The important factor to develop test cycle

Prepared by Japan

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Driving energy

◆In general, there are relationship between Fuel consumption (L/km) and Driving energy (Wh/km=J/km). Driving energy can be calculated as follows;

$$F_i = \mu r \cdot W \cdot \cos\theta_i + \mu a \cdot V_i^2 + (W + \Delta W) \cdot \alpha_i + W \cdot g \cdot \sin\theta_i$$

$$P_i = F_i \times V_i$$

(*) Work [Nm=J] = Force * Dist., Power [J/s=W] = Work / time

$$E = \frac{\sum(P_i)}{x} = \frac{\sum(F_i \times V_i)}{x}$$

(*) Driving energy [J/km]=Cum. Work [Wh] / Dist. [km]

$$= \frac{\sum((\mu r \cdot W \cdot \cos\theta_i) \cdot V_i + \mu a \cdot V_i^3 + (W + \Delta W) \cdot \alpha_i \cdot V_i + W \cdot g \cdot \sin\theta_i \cdot V_i)}{x}$$

$$= \mu r \cdot W \cdot \frac{\sum(\cos\theta_i \cdot V_i)}{x} + \mu a \cdot \frac{\sum(V_i^3)}{x} + (W + \Delta W) \cdot \frac{\sum(\alpha_i \cdot V_i)}{x} + W \cdot g \cdot \frac{\sum(\sin\theta_i \cdot V_i)}{x}$$

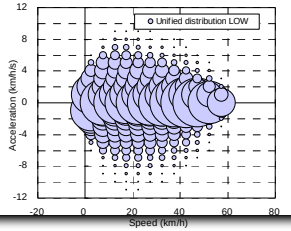
◆When the road gradient is small, it is able to estimate $\cos\theta \fallingdotseq 1$, $\sin\theta \fallingdotseq \theta/100$

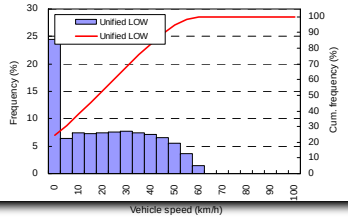
$$E \approx C_1 + C_2 \cdot \frac{\sum(V_i^3)}{x} + C_3 \cdot \frac{\sum(\alpha_i \cdot V_i)}{x} + C_4 \cdot \frac{\sum(\theta_i \cdot V_i)}{x}$$

Speed and frequency　Speed*Acceleration and frequency

The important factor

- The important factors are “speed”, “speed * acceleration” and “Time (frequency)”.
  - It means that “speed-acceleration distribution” and “speed frequency distribution” are important.
- DHC methodology
  - speed-acceleration distribution (the least X^2)
  - speed frequency distribution
  - “Average speed”, “acc./dec./cruise/idle ratio”, RPA and so on





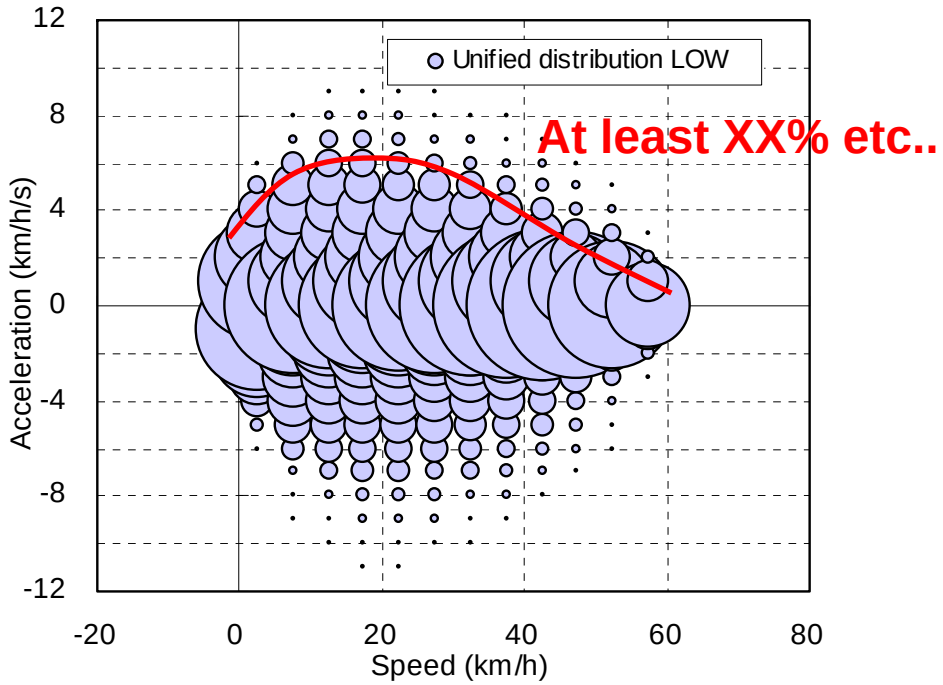
Parameter		Cycle duration	Driving distance	Average speed	Max. speed	Max. acceleration	Max. Deceleration	RPA	Average short trip duration	Average idling duration	Acceleration ratio	Deceleration ratio	Cruise ratio	Idling ratio	Chi-squared value		
		s (h)	km	km/h	km/h	km/h/s	km/h/s	m/s²	s	s	%	%	%	%	VA distribution	Cum. speed frequency	Cum. acceleration frequency
Unified	LOW	(6107)	114440	19.8	60.0	-	-	0.192	84.0	21.9	27.5	25.4	22.7	24.5	-	-	-
Combination of Actual STs	L-1 (adopted)	589	2.98	18.2	50.9	5.3	-5.3	0.165	89.0	24.0	26.1	27.8	19.7	26.3	0.2479	0.002	0.005
	L-2	589	2.98	18.2	50.9	5.3	-5.3	0.165	89.0	24.0	26.7	27.7	19.5	26.1	**0.2481**	0.002	0.005
	L-3	589	2.91	17.8	50.9	5.3	-6.4	0.159	89.0	24.0	26.1	26.1	21.7	26.0	**0.2498**	0.003	0.005
	L-4	589	2.98	18.2	50.9	5.3	-5.3	0.165	89.0	24.0	26.3	27.3	19.9	26.5	**0.2502**	0.002	0.005

