1.146 Application Portfolio: Construction of a new Rapid Transit Corridor

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System Characteristics

- Transit corridor, part of larger network
- Expecting significant growth
- City would like to upgrade to rapid transit
- Options:
  - Build Light Rail
  - Build Bus Rapid Transit with option to upgrade to Light Rail

Uncertainties

- Top uncertainty: Ridership
- Secondary uncertainties:
  - Energy costs
  - Policy and political support
  - Land use and automobile ownership
  - Public transportation technologies

Ridership

Passenger trips per day:

Year 0	Year 12	Year 24
	12000	18000
6000	9000	14000
	6000	10000

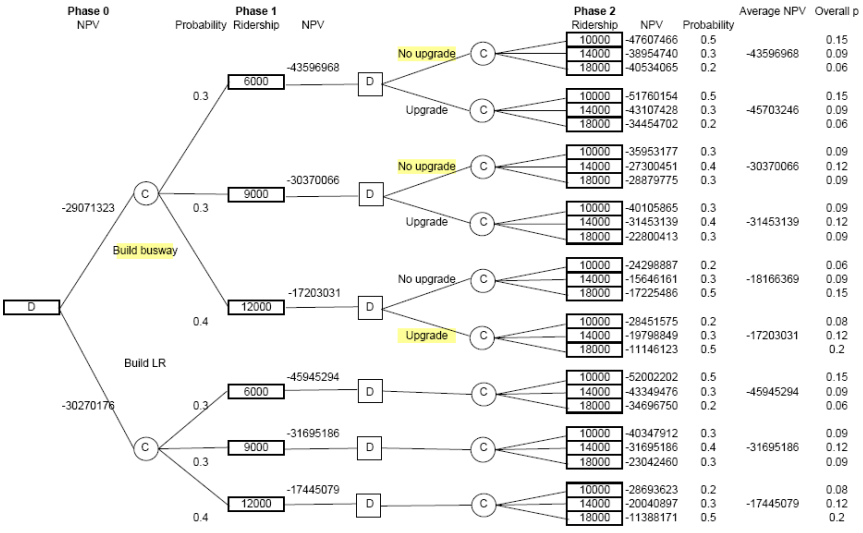
- "Most likely outcome" in year 24: 15k trips per day
- Bus system as planned can handle a maximum of 14k trips per day.
- Above that, light rail should be in place.
- If we don't have a light rail and ridership goes above 14k, operations become expensive (additional rentals, delays)

Design details

- Primary objective is to provide service in most effective way
- Avg. operating speed of rail is higher than bus -> Less vehicles
- FTA carries 80% of capital investment costs
- Cost of flexibility in this case is very low

Item	Cost estimate	New Busway	New Light Rail	Light Rail Upgrade
Traffic control and mobilization	8.650.000	Yes	Yes	Yes
Segregated right of way	22.670.000	Yes	Yes	No
Stations	4.885.000	Yes: Half	Yes	Yes: Half
Utilities	11.273.000	Yes	Yes	No
Tracks	27.195.000	No	Yes	Yes
Overhead power system	20.400.000	No	Yes	Yes

Decision Tree



Lattice Analysis

- Have to change assumptions
- Continuous ridership development
- Growth in all cases

$$u = \sqrt[6]{\frac{18000}{S}} \approx 1.201$$

$$d = \sqrt[6]{\frac{10000}{S}} \approx 1.089$$

$$v = \sqrt[6]{\frac{15000}{S}} \approx 1.152$$

OUTCOME LATTICE

Year	0	4	8	12	16	20	24
	6000.00	7206.00	8654.41	10393.94	12483.12	14992.23	18005.67
		6534.00	7847.33	9424.65	11319.00	13594.12	16326.54
			7115.53	8545.75	10263.44	12326.39	14804.00
				7748.81	9306.32	11176.89	13423.44
					8438.45	10134.58	12171.63
						9189.47	11036.56
							10007.34

Dynamic programming approach

NPV - Fixed version (Dynamic programming procedure)

Year	0	4	8	12	16	20	24
	-3.81E+07	-1.26E+07	-4.19E+06	3.23E+06	8.82E+06	1.14E+07	9.18E+06
		-1.82E+07	-9.97E+06	-2.43E+06	3.61E+06	7.10E+06	6.57E+06
			-1.52E+07	-7.57E+06	-1.11E+06	3.24E+06	4.20E+06
				-1.22E+07	-5.39E+06	-2.58E+05	2.05E+06
					-9.27E+06	-3.43E+06	1.09E+05
						-6.31E+06	-1.65E+06
							-3.25E+06

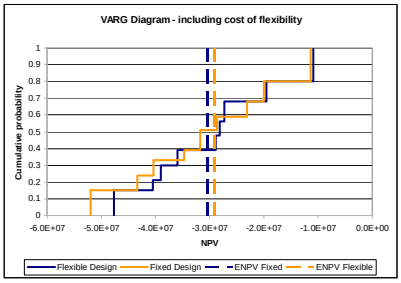
NPV - Flexible version using decision rule (Dynamic programming procedure)

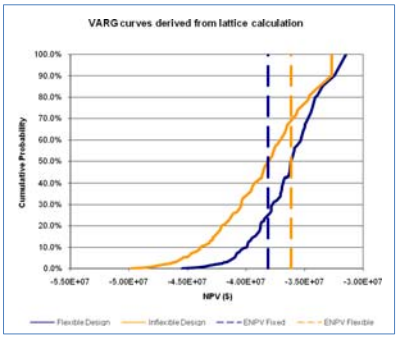
Year	0	4	8	12	Upgrade?	16	20	24
	-3.62E+07	-2.39E+07	-1.64E+07	-1.03E+07	YES	...	...	...
		-2.80E+07	-2.00E+07	-1.29E+07	NO	...	...	...
			-2.38E+07	-1.62E+07	NO	...	...	...
				-1.96E+07	NO	...	...	...
						...	...	...
							...	...
								...

- Optimal decision found by comparing NPV lattices for flexible approach with and without upgrade

VARG diagrams

From DA (below) and lattice (right)





- 5% Discount rate
- ENPV breakeven point in decision analysis: 4.1%

Decision

From DA:

	Flexible Design	Fixed Design	Which is preferable ?
Max NPV	-11146123	-11388171	Flexible
Min NPV	-47607466	-52002202	Flexible
ENPV	-29071323	-30270176	Flexible
Initial CapEx	11444400	23754600	Flexible
ENPV/CapEx	-2.540222536	-1.274286897	Flexible

From Lattice:

	Flexible Design	Fixed Design	Which is preferable?
Max NPV	-31476843	-31718891	Flexible
Min NPV	-45435745	-49830480	Flexible
ENPV	-36165769	-38140085	Flexible
Initial CapEx	11444400	23754600	Flexible
ENPV/CapEx	-3.160128	-1.605587	Flexible

- Flexible approach clearly has financial advantages
- However: Savings may be offset by uncertainty about future funding levels and political support