

## **INTELLIGENT ROAD ACCESS & WEIGHT CONTROL SYSTEM - FIRST APPLICATION FOR HIGH CAPACITY TRANSPORT VEHICLES**



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### **Abstract**

The introduction of high capacity transport vehicles has been shown beneficial to the society, but only if the vehicles not drive outside the allowed network, not overload and comply with other regulations. Hence, the access and weigh control system ITK has been developed to ensure regulatory compliance. Already installed fleet management systems are used where authorities via a standard interface get access to data regarding route, weight and vehicle configuration for compliance enforcement and statistic. Systems specifications were developed and three demonstration systems were built. The first application is intended for monitoring the 64 - 74 tons and max 25.25 m trucks that will be allowed 2018-07-01 on dedicated roads in Sweden. The same telematics framework can preferably be use for other regulatory reforms requiring the same data e.g. preventing vehicles in walking zones, access to environmental zones, monitoring special permit vehicles, platooning, road use charging, weight control according to EU 96/53, dangerous goods, cabotage rules, and electrical roads.

**Keywords:** High productivity vehicles, High Capacity transport, Smart logistics, Infrastructure access, Pavement and bridge loading, Standards and regulations, Compliance and enforcement, IAP, Telematics, Fleet management, Digital infrastructure, Satellite positioning, Geofencing, Environmental zones, Platooning, Road use charging, Weight control, Dangerous goods, and Cabotage.

## 1. Introduction

### 1.1. Changes in length and weight

Over the years the maximum allowed length and weight for general access on most of the roads in Sweden have increased according to Table 1, which is a long-term trend of 1.16% per year. From the beginning the maximum length was unrestricted and road trains over 30 m were occasionally used in forestry. Analyses showed that it would have been far too costly for the society to restrict to the EU norm 40 ton/18.25 m. Instead, the length was in 1986 limited to 24 m to fit three 20 foot containers and then 1997 increased to 25.25 m as part of the EU module system. The successive investments in road upgrading have considerably increased the productivity of both the vehicles and the infrastructures, reduced costs and decreased energy consumption and thereby also emissions per transported tonkm, all to the benefit of the society.

The public roads in Sweden were until 2017 divided into three gross weight classes, called BK1, BK2 and BK3. BK1, which constitutes of 94% of the public roads, allows for a maximum gross of 64 tons and 10 tons axel load (11.5 on driving axel); BK2 allows for a gross 51.4 tons and 10 tons on all axels; and BK3 for a gross weight of 37 tons and 8 tons on all axels. The maximum length of the road trains is 24 m and, if EU modules are used, 25.25 m.

**Table 1. Changes of maximum length and weight of trucks in Sweden**

Year	Max lenght	Max gross weight
before 1930	No restriction	10 ton
1930	"	12 ton
1947	"	23 ton
1951	"	34 ton
1966	"	37 ton
1968	24 m	"
1974	"	51,4 ton
1990	"	56 ton
1993	"	60 ton
1997	25,25 m	"
2015	"	64 ton
2018	"	74 ton
??	34 m?	90 ton?

### 1.2.The High Capacity Transport research and innovation program

Around 2007 trails with several 74 ton/24 m and one 90 ton/32 m timber truck started and has

since been followed by about 40 test vehicles adapted to the needs of different industries, all larger than the ones allowed for general access. In 2009 collaboration with Transport Compliance Australia (TCA) commenced and in 2012 a memo of understanding was signed between the Swedish Transport Administration and TCA regarding collaboration regarding high capacity vehicles, with special focus on the Intelligent Access Program and Performance Based Standards.

In 2012 the Swedish High Capacity Transport (HCT) Research and Innovation program was established to prepare for a reform to create a dedicated road network accessible to vehicle combinations exceeding 60 ton/25.25 m. This initiative was the first of its kind in Europe, and has required a high level of cooperation between the major stakeholders: industrial groups, governmental agencies, universities and government. These stakeholders developed and agreed 2013 on a road map for coordinated actions to prepare for introducing the HCT reform (Kyster et al 2013). The reform aims to primarily respond to community demand for reduced impact on climate change and handle part of the projected growth in demand for freight transport by smarter use of the existing infrastructure, while maintaining a high level of safety and preserve the functionality and value of the infrastructure.

