U.S. Department of Transportation
Federal Railroad Administration

1985 TRACK SURVEY National Railroad Passenger Corporation (Amtrak)

Office of Safety
Washington, D.C. 20590

OCTOBER 1985

SURVEY OF NATIONAL RAILROAD PASSENGER CORPORATION TRACK (AMTRAK)

OFFICE OF SAFETY

FEDERAL RAILROAD ADMINISTRATION

U.S. DEPARTMENT OF TRANSPORTATION

PASSENGER CORPORATION TRACK
(AMTRAK)
OFFICE OF SAFETY
FEDERAL RAILROAD ADMINISTRATION

SUMMARY

Although the Office of Safety of the Federal Railroad Administration (FRA) routinely inspects tracks used by the National Railroad Passenger Corporation (Amtrak), a series of accidents in 1984 precipitated a comprehensive reinspection of these lines.

From September through December 1984, the FRA conducted an intensive survey of all mainline track utilized by Amtrak (see fig. 1). Three automated track geometry railcars -- the latest in railroad state-of-the-art inspection technology -- measured track gage, crosslevel, warp, profile, alignment and curvature. The inspection cars provided analog charts of the measured parameters and exception[1] reports detailing exceptions, by location, to the allowable limits.

Amtrak accident statistics over recent years were also analyzed. A 59-percent reduction in the accident rate for Amtrak trains has occurred from 1978 through 1983.

Data gathered during the surveys were monitored by the FRA inspectors on board and were given to the various on-board carrier officials so that they were immediately available for use in locating and correcting deviations. FRA track inspectors made followup inspections on the ground to verify the data and ascertain that the railroads had taken appropriate corrective actions.

[1]Track deviation from the Federal Track Safety Standards for the posted class of track. Exceptions are reported based on exceeding the thresholds of a rigid set of standards (see Appendix A) which lend themselves to computer analysis. Generally, each exception is caused by one or more defects in the geometry structure of the rails or roadbed.

FEDERAL RAILROAD ADMINISTRATION AMTRAK NETWORK SURVEY (SEPT-DEC 1984)

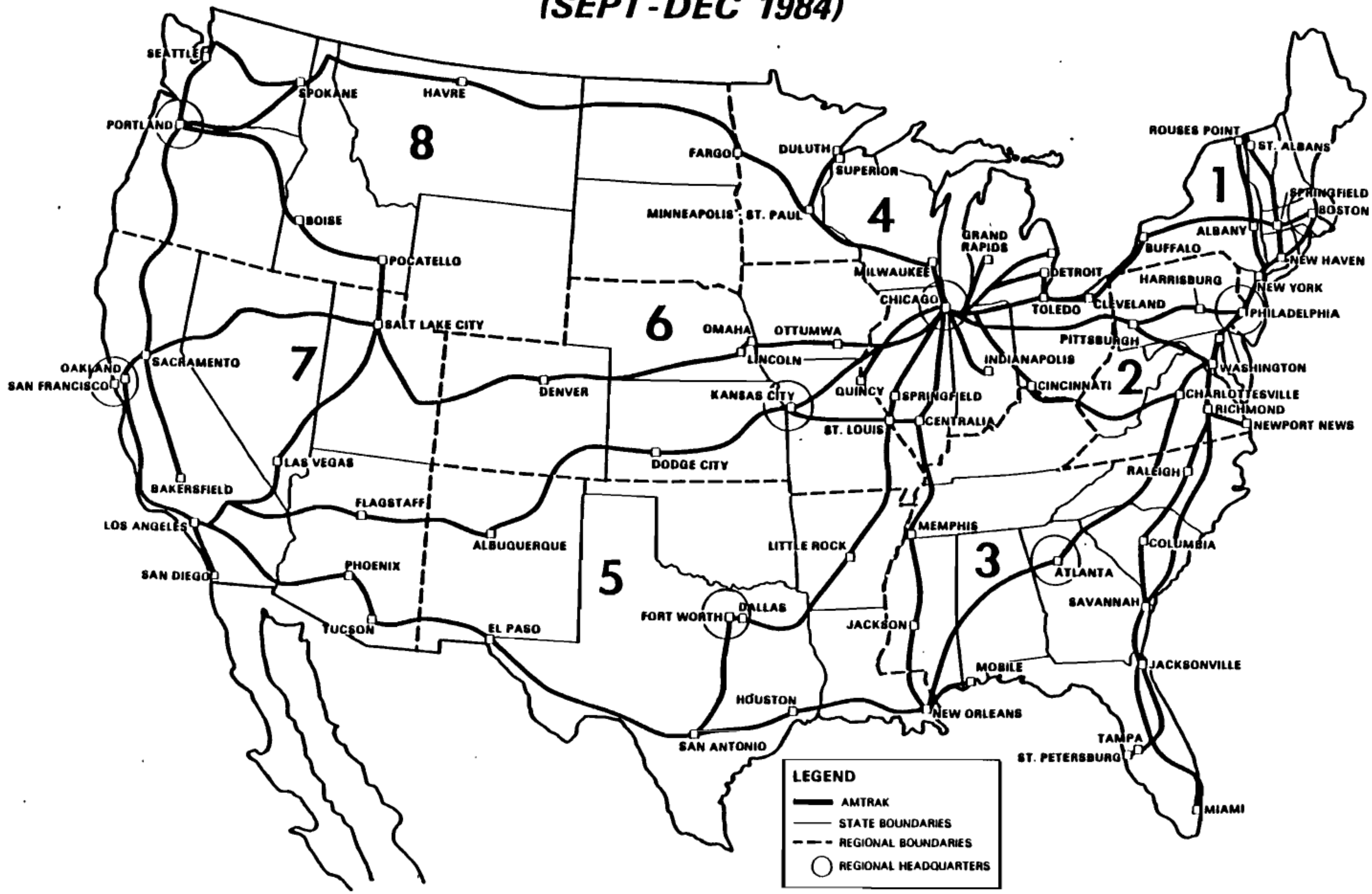


Figure 1. Network Survey Map

An enormous quantity of data (57,000 feet of charts) was generated. To obtain a general assessment of trackage conditions and still keep the analysis manageable and timely, the Office of Safety thoroughly investigated a 5,000-mile sample of the information contained in the exception reports.

