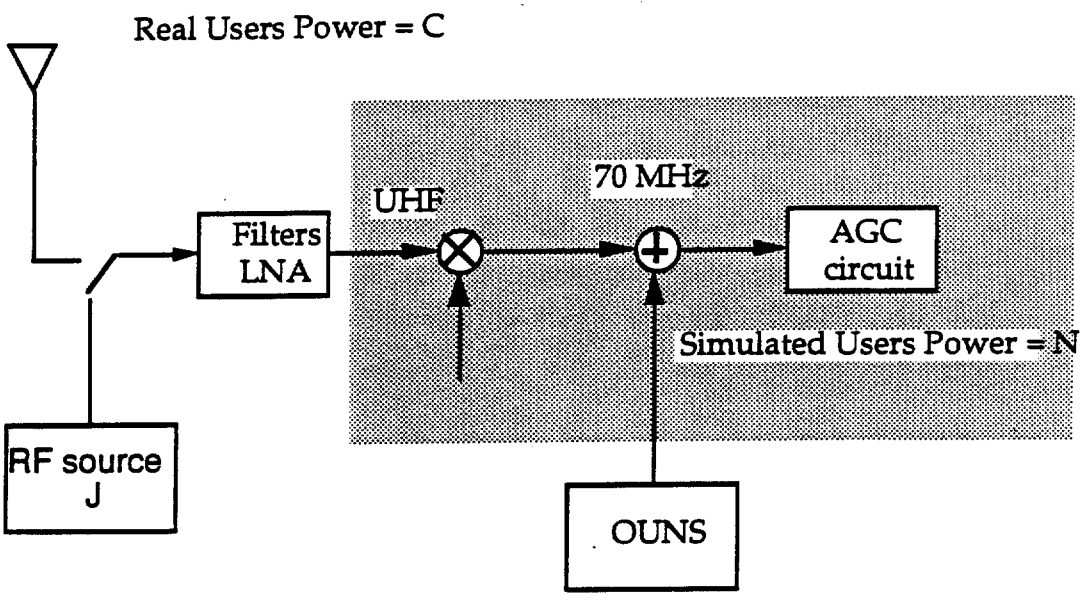

Figure 5-1. Open Loop Operation of OUNS for the Forward Link

Closed Loop Calibration

The closed loop operation of the OUNS used was calibrated incorrectly due to a "bug" in the software that controls the operation of the CDMA receivers and OUNS. This version of software was installed in the field shortly before the beginning of the November field tests. Under normal conditions in closed loop operation, the software should perform the following steps:

(a) Run a calibration of all four (4) AGC circuits and store the calibration curves as tables in memory.

(b) Monitor the CDMA power from real users, through the use of 2 of the 4 AGC circuits, and use the previously stored calibration tables to determine the correct adjustment to the simulated users power.

However, due to the "software bug," the actual tables built during the calibration procedure were not used but rather a "default table" was addressed. The result of that was that closed loop adjustments were not made unless the input power from real users was extremely high and not representative of normal operating conditions.

The OUNS produced the correct amount of noise, corresponding to the simulated users, but the aforementioned software "bug" changed the variability of the process which did not follow the behavior of the real users in the field.

OUNS/OCNS Parameters

- Each OCNS user was equivalent to 0.5 Watts during the capacity test.

6. Capacity Test Scenarios

The following sections summarize the daily test scenarios that were set up and performed during the system capacity tests from November 18 through November 23, 1991. The sections detail the type of test scenario performed, the active sectors in each cell, the number of mobiles used in each run, the routes driven during the runs, and the status of the OUNS/OCNS.

6.1 Monday, November 18, 1991

Testing on November 18, 1991 utilized the Mission Bay Gamma sector. The scenario included an isolated sector test, and only a single sector (Mission Bay Gamma) was active. The Gamma sector of Mission Bay Cell covered the Fiesta Island loop.

Nine runs were performed with 30 mobiles in runs 1, 2, 3 and 4; 40 mobiles in runs 5 and 6; 50 mobiles in runs 7 and 8; and 61 mobiles in run 9. During the runs, the mobiles were evenly distributed within the coverage of the Gamma sector except for mobiles that were located in the cell.

Other User Noise Simulation (OUNS) and Orthogonal Channel Noise Simulation (OCNS) were not used during these tests.

6.2 Wednesday, November 20, 1991

The Mission Bay Alpha sector was the only active sector used for testing the coverage of isolated cells in the Old Town area on November 20, 1991. All mobiles drove routes in Old Town and the adjacent areas.

The tests included eight runs designated F1 through F8. Runs F1, F2, F3 and F4 were performed with 30 evenly distributed mobiles. In runs F5 and F6, 33 mobiles were tested, and in runs F7 and F8, 25 mobiles were operational during the tests.

OUNS and OCNS were not used during runs F1 through F8.

On November 20, 1991, an additional set of four runs for OUNS calibration was performed. Run C1 consisted of 30 mobiles, no OUNS, and logged receive power at the cell in all three sectors. Run C2 consisted of 10 mobiles and 20 users simulated with OUNS. Runs C3 and C4 had the same set as run C2, but varied OUNS parameters to compare test results.

6.3 Thursday, November 21, 1991

On November 21, 1991, the Mission Bay Alpha, Beta, and Gamma sectors were active while mobiles drove routes in Old Town and adjacent areas. Ten runs were performed to test the performance of the system in a cell with all the sectors operational. Runs 1 and 4 were specifically performed for logging CAI handoff messages in the QTSO. Run 1 consisted of 20 mobiles, and in run 4, 30 mobiles were operational.

Runs 2 and 3 consisted of 20 mobiles, runs 5 through 7 consisted of 30 mobiles, and runs 8 and 9 consisted of 40 mobiles. Run 10 had 47 operational mobiles.

OUNS/OCNS simulated even system loading in each sectors. Table 6.3-1 shows the configuration setup for the OUNS/OCNS during these runs.

