REAL OPTIONS ANALYSIS: RUNWAY EXPANSION AT A NEW AIRPORT IN LISBON

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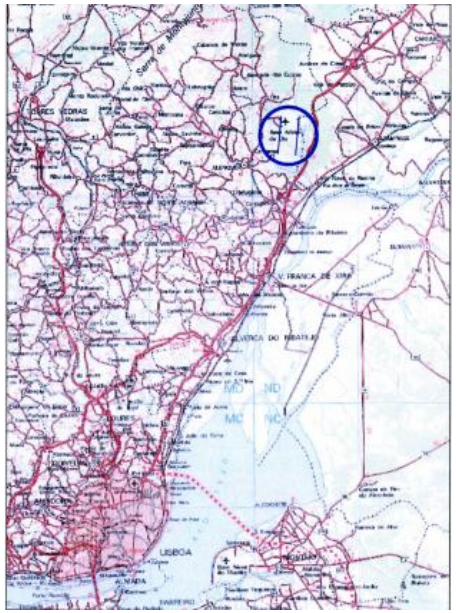
Problem background

- Currently single airport located in Lisbon, Portugal, cannot be expanded due to location in densely populated area
- Serviced approximately 12 mn passengers in 2006
- Projected traffic indicates capacity problems beginning in 2009 (Chevalier 2005)
- A new airport (NLA= new Lisbon airport) has been planned to be built since the early 90's
- Traffic forecasts highly uncertain due to cyclicity of aviation industry and complexity of factors that determine traffic demand at an airport



Regional Map

National Map

Traffic demand as main source of uncertainty

Sources of uncertainty in traffic demand

- Internal: Development in Lisbon area (and Portugal as a whole) of population, average income, general economy, travel-intensive industries…
- External: development of travel-intensive industries of relevance for Lisbon/Portugal in other parts of the world, attractiveness of Lisbon/Portugal as destination for tourism, conferences, higher education, business; attractiveness as hub
- Runways are very often the bottleneck of capacity at airports

→ Focus on runway systems in this analysis

→ Exploration of flexibility in runway design

- Runway system in this analysis includes two parallel independent runways, excludes gates, terminals, and air bridges as possible capacity constraints
- Metric of uncertainty: number of passengers
  Benefits of system: Revenues created through landed airplanes

Fixed and flexible design

Fixed design

- 2 runways built immediately, total capacity of 159,870 landings/year
- Total construction cost of both runways $300mn
- Lifecycle =25 years, costs paid back in equal rates over lifecycle
- Total annual capital cost of both runways $12mn
- Annual operating costs for both runways $4mn

Flexible design

- 1 runway built immediately, capacity of 79, 935 landings/year
- Option at a cost of 50mn in year 0 buys the right to build a second runway in year 10
- Expansion can only happen in year 10, with capital costs being paid and additional capacity being available from year 10 on
- Construction cost, operating cost, lifecycle are the same as for fixed design, construction costs paid back during 25 years (hence a discounted rest cost of $1,6 mn needs to be paid after year 25 for the second runway, which is neglected in this analysis)

Runway data

Inputs derived from hypothetical aircraft mix data:

- Average capacity= 224 passengers/aircraft
- Average landing fee per aircraft= $400
- Average revenue per passenger= $1.78
  (used to calculate revenues from met demand)

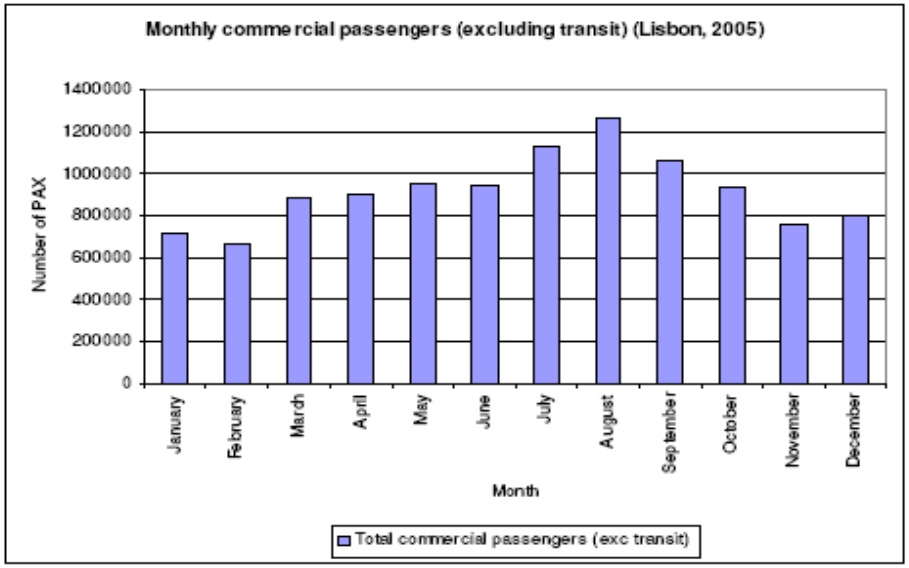
Inputs derived from external data sources:

- Assumed hourly capacity= 35 movements/hours
  (Wikipedia, Ota)
- σ=19% per year (derived from monthly pax in 2005)
- Annual capacity= 79, 935 landings
  (= ½ of total capacity)

  Annual capacity= # hourly movements
  *16*365*0.85*(0.5+0.5/ σ)*0.5
  (de Neufville, Odoni (2003), p. 450-453)

  Annual maximum of passengers carried
  = 35,842,854 (2 runways)
  = 17,921,427 (1 runways)

Aircraft Mix				
	Avg. Capacity	MTOW	% Movements	Revenue/ Landing
	[pax]	[mt]	[% Total]	[$]
B737-500	115.0	52.6	20.00%	$342.49
A320-200	162.0	73.9	30.00%	$342.49
B757-200	190.0	109.3	20.00%	$342.49
B747-400	382.0	398.3	30.00%	$533.53



ANA SA, Bolletim de Estatistica 2005

Two-stages decision analysis

- 3 growth modes (scenarios, 'Sc'):
  Base case: 4%
  Optimistic growth: 10%
  Pessimistic growth: 2%

- Two phases:
  Phase 1: 10 years, at the beginning decision for fixed or flexible design must be made
  Phase 2: 15 years, at beginning decision for or against expansion must be made

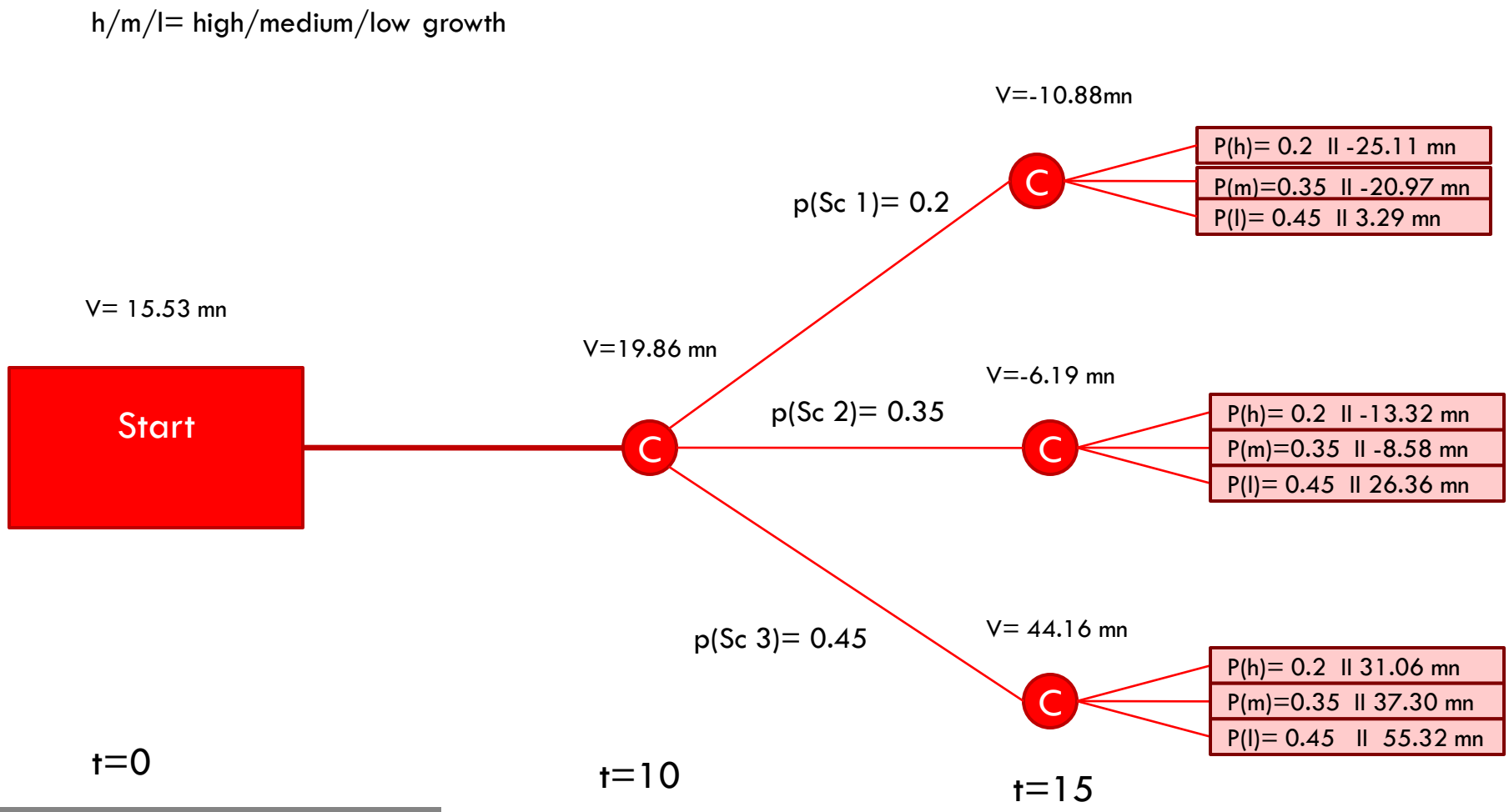
Phase 1	Pessimistic Sc1, (2%)	Base case Sc 2, (4%)	Optimistic Sc 3,(10%)
1 runway	40%	30%	30%
2 runways	20%	35%	45%

