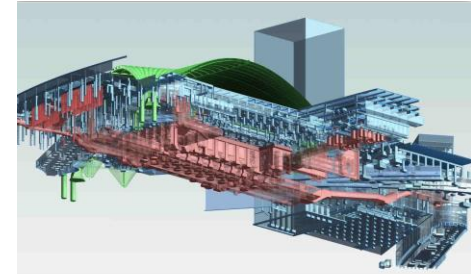




# DIGITAL OPTIMIZATION OF UNDERGROUND RAIL PROJECTS

## SETEC FEEDBACK FROM CURRENT PARIS RAILWAY PROJECTS

23/10/2019



# GENERAL OVERVIEW

## ■ Introductory note

- Optimization of a rail tunnel has to deal with constraints such as minimal cross section in relation to the rail system and related functions, vertical and horizontal alignment constraints, constraints for location of stations and shafts.
- The FCC tunnel will have to deal with similar constraints
- That is why we, in Setec, are convinced that feedback on rail tunnels alignment optimization is relevant for FCC tunnel optimization.



# GENERAL FLOWCHART



## FIRST BOX : CONTEXTUAL DATA TREATMENT

- Topography, Geology, hydrogeology
- Existing surroundings



## SECOND BOX : EXPLORATION OF ALTERNATIVES

- Parametrization of typical cross section
- Parametrization of alignment components



## THIRD BOX : MULTICRITERIA ANALYSIS

- Dynamic reports on individual criteria
- Evaluation and weighting of criteria



# FIRST BOX: CONTEXTUAL DATA TREATMENT

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# FIRST BOX: DATA TREATMENT



## ■ Data come from variable origins and formats:

- topography, digital terrain model (in France MNT from BD alti by IGN)
- geology, hydrogeology,
- existing surrounding buildings, other constructions and utilities

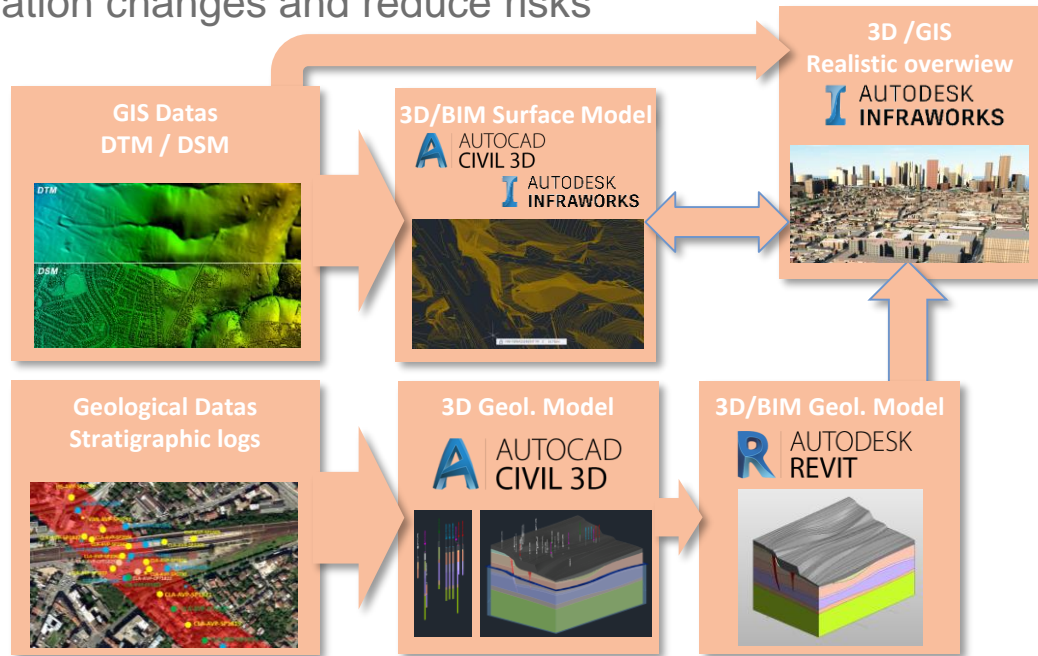


# FIRST BOX: DATA TREATMENT



## ■ BIM tools provide helpful workflow

- to turn raw data into realistic models,
- to improve understanding of ground conditions
- to manage information changes and reduce risks





