

PROGRESS REPORT

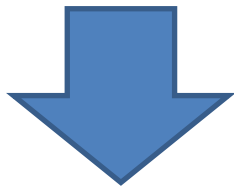
“Speed Trace Violations / Drive Trace Index” (OIL#29/30/41)

Prepared by WLTP Trace Index Task Force(TF)

10th June 2015

How can we improve the drive traceability ?

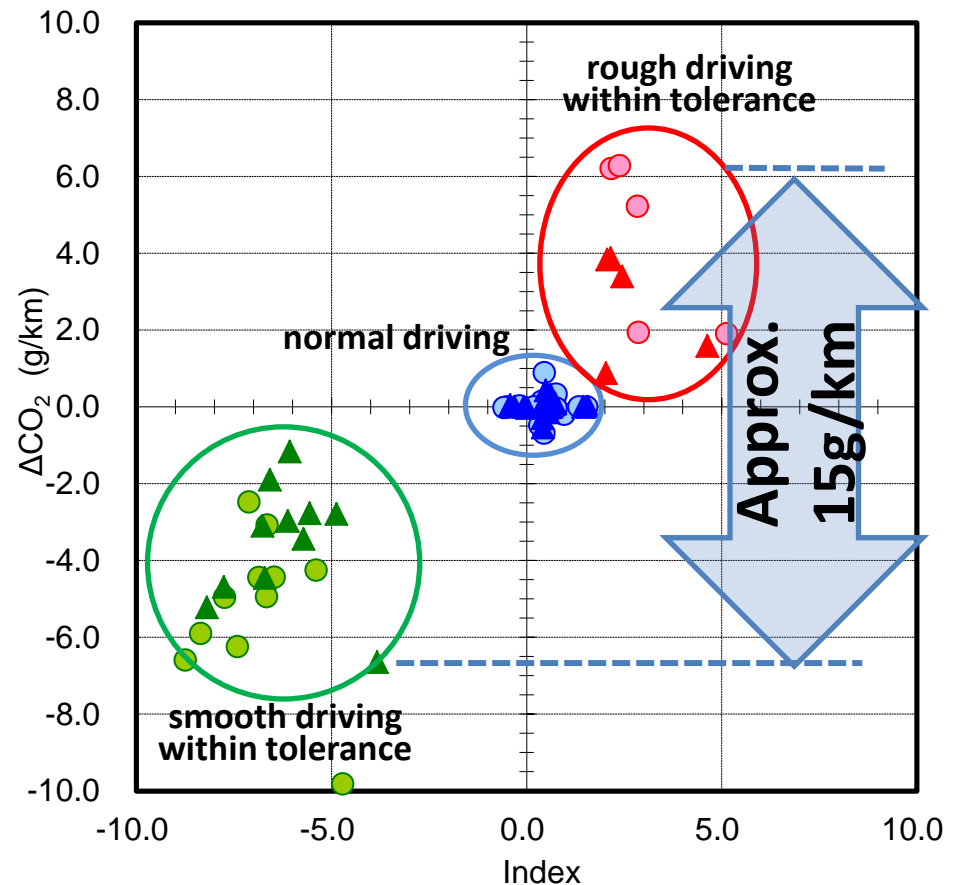
Current drive trace tolerance allows relatively wide range of CO2 variety.



