Experimental study of elevated MRT rail noise

Shing Chen

Industrial Technology Research Institute

shingchen@itri.org.tw

Objectives

- Find a suitable way to evaluate the insertion loss of noise barriers for elevated MRT trains when a reference microphone position is not available according to ISO 10847 or ANSI S12.8.
  - train noise characteristics

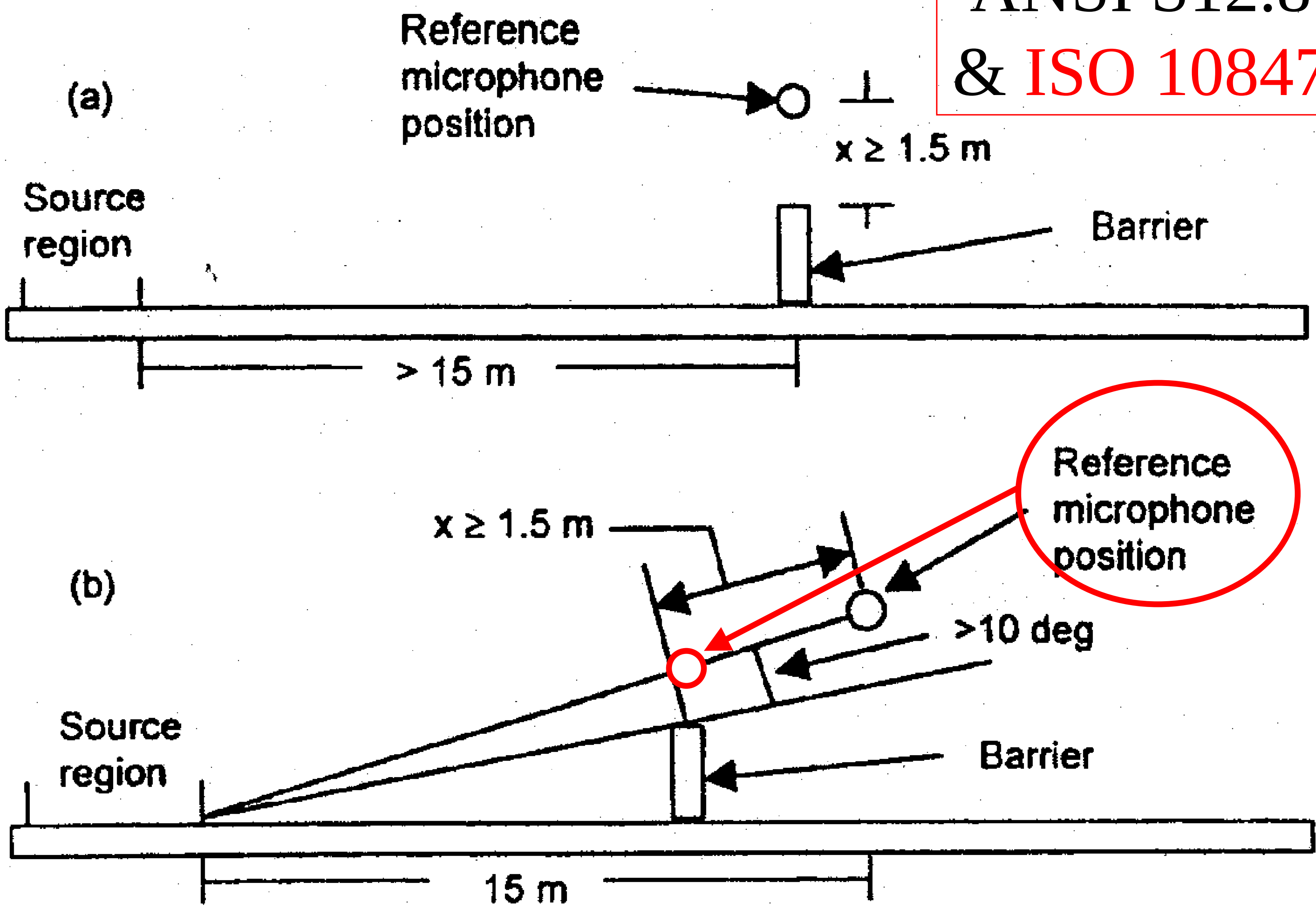
Insertion loss (IL) of noise barriers

- *In-situ* determination
  - ISO 10847, ANSI S12.8
  - Need a “reference microphone position”
- $IL = (L_p - L_{ref})_{before} - (L_p - L_{ref})_{after}$
  - $(L_p - L_{ref})_{before}$: SPL before noise barriers is installed
  - $(L_p - L_{ref})_{after}$: SPL after noise barriers is installed
  - L_p: SPL at receiver position
  - L_{ref}: SPL at reference position

