RESEARCH LABORATORIES FOR THE ENGINEERING SCIENCES

SCHOOL OF ENGINEERING AND APPLIED SCIENCE

UNIVERSITY OF VIRGINIA

Charlottesville, Virginia 22901

A Final Report

OPTIMIZATION OF MLS RECEIVERS FOR MULTIPATH ENVIRONMENTS

NASA Grant NSG 1128

Submitted to:
NASA Scientific and Technical Information Facility
P. O. Box 8757
Baltimore/Washington International Airport

Submitted by:
G. A. McAlpine
Associate Professor

J. H. Highfill III
Senior Scientist

REPORTED BY NATIONAL TECHNICAL INFORMATION SERVICE U.S. DEPARTMENT OF COMMERCE SPRINGFIELD, VA. 22161

Report No. UVA/528062/EE79/107
June 1979
RESEARCH LABORATORIES FOR THE ENGINEERING SCIENCES

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June 1979
ACKNOWLEDGEMENT

The authors would like to acknowledge the contributions of the following technical assistants who served on the project at various times and without whose collective effort, little would have been accomplished.

R. A. Hale
S. M. Harper
K. C. Henderson
T. C. Hu
S. H. Irwin, Jr.
G. Koleyni
R. E. Nelson
R. C. Newman
J. E. Padgett
S. V. Pizzi
R. D. Steed
J. R. Troxel
C. P. Tzeng
P. D. Via
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### Table Notes:
- **S/N=40 db**: Noise-to-signal ratio of 40 dB.
- **S/N=30 db**: Noise-to-signal ratio of 30 dB.
- **S/N=20 db**: Noise-to-signal ratio of 20 dB.
- **S/N=14 db**: Noise-to-signal ratio of 14 dB.
- **p=0.8**: Probability level of 0.8.
- **p=0.5**: Probability level of 0.5.
- **$\theta_{sep}=1.5^\circ$**: Separation angle of 1.5 degrees.
- **NO CONSTRAINTS**: No additional constraints applied.
- **WITH CONSTRAINTS**: Additional constraints applied.
- **(\beta, \omega_{sc}) tethered to (\pi/2, 0)**: Tethering condition specified.

---

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SECTION I

INTRODUCTION

This is the final report of research under Grant NSG 1128, awarded to the University in December 1974. The project is concerned principally with the angle-tracking problems in Microwave Landing System (MLS) receivers, the goal of the research being a receiver design capable of optimal performance in the multipath environments found in air terminal areas. The scope of the work included various theoretical and evaluative studies associated with the project goal, e.g.

i. Signal model development

ii. Derivation of optimal receiver structures

iii. Development and use of computer simulations for receiver algorithm evaluation

and also, at least initially, the development of an experimental receiver for flight testing. Reference is made to the progress reports [1-5] for details of the research. This report provides an overview of the work and a summary of principal results and conclusions.

During the 1976-77 annum a study of the DME was also undertaken along with the ongoing angle receiver research. The DME work included some preliminary theoretical analysis but mostly simulation studies of the various designs, i.e. fixed threshold, adaptive threshold and delay and compare DME receivers. The simulations showed the delay and compare receiver to be the most robust of the three designs simulated. The DME study was peripheral to the focal research on the angle receiver and is not discussed further in this report. Reference is made to [4, pp. 51-100] for more detail.
The early study established that multipath propagation in air terminal areas is due principally to reflections from hangars and other buildings, other aircraft and the ground -- all cases where the multipath interference is very nearly specular in nature and either an actual or virtual specular point can be identified. A math model for the received signal in such a case contains parameters which, together with selected time derivatives, constitute a vector which is easily conceptualized into the "state" of a state space model of the problem dynamics. And the latter provides the mathematical framework necessary for applying recursive state estimation techniques to the optimal receiver design problem. This was the approach taken in the research.

Two algorithms resulting were studied extensively:

i. An Optimal receiver: The state vector included signal-to-noise ratios, angular coordinates, angular rates, the phase difference and scalloping frequency parameters.

ii. A Suboptimal receiver: A structure similar in some respects to the optimal receiver but the phase difference and scalloping frequency parameters were not estimated.

Both algorithms generally outperformed in simulation a "threshold receiver" design which was approximately representative of the current Phase III Receiver. The Optimal design generally was the best, at least when the scalloping rate was less than half the angle function repetition rate and hence the phase difference parameter could be tracked successfully. The suboptimal design, at least in the simulation, suffered from extremely complex and length computations. The optimal design (and presumably the suboptimal design, would also) exhibited a
high sensitivity to error in the (presumed) beam width of the MLS ground antenna. These and other simulation results are discussed at length in the report, and approaches are suggested for possible improvements in performance.

Some considerations relating to an experimental receiver design are also offered.
SECTION II
SIGNAL MODEL AND ESTIMATOR DESIGNS

The signal available to the processor is a log video signal with bandwidth approximately half that of the i-f channel of the receiver. We begin at this point with the adaptation of this signal, in part A below, for use by the processor. Part B presents a state space model of the evolving problem geometry. Part C describes the general approach used to optimal receiver design, and Part D develops specific designs studied in the research. The reader is assumed to be familiar with the MLS system concepts and signal formats; for this orientation, refer to [6], [7] and [8].

A. THE AMPLITUDE-SQUARED ENVELOPE SIGNAL

The receiver log-envelope signal, a continuous-time signal within a scan, is sampled throughout a window on each semi-scan (centered on the expected centroid of the direct path pulse) at a sampling rate approximately equal to the i-f bandwidth and then suitably exponentiated and squared; the resulting J samples of the amplitude-squared envelope taken within a given scan are then normalized to a suitable measure of receiver noise power and assembled into an observations, or measurement, vector \( \mathbf{u} \), which clearly is nonlinear in the problem parameters of interest and also corrupted non-additively by receiver noise. Specifically, for the kth scan, \( k = 0,1,2, \ldots \), and in terms of a discrete-time variable \( r_j \) local to the scan, and assuming the presence of a direct-path component, a single multipath component and receiver noise, the jth component of \( \mathbf{u} \), say \( u_j \), \( j = 1, \ldots, J \) is modeled as follows:
where

\[ u_j = \{\alpha p[\theta - \theta_A(t_j)] + \alpha_R p[\theta - \theta_A(t_j)]\cos \beta_j + n_{c_j}\}^2 \]
\[ + \{\alpha_R p[\theta - \theta_A(t_j)]\sin \beta_j + n_{s_j}\}^2 \]  \hspace{1cm} (2.1)
This model neglects second-order effects ([3], p. 9) chiefly

a. Doppler effects not influencing the scalloping rate

b. Differential propagation delays (e.g. \( \frac{\text{reflect} - \text{direct}}{c} \), which
tend to distort the mirror symmetry that exists between the
TO-, FRO-scan signals.

B. THE STATE-SPACE MODEL

The various parameters appearing in \( u \), (2.1) above, together with
time derivatives of interest, are assembled into an \( N_s \)-dimensional state
vector, \( x \), modeled as the solution of a suitable linear difference
equation evolving in discrete-time, from scan-to-scan, and excited by a
white, zero-mean random process, representing external influences.
Hence, the composite generator-of-observations model is taken as a state
space formulation with form as follows:

\[
x(k+1) = F(k)x(k) + G(k)z(k) \\
u(k) = h(x(k),n(k)) 
\] (2.12)

where

\[
x(k) = \text{state } N_s \text{-vector} \\
z(k) = \text{representation of the various external influences on the}
\text{modeled environment, taken as an } M \text{-vector random process,}
\text{white with mean zero and covariance matrix } Q(k),
\text{where}
\end{array}
\] (2.13)

\[
Q(k) \triangleq <z(k)z^T(k)> 
\] (2.15)

\[
F(k) = \text{state 1-step transition matrix} 
\] (2.16)

\[
G(k) = \text{an } N_s \times M \text{ input constraint matrix of rank } M, \text{ where} 
\] (2.17)

\[
M \leq N_s 
\] (2.18)

\( u(k) = \text{observations } J \text{-vector} \)
\( n(k) = a 2J\)-vector of the quadrature components \( n_{c_j} \)
\[ n_{s_j} \] of receiver noise associated with the \( J \) samples of the noisy envelope \((n(j) \text{ and } n(k) \text{ are independent if } j \neq k)\). \hfill (2.19)

\( h(\cdot,\cdot) = \) a nonlinear vector-valued function of its arguments, constructing \( u(k) \) as a \( J \)-vector of envelope samples \( u_j \), equation \((2.1)\). \hfill (2.20)

C. THE ESTIMATION APPROACH

In developing a procedure for estimating the angular coordinate \( \theta \), it was clear from \((2.1)\) that performance would be better if more of the state variables than just \( \theta \) were estimated. It was also clear that not all of the state variables influence the vector \( u(k) \) of observation's taken within a single scan; in the present formulation, for example, \( \theta \) and \( \theta_R \) are considered constants during the active scan, hence \( \dot{\theta} \) and \( \dot{\theta}_R \) are absent from \((2.1)\), nevertheless they are necessarily included as variables in the state vector to afford modeling tractably a varying geometry over a sequence of scans. The functional dependence of \( u(k) \) on only a subset of the state variables posed a choice:

1. Estimate only the subset of state variables associated with \( u(k) \).
2. Estimate the full state vector \( x(k) \).

The first option very likely would result in severe degeneration in performance, during signal fades, including possibly loss of lock. The benefits promised by a modest filter memory, however, (represented by rate estimates in a receiver state estimator, e.g.) prompted the second choice, and we began to consider the criterion under which a suitable
estimate of the full state $x(k)$ could be calculated recursively, given
the complexity of the observations.

Ideally, given a sequence of observations $u$, (2.12b), say from some
initial scan through the present ($k$th) scan, represented as follows:

$$U(k) \triangleq \{u(1), u(2), \ldots, u(k)\},$$

(2.21)

we might adopt as a candidate criterion of performance the mean square
error criterion and seek to calculate the conditional mean $<x(k)|U(k)>$
as a basis for an optimal MLS receiver design. Without loss of generality,
however, the conditional mean can be written as

$$<x(k)|U(k)> = <x(k)|U(k-1)> + <E(k)|U(k)>$$

(2.22)

where

$$<x(k)|U(k-1)> = F(k+1)<x(k-1)|U(k-1)>$$

(2.23)
is the extrapolation of the prior estimate to the present, and

$$<E(k)|U(k)>$$
is the conditional mean of the error

$$E(k) \triangleq x(k) - <x(k)|U(k-1)>$$

(2.24)
in the extrapolated estimate (2.23). Hence, via (2.22), a conditional
mean receiver is essentially equivalent to a calculation of $<E(k)|U(k)>$,
a task which, generally,

1. As the notation suggests, may involve individually each and
every observation constituting the sequence $U(k)$, and in addition,

2. May not even be computable in a finite number of operations,
or even easily approximated.

A class of notable exceptions exists in which not only is $<E(k)|U(k)>$
computable or easily approximated, but all the historical information in
dated observations necessary for the calculation of $<E(k)|U(k)>$ is
carried in the extrapolated prior state estimate \( \langle x(k) \mid U(k-1) \rangle \), (2.23); that is \( \langle E(k) \mid U(k) \rangle \) can be written

\[
\langle E(k) \mid U(k) \rangle = f(\langle x(k) \mid U(k-1) \rangle, u(k)), \text{ for some } f(\cdot, \cdot).
\]

Two examples are the following:

1. The Kalman filter, applicable when \( h(x,n) \) is linear in both \( x \) and \( n \), gives an exact calculation of \( \langle E(k) \mid U(k) \rangle \);

2. The Extended Kalman filter, applicable when \( h(x,n) \) represents an additive corruption of the observations by \( n \), gives an approximate calculation of \( \langle E(k) \mid U(k) \rangle \) when \( h(x,n) \) is nonlinear in \( x \).

Because of the complexity of the observation \( h(x,n) \) [recall \( h_j, (2.1) \)] and the computability requirement (for simulation and also, potentially, hardware), the estimation approach used in this research was, of necessity, an approximation. An adaptation of the preceding was used, producing a state estimate (generally now suboptimal), denoted \( \hat{x}(k \mid k) \) to distinguish it from the exact conditional mean, and obtained, as follows:

\[
\hat{x}(k \mid k) = \hat{x}(k \mid k-1) + \hat{\xi}(k \mid k)
\]

where

\[
\hat{x}(k \mid k-1) = \mathbf{F}(k-1)\hat{x}(k-1 \mid k-1)
\]

and \( \hat{\xi}(k \mid k) \) is a "suitable" estimate to be defined below, of the error \( \xi(k) \) in \( \hat{x}(k \mid k-1) \), given \( \hat{x}(k \mid k-1) \) and \( u(k) \), where

\[
\xi(k) \triangleq x(k) - \hat{x}(k \mid k-1)
\]

The estimate \( \hat{\xi}(k \mid k) \) will be functionally dependent only upon \( \hat{x}(k \mid k-1) \) and \( u(k) \). A final error definition needed and an easily proved result of interest are, as follows:

\[
e(k) \triangleq \xi(k) - \hat{\xi}(k \mid k)
\]

\[
e(k) = x(k) - \hat{x}(k \mid k)
\]
i.e., the error in the estimate \( \hat{\xi}(k|k) \) is the residual error in the updated state estimate \( \hat{x}(k|k) \).

Since the observations \( u(k) \) are functionally dependent upon only a subset of the state variables, the calculation of \( \hat{\xi}(k|k) \), i.e. the estimation of the error \( \xi(k) \) in \( \hat{x}(k|k-1) \), given \( \hat{x}(k|k-1) \) and \( u(k) \), was accomplished in 2 stages, characterized respectively as the Scan Data Processor (SDP) and the Tracking Loop Filter. The SDP essentially does a curve-fitting of a noiseless, internal version of the observations with the noisy, actual ones, calculating perturbations (error estimates) of the associated elements of \( \hat{x}(k|k-1) \) to improve the fit. The Tracking Loop, closed around the SDP in a conventional recursive structure, develops an estimate of the full error vector \( \xi(k) \), taking the assumed state evolution dynamics into account. A detailed discussion of these two stages is given below.

The approach taken was modified, in part, by two factors, as follows:

1. The presumed low-bandwidth of the state evolution model wrt the repetition rate, implying, quantitatively,
\[
    x(k) \approx F(k-1)x(k-1)
\]
   (i.e. \( G(k-1)w(k-1) \) in (2.12) is small).

2. The "tracking" nature of the estimation task implying, presumably,
\[
    x(k) \approx \hat{x}(k|k)
\]
   (i.e. the estimation error \( e(k) \), (2.31), is "small").

Equations (2.27), (2.28), (2.30) and (2.31) above imply that \( \xi(k) \) may be approximated, as follows:
\( \xi(k) \approx F(k-1)e(k-1) \) \hspace{1cm} (2.33)

and this, with (2.32) above implies that

\( \xi(k) \) is "small", \hspace{1cm} (2.34)

a result important to the design of the SDP described next.

**Scan Data Processor**

Let \( \gamma \) denote the parameter vector comprising the subset of \( N_G \) state variables on which \( u_j \), (2.1), is functionally dependent. The general relation

\[ \gamma = Hx \] \hspace{1cm} (2.35)

then defines a masking matrix \( H, N_G \times N_s \), having rank \( N_G \leq N_s \) and consisting appropriately of 1's and 0's. Other \( N_G \)-vector quantities of interest are obtained, as follows:

- **Extrapolated Prior Est:** \( \hat{\gamma}(k|k-1) = H\hat{x}(k|k-1) \) \hspace{1cm} (2.36)
- **Error in \( \hat{\gamma}(k|k-1) \):** \( \varepsilon(k) = H\xi(k) \) \hspace{1cm} (2.37)

By (2.34), \( \varepsilon(k) \) in (2.37) is "small", and Murphy's Locally Optimum Estimation (LOE) theory, [9], was brought to bear on the calculation of an estimate which, around \( \varepsilon=0 \), should be optimal in an intuitively appealing sense. The LOE criterion is summarized, in the notation of the SDP, as follows:

**Locally Optimum Estimation:** The estimate \( \hat{\varepsilon} \) of the error \( \varepsilon \) (in the present estimate \( \hat{\gamma} \) of the parameter \( \gamma \)) is **locally optimum** at the point \( \varepsilon=0 \), if and only if (iff) the following two conditions are satisfied:

1) \( \hat{\varepsilon} \) is a **locally unbiased** estimate of \( \varepsilon \) at the point of \( \varepsilon=0 \), and
2) \( \hat{e} \) is a **locally minimum mean-squared error (MMSE)** estimate of \( e \) at the point \( e=0 \),

where 'locally unbiased' and 'locally MMSE' estimations are defined as follows:

**Locally Unbiased Estimation:** Defining the error in the estimate \( \hat{e} \) of the quantity \( e \) as follows:

\[
\eta(k) \triangleq \hat{e}(k|k) - e(k) \tag{2.38}
\]

and then defining the bias of the estimate \( \hat{e} \) of the error \( e \) (in the estimate \( \hat{y} \) of the parameter \( y \)), as follows:

\[
b(e) \triangleq \langle \eta(k)|y - \hat{y} = e \rangle \tag{2.39}
\]

then the estimate \( \hat{e} \) of the error \( e \) (in the estimate \( \hat{y} \) of the parameter \( y \)) is **locally unbiased** at the point \( e=0 \) iff the following two conditions are satisfied:

1) \( b(0) = 0 \), on \( N_G \)-vector \( (2.40a) \)

2) \[
\left. \frac{db(e)}{de} \right|_{e=0} = 0 \), on \( N_G \times N_G \) matrix \( (2.40b) \)

**Locally MMSE Estimation:** Defining the mean-squared error of \( \hat{e} \) in terms of \( \eta \), (2.38) above, as follows:

\[
\Sigma (e) \triangleq \langle \eta(k)\eta^T(k) | y - \hat{y} = e \rangle, \ (\cdot)^T = \text{transpose}, \tag{2.41}
\]

then the estimate \( \hat{e} \) of the error \( e \) (in the estimate \( \hat{y} \) of the parameter \( y \)) is **locally MMSE** at the point \( e=0 \) iff, for any estimate, \( \hat{d} \), if \( \hat{e} \) locally unbiased at \( e=0 \), the mean-squared errors of \( \hat{e} \) and \( \hat{d} \) satisfy, in the usual non-negative definite sense,
\[
\Sigma(0) \geq \Sigma(0), \quad N_G \times N_G \text{ matrices} \tag{2.42}
\]

The error \( \eta(k) \) is induced by the noise \( n(k) \) which is white (recall (2.11) and (2.19)); hence, clearly, local to the point \( \varepsilon = 0 \), when \( \langle n \rangle = 0 \) via (2.39), it is true also that \( \eta(k) \) is white, i.e.

\[
\langle \eta(j)\eta^T(k) \rangle = 0, \quad j \neq k \tag{2.43}
\]

We take note, in passing, of the important and beneficial property given in (2.40b), requiring that errors made in estimating the various components of the vector \( \varepsilon \) be decoupled when \( \varepsilon = 0 \). In addition to making the estimate unique, this is probably effective in extending the properties in (2.40a) and (2.42) into the open region around the point \( \varepsilon = 0 \).

Murphy has meticulously expounded the theory and solution of the locally optimum estimation problem in his scholarly work [9] and illustrated his results in diverse examples in communications. The solution, applied to the SDP design problem at hand, involves, first, the definition of several additional quantities:

1. The noiseless quadratic envelope vector \( \eta \) with element \( q_j \).
2. The linear envelope vectors \( m \) and \( v \) (and associated elements), corresponding respectively to quadratic envelopes \( q \) and \( u \).
3. The conditional probability density function (pdf) \( p(v|m) \)
4. The likelihood ratio \( \lambda(u|\gamma) \). Let \( m_{c,j} \) and \( m_s \) respectively be the linear envelope functions associated with a cosine and sine orthogonal decomposition of the noiseless i-f (or r-f) signal:

\[
m_{c,j} = \alpha_R[p[\theta - \theta_A(\tau_j)] + \alpha_Rp[\theta_R - \theta_A(\tau_j)]\cos \beta_j \tag{2.44a}
\]

\[
m_{s,j} = \alpha_R[p[\theta - \theta_A(\tau_j)]\sin \beta_j \tag{2.44b}
\]
various parameters of which are as defined, following (2.1). Then, in
the same manner that the J-vector u of observations u_j was constructed,
a noiseless quadratic envelope vector q is defined with elements q_j,
j=1,2,...,J, where

\[ q_j = m_j^2 + m_j^2 \]  \hspace{1cm} (2.45)

\[ = a^2 p_j^2(\theta) + 2a_x p_j(\theta) p_j(\theta_R) \cos \beta_j + a_x^2 p_j^2(\theta_R) \]  \hspace{1cm} (2.46)

in which \( p_j(\theta) \) is short-hand for \( p[\theta-\theta_A(v_j)] \), and similarly for \( p_j(\theta_R) \).
The observations sample \( u_j \), (2.1) may then be written as

\[ u_j = (m_j^c + n_j^c)^2 + (m_j^s + n_j^s)^2 \]  \hspace{1cm} (2.47)

or, equivalently

\[ u_j = q_j + 2n_j^c q_j^{1/2} + n_j^c + n_j^s \]  \hspace{1cm} (2.48)

Now, let \( m \) and \( v \) respectively represent noiseless and noisy linear
envelope vectors with elements \( m_j \) and \( v_j \), respectively, for \( j=1,2,...,J \),
where

\[ m_j = \sqrt{q_j} = [m_j^c + m_j^s]^{1/2} \]  \hspace{1cm} (2.49)

\[ v_j = \sqrt{u_j} = [(m_j^c + n_j^c)^2 + (m_j^s + n_j^s)^2]^{1/2} \]  \hspace{1cm} (2.50)

Since the sampling rate within the scan equals the i-f bandwidth, the
noise samples are all nearly independent (and zero mean, Gaussian with
variance 0.5; recall (2.11)). Hence, referring to [10, eq. (8-115)] for
the conditional pdf \( p(v_j|m_j) \), the conditional pdf \( p(v|m) \) can be written

\[ p(v|m) = \prod_{j=1}^{J} p(v_j|m_j) \]  \hspace{1cm} (2.51)

\[ = 2^J \prod_{j=1}^{J} v_j I_0(2m_j v_j) \exp(-m_j^2 - v_j^2) \]  \hspace{1cm} (2.52)
where $I_o(\cdot)$ is the modified Bessel function of the first kind, zeroth
order. The likelihood ratio of interest is the following:

$$\lambda = \frac{p(v|m)}{p(v|0)} = \prod_{j=1}^{J} I_o(2m_j v_j) \exp(-m_j^2) \tag{2.53}$$

or, defining a new function $M_o(\cdot): \mathbb{R}^+ \to \mathbb{R}^+$, as follows, in relation to
the even function $I_o(\cdot)$ ([3], p. 13):

$$M_o(x^2) = I_o(x), x \in \mathbb{R}^+ \tag{2.54}$$

then, in terms of $q_j$ and $u_j$, we may write

$$\lambda(u|y) = \prod_{j=1}^{J} M_o(4q_j u_j) \exp(-q_j) \tag{2.55}$$

$$= \prod_{j=1}^{J} \lambda_j(u_j|q_j) \tag{2.56}$$

where the conditioning variable on the left is shown as $y$, rather than $q(=q(y))$, to emphasize the parameter values.

The theory provides, further, that if one of the parameters upon
which $q$ is dependent is, in fact, a random variable, say $\zeta$, in which
there is no estimation interest, then it is to be averaged out before
proceeding, i.e. the average likelihood ratio

$$\lambda(u|y) = \langle \prod_{j=1}^{J} \lambda_j(u_j|q_j(y,\zeta)) \mid u, y \rangle \tag{2.57}$$

is used in the work below. In this approach (which formed the basis of
one variant of MLS receiver design studied) clearly the noiseless enve-
lope vector $q$ has no further significance.

The Scan Data Processor design by the LOE approach can now be
completed. In the notation of the SDP design problem (but otherwise
quite generally) the estimate $\hat{\varepsilon}(k|k)$ of the error $\varepsilon(k)$ (in the estimate
\( \hat{y}(k|k-1) \) of the parameter vector \( y \) which is locally optimum at \( \varepsilon=0 \) is given by

\[
\hat{e}(k|k) = \phi^{-1}(\hat{y}) \Lambda(u|\hat{y})
\]

where, recognizing \( u(k) = u(y(k),n(k)) \),

\[
\phi(\hat{y}) \triangleq \langle \Lambda(u(y,n)|\hat{y}) \Lambda^T(u(y,n)|\hat{y}) \mid \gamma = \hat{\gamma} \rangle
\]

denoted as the LOE (Fisher) Information Matrix, and

\[
\Lambda(u|\hat{y}) \triangleq \begin{cases} 
\frac{\partial}{\partial \hat{y}} \ln \Lambda(u|\hat{y}) & \Lambda(u|\hat{y}) \neq 0 \\
0, & \text{otherwise}
\end{cases}
\]

Further, the mean-squared error, \( \Sigma \), (2.41), of this estimate local to the point \( \varepsilon=0 \) is

\[
\Sigma(0) = \phi^{-1}(\gamma)
\]

As indicated above, several variants to the basic MLS receiver design using this approach were studied, differing initially in their definitions of the state and/or parameter vectors, \( x \) and \( y \) respectively. Detailed development of the LOE quantities defined above is deferred until the next section of this chapter where the various designs specific to particular state and/or parameter vector formulations will be described. We conclude this discussion of the Scan Data Processor by noting that, in view of (2.58) and (2.61) above, the principle calculations done by the SDP are those of \( \phi(\hat{y}) \) and \( \Lambda(u|\hat{y}) \). These, in fact, are the quantities passed to the Tracking Loop Filter, discussed next.

**Tracking Loop Filter**

Inputs to the Tracking Loop Filter from the Scan Data Processor are the quantities \( \Lambda(u|\hat{y}(k|k-1)) \) and \( \phi(\hat{y}(k|k-1)) \). If we form the estimate
\[ \hat{\gamma}(k|k) = \gamma(k|k-1) + \hat{\gamma}(k|k) - \varepsilon(k) \]  
(2.62)

where \( \gamma(k|k-1) \) (2.63) and

\[ R(\hat{\gamma}) \overset{\Delta}{=} \phi^{-1}(\gamma(k|k-1)) \]  
(2.64)

and then tentatively form a "pre-estimate", \( \hat{\gamma}(k|k) \), in the following manner:

\[ \hat{\gamma}(k|k) = \gamma(k|k-1) + \hat{\gamma}(k|k) \]  
(2.65)

we find that \( \hat{\gamma} \) can be written

\[ \hat{\gamma} = \gamma(k|k-1) + \varepsilon(k) + \hat{\gamma}(k|k) - \varepsilon(k) \]  
(2.66)

\[ = \gamma(k) + \eta(k) \]  
(2.67)

\[ = Hx(k) + \eta(k) \]  
(2.68)

i.e. the pre-estimate \( \hat{\gamma}(k|k) \), in a neighborhood of \( \varepsilon=0 \), is in fact, a "pseudo-observation" which is both linear in \( x \) and corrupted additively by the zero mean, white noise \( \eta(k) \) with covariance \( R(\gamma(k|k-1)) \), (2.63).

Following conventional Kalman filter theory and forming the innovations process, \( \hat{\gamma}(k|k-1) - \hat{\gamma}(k|k) \), gives

\[ \hat{\gamma}(k|k-1) - \hat{\gamma}(k|k) = \hat{\varepsilon}(k|k) \]  
(2.69)

i.e. the innovations process is the estimate \( \hat{\varepsilon}(k|k) \), (2.62), produced (effectively) by the LOE-theory-based Scan Data Processor. The filter state update equation has the form

\[ \hat{x}(k|k) = \hat{x}(k|k-1) + \kappa(k) \hat{\varepsilon}(k|k) \]  
(2.70)

where \( \kappa(k) \), the Kalman gain, is calculated by cycling through 3 equations for each value of \( k, k = 1, 2, \ldots \), usually as follows:

Extrapolated Error Covariance:

\[ P(k|k-1) = F(k-1)P(k-1|k-1)F^T(k-1) + G(k-1)Q(k-1)G^T(k-1) \]  
(2.71)
Kalman Gain:

\[
\kappa(k) = P(k|k-1)H^T[HP(k|k-1)H^T + R(\hat{y})]^{-1}
\]  
(2.72)

Updated Error Covariance:

\[
P(k|k) = (I-\kappa(k)H)P(k|k-1)(I-\kappa(k)H)^T + \kappa(k)R(\hat{y})\kappa^T(k)
\]  
(2.73)

In the present application some simplification is possible, however.

Comparing (2.26) and (2.70) above indicates that

\[
\xi(k|k) = \kappa(k)\xi(k|k-1)
\]  
(2.74)

= \kappa(k)R(\hat{y})\Lambda(u|\hat{y})
\]  
(2.75)

and substituting from (2.72) into the latter gives

\[
\xi(k|k) = P(k|k-1)H^T[HP(k|k-1)H^T + R(\hat{y})]^{-1}R(\hat{y})\Lambda(u|\hat{y})
\]  
(2.76)

or, after simplifying,

\[
\xi(k|k) = \Gamma(k)\Lambda(u|\hat{y})
\]  
(2.77)

where

\[
\Gamma(k) = P(k|k-1)H^T[I + \Phi(\hat{y})HP(k|k-1)H^T]^{-1}
\]  
(2.78)

is a new \(N_s \times N_G\) gain matrix not requiring the inversion of the matrix \(\Phi(\hat{y})\) (produced by the SDP) for its calculation (by (2.64), \(R^{-1}(\hat{y})\) appearing in the simplification, was replaced by \(\Phi(\hat{y})\)). The refined state-estimate update equation, corresponding to (2.70) is the following:

\[
\hat{x}(k|k) = \hat{x}(k|k-1) + \Gamma(k)\Lambda(u|\hat{y})
\]  
(2.79)

Comparing (2.75) and (2.77) indicates that

\[
\kappa(k)R(\hat{y}) = \Gamma(k)
\]  
(2.80)

or that

\[
\kappa(k) = \Gamma(k)R^{-1}(\hat{y}) = \Gamma(k)\Phi(\hat{y})
\]  
(2.81)

Substituting this into (2.73) and simplifying gives the following:
Updated Error Covariance:
\[ P(k|k) = (I - \Gamma(k)\Phi(\hat{\gamma})H)P(k|k-1)(I - \Gamma(k)\Phi(\hat{\gamma})H)^T + \Gamma(k)\Phi(\hat{\gamma})\Gamma^T(k) \] (2.82)
which also does not require the inversion of \( \Phi(\gamma) \).

In summary, the MLS receiver design developed, a tracking receiver, will operate as a recursive state estimator and begin the (kth) data processing cycle by extrapolating the prior state estimate \( \hat{x}(k-1|k-1) \) to the present, producing the

**Extrapolated State Estimate**, \( \hat{x}(k|k-1) \), (2.27)

and then masking it, giving the

**Extrapolated Parameter Estimate**, \( \hat{\gamma}(k|k-1) \), (2.36)

this, an estimate of parameter vector \( \gamma(k) \) with error \( \varepsilon(k) \). Next, given \( \hat{\gamma}(k|k-1) \) and the vector \( u(k) \) of observations, the Scan Data Processor, designed under a criterion of producing an estimate \( \hat{\varepsilon}(k|k) \) of error \( \varepsilon(k) \) that is **locally optimum** at \( \varepsilon=0 \), stops short of this result and instead calculates the following:

**Log Likelihood Ratio**, \( \Lambda(u|\hat{\gamma}) \), (2.60)

**LOE Information Matrix**, \( \Phi(\hat{\gamma}) \), (2.59)

The Tracking Loop Filter accepts \( \Lambda \) and \( \Phi \) from the SDP and completes the data processing cycle with following sequence of calculations.

**Extrapolated Error Covariance**, \( P(k|k-1) \), (2.71)

**Filter Gain**, \( \Gamma(k) \), (2.78)

**Updated State Estimate**, \( \hat{x}(k|k) \), (2.79)

**Updated Error Covariance**, \( P(k|k) \), (2.82).

This concludes the derivation at the general level. The results are specialized to particular state- and parameter-vector formulations next.
D. SPECIFIC DESIGNS

Throughout the research program three specializations of the above general design structure received most of the attention. These are characterized by the formulations of their parameter and state estimate vectors, as follows:

i. "Non-adaptive" Design

\[ N_G = 2, \quad \hat{\gamma} = (\hat{\alpha}, \hat{\theta})^T \quad (2.83) \]
\[ N_S = 3, \quad \hat{x} = (\hat{\alpha}, \hat{\theta}, \hat{\delta})^T \quad (2.84) \]

ii. "Optimal" Design (Adaptive)

\[ N_G = 5, \quad \hat{\gamma} = (\hat{\alpha}, \hat{\theta}, \hat{\alpha}_R, \hat{\theta}_R, \hat{\beta})^T \quad (2.85) \]
\[ N_S = 8, \quad \hat{x} = (\hat{\alpha}, \hat{\theta}, \hat{\theta}, \hat{\alpha}_R, \hat{\theta}_R, \hat{\beta}, \hat{w}_c)^T \quad (2.86) \]

iii. "Suboptimal" Design (Adaptive)

\[ N_G = 4, \quad \hat{\gamma} = (\hat{\alpha}, \hat{\theta}, \hat{\alpha}_R, \hat{\theta}_R, \hat{\rho})^T \quad (2.87) \]
\[ N_S = 6, \quad \hat{x} = (\hat{\alpha}, \hat{\theta}, \hat{\theta}, \hat{\alpha}_R, \hat{\theta}_R, \hat{\rho})^T \quad (2.88) \]

The non-adaptive design was identified and studied as a baseline design in accessing the benefits of adaptivity as supplied by the other designs. The optimal design was the principal focus of the study; the definitions (2.85) and (2.86), and the resulting design, are predicated on the assumption that the multipath interference phenomenon, when present (in \( q, (2.46), e.g. \)), is one which is fully described by samples taken at the angle function repetition rate, or more concisely, via the sampling theorem,

\[ w_{sc} < \pi(\text{Rep. Rate}) = \frac{\pi}{T} \quad (2.89) \]

where \( T \) is the interval between scans. Under this assumption then, \( \beta \) on the active scan is nearly constant, i.e. in \( q, (2.46), \).
\[ \beta_j \sim \beta(k), \text{ for all } j = 1, 2, \ldots, J \] (2.90)

(where \( \beta(k) \) is the phase difference at the start of the kth scan) and hence \( \hat{w}_{sc} \) does not appear in the \( \hat{y} \)-formulation for this design. The relation (2.89) is a restriction that would not always be met in practice, of course, and the suboptimal design represented an effort to formally relax this condition and simultaneously reduce the dimensions of the vectors and hence the complexity of the algorithm. This design was accomplished by

i. Assuming the \( \beta_j \) in q (2.46) were all independent random variables, uniformly distributed on the interval \((-\pi, \pi)\) (corresponding to the assumption that \( w_{sc} \rightarrow \infty \)); then

ii. Following (2.57) and taking the average of the likelihood ratio over all the \( \beta_j \) and then using it in the subsequent design.

Both the state and parameter vectors are devoid of both \( \beta \) and \( w_{sc} \) in this third design.

A fourth and very recently conceived design, motivated also by the desire to relax the restriction (2.89), though more complex than the "Optimal" design, is characterized as follows:

"6D LOE" Design (adaptive)

\[ \mathbf{N}_G = 6, \quad \hat{\mathbf{y}} = (\hat{\alpha}, \hat{\theta}, \hat{\alpha}_R, \hat{\theta}_R, \hat{\beta}, \hat{w}_{sc})^T \] (2.91)

\[ \mathbf{N}_s = 8, \quad \hat{\mathbf{x}} = (\hat{\alpha}, \hat{\theta}, \hat{\alpha}_R, \hat{\theta}_R, \hat{\beta}, \hat{w}_{sc})^T \] (2.92)
or

\[ \mathbf{N}_s = 9, \quad \hat{\mathbf{x}} = (\hat{\alpha}, \hat{\theta}, \hat{\alpha}_R, \hat{\theta}_R, \hat{\beta}, \hat{w}_{sc}, \hat{\hat{w}}_{sc})^T \] (2.93)

The assumption here is that there is sufficient information in the J
samples taken within a single scan (J/2 on each semi-scan, centered on the expected centroid of the direct path pulse) to produce an estimate of $\omega_{sc}$ using just one scan's data; it appears also the fractional accuracy of such an estimate would improve with increasing $\omega_{sc}$, though it may be somewhat $\theta$-dependent, since the interval between the TO-scan and FRO-scan pulses is both $\theta$-dependent and relevant to the $\omega_{sc}$-estimate produced (or, more specifically, the LOE estimate of the error in $\hat{\omega}_{sc}(k|k-1)$). The "6D LOE" design will be described in Appendix C with any results obtained at the time of grant closure.

