

ID-1 Round Robin Crossplay Report
Presented at the October, 1996 Meetings of THIC

Alan Montgomery
Dept. Of Defense
9800 Savage Rd. Suite 6512
Ft. Meade, MD 20755-6512
Voice: 301/688-0865 Fax: 301/688-0588

Introduction
(A Little History)

ID-1 is an instrumentation digital recording format that was standardized during the late 80's at about the same time as ID-1 recorders were introduced into the market place. Usually a standard format does not come about this way. Generally standards are generated when the proprietary format of a manufacturer becomes a "defacto standard" which is then adopted by others. Examples of the latter include the VHS format, the 3490 "square tape" formats, and the Phillips audio cassette. The ID-1 American National Standard for 19mm cassettes allows for several engineering hardware implementations of recording devices, all capable of making recordings which "meet" the footprint standard. Four companies have manufactured ID-1 recorders since the late 80's and each one uses a different hardware implementation, providing the opportunity for competition in the market and for non-fraternal crossplay among users. While the competition is welcomed by the user groups, the non-fraternal crossplay performance has been less than satisfactory.

Because of user frustration with poor non-fraternal crossplay performance of the ID-1 recorders, a series of voluntary crossplay meetings was initiated by the author hoping to bring issues out on the table and in doing so deduce some direction or recommendations that might improve the situation for the users. These meetings had the support of both the ANSI committee on flexible media and the support of the Tape Head Interface Committee, a forum for the interchange of information about all sorts of recording devices and systems. The users' position was stated by the American National Standards Institute committee on flexible recording media:

(Taken from the 1996 annual report of the ANSI X3B5 committee) ...Based on feedback from the user community, the performance of this technology [ID-1] has been unacceptable with respect to crossplay of tapes from one vendor's machine to another. Performance data is currently under evaluation [this report], and the Ad Hoc Group [within the ANSI X3B5 committee] is confident that its approach will produce a much more robust standard than in the first edition. ... A projection for completion of this revision project is 12/97.

Voluntary crossplay meeting discussions led to the claim by the manufacturers of the ID-1 hardware that there is no crossplay problem and the user group volunteered to perform testing to show there indeed is a problem when

<p style="text-align: center;">ID-1 Round Robin Crossplay Report Presented at the October, 1996 Meetings of THIC</p>

“plug and play“ is the desired goal. The manufacturers agreed to participate and these ID-1 Round Robin crossplay tests were born.

Summary Round Robin Results

Unfortunately there was no single failure signature common to a majority of the failed crossplay attempts. Two Round Robin recordings did not conform to the ANSI ID-1 footprint standard. There were even failed fraternal crossplay attempts and some of the playback machines would not auto-track to certain Round Robin recordings and required the use of manual tracking in order to acquire data in those cases.

"Plug and play" successes as a percent of the total number of unique crossplay attempts, including fraternal attempts, was 77%. That percentage increased to 84% if we exclude crossplay attempts which failed and subsequently passed using manual tracking. A “plug and play” success is a hands off playback of a Round Robin recording resulting in a corrected bit error rate (CBER) of 1E-10 or better after adjustment of the reproducing recorder to acceptably read the Sony, video grade, electrical calibration tape¹. Users of ID-1 recorders typically desire crossplay success in the 95+% range and therefore this Round Robin testing supports the users view that ID-1 recorders presently do not exhibit acceptable non-fraternal crossplay performance. If we consider the Sony recording on Sony data grade media as anomalous, due to low recorded levels, and that a recording with average levels would have produced acceptable results when read on Sony reproducers, then this testing is supportive of the present situation where fraternal crossplay success is assured 95+% of the time.

Best Crossplay Combinations

The best and most consistent recordings were made on Datatape equipment and the most successful reproducer was the Martin Marietta recorder which successfully played all eight Round Robin recordings with a CBER of better than 1E-10.

Best crossplay combination: write on Datatape - playback on Martin

Next best combination: write on Loral/Schlumberger - playback on Sony

Best bi-directional combination: Sony and Loral/Schlumberger. Bi-directional means that performance is measured when exchanging recordings

¹ All results of crossplay attempts using data grade media have been excluded from the summary. Results from the Martin recording on Ampex video grade media and the Sony recording on Ampex media are also excluded.

ID-1 Round Robin Crossplay Report
Presented at the October, 1996 Meetings of THIC

made on each recorder, that is, record Sony, read on Schlumberger, record Schlumberger, read on Sony.

Problematic Crossplay Combinations

There were 5 problematic crossplay combinations out of the 20 valid combinations tested; roughly 30%, although not enough data has been taken to make a strong statistically significant statement. The Datatape recorder was the worst playback device and the worst recordings were made by Martin Marietta equipment. The worst combinations are listed in no particular order (for more detail see Table 4).

Martin write - Datatape playback

Martin write - Loral/Schlumberger playback

Loral/Schlumberger write - Datatape playback using Sony video grade tape

Datatape write - Loral/Schlumberger playback using Ampex video grade tape

Martin write - Sony playback using Sony video grade tape

Because the data set is so small, it would be more reassuring if information gained from users of the equipment also verified the results of the Round Robin testing.

Information from ID-1 Users

NAWC, who primarily use Martin RDR400 recorders and Sony DIR 1000s for reproducers have had excellent success - 97% error free playbacks. The NAWC uses largely Ampex "New Formulation" media. Although this looks extremely good, the Navy personnel worked hard with both Sony and Martin Marietta to make this happen. From several user groups within the Dept. of Defense we know that Martin recorders are the poorest of the vendor set for making compatible recordings. This could be attributable to their digital record pre-equalization; everyone else uses analog pre-equalization. Although the two pre-equalization techniques are theoretically equivalent, the practical non-fraternal crossplay performance shortcomings seem evident. Government users of Datatape recorders have commented that they seem to be the weakest playback performers; perhaps attributable either to low margin in the read electronics or limited SNR at the playback heads.

Selecting D-1 Media for the Testing

Two types of new media, on large size D-1 cassettes, were selected by the NAWC at their facility in Warminster, PA. Both Ampex and Sony media were numbered, tested then degaussed prior to shipment to the vendors. Ampex media was of the “new formulation” video grade vintage, 16 microns thick. Sony media was video grade vintage, 16 microns thick. Media was selected if there were no errors attributable to media defects after two passes on a Sony DIR 1000 at 256 Mb/sec. A pseudorandom data set was used as an input signal during media selection.

In addition to the selected media, each manufacturer, except Sony, was given a Sony electrical calibration tape to be used in calibrating their recording equipment.

Making Round Robin Recordings

In support of the recording phase, two selected tapes, one Ampex and one Sony, were shipped to Loral Data Systems, Datatape, Inc. and Martin Marietta Corp. Sony was only sent one tape which was Ampex media. For the second media, Sony chose to use their data grade Sony media as opposed to the video product. Loral was sent two tapes but inadvertently damaged the Ampex tape and chose to replace it with an Ampex data grade tape from in-house stock. This substituted tape was recorded in France on a Schlumberger ID-1 recorder.

