Rail Research Laboratories in Brazil

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Abstract

This paper aims to present the historical factors that influenced the project and implementation of the rail engineering laboratories in Brazil and the facts behind the cooperation among then and the rail operators. The increasing of the operations experienced in the last 14 years has demonstrated as the main driver of the personnel skills requirements and the supply of these ones are due to the partnerships with Universities and Industry, to carry out tests, studies and projects. Into this scenario arose the LABFER project, with the objective to be a research centre for the Brazilian rail industry, both in terms of operations and components analysis. A survey was taken with the industry partners and the results demonstrated that the main focus of needs in the industry relies on the studies of components integrity and reliability, and the analysis of the dynamical behaviour in operation of the heavy-haul trains. Then the conclusions are that the existing forces of volume increase, the increase velocity of operations to be more competitive over other transportation modes and the flexibility of the operations, forced railways companies to push up the education of its staffs.

Keywords: Brazilian railways, manpower training, rail engineering laboratory.

INTRODUCTION

The Brazilian railway freight operation, which is based in heavy-haul freights and medium distances, has experienced a consistent growth in the recent years, after 14 years since the beginning of the privatization process, carried out in the 1996, the railroad industry in Brazil is challenged by another moment of transformation. Unsatisfied with the difficulties faced in rail freight, large shippers are linking to each other, and with the National Transportation Agency (ANTT) to revisit the existing regulatory framework of concession agreements.

Before analysing the development of rail Brazil in the last decade, it is important to understand that the starting point of dealerships receive the assets transferred by the Federal Railways (RFFSA). The low density of railway lines, lack of intra-and intermodal integration, the huge lack of investment, the high accident rate and low average speed, negatively impacted the financial and operating performance of the new concessionaires. The fragility of the railroads at the time of beginning of the concessions was such that forced operators to spend four early in the technological, organizational, commercial and operational intensive recovery process. As seen in Table 1, the concession of the railways to private initiative led to a rapid and significant improvement in the performance indicators of the rail network in Brazil, with the exception of average speed and average distance trade, which were little changed between 1997 and 2001 (from 21.1 km/h to 22 km/h and 518 km to 531 km, respectively) [1].

Table 1 - Evolution of rail freight in TKU in the Brazilian concessions rail companies (ANTT/2012)[1]

Rail Companies	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*
ALLMN	2.103	2.259	7.957	7.446	9.394	11.297	13.887	14.618	16.073	8.848
ALLMO	1.232	1.191	1.312	1.431	1.202	1.345	1.312	1.783	1.760	866
ALLMP	9.221	9.473	2.286	2.240	1.920	3.054	3.019	4.004	4.689	1.838
ALLMS	13.850	14.175	15.415	18.423	17.147	17.378	17.196	17.474	18.121	7.651
EFC	52.411	63.622	69.525	76.691	83.334	87.513	83.945	91.044	98.897	46.851
FERROESTE	406	323	349	1.005	620	747	469	273	209	112
EFVM	60.487	64.773	68.648	73.442	75.511	72.783	57.929	73.480	74.554	35.461
FCA	7.477	9.523	10.712	9.143	14.231	15.060	14.198	15.320	13.606	8.325
FNS	—	—	—	—	—	1.026	1.155	1.524	1.884	996
FTC	152	169	170	183	189	213	202	185	173	98
MRS	34.515	39.355	44.445	47.662	52.590	55.621	51.273	57.490	61.259	31.032
TLSA	790	848	814	678	963	920	730	728	681	376
TOTAL	182.644	205.711	221.633	238.345	257.101	266.958	245.315	277.922	291.906	142.456

The largest growth occurred in investment, as seen in Table 2, jumping from R$350 million in 1997 to almost R$ 5 Billion in 2011, corresponding to a total of R$ 35 billion in 15 years [1][2][3].

Table 2 - Investment evolution in Brazilian railways (ANTT/2012)[2]

Rail Companies	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*
ALLMN	141	83	85	141	308	368	59
ALLMO	23	27	26	25	25	28	5
ALLMP	25	57	100	94	73	91	26
ALLMS	140	374	207	178	236	267	57
EFC	578	601	1.033	526	458	1.069	326
FERROESTE	0	0	0	0	0,1	0	0
EFVM	406	156	399	325	185	458	57
FCA	62	86	126	113	101	188	74
FNS	0	0	76,4	11,9	35,5	33	8
FTC	1	2	3	2	2	2	0
MRS	380	567	1.096	317	488	1.054	179
TLSA	31	69	212	163	1.324	1.369	287
Total	1.787	2.021	3.363	1.898	3.235	4.927	1.078

The private investment provides an increase of 117% of the productivity in the Brazilian railways. In order hand, while the Brazilian GDP growing about 0.9% in 2012, the railway production increases 2.5% with investments in bottlenecks eliminations and capacity expansions, and the accidents experienced a 82.8% reduction in the same period [3].