The road map also resulted in the following originally 11 work packages of the HCT Research and Innovation:

1. assessing and assuring the long-term effects on the whole transport system,
2. assessing and improving the overall impact on traffic safety,
3. adapting the infrastructure to HCT vehicles,
4. organizing and evaluating demonstrations of HCT vehicles for different industries,
5. developing blue print vehicles that are certified,
6. establishing an access and monitoring system using existing fleet management boxes,
7. developing Performance Based Standards for vehicle-infrastructure matching,
8. adapting logistics for HCT vehicles, including intermodal considerations,
9. propose a consolidated regulatory and institutional framework,
10. international collaboration and communication,
11. simultaneous evaluation of the ongoing R&I to learn for future reforms

The whole program is led by a steering group with representatives from major stakeholders, each work package has its own steering group, and most work packages consist of several projects that each must find its own financing and researchers. However, some major research funds are using the agreed road map as one of several bases for their funding decisions.

## **2. Expected long term effects on the whole transport system of HCT reforms**

Vehicles that are longer and/or heavier than the currently 64 ton/25.25 m allowed for general access are called HCT (High Capacity Transport) in Sweden and internationally often High

Productivity Vehicles. Tests with about 50 HCT vehicles, between 74 – 90 ton and 22 - 32 m over the last 15 years in Sweden indicate per introduced HCT vehicle 10-30% reduction in CO<sub>2</sub> and up to 25% lower cost, depending on what vehicle is replaced; less traffic since fewer vehicles for the same load and hence less need for road capacity investments; less road maintenance since higher load/gross weight ratio and often less axel loads; and the same or better safety since fewer vehicles, better breaks and tilt stabilizers. OECD/ITF (2010) came to similar conclusions regarding the positive effects and that study is now being updated in an ongoing project expected to finish later in 2018.

However, since HCT vehicles cannot replace all freight vehicles and it will take at least 15 years to upgrade the infrastructure, the effects on the whole transport system, including all modes and transport of passengers, will be much less than that for an individual vehicle replacement. Hence, Lund University was commissioned to make a systems analyses study, which was reported in (Pålsson et al 2017) and a larger report in Swedish.

To make quantitative assessments a simulation model was developed over freight transport in Sweden with sea, rail and road transport, 10 industrial sectors and each with three types of road transports: direct, terminal and distribution. Data for the model came from the national model used for forecasting and infrastructure planning and the cost and performance of traditional and HCT vehicles came mainly from the HCT demonstration projects. The time span was 40 years from 2018 to 2057.

For the development of the society, transport policy and transport demand two different scenarios were used, one published by the Transport Administration and used for infrastructure planning and the other published by the governmental commission on Fossil Free Vehicles by 2030. For the HCT reform we used three alternatives regarding size of the HCT road network and infrastructure charges and for each of them two maximum vehicle sizes: 74ton/25.25m and 74ton/34m. To identify the effects of HCT we compared with a reference scenario with no HCT-reform.

The output from that model was used as input to a cost-benefit analyses by calculating the net present value over the 40 years. Same methodology and assumptions were used as mandated for cost-benefit analyses for investments in road and rail infrastructure.

Expected direct and indirect effects on ton-km, vehicle-km, modal split, CO<sub>2</sub> and some socio-economic factors were calculated. CO<sub>2</sub> emissions decreased in all scenarios except one, and the benefits were larger than the cost for upgrading the infrastructure (about 10 billion SEK) for all scenarios and largest for increasing to 74 ton/34 m on most but not all BK1 roads. The benefit/investment ratio was over 13 when transport growth was according to the forecast used in the current infrastructure plan and almost 7 in a low growth climate friendly scenario. Since this is very much higher than almost any investment that have been considered, it is disputed. Therefore, we intend to make a new calculation using another and more aggregated

model.

