

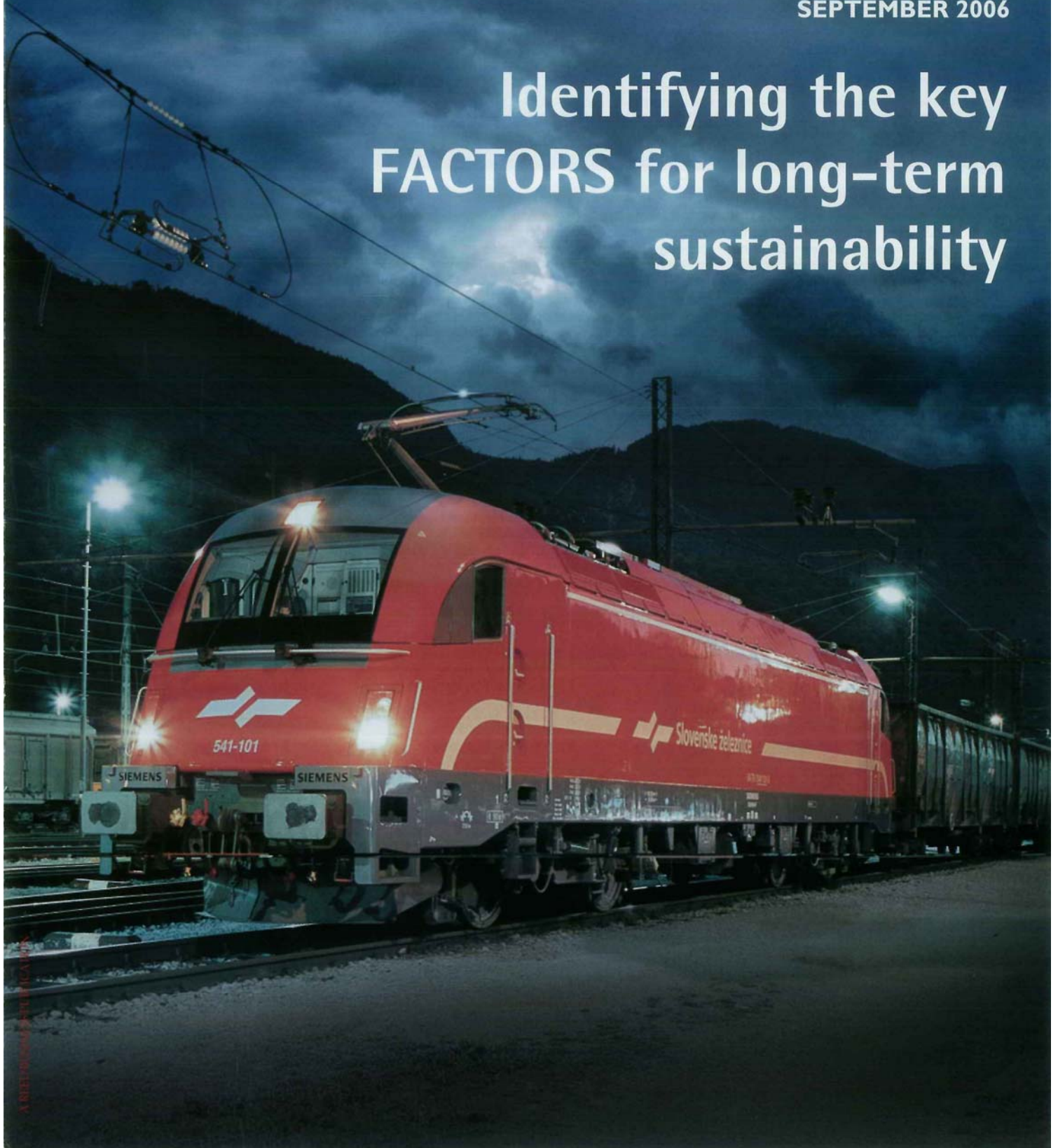
# RAILWAY GAZETTE

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Identifying the key  
**FACTORS** for long-term  
sustainability