In addition, data from earlier surveys in 1980, under the FRA Automated Track Inspection Program (ATIP), were compared to the 1984 sample. The parameter selected as an indicator for track geometry conditions was the percentage of track-miles that could meet the standards for the posted class, and a data base that was compiled by entering the exception information for each of the measured track geometry parameters. An analysis was performed for each track class, and the 1980 and 1984 inspection results were compared.

The major findings of the 5,000-mile sample and the analysis of accident statistics are:

(1) Posted speeds for the sampled track have increased, indicating a general upgrading of track maintenance.

(2) A higher percentage of 1984 track-miles meets the FRA standards than in 1980, reflecting a general improvement in track geometry quality over the intervening years.

(3) In both 1980 and 1984, the mean value of the sampled track footage meeting or exceeding the posted class was 99.9%.

(4) The inspection by the three automated track geometry measurement railcars confirmed the generally improving conditions on Amtrak's main lines that were originally revealed as part of FRA's routine inspections.

(5) The "exceptions" that were found are not considered to present a hazard to AMTRAK passengers. The magnitude and the rate of occurrence of "exceptions" are comparable to typical well-maintained track.

In summary, the "exceptions" found during the Amtrak network survey were few in number and generally caused by isolated defects. Many of the defects were marginal and lowered the posted track class by only one step. As in general practice, defects found by track geometry inspection cars are promptly corrected and have presented no hazard to Amtrak passengers. This is one of the immediate benefits of conducting track geometry surveys.

FEDERAL TRACK SAFETY STANDARDS

The Office of Safety of the Federal Railroad Administration (FRA) monitors and enforces Federal regulations on the Nation's railroads. The Federal Track Safety Standards (FTSS), Title 49, Code of Federal Regulations, Part 213, divide railroad track into six classes and define minimum standards for each class. (FRA track safety inspectors routinely inspect track to insure compliance with the FTSS.)

These minimum standards set forth different aspects of track safety, including roadbed, rail, track appliances and track-related devices, track geometry, and inspection requirements. Track geometry is the portion of the Federal Track Safety Standards that can be assessed by automated track inspection vehicles.

The six categories of track -- Class 1 through Class 6 -- permit a maximum allowable speed for each class. Class 6 is the highest speed track and, therefore, has the most rigid track geometry requirements. (Minimum requirements for each class of track are shown in Appendix A.)

Since 1978, FRA has used one or more high-speed track geometry measurement vehicles to monitor FTSS compliance. (Inspection routes generally include tracks used to ship hazardous materials and track used by Amtrak).

PARAMETERS MEASURED

The following critical safety related parameters are computed by the track geometry measurement vehicles (see figs. 2-4).

- o GAGE -- The distance between the rail, measured 5/8-inch below the top surface of the rail.

- LEFT AND RIGHT PROFILE -- Surface uniformity of each rail measured at the midpoint of a 62-foot chord.
- LEFT AND RIGHT ALIGNMENT -- The line uniformity of each rail measured at the midpoint of a 62-foot chord.
- CROSSLEVEL (Superelevation) -- The amount of elevation of one rail above the other.
- WARP -- The maximum change of crosslevel over 62 feet in non-spiral track and over 31 feet in spiral track, derived from crosslevel.
- CURVATURE -- A measure of the angular change in track direction per 100 feet of track distance.
- CURVE LIMITING SPEED -- The maximum allowable train speed through curves, based on the 3-inch "under balance" formula.

$$V_{(max)} = \frac{E_a + 3}{0.0007D}$$

$V_{(max)}$ = maximum allowable operating speed.
E_a = actual elevation, in inches.
D = degree of curvature, in degrees.

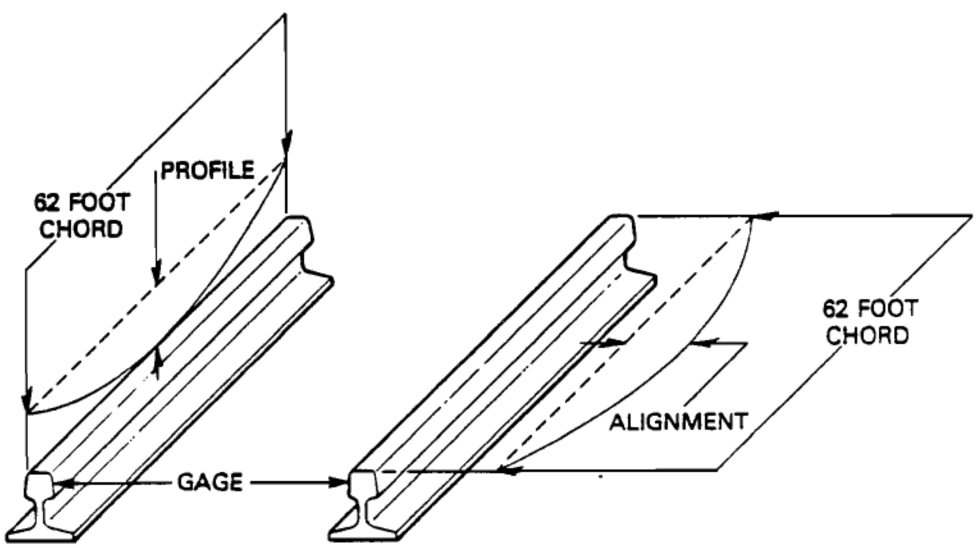


Figure 2. Gage, Profile and Alignment Measurements.

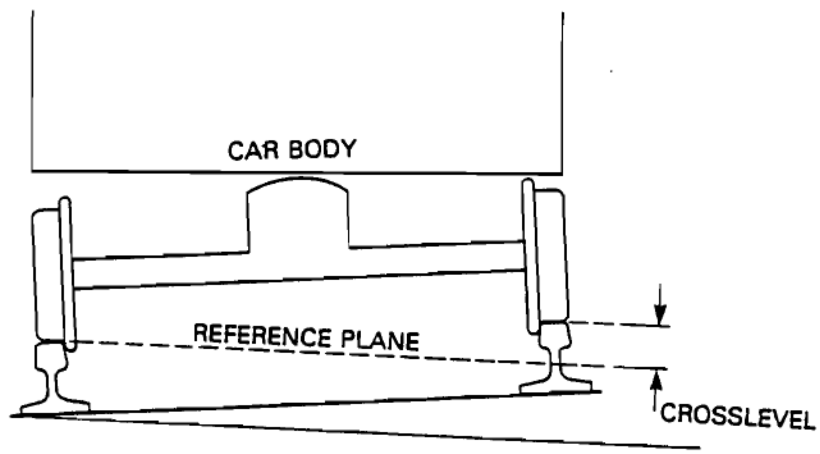


Figure 3. Crosslevel Measurement.

