MONITORING OVERLOADED VEHICLES: IMPROVING TRAFFIC CONTROL CENTRE PERFORMANCE BY USING MANAGEMENT INFORMATION SYSTEMS

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ABSTRACT

Decision making is an important function of management and to facilitate decision making that is relevant to any organisation, it is imperative that managers have the correct information at the right time. Since the 1990's, the Transport Systems and Operations research group at the Council for Scientific and Industrial Research (CSIR) started developing a Management Information System to assist road traffic authorities and vehicle load control centres in decision making. A management information system is a combination of devices, software, data and procedures designed to address the collection and processing of information with the aim of providing management with relevant information for decision making purposes. This paper describes a management information system (MIS) developed and implemented in the Western Cape Province since 2006 and recently in KwaZulu-Natal in South Africa, to assist road authorities with heavy vehicle load control.

Since its implementation in the Western Cape average overloads has shown reduction from 755 kg in 2006 to 529 kg in 2015, part of the reduction in average overloads can be credited to the use of the MIS. The benefits gained by the road authorities are many and includes the ability to identify operational problems in near real time; monitor scale operator's performance; to identify problematic hauliers who overload vehicles deliberately; to monitor operational performance and schedule shifts accordingly. The management information system has proved to be successful and useful, as management is able to track irregularities and reduce corruption. Operational performance has improved as underlined by management increasingly requesting training of scale operators to bridge the gaps identified by the system.

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1 INTRODUCTION

1.1 Background

Decision making is an important function of management and to facilitate decision making that is relevant to any organisation, it is imperative that managers have the correct information at the right time and by making use of Information Technology (IT) this goal can be achieved as IT can assist in improving business processes and reduce costs (Willcocks 2013). Empirical research in the previous decades has proven that strategic planning is an essential prerequisite for any organisation to be successful, and decision making need to be based on current and relevant information (Phillips 2003). For effective decision making it is important to co-ordinate strategic activities across multiple business units and functional areas and fully integrate the management team (Phillips 2003). Information and Communication Technology (ICT), such as mobile technologies, has been successful in the collection and communication of valuable information to users.

Transport operators and road authorities are no exception to the use of ICT. Research shows that ICT, which was introduced to the transportation sector in the 1990's, has since evolved, giving rise to concepts such as intelligent vehicles; smart trucks; and near real time traffic monitoring; offering intelligence in traffic data and near real time advice to authorities (Giannopoulos 2004, Jitsuzumi, Mitomo et al. 2000). In South Africa, due to the problems of heavy vehicle overloading and the need of authorities to manage and control loads on heavy vehicles, computer systems were introduced at various Traffic Control Centres (TCC's). To use the data from Traffic Control Centres making use of computerised systems the Council for Scientific and Industrial Research (CSIR) developed a Vehicle Overloading Management System (VOMS) to assist the authorities with the analysis of weigh data and to produce scientific statistical reports (Nordengen, Hellens 1991).

VOMS was initially developed as a desktop based Management Information System (MIS) in the 1990's. The system proved to be very successful in producing statistical reports that can be used by various authorities to make decisions. The reports produced by VOMS are based on monthly data, allowing authorities to make decisions based on data for the previous month or older. The scientific knowledge applied to the analysis of the reports proved to be valuable, such that the statistics produced are also used by the Transport ministry to report nationally on heavy vehicle load control operations.

1.2 Problem Statement

VOMS was developed as a Desktop System and could only report on a monthly basis, while it is important for operational purposes that management are informed in near real time[1] about weighbridge operations. Real time information can assist management in identifying operational problems as they occur; monitor performance in real time; identify problematic hauliers who overload vehicles deliberately.

[1] For the purpose of this paper near real-time refers to the system updating information within 30 minutes of the events occurring.

The CSIR working together with Datron Rekenaardienste and Western Cape province developed a web based version of VOMS as a module of the CSIR's weighbridge software (WinNuwei) referred to as the Management Module (MM) to provide real-time monitoring and reporting. This is in line with global trends in system development for near real time monitoring and systems (Qin, Feng et al. 2015, Santos, de Sousa et al. 2013, Shapira, Lu 2012). The management module has now been upgraded to be able to connect to any weighbridge that is making use of a computerised system and not only limited to the CSIR's WinNuwei.

