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Preliminary Analysis of Continuous Descent Approaches into Ottawa Macdonald-Cartier International Airport

Executive Summary

Concerns regarding the cost and price volatility of fuel, the recent economic downturn, stiff marketplace competition and growing public awareness of the environmental impact of greenhouse gas (GHG) emissions on the climate are spurring airlines to optimize their flight operations to reduce fuel burn. The operational challenge is to achieve an optimized fuel burn within both schedule constraints and the existing Air Navigation System (ANS), which has the primary objective of safe control and separation of traffic under constantly varying weather conditions. In this context, the Air Navigation Service Provider (ANSP) also seeks to be responsive to its user community and to the public interest.

This paper by Specific Range Solutions Ltd. presents an analysis of Continuous Descent Approaches (CDA's) into Ottawa Macdonald-Cartier International Airport (YOW). The analysis consists of two case studies with the goal of estimating fuel burn savings for a Boeing 737-700, which is a latest generation medium-sized turbofan-powered commercial aircraft. The first case study assesses a straight-in vertically optimized CDA and the second, a laterally optimized CDA.

In addition to reduced fuel consumption, the other direct benefits of CDA's are:

- Correspondingly reduced emissions of CO_2, NO_X and other exhaust gases;
- Shorter flight times;
- Reduced noise exposure to communities on approach paths due to less low-level manoeuvring at higher engine setting;
- Reduced engine and associated systems maintenance costs due to less throttle movement;
- Shorter engine line maintenance turn-around time due to cooler engines at arrival to gate.

The results of these two simulations indicate that vertically and laterally optimized Continuous Descent Approaches can generate notable fuel burn and emissions reductions, as well as fuel cost savings under ISA and zero wind conditions.

The fuel burn reduction for a 737-700 using an optimized straight-in Continuous Descent Approach from 31,000 ft compared to a standard descent approach is approximately 31 kg.

Using the same type of aircraft for a CDA from 39,000 ft with a ground track reduced by 8.0 NM compared to a standard ground track results in an estimated 39 kg fuel burn reduction.

The combined vertical and lateral optimizations result in 70 kg of fuel savings. This result is applicable for the Airbus A320-series aircraft, as well. While the analyses were based on idealized conditions, this figure is consistent with the 55 to 70 kg fuel savings range previously referenced by other sources for the 737 type.

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1. Introduction

Concerns regarding the cost and price volatility of fuel, the recent economic downturn, stiff marketplace competition and growing public awareness of the environmental impact of greenhouse gas (GHG) emissions on the climate are spurring airlines to optimize their flight operations to reduce fuel burn. The operational challenge is to achieve an optimized fuel burn within both schedule constraints and the existing Air Navigation System (ANS), which has the primary objective of safe control and separation of traffic under constantly varying weather conditions. In this context, the Air Navigation Service Provider (ANSP) also seeks to be responsive to its user community and to the public interest.

The focus of this paper by Specific Range Solutions Ltd. (SRS Ltd.) will be an analysis of Continuous Descent Approaches (CDA's) into Ottawa Macdonald-Cartier International Airport (YOW), which is a moderately busy airport by Canadian standards. The analysis will consist of two case studies with the goal of estimating fuel burn savings for a medium-sized turbofan-powered commercial aircraft, the first one assessing a straight-in vertically optimized CDA and the second, a laterally optimized CDA.

A Continuous Descent Approach is a procedure where the aircraft descends from the Top of Descent (TOD) point at the end of cruise to the runway threshold with the engines at idle or as close to idle setting as possible. However, as an aircraft slows and descends on the final approach glide slope of typically 3^o, its flaps and landing gear are deployed which increases drag and thus engine thrust.

The procedure reduces total fuel burn because it seeks to maximize distance covered at high altitude where the engines operate efficiently at their cruise setting and to minimize fuel burn at lower, denser altitudes where the engines operate less efficiently. Based on performance calculations by SRS Ltd., a modern single aisle aircraft like an A320 or 737NG will burn approximately 5 to 6 kg/NM in cruise at 35,000 ft and M0.78, while the fuel burn will be in the order of 9 to 10 kg/NM at 3,000 ft and 210 KIAS.

In addition to reduced fuel consumption, the other direct benefits of CDA's are:

- Correspondingly reduced emissions of CO_2, NO_X and other exhaust gases;
- Shorter flight times;
- Reduced noise exposure to communities on approach paths due to less low-level manoeuvring at higher engine setting;
- Reduced engine and associated systems maintenance costs due to less throttle movement;
- Shorter engine line maintenance turn-around time due to cooler engines at arrival to gate.

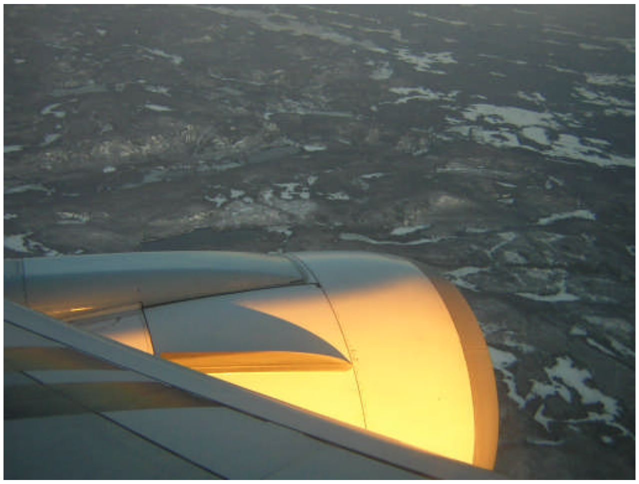

Figure 1.1 – Early Winter Descent into Ottawa International Airport

2. Historical Context

While Continuous Descent Approaches are increasingly referenced as a means to save fuel, cut emissions and reduce noise, the concept in regards to jet transport operation has been around for over 30 years. A seminal paper written by H. Dibley in 1974 [Ref. 1] made convincing arguments for performing descent into London's Heathrow airport at idle power and then flying the final 3 miles on a stabilized 3^o glide slope in the interests of saving fuel and reducing the noise impact on communities on the various approach paths. The problem of accurate aircraft vertical navigation (VNAV) was addressed by the author via the design of a handheld computer similar to the ubiquitous E6B. Even today, noise around Heathrow continues be a major issue, so much so that it influenced the design specification of the A380.

