



New Route Forecasting Process

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M.Sc. Program

Network, Fleet and Schedule
Strategic Planning
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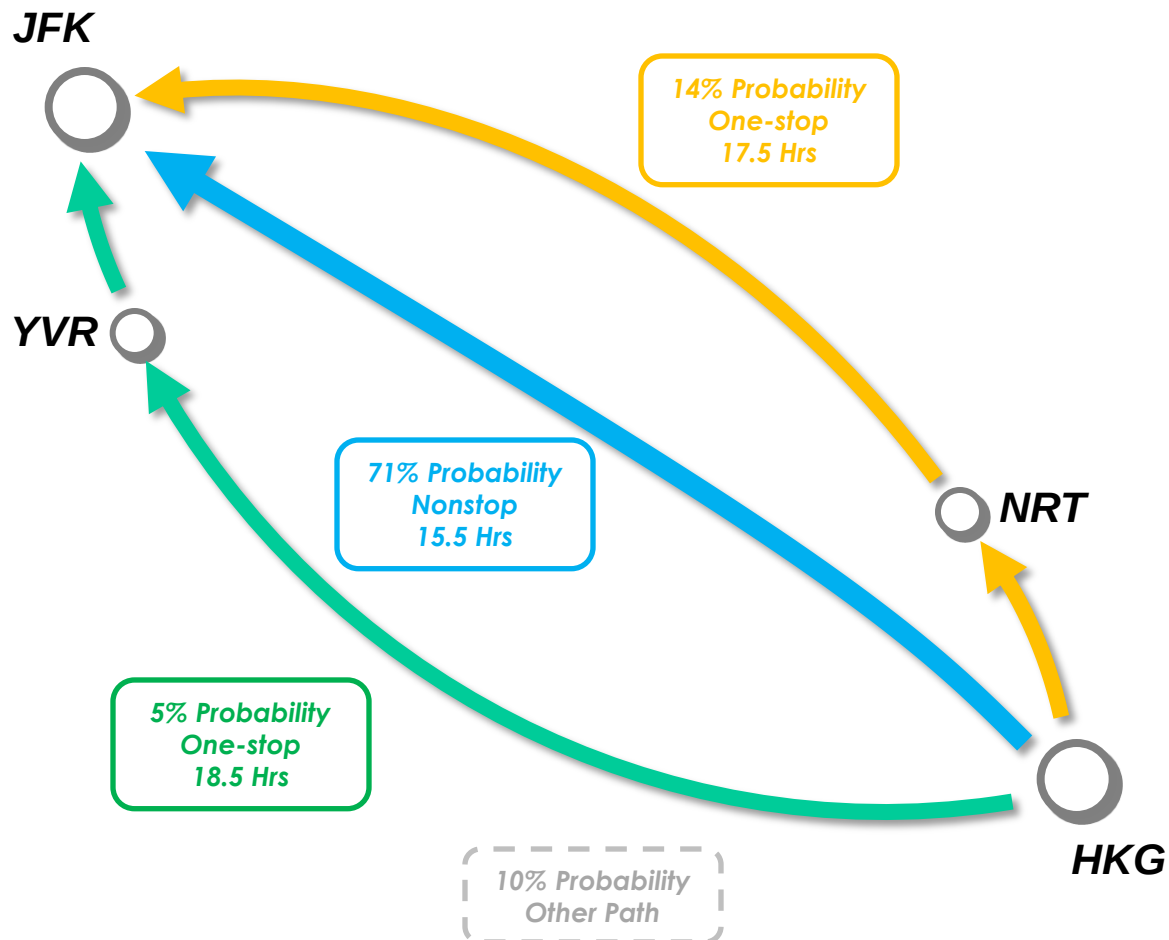
Lecture Outline

- **How does Boeing select & forecast new markets?**
- **Boeing data & tools**
- **Methodology & Process**
- **Examples**

