WAVETRAIN
SYSTEMS

THE LCWS CONCEPT

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THIS DOCUMENT REVISION LIST

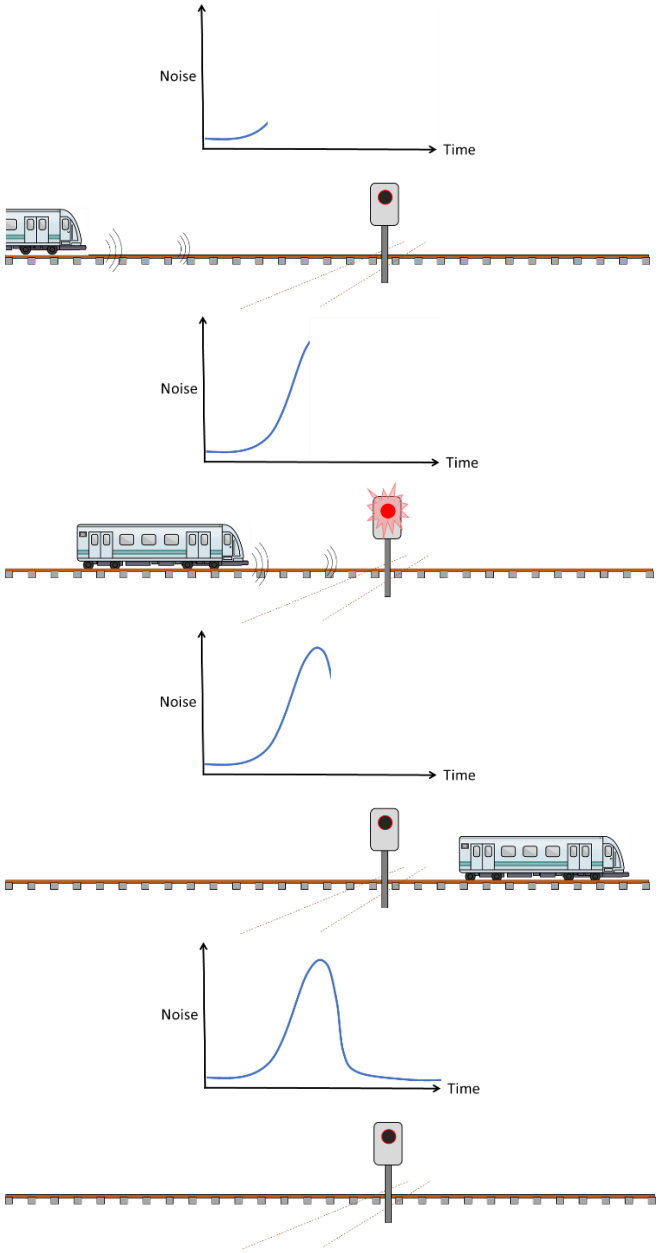
Date	Ver-sion	Author	Verified by	Approved by	Changes / Added information
09.11.2015	1.0	Svein Hansen	Monika L. Eknes	Ørjan Sommerseth	Version 1.0 LCWS 1.3

1 INTRODUCTION

WaveTrain® Systems (WTS) Level Crossing Warning System (LCWS) is a product that provides increased safety at railway level crossings. It is based on new technology that gives a significant cost advantage over traditional warning systems.

2 THE LCWS CONCEPT

The LCWS system uses sensors on the rails at the level crossing to pick up the sound waves induced by oncoming trains. The viability of this idea has been proven by extended field trials in several countries.



1
Sound waves are generated as the train is rolling. They will travel along the rails. The sound waves are picked up by the sensors at the level crossing.

2
As the train comes closer, the sound level increases. At a suitable noise level, the warning lights are lit.
The LCWS will filter and process the sound in order to focus on train sounds, not other kinds of noise.

3
When the train has passed the level crossing, the warnings are extinguished.

4
Ready for the next train.
For multi-track sites, the LCWS can issue a different warning signal if another train is approaching a short time after the first.

