

## INNOVATIVE RAIL FREIGHT WAGONS – A PRECONDITION TO INCREASE THE MARKET-SHARE OF RAIL FREIGHT

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**Abstract:** *Rail transport is a very important type of transport. Due to its environmentally friendly nature it is necessary to dedication him considerable attention. The article stated the need for the implementation of innovative solutions for wagons. This article presents precondition to increase market share of rail freight. Considerations that must be met by modern rail transport were presented in details. The main focus was on provide assumptions to implement innovative wagons and their areas of influence.*

**Key words:** *Environmental friendliness, Co2 emission, costs, rail freight, quality of transportation, zero emission, innovation, loading space, fast transport, reliability*

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### 1. Introduction

In Europe rail freight is mainly used for bulk traffic but not for merchandize traffic. Rail freight can be very environmentally friendly. The reasons for this are low running resistance of steel wheels and rail, low air drag because of train formation, regenerative braking and low space consumption. If green electrical energy is used for propulsion, then rail freight is zero emission. But this advantages can be used only, if the quality of rail transportation is sufficient. This is not the case very often today.

A team of Swiss, German and partly Austrian and French experts from Railway undertakings, Wagon keepers, wagon producers, subsystem producers shippers, steel- and chemical industry together with several universities worked for 3 years to get the findings presented here. The “5 L” future initiative wants to be a basis for growth in rail freight transportation.

The main intension is to stop the process of reduced importance to enable substantial growth of rail freight because of its advantages. Very soon it became clear that the improvement must start at the wagon. The central idea of the innovative rail freight wagon 2030 consists of an **overall technical and operational concept** for its design and use. To achieve this, new scope has to be created to encourage an efficient, coordinated and ongoing innovation process at both national and international level [1].

### 2. Research problem and research methodology

Compared to passenger traffic, where significant innovation is found in the last 20 years all over Europe, the changements in rail freight are mainly organizational. Technical innovations did not find broad introduction into the market.

The “5 L” future initiative creates a framework for **five growth factors** that have been identified for successful introduction of the innovative freight wagon:

#### **Low noise – Lightweight – Long-running – Logistics capable – LCC-oriented**

A combination of two strategies will ensure practical application of the innovative freight wagon 2030: firstly the construction of new wagons and secondly the retrofitting of existing ones. Rapid, coordinated action is needed from 2014 to 2030. If retrofitting of wagon fleets extends beyond this time frame, the chances for realisation and growth of the innovative freight wagon will not only be reduced, but the consensus achieved would be significantly impeded at an early stage.

Timely availability of sufficient funding for the initiative will ensure the required lead-time for the wagon building industry. This lead is important and urgently required if there is to be a **coordinated and internally harmonised multi-stage programme beginning in 2014** for the manufacture and market launch of the innovative

rail freight wagon by German and European railways as well as by relevant service providers. Compared to the current situation, global, cross-border operation of the innovative rail freight wagon will also produce further positive effects in terms of modernisation and greater competitiveness of rail freight transportation. This includes in particular greater efficiency through standardisation, process optimisation, noise reduction and simplifications in railway production as well as at its interfaces.

It is obvious that the general goods structure will move away from bulk commodities to individually packed goods. Also the focus will change from mass to volume.

Without the innovative rail freight wagon the market share of railways will decrease further. To improve the competitiveness of rail freight transportation, it is necessary:

- to rapidly increase the attractiveness, economic efficiency and performance of rail freight transportation on a large scale
- to adapt to the requirements of logistics chains and
- to achieve improvements for the environment and climate and reduce harmful emissions.

If a clear target is set of increasing the modal share of rail freight transportation in EU 27 to 25% by introducing the innovative rail freight wagon, then current transport forecasts indicate that an additional 286 billion tkm would be transported by rail.

If all aspects of sustainability are to be integrated into an adequate freight mobility concept, then an effective contribution from rail freight transportation is of great interest. Today

approximately 20% of total CO2 emissions come from the transport sector – with one third of this generated by road freight transportation alone. More than 70% of total traffic depends on the availability of fossil fuels [3]. Rail freight transportation can substantially contribute to improving this situation. Decisions are already being taken today to provide traction energy on electrified lines increasingly from renewable energy sources. The goal of the European Commission is to cut CO2 emissions in the transport sector by 20% by 2030 (compared to 2008) and by 60% by 2050 (compared to 1990) as well as to considerable reduce energy consumption. Even with further improvement of the environmental balance of road freight transportation, it is essential that rail transport should account for the lion’s share of transport volume growth, Figure 1.

