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#182

Task Load Analysis of KTX Drivers using the NASA-TLX Method

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On the agenda

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II. Introduction

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VI. Conclusion

KTX

Korea Train eXpress

- commercial operation : 1st April, 2004
- trainset
  - 20 cars
    - 1 motorcar + 1 powered passenger carriage + 16 passenger carriages + 1 powered passenger carriage + 1 motorcar
  - total length : 388.1 meters
  - gross weight : 701.1 tons
- 46 trainset in Korea
- only one driver in a cab
- about 300 of KTX drivers in Korea

KTX


Haengshin Depot
Seoul
Shiheung
Gwangmyeong
Cheonan-Asan
Osong
Daejeon Marshalling Yard
Seodaejeon
Daejeon
Okcheon
DongDaegu
Iksan
Sindong
ShinGyeongju
ShinUlsan
Honam Line
Miryang
Gwangju
Busan
Songjeongni
Gyeongbu Line
Mokpo
Conventional Line: 450.8 km (66%)
New High-Speed Line: 232 km (34%)
Under construction (2nd Phase)

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Human error

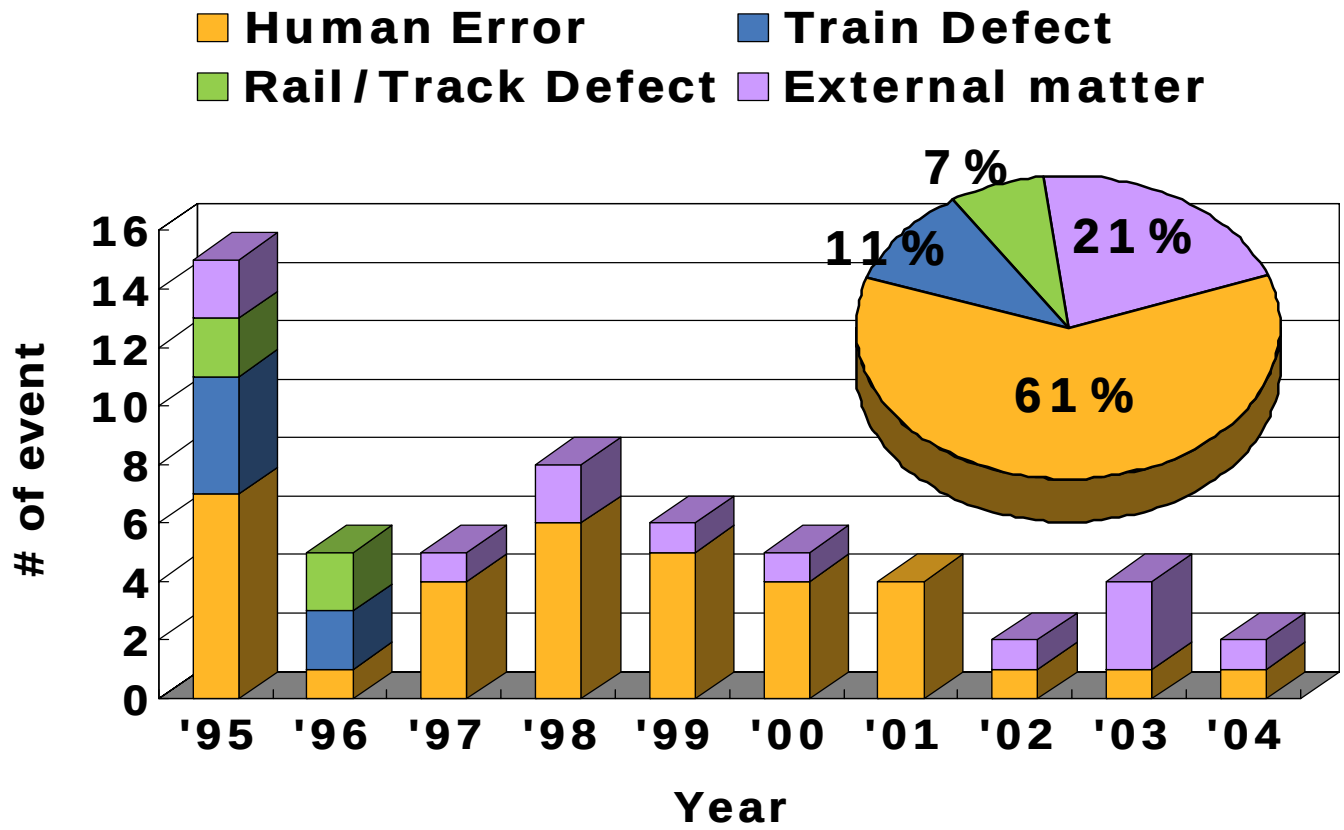
❖ Distribution of railway accident causes on 4 British main lines

