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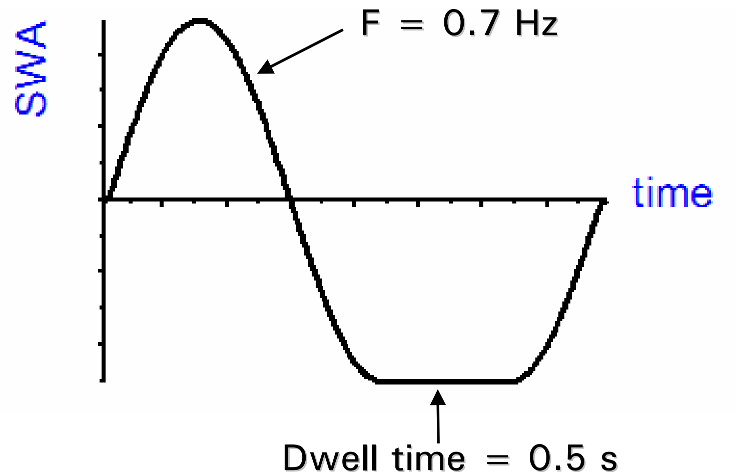
Alternative analysis method for the evaluation of vehicle limit handling performance to be adopted by a primary safety assessment programme

Josep Maria Dalmau
Project Engineer, Vehicle Dynamics
IDIADA

Objective

- To present an alternative ***analysis*** method for the dwell sine objective test.



Test conditions:

- Recommended test speed = 80 km/h
- Amplitudes are equal in both directions
- Gear in neutral position

Both dwell time and frequency are based on analysis of real driving situations

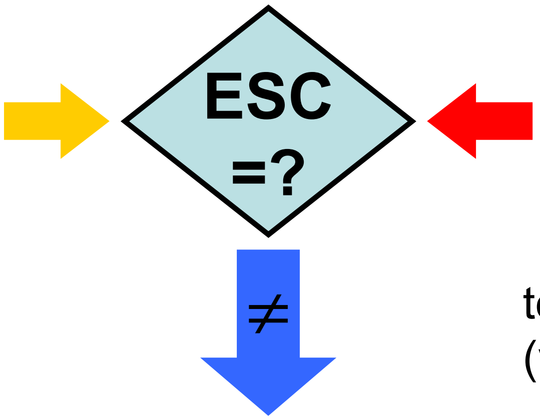
Background

- Handling performance test (active and passive systems).
- Test currently used by NHTSA for ESC testing (**FMVSS 126**). Pass/Fail criteria.

Analysis based on ESC operating principle

- ESC compares:

The driver's **intended direction** (SWA)

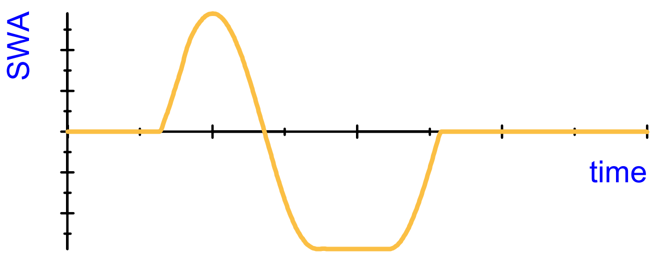


to the vehicle's **actual response** (yaw rate, lateral acceleration...)

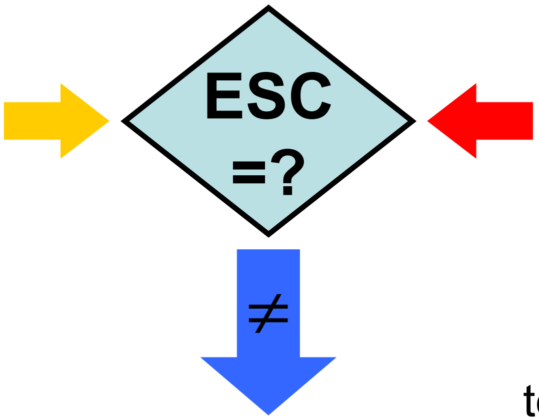
ESC then brakes individual front or rear wheels and/or reduces excess engine power as needed to help correct understeer or oversteer