Lufthansa developed a similar technique called "low drag, low power" in the mid-1970's to reduce noise over the city of Offenbach which was directly on a Frankfurt runway approach path [Ref. 2]. Yet, the U.K. Civil Aviation Authority resisted the introduction of this procedure for use into London for reasons related to concerns over safety and reluctance to change existing standard approach procedures [Ref. 3].

A study in 2000 by the NLR evaluated the environmental benefits of nighttime Continuous Descent Approaches into Schiphol Airport using aircraft operational data [Ref. 4]. Average fuel savings using CDA's were 55 kg for 737-300/400 aircraft and 400 kg for 747-400 aircraft compared to standard 3,000 ft altitude waypoint approaches. The 65 dB(A) noise footprint was reduced from 25 km^2 to 17 km^2 for the 737-300/400 and from 74 km^2 to 43 km^2 for the 747-400 when comparing standard 3,000 ft approaches to CDA's.

3. Recent Developments

Significant progress has been made to date in developing and operationally validating 4D trajectories (4DT) during Continuous Descent Approaches. An aircraft 4D trajectory is the definition of its flight path in the three spatial dimensions and in time. The 4DT CDA concept involves the aircraft's Flight Management System (FMS) calculating the Top of Descent point where throttles are retarded and the estimated time of arrival at the runway threshold based on parameters such as aircraft weight, altitude, static air temperature, wind speed and direction,. The aircraft then communicates its Estimated Time of Arrival (ETA) via datalink to Air Traffic Control (ATC) which can approve or adjust the landing time up to an hour before descent commences. This process enables the aircraft to achieve a more efficient descent profile while enabling ATC to sequence traffic at high altitude instead of down low with traditional radar vectors. Lateral navigation is performed using Area Navigation (RNAV) and the final approach is performed via intercept of the Instrument landing System (ILS) as the requirement for a stabilized approach remains essential [Ref. 5].

Avtech of Stockholm, Sweden is a technology consulting firm that has the leadership position in the area of 4DT Continuous Descent Approaches. The Arlanda 4DT project started in 2006 with European Commission funding under the auspices of the Single European Sky ATM Research (SESAR) program. They have been working with LFV Group, Sweden's air navigation service provider and Scandinavian Airlines (SAS), along with partners Boeing, Rockwell Collins and GE Aviation to develop the technologies and procedures for 4D trajectory descents and approaches.

During 2008, SAS flew 4,000 4DT approaches into Stockholm saving 240 metric tones of fuel or 60 kg per flight, 756 metric tonnes of CO2 emissions and 2.6 metric tonnes of NOx [Ref. 6].

Using a computer simulation, Avtech estimated fuel savings of approximately 70 kg with a 4DT CDA to ILS procedure compared to a baseline standard ILS approach procedure with radar vectors using a 737-600 weighing 115,000 lb under no wind and iso-atmospheric conditions, descending from FL330. [Ref. 5]. The fuel savings come from transforming three level-offs (FL130, 5,000 ft, 2,500 ft) in descent to just one at 2,500 ft and from the shortened ground track, which was reduced by 9 NM from 131 NM to 122 NM. It should also be noted that reducing low altitude manoeuvring and ground track also saves flight time.

As far as Avtech is concerned, the 4DT approaches are beyond the laboratory stage. Future efforts will focus on combining 4DT CDA procedures with Required Navigation Performance (RNP) procedures which can potentially significantly reduce ground track for even greater fuel and time savings. Naverus of Kent, Washington is the leading company in the area of RNP [Ref. 5].

In the future, a flight could be managed gate to gate by employing the user's "business trajectory" that would be based on the trade-off between time and cost [Ref. 7], much in the way pilots today set their aircraft FMS based on a Cost Index, which is the ratio of the cost of time to the cost of fuel.

The notion of business trajectory ties in with the concept of Performance Based Operations (PBO) which seeks to maximize aircraft operational efficiency by taking into account navigation and time in the flight planning and management [Ref. 8]. It is important to be able to identify the optimum trajectory for any given flight and the deviation from that trajectory so that improvements can be continually made, thereby applying the principle of *kaizen* to both flight operations and air traffic management. One of the big challenges in managing air traffic at a commercial airport such as Arlanda or Ottawa is the heterogeneous mix of arriving and departing aircraft of different sizes and speeds which greatly increases the real-world challenge of maintaining the safe separation distance between each aircraft.

The nexus of aircraft performance optimization and air traffic management serves as today's operational challenge and is cited as the basis the EU's *SESAR* and the FAA's *NextGen* future system roadmaps.

4. Analysis of CDA Procedures into Ottawa International Airport

As previously discussed, the analysis of Continuous Descent Approaches will consist of two case studies that are representative of typical commercial arrivals into Ottawa Macdonald-Cartier International Airport. The aircraft type used for the case study will be a Boeing 737-700 NG (New Generation), which will permit more ready comparison to fuel savings data presented in the previous section. The savings for an Airbus A320 would be very similar.

The methodology developed by Specific Range Solutions Ltd. for calculating total distance and fuel burn developed is shown in Figure 4.1 and is based on ISA and zero wind conditions.

