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Final Report

AN INTEGRATED TRANSPORTATION LAND USE MODELING SYSTEM FOR INDIANA

Part II
Implementation Report and
User's Manual

Andrew Ying-Ming Yen
Jon D. Fricker

August 1998

Indiana
Department
of Transportation

Purdue
University

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PART II
IMPLEMENTATION REPORT AND USER'S MANUAL

by

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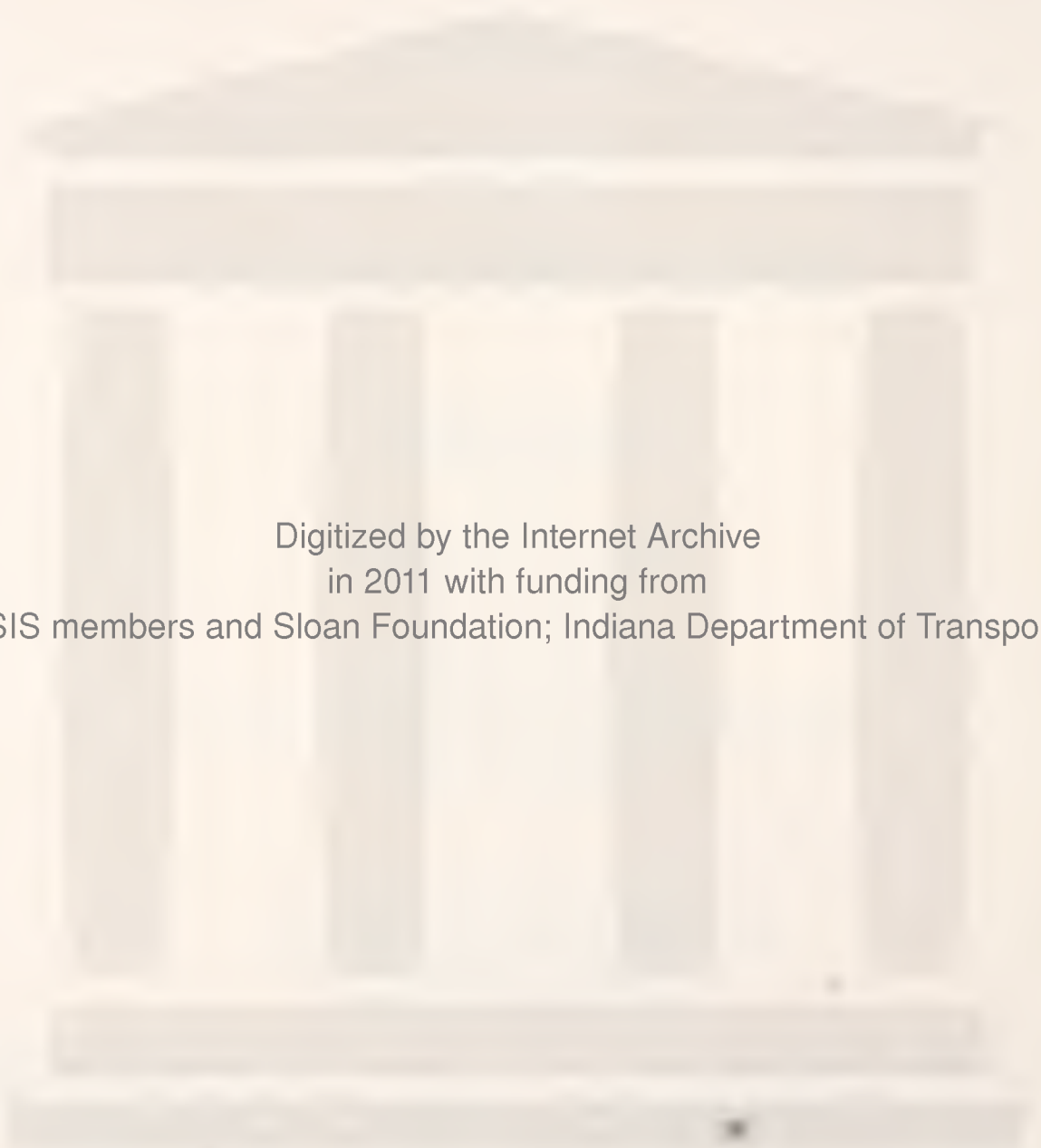
The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Indiana Department of Transportation or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

Purdue University
West Lafayette IN 47907-1284
August 1998



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16. Abstract

The principle objective of this research was to develop an integrated model to represent the interrelationships between land use and transportation, subject to the requirements of the ISTEA of 1991 and the CAAA of 1990. The integrated model includes two major parts: a land-use allocation module and a travel demand module. An interface module has also been built to transform data between these two modules. The land-use allocation module consists of a residential location model, an employment location model, a land use potential model, and a land consumption model. One unique feature of the residential and employment location models is that they simultaneously estimate passenger movement by work-to-home, home-to-shop and work-to-shop trips between zones before entering the travel demand module. Then the TRANPLAN-based travel demand module carries out trip generation and trip distribution stages for estimating home-based school, home-based other, non-home-based, external-internal and external-external trips. The land consumption model, which is significantly different from the LANCON procedure of DRAM/EMPAL, is based on micro-economic theory to simulate the profit-maximizing behavior of housing or landowners over time. The major purpose of the land consumption model is to satisfy the need to reach a balance between demand and supply in the housing market during each time period. The land consumption model is also influenced by Anas's work in CATLAS, which did not deal with employment location, but simultaneously considers housing location and employment location. The integrated model can be used to evaluate land use policies and transportation policies. Tests run for the Lafayette area have demonstrated that the model can be used to quantify positive and negative effects of long range transportation and land use plans.

The final report has two parts. Part I is the technical report that describes how the Indiana Transportation Land Use Modeling System (ITLUMS) was developed. Part II is a separate user's guide, which describes the FORTRAN programs that make up ITLUMS, the sequence in which the programs must be run, and the format of the input files needed by the ITLUMS programs.

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Introduction

This report is intended to be a user's manual. The authors have attempted to create a clear step-by-step guide to using the computer programs that make up the Indiana Transportation Land Use Modeling System (ITLUMS). Emphasis is on the sequence in which the programs must be used, the input files (names, content, and formats) that they require, and the output files (names, contents, and formats) that they produce. The explanation of each of ITLUMS' components is kept as succinct as possible. Theoretical discussions are non-existent; they can be found in the project's final report. Because some input data files are used for more than one computer program, information on the input files is presented in alphabetical order after the program descriptions. A detailed table of contents is provided.

On pages 4 and 5, flow diagrams show the sequence in which the FORTAN programs that make up ITLUMS must be run. Note that, in the Target Year flow diagram on page 5, the sequence of programs that includes "generapa.for", TRANPLAN, "luam.for", and "se.for" will probably have to be run more than twice, until *convergence* is achieved. This sequence of programs allows for the interaction of land use and transportation system changes to reach an equilibrium situation. "Convergence" is reached for the Target Year Base Case when the values in Columns B and E of output file "*.out" are "reasonably close" to the corresponding values in the previous run. If a policy test is being conducted, the values in Columns C and F of output file "*.out" must be "reasonably close" to the corresponding values in the previous run.

The ITLUMS programs are made available as executable codes. The source codes are also available from the authors, but we would prefer to receive comments on how to improve the code for all users, rather than having several different versions of ITLUMS emerge. If variations on the "standard" ITLUMS proliferate, it will become much more difficult to offer technical assistance to any user who has made independent changes to the code. The authors invite questions and feedback, both on ITLUMS in general and on this User's Guide.

