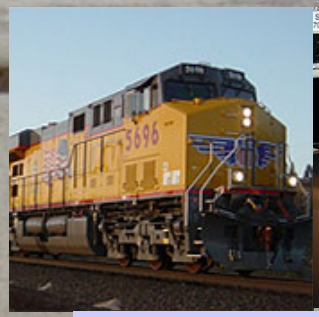




Whole-body Vibration related Ergonomic Study of U.S. Railroad Locomotives & Operators

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3 Berufsgenossenschaftliches Institut für Arbeitsschutz - BGIA, St. Augustin, Germany.

Aim of study:

- Ergonomic factors in relation to whole-body vibration exposure in US locomotives
- Assess Cab and Seats currently in use
- Assess ergonomic factors and confounders possibly mitigating WBV exposure effects

Background:

- Low back disorder occupational risk factors
  - Bending, twisting, lifting,
  - **awkward posture & WBV**
- Rail bound vehicles:
  - Unique environment with exposure to multi-axis whole-body vibration and shocks (WBV):

    lateral acceleration

    frequent irregular shocks

    events often unpredictable

Epidemiology of neck and lower back disorders :

- Method:
  - self-administered 200-item survey (cross-section)
    - Musculoskeletal diseases (back, neck, large joints)
    - Working conditions and ergonomic factors
    - Psycho-social stress (Karasak et al Model)
  - US & Canada randomly selected group of active railroad engineers and a comparison group (civil engineers)
  - Response rate: 47% for railroad engineers (n= 1195) and 41% for controls (n=323).

Journal of Transportation Research Board; No 1899, 2004, p145-155

Epidemiology of neck and lower back disorders :

- Serious LBP and neck/shoulder complaints among locomotive engineers was ~ double c/w control group
- Adjusted* OR for sciatic pain (a back condition with neurological complications) was 2.17 (95% CI 1.33-3.56) *Age, gender, race, smoking, non-occupational WBV exposure
- Attenuation of risk after controlling for psychosocial work factors, time sitting at work, and time at work being bothered by vibration

Journal of Transportation Research Board; No 1899, 2004, p145-155

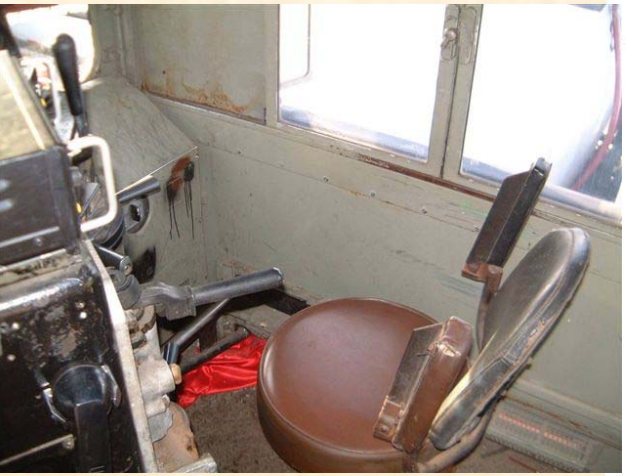
Method:

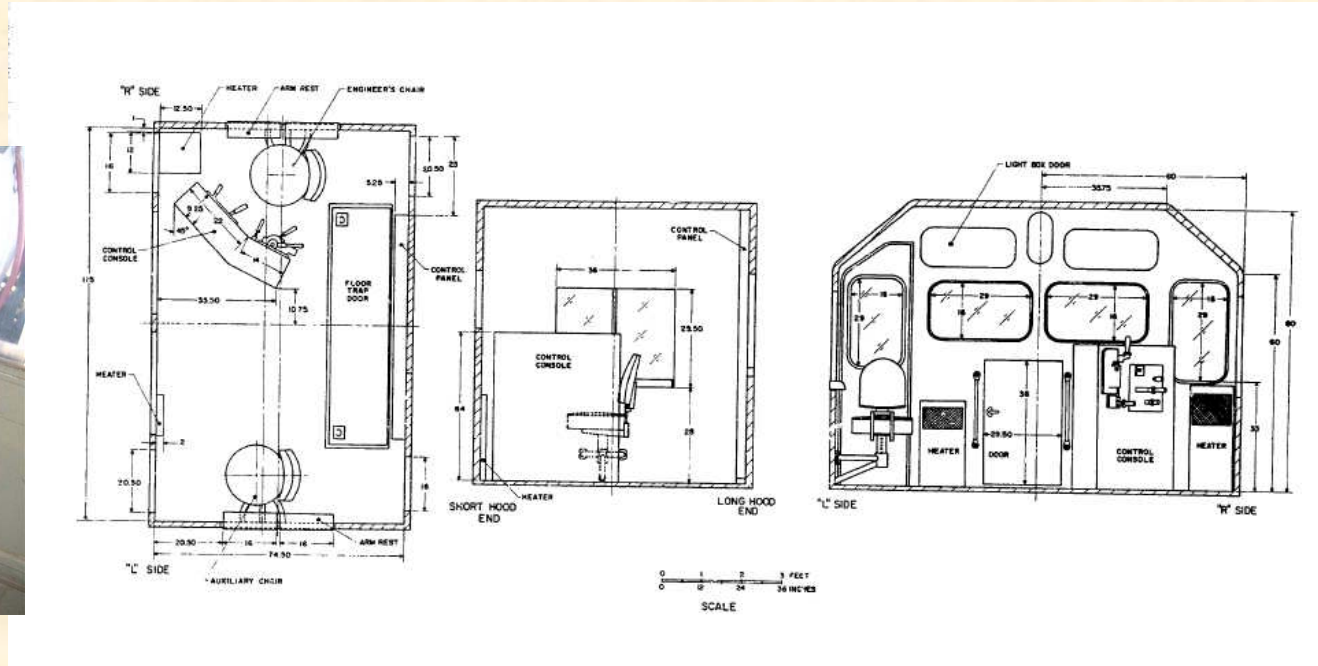
- Standardized cross-sectional questionnaire survey of North-American locomotive engineers (n= 1195) and controls (n=323).
- Comparison with a non-exposed control group (sedentary office worker)
- 50+ locomotive cab and seat inspections
- Observation of tasks and body movements of locomotive operators during routine revenue service