The study also indicated that the growth in rail and sea transport were expected to become somewhat less than if no increases in length or weight of road vehicles would be allowed and if no measures were taken to improve the competitiveness of sea and rail. Even if this modal shift impact is heavily disputed among experts, this worried the Green party despite the undisputed positive effect on climate change even when considering modal shift and increased transport due to lower road freight prices. Since the small green party forms the government together with the much larger social democratic party, the 74-ton reform has evolved slower than originally foreseen in the HCT road map.

The expected impact on traffic safety has been reported in several research reports, e.g. **Sandin 20xx**. In summary, the HCT-vehicles are as safe as traditional vehicles, particularly since the recently decided technical requirement for being registered as HCT road trains are stricter regarding breaks and tilt stabilizers than for traditional trucks. These technical requirements for HCT road trains are partly based on our research on Performance Based Standards and blue print vehicles. Since fewer trucks are needed for the same transport job, less accidents per ton-km is expected, particularly if actions are taken to monitor and enforce regulatory compliances of the HCT vehicles.

### **3. Actual implementation of HCT reforms**

The industry, particularly the forest industry, has lobbied for increased gross weight on all roads, particularly after Finland increased the maximum gross weight from 60 to 76 ton for general access 1 October 2013. The Swedish government responded by giving the two agencies responsible for transport assignments to propose a reform to increase the maximum gross weight from 60 to 74 ton on a dedicated road network. The proposal, to a large extent based on the results from the HCT R&I program, was handed over to the government in August 2014. However, in September there was an election which resulted in a change in government. The new government, a coalition between the Social democrats and the Green party, hesitated to implement the 74 ton reform since the Green party was against measures that didn't favor rail and sea transport. However, as a response to the demand from industry the government increased the gross weight from 60 to 64 ton on all BK1 roads 1 July 2015. They also commissioned two additional studies - longer and heavier trains respectively heavier truck combinations. These studies were reported during 2017.

In 2017 the parliament decided to introduce a new road class called BK4 that will allow for maximum gross of 74 tons while maintaining maximum 10 tons axel load (11.5 on driving axel) and 25.25 m. The first BK4 classified roads are expected to be opened 1 July 2018. In the beginning, the BK4 network will be rather limited, since there are thousands of bridges as well as road sections that cannot handle 74 tons gross weight without being prematurely broken down. However, in the forthcoming infrastructure plan 2018-30 means are expected to

be earmarked for upgrading a large portion of the BK1 (64 ton) roads to BK4 (74 ton) standard. The Swedish industry is lobbying to also increase the length from 25.25 m to 34 m on most BK4 roads and weight to up to 90 ton for a few dedicated roads. There is already one road in the far north where 90 ton vehicles for transport of iron ore from the mine to the railhead operates on a special permit. The vehicles must keep a 5 minutes distance to allow the water to re-enter the body of the road, like a sponge. Before passing some bridges, the driver presses a button to turn on red light preventing other vehicles on the bridge and the vehicle must drive slowly in the middle among the lanes when passing. It was considered much cheaper to upgrade the road to allow 90 ton vehicles than extend the railway, particularly since the life of the mine was uncertain.

#### **4. The proposed Intelligent Access & Weight Control System, ITK**

##### **4.1. Background**

The above described very positive effects on the society by HCT reforms assumes that all vehicles follows the regulations 100%. However, measurements show that 15-20% of the heavy vehicles are overloaded with more than 3 tons and the majority drive faster than the speed limit of 80 km/h. The risk for increased numbers and severity of accidents and for destroying the roads and bridges if the HCT vehicles are driven outside the dedicated network or overloaded is considered unacceptable. Therefore, the Transport Administration requires that the driving with HCT vehicles are monitored and violations enforced. This policy is in line with the findings in the study by Moore, Regehr, and Rempel (2014), which noticed that all countries that have implemented HCT on part of their networks are using some extra compliance mechanism for the HCT vehicles. However, only Australia are using on board GPS units that report actual routes via mobile telecom network to back-end servers for compliance monitoring.

