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title

# Specifications for implementation of performance measurement and feedback systems for the Leopard 2 and YPR-765 driving simulators

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date
30 July 1996

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Teneinde de efficiency van de training van leerling-bestuurders op de Leopard 2 en YPR-765 rijsimulatoren te verhogen, werden in een eerder rapport specificaties en richtlijnen geleverd, voor de implementatie van twee prestatiemeting en feedback (PMF) systemen. Naar aanleiding van een aankomende upgrade van beide rijsimulatoren, is besloten deze systemen door de fabrikant te laten bouwen en implementeren. Met dit doel voor ogen is het bovengenoemde rapport geheel herzien, waarbij tevens veranderingen in het leertraject en opmerkingen van de, inmiddels ervaren, gebruikers van de betreffende simulatoren in beschouwing zijn genomen. Met het verschijnen van het onderhavige rapport komt rapport IZF 1992 A-20 te vervallen.

De PMF systemen zijn gebaseerd op een selectie van de meest relevante deeltaken waarvan de kritische variabelen objectief worden gemeten. Om het mogelijk te maken dat deze systemen correct geprogrammeerd en geïmplementeerd worden levert het huidige rapport een gedetailleerde beschrijving van scores, voertuig referentiepunten voor scoreberekening en de trajecten waarover scores moeten worden gemeten, en gewichten voor deeltaakvariabelen en taakclusters. Tevens worden eisen geformuleerd ten aanzien van de berekening en presentatie van scores en cijfers, het beheer van bestanden, en de systeembediening.

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In a previous report, specifications and guidelines were given for the implementation of Performance Measurement and Feedback (PMF) systems for the Leopard 2 and YPR-765 driving simulators (Korteling & Padmos, 1992). In connection with an update program for both simulators, the Dutch Armed Forces have decided to implement both systems. Therefore, the above-mentioned report is revised, taking into consideration changes in the learning trajectories, and comments of the, by now, experienced users of both simulators. Report IZF 1992 A-20 is herewith expired.
The PMF systems objectively measure the critical task variables of a selection of the most relevant subtasks. Application of these systems is expected to improve the efficiency of the training of student drivers on these simulators. In order to enable system engineers to program and implement these systems on both simulators, the present report provides an exact and detailed description of scores, vehicle reference points for calculation of scores and for the trajectories over which scores will be measured, and weights for subtask variables and for clusters of subtasks. In addition, general requirements are provided with regard to the calculation and presentation of scores and marks, database management, and system operation.

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SUMMARY

In a previous report, specifications and guidelines were given for the implementation of Performance Measurement and Feedback (PMF) systems for the Leopard 2 and YPR-765 driving simulators (Korteling & Padmos, 1992). In connection with an update program for both simulators, the Dutch Armed Forces have decided to implement both systems. Therefore, the above-mentioned report is revised, taking into consideration changes in the learning trajectories, and comments of the, by now, experienced users of both simulators. Report IZF 1992 A-20 is herewith expired.

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TNO Technische Menskunde
Soesterberg

**Specificaties voor de implementatie van prestatiemeting en feedback systemen voor de Leopard 2 en YPR-765 rijsimulatoren**

J.E. Korteling, J.B.F. van Erp en P. Padmos

SAMENVATTING

Teneinde de efficiency van de training van leerling-bestuurders op de Leopard 2 en YPR-765 rijsimulatoren te verhogen, werden in een eerder rapport (Korteling & Padmos, 1992) specificaties en richtlijnen geleverd, voor de implementatie van twee prestatiemeting en feedback (PMF) systemen. Naar aanleiding van een aankomende upgrade van beide rijsimulatoren, is besloten deze systemen door de fabrikant te laten bouwen en implementeren. Met dit doel voor ogen is het bovengenoemde rapport nogmaals geheel herzien, waarbij tevens veranderingen in het leertraject en opmerkingen van de, inmiddels ervaren, gebruikers van de betreffende simulatoren in beschouwing zijn genomen. Met het verschijnen van het onderhavige rapport komt rapport IZF 1992 A-20 te vervallen.

De PMF systemen zijn gebaseerd op een selectie van de meest relevante deeltaken waarvan de kritische variabelen objectief worden gemeten. Om het mogelijk te maken dat deze systemen correct geprogrammeerd en geïmplementeerd worden levert het huidige rapport een gedetailleerde beschrijving van scores, voertuig referentiepunten voor scoreberekening en de trajecten waarover scores moeten worden gemeten, en gewichten voor deeltaakvariabelen en taakclusters. Tevens worden eisen geformuleerd ten aanzien van de berekening en presentatie van scores en cijfers, het beheer van bestanden, en de systeembediening.

# 1 INTRODUCTION

The driving simulators of the Leopard 2 and YPR-765 are equipped with a so-called Performance And Marking system (PAM) to increase the objectivity of performance evaluations, and enhance the quality of the feedback. However, preliminary usage indicated that this system is not capable to realize these goals, as stated by Korteling and Padmos (1992). Because the PAM systems for both simulators showed many problems, a new kind of Performance Measurement and Feedback system was proposed (Korteling & Padmos, 1990; Korteling, 1991; Korteling & Padmos, 1992).
This PMF system is designed to improve the efficiency of the training of Leopard 2 and the YPR-765 student drivers, by measuring and qualifying objectively the most critical task variables of a selection of the most relevant subtasks. Above mentioned reports entail guidelines for implementation and usage of the system, calculations of scores, and data-presentation.

In connection with an update program for both simulators, the Dutch Armed Forces have decided to implement both systems as proposed and described by Korteling and Padmos (1992). However, in the last four years, the simulators have been validated and taken into practise, which has generated some new insights and ideas concerning PMF usage. In addition, the technical specifications had to be formulated such that the manufacturer is enabled to provide the soft- and hardware of the system and implement this into the simulators. Therefore, it was decided to completely revise the technical report by Korteling and Padmos (1992) in close cooperation with the simulator instructors, who have been working with the simulator for more than seven years. As a result of this exercise, *the present report is a completely revised edition of the former technical report, which was entitled "Technical specifications for the PMF systems of the Leopard 2 and YPR-765 driving simulators" (Korteling & Padmos, 1992), including additions and a number of minor adaptations. This former report is herewith expired.*

Both PMF systems are based on subtasks which are grouped in three task clusters. For each subtask, on the 1−4 most critical performance variables, raw scores are calculated. The raw scores are weighted and summed for each task cluster. The scores on the task clusters are weighted and summed into a total score. The raw scores provide absolute indications. In order to enable comparison with peer students, the PMF system calculates the percentile marks, which indicate performance relative to students in the same phase. In addition, the system calculates so-called learning marks, which indicate performance relative to absolute beginners and students who passed their driving examination (criterion). Raw scores and both relative marks must as well be presented in the driving report.

Throughout the present report, the following norms are used. The word "shall" or "must" expresses a *mandatory requirement* of the specification. The word "should" in the text expresses a *recommendation* or *advice* with regard to the implementation. The costumer expects such recommendations to be followed unless reasons are stated not doing so.

Chapter 2 presents the subtasks, their critical performance measures and weights, and their arrangement in task clusters. Chapter 3 describes the calculation of relative scores compared

to peer students in the same and in other phases. Chapter 4 describes the lay-out of the output of the PMF system (the driving report in Dutch). Finally, Chapter 5 gives general system usage specifications. Details of the calculations of the performance measures for each subtask are given in the Appendix.

