

# Status Report of New Issues TF –CFD\* sub wg

\*CFD: Computational Fluid Dynamics method, method to simulate aero drag

7<sup>th</sup> Jan., 2019

Mayumi “Sophie” Morimoto (JASIC)


## Background of CFD wg under New Issues TF

1/4

- During Dec. 2017 New Issues TF meeting, Exa (software vender) proposed revisions to text related to CFD in Annex 7 of GTR 15.

WLTP Simulation Requirements  
ECE/TRANS/WP.29/2017/140 (page 247)


- Current text:
  - a) The alternative determination method shall fulfill an accuracy for  $\Delta(CD \times Af)$  of  $\pm 0.015 \text{ m}^2$  and additionally, in the case that simulation is used, the Computational Fluid Dynamics method should be validated in detail, so that the actual air flow patterns around the body, including magnitudes of flow velocities, forces, or pressures, are shown to match the validation test results;
- Comments:
  - The requirements for the validation of the alternative method state that the "method should be validated in detail". It is also stated that "the actual air flow patterns around the body, including magnitudes of flow velocities, forces, or pressures, are shown to match the validation test results." These statements are vague. The validation requirements need to be quantified in order to enable clear validation procedure.
  - The validation with respect to test results needs to take into account the measurement accuracy. The drag coefficient can be measured  $\pm 1\%$  accurate, while the velocity and pressure not less than  $\pm 10\%$
  - The validation for any alternative determination method should have the same requirements when it comes to the prediction of the flow pattern. For example, based on the current regulation text a wind tunnel with static ground could be used for evaluation of the rotating wheel drag despite the fact the the flow pattern will be wrong.
- Proposal:
  - a) The alternative determination method shall fulfill accuracy level for  $\Delta(CD \times Af)$  of  $\pm 0.015 \text{ m}^2$  and should be validated so that the actual air flow patterns around the body match the validation test results. The predicted flow velocities and pressures need to be within 10% of the validation test results accuracy band;

 © Exa Corporation - used for authentication

WLTP Simulation Requirements  
ECE/TRANS/WP.29/2017/140 (page 247)

- Current text:
  - b) The alternative method shall be used only for those aerodynamic-influencing parts (e.g. wheels, body shapes, cooling system) for which equivalency was demonstrated;
- Comments:
  - Since an alternative method can be used for the evaluation of variances, it should be explicitly stated that the equivalency needs to be demonstrated for variances in aerodynamic-influencing parts.
  - It is not clear how the equivalence should be demonstrated and to whom. It would be helpful to have an explicit statement about it.
- Proposal:
  - b) The alternative method shall be used only for those aerodynamic-influencing parts (e.g. wheels, body shapes, cooling system) for which variance equivalency was demonstrated. The equivalency needs to be demonstrated for each of the variances:
    - Between different wheels if alternative method is to be used for wheels
    - Between different body shapes if alternative method is to be used for body shapes
    - Between different cooling systems if alternative method is to be used for cooling systems

The variance equivalency can be verified by a responsible authority.

 © Exa Corporation - used for authentication

- During Mar. 2018 New Issues TF meeting in Paris, Japan proposed to compose a CFD expert working group as a reply to Exa proposal. TF members agreed Japan to compose the member list and lead a kick-off meeting of CFD expert working group.

Comments by Japan

- We should consider these text revisions after we discuss to create a concrete regulatory text like Paragraph 3.2. of Annex 4 Wind tunnel criteria. Or, after we discuss whether we should create a regulatory text like Paragraph 3.2. or not, at first.
- To do this, we propose to set a separate working group in New Issues TF for discussion of CFD and invite specialists from software venders and vehicle manufacturers. And in that TF, we discuss Terms of Reference (ToR) at first, then solve those problems.
- If there are any requests on urgent discussions on this from software venders and vehicle manufacturers, they should make clear on the proposal of regulatory text development plan.

[Example of discussion timeline in UN]

- To finalize GTR in 2019 summer: Need to finish discussion within 2018. (Preferably by Sep. 2018.)
- To finalize GTR in 2020 summer: Need to finish discussion by Sep. 2020.

## Discussion Points raised by members

3/4

### 1. Certification criteria of CFD simulation model

- Air flow patterns, delta-cw accuracy, etc.

### 2. Certification demonstration/process of CFD simulation model

- Equivalency validation
- Validation of CFD simulation models by software vender/manufacturere
- Documentation format, etc.