Boeing Primary Data Sources

- **Sabre Global Demand Data**
 - Worldwide Origin/Destination, Segment, Fare/Revenue, Schedule data
- **CargoIS**
 - Origin/Destination cargo & yields
- **Innovata Data**
 - Worldwide schedule data
- **Airline provided data**
 - Various forms and detail levels provided, becoming more common
- **U.S. DOT data**
 - DB1B, T-100, Form 41 (traffic & financial data)
- **Market growth data**
 - Boeing Current Market Outlook
 - IATA/Oxford Economics growth forecasts

Global Market Allocation System (GMAS)

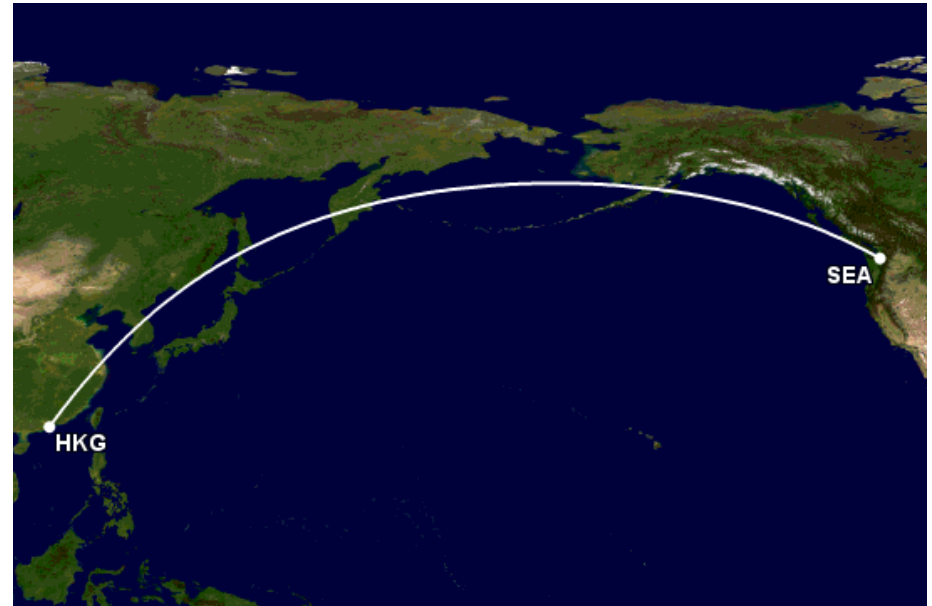


- GMAS forecasts the probability of passenger choice for all flight paths between an O&D city-pair
- Probabilities are derived from competitive flight paths based on flight duration and number of stops
- Results calibrated to airline data (if available)
- Performs allocation on all O&D city-pairs

* Path probabilities not based on actual results

Boeing Primary Data Sources

- In 2013, no non-stop flight existed in the Seattle-Hong Kong market. Boeing evaluated the demand and profit potential of a new route
- SEA-HKG one daily round-trip (will focus on HKG-SEA leg directionally)
- Competitive schedules as of November 2013
- Demand from Sabre global demand data, grown to 2018 at Boeing current market outlook rates
- Cost data from Boeing internal systems
- Assumed mission flown by a 787 Dreamliner



New market forecasting steps

- **Step #1:** Determining flight schedules to evaluate in the choice model
- **Step #2:** Evaluating choice model results and selecting best flight schedule scenario
- **Step #3:** Apply stimulation and other demand adjustments based on real world knowledge
- **Step #4:** Utilize spill modeling to apply unconstrained demand to a constrained flight
- **Step #5:** Evaluate and refine revenue results by cabin and for cargo
- **Step #6:** Allocate fixed and variable costs to both the airplane operation and passengers
- **Step #7:** Calculate flight profitability and adjust as necessary to refine analysis

Step 1: Flight Scheduling

- Evaluating/testing for best departure times
- Produce updated schedule file for each scenario to be tested
- O&D flows & connectivity analysis
- In this case, used YVR-HKG departure times for SEA-HKG
- Produced two schedule files, one with late night flights, one with afternoon flights
- Schedule files serve as base schedule for other tools

SCENARIO A:

HKG-SEA

Dep: 01:00

Arr: 21:25

Turn: 04:00

SEA-HKG

Dep: 01:25

Arr: 07:28

SCENARIO B:

HKG-SEA

Dep: 16:25

Arr: 11:45

Turn: 01:45

SEA-HKG

Dep: 13:30

Arr: 19:33

Step 1: Flight Scheduling at hubs

HKG Minimum Connection Time: 60 min

DEPARTURES

HKG

ARRIVALS

0400	0430	0500	0530	0600	0630	0700	0730	0800	0830	0900	0930	1000	1030	1100	1130	1200	1230	1300	1330	1400	1430	1500	1530	1600	1630	1700	1730	1800	1830	1900	1930	2000	2030	2100	2130	2200	2230	2300	2330	0000	0030	0100
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[illegible]

SEA Minimum Connection Time: 70 min (Dom->Int'l)
90 min (Int'l->Dom)

DEPARTURES

SEA

ARRIVALS

500	530	600	630	700	730	800	830	900	930	1000	1030	1100	1130	1200	1230	1300	1330	1400	1430	1500	1530	1600	1630	1700	1730	1800	1830	1900	1930	2000	2030	2100	2130	2200	2230	2300	2330	0	30
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OGG	FAI	YVR	KOA	BIL	OAK	LAX	ANC	COS	EWB	DCA	BOS	LAS	SIC	PSP	FAI	LAX	ANC	MSP	ANC	DFW	HNL	DEN	SAN	OMA	ORD	MCI	PVR	ANC	IAH	HNL	ATL	OGG	FLL	SFO	SNA	ANC	LAX
ANC	FCA	YKM	BZN	YEG	GEG	SJC	PHX	SAN	SNA	ORD	ANC	OAK	SLC	SNA	SAN	BUR	PHX	SNA	SFO	BOI	LAX	LAX	JNU	PHX	ANC	LAX	LAX	TUS	LGB	LAX	PHL	SJD	EWB	LIH			
PDX	GEG	EAT	BOI	GTF	PDX	SMF	ONT	BUR	FAT	PHX	SFO	BOI	SFO	LGB	DEN	MSO	YEG	LAS	ALW	GEG	KTN	SFO	FAT	SFO	SAN	GEG	PSP	ONT	LAS	PHX	AUS	DCA	KOA				
BLI		YYJ	EUG	YUC		PDX	SFO	BLI	PDX	SAN	EUG	GEG	KTN	LAS	ONT	MFR	PDX	OAK		YLV	GEG	HNL	BZN	BOI	SNA	PSC	SJC	YEG	BIL	SAN	STL	FAI	MCO				
			RDM	MSO			GEG	SJC		DEN	PDX	YKM	RNO	STS	YYC	GEG	PDX	GEG		PSC	PDX	YLV	PDX	GEG	BOI	SNA	RNO	YEG	YYC	DEN	MSP	PSP	BOS				
			GEG	MFR			PDX	BOI		SNA	YVR	EAT	PUW	SMF	BOI		BLI				PDX	YYJ	GEG		SLC		PDX	BLI	BOI	SNA	LAX	LAX	SAT				
			YLV				YYJ	GEG		LAX		YYJ	RDM	PSC	YLV							YYJ	PDX	YVR		SMF		YKM	MSO	BUR	BOI	SBA	ORD				
			ALW					PDX		GEG			PDX	GEG	PDX											PDX			LWS	SJC	PSC	SFO	DFW				
			PSC					YVR																					PUW	KTN	PDX	SMF	LAX				
			PDX																										EUG	OAK	YVR	RNO	PDX				
																													RDM	GEG							
																													PDX	PDX							

Step 2: Choice Modeling

- GMAS (Logit based) is Boeing choice model
- Growth rates determined in each O & D by Boeing Current Market Outlook (airline provided growth rates can also be used)
- Path probability calculated, then unconstrained demand for all flights worldwide apportioned
- Path probability is function of multiple factors (betas) including time of day preference, business/leisure, price sensitivity, etc.
- Connections determined by shortest total travel time
- Test schedules imported to GMAS from ODSE, competitive schedules from OAG