# 2 ARRANGEMENT, WEIGHTS AND VARIABLES OF SUBTASKS AND TASK CLUSTERS

This Chapter presents the arrangement, weights, and performance variables of subtasks and task clusters. Because of differences between the Leopard and YPR-765 PMF systems, they are presented in different Sections. Please note that the lay-out of the driving report (see Chapter 4) is substantially different from the presented overviews. The detailed calculation of the performance measures is described in the Appendix.

## 2.1 Leopard 2

Table I presents an overview of the PMF system for the Leopard 2 driving simulator. The three task clusters each represent different subsequent components of the training program. Route driving: lessons 4 to 9, obstacles: lessons 10 and 11, and special actions: lesson 12 (lessons numbered according the presently used manual).

Table I Overview of the PMF subtask, task clusters, performance measures and weights for the Leopard 2.

| subtask | performance measure | variable weight | cluster weight |
|---|---|---|---|
| **Task cluster 1: route driving** | | | **0.50** |
| Driving right straight/curves | RMS lane error (cm) | 0.20 | |
| | Distance of verge driving (m) | 0.08 | |
| | Duration in too low gears (s) | 0.08 | |
| | Gear shift in curves | 0.08 | |
| Driving left straight | RMS lane error (cm) | 0.12 | |
| | Distance of verge driving | 0.08 | |
| Sharp curves and intersections | RMS lane error (cm) | 0.20 | |
| | Distance of verge driving | 0.08 | |
| | Gear shift in curve(s) | 0.08 | |

| subtask | performance measure | variable weight | cluster weight |
|---|---|---|---|
| **Task cluster 2: obstacles** | | | **0.25** |
| Step up | Jerkiness (m/s³) | 0.12 | |
| | Mean driving speed (km/h) | 0.04 | |
| Sloping block | Jerkiness (m/s³) | 0.12 | |
| | Mean driving speed (km/h) | 0.04 | |
| Small ditches (slow) | Jerkiness (m/s³) | 0.24 | |
| | Mean driving speed (km/h) | 0.08 | |
| Normal camber | Lateral instability (cm) | 0.12 | |
| Adverse camber | Lateral instability (cm) | 0.12 | |
| Alternating camber | Lateral instability (cm) | 0.12 | |
| **Task cluster 3: special actions** | | | **0.25** |
| "Slalom" course | Number of beacons hit | 0.07 | |
| | Time needed (s) | 0.07 | |
| Vehicle clearing course | RMS lane error (cm) | 0.26 | |
| | Duration in wrong gear (s) | 0.09 | |
| | Mean driving speed (km/h) | 0.09 | |
| Lowloader | RMS lane error (cm) | 0.18 | |
| | Jerkiness (m/s³) | 0.18 | |
| | Mean driving speed (km/h) | 0.06 | |

On request of the instructors of the Leopard 2 driving simulator, a first evaluation for route driving is introduced at the end of lesson 6. This first evaluation contains measurement of right and left driving only, and will not be included in the final driving report. The weights of the different variables for this initial evaluation are adapted to sum to 1.00, see Table II for details.

Table II Overview of the subtasks and variables for the initial evaluation of the Leopard 2 training program.

| subtask | performance measure | weight |
|---|---|---|
| **First evaluation** | | |
| Driving right straight/curves | RMS lane error (cm) | 0.30 |
| | Distance of verge driving (m) | 0.13 |
| | Duration in too low gears (s) | 0.13 |
| | Gear shift in curves | 0.13 |
| Driving left straight | RMS lane error (cm) | 0.18 |
| | Distance of verge driving (m) | 0.13 |

## 2.2 YPR-765

Table III presents a summary of the PMF system for the YPR-765 driving simulator. The three task clusters represent different lessons during the training program. Route driving: lessons rij02 – rij07; obstacles: rij06 – rij07, and special actions: rij08.

Table III Overview of the PMF subtasks, task clusters, performance measures and weights for the YPR-765.

| subtask | performance measure | variable weight | cluster weight |
|---|---|---|---|
| **Task cluster 1: route driving** | | | **0.50** |
| Driving right straight/curves | RMS lane error (cm) | 0.18 | |
| | Distance of verge driving (m) | 0.07 | |
| Driving left straight | RMS lane error (cm) | 0.18 | |
| | Distance of verge driving (m) | 0.07 | |
| Sharp curves and intersections | RMS lane error (cm) | 0.18 | |
| | Distance of verge driving (m) | 0.07 | |
| | Duration in wrong gear (s) | 0.07 | |
| Stopping/braking | RMS lane error (cm) | 0.12 | |
| | Mean deceleration ($m/s^2$) | 0.06 | |
| **Task cluster 2: obstacles** | | | **0.25** |
| Step up | Jerkiness ($m/s^3$) | 0.13 | |
| | Mean driving speed (km/h) | 0.03 | |
| Sloping block | Jerkiness ($m/s^3$) | 0.13 | |
| | Mean driving speed (km/h) | 0.03 | |
| Small ditches (slow) | Jerkiness ($m/s^3$) | 0.26 | |
| | Mean driving speed (km/h) | 0.06 | |
| Normal camber | Lateral instability (cm) | 0.12 | |
| Adverse camber | Lateral instability (cm) | 0.12 | |
| Alternating camber | Lateral instability (cm) | 0.12 | |
| **Task cluster 3: special actions** | | | **0.25** |
| "Slalom" course | Number of beacons hit | 0.07 | |
| | Time needed (s) | 0.07 | |
| Vehicle clearing course | RMS lane error (cm) | 0.26 | |
| | Duration in wrong gear (s) | 0.09 | |
| | Mean driving speed (km/h) | 0.09 | |
| Lowloader | RMS lane error (cm) | 0.18 | |
| | Jerkiness ($m/s^3$) | 0.18 | |
| | Mean driving speed (km/h) | 0.06 | |

# 3 CALCULATIONS OF RELATIVE SCORES

The raw scores, which calculation is described in the Appendix, provide absolute performance measures for each variable of a subtask. Besides these absolute scores, the PMF system must calculate two relative scores: so-called percentile marks and learning marks. These marks are measures of performance relative to a comparison group, and therefore require raw scores of these comparison groups. The definition of these comparison groups, which corresponds to various phases in the training, will be presented in § 3.1. In § 3.2, the definitions of percentile marks and learning marks will be provided.

## 3.1 Comparison groups

For the calculation of percentile scores and marks, and learning marks (see § 3.2), it is necessary to store in the computer the raw scores of comparison groups, consisting of previously trained peer students in various *phases* (0−4, see Table IV) of driving skill. The fact that the amount of data of comparison groups will increase over time (also when the system is in use), means that the system will be "learning".

Table IV Summary of comparison groups needed by the PMF system.

| phase | needed for | student who |
|---|---|---|
| 0 | learning score | is an absolute beginner (baseline group) |
| 1 | percentile score | finished the training of task cluster 1 (route driving) |
| 2 | percentile score | finished task cluster 1 and 2 (obstacles) |
| 3 | percentile score | finished task cluster 1, 2, and 3 (special actions) |
| 4 | learning score | has passed the final driving examination (criterion group) |

Percentile scores reflect the skill of the student driver relative to peer students in the same phase of the training program. In order to calculate percentile scores and marks, phases 1−3 are relevant. Phase 1, 2, and 3 refer to raw scores of previous students who have finished the training of Route Driving, Obstacles and Special Actions, respectively. According to the training program, these three clusters of subtasks will be trained in this order.
Learning marks reflect the skill of the student relative to the trajectory from an absolute beginner to criterion. For the calculation of learning marks (see § 3.2), raw scores of absolute beginners (baseline group, phase 0) and ex-students who passed the final driving examination (criterion group, phase 4) must be stored.