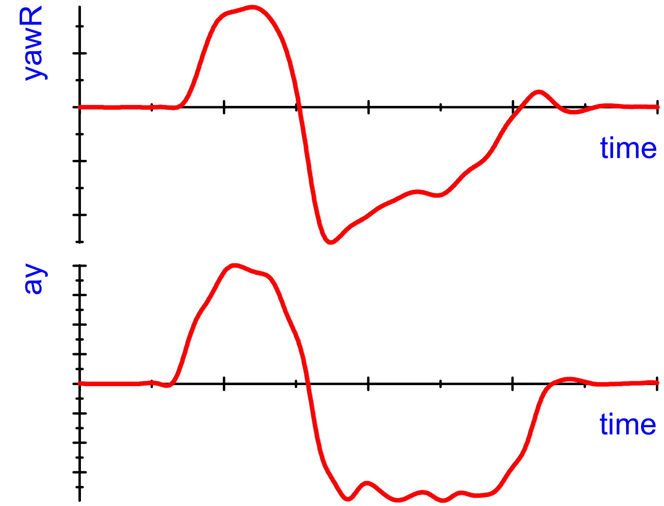
ESC principle on dwell sine test

- ESC compares:

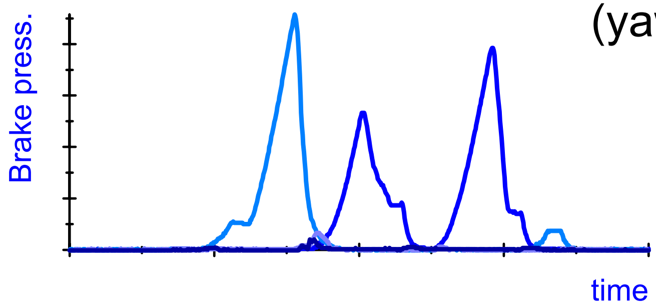


The driver's **intended direction** (SWA)





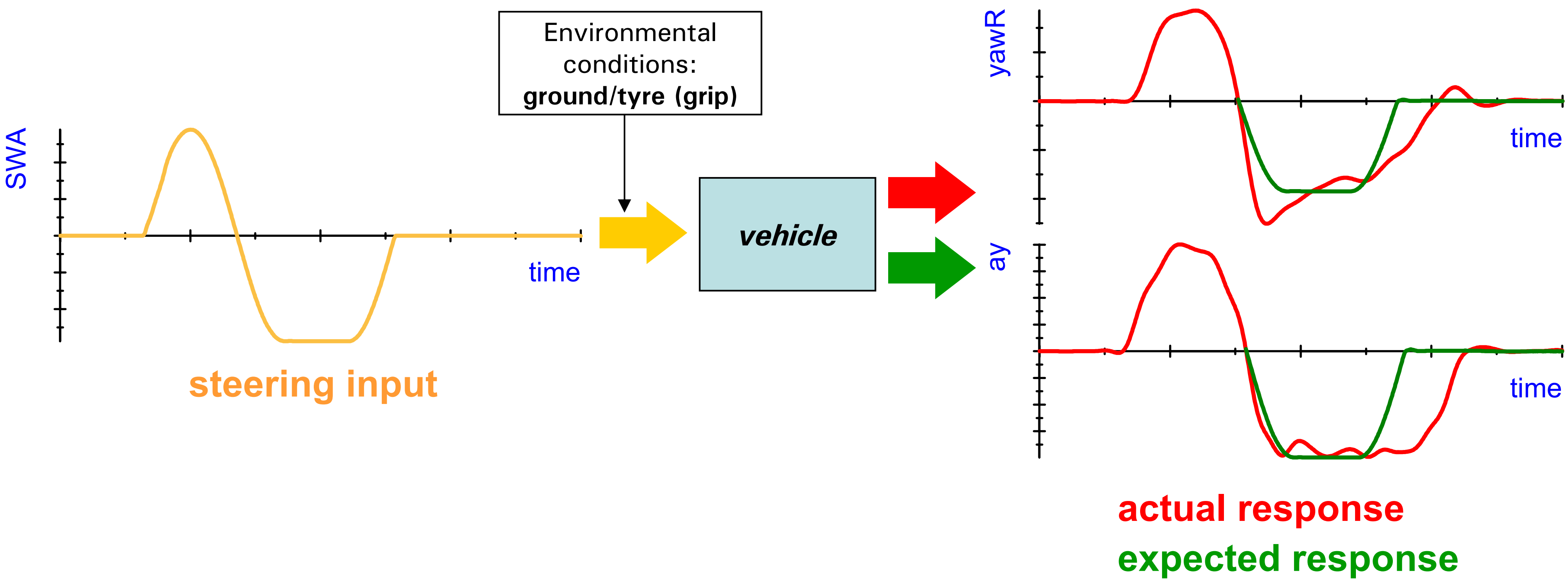
to the vehicle's **actual response** (yaw rate, lateral acceleration...)