# SECOND BOX: EXPLORATION OF ALTERNATIVES

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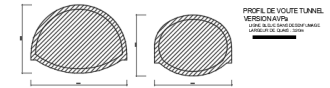
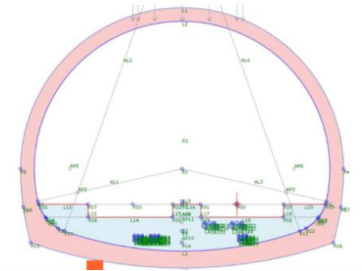
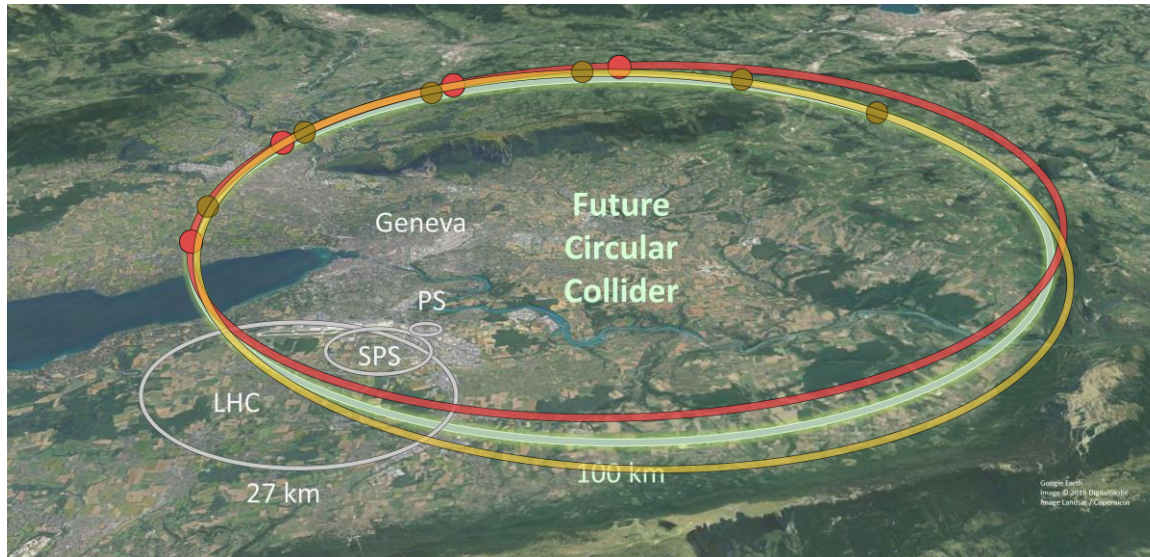
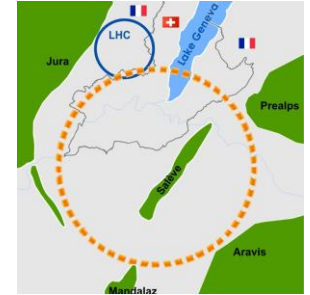


# SECOND BOX: EXPLORATION OF ALTERNATIVES

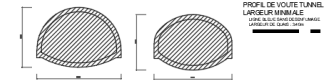


## ■ FCC project parameters for optimization :

- Tunnel, shafts and station locations regarding geology
- horizontal and vertical tunnel alignment
- tunnel cross section



PROFIL DE VOLUTE TUNNEL  
VERSION A1/0  
L'ŒUVRE EST LA PROPRIÉTÉ DE SETEC  
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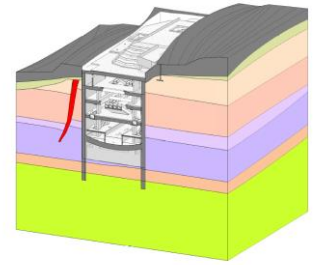
# SECOND BOX: EXPLORATION OF ALTERNATIVES



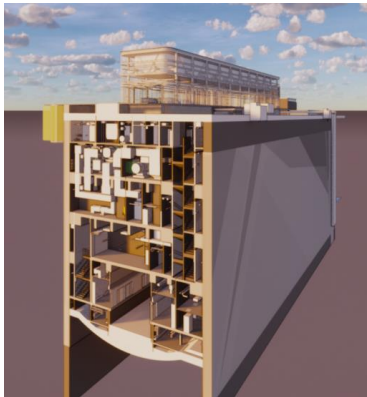
## ■ Paris Railway Projects : modelling of stations



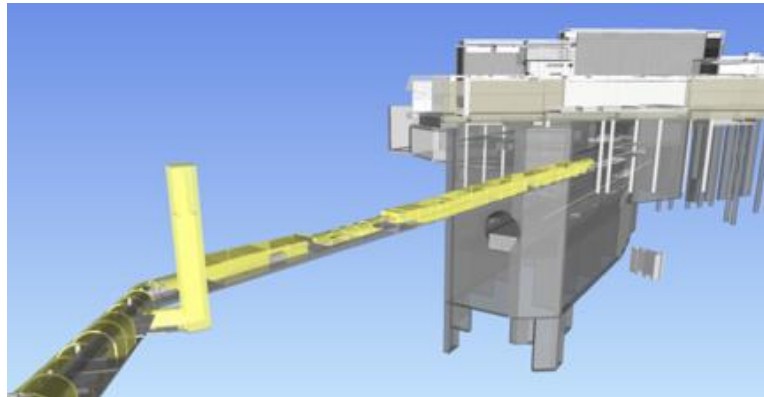
- regarding topography and geology
- regarding existing utilities
- regarding functionality