Because in phase 1, only Route Driving has been trained, while in phase 2, Route Driving as well as Obstacles have been trained, and in phase 3 all task clusters have been trained, the driving sections in the environmental model (see Appendix) must be geographically grouped according to the task clusters. This means that after completing a phase in the training program, all trained cluster(s) at that moment can be evaluated. Hence, a PMF evaluation usually will start with Route Driving and, dependent on the training phase of the

student, Obstacles and Special Actions will follow. Therefore, the relevant PMF cluster sections must be linked in this order.
However, it shall also be possible to drive only 1 or 2 parts of the complete PMF trajectory (PMF cluster sections) in an arbitrary order. Consequently, each cluster section must have a starting point at the beginning, such that the vehicle can be positioned at this spot from the instruction console.

Groups of experts, composed of either students who have finished other phases of the practical training (terrain driving, driving in traffic), or instructors, who are very experienced, represent other comparison groups, showing more progressed and optimal driving performance. In order to be able to evaluate skill development, resulting from the succeeding phases of training and skill development, the system must also be able to save and represent the performances of these (expert) groups over several later training phases (> phase 4).

In summary, with regard to level of experience (phase) and task clusters, the PMF system shall have 8 reference groups, with a total of 21 kinds of performance databases (see Table V).

Table V The complete set of reference groups and performance databases the PMF system must be able to handle.

| phase | training | kind of performance database | | |
|---|---|---|---|---|
| | | route driving | obstacles | special actions |
| 0 | none | × | × | × |
| 1 | ca. 6 simulator lessons | × | | |
| 2 | + ca. 2 simulator lessons | × | × | |
| 3 | + ca. 2 simulator lessons | × | × | × |
| 4 | + real vehicle training | × | × | × |
| 5 | + traffic training | × | × | × |
| 6 | + terrain training | × | × | × |
| 7 | + instructor training | × | × | × |

## 3.2 Percentile marks and learning marks

*Percentile marks*

Percentile *marks* are based on the percentile *scores*, defined as: the percentage of the students who had a lower raw score on the relevant variable. When higher scores express poorer performance, complementary percentile scores must be used (i.e., 100 minus percentile score). Three kinds of percentile marks are distinguished: *variable percentile marks* (i.e., the percentile mark per variable), *cluster percentile marks* and *total percentile marks*. All percentile marks are based on the percentile scores according to the five categories of Table VI.

Table VI Relation between percentile score and percentile mark.

| percentile score | percentile mark | Dutch term |
|---|---|---|
| 0–9 | poor | slecht |
| 10–29 | mediocre | matig |
| 30–69 | average | gemiddeld |
| 70–89 | good | goed |
| 90–99 | excellent | uitstekend |

*Variable percentile marks* are based on the percentile score on the relevant variable. *Cluster percentile marks* are based on the sum of the weighted variable percentile *scores* within each task cluster (formula 1), the *total percentile score* is based on the weighted cluster percentile scores (formula 2).

$$\textit{cluster percentile score} = \sum \text{(variable percentile score} \times \text{variable weight)} \qquad \textbf{(1)}$$

$$\textit{total percentile score} = \sum \text{(cluster percentile scores} \times \text{cluster weight)} \qquad \textbf{(2)}$$

The weights for each variable and each task cluster are fixed (see Tables I and II). Within each task cluster, the sum of the weights equals 1 and the weights reflect the relative importance of each variable. Also the sum of the cluster weights equals 1.

*Cluster percentile marks* and *total percentile marks* are presented on the driving report, according to the same five percentile categories (also in the same terms) as stated in Table VI. For example, a cluster percentile score of 25 is presented as the cluster percentile mark "mediocre" and a total percentile score of 70 is presented as the total percentile mark "good". Percentile *scores* shall never be presented on the driving report. However, instructors must be enabled to ask the system for exact percentile scores.

*Learning marks*

Percentile scores do not provide absolute, criterion-related, information about a students driving performance, indicating what is already learned and how performance relates to the ultimate training objectives. Therefore, learning marks are necessary. Three kinds of learning marks will be distinguished: variable learning marks, cluster learning marks and total learning marks.

For the calculation of these kinds of marks, two other kinds of scores are needed: the *baseline raw score* and the *criterion raw score*.
Baseline raw scores reflect the performance level of the absolute beginner (phase 0, see § 3.1). This will be represented by the raw scores on each variable linearly averaged over a number (e.g., 25) of students, who drive for the first time in the simulator, after having received only the most basic information enabling someone to drive.

Criterion raw scores reflect the average raw scores on each variable of a group of student drivers who have been trained and examined on the operational vehicle and who meet the criteria set by the training objectives for Route Driving, Obstacles, and Special Actions (phase 4, see § 3.1). Hence, these scores represent the global level of sufficient performances (absolute criteria) with regard to the ultimate objectives of the involved parts of the training program.
In order to calculate *variable learning marks* (see formula 3), it will be necessary that the raw scores on all variables of driving performance of a baseline and a criterion group are saved in separate databases in advance.

$$\textit{variable learning mark} = \left( \frac{\text{raw score} - \text{baseline raw score}}{\text{criterion raw score} - \text{baseline raw score}} \right) \times 100\ (\%) \qquad \textbf{(3)}$$

The *cluster learning marks* represent the sum of the weighted variable learning marks within each of the three task clusters, analogous to the manner in which cluster percentile scores were defined (see formula 1). According to the same procedure, a *total learning mark* must be calculated (see formula 2) and presented on the driving report. Learning marks are not presented in terms of percentage categories, as was the case for percentile marks. Both kinds (percentile and learning) of cluster and total marks shall be presented on the heading of the driving report (see Chapter 4).

*Reliability of percentile and learning marks*

The percentile marks for students will only be available after a sufficient number of subjects in each group has driven the three PMF cluster sections. Also the learning marks can only be calculated after sufficient raw scores of a baseline group and a criterion group are known. The reliability of scores will increase with the number of subjects saved. In order to be able to calculate the reliability of percentile and learning marks, the number of subjects (n) whose driving performance has been saved for calculating the percentile marks and learning marks shall be presented on each driving report if $n \leq 25$, if $n > 25$ it shall only be presented on request of the instructor (see Chapter 4).

## 4 LAY-OUT OF THE DRIVING REPORT IN DUTCH

The driving report consists of a header and an overview of all measured variables and their scores and marks. The content of the headers for the Leopard 2 and the YPR-765 are alike, this common header is presented in Table VII. The measured variables for the Leopard 2 and the YPR-765 are not completely similar, and are mentioned in Tables VIII and IX, respectively. Finally, the printout of the results of the initial evaluation of the Leopard 2 (as introduced in § 2.1) must have the lay-out presented in Table X. Additional information on the driving report is presented in the end of this Chapter.

