# INDUSTRIAL AGE MEETS INFORMATION AGE: HEAVY HAUL AS SURVIVAL STRATEGY FOR FREIGHT RAILWAYS

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## Abstract

Global competition dismisses tolerance for non-competitive transport modes. Information technology fragments value chains and disintermediates ineffective players, thereby destabilising or destroying traditional business models. In that milieu, railways typically adapt to strategic challenges by deregulation and competition. It has forced railways to re-examine their core competencies and to add value to their traditional offerings. Within a strategic consistency paradigm, the writer examines freight railways vis-à-vis road-haulier competitors. From the premise that freight railways require impregnable competitive advantage to survive, he formulates the hypothesis that they can only survive in the information age where they can leverage heavy-haul technology to advantage. At present this appears viable only in high-volume, dedicated, bulk-commodity traffic and double-stack intermodal traffic.

## 1. INTRODUCTION

The author reviews patterns in contemporary freight railway industry strategic development from three distinct perspectives. First, he examines corporate strategy in an open-systems paradigm. The field is refining its understanding of the fit between an organisation and its environment. Second, he examines railways as competitors in the logistics and transportation business ecosystems. They are in turn being continually redefined by environmental changes to which railways have adapted both voluntarily and involuntarily. Third, he evaluates the railway industry's response to the foregoing issues. Emphasis on client needs rather than modal peculiarities has seen the offerings of competing modes converge. Last, within the context so established, the author hypothesises how freight railways might survive into the next century.

## 2. ORGANISATION-ENVIRONMENT CONSISTENCY

### 2.1. Context

The notion *consistency* describes an organisation's mesh with its environment. It has served as foundation for much organisational behaviour and strategic management research. One may alternatively term consistency adaptation, alignment, co-alignment, congruence or fit. It addresses the many ways in which organisations adapt to their environments. One or more of choice, contingency, ecology, and enactment underpin strategic consistency between organisation and environment. Organisations manage their behaviour to the degree that they can purposely affect their domain (Van der Meulen, 1994: 38). The information age has accelerated the dynamics and extended the scope of organisation-environment adaptation.

## 2.2. Adaptation modes

The organisational ecology paradigm rests on open systems theory (Wilson & Rosenfeld, 1990: 325). It posits that organisations in a population exploit opportunities in niches, the latter being the confluence of resources, demands and constraints, that both facilitate and constrain their performance (Zammuto, 1988: 106). Environmental selection differentially favours different strategies under different conditions. Managerial choice or enactment may moderate organisational effectiveness within this paradigm. The information age provides dramatic empirical evidence of organisational ecology in action. In global commercial hot spots, emerging new business organisations do not respect traditional industry paradigms and partitions. They tend rather to upend business and industry models, and to redraw increasingly porous boundaries. Business ecosystems are supplanting traditional industries. Conventional outright competition is fading: Nevertheless, competition per se is not vanishing, but intensifying. Business organisations need to co-evolve with others in their environment, a process that involves conflict, as well as co-operation through strategic alliances (Kefalas, 1995: 73; Moore, 1996: 78).

Apropos this paper, markers are discernible in the transportation value chain at two strategy levels. *Macro-adaptation* occurs at corporate strategy level. For example, the United States' 1991 Intermodal Surface Transportation Efficiency Act identified a shift in transportation priorities: There was a need to optimise the yield from existing resources, rather than to rely solely on system expansion (U.S. Department, 1994: Foreword). That intervention aimed to exploit organisation-ecological action to deliberately apportion modal shares in a sensible, symbiotic way. *Micro-adaptation* occurs at business strategy level. For example, reduced intervention in transport markets has stimulated transport supply industries to modify their management practices. They exploit real-time information systems, to closely control their operations and rapidly adapt their strategies to evolving market trends (Brooks & Button, 1994: 177). The recent ascendancy of yield management is an example of how information can enhance, or even transform, a business (Davis & Botkin,1994: 165) through fine-tuning organisation-environment adaptation.