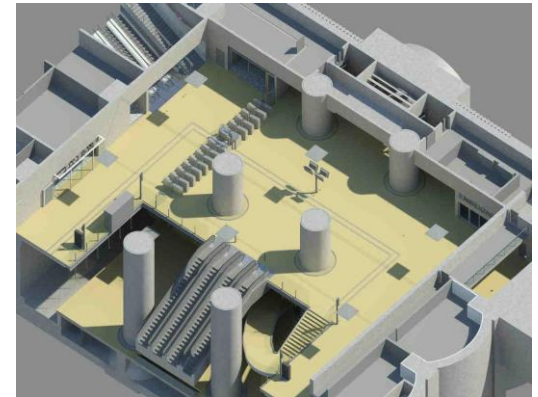
Saint-Cloud Station  
Grand Paris Express Line 15W



Villejuif Louis Aragon Station  
Grand Paris Express Line 15S



Chatillon Montrouge Station  
Grand Paris Express Line 15S



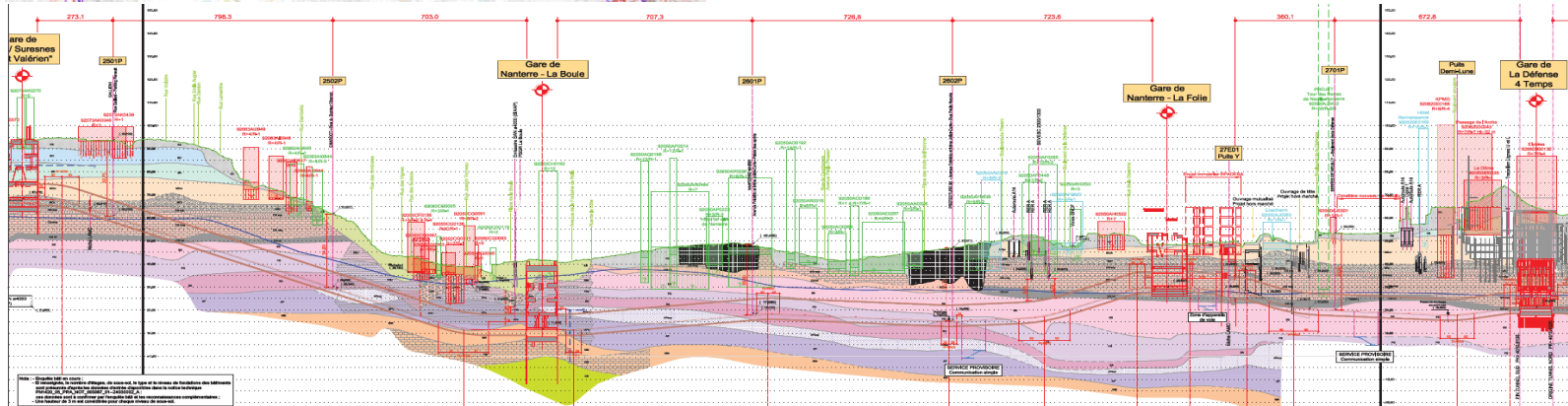
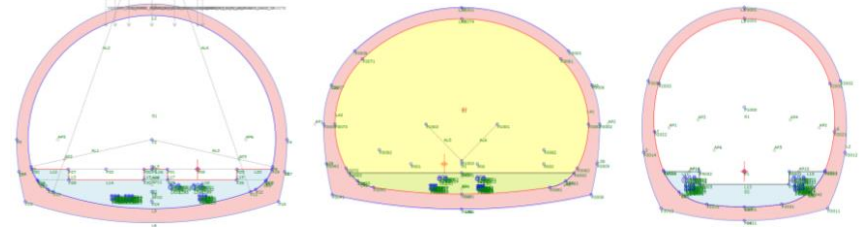
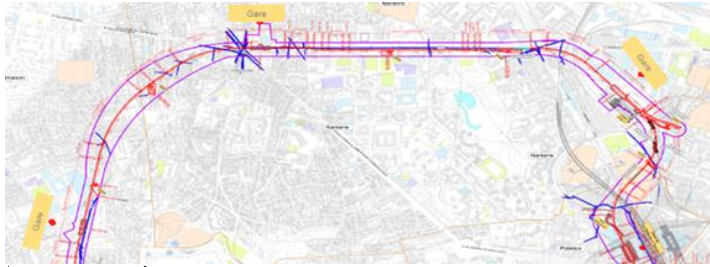
Eole Paris La Défense Station  
RER E extension