Case: SEAHKG_Afternoon_Growth

(Report 1) UnConstrained Leg Flight Summary

Leg	AL	Flt #	EQ	Seats	DOW	Dept	Arrl	GCM	Dmd Loc	Dmd Flow	Dmd Leg	Rev Loc	Rev Flow	Rev Leg	Rev Online	Rev Network	Rev Offline	Fare Loc	Fare Flow	Fare Leg	LF %	Spill
HKGSEA	XX	2701	787	276	1	1625	1251	6484	62.2	310	372.3	79,254	269,573	348,828	58,029	406,857	29,344	1,273.38	869.49	937.02	134.90%	96
HKGSEA	XX	2701	787	276	2	1625	1251	6484	62.7	210.2	272.9	79,580	171,152	250,732	27,866	278,598	20,266	1,270.06	814.24	918.91	98.90%	0
HKGSEA	XX	2701	787	276	3	1625	1251	6484	60.2	184	244.2	77,697	157,497	235,193	32,862	268,056	15,222	1,289.89	856.07	963.07	88.50%	0
HKGSEA	XX	2701	787	276	4	1625	1251	6484	62.6	283	345.5	79,677	237,291	316,968	42,669	359,637	26,293	1,273.37	838.55	917.28	125.20%	70
HKGSEA	XX	2701	787	276	5	1625	1251	6484	62.4	188.8	251.2	79,393	176,354	255,746	45,141	300,888	16,870	1,271.96	933.96	1,017.93	91.00%	0
HKGSEA	XX	2701	787	276	6	1625	1251	6484	60.2	229.8	290	77,697	179,080	256,776	32,777	289,553	21,067	1,289.89	779.4	885.43	105.10%	14
HKGSEA	XX	2701	787	276	7	1625	1251	6484	60.2	196.3	256.6	77,697	178,316	256,013	48,654	304,667	17,538	1,289.89	908.19	997.8	93.00%	0
SEAHKG	XX	2702	787	276	1	1330	1933	6484	54.2	208.3	262.6	68,084	179,368	247,452	10,126	257,578	28,442	1,255.75	860.9	942.44	95.10%	0
SEAHKG	XX	2702	787	276	2	1330	1933	6484	56.5	255.9	312.4	69,979	218,417	288,396	17,807	306,203	30,049	1,239.54	853.36	923.15	113.20%	36
SEAHKG	XX	2702	787	276	3	1330	1933	6484	54.2	206.9	261.1	68,084	183,102	251,186	16,826	268,012	26,228	1,255.75	885.01	961.99	94.60%	0
SEAHKG	XX	2702	787	276	4	1330	1933	6484	54.2	221.2	275.4	68,084	188,388	256,472	15,383	271,855	26,951	1,255.75	851.62	931.17	99.80%	0
SEAHKG	XX	2702	787	276	5	1330	1933	6484	56.5	251.2	307.6	69,979	225,940	295,920	23,533	319,452	31,865	1,239.54	899.51	961.91	111.50%	32
SEAHKG	XX	2702	787	276	6	1330	1933	6484	54.3	232.7	287	68,149	208,539	276,689	24,226	300,914	32,333	1,254.95	896.36	964.22	104.00%	11
SEAHKG	XX	2702	787	276	7	1330	1933	6484	54.2	199.8	254	68,084	172,258	240,342	11,028	251,370	25,404	1,255.75	862.17	946.18	92.00%	0

Step 2: Choice Modeling

- Origin & Destination (O&D) traffic can be evaluated in the choice model to better understand connectivity and competitiveness

