estimating resupply requirements range from software tools that analyze and determine supply needs to the personal experience of senior enlisted personnel. To determine the supply needs used in this simulation, a "basic" estimate generated by the "supply consumption calculator" is being used. This calculator projects an average demand of 63.6 kg of supplies per person per day. The supplies in this figure include major supply items such as rations, ammo, and POL (petroleum, oil, lubricant), and other items including repair parts, technical stores, defensive stores, and whole blood. It is recognized that this is a "basic" calculation and not a "universal" solution.

The composition of military units appears to be based on guidelines rather than rules in regards to the number of personnel assigned. For these simulations, several units of different sizes have been selected and the daily demand of supplies (63.6 kg) has been applied (Canadian Army, 2012, January 13).

For these simulations the province of Nova Scotia has been selected as the theatre of operations. In terms of area, Nova Scotia (53,283 $km^2$) is slightly smaller than the province of Kandahar in Afghanistan (54,022 $km^2$), (a difference of 739 $km^2$). [18] Using available Internet based mapping tools, air and ground distances have been calculated

[18] Kandahar province was Canada's area of responsibility during Phase II of "Operation ATHENA" (the Canadian contribution of peace-support and combat forces to the International Security Assistance Force in Afghanistan, July 2003 - December 2011)

between Halifax and several airports around Nova Scotia, which will act as delivery points. In this case, Halifax Stanfield International Airport (CYHZ) represents the location of the National Support Element (NSE) (similar to Kandahar Airfield (KAF)) and the origin of the deliveries. A map of the Theatre of Operations, selected sites, air-routes, and ground-routes is found in Appendix 32.

For these simulations, the destination and unit size have been randomly selected.

**Simulation 1**
Halifax (CYHZ) to Port Hawkesbury (CYPD);
Section (8 Personnel); 508.8 kg.

| Mode | Airdrop | Airland | Ground |
|---|---|---|---|
| Distance (km) | 188 | 188 | 245 |
| Vehicles (delivery) | CC-130J: 1 | CH-147F: 1 | AHSVS: 1 |
| Vehicles (escort) | n/a | CH-146: 2 | LAV III: 2; RG-31: 0 |

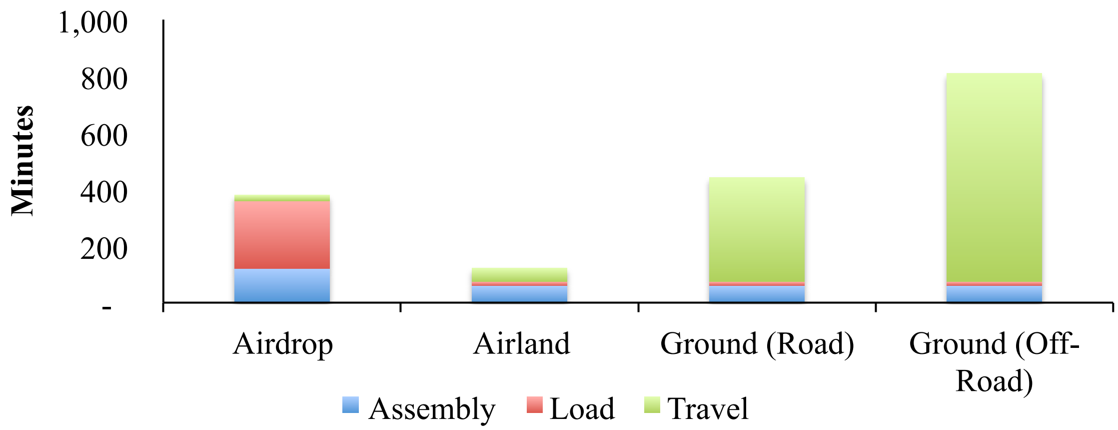
An 8-person *Section* requires approximately 508.8 kg of supplies per day. Based on the model only a single delivery vehicle is required along with a minimal escort. In the case of airdrop, the load (based on weight) can be delivered by a single bundle. The resupply times for this load are displayed in Table 2 and Figure 18.

**Table 2: Resupply Time- 508.8 kg (Section)**

| Activity | Airdrop | Airland | Ground (Road) | Ground (Off-Road) |
|---|---|---|---|---|
| Assembly | 120 | 60 | 60 | 60 |
| Load | 240 | 15 | 15 | 15 |
| Travel | 20 | 47 | 368 | 735 |
| Operational Time / Elapsed Time | 260 | 62 | 383 | 750 |
| Total Time | 380 | 122 | 443 | 810 |

Based on this scenario, the delivery of this load by a CC-130J would require a *Total Time* of 380 minutes, 260 minutes of which would involve *Operation Time* functions. The Travel time (20 minutes) of this mode is the lowest of those in the scenario. In contrast, traveling by road at a speed of 40 km/hr took almost as long (368 minutes) as the entire airdrop operation. The *Operational Time* of the airland was only 2 minutes greater then the time required to assemble the load (60 minutes). A graphical comparison is found in Figure 18.

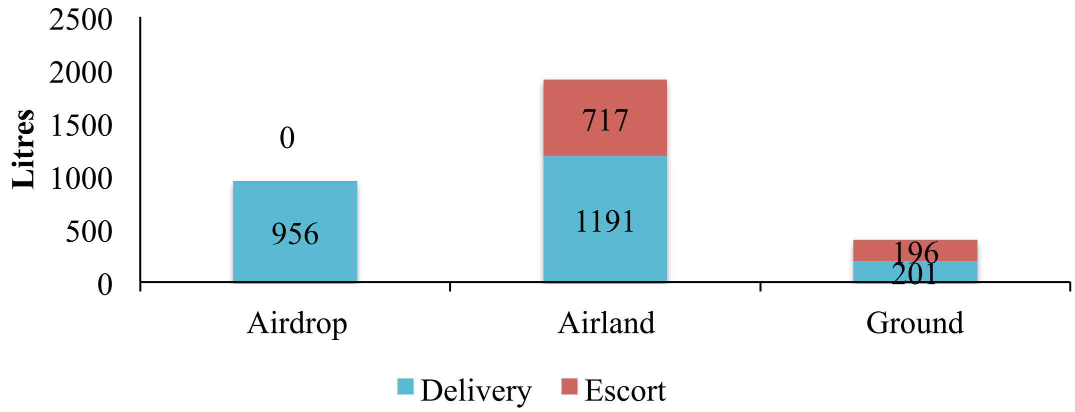
**Figure 18: Total Time- 508.8 kg (Section)**




As emphasized in the previous figure, over 60% of the *Total Time* required for the airdrop delivery was due to the loading of the aircraft.

Figure 19 compares the fuel requirements of the delivery.

**Figure 19: Fuel Requirements- 508.8 kg (Section)**




Based on this scenario, the ground convoy consumes 42% of the fuel required by the CC-130J and 21% of the fuel required by the CH-147F and its escorts.

In regards to the "footprint", based on the model parameters the ground convoy would consist of 3 vehicles (1 AHSVS, 2 LAVIII) and would extend 125 m. The airdrop would require a DZ 350 m. in length (70,000m$^2$ total area).

**Simulation 2**
Halifax (CYHZ) to Trenton (CYTN);
Platoon (36 Personnel); 2,289.6 kg

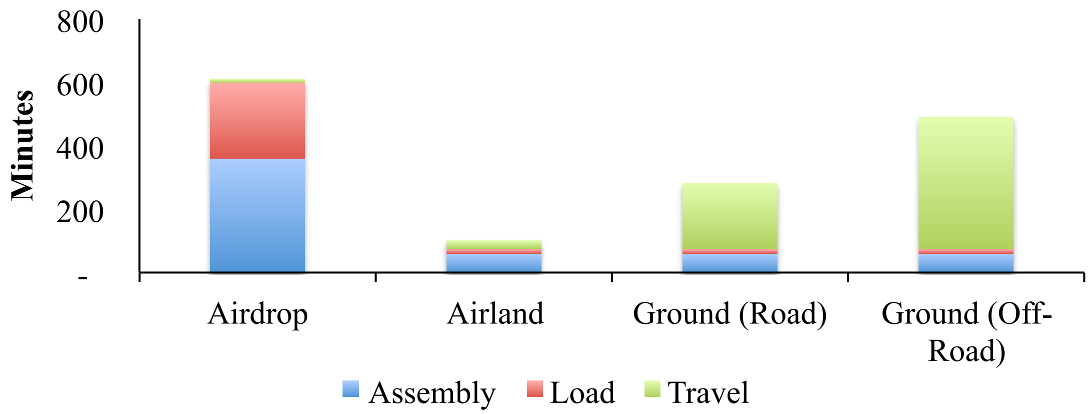
| Mode | Airdrop | Airland | Ground |
|---|---|---|---|
| Distance (km) | 108 | 108 | 139 |
| Vehicles (delivery) | CC-130J: 1 | CH-147F: 1 | AHSVS: 1 |
| Vehicles (escort) | n/a | CH-146: 2 | LAV III: 2; RG-31: 0 |

The time required to complete the delivery is found in Table 3 and Figure 20.

**Table 3: Resupply Time- 2,289.6 kg (Platoon)**

| Activity | Airdrop | Airland | Ground (Road) | Ground (Off-Road) |
|---|---|---|---|---|
| Assembly | 360 | 60 | 60 | 60 |
| Load | 240 | 15 | 15 | 15 |
| Travel | 12 | 27 | 209 | 417 |
| Operational Time / Elapsed Time | 252 | 42 | 224 | 432 |
| Total Time | 612 | 102 | 284 | 492 |

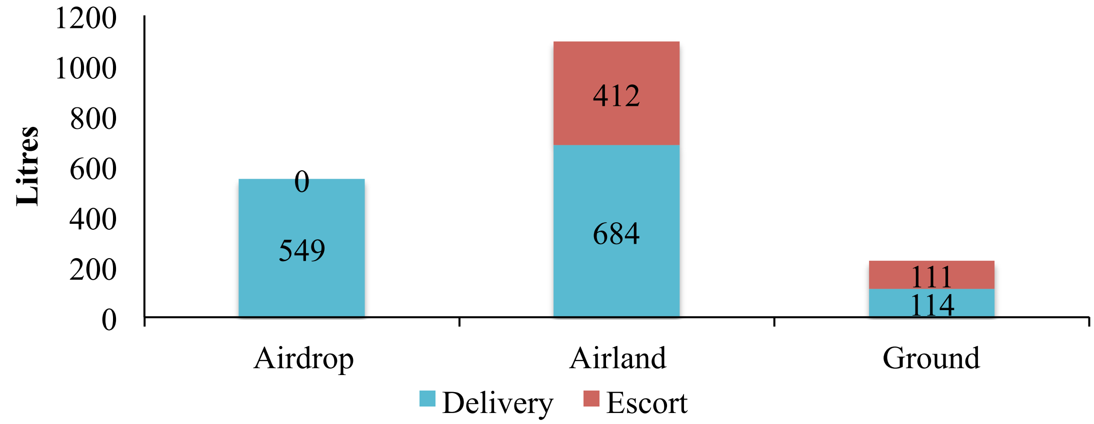
**Figure 20: Total Time- 2,289 kg (Platoon)**




A 36-person platoon requires approximately 2,289.6 kg of supplies for a single day. This load can be delivered by airdrop using 3 bundles, requiring 6 hours to assemble. Although the travel time is minimal (12 minutes, shortest of the 4 delivery options), the time required to load the aircraft lengthens the Operational Time to 252 minutes. In comparison, this Operational Time is six times longer then that of the airland (42 minutes) and 10 minutes longer then a ground convoy travelling by road (though it is still faster then a ground convoy travelling off-road, 432 minutes).

The escort required for this simulation is the same as Simulation 1. Figure 21 compares the fuel requirements of the delivery.

**Figure 21: Fuel Requirements- 2,289.6 kg (Platoon)**




Based on this scenario, the CC-130J consumes 80% of the fuel required by the CH-147F (684 L) and 50% of the fuel required to operated the CH-147F and it's escorts (412 L), while the ground convoy (1 AHSVS, 2 LAVIII) consumes approximately 41% of the fuel required by the CC-130J.

In order to conduct an airdrop, a DZ measuring 450 m in length is required (90,000 $m^2$, total area).

**Simulation 3**
Halifax (CYHZ) to CFB Greenwood (CYZX);
Company (148 Personnel); 9,412.8 kg.

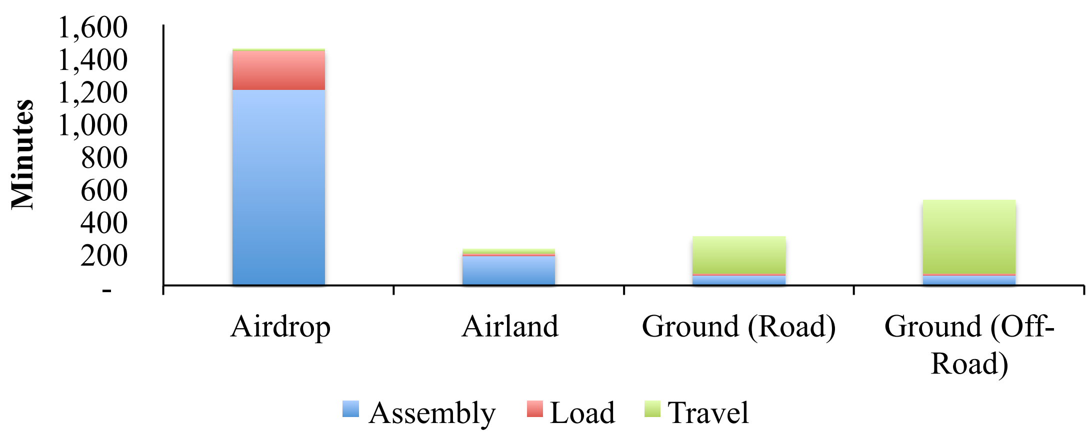
| Mode | Airdrop | Airland | Ground |
|---|---|---|---|
| Distance (km) | 111 | 111 | 150 |
| Vehicles (delivery) | CC-130J: 1 | CH-147F: 1 | AHSVS: 1 |
| Vehicles (escort) | n/a | CH-146: 2 | LAV III: 2; RG-31: 0 |

A Company composed of 148 personnel requires approximately 9,413 kg of supplies for a single day. This can be delivered using a single delivery vehicle. The time required for this delivery is displayed in Table 4 and Figure 22.

**Table 4: Resupply Time- 9,412.8 kg (Company)**

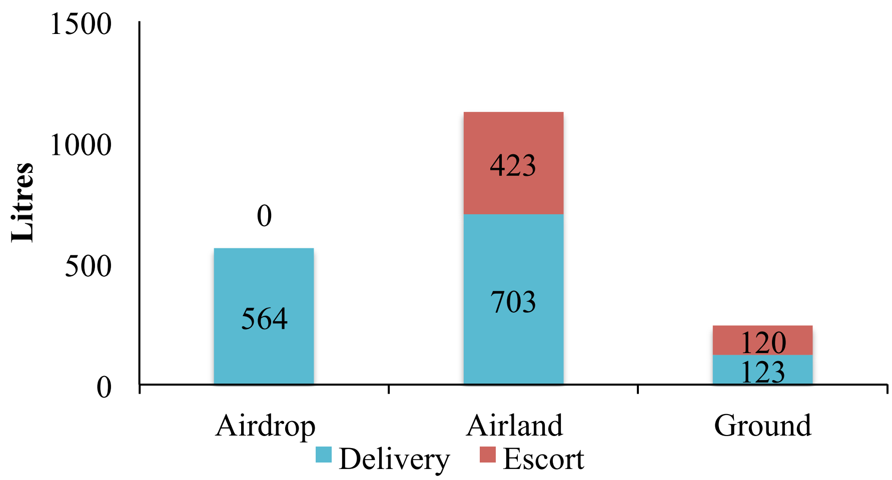
| Activity | Airdrop | Airland | Ground (Road) | Ground (Off-Road) |
|---|---|---|---|---|
| Assembly | 1,200 | 180 | 60 | 60 |
| Load | 240 | 15 | 15 | 15 |
| Travel | 12 | 28 | 225 | 450 |
| Operational Time<br>Elapsed Time | 252 | 43 | 240 | 465 |
| Total Time | 1,452 | 223 | 300 | 525 |

**Figure 22: Resupply Time- 9,412.8 kg (Company)**



Based on the model parameters, the time required to assemble the load is approximately 4 times that needed to complete the entire operation by a ground convoy travelling by road (approximately 2.3 times a ground convoy travelling off-road). In this simulation, the *Operational Time* required by the ground convoy travelling by road is the same as the *Load* time of the airdrop (240 minutes). However, the *Operational* time of a CC-130J is just over half (56%) of the travel time needed by an AHSVS travelling off-road. The *Total* time needed by the airland (223 minutes) is less than the *Operational* time of all other modes. The fuel requirements for this operation are found in Figure 23.

**Figure 23: Fuel Requirements- 9,412.8 kg (Company)**




The total fuel consumption of the road convoy (243 L), is approximately 43% of that consumed by the CC-130J (564 L) and 35% of the fuel consumed by the CH-147 (approximately 22% of the total fuel consumed by the CH-147 and the CH-146 escorts).

Based on weight, this delivery would be packed on 10 bundles, requiring a DZ approximately 600 m. in length (total area 120,000 $m^2$).

