Railway Test Center in Turkey

- A Good Idea?

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Abstract

The purpose with this report is to find out whether it is a good idea or not to build a railway test center in Ankara, Turkey.

The background that leads to our recommendation starts with an analysis of the current conditions in Turkey. The country has committed itself to a huge railway investment program, which means that the domestic railway network will expand with 10 000 kilometers of high speed rail and 4000 kilometers of conventional rail. Turkey has a strategic geographic position for freight transports between Europe and Asia. Railway is seen as a preferred solution for the freight transports, therefore are logistic hubs and strategic connections being built throughout the country. Turkish State Railways (TCDD) has still monopoly of domestic railway transportation, but the legislation might change according to European standards as Turkey wants to become a member of the European Union. A change in legislation would open up the market for external operators. Because of the massive railway expansion program there will be a great need of rolling stock. TCDD has estimated that the future need of rolling stock will be additionally 30 000 units by 2023.

It is possible for Turkish manufacturers to test and certify their vehicles given current conditions. However, if something has to be done at a test center, the nearest one is in Czech Republic about 2300 kilometers away from Turkey. Hence, a future test center in Ankara would mean a more accessible service.

Examples of opportunities and positive effects that we have identified are: Increased railway knowledge, possibility of issuing TSI certificates, cooperation between industry and university and promoted vehicle development. Examples of weaknesses and threats are: long startup time for research and development, political interference and tough competition.

The existing test centers we have studied in Europe and Asia are all different in terms of size, purpose and financing. The suggested Turkish investment from Rayder [1] means a basic test center with 2, 5 kilometers of double track and necessary equipment to perform vehicle tests. The estimated investment cost for the center is 15, 5 million €. This is significantly cheaper than the test centers we have studied, mainly because of the short track length.

Finally, by comparing advantages and disadvantages we recommend to build the test center with the motivation that it is a small investment compared to the possible benefits it would bring. However, before constructing it we have

[1]RAYDER, civil society organization founded to carry out technical and social works for developing the railway sector in Turkey

identified two crucial aspects to make it successful: Cooperation with academia and long term planning with a clear mission and vision.

Keywords: Railway, test center, Turkey, rolling stock, certification, TSI, train.

Sammanfattning

Syftet med den här rapporten är att försöka svara på frågan huruvida det är en bra idé eller inte att bygga ett järnvägstestecenter i Ankara, Turkiet.

Bakgrunden som leder fram till vår rekommendation börjar med en beskrivning av den nuvarande situationen i Turkiet. Regeringen har bestämt sig för att satsa på en gigantisk utbyggnad av järnvägen i landet. Expansionsplanerna innebär 10 000 kilometer ny höghastighetsjärnväg och 4000 kilometer ny konventionell järnväg. Geografiskt har Turkiet har en strategisk position för godstransporter mellan Europa och Asien. Godstranporter på järnväg är en lösning som föredras, därför byggs just nu logistik centraler och strategiskt viktiga järnvägsanslutningar runt om i landet. Turkiets statliga järnvägsbolag (TCDD) har fortfarande monopol på de inhemska järnvägstransporterna, men lagstiftningen kan komma att ändras. Turkiet vill bli medlem i EU och en ändring i lagstiftningen skulle därför öppna upp järnvägsmarknaden för externa operatörer. På grund av de gigantiska expansionsplanerna kommer det uppstå ett stort behov av järnvägsfordon inom en snar framtid. TCDD har uppskattat att det kommer behövas ytterligare 30 000 enheter till 2023.

Med dagens förutsättningar är det möjligt för turkiska fordonstillverkare att både testa och certifiera sina fordon. Om något däremot skulle behöva utföras på ett testcenter så ligger det närmsta i Tjeckien, ungefär 230 mil från Turkiet. Ett framtida testcenter i Turkiet hade alltså inneburit bättre tillgänglighet.

Vi har även identifierat en del möjligheter och positiva effekter som till exempel: ökad järnvägskunskap, möjlighet att utfärda TSI certifikat, samarbete mellan näringsliv och universitet och förbättrad möjlighet att utveckla fordon. Ett par exempel på hot och negativa effekter är: lång uppstartstid för FoU, politisk inblandning och hård konkurrens.

De etablerade testcenter vi har studerat är alla olika gällande storlek, syfte och finansieringslösningar. RAYDER har tagit fram ett förslag på ett turkiskt testcenter som innebär en 2,5 kilometer lång testbana och nödvändig utrustning som behövs för att utföra fordonstester. Investeringskostnaden är beräknad till 15,5 miljoner €. I jämförelse med de etablerade testcenter är det en betydligt lägre kostnad, framför allt beroende på den korta testbanan.

Vår slutsats blir att vi rekommenderar att bygga ett testcenter i Turkiet. Motivet är att det är en liten investering i förhållande till nyttorna och möjligheterna. Dock vill vi understryka två saker som bör beaktas innan man

startar byggnation: centret bör drivas i samarbete med näringsliv och universitet samt planera långsiktigt med tydliga mål och ett uttänkt syfte.

Nyckelord: järnväg, test center, Turkiet, certifiering, TSI, tåg.

Foreword

During the work with this report we have got help from different sources. The ones we especially want to thank for making it possible is:

- Railistics GmbH – For providing us with information, input and office facilities.
- Peter Linde, Kockums Industrier – For helping us to understand the rolling stock manufacturer's perspective and how the TSI certification works.
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List of contents

1 Introduction 1
1.1 Purpose 1
1.2 Methodology 1
1.3 Scope 1
2 Brief Facts - Turkey 2
3 Present situation 3
3.1 The railway network and TCDD 3
3.2 Future ambitions for Turkish Railways 5
3.3 Urban rail expansion plans in Turkey 5
3.4 High speed network 6
3.5 Status of rolling stock 7
3.6 Turkeys strategic position 7
Market overview 9
3.7 Actors of the Rolling Stock Market 9
3.8 Rolling stock market analysis 10
3.9 National Train Manufactures 11
4 TSI 13
5 Railway test center 14
6 Financing examples 17
7 Size of Investment 19
8 Analysis 20
8.1 Location 20
8.2 Purpose 21
8.3 Option 1. Present Situation 21
8.4 Option 2. Future test center in Turkey 22
9 Discussion 26
10 References 28

1 Introduction

Hacettepe University in Ankara has expressed an interest in building a railway test center connected to their technological research park. Currently there is no test center in Turkey, which means that a future facility will be the first ever in Turkey. In fact railway test centers are rare, even in a global perspective. In Europe there are only three established centers. To get a better understanding of the consequences in investing a railway test center, Hacettepe University asked for a feasibility study/business plan.

