Submitted by the experts from Japan

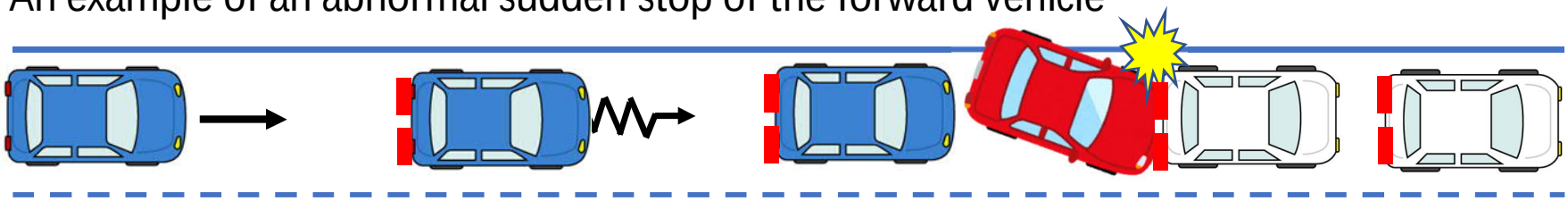
UNR157-05-03
5h SIG on R157
10,11 May 2021

Japanese proposal of minimum following distance for ALKS

National Traffic Safety and Environment Laboratory

- ADS vehicle has to avoid a collision with the forward vehicle as well as a vehicle which is driven by a human driver even when the forward vehicle suddenly stops. A sudden stop of the forward vehicle includes the case that the forward vehicle stops abnormally by the effect other than the braking device (for example, a rear end collision).
  (Note: Current minimum following distance requirement in R157 was decided based on the concept above.)
- Therefore, Japan considers that the minimum following distance of ALKS should be decided based on the capability of braking distance.

An example of an abnormal sudden stop of the forward vehicle



- Japan proposes to apply the values which are based on braking distance researched by Korea (ACSF-22-09r1) to the minimum following distance in the speed range above 60km/h.
- No change is needed below 60 km/h, because the values are almost equal to or greater than the value based on braking distance.

Present speed of the ALKS vehicle		*Minimum time gap*	*Minimum following distance*
(km/h)	(m/s)	(s)	(m)
7.2	2.0	1.0	2.0
10	2.78	1.1	3.1
20	5.56	1.2	6.7
30	8.33	1.3	10.8
40	11.11	1.4	15.6
50	13.89	1.5	20.8
60	16.67	1.6	26.7
70	**19.44**	**1.9**	**36.3**
80	**22.22**	**2.1**	**46.1**
90	**25.00**	**2.3**	**57.2**
100	**27.78**	**2.5**	**69.5**
110	**30.56**	**2.7**	**83.1**
120	**33.33**	**2.9**	**97.9**
130	**36.11**	**3.2**	**113.9**

- Notwithstanding the above requirement, the requirement can be deemed to be satisfied if the TS admit that the ADS is capable of avoiding collision in case of a sudden stop (i.e. velocity decreased suddenly to 0km/h) of the leading vehicle.

Appendix

Extracts from ACSF-22-09r1

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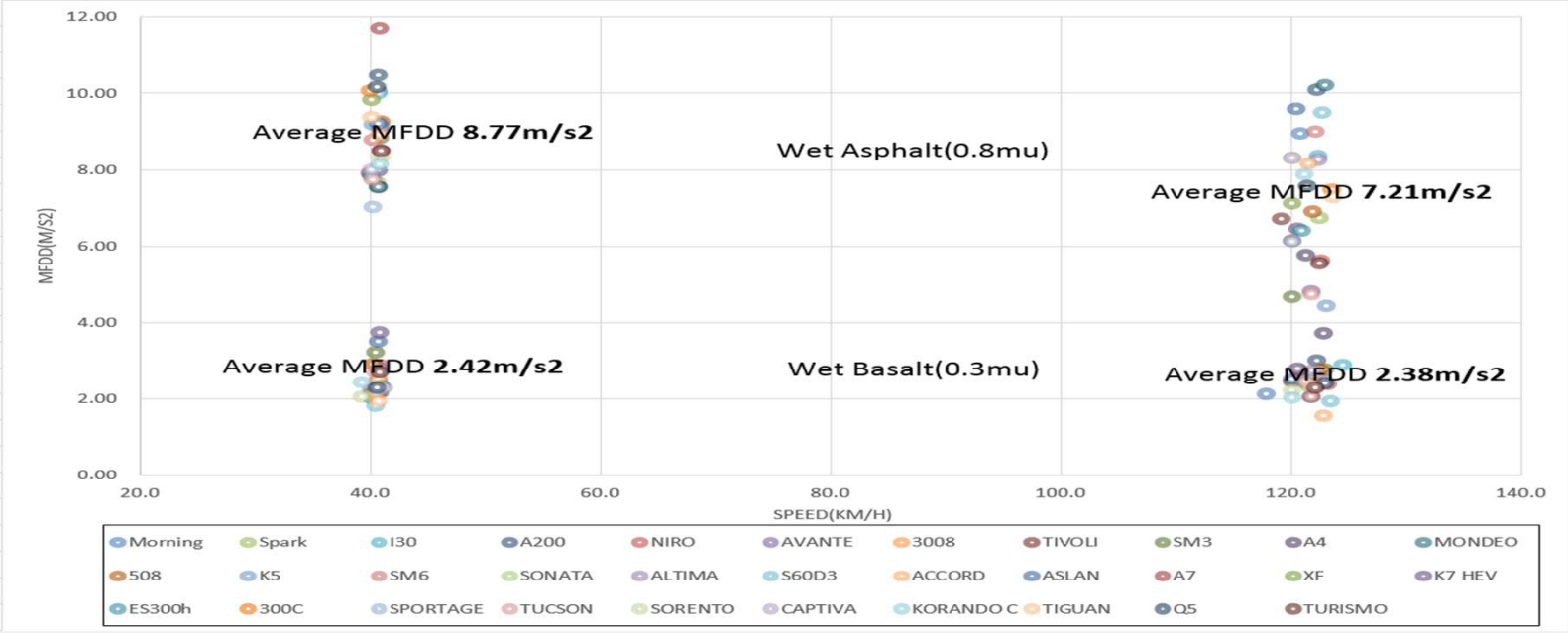
New Approach for appropriate deceleration(1)