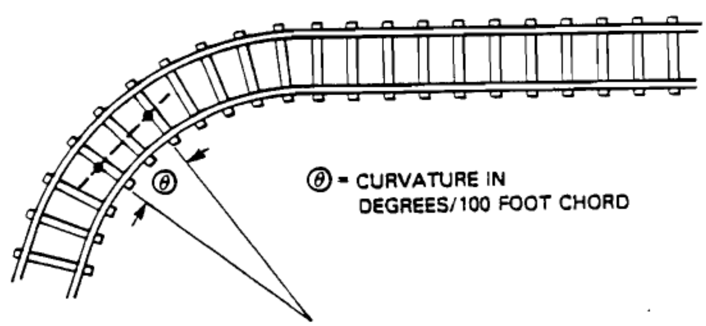


Figure 4. Curvature Measurement.

THE FTSS EXCEPTION REPORT

FTSS exception-detection software built into all the track geometry vehicles compares each individual track geometry parameter to the appropriate limits in the FTSS and prints exceptions (deviations) to FTSS. The posted class of each segment of track is entered as the track geometry vehicle traverses it. If any parameter does not meet FTSS for the posted class, then the value, location, and length of the exception are reported. The software next compares the measured value against thresholds set for a lesser class of track and reports the limiting class that the track finally does meet. The parameters are reported independently, so that a track segment may be limited to different classes by different parameters. Therefore, although each exception may lower the operating class by one or more levels, the lowest limiting class among all parameters becomes the ruling limiting class for the entire track segment.

An FTSS Exception Report includes the following:

- Title Information
- Standards Information -- A summary of Federal Track Safety Standards values.
- Class Summary -- A complete listing of the posted class for all tracks surveyed that day.
- Track Geometry Exceptions -- Also called the "detailed report," a list of each exception, its location, length, magnitude, and limiting class.
- Curve Analysis -- A list of each curve, the location of tangent spiral-curve transition points, length, average curvature, average elevation, posted speed, and limiting speed if less than posted (based on the 3-inch under balance formula from the FTSS).
- Exception Summary -- A list of each mile surveyed, its length (in feet), the number of exceptions to each parameter, and the limiting class.

AMTRAK ACCIDENT STATISTICS

The extent and range of track accidents can be comprehended by examining six years (1978-1983) of national railroad accident statistics, according to class of track as shown in table 1.

TABLE 1

U.S. TRACK DERAILMENTS COMPARED TO AMTRAK TRACK DERAILMENTS, 1978-1983

CLASS	1978	1979	1980	1981	1982	1983
U. S. TRACK DERAILMENTS						
1	2,797	2,373	2,069	1,330	1,009	926
2	916	794	663	439	344	278
3	711	555	267	292	249	235
4	206	198	171	136	110	76
5	24	18	12	7	8	15
6	0	0	1	0	0	0
	4,654	3,938	3,383	2,204	1,720	1,530
AMTRAK TRACK DERAILMENTS						
1	19	19	19	13	14	9
2	5	1	3	6	6	3
3	6	5	10	3	4	1
4	2	3	1	2	5	2
5	2	2	2	0	1	1
6	0	0	0	0	0	0
	34	30	35	34	30	16

Source: Federal Railroad Administration, Office of Safety.

The relationship between class of track and train speed is shown in Table 2.

TABLE 2

CLASS OF TRACK AND TRAIN SPEED

Class	Maximum Allowable Freight Train Speed (mph)	Maximum Allowable Passenger Train Speed (mph)
1	10	15
2	25	30
3	40	60
4	60	80
5	80	90
6	100	110[1]

[1] Amtrak operates up to 120 mph at specific locations in the Northeast Corridor.

Source: Federal Railroad Administration, Office of Safety.

For the six years, 1978 through 1983, there has been a continuous decline in track-caused derailments for all railroads -- a 67-percent decline in derailments when the two years, 1978 and 1983, are compared. Amtrak track-caused derailments make up approximately 1 to 2 percent of national track-caused derailments. However that percentage appeared questionable, so the Office of Safety examined the FRA accident statistic data base for the years 1982 and 1983. Amtrak-reported track accidents are tabulated and compared to nationwide Figures in Table 3.

TABLE 3

CAUSES OF AMTRAK TRACK DERAILMENTS, 1982-83

CATEGORY	CAUSE					NON-PASSENGER, NON-TRACK-RELATED
			1982			
Track Class	Gage	Alignment	Switch Point	Broken Rail	Flash Flood Mud Slide	Conrail, Work Train, Yard Switch, Other
1	2	0	2	0	0	9
2	2	0	1	1	0	3
3	1	0	1	1	0	1
4	0	1	0	1	3	0
5	0	1	0	0	0	0
6	0	1	0	0	0	0
	5	2	4	3	3	13
			1983			
1	1	0	4	0	0	4
2	1	0	0	0	0	2
3	1	0	0	0	0	0
4	0	0	0	1	0	1
5	0	0	0	1	0	0
6	0	0	0	0	0	0
	3	0	4	2	0	7

Notes: In 1982, there were 17 passenger train derailments; and 13 derailments other than passenger trains, resulting in 30 derailments on Amtrak track.

In 1983, there were 9 passenger train derailments; and 7 derailments other than passenger trains, resulting in 16 derailments on Amtrak track.

Source: Federal Railroad Administration, Office of Safety.

In 1982, the ratio of track derailments of Amtrak passenger trains to all track-related derailments was:

$$\frac{17}{1,720} \text{ or } 1\% .$$

In 1983, the ratio of track derailments of Amtrak passenger trains to all track-related derailments was:

$$\frac{9}{1,530} \text{ or } 0.6\% .$$

In addition, further study of the data base for the two years shows that 40 percent of Amtrak's reported track derailments involved non-passenger freight trains or non-revenue trains, such as Conrail's freight trains moving on the Northeast Corridor and Amtrak's non-revenue work trains. This statistical reduction alters the numbers in Table 1 and reduces the annual total of Amtrak track derailments for Amtrak passenger trains.

