VTAC calculator:
Guidance note for determining $T\gamma$ values

The surface damage component of the VTAC calculator allows users to either select the vehicle characteristics (primary yaw stiffness and vehicle weight) from a pre-determined list or to enter values of $T\gamma$ which have been derived for that particular vehicle. Recently, some users have raised questions regarding the methodology, so this guidance note presents an update to the original instruction sheet which accompanied the VTAC calculator spreadsheet.

$T\gamma$ definition

The contact patch frictional energy, $T\gamma$ (or T-gamma), is calculated from lateral and longitudinal creep forces, T_x and T_y, and creepages, γ_x and γ_y, using the formula:

$$T\gamma = T_x \gamma_x + T_y \gamma_y$$

and can usually be output direct from most vehicle dynamics software modelling packages.

Parameters for calculating T-gamma

Calculation of $T\gamma$ generally requires use of a multi-body vehicle dynamics simulator that is capable of calculating creepage and creep forces at the wheel rail interface. A series of standardised parameters for these simulations is presented in UK NR Report No. 08-002 "Methodology to Calculate Variable Usage Charges for Control Period 4" published in March 2008.

Since the publication of that report an updated version of the Vampire vehicle dynamics software has been issued which changes the way that $T\gamma$ is calculated: the calculation now includes the effect of 'spin creep' in the calculation, which can have some effect on the calculated magnitude of $T\gamma$ compared with earlier methodologies. Since Vampire was used to calculate the reference values of $T\gamma$ used as input to the VTAC calculator, and has been used by many users to determine inputs to the VTAC calculator, this guidance note has been updated to reflect these changes and the recommended methodology for determining $T\gamma$.

Simulation condition parameters

- It is recommended that **Vampire 5.0** be used for the simulations. Later versions of Vampire (or other simulation packages) include the contribution of spin creep in the $T\gamma$ calculation, which can give higher predicted values of $T\gamma$ which are out of line with the reference values in the calculator
- If later versions of **Vampire** than **5.0** are used then it is recommended that the form of the "`*output`" section of the "`.run`" file given in the

sample run file in Appendix 2 should be used: this will determine $T\gamma$ without the contribution of spin creep.

- If simulation packages other than Vampire are used then it is suggested that contact with a member of V/T SIC PPG is made to discuss any differences between the results from the two simulation packages: contact details for PPG are supplied at the end of this document.
- Calculations are to be made on **right-hand curves**
- Track irregularity files are not used: the analysis should be for the vehicle under steady-state conditions. The track file should consist of an entry transition followed by a section of constant radius and constant cant of at least 350 m length. The $T\gamma$ values should be determined as the average of the vehicle running over at least 250m of track on the constant radius curve. The start of the track section over which the average is taken should be at least 100m after the end of the entry transition into the curve to allow any transient effects to be sufficiently damped.
- **Cant deficiency**
  - For all passenger vehicles (except tilting trains) simulations should be run at a **cant deficiency of 40 mm**
  - For freight vehicles not limited to 45 mph simulations should be run at **balance speed**
  - For freight vehicles limited to 45 mph simulations should be run at **20 mm cant excess**
- **Coefficient of friction**
  - All contact points on the left (high) rail except the gauge face use a **coefficient of friction of 0.4**
  - For the gauge face of the left (high) rail use a **coefficient of friction of 0.2**
  - All contact points on the right (low) rail use a **coefficient of friction of 0.45**

Curve radii

Calculations should be carried out for the vehicle running over each of the 15 curve radii shown in Table 1.

Table 1: Curve radii to include in simulations

Curve radii (m)		
200	1200	3000
400	1400	4000
600	1800	6000
800	2200	8000
1000	2600	10,000

Wheel and rail profiles

For the analysis of passenger vehicles with P8 wheels a standard Vampire contact file ("**F_mod_L_on_0-750-H_type2.con**") is available, and is recommended for $T\gamma$ studies. A listing of the ".con" file is given in Appendix 1.

All wheel/rail contact data should be generated assuming a track gauge of 1435mm and a wheelset back-to-back spacing of 1360mm. It is important that the flange contact 'L' and 'R' markers in the contact data files are not edited or moved within the contact file.