Main classification:	Subclasses	1900-97		1970-97	
		Number of accidents	Percentage of accidents	Number of accidents	Percentage of Accidents
Driver Error	SPAD (no ATC/AWS)	34	24.1	5	12.8
	SPAD (AWS ineffective)	6	4,3	7	18.0
	Too fast over junctions	6	4.3	2	5.1
	Other excessive speed	11	7.8	2	5.1
	Maloperation of brakes			2	5.1
Signalman's error/	Two trains in a section etc.	16	11.3	0	0.0
Miscellaneous errors by various staff		25	17.7	5	12.8
Total; all human error causes		**98**	**69.5**	**23**	**58.9**
Faulty track		15	10.6	4	10.3
Obstruction on track		4	2.8	3	7.7
Rolling stock failure		17	12.1	6	15.4
Fire on train		7	5	3	7.7
Total		**141**	**100**	**39**	**100**

☞ Reference : Terje Andersen, 'Human Reliability and Railway Safety', 16th ESReDA Seminar, 1999.
Stanley Hall, Railway Accidents, Ian Allan Publishing, 1997.

Human error

❖Causes of *train accident in Korea



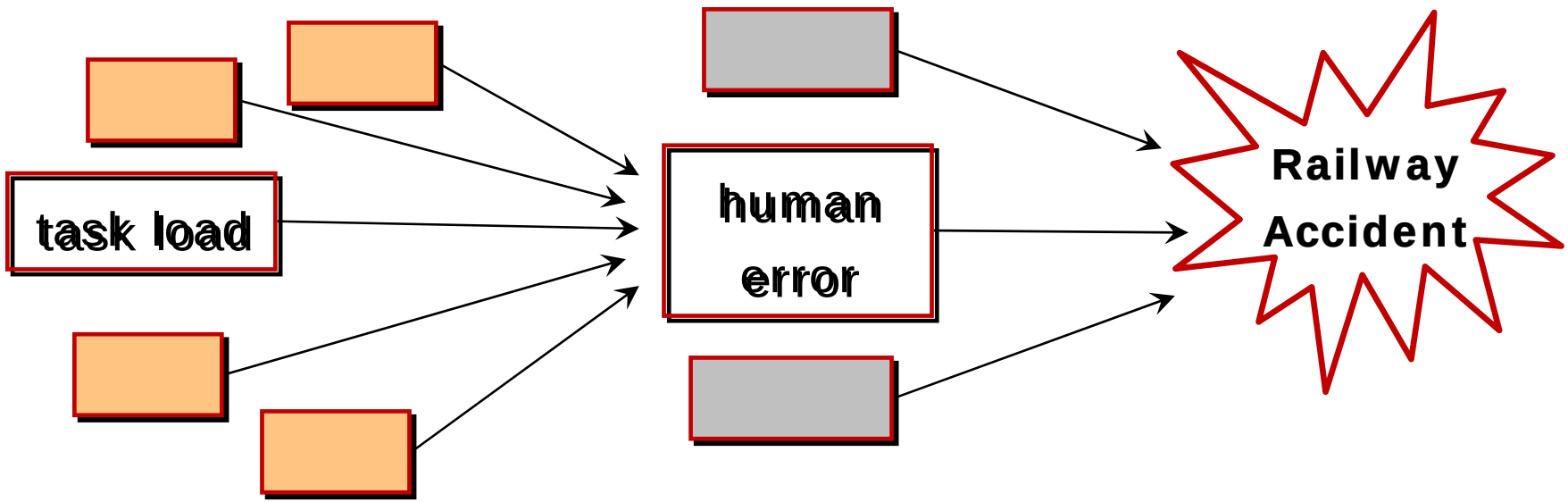
*train accident : train derailment, train collision, train fire

☞Reference : The Ministry of Construction and Transportation of Korea, “Integrated Plan of Railway Safety ; the first (2006~2010)”, the Ministry of Construction and Transportation of Korea , 2006.

Background & Objective

- Railway accidents caused by human error
- Human error caused by task load

→ We need identify the task load



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KTX driving tasks

Why KTX drivers?