ESC then applies brake pressure to individual front or rear wheels as needed to help correct understeer or oversteer

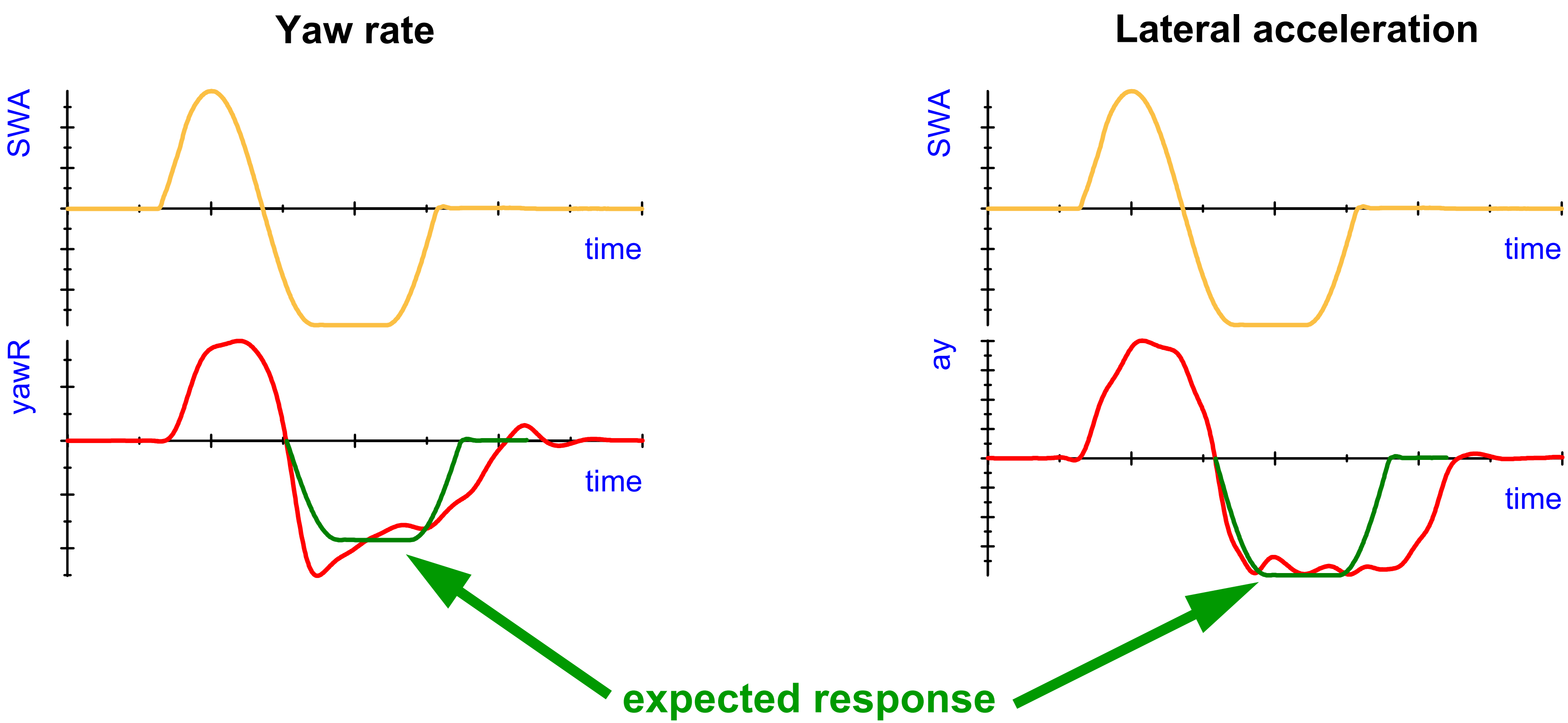
ESC effectiveness

- Based on the ESC principle, an effective ESC makes the car **respond** according to the **driver's intention → expected response.**



