



RailScanner Technical paper

1. Introduction

RailScanner is an electronic monitoring system that checks the condition of the railroad track under real operational loading. It does this by measuring the dynamic behaviour of rail wagons under real operating conditions and reporting on excessive dynamic mobility, which indicate faults with the railroad track. The complete system consists of transducers installed on a suitable location on the bogie, electronic conditioning circuitry, on-board computerised data acquisition system, post-processing software and an intelligent database.

Keeping the railroad in good condition is important for the safe operation of trains. A well-maintained track has little dynamic impact on rail wagons, thereby prolonging their life and ensuring continued safe operation. Since the dynamic behaviour of the wagons is directly linked to the condition of the track, it is important to understand the behaviour of the train during operation. By pointing out areas on the track that cause excessive dynamic mobility of rail wagons, RailScanner allows the operator to focus maintenance efforts on those areas of the track that most adversely affect the trains. This targeted approach saves maintenance costs for both wagons and rail and ultimately minimises the chances of costly derailments.

Railroad operators can experience unexpected structural and mechanical failures on their wagons, despite the fact that the tracks are regularly scanned with track geometry measuring cars. These continued structural and mechanical problems indicate that track geometry measurements alone are not enough to ensure the discovery of track faults that adversely affect the safe operation of trains.

Unlike specialised track surveying equipment (which requires special stand-alone vehicles), RailScanner becomes a part of the train. The system effectively assesses the performance of rail wagons under Real Operational Loading (ROL) - that is, it monitors the train's reaction as it passes over the track. Some track faults are not picked up during periodical audits by special measuring cars, because the measuring car exerts a completely different operational load on the track than a regular operating train.

The behaviour of individual wagons and the train as a whole depends on loading, speed, driving techniques, rail condition, condition of sleepers and the condition of the ballast and sub-grade. RailScanner closely monitors the behaviour of the wagon in response to the combined effect of all these factors.

RailScanner therefore offers a tool for track maintenance, which assesses the condition of the rail by measuring the dynamic behaviour of the wagons in response to the overall track condition. The dynamic behaviour of the wagon tells us whether the overall track condition is acceptable. RailScanner ideally complements other track condition assessment tools, such as track geometry measuring cars.

2. Track Geometry and Track Faults

Railroad operators require a tool that confidently and cost effectively assesses the performance of a train during real operational conditions. Although track geometry measuring vehicles are useful in track maintenance (by allowing the operator to maintain correct track geometry), they can only assess the track condition with reference to themselves and frequently do not detect faults that can cause problems for the train. Furthermore, track geometry measuring vehicles cannot be



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operated continuously without interrupting operating schedules. Since they are used for periodical monitoring, they cannot pick up rail track faults early, as soon as they start to develop and at a stage when they may be less costly to repair.

Track geometry is important to ensure general correct alignment of the track. Geometry measurements uncover deviations that can cause problems for a train. However, track geometry alone does not affect the dynamic performance of the train.

Faults which may not be detected by track geometry measurements include:

- weakened sub-grade
- loose fasteners
- structural problems with the rail or sleepers
- geometrical anomalies that are not picked up as faults (e.g., vertical or horizontal motion)

Such faults may not affect the geometry of the track, but they do impact on the dynamic behaviour of the train. RailScanner picks up these faults, since they result in undesirable dynamic mobility of the train.

3. Behaviour of Trains During Real Operational Conditions

Track geometry measuring cars cannot take into account the load conditions, velocity, and driving techniques of a train during Real Operational Conditions. Experience has shown that keeping the track geometry in optimal condition does not ensure optimal performance of the train. RailScanner fulfils the need for a tool that takes these operational parameters into account.

4. Early Fault Detection

Since train and track operate as a dynamic system track faults can develop quickly and periodic scanning can miss these changes. Since RailScanner can be permanently installed on the train and records track conditions every time the train travels, it will not miss rapidly developing faults. Because these faults are noticed early, necessary maintenance can be implemented earlier, thus avoiding further damage to the wagons or proliferation of rail faults. If faults are detected in their early stages, the faulty section of the track may be relatively small, and early, targeted maintenance can contain further damage to the track.

RailScanner uses powerful fault detection computer programs, and the operator can gain information about the condition of the track as soon as the train reaches its destination.

5. Continuous Monitoring

Because it can be used as a continuous monitoring system, the system's intelligent database will trend the history of rail fault development. This allows the operator to establish which areas of the track are most prone to damage caused by environmental and /or operational loadings and the rate at which the damage develops.

To maintain an optimal track it is not only important to measure track geometry from time to time. It is equally important to assess continuously the condition of the track by monitoring the behaviour of the train as it travels.

RailScanner was tested several times on major heavy haul railroads in Western Australia. The system was able to identify areas of track that contribute to excessive dynamic mobility of the trains.



