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SPACE/TIME ADAPTIVE PROCESSING (STAP) ANALYSIS

Syracuse Research Corporation

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SPACE/TIME ADAPTIVE PROCESSING (STAP) ANALYSIS

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ABSTRACT

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1.0 INTRODUCTION

This program had three goals. The first goal was [for Syracuse Reseach Corporation (SRC)] to develop an antenna pattern computation computer code that would interface with the Air Force Research Laboratory's (AFRL's) RLSTAP computer code. The patterns were to provide some reasonable full sphere representation of element (or subarray) radiation that could be applied, in turn, to "launching" an exciting field for computing platform multipath scattering. The approach taken was to construct a relatively simple model of an array in front of a finite conducting back plane. This method did not resort to computationally intensive moment methods and ensured reasonable active impedance match between elements. An array imbedded element pattern model was combined with back plane edge diffraction and the resulting module ("ELEMPAT") was completed and delivered to AFRL.

Unfortunately, the diffraction model in ELEMPAT was valid only for tall back planes, on the order of at least three wavelengths and the immediate problems of interest called for UHF arrays with narrow back planes of only one wavelength height. The model would apply to such arrays if, for example, the antenna were located near the under side of the vehicle so that the continuation of the back plane into the fuselage proper would justify a larger equivalent back plane model. The array of immediate interest, however, was to be more centrally positioned on the vehicle. Consequently, in place of SRC's code, a moment method analysis of the antenna array and back plane was carried out (by another firm) for specific platform geometries and this, in conjunction with Physical Optics modeling of platform scattering, was applied to RLSTAP in generating data for the evaluations discussed below. Nevertheless, ELEMENT is a worthy tool for use in conjunction with RLSTAP. The module is briefly reviewed in Section 2.

The second goal was to assist AFRL in adapting a Space/Time Adaptive Processing (STAP) code to interface with RLSTAP. This code had been developed by SRC under an earlier contract with AFRL. It featured selection from eight post pulse compression STAP methods (in addition to conventional low sidelobe, nonadaptive processing). Part of the task was to add a STAP performance measure to the module, in particular, SNR Loss. The module was successfully interfaced with RLSTAP and is briefly described in Section 3.

The third goal was to assist AFRL in applying the STAP module to RLSTAP generated UHF airborne radar scenarios of interest. The results are described in Section 4. Four RLSTAP data cubes were processed. The data cubes were generated from Gaussian clutter scenarios with one imbedded target in each scenario. The scenarios differed in target Doppler velocity (15 m/s and 8 m/s) and in element patterns (ideal and "installed"). The ideal patterns were cosine theta patterns. The "installed" patterns were the result of the comprehensive moment method analysis of mutual coupling and Physical Optics platform scattering referred to above applied to an array of 26 columns of two elements each mounted on a Dash 7 aircraft. The two elements within each column were combined into a single "subarray" channel.

The 15 m/s target was visible with conventional (nonadaptive) processing. The 8 m/s target required STAP. Although the 8 m/s target was visible with the limited degree of freedom STAP method - Joint Domain Localized (JDL) - for the ideal antenna pattern case, it was not visible with JDL for the installed pattern case. Part of the problem with STAP in the installed pattern cases may have been attributable to the apparent severe mismatch of the outer four installed subarray patterns on both ends of the array with respect to the center 18 subarray patterns. This mismatch was observed in the subarray patterns resulting from the moment method analysis of mutual coupling for the array in front of a wavelength wide back plane. Application of other STAP methods based on all available spatial channels as degrees of freedom (in particular, 3-pulse Element Space Post Doppler ADPCA and Factored STAP) yielded only marginal improvement (under 5 dB). Correction for steering vector/target vector mismatch or elimination of outer elements from the processing did not appear to improve performance substantially either.

The main conclusion was that realistic ("installed") patterns appear to have a major impact on performance and must be dealt with early in the system design process. Further study was warranted.

2.0 ANTENNA ELEMENT PATTERN COMPUTATION MODULE (ELEMPAT)

SRC developed an element gain pattern computation module, ELEMPAT, to interface with RLSTAP. The element gain patterns include back plane diffraction. An engineering manual and user manual are available [1]. The underlying theory is briefly summarized below. This is followed by a description of the I/O. ELEMPAT is written in C.

2.1 ELEMPAT Array Element Pattern Modeling

The full radiation sphere far field radiated by a uniformly excited column array (subarray) of dipole radiators "imbedded" in a single row of a large number (more than ten or so) of identical such subarrays is computed in ELEMPAT. The subarray is composed of horizontally or vertically oriented dipoles in front of a finite sized conducting sheet back plane. A fully excited array "transmit pattern" also is computed in ELEMPAT.

The "imbedded element pattern" is defined as the far field radiated by one array element when all other elements are terminated. It is referred to here as an "imbedded subarray pattern" because each "element" is a subarray composed of a column of radiators. The terminations are assumed to be matched to the active impedance; i.e., impedance mismatch loss is assumed to be zero.

Consider the geometry shown in **Figure 2-1**. The horizontal plane ($\phi = 0, \pi$) pattern is assumed to be representative of that consistent with the element gain pattern of a matched (to active impedance) element in a $\sim\lambda/2$ spaced large phased array; the horizontal plane (voltage) pattern thus is set to $\sqrt{\cos\theta}$ in the model [2], [3]. The vertical plane pattern is determined from a diffraction analysis of a subarray with finite back plane. All diagonal plane pattern points are determined by trigonometric interpolation between the principal plane patterns. The interpolation functions are chosen to ensure uniqueness of the fields at the coordinate poles ($\phi = 0, \pi$). The transmit pattern is obtained by multiplying the imbedded subarray pattern with an appropriate linear array factor; the array scan angle and sidelobe weighting is user specified.

The program I/O is described in Sections 2-2 and 2-3. The output data is chosen to facilitate interface with RLSTAP. All coordinates (angular and Cartesian) are in the RLSTAP platform system ("NEC-BSC coordinates") as indicated with subscript p in **Figure 2-2**. "Azimuth" is the standard spherical phi coordinate (ϕ_p) and "elevation" is the supplement of the standard spherical theta coordinates ($\theta'_p = \pi - \theta_p$).

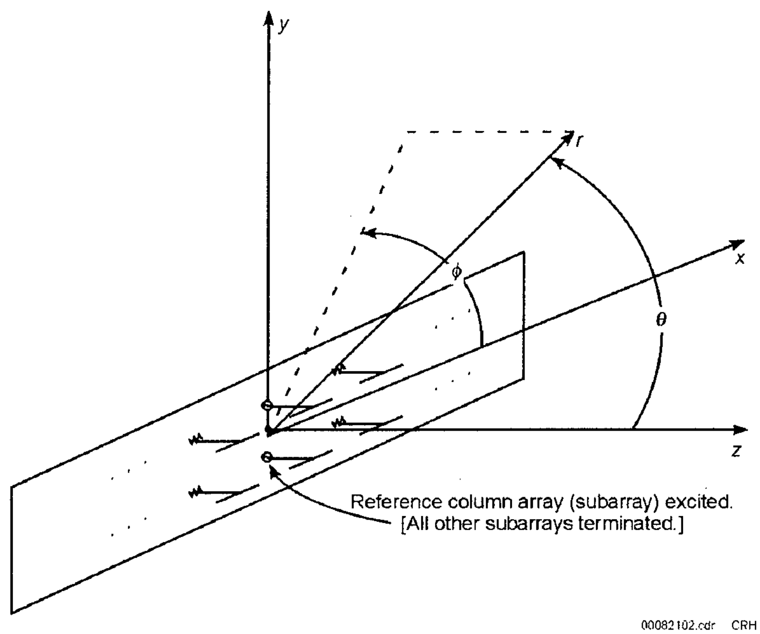

Figure 2-1. Array with Back Plane and Column (Subarray) Coordinate System

ELEMPAT is limited to arrays with back planes at least three wavelengths wide. The imbedded subarray gain, in dBi is approximated by 10 log(4N) where N is the number of subarray elements. The transmit array gain includes weighting loss. The coordinate origin is centered in the array back plane at a reference subarray. The subarray dipoles are located $\lambda/4$ in front of the back plane and spaced $\lambda/4$ above and below the upper and lower elements, respectively. (The latter dimensions are "hardwired" in the code for convenience but can be changed easily because of the generality of the pattern computation subroutine in ELEMPAT.) The subarray spacing for the transmit array is $\lambda/2$.

