Whither Gander? A Business Case to Revive a Northern Hub Airport to Reduce Transatlantic Emissions

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This paper identifies the environmental benefits of reintroducing the concept of a technical stop for commercial flights across the North Atlantic. This paper provides a historical overview of flight schedules between North America and Europe beginning in the propeller era and ending in post-COVID times. We can see the potential for significantly lower per-passenger fuel burn for flights to Europe through higher-density interior "daylight" crossings of the North Atlantic. While limited "daylight" flights can be operated from select east coast cities, schedules involving overnight technical stops at Gander Airport (CYQX) enable a broader array of connecting opportunities for passengers.

I. Introduction

GANDER airport (CYQX), in Newfoundland, Atlantic Canada, has an interesting history. It began construction in the 1930's, when Newfoundland was still a British colony; Newfoundland & Labrador only joined the Canadian nation in 1949. During the Second World War, Gander airport served as major staging point for aircraft flying between North America and Europe. After the war, airlines including Pan-Am, TWA, TCA (the predecessor to Air Canada) and BOAC (the predecessor to British Airways) used Gander as transit hub for passenger flights destined to cross the North Atlantic. Today, Gander is known solely as a safe-haven refueling point for technical stops. In 2022, the Gander Airport website states "twenty percent of business jets flying the North Atlantic stop at Gander." [1]

Anthropogenic climate change concerns as well as operational economics motivate this study. Hydrocarbon fueled aircraft emit carbon dioxide (CO2) and nitrogen oxide (NOx) emissions as an operational byproduct of their Brayton cycle engines. The U.S. Environmental Protection Agency (EPA) states that, in 2020, 79% of total U.S. greenhouse gas emissions were CO2 and 7% was NOx. The transportation sector (land and sea as well as air) was the largest source of CO2 emissions in 2020, accounting for about 33% of total U.S. CO2 emissions and 26% of total U.S. greenhouse gas emissions.[2] In 2018, aviation was the source of ~3% total U.S. carbon dioxide emissions. Commercial air (passengers and cargo) account for ~9% of greenhouse gas emissions arising in the U.S. transportation sector. [3] Thus, plans for aviation must consider its impact to regional and global greenhouse gas emissions. We note that long-haul flights requiring high-fuel fraction departures are less efficient than a series of shorter stages; it is no surprise that for operating economic reasons that many overseas air-cargo flights make technical stops at remote airports like Gander.

As an aviation enthusiast, and frequent traveler (albeit on a budget), I have been troubled by the dominant transatlantic flight paradigm of the jet age – the eastbound "red-eye" to the UK and Europe. As one who sleeps poorly on aircraft, with or without luxurious on-board accommodations, I am neither rested nor relaxed upon arrival in the Old World. A 7:00am arrival into Heathrow deposits me, and my considerable luggage, into the morning rush hour crush on the London Underground; having to keep my bags with me until the 3:00pm check-in time at the hotel only adds further insult to injury. Even with luggage concierge service, I find myself unable to be productive on the day of arrival.

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In recent years, I discovered a booking strategy that largely resolved these problems. I would fly from Phoenix and overnight on the east coast in order to fly to Heathrow on a morning flight, Routing PHX→YYZ→LHR or PHX→IAD→LHR was comfortable even in coach. With full internet connectivity across the Atlantic, I would also retain a productive workday while in transit. After a ~9:00pm arrival into Heathrow, I could clear passport control and arrive at my hotel in time for "last call" at the pub. The next morning, I would be ready for the adventures of a full workday in London.

I am dismayed that current aircraft and route structures preclude daylight flights deeper into Europe. What works so nicely when flying to London surely could be replicated for flights to Paris, Amsterdam or Frankfurt if it were not for late arrival curfews? In previous work with my students, we demonstrated how even modest (i.e. Mach 1.3 cruise speeds) supersonic capability enables practical daylight flights to Europe. In order to schedule arrival times in central Europe at or before 10:00pm local time, a daylight flight needs to depart from points considerably further northeast than Toronto or Washington. Which brings us back to Gander.

In 2022, the primary runway (03/21) at Gander is 10,200-ft long; the crosswind (13/13) is 8,900-ft. The airport is equipped with ILS, and certified for RNAV (GPS) operations. Both the tower, the FBO and Canada Border Services operate 24-hours a day. [3a] At the present time, the US Customs & Border Protection does not offer US departure pre-clearance at Gander, but they do at nine other Canadian airports. [3b]

In this paper, I consider the personal productivity and environmental benefits that an Atlantic Canada hub airport could offer existing subsonic aircraft. It addresses two questions: 1) what is the fuel savings associated purely with a technical stop @ CYQX? 2) what is the environmental impact associated with an overnight technical stop @ CYQX where the daylight flight routing enables a higher density seating configuration without a loss in passenger comfort. The second question can be looked at two ways: 3) daylight flights using existing wide body aircraft and increasing passenger load and 4) downgrading to narrow body equipment holding the per-flight seating capacity approximately constant. We will see that option (3) provides the greatest environmental benefits over the present long-haul point-to-point nonstop "red-eye."

II. History of CYQX and the Sleeper Flight to Europe

Transatlantic scheduled commercial flights began in the 1930's with airships. Beginning in the summer of 1936, the Deutsche Zeppelin Reederei Gmbh offered seasonal service from Frankfurt in Hesse, Germany to Lakehurst, New Jersey in the NYC / Philadelphia Metropolitan area.[4] Due to its slow flight speed, its flight time varied widely (from 53 to 78 hours heading to North America, from 43 to 61 hours heading to Germany). [4] Despite the low ground speed, the Hindenburg offered non-stop service with passengers fully accommodated in sleeping cabins along with other steam-ship service amenities like a dining room, promenade and smoking room. American Airlines offered direct service to Lakehurst from Boston, New York, Washington with connections to points west; see FIGURE 1. [5]

FIGURE 1 – American Airlines Advertisement for the 1936 summer with code-share connections on the Hindenburg [5]

In July 1939, Pan American World Airways began seaplane services from New York to Southampton with its "Yankee Clipper" flying boat. [6] The trip was completed in 27.5 hours with a flight time of 19 hours and 34 minutes. The flying boat departed Port Washington Long Island, with technical stops at Shediac, New Brunswick; Botwood, Newfoundland, and Foynes, Ireland. Clearly, whether flying east-to-west or west-to-east, passengers were expected to sleep on board.

