Alaska's Airlines Itinerary Planning Problem as a Shortest Path Problem

Context: Alaska Airlines is the sixth largest commercial passenger airline in North America. Their corporate headquarters in Seattle, Washington is roughly in the middle of their flight network. This network of 78 airports includes major airport hubs throughout the continental US, some regional airports in the western US (particularly Hawaii), and many little known airports in the state of Alaska (AK), such as the communities of Adak Island, Kotzebue and Yakutat. *Alaska Airlines Flight data.xlsx* provides the distance in miles of all flights maintained or code-shared between the 78 different airports Alaska Airlines serves, as well as a key to the full names and locations of those airports. Viewed as a network, each of these 78 airports is a node and each flight a connection;

Part B: Analysis: Itineraries are sets of flights that a passenger must take in order to travel from a particular point of departure to a particular destination. Build a model that frames this problem for Alaska Airlines as a **shortest path problem** to determine and report the shortest itineraries in terms of flight distance for the following hypothetical passengers:

	Departure Airport	Destination Airport
Passenger 1	Boston, MA: Logan Intl (BOS)	Kotzebue, AK (OTZ)
Passenger 2	Lihue, HI (LIH)	Kotzebue, AK (OTZ)
Passenger 3	Barrow, AK (BRW)	El Paso, TX (ELP)
Passenger 4	Barrow, AK (BRW)	Orlando, FL (MCO)
Passenger 5	Bethel, AK (BET)	Sitka, AK (SIT)
Passenger 6	Houston, TX: George Bush Inl (IAH)	Kona, HI (KOA)
Passenger 7	Newark, NJ (EWR)	Kona, HI (KOA)
Passenger 8	Newark, NJ (EWR)	Reno, NV (RNO)

Passenger 9	Raleigh/Durham, NC (RDU)	Reno, NV (RNO)
Passenger 10	Burbank, CA (BUR)	Detroit, MI (DTW)

Shortest distance path for 10 passengers

	Departure Airport	Destination Airport	Shortest Length	Route
Passenger 1	Boston, MA: Logan Intl (BOS)	Kotzebue, AK (OTZ)	**4155**	BOS -> MNP -> JNU -> FAI -> OTZ
Passenger 2	Lihue, HI (LIH)	Kotzebue, AK (OTZ)	**3686**	LIH -> KOA -> ANC -> OTZ
Passenger 3	Barrow, AK (BRW)	El Paso, TX (ELP)	**2886**	BRW -> FAI -> CDV -> PAE -> ELP
Passenger 4	Barrow, AK (BRW)	Orlando, FL (MCO)	**4060**	BRW -> FAI -> CDV -> PAE -> BZN -> MCO
Passenger 5	Bethel, AK (BET)	Sitka, AK (SIT)	**1003**	BET -> ANC -> YAK -> SIT
Passenger 6	Houston, TX: George Bush Inl (IAH)	Kona, HI (KOA)	**3856**	IAH -> AUS -> TUS -> SAN -> KOA
Passenger 7	Newark, NJ (EWR)	Kona, HI (KOA)	**4981**	EWR -> MCI -> SAN -> KOA
Passenger 8	Newark, NJ (EWR)	Reno, NV (RNO)	**2391**	EWR -> DTW -> RNO
Passenger 9	Raleigh/Durham, NC (RDU)	Reno, NV (RNO)	**2241**	RDU -> MCI - > RNO
Passenger 10	Burbank, CA (BUR)	Detroit, MI (DTW)	**1968**	BUR -> DTW

Part C: Reframing Shortest Path Travel in Terms of Time

Context: You analysis in Part B recommends travel itineraries for ten passengers based on minimizing distance flown, but more often the objective of an itinerary is to minimize time spent traveling. For example, the time required to complete any one of the flights in your Part B model can be estimated as:

Time required by flight in minutes = 0.12*distance in miles + 20 minutes (taxi time at either end of flight)

A traveler's total time spent traveling is also not necessarily spent inside airplanes, because an itinerary requiring more than one flight also requires *layover time* at each connecting airport.

Analysis: Create a second version of your Part B model which minimizes total itinerary travel time (instead of distance). To model itinerary travel time, use the formula provided in Context to recast the flight distances as flight times, and assume that each connecting layover in the itinerary adds another 2 hours onto the total itinerary travel time.