An associated engineering manual [1] contains detailed modeling equations.

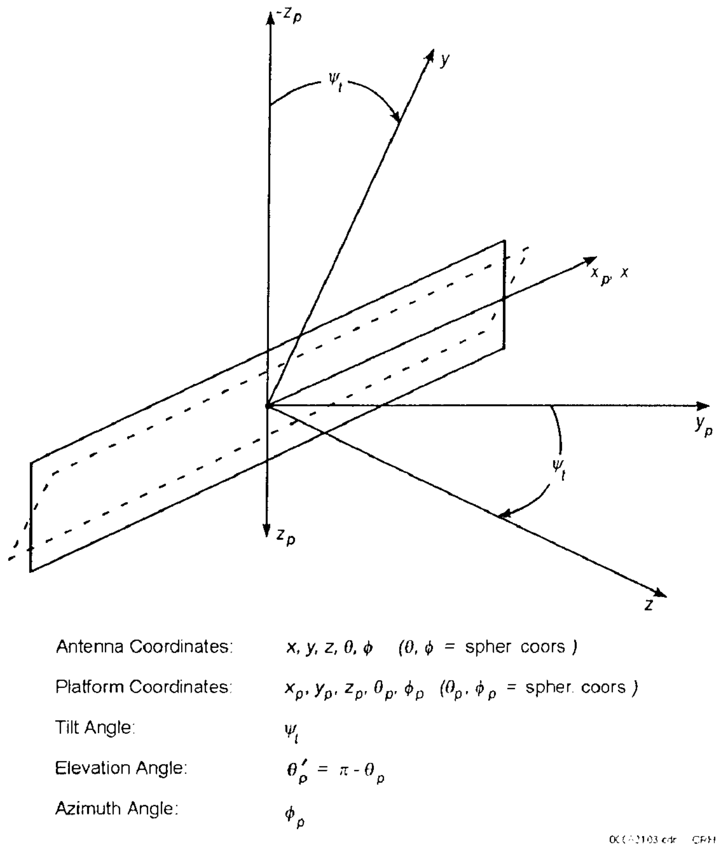

Figure 2-2. Antenna and Platform Coordinates

2.2 *ELEMPAT Input Data*

The user is queried for the following data. Default values are printed with the query.

1. The scan direction of the ("transmit") array antenna in standard spherical angular coordinates of the <u>antenna coordinate system</u> (degrees). Although the array can only be steered in the antenna horizontal plane, the desired pointing direction is arbitrary. Consequently, the pattern peak might not coincide with the scan direction.
2. Tilt angle of the array with respect to platform vertical, positive tilt is "downward" (degrees).
3. Number of elements in each column (subarray).
4. Number of subarrays in the transmit array.
5. Sidelobe level of transmit array factor in *dB* (positive and negative entries yield same patterns). Uniform weighting is applied for all entries between –14 and 14. Taylor weighting with appropriate *nbar* is applied otherwise.

6. Number of elevation coordinates (θ'_p) values between 0° and 180° inclusive for pattern computation.
7. Number of azimuth coordinates (ϕ_p) values between 0° and 180° inclusive for pattern computation.
8. Polarization (horizontal or vertical).
9. Logical file number (*Nfo*) of output data File 1. (That for File 2 is assumed to be *Nfo +1* and that for File 3, *Nfo +2*.)

2.3 ELEMPAT Output Data

The gains of the embedded subarray and the transmit array are printed to the terminal in *dBi.* The subarray gain is that at antenna broadside. The transmit array gain is that in the scan direction. The normalized far field "voltage" patterns are printed to three files (one each for subarray pattern magnitude, subarray complex pattern Cartesian components, and transmit array pattern). The field points are distributed throughout the entire radiation sphere. Both -180° and 180° azimuth points are plotted for convenience in using RLSTAP interpolation processing.

3.0 SPACE/TIME ADAPTIVE PROCESSING MODULE

SRC assisted AFRL in adapting a STAP module to interface with AFRL's RLSTAP code. The module, called Airborne Radar Post Pulse Compression STAP Analysis Module (STAPm1_RL2), was originally developed for AFRL under an earlier contract [4]. The module contains nine processing methods, including eight STAP methods that apply to pulse compressed data. The STAP methods are briefly discussed below. The number of Doppler frequencies applied in the analysis is set to *nf=2^(ipow2+1),* where *ipow2* is user specified, enabling use of FFT. If too small, *ipow2* is set to the nearest power of 2 for which nf is greater than or equal to the number of pulses in the data cube. {A companion version is available (STAPm0_RL1) that does not rely on FFT, and the number of Doppler frequencies is user defined.} The filter weights are CFAR normalized.

The STAP discussion is followed by a discussion of measures of performance and effectiveness and a discussion of the module I/O. Example analyses are deferred to Section 4. The module code is written in C.

3.1 STAP

Conventional airborne radar clutter suppression filtering methods usually are limited to deterministic beamforming and Doppler filtering; airborne moving target indicator (AMTI); and displaced phase center antenna (DPCA). Essentially antenna elements (or subarrays) and pulses are deterministically (nonadaptively) weighted and combined to yield Doppler filter resolution cells ("bins") within antenna sum and difference beams with ground clutter interference suppressed in each beam/bin combination. With AMTI, a null is placed in that part of the Doppler filter response pattern corresponding to ground clutter within a narrow strip of the antenna mainlobe. With DPCA, pulses and antenna elements (or subarrays) are appropriately combined to effectively null ground clutter throughout most of the mainlobe.

STAP methods, essentially, apply adaptivity to these filtering methods. The potential effectiveness of deterministic methods, e.g., DPCA and AMTI, are limited by the unknowns associated with antenna errors, receiver mismatch and instability, and platform motion uncertainty. STAP automatically "corrects," within limits, for such unknowns in the weight determination. STAP also suppresses jamming and other interference simultaneously with clutter. There are many variations of STAP that have been proposed since as far back as the late 1960s. Practically all of the variations can be grouped into eight general methods. SRC's STAP module contains options for exercising any of these methods. Because Doppler filtering and beamforming are intimately intertwined in STAP, the STAP module includes beamforming and Doppler filtering.