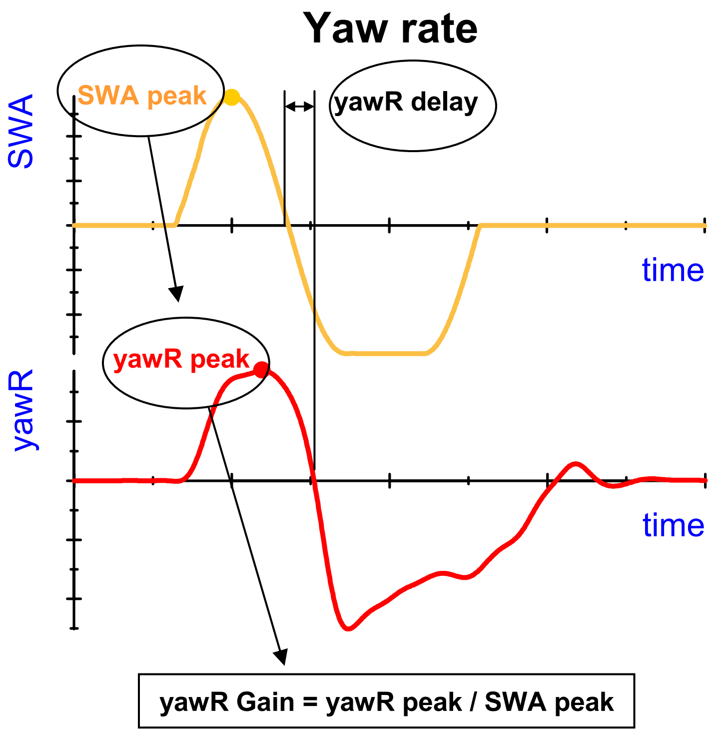
Expected response determination

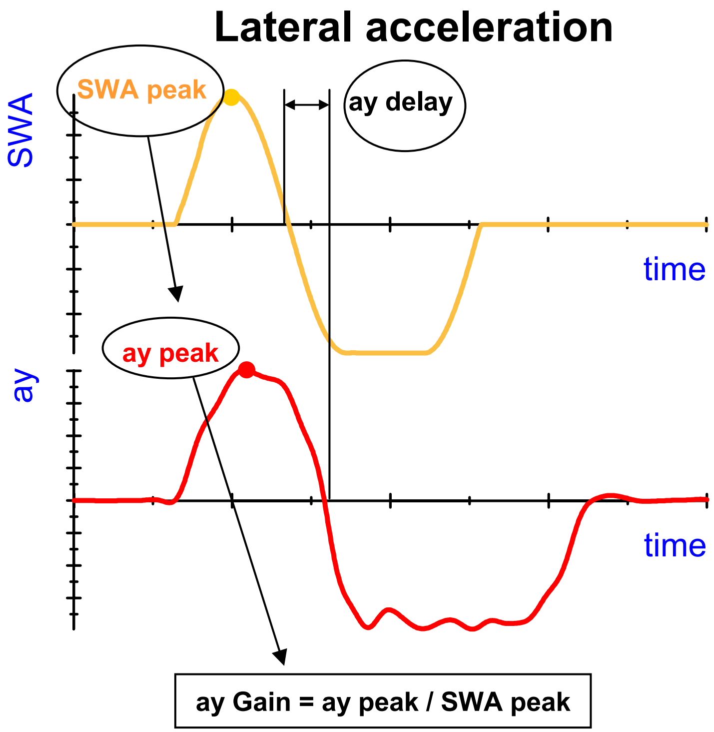
- Based on the **steering input (shape)** and on the **vehicle's response (gain and delay)**, the **expected response** can be generated for the **yaw rate and lateral acceleration.**



Determination of expected response

- The **response gain** is taken from the first SW input (vehicle's natural response)
- The **response delay** is considered at the zero crossing
- The target **expected response** is defined by the vehicle itself