The manufacturers were instructed to use a typical recorder from their production to make the Round Robin recordings and to ensure that the recorder used was functioning to specification. Both Ampex and Sony tapes were to be recorded over their full length. Before recording, however, the manufacturers were to optimally calibrate the reproduce side of their recorder to the Sony electrical calibration tape. Following that calibration the supplied media were to be used to optimize the record side using the newly calibrated playback settings. Record side optimization was expected to involve both pre-equalization and record head currents. Mechanical adjustments were not specifically prohibited. Once the manufacturer was satisfied with the performance of the recorder under these conditions, full length recordings were made using a pseudorandom bit stream at the recording equipment’s highest record data rate.

The use of the equipment’s highest data rate was based on the idea that these ID-1 recorders are very expensive, typically costing around \$250K. Because of the cost, organizations buy them for their very high data rate capability, a capability not available today in any other recording equipment.

Crossplay Testing the Round Robin Recordings

Two recorded tapes from each manufacturer were received by the Government and all eight tapes were tested on a variety of ID-1 reproducers.

ID-1 Round Robin Crossplay Report
Presented at the October, 1996 Meetings of THIC

During crossplay testing, no manual optimization of playback equalizer settings was allowed. Manual optimization is considered to be a function outside the specialty of most operators and is certainly inconsistent with the “plug and play” idea. The one exception to this involved the Datatape LP 400 recorder, Datatape was allowed to use a different set of play equalization settings corresponding to the media type. This allowance was granted because the choice of equalizer settings on these recorders is a user function and is invoked at the touch of a button. The function pulls the settings from a table of equalizer values in memory and makes the change not only easy but nearly instantaneous.

The Martin Marietta recorder differs from other vendors in that an auto-calibration function is available which when invoked resulted in good crossplay with Sony recordings but poor crossplay with the other vendors. All data from Martin Marietta playbacks was taken after manual alignment of the RDR400 play side to the Datatape Round Robin recording on Sony media. On Martin recorders, this manual alignment procedure has been found to produce acceptable crossplay of the Sony calibration tape and of both fraternal and non-fraternal recordings.

Since the intent of the Round Robin was to test for compatibility between recorders, error bursts due to known tape defects were ignored. Some of the Sony recorders used in the playback of Round Robin recordings had tape scrapers installed, ostensibly to “clean the media” before recording. Any tape scrapers found on Sony recorders were covered with a single layer of a pelon wipe for all playback testing. Also, the first 3% and last 10% of the recordings were not tested.

For all video grade media tested in this report, the Corcoran Exclusion was invoked which allows the exclusion, from the error set, of one error burst per tape pass. This exclusion is based on media testing performed by the SMPTE committee (Society of Motion Picture and Television Engineers) which indicates that one should expect an error burst occasionally when using video grade D-1 media. This exclusion was not allowed for data grade media.

In all cases, playback testing was performed in a benign laboratory environment with laboratory models of ID-1 recording equipment. No ruggedized, militarized, or tempested equipment was used.

Most modern tape recorders, whether they be analog voice, analog video, or digital data, operate at a single head to tape speed, so as not to suffer the signal degradation which is inherent in the exchange of data/signals at differing read and write speeds. Another way of saying this is that having identical read and write speeds define one of the easiest conditions under which to exchange data between two different recorders. The ID-1 Round Robin testing turned out to be a multi-rate crossplay series of tests because no two ID-1 vendors fabricate an ID-1 recorder with the same maximum head to tape writing speed.

<p>ID-1 Round Robin Crossplay Report Presented at the October, 1996 Meetings of THIC</p>

Round Robin individual head write and read rates in megabits per second

ID-1 Vendors	write rates at the record head, overhead excluded	read rates at the play head, overhead excluded
Datatape	67	67
Martin	89	80
Loral	80	80
Sony	64	64

The more dissimilar the record and playback rates, the more difficult the job of reading without error. With this in mind the table would imply that easiest crossplay combination should be a Loral recording read on Martin equipment. In fact when the data is examined, that crossplay combination never failed. One might also expect that recordings made on Martin equipment would have the most difficulty when played back on Sony and Datatape drives. In fact Martin/Datatape combinations exhibited either tracking problems or error failure 75% of the time. Martin/Sony combinations exhibited error failure 17% of the time. The bottom line is that the results are probably encumbered somewhat by the multi-rate nature of the crossplay combinations.

Overall Observations

Most likely each ID-1 recorder manufacturer sets up their machines without regard to how other ID-1 manufacturers set up their machines. Users and manufacturers alike must be aware that the equalization settings obtained at the factory may only be optimum for fraternal crossplay and, as we have seen with the Martin recorder, there possibly are other settings which, although not optimal for fraternal crossplay, are optimal for maximizing non-fraternal crossplay.

We know from in-house testing and from the pristine quality of the one Round Robin tape that was recorded at half rate, that most vendors seem to be pushing the head to tape interface either when writing or reading at the highest rate of their equipment. The consequence of this observation is that the overall signal to noise ratio of the read/write channel is reduced and the inter-symbol interference is increased compared to lower speeds. This reduces the available margin in the hardware and consequently higher error activity is observed at the highest rates for recorders from Datatape, Martin Marietta, and Loral/Schlumberger.

ID-1 Round Robin Crossplay Report

Presented at the October, 1996 Meetings of THIC

On the majority of the failed playbacks, the data was error free most of the time and the primary contributor to poor CBER was usually only a few error events.

In any multi-pass tape testing there is always the concern that the recordings may be damaged by the machines used in the tests. To make sure that none of the Round Robin recordings were damaged during testing each recording was given a final run on a Sony DIR 1000 and an RDR400. The performance looked identical to what had been seen before. Of note is that on the last read pass of each recording, the RDR400 read all Round Robin recordings with CBERs of better than $1E-10$ indicating that none of the recordings had been damaged. This would indicate there was no readily apparent tape damage imparted to any of the tapes during Round Robin playback through nine recorders and 143 passes. The performance of each pass is presented in Table 1 in an attempt to reveal any patterns of degradation or improvement with use.

ID-1 Round Robin Crossplay Report
Presented at the October, 1996 Meetings of THIC

Table 1 Round Robin Recording Performance Versus Pass Number

Re-cording > Pass #	Datatape on Ampex media	Datatape on Sony media	Martin on Ampex media	Martin on Sony media	Loral on Ampex data grade	Loral on Sony media	Sony on Ampex media	Sony on Sony data grade
1	Dark	Dark	White	White	White	White	White	White
2	White	Dark	White	White	White	White	White	White
3	White	Dark	White	White	White	Light	White	Light
4	White	Dark	White	White	Dark	Dark	Light	Light
5	Dark	Dark	White	White	Dark	White	Light	Light
6	Dark	Dark	Light	White	White	White	White	Light
7	Dark	Dark	Dark	Dark	White	White	Light	Light
8	Dark	Dark	Light	Dark	Dark	White	White	White
9	Light	Dark	Dark	Light	Dark	Dark	White	Light
10	Light	Dark	White	White	White	Light	White	Light
11	White	Dark	White	White	White	White	Dark	Light
12	White	Dark	White	Light	White	White	Light	Dark
13	White	Dark	White	White	White	White	Light	White
14	Dark	Dark	Dark	Dark	White	White	White	White
15	Dark	Dark	Dark	Light	White	White	White	White
16	Dark	Light	Dark	Light	White	White	White	White
17	Light	Dark	Dark	White	White	White	White	White
18	White	White	Dark	White	White	White	White	White
19	White	White	Light	White	White	White	White	White
20	White	White	Light	White	White	White	White	White
21	White	White	Light	White	White	White	White	White
22	Dark	White	White	White	White	White	White	White
23	White	Dark	White	White	White	White	White	White
24	Dark	Dark	White	White	White	White	White	White
25	White	Dark	White	White	White	White	White	White
26	Light	White	White	White	White	White	White	White
27	White	White	White	White	White	White	White	White
28	White	White	White	White	White	White	White	White