Figure 1: Detection based on sound

In effect, the sensors will listen to the track. The sounds picked up are transmitted to a computer which constantly analyses the data. If the software identifies an approaching train, warning signals are activated. When the train has passed, these warning signals are deactivated.

3 BENEFITS

- Using LCWS will allow the operator to increase public safety at more sites within a limited budget
- The LCWS covers one- or bi-directional traffic on single or double track.
- The LCWS is designed for installation at rural sites where mains power can be unreliable. It has a significant a battery backup, giving at least 24 hours of operational time after mains power is lost.
- The system is fully automatic during normal duty, and logs all system events.
- Statistics can be automatically forwarded to a central point, using wireless communication.
- The LCWS does not rely on track circuits, and does not influence track circuits already present.
- The LCWS does not require treadles or other devices to be placed far from the level crossing. All components are local. This makes installation comparatively easy.
- WTS has designed the LCWS to be self contained, self monitoring and with little need for unscheduled maintenance. Scheduled maintenance need is limited.
- Extensive use of redundancy gives good reliability, availability and safety performance.

4 A DIFFERENT APPROACH

Using the sound waves induced by the oncoming trains as the basis for triggering a warning event is fundamentally different from competing concepts. The unique technology gives unique benefits.
Whereas other warning systems rely on detection devices like e.g. treadles that are physically activated by the train, the LCWS does not require any devices far from the crossing itself. This gives the LCWS a cost advantage.
It does not rely on track circuits, either, which lets existing circuits stay as they are.
The LCWS is autonomous, and independent of the signalling infrastructure.
In order to gather traffic data, alarms, signalling logs, etc., there is a provision for communication between the LCWS installation and a central monitoring function. Such communication is based on commercial GSM data services, and it is fully automatic.

5 WARNING SIGNALS

Public signals are adaptable to different client requirements.
The basic function is to activate a warning light either side of the track to warn the public about the oncoming train.
The client may want to supplement the warning lights with audible signals, like a siren, horn, bell or similar devices.
Physical barriers can also be lowered and raised based on control signals from the LCWS.

Figure 2: Warning lights for LCWS, Network Rail example

6 SAFETY AND QUALITY

WTS has made the LCWS with safety, quality and value as priorities. The LCWS is certified to the SIL 2 level according to CENELEC EN 50126, 50128 and 50129, and fills a market niche where high safety gains are sought for modest investments.

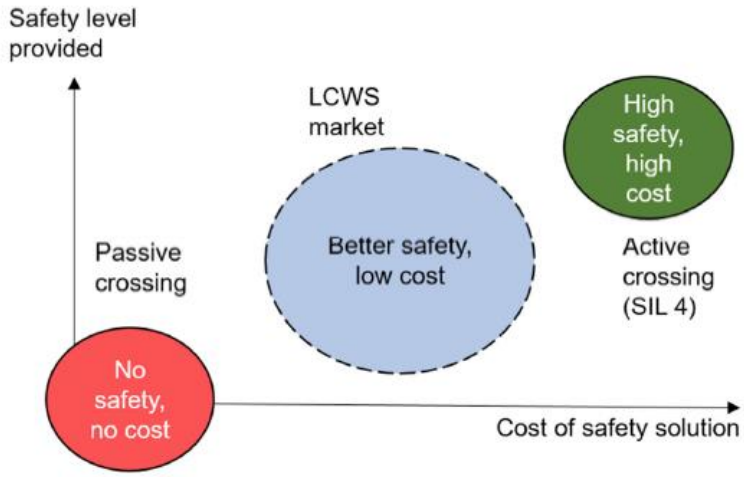


Figure 3: LCWS market niche

For the unlikely event that the system is unable to fulfil all its intended functionality or the system is out of order, the system will enter redundancy mode. If the sound picked up through the rail is impossible to interpret with confidence, safe mode is invoked.
The LCWS is installed with some parts directly attached to the rails and other parts in close proximity to the tracks. Hence, the equipment is subject to environmentally harsh conditions, like severe vibration, noise and EMC influences. The LCWS is built and tested with such demands in mind.
In general, the LCWS is using redundancy of vital parts in order to ensure the continued safe operation of the system in case of failures.