1.3 Aim of the Paper

The aim of the paper is firstly to give the background on how VOMS was developed and the systems planning behind its design, the analysis and reporting of the weighbridge data. Secondly, give information on the design of the management module and the technology applied to access information in near real time. The paper then presents some statistical results and reports that can be produced by the management module in near real time. The paper also indicate some examples of management alerts that can be produced.

1.4 Scope of the Paper

The paper reports on the development of a management information system developed for weighbridges in the Western Cape Province and later in the KwaZulu-Natal (KZN) province and noting that the system is also connected to weighbridges in Gauteng and Limpopo provinces.

2 CONTROL OF VEHICLE OVERLOADING

The deterioration of road pavements is mainly because of heavy vehicle traffic loads acting on the pavement. Overloaded heavy vehicles contribute more to the deterioration than legally loaded vehicles and are a major problem in many countries throughout the world (Roux, Lotter et al. 2015). In South Africa, due to the problems of heavy vehicle overloading and the need by authorities to manage and control loads on heavy vehicles, dedicated TCC's that specialises in weighing heavy vehicles have been implemented in all nine provinces. Some of the TCC's make use of computerised systems to weigh vehicles. These systems comply with the National Road Traffic Act (NRTA) regulations and therefore are acceptable as a tool for law enforcement.

In South Africa, overload control is carried out at a number of weighbridges throughout the country and about 118 sites have been sending data to the CSIR since the 1990's. Most of these weighbridges are provincial, but there are some municipal weighbridges at testing stations. There are also a number of weighbridges that are operated by toll road concessionaires in cooperation with provincial road authorities and privately owned weighbridges that are utilised by traffic officials for law enforcement.

3 THE VEHICLE OVERLOADING MANAGEMENT SYSTEM (VOMS)

A step further from just weighing vehicles using computerised systems, was to find a way to make use of the collected data to provide information to management for decision making purposes. The CSIR, initially in collaboration with the KZN Department of Transport developed VOMS as a tool to scientifically analyse the weighbridge data. The main aim was to issue statistical reports and for traffic authorities to monitor trends in overloading, as well as to identify the predominant offenders from the operators that are weighed.

3.1 Desktop System (VOMS)

Windows based systems were introduced in 1980's after Microsoft has introduced an operating systems called Windows, due to the growing interest in graphical user interfaces (GUI) (A history of Windows). The MIS discussed in this paper was upgraded to operate in the Windows environment during the early 1990's. The system has the functionality to report on a monthly basis as well as on an annual basis. Various validations routines were added to improve the integrity of the data processed by VOMS. The core of the system is the reporting of various overloading trends as well as the identification of operators that continually overload their vehicles.

For ease of use and easy of deployment, local data files are used to validate data and run monthly reports. VOMS is currently being developed in Visual Studio 2015 and makes use of the .net framework. Due to historical reasons, the development language being used is Visual Basic (.net) and for the same historical reasons, Microsoft Access Database (mdb) files are used to store the data as illustrated in Figure 1. The mdb files are portable and don't require server infrastructure, making it easy to share the files with other users.

Some of the benefits derived from using an Overload Control Monitoring System include the following:

- It allows for the monitoring of trends in heavy vehicle overloading;
- The effect of a change in policy or regulations or the opening of new weighbridges can be evaluated;
- It will assist in identifying those fleet operators who overload their vehicles on a regular basis and will provide data on regional and national freight traffic trends and commodity movements. Moreover, this type of information will facilitate road network planning, engineering design and maintenance and rehabilitation activities;
- Detailed listings of each vehicle weighed, including the mass of overloading on each axle / axle unit can be obtained;
- Statistics indicating percentage overloading of all vehicles weighed in terms of individual weighbridges, individual regulations, vehicles classes, cargo types and origin-destination matrices based on selected months, selected quarters and selected years can be obtained.