- **Using deceleration data from the state of the art vehicle** (MY 2016 to 2018)
  - UN Reg. R13-H ABS Test(Additional Check)
  - 32 vehicle model, GVWR, 40km/h and 120km/h, 0.8μ / 0.3μ



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New Approach for appropriate deceleration(2)

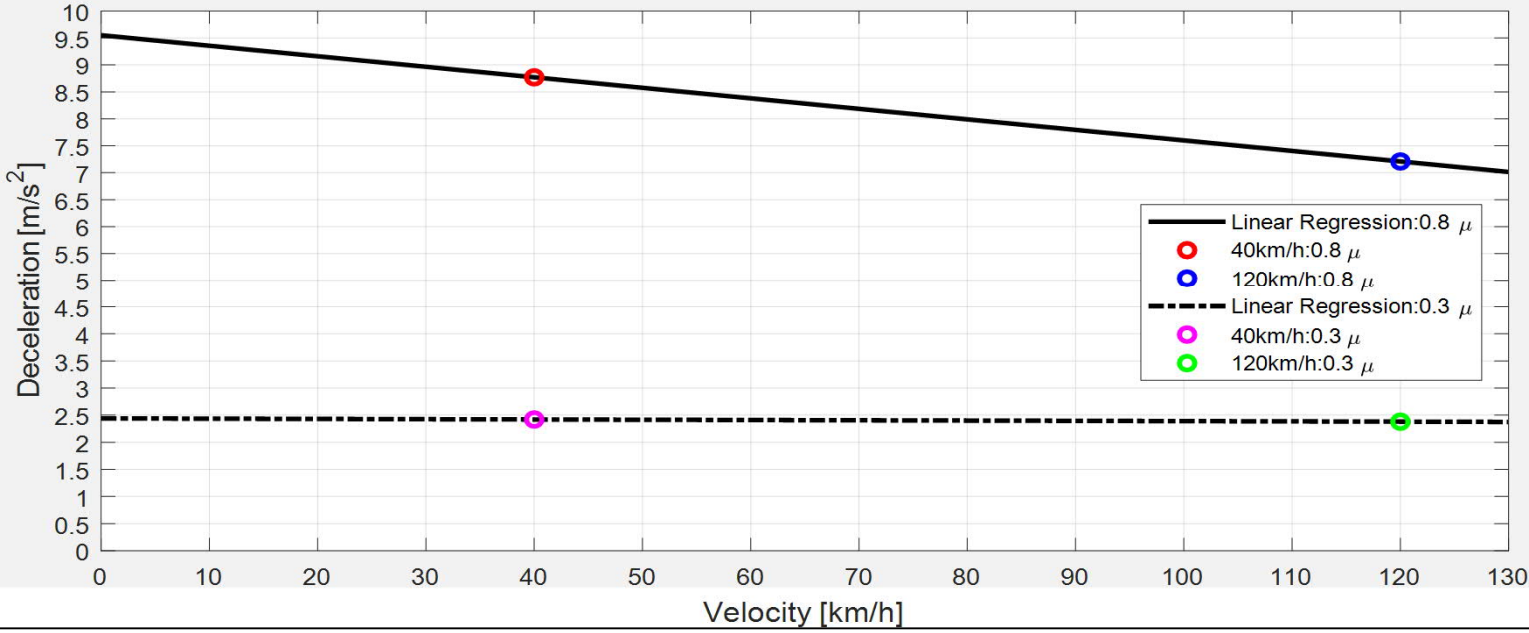
- **Deceleration ($a_{x,max}$) formulas by road condition(wet asphalt, wet basalt)**
  - Avg. MFDD deceleration ($a_{x,max}$) at 40km/h and 120km/h (0.8μ)= $8.77 m/s^2$ and $7.21 m/s^2$