Results: Seat transfer function (SEAT)

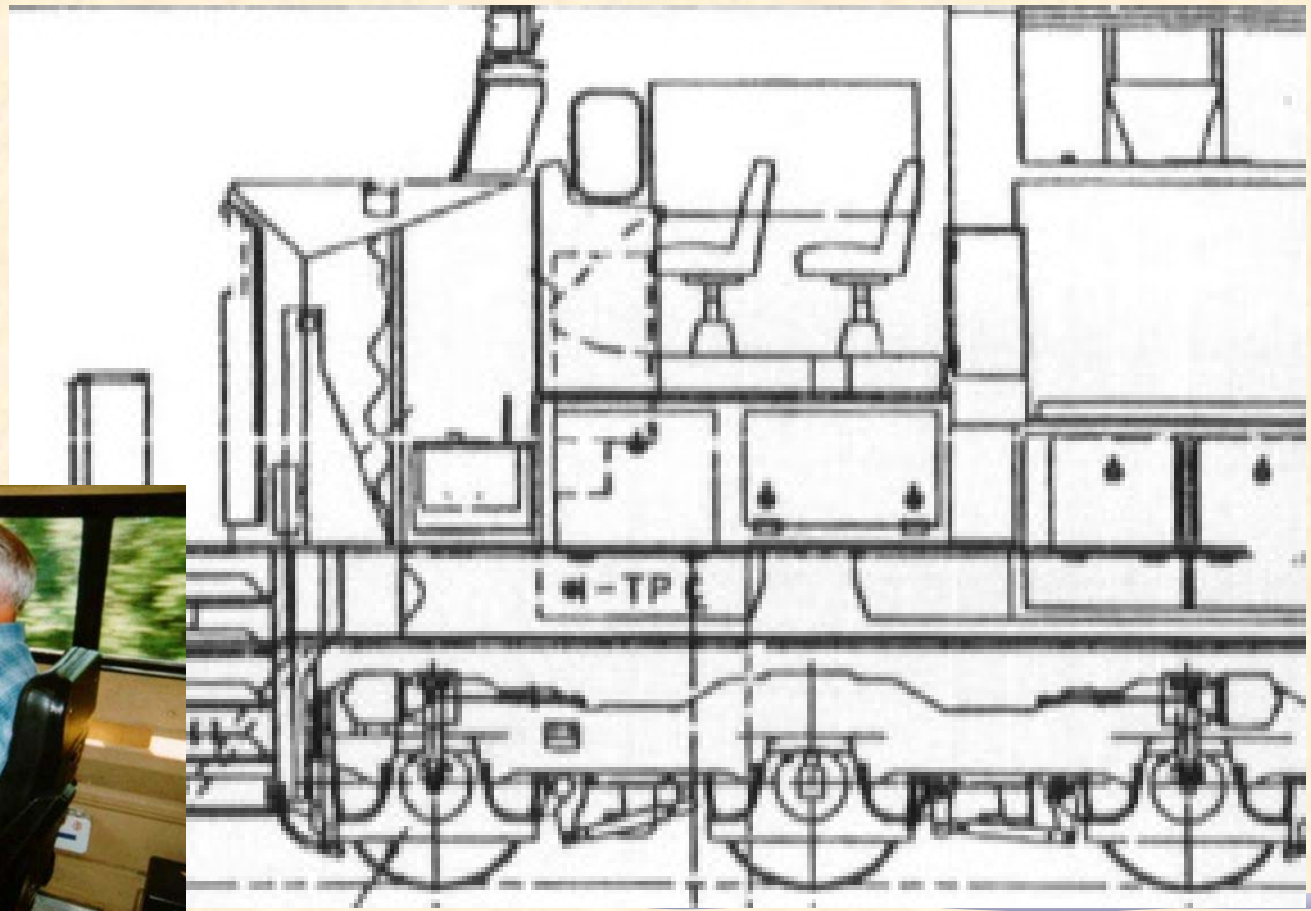
n	42	42	42
	x	y	z
Mean	**1.43**	**1.21**	**0.97**
Min	1.00	1.03	0.61
Max	2.32	1.51	1.56
SD	0.32	0.11	0.17
Mode	1.20	1.25	0.92