# Identifying the key **FACTORS** for long-term sustainability

In an era of ever-increasing globalisation, and competition between modes, railways need to identify and capitalise on the core strengths of their technology if they are to be sustainable in the long term, argues Dave van der Meulen



Formerly Chief Engineer (Systemic Rail Solutions) at Spoornet, Dr Dave van der Meulen is Managing Director of Tshwane-based consultancy Railway Corporate Strategy CC

**T**HE MIXED TRAFFIC railway is dead – or at least dying. In the new world order, specialism is the name of the game, focusing on core skills and technologies inherent to the rail mode.

As globalisation advances, battle lines are being drawn between railways and competing modes, and between contending ideologies for liberating the railway's competitive strengths.

But which railways will survive, and which will not? Who will be able to change, and who will be held back by the political or social climate within which they operate? This article attempts to address these questions, based on the data and findings presented in my paper to the 2006 World Congress on Railway Research in Montréal<sup>1</sup>.

For the past three or four decades the world's railways have been changing. Once the pre-eminent mode of land transport, the leading players are increasingly focusing on distinct market spaces where

they can dominate. To a considerable degree, these can be defined by three applications: high speed inter-city passenger trains, which made their appearance in the 1960s; heavy haul, as developed in the 1970s; and double-stack intermodal, which dates from the 1980s.

Railways exist within a complex economic, political, and social framework, which is demarcated by many opposing poles, for example: command and free economies; competitive or monopolistic route structures; open access or vertical integration; monolithic state railways or small independent operators. Within their framework, the leading railways have expanded and invested in renewing their assets, while the laggards have atrophied.

Can we derive any meaningful insights from this transformation? While not universally welcomed, the turbulence of recent years does show that the railways affected are open systems that have responded constructively to global trends.

Unaffected railways either do not have the freedom or the will to expose themselves to global drivers. But as closed systems, they will inevitably deplete their reserves and resources until they can no longer relate meaningfully to their business environment.

## Fundamentals of competitiveness

As a simple example, we can consider competitiveness in terms of freedom of movement. Air and submarine transport possess three degrees of freedom; they offer spatial mobility, but at relatively high cost. Unguided surface transport has two degrees of freedom; it trades off reduced mobility against lower cost.

Guided surface transport possesses only a single degree of freedom: back and forth

Table 1: Variables used in the Railway Globalisation Database

Variable	Upper limit	Lower limit			
<b>Competitiveness</b>					
Research & Development Level	industry leader	base technology	Rolling Stock Ownership Locus	private	public
Relative Maximum Axleload	high	low	Infrastructure Commitment Horizon	long term	medium term
Relative Maximum Speed	high	low	Rolling Stock Commitment Horizon	long term	medium term
Distributed Power Presence	present	absent	<b>Presence</b>		
Heavy Haul Presence	present	absent	Route km	high	low
High Speed Inter-City Presence	present	absent	Freight Traffic Volume	high	low
Double Stack Presence	present	absent	Passenger Traffic Volume	high	low
Diesel Traction	present	absent	Employee Count	high	low
Electric Traction	present	absent	<b>Society</b>		
Attitude to Competition	enabling	protective	National Economic Freedom	high	low
			National Population	high	low
<b>Market</b>			Gross National Income	high	low
Route Diversity	parallel options	single only	Country Physical Size	high	low
Operator Diversity	open access	monopolistic	Initiative Source	railway industry	society
Concerned Stakeholder Sensitivity	concerned	complacent	Determinism	authoritarian	laissez-faire
<b>Networkability</b>			<b>Sustainability</b>		
Narrow Gauge	high	low	Infrastructure Investment Capacity	expansion	abandonment
Standard Gauge	high	low	Rolling Stock Investment Capacity	expansion	abandonment
Broad Gauge	high	low	Stakeholder Satisfaction Level	high	low
Networkability	high	low	Service Reputation	positive	negative
Strategic Horizon	intercontinental	national	Safety Reputation	positive	negative
			Subsidy Influence	toward receiver	toward provider
<b>Ownership</b>			<b>Time</b>		
Infrastructure-Operations Separation	separated	integrated	Calendar year	2005	2002
Infrastructure Ownership Locus	private	public			