Reference microphone position

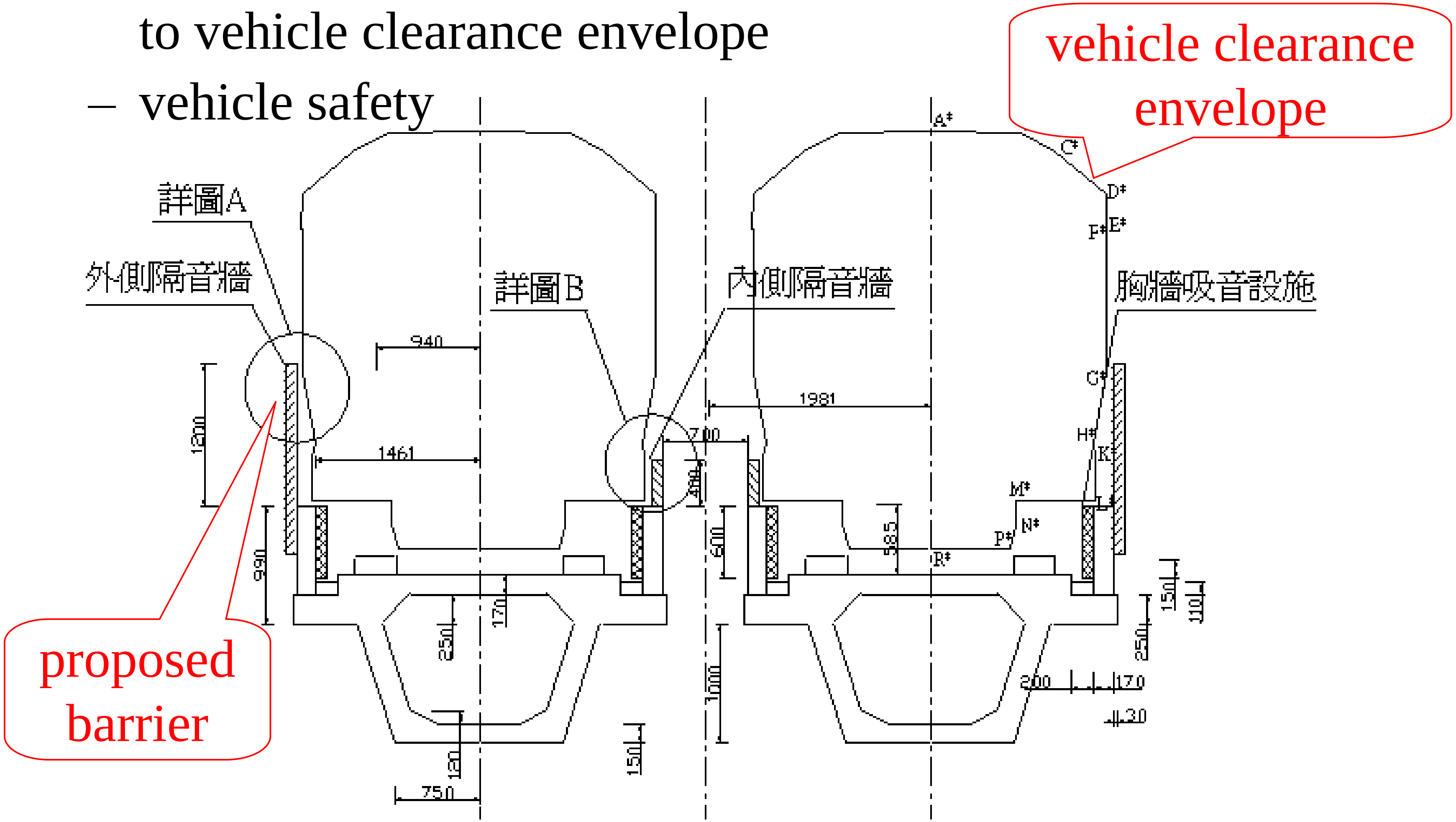
- avoiding near field, reflection, diffraction effects
- ISO 10847 & ANSI S12.8
  - at least 1.5 m above the barrier top
  - 10° greater than to the top of the barrier
    - distance from source to barrier is less than 15m

ANSI S12.8 & ISO 10847



Noise barriers in an elevated MRT viaduct

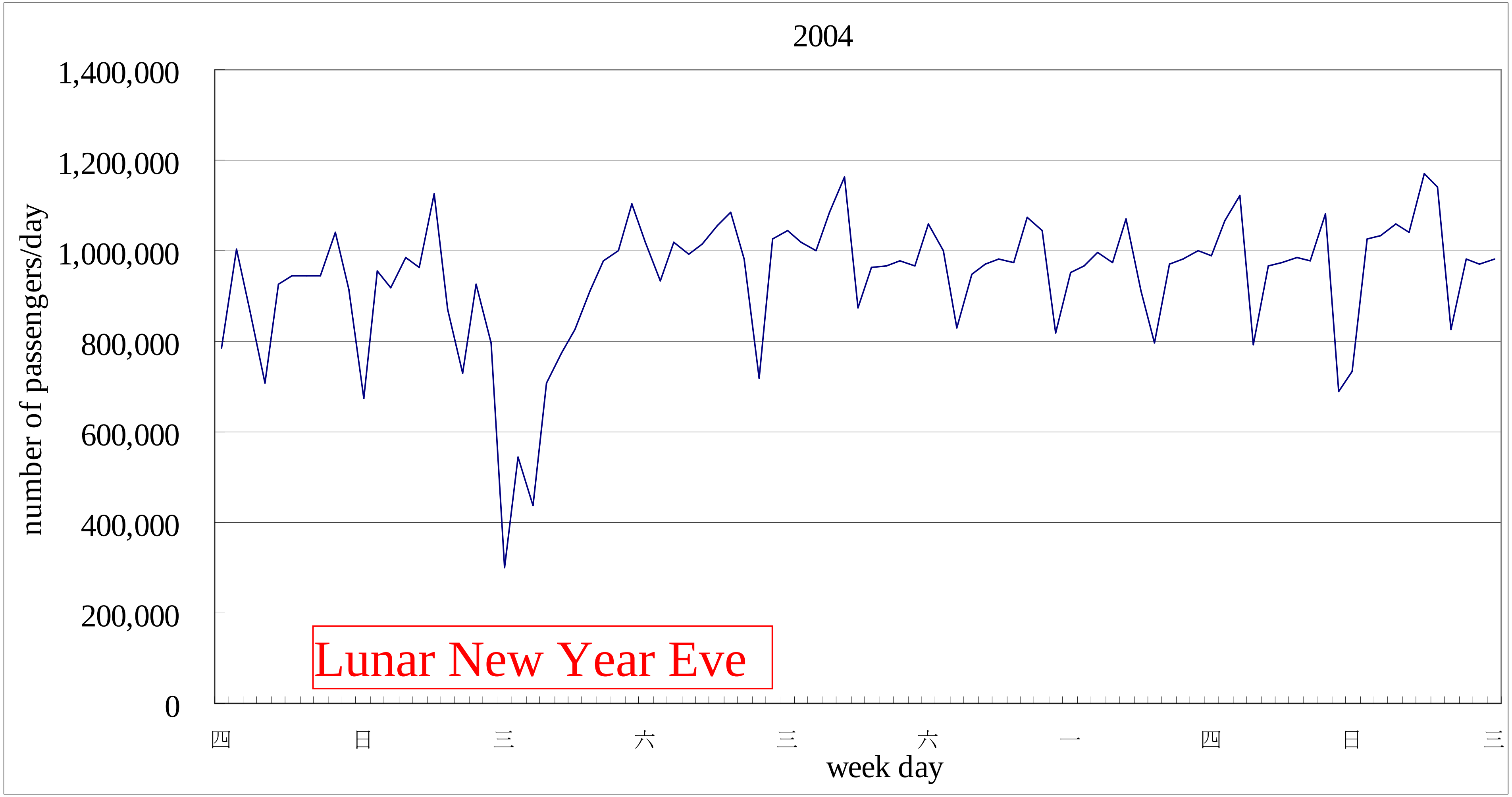
- Reference microphone position is not available
  - distance is less than 10 cm or 15 cm from noise barrier to vehicle clearance envelope
  - vehicle safety



