Scenario Generation Process

Presented by

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ACT-250

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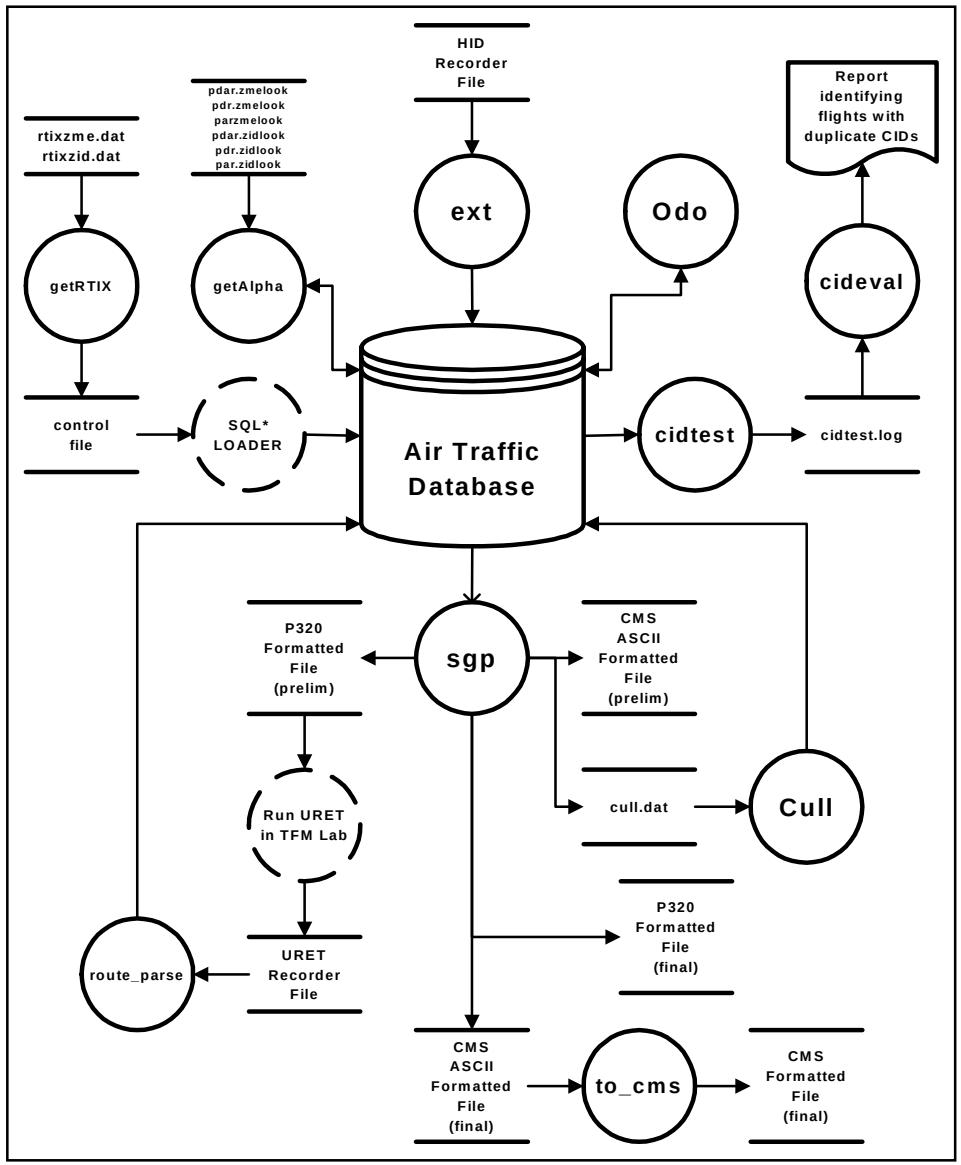
Scenario Generation Data Flow



