

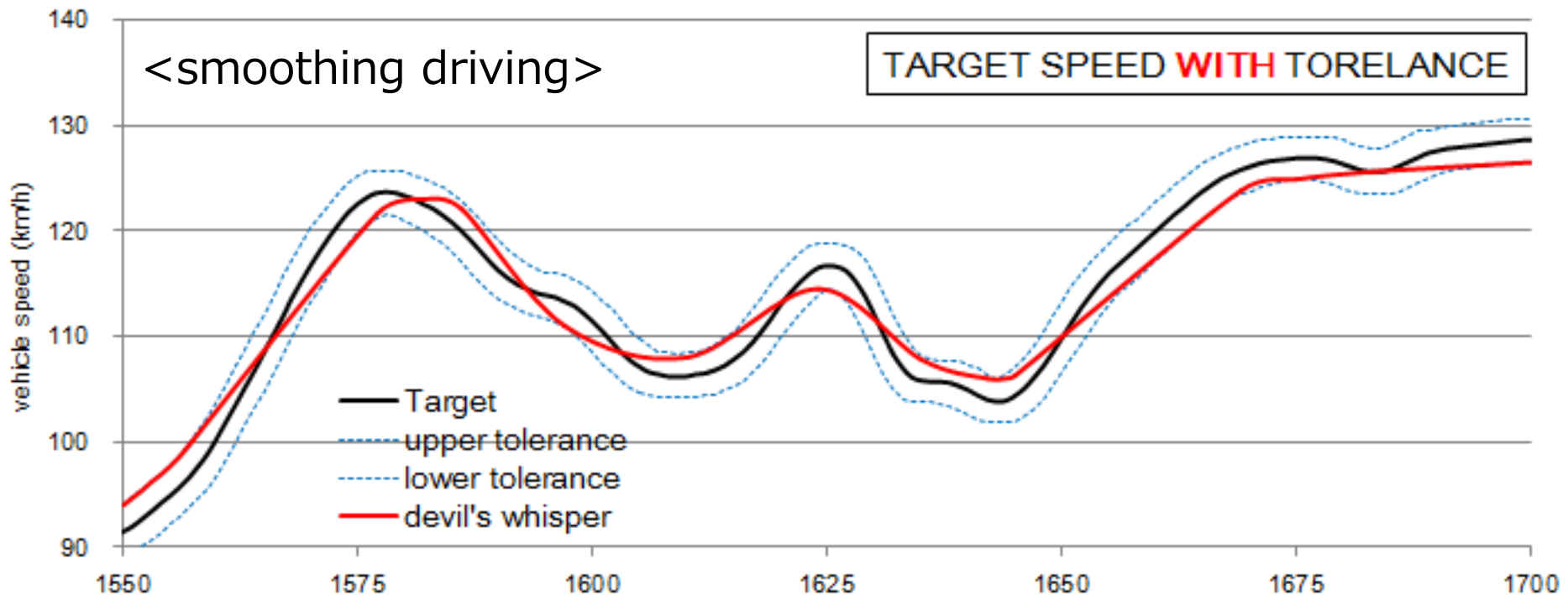


Proposal for Adoption
“Speed Trace Violations / Drive Trace Index”

Prepared by WLTP Trace Index Task Force
18th September 2015

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 ~~~



# Progress Status

During 10<sup>th</sup> WLTP meeting,

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

During 1<sup>st</sup> TF meeting (on 28<sup>th</sup> May)

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



During 11<sup>th</sup> WLTP meeting and email exchange afterward

5. Technical Secretary provided the proposals based on feedback from TF member
6. No decision was made on drive trace “index” and “tolerance”

During 2<sup>nd</sup> TF meeting (on 25<sup>th</sup> August)

7. TF developed the proposals to be adopted during WLTP 12<sup>th</sup> IWG meeting.
8. According to the proposals, TF leader is working on gtr modification (should be ready by 12<sup>th</sup> IWG meeting)

# Discussion Points and TF Decisions

| Items                                                                                                      | Possible solutions |                                                           | Profits / Concerns                                                                                                                                                                                                 |
|------------------------------------------------------------------------------------------------------------|--------------------|-----------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Drive Trace Tolerance<br> | 1                  | Keep as it is                                             | ▼No improvement (smooth and/or rough driving technique continue to be expected).                                                                                                                                   |
|                                                                                                            | 2                  | <b>Keep as it is, but require "no show" on DAD screen</b> | <b>△Slight improvement is expected (test drivers try to follow the prescribed cycle as much as possible).</b>                                                                                                      |
|                                                                                                            | 3                  | Eliminate the tolerance and apply index(es)               | △Improvement is expected (test drivers should follow the prescribed cycle as much as possible).<br>▼# of invalid test may be increased.                                                                            |
| Drive Trace Index<br>    | 1                  | No index is applied                                       | ▼No improvement (smooth and/or rough driving technique continue to be expected).                                                                                                                                   |
|                                                                                                            | 2                  | <b>Index(es) is(are) applied as a reference.</b>          | <b>△Slight improvement is expected (test drivers try to follow the prescribed cycle as much as possible).</b><br><b>△Gather data to decide the concrete criteria in future (also consider the "normalization")</b> |
|                                                                                                            | 3                  | Index(es) is(are) applied for judgment of test validity.  | △Improvement is expected (test drivers should follow the prescribed cycle as much as possible).<br>▼# of invalid test may be increased.                                                                            |