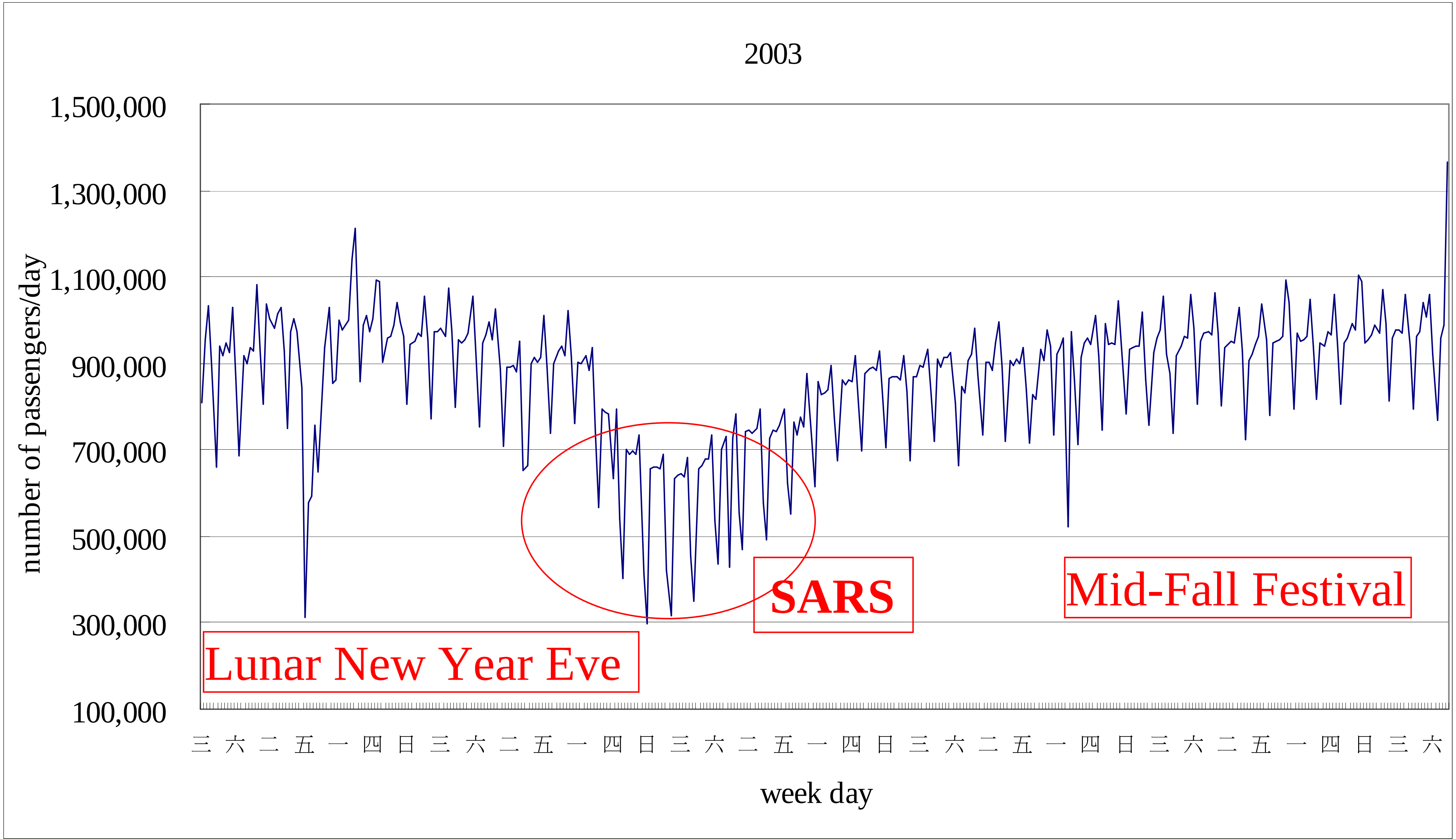
Insertion loss (IL) of noise barriers without a reference microphone in an elevated MRT viaduct

- $IL = (L_p)_{before} - (L_p)_{after}$
  - $(L_p)_{before}$: SPL at receiver position before noise barriers is installed
  - $(L_p)_{after}$: SPL at receiver position after noise barriers is installed
- Train noise characteristics:
  - passenger loading is periodical with time in a wide sense
  - non-steady
  - intermittent

