

## Chapter 9

# Program Output

When LTS is run, several output files are generated:

- Standard print output goes to the \*.out file.
- Spreadsheet-formatted output data goes to several files that are always named tmp1.prn, tmp2.prn, tmp3.prn and etc. See Section 9.2 for more detail.
- Plot output (for use with the LTG.EXE program) goes to the \*.plt file.
- Optionally, a series of files are written by LTS for import into Pi Research Ltd Analysis Software (Version 6.6.2 or higher).
- Optionally, a series of files are written by LTS for use by Track Master 2000 software.

User controllable input/output filenames are read from the LTS.INP file. In the command line (DOS-box) version, to change car, track or tire data for a run, simply edit this file and change the appropriate input filename (and output filenames, to save previous output data). In the Windows version LTS.INP is changed through on-screen selections. See Chapter 3 for more detail on the LTS.INP file.

### 9.1 Output (Print) File Description

The print file (\*.out) is a standard DOS-ASCII data file that can be viewed/edited with any text editor (or programmer's editor). This file documents a single LTS run and is primarily intended for debugging purposes. The print file can be directed to a printer with the DOS PRINT command as needed. Note that the file contains lines longer than 80 columns; therefore either a 132 column printer should be used or an 80 column printer should be in "compressed mode" — see your printer manual.

With the Windows front end, an icon for the print file appears on the main screen after a single LTS run is made. The print file can be viewed by double clicking on this icon, assuming that the .out file type (extension) has been previously associated with an application (a text editor).

#### Input Documentation and Output Summary

The print file contains several sections that document the input and summarize the output:

1. An echo of the comment lines and data from the input files.
2. A block of data calculated from the car inputs — this may be useful in sorting out input data problems. Included is: total weight, CG locations (sprung and unsprung), other dimensional data and calculated spring rate data.
3. An echo of the comment lines from the tire datafile and a tire data listing.
4. An echo of the comment lines from the track file and a calculation of the position and heading at the end of the track, relative to the starting section. Section-by-section track geometry data is included in the station output data.
5. If there were any convergence errors reported by the solver, they are printed in this location.
6. Lap time and average speed for this simulation run.

### Cutoff Point Output Data

A list of all acceleration/braking transition points (or cutoff points) on the track is given next. This list includes the following:

sta	Station number after which the transition occurs.
vprime	Speed at the transition point — mph.
lprime	Distance from the beginning of the section to the transition point — ft.
tpwr	Time spent under power from the start of the section to the transition point — sec.
tbrk	Time spent under braking from the transition point to the beginning of the next station — sec.

### Station Output Data

The output printed by the program at each station on the track includes a description of the track section geometry and a number of vehicle operational variables at that point on the track. This data is given in a multi-line format to allow it to fit within the 132 column limit of most printers.

The printed data for each station (not necessarily in this order) includes:

seg	The segment number within which the station resides. The first segment printed is the segment number associated with the start/finish line (isf in the track data file).
sta	The station number. Recall that each segment may contain more than one station. This number reflects the cumulative number of stations from the

beginning of the track data set but are printed in sequence from the S/F line.

frc	Tire/ground friction multiplier for this station. This is the product of the global friction multiplier (uglob) and the local friction multiplier (sfrc(sta)).
ba	Bank angle of the station, positive for the right side of the track down — deg.
ga	Grade angle of the station, positive for uphill — deg.
bounce	Inverse of the vertical radius of the station. Positive for a dip (increase in normal load), negative for a bump (decrease in normal load). Units are 1/ft.
rad	Plan view path radius at this station, positive for a RH turn — ft.
dist	Cumulative distance from the S/F line — ft.
time	Cumulative time from the S/F line — sec.
v	Forward speed of the car along the path, at the start of the section — mph.
ax	Acceleration in the x direction. This is the rate of change of "v" along the path with respect to time. Positive values increase speed — g's. This is not equivalent to a body fixed accelerometer.
ay	Acceleration perpendicular to the path and in the ground. This is the lateral acceleration that would be measured by an accelerometer mounted at the c.g. of the car corrected for yaw rate, yaw angle, pitch angle and absolute roll angle — g's.
v0a	This is the car speed along the path at which $a_x = 0$ . Assumed to be the maximum speed at which the car can traverse the station. Due to aerodynamic and sideslip drag, driving forces must exist to maintain $a_x = 0$ . For straights or very large radius sections, an approximate value is used representing the power limited speed of the car — mph.
bal	Brake or power balance. The fraction of the x-force that is applied by the rear wheels. For negative x-force, it appears as a negative number. It is +1.0 for a rear drive car under power; -0.25 for braking with 25% of the braking force at the rear.
phi	Car roll angle (positive right side down) — deg.