# Other discussion points

- ✓ Data sampling frequency : to be decided. TF member suggested the specific frequency to be compatible.
- ✓ Interpolation method : to be decided.
- ✓ Data filtering : to be decided (according to SAE J2951)

# SUMMARY of TF Proposals (1)

1. Introduce “Drive Trace Indexes\*” to be documented in homologation report. No criteria is set at this moment.

|                                 |             |            |              |
|---------------------------------|-------------|------------|--------------|
| <b>Indexes to be documented</b> | <b>ER</b>   | <b>DR</b>  | <b>EER</b>   |
|                                 | <b>ASCR</b> | <b>IWR</b> | <b>RMSSE</b> |

(brief description and calculation formula are shown in appendix)

note)

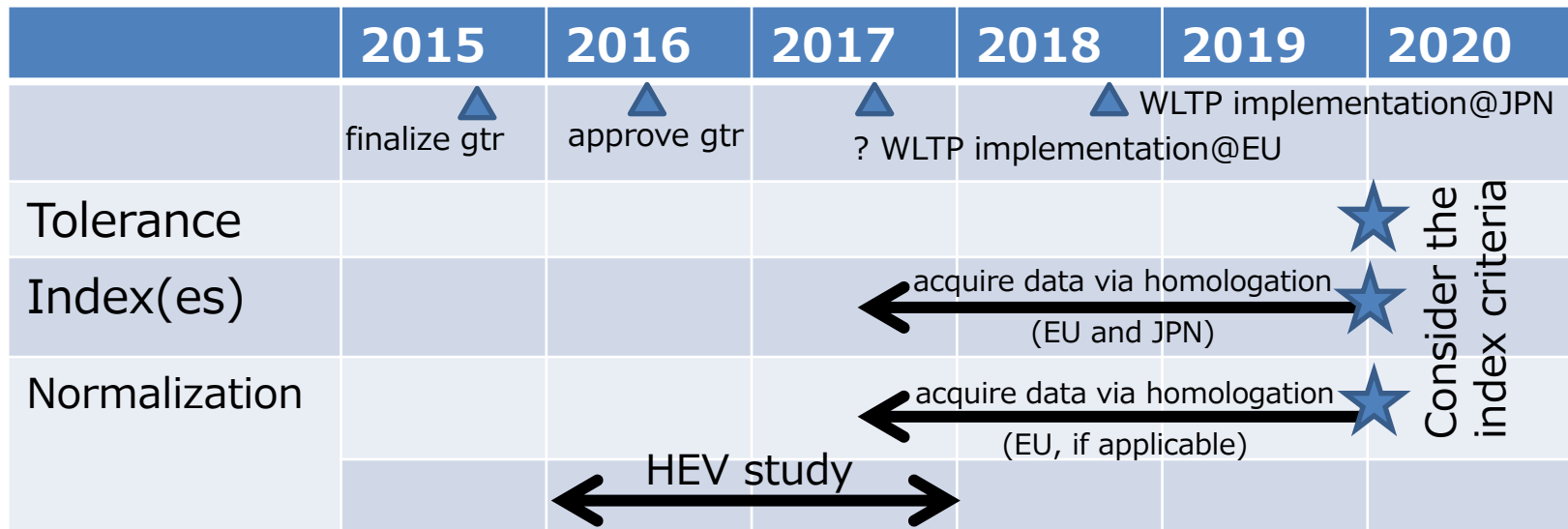
- W.O.T. operation : use target trace during WOT operation
- Gear Shift operation : no treatment is necessary
- Possible indexes : please refer the appendix

2. Keep current “Drive Trace Tolerance”, but “No show” on drivers aid screen.

# SUMMARY of TF Proposals (2)

3. Data sampling : not less than 10Hz and no more than 10Hz
4. Interpolation method of the prescribed drive trace : linear
5. Data filtering : according to SAE J2951

Future scenario : re-visit to set criteria after data acquisition and HEV study



# appendix

## Brief description of each index

| Possible Indexes | brief description                                                                                                                             |
|------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|
| ER               | is defined as the percent difference between the total driven and target cycle energy                                                         |
| DR               | is defined as the percent difference between the total driven and scheduled distance                                                          |
| EER              | is defined as the percentage difference between the distance per unit cycle energy for the driven and target traces                           |
| ASCR             | is defined as the percentage difference between the ASC for the driven and target traces                                                      |
| IWR              | is defined as the percentage difference between the inertial work for the driven and target traces                                            |
| 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 |