Phase 2	Pessimistic Sc 1, (2%)	Base case Sc 2, (4%)	Optimistic Sc 3, (10%)
1 runway	30%	40%	30%
2 runways	20%	35%	45%

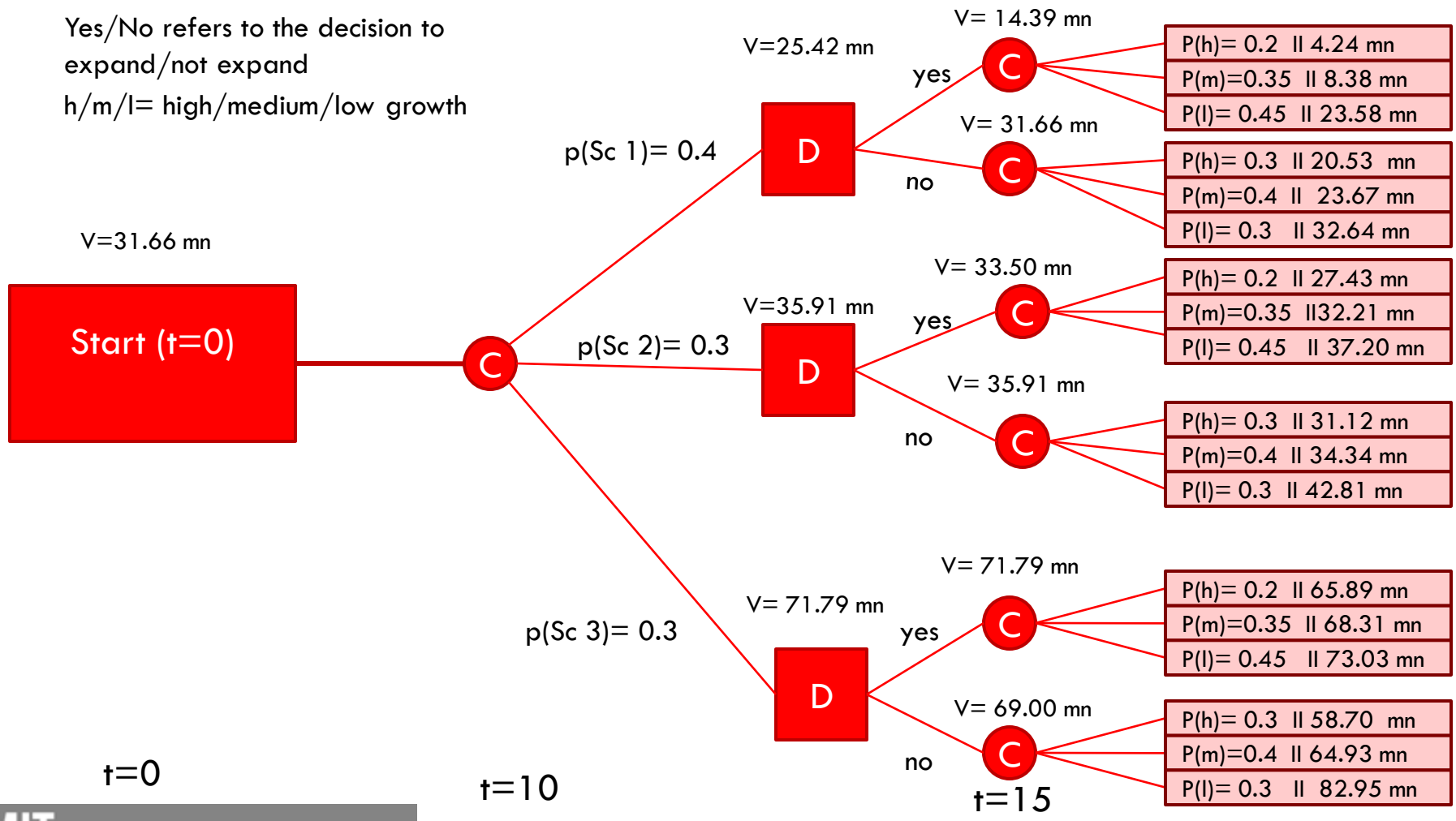
Probabilities for different growth modes