It wasn't until 1946 that commercial land-based aircraft began to fly the North Atlantic; see FIGURE 2. The February 1946 timetable for Trans World Airlines (TWA), a predecessor of the modern American Airlines, announced scheduled service between New York/LaGuardia (KLGA) and Paris (Orly), France (ORY/LFPO) with Technical Stops at Gander, NL (CYQX) and Shannon, IE (SNN/EINN). [7]

Shortly thereafter, on July 1st, 1946, the British Overseas Airways Corporation (BOAC), a predecessor of the modern British Airways, began Lockheed L-049 Constellation flights from New York to London/Heathrow (LHR/EGLL) also with en-route technical stops at Gander and Shannon, IE. [8]

FIGURE 2 – TWA Advertisement from 1946 introducing Lockheed Constellation service to Europe. [7]

FIGURE 3 – BOAC 1947 North Atlantic Route Structure [8]

A. 1946 Season –TWA / Lockheed L-049

For the 1946 season, TWA scheduled a 2:00pm departure from New York's LGA airport, with a 7:35pm arrival into CYQX. Passengers would disembark and eat during the long technical stop. The Constellation would leave Gander at 9:05pm and arrive Shannon, IE at 9:25am the next morning. After a brief technical stop, it would depart at 10:25am to arrive at Paris/Orly at 1:00pm local time. [7]

The return flight would depart Orly at noon, arrive in Shannon at 2:45pm. Passengers would disembark for dinner and a long technical stop. Flying would resume with a 4:15pm departure scheduled to arrive at Gander at 9:20am the next morning. After a short technical stop, the aircraft would leave Gander at 10:20am and arrive at New York/LGA at 3:05pm. Passengers could further connect to U.S. east coast destinations with evening arrivals. [7]

B. 1947 Season – BOAC / Lockheed L-049

For the 1947 season (see FIGURE 3), BOAC scheduled its "Speedbird" Lockheed L-049 Constellations with a 2:30pm departure from New York's LGA airport, with an 8:30pm arrival into CYQX. Once again, passengers would disembark and eat during a long technical stop. The Constellation would leave gander at 10:30am and arrive at Shannon, IE at 10:00am the next morning. After a long technical stop, it would depart Shannon at 11:30am to arrive at Heathrow at 1:30pm. [8]

The return flight would depart Heathrow at 8:00pm to arrive in Shannon at 11:45pm. After a brief technical stop, flying would resume with a 12:15am departure scheduled to arrive at Gander at 7:15am the next morning. After another technical stop, the aircraft would leave Gander at 8:45am to arrive at New York/LGA at 12:30pm. [8]

Alternatively, BOAC offered routing through Glasgow/Prestwick (EGPK) in Scotland rather than Shannon in Ireland. For those flights, the Constellation would leave LGA as before at 2:30pm to arrive CYQX at 830pm. After the long dinner break and technical stop, flying would resume at 10:30pm arriving at Glasgow at 10:30am the next morning. After a 90-minute technical stop, a noon departure leads to a 1:45pm scheduled arrival into Heathrow. [8]

The return flight would depart Heathrow at 8:00pm to arrive in Glasgow at 10:15pm. After a brief technical stop, flying would resume with an 11:55pm departure scheduled to arrive at Gander at 7:30am the next morning. After another technical stop, the aircraft would leave Gander at 9:00am to arrive at New York/LGA at 12:45pm. [8]

BOAC also flew a later afternoon departure from Dorval Airport (CYUL) in Montréal, QC. This flight left Dorval at 3:30pm to arrive at CYQX at 830pm. After a two-hour technical stop and dinner, it would depart for Glasgow/Prestwick at 10:30pm and follow the same route as the New York Flight. The return began the same as the New York flight, but instead the 9:00am Gander departure would arrive at Dorval at 11:30am. [8]

Once again, these schedules show that both east-to-west and west-to-east crossings of the Atlantic were made at night.

C. 1949 Season – Pan-Am / Lockheed L-049

The 1949 season Pan Am schedule demonstrates continued utilization of CYQX but with much shorter technical stops; see FIGURE 4. Pan Am scheduled a 7:00pm departure from New York's LGA airport, with a 1:05am arrival into CYQX followed 45 minutes later with a 1:50am departure to arrive at London/Heathrow at 1:50pm the following day. The return flight would depart Heathrow at 9:50pm to arrive at Gander at 6:00am the next morning. After another brief technical stop, the aircraft would leave Gander at 7:15am to arrive at New York/LGA at 10:50am. [9] We note that Pan Am's evening departures maximize connection opportunities at New York without an overnight stay on the US east coast.

EASTBOUND			4	2	6	8
Pan American Airways, Inc. (PAA)			Tu☆	We☆	Sa ☆	Su☆
NEW YORK (LaG.), U.S.A.	EST	Lv	19:00	19:00	19:00	19:00
			We	Th	Su	Mo
GANDER, Newfoundland	52½°W	Ar	1:05	1:05	1:05	1:05
GANDER, Newfoundland	"	Lv	1:50	1:50	1:50	1:50
LONDON, England	0°	Ar	13:50	13:50	13:50	13:50
LONDON, England	"	Lv	15:00	15:00	15:00	15:00
WESTBOUND			3	5	1	7
LONDON, England	0°	Ar	21:15	21:15	23:05	21:15
LONDON, England	"	Lv	22:15	22:15	23:59	22:15
			Su	Mo	Th	Fr
GANDER, Newfoundland	52½°W	Ar	6:00	6:00	7:45	6:00
GANDER, Newfoundland	"	Lv	7:15	7:15	9:00	7:15
NEW YORK (LaG.), U.S.A.	EST	Ar	10:50	10:50	12:35	10:50

FIGURE 4 – Pan American 1949 Schedule to Europe. [9]

D. 1951 through 1953 Season – BOAC

On July 1, 1948, New York opened a new International Airport built on the site of the Idle wild Golf Course on the Jamaica Bay. This Airport, presently known as JFK, became the dominant transit airport for international arrivals especially for foreign airlines. [10]

By 1951, BOAC employed the Boeing Stratocruiser with a three-class interior for their "Monarch" service from New York to London. The interior included a private stateroom, "Pullman" style sleeper berths as well as a 4-abreast recliner seat cabin. The timetable does not specifically call out the use of CYQX, merely stating "a technical call may be made en-route." BOAC schedule departures to leave New York's International Airport (KJFK) at 3:30pm and arrive at London/Heathrow at 9:00am the next morning with a return leaving Heathrow at 9:00pm arriving back to New York at 8:00am the next morning. [11]

The 1953 schedule differs only subtly, with the "Monarch" service showing a 5:00pm departure and 10:45am arrival from New York into London/Heathrow followed by an 8:00pm return from London scheduled to arrive at New York (KJFK) at 8:15am the next morning. The "Monarch" continued with the roomy sleeper + berth interior suitable for overnight accommodations. [12]

