Working Paper No HDH-13-06e
13th HDH meeting,21/22 March 2013

Basic Examination Regarding WHDHC (2)

JAPAN AUTOMOBILE STANDARDS INTERNATIONALIZATION CENTER

Purpose

At the 11th meeting of IG on UNECE/HDH held in Ottawa on October 10 to 12, 2012, we reported the results of our examination regarding WHDHC (World Heavy Duty Hybrid Cycle).

Report to Ottawa meeting:

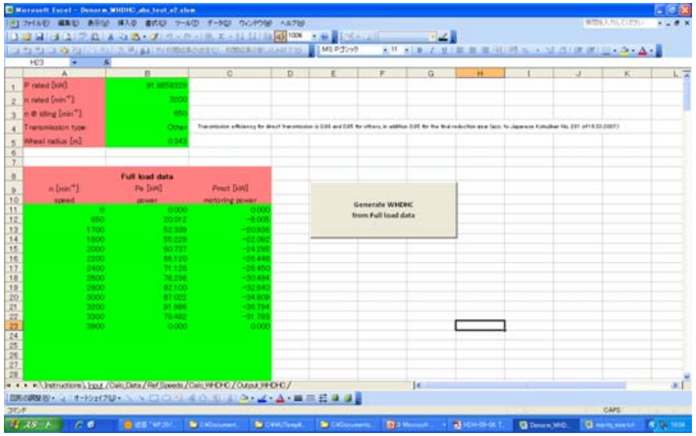
Replacing the target power patterns of WHDHC with slopes produces an unrealistically steep uphill slope. HILS attempted by JARI failed halfway.

So, we examined a way to convert the unrealistically deviating slopes into practical slopes. The results of the examination are as follows:

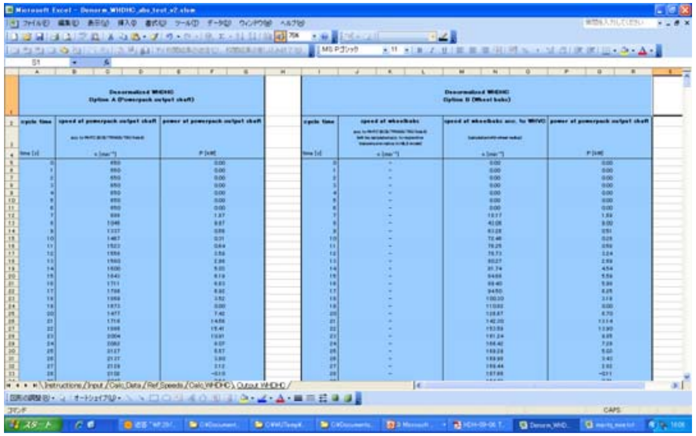
Method of examination

The method of examination was as follows. The boxes 1 to 6 recapitulate what we reported to the Ottawa meeting.

1. Rated output of power pack, full-load curves, etc. are input. The WHDHC operation points are calculated with the Excel tool developed by TU/Graz.



2. The calculation gives both Pre-TM and Post-TM (hub input), but only Post-TM is used.



3. WHDHC negative work is smaller than WHVC negative work in flat conditions, so power patterns are corrected on the negative side only. (x 1/0.7)

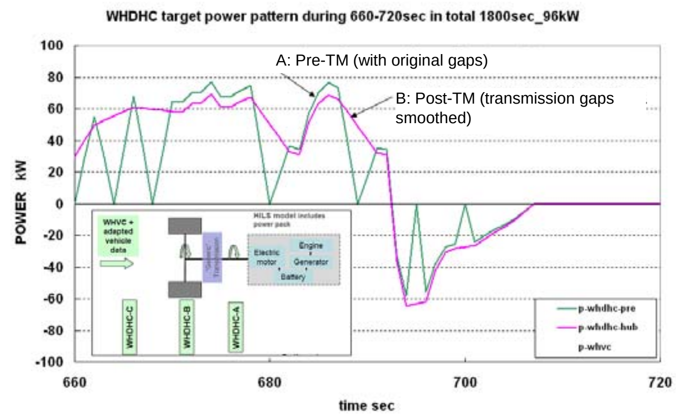
Method of examination

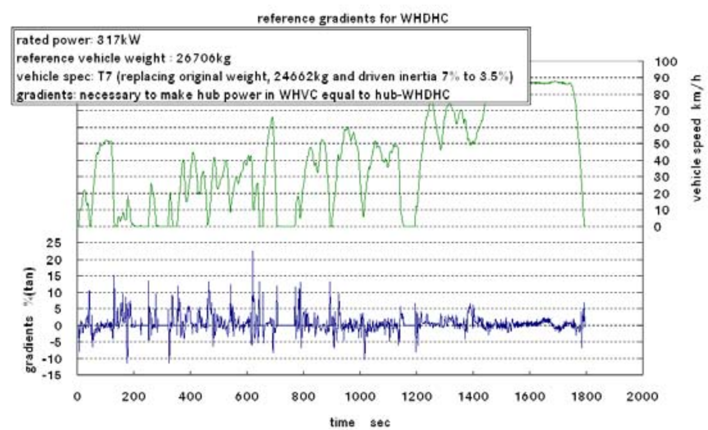
4. WHDHC power patterns include transmission shift changing gaps, so they are smoothed (by simply filling the gaps).

5. The vehicle weight is determined from the system maximum power.

vehicle weight (kg) =0.111265x (rated power kW)^2+ 48.9025 x (rated power kW)

6. Slope patterns are obtained from WHDHC power patterns (negative side: x 1/0.7, smoothed), WHVC speed patterns, and vehicle weight. (Reference expressions prescribed in Japanese Safety Regulations are used for air resistance, rolling resistance, rotating part equivalent inertia mass, etc.)



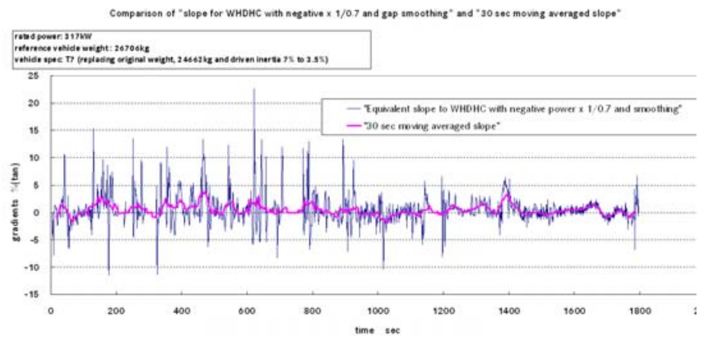


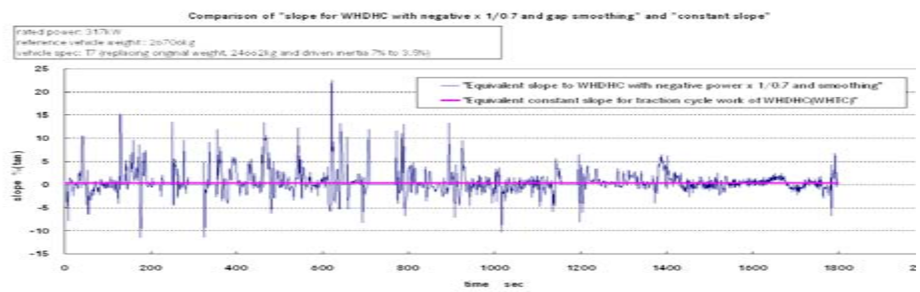
Method of examination

7. To be suited for practical use, the slope patterns thus obtained are corrected by the following two methods.

- Correct them using a 30-second moving average: The positive work will deviate, but will mitigate steep uphill slopes and prevent failures

- Correct the constant slope (match positive work)





8. Calculate the WHVC speed pattern operating points in the original slope patterns and the corrected slope patterns and compare the following:

- The correlation determination coefficient of power patterns and torque patterns (hub input)

- Positive and negative cycle work

Results

Table below shows the results of comparison between the original slope patterns and corrected slope patterns.