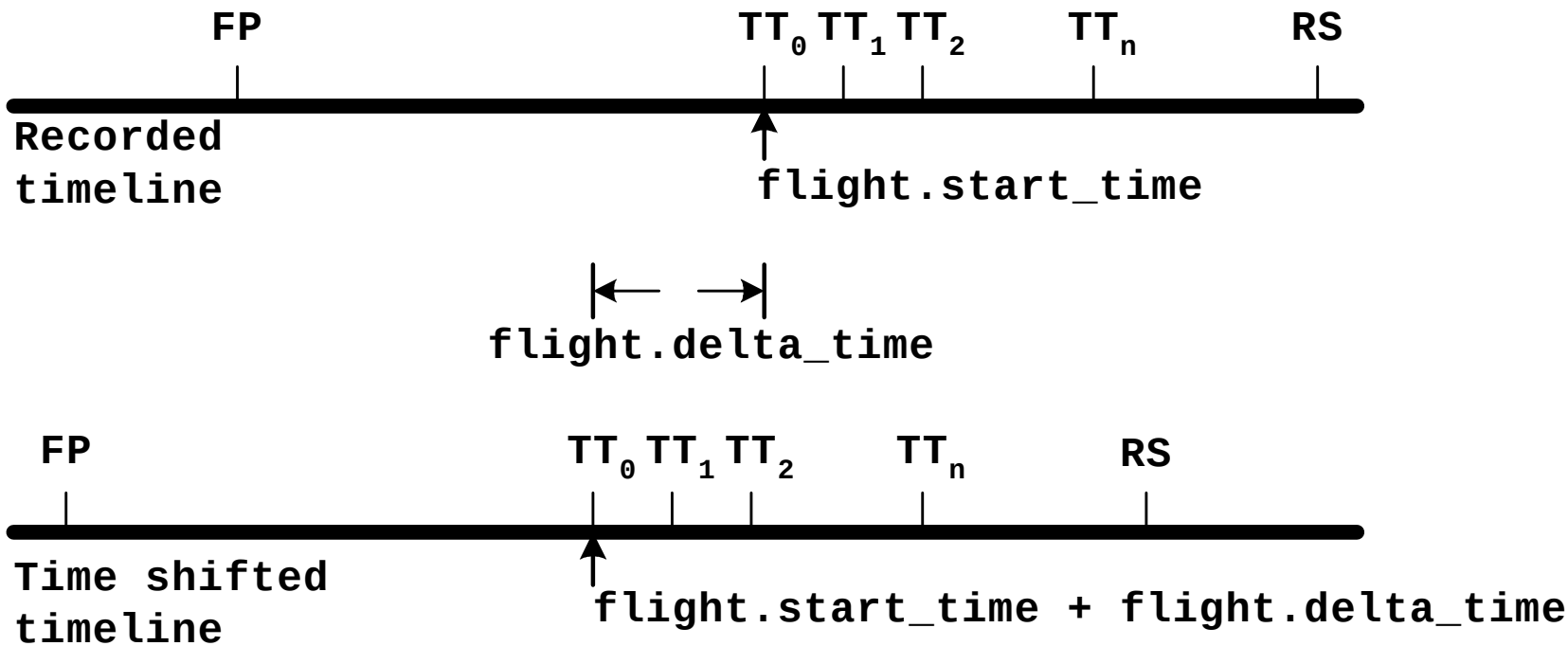
Air Traffic Database

- **Bookkeeping tables**
  - contain data set and run identification information
- **Environment tables**
  - contain center specific data
    - » constants for lat-long to x-y
    - » sector assignment and route status messages
- **Flight tables**
  - contain flight-centric message data

Flight-Centric Message Data

- A flight is established for each unique ACID / CID with a flight plan message.
- Each flight has a *start_time*, which is the time of the flight's first recorded track message.
- All other event times associated with a flight are relative to this *start_time*.
- Each flight also has a *delta_time* which changes the time events associated with flights.