## 2.3. Complex adaptive systems

The foregoing section rests on a widely accepted system dynamics assumption, namely that negative feedback processes drive successful systems toward predictable states of adaptation to the environment (Stacey, 1995: 477). However, during the past quarter-century, the economy's centrifugal, fractionating forces—globalisation, technological change, deregulation—have grown stronger than its centripetal, conglomerating forces—economies of scale and scope (Stewart, 1995b: 197). Evidently, positive feedback is complementing negative feedback as the information age overtakes the industrial age. Conventional economic theory rests on negative feedback, that yields diminishing returns and single-point predictable equilibrium for prices and market shares. However, positive feedback, that yields increasing returns, makes for many possible equilibrium points (Arthur, 1994: 81). Studies of the dynamics of non-linear and network feedback systems have revealed that, to produce creative, innovative, continually changeable behaviour, they must operate far from equilibrium, to drive them to paradoxical states of stability and instability, predictability and unpredictability. Two properties of such systems apply to organisations, namely bounded instability, plus spontaneous self-organisation and emergent order (Stacey, 1995: 478, 481).

## 3. KEY ATTRIBUTES OF RAILWAY ENVIRONMENTS

### 3.1. Broad issues

#### 3.1.1. The competitive milieu

The next wave of economic growth will come from knowledge-based business (Davis & Botkin, 1994: 165). Massive, cheap computing power has fragmented traditional value chains. Deregulation has changed the economics of transportation, telecommunications, and other services (Stewart, 1995a: 90). In an economy of readily replicable goods and services, conventional analysis is, at best, only marginally relevant (Clarke, 1994: 39): Revenues, not assets, are now the best measure of size. Rapid product and process innovations are essential to sustain competitive advantage, as speed-based organisational processes accelerate technological change (Bettis & Hitt, 1995: 7). The strengths of the industrial oligarchy are yielding to deregulation, technological upheaval, globalisation and social change (Hamel, 1996: 70). Freight railways need strategies that will align them to that milieu. In Table 1, the author explores some indicators of how this environment has influenced transportation. It emanates from the *Fortune* rankings of the 500 largest United States' and Global corporations. In recognising the dominance of the

**Table 1: Some indicators of the state of the transportation industry**

| INDUSTRY REVENUE US$ x $10^9$ | THE *FORTUNE* 500 (1) | | | | | THE *FORTUNE* GLOBAL 500 (2) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1994 | Share % | 1995 | Share % | Y-on-Y % | 1994 | Share % | 1995 | Share % | Y-on-Y % |
| Airlines | 73.0 | ***17.3*** | 75.6 | ***16.7*** | ***3.6*** | 108.2 | ***13.1*** | 104.2 | ***11.3*** | ***-3.7*** |
| Mail, package, freight delivery | 33.7 | ***8.0*** | 36.8 | ***8.2*** | ***9.2*** | 139.4 | ***16.8*** | 168.8 | ***18.4*** | ***21.1*** |
| Pipelines | 28.0 | ***6.6*** | 31.0 | ***6.9*** | ***10.7*** | No data | No data | No data | No data | No data |
| Railroads | 39.4 | ***9.3*** | 37.1 | ***8.2*** | ***-5.8*** | 107.4 | ***13.0*** | 112.9 | ***12.3*** | ***5.1*** |
| Shipping and marine | 4.0 | ***0.9*** | 3.9 | ***0.9*** | ***-2.5*** | 17.9 | ***2.2*** | 19.6 | ***2.1*** | ***9.5*** |
| Telecommunications | 227.3 | ***53.8*** | 248.7 | ***55.1*** | ***9.4*** | 454.8 | ***54.9*** | 513.3 | ***55.9*** | ***12.9*** |
| Trucking | 17.4 | ***4.1*** | 18.3 | ***4.1*** | ***5.2*** | No data | No data | No data | No data | No data |
| Total | 422.8 | 100 | 451.4 | 100 | ***6.8*** | 827.7 | 100 | 918.8 | 100 | ***11.0*** |

(1) *Fortune*: May 15, 1995, pp. 178 *et seq*. and April 29, 1996, pp. F-43 *et seq*.
(2) *Fortune*: August 7, 1995, pp. F-15 *et seq*. and August 5, 1996, pp. F-15 *et seq*.