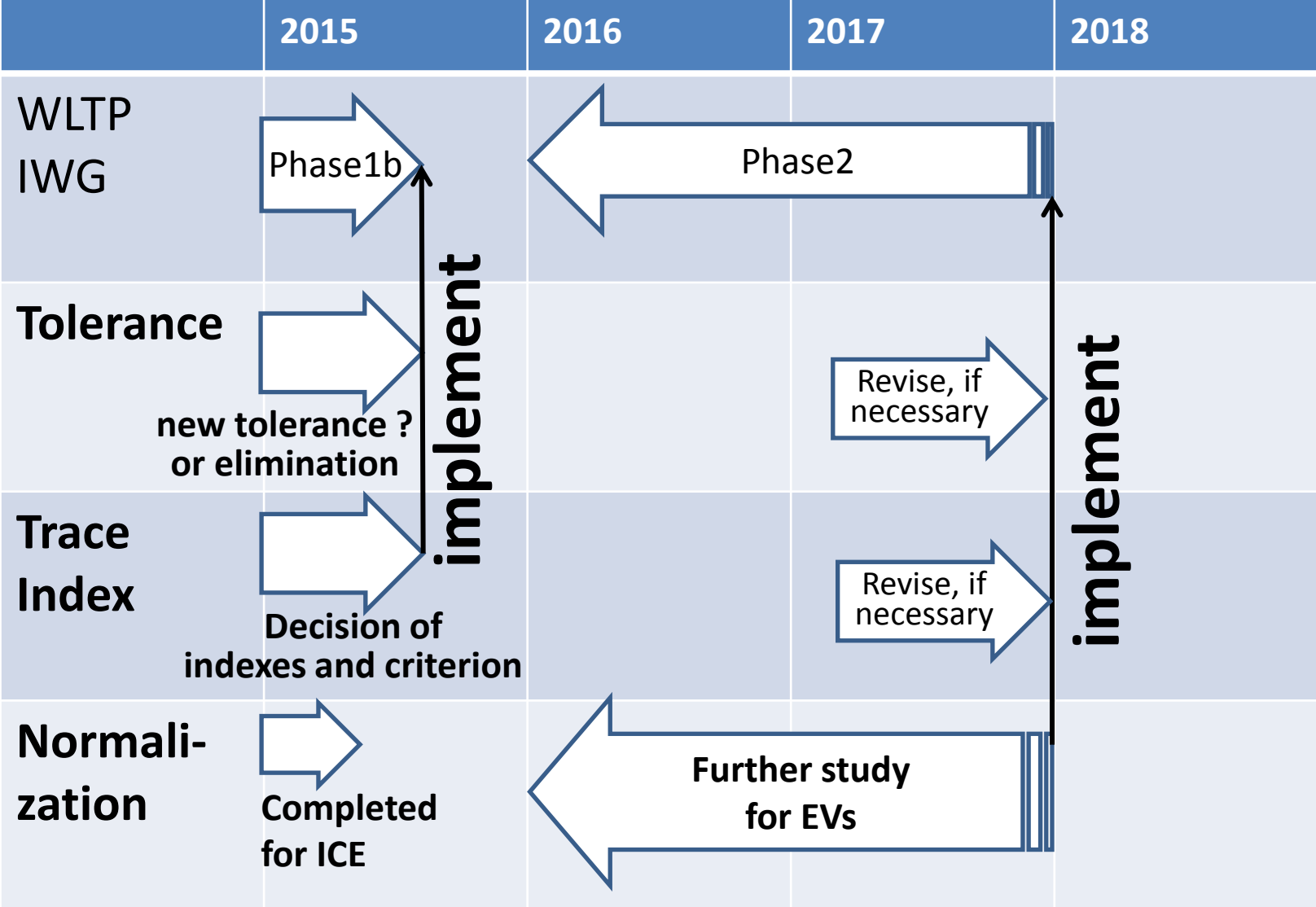
Possible solutions

- ✓ Normalization
- ✓ Tighten the tolerance
- ✓ Trace index

All data are within drive trace tolerance



Possible Future Scenario



Current Status

During 10th WLTP meeting,

1. Technical Secretary provided the initial proposals
2. WLTP IWG has requested to establish TF(Task Force) for further discussion