Traditional cab and seat design ("AAR Control Stand")





New Generation "Wide body" locomotive cab and seating



Yard switcher GP40-2 (2004)AAR control stand

Communication radio

reverser

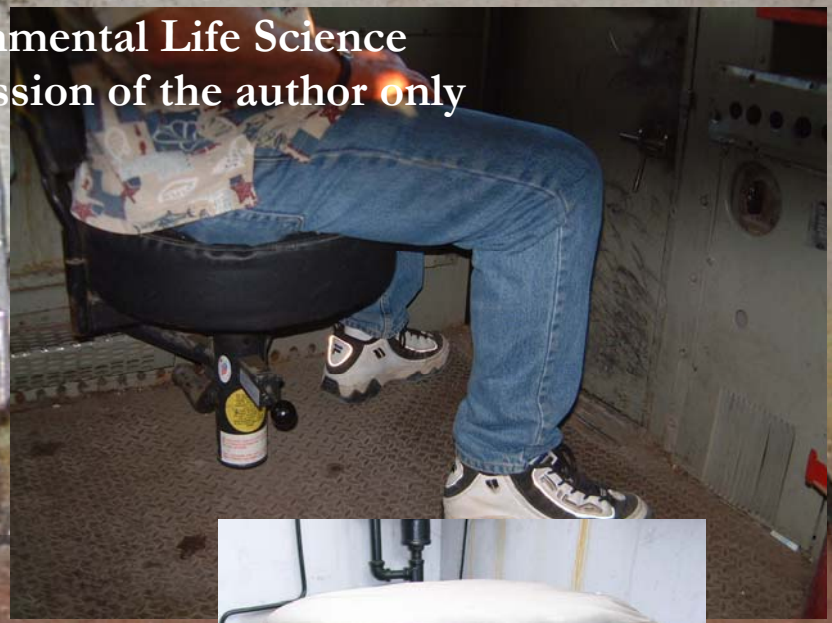
Throttle

Field observations:

Posture during yard - switching

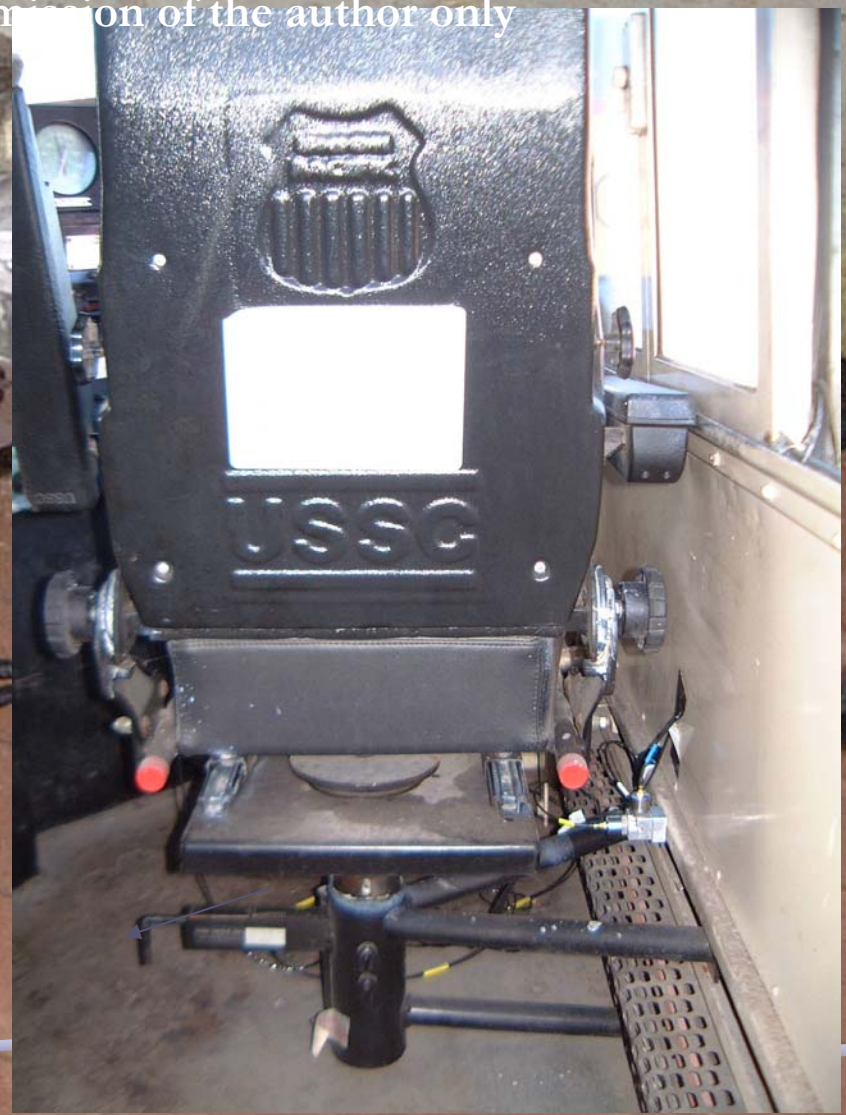
Conductor and fireman seat SD40-2 cab

Traditional toad stool



Newer type floor and side mounted seat

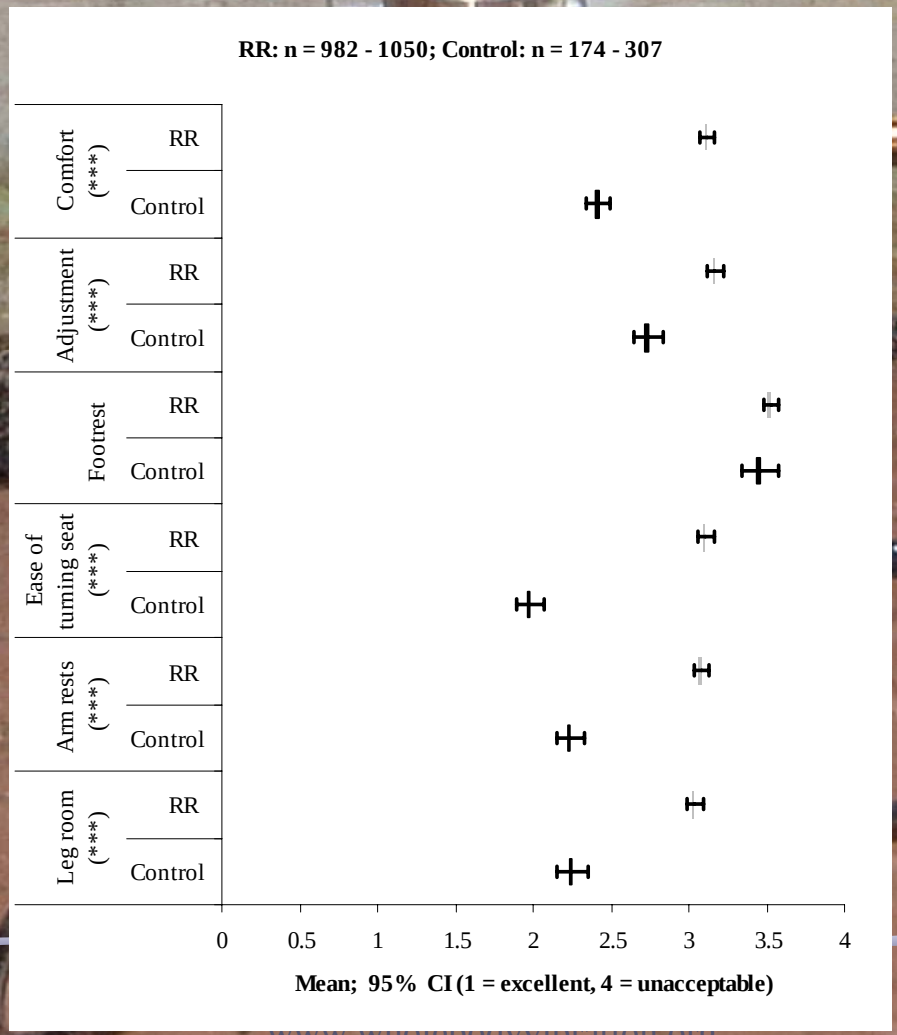
Model GE C41-8, 4135 hp, built in 1991 (UP 9077) – USSC Seat retrofitted (2001)



Seat characteristics (n=1419)

	Locomotive operator		Control			
	(%)	N	(%)	N	χ^2	p(χ^2)
Arm rest	**82.3**	**1011**	**89.1**	**313**	**8.29**	**0.004**
Any back support	**78.7**	**1043**	**90.3**	**310**	**21.24**	**<0.001**
Adjustable back support	**30.5**	**1026**	**14.7**	**299**	**29.33**	**<0.001**
Air cushion system	**11.1**	**1026**	**37.4**	**297**	**112.55**	**<0.001**
Round seat pad (toad stool)	**20.0**	**985**	**23.1**	**303**	**1.36**	**0.244**
Footrest available?	**34.1**	**954**	**5.6**	**305**	**94.83**	**<0.001**

Evaluation of seat features and comfort rating (*** p < 0.001)



Wide-body locomotives working conditions and rating (n=1019)

	YES	
	(%)	N
Any particular problem with wide body locomotives?	**62.7**	**1019**
Cab lay out	**49.1**	**639**
Vibration	**21.9**	**639**
Air conditioning	**11.1**	**639**
Ventilation	**6.4**	**639**