In 1953, BOAC also offered a less expensive higher density (a 4-abreast interior akin to modern domestic "First Class") interior "Mayflower" service on their Constellations. These flights had a clearly defined technical stop at both CYQX and Glasgow/Prestwick. It left New York two hours earlier, at 3:00pm to arrive at CYQX by 9:00pm. After a technical stop, it would depart Gander and arrive Glasgow at 9:15am the next morning. After another technical stop, it would arrive at Heathrow at 12:00pm. The return departed Heathrow at 3:15pm to arrive at Glasgow at 5:00pm. After a short technical stop, it would depart Glasgow to arrive CYQX at 2:30am only to refuel and arrive at New York at 7:15am. [12]

E. 1958 Season – Pan-Am DC-6 / Boeing Stratocruiser offerings

In 1958, just before the dawn of the jet age. Pan Am offered two distinctive products for the transatlantic market: a DC-6 "Clipper" with a 5-abreast 82-seat "tourist class" interior (see FIGURE 5) and a larger Boeing Stratocruiser seating a mixed collection of 27 berths and 37 seats (see FIGURE 6).

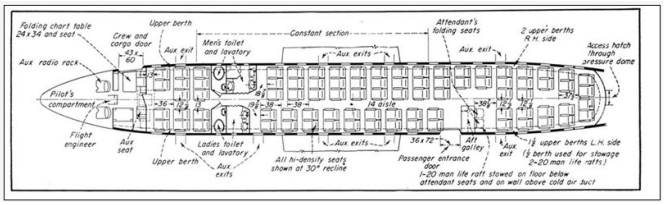

FIGURE 5 – PanAm DC-6 Tourist Class Interior [13]

The high-density DC-6 route departed New York/ LGA at 1:00am with a technical stop at Boston (KBOS) 12:15pm. Leaving Boston at 1:00pm it would fly overnight to arrive at Shannon 4:05am the next morning. After a 45-minute technical stop, it would leave Shannon at 4:50am in order to arrive London/Heathrow at 6:40am. Pan Am scheduled the return to leave Heathrow just before midnight, at 11:59pm, in order to arrive at Shannon at 2:00am, depart Shannon at 2:45am and arrive at Boston for lunch at 12:15pm only to leave at 1:00pm for a New York/LGA arrival at 2:15pm. [15]

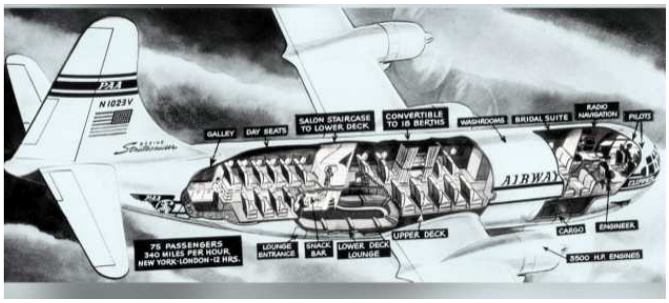

FIGURE 6 – PanAm Boeing Stratocruiser Interior [14]

Alternatively, the premium service Stratocruiser flight – with no scheduled technical stop – was to leave New York's International Airport (JFK) at 4:00pm to arrive at London/Heathrow by 8:30am the next morning. The return departs Heathrow at 7:00pm for an overnight return to New York arriving at 7:50am. [15]

Taken together, the propeller era schedules expect passengers to sleep during both east-to-west and west-to-east Atlantic crossings. All but the late Pan Am "tourist" flight place avoid technical stops made in the "middle-of-the-night."

F. 1959 Pan Am and the introduction of the Boeing 707

Beginning in 1959, Pan Am flew the North Atlantic with a Boeing 707. A 1959 schedule lists two round trip flights per day from New York to London. This is the first instance of a daytime crossing: the morning flight departs JFK at 10:00am and arrives at LHR at 9:55pm the same day; a "red-eye" leaves JFK at 9:00pm to arrive at London/Heathrow 7:55am the next morning. Pan Am offered a similar choice of return flights, an 11:00am departure from LHR, which arrived at JFK at 3:05pm, and a 1:30am departure from Heathrow to arrive at JFK at 5:35am. The very late departure coordinated with in-bound same-day feeder flights across the globe. So 50% of Pan Am's New York to London service was offered as a "daylight" flight. [16]

In 1959, TWA offered two alternatives to London. Either a Lockheed L1649 "Starliner" piston powered non-stop, with an early evening departure from Idle wild (JFK) 6:00pm and a next-morning arrival into London 10:05am (+1) or a 707 "Superjet" with a later evening departure from JFK at 8:00pm and early-the-next-morning arrival into London at 7:30am (+1). The L1649 flew the return as a "red-eye" sleeper, with 9:00pm departure from London/Heathrow arriving back at Idle wild (JFK) 6:00am (+1). The 707 flew the return as a daylight flight, with a noon departure from Heathrow and 2:25pm arrival at JFK. [17]

Although I understand that CYQX was occasionally used for technical stops in the early jet era, examined turbojet-era B707-100 series flight schedules do not expressly call out (or reserve time) for such a stop.

G. 1966 State of the Industry – Heyday of B707 operations

Moving later into the 1960's, let us consider operations in 1966.

In the fall of 1966, Pan Am offered a broad mix of daylight and red-eye flights across the North Atlantic; see FIGURE 7. Flight PA 118 began the morning at Washington/Dulles (IAD) with a 6:30am departure, a quick stop at Baltimore (BWI) to pick up additional passengers and then on to New York/JFK. It departed JFK at 9:45am to arrive at Paris/Orly at 10:45pm same-day with continuing service to Rome (FCO/LIRF) with a 1:05am (+1) arrival. Similarly, PA 100 departed New York/JFK at 10:00am for a 9:40pm arrival into London/Heathrow with same-day continuing service into Frankfurt (FRA/EDDF) at 12:45am (+1) and a final stop at Munich (MUC) at 2:10am. Thus, using JFK as an impromptu "hub," morning passengers originating in either the National Capital or the New York area had a choice of a daylight crossing to London, Paris, Frankfurt, Rome or Munich. Alternatively, PA 2 departed JFK at 7:00pm for a "red-eye" across the North Atlantic arriving LHR at 6:40am with continuing around-the-world service to Frankfurt and points further east. PA 102 departed JFK at 8:00pm for a "red-eye" across the North Atlantic arriving LHR at 7:40am with continuing service into central Europe. Pan Am also offered evening departures from JFK to a broad variety of European cities. However, the statistics show how daylight services were doomed; only 2 of the 12 daily eastbound services through NY were morning departures. [18]

FIGURE 7 – Pan Am North Atlantic Route Structure in 1966.