The main actors in rail freight have to work close together, that means that efforts and benefits must be contributed in an appropriate manner, figure 2. Rail freight transportation **customers** are interested in freight wagons that meet their logistics needs, are suitable for the load concerned and the loading/unloading process and offer high-quality transportation.

Apart from the availability of consignment-related information, this includes safety, reliability and punctuality as well as predictability of turnaround times. Furthermore, customers have an increasing interest in volume transports and/or high loads.

A more favourable environmental balance is becoming increasingly important. Figure 3 shows the method of improvement.

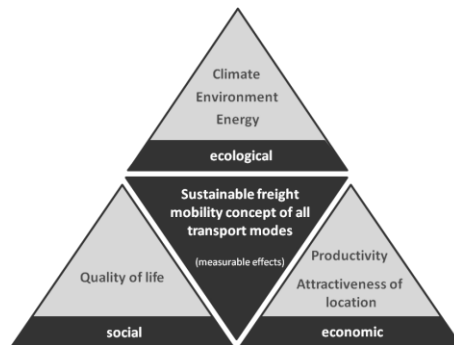


Fig 1. Elements of sustainable growth concept

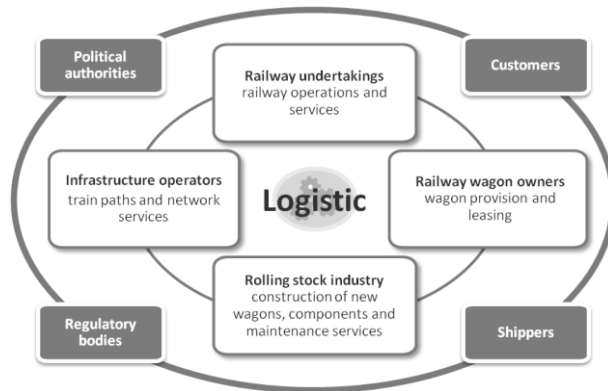


Fig. 2. Main Players of rail transportation

Basis must be the economic efficiency and environmental and climate protection. Of course safety in terms of a risk investigation is a sub element of this basic demands. In the past the cost of the freight wagon was a criterion alone, but now the overall costs of the whole process must be regarded. It is inevitable that the new freight wagon will be more expensive in investment than the previous ones but the productivity must be much higher and by this the economical advantage will be given.

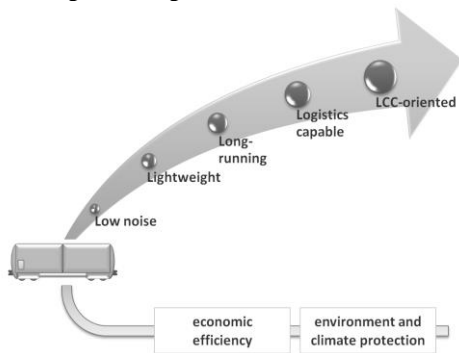


Fig. 3. Growth factors for rail freight transport

**3. Noise**

The environmental bottleneck of rail freight in Europe is noise. Therefore the innovative freight wagon must be much less noisy than today wagons.

Today in Germany nearly as 4 Mio people suffer unacceptable noise levels from freight trains at night and also 4 Mio people from road traffic whereas air traffic only affects 0,25 Mio people.

In the core areas the acceptable level of Lden 55 dB(A) is exceeded by up to 25 dB today [2]. Besides freight wagons of course tracks and locomotives must contribute to the noise reduction.

**4. Lightweight**

The weight of the wagon must be adapted to the goods type. Merchandize goods typically are much lighter than bulk and therefore the loading gauge should be used much more. The European transit corridors must be cleared for the GC Profil. This cross section enables about twice as much space than a standard ISO Container. This means that two container-trains can be replaced by one wagon load train with GC-profile wagons.