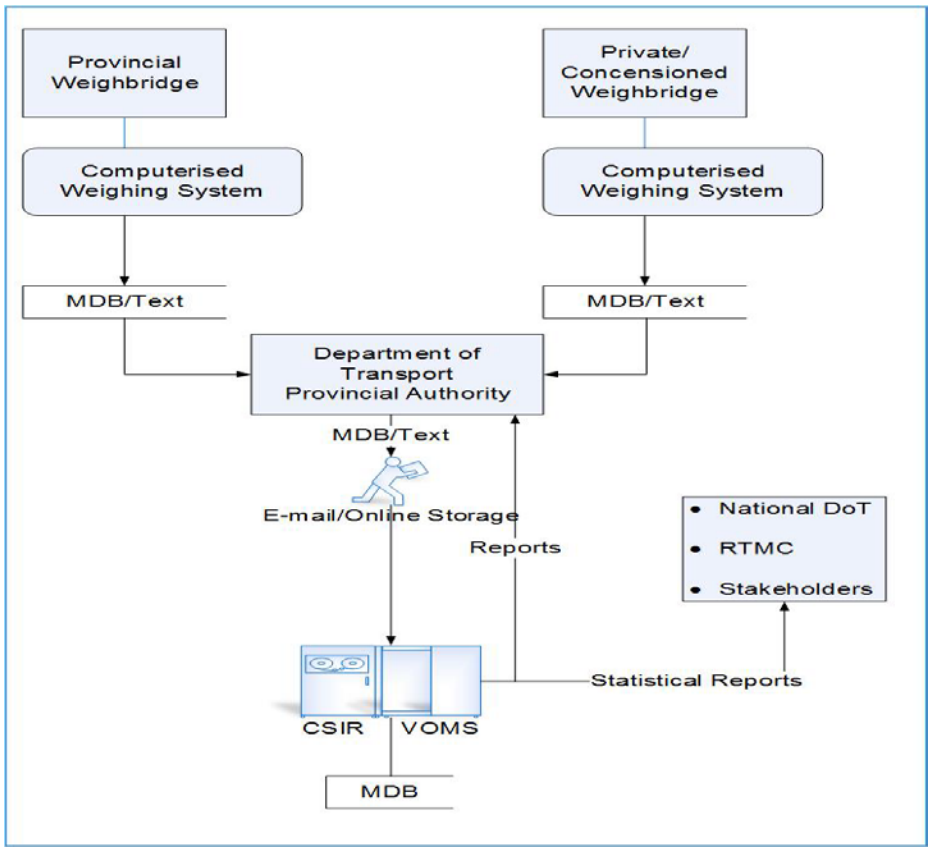


Figure 1: Weighbridge to VOMS data flow diagram

The National Overload Control Technical Committee (NOCTC) under the leadership of the Road Traffic Management Corporation (RTMC) requested that all South African weighbridges operating for law enforcement purposes should send their weighing data to the CSIR. This is to promote centralisation of overload control data collection and to encourage centralised reporting of weigh statistics. Figure 1 shows a high level diagram of the process to get data to CSIR and Table 1 shows national statistics[2] for the year 2013 as produced by VOMS.

The weighbridges that are making use of computerised systems irrespective of which authority is operating the site will forward their data files on a monthly basis to the provincial authority. The provincial authority will then collectively send all monthly data from various weighbridges in the province to the CSIR. The data files are usually in mdb and/or Text files and the files can either be emailed to the CSIR or uploaded to a web data storage such as Google Drive. The CSIR downloads the data files, validates and analyse the data and can then issue statistical reports on weighing.

[2] Not all provinces are sending data from all weighbridges and the national statistics in Table 1 are based on data that was received by the CSIR.

