Some insights from long, heavy, freight trains

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Structure of this presentation

1. A selected South African heavy haul chronology
2. A worldview on transport modes
3. Some insights from long, heavy, freight trains
4. Potential for alignment and cooperation
A selected South African heavy haul chronology
1976:
Sishen-Saldanha in service

26 tonnes/axle, 202 cars, 21 000 tonnes

Line profile:
0.4% ascending
1.0% descending
1976: Ermelo-Richards Bay in service

20 tonnes/axle, 80 cars, 6 400 tonnes, 1.52% ascending
1978: Ermelo-Richards Bay

Driving is a cognitive task

160 cars, 12 800 tonnes
1978: Ermelo-Richards Bay

Driving is a cognitive task

160 cars, 12 800 tonnes
1985-9: Ermelo-Richards Bay
Axle load increased to 26 tonnes ...

New CCL$^{-5}$ cars, compared to old CCL$^{-3}$ cars
1985-9: Ermelo-Richards Bay

... ascending grades eased to 0.63%

New CCL$^{-5}$ cars, compared to old CCL$^{-3}$ cars
1988:
A 200-car coal train...

26 tonnes/axle, 20800 tonnes, 4 x Class 11E leading...
with manned helper locomotives

26 tonnes/axle, 20800 tonnes, 6 x Class 34 helping
1989: Ermelo-Richards Bay 200-car trains

26 tonnes/axle, 20800 tonnes, 4 x Class 11E at head-end only

Line profile:
0.625% ascending
1.52% descending
1983-93: Optimized sensory feedback

Systemic relations

- Instruments
- Driver
- Locomotive
- Time
- Topography
- Control Modulation
- Traction & Braking
- Local Feedback
- Sensory Feedback
1983-93: Optimized sensory feedback
Friction/dynamic braking balance
1983-93: Optimized sensory feedback
Curves shaped for intuitive feel

< Speed >

Tractive Effort

Braking Effort
1989:
World record freight train
70,000 tonnes, 7,300 meters, 660 cars, 861 km
1994: Full-motion driver training simulator
1994: Mercer Management Consulting benchmark

Spoornet rated global cost/net tonne-km leader

Coal
Iron ore
1998: 300-car automatibility test train
Segmented power & braking

300 cars, 34 300 tonnes, leading locomotive consist
1998: 300-car automatibility test train

Segmented power & braking

300 cars, 34 300 tonnes, instrumentation & 2\textsuperscript{nd} locomotive consist
1998: 300-car automatibility test train

Segmented power & braking

300 cars, 34 300 tonnes, third locomotive consist
1998: Intelligent multiple-unit cable

Enhanced flexibility: Electric & diesel locomotives in multiple
1998: Intelligent multiple-unit cable

Inter-locomotive equipment
1998: Intelligent multiple-unit cable

Driver's controls
1999: Pilot scheme

Electronically-controlled pneumatic (ECP) braking & distributed power

A wireline controls train braking and remote locomotives
1999: Pilot scheme
Electronically-controlled pneumatic (ECP) braking & distributed power

Car control device
1999: Pilot scheme
Electronically-controlled pneumatic (ECP) braking & distributed power

Overlay electronic equipment
1999: New 30 tonne/axle car for Orex

Self-steering bogies
Where next?

• Several slides have presented incremental advances in recent years
• One can continue extending limits, but is that all there is?
• Same for high-speed intercity passenger?
• Where can railways find a quantum advance, a competitive breakthrough?
A worldview on transport modes ...
Three degrees of freedom of translation:
Longitudinal, lateral, & vertical

High mobility, high cost
Three degrees of freedom of translation: Longitudinal, lateral, & vertical

High mobility, high cost
Two degrees of freedom of translation:

- Longitudinal & lateral

Less mobility, surface loading is an issue
Single degree of freedom of translation: Longitudinal only ...
... constrains origin-destination versatility

Offers precise application of load, plus secure guidance
Single degree of freedom of translation: Longitudinal only ...
... constrains origin-destination versatility

Offers precise application of load, plus secure guidance
What compensatory trade-offs ...
What compensatory trade-offs ...

Heavy axle load

High speed
What compensatory trade-offs ...

<table>
<thead>
<tr>
<th>Heavy axle load</th>
<th>Light axle load</th>
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... give competitive advantage?

- Heavy axle load
  - Heavy haul
  - Intermodal

- Light axle load
  - Intercity
  - Low speed
  - High speed
... and invite predatory attacks?

Heavy axle load
- Heavy haul
- Intermodal

Light axle load
- City rail
- Intercity

Low speed
High speed
... and invite predatory attacks?

- **Heavy axle load**
  - Heavy haul
  - Intermodal

- **Light axle load**
  - Wagon-load freight
  - Intercity

- **Speed**
  - Low speed
  - High speed
... and invite predatory attacks?

- Heavy axle load:
  - Heavy haul
  - Intermodal

- Light axle load:
  - Railway mode is ecologically vulnerable
  - Intercity

- Low speed
- High speed
... and invite predatory attacks?

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Low speed  High speed
and invite predatory attacks?