**Simulation 4**
Halifax (CYHZ) to Yarmouth (CYQI);
Combat Team (250 Personnel); 15,900 kg.

| Mode | Airdrop | Airland | Ground |
|---|---|---|---|
| Distance (km) | 237 | 237 | 316 |
| Vehicles (delivery) | CC-130J: 1 | CH-147F: 2 | AHSVS: 2 |
| Vehicles (escort) | n/a | CH-146: 2 | LAV III: 2; RG-31: 0 |

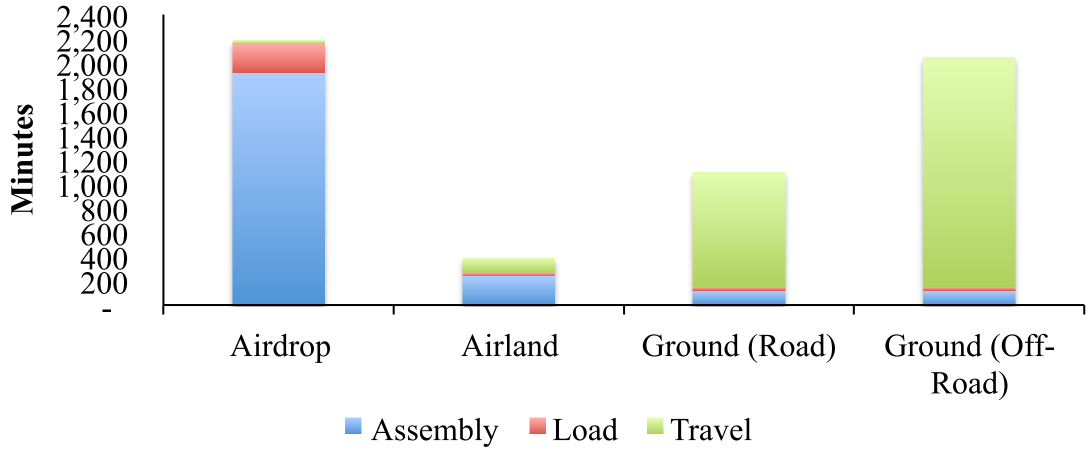
A 250 person "Combat Team" requires approximately 15,900 kg. of supplies for a single day. The delivery of this load can be carried out using 1 CC-130J, 2 CH-147F, or 2 AHSVS. The time required for this delivery is displayed in Table 5.

**Table 5: Resupply Time- 15,900 kg (Combat Team)**

| Activity | Airdrop | Airland | Ground (Road) | Ground (Off-Road) |
|---|---|---|---|---|
| Assembly | 1,920 | 30 | 30 | 30 |
| Load | 240 | 30 | 30 | 30 |
| Travel | 26 | 118 | 948 | 1,896 |
| Operational Time | 266 | 148 | 978 | 1,926 |
| Elapsed Time | | 89 | 504 | 979 |
| Total Time | 2,186 | 388 | 1,098 | 2,046 |

This load requires approximately 16 bundles to deliver the load via airdrop. Based on the parameters of the model, this would take approximately 1,920 minutes to assemble, contributing to a long *Total Time* (2,186 minutes). The *Total Time* required by the airland delivery is approximately 18% of that needed by the airdrop, while the *Total Time* required by the AHSVS (on good roads) is half that needed by the airdrop. The same route based on "off-road" conditions is approximately 94% of the *Total Time* needed by the airdrop. The *Operational Time* of the airland delivery is approximately 56% that of the airdrop. When compared to a ground convoy, the *Operational Time* of the airdrop is approximately 27% of that of road and 14% of that of off-road conditions. The resupply times used in this scenario are further displayed in Figure 24.

**Figure 24: Total Time- 15,900 kg (Combat Team)**

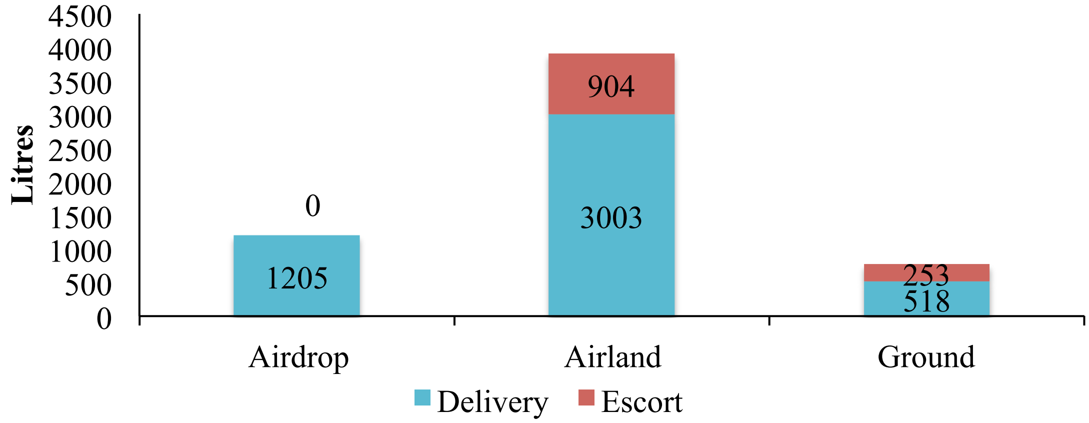



In this simulation the delivery requires multiple vehicles (in the case of the CH-147F and the AHSVS), resulting in Elapsed Times that are different from the Operational Times. In this scenario, the airland delivery has an elapsed time 89 minutes, approximately 34% of the Elapsed/Operational time required to complete an airdrop. The Elapsed time required to complete the delivery by ground (road) is almost twice the time required to complete the delivery by airdrop. Traveling off-road would require 949 minutes and an Elapsed time of 979 minutes.

In this scenario, the four-vehicle convoy would have a footprint of 186 meters. Measuring the time required to travel the entire route and adding the time required to travel the length of the convoy equals the time from the first vehicle leaving through to the last vehicle arriving, approximately 752 minutes (40 km) and 1,505 minutes (20 km).

The fuel requirements for this delivery are displayed below in Figure 25.

**Figure 25: Fuel Requirements- 15,900 kg (Combat Team)**




Based on the delivery requirements, the airdrop mission would consume approximately 1,205 l. of fuel. This is approximately 40% of the fuel required by the CH-147Fs (3,003 l) and 31% of the total fuel required by the airland flight (3,907 l). The ground convoy would consume approximately 64% of the total fuel required by the airdrop.

As described earlier, the airdrop load would require approximately 16 bundles. This would require a DZ with a length of 750 m. (total area 150,000 $m^2$). For simultaneous delivery by the CH-147F, an LZ with a minimal area of 15,708 $m^2$ would be needed (though simultaneous delivery may not be required).

**Simulation 5**
Halifax (CYHZ) to Sydney (CYQY);
Battle Group (750 Personnel); 47,700 kg.

| Mode | Airdrop | Airland | Ground |
|---|---|---|---|
| Distance (km) | 306 | 306 | 391 |
| Vehicles (delivery) | CC-130J: 3 | CH-147F: 5 | AHSVS: 4 |
| Vehicles (escort) | n/a | CH-146: 2 | LAV III: 2; RG-31: 0 |

A 750 person "Battle Group" requires 47,700 kg of supplies for a single day.[19] Based on the scenario, the delivery of this load would require 3 CC-130Js, 5 CH-147F, or 4 AHSVS. The resupply times are displayed in Table 6.

**Table 6: Resupply Time- 47,700 kg (Battle Group)**

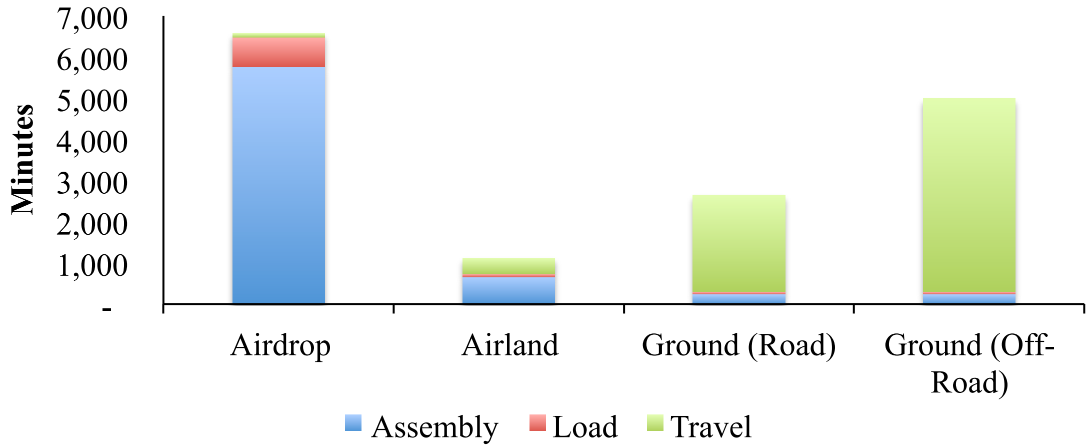
| Activity | Airdrop | Airland | Ground (Road) | Ground (Off-Road) |
|---|---|---|---|---|
| Assembly | 5,760 | 660 | 240 | 240 |
| Load | 720 | 75 | 60 | 60 |
| Travel | 99 | 381 | 2,346 | 4,692 |
| Operational Time | 819 | 456 | 2,406 | 4,752 |
| Elapsed Time | 273 | 151 | 647 | 1,234 |
| Total Time | 6,579 | 1,116 | 2,646 | 4,992 |

The assembly of the airdrop load requires approximately 5,760 minutes (based on model parameters). This is longer than the *Total Time* required by the other modes to complete the entire delivery. The *Operational Time* of an airdrop is 819 minutes, approximately 34% of the time required by a convoy travelling on "good" roads and 17% of the time required by the same convoy travelling on "off-road" conditions. The airland delivery

[19] Alternatively, this could also represent 3 days of supplies for a Combat Team.

would be completed in 56% of the *Operational Time* required by the airdrop mode. The resupply times are presented in Figure 26.

**Figure 26: Total Time- 47,700 kg (Battle Group)**



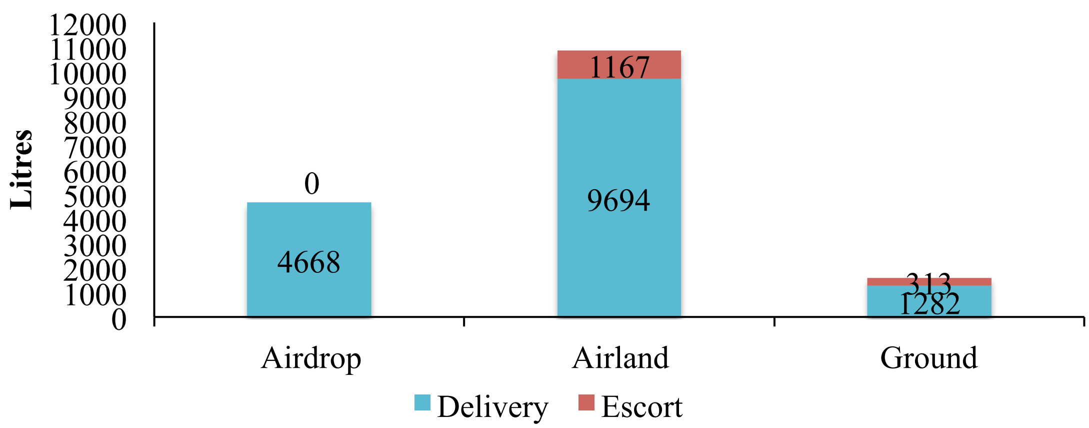

The Elapsed time of the airland delivery would be approximately 151 minutes, split evenly between Load and Travel (approximately 75 minutes).

Based on the distance of the delivery and the length of the road convoy (6 vehicles, 307 meters), it would take approximately 587 minutes (travelling by road) or 1,174 minutes (based on off-road conditions) for the entire convoy to travel the delivery route. Overall, this would result in Elapsed delivery times of 647 minutes (road) and 1,234 minutes (off-road).

The Elapsed time of the Airdrop is approximately 273 minutes, 88% of which consists of Load time. The Travel time during this delivery is 33 minutes. Comparatively, the Elapsed time of an airland delivery is approximately 55% that of the Elapsed time required to complete an airdrop. Based on Elapsed time, an airdrop can be completed 374 minutes faster than a ground convoy traveling by road and 961 minutes faster than a ground convoy traveling off-road.

Figure 27 displays the fuel requirements for the simulated delivery.

**Figure 27: Fuel Requirements- 47,700 kg (Battle Group)**



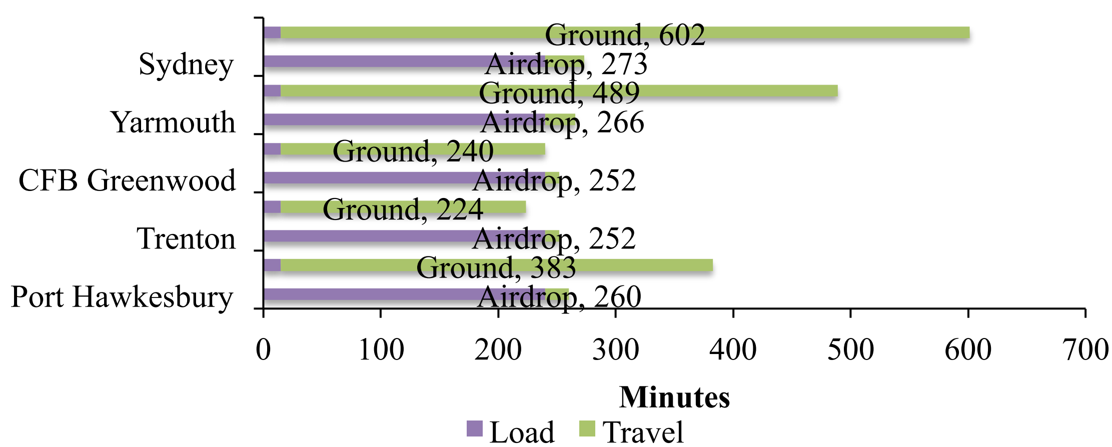

The airdrop delivery consumes nearly 3 times the fuel used by the 6-vehicle ground convoy. Conversely, the CC-130J requires only 43% of the total fuel consumed by the 7-aircraft "flight" delivering by airland.

Based on the simulated load, an airdrop delivery would consist of 48 bundles (delivered by 3 CC-130Js). The size of the DZ would depend on the layout and would require, at the minimum, an area of 310,000 $m^2$. Depending on the sequence in which the airland vehicles deliver their loads, an LZ with an area of 39,270 $m^2$ could be required.

**Extended Theatre**

As displayed in the previous simulations, despite airdrop having a longer *Load* time compared to the ground convoy (240 min vs. 15 min, based on single vehicles), the *Travel* time is quite shorter (in comparison) due to the operating speed of the CC-130J (556 km/hr vs. 20-40 km/hr, based on road conditions). A comparison of the *Load* and *Travel* times for the airdrop and ground delivery methods, based on the distances used in the simulations is displayed below in Figure 28.

**Figure 28: Operational Time Comparison (Airdrop and Ground, Single Vehicle)**




Based on the simulation delivery locations, in only two cases was it faster to deliver by ground than by airdrop (Trenton, CFB Greenwood). Based on the compared *Load* times, the ground convoy has a 225 minute "head-start" over the airdrop delivery (based on single vehicle loads) which would result in the ground convoys (travelling by road) covering 150 km before the CC-130J took off. In the two cases in which it was faster to travel by ground, each of the locations were less than or equal to the distance traveled by the convoy while the aircraft was being loaded, (Trenton- 139 km, CFB Greenwood- 150 km).

In reducing the logistics footprint of the CF, major depots, warehouses, and inventories could be centralized in the theatre of operations or pushed back even further (such as the port of disembarkation), with the combined speed, range, and capacity of airdrop making up for the longer distances. Based on the previous section, the origin used for the deliveries in the scenario was located within the same province as the final destinations. Although this is similar to the CF operations in Kandahar province, other situations may arise where delivery is required in neighboring provinces or where an airfield is not available either within province or within country. This was the case before the establishment of the JTF Afghanistan Air Wing (Task Force Silver Dart) at Kandahar Airfield in 2008 (Canada, 2009). Prior to this, the Tactical Airlift Unit (Task Force Canuck) was operating from Camp Mirage, an "undisclosed" forward logistics facility widely believed to be located at Al Minhad Air Base in Dubai, UAE. Flying from this location to Afghanistan would require a route over the Gulf of Oman and into Pakistan in order to avoid Iran.[20]

In continuing to apply Canadian locations to the simulation model, the travel times between Halifax and airports in Newfoundland, New Brunswick, and Ontario are listed in Table 7 and a map is provided in Appendix 33.

[20] A basic route traveling from Minhad AB to KAF via Gwadar and Turbat Pakistan is approximately 1,485 km. The actual distance based on the route(s) used by the CF may be different.