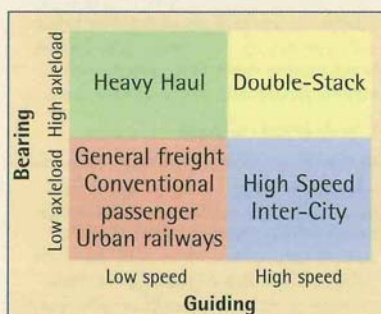


Fig 1. Cross-relating the fundamental technologies of Bearing and Guiding reveals three core strengths of the rail mode

on a guideway. By itself, this offers limited mobility. And to the extent that this reduces value, railways must offer compensating advantages to hold their own.

I believe that the key to rail's competitiveness lies in three fundamental technologies that distinguish it from all other transport modes. And railway competitiveness can be measured by the extent to which different operators exploit these genetic technologies. They are:

- **Bearing:** the vehicle-guideway pair ensures precise application of vertical loads, supporting relatively high axleloads;
- **Guiding:** the guideway also ensures secure application of lateral loads, in terms of steering and curving, which permits operation at very high speeds;
- **Coupling:** allows the matching of supply to demand by adding or subtracting vehicles to scale capacity as required.

This third technology is common to all variants of railway operation. Fig 1 cross-relates the other two to identify three intensely-competitive market spaces – Heavy Haul, High Speed and Double-Stack – in which railways have demonstrated inherent sustainability.

Fig 1 also reveals one weak area – low axleloads in combination with low speed. This is exemplified by general freight operations, conventional long-distance passenger trains and urban rail services. The criteria surrounding the urban rail business are so fundamentally different

from line-haul operations that it is virtually a distinct mode; thus urban railways have been excluded from this analysis.

Line-haul railways that fail to exploit their technologies are weak, so competitors will erode their markets. Depending on whether economic, political or social criteria determine their destiny, they will be eliminated, protected, or subsidised.

#### First build a database

To determine each railway's long-term prospects, it is necessary to examine the framework within which it operates. Cases are considered by country, because by and large railways must still operate under national legislation.

Obtaining data for analysis has not been easy. We are moving from the old era of comprehensive, transparent national railway statistics towards a future in which private operators concerned with confidentiality will only release minimal statistics.

Existing databases such as the UIC annual statistics or the World Bank Railway Database have not yet evolved to reflect the impact of globalisation, so a new, dedicated database was created using metric and non-metric data<sup>1</sup>. Hard and soft data were extracted from a number of rail industry publications including *Railway Directory* and *Railway Gazette International*.

Information in the public domain is adequate to support behavioural research, and avoids the need to obtain proprietary data. Even where more detailed figures are available, it is unlikely that these would be consistent across the full range.

The number of countries having line-haul railways with a track gauge of 914 mm or wider barely exceeds 100. As statistical significance demands a fair case-to-variable ratio, we can only compare railways at a relatively high level. Longitudinal analysis over the years 2002–05 leveraged the number of cases, and hence the number of variables that could be considered.

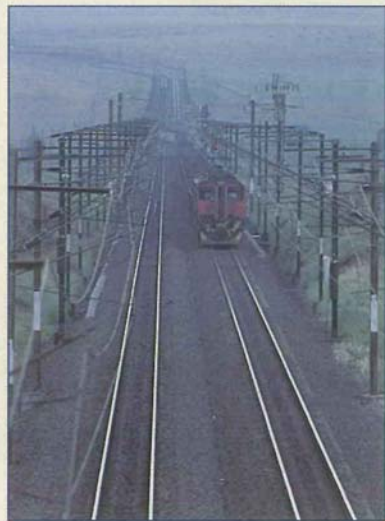
Around 40 variables were felt to be sufficient to describe the essential distinctions between countries and railways. Table 1 lists the variables that we used, and the categories into which they can be grouped. It also gives the upper and lower limits, although it is important to note that several scales have intermediate values.