Table 6.3-1. OUNS/OCNS Scenarios for 11/21/1991

	OCNS			OUNS [own, other]		
Case	**Alpha**	**Beta**	**Gamma**	**Alpha**	**Beta**	**Gamma**
20 Mobiles	0	20	20	0, 20	10, 20	10, 20
30 Mobiles	0	30	30	0, 30	15, 30	15, 30
40+ Mobiles	0	40	40	0, 40	20, 40	20, 40

6.4 Friday, November 22, 1991

A three-sector test was conducted on November 22, 1991 with the Mission Bay Alpha, Beta, and Gamma sectors active. Sixty mobiles drove routes in the Mission Bay coverage areas for nine test runs. Run 1 was specifically performed for logging CAI handoff messages in the Qualcomm Telephone Switching Office (QTSO).

In run 2, 60 mobiles were operational; run 3 had 58 active mobiles; and runs 4 and 5 consisted of 60 and 62 mobiles, respectively. Runs 1 through 5 were performed without OUNS/OCNS. Runs 6 and 7 had 63 mobiles with OUNS/OCNS, and runs 8 and 9, had 66 mobiles without OUNS/OCNS. In runs 8 and 9, the new forward link outer loop was activated.

The van groups drove four routes. Vehicle group 702 drove on route 3; vehicle group 703 drove on route 17; vehicle group 704 drove on route 11; and vehicle group 705 drove on route 14.

Table 6.4-1 shows the configuration setup for the OUNS/OCNS during these runs.

Table 6.4-1. OUNS/OCNS Scenarios for 11/22/1991

	OCNS			OUNS [own, other]		
Case	**Alpha**	**Beta**	**Gamma**	**Alpha**	**Beta**	**Gamma**
60 Mobiles (20 per sector)	0	0	0	0, 20	0, 20	0, 20

This OUNS/OCNS setup is designated as configuration 3B.

6.5 Saturday, November 23, 1991

Testing on November 23, 1991 consisted of active cells in the Mission Bay (Alpha, Beta and Gamma sectors), the Mt. Ada, Mission Valley, and Downtown sites. Between 40 and 60 mobiles drove routes in Old Town and adjacent areas, which included several runs that varied interference and included soft handoff areas.

Run 1 was specifically performed for logging CAI handoff messages in the QTSO. Runs 2 and 3 consisted of 40 mobiles with OUNS/OCNS.

Interference tests were performed in run 4 with 40 mobiles, and in run 7 with 60 mobiles. OCNS/OUNS was active in both runs.

Runs 5 and 6 had 60 mobiles with OUNS/OCNS. The van groups drove four routes. Vehicle group 702 drove on route 9; vehicle group 703 drove on route 16' (route 16 and route 15); vehicle group 704 drove on route 10' (route 10 and route 12); and vehicle group 705 drove on route 8.

Table 6.5-1 shows the configuration setup for the OUNS/OCNS during these runs.

Table 6.5-1. OUNS/OCNS Scenarios for 11/23/1991

	OCNS			OUNS [own, other]		
Case	**Alpha**	**Beta**	**Gamma**	**Alpha**	**Beta**	**Gamma**
Mission Bay:						
40 Mobiles*	0	20	20	0, 20	10, 20	10, 20
60 Mobiles **	0	30	30	0, 30	15, 30	15, 30
Mt. Ada, Mission Valley, Downtown:						
40 Mobiles	20			10, 20		
60 Mobiles	30			15, 30		

*This OUNS/OCNS configuration is designated 4A.
**This OUNS/OCNS configuration is designated 4B.

7. Capacity Test Results

This chapter details and summarizes the results of the capacity tests that were performed in the San Diego area from November 18, 1991 through November 23, 1991. The capacity test results are described according to the following categories:

- Frame Error Rates
  - FER Results
  - FER versus Speed Results
- Cell Rx E_b/N_0 Results
- Tx Power Results
- Handoff Results

The results for each category are detailed in the following sections.

7.1 Frame Error Rate (FER) Results

The Frame Error Rate (FER) measures the quality of the link or the quality that the user recognizes in the system. It is expressed as a percentage of the number of frames in error over the total number of transmitted frames. A frame, on voice and paging channels, is defined as the 20 msec basic timing interval. Frames in error are determined through the use of the Markov test mode in the system and are defined as frames that either receive incorrect rates during the Markov process checking or frames that contain bits in error.

Frame Error Rates (FERs) for all cells tested were plotted against a Cumulative Distribution Function (cdf). The cdf is the summation of the FERs probability density function (pdf) in which the probability of the FER is less than or equal to the X axis. All frame error data presented in the following graphs consist of only frame errors detected during the full rate transmission (9600 bps). If the FER of a given MIN substantially deviated from the majority FERs, the MIN was deemed an outlier and was removed from the statistics. FERs for outliers are listed next to the identified MINs in parentheses.

The Frame Error Rates also determine the mean time between events. During typical conversations, full rate frames (9600 bps) comprise roughly 30% to 40% of all frames. Assuming that 35% of the frames are full rate frames, there are 17.5 full rate frames per second. A 0.5% full-FER is equal to 1 error per 200 full rate frames or 1 error per 11.5 seconds. A 1.0% full-FER is equal to one error per 100 full rate frames or 1 error per 5.7 seconds, and a 5.0% full-FER equals 1 error per 20 full rate frames or 1 error per 1.1 seconds

Because the Markov mode does not recognize signaling, frames received with a blank-and-burst signaling message were assumed to be received correctly and were not included in the overall frame error count. Also, in a few cases, if the QTSO received a Markov Sync Error message, the message was noted. Mobiles in which the call setups occurred after the data logging process started (deemed "late starters") and mobiles that had calls re-initiated during the data logging process are also noted.

7.1.Reverse Link

FER statistics for the reverse link were compiled for November 18 through the 23, and are described in the following sections.

7.1.1 Reverse Link FER Results for November 18, 1991

During the first day of isolated sector tests on Fiesta Island, the average FER over full rate for 30-60 mobiles without OUNS/OCNS ranged between 0.41% and 0.58%. The Reverse Link FER results for November 18, 1991 are depicted in the enclosed graphs.

7.1.2 Reverse Link FER Results for November 20, 1991

The average FER for isolated sector tests that were conducted without OUNS/OCNS was 1.14%. In the tests that had the OUNS/OCNS active with 25 to 33 mobiles, the average FER ranged from 1.1% to 1.86%.