7 FIELD TRIALS

The LCWS has been field tested at sites in the United Kingdom, Norway, Finland, South Africa and Australia, racking up about 8300 days of operational use, or close to 23 years.

Figure 4 Trial installation of LCWS version 1.1 at Maltings, UK

During the trials, some problems did arise with the first version of the sensor unit. The weaknesses have been corrected in later versions. During the trial period WTS has also repackaged the LCWS to fit in one trackside cabinet.
Below are statistics for some of the trial sites (some trials are ended and some are continuing):

		Passages		Operating hours		Statistics period		
Site	Trains, avg per day	Main Assy	Sensor	Main Assy	Sensor	From	Until	System Operating Days
Beeston-Regis	27	18 252	73 008	32 448	64 896	24.08.2013	01.07.2015	676
Belaugh Lane	4	2 544	10 176	30 528	61 056	11.02.2014	09.11.2015	636
Bloss	12	10 044	40 176	40 176	80 352	16.03.2013	01.07.2015	837
Coltishall Lane	4	2 472	9 888	29 664	59 328	12.02.2014	23.10.2015	618
Dock Lane	12	9 732	38 928	38 928	77 856	11.04.2013	01.07.2015	811
Ellingers	12	8 760	35 040	35 040	70 080	01.07.2013	01.07.2015	730
Golf Links	300	188 700	754 800	30 192	120 768	01.02.2014	23.10.2015	629
Maltings	12	10 488	41 952	41 952	83 904	01.06.2013	23.10.2015	874
Melton Sewage	12	11 808	47 232	47 232	94 464	28.02.2013	09.11.2015	984
Uffold	12	6 504	26 016	26 016	52 032	16.05.2014	09.11.2015	542
White House	27	22 086	88 344	39 264	78 528	13.08.2013	09.11.2015	818
Tom Price (AU)	34	5 950	23 800	8 400	16 800	10.12.2014	03.06.2015	175
Sum:		**297 340**	**1 189 360**	**399 840**	**860 064**			**8 330**

Table 1: Trial statistics (as per primo November 2015)

The sensors that are attached to the rail head is the component that is exposed to the toughest conditions. We have close to 1,2 million train passes over the sensors, as per primo November 2015, proving the durability of the design.

Figure 5: The LCWS sensor

8 RELIABILITY, AVAILABILITY AND MAINTAINABILITY (RAM)

All components of the LCWS Sensor Unit version 1.3, are according to their data sheets in general resistant to temperatures in the region from -40°C to at least +80°C. The table below summarises the MTBF and availability calculations for 25°C. Reliability and availability calculations are also available for -40°C and 80°C.

Scenario	Risk Assessment Result
LCWS System Availability[1]	99,9999982 % (Single track) 99,9999974 % (Double track)
LCWS System hazard rate for hardware failures resulting in System Safe Mode	7,54E-10 (per LCWS system hour, single track) 1,09E-09 (per LCWS system hour, double track)
Mean Time Between Failure for LCWS System	1,33E+09 (LCWS system hours, single track) 9,21E+08 (LCWS system hours, double track)

Table 2: RAM figures for the LCWS

In order to ensure that the LCWS is maintainable, the design of LCWS is based on the following principles:

- The design of hardware units are based on the principle of modularity so that entire units easily may be replaced
- The software maintainability is ensured through quality assurance according to CENELEC EN 50128
- Software maintenance such as patches, upgrades or other changes can be done remotely and will be done by WTS or a WTS Certified Partner.

[1] Safe Mode events due to LCWS Software decisions (except due to failure of several sensors) are excluded as this is the valid fail safe state of the system in some predefined cases

9 WHY THE LCWS

The LCWS is a novel approach to an old problem: how to increase safety at level crossings given tight budget constraints.

Due to the relatively easy installation, modest product cost and the autonomous operation, the LCWS gives a highly competitive offering.

In simple terms: The SIL2 LCWS reduces risk at a competitive price with simple installation and maintainability.