### 3. Certification process of vehicle aero drag using CFD simulation model

- Evidence of CFD result ([How to prove the usage of authorised simulation method](#))

### 4. Re-certification criteria of CFD simulation model

- Define what is „change in simulation model“

### 5. Certification scope using CFD simulation model

(NEWLY raised after kick-off meeting)

- R/L family are not relevant with aerodynamic drags.

### 6. Certification motivation using CFD simulation model

(NEWLY raised after kick-off meeting)

- CFD process must be feasible, reasonable, time/resource consumption

There are several points which need **involvement of CPs/TAs**

## Background of CFD discussion/Status

1/2

### ■ Review of 22<sup>nd</sup> WLTP IWG in April 2018

- Sub working group members requested to CPs/TAs and IWG to join the meeting.
- Because of lack of resources, WLTP IWG decided to postpone the discussion of CFD sub working group until GTR15 Amd5 discussion finish.

### ■ During the CFD discussion on May

- Even with WLTP IWG decision, some manufacturers strongly requested discussion even without TA/CPs, to make some proposals on Spring 2019. They also did not accept discussion between manufacturers within each regions.
- Therefore, web meeting of CFD sub wg in UN level was held on 5<sup>th</sup> Sep.

### ■ Status & Schedule

- 2 meetings were held after April WLTP IWG.
- Next meeting will be held at late November or early December

## ■ Status & Schedule

- 1 meeting was held after 24<sup>th</sup> Sep. WLTP IWG.
- Next meeting is planned on February.

## ■ Current discussion in CFD sub wg

### Introduction

#### Section 3.2.3.2.2.3.2 (a)

##### ▶ Current GTR states:

- ▷ “The alternative method shall fulfil an accuracy for  $\Delta(C_D \times A_f)$  of  $\pm 0.015 \text{ m}^2$  and, additionally, in the case that simulation is used, the Computational Fluid Dynamics method should be validated in detail **such that the actual air flow patterns around the body, including magnitudes of flow velocities, forces, or pressures, are shown to match the validation test results**”

##### ▶ It was agreed that validating air flow patterns would be difficult for many reasons

- ▷ No objective/quantitative metric available
- ▷ Flow visualization is not usually available unless dedicated physical tests are performed
- ▷ Accuracy/Repeatability of wind tunnel flow measurements is not good

##### ▶ Proposals were suggested of how to proceed

## Proposal #3

- ▶ Define demonstration of equivalence to be 'sufficiently large'
  - ▷ Require a well defined set of cases such that it is very unlikely CFD results could be correct for incorrect reasons (e.g. cancellation of errors)
  - ▷ Multiple vehicles must be demonstrated
    - ▶ Multiple variants must be shown for each vehicle
- ▶ Reasoning
  - ▷ Provides well defined process for OEM to follow to certify CFD method
  - ▷ Eliminates uncertainty of flow visualization
  - ▷ Relies on data OEM already has from physical WLTP process
  - ▷ Volume of variants demonstrated gives confidence that CFD method is accurate
- ▶ Drawbacks
  - ▷ Does not compare to measured flow field results
  - ▷ OEMs with limited vehicles may not have enough variants to meet requirements
    - ▶ Depending on how demonstration of equivalence requirements are defined

### Proposal #3

Example of individual vehicle variants

	Test configurations per vehicle				
		Wheel A		Wheel B	Wheel C
Baseline	OPEN GRILLE	50% OPEN	CLOSED	OPEN GRILLE	OPEN GRILLE
Optional Equipment A	OPEN GRILLE	-	-	-	-
Optional Equipment B	OPEN GRILLE	-	-	-	-



### Proposal #3

Require at least 3 different vehicles for all deltas

	Test configurations per vehicle				
		Wheel A		Wheel B	Wheel C
Optional Equipment					
Baseline	OPEN GRILLE	50% OPEN	CLOSED	OPEN GRILLE	OPEN GRILLE
Optional Equipment A	OPEN GRILLE	-	-	-	-
Optional Equipment B	OPEN GRILLE	-	-	-	-



- ▶ Total vehicles: 3
- ▶ Variants per vehicle: 7
- ▶ Total vehicle deltas: 18
  - ▷ Very unlikely 18 deltas could be predicted correctly by random chance (0.00038% chance)

**Is it acceptable to define the common procedure to certify CFD software?**

**Does any CPs/TAAAs/TSs require workshop on CFD?**

**Thank you very much  
for your attention!**

---