The Reverse Link FER results for November 20, 1991 are depicted in the enclosed graphs.

7.1.3 Reverse Link FER Results for November 21, 1991

The all-sector test in old town resulted in an average FER of 0.83% for 20 mobiles in runs 2-3, an average FER of 0.96% for 30 mobiles in runs 5-7, an average FER of 0.97% FER for 40 mobiles in runs 8-9, and an FER of 0.97% for 47 mobiles in run 10.

The Reverse Link FER results for November 21, 1991 are depicted in the enclosed graphs.

7.1.4 Reverse Link FER Results for November 22, 1991

On November 22, the test included approximately 60 mobiles that were evenly distributed between the three sectors of the Mission Bay cell. No other cells were active. Of the nine logging runs conducted, only runs 6 and 7 had OUNS/OCNS active. The OCNS was off for those runs. The OUNS simulated 20 users per sector. For all runs, the averaged FER ranged from 0.56% to 0.95%. The average FER for runs 2-5 with 60 mobiles and no OUNS was 0.95%. The average FER for 60 mobiles with 20 simulated users per sector or ten times analog capacity was 0.81%. The average FER for runs 8-9 which had 65 mobiles, no OUNS and introduced a new outer loop, averaged 0.56%.

The Reverse Link FER results for November 22, 1991 are depicted in the enclosed graphs.

7.1.5 Reverse Link FER Results for November 23, 1991

These test included more than 60 mobiles, placed in the Mission Bay Alpha sector and in its adjacent soft and softer handoff regions. All sectors of Mission Bay, plus the Mt. Ada, Mission Valley, and Downtown cells were active.

Two configurations for OUNS were used on November 23, 1991. The first configuration included OCNS/OUNS in order to simulate even loading of 20 users per sector in all sectors of all cells. Forty mobiles were used for the test. Only runs 3 and 4 from this configuration are analyzed here for the reverse link. Run 1 was performed as a QTSO control-only run for handoff statistics; run 2, does not contain QTSO FER data, and run 4 was an external interference test.

The second configuration included OCNS/OUNS to simulate even loading of 30 users per sector in all sectors of all cells. Sixty mobiles were used for the test. Only runs 6 and 7 from this configuration are analyzed here for the reverse link. Run 5 does not contain QTSO FER data and run 7 was an external interference test.

The overall capacity for all cells tested with the first configuration (with and without interference) was approximately 10 times analog capacity.

The FER for 40 mobiles without interference was 0.76%. The overall average FER for 40 Mobiles with injected interference in this first configuration was 0.95%.

Under the second configuration, the overall capacity for all cells tested with and without interference was approximately 15 times analog capacity. The overall average FER for 60 mobiles without interference was 0.71%. The FER for 60 mobiles with interference was 1.01%.

The Reverse Link FER results for November 23, 1991 are depicted in the enclosed graphs.

7.2. Forward Link

FER statistics for the forward link were compiled for November 20 and 22, and are described in the following sections.

Forward link FER statistics for November 18 were not collected during the tests. Since November 21 was not considered a formal testing day, forward link FER data was also not logged.

7.2.1 Forward Link FER Results for November 20, 1991

The FER for all runs on November 20th averaged 0.34%. Runs 1-4 had 30 mobiles, no OUNS and an average FER of 0.30%. Runs 5-6 had 33 mobiles, no OUNS and an average FER of 0.59%. Runs 7-8 had 25 mobiles, no OUNS and produced an average FER of 0.34%.

The Forward Link FER results for November 20, 1991 are depicted in the enclosed graphs.

7.2.2 Forward Link FER Results for November 22, 1991

The FER for all runs on November 22 averaged 0.61%. Runs 2-5 had a configuration of 60 mobiles and no OUNS and an average FER of 0.53%. Runs 6-7 consisted of 62 mobiles, an OUNS Configuration of 3B and an average FER of 0.61%. Runs 8-9 consisted of 65 mobiles, no OUNS, a new outer loop and an FER of 0.77%.

The Forward Link FER results for November 22, 1991 are depicted in the enclosed graphs.

7.2.3 Forward Link FER Results for November 23, 1991

Tests on November 23 involved all the cells and mobiles. In these scenarios, the mobile could receive more than three pilots. A software "bug" in the QTSO however, caused an improper selection of the mobile's active set when more than three pilots were detected by the mobile. Because of this bug, mobile did not select the strongest pilot available. Therefore, Forward FER statistics for this day do not show an accurate representation of the system performance. These tests will be repeated in the second series of capacity tests.

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Reverse Link
Frame Error Rate Results
for 11/18/1991