# SECOND BOX: EXPLORATION OF ALTERNATIVES



## ■ Paris Railway Projects : modelling of tunnels

- use of parametrical cross sections along tunnel alignment



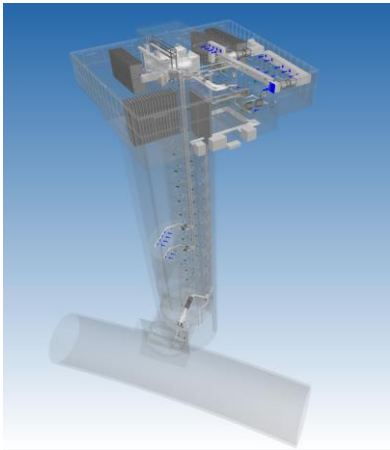
Vertical alignment with geological

# SECOND BOX: EXPLORATION OF ALTERNATIVES

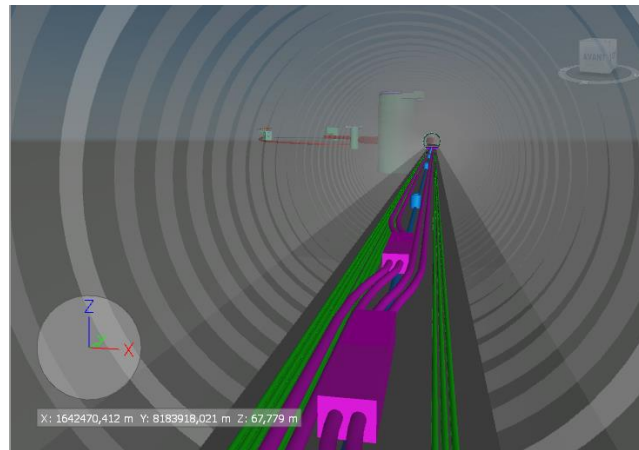


## ■ Paris Railway Projects : coordinated models

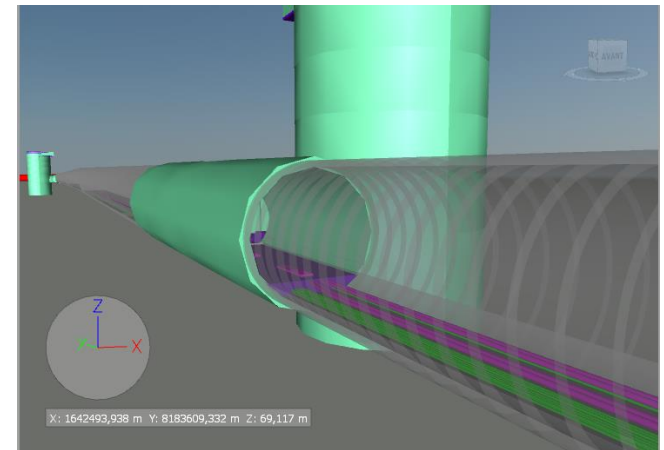
- final integration of tunnel and stations



Tunnel shaft  
Grand Paris Express Line 15S



Tunnel rings and power networks  
Grand Paris Express Line 15W



Tunnel and shaft connection  
Grand Paris Express Line 15W

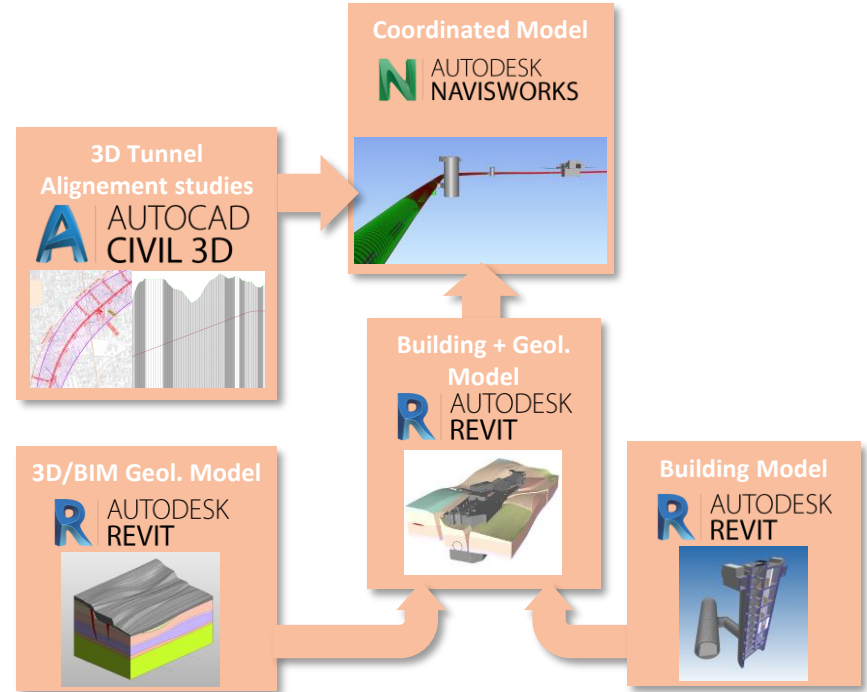
# SECOND BOX: EXPLORATION OF ALTERNATIVES