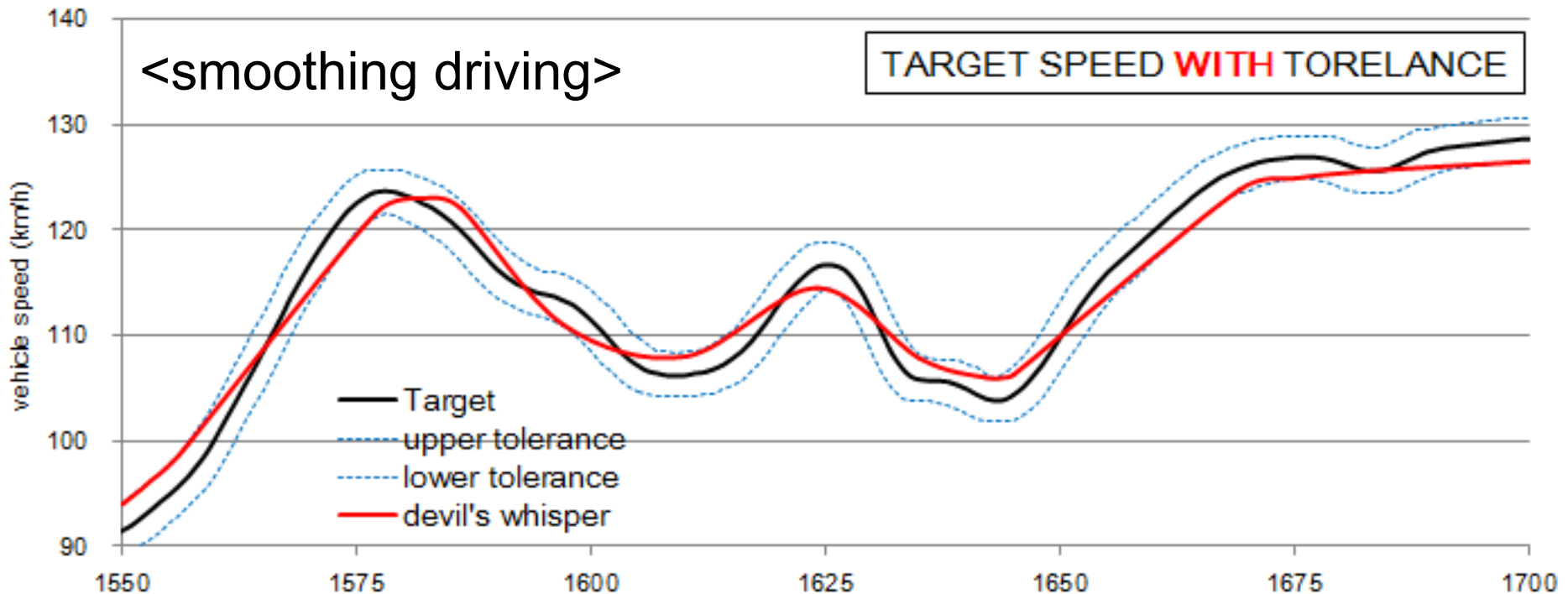
During 1st TF meeting (on 28th May)

