ALTERNATE DOUBLE-SINGLE TRACK

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Talk's Index

The talk has been divided in following points:

High Speed Railway development in Spain

While at the beginning, high speed lines construction in Spain was oriented to **link two large population centers**, at the present time current and future plans involve **new lines in which only one of the ends is a large population**.

This implies a **completely different approach** and some reflections:

1. The first reflection consists to realize that in the case of peripheral lines, **the number of users is necessarily much lower** and consequently the **demand is much more reduced** leading to **train frequencies much smaller**.
2. The second reflection must be relative to **the question of whether or not the expensive double track is necessary**, or a **new alternative should be contemplated**.
3. Then and without necessarily **rejecting the single track solution**, **new solutions** are required. This is how the **alternate double single track (ADST)** arises.
4. Finally, since decisions with optimal criteria are required, computer programs are **unavoidable** to design, develop preliminary projects and evaluate the proposed solutions.

What is the Alternate double-single track(ADST)?

The Alternate double-single track (**ADST**) essentially consists in utilizing: **single track throughout expensive segments** (tunnels and viaducts) and **double track in cheap segments** (plain areas) and **only where it is necessary**.
It should be clearly stated that:

1. **An ADST line is not a single track line**.
2. **An ADST line is not a double track line**.
3. The ADST performance is much **closer to double** than to single track.
4. The ADST cost is much **closer to single track** than to double track.
5. It reaches practically the **same performance as the double track solution** for the expected demand and even slightly superior to it.
6. **It decreases markedly the construction cost** (until a $40\ \%$).
7. **Maintenance cost are significantly reduced**.
8. Finally, lines, which are nor economically viable as double track lines **can become viable** as ADST lines.

WHY ARE OPERATION RESEARCH METHODS NECESSARY?

The design and management of an alternate double single track line is complex, because it requires:

1. Deciding **which segments** should be constructed in **single track and which others in double track**.
2. **Satisfy the safety and time table constraints** of the different services with the aim of obtaining small travel times when we have a single track in some segments.
3. **Minimize costs and travel times** and optimize the infrastructure usage.

Due to the complexity of the problem, **the use of an optimization program is necessary** in order to satisfy all the imposed **safety and service conditions**.

Problem solving difficulties

1. It is a mixed problem which **combines continuous variables and binary variables**, that is known to present difficulties mainly if there are non-linear constraints.
2. The **number of binary variables is really high**, It and can reach several hundred thousands in medium problems with important cpu time and memory requirements.
3. Certain **constraints are initially non linear**. This is especially complex in mixed variable cases.
4. Depending on the objective function, the problem **can have an infinite number of solutions**.