Another measure of accidents is the number of train accidents per million train-miles. Table 4 includes all train accidents (collisions and derailments), and aggregates the causes by:

Human Factors
Equipment
Track
Other

TABLE 4

ACCIDENTS/MILLION TRAIN-MILES

	Accidents Per Million Train-Miles		Train-Miles	
Year	Amtrak	All	Amtrak	All
1983	2.1	7.0	29,626,679	558,190,305
1982	3.9	8.0	29,917,844	573,368,609
1981	3.1	8.5	31,125,104	676,216,511
1980	4.1	11.8	29,940,609	717,661,741
1979	4.4	12.8	32,292,746	763,428,674
1978	5.1	15.0	32,797,746	751,964,275

Source: Federal Railroad Administration, Office of Safety, Accident/Incident Bulletins for Calendar Years 1978, 1979, 1980, 1981, 1982 and 1983.

Table 4 shows a 59-percent reduction in Amtrak accidents over a 6-year period as compared to a 53-percent reduction in national accident statistics over the same period. During that time, there was a significant reduction in national train-miles traveled, while Amtrak's train-miles traveled remained relatively constant.

THE TRACK GEOMETRY VEHICLES

FRA's coach size track geometry measurement vehicles -- inspection cars T2-T4, T-10 and Amtrak's 10001 -- are able to reveal conditions undetected by the human eye. The vehicles can:

- o Measure track under load and high speed, thereby measuring true deflection and distortion
- o Measure continuously in 1-foot increments
- o Continuously compare measurements against the FTSS

In August 1984, FRA reactivated test cars T2-T4, rescheduled the operation of the active single car T-10, and, in cooperation with Amtrak, coordinated the use and operation of Amtrak's 10001 car. The three consists were examined and overhauled, if necessary, and the vehicles were prepared for the national survey, beginning in September.

Type	Description
T-10	A single-unit, self-propelled track geometry measuring vehicle built on a Budd SPV-2000 diesel-propelled passenger coach, operating independently of a locomotive or support car.
T-2	A locomotive-hauled track geometry-measuring vehicle with instrumentation and on-line data processing.
T-4	A locomotive-hauled car with a generator, a workshop, an office, kitchenette; it works in support of T-2.
10001	An Amfleet coach equipped with rear viewing area, kitchenette, and self-support systems; instrumented with track geometry-measurement equipment and towed on the rear of Amtrak passenger trains.

Maximum Operating Speeds

T2/T4	110 mph
T-10	80 mph
10001	110 mph

THE AMTRAK NETWORK SURVEY SAMPLE

For the purpose of this assessment, a sample of 5,000 miles of track was selected, for both the 1984 survey and the survey of 1980. Track quality was judged by calculating the number of miles that fell into each class of track.

Since each mile of track is rated according to the lowest class met for any part of the mile, the analysis uses one track-mile as the basic calculating unit. Each mile with a class rating lower than the posted class may only have one exception within the mile, or may have a very large number of exceptions. The measured, or "limiting," class of the mile is determined by the allowable class of the most severe exception.

The FRA vehicles, T2-T4 and T-10, began to survey the passenger network in Washington, DC, on September 4, 1984. The T2-T4 were attached to the rear of Amtrak trains on the following routes: east-west routes between the northeast and Chicago; east-west routes between the midwest and the Pacific States; and the north-south route between San Diego and Seattle.

The self-propelled T-10 concentrated on the following routes: the two east-west routes between Washington, DC, and Chicago; the two north-south routes between Washington, DC, and south-central or southern Florida; the north-south route between Washington, DC, and New Orleans; the Gulf States' route between Mobile and San Antonio; and the north-south route between St. Louis, Dallas-Ft. Worth and San Antonio.

Amtrak's vehicle 10001, attached to the rear of passenger trains, surveyed the Northeast Corridor between Washington, DC, and Boston. The 10001 also surveyed passenger routes, radiating in spokelike fashion from Chicago.

FRA's two-car operation, T2-T4, was attached to the rear of scheduled Amtrak passenger trains moving at speeds of up to 90 mph and for distances exceeding 500 miles. On the final day of operation, November 30, 1984, the T2-T4 had surveyed 26,059 miles of track.

The self-propelled T-10 surveyed in daylight hours, 5 days per week. An average distance per day was 200 miles, and, upon the completion of the final day, December 19, 1984, the T-10 had surveyed 9,270 miles of track.

On the Northeast Corridor, Amtrak's vehicle 10001 surveyed 450 miles per month in September, October, November, and December. In addition, 10001 surveyed 5,289 miles of contract carrier routes during this period. Table 5 shows the mileage surveyed by the three track geometry vehicles.

TABLE 5

TRACK-MILES SURVEYED BY GEOMETRY VEHICLES, SEPT-DEC 1984[1]

Geometry Vehicle	NEC Track (mileage)	Contract Carriers' track[2] (mileage)
T2-T4	0	26,059
T-10	0	9,270
10001	1,797	5,289
	1,797	40,618

[1] Includes second or multiple main track.

[2] Includes the vehicles' return over single track if the instruments were "on" and measuring. For example: Shelby, MT, to Fargo, ND, and return.

Source: Office of Safety, Federal Railroad Administration.

THE DATA, ITS COLLECTION AND DISTRIBUTION

FRA's track geometry vehicles continuously record data on strip charts mounted at the rear (in the vestibule viewing area) and process and print exceptions digitally (at the computer area in the center of the car). Carbody-mounted sensors, accurate to within 1/10th inch, continually collect data on track gage, crosslevel, curvature, alignment, and track profile.

Strip charts with these parameters are furnished to carriers' representatives and the FRA inspector onboard. Digital printouts are usually distributed at the end of each day, but, if further processing, editing, and data validation are required, digital reports are mailed to the railroad and the FRA inspector.

Analog Charts

Computed track geometry parameters are displayed on continuous paper charts (see fig. 5). Chart length is scaled to distance traveled, at the rate of 17 inches per mile, regardless of survey speed. Data channels include left and right rail profile, left and right rail alignment, track crosslevel, track curvature, gage, and automatic location detection (ALD). The ALD channel provides signatures of such track structures as switches, bridges, and road crossings for reference to physical locations. Manually entered milepost locations are also displayed on the ALD channel for additional location reference. In T-10 and T-2, where real-time outputs are available, multiple copies are produced for onboard inspectors and track maintenance personnel to examine and review during and after the test.