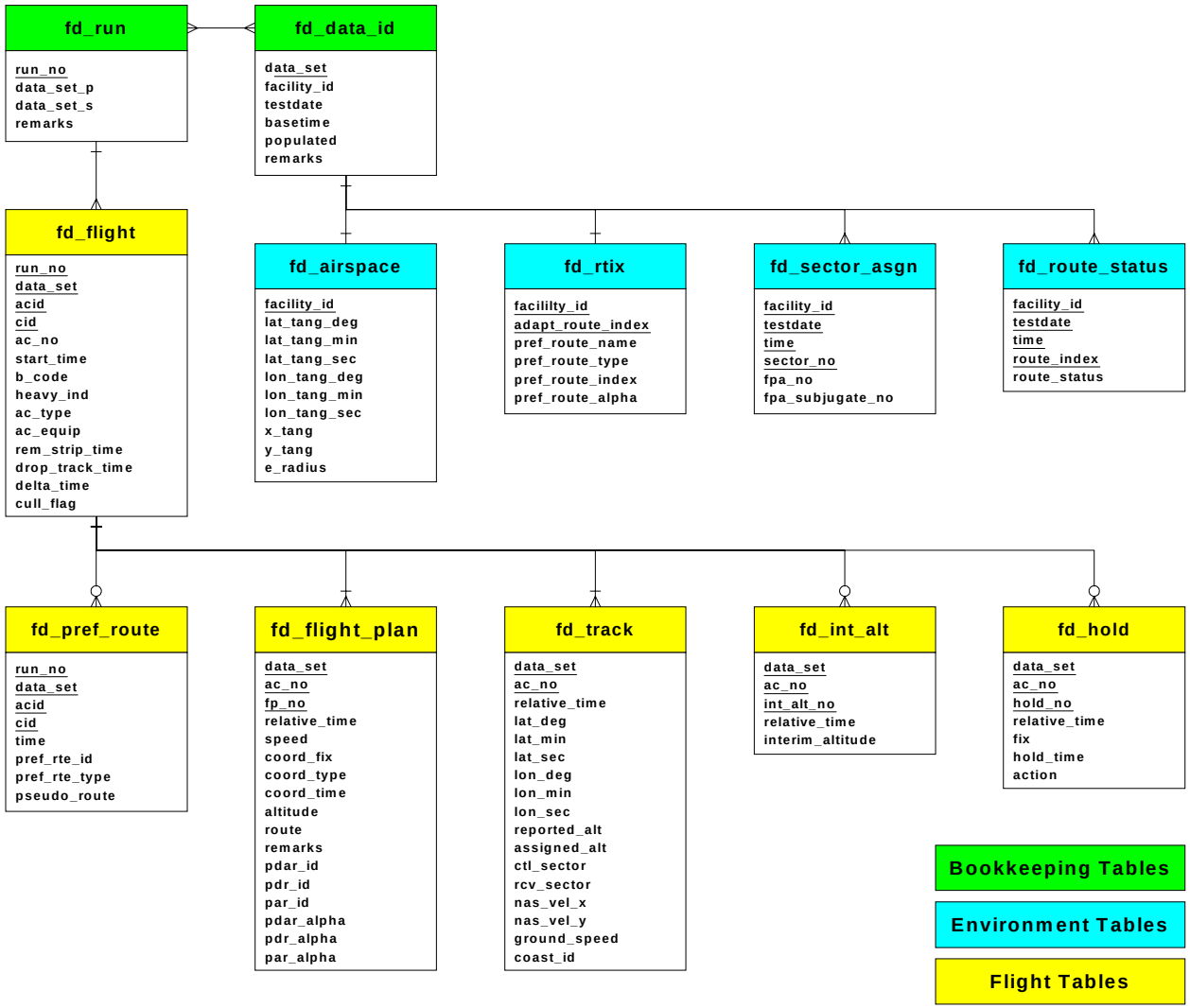
Example of Modifying a Flight by *delta_time*



Note 1: The messages in this graphic are shown using P320 message type codes.

Note 2: This graphic presents an example of a negative flight.delta_time.

ER-Diagram of Air Traffic Database



The Program *ext*

Extracts message data from a P320 HID recorder file and inserts data into the Air Traffic Database

- C++ program using the Oracle Pro*C/C++ Precompiler
- Uses *pc320fileclass* developed by MITRE
- Assigns the *data_set* number
- Establishes the nominal run for this *data_set*

  (i.e., assigns the *run_no* in which *delta_time=0* for each flight)

Sample *fd_flight* Data

DATA SET	ACID	CID	AC NO	START TIME	BEACON CODE	HEAVY IND	AC TYPE	AC EQUIP	RS TIME	DT TIME	RUN NO	DELTA TIME	CULL FLAG
1	N980WM	242	1	-1	1526		AC90	I	42530.453	0	1	0	0
1	N402BF	261	2	-1	1527		C402	A	43670.46	0	1	0	0
1	N28GP	682	3	40938.004	2031	T	H25A	G	2174.434	0	1	0	0
1	AAL445	666	4	41129.059	7050	T	MD80	G	10233.387	0	1	0	0
1	N440JC	160	5	39761.004	1540		LR60	I	0	0	1	0	0
1	N1640	636	6	39533.059	6375	T	H25B	E	1869.388	0	1	0	0
1	UPS396	370	7	39545.463	1605	F	B752	E	860.991	0	1	0	0
1	AMF667	444	8	39569.063	7316		SW4	A	0	0	1	0	0
1	N66634	684	9	39569.063	1677		BE55	I	7833.377	0	1	0	0
...													
1	BTA4006	942	391	44345.593	2561	T	E145	A	2042.856	0	1	0	0
...													