1.1 Purpose

The purpose with this report is to provide decision support for the question: is it a good idea to build a railway test center in Turkey?

1.2 Methodology

This report is produced by studying literature, performing interviews and study visits. Most of our work was done at Railistics (railway transport consulting and engineering firm) office in Wiesbaden, Germany.

The literature study includes information handed over by Railistics, internet sources and articles from railway magazines. Since Railistics are involved in many Turkey based projects we got the bulk of information from their database, and help from our supervisor in Ankara. The interviews have been made via telephone or e-mail conversations. The study visits were at Kockums Industrier in Malmö, Det Norske Veritas in Copenhagen and Interfleet Technology in Stockholm. We attempted to visit one of the European test centers located in Germany, France and Czech Republic but unfortunately for various reasons we were not granted access.

1.3 Scope

We have chosen to study the current situation, regarding railway investments, future goals, status of Turkish vehicle fleet etc. The primary focus in this report lies on the effects and benefits, not costs, because the cost information that was available was not specific enough.

2 Brief Facts - Turkey

Given its location Turkey is known as the bridge between Europe and Asia. Currently the national economy is booming and according to OECD[2] is Turkey expected to be the second fastest growing country in the world by 2018. The Istanbul economy is larger than 12 of the EU countries' economies. Turkey also has the youngest and fastest growing educated population in Europe, with about 450 000 graduates per year.

Figure 1, map Turkey, photo CC KarlMarx

Turkey is the seventh most visited country in the world today and aims to be in the top five by 2023. Even if it is not the capital, Istanbul is the major city with almost 20 percent of Turkey's population living there. Istanbul is the third most visited city in Europe, after Paris and London (UK, Trade & Investment, 2011).

Table 1, brief facts – Turkey, (UK, Trade & Investment, 2011)

Category	Comment
Official name of country	Republic of Turkey
Capital city	Ankara
Goverment	Parliamentary democracy
Population	74 million (2010)
Official language	Turkish
Neighbouring countries	Bulgaria, Greece, Syria, Iraq, Iran, Azerbaijan, Armenia, Georgia
Existing rail border crossings	Bulgaria, Greece, Iraq, Iran, Syria
Major cities (Population)	Istanbul(13,3 million), Ankara (4,8 million), Izmir (3,9 million)
GDP	USD 618 $ billion (2009)

[2] OECD, Organization for Economic co-operation and development

3 Present situation

The Turkish transport minister Binali Yildirim says in an article in Railway Gazette:

"It is our priority to connect the economics of Europe and Asia by fulfilling not only our potential as a gateway, but also by working with our neighbours", describing Turkey as a "bridge yet to be completed".

Turkey is currently going through a rapid modernization on many levels. The national economy has continually grown stronger the last years, and today it is the 15th largest in the world (World Bank, 2012). The annual growth rate of Turkey's GDP PPP [3] between the period 2011- 2018 is expected to be 6.7 %, fastest of all the OECD countries (UK Trade & Invest report 2011). The development of railways has been given the status as the most significant government policy by the Turkish government according to RAYDER.

In today's Turkey, 95 % of the passenger and 90 % of the freight transports on land carried on the roads (ISPAT, 2012 a).

The railway transportation in Turkey is currently a monopoly, according to The Railway Insider, new laws is on the way that will allow private companies to transport freight and passengers by rail.

3.1 The railway network and TCDD

Turkey's national railway network is a monopoly market, managed and operated by Turkish state railways, TCDD.

Current status of the domestic network:

- Total length -12000 km (95 % is single line operated)
- Electrified - 2300 km
- Signalized - 2700 km
- High speed lines in operation - 420 km

[3] GDP PPP, Gross domestic product at power purchasing parity per capita

TCDD is a huge organization with different branches and subsidiaries:

Employees – 30 000
Subsidiaries – Tülomsas, Tüvasas and Tüdemsas
Shareholdings – Eurotem and Egeray
Factories – Five factories who manufactures for example rail, sleepers, and switches.

TCDD also owns and operates four large ports in Turkey: Izmir, Iskenderun, Derince and Haydarpas (TCDD, 2012).

The market share for TCDD's transports has changed a lot over the years. The freight transports has declined from 65% in the 1950s to about 5 % in the recent years. The passenger transportation has dropped from 40 % in the 1950s to about 2 % today (TCDD Business plan, 2011-2015)The reasons for this decrease are several, for example are TCDD products and services not meeting the market demand. Old unreliable rolling stock generates lots of cancellations, political interference and a highway oriented transport policy creates further obstacles (Geitz, 2012)

TCDD is the largest loss-making state enterprise in Turkey; the losses each year are significant as can be seen in the figure below.

Table 2, TCDD's annual economical statistic 2005-2009

TCCD Finances (million €)	2005	2006	2007	2008	2009
Revenue	460	484	470	453	397
Expenditures	1035	1035	1142	1185	1102
Profit/loss	- 575	-551	-672	-732	-704

A couple of reasons for the losses are: privatization of TCDDs ports (which are profitable), too much and inefficient staff, global financial crisis and competition from air transportation (World Bank, 2012)

Currently TCDD is going through a major restructuring process. The project is financed by the World Bank and the main purpose is to improve TCDD to a profitable railway organization (World Bank, 2011)

The effect of reforming TCDD and drafting two new railway laws will be that Turkey adopts the EU railway directives. If the new laws are accepted it will mean the end of the monopoly of TCDD for passenger and freight transports. This is a positive approach since Turkey is aiming to be a member of the European Union (Railway Gazette, 2012).

3.2 Future ambitions for Turkish Railways

Until 2035 Turkey has committed to invest $45 Billion USD in a large railway network expansion program, where $ 23,5 Billion USD will be invested before 2023 which is a future important milestone in Turkish history. It is the year of the 100th anniversary of Turkey as a Republic. Because of this, Turkey is keen to finish many projects by 2023 (UK Trade & Invest 2011).