#### Statistical analysis

The database represents an array of complex, initially incomprehensible issues. So multivariate statistical analysis was used to extract comprehensible relationships – Statgraphics Centurion XV software in this case. But the numerical outcomes must then be interpreted in the light of practical knowledge. Not surprisingly, some interpretations are intuitively obvious. This gives confidence that other outcomes, which may at first sight seem counter-intuitive, are in fact well-founded.

*Heavy Haul offers narrow-gauge railways a route to competitiveness despite their lack of networkability. Spoonet's Coallink and Orex lines are among the few remaining heavy freight operations on the narrow gauge*

Photo: Marcel Vleugels



As a first step, factor analysis was used to look at the relationships between the variables (the columns in the database) and explain them in terms of a smaller number of common factors. The Statgraphics factor analysis in Table II shows how each variable loads onto one of 10 underlying factors. Each variable loads high on its principal factor, and comparatively low on the others – in an ideal situation the factors should be mutually exclusive.

Looking at the results over the four years,

#### Identifier les facteurs clés du développement durable

Pour Dave van der Meulen, dans cette période de globalisation croissante, les chemins de fer ont besoin de compter sur le noyau dur de leur technologie s'il veulent être partie prenante du développement durable. Trains de voyageurs à grande vitesse, convois lourds et services intermodaux à longue distance ont un puissant avenir commercial, mais les perspectives sont moins claires pour les chemins de fer conventionnels à trafics mixtes. L'expérience laisse à penser que la liberté de concurrence et la participation réussie du secteur privé dépendent de la manière dont on tire partie de la force de la concurrence, la privatisation à elle seule ne pouvant maintenir l'avenir aux chemins de fer qui ont des performances réduites ou à ceux qui sont isolés.

#### Identifikation der Schlüsselfaktoren für langfristigen Erfolg

Im Zeitalter der zunehmenden Globalisierung müssen sich die Eisenbahnen auf die hauptsächlichsten Stärken ihrer Technik konzentrieren, damit sie langfristig erfolgreich sein können, argumentiert Dave van der Meulen.

Hochgeschwindigkeitsverkehr, Schwerlast und kombinierter Verkehr über lange Strecken haben eine kommerzielle Zukunft, aber die Aussichten sind weniger klar für konventionelle gemischte Verkehre. Die Erfahrung zeigt, dass Freiheit im kompetitiven Umfeld sowie erfolgreiche Beteiligung des privaten Sektors stark von der Ausnutzung dieser kompetitiven Vorteilen abhängt, und dass eine Privatisierung allein die Zukunft von leistungsschwachen oder isolierten Bahnen nicht garantieren kann.

#### Identificación de los factores clave para la sostenibilidad a largo plazo

En una era de crecimiento de la globalización, los ferrocarriles necesitan sacar partido de los puntos fuertes básicos de su tecnología, si quieren ser sostenibles a largo plazo, afirma Dave van der Meulen. Los trenes de pasajeros de alta velocidad, de carga pesada y de transporte combinado de largo recorrido poseen un gran futuro comercial, aunque para los ferrocarriles convencionales mixtos las perspectivas no son tan buenas. La experiencia sugiere que la libertad competitiva y la participación exitosa del sector privado dependen de la explotación de estas ventajas competitivas y que, además, la privatización por sí sola no puede preservar el futuro de los ferrocarriles de bajo rendimiento o aislados.



we can interpret the movements in the underlying factors as global drivers.

1. **Societal Orientation** suggested that a societal or people orientation associated with high-tech development. Freight traffic also loaded onto it, suggesting that passenger-oriented railways also accommodate mixed traffic. This reflects the archetypal national railway in Western Europe.