Summary

- RPA (Dynamics) is one of important factor. However we should also consider other parameter / frequency distribution.

One idea

- We can modify test cycle which have dynamics based on original method.

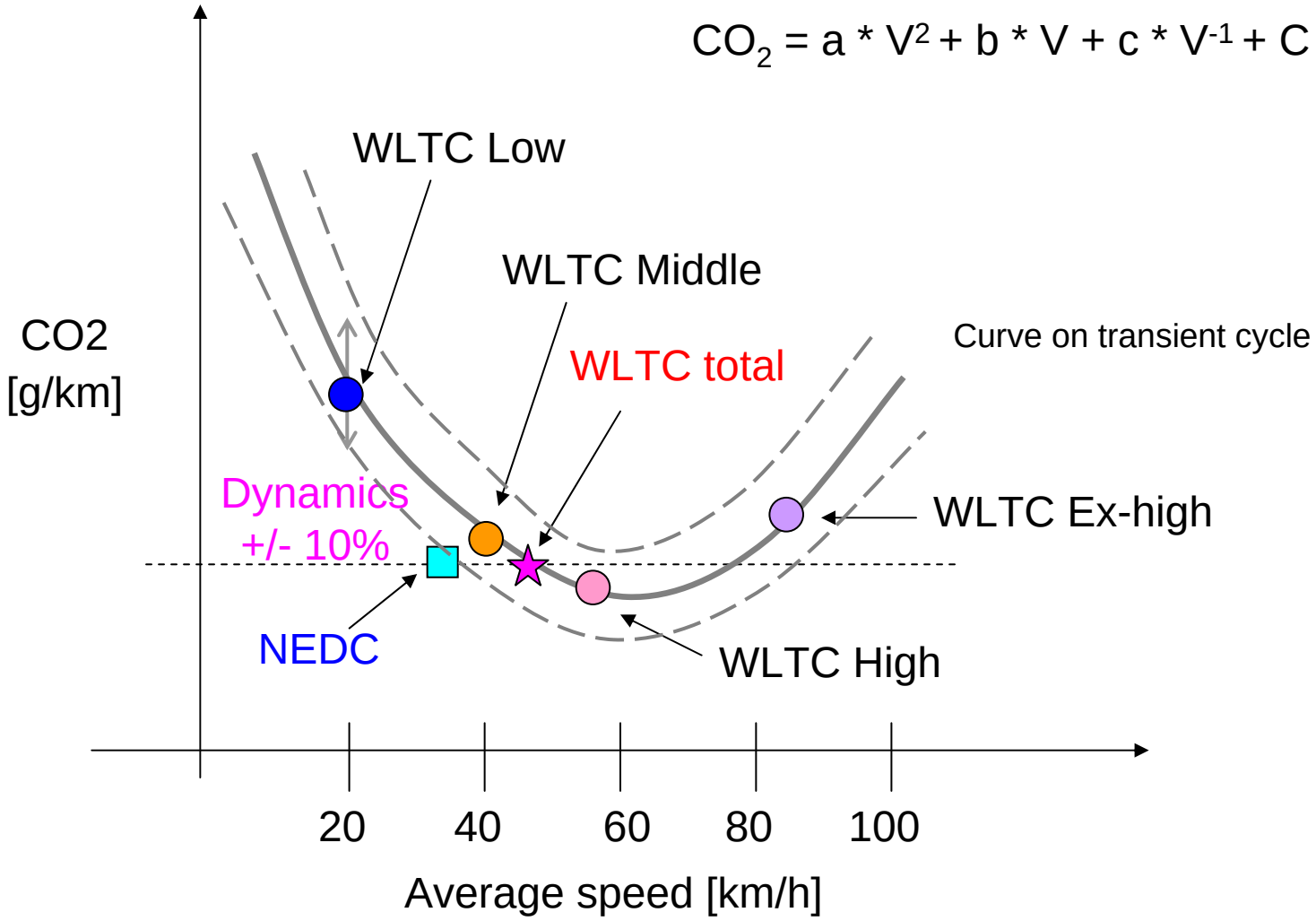


$$\frac{\sum(V_i^3)}{x} : \mathrm{Relative\_Cubic\_Speed(RCS)}$$