For the analysis of freight vehicles measured part-worn wheel and rail profiles should be used in the calculations. The wheel profiles which should be used are shown in Table 2. Separate rail profiles are used for left and right rails as follows:

Left (high) rail: 0-750-H.ban
Right (low) rail: 0-750-L.ban

Table 2: Wheel profile names

Profile type	Left (high rail) wheel profile	Right (low rail) wheel profile
Worn P5	P5_20001009-0131.whl	P5_20001009-0131.whl
Worn P10	P10_20040826-0061.whl	P10_20040826-0061.whl

Outputs

The output should be the average value of $T\gamma$, determined as described in the previous sections, from the high rail for each wheelset of a bogie for the vehicle running on each curve. If there are different results from the leading and trailing bogies, the values should be chosen from the bogie which gives the highest $T\gamma$ values.

If there are two points of contact on the high rail (tread and flange) choose the one with the highest $T\gamma$.

Vampire input files

All the required input files are available from Network Rail PPG. These include sample track geometry files, "`.run`" files containing the appropriate speed and coefficients of friction and output channels, and wheel/rail contact data files. Listings of a typical Vampire "`.run`" file is given in Appendix 2, and Appendix 3 details curvature, cant and speed combinations which have been used to obtain the appropriate cant deficiencies on each curve.

PPG contact

For copies of the track or run files previously used in these analyses, or queries regarding the procedure for $T\gamma$ calculation please contact:

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Appendix 1

Listing of Vampire contact file, "**F_mod_L_on_0-750-H_type2.con**", for use with passenger vehicles with P8 wheels

```
*******************************************
   VAMPIRE Version 5.01.0003  (July 2006)
       CONTACT DATA GENERATION PROGRAM
*******************************************
**
VAMPIRE WHEEL/RAIL CONTACT DATA
**
*WHEEL
F_mod_L.whl and F_mod_R.whl
FLANGEBACK   1360.00 mm
DIAMETER      850.00 mm
YAW ANGLE       0.00 mrad
**
*RAIL
0-750-H.ban and 0-750-L.ban
TRACK GAUGE  1435.00 mm
**
*AXLELOAD
             150.00 KN
**
*LATERAL OFFSET
**  YREL     DRL      DRR   DELTL   DELTR    CONYL    CONYR    CONXL    CONXR  CONZL  CONZR    AREAL    AREAR     AOBL     AOBR   RHOL   RHOR     ROLL
  -15.00  22.183   -0.689  56.96   -0.24 -704.28  779.32     0.00     0.00  13.15  -0.10    20.95    50.57   21.707    3.980  0.023  0.185    9.043
  -14.50  21.999   -0.688  61.16   -0.24 -704.39  778.82     0.00     0.00  12.32  -0.09    19.58    51.87   23.874    3.813  0.019  0.196    8.481
  -14.00  21.197   -0.687  61.57   -0.24 -704.88  778.32     0.00     0.00  11.46  -0.09    22.31    55.23   22.210    3.485  0.024  0.222    7.902
  -13.50  20.444   -0.680  62.46   -0.41 -705.28  777.79     0.00     0.00  10.48  -0.09    22.35    61.29   24.224    2.965  0.023  0.274    7.239
  -13.00  20.222   -0.680  66.14   -0.41 -705.39  777.31     0.00     0.00   9.40  -0.09    24.34    64.88   22.045    2.701  0.028  0.309    6.509
  -12.50  19.341   -0.679  67.51   -0.37 -705.78  776.76     0.00     0.00   8.22  -0.09    25.95    69.25   22.316    2.439  0.031  0.351    5.718
  -12.00  18.589   -0.677  69.18   -0.41 -706.07  776.30     0.00     0.00   6.88  -0.08    36.38    66.44   18.222    2.609  0.054  0.323    4.811
  -11.50  18.589   -0.679  70.95   -0.41 -706.07  775.80     0.00     0.00   5.44  -0.09    35.43    69.39   18.603    2.431  0.052  0.352    3.843
  -11.00  16.919   -0.674  71.01   -0.40 -706.65  775.23     0.00     0.00   3.95  -0.08    43.24    69.41   16.162    2.430  0.073  0.353    2.830
  -10.50  16.830   -0.676  72.74   -0.43 -706.68  774.79     0.00     0.00   2.35  -0.08    47.65    68.10   14.456    2.509  0.089  0.339    1.758
  -10.10   6.820   -0.676  35.23   -0.43 -712.67  774.39     0.00     0.00   1.09  -0.08    69.95    69.06    3.039    2.451  0.332  0.349    0.899
L -10.00   6.755   -0.676  34.82   -0.43 -712.77  774.29     0.00     0.00   1.02  -0.08    58.02    69.06    4.005    2.451  0.227  0.349    0.855
   -9.90   2.992   -0.676  13.12   -0.43 -722.87  774.19     0.00     0.00   0.99  -0.08    99.29    70.45    1.359    2.367  0.680  0.364    0.827
   -9.50   2.286   -0.679  10.46   -0.40 -726.36  773.79     0.00     0.00   0.91  -0.09    92.41    71.53    1.530    2.314  0.600  0.374    0.775
   -9.00   2.489   -0.683  11.65   -0.39 -725.31  773.29     0.00     0.00   0.81  -0.09    91.55    72.03    1.559    2.288  0.590  0.379    0.711
   -8.50   1.805   -0.681   9.10   -0.39 -729.17  772.79     0.00     0.00   0.73  -0.09    85.70    73.18    1.735    2.230  0.524  0.391    0.653
   -8.00   1.805   -0.681   9.47   -0.39 -729.17  772.29     0.00     0.00   0.65  -0.09    85.29    72.74    1.749    2.253  0.520  0.386    0.599
   -7.50   1.555   -0.682   8.79   -0.39 -730.74  771.79     0.00     0.00   0.57  -0.09    86.79    75.15    1.696    2.129  0.536  0.412    0.547
   -7.00   1.472   -0.684   8.69   -0.39 -731.29  771.29     0.00     0.00   0.49  -0.09    83.03    69.57    1.825    2.420  0.496  0.354    0.498
```