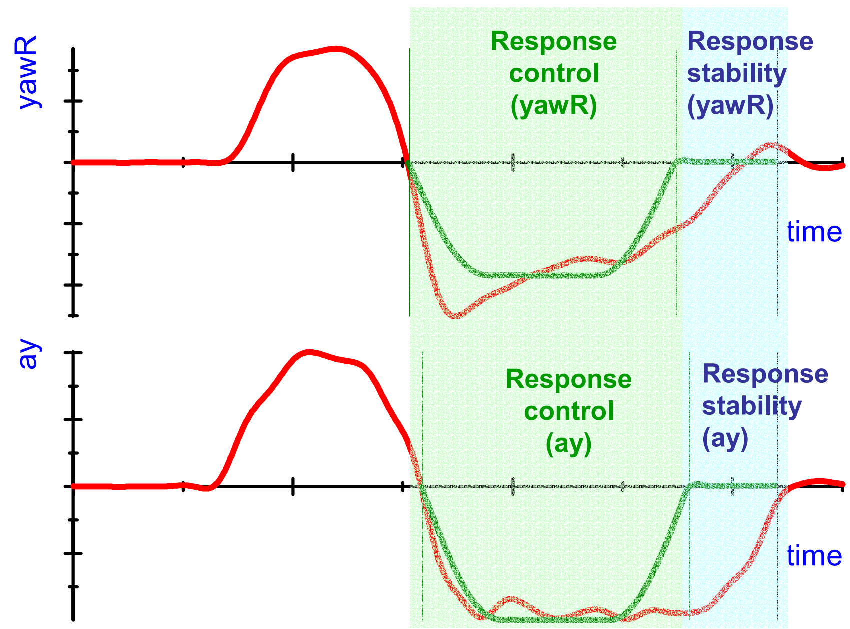




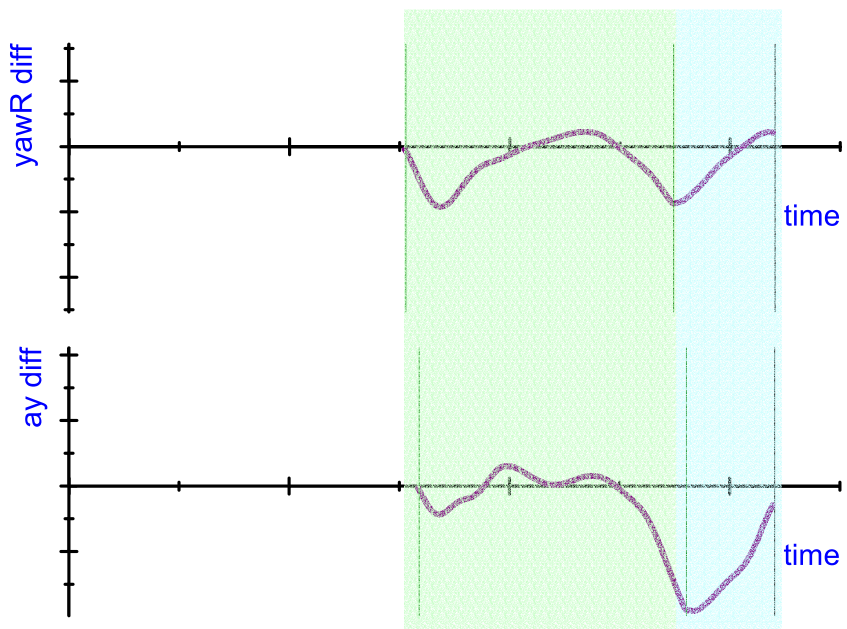
Metrics

- The metrics are evaluated in two regions: **response control and response stability**
- The metrics consist of an integration (area) ratio: $1 - \frac{\int \text{difference}}{\int \text{expected}}$ **Good metric ≈ 1**, **Poor metric < 1**