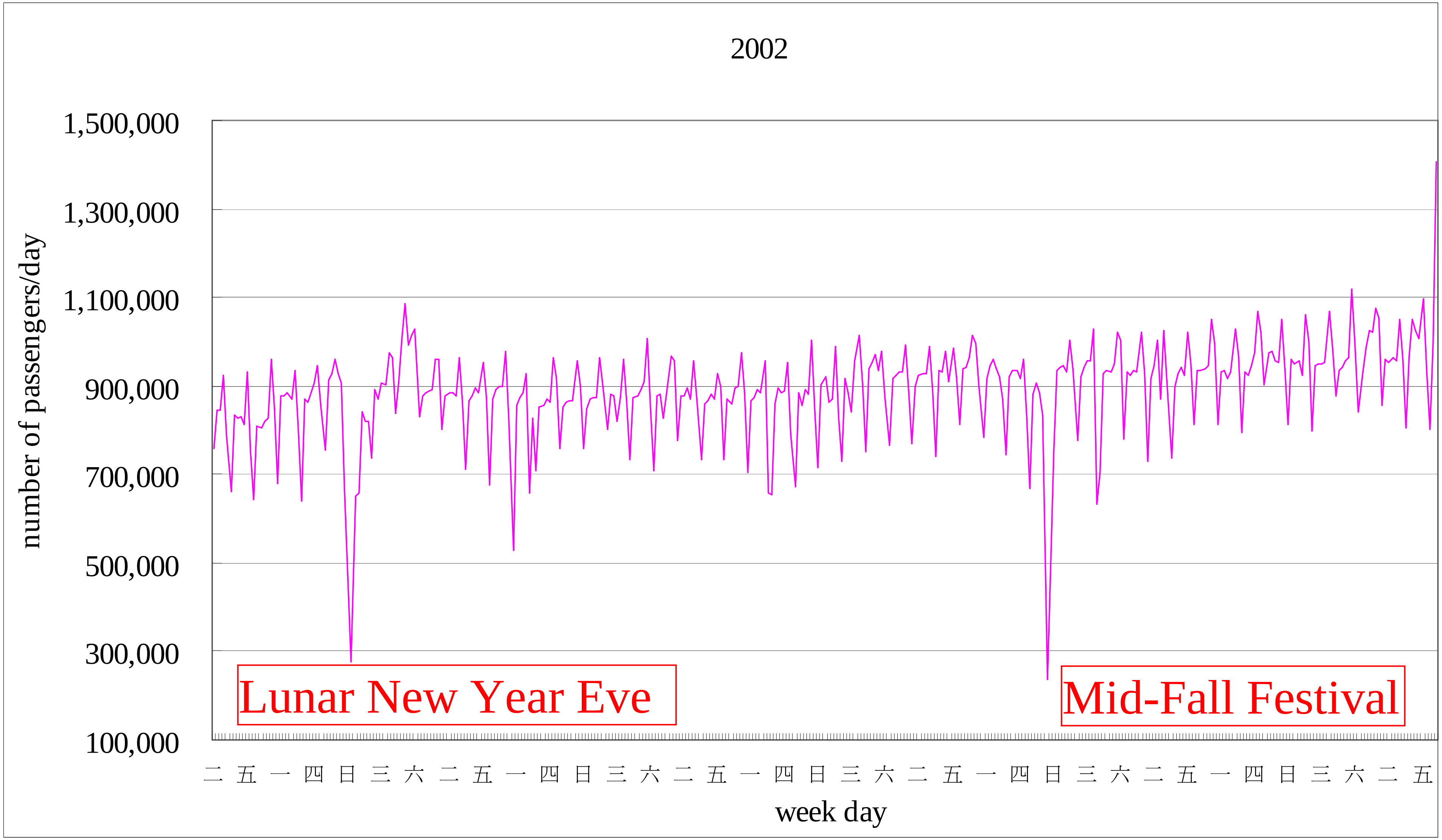
Number of passengers/day, year 2004



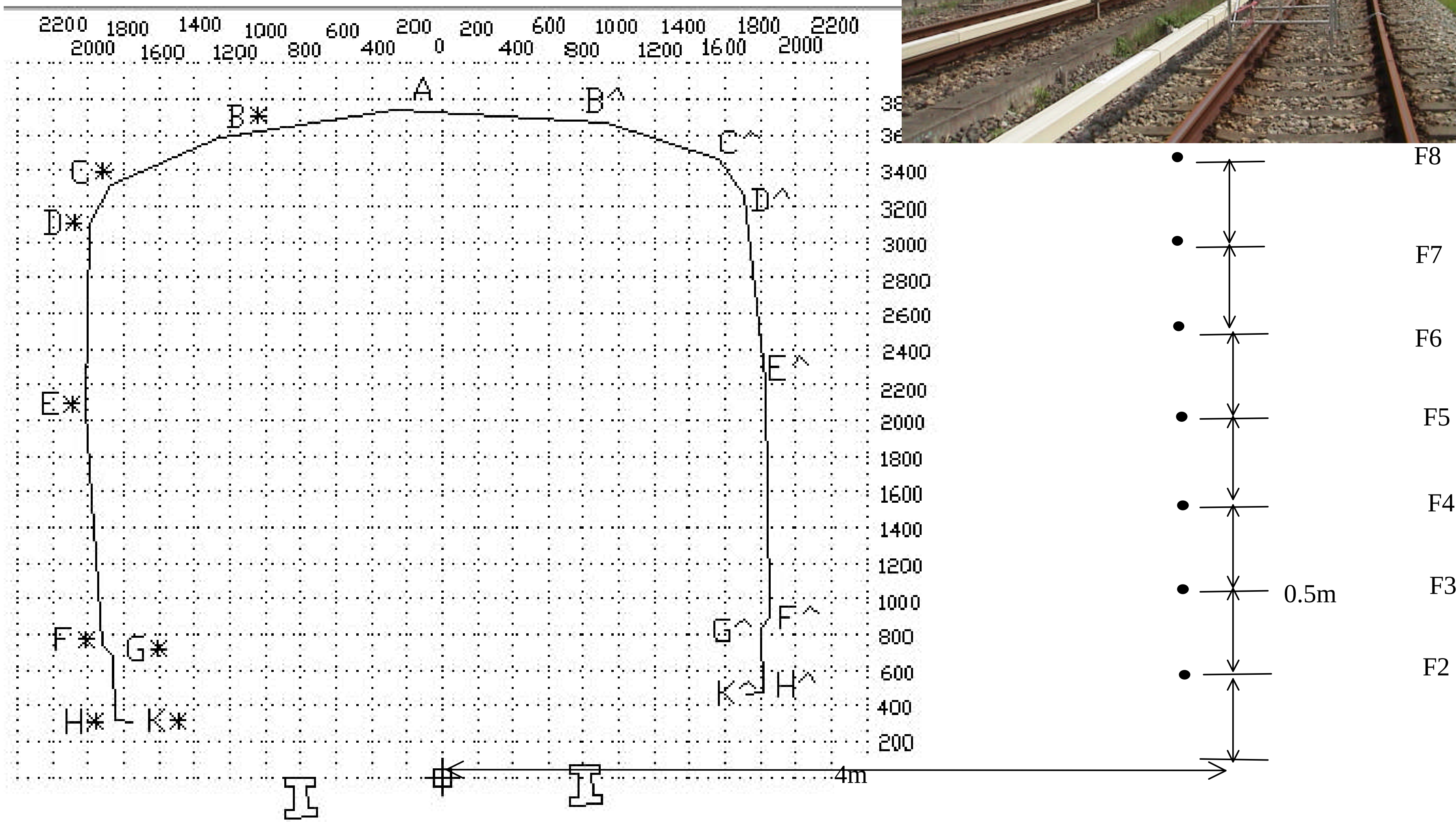
Number of passengers/day, year 2003