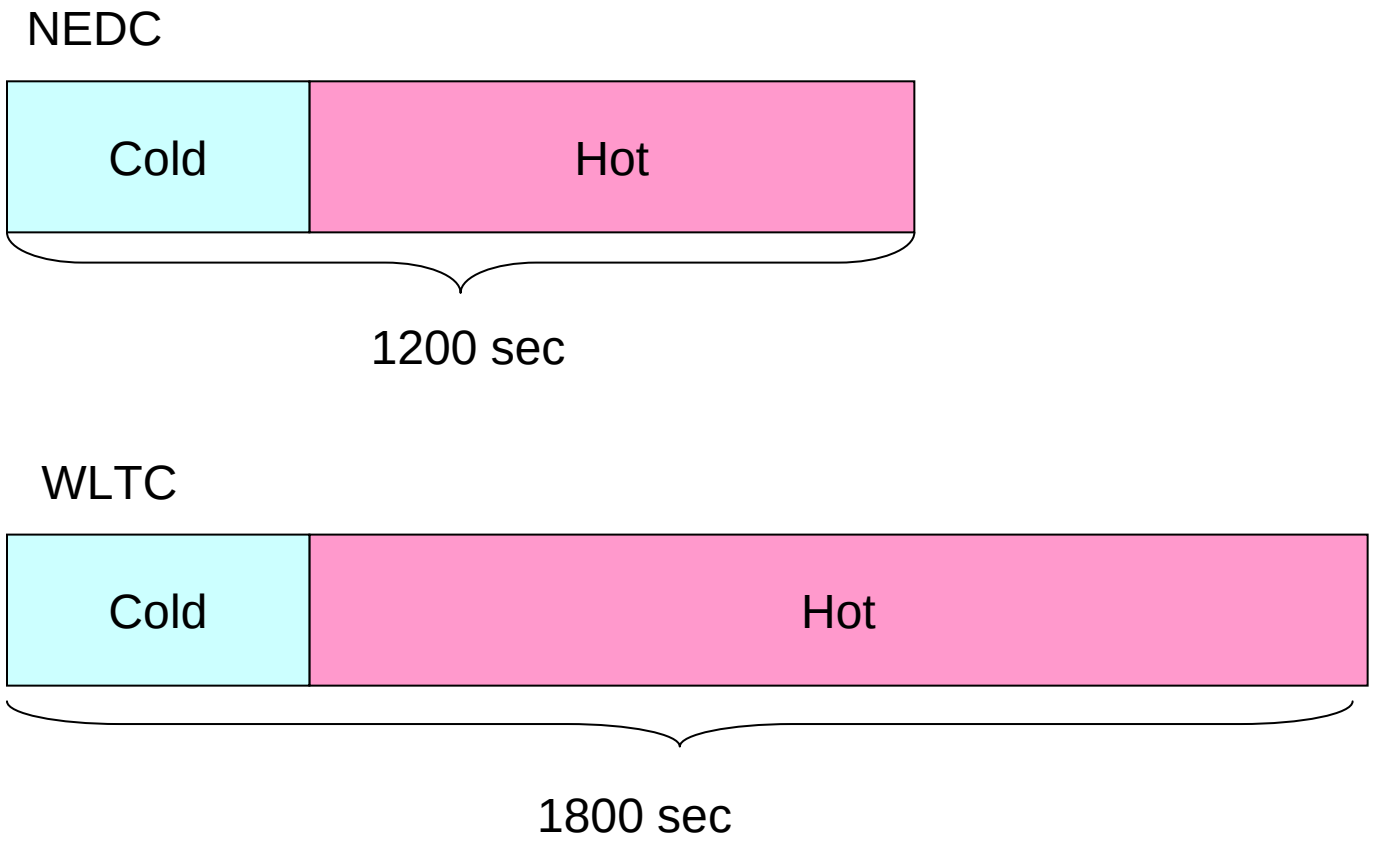
$$\frac{\sum(\alpha_i \cdot V_i)}{x} : \mathrm{Relative\_Positive\_Acceleration(RPA)}$$

$$\frac{\sum(\theta_i \cdot V_i)}{x} : \mathrm{Relative\_Positive\_Gradient(RPG)}$$

Relationship between Average speed and CO_2 emission



Cold / Hot ratio



Cold/Hot ratio should be considered