In 1966, BOAC offered 4 non-stops per day from New York to London/Heathrow with a mix of Vickers VC-10 and Boeing 707 product. Eastbound BOAC flew one daylight (10:00am → 9:40pm) and three red-eyes (8:00pm, 9:00pm and 10:00pm departures with arrivals the next morning). All returns were daylight flights with 11:00am, noon, 1:00pm and 6:00pm departures. [19]

Similarly, in 1966 Air France offered one morning (10:00am → 10:00pm) and three red-eye 707s from JFK to Paris/Orly. Morning flights from the North American west coast could also connect to two red-eyes from Montréal/Dorval (YUL) to Paris/Orly. One in six eastbound crossings were daylight; while all returns were daylight flights. [20]

Lufthansa in 1966 offered four daily 707s from New York/JFK to Germany, one to Bonn (CGN/EDDK), the other three to Frankfurt (FRA/EDDF) all "red-eyes" departing New York in the evening and arriving in the morning. The once-a-day flights from Chicago, Boston and Montréal were also evening departures. All returns were daylight flights. [21]

SwissAir in 1966 offered a daily DC-8 from JFK to Zürich (LSZH) with an evening departure from New York early morning arrival. They also offered a second DC-8 with an evening departure from JFK and eventual arrival in Zürich with intermediate stops in Lisbon and/or Geneva. A third DC-8 departed Chicago O'Hare (KORD) in the evening with a later morning arrival into Zürich and a stop in Montréal (CYUL). [22] Similarly, Scandinavian offered evening DC-8 service from Chicago (KORD) via Montréal (CYUL) to Copenhagen as well as a daily nonstop from New York (KJFK). [23] AerLingus offered evening Boeing 707 departures from Boston, New York/JFK and Montréal to Shannon with continuing service to Dublin (DUB/EIDW). [24] KLM offered evening non-stop DC-8 service from NewYork/JFK to Amsterdam (AMS/EHAM) with a daylight return. [25] Thus, all eastbound flights involved an overnight crossing; while all returns were daylight flights

This sets in place the pattern for the next 55 years; the vast majority of eastbound north atlanatic crossings are flown as "red-eye" sleepers. Due to conservation of passenger bookings and equipment, this means that almost all westbound crossings are flown as "daylight" flights with the same interior.

H. Recent Schedule from East Coast Gateway Airports to London

A survey using FlightAware in September 2022 reveals the following operations from the New York metropolitan area (KEWR and KJFK) to the London area (LHR and LGW). [26] JFK to LHR has 16 daily departures on British (BA), Virgin Atlantic, American Airlines, Delta Airlines and Jet Blue; of these, 19% are daylight flights (one each on British Airways, Virgin and American Airlines). JFK to LGW has three daily departures, one each on Norse Atlantic, Jet Blue and British; all "red-eye." Newark (EWR) has nine daily departures split between British Airways and United Airlines; two of the nine (22%) are daylight flights. Thus, ~80% of seating capacity in this market involve overnight flights with sleeper premium class seats. Once again, all returning flights are daylight operations. There are no regularly scheduled daylight flights deeper into Europe.

In September 2022, Air Canada offers a morning flight from Halifax (CYHZ) to London/Heathrow using a Boeing 737-8MAX with an 11:00am scheduled departure and 9:00pm arrival. [26] This flight leaves Halifax late enough to permit same-day connections orginating in Toronto (CYYZ), Montréal (CYUL) and Ottawa (CYOW). The return is also a daylight flight leaving Heathrow at 11:05am and arriving Halifax at 1:55pm; this permits same-day returning connections nationwide. Rival WestJet flies a "red-eye" Boeing 737-8MAX from Halifax to Paris (CDG) leaving Halifax at 11:00pm arriving mid morning. The return has a lunch-time departure from Paris and mid-afternoon arrival in Halifax. [26]

Historically, St Johns NFL (CYYT) saw regular transatlantic service. As late as 2016, WestJet offered 737 service departing St John's at 11:35pm to arrive London/Gatwick at 8:00am (+1). [27] Air Canada offered a thrice-a-week A319 with a 12:40am departure to arrive London/Heathrow at 9:15am (+1). With sub 5-hour block times, these "red-eye" flights offer limited opportunities to sleep on-board an aircraft featuring a standard "domestic" interior.

Although Air Canada once flew a morning B767-300 from Toronto (CYYZ) to London/Heathrow, that departure has been suspended. [29] In September 2022, FlightAware shows five nonstop flights per day between Toronto and Heathrow, three on Air Canada, two on British Airways, all are evening departure "red-eye" flights. WestJet and and AirTransat each fly an evening departure "red-eye" from Toronto (CYYZ) to London/Gatwick (EGKK). There are no regularly scheduled daylight flights deeper into Europe. [26]

Pre-Covid, British Airways flew a specially equipped Airbus A318 from London/City (EGLC) airport to New York (JFK). [30] While the eastbound flight is operated nonstop, due to runway constraints at LCY, the westbound flight makes a technical stop at Shannon, IE to take on a full fuel load. BA initially scheduled two flights per day, later pared back to a single "red-eye"eastbound and daylight westbound flight.

In September 2022, eight flights per day operate between Boston (KBOS) and London/Heathrow. British Airways offers a morning flight using a B777-300 with a 7:05am departure and 6:35pm arrival as well as a late evening "red-eye." United, Virgin, JetBlue and Delta all offer "red-eye" non-stops with evening departures and morning arrivals. Jet Blue also offers a single "red-eye" non-stop between Boston and London/Gatwick (EGKK). All return flights are flown during the daytime. [26]

Although United once flew a morning B757-200 from Washington/Dulles (KIAD) to London/Heathrow, that departure has been suspended. [31] In September 2022, FlightAware shows five nonstop flights per day between Washington/Dulles and London/Heathrow, two on United, two on British and one on Virgin Atlantic; all are "red-eye" depatures with arrivals into London throughout the morning. British presently flies a single "red-eye" from Baltimore/Washington (KBWI) to Heathrow with a 9:00pm departure and mid-morning arrival. [26]

In September 2022, three flights per day operate between Philadelphia (KPHL) and London/Heathrow. British Airways offers a single departure; American offers two. All are "red-eye" flights with evening departures and morning arrivals.[26]

Interestingly, there is a daylight flight in 2022 between Chicago/O'Hare (KORD) and London/Heathrow. American Airlines offers a morning B787-9 with a ~10:00pm scheduled arrival. American, United and British collectively operate seven other departures each day, all with evening departures and a morning arrival. [26]