	-6.50	1.217	-0.682	7.93	-0.38	-733.04	770.66	0.00	0.00	0.42	-0.09	89.50	71.53	1.597	2.313	0.569	0.374	0.449
	-6.00	1.086	-0.688	7.62	-0.43	-734.06	770.29	0.00	0.00	0.36	-0.09	93.65	75.02	1.472	2.136	0.616	0.411	0.410
	-5.50	0.882	-0.673	6.96	-0.12	-735.68	768.84	0.00	0.00	0.30	-0.09	98.12	76.24	1.349	2.072	0.668	0.425	0.371
	-5.00	0.732	-0.500	6.71	1.74	-736.98	757.31	0.00	0.00	0.24	-0.07	101.26	68.87	1.266	2.464	0.707	0.347	0.319
	-4.50	0.321	-0.494	4.86	1.68	-741.10	757.09	0.00	0.00	0.19	-0.06	99.79	65.26	1.297	2.680	0.689	0.312	0.274
	-4.00	0.321	-0.500	5.04	1.57	-741.10	757.31	0.00	0.00	0.14	-0.05	101.68	71.87	1.251	2.297	0.712	0.377	0.234
	-3.50	0.321	-0.493	5.28	1.51	-741.10	757.06	0.00	0.00	0.09	-0.04	97.80	71.00	1.348	2.341	0.665	0.369	0.197
	-3.00	0.055	-0.496	4.18	1.40	-744.20	757.16	0.00	0.00	0.06	-0.02	100.61	74.43	1.274	2.168	0.699	0.404	0.164
	-2.50	0.018	-0.493	4.17	1.35	-744.70	757.06	0.00	0.00	0.02	-0.01	101.39	78.53	1.255	1.978	0.709	0.448	0.134
	-2.00	-0.017	0.478	4.17	6.21	-745.20	739.79	0.00	0.00	-0.02	0.01	102.94	53.61	1.222	3.651	0.726	0.209	0.092
	-1.50	-0.054	0.501	4.18	6.05	-745.70	739.55	0.00	0.00	-0.05	0.06	102.23	54.89	1.237	3.528	0.718	0.219	0.038
	-1.00	-0.084	0.478	4.17	5.59	-746.20	739.79	0.00	0.00	-0.08	0.10	101.37	67.02	1.255	2.586	0.709	0.328	-0.013
	-0.50	-0.315	0.501	2.71	5.44	-750.46	739.55	0.00	0.00	-0.11	0.15	105.66	67.44	1.150	2.559	0.758	0.332	-0.065
	0.00	-0.344	0.501	2.69	5.15	-750.96	739.55	0.00	0.00	-0.14	0.19	104.14	74.37	1.185	2.179	0.740	0.403	-0.113
	0.50	-0.427	0.910	2.23	7.61	-753.01	735.41	0.00	0.00	-0.16	0.24	105.68	52.60	1.152	3.766	0.758	0.201	-0.154
	1.00	-0.427	0.919	2.34	7.30	-753.01	735.33	0.00	0.00	-0.18	0.30	110.45	58.31	1.057	3.227	0.813	0.248	-0.205
	1.50	-0.460	1.002	2.14	7.44	-754.03	734.62	0.00	0.00	-0.19	0.36	99.17	55.89	1.301	3.460	0.682	0.226	-0.255
	2.00	-0.460	1.064	2.33	7.46	-754.03	734.10	0.00	0.00	-0.21	0.42	102.34	56.68	1.225	3.389	0.720	0.233	-0.307
	2.50	-0.656	1.160	0.44	7.70	-762.48	733.34	0.00	0.00	-0.23	0.48	145.42	53.80	0.596	3.663	1.166	0.210	-0.363
	3.00	-0.662	1.228	0.45	7.74	-762.98	732.81	0.00	0.00	-0.24	0.55	141.49	54.46	0.633	3.603	1.132	0.215	-0.410
	3.50	-0.634	1.294	-0.86	7.74	-769.93	732.31	0.00	0.00	-0.24	0.61	74.62	54.25	2.157	3.624	0.406	0.213	-0.453
	4.00	-0.646	1.360	-0.53	7.74	-768.45	731.81	0.00	0.00	-0.23	0.68	95.88	56.51	1.388	3.416	0.644	0.231	-0.495
	4.50	-0.634	1.432	-0.68	7.74	-769.96	731.31	0.00	0.00	-0.23	0.75	79.31	57.39	1.945	3.330	0.456	0.239	-0.539
	5.00	-0.634	1.500	-0.45	7.74	-769.93	730.81	0.00	0.00	-0.23	0.82	84.08	56.08	1.756	3.460	0.508	0.227	-0.584
	5.50	-0.634	1.571	-0.51	7.82	-769.95	730.31	0.00	0.00	-0.22	0.89	92.09	59.69	1.495	3.133	0.599	0.259	-0.627