Sample *fd_flight_plan* data

DATA SET	AC NO	FP NO	RELATIVE TIME	SPEED	COORD FIX	COORD TYPE	COORD TIME	ALT	ROUTE
1	391	1	-1841.109	437	ELD	E	1216	330	IAH./.ELD.ELDTRANS.UJM.UJM3.MEM/1250
1	391	2	-437.133	437	ELD	E	1220	330	IAH./.ELD.ELDTRANS.UJM.UJM3.MEM/1250
1	391	3	-287.48	437	ELD	E	1220	290	IAH./.ELD.ELDTRANS.UJM.UJM3.MEM/1250

Sample *fd_track* Data

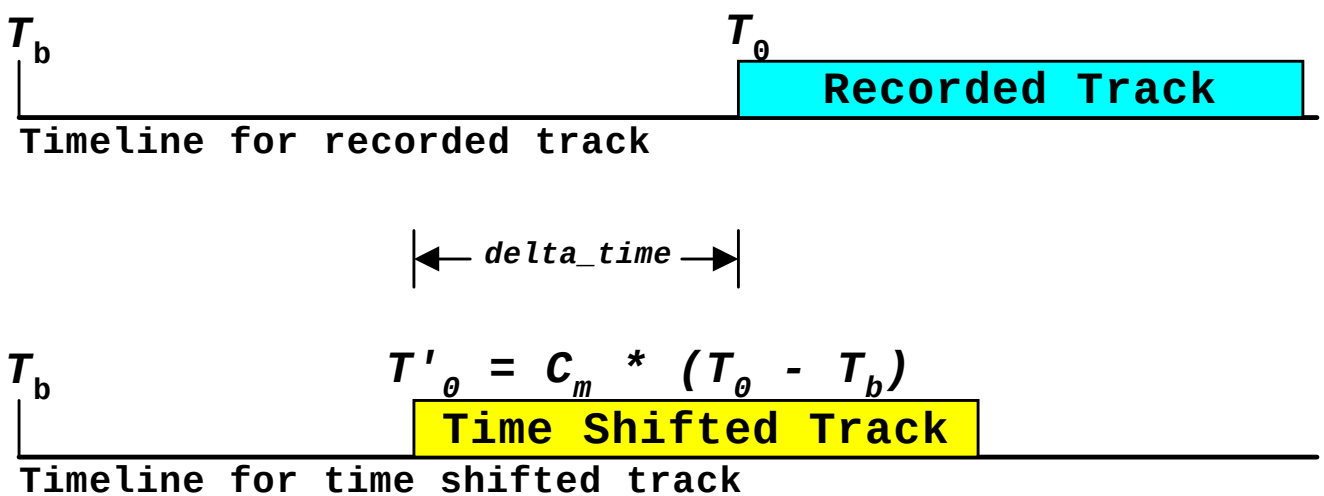
DATA SET	AC NO	RELATIVE TIME	LAT DEG	LAT MIN	LAT SEC	LON DEG	LON MIN	LON SEC	ALT	CTL SEC	RCV SEC	NAS VX	NAS VY
1	391	0	33	5	33	92	55	33	29000	~~F	44	299	346
1	391	12.541	33	6	19	92	54	32	29000	~~F	44	300	343
1	391	24.01	33	7	44	92	52	56	29000	~~F	44	303	343
1	391	36.003	33	9	0	92	51	56	29000	~~F	44	304	346
1	391	48.002	33	10	1	92	50	46	29000	~~F	44	305	346
1	391	60.006	33	11	3	92	49	27	29000	~~F	44	305	343
1	391	72.548	33	12	20	92	48	9	29000	44		307	343
1	391	84.001	33	13	29	92	46	50	29000	44		306	339
...													
1	391	1007.975	34	27	12	90	50	45	16200	15		337	284
1	391	1019.972	34	27	27	90	50	17	15700	15	MMM	329	278
1	391	1032.494	34	28	13	90	48	56	15300	15	MMM	326	272
1	391	1043.983	34	29	43	90	47	8	14400	NC		316	266
...													
1	391	1619.976	34	47	22	89	58	13	5000	NC		38	149
1	391	1632.476	34	47	52	89	58	4	4900	NC		30	153