CBER better than 1E-10
 Set-up pass in which no data was taken
 CBER poorer than 1E-10

ID-1 Round Robin Crossplay Report
Presented at the October, 1996 Meetings of THIC

Results

Plug and Play CBER - Tables 2 and 3 describe the corrected bit error rate (CBER) results of all the unique crossplay combinations tested. In addition, the inner error corrector activity is represented by alphabetic characters overlaid on the CBER result. Each entry in a box of these tables represents a unique crossplay combination of recorder and reproducer having different serial numbers. No Round Robin data has been excluded from these two tables. RF levels of the Sony recording on Sony data grade media were about half of the value of the RF levels of the other Round Robin recordings and this recording exhibited more frequent, large error bursts when played on the Sony and Datatape recorders which have no AGC. The Loral recording on Ampex data grade media was made at half speed on a two headed machine and consequently is more uniform and has less pre-equalization and less inter-symbol distortion than the other Round Robin recordings and this may explain its excellent crossplay performance. Of note: The three failed Sony fraternal entries were all playbacks on Sony recorders of the early design without scrapers.

Table 2 CBER of Tested Combinations, Sony Media

Reproducer-> Recorder ù	Datatape e SN 1041	Martin SN304	Loral SN 83	Sony DIR 1000					
				u	v	w	x	y	z
Datatape	L	M	M	M	M	-	-	L	-
Martin	H	M	H	H	H	M	H	H	L
Loral	H	H	H	L	M	-	L	M	-
Sony (data grade) {low RF level}	H	M	M	L	L	-	L	L	-




 Better than 1E-10 CBER plug and

Table 3 CBER of Tested Combinations, Ampex Media

Reproducer-> Recorder	Datatape SN 1041	Martin SN 304	Loral SN 83	Sony DIR 1000					
				u	v	w	x	y	z
Datatape	L	L	M	H	M	M	M	M	L
Martin (non- conformant to ID-1 standard)	H	M	H	H	H	L	M	M	M
Loral/Schlum. (data grade)	L	L	-	L	L	-	-	-	-

 Better than 1E-10 CBER using manual tracking

 Poorer than 1E-10 CBER regardless of tracking method

ID-1 Round Robin Crossplay Report
Presented at the October, 1996 Meetings of THIC

Reproducer-> Recorder	Datatape SN 1041	Martin SN 304	Loral SN 83	Sony DIR 1000						
				u	v	w	x	y	z	
Sony (non-conformant to ID-1 standard)	H	L	H	M	L	-	L	L	-	

L = very low or no inner error correction activity
M = low to moderate inner error correction activity
H = moderate to high inner error correction activity
- not tested

ID-1 Round Robin Crossplay Report Presented at the October, 1996 Meetings of THIC

Table 4 Poor Round Robin Recorder/Reproducer Combinations

Recorder and media	Reproducer	CBER	scanner hours	% humidity	corrector activity	RF volts	pass
Datatape on Ampex media+	Loral SN 83	2E-9	67	55	moderate	-	17
Martin on Ampex media (non-conformant to ID-1 standard)	Loral SN 83	7E-4	66	55	high	-	8
Martin on Ampex media (non-conformant to ID-1 standard)	Sony SN 10610	2E-7	611	48	high	-	6
Martin on Sony media	Loral SN 83	5E-6	64	55	high	-	9
Martin on Sony media+	Sony SN 10202	3E-8	19	62	high	-	12
Sony on Sony data grade	Sony SN 10201	2E-8, 1E-8	12	63	very low	-	6,7
Sony on Sony data grade	Sony SN 10202	5E-8	20	63	very low	-	5
Sony on Sony data grade	Sony SN 10002	5E-8, 7E-8	382	37	very low	-	3, 4
Sony on Sony data grade	Datatape SN 1041	2E-3	127	67	high	0.570	9
Martin on Sony media	Datatape SN 1041	1E-7	127	67	high	-	15
Martin on Ampex media (non-conformant to ID-1 standard)	Datatape SN 1041	3E-2	125	67	high	0.875	19
Loral on Sony media	Datatape SN 1041	1E-3	128	67	high	-	10
Sony on Ampex media (non-conformant to ID-1 standard)	Datatape SN 1041	6E-8	124	67	high	0.725	12

+ There was not enough information taken by the operator to determine if there was more than one error burst during this playback pass. In addition this crossplay combination ran with moderate to high inner corrector activity over the entire recording indicating a poor equalization match, therefore this playback is labeled as a poor combination.

Footprint Results: A footprint analysis revealed that most of the recordings were within the tolerances set forth in the ANSI, ID-1 standard, X3.175 - 1990. Straightness Plots, **Figures One through Five**, of the helical scan data of five Round Robin recordings were measured using the ferro-fluid method. In these figures, perfect recordings would appear as straight horizontal lines starting at the