usep	Power usage. The percentage of available engine power that is being used. Under full power, 1.0. Under braking, it is negative and provides a measure of braking horsepower relative to peak engine power.
usef	percentage of current front axle force (in the plane of the road) to the maximum force available from the front tires.
user	percentage of current rear axle force (in the plane of the road) to the maximum force available from the rear tires.
del	Front wheel reference steer angle. This is the steering wheel angle divided by the overall steering ratio — deg.
bet	Car sideslip angle — deg.
fzlf	Left front tire normal force — lb.
fzrf	Right front tire normal force — lb.
fzlr	Left rear tire normal force — lb.
fzrr	Right rear tire normal force — lb.
fylf	Left front tire lateral force — lb.
fyrf	Right front tire lateral force — lb.
fylr	Left rear tire lateral force — lb.
fyr	Right rear tire lateral force — lb.
fxlf	Left front driving force — lb.
fxrf	Right front driving force — lb.
fxlr	Left rear driving force — lb.
fxrr	Right rear driving force — lb.
fslipd	Front axle tire sideslip drag. This represents the sum of the front tire side force components along the path — lb.
rslipd	Rear axle tire sideslip drag — lb.
alplf	Left front tire slip angle — deg.
alprf	Right front tire slip angle — deg.
alplr	Left rear tire slip angle — deg.

alpr	Right rear tire slip angle — deg.
SMhcg	Sprung mass CG height above ground — in.
theta	Pitch attitude, positive pitch angle is nose up — deg.
power	Engine power output at the current station — hp.
engrpm	Engine speed at the current station — rpm
gear	Transmission gear (for standard transmission) or transmission gear ratio (for cvt) at current station. Note that for a standard transmission a gear of 0 will occur at a station for which the shift time is greater than the time required to traverse the section.
vaero	Apparent wind speed (car speed plus ambient wind speed) — mph
psiaero	Apparent wind angle (per SAE aero axis) — deg.
fxa	Aerodynamic drag force acting on the car — lb.
fzfa	Front aerodynamic lift force (positive for downforce) — lb.
fzra	Rear aerodynamic lift force (positive for downforce) — lb.
fyfa	Front aero side force (positive to right) — lb.
fyra	Rear aero side force (positive to right) — lb.
mx aero	Aero rolling moment (positive right side down) — lb. ft.
gamlf	Left front wheel inclination angle — deg.
gamrf	Right front wheel inclination angle — deg.
gamlr	Left rear wheel inclination angle — deg.
gamrr	Right rear wheel inclination angle — deg.
qlf	Left front wheel rotational speed — rad./sec.
qrf	Right front wheel rotational speed — rad./sec.
qlr	Left rear wheel rotational speed — rad./sec.
qrr	Right rear wheel rotational speed — rad./sec.
helf	Left front effective radius — in.

herf	Right front effective radius — in.
helr	Left rear effective radius — in.
herr	Right rear effective radius — in.
	Note: If effective radius data (REI and KRE) are not supplied, these radii outputs default to free radius (unloaded radius).
tqlf	Left front wheel driving torque — lb-ft.
tqrf	Right front wheel driving torque — lb-ft.
tqlr	Left rear wheel driving torque — lb-ft.
tqrr	Right rear wheel driving torque — lb-ft.
atlf	Left front aligning torque — lb-ft.
atrf	Right front aligning torque — lb-ft.
atlr	Left rear aligning torque — lb-ft.
atrr	Right rear aligning torque — lb-ft.
fsalf	Left front shock force — lb.
fsarf	Right front shock force — lb.
fsalr	Left rear shock force — lb.
fsarr	Right rear shock force — lb.
shdlf	Left front shock displacement — in.
shdrf	Right front shock displacement — in.
shdlr	Left rear shock displacement — in.
shdrr	Right rear shock displacement — in.
silf	Left front longitudinal slip ratio — %
sirf	Right front longitudinal slip ratio — %
silr	Left rear longitudinal slip ratio — %
sirr	Right front longitudinal slip ratio — %

uself	Percentage of left front tire capability used — %
userf	Percentage of right front tire capability used — %
uselr	Percentage of left rear tire capability used — %
userr	Percentage of right rear tire capability used — %
hilf	Left front loaded radius — in.
hirf	Right front loaded radius — in.
hilr	Left rear loaded radius — in.
hirr	Right rear loaded radius — in.
ulf	Left front wheel center longitudinal velocity — ft./sec.
urf	Right front wheel center longitudinal velocity — ft./sec.
ulr	Left rear wheel center longitudinal velocity — ft./sec.
urr	Right rear wheel center longitudinal velocity — ft./sec.
delwlf	Left front wheel center ride travel. Positive for jounce, negative for rebound - in.
delwrf	Right front wheel center ride travel. Positive for jounce, negative for rebound - in.
delwlr	Left rear wheel center ride travel. Positive for jounce, negative for rebound - in.
delwrr	Right rear wheel center ride travel. Positive for jounce, negative for rebound - in.