information age, this periodical combined previously separate industrial and service businesses into a single list since 1995 (statistics of 1994). One can therefore, regrettably, only rigorously compare this source for the two immediately past years. Nevertheless, note how industries that offer information-oriented alternatives to physical movement (mail, package- and freight delivery, telecommunications), outstrip both the revenue share and year-on-year growth of those that offer freight-oriented physical movement (airlines, pipelines, railways, shipping, trucking). Note also that the revenue of the freight railway industry in the United States, where overland transportation is relatively more prominent than shipping in a global context, is skidding. The relevant columns are in boldface italics. The author presents this table on the strength of the reputation of its source, recognising that many caveats will spring to the mind of critics who prefer a representative sample to one skewed toward a particular stratum.

### 3.1.2. Logistics solutions

The competitive milieu described above is changing the very nature of meeting human needs and wants. New technologies enable mass-customisation in many industries and alter the economics of product variety (Bettis & Hitt, 1995: 7). The notion of virtual reality shopping means directing capital to warehousing and delivery systems, not into new store designs that will soon be obsolete (Popcorn, 1992: 109, 112). Production or value-adding facilities are gravitating to raw material sources, so that only higher-value finished products require transport. The result is a move towards smaller consignments and containerisation ("Improving customer," 1995). The means of distribution will be the next consumer-oriented revolution. Direct shopping from producer to consumer will disintermediate go-betweens and retailers: Home delivery will become a way of life. One truck delivering to many customers will use resources more efficiently than many customers driving to stores (Popcorn, 1992: 165). In future, logistics firms will receive and process major deliveries from different manufacturers, at distribution hubs on the edges of major conurbations, and then distribute them into cities in smaller loads. Outsourcing everything from order processing through warehousing to delivery will allow logistics solutions providers' customers to concentrate on what they do best, namely producing the goods (Keeler, 1995: 70). How meaningfully railways will participate will depend on how competitively they deliver their core competencies, what added value they offer, and on how seamlessly they interface with other players.

### 3.1.3. Intermodalism

In major economies around the world, different modes of transport are seeking to co-operate with one another in intermodal- or combined transport. In Europe, trans-national transport networks provide sustainable freight transport: This means using all modes of transport in combination, with due respect for their comparative advantages (Schulze, 1994: 8). In the United States, new information technology and sophisticated logistics operations, including just-in-time delivery, facilitated by deregulation and competition, have driven substantial increases in intermodal freight traffic (National Commission, 1994: 9). Globally, the seacoast ports that handle international container traffic are beginning an era of consolidation. Manufacturing and distribution patterns change constantly, and these external forces will affect system design (Carmichael, 1994: 128-129). In this milieu, customers expect to experience the following attributes; delivery quality, service reliability, equipment availability, fast transit, minimal damage, acceptable price, accurate billing, equipment quality, status reporting, quality salespersons and electronic data interchange capability (Welty, 1994: 36). Railways will have to integrate seamlessly with their partners to meet those expectations.

### 3.2. Competitors' technological thrusts

World-wide, freight railways have experienced intense competition in recent years. Rates have fallen and railways that dared charge a premium have seen market share fall (Kazimirski, 1994: 75; "NZ rail," 1995: 23). Stretching limits to gain competitive advantage is a natural consequence. Railways have increased axle load in heavy-haul operations, raised height by double stacking, and realised high speeds through sophisticated train control. Railways and their competitors obey the same natural laws, whence stretching physical constraints on trucks can also reduce the cost of moving goods. Serendipitously for the road freight industry, cost savings due to more efficient trucks generally exceed the concomitant additional pavement and bridge costs (Transportation Research, 1990: 14). Consider now three competitive thrusts by that industry, setting aside service quality issues for the moment. These are raising permissible axle load, and raising permissible combination length and gross mass—note that safety considerations and increasing congestion generally preclude road hauliers from following the railways' lead regarding permissible speed. The author examines only the range of the variables mentioned. He argues that, after taking cognisance of error variance, a narrower range indicates the existence of grounded theory, and a wider range indicates the existence of omitted or latent variables. Globally, innumerable premises and exceptions govern permissible truck size and mass. One could arguably examine the concomitant variance by controlling for traffic flows and the economic value of the associated services, but such complexity exceeds the scope of this paper.