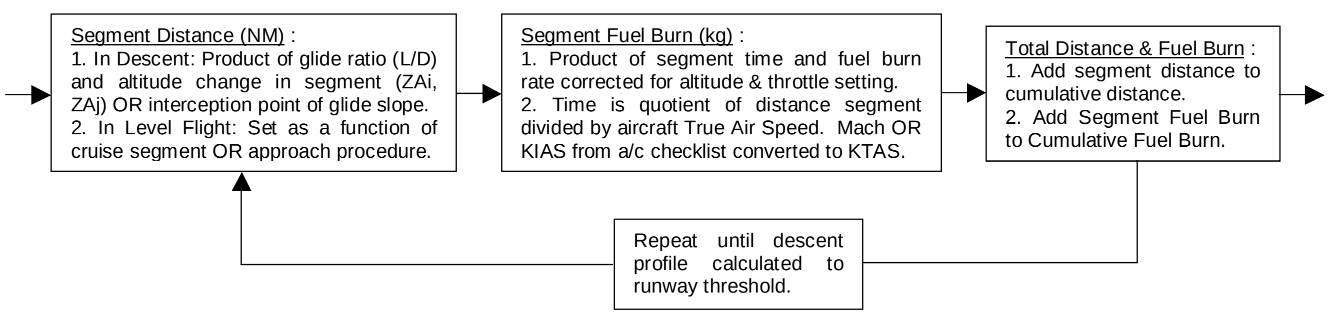

Figure 4.1 – Fuel Burn and Distance Calculation Methodology, ISA & Zero Wind Conditions

The first case study is a comparison of straight-in vertically optimized CDA to a normal descent approach based on a flight departing Toronto (YYZ) and landing at Ottawa (YOW) on Runway 07.

The second case study is a comparison of a laterally optimized CDA to a CDA following a normal track based on a flight departing Winnipeg (YWG) and landing at Ottawa (YOW) again on Runway 07.

4.1 Vertically Optimized CDA Case Study (YYZ to YOW)

This case study evaluates the fuel and cost savings, as well as CO2 and NOx emissions reductions for a typical flight between Toronto Pearson (YYZ) and Ottawa Macdonald-Cartier (YOW) airports in a 737-700 aircraft. As the descent and approach is a straight-in arrival, the evaluation seeks to determine the difference in fuel consumption between a vertically optimized Continuous Descent Approach and a standard descent approach where the ground track is the same.

The assumptions are for standard atmospheric conditions (ISA) and no winds.

For arrival in the terminal area of Ottawa Macdonald-Cartier International Airport, there are four Standard Terminal Arrival Routes (STAR) and four Standard Terminal Arrival Routes using Area Navigation (RNAV) per the Canada Air Pilot [Ref. 9]. Five runway approaches have been published in [Ref. 9]. All are summarized in the following table:

STAR	STAR (RNAV)	Runway Approaches
CYRIL EIGHT	CAPITAL NINE	NDB RWY 25
LANRK THREE	DEANS FOUR	VOR RWY 14
OTTAWA SIX	MEECH SIX	LOC(BC) RWY 25
THURO ONE	RIVER SIX	ILS or NDB RWY 07
		ILS or NDB RWY 32

Table 4.1 – CYOW Standard Terminal Arrival Routes & Approaches [Ref. 9]

A straight-in arrival from the west to Runway 07 would normally use the CAPITAL NINE STAR (RNAV) procedure combined with an ILS approach to Runway 07.

CAPITAL NINE involves descending to 10,000 ft ASL or below at the LANRK waypoint and then proceeding 25.6 NM to VISOL, which is the Final Approach Course Fix (FACF) and not descending below 3,000 ft ASL until the glide slope is intercepted. The distance from VISOL to the runway threshold is 10.2 NM.

Data from a typical flight on November 2nd, 2009 from YYZ to YOW was obtained from the FlightAware website (flightaware.com) for an A320 / 737NG-sized aircraft [Ref. 10]. Figure 4.2 shows the full ground track mapped onto Google Earth with LANRK and VISOL indicated. Figure 4.3 is the plot of the descent and approach ground track with latitude and longitude indicated, also shown is the TOD point and VISOL and LANRK. The accuracy of the FlightAware lateral data is in the order of ±2 NM, the altitude data appears to be per the aircraft altimeter.

The altitude profile for the flight is shown in Figure 4.4. The distance from Top of Descent to touchdown on Runway 07 is approximately 104 NM, prior to VISOL there is a level-off at 3,000 ft ASL of approximately 10.3 NM. From the available data, it is not possible to determine how close the descent profile and fuel burn are to flight idle optimum because key parameters such as aircraft weight, airspeed, engine thrust level, associated fuel burn, wind speed and direction, outside temperature are unknown.

However, it is possible to construct a standard profile with certain assumptions and compare it to an idealized CDA.

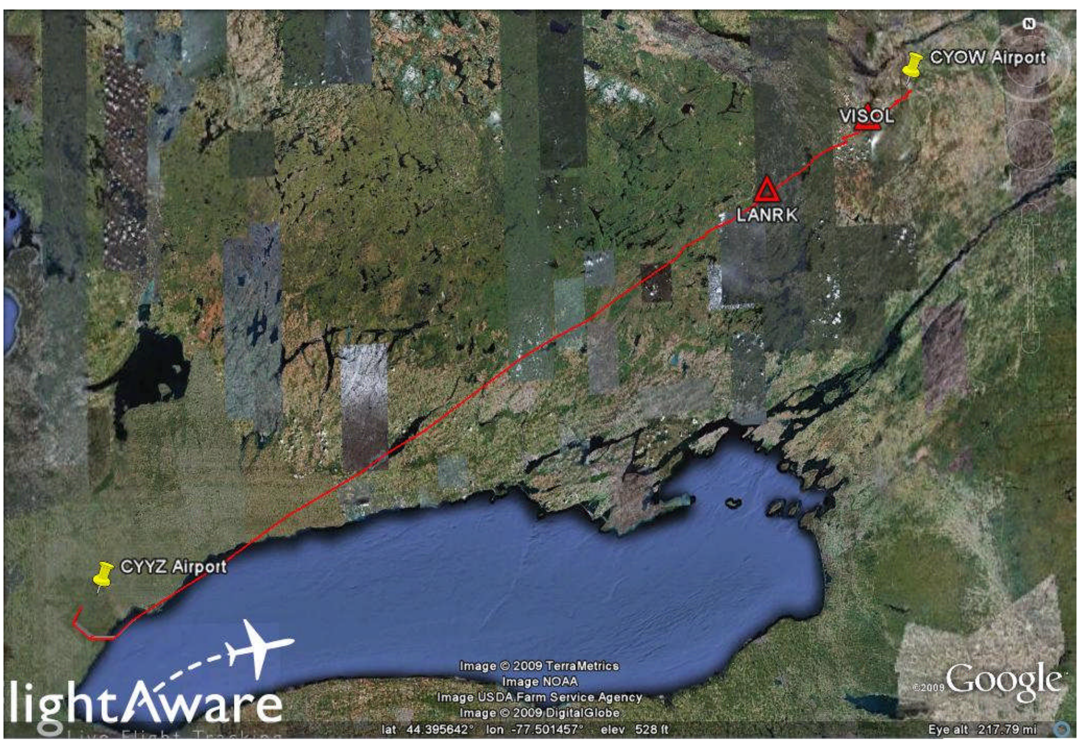

Figure 4.2 – Typical Flight Ground Track from YYZ to YOW (RWY 07) [Ref. 10]