- Safety of KTX is very important
- KTX drivers have to conduct some special tasks
- Single driver operate the KTX

Techniques

- Observational technique
- HTA(Hierarchical Task Analysis) technique

Task Analysis of KTX Drivers

❖ 14 Generic about driving the KTX Tasks

Task No.	Task Title
1	Attending the work
2	Moving to the train
3	Checking out train before departure
4	Departure
5	Acceleration
6	Deceleration
7	Passing through dead section of conventional line
8	Passing through dead section of high-speed line
9	Proceeding from conventional line to high-speed line
10	Proceeding from high-speed line to conventional line
11	Stopping the train at intermediate station
12	Stopping the train at terminal station
13	Handing over the train and reporting arrival of the train
14	Subordinate Shunting

Example of subtask

❖ Subtask of the 7th task

Subtask	
①	Listen to “Dead section precaution! Dead section precaution! Open the VCB” from notice system for dead section (GPS)
②	Verify dead section precaution post located on the track side
③	Put the main control lever(MC-IC-01) to the ‘0’ position and verify ‘0’ position indication lamp of the main control lever(LS-CO-TT-01) is turned on
④	Pull down the main circuit breaker switch(SW-VCB-01) to the ‘OFF’ position and verify the ‘OPEN’ position indication lamp of the main circuit breaker(LS-VCB-01) is turned on
⑤	Verify dead section post located on the track side
⑥	Verify power running post located on the track side. Check out the voltage through contact wire voltage meter(VM-HV-01) after passing through the power running post
⑦	Put the main circuit breaker switch(SW-VCB-01) to ‘ON’ position and verify the closing permission indication lamp(LS-VCB-CS-01) of the main circuit breaker is turned on
⑧	Put the closing permission push button of the main circuit breaker (PB-CS-VCB-01) to the ‘UP’ position

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NASA-TLX?

Task Load

- using the NASA-TLX method

NASA-TLX (Task Load indeX) method

- was developed by National Aeronautics and Space Administration(NASA) in the early 1980s
- is a subjective evaluation method of a task load
- is regarded as the most stable technique for measuring a subjective task load felt by human operators

NASA-TLX?

❖ 6 subscale of NASA-TLX

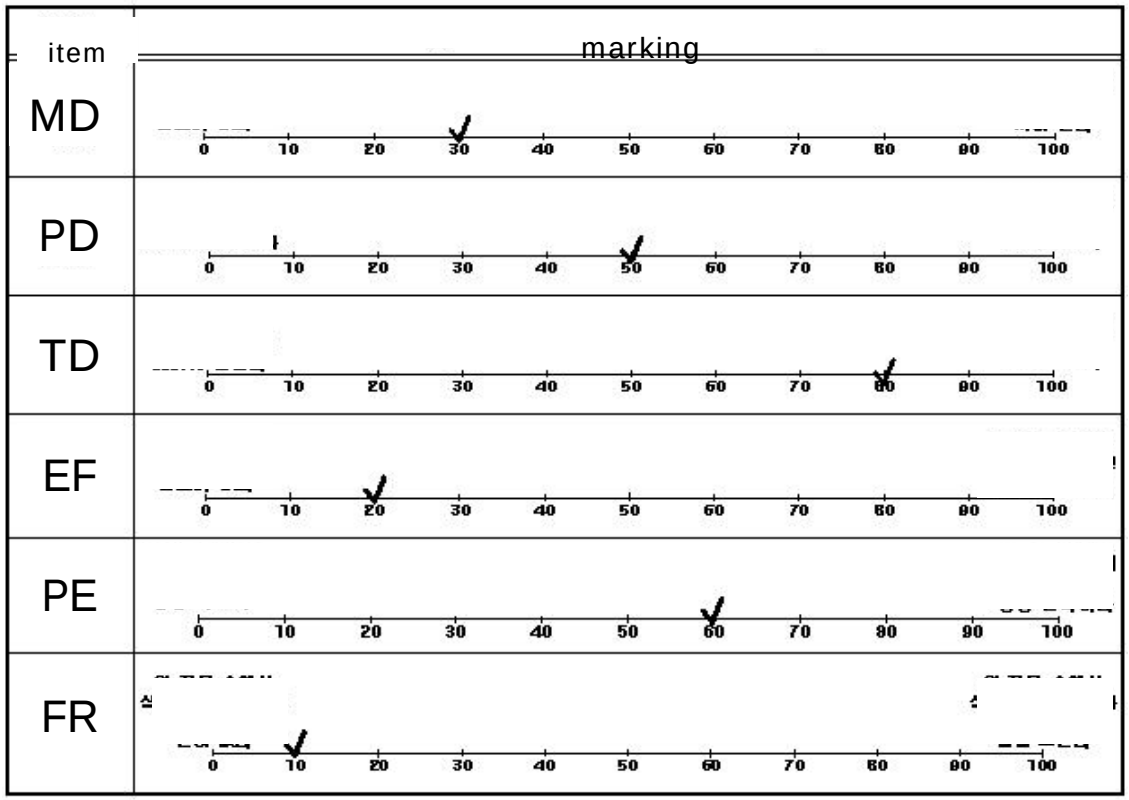
Subscale	Acronym	Descriptions
Mental Demand	MD	How much mental and perceptual activity was required (e.g., thinking, deciding, calculating, remembering, looking, searching, etc.)?
Physical Demand	PD	How much physical activity was required (e.g., pushing, pulling, turning, controlling, activating, etc.)?
Temporal Demand	TD	How much time pressure did you feel due to the rate or pace at which the tasks or task elements occurred?
Effort	EF	How hard did you have to work (mentally and physically) to accomplish your level of performance?
Performance	PE	How successful do you think you were in accomplishing the goals of the task set by the experimenter (or yourself)?
Frustration	FR	How insecure, discouraged, irritated, stressed and annoyed versus secure, gratified, content, relaxed and complacent did you feel during the task?