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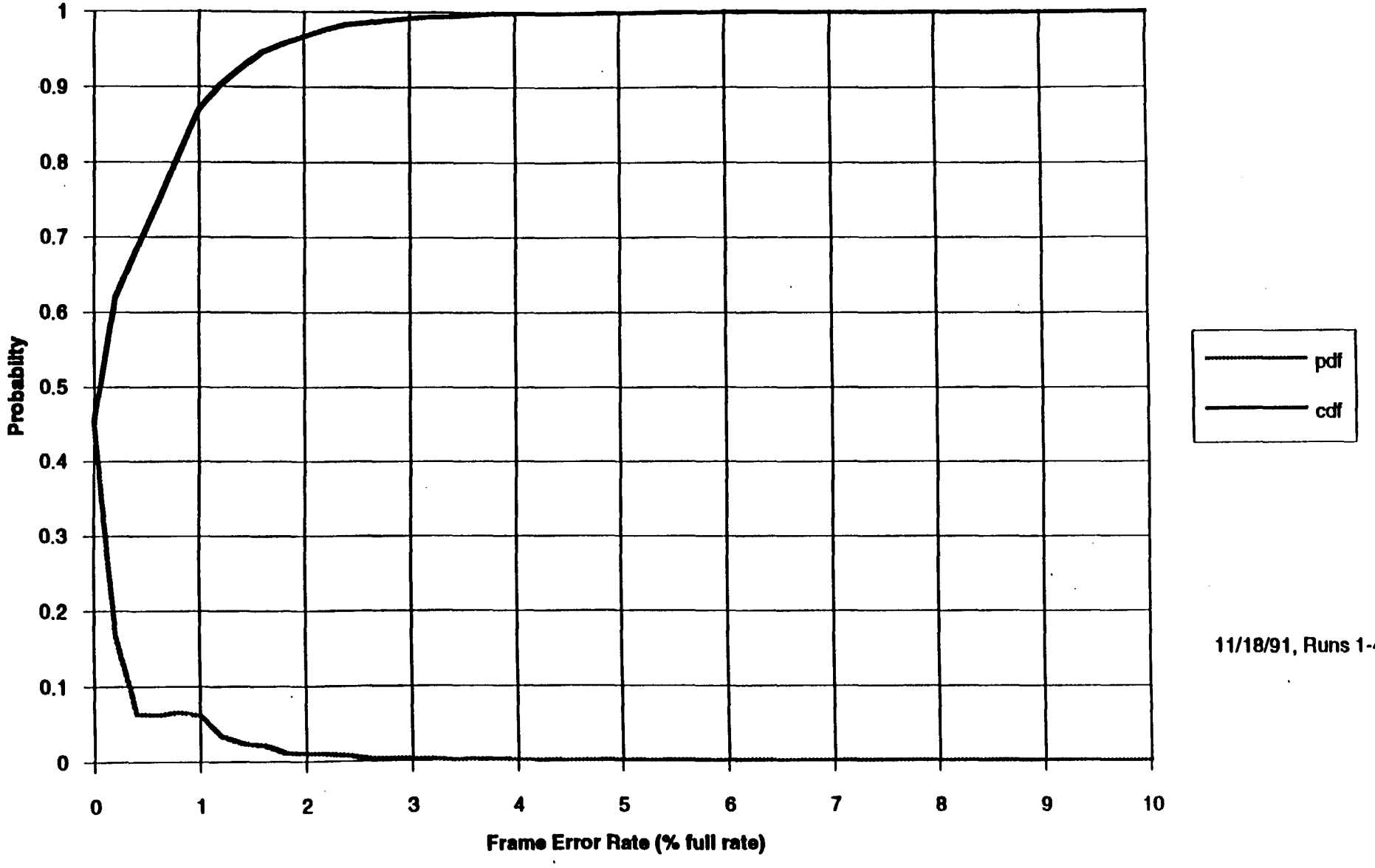
30 Mobiles, no OUNS