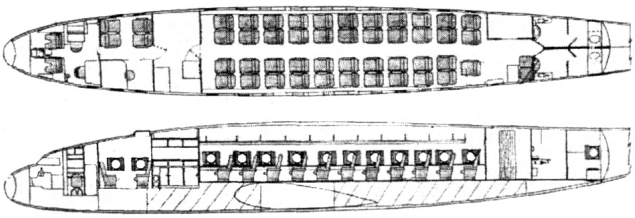

FIGURE 8 – BOAC Lockheed L-049 Transatlantic Interior [32]

FIGURE 9 – Boeing Stratocruiser 180-deg lie flat "Pullman Suite" interior [33]

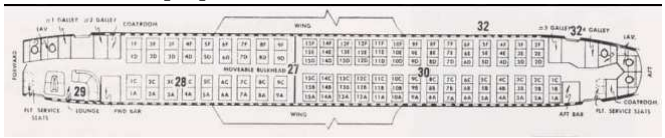

FIGURE 10 - 1959 B707 PA interior (2x2 in F, 3x3 in Y) [34]

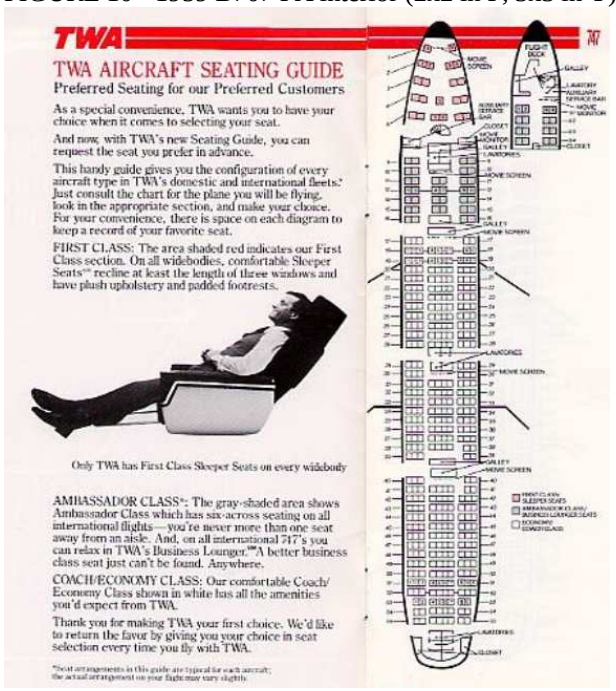

FIGURE 11 – TWA B747 three class interior [35]

III. Aircraft Interiors and the Sleeper Flight to Europe

A historical search has found that since its inception airlines fly the North Atlantic with a wide variety of interior schemes ranging from extremely cramped to near private "Pullman" suites.

A. 1940's and 1950's Piston Era Interiors

While the Lockheed L-049 Constellation typically had a 5-abreast (3x2) single-aisle interior seating up to 81 passengers, those used for North Atlantic overnight flights had much more spacious seating. For example, BOAC's L-049s featured only seats for 43 paid fares; see FIGURE 8.[32] Due to long flight times, there was a 4 place crew rest station ahead of the forward galley. As shown in FIGURE 9, the mid 1950's Stratocruiser had a more posh interior featuring 180-deg lie-flat seats that convert into "Pullman" style sleeping pods as well as more traditional reclining seats. [33]

B. First Generation Jet Era Interiors

The early jet era featured a turn to much higher density interiors. Turning to FIGURE 10, we can see the 1959 Pan Am B707-100 series interior with 123 seats arranged in 9 rows of 2x2 "First Class" seats with ~38-inch pitch and some recline (similar to modern Domestic "First Class") as well as 14.5 rows of 3x3 "Economy Seats" with ~34-inch pitch and limited recline. [34] While comfortable for daylight flights, the First Class interior is not particularly comfortable to sleep and offers much less privacy and space than was found on the Stratocruiser.

Turning next to FIGURE 11, we can see an early three-class interior from a 1980's era TWA 747-200. [35] It offered 21 "First Class" seats with substantial (but not "lie-flat") recline, 36 "Ambassador Class" seats arranged 2x2x2 with generous seat pitch and substantial recline as well as a cramped 3x4x3 "Economy" class interior.

C. Growing Inequality In the 21st Century

In the Twenty First century, transatlantic flights with the four engined B747 have been eclipsed by the twin engine airliner such as the B777 and

B787. Recall that a Boeing B747 has a 240-inch wide interior on the main deck while a B777 has a 231-inch wide interior and a B787 has a 216-inch wide interior.

FIGUREs 12, 13 and 14 highlight a growing trend towards inequality in seating among first world airlines; "First Class" and "Business Class" amenities grow ever more posh with "Economy Class" seats grow ever more cramped. FIGURE 12 depicts the original interior of the United Airlines B777-200 fleet for Transatlantic operations; 292-seats in total with 12 First Class "sleeper" (but not "lie-flat") seats, 49 Business Class recliners arranged 2x3x2 and 231 Economy seats arranged 2x5x2.[36] Move forwards 27 years, in FIGURE 13 we see the soon to be phased out 269-seat interior but with 8 First Class "suites" and 40 flat bed Business class pods. [37] In FIGURE 14, we see American Airlines interior with 37 flat bed seats, 24 recliners 8-abreast marketed as "premium economy" followed by 212 "economy" seats now even more cramped in a 3x4x3 10-abreast configuration. [38]

This trend is not unique to US based airlines. Turn next to FIGURE 15 to examine the interior of a British Airways B787-8. [39] While lacking the "suites" of the United 777, it still features 35 flat-bed "club world" seats, 25 recliner "world traveller plus" seats in 2x3x2 and 154 cramped seats in arranged 3x3x3 in economy. It is no wonder that United and American downgraded their 9-abreast 777's to to 10 abreast once a 9 abreast 787 became the norm for long haul travel in economy.

The disparity in seating is also evident in modern narrow body flights for the North Atlantic. Turn next to FIGURE 16 to look at the newly delivered Jet Blue A321 "Mint" interior used for overseas "red-eye" flights. [40] It offers 4 "suite" and 12 open flat bed seats up front followed by 143 seats 3x3 in economy/economy-plus. Once again, the vast majority of seats are really unsuitable for restful sleep.