In a sequence of research projects, a proposal for an Intelligent Access & Weight Control System has been developed. We noticed in 2009 that Australia were about to implement their IAP, Intelligent Access Program (Cai et al 2010). We started a research collaboration with TCA in Australia for technology transfer, and during 2013-16 we tested the Australian IAP system, without on-board weight, on 5 HCT test vehicles, where Sweden became the seventh state in the Australian IAP platform. However, we could not implement IAP, with on-board weight, directly since we had to consider the legal and institutional context in EU and Sweden, other current or proposed governmental applications using the same data, and the emerging telematics eco-systems of connected vehicles, where the OEMs have a larger role than in Australia. Another difference between Australia and Sweden is that ITK from the start is proposed to be mandatory for all operators and vehicles larger than 64 ton/25.25 m, while IAP started as a voluntary option for operators to take more loads on PBS-certified vehicles.

##### **4.2. Objectives with ITK**

To maintain a high safety level, prevent a premature degradation of the roads, and contribute to the government's goal to improve order and settlement in the road freight industry, extra measures to control the traffic with the BK4 vehicles are required. Particularly to minimize:

- driving outside the BK4 network when loaded above 64 ton
- frequency and sizes of overloads
- combinations of prime movers, trailers and dollies that not are approved for BK4

ITK is also expected to:

- Improve traffic safety
- Competition on a level playing field and support "Fair transport" initiative by the industry
- Less stress for the drivers has been observed in the HCT tests
- Better statistics for more precise planning of maintenance and upgrading of the infrastructure
- More efficient and more risk based monitoring of rule compliance and enforcement.
- Above all, ITK is the first step towards a national certified telematics framework and IT platform for other application in both private and public sector.

### **4.3. Description of the ITK platform**

Based on the experience from the IAP pilot, and requirements from stakeholders and from the EU and the Swedish legal environments, system specifications were proposed and published (Asp et al 2016). The proposed system, called ITK (Intelligent Access and Control), uses already installed fleet management systems, where the on-board computer registers GPS position every minute, axle loads, gross weight and ID of the prime mover and all vehicle modules, and reports to the back-end server of the telematics and fleet management service provider. Nor driver or speed is reported. This information must be securely stored for one year and made available through a standardised interface at the back-end server for compliance inspections by the police and other enforcement agencies in a similar way as tachograph data are checked. After all IDs are taken away, the information must be sent to the Road Administration for statistical purposes, e.g. calculating degree of regulatory compliance and maintenance planning. The technical architecture is depicted in Figure 1. The two FMS standard interfaces used, which are high-lighted in yellow, are developed and supported by ACEA, the European Automobile Manufacturers' Association.

In the end of 2016, Volvo, Scania and Vehco (third party fleet management company) started adapting their fleet management systems to deliver services that comply with the ITK specifications.

The experiences from these three prototype systems with a total of 8-10 vehicles will be used for fine-tuning the ITK specifications and the legal framework. They are also role models for

the deployment of commercial systems to be ready when the first 74-ton network opens in Sweden in the middle of 2018.