$$a_{x0.8\mu}(v_x) = -0.0702 \times v_x + 9.55$$

  - Avg. MFDD deceleration ($a_{x,max}$) at 40km/h and 120km/h (0.3μ)= $2.42 m/s^2$ and $2.38 m/s^2$

$$a_{x0.3\mu}(v_x) = -0.0018 \times v_x + 2.44$$

  - Linear Decelerations by velocity



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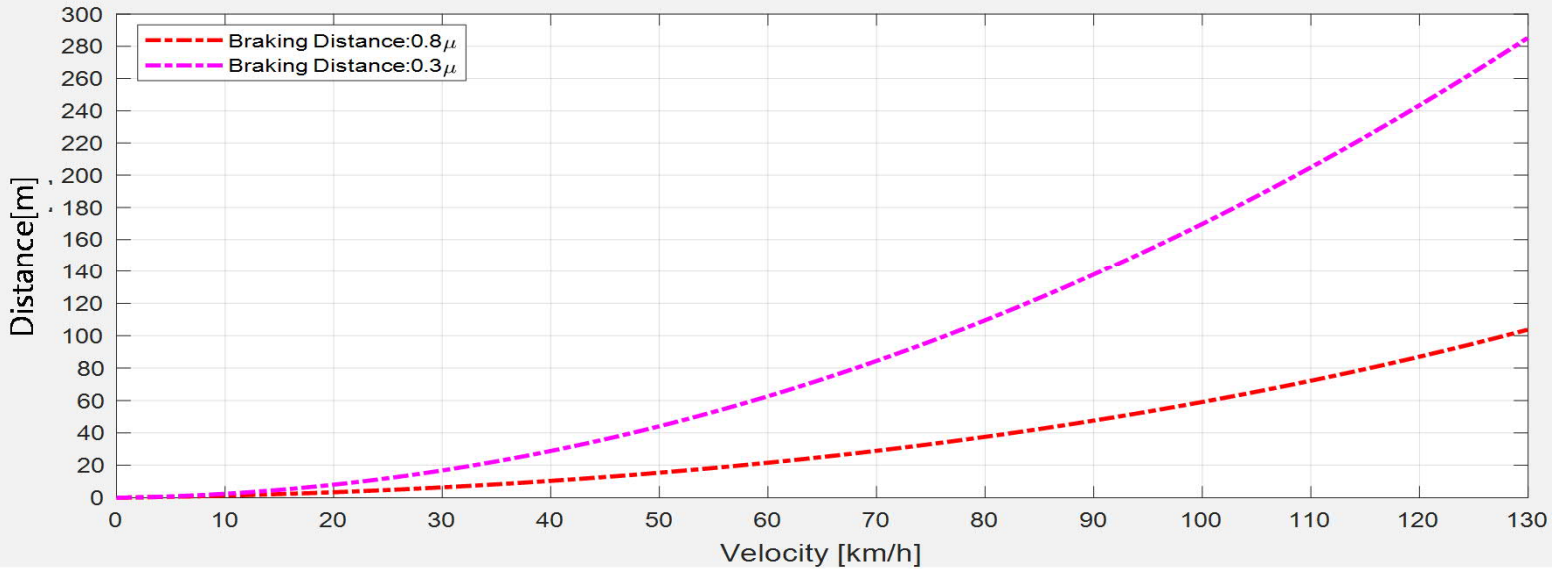
Braking Distance based on appropriate decel.

- **Braking distance (d_{brake})**
  - System delay (t_{sys}) = 0.3sec
  - Braking distance by deceleration & velocity

$$d_{brake(0.8\mu)} = (t_{sys} + {}^{v_x}/_{2a_x(v_x)}) \times v_x \leftarrow a_{x0.8\mu}(v_x) = -0.0702 \times v_x + 9.55$$

$$d_{brake(0.3\mu)} = (t_{sys} + {}^{v_x}/_{2a_x(v_x)}) \times v_x \leftarrow a_{x0.3\mu}(v_x) = -0.0018 \times v_x + 2.44$$