Case: SEAHKG_Afternoon_Growth

(Report 2) UnConstrained Leg Flight Allocation By OD

Leg	AL	Flt #	EQ	Seats	DOW	Dept	Arrl	GCM	Dmd Loc	Dmd Leg	Rev Loc	Rev Leg	Rev Network	Leg RPM Yld	True OD	Type	OD Dmd Leg	OD Rev Leg	OD RPM Yld	OD NetRev	OD Offline
HKGSEA	XX	2701	787	276	1	1625	1251	6484	62.2	372.3	79,254	348,828	406,857	14.45	HKGSEA	LOCAL	62.24	79,254	19.64	79,254	0
															SGNSEA	BEFORE	39.39	25,499	9.98	29,265	1,710
															MNLSEA	BEFORE	22.95	13,330	8.96	15,608	150
															CGKSEA	BEFORE	20.83	23,869	17.67	30,870	2,159
															TPESEA	BEFORE	18.97	17,479	14.21	19,649	437
															PNHSEA	BEFORE	14.87	8,185	8.49	8,185	1,646
															HYDSEA	BEFORE	14.63	13,830	14.58	19,391	0
															BKKSEA	BEFORE	14	10,029	11.05	12,038	206
															HKGPDX	BEYOND	8.2	10,614	19.97	10,614	681
															MAASEA	BEFORE	8.01	6,467	12.45	9,197	0
															KULSEA	BEFORE	7.35	9,251	19.42	11,777	428
															BKKYEG	FLOW	6.96	5,187	11.5	6,328	730
															SGNPDX	FLOW	6.04	3,421	8.74	4,155	219
															HKGYEG	BEYOND	5.86	6,489	17.07	6,489	913
															DELSEA	BEFORE	5.84	2,763	7.3	3,496	432
															HKGLAX	BEYOND	5.82	3,709	9.83	3,709	790
															BLRSEA	BEFORE	5.75	5,580	14.96	5,580	2,468
															CCUSEA	BEFORE	5.46	4,783	13.52	4,783	1,475
															BOMSEA	BEFORE	4.87	4,700	14.89	6,652	0
															SINSEA	BEFORE	4.47	4,102	14.14	5,400	0
															HANSEA	BEFORE	4.45	3,971	13.75	3,971	586
															KTMSEA	BEFORE	4.29	4,028	14.49	4,028	1,377
															SGNYEG	FLOW	4.12	3,514	13.16	4,268	495
															MELSEA	BEFORE	3.7	5,647	23.56	9,924	0
															PERSEA	BEFORE	2.84	5,558	30.19	9,023	0
															HKGYVR	BEYOND	2.71	1,657	9.43	1,657	111

Step 2: Choice Modeling

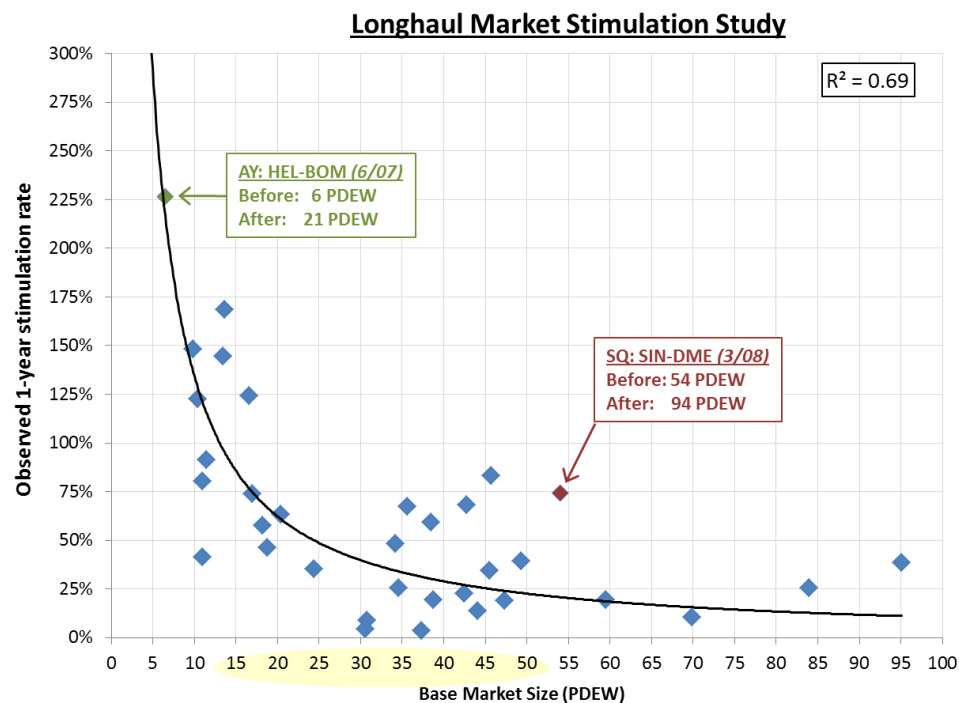
- Both schedule scenarios tested, afternoon HKG departure significantly greater demand due to stronger connectivity
- Focus on remaining steps will be on Scenario B flight schedules