Important vibration risk assessment factors:

- Vibration basic values
- Crest factor, MTVV, VDV etc.
- Resonance range (hertz) (PSD)?
- Exposure duration
- Seating Posture
- Adequate rest periods
- Consider all facts in overall analysis

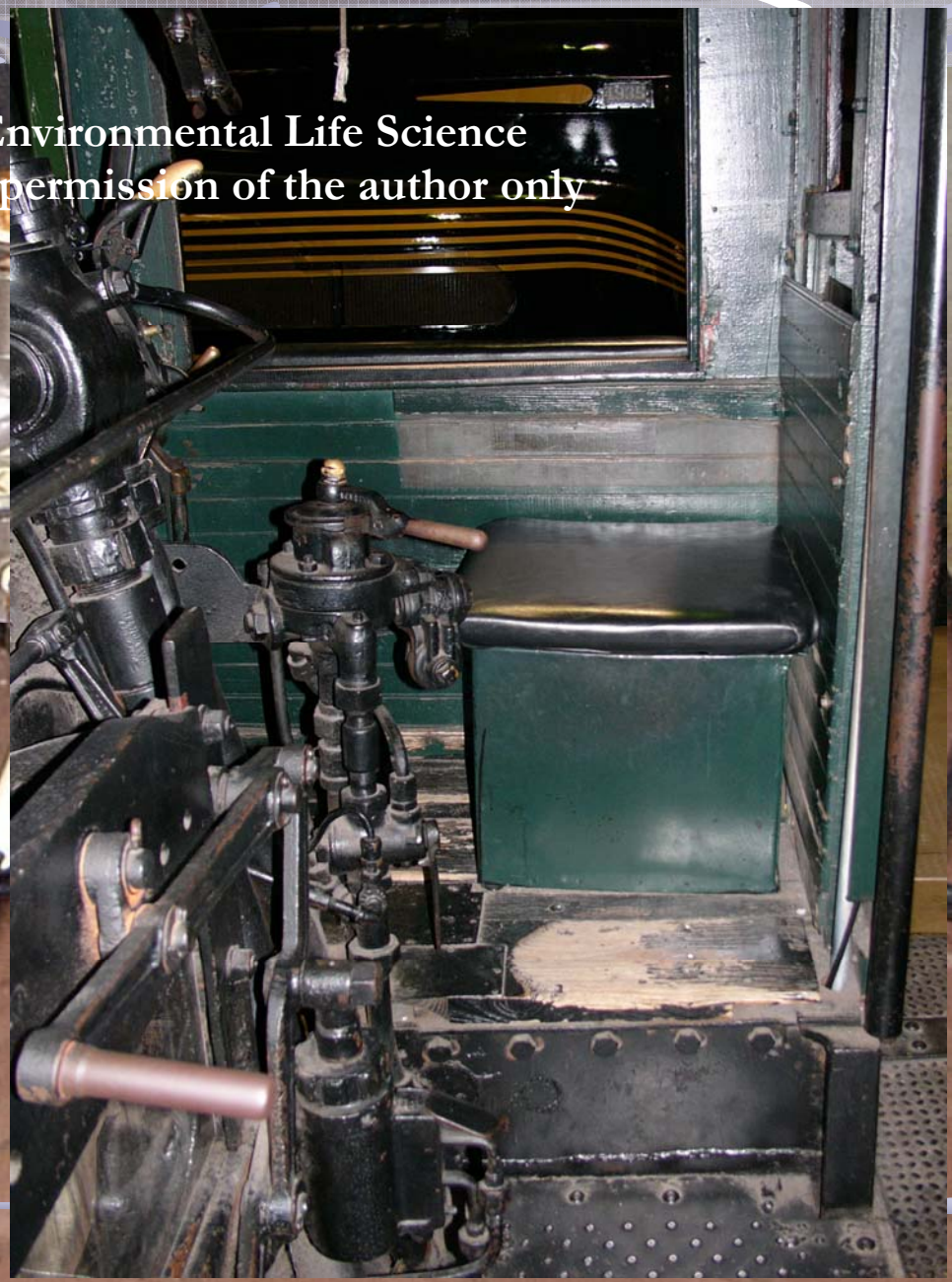
Other discussion points

- Locomotive engineers are working often overtime and long hours (+60 h/week)
- Seats in use are often defective, loose and poorly adjustable
- Seat position and mounting contributes to ergonomic postural stress (back).
- A health survey indicates high MSD risk

Discussion

- Study limitation:
  - No exact time motion / postural measurements over work shift
  - CUELA measuring system
  - Logistical problems
  - Equipment variation
  - Participation

Steam engine seat...



"Union" Inductive Train Communication-Cab Signals

SHOCK & VIBRATION - History

July 1969

German Railroads developed an “idealized” dampened locomotive cab seat.

