A CONTINUOUS OPERATING RAIL BREAK DETECTION SYSTEM USING GUIDED WAVES

PAPER No: 627

PRESENTER: FRANCOIS BURGER
INTRODUCTION

- MANY METHODS ARE EMPLOYED TO RELIABLY AND TIMEOUSLY DETECT BREAKS IN RAILS

- SCANS DONE AT SCHEDULED INTERVALS, RESULTING IN EXTENDED PERIODS OF TIME DURING WHICH A RAIL BREAK MAY NOT BE DETECTED

- MAN POWER INTENSIVE, EXPENSIVE, AND INTERFERE WITH TRAIN OPERATIONS

- WITH THE ADVENT OF COMMUNICATION BASED TRAIN CONTROL SYSTEMS (CBTC), MAKING TRACK CIRCUITS OBSOLETE, OPERATORS MAY STAND TO LOOSE THEIR BREAK DETECTION CAPABILITY

- RAILS BREAKS ARE A SERIOUS THREAT ON SOUTH AFRICAN FREIGHT RAILS
INTRODUCTION Continued

SOUTH AFRICAN FREIGHT TRAINS OF 3700 METERS LENGTH - DERAILMENTS ARE CATASTROPHIC AND EXTREMELY COSTLY
INTRODUCTION Continued

• IMT DEVELOPED AN ULTRASONIC BROKEN RAIL DETECTOR (RAILSONIC UBRD) TO WARN OPERATORS WHEN BREAKS OCCUR

• THE RAILSONIC UBRD CONTINUOUSLY MONITORS RAILS USING ULTRASOUND WAVES

• REPORTS BREAKS AT INTERVALS DOWN TO A FEW MINUTES

• INTERROGATES CONTINUOUSLY WELDED RAIL IN SECTIONS UP TO 1 KILOMETRE LONG

• THE ULTRASONIC TRANSDUCER USED IN THE SYSTEM WAS DEVELOPED BY THE COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH – SEE PAPER 268 PRESENTED EARLIER TODAY

• THE PRINCIPLE OF OPERATION IS DESCRIBED IN SECTION 2

• VARIOUS CHALLENGES ENCOUNTERED DURING DEVELOPMENT FOLLOWS IN SECTION 3

• CURRENT STATUS AND FUTURE DEVELOPMENT PLANS ARE DISCUSSED IN SECTION 4
2. OPERATING PRINCIPLE AND SYSTEM DETAILS

• **GUIDED WAVES PROPAGATE REASONABLY WELL IN STEEL RAIL**

• **THE RAIL IS EXCITED WITH ULTRASOUND SIGNALS AT ONE POINT, AND MONITORED FOR THE PRESENCE OF THESE SIGNALS SOME DISTANCE AWAY.**

• **SHOULD SIGNALS NOT ARRIVE AT THE MONITOR POINT, AN ALARM IS TRIGGERED**

• **TRANSMIT AND RECEIVE STATIONS ARE INTERLEAVED ALONG THE RAIL**
• **A SPECIFIC RECEIVER RECEIVES SIGNALS FROM BOTH RAILS AND DIRECTIONS**

• **TRANSMITTED SIGNALS CONSISTING OF FIVE SEPARATE BURSTS, ARE CODED BY MEANS OF BURST REPETITION INTERVALS WHICH DIFFERS FOR THE LEFT AND RIGHT RAILS, AND ALSO FOR DOWN AND UP DIRECTIONS**

• **BURST TRAINS ARE REPEATED AT A SPECIFIC INTERROGATION INTERVAL**
• RECEIVERS MEASURE THE BURST REPETITION INTERVAL TO IDENTIFY THE DIRECTION OF THE SPECIFIC TRANSMITTER

• RECEIVERS RECOGNISE VALID SIGNALS USING THE FOLLOWING CRITERIA:

(a) SIGNAL FREQUENCY
(b) BURST LENGTH
(c) BURST REPETITION INTERVAL

• SEVERE CONTINUOUS NOISE AT A RECEIVER JEOPARDIZES SIGNAL DETECTION – AN APPROACHING TRAIN WILL MANIFEST AS A TYPICAL CASE

• UNDER SUCH CIRCUMSTANCES, THE RECEIVER WILL INDICATE “TRAIN IN SECTION”, AND STOP PROCESSING SIGNALS UNTIL THE NOISE SUBSIDES
OPERATING PRINCIPLE AND SYSTEM DETAILS Continued

- TRANSMITTERS DRIVES ULTRASONIC TRANSDUCERS WITH HIGH VOLTGE PULSES (1300Vp)
- THE TRANSDUCER CONVERTS THESE DRIVING PULSES INTO ULTRASONIC ENERGY, PROPAGATING IN BOTH RAIL DIRECTIONS
- THE TRANSDUCER IS KEPT IN FIRM CONTACT WITH RAIL USING A HEAVY DUTY RAIL CLAMP
THE SYSTEM IS DESIGNED TO CONSUME MINIMAL POWER AND RUNS FROM SOLAR POWER AT REMOTE AREAS
DEDICATED ALARM TERMINAL
3. IMPLEMENTATION PROBLEMS