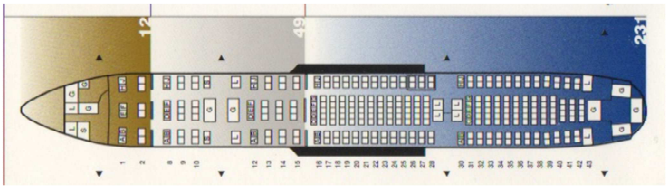

FIGURE 12 – 1995 United B777-200 292-pax three class interior (2x2x2 in F, 2x3x2 in B, 2x5x2 in Y) [36]

FIGURE 13 - 2022 United 777-200 interior – 269-pax four class interior (8 suites in F, 40 flat-bed B, 221 3x4x3 Y+/Y)

FIGURE 14 - 2022 American 777-200 interior – 37 flat bed, 24 recliner 2x4x2, 212 3x4x3 Y+/Y)

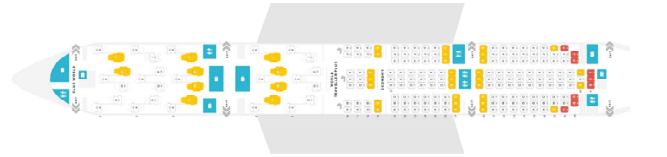

FIGURE 15 - 2022 British 787-8 interior – 35 flat bed "club world" 25 recliner "word traveller plus" and 154 Y in 3x3x3

FIGURE 16 - 2022 Jet Blue A321 "Mint" – 16 flat bed (4 en "suite", 12 open), 41 Y+ 3x3, 102 3x3 Y

FIGURE 17 – 2022 United B767-300ER "North Atlantic" interior – 167 pax - 46 flat bed suites, 22 premium-plus 2x2x2, 99 2x3x2 Y

FIGURE 18 – 2022 United B757-200 "Domestic" – 169 pax - 16 lie-flat in F, 45 Y+ 3x3, 108 Y 3x3.

IV. Fuel Savings Employing a CYQX as Technical Stop for Flights Across the North Atlantic

In this section, we will look at the potential fuel savings to be realized with current "last-generation" aircraft repurposed to fly the North Atlantic with a technical stop at Gander (CYQX).

The first question to ask is "What is the Fuel Savings Associated with a Technical Stop at CYQX as opposed to a non-stop flight?"

The second question asks the same question but supposes that Gander were to dramatically expand its fixed base operation with a sterile area hotel and expanded US Customs and Border Protection to enable passengers to sleep on the ground during an overnight technical stop so as to enable comfortable and productive travel in a much higher density seating arrangement.

The two baseline "last-generation" aircraft considered here are the Boeing B767-300ER and the Boeing B757-200; see FIGUREs 17 and 18, prior. [41][42] We consider the baseline aircraft to be the B767-300ER with a 2022-era "North Altantic" interior as operated by United Airlines (167 passengers – 46 in flat-bed suites, 22 in "premium" recliners and 99 in a typical economy interior). We trade this against a higher density "domestic" interior, unsuitable for sleep, the 282 passenger Air Canada "Rouge" interior with 24 business class recliners, 28 in 2x3x2 Y+ and 230 in 2x3x2 Y; a 68% increase in available seating. [43] We can also trade this against a higher density interior in a smaller, lighter airframe, the 169 passenger United B757-200 domestic interior with 16 lie-flat seats, 45 in 3x3 Y+ and 108 in 3x3 Y.

Fuel consumption can be estimated from manufacturer supplied payload-range charts; see FIGURE 20 and 21. [44][45] Manufacturers supplied data for required fuel load assumes cruise at M=0.80 at standard ATC altitudes, with nominal reserves. With reserves being largely independent of takeoff weight, we can curve fit this data to estimate an approximate fuel burn over a given mission. These fuel burns are characterized in terms of pounds-mass-fuel per equivalent still air distance nautical-mile.

For the B767-300ER, the fuel burn with a 167 passenger load is approximately:

FIGURE 19 – 2022 Air Canada B767-300ER – 282 pax - 24 B 2x2x2, 28 2x3x2 Y+, 230 2x3x2 inY.

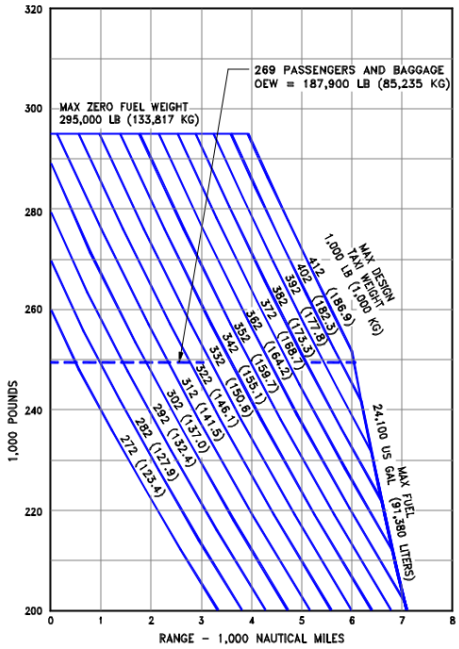

FIGURE 20 – B767-300ER Payload Range Chart

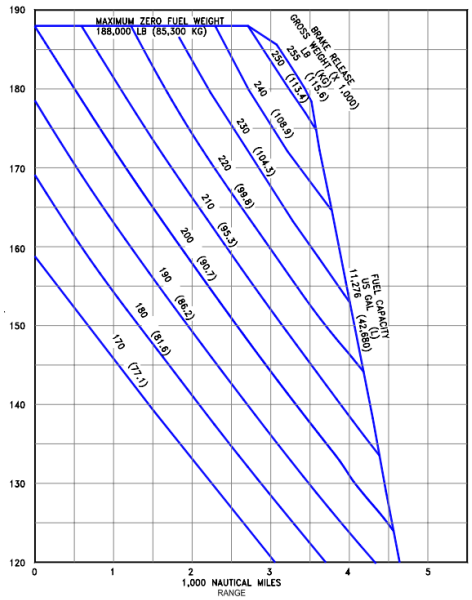

FIGURE 21 – B757-200 Payload Range Chart

W_FUELBURN ~ 3E-07 ESAD^3 - 0.0009 ESAD^2 + 22.232 ESAD

Similarly the B767-300ER, with a higher-density, 282 passenger load is approximately:

W_FUELBURN ~ 2E-06 ESAD^3 - 0.011 ESAD^2 + 40.014 ESAD

While the smaller B757-200 with 169 passengers consumes about:

W_FUELBURN ~ 19.214 ESAD

We can also establish the Equivalent Still Air Distances for flights from select US based cities to Europe using a commercial flight planning service. [46] We can see that the ESAD penalty to enable a technical stop at CYQX, as opposed to a non-stop flight is quite small, well under 100-nM even for flights from Southern California. This is because Gander is essentially on the "great circle route" from Toronto, New York, Washington and Atlanta to London and only a minor deviation for flights from the U.S. west coast to Europe.