- The slope smoothed with 30-second moving average is within the scope of practical use. The constant slope is 0.35%, which is almost flat.

- The correlation between the power patterns and torque patterns on the positive side shows that, in terms of the coefficient of determination R^2, the slope smoothed with 30-second moving average is better than the constant slope.

System maximum power	Item	How WHDHC target power patterns are replaced with slopes		
		Original (Ottawa Report)	30-sec moving average	Constant slope
317kW	Minimum-maximum slope % (tan)	**-11.4～22.6**	**-1.9～3.9**	**0.35**
	Traction <u>power</u>”R^2”	**base**	**0.768**	**0.656**
	Traction hub-<u>torque</u>”R^2”	**base**	**0.643**	**0.550**
96kW	Minimum-maximum slope % (tan)	**-11.5～23.9**	**-1.9～6.5**	**0.35**
	Traction <u>power</u> ”R^2”	**base**	**0.793**	**0.640**
	Traction hub-<u>torque</u> ”R^2”	**base**	**0.685**	**0.550**

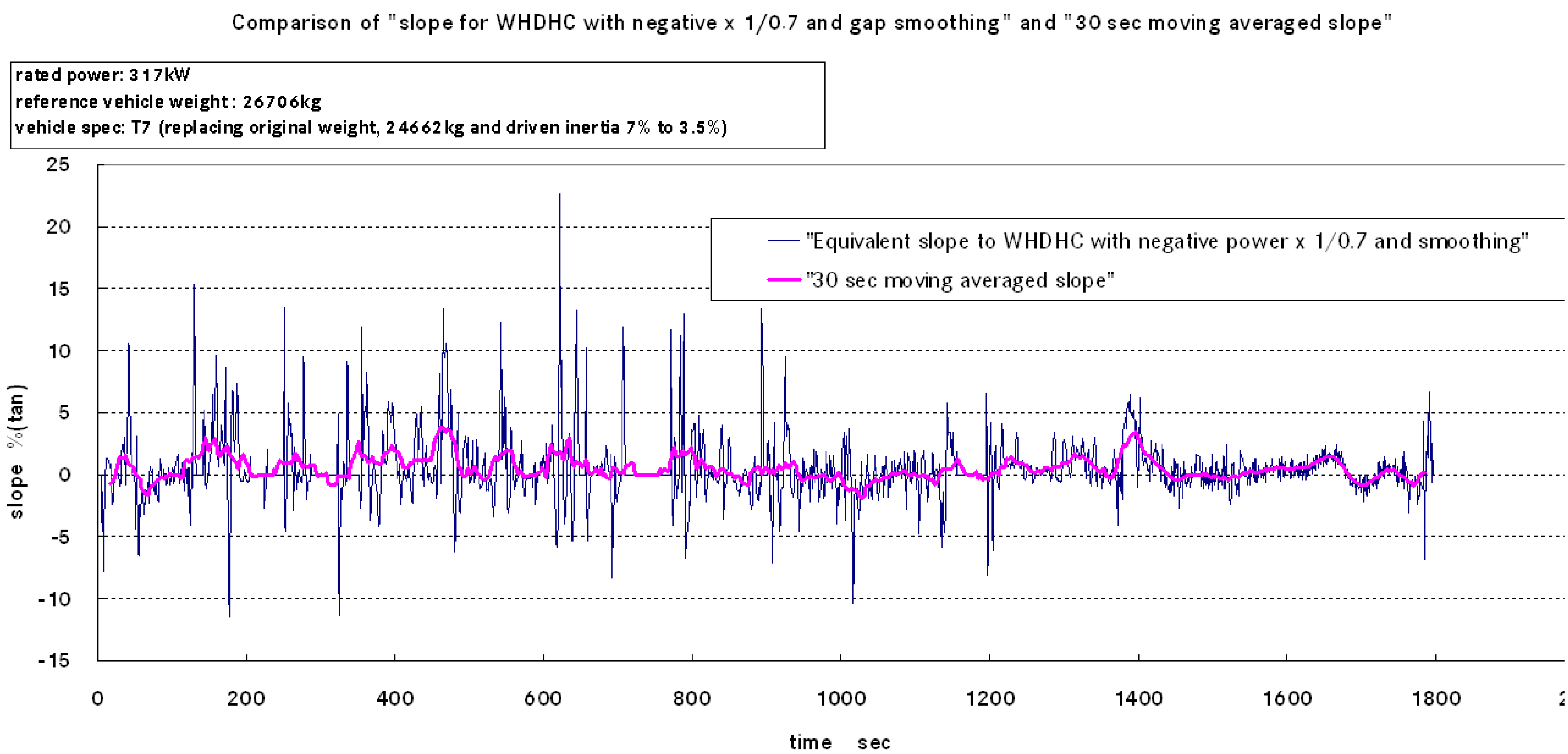
Results

- As to positive cycle work, the constant slope matches with the original slope, because this is matching positive work. The 30-second moving average increases because slope patterns changed (especially small vehicles).
- Both of the constant slope and 30-second moving average decreased from the original slope for large vehicles and increased for small vehicles in terms of positive and negative work.
- Overall, we find the 30-second moving average better than the constant slope.