3. Japan provided further study on drive indexes
4. Feedback and/or comments by TF member on TS initial proposals

Missions of the TF

Seek the effective and essential way how to obtain right performance (pollutants, fuel consumption and so on)

~~~ avoid “smooth or rough driving technique ~~~



# Initial Proposals @ 10<sup>th</sup> IWG Meeting

(please refer WLTP-10-31e for more detail)

## 1. Introduce “Drive Trace Index” for new criteria to detect smooth and/or rough driving technique

| Indexes | Whole cycle     |          | Each phase |
|---------|-----------------|----------|------------|
|         | 4phases         | 3 phases |            |
| ASCR    | 3%              |          | NA         |
| RMSSE   | 0.8             |          | NA         |
| IWR     | under the study |          | NA         |

note)

- W.O.T. operation : use target trace during WOT operation
- Gear Shift operation : no treatment is necessary
- Possible indexes : please refer the appendix

## 2. Eliminate the “Drive Trace Tolerance” to avoid smooth driving

# 1<sup>st</sup> TF meeting (Index)

Correct feedbacks and/or comments from TF member

| Indexes         | JPN data<br>(AVE $\pm$ 3 $\sigma$ ) |                        | CO <sub>2</sub><br>deviation<br>(2.0 g/km) | TS<br>proposal*            | PSA<br>Proposal*<br>*        | FORD<br>proposal*<br>**                    | BMW              | HS               |
|-----------------|-------------------------------------|------------------------|--------------------------------------------|----------------------------|------------------------------|--------------------------------------------|------------------|------------------|
|                 | LMH                                 | LMHxH                  | LMH/<br>LMHxH                              | LMH/<br>LMHxH              | LMHxH<br>(phase)             | LMHxH                                      | LMHxH            | LMHxH            |