Table VII Lay-out for the header of the driving report for the Leopard 2 and the YPR-765. Fields marked [keyboard] must be filled in by the instructor, fields marked [...] must be filled in by the PMF system (automatically), fields marked ([...]) must be filled in by the PMF system and placed between parenthesis. The values Nfi (i = 0, 1,...,4) denote the number of subjects who's score is stored for phase i.
English translations of Dutch terms are as follows: datum (date), fase (phase), route rijden (route driving), obstakels (obstacles), totaal (total), bijzondere verrichtingen (special actions), cluster gewicht (cluster weight), percentiel score (percentile mark), leer score (learning mark).

**Simulator rapport Leopard 2 / YPR-765**

**Naam: [keyboard]**
**Registratienummer: [keyboard]**
**Klas: [keyboard]**

| Datum: [...]<br>Fase: 1 | cluster gewicht | percentiel score | Nf2 | leer score | Nf0 | Nf4 |
|---|---|---|---|---|---|---|
| Route rijden | (0.50) | [...] | ([...]) | [...] | ([...]) | ([...]) |
| **Datum: [...]<br>Fase: 2** | **cluster gewicht** | **percentiel score** | **Nf2** | **leer score** | **Nf0** | **Nf4** |
| Route rijden | (0.50) | [...] | ([...]) | [...] | ([...]) | ([...]) |
| Obstakels | (0.25) | [...] | ([...]) | [...] | ([...]) | ([...]) |
| Totaal | | [...] | ([...]) | [...] | ([...]) | ([...]) |
| **Datum: [...]<br>Fase: 3** | **cluster gewicht** | **percentiel score** | **Nf2** | **leer score** | **Nf0** | **Nf4** |
| Route rijden | (0.50) | [...] | ([...]) | [...] | ([...]) | ([...]) |
| Obstakels | (0.25) | [...] | ([...]) | [...] | ([...]) | ([...]) |
| Bijzondere verrichtingen | (0.25) | [...] | ([...]) | [...] | ([...]) | ([...]) |
| Totaal | | [...] | ([...]) | [...] | ([...]) | ([...]) |

Table VIII Lay-out of the overview of measured variables of the Leopard 2 PMF system. Fields marked with [ ] must be filled in by the PMF system, (l/r) means that the direction (sign) must be presented. Percentiel score (percentile mark) shall be presented in the Dutch terms according to Table VI. A minus sign (−) in the column percentiel score indicates that the complementary percentile score is required (see § 3.2). The number of beacons hit in the slalom course must be presented for left and right, separately, percentile and learning marks will be based on the total number of hits.

| taak | gewicht | variabele | ruwe score | percentiel score | leer score |
|---|---|---|---|---|---|
| **Route rijden** | | | | | |
| Rechts rijden, rechtuit | 0.20 | gemiddelde baanfout (cm) (l/r) | [..] | −[cat] | [..%] |
| en in bochten | 0.08 | afstand in de berm (m) | [..] | −[cat] | [..%] |
| | 0.08 | tijdsduur met te lage versnelling (s) | [..] | −[cat] | [..%] |
| | 0.08 | schakelen in de bocht | [..] | −[cat] | [..%] |
| Links rijden, rechtuit | 0.12 | gemiddelde baanfout (cm) (l/r) | [..] | −[cat] | [..%] |
| | 0.08 | afstand in de berm (m) | [..] | −[cat] | [..%] |
| Scherpe bochten | 0.20 | gemiddelde baanfout (cm) (l/r) | [..] | −[cat] | [..%] |
| en kruisingen | 0.08 | afstand in de berm (m) | [..] | −[cat] | [..%] |
| | 0.08 | tijdsduur met te lage versnelling (s) | [..] | −[cat] | [..%] |
| **Obstakels** | | | | | |
| Opstap | 0.12 | schokkerigheid (m/s³) | [..] | −[cat] | [..%] |
| | 0.04 | gemiddelde rijsnelheid (km/h) | [..] | [cat] | [..%] |
| Steile helling | 0.12 | schokkerigheid (m/s³) | [..] | −[cat] | [..%] |
| | 0.04 | gemiddelde rijsnelheid (km/h) | [..] | [cat] | [..%] |
| Greppels (langzaam) | 0.24 | schokkerigheid (m/s³) | [..] | −[cat] | [..%] |
| | 0.08 | gemiddelde rijsnelheid (km/h) | [..] | [cat] | [..%] |
| Kombocht | 0.12 | slingeren (cm) | [..] | −[cat] | [..%] |
| Afhangende bocht | 0.12 | slingeren (cm) | [..] | −[cat] | [..%] |
| Wisselende dwarshelling | 0.12 | slingeren (cm) | [..] | −[cat] | [..%] |
| **Bijzondere verrichtingen** | | | | | |
| Slalom | 0.07 | aantal geraakte pilonen | [..] | −[cat] | [..%] |
| | 0.07 | benodigde tijd (s) | [..] | −[cat] | [..%] |
| Koersoefenbaan | 0.26 | gemiddelde baanfout (cm) | [..] | −[cat] | [..%] |
| | 0.09 | tijdsduur met foute versnelling (s) | [..] | −[cat] | [..%] |
| | 0.09 | gemiddelde rijsnelheid (km/h) | [..] | [cat] | [..%] |
| Dieplader | 0.18 | gemiddelde baanfout (cm) | [..] | −[cat] | [..%] |
| | 0.18 | schokkerigheid (m/s³) | [..] | −[cat] | [..%] |
| | 0.06 | gemiddelde rijsnelheid (km/h) | [..] | [cat] | [..%] |

Table IX Lay-out of the overview of measured variables of the YPR-765 PMF system. Fields marked with [ ] shall be filled in by the PMF system, (l/r) means that the direction (sign) must be presented. Percentiel score (percentile mark) shall be presented in the Dutch terms according to Table VI. A minus sign (−) in the column percentiel score indicates that the complementary percentile score is required (see § 3.2). The number of beacons hit in the slalom course must be presented for left and right, separately, percentile and learning marks will be based on the total number of hits.

| taak | gewicht | variabele | ruwe score | percentiel score | leer score |
|---|---|---|---|---|---|
| **Route rijden** | | | | | |
| Rechts rijden, rechtuit | 0.18 | gemiddelde baanfout (cm) (l/r) | [..] | −[cat] | [..%] |
| en in bochten | 0.07 | afstand in de berm (m) | [..] | −[cat] | [..%] |
| Links rijden, rechtuit | 0.18 | gemiddelde baanfout (cm) (l/r) | [..] | −[cat] | [..%] |
| | 0.07 | afstand in de berm (m) | [..] | −[cat] | [..%] |
| Scherpe bochten | 0.18 | gemiddelde baanfout (cm) (l/r) | [..] | −[cat] | [..%] |
| en kruisingen | 0.07 | afstand in de berm (m) | [..] | −[cat] | [..%] |
| | 0.07 | tijdsduur met foute versnelling (s) | [..] | −[cat] | [..%] |
| Noodstop | 0.12 | gemiddelde baanfout (cm) (l/r) | [..] | −[cat] | [..%] |
| | 0.06 | vertraging ($m/s^2$) | [..] | [cat] | [..%] |
| **Obstakels** | | | | | |
| Opstap | 0.13 | schokkerigheid ($m/s^3$) | [..] | −[cat] | [..%] |
| | 0.03 | gemiddelde rijsnelheid (km/h) | [..] | [cat] | [..%] |
| Steile helling | 0.13 | schokkerigheid ($m/s^3$) | [..] | −[cat] | [..%] |
| | 0.03 | gemiddelde rijsnelheid (km/h) | [..] | [cat] | [..%] |
| Greppels (langzaam) | 0.26 | schokkerigheid ($m/s^3$) | [..] | −[cat] | [..%] |
| | 0.06 | gemiddelde rijsnelheid (km/h) | [..] | [cat] | [..%] |
| Kombocht | 0.12 | slingeren (cm) | [..] | −[cat] | [..%] |
| Afhangende bocht | 0.12 | slingeren (cm) | [..] | −[cat] | [..%] |
| Wisselende dwarshelling | 0.12 | slingeren (cm) | [..] | −[cat] | [..%] |
| **Bijzondere verrichtingen** | | | | | |
| Slalom | 0.07 | aantal geraakte pilonen | [..] | −[cat] | [..%] |
| | 0.07 | benodigde tijd (s) | [..] | −[cat] | [..%] |
| Koersoefenbaan | 0.26 | gemiddelde baanfout (cm) (l/r) | [..] | −[cat] | [..%] |
| | 0.09 | tijdsduur met foute versnelling (s) | [..] | −[cat] | [..%] |
| | 0.09 | gemiddelde rijsnelheid (km/h) | [..] | [cat] | [..%] |
| Dieplader | 0.18 | gemiddelde baanfout (cm) (l/r) | [..] | −[cat] | [..%] |
| | 0.18 | schokkerigheid ($m/s^3$) | [..] | −[cat] | [..%] |
| | 0.06 | gemiddelde rijsnelheid (km/h) | [..] | [cat] | [..%] |