Table 1: Annual National Weigh Statistics per Province (2013)

Province	Weighed	Overloaded	Percentage Overloaded	Average Overload (kg)	Chargeable	Percentage Chargeable
Eastern Cape						
Free State	22 039	2 133	9.7	890	408	1.9
Gauteng	193 274	44 743	23.2	616	7 835	4.1
Kwazulu-Natal	160 909	28 567	17.8	749	6 093	3.8
Limpopo	289 208	56 965	19.7	511	8 687	3.0
Mpumalanga	602 891	160 573	26.6	642	13 986	2.3
Northern Cape	11 775	1 708	14.5	822	371	3.2
North West	137 834	33 334	24.2	580	6 171	4.5
Western Cape	633 425	78 184	12.3	525	13 003	2.1
South Africa	**2 051 355**	**406 207**	**19.8**	**667**	**56 554**	**2.8**

This report shows the extent of overloading and information on the number of vehicles weighed, overloaded and chargeable at a national level for South Africa. The statistics presented in this report are based on all available electronic data submitted to the CSIR. Overloaded vehicles refer to vehicles that exceed one or more of the mass limits in terms of Regulations 234 to 242 of the National Road Traffic Regulations, 2000. The term “chargeable” refers to all vehicles that exceed the tolerance (a prosecution guideline) applied to all mass limits.

3.2 Web-based System (Management Module)

The management module is a web based application allowing any authorised user to access information via the Internet. In order to improve the accessibility and efficiency of VOMS, Datron developed the web based management module that is primarily used as a management tool to keep managers informed of what is happening on sites across the country and even across the border, without having to physically visit each site and also provide a secondary backup for data from weighbridges. The idea of developing a web based system was initiated in 2006 and for the past 6 years (from 2009) Datron has been effectively working on improving the MM and currently has more than 20 weighbridges connected and uploading data to it in some form or another.

The MM was developed using Delphi, HTML and Javascript and it uses MySQL or PostgreSQL Databases. The MM is a web based application that can be connected to and used from any device that has a browser installed as well as an internet connectivity. The basic data flow structure is illustrated on Figure 2.