## ■ Paris Railway Projects : BIM tools provide helpful workflow



- for setting up parametric data
- for generation of alternatives



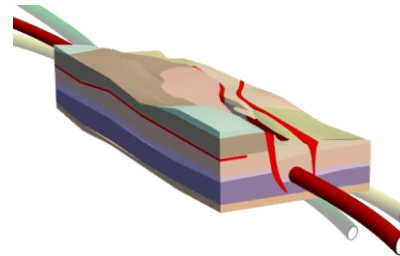
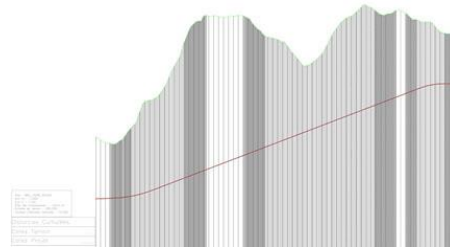
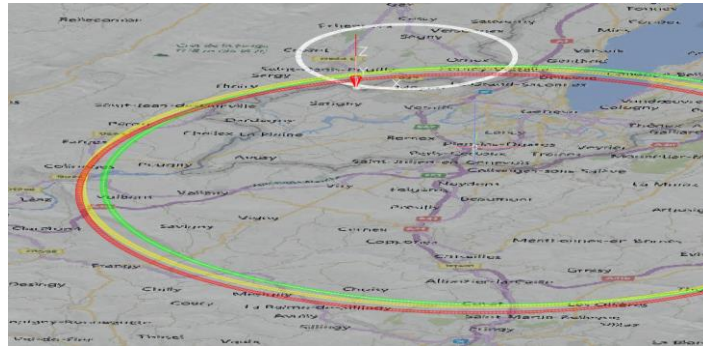
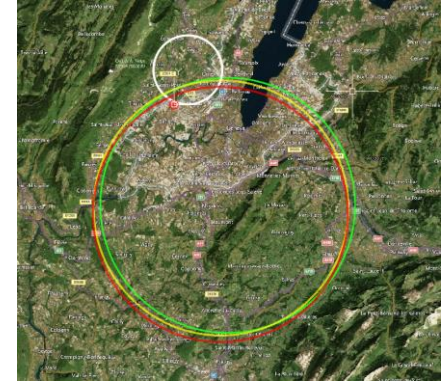
# SECOND BOX: EXPLORATION OF ALTERNATIVES



## ■ FCC project parameters for optimization



- generation of numerous alternatives
- manage horizontal and vertical alignment
- to manage information changes and reduce risks





# THIRD BOX: MULTICRITERIA ANALYSIS

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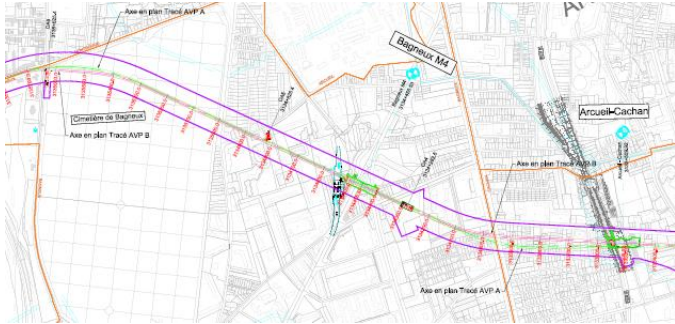


# THIRD BOX: MULTICRITERIA ANALYSIS



## ■ Extraction process from the data lake resulting from exploration of alternatives

- from digital drawing to calculation database
- many opportunities for bijective changes



Tunnel horizontal alignment  
Grand Paris Express Line 15S

N°	Chaînage	Longueur	PR	X	Y	Z
23	ARC R <sub>0</sub> = 325.000 Centre X = 1650872.061 Y = 8177309.958	143.964	3133121.012	1650902.449	8177455.904	35.049
24	CLOTHOÏDE R <sub>0</sub> = 325.000 P <sub>0</sub> = 161.145 R <sub>1</sub> = 0.820 Tau = 7.835 Sommet X = 1650871.062 Y = 8177570.585	80.000	3133264.976	1650871.864	8177566.284	42.136
25	DROITE G <sub>0</sub> = 334.316	534.873	3133344.976	1650804.996	8177610.100	43.000
26	CLOTHOÏDE R <sub>0</sub> = 600.000 P <sub>0</sub> = -256.905 R <sub>1</sub> = 0.840 Tau = 5.836 Sommet X = 1650283.004 Y = 8177922.314	110.000	3133879.849	1650345.966	8177884.655	43.000
27	ARC R <sub>0</sub> = 400.000 Centre	115.672	3133989.849	1650253.368	8177943.954	41.880