	6.00	-0.636	1.910	-0.33	9.53	-769.68	728.22	0.00	0.00	-0.22	0.97	96.17	65.38	1.381	2.722	0.647	0.312	-0.679
	6.50	-0.634	2.315	-0.21	11.63	-769.93	725.92	0.00	0.00	-0.22	1.06	91.80	53.21	1.504	3.748	0.596	0.205	-0.739
	7.00	-0.634	2.362	-0.15	11.40	-770.16	725.65	0.00	0.00	-0.22	1.15	92.31	60.95	1.489	3.066	0.602	0.269	-0.798
	7.50	-0.636	2.504	-0.14	11.83	-770.66	724.90	0.00	0.00	-0.22	1.24	89.14	59.71	1.582	3.159	0.566	0.259	-0.864
	8.00	-0.636	2.606	0.11	11.87	-769.68	724.37	0.00	0.00	-0.21	1.34	92.29	62.36	1.490	2.975	0.601	0.281	-0.925
	8.50	-0.634	2.710	0.20	11.89	-770.17	723.87	0.00	0.00	-0.21	1.44	86.04	63.24	1.688	2.919	0.530	0.289	-0.993
	9.00	-0.636	3.196	0.20	13.82	-770.67	721.79	0.00	0.00	-0.21	1.56	83.80	77.33	1.766	2.118	0.505	0.431	-1.076
	9.10	-0.637	5.697	0.20	28.61	-770.77	714.64	0.00	0.00	-0.21	1.59	85.32	41.58	1.713	6.102	0.522	0.114	-1.100
	9.50	-0.635	5.697	0.29	26.96	-769.81	714.64	0.00	0.00	-0.21	1.79	87.59	45.53	1.633	5.212	0.548	0.141	-1.232
	9.70	-0.634	6.644	0.31	34.21	-769.93	712.93	0.00	0.00	-0.21	1.90	76.56	52.16	2.059	4.668	0.428	0.182	-1.308
	9.80	-0.634	6.859	0.34	35.41	-769.93	712.62	0.00	0.00	-0.21	1.97	76.56	56.79	2.059	4.169	0.428	0.216	-1.354
	9.90	-0.634	12.024	0.37	68.92	-769.93	708.35	0.00	0.00	-0.21	2.07	76.56	38.44	2.059	18.177	0.428	0.059	-1.426
R	10.00	-0.634	12.316	0.38	69.21	-769.99	708.25	0.00	0.00	-0.21	2.36	76.56	29.23	2.059	23.548	0.428	0.036	-1.624
	10.10	-0.634	12.619	0.38	69.21	-770.09	708.15	0.00	0.00	-0.21	2.66	76.56	28.01	2.059	25.741	0.428	0.032	-1.829
	10.50	-0.636	14.157	0.32	71.39	-770.70	707.66	0.00	0.00	-0.21	3.96	78.66	25.20	1.972	27.579	0.449	0.026	-2.708
	11.00	-0.637	15.910	-0.31	71.68	-774.56	707.14	0.00	0.00	-0.22	5.73	92.81	18.09	1.474	27.579	0.608	0.016	-3.902
	11.50	-0.637	17.195	-0.11	69.50	-774.56	706.69	0.00	0.00	-0.22	7.24	86.64	19.59	1.667	27.579	0.537	0.018	-4.923
	12.00	-0.641	18.522	-0.27	68.19	-775.59	706.22	0.00	0.00	-0.22	8.67	88.03	17.02	1.617	27.579	0.553	0.015	-5.892
	12.50	-0.642	19.635	-0.25	67.97	-775.67	705.74	0.00	0.00	-0.22	9.88	88.06	18.97	1.616	27.579	0.554	0.017	-6.707
	13.00	-0.639	20.496	0.14	64.89	-774.69	705.33	0.00	0.00	-0.22	11.00	82.36	19.85	1.816	27.258	0.490	0.019	-7.461
	13.50	-0.647	21.059	-0.24	60.81	-776.87	705.04	0.00	0.00	-0.23	11.98	81.09	19.21	1.870	26.617	0.475	0.018	-8.129
	14.00	-0.649	21.490	-0.23	57.84	-777.40	704.79	0.00	0.00	-0.23	12.84	74.78	21.07	2.148	23.027	0.408	0.022	-8.708
	14.50	-0.646	22.052	0.21	57.05	-776.20	704.42	0.00	0.00	-0.22	13.65	78.70	19.29	1.971	22.646	0.449	0.019	-9.253
	15.00	-0.647	22.133	0.14	54.55	-776.87	704.37	0.00	0.00	-0.23	14.39	69.27	20.28	2.439	21.139	0.351	0.022	-9.755