ER(Energy Rating), DR(Distance Rating),  
EER(Energy Economy Rating)

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

$$ER = \frac{(CE)_{\text{actual}} - (CE)_{\text{theoretical}}}{(CE)_{\text{theoretical}}} \cdot 100 \quad DR = \frac{(D)_{\text{actual}} - (D)_{\text{theoretical}}}{(D)_{\text{theoretical}}} \cdot 100$$

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

D : Distance

Evaluate "Energy Efficiency" = Driving Distance / Cycle Energy

Impact : high speed > low speed

## ASCR(Absolute Speed Change Rating )

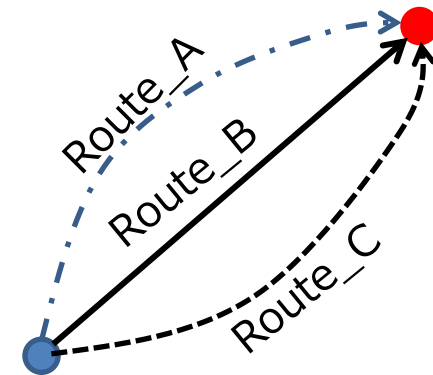
$$ASCR = \frac{ASC_{\text{actual}} - ASC_{\text{theoretical}}}{ASC_{\text{theoretical}}} \cdot 100 \text{ [%]}$$

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

## 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

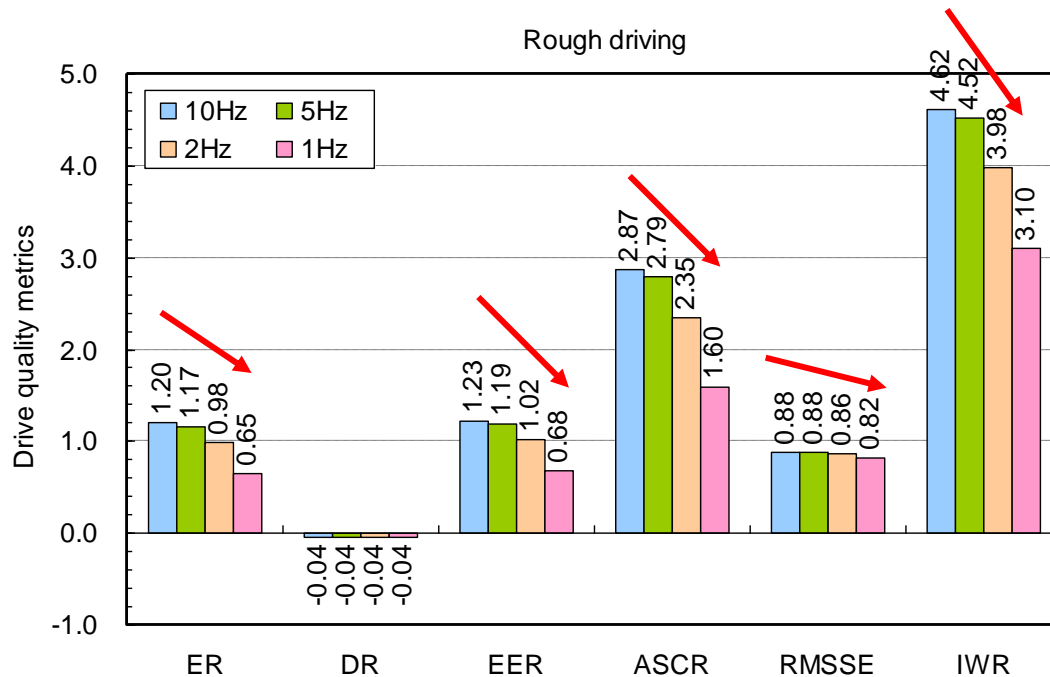
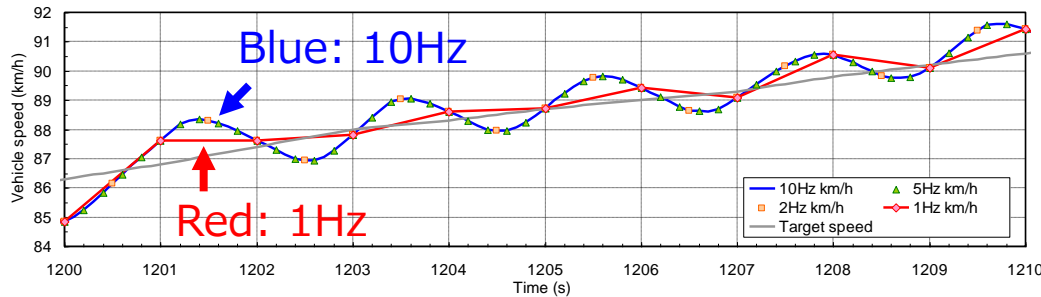
Accumulate the difference between actual and target vehicle speed over the cycle

### 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-11-21e/22e, JUN 2015

# 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.