**Table 7: Air Distance and Travel Time to Halifax (CC-130J)**

| Origin | Distance (km) | Time (min.) |
|---|---|---|
| St. John's, NL (CYYT) | 882* | 95 |
| Fredericton, NB (CYFC) | 261* | 28 |
| Ottawa, ON (CYOW) | 958 | 103 |
| Toronto, ON (CYYZ) | 1,292 | 140 |
| Sault Ste. Marie, ON (CYAM) | 1,642 | 177 |
| Thunder Bay, ON (CYQT) | 2,005 | 217 |
| *Distance permits a "larger" load, based on model parameters | | |

Despite the long distances between the locations in Table 7, the CC-130J is still able to complete the trip in a (relatively) short time. Table 8 compares the *Travel* times between CC-130J flying airdrop deliveries starting at the origins listed previously and ground convoys traveling from Halifax.[21]

**Table 8: Extended Theatre Travel Time Comparison (Single Delivery Vehicle)**

| MINUTES | Port Hawkesbury | Trenton | CFB Greenwood | Yarmouth | Sydney |
|---|---|---|---|---|---|
| **Halifax** | 20 | 12 | 12 | 26 | 33 |
| **St. John's** | 116 | 107 | 107 | 121 | 128 |
| **Fredericton** | 48 | 40 | 40 | 54 | 61 |
| **Ottawa** | 124 | 115 | 115 | 129 | 137 |
| **Toronto** | 160 | 151 | 152 | 165 | 173 |
| **Sault Ste. Marie** | 198 | 189 | 189 | 203 | 210 |
| **Thunder Bay** | 237 | 248 | 260 | 286 | 319 |
| **Ground (Road)** | 368 | *209* | *225* | 474 | 587 |
| **Ground (Off-Road)** | 735 | 417 | 450 | 948 | 1,173 |

[21] The air routes have been directed through Halifax (e.g. Ottawa > Halifax > Port Hawkesbury). Although this may add additional travel time, it was thought that it may provide easier comparison with previous tables and figures (that calculated the delivery origin from Halifax).

In comparing the *Travel Time* between modes, the CC-130J (based on the model parameters) is able reach delivery locations quicker then ground units, even when starting at locations outside of the (simulation) area of operations. For example, a CC-130J leaving from Thunder Bay traveling to Port Hawkesbury, (2,193 km) could complete the trip in 237 minutes, while an AHSVS leaving from Halifax and traveling by road (245 km) would require 368 minutes. In only two cases would the ground convoy travel faster (traveling by road from the NSE to Trenton and CFB Greenwood).

Although airdrop (using the CC-130J) is able to travel faster than ground based convoys, it also takes longer to load (as displayed previously). A comparison of the Operational Times using the alternative delivery origins is presented in Table 9.

**Table 9: Extended Theatre Operational Time Comparison (Single Delivery Vehicle)**

| MINUTES | Port Hawkesbury | Trenton | CFB Greenwood | Yarmouth | Sydney |
|---|---|---|---|---|---|
| **Halifax** | 260 | 252 | 252 | 266 | 273 |
| **St. John's** | 356 | 347 | 347 | 361 | 368 |
| **Fredericton** | 288 | 280 | 280 | 294 | 301 |
| **Ottawa** | 364 | 355 | 355 | 369 | 377 |
| **Toronto** | 400 | 391 | 392 | 403 | 413 |
| **Sault Ste. Marie** | 438 | 429 | 429 | 443 | 450 |
| **Thunder Bay** | 477 | 488 | 500 | 526 | 559 |
| **Ground (Road)** | 383 | 224 | 240 | 489 | 602 |
| **Ground (Off-Road)** | 750 | 432 | 465 | 963 | 1,188 |

Based on Operational Time (Load and Travel), airdrops leaving from locations outside of the theatre of operations can still complete deliveries ahead of ground convoys traveling within the theatre. The primary exceptions are the loads traveling by road to Trenton and CFB Greenwood. As described earlier, the distance travelled by the ground convoy can be complete during the period that the aircraft is being loaded. However, this applies primarily to loads traveling by road. If travelling off-road, in many cases an airdrop can be delivered ahead of the ground convoy.

Although the CC-130J can travel great distances (compared to other means of transportation), it does so at the expense of fuel. When traveling from the same starting location in the simulations (Halifax), based on the routing an AHSVS would consume roughly 21% of the fuel required by the CC-130J to reach the same destination. Travelling from locations located outside of the theatre of operations would require additional fuel. Table 10 displays the fuel requirements for deliveries originating outside of the theatre of operations.

**Table 10: Extended Theatre Travel Fuel Comparison (Single Delivery Vehicle)**

| Fuel (L) | Port Hawkesbury | Trenton | CFB Greenwood | Yarmouth | Sydney |
|---|---|---|---|---|---|
| **Halifax** | 956 | 549 | 564 | 1,205 | 1,556 |
| **St. John’s** | 5,440 | 5,034 | 5,049 | 5,690 | 6,040 |
| **Fredericton** | 2,283 | 1,876 | 1,891 | 2,532 | 2,883 |
| **Ottawa** | 5,827 | 5,420 | 5,435 | 6,076 | 6,427 |
| **Toronto** | 7,525 | 7,118 | 7,134 | 7,774 | 8,125 |
| **Sault Ste. Marie** | 9,305 | 8,898 | 8,913 | 9,554 | 9,905 |
| **Thunder Bay** | 11,150 | 11,699 | 12,264 | 13,469 | 15,025 |
| **Ground** | 201 | 114 | 123 | 259 | 321 |

Depending on the origin, the fuel required to deliver by airdrop can increase significantly (compared to delivering from within province). For example, a CC-130J travelling from Halifax to CFB Greenwood consumes approximately 564 litres of fuel. Starting from Fredericton adds an additional 261 km to the trip (approximately 28 minutes of flight time), but consumes 1,891 litres of fuel. The greater distances add fuel constraints and reduce cargo capacity. However as a consideration, these locations may be able to offer secure fuel sources.

On a performance basis, it appears that airdrop could provide replenishment and resupply for ground forces from centralized locations outside of the theatre of operations while maintaining travel times that are similar, if not better than ground based transport traveling within theatre. However, the performance would depend on the size of the load and the number of vehicles required (i.e. the Load time). Based on this, it appears that forward warehouses/depots could be eliminated and airdrop could be used without loss of delivery performance, promoting a zero-footprint strategy, though at the cost of greater fuel consumption.

**Qualitative Analysis**

Although it appears that airdrop can be used to reduce the forward supply "footprint", from a quantitative standpoint, additional qualitative research (primarily in the form of interviews) was conducted in an effort to examine if this was a sound strategy or if there were other considerations that did not appear in the quantitative models. The qualitative analysis focused primarily on the CF "Fundamentals of Sustainment" (described below) along with additional issues that were raised during the interview process.

**Fundamentals of Sustainment**

The Canadian Forces promotes six fundamentals in sustainment planning and operations. These fundamentals are treated as guidelines rather than rules in the sustainment process and are universally held by the three Canadian military branches (Canada, 1999; Canada, 2011). These fundamentals, *Foresight*, *Economy*, *Flexibility*, *Simplicity*, *Co-operation*, *Self-sufficiency*, should be considered in the development of a sustainment operation, plan, or technique. For the purpose of this thesis, the airdrop process has been separated into four sections; Plan, Prepare, Deliver, and Receive. Each of these sections will be compared against the six fundamentals from the perspective(s) of the personnel involved in each process.

<u>Foresight</u>

How much lead-time is needed to implement a plan or operation? The length of the time needed to arrange and/or carry out an operation can limit the options available to a commander or planner.

<u>Economy</u>

How much does an operation cost to carry out? While this may include financial costs (e.g. fuel, maintenance costs, etc.), it also considers the maximum utilization of resources (vehicles, personnel, etc.), while minimizing wastes such as excess inventories, empty/deadhead moves, and backhaul/reverse transportation.

Flexibility
Can a system respond to change? "Rigid" planning may limit options available to planners and commanders and may fall apart when encountering unforeseen circumstances in the field. Flexibility in a sustainment system may refer to the ability to adjust delivery times and/or destinations.

Simplicity
Flexibility is facilitated by simplicity. Simple, yet flexible plans will withstand shock and have a greater chance of success (Canada, 1999).

Co-Operation
A combat /military environment consists of many different units. The ability for these units to co-operate is critical to success at the unit, tactical, and strategic levels. This could include co-operation between logistics and combat arms, between services (e.g. Army, Air Force, Navy), and national militaries (e.g. Canada and the United States).

Self-Sufficiency
Self-sufficiency reduces the need for additional units and equipment, which may be in low supply or high demand. By promoting self-sufficiency, planners can maintain simplicity and flexibility.

**Plan**
In order to properly supply CF units, Logistics Officers work with various CF staff to develop adequate logistics plans and strategies. CF logistics uses a "Push" and "Pull" replenishment system. Based on basic operational information (e.g. number of personnel, weapon stocks, type of operation, etc.), logistics planners can estimate the amount of "combat" supplies (e.g. food, water, ammo, etc.) that will be needed and "push" these loads out to the units. However, as it is described in the CF Land Force Sustainment

manual "no matter how sophisticated the push technology becomes, the unexpected will always occur on the battlefield" (Canada, 1999). In these situations, unit demand will "pull" supplies from inventory. The CF logistics system will then coordinate the delivery of the load to the final destination.

Foresight

Due to the limited number of available air assets, aerial resupply required additional time to plan and arrange. As one Army Captain serving as logistics officer described, "Foresight was a big, big thing in the use of any kind of air (fixed-wing) or aviation (rotary-wing) asset, more than ground convoys." In addition to the aircraft and aircrews, another consideration that required advanced planning was for finding an appropriate DZ (see also *Receive)*. Due to requirements based on size and geography containing limited obstacles (e.g. mountains, water, settlements, etc.) establishing an adequate delivery point could prove problematic and require additional planning and foresight.

Economy

From the perspective of an Army logistician, aerial resupply seems to provide an economy of effort as fewer vehicle assets (e.g. 1 CC-130 vs. convoy of vehicles) and fewer personnel (e.g. flight crew of 3 vs. personnel needed to drive, defend, and clear the route). However, as described previously, flight hours in Afghanistan were at a premium and their use needed to be prioritized (regarding mission selection).

Flexibility

Logisticians must not only schedule the delivery of supplies, but must also coordinate the backhaul traffic from deployed units. Often these loads include personnel, damaged vehicles and equipment, and waste that cannot be disposed of in the field. Road convoys traveling to CF units can provide backhaul capacity for these loads. As well, the convoys can provide protection to vehicles that would otherwise need to make this journey (e.g. recovery vehicles). As airdrop is a one-way delivery (backhaul cannot be loaded), some logisticians view this as a limit on flexibility.

Simplicity

An Army Captain referred to simplicity as "trying to be as simple as possible, so we don't need so much coordination with everyone else". The officer noted that in his experience that although logisticians were interested in trying airdrop, it was a big effort. Alternatively, they thought that road convoys were probably the easiest delivery solution, in part because it was the method that they trained with the most.

Co-Operation

Although airdrop requires the Army to use Air Force assets, both elements are able to coordinate easily together. In Afghanistan, Army logisticians worked with Air Force air and aviation planners in blended units for developing delivery plans at the tactical level. In addition to co-operation within the CF to carry out resupply operations, CF units also co-operate with other countries. In addition to road convoys, Canada and its allies would share flight hours. This included Canadian airdrops to Dutch units during Operation Mountain Thrust in 2006. Although the allies are able to co-operate and coordinate resupply operations, one officer noted that in non-emergency cases "at the end of the day if there's a (scheduling) conflict between you and another nation, they will take care of their own people first".

Self-Sufficiency

As described previously, air assets in Afghanistan were in high demand by Canadian and (in some cases) allied forces. As a result, these assets were often controlled at the highest command levels (e.g. Divisional) in order to establish priorities. Lower command levels (e.g. Company) could not necessarily depend on these assets being available. However, units at this level (Company) had the capacity (i.e. assets and ability) to operate their own ground convoys. As one Captain (Army) explained, “ground convoys, we own them, they’re controlled by local commanders, and they’re pretty easily re-routable and easily taskable on short notice”.

**Prepare**

Basic Aerial Delivery

The preparation, assembly, and recovery of airdrop loads is taught through a 14-day course at the Canadian Forces Land Advanced Warfare Centre (CFLAWC) (Canadian Forces Land Advanced Warfare Centre, 2012a). During this course, students are taught how to build a variety of loads from the ground up (i.e. building the platform, strapping the load, and applying the parachute). Although the course was originally directed towards Traffic Technicians, over the past several years there has been an increase in mixture of trades attending. This has included combat specialists (e.g. infantry, artillery, etc.), support, and naval personnel. In addition to the Traffic Technicians (and members who have completed the Basic Aerial Delivery course), Parachute Riggers also serve a key role in the preparation of airdrop loads (see below).

Parachute Riggers

In the process of aerial delivery, a major role is found in that of the *Parachute Riggers*. All parachutes used in the delivery of Canadian Forces personnel and cargo are packed and maintained by parachute riggers or “Riggers”[22]. Every parachute in the CF

[22] Excluding the parachutes found in RCAF ejection seats.

inventory goes through the Parachute Depot at the CFLAWC in CFB Trenton, where they are tested, maintained, packed, and warehoused until they are needed. After their use, parachutes and airdrop equipment are shipped back to the Parachute Depot for inspection, maintenance, and repacking by the riggers. Parachute rigging is a full-time specialty within the *Supply Technician* MOC[23]. Currently, every rigger is airborne qualified and undergoes nearly 3 years of training and apprenticeship to learn the skills of parachute packing, maintaining, and quality control/supervision.

In addition to parachute packing and maintenance at the Parachute Depot at the CFLAWC, riggers are also assigned throughout the Canadian Forces, working in the search and rescue (SAR) squadrons, light infantry airborne companies (RCR, R22eR, PPCLI, QOR), and special operations units (CSOR, JTF2). In these units, the role of the parachute rigger has been expanding to include cargo delivery in additional to personnel delivery. In addition to packing and maintaining parachutes, these riggers are becoming aerial delivery subject experts specializing in aerial delivery load preparation (both parachute and helo-sling) and drop zone coordination (planning and operation). To handle these expanding responsibilities, the parachute rigger training course is in the process of adding an additional 12 months of training and apprenticeship in aerial delivery and the preparing of loads. To more appropriately classify these riggers, the current positions of field riggers and technical quartermasters will be re-designated as *Airdrop Technicians*.

[23] Military Occupation Code

Foresight

Although it depends on what is being dropped, loads can be assembled fairly quickly. Although as one instructor noted, “the more lead time, the better”. Another consideration (regarding *foresight*) is having the available personnel with the technical skills to assemble aerial delivery loads. In the past, there were some problems with having enough personnel with the required skill set. However, with the increased attendance of the basic aerial delivery course, the occurrence of this issue may be reduced.

Economy

Training a variety of trades in basic aerial delivery and load assembly helps maximize the economy of personnel. An example of this may be found in the use of Transportation Technicians in the assembly of airdrop loads. These technicians prepare the loads moved by all modes of transport in the CF (though airdrop and helicopter slinging are special skills). During operations where airdrop is not being used the technicians will still be utilized in a variety of functions. It should be noted that although personnel may be trained in aerial delivery, without frequent use these skills (like any skill) can diminish. Personnel in a “dedicated” role (such as *Airdrop Technicians*) may be able to provide a level of expertise that will ensure success.

Flexibility

Although some heavy items in the CF inventory can provide challenges and some “dangerous” goods require additional care, most supply items in the Canadian Forces inventory can be prepared and delivered by airdrop.

Simplicity

Due to the nature of airdrop (i.e. dropped off the back of an airplane vs. carried on a truck), preparing loads is a more "involved" process.[24] However as an instructor described, this does not mean it is a complicated process. The technique for assembling loads has been standardized and documented. Personnel can reference the necessary manuals to safely assemble loads for airdrop.

Co-Operation

The personnel trained to assemble aerial delivery loads work to a common method and standard (both within the CF and NATO). This allows for co-operation between units and services.

Self-Sufficiency

Based on the structure of the CF supply system, the assembly of aerial delivery loads is largely a self-sufficient process.

**Delivery**

The Canadian Forces aerial delivery role is primarily conducted by CC-130. Previous models of CC-130 (legacy models) require a five-person flight crew (pilot, co-pilot, navigator/air combat systems officer, flight engineer, loadmaster).[25] Canada's newest Hercules, the CC-130J Super Hercules, has replaced the navigator and flight engineer with computerized systems, requiring two pilots and a loadmaster to carry out flight operations.

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[24] Alternatively, the *Basic Land Helicopter Operations* course which covers the rigging of loads for helicopter slinging operations is taught over 5-days at CFLAWC (Canadian Forces Land Advanced Warfare Centre, 2012).

[25] With the acquisition of the J-model, Canada's "legacy" models are being moved to fill support roles in the Search and Rescue squadrons.

Pilots

Aerial delivery is part of the CC-130J six-month pilot training program carried out by the Canadian Forces, with the vast majority of pilots qualified to conduct aerial delivery operations (though there are some exceptions). Pilots must re-qualify semi-annually by performing a minimum of two drops over a six month period. During aerial delivery operations, pilots are involved in the planning and delivery of the load. The aircrew receives a request from the end user detailing the location and delivery time needed by those on the ground.[26] Based on the delivery demands and the environmental parameters (e.g. elevation, terrain, obstacles, enemy threats, etc.), the aircrew will work backwards to develop a flight plan. During the flight, aircrews will follow the flight plan using the aircraft's flight management system, while providing updates to adjust for conditions. With the aid of these systems, CF aircrews can generally deliver loads within a 15 second window of requested delivery times, though this can be pushed to an outer limit of 2 minutes. Once the aircraft is in the drop-zone envelop, the load release process can be initiated either by the pilots or through an automated process by the aircraft (following the activation by the pilots). Typically, aircrews will allow the automatic system to handle the release, in order to focus their attention on flying the aircraft as it is in a critical stage with an increased vulnerability (e.g. lower altitude, lower speed, etc.).