2. **Territorial Orientation** associates with liberal competition among high-tech freight railways over long distances. This mirrors the competitive North American situation, with long, heavy trains conveying bulk commodities or high-value goods.

As railways invariably use diesel traction, whether or not they also use electric, Diesel is intractable in multivariate analysis.

Nevertheless it commonly associates with the North American archetype. Counter-intuitively, Freight Traffic Volume did not load onto Factor 2, which suggests that dedicated freight railway capacity is inherently more scalable to demand than mixed traffic and/or electric railways.

3. **Global Networkability** reflected the potential for railways to participate in emerging continental and/or inter-continental networks with the benefits of longer and more competitive hauls. Narrow Gauge loaded negatively, suggesting that sub-standard gauge impedes this ability.

4. **Rising Expectations**, on which Stakeholder Satisfaction Level loaded negatively, suggested that a free, developed economy nurtures demanding freight shippers and passengers.

5. **Competitive Freedom** suggested that transformation from state ownership to private participation associates with good service and ultra-long hauls.

6. **Continuous Improvement**, on which both variables loaded negatively, suggested that relatively short commitment horizons encourage better use of capital assets and/or effective public-private partnerships.

7. **Inherent Sustainability** indicated that timely renewal of assets or investment in expansion associates with sustainability. By contrast, time is running out for railways

that show signs of deterioration, withdrawal or abandonment.

8. **Government Encouragement** offered the obvious interpretation that government support, through subsidy, influence and enabling competition, associates with the development of the genetic technologies to a level of leadership within the industry.

9. **Self-Regulation** on which Determinism loaded negatively, suggested that railway self regulation associates with a positive safety reputation in a laissez-faire society. Railway operators who must compete for custom and funding simply cannot afford the catastrophic accidents that might be tolerated in more protected railways.

10. **Broad-Gauge Conundrum** also looks at networkability. Broad Gauge loaded negatively, suggesting that despite its arguable superiority broad gauge opposes the critical mass of standard gauge. As with the Betamax versus VHS battle in the video industry, market dominance outweighs technical advantage.

The next step was to apply cluster

Table II: The Factor Loading Matrix groups individual variables onto 10 underlying factors