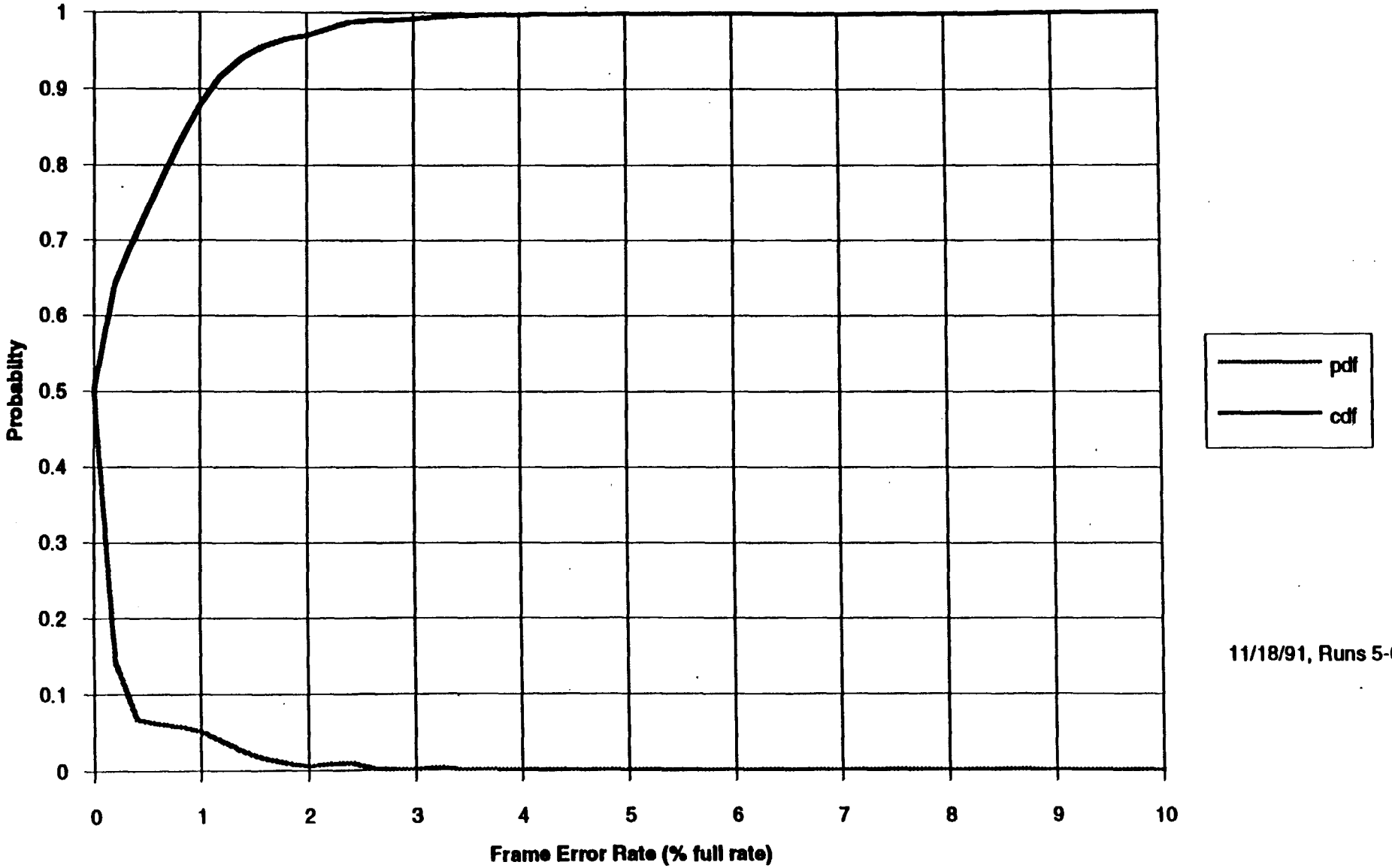
Overall Average FER: 0.45%



11/18/91, Runs 1-4

40 Mobiles, no OUNS

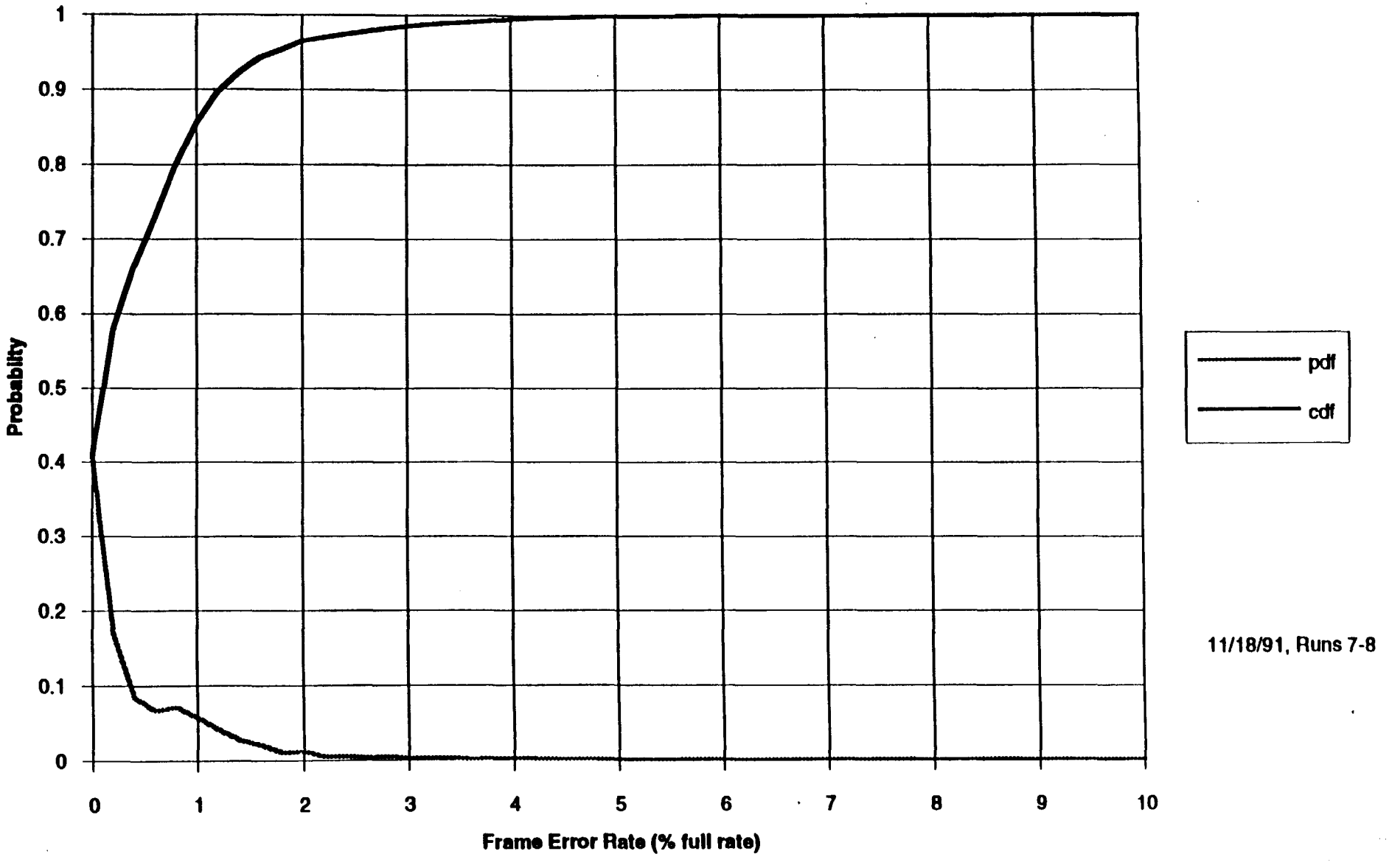
Overall Average FER: 0.41%



11/18/91, Runs 5-6

50 Mobiles, no OUNS

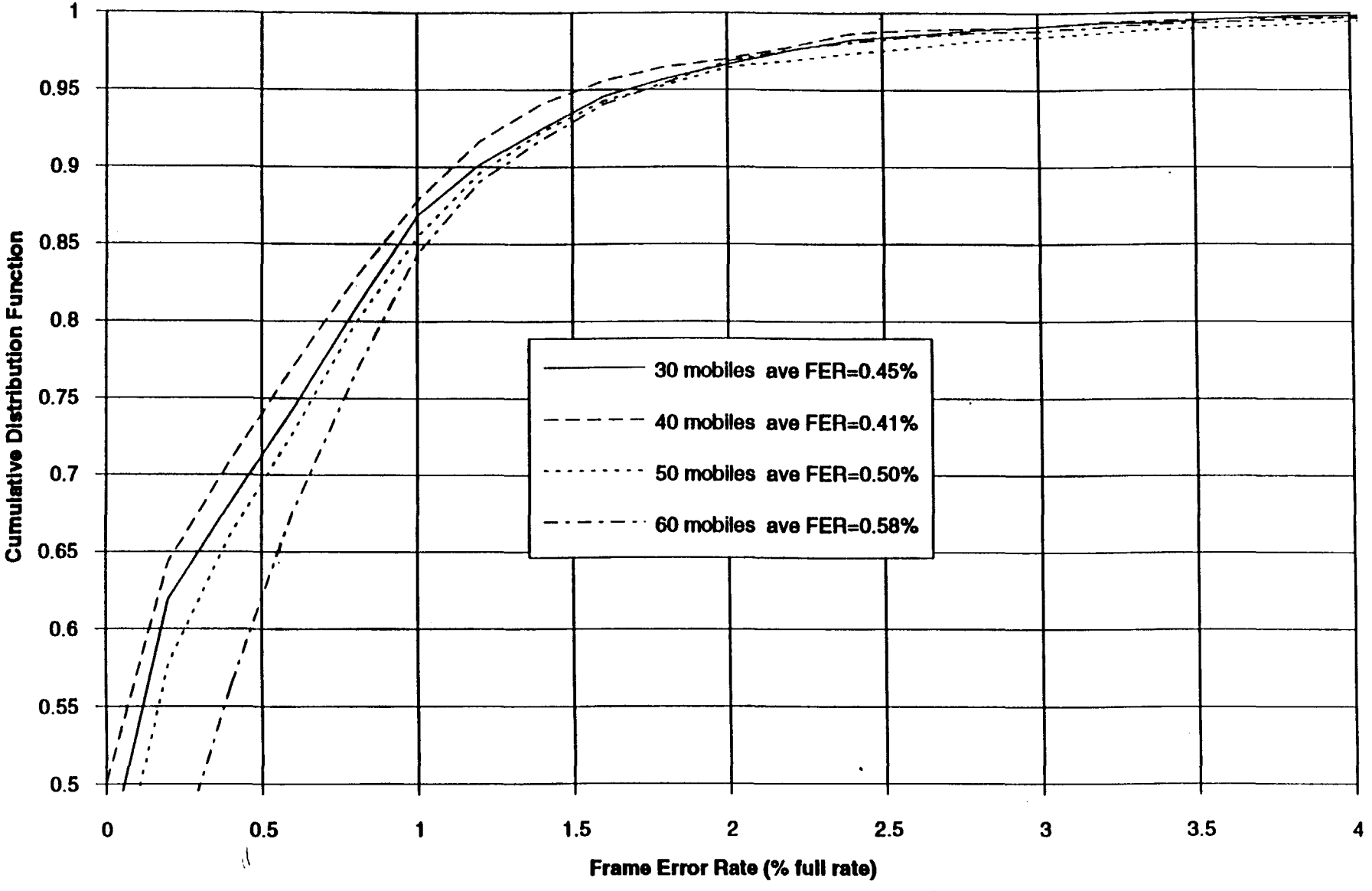