Shortest distance path for 10 passengers

	Departure Airport	Destination Airport	Shortest travelling time (mins)	Shortest Distance	Route
Passenger 1	Boston, MA: Logan Intl (BOS)	Kotzebue, AK (OTZ)	**804.6**	**4205**	BOS -> MKE -> ANC -> OTZ
Passenger 2	Lihue, HI (LIH)	Kotzebue, AK (OTZ)	**742.32**	**3686**	LIH -> KOA -> ANC -> OTC
Passenger 3	Barrow, AK (BRW)	El Paso, TX (ELP)	**584.68**	**3539**	BRW -> ANC -> ELP
Passenger 4	Barrow, AK (BRW)	Orlando, FL (MCO)	**815.16**	**4293**	BRW -> FAI -> ORD -> MCO
Passenger 5	Bethel, AK (BET)	Sitka, AK (SIT)	**420.36**	**1003**	BET -> ANC -> YAK -> SIT
Passenger 6	Houston, TX: George Bush Inl (IAH)	Kona, HI (KOA)	**623.08**	**3859**	IAH -> SAN -> KOA
Passenger 7	Newark, NJ (EWR)	Kona, HI (KOA)	**757.72**	**4981**	EWR -> SAN -> KOA
Passenger 8	Newark, NJ (EWR)	Reno, NV (RNO)	**446.92**	**2391**	EWR -> DTW -> RNO
Passenger 9	Raleigh/Durham, NC (RDU)	Reno, NV (RNO)	**428.92**	**2241**	RDU -> MCI -> RNO
Passenger 10	Burbank, CA (BUR)	Detroit, MI (DTW)	**256.16**	**1968**	BUR -> DTW

ANALYSIS BY COMPARISON:

			Part B	Part C	
	Departure Airport	Destination Airport	Shortest Length	Shortest Distance	Difference in distance
Passenger 1	Boston, MA: Logan Intl (BOS)	Kotzebue, AK (OTZ)	**4155**	**4205**	**50**
Passenger 2	Lihue, HI (LIH)	Kotzebue, AK (OTZ)	**3686**	**3686**	**0**
Passenger 3	Barrow, AK (BRW)	El Paso, TX (ELP)	**2886**	**3539**	**653**
Passenger 4	Barrow, AK (BRW)	Orlando, FL (MCO)	**4060**	**4293**	**233**
Passenger 5	Bethel, AK (BET)	Sitka, AK (SIT)	**1003**	**1003**	**0**
Passenger 6	Houston, TX: George Bush Inl (IAH)	Kona, HI (KOA)	**3856**	**3859**	**3**
Passenger 7	Newark, NJ (EWR)	Kona, HI (KOA)	**4981**	**4981**	**0**
Passenger 8	Newark, NJ (EWR)	Reno, NV (RNO)	**2391**	**2391**	**0**
Passenger 9	Raleigh/Durham, NC (RDU)	Reno, NV (RNO)	**2241**	**2241**	**0**
Passenger 10	Burbank, CA (BUR)	Detroit, MI (DTW)	**1968**	**1968**	**0**

			Part B	Part C
	Departure Airport	Destination Airport	Route	Route
Passenger 1	Boston, MA: Logan Intl (BOS)	Kotzebue, AK (OTZ)	BOS -> MNP -> JNU -> FAI -> OTZ	BOS -> MKE -> ANC -> OTZ
Passenger 2	Lihue, HI (LIH)	Kotzebue, AK (OTZ)	LIH -> KOA -> ANC -> OTZ	LIH -> KOA -> ANC -> OTC
Passenger 3	Barrow, AK (BRW)	El Paso, TX (ELP)	BRW -> FAI -> CDV -> PAE -> ELP	BRW -> ANC -> ELP
Passenger 4	Barrow, AK (BRW)	Orlando, FL (MCO)	BRW -> FAI -> CDV -> PAE -> BZN -> MCO	BRW -> FAI -> ORD -> MCO
Passenger 5	Bethel, AK (BET)	Sitka, AK (SIT)	BET -> ANC -> YAK -> SIT	BET -> ANC -> YAK -> SIT
Passenger 6	Houston, TX: George Bush Inl (IAH)	Kona, HI (KOA)	IAH -> AUS -> TUS -> SAN -> KOA	IAH -> SAN -> KOA
Passenger 7	Newark, NJ (EWR)	Kona, HI (KOA)	EWR -> MCI -> SAN -> KOA	EWR -> SAN -> KOA
Passenger 8	Newark, NJ (EWR)	Reno, NV (RNO)	EWR -> DTW -> RNO	EWR -> DTW -> RNO
Passenger 9	Raleigh/Durham, NC (RDU)	Reno, NV (RNO)	RDU -> MCI - > RNO	RDU -> MCI -> RNO
Passenger 10	Burbank, CA (BUR)	Detroit, MI (DTW)	BUR -> DTW	BUR -> DTW

Key observations:

- Passenger 3 is taking just 1 layover in part C when compared to 3 layovers in part B but distance has increased by 650 miles
- Similarly, Passenger 4 is taking just 2 layovers in part C when compared to 4 layovers in part B but distance has increased by 230 miles
- Passenger 6 and 7 takes 3 and 2 layovers in Part B respectively, whereas there is only one layover in Part C but the distance is almost the same