[1] The 2012 freight volumes correspond to the volume accumulated until June, 2012.

[2] The 2012 investments correspond to the investments accumulated until June, 2012.

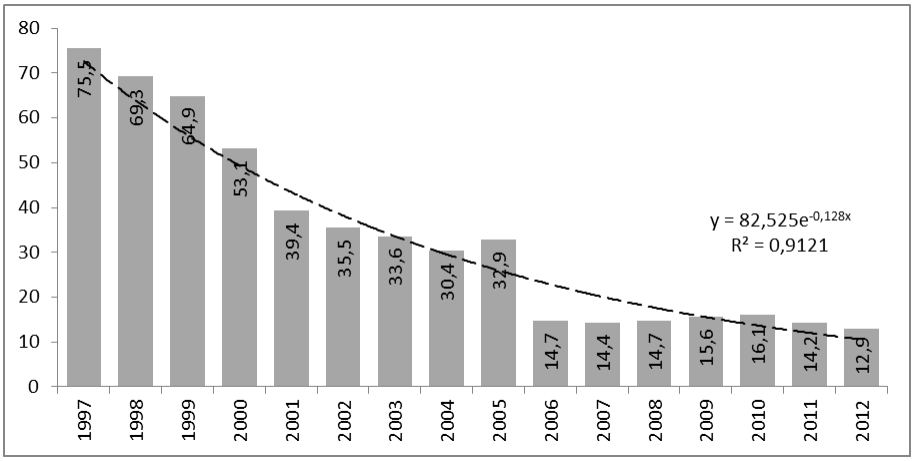

Figure 1 - Accidents' reduction (number of accidents/million TKU) [3]

DEMAND FOR NEW CAPABILITIES IN RAIL ENGINEERING

The demand for rail engineering capabilities in Brazil has experienced a consistent growth in the last decades, as shown by Figure 2, what reflects the efforts made by the main operators to improve the quality of its services, in terms of productivity and accidents/incident reductions.

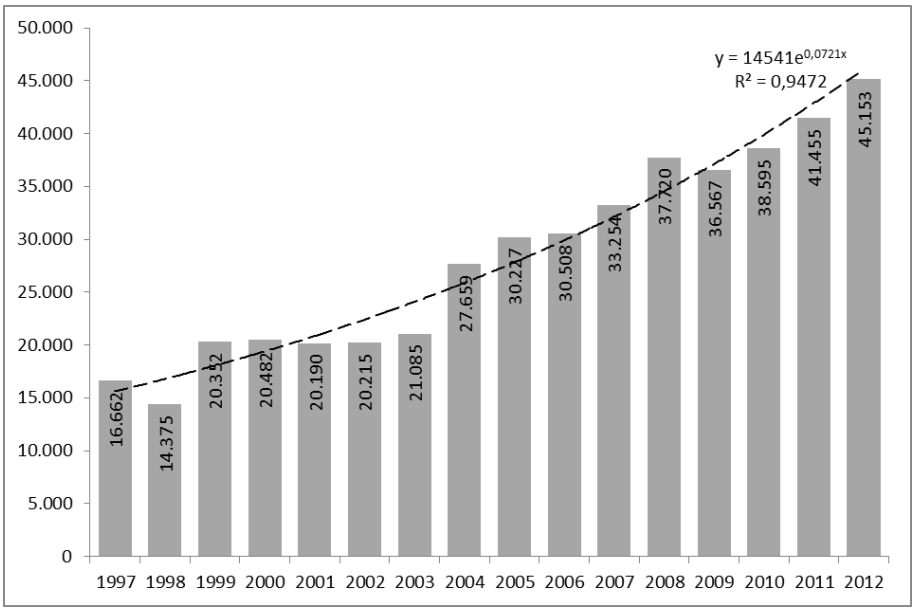

Figure 2 - Growth of the employees´ number in the railway operators [2]

The elimination of the existing gaps between the rail industry and other economics sectors, as automotive and mining and oil & gas industries, as well as the attraction of qualified manpower, has been the main objective of the rail companies in Brazil. The principal result of these efforts is shown in the Table 3, in which states the personnel trained in several rail functions. The total of investments carried out by the rail companies in training has summed about R$14.7 million until June, 2012.

Table 3 – Manpower training in the period of 2001-2012 [3]

Rail Functions	*Qty*
Station Officer	760
Machinist	6.659
Maintenance Mechanical	2.633
Maintenance Electrical	1.588
Railway Maintener	1.330
Maintenance Technician	684
Railway Engineer	449
Total	14.103

RAIL ENGINEERING LABORATORIES IN BRAZIL

The rail engineering in Brazil played a main role between the years of 1950 and 1980, and experienced a vertical decreasing after 1990, being reappointed in the figure in the end on 90´s. The schools and its courses were faced against the growth of other economy sectors that offered bigger salaries and more attractive career paths [1].

