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5.3 THEMATIC MAPPER PERFORMANCE*

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Just a brief overview, if some of you aren't familiar with how the thematic mapper primarily differs from MSS. The spatial resolution is the key improvement where the TM has 30-meter resolution and the MSS has 80-meter resolution. For the agricultural users, this should provide an ability to accurately classify 10-acre fields with the TM versus 70-acre fields with the MSS data. As far as spectral resolution, there are six reflected light bands in the thematic mapper. Two of those bands are of basically a new spectral region out in the the near IR, the shortwave IR region, 1.55 to 1.75 microns and 2.08 to 2.35 microns as opposed to MSS's four reflected light bands. The other four thematic mapper reflected light bands in the visible portion of the spectrum are designated to enhance the classification capability. They are much more ideally selected from a spectral standpoint, narrow spectral bands more optimally selected to enhance classification accuracy. The TM also has better signal-to-noise ratio performance and radiometric sensitivity, and in order to obtain that we have had to increase the size of the optics, basically a 16-inch telescope as opposed to an 9-inch telescope in MSS. We've increased the scan efficiency through the use of bidirectional scanning, which gives us a scan efficiency of 85% versus 45% with the multispectral scanner, and more detectors per band, 16 versus 6. We also have greater encoding resolution in our multiplexer, 8-bit resolution versus 6 bits for MSS.

One of the features that is of particular interest is the scan profile and the registration capability. Certainly the scan profile is more linear than was obtained in the MSS, and for a large selection of the users, the imagery could be used without resampling and I think satisfy many of the needs that I've heard expressed today. As far as geometric accuracy or scan profile, a typical Landsat D MSS scan profile exhibits nonlinearities on the order of five instantaneous fields of view. For the MSS, with 80-meter resolution, those were on the order of 500-microradian nonlinearities in the scan profile.

The thematic mapper profile data, on which, as I indicated, we are still doing some final refinements in the processing, is our measured forward scan profile, as shown in Figure 1. You can see the peak nonlinearity in the scan has a magnitude of about 30 microradians. The rms nonlinearity I believe is on the order of 10 microradians. The reverse scan profile has a slightly different shape (Figure 2). It's not quite as linear as the forward scan, but it's well characterized. The peak nonlinearity in the reverse scan as measured in our vacuum tests just prior to delivery was about 60 microradians. Each figure would have to be flipped end for end in order to see how they register in object space. Note also that they are both plotted on a time scale instead of an object space scale.

As far as the overlap/underlap characteristics, Figure 3 summarizes the various contributors to the overlap/underlap effects within the system. We have chosen to optimize the scanning parameters at 712.5-km altitude and an average 40° north latitude where most of the scenes of interest appear to be located

*Edited oral presentation.

throughout the world. As the scanning parameters were optimized for that altitude and latitude, the resultant underlap and overlap of about 3.4 and -3.4 microradians occurs (Figure 4).

The bow-tie effect (Figure 4) is basically due to the path length over the scan angle. From one end of the scan to the other this contributes an overlap effect of about 6.5 microradians at the end of scan. Scan mirror performance has these contributions. Basically, within the prime focal plane, we have a maximum over/underlap of about 7.3 microradians, and with the bow-tie effect included we have a maximum overlap of about 11.1. For the cooled focal plane, we have 7.9 with a maximum overlap of 10.5. Our requirement is 8.5 microradians neglecting the bow-tie effect so we're fairly well within our requirements. Basically, the altitude variations globally sort of wash out or certainly dominate the overlap/underlap performance on a global scale.

As far as band-to-band registration, we chose the band-to-band registration between bands 5 and band 1 which are the furthest separated bands within the thematic mapper (Figures 5 and 6). The nominal band spacing is 146 instantaneous fields of view and the dynamic registration measured at 30 points in the scan profile is as plotted with a typical, an average registration of about 145.95. Our requirement is that the prime and cool focal planes be registered to within .3 of an instantaneous field of view and about the nominal band separation. So we are well within our requirement on a dynamic registration basis between the prime and cooled focal planes. All the other spectral bands, with respect to band 1 are more closely registered.