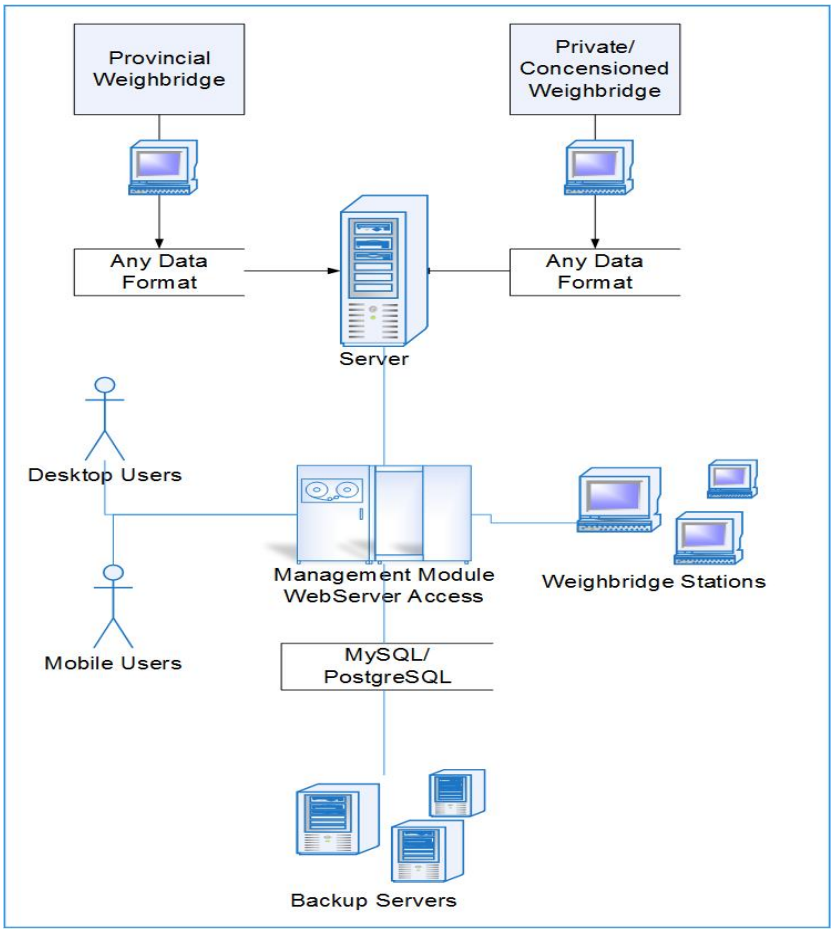


Figure 2: The Management Module, basic data flow diagram

The data upload to the MM happens automatically via a web service that connects the site to the server every 20 minutes and synchronises the newest data from the site database to a database on the server with an identical data structure. The MM is a versatile tool and can be used in many different ways; from generating monthly reports to investigating corruption. It gives a manager at any level an easy to access and use platform to access the information needed to manage the weighbridge operations optimally. As an example the system also picked up that most weighing sites had more 100 vehicles in the yard, but when management went to the yard, the yard was empty and this meant that there are vehicles that were allowed to leave the yard without following proper procedures.

3.2.1 *Some of the benefits of the MM include:*

- Off-site backup of weigh and prosecution data;
- Post-process data validation & flagging;
- Tracking of a vehicle's weigh history, even that from other weighbridges;
- Tracking overloaded vehicles that "escaped" from other sites without being charged; and
- Serving as an operations watchdog or corruption buster; prompting the weighbridge supervisor to investigate and/or explain irregularities, e.g. vehicles passing over the scale without being weighed.

Reporting, inherited from VOMS is another big part of the MM. Having data from multiple sites in one place, means that there are many reports a user can generate such as “Average Daily Operating Hours per Weighbridge” which gives the amount of vehicles weighed per hour of each day of a month, as well as daily, monthly and annual summary reports which can be grouped by weighbridge, by corridor or by province.

3.3 Examples of Real-Time Reports

The near real time reporting that the management information systems offers to authorities that have implemented it, has proved to be successful and useful. In the Western Cape average overloads has reduced since its implementation from 755 kg in 2006 to 529 kg in 2015 (a reduction of 33%), while operational performance has improved as underlined by management increasingly requesting training of scale operators to bridge the gaps identified by the system. As of 2015, more than 200 users have been trained in the Western Cape; KwaZulu-Natal; Gauteng and Limpopo provinces combined, including traffic officers, traffic college trainers and weighbridge operators.

Examples of some of the near real time reports are shown in Figure 3; Figure 4 and Figure 5 indicating alerts that management are issued with in relation to weighbridge operational problems. Figure 3 and 4 shows an alert in relation to issues that require supervisory or management attention, for example when a user has cancelled a weigh record or when there are vehicles that should have been issued with traffic fines but were not. These alerts assist management in dealing with the issues immediately and/or in some cases in near real time.