The eight general STAP options included in this module are

1. Factored
2. Element Space Post Doppler ADPCA
3. Element Space Pre-Doppler ADPCA
4. Beam Space Post Doppler ADPCA
5. Beam Space Pre-Doppler ADPCA
6. Joint Domain Localized
7. SLC Post Doppler ADPCA (Σ,Δ & Subarrays Post Doppler)
8. SLC Pre-Doppler ADPCA (Σ,Δ & Subarrays Pre-Doppler)

The term "ADPCA" refers to "adaptive DPCA." This term occasionally is dropped from the method references in the descriptions that follow. The term "SLC" refers to "sidelobe cancellation." The SLC ADPCA methods (7 and 8) sometimes are referred to as "Σ,Δ & Subarrays" methods. Element Space Post Doppler ADPCA (Method 2) is referred to in the literature, occasionally, as "PRI Staggered." Although not indicated in the above list, a nonadaptive conventional Σ,Δ beamformer/Doppler filter option is included in the module, as well (Option 0).

In Factored STAP, as it is defined here, first, the pulses associated with each subarray channel are passed through a Doppler filter. Spatial adaptivity then is applied to all corresponding resolution cell (bin) outputs of the Doppler filters.

Joint Domain Localized (JDL) refers to processing whereby Doppler bins and spatial beams are combined adaptively. Several combinations of beams and bins have been explored using sum and difference channels and digitally formed beams. Three Doppler bins (the target [or "test"] bin and immediate adjacent bins) and four beams (target sum and difference beams and immediate adjacent sum beams) have been found to be nearly optimal through extensive simulation.

Adaptive DPCA (ADPCA) methods refer to processing whereby a subset of successive samples (sometimes referred to as a "sub-CPI" where "CPI" refers to the coherent processing interval) from all spatial channels are adaptively combined. The channels can be beams (beam space) or subarrays (element space) and the samples either pulses (pre-Doppler) or Doppler bins (post Doppler). All pre-Doppler ADPCA methods implemented in the STAP module compute only one set of adaptive weights for the entire CPI. The weights computed using the first sub-CPI are reapplied for all successive sub-CPIs. This implementation is computationally efficient. Its effectiveness may deteriorate if receiver pulse to pulse stability is an issue. In such cases, recomputation of the weights for each sub-CPI would be of value.

Post Doppler (or Pre-Doppler) "Sidelobe Canceler (SLC)" STAP is similar to ADPCA with the inclusion of both beams and subarrays as spatial degrees of freedom in the adaptive algorithm. Because the beams are typically the sum and difference beams, this STAP method also is referred to as "Σ,Δ & Subarrays STAP." These methods have been found, through extensive processing of measured data cubes, to be particularly effective especially if well formed analog Σ,Δ channels are available.

For all STAP options, the adaptive weights are determined in the module according to $\boldsymbol{w}=\boldsymbol{R}^{-1}\boldsymbol{s}$ where $\boldsymbol{R}$ is the interference covariance matrix and $\boldsymbol{s}$ is the standard steering vector corresponding to the target direction and Doppler. This expression would result in weights that maximize signal to interference plus noise if $\boldsymbol{R}$ and $\boldsymbol{s}$ are known exactly. Standard steering vectors are employed in the module, and the covariance matrix is estimated from reference data corresponding to range cells other than the target (test) cell and immediate neighboring cells (guard cells).

A minimum amount of diagonal loading may be desirable to prevent target signal suppression (mainlobe gain loss) in the STAP process regardless of the STAP method selected. With diagonal loading, as applied in the STAP module, the diagonal elements of the estimate of $\boldsymbol{R}$ are increased by adding some multiple of the receiver noise level. The option for specifying that multiple is provided for in the STAP module in units of dB.

For post pulse compression STAP, a sliding window method of reference data selection, for STAP weight generation, is applied. The reference data is obtained from range cells neighboring the test cell but exclusive of "guard" cells immediately surrounding the test cell. The purpose of the guard cells is to help prevent "mainlobe" gain loss in the adaptive process that results from target response signal influencing weight generation.

3.2 Measures of Performance and Effectiveness

Measures of performance (MOPs) typically include Signal to Interference Plus Noise Ratio Improvement (SINR Improvement), Signal to Noise Ratio Loss (SNR Loss), minimum detectable velocity, probabilities of detection and false alarm determined from generalized Likelihood Ratio Test (GLRT) and Adaptive Matched Filter (AMFT) statistics, and angle estimation error. Also, appropriate measures of effectiveness (MOEs) include target detectability (percent targets detected). Note that SNR Loss is the ratio of SNR without clutter and without STAP ("radar range equation SNR") to SINR (includes clutter and STAP). SNR Loss is independent of target strength. One MOE can be conveniently estimated by computing SNR Loss for an entire range Doppler image and determining the percent of the image where the

SNR margin built into the radar exceeds SNR Loss. This percentage would be a measure of detectability.

SNR Loss is a measure of the reduction in SNR due to the introduction of interference and the applied STAP. This "loss" is always nonnegative (in dB). [Note, however, that the reciprocal ratio (negative dB) is typically plotted in SNR Loss curves, and this convention is followed in the figures of Section 4.] SINR Improvement is a measure of the increase in SINR associated with STAP. This "improvement" should always be nonnegative (in dB), as well. Correspondingly large values of SNR Loss and SINR Improvement, for example, would imply substantial clutter suppression associated with STAP but considerable loss in SNR, as well. Either more SNR "margin" would have had to be included in the original "quiescent conditions" design of the radar system, or SNR enhancement methods such as multiple pulse integration would have to be applied, in addition to STAP. Note that SNR Loss added (in dB) to SINR Improvement is a measure of the loss in SNR due to interference if conventional (nonadaptive) processing only is applied.

Only SNR Loss was implemented in the STAP module in this effort.

3.3 STAP Module Input Data

Input data are defined below. First integer variables are defined, followed by real variables and finally file data. Suggested default values are indicated in square brackets.

DATA TYPE "int":

Na=number of spatial channels in data cube [26]

Ns=number of spatial degrees of freedom [4]

Npl=number of pulses in data cube [128]

Nb=number of temporal degrees of freedom [3]

Nrc=number of range cells in data cube [260]

ipow2=power of 2 of number of Doppler frequencies [9]

Nsp=number of reference data range cells on one side of sliding window (half total number of reference data range cells) [12]

id=1 if difference beam is included as a spatial DOF in beamspace STAP (including JDL), 0 otherwise [1]

iw=1 if binomial weighted steering vector for ADPCA, 0 if Taylor weighted steering vector for ADPCA [0]

nbar(0)=spatial low sidelobe weighting Taylor nbar [6]

nbar(1)=temporal low sidelobe weighting Taylor nbar [8]

Nguard=number of guard cells on one side of sliding window (half total number of guard cells) [5]

Filter_Type=1 if Doppler filter precedes STAP, 2 if it follows STAP [1]

STAP_Method=0 if no STAP, 1 if Factored STAP, 2 if Element Space Post Doppler ADPCA (MTI), 3 if Element Space Pre-Doppler ADPCA (MTI), 4 if Beam Space Post Doppler ADPCA (MTI), 5 if Beam Space Pre-Doppler ADPCA (MTI), 6 if Joint Domain Localized, 7 if Sidelobe Canceler (SLC) Post Doppler ADPCA (MTI) {Referred to also as "Sum, Difference, and Subarrays Post Doppler"}, and 8 if Sidelobe Canceler (SLC) Pre-Doppler ADPCA (MTI) {Referred to also as "Sum, Difference, and Subarrays Pre-Doppler"}[6]

Note: if Joint Domain Localized is selected, the spacings of the spatial beams and Doppler beams are automatically set to half a standard beamwidth in angle and Doppler, respectively.