TABLE 1 – ESAD for Heavy Aircraft

	Nonstop ESAD (nM)	ESAD to CYQX	ESAD to LHR	Total ESAD	ESAD penalty (nm)
YYZ to LHR	2821	987	1848	2835	14
BOS to LHR	2562	756	1848	2604	42
JFK to LHR	2709	875	1848	2723	14
IAD to LHR	2891	1057	1848	2905	14
ATL to LHR	3325	1505	1848	3353	28
MIA to LHR	3570	1785	1848	3633	63
ORD to LHR	3171	1337	1848	3185	14
LAX to LHR	4431	2653	1848	4501	70

Turning next to TABLE 2, we can estimate the total fuel burns from Toronto (YYZ), Boston (BOS), New York (JFK), Washington (IAD), Miami (MIA), Chicago (ORD) or Los Angeles (LAX) to London/Heathrow (EGLL) based on the inferred equivalent still-air-distances found in TABLE 1, above. We consider the 167 seat international interior B767-300ER nonstop as well as with a technical stop at Gander; we also consider a 282 "domestic" interior B767-300ER and a 169-seat "domestic"interior B757-200 flown with a technical stop at Gander. It becomes clear that for the "international" cabin B767-300ER for all missions but BOS→LHR, a technical stop at Gander can save some fuel. We can also see that the higher zero-fuel-weight of the "domestic" cabin B767-300ER leads to noticably higher overall fuel burns; and that the equipment-downgrade B757-200 "domestic" cabin option burns noticably less fuel.

TABLE 2 – Estimated Total Fuel Burns from various North American airports to LHR

	B767	B767			B767 high density			B757		
	Nonstop Fuel	Fuel to CYQX	Fuel to dest	Total Fuel w/ stop	Fuel to CYQX	Fuel to dest	Total Fuel w/ stop	Fuel to CYQX	Fuel to dest	Total Fuel w/ stop
YYZ to LHR	62289	21355	39904	61259	30701	49002	79703	18950	35482	54432
BOS to LHR	56096	16423	39904	56327	24828	49002	73830	14515	35482	49997
JFK to LHR	59586	18965	39904	58869	27930	49002	76932	16800	35482	52282
IAD to LHR	63999	22848	39904	62752	32367	49002	81369	20294	35482	55776
ATL to LHR	74999	32443	39904	72348	42124	49002	91125	28896	35482	64378
MIA to LHR	81548	38523	39904	78427	47751	49002	96753	34272	35482	69754
ORD to LHR	71014	28832	39904	68737	38615	49002	87617	25670	35482	61152
LAX to LHR	106939	58249	39904	98153	66080	49002	115082	50938	35482	86419

Since lift-induced-drag is proportional to the square of the aircraft weight, it makes sense that the heavier zero-fuel-weight aircraft will need substantially more fuel to cover the same mission. Yet this is not the metric that impacts airfare and critical emssions metrics. To understand this, we must consider the fuel burn per passenger over each segment; see TABLE 3. Here, we see that a simple technical stop on Gander on flights from Washington, Boston,

New York saves little fuel (<2% savings) where a technical stop on flights from Atlanta, Miami, Chicago and Los Angeles can save up to 8% fuel.

The real savings per passenger comes where the technical stop can be used to eliminate "red-eye" flights, allowing comfortable transit with a higher density "domestic" interior aircraft. Under these routings, we find that an existing B767-300ER with a technical stop at CYQX could reduce the fuel burn per passenger by 21 to 36%. If passenger volumes were insufficient, a downgrade to a B757-200 with technical stop at CYQX would still save 12 to 20% fuel per passenger. Since return flights are all presently operated as daylight flights, we see that most westbound traffic could avoid CYQX with minimal environmental penalties.

TABLE 3 – Estimated Fuel Burns per Passenger from various North American airports to LHR

	Fuel Burn Per Passenger (lbm per pax)						
	767 nonstop	int'l 767 w/ technical stop	dom 767 w/ overnight stop	dom 757 w/ overnight stop	% savings w/ stop	% savings high density 767 w stop	% savings high density 757 w stop
YYZ to LHR	373	367	286	322	2%	23%	14%
BOS to LHR	336	337	265	296	0%	21%	12%
JFK to LHR	357	353	276	309	1%	23%	13%
IAD to LHR	383	376	292	330	2%	24%	14%
ATL to LHR	449	433	327	381	4%	27%	15%
MIA to LHR	488	470	347	413	4%	29%	15%
ORD to LHR	425	412	314	362	3%	26%	15%
LAX to LHR	640	588	412	511	8%	36%	20%

V. Possible Schedules to Employ CYQX as Technical Stop for Flights Across the North Atlantic

This section highlights possible airline routing schemes utilizing CYQX for technical stops to enable daylight flights across the North Atlantic. Flight times, wall-clock-times and time-zone differences may all be found in TABLE 4 (overleaf).

We see that a lunchtime CYQX hub operation can support same-day "daylight" flights to the British Isles. beginning with a morning departure to Gander. East coast gateway (Washington DC through Boston, Montréal, Ottawa and Toronto) departure times could be staggered between 7:00am and 8:00am to ensure arrival at CYQX before noon. Early afternoon departures to the British Isles could be as late as 2:00pm and still arrive into Ireland (Dublin), Scotland (Glasgow and Edinburgh) and England (Manchester and London) comfortably before any curfew. Lunchtime departures to Paris/CDG and Amsterdam, with 9:15 clock-hour block times, could also be scheduled. Flights deeper into Europe are unlikely to arrive before curfew.

The more general CYQX hub operation would involve an overnight stop with hotel accommodations preferably within the sterile zone at a revised Gander terminal. These sorts of accommodations exist at select world airports such as Seoul/ICN, Bangkok/BKK, and Amsterdam/AMS. This permits a proper meal and good night's sleep while avoiding "red-eye" operations and enabling comfortable travel with higher density "domestic" seating layouts. In order to arrive at Gander between 9:00pm and 10:00pm, east coast gateway flights would need to depart at dinner time while flights from Southern California and the Pacific Northwest would need to depart late morning. Denver and Dallas departures must be in the early afternoon; Chicago in the late afternoon. This schedule permits legacy airlines to schedule regional connections at major hub airports with no impact to their schedules.