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Data File Naming Convention

In the flow diagrams and descriptions that follow in this report, some data files are represented with an asterisk (*) before the file name extension. The names of these files must follow the same guidelines used by the trip generation package developed for INDOT by Bernardin-Lochmueller & Associates. The name must have the structure "innycccc.se", where

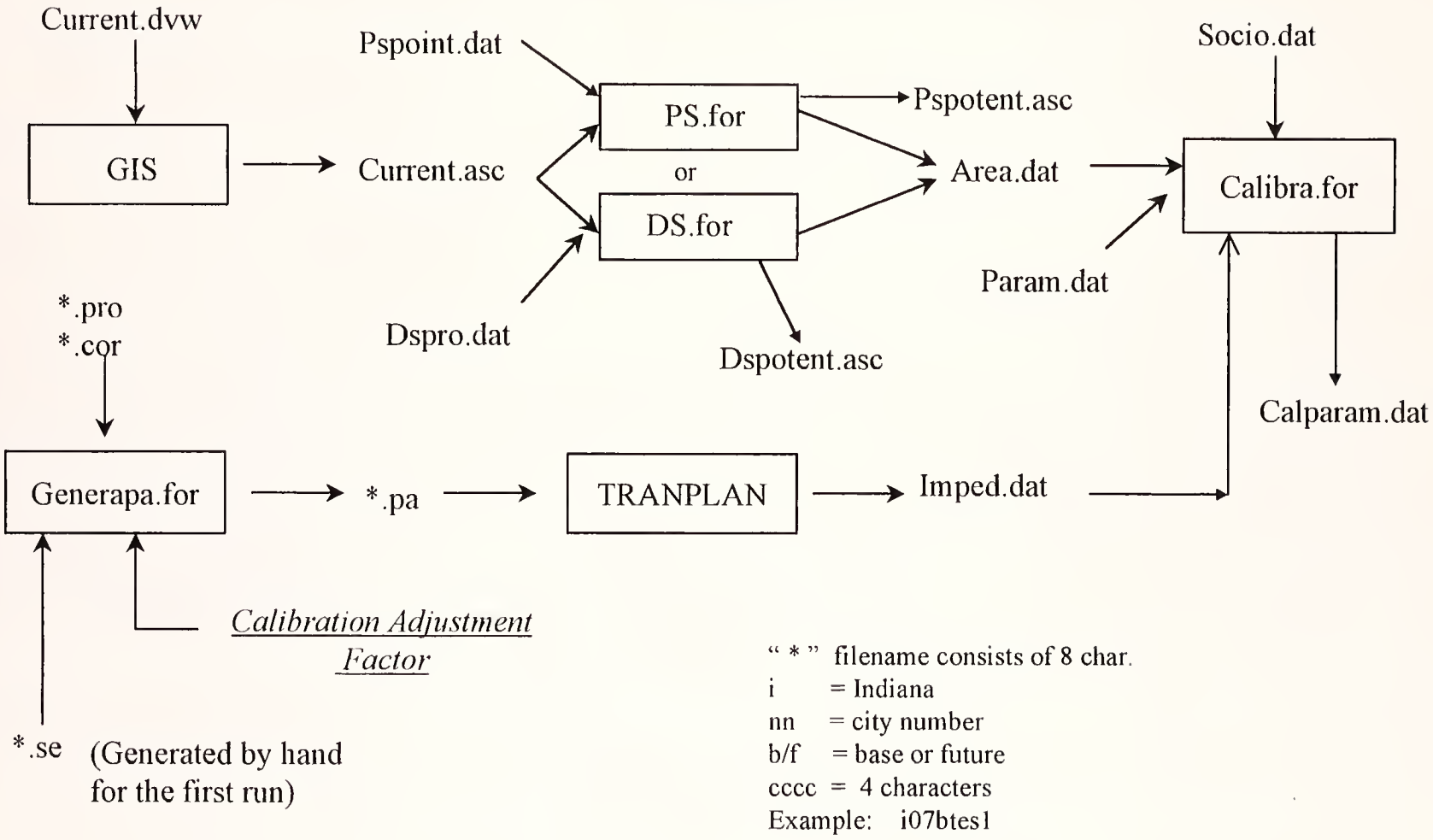
- "i" represents "Indiana".
- "nn" is the 2-digit city number taken from the table below.

nn	City	nn	City
01	Indianapolis	13	Richmond
02	Gary-Hammond Area	14	New Albany
03	Fort Wayne	15	Michigan City
04	South Bend-Mishawaka	16	Marion
05	Evansville	17	Columbus
06	Muncie	18	Lawrence
07	Lafayette-W Lafayette	19	Greenwood
08	Elkhart-Goshen	20	Carmel
09	Bloomington	21	Valparaiso
10	Anderson	22	Jeffersonville
11	Terre Haute	23	LaPorte
12	Kokomo		

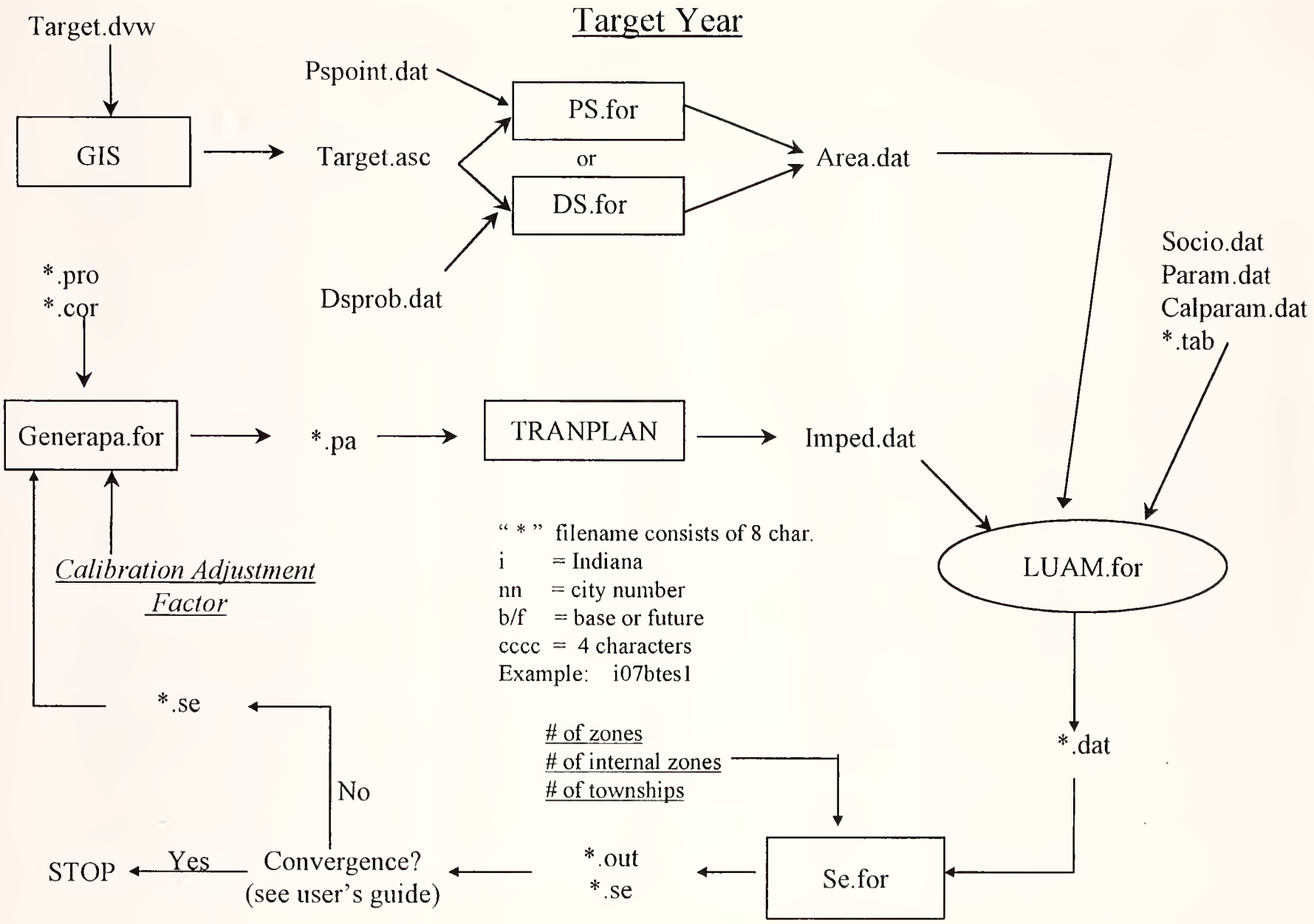
- "y" is "b" or "f", depending on whether the data are for a base or future year.
- "cccc" is a string of at most 4 characters defined by the user. This string is called the "file tag" in user-prompts by various ITLUMS computer programs.