ID-1 Round Robin Crossplay Report

Presented at the October, 1996 Meetings of THIC

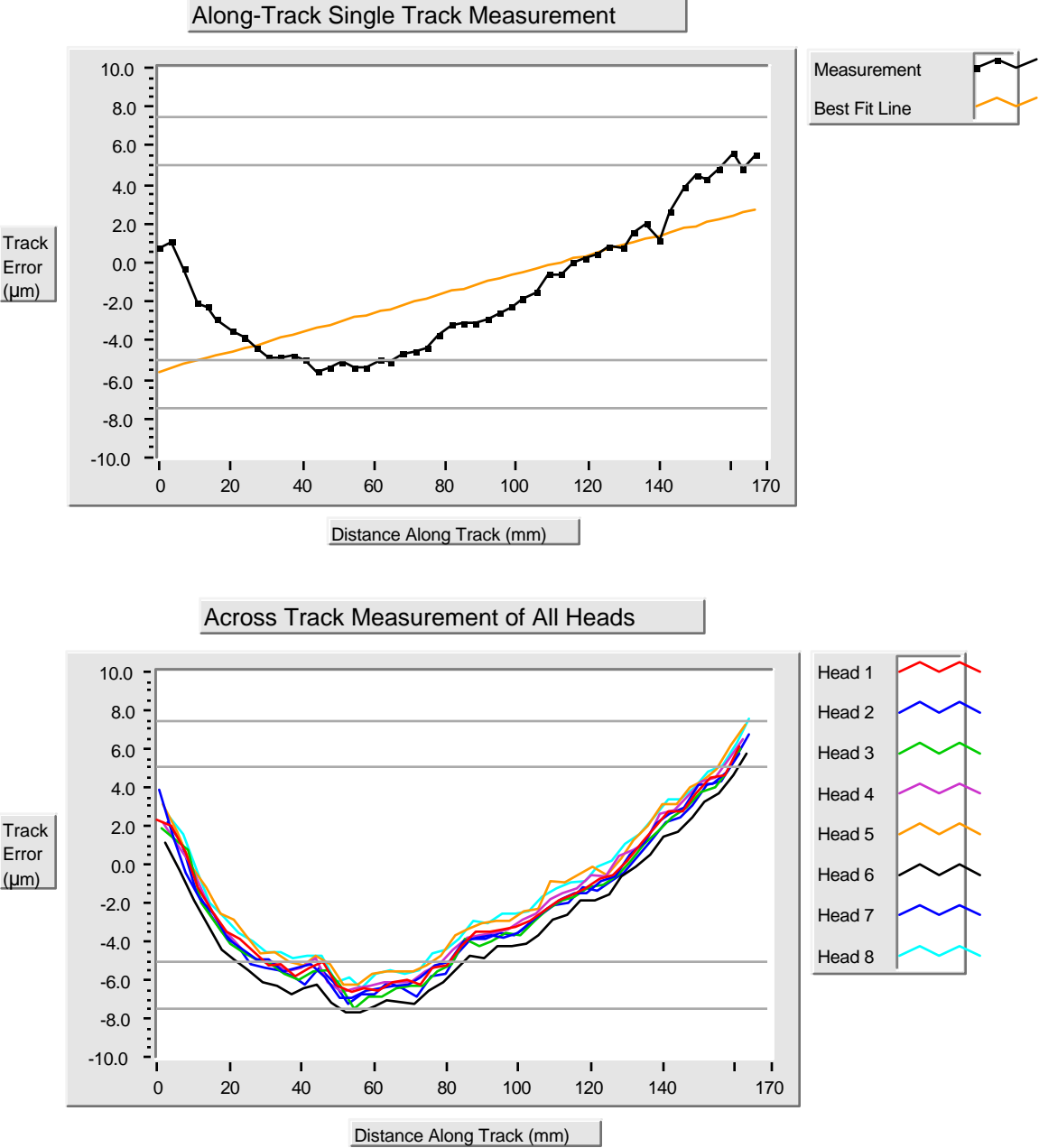
zero point of the vertical axis. In all figures the horizontal gray lines are the tolerance limits allowed by the ANSI standard. The inner pair, $\pm 5 \mu\text{m}$, is the allowed excursion for the first measured scan of the ANSI 6 track measurement. According to the standard all the rest of the helical scans must fall within the outer pair of lines, $\pm 7.5 \mu\text{m}$, in order to be able to claim that the recording conforms to the standard. These figures show that the Sony recording on Ampex media and the Martin recording on Ampex media are both non-conformant to the ANSI ID-1 footprint standard, X3.175 - 1990. The data in figures 1 and 2 is in good agreement with track straightness measurements taken by Sony in Japan on the other half of the two Sony Round Robin tapes. Datatape measured their recording on Sony media to be conformant to the ANSI standard. As of this writing, this has not been verified by the author, however, the Datatape recording on Ampex media has been verified as conformant but marginally so. The plug and play results from the non-conformant recordings is not included in statistical summaries but is included in the tables and figures for completeness.

Upper Graph - straightness plots of one scan, taken via the along-track method. The along track method gives the true helix angle of the recording. This angle is obtained from a straight line fit to the single scan data in the graph.

Lower Graph - straightness plots, taken via the cross-track method. The lower graphs have been corrected with the addition of the helix angle error from the upper graph and therefore show absolute straightness.

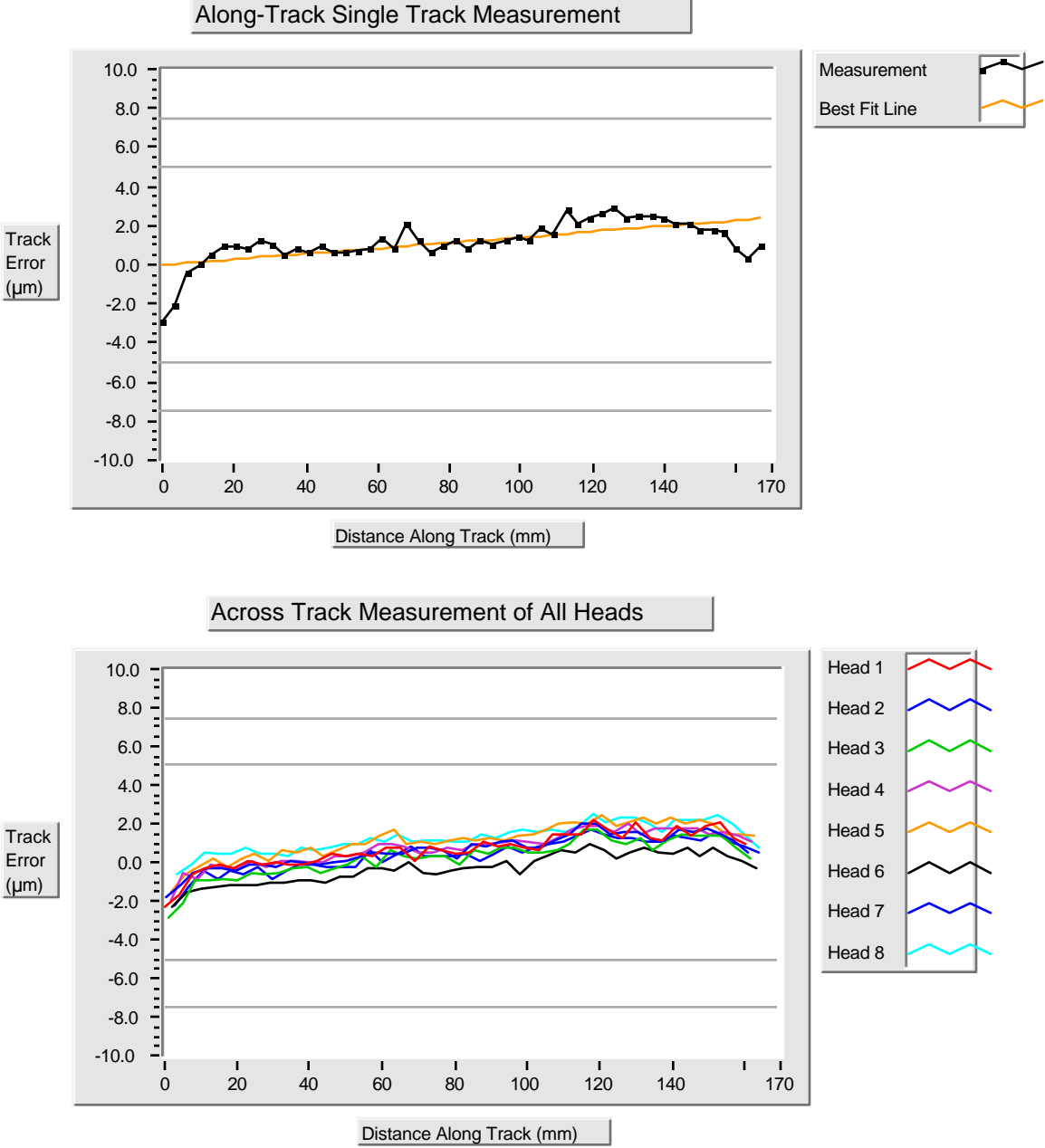
ID-1 Round Robin Crossplay Report
Presented at the October, 1996 Meetings of THIC