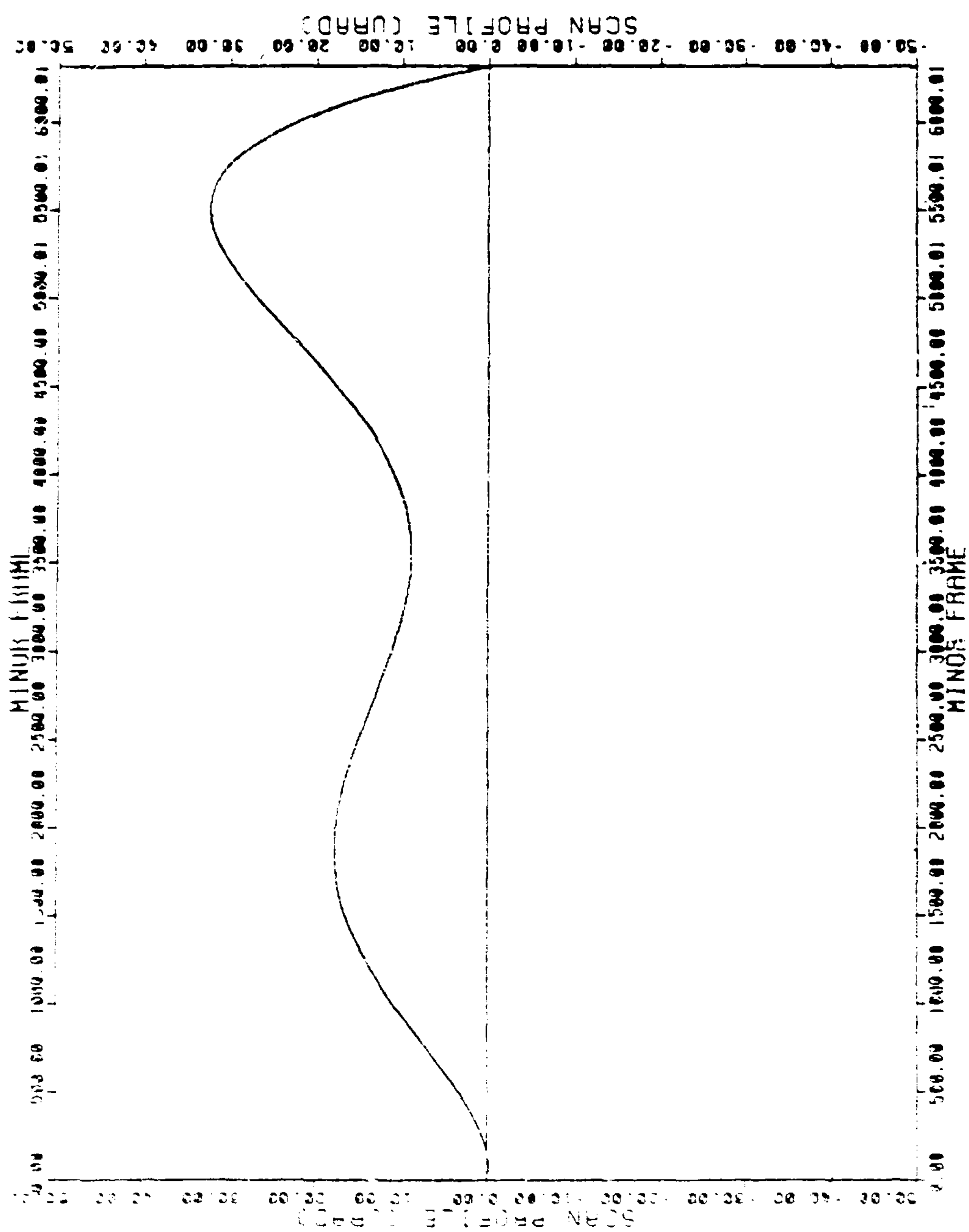

Figure 1. Forward Scan Profile

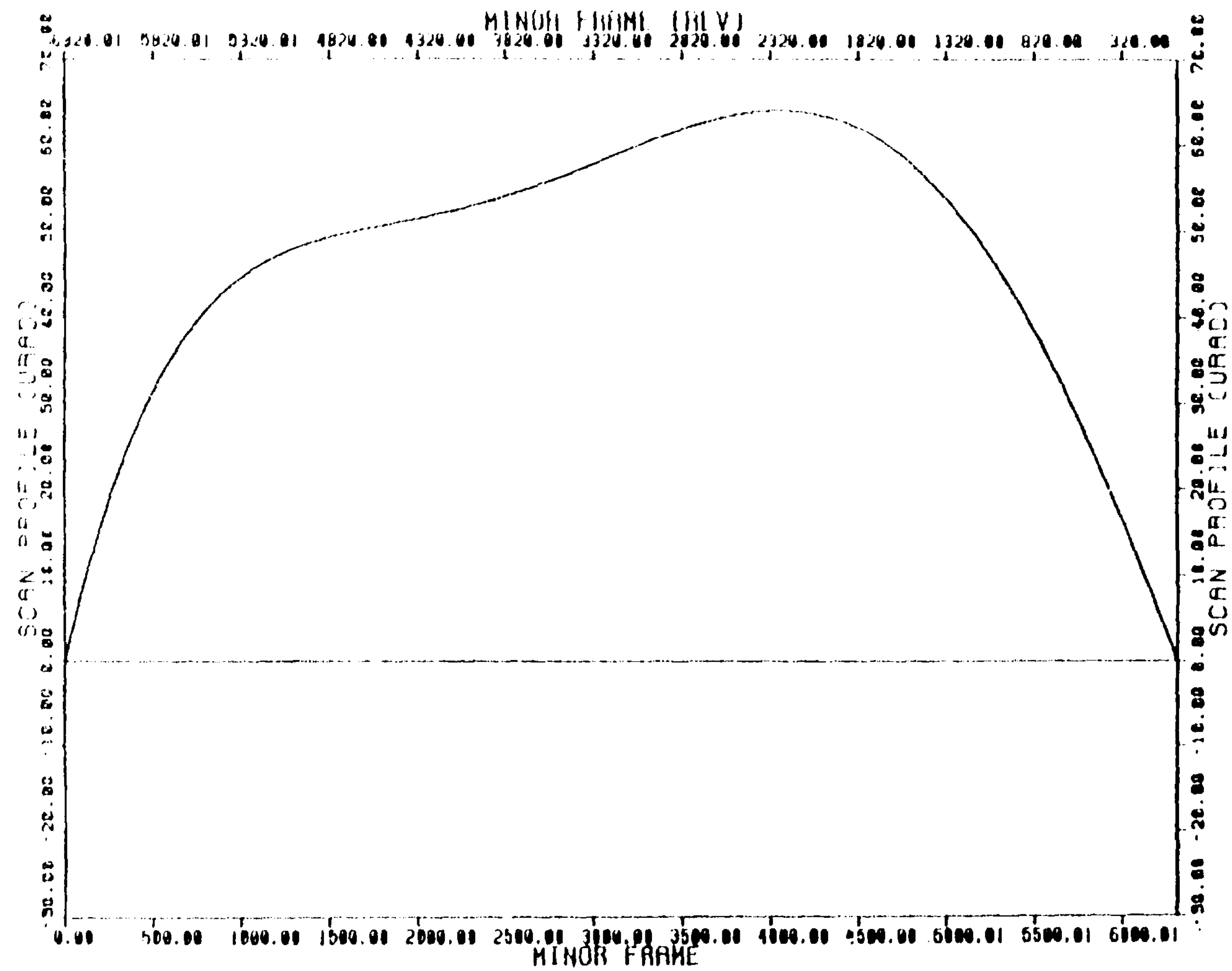

Figure 2. Reverse Scan Profile

SOURCE	PROTOFLIGHT UNDER	PROTOFLIGHT OVER	PROTOFLIGHT RANDOM*
NOMINAL ORBIT AND SCAN PARAMETERS**	3.4	-3.4	
BOW TIE EFFECT	0.0	6.5	
SMA			
SM CROSS AXIS MOTION	2.0	2.0	1.0†
SM PERIOD VARIATION	2.6	1.3	0.0
VIBRATION			0.5
RADIOMETER			
NON-IDEAL SLC SCAN	2.0	2.0†	0.2
EFL DEVIATION			
TELESCOPE	-1.0	1.0	
RELAY OPTICS	4.3††	4.3††	
DETECTOR IFOV SIZE	-5.4††	+5.4††	
VIBRATION	-1.7†††	+1.7†††	1.4
TOTAL PFPA	7.3	11.1	1.8
TOTAL CFPA	7.9	10.5	
SPECIFICATION		8.5	
EFFECT OF ORBITAL ALTITUDE VARIATIONS BETWEEN 45°N AND 45°S LATITUDES	22.0	15.7	