Overall Average FER: 0.50%



11/18/91, Runs 7-8

Isolated Sector Tests , Fiesta Island , no OUNS

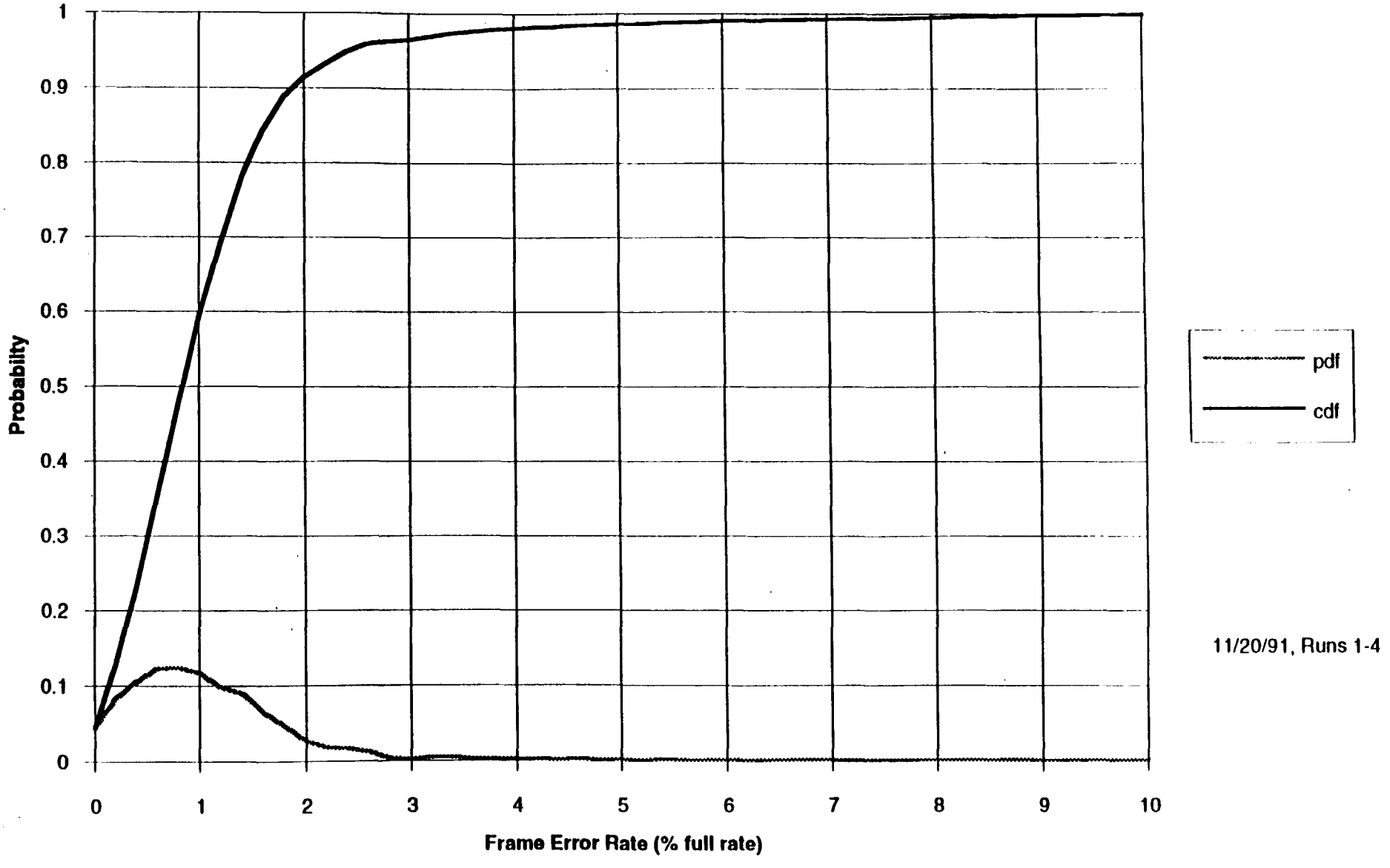
test date : Nov. 18, 1991



Reverse Link
Frame Error Rate Results
for 11/20/1991

30 Mobiles, no OUNS