System maximum power	Item	How WHDHC target power patterns are replaced with slope		
		Original (Ottawa Report)	30-sec moving average	Constant slope
317kW	**①Traction cycle work kWh**	**29.3**	**30.1**	**29.3**
	②Braking cycle work kWh	**-11.0**	**-9.9**	**-9.6**
	②/① %	**37.6**	**33.0**	**32.9**
96kW	**③Traction cycle work kWh**	**8.06**	**8.65**	**8.09**
	④Braking cycle work kWh	**-1.01**	**-1.22**	**-1.74**
	④/③ %	**12.5**	**14.1**	**21.5**

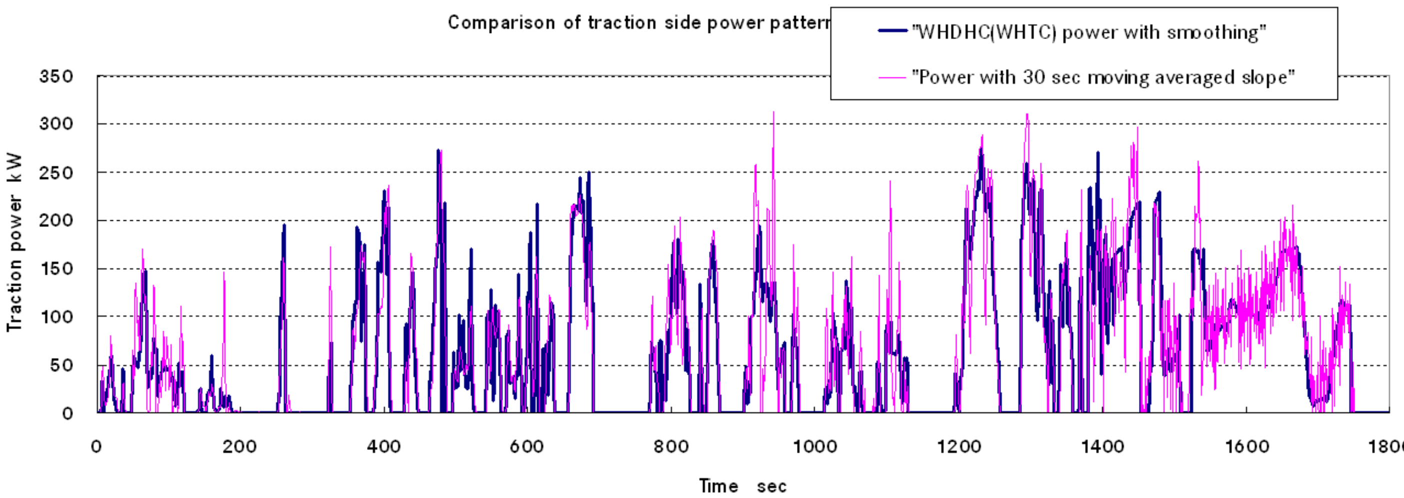
Graphs: 30 sec moving average: Large vehicles

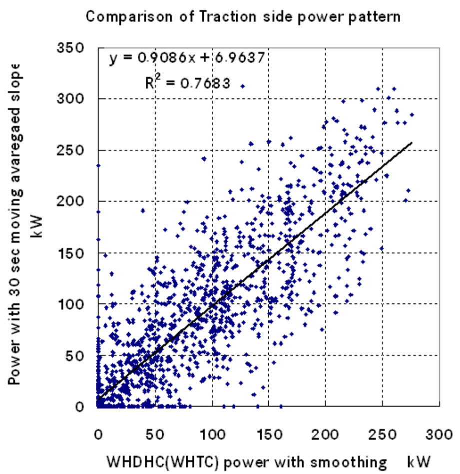
317kW slope



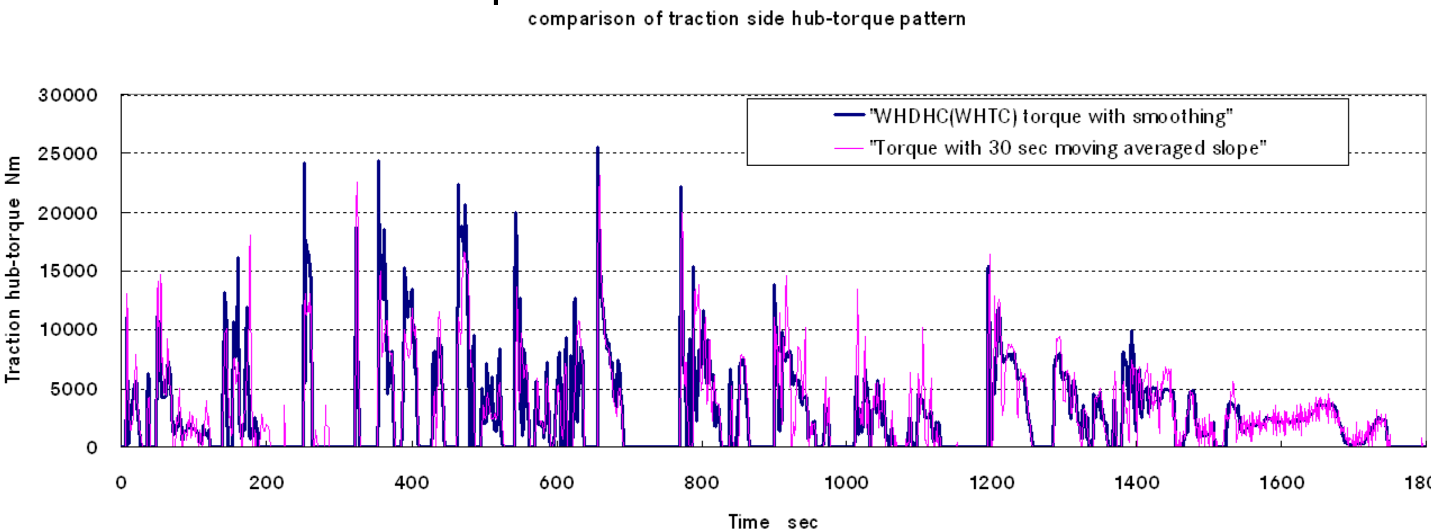
Graphs: 30 sec moving average: Large vehicles