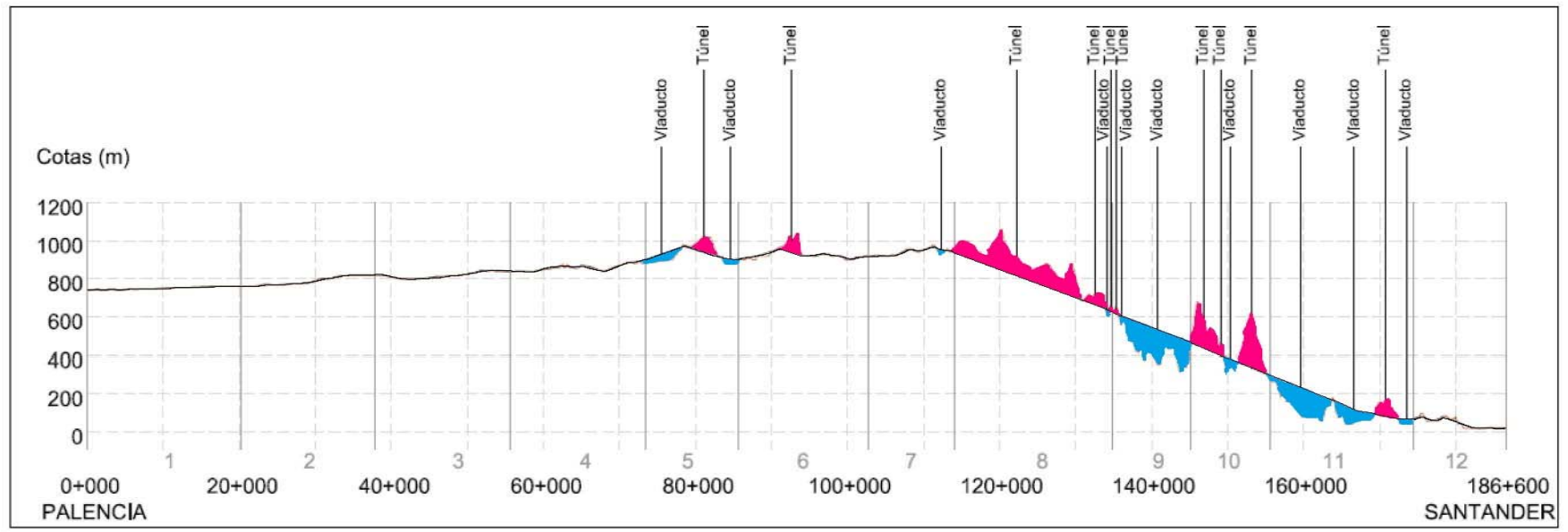
Some solutions

1. The **number of binary variables can be reduced**, identifying in advance the value of many of them, and then checking them.
2. The **nonlinear constraints can be linearized** without altering the solution.
3. We can **use a hierarchized objective function,** which includes the goals in the desired order.

ADST Application

Palencia-Santander line

GEOMETRIC DESCRIPTION OF THE PALENCIA-SANTANDER LINE



DESIGN PARAMETERS:

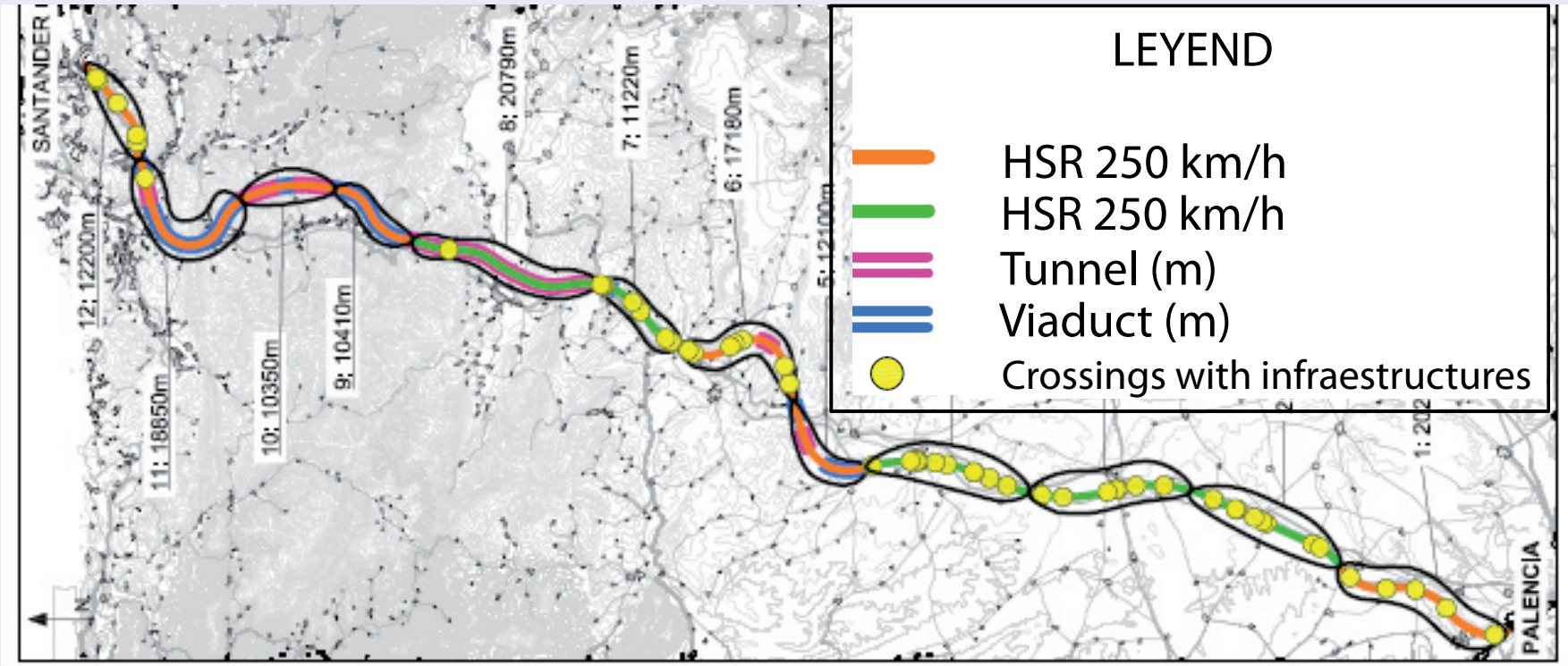
Slopes:

- maximum=15 mm/m; exceptional = 18mm/m
- In tunnel: minimum = 5 mm/m; exceptional = 2 mm/m
- Max L in maximum slope= 3000 m.

Vertical curves:

- For S=300 km/h, minimum Kv=32000 m.
- For S=250 km/h, minimum Kv=22000 m.

Description in the Palencia-Santander line



SELECTED SEGMENTS AND COST PER KILOMETER FROM THE DIFFERENT ALTERNATIVES

Segment	Origin	End	Leng (Km)	Construction Cost per Kilometer (M€)			
				Double HSR	Simple HSR	Simple HSR and Rehabilitated	Rehabilitated
1	Palencia	Amusco	20.22	6.89	4.12	4.42	0.3
2	Amusco	Santillana	17.70	6.03	3.87	4.17	0.3
3	Santillana	Espinosa	17.80	5.965	3.79	4.09	0.3
4	Espinosa	Alar	17.80	6.37	3.92	4.22	0.3
5	Alar	Aguilar	12.10	22.89	14.58	14.88	0.3
6	Aguilar	Mataporquera	17.18	15.67	9.82	10.12	0.3
7	Mataporquera	Reinosa	21.22	14.09	9.47	9.77	0.3
8	Reinosa	Santiurde	10.79	52.91	31.87	32.17	0.3
9	Santiurde	Barcena	10.41	33.66	21.52	21.82	0.3
10	Barcena	Los Corrales	10.35	47.86	28.75	29.05	0.3
11	Los Corrales	Torrelavega	8.55	34.73	22.17	22.47	0.3
12	Torrelavega	Santander	22.20	8.85	6.14	6.44	0.3