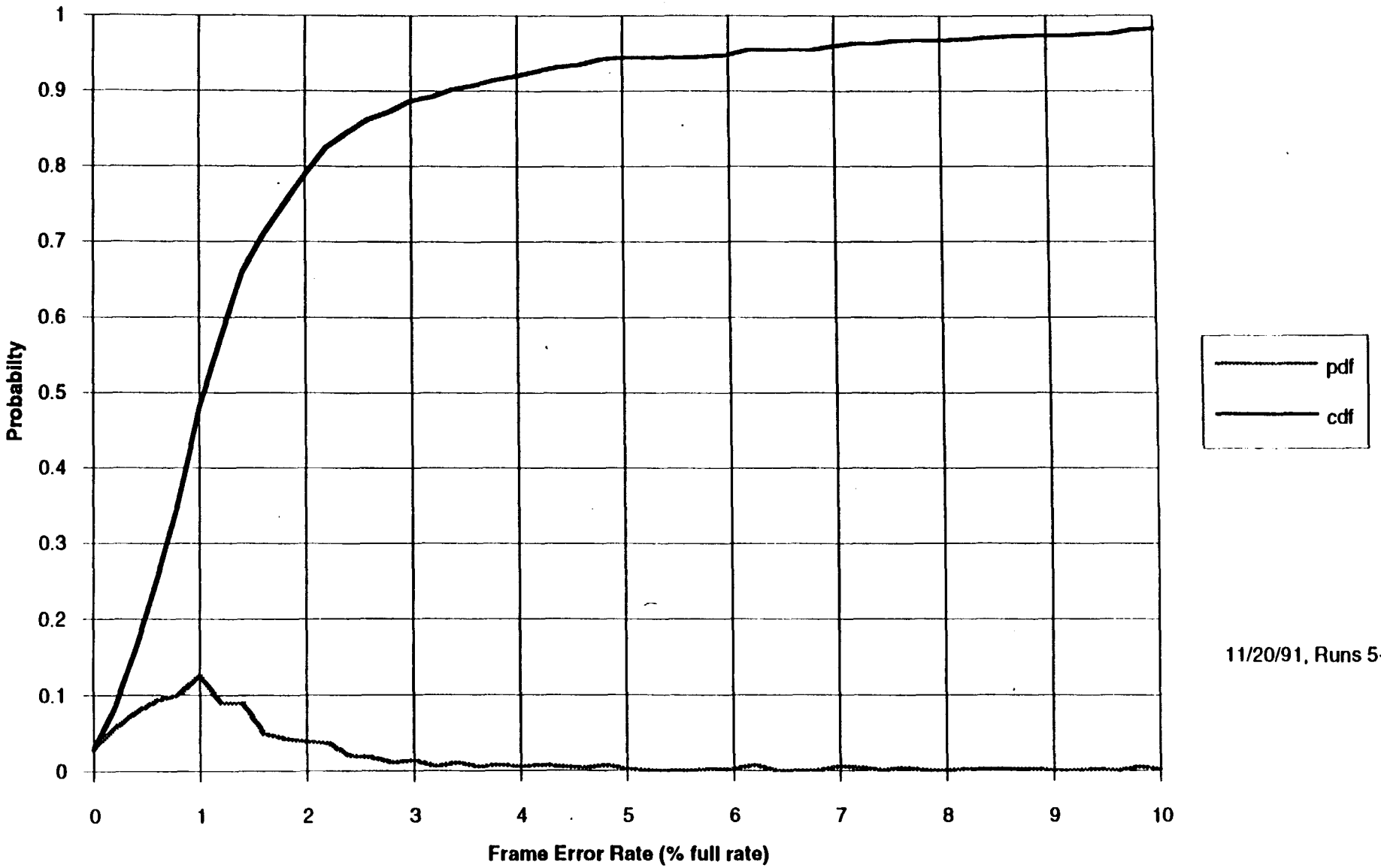
Overall Average FER: 1.14%



11/20/91, Runs 1-4

33 Mobiles, no OUNS

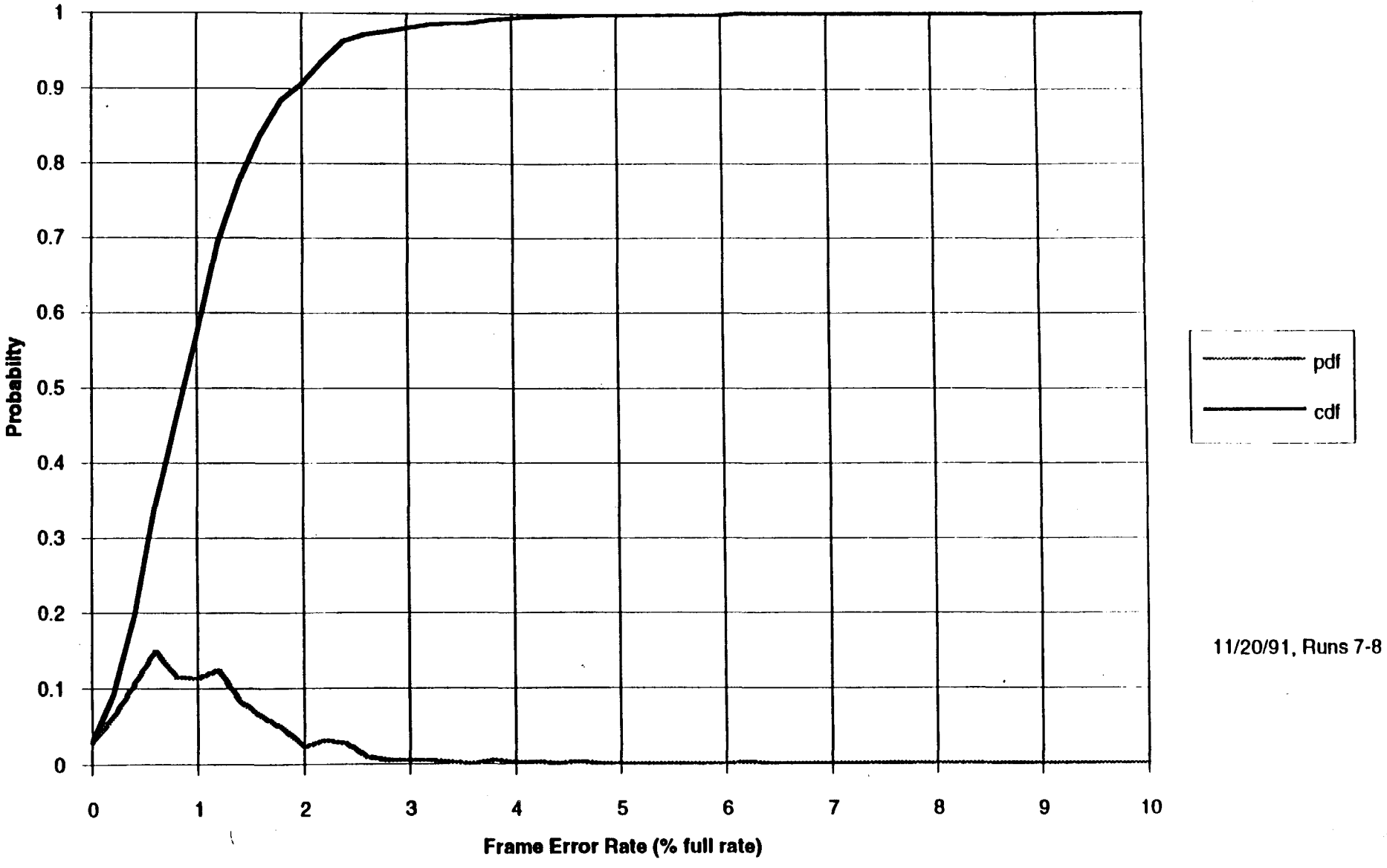
Overall Average FER: 1.86%



11/20/91, Runs 5-6

25 Mobiles, no OUNS