Table X Lay-out of the driving report for the initial evaluation of the Leopard 2. Fields marked [keyboard] must be filled in by the instructor, fields marked [...] must be filled in by the PMF system (automatically), fields marked ([...]) must be filled in by the PMF system and placed between parenthesis. Percentiel score (percentile mark) shall be presented in the Dutch terms according to Table VI. A minus sign (−) in the column percentiel score indicates that the complementary percentile score is required (see § 3.2).

**Tussenevaluatie Leopard 2 rijsimulator**

**Naam: [keyboard]**
**Registratienummer: [keyboard]**
**Klas: [keyboard]**

| | | | | |
|---|---|---|---|---|
| Datum: [...]<br>Fase: tussenevaluatie | | leer score | Nf0 | Nf4 |
| Route rijden (tussenevaluatie) | | [...] | ([...]) | ([...]) |

| taak | gewicht | variabele | ruwe score | percentiel score | leer score |
|---|---|---|---|---|---|
| Rechts rijden, rechtuit | 0.30 | gemiddelde baanfout (cm) | [..] | −[cat] | [..%] |
| en in bochten | 0.13 | afstand in de berm (m) | [..] | −[cat] | [..%] |
| | 0.13 | tijdsduur met te lage versnelling (s) | [..] | −[cat] | [..%] |
| | 0.13 | schakelen in de bocht | [..] | −[cat] | [..%] |
| Links rijden, rechtuit | 0.18 | gemiddelde baanfout (cm) | [..] | −[cat] | [..%] |
| | 0.13 | afstand in de berm (m) | [..] | −[cat] | [..%] |

Driving reports and the PMF systems must function according to the following:

- Before each evaluation ride, the system must ask for (Dutch terms between parenthesis): the name (naam), registration number (registratienummer), class (klas), phase (fase, 0−7), and finally the cluster sections (cluster sectie) of the PMF trajectory that will be driven (route driving (route rijden), obstacles (obstakels), special actions (bijzondere verrichtingen).
- Data which are only relevant for the interpretation of marks by instructors, have to be put between parenthesis.
- The header of the driving report shall contain the information showed in Table VII. This entails the student's name, registration number, class, cluster and total marks (percentile categories as well as learning marks), weights, numbers of subjects used to calculate marks, and the date(s) of evaluations.
- The system must automatically fill-in the dates of the evaluations and the numbers of subjects used to calculate marks.
- In case of a subject who drove a PMF cluster section more than once in the same training phase, the header also will be longer because it also has to present these prior results.
- The system shall use defaults when a <return> is typed. When for registration a <return> is keyed, the system shall not save the driving results. In that case, the driving results only can be observed by printout and on the monitor screen. When for class a <return> is typed, the space behind "class" on the report also will remain empty. The training/experience phase of the driver determines default values for the next questions concerning which PMF cluster sections will be driven. The default for phase 1 is **R**oute **D**riving and the default for phase 2 is **R**oute **D**riving and **O**bstacles. For the other five phases (0, 3−7) all three sections of the PMF trajectory are default.
- Depending on the PMF cluster sections that have been chosen, the driver automatically must be placed at the correct starting point in the driving environment.
- It shall not be possible to drive a PMF cluster section without specifications of training phase!
- When only one or two of the three PMF cluster section have been driven, the driving report shall only contain the items concerning these two driven parts.
- When the same person (same registration number) has driven a PMF cluster section several times in different phases, all prior evaluations must also be presented.
- When the same subject repeatedly drives the same part(s) of the section under the same training phase, only the data of the last time shall be saved for calculation of percentile scores for next students. In other words, data gathered under a known registration number *and* training phase will be written over the former data.
- When a subject does not complete a prior specified PMF part (route, special actions or obstacles), the data will not be saved and the relevant part must be driven again. Table VII presents the format of a driving report header of a student who has completed the three successive training phases.

# 5 GENERAL SYSTEM USAGE SPECIFICATIONS

## 5.1 Flexibility

This PMF system is in a developmental stage. Therefore, it may be expected that after first testing, some adaptations have to be made. For example, a variable may appear not to be sensitive enough to discriminate between students. It must then be possible to delete this variable from the system. In that case the weights have to be adapted as well, such that they still add to 1.00 within each task cluster. Furthermore, the driving environment may require adaptations, for example, trajectories for measurements may appear too long or too short. It must be possible to implement these kinds of adaptations rather easily by the users themselves.
It must also be easy to link the PMF system to specially modelled PMF environments, which are designed and implemented by the working group Database Specifications of the Royal Netherlands Army.

## 5.2 Handling and checking performance databases

A user-friendly system for handling of performance databases is required, with a well-documented manual (in Dutch), containing the specifications of the system and directions for use. It must be easy to handle (e.g., make copies on diskettes, backup facilities) and manipulate files containing the data of student groups, criterion group, or expert group, cluster marks and total marks. The deletion of data must be possible, per student and per cluster. It must be easy to get an overview (on the screen and on printout) of the saved driver performance data concerning individual subjects, groups of each training phase, average raw scores and marks, standard deviations, and numbers of subjects per measured variable.

## 5.3 Additional requirements

Output presented on the driving report as well as on the computer screen has to be presented in Dutch language.
Breakdown of the simulator would interfere with the evaluation of driving speed or time taken to perform a subtask. Therefore, rough driving shall not result in a system breakdown.
The sample frequency for performance measurements shall be at least 5 Hz.
Last, but not least, the system must be protected against illegal use.

REFERENCES

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Korteling, J.E. & Padmos, P. (1992). *Technical specifications for the PMF systems of the Leopard 2 and YPR-765 driving simulators* (Report IZF 1992 A-20). Soesterberg, The Netherlands: TNO Institute for Perception.

Soesterberg, 30 July 1996

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[1] On January 1, 1994 the name "TNO Institute for Perception" has been changed to "TNO Human Factors Research Institute".