| ER (%)          | <b>-1.0 ~<br/>+1.4</b>              | <b>-0.6 ~<br/>+0.8</b> | <b>+/- 1.5</b>                             | -                          | -                            | -                                          | -                | -                |
| DR (%)          | <b>-0.5 ~<br/>+0.3</b>              | <b>-0.4 ~<br/>+0.2</b> | <b>+/- 0.4</b>                             | -                          | -                            | -                                          | -                | -                |
| EER (%)         | <b>-1.1 ~<br/>+1.7</b>              | <b>-0.7 ~<br/>+1.1</b> | <b>+/- 1.5</b>                             | -                          | <b>+/- 2.0<br/>(+/- 4.0)</b> | -                                          | <b>+/- 2.0</b>   | <b>+/- 2.0</b>   |
| ASCR<br>(%)     | <b>-2.6 ~<br/>+4.0</b>              | <b>-2.3 ~<br/>+3.8</b> | <b>+/- 3.0</b>                             | <b>+/- 3.0</b>             | <b>+/- 6.0<br/>(+/- 8.0)</b> | <b>-2.0 ~<br/>+4.0</b>                     | <b>+/- 3.0</b>   | <b>+/- 3.0</b>   |
| IWR (%)         | <b>-2.9 ~<br/>+4.8</b>              | <b>-2.8 ~<br/>+4.6</b> | <b>+/- 3.5</b>                             | <b>Under<br/>the study</b> | -                            | <b>IWR is very<br/>similar to<br/>ASCR</b> | -                | -                |
| RMSSE<br>(km/h) | <b>~ +0.7</b>                       | <b>~ +0.7</b>          | <b>+0.8</b>                                | <b>&lt; +0.8</b>           | -                            | <b>&lt; +1.3</b>                           | <b>&lt; +1.3</b> | <b>&lt; +1.3</b> |

(\*) WLTP-10-31e - Trace Index Tolerance OIT # 29 30 41 \_ Ichikawa.pdf

(\*\*) PSA\_WLTC Cycle violations status and proposals.pptx

(\*\*\*) driving trace index - Ford - WLTP.pdf

# 1<sup>st</sup> TF meeting –others–

Correct feedbacks and/or comments from TF member

## 1. Drive trace tolerance

✓ no decision was made

→ further discussion is necessary in TF