Number of passengers/day, year 2002



Train noise at controlled running conditions



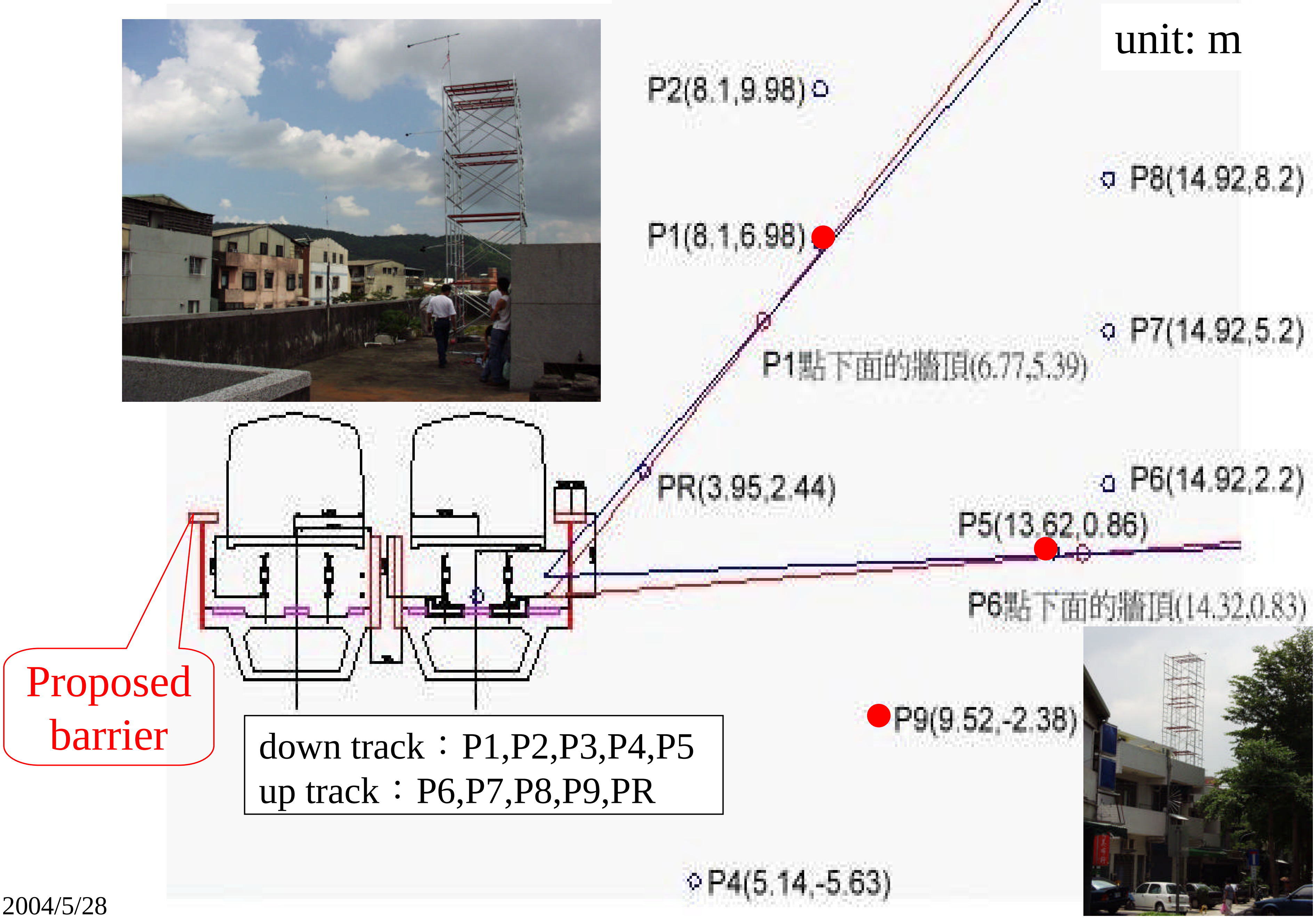
Controlled conditions: Repeated Train noise levels