The Turkish Investment Support and Promotion Agency (ISPAT, 2012 b), presents a number of railway related visions that Turkey strives to complete until 2023:

- 10,000 km high speed rail, 4,000 km additional railway (equal of one third lap around the globe)
- 8,000 km rail with electricity and signaling
- 500 km rail will be renovated annually
- Deregulation of railways concerning passenger and freight operations
- Support railway projects to connect Turkey with Caucasus, the Middle East and North Africa
- Connection of main ports with railways
- Renovation of logistical terminals, train stations and construction of new terminals for high-speed trains
- The goal of increasing rail freight share of the domestic freight market to 15 % has been set to be achieved in 2023

3.3 Urban rail expansion plans in Turkey

Most of the urban rail transportation in Turkey are owned and managed by regional metropolitan municipalities. Many of the major cities already have different kinds of rail systems in operation (heavy rail, light rail, tramway and metro), however the traffic congestion on the roads is steadily increasing in the large cities and there is a need for investments to expand the rail-commuter systems.

The rail-expansion plans for the three largest cities are:

Istanbul – Projects to be finished in 2012, 144 km new tracks of which 89 km are the Marmaray tunnel project. Further on 395 km to be completed in 2023.
Ankara – Has an urban transportation plan for 2015 which means three new metro lines and an extension of the Ankaray light rail line. The completion of this project will add about 42 km to the metro system and 12 km to the Ankaray line (UK Trade & Invest report 2011).

Izmir – The metropolitan municipality of Izmir have a transportation plan where 28 km of new metro and suburban rail lines are under construction (Izmir metro, 2012).

The expansion plans in urban railways like the ones mentioned above will of course create a large demand of new rolling stock. Only in Istanbul there will be a need for over 2 900 new coaches until 2023 (UK Trade & Invest report 2011).

3.4 High speed network

At present, Turkey has two high speed lines in operation: Ankara – Eskisehir and Ankara – Konya. The lines are doubled tracked with a length of 42 0km. The expansion plans regarding high speed rail are as mentioned before, massive. Turkeys goal is to have a high speed network of 10 000 km completed by 2023, which will cover almost the entire country. One of the most important phases, the Ankara – Istanbul connection is currently under construction. When completed, the travel time between the cities will decrease from seven hours to three hours (TCDD Investment, 2010).

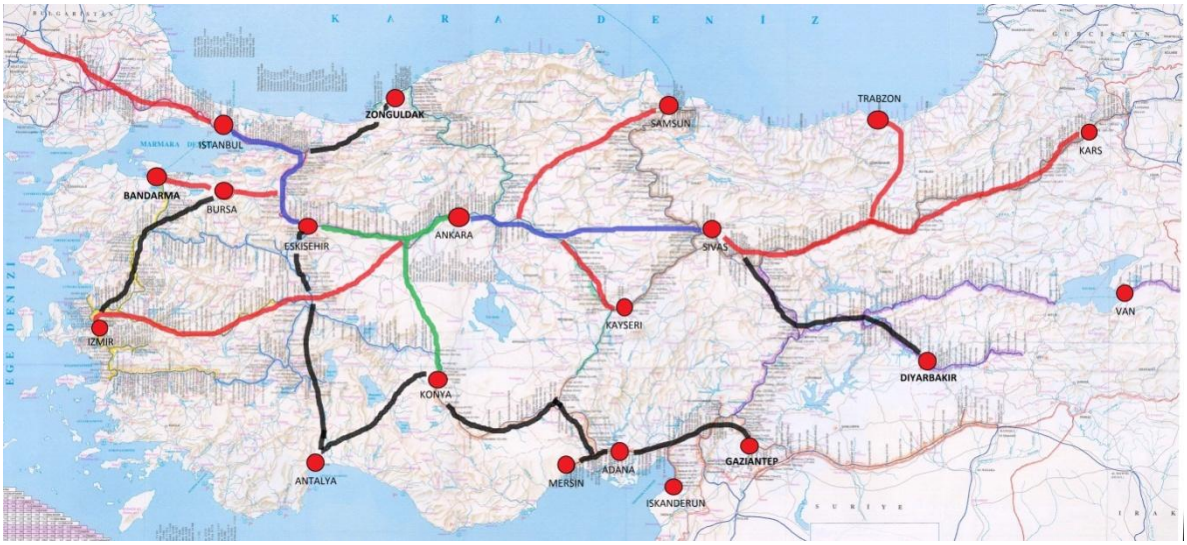

Figure 2, Overview of Turkeys high speed network, Green = under operation, Blue = under construction, Red = left to be built, Black = expressed to be build, TCDD

Since TCDD does not have any high speed trains of their own, the first 12 sets were bought from the Spanish manufacturer CAF, but these 12 sets will not be able to meet the future need for a long time. According to calculations by Railistics GmbH there will be an additional need of 83 sets by 2016.

3.5 Status of rolling stock

The current vehicle fleet of TCDD consists of about 17 000 freight wagons, 1 000 passenger coaches and 600 locomotives, a total of 18 600 vehicles. With 62 % of the rolling stock more than 20 years old, it is an old fleet, especially the locomotives as shown in figure below.

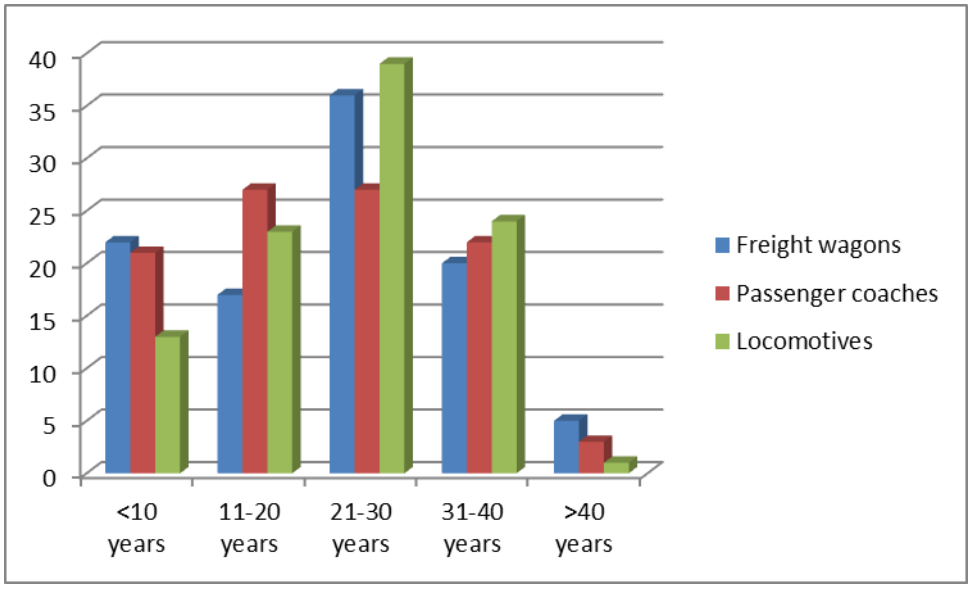

Figure 3, Rolling stock divided into age-groups, Y-axis is in percent. (World Bank, 2011)

Even if the main part of TCDD's vehicle fleet is more than 20 years old, the productivity is good. The table below shows TCDDs productivity compared to EU described in percent.