Case: SEAHKG_Overnight_Growth										
(Report 1) UnConstrained Leg Flight Summary										
Leg	AL	Flt #	DOW	Dept	Arrl	Dmd Loc	Dmd Flow	Dmd Leg	LF %	Spill
HKGSEA	XX	2701	1	100	2126	62.1	115	177.1	64.20%	0
HKGSEA	XX	2701	2	100	2126	62.5	160.4	222.9	80.80%	0
HKGSEA	XX	2701	3	100	2126	60	109.9	169.9	61.60%	0
HKGSEA	XX	2701	4	100	2126	62.4	109	171.4	62.10%	0
HKGSEA	XX	2701	5	100	2126	62.3	151.7	214	77.50%	0
HKGSEA	XX	2701	6	100	2126	60	111.4	171.4	62.10%	0
HKGSEA	XX	2701	7	100	2126	60	105.6	165.6	60.00%	0
SEAHKG	XX	2702	1	125	728	52.6	161.5	214.1	77.60%	0
SEAHKG	XX	2702	2	125	728	54.9	202.6	257.6	93.30%	0
SEAHKG	XX	2702	3	125	728	52.6	150.1	202.7	73.40%	0
SEAHKG	XX	2702	4	125	728	52.6	154.6	207.3	75.10%	0
SEAHKG	XX	2702	5	125	728	54.9	213.9	268.9	97.40%	0
SEAHKG	XX	2702	6	125	728	54.1	129	183.1	66.30%	0
SEAHKG	XX	2702	7	125	728	52.6	150.1	202.8	73.50%	0

Case: SEAHKG_Afternoon_Growth										
(Report 1) UnConstrained Leg Flight Summary										
Leg	AL	Flt #	DOW	Dept	Arrl	Dmd Loc	Dmd Flow	Dmd Leg	LF %	Spill
HKGSEA	XX	2701	1	1625	1251	62.2	310	372.3	134.90%	96
HKGSEA	XX	2701	2	1625	1251	62.7	210.2	272.9	98.90%	0
HKGSEA	XX	2701	3	1625	1251	60.2	184	244.2	88.50%	0
HKGSEA	XX	2701	4	1625	1251	62.6	283	345.5	125.20%	70
HKGSEA	XX	2701	5	1625	1251	62.4	188.8	251.2	91.00%	0
HKGSEA	XX	2701	6	1625	1251	60.2	229.8	290	105.10%	14
HKGSEA	XX	2701	7	1625	1251	60.2	196.3	256.6	93.00%	0
SEAHKG	XX	2702	1	1330	1933	54.2	208.3	262.6	95.10%	0
SEAHKG	XX	2702	2	1330	1933	56.5	255.9	312.4	113.20%	36
SEAHKG	XX	2702	3	1330	1933	54.2	206.9	261.1	94.60%	0
SEAHKG	XX	2702	4	1330	1933	54.2	221.2	275.4	99.80%	0
SEAHKG	XX	2702	5	1330	1933	56.5	251.2	307.6	111.50%	32
SEAHKG	XX	2702	6	1330	1933	54.3	232.7	287	104.00%	11
SEAHKG	XX	2702	7	1330	1933	54.2	199.8	254	92.00%	0