train set		microphone number													
		F2		F3		F4		F5		F6		F7		F8	
		SEL	L_{max}	SEL	L_{max}	SEL	L_{max}	SEL	L_{max}	SEL	L_{max}	SEL	L_{max}	SEL	L_{max}
01/02	1st east bound	97.9	91.8	97.4	90.8	97.2	90.5	96.8	90.2	96.4	89.9	95.8	89.1	94	87.3
	2nd east bound	97.8	90.9	97.3	90.2	97	90.1	96.7	89.2	96.3	88.7	95.6	88.2	93.7	86.1
	1st west bound	100	93.8	99	92.6	98.8	92.3	98.7	91.6	98	91.1	97.5	90.4	95.7	88.6
	2nd west bound	98.5	92.7	97.8	91.9	97.6	91.5	97.3	91	96.8	90.2	96.2	89.9	94.5	88.1
107/108	1st east bound	99	92.2	98.9	92.1	99.1	92.4	98.6	92	97.8	91.1	97.3	90.5	95.6	88.7
	2nd east bound	99	92	98.8	91.7	99	92.1	98.5	91.9	97.7	91.0	97.2	90.5	95.5	88.7
	1st west bound	98.6	91.5	98.7	92.1	98.5	91.6	98.4	92	97.9	91.5	97.3	90.9	95.5	89.1
	2nd west bound	98.3	92.4	99.3	93.1	99	93.3	98.7	92.4	98.4	92.2	97.6	91.2	95.8	89.4

SPL max difference: 1.7 dB(A)
SPL difference average: 0.6 dB(A)

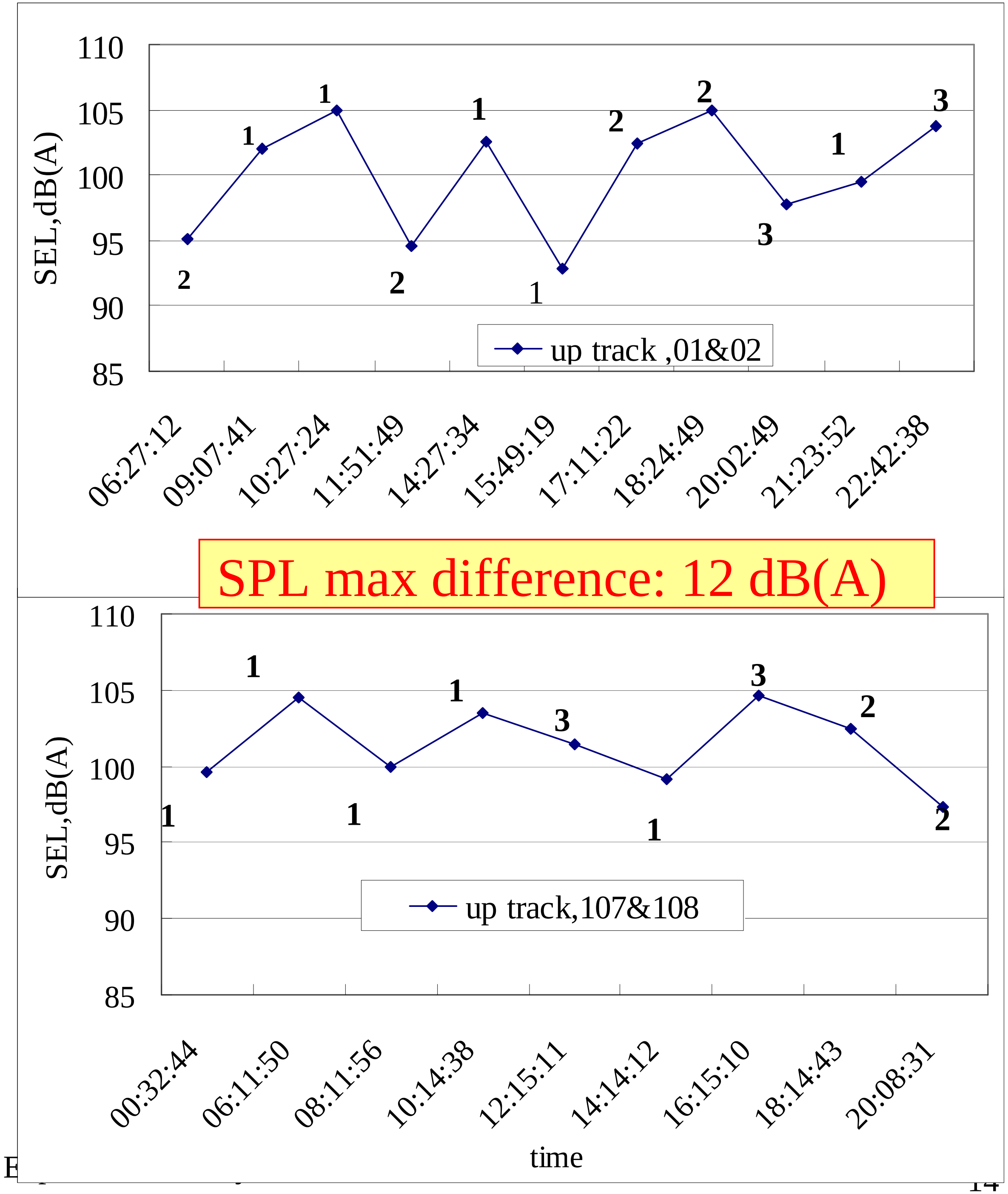
train speed at 80 km/hr
without passengers
(test date: 2002/09/14)