☞Reference : Human Performance Research Group,
"NASA Task Load Index(TLX) v. 1.0 Computerized Version", NASA Ames Research Center, 1987.

Questionnaires

Task # : Task Title

Task description



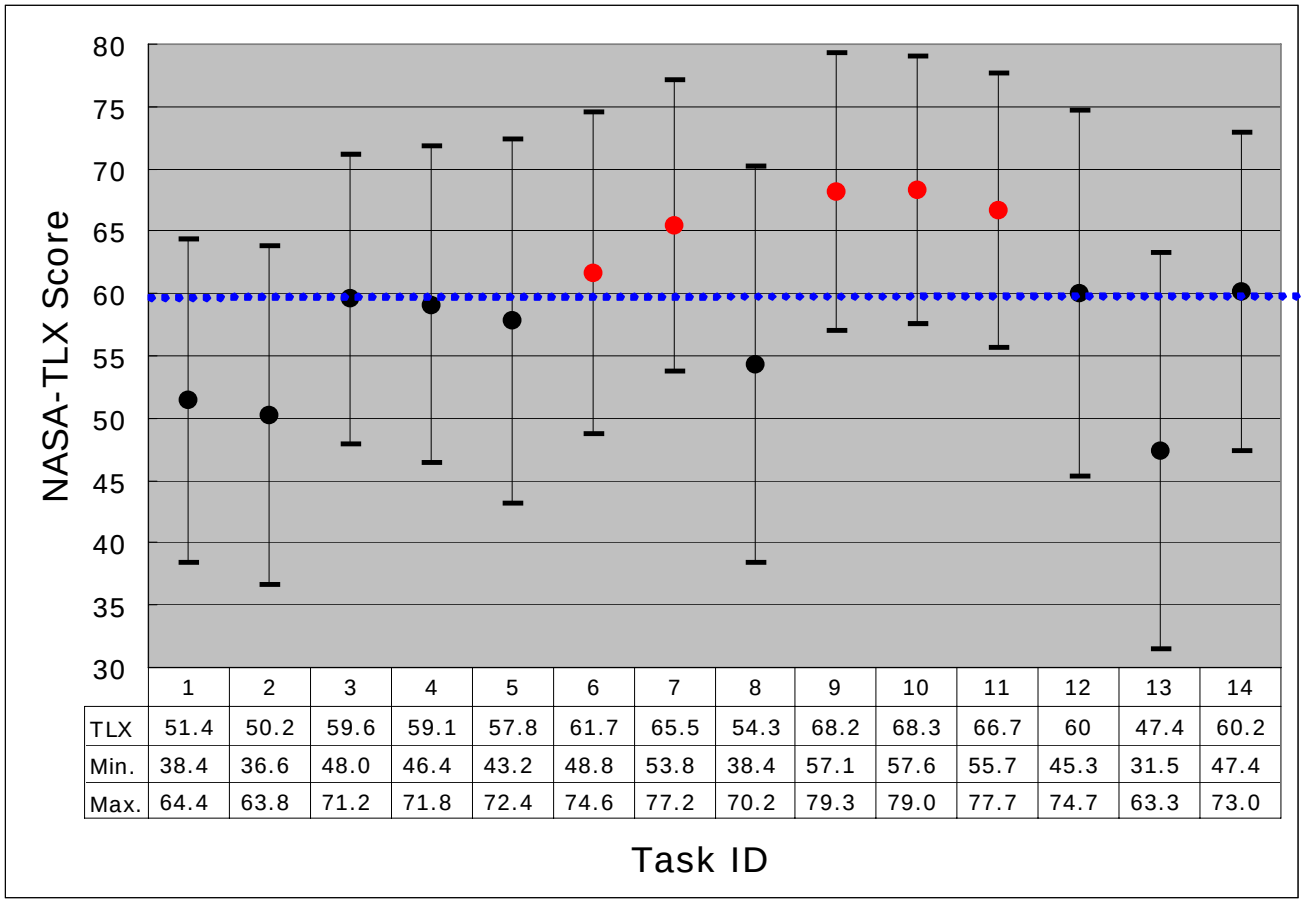
Results

❖ NASA-TLX Evaluation Score about 14 Generic Tasks

Task No.	Task Title	Avg. Score	Standard Deviation	Ranking
1	Attending the work	51.4	13.0	12
2	Moving to the train	50.2	13.6	13
3	Checking out train before departure	59.6	11.6	8
4	Departure	59.1	12.7	9
5	Acceleration	57.8	14.6	10
6	Deceleration	61.7	12.9	5
7	Passing through dead section of conventional line	65.5	11.7	4
8	Passing through dead section of high-speed line	54.3	15.9	11
9	Proceeding from conventional line to high-speed line	68.2	11.1	2
10	Proceeding from high-speed line to conventional line	68.3	10.7	1
11	Stopping the train at intermediate station	66.7	11.0	3
12	Stopping the train at terminal station	60.0	14.7	7
13	Handing over the train and reporting arrival of the train	47.4	15.9	14
14	Subordinate Shunting	60.2	12.8	6

Results

- The Comparison of the Task Load Scores about 14 Generic Tasks



	1	2	3	4	5	6	7	8	9	10	11	12	13	14
TLX	51.4	50.2	59.6	59.1	57.8	61.7	65.5	54.3	68.2	68.3	66.7	60	47.4	60.2
Min.	38.4	36.6	48.0	46.4	43.2	48.8	53.8	38.4	57.1	57.6	55.7	45.3	31.5	47.4
Max.	64.4	63.8	71.2	71.8	72.4	74.6	77.2	70.2	79.3	79.0	77.7	74.7	63.3	73.0

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Factor analysis method

❖ Example of factor analysis

Task No.10 Proceeding from high-speed line to conventional line						
KTX Driver	MD	PD	TD	EF	PE	FR
#1	100	70	100	80	40	100
#2	90	60	90	90	10	90
#3	20	20	30	60	20	20
⋮	⋮	⋮	⋮	⋮	⋮	⋮
#136	90	50	90	90	10	50
sum.	11810	8620	10690	11650	2605	10330