*1 SIGMA
**ALTITUDE = 712.5KM
VELOCITY = 6821 KM/SEC
SCAN PERIOD = 142.925 MSEC

† OVER FULL TEMPERATURE RANGE
†† AFFECTS COOLED FOCAL PLANE ONLY
††† AFFECTS PRIME FOCAL PLANE ONLY

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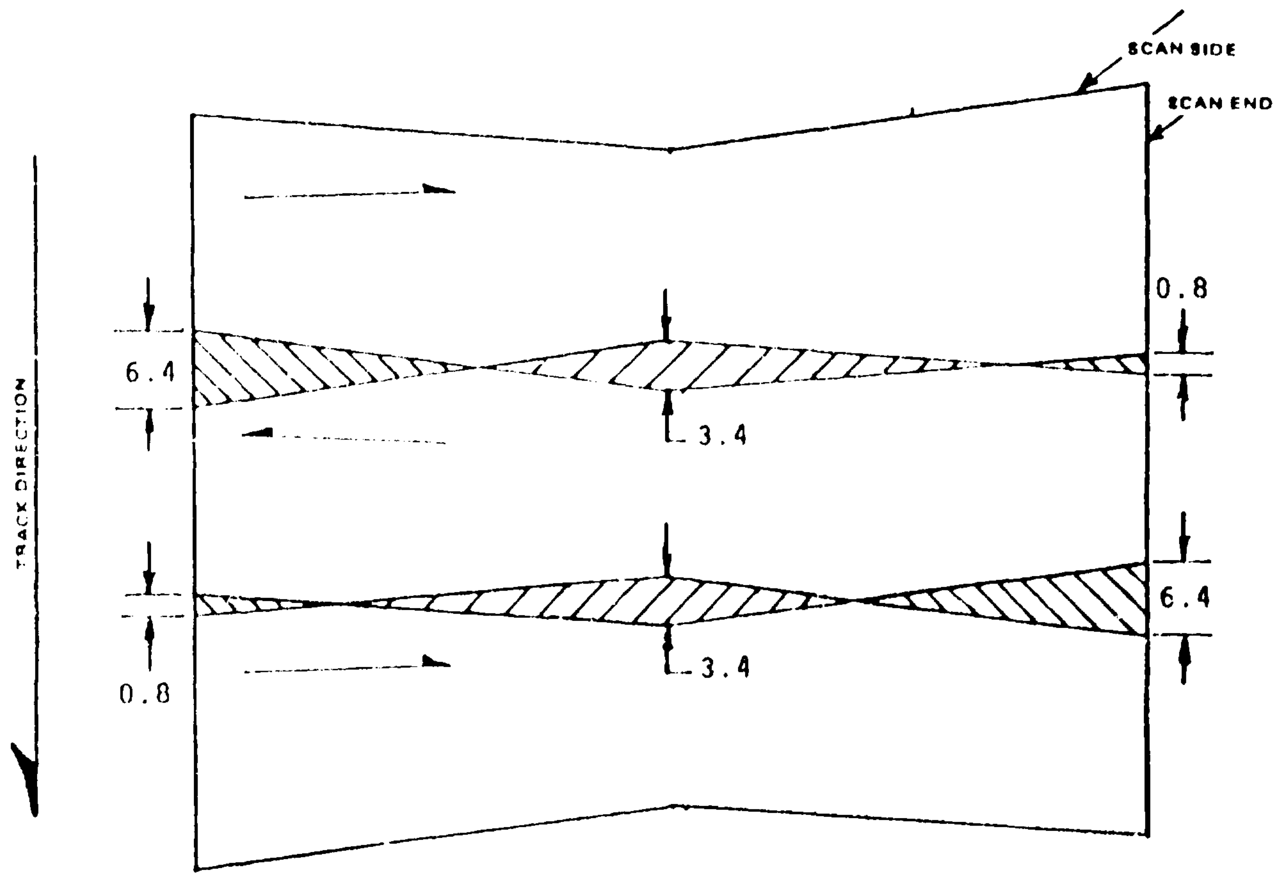
Figure 3. Overlap/Underlap (3.2.7.2) (microradians)