- Growth and revenue is calculated using the New Runway Model (Duane-Chambers, 2007)
- Assumptions for probabilities of growth scenarios, incorporating known evidence from several airports that indicate that airlines are attracted to facilities which can accommodate their growth most easily. (Bonnefoy, 2005)

Decision tree for fixed design



Decision tree for flexible design



Results from decision analysis

- Expected value is positive in both fixed and flexible case ($15.53mn and $31.66mn, respectively)
- Optimal strategy
  Flexible design, don't expand in cases of 2% or 4% growth in phase 1, do expand in case of 10% growth
- The value of staying small makes a considerable difference between both designs
- Value increase through option= $31.66mn- $15.53 mn=$16.13mn (option already considered in calculation)

Lattice model of probability

Year 0	1	2	3	4	5	…	23	24	25
1.00	0.61	0.37	0.222	0.134	0.081	…	0.000	0.000	0.000
	0.39	0.48	0.434	0.350	0.265	…	0.000	0.000	0.000
		0.16	0.283	0.342	0.345	…	0.001	0.001	0.000
			0.062	0.149	0.225	…	0.005	0.003	0.002
				0.024	0.073	…	0.015	0.011	0.007
					0.010	…	0.038	0.029	0.018
						…	…	…	…
							0.000	0.000	0.000
								0.000	0.000
									0.000