Tunnel kilometer points locations  
Grand Paris Express Line 15S

ID	Chaque	PseudoStation	PhasSubStation	Variable	ValeurInitial	Statut	Valeur	Commentaire	Déclassement
1	1796272	1796870	0	NULL	NULL	NULL	38.62537933474	NULL	NULL
2	1796880	2295977	0	NULL	NULL	NULL	1.9379999999999999	SB	-2.9999999999999999
3	1796882	2295977	0	NULL	NULL	NULL	1.9379999999999999	SB	-2.9999999999999999
4	1796884	2295977	0	NULL	NULL	NULL	1.8629644473488	SB	-2.9999999999999999
5	1796886	2295977	0	NULL	NULL	NULL	1.8629644473488	SB	-2.9999999999999999
6	1796888	2295977	0	NULL	NULL	NULL	1.9379999999999999	SB	-2.9999999999999999
7	1795436	2295977	0	NULL	NULL	NULL	1.9379999999999999	SB	-2.9999999999999999
8	1795438	2295977	0	NULL	NULL	NULL	1.8629679914989	SB	-2.9999999999999999
9	1795440	2295977	0	NULL	NULL	NULL	1.8629679914989	SB	-2.9999999999999999
10	1796251	2295646	0	NULL	NULL	NULL	19.316748946578	SB	-0.3
11	1787932	2295646	0	NULL	NULL	NULL	19.316748946578	SB	-0.3
12	1788089	2295646	0	NULL	NULL	NULL	19.316748946578	SB	-0.3
13	1788096	2295646	0	NULL	NULL	NULL	19.316748946578	SB	-0.3
14	1789849	2295977	0	NULL	NULL	NULL	3.3900000000000000	SB	-0.3
15	1789851	2295977	0	NULL	NULL	NULL	3.3900000000000000	SB	-0.3
16	1789853	2295977	0	NULL	NULL	NULL	3.1896022424819	SB	-0.3
17	1789855	2295977	0	NULL	NULL	NULL	3.1896022424819	SB	-0.3
18	1789857	2295977	0	NULL	NULL	NULL	3.3900000000000000	SB	-0.3
19	1789859	2295977	0	NULL	NULL	NULL	3.3900000000000000	SB	-0.3

Stations information general database  
Grand Paris Express Line 15S

# THIRD BOX: MULTICRITERIA ANALYSIS



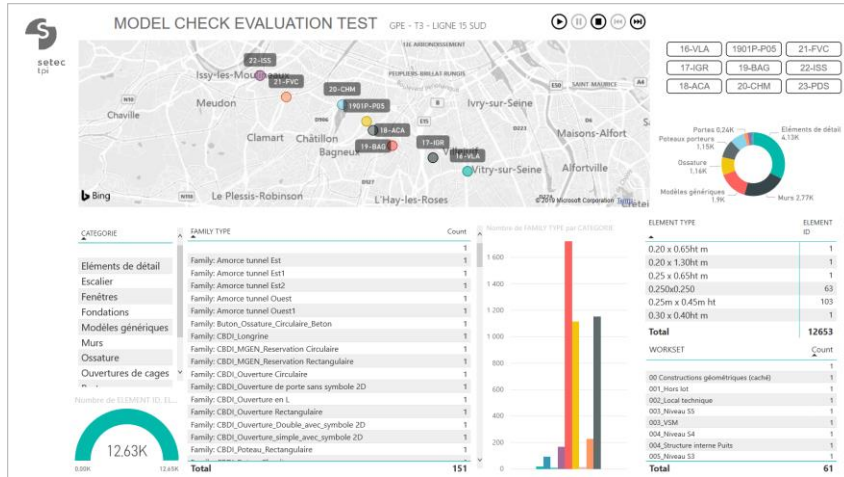
## Dynamic reports results from alternatives