For example, "i07bla89.se" contains base-year data for Lafayette from 1989.

Base Year



" * " filename consists of 8 char.
i = Indiana
nn = city number
b/f = base or future
cccc = 4 characters
Example: i07btes1


Target Year
Target.dvw
GIS
Target.asc
Pspoint.dat
PS.for
or
DS.for
Dsprob.dat
Area.dat
Socio.dat
Param.dat
Calparam.dat
*.tab
*.pro
*.cor
Generapa.for
*.pa
TRANPLAN
Imped.dat
LUAM.for
Calibration Adjustment Factor
" * " filename consists of 8 char.
i = Indiana
nn = city number
b/f = base or future
cccc = 4 characters
Example: i07btes1
*.se
*.dat
# of zones
# of internal zones
# of townships
No
Yes
STOP
Convergence?
(see user's guide)
*.out
*.se
Se.for

Descriptions of Computer Programs used in ITLUMS

1. GIS

Purposes: (1) To facilitate the entry and organization of land use suitability data.
(2) To permit the graphic display of geographic data.
Input files: current.dvw
Output files: current.asc
Comments: Use of a geographic information system (GIS) package is not necessary, but it makes the most tedious activity associated with the use of ITLUMS more manageable. One example is to acquire soil characteristics data in electronic form from the appropriate public agency and use GIS to lay it over the cell structure referred to in the description of the "current.dvw" file later in this user's guide. GIS can also be used to compute the distance to utilities and transportation facilities. The alternative is to generate the file "current.asc" by hand or some custom-built computer program.

2. PS.for

Purpose: To use the Point System method (Appendix A of the Technical Report) to determine the highest potential use of each land cell and to calculate the area allocated to residential, commercial, and industrial use.
Input files: current.asc, pspoint.dat
Output files: area.dat, pspotent.asc

3. DS.for

Purpose: To use the Dempster-Shafer method (Appendix B of the Technical Report) to determine the highest potential use of each land cell and to calculate the area allocated to residential, commercial, and industrial use.
Input files: current.asc, dspro.dat
Output files: area.dat, dspotent.asc

4. Generapa.for

Purpose: To generate a production/attraction file to be used by TRANPLAN in trip generation and trip distribution calculations.
Input files: *.se, *.pro, *.cor
Output files: *.pa
Comments: This program is used in both the Base Year and Target Year portions of ITLUMS.

5. TRANPLAN

Purpose: To carry out the travel demand modeling aspects of ITLUMS.
Input files: *.pa, plus all other input files normally required by TRANPLAN.
Output files: imped.dat, plus all other output files normally produced by TRANPLAN.
Comments: (a) TRANPLAN was used in ITLUMS because it is available to all MPOs in Indiana. Any other travel demand model may be used in place of TRANPLAN, as long as the output file "imped.dat" has a format useable by the next FORTRAN program in ITLUMS. (b) The GIS software used in developing ITLUMS was TransCAD. TransCAD has the ability to carry out travel demand modeling. If it can also be given the ability to carry out at least some of the other elements of ITLUMS, a streamlined version of ITLUMS would be possible.

6. Calibra.for

Purpose: To estimate parameter values in the residential and employment models that will calibrate ITLUMS to base year data.
Input files: area.dat, param.dat, imped.dat, socio.dat
Output files: calparam.dat
Comments: This program will probably take the longest time to run. On a Pentium machine, one calibration run on Lafayette data took more than 30 minutes.

7. Luam.for

Purpose: To distribute population and the number of retail employees based on zonal data for a target year.
Input files: area.dat, imped.dat, socio.dat, param.dat, calparam.dat
Output files: *.dat

8. Se.for

Purpose: First, to add up the population and the number of retail employees in each township based on zonal data created by "luam.for". Second, to produce a socioeconomic data file that includes population, the number of retail and nonretail employees, the number of housing units and the number of private vehicles in each zone.
Input file: *.dat (In the Lafayette case study, "i07ftes3.dat" is used in Policy Test 3.)
Output files: *. out and *.se. (In the Lafayette case study, "i07ftes3.out" and "i07ftes3.se" are produced during Policy Test 3.)

Description of Data Files in ITLUMS

***.cor**

This file, one of three required by "generapa.for" in either the Base Year or Target Year portion of ITLUMS, contains trips produced by zones that are external to the study area. In the Lafayette case study, one such file was called "i07bla89.cor", as shown below. If the number of trips produced by external zones does not change between the Base Year and Target Year, the "*.cor" input file will be the same in both years.

A	B
183	3415
184	730
185	9810
186	2991
187	13509
188	7337
189	1462
190	496
191	8250
192	1250
193	2491
194	100
195	330
196	731
197	531
198	594
199	343
200	180
201	1896
202	526
203	6192
204	6736
205	9129
206	1604
207	8859
208	11403
209	503
210	640

Col	variable name	format	description
A	L	I7	ID number of external station
B	CORDPS(L)	I8	Trips produced by external station L

***.dat**

As one of two output files produced by "luam.for", "*.dat" shows the expected distribution of land uses among zones. The output file shown below is from Lafayette Policy Test 3, and is called "i07ftes3.dat". Note that columns D and G have only zero entries, while columns E and H have mostly non-zero values. This is because "i07ftes3.dat" is for Policy Test 3 in a Target Year, not for the Base Case in the Target Year.

A	B	C	D	E	F	G	H	I	J	K
1	7	21	0	21	14	0	14	1	0	199
2	7	127	0	108	233	0	233	117	49	709
3	7	0	0	1	230	0	230	3	0	769
4	7	11	0	11	264	0	264	4	15	875
5	7	138	0	137	27	0	27	71	47	679
6	7	748	0	656	412	0	412	342	331	1515
7	7	475	0	421	155	0	160	271	303	381
8	7	1612	0	1551	66	0	136	694	948	238
9	7	1191	0	1112	12	0	18	565	680	120
10	7	40	0	40	58	0	31	44	38	861
11	7	1201	0	1209	22	0	26	577	713	123
12	7	1200	0	1207	64	0	62	544	764	262
13	7	1016	0	1037	7	0	5	505	720	14
14	7	1021	0	967	51	0	55	440	595	147
15	7	296	0	276	0	0	0	127	192	393
16	7	177	0	163	21	0	21	56	115	1650
17	7	317	0	317	462	0	479	185	228	634
18	7	15	0	15	595	0	567	16	30	800
19	7	579	0	531	42	0	61	236	218	1545
10	7	12	0	12	983	0	810	6	12	420
21	7	577	0	579	0	0	0	265	507	10
22	7	1017	0	1050	81	0	86	396	754	67
23	7	0	0	0	49	0	40	0	0	75