avg.	86.8	63.4	78.6	85.7	19.2	76.0

MD > EF > TD > FR > PD > PE

Factor about task load

- **The Summarized Result of Six Subscales about 14 Generic Tasks**

Subscale Order / Task No.	High ⟷ Low					
10	MD	EF	TD	FR	PD	PE
9	MD	EF	TD	FR	PD	PE
11	EF	MD	TD	FR	PD	PE
7	MD	EF	FR	TD	PD	PE
6	EF	MD	TD	FR	PD	PE
14	MD	EF	TD	PD	FR	PE
12	MD	EF	TD	FR	PD	PE
3	EF	TD	MD	FR	PD	PE
4	EF	MD	TD	FR	PD	PE
5	EF	MD	TD	FR	PD	PE
8	MD	EF	FR	TD	PD	PE
1	TD	EF	MD	FR	PD	PE
2	TD	EF	PD	FR	MD	PE
13	EF	MD	TD	PD	FR	PE

- **EF:14**
- **MD:11**
- **TD: 3**

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Conclusions

KTX driving tasks

- KTX driver's tasks consist of a total of 14 generic tasks as a result of a task analysis.
- each detailed procedure and task type, related signal/instrument system and MMI(Man Machine Interface).

Task load analysis

- Evaluating relative task load using the NASA-TLX method

Factor about task load

- KTX drivers have to conduct mental activities (i.e., Mental Demand) and they experienced hard working (i.e., Effort).

Human error is ...

☞Reference : Reason, J.(1997), “Managing the Risks of Organizational Accidents”, Ashgate Publishing Ltd.

- “... human error is a consequence not a cause. Errors... are shaped and provoked by upstream workplace and organizational factors. Identifying an error is merely the beginning of the search for cause, not the end... Only by understanding the context that provoked the error can we hope to limit its recurrence.”

Thank you!!

Contact kjh1350@samchang.com

My paper is updated than that included the CD-ROM Proceedings.

If you want to get final paper, please email to me.

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