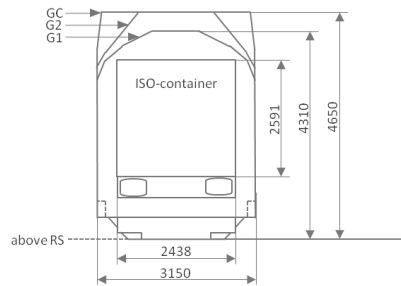
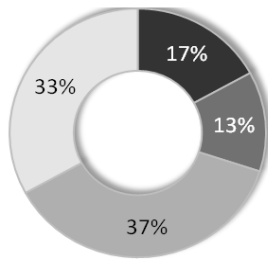


Fig. 4. Clearance loading gauges comparison (static loading gauge)

**Longrunning Capability**

Today many freight wagons operate 20000 km per year, whereas ten times more is possible and more wagons should operated like these.

**Shuttle traffic chemical tank wagon – components of round-trip time**



line: Buna (D) – Lenzing (A)  
 distance: 548 kilometres  
 average round-trip time: 6 days  
 period: 15.01.2007 – 15.02.2007

- loading and unloading
- running time
- time of intermediate stops
- time of stops at end stations

Fig. 5. Example of round-trip time in wagon load traffic

Diagnosis, automatic brake test and freight push pull trains are modes to achieve this. Logistics and LCC are other means, figure 6.

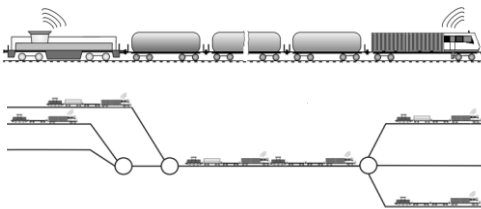


Fig. 6. Push-Pull train with remote control from a 20` Cab, above being positioned on a Container wagon, below train coupling - train sharing as a new operation mode in freight traffic [4]

In recent decades loading and unloading operations have been successfully speeded up. But there is also a need to speed up the process of putting together a train following shunting operations. In this area, wagon inspection and brake testing have to be reduced in terms of time and cost, as has happened in the passenger rail segment.

Although malfunctions of individual rail freight wagons are relatively rare, their impact on the entire train is very significant. The locomotive and the other rail freight wagons cannot continue when a malfunction of a single wagon occurs. Thus it is important to work towards a further reduction in unscheduled downtimes and repair times.

Outside Europe, train condition monitoring portals are used with great success for gathering data on the state of the vehicles. Data is captured by independent private firms and then sold to the wagon owners. It has to be clarified whether these systems are more efficient than on-board condition monitoring systems where the data remains directly in the hands of the owner.

For Europe an on board diagnosis system seems to be more likely where technical and logistical demands can be fulfilled, figure 7.



Figure 7. Diagnosis Module Cargo CBM with axle generator and telematic box [5]

For instance :

- Tracking
  - Wheel flat detection
  - Stability surveillance
  - Automatic protocol for ECM (entity in Charge of maintenance) requirements
- can be handled by these systems.

Low investment costs for rail freight wagons and fixed installations, a high level of system reliability and ease of operation are crucial

factors. The one-to-one wagon numbering system and the GCU database<sup>1</sup> for the whole of Europe offer a good basis for further development.

The same goes for the connections between rail freight wagons – the coupling technology. Faster, safer and more ergonomic procedures are possible with automatic coupling systems. These systems must also be compatible with the old screw couplings. Examples in Finland and Turkey demonstrate how even permanent operation with mixed systems can be successfully realised.

However, this considerably reduces the benefits, and for this reason mixed operation should be limited to as short as possible a transitional period (max. 8 years).

**Automatic couplers** serve above all to considerably simplify operations in marshalling yards. They help speed up certain processes by combining rail freight wagons into new train compositions for example during distribution after shunting or humping. This makes it possible to overcome the dangerous and physically exhausting process of manual coupling that is still needed with screw couplers – a considerable advantage considering demographic change and the increased average age of railway employees; and it is in line with the improvement in working conditions in the transport sector called for in the EU Commission's White Paper. In the USA, a desire to improve working conditions for shunting personnel was the main reason for the statutory introduction of the automatic central coupler in 1893 (Safety Appliance Act), which was completed in 1900.