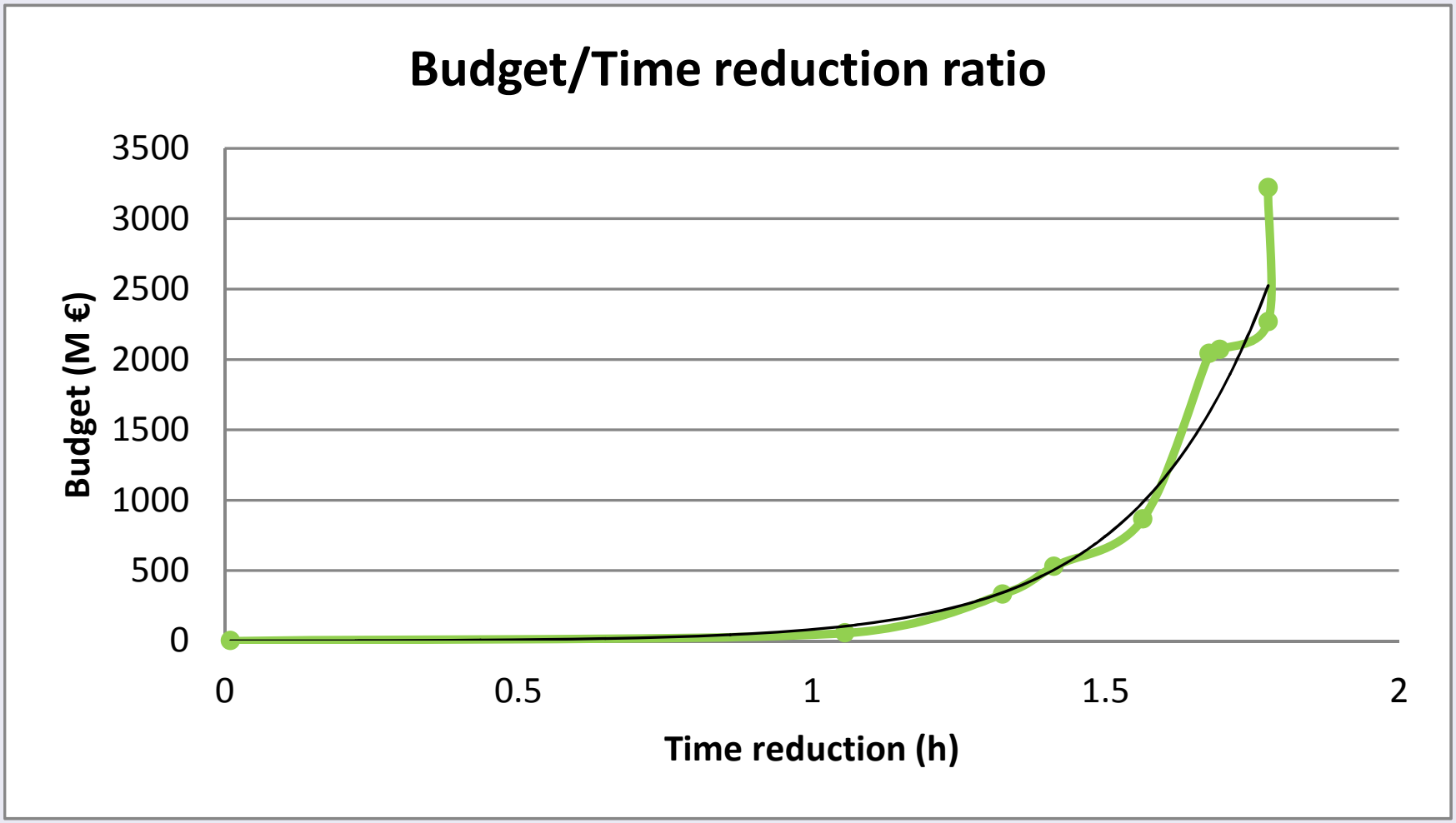
Chart showing the different solutions an associated budget and travel times for the Santander-Palencia line

Cases	Segments												Track Typology			Budget (M€)	Travel time	Time reduction	Budget saving (M€)	
	1	2	3	4	5	6	7	8	9	10	11	12	Double HSR	Simple HSR	RH					
Double													100%	0%	0%	3,221	1 h 3 min	1 h 47 min	0	0%
0													42%	58%	0%	2,267	1 h 3 min	1 h 47 min	954	30%
1													10%	90%	0%	2,070	1 h 8 min	1 h 41 min	1,151	36%
10													0%	100%	28%	2,042	1 h 9 min	1 h 41 min	1,179	37%
20													0%	67%	54%	866	1 h 16 min	1 h 34 min	2,355	73%
30													0%	51%	68%	528	1 h 25 min	1 h 25 min	2,693	84%
40													0%	39%	80%	334	1 h 30 min	1 h 20 min	2,887	90%
50													0%	0%	100%	56	1 h 46 min	1 h 4 min	3,165	98%
																Current	2 h 50 min			