Loadmasters

Canadian Forces loadmasters are specialized traffic technicians who help ensure the efficient operation of the aircraft. Training for loadmasters assigned to the CC-130J takes place over a six-month period, where the students are taught all aspects of the aircraft in

[26] Delivery requests would normally be submitted to the proper organization depending on the theater of operations. Most likely, this would be through a squadron or air-wing.

both the tactical and strategic functions (previously, loadmasters went through a basic course, followed by on the job training, and then completed a specialized tactical or strategic air course). Similar to pilots, loadmasters must maintain their aerial delivery qualifications. Loadmasters carry out a variety of jobs throughout the aerial delivery process. Prior to takeoff, loadmasters inspect the cargo ensuring that the loads are both secure for flight and rigged for proper release. Loadmasters also make sure that the aircraft is properly balanced, both with the cargo and the fuel load. During the flight, loadmasters monitor fuel management to maintain the balance of the aircraft, while also acting as additional spotters. Loadmasters have also taken up some of the responsibilities previously held by the flight engineer on the legacy model CC-130[27]. During the aerial delivery phase, loadmasters will inspect the load to confirm it's ready for release, and enter data into the flight computer for the release. Although the release is automatic, loadmasters are on-hand to handle any faults or malfunctions that may arise and can carry out the release manually if required.

Foresight

From the perspective of the pilots, the planning cycle can be as little as four hours (from the time they receive the initial information to going airborne). The time required to plan a delivery can increase due to the surrounding operating environment. One CF Pilot reported that the planning of a mission in Afghanistan could take 12 hours, due to the amount of coordination required to guarantee a safe and protected airspace, however

[27] Although the CC-130J is designed to operate with a single loadmaster, some missions require multiple crewmembers. In some cases, squadrons have employed two loadmasters (generally pairing a new and "seasoned" loadmaster together), which has promoted both training and efficiency.

depending on the circumstances, “Things can happen quickly”. In general, loadmasters budget 4 hours to prepare the aircraft for tactical missions, such as airdrop (alternatively, 3 hours are budgeted for strategic airlift operations). During this time cargo is loaded, rigged, inspected and the preflight of the aircraft is conducted. Although 4 hours is used as a gauge for a single loadmaster, teams of loadmasters can work through a checklist faster.

Economy

As described by a CF pilot, “the aircraft (CC-130) is a finite resource, along with the personnel that operate and maintain it”. Between June 2010 and May 2012, Canada received 17 new J-model aircraft. These aircraft are responsible for a variety of tactical and strategic airlift missions, in diverse domestic and international environments (e.g. CFS Alert resupply, DART humanitarian aid, etc.). During Canada’s operations in Afghanistan, the Tactical Airlift Unit (Task Force CANUCK) of the Joint Task Force Afghanistan Air Wing (Task Force SILVER DART) consisted of 3 Hercules’ (initially “legacy” models, which were replaced with “Super” J-models as they were delivered). Prior to the purchase of the CC-177 Globemaster III, Canadian CC-130’s carried out strategic airlift between Camp Mirage (the Canadian forward logistics facility in Dubai) and Afghanistan, serving as the primary means of getting into and out of Afghanistan. With the introduction of the CC-177, the CC-130 began expanding its intra-theater role, providing transportation of personnel and equipment of all of the NATO allies throughout Afghanistan. With a limited number of aircraft, aircrew, and available flight hours, missions required prioritizing with the most important being carried out. Aircraft also require a number of personnel and crews to service and operate them. Initially, the Afghanistan Air Wing consisted of 200 personnel who were deployed with Task Force

Canuck (CC-130), Task Force Erebus (CU-170 Heron UAV), and the Theatre Support Element (Canada, 2009). This later grew to 450 personnel with the introduction of Task Force FAUCON, operating 6 CH-147 (Chinook) and 8 CH-146 (Griffon) helicopters (Canada, 2009). As a comparison, the Managed Readiness model lists a support section of 283 logistic soldiers to support an infantry battle group of 641-655 soldiers, (though some have questioned the accuracy of the managed readiness model) (Conrad, 2009).

Flexibility

Based on current CF guidelines, aerial delivery may offer a limited level of flexibility from the flight crew perspective. Flight crews deliver to pre-determined drop zones that have been inspected ("recceed"), laid out, and are manned by a drop zone controller (see *Receive*). A CF Pilot noted that delivering to a site that has not been pre-defined involves an "element of risk" (such as property damage) and that the aircrews "like to work within defined constraints to minimize risk". However, it was noted that in extreme situations where lives were at stake, it would be possible to deliver to a drop zone that has not been pre-determined. This is in contrast to other delivery methods such as helicopters and ground convoys, which can adjust delivery routes and locations while in transit to meet delivery needs.

Simplicity

From the perspective of the aircrew, the aerial delivery process is not a complex operation, but rather a "deliberate" operation. One CC-130 pilot noted that although airdrop has a general perception of high risk it is actually a lower risk then an airland mission, describing the simplicity of the airdrop process, *The visibility is a little bit higher because it seems like it is a complex mission, but from our perspective where we do this on a regular basis, it is not. It's a mission that we have been doing for a very long time and we will continue to do it into the future. It's certainly not something that needs to be made into something that appears to be bigger then it actually is.*

Co-Operation

Aerial delivery often requires co-operation between the RCAF delivering and the crews (primarily Army) on the ground receiving. However, the techniques and training that are used are universal among all of the CF branches. At an international level, aerial delivery techniques are fairly standardized among the NATO partners, which allows Canadian crews to deliver to "foreign" recipients.

Self-Sufficiency

As described earlier in the "Economy" section, specialized crews and equipment operate and maintain the aircraft. In addition, during long deployments spare parts and equipment are kept in inventory to ensure that aircraft keep flying. During cases where spares were unavailable, they often would need to be sourced from Canada (though parts may be available in theater through allied forces).

**Receive**

DZ/LZ Controller

To carry out aerial resupply, a Drop Zone (DZ)/Landing Zone (LZ) Controller is required. Controllers are CF soldiers who have received additional training in DZ/LZ operations at the CFLAWC. The five-day course instructs the controllers in the Recce, selection, layout, marking and controlling of DZ and helicopter LZ, as well as marking and controlling "austere" airstrips for tactical air landing operations (Canadian Forces Land Advanced Warfare Centre, 2012b).

Foresight

As described above, in order to conduct aerial delivery operations, specially trained soldiers (DZ/LZ Controllers) are needed. If soldiers lack this training, aerial delivery operations cannot be carried out. DZ's require advanced scouting (recce) and proper distance and bearings must be mapped out and registered with the planners. Alternatively, a helicopter LZ can be assessed rather quickly focusing on the approach and ensuring proper rotor clearance. An infantry officer (Major) also noted "it (aerial delivery) often takes more hours to coordinate between units than it would for a ground resupply".

Economy

During aerial resupply operations, the DZ/LZ may require defending. Given the potential size of a DZ (80,000-190,000 $m^2$), the number of soldiers needed to perform security could be larger than those required to protect an LZ. Due to the need to recover and salvage the delivery equipment (e.g. parachutes, platforms, etc.) used in an airdrop, rearward units must move forward. During this transit, troops are used to guard the equipment, though it was noted, "the use of troops to guard this equipment takes away from the unit's fighting strength".

Flexibility

The use of aerial delivery provides flexibility to the ground units being resupplied. As one officer noted, "Aerial delivery provides the commander with the flexibility of adapting to the ever changing battlefield. Aerial resupply can allow the commander to push forward through a weakened enemy before they have time to reorganize".

In establishing a resupply area, a helicopter LZ offers more flexibility than a DZ. As an instructor described, "You've got a drop zone and that's where you've got to drop because it has to be pre-registered and you have to make sure it's big enough for what you're dropping. Helicopter, as long as it can get in safely, which you can determine pretty quickly by just looking, it's a lot more flexible".

Simplicity

As described previously, the use of airdrop requires specially trained personnel and advanced planning to locate and organize a DZ. Although these can provide challenges (compared to other delivery methods) the delivery process does not appear to be "complex". One officer explained, "Once trained and proficient, resupply by parachute is no more difficult than being resupplied by other means".

Co-Operation

Training is designed to allow both Army and Air Force units to work together, however this may not be without challenges. As an Army officer described, "When working with any unit other than your own, there may be challenges. Every unit has their own operating procedures. Once the coordination has been done, these challenges are lessened over time". From a further "standpoint" (in-terms of co-operation), the courses taught at the CFLAWC (in aerial delivery) are standardized to allow the students to operate with all the members of NATO.

Self-Sufficiency

In regards to delivery, one officer suggested, "the use of ground transport would require less coordination as most units have a means of transporting equipment internally". In addition to DZ/LZ Coordinator skills required to conduct an aerial delivery operation, special consideration may be needed in recovering the load. As an officer explained "Trained soldiers are required to recover equipment and supplies. Training these soldiers is the only challenge associated with aerial resupply". Depending on the size of the load, recovery equipment (such as cranes, zoom-boom loaders, etc.) may be required.

**Considerations**

Based on delivery performance, airdrop could be used to reduce the logistics "footprint" of CF operations. With the centralization of inventories, CC-130 aircraft can travel the extended distances, while matching (and beating) the delivery performance of other modes based within the Theatre of Operations. However, there are several factors that limit the practicality and ability of using airdrop as a primary means of resupply.

**Aircraft**

As several personnel described, the availability of aircraft can prove to be a challenge in aerial resupply operations. Due to limited availability and high demand for aircraft in Afghanistan, command (e.g. planning and scheduling) was held at a higher level, which reduced self-sufficiency and flexibility, and required additional foresight for aerial resupply operations. The demand for aircraft is not limited to those in theatre. CF aircraft and aircrews are needed for a variety of operations (e.g. airlift, SAR, aerial refueling, etc.) in foreign and domestic locations. To increase the availability of aircraft for aerial resupply operations, the CF might consider outsourcing airfreight to private contractors.

The CF has a history of contracting aircraft services. Previously, the CF has rented aircraft and aircrews for strategic lift (e.g. AN-225 and AN-124 were used to augment CC-130 and CC-150 to deliver DART and relief supplies to Pakistan during Operation Plateau in 2005) (Bridges, 2005) . In Afghanistan, the CF chartered 2 types of medium-lift helicopters to transport troops and supplies. In November 2008, six Mi-8 helicopters and crews were chartered from Skylink, a Canadian air charter group, which were joined several months later by (newly) CF-owned CH-147D in January 2009 (Canada, 2009). In addition, Canada leased several MI-17 helicopters and trained CF flight crews to operate them (Tories mum on Russian choppers lease.2010).

As the DND has contracted aerial services before, it might consider contracting airdrop delivery from private aviation firms. The United States has augmented its delivery capability in Afghanistan and Iraq with the use of private contractors. Early in the development of LCLA delivery, flights in Afghanistan were piloted by Blackwater Corp (now Academi) pilots flying CASA 212 aircraft (Peterman, Narowski, Litynski, & Clouse, September 2007) . Even as LCLA became certified on various military aircraft (e.g. UH-60, CC-130, CH-53, etc.), delivery opportunities for private contractors remained available.

Contracting air services for airdrop operations may offer some benefits to the CF. Contracted services would free CF air equipment for other operations. Contractors may be able to provide specialized services that may be unavailable through the CF. Contracting and/or leasing may also be a cost effective strategy (as opposed to using CF aircraft and crews). Ultimately, further investigation would be required to determine if this strategy would be appropriate for the CF in an effort to expand aerial delivery capability.

**DZ, LZ, Convoy Footprint**

Based on current Drop Zone (DZ) protocol, airdrops can potentially create a large footprint. As explained in the *Quantitative Analysis* chapter, the minimum area required for the delivery of a single airdrop bundle is 80,000 $m^2$ (200m x 400m), while the delivery of a full CC-130J (24 bundles) would require a minimum DZ of 190,000 $m^2$ (200m x 950m). In addition to the size of the DZ "footprint", DZ's have other requirements. The CF DZ/LZ Controller's Handbook notes that in selecting a DZ, a detailed reconnaissance (reccee) must be conducted where factors such as terrain, water, and "hazards" must all be considered (Canada, 2008). In Afghanistan, the terrain varied and in some provinces, presented few suitable locations for airdrops. In addition to natural features that presented obstacles, man made features and civilian populations were also hazards. Errant loads can cause damage to property and potentially injure civilians, serving as a source of animosity between locals and Canadian troops. As one CF officer explained from their experiences in Afghanistan, "So you had to be really careful about all weapons and all things falling out of the sky because it would be easy for a load, for example, to come through the roof of someone's house and kill somebody. So you would have to be careful of where you can drop these things and the risks of the civilian population and things like that." One officer described the limited availability of DZs as "one of the biggest show stoppers for the use of aerial delivery." The officer went on to explain, "if you drop it there once (a resupply), well more likely you're not going to be able to drop it there twice because then there's going to be trouble with IED's and stuff". This is due to the need for identifying and marking DZs in advance. If the local population views a group of soldiers surveying out a field and the next day a plane appears to conduct an airdrop, the next time soldiers are surveying the same field, the local population can advise insurgents of what will be arriving based on previous activity. To increase the potential utilization of airdrop, the size of DZs may need to be reduced. There may be two potential ways of doing this, using technology and technique.

Technology:

The Joint Precision Airdrop System (JPADS) is a steerable parachute system that uses GPS and a variety of sensors to direct the load to its destination. Although the accuracy of JPADS is classified, industry representatives have claimed, "the parachute systems land within 150 meters of their target in 80 per cent of airdrops" (Knoll, 2008) . The precision of these systems could greatly reduce the required size of DZs. One company, Airborne Systems, has developed a series of JPADS platforms that can carry loads weighing between 100-42,000 lbs. (MicroFly, FireFly, DragonFly, 2K1T, and Flyclops Guided Precision Aerial Delivery Systems) (Airborne Systems, 2013). In addition to accuracy, these systems provide additional safety to aircraft and flight crews. Currently, CF CDS airdrops are conducted at altitudes between 400-1,000 ft., while the GPADS platforms can be dropped from altitudes of 25,000 ft. (Airborne Systems, 2011) . One CF pilot observed that flying at higher altitudes provided flight crews with a greater level of flexibility and safety then flying at lower altitudes where more attention must be focused on potential threats and obstacles. In addition to dropping from higher distances, crews can also drop further from the DZ and allow the platform to steer itself to the final destination. For example, although it would depend on the load size and atmospheric conditions, it was explained that a load dropped from an altitude of 35,000 ft. could potentially travel 50 kilometers. Although this system would have a greater accuracy and provide additional safety and flexibility to delivery crews, it would be more expensive (due to the onboard sensors and automated systems) and would (ideally) need to be recovered.[28]

Technique:

Due to the geography and limited infrastructure of Afghanistan, American Army logistics planners turned to aerial delivery by parachute as a means of supplying bases and troops in remote locations. Conventional airdrop equipment is expensive and the army requires that units recover and return these assets. At the time (2005), backhaul logistics, using contracted drivers, resulted in the destruction of over 90% of all parachutes that were recovered (Martin, 2010).

At that time, the JPADS was a complex and expensive option that still required a backhaul recovery. Based on demands from deployed units, it was determined that a disposable, single use delivery system was needed  (Zello & Labin, 2008) . The result was the development of the *Low Cost Low Altitude* (LCLA) system. LCLA, as the name describes, uses *low cost* parachutes (expired personnel (T-10) and reserve personnel (T-10R) parachutes and low cost "Stalker" Cross parachutes) dropped from (relatively) low altitudes  (Peterman, Narowski, Litynski, & Clouse, September 2007) . Following successful development, testing, and certification (initially using CASA-212, UH-60, and CH-47), The LCLA technique was transferred to the 782nd Brigade Support Battalion (BSB) of the 4th Brigade Combat Team of the 82nd Airborne Division for practical training and testing in Afghanistan (Peterman, Narowski, Litynski, & Clouse, 2007). Since then, LCLA techniques have been formalized and added to new versions of the

[28] Though Airborne Systems has developed a single use GPADS, the 2K1T, that is designed so that the guidance system can be removed while leaving the parachute behind (Airborne Systems, 2013).

Army Field Manual[29] and training of LCLA has become the responsibility of the U.S. Army Quartermaster School (U.S. Army Quartermaster School, 2013). In February 2010, LCLA loads were delivered into Afghanistan by U.S. Air Force C-130 aircrews (Kapinos, 2010). Although LCLA has been well received based on the simplicity, flexibility, and (relative) low-cost, the system's accuracy may be of specific interest to the CF. During the initial development of the LCLA system, metrics called for loads weighing 350 lbs., delivered from altitudes below 500 ft., landing within 75 meters of the designated DZ (Zello & Labin, 2008) . During the practical training and testing period in Afghanistan, LCLA "Speedball" crews (US Army Jump Masters and contracted aircraft/flight crews) were able to reduce the DZ area, with loads landing within 20 meters of the target (Peterman, Narowski, Litynski, & Clouse, September 2007) . The CF has its own versions of the parachutes used for LCLA. The CCP-24 and CCP-35 are recycled CT-1 personnel parachutes that have been designated as "expired". Similarly, the DND purchased a number of low cost parachutes (Unicross) from Airborne Systems, which can be used in a single-use fashion, or recovered, repaired, and redeployed (generally up to five times) (Comelli, 2009) .[30] Based on the success of LCLA, the CF may be able to adopt these delivery techniques in an effort to reduce the space requirements for DZs.

Although some environments offer a variety of open terrain and suitable DZ locations, the size requirements of DZs (based on current procedures) can provide challenges and

[29] FM 4-20.103 Airdrop of Supplies and Equipment
[30] The parachutes described (CCP-24, CCP-35, Unicross) were used for the models and simulations.

limit delivery opportunities. By reducing the DZ size requirements, additional DZs may become available and increase the flexibility available to CF units.