Table 3, TCDD's rolling stock productivity 2009, (World Bank, 2011)

Year	Freight wagon EU average=100	Passenger coach EU average=100	Locomotive EU average=100
Productivity 2009	89	100	109

The high aged freight wagon fleet requires a lot of maintenance. According to TCDD business plan 2011-2015 will 11% of the total freight expenditures be spent on repairing and maintaining the wagon fleet. As mentioned before Turkey has committed to a huge investment program, and will need to extend the current vehicle fleet significantly. TCDD has estimated that their future need of rolling stock will be a total of 51 100 units by 2023, of which 49 000 are freight wagons (TCDD, 2012).

3.6 Turkeys strategic position

Turkey's strategic geographic position makes it attractive for railway freight transportation. It has been estimated that there is a potential freight flow with a value of 75 Billion $ USD per year between Europe and Asia. Turkey is keen to make some profit out of this freight flow and is currently working on many

different levels to turn the country into a big logistic center. Railway corridors are created in all directions and freight hubs are built throughout the country. One of the most important projects is the Marmaray connection in Istanbul, which links the Asian and European side of Istanbul together with a tunnel under the Bosporus. (UK Trade & Invest report 2011).

Furthermore, many of the bordering countries are developing countries which are in great need of low cost transport solutions.

Figure 4, Strategic connections, TCDD Investment presentation 18/1-2010

Market overview

The rolling stock market can be divided into two different market segments:

1. Passenger trains

Figure 5, photo CC KarlMarx

2. Freight trains

Figure 6, photo CC LocoSteve

These two market segments consist of different sub segments:

- Tram, metro and light rail amongst many other sub segments offers different qualities to fulfill the needs of passenger transportation.
- Different types of freight wagons like tank wagons and container wagons are created to transport a specific type of goods in the most effective and safe way.

3.7 Actors of the Rolling Stock Market

The passenger train manufactures are actors of a global market. Many of the major and most successful passenger train manufacturers have their home base in Europe and Asia:

- Alstom (France)
- Ansaldo - Breda (Italy)
- Bombardier (Canada)
- CAF & Talgo (Spain)
- Siemens (Germany)

Examples of large Asian manufacturers are CSR (China South Locomotive Group), CNR (China North Locomotive and Rolling Stock Corporation Limited) and Hyundai Rotem from South Korea.

The freight wagon market is somewhat special, because it is tightly connected to the domestic market and often dominated by domestic manufacturers. Global freight wagon manufacturers barely exist.

The freight locomotive market however consists of both global- and domestic companies like:

- Stadler (Switzerland)
- Bombardier (Canada)
- Electro-Motive Diesel (USA)

3.8 Rolling stock market analysis

In a report (Berger, 2012) written 2008 for UNIFE, the annual expected growth rate for accessible markets[4] during the period 2007-2016 in rolling stock was 2-2.5 %. High growth rate is expected for high speed trains, intercity multiple units and light rail vehicles, whereas a slight decline for passenger coaches could be expected.

One third of the rolling stock market volume belongs to Western Europe.

Table 4, accessible rolling stock market volume 2005-2007, (Berger, 2012)

Region	Rolling stock order (million €)	Market share (%)
Western Europe	10 718	34,1
Asia/Pacific	8335	26,5
NAFTA [5]	5260	16,7
CIS [6]	2500	8
Africa/Middle East	2090	6,6
Eastern Europe	1615	5,6
Rest of America	780	2,5
Total	**31 305**	

According to the same report the overall trends are pointing upwards. Factors that are driving the trend in an upwards direction is:

- urbanization
- ecological awareness and energy consumption
- leasing and financing
- ERTMS
- deregulation and liberalization

At the same time, shortage of engineering capacity could cause obstacles for the future growth.

[4] Accessible market, a market is considered accessible if it is open to any external supplier and is not served exclusively by domestic railways
[5] NAFTA, north American free trade agreement, USA, Mexico and Canada
[6] CIS, Commonwealth of Independent states, former soviet republics

3.9 National Train Manufactures

There are several rolling stock manufacturing companies in Turkey, the dominating ones are: Tülomsas, Tüdemsas and Tüvasas, all of them are fully owned subsidiaries of TCDD.

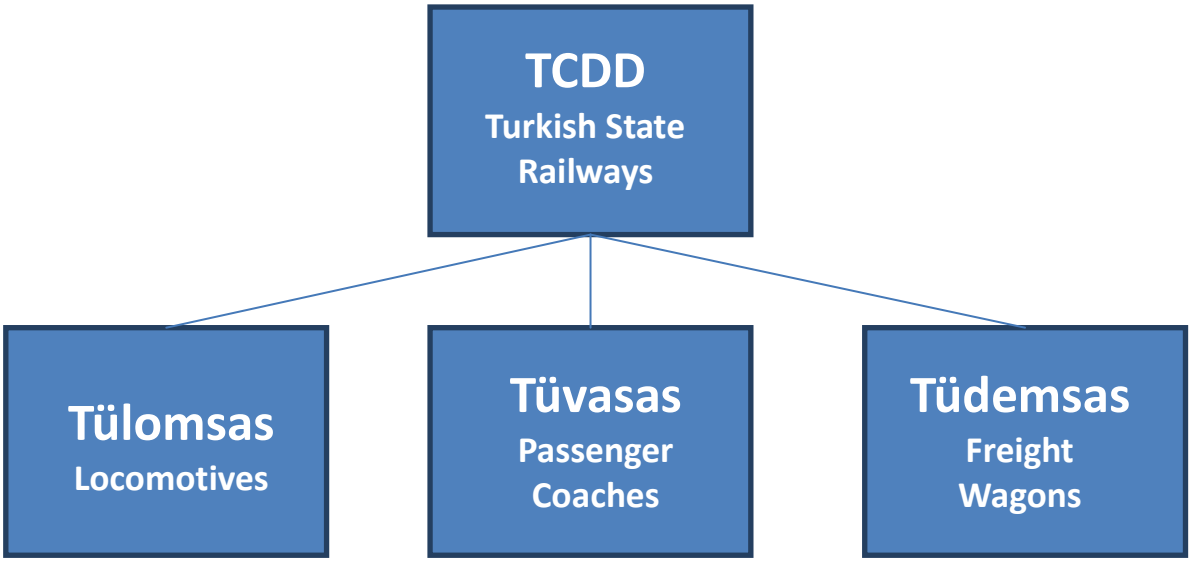

Figure 7, TCCD's subsidiaries

Tülomsas – Is the only locomotive manufacturer in Turkey. The company was founded 1894 as a small repair workshop. Today the company has seven production plants and about 2 000 employees who supply a wide range of products such as locomotives, bogie freight cars, diesel engines, alternators, traction motors and railway maintenance vehicles.