DATA TYPE "double":

f0=frequency (*Hz*) [4.35e+08]

T=pulse repetition interval (*s*) [.001]

thetas=steering vector spatial angle {w/to broadside in horizontal plane of antenna-sense consistent with that of *alpham*} (radians) [0]

va=platform speed (*m/s*) [115]

alpham=angle between platform velocity vector and antenna broadside {sense consistent with thetas; complement of crab angle} (radians) [1.3963]

dx=horizontal spacing between subarrays (*m*) [0.345]

thetat=antenna tilt angle {positive is "up"} (radians) [-.092991]

sdlb(0)=spatial Taylor weighted sidelobe level (*dB*) {positive or negative acceptable} [40]

sdlb(1)=temporal Taylor weighted sidelobe level (*dB*) {positive or negative acceptable} [60]

pdl_dB=diagonal loading (*dB* w/to receiver noise power) [-3.]

sigma=receiver noise (*rms*) [5.1168e-09]

INPUT FROM FILE:

The real and imaginary parts of the data cube are read separately from binary files (eight bites per word). The data is stored with range cells varying most rapidly, next channels, and finally pulses. The path names, easily found within the code, must be modified to suit the user. The current path names are:

"/disk4/ping/data/cuber" for real part
"/disk4/ping/data/cubei" for imaginary part

3.4 *STAP Module Output Data*

Three range/Doppler data files are written upon successful completion of a run: processed with adaptivity (via STAP_Method selected), processed without adaptivity (via STAP_Method 0), and SNR Loss. The first two are double precision complex voltage, the last is single precision real linear power (not dB). Each file contains *nf* Doppler by *Nrc* range cells stored with range index varying most rapidly. (See Section 3.0 for determination of *nf*.) The path names, easily found within the code, must be modified to suit the user. The current path names are:

"/disk4/ping/imgdata/drimg_a.dat" for adaptivity output
"/disk4/ping/imgdata/drimg_q.dat" for nonadaptivity output
"/disk4/ping/imgdata/snrloss.dat" for adapted output

4.0 ANALYSES

Four RLSTAP data cubes were analyzed with the STAP module. The pertinent scenario parameters are listed below. Processing parameter values were the default values listed with the input data in Section 3.3.

Center Frequency	435 MHz
Bandwidth	2 MHz
PRF	1 kHz
Steering Angle	0 deg
Crab Angle	10 deg
No. of Pulses	128
No. of 2-Element Vertical "Subarrays"	26
No. of Range Samples	601
Range Per Sample	25 m
Range Resolution	75 m
Radiated Power	2 kW
Transmit Array Pattern	30 dB Taylor
Pulse Width (Uncomp.)	100 μs
Pulse Width (Comp.)	0.5 μs
Pulse Comp. Weighting	40 dB
Target RCS	10 dBsm
Target Velocity	8 and 15 m/s East
Platform Altitude	6.5 km
Platform Velocity	115 m/s South
Grazing Angle	~5 deg
Target Range	70 km
Target Range Cell (Following 3:1 Decimation)	~141
Receiver Losses	2 dB
Noise Figure	4 dB
Clutter Model	Gaussian

The data cubes differed in target Doppler velocity (15 m/s and 8 m/s) and in element patterns (ideal and "installed"). The ideal patterns were cosine theta patterns. The installed patterns were the result of a comprehensive moment method analysis of mutual coupling and airframe scattering for an array of 26 columns (two horizontal dipole elements per column) mounted on a Dash 7 aircraft. The two elements within each column constituted a subarray; they were combined into a single channel.

Consider first the ideal pattern cases. The 15 m/s target (at range cell 141) was visible with conventional low sidelobe nonadaptive processing as is evident in Figure 4-1. Detection was improved with STAP (JDL with 4 spatial channels - sum, difference, and two auxiliary sum beams - and 3 Doppler beams) as is evident in Figures 4-2 and 4-3 and by the STAP SNR Loss plot of Figure 4-4. [The presence of the target and the use of guard cells are clearly evidenced in the SNR Loss plot by the high loss values in the vicinity of the target range and Doppler velocity.] The 8 m/s target clearly was not visible with conventional processing but was visible with JDL STAP (Figures 4-5 through 4-7).

The installed pattern data cases, on the other hand, clearly taxed both conventional processing and STAP substantially. Figures 4-8 through 4-11 show that the 15 m/s target was barely visible, if at all, with conventional processing, although easily detectable with STAP. The high sidelobes toward the aft of the aircraft, resulting from the installed patterns, are clearly evident by the high clutter responses in the negative Doppler region in Figure 4-8. Figures 4-12 through 4-14 show that the 8 m/s target was not visible with either conventional processing or with JDL STAP.

Part of the problem with STAP in the installed pattern cases may be attributed to the apparent severe mismatch of the outer four installed subarray patterns on both ends of the array with respect to the center 18 subarray patterns. This mismatch was observed in the subarray patterns resulting from the moment method analysis of mutual coupling for the array in front of a wavelength wide back plane. Application of other STAP methods based on all available spatial channels as degrees of freedom (in particular, 3-pulse Element Space Post Doppler ADPCA and Factored STAP) yielded only marginal improvement (under 5 dB). Correction for steering vector/target vector mismatch or elimination of outer elements from the processing did not appear to improve performance substantially either. Further study is warranted.