Actual and expected response



Response difference



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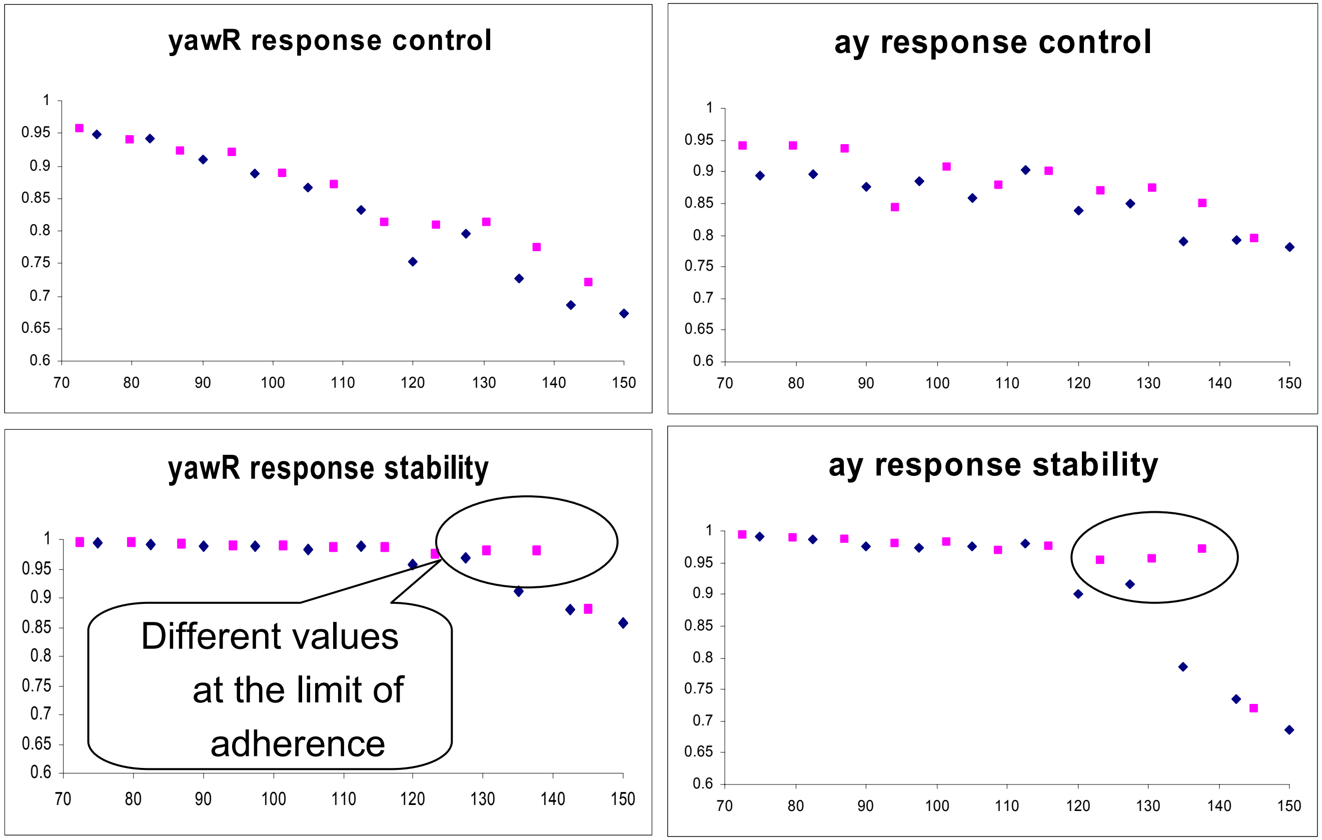
Metric results versus **SWA**

- Results are affected by grip conditions. Different grip → different performance
- Example of results obtained on different tracks at IDIADA:

Dynamic Platform A

versus

Dynamic Platform B



Idea! To plot Control and Stability metrics versus a manoeuvre severity parameter

- Express the severity of the manoeuvre in terms of yaw motion. Taken at the 2nd yawR peak.
- Is the ratio of the yaw rate over lateral acceleration.
- For steady state the value of the ratio is $\frac{1}{v_x}$