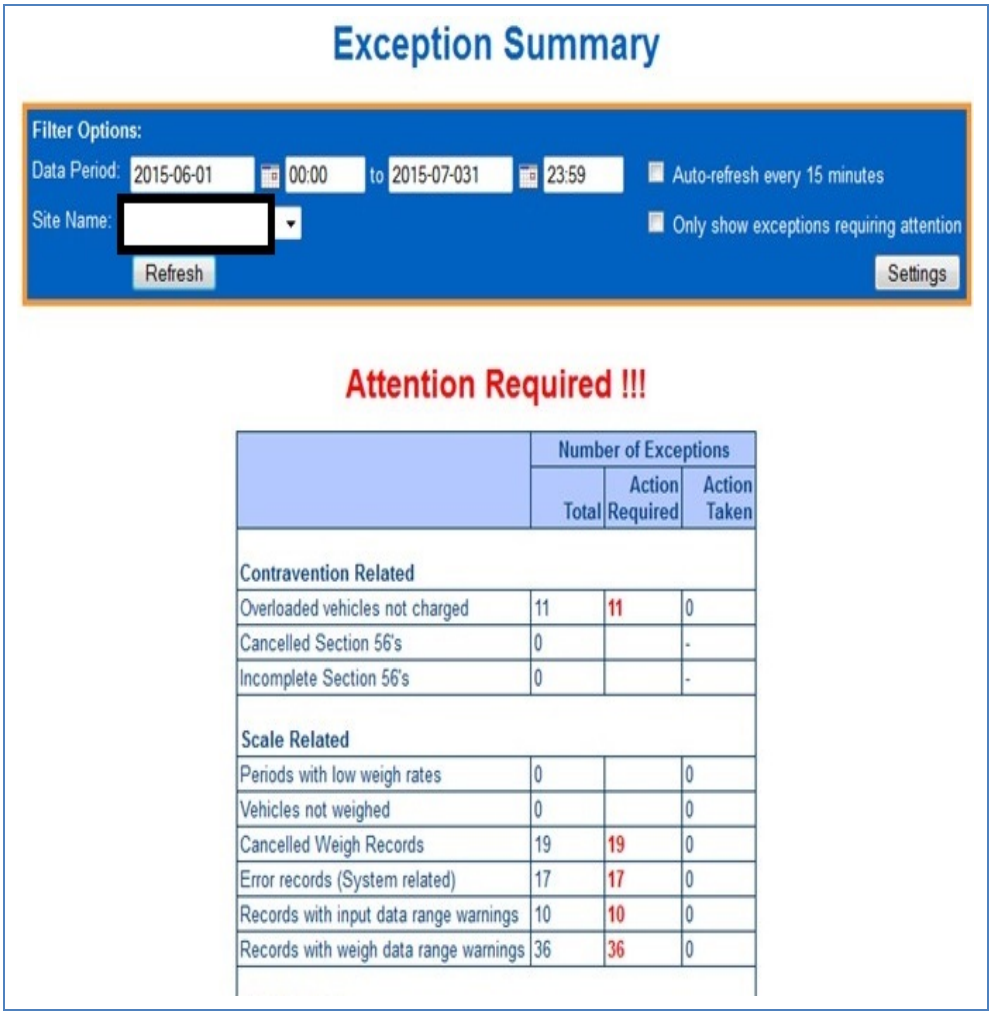


Figure 3: Attention alert at a specific weighbridge.