**Delivery Vehicle Vulnerability**

During operations in Afghanistan, Canadian and Coalition troops faced constant threats from ambush, suicide attacks, and Improvised Explosive Devices (IEDs). IEDs caused the deaths of 98 of Canada's 157 military casualties (Fisher, 2011). IED's represented a major threat to convoys on patrol and conducting resupply operations. As one officer described, "I think personally some of the most brave guys in Afghanistan were the guys that drove the logistics trucks because they were probably more at risk more of the time then a lot of the infantry were". Aerial delivery offers the benefit of reducing personnel exposure to ground based threats. An RCAF overview of the CH-147D (of which Canada purchased six for use in Afghanistan) described "with the addition of helicopter airlift, there will be a corresponding reduction in the need for troops to travel by road, thereby lowering their risk of ambushes, land mines and improvised explosive devices (Royal Canadian Air Force, 2011). Although helicopters offer relief from IEDs they still face threats from the ground.

During operations in Afghanistan a variety of transport and attack helicopters were brought down by ground fire. This included a Canadian operated CH-147 Chinook which burst into flames following a "hard" landing after being hit by small arms fire in August 2010 (Canadian forces confirms helicopter was brought down by small arms fire.2010). While describing helicopters used in resupply operations, one CF officer noted, "The exposure time to an enemy is greatly increased while resupplying in forward areas". This officer further explained that, “the use of parachute resupply allows the Air Force to minimize their exposure to anti-aircraft guns (AAA) and other means of exposure to the enemy”. Although there have not appeared to be any reports of losses of fixed-wing craft to ground fire in Afghanistan, several officers noted during interviews and discussions that if Canada were to be facing a force with air defence weapons and/or units, it would be less likely that the Canadian military would risk its limited air assets in resupply operations. However as one CF officer explained, “Anything you can do to reduce the amount of guys that have to drive down the roads to do just simple sustainment stuff is valuable and I think will continue to be valuable in the future because the IED and the mine are weapons that are very much going to continue being a threat on the battlefield”.

**Backhaul Logistics**

Backhaul generally refers to the return trip of the delivery vehicle. In commercial logistics operations, companies often attempt to find loads for returning vehicles in an effort to minimize empty “deadhead” moves and maximize vehicle utility. The issue of “Backhaul Logistics” in regards to airdrop has two “perspectives”.

One consideration is the recovery of the airdrop equipment (e.g. parachute, container, etc.). Ideally, airdrop (or airlift) equipment will be recovered for reuse. The recovery of the equipment would likely happen in one of two ways. Mounted units traveling with vehicles, may pack the delivery equipment and transport it with them. However, depending on the amount of equipment and how it is recovered, this can occupy a large amount of a limited space. Alternatively, rearward units can travel to forward locations to recover delivery equipment. However as once officer noted, “The use of troops to guard this equipment (as the rearward units move forward) takes away from the unit's fighting strength. In Afghanistan, the United States military used local contractors to return airdrop equipment from FOBs, which resulted in more than 90% of the parachutes being returned in a damaged, un-repairable state (Martin, 2010). As a result, the United States military began to develop a low-cost airdrop capability (Martin, 2010). Although Canadian airdrop equipment such as the CCP-24, CCP-35, and Unicross (used in the modeling) is designated as "recoverable", they are still cheaper than other airdrop systems (such as the CCP-64, a dedicated cargo parachute). Depending on the situation (and when deemed appropriate), this equipment could be disposed of following the resupply, eliminating the need for recovery by rearward units or transporting the equipment by the receiving force.

Although backhaul logistics serves as a method of maximizing utilization and profitability in commercial transportation, it appears to be a necessity in military logistics.

Patrols and forward locations (e.g. FOB, COP, etc.) use backhaul capacity to transport a variety of items. For example, during CF operations in Afghanistan there was a need to return vehicles for repairs and retrofitting. Recovery teams would accompany supply convoys travelling to forward units to shuttle these vehicles back to KAF.  Another example that was explained is the need to transport waste items that cannot be disposed of properly in the field. One of the reasons for this is the enemy's ability to convert this waste into components for IEDs. In addition to these examples, backhaul loads also provide the opportunity to transport/rotate supplies and personnel.

Supply operations conducted by ground convoy and airland have the capability of providing backhaul logistics. Airdrop can only operate in a single direction, providing delivery but unable to recover loads for return.

The ability to transport cargo from the forward to rearward locations enables the CF to increase utility (e.g. reuse and repair of equipment), while denying the enemy access to supplies that could harm the CF and its' allies. Ideally, a reliable form of backhaul transport in some capacity would be available. As a result, a unit could not necessarily be exclusively supplied via airdrop.

**Conclusion**

Based on performance, it appears that airdrop could be used to meet the resupply demands of various CF units. For example, 3 CC-130J Super Hercules have the capacity to deliver the daily supply requirements of a battle group containing 750 personnel (approximately 47,700 kg). In addition, based on the parameters used in the model, the CC-130J has both the range and speed to travel from rearward origins to frontline destinations in faster times than ground based convoys traveling within the theatre of operations. This could include cases where units are maneuvering offensively with rapid speed (e.g. "surge"). Based on this, the CF could potentially reduce or remove supply bases located in the forward areas of a theater of operations, creating a zero-footprint logistics environment, while fulfilling demand.

Although the performance of airdrop appears to be able to meet the resupply needs of the CF, additional considerations may limit its operational suitability as a sole source delivery mode. This includes the availability of aircraft, drop zone size and geographic requirements, delivery vehicle vulnerability, and the need for backhaul logistics.

As a result, while airdrop could potentially reduce the need for forward based supply depots, it does not appear that it could replace them entirely.

In the future, the development and/or adoption of various airdrop techniques and technology (e.g. LCLA, JPADS, etc.) may reduce some of the constraints that currently limit the adoption of airdrop as a primary means of resupply. According to one CF logistics officer:

*"I think that it (airdrop) is a good tool. It is a useful tool that fits into the planners "toolbox" and that we need to develop such a tool so that it is in the "toolbox" for when we need it. It has to not only be maintained, but also, best practices need to be found and developed into a more useful tool. We might not need it in the next 20 years, but who knows where we'll be in the next 20 years".*

**Limitations**

Due to the civilian status of the researcher and the public availability of the thesis, some of the information that was provided by CF SMEs was generalized for security purposes. As a result, the models used in this study were simplified. Performance data (e.g. speed, range, etc.) for the delivery vehicles used in the models was somewhat generalized to provide the researcher with the means to perform simple calculations, while at the same time, without releasing (potentially) sensitive information regarding CF operational techniques. In addition, the researcher used a basic weight input (63.6 kg/person) to develop delivery demands. Although this provides a summary of the tonnage, it does not address the issue of size. As one helicopter pilot noted of the CH-147, “generally it will bulk out before it goes over weight”. As well, the classes of supplies were not addressed which could (potentially) affect assembly times. As a result, the models provided a general comparison between delivery methods with a range in accuracy.

For further study, the CF may consider developing a set of specific manifests, containing appropriate amounts and classes of supplies. With these manifests, they could then develop the delivery configurations (package and vehicle) needed to carry out the resupply. As well, delivery locations could be based on operational conditions (outside of Canada) and realistic delivery plans (concerning preparation time, delivery characteristics, etc.) could be developed by appropriate SMEs.

**Further Study**

Although airdrop may not entirely reduce the forward inventory footprint in a conflict area, as outlined in the models, it may prove useful as a means of resupply in other environments. Future research would be needed to assess the suitability of airdrop for other environments, such as northern operations and humanitarian operations.

Northern Operations

It was suggested by some CF personnel that airdrop would serve as a practical means of support for operations in the Canadian north. As described in the Canada First Defence Strategy, the CF will have the capacity to “conduct daily domestic and continental operations, including in the Arctic” (Pg.10). As natural resources become available and accessibility for shipping increases, Canadian sovereignty is becoming a growing issue. It was suggested that airdrop may serve as a means of supporting sovereignty operations, such as those carried out by the Canadian Rangers. Much like forward supply bases, equipment and supply caches may represent a concentration of capital with limited accessibility. Resupply from central locations (e.g. Yellowknife) by airdrop to units conducting sovereignty operations may serve as a means of reducing remote supply inventories. During interviews, one CF member mentioned trials of airdropped goods using a CC-138 Twin Otter. This may represent a potential means of extending the Canadian presence in the north.

Humanitarian Operations

Although zero-footprint logistics is a choice to reduce/remove a fixed forward based inventory, in some situations, a (semi-) permanent supply base is not an available option. An example of this is a natural disaster, where key infrastructure (such as a port or airport) is damaged and capacity is limited. In January 2010, CF units were deployed to Haiti in response to a significant earthquake, measuring 7.3 on the Richter scale. Operation HESTIA saw a combined force of Canadian Army, Navy, and Air Force units (including the Disaster Assistance Response Team (DART)) providing medical, security, engineering, communications, transportation, and logistical support(CJOC, January 28, 2013).[31] In addition to Canada, international governments and NGOs provided personnel and support to Haiti. However, due to the infrastructure damage to the airport, seaport, and roads, aid was hampered by massive bottlenecks. In an effort to deliver much needed supplies, the United States military turned to airdrop. Initially Secretary of Defense, Robert Gates, had ruled out an airdrop due to fears of rioting by the population in an effort to secure supplies, referring to an airdrop as "a formula for contributing to chaos rather than preventing it" (U.S. military begins air drops in haiti.2010) However, as conditions grew more severe, airdrop operations were authorized in an effort to bypass congested ports. The first American airdrop, as part of Operation Unified Response, was conducted on January 23 (2010) by a C-17 Globemaster flying from Pope AFB, N.C., that dropped 14,000 bottles of water and 14,500 Meals Ready to Eat (MRE) to a field outside of Port-au-Prince (Kistler, 2010). To avoid rioting, the DZ was secured by U.S. military members and distribution was conducted by JTF-Haiti, USAID, and additional relief personnel (Air deliveries provide critical supplies to earthquake victims, 2010) . During relief operations, U.S. Air Mobility Command conducted four airdrops, delivering 246,480 lbs of water and MREs (Sturkol, 2010). The CF may be able to use airdrop in a similar fashion as a means to reduce or by-pass infrastructure congestion during humanitarian operations. Operations would likely need to be conducted as they currently are done with a reconnaissance of the DZ to avoid injury and damage to civilians and/or property. Similarly, the DZ would need to be secured to receive and distribute relief items

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[31] In addition to CF personnel, members of the Department of Foreign Affairs and International Trade and the Canadian International Development Agency were also involved in relief efforts.

in an orderly method. Potentially, CF experience with airdrop may provide a niche opportunity to extend the range of relief teams (such as DART) during humanitarian crisis.

**Glossary**

AAA: Anti-aircraft artillery
AHSVS: Armoured Heavy Support Vehicle System
CF: Canadian Forces
CFAWC: Canadian Forces Aerospace Warfare Centre
CFLAWC: Canadian Forces Land Advanced Warfare Centre
COP: Combat outpost
CSOR: Canadian Special Operations Regiment
DART: Disaster Assistance Response Team
DZ: Drop zone
FOB: Forward operating base
GPES: Ground proximity extraction system
HEMTT: Heavy Expanded Mobility Tactical Truck
HMMWV: High mobility multipurpose wheeled vehicle
IED: Improvised explosive device
JIT: Just-in-time
JPADS: Joint precision airdrop system
JTF2: Joint Task Force 2
KAF: Kandahar Air Field
LAPES: Low altitude parachute extraction system
LCLA: Low cost low altitude
LZ: Landing zone
MOC: Military Occupation Code
NSE: National Support Element
POD: Port of disembarkation
PPCLI: Princess Patricia's Canadian Light Infantry
QOR: Queen's Own Rifles of Canada
R22eR: Royal 22e Régiment
RCR: Royal Canadian Regiment
SME: Subject matter expert
TSB: Theatre support base

**Appendix**

**Appendix 1: Delivery Vehicle Performance**

| Delivery Method | Delivery Vehicle | Speed (kph) | Range (max) (km) | Capacity (max) (kg) |
|---|---|---|---|---|
| Airdrop | CC-130J | 555 | 3,889 | 13,636 (> 926 km)<br>21,319 (< 926 km) |
| Airland | CH-147F | 240 | 1,324 | 5,454-12,500 |
| Ground (Road) | AHSVS | 40 | 732 | 12,000[32] |
| Ground (Off-Road) | | 20 | | |

**Appendix 2: Delivery Package Capacity**

| Delivery Method | Delivery Package | Capacity (kgs) |
|---|---|---|
| Airdrop | CCP-24 / CCP-35 | 34 – 227 |
| | CCP-64 / Unicross | 227 – 1000 |
| Airground | Sling Net, 8 Ft.<br>3 Loop Suspension | 4545 |
| Ground | 20' Container | 12,000[33] |

**Appendix 3: Vehicle Fuel Consumption**

| Delivery Method | Vehicle | Fuel Consumption (l/km)[34] |
|---|---|---|
| Airdrop | CC-130J | 5.1 |
| Airland | CH-147F | 6.3 |
| | CH-146 | 1.9 |
| Ground | AHSVS | 0.82 |
| | LAV III | 0.40 |
| | RG-31 | 0.15 |

[32] The capacity of the AHSVS exceeds 16,000 kgs, but for the purpose of modeling, the capacity is limited to the limits of the delivery package (20' container).

[33] 20' Container is rated to carry 26,000 kgs, but weight is limited to 12,000 kg for handling in theatre.

[34] For these models, fuel economy is constant (based on mileage) and does not fluctuate with speed.

**Appendix 4: Total Time 25 - 300 km (100 kg)**

| | | Distance (km) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **25** | **50** | **75** | **100** | **125** | **150** | **175** | **200** | **225** | **250** | **275** | **300** |
| **Airdrop** | Assembly | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 |
| | Load | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 |
| | Travel | 3 | 5 | 8 | 11 | 13 | 16 | 19 | 22 | 24 | 27 | 30 | 32 |
| | Total Time | **303** | **305** | **308** | **311** | **313** | **316** | **319** | **322** | **324** | **327** | **330** | **332** |
| **Airland** | Assembly | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 |
| | Load | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| | Travel | 6 | 12 | 19 | 25 | 31 | 37 | 44 | 50 | 56 | 62 | 69 | 75 |
| | Total Time | **81** | **87** | **94** | **100** | **106** | **112** | **119** | **125** | **131** | **137** | **144** | **150** |
| **Ground (Road)** | Assembly | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 |
| | Load | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| | Travel | 38 | 75 | 113 | 150 | 188 | 225 | 263 | 300 | 338 | 375 | 413 | 450 |
| | Total Time | **113** | **150** | **188** | **225** | **263** | **300** | **338** | **375** | **413** | **450** | **488** | **525** |
| **Ground (Off-Road)** | Assembly | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 |
| | Load | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| | Travel | 75 | 150 | 225 | 300 | 375 | 450 | 525 | 600 | 675 | 750 | 825 | 900 |
| | Total Time | **150** | **225** | **300** | **375** | **450** | **525** | **600** | **675** | **750** | **825** | **900** | **975** |

**Appendix 5: Total Time 325 - 600 km (100 kg)**

| | | Distance (km) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **325** | **350** | **375** | **400** | **425** | **450** | **475** | **500** | **525** | **550** | **575** | **600** |
| **Airdrop** | Assembly | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 |
| | Load | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 |
| | Travel | 35 | 38 | 40 | 43 | 46 | 49 | 51 | 54 | 57 | 59 | 62 | 65 |
| | Total Time | **335** | **338** | **340** | **343** | **346** | **349** | **351** | **354** | **357** | **359** | **362** | **365** |
| **Airland** | Assembly | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 |
| | Load | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| | Travel | 81 | 87 | 93 | 100 | 106 | 112 | 118 | 125 | 131 | 137 | 143 | 150 |
| | Total Time | **156** | **162** | **168** | **175** | **181** | **187** | **193** | **200** | **206** | **212** | **218** | **225** |
| **Ground (Road)** | Assembly | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 |
| | Load | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| | Travel | 488 | 525 | 563 | 600 | 638 | 675 | 713 | 750 | 788 | 825 | 863 | 900 |
| | Total Time | **563** | **600** | **638** | **675** | **713** | **750** | **788** | **825** | **863** | **900** | **938** | **975** |
| **Ground (Off-Road)** | Assembly | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 |
| | Load | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| | Travel | 975 | 1050 | 1125 | 1200 | 1275 | 1350 | 1425 | 1500 | 1575 | 1650 | 1725 | 1800 |
| | Total Time | **1050** | **1125** | **1200** | **1275** | **1350** | **1425** | **1500** | **1575** | **1650** | **1725** | **1800** | **1875** |

**Appendix 6: Total Time 25 - 300 km (1,000 kg)**

| | | Distance (km) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **25** | **50** | **75** | **100** | **125** | **150** | **175** | **200** | **225** | **250** | **275** | **300** |
| **Airdrop** | Assembly | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 |
| | Load | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 |
| | Travel | 3 | 5 | 8 | 11 | 13 | 16 | 19 | 22 | 24 | 27 | 30 | 32 |
| | Total Time | **363** | **365** | **368** | **371** | **373** | **376** | **379** | **382** | **384** | **387** | **390** | **392** |
| **Airland** | Assembly | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 |
| | Load | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| | Travel | 6 | 12 | 19 | 25 | 31 | 37 | 44 | 50 | 56 | 62 | 69 | 75 |
| | Total Time | **81** | **87** | **94** | **100** | **106** | **112** | **119** | **125** | **131** | **137** | **144** | **150** |
| **Ground (Road)** | Assembly | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 |
| | Load | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| | Travel | 38 | 75 | 113 | 150 | 188 | 225 | 263 | 300 | 338 | 375 | 413 | 450 |
| | Total Time | **113** | **150** | **188** | **225** | **263** | **300** | **338** | **375** | **413** | **450** | **488** | **525** |
| **Ground (Off-Road)** | Assembly | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 |
| | Load | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| | Travel | 75 | 150 | 225 | 300 | 375 | 450 | 525 | 600 | 675 | 750 | 825 | 900 |
| | Total Time | **150** | **225** | **300** | **375** | **450** | **525** | **600** | **675** | **750** | **825** | **900** | **975** |