The Program *Odo*

Creates runs using time shifting

- Asks what *data_set* (or *data_sets*) to use in run
  - » Primary data set is center under test
  - » Secondary data set is its interfacility center
- Assigns *run_no*
- Creates *fd_flight* entries from those *data_sets*
  - » with that *run_no*
  - » with *delta_time* modified
- The *delta_times* are modified by:
  - » scenario time compression
  - » random time adjustment

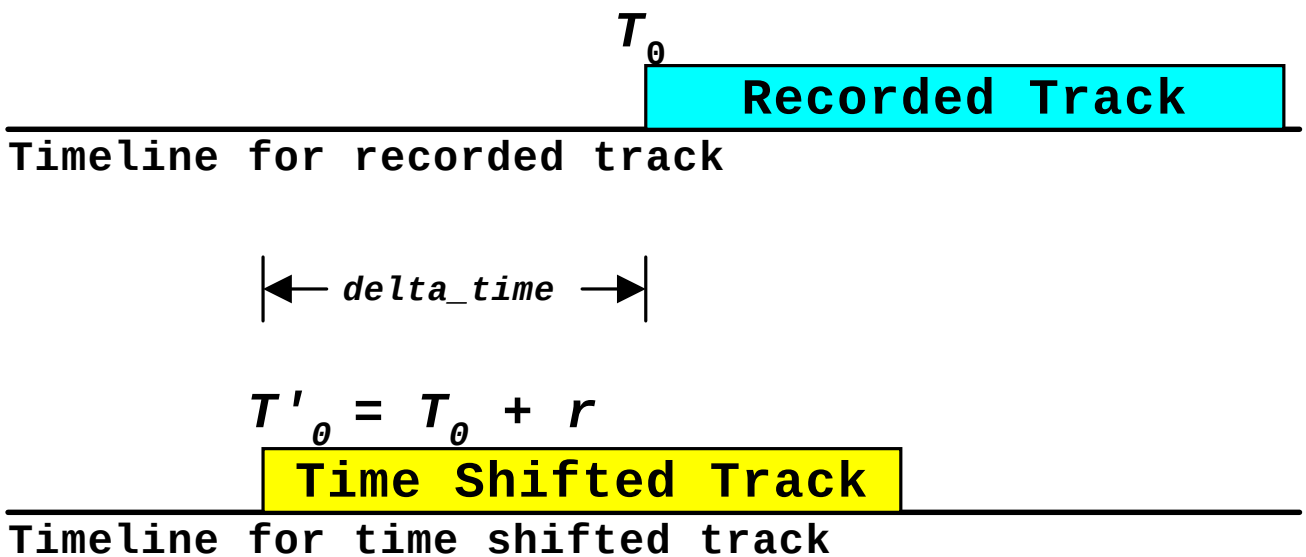
Scenario Time Compression



Where:

- C_m is a positive number between 0.0 and 1.0 and
- T_b is a basetime defined to precede all track start times in the scenario.

Random Time Adjustment



Where r is obtained from a pseudorandom number generator.
NOTE: This graphic shows an example in which r < 0.

