

Decision Aids for Tunneling – A CATALOGUE FOR APPLICATION TO SMALL TUNNELS

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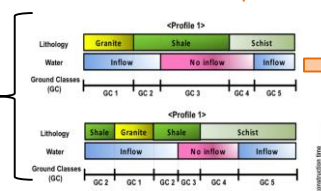
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OBJECTIVES: HOW TO ENCOURAGE THE USE OF THE DAT TO SMALL TUNNELS? HOW TO DEVELOP THE DAT CATALOGUE?

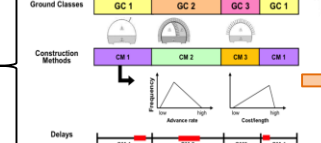
DECISION AIDS FOR TUNNELING

### PRESENTATION chapter 1


**Geology Module**



**Construction Module**



**Time-Cost scattergram**



### ILLUSTRATIVE EXAMPLE chapter 2

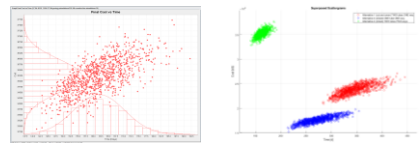
Deterministic calculations:

- only one value for time and cost
- No variabilities or uncertainties considered

STA [ft]	Linear Dist. [ft]	Strata	Cost [\$ / Liner ft]	Time [ft/d]	Section cost [\$]	Section Time [d]		
23700	23780	80	Mixed Cost+	59000 x 1.25	11250	5	900000	16
23780	24150	370	Soft Bolders Cost+	59000 x 1.25	11250	10	4162500	37
24150	24250	100	Soft Bolders	59000	9000	8	900000	12.5
24250	24370	120	Mixed	59000	9000	6	1080000	20
24370	25200	930	Soft NO Bolders	57000	7000	20	6440000	46
25200	25400	110	Soft Bolders	59000	9000	12	990000	9.17
25400	25680	280	Mixed	59000	9000	6	2520000	46.7
25680	26300	620	Mixed Cost+	59000 x 1.25	11250	5	6975000	124
<b>extra costs/ delays</b>								40
<b>TOTAL COST</b>						<b>\$23 967 500</b>		<b>351.33</b>

Probabilistic DAT simulations:

- [Min; Mean; Max] values for time and cost
- Visual spread on the scattergrams



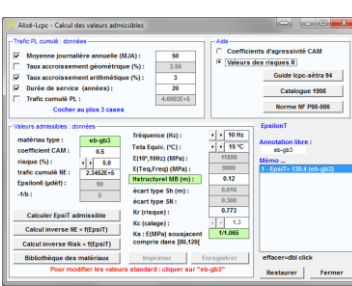
CALCULATOR VS. CATALOGUE

### CALCULATOR chapter 3

Simplification of the existing DAT:

- Drop off unused modules
- Hide complicated aspects
- User friendly interface
- Pre-defined options to pick from

User can model tunnels with ease and in very short time with no room for errors and without any previous DAT experience.



Alizé software for illustration only

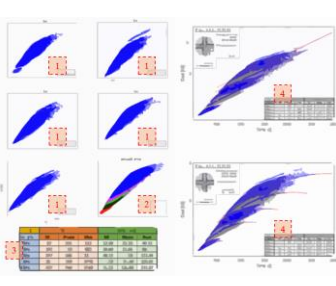
Verdict: pending, not developed

### CATALOGUE chapter 3

Generate charts using the DAT for the user to consult directly in order to obtain cost and time estimates.

Present results in form of:

- Five scattergrams for L[km] 1 to 5
- Superposed scattergrams
- Summary table [Min; Mean; Max] values for cost and time
- Two summary charts with fits



Verdict: retained, developed

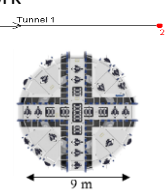
CATALOGUE INPUTS

### TUNNELING chapter 4

Cost-Time inputs for 5 ground classes

TBM	GC	GC names	Min	Mean	Max	Unit
Advance Rate	1	Very Good	22	28	42	m/d
	2	Good	13	18	20	
	3	Fair	8	12	15	
	4	Bad	3	7	9	
	5	Very Bad	1	2	3	
Cost	1	Very Good	3	5	8	k\$/m
	2	Good	11	13	16	
	3	Fair	14	16	21	
	4	Bad	20	23	29	
	5	Very Bad	51	57	73	

Tunnel Network



Section type:

- TBM
- d = 9 m

Reference Table for geology conditions

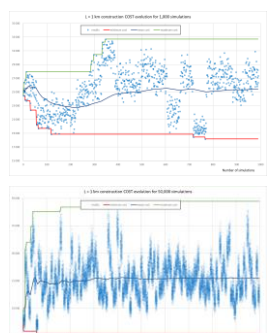
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
A	GP	SECONDARY SETTING					MIXED SETTING					GP STATE				
B	C	SCHE					SCHE					SCHE				
D	E	Percent					Percent					Percent				
F	FUNCTION	NL	50/50	Table 7	Table 8	Table 9	Table 10	Table 11	Table 12	Table 13	Table 14	Table 15	Table 16	Table 17	Table 18	Table 19

### MONTE CARLO chapter 5

Parametric analysis to find the optimal number of iterations to generate the results of the Catalogue. Compromise between practicality and accuracy.

Results show that the number of iterations:

- above 50,000 is not justified
- below 10,000 is not recommended
- closer to 10,000 is more practical
- closer to 50,000 is more accurate



Retained value: 50,000 iterations

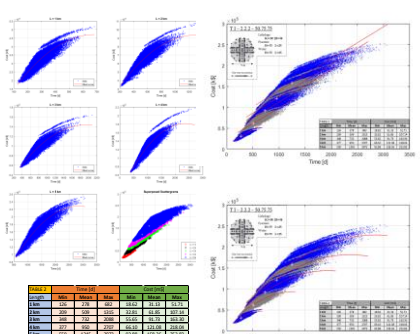
CATALOGUE RESULTS

### CHARTS chapter 6

Developed 27 Tables using the proposed format above.

Catalogue FAQ and Recommendations for interpolations and extrapolations to new data.

Propositions for future developments and expansions of the Catalogue.



### ANALYSES chapter 7

Investigations to understand:

- Bilinear shape of scattergrams
- Detachment of points
- Influence of number of occurrences