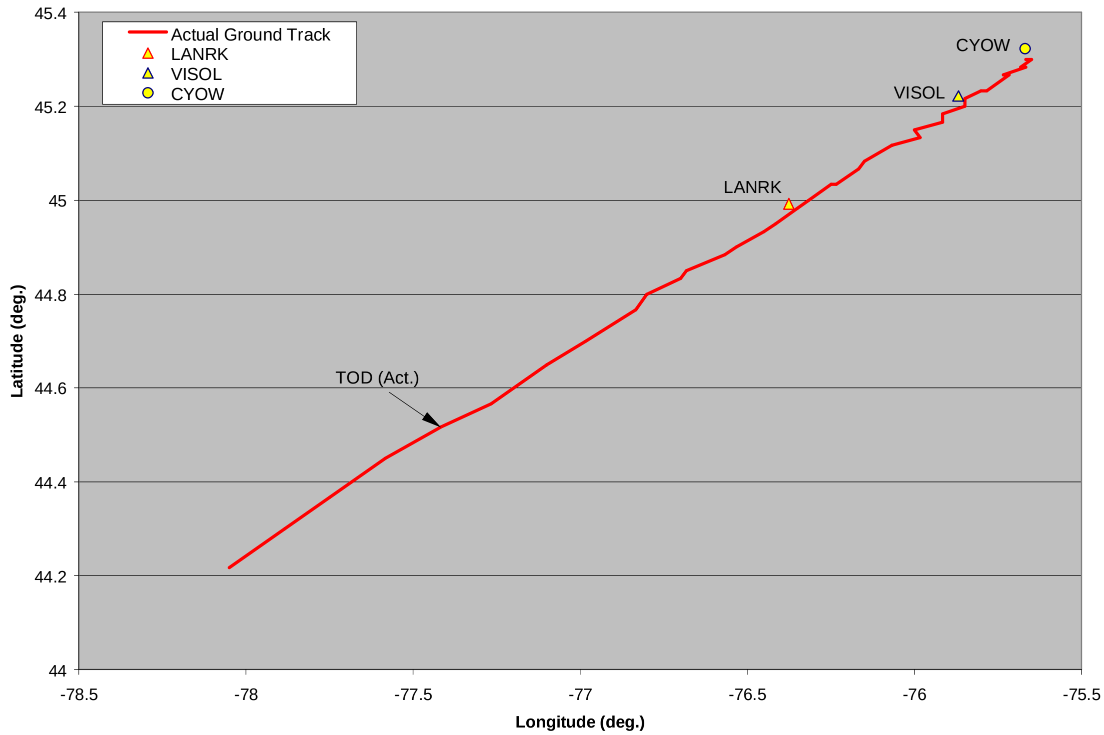

Figure 4.3 – Typical Flight Ground Track, Descent & Approach YYZ to YOW (RWY 07) [Ref. 10]

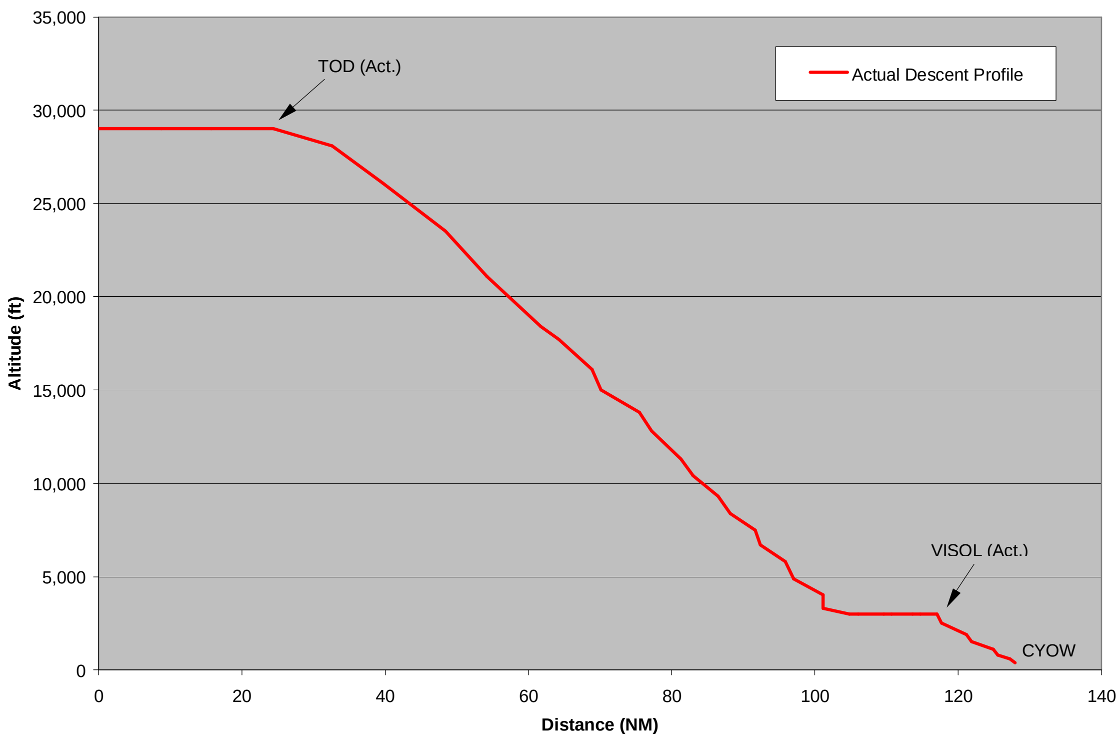

Figure 4.4 – Typical Flight Altitude Profile, Descent & Approach YYZ to YOW (RWY 07) [Ref. 10]

Two different descents were simulated using a 737-700 aircraft weighing 135,700 lb, the airspeeds for descent and approach were based on a 737NG checklist [Ref. 11].