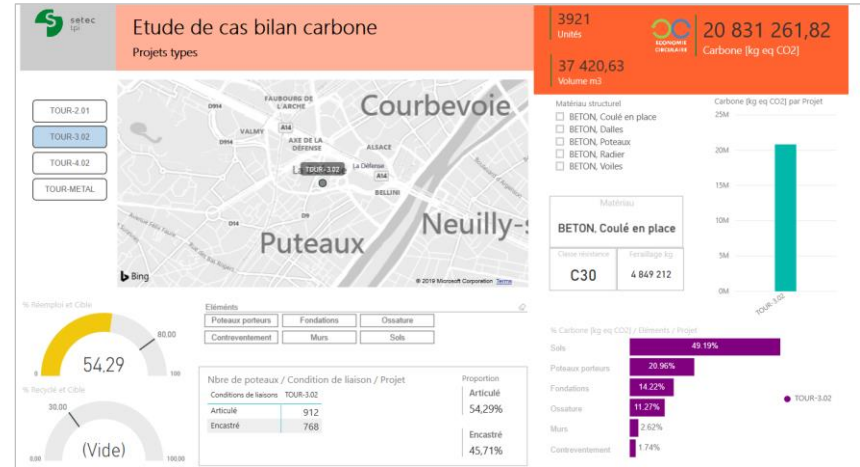
Examples:



- general estimated excavation volume, and for each ground layer
- carbon balance assumption vis-à-vis expected results



Stations information report  
Grand Paris Express Line 15S



Carbon balance report from tower building  
studies

Paris La Défense

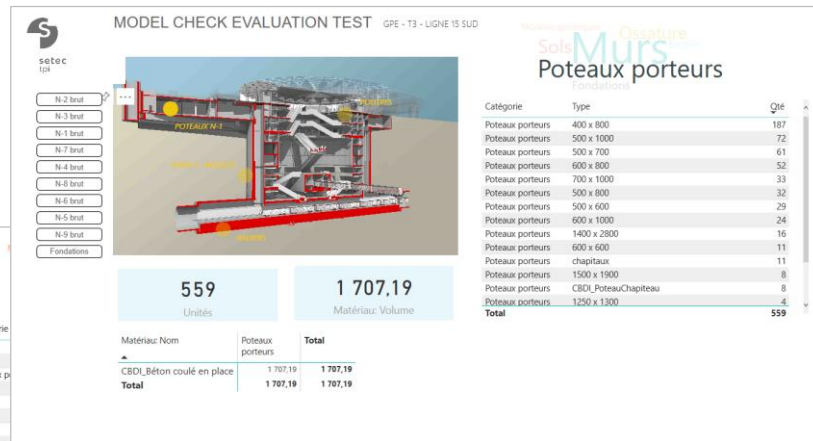
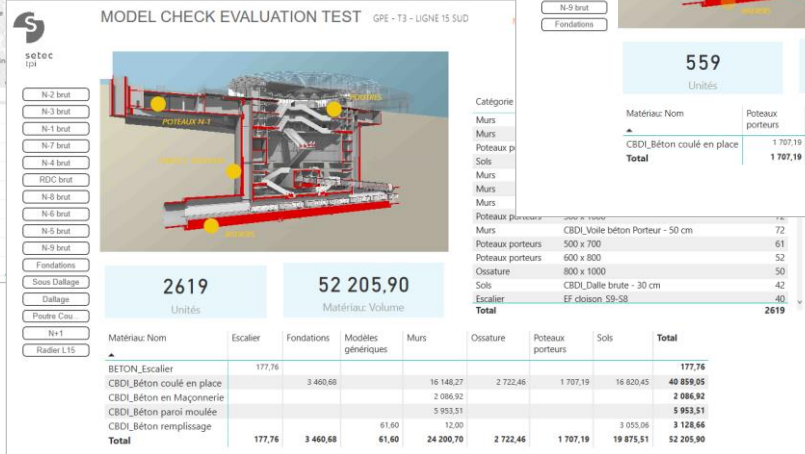
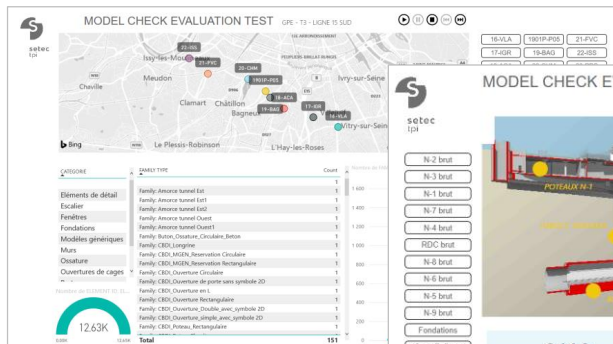