Comments About Modifying Time

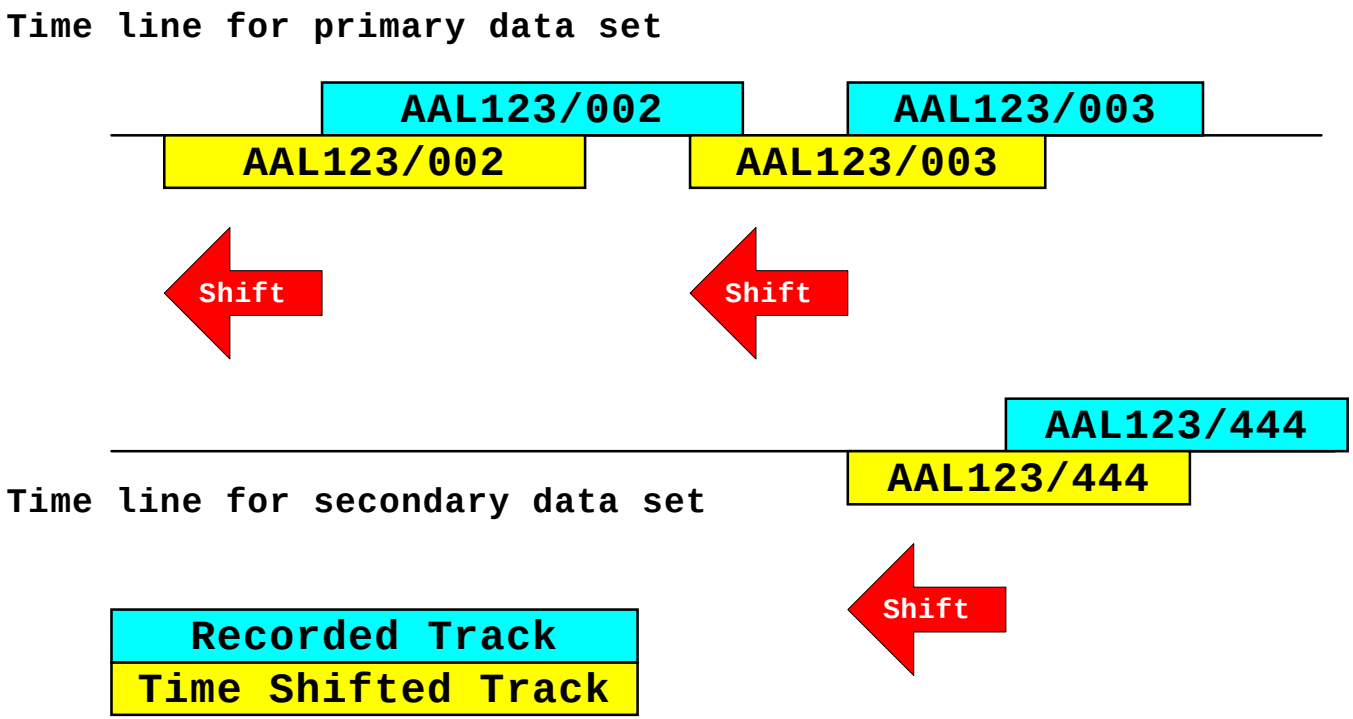
- For scenario time compression
  - 10% compression means $C_m = 0.9$
- For random time adjustment
  - pseudorandom variable optionally generated from:
    - » normal distribution
      - w / mean=0 and user defined standard deviation
    - » uniform distribution
      - w / user defined lower and upper bounds
- For both techniques
  - *delta_time* for a specific ACID is kept constant within both the primary and secondary data sets.

Maximum Time Shift

- For the accuracy scenarios ACT-250 used 10% compression, which resulted in a maximum time modification of 30 minutes earlier.
- For the accuracy scenarios ACT-250 used a uniform distribution in the interval (-1800, 0) seconds, which resulted in an additional maximum time modification of 30 minutes earlier.
- Therefore no tracks were shifted more than one hour earlier.
- ACT-250 proved that time shifting tracks up to one hour earlier does not adversely affect trajectory accuracy.*

**Reference: URET Request Evaluation Tool Daily Use Time Shifting Trajectory Prediction Accuracy Degradation Study, December 15, 1999.*

Interfacility Flights Example



Example of a flight that enters ZME airspace, lands within ZME airspace, departs, and enters ZID airspace. All timeshifts for this flight would be equal.

The Program *sgp*

Retrieves data from the Field Data Database and constructs ASCII scenario files.

- C++ program using Oracle Pro*C / C++ Precompiler
- Generates a scenario for a specific *run_no*
- Optional generates:
  - » P320 formatted scenario file
  - » CMS formatted scenario file
  - » or both
- Generates unsorted ASCII scenario file(s), which are subsequently sorted using a UNIX script

P320 Formatted Scenario File

- ASCII file
- Mutation of HCS 3.20 patch messages
- Defined by MITRE for URET testing