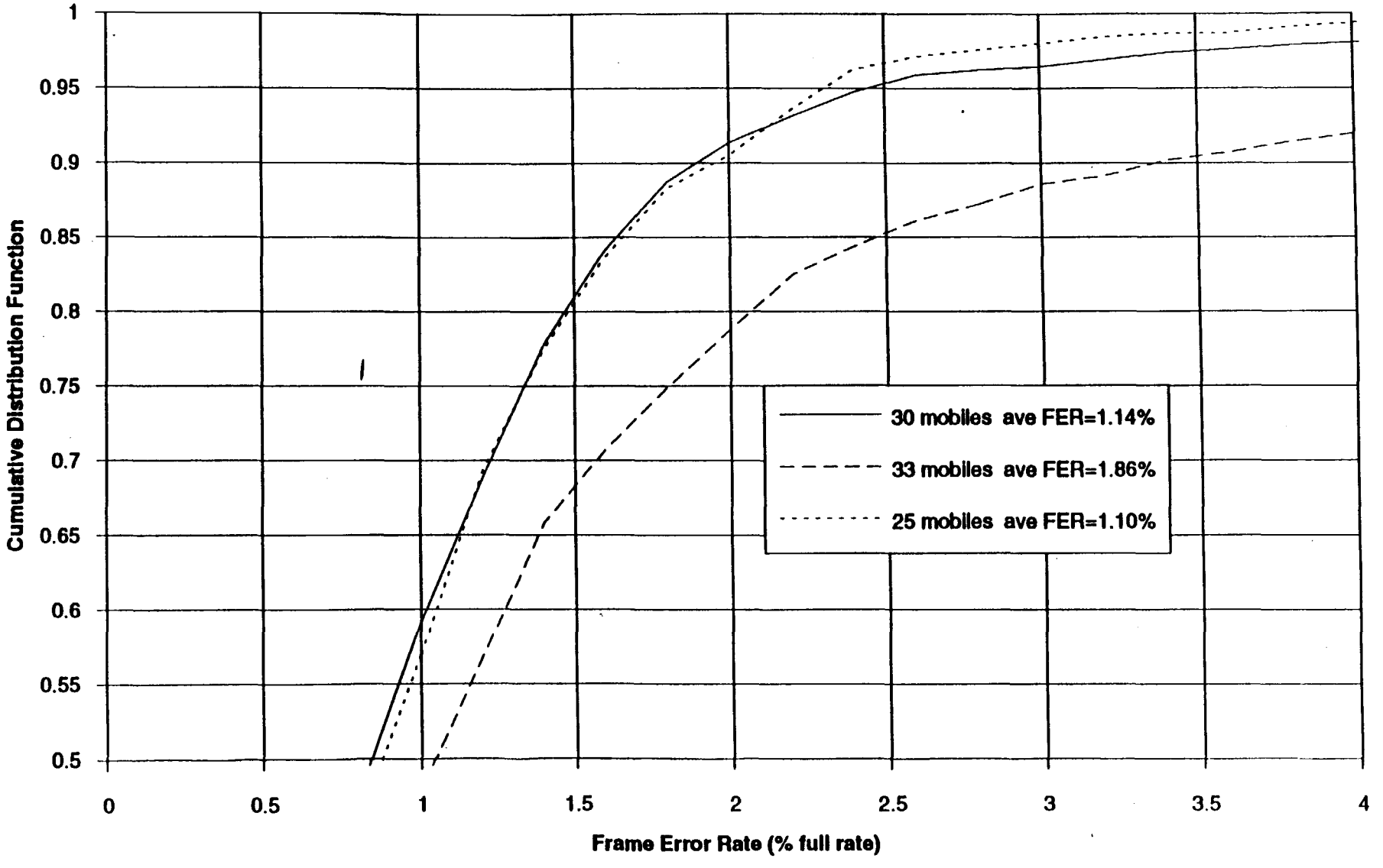
Overall Average FER: 1.10%



11/20/91, Runs 7-8

Isolated Sector Tests , Old Town , no OUNS

test date: Nov 20, 1991



Reverse Link
Frame Error Rate Results
for 11/21/1991

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