Here we focus on the earlier designs, in particular, the details for the optimal and suboptimal designs. The non-adaptive design is clearly imbedded, in a sense, in both of these designs and needn't be treated separately.

**Optimal Design**

For this case, referencing (2.56), $\lambda(u_j|\hat{\omega})$ can be written as follows:

$$\lambda(u_j|\hat{\omega}) = J \prod_{j=1}^{J} \lambda_j(u_j|\hat{\omega}_j)$$

where

$$\lambda_j(u_j|\hat{\omega}_j) \triangleq M_o (4\hat{\omega}_j u_j) \exp(-\hat{\omega}_j)$$

$$> 0, \text{ for all } u_j \text{ and finite } \hat{\omega}_j$$

and

$$\hat{\omega}_j \triangleq q_j(\hat{\omega})$$

$$= \hat{\omega}^2 p^2_j(\hat{\omega}) + 2\hat{\omega} \hat{\omega}_R p_j(\hat{\omega}) p_j(\hat{\omega}_R) \cos(\hat{\omega}) + \hat{\omega}^2 p_R^2_j(\hat{\omega}_R)$$
Hence, via (2.60)
\[ \Lambda(u | \hat{y}) \triangleq \frac{\partial \ln \lambda(u | \hat{y})}{\partial \hat{y}} = \sum_{j=1}^{J} \lambda_j(u_j | \hat{u}_j) \]
(2.99)

where
\[ \Lambda_j(u_j | \hat{u}_j) \triangleq \frac{\partial}{\partial \hat{y}} \ln \lambda_j(u_j | \hat{u}_j) = \frac{\partial \lambda_j}{\partial \hat{y}} (u_j | \hat{u}_j) \]
(2.100)

or
\[ \Lambda(u | \hat{y}) = D(\hat{y})w(u | q(\hat{y})) \]
(2.101)

in which
\[ D(\hat{y}) \triangleq \frac{d \hat{u}_j}{d \hat{y}} = \begin{pmatrix} \frac{\partial \hat{u}_1}{\partial \hat{y}} & \cdots & \frac{\partial \hat{u}_J}{\partial \hat{y}} \\ \frac{\partial \hat{y}_1}{\partial \hat{y}} & \cdots & \frac{\partial \hat{y}_J}{\partial \hat{y}} \\ \frac{\partial \hat{u}_N}{\partial \hat{y}} & \cdots & \frac{\partial \hat{u}_N}{\partial \hat{y}} \end{pmatrix}, N \times J \]
(2.102)

\[
\begin{pmatrix}
-2 \hat{\alpha}_{p_j}^2(\hat{\theta}) + 2 \hat{\alpha}_{R_j} \hat{p}_j(\hat{\theta}_j) \hat{p}_j(\hat{\theta}_R) \cos \hat{\beta} \\
-2 \hat{\alpha}_{p_j}^2(\hat{\theta}_j) \hat{p}_j(\hat{\theta}_j) + 2 \hat{\alpha}_{R_j} \hat{p}_j(\hat{\theta}_j) \hat{p}_j(\hat{\theta}_R) \cos \hat{\beta} \\
-2 \hat{\alpha}_{p_j} \hat{p}_j(\hat{\theta}_j) \hat{p}_j(\hat{\theta}_j) \cos \hat{\beta} + 2 \hat{\alpha}_{R_j} \hat{p}_j(\hat{\theta}_j) \hat{p}_j(\hat{\theta}_R) \\
-2 \hat{\alpha}_{R_j} \hat{p}_j(\hat{\theta}_j) \hat{p}_j(\hat{\theta}_j) \cos \hat{\beta} + 2 \hat{\alpha}_{R_j} \hat{p}_j(\hat{\theta}_j) \hat{p}_j(\hat{\theta}_R) \\
\end{pmatrix}
\]
(2.103)

where
\[ \dot{p}_j(\theta) \triangleq \left. \frac{d}{d \theta} p[\theta | e] \right|_{\theta = \theta - \theta_A(\tau_j)} \]
(and similarly for \( \dot{p}_j(\theta_R) \)),
(2.104)
and
\[ w(u|\hat{y}) \triangleq (\cdots, w_j(u_j|\hat{y}), \cdots)^T, \quad J\text{-vector} \quad (2.105) \]

where
\[ w_j(u_j|\hat{y}) \triangleq \frac{\partial \lambda_j}{\partial \hat{q}_j} (u_j|\hat{q}_j) \]
\[ \lambda_j(u_j|\hat{q}_j) \]
\[ = 4u_j \frac{M_1}{M_0}(4q_j(\hat{y})u_j) - 1 \quad (2.107) \]
in which
\[ \frac{M_1}{M_0}(\cdot) \triangleq \frac{M_1(\cdot)}{M_0(\cdot)} \quad (2.108) \]
and, for any real \( z > 0 \),
\[ M_1(z) \triangleq \frac{d}{dz} M_0(z) \quad (2.109) \]

where \( M_0(\cdot) \) was as defined in (2.54) in relation to \( I_0(\cdot) \), as follows for any real \( x \):
\[ M_0(x^2) = I_0(x) \quad (2.110) \]

A corresponding relation for \( M_1(\cdot) \) is as follows:
\[ M_1(x^2) = \frac{1}{2x} I_1(x) \quad (2.111) \]

where \( I_1(\cdot) \) is the modified Bessel function of the first kind, first order. The well-known soft-limiter characteristic of \[ \frac{I_1}{I_0}(\cdot) \quad \text{(initial slope of \( \frac{1}{x} \), saturation value of 1) \]
corresponds to the following for \( \frac{M_1}{M_0}(x) \), \( x \geq 0 \):
\[ \left. \frac{M_1}{M_0}(x) \right|_{x=0} = \frac{1}{4} \quad (2.112) \]
\[
\frac{d}{dx} \frac{M_1}{M_0} (x) \bigg|_{x=0} = -\frac{1}{32} \quad (2.113)
\]
\[
\frac{M_1}{M_0} (x) \bigg|_{x \text{ large}} \to -\frac{1}{2} x \quad (2.114)
\]

These conditions are satisfied exactly by the approximation ([3], pp. 15-17)

\[
\frac{M_1}{M_0} (x) \approx \frac{1}{2 (4+x)^{\frac{3}{2}}} \quad (2.115)
\]

whose error peaks at only 4% around \(x=30\). Substituting this in (2.107) above for \(w_j(u_j \mid \hat{y})\) gives the expression

\[
w_j(u_j \mid \hat{y}) \approx \frac{u_j}{(1 + q_j(\hat{y})u_j)^{\frac{3}{2}}} - 1 \quad (2.116)
\]

which was used in this design.

Substituting (2.101) above in the defining equation (2.59) for the LOE Information Matrix \(\Phi\) gives

\[
\Phi(\hat{y}) \triangleq \langle \Lambda(u(\gamma, n)) \Lambda^T(u(\gamma, n)) \mid \hat{y} \rangle \mid \gamma = \hat{y} \rangle = \mathbf{D}(\hat{y}) \mathbf{H}_w(q(\hat{y})) \mathbf{D}^T(\hat{y}) \quad (2.117)
\]

where

\[
\mathbf{H}_w(q(\hat{y})) \triangleq \langle \omega(u(\gamma, n)) \omega^T(u(\gamma, n)) \mid \hat{y} \rangle \mid \gamma = \hat{y} \rangle \quad (2.118)
\]

The criterion for locally optimum estimation (more specifically, locally unbiased estimation) at \(\varepsilon=0\) assures that

\[
0 = \langle \Lambda(u(\gamma, n)) \mid \gamma = \hat{y} \rangle = \mathbf{D}(\hat{y}) \langle \omega(u(\gamma, n)) \mid \hat{y} \rangle \mid \gamma = \hat{y} \rangle \quad (2.119)
\]

A simulation study ([4], p.15) of the process \(w(u \mid \hat{q})\), using the approximation (2.116) gave support for (2.120) as well as strong evidence that \(w(u \mid \hat{q})\) is white, i.e.
\begin{align*}
\langle \hat{w}_i(\gamma, n_i) | \hat{\gamma} \rangle w_j(\gamma, n_j) \rangle | \gamma = \hat{\gamma} \rangle &= \begin{cases} 0, & \text{for } i \neq j \\ h_{w_j}(\hat{\gamma}), & \text{for } i = j \end{cases} \quad (2.121)
\end{align*}

and on this basis $H_w(\hat{\gamma})$, (2.119), which is the covariance of $w(u| \hat{q})$ local to $\gamma - \hat{\gamma} = 0$, was taken as diagonal, i.e.

$$H_w(\hat{\gamma}) = \text{Diag}(..., h_{w_j}(\hat{\gamma}), ...), \quad J \times J$$

(2.122)

where $h_{w_j}(\hat{\gamma})$, it was also found ([4], Appendix A), could be approximated, as follows:

$$h_{w_j}(\hat{\gamma}) \approx \frac{1}{1 + 2 \cdot q_j(\hat{\gamma})}$$

(2.123)

with an error that peaked at about 20\% for $\hat{q}_j = 2$.

The antenna scanning function, $\theta_A(\tau)$, used was the following

$$\theta_A(\tau_j) \triangleq \begin{cases} \theta_{A_{\max}} + \Omega \tau_j, & 0 < \tau_j < T_s \\ \theta_{A_{\min}}, & T_s \leq \tau_j < T_F \\ \theta_{A_{\min}} - \Omega(\tau_j - T_F), & T_F \leq \tau_j < T_1 \end{cases}$$

(2.124)

where the parameters are defined, as follows: (see Figure 2.1)

$$\Omega \triangleq -\frac{\theta_{A_{\max}} - \theta_{A_{\min}}}{T_s}$$

(2.125)

$$T_F \triangleq T_s + T_R - 2 \frac{\theta_{A_{\min}}}{\Omega}$$

(2.126)

$$T_s \triangleq \text{duration of the TO-scan}$$

(2.127)

$$T_R \triangleq \text{interval between zero intercepts}$$

(2.128)

$$T_1 \triangleq T_s + T_F$$

(2.129)

Values for the parameters $\theta_{A_{\max}}, \theta_{A_{\min}}, T_s$ and $T_R$ are essentially prescribed by the MLS specifications and will be given in the simulation
Figure 2.1 MLS Antenna Scanning Function
discussion. The antenna selectivity function, \( p(\cdot) \), and its derivative \( \dot{p}(\cdot) \), are not prescribed in the specifications; plausible functions were chosen for simulation use, however, and these will be described later, also. This completes the description of the scan data processor for the optimal design.

The \( \hat{y} \) and \( \hat{x} \) vector formulations in (2.85) and (2.86) require matrices \( F \) and \( H \) in the tracking loop, as follows:

\[
F = \begin{pmatrix}
1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 1 & T & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 1 & T & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\
\end{pmatrix}
\]

(2.130)

\[
H = \begin{pmatrix}
1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\
\end{pmatrix}
\]

(2.131)

The product matrix \( GQ^T \) used was a diagonal one in which the diagonal elements represented generally measures (variances) of the intuitive uncertainty in the elements of \( x(k) \), given those of \( x(k-1) \). The following values were selected as part of the tracking loop design:

\[
GQ^{T}_{11} = GQ^{T}_{44} = \text{Max} \{ (\frac{\hat{y}}{10})^2, (\frac{\dot{y}}{10})^2 \} \]  

(2.132)

representing 10% uncertainty for \( S/N \geq 14 \) db (in the direct path signal strength only; the assignment of the same value to the '44' component was arbitrary);

\[
GQ^{T}_{22} = GQ^{T}_{55} = GQ^{T}_{77} = 0 \]

(2.133)

representing full reliance in these coordinates on integrations of derivatives.
\[
\mathbf{GQG}_{33}^T = \mathbf{GQG}_{66}^T = \left| \dot{\theta}_{\text{max}} \right|_{AZ}^{2_T} = 0.1 \text{deg/sec}^2
\]  

(2.134)

where \( \left| \dot{\theta}_{\text{max}} \right| = 0.1 \text{deg/sec}^2 \) in Azimuth, was determined from a study of a representative set of landing patterns ([3], pp. 40ff);

\[
\mathbf{GQG}_{33}^T = \left( \frac{\Delta \phi}{T} \right)^2 = 0.04 \left( \frac{T^2}{T} \right)^2
\]  

(2.135)

representing an error \( \Delta \phi \) in phase (due to \( \omega_c \) uncertainty (i.e. error)) of 0.2 radians between scans, well within the limit of \( \pi \) radians associated with the sampling theorem.

Finally, in recognition of the limitations on the true values of the states, imposed by system geometry, modeling ambiguities, etc., the results obtained from the estimation algorithm described thus far were subjected to various additional constraint operations before being designated and subsequently evaluated as "the estimates". Each of these constraints are described pictorially in Figure 2.2 in the conventional format of an input-output graph of a function of one variable. In all cases the abscissa (input) is the result of the estimation update, (2.79) above, and the ordinate is the estimate to be output (or used in the next estimation cycle).

Suboptimal Design

For this case, the \( \beta_j, j=1,2, \ldots, J \), are taken as independent random variables, each uniformly distributed on \([-\pi, \pi]\). Conceptually, \( \hat{q}_j \) is also random and can be written

\[
\hat{q}_j = \hat{q}_A + \hat{q}_B \cos \beta_j = q_j(\hat{\gamma}, \beta_j)
\]  

(2.136)

where

\[
\hat{q}_A = \hat{\alpha}^2 \hat{p}_j^2(\theta) + \hat{\alpha}^2 \hat{p}_R^2(\hat{\theta}_R) = q_A(\hat{\gamma}, > 0
\]  

(2.137)
Figure 2.2 Constraints on Estimates
\[
\hat{A}_B \triangleq 2 \Delta_{\theta} p_j(\hat{\theta}) p_j(\hat{\theta}_R) = q_{B_j}, \text{ indefinite}
\] (2.138)

and
\[
- \hat{A}_A \leq \hat{A}_B \leq \hat{A}_A
\] (2.139)

We seek \(\lambda(u|\hat{\gamma})\), which, applying (2.57), is given by
\[
\lambda(u|\hat{\gamma}) = \prod_{j=1}^{J} \lambda_j(u_j|q_j(\hat{\gamma}, \beta_j))|u_j, \hat{\gamma}>\quad \text{(2.140)}
\]
in which the averaging is done wrt the \(\beta_j\), \(j=1,2,\ldots, J\). Because the \(\beta_j\) are independent this can be written in a form similar to (2.94) as follows:
\[
\lambda(u|\hat{\gamma}) = \prod_{j=1}^{J} \lambda_j(u_j|\hat{A}_A, \hat{A}_B) \quad \text{(2.141)}
\]
where
\[
\lambda_j(u_j|\hat{A}_A, \hat{A}_B) \triangleq \lambda_j(u_j|q_j(\hat{\gamma}, \beta_j))|u_j, \hat{\gamma}> \quad \text{(2.142)}
\]
\[> 0 \quad \text{(by virtue of (2.95), (2.96))} \quad \text{(2.143)}
\]
And, as in (2.99),
\[
\Lambda(u|\hat{\gamma}) = \sum_{j=1}^{J} \lambda_j(u_j|\hat{\gamma}) \quad \text{(2.144)}
\]
where, here,
\[
\lambda_j(u_j|\hat{\gamma}) = \frac{\partial}{\partial \hat{\gamma}} \ln \lambda_j(u_j|\hat{A}_A, \hat{A}_B) \quad \text{(2.145)}
\]
\[
= \frac{\partial}{\partial \hat{\gamma}} \lambda_j(u_j|\hat{A}_A, \hat{A}_B) \quad \text{(2.146)}
\]
\[
= (\frac{d}{d \hat{\gamma}}) (\frac{\lambda(u_j|\hat{A}_A, \hat{A}_B)}{\lambda(u_j|\hat{A}_A, \hat{A}_B)}) + \frac{d}{d \hat{\gamma}} (\frac{\lambda(u_j|\hat{A}_A, \hat{A}_B)}{\lambda(u_j|\hat{A}_A, \hat{A}_B)}) \quad \text{(2.147)}
\]

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Consequently, $A(u|\hat{y})$ in (2.144) above, may be written

$$A(u|\hat{y}) = D_A(\hat{y})w_A(u|\hat{y}) + D_B(\hat{y})w_B(u|\hat{y})$$

(2.148)

where

$$D_A(\hat{y}) \triangleq \begin{pmatrix}
\frac{\partial q_{A,1}(\hat{y})}{\partial \hat{y}_1} \\
\vdots \\
\frac{\partial q_{A,1}(\hat{y})}{\partial \hat{y}_{N_G}}
\end{pmatrix}, \quad N_G \times J$$

(2.149)

$$D_B(\hat{y}) \triangleq \begin{pmatrix}
\frac{\partial q_{B,1}(\hat{y})}{\partial \hat{y}_1} \\
\vdots \\
\frac{\partial q_{B,1}(\hat{y})}{\partial \hat{y}_{N_G}}
\end{pmatrix}, \quad N_G \times J$$

(2.150)

$$w_A(u|\hat{y}) \triangleq (---w_A(u_j|\hat{y}) ---)^T, \quad J\text{-vector}$$

(2.153)
\[ w_B(u|\hat{y}) = (\ldots w_B(u_j|\hat{y})\ldots)^T, \text{ J-vector} \] (2.154)

In which

\[ w_{A,j}(u_j|\hat{y}) \triangleq \frac{\lambda_j(u_j|\hat{q}_{A,j},\hat{q}_{B,j})}{\lambda_j(u_j|\hat{q}_{A,j},\hat{q}_{B,j})} \] (2.155)

\[ \frac{\lambda_j(u_j|q_j(\hat{y},\beta_j))|u_j,\hat{y})}{\lambda_j(u_j|\hat{q}_j(\hat{y},\beta_j))|u_j,\hat{y})} \] (2.156)

\[ \frac{\lambda_j(u_j|\hat{q}_j)|u_j,\hat{y})}{\lambda_j(u_j|\hat{q}_j)|u_j,\hat{y})} \] (2.157)

\[ \frac{\lambda_j(u_j|\hat{q}_j)|u_j,\hat{y})}{\lambda_j(u_j|\hat{q}_j)|u_j,\hat{y})} \] (2.158)

And, similarly

\[ w_{B,j}(u_j|\hat{y}) \triangleq \frac{\lambda_j(u_j|\hat{q}_{A,j},\hat{q}_{B,j})}{\lambda_j(u_j|\hat{q}_{A,j},\hat{q}_{B,j})} \] (2.159)

\[ \frac{\lambda_j(u_j|\hat{q}_j)|u_j,\hat{y})}{\lambda_j(u_j|\hat{q}_j)|u_j,\hat{y})} \] (2.160)

\[ \frac{\lambda_j(u_j|\hat{q}_j)|u_j,\hat{y})}{\lambda_j(u_j|\hat{q}_j)|u_j,\hat{y})} \] (2.161)
Making use of (2.106) in (2.158) and (2.161) [and noting that $\hat{\gamma}$ in (2.106) included the phase difference parameter] gives

$$w_{A_j}(u_j|\hat{\gamma}) = \frac{<w_j(u_j|\hat{\gamma},\beta_j)\lambda_j(u_j|\hat{\alpha}_j)|u_j,\hat{\gamma}>}{<\lambda_j(u_j|\hat{\alpha}_j)|u_j,\hat{\gamma}>}$$ (2.162)

$$= \frac{<w_j(u_j|\hat{\gamma},\beta_j)\lambda_j(u_j|\hat{\alpha}_j)|u_j,\hat{\gamma}>}{<\lambda_j(u_j|\hat{\alpha}_j)|u_j,\hat{\gamma}>}$$ (2.163)

$$w_{B_j}(u_j|\hat{\gamma}) = \frac{<w_j(u_j|\hat{\gamma},\beta_j)\cos \beta_j\lambda_j(u_j|\hat{\alpha}_j)|u_j,\hat{\gamma}>}{<\lambda_j(u_j|\hat{\alpha}_j)|u_j,\hat{\gamma}>}$$ (2.164)

where

$$\lambda_j(u_j|\hat{\alpha}_j) \triangleq \frac{\lambda_j(u_j|\hat{\alpha}_j)}{<\lambda_j(u_j|\hat{\alpha}_j)|u_j,\hat{\gamma}>} > 0$$ (2.165)

is a weighting factor which essentially modifies the (uniform) a priori distribution of $\beta_j$, giving an a posteriori one conditioned on $u_j$ and $\hat{\gamma}$, i.e.

$$p(\beta_j|u_j,\hat{\gamma}) = \lambda_j(u_j|\hat{\alpha}_j) > 0$$ (2.166)

(Clearly

$$\int_{-\hat{\beta}}^{\hat{\beta}} p(\beta_j|u_j,\hat{\gamma})d\beta_j = \frac{<w_j(u_j|\hat{\gamma},\beta_j)|u_j,\hat{\gamma}>}{<\lambda_j(u_j|\hat{\alpha}_j)|u_j,\hat{\gamma}>} = 1$$ (2.167)

independent of $u_j$, $\hat{\gamma}$, as expected.) A more explicit form for $w_{A_j}$ results from the substitution of (2.95) for $\lambda_j$ and (2.107) for $w_j$ into (2.162); writing the expectations in integral form and taking advantage of the even symmetry wrt $\beta_j$ (i.e. as $\cos \beta_j$ in $\hat{\alpha}_j$) gives:

$$w_{A_j}(u_j|\hat{\gamma}) = \frac{\int_{0}^{\pi} \frac{M_1}{M_0} (4\hat{\alpha}_j u_j - 1) M_0 (4\hat{\alpha}_j u_j) \exp(-q_j)d\beta_j}{\int_{0}^{\pi} M_0 (4\hat{\alpha}_j u_j) \exp(-q_j)d\beta_j}$$ (2.168)

or, in terms of the more familiar modified Bessel functions of the first kind, $I_0$, and $I_1$,
Substituting the approximations (for any real $z$)

$$\frac{I_1}{I_0}(z) \approx \frac{-z}{(4 + z^2)^{3/2}} \quad \text{(good to about 4%)} \quad (2.170)$$

$$I_0(z) \approx \frac{\exp[(4 + z^2)^{3/2} - \frac{2}{l+1}]}{(1 + 2\pi)^{3/2}} \quad \text{(good to about 7%)} \quad (2.171)$$

and the following expansion for $\hat{q}_j$

$$\hat{q}_j = \hat{a}_{A,j} (1 + B_j \cos \beta_j) \quad (2.172)$$

where

$$B_j \overset{\Delta}{=} \frac{\hat{a}_{B,j}}{\hat{a}_{A,j}} \quad (2.173)$$

(and, by virtue of (2.139))

$$-1 \leq B_j \leq +1 \quad (2.174)$$

gives

$$w_{A,j} = \frac{\int_{\sigma}^{\pi} \omega_j L_j \, d\beta_j}{\int_{\sigma}^{\pi} L_j \, d\beta_j} \quad (2.175)$$

$$w_{B,j} = \frac{\int_{\sigma}^{\pi} \omega_j \cos \beta_j L_j \, d\beta_j}{\int_{\sigma}^{\pi} L_j \, d\beta_j} \quad (2.176)$$

where

$$w_j \overset{\Delta}{=} \frac{\hat{a}_{A,j} u_j}{(1 + \hat{a}_{A,j} u_j (1 + B_j \cos \beta_j))^2} - 1 \quad (2.177)$$
and

$$\exp \left[ 2 \left( \left( 1 + \frac{1}{2} \frac{1}{1 + 2 \left( \frac{q_{b_j}}{q_{a_j}} \right)^2} \frac{1}{(1 + B_j \cos \beta_j)^2} \right) - q_A (1 + B_j \cos \beta_j) \right) \right]$$

$$L_{\Delta j} = \frac{1}{1 + 4\pi \left( \frac{q_{b_j}}{q_{a_j}} \right)^{\frac{A_j}{2}} (1 + B_j \cos \beta_j)^{\frac{A_j}{2}}}$$

(2.178)

These last models, (2.175) and (2.176), were the basis of the calculations below.

Substituting (2.148) for $A(u|\hat{Y})$ into (2.59) for $\Phi(\hat{Y})$ gives

$$\Phi(\hat{Y}) = D_A(\hat{Y})H_{A}(\hat{Y})D_A^T(\hat{Y}) + D_A(\hat{Y})H_{B}(\hat{Y})D_B^T(\hat{Y})$$

$$+ (D_A(\hat{Y})H_{AB}(\hat{Y})D_B^T(\hat{Y}))^T + D_B(\hat{Y})H_{AB}(\hat{Y})D_B^T(\hat{Y})$$

(2.179)

where, noting that now

$$u = u(\gamma, \beta_u, n)$$

(2.180)

the $J \times J$ matrices $H_A, H_B$, and $H_{AB}$ are given by the following:

$$H_{A}(\hat{Y}) \triangleq <w_A(u(\gamma, \beta_u, n) \mid \hat{Y})w_A^T(u(\gamma, \beta_u, n) \mid \hat{Y}) \mid \gamma = \hat{Y}>$$

(2.181)

$$H_{B}(\hat{Y}) \triangleq <w_B(u(\gamma, \beta_u, n) \mid \hat{Y})w_B^T(u(\gamma, \beta_u, n) \mid \hat{Y}) \mid \gamma = \hat{Y}>$$

(2.182)

$$H_{AB}(\hat{Y}) \triangleq <w_A(u(\gamma, \beta_u, n) \mid \hat{Y})w_B^T(u(\gamma, \beta_u, n) \mid \hat{Y}) \mid \gamma = \hat{Y}>$$

(2.183)

in which these averages are taken wrt to the noise $n$ and phase difference $\beta_j$ in $u$. Assurances given by the LOE theory that

$$0 = <A(u(\gamma, \beta_u, n) \mid \hat{Y}) \mid \gamma = \hat{Y}>$$

(2.184)

$$= D_A(\hat{Y})w_A(u(\gamma, \beta_u, n) \mid \hat{Y}) \mid \gamma = \hat{Y}) + D_B(\hat{Y})w_B(u(\gamma, \beta_u, n) \mid \hat{Y}) \mid \gamma = \hat{Y}>$$

(2.185)

strongly suggest that

$$<w_A(u(\gamma, \beta_u, n) \mid \hat{Y}) \mid \gamma = \hat{Y}> = 0$$

(2.186)

$$<w_B(u(\gamma, \beta_u, n) \mid \hat{Y}) \mid \gamma = \hat{Y}> = 0$$

(2.187)
and a simulation study of the processes \( w_A(u | \hat{y}) \) and \( w_B(u | \hat{y}) \), using numerical approximations of (2.175) and (2.176) (discussed below) respectively, gave support for (2.186) and (2.187), as well as strong evidence that

\[
\langle w_A(u_i(\gamma_0, \beta_{ui}, n_i)) | \hat{y} \rangle w_A(u_j(\gamma_0, \beta_{uj}, n_j)) | \hat{y} \rangle | \gamma = \hat{y} \rangle = \begin{cases} 0 & \text{if } i \neq j \\ h_{wA_j}(\hat{y}), i=j & \end{cases} \tag{2.188}
\]

\[
\langle w_B(u_i(\gamma_0, \beta_{ui}, n_i)) | \hat{y} \rangle w_B(u_j(\gamma_0, \beta_{uj}, n_j)) | \hat{y} \rangle | \gamma = \hat{y} \rangle = \begin{cases} 0 & \text{if } i \neq j \\ h_{wB_j}(\hat{y}), i=j & \end{cases} \tag{2.189}
\]

\[
\langle w_A(u_i(\gamma_0, \beta_{ui}, n_i)) | \hat{y} \rangle w_B(u_j(\gamma_0, \beta_{uj}, n_j)) | \hat{y} \rangle | \gamma = \hat{y} \rangle = \begin{cases} 0 & \text{if } i \neq j \\ h_{wAB_j}(\hat{y}), i=j & \end{cases} \tag{2.190}
\]

and, on the basis of these conclusions, the matrices \( H_{wA}(\hat{y}) \) and \( H_{wB}(\hat{y}) \) which are the covariances of processes \( w_A(u | \hat{y}) \) and \( w_B(u | \hat{y}) \) local to \( \gamma - \hat{y} = 0 \), and the matrix \( H_{wAB}(\hat{y}) \), the cross-variance of the processes \( w_A \) and \( w_B \) local to \( \gamma - \hat{y} = 0 \), were taken as diagonal, i.e.

\[
H_{wA}(\hat{y}) = \text{Diag}(---, h_{wA_j}(\hat{y}), ---), J \times J \tag{2.191}
\]

\[
H_{wB}(\hat{y}) = \text{Diag}(---, h_{wB_j}(\hat{y}), ---), J \times J \tag{2.192}
\]

\[
H_{wAB}(\hat{y}) = \text{Diag}(---, h_{wAB_j}(\hat{y}), ---), J \times J \tag{2.193}
\]

where definitions for \( h_{wA_j}(\hat{y}) \), \( h_{wB_j}(\hat{y}) \) and \( h_{wAB_j}(\hat{y}) \) were taken from equations (2.188), (2.189) and (2.190), respectively, above.

Efforts to use (2.175), (2.176), (2.188), (2.189) and (2.190) and
obtain approximations, respectively, for \( w_A^j \), \( w_B^j \), \( h_{WA}^j \), \( h_{WB}^j \) and \( h_{WAB}^j \), analogous to those in (2.116) and (2.123) for \( w_j \) and \( h_j \), respectively, in the optimal design, were not successful. As indicated above, it was necessary to use numerical procedures to perform the averaging indicated in the calculations of \( w_A^j (u_j \mid \gamma) \), \( w_B^j (u_j \mid \gamma) \) and \( \Phi(\gamma) \). Numerical versions of (2.175) and (2.176) were used to calculate \( w_A^j (u_j \mid \gamma) \) and \( w_B^j (u_j \mid \gamma) \) in which integrations wrt \( \beta \) were replaced by simulation averages -- i.e. by summations over on index set of LMAX values of \( \beta \) taken uniformly over the interval \([0, \pi]\), with due regard for the dynamic range of the computing machine. The forms used are, as follows, suppressing the "j" subscript temporarily:

\[
\begin{align*}
\omega_A &= \frac{\max(1, |h_a_\ell|)}{\max(1, h_\ell)} \left( \frac{f_{sA}^\ell}{f_s^\ell} \right) \\
\omega_B &= \frac{\max(1, |h_b_\ell|)}{\max(1, h_\ell)} \left( \frac{f_{sB}^\ell}{f_s^\ell} \right)
\end{align*}
\tag{2.194, 2.195}
\]

where

\[
\begin{align*}
h_\ell &= \frac{1}{(1 + 4\pi (q_A u)^\frac{1}{2} (1 + Bcos\beta_\ell)^\frac{3}{2})^2} \\
h_a_\ell &= (-1 + u) \left( \frac{1}{(1 + q_A u(1 + Bcos\beta_\ell))^{\frac{3}{2}}} \right)^{\frac{3}{2}} h_\ell \\
h_b_\ell &= h_a_\ell cos\beta_\ell \\
f_s = \sum_{\ell} \left( h_a_\ell \exp(g_\ell - g_m) \right) \\
f_s^A = \sum_{\ell} \left( h_a_\ell \exp(g_\ell - g_m^A) \right)
\end{align*}
\tag{2.196, 2.197, 2.198, 2.199, 2.200}
\]
\[ f_{SB} = \sum_{\ell} h_{b_{\ell}} \exp(g_{\ell} - g_{m_{b}}) \]  
(2.201)

\[ g_{m} = \ln(LMAX) + \ln(\max(1, h_{\ell})) + \max(g_{\ell}) - \text{EXPMAX} \]  
(2.202)

\[ g_{m_{a}} = \ln(LMAX) + \ln(\max(1, h_{a_{\ell}})) + \max(g_{\ell}) - \text{EXPMAX} \]  
(2.203)

\[ g_{m_{b}} = \ln(LMAX) + \ln(\max(1, h_{b_{\ell}})) + \max(g_{\ell}) - \text{EXPMAX} \]  
(2.204)

and

\[ \text{EXPMAX} \triangleq \ln(\text{largest REAL variable representable on the computer}) \]  
(2.205)

(≈ 88. on the PDP-11, 322. on the CDC Cyber 172)  
(2.206)

These equations were the basis for the simulation study that led to the conclusions of whiteness, equations (2.186) thru (2.190), and the consequent diagonality of \( H_{A}, H_{B}, \) and \( H_{AB}, \) (2.191) thru (2.193). These same equations were used in a numerical study of \( w_{A_j}, w_{B_j}, \) and \( w_{AB_j} \) as functions \( u_j, q_{A_j}, \) and \( B_j \) in an effort to find approximating functions,

\[ w_{A_j}(u_j | q_{A_j}, B_j), w_{B_j}(u_j | q_{A_j}, B_j) \]

"after the fact", again without success. As a result

i. The numerical computation of \( w_{A_j}, w_{B_j}, \) given \( u_j, q_{A_j}, \) and \( B_j, \) equations (2.194) thru (2.204) had to be programmed as part of the receiver design, to run "on-line" (with a substantial increment in processing time). More will be said about this in the simulation discussion in the next chapter.

ii. Also, the second-order averages, \( h_{w_{A_j}}, h_{w_{B_j}}, \) and \( h_{w_{AB_j}} \), associated with the calculation of \( \Phi \) could not be adequately approximated
in closed-form, and numerical averages based on (2.188) thru (2.190) had to be done.

These latter calculations will be summarized at this point in the discussion since they were done "off-line" and hence were not part of the receiver simulation per se, but more a part of the design.

As (2.188) thru (2.190) suggests, the second-order averages had to be taken wrt the $u_j$-variable and the noise $n_j$ in the observation sample, $u_j$, appearing as an argument of the conditional mean processes $w_{A_j}$, $w_{B_j}$--clearly a very lengthy process but one fortunately that could be done off-line. Such an approach was used, but the effort then to find approximating functions "after the fact" was again not successful, and a plan was pursued involving calculating and storing many values of the second-order averages in tables off-line, then using table-lookup procedures indexed by $q_{A_j}$ and $B_j$ and interpolation on-line to calculate $\Phi(\hat{\gamma})$.