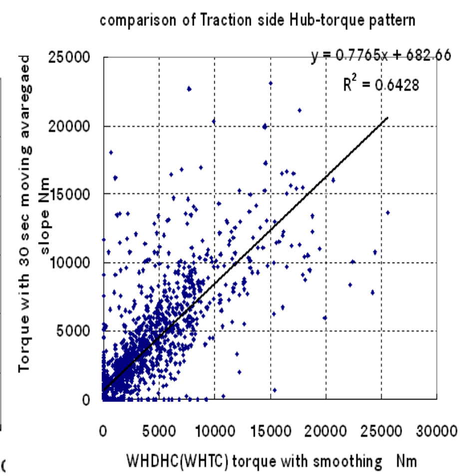
317kW traction hub-power





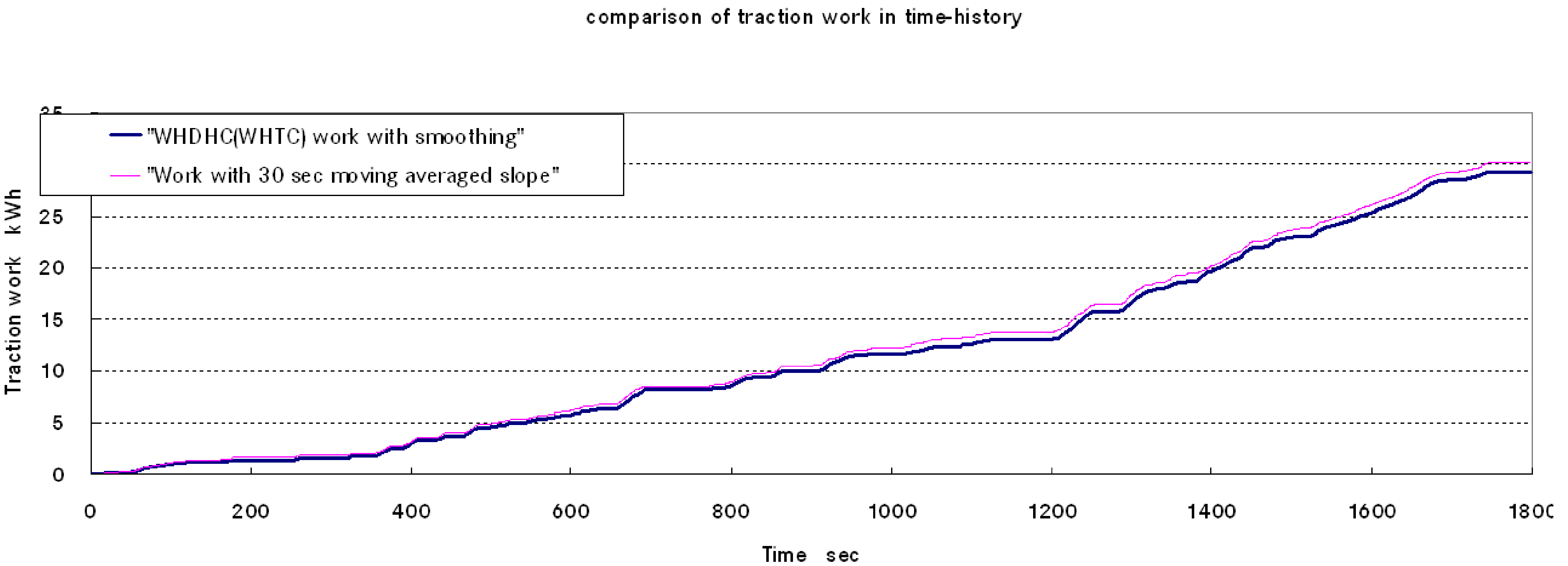
317kW traction hub-torque





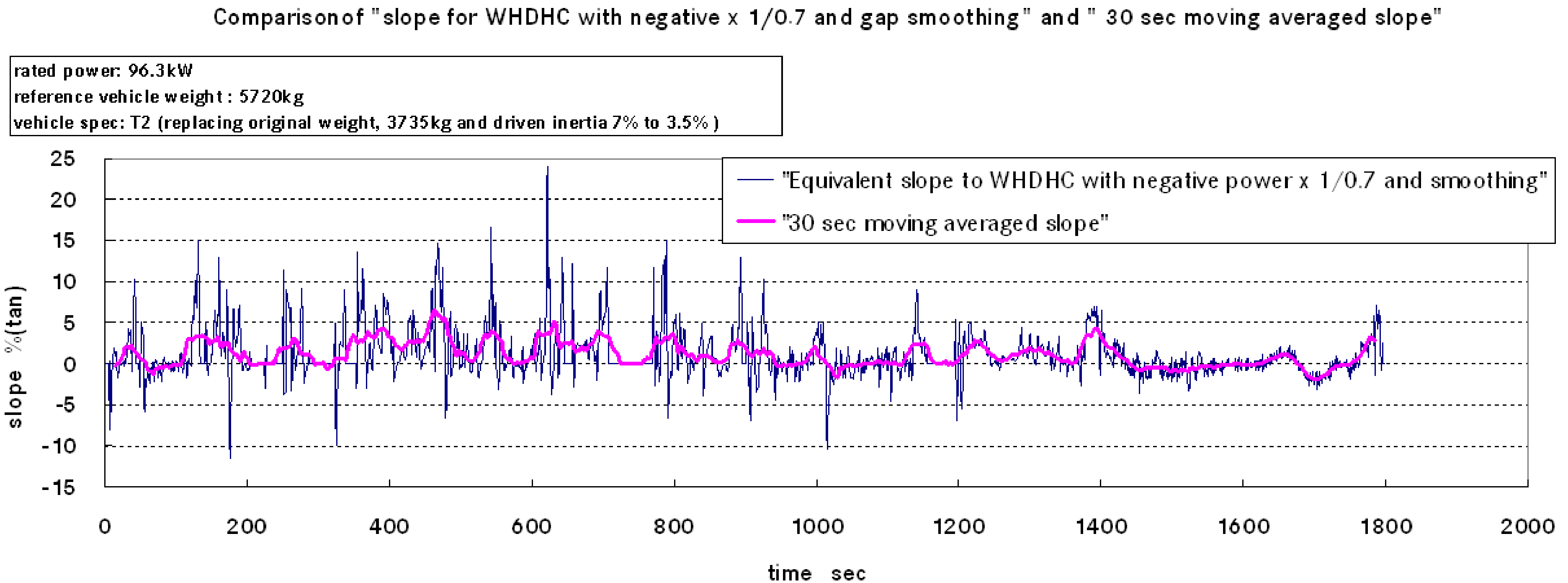
Graphs: 30 sec moving average: Large vehicles

317kW traction work



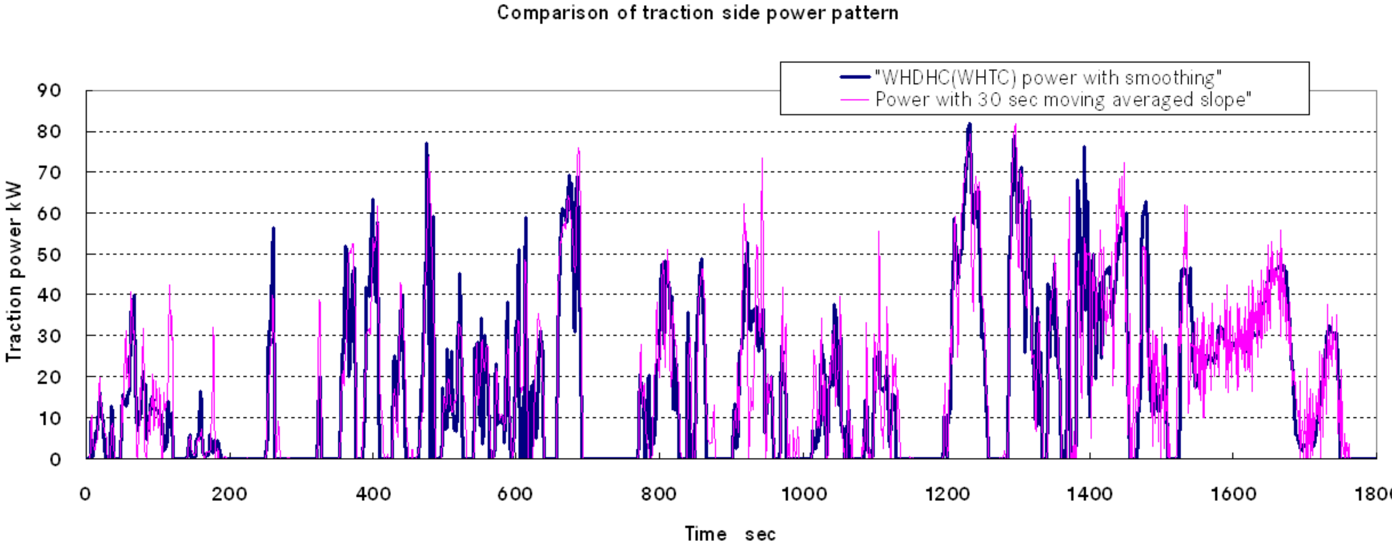
Graphs: 30 sec moving average: Small vehicles