Receiver’s positions

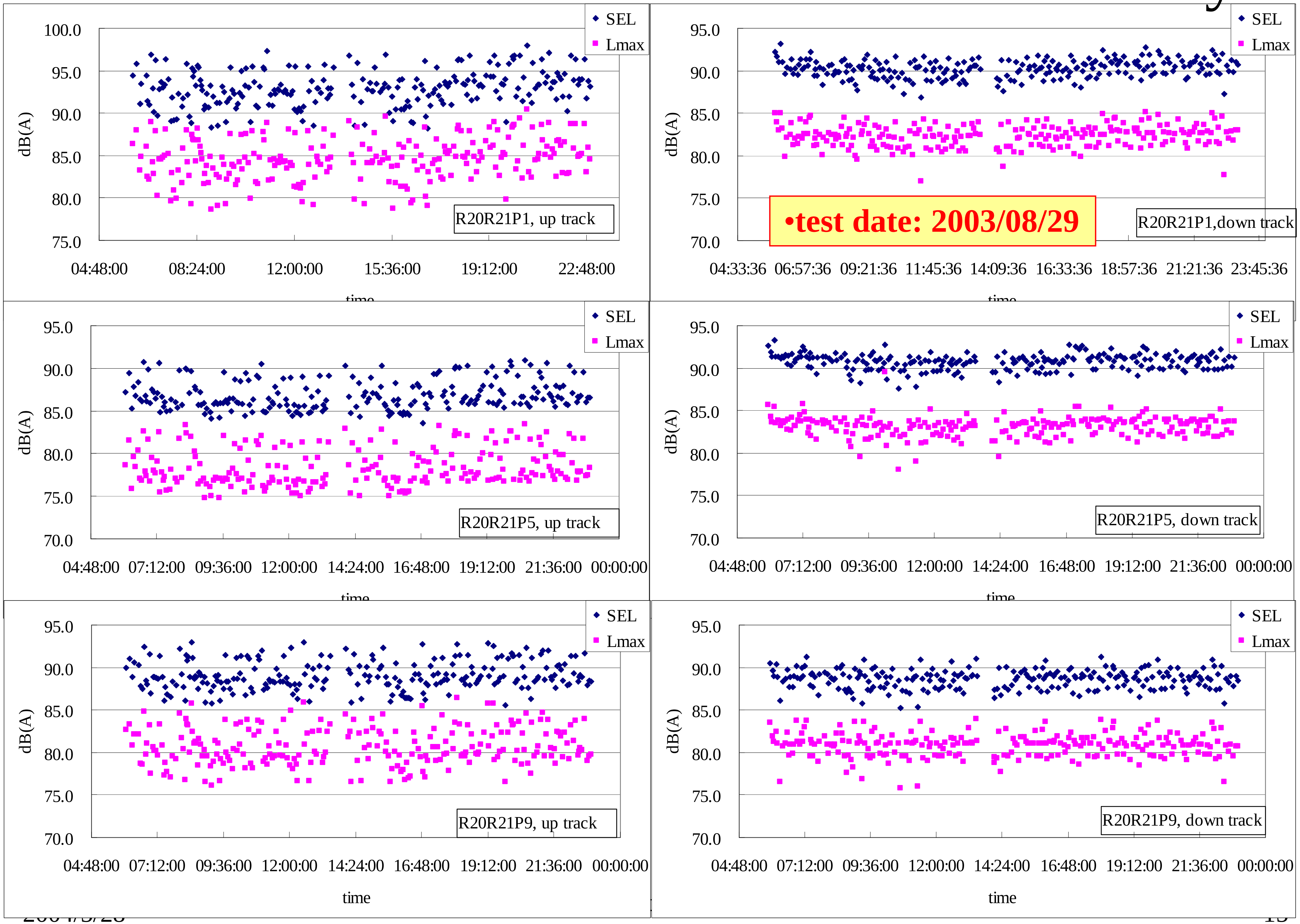


Uncontrolled conditions: Repeated noise levels of same train set in one service day