Double HSR	Simple HSR	Simple HSR + Rehabilitated	Rehabilitated

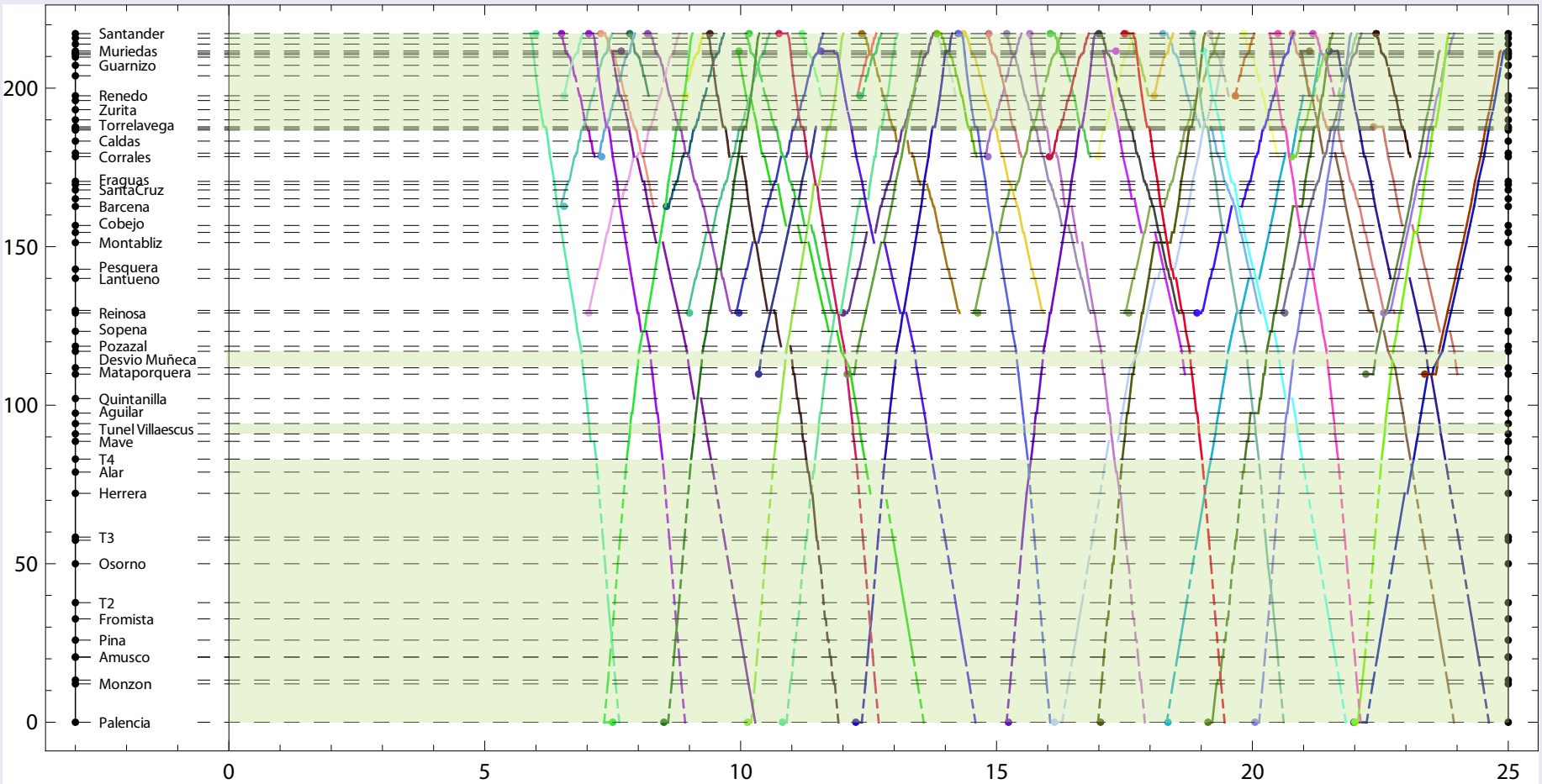
Travel time-Budget Graphic

The figure shows the cost versus reduction in travel time (in hours).