#### 3.2.1. Axle load

Permissible axle load appears to be one of the more scientifically grounded limits imposed on trucks. Being a thoroughly researched engineering topic, the relations between technology and economics seem well understood. This paper therefore does not examine such relations, but merely gauges the range of permissible axle load variation. Globally, examples range from around 18.8 tonnes to around 24.5 tonnes, on a tridem axle (American Trucking Associations, 1995): The most liberal exceeds the most conservative by some 30%. The range of permissible loads on steering and non-steering single-, and tandem axles is somewhat smaller. Nevertheless, some real-world situations belie the understanding: Direct and indirect charges for road use often appear to rest on political expediency rather than on modal equity.

#### 3.2.2. Combination length

This discussion concerns intercity traffic, where road competes directly with rail: Trucks that serve congested or antiquated city centres do not compete directly with rail, and their length is not now pertinent. As for railways, road hauliers seek economy of scale by operating multiple vehicles in combination. Familiar configurations include a truck drawing two drawbar trailers, a tractor drawing a semi-trailer and two drawbar trailers, and a tractor drawing two semi-trailers. Maximum permissible combination length is thus a crucial competitive issue. The impact of physical length seems less well understood, because the range is greater than for axle load. Globally, examples range from around 22 metres ("Maximum mass," 1996: 9-11) to around 36.5 metres (American Trucking Associations, 1995): The most liberal exceeds the most conservative by some 70%.

A range larger than that of permissible axle load indicates the presence of softer, less quantifiable constructs. Ever longer vehicle combinations fit increasingly badly on existing roads, designed to bygone geometric requirements. Economic imperatives encourage, on the one hand, tolerance of the concomitant hazards and, on the other hand, formalised permission to exceed normal limits in accessing terminals and services. One hazard is that longer vehicle combinations cannot make nearside turns at most local intersections, without either running over the curb, or encroaching into the oncoming lane on the offside. This poses a danger to other road users and pedestrians (Haight, 1994: 86). Another hazard is that drivers must trade-off the dangers of low-speed and high-speed off-tracking ("Safety debate," undated: 37-42). Such hazards are geometrically definable or dynamically measurable, but not readily economically or technically quantifiable. They lead to emotional assertions that longer trucks are inherently more dangerous (Bosco, 1995: 3), absent a grounded theoretical foundation for decision making.

### 3.2.3. Gross vehicle mass

Longer combination length ultimately stimulates higher gross vehicle mass (GVM). Such vehicles tend to spread their mass over more axles: They do not increase pavement wear, but may even cause less damage than shorter combinations ("Report questions," 1994: 51). However, constraints on GVM seem less well understood, for the range is greater than for both axle load and vehicle combination length. Globally, examples range from around 28.0 tonnes (Lewis, 1996: 5) to around 64.9 tonnes (American Trucking Associations, 1995): The most liberal exceeds the most conservative by some 130%.

The limits apparently encompass several considerations or latent variables other than GVM. Several, diverse, arguments exist to justify GVM restrictions. Heavier trucks are allegedly incompatible with other traffic. They travel more slowly on upgrades, and, on two-lane, two-way roads, increase the incidence of illegal passing manoeuvres (Claybrook, 1994: 9). Some observers report insufficient traction for climbing hills in wet weather (Bosco, 1995: 4). Austria and Switzerland deter mammoth trucks to placate environmentalists (Kazimirski, 1994: 75). There is criticism regarding loss of driver control due to wheel lock-up during braking, leading to jack-knifing, and the ability to meet stringent stopping distance requirements. However, both seem to respond adequately to anti-lock brakes (Insurance Institute, 1994), which are now available globally. In the limit, however, only a bridge formula, or equivalent prescribed minimum axle spacings, retain credibility as an equitable upper limit on GVM (Transportation Research Board, 1990: 3, 8).

### 3.2.4. Emotion versus science

Incomplete understanding and unscientific arguments regarding truck size and mass have left a legacy of more-or-less arbitrary sanctions that stakeholders can manipulate for devious or selfish purposes. Some examples, which by their nature can never be exhaustive, follow. They illustrate the partisan lines that separate present reality from the elusive level playing field.