The first serves as the reference and is a normal descent approach following STAR (RNAV) with a 10.3 NM level-off at 3,000 ft ASL before intercepting the ILS glide slope per the red line in Figure 4.5.

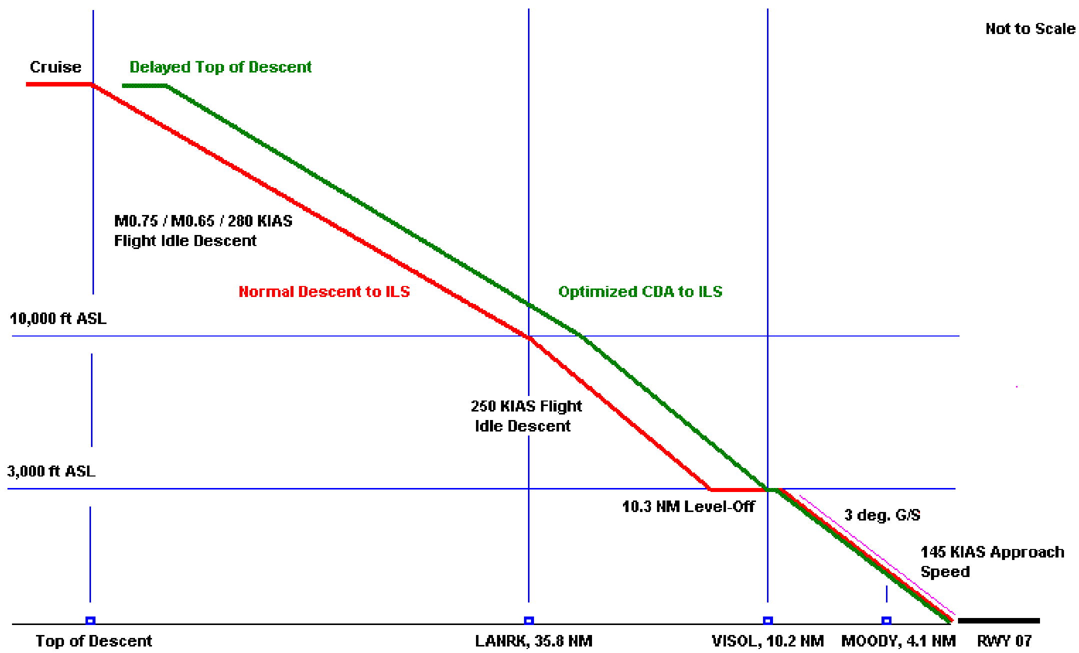

Figure 4.5 – Normal Descent vs. Optimized CDA for 737-700 to YOW (RWY 07), ISA No Wind

The second profile, shown is green in Figure 4.4, is an optimized Continuous Descent Approach that descends directly to VISOL and levels off at 3,000 ft ASL for 2.0 NM before intercepting the ILS. This would be achievable using the existing RNAV and VNAV functions of the aircraft and would allow 2.0 NM of stabilization before G/S intercept. The procedure is not compliant with existing ATC procedures in that the aircraft would pass LANRK at an altitude greater than 10,000 ft ASL, but the point of this profile is to limit leveling-off in descent.

Note that the descent segment to 10,000 ft ASL is based on a flight idle engine setting with an air speed for $(L/D)_{Max}$ while the descent segment to 3,000 ft is also at flight idle, but with a reduced (L/D) due to the 250 KIAS air speed restriction below 10,000 ft ASL. Additional drag induced by flap settings and landing gear is accounted for by higher fuel burn during the level-off and final approach segments. Optimally, the aircraft shall remain clean (no flaps) and at flight idle for as long as possible.

The total fuel burn was calculated per the methodology outlined in Figure 4.1 for three different cruise altitudes: 29,000 ft, 31,000 ft and 33,000 ft assuming zero wind and ISA conditions. The Top of Descent point for the normal descent serves as the distance datum for both types of approaches to enable a relevant comparison. As can be seen schematically from Figure 4.4, the optimized CDA is longer in cruise prior to its Top of Descent point. Therefore less fuel is burned at high altitude than at low altitude and that is the source of fuel savings in this case. The fuel burn values for the CFM56-7B24/3 engine of the 737-700 for idle and approach settings were obtained from [Ref. 12] and for cruise were obtained from [Ref. 13].

Cruise Altitude (ft ASL)	**Total Distance from Datum** (NM)	**Std. Descent Total Fuel Burn** (kg)	**Opt. CDA Total Fuel Burn** (kg)	**Fuel Burn Reduction** (kg)
29,000	92.1	310.7	283.6	27.1
31,000	98.0	314.4	283.0	31.4
33,000	103.9	317.8	282.1	35.8

Table 4.2 – Fuel Burn Reduction with Optimized Straight-In CDA for 737-700 to YOW (RWY 07)

Therefore, the fuel saving is estimated in the order of 27.1 kg to 35.8 kg depending on the cruise altitude at Top of Descent. The higher the cruise altitude, the greater the descent distance and the greater the fuel burn reduction with the CDA due to the low altitude distance being covered in cruise. However, extra fuel needs to be burned during climb to reach a higher cruise altitude. Optimized fuel burn for an entire flight is a subject for another study. The fuel saved using an optimum descent and approach for any particular flight will depend on the multiple factors including aircraft type and weight, wind speed and direction, temperature, altitude, flap deployment schedule and runway in use. Those savings will always be with respect to a particular reference profile.