GROUND TRACE OVERLAP/UNDERLAP AT 40° N DESIGN POINT, μrad

Figure 4. Overlap/Underlap With Bow-Tie Effect

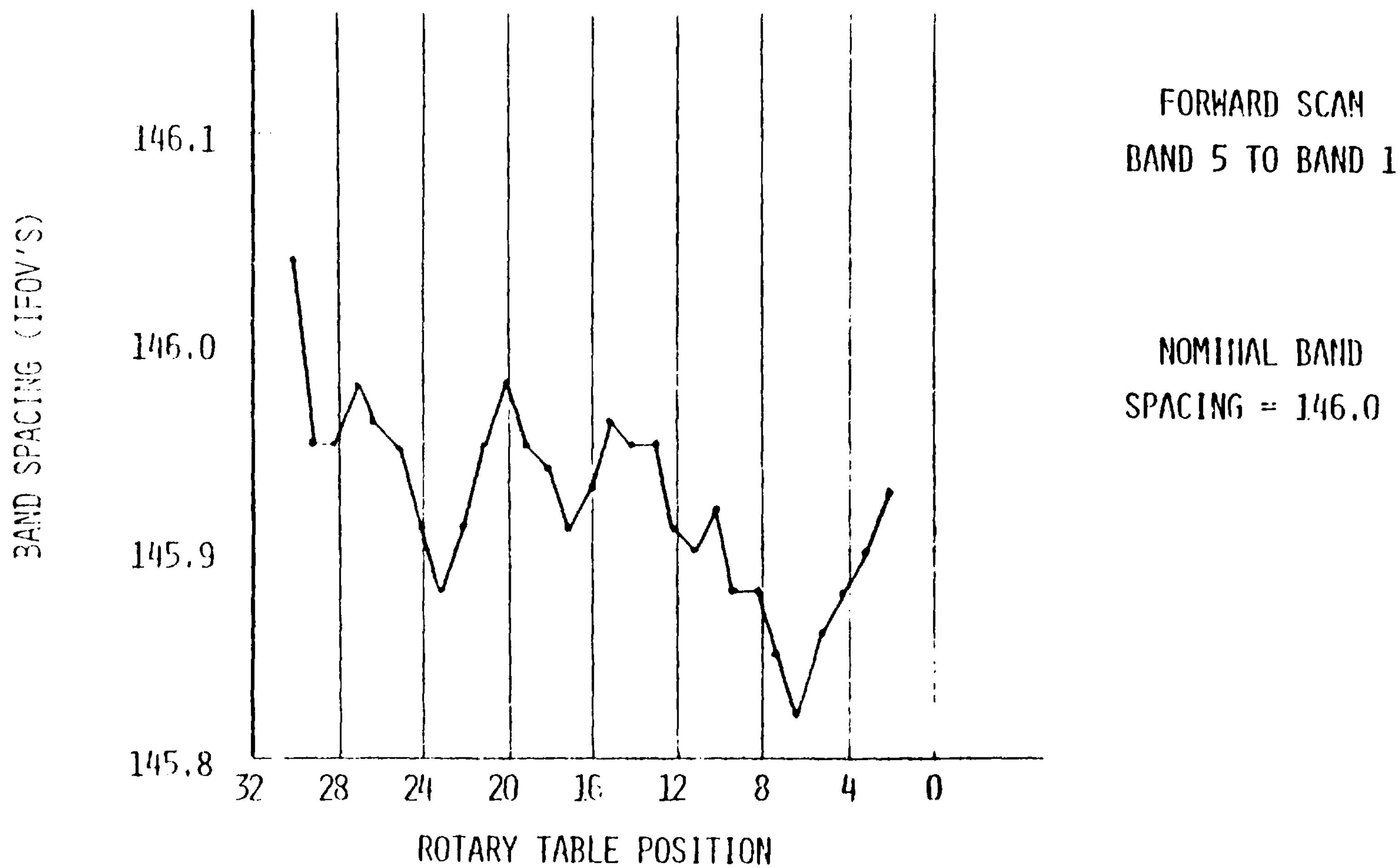


Figure 5. Dynamic Band-to-Band Registration (Along Scan)