The current laboratories that work with topics related to railway engineering are:

1. Eng. James C. Stewart School in conjunction with SENAI/SP is dedicated to the training of manpower to the CPTM – Paulista Metropolitan Railway Company.[4];
2. LAFER – Rail Laboratory, colligated to the Mechanical School of UNICAMP, is focused on three main areas of research: the study on vehicle-railway interactions, the wheel-rail dynamics and the friction analysis of the operation and breaking rail systems.[5]
3. CEPEFER – Railway Research and Studies Centre, is a centre for research and advanced studies in Brazilian railway industry, focused on manpower training with in-company courses and courses teach at the railway-school with 14 km of rail line to train [6].

Other initiatives has been taken in an isolated manner as ITV – Technology Institute of Vale S.A. that is correlated to the USP – University of Sao Paulo and specific courses with the collaboration of the railway industry and academic institutions as IME – Military Institute of Engineering, and MRS Logistica S.A.

THE LABFER INITIATIVE

With the support of the Secretariat of State for Science and Technology and the Carlos Chagas Filho Foundation for Research Support of the State of Rio de Janeiro (FAPERJ), the Military Institute of Engineering welcomes the LABFER, with the main objectives as:

(i) To contribute to the increased efficiency rail system for cargo and passengers in the state of Rio de Janeiro and in Brazil, improving the mobility of society as a whole and

(ii) To integrate Universities, ICT and Railway Concessions Operators with the focus on using the most modern techniques of railway engineering in particularly in friction management and operation optimization.

In order to extent that increases the cargo transported, companies must learn to use materials and equipment that technically meet the new internal forces, and efficient ways to operate existing equipment in order to expand cargo capacity by optimizing the system. This requires expansion of crossing yards and terminals, increasing capacity per axle, reinforcement of works of art and railway superstructure, study of special alloys for electrical shock and traction rails, wheels and bearings.

Team

LABFER staff consists of professors and researchers from Section of Engineering and Fortification Construction (SE/2) of the Military Institute of Engineering (IME), of the Industrial Engineering Department of Federal University of Rio de Janeiro (UFRJ) and the Centre for Railway Studies and Research (CEPEFER) and wrapped with innovation companies in the area of mobility and freight transport.

Survey results

In the end of 2012 was carried a survey with the specialists of the railway industry in order to map the demand of the rail industry in Brazil, in terms of quality tests and technical competencies. The survey was required the participation of focal personnel of the operators, suppliers and agencies, as well, was criticized by senior specialists both of the academy and industry.

The non-probabilistic sample was collected intentionally between:

1. Engineers in the rail development and technical services at VALE SA, the biggest national rail operator, operating about 10 thousand of kilometres of railway in Southeast and North of Brazil.
2. Engineers in the AmstedMaxion SA. Railway Wheels and Steel Castings Division and Engineers in the unit of wagons, locomotives and welded structures.
   The AmstedMaxion S.A is the leading manufacturer of rolling stocks components, with a 35% share of the Brazilian market.
3. Engineers in educational unit of the Centre for Studies and Research Railway Ltda.
4. CEPEFER is the pioneer organization in education and applied research in national rail industry, headquartered in the State of Rio de Janeiro.
5. Engineers selected by HR of Transnordestina Logistica SA
   Operator of the Northeast Network, linking the ports of Pecém (CE) and Suape (PE). Subsidiary of National Steel Company (CSN).

The survey results of the 22 respondents are demonstrated in the sequence of tables, from Table 4 to Table 10.

Table 4 - Results of the survey of the necessity of tests in railway systems.

Tests in the railway systems	
Test in the systems of wagons, bogies, couplers and accessories	27%
Test in the systems of wheels, axles, bearings and wheel sets	**40%**
Test in the systems of rails and fixings	13%
Test in the systems of sleepers and ballast	13%

Test in the systems of switches and crossings	7%

Table 5 - The aspects of the needed tests in the railway systems.

Aspects of the tests	
Acoustics, noise and vibration aspects	0%
Stress, specific density, dimensional and volume aspects	7%
Resistance, fatigue and materials behaviour aspects	**87%**
Materials composition aspects	7%

Table 6 - Necessity of studies in the wheel wear in the wheels subsystem.

Specifically related to the subject of wheel wear, what theme would coach next priority in terms of technical depth in your company:	
Study of the wheel sets typology (cast iron or forged steel)	20%
Study of the gravity centre and wheel conicity	20%
Study of the friction mechanisms (abrasive or sliding)	**60%**

Table 7 - Wheel-rail interface studies priority results.