To improve the accuracy of these results and more nearly guarantee the non-negativeness of the calculated $\Phi(\hat{\gamma})$, the $\Phi$-matrix was determined element-wise, as follows:

$$\Phi_{2i} = \Phi_{i2} = \sum_{j=1}^{J} \left( s_{w_{A_j}A_{ij}} - s_{w_{B_jA_{ij}}} \right) \left( s_{w_{A_j}B_{ij}} - s_{w_{B_jB_{ij}}} \right) + \left( 1 + R_{AB} \right) s_{w_{A_j}B_{ij}} s_{w_{B_jB_{ij}}} \left( D_{A_{ij}A_{ij}} B_{ij} + D_{A_{ij}B_{ij}} \right) \tag{2.207}$$

where

$$s_{w_{A_j}A_{ij}} \approx \left( h_{w_{A_j}} \right)^{\frac{1}{2}} , \quad s_{w_{A_j}} > 0 \quad \tag{2.208}$$

$$s_{w_{B_j}B_{ij}} \approx \left( h_{w_{B_j}} \right)^{\frac{1}{2}} , \quad s_{w_{B_j}} > 0 \quad \tag{2.209}$$
The averaging associated with these calculations also was done by simulation rather than by using numerical integration of the associated probability integrals. In particular, suppressing the above "j" subscript temporarily and considering (2.136) and (2.172) then clearly \( u(j) \) in (2.48) can be written without confusion as

\[
\begin{align*}
  u &= q(q_{A,B}, \beta_u) + 2n_c[q(q_{A,B}, \beta_u)]^{\frac{1}{2}} + n_c^2 + n_s^2 \\
  &= u(\beta_u, n|q_{A,B}) \\
\end{align*}
\]

\( u(j) \) can be written as

\[
\begin{align*}
  u &= q(q_{A,B}, \beta_u) + 2n_c[q(q_{A,B}, \beta_u)]^{\frac{1}{2}} + n_c^2 + n_s^2 \\
  &= u(\beta_u, n|q_{A,B}) \\
\end{align*}
\]

where, of course \( q_A = q_A(\gamma) \) and \( B=B(\gamma) \). Then \( w_A(j) \) can be denoted as

\[
\begin{align*}
  w_A(u|\hat{q}_{A,B}) &= w_A(u(\beta_u, n|q_{A,B})|\hat{q}_{A,B}) \\
\end{align*}
\]

and with this notation the calculation of \( s_w \) is described, as follows

\[
\begin{align*}
  s_w = \left[ \frac{1}{L_{\text{max}} J_{\text{max}}} \sum_{L=1}^{J_{\text{max}}} \sum_{n=1}^{J_{\text{max}}} w_A^2(u(\beta_{u_n}, n_i|q_{A,B})|\hat{q}_{A,B}) \right]^{\frac{1}{2}} \\
\end{align*}
\]

and similarly for \( s_w \) etc. where the components \( n_c, n_s \) of the \( J_{\text{max}} \) noise vectors \( n_i \) were drawn from a Gaussian pseudorandom noise generator (with mean zero, variance 0.5, see (2.11)) and the \( L_{\text{max}} \) values of \( \beta_{u_n} \) were taken uniformly from the interval \([0, \pi]\). Values for \( L_{\text{max}} \) and \( J_{\text{max}} \) used were

\[
\begin{align*}
  L_{\text{max}} &= 11 \\
  J_{\text{max}} &= 400 \\
\end{align*}
\]
for each \((q_{A_j}, B_j)\) point. In building the tables 300 \((q_{A_j}, B_j)\) points were employed distributed generally, as follows:

\[
0.1 \leq q_{A_j} \leq 10^8 \quad (25 \text{ values})
\]

\[
0.01 \leq B_j \leq 0.990 \quad (12 \text{ values})
\]

and values for \(\ln(s_{A_j}^w), \ln(s_{B_j}^w)\) and \(R_{ABj}\) were calculated and stored. These off-line calculations were done by PROGRAM WLOGSW, associated subroutines WAVGS and WAWB, and FUNCTION GAUSS, which are all included in Appendix A. Values calculated for \(\ln(s_{A_j}^w), \ln(s_{B_j}^w)\), and \(R_{ABj}\) are given in Tables 2.1, 2.2 and 2.3 respectively.

Then, in the receiver, for each \((q_{A_j}, B_j)\) point associated with the estimate \(\hat{y}(k-1)\), the tables were entered and

i. Values \(\hat{q}_{A_i}, \hat{q}_{A_{i+1}}, \hat{B}_i, \hat{B}_{i+1}\) from the tables were found, such that

\[
\hat{q}_{A_i} \leq q_{A_j} \leq \hat{q}_{A_{i+1}}
\]

\[
\hat{B}_i \leq B_j \leq \hat{B}_{i+1}
\]

ii. Then, linear interpolation between calculated averages in the table was done, using the general formula

\[
f(x_1 + \Delta x, y_1 + \Delta y) = f(x_1, y_1) + \frac{f(x_2, y_1) - f(x_1, y_1)}{x_2 - x_1} \Delta x + \frac{f(x_1, y_2) - f(x_1, y_1)}{y_2 - y_1} \Delta y + \frac{f(x_1, y_1) + f(x_2, y_2) - f(x_1, y_2) - f(x_2, y_1)}{(x_2 - x_1)(y_2 - y_1)} \Delta x \Delta y
\]

iii. The interpolated values of \(\ln(s_{A_j}^w), \ln(s_{B_j}^w)\) were exponentiated,
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**Table 2.1** \( \ln (e_{A_j}^{w_j} (q_{A_j}^q, B_j)) \)
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</table>

Table 2.2 $\ln (Q_{\beta_j} (q_{A_j}, B_j))$
|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
and the results with the interpolated value of $R_{AB}$ were used in calculating $\Phi_{\hat{z}_i}$ via (2.207).

This completes the calculation of $\Lambda(u|\hat{y})$ and $\Phi(\hat{y})$, hence the description of the Scan Data Processor, for the Suboptimal Design.

The Tracking Loop for the Suboptimal Design is identical with that of the Optimal Design, except for changes due to the lower dimensions of the state and parameter vectors. Generally

i. The last two rows of the state vector estimate and corresponding rows and/or columns of associated matrices were eliminated;

ii. The last row of the parameter-vector (estimate) and corresponding rows and/or columns of associated matrices were eliminated.

This simple adaptation procedure results from the special formulations of the state- and parameter-vectors adopted. It was employed in the simulation easily and without problem.

This same general procedure was used also in obtaining the Non-Adaptive Design (recall (2.83), (2.84)) -- simply by (initializing $\hat{z}_R=0$ and then) pruning the several vectors and matrices back to the appropriate dimensions, starting with either the optimal or suboptimal designs (both give the same results). This too was used in simulation without problem.

This concludes the formal development of the receiver algorithms. We turn next to the simulation studies and discussion of results.
SECTION III
SIMULATION STUDIES

The principal simulation result used in evaluating the performance of the various receiver designs was the calculated root mean square error (RMSE) (sample) statistic. A large number of studies of RMSE versus $\theta_{sep}$ were conducted, where

$$\theta_{sep} = \theta - \theta_R$$

These studies were parameterized, in general, by the following:

- $\text{DSNRDB (or S/N)} \triangleq 20 \log_{10} \alpha$ (3.2)
- $\rho \triangleq \alpha_R/\alpha$ (3.3)
- $\beta$, the phase difference at the beginning of the simulation run (3.4)
- $F_{sc} = \omega_{sc}/2\pi$, the scalloping rate (Hz) (3.5)
- $B_{\text{MLS}} \triangleq$ the 3 db beam width of the MLS transmitting antenna (3.6)
- $B_{\text{RCVR}} \triangleq$ the presumed 3 db beam width in the receiver of the MLS transmitting antenna (3.7)

Other RMSE studies performed included:

1. RMSE versus $(B_{\text{RCVR}}/B_{\text{MLS}})$, parameterized by $S/N, \rho, \beta, F_{sc}$ and $\theta_{sep}$; this study was deemed important because of the presumption in the Optimal and Suboptimal receivers of a value for the MLS ground (transmitting) antenna beam width, a parameter not currently transmitted in the preamble of the MLS signal.

2. RMSE versus $F_{sc}$, parameterized by $S/N, \rho, \beta, \theta_{sep}, B_{\text{MLS}}, B_{\text{RCVR}}$. 


Two series of error time-history studies were conducted also, all runs in both cases being parameterized by the full set, $S/N$, $\rho$, $\beta$, $F_{sc}$, $\Theta_{sep}$, $B_{MLS}$, $B_{RCVR}$, as well as other variants, such as the presence or absence of the constraints imposed on the estimates, etc. One set of error time-history studies, termed Interference Acquisition scenario runs, evaluated the "pull-in" ability of the interference tracker for potential use in interference acquisition. The second set of error time-history studies, termed Crossing Multipath scenario runs, evaluated the tracking performance of the receiver designs in dynamic environments involving multipath interference which is initially out-of-beam, then closes to in-beam, crosses, and finally opens to out-of-beam.

A major portion of the research was devoted to simulation studies -- both program development and receiver performance evaluation. The programs used in the receiver performance studies, totaling about 100 pages of FORTRAN code, are listed in Appendix A and are briefly discussed in the first part of this section. The second part of this section presents a representative selection of data from the various simulation runs, and discusses the results.

A. SIMULATION MODELS

The bulk of the computation performed in the simulation was done in FORTRAN subroutines described as follows:

MLSSUB: Simulation of the environment (via a state-space model with "true"-state, $x(k)$) and the received (envelope) signal vector, $u(k)$; we note here that within a scan the quantity ;
\[ \beta_j = \beta + w_{scj} \]  

is used as a better approximation of the phase difference (rather than simply \( \beta \)) in computing the jth sample, \( u_j \), of the received envelope signal.

**RCVR:** Computation of the estimate, \( \hat{\theta}(k|k) \), of the angular coordinate \( \theta(k) \), given the observations vector, \( u(k) \);

**CONTRL:** Conduct of the simulation run, including performing all I/O operations, special initializations and performance evaluation calculations.

The macro-flow-charts in Figure 3.1 show the organizations of these routines and their interrelations.

The simulation main program, MLSSIM, simply establishes COMMON storages and calls MLSSUB. Subroutine MLSSUB calls a library gaussian pseudorandom number generator function GAUSS and the following two MLS functions, in addition to RCVR and CONTRL:

**PMLS:** The antenna selectivity function, \( P_{MLS}(\theta_e) \), of the MLS transmitting antenna, used in constructing the observations vector \( u(k) \). The following -23 db sidelobe function was used in the study:

\[
P_{MLS}(\theta_e) = \begin{cases} 
\pi/4, & |z| = 1 \\
\cos \frac{\pi}{2} \frac{z}{1 - z^2}, & |z| \neq 1 
\end{cases} \]  

where \( z \triangleq 2.4 \theta_e / R_{MLS} \)  

\[ \theta_e \triangleq \text{angle from beam center} \]  

51
Figure 3.1 Flow Charts for MLSSU, (OPT) RCVR, and CONTRL
THA: The antenna scanning function, $\theta_A(t)$, of the MLS transmitting antenna, used in constructing the vector $u(k)$. The function in (2.124) above was specified in the MLS specifications and used in the study.

The programs MLSSIM, MLSSUB, THA, DFLTR1 (a 1st-order digital filtering subroutine used when the threshold receiver is running) and a BLOCK DATA program, MLS, collectively constituted a software module (or file), denoted MLSSIM. The function PMLS, and BLOCK DATA program PMLSID were put into a separate module, PMLS1, to facilitate changing the $p_{MLS}(\cdot)$ function. The listouts of these and other programs found in Appendix A are grouped into modules.

Two scenarios of subroutine RCVR were used, which are distinguished by module (or file) names suggestive of their natures, as follows:

**OPTRVR**: The optimal structure, comprising the Scan Data Processor and the Tracking Loop; calls subroutine PHILM (which calculates SDP quantities $\Phi, \Lambda$, and is described below) as well as matrix arithmetic subroutines MATSM, MATMUL and MATINV.

**THDRVR**: A design similar to present commercial approaches using thresholding principles [11]. The simulation model, which involved

i) A 3db-below-peak threshold (referred to the linear envelope)

ii) A 300 microsec tracking gate for interference exclusion.
iii) A dwell gate for "loss-of-track"

decisions

iv) Input of the log envelope signal, filtered by a 25 KHz low pass filter.

v) Error filtered with a 10 r/s bandwidth low pass filter for evaluation,

was developed to provide baseline data for performance comparisons. See the references [11], [4, pp. 25,26] and the program in Appendix A for further details. The program calls subroutine DFLTR1 to provide the 25 KHz filtering.

Two versions of PHILM were used, distinguished by module names, as follows:

**PLOPT:** The Scan Data Processor calculations of \( \Phi, \Lambda \) for the Optimal design. This uses function THA, (2.124) above, and functions \( P \) and \( PDOT \) given below. We note here that in the calculation of matrix \( D \) in PLOPT, analogous to (3.7a), the quantity

\[
\hat{\beta}_j = \hat{\beta} + \hat{\omega}_{sc} \tau_j
\]

was used for \( \hat{\beta} \) in (2.103) in an effort to improve the receiver performance by making use of the \( \hat{\omega}_{sc} \) information at this point.

**PLSUB:** The SDP calculations of \( \Phi, \Lambda \) for the Suboptimal design. This calls the same functions THA, \( P \), \( PDOT \) used by PLOPT, preceding, but also calls subroutines WAWBJ (which calculated "on-line" conditional averages
\( w_A(u, \gamma) \) and \( w_B(u, \gamma) \) using (2.194), (2.195) and succeeding equations) and subroutine SWFCNS (which did the table look-up and necessary interpolation to produce the values \( s_{wA_j}, s_{wB_j} \) and \( R_{AB_j} \) (2.208), (2.209) and (2.210) respectively needed to calculate matrix \( \Phi \) via (2.207). See the program in Appendix A for further details.

The functions \( P, PDOT \) constitute the module POPT1 and are used by both versions of PHILM. They are described as follows:

**P:**

The antenna selectively function \( p(\theta_e) \) assumed in the receiver design to be in effect in the received signal vector \( u(k) \). The following -23 dB sidelobe function was used in the study:

\[
p(\theta_e) = \begin{cases} 
\pi/4, & |z| = 1 \\
\cos \frac{\pi}{2} \frac{z}{1 - z^2}, & |z| \neq 1 
\end{cases}
\]

(3.11)

where

\[
z \triangleq 2.4 \frac{\theta_e}{B_{RCVR}}
\]

(3.12)

\[
\theta_e \triangleq \text{angle from beam center}
\]

(3.13)

This is the same function as \( p_{MLS}(\theta_e), (3.8) \), but it was programmed twice with distinct names to allow different functions to be used (alternate function were not studied, however). Figure 3.2 shows the function \( p(\cdot), (3.11) \) above, centered in the same 65-sample window on the same sampling grid (FSAMP = 160 kHz, OMEGA = 20,000 Deg./sec.) as in the receiver.
Figure 3.2 Antenna Selectivity function, \( p(\theta) \), used
PDOT: The function \( \frac{dp(\Theta_e)}{d\Theta_e} \). On the basis of (3.11) thru (3.13) the following was used:

\[
\begin{align*}
\frac{dp(\Theta_e)}{d\Theta_e} &= \begin{cases} \\
\frac{-0.3\pi}{B_{RCVR}} \text{signum} (z), |z| = 1 \\
\frac{0.3\pi^2}{B_{RVCR}} \left( \frac{\cos(z+1)\pi/2 - \sin(z+1)\pi/2}{(z+1)\pi/2} + \frac{\cos(z-1)\pi/2 - \sin(z-1)\pi/2}{(z-1)\pi/2} \right), |z| \neq 1 \end{cases}
\end{align*}
\]

Several versions of subroutine CONTRL, distinguished by module names, as follows, were used, conducting the simulation through various types of scenarios and test runs:

**CTLACQN:** An interference acquisition scenario, testing the "pull-in" power of the interference tracking algorithm. Initially no interference is present and the interference tracker states are tethered to "idler" values, as follows:

\[
\begin{align*}
\hat{\phi}_R^0 &= 0.5 \hat{\theta} \\
\hat{\theta}_R^0 &= \hat{\theta} - 1.5 \text{ degrees} \\
\hat{\dot{\theta}}_R^0 &= 0 \text{ degrees/second} \\
\beta_o &= \pi/2 \text{ radians} \\
\hat{\omega}_s^0 &= 0 \text{ radians/second}
\end{align*}
\]

A step of interference then occurs with prescribed parameter values, the interference tracker is untethered and the estimate error-time-histories are generated.
CTLCRMP: A crossing multipath scenario, testing the tracking abilities of a receiver design from an out-of-beam interference condition, thru a crossing in-beam condition to an out-of-beam situation again under prescribed conditions; error-time-histories are generated.

CTLMSTH: An RMS error versus $\theta_{sep}$ study in which, by a suitable nonzero assignment of $w_{sc}$, the effects of $\beta$ are approximately averaged out as the statistical sample of desired size, 100 scans, evolves. 110 scans are calculated and the first 10 discarded in computing error statistics for each value of $\theta_{sep}$. The program increments $\theta_{sep}$ and repeats the calculation for up to 13 values of $\theta_{sep}$.

CTLOGE: Another, more expensive, RMS error versus $\theta_{sep}$ study in which for each value of $\theta_{sep}$ $\beta$ is stepped through 20 values uniformly spaced on the $(-\pi,\pi)$ interval and, for each value of $\beta$, 30 scans are generated, the first 10 being discarded and the latter 20 being used in the statistical calculations.

CTLMSSBB: An RMS error versus $B_{ratio}$ study, where

$$B_{ratio} = B_{RCVR}/B_{MLS}$$

(3.20)

The study is performed in a manner similar to that in CTLMSTH above, including the use of nonzero $w_{sc}$.
7 values of $B_{ \text{ratio}}$ were used in the range

$$10^{-k} \leq B_{ \text{ratio}} \leq (10)^{\frac{1}{2}}$$

with

$$B_{ \text{RCVR}} = 1^\circ \quad \text{when } B_{ \text{ratio}} < 1$$

$$B_{ \text{MLS}} > 1^\circ \quad \text{when } B_{ \text{ratio}} > 1$$

(3.21)

(3.22)

(3.23)

CTLMSFS: An RMS Error versus $F_{sc}$ study. This study is also performed in a manner similar to that in CTLMSTH above, except that $w_{sc}$ is assigned higher and higher integer multiples of the minimum value (0.135 Hz in AZIMUTH) which would integrate $\theta$ over a $2\pi$ interval during a 100-scan time period.

Block data programs were included in many modules to initialize COMMON storages. A library of general math and utility programs was also used and is included in the program listings in Appendix A.

All simulation runs were made with Azimuth angle function data, though the option for elevation simulation was included in the programs.

Parameter values written in storages are, as follows:

$$\begin{array}{ccc}
\theta_{A_{\text{max}}} &=& \frac{\text{AZ}}{62.66666^\circ} \\
\theta_{A_{\text{min}}} &=& -62.0^\circ \\
T_{S} &=& 6.233333 \text{ ms} \\
T_{R} &=& 6.6 \text{ ms} \\
\text{Rep. Rate} = 1/T &=& 13.5 \text{ Hz}
\end{array}$$

$$\begin{array}{ccc}
\text{EL} &=& \frac{30.66666^\circ}{}
\theta_{A_{\text{min}}} &=& 0.0^\circ \\
T_{S} &=& 1.533333 \text{ ms} \\
T_{R} &=& 0.4 \text{ ms} \\
\text{Rep. Rate} = 1/T &=& 40.5 \text{ Hz}
\end{array}$$

(3.24)

(3.25)

(3.26)

(3.27)

(3.28)
Except as noted above for Bratio studies, values assigned $B_{\text{MLS}}$ and $B_{\text{RCVR}}$ were, as follows:

$$B_{\text{MLS}} = B_{\text{RCVR}} = 1^\circ \quad (3.29)$$

Specification of the intensity of the interference was made using the parameter $\rho$ defined in (3.3). As indicated above in connection with Figure 3.2, 65 samples were taken in each semiscan, i.e.

$$J = 130 \quad (3.30)$$

at the sampling rate

$$F_{\text{samp}} = 160 \text{ KHz} \quad (3.31)$$

with the 33rd and 98th samples occurring where the peaks of the direct path pulses were expected, based on $\hat{\theta}(k|k-1)$.

Estimation error was calculated in the expected manner, i.e. $x-x$, except for components associated with $\beta$, $\hat{\omega}_{\text{sc}}$ (and $\hat{\omega}_{\text{sc}}$ in the 6D LOE model). In these components, the differences in absolute values, e.g. $|\beta| - |\hat{\beta}|$, were used for error evaluation to accommodate the ambiguity in these variables.

B. SIMULATION RUNS AND RESULTS

The results of nearly 50 runs are reported here in 23 plots and 23 tables. Table 3.1 summarizes the runs made—by type of run and CONTRL module, parameter values used, RCVR type used and figure numbers and table numbers in which the results appear. [In these discussions "OPTRVR" implies the use of modules OPTRVR and PLOPT (an abuse of terminology, perhaps), "SUBOPT" implies the use of modules OPTRVR and PLSUB.]

Figure 3.3 shows the computed RMS error ($\theta$ component) versus $\theta_{\text{sep}}$ for several S/N values for the OPTRVR, $\rho=0.8$. Figure 3.4 presents the
Table 3.1 Summary of Simulation Runs

<table>
<thead>
<tr>
<th>FIGURE NO.</th>
<th>SUB-Figure</th>
<th>OTHERS</th>
<th>NOTES</th>
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**Notes:**
- Table continues with similar columns for each figure number.
- Each column represents different data related to the simulation runs.
Figure 3.3 RMSE ($\theta_{\text{sep}}$), OPTRVR, $p=0.8$
Figure 3.4 RMSE (θ_{sep}), OPTRVR, ρ=0.5
same type of data for \( \rho = 0.5 \). The scatter in the points for the lower S/N cases is due to noise; the apparent odd symmetry in the scatter about the origin is due to several causes:

i. The lack of symmetry between the TO, FRO scans wrt the noise samples;

ii. The effect of noise on the \( \beta \)-estimate (in one run, not included here, \( \hat{\beta} \) was tethered to the true value \( \beta \) and the calculated RMSE \( (\theta_{\text{sep}})_{(\theta \text{-component})} \) exhibited more nearly the expected even symmetry wrt \( \theta_{\text{sep}} \).

iii. The use of the same noise sample function for each data point.

Figures 3.5 thru 3.7 show comparisons of RMSE \( (\theta_{\text{sep}}) \) for the receivers for various values of S/N and \( \rho \). Figure 3.6, for example, shows that with S/N=20 db, \( \rho = 0.8 \), the optimal design offers improvement by a factor up to about 30 over the threshold receiver. The suboptimal design, without tracking phase difference, shows improvement by a factor up to about 15 over the threshold receiver. The non-adaptive design, basically of optimal structure, but premised on interference-free reception, shows approximately equivalent performance as the threshold receiver.

Tables 3.2 thru 3.12 give the full results of the OPTVR and SUBOPT simulation runs associated with Figures 3.3 thru 3.7 -- error statistics for each coordinate of the state estimate as a function of \( \theta_{\text{sep}} \). One observation that can be made from this data is that the mean error at small separation angles becomes a more significant contributor to the RMSE as the S/N diminishes. This probably signals a diminishing validity of the LOE criterion (error being in a neighborhood of zero), due
NOTE: 1) Aborts are shown for each test data point when the threshold receiver aborts. It outputs the last good estimate.
NOTE: % Aborts are shown for each THDVR data point. When the Threshold receiver aborts, it outputs the last good estimate.

Figure 3.6 RMSE ($\theta_{sep}$), comparison of receivers, $S/N=20$ dB, $r=0.8$
NOTE: % Aborts are shown for each THDRVR data point. When the Threshold receiver aborts, it outputs the last good estimate.

Figure 3.7 RMSE (θ_{sep}), comparison of receivers
S/N = 20db, ρ=0.5
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| ERMS: | -0.375 | -4.12 | -8.46E-02 | -2.36E-01 | 4.15 | -1.13E-01 | -2.95E-01 | -6.78E-01 | -4.38 |
| -0.125 | 12.7 | -9.98E-02 | -2.09E-01 | 15.0 | -2.09E-01 | -2.69E-01 | -2.16E-02 | -8.75 |
| 1.25 | 10.9 | -9.56E-02 | -2.68E-01 | 13.9 | -1.86E-01 | -2.69E-02 | -1.61E-02 | -6.18 |
| 1.375 | 3.67 | -7.93E-02 | -2.37E-01 | 3.87 | -1.05E-01 | -2.44E-01 | -1.45E-01 | -2.38 |
| 1.625 | 1.19 | -5.02E-02 | -2.23E-01 | 3.18 | -6.38E-02 | -2.12E-01 | -4.07E-01 | -3.49 |
| 675 | -4.81 | -2.76E-02 | -1.72E-01 | -4.56 | -3.58E-02 | -1.93E-01 | -2.24E-01 | -2.41 |
| 1.13 | -2.247 | -1.88E-02 | -1.52E-01 | -2.32 | -2.33E-02 | -1.67E-01 | -2.51E-01 | -2.59 |
| 1.38 | -1.03 | -1.54E-02 | -1.04E-01 | -2.64 | -1.16E-02 | -1.54E-01 | -5.23E-01 | -2.49 |
| 1.63 | -1.61 | -1.72E-02 | -1.42E-01 | -1.67 | -1.62E-02 | -1.57E-01 | -3.13E-01 | -3.57 |
| 1.88 | -1.61 | -1.25E-02 | -1.37E-01 | -1.77 | -1.45E-02 | -1.52E-01 | -3.91E-01 | -4.74 |

| LSSTD: | -0.375 | 3.87 | -7.96E-02 | -2.36E-01 | 4.01 | -1.10E-01 | -2.94E-01 | -6.22E-01 | -4.35 |
| -0.125 | 12.1 | -9.54E-02 | -2.09E-01 | 8.79 | -1.30E-01 | -2.68E-01 | -1.58 | -825 |
| 1.25 | 10.6 | -9.28E-02 | -2.07E-01 | 11.2 | -1.57E-01 | -2.80E-01 | -1.71 | -873 |
| 1.375 | 3.63 | -7.80E-02 | -2.37E-01 | 3.13 | -6.40E-02 | -2.43E-01 | -4.43E-01 | -437 |
| 1.625 | 1.19 | -5.02E-02 | -2.23E-01 | 0.10 | -5.04E-02 | -2.12E-01 | -3.62E-01 | -4.86 |
| 675 | -4.81 | -2.76E-02 | -1.72E-01 | -4.56 | -3.58E-02 | -1.93E-01 | -2.24E-01 | -2.41 |
| 1.13 | -2.247 | -1.88E-02 | -1.52E-01 | -2.32 | -2.33E-02 | -1.67E-01 | -2.51E-01 | -2.59 |
| 1.38 | -1.03 | -1.54E-02 | -1.04E-01 | -2.64 | -1.16E-02 | -1.54E-01 | -5.23E-01 | -2.49 |
| 1.63 | -1.61 | -1.72E-02 | -1.42E-01 | -1.67 | -1.62E-02 | -1.57E-01 | -3.13E-01 | -3.57 |
| 1.88 | -1.61 | -1.25E-02 | -1.37E-01 | -1.77 | -1.45E-02 | -1.52E-01 | -3.91E-01 | -4.73 |

Table 3.2 Error Statistics vs \( \theta_{sen} \), OPTRVR, S/N=40db, \( \rho=0.8 \)
Table 3.3 Error Statistics vs $\theta_{sep}$, OPTVR, S/N=40db, $\rho=0.5$
<table>
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<th>THESEP</th>
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Table 3.8 Error Statistics vs $\theta_{sep}$, OPRTRVR, S/N=14 db, $\rho=0.8$
Table 3.9 Error Statistics vs $\theta_{sep}$, OPTRVR, S/N=14db, $\rho=0.5$

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Table 3.10 Error Statistics vs $\theta_{sep}$, SUBOPT, S/N=30db, $\rho=0.8$
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| | .375 | 4.29 | .248 | .149 | 2.94 | .188 | .178 |
| | .625 | 2.43 | .128 | .114 | 2.89 | .249 | .106 |
| | .875 | .920 | .791E-01 | .666E-01 | 1.00 | .116 | .662E-01 |
| | 1.13 | .349 | .416E-01 | .391E-01 | .356 | .623E-01 | .605E-01 |
| | 1.38 | .178 | .202E-01 | .305E-01 | .195 | .273E-01 | .369E-01 |
| | 1.63 | .174 | .168E-01 | .267E-01 | .213 | .143E-01 | .318E-01 |
| | 1.88 | .171 | .121E-01 | .253E-01 | .203 | .171E-01 | .269E-01 |

| ESTD: | -.375 | .679 | .117 | .165 | 3.43 | .197 | .164 |
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| | .375 | 5.18 | .123 | .149 | 2.94 | .182 | .163 |
| | .625 | 2.42 | .127 | .110 | .661 | .879E-01 | .985E-01 |
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| | 1.63 | .171 | .107E-01 | .267E-01 | .211 | .141E-01 | .318E-01 |
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Table 3.11 Error Statistics vs $\theta_{sep}$, SUBOPT, S/N=20db, $\rho=0.8$
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Table 3.12 Error Statistics vs \( \theta_{\text{sep}} \), SUBOPT, S/N=20db, \( \rho=0.5 \)
in part to the relatively large value of GQQT (8.8) used, \( \frac{z(2.7r/s)^2}{\text{in AZ}} \). This value was selected to facilitate tracking a varying \( \omega_{sc} \) under the condition that it is changing at the maximum rate at which it can be tracked in the present structure, based on angle function rep. rate considerations (recall (3.135)) (i.e. without extracting its derivative and integrating (as in the 6D LOE design)). This was a practical consideration that penalized some the performance in the steady state (when \( \omega_{sc} \) was not changing).

Figure 3.8 summarizes a study of the SUBOPT receiver; it shows that

1. In the worst cast wrt \( \beta \), i.e. \( \beta=180^\circ \), the constraints on the estimate helped for small \( \theta_{sep} \) and did not influence the performance for larger \( \theta_{sep} \); and that

2. Averaging over noise effects and \( \beta \) simultaneously by using a small non-zero \( \hat{\beta} (=\omega_{sc}) \) to sweep \( \beta \) over a 2\( \pi \) interval seems adequate generally, with some error possibly arising for small \( \theta_{sep} \). This method of averaging over \( \beta \) was used generally.

Figure 3.9 and Tables 3.13 thru 3.16 following show the effects of a form of mismatch between the receiver design and its signal environment, specifically a mismatch in the presumed and actual values of the transmitting antenna beamwidth, (given the antenna selectivity functions, \( p, p_{HLS} \), are otherwise identical). Much can be said about the necessity of tuning a high-performance signal processor to its signal environment, but the manifest RMSE sensitivity here to \( B_{RCVR}/B_{HLS} \) is nevertheless striking. The tables provide some insight, for example
Figure 3.8 RMSE ($\theta_{sep}$), SUBOPT, effects of $\beta$ averaging and constraints, $S/N=20\text{db}$
$\rho=0.8$
Figure 3.9 RMSE (B_{RCVR}/B_{MLS}), OPTRVR, $\theta_{sep} = 1.5^\circ$
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Table 3.13 Error Statistics vs B ratio, OPTRVR, S/N=20db, r=0.8, $\theta_{sep}=1.5^\circ$
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Table 3.14 Error Statistics vs $B_{ratio}$, OPRTR, S/N=30db, $\rho=0.8$, $\theta_{sep}=1.5^\circ$
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Table 3.15 Error Statistics vs Bratio, OPTRVR, S/N=30db, ρ=0.5, θsep=1.5°
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Table 3.16  Error Statistics vs B\text{ratio}, OPRTRVR, S/N=20db, p=0.5, \theta_{sep}=1.5^\circ
1. An estimation of $\alpha$ and $\alpha_R$ by integration of the signal, such as in done here, may be especially vulnerable to uncertainties in other parameters that affect signal energy, such as beam width; and

2. The errors in the $\theta$ and $\theta_R$ components are heavily biased, when $\beta_{ratio} \neq 1$, indicating loss of LOE validity, specifically with decoupling of estimates of errors.

Perhaps peak detection, maybe in conjunction with an integration approach, would provide more robust estimates of $\alpha$ and $\alpha_R$. Smaller errors in the $\theta$ and $\theta_R$ components should then result, but the residual errors might be reduced further by having the nominal beam width at each air terminal coded and transmitted in the MLS preamble. Additional robustness and possibly some simplification advantages might result from use in the receiver of a $p(\cdot)$ function which doesn't model exactly any particular transmitting antenna selectivity function but does produce a best fit in some sense over the class of transmitting antenna selectivity functions to which the receiver is exposed. This is a problem area that needs further study.

Figure 3.10 presents an RMSE ($F_{sc}$) study for scalloping rates in the first lobe of the rep. rate sampled signal spectrum, i.e.

$$F_{sc} < \frac{13.5}{2} \ Hz = 6.75 \ Hz$$

(3.32)

All the values of $F_{sc}$ for which the RMSE was calculated, except 0.0 Hz, cause $\beta$ to integrate an integral number of times around a $2\pi$ interval as the run progresses hence the results should be independent of the initial $\beta$. The RMSE value at 0.0 Hz is probably dependent upon the
Figure 3.10 RMSE ($F_{sc}$), OPTVR,
1st Lobe, S/N=30db,
$p=0.8$, $\theta_{sep}=1.5^\circ$
value of $\beta$, $0^\circ$, during the run. Table 3.17 shows all computed statistics of all error components for this simulation run.

Figure 3.11 and the associated Tables 3.18 thru 3.23 present the results of several statistical error studies versus $F_{sc}$ with the latter ranging on the fifth lobe of the rep. rate sampled signal spectrum, i.e.

$$47.25 \leq F_{sc} \leq 60.75 \text{ Hz.} \quad (3.23)$$

These studies indicate

1. The OPTRVR without constraints is definitely superior to the same receiver with constraints (Tables 3.18 and 3.19).
2. The SUBOPT performance is the same with and without constraints (Tables 3.20 and 3.21).
3. The OPTRVR with tethered estimates $\beta, \hat{w}_{sc}$ as shown performs the same with and without constraints (Tables 3.22 and 3.23).
4. Items (2) and (3) above suggest it is the constraint on $\hat{w}_{sc}$ only that degrades the OPTRVR performance referenced in item (1) above.

Relaxing the constraint on $\hat{w}_{sc}$ in OPTRVR may be beneficial here without harming the performance for low $F_{sc}$ cases, but there is no certainty of that without more tests. The benefits of the constraints generally were established in Figure 3.8 but that involved the SUBOPT receiver where there was no $w_{sc}$ estimate. Clearly, relaxing the $\hat{w}_{sc}$ constraint in the OPTRVR will not in any sense enable tracking of $w_{sc}$ above half the rep. rate, since the 5D LOE does not exploit individually (for $w_{sc}$ information) the TO and FRO scan pulses (as the 6D LOE would do). Further study at other values of $S/N, \rho$ and $\theta_{sep}$ are needed here.
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|      | 3.11 | .168  | .334E-02 | .194E-01 | .177  | .412E-02 | .200E-01 | .469E-01 | .781E-01 |
|      | 4.19 | .164  | .327E-02 | .193E-01 | .177  | .417E-02 | .210E-01 | .552E-01 | .792E-01 |
|      | 5.27 | .167  | .337E-02 | .197E-01 | .181  | .414E-02 | .207E-01 | .523E-01 | .813E-01 |
|      | 6.35 | .165  | .310E-02 | .192E-01 | .171  | .403E-02 | .196E-01 | .500E-01 | .797E-01 |
|      | 6.75 | .169  | .315E-02 | .195E-01 | .180  | .366E-02 | .189E-01 | .103  | 1.09E-01 |

| ESTDF | 0   | .167  | .377E-02 | .210E-01 | .179  | .423E-02 | .207E-01 | .105  | .873E-01 |
|       | 1.49 | .161  | .357E-02 | .203E-01 | .174  | .409E-02 | .195E-01 | .572E-01 | .834E-01 |
|       | 3.11 | .168  | .333E-02 | .194E-01 | .177  | .399E-02 | .200E-01 | .451E-01 | .781E-01 |
|       | 5.27 | .166  | .336E-02 | .197E-01 | .181  | .410E-02 | .207E-01 | .490E-01 | .613E-01 |
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|       | 6.79 | .159  | .315E-02 | .199E-01 | .180  | .363E-02 | .189E-01 | .105  | .713E-01 |

Table 3.17 Error Statistics vs F, OPTRVR, 1st Lobe S/N=30db, ρ=0.8, θ =1.5°
Figure 3.11 RMSE ($F_{sc}$), comparison of receivers and effects of constraints, 5th lobe, $S/N=30$db, $p=0.8$, $\theta_{sep}=1.5^\circ$
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Table 3.21 Error Statistics vs F, SUBOPT, 5th Lobe, S/N=30db, \( \rho=0.8, \theta =1.5^\circ \), WITH CONSTRAINTS
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Table 3.22 Error Statistics vs F_{sc}, OPTRVR, 5th Lobe, ({\hat{\beta}, \omega_{sc}}) tethered to (\pi/2,0)
S/N=30db, \rho=0.8, \theta_{sep}=1.5^\circ, NO CONSTRAINTS
Table 3.23  Error Statistics vs $F_{sc}$, OPTRVR, 5th Lobe, ($\beta, \omega_{sc}$). tethered to ($\pi/2, 0$)  
S/N=30db, $\rho=0.8, \theta=1.5^\circ$, WITH CONSTRAINTS.
Figures 3.12 thru 3.23 present a study of the interference acquisition capabilities of the interference trackers in the OPTRVR and SUBOPT designs. The 4 top traces on each figure are error time histories respectively (from the top) of the $\alpha$, $\theta$, $\alpha_R$ and $\theta_R$ estimate components; the bottom trace shows when the step of interference ($\rho=0.8$) occurs and simultaneously when the interference tracker estimate-vector elements are released from the idler values (equations 3.15 thru 3.19 above). The direct path pulse is being tracked from time zero. All plots have the same time-axis scaling.