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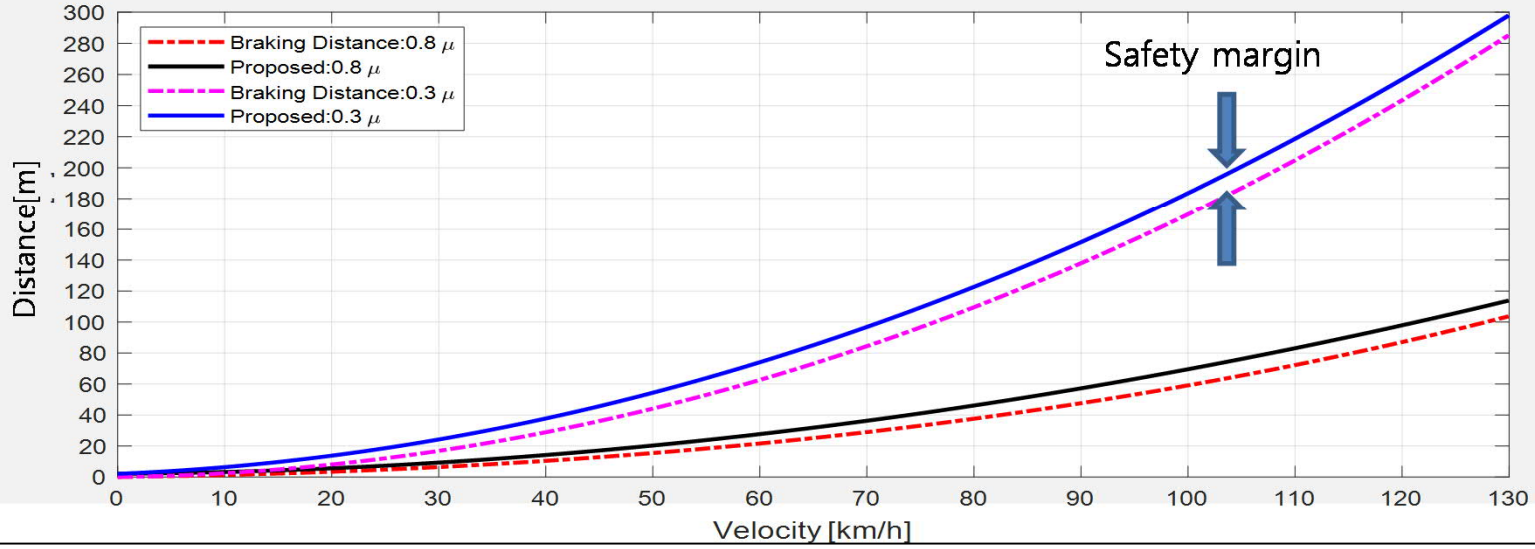
Time gap selection for Minimum Safety Distance

- **Principle of time gap selection**
  - Minimum safety distance should be greater than braking distance
  - As the vehicle speed increase, safety margin should be larger.
    (e.g. safety margin at 20kph < safety margin at 30kph)
- **Selected time gap**
  - time gap 0.2 at 0 km/h and 3.1 at 130km/h for μ 0.8
  - time gap 1.0 at 0 km/h and 8.2 at 130km/h for μ 0.3



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Formula for Minimum Safety Distance

- proposal

$$S = V_{ALKS} \times t_{front} + d_s$$

Where :

V_{ALKS} : the actual speed of the ALKS vehicle in m/s;

t_{front} : time gap between the ALKS vehicle and the leading vehicle in front in second

$= 0.2 + \frac{2.9 * V_{ALKS}}{36.1}$ for dry and wet condition

$[= 1.0 + \frac{7.2 * V_{ALKS}}{36.1}$ for snowy condition]

ds : minimum distance between the ALKS vehicle and the leading vehicle of 2m*

*Get from ACSF 19-06

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Result of Formula

VALKS (km/h)	a (0.8mu)	a (0.3mu)	d brake (0.8mu)	Proposed MSD (0.8mu)	d brake (0.3mu)	Proposed MSD (0.3mu)
0	-	-	0	2.0	0	2.0
10	9.36	2.44	1.2	3.2	2.4	6.3
20	9.16	2.43	3.4	5.6	8.0	13.7
30	8.97	2.43	6.4	9.2	16.8	24.2
40	8.77	2.42	10.4	14.1	28.8	37.7
50	8.58	2.42	15.4	20.3	44.1	54.4
60	**8.38**	**2.41**	**21.6**	**27.6**	**62.6**	**74.1**
70	8.19	2.41	28.9	36.3	84.4	96.8
80	7.99	2.40	37.6	46.1	109.5	122.7
90	7.80	2.40	47.6	57.2	138.0	151.6
100	7.60	2.39	59.1	69.5	169.8	183.6
110	7.41	2.39	72.2	83.1	204.9	218.7
120	7.21	2.38	87.1	97.9	243.4	256.9
130	**7.02**	**2.38**	**103.8**	**113.9**	**285.4**	**298.1**