Tülomsas are able to produce 60 locomotives and 500 bogie freight cars per year. However, even though the company has a long history of maintenance and production, most of the locomotives and technology are made under license agreements with joint venture production.

Tülomsas supplies both the domestic and foreign market. Examples of export to international markets are Syria, Turkmenistan, France, Switzerland and Iran.

The company's future goals are to meet the needs of the expanding national market and continue to increase the international export capacity (Tülomsas, 2012).

Tüvasas – produces, rebuilds and modernize old passenger coaches. The company was founded as a passenger coach repair workshop in 1951 and remained so until 1962 when they began to produce passenger coaches. Currently Tüvasas has about 650 employees, and is able to produce 65

passenger coaches per year. The repair and maintenance section is still a big part of the company. Tüvasas has capacity for 500 rebuilds/repairs per year. Tüvasas main market is domestic but recently, export deals have been made with Iraq and Bulgaria (Tüvasas, 2012).

Tüdemsas – is the railway freight wagon manufacturer in Turkey. Tüdemsas started in the same tracks as Tülomsas and Tüvasas, starting as a repair workshop for steam locomotives and freight wagons. They started to produce their own freight wagons in 1953. With approximately 1 500 employees and good facilities Tüdemsas is able to produce 1 500 various types of freight wagons per year. The repair capacity is 7 600 units annually. Tüdemsas ambition is to become the leading freight wagon manufacturer in the region and a competitive player on the global market, by producing high quality wagons according to international standards (Tüdemsas, 2012).

Rayvag – is a private company who produces freight wagons, bogies and spare parts (Rayvag, 2012)

Railtur - is a private company who produces freight wagons, bogies and spare parts (Railtur, 2012)

Eurotem – is since 2006 a joint enterprise consisting of Hyundai Rotem and Tüvasas. The company produces electric multiple units, light rail vehicles and high speed trains by assistance and technology transfer from the experienced Hyundai Rotem company. Eurotems ambition is to contribute to Turkey's railway industry and economic growth (Eurotem, 2012).

4 TSI

The European Railway Agency (ERA) defines TSI as: “Technical specifications for interoperability means the specifications by which each subsystem or part of subsystem is covered in order to meet the essential requirements and to ensure the interoperability of the trans-European high speed and conventional rail systems” (ERA, 2012).

In common words you can describe the TSI as a “Construction and design standard for railways to meet interoperability requirements”.

What is interesting in our case is the TSI concerning rolling stock. According to ERA, all newly built vehicles that fall within the geographical scope of the existing TSIs (TSI high speed and conventional rail system) shall be in conformity with them. Important to notice is that you only need to TSI-certificate the type model from a series.

There are two common methods to get railway vehicles TSI approved:

1. At an accredited test center like VUZ Velim, Czech Republic or Siemens Wegberg-Wildenrath, Germany.
2. With a mobile notified body: The manufacturer works in close contact with a notified body throughout the whole development process, blueprint-stage, construction-stage and prototype-stage. Later on when the unit is ready for functional tests a time is scheduled with an ISO-accredited consulting firm who examines the vehicle according to TSI standards. The tests are performed on live track on a place agreed between the involved parties. If everything turns out positive the documents are sent to the Ministry of Transport for final approval Linde, 2012).

The implementation of TSI is an important EU project. Another quote from ERA says “The construction of a safe, modern integrated railway network is one of the EU’s major priorities. Railways must become more competitive and offer high-quality, end-to-end services without being restricted by national borders” (ERA, 2012).

5 Railway test center

What is a railway test center? The definition in this report is a facility with a dedicated test track where it is possible to perform both static tests and running tests on rolling stock. An overview of a basic test center could look like this:

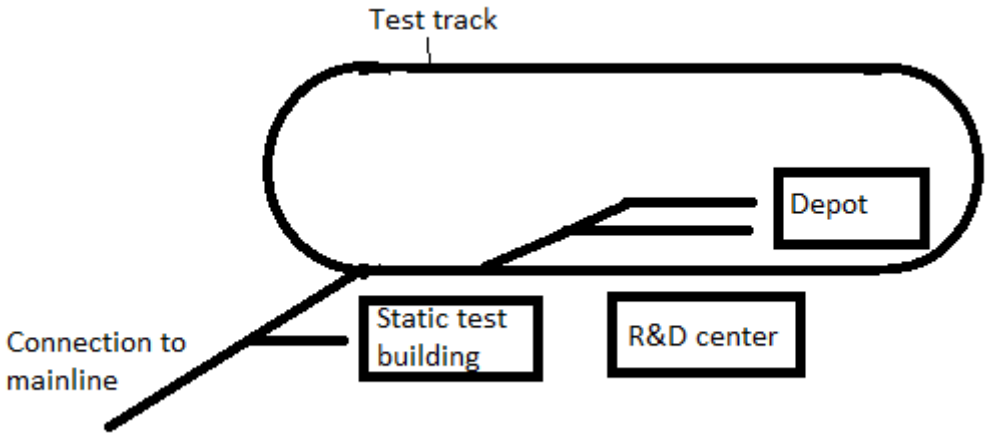

Figure 8, basic test center

Figure 8 shows the basic components of a test center. The existing centers in Europe have for example different track length, curve radius and electric supplies as will be shown in the effect-evaluation chapter. Otherwise are the major differences organizational structure and purpose. Some of the leading centers are very research oriented with close connections to universities and research institutes. The comparison below shows different types of successful test centers and their mission.

Table 5, type and mission of test centers

Test Center	Type	Mission
Centre de d'Essais Ferroviaire (France)	Joint-stock venture	Contribute to the preparation and development of rolling stock certification
Korea Railroad Research Institute (South Korea)	Institute	Shape the nations railway transport systems
Railway Technical Research Institute (Japan)	Institute	Creation of new technologies aimed at sustainable development of railways
Siemens Wegberg-Wildenrath (Germany)	Private	Deliver railway vehicles which are well tested and certified
VUZ Velim (Czech Republic)	Joint-stock venture	Provide special services in the design of railway vehicles
Adif (Spain)	Institute/Administrator of railway infrastructures	Promoting the Spanish railway system

Which type of test center that is the most suitable depends highly of the purpose and conditions. Yet, one thing they all have in common is the cooperation with academic institutions.