Figures 3.11 thru 3.20 for the OPTRVR design (with constraints) show the following:

1. Successful pull-in for small scalloping rates and separation angles as small as the following:
   a. $\theta_{sep} = 0.25^\circ @ S/N = 40$ db (Figure 3.12)
   b. $\theta_{sep} = 0.5^\circ @ S/N = 20$ db (Figure 3.16)
   c. $\theta_{sep} = 1^\circ @ S/N = 14$ db (Figure 3.19)

2. Successful pull-in for small scalloping rates and separation angles probably extending nearly to the window edge ($4^\circ$).

3. Successful pull-in @ $S/N$ 40 db, $\theta_{sep} = 1^\circ$ and $F_{sc}$ in the 5th lobe (Figure 3.20). The exact $F_{sc}$ (51.3 Hz) and initial $\beta$ (-168°) were selected to produce, in the middle of the run, a maximum enhancement of the TO pulse and a maximum cancellation of the FRO pulse.

Figures 3.21 thru 3.23 for the SUBOPT design show the following:

1. Results for $\theta_{sep} = 0.5^\circ$ and $F_{sc} = 0.6$ Hz (low):
Figure 3.12 Interference Acquisition, OPTRVR, S/N=30db, p=0.8,  
θ = 0.25°, β=45°, F = 0.6Hz
Figure 3.13 Interference Acquisition, OPTRVR, S/N=40db, ρ=0.8
θ = 20°, β = 45°, F = 0.6Hz

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Figure 3.14 Interference Acquisition, Optrvrr, S/N=40db, p=0.8

\[ \theta = 30°, \beta = 45°, F_s = 0.6 \text{Hz} \]
Figure 3.15  Interference Acquisition, OPTRVR, $S/N=40\text{db}$, $\rho=0.8$, $\theta_{sep}=2^\circ$, $\beta=45^\circ$, $F_{sc}=2.5\text{Hz}$
Figure 3.16 Interference Acquisition, OPTRVR, S/N=20db, p=0.8, $\theta_{\text{sep}}=0.5^\circ$, $\beta=45^\circ$, $F_{\text{sc}}=0.6\text{Hz}$
Figure 3.17 Interference Acquisition, OPTRVR, S/N=20db, $\phi=0.8$, $\theta_{sep}=3^\circ$, $\beta=45^\circ$, $f_{sc}=0.6$ Hz.
Figure 3.18  Interference Acquisition, Optrvr, S/N=20db, \( \rho=0.8 \), \( \theta_{sep}=0.5^\circ \), \( \beta=45^\circ \), \( f_{sc}=2.5Hz \)
Figure 3.19 Interference Acquisition, OPTRVR, S/N=14db, \( \rho=0.8 \), \( \theta_{\text{sep}}=1^\circ \), \( \beta=45^\circ \), \( f_{\text{sc}}=0.6\text{Hz} \)
Figure 3.20  Interference Acquisition, OPRVR, S/N=40db, \( \rho=0.8 \)

\[ \theta_{sep}=1^\circ, \beta=-168^\circ, F_{sc} = 51.3 \text{Hz} \]
Figure 3.21 Interference Acquisition, SUBOPT, S/N=40db, $\rho=0.8$, $\theta_{sep}=0.5^\circ$, $\beta=45^\circ$, $f_{sc}=0.6$Hz
Figure 3.22 Interference Acquisition, SUBOPT, S/N=20db, $p=0.8$, 
$\theta_{sep} = 0.5^\circ$, $\beta=45^\circ$, $F_{sc} = 0.6$ Hz
Figure 3.23  Interference Acquisition, SUBOPT, S/N = 40 db, $\rho = 0.8$, $\theta = 1^\circ$, $\theta = -168^\circ$, 51.3 Hz
a. $S/N = 40 \text{ db} -- \text{unsuccessful pull-in, in fact loss of track of the direct path pulse (Figure 3.21);}$
b. $S/N = 20 \text{ db} -- \text{successful pull-in (Figure 3.22);}$

2. Successful pull-in @ $S/N = 40 \text{ db, } \theta_{sep} = 1^\circ$ and $F_{sc}$ in the 5th lobe, again maximum enhancement of TO pulse, maximum cancellation of FRO pulse (Figure 3.23).

The poor performance shown in Figure 3.21 is probably attributable to the low scalloping rate, the successful pull-in of Figure 3.22 notwithstanding. The SUBOPT design is essentially premised upon an arbitrarily high scalloping rate, and under these circumstances the results of Figure 3.21 are probably more to be expected than those of Figure 3.22. The successful pull-in of Figures 3.22 is probably only a testament to the beneficial effects of noise acting as dither; or worse, it may be sample function dependent. More study here should be done.

Finally, Figures 3.24 and 3.25 provide comparisons of the three receivers OPTRVR, SUBOPT and the threshold receiver, in a crossing multipath scenario, beginning with the receivers in track and the interference initially out-of-beam. The same noise sample function was used to construct the envelope signal applied to the receiver in each case, and the error time histories are all plotted to the same scale. Two significant differences in the figures, one intentional, one not, are, as follows:

1. In Figure 3.24, the OPTRVR and SUBOPT designs include constraints, in Figure 3.25 these are without constraints.
2. In the two figures that OPTRVR and SUBOPT error time history traces are interposed; in Figures 3.24, that for OPTRVR is on top; in Figure 3.25, that for SUBOPT is on top.
Figure 3.24 Crossing Multipath, Optrvr and Subopt with constraints

S/N=20.0 db, Rho=0.8, Beta=-168.0 Dec, Fsc=51.3 Hz, XM=100 SCANS, BM=1.00, PM=1.0.
Figure 3.25 Crossing Multipath, OPTRVR and SUBOPT without constraints

S/N=20.0 db, rho=0.8, beta=-168°, F_sc = 51.3 Hz
Another very significant difference is in the OPTRVR error time histories themselves -- that without constraints peaks at about 1/50°, and that with constraints, at about 1/4°, worse than the SUBOPT response, which peaks at about 1/20° with and without constraints. Again, we suspect the \( \hat{w} \) constraint for the deterioration of the OPTRVR performance. Nevertheless, all optimal structure receivers performed better in this demonstration than did the threshold receiver, which peaked at 0.71°. The lowest trace shows the carrier signal-to-noise ratio CSNR, evaluated at the peak of the direct path pulse on the TO-scan, as the simulation evolves. The \( F_{sc} \) used here is in the 5th lobe, the exact \( \beta, \ F_{sc}, \) values used being again that combination producing maximum enhancement of the TO-pulse and maximum cancellation of the FRO-pulse at crossover.

In summary, a simulation study involving principally statistical error studies but also some error time histories has been carried out; a substantial collection of FORTRAN programs was developed. Simulation results show for the OPTRVR design:

1. RMSE performance improvement factors wrt the threshold receiver sometimes approaching 30 at 20 db S/N;
2. Full track capability limited to scalloping rates below 1/4 of rep. rate (below 6.75 Hz in AZ).
3. Some deterioration in performance when constraints are used believed attributable to the \( \hat{w} \) constraint. Removal of this one constraint may restore the generally higher RMSE performance of the unconstrained OPTRVR without reducing the resistance to loss of track apparently characterizing the constrained receiver (see SUBOPT below). Also perhaps a depend-
able angle-tracking capability at higher scalloping rates might result from removal of the $\hat{\omega}_\text{sc}$-constraint.

The results show for the SUBOPT design

1. Lesser performance than the OPTRVR design, improvement factors wrt the threshold receiver sometimes approaching 15 at 20 db S/N;
2. Performance probably better at higher scalloping rates, deteriorating at lower rates;
3. Very definite improvement in track-holding ability at small separation angles when the receiver constraints are applied.

There is no $\omega_\text{sc}$-estimate, hence no $\hat{\omega}_\text{sc}$-constraint in the SUBOPT design.

Based on studies of the OPTRVR, we expect both the OPTRVR and SUBOPT design performance to be quite sensitive to error, in the receiver model, of the transmitting antenna selectivity function, particularly the beam width parameter. Possible approaches to reduce the effects on performance were discussed. Finally, in error time history studies

1. Strong interference pull-in capabilities at various S/N's and $F_{\text{sc}}$'s were demonstrated, which might be used in an interference acquisition scheme; and
2. A high performance in a representative crossing multipath situation was demonstrated, and is to be generally expected, particularly if the removal of the $\hat{\omega}_\text{sc}$-constraint will have the effects expected and discussed.
SECTION IV

EXPERIMENTAL SYSTEM CONSIDERATIONS

An experimental receiver development project was included in the original research proposal and begun in 1976 in parallel with tracking algorithm development then in progress. The project was short-lived, however, and abandoned the following year, principally because the computational demands of the evolving tracking algorithms simply could not be met with any economically feasible microcomputer that was available at the time. The general design philosophy and the allocation of tasks among

1. the interface hardware
2. the foreground software
3. the background software

were described in [3, pp. 52-60]; the approach to the interface design, involving specifically a state controller, is conveyed in Appendix B of this final report.

At the present time, both the MLS tracking algorithm development and the state-of-the-art in microcomputing are more advanced. It seems safe to conjecture, in conclusion, that one way the requisite computer power might be obtained economically, certainly in the near future, is to make use of a bank, or an array, of now diminishingly expensive microprocessors. One or more microprocessors might serve the executive function, allocating the resources provided by the others to the various computational needs as they arise. Advantages of such an arrangement might be, as follows:
1. It would be able to exploit the large potential for parallel computation in the tracking receiver calculations;

2. It would have high protection against total system failure due to isolated failures;

3. It would easily accommodate the randomized repetition rates in the MLS.
SECTION V

SUMMARY AND CONCLUSIONS

This report has described research performed at the University and concerned with optimal MLS receiver theory, design and simulation evaluation. The program has produced a general receiver structure which, it is believed, gives close to limiting performance; it consists of a Scan Data Processor (SDP) based on the theory of Locally Optimum Estimation enclosed in a Tracking Loop Filter (TLF) based on MMSE recursive state estimation. Three concrete specializations of the general structure were carried out, characterized by both the dimension of the Scan Data Processor and the method of extraction of phase difference ($\beta$) and scalloping frequency ($\omega_{sc}$) information, as follows:

5D SDP: Denoted the Optimal design (OPTRVR); SDP extracts $\beta$ information from each scan; TLF extracts $\omega_{sc}$ information from the sequence of scans;

4D SDP: Denoted the Suboptimal design (SUBOPT); Both $\beta$ and $\omega_{sc}$ are suppressed from the model and not estimated;

6D SDP: Denoted the 6D LOE design; SDP extracts $\beta$ and $\omega_{sc}$ information from each scan; TLF may optionally extract $\omega_{sc}$ information.

Two of these, the OPTRVR and SUBOPT designs were studied extensively in simulation studies, including:

a. Statistical error studies under various conditions;

b. Studies of interference acquisition capability using "pull-in",

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c. Performance evaluations with "crossing" multipath interference.

and comparisons of performances were made with a simulated "threshold" receiver approximately representative of the Phase III design. Finally, a limited effort to implement an experimental receiver was undertaken, but was aborted with little more result than the tentative approach planned and the insights gained.

In the simulation studies of RMSE the OPTRVR and SUBOPT designs showed improvements over the threshold receiver by factors approaching 30 and 15, respectively, at low scalloping rates. Constraints were imposed on the computed estimates, based largely on natural limitations on the true state values, and as a result, improved ability to maintain track was noted in the SUBOPT design at small separation angles and moderate S/N. At higher values of scalloping rate, $w_{sc}$, the SUBOPT design was superior to the OPTRVR with constraints. The data suggests, however, that the $\hat{w}_{sc}$-constraint in OPTRVR may be hurting performance some, though even with its removal, successful full-state tracking can't be expected in OPTRVR in the strict sense at higher scalloping frequencies. A high sensitivity to error in the receiver model of the MLS transmitting antenna selectivity function, particularly the beam width parameter, was observed in the SUBOPT design (and believed to be characteristic of the OPTRVR design also). Approaches were discussed to reduce this problem. Both the OPTRVR and SUBOPT designs exhibited sufficient multipath "pull-in" capability to merit a "pull-in" approach to interference acquisition. In summary, the receiver designs developed in this research have demonstrated in simulation superior levels of.
performance for MLS receivers. Some areas of consideration need further study, however, to fine-tune the designs to the signal and state dynamics environment and other aspects of the application. On the basis of available data the SUBOPT design appears to be the more appropriate for the MLS aircraft receiver application, where the scalloping rates experienced are generally greater than one-half the MLS angle function repetition rate, and thus beyond the full-track capability of the OPTRVR design.

From the viewpoint of implementation, it would appear that, on the basis of trends in the microprocessor art,

1. Input of the envelope samples to the computer should be made by direct memory access (DMA), and
2. The computer should, perhaps, be a bank of microprocessors performing many operations in parallel (to supply the requisite computing power) and operating as a unified system under an executive function microprocessor.

Finally, an operational receiver should probably be structurally adaptive also with an ability to expand the state vector (by appending a "sentry" tracker channel tethered to "idler" values) as additional interference pulses are recognized and acquired. The "sentry" should move from a position one side of the sampling window to the opposite side and then back on alternate scans to preserve the integrity of the main pulse track. Also when the separation angle for an interference pulse drops below a certain threshold and information needed to distinguish the pulse becomes less available, track of that interference pulse should then be dropped and the state dimension suitably decremented.
REFERENCES


APPENDIX A

COMPUTER PROGRAMS

Programs in this appendix are listed below in the order presented, generally alphabetized by Module name in two groups. Programs within each Module are listed with a brief characterization of the Module.

Programs for the 6D LOE design are given in Appendix C.

SIMULATION PROGRAMS

- CTLACQN3: CONTRL, Interference Acquisition Scenario
- CTLCRMP: CONTRL, Crossing Multipath Scenario
- CTLMSBB1: CONTRL, RMSE (\(B_{ratio}\))
- CTLMSFS1: CONTRL, RMSE (\(F_{sc}\))
- CTLMSFS2: CONTRL, RMSE (\(F_{sc}\), \((\hat{\beta}, \hat{\omega}_{sc})\) tethered to (\(\pi/2, 0\))
- CTLMSFH2: CONTRL, RMSE (\(\theta_{sep}\)), averaging with \(F_{sc} \neq 0\)
- CTLLOE: CONTRL, RMSE (\(\theta_{sep}\)), averaging with \(F_{sc} = 0\)
- MLSSIM: MLSSIM, MLSSUB, THA, DFLTR1, MLS
- OPTRNC: RCVR, ORVRID, No constraints, except on \(\beta\)
- OPTRVR: RCVR, ORVRID, with constraints
- PLSUB: PHILM, WAWBJ, SWFCNS, PLUSID, Suboptimal SDP
- PLOPT: PHILM, PLOPID, Optimal SDP
- PMLS1: PMLS, PMLSID, p-function used in generating signal
- POPT1: P, PDOT, POPTID, p-function presumed in receiver
- THDRVR: RCVR, TRVRID, threshold receiver

UTILITY AND SERVICE PROGRAMS

- ACQMPI: ACQMPI, Acquisition plot generator
- LABLIB: CLIP, GAUSS, INTIO, LOGIO, MATIN, MATMUL, MATOUT, MATSM, MULPLT, PLOTR, PVALUE, REALTO, RETURN, SATU, library of utility routines
- PCRMPI: PCRMPI, Crossing multipath plot generator
- RLOGSW: RLOGSW, Reads and lists out SWAJ, SWBJ, & RABJ data from file
- WLOGSW: WLOGSW, WAWB, WAVGS, computes SWAJ, SWBJ, & RABJ data and writes files
SUBROUTINE CONTRL(ISW)
C THIS CONDUCTS THE MLS SIMULATION THROUGH A 
C CROSSING MULTIPATH SCENARIO
C
REAL LAMDA
INTEGER XNAME(2),YNAME(2),DATIN(4),DATOUT(4)
INTEGER YNAME(2),YNAME(2),YNAM3(2),YNAM5(2),FUNCTN(2)
LOGICAL NKLNM,NLOE,NGAC,KALKA,JDEG,TETHD,HORE,NFIRST,ADAPTV
LOGICAL FOUTL,FILEIN
COMMON/DDATA/I51,PLS,IRCVE,IAADT,ITETHD,IPDPT
COMMON/RCVR0/THRAY,THAMIN,T5,T1,THMRA,TF
COMMON/RCVR1/NGMAX,NGMIN,DEL,NGM,IR,IAE
COMMON/RCVR02/RKORAX,DTHD,TDRO,SD,WSCD,NGO(4),NGO(4)
COMMON/RCVR03/FL25(4),FL25(4),FL25(4),FL25(4)
COMMON/RCVR04/DLT,ET1(8),G(T8),HI(8),SCH,LS,LS,HG,
COMMON/RCVR05/HOLDK,NDKLNM,NDLC,NAME(2),NAME(2),NAME(2)
COMMON/RCVR06/P001(8),P001(8),P001(8),P001(8),P001(8)
COMMON/RCVR07/IN130,VI30
COMMON/RCVR08/XS1,8),XS(8)
COMMON/RCVR09/XS1,8),XS(8)
COMMON/RCVR10/XS1,8),XS(8)
COMMON/RCVR11/XS1,8),XS(8)
COMMON/RCVR12/XS1,8),XS(8)
COMMON/RCVR13/XS1,8),XS(8)
COMMON/RCVR14/XS1,8),XS(8)
DATA ABORT/1,1,1/ ,NFIRST/.FALSE./,ADAPTV/.TRUE./
DATA DMTIN/1000,200,300,400,500,600,700,800,900,1000,1100,1200/ISW
DATA XNAME/8H SCAN *8H NUMBER
DATA YNAME/8H ETHER *8H DEGREE
DATA DATOUT/1000,200,300,400,500,600,700,800,900,1000,1100,1200/ISW
GO TO (100,200,300,400,500,600,700,800,900,1000,1100,1200,ISW)}
CONTINUE

C THIS IDENTIFIES THE SCENARIO AND REINITIALIZES, AS NEEDED.
C THE FOLLOWING RECEIVER PARAMETERS
C SIGMA, LAC, O6H, RHO, FSC, TETA, JHC, HML
1: (N FIRST) GO TO 155
   NOAC = .FALSE.,
   N FIRST = .TRUE.,
   JOBNAM = JOBNAM(I),
   ISIN  = 5,
   INGO = 3
   WRITE (7,110)
110 FORMAT (4X,'INTERFERENCE ACQUISITION SCENARIO/)
   IF (INCRV .NE. 1) GO TO 116
   WRITE (7,115)
115 FORMAT (35X,'THIS IS NOT FOR THRESHOLD RECEIVER')
   STOP ! ABDATED--NOT FOR THRVR.
116 CONTINUE
   WRITE (7,120)', (DATIN(I), I=1,2)
120 FORMAT (26H THIS MAY READ INPUT FILE, 2A10/)
   CALL LOGIO(INFILE, FILEIN, 0)
   IF (.NOT. FILEIN) NSTART = 0
   CALL INTIO(HFILEIN, HSTART, 100, 0)
   NSTUP = NSTART
   CALL INTIO(HFILEOUT, HSTOP, 0, 1)
   CALL LOGIO(HFILEOUT, 0, 0)
   IF (NADAPT) GO TO 135
   INSIG = 1
   LADAP = 3
135 CONTINUE
   IF (.NOT. FILEIN) NRUN = 1
   DO 146 I = 1, 6
      IASC = (I-1)*IO(NR(1)) + 1
      IDENT(I) = 10*A(IASC)
145 CONTINUE
   ENCODE(8, 150, IDENT(I), MOD)
150 FORMAT (7X, 14X, 'IDENT', I5, 1X, 'MOD')
   WRITE (7,152)', (IDRIS(I), I=1,MOD)
152 FORMAT (7X, 14X, 'IDRIS', I5, 1X, 'MOD')
   WRITE (7,153)', (IDENT(I), I=1,MOD)
153 FORMAT (7X, 14X, 'IDENT', I5, 1X, 'MOD')
   CALL REALIO (6H RMAX, 0, 0, 0)
   CALL REALIO (6H RMIN, 0, 0, MOD)
   CALL REALIO (6H THETA, 0, 0, MOD)
   BETA0 = 180.*PI
   FSCO = WSC0**2./PI
   CALL REALIO (6H TETAR, 0, 0, MOD)
105 CALL REALIO (6H BETAR, BETA0, 0, MOD)
   CALL REALIO (6H FSCO, FSCO0, 0)
   BETA + BETA0/180.,
   WSC0 = FSCO*2.*PI
   CONTINUE
155 CALL REALIO (6H O6H, 0, 0, MOD)
   CALL REALIO (6H TGO, TGO, 0, MOD)
   BETA0 = 180.*PI
   FSCO = WSC0**2.*PI
   CALL REALIO (6H TETAR, 0, 0, MOD)
105 CALL REALIO (6H TETAR, BETA0, 0, MOD)
   CALL REALIO (6H FSCO, FSCO0, 0)
   BETA + BETA0/180.,
   WSC0 = FSCO*2.*PI
   CONTINUE
155 CALL REALIO (6H RMIN, 0, 0, MOD)
   CALL REALIO (6H RMAX, 0, 0, MOD)
   CALL REALIO (6H O6H, 0, 0, MOD)
   CALL REALIO (6H TGO, TGO, 0, MOD)
   BETA0 = 180.*PI
   FSCO = WSC0**2.*PI
   CALL REALIO (6H TETAR, 0, 0, MOD)
105 CALL REALIO (6H TETAR, BETA0, 0, MOD)
   CALL REALIO (6H FSCO, FSCO0, 0)
   BETA + BETA0/180.,
   WSC0 = FSCO*2.*PI
   CONTINUE
155 CALL REALIO (6H RMIN, 0, 0, MOD)
   CALL REALIO (6H RMAX, 0, 0, MOD)
   CALL REALIO (6H O6H, 0, 0, MOD)
   CALL REALIO (6H TGO, TGO, 0, MOD)
   BETA0 = 180.*PI
   FSCO = WSC0**2.*PI
   CALL REALIO (6H TETAR, 0, 0, MOD)
105 CALL REALIO (6H TETAR, BETA0, 0, MOD)
   CALL REALIO (6H FSCO, FSCO0, 0)
   BETA + BETA0/180.,
   WSC0 = FSCO*2.*PI
   CONTINUE
155 CALL REALIO (6H RMIN, 0, 0, MOD)
   CALL REALIO (6H RMAX, 0, 0, MOD)
   CALL REALIO (6H O6H, 0, 0, MOD)
SUBROUTINE CONTRL

CALL INIDIO(6H NRUN, NRUN, 100, 0)
CALL REALIDIO(6H NRUN, NRUN, 100, 0)
CALL REALIO(6H NRUN, NRUN, 0, 0)
CALL REALIO(6H BRCVR, BRCVR, 0, 0)
CALL REALIO(6H THESEP, THESEP, 0, 0)
CALL INIDIO(6H KSTART, KSTART, 100, 0)
MORE = .FALSE.
GO TO 170

CONTINUE

CALL INTIO(6H NRUN, NRUN, 100, 0)
CALL REALIO(6H NRUN, NRUN, 0, 0)
CALL REALIO(6H BRCVR, BRCVR, 0, 0)
CALL REALIO(6H THESEP, THESEP, 0, 0)
CALL INIDIO(6H KSTART, KSTART, 100, 0)
MORE = .FALSE.
GO TO 170

CONTINUE

CALL REALIO(6H NRUN, NRUN, 100, 0)
CALL REALIO(6H BRCVR, BRCVR, 0, 0)
CALL REALIO(6H THESEP, THESEP, 0, 0)
CALL INIDIO(6H KSTART, KSTART, 100, 0)
MORE = .FALSE.
GO TO 170

CONTINUE

CALL REALIO(6H NRUN, NRUN, 100, 0)
CALL REALIO(6H BRCVR, BRCVR, 0, 0)
CALL REALIO(6H THESEP, THESEP, 0, 0)
CALL INIDIO(6H KSTART, KSTART, 100, 0)
MORE = .FALSE.
GO TO 170

CONTINUE

CALL REALIO(6H NRUN, NRUN, 100, 0)
CALL REALIO(6H BRCVR, BRCVR, 0, 0)
CALL REALIO(6H THESEP, THESEP, 0, 0)
CALL INIDIO(6H KSTART, KSTART, 100, 0)
MORE = .FALSE.
GO TO 170

CONTINUE
**SUBROUTINE CONTRL**

731172 TS

FTN 4.0.452

05/17/79

17.Z5.29

PAGE

CONTINUE

175

C THIS IDENTIFIES THE BASIC RECEIVER STRUCTURE (THRHD, OPT, SUBOPT)
AND REINITIALIZES, AS NECESSARY, THE FOLLOWING RCVR DATA.
CTH (NEGATE UNLY), NOAC, NOKL, NOLDS, RCVR, DELDL, TETHD
17T = MIND(RCVR, 2)

180

C NEGATE IR WITH THE FOLLOWING FOR NONADAPTIVE RECEIVER
IF(ISIGN = LT.0) IR = -IR

RETURN

185

CONTINUE

460 C CONTINUE

C THIS OUTPUTS BASIC RECEIVER DATA OF INTEREST.
WRITE(7, 410) (IDENTS(I), I = 1, 4), IR, NG, NS

410 FORMAT (I0, A8, 4HRCVR/I0, A8, 6HDESIGN/SH(I0, A2, 4HNG/I0, A11,
* 4HNS, 11H))
WRITE(7, 420) (IDENTS(I), I = 5, 6)

420 FORMAT(1, H0, A8, 7H)

RETURN

190

CONTINUE

C THIS IDENTIFIES THE BASIC RECEIVER STRUCTURE (THRHD, OPT, SUBOPT)
AND REINITIALIZES, AS NECESSARY, THE FOLLOWING RCVR DATA.
CTH (NEGATE UNLY), NOAC, NOKL, NOLDS, RCVR, DELDL, TETHD
17T = MIND(RCVR, 2)

180

C NEGATE IR WITH THE FOLLOWING FOR NONADAPTIVE RECEIVER
IF(ISIGN = LT.0) IR = -IR

RETURN

185

CONTINUE

460 C CONTINUE

C THIS OUTPUTS BASIC RECEIVER DATA OF INTEREST.
WRITE(7, 410) (IDENTS(I), I = 1, 4), IR, NG, NS

410 FORMAT (I0, A8, 4HRCVR/I0, A8, 6HDESIGN/SH(I0, A2, 4HNG/I0, A11,
* 4HNS, 11H))
WRITE(7, 420) (IDENTS(I), I = 5, 6)

420 FORMAT(1, H0, A8, 7H)

RETURN

190

CONTINUE

C THIS SETS-UP THE K-LOOP FOR THE (LG)-TH SET OF KM SCANS
CALL INTIO(6HKM, K, 1, 1)

WRITE(7, 710)

710 FORMAT (4H0, K, 3X, 6HCSNRTD, 5X, 6HCSNRFR, 6X, 3HOTY, 7X,
* 4WHALFAY, 5X, 5HTHETA, 5X, 5HTHEDOT, 5X, 5HALFAY, 6X, 5HTHETA, 5X,
C 6HTHEDOT, 5X, 4H B, 7X, 3HWSCE)

RETURN

200

CONTINUE

C THIS SETS-UP THE LG-LOOP FOR THE (HSET)-TH SERIES OF SETS
RETURN

205

CONTINUE

C THIS SETS-UP THE LG-LOOP FOR THE (HSET)-TH SERIES OF SETS
RETURN

210

CONTINUE

C THIS SETS-UP THE LG-LOOP FOR THE (HSET)-TH SERIES OF SETS
RETURN

215

CONTINUE

C THIS SETS-UP THE LG-LOOP FOR THE (HSET)-TH SERIES OF SETS
RETURN

220

CONTINUE

C THIS SETS-UP THE K-LOOP FOR THE (LG)-TH SET OF KM SCANS
CALL INTIO(6HKM, K, 1, 1)

WRITE(7, 710)

710 FORMAT (4H0, K, 3X, 6HCSNRTD, 5X, 6HCSNRFR, 6X, 3HOTY, 7X,
* 4WHALFAY, 5X, 5HTHETA, 5X, 5HTHEDOT, 5X, 5HALFAY, 6X, 5HTHETA, 5X,
C 6HTHEDOT, 5X, 4H B, 7X, 3HWSCE)

RETURN

225

CONTINUE

C THIS SETS-UP THE K-LOOP FOR THE (LG)-TH SET OF KM SCANS
CALL INTIO(6HKM, K, 1, 1)

WRITE(7, 710)

710 FORMAT (4H0, K, 3X, 6HCSNRTD, 5X, 6HCSNRFR, 6X, 3HOTY, 7X,
* 4WHALFAY, 5X, 5HTHETA, 5X, 5HTHEDOT, 5X, 5HALFAY, 6X, 5HTHETA, 5X,
C 6HTHEDOT, 5X, 4H B, 7X, 3HWSCE)

RETURN

C THIS SETS-UP THE K-LOOP FOR THE (LG)-TH SET OF KM SCANS
CALL INTIO(6HKM, K, 1, 1)

WRITE(7, 710)

710 FORMAT (4H0, K, 3X, 6HCSNRTD, 5X, 6HCSNRFR, 6X, 3HOTY, 7X,
* 4WHALFAY, 5X, 5HTHETA, 5X, 5HTHEDOT, 5X, 5HALFAY, 6X, 5HTHETA, 5X,
C 6HTHEDOT, 5X, 4H B, 7X, 3HWSCE)

RETURN

C THIS INITIALIZES THE K-TH SCAN
IF(K.EQ.KSTART) X(4) = RHO*X(1)
IF(K.EQ.KSTART) NGM = NGM

RETURN

C THIS INITIALIZES THE K-TH SCAN
IF(K.EQ.KSTART) X(4) = RHO*X(1)
IF(K.EQ.KSTART) NGM = NGM

RETURN

C THIS INITIALIZES THE K-TH SCAN
IF(K.EQ.KSTART) X(4) = RHO*X(1)
IF(K.EQ.KSTART) NGM = NGM

RETURN

C THIS INITIALIZES THE K-TH SCAN
IF(K.EQ.KSTART) X(4) = RHO*X(1)
IF(K.EQ.KSTART) NGM = NGM

RETURN

C THIS INITIALIZES THE K-TH SCAN
IF(K.EQ.KSTART) X(4) = RHO*X(1)
IF(K.EQ.KSTART) NGM = NGM

RETURN
900 CONTINUE
C THIS SAVES/PREPROCESSES DATA FROM THE K-TH SCAN
    CULB+SORT(PPDIAG(2))
230 DO 910 I=1,NS
    ES(I)+X(I)-XS(I)
    RMSVAL(I)+SORT(PPDIAG(I))
    CONTINUE
    IF (NS.GE.7) ES(7) = ABS(X(7))-ABS(XS(7))
    IF (NS.GE.8) ES(8) = ABS(X(8))-ABS(XS(8))
240 SCANN(K)+K
    EALFA(K)+ES(1)
    ETHET(K)+ES(2)
    EALFA(K)+ES(4)
    ETHET(K)+ES(5)
    XFOUR(K)+X(1)/K
    CONTINUE
    IF (NS.LE.6) GO TO 915
    ETA(K)+ES(T)/PI.
    EPS(K)+0.5*ES(8)/PI
245 WRITE(7,920) K, CSNRT,CSNRF,1HX,(X(I),I=1,8)
    CONTINUE
260 C**************************************************************************
7172 15 FTN 4,6,452 05/17/79 17.25.29 PAGE 5
100 CONTINUE
C THIS SAVES/PREPROCESSES/OPTS DATA FROM THE (LG)-TH SET OF KM SCANS
C WRITE(7,1060) (GOGT(I)),I=1,NS
260 FORMAT (10/I),35H LATTICE DATA
    YMIN=YMAX=0.
    CALL PLOTR(SCANNR, EALFA,KM,XNAME,YMAX,YMIN)
    CALL REALIO(6H YMIN,YMIN)
    YMIN=YMAX=0.
270 CALL PLOTR(SCANNR, ETHET,KM,XNAME,YMIN,YMAX)
    CALL REALIO(6H YMIN,YMIN)
    YMIN=YMAX=0.
275 CALL PLOTR(SCANNR, ETA,KM,XNAME,YMIN,YMAX)
    CALL REALIO(6H YMIN,YMIN)
    YMIN=YMAX=0.
280 CALL PLOTR(SCANNR, ETA,KM,XNAME,YMIN,YMAX)
    CALL REALIO(6H YMIN,YMIN)
    YMIN=YMAX=0.
285 CALL PLOTR(SCANNR, ETA,KM,XNAME,YMIN,YMAX)
SUBROUTINE CONTROL 73/172 TS

YMIN+YMAX<0.
WRITE (7,11)
CALL PLOTR(SCANNR, XFUR, XNAME, YNAME, YMIN, YMAX, 0)
CALL REALIO(6H YMIN, YMAX, 1)

290 IF (NS.LT.6) GO TO 1065
WRITE (7,11)
YMIN+YMAX<0.
CALL PLOTR(SCANNR, EBETA, XMNAME, YNAME, YMIN, YMAX, 0)
CALL REALIO(6H YMIN, YMAX, 1)

300 YMIN+YMAX<0.
WRITE (7,11)
CALL PLOTR(SCANNR, EFS, XMNAME, YNAME, YMIN, YMAX, 0)
CALL REALIO(6H YMIN, YMAX, 1)

1065 CONTINUE
IF (.NOT. FIlOUT) RETURN
WRITE (7,11)
DATA (I=1,2)
WRITE (7,1070) (DATOUT(I), I=1,2)
WRITE (7,1072) DMOUT, DELT, MTIMES, MGMAX, KM, TODAY, JBNAM
WRITE (7,1074) IDENTS, KSTART
WRITE (7,1076) NRUN, DSNROB, RHOB, BETAD, FSC, BML, BCRV, THESP
WRITE (7,1078) (3, 7(3X, G12.6, 0))
DO 1077 1=1, KMAX
1077 WRITE(7,1078) EALFA(I), ETHET(I), EALFR(I), ETHEK(I), XFUR(I)
WRITE(7,1079) RHOMAX, OTHD, TORO, BETAO, EFSC, EFSO, EBETA(KM)
WRITE(7,1081) EALFA(I), ETHET(I), EALFR(I), ETHEK(I), XFUR(I)
WRITE(7,1083) RHOMAX, OTHD, TORO, BETAO, EFSC, EFSO, EBETA(KM)
WRITE(7,1085) EALFA(I), ETHET(I), EALFR(I), ETHEK(I), XFUR(I)
WRITE(7,1087) RHOMAX, OTHD, TORO, BETAO, EFSC, EFSO, EBETA(KM)
WRITE(7,1089) EALFA(I), ETHET(I), EALFR(I), ETHEK(I), XFUR(I)
WRITE(7,1091) EALFA(I), ETHET(I), EALFR(I), ETHEK(I), XFUR(I)
WRITE(7,1093) RHOMAX, OTHD, TORO, BETAO, EFSC, EFSO, EBETA(KM)
WRITE(7,1095) EALFA(I), ETHET(I), EALFR(I), ETHEK(I), XFUR(I)
WRITE(7,1097) EALFA(I), ETHET(I), EALFR(I), ETHEK(I), XFUR(I)
WRITE(17) (DATOUT(I), I=1,2)
CALL RETURN(6LTAPE20, DATOUT)

335 IF (IX.NE.0) GO TO 1095
IX=ICATALO(6LTAPE17, DATOUT, 2LP, 6), (6LTAPE17, DATOUT, 2LP, 365)
GO TO 1096

340 IF (IX.NE.0) CALL INTIO(6LTAPE17, DATOUT, 2LP, 6), (6LTAPE17, DATOUT, 2LP, 365)
IF (IX.NE.0) STOP

A-7

CTLACQN3
Page 6 of 7
CALL RETURN(6LTAPE17)
WRITE (7,1099) (DAIOUT(I),I=1,2)
1099 FORMAT(13HOUTPUT FILE ,2A10,3BH IS WRITTEN, CATALOGED AND CLOSED) RETURN

C********************************************
C THIS SAVES/PROCESSES/OUTPUTS DATA FROM THE (MSET)-TH SERIES OF
C LGMAX SETS OF KN SCANS
C********************************************
1100 CONTINUE RETURN

C********************************************
1200 CONTINUE RETURN

C********************************************

WRITE (7,11) RETURN

C********************************************

END

C14-STORAGE USED 6.147 SECONDS

440308 CH STORAGE USED
SUBROUTINE CONTRL(ISW)

C THIS CONDUCTS THE MLS SIMULATION THROUGH A CROSSING MULTIPATH SCENARIO

REAL LAMDA

INTEGER XNAME(Z),YNAME(2),DATINHI),DATOUT(4),DOUT

INTEGER TITLE1(3),TITLE2(3),FUNCTN(Z)

LOGICAL NOKLMNNOLOENOAC,KALMANLOETETHRDMORENFIRSTADAPTIV

COMMON/IDATA/ISIMIPMLSIRCVR,IADAPITETHRIPOPT-...-

COMMON/RCVROO/THAMAX,THAIN,TS,TR,OMEGA,TF

COMMON/RCVRO1/NGHINNGNAXDELBLNG,IRIAE

COMMON/RCVRO2/PI,F(8,8),FLZD(4),FSAMPKKMTETHRDNGNSJN

COMMON/RCVRO3/DELT,EO(B),GQGT(B,8),H(5,8),ICOUNTSIGNA

COMMON/RCVRO4/NOLDENOKLMNNOACGAMAES(5),ROIAG(5),PHDIAG(O)

COMMON/RCVRO5/PHI(5,5),PA(OO),LAMDAI5

COMMON/RCVRO6/PPDIAG(8),RNAT(5,5),PHI(5,5),PA(OO),LAMDAI5

COMMON/RCVRO9/BRCVRBBPOCRITCC

COMMON/RCVRIO/XSZ(8),X(48)

DIMENSION CSNRTO(100),THESEP(100),THESEP(100),ABBORT(100)

DIMENSION IDNRS(6),IDASCI(18),IDENTS(6),CSNRFR(lOO)

DATA ABORT1/HAISPACE/1H

DATA DATIN/1HMLSSIMDATAIOH100000FOOO,2*O/

DATA DATOUT/IOHMLSSIMDATA,3*O/

DATA DATIN/1HMLSSIMDATAIOH100000FOOO,2*O/

DATA TITLE1/6H X(2) 

DATA TITLE2/6HFIL 

DATA FUNCTN/7HAZINUTHITHELEVAT./

DATA XNAME/8HTHETASEP,6HDEGREES /

C THIS IDENTIFIES THE SCENARIO AND REINITIALIZES, AS NECESSARY, THE FOLLOWING RECEIVER PARAMETERS

C SIGMAIAEDSNRDBRHODFSC, ETAJMBMLS

IF(NFIRST) GO TO 15

ENDIF/TRUE./

C 100 CONTINUE

C***SUBROUTINES ENDING***
SUBROUTINE CONTRL

60 110 FORMAT (24MICRO/CROSSING=MULTIPATH SCENARIO)

GO TO 122

COLD IX=ATTACH(6LTAPE15,DATIN)
COLD IF(IX.NE.O) CALL INTIO6MHIX(AT,IX,1,1)
COLD IF(IX.NE.O) STOP#INPUT FILE ATTACH NOT SATISFACTORY
COLD WRITE(7,120) (DATIN(I),I=1,1,2)

120 FORMAT(2SH THIS READS INPUT FILE #2410/
122 CONTINUE

NULL TRANSFER STATEMENT -- TRANSFER IGNORED
CALL INTO6H0NSTART,0NSTART,100,0)
NSTOP=NSTART
CALL INTO6H NSTOP,0NSTOP,100,0)

CALL LOGIO(6H,NSTART,100)
NSTOP=NSTART CALL INTO6H
NSTOP,NSTOP,100,0)

CALL LOGIO(6H,NSTOP,ADAPT,0)

IF(IX.NE.0) STOP#OUTPUT FILE REQUEST NOT SATISFACTORY

125 CONTINUE

COLD* WRITE(7,152) IDNRS--...