Green segments are double track.

Example of circulation diagram with 8 additional long trip trains: Santander-Palencia

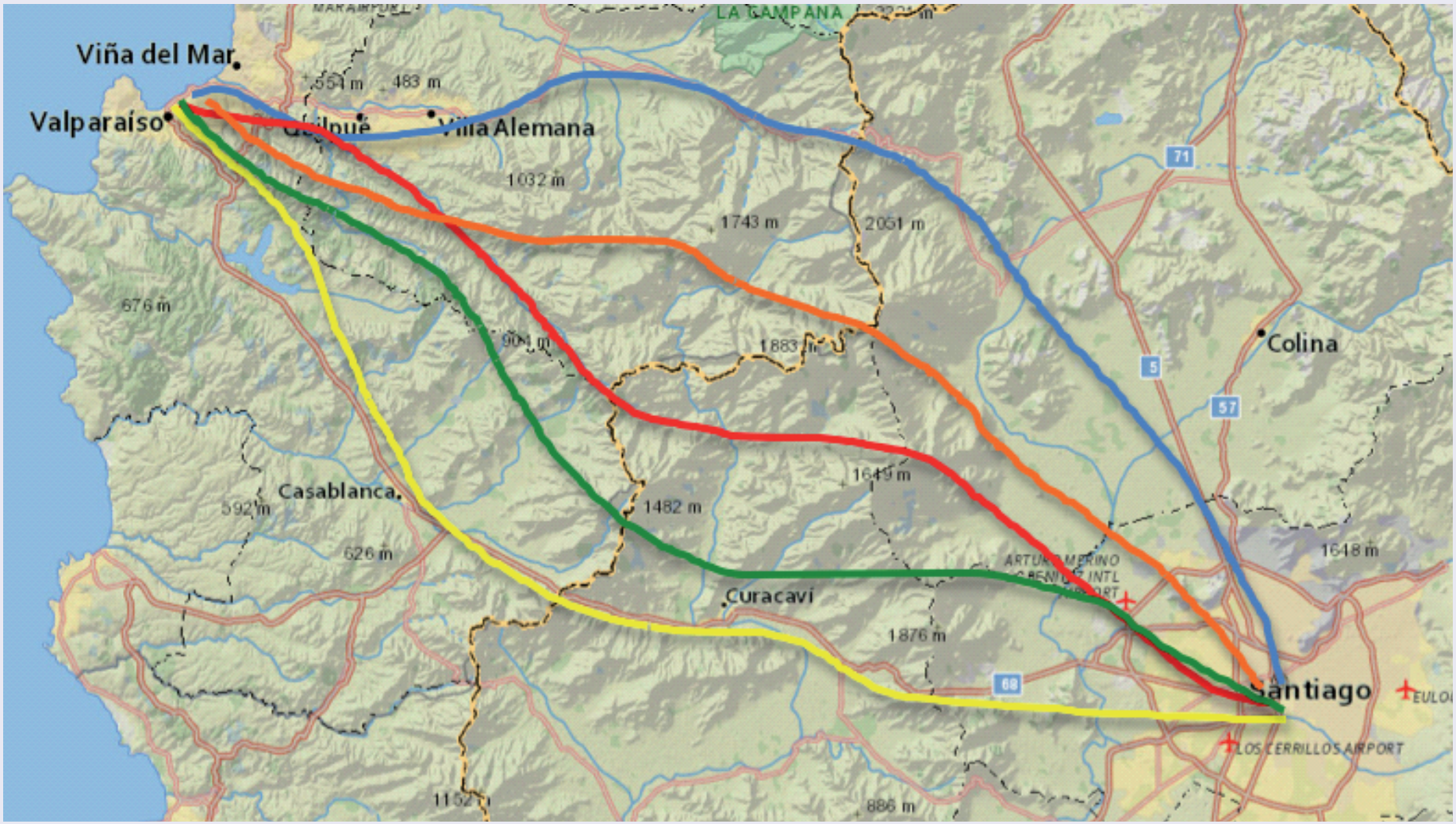


Valparaiso-Santiago line

Next Steps

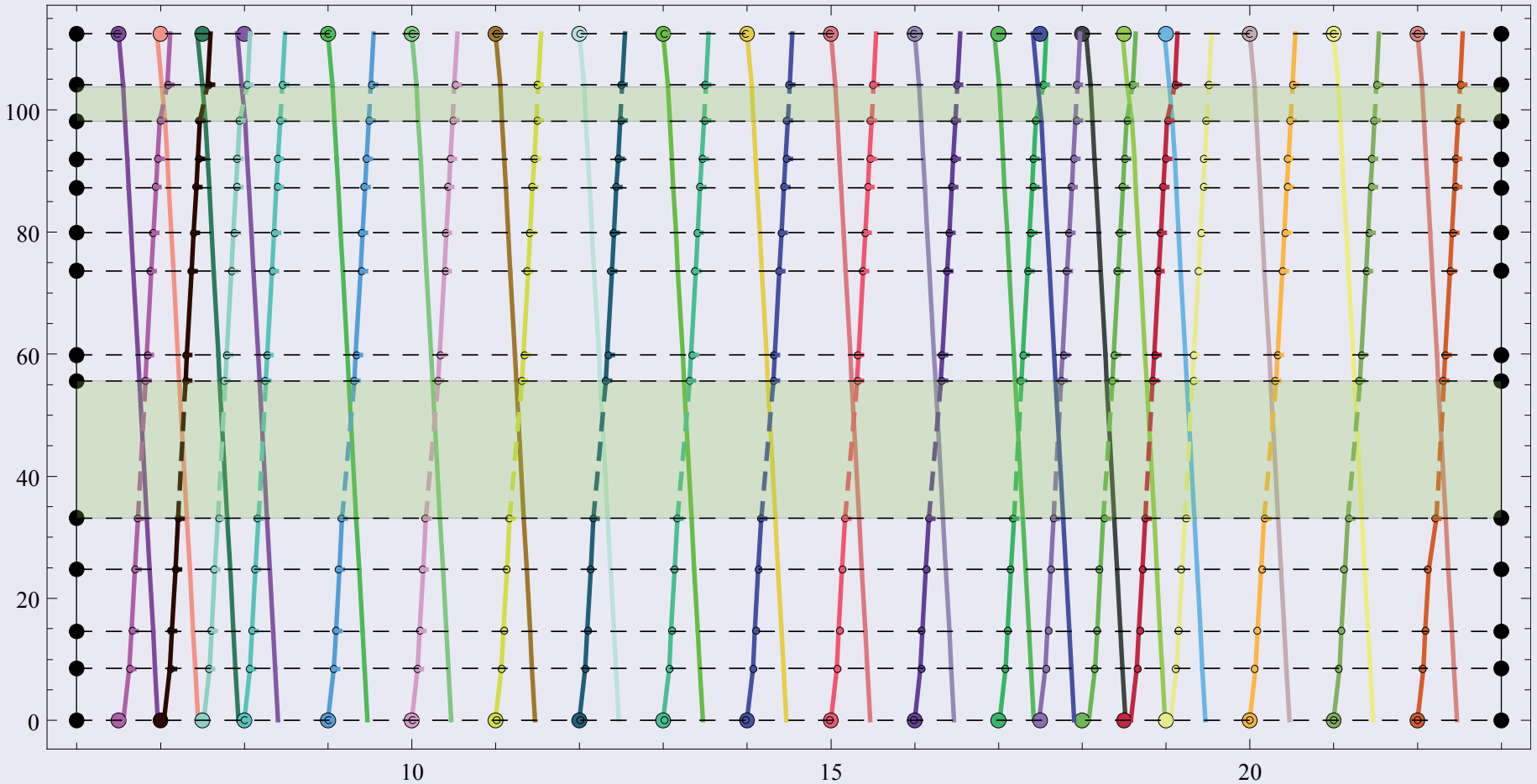
- Santiago: 7.5 Million of habitants.
- Valparaiso Metro Area: 1 Million Habitants
- Highway distance 120 Km.
- Travel times:
  - Bus 2 hours
  - Car 1,5 hours
- 15.000 people travel every day between Valparaiso-Santiago

Five possible railway traces to link Santiago and Valparaiso



Green segments are double track.