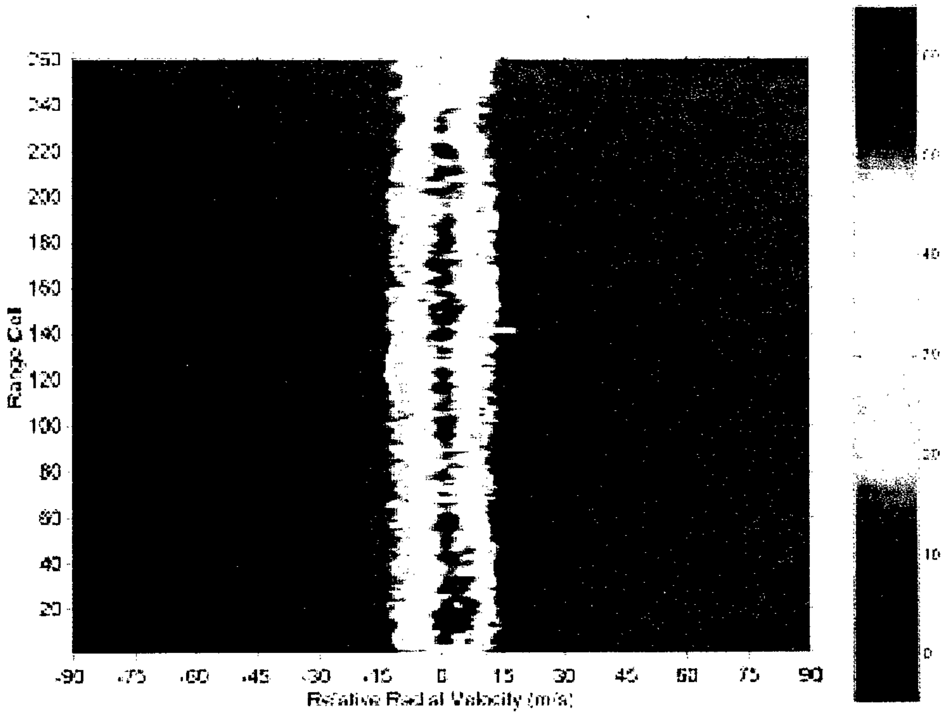

Figure 4-1. No Adaptivity: Ideal Antenna Patterns, 15 mps Target

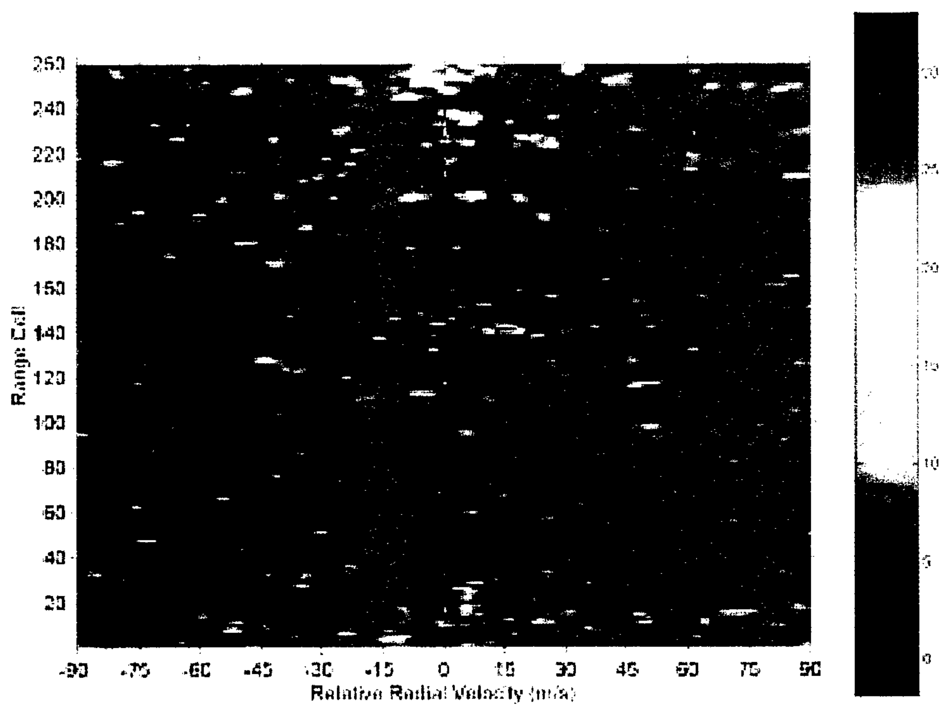

Figure 4-2. STAP: Ideal Antenna Patterns, 15 mps Target

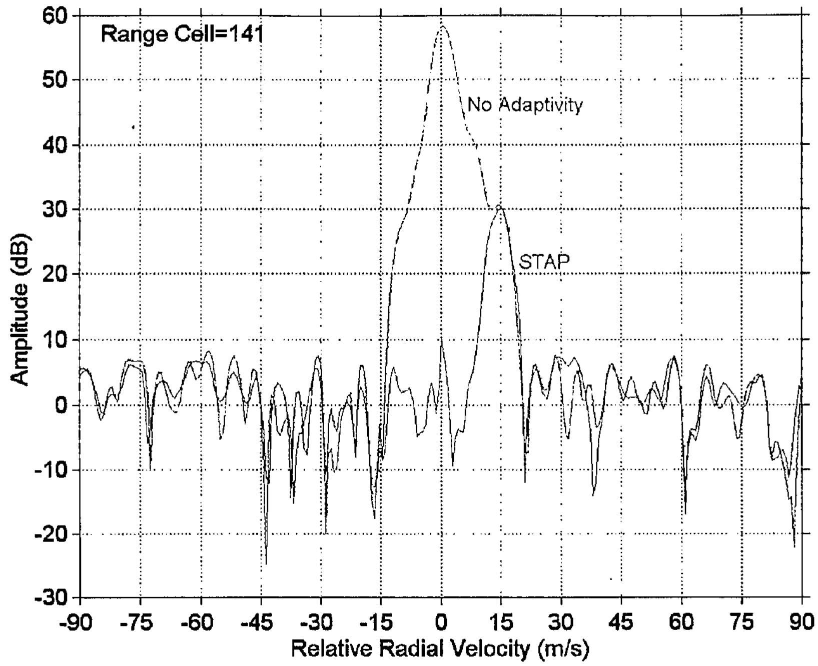

Figure 4-3. Comparison: Ideal Antenna Patterns, 15 mps Target

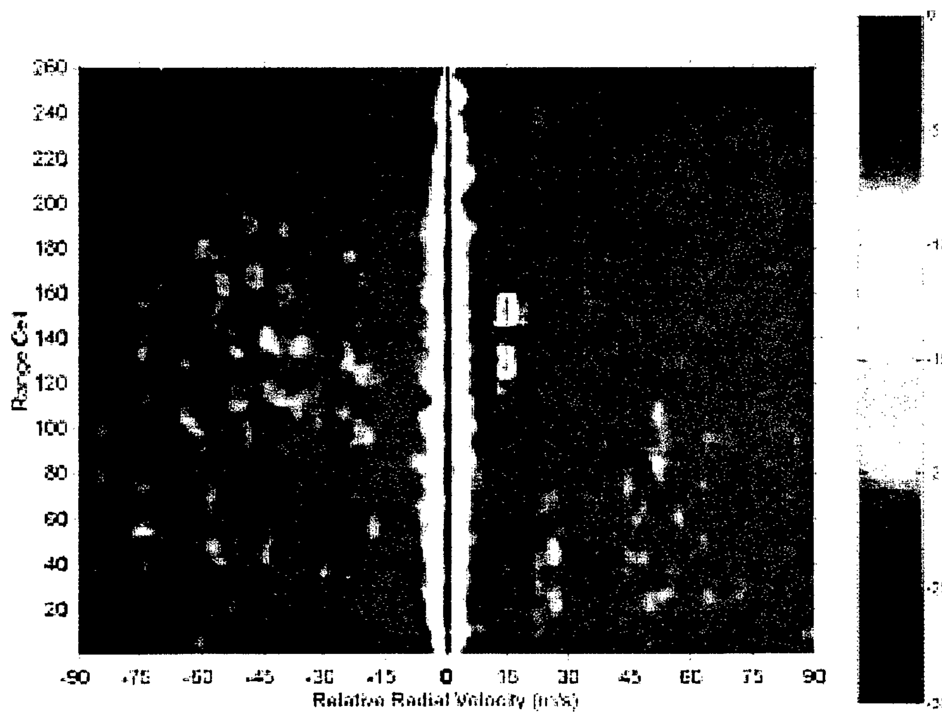

Figure 4-4. SNR Loss: Ideal Antenna Patterns

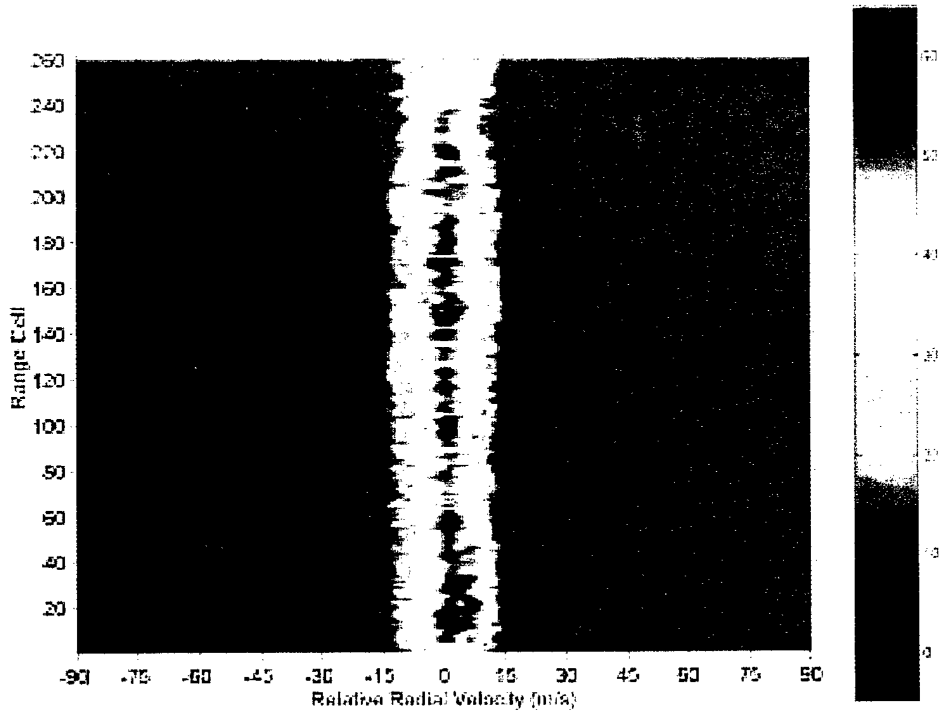

Figure 4-5. No Adaptivity: Ideal Antenna Patterns, 8 mps Target

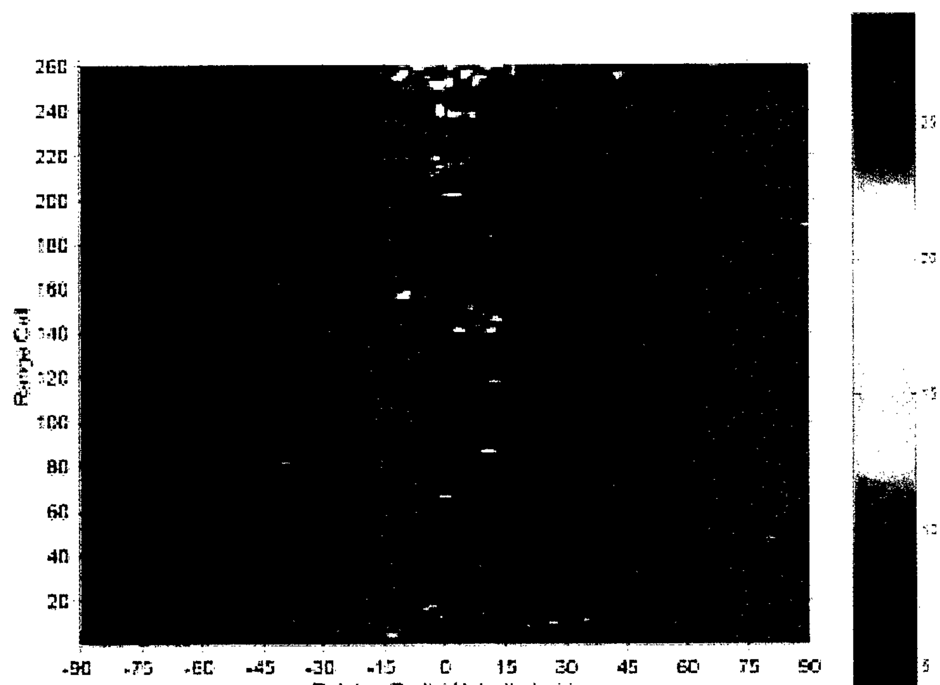

Figure 4-6. STAP: Ideal Antenna Patterns, 8 mps Target

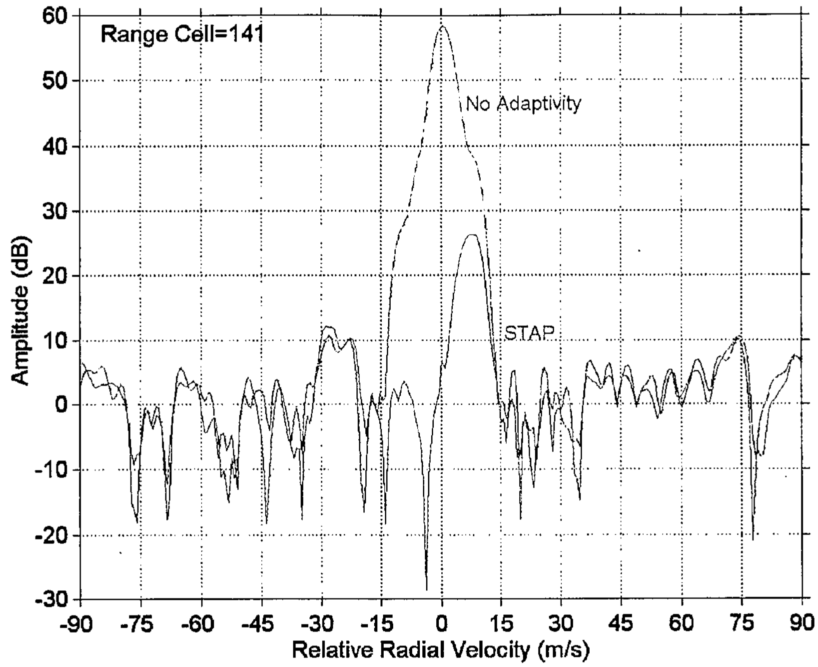

Figure 4-7. Comparison: Ideal Antenna Patterns, 8 mps Target