152 FORMAT (611,AlI,Il,12)

IF(NRUN.LE.9)
ENCODE(10,220,DOUT)

IF(NRUN.GE.10)
ENCODE(10,230,DOUT)

COLD* WRITE(7,240) (DATOUT(I),I=1,2)

110 CONTINUE

C THIS OUTPUTS BASIC SIMULATION DATA OF INTEREST, SUCH AS
C THE ANGLE FUNCTION, INITIAL STATE, ETC.
WRITE(7,210) NRUN,SDNRB,RHO,BETA,FSC,RMLS,BRCVR

WRITE(7,225) NRUN,SDNRB,RHO,BETA,FSC,RMLS,BRCVR

WRITE(7,250) (DATOUT(I),I=1,2)

X=IREST(6LTAPE17,3L*PF)

IF(IX.NE.O) CALL INTIO6MIX(R0,IX,1,1)
IF(IX.NE.O) STOP#OUTPUT FILE REQUEST NOT SATISFACTORY

WRITE(7,240) (DATOUT(I),I=1,2)

110 CONTINUE

C***************************************************************

100 C THIS OUTPUTS BASIC SIMULATION DATA OF INTEREST, SUCH AS
C THE ANGLE FUNCTION, INITIAL STATE, ETC.
WRITE(7,210) NRUN,SDNRB,RHO,BETA,FSC,RMLS,BRCVR

WRITE(7,225) NRUN,SDNRB,RHO,BETA,FSC,RMLS,BRCVR

WRITE(7,250) (DATOUT(I),I=1,2)

X=IREST(6LTAPE17,3L*PF)

IF(IX.NE.O) CALL INTIO6MIX(R0,IX,1,1)
IF(IX.NE.O) STOP#OUTPUT FILE REQUEST NOT SATISFACTORY

WRITE(7,240) (DATOUT(I),I=1,2)

110 CONTINUE

C***************************************************************
SUBROUTINE CONTRL

CALL DATE(TODAY)
WRITE(7,250) FUNCTION (IAE),IAE
WRITE(7,260) (IX(I),I=1,1)
WRITE(7,270) IDENTS(2)
RETURN

C THIS IDENTIFIES THE BASIC RECEIVER STRUCTURE (THRLNL,DWT,SUBP)
C CONTINUE
C NEGATE IR WITH THE FOLLOWING FOR NONADAPTIVE RECEIVER
IF(IRSIGN.LT.0) IR-IR
RETURN

C THIS OUTPUTS BASIC RECEIVER DATA OF INTEREST
WRITE(7,410) (IDENTS(I),I=3,4),IRNGNS
RETURN

C THIS SETS-UP THE MSET-LOOP
RETURN

C THIS SETS-UP THE LG-LOOP FOR THE (MSET)-TH SERIES OF SETS
RETURN

C THIS SETS-UP THE K-LOOP FOR THE (LG)-TH SET OF KM SCANS
CALL INTIO(6B
RETURN

C***----------------------------------
CALL INTIO(6B
RETURN

C***----------------------------------
CALL INTIO(6B
RETURN

C***----------------------------------
CALL INTIO(6B
RETURN

C***----------------------------------
CALL INTIO(6B
RETURN

C***----------------------------------
CALL INTIO(6B
RETURN

REAL X(0),Y(0),Z(0),
COMMON X(0),Y(0),Z(0),
C
COMMON X(0),Y(0),Z(0),
COMMON X(0),Y(0),Z(0),
COMMON X(0),Y(0),Z(0),
COMMON X(0),Y(0),Z(0),
COMMON X(0),Y(0),Z(0),
SUBROUTINE CONTRL 73/172 TS FTN 4.6+452 05/18/79 13.43.46 PAGE 4

C*******************************************************************************
C 800 CONTINUE
C THIS INITIALIZES THE K-TH SCAN
SEP=SPACE
RETURN
C*******************************************************************************

C 900 CONTINUE
C THIS SAVES/PREPROCESSES DATA FROM THE K-TH SCAN
IF (ICOUNT .NE. LASTCT) SEP=ABORT
THERR=K(2)-X(2)
CLOB=THERR
OTHE=X(2)-X(2)
IF (IRCVR .EQ. 1) CALL DFLTR1(CLOB,THERR,FL10)
WRITE(7,910) K,CNRT,X,Z,DTHEE(XS(Z)),ATHEE(XS(Z))
910        FORMAT (I2,5X,E13.6,5X,E13.6,5X,E13.6)
CSCNRT(K)=CSNRT
CSNRF(K)=CSNRF
THESER(K)=THERR
ABBORT(K)=SEP
LASTCT=ICOUNT
EAMEN=EAMEN+THEER
ERM=EAMEN+THEER
ESTDEV=ESTDEV+THEER
RETURN

C*******************************************************************************
C 1000 CONTINUE
C THIS SAVES/PROCESSES/OUTPUTS DATA FROM THE (L6)-TH SET OF KM SCANS
EAMEN=EAMEN/KM
ERM=EAMEN/KM
ERMS=SORT(ERM)
ESTDEV=SORT(ERMS-EAMEN**2)
XW=ICOUNT
TCTOUNT=100.*XW/KM
WRITE(7,1010)
1010         FORMAT (IHOTHETA-ERROR SAMPLE'STATISTICS:)
IF (IRCVR .EQ. 1) WRITE(7,1020)
1020         FORMAT (17H(FILTERED ERROR))
WRITE(7,1030) EAMEN,ERM,ESTDEV
1030         FORMAT (25HSCANS ARE ABORTED)
IF (IRCVR .NE. 1) WRITE(7,1040)
1040         FORMAT (110(/)135H ON LAST SCAN, DIAGONAL
OF GQGT WAS/CTLCRMP
CALL PLOTR(THESEP THESER K, XNAME, YNAME, YMIN, YMAX, 0)
CALL REALIO(6H- YH, YMIN1)
CALL REALIO(6H YMAX, YMAX1)
IF (IRCVR .NE. 1) WRITE(7,1060) (GQGT(I,J),I=1,HS)
1060         FORMAT (101(/)135H ON LAST SCAN, DIAGONAL OF GQGT WAS/
SUBROUTINE CONTRL '73117Z TS

*IH,GI1.4s7(IH,GI1.4s7(IH)
WRITE(7,111)
WRITE(7,1070) (DATOUT(I),I=1,2)
FORMAT(13H OUTPUT FILE ,6A3/)
WRITE(7,1072) DATOUT,DELT,RTIMES,LMAX,KM,TODAY,JBNAM
WRITE(7,1074) IDENT
FORMAT(1H X6(A9,9X))
WRITE(7,1076) NRUN,DSNRDBR,HOBET,FSCL,BMLS,BRCVR
...--
1077 WRITE(7,1078) CSNRTO(I),CSNRFR(I),THESER(I),ABBORT(I),THESEP(I),I
FORMAT(1H 53X,12,6X#6(5XG13.6)/)
WRITE(7,1079) EMean,ERS,ESTDEV,TCOUNT,YMIN,YMAX
REWIND 17
IF(IX.NE.0) STOP.OUTPUT FILE CATALOG NOT SATISFACTORY
CALL RETURN(6LTAPE-O)
1200 CONTINUE
CTLCRMP
Page 5 of 6
SUBROUTINE CONTRL 73/172 TS

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END

43000B CM STORAGE USED 4.098 SECONDS
SUBROUTINE CONTRL
C
C THIS CONDUCTS THE MLS SIMULATION THROUGH A
C RMSE VS. BRAID (... = BRCVR/BMLS).
C
REAL LAMDA
INTEGER XNAME(2),YNAME(2),DATIN(4),DATOUT(4),DOUT
INTEGER TITLE(19),FUNCTN(2)
LOGICAL NOKLMH,NOKLP,NLOCKALMA,LOE,TETHR,MORE,NEIRST,ADAPTV,
CFILEIN,FILEOUT
COMMON/IDDATA/ISINIPNLSTCRTTVROAOAPIETNR,IPLOPT
COMMON/RCVROI/THAMAX,THAMIN,TSTR,OMEGATF
COMMON/RCVROI/NGMINPNGMAXUELDLNGIRIAE
COMMON/RCVR04/DELTEO(B),GQGT(8,O),H(5,B),ICOUNTSIGMA
COMMON/RCVR06/PPDIAG(C),RMAT(5,S),PHI(5,5),PA(8,8),ILAMDA(5)
COMMON/MLSOOICSNRTCSNRFDSNRDBRHDBETAFSCLGMAX
COMMON/NLSOO3IDCS RCSRLGTPKTTPKF
COMMON/MLSOOZ/FLIOAE(NFLO)KETATP2)KXO(P#2),YG(4,2)
COMMON/MLSOO4/BMLSBBBMTIMESMSETMORE
DIMENSION X(B),THESER(115),XDATUM(CI5),EEME(13),EERM(13)
DIMENSION IDNRS(6),lbs,(13),YY(13)
DIMENSION BRATIO(13
DIMENSION EEMEA(13,2),EERMSC(2),EEST(13),EESTD(13)
DIMENSION EMEAN(9),EMS(9),ERKS(9),ESD(9)

EQUIVALENCE (EEME(1),EEMEA(1,2),EERM(1),EERMSC(1,2))
EQUIVALENCE (THERRES(2))
EQUIVALENCE (ALFAX(1),ISIM,IGNRS(l)),(DOUT,DATOUTCZ))
DATA YNAM/BHALF
DATA ABORT/1HAISPACE/IH
DATA DATIN/1OHMLSSIMDATAlOH200000FOOO,2*0/
DATA DATDUT/IOHMLSSINDATA,3*0/
DATA SIDASCI/CHCROSSMPTHRMSE(T),CHRMSE(B),CHRMSE(F),CH
8H
PMLS,-,PMLS2,-PMLS3,-THRHLO 6BHOPTIML
DATA NONADAP,OHUNTETHRDPBHTETHEREOZH *88H POPT3
DATA DATIN/1OHMLSSIMDATAlOH200000FOOO,2*0/
DATA DATDUT/IOHMLSSINDATA,3*0/
DATA SIDASCI/CHCROSSMPTHRMSE(T),CHRMSE(B),CHRMSE(F),CH
8H
PMLS,-,PMLS2,-PMLS3,-THRHLO 6BHOPTIML
DATA NONADAP,OHUNTETHRDPBHTETHEREOZH *88H POPT3

DATA JTITLE/6H.ALFA

DATA XNAME/8H BETA /8HDEGREES /YNAME/8HTHES ERR/8HDEGREES /
DATA XNAME/8H BETA /8H
DATA FUNCTION/7HAZIMUTH,7HELEVAT,
SUBROUTINE CONTRL

GO TO (100, 200, 300, 400, 500, 600, 700, 800, 900, 1000, 1100, 1200), ISW

FORMAT(114)

10 FORMAT(V/)

11 FORMAT(1,1)

150 CONTINUE

C THIS IDENTIFIES THE SCENARIO AND REINITIALIZES, AS NECESSARY

C THE FOLLOWING RECEIVER PARAMETERS

CSIGMA, JSR, RMD, PSC, PENA, JR, BMLS

IF(NFIRST) GO TO 155
NOAC = TRUE.
NFIRST = TRUE.
JENM = JOSNAME(I)
ISIM = 3
IMOD = 1.
WRITE (7, 110)
110 FORMAT(2H1RMSE VS.BRATIO = BCVR/BMLS SCENARIO)

CALL LOGIO(6HFILEIN, FILEIN, 0)

IF (.NOT.FILEIN) GO TO 122
IX = IATTACH6TAPE15, DATIN)

IF (IX .NE. 0) CALL INTIO(6HAT, IX, 1, I)
IF (IX .NE. 0) STOPOINPUT FILE ATTACH NOT SATISFACTORY

WRITE(7, 120) (DATIN[I] I, 1, 2)
120 FORMAT(2H THIS READS INPUT FILE; 2A10/

CALL LOGIO(6HLGMAX, LGMAX, 13, 0).

CALL LOGIO(6HTHRDO, THRDO, 0).

IF (IRCVR .EQ. 0) GO TO 135

135 CONTINUE

IASC = (I-1)/2+1

IF (I .EQ. 3) GO TO 135

IASC = (I-1)/2+2

ENCDE(8, 150, IDENTS(I)) IDASC(IASC)

CONTINUE

WRITE (7, 152) IDNRS(I), IMOD
152 FORMAT(2H6112, IX, I1/

WRITE (7, 153) IDENTS(I)
153 FORMAT(2H6112, IX, I1/

CALL INTIO(6HLGMAX, LGMAX, 13, 0)

CALL INTIO(6HCMAX, CMAX, 13, 0)

CALL REALIO(6HBRATL, BRATL, 0)

XSTART = MNO(KMAX, XSTART)

BRATL(I) = 1.

BRATL = SORT(BRATL)

CALL LOGIO(6HTETHRDO, THRDO, 0).
SUBROUTINE CONTRL

ROOT = 1 / (LOGMAX - 1)

IF (LOGMAX .LE. 1) GO TO 156
DO 154 I = 1, LOGMAX

154 BRAHIO(I) = BRAHIO**(2 + *ROOT**(I-1) - 1)

CONTINUE

156

KNET = KM - KSTART + 1
FSKIN = 1 / (DELTAT(I) * KNET)
NRUN = NSTART - 1
OSNRDB = 20.
RHO = 0.5
BETA = 45.
IFS = 1
TSEP = 1.
CONTINUE

155 CONTINUE

IF (FILEIN) GOTO 158
NRUN = NRUN + 1
WRITE (7, 11)
CALL INTIO (6, NRUN, NRUN, I), 1
CALL REALIO (6, RHO, RHO, 0)
CALL REALIO (6, BETA, BETA, 0)
CALL INTIO (6, IFS, IFS, 100, 0)
CALL REALIO (6, TSEP, TSEP, 0), 167
GOTO 167

156

CONTINUE

140 READ (15, 160) NRUN, OSNRDB, RHO, BETA, IFS, TSEP
IF (EOF(15) .NE. 16) 160
FORMAT (15, 3G10.3, 5X, 2G10.3)
IF (NRUN .LT. NSTART) GO TO 158

160 IF (NRUN .LE. NSTOP) MORE = .FALSE.

145 FSC = IFS * FSKIN
XS = (I, IAE) - TSEP
XS = (I, IAE) = 0.
XS = (I, IAE) = 0.
RETURN

150

170 STOP * EOF REACHED ON INPUT FILE#

C**************************************************************

C THIS OUTPUTS BASIC SIMULATION DATA OF INTEREST, SUCH AS
C THE ANGLE FUNCTION, INITIAL STATE, ETC.

C**************************************************************

195 CONTINUE

200 FORMAT (15, 3G10.3, 5X, 2G10.3)
210 FORMAT (15, 3G10.3, 5X, 2G10.3)
220 FORMAT (15, 3G10.3, 5X, 2G10.3)
230 FORMAT (15, 3G10.3, 5X, 2G10.3)
240 FORMAT (15, 3G10.3, 5X, 2G10.3)
245 CALL DATE (TODAY)
SUBROUTINE CONTRL

WRITE (7,250) FUNCTN (IAE), IAE
250 FORMAT (1HOA7,15H FUNCTION (IAE*, [1L1H])
WRITE (7,260) ([1X(I1)], [=1*0])
260 FORMAT (15H INITIAL STATE: (15X K1, [1L1H] = [913*6])
WRITE (7,270) IDENTS(I)
270 FORMAT (1HOA7)
RETURN
C
C**********************
C
C 300 CONTINUE
C THIS IDENTIFIES THE BASIC RECEIVER STRUCTURE (THRHLD, DPT, SUBOPT)
C AND REINITIALIZES AS NECESSARY THE FOLLOWING RCVR DATA
C
CIR (NEGATE ONLY), NOAC, NOKLMN, NOLDG, BRCVR, DELBL, TETHRD
C
IINIT=MIX0(IRCVR, 2)
C
C NEGATE IR WITH THE FOLLOWING FOR NONADAPTIVE RECEIVER
CIR = ISIGN(IR, IRESIGN)
C
C**********************
C
C 400 CONTINUE
C THIS OUTPUTS BASIC RECEIVER DATA OF INTEREST
WRITE(7,410) IDENTS(I[1,4] RINGS
410 FORMAT (1HOAB4HRCVR1IH, 4HDESIGN STOP (IR*, I2, 4HNG-, I1, * HLSIL LH))
C
C 500 CONTINUE
C THIS SETS UP THE MS=0 LOOP
ICOUNT=0
DO 510 I=1, LGMAX
YMH(I)=1.E322
510 YMH(I)=1.E322
RETURN
C
C**********************
C
C 600 CONTINUE
C THIS SETS UP THE LG=0 LOOP FOR THE (MS=) TH SERIES OF SETS
RETURN
C
C**********************
C
C 700 CONTINUE
C THIS SETS UP THE LG=0 LOOP FOR THE (LG=) TH SERIES OF KM SCANS
BML, AMAX1(L, 1) / RATIO(LG)
BML = MAX1(RATIO(LG), 1)
BML = MAX1(AMAX1(L), BML)
BRCVR = MAX1(BRCVR, 1)
PDCRIT = P1*P2/8
CC = P1*PDCRIT
RETURN
C
C**********************
C

SUBROUTINE CTRL

230 X(7) = X0(7,IAE)
230 DUM = GAUSS(1,0)
230 WRITE(7,11)
230 CALL INTIO(6H NRUN, NRUN, 1, 1)
230 WRITE(7,705) LG, BRATIO(LG), BMLS, BRCVR

235 FORMAT(1H, 4X, 3HLG*, 12.5X, 9.5BRATIO* = 612.5/68 BMLS = 612.5/5X, 9.5)
235 BRCVR = 612.5
235 CALL INTO(6H K, K, K, 1, 1)
235 WRITE(7,710) (TITLE(I), I = 1, NS)
235 FORMAT(4H0 K, 4X, 5HCNTRY, 4X, 5HTY, 9(5X, A6, 2X))

240 WRITE(7,712) I, NS
240 CONTINUE
240 RETURN

250 C
250 CONTINUE
250 C THIS INITIALIZES THE K-TH SCAN
250 SEP = SPACE
250 RETURN

260 C
260 CONTINUE
260 C THIS SAVES/PREPROCESSES DATA FROM THE K-TH SCAN.
260 IF (ICOUNT NE LASTCT) SEP = ABORT
260 DO 905 I = 1, NS

265 IF (NS.GE.7) ES(7) = ABS(X(7)) - ABS(XS(7))
265 ES(7) = BETTA*(I80./PI)*X(7)
265 IF (IRCVR.EQ.1) CALL DFLTR1(COLB, THERR, FL10)
265 IF ((NRUN.GE.NSTART.AND.LG.EQ.K).OR.(K.EQ.KM)) GOTO 906
265 GO TO 950

270 WRITE(7,910) K, CSNRT, (X(I), I = 1, NS)
270 FORMAT(3HO I3, 2X, G10.3, 5H X, ZX, G10.3, 1X)
270 WRITE(7,920) (XS(I), I = 1, NS)
270 FORMAT(18X, 5H XS-, ZX, 9(G10.3, 1X))
270 WRITE(7,930) (ES(I), I = 1, NS)
270 FORMAT(18X, 5H ES-, 2X, 9(G10.3, 1X))
270 IF (IRCVR.EQ.1) WRITE(7,940) COLB
270 COMB = PPDIA(2)
270 IF (IRCVR .EQ. 1) CALL DFLTR1(COLB, THERR, FL10)
270 IF ((NRUN .GE. NSTART).AND.(LG .EQ. 1).OR.(K .EQ. KK)) GOTO 906
270 GO TO 950

280 WRITE(7,950) WRIT(7,910) XDATUM(K) = BETTA
280 THESER(K) = THERR
280 LASTC + ICOUNT
280 IF (K .LT. KSTART) RETURN

285 DO 960 I = 1, NS
285 CONTINUE
285 RETURN

950 CONTINUE
950 C THIS SAVES/PREPROCESSES DATA FROM THE K-TH SCAN.
950 IF (ICOUNT NE LASTCT) SEP = ABORT
950 DO 905 I = 1, NS

960 CONTINUE
960 RETURN

905 ES(I) = X(I) - XS(I)
905 E(I) = E(I) + ABS(X(I)) - ABS(XS(I))
905 E(I) = BETTA*(I80./PI)*X(I)
905 IF (IRCVR .EQ. 1) CALL DFLTR1(COLB, THERR, FL10)
905 IF (( NRUN .GE. NSTART).AND.(LG .EQ. 1).OR.(K .EQ. KK)) GOTO 906
905 GO TO 950

910 WRITE(7,910) K, CSNRT, (X(I), I = 1, NS)
910 FORMAT(3HO I3, 2X, G10.3, 5H X, ZX, G10.3, 1X)
910 WRITE(7,920) (XS(I), I = 1, NS)
910 FORMAT(18X, 5H XS-, ZX, 9(G10.3, 1X))
910 WRITE(7,930) (ES(I), I = 1, NS)
910 FORMAT(18X, 5H ES-, 2X, 9(G10.3, 1X))
SUBROUTINE CONTRL

EMEAN(I) = EMEAN(I) + ES(I)
RETURN

C*****************************************************************************

C CONTINUE
C THIS SAVES/PROCESSES/OUTPUT DATA FROM THE (LG)-TH SET OF KM SCANS

DO 1005 I = 1, NS
  EMEAN(I) = EMEAN(I) / KMNET
  EMS(I) = EMS(I) / KMNET
  ERS(I) = SQRT(EMS(I))
  ESD(I) = SQRT(EMS(I) - EMEAN(I)**2)
1005 CONTINUE

XW = ICOUNT
TCOUNT = 100.*XW/KM
WRITE(7, 1009)
1009 FORMAT(2I5)
WRITE(7, 1010)(TITLE(I), I = 1, NS)
1010 FORMAT(1X, 4X, 4H#), (9(3X, A6, 2X))
WRITE(7, 1011)(EMEAN(I), I = 1, NS)
1011 FORMAT(16XB), (9(G10.3, IX))
WRITE(7, 1012)(ERMS(I), I = 1, NS)
1012 FORMAT(1GX, 9HERMS - 9060.3, IX)
WRITE(7, 1013)(ESD(I), I = 1, NS)
1013 FORMAT(1GX, 9HESD - 9060.3, IX)
IF (IRCVR.EQ.1) WRITE(7, 1060) TCOUNT
1060 FORMAT(5(/), 4X, 35H ON LAST SCAN, DIAGONAL OF GQGT WAS/26X
      0)

DO 1071 I = 1, NS
  YMIN(LG) = AMIN1(YMIN(LG), YMIN(I))
  YMAX(LG) = AMAX1(YMAX(LG), YMAX(I))
  TTCO(LG) = TCOUNT
IF (LG.NE.1) RETURN
1071 EMEAN(LG) = EMEAN(I)
EEKSI(LG) = EMS(I)
ESTD(LG) = ESD(I)
DO 1075 I = 1, KM
  YYMI(LG) = AMIN1(YYMI(LG), YYMI(I))
  YYMA(LG) = AMAX1(YYMA(LG), YYMA(I))
1075 IF (LG.EQ.1) RETURN

CALL INTIO(6H NRUN, NRUN, 1, 1)
CALL PLOT1(XDATUM, THESER, KM, YNAME, YNAME, YMIN, YMAX, 0)
RETURN

C*****************************************************************************

C CONTINUE
C THIS SAVES/PROCESSES/OUTPUT DATA FROM THE (MSET)-TH SERIES OF KM SCANS

CALL INTIO(6H NRUN, NRUN, 1, 1)
RETURN
SUBROUTINE CONTRL

DO 1130 J=2,LGMAX
   WRITE(7,1160) BRATIOD(J), (EESTO(J,I), I=1,NS)
   WRITE(7,1161) (EESTO(J,I), I=1,NS)
   WRITE(7,1165) (EESTO(J,I), I=1,NS)
   WRITE(7,1166) G=13.6, 5X, A10, 8X, A10)
   DO 1175 LGN=LGHAX
      WRITE(7,1182) EEME(LGN), EERM(LGN), EESTC(LGN), TTCO(LGN), YYM1(LGN), BRATIO(LGN), LGN
      ... (continued)
SUBROUTINE CONTRL

YMAX=0.
DD 1101 LG1=1, LGMAX
1101 EEME(LG1)=EERMS(LG1,I)*FACTOR
    YNAME1(I)=YNAM1(I)
    YNAME1(I)=YNAM1(I)

405 KL=MOD(K1,2)
IF(K1.EQ.1) WRITE(7,11)
IF(K1.EQ.1) WRITE(6H,10)
    CALL INTIO(KRUN,1,1)
IF(K1.EQ.0) WRITE(7,10)
    CALL PLOTR(BRATI0,EEME(LG1),XNAME1,YNAME1,YMIN,YMAX,0)

410 CONTINUE

RETURN

C*************************************************************************
C
415 CONTINUE
C THIS EFFECTS CLOSURE OF THE SIMULATION RUN
C
420 C*************************************************************************
C
END
SUBROUTINE CONTRL(ISW)

C THIS CONDUCTS THE MLS SIMULATION THROUGH A.
C RMSE VS. FSC STUDY

REAL LANDA
INTEGER XNAME(12), YNAME(2, YNAME), DATIN(4), DATOUT(4), DOUT
INTEGER TITLE(13), FUNCTION(2)
LOGICAL NDKLMS, NOC, NLAM, LTE, TETHRD, MORE, FIRST, ADAPTV

CFILEN, FFILET
COMMON/IODATA/ISIH, PMLS, IRCVR, IADAPTV, TETHRD, IPOPT
COMMON/KNAME/VNAME, XNAME, YNAME, VSNAME, XNAME, YNAME
COMMON/VCVR/NNAME, VNAME, WNAME, VNAME, WNAME
COMMON/BCVR/RNAME, TNAME, XNAME, YNAME
COMMON/DXNAME/RNAME, TNAME, XNAME, YNAME
COMMON/NAME/NAME, NAME, NAME, NAME
COMMON/RNAME/RNAME, TNAME, XNAME, YNAME
COMMON/NAME/RNAME, TNAME, XNAME, YNAME
COMMON/NAME/RNAME, TNAME, XNAME, YNAME
COMMON/NAME/RNAME, TNAME, XNAME, YNAME
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COMMON/NAME/RNAME, TNAME, XNAME, YNAME
COMM...
SUBROUTINE CONTRL

C
100 CONTINUE
C THIS IDENTIFIES THE SCENARIO AND REINITIALIZES, AS NECESSARY.
C THE FOLLOWING RECEIVER PARAMETERS
CSIGMAs IAE, DSN, H, FSC, BETA, JN, BMLS

70 IF (NFIRST) GO TO 155
NOAC=TRUE,
NFIRST=TRUE,
JOBNAME(I)
ISIM=4,
IMOD=1
WRITE (7,110)
FORMAT (19H1RMSE VS. FSC STUDY)
CALL LOGIO (6HFILEIN, FILEINO)
IF (.NOT. FILEIN) NSTART=0
80 IF (.NOT. FILEIN) GO TO 122
IX=ATTACH (6LTAPES, DATIN)
IF (IX.NE.0) CALL INTIO (6HIXCAT), IX; 0)
IF (IX.NE.0) STOP#INPUT FILE ATTACH NOT SATISFACTORY
WRITE (7,120) (DATIN (I), I=1, 2)
90 CALL LOGIO (6HFILEOUT, FILEOUT)
IF (.NOT. FILEOUT) NSTART=0
NSTOP=NSTART
CALL INTIO (6HNSTART, NSTART, 100, 0)
CALL LOGIO (6HTETHR, TETHR, 0)
IF (IRCVR.EQ.1) GO TO 125
CALL LOGIO (6HADAPT, ADAPT)
125 CONTINUE
IF (TETHR) ITETHR=2
IF (ADAPT) GO TO 135
IRSIGN=-1,
IADAP=3
135 CONTINUE
GO 145 I=2, 6
IASC=3*(I-1)+IDNRS(I)+2
IDENTS(I)=IDASC(I/IASC)
145 CONTINUE
ENCODE (8, 150, IDENTS(I)) IDASC(ISIM), IMOD
150 FORMAT (7,111)
WRITE (7,152) IDNRS, IMOD
152 FORMAT (1H, 5I1, 1X, 11/)
WRITE (7,153) IDENTs
153 FORMAT (1H, 1B0)
CALL INTIO (6H KMK, 115, 0)
KSTART=MINO(KMK)
KMNETHK=KSTART+1
FSCMIN=1/(DELTAT(I), I=1, LGMAX)
READ (10, 105) LGMAX, (FSC(I), I=1, LGMAX)
105 FORMAT (19)

C

SUBROUTINE CONTRL

WRITE(7,106) LGMAX, (IFSCA(I), I = 1, LGMAX)
FORMAT(9HOLGAX I2/IH,13(17p2X))
WRITE(7,107) (IFSCA(I), I = 1, LGMAX)
FORMAT(1H,13(17p2X))
GO TO 154

106

FSCA(I) = FSCMIN + IFSCA(I)
WRITE(7,107) (FSCA(I), I = 1, LGMAX)
FORMAT(1H,13(17p2X))
GO TO 154

107

NRUN = NSTART - 1
DSHRDB = 20.
RHO = 0.5
BETA = 45.
BMLS = 1.
BRCVR = 1.
TSEP = 1.

108 CONTINUE
IF (FILEIN ) GOTO 158

109

NRUN = NRUN + 1
WRITE(7, 11) NRUN, NRUN, NRUN
FORMAT(5HNRUN,5X,6HDSNROB,1ZX,3HRHO,1ZX,4HBETA1ZX,4HBMLSIX,----------....-. 

110

IF (.NOT. FIOUT) GOTO E45

111

IF (NRUN .GT. NSTOP) MORE = .FALSE.
FSC = FSCA(1)
XO(3, IAE) = XO(2+IAE) - TSEP.
XO(3, IAE) = 0.
XO(16, IAE) = 0.
RETURN

112

CONTINUE
C THIS OUTPUTS BASIC SIMULATION DATA IF OF INTEREST, SUCH AS
C THE ANGLE FUNCTION, INITIAL STATE, ETC.
WRITE(7,210) NRUN, DSNRROB, RHO, BETA, BMLS, BRCVR, TSEP
FORMAT(5HNRUN,5X,6HDSNROB,1ZX,3HRHO,1ZX,4HBETA1ZX,4HBMLSIX,----------....-. 

113

IF (.NOT. FIOUT) GOTO E45

114

IF (NRUN .LE. NSTOP) GOTO 150

115

E45
CALL INTIO (6H IX(RQ), IX, 1, 1)
IF (IX = 0) STOP
EOF REACHED ON INPUT FILE

116

THE OUTPUT FILE REQUEST NOT SATISFACTORY
WRITE(7,240) (DATOUT(I), I = 1, 2)
CALL DATEDTODAY

117

C*******************************************************************************
C
118

CONTINUE
C

119

C*******************************************************************************
C
120

CONTINUE
C THIS OUTPUTS BASIC SIMULATION DATA IF OF INTEREST, SUCH AS
C THE ANGLE FUNCTION, INITIAL STATE, ETC.
WRITE(7,210) NRUN, DSNRROB, RHO, BETA, BMLS, BRCVR, TSEP
FORMAT(5HNRUN,5X,6HDSNROB,1ZX,3HRHO,1ZX,4HBETA1ZX,4HBMLSIX,----------....-. 