Cooperation between Industry and University

A report named "How a German Technical University interacts with the Railway Industry" (Fengler, 2012) presents a model of how collaboration between an academic institution and private industry could look like.

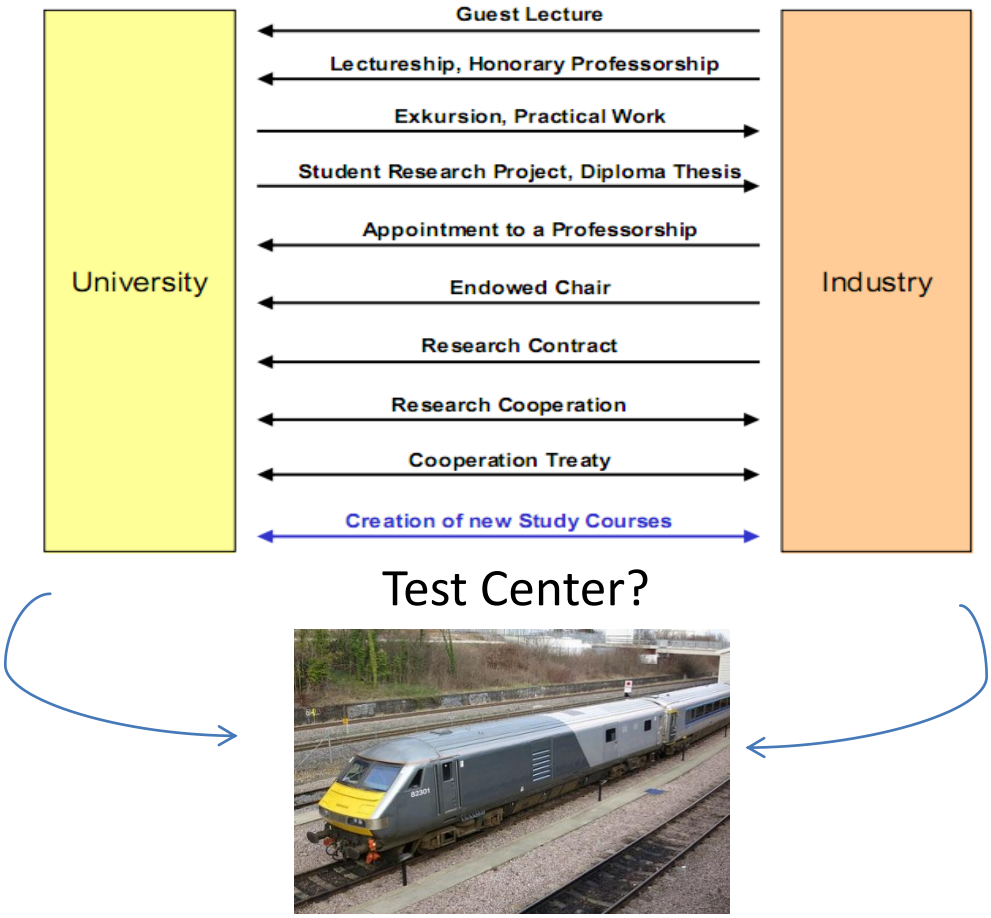

Figure 9, Cooperation overview, (Fengler 2012). Photo CC Mick Baker

Guest lecture – people from the industry can provide "real-life" information and give the students an inside view of the industry of interest.

Excursions, Practical Work – students from the university can visit the industry to get a deeper understanding and also spark a deeper interest and commitment to the industry.

Student Research Project, Diploma Thesis - the industry can provide research subjects for students to create a win-win situation.

Research Contract – subjects of interested can be thoroughly investigated by universities.

Creation of new study courses – that matches the interests of the industry.

In our opinion, the obvious implementation of this model could be in form of a **Test Center** a shared platform where industry and university can strengthen their ties through research contract, practical work etc.

6 Financing examples

France
The investment and capitalist partners of the French test center in Nord Pas de Calais are: Alstom, Bombardier, Certifier (Railway Certification Agency) and GRRT(Coordination and impulsion of research) (CEF Finance, 2012).

Germany
Siemens Wegberg-Wildenrath Test Center was paid entirely by private means. The purpose with Siemens investment was to make it easier to deliver well tested and certified trains to customers (Kruber, 2012).

Czech Republic
The test center was founded as a government controlled research and testing institute in 1950 belonging to Czech Railways. The test ring, today known as VUZ Velim was build 1963 and became a daughter company of Czech Railways in 2005 (VUZ). The present structure of the company is joint-stock enterprise, which is financed by profit from VUZ activities, grants from EU and investment loans (Hajkovat, 2012).

Japan
The Railway Technical Research Institute Japan is financed by Japan Rail companies, contract based projects, government subsidies and miscellaneous. Japan Rail companies contributed with 75% (125 million €) of the total expenditure of 161,9 million € (RTRI Annual Report, 2010)

Spain
Adif is the state owned railway administrator in Spain (Adif, 2012a). R&D is a priority for Adif and big investment plans are currently discussed to extend their modern test center in Malaga with a high speed test loop. The loop will be designed for speeds up to 520 km/h, with the investment cost of € 400 million. The project is promoted by the Spanish government and will attract investments from European technical funds and private means. When and if, it is completed it will be the biggest test center in the world (Adif, 2012b).

As shown above, most of the centers are financed by joint investors. The only exception is (Siemens test center) in Germany which was fully financed by Siemens.

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Turkey
To finance a future test center Turkey has several different possible sources of funding bodies:

- RAYDER (governmental authority)
- Tübitak - Aiming to fasten the process of conversion of technology to profit. Technology and Innovation Funding Programs Directorate (TEYDEB) was established by Tübitak to fund the technology development and innovation activities of the companies in Turkey(Tübitak)
- Regional municipalities
- Academic institutions
- World Bank
- Islamic Development Bank – funding of 80 electrical mainline locomotives according to an article in European Railway Review
- European Investment Bank – funding of 12 diesel train sets (DMU) according to an article in European Railway Review
- National Private sector – Such as Railtur and Rayvag
- TCCD – Tülomas, Tüvasas, Tüdemsas

In an innovation survey during 2008-2010 from Turkish Statistical Institute 28, 2 % of enterprises with technological innovation activities received public funds during the period 2008-2010. The most common funding institution was government agencies or ministries with 26, 3 % while 0, 9 % of enterprises with technological innovation activities received fund from European Union (Turkstat, 2012)

7 Size of Investment

Would the establishment of a test center be a high cost investment? It depends on how you compare the costs of the investment.
According to Tübitak (The Scientific and Technological Research Council of Turkey), infrastructure is an essential element for R&D activities. A railway test center is definitely an investment in railway R&D.