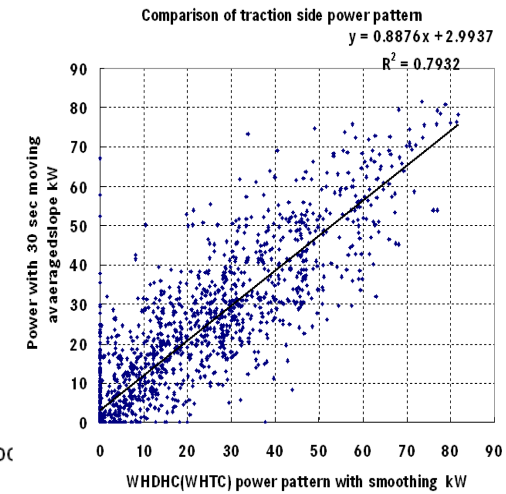
96kW slope



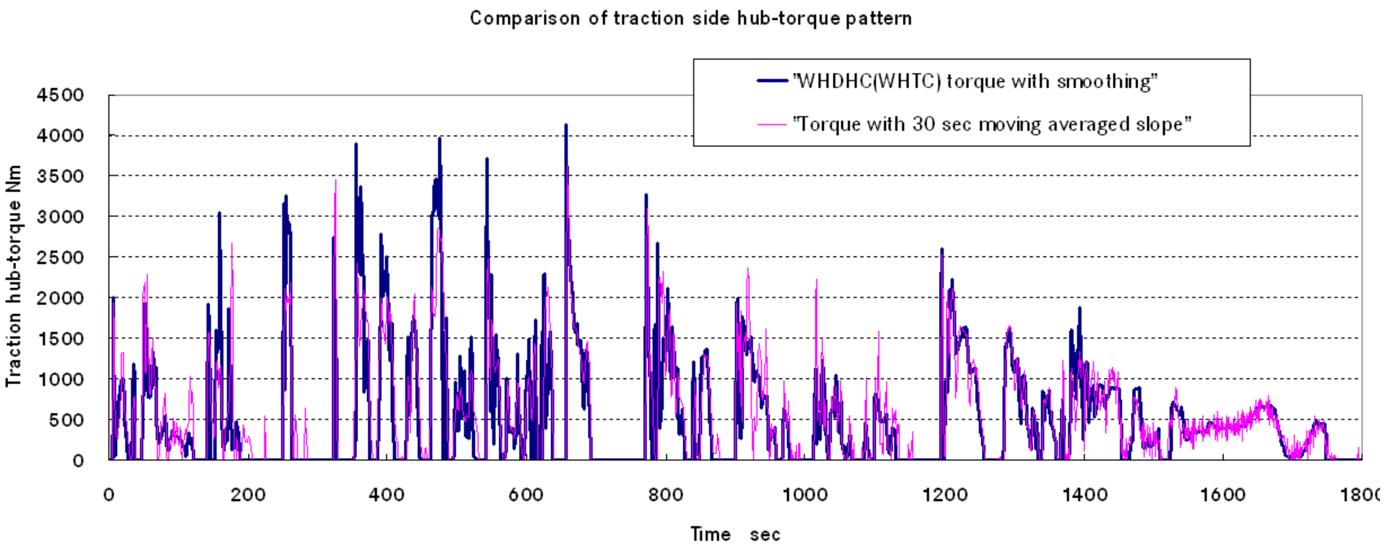
Graphs: 30 sec moving average: Small vehicles