Figure 1: Recorder: Sony Media: Ampex Video Grade



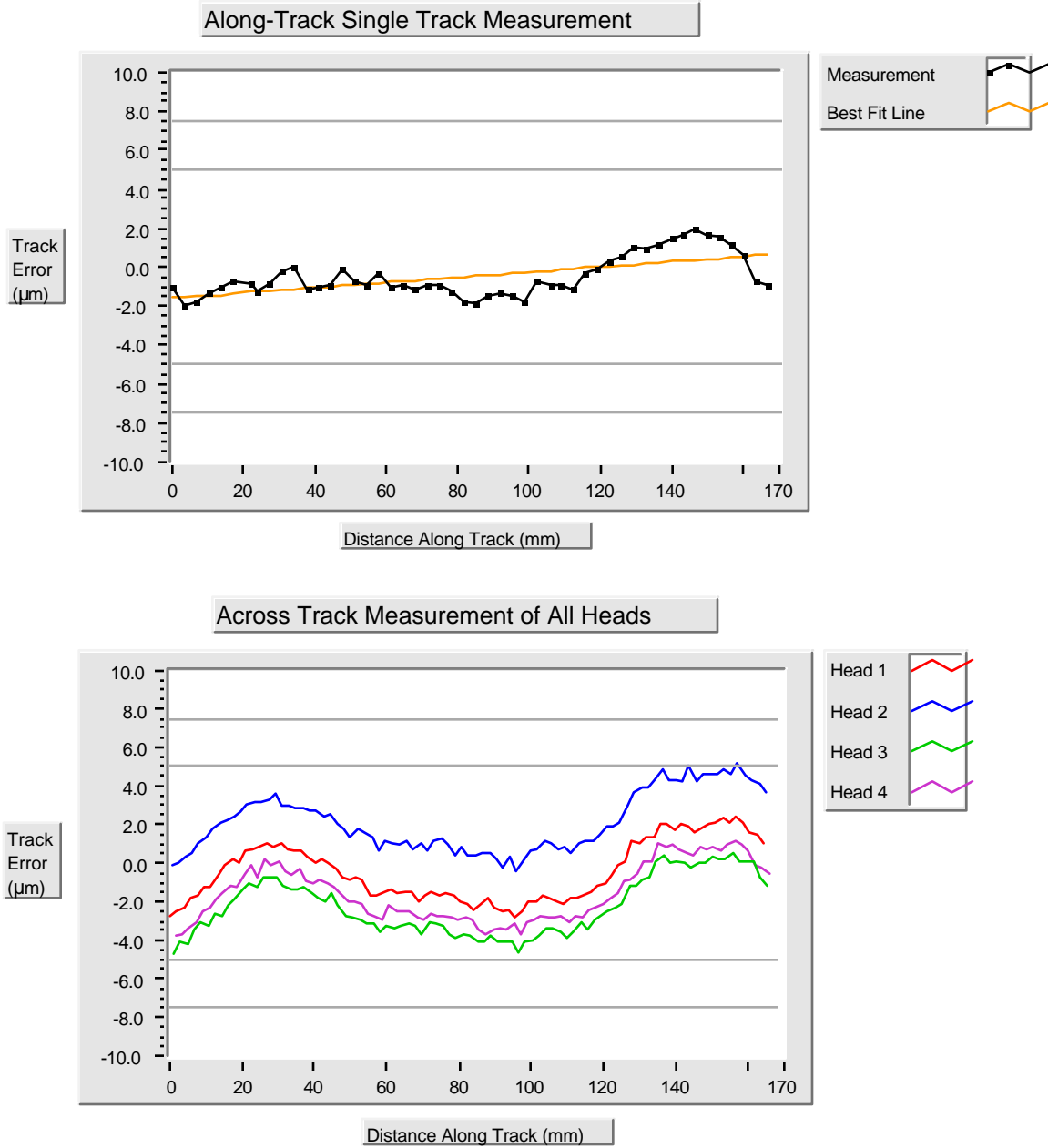
ID-1 Round Robin Crossplay Report
 Presented at the October, 1996 Meetings of THIC

Figure 2: Recorder: Sony Media: Sony Data Grade



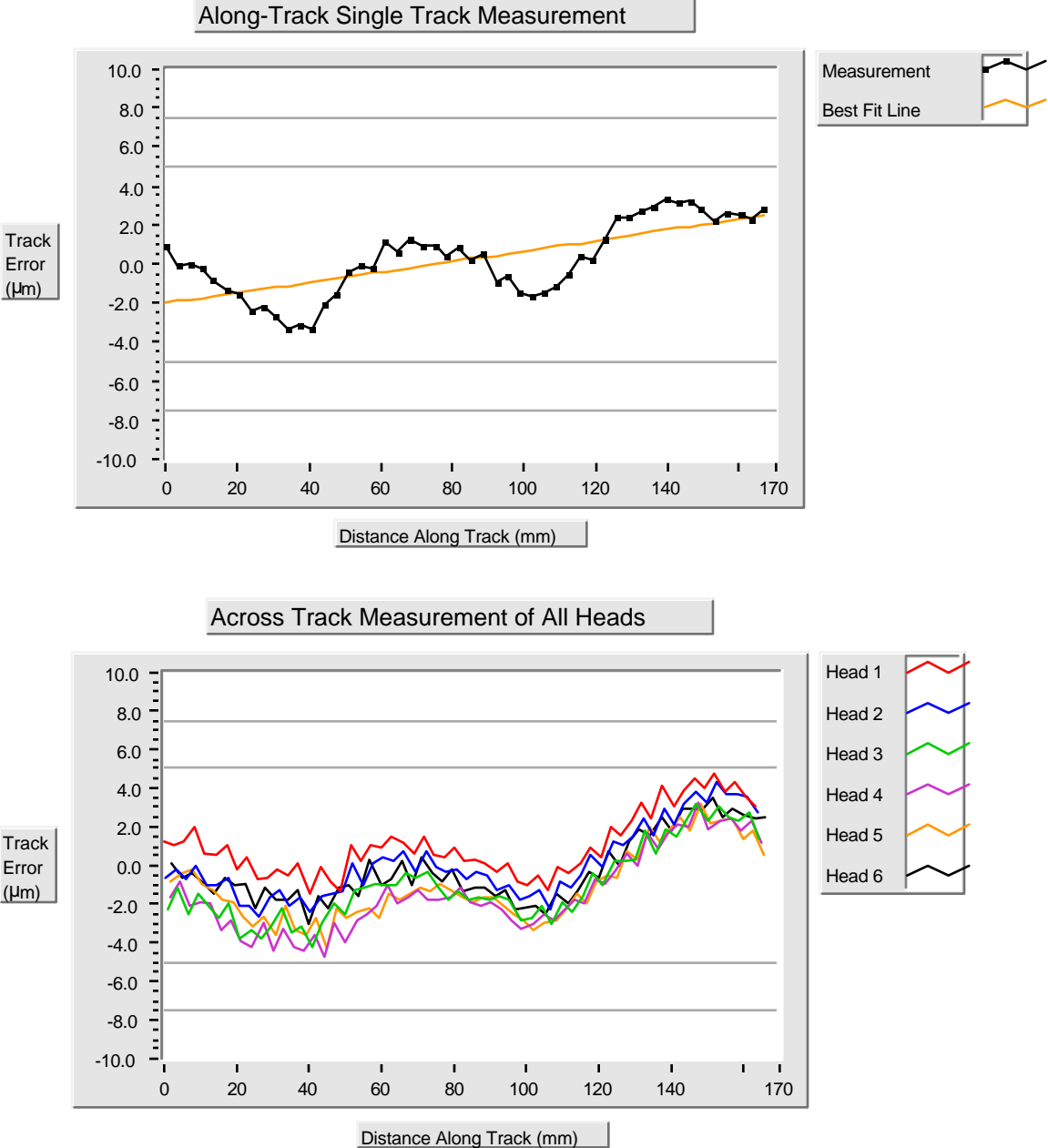
ID-1 Round Robin Crossplay Report
Presented at the October, 1996 Meetings of THIC