# THIRD BOX: MULTICRITERIA ANALYSIS



## Dynamic reports results for main project and special points

- fully consistent
- on any criteria at request
- and for each alternative



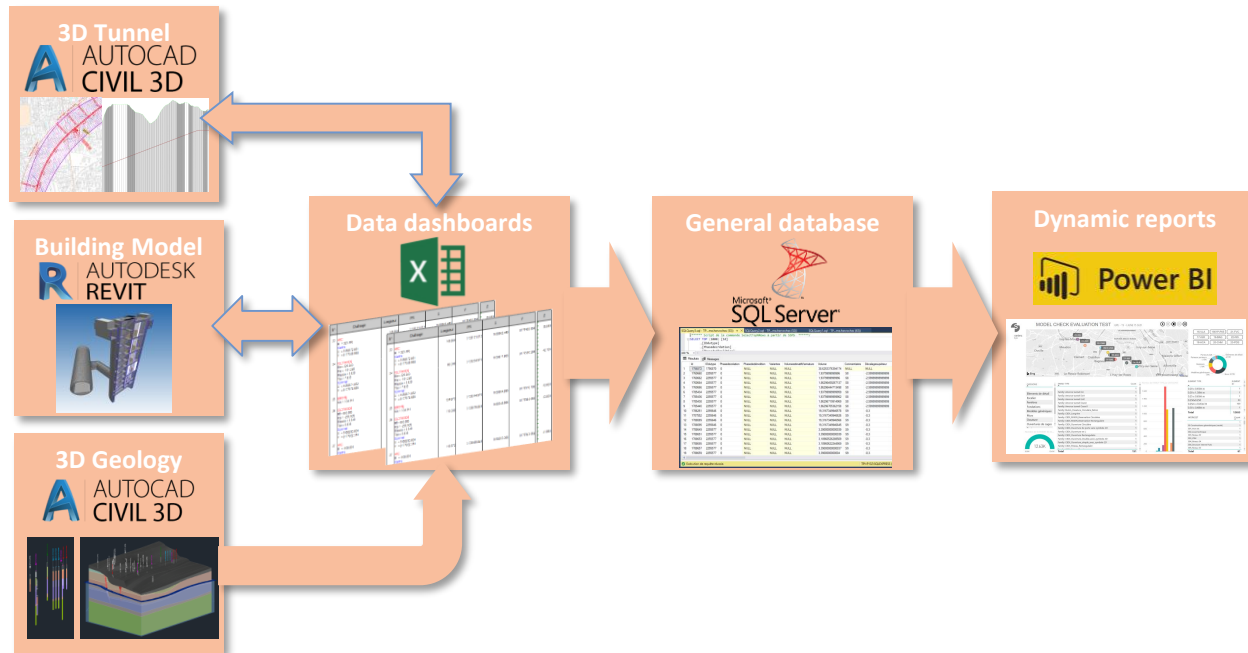
Villejuif IGR station  
Grand Paris Express Line 15S

# THIRD BOX: MULTICRITERIA ANALYSIS



## ■ Paris Railway Projects : data reporting workflow

- for data choices management
- for decision making among numerous alternatives

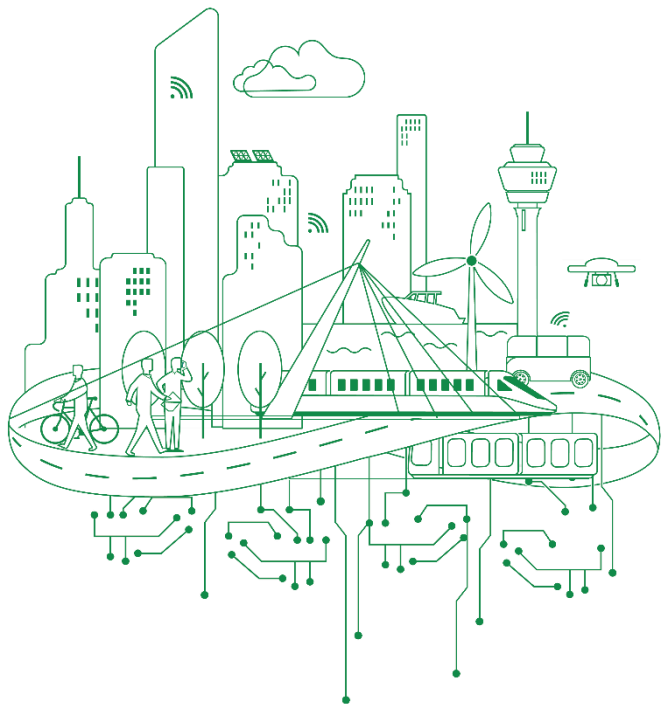


# CONCLUSION

## ■ Benefits of the approach

- All alternatives are fully compliant to design criteria
- At any time, possible dialogue with Owner and stakeholders, with access, thanks to Power BI, to automatic reports
- Iterative process
- Decision aid with clear evaluations on any criteria
- Takes advantage of future technological developments, based upon Setec feedback on other projects





# THANKS FOR YOUR ATTENTION

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**[www.setec.fr](http://www.setec.fr)**