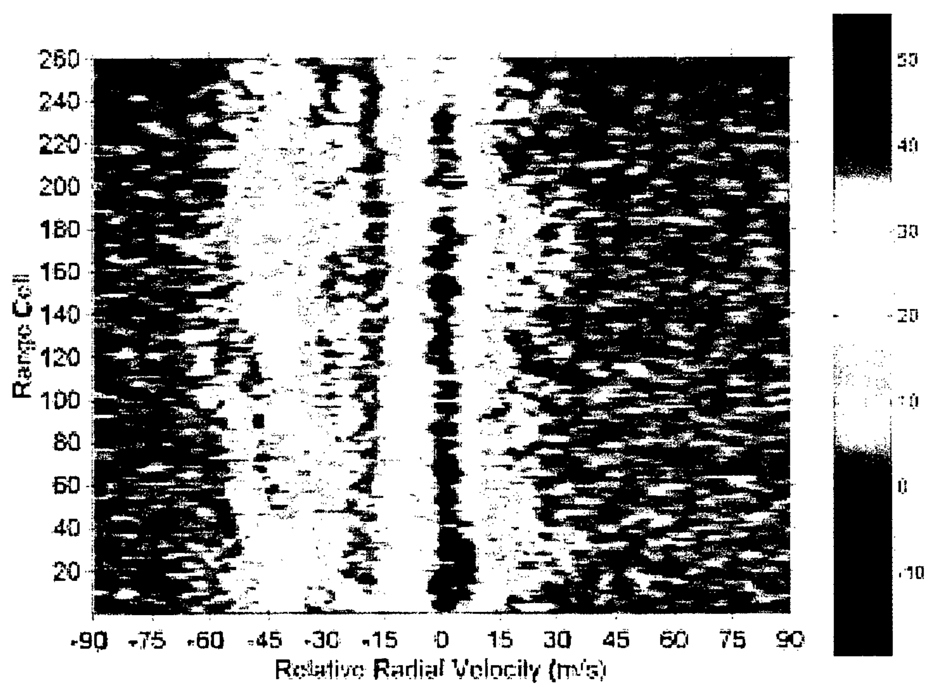

Figure 4-8. No Adaptivity: Installed Antenna Patterns, 15 mps Target

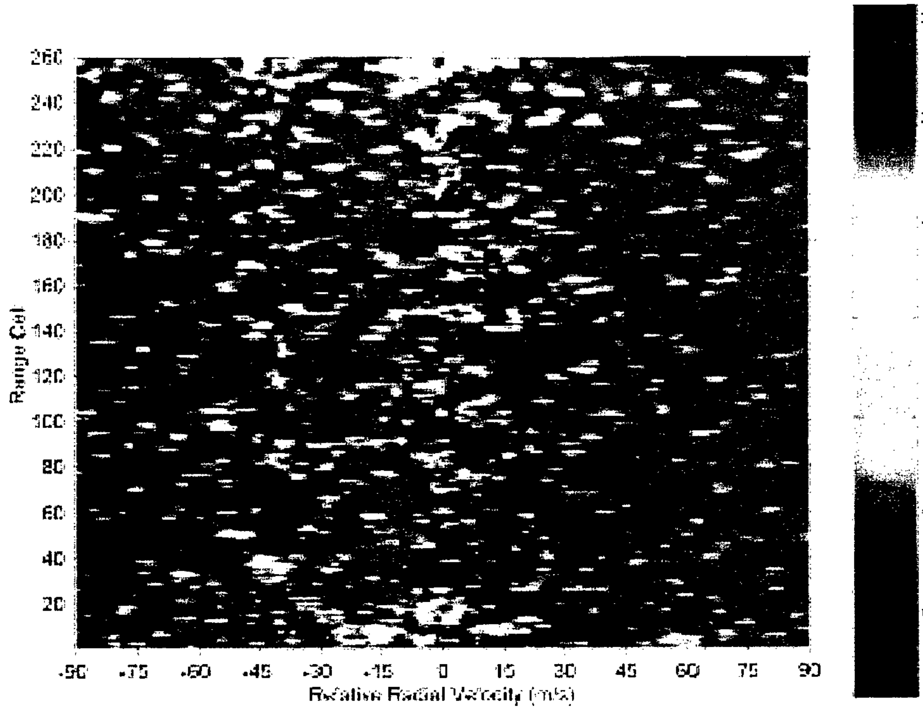

Figure 4-9. STAP: Installed Antenna Patterns, 15 mps Target

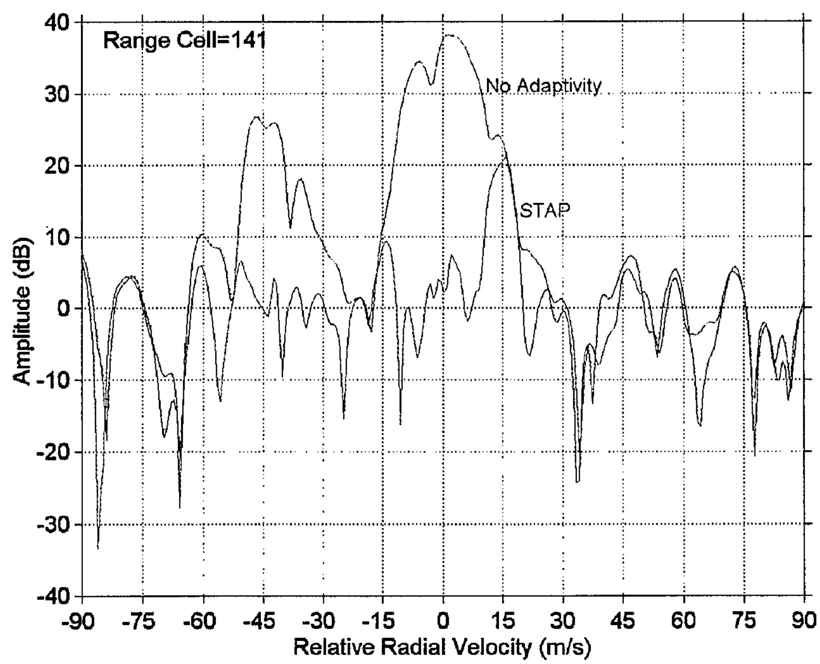

Figure 4-10. Comparison: Installed Antenna Patterns, 15 mps Target

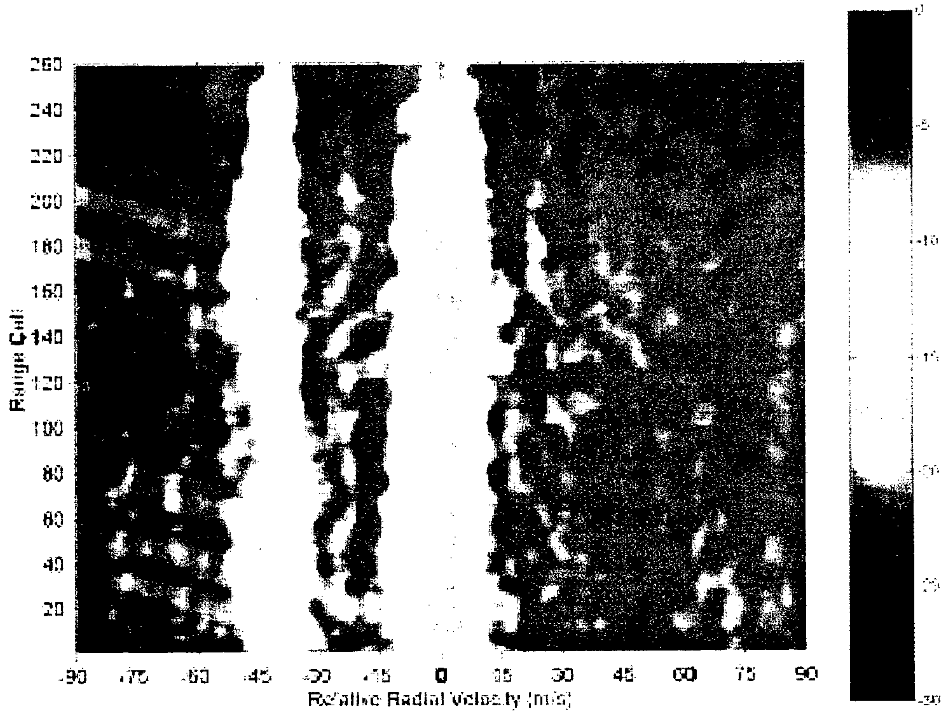

Figure 4-11. SNR Loss: Installed Antenna Patterns

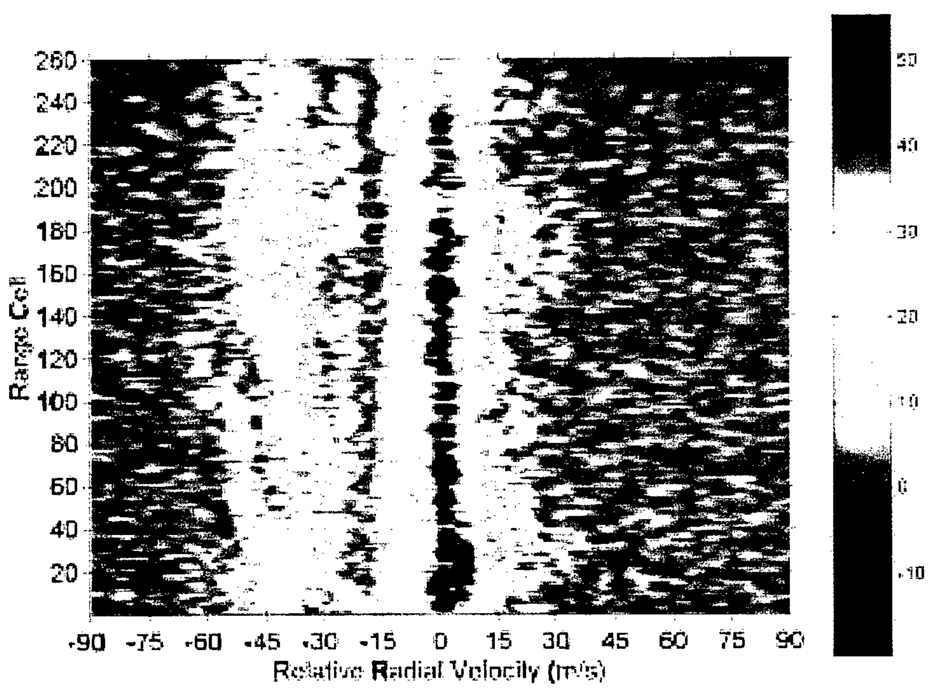

Figure 4-12. No Adaptivity: Installed Antenna Patterns, 8 mps Target

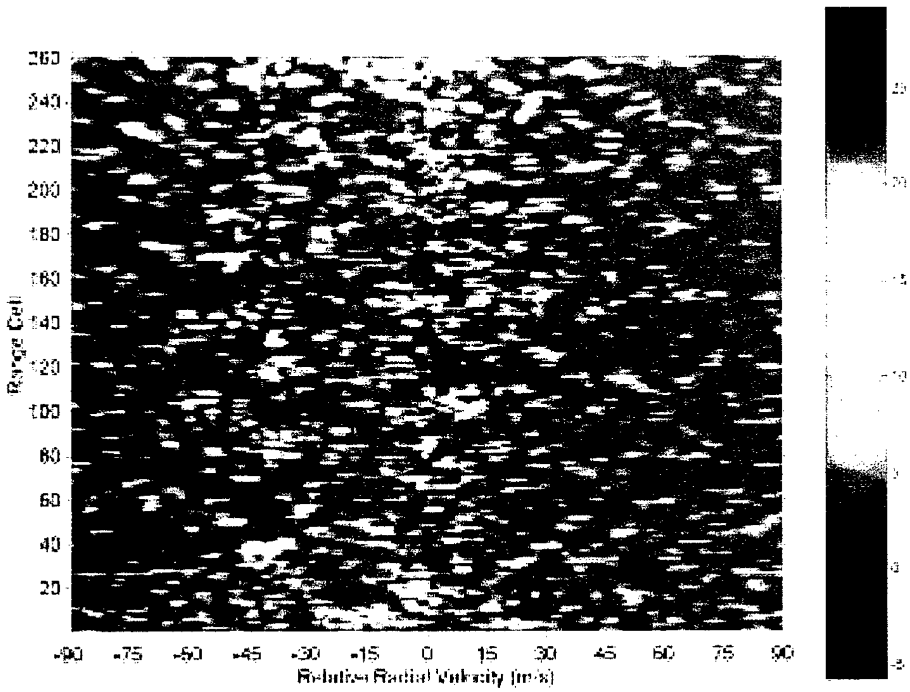

Figure 4-13. STAP: Installed Antenna Patterns, 8 mps Target

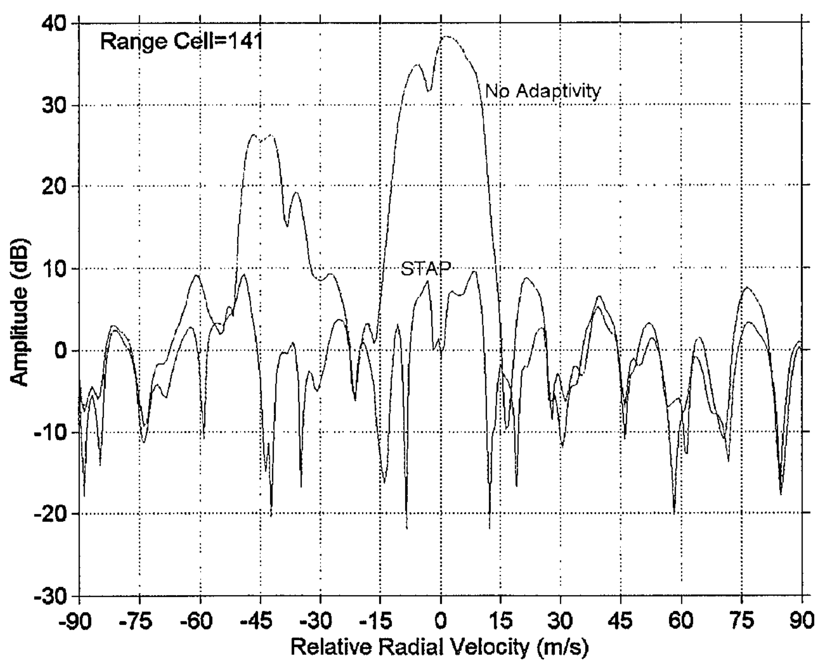