APPENDIX Details on calculating performance measures

In this Appendix the detailed calculation of each performance variable for each subtask is described. For each task cluster and for each variable, the Dutch term and weight are given as well. Presented for each variable are (when applicable): calculation of the raw score, the Vehicle Reference Point (VRP), the section on which the variable must be calculated, the mark, and finally specific remarks for that variable.

**Task cluster 1: Route Driving**

Dutch term: Route rijden
Weight: 0.50
Mark: Cluster percentile mark, cluster learning mark

***Subtask 1:*** ***Driving right, straight and curves***
Dutch term: Rechts rijden, rechtuit en in bochten

*Variable 1:* RMS lane error
Dutch term: Gemiddelde baanfout
Raw score: RMS error, i.e., $\sqrt{\Sigma d^2/n}$ (cm)
n = number of sample points
In case of edge marking lines:
d = rightward distance in cm from the left edge of the right line to the VRP (d becomes positive if the VRP is over the line's left edge)
In case of no edge marking lines:
d = rightward distance in cm from the right road edge to the VRP minus 15 (d becomes positive if the VRP is closer than 15 cm to the right road edge)
VRP: Longitudinal middle of the right edge of the right track
Section: Over all route driving sections of this cluster except the section intended to drive left and on sharp curves and intersections
Weight: Leopard 2: 0.20
YPR-765: 0.18
Mark: Variable percentile mark and variable learning mark, the former based on 100 minus percentile score
Others: Also the direction (sign) of the linearly averaged $\bar{d}$ ($\bar{d} = \Sigma d/n$) must be presented in terms of left (if the sign is negative) and right (if the sign is positive).

*Variable 2:* Distance of verge driving
Dutch term: Afstand in de berm
Raw score: Distance driven on the verge, i.e., $d > 15$ cm (m)
VRP: Longitudinal middle of the right edge of the right track
Section: Over all route driving sections of this cluster except the section intended to drive left and on sharp curves and intersections
Weight: Leopard 2: 0.08
YPR-765: 0.07
Mark: Variable percentile mark and variable learning mark, the former based on 100 minus percentile score.

*Variable 3:* Duration in too low gears (only for Leopard 2)
Dutch term: Tijdsduur in te lage versnelling

Raw score: Time driven in a gear lower than specified in the following table:

| curve radius (m)[2] | minimum gear |
|---|---|
| 40 | A2 |
| 60 | A3 |
| > 80 | A4 |

VRP: Longitudinal middle of the vehicle
Section: Over all route driving sections of this cluster except the section intended to drive left and on sharp curves and intersections
Weight: Leopard 2: 0.08
Mark: Variable percentile mark and variable learning mark, the former based on 100 minus percentile score
Others: Road width: 7.20 m.

*Variable 4:* Gear shift in curves (only for Leopard 2)
Dutch term: Schakelen in bochten
Raw score: Number of gears shifts
VRP: Longitudinal middle of the vehicle
Section: Over all route driving sections of this cluster except the section intended to drive left and on sharp curves and intersections
Weight: Leopard 2: 0.08
Mark: Variable percentile mark and variable learning mark, the former based on 100 minus percentile score
Others: Road width: 7.20 m.

***Subtask 2:*** ***Driving left, straight***
Dutch term: Links rijden, rechtuit

*Variable 1:* RMS lane error
Dutch term: Gemiddelde baanfout
Raw score: RMS error, i.e., $\sqrt{\Sigma d^2/n}$ (cm)
n = number of sample points
In case of edge marking lines:
d = rightward distance in cm from the right edge of the left line to the Vehicle Reference Point, i.e. the VRP (d becomes negative if the VRP is over the line's right edge)
In case of no edge marking lines:
d = rightward distance in cm from the left road edge to the VRP minus 15 (d becomes negative if the VRP is closer than 15 cm to the left road edge)
VRP: Longitudinal middle of the left edge of the left track
Section: From entering to leaving the straight section intended to drive left
Weight: Leopard 2: 0.12
YPR-765: 0.18
Mark: Variable percentile mark and variable learning mark, the former based on 100 minus percentile score
Others: Also the direction (sign) of the linearly averaged $\bar{d}$ ($\bar{d} = \Sigma d/n$) must be presented in terms of left (if the sign is negative) and right (if the sign is positive).

*Variable 2:* Distance of verge driving
Dutch term: Afstand in de berm
Raw score: Distance driven on the verge, i.e., $d < -15$ cm (m)
VRP: Longitudinal middle of the left edge of the left track

[2] Curve radius measured over the road axis.

Section: From entering to leaving the straight section intended to drive left
Weight: Leopard 2: 0.08
YPR-765: 0.07
Mark: Variable percentile mark and variable learning mark, the former based on 100 minus percentile score
Others: The database shall clearly show where left driving is demanded.

***Subtask 3:*** ***Sharp curves and intersections***
Dutch term: Scherpe bochten en kruisingen

*Variable 1:* RMS lane error
Dutch term: Gemiddelde baanfout
Raw score: RMS error, i.e., $\sqrt{\Sigma d^2/n}$ (cm)
n = number of sample points
In case of edge marking lines:
d = rightward distance in cm from the left edge of the right line to the VRP (d becomes positive if the VRP is over the line's left edge)
In case of no edge marking lines:
d = rightward distance in cm from the right road edge to the VRP minus 15 (d becomes positive if the VRP is closer than 15 cm to the right road edge)
VRP: Longitudinal middle of the right edge of the right track
Section: From entering to leaving the curves in the section(s) intended to drive on sharp curves and intersections
Weight: Leopard 2: 0.20
YPR-765: 0.18
Mark: Variable percentile mark and variable learning mark, the former based on 100 minus percentile score
Others: Also the direction (sign) of the linearly averaged $\bar{d}$ ($\bar{d} = \Sigma d/n$) must be presented in terms of left (if the sign is negative) and right (if the sign is positive).

*Variable 2:* Distance of verge driving
Dutch term: Afstand in de berm
Raw score: Distance driven on the verge, i.e., $d > 15$ cm (m)
VRP: Longitudinal middle of the right edge of the right track
Section: From entering to leaving curves in the section(s) intended to drive on sharp curves and intersections
Weight: Leopard 2: 0.08
YPR-765: 0.07
Mark: Variable percentile mark and variable learning mark, the former based on 100 minus percentile score.

*Variable 3*: Duration in wrong gear
Dutch term: Tijdsduur met foute versnelling
Raw score: Leopard 2: Time driven in another gear than specified in the following table (s):

| curve radius | gear |
|---|---|
| 10 | 1 |
| 15 | 1 |
| 20 | A2 |
| 30 | A2 |

YPR-765: When the curve radius, measured over the road axis, exceeds 14.13 m, the score is: duration of driving (s) on the curve in gear shift "1" or "3"; when the curve radius is smaller than 14.13 m, the score is: duration (s) of driving on curves in shift "2" or "3"
VRP: Longitudinal middle of the vehicle

Section: From entering to leaving the curves in the section(s) intended to drive on sharp curves and intersections. This variable is not relevant on the straight stretches between the curves

Weight: Leopard 2: 0.08
YPR-765: 0.07

Mark: Variable percentile mark and variable learning mark, the former based on 100 minus percentile score

Others: Road width for Leopard 2: 7.20 m; for YPR-765: 5.60 m.