A further advantage of the automatic coupler – as in the USA and the countries of the former Soviet Union – is the fact that higher tractive forces can be transmitted than with the conventional screw coupler – one of the factors that would allow for longer trains, provided infrastructure and technical conditions permit. These allow for traction and above all train path allocation cost savings. The potential of existing railway lines can be better used by operating longer trains.

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<sup>1</sup> GCU: General Contract for Use of Wagons – multilateral contract between various actors of the sector specifying the mutual rights and obligations of players in the use of rail freight wagons

A fully equipped rail freight wagon fleet would also make it possible to transmit electrical energy and exchange data via the automatic coupler.

With these measures a significant reduction of round trip time can be expected, see figure 8.

The commercial availability of rail freight wagons must be increased. The technology used in locomotives has proved that greater complexity and reliability are no longer incompatible, thanks to diagnostics and IT-based maintenance systems. This finding has triggered extensive new procurement and a far-reaching process of modernization of main line locomotive fleets in the last decade. But this technology still has to be adapted to rail freight wagons. Unscheduled maintenance work, whether in workshops or by mobile teams, needs to be drastically reduced.

The growth factor “long-running” will also improve the punctuality of rail freight transportation, which is at present unsatisfactory in some cases. This would then fulfil a basic condition for the next element: “logistics-capable”.

## 5. Logistics capable

Major requirements for increasing the attractiveness and competitiveness of rail freight wagons are

their ability to be integrated into customers' logistics chains

the application of sustainable technological concepts, among others for “green logistics” [5].

In this respect the growth factor “logistics-capable” is set to become increasingly important.

This is also suggested by the goods structure effect and goods volume effect mentioned in Section 1, as well as by the growing need for sustainable logistical services that conserve resources.

Existing supply chain processes have in many cases reached their limits of optimisation. The main potential for improvement can be found in increased interlinking of service providers, processes and resources. This includes among other things new approaches to bundling of wagon groups and individual wagons through new networking strategies in procurement and distribution, rapid grouping and delivery of partial and complete loads, transfer of international transport from road to rail, and the

development of new production technologies in rail freight transportation.

A particularly strong stimulus to increase the attractiveness of rail transportation can be expected from a new way of thinking about the combination of existing and innovative products in both intra- and intermodal transportation. In this context customers are particularly interested in logistics-oriented approaches through so-called co-modality of combined offers of road and rail. The strength of rail as an environmentally friendly transport mode will be increased even more by combining the rail freight wagon with hybrid or electric road vehicles [7]. Furthermore the innovative rail freight wagon 2030 will offer higher availability and make possible a higher quality and efficiency of transport and logistical services. The position of rail freight transportation as an environmentally appropriate solution for modern transport logistics will further improve between now and 2030 and it can therefore be assumed that there will be even more scope for freight to be transferred to rail as a result, see Fig. 9.

Sustainability and intelligent resource management call for interlinking of rail freight transportation with other transport modes and their offers in logistical chains. This potential will be fully achieved if the rail freight wagon is positioned and permanently integrated into the network levels:

- supply chain,

- interfaces across transport modes,
- customers' loading facilities
- accompanying process control.

This means more information about the rail freight wagon and its load (among other things by targeted use of sensors) as well as greater transparency along the transport chain. This allows for better integration of rail freight transportation into intermodal planning and management systems. Appropriate design measures and marginal conditions will create new offers to increase the useable interior loading gauges, to speed up loading and unloading processes and, if necessary, to load through the bulkhead.

In a world of logistics in which globalisation and sustainability are becoming increasingly important, entire industrial sites and factories depend on well-functioning transport logistics. In Europe and beyond, the above-mentioned interlinking and logistical tasks are therefore a strategically important factor for business success. The rail freight wagon consequently only has a chance if it meets logistics-related requirements:

- Access to or strategic compatibility with networks and processes
- Technological adjustment (properties, material, size)
- Information networking