*Measurement of transport activity* tends to be contextual rather than absolute. The conventional units of output are vehicle-kilometres or tonne-kilometres. The cost thereof can assume two meanings—either *cost to supplier* or *cost to user* (Milne & Laight, 1963: 76): In practice they can differ considerably. One could, therefore, argue that the contribution of an activity to *profit* or *value*, respectively, is ultimately a more appropriate unit of output for evaluating constraints on vehicle size and mass.

*Permits for over-length and over-mass vehicles* can control movement, where it is invaluable or undeniable. Furthermore, an appropriate fee structure presents an opportunity to charge users for additional costs. By contrast, tolls proportionate to damage never seem to happen. Presumably toll authorities do balance revenue against amortisation, maintenance and profit over the life of their investments. In the quest toward equitable road user charges, licences and fuel taxes seem also to generate more contention than contentment.

*Interference between heavy trucks and citizens' quality-of-life* elicits political responses. Examples are: Regulated power-to-mass- and traction ratios to address objections to inadequate heavy vehicle performance; bans on weekend, public holiday and night road collection and delivery services in intermodal transport within the EU (Schulze, 1994: 7); and GVM limits for environmental protection.

*Economic and natural laws apply universally*, but incomplete understanding may allow aberrant limits to co-exist with grounded ones. Furthermore, inability or reluctance to enforce them can cause differences between *de jure* and *de facto* limits, thereby distorting the competitive balance between modes. Nevertheless, the author expects that global competitive forces will roll back constraints on truck size and mass until the industry converges on technologically hard, economically defensible, universal limits.

## 3.3. Liberation from social obligation

### 3.3.1. Attitudes to railways

In the competitive global economy, countries with high-cost railways are at a disadvantage, because railway inefficiency increases the cost of export freight. Their railways also increase the cost of domestic freight and, by losing traffic to road hauliers, increase road congestion (Rennicke, 1993: 12). Furthermore, given their meagre share of the general freight market, one can no longer consider many of the services rendered by railways to be essential (Viegas, 1995: 13). Many governments have thus concluded that their railways need fundamental, rather than incremental, change (Rennicke, 1993: 12). They are increasingly unwilling to subsidise their railways, and the notion of infrastructure investment by government is currently unpopular. These considerations have promoted a trend towards commercialisation or privatisation (Clarke, 1994: 10; Knutton, 1995). Economically savvy societies thus show a dispassionate face to railways.

### 3.3.2. A new direction

Given the foregoing attitudes, observers variously perceive railways as expensive, inflexible and inefficient. However, none of these conditions is necessarily true (Bradshaw, 1996: 43). The role of railways in the economies of nations is changing from developmental to business. When nations relieve their railways of traditional social burdens, they free them to adapt and become vibrant. The government-owned, heavily subsidised enterprise is thus in discredit. Nevertheless, reforms toward privatisation and market economies come spasmodically (Carmichael, 1995: 15). Evidence from around the world substantiates the trend. In the United States, deregulation encouraged the concentration of Class I railways, the emergence of many short line railways, and the coalescence of several regional railways, leading to a new, symbiotic, industry structure. In Mexico, privatisation seeks the development of a modern, efficient, competitive rail network to support a growing economy ("Sale of," 1995: 28). In Europe, state railways should aspire to the United States' freight model, where taxes replace subsidy and costs per tonne-kilometre are half, but they need to consider selling off their freight business to make it work ("Health check," 1995). In New Zealand, privatisation claims success: Tranz Rail is in business for the long haul and for growth ("NZ rail," 1995: 22). In analysing such transformation, it is important to consider government attitudes toward business and free markets, and toward railways in particular (Burkhardt, 1995: 856).