• CHALLENGE TO SELECT CORRECT FREQUENCY AND EXCITATION CONFIGURATION TO OBTAIN REASONABLE OPERATING DISTANCE

• SIGNAL AMPLIFIER SELF-NOISE (ULTRA LOW NOISE DESIGN)

• ROBUSTNESS AND LOGIC TO ELIMINATE FALSE ALARMS

• ISSUES THAT COMPLICATE PRACTICAL IMPLEMENTATION AND COMPROMISE RELIABILITY:

  (a) BIG VARIANCE IN SIGNAL PROPAGATION LOSS

  (b) TEMPERATURE RELATED SIGNAL CHANGES

  (c) TRAIN MOVEMENT INDUCED NOISE

  (d) SIGNAL CROSS TALK BETWEEN RAILS

  (e) HARDENING OF ELECTRONICS FOR VERY HOSTILE ELECTROMAGNETIC ENVIRONMENT

  (f) PRESENCE OF INSULATED/BOLTED JOINTS AND TURN-OUTS
TYPICAL SIGNAL ATTENUATION – 60 KG RAIL

**60KG RAIL ATTENUATION MEASUREMENT RESULTS**

- **MEASURED SIGNAL LEVEL (Vp NORMALIZED TO UNITY GAIN dB)**
- **PROPAGATION DISTANCE (METERS)**

**INSULATED JOINTS**

56 dB/Km

**IMPLEMENTATION PROBLEMS Continued**
IMPLEMENTATION PROBLEMS Continued

PROPAGATION LOSS IN CURVED SECTION

COAL LINE RAIL COMPARISON: Pole 25-11 to 26-8

Distance From Transmitter 25-10 (meters)

Comparative Signal Level (dB)

0 5 10 15 20 25 30 35 40 45 50

0 100 200 300 400 500 600 700 800 900 1000

V-Left  V-Right  Left Trend  Right Trend

15.4 dB/Km

100 dB/Km
TEMPERATURE RELATED RECEIVED SIGNAL LEVEL CHANGES

RECEIVED SIGNAL AMPLITUDE AND TEMPERATURE RELATIONSHIP

SIGNAL LIMITING (CLIPPING)

Implementation Problems Continued
4. CURRENT STATUS AND PLANNED DEVELOPMENTS

- SYSTEM IS NOW OPERATING FALSE ALARM FREE AT FREIGHT RAIL LOCATIONS AFTER MANY YEARS OF FINE TUNING

- IT CONTINUOUSLY INTERROGATES WELDED RAIL SECTIONS OVER 900 METERS

- DETECTED 3 BREAKS AND 6 LARGE FLAWS IN A 34 KM SECTION OF THE IRON ORE LINE (OREX) IN 15 MONTHS POTENTIALLY PREVENTING EXTREMELY COSTLY DERAILMENTS

- ROLL-OUT OF THE SYSTEM OVER THE ENTIRE 850KM ORE LINE IS EXPECTED TO COMMENCE WITHIN THE NEXT FEW MONTHS
CURRENT STATUS AND PLANNED DEVELOPMENTS Continued

- **THE DEPARTMENT OF SCIENCE & TECHNOLOGY IS GENEROUSLY SPONSORING AN UPGRADE PROGRAM**

- **AIM: 1800 METER OPERATING RANGE AND COMPATIBILITY WITH ALL RAIL TYPES AND THE METRO (FAST) ENVIRONMENT**

- **UPGRADED TO INCLUDE NEWLY DEVELOPED ULTRASONIC TRANSDUCER AND STATE OF THE ART SIGNAL PROCESSING TECHNOLOGY**

- **SMALL SIZE ULTRASONIC TRANSDUCER CAN NOW BE FITTED UNDER THE INSIDE RAIL CROWN, NEED NOT REMOVE THE TRANSDUCER FOR RAIL MAINTENANCE OPERATIONS (BALLAST TAMPING)**

- **THE TRANSDUCER ALONE (AS TRANSMIT-RECEIVE PAIR) IMPROVES SENSITIVITY WITH 40 dB (500 METER OPERATING RANGE INCREASE)**

- **THE RECEIVER WILL USE SOPHISTICATED TRANSIENT ANALYSIS AND WILL BE ABLE TO WORK FASTER (FOR METRO SYSTEMS) AND AT LOW SIGNAL-TO-NOISE RATIOS**

- **THE PROSPECTS OF IMPLEMENTING CONDITION MONITOR FUNCTIONALITY IS POSITIVE**