Col	variable name	format	description
A	tazn	i3	Zone number
B	dis	i6	District or township number
C	pop20	i6	forecasted zone population for target year (user-supplied)
D	pop20b	i6	base case population in zone for target year produced by "luam.for"
E	pop20f	i6	population forecast for policy test produced by "luam.for"
F	ser20	i6	retail employment forecast for zone in target year (user-supplied)
G	ser20b	i6	base case retail employment in zone for target year produced by "luam.for"
H	ser20f	i6	retail employment forecast for policy test produced by "luam.for"
I	du	i6	number of dwelling units in zone, target year (user-supplied)
J	autos	i6	number of autos in zone, target year (user-supplied)
K	nonret	i6	non-retail employment in zone, target year (user-supplied)

***.out**

This is an output file produced by "se.for". It echoes the user-supplied target year forecasts of population and retail employment in each district and adds the model's forecasts for either the target year base case or the target year policy test case. The user must compare the model's forecasts from consecutive runs of "se.for" to determine whether convergence of the land use allocation model has been achieved. The file "i07ftes3.out" for Policy Test 3 in the Lafayette case study is shown below. Each line of output is for a separate township or district, except for the last line, which gives the totals for the study area.

A	B	C	D	E	F
2110	0	1984	21	0	0
50822	0	50352	3350	0	3031
5229	0	5256	80	0	33
1983	0	1757	29	0	1
3717	0	3805	3	0	0
3167	0	2852	71	0	2
48178	0	48137	9703	0	10191
15985	0	16915	371	0	389
1378	0	1409	5	0	0
1014	0	1063	12	0	3
753	0	626	4	0	0
1136	0	1168	20	0	4
1820	0	1880	50	0	2
137292	0	137204	13719	0	13656

Col	Description
A	target year population forecast supplied by user
B	target year base case population forecast produced by model
C	target year population forecast produced by model for policy test
D	target year retail employment forecast supplied by user
E	target year base case retail employment forecast produced by model
F	target year retail employment forecast produced by model for policy test

***.pa**

Running "generapa.for" in either the Base Year or the Target Year produces the output file "*.pa". This output file contains production and attraction totals by trip purpose for each zone. The file's format matches TRANPLAN's requirements for input to TRANPLAN's Gravity Model function. (See Models page 1-7 of the TRANPLAN User's Manual, Version 8.0.) If the user prefers, this file can be created by hand or by other means exogenous to ITLUMS. Below, file "i07bla89.pa" from the Lafayette case study is shown.

```
GP     1 1        0       0     654       0
GA     1 1      632     602     654     449
GP     2 1      119     113    2070       0
GA     2 1     1903    1361    2070    1029
GP     3 1        1       1    2148       0
GA     3 1     2018    1305    2148    1029
GP     4 1       18      18    2449       0
GA     4 1     2301    1497    2449    1167
GP     5 1      124     117    1790       0
GA     5 1     1628     816    1790     748
GP     6 1      734     696    4309       0
GA     6 1     3893    2534    4309    1931
GP     7 1      539     511    1339       0
GA     7 1     1172    1190    1339     806
GP     8 1     1751    1661    1135       0
GA     8 1      806    1173    1135     728
GP     9 1     1295    1228     579       0
GA     9 1      303     450     579     325
GP    10 1       55      52    2046       0
GA    10 1     1836     463    2046     649
GP    11 1     1387    1315     627       0
GA    11 1      335     532     627     366
GP    12 1     1418    1344    1002       0
GA    12 1      705     761    1002     537
GP    13 1     1277    1211     291       0
GA    13 1       51     315     291     216
GP    14 1     1165    1105     677       0
GA    14 1      452     633     677     430
GP    15 1      359     340     946       0
GA    15 1      794     161     946     306
GP    16 1      214     203    3807       0
GA    16 1     3404     599    3807    1037
GP    17 1      382     362    2337       0
GA    17 1     2206    2468    2337    1544
GP    18 1       33      32    2792       0
GA    18 1     2717    2849    2792    1805
GP    19 1      540     512    3734       0
GA    19 1     3285     884    3734    1129
GP    20 1       15      14    2201       0
GA    20 1     2252    3480    2201    1963
```

***.pro**

Create a *city profile* for input to "generapa.for" in either the Base Year or Target Year portion of ITLUMS. The file name must follow the file naming convention shown on page 4, with the file extension "pro". For example, a file used in the Lafayette case study was called "i07bla89.pro".

This file has the ability to adjust trip generation results for special conditions in specific zones. The "FAC" value, if given for a zone, can be used as part of a multiplying *factor* to scale up or down the trip generation results that had been calculated by standard procedures. The "OFF" value, if given, will *offset* standard trip generation results by adding or subtracting the value given. The "REP" value, if given, will *replace* standard trip generation results with the user-specified value. This file is most often used in cases of special generators. If, for example, there are no special generators in the study area, or there are no changes in their trip-generating characteristics, the Base Year and Target Year versions of this file will be identical.

The contents of "i07bla89.pro" are in TRANPLAN format, as shown below and on the next page. Of the 210 zones in Lafayette, only the trip generation results for those zones shown on the next page needed to be adjusted using this file.

Line	variable name in "generapa.for"	format	description
1			Label in file
2			Population of study area
3	JSPEC(p)		Values to define factors "F1" - "F4" in "generapa.for"
4	ICORD		Trip production control total at cordon line
5	MAXZON		Maximum zone number in study area
5	INTZN1		Lowest zone number in study area
6			Ending mark
7-9			Column headers and comments
10-22*	ZON NUM	I4	Number of zones to be adjusted
10-22*	FAC	F6.0	Production multiplying factor, if desired by user
10-22*	OFF	I6	Production offset value, if desired by user
10-22*	REP	I6	Production replacement value, if desired by user
23*			Indicates end of trip production adjustments
24-26*			Column headers and comments
27-39*	ZON NUM	I4	Number of zones to be adjusted
27-39*	FAC	F6.0	Attraction multiplying factor, if desired by user
27-39*	OFF	I6	Attraction offset value, if desired by user
27-39*	REP	I6	Attraction replacement value, if desired by user
40*			Indicates end of trip attraction adjustments

* These line numbers apply to the Lafayette file shown above. As the number of zones that need adjustment vary, so will the number of lines in the file.

```
&CITYPROFILE
POPULATION=101500
JSPEC(1)=0,JSPEC(2)=0,JSPEC(3)=0,JSPEC(4)=0
ICORD=51315
 MAXZON=210, INTZN1 = 1
/
PRODUCTIONS:
```

ZON	HBW			HBNW			NHB		
NUM	FAC	OFF	REP	FAC	OFF	REP	FAC	OFF	REP
112			117			1821			1219
113			167			3943			1387
114			167			9525			5598
115			0			5130			4378
116			1487			2239			0
118			150			3626			2390
119			100			134			3442
120			100			6417			3526
121			50			0			0
122			0			869			852
123			150			401			217
126			0			2222			1220
127			351			0			0

```
9999
ATTRACTIONS:
```

ZON	HBW			HBNW			NHB			CORD		
NUM	FAC	OFF	REP	FAC	OFF	REP	FAC	OFF	REP	FAC	OFF	REP
112			0			3893			1136			0
113			0			4445			1303			0
114			2824			16409			5230			1788
115			4378			8839			4094			2857
116			0			0			0			0
118			1270			7519			2222			802
119			1838			217			3225			1170
120			818			11045			3309			535
121			0			0			0			0
122			2072			1504			802			1337
123			0			685			201			0
126			518			3827			1186			351
127			0			0			0			0

```
9999
```

***.se**

Before we run "calibra.for", we need to generate a file that contains travel cost data. This is accomplished in several steps, as can be seen in the flow diagram. The process begins by generating by hand a socioeconomic file "*.se" for input to FORTRAN program "generapa.for" in either the Base Year or Target Year portion of ITLUMS. It is likely that the Base Year and Target Year versions of this file will be different, because the Target Year file will reflect changes in population, auto ownership, and employment since the Base Year.