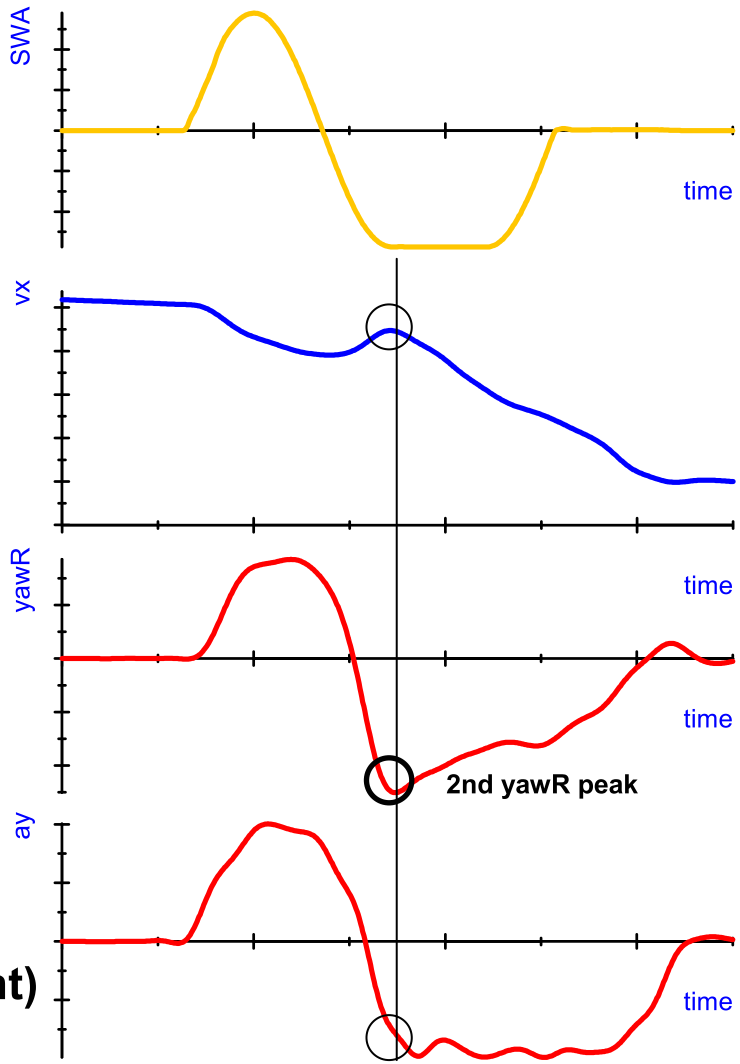
$$\dot{\psi} = \frac{a_y}{v_x} \rightarrow \frac{\dot{\psi}}{a_y} = \frac{1}{v_x}$$

- By dividing this ratio by the steady state value the parameter is normalised.

$$\frac{\dot{\psi}/a_y}{1/v_x} = TL_1 = \frac{\dot{\psi} \cdot v_x}{a_y}$$

TL_1 = 1 (Steady state)

TL_1 > 1 (transient component)



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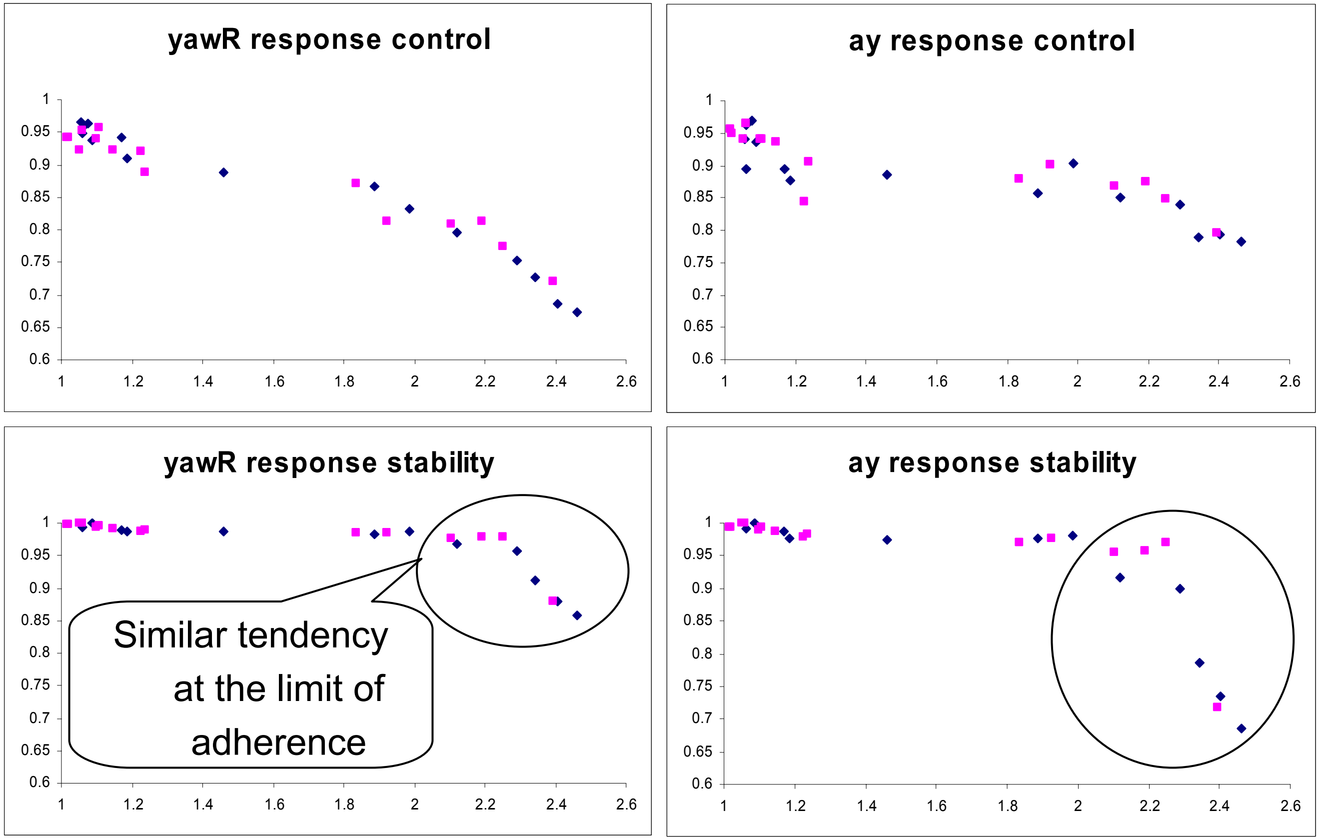
Metric results versus **transient level normalised**