After overnight in Gander, passengers would connect to a "morning" departure to the British Isles or Europe. Arrivals in London, with 8 hours wall-clock from departure to arrival, could be scheduled as early as 5:00pm permitting additional connection opportunities. Elsewhere in Europe, with approximately 10 hours wall-clock from departure to arrivals could easily be scheduled before 7:00pm.

Presently, westbound return flights are scheduled as “daylight” flights; technical stops at Gander would not impact this.

For example, wall clock times from a European or British departure to arrival at Gander vary from 1:30 to 2:45. Similarly wall clock times from Gander to North American cities vary from approximately 1:00 for destinations like Boston, Montréal and Ottawa to a worst case 3:30 travelling on to LAX. Thus, Gander could easily support a wide variety of westbound departure times from Europe to enable hub operations throughout the afternoon and early evening that do not conflict with any eastbound departures.

TABLE 4- City Pair, Flight Time (including seasonal winds as of September 2022 + ground segment), Time Zone offsets

City Pair	Wall Clock	Flight Time	Time Zone		City Pair	Wall Clock	Flight Time	Time Zone
BOS -> CYQX	3:15	1:45	+1:30		CYQX->BOS	1:00	2:30	-1:30
YOW -> CYQX	3:15	1:45	+1:30		CYQX->YOW	1:00	2:30	-1:30
YUL -> CYQX	3:15	1:45	+1:30		CYQX->YUL	1:00	2:30	-1:30
EWR -> CYQX	3:30	2:00	+1:30		CYQX->EWR	1:15	2:45	-1:30
JFK -> CYQX	3:30	2:00	+1:30		CYQX->JFK	1:15	2:45	-1:30
DCA -> CYQX	3:45	2:30	+1:30		CYQX->BWI	1:30	3:00	-1:30
BWI -> CYQX	3:45	2:15	+1:30		CYQX->PHL	1:30	3:00	-1:30
PHL -> CYQX	3:45	2:15	+1:30		CYQX->IAD	1:45	3:15	-1:30
YYZ -> CYQX	3:45	2:15	+1:30		CYQX->DCA	1:45	3:15	-1:30
IAD -> CYQX	4:00	2:30	+1:30		CYQX->YYZ	1:45	3:15	-1:30
ATL -> CYQX	5:00	3:30	+1:30		CYQX->ORD	1:45	4:15	-2:30
ORD->CYQX	5:30	3:00	+2:30		CYQX->DEN	2:30	6:00	-3:30
MIA-->CYQX	5:45	4:15	+1:30		CYQX->YVR	2:30	7:00	-4:30
DFW ->CYQX	7:00	4:30	+1:30		CYQX->MIA	2:30	5:00	-2:30
DEN->CYQX	8:15	4:45	+3:30		CYQX->ATL	3:00	4:30	-1:30
YVR->CYQX	10:15	5:45	+4:30		CYQX->DFW	3:15	5:45	-2:30
LAX->CYQX	10:45	6:15	+4:30		CYQX->LAX	3:30	8:00	-4:30
CYQX->DUB	7:30	4:00	+3:30		DUB->CYQX	1:30	5:00	-3:30
CYQX->GLA	7:30	4:00	+3:30		GLA->CYQX	1:30	5:00	-3:30
CYQX->EDI	7:45	4:15	+3:30		CDG->CYQX	1:30	6:00	-4:30
CYQX->MAN	7:45	4:15	+3:30		AMS->CYQX	1:30	6:00	-4:30
CYQX->LGW	7:45	4:30	+3:30		EDI->CYQX	1:45	5:15	-3:30
CYQX->LHR	8:00	4:30	+3:30		MAN->CYQX	1:45	5:15	-3:30
CYQX-> CDG	9:15	4:45	+4:30		FRA->CYQX	1:45	6:15	-4:30
CYQX-> AMS	9:15	4:45	+4:30		CPH->CYQX	1:45	6:15	-4:30
CYQX->BCN	9:45	5:15	+4:30		LGW->CYQX	2:00	5:30	-3:30
CYQX->FRA	9:45	5:15	+4:30		LHR->CYQX	2:00	5:30	-3:30
CYQX->CPH	9:45	5:15	+4:30		BCN->CYQX	2:00	6:30	-4:30
CYQX->MUC	10:00	5:30	+4:30		ZRH->CYQX	2:00	6:30	-4:30
CYQX->ZRH	10:00	5:30	+4:30		MUC->CYQX	2:15	6:45	-4:30
CYQX->FCO	10:30	6:00	+4:30		FCO->CYQX	2:45	7:15	-4:30

From an airport operations perspective, eight waves per day of can be envisioned.

- First, an early morning departure wave to Britain and Europe (using equipment arriving the previous evening)
- Second, a series of late morning arrivals from Northeastern Gateway airports
- Third, a wave of lunchtime departures to Britain and Europe (continuation of late morning arrivals)
- Fourth, a wave of mid-afternoon arrivals from Britain and Europe
- Fifth, a wave of late afternoon departures across North America (continuation of mid-afternoon arrivals)
- Sixth, a wave of early evening arrivals from Britain and Europe
- Seventh, a wave of evening departures across North America (continuation of mid-afternoon arrivals)
- Eighth, a wave of late evening arrivals from across North America

This arrangement would minimize the number of aircraft on the ground at any one time to those occupying gates loading and/or unloading passengers, refueling and provisioning. Presumably equipment sizing could be optimized to enable a wide range of legacy airlines and airline alliances to utilize this scheme. With interline plane changes and code-share at CYQX, Gander could help reduce congestion at major hub airports. One could imagine a Star Alliance interline booking from Los Angeles/LAX on United connecting in CYQX to a Scandinavian Airlines flight to Stockholm/ARN; a One World interline route from Edinburgh, Scotland on BA connecting in CYQX to an American Airlines flight to Charlotte, NC or a SkyTeam interline route from Salt Lake City, UT connecting in CYQX to an Air France flight to Paris/CDG. None of these routes are presently serviced non-stop, all would require a stateside, British or European plane change.

VI. Summary and Conclusions

Clearly, the flying public does not enjoy cramped accommodations and "red-eye" flights. [47] This study shows how a northern hub airport in Gander, NL, Canada could enable a wide range of "daylight" eastbound flights to the British Isles, Europe and beyond all while achieving the admirable policy goal of reducing fuel burn, and hence a reduction in CO2 emissions, per passenger between 21 and 36% using even last-generation aircraft. Newer aircraft, while more efficient, would expect to see similar trends as the dominant driver in reducing per-passenger fuel burns arises from the higher density interior rather than from a fuel savings associated with the technical stop. The ability to offer spacious sleeping accommodations on the ground (in Canada), rather than in the air, makes the difference.

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