This is what the top part of the file "i07bla89.se" for the Lafayette case study looks like:

A	B	C	D	E	F
1	0	20	0	114	313
2	117	119	49	233	942
3	3	1	0	230	999
4	4	10	15	264	1139
5	70	134	46	127	806
6	341	726	330	412	1927
7	270	457	301	200	581
8	686	1550	937	161	399
9	566	1157	681	30	150
10	43	38	37	48	909
11	604	1219	746	43	166
12	565	1210	793	87	349
13	532	1035	758	11	25
14	459	1036	620	77	224
15	134	305	202	0	393
16	59	183	121	35	1685
17	185	305	228	457	1091
18	16	14	30	544	1344
19	238	568	219	81	1626
20	5	11	10	696	1116
21	273	606	522	0	10
22	411	1029	782	107	174
23	0	0	0	60	135
24	0	0	0	0	90
25	104	212	51	224	1028
26	339	748	434	16	60
27	500	1053	759	32	134
28	597	1268	752	17	49
29	53	191	52	62	293
30	339	713	567	32	44

Col	variable name	format	description
A	IZONE	I4	ID number for zone
B	DU(i)	I6	Number of dwelling units in zone i for policy test
C	POP(i)	I6	Population in zone i for base case or policy test
D	AUTOS(i)	I6	Number of autos in zone i for base case or policy test
E	RETAIL(i)	I6	Retail employment in zone i for base case or policy test
F	TOTEMP(i)	I6	Total employment in zone i for base case or policy test

***.tab**

Input file for "luam.for", containing zonal data on dwelling units, auto ownership, and non-retail employment. The file "i07ftes3.tab" excerpt is shown below.

```
  1      7      1      0    199
  2      7    117     49    709
  3      7      3      0    769
  4      7      4     15    875
  5      7     71     47    679
  6      7    342    331   1515
  7      7    271    303    381
  8      7    694    948    238
  9      7    565    680    120
 10      7     44     38    861
 11      7    577    713    123
 12      7    544    764    262
 13      7    505    720     14
 14      7    440    595    147
 15      7    127    192    393
 16      7     56    115   1650
 17      7    185    228    634
 18      7     16     30    800
 19      7    236    218   1545
 10      7      6     12    420
 21      7    265    507     10
 22      7    396    754     67
 23      7      0      0     75
```

Col	variable name	format	description
A	IZONE	I3	ID number for zone
B	DIS(i)	I6	Number of township or district in which zone lies
C	DU(i)	I6	Number of dwelling units in zone in target year
D	AUTOS(i)	I6	Number of autos in zone in target year
E	NONRETAIL(i)	I6	Non-retail employment in zone in target year

area.dat

This is one of two output files from "ps.for". It contains the areas devoted to residential, industrial, and commercial land uses in each traffic analysis zone. The first few lines of "area.dat" and its format are shown below. The first two lines (italicized) are added to help the user adhere to the prescribed file format.

```
         1         2         3         4
12345678901234567890123456789012345678901234567890123456789012345678
    1   .018  .000  .000  .018  .001  .000  .018
    2   .021  .000  .000  .021  .001  .000  .021
    3   .017  .000  .000  .017  .001  .000  .017
    4   .019  .000  .000  .019  .001  .000  .019
    5   .041  .000  .000  .041  .001  .000  .041
    6   .101  .018  .021  .062  .001  .059  .042
    7   .099  .021  .019  .040  .001  .059  .040
    8   .126  .066  .000  .061  .066  .020  .041
    9   .112  .044  .000  .023  .089  .000  .023
   10   .188  .024  .065  .022  .001  .111  .000
   11   .101  .080  .000  .020  .080  .000  .020
   12   .185  .097  .000  .044  .058  .083  .044
   13   .219  .140  .000  .016  .179  .000  .016
   14   .165  .042  .021  .039  .042  .040  .019
   15   .138  .046  .000  .000  .090  .000  .000
   16   .111  .046  .019  .022  .046  .019  .022
   17   .154  .023  .038  .093  .023  .055  .077
   18   .232  .020  .098  .114  .020  .118  .094
   19   .130  .040  .047  .043  .040  .069  .021
   20   .119  .026  .000  .073  .047  .024  .048
   21   .166  .100  .000  .000  .166  .000  .000
   22   .244  .140  .040  .064  .140  .040  .064
   23   .083  .000  .061  .021  .001  .083  .000
```

Fields	Variable name	Description
1-5	i	Traffic analysis zone
6-12	c(i)	Total area of zone i
13-18	b(i,1)	Current area with residential land use in zone i
19-24	b(i,3)	Current area with industrial land use in zone i
25-30	b(i,4)	Current area with industrial land use in zone i
31-36	p(i,1)	Potential area for residential land use in zone i
37-42	p(i,3)	Potential area for industrial land use in zone i
43-48	p(i,4)	Potential area for industrial land use in zone i

Calibration Adjustment Factor

In "generapa.for", the user is prompted for this value. It represents an attempt to balance the total productions in the study area to the total attractions. In the Lafayette case study, a value of 1.08 was used.

calparam.dat

The program "calibra.for" produces an output file "calparam.dat". It contains the values of five key parameters that define the calibrated form of the land use model. The contents of "calparam.dat" are shown below.

```
Parameter Value  Parameter name
 7.306281E-01  ← central
     1.033095  ← arfap
 7.029919E-01  ← gamma
 5.830720E-01  ← gammap
     1.783922  ← gammaq
```

- The parameter "central" is the central tendency parameter. It controls how much agglomeration (i.e., the tendency for businesses to locate near each other) will occur in the service sector. This parameter is called "gamma2" in the technical report.
- The parameter "arfap" converts developable service area into one component of a zone's service (or retail) attractiveness. This parameter is called "gamma1" in the technical report.
- The parameter "gamma" converts available dwelling units into one component of a zone's residential attractiveness. This parameter is called "alpha2" in the technical report.
- The parameter "gammap" converts net developable area into one component of a zone's residential attractiveness. This parameter is called "alpha1" in the technical report.
- The parameter "gammaq" converts rent and travel cost into one component of a zone's residential attractiveness. This parameter is called "alpha3" in the technical report.

Having produced the file "calparam.dat", a calibrated land use model for the Base Year has been achieved. If time and data permit, it is wise to repeat the calibration process for at least one other historical year, then compare the parameters that result. If the parameters from two or more calibrations agree, then "consensus" or average values can be used. If there is significant difference between parameter values for different years, look for trends or explanations before adopting parameter values to use in the forecast phase of ITLUMS. The file "calparam.dat" can be edited to reflect the judgment of the user regarding the best parameter values to use as input to program "luam.for" in the Target Year portion of ITLUMS.

current.asc

This is a file normally produced by GIS software. This file is produced because the input file "current.dvw" can be read only by the Maptitude or TransCAD GIS software. The file "current.dvw" can be viewed by the user while in Maptitude or TransCAD, but it cannot be printed to a file or read by an external program in its *.dvw format. However, it is possible to create the "current.asc" file in the proper format (see below) by hand.