Turkey's gross domestic expenditure on R&D has shown an impressive growth rate the last decade. With an increase from 2 billion (1998) to 9 billion (2009) USD in PPP, Turkey has the fastest growth rate among the OECD countries.

The investment cost for the test center (rounded to € 15 million) is compared below to domestic investments in R&D and infrastructure:

- Turkeys Gross domestic expenditure on R&D 2009 - 6,8 billion PPP € (Tübitak STI report 2010). Test center equals 0,2% of this.
- Turkeys technological research investment budget – 300 million PPP € (Tübitak STI report 2010). Test center equals 5% of this.
- Railway investment allocations in Turkey 2011 – 1,4 billion € (European Railway Review, 2012). Test center equals 1% of this.
- TCDDs annual revenue – about 300 million €. Test center equals 5% of this (World Bank, 2012).

8 Analysis

8.1 Location

The initial interest of building a railway test center in Ankara was expressed by Hacettepe University. The university wants the test center to be part of their technological research park. Two positive aspects of placing the test center in Ankara are:

1. Ankara's geographical position in Turkey – The city is accessible and could be called "the heart" of the railway network.
2. The regional climate reflects the national conditions.

Trains which operate nationwide must be able to manage the harsh and varied weather conditions. Turkey has a very varied climate with both hot, dry summers and cold, snowy winters. The coastal regions by the Mediterranean and Black sea, has both hot summers and cool, rainy winters with an average temperature of 9° C in the winter and 29°C in the summer. The inland – and eastern Anatolian climate is different, with long and very cold winters where the temperature can drop to almost - 40° C and the snow can lie on the ground for 120 days per year (Turkish state meteorological service).Whit this in consideration, Ankara makes a good location to place a test center because of the local climate which can vary from -20° C in the winter to 40° C in the summer (Turkish state meteorological service, 2012).

8.2 Purpose

The purpose with this effect analysis is to compare the costs and effects of the two following options:

1. Continue with current methods (no test center).
2. Build a test center.

8.3 Option 1. Present Situation

In today's current situation Turkey has no test center.

Table 6, the TSI- certification costs are highly dependable on which type of rolling stock and the amount of tests needed (Linde, 2012)

TSI certification (freight wagon)	Costs (€, Euro)
At test center	270 000 – 400 000
With mobile Nobo	300 000 – 400 000
Standard Vehicle Test (freight wagon)	Costs (€, Euro)
Track forces	200 000
Brake	30 000
Noise	20 000
Torsional rigidity	15 000
Static	50 000
Dynamic	50 000
TOTAL	**365 000**

The cost for TSI certification at a test center above, regards a freight wagon sent to Velim from Turkey according to Halis Turgut at Railtur, Turkey.
In this context "mobile Nobo" means a notified body that comes to the customer (ex. Interfleet) instead of the customer coming to the notified body.
The standard vehicle tests are rough price examples from Interfleet on how much they would charge to perform tests for a freight wagon model in Turkey.

8.4 Option 2. Future test center in Turkey

Investment cost example

The investment costs are highly dependable of the size and technical components of a test center. Below is a comparison to illustrate the differences between a small test center (CEF Test center) and a bigger one (Siemens Test center) together with different levels for a railway test center in Turkey given by RAYDER. The estimated total cost for a Turkish railway test center does not include the cost of the land needed to build a test center.

Table 7, investment costs from Siemens 1997 and CEF 2000 are calculated to today's value by using the average inflation rate of 2,24 % in the Euro area from 1991 – 2010 (Euro Area Inflation Rate)

Test Center	Area (1000 m2)	Track length (km)	Electric Power supply	Accredited	Service, tests	Gauge (mm)	Max Speed (km/h)	Total Investment (million €)
Siemens	350	28	15kV/16,7Hz 25 kV/50 Hz 12 kV/25 Hz 25 kV/60 Hz 400-4000 V DC	ISO 17020 ISO 17025	Rolling stock systems (vehicle and infrastructure components)	1435, 1000	160	143,2
CEF	?	7	25 kV/50 Hz 25kV/60 Hz 15 kV/60 Hz 15kV/16,7 Hz 750 V DC 1500 V DC 3000 V DC	?	Rolling stock systems (vehicle components)	1435	110	32,7
Turkey (level 1)	202,35	2,5	25kV/ 50 Hz	?	Wagon and locomotive tests	1435	120	13,3
Turkey (level 2)	202,35	?	25kV/ 50 Hz 750 V DC 1500 V DC 3000 V DC	?	DMU and EMU tests	1435, 1000	160	13,3 + ?
Turkey (level 3)	202,35	?	?	?	High speed train	1435	?	13,3 + 2:nd + ?

The major difference in investment costs between CEF and Siemens, about 110 million € (≈ 77 %) mainly depends on the track length which is four times longer in the Siemens facility and the extra gauge to be able to test trams. In addition, Siemens test track also allows larger curve radius and therefore higher maximum speed.

Running costs
The following running costs are from Korean railroad research institute (KRRI budget) and Railway technical research institute Japan (RTRI annual report, 2012):

Table 8, running cost of South Korea's and Japan's railway research institutes

Facility	Employees	Income (€)	Expenditure (€)
RTRI	499	161,9 million	166,9 million
KRRI	270	69,1 million	Not available

RTRI has about twice the number of employees that KRRI has, and approximately 100 million € more in expenses. Important to mention in this context is that KRRI's 69,1 million € in income is a budget figure for 2011.

Note that KRRI and RTRI are more research oriented than the CEF and Siemens facilities.

Effects of Option 2

Weaknesses

- **Financial risk with R&D –** the success of efforts and money put in R&D will only be determined in the very end, and there is no guarantee for success.
- **Long startup time for R&D -** the development of rolling stock is often a time costly procedure before research and development turns into something sellable or usable.
- **Unknown to customers –** good and effective marketing is necessary to attract both customers and partners. Showing evidence of quality such as "accredited by the EBA" (Eisenbahn –Bundesamt) will help the credibility.