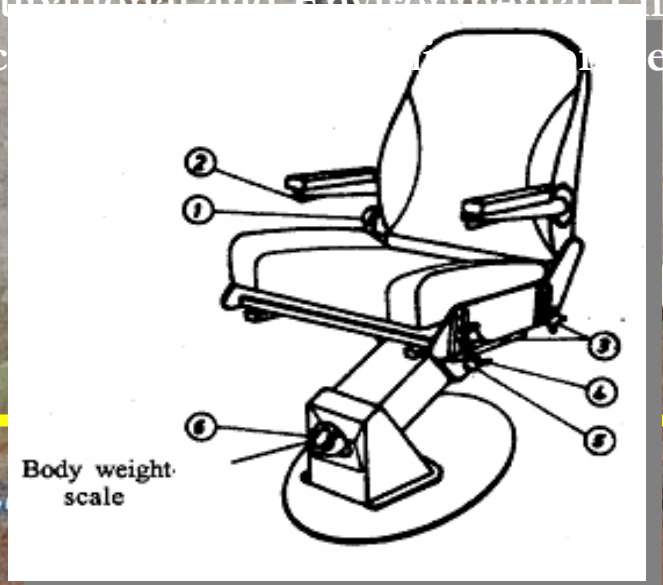


Fig.5.1 Proposed standard seat for The German Federal Railways

1. Backrest incline adjustment
2. Seat cushion adjustment (angle & height)
3. Seat cushion adjustment
4. Seat depth adjustment
5. Fixed turn position
6. Body weight adjustment

SHOCK & VIBRATION History

1969

Swiss standard locomotive seat.

Primary criteria was to dampen vertical vibration.

better detail.

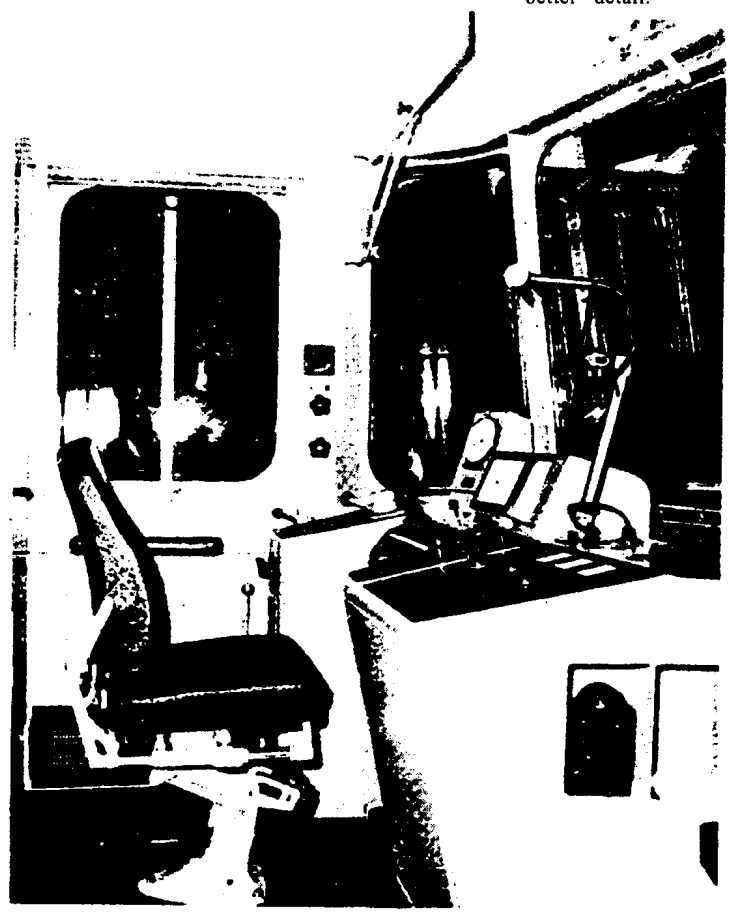
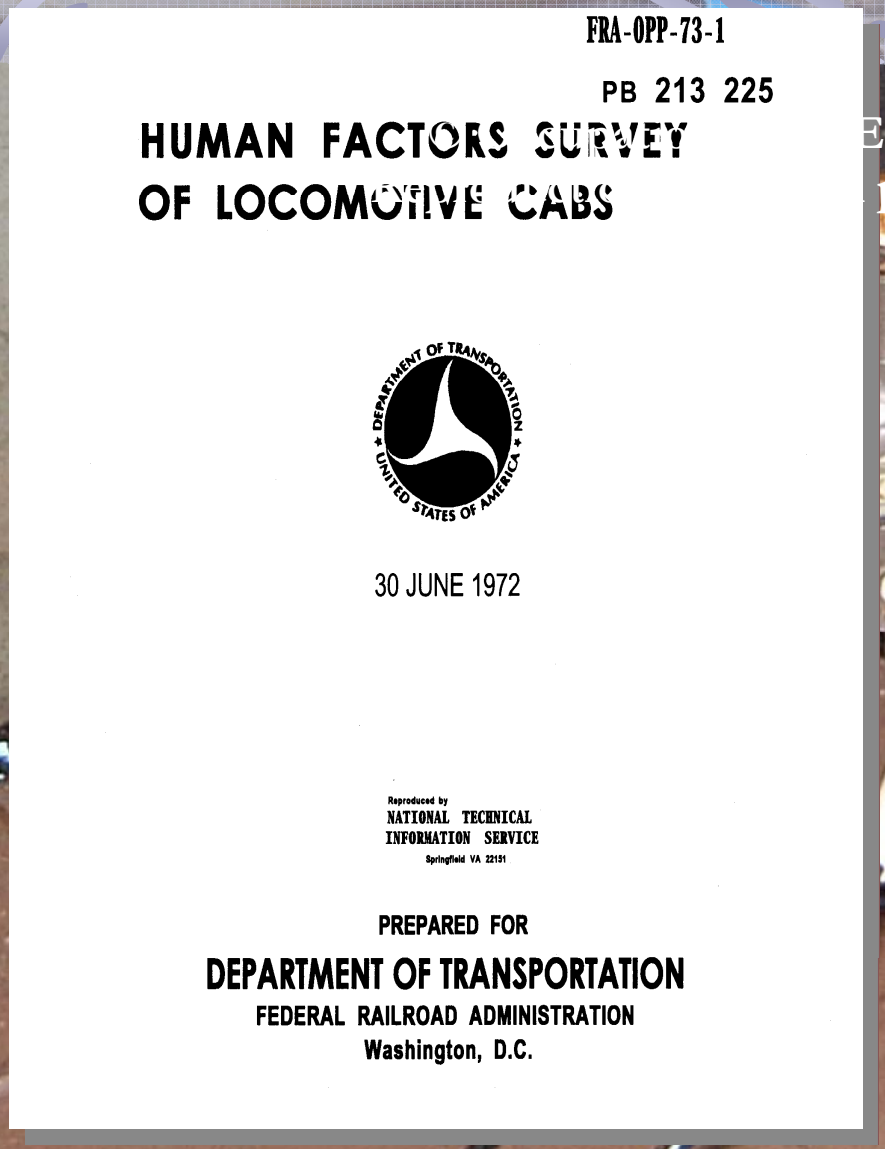