## 2. Others

✓ 10Hz sampling : to be decided (please refer next slide)

✓ 10Hz interpolation method : to be decided

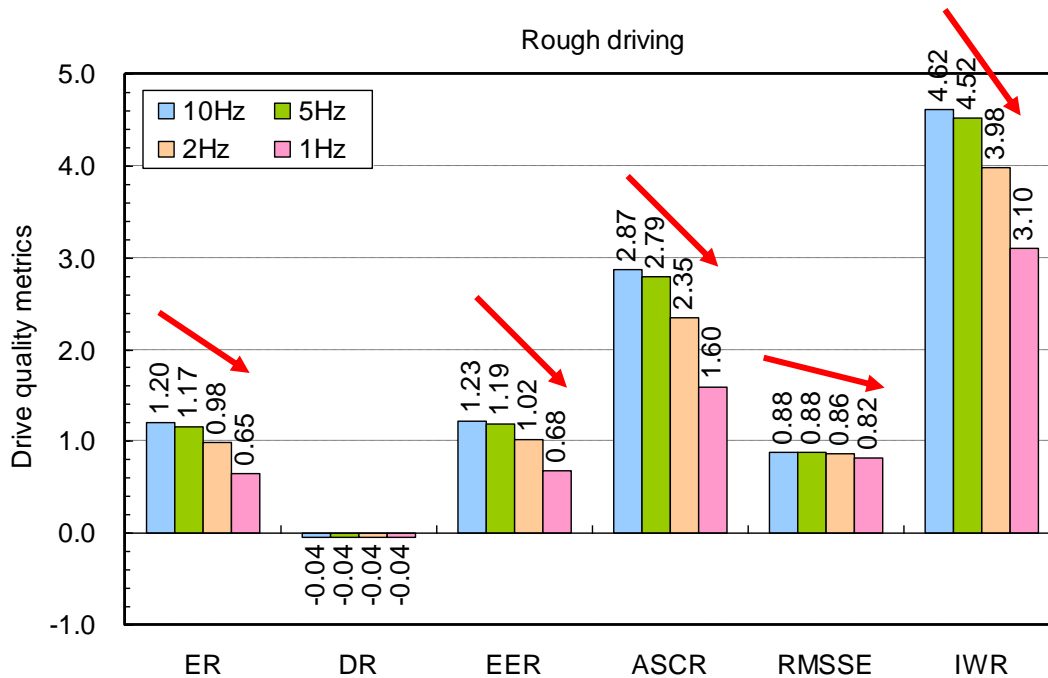
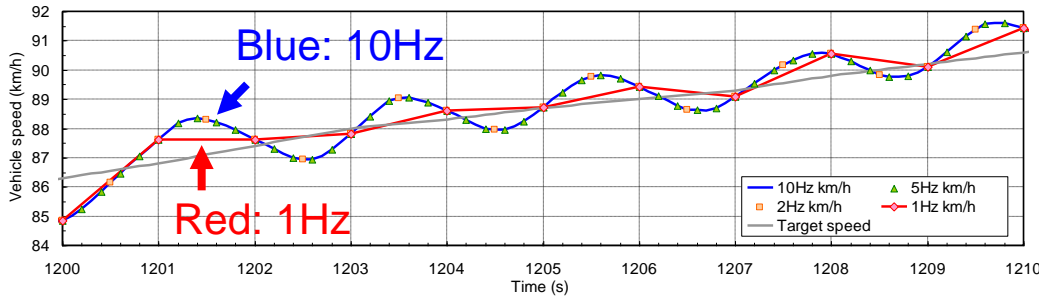
✓ data filtering : to be decided (according to SAE J2951)

→ Mr. Steven and TF leader will provide the proposal during next TF meeting



# Sampling frequency of drive trace

## ◆ Comparison between in each frequency data



- The low sampling frequency data couldn't measure the micro-fluctuations.
- If the low frequency data was used for the calculation, the lower value will be obtained.
- In order to evaluate drive quality appropriately, 10Hz data are necessary.

### 3. Next Actions

|                 | 5               | 6                                                                                                                                                                             | 7   | 8                                           | 9                   | 10 |
|-----------------|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|---------------------------------------------|---------------------|----|
| IWG meeting     | ★<br>TF Meeting | ★ 11 <sup>th</sup> Meeting<br>(★)                                                                                                                                             | (★) | 12 <sup>th</sup> Meeting<br>★<br>TF Meeting | ★<br>: Finalization |    |
| Drive Indexes   | →               | Further study on criteria setting including other indexes (EER, IWR)<br>★ Provide potential proposals by TF<br>→<br><b>Feedback and comments from CPs and Web. conference</b> |     |                                             |                     |    |
| Drive Tolerance | →               | <b>Feedback and/or Comments with Counter-Proposal</b><br>★ Progress report<br>→<br>2 <sup>nd</sup> Proposal by TF<br>(and Web. conference, if necessary)                      |     |                                             |                     |    |
