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## Discussion on “Field Test Performance of Noncontact Ultrasonic Rail Inspection System”

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1 **Discussion of “Field Test Performance of Noncontact Ultrasonic Rail**  
2 **Inspection System” by Stefano Mariani, Thompson Nguyen, Xuan**  
3 **Zhu and Francesco Lanza di Scalea.**

4  
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7  
8 **Sakdirat Kaewunruen<sup>1</sup>**

9  
10 In general, the development of novel technology for rail inspection is very welcome  
11 indeed. The paper under discussion was well written by the authors. The field  
12 investigation results at the Rail Defect Test Facility of the Transportation Technology  
13 Center in Pueblo, Colorado are critical for rail inspection management in practice. In  
14 the paper under discussion, the authors have focussed on the effectiveness of  
15 noncontact air-coupled ultrasonic inspection system (or so-called ‘UCSD System’) on  
16 rail defect detection using the imbalance of two ultrasonic arrays. The ‘new-  
17 generation’ UCSD system collects data on the gauge side of rail(s). The authors have  
18 found that the velocity of the inspection vehicle or the test speed plays a key role on  
19 the performance of defect detection in the field. Their experiments show that

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20 reasonable performance of the UCSD system can be achieved at the test speeds  
21 between 1.6 and 8 km/h. In addition, it is highly appreciative that the authors  
22 concluded that there are limitations of the system and the authors plan to develop  
23 more work in order to distinguish between defects and welds; and to expand the  
24 coverage area of the system over rail head.

25

26 The field trials by the authors were carried out on curves with radii of 233m (or  $7.5^\circ$ )  
27 and 350m (or  $5^\circ$ ). Note that the curve radius (R) has been converted from  $R = 50 / \sin$   
28  $(D/2)$ . The assumption is based on 30.5m (100ft) chord and D is the degree of  
29 curvature in radians. It is very frequently found that in practice various types of rail  
30 defects can develop on railway tracks with sharp curves (i.e.  $<350\text{m}$  radius)  
31 depending on the characteristics of rail (i.e. standard carbon rail, head hardened rail,  
32 residue stress, manufacturing imperfection), operational parameters (i.e. train speed,  
33 axle load, rolling stock imperfection, cant deficiency), and maintenance quality (e.g.  
34 grinding frequency, tamping method, etc.). A common rail defect is of course the  
35 rolling contact fatigue (RCF) on gauge corner (or called 'head check' or 'gauge  
36 corner'). This RCF defect can further grow and cause rail squats, rail studs, transverse  
37 defects and other modes of failure. Figure 1 shows an example of moderate rail  
38 squats. The real examples of various rail defects found on curved tracks can be seen in  
39 Ishida (1989; 2015), Li et al. (2008), Grassie (2012), Grassie et al. (2012), Wilson et  
40 al. (2012), Kaewunruen and Ishida (2014, 2016), Kaewunruen et al. (2014),  
41 Kaewunruen (2015), and Andersson (2015). Note that the type of defect, its size and  
42 severity help track engineers to prioritise inspection and maintenance tasks. On this  
43 ground, not only is the defect identification essential to rail industry, the classification  
44 of defect type and maintenance prioritisation is also mutually crucial to mitigate

45 safety risks in railway operations. It is even more important that early-age rail defects  
46 are detected quickly enough to enact predictive and preventative track maintenance,  
47 instead of costly corrective one. The deflection of transverse defects might be slightly  
48 too late for any preventative actions.

49

50 The field data shown in Figure 1 demonstrates that rail surface defects can potentially  
51 spread over the rail head. Note that the field observations showed that rail surface  
52 defects can also develop at both low (inner) and high (outer) rails in curved tracks.  
53 The dimension and scale of rail defects are again dependent on various factors. If rail  
54 corrugations and wheel burns are present, additional vibration might also provide  
55 additional problems to the system in practice. As such, suitable device installation and  
56 noise cancelling technique will be required to enhance reliability of data analyses such  
57 as receiver operating characteristics (ROC), damage index (DI), probability of  
58 detection (PD), and probability of false alarms (PFA).

59

60 Hopefully, the field experience and some practical findings in this discussion would  
61 be useful and should encourage the authors to extend their future research and  
62 development with respect to the classification and quantification of rail surface  
63 defects in practice.

64

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97  
98



a) WEL-related stud (multiple squats)



b) RCF-related squat (single squat)

**Figure 1.** Rail squats in railway tracks based on their initiation types (photos taken in 2012 by Sakdirat Kaewunruen)