121

IF (.NOT. FIOUT) GOTO E45

122

IF (NRUN .LE. 9) ENCODE(10,220, OOUT) IDNRS, 1H1, IMOONRUN
FORMAT(6I1, A1, 112)
IF (IX.EQ.0) CALL INTIO (6H IX(RQ), IX, 1, 1)
IF (IX.EQ.0) STOP
E0F REACHED ON INPUT FILE

123

THE OUTPUT FILE REQUEST NOT SATISFACTORY
WRITE(7,240) (DATOUT(I), I = 1, 2)
CALL DATEDTODAY

124

CONTINUE
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245
SUBROUTINE CONIRL

WRITE (7, 250) FUNCTN (IAE), IAE
250 FORMAT (15H0A7,15H FUNCTION (IAE=I11I1H))
WRITE (7, 260) (I1(I1), I=1,4)
260 FORMAT (15H0INITIAL STATE/1/1H X(I1),4H = ,G13.61)
WRITE (7, 270) IDENT1(2)
270 FORMAT (1H0A7)
RETURN

C*****************************************************************************
C 300 CONTINUE
C THIS IDENTIFIES THE BASIC RECEIVER STRUCTURE (THRDLOPT, SUBOPT)
C AND REINITIALIZES, AS NECESSARY, THE FOLLOWING RCVR DATA
CIR (NEGATE ONLY), NOACNLKLN, NLDEE, BRCVR, DELBL, TETHRD
ITIT6RINGOINRCVR, 2)
C NEGATE IR WITH THE FOLLOWING FOR NONADAPTIVE RECEIVER...
IR=ISIGN(IN, I=IRSIGN)
C
RETURN
300 C*****************************************************************************

C*****************************************************************************
C 400 CONTINUE
C THIS OUTPUTS BASIC RECEIVER DATA OF INTEREST
WRITE (7, 410) (IDENTS(I), I=1,4), IR, HG, NS
410 FORMAT (1H0A84HRCVR/1H0A6,6HDESIGN/5H (IR., I2,4HNGeI1, *
255 4HNS-PI1,1H))
WRITE (7, 420) (IDENTS(I), I=1,5, 6)
420 FORMAT (1H0A6,6H, 5H0A7)
RETURN
C*****************************************************************************

C*****************************************************************************
C 500 CONTINUE
C THIS SETS-UP THE MS-SET-LOOP
ICOUNT=0
DO 510 I=1, LGMAX
YMYI(I)=1.E322
510 YMYA(I)=1.E322
RETURN
C*****************************************************************************

C*****************************************************************************
C 600 CONTINUE
C THIS SETS-UP THE LG-LOOP FOR THE (MSSET) TH SERIES OF SETS...
RETURN
C*****************************************************************************

C*****************************************************************************
C 700 CONTINUE
C THIS SETS-UP THE K-LOOP FOR THE (LG) TH SET OF KM SCANS
FSC+FSCA(LG)
XO(6, IAE)=2.*PI*FSC
X(7) = XO(0, IAE)
X(7) = XO(7, IAE)
DUM*GAUSA(1, 0)
WRITE (7, 11)
C*****************************************************************************
SUBROUTINE CONTRL  

CALL INTIO(6H NRUN=NRUN+1,1)
WRITE(7,703) LG,FSC
WRITE(7,710) TITLE(11)=1,NS

FORMAT(1H,4X,LG,FSC=S12.5)

CALL INTIO(6H KG,KG+1,1)
FORMAT(6HO KG=4X,5HSNRN,4X,5HQTY ,9(3X,A6,2X))

DO 712 I=1,NS
EMEN(I)=0.
LASTCT=0
ICOUNT=0
DO 730 IPA=1,NS
PA(IPA)=0.
CONTINUE
730 CONTINUE
RETURN

C
C THIS INITIALIZES THE K-TH SCAN
SEP=SPACE
RETURN

C
C THIS SAVES/PREPROCESSES DATA FROM THE K-TH SCAN
IF(ICOUNT.NE.LASTCT) SEP=ABORT
DO 905 I=1,NS

ES(I)=X(I)-XS(I)
IF(NS.GE.7) ES(7)=ABS(X(7))-ABS(XS(7))
IF(NS.GE.8) ES(8)=ABS(X(8))-ABS(XS(8))
BETTA=(O/PI*X(7)
COLE=THERR
IF (IRCVR .NE. 1) COL8=SQRT(PPDIAG(-))
IF (IRCVR .EQ. 1) CALL OFLTR1(COLB,THERR,FL10)
IF(NRUN.EQ.NSTART.AND.LG.EQ.1).OR(K.EQ.K)) GOTO 906
GO TO 950
905 WRITE(7,910) KG,FNRN,T(11),X(I),I=1,NS

FOR20 FORMAT(3HO K=3X,Z2,F10.3)
WRITE(7,920) (X(I),I=1,NS)

FORMAT(10X,H5,ES(I)=2X,Z2,F10.3)
WRITE(7,930) (ES(I),I=1,NS)

IF(IRCVR .EQ. 1) WRITE(7,940)
940 FORMAT(8X,ISHUNFILT.ES(2)=2X,Z2,F10.3)
XDATUM(K)=THESE(K)=THERR
THESE(K)=THERR
LASTCT=ICOUNT
IF(K.LT.KSTART) RETURN
DO 960 I=1,NS
EMEN(I)=EMEN(I)+ES(I)
960 EMS(I)=EMS(I)+ES(I)**2
RETURN

C

CTLMFS1
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SUBROUTINE CONTRL

DO 1005 I=1,NS
EMEAN(I)=EMEAN(I)/KMNET
EVAR(I)=EVAR(I)/KMNET
ESD(I)=SQRT(EVAR(I))

CONTINUE

XW=ICOUNT
TCOUNT=100.*XW/KM
WRITE(7,1009)
   FORMAT(3(/)I)
WRITE(7,1010)KMNET
   FORMAT(5X,I6,15X,F7.2,22X('% OF SCANS ARE ABORTED'))
IF(IRCVR.EQ.1) WRITE(7,1015)
   FORMAT(5X,B1H,THRESHOLD RCVR (FILTERED ERROR))
WRITE(7,1020) TITLE(I),I-1,NS)
   FORMAT(5(/),4X,35H ON LAST SCAN, DIAGONAL OF GOGT WAS/26X)
WRITE(7,1030)(EMEAN(I),I-INS)
   FORMAT(1HO,16XBHEMEAN
WRITE(7,1040)(ERMS(I),I-INS)
   FORMAT(18X,7HERMS
WRITE(7,1050)(ESD(I),I-INS)
   FORMAT(19X,6HESD
IF(IRCVR.EQ.1) WRITE(7,1060)TCOUNT
   FORMAT(//1H 4X,F7.2,22H(% OF SCANS ARE ABORTED))
IF(IRCVR.NE.1) WRITE(7,1070)
   FORMAT(5(/),4X,35H ON LAST SCAN, DIAGONAL OF GOGT WAS/26X)
WRITE(7,11)
   CALL INTIO(6H NRUNNRUN,1I).
WRITE(7,1110)
   6H FSC(TITLE1(I),I-INS)
WRITE(7,1120)
   1H,7I)
RETURN
C

C THIS SAVES/PROCESSES/OUTPUTS DATA FROM THE (LG)-TH SET OF KM SCANS
DO 1005 I=1,NS
EMEAN(I)=EMEAN(I)/KMNET
EVAR(I)=EVAR(I)/KMNET
ESD(I)=SQRT(EVAR(I))

CONTINUE

XW=ICOUNT
TCOUNT=100.*XW/KM
WRITE(7,1009)
   FORMAT(3(/)I)
WRITE(7,1010)KMNET
   FORMAT(5X,I6,15X,F7.2,22X('% OF SCANS ARE ABORTED'))
IF(IRCVR.EQ.1) WRITE(7,1015)
   FORMAT(5X,B1H,THRESHOLD RCVR (FILTERED ERROR))
WRITE(7,1020) TITLE(I),I-1,NS)
   FORMAT(5(/),4X,35H ON LAST SCAN, DIAGONAL OF GOGT WAS/26X)
WRITE(7,1030)(EMEAN(I),I-INS)
   FORMAT(1HO,16XBHEMEAN
WRITE(7,1040)(ERMS(I),I-INS)
   FORMAT(18X,7HERMS
WRITE(7,1050)(ESD(I),I-INS)
   FORMAT(19X,6HESD
IF(IRCVR.EQ.1) WRITE(7,1060)TCOUNT
   FORMAT(//1H 4X,F7.2,22H(% OF SCANS ARE ABORTED))
IF(IRCVR.NE.1) WRITE(7,1070)
   FORMAT(5(/),4X,35H ON LAST SCAN, DIAGONAL OF GOGT WAS/26X)
WRITE(7,11)
   CALL INTIO(6H NRUNNRUN,1I).
WRITE(7,1110)
   6H FSC(TITLE1(I),I-INS)
WRITE(7,1120)
   1H,7I)
RETURN
C

C THIS SAVES/PROCESSES/OUTPUTS DATA FROM THE (LG)-TH SET OF KM SCANS
DO 1005 I=1,NS
EMEAN(I)=EMEAN(I)/KMNET
EVAR(I)=EVAR(I)/KMNET
ESD(I)=SQRT(EVAR(I))

CONTINUE

XW=ICOUNT
TCOUNT=100.*XW/KM
WRITE(7,1009)
   FORMAT(3(/)I)
WRITE(7,1010)KMNET
   FORMAT(5X,I6,15X,F7.2,22X('% OF SCANS ARE ABORTED'))
IF(IRCVR.EQ.1) WRITE(7,1015)
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   FORMAT(5(/),4X,35H ON LAST SCAN, DIAGONAL OF GOGT WAS/26X)
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   FORMAT(1HO,16XBHEMEAN
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   FORMAT(18X,7HERMS
WRITE(7,1050)(ESD(I),I-INS)
   FORMAT(19X,6HESD
IF(IRCVR.EQ.1) WRITE(7,1060)TCOUNT
   FORMAT(//1H 4X,F7.2,22H(% OF SCANS ARE ABORTED))
IF(IRCVR.NE.1) WRITE(7,1070)
   FORMAT(5(/),4X,35H ON LAST SCAN, DIAGONAL OF GOGT WAS/26X)
WRITE(7,11)
   CALL INTIO(6H NRUNNRUN,1I).
WRITE(7,1110)
   6H FSC(TITLE1(I),I-INS)
WRITE(7,1120)
   1H,7I)
RETURN
C

C THIS SAVES/PROCESSES/OUTPUTS DATA FROM THE (LG)-TH SET OF KM SCANS
DO 1005 I=1,NS
EMEAN(I)=EMEAN(I)/KMNET
EVAR(I)=EVAR(I)/KMNET
ESD(I)=SQRT(EVAR(I))

CONTINUE

XW=ICOUNT
TCOUNT=100.*XW/KM
WRITE(7,1009)
   FORMAT(3(/)I)
WRITE(7,1010)KMNET
   FORMAT(5X,I6,15X,F7.2,22X('% OF SCANS ARE ABORTED'))
IF(IRCVR.EQ.1) WRITE(7,1015)
   FORMAT(5X,B1H,THRESHOLD RCVR (FILTERED ERROR))
WRITE(7,1020) TITLE(I),I-1,NS)
   FORMAT(5(/),4X,35H ON LAST SCAN, DIAGONAL OF GOGT WAS/26X)
WRITE(7,1030)(EMEAN(I),I-INS)
   FORMAT(1HO,16XBHEMEAN
WRITE(7,1040)(ERMS(I),I-INS)
   FORMAT(18X,7HERMS
WRITE(7,1050)(ESD(I),I-INS)
   FORMAT(19X,6HESD
IF(IRCVR.EQ.1) WRITE(7,1060)TCOUNT
   FORMAT(//1H 4X,F7.2,22H(% OF SCANS ARE ABORTED))
IF(IRCVR.NE.1) WRITE(7,1070)
   FORMAT(5(/),4X,35H ON LAST SCAN, DIAGONAL OF GOGT WAS/26X)
WRITE(7,11)
   CALL INTIO(6H NRUNNRUN,1I).
WRITE(7,1110)
   6H FSC(TITLE1(I),I-INS)
WRITE(7,1120)
   1H,7I)
RETURN
C

C THIS SAVES/PROCESSES/OUTPUTS DATA FROM THE (LG)-TH SET OF KM SCANS
DO 1005 I=1,NS
EMEAN(I)=EMEAN(I)/KMNET
EVAR(I)=EVAR(I)/KMNET
ESD(I)=SQRT(EVAR(I))

CONTINUE

XW=ICOUNT
TCOUNT=100.*XW/KM
WRITE(7,1009)
   FORMAT(3(/)I)
WRITE(7,1010)KMNET
   FORMAT(5X,I6,15X,F7.2,22X('% OF SCANS ARE ABORTED'))
IF(IRCVR.EQ.1) WRITE(7,1015)
   FORMAT(5X,B1H,THRESHOLD RCVR (FILTERED ERROR))
WRITE(7,1020) TITLE(I),I-1,NS)
   FORMAT(5(/),4X,35H ON LAST SCAN, DIAGONAL OF GOGT WAS/26X)
WRITE(7,1030)(EMEAN(I),I-INS)
   FORMAT(1HO,16XBHEMEAN
WRITE(7,1040)(ERMS(I),I-INS)
   FORMAT(18X,7HERMS
WRITE(7,1050)(ESD(I),I-INS)
   FORMAT(19X,6HESD
IF(IRCVR.EQ.1) WRITE(7,1060)TCOUNT
   FORMAT(//1H 4X,F7.2,22H(% OF SCANS ARE ABORTED))
IF(IRCVR.NE.1) WRITE(7,1070)
   FORMAT(5(/),4X,35H ON LAST SCAN, DIAGONAL OF GOGT WAS/26X)
WRITE(7,11)
   CALL INTIO(6H NRUNNRUN,1I).
WRITE(7,1110)
   6H FSC(TITLE1(I),I-INS)
WRITE(7,1120)
   1H,7I)
DO 1130 J=2,LGMAX
1130 WRITE(7,1161) FSCA(J), EEMAS(J,I), I=1,NS
WRITE(7,1140) FSCA(J), EERMS(J,I), I=1,NS
DO 1190 J=2,LGMAX
1190 WRITE(7,1161) FSCA(J), EEST(J,I), I=1,NS
DO 1165 J=2,LGMAX
1165 WRITE(7,1161) FSCA(J), EEST(J,I), I=1,NS
1161 FORMAT(15X,9(G10.3,1X))
DO 1103 I=INS
1103 IF(I.EQ.7) FACTOR=180./PI
IF(I.EQ.8) FACTOR=5./PI
IF(I.EQ.9) FACTOR=5./PI
YMIN=.0
DO 1101 LG1=1,LGMAX
1101 EEME(LG1)=EERMS(LG1,I)*FACTOR
YNAME1(I)=YNAME1(I,I)
YNAME2(I)=YNAME2(I,I)
K1=MOD(I,2)
IF(K1.EQ.1) WRITE(7,11)
IF(K1.EQ.0) WRITE(7,10)
CALL PLOT1(FSCA,EEME,LGMAX,YNAME1,YMIN,YMAX,0)
CONTINUE
IF(.NOT.FILOUT) RETURN
WRITE(7,11) (OATOUT(I), I=1,2)
1170 FORMAT(13H OUTPUT FILE ZA10,/)
WRITE(7,1172) (OATOUT(I), I=1,2)
WRITE(17) IDENT,START
WRITE(17) NRUN,DSNR,DSRB,DSB,ECST,SEP
DO 1190 LGN=1,LGMAX
1190 WRITE(17) EEME(LGN), EERMS(LGN), EEST(LGN), TTC(LGN), YYMI(LGN), YYMA(LGN), FSCA(LGN), LGN
IX=ICATAL046LTAPE17,ATOUTZLPW,8RHIGHFILLZLRP,365)
GO TO 1196
CALL RETURN(6LTAPE17)
REWIND 17
IX=ICATAL046LTAPE17,ATOUTZLPW,8RHIGHFILLZLRP,365)
GO TO 1196
CALL RETURN(6LTAPE17)
REWIND 17

CTLMSPS1
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SUBROUTINE CONTRL

8400 IX=ICATALOG(6LTape17,OUTOUT,2LXR,3RHQFILL,2LRP,355)
   IF(IX.NE.0) CALL INTID(4HIX(I,1,1)
   IF(IX.NE.0) STOP#OUTPUT FILE CATALOG NOT SATISFACTORY#
   CALL RETURN(6LTape17)
   WRITE (7,1190) (OUTOUT(I),I=1,2)
   CALL RETURN(6LTape17)
   WRITE (7,1190) (OUTOUT(I),I=1,2)

405 CONTINUE
   C THIS EFFECTS CLOSURE OF THE SIMULATION RUN
   WRITE(7,11) RETURN

410 CONTINUE
   C THIS EFFECTS CLOSURE OF THE SIMULATION RUN
   WRITE(7,11) RETURN

415 CONTINUE
   C
   END

45000B CM STORAGE USED 13.054 SECONDS
SUBROUTINE CONTRL(ISW)

C THIS CONDUCTS THE MLS SIMULATION THROUGH A RMSE VS. FSC STUDY

C REAL LAMDA

INTEGER XNAME(2),YNAME(2),YNAM(2,9)

INTEGER XNAME(2),YNAME(Z),DATIN(4),DATLDUT(4),DOUT

INTEGER TITLEI(g),FUNCTN(2)

LOGICAL NDKLFINNOLENDACKALMAN,LOEJTETHRDMORENFIRSTPADAPTVI ...

COMMON/DCVROZ/RHOHAXDTHOTDROEOWSCONSO(4),NGO(4)

COMMON/RCVROA/DELTED(8),GQGT(D,8)H(C5,8),COUNTSIGMA

COMMON/RCVROS/NOLOENOKLMNNOACGAMAES(),ROIAG(5),PMDIAG(8)

COMMON/RCVR1O/XSI(8),XS(8)

C DIMENSION

DIMENSION X(8),THESER(1iS),XDATU(115),EEE(13),EERM(13)

DIMENSION IDNRS(6),IOASCI(20),IDENTS(6),EEST(1B),TTCO(13);YYMI(13)

DIMENSION VYMA(iB)

DIMENSION FSCA(13),ESME(13)

DIMENSION EEMEA(13D9),EERMS

DIMENSION EMEAN(9),EMS(9),ERMS(9),ESD(9)

EQUIVALENCE (EEME(C),EEMEA(1,2)),(EERM(1),EERMS(1,2)),...

EQUIVALENCE(THERRES(2))

DATA YNAM1/8HALF RMSE,8HMHDEGREES r

DATA YNAM2/RMSE,BHDEGREES /SHALR RMSE,8HTHR RS

DATA YNAM3/RMSE,BHDEGREES,

DATA ABORT(1HA/,SPACEIlH INFIRSTI.FALSE./,ADAPTV/.TRUE./

DATA DATIN/IOHMLSSIMOATAZOHZOOOOOFOOO,2*0 .. .

DATA DATDUT/1OHMLSSIMDATA,3*U/

DATA IDASCI/7HCROSSMP7HRSET)7HRMSE(B),7 BRH(F),IH

DATA XNAME/8HSCAN NO.,aH K /,YNAE/HTHES ERRSHDEGREES /

DATA XNAME1/8H FSC ,8H "HZ /

DATA DATA /...

DATA TITLE3/3/,TIT4/4/,FILEIN

DATA TITLE1/6H ALFA ,6H THETA,6H THEODOT,6H ALFAR,6H THETAR,6H THRDMORE

DATA TITLE2/6H ALFA ,6H THETA,6H THEODOT,6H ALFAR,6H THETAR,6H THRDMORE

DATA XNAME/8HSCAN NO.,8H K

DATA XNAME/FSC ,8H "HZ /

DATA FUNCTION/THAZITH,FHTE5AT,/

DATA CTLMNSFS2

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SUBROUTINE CTRL

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C

GO TO (160,200,300,400,500,600,700,800,900,1000,1100,1200),ISW

1 FORMAT (IN1)

10 FORMAT(9/I1)

11 FORMAT (1H1)

C

C*******************************************************************************

C

100 CONTINUE

C THIS IDENTIFIES THE SCENARIO AND REINITIALIZES, AS NECESSARY,

C THE FOLLOWING RECEIVER PARAMETERS

C SIGMA, IA, E, OSNR, RHD, FSC, BETA, JM, BML

70 IF (NFRST) GO TO 155

NDAC = TRUE,

NFIRST = TRUE,

JBNAM = JBNAM(EII)

ISIM = I

IMO = 2

WRITE (7,110)

110 FORMAT (9/HIEVIE VS. FSC STUDY)

CALL LOGIO(FHI,FILEIN,0)

IF (.NOT.FILEIN) NSTART = 0

120 CONTINUE

IF (.NOT.FILEIN) GO TO 122

IX = ATTACH(6LTAPE15,FILEIN)

IF (IX.EQ.0) CALL INTID(6HFILEIN,FILEOUT,0)

122 CALL LOGIO(FHI,FILEIN,FILEOUT,0)

NSTOP = NSTART

CALL INTID(6HSTOPT,FILEOUT,0)

CALL LOGIO(FHI,FILEOUT,FILEOUT,0)

IF (.NOT.FILEIN) GO TO 120

CONTINUE

95 IF (.NOT.FILEIN) ITETHRD = 2

CONTINUE

135 CONTINUE

DO 145 II2 = I

145 CONTINUE

120

150 CONTINUE

IDASC = 3*(I - 1) + 3NRS + 1

IDENTS(I) = IDASC(IASC)

CONTINUE

IASCDE(1) = 150, IDENTS(I) = IDASC(IASC) = IMCD

FORMAT(I7,11)

110 WRITE (7,5/12) IDNR, IMCD

FORMAT(12H, 1)

WRITE (7,153) IDENTS

FORMAT (12H, A9)

CALL INTIO(HKM, KM, KSTART)

KSTART = KM - KSTART + 1

WRITE (7,153) IDENTS

FORMAT (12H, A9)

CALL INTIO(HKM, KM, KSTART)

KSTART = KM - KSTART + 1

WRITE (7,153) IDENTS

FORMAT (12H, A9)

CALL INTIO(HFSC, FSC, KMAX)

READ (10,105) LMAX, (FSCA(I), I = 1, LMAX)

105 FORMAT (14/I5)
SUBROUTINE CONTRL

WRITE (7,250) FUNCTN (IAE), IAE

WRITE (7,260) ((1,H0)7,15H FUNCTION (IAE,1=I1=1N))

WRITE (7,270) IDENTS(I)

RETURN

C***************
C THIS IDENTIFIES THE BASIC RECEIVER STRUCTURE (THRHO, OPT, SUBOPT)
C AND REINITIALIZES AS NECESSARY THE FOLLOWING RXVR DATA
C (NEGATE ONLY), NOATOM, NOLMN, NOLOEB, RXVR, DELBL, TETHRD
C, NOLMN(2)

C NEGATE IR WITH THE FOLLOWING FOR NONADAPTIVE RECEIVER
C

RETURN

C***************
C THIS OUTPUTS BASIC RECEIVER DATA OF INTEREST
WRITE (7,410) (IDENTS(I), I=1,3,4),IRNG, NS, NS

RETURN

C***************
C THIS SETS-UP THE MSET-LOOP
ICOUNT=U
DO 510 I=1,LMAX
VNI(I)=-1.E322
510 YMA(I)=1.E322
RETURN

C***************
C THIS SETS-UP THE K-LOOP FOR THE KTH SET OF KTH SCANS
FSC=FSCA(LG)
X0(I,IAE)=2.*PI*FSC
X(I) = XG(I,IAE)
X(I) = XGRID(I,IAE)
DUN=GAUS(1.0)
WRITE (7,111)}
SUBROUTINE CONTRL

CALL INMOD6H NRUN,NAUN+1,1)
WRITE(7,703) LGFSC
CALL INMOD6H
WRITE(7,710) (TITLE(I),I=1,NS)
710 FORMAT(HD)
KX,K5,5HCSNH,4X,5HOTT "+73,A6,2X)
DO 712 I=1,NS
EMSN(I)+0.*
712 EMN(I)+0.*
LASTC+0.
COUNT=0.
DO 730 IPA=1,NS
CALL INTIOKMKM,1D1)
WRITE(7,710) (TITLEI,AINDNS)
710 FORMAT(bHOn",",4X,HCSNRT,4XHSTY:"-735
9(3AXA6,2X)
DO 733 IS=1,NS
COUNT=1.
CONTINUE
733 CONTINUE
RETURN
C
500 CONTINUE
C THIS INITIALIZES THE K-TH SCAN
SEP=SPACE
RETURN
C
500 CONTINUE
C THIS SAVES/PREPROCESSES DATA FROM THE K-TH SCAN
IF(I=ICOUNT-2,1) SEP=ABORT
WRITE(7,910) KCSNRT,(XSI,4=1,NS)
910 FORMAT(3HO ',13X,GIO.3,5H,-X-,9(GIO.3,1X)
WRITE7,920) (XS(I),I=INS)
920 FORMAT(1BXSH'XS-ZX,9G10.3,1X)
WRITE7,930) (ES(IINSI)
930 FORMAT(1BXH"ES-2"-G10.3)
IF(IRCVR.EQ.1) WRITE(7,940) COL8THERR
940 FORMAT(bX,15HUNFILT.ES(2),13X,G10.3)
RETURN
DO 960 I=1,NS
C
960 CONTINUE
C THIS SAVES/PREPROCESSES DATA FROM THE K-TH SCAN
C
IF(I=ICOUNT.1) SEP=ABORT
WRITE(7,910) KCSNRT,(XSI,4=1,NS)
910 FORMAT(3HO ',13X,GIO.3,5H,-X-,9(GIO.3,1X)
WRITE7,920) (XSI,1=1,NS)
920 FORMAT(1BXSH'XS-ZX,9G10.3,1X)
WRITE7,930) (ES(IINSI)
930 FORMAT(1BXH"ES-2"-G10.3)
RETURN
DO 960 I=1,NS
RETURN

C

C*******************************************************************************
C
100 CONTINUE
C THIS SAVES/PROCESSES/OUTPUTS DATA FROM THE (LG)-TH SET OF KM SCANS
DU LOUS I=1,NS
EMEAN(I)=EMEAN(I)/KMNET
EMSN(I)=EMSN(I)/KMNET
EMRMS(I)=SGRT(EMSN(I))
ESD(I)=SORT(EMSN(I)) - EMEAN(I)**2

1005 CONTINUE
X=ICOUNT
TCOUNT=LOUS.*XM/KM
WRITE(7,1009)
WRITE(7,1010)KMNET
WRITE(7,1015)ERRORSAMPLE STATISTICS: (.13,9H SAMPLES))
WRITE(7,1020)(TITLE1(I),I=1,NS)
WRITE(7,1030)(EMEAN(I),I=1,NS)
WRITE(7,1040)(EMSN(I),I=1,NS)
WRITE(7,1050)(ESD(I),I=1,NS)
IF(LG.EQ.1)WRITE(7,1060)(TCOUNT(TITL1(I)),I=1,NS)
WRITE(7,1070)(GQGT(I,I),I=1,NS)
WRITE(7,1080)(GQGT(I),I=1,NS)
WRITE(7,1090)(C1X,F7.2,F7.2)
WRITE(7,1091)(TTCO(I),I=1,NS)
IF(LG.EQ.1)RETURN
CALL INTIO(6HNRUN,RUN,1,1)
RETURN

C*******************************************************************************
C THIS SAVES/PROCESSES/OUTPUTS DATA FROM THE (MSET)-TH SERIES OF KM SCANS
WRITE(7,1100)
CALL INTIO(6HNRUN,RUN,1,1)
WRITE(7,1110)6H FSC (TITL1(I),I=1,NS)
1110 FORMAT(15H,10X,3HOTY -9(3X,A0,2X))
SUDROUIINE
CONTRL
73/172 TS
FTN 4,6+452
05/17/79 17:19:25

WRITE(7,1120)FSCA(J),(EEMEA(J,1),I-1,NS)

1120 FORMAT(1HG,7X,THEMEAN:9(G10.3,1X))
DO 1130 J=2,LGMAX
1130 WRITE(7,1161)FSCA(J),(EEMEA(J,1),I-1,NS)
WRITE(7,1140)FSCA(J),(EERM(J,1),I-1,NS)
DO 1150 J=2,LGMAX
1150 WRITE(7,1161)FSCA(J),(EERM(J,1),I-1,NS)
WRITE(7,1160)FSCA(J),(EEST(J,1),I-1,NS)
DO 1165 J=2,LGMAX
1160 WRITE(7,1161)FSCA(J),(EEST(J,1),I-1,NS)

355 IF(I.EQ.7) FACTOR180./PI.
IF(I.EQ.9) FACTOR180./PI.
YMIN=0.
YMAX=0.

1101 EEME(LGI)=EERM(LG1,1)*FACTOR

365 YNAME1(I)=YNAME1(I,1)
YNAME2(I)=YNAME2(I,2)
KL=NO(1,2)

372 IF(K1.EQ.1)WRITE(7,11)
IF(K1.EQ.1) Call XRTJO(6H NRUN,1,1)

1175 WRITE(7,1170) (DATOUT(I,1),I=1,2)
1170 FORMAT(2H OUTUP, FILE: ZA10,1M)
WRITE(7,1172) DOUT, DELT, TIMES, LGMAX, KM, TODAY, JNNAM
1172 FORMAT(1H A10,8X,G13.6,5X,3,15,1X),A10,8X,A10/L
WRITE(7,1174) IENDS, KSTART
1174 FORMAT(1H A10,8X,G13.6,5X,3,15,1X),A10,8X,A10/L
WRITE(1176) NRUN, DSNRD, RHO, BETA, FSC, TSEP
1176 FORMAT(1H A10,8X,G13.6,5X,3,15,1X),A10,8X,A10/L
DO 1175 LGN=1,LGMAX
1175 WRITE(7,1182) EEME(LGN), EERM(LGN), EEST(LGN), TTCD(LGN), YYM1(LGN),

385 YYML(LGN), FSCA(LGN), LGN

1182 FORMAT(1H A10,8X,G13.6,5X,3,15,1X),A10,8X,A10/L
WRITE(117) DOUT, DELT, TIMES, LGMAX, KM, TODAY, JNAM
WRITE(117) IENDS, KSTART
WRITE(117) NRUN, DSNRD, RHO, BETA, BLS, BRCVR, TSEP
DO 1190 LGN=1,LGMAX
1190 WRITE(7) EEME(LGN), EERM(LGN), EEST(LGN), TTCD(LGN), YYM1(LGN),

390 YYML(LGN), FSCA(LGN), LGN

1X=IATTACH(6LTAPE20,DATOUT) READ(20) DUM,DUM,DUM,DUM,DUM,DUM,DUM,DUM,DUM
CALL "RETURN(6LTAPE20)"
REWIND 17
1X=ICATAL0(6LTAPE17,DATOUT,2LHP,6RHTCHF1L,2LR,365)
GO TO 1196
400 CALL RETURN(6LTAPE20)
       REWIND 17
       IX=ICATALOG(6LTAPE17,OUTUT,2LXR,8NHIGHFILL,2LRF,359)
       IF(IX.NE.0) CALL INTIO(CAMIX(IX),IX,1,1)
       IF(IX.NE.0) STOP#OUTPUT FILE CATALOG NOT SATISFACTORY
       CALL RETURN(6LTAPE17)
       WRITE (7,1198) (OUTUT(IX),IX=1,2)
       WRITE (7,1198) "FORMAT(30#OUTPUT FILE )2A10,35H IS WRITTEN, CATALOGED AND CLOSED"
       RETURN
       CONTINUE
       THIS EFFECTS CLOSURE OF THE SIMULATION RUN
       WRITE(7,111)
       RETURN
       END
       450000 BM STORAGE USED 15561 SECONDS
SUBROUTINE CONTRL(ISW,
--C
C THIS CONDUCTS THE MLS SIMULATION THROUGH A
C RMSE VS. THETA SEP.
C--C

REAL LAMDA

INTEGER XNAE1(2),YNANE1(2),YNAM112(2),9
INTEGER TITL1(9),FUNCTN(2)
LOGICAL NOLAM,NOLOC,KALMAN,KOE,TETHRD,NORE,NFIRST,ADAPTV

CFILEIN,FILEOUT

COMMON/IDDATA/ISINO,IPMLSIRCVRIADAPITETHR IPOPT
COMMON/RCVRO/THAMAN,YTH2IN,YTS,THQEGA,YF
COMMON/XNAME1,THNAME1,ALPNAME1,ALPNAME1
COMMON/RCVRO/THAMAN,TORD,B0,DS,NGO(4),NGO(4)
COMMON/RCVRO/FI,F0,(8),FF,(8),FSEMPR,KR,TH,THD,NG,NS,SM
COMMON/RCVRO/DGT,EDO(8),GCT(8),H5(8),DOUT,STEM,COF
COMMON/RCVRO/NOLAM,NOLAM1,NOLOC,KALMAN,GAMES(3),RADI(3),PMG(3)
COMMON/RCVRO/PMG(8),RMAT(5,5),PHI(5,5),PA(8,8),LAMDA(5)
COMMON/RCVRO/THAMAN,TORD,B0,DS,NGO(4),NGO(4)
COMMON/RCVRO/THAMAN,THAMAN,TORD,B0,DS,NGO(4),NGO(4)
COMMON/RCVRO/THAMAN,THAMAN,TORD,B0,DS,NGO(4),NGO(4)
COMMON/RCVRO/THAMAN,THAMAN,TORD,B0,DS,NGO(4),NGO(4)
COMMON/RCVRO/THAMAN,THAMAN,TORD,B0,DS,NGO(4),NGO(4)
COMMON/RCVRO/THAMAN,THAMAN,TORD,B0,DS,NGO(4),NGO(4)
COMMON/RCVRO/THAMAN,THAMAN,TORD,B0,DS,NGO(4),NGO(4)
COMMON/RCVRO/THAMAN,THAMAN,TORD,B0,DS,NGO(4),NGO(4)
COMMON/RCVRO/THAMAN,THAMAN,TORD,B0,DS,NGO(4),NGO(4)
COMMON/RCVRO/THAMAN,THAMAN,TORD,B0,DS,NGO(4),NGO(4)
COMMON/RCVRO/THAMAN,THAMAN,TORD,B0,DS,NGO(4),NGO(4)
COMMON/RCVRO/THAMAN,THAMAN,TORD,B0,DS,NGO(4),NGO(4)
COMMON/RCVRO/THAMAN,THAMAN,TORD,B0,DS,NGO(4),NGO(4)
COMMON/RCVRO/THAMAN,THAMAN,TORD,B0,DS,NGO(4),NGO(4)
COMMON/RCVRO/THAMAN,THAMAN,TORD,B0,DS,NGO(4),NGO(4)
COMMON/RCVRO/THAMAN,THAMAN,TORD,B0,DS,NGO(4),NGO(4)
COMMON/RCVRO/THAMAN,THAMAN,TORD,B0,DS,NGO(4),NGO(4)
COMMON/RCVRO/THAMAN,THAMAN,TORD,B0,DS,NGO(4),NGO(4)
COMMON/RCVRO/THAMAN,THAMAN,TORD,B0,DS,NGO(4),NGO(4)
COMMON/RCVRO/THAMAN,THAMAN,TORD,B0,DS,NGO(4),NGO(4)
COMMON/RCVRO/THAMAN,THAMAN,TORD,B0,DS,NGO(4),NGO(4)
COMMON/RCVRO/THAMAN,THAMAN,TORD,B0,DS,NGO(4),NGO(4)
COMMON/RCVRO/THAMAN,THAMAN,TORD,B0,DS,NGO(4),NGO(4)
COMMON/RCVRO/THAMAN,THAMAN,TORD,B0,DS,NGO(4),NGO(4)
COMMON/RCVRO/THAMAN,THAMAN,TORD,B0,DS,NGO(4),NGO(4)
COMMON/RCVRO/THAMAN,THAMAN,TORD,B0,DS,NGO(4),NGO(4)
COMMON/RCVRO/THAMAN,THAMAN,TORD,B0,DS,NGO(4),NGO(4)
COMMON/RCVRO/THAMAN,THAMAN,TORD,B0,DS,NGO(4),NGO(4)
COMMON/RCVRO/THAMAN,THAMAN,TORD,B0,DS,NGO(4),NGO(4)
COMMON/RCVRO/THAMAN,THAMAN,TORD,B0,DS,NGO(4),NGO(4)
COMMON/RCVRO/THAMAN,THAMAN,TORD,B0,DS,NGO(4),NGO(4)
COMMON/RCVRO/THAMAN,THAMAN,TORD,B0,DS,NGO(4),NGO(4)
COMMON/RCVRO/THAMAN,THAMAN,TORD,B0,DS,NGO(4),NGO(4)
COMMON/RCVRO/THAMAN,THAMAN,TORD,B0,DS,NGO(4),NGO(4)
COMMON/RCVRO/THAMAN,THAMAN,TORD,B0,DS,NGO(4),NGO(4)
COMMON/RCVRO/THAMAN,THAMAN,TORD,B0,DS,NGO(4),NGO(4)
COMMON/RCVRO/THAMAN,THAMAN,TORD,B0,DS,NGO(4),NGO(4)
COMMON/RCVRO/THAMAN,THAMAN,TORD,B0,DS,NGO(4),NGO(4)
COMMON/RCVRO/THAMAN,THAMAN,TORD,B0,DS,NGO(4),NGO(4)
COMM
SUBROUTINE CONTRL 73/172 TS