| others          |                 | →<br>Data handling (10Hz interpolation method, filtering and so on )                                                                                                          |     |                                             |                     |    |

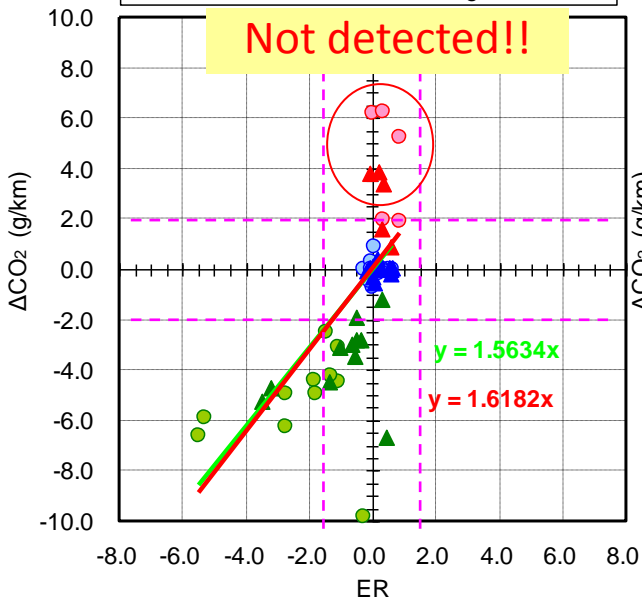
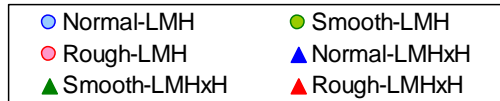
# appendix

## Possible indexes and its applicability

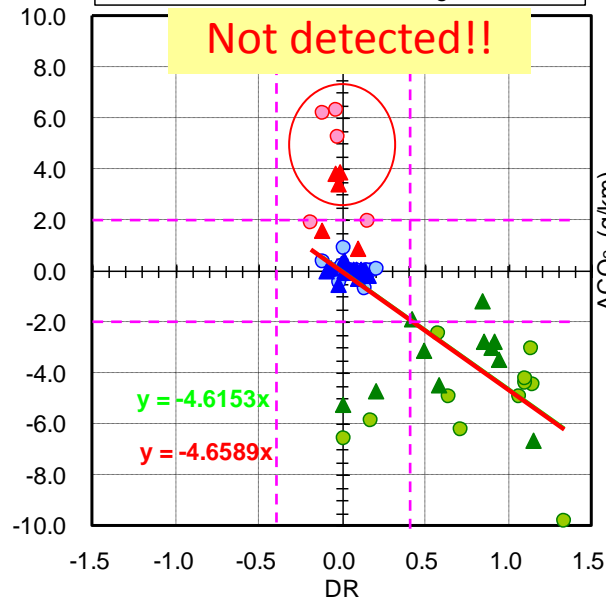
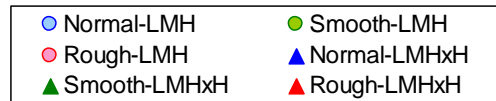
| Possible Indexes | brief description                                                                                                                             | applicability | (Ref) EPA requires |
|------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|---------------|--------------------|
| ER               | is defined as the percent difference between the total driven and target cycle energy                                                         | NG            |                    |
| DR               | is defined as the percent difference between the total driven and scheduled distance                                                          | NG            |                    |
| EER              | is defined as the percentage difference between the distance per unit cycle energy for the driven and target traces                           | NG            | ✓                  |
| ASCR             | is defined as the percentage difference between the ASC for the driven and target traces                                                      | OK            | ✓                  |
| IWR              | is defined as the percentage difference between the inertial work for the driven and target traces                                            | OK            | ✓                  |
| RMSSE            | provides the driver's performance in meeting the schedule speed trace throughout the test cycle in terms of the Root Mean Squared Speed Error | OK            |                    |