- test site: R20R21P1
- test date: 2002/09/04



individual train noise level in one service day

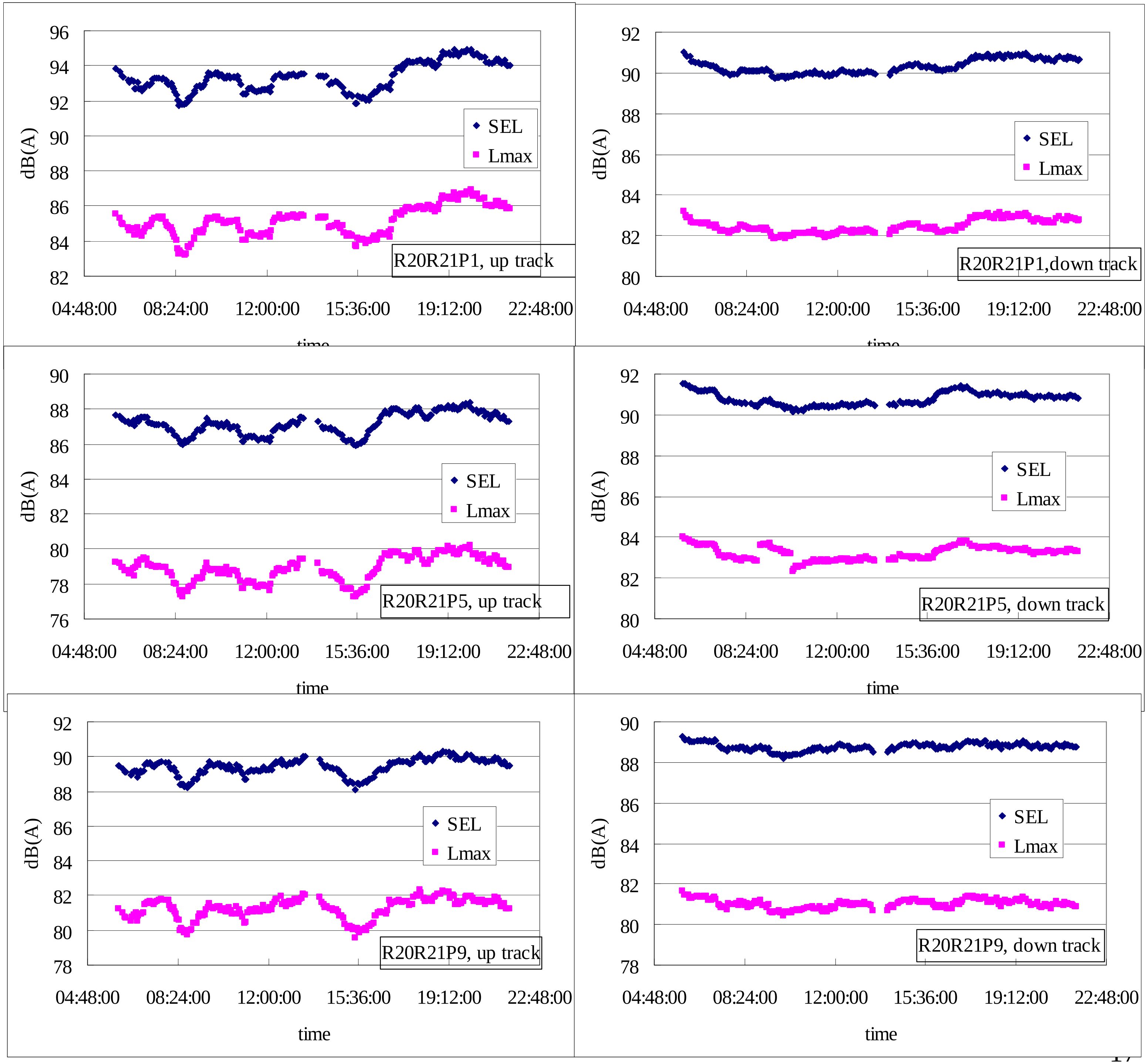


Statistics of train noise levels in one service day

site	noise level	up track				down track			
		2002/09/04		2003/08/29		2002/09/04		2003/08/29	
		average value	standard deviation	average value	standard deviation	average value	standard deviation	average value	standard deviation
R20R21P1	SEL	101.3	3.7	93.5	2.1	95.9	3.8	90.4	1.1
	L_{max}	93.6	3.9	85.2	2.5	88.1	4.2	82.5	1.3
R20R21P5	SEL	93.0	2.1	87.2	1.7	92.9	1.7	90.8	0.9
	L_{max}	84.4	2.3	78.9	2.2	84.8	1.8	83.3	1.2
R20R21P9	SEL	97.2	3.0	89.4	1.7	94.5	3.5	88.8	1.1
	L_{max}	88.8	3.4	81.3	2.0	86.6	3.7	81.0	1.4

- railhead grinding: May 2003.

Average noise levels of 20 trains in one service day (test date: 2003/08/29)



Statistics of average noise levels of 10 trains and 20 trains in one service day

site	no. of trains	noise level	up track				down track			
			2002/09/04		2003/08/29		2002/09/04		2003/08/29	
			average value	standard deviation	average value	standard deviation	average value	standard deviation	average value	standard deviation
R20R21P1	10	SEL	102.3	2.0	93.4	1.0	97.6	2.4	90.3	0.4
		L_{max}	94.7	2.1	85.2	1.1	90.0	2.5	82.5	0.4
	20	SEL	102.4	1.6	93.4	0.8	97.9	1.8	90.3	0.4
		L_{max}	94.8	1.8	85.2	0.9	90.3	1.9	82.5	0.3
R20R21P5	10	SEL	93.4	0.8	87.2	0.8	93.2	0.6	90.8	0.4
		L_{max}	84.8	0.8	78.9	1.0	85.1	0.7	83.2	0.4
	20	SEL	93.4	0.5	87.2	0.6	93.2	0.4	90.8	0.3
		L_{max}	84.8	0.5	78.9	0.7	85.1	0.5	83.2	0.3
R20R21P9	10	SEL	98.1	0.9	89.4	0.7	95.8	1.2	88.8	0.3
		L_{max}	90.0	1.1	81.3	0.9	87.9	1.5	81.0	0.3
	20	SEL	98.2	0.6	89.4	0.5	95.8	0.9	88.8	0.2
		L_{max}	90.0	0.7	81.3	0.6	87.9	1.0	81.0	0.2

- railhead grinding: May 2003.

Conclusions

- Insertion loss of noise barrier for an elevated MRT viaduct $(L_p)_{before} – (L_p)_{after}$,
  - may be conservative since the noise level from trains may be increased due to the degradation of wheel/rail interaction
- Sample sizes: 20 trains
- Noise measurement time for $(L_p)_{before}$ and $(L_p)_{after}$,
  - same week day
  - same train schedule
  - time period between $(L_p)_{before}$ and $(L_p)_{after}$: as short as possible
- No any railroad work or wheel grinding during the time period between $(L_p)_{before}$ and $(L_p)_{after}$

Thank you for your attention