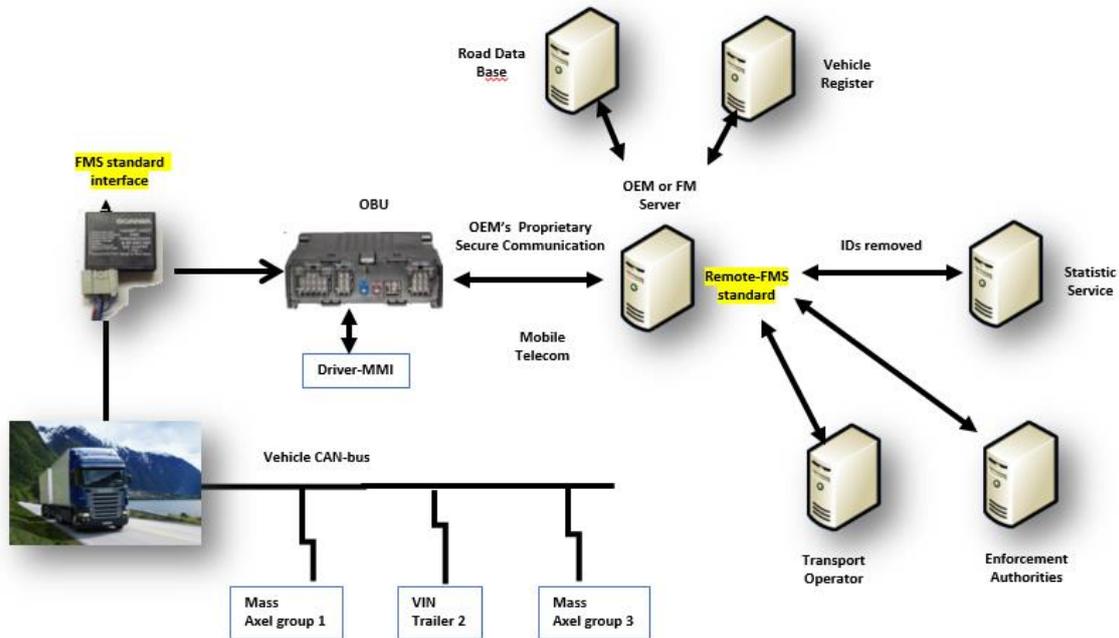


Figure 1. Technical architecture of ITK

The differences compared to the Australian IAP system is as follows. In ITK1 the service provider (most often the vehicle manufacturer) and his HW and SW is not certified and he doesn't produce NCRs. Instead his back-end server must be provided with a FMS-remote ACEA standard interface via which enforcement agencies (police and the Transport Agency) can download actual and one year's history of routes and weights and compare with what is allowed. Deviations is then used as input to the risk management system of the enforcement agencies to initiate road side inspection, to allow by-pass of weight station or inspection visit to the operator, but not for direct sanctions as in Australia, since the FMS-systems are not certified. Data from the back-end server, where all IDs have been removed, must be sent to the Transport Administration that uses the data for statistics that improves maintenance management and to access regulatory compliance.

The details of the ITK proposal and its implementation have been discussed with the major stakeholders in a series of three workshops. 17 use cases were developed to analyse the sub-processes and data management in detail. In the beginning manual reporting into the OBU of gross and preferable also axel weights and ID of the vehicle components will be allowed. Developments towards automatic reporting to the OBU of weights and IDs is under way. In the research plan we suggest that ITK1 will be further developed in stages ITK2, ITK3 etc. to 8

become more like IAPm. Certification of HW and SW to allow direct sanctions and to ensure the quality of the data to be used for e.g. road charging requires an institution that gets a similar role as TCA in Australia to set up and manage a certified telematics framework. In Sweden we may consider to also outsource from the enforcement agencies to one or several trusted third parties the process of providing non-compliance reports (NCR). One option is to let the fleet management providers to also to provide NCR as in Australia.

#### **4.4. Legal aspects**

In parallel to developing the technical ITK system, the feasibility of developing a legal and institutional framework was analysed.

One aspect is to replace physical road signs regarding vehicle seize restrictions with signs only in the digital maps, which then are used for driver support and compliance monitoring. Thereby will the deployment of several thousand of road signs indication BK4 roads be avoided. The Vienna Convention on Road Signs and Signals from 1948 set the rules for road signs. However, it doesn't regulate signs for maximum allowed weights, which is regulated nationally and hence there is no barrier for Sweden to use digital signs.

The current regulations for overloads can be used and issues regarding the new EU integrity law GDPR is no barrier since the fleet management systems that ITK is based on must be GDPR certified even without the ITK application. Issues regarding responsibilities if something go wrong was also investigated and there seems to be no need to change the current legislation.

However, the EU 96/53 directive art. 10 (d) is no barrier for mandating on board weight systems for Swedish vehicles but prevent from mandating it on vehicles registered in other nations. This requires closer analyses and probably some adjustments of the proposed ITK system and its legal regulation.

It turned out that establishing the legal and institutional framework, particularly regarding foreign vehicles and operators, were much more difficult and will take more time than developing the hardware and software. Passing a new law through parliament takes 1-3 years. Therefore, it is now expected that the necessary changes in laws and regulations will not be ready before January 1, 2020.

#### **4.5. Remaining research and development for ITK for BK4**

Standards, calibrations and certifications of weigh sensors and automatic registrations of ID-numbers of all vehicles in the road train are not yet well established. Hence, manual reporting of weights and vehicle configuration will be accepted in the beginning. The enforcement authorities want that data in the system are used for automatic fines and other sanctions, in

analogy with speed cameras, instead of only indicating suspicion that require stopping the vehicle for inspection and checking the weights to issue sanctions. The police want technology that improves productivity and makes the compliance control easier. However, this requires high quality of the data being registered and measures to reduce tampering to stand up in court.