***Subtask 4:*** ***Emergency stop*** (only for YPR-765)

Dutch term: Noodstop

*Variable 1:* RMS lane error

Dutch term: Gemiddelde baanfout

Raw score: RMS error, i.e., $\sqrt{\Sigma d^2/n}$ (cm)
n = number of sample points
In case of edge marking lines:
d = rightward distance in cm from the left edge of the right line to the VRP (d becomes positive if the VRP is over the line's left edge)
In case of no edge marking lines:
d = rightward distance in cm from the right road edge to the VRP minus 15 (d becomes positive if the VRP is closer than 15 cm to the right road edge)

VRP: Longitudinal middle of the right edge of the right track

Section: A section where initial driving speeds and maximal braking actions are required

Weight: YPR-765: 0.12

Mark: Variable percentile mark and variable learning mark, the former based on 100 minus percentile score

Others: Also the direction (sign) of the linearly averaged $\bar{d}$ ($\bar{d} = \Sigma d/n$) shall be presented in terms of left (if the sign is negative) and right (if the sign is positive).

*Variable 2:* Deceleration

Dutch term: Vertraging

Raw score: Mean decelerations (a in $m/s^2$) during braking manoeuvres, that is, $\Sigma a/n$, where a is only counted when $a > 2$ ($m/s^2$)

VRP: Not critical

Section: A section where some initial driving speeds are demanded and with spots where maximal braking actions are required

Weight: YPR-765: 0.06

Mark: Variable percentile mark and variable learning mark, the former based on the percentile score

Others: The database will clearly show what speeds have to be chosen and where the maximal braking actions are required.

**Task cluster 2: Obstacles**

Dutch term: Obstakels
Weight: 0.25
Mark: Cluster percentile mark, cluster learning mark

***Subtask 1:*** ***Step up***
Dutch term: Opstap

*Variable 1:* Jerkiness
Dutch term: Schokkerigheid
Raw score: $\sqrt{[\{(\mathring{a}_1)^2+(\mathring{a}_2)^2+(\mathring{a}_3)^2\}/3]}$ (m/s³), where the å's represent the three highest absolute peak derivatives (differentials) of the compound acceleration (in m/s²) in the surge, heave and pitch degrees of freedom
VRP: The driver's place for measuring jerkiness (see Raw score); one frontal terrain detection point for approaching the obstacles and one backward terrain detection point for leaving the obstacles (see Section)
Section: From 1 m before the obstacles during approach to 1 m after the obstacle during drive off
Weight: Leopard 2: 0.12
YPR-765: 0.13
Mark: Variable percentile mark and variable learning mark, the former based on 100 minus percentile score.

*Variable 2:* Mean driving speed
Dutch term: Gemiddelde rijsnelheid
Raw score: Mean driving speed over the section (km/h)
VRP: One frontal terrain detection point for approaching the obstacles and one backward terrain detection point for leaving the obstacles (see Section)
Section: From 1 m before the obstacles during approach to 1 m after the obstacles during drive off
Weight: Leopard 2: 0.04
YPR-765: 0.03
Mark: Variable percentile mark and variable learning mark, the former based on the percentile score.

***Subtask 2:*** ***Sloping block***
Dutch term: Steile helling

*Variable 1:* Jerkiness
Dutch term: Schokkerigheid
Raw score: $\sqrt{[\{(\mathring{a}_1)^2+(\mathring{a}_2)^2+(\mathring{a}_3)^2\}/3]}$ (m/s³), where the å's represent the three highest absolute peak derivatives (differentials) of the compound acceleration (in m/s²) in the surge, heave and pitch degrees of freedom
VRP: The driver's place for measuring jerkiness (see Raw score); one frontal terrain detection point for approaching the obstacles and one backward terrain detection point for leaving the obstacles (see Section)
Section: From 1 m before the obstacles during approach to 1 m after the obstacle during drive off
Weight: Leopard 2: 0.12
YPR-765: 0.13

Mark: Variable percentile mark and variable learning mark, the former based on 100 minus percentile score.

*Variable 2:* Mean driving speed
Dutch term: Gemiddelde rijsnelheid
Raw score: Mean driving speed over the section (km/h)
VRP: One frontal terrain detection point for approaching the obstacles and one backward terrain detection point for leaving the obstacles (see Section)
Section: From 1 m before the obstacles during approach to 1 m after the obstacles during drive off
Weight: Leopard 2: 0.04
YPR-765: 0.03
Mark: Variable percentile mark and variable learning mark, the former based on the percentile score.

***Subtask 3:*** ***Small ditches (slow)***
Dutch term: Greppels (langzaam)

*Variable 1:* Jerkiness
Dutch term: Schokkerigheid
Raw score: $\sqrt{[\{(\mathring{a}_1)^2+(\mathring{a}_2)^2+(\mathring{a}_3)^2\}/3]}$ (m/s³), where the å's represent the three highest absolute peak derivatives (differentials) of the compound acceleration (in m/s²) in the surge, heave and pitch degrees of freedom
VRP: The driver's place for measuring jerkiness (see Raw score); one frontal terrain detection point for approaching the obstacles and one backward terrain detection point for leaving the obstacles (see Section)
Section: From 1 m before the obstacles during approach to 1 m after the obstacles during drive off
Weight: Leopard 2: 0.24
YPR-765: 0.26
Mark: Variable percentile mark and variable learning mark, the former based on 100 minus percentile score.

*Variable 2:* Mean driving speed
Dutch term: Gemiddelde rijsnelheid
Raw score: Mean driving speed over the section (km/h)
VRP: One frontal terrain detection point for approaching the obstacles and one backward terrain detection point for leaving the obstacles (see Section)
Section: From 1 m before the obstacles during approach to 1 m after the obstacles during drive off
Weight: Leopard 2: 0.08
YPR-765: 0.06
Mark: Variable percentile mark and variable learning mark, the former based on the percentile score.

***Subtask 4:*** ***Normal camber***
Dutch term: Kombocht

*Variable*: Lateral instability
Dutch term: Slingeren
Raw score: Standard deviation, i.e., $\sqrt{\Sigma (d - \bar{d})^2/n}$ (cm)
$n$ = the number of sample points
$d$ = the position in cm on the road of the VRP
$\bar{d} = \Sigma d/n$

| | |
|---|---|
| VRP: | One frontal (standard deviation, entering the cambers) and one backward (leaving the cambers) terrain detection point |
| Section: | From entering to leaving the camber(s) |
| Weight: | Leopard 2: 0.12<br>YPR-765: 0.12 |
| Mark: | Variable percentile mark and variable learning mark, the former based on 100 minus percentile score. |

***Subtask 5:*** ***Adverse camber***

Dutch term: Afhangende bocht

| | |
|---|---|
| *Variable*: | Lateral instability |
| Dutch term: | Slingeren |
| Raw score: | Standard deviation, i.e., $\sqrt{\Sigma (d - \bar{d})^2/n}$ (cm)<br>n = the number of sample points<br>d = the position in cm on the road of the VRP<br>$\bar{d} = \Sigma d/n$ |
| VRP: | One frontal (standard deviation, entering the cambers) and one backward (leaving the cambers) terrain detection point |
| Section: | From entering to leaving the cambers |
| Weight: | Leopard 2: 0.12<br>YPR-765: 0.12 |
| Mark: | Variable percentile mark and variable learning mark, the former based on 100 minus percentile score. |