GO TO (100,200,300,400,500,600,700,800,900,1000,1100,1200), ISW

1 FORMAT(1H)
10 FORMAT(1H1)
11 FORMAT(1H1)

C
C THIS IDENTIFIES THE SCENARIO AND REINITIALIZES, AS NECESSARY,
C THE FOLLOWING RECEIVER PARAMETERS
C SISMA, JAE, OSNRDB, RHO, FSC, ETA, JX, MKSML
C
70 IF(NFIRST) GO TO 155
NOAC=TRUE,
NFIRST=.TRUE.,
JUNAM=JOBNAME(I)
ISW=2,
IND=2,
WRITE (7,110)
110 FORMAT(25HIRMSE VS. THESEP SCENARIO/)
CALL LOGID(6HFILEINFILEIN,0)
IF (.NOT.FILEIN) NSTART=0

80 IF(.NOT.FILEIN) GO TO 122
IF(.NOT.FILEIN) CALL INTIO(6HFILEIN,0)
IF(IX.EQ.0) CALL INTIO(6HAT,IXI,IX11)
IF(IX.EQ.0) STOP=
IF(IX.EQ.0) INPUT FILE ATTACH NOT SATISFACTORY
WRITE(7,120) (DATIN(I),I=1,2)
120 FORMAT(6HTHIS READS INPUT FILE-,1A1O/)
CALL INTIO(6HFILEOUT,FILEOUT,0)
CALL INTIO(6HFILEATTACH NOT SATISFACTORY)
NSTOP=NSTART
CALL INTIO(6HFILEOUT,FILEOUT,0)
CALL INTIO(6HFILEATTACH NOT SATISFACTORY)
CONTINUE

95 IF(IADAP) IADAP=2,
IF(IADAP) GO TO 135
IF(TETHR) TETHR=2
CONTINUE

135 CONTINUE
DO 145 I=216

100 IASC=3*(I-1)+IDNRS(I)+2
IDENTS(I)=IDASC(IASC)
CONTINUE
WRITE(7,152) IDNRS,IMOD
CALL INTIO(1H,1A)
WRITE(7,153) IDENTS
CALL INTIO(6H LGMAX, LGMAX,13,0)

110 CALL INTIO(6H KM, KM,112,0)
CALL REALINT(6H TSEP, TSEP,0)
CALL REALINT(5H DTSEP, DTSEP,0)
KSTART=MENG(KM,KSTART)
DO 154 I=1,LGMAX

Page 2 of 8
SUBROUTINE CONTRL

TSEP(1) = TSEP0 + TSEP(1-1)
KNET = KM + KSTART + 1
FSCMIN = 1.0 / DELTA(IAE) * KNET
DTSEP = 2.0
RHO0 = 0.5
BETA = 0.5
IFS = 1.0
BHLS = 1.0
BRCVR = 1.0

CONTINUE

IF(FILEIN) GOTO 150
NRUN = NRUN + 1
WRITE(7,111)
CALL INTIO(6HNRUN,NRUN+1)
CALL REALIO(6HDSNRDB,DSNRDB0)
CALL REALIO(6H RHO,RHO0)
CALL REALIO(6H BETA,BETA0)
CALL INTIO(6H IFS,IFS0)
CALL REALIO(6H BHLS,BHLS0)
CALL REALIO(6H BRCVR,BRCVR0)

GOTO 167

CONTINUE

READ(15,160) NRUN, DSNRDB, RHO, BETA, IFS, BHLS, BRCVR
IF(EOF(15)) 170, 165
WRITE(7,111)
FORMAT(IS,3G10.3, SX, 15, ZG10.3)
IF(NRUN.LT.NSTART) GO TO 158
IF(NRUN.GE.NSTOP) MORE = .FALSE.
FSC = IFS * FSCMIN
XO(3,IAE) = XO(2,IAE) - TSEP(1)
XO(6,IAE) = XO(3,IAE)
RETURN

STOP
EOF
REACHED ON INPUT FILE

C-------------------------------
C THIS OUTPUTS BASIC SIMULATION DATA OF INTEREST, SUCH AS
C THE ANGLE FUNCTION, INITIAL STATE, ETC.
WRITE(7,210) NRUN, DSNRDB, RHO, BETA, IFS, BHLS, BRCVR
FORMAT(IS, 210)
IF(.NOT.FILOUT) GOTO 245
IF(NRUN.LT.EO) ENCODE(10, 220, DOUT) IDNR, IHU, IMOD, IHO, NRUN
FORMAT(IS, 220)
IF(NRUN.GE.EO) ENCODE(10, 230, DOUT) IDNR, IHU, IMOD, NRUN
FORMAT(IS, 230)
IF(NRUN.EQ.EO) CALL INTIO(6H NRUN, NRUN)
IF(.NOT.FILOUT) GOTO 245
IF(IHO.GT.0) WRITE(7, 240) DOUT(1), IHO, 1.2
FORMAT(IS, 240)
IF(IHO .LE. 0) CALL DATE(TODAY)
WRITE (7, 250) FUNCT(IAE), IAE
FORMAT(IS, 250)
SUBROUTINE CONTRL

73/172 TS

WRITE (7, 260) ((IXCI), I = 1, 8)

260 FORM (15H INITIAL STATE // (1H X(1), 4H = , G13, 6))
WRITE (7, 270) IDENTS(2)

175 CONTINUE

270 FORMAT (1H G, 13.6)
RETURN

C******************************************************************************

180 CONTINUE

C THIS IDENTIFIES THE BASIC RECEIVER STRUCTURE (THRHO, OPT, SUBOPT).

C AND REINITIALIZES, AS NECESSARY, THE FOLLOWING RCVR DATA.

CIR (NEGATE ONLY), NDAK, NOK, NDK, BCR, DEL, THROD.

ITIT = MIN(I, CIR, 2)

185 C NEGATE IR WITH THE FOLLOWING FOR NONADAPTIVE RECEIVER

C = ISIGN(IR, ISIGN)

C RETURN

190 C******************************************************************************

400 CONTINUE

C THIS OUTPUTS BASIC RECEIVER DATA OF INTEREST

WRITE (7, 410) IDENTS(1), I = 1, 4H IRNG, NS

410 FORMAT (1H G, 13.6, 6H DESIGN / 5H (IR-, 2, 4H NG-, I1, ZH)

WRITE (7, 420) IDENTS(I), I = 5, 6

420 FORM (1H G, 13.6, 7H)
RETURN

C******************************************************************************

500 CONTINUE

C THIS SETS-UP THE MSET-LOOP.

C COUNT = 0

DO 510 I = 1, LGMAX

510 YMY(I) = I - 1

RETURN

C******************************************************************************

600 CONTINUE

C THIS SETS-UP THE LG-LOOP FOR THE (KSET)-TH SERIES OF SETS.

RETURN

C******************************************************************************

700 CONTINUE

C THIS SETS-UP THE X-LOOP FOR THE (LG)-TH SET OF KM SCANS.

X(5), X(2), TSEP(LG)

705 FORM (1H G, 13.6, 5X, 5H X(5) = , G13, 6)

CALL INTO(6H "NRUN", NRUN = 1, 1)

CALL INTO(6H "KM", KM = 1, 1)
SUBROUTINE COITRL

WRITE(7,710) (TITLE(I, I=1, NS)

710 FORMAT(6HO
K,4X,5HCSNRT,4X,5HGTY ,9(3X,A6,2X))

DO 712 I=1, NS

712 EMEAN(I)=0.

ICOUNT=0

DO 720 IPA=1, NS

DO 720 JPA=1, NS

PA(IPA,JPA)=0.

720 CONTINUE

DO 730 I-1, NS

EMEAN(I)=EMEAN(I)+PA(I)

730 CONTINUE

RETURN

800 CONTINUE

230 WRITE(7,710) TITLE(I, I=1, NS)
SUBROUTINE CONTRL '73/172' TS

DO 1005 I=1,NS
  EMEAN(I)=EMEAN(I)/KMNET
  ENS(I)=ENS(I)/KMNET
  ERMS(I)=SQRT(ENS(I)-EMEAN(I)**2)
  ESD(I)=SORT(ENS(I)-EMEAN(I)**2)
  CONTINUE
X=ICOUNT
TCOUNT=100.*X/W/KM
WRITE(7,1009)
* 1009 FORMAT(18X,7HERMS ,9(G2.3,1X))
WRITE(7,1050)(EMEAN(I),I=1,NS)
* 1050 FORMAT(18X,7HERMS ,9(G2.3,1X))
WRITE(7,1040)(ERMS(I),I=1,NS)
* 1040 FORMAT(18X,7HERMS ,9(G2.3,1X))
WRITE(7,1030)(ESD(I),I=1,NS)
* 1030 FORMAT(18X,7HERMS ,9(G2.3,1X))
IF(IRCVR.EQ.1)WRITE(7,1060)TCOUNT
* 1060 FORMAT(18X,5H,4X,F7.2,22HX OF SCANS ARE ABORTED)
IF(IRCVR.NE.1)WRITE(7,1070)(GQGT(I),I=1,NS)
* 1070 FORMAT(18X,5H,4XSSH ON LAST SCAN, DIAGONAL OF GQGT WAS/26X)
  CY(G10.3,1X))
  RETURN
C
C THIS SAVES/PROCESSES/OUTPUTS DATA FROM THE (MSET)-TH SERIES OF CLGMAX SETS OF KK SCANS
CALL PLOTR(XDATUM,THESEP(1),THESEP(2),THESEP(3),THESEP(4))
RETURN
SUBROUTINE CONTRL

WRITE(7,1161) TSEP(J), (EERM(J,1), I=1,NS)
WRITE(7,1160) TSEP(1), (EESTD(1,1), I=1,NS)
DO 1165 J=1,LMAX
WRITE(7,1161) TSEP(J), (EERM(J,1), I=1,NS)
WRITE(7,1161) TSEP(J), (EESTD(J,1), I=1,NS)
DO 1175 LGH=1,LMAX
WRITE(7,1162) EEME(LGH), EERS(LGH), EEST(LGH), TTOC(LGH), YYNI(LGH), YMIN(LGH), YMAX(LGH), TSEP(LGH), LGH
CALL RETURN(6LTAPE20.
REWIND 17
CALL RETURN(6LTAPE17)
IF(K1.EQ.0) CALL INTIO(6H1X(CA, 1,1)
IF(K1.EQ.1) WRITE(7,1198)
CONTINUE
DO 1193 I=1,NS
FACTOR=1.
IF(I.EQ.7) FACTOR=180./PI
IF(I.EQ.8) FACTOR=.5/PI
IF(I.EQ.9) FACTOR=.5/PI
YMIN=0.
YMAX=0.
DO 1101 LGI=1,LMAX
EENE(LGI)=EERM(LGI,1)*FACTOR
YNAME1(LGI)=YMA1(LGI,1)
YNAME2(LGI)=YMA1(LGI,2)
KI=MOD(122,
IF(KI.EQ.1) WRITE(7,11)
IF(KI.EQ.2) WRITE(7,11)
IF(KI.EQ.3) WRITE(7,11)
IF(KI.EQ.4) WRITE(7,11)
IF(KI.EQ.5) WRITE(7,11)
IF(KI.EQ.6) WRITE(7,11)
IF(KI.EQ.7) WRITE(7,11)
IF(KI.EQ.8) WRITE(7,11)
IF(KI.EQ.9) WRITE(7,11)
IF(KI.EQ.0) WRITE(7,11)

CALL RETURN(6LTAPE20.
REWIND 17
CALL RETURN(6LTAPE17)
IF(K1.EQ.0) STAMP(OUTPUT FILE CATALOG NOT SATISFACTORY)
CALL RETURN(6LTAPE17)
WRITE(7,1198)
CONTINUE
DO 1193 I=1,NS
FACTOR=1.
IF(I.EQ.7) FACTOR=180./PI
IF(I.EQ.8) FACTOR=.5/PI
IF(I.EQ.9) FACTOR=.5/PI
YMIN=0.
YMAX=0.
DO 1101 LGI=1,LMAX
EENE(LGI)=EERM(LGI,1)*FACTOR
YNAME1(LGI)=YMA1(LGI,1)
YNAME2(LGI)=YMA1(LGI,2)
KI=MOD(122,
IF(KI.EQ.1) WRITE(7,11)
IF(KI.EQ.2) WRITE(7,11)
IF(KI.EQ.3) WRITE(7,11)
IF(KI.EQ.4) WRITE(7,11)
IF(KI.EQ.5) WRITE(7,11)
IF(KI.EQ.6) WRITE(7,11)
IF(KI.EQ.7) WRITE(7,11)
IF(KI.EQ.8) WRITE(7,11)
IF(KI.EQ.9) WRITE(7,11)
IF(KI.EQ.0) WRITE(7,11)

CALL RETURN(6LTAPE20.
REWIND 17
CALL RETURN(6LTAPE17)
IF(K1.EQ.0) STAMP(OUTPUT FILE CATALOG NOT SATISFACTORY)
CALL RETURN(6LTAPE17)
WRITE(7,1198)
CONTINUE
DO 1193 I=1,NS
FACTOR=1.
IF(I.EQ.7) FACTOR=180./PI
IF(I.EQ.8) FACTOR=.5/PI
IF(I.EQ.9) FACTOR=.5/PI
YMIN=0.
YMAX=0.
DO 1101 LGI=1,LMAX
EENE(LGI)=EERM(LGI,1)*FACTOR
YNAME1(LGI)=YMA1(LGI,1)
YNAME2(LGI)=YMA1(LGI,2)
KI=MOD(122,
SUBROUTINE CONTRL 73/172 T5  

CALL PLOTR(TSEP, EME, LGMAX, XNAME1, YNAME1, YMIN, YMAX, 0)

CONTINUE
RETURN

CONTINUE
RETURN

END

40000 CM STORAGE USED 12.547 SECONDS
SUBROUTINE CONTRL(ISW)
C
THIS CONDUCTS THE MLS SIMULATION THROUGH A
STUDY OF LOE PERFORMANCE

REAL LAMDA
REAL E(1), TE(1), HSE

INTEGER FUNCTN(2)
REAL XNA(1), YNA(1)

DIMENSION IDNRS(6), IDASC(6), IDENTS(6)

DIMENSION AK(50), ATE(50), PA(50), PA(50)

DATA ABORT/1H1, SPACE/I, ADAPTV/0.0/ 

DATA NAMES/6H EIAVG, 6H E2AVG, 6H EIMIN, 6H EZMIN, 
45 6H E1MAX, 6H EZMAX, 6H E1RMS, 6H E2RMS, 6H ARIDAVG, 

DATA NAMEO/6H TEAVG, 6H TEMIN, 6H TEMAX, 6H TERM, 6H ZH 

DATA XNA(b), YNA(b)

GO TO (100;20/300jD;0040;00;800;900;800,800,1000,1100,1200) ISM

FORMAT (1H)
FORMAT (9(1H))
FORMAT (1H)
CCONTINUE

CTHIS IDENTIFIES THE SCENARIO AND REINITIALIZES, AS NECESSARY.
CTHE FOLLOWING RECEIVER PARAMETERS
C\SIGMA, IAE, DSNRDB, RHOD, FSC, BETA, JM, BML.

CONTINUE

XO(I,3,AE) = XO(2,IAE) + TSEP(I) + (I-1) * DTSEP
XO(I,6,IAE) = XO(3,IAE) - BETA * FLTMIN

CONTINUE

IF (IRCVR.EQ.1) GO TO 125
CONTINUE

DO 120 I = 1, LGMAX
...
C This outputs basic simulation data of interest, such as the angle function, initial state, etc.
CALL DATE(TODAY)
WRITE (7,250) FUNCTION (IAE),IAE
WRITE (7,260) ((IX(I)),I=1,B)
WRITE(7,270) IDENTS(2)
WRITE(7,410) (IDENTS(I),I=3,6)
WRITE(7,420) (I0ENTSCI)bI=5,6)
DO 50 J=1,LGMAX
BULL(11,J)=0,
BULL(12,J)=+I.E32
BULK(13,J)=1.E32
BULK(14,J)=0.
BULK(15,J)=0.
BULK(16,J)=0.
SERCQUIRE CONH 73/172  
SUADOUNE CONH 73/172  
TS  
FTN 4,6+452  
05/17/79 17.25.54 PAGE 3
```
SUBROUTINE CONTROL

BULK(17, J) = 1.32
BULK(19, J) = -1.32
BULK(21, J) = 1.32
BULK(22, J) = -1.32
BULK(23, J) = 0.
BULK(24, J) = 0.
BULK(25, J) = 0.

CALL INTO (MSETM, M1, 0)
WRITE(7, 510)
FORMAT(1L1, 1.E32, 2, 1.E32, ERROR PERFORMANCE)
WRITE(7, 511) (TSEP(I), I = 1, LMAX)
WRITE(7, 512) (TSEP(I), I = 1, LMAX)
RETURN

C******************************************************************************
C
C 500 CONTINUE
C THIS SETS-UP THE L-G LOOP FOR THE (MSET)-TH SERIES OF SETS
BETA = BETA(MSET)
X0(I, IA) = PI * BETA / 180.
X(I) = X0(I, IA)
IF(MOD(MSET, 10) .EQ. 0) WRITE(7, 511) (TSEP(I), I = 1, LMAX)
RETURN

C******************************************************************************
C
C 600 CONTINUE
C THIS SETS-UP THE K-LOOP FOR THE (L-G)-TH SET OF KM SCANS
THESEP = TSEP(LG)
X(I) = X2(I, THESEP)
DUR = GAUSS (L0)
LASTCT = 0
ICOUNT = 0
FL10(I) = 0.
THETAV = 0.
THETMX = 1.32
THETMN = -1.32
THERMS = 0.
E1AVG = 0.
E2AVG = 0.
E1MIN = -1.32
E2MIN = -1.32
E1MAX = 1.32
E2MAX = 1.32
E1RMS = 0.
E2RMS = 0.
MSE = 0.
LASTCT = 0
DO 705 I = 1, 6
DO 705 J = 1, 6
PA(I, J) = 0.
705...
```
SUBROUTINE CONTRL

53/172 S.

FTN q.6+452

05/17179

17.25.54

PAGE

RETURN

C

CONTINUE

C THIS INITIALIZES THE K-TH SCAN

DD 810 I=1,5

IFI(TIETHIKD) RETURN

RETURN

C

CONTINUE

C THIS SAVES/PREPROCESSES DATA FROM THE K-TH SCAN

DO 810 I=1,5

RDIAG(I)=0

IF(ABS(T&THIKD)) RETURN

RETURN

C

CONTINUE

C FOLO SHOULD BE IN RCVR

CONTINUE

C THIS SAVES/PREPROCESSES DATA FROM THE K-TH SCAN

C

FOLO SHOULD BE IN RCVR

C

XS(1)=ABS(XS(1))

X5(4)=ABS(XS(4))

IF(LASTCT=ME) SEPIABORT

THER=X(2)-XS(2)

THET=E1MAX1(THET,E(2))

THEMV-E1MAX1(THET,M(E(2)))

DS1G(SIG1,SQRT(RDIAG(1)))

SIG2=SQR{T(RDIAG(2))}

E(1)=TE(1)/SIG1

E(2)=TE(2)/SIG2

E1AVG=E1AVG+E(1)

E2AVG=E2AVG+E(2)

EIMIN=AMIN1(E1,EIMIN)

EIMAX=AMAX1(E1,EIMAX)

E1AVG=E1AVG+E(E(1))

E2AVG=E2AVG+E(E(2))

DO 920 J=1,2

NSW.J=NSW.J+TE(J)*PHI(I,J)

RETURN

C

CONTINUE

SIG1=SIG1+TE(1)

SIG2=SIG2+TE(2)

E1AVG=E1AVG+TE(1)

E2AVG=E2AVG+TE(2)

EIMIN=AMIN1(E1,EIMIN)

EIMAX=AMAX1(E1,EIMAX)

E1AVG=E1AVG+TE(1)

E2AVG=E2AVG+TE(2)

DO 920 J=1,2

NSW.J=NSW.J+TE(J)*PHI(I,J)

RETURN

C
SUBROUTINE CONTRL

C THIS SAVES/PROCESSES/OUTPUTS DATA FROM THE (LG)-TH SET OF KM SCANS

C

BULL(1,LG)=THETAY/KMNET
BULL(2,LG)=THETXM
BULL(3,LG)=THETMN
BULL(4,LG)=THETMX
BULL(5,LG)=BULL(1,LG)+BULL(2,LG)
BULL(6,LG)=BULL(3,LG)+BULL(4,LG)
BULL(7,LG)=BULL(5,LG)+BULL(6,LG)
BULL(8,LG)=BULL(5,LG)+BULL(7,LG)
BULL(9,LG)=BULL(6,LG)+BULL(8,LG)
BULL(10,LG)=BULL(7,LG)+BULL(9,LG)
BULL(11,LG)=BULL(8,LG)+BULL(10,LG)
BULL(12,LG)=BULL(9,LG)+BULL(11,LG)
BULL(13,LG)=BULL(10,LG)+BULL(12,LG)
BULL(14,LG)=BULL(11,LG)+BULL(13,LG)
BULL(15,LG)=BULL(12,LG)+BULL(14,LG)
BULL(16,LG)=BULL(13,LG)+BULL(15,LG)
BULL(17,LG)=BULL(14,LG)+BULL(16,LG)
BULL(18,LG)=BULL(15,LG)+BULL(17,LG)
BULL(19,LG)=BULL(16,LG)+BULL(18,LG)
BULL(20,LG)=BULL(17,LG)+BULL(19,LG)
BULL(21,LG)=BULL(18,LG)+BULL(20,LG)
BULL(22,LG)=BULL(19,LG)+BULL(21,LG)
BULL(23,LG)=BULL(20,LG)+BULL(22,LG)
BULL(24,LG)=BULL(21,LG)+BULL(23,LG)
BULL(25,LG)=BULL(22,LG)+BULL(24,LG)
BULL(26,LG)=BULL(23,LG)+BULL(25,LG)
BULL(27,LG)=BULL(24,LG)+BULL(26,LG)
BULL(28,LG)=BULL(25,LG)+BULL(27,LG)
BULL(29,LG)=BULL(26,LG)+BULL(28,LG)
BULL(30,LG)=BULL(27,LG)+BULL(29,LG)
BULL(31,LG)=BULL(28,LG)+BULL(30,LG)
BULL(32,LG)=BULL(29,LG)+BULL(31,LG)
BULL(33,LG)=BULL(30,LG)+BULL(32,LG)
BULL(34,LG)=BULL(31,LG)+BULL(33,LG)
BULL(35,LG)=BULL(32,LG)+BULL(34,LG)
BULL(36,LG)=BULL(33,LG)+BULL(35,LG)
BULL(37,LG)=BULL(34,LG)+BULL(36,LG)
BULL(38,LG)=BULL(35,LG)+BULL(37,LG)
BULL(39,LG)=BULL(36,LG)+BULL(38,LG)
BULL(40,LG)=BULL(37,LG)+BULL(39,LG)
BULL(41,LG)=BULL(38,LG)+BULL(40,LG)
BULL(42,LG)=BULL(39,LG)+BULL(41,LG)
BULL(43,LG)=BULL(40,LG)+BULL(42,LG)
BULL(44,LG)=BULL(41,LG)+BULL(43,LG)
BULL(45,LG)=BULL(42,LG)+BULL(44,LG)
BULL(46,LG)=BULL(43,LG)+BULL(45,LG)
BULL(47,LG)=BULL(44,LG)+BULL(46,LG)
BULL(48,LG)=BULL(45,LG)+BULL(47,LG)
BULL(49,LG)=BULL(46,LG)+BULL(48,LG)
BULL(50,LG)=BULL(47,LG)+BULL(49,LG)
BULL(51,LG)=BULL(48,LG)+BULL(50,LG)
BULL(52,LG)=BULL(49,LG)+BULL(51,LG)
BULL(53,LG)=BULL(50,LG)+BULL(52,LG)
BULL(54,LG)=BULL(51,LG)+BULL(53,LG)
BULL(55,LG)=BULL(52,LG)+BULL(54,LG)
BULL(56,LG)=BULL(53,LG)+BULL(55,LG)
BULL(57,LG)=BULL(54,LG)+BULL(56,LG)
BULL(58,LG)=BULL(55,LG)+BULL(57,LG)
BULL(59,LG)=BULL(56,LG)+BULL(58,LG)
BULL(60,LG)=BULL(57,LG)+BULL(59,LG)
BULL(61,LG)=BULL(58,LG)+BULL(60,LG)
BULL(62,LG)=BULL(59,LG)+BULL(61,LG)
BULL(63,LG)=BULL(60,LG)+BULL(62,LG)
BULL(64,LG)=BULL(61,LG)+BULL(63,LG)
BULL(65,LG)=BULL(62,LG)+BULL(64,LG)
BULL(66,LG)=BULL(63,LG)+BULL(65,LG)
BULL(67,LG)=BULL(64,LG)+BULL(66,LG)
BULL(68,LG)=BULL(65,LG)+BULL(67,LG)
BULL(69,LG)=BULL(66,LG)+BULL(68,LG)
BULL(70,LG)=BULL(67,LG)+BULL(69,LG)
BULL(71,LG)=BULL(68,LG)+BULL(70,LG)
BULL(72,LG)=BULL(69,LG)+BULL(71,LG)
BULL(73,LG)=BULL(70,LG)+BULL(72,LG)
BULL(74,LG)=BULL(71,LG)+BULL(73,LG)
BULL(75,LG)=BULL(72,LG)+BULL(74,LG)
BULL(76,LG)=BULL(73,LG)+BULL(75,LG)
BULL(77,LG)=BULL(74,LG)+BULL(76,LG)
BULL(78,LG)=BULL(75,LG)+BULL(77,LG)
BULL(79,LG)=BULL(76,LG)+BULL(78,LG)
BULL(80,LG)=BULL(77,LG)+BULL(79,LG)
BULL(81,LG)=BULL(78,LG)+BULL(80,LG)
BULL(82,LG)=BULL(79,LG)+BULL(81,LG)
BULL(83,LG)=BULL(80,LG)+BULL(82,LG)
BULL(84,LG)=BULL(81,LG)+BULL(83,LG)
BULL(85,LG)=BULL(82,LG)+BULL(84,LG)
BULL(86,LG)=BULL(83,LG)+BULL(85,LG)
BULL(87,LG)=BULL(84,LG)+BULL(86,LG)
BULL(88,LG)=BULL(85,LG)+BULL(87,LG)
BULL(89,LG)=BULL(86,LG)+BULL(88,LG)
BULL(90,LG)=BULL(87,LG)+BULL(89,LG)
BULL(91,LG)=BULL(88,LG)+BULL(90,LG)
BULL(92,LG)=BULL(89,LG)+BULL(91,LG)
BULL(93,LG)=BULL(90,LG)+BULL(92,LG)
BULL(94,LG)=BULL(91,LG)+BULL(93,LG)
BULL(95,LG)=BULL(92,LG)+BULL(94,LG)
BULL(96,LG)=BULL(93,LG)+BULL(95,LG)
BULL(97,LG)=BULL(94,LG)+BULL(96,LG)
BULL(98,LG)=BULL(95,LG)+BULL(97,LG)
BULL(99,LG)=BULL(96,LG)+BULL(98,LG)
BULL(100,LG)=BULL(97,LG)+BULL(99,LG)

RETURN

C

C******************************************************************

C 1100 CONTINUE

C THIS SAVES/PROCESSES/OUTPUTS DATA FROM THE (MSET)-TH SERIES OF
C LGMAX SETS OF KM SCANS

WRITE(7,1101) BETA

1101 FORMAT(1HO,F7.2)

DO 1160 1=1,4
WRITE(7,1150) NAMEB(I),(BULK(I,J),J-1,LGMAX)
1150 FORMAT(1H,7X,A6,1H,10(X,G10.3))
1160 CONTINUE

IF(IRCVR.EQ.1) WRITE(7,1190) (PABORT(J),J-1,LGMAX)
1190 FORMAT(1H,7X,A6,1H,10(X,G10.3))

WRITE(7,1115) NAMES(I),(BULK(I,J),J-1,LGMAX)
1115 FORMAT(1H,7X,A6,1H,10(X,G10.3))

CONTINUE
RETURN

345

CONTINUE

C THIS EFFECTS CLOSURE OF THE SIMULATION RUN

350

BULL(14, I) = SORT(BULL(14, I) / MTIMES)

355

IF (IRCVR = EQ. 1) GOTO 1200

BULK(15, I) = BULK(15, I) / MTIMES

360

CONTINUE

WRITE (7, 1230)

1230

FORMAT (3, 4X, A4, A6, I6, 10X, G10.3)

1233

CONTINUE

IF (IRCVR = EQ. 1) WRITE (7, 1234) ABMAX, 6HABGRT, (PASMAX (J), J = 1, LGMAX)

370

IF (IRCVR = EQ. 1) GOTO 1240

WRITE (7, 1240) NAMES (IT), NAMES (IT), (BULK (I, J), J = 1, LGMAX)

1243

FORMAT (3S, 4X, A4, A6, I6, 10X, G10.3)

1245

CONTINUE

1248

CONTINUE

WRITE (7, 1250)

1250

FORMAT (13H GQGT (II)', G13.6, A7, X, G13.6)

RETURN

380

END

440 GB CM STORAGE USED 7.674 SECONDS
SUBROUTINE MLSSUB
REAL LAMDA
LOGICAL NOKLM, NOLOE, NDAC, KALMAN, LOE, TETHRO, MORE
COMMON/KCVR0/D, THAMAX, THAMIN, 15, TR, OMEGA, TF
COMMON/KCVR1/NGIN, NGMAX, NGA, OMEGA, TF
COMMON/KCVR2/Omega, DTHO, T0R0, BD, WSCD, NSON(4), NGO(4)
COMMON/KCVR3/P, F, 1(6, 1), FL251(4), FSAMP, K, TETHRO, NG, HS, JM
COMMON/KCVR4/DELTA, ED(4), GGT(8, 1), HS(8), COUNT, SIGMA
COMMON/KCVR5/NG, NOKLM, NDAC, GAMES(5), RDIAG(5), PHDIAG(8)
COMMON/KCVR6/PA(60), P(14), VM, VE
COMMON/KCVR7/IR(130), V(8)
COMMON/KCVR8/RO(130), V(8)

COMMON/NLSUO/CSNRT, CSNRF, DSNRDB, RHO, BETS, FSC, LGMAX
COMMON/NLSU1/CSNRT, CSNRF, DSNRDB, RHO, BETS, FSC, LGMAX
COMMON/NLSU2/OSNRRT, CSNRF, DSNRDB, RHO, BETS, FSC, LGMAX
COMMON/NLSU3/CF1OAEL(4, 2), CF1O(4), DELTAT(2), XO(8, 2), YO(4, 2)
COMMON/NLSU4/OMEGA, OMEGA, OMEGA
COMMON/NLSU5/OMEGA
COMMON/NLSU6/OMEGA
COMMON/NLSU7/OMEGA
COMMON/NLSU8/OMEGA
COMMON/NLSU9/OMEGA
COMMON/NLSU10/OMEGA

C GENERAL SIMULATION: OPTIMIZATION OF MLS RECEIVERS FOR
C MULTIPATH ENVIRONMENTS.

DIMENSION XI(0), INDEX(2), Y(4), X(8)

C EQUIVALENCE (THAMAX, Y(1)), (ALFA, X(1))

C FOLG BEGINS EXECUTABLE STATEMENTS

PI1 = 4.0 * PI
SQ2 = SQRT(2.0)

DO 10 I = 1, 8
F(I) = 1.0
10 CONTINUE

CALL CONTROLL(1)

DO 20 I = 1, 8

C FOLLOWING COMPLETE INITIALIZATION AND COMPUTES SECONDARY
C PARAMETERS.