Railroad officers and employees remedy the defects by either slowing the speed of the trains, correcting the defects, or varifying (by a field inspection) that the alleged defects are within tolerance levels.

OSCILLOGRAPH RECORDING

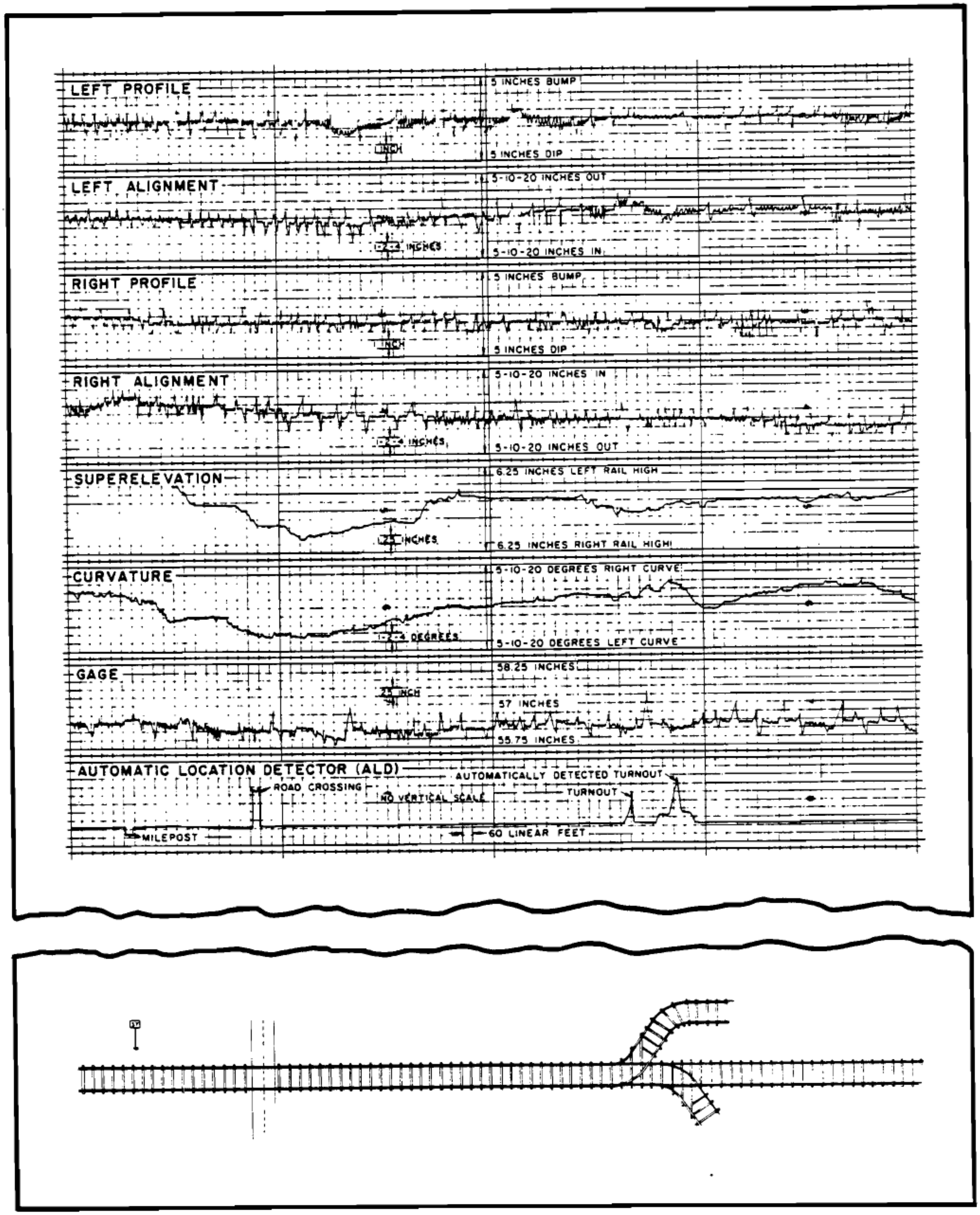


Figure 5. Analog Chart.

FRA safety inspectors follow up the original inspection no later than 60 days after each survey to make certain that railroads have brought the surveyed track into compliance with FTSS.

TRACK SAMPLE

Figure 6 shows the posted class distribution of the sampled trackage for 1980 and for 1984. Note that most of the track is Class 4 or 5, a valid representation of the class distribution for Amtrak. Since the samples from 1980 and 1984 are taken from identical track routes, the upward shift in posted class distribution represents changes in class designations made by the railroads. Significant portions of the track were upgraded from Class 4 (1980) to Class 5 (1984). This, in itself, shows a higher maintenance level and thus permits higher operating speeds by the railroads.