***Subtask 6:*** ***Alternating camber***

Dutch term: Wisselende dwarshelling

| | |
|---|---|
| Variable: | Lateral instability |
| Dutch term: | Slingeren |
| Raw score: | Standard deviation, i.e., $\sqrt{\Sigma (d - \bar{d})^2/n}$ (cm)<br>n = the number of sample points<br>d = the position in cm on the road of the VRP<br>$\bar{d} = \Sigma d/n$ |
| VRP: | One frontal (standard deviation, entering the cambers) and one backward (leaving the cambers) terrain detection point |
| Section: | From entering (frontal VRP) to leaving (backward VRP) the cambers |
| Weight: | Leopard 2: 0.12<br>YPR-765: 0.12 |
| Mark: | Variable percentile mark and variable learning mark, the former based on 100 minus percentile score. |

**Task cluster 3: Special Actions**

Dutch term: Bijzondere verrichtingen
Weight: 0.25
Mark: Cluster percentile mark, cluster learning mark

***Subtask 1:*** ***Slalom course***
Dutch term: Slalom

*Variable 1:* Number of beacons hit
Dutch term: Aantal geraakte pilonnen
Raw score: The number of beacons hit at right and at left VRPs; each beacon can only be hit once
VRP: All terrain detection points
Section: Slalom course
Weight: Leopard 2: 0.07
YPR-765: 0.07
Mark: Variable percentile mark and variable learning mark, the former based on 100 minus percentile score. The learning mark and percentile score has to be based on the total number of beacons hit
Others: A correctly scaled plot (seen from above) shall be made of the path of the vehicle relative to the beacons.

*Variable 2:* Time needed
Dutch term: Benodigde tijd
Raw score: Duration of the vehicle on the slalom section (s)
VRP: The right frontal terrain detection point when entering and the right backward terrain detection point when leaving the course
Section: Slalom course, starting 1 m before and ending 1 m after the slalom course
Weight: Leopard 2: 0.07
YPR-765: 0.07
Mark: Variable percentile mark and variable learning mark, the former based on 100 minus percentile score.

***Subtask 2:*** ***Vehicle clearing course***
Dutch term: Koersoefenbaan

*Variable 1:* RMS lane error
Dutch term: Gemiddelde baanfout
Raw score: RMS error, i.e., $\sqrt{\Sigma d^2/n}$ (cm)
d = rightward distance in cm from lane midline to the VRP
VRP: Centre point between left and right frontal runwheel terrain detection points
Section: On the stretches between the cones, from entering to leaving the course (both based on a frontal terrain detection point)
Weight: Leopard 2: 0.26
YPR-765: 0.26
Mark: Variable percentile mark and variable learning mark, the former based on 100 minus percentile score
Others: 1. Also the direction (sign) of the linearly averaged $\bar{d}$ ($\bar{d} = \Sigma d/n$) must be presented in terms of left (if the sign is negative) and right (if the sign is positive)
2. A correctly scaled plot (seen from above) must be made of the path of the vehicle relative to the pilons of the course.

*Variable 2:* Duration in wrong gear
Dutch term: Tijdsduur met foute versnelling
Raw score: The time driven in another gear than "2" (s)
VRP: One frontal terrain detection point for entering and one backward terrain detection point for leaving the course
Section: Vehicle clearing course, starting 1 m before and ending 1 m after the course
Weight: Leopard 2: 0.09
YPR-765: 0.09
Mark: Variable percentile mark and variable learning mark, the former based on 100 minus percentile score.

*Variable 3:* Mean driving speed
Dutch term: Gemiddelde rijsnelheid
Raw score: Mean driving speed over the vehicle clearing course (km/h)
VRP: One frontal terrain detection point for entering and one backward terrain detection point for leaving the course
Section: Vehicle clearing course, starting 1 m before and ending 1 m after the course
Weight: Leopard 2: 0.09
YPR-765: 0.09
Mark: Variable percentile mark and variable learning mark, the former based on the percentile score.

***Subtask 3:*** ***Lowloader***
Dutch term: Dieplader

*Variable 1:* RMS lane error
Dutch term: Gemiddelde baanfout
Raw score: RMS error, i.e., $\sqrt{\Sigma d^2/n}$ (cm)
d = rightward distance from the virtual and extended midline of the lowloader to the VRP
VRP: Centre point between the left and right frontal runwheel terrain detection points
Section: From 1 m before the lowloader at entering to 1 m before the lowloader at leaving
Weight: Leopard 2: 0.18
YPR-765: 0.18
Mark: Variable percentile mark and variable learning mark, the former based on 100 minus percentile score
Others: Also the direction (sign) of the linearly averaged $\bar{d}$ ($\bar{d} = \Sigma d/n$) shall be presented in terms of left (if the sign is negative) and right (if the sign is positive).

*Variable 2:* Jerkiness
Dutch term: Schokkerigheid
Raw score: $\sqrt{[\{(\mathring{a}_1)^2+(\mathring{a}_2)^2+(\mathring{a}_3)^2\}/3]}$ (m/s³), where the å's represent the three highest absolute peak derivatives (differentials) of the compound acceleration (in m/s²) in the surge, heave and pitch degrees of freedom
VRP: The driver's place for measuring jerkiness (see Raw score); one frontal terrain detection point for entering and leaving the lowloader (see Section)
Section: From 1 m before the lowloader at entering to 1 m before the lowloader at leaving
Weight: Leopard 2: 0.18
YPR-765: 0.18
Mark: Variable percentile mark and variable learning mark, the former based on 100 minus percentile score.

| | |
|---|---|
| *Variable 3:* | Mean driving speed |
| Dutch term: | Gemiddelde rijsnelheid |
| Raw score: | Mean driving speed over the section (km/h)<br>This variable shall not be measured when the vehicle is standing still on the parking place of the lowloader (before driving backwards) |
| VRP: | One frontal terrain detection point, relevant for entering and leaving the lowloader |
| Section: | From 5 m before the lowloader at entering to 1 m before the lowloader at leaving |
| Weight: | Leopard 2: 0.06<br>YPR-765: 0.06 |
| Mark: | Variable percentile mark and variable learning mark, the former based on the percentile score. |

# REPORT DOCUMENTATION PAGE

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10. TITLE AND SUBTITLE

Specifications for implementation of performance measurement and feedback systems for the Leopard 2 and YPR-765 driving simulators

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14. SUPPLEMENTARY NOTES

15. ABSTRACT (MAXIMUM 200 WORDS, 1044 BYTE)

In a previous report, specifications and guidelines were given for the implementation of Performance Measurement and Feedback (PMF) systems for the Leopard 2 and YPR-765 driving simulators (Korteling & Padmos, 1992). In connection with an update program for both simulators, the Dutch Armed Forces have decided to implement both systems. Therefore, the above-mentioned report is revised, taking into consideration changes in the learning trajectories, and comments of the, by now, experienced users of both simulators. Report IZF 1992 A-20 is herewith expired.
The PMF systems objectively measure the critical task variables of a selection of the most relevant subtasks. Application of these systems is expected to improve the efficiency of the training of student drivers on these simulators. In order to enable system engineers to program and implement these systems on both simulators, the present report provides an exact and detailed description of scores, vehicle reference points for calculation of scores and for the trajectories over which scores will be measured, and weights for subtask variables and for clusters of subtasks. In addition, general requirements are provided with regard to the calculation and presentation of scores and marks, database management, and system operation.

| 16. DESCRIPTORS | IDENTIFIERS |
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Extra exemplaren van dit rapport kunnen worden aangevraagd door tussenkomst van de HWOs of de DWOO.