6. Rail/Wheel Interaction

The philosophy behind RailScanner is based on the interrelation between rail and wheel. There is a direct relationship between the wagon's dynamic behaviour and the dynamic response of the track as it reacts to the wheel loading.

From extensive studies and many years of experience in measuring the behaviour of railway vehicles, Lynx Engineering established that measuring the dynamic behaviour of the wagon is a reliable indicator of the condition of the track.

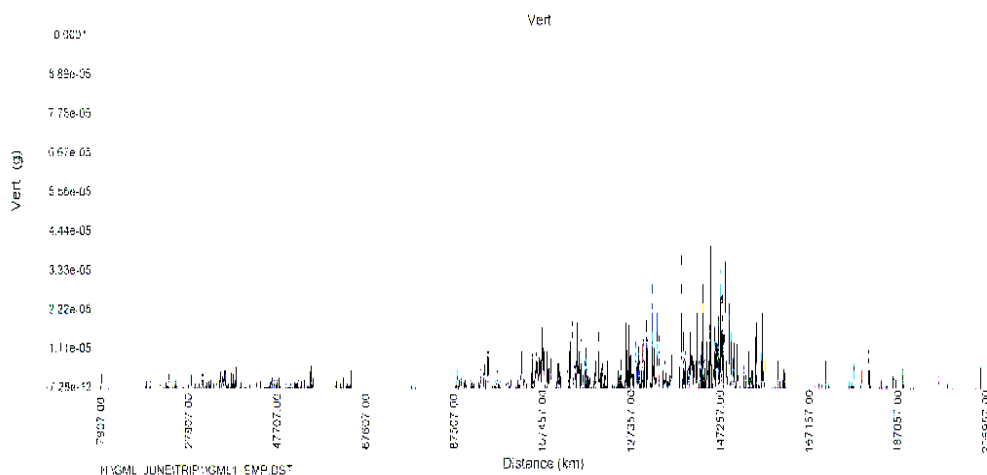
RailScanner measures the dynamic response of the wagon as well as its velocity. Using the dynamic signature of the transducers, the system establishes the level of energy in the wagon that is generated by train operation and the track conditions.

7. Measuring Dynamic Mobility

RailScanner continuously monitors the dynamic mobility of the wagon it is installed on. The sampling rate chosen ensures accurate assessment of the wagon behaviour. The powerful data acquisition techniques ensure the validity of the data gathered. At the end of the train journey, the post-processing software gives the operator almost immediate access to the findings for a particular journey (currently, post-processing for a six hour train trip takes about 25 minutes).

This method of correlating rail faults to dynamic behaviour of wagons is able to assess the severity of faults in real-time. Other systems that monitor track condition are not based on ROL or real-time assessment.

RailScanner informs the operator where excessive dynamic mobility of the instrumented wagon occurred on the track. Since RailScanner allows the operator to identify accurately the faulty track areas, the operator can then zero in on the area in question. This method saves time and resources, since only those areas that contribute to excessive dynamic mobility are identified.



8. Energy That Is Not Related To Rail Faults

Since RailScanner measures the dynamic mobility of the wagon, it will also pick up energies that are generated by wheel/rail interaction but are not related to rail faults. However, since the



RailScanner system is intended for continuous condition monitoring, this limitation is overcome after several scans of the track are performed and the resultant energy profiles are statistically analysed. Making a series of scans of the track eliminates the random nature of the energies created by wheel/rail interaction. The energy generated by rail faults will always recur. This has been proven throughout various runs with RailScanner.

RailScanner can operate on any type of track, regardless of rail or sleeper types.

9. How RailScanner Operates

As the wagon travels over the rails, the wagon is subjected to a variety of loadings, all of which affect its dynamic behaviour. Any faults on the rails will increase the wagon's normal dynamic mobility.

Once the RailScanner is installed it does not affect the safe operation of the train in any way. The RailScanner can withstand any travelling speed on any kind of track. It is designed to be robust.