The liberation process typically concerns existing investments, not new investments that comply with contemporary thinking from the outset. The key to future success lies with government strategy on charging for infrastructure and equalising competitive conditions vis-à-vis road transport (Poinssot, 1994). However, it is not a simple cost decision, because many service intangibles influence users' modal choice. The process has developed characteristic modalities that include one or more of: Aversion to government involvement on the one hand, and reluctance of governments to get involved on the other hand; commercialisation; concessioning; deregulation; full cost recovery; infrastructure and operator separation; open access; privatisation; track sharing; and user pays all. Note that these ideas do not offer a panacea, but rather offer a migration path from historical strictures to current reality, by enabling open systems theory to take its course through enlightened corporate governance. Furthermore, some are mutually exclusive, some are necessarily sequential, and some do not support the heavy-haul way.

## 4. THE RAILWAY INDUSTRY'S STRATEGIC RESPONSE

### 4.1. A bifurcation of business areas

#### 4.1.1. Customers' value chains

Freight railways compete with other overland transport modes such as belt conveyors, pipelines and road hauliers. Their market has a propensity to regard physical movement as cost one should avoid, rather than added value one should desire. Their customers' entire value chain includes a wide variety of financial, information and logistics services. By contrast, high-speed passenger railways compete with airlines and highways. Their customers' entire value chain also includes a wide variety of accommodation, complementary transport, financial and reservation services: Anything like alternative travel arrangement packages and video conferencing threaten it. For both freight and passenger railways, survival depends on offering products and services that attract willing buyers. As freight and passenger railways adapted to their changing environments, their respective value chains diverged. Originally passenger and freight railways could coexist: Nowadays high-speed passenger- and core freight traffic is increasingly incompatible. Whereas physical movement once provided the cohesion, it now represents only one of many value-chain elements: Other elements in their respective value chains hardly intersect. Their preferred infrastructure differs fundamentally. High-speed passenger trains need easy curves, but accept relatively steep gradients; freight trains need easy gradients, but accept relatively tight curves. Accentuating these differences through deliberate segregation is attractive. One could reduce maintenance standards on freight-only lines, reducing cost compared to maintaining them for mixed traffic. Capacity would also increase significantly, because one could path more trains if they ran at the same speed (“Freight and,” 1996).

#### 4.1.2. Development landmarks

It is remarkable how the Elmer A. Sperry Award has highlighted first the genesis of high-speed passenger railways, then the heart of heavy-haul equipment, and ultimately the convergence of intermodal- and heavy-haul technology. The award recognises distinguished engineering contributions that, through application, proved in actual service, have advanced the art of transportation, whether by land, sea or air (ASME, 1994). In 1966 it cited the design, development and construction of the New Tokaido Line, with its many important advances in railway passenger transportation. In 1987 it cited the development and application of curved-plate railway wheel designs, to support the heavy axle loads and increased speeds that underpin freight railway competitiveness. In 1994 it cited the conception, design and development of the slack-free connector for articulated railway freight cars, that finally united heavy-haul and intermodal train technology. Apropos their broad transportation context, these landmarks clearly expose the basic pattern of contemporary freight railway strategic development.

### 4.2. Reinventing rail freight business

Freight railways are reinventing their business to meet competition from road hauliers. They re-engineer service processes into co-ordinated, disciplined interconnecting systems that approach road haulier reliability, door-to-door. They plan trains to arrive on time. Given sufficient volume, they schedule entire trains to one destination. On low-volume branch lines they schedule weekly trips (Reistrup, 1996: 7). Train coupling and sharing has reduced the high cost of forming and separating trains. This arrangement uses train paths optimally, because longer trains occupy fewer paths for the same volume of traffic (Jahnke, 1994). Initiatives such as these are additional to continual advances in railway-specific technology.

From an information technology perspective, the foregoing initiatives demand an increasing menu of variables that operators need to manage to meet ever higher service levels. The complexity of railway networks is frequently such that unaided human intellect can neither understand nor predict its behaviour. Many observers therefore view some form of interline service management system as essential to achieving seamless transportation (Richter, 1995: 31). Regarding scope, they address transit and delivery of traffic moving either entirely or partly by rail. Regarding level, they may progress from organisational sub-structures within a single railway, through contiguous railways within a country or region, and on to intermodal movements, alliance partnering and logistics services on global scale. In this milieu, freight railways compete, on the one hand with logistics service providers, and simultaneously, on the other hand, with road hauliers and other low-cost operators. Value chains are fragmented, and disintermediation is an ever-present risk: Note also that other traditional industries have become increasingly characterised by positive feedbacks as they have adopted new technologies (Bettis & Hitt, 1995:10).