In the Lafayette case study, the content of the output file "current.asc" was not different from "current.dvw" in any way, except that it was in ASCII text format, which made it readable by the next computer program. The ASCII text format is exactly as shown in the format table for "current.dvw".

current.dvw

Create a Land Use data file suitable for use in a Land Suitability Analysis. (See Section 3.3 and Appendices A and B in the Technical Report for descriptions of such an analysis.) This file should be based on a recent year for which good data are available. The tasks that lead to such a data file are:

- Divide the study area into small cells. In the Lafayette case study, each square mile in urbanized areas was divided into 36 cells. In rural areas, each square mile was divided into 16 cells.
- Establish factors that help determine the suitability of a piece of land to support a particular land use type. The factors used in Lafayette are listed in Table A.1 of the Technical Report. Table A.1 is reproduced on the next page.
- Assign values for each factor in each cell, according to criteria such as those shown in Table A.1.

The creation of the Land Use data file is by far the most tedious step in the entire ITLUMS process. Using a geographic information system (GIS) software package can assist this effort. Some GIS packages can generate cells with user-specified dimensions automatically. GIS software can also display the data as they are being assembled, facilitating error checking.

The first portion of the 22,576-line land use data file created for the Lafayette case study is shown on the page after Table A.1. The format shown is the text version of the input file used in the TransCAD GIS package. It has the same format as the "current.asc" file that is produced by the GIS package in the Base Year flow diagram on page 2. This format was chosen by the developer of ITLUMS. The user can choose any format that suits him/her and the GIS software being used. What matters is that the format of the *output* file (called "current.asc" in the flow diagram on page 2) is suitable for use as the input file for the next computer program in ITLUMS. This matter is discussed later in this user's guide.

Table A.1 Land use potential decision-making matrix

Factors	Residential				Agricultural			
	2	1	0	-1	2	1	0	-1
Soil Productivity	low	m	h	vh	vh	h	m	low
Soil Limitation	slight		m	severe			all	
Tendency To Flood			all soils				all soils	
Forested		yes					yes	
Sanitary Sewer (ft)	<1000							< 1000
Accessibility	paved <.5 mi	paved >.5 mi		major ins. or R.O.W			all	
Railroads & Airports (ft)			> 300	< 300			all	
Current & Expected Use	R			O	A			O

Factors	Industrial				Commercial			
	2	1	0	-1	2	1	0	-1
Soil Productivity	low	m	h	vh	low	m	h	vh
Soil Limitation	slight		m	severe	slight		m	sever e
Tendency To Flood			all soils				all soils	
Forested				yes			yes	
Sanitary Sewer (ft)	<1000	1000-7920		>7920	<1000	1000-2640		>2640
Accessibility	major ins. R. O.W	paved <.5 mi	int. R.O .W	paved >.5 mi	major ins. R. O.W	pave d <.5mi	int. R.O .W	paved <.5 mi
Railroads & Airports (ft)	< 300	300-2640	> 2640				> 300	< 300
Current & Expected Use	I			O	C			O.

Factors	Open Space			
	2	1	0	-1
Soil Productivity			all	
Soil Limitation			all	
Tendency To Flood	flooding soils		all other soils	
Forested	yes			
Sanitary Sewer (ft)			all	
Accessibility			all	
Railroads & Airports (ft)		< 300	> 300	
Current & Expected Use	O			

m: moderate
h : high
vh: very high

R: residential
A: agricultural
I: industrial
C: commercial
O: open space

Format of "current.dvw"

The italicized numbers in the first two lines below are not a part of the file. They are field numbers, inserted to help the user determine exactly where on each line a variable value should appear.

```
         1         2         3         4         5
12345678901234567890123456789012345678901234567890123456
    1VHSE0.35No  80000.0705.110A A199  0.018353     14702
    2VHSE0.37No  80000.0705.110A A199  0.017837     14631
    3VHSE0.44No  80000.0705.120A A199  0.016719     14776
    4VHSE0.55No  80000.0705.130A A199  0.019682     14703
    5VHSE0.69No  80000.0705.150A A199  0.017207     14704
    6VHSE0.84No  80000.0705.180A A199  0.018726     14705
    7VHM 0.99No  80000.0705.210A A199  0.015591     14920
    8VHM 1.14No  80000.0705.240A A199  0.018067     14847
    9VHM 1.30No  80000.0705.280A A199  0.016150     14848
   10VHM 1.45No  80000.0705.320A A199  0.016739     14849
   11VHM 1.59No  80000.0705.360A A199  0.014916     15064
   12VHM 1.74No  80000.0705.400A A199  0.015570     14991
   13VHM 1.89No  80000.0705.440A A199  0.017180     14992
   14VHM 2.05No  80000.0705.480A A199  0.015769     14993
   15VHM 1.92No  80000.0705.520A A199  0.014474     15206
   16VHM 1.80No  80000.0205.550A A190  0.015533     15135
   17VHM 1.68No  80000.0705.590A A190  0.017037     15280
   18VHM 1.54No  80000.0705.640A A190  0.018619     15207
   19VHM 1.42No  80000.0705.690A A190  0.016192     15208
   20VHM 1.32No  80000.0705.740A A190  0.016344     15209
   21H M 1.22No  80000.0705.780A A190  0.017177     15424
   22H M 1.42No  80000.0705.820A A190  0.018075     15351
   23VHM 1.32No  80000.0705.860A A190  0.015329     15352
```

Fields	variable name	format	description
1-5	dscell	I5	cell number
6-7	soilprod	A2	Soil productivity
8-9	soilimit	A2	Soil limitation
10-13	floodpla	F4.2	Distance to nearest river (miles) -- calculated by GIS
14-16	forest	A3	At least 50 percent forested?
17-21	sansewer	i5	Distance (feet) from sewer
22-26	accessib	F5.2	Distance (miles) from nearest road
27-31	railair	F5.2	Distance (miles) from railroad or airport
32-33	current	A2	Current and expected land use
34	potent	A1	Current and expected land use (field saved for output file)
35-37	taz	i3	Traffic Analysis Zone to which cell belongs
38-47	area	f10.2	Area of cell (square miles)
48-57	id	i10	ID number given to cell by GIS

dspotent.asc

This is one of two output files produced by the program "ds.for" produces two output files. Its format is the same as "current.asc", except the variable "potent" in field 34 has been updated to reflect the results of the Land Suitability Analysis. This file can be imported into GIS software to plot the results of the Land Suitability Analysis.

dspro.dat

Create this input file for Land Suitability Analysis using the Dempster-Shafer Method. For details about the Dempster-Shafer Method, see Appendix B of the Technical Report. The format for "dspro.dat" is shown below. The "dspro.dat" file used in the Lafayette case study appears on the next page. The first two lines (italicized) in the file are added to help the user adhere to the prescribed file format.

Line(s)	Fields	variable name in "ds.for"	format	description
1		dszone	free	Number of zones in study area
2		dsfactor	free	Number of factors in Land Suitability Analysis
3-(dsfactor+2)		dscatego	free	Number of attribute values possible for each factor
(dsfactor+3)	1	char	A1	If attribute value is alphabetic character, char = "c" If attribute value is integer, X?? = "i" If attribute value is real number, X?? = "r"
(dsfactor+4)-?	1-10	dac dai dar	A10 I10 F10.2	Attribute value, if char = c Attribute value, if char = i Attribute value, if char = r
(dsfactor+4)-?	11-16	ds	A6	First land use combination to be assigned a Dempster-Shafer value (see Appendix B of Technical Report)
(dsfactor+4)-?	17-21	pro	F5.2	D-S value for land use combination cited in fields 11-16
(dsfactor+4)-?	22-27	ds	A6	Second land use combination to be assigned a Dempster-Shafer value
(dsfactor+4)-?	28-32	pro	F5.2	D-S value for land use combination cited in fields 22-27
(dsfactor+4)-?	33-?			Additional land use combinations and corresponding D-S values, as decided by user.