Factor	1	2	3	4	5	6	7	8	9	10
	Societal Orientation	Territorial Orientation	Global Networkability	Rising Expectations	Competitive Freedom	Continuous Improvement	Inherent Sustainability	Government Encouragement	Self Regulation	Broad-gauge Conundrum
Employee Count	0.89	0.12	0.13	0.13	0.08	0.06	0.07	0.10	0.04	0.12
Route Kilometers	0.82	0.42	0.10	0.03	0.11	0.09	0.10	0.12	0.02	0.02
Passenger Traffic Volume	0.79	0.12	0.03	0.20	0.11	0.01	0.09	0.04	0.11	0.09
Freight Traffic Volume	0.68	0.34	0.28	0.09	0.13	0.14	0.04	0.10	0.08	0.18
Electric Traction	0.67	0.16	0.33	0.24	0.03	0.08	0.07	0.00	0.05	0.10
Relative Maximum Speed	0.65	0.00	0.31	0.43	0.13	0.04	0.03	0.29	0.10	0.15
National Population	0.61	0.26	0.42	0.40	0.02	0.12	0.08	0.05	0.09	0.13
Concerned Stakeholder Sensitivity	0.54	0.27	0.05	0.37	0.23	0.20	0.02	0.14	0.11	0.15
High Speed Inter-City Presence	0.48	0.04	0.06	0.37	0.12	0.19	0.02	0.39	0.14	0.24
Route Diversity	0.01	0.90	0.07	0.10	0.02	0.14	0.06	0.05	0.02	0.05
Double Stack Presence	0.06	0.86	0.11	0.06	0.03	0.06	0.07	0.04	0.07	0.06
Heavy Haul Presence	0.17	0.84	0.04	0.03	0.00	0.19	0.00	0.08	0.05	0.02
Distributed Power Presence	0.07	0.82	0.04	0.11	0.02	0.00	0.06	0.10	0.15	0.03
Relative Maximum Axleload	0.14	0.63	0.53	0.13	0.03	0.19	0.06	0.08	0.02	0.18
Rolling Stock Ownership Locus	0.20	0.58	0.05	0.14	0.55	0.02	0.06	0.08	0.03	0.20
Country Physical Size	0.31	0.54	0.44	0.41	0.06	0.08	0.02	0.07	0.05	0.02
Narrow Gauge, km	0.04	0.06	-0.86	0.04	0.07	0.04	0.01	0.02	0.03	0.14
Networkability	0.28	0.02	0.75	0.16	0.14	0.02	0.05	0.01	0.11	0.14
Economic Freedom	0.07	0.16	0.06	0.84	0.21	0.05	0.03	0.04	0.14	0.07
Gross National Income	0.29	0.15	0.20	0.73	0.13	0.05	0.10	0.17	0.11	0.23
Stakeholder Satisfaction Level	0.01	0.18	0.12	-0.39	0.18	0.35	0.15	0.25	0.18	0.02
Infrastructure-Operations Separation	0.02	0.10	0.10	0.01	0.75	0.03	0.03	0.24	0.11	0.00
Operator Diversity	0.27	0.04	0.13	0.43	0.54	0.12	0.06	0.16	0.14	0.08
Infrastructure Ownership Locus	0.29	0.48	0.13	0.12	0.53	0.01	0.18	0.13	0.12	0.21
Service Reputation	0.12	0.04	0.06	0.14	0.51	0.09	0.08	0.14	0.06	0.23
Strategic Horizon	0.30	0.19	0.28	0.16	0.36	0.10	0.33	0.02	0.04	0.25
Rolling Stock Commitment Horizon	0.07	0.01	0.05	0.07	0.09	-0.88	0.05	0.01	0.07	0.08
Infrastructure Commitment Horizon	0.21	0.01	0.06	0.04	0.10	-0.82	0.09	0.03	0.17	0.05
Calendar Year	0.16	0.02	0.03	0.02	0.19	0.05	0.70	0.14	0.07	0.01
Infrastructure Investment Capacity	0.32	0.09	0.02	0.14	0.08	0.01	0.65	0.17	0.25	0.10
Rolling Stock Investment Capacity	0.32	0.17	0.14	0.02	0.09	0.11	0.58	0.10	0.23	0.17
Subsidy Influence	0.11	0.16	0.07	0.04	0.05	0.09	0.07	0.71	0.04	0.01
Attitude to Competition	0.13	0.02	0.17	0.03	0.17	0.22	0.33	0.60	0.11	0.08
Research & Development Level	0.32	0.35	0.08	0.20	0.14	0.14	0.16	0.51	0.17	0.01
Initiative Source	0.16	0.11	0.08	0.07	0.09	0.03	0.12	0.00	0.77	0.09
Safety Reputation	0.14	0.32	0.05	0.18	0.05	0.22	0.12	0.16	0.65	0.06
Determinism	0.26	0.17	0.03	0.16	0.21	0.23	0.36	0.17	-0.44	0.01
Broad Gauge, km	0.29	0.03	0.14	0.08	0.08	0.17	0.01	0.05	0.04	-0.81
Standard Gauge, km	0.37	0.25	0.49	0.12	0.07	0.02	0.09	0.02	0.05	0.53





North America's freight railways have been able to build on their competitive strengths with double-stack operations over long distances

Photo: Scott A Hartley

analysis, by which the statistical package reduced all the cases (the rows in the database) to a smaller number of distinct clusters. In this respect, fewer clusters is preferable to many, so I have selected four: A. Railways in Intense Competition; B. Railways in Privatisation; C. Railways in Emerging Economies; D. Constrained Railways.