# Applicability of each index -1-

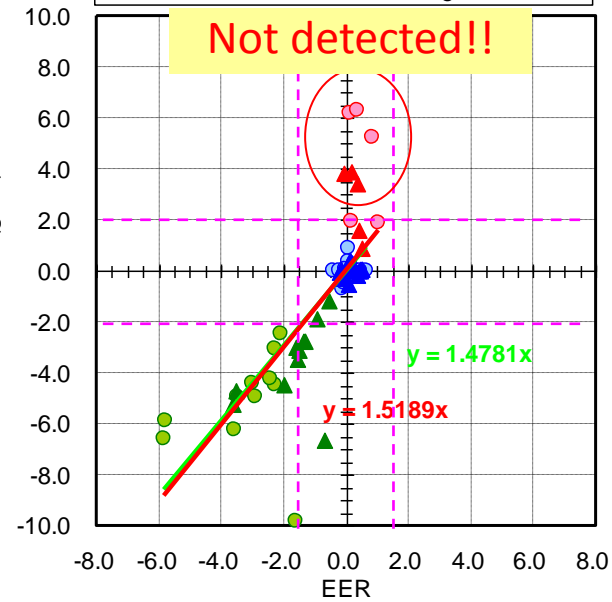
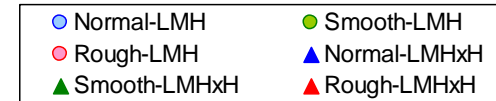
◆ ER



◆ DR

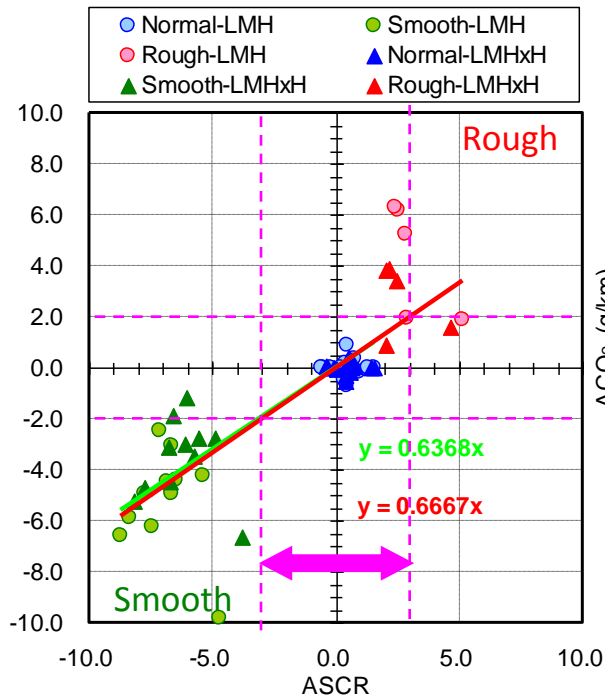


◆ EER

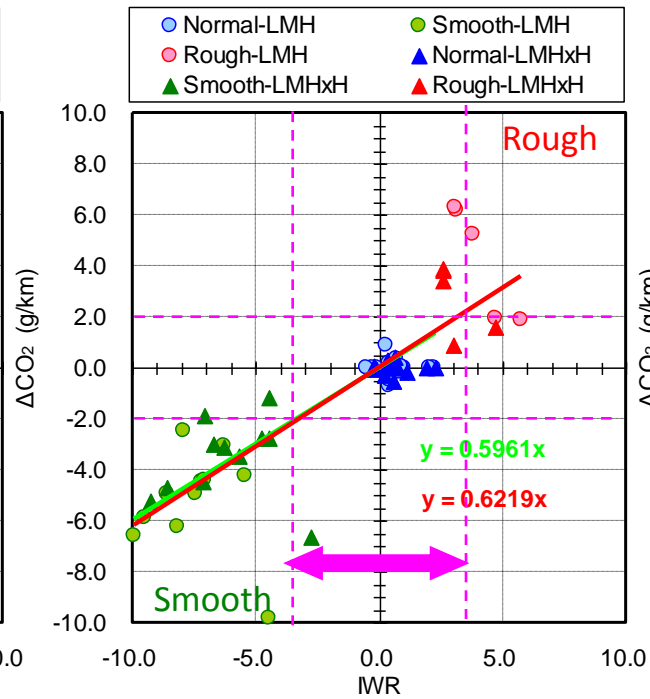


# Applicability of each index -2-

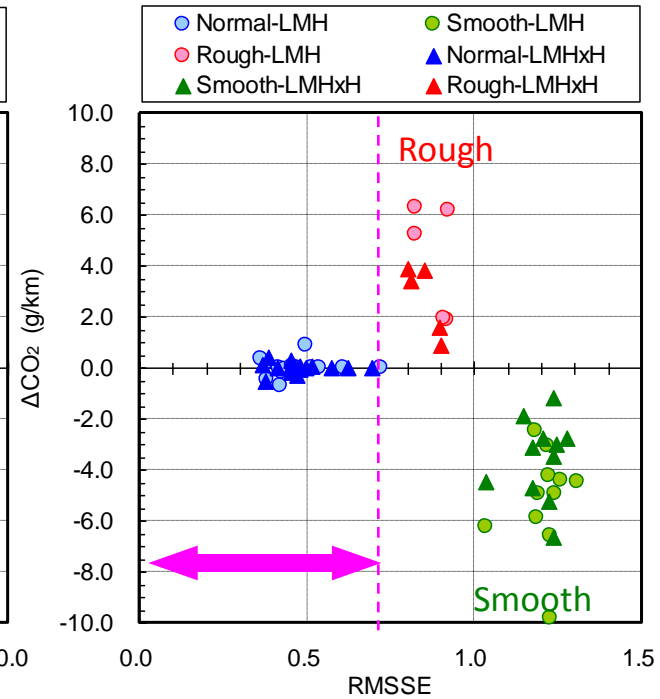
## ◆ ASCR



## ◆ IWR



## ◆ RMSSE



↔ possible criterion

## EER(Energy Economy Rating)

$$\text{EER} = \frac{\left(\frac{D}{CE}\right)_{\text{theoretical}} - \left(\frac{D}{CE}\right)_{\text{actual}}}{\left(\frac{D}{CE}\right)_{\text{theoretical}}} \cdot 100 \quad [\%]$$

$$CE = \sum_{i=1}^N \left[ (M \cdot a_i + F_0 + F_1 V_i + F_2 V_i^2) \cdot d_i \right]^+ \quad [\text{J}]$$

CE : Cycle Energy

D : Distance

Evaluate “Energy Efficiency” = Driving Distance / Cycle Energy  
Impact : high speed > low speed (possible to “make-up”)

## ASCR(Absolute Speed Change Rating )

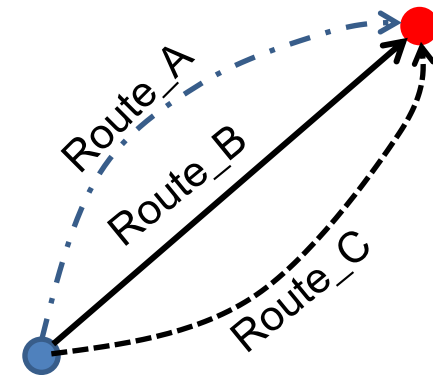
$$ASCR = \frac{ASC_{\text{actual}} - ASC_{\text{theoretical}}}{ASC_{\text{theoretical}}} \cdot 100 \text{ [%]}$$

$$ASC = \Delta t \sum_{i=1}^N |a_i| \text{ [m/s}^2\text{]}$$

## IWR(Inertial Work Rating)

$$IWR = \frac{IW_{\text{actual}} - IW_{\text{theoretical}}}{IW_{\text{theoretical}}} \cdot 100 \text{ [%]}$$

$$IW = \sum_{i=1}^N [M \cdot a_i \cdot d_i]^+ \text{ [J]}$$



All ASCR(route\_A&B&C) are same, but  
 $IWR_{\text{route\_A}} > IWR_{\text{route\_B}} > IWR_{\text{route\_C}}$

## RMSSE(Root Mean Squared Speed Error)

$$\text{RMSSE} = \sqrt{\sum_{i=1}^N \frac{(\text{VA}_i - \text{VT}_i)^2}{N}}$$

VA : Actual Vehicle Speed

VT : Target Vehicle Speed

Accumulate the difference between actual and target vehicle speed over the cycle

### Reference documents

- ✓ WLTP-DTP-07-05e, SEP 2011
- ✓ WLTP-DTP-LabProcICE-189, FEB 2013
- ✓ WLTP-DTP-LabProcICE-222, APR 2013
- ✓ PSA\_WLTC Cycle violation status and proposals, JUL 2013
- ✓ WLTP-06-16e, MAR 2014
- ✓ WLTP-10-31e, APR 2015
- ✓ WLTP-11-xye-suppli, MAY 2015