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Having three profitable quadrants

Heavy axle load

Heavy haul

Intermodal

Intercity
Rites of passage to railway profitability

- Japan & Europe have reached the high speed quadrant
- Several countries have reached the heavy axle load quadrant
  - Australia, Brazil, Canada, China, Russia, South Africa, and United States are members of the International Heavy Haul Association

United States, Canada, & Australia have
Some insights from long, heavy trains ...
Heavy haul *can do*:

- High throughput capacity
- High asset utilization
- High labour productivity

What can one leverage off this foundation?
Heavy haul exposes aspects of global role of railways

- Recognize what railways can do that other modes cannot do
- Recognize what railways cannot do well
- Regard the four quadrants as distinct modes, with own attributes and identity
- Recognize the presence of divergent and convergent drivers
Divergent drivers:

**Passenger & freight stress**

High speed intercity trains:

- Require wide curves
- Tolerate steep gradients
- Prefer new, dedicated, infrastructure
- Run at relatively high frequency
Divergent drivers:

Passenger & freight stress

Heavy freight trains:

- Require easy gradients
- Tolerate sharp curves
- Accept legacy infrastructure with upgraded permissible axle load
- Run at relatively low frequency
Heavy haul:

– Driven by global competition among sources
– Symbiotic relation with customers
– Length-of-haul under downward pressure

Divergent drivers:

Heavy haul/intermodal aspirations
Divergent drivers:

Heavy haul/intermodal aspirations

Intermodal:

- Driven by competition among modes
- Medium-term opportunities on continental scale
- Long-term opportunities on intercontinental scale
- Length-of-haul on upward trend
New challenges: Time-sensitive freight characteristics

- Postponed manufacture
- Outsourced manufacture
- Few or single global suppliers
- Value-added logistics
- Volatile demand
- Short transit time
- High value/low density goods
- Focused versus multi-functional parts
New challenges: Time-sensitive freight characteristics ...

- Postponed manufacture
- Outsourced manufacture
- Few or single global suppliers
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- Focused versus multi-functional parts
hanging relations among clients and service providers

One to one
(e.g. Sishen-Saldanha)

Many to one
(e.g. Ermelo-Richards Bay)

Many to many
(e.g. Freight Logistics Solutions)
hanging relations among clients and service providers

One to one (e.g. Sishen-Saldanha)

Many to one (e.g. Ermelo-Richards Bay)

Many to many (e.g. Freight Logistics Solutions)
Define railway business: Intermodal or internodal?
Potential for alignment and cooperation
Convergent drivers:
Alignment philosophies

- Only one, interoperable, technology set will ultimately dominate a transport mode.
- Railway technologies are becoming global, and hence standardized.
- There is virtue in global unification around graduated release, without compromising train length.
Convergent drivers:

Service scalability ...

Chaotic  Trafiic  Nature  Ordered

Train sizing

Capacity Management
Convergent drivers:

Service scalability ...

Train sizing

Capacity Management

Traffic

Nature

Ordered

Chaotic

Yard-to-yard
Convergent drivers:

Service scalability ...

Train sizing

Capacity Management

chaotic

Traffic

Nature

Ordered

Yard-to-yard

Heavy freight + distributed power
Convergent drivers:

Service scalability ...

Train sizing

Capacity Management

Traffic

Chaotic

Nature

Ordered

Yard-to-yard

Heavy freight + distributed power

Predictable service
Convergent drivers:
Service scalability ...

Train sizing

Cargo-Sprinter

Predictable service

Capacity Management

Traffic

Nature

Chaotic

Ordered

Yard-to-yard

Heavy freight + distributed power
Convergent drivers:
... could shape train technology

These technologies build on a common platform... networked braking & distributed power...
Convergent drivers:

Impact of a common platform

- Reduces interchange and interoperability contention
- Encourages adoption of other harmonization requirements
- Simplifies understanding of a railway
- Complements information technology in facilitating seamless service
Convergent drivers:

**Intra-train communication**

- A data network is a prerequisite
- Spoornet has an ECP braking & DP pilot scheme under way
- Related to European initiatives (EBAS, TCN, etc.)
- Information and bandwidth requirements are still open issues
Convergent drivers:

Automation of long, heavy, trains

- Competing modes (air and sea) routinely automate long hauls
- Graduated release a prerequisite
- ECP braking has filled the missing link
- Spoornet’s 300-wagon train demonstrated understanding of handling principles
The existing intermodal mindset is predicated, among other, on a long-standing US statutory limit. When will technology topple this constraint? Anticipate the role of transmission-based signaling!
A single-stack, high axle-load, intercontinental, intermodal car*

Variable-gauge single wheelpair

Articulated connector
Speculative thresholds & limits

Heavy axle load

25 t

Light axle load

40 t

Opportunity space
5 - 10 000 tonne trains

120 km/h

500 km/h
A prognosis

- Heavy haul and high-speed intercity were killer apps for railways in the 20th century
- Railways have competitive advantages vis-à-vis other modes
- Opportunities for breakthrough exist
- Intermodal could be the killer app in the new millennium, but
... we need global cooperation to converge high speed and heavy axle load

Spoornet, and others, have the heavy haul expertise

Europe, and others, have the high speed expertise

Maritime and air transport are our prey
There is a difference between knowing what needs to be done and knowing how to do it.