Step 3: Stimulation & adjustment

- Stimulation of local O&D for new nonstop service
- Proxy markets and/or stimulation curves used as a guide
- Sanity check connectivity (remove unreasonable or circuitous connections)
- Other adjustments based upon market specific or airline specific knowledge
- In this case, no stimulation assumed due to extensive existing Asia service from SEA and to create more conservative forecast



Step 4: Spill model (by class)

- Use of Boeing spill model to determine on-board loads (by class)
- Spill by class to account for different variability in each class of service (higher k-cyclic in premium classes)
- Spill can be done on an individual flight, or a set of flights
- Studies based on airline data shows economy k-cyclic between .28 and .32, business k-cyclic between .35 and .40
- Capacity used for spill typically adjusted for performance (payload range, blocked seats)

Spill Results by Class: HKG-SEA

Afternoon flight, Bus K-Cyclic: 0.35, Econ K-Cyclic: 0.30

Day	Unconstrained Demand			
	First	Business	Economy	Total
1	4	53	313	370
2	3	38	233	274
3	2	34	212	248
4	3	48	291	342
5	2	35	215	252
6	3	39	248	290
7	2	36	223	261
787 Seats	0	40	236	276
Day	Constrained Demand			
	First	Business	Economy	Total
1	0	36	223	259
2	0	32	205	237
3	0	31	195	226
4	0	35	220	255
5	0	31	197	228
6	0	33	210	243
7	0	32	200	232

Step 5: Revenue (by class)

- Revenue can come from multiple sources:
 - GMAS (straight mileage proration, equal fares for all carriers)
 - Sabre (proxy market)
- GMAS uses actual on-board O&D determined in path probability to determine average fares
- “Real world” fares via Sabre may be applied to account for competitive, fare mix and stimulation effects
- Cargo revenue determined based on available payload after pax, multiplied by yield provided by airline or external sources (not considered in this analysis)

Revenue Results by Class: HKG-SEA

Afternoon flight, Bus K-Cyclic: 0.35, Econ K-Cyclic: 0.30

Day	Average Fares			
	First	Business	Economy	Total
1	\$4,860	\$2,608	\$607	\$887
2	\$4,798	\$2,575	\$612	\$880
3	\$5,082	\$2,727	\$635	\$919
4	\$4,780	\$2,565	\$603	\$875
5	\$5,292	\$2,839	\$664	\$961
6	\$4,666	\$2,504	\$592	\$851
7	\$5,222	\$2,802	\$655	\$947

Day	Revenue			
	First	Business	Economy	Total
1	\$0	\$94,473	\$135,296	\$229,770
2	\$0	\$83,582	\$125,145	\$208,728
3	\$0	\$83,390	\$123,756	\$207,147
4	\$0	\$90,759	\$132,549	\$223,308
5	\$0	\$88,302	\$130,447	\$218,749
6	\$0	\$82,267	\$124,244	\$206,511
7	\$0	\$88,496	\$131,233	\$219,729

Step 6: Costs

- Revenue can come from multiple sources:
 - GMAS (straight mileage proration, equal fares for all carriers)
 - Sabre (proxy market)
- GMAS uses actual on-board O&D determined in path probability to determine average fares
- “Real world” fares via Sabre may be applied to account for competitive, fare mix and stimulation effects
- Cargo revenue determined based on available payload after pax, multiplied by yield provided by airline or external sources (not considered in this analysis)

Total Cost: HKG-SEA

Fuel: \$3.31 per USG, Standard Rules, Study Loads

Day	Costs			
	Pax Count	Trip Cost	Ownership	Total Cost
1	259	\$139,744	\$40,353	\$180,097
2	237	\$136,979	\$40,353	\$177,332
3	226	\$135,597	\$40,353	\$175,950
4	255	\$139,242	\$40,353	\$179,595
5	228	\$135,848	\$40,353	\$176,201
6	243	\$137,734	\$40,353	\$178,087
7	232	\$136,351	\$40,353	\$176,704