## 5. DEVELOPING A HYPOTHESIS

### 5.1. Converging modal characteristics

As value chains become fragmented, the market demands service quality that depends less on mode, and more on particular operators working together seamlessly with other modes or operators, as well as with logistics solutions providers. Indeed, as road hauliers continually lower their costs through using longer combination vehicles, they must, like railways, consider investing in collection and distribution depots. Conversely, as railways continually improve service levels by eliminating the cost and delay of collection and distribution, they must, like road hauliers, consider agility in process changes and resource deployment. A convergence of characteristics erodes advantages over an opposing mode, thereby suggesting opportunities for strategic alliance rather than outright competition. A critical question for railways is therefore: As they try to look like road hauliers, what will give them a distinct competitive advantage? Imitation does not seem to be a sound strategy for an industry characterised by long-term, capital-intensive investments. Rule-taking is depressingly futile as a strategy (Hamel, 1996: 69).

Consequently there seems to be no long-term role for full-range, full-service providers. Unless companies segment and focus, they will find competitors picking off profitable niches and offering them improved service at lower costs (Braithwaite, 1992: 9). As a mode in organisation-ecological interaction with other players, freight railways thus need to develop sustainable niches. However, one must appreciate that a *profit engine* differs from a *value chain*. A profit engine encompasses convictions about what business an organisation is in, what it delivers to customers, how it makes money, what assets and skills are critical, and who its competitors are (Hamel & Prahalad, 1994: 64). Where road hauliers and railways compete in a similar market, road hauliers are currently more flexible and offer a door-to-door service. By contrast, railways enjoy the perception that they are more efficient and cost-effective in moving freight over longer distances. Internationally, thus, a trend to co-operate is emerging between the two modes, to maximise the benefits to each ("Improving customer," 1995). However, in distinguishing profit for the operator, from value for the customer, critical questions are: What criteria determine the choice of carriers to execute a particular sequence of movements? How do principals choose a mode in each sector of an intermodal movement? How feasible is participation in logistics service provision by particular transport operators?

### 5.2. Conditions for survival

In the competitive milieu described above, what can freight railways do to survive? They need an invincible competitive advantage, a unique selling proposition. The forces of organisational ecology have already encouraged many of them to target low value commodities, where cost outweighs other transportation considerations. This phenomenon stereotypes railways as relics of the industrial age, of which the industry is indeed a founder member. Those parts of the economy that are resource-based, such as agriculture, bulk-goods production, and mining, are still largely subject to diminishing returns. In associating with them, railways seem to confirm their stereotype. However, those parts of the economy that are knowledge-based, are largely subject to increasing returns (Arthur, 1994: 83-84). Freight railways will, by implication, have to meet two conditions to enter the information age. First, they need to acquire sufficient agility to follow positive feedback to many possible equilibrium points. Second, they need to offer some invincible advantages to qualify as an alliance partner of choice. Railways are addressing the first condition, by re-engineering to exploit information technology in their businesses, as mentioned in section 4.2. However, the author argues that this is not a sufficient condition for survival, because it does not pre-empt the choice falling on cost-competitive modes in sectors where both operate. The author therefore offers the following hypothesis:

> ***In a globalised, informationalised environment, freight railways can only survive in niches where permissible speed and axle load are sufficient to give them an invincible advantage over road hauliers.***

This hypothesis places heavy-haul technology at the forefront, of the freight railway industry's strategy for survival into the next century. During continual development, it has raised these two critical limits, namely speed and axle load, to respectively twice and five times as high as road competitors. Around the world, unit trains conveying bulk commodities have established the credence of the heavy-haul way. Over the last decade, intermodal traffic has also emulated its economic and operational virtues, through double-stacked containers on articulated railway cars. However, conventional economic analysis has limitations in a world where organisational ecology, positive feedback and bounded instability make for many possible equilibrium points: Time will therefore test this hypothesis. Nevertheless, it is useful to explore some bounds on the probable outcome space, as in the next section.