Fig. 5.2 Standard seat of the Swiss Federal Railways installed in the cab

Standard locomotive seat (FRG) since 1970/80

Suspension seat with head support - passenger locomotive - FRG 2002



1. Improve seats – eliminate the “toad stool.”
2. Measure locomotive cab vibrations.
3. Dampen vibration.
4. Design appropriate foot rest. Piece of pipe – not adequate.

The FEDERAL GOVERNMENT Studied Shock & Vibration in Locomotives in Order to Protect Rail Employees

FRA-OPP-73-1

PB 213 225

HUMAN FACTORS SURVEY OF LOCOMOTIVE CABS

30 JUNE 1972

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PREPARED FOR

DEPARTMENT OF TRANSPORTATION
FEDERAL RAILROAD ADMINISTRATION
Washington, D.C.

1972

U.S. Department of Transportation
Federal Railroad Administration

Human Factors Guidelines for Locomotive Cabs

Office of Research and Development
Washington, D.C. 20590

U.S. Department of Transportation
John A. Volpe National Transportation Systems Center
55 Broadway
Cambridge MA 02142-1093

DOT/FRA/ORD-98/03
DOT-VNTSC-FRA-98-8

Final Report
November 1998

This document is available to the U.S. public through the National Technical Information Service, Springfield, VA 22161