The structure of this file's first four lines is the same as for "pspoint.dat". Once again, line 5 begins with the attribute value, but this time it is followed by one or more land use combinations and a corresponding Dempster-Shafer value. The entry "RIC" in line 5 above means that residential, industrial, and commercial land uses are all equally feasible land uses in a given cell. The entry "0.85" expresses the degree of belief that these land uses are feasible. The program "ds.for" can accept as many as 6 pairs of land use combination and D-S value data on a line.

Format of **dspro.dat**

```
         1         2         3         4         5
12345678901234567890123456789012345678901234567890123456789012
210
8
4
3
2
2
4
4
3
5
c
     L  RIC   0.85 O     0.10 RAICO 0.05
     M  RIC   0.50 AO    0.30 RAICO 0.20
     H  A     0.85 RICO  0.10 RAICO 0.05
     VH A     0.90 O     0.05 RAICO 0.05
c
     SL RIC   0.85 AO    0.10 RAICO 0.05
     M  RIC   0.48 AO    0.48 RAICO 0.04
     SE RIC   0.10 AO    0.85 RAICO 0.05
r
  0.189 AO    0.95 RAICO 0.05
  0.189 RAICO 1.00
c
    Yes O     0.55 R     0.35 AC    0.05 RAICO 0.05
    No  RAICO 1.00
i
   1000 RIC   0.95 RAICO 0.05
   2640 IC    0.80 O     0.05 RAICO 0.15
   7920 IC    0.70 O     0.10 RAICO 0.20
   7920 A     0.75 O     0.20 RAICO 0.05
r
     -1 IC    0.30 AO    0.10 RAICO 0.60
      0 IC    0.85 AO    0.10 RAICO 0.05
    0.5 R     0.50 IC    0.45 RAICO 0.05
    0.5 R     0.45 AO    0.40 RAICO 0.15
r
 0.0568 I     0.80 O     0.15 RAICO 0.05
    0.5 I     0.70 RAICO 0.30
    0.5 RAICO 1.00
c
     r  R     0.99 RAICO 0.01
     a  A     0.85 RAICO 0.15
     i  I     0.99 RAICO 0.01
     c  C     0.99 RAICO 0.01
     o  O     0.85 RAICO 0.15
```

imped.dat

The output file "imped.dat", which contains the generalized cost between each zone pair for the policy test being worked on, is produced by TRANPLAN. The file "imped.dat" is used as input to program "luam.for". File "imped.dat" has free format, with costs to ten destination zones in each line. In the excerpt below, the costs from zone 1 to all 210 zones in the Lafayette study area are shown in 21 lines of data. In the complete file, each succeeding origin zone, 2 through 210, has a set of 21 lines of data that show the cost to each destination zone. Note the changes in travel costs between the Base Year and Target Year versions of "imped.dat". If you want to preserve the base-year "imped.dat" file, save it under another name.

1	0.57	1.13	1.83	1.13	1.93	2.8	2.87	4.17	5.73	5.7	10
11	4.24	6.37	8.17	6.64	8.3	6.88	9.77	10.6	6.51	8.29	20
21	8.32	9.21	10.5	11.09	9.23	8.65	8.64	10.13	9.9	11.41	30
31	10.77	11.9	12.81	12.6	11.4	13.13	11.85	13.28	12.07	13	40
41	21.59	30.11	23.42	29.44	29.95	16.38	21.96	25.78	4.95	3.13	50
51	4.83	5.07	6.95	8.01	8.82	10.21	6.56	5.93	6.85	8.25	60
61	9.22	10.74	11.45	7.55	9.21	10.26	11.57	11.07	10.11	11.92	70
71	10.34	11.59	12.86	14.26	13.54	11.66	13.05	15.66	15.84	17.27	80
81	13.65	15.34	13.86	16.61	15.73	13.18	12.46	8.93	10.31	12.66	90
91	11.28	15.12	13.42	11.91	13.2	16.38	16.98	20.46	16.75	21.13	100
101	19.28	22.63	24.93	27.69	18.1	17.24	16.55	22.4	20.53	6.45	110
111	4.62	6.63	7.08	7.83	9.7	11.56	7.22	8.23	7.83	9.06	120
121	10.28	8.29	10.46	9.68	10.13	12.44	10.09	10.91	11.83	11.64	130
131	13.66	14.28	15.23	17.3	15.9	15.88	7.23	13.22	15.15	13.38	140
141	12.14	17.12	14.42	14.72	17.06	13.62	14.95	14.96	16.96	15.81	150
151	18.61	19.27	26.69	23.18	23.04	15.72	17.02	20.23	17.18	18.04	160
161	22.47	21.2	19.47	23.33	15.24	18.9	18.58	16.89	11.41	19.11	170
171	19.85	23.4	23.07	23.23	15.07	14.07	14.21	11.85	13.53	18.11	180
181	13.97	10.58	29.63	33.71	30.46	25.42	27.83	27.15	24.09	24.33	190
191	22.95	19.94	19.58	22.04	25.06	30.17	35.94	34.35	27.41	25.73	200
201	18.3	18.9	27.4	19.1	18.9	22.2	21.7	24.3	26.2	31.6	210

luam.out

As one of two output files produced by "luam.for", this file displays lots of diagnostic data and may be deleted after being inspected by the user.

param.dat

The input file "param.dat" contains values to control the operation of program "calibra.for".

```
1.0000
0.00
0.00
2
8
1
1
1
```

Line	Variable name in "calibra.for"	Format	Description
1	central	F8.4	Initial value of central tendency variable ...??
2	wbeta0	F8.2	Initial value of first parameter in exponential deterrence function
3	sbeta0	F8.2	Initial value of second parameter in exponential deterrence function
4	pbeta2	F8.0	Initial value of parameter in power form of deterrence function
5	num	I8	Maximum number of iterations
6	indicator	I8	= 1 if exponential deterrence function is used; = 0 if power form is used
7	popcons	I8	= 1 if population constraint is to be used; = 0 otherwise
8	sercons	I8	= 1 if retail employment constraint is to be used; = 0 otherwise

pspoint.dat

Create this input file if you want to do Land Suitability Analysis using the Point System. For details about the Point System, see Appendix A of the Technical Report. The file implements the point system shown in Table A.1 in the "current.dvw" section of this user's guide. Its format is shown below. The first two lines (italicized) are added to help the user adhere to the prescribed file format.

```
          1          2
12345678901234567890123
210
8
4
3
2
2
4
4
3
5
c
     L    2 -1  2  2  0
     M    1  0  1  1  0
     H    0  1  0  0  0
     VH  -1  2 -1 -1  0
c
     SL   2  0  2  2  0
     M    0  0  0  0  0
     SE  -1  0 -1 -1  0
r
  0.189   0  0  0  0  2
  0.189   0  0  0  0  0
c
    Yes   1  0 -1  0  2
    No    0  0  0  0  0
i
   1000   2 -1  2  2  0
   2640   0  0  1  1  0
   7920   0  0  1 -1  0
   7920   0  0 -1 -1  0
r
     -1   0  0  0  0  0
      0  -1  0  2  2  0
    0.5   2  0  1  1  0
    0.5   1  0 -1 -1  0
r
 0.0568  -1  0  2 -1  1
    0.5   0  0  1  0  0
    0.5   0  0  0  0  0
c
     R    2  0  0  0  0
     A    0  2  0  0  0
     I    0  0  2  0  0
     C    0  0  0  2  0
     O   -1 -1 -1 -1  2
```

Line(s)	Fields	variable name in "ps.for"	format	description
1		pszone	free	Number of zones in study area
2		psfactor	free	Number of factors in Land Suitability Analysis
3-(psfactor+2)		pscatego	free	Number of attribute values possible for each factor
(psfactor+3) - ?	1	char	A1	If attribute value is alphabetic character, char = "c" If attribute value is integer, X?? = "i" If attribute value is real number, X?? = "r"
(psfactor+3) - ?	1-7	pac pai par	A7 I7 F7.3	Attribute value, if char = c Attribute value, if char = i Attribute value, if char = r
(psfactor+3) - ?	8-22	PC	5i3	Point value for each of 5 land use types that corresponds to each attribute value

The first two lines in the file above indicate that there were 210 zones in the Lafayette study and that 8 factors used in the Land Suitability Analysis. Line three shows that the first factor (Soil Productivity) had 4 possible attribute values (low, moderate, high, and very high in Table A.1), the second factor had 3 possible attribute values, and so on. Line 4 indicates that the first factor's attribute values are represented by letters, namely, "L", "M", "H", and "VH".