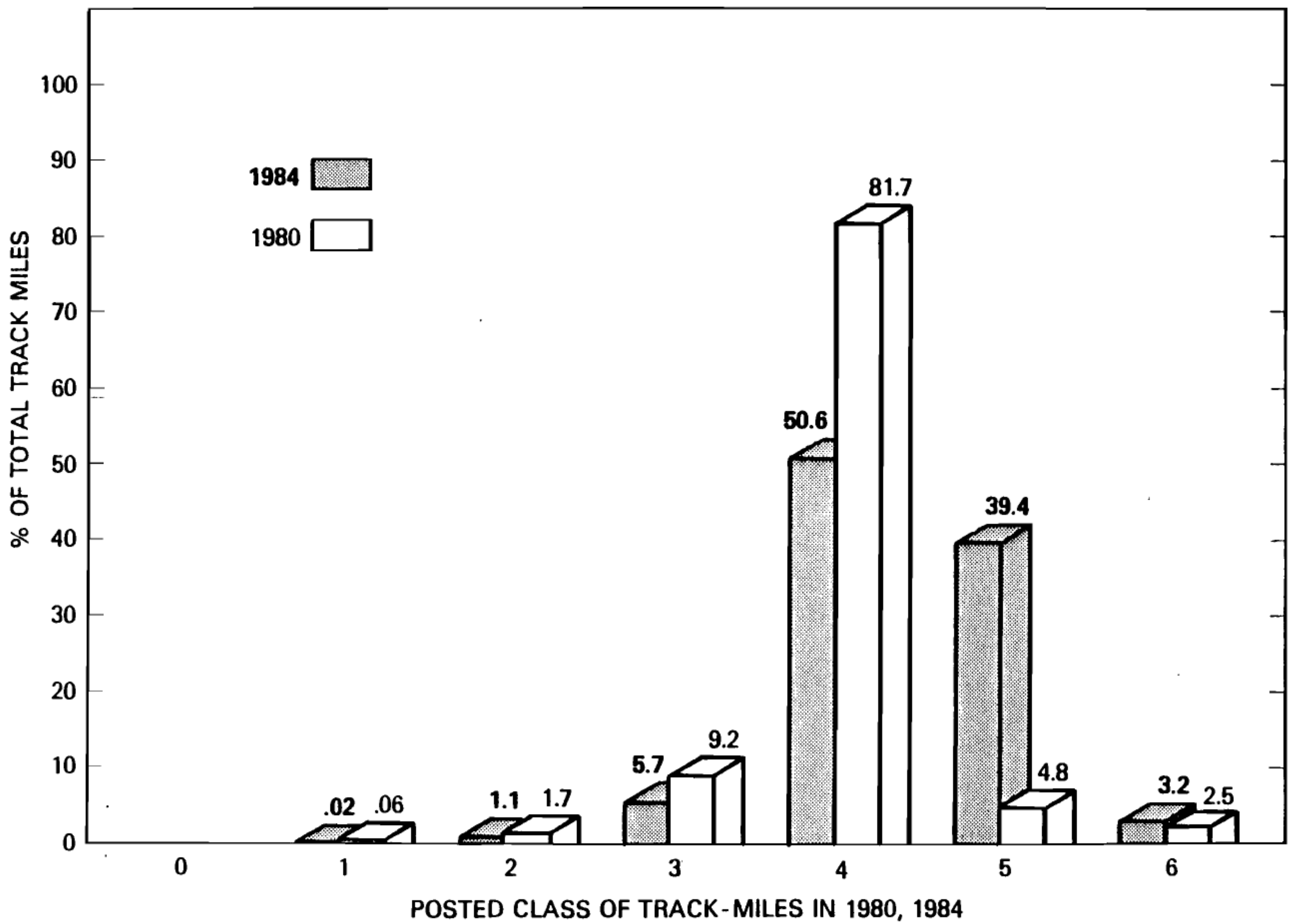
OVERALL TRACK CONDITIONS

A detailed analysis of "exceptions" based on track footage was performed. Table 6 shows the percentage of footage for each class of track that met posted class, based on total surveyed footage. The mean percentage of track-feet which met the required value was 99.90 percent in 1980 and 99.93 percent in 1984.

To establish a trend for the average quality of the track, FRA has used the percentage of track-miles meeting the specific posted track class. Since only one foot, or less than .02%, of a given mile can cause the entire mile to be reduced in class, the track-mile measure yields a broader and more severe description of track quality.

It should be noted that in the practical application of the FRA TSS some exceptions are found even in the best maintained trackage. The percent of track-miles containing exceptions is thus a useful measure of relative track quality and it also

SUMMARY OF POSTED CLASS TRACK



SOURCE; FEDERAL RAILROAD ADMINISTRATION, OFFICE OF SAFETY

Figure 6. Summary

TABLE 6

PERCENTAGE OF TRACK-FEET MEETING POSTED CLASS

Class	Warp		Gage		Crosslevel		Profile	
	1980	1984	1980	1984	1980	1984	1980	1984
1	100.00	100.00	100.00	99.65	100.00	100.00	100.00	100.00
2	99.83	99.92	99.90	99.86	99.99	99.99	100.00	100.00
3	99.94	99.96	99.98	99.92	99.99	99.96	100.00	100.00
4	99.86	99.93	99.90	99.83	99.97	99.98	100.00	100.00
5	99.69	99.91	99.62	99.95	99.93	99.97	99.98	100.00
6	98.97	99.30	98.67	99.98	97.87	98.73	99.14	99.77
OVERALL	99.84	99.90	99.85	99.89	99.93	99.94	99.98	99.99

Note: A typical warp exception length of eight feet is assumed.

Source: Office of Safety, Federal Railroad Administration.

provides information to track maintenance personnel on where spot maintenance might be needed.

Common Type of Track Exceptions

To determine the contribution from specific parameters to the reduction of track class, data for individual parameters for Class 4 track, (the largest data base class) were examined.

Figures 7 through 9 give the results for warp, gage, and crosslevel. Profile "exceptions" are relatively rare, and their contribution to lowering the track class is insignificant. Overall, warp is the largest contributor to "exceptions," followed by gage, and crosslevel -- consistent with earlier track geometry data.