Example of a Sorted P320 Formatted Scenario File

```
114824 FP  BTA4006 942 E145 1 A 437 ELD 1216 E 330 'IAH./.ELD.ELDTRANS.UJM.UJM3.MEM/1250' ' ' T 2561
121148 FP  BTA4006 942 E145 1 A 437 ELD 1220 E 330 'IAH./.ELD.ELDTRANS.UJM.UJM3.MEM/1250' ' ' T 2561
121418 FP  BTA4006 942 E145 1 A 437 ELD 1220 E 290 'IAH./.ELD.ELDTRANS.UJM.UJM3.MEM/1250' ' ' T 2561
121905 TK  BTA4006 942 0 -1 44 0 290 0.0 0.0 418.38 373.92 0.0  0.0  0 299.00 346.00 0.0 0.0 0
121917 TK  BTA4006 942 0 -1 44 0 290 0.0 0.0 419.25 374.67 0.0  0.0  0 300.00 343.00 0.0 0.0 0
121929 TK  BTA4006 942 0 -1 44 0 290 0.0 0.0 420.63 376.05 0.0  0.0  0 303.00 343.00 0.0 0.0 0
121941 TK  BTA4006 942 0 -1 44 0 290 0.0 0.0 421.5 377.29 0.0  0.0  0 304.00 346.00 0.0 0.0 0
121953 TK  BTA4006 942 0 -1 44 0 290 0.0 0.0 422.5 378.29 0.0  0.0  0 305.00 346.00 0.0 0.0 0
122005 TK  BTA4006 942 0 -1 44 0 290 0.0 0.0 423.63 379.29 0.0  0.0  0 305.00 343.00 0.0 0.0 0
122017 TK  BTA4006 942 0 44 -1 0 290 0.0 0.0 424.75 380.55 0.0  0.0  0 307.00 343.00 0.0 0.0 0
122029 TK  BTA4006 942 0 44 -1 0 290 0.0 0.0 425.88 381.67 0.0  0.0  0 306.00 339.00 0.0 0.0 0
...
122541 TK  BTA4006 942 0 44 -1 0 290 0.0 0.0 460.25 404.79 0.0  0.0  0 403.00 256.00 0.0 0.0 0
122546 QQ  BTA4006 942 240
122553 TK  BTA4006 942 0 44 -1 0 290 0.0 0.0 461.62 406.16 0.0  0.0  0 402.00 258.00 0.0 0.0 0
...
123129 TK  BTA4006 942 0 15 -1 0 240 0.0 0.0 498.38 432.41 0.0  0.0  0 353.00 294.00 0.0 0.0 0
123137 QQ  BTA4006 942 130
123141 TK  BTA4006 942 0 15 -1 0 240 0.0 0.0 499.51 433.42 0.0  0.0  0 349.00 295.00 0.0 0.0 0
...
123517 TK  BTA4006 942 0 15 -1 0 179 0.0 0.0 519.76 450.68 0.0  0.0  0 345.00 296.00 0.0 0.0 0
123525 QQ  BTA4006 942 110
123529 TK  BTA4006 942 0 15 -1 0 171 0.0 0.0 521.5 451.92 0.0  0.0  0 342.00 286.00 0.0 0.0 0
...
124617 TK  BTA4006 942 0 -1 -1 0 49 0.0 0.0 567.12 474.54 0.0  0.0  0 30.00 153.00 0.0 0.0 0
125308 RS  BTA4006 942
```

Note: This is a single flight grepped from a P320 scenario file created by sgp

CMS Formatted ASCII Scenario File

- ASCII
- Defined by ACT-250
- Includes selected fields from the CMS IRD
- Uses “ | ” as a field delimiter