Because the first factor has 4 possible attribute values, each of the next 4 lines contains an attribute value and the point value for that attribute value that corresponds to each of the 5 land use types. For example, line 5 has the attribute value "L", followed by the point values 2 for Residential land use, -1 for Agricultural land use, 2 for Industrial land use, 2 for Commercial land use, and 0 for Open Space. After the next three attribute values have been listed in the next three lines, information on the second factor is listed. It also has alphabetic values ("SL", "M", and "SE"). The third factor (distance to nearest river) has real-valued attribute values, so line 13 in the file shown above has the entry "r". In the next two lines, the value "0.189" is given as the distance in miles from a river beyond which a cell is not thought to be susceptible to flooding. In line 14, the point values correspond to the condition "distance < 0.189 mile". In line 15, the point values correspond to the condition "distance > 0.189 mile".
Two factors later, the attribute value type is "i", meaning the values are integers. For the fifth factor (distance to sanitary sewer), each attribute value (except for the last value) is the upper bound on a range of distances. For example, "2640" means that a cell is between 1000 and 2640 feet from a sewer line. The second instance of "7920" applies to those cells more than 7920 feet from a sewer.

pspotent.asc

This is one of two output files produced by the program "ps.for". Its format is the same as "current.asc", except the variable "potent" in field 34 has been updated to reflect the results of the Land Suitability Analysis. This file can be imported into GIS software to plot the results of the Land Suitability Analysis.

socio.dat

This is one of three files required by program "calibra.for". This file contains the population and employment data that form the basis for calibrating the land use model. It is also one of five input files required by "luam.for" to allocate land use within the study area. The first few lines of the Base Year "socio.dat" for "calibra.for" are shown below. The first two lines (italicized) are added to help the user adhere to the prescribed file format. The first few lines of the Target Year "socio.dat" for "luam.for" are shown on the next page. Because the Target Year file is for the year 2015 and policy test 3, its contents reflect the changes in population and employment that are expected.

```
         1         2         3         4         5         6
123456789012345678901234567890123456789012345678901234567890123456
  1    21    99   113  .00002    21    14     4   200    90  1
  2   127   709   942  .00002   127   233   117   250   210  1
  3     0   669   899  .00002     1   230     3   284   284  1
  4    11   875  1139  .00002    11   264     4   200   180  1
  5   138   379   406  .00002   138    27    71   200   140  1
  6   748  1515  1927  .00002   748   412   342   372   307  1
  7   475   381   536  .00002   475  9999   271   372   352  1
  8  1612   238   304  .00004  9999  9999   694   384   372  1
  9  1191   120   132  .00004  9999  9999   565   372   355  1
 10    40   861   919  .00004    40  9999    44   284   284  1
 11  1201   123   145  .00004  9999  9999   577   404   437  1
 12  1200   262   326  .00004  9999  9999   544   404   427  1
 13  1016    14    21  .00004  9999  9999   505   417   530  1
 14  1021   147   198  .00004  9999  9999   440   354   343  1
 15   296   393   393  .00004  9999  9999   127   354   421  1
 16   177  1650  1671  .00002  9999  9999    56   354   426  1
 17   317   634  1096  .00004   317  9999   185   354   354  1
 18    15   800  1395  .00004    15  9999    16   500   500  1
 19   579  1545  1587  .00002  9999  9999   236   354   359  1
 20    12   420  1403  .00004    12  9999     6   384   384  1
 21   577    10    10  .00004  9999  9999   253   404   494  1
 22  1017    67   148  .00004  9999  9999   396   404   453  1
 23     0    75   124  .00004     1  9999     0   400   400  1
```

Field	Variable name in "calibra.for"	Format	Description
1-3	taz	I3	Traffic analysis zone
4-9	total	I6	Total population in zone in base year
10-15	d(i,0)	F6.0	Total non-retail employment in zone i in base year
16-21	labor	I6	Total employment in zone i in base year
22-29	areaempl	F8.5	Area per service employee (square mile) in base year
30-37	poplimit	F8.0	Upper bound for population in zone in base year
38-45	serlimit	F8.0	Upper bound for retail employment in zone in base year
46-51	dwell	F6.0	Number of dwelling units in zone in base year
52-57	rent1*	F6.0	Housing rent in zone in base year
58-63	rent(i)	F6.0	Housing rent in zone in base year
64-66	ldummy	I3	= 1 if zone is in Lafayette or West Lafayette; = 0 otherwise

Initial housing rent values were estimated from real estate listings. The rents were subsequently adjusted by "calibra.for" to achieve a better zone-by-zone match of observed and modeled populations.

```
         1         2         3         4         5         6
123456789012345678901234567890123456789012345678901234567890123456
  1    21   199   313  .00002    21   114     1   200    90  1
  2   119   709   942  .00002   119   233   117   250   210  1
  3     0   769   999  .00002     1   230     3   284   284  1
  4    10   875  1139  .00002    10   264     4   200   180  1
  5   134   679   806  .00002   134   127    71   200   140  1
  6   726  1515  1927  .00002   726   412   342   372   307  1
  7   457   381   536  .00002   457  9999   271   372   352  1
  8  1566   238   304  .00004  9999  9999   694   384   372  1
  9  1153   120   132  .00004  9999  9999   565   372   355  1
 10    38   861   919  .00004    38  9999    44   284   284  1
 11  1163   123   145  .00004  9999  9999   577   404   437  1
 12  1164   262   326  .00004  9999  9999   544   404   427  1
 13   982    14    21  .00004  9999  9999   505   417   530  1
 14   991   147   198  .00004  9999  9999   440   354   343  1
 15   288   393   393  .00004  9999  9999   127   354   421  1
 16   173  1650  1671  .00002  9999  9999    56   354   426  1
 17   305   634  1096  .00004   305  9999   185   354   354  1
 18    14   800  1395  .00004    14  9999    16   500   500  1
 19   563  1545  1587  .00002  9999  9999   236   354   359  1
 20    11   420  1353  .00004    11  9999     6   384   384  1
 21   587    10    10  .00004  9999  9999   265   404   494  1
 22   991    67   148  .00004  9999  9999   396   404   453  1
 23     0    75   124  .00004     1  9999     0   400   400  1
```

target.asc

Run the GIS software on the "target.dvw" file to produce an ASCII text file "target.asc". As stated for "current.asc", this produces a file that can be read by an external program. In this case, the external program is either "ps.for" or "ds.for", depending on the user's preference for the Land Suitability method. However, it is suggested that both methods be used and the results at the end of the ITLUMS process be compared.

target.dvw

The file "target.dvw" is simply an edited version of the "current.dvw" file. It will show any changes that affect the factors in the study area's cells. For example, if the road network is expanded, the accessibility of some cells will be improved. If no such changes take place between the base year and target year, the "target.dvw" here will have the same contents as the original "current.dvw".