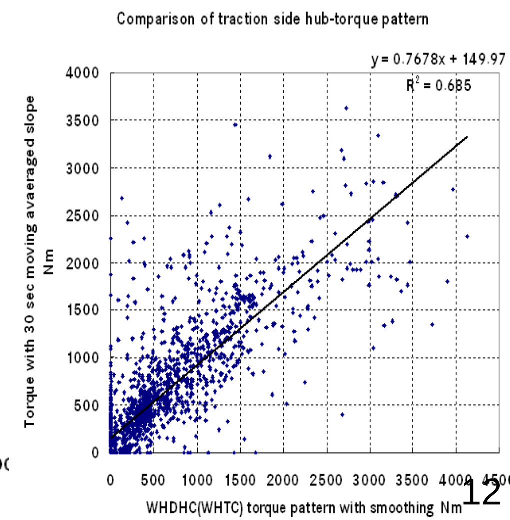
96kW traction hub-power





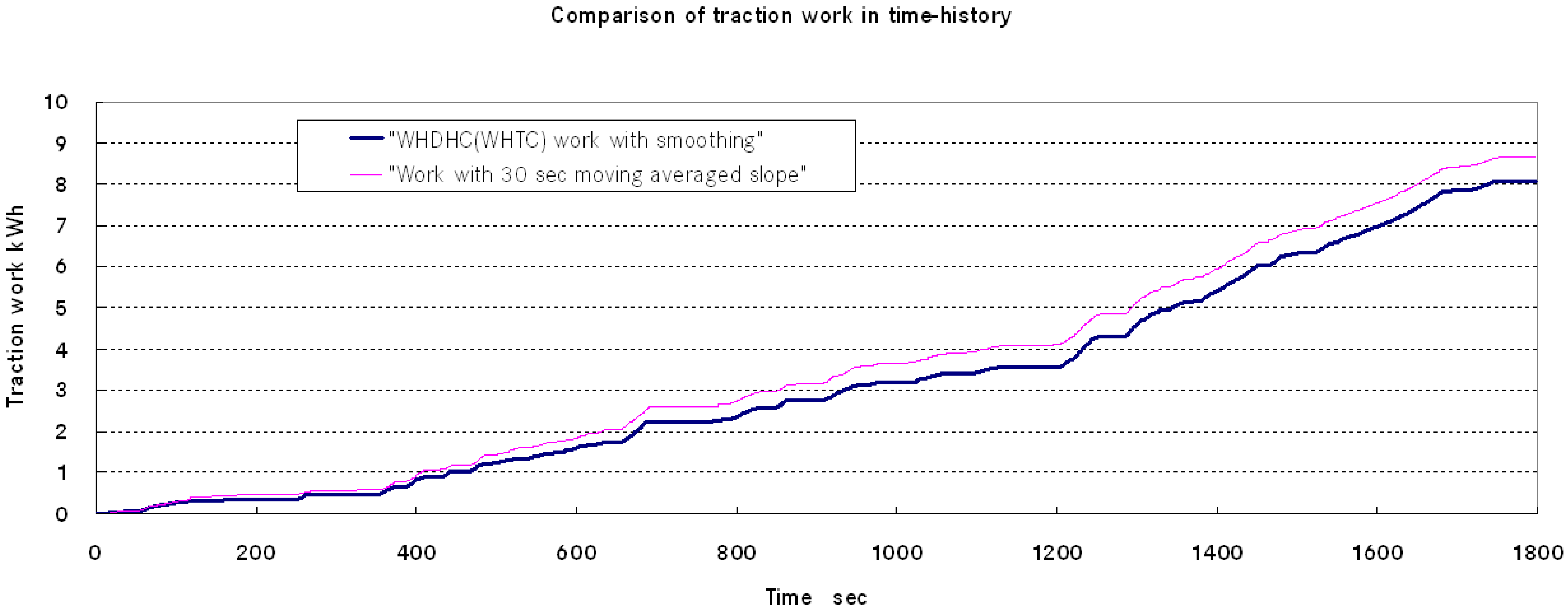
96kW traction hub-torque





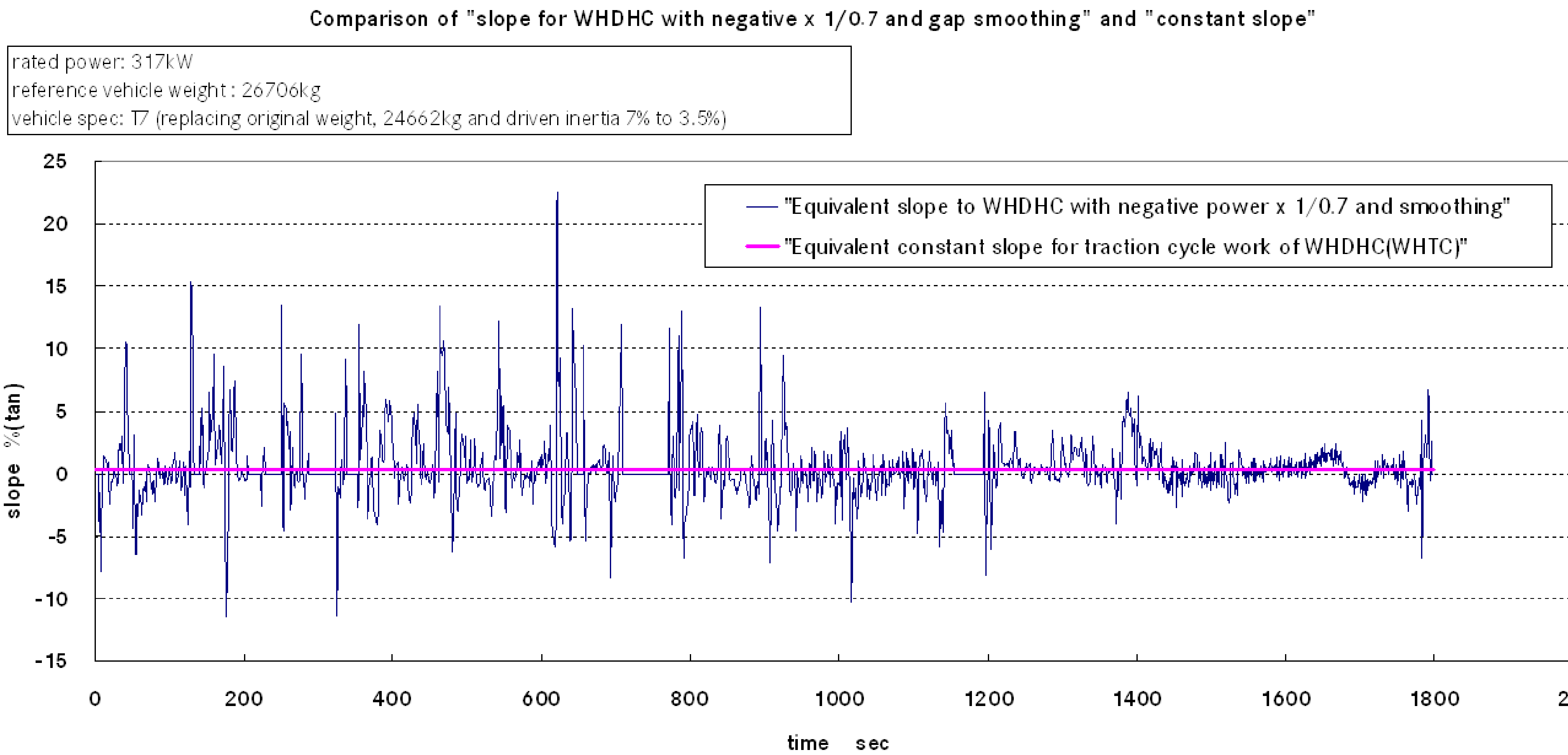
Graphs: 30 sec moving average: Small vehicles