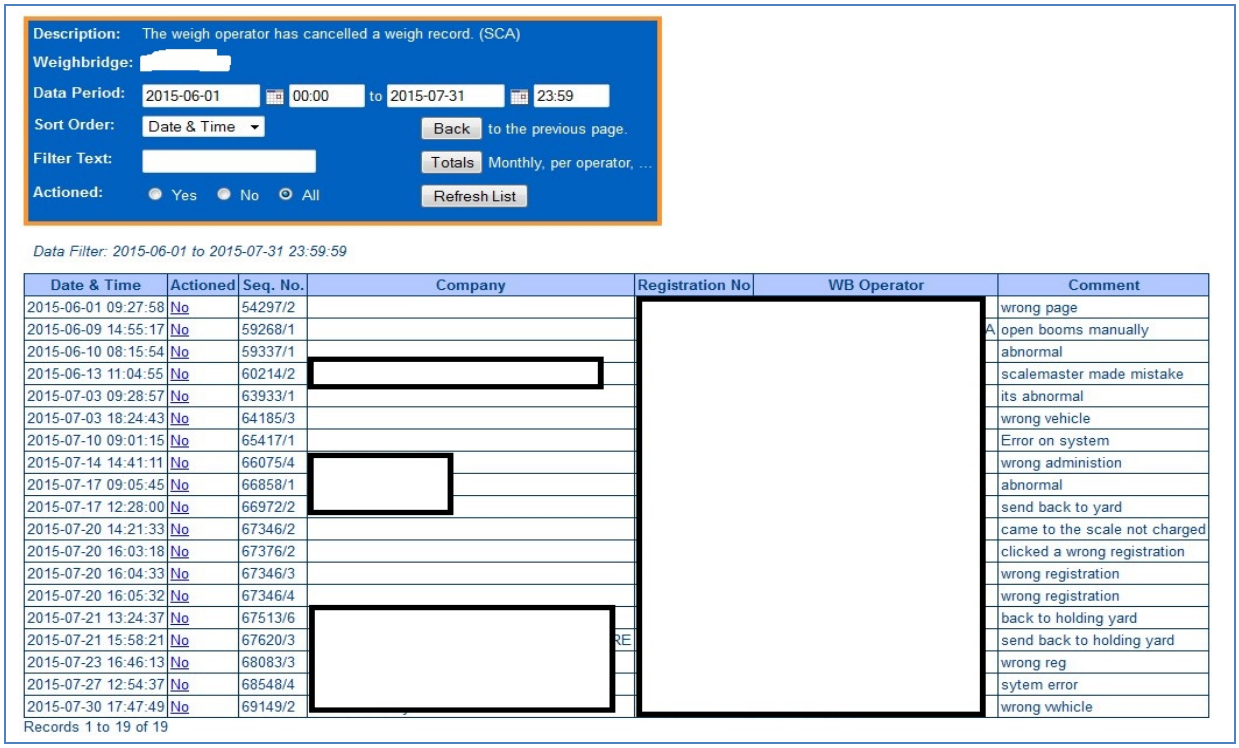
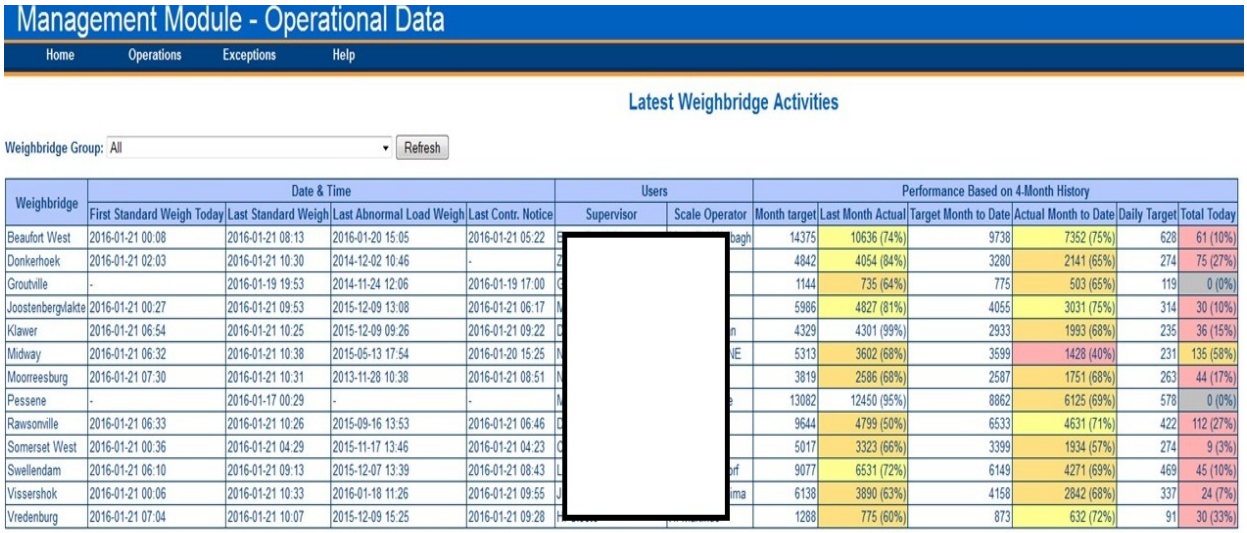


Figure 4: Exceptions Summary at a specific weighbridge.

Figure 5 shows current activities on the selected sites. For this example, sites connected to the management information system on 21 January 2016 between 00:00 and 11:00, are shown. This report allows management to set realistic performance targets, based on current and historical operations and also advices if goals are being met.