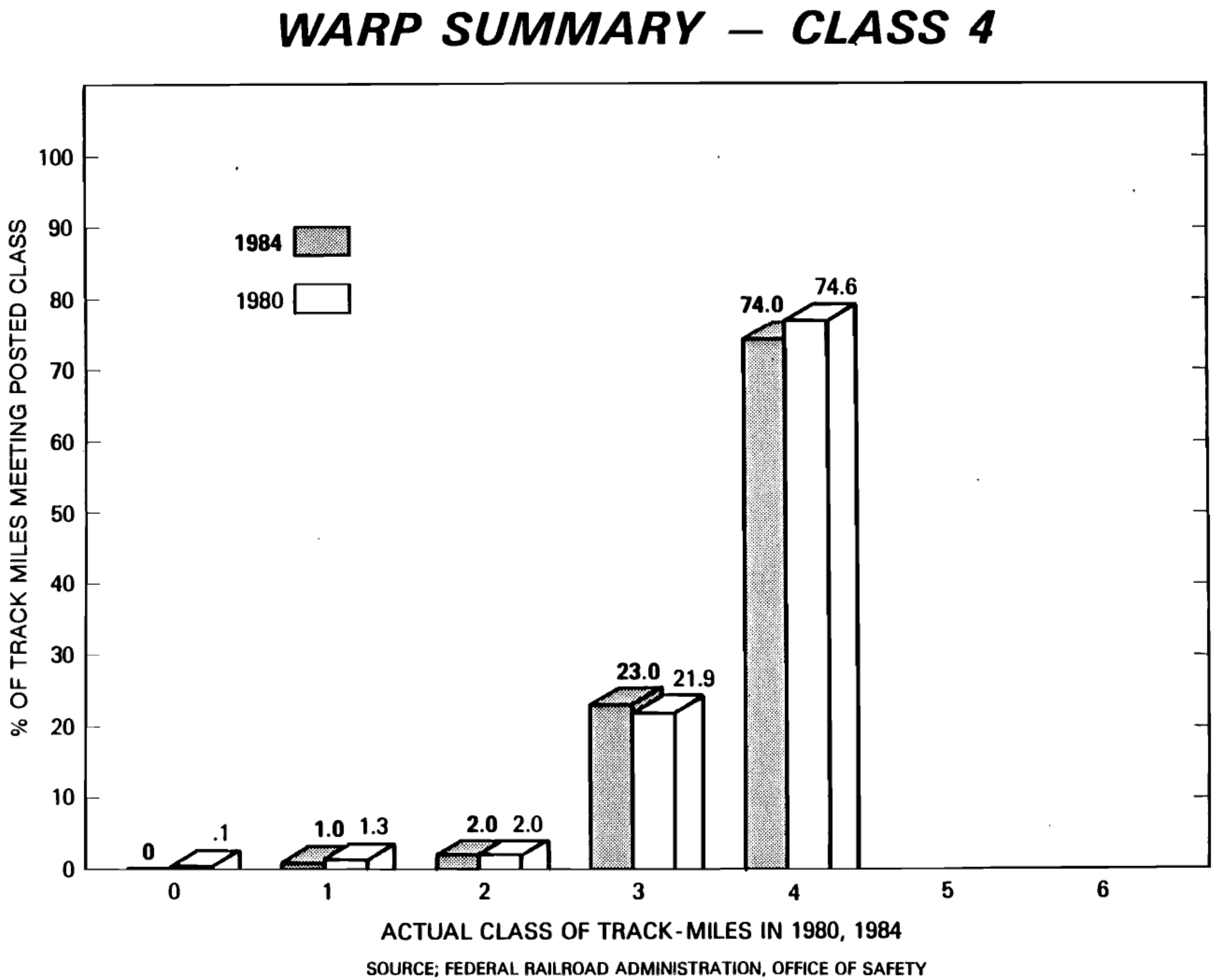


Figure 7 Warp Summary — Class 4

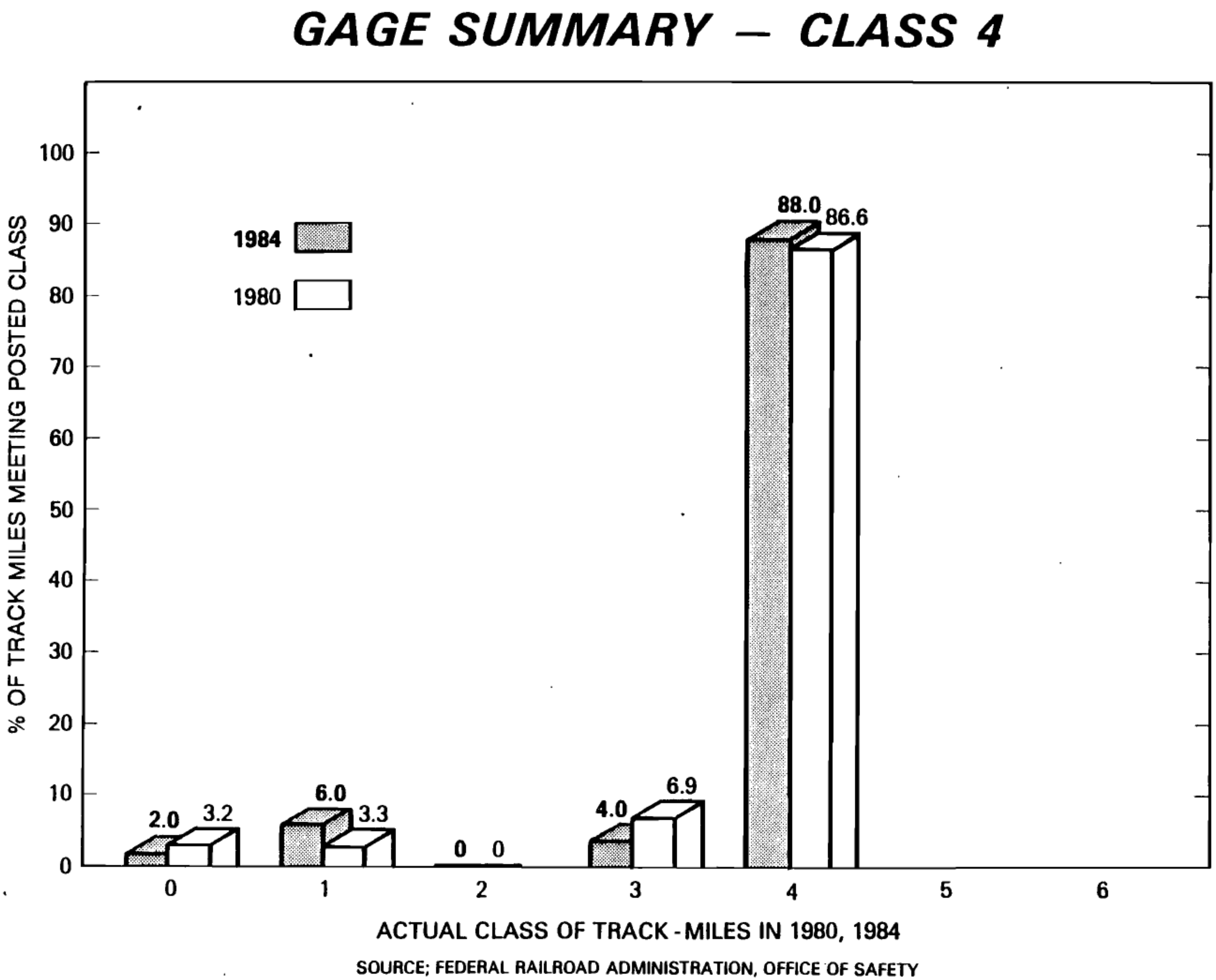
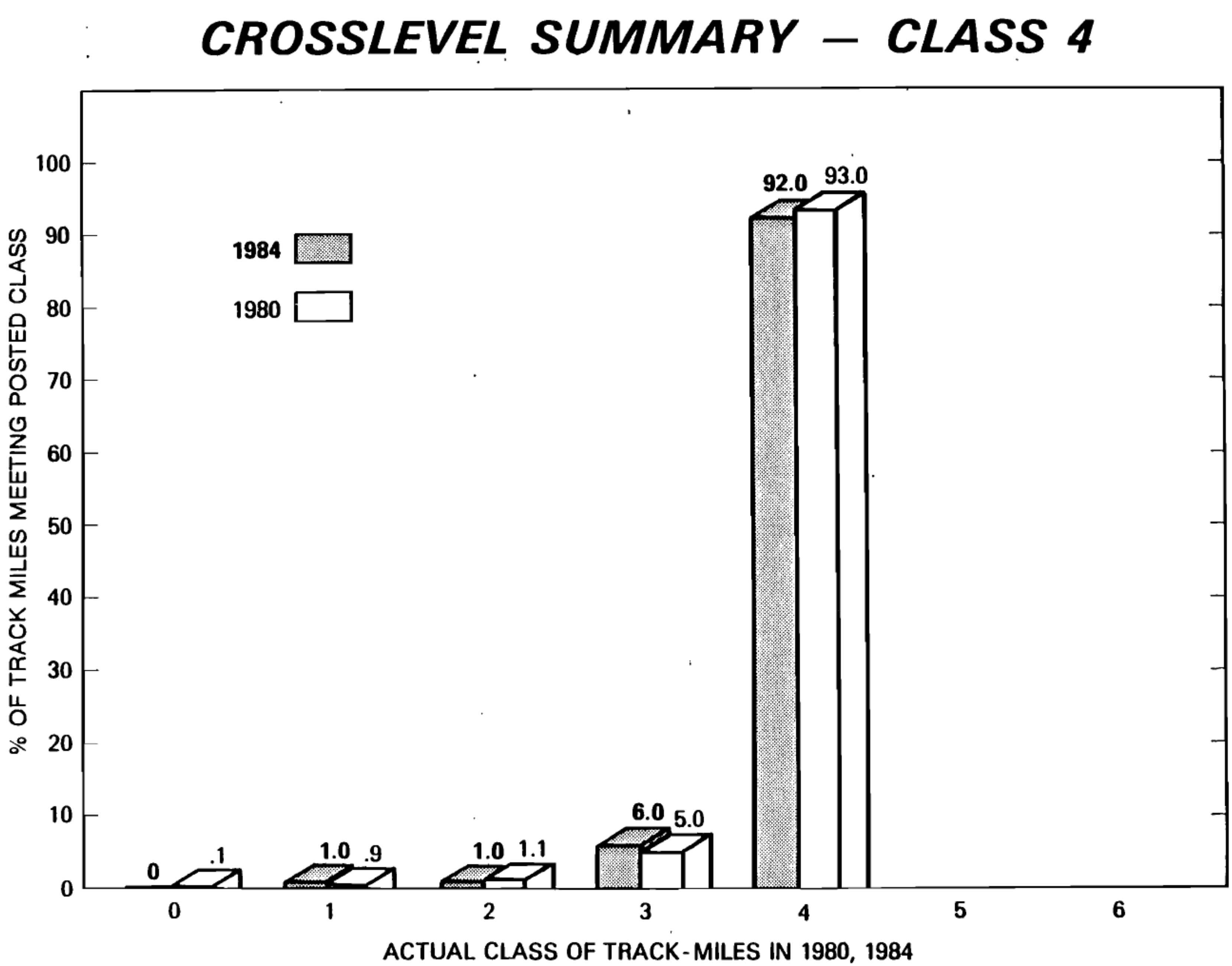