Strengths

- **Rolling stock development** – A test center will offer possibilities to develop railway vehicles for Turkish rolling stock manufacturers. Currently most of the advanced rolling stock made in Turkey is based on license production from foreign manufacturers. For example are five of Tülomsas nine different locomotive types made in license agreements (Tülomsas, 2012).
- **Growth of railway knowledge** – a railway test center which is shared by both industry and academia will be a long term investment for the national railway knowledge. Cooperation between industry and academia is something countries with the most developed railway

technologies such as Spain, France, Germany, Japan and South Korea all have in common. All of these countries have developed their own high speed trains amongst many other train types.

- **More accessible services** - the nearest accredited test center is VUZ Velim about 2 300km from Ankara, five different borders have to crossed (Bulgaria, Serbia, Hungary, Slovakia and Czech Republic) to get there.

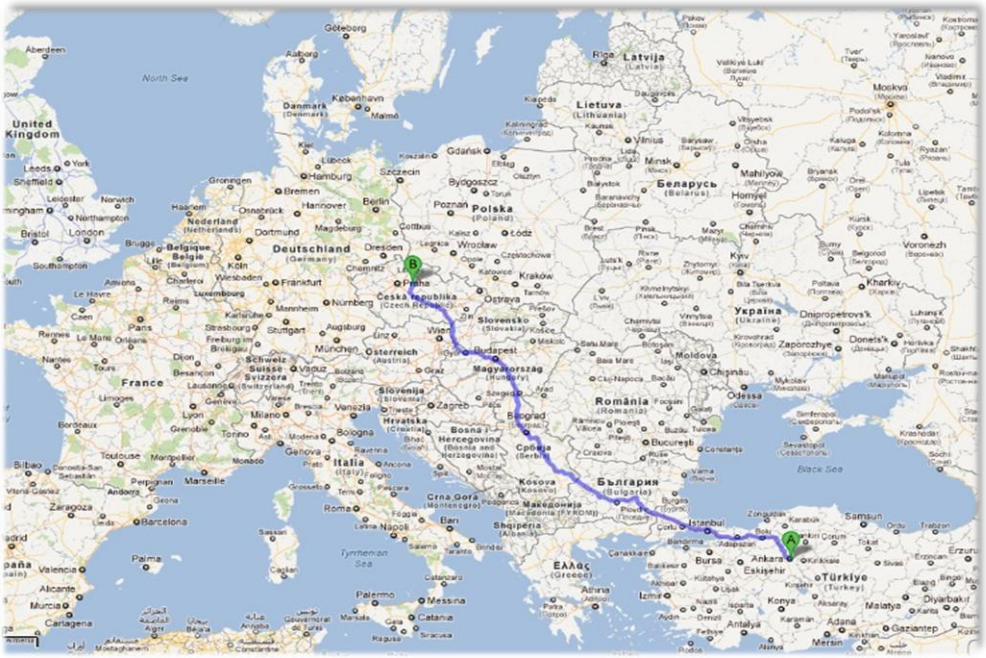

Figure 10, distance Turkey, Ankara – Czech Republic, VUZ Velim test center

Opportunities

- **Strategic alliances, partnerships** – a test center creates a platform where both industry and academia can work together. It also creates an opportunity to partner several universities together to have a broader scope.
- **Consulting services –** There is a possibility to run consulting business like VUZ in Czech Republic.
- **Making European market more attainable -** having a test center located in Turkey simplifies the procedure of getting a vehicle approved accordingly to TSI – standards for Turkish railway manufacturer. Additionally it will simplify the steps needed for Turkish manufacture to enter the European market.

Threats

- **Political disagreements** – fast changes in political opinions and legislation can affect the outcome.
- **Demand of qualitative staff** – there is a need for highly qualified technical staff.

- **Tough competition -** there are three well established test centers in Europe that offers testing and TSI – certification services.

SWOT - analysis

Table 9, SWOT table

Strenghts	Opportunities
More accesible services	Strategic alliances, partnerships
Employment	Consulting services
Growth of railway knowledge	Making the European market more attainable
Weaknesses	Threats
Financial risk	Political interferance
Long startup time	Demand of highly technical staff
Strong competition	Tough competition

Results

Option 1 (no test center, current situation) – around 400 000 Euros for TSI certification and 365 000 Euros for standard vehicle tests.

Option 2 (test center) – To estimate a more realistic running cost we divided Japan's RTRI total expenditure for 2010 by five. The running cost will then be of the size of 33, 4 million Euros.

The investment cost for a Turkish first level center is estimated to be around 13, 3 million Euros.

9 Discussion

A test center can offer many different possibilities, the two most obvious are certification and R&D. We consider R&D the most important argument on why Turkey should construct a test center. Our view of a railway test center is that its primary focus is development of railway vehicles.

Turkey is investing large sums of money to extend and improve the domestic railway network. This expansion requires more railway vehicles to operate the new, bigger network. If Turkey could manage to develop suitable railway vehicles for their expanding railway network, they have much to gain. Spain is an excellent example, since they were in a similar situation as the one Turkey currently is in. The Spanish government introduced a huge investment plan for the national railway network and Spanish railway related companies such as Talgo profited much on this and later became a considerable player in the railway industry. Currently Turkey has no companies that can offer any advance railway vehicles. However this should not stop Turkey from trying to develop its own trains.

If the purpose with a future test center in Turkey only is to test and certify rolling stock, we do not recommend construction. Today it is possible for Turkish manufacturers to get their vehicles both tested and certified in current conditions. Halis Turgut, CEO at Railtur who produces freight wagons in Turkey has the opinion that it is unnecessary to build a Turkish test center, especially from the freight wagon perspective. Mainly, due to the fact that freight wagons generally has been constructed in the same way and with similar technology the last 50 years. He also believes that the Turkish rolling stock manufacturers are not ready to take advantage of the possibilities offered by a railway test center.

Yet, taking in mind all the positive effects a railway test center can bring, we recommend construction of a railway test center in Turkey. There are three aspects we consider crucial to make the test center successful:

First: purpose, i.e. the why-questions should be asked, for example: why are we building it? What do we want to achieve with the test center?

Second: long term planning, i.e. a clear mission and vision should be defined before building the test center.

Third: cooperation between industry and university, which will create a win-win situation for both parts.

Further development of our thesis could be to answer these questions:

Is Turkey willing of using the possibilities a railway test center can give? If so, when would Turkey be capable of taking advantage of the possibilities a railway test center can give? If not, why?

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