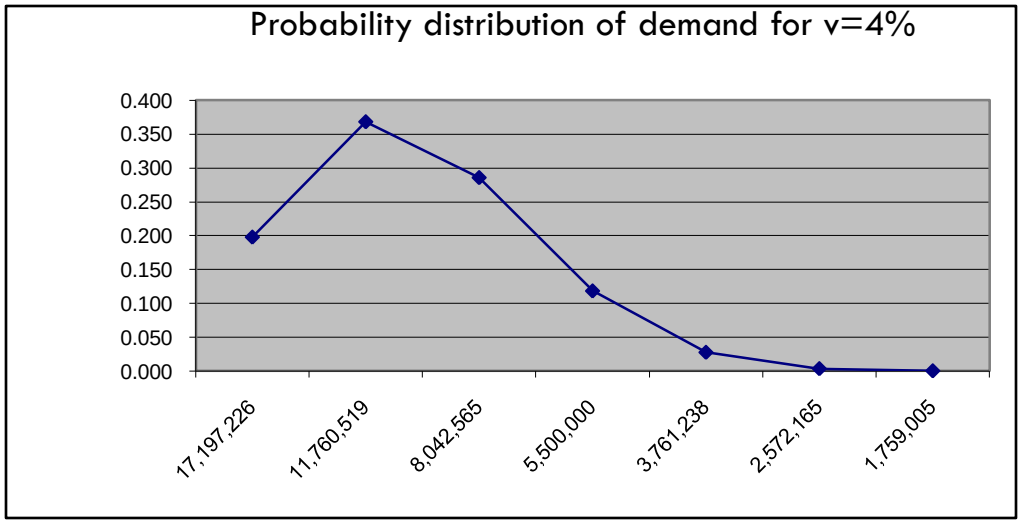
Inputs

- **$p = 0.5 + 0.5(v/\sigma)*\sqrt{\Delta T} = 0.61$**
- **$u = \exp(\sigma * \sqrt{\Delta T}) = 1.21$**
- **$d = 1/u = 0.83$**
- **σ=19% per year** (from historical data)
- **Growth rate v= 4%** (base case)
  (Through regression analysis of logarithmic historical data and forecast (1988-2050, ANA e Parsons FCG (2006)), fitted to growth model of the form pax(t)=A*exp(r*t), (R^2=0.95)
- **Initial demand= 5.5 mn per year**
  (roughly one third of what Portela is forecast to be serving in 2016, the assumed date of opening of NLA)

Lattice model of demand

Year 0	1	2	3	4	5	…	23	24	25
5.5	6.7	8.0	9.7	11.8	14.2	…	434.7	525.7	635.7
	4.5	5.5	6.7	8.0	9.7	…	297.3	359.5	434.7
		3.8	4.5	5.5	6.7	…	203.3	245.9	297.3
			3.1	3.8	4.5	…	139.0	168.1	203.3
				2.6	3.1	…	95.1	115.0	139.0
					2.1	…	65.0	78.6	95.1
						…	…	…	…
							0.1	0.1	0.1
								0.1	0.1
									0.1

Values in $ mn



Optimal expansion choice in flexible design

Year 0	1	2	3	4	5	6	7	8	9	10	Ex. Option?
460	554	633	691	720	714	673	607	526	439	348	Yes
	280	365	440	499	533	538	508	445	361	271	Yes
		126	200	267	320	354	360	334	272	177	Yes
			0	65	123	170	200	205	177	110	No
				-94	-37	15	57	84	89	64	No
					-158	-105	-57	-16	12	20	No
						-193	-141	-92	-49	-16	No
							-201	-146	-93	-43	No
								-184	-123	-61	No
									-144	-74	No
										-83	No

Values in $ mn

- Calculation of net revenues for 1 and 2 runways
- Calculation of value of being in each state in lattice
- Subtracting future value of option cost in year 10 from values of expanded case (future value of option cost in year 10 = $39.4 mn)
- Building lattice from maximum values of 1 or 2 runways in year 10, backtracking until present
- NPV= $ 460 mn

Results from lattice analysis

- Option value in base case is $ 422.6mn
- Flexible design is advantageous because cost for unused capacity does not occur
- Option value and decision for flexible design robust against different growth modes, as indicated by table below

Values in $ mn

	2%	4%	6%	8%	10%
ENPV (flexible)	274.4	420.9	564.5	697.5	813.4
ENPV(fixed)	20.9	1.7	20.57	45.1	70.5
Value of call	295.3	422.6	543.93	652.4	742.9

Concluding remarks

- Design recommendation: Flexible design turns out to be of considerable advantage
- This decision proves robust against different growth rates in the lattice analysis
- This indicates that the advantage of flexible design in runway construction lies in the cost saving while traffic demand does not require a second runway, not so much in the value of flexible reactions to external developments
- Remarks:
  This model, while seeking to use a reasonable capacity level, does not take congestion at the single runway into account that might make a second runway desirable earlier on
- Several important interactions, e.g. impact of availability of capacity and prime slots on airlines' decisions to use NLA as a hub, are not considered here

Sources

- ANA SA, Bolletim de Estatistica (2005); ANA e Parsons FCG (2006). www.ana.pt. Cited after 'Consulta para a realização de "Estudio de geração e repartição de tráfego terrestre do novo aeroporto de Lisboa" (source: RdN)
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