Figure 3: Recorder: Loral Media: Sony Video Grade



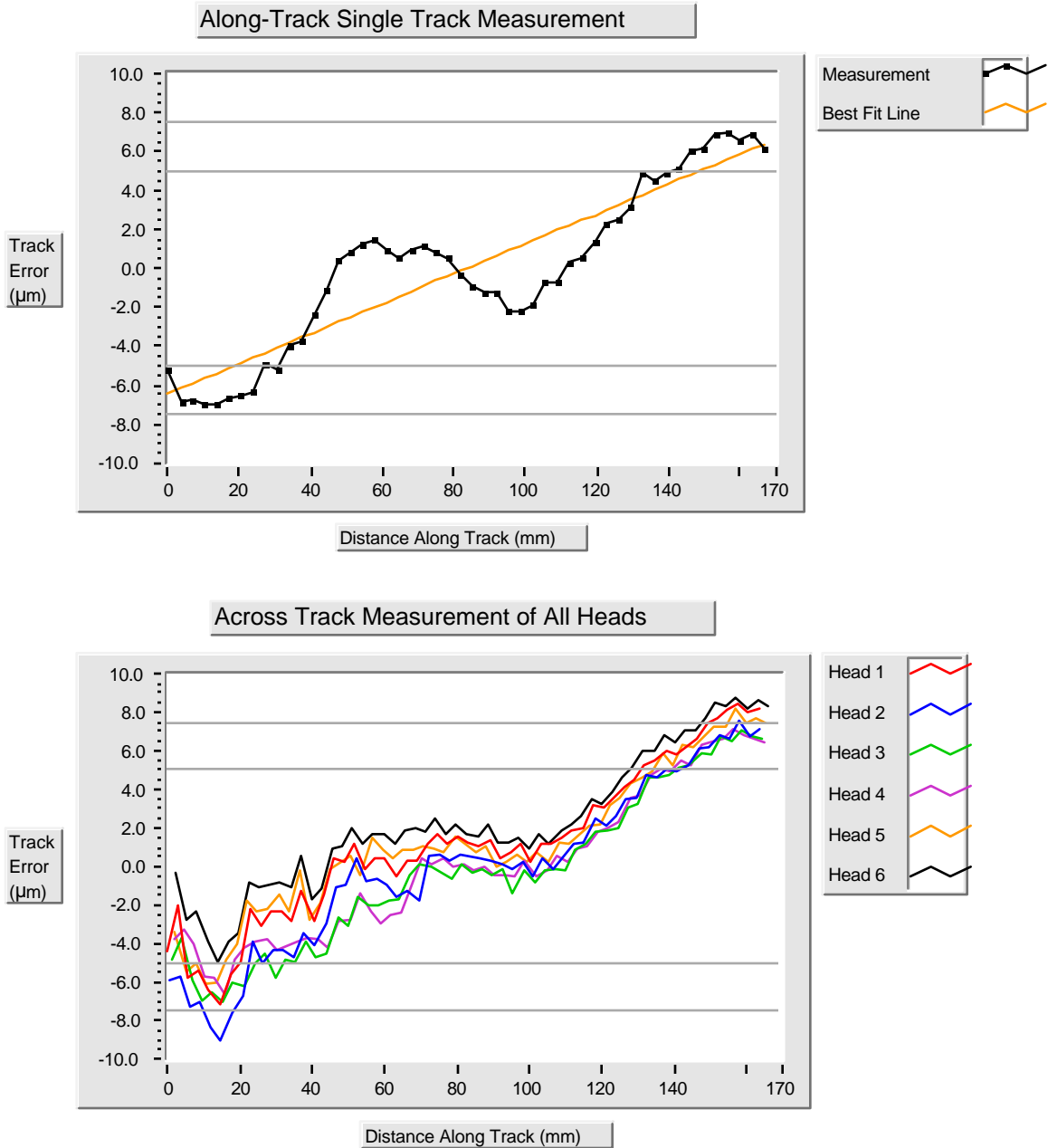
ID-1 Round Robin Crossplay Report
Presented at the October, 1996 Meetings of THIC

Figure 4: Recorder: Martin Media: Sony Video Grade



ID-1 Round Robin Crossplay Report
Presented at the October, 1996 Meetings of THIC

Figure 5: Recorder: Martin Media: Ampex Video Grade



Observations related to Media

Media as a CBER predictor: The correlation between poor performance and tape manufacturer is observed to be weak. There was a much stronger correlation between poor performance and crossplay between certain combinations of equipment.(see Table 4) The Navy has found that video grade Ampex media works “better” in their judgment, than the video grade Sony media; (see “Information from ID-1 Users”).

ID-1 Round Robin Crossplay Report
Presented at the October, 1996 Meetings of THIC

Data Grade Media Effect: It was difficult to tell if the data grade media affected the test results unfairly. The criteria used for successful crossplay using data grade media was more stringent than for video grade media. It is also possible that optimum equalization for data grade media may be different from those obtained using video grade media. Because of these differences, the data grade results are tabulated so interested parties may see them but they are not used in calculating the final success/performance percentages which appear in the results.

Record Side Media Optimization for tape type was not observed to be an overwhelming discriminant in being able to predict crossplay performance. No vendors optimized their record pre-equalization for tape type and only Martin optimized the record current to the tape type. The Ampex and Sony video grade media have similar magnetic characteristics. Testing performed by NAWC on these two media, Sony video grade and Ampex video grade, does support this belief. The two video grade media types do exhibit some differences in the tensions within the tape path of the various recorders and this could be explained by surface friction differences.

Future Media Sony no longer makes the video grade, 16 micron media used in these Round Robin tests. The problem of marketing and developmental changes in the magnetic media from a tape manufacturer has always been with us. If our intent was to compare media types then the situation would be much worse. Our intent here was to test differences in the recording hardware. Any testing can be said to be invalid as soon as the media changes. However, for a point in time this testing was valid and shows a comparison of recorder performance based on using the same media vendor's product in all the testing. At the time of this writing, there is indication that Sony may change the media in their Sony electrical calibration tape to their data grade, 16 micron media.