Looking at the middle case with a TOD at 31,000 ft which gives 31.4 kg of fuel savings for a CDA, the fuel cost savings assuming $CDN 1.44 per liter of Jet-A[1], as well as reductions in CO_2 and NO_x emissions on a per flight and annual basis have been estimated in Table 4.3. The NO_x emissions reductions are not significant because while the CDA profile reduces fuel burn, the additional fuel burned in cruise generates proportionately more NO_x per kg of Jet-A burned because of higher combustor flame temperatures. On an annual basis, more than 11 tonnes of fuel would be saved, there would be almost 36 tonnes of CO_2 and just 16 kg of NO_x not emitted into the atmosphere. The airline would stand to save over $20,000 per year on this one daily flight alone based on a modest, but achievable CDA fuel burn reduction.

Reference Period	Fuel Burn Reduction (kg)	Fuel Cost Savings ($CDN)	CO2 Reduction (kg)	NOx Reduction (kg)
Per Flight	31.4	55.14	98.1	0.04
Per Annum	11461.0	20125.36	35817.9	15.89

Table 4.3 – Fuel Cost Savings, CO_2 & NO_x Reductions with Optimized Straight-In CDA from FL310 for 737-700 to YOW (RWY 07)

4.2 Laterally Optimized CDA Case Study (YWG to YOW)

The second analysis evaluates the fuel and cost savings and emissions reductions for a typical flight between Winnipeg Richardson (YWG) and Ottawa Macdonald-Cartier (YOW) airports in a 737-700 aircraft. The descent and approach from the northwest involves a descent to the YOW VOR followed by navigation to the MODON waypoint and VISOL Final Approach Course Fix per the MEECH SIX STAR RNAV route and then an ILS approach and landing on Runway 07.

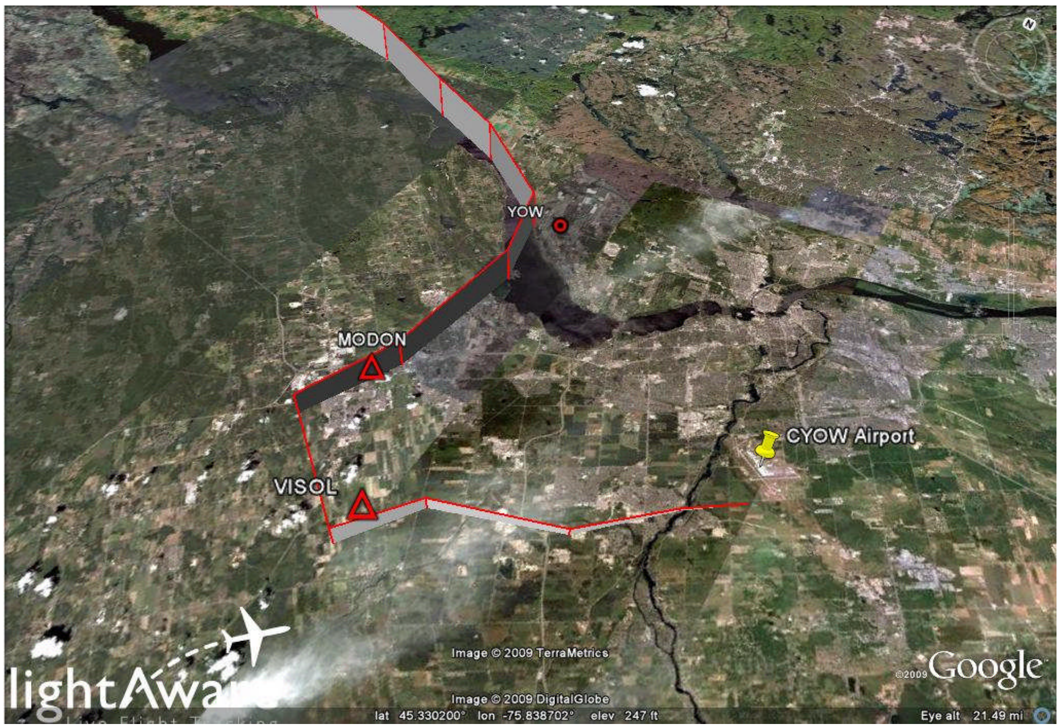

Figure 4.6 - Typical Flight Ground Track, Descent & Approach YWG to YOW (RWY 07) [Ref. 10]

Data was obtained from the FlightAware website (flightaware.com) for an A320 / 737NG-sized aircraft [Ref. 10] for a YWG to YOW flight on October 30th, 2009. Figure 4.6 shows the ground track for descent and approach to Ottawa mapped onto Google Earth with YOW VOR, MODON and VISOL

[1] Esso Avitat CYOW Jet A-1 price on Oct. 22nd, 2009: $1.44/L. Airline price for fuel may be more or less per many factors.

indicated. Figure 4.7 is the plot of the descent and approach ground tracks for the actual flight in red and for the optimized ground track in green. The optimized track is 8.0 NM shorter than the actual track flown, and while it not compliant with normal ATC procedures to fly direct to VISOL from the enroute airway, it is entirely technically feasible using the aircraft's RNAV function.