**Appendix 7: Total Time 325 - 600 km (1,000 kg)**

| | | Distance (km) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **325** | **350** | **375** | **400** | **425** | **450** | **475** | **500** | **525** | **550** | **575** | **600** |
| **Airdrop** | Assembly | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 |
| | Load | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 |
| | Travel | 35 | 38 | 40 | 43 | 46 | 49 | 51 | 54 | 57 | 59 | 62 | 65 |
| | Total Time | **395** | **398** | **400** | **403** | **406** | **409** | **411** | **414** | **417** | **419** | **422** | **425** |
| **Airland** | Assembly | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 |
| | Load | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| | Travel | 81 | 87 | 93 | 100 | 106 | 112 | 118 | 125 | 131 | 137 | 143 | 150 |
| | Total Time | **156** | **162** | **168** | **175** | **181** | **187** | **193** | **200** | **206** | **212** | **218** | **225** |
| **Ground (Road)** | Assembly | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 |
| | Load | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| | Travel | 488 | 525 | 563 | 600 | 638 | 675 | 713 | 750 | 788 | 825 | 863 | 900 |
| | Total Time | **563** | **600** | **638** | **675** | **713** | **750** | **788** | **825** | **863** | **900** | **938** | **975** |
| **Ground (Off-Road)** | Assembly | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 |
| | Load | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| | Travel | 975 | 1050 | 1125 | 1200 | 1275 | 1350 | 1425 | 1500 | 1575 | 1650 | 1725 | 1800 |
| | Total Time | **1050** | **1125** | **1200** | **1275** | **1350** | **1425** | **1500** | **1575** | **1650** | **1725** | **1800** | **1875** |

**Appendix 8: Total Time 25 - 300 km (2,000 kg)**

| | | Distance (km) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **25** | **50** | **75** | **100** | **125** | **150** | **175** | **200** | **225** | **250** | **275** | **300** |
| **Airdrop** | Assembly | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 |
| | Load | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 |
| | Travel | 3 | 5 | 8 | 11 | 13 | 16 | 19 | 22 | 24 | 27 | 30 | 32 |
| | Total Time | **483** | **485** | **488** | **491** | **493** | **496** | **499** | **502** | **504** | **507** | **510** | **512** |
| **Airland** | Assembly | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 |
| | Load | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| | Travel | 6 | 12 | 19 | 25 | 31 | 37 | 44 | 50 | 56 | 62 | 69 | 75 |
| | Total Time | **81** | **87** | **94** | **100** | **106** | **112** | **119** | **125** | **131** | **137** | **144** | **150** |
| **Ground (Road)** | Assembly | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 |
| | Load | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| | Travel | 38 | 75 | 113 | 150 | 188 | 225 | 263 | 300 | 338 | 375 | 413 | 450 |
| | Total Time | **113** | **150** | **188** | **225** | **263** | **300** | **338** | **375** | **413** | **450** | **488** | **525** |
| **Ground (Off-Road)** | Assembly | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 |
| | Load | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| | Travel | 75 | 150 | 225 | 300 | 375 | 450 | 525 | 600 | 675 | 750 | 825 | 900 |
| | Total Time | **150** | **225** | **300** | **375** | **450** | **525** | **600** | **675** | **750** | **825** | **900** | **975** |

**Appendix 9: Total Time 325 - 600 km (2,000 kg)**

| | | Distance (km) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **325** | **350** | **375** | **400** | **425** | **450** | **475** | **500** | **525** | **550** | **575** | **600** |
| **Airdrop** | Assembly | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 |
| | Load | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 |
| | Travel | 35 | 38 | 40 | 43 | 46 | 49 | 51 | 54 | 57 | 59 | 62 | 65 |
| | Total Time | **515** | **518** | **520** | **523** | **526** | **529** | **531** | **534** | **537** | **539** | **542** | **545** |
| **Airland** | Assembly | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 |
| | Load | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| | Travel | 81 | 87 | 93 | 100 | 106 | 112 | 118 | 125 | 131 | 137 | 143 | 150 |
| | Total Time | **156** | **162** | **168** | **175** | **181** | **187** | **193** | **200** | **206** | **212** | **218** | **225** |
| **Ground (Road)** | Assembly | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 |
| | Load | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| | Travel | 488 | 525 | 563 | 600 | 638 | 675 | 713 | 750 | 788 | 825 | 863 | 900 |
| | Total Time | **563** | **600** | **638** | **675** | **713** | **750** | **788** | **825** | **863** | **900** | **938** | **975** |
| **Ground (Off-Road)** | Assembly | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 |
| | Load | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| | Travel | 975 | 1050 | 1125 | 1200 | 1275 | 1350 | 1425 | 1500 | 1575 | 1650 | 1725 | 1800 |
| | Total Time | **1050** | **1125** | **1200** | **1275** | **1350** | **1425** | **1500** | **1575** | **1650** | **1725** | **1800** | **1875** |

**Appendix 10: Total Time 25 - 300 km (5,000 kg)**

| | | Distance (km) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **25** | **50** | **75** | **100** | **125** | **150** | **175** | **200** | **225** | **250** | **275** | **300** |
| **Airdrop** | Assembly | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 |
| | Load | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 |
| | Travel | 3 | 5 | 8 | 11 | 13 | 16 | 19 | 22 | 24 | 27 | 30 | 32 |
| | Total Time | **843** | **845** | **848** | **851** | **853** | **856** | **859** | **862** | **864** | **867** | **870** | **872** |
| **Airland** | Assembly | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 |
| | Load | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| | Travel | 6 | 12 | 19 | 25 | 31 | 37 | 44 | 50 | 56 | 62 | 69 | 75 |
| | Total Time | **141** | **147** | **154** | **160** | **166** | **172** | **179** | **185** | **191** | **197** | **204** | **210** |
| **Ground (Road)** | Assembly | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 |
| | Load | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| | Travel | 38 | 75 | 113 | 150 | 188 | 225 | 263 | 300 | 338 | 375 | 413 | 450 |
| | Total Time | **113** | **150** | **188** | **225** | **263** | **300** | **338** | **375** | **413** | **450** | **488** | **525** |
| **Ground (Off-Road)** | Assembly | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 |
| | Load | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| | Travel | 75 | 150 | 225 | 300 | 375 | 450 | 525 | 600 | 675 | 750 | 825 | 900 |
| | Total Time | **150** | **225** | **300** | **375** | **450** | **525** | **600** | **675** | **750** | **825** | **900** | **975** |

**Appendix 11: Total Time 325 - 600 km (5,000 kg)**

| | | Distance (km) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **325** | **350** | **375** | **400** | **425** | **450** | **475** | **500** | **525** | **550** | **575** | **600** |
| **Airdrop** | Assembly | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 |
| | Load | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 |
| | Travel | 35 | 38 | 40 | 43 | 46 | 49 | 51 | 54 | 57 | 59 | 62 | 65 |
| | Total Time | **875** | **878** | **880** | **883** | **886** | **889** | **891** | **894** | **897** | **899** | **902** | **905** |
| **Airland** | Assembly | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 |
| | Load | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| | Travel | 81 | 87 | 93 | 100 | 106 | 112 | 118 | 125 | 131 | 137 | 143 | 150 |
| | Total Time | **216** | **222** | **228** | **235** | **241** | **247** | **253** | **260** | **266** | **272** | **278** | **285** |
| **Ground (Road)** | Assembly | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 |
| | Load | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| | Travel | 488 | 525 | 563 | 600 | 638 | 675 | 713 | 750 | 788 | 825 | 863 | 900 |
| | Total Time | **563** | **600** | **638** | **675** | **713** | **750** | **788** | **825** | **863** | **900** | **938** | **975** |
| **Ground (Off-Road)** | Assembly | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 |
| | Load | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| | Travel | 975 | 1050 | 1125 | 1200 | 1275 | 1350 | 1425 | 1500 | 1575 | 1650 | 1725 | 1800 |
| | Total Time | **1050** | **1125** | **1200** | **1275** | **1350** | **1425** | **1500** | **1575** | **1650** | **1725** | **1800** | **1875** |

**Appendix 12: Total Time 25 - 300 km (10,000 kg)**

| | | **Distance (km)** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **25** | **50** | **75** | **100** | **125** | **150** | **175** | **200** | **225** | **250** | **275** | **300** |
| **Airdrop** | Assembly | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 |
| | Load | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 |
| | Travel | 3 | 5 | 8 | 11 | 13 | 16 | 19 | 22 | 24 | 27 | 30 | 32 |
| | Total Time | **1443** | **1445** | **1448** | **1451** | **1453** | **1456** | **1459** | **1462** | **1464** | **1467** | **1470** | **1472** |
| **Airland** | Assembly | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 |
| | Load | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| | Travel | 6 | 12 | 19 | 25 | 31 | 37 | 44 | 50 | 56 | 62 | 69 | 75 |
| | Total Time | **201** | **207** | **214** | **220** | **226** | **232** | **239** | **245** | **251** | **257** | **264** | **270** |
| **Ground (Road)** | Assembly | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 |
| | Load | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| | Travel | 38 | 75 | 113 | 150 | 188 | 225 | 263 | 300 | 338 | 375 | 413 | 450 |
| | Total Time | **113** | **150** | **188** | **225** | **263** | **300** | **338** | **375** | **413** | **450** | **488** | **525** |
| **Ground (Off-Road)** | Assembly | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 |
| | Load | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| | Travel | 75 | 150 | 225 | 300 | 375 | 450 | 525 | 600 | 675 | 750 | 825 | 900 |
| | Total Time | **150** | **225** | **300** | **375** | **450** | **525** | **600** | **675** | **750** | **825** | **900** | **975** |

**Appendix 13: Total Time 325 - 600 km (10,000 kg)**

| | | Distance (km) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **325** | **350** | **375** | **400** | **425** | **450** | **475** | **500** | **525** | **550** | **575** | **600** |
| **Airdrop** | Assembly | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 |
| | Load | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 |
| | Travel | 35 | 38 | 40 | 43 | 46 | 49 | 51 | 54 | 57 | 59 | 62 | 65 |
| | Total Time | **1475** | **1478** | **1480** | **1483** | **1486** | **1489** | **1491** | **1494** | **1497** | **1499** | **1502** | **1505** |
| **Airland** | Assembly | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 |
| | Load | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 30 | 30 | 30 | 30 | 30 |
| | Travel | 81 | 87 | 93 | 100 | 106 | 112 | 118 | 249 | 262 | 274 | 287 | 299 |
| | Total Time | **276** | **282** | **288** | **295** | **301** | **307** | **313** | **459** | **472** | **484** | **497** | **509** |
| **Ground (Road)** | Assembly | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 |
| | Load | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| | Travel | 488 | 525 | 563 | 600 | 638 | 675 | 713 | 750 | 788 | 825 | 863 | 900 |
| | Total Time | **563** | **600** | **638** | **675** | **713** | **750** | **788** | **825** | **863** | **900** | **938** | **975** |
| **Ground (Off-Road)** | Assembly | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 |
| | Load | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| | Travel | 975 | 1050 | 1125 | 1200 | 1275 | 1350 | 1425 | 1500 | 1575 | 1650 | 1725 | 1800 |
| | Total Time | **1050** | **1125** | **1200** | **1275** | **1350** | **1425** | **1500** | **1575** | **1650** | **1725** | **1800** | **1875** |

**Appendix 14: Total Time 25 - 300 km (20,000 kg)**

| | | Distance (km) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **25** | **50** | **75** | **100** | **125** | **150** | **175** | **200** | **225** | **250** | **275** | **300** |
| **Airdrop** | Assembly | 2400 | 2400 | 2400 | 2400 | 2400 | 2400 | 2400 | 2400 | 2400 | 2400 | 2400 | 2400 |
| | Load | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 |
| | Travel | 3 | 5 | 8 | 11 | 13 | 16 | 19 | 22 | 24 | 27 | 30 | 32 |
| | Total Time | **2643** | **2645** | **2648** | **2651** | **2653** | **2656** | **2659** | **2662** | **2664** | **2667** | **2670** | **2672** |
| **Airland** | Assembly | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 |
| | Load | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| | Travel | 12 | 25 | 37 | 50 | 62 | 75 | 87 | 100 | 112 | 125 | 137 | 150 |
| | Total Time | **342** | **355** | **367** | **380** | **392** | **405** | **417** | **430** | **442** | **455** | **467** | **480** |
| **Ground (Road)** | Assembly | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 |
| | Load | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| | Travel | 75 | 150 | 225 | 300 | 375 | 450 | 525 | 600 | 675 | 750 | 825 | 900 |
| | Total Time | **225** | **300** | **375** | **450** | **525** | **600** | **675** | **750** | **825** | **900** | **975** | **1050** |
| **Ground (Off-Road)** | Assembly | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 |
| | Load | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| | Travel | 150 | 300 | 450 | 600 | 750 | 900 | 1050 | 1200 | 1350 | 1500 | 1650 | 1800 |
| | Total Time | **300** | **450** | **600** | **750** | **900** | **1050** | **1200** | **1350** | **1500** | **1650** | **1800** | **1950** |

**Appendix 15: Total Time 325 - 600 km (20,000 kg)**

| | | Distance (km) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **325** | **350** | **375** | **400** | **425** | **450** | **475** | **500** | **525** | **550** | **575** | **600** |
| **Airdrop** | Assembly | 2400 | 2400 | 2400 | 2400 | 2400 | 2400 | 2400 | 2400 | 2400 | 2400 | 2400 | 2400 |
| | Load | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 |
| | Travel | 35 | 38 | 40 | 43 | 46 | 49 | 51 | 54 | 57 | 59 | 62 | 65 |
| | Total Time | **2675** | **2678** | **2680** | **2683** | **2686** | **2689** | **2691** | **2694** | **2697** | **2699** | **2702** | **2705** |
| **Airland** | Assembly | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 |
| | Load | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 45 | 45 | 45 | 45 | 45 |
| | Travel | 162 | 174 | 187 | 199 | 212 | 224 | 237 | 374 | 393 | 411 | 430 | 449 |
| | Total Time | **492** | **504** | **517** | **529** | **542** | **554** | **567** | **719** | **738** | **756** | **775** | **794** |
| **Ground (Road)** | Assembly | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 |
| | Load | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| | Travel | 975 | 1050 | 1125 | 1200 | 1275 | 1350 | 1425 | 1500 | 1575 | 1650 | 1725 | 1800 |
| | Total Time | **1125** | **1200** | **1275** | **1350** | **1425** | **1500** | **1575** | **1650** | **1725** | **1800** | **1875** | **1950** |
| **Ground (Off-Road)** | Assembly | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 |
| | Load | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| | Travel | 1950 | 2100 | 2250 | 2400 | 2550 | 2700 | 2850 | 3000 | 3150 | 3300 | 3450 | 3600 |
| | Total Time | **2100** | **2250** | **2400** | **2550** | **2700** | **2850** | **3000** | **3150** | **3300** | **3450** | **3600** | **3750** |

**Appendix 16: Total Time 25 - 300 km (50,000 kg)**

| | | Distance (km) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **25** | **50** | **75** | **100** | **125** | **150** | **175** | **200** | **225** | **250** | **275** | **300** |
| **Airdrop** | Assembly | 6000 | 6000 | 6000 | 6000 | 6000 | 6000 | 6000 | 6000 | 6000 | 6000 | 6000 | 6000 |
| | Load | 720 | 720 | 720 | 720 | 720 | 720 | 720 | 720 | 720 | 720 | 720 | 720 |
| | Travel | 8 | 16 | 24 | 32 | 40 | 49 | 57 | 65 | 73 | 81 | 89 | 97 |
| | Total Time | **6728** | **6736** | **6744** | **6752** | **6760** | **6769** | **6777** | **6785** | **6793** | **6801** | **6809** | **6817** |
| **Airland** | Assembly | 660 | 660 | 660 | 660 | 660 | 660 | 660 | 660 | 660 | 660 | 660 | 660 |
| | Load | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 |
| | Travel | 31 | 62 | 93 | 125 | 156 | 187 | 218 | 249 | 280 | 312 | 343 | 374 |
| | Total Time | **766** | **797** | **828** | **860** | **891** | **922** | **953** | **984** | **1015** | **1047** | **1078** | **1109** |
| **Ground (Road)** | Assembly | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 |
| | Load | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 |
| | Travel | 188 | 375 | 563 | 750 | 938 | 1125 | 1313 | 1500 | 1688 | 1875 | 2063 | 2250 |
| | Total Time | **563** | **750** | **938** | **1125** | **1313** | **1500** | **1688** | **1875** | **2063** | **2250** | **2438** | **2625** |
| **Ground (Off-Road)** | Assembly | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 |
| | Load | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 |
| | Travel | 375 | 750 | 1125 | 1500 | 1875 | 2250 | 2625 | 3000 | 3375 | 3750 | 4125 | 4500 |
| | Total Time | **750** | **1125** | **1500** | **1875** | **2250** | **2625** | **3000** | **3375** | **3750** | **4125** | **4500** | **4875** |