General Observations and Recommendations

The ANSI ID-1 standard as written does not guarantee non-fraternal crossplay in the "plug and play" sense. The manufacturers need to continue to work together publicly to further refine those items which will enhance plug and play performance.

Two of the eight Round Robin recordings were found to be non-conformant to the ID-1 footprint standard with respect to track straightness and one was judged as marginally conformant. All were on Ampex media (see Figures 1 & 5). If the surface friction differences of the two media are large enough, aligning the mechanical tape path to one media can produce an out-of-tolerance condition on the other. For better crossplay, one way to align the mechanical tape path would be to compromise on an alignment which results in

ID-1 Round Robin Crossplay Report
Presented at the October, 1996 Meetings of THIC

recordings on both media which are conformant to the standard but may not be “as good as it could be” on either one of the media.

It was originally believed that tailoring the record pre-equalization for each tape type would result in a significant improvement in any plug and play crossplay situation. However, since for these tests none of the manufacturers chose to change their pre-equalization from their factory settings, these tests can not be used to support that belief. It is recommended that the ANSI committee conduct this type of testing to determine the sensitivity of this parameter with respect to error rate performance. If the results of such testing show great differences in performance versus pre-equalization, then an auto-calibration feature would enhance the users’ ability to tailor his recorder to the tape type. Only one vendor provides auto-calibration of their ID-1 machine’s record side. Users and especially maintenance groups have lobbied for automatic calibration on all ID-1 recorders believing that crossplay gains could be achieved. A less expensive alternative to automatic calibration would include a memory bank of equalization settings for each media type.

It is possible that inter-symbol interference and non-linear, high-end, spectral response are large contributors to poor non-fraternal performance. An internal manufacturer review of record pre-equalization and read equalization may produce items that could improve margin.

The vendors need to be encouraged to use the reference tape approach for calibrating their recorders and making sure that the record side is optimized for non-fraternal crossplay at the factory. The procedure of using a reference tape to set up the read side is known to be a reasonable approach for crossplay, although it is not clear that the present Sony electrical calibration tape is optimal for all ID-1 recorders.

The ANSI ID-1 standard incorporates a Reed-Solomon error correcting code for user data recovery. It is well known that vendors are using different decoding strategies in their read electronics. This was evidenced by relatively error free performance even when a high level of inner errors were being passed to the outer corrector as displayed on the some vendors’ front panels. Other vendors reading the same recording had very few inner errors passed to the outer corrector. Decoding strategy remains an area in which gains can be made to improve crossplay performance.

It was noticed that on most of the vendors’ machines, only one head/channel contributed most of the errors. Perhaps more careful head parameter matching and tighter channel parameter matching may lead to recorders with better performance overall.

ID-1 Round Robin Crossplay Report
Presented at the October, 1996 Meetings of THIC

Another item for review would be to develop field procedures on how to use or adjust the ID-1 recorder to compensate for physical differences between media types. This is especially true for the record side as it was seen in the cases where non-conformant footprints were recorded on Ampex media when the recorders are set up for Sony media.

It is possible that for best non-fraternal crossplay, the playback settings of the various recorders are not optimum when adjusted to the Sony electrical calibration tape. This was demonstrated with the Martin RDR400 recorder. In crossplay situations the Martin recorder was found to work best when manually adjusted to the Datatape Round Robin recording on Sony video grade media. The settings thus obtained on the Martin machine's read electronics produced acceptable, but sub-par fraternal performance and yet produced very acceptable non-fraternal performance.

Vendor Specific Observations and Recommendations

Loral/Schlumberger: Both Loral Round Robin recordings were made on a recorder which had its record currents and pre-equalization optimized for Sony SD-1 data grade media, that is, no record side optimization was attempted since according to Schlumberger, the average UBER is similar for SD-1 and Ampex data grade media.

The Schlumberger recording on Ampex data grade media was recorded at half of the maximum rate capability of the machine and produced a recording which was read without error by recorders from all other vendors.

Before playback tests were run with the Loral recorder, the Loral technician adjusted the Loral equalizers to a position/setting which he considered to be slightly "off" from the factory settings in order to read the Sony electrical calibration tape acceptably.

Schlumberger does not recommend the use of video grade media for data recording applications.

Martin Marietta: Martin recordings were involved in nearly half of the "bad" non-fraternal, valid crossplay combinations in these Round Robin tests, but it is not clear why. It is possible that there is inter-symbol interference mismatch due to their digital record pre-equalizer. If that is the cause then in a crossplay sense, Martin Marietta would benefit by redesigning the record pre-equalization to use an analog technique, thereby making the RF signature of their recordings much more similar to other vendors' recordings.

On two unique crossplay attempts where the tracking algorithms failed to converge, subsequent manual tracking playbacks produced acceptable crossplay

ID-1 Round Robin Crossplay Report
Presented at the October, 1996 Meetings of THIC

performance. Other vendors' tracking algorithms were able to converge on the same Round Robin recordings. This indicates that there may be room to improve the automatic tracking firmware. (Lockheed Martin engineers confirmed that they know how their tracking firmware can be improved.)

Martin Marietta re-optimized the record current of their recorder to each of the supplied media types but the record pre-equalization was left at the factory settings which are set using Sony video grade media to give best results when crossplayed with Sony equipment. In these tests, both Martin Round Robin recordings produced exactly the same crossplay CBER results. (See tables 2&3)

The Martin recording on Ampex video grade tape was measured to be outside the tolerances of the ANSI ID-1 standard. Martin has always recommended that only Sony media be used with their equipment and has contended that performance on their equipment with any other media is not assured. On the other hand it may be possible to compromise somewhat on the mechanical alignment such that recordings conformant to the standard could be made on both Ampex and Sony media.

To their credit, the Martin hardware read every Round Robin recording without error, including the ones non-conformant to the ID-1 footprint. This accomplishment is most likely the result of significant SNR and decoding margin in the read electronics of their RDR400 recorder.

Sony: On some of the playbacks of various Round Robin recordings, Sony recorders exhibited tracking problems characterized by the auto-tracking algorithm's inability to pick a consistent tracking position. On three unique crossplay attempts where the tracking algorithms failed to converge, subsequent manual tracking playbacks produced acceptable crossplay performance. Other vendors' tracking algorithms were able to converge on these same Round Robin recordings. This indicates that there may be room to improve the auto-tracking firmware.

Sony recorders do not have the capability of adjusting the record settings and therefore their Round Robin recording on Ampex media was not optimal. The Sony recorder has no user or maintenance adjustments on the equalizers, but it has been confirmed by Sony that their equalizer settings produce acceptable, but not necessarily optimal, performance when reading the Sony electrical calibration tape.

Sony was the only equipment that had any sort of trouble playing fraternal recordings. The Sony fraternal recording on Sony data grade media exhibited low RF levels. A sampling of peak to peak RF voltage levels at the output of the preamplifier of one channel of a LP400 reproducer gave these results at 400Mbps: Sony recording on Sony data grade media, 0.570volts; Sony DR5-1D

ID-1 Round Robin Crossplay Report

Presented at the October, 1996 Meetings of THIC

electrical calibration tape (serial 01 30705-4), 0.725volts; Sony recording on Ampex video grade media, 0.725volts; Martin recording on Ampex video grade, 0.875; and a simulplay RF level on the measuring LP400 using Sony video grade media was 0.945volts. [Similar RF voltage levels were obtained when measured on a Martin RDR400.] Several DIR 1000s exhibited frequent, large uncorrected errors while reading the Sony recording on Sony data grade media. It is possible that this is due to the fact that Sony recorders do not have AGC (automatic gain control) in the signal path.