96kW traction work



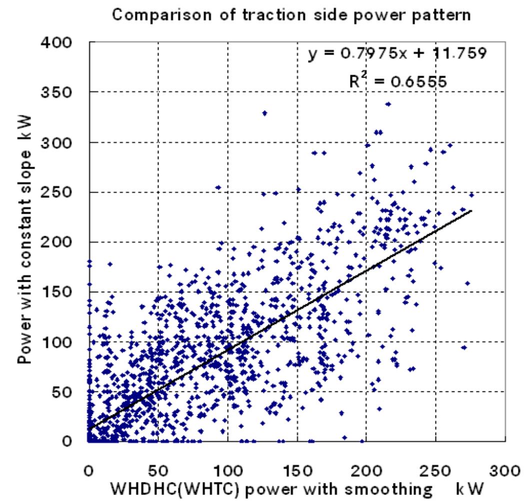
Graphs: Constant slope: Large vehicles

317kW slope

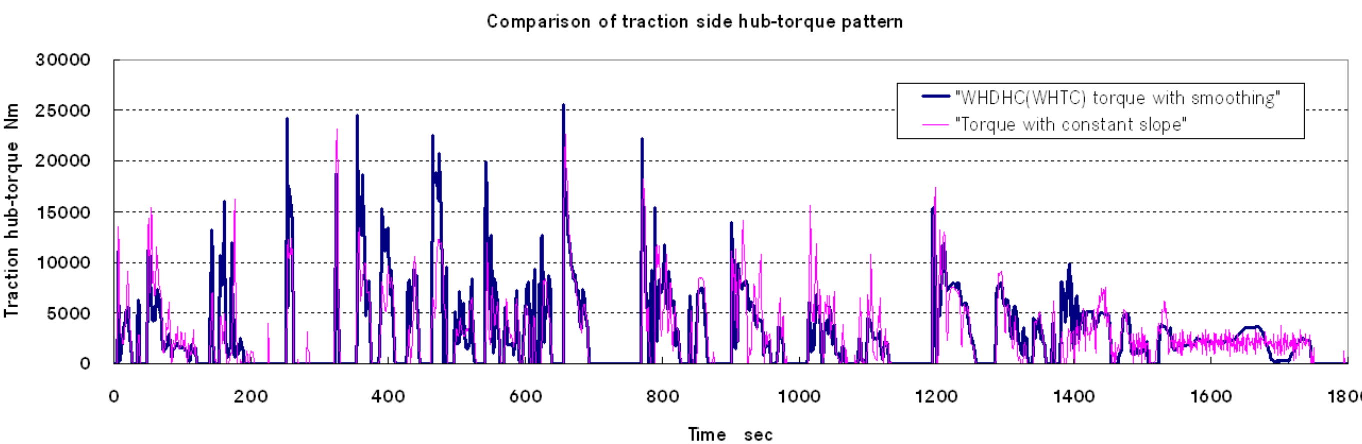


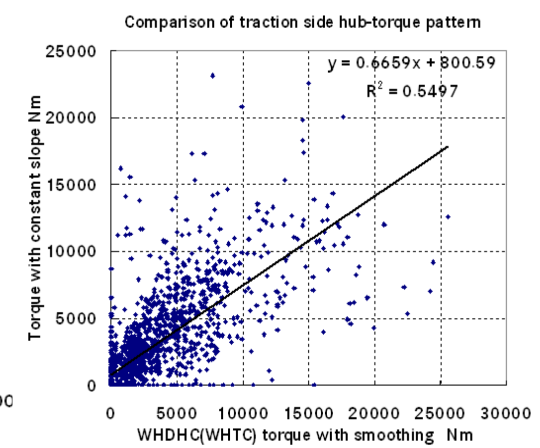
Graphs: Constant slope: Large vehicles

317kW traction hub-power



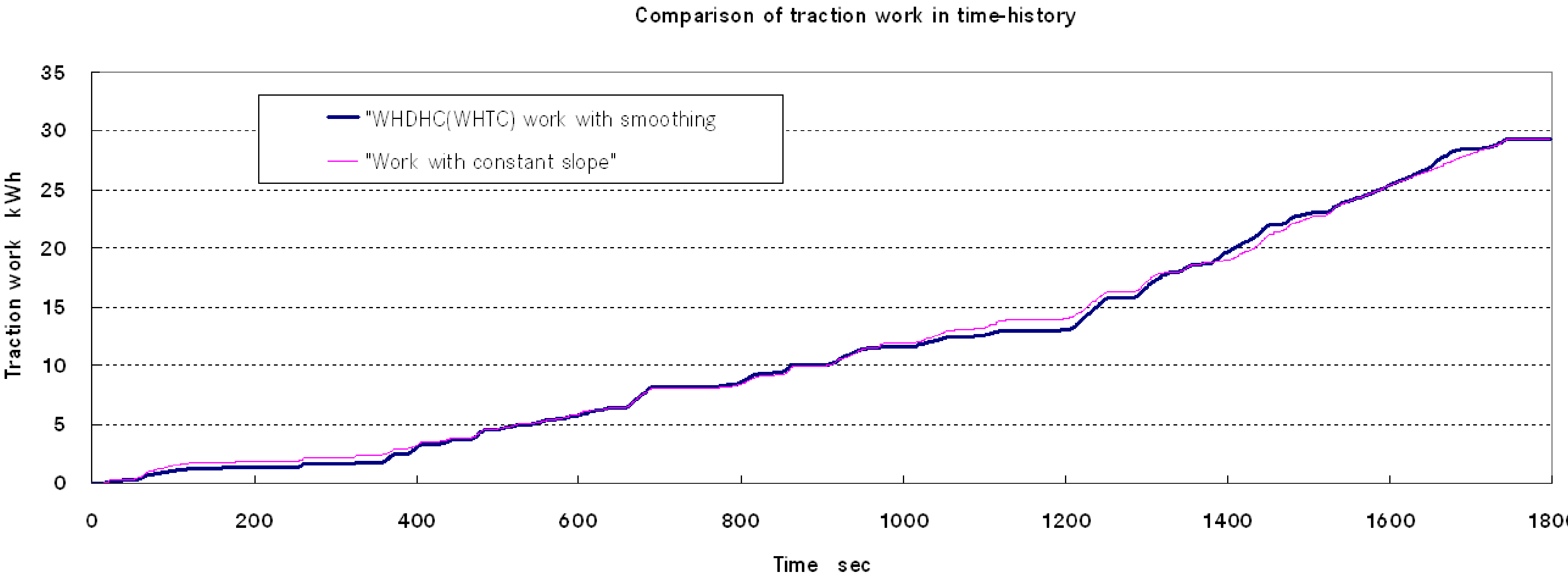
317kW traction hub-torque





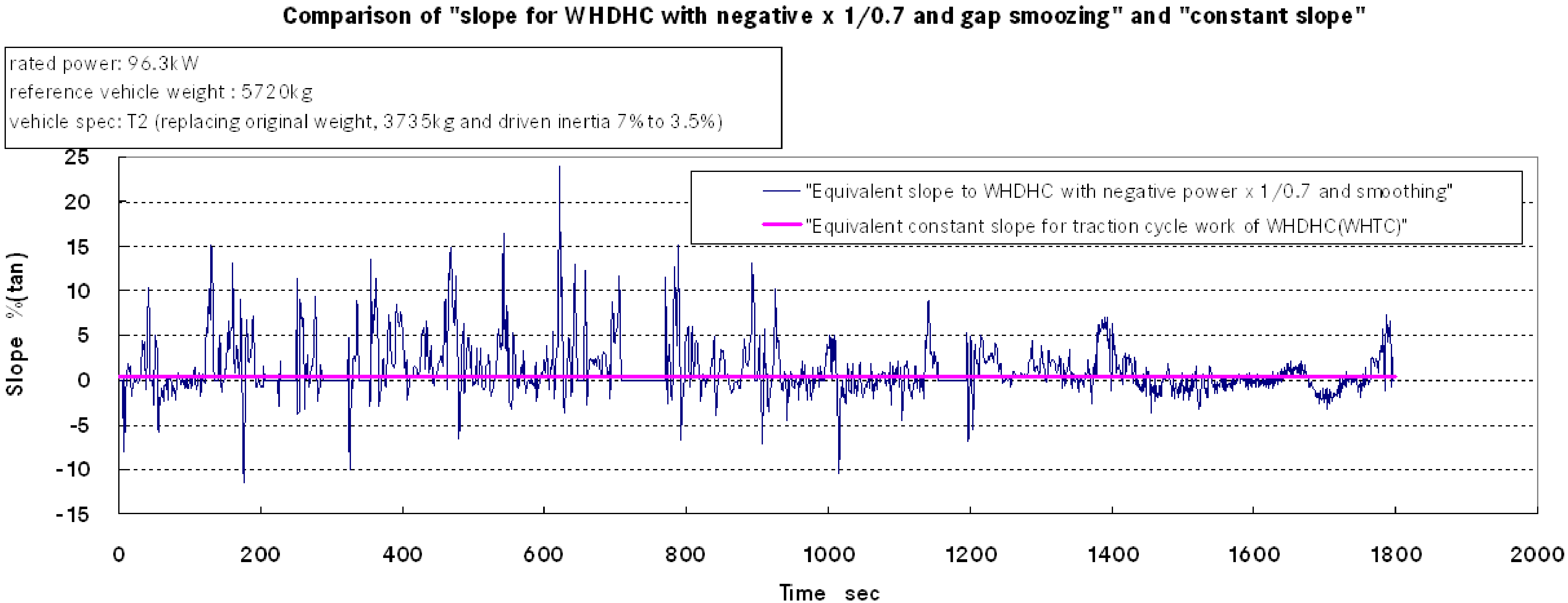
Graphs: Constant slope: Large vehicles