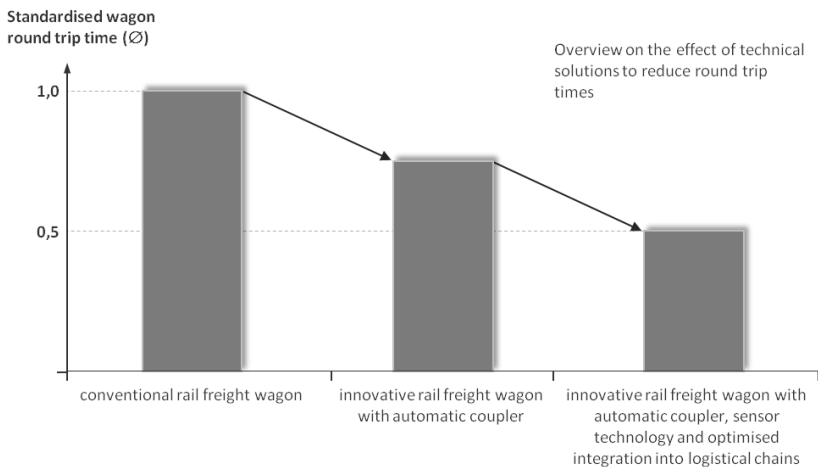


Fig. 8. Reduction of average round trip duration

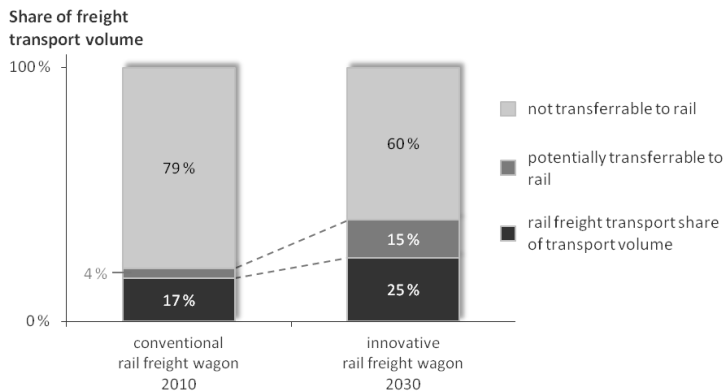


Fig. 9. Opening up of new market potential (example of Germany)

Support for automation of associated processes.

In each of these requirements it is understood that the rail freight wagon has to deliver a substantial and new contribution towards reducing energy and resource consumption (improved performance and consumption parameters, reduction of emission values). If it meets these expectations, the innovative rail freight wagon 2030 will occupy a new system-building position in the alternative supply chain as well as achieving society's climate and environmental goals.

The rail freight wagon has a key role to play. It forms the interface between the rail freight transportation system and customers' production systems as connecting link between transport and industrial logistics. This also partly applies to transport chains in which rail freight transportation would be the right choice for an optimised material flow, but no rail infrastructure may exist at loading and unloading sites. Under these conditions, appropriate solutions for a co-modality of road and rail have to be strengthened in order to achieve economically viable transport solutions.

The installation of Rail Ports<sup>2</sup>, or, in more general terms, intermodal platforms can serve as an example. These allow access to the rail freight network for shippers and recipients without their

own private siding. The rail freight wagon 2030 supports the interlinking approach that this involves:

- Volume capability (storage space in the wagon that is adapted or adaptable to the size of receptacles and goods to be transported, as well as up to 3.00 m high openings for loading)
- Fast – where possible automatic – door opening technology (without additional staff, capable of functioning in all seasons)
- Loading and unloading without hindrance, with the possibility for docking to automatic loading and unloading systems (entire wagon length, in future possible bulkhead opening)
- Competitive layout of the loading space based on the goods structure effect
- Grouping and train uncoupling without need for staff and time for coupling process (benefiting from the automatic coupler, see Paragraph 3.4).

Beyond these elements, further innovative approaches to process improvement on the so-called "last mile" are proposed. Such approaches have been scientifically studied or are already being piloted [8]. All are aimed at strengthening the rail freight wagon and its ability to meet the needs of logistics service providers.

## 6. LCC-Oriented

Though new ideas for design and operation of the innovative rail freight wagon are being

<sup>2</sup>Registered trademark of Deutsche Bahn AG

developed, it will still remain a product with a relative long lifetime. Against this background and apart from its suitability for high-quality transport services in modern logistics, the economic performance of the innovative rail freight wagon must above all be ensured throughout its whole life-cycle. The costs arising during the separate phases of its life also have to be considered in relation to the benefits, its profitability and revenues as well as to the issue of sustainability. A fundamental distinction between procurement and subsequent costs has to be made (the latter are mainly operating and maintenance costs and end-of-life costs). Purchasing decisions are currently still primarily based on procurement costs, as there is full transparency for these costs at the time of making the decision, whereas the subsequent costs of freight operation in relation to the wagon are still difficult to measure and predict. Furthermore they often vary considerably. In this respect there is an urgent need for well-founded calculations of the total life-cycle costs. Procurement processes can then rely on a basis that takes into account the entire life-cycle of the rail freight wagon.