always expect a train

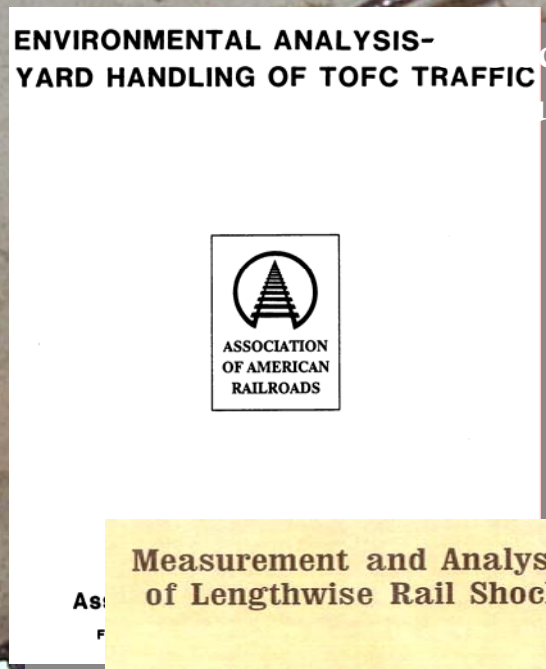
1998

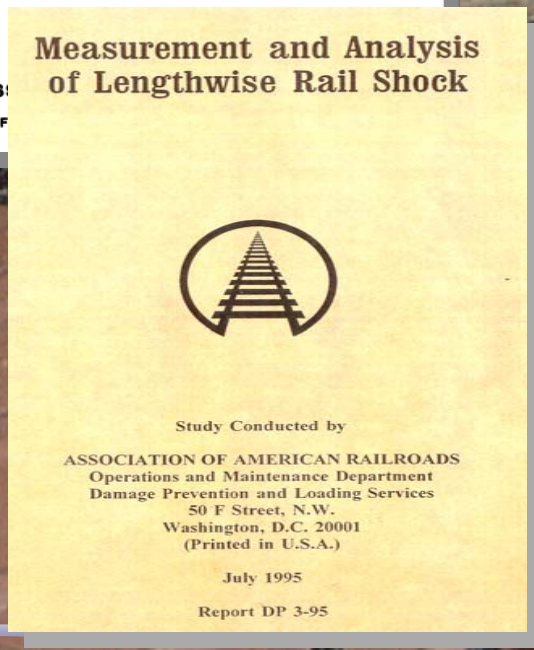
Railroad Industry Concern:

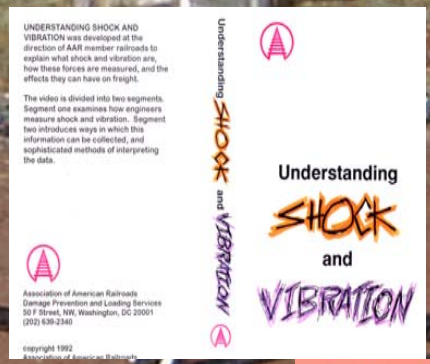
PASSENGERS

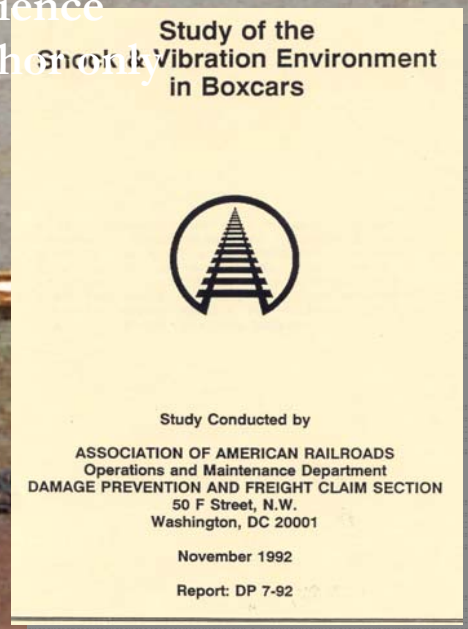
FREIGHT

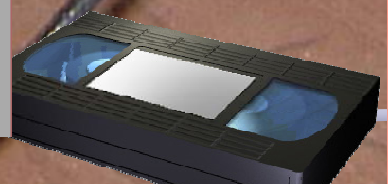
EQUIPMENT

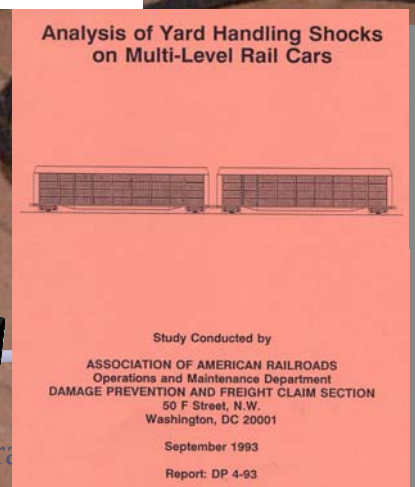


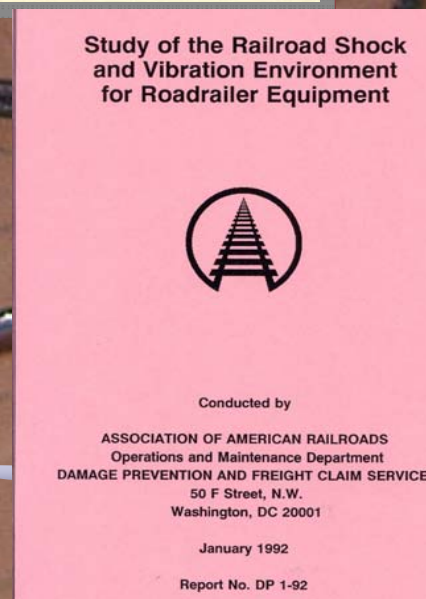












Summary and Conclusion

- Seated locomotive engineers are exposed to unique vibration and shock in all three direction.
- Lateral vibration and unpredictable irregular shocks are of concern.
- Current seats, including newer type seats appear inadequate to reduce vibration and provide sufficient postural support.
- Combined ergonomic risk factors and WBV exposure
- Preventive engineering and interventions utilizing current technology and medical knowledge appear prudent

Thank you for your attention.

Texas Railroad Research Yard 2004

Figure 5: EUDD demonstrator in the Virtual Reality laboratory

European Union Driver Desk Concept (EUDD) 2004