While statistical packages deliver ratio numbers, it is fallacious to interpret output from ordinal data more precisely than its input. The thumbnail descriptions shown in Table III are scientifically defensible interpretations from the cluster analysis.

The following insights illustrate some of the ways in which the factors and clusters can be used to support theoretical relations between railway competitiveness, freedom and sustainability.

#### Freight versus passenger

Variables that do not load onto particular factors are as significant as those that do. Factors 1 and 2 represent antithetic archetypes: sustainable railways target freight or passengers, while strugglers embrace both.

Western Europe's low share of the rail freight market bears witness to irreconcilable contention between freight and

societal orientations. However, the emergence of dedicated, competitive, rail freight corridors, both on a continental and intercontinental scale, could revitalise the freight business. A successful outcome for the New Opera Project and/or the Trans-European Rail Freight Network programme could mark a watershed for Europe's railways.

Long-distance passenger trains in North America face a similar contention. Constrained in most instances by low speeds on infrastructure shared with freight railways, while the available heavy axleload is immaterial, the passenger operators are unable to exploit the competitive commercial strengths of high speed operation. Their generally moribund state seems consistent with this theory.

#### Competition and protection

Intense competition associates with innovation, while competitive infrastructure and operations associate with continental and intercontinental service. As Europe continues to separate its train operations from the infrastructure networks, and as Asia's Iron Silk Road projects progress, archetypal high-tech North American parallel competition offers the prospect of invigorating their freight railways.

Even as many countries tackle the ideological obstacles to on-rail and/or parallel competition, Factor 5 predicts that DB's favoured option for privatising Germany's railway as a vertically-integrated business would in fact shorten the strategic horizon, whereas vertical separation would lengthen it. The outcome of the debate will be decisive for pan-European rail freight competitiveness and sustainability.

Note nevertheless that competitive freedom, which associates with successful private participation, presupposes exploitable competitive strengths. The experiences of privatisation and concessioning in New Zealand, some parts of Africa and South America over the past 10 to 15 years show that privatisation alone cannot sustain the renewal of low axleload, low speed, railways with low networkability (p517).

#### Optimising asset life

Markets mutate continuously. Today, low-cost short-life assets are probably more effective than long-lived assets that reach commercial obsolescence before they are worn out or technically obsolete. Given that axleload and speed drive competitiveness, continuous improvement demands concurrent renewal and/or upgrading of infrastructure and rolling stock.

Factor 6 predicts that railways that only refurbish assets back to their original performance, typically state railways that shun competition, implicitly risk compromising their objectives.

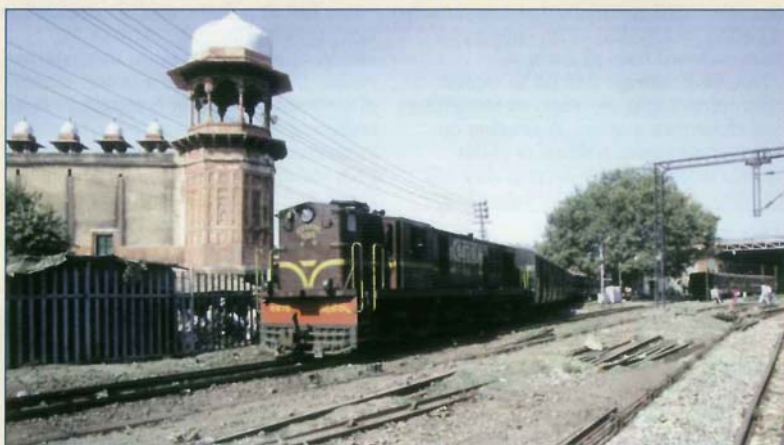
#### The gauge conundrum

Forward-thinking broad-gauge railways have recognised standard gauge's critical mass. In illustrating Factor 10, the Iberian railways have already committed to developing a standard-gauge trunk network based on the twin pillars of high speed and long-distance intermodal. Kazakhstan's