**Appendix 17: Total Time 325 - 600 km (50,000 kg)**

| | | Distance (km) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **325** | **350** | **375** | **400** | **425** | **450** | **475** | **500** | **525** | **550** | **575** | **600** |
| **Airdrop** | Assembly | 6000 | 6000 | 6000 | 6000 | 6000 | 6000 | 6000 | 6000 | 6000 | 6000 | 6000 | 6000 |
| | Load | 720 | 720 | 720 | 720 | 720 | 720 | 720 | 720 | 720 | 720 | 720 | 720 |
| | Travel | 105 | 113 | 121 | 130 | 138 | 146 | 154 | 162 | 170 | 178 | 186 | 194 |
| | Total Time | **6825** | **6833** | **6841** | **6850** | **6858** | **6866** | **6874** | **6882** | **6890** | **6898** | **6906** | **6914** |
| **Airland** | Assembly | 660 | 660 | 660 | 660 | 660 | 660 | 660 | 660 | 660 | 660 | 660 | 660 |
| | Load | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 90 | 90 | 90 | 90 | 90 |
| | Travel | 405 | 436 | 467 | 498 | 530 | 561 | 592 | 748 | 785 | 822 | 860 | 897 |
| | Total Time | **1140** | **1171** | **1202** | **1233** | **1265** | **1296** | **1327** | **1498** | **1535** | **1572** | **1610** | **1647** |
| **Ground (Road)** | Assembly | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 |
| | Load | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 |
| | Travel | 2438 | 2625 | 2813 | 3000 | 3188 | 3375 | 3563 | 3750 | 3938 | 4125 | 4313 | 4500 |
| | Total Time | **2813** | **3000** | **3188** | **3375** | **3563** | **3750** | **3938** | **4125** | **4313** | **4500** | **4688** | **4875** |
| **Ground (Off-Road)** | Assembly | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 |
| | Load | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 |
| | Travel | 4875 | 5250 | 5625 | 6000 | 6375 | 6750 | 7125 | 7500 | 7875 | 8250 | 8625 | 9000 |
| | Total Time | **5250** | **5625** | **6000** | **6375** | **6750** | **7125** | **7500** | **7875** | **8250** | **8625** | **9000** | **9375** |

**Appendix 18: Operational Time 25 - 300 km (Single Vehicle)**

| | | Distance (km) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **25** | **50** | **75** | **100** | **125** | **150** | **175** | **200** | **225** | **250** | **275** | **300** |
| **Airdrop** | Load | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 |
| | Travel | 3 | 5 | 8 | 11 | 13 | 16 | 19 | 22 | 24 | 27 | 30 | 32 |
| | Operational Time | **243** | **245** | **248** | **251** | **253** | **256** | **259** | **262** | **264** | **267** | **270** | **272** |
| **Airland** | Load | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| | Travel | 6 | 12 | 19 | 25 | 31 | 37 | 44 | 50 | 56 | 62 | 69 | 75 |
| | Operational Time | **21** | **27** | **34** | **40** | **46** | **52** | **59** | **65** | **71** | **77** | **84** | **90** |
| **Ground (Road)** | Load | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| | Travel | 38 | 75 | 113 | 150 | 188 | 225 | 263 | 300 | 338 | 375 | 413 | 450 |
| | Operational Time | **53** | **90** | **128** | **165** | **203** | **240** | **278** | **315** | **353** | **390** | **428** | **465** |
| **Ground (Off-Road)** | Load | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| | Travel | 75 | 150 | 225 | 300 | 375 | 450 | 525 | 600 | 675 | 750 | 825 | 900 |
| | Operational Time | **90** | **165** | **240** | **315** | **390** | **465** | **540** | **615** | **690** | **765** | **840** | **915** |

**Appendix 19: Operational Time 325 - 600 km (Single Vehicle)**

| | | Distance (km) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **325** | **350** | **375** | **400** | **425** | **450** | **475** | **500** | **525** | **550** | **575** | **600** |
| **Airdrop** | Load | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 |
| | Travel | 35 | 38 | 40 | 43 | 46 | 49 | 51 | 54 | 57 | 59 | 62 | 65 |
| | Operational Time | **275** | **278** | **280** | **283** | **286** | **289** | **291** | **294** | **297** | **299** | **302** | **305** |
| **Airland** | Load | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| | Travel | 81 | 87 | 93 | 100 | 106 | 112 | 118 | 125 | 131 | 137 | 143 | 150 |
| | Operational Time | **96** | **102** | **108** | **115** | **121** | **127** | **133** | **140** | **146** | **152** | **158** | **165** |
| **Ground (Road)** | Load | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| | Travel | 488 | 525 | 563 | 600 | 638 | 675 | 713 | 750 | 788 | 825 | 863 | 900 |
| | Operational Time | **503** | **540** | **578** | **615** | **653** | **690** | **728** | **765** | **803** | **840** | **878** | **915** |
| **Ground (Off-Road)** | Load | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| | Travel | 975 | 1050 | 1125 | 1200 | 1275 | 1350 | 1425 | 1500 | 1575 | 1650 | 1725 | 1800 |
| | Operational Time | **990** | **1065** | **1140** | **1215** | **1290** | **1365** | **1440** | **1515** | **1590** | **1665** | **1740** | **1815** |

**Appendix 20: Operational Time 25 - 300 km (CC-130 J Capacity, 21,319 kg)**

| | | Distance (km) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **25** | **50** | **75** | **100** | **125** | **150** | **175** | **200** | **225** | **250** | **275** | **300** |
| **Airdrop** | Load | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 |
| | Travel | 3 | 5 | 8 | 11 | 13 | 16 | 19 | 22 | 24 | 27 | 30 | 32 |
| | Operational Time | **243** | **245** | **248** | **251** | **253** | **256** | **259** | **262** | **264** | **267** | **270** | **272** |
| **Airland** | Load | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 45 | 45 | 45 |
| | Travel | 12 | 25 | 37 | 50 | 62 | 75 | 87 | 100 | 112 | 187 | 206 | 224 |
| | Operational Time | **42** | **55** | **67** | **80** | **92** | **105** | **117** | **130** | **142** | **232** | **251** | **269** |
| **Ground (Road)** | Load | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| | Travel | 75 | 150 | 225 | 300 | 375 | 450 | 525 | 600 | 675 | 750 | 825 | 900 |
| | Operational Time | **105** | **180** | **255** | **330** | **405** | **480** | **555** | **630** | **705** | **780** | **855** | **930** |
| **Ground (Off-Road)** | Load | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| | Travel | 150 | 300 | 450 | 600 | 750 | 900 | 1050 | 1200 | 1350 | 1500 | 1650 | 1800 |
| | Operational Time | **180** | **330** | **480** | **630** | **780** | **930** | **1080** | **1230** | **1380** | **1530** | **1680** | **1830** |

**Appendix 21: Operational Time 325 - 600 km (CC-130 J Capacity, 21,319 kg)**

| | | Distance (km) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **325** | **350** | **375** | **400** | **425** | **450** | **475** | **500** | **525** | **550** | **575** | **600** |
| **Airdrop** | Load | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 |
| | Travel | 35 | 38 | 40 | 43 | 46 | 49 | 51 | 54 | 57 | 59 | 62 | 65 |
| | Operational Time | **275** | **278** | **280** | **283** | **286** | **289** | **291** | **294** | **297** | **299** | **302** | **305** |
| **Airland** | Load | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 |
| | Travel | 243 | 262 | 280 | 299 | 318 | 336 | 355 | 374 | 393 | 411 | 430 | 449 |
| | Operational Time | **288** | **307** | **325** | **344** | **363** | **381** | **400** | **419** | **438** | **456** | **475** | **494** |
| **Ground (Road)** | Load | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| | Travel | 975 | 1050 | 1125 | 1200 | 1275 | 1350 | 1425 | 1500 | 1575 | 1650 | 1725 | 1800 |
| | Operational Time | **1005** | **1080** | **1155** | **1230** | **1305** | **1380** | **1455** | **1530** | **1605** | **1680** | **1755** | **1830** |
| **Ground (Off-Road)** | Load | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| | Travel | 1950 | 2100 | 2250 | 2400 | 2550 | 2700 | 2850 | 3000 | 3150 | 3300 | 3450 | 3600 |
| | Operational Time | **1980** | **2130** | **2280** | **2430** | **2580** | **2730** | **2880** | **3030** | **3180** | **3330** | **3480** | **3630** |

**Appendix 22: Elapsed Time 25 - 300 km (CC-130 J Capacity, 21,319 kg)**

| | | Distance (km) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **25** | **50** | **75** | **100** | **125** | **150** | **175** | **200** | **225** | **250** | **275** | **300** |
| **Airdrop** | Load | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 |
| | Travel (Elapsed) | 3 | 5 | 8 | 11 | 13 | 16 | 19 | 22 | 24 | 27 | 30 | 32 |
| | Elapsed Time | **243** | **245** | **248** | **251** | **253** | **256** | **259** | **262** | **264** | **267** | **270** | **272** |
| **Airland** | Load | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 45 | 45 | 45 |
| | Travel (Elapsed) | 6 | 12 | 19 | 25 | 31 | 37 | 44 | 50 | 56 | 62 | 69 | 75 |
| | Elapsed Time | **36** | **42** | **49** | **55** | **61** | **67** | **74** | **80** | **86** | **107** | **114** | **120** |
| **Ground (Road)** | Load | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| | Travel (Elapsed) | 38 | 75 | 113 | 150 | 188 | 225 | 263 | 300 | 338 | 375 | 413 | 450 |
| | Elapsed Time | **68** | **105** | **143** | **180** | **218** | **255** | **293** | **330** | **368** | **405** | **443** | **480** |
| **Ground (Off-Road)** | Load | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| | Travel (Elapsed) | 75 | 150 | 225 | 300 | 375 | 450 | 525 | 600 | 675 | 750 | 825 | 900 |
| | Elapsed Time | **105** | **180** | **255** | **330** | **405** | **480** | **555** | **630** | **705** | **780** | **855** | **930** |

**Appendix 23: Elapsed Time 325 - 600 km (CC-130 J Capacity, 21,319 kg)**

| | | Distance (km) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **325** | **350** | **375** | **400** | **425** | **450** | **475** | **500** | **525** | **550** | **575** | **600** |
| **Airdrop** | Load | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 |
| | Travel (Elapsed) | 35 | 38 | 40 | 43 | 46 | 49 | 51 | 54 | 57 | 59 | 62 | 65 |
| | Elapsed Time | **275** | **278** | **280** | **283** | **286** | **289** | **291** | **294** | **297** | **299** | **302** | **305** |
| **Airland** | Load | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 |
| | Travel (Elapsed) | 81 | 87 | 93 | 100 | 106 | 112 | 118 | 125 | 131 | 137 | 143 | 150 |
| | Elapsed Time | **126** | **132** | **138** | **145** | **151** | **157** | **163** | **170** | **176** | **182** | **188** | **195** |
| **Ground (Road)** | Load | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| | Travel (Elapsed) | 488 | 525 | 563 | 600 | 638 | 675 | 713 | 750 | 788 | 825 | 863 | 900 |
| | Elapsed Time | **518** | **555** | **593** | **630** | **668** | **705** | **743** | **780** | **818** | **855** | **893** | **930** |
| **Ground (Off-Road)** | Load | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| | Travel (Elapsed) | 975 | 1050 | 1125 | 1200 | 1275 | 1350 | 1425 | 1500 | 1575 | 1650 | 1725 | 1800 |
| | Elapsed Time | **1005** | **1080** | **1155** | **1230** | **1305** | **1380** | **1455** | **1530** | **1605** | **1680** | **1755** | **1830** |

**Appendix 24: Elapsed Time 25 - 300 km (50,000 kg)**

| | | Distance (km) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **25** | **50** | **75** | **100** | **125** | **150** | **175** | **200** | **225** | **250** | **275** | **300** |
| **Airdrop** | Load (Elapsed) | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 |
| | Travel (Elapsed) | 0 | 3 | 5 | 8 | 11 | 13 | 16 | 19 | 22 | 24 | 27 | 30 |
| | Elapsed Time | **0** | **243** | **245** | **248** | **251** | **253** | **256** | **259** | **262** | **264** | **267** | **270** |
| **Airland** | Load | - | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 |
| | Travel (Elapsed) | 0 | 6 | 12 | 19 | 25 | 31 | 37 | 44 | 50 | 56 | 62 | 69 |
| | Elapsed Time | **0** | **81** | **87** | **94** | **100** | **106** | **112** | **119** | **125** | **131** | **137** | **144** |
| **Ground (Road)** | Load | 0 | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 |
| | Travel (Elapsed) | 0 | 38 | 75 | 113 | 150 | 188 | 225 | 263 | 300 | 338 | 375 | 413 |
| | Elapsed Time | **0** | **113** | **150** | **188** | **225** | **263** | **300** | **338** | **375** | **413** | **450** | **488** |
| **Ground (Off-Road)** | Load | 0 | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 |
| | Travel (Elapsed) | 0 | 76 | 151 | 226 | 301 | 376 | 451 | 526 | 601 | 676 | 751 | 826 |
| | Elapsed Time | **0** | **151** | **226** | **301** | **376** | **451** | **526** | **601** | **676** | **751** | **826** | **901** |

**Appendix 25: Elapsed Time 325 - 600 km (50,000 kg)**

| | | Distance (km) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **325** | **350** | **375** | **400** | **425** | **450** | **475** | **500** | **525** | **550** | **575** | **600** |
| **Airdrop** | Load (Elapsed) | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 |
| | Travel (Elapsed) | 32 | 35 | 38 | 40 | 43 | 46 | 49 | 51 | 54 | 57 | 59 | 62 |
| | Elapsed Time | **272** | **275** | **278** | **280** | **283** | **286** | **289** | **291** | **294** | **297** | **299** | **302** |
| **Airland** | Load | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 90 | 90 | 90 | 90 |
| | Travel (Elapsed) | 75 | 81 | 87 | 93 | 100 | 106 | 112 | 118 | 125 | 131 | 137 | 143 |
| | Elapsed Time | **150** | **156** | **162** | **168** | **175** | **181** | **187** | **193** | **215** | **221** | **227** | **233** |
| **Ground (Road)** | Load | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 |
| | Travel (Elapsed) | 450 | 488 | 525 | 563 | 600 | 638 | 675 | 713 | 750 | 788 | 825 | 863 |
| | Elapsed Time | **525** | **563** | **600** | **638** | **675** | **713** | **750** | **788** | **825** | **863** | **900** | **938** |
| **Ground (Off-Road)** | Load | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 |
| | Travel (Elapsed) | 901 | 976 | 1,051 | 1,126 | 1,201 | 1,276 | 1,351 | 1,426 | 1,501 | 1,576 | 1,651 | 1,726 |
| | Elapsed Time | **976** | **1,051** | **1,126** | **1,201** | **1,276** | **1,351** | **1,426** | **1,501** | **1,576** | **1,651** | **1,726** | **1,801** |

**Appendix 26: Fuel Usage 25 - 300 km (5,000 kg)**

| | | Distance (km) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **25** | **50** | **75** | **100** | **125** | **150** | **175** | **200** | **225** | **250** | **275** | **300** |
| **Airdrop** | Delivery | 127 | 254 | 381 | 508 | 636 | 763 | 890 | 1017 | 1144 | 1271 | 1398 | 1525 |
| | Escort | - | - | - | - | - | - | - | - | - | - | - | - |
| | Total Fuel | **127** | **254** | **381** | **508** | **636** | **763** | **890** | **1017** | **1144** | **1271** | **1398** | **1525** |
| **Airland** | Delivery | 158 | 317 | 475 | 634 | 792 | 950 | 1109 | 1267 | 1426 | 1584 | 1742 | 1901 |
| | Escort | 95 | 191 | 286 | 381 | 477 | 572 | 667 | 763 | 858 | 953 | 1049 | 1144 |
| | Total Fuel | **254** | **507** | **761** | **1015** | **1269** | **1522** | **1776** | **2030** | **2284** | **2537** | **2791** | **3045** |
| **Ground** | Delivery | 21 | 41 | 62 | 82 | 103 | 123 | 144 | 164 | 185 | 205 | 226 | 246 |
| | Escort | 20 | 40 | 60 | 80 | 100 | 120 | 140 | 160 | 180 | 200 | 220 | 240 |
| | Total Fuel | **41** | **81** | **122** | **162** | **203** | **243** | **284** | **324** | **365** | **405** | **446** | **486** |

**Appendix 27: Fuel Usage 325 - 600 km (5,000 kg)**

| | | Distance (km) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **325** | **350** | **375** | **400** | **425** | **450** | **475** | **500** | **525** | **550** | **575** | **600** |
| **Airdrop** | Delivery | 1652 | 1780 | 1907 | 2034 | 2161 | 2288 | 2415 | 2542 | 2669 | 2796 | 2924 | 3051 |
| | Escort | - | - | - | - | - | - | - | - | - | - | - | - |
| | Total Fuel | **1652** | **1780** | **1907** | **2034** | **2161** | **2288** | **2415** | **2542** | **2669** | **2796** | **2924** | **3051** |
| **Airland** | Delivery | 2059 | 2218 | 2376 | 2534 | 2693 | 2851 | 3010 | 3168 | 3326 | 3485 | 3643 | 3802 |
| | Escort | 1239 | 1335 | 1430 | 1525 | 1621 | 1716 | 1811 | 1907 | 2002 | 2097 | 2193 | 2288 |
| | Total Fuel | **3299** | **3552** | **3806** | **4060** | **4313** | **4567** | **4821** | **5075** | **5328** | **5582** | **5836** | **6090** |
| **Ground** | Delivery | 267 | 287 | 308 | 328 | 349 | 369 | 390 | 410 | 431 | 451 | 472 | 492 |
| | Escort | 260 | 280 | 300 | 320 | 340 | 360 | 380 | 400 | 420 | 440 | 460 | 480 |
| | Total Fuel | **527** | **567** | **608** | **648** | **689** | **729** | **770** | **810** | **851** | **891** | **932** | **972** |