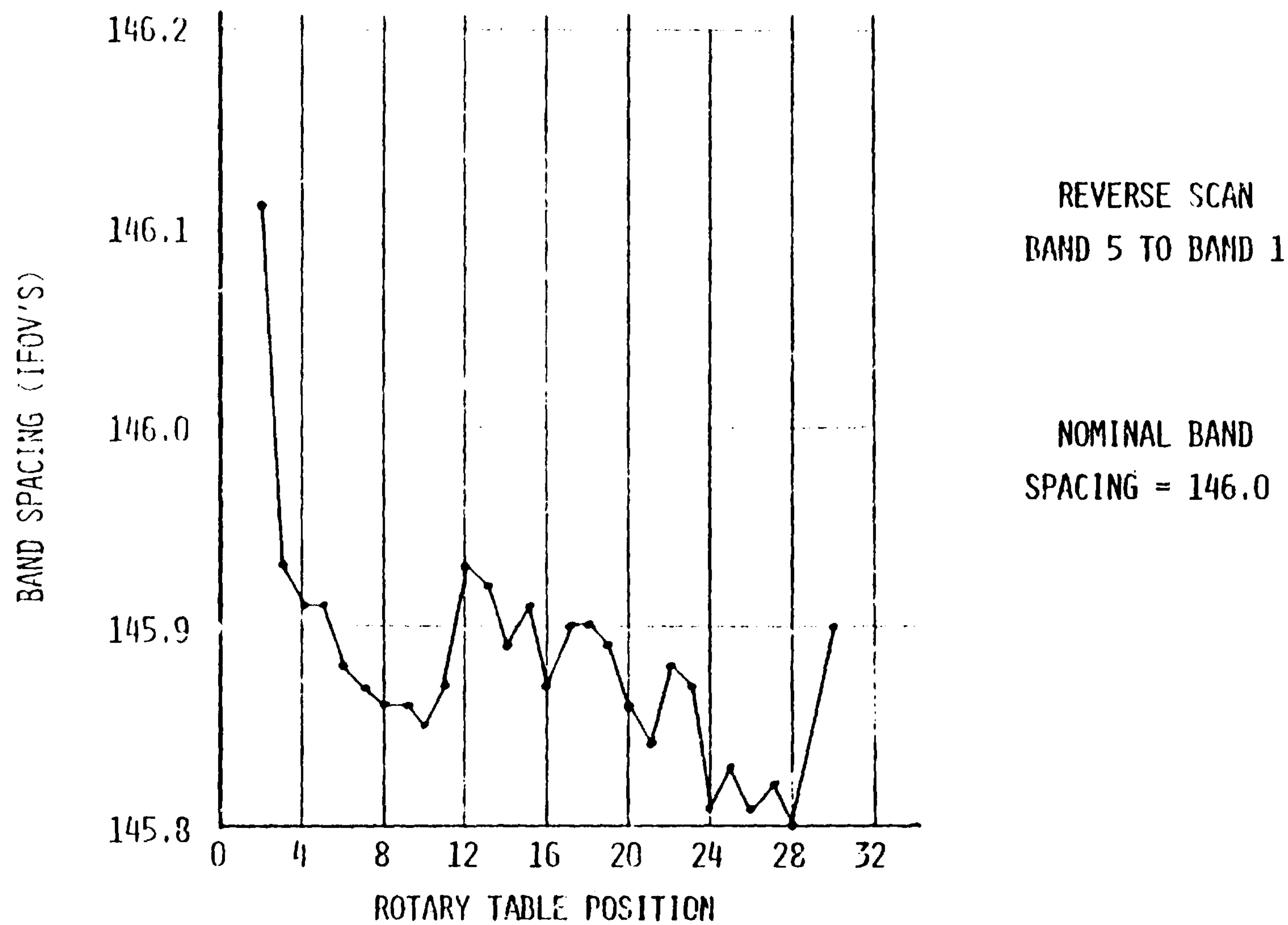


Figure 6. Dynamic Band-to-Band Registration (Along Scan)