## 6. CONCLUDING DISCUSSION

### 6.1. Breakthroughs needed

Infrastructure and equipment, to support heavy axle loads and relatively high speeds concurrently, seem viable only on routes where traffic volume can justify substantial investment. This solution works for higher-volume bulk commodities, but can double-stack-and-articulate work for lower-volume intermodal routes? To merely raise permissible axle load, absent a base load of bulk-commodity traffic with which to share common costs, seems absurd. Even though intermodal traffic may generate revenue in both directions, lack of evidence to the contrary suggests that double-stack-and-articulate is probably not viable by itself, other than in isolated niches. Track sharing may improve utilisation (Murphy, 1995: 47), as may the European notion of open access: However, the hypothesis suggests that intermodal traffic may only be viable in a symbiotic relationship with heavy, bulk-commodity traffic. It will be interesting to follow the future adaptation process of freight railways in Western Europe, where heavy haul has been inconspicuous and competitors have pillaged their market share. Freight railways thus need breakthroughs, in their specific technology, to drive heavy-haul costs still lower, to prepare them as alliance partner of choice in competition with aggressive road hauliers. The prognosis for railways that do not exploit heavy-haul technology to reduce costs, but cling to traditional practices, looks bleak.

### 6.2. Constraints …

The freight railway industry has established competitiveness through heavy axle loads on both standard and narrow gauges, as well as double-stacked articulated container trains on standard gauge. However, on narrow gauge, the possibility of double-stacking to raise axle load seems remote: Inadequate stability against lateral disturbances and overturning by wind loading, and conservative fixed-structure gauge, are critical issues. Perhaps, on narrow gauge, only bulk commodities are amenable to the heavy-haul way. This constraint could represent a strategic obstacle to development of freight railways in regions where extensive narrow-gauge networks exist, such as in Southeast Asia and Sub-Saharan Africa. Naturally, the additional constraint imposed by overhead catenary on electrified lines applies, independently of track gauge.

### 6.3. … and challenges

The author examined organisation-environment consistency generally, as well as in the context of information-age drivers. Organisational ecology and positive feedback oblige business organisations to adapt, through seeking out multiple equilibrium points within a bounded-instability outcome set. Contemporary environments are dispassionate to railways' legacy from the era of regulation and intervention, but willing to liberate them to adapt to the challenges of a new paradigm. In a deregulated and competitive environment, freight railways may transform from their industrial-age guise to seek a new gestalt in the information age. There is evidence that this liberty leads to stability and even growth, but there is also evidence of churning within the organisational-ecology pecking order. Given the natures of organisational ecology and positive feedback, alternate outcomes should not surprise. One should, therefore, ask whether current owners, and new investors, are harvesting their domains, through restructuring assets, franchises and ownership to conclude an organisation's life cycle, or are creating a new, sustainable order. There appears to be scope for exploratory research and scenario development regarding the emerging form, role and scope of freight railways, so that resource planning and allocation can address the long-term commitments that will probably still characterise the industry for years to come.

### 6.4. A way forward

The railway industry's fundamental strategic response, in moving from the industrial age to the information age, has been to bifurcate passenger and freight business areas and then reinvent them. Apropos freight railways, the response emphasised using information technology to manage service delivery, to follow positive feedback to whichever of many possible equilibrium points may emerge. They therefore need to acquire relevance to business ecosystems that subsume several other players, and to leverage their competencies and those of the other players. Regarding contributions to extended, complex, value chains, several questions arise. Do freight railways have the wherewithal to offer more than merely low-cost physical movement? What competencies might distinguish low-cost movement providers who aspire to participate in a higher-order environment of logistics solutions, from entrenched participants? Which player dominates an extended value chain, and which one controls the freight logistics portion thereof? The competencies required to manage a successful heavy-haul railway seem, prima facie, to differ from those required to manage alliances and networking. At the same time, information-age freight business opportunities seem to need the symbiotic support of heavy-haul technology to make railways cost-competitive with other modes. There thus appear to be opportunities for research into the role that freight railways can play vis-à-vis national, regional and global logistics industries.

## ACKNOWLEDGMENT

The author thanks Mr. G. Parker for his thoughtful comments on this paper.

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