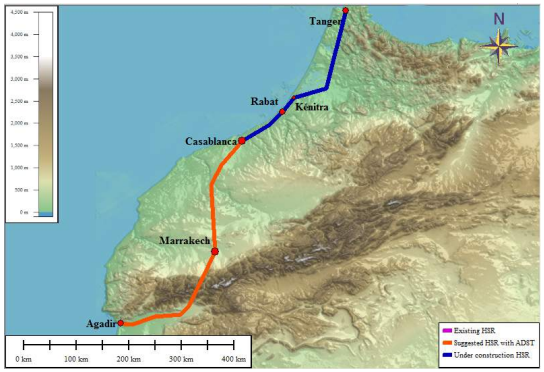
EXAMPLE OF CIRCULATION DIAGRAM WITH 40 SERVICES: VALPARAISO-SANTIAGO

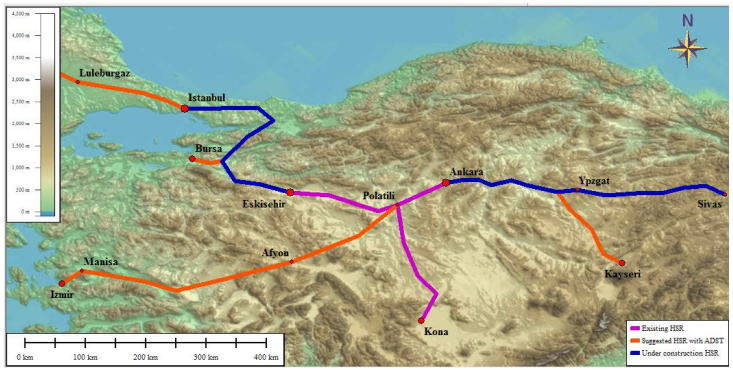


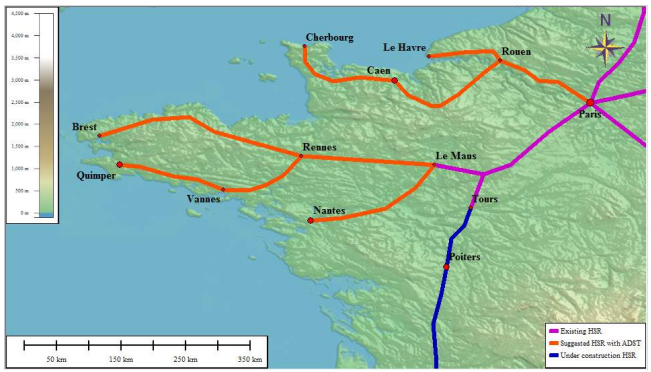
Next Steps

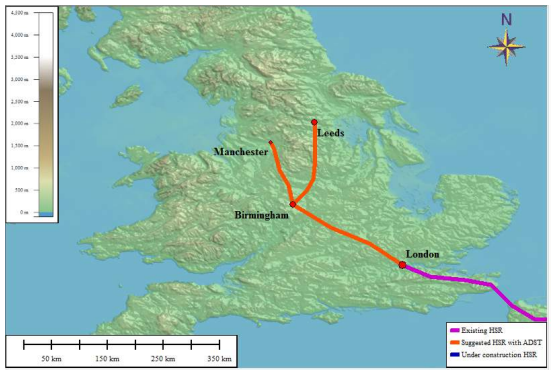
- Analyze different traces and alternatives
- Optimize the alternatives regarding:
  - Cost
  - Travel time
  - Number of services

Some lines where ADST could be applied









MANY THANKS

THANKS