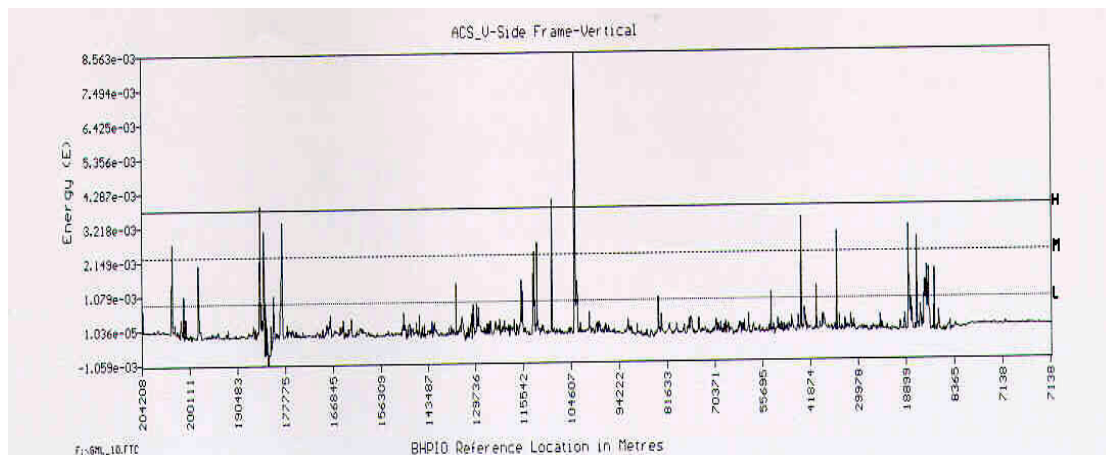
At the end of the journey the data is analysed on the on-board computer. Within a short time (typically about twenty-five minutes) the energy related to rail track faults is calculated. The final data is then transferred via cable or radio communication network to the computer in the workshop. Final post-processing for trending history now takes place, and the information on the track condition is available to the operator almost immediately. The workshop computer also performs trending analysis of the track and references all the track faults to their locations on the line.

10. Reporting

RailScanner records the entire dynamic mobility of the wagon, but stores only the excessive mobility that is related to track faults.

After post-processing, the operator is presented with a graph and a working table that show areas of excessive dynamic mobility. The track faults are located in these areas. Currently, RailScanner locates track faults with 10 meters accuracy.

The intelligent data base installed on the workshop computer performs all the reporting functions, trending analysis, keeps the history of the measurements and has extensive graphical user interface functions to allow the operator to access whichever information is required.



The above graph shows the dynamic mobility of a particular section of track

L = low dynamic mobility
M = medium
H = high

From	To	V (LO)	V (MED)	V (HI)	V (>HI)	V (Avr)	H (LO)	H (MED)	H (HI)	H (>HI)	H (Avr)
42502	42602	50	30	20	0	4.31189	60	30	0	10	4.75022
42802	42902	70	10	20	0	3.98668	70	10	10	10	5.70832
47102	47202	50	30	20	0	4.78987	80	0	20	0	5.90393
51702	51802	70	10	20	0	4.81943	80	10	10	0	3.5239
52502	52602	70	10	20	0	3.89295	90	10	0	0	2.79741
55602	55702	40	40	20	0	4.13543	80	0	10	10	6.65408
56002	56102	60	20	20	0	4.4782	50	50	0	0	3.54175
56202	56302	60	20	20	0	4.37335	60	10	30	0	5.19051
56402	56502	60	20	20	0	4.17173	70	0	30	0	5.26747
62702	62802	50	30	20	0	4.22729	60	30	0	10	6.03406
90802	90902	60	20	20	0	4.39851	90	0	10	0	4.79178
91502	91602	50	20	30	0	4.5323	80	0	20	0	5.08211
92302	92402	50	30	20	0	4.44393	60	20	20	0	5.28848
94802	94902	70	10	20	0	4.5973	50	20	10	20	6.21874
95402	95702	20	60	20	0	4.14574	56.6667	23.3333	13.3333	6.66667	5.3452
95802	95902	50	30	20	0	4.27387	40	40	10	10	5.24306
173082	173182	80	0	20	0	4.44725	80	10	10	0	4.49591
194882	194982	70	10	20	0	3.88866	90	10	0	0	2.15337

The above table shows the areas of excessive mobility on a particular track in 100 metre intervals.

The accuracy of finding track faults increases with every scan. This information allows the operator to plan his targeted track maintenance, starting from those areas that require maintenance most urgently.

11. Personnel Resources Required

To operate RailScanner, a technician conversant with computers is required to download the data from the on-board computer onto the workshop computer. The technician also generates reports. A technician with adequate computer skills needs no more than two days training to use the RailScanner system effectively. Lynx Engineering provides around-the-clock support for RailScanner.

The reporting facilities are available over the network and can therefore be accessed by any authorised personnel. The reports are useful for daily inspections as well as long-term strategic maintenance planning.

12. Summary

- RailScanner is a proven tool for targeted railway track maintenance, enabling the operator to identify systematically the location of track faults on a continuous basis.
- The system is easy to use and does not require additional railroad vehicles. Once installed it provides a continuous flow of useful information on the state of the railroad track.
- RailScanner is a robust system designed for long-term continuous or periodic monitoring of rail tracks
- It uses Real Operating Loads (ROL) to assess the effect of the track condition on rolling stock



- The system does not require specialised track monitoring vehicles
- Data and information is available to the operator within 25 minutes of the completion of the trip
- RailScanner provides output in the form of graphs showing excessive mobility of rolling stock along the entire length of the track. This includes the location of the faults to an accuracy of +/- 10 metres.