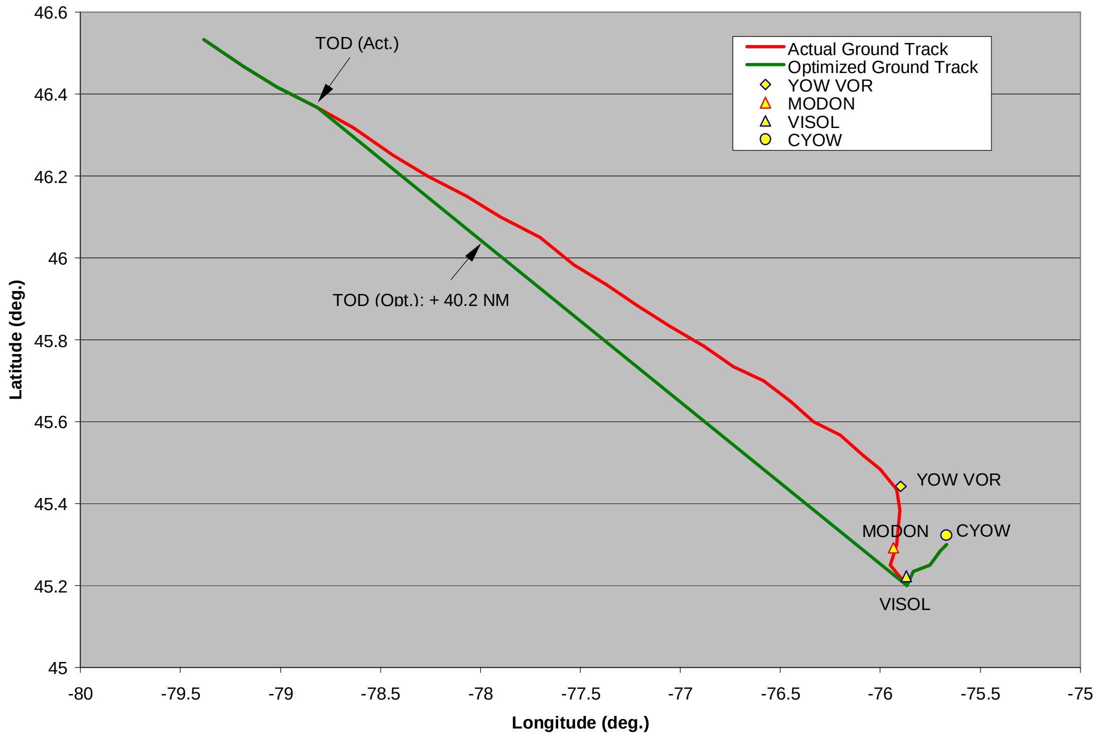

Figure 4.7 – Flight Ground Tracks, Descent & Approach YWG to YOW (RWY 07) [Ref. 10]

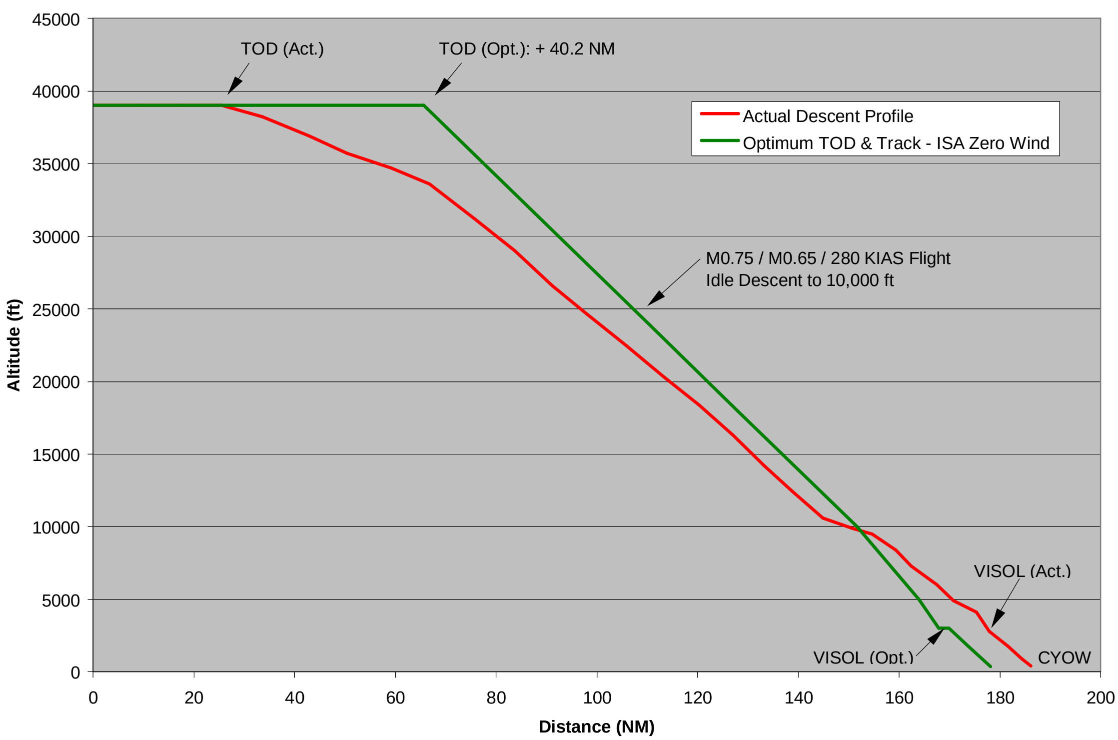

Figure 4.8 – Flight Altitude Profiles, Descent & Approach YWG to YOW (RWY 07) [Ref. 10]

The altitude profiles for the actual and optimized flights are shown in Figure 4.8. For the actual flight, the distance from Top of Descent to touchdown on Runway 07 is approximately 161 NM with slight leveling–offs at approximately 10,000 ft ASL and 4,000 ft ASL. For the optimized flight without wind and at ISA conditions, the distance from TOD to touchdown is approximately 112 NM with a 2.0 NM level-off just prior to VISOL.

The influence of a tailwind likely explains the earlier TOD and longer descent track for the actual flight. Tailwind components of 49 kts at 39,000 ft and 25 kts at 20,000 ft were estimated for the actual flight based on assumed airspeeds. The shape of the actual flight profile appears to be strongly influenced by the winds aloft, especially when compared to the zero wind ISA optimized flight profile. Upper winds clearly have an important influence on the TOD calculation.

The actual comparative analysis was defined as a comparison the impact of the typical ground track versus the optimized ground track for three different cruise altitudes: 37,000 ft, 39,000 ft and 41,000 ft. All the cases would be Continuous Descent Approaches with zero wind and ISA conditions, that way the lateral navigation and altitude parameters would be the only variables. The resulting fuel savings are shown in Table 4.4 shown below. The datum for each altitude is the TOD for the standard CDA track case, which is 8.0 NM longer than for the optimized CDA track. The fuel burn reduction decreases with increasing altitude as the cruise fuel burn decreases with increasing altitude. No additional fuel is burned at low altitude because all descents are CDA's.