Appendix 2

Listing of Vampire run file for use with $T\gamma$ simulations

This listing does not use the $T\gamma$ output channel available in Vampire, but calculates $T\gamma$ from the creep forces and creepages directly. This is to ensure that the influence of spin creep is not included in the evaluation of $T\gamma$.

```
%insert run title here%
UNITS VAMPIRE
%insert vehicle file name here%
*TRANSIENT
      1000     0.001     0.005      0.00
SPEED     %speed%
TRACKDESIGN       %curve%
*CREEP
      0.40      0.45      8.00      0.20      0.45      0.45      0.45
NON-LINEAR
PROFILE   %contact%
*OUTPUT
Longitudinal creep force- wset1- L       kN
CL01X
Longitudinal creep force- wset1- R       kN
CR01X
Longitudinal creep force- wset1- F       kN
CF01X
Longitudinal creep force- wset2- L       kN
CL02X
Longitudinal creep force- wset2- R       kN
CR02X
Longitudinal creep force- wset2- F       kN
CF02X
Lateral creep force- wset1- L            kN
CL01Y
Lateral creep force- wset1- R            kN
CR01Y
Lateral creep force- wset1- F            kN
CF01Y
Lateral creep force- wset2- L            kN
CL02Y
Lateral creep force- wset2- R            kN
CR02Y
Lateral creep force- wset2- F            kN
CF02Y
Wear number (no spin)- wset 1- L         N
1000*(ABS(CL01X*VL01X)+ABS(CL01Y*VL01Y))
Wear number (no spin)- wset 1- F         N
1000*(ABS(CF01X*VF01X)+ABS(CF01Y*VF01Y))
Wear number (no spin)- wset 2- L         N
1000*(ABS(CL02X*VL02X)+ABS(CL02Y*VL02Y))
Wear number (no spin)- wset 2- F         N
1000*(ABS(CF02X*VF02X)+ABS(CF02Y*VF02Y))
velocity                                 m/s
SP
*
```

Appendix 3

Details of track files and vehicle speeds to attain the required cant deficiencies

Curve radius (m)	Installed cant (mm)	Vehicle speed (m/s)		
		40mm cant deficiency	Cant equilibrium	20mm cant excess
200	100	13.51	11.42	10.21
400	100	19.11	16.15	14.44
600	100	23.40	19.78	17.69
800	100	27.02	22.84	20.42
1000	100	30.21	25.53	22.84
1200	100	33.10	27.97	25.02
1400	100	35.74	30.21	27.02
1800	100	40.53	34.25	30.64
2200	75	40.61	32.80	28.08
2600	50	39.05	29.11	22.55
3000	30	37.00	24.22	13.98
4000	25	41.17	25.53	11.42
6000	10	44.22	19.78	n/a
8000	10	51.06	22.84	n/a
10,000	5	54.16	18.05	n/a