**Appendix 28: Fuel Usage 25 - 300 km (20,000 kg)**

| | | Distance (km) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **25** | **50** | **75** | **100** | **125** | **150** | **175** | **200** | **225** | **250** | **275** | **300** |
| **Airdrop** | Delivery | 127 | 254 | 381 | 508 | 636 | 763 | 890 | 1017 | 1144 | 1271 | 1398 | 1525 |
| | Escort | - | - | - | - | - | - | - | - | - | - | - | - |
| | Total Fuel | **127** | **254** | **381** | **508** | **636** | **763** | **890** | **1017** | **1144** | **1271** | **1398** | **1525** |
| **Airland** | Delivery | 317 | 634 | 950 | 1267 | 1584 | 1901 | 2218 | 2534 | 2851 | 3168 | 3485 | 3802 |
| | Escort | 95 | 191 | 286 | 381 | 477 | 572 | 667 | 763 | 858 | 953 | 1049 | 1144 |
| | Total Fuel | **412** | **824** | **1236** | **1649** | **2061** | **2473** | **2885** | **3297** | **3709** | **4121** | **4533** | **4946** |
| **Ground** | Delivery | 41 | 82 | 123 | 164 | 205 | 246 | 287 | 328 | 369 | 410 | 451 | 492 |
| | Escort | 20 | 40 | 60 | 80 | 100 | 120 | 140 | 160 | 180 | 200 | 220 | 240 |
| | Total Fuel | **61** | **122** | **183** | **244** | **305** | **366** | **427** | **488** | **549** | **610** | **671** | **732** |

**Appendix 29: Fuel Usage 325 - 600 km (20,000 kg)**

| | | Distance (km) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **325** | **350** | **375** | **400** | **425** | **450** | **475** | **500** | **525** | **550** | **575** | **600** |
| **Airdrop** | Delivery | 1652 | 1780 | 1907 | 2034 | 2161 | 2288 | 2415 | 2542 | 2669 | 2796 | 2924 | 3051 |
| | Escort | - | - | - | - | - | - | - | - | - | - | - | - |
| | Total Fuel | **1652** | **1780** | **1907** | **2034** | **2161** | **2288** | **2415** | **2542** | **2669** | **2796** | **2924** | **3051** |
| **Airland** | Delivery | 4118 | 4435 | 4752 | 5069 | 5386 | 5702 | 6019 | 9504 | 9979 | 10454 | 10930 | 11405 |
| | Escort | 1239 | 1335 | 1430 | 1525 | 1621 | 1716 | 1811 | 1907 | 2002 | 2097 | 2193 | 2288 |
| | Total Fuel | **5358** | **5770** | **6182** | **6594** | **7006** | **7418** | **7831** | **11411** | **11981** | **12552** | **13122** | **13693** |
| **Ground** | Delivery | 533 | 574 | 615 | 656 | 697 | 738 | 779 | 820 | 861 | 902 | 943 | 984 |
| | Escort | 260 | 280 | 300 | 320 | 340 | 360 | 380 | 400 | 420 | 440 | 460 | 480 |
| | Total Fuel | **793** | **854** | **915** | **976** | **1037** | **1098** | **1159** | **1220** | **1281** | **1342** | **1403** | **1464** |

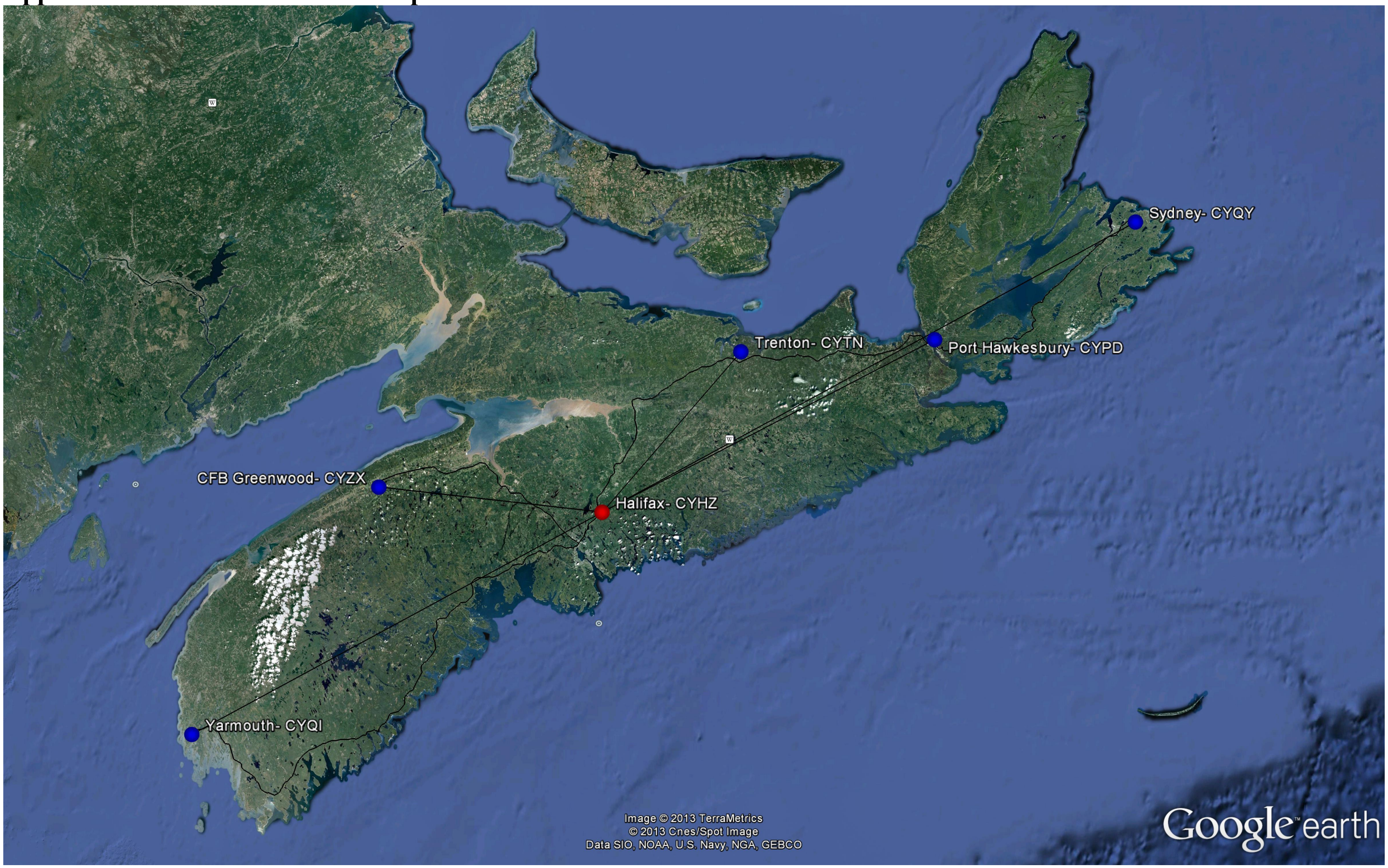
**Appendix 30: Fuel Usage 25 - 300 km (50,000 kg)**

| | | Distance (km) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **25** | **50** | **75** | **100** | **125** | **150** | **175** | **200** | **225** | **250** | **275** | **300** |
| **Airdrop** | Delivery | 381 | 763 | 1144 | 1525 | 1907 | 2288 | 2669 | 3051 | 3432 | 3813 | 4195 | 4576 |
| | Escort | - | - | - | - | - | - | - | - | - | - | - | - |
| | Total Fuel | 381 | 763 | 1144 | 1525 | 1907 | 2288 | 2669 | 3051 | 3432 | 3813 | 4195 | 4576 |
| **Airland** | Delivery | 792 | 1584 | 2376 | 3168 | 3960 | 4752 | 5544 | 6336 | 7128 | 7920 | 8712 | 9504 |
| | Escort | 95 | 191 | 286 | 381 | 477 | 572 | 667 | 763 | 858 | 953 | 1049 | 1144 |
| | Total Fuel | **887** | **1775** | **2662** | **3549** | **4437** | **5324** | **6211** | **7099** | **7986** | **8873** | **9761** | **10648** |
| **Ground** | Delivery | 103 | 205 | 308 | 410 | 513 | 615 | 718 | 820 | 923 | 1025 | 1128 | 1230 |
| | Escort | 24 | 48 | 71 | 95 | 119 | 143 | 166 | 190 | 214 | 238 | 261 | 285 |
| | Total Fuel | **126** | **253** | **379** | **505** | **631** | **758** | **884** | **1010** | **1136** | **1263** | **1389** | **1515** |

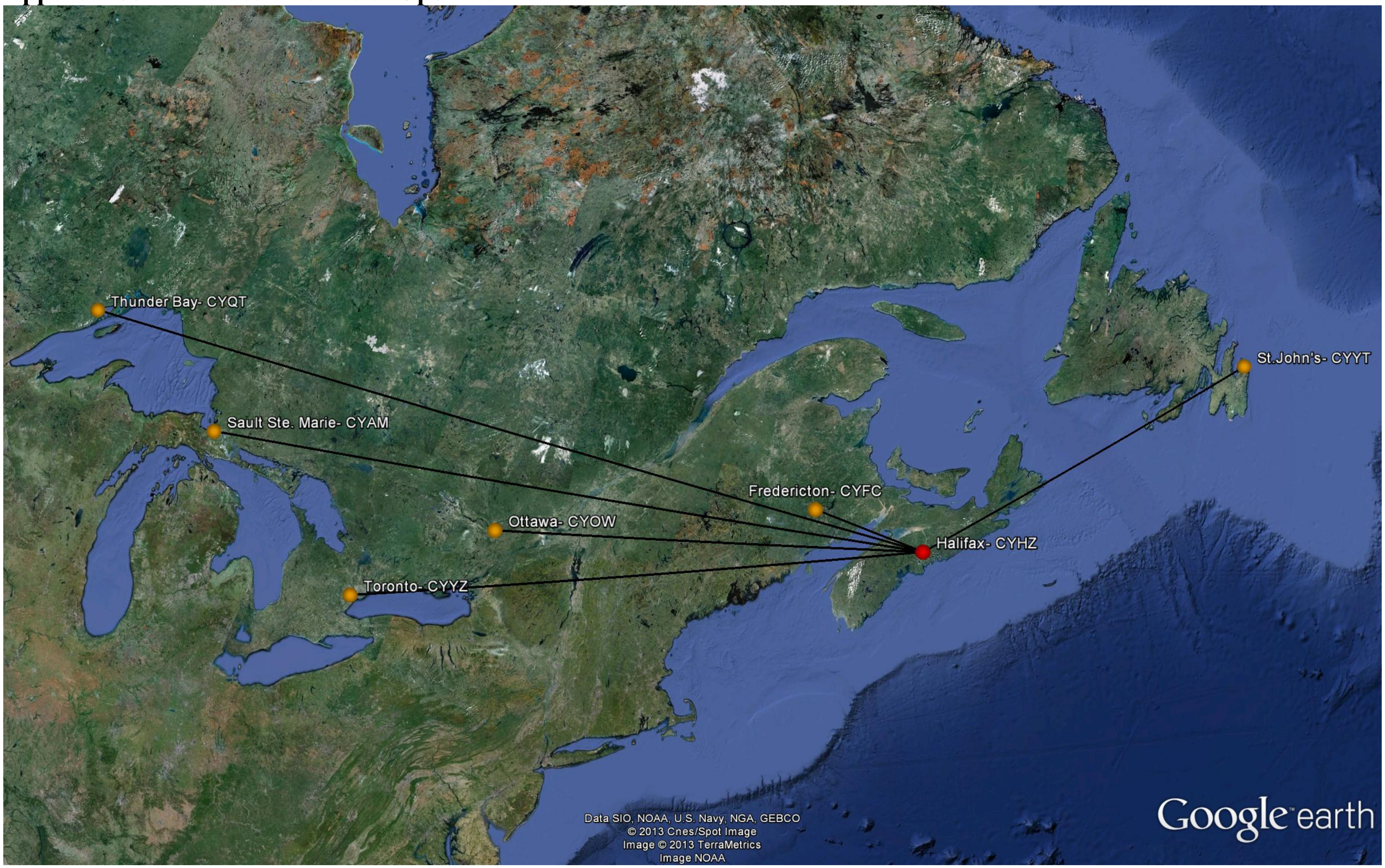
**Appendix 31: Fuel Usage 325 - 600 km (50,000 kg)**

| | | Distance (km) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **325** | **350** | **375** | **400** | **425** | **450** | **475** | **500** | **525** | **550** | **575** | **600** |
| **Airdrop** | Delivery | 4957 | 5339 | 5720 | 6101 | 6483 | 6864 | 7245 | 7627 | 8008 | 8389 | 8771 | 9152 |
| | Escort | - | - | - | - | - | - | - | - | - | - | - | - |
| | Total Fuel | **4957** | **5339** | **5720** | **6101** | **6483** | **6864** | **7245** | **7627** | **8008** | **8389** | **8771** | **9152** |
| **Airland** | Delivery | 10296 | 11088 | 11880 | 12672 | 13464 | 14256 | 15048 | 19008 | 19959 | 20909 | 21859 | 22810 |
| | Escort | 1239 | 1335 | 1430 | 1525 | 1621 | 1716 | 1811 | 1907 | 2002 | 2097 | 2193 | 2288 |
| | Total Fuel | **11535** | **12423** | **13310** | **14197** | **15085** | **15972** | **16859** | **20915** | **21961** | **23006** | **24052** | **25098** |
| **Ground** | Delivery | 1333 | 1435 | 1538 | 1640 | 1743 | 1845 | 1948 | 2050 | 2153 | 2255 | 2358 | 2460 |
| | Escort | 309 | 333 | 356 | 380 | 404 | 428 | 451 | 475 | 499 | 523 | 546 | 570 |
| | Total Fuel | **1641** | **1768** | **1894** | **2020** | **2146** | **2273** | **2399** | **2525** | **2651** | **2778** | **2904** | **3030** |

**Appendix 32: Scenario Theatre of Operations**



**Appendix 33: Extended Theatre of Operations**



## Appendix 34:  Sample Interview Consent Form

**Information and Consent Form**

**Study Name:** *Examining the potential application of Low Cost Low Altitude parachutes to supply the Canadian Forces*

**Principle Investigator:** Stephen Wright, M.Sc.
Supply Chain Management
umwright@cc.umanitoba.ca, (204) 474-7466
**Research Supervisor:** Dr. Paul Larson,
Department Head, Supply Chain Management
larson@cc.umanitoba.ca, (204) 474-6054

This form is part of the process of informed consent. Please review it carefully and address any questions to Stephen Wright. A signed copy will be left with you.

Stephen Wright is conducting this study as his Master's Thesis, under the supervision of Dr. Paul Larson and with the knowledge and guidance of personnel from Canadian Operational Support Command (CANOSCOM) and the Canadian Forces Aerospace Warfare Centre (CFAWC). The purpose of this research project is to examine the potential effect on the Canadian Forces supply system in Afghanistan if routine supply operations are changed from ground convoy and helicopter to aerial delivery using *Low Cost Low Altitude* (LCLA) parachutes.

In order to gain an understanding of the Canadian Forces supply operations and to develop a quantitative comparison of delivery methods, the researcher will be conducting interviews in which you will be asked a variety of questions based on your knowledge and experience. Based on your responses, you may be asked follow-up questions for the researcher's clarification. Interviews should last approximately one hour.

As the completed thesis will be made publically available, it is asked that you not reveal sensitive information to the researcher. Your participation in this study is completely voluntary. You may choose to decline response or withdraw from the study at any point. The interview will be recorded using a digital recorder and hand written notes, both of which will remain confidential. Should you prefer not to be recorded, please let the researcher know and he will turn the recorder off. Should you wish, an audio copy of the interview can be made available. You will be identified by only a description and generic title, known only to the researcher.

Your signature indicates that you agree to participate. This does not waive your legal rights nor release the researchers or involved institutions from their legal and professional responsibilities.
This research has been approved by the Joint Faculty Research Ethics Board of the University of Manitoba. If you have any concerns or complaints about this project, please contact either the Principle Investigator, Research Supervisor, or the Human Ethics Coordinator {Margaret_bowman@umanitoba.ca, (204) 474-7122}.

| | |
|---|---|
| Participant's Signature | Researcher's Signature |
| Participant's Printed Name | Researcher's Printed Name |
| Date | Date |

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## Interviews/Correspondence

Interview 1: July 6, 2011
Subjects: 2 CF Logistics Officers (Capt.), 1 Traffic Technician

Interview 2: July 12, 2011
Subject: 1 Rigger (MWO)

Interview 3: July 13, 2011
Subject: 1 CFLAWC Instructor (MWO)

Interview 4: September 1, 2011
Subject: 1 CF CH-147 Pilot (Capt.)

Interview 5: September 7, 2011
Subject: 1 CF CH-147 Pilot (Maj.)

Interview 6: November 29, 2011
Subject: 1 CF Artillery Officer (Lt.Col)

Interview 7: January 12, 2012
Subject: 1 CF CC-130 Pilot (Maj.)

Interview 8: February 29, 2012
Subjects: 3 CF Loadmasters

Correspondence 1: May 23, 2012
Subject: 1 CF Transportation Instructor (WO)

Correspondence 2: September 4, 2012
Subject: 1 CF Infantry Officer (Maj.)