Ownership Calculation:

$$(\$1,332,000 \text{ Per Month} * 12 \text{ Months} /$$

$$13.5 \text{ Block Hour Utilization} * 365 \text{ Days}) *$$

$$12.44 \text{ Block Hour Mission}$$

= \$40,353 Per Trip

Step 7: Profitability

- Calculate out profit based on specific cost and revenue as defined in previous steps
- Depending on nature of study, cost/revenue escalated and net present value calculated
- Attempt make to benchmark/adjust to publicly available airline results and in many cases, to actual airline data

Profitability: HKG-SEA

Study Loads, Costs, Revenue

Day	Profitability			
	Pax	Total Rev	Total Cost	Profit/Loss
1	259	\$229,770	\$180,097	\$49,672
2	237	\$208,728	\$177,332	\$31,395
3	226	\$207,147	\$175,950	\$31,196
4	255	\$223,308	\$179,595	\$43,713
5	228	\$218,749	\$176,201	\$42,548
6	243	\$206,511	\$178,087	\$28,424
7	232	\$219,729	\$176,704	\$43,025

Weekly Profit: \$269,973

Annual Profit: \$14,038,597

Step 7: Profitability

- Calculate out profit based on specific cost and revenue as defined in previous steps
- Depending on nature of study, cost/revenue escalated and net present value calculated
- Attempt make to benchmark/adjust to publicly available airline results and in many cases, to actual airline data

Profitability: HKG-SEA

Study Loads, Costs, Revenue

Day	Profitability			
	Pax	Total Rev	Total Cost	Profit/Loss
1	259	\$229,770	\$180,097	\$49,672
2	237	\$208,728	\$177,332	\$31,395
3	226	\$207,147	\$175,950	\$31,196
4	255	\$223,308	\$179,595	\$43,713
5	228	\$218,749	\$176,201	\$42,548
6	243	\$206,511	\$178,087	\$28,424
7	232	\$219,729	\$176,704	\$43,025

Weekly Profit: \$269,973

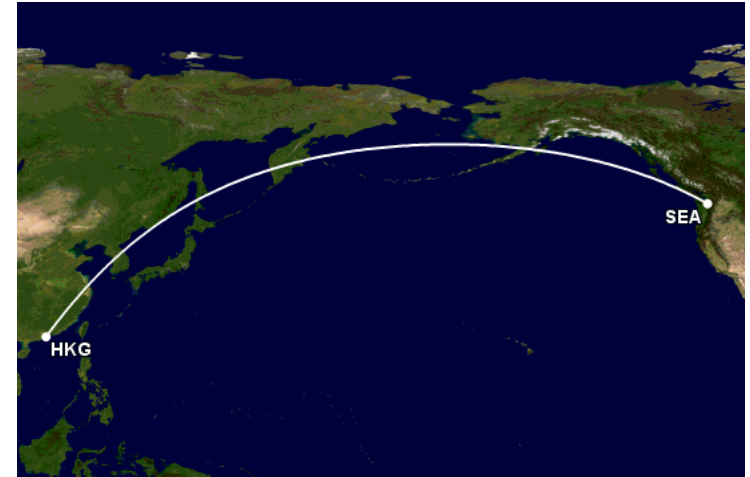
Annual Profit: \$14,038,597

Variations & Refinements

- Depending on nature of study, cost/revenue escalated and net present value calculated
- Attempt made to benchmark/adjust to publicly available airline results and in many cases, to actual airline data
- Unconstrained demand grown over time (typically at rate agreed upon by airline)
- Comparison of potential solutions is common use of forecasting (i.e. 787 v. A350 in given market)
- Introductory costs can be estimated and included in profitability for a given solution
- Sensitivity analysis is common (demand, fuel price, escalation, fares)

Postscript: Actual results vs. forecast

- Delta Air Lines launched non-stop Seattle – Hong Kong in June 2014 with an A330 airplane
- Although not directly comparable, we can evaluate the forecast against actual results



	<u>Forecast</u>	<u>Reality</u>
Airplane	787	A330
Seats/flight	276	234
Frequency	Daily	Daily
Local Stimulation	0%	34%
Load Factor	89%	80%
Average Fare	\$901	\$1,026