Table III: Railway Clusters defined by essential differences

A: Intense Competition	B: Privatisation	C: Emerging Economies	D: Constrained Railways
Australia, Canada, United States, Mexico	Austria, Czech Republic, Italy, Sweden, Belgium, Netherlands, Switzerland, Denmark, Norway, Finland, South Korea, Luxembourg, Germany, United Kingdom, Japan	Brazil, South Africa, China, India, Russia (all IHHA members)	All countries except those in Clusters A, B and C (77% of total count)
Freight traffic dominates	Mixed traffic, moderate freight, moderate to high passenger	Substantial freight traffic, plus significant passenger traffic	Low freight and/or passenger traffic volume
High operator or route diversity	Operator diversity trending upward	Monopolistic markets	Insignificant diversity
High networkability, continental strategic horizon	High networkability, conservative strategic horizon	Relatively low networkability, conservative strategic horizon	Low networkability, strategic horizon limited to national borders
High technology, freight competitive strengths	High technology, high-speed	Relatively high technology,	Low technology, do not exploit rail's competitive strengths
Private-sector ownership dominates, relatively long commitment horizons	Emerging to liberal private-sector ownership, moderate commitment horizon	Public ownership, relatively short commitment horizon	Public ownership, long commitment horizons
Relatively high economic freedom, relatively high national income	Relatively high economic freedom, moderate to high national income	Low economic freedom, low national income	Low economic freedom, relatively low national income
Relatively high sustainability	Moderate to relatively high sustainability	Relatively high sustainability	Low sustainability





*Indian Railways' decision to convert its metre-gauge routes was intended to improve network benefits, but a move to standard gauge might have offered more potential in the longer term*

Photo: Peter Jordan

vision of building a standard-gauge link will leverage its strategic location between the European, Middle Eastern, and Chinese standard-gauge networks.

In future, we can also expect gauge tensions to emerge in Central Asia and the Indian subcontinent. With retrospect, the ongoing programme to convert India's metre-gauge routes to broad gauge might have focused more sensibly on developing

a future standard-gauge network.

Heavy Haul strength is relatively insensitive to gauge, offering narrow-gauge railways a route to competitiveness in the appropriate circumstances. However, heavy haul movements are ideally short, whereas double-stack hauls benefit from being very long. So, for narrow-gauge railways, Heavy Haul is arguably the only entrée to globalisation, but Factor 3 indicates that it cannot support networkability. Significantly, Australia's QR, Brazil's CVRD, and South Africa's Spoornet, all heavy haulers, are the only surviving narrow gauge freight railways of any consequence.

The railways of Sub-Saharan Africa, South America, and Southeast Asia need to

address gauge and networkability before they can occupy the competitive Double-Stack market space from which their narrow gauge currently excludes them.

#### Constrained railways

Cluster D accommodates many countries whose constrained railways are at best marginally sustainable – accounting for around three-quarters of the world's current total of countries with line-haul railways. The rites of passage for these railways to enter the world of globalisation will require a transformation to a sustainable cluster, by the introduction of one or more of Heavy Haul, High Speed or Double-Stack. At the same time, it will be essential to attain a degree of liberal competition and private ownership.

Railways that are already in this position have all passed through a period of considerable turbulence. Those that are not yet there face a turbulent future. But the alternative is uninviting. At least we now have some insight into the numbers, which can help the industry to make informed strategic decisions. ■

#### References

1. Van der Meulen R D and Möller L C. Leveraging insight from developed into developing regions. World Congress on Railway Research, Montréal, June 2006
2. Further details of the Railway Globalisation Database can be found at [www.railcorpstrat.com](http://www.railcorpstrat.com)



### RAILWAY CORPORATE STRATEGY CLOSE CORPORATION

Railway Corporate Strategy CC undertakes work in the themes  
of railway corporate citizenship and strategic intent

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