Example of a Sorted CMS Formatted ASCII Scenario File

```
19990526.113231000 FH
BTA4006|942|1|E145|A|2561|437|ELD|E1216|330|IAH./.ELD.ELDTRANS.UJM.UJM3.MEM/1250|PBWG1|DOLL3||||| |
19990526.115555000 AH
BTA4006|942|1|E145|A|2561|437|ELD|E1220|330|IAH./.ELD.ELDTRANS.UJM.UJM3.MEM/1250|PBWG1|DOLL3||||| |
19990526.115825000 AH
BTA4006|942|1|E145|A|2561|437|ELD|E1220|290|IAH./.ELD.ELDTRANS.UJM.UJM3.MEM/1250|PBWG1|DOLL3||||| |
19990526.120312000 TH BTA4006|942|000|290|290||44|33533N/925533W|299/346|T|
19990526.120325000 TH BTA4006|942|458|290|290||44|33619N/925432W|300/343|T|
19990526.120336000 TH BTA4006|942|458|290|290||44|33744N/925256W|303/343|T|
19990526.120348000 TH BTA4006|942|458|290|290||44|3390N/925156W|304/346|T|
19990526.120400000 TH BTA4006|942|458|290|290||44|33101N/925046W|305/346|T|
19990526.120412000 TH BTA4006|942|458|290|290||44|33113N/924927W|305/343|T|
19990526.120425000 TH BTA4006|942|458|290|290|44||331220N/92489W|307/343|T|
19990526.120436000 TH BTA4006|942|458|290|290|44||331329N/924650W|306/339|T|
...
19990526.120948000 TH BTA4006|942|479|290|290|44||333719N/92621W|403/256|T|
19990526.120953000 LH 240|BTA4006|942|
19990526.121000000 TH BTA4006|942|479|290|290|44||333843N/92444W|402/258|T|
...
19990526.121536000 TH BTA4006|942|466|290|240|15||34529N/91211W|353/294|T|
19990526.121544000 LH 130|BTA4006|942|
19990526.121548000 TH BTA4006|942|461|290|240|15||34630N/911940W|349/295|T|
...
19990526.121925000 TH BTA4006|942|457|290|179|15||342356N/905524W|345/296|T|
19990526.121932000 LH 110|BTA4006|942|
19990526.121936000 TH BTA4006|942|447|290|171|15||342511N/905318W|342/286|T|
...
19990526.123025000 TH BTA4006|942|155|290|49|||344752N/89584W|30/153|T|
19990526.123715000 CL BTA4006|942|IAH|MEM|
```

Note: This is a single flight grepped from a CMS ASCII scenario file created by sgp

CMS Formatted Scenario File

- File containing a hodgepodge of:
  - Numerous ASCII encoded headers
  - Binary data
  - EBCDIC encoded messages
- Based on message formats specified in Revision M CMS IRD dated September 1, 2000.
- SIG 264 specifies the contents and format of the deliverable CMS Formatted Scenario File
- Created by *to_cms*, using the sorted CMS Formatted ASCII file as input

Example of a CMS Formatted Scenario File

```
0000000 474d 5420 3139 3939 3035 3236 2e31 3032
0000020 3532 3330 3030 0000 00e0 0000 0001 0000
0000040 0000 3139 3939 3035 3236 3130 3235 3233
0000060 00b4 0000 5c5c 5c5c 5c5c 5c5c 5c5c 5c5c
0000100 5c5c 5c5c 00b0 c6c8 000a 0000 81f1 f0f2
0000120 f5f2 f3f0 f0f0 f000 0600 0281 c5c7 c6f5
0000140 f6f0 0003 0002 84f1 f6f5 0001 0003 81f1
0000160 0004 0003 82c1 e3f7 f200 0100 0385 c100
0000200 0400 0481 f2f1 f4f6 0003 0005 81f2 f7f0
0000220 0003 0006 81e2 c7c6 0005 0007 84d7 f1f1
0000240 f3f3 0003 0008 81f1 f6f0 0016 000a 81e2
0000260 c7c6 4b4b c2e8 d74b c2e8 d7f3 4bc4 c6e6
0000300 61f0 f1f2 f600 0500 8d81 d7c3 e6f1 f100
0000320 0500 8d82 c4e2 c5d9 f100 0300 9581 c5d6
0000340 d447 4d54 2031 3939 3930 3532 362e 3130
0000360 3239 3433 3030 3000 0001 0200 0000 0200
0000400 0000 0031 3939 3930 3532 3631 3032 3934
0000420 3300 d600 015c 5c5c 5c5c 5c5c 5c5c 5c5c
0000440 5c5c 5c5c 5c00 d2c6 c800 0a00 0081 f1f0
0000460 f2f9 f4f3 f0f0 f0f1 0005 0002 81c5 e6e6
0000500 f4f0 0003 0002 84f1 f7f2 0001 0003 81f1
0000520 0004 0003 82c4 c3f8 f700 0100 0385 c700
0000540 0400 0481 f1f5 f2f5 0003 0005 81f4 f7f4
0000560 0003 0006 81d4 c5d4 0005 0007 84d7 f1f1
0000600 f3f0 0003 0008 81f3 f1f0 0004 000a 81d4
...
```

Note: This is an od HEX dump of a CMS-formatted scenario file created by to_cms