Weighbridge	Date & Time				Users		Performance Based on 4-Month History					
	First Standard Weigh Today	Last Standard Weigh	Last Abnormal Load Weigh	Last Contr. Notice	Supervisor	Scale Operator	Month target	Last Month Actual	Target Month to Date	Actual Month to Date	Daily Target	Total Today
Beaufort West	2016-01-21 00:08	2016-01-21 08:13	2016-01-20 15:05	2016-01-21 05:22	[redacted]		14375	10636 (74%)	9738	7352 (75%)	628	61 (10%)
Donkerhoek	2016-01-21 02:03	2016-01-21 10:30	2014-12-02 10:46	-			4842	4054 (84%)	3280	2141 (65%)	274	75 (27%)
Groutville	-	2016-01-19 19:53	2014-11-24 12:06	2016-01-19 17:00			1144	735 (64%)	775	503 (65%)	119	0 (0%)
Joostenbergvlakte	2016-01-21 00:27	2016-01-21 09:53	2015-12-09 13:08	2016-01-21 06:17			5986	4827 (81%)	4055	3031 (75%)	314	30 (10%)
Klawer	2016-01-21 06:54	2016-01-21 10:25	2015-12-09 09:26	2016-01-21 09:22			4329	4301 (99%)	2933	1993 (68%)	235	36 (15%)
Midway	2016-01-21 06:32	2016-01-21 10:38	2015-05-13 17:54	2016-01-20 15:25			5313	3602 (68%)	3599	1428 (40%)	231	135 (58%)
Moorreesburg	2016-01-21 07:30	2016-01-21 10:31	2013-11-28 10:38	2016-01-21 08:51			3819	2586 (68%)	2587	1751 (68%)	263	44 (17%)
Pessene	-	2016-01-17 00:29	-	-			13082	12450 (95%)	8862	6125 (69%)	578	0 (0%)
Rawsonville	2016-01-21 06:33	2016-01-21 10:26	2015-09-16 13:53	2016-01-21 06:46			9644	4799 (50%)	6533	4631 (71%)	422	112 (27%)
Somerset West	2016-01-21 00:36	2016-01-21 04:29	2015-11-17 13:46	2016-01-21 04:23			5017	3323 (66%)	3399	1934 (57%)	274	9 (3%)
Swellendam	2016-01-21 06:10	2016-01-21 09:13	2015-12-07 13:39	2016-01-21 08:43			9077	6531 (72%)	6149	4271 (69%)	469	45 (10%)
Vissershok	2016-01-21 00:06	2016-01-21 10:33	2016-01-18 11:26	2016-01-21 09:55			6138	3890 (63%)	4158	2842 (68%)	337	24 (7%)
Vredenburg	2016-01-21 07:04	2016-01-21 10:07	2015-12-09 15:25	2016-01-21 09:28			1288	775 (60%)	873	632 (72%)	91	30 (33%)

Notes:

1. Last Weigh: Time of the last normal weigh or the last reweigh.
2. Users: Names of the supervisor and scale operator logged in during the standard weigh operation.
3. Daily Target: A daily total that has been exceeded 10% of the time in the last 4 months (90 percentile).
4. Colours for actual values: White: within 10% of the target; Yellow: 10 to 30%; Orange: 30 to 50%; Red: Less than 50%

Figure 5: Operational performance indicators based on current activities

4 CONCLUSIONS

The Vehicle Overloading Management System has proven to be a useful tool and source of information for authorities and stakeholders making use of it. IT can be beneficial to all involved in heavy vehicle overload control activities. The benefits gained by the road authorities are many and includes the ability to identify operational problems in near real time; to monitor scale operator's performance; identify problematic hauliers who overload vehicles deliberately; to monitor operational performance and schedule shifts accordingly; to validate transactions for corrupt activities, etc. The management information system has proven to be successful and useful, as average overloads has reduced since its implementation and operational performance has improved, underlined by management increasingly requesting training of scale operators to bridge the gaps identified by the system, as an example the system picked up that most weighing sites had more 100 vehicles in the yard, but when management went to the yard the yard was empty and this meant that there are vehicle that were leaving the yard without following proper procedures.

5 RECOMMENDATIONS

A Management Information System, such as the one described in this paper would be beneficial to authorities like the Road Traffic Management Corporation, National Department of Transport, SANRAL and provincial departments of transport. It is therefore recommended that:

1. all weighbridges operating for law enforcement purposes be upgraded to make use of computerised systems and all weigh data be collected electronically and be stored in a centralised database.

2. A management information system should be installed to access the centralised database in near real time, allowing for management of all weighbridges to enjoy the same benefits that are currently available for authorities mentioned in this paper.

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