The growth factor “LCC-oriented” relates to calculating total costs and ensuring that they are as low as possible both at the procurement stage and during the rest of the life-cycle. This across-the-board approach allows for a new way of thinking and acting when selecting components for the innovative rail freight wagon. It may therefore make economic sense to apply changes at the design stage and accept slightly higher initial costs if these can be compensated by subsequent potential benefits and lower costs. A consistent consideration of this trade-off between initial and subsequent costs makes it possible to ultimately reduce the total costs over the life cycle as well as improve the wagon’s technical and operational properties.

LCC-orientation requires a transparent information basis that is verified by powerful and route-oriented cost models. Building on this, target-oriented technical, operational and maintenance strategies can be developed and coordinated. This requires the availability of information on cause-and-effect chains and points in time for cost and benefit factors. It is crucial for the different players involved to cooperate

across companies to determine these [9]. At the same time the growth factor “LCC-oriented” tries to improve interdisciplinary cooperation between organisations in order to achieve comprehensive and effective solutions in a new sphere of partnership and with the support of scientific institutions.

Lasting cost reductions for operation and maintenance will be achieved through integration of this growth factor into the development of the innovative rail freight wagon. At the same time adaptation to modern logistics requirements will steadily improve, thanks to an understanding of the central life-cycle cause-and-effect chains. This will make an important contribution towards shortening payback times and return of capital employed (ROCE) for the innovative rail freight wagon, see Figure 10.

A systematic analysis of the life cycle of rail freight wagons and the translation of the obtained results into benefits and sustainability will enable the growth factor “LCC-oriented” to become an important basis for increased competitiveness of rail freight transportation in logistical chains. At the same time it will also be a promising approach to strengthening the result-oriented cooperation of players in the use of innovative rail freight wagons.

## **Results**

The deliberations must be implemented into the real world. This must happen gradually. A first step is a research and demonstration project foreseen in the European Horizon 2020 Research program which is called shift2rail, innovation program 5 [3].

## **7. Conclusions**

The step-by-step transition towards the innovative rail freight wagon 2030 will be made possible by targeted introduction of technologies and modules that already exist to a large extent or are already at an advanced stage of testing. Their selection and integration will be consistently oriented towards increasing competitiveness and growth through economic efficiency, tangible customer benefits, and – more than ever – towards environmental protection and resource conservation. The innovative rail freight wagon will open up new technological possibilities that have hitherto not been used or have only been



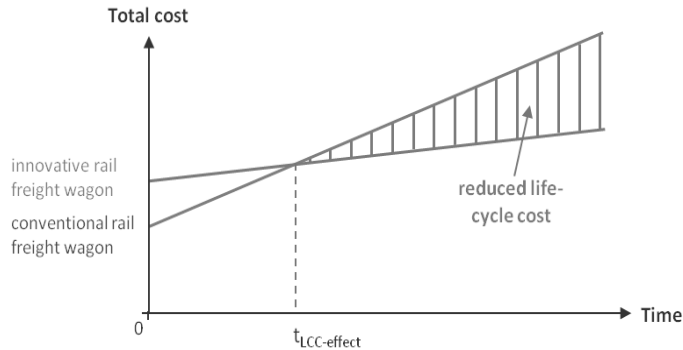


Fig. 10. Objective function of reduced life-cycle costs

used for special transportation tasks, and will immediately generate high operational and logistical benefits as well as bringing about a lasting improvement in public acceptance of rail transportation.

This approach includes above all shorter journey times, more productive deployment of freight wagons, greater benefit from size advantages, increased load capacity, more up-to-date and higher quality information on transport and load status, a significant reduction in noise emissions, and lower life-cycle costs. The full use of technical and operational possibilities will at the same time increase the utilization rate of the existing rail infrastructure and globally improve the attractiveness of the rail freight wagon for customers and operators as well as for policymakers and society.

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