Figure 8. Gage Summary — Class 4.



SOURCE; FEDERAL RAILROAD ADMINISTRATION, OFFICE OF SAFETY

Figure 9. Crosslevel Summary — Class 4.

FRA FIELD ACTIVITIES

The FRA has eight Office of Safety Regions throughout the United States (see fig. 1), supervised by Regional Directors of Railroad Safety. Each regional director was responsible for the scheduled operations of T2-T4 and T-10 while the vehicles were operating within the director's region. Amtrak transportation and engineering officers were responsible for the operation of the 10001 and the coordination of its movement with FRA's Washington Headquarters.

Overall, the inspectors found that the data, when edited to eliminate anomalies, proved quite accurate. There were cases in which data were either misleading or false, but they were relatively few. An example of such 'false' readings would be superelevated curves of approximately 1/2 degree or less and construed by the computer as tangent track with excessive cross-level. However, misrepresentations such as these are not new to the inspectors and their field followups were conducted to allow for them.

The Amtrak routes tested well and proved to be in very good condition. Even in areas where FRA expected to find instances of wide gage or track warp, conditions were found generally in compliance. Routine inspection activites over the past year or so have been producing indications of generally improving conditions on the major mainlines, and this series of Automated Track Inspection Vehicle surveys tended to confirm that.

Concerning the response of the carriers in taking corrective actions, inspectors found that in virtually all cases the various carriers had taken the data, located defects that were verifiable, and made prompt repairs to achieve compliance.

In summary, this series of Amtrak route surveys produced very good overall results and served to confirm our perceptions of the track conditions on the major mainline routes. The resurging economy and increasing revenues of the various railroads are definitely being reflected in a higher level of track maintenance.

APPENDIX A

Tables extracted from FRA Track Safety Standards from which exception calculations are made.

SPEED
(in miles per hour)

Class	Freight	Passenger
1	10	15
2	25	30
3	40	60
4	60	80
5	80	90
6	110	110

PROFILE
62′ Midchord Offset
(in inches)

Class	Deviation From Profile
1	3.00
2	2.75
3	2.25
4	2.00
5	1.25
6	0.50

ALIGNMENT
62′ Midchord Offset
(in inches)

Class	Tangent Track	Curved Track
1	5.00	5.00
2	3.00	3.00
3	1.75	1.75
4	1.50	1.50
5	0.75	0.625
6	0.50	0.375

WARP
(in inches)

Class	Spiral (31′ chord)	Non Spiral (62′ Chord)
1	2.00	3.00
2	1.75	2.00
3	1.25	1.75
4	1.00	1.25
5	.75	1.00
6	.50	0.50

CURVATURE

Computation made on basis of 3-inch unbalance formula

GAGE
(in inches)

Class	Minimum Not less than	Maximum
1	56.0	58.00
2	56.0	57.75
3	56.0	57.75
4	56.0	57.50
5	56.0	57.50
6	56.0	57.25

CROSSLEVEL
(in inches)

Class	Tangent and Curve
1	3.00
2	2.00
3	1.75
4	1.25
5	1.00
6	0.625