- Results show a **very similar tendency** and absolute values in two different tracks!
- Example of results obtained on different tracks at IDIADA:

Dynamic Platform A

versus

Dynamic Platform B



Next steps

- Round robin test to prove that results are consistent on different proving grounds.
- Test a wider range of vehicles to define rating boundaries.

Conclusions

- By considering the manoeuvre severity parameter in the analysis, the effect of the proving ground grip on the results is significantly reduced.
- The vehicle performance target is determined by the vehicle response itself therefore the performance target fits to any vehicle type.
- Dwell sine test clearly excites the yaw motion of the vehicle to an oversteer situation therefore ESC oversteer intervention can be assessed.

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For further information:

Applus+ IDIADA
Head Quarters and Technical Centre
L'Albornar – PO Box 20
E-43710 Santa Oliva (Tarragona) Spain
T +34 977 166 000
F +34 977 166 007
e-mail: idiada@idiada.com

www.idiada.com

IDIADA Fahrzeugtechnik GmbH
T +49 (0) 841 8 85 38 0 (Ingolstadt)
T +49 (0) 893 0 90 56 0 (München)
e-mail: idiada_germany@idiada.com

Applus Airon Technic, a.s.
T +420 493 654 811
e-mail: info@airontechnic.com

Applus Automotive Technology Luxembourg
T +352 779 113
e-mail: idiada_luxembourg@idiada.com

CTAG IDIADA Safety Technology SL
T +34 986 900 300
e-mail: ctag_idiada@idiada.com

TechnoCentrum CAD s.r.o.
T +420 482 424 299
e-mail: tccad@tccad.cz

Applus+ IDIADA France
T +33 (0) 1 41 14 60 85
e-mail: idiada_france@idiada.com

Applus+ IDIADA Italy
T +39 011 3997 764
e-mail: idiada_italia@idiada.com

Applus+ IDIADA Madrid
T +34 915 095 795
e-mail: idiada_madrid@idiada.com

Applus+ IDIADA Poland
T +48 61 6226 905
e-mail: idiada_poland@idiada.com

Applus+ IDIADA UK
T +44 (0) 1472 882994
e-mail: idiada_uk@idiada.com

Applus+ IDIADA China
T +86 (21) 6210 0894
e-mail: idiada_china@idiada.com

Applus+ IDIADA India
T +91 12 44201156
e-mail: idiada_india@idiada.com

Applus+ IDIADA Japan
T +81 (0) 3 5979 2286
e-mail: idiada_japan@idiada.com

Applus+ IDIADA Korea
T +82 31 478 1821
e-mail: idiada_korea@idiada.com

Applus+ IDIADA Malaysia
T +603 2140 2266
e-mail: idiada_malaysia@idiada.com

Applus+ IDIADA Taiwan
T +886 4 7810702
e-mail: idiada_taiwan@idiada.com