Cruise Altitude (ft ASL)	**Std. Track CDA Distance** (NM)	**Std. Track Total Fuel Burn** (kg)	**Opt. Track CDA Distance** (NM)	**Opt. Track Total Fuel Burn** (kg)	**Fuel Burn Reduction** (kg)
37,000	123.8	367.1	115.8	324.1	43.0
39,000	129.7	366.0	121.7	327.0	39.1
41,000	135.6	365.1	127.6	329.6	35.5

Table 4.4 – Fuel Burn Reduction with Optimized Track CDA for 737-700 to YOW (RWY 07)

Using the 39,000 ft case as a reference, the fuel cost savings as well as reductions in CO_2 and NO_x emissions on a per flight and annual basis have been estimated in Table 4.5.

Reference Period	**Fuel Burn Reduction** (kg)	**Fuel Cost Savings** ($CDN)	**CO2 Reduction** (kg)	**NOx Reduction** (kg)
Per Flight	39.1	68.66	122.2	0.49
Per Annum	14271.5	25062.15	44601.3	177.90

Table 4.5 – Fuel Cost Savings, CO_2 & NO_x Reductions with Optimized Track CDA from FL390 for 737-700 to YOW (RWY 07)

On an annual basis, more than 14 tonnes of fuel would be saved, there would be almost 45 tonnes of CO_2 and 188 kg of NO_x not emitted into the atmosphere. The airline would stand to save over $25,000 per year.

5. Conclusions

The results of these two simulations indicate that vertically and laterally optimized Continuous Descent Approaches can generate notable fuel burn and emissions reductions, as well as fuel cost savings under ISA and zero wind conditions for a medium-sized commercial aircraft.

The fuel burn reduction for a 737-700 using an optimized straight-in Continuous Descent Approach from 31,000 ft compared to a standard descent approach is approximately 31 kg.

Using the same type of aircraft for a CDA from 39,000 ft with a ground track reduced by 8.0 NM compared to a standard ground track results in an estimated 39 kg fuel burn reduction.

The combined vertical and lateral optimizations result in approximately 70 kg of fuel savings, however with different Top of Descent altitudes. This result is relevant for the A320-series aircraft, as well. While the analyses were based on idealized conditions, this figure is within the 55 to 70 kg range for the 737 type indicated by References [4], [5] and [6].

The simulations could be developed to take into account winds aloft and temperature. Ultimately, a detailed model incorporating an engine fuel flow algorithm as a function of thrust settings, altitude and temperature would enable more complex profiles to be modeled.

The potential for even greater reductions in fuel consumption during descent and approach exists per [Ref. 10], fuel savings of up to 163 kg can be achieved per flight by combining optimized vertical and lateral profiles in the form of a Continuous Descent Approach coupled with a Required Navigation Performance (RNP) procedure. An RNP procedure alone could eliminate more than 12 NM of ground track when compared to a traditional RNAV for a downwind and crosswind type arrival.

A review of recent commercial flights on flightaware.com indicates that RNAV procedures are frequently used at Ottawa airport and that many descents are continuous without level-offs for glide slope intercepts. That being said, the exact accuracy of the lateral data FlightAware needs to be verified. The data resolution is based on transmissions every 60 seconds. Ground speed and track are known, but not air speed. Thus, wind speed and direction cannot be precisely calculated with the available data.

Insertion of an aircraft performing a CDA into the terminal area traffic stream is complex as its speed and altitude profile will be different from other aircraft performing more “classic approaches”, resulting in potential impact on other traffic. Proper energy management (air speed and altitude) of a CDA is very important for the safe and efficient operation of the aircraft.

It must be recognized that the operation of any commercial aircraft in Canada is governed by the Aircraft Flight Manual (AFM), the airline’s Standard Operating Procedures (SOP), as well as Air Traffic Control procedures and instructions. These rules necessarily exist to ensure flight safety, however they render flight optimization more challenging. Any changes to arrival and approach procedures would require the approval of the regulator, Transport Canada.

Some questions which arise out of this study are:

1. What is the average fuel burn for descent and arrival for each commercial flight at Ottawa airport as a function of aircraft type and active runway?
2. How close to achieving their optimum vertical profile for minimum fuel burn are commercial flights flying into Ottawa given that conditions for every flight are the different and traffic load varies with the time of the day? Important aspects of the analysis would involve investigating engine thrust levels through the descent and approach, as well as flap deployment.
3. To what extent are the commercial flights fully exploiting the existing RNAV procedures and capabilities of their aircraft to minimize their lateral tracks?
4. What are the time and separation impacts of an aircraft performing a CDA in the present ATC environment?
5. What benefits can be derived from a “cleared visual” approach compared to a standard RNAV and ILS approach? The weather cannot always be assumed to be bad. What percentage of arrivals are in visual conditions at Ottawa?
6. What is the influence of winter weather on CDA’s? Use of anti-icing and de-icing systems will impact fuel burn and aircraft performance.
7. What modifications to existing procedures without technological investment at YOW could be made to reduce fuel burn during descent and approach and what would be the estimated savings?
8. What are the technologies on the horizon to facilitate optimization of operations for both the airlines and NavCanada, the Air Navigation Service Provider?
9. What would be the overall benefit in terms of emissions and noise reductions of optimized current operations for the airport as a whole on an annual basis? What will be the impact of future traffic growth and technological as well as approach procedure evolution?
10. What is the public perception of the value of greener operations by airlines and the ANSP?

There is significant financial, operational and ecological value in optimizing descents and arrivals for all the stakeholders from the airlines, the Air Navigation Service Provider, the regulator, the airport authority, local communities and the traveling public.

Specific Range Solutions Ltd. has the willingness and capability to investigate the aforementioned questions in more depth.

6. References

[1] *How to Reduce Noise and Save Fuel - Now*, H. Dibley, Journal of the Guild of Air Pilots and Air Navigators, March 1974.

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