The Sony recording on Ampex video grade tape was measured (see Figure 1) to be outside the tolerances of the ANSI ID-1 standard. In view of the phenomenal track straightness with Sony data grade media(see Figure 2), it may be possible to compromise somewhat on the mechanical alignment such that recordings conformant to the standard could be made on both Ampex and Sony media.

Datatape: Datatape Round Robin recordings on Ampex media were made without optimizing the pre-equalization or the record current. Datatape chose not to optimize their record side for the Ampex video grade media, they said, because the resultant self play performance was acceptable and similar for both of the Round Robin media. Datatape used factory record side settings in making the Round Robin recordings. These factory settings are optimized to stock, video grade, Sony D-1 media similar to, but not necessarily identical to the Sony Round Robin media.

Datatape was the only vendor whose equipment made a recording on video grade tape which was read without error on all the other vendors' equipment. The conclusion is that the spectral content, the inter-symbol interference, and the record current were extremely well matched to the same parameters in the Sony Electrical Calibration tape.

Datatape recorders do not have AGC (automatic gain control) in the signal processing path and one of the more noticeable observations was the reduced performance of Datatape ID-1 recorders when reading the Sony Round Robin recording which had low RF levels.

ID-1 Round Robin Participants

Government participants in the testing:

Department of Defense at Fort Meade, Maryland, USA

Naval Air Warfare Center, Warminster, Pennsylvania, USA

User and interested organizations attending most or all of the crossplay meetings

Naval Surface Warfare Center, Carderock Division, Bethesda, Maryland

National Aviation Intelligence Center, Wright Patterson AFB, Dayton, Ohio, USA

ID-1 Round Robin Crossplay Report
Presented at the October, 1996 Meetings of THIC

Technology Solutions, Fulton, MD, USA
Data Storage and Retrieval Consultants, Crownsville, MD, USA
National Media Laboratory, St. Paul, Minnesota, USA
Vendor participants in the testing:

Sony, Japan
Schlumberger Industries, Velizy-Villacoublay, France
Quantegy, Inc. Opelika, AL, USA
Loral Data Systems, Sarasota, FL, USA
Lockheed-Martin Inc., Camden, New Jersey, USA
Datatape, Inc., Monrovia, California, USA
Ampex Corporation, Redwood City, CA

Credits

Many thanks to Don Sanders for the hours of work in the lab taking data and for helping me obtain tape drives to play the Round Robin recordings. Also a thank you goes to Mark Morris who labored diligently to take the data on the footprint analyses for the figures in this report. The kind help provided by all the vendors during this testing is greatly appreciated. A note of appreciation also goes out to Jim Keeler who served as co-chair for the crossplay meetings. A note of thanks goes to Glenn Jadney, E. J. Wendell and Jack Hirsh for helping with data analysis, the meetings and certifying the media. Also appreciated was the meeting support provided by THIC, Inc. And by the ANSI X3B5 standards committee on flexible recording media.

National Media Laboratory Comments:

Only editorial comments were received from the NML. The author wishes to thank the NML for reviewing this report.

Vendor comments on the draft of this report:

Datatape: Datatape would like to express its appreciation for the work done by Alan Montgomery in both the evaluation of the recorders and preparation of the report. Based upon preliminary results of his work, Datatape has been able to improve its manufacturing processes and, ultimately, the performance of its ID-1 products.

As noted by the author, it is difficult to draw strong conclusions from the given data. Several variables, which were not in control of the author, worked to dilute the data. These included the use of data grade tape, which in one case was not recorded at the record level specified by the ANSI X3.175-1990 standard. This caused some machines to have difficulty with detection of the signal, as its reproduce amplitude was significantly below the expected level.

ID-1 Round Robin Crossplay Report
Presented at the October, 1996 Meetings of THIC

Additionally, the fact that the Ampex media did not track identically with the Sony media, and, in fact was not in footprint in [at least] two of the four recordings tends to unfavorably bias the Datatape reproduce results. It is reasonable to assume that had the recordings been within specification the reproduction of those recordings would have improved.

Despite the above deficiencies in the data, the results were enlightening enough to prompt product improvements in the Datatape LP ID-1 recorders. These include an improved crossplay alignment procedure, whereby all LP recorders are aligned to the Sony electrical alignment tape. This has greatly improved Datatape's ability to consistently achieve crossplay with Sony ID-1 recorders, in particular.

Additionally, all Datatape ID-1 recorders delivered to the Department of Defense now include a field acceptance criteria whereby non-fraternal crossplay with Sony ID-1 recorders is demonstrated in both directions to the satisfaction of the customer.

In addition to the above improvements, future improvements to the Datatape LP series recorders will include downloadable equalizer settings. This will allow a user to save and restore multiple reproduce settings. The user can then at any time restore a setting which is optimized for the particular vendor's recording that he is about to reproduce.

Finally, Datatape is pursuing an improved head technology with the intent of increasing the signal to noise margin, and ultimately, crossplay performance. While this technology will additionally benefit the user with an improved head like, the primary focus of the effort is crossplay performance.

Datatape is committed to supporting the ID-1 community with a continuously improving product, and looks forward to working with the industry toward 100% fraternal and non-fraternal crossplay capability.

Sony: On page 4, there is a description on record side optimization which is not the case for Sony. Sony did not apply this reproduce side calibration and record side optimization process, and used a brand new off-the-shelf recorder. This is because of Sony's design philosophy of the DIR 1000, i. e., no electrical adjustment is required throughout the life of a headwheel, nor is adjustment required upon replacement of a headwheel.

Sony reserves the right to express a future position on a possible side effect from covering the built-in scrapers with pelon wipes. The theory behind this is that pelon wipes may change the tape tension and/or tape wrap angles around guiding elements, which might lead to the low RF levels reported on pages 8 and 19. The scrapers are a countermeasure against occasional drop-outs due to dust. It is

ID-1 Round Robin Crossplay Report
Presented at the October, 1996 Meetings of THIC

possible that with scrapers active, the failed fraternal crossplays could pass. Recognizing that the main contributor to failed crossplays may be a few error events, scrapers might be effective in removing dust which may lead to error events in conjunction with low RF levels.

The author notes that Sony submitted measurements from the other half of the Sony Round Robin recording on Sony data grade media which indicated no degradation in RF levels as compared to the Sony electrical calibration tape and to the Sony Round Robin recording on Ampex media. No theory has been proposed as to the cause of the different RF levels on the two halves of the Sony data grade tape.

Schlumberger: Mostly editorial comments were received from Schlumberger. Schlumberger did relate that in their experience they see a $\pm 5 \mu\text{m}$ variation in the track straightness of the Ampex media from batch to batch. From their comment it was unclear whether they were referring to Ampex data grade or Ampex video grade. Schlumberger has not seen this variation in the data grade Sony SD-1 media.