#### 4.6. Other regulatory applications of the platform

The proposed system is the first governmental service based on the private sector's telematics system for fleet management outside Australia as we know. Several other services using the same data that are registered in vehicles are being proposed, both for the private sector and for government agencies. Hence, efforts are made to harmonize the specifications and legal/institutional framework so the same platform, (vehicle box, back-end system and software) could be used for most of these services. Examples of other governmental services considered are: preventing vehicles to enter walking zones (vehicle slows down to 5 km/h, was triggered by last year's terrorist attacks using vehicles), access to environmental zones (some diesel engines will be forbidden), monitoring oversized vehicles on special permit, platooning, road use charging based on actual road wear and congestion, weight control according to EU 96/53 being mandated by 2021, dangerous goods, cabotage rules, and electrical roads.

Table 2 from Thomas Asp et al 2016 shows expected how some regulatory applications are expected to evolve.

**Table 2. Regulatory freight applications – Expected chronologic order, Red=implemented**

**Freight Regulatory Applications**  
 Estimated chronologic order. Red = implemented

Service	Australia One FM Box	Sweden One FM Box?	EU Separate Boxes
Access compliance (IAP)	1	1	
Speed compliance (ISC)	2		
Mass compliance (OBW, EU 96/53)	3	2	3
Fatigue compliance (EWD, Tachograf)	4	Separate Box	1
Dangerous goods trsp	6	Voluntary	5
Cabotage compliance		4	
Road charge (EETS)		3	2
E-call		Separate Box	4
Accident data recorder			7
Live stock trsp			6
Busses, Taxameter, Driverless trains	5		

The Swedish government proposes to change from time to distance based road charging for goods vehicles. They write that they will try to use already installed fleet management systems as was done in Hungary. However, the ministry of finance is keen on making it very hard to cheat and may set up so strict anti-tamper and other criteria that it in practise requires the installation of new dedicated on-board equipment as well as dedicated back end servers. If Sweden follows the Belgian, German and Slovakia route, it is quite possible that most member states will follow, particularly since the EU policy historically has been one new box for each new governmental application. The Australian policy is the opposite, one box for all applications for both regulatory and private sector.

## 5. Conclusions and discussions

The ITK-platform enables more differentiated and dynamic access regimes that are based on e.g. weight, length, load type, engine, fuel, time and fee. This means that vehicles, road and traffic could be matched better and in real time. Many more than the current four road classes can be used and access and fees vary dependent on actual conditions. This has several positive consequences including better capacity of the infrastructure, less congestion, lower cost, less energy consumption, and less accidents.

The proposed Swedish ITK is the first automated intelligent access system outside Australia and a forerunner of a national certified telematics platform with many expected governmental and civil applications. The experiences from Australia and Sweden was in the report Wandel, Sternberg, Hill (2015) summarized in the following hypothetical recommendations:

- On-board Units (OBUs)/hardware which can perform multiple applications and services for both regulatory and private sector
- Avoidance of proprietary-based systems
- A multi-provider model for both hardware and services to promote innovation, competition and consumer choice
- Performance and outcome based specifications to promote innovation
- Supported by an independent certifier and auditor (TCA) to ensure technology and services works, and continues to work, as intended
- Underpinned by a strong, deliberate separation between technology provision and policy use
- Defined roles and responsibilities between users, regulators and technology providers (to minimise real or perceived conflicts of interest in the management of data and information).
- Supports Co-operative ITS (C-ITS) applications – including Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I), both of which hold the promise of significant road safety gains – now and into the future.
- Operating Model (including certification, audit and enforcement)

- Communications platform (Introduction to Communications Access for Land Mobiles or commonly called CALM)
- System Security. Minimize the risk for tampering, spoofing and jamming
- System Integrity. Safeguard against being used for other purposes than intended.”

In the further developments made since then, we have verified most of these hypothetical recommendations.

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