317kW traction work



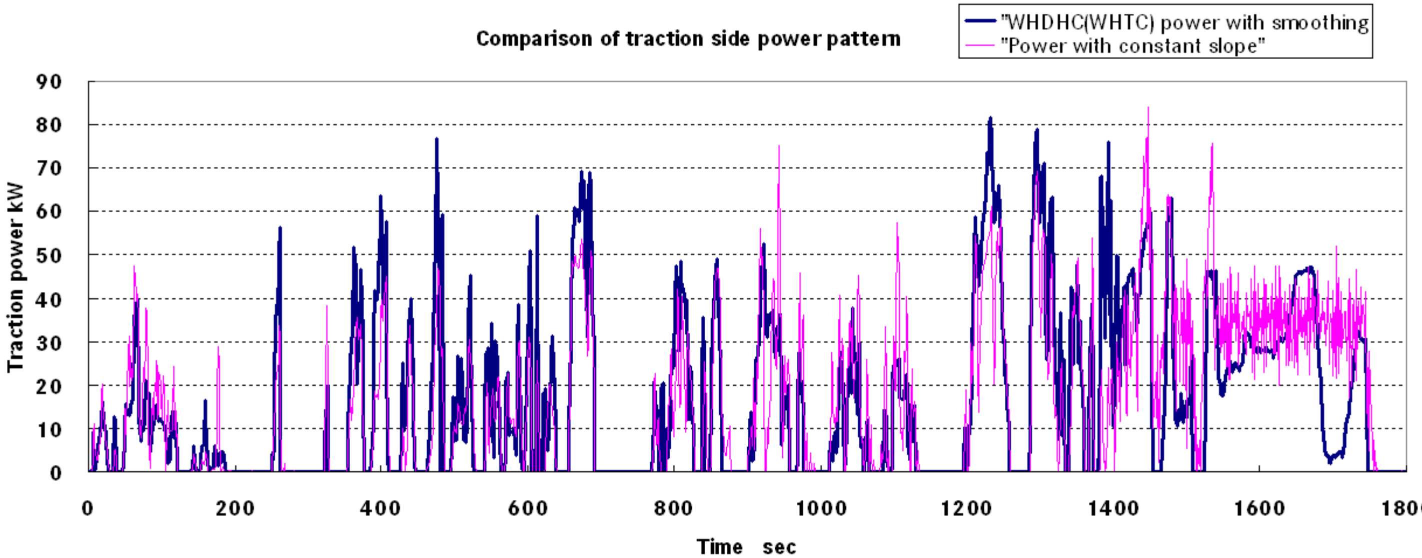
Graphs: Constant slope: Small vehicles

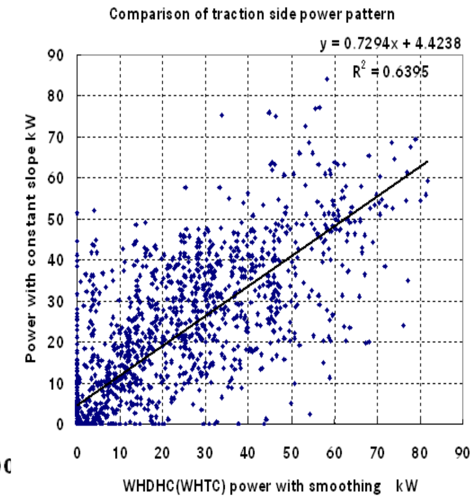
96kW slope



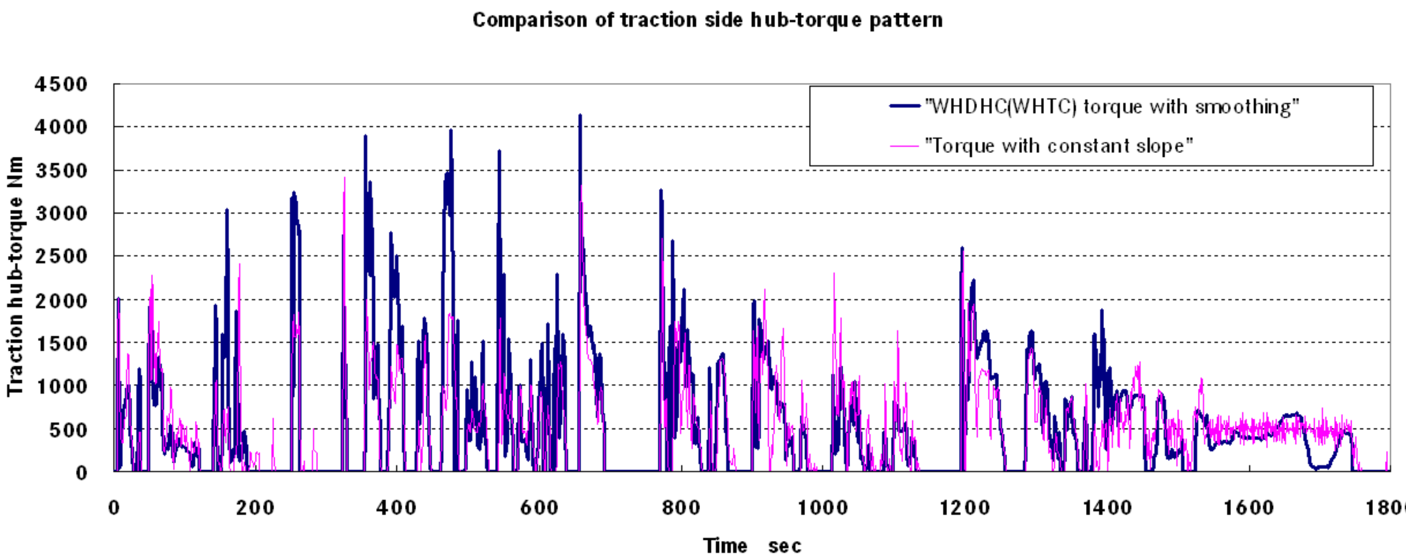
Graphs Constant slope: Small vehicles

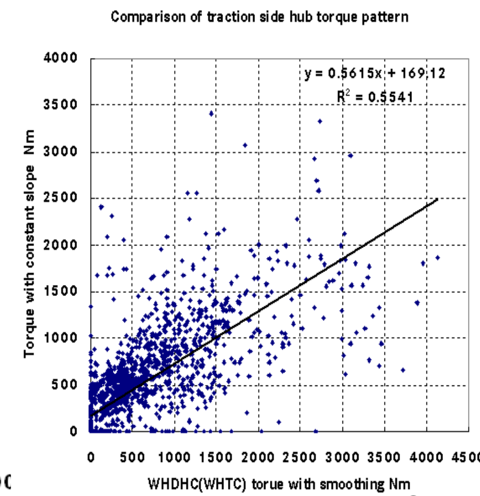
96kW traction hub-power





96kW traction hub-torque





Graphs: Constant slope: Small vehicles

96kW traction work