Regarding specifically the wheel-rail contact issue, technical theme which would be next priority in terms of technical depth in your company:	
Study of the friction management techniques	20%
Study of the mathematical modelling of the movement and wheel-rail interface	33%
Study of the contact dynamics through instrumented wheel sets	**47%**

Table 8 - Results of the importance of issues related to wheel-rail interface.

Also with respect to the wheel-rail contact issue, what is your opinion on the impact of the measures usually taken to deal with the issue:	Very important	Important	Less important	N.A.
Billet grinding the rails	30%	30%	10%	30%
Measurement of friction coefficient	20%	**40%**	30%	10%
Study modifications of wheel profiles	29%	**50%**	7%	14%
The use of new manufacturing materials in the wheel and rail fabrication	18%	9%	18%	55%

Table 9 - The results of studies interest of shock and traction system.

Regarding specifically to handset component of shock and traction, what should the main interests of deeping technology investigation	
General studies of the design of the efforts behaviour of the coupler component with the AAR specifications	15%
Efforts simulations on the freight trains operation	**38%**
Knowledge of design and manufacturing characteristics of the shock component	8%
Study of the dynamical behaviour of components in heavy-haul trains	**38%**

Table 10 – Results of demand in simulation studies in the railway operations.

Specifically related to simulation models, which theme would be the next priority in terms of technical depth in your company:	
Simulation application to the study of intermodal operations	8%
Simulation modelling to evaluate the reliability and the risks of systems operation	23%
Simulation of the timetable construction of trains and crew planning	8%
Simulation modelling on the investment planning in yards and terminals	8%
Strain simulation of the length of the trains and stability analysis	**54%**

CONCLUSIONS

This paper aims to shown how the research laboratory initiative should led to provide support in the new challenges faced by the Brazilian rail operators, supplying teaching capabilities and engineering research to the noticed improvement of the operating condition of the railway concessions, focusing on the aspects of security and transit time and the growing investments in acquisition of rolling stock, locomotives and cars, as well as improvement of the fleet conditions.

The gradual introduction of new technologies and traffic control systems, aimed at increasing productivity, safety and reliability of operations, as well as the preservation of the environment, is the main field of laboratory creation and implementation, via the partnerships adoption with universities, customers and other operators seeking markets with higher value added.

The increasing of intermodal transportation has forced the operators to acquire new operations skills and a major understanding of the entire logistics chain of the customers' railway, as shown by Figure 3.

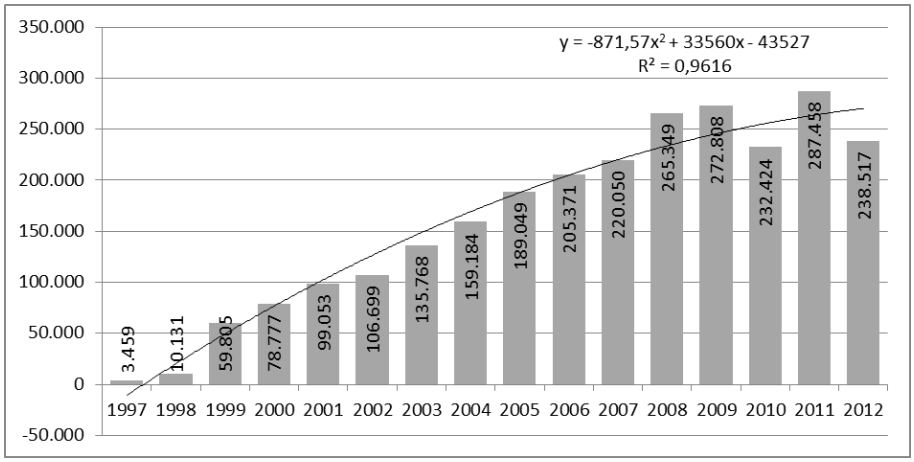

Figure 3 – Evolution of container transportation by rail (in TEU) [3].

The results of the survey carried out with 22 respondents have shown that the tests necessity are concentrated on studies of the resistance, fatigue and materials behaviour of the wheels, axles,

bearings and wheel sets systems, more specifically studies of the friction mechanisms, both abrasive or sliding sources.

The results have also shown that a direction of the research interest of the operators is the wheel-rail contact studies, along with is performed with instrumented wheelsets, concentrating in the measurement of friction coefficient and the study modifications of wheel profiles.

Another area of relevant interest is the study of dynamical behaviour of components in heavy-haul trains, leading to strain simulation modelling of the length of the trains and stability analysis.

Regarding to railway operations, the main issue is the reliability of the system operation, with the objective to evaluate the reliability and the risks of systems operation.

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