Figure 4-14. Comparison: Installed Antenna Patterns, 8 mps Target

5.0 CONCLUSIONS

Syracuse Research Corporation (SRC) accomplished three tasks under this effort. A "full sphere" subarray pattern computation module, ELEMENT, was developed that featured back plane scattering and interface with AFRL's RLSTAP code. SRC assisted AFRL in interfacing a SRC developed STAP module, featuring selection from eight STAP methods, to RLSTAP. Finally, SRC assisted AFRL in analyzing several UHF airborne STAP radar scenarios of interest.

The main conclusion from the analyses was that realistic ("installed") patterns appear to have a major impact on STAP performance and must be dealt with early in the system design process.

6.0 REFERENCES

1. H. K. Schuman and P. G. Li, "Phased Array Imbedded Element Pattern Computer Program (ELEMPAT)," Version 1.0, Engineering Manual and User Manual, Syracuse Research Corporation Reports TP 00-1333 and TP 00-1290 (AFRL Contract F30602-00-C-0149), North Syracuse, NY, August 2000

2. P. W. Hannan, "The Element Gain Paradox for a Phased Array Antenna," IEEE Trans. and Ant. Propq. pp. 423-433, July 1964

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4. H. K. Schuman, et. al., "Space/Time Adaptive Processing-FPS Level 2 Airborne Radar Model: Module 'STAP'," Syracuse Research Corporation Report TD 97-1533, Contract No. F30602-97-C-0237 with AFRL-Rome, December 1997