DO 15 I = 1, 4

FLD(I) = CF1OAEL(I, 1)
15 CONTINUE

DO 20 I = 5, 8

V(I) = Y(I, 1)
20 CONTINUE

OMEGA = (THAMAX - THAMIN) / TS

SECPD = 1.0 / OMEGA

TF = TS + TR * 2.0 + THAMIN * SECPD

C FOLG ARE CONSTANT PARAMETERS USED BY P

BBD = 2.4 / MLS

DUM = GAUSS1(1.0)

ALPHA = 10.0 * (DSNRD8 / 20.0)

XO(1) = ALPH(2)

ALPHA = RNO + ALPHA

ALPHA = RNO + ALPHA
PROGRAM MLSSIM (INPUT, OUTPUT, TAPE10=INPUT, TAPE12, TAPE15, TAPE7=OUTPUT, TAPE17, TAPE20)
REAL LAMDA
LOGICAL KOLMN, NOLOE, NOAC, KALMAN, LOE, TETHRD, MORE
COMMON /IDDATA/ IDNRS(6)
COMMON /RCVRO6/ THNAX, THAMIN, TS, TR, OMEGA, TF
COMMON /RCVRO1/ NMIN, NMAX, DELB, NMIN, TR, NAE
COMMON /RCVRO2/ RMINAX, OTH10, TD00, WSDO, NSD(4), NGO(4)
COMMON /RCVRO3/ P1, F(8, 6), FL25(4), FSAP, KM, TETHRD, NG, NS, JM
COMMON /RCVRO4/ DELT, EDI, GORT(8, 8), K(5, 8), ICOUNT, SIGMA
COMMON /RCVRO5/ NOLOE, NOCLNR, LAC, GAMES(5), MID1G(4), PMD1G(8)
COMMON /RCVRO6/ PPD1G(8), RMAT(5, 5), PHI(5, 5), PA(8, 8), LAMDA(5)
COMMON /RCVRO7/ T, V(130), V(130)
COMMON /RCVRO8/ /SLOE(8), ESLDE(8), ES(8)
COMMON /RCVRO9/ BCRVR, B8, PDCRIT, TC
COMMON /RCVRO10/ XS1(8), XS(6)
COMMON /MLSO01/ CSNRT, CSNRF, OSNRD, RMD, BETA, FSC, LGMAX
COMMON /MLSO02/ DCSNR, CSNR, LG, TPKT, TPKF
COMMON /MLSO03/ FLIOAE(4, 2), FL10(4), DELTAT(2), XO(8, Z), TO(4, 2)
COMMON /MLSO04/ BALS, B88, ATIES, HSET, MORE

CONTINUE
CALL MLSSUB
IF (MORE) GO TO 10
STOP
END

410008 CM STORAGE USED 134 SECONDS
FUNCTION THA(T)

C THIS COMPUTES THE ANTENNA SCAN ANGLE AT LOCAL SCAN TIME T.
C THE PARAMETERS OF THE SCAN WAVEFORM HENCE THE IDENTITY OF
C THE ANGLE FUNCTION ARE PASSED THROUGH COMMON AND ARE DEFINED
C AS FOLLOWS:
C TS = DURATION OF THE TO SCAN
C TF = DURATION OF THE TO SCAN + INTERSCAN REST INTERVAL
C THAMAX = ANTENNA ANGLE AT BEGINNING OF TO SCAN
C THAMIN = ANTENNA ANGLE AT END OF TO SCAN
C OMEGA = ANTENNA ANGULAR SCAN RATE, DEG/SEC, DURING TO SCAN
C
C COMMON/RCVR00G/THAMAX, THAMIN, TS, TR, OMEGA, TF
C
15 TI = TS + TF

C IF (T.GE.0.0) GO TO 50
C
THA = THAMAX
RETURN

20 IF (T.GT.TR) GO TO 100
THA = THAMAX + OMEGA * T
RETURN

100 IF (T.GE.TF) GO TO 200
THA = THAMIN
RETURN

200 IF (T.GT.TI) GO TO 250
THA = THAMIN + OMEGA * (T - TF)
RETURN

250 THA = THAMAX
RETURN

END

41000D* CM STORAGE USED ---- 118 SECONDS
SUBROUTINE MLSSUB

GO(4,IAE)=ALPHAR
GO(7,IAE)=PI*Beta(1)
GO(6,IAE)=PI*FSAC
DELT=DELTAT(IAE)
F(2,3)=DELT
F(5,6)=DELT
F(7,8)=DELT
JM3=JM+1
JNZ=JM/2

DO 30 I=1,8
X(I)=GO(I,IAE)
CONTINUE
CALL CONTRL(2)

C FOLG CALLS RECEIVER FOR INITIALIZATION

75
K=O
CALL RCVR

80
C FOLLOWING BEGINS SIMULATION PER SE, LGMAX RUNS OF KM SCANS EACH

CALL CONTRL(5)
DO 777 MMSET=1,MTIMES
MSET=MMSET

CALL CONTRL(6)
DO 1 LGG=1,LGMAX
LG=LG+1
CALL CONTRL(7)
DO 2 KK=1,KM

CALL CONTRL(8)
IF(K.EQ.1) GO TO 122

90
C FOLLOWING ADVANCES THE TRUE STATE AND SAVE PRIOR VALUE

DO 100 I=1,8
X(I)=X(I)
100 CONTINUE

DO 120 J=2,8
X(J)=F(I,J)*X(I)
110 CONTINUE

B=VALUE(B+PI,O)

C FOLG SETS THESE PRIOR TO COMPUTING SAMPLE TIMES

THES=XS(2)*DELT*XS(3)
110
IF(.NOT.TETHRO) GO TO 124

122 CONTINUE
DO 123 I=1,8
XS1(I)=XS(I)
123 CONTINUE
THERESIX(2)

C FOLG BEGINS COMPUTATION OF SIGNALS AND RELATED QUANTITIES
C FIRST, CALCULATION OF CONSTANTS ON THE PRESENT SCAN
C
ALZ*ALFA**2
AR2*ALFAR**2
AAZ*2*ALFA*ALFAR
TPS+(THES-THAPAX)*SECPO
TPSF+TF+(THAMIN-THES)*SECPD
I2=TPST=I2W2
TTPS=TPSF+I2W2
C FOLG COMPUTES FOR THIS KTH SCAN THE SIGNAL PEAK TIMES TPKT, TPKF AND
C THE COMPOSITE SIGNAL-TO-NOISE RATIO CSNR(K)
TPKT+(X(Z)-THAMAX)*SECPD
TPKF+TF+(THAMIN-X(Z))*SECPD
C
THAJ=THA(TPKT)=X(Z), BY DEFINITION
C
PJ=PLS(THE-THA(TPKT))=1.0, BY DEFINITION
C
AND SIMILARLY FOR TPKF
C
PRJ=PLS(X(2))
BT=PVALUE(B+WSC*TPKF,PI0.)...BFR=PVALUE(B+WSC*TPKFI10.)
JFJ-J
INDEX (l) J
INDEX (2) JFR
C FOLG computes Sample Times
TJ=THA(TPKT)
PRJ=PMLS(THE-THA(TPKT))
C FOLG computes ENVELOPE SAMPLES
C
DO 127 1=1,2
JVAL=INDEX(I)
XN=SQ22*GAUSS(O.)
BLOCAL=PVALUE(B+WSC*T(JVAL)+PI0.)
JQ=ALZ+(PRJ**2)+AAZ*PRJ*COS(BLF)+AR2*(PRJ**2)
QJ=AMAX1(QJ,0.0)

MLSSIM
Page 5 of 8
C FOLLOWING COMPUTES RECEIVER RESPONSES

CALL RCVR

C FOLLOWING ASSIMILATES DATA FROM THIS SCAN FOR FUTURE EVALUATION

CALL CONTRL(9)

C FOLLOWING ASSIMILATES DATA FROM THIS LG-TH SET OF SCANS

CALL CONTRL(10)

C FOLLOWING ASSIMILATES DATA FROM THIS MSET-TH SERIES OF LCMAX SETS OF KM SCANS

CALL CONTRL(11)

C FOLLOWING CLOSES THE SIMULATION RUN

CALL CONTRL(12)

RETURN

END

10008 CM STORAGE USED   1.399 SECONDS
SUBROUTINE DFLTRI

DIMENSION C(4)

S = X - C(3)*C(4)
Y = C(1) + S*C(2) + C(4)
C(4) = S

RETURN

END

$1000 C4 STORAGE USED 0.043 SECONDS
SUBROUTINE RCVR
REAL LAIDAMJM2 ..
LOGICAL NOKLMN
COM$ON/RCVROO/THAMAX
COMMON/RCVRO2/THAMAX
COMMON/RCVRO3/THAMAX
COMMON/RCVRO4/THAMAX
COMMON/RCVRO5/THAMAX
COMMON/RCVRO6/THAMAX
COMMON/RCVRO7/THAMAX
COMMON/RCVRO8/THAMAX
COMMON/RCVRO9/THAMAX
COMMON/RCVRO10/THAMAX
DIMENSION TPA1(8,8),PHT(8,5),TPA2(8,8),IVNG(5)
DIMENSION RVNG(5),GAIN(8,5)

C IF (K > 0)
GO TO 40
20 C FOLG IS INITIALIZATION
PI2=2.2+PI
S12=2.2*(SIGMA**2)
CALL PHILM
NS=NSD(I)
NG=NGD(I)
GMIN=2
NGMAX=NGD(I)
GOGT33=GOGT3
GOGT(3,3)=GOGT33
GOGT(6,6)=GOGT33
GOGT(0,0)=6.6/(DELT**2)
DO 20 I=1,NS
DO 10 J=1,NS
PA(I,J)=0.
10 CONTINUE
20 CONTINUE
CALL CONTRL(3)
BB2.4/RCVR
POCRIT=PI*POCRIT
IF(IR.GT.0) GO TO 30
NS=NSD(I)
NG=NGD(I)
CONTINUE
45 H=NGMIN
IF(NOAC) NGM=NG
KALMAN=NO
NOKLMN=NO
LOGE=NO
NOAC=NO
CONTINUE
50 CONTINUE
C DIAGNOSTIC OUTPUT OF INPUT DATA FOR K=1 GOES HERE
SUBROUTINE RCVR

C FOLG EXTRAPOLATES STATE ESTIMATE, AS REQD

IF (TETH & 0)

DO 70 I = 1, NS

XSI(I) = F(I) * XSI(J)

CONTINUE

70 CONTINUE

80 CONTINUE

90 CONTINUE

C GGT(I,J) = MAX1([.25, .01*(XSI(I)**2)])

GGT(I,J) = GGT(I,J) * GGT(I,J)

C FOLLOWING COMPUTES VECTORS Q(JM), H(JM), LAMDA(NG), AND MATRICES DT(JM,

C NGH), PHI(NG, NS) ALSO SQUARED AMPLITUDE ENVELOPE VECTOR U(JM), AND

75 C INOVATION PROCESS VECTOR W(JM)

C CALL PHILM

IF (NLOE) GO TO 120

80 C FOLG COMPUTES RMAT-PHI-INVERSE AND THE LOE

CALL MATINV(RMAT, NS, IVNSRNVNG)

DU 100 I = 1, NS

KDIAG (I) = RMAT (I, I)

100 CONTINUE

C FOLLOWING EXTRAPOLATES STATE ESTIMATES ERROR

C COVARIANCE MATRIX PA(NSNS)

C CALL MATMUL (6, NSNS, 6, NSNS, PA, F, TPAl, 3)

CALL MATMUL (6, NSNS, 6, NSNS, PA, TPAl, 1)

100 CONTINUE

DO 130 I = 1, NS

PMDIAG (I) = PA(II)

130 CONTINUE

C FOLLOWING COMPUTES MODIFIED-KALMAN GAIN MATRIX GAIN(NS, NG)

135 C CALL MATMUL (6, NSNS, 6, NSNS, PA, TPAl, 5, PHHT, 3)

CALL MATMUL (6, NSNS, 6, NSNS, PA, TPAl, 5, PHHT, TPAl, 1)

110 CONTINUE

DO 140 I = 1, NS

TPA2(I, J) = TPAl(I, J)

140 CONTINUE

C CALL MATINV(TPA2, NS, IVNSRNVNG)

CALL MATMUL (6, NSNS, 6, NSNS, PA, TPAl, 5, PHHT, TPAl, 6, GAIN)

C

OPTRNC

Page 2 of 4
SUBROUTINE RCVR

CALL MATHMUL (8,NS,NG,5,NG,1,8,1,GAIN,LAMDA,ES,1)
CALL MATSM (X5,X5,ES,1,8,1,8,NS,1,8,NS,1,8)

CALL MATHMUL (8,NS,NG,8,NG,8,8,8,GAIN,TPA1,TPA2,1)
DO 150 I=1,NS
TPA2(I+1)=TPA2(I+1)-1.

CONTINUE
DO 150 I=1,NS
CALL MATHMUL (8,NS,NG,8,NG,8,8,8,GAIN,TPA1,TPA2,1)
DO 160 I=1,NS
PPDIA(I)=PA(I)+1.
CONTINUE
CONTINUE
CONTINUE
CONTINUE
CONTINUE
CONTINUE

RETURN
END

1.082 SECONDS
<table>
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<tr>
<th>BLOCKDATA ORVRID</th>
<th>73/172 TS</th>
<th>FTN 4.6+45</th>
<th>05/17/79 16:19:37</th>
<th>PAGE 1</th>
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<tr>
<td>COMMON /IDDATA/I0NRS(6)</td>
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<tr>
<td>DATA I0NRS(4)/2/</td>
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<td>END</td>
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<tr>
<td>41000B CM STORAGE USED</td>
<td>0.014 SECONDS</td>
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OPTRNC
Page 4 of 4
SUBROUTINE RCVR

REAL LAMDA, KJM2
LOGICAL NOKLMN, NOLOE, NOAC, KALMAN, LOE, TETHRD
COMMON/RCVR00/THAMAK, THAMIN, TS, TR, OMEGA, TF
COMMON/RCVR01/NOR, NGR, NGMAX, NGNM, DELB, NGTH, THETA
COMMON/RCVR02/RCVR03, DTHO, TDR0, B, WSCD, NSO(4), NCO(4)
COMMON/RCVR03/PIF((0,6)), FL254(), FSAHP, X, DH, TETHRD, NG, NS, JM
COMMON/RCVR04/DELTA, ED(8), GQGT(8,8), X(5,8), ICOUNT, SIGMA
COMMON/RCVR05/NGLOE, NOAC, NOAC, NGMAE, GAMMA(5), NGNS, M
COMMON/RCVR06/PPD08(8), RMS(5,5), PHI(5,5), PA(8,8), PDIAG(8)
COMMON/RCVR07/T(130), Y(130), COMMON/RCVR08/XSLOE(8), ESLDE(8), ES(8)
COMMON/RCVR09/BRVR, BB, PDIAG(8)
COMMON/RCVR10/XS1(8), X5(8)
COMMON/ML5000/X(8)

DIMENSION TPAI(8,130), PHT(8,5), TPA2(8,8), IVNG(5)

C
IF (K .GT. 0) GO TO 40
C FOLD IS INITIALIZATION
PZ = 2.*PI
SS = .5/(SIGMA**2)
CALL PHILM
NS = NSO(IR)
NG = NGO(IR)
NGNM = 2
NGMAX = NGO(IR)
GQGT(3,3) = DELT
GQGT(3,3) = GQGT(3,3)
GQGT(6,6) = GQGT(6,6)
GQGT(6,6) = GQGT(6,6)
DO 20 I = 1, NS
DO 20 J = 1, NS
PA(I,J) = 0
CONTINUE
20 CONTINUE
CALL CONTRL(3)
BB = 2.*BB
PDCRIT = PI*BRCVR
DO 40 I = 1, NS
DO 40 J = 1, NS
CC = PI*PDCRIT
IF (IR .GT. 0) GO TO 30
NS = NSO(4)
NG = NGO(4)
CONTINUE
30 CONTINUE
NG = NGNM
IF (NOAC) NG = NG
KALMAN = NOT, NOKLMN
LOE = NOT, NOLOE
CALL CONTRL(4)
RETURN
40 CONTINUE
IF (K .GT. 10) GO TO 50
C DIAGNOSTIC OUTPUT OF 'INPUT DATA FOR K=1' GOES HERE
C
50 CONTINUE
GO TO 90
C

SUBROUTINE RCVR

C FOLG EXTRAPOLATES STATE ESTIMATE, AS REQD.
IF(TETHRD) GO TO 80
DO 70 I=1,NS
XSL(I)=.O.
DO 60 J=1,NS
XSl(I)=Xsl(I)+F(I,J)*Xs(J)
65 CONTINUE
70 CONTINUE
CONTINUE
CONTINUE
CONTINUE
CONTINUE
.
C GQGT11=MAXI(25,.O1*(XSl(I)**2))
GQGT(I,J)=GQGT11
GQGT(4,4)=S0111
C FOLLOWING COMPUTES VECTORS Q(I,J),MATrices D(I,J), CNG),PHI(NG,NS) ALSO SQUARED AMPLITUDE ENVELOPE VECTOR UI(J), AND.
C INNOVATIOnS PROCESS VECTOR W(I,J)
C
CALL PHILM
IF (NOLOE) GO TO 120

C FOLG COMPUTES RMAT=PHI-INVReS AND THE LOE
CALL MATINV(RMAT,5,NG,IVNG,RNG)
DO 100 I=1,NG
ROLAG(I)=RMA(I)
100 CONTINUE
CALL MAtMUL(5,NG,5I5,NG,5,5,ROLAG,PA,PA)
CALL MATMUL(5,5,5,5,5,5,PA,PA)
DO 110 I=1,NS
XSLOR(I)=Xs(I)+ESLOE(I)
IF (NOKLNN) XSL(I)=XSLOR(I)
110 CONTINUE
CONTINUE
CONTINUE
IF (NOKLMN) GO TO 170

C FOLLOWING EXTRAPOLATES STATE ESTIMATES,ERROR
COVARIANCE MATRIX PA(NS,NS)
C
CALL MATMUL(5,NS,5I5,NS,P,PA,PA)
CALL MATMUL(5,5,5,5,5,5,P,PA,PA)
DO 130 I=1,NS
PMOLAG(I)=PA(I)
130 CONTINUE

C FOLLOWING COMPUTES MODIFIED-KALMAN GAIN MATRIX GAINCHS,NS).
C
CALL MATMUL(5,NS,5,5,5,5,5,P,PA,PA)
CALL MATMUL(5,5,5,5,5,5,P,PA,PA)
DO 140 I=1,NS
TPAd(I)=TPA(I)
140 CONTINUE
C
CALL MATINV(TPA,NS,5,IVNG,RNG)
CALL MATMUL(5,NS,5,5,5,5,5,P,PA,PA,GAIN,PA)
C
SUBROUTINE RCVR

115 C FOLLOWING UPDATES STATE ESTIMATE
CALL MATMUL (8,NS,NG,SN,1,0,1,GAIN,LAMDA,ES,1)
CALL MATHMUL (XS,XS1,ES,1,0,1,1,8,NS,1,8,NS,1,0)

120 C FOLLOWING UPDATES STATE ESTIMATE, ERROR COVARIANCE MATRIX
P(NS,NS)
CALL MATHMUL (8,NS,NG,8,NG,NS,8,8,8,GAIN,TPA1,TPA2,1)
DO 150 I=1,NS
TPA2(I+1)=TPA2(I)+1.
CONTINUE
CALL MATHMUL (8,NS,NG,8,NG,NS,8,8,8,GAIN,TPA1,TPA2,1)
DO 150 I=1,NS
CONTINUE

130 CALL MATHMUL (8,NS,NG,8,NG,NS,8,8,8,GAIN,TPA1,TPA2,1)
CALL MATHMUL (8,NS,NG,8,NG,NS,8,8,8,GAIN,TPA1,TPA2,1)
CALL MATHMUL (8,NS,NG,8,NG,NS,8,8,8,GAIN,TPA1,TPA2,1)

135 XS(1).ABS(XS(1))=AN-(THAMAX+THAMIN)/2.
XS(2).SATU(XS(2))-AN,(THAMAX-THAMIN)/2.)+AN
IF(NS.GE.3) XS(3).SATU(XS(3),1.)
IF(NS.GE.4) XS(4).SATU(XS(4),1.)

140 MJZ+FLOAT(-J/2+1)
TMWZ=MJZ+ONEGA/(2.*FSAMP)
AKN-XS(2)-THMWZ

145 IF(NS.GE.5) XS(5).SATU(XS(5)-ANZ,(AMX-AMNI)/2.)+ANZ
IF(NS.GE.6) XS(6).SATU(XS(6),1.)
IF (NS.GE.7) XS(7)=PVALUE(XS(7),PI,0.)
IF(NS.GE.8) XS(8)=PVALUE(XS(8),PI/DELT,0.)
RETURN
END

150 CONTINUE
CONTINUE
CONTINUE
CONTINUE
CONTINUE
CONTINUE
CONTINUE
CONTINUE

41000B CM STORAGE USED 1.381 SECONDS
BLOCK DATA ORVRID
COMMON /IDDATA/IDNRS(6) DATA IDNRS(4)/2 END

410000 CM STORAGE USED .015 SECONDS
SUBROUTINE PHILM

C
C THIS SUBOPTIMAL VERSION OF PHILM IS
C BASED ON A 4-ELEMENT PARAMETER VECTOR
C AND PROVIDES A CRUDE SEARCH AND ACQUISITION.
C
C FUNCTION ACCESSED AS FOLLOWS
C
C CASEARCH MODE: NGM = NGMIN
C ACQUISITION MODE: NGM = NGMIN..NGMAX
C
C FULL TRACK, MODE: NGM = NGMAX

5 C

THIS NEEDS NGMIN <= NGM <= NGMAX.
REAL LAMBDA
LOGICAL NOKLMN,NHOLOE,NOACKALMANLOETHRD

15 COMMON/RCVRO1/PH(4,4),RL(4)
EQUIVALENCE (RL1,RL(1)),(RL2,RL(2)),(RL3,RL(3)),(RL4,RL(4))

20 COMMON/RCVRO2/PHH(1,1),PHZ1,PH(2,1),PH22,PH(2,2),PH32,PH(3,2),PH33,PH(3,3),PH41,PHJ4,1
EQUIVALENCE (PH,PH(1,1)),(PHZ1,PH(2,1)),(PH22,PH(2,2)),
(PH32,PH(3,2)),(PH33,PH(3,3)),(PH41,PH(4,1)),(PHJ4,PH(4,4))

30 COMMON/RCVRO3/INFO(8),F(43,NGM),IRPIAE-COMDUN/RCVRO1/NGMIN..NGMAX

25 COMMON/RCVRO4/DELTEO(RHOMAX,8,5),H(5,B),ICOUNTSIGMA

30 COMMON/RCVRO5/NOLOENOKLMNNOACGAMAES(43),RDIAG(5),PMDIAG(5)

40 COMMON/RCVRO6/PPDIAG(5),RDIAG(5),PMDIAG(5)

50 COMMON/RCVRO7/T(1503),V(1303)

60 COMMON/RCVR10/ALFARTHRSTHRSOTBWSC,XS(8)

DIMENSION PH(4,4),RL(4)

65 IF(K.GT.0) GO TO 10
JM=JM/2
JMI=JM+1
55 SIGMA=SIGMA**2
IR=3
RETURN

10 CONTINUE

35 IF(NGH.GT.NGMIN) GO TO 30
ALFA=ALFA*RHOMAX
THRS=THRS*RHOMAX

45 CONTINUE

30 IF(NGM.NE.NGMIN) GO TO 50
ALFA=ALFA*IRPIAE
THRS=THRS*IRPIAE

55 CONTINUE

50 IF(NOKLMN.EQ.NOACKALMANLOETHRD) GOTO 55
ALFA=ALFA*IRPIAE
THRS=THRS*IRPIAE

50 CONTINUE

60 COMMON/RCVR10/PH(4,4)
EQUIVALENCE (PH,PH(1,1)),(PHZ1,PH(2,1)),(PH22,PH(2,2)),
(PH32,PH(3,2)),(PH33,PH(3,3)),(PH41,PH(4,1)),(PHJ4,PH(4,4))
SUBROUTINE PHILM

173/172 TS FTN

16.20.18

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65

DO 60 J1=1, J2
THAJ=THA(T(JJ))
THEE=THES-Thaj

70

PJ=P(THEE)
PQ=PQ(initial)

75

THER=THRS-Thaj
PRJ=PRJ**2

80

DAJ1=ALZ*P2J
DAJ2=ALZ*P2J

85

IF (NGOEL .LT. 0) GO TO 40

90


95

CONTINUE

100

CALL WAWBJ (WA1, WB1, QAJ, BA)
CALL WAWBJ (WA2, WB2, QAJ, BA)

105

RAB1=RAB1

110

SD1=SD1

PLSUB
SUBROUTINE PHIL

115 PH21 = PH21 + DSD1 * DSD2 + RA21 * (SDA2 + SDB1 + SDA1 + SDB2)
   PH22 = PH22 + DSD2 * RA22 + SDA2 + SDB2
   IF (NGOE < 0) GO TO 50
   RL3 = RL3 + DSA3 + WA + DJ3 + WE
   RL4 = RL4 + DSA4 + WA + DJ4 + WE

120 SDA3 = DSA3 + SA
   SDA4 = DSA4 + SA
   SDB3 = DDB3 + SB
   SDB4 = DDB4 + SB
   DSD3 = DSD3 + SDB1
   DSD4 = DSD4 + SDB2
   DSD1 = DSD1 + SDB3
   DSD2 = DSD2 + SDB4
   PH31 = PH31 + DSD1 * SDA3 + SDB1 + SDA1 + SDB2
   PH32 = PH32 + DSD2 * SDA3 + SDA2 + SDB2
   PH33 = PH33 + DSD3 * SDA3 + SDB3 + SDA1 + SDB2
   PH34 = PH34 + DSD4 * SDA3 + SDA2 + SDB2

130 PH21 = PH21 + DSD1 * DSD2 + RA21 * (SDA2 + SDB1 + SDA1 + SDB2)
   PH22 = PH22 + DSD2 * RA22 + SDA2 + SDB2
   IF (NGOE < 0) GO TO 50
   RL3 = RL3 + DSA3 + WA + DJ3 + WE
   RL4 = RL4 + DSA4 + WA + DJ4 + WE

135 CONTINUE

140 DD 110 I = 1,NG
     DD 100 L = 1,1
     PHII = PHII + PHII(I)
     PHII(I) = PHII
     PHII(I,L) = PHII
     IF (NOGE) GO TO 90

145 CONTINUE
     CONTINUE
     CONTINUE
     CONTINUE
     CONTINUE
     CONTINUE
     CONTINUE
     CONTINUE
     CONTINUE
     RETURN

END

410000 CM STORAGE USED 1.381 SECONDS
SUBROUTINE WAWOJ

SUBROUTINE WAWOJ(WA;WB;QA;BU)

CTHIS COMPUTES A SAMPLE EACH OF THE PROCESSES WA % WB,
GIVEN SAMPLES OF QA;BU AND U

LOGICAL NFIRST
DIMENSION HA(11);HB(11);COSB(1);G(1);H(11)

DATA LMAX/10/;NFIRST/.FALSE./

C
IF(NFIRST) GO TO 10
LMAX=LMAX+1
RLMAX=ALOG(LMAX1)
BETA=3.1415927/LMAX
DO 5 L=1,LMAX
COSBL=COS((L-1)*BETA)
CONTINUE
5
NFIRST=.TRUE.

10 CONTINUE
GMAX=1.E+322
HMAX=1.

20 CCBL=AMAX1(1.*COSBL,0.)
CCBL=1.+B*COSBL
ABC=QA*CCBL
AB=QA*AB
UBC=UB
RAD=2.-SORT(UABC)
RAD1=SORT(1.+UABC)
GL=2.*(RAD1-1.)/(1.+RAD))=ABC
GL(1)=GL
ML=1.+SORT(1.+6.2831846*RAD)
HL(1)=HL
HALL=HAL
HAL(1)=HAL
HBL=HAL*COSBL
HBL(1)=HBL
GMAX=AMAX1(GL;GMAX)
HMAX=AMAX1(HL;HMAX)

40 CONTINUE
GZ=GMAX-741.

50 FX=ALOG(HMAX)+GZ
FX=FX+ALNMX
GZ=FZ+ALNMX
GPA=GZ+ALOG(HMAX)

55 FS=0.
FSB=0.
SUBROUTINE WAWBJ

DO 30 L=1,LMAX1
   GL=GL(L)
   GLP=GL-GL
   GLMA=GL-GLMA
  河流域
   GLB=GL-GRB
   IF(GLM.GE.-674.) FS=FS+EXP(GLM)*H(L)
   IF(GLMA.GE.-674.) FSA=FSA+EXP(GLMA)*HMA(L)
   IF(GLMB.GE.-674.) FSB=FSB+EXP(GLMB)*HBL(L)
30   CONTINUE

WA*(HMAX/HMAX)*(FSA/FS)

RETURN

END
SUBROUTINE SWFCNS(HWAJHWBJPRABJQAVBA)
INTEGER FNA(4)
LOGICAL NFIRST
DIMENSION BULK(12,25,3),OA(25),B(25),DEX(tZ),DEY(11)
DIMENSION AA(33,BB(3),CC(3),DD(3),APPVA(3) . .
DIMENSION OAB( 2512,B(2),IOBAX(2), IJB(2)
EQUIVALENCE (OA(1hAB(1,1)),(B(1),OAB(1,2).
EQUIVALENCE (IOMAXIOBMAX(i)),(JBMAX,IOBMAX(2))
EQUIVALENCE (IQ,IQJB(1)),(IBIQJB(2)),(BVQB(2))
DATA FNA/1OHMLSLOGSWCD,1LC,2*0/
DATA NFIRST/.FALSE./
         C
         C FOLG GENERATES TABLE FROM DATA FILE
         C IF(NFIRST) GO TO 10
         NFIRST=.TRUE.
         10 IX=ATTACH(6LTAPE12,FNA,2LID,6RM3497E)
         IF (IX.EQ.0) GO TO 5
         CALL INTIO(BHIXATIZIX,1,1)
         STOP
         INPUT FILE ATTACH (TAPE12) NOT SATISFACTORY
         CONTINUE
         READ (12) IDUN,IDUN
         READ (12) IQMAX,IOA(I),I=1,IOMAX)
         READ (12) JHMAX,(B(J),J=1,JHMAX)
         READ (12) (((BULK,L=1,K,J=1,JHMAX),I=1,1,IOHMAX),K=1,3)
         IOMAX=1
         DO 3 J=1,2
         3 IF(IQ.IEQ.IOCHMAX)
         JEN=JBMAX-1
         DO 6 J=1,JB
         6 IF(IQ.IEQ.IOCHMAX)
         DEY(I)+B(I)
         40 CALL RETURN(6LTAPE12)
         CONTINUE
         C
         C FOLG TRUNCATES ARGUMENTS AND HANDLES SMALL BV CASES
         C BVABS(BA)
         IF (BV.LT.0.0) GO TO 40
         HWAJ=1./SORT(1.+QAV)
         HWBJ=0.
         RAB=0.
         RETURN
         CONTINUE
         C
         C FOLG DETERMINES IO;IV
         OEB(I)+QAV
         55 DD 1200 L=1,2
         OEB+OEB(L)
         1001 IF(IOBL.LT.QAB(IQJB(L)),L) GO TO 1101
SUBROUTINE SWFCNS

60     IQBPL=IQB(L)+1
       IQBMM=IQBMAX(L)
       IF (IQB.LT.QAB(IPL)) GO TO 1201

1201  CONTINUE

1202  IQB(L)=I-1
       GO TO 1500

65  1101  IQJMI=IQJ(L)-1
       UO  1301  I=IQJMI+1
       MI=IQJMI-1+1
       IF (OBL.GE.QAB(MII)) GO TO 1302

1301  CONTINUE

1302  IQJ(L)=MII

70  1500  CONTINUE

C
C DETERMINES INTERPOLATED VALUES
C
75     DIX=OAV-OA(IQ)
       DIY=OV-B(IB)
       CX=DIX/DEX(IQ)
       CY=DIX/DYY(IB)

80  301  K=1,3
       AA(K)=BULK(IB+1,IO+K)
       BB(K)=BULK(IB+1,10+K)
       CC(K)=BULK(IB+1,IO+1+K)
       DD(K)=BULK(IB+1,110+1+K)

85       APPVA(K)=AA(K)+CC(K)=AA(K)*CX+(BB(K)-AA(K))*CY+CX*CY*(AA(K)
       +DD(K)-CC(K)-BB(K)).

301  CONTINUE

HWAJ=EXP(APPVA(1))
HWBJ=EXP(APPVA(2))
RABJ=APPVA(3)
IF (BA.LT.0.) RABJ=RABJ
RETURN
END

410008 CM STORAGE USED .666 SECONDS
SUBROUTINE PHILM

THIS OPTIMAL VERSION OF PHILM IS FOR ALL SCALLOPING RATES
AND PROVIDES A CRUDE SEARCH-AND-ACQUISITION FUNCTION
ACCESSIBLE AS FOLLOWS:
SEARCH MODE: NGM=NGMIN
ACQUISITION MODE: NGMIN,LT=NGM,LT=NGMAX
FULL TRACK MODE: NGM=NGMAX

THIS NEEDS NGMIN,LE=NG <LE=NGMAX

REAL LAMDA
LOGICAL NOALM,NOKLMHNOLOE,NOACKALM
COMMON/RVOR1/NGMIN,NGMAX,DELAM,NGM,IR,IAE
COMMON/RVOR2/RHOMAX,OTH0,T0R0,0G,WSCD,NGD(4),NGD(4)
COMMON/RVOR3/FL(8),FLE(4),FSAMP,K,R,THTHD,NGNJ,NN
COMMON/RVOR4/DELZ,ED(8),GQGT(8,8),MT(8,8),ICOUNT,NGR
COMMON/RVOR5/NOKLM,NOKLHM,NGM,NGMAX,RODIAG(5),PMdiag(8)
COMMON/RVOR6/FPIDA(8),RMAI(5,5),PHI(5,5),PA(8,8),LAMDA(5)
COMMON/RVOR7/T(130),V(130)
COMMON/RVOR8/XSLOE(8),XSLOE(8),XSLOE(8)
COMMON/RVOR9/RBCVR,8B,POCRIT,CC
COMMON/RVOR10/ALFAM,THES,THESD,ALFAM,THESD,T9DS,T9DS,T9D,WSCD(8)

DIMENSION INDEX(2),GT(130,5),HW(130),W(130)

Following effects initialization
IF(K.GT.0) GO TO 10
JM=JM+1
SIGMA=SIGMA**2
IR=IR+1
RETURN
CONTINUE

Following programs the search
IF (NGM.GT.NGMIN) GO TO 30
ALFAM=ALFAM*RHOMAX
THESD=T9D
WSCD=WSCD
CONTINUE

Following computes constants for present scan
ALZ=ALFAM
AL2=ALFAM
AR=ALFAM
AR2=ALFAM
AA=ALFAM

Following initiates loop and computes functions for each J

PLOPT
00 50 JI=1,1J2
INDEX(I)=J1
INDEX(J)=J1
THAA=THAT(J1)
THEE=THEE-THA
PJ+P(THEE)
PO+P(Q)IT(THEE)

65 PE+PE
THAP=THAP-THA
PR+P(THAP)
PRR+PRR(THP)
PRJ+PRJ+P
PRRJ+PRRJ+P

70 ONJ+ONJ+P2J+P2J
QR+QR+QR2+PR2J
DINE=AL2+PR2J
C1=AR2+PRRJ
O2J=AL2+PRRJ
C3=AL2+PRRJ

80 D1J=AIN(J)

BLOCAL=VALUE(B+WSC*T(J),3.1415927,DELBL)
CB=CS(BLOCAL)
C2=CS(BLOCAL)
GJ=GRJ
QRJ=GRJ
C1=C2
C2=C2

85 C FOLG COMPLETES CALCULATIONS FOR TG,FRO SCANS, RESP;
DO 50 1=1,2
INDEX(1)=J1
INDEX(2)=J2

90 BLOCAL=VALUE(B+WSC*T(J),3.1415927,DELBL)
SB=SB+(BLOCAL)
CB=CS(BLOCAL)

95 C FOLG IS FOR A 60 DEG DESIGN
C FOLLOWING COMPUTES VECTOR HW(J),AND INNOVATIONS PROCESS VECTOR W(J)

100 C FOLLOWING COMPUTES VECTOR LAMDA(NG) AND MATRICE PHI(NG,NG)

105 C PLOPT Page 2 of 4
SUBROUTINE PHILM

DO 110 I=1,NG
   LAMDA(I)+O.O
   DO 70 J=1,JM
      LAMDA(I)=LAMDA(I)+DT(J,L)*W(J)
      CONTINUE
   DO 100 L=1,I
      PHI(I)+O.
   DO 80 J=1,JM
      PHIL1-PHI1+HW(J)*DT(J,L)
   CONTINUE
   PHI(L,I)=PHIL1
   PHI(L,I)-PHI1

   IF (NOLOE) GO TO 90
   RMAT(L,I)=PHI1
   CONTINUE
   90 CONTINUE
   100 CONTINUE
   110 CONTINUE

RETURN

END

410068 CM STORAGE USED .605 SECONDS
FUNCTION PILS(THETA)

THIS COMPUTES THE TRANSMITTED SIGNAL INTENSITY RELATIVE TO THAT AT BEAM CENTER AS A FUNCTION OF THE ANGLE-OFF-BORESIGHT.

THE MODEL GIVES FIRST SIDE LOBES 23 DB BELOW THE MAIN LOBE.

COMMON/MLS004/MLS,888,TIMES,MSET,MORE

DATA PCRT/.7853981635/,AA/1.5707963271

PMLS=PCRT

Z=888*THETA

10

IF (ABS(ABS(Z)-1.) .LE. 1.E-7) RETURN

PMLS=(COS(AA*Z))/(1.-Z**2)

RETURN

END

419008 CM STORAGE USED

.671 SECONDS
41000B CM STORAGE USED

.016 SECONDS
FUNCTION P(THETA)

C THIS COMPUTES THE TRANSMITTED SIGNAL INTENSITY (RELATIVE TO
C THAT AT BEAM CENTER AS A FUNCTION OF THE ANGLE-OFF-BORESIGHT.
C THE MODEL GIVES FIRST SIDE LOBES 23 DB BELOW THE MAIN LOBE.

COMMON/RCVR9/BRCVR,PDCRIT,CC
DATA PDCRIT/7853901635/,AA/1.570796327/
1 = BB * THETA

10 IF (ABS(ABS(Z)-1.) LE. 1.E-7) RETURN

P = (COS(AA+Z)/(1.-Z**2)) RETURN

END

410008 CM STORAGE USED 5060 SECONDS
FUNCTION POOT (THETA)

THIS COMPUTES THE DERIVATIVE DP(THETA)/DTHETA WHERE P(THETA)
IS THE TRANSMITTED SIGNAL INTENSITY RELATIVE TO THAT AT BEAM
CENTER AND THETA IS THE ANGLE OFF BORESIGHT. THE P-MODEL USED
IS THAT GIVING FIRST SIDE LOBES 23 DB BELOW THE MAIN LOBE.

COMMON/RCVR09/RCVR,R8,PDCRIT,CC
DATA AA/1.,5707/58327/

10 C
POOT=SIGN(PDCRIT-THETA)
2*BB*THETA
1 IF (ABS(ABS(Z)-1.) .LE. 1.E-7) RETURN
CP=AA+(Z-1.)
CM=AA-(Z-1.)
POOT+CC*ICOS(CP)-SIN(CP)/CP)+ICOS(CM)-SIN(CM)/CM)
RETURN
END

41000B CM STORAGE USED .119 SECONDS
SUBROUTINE RCVR
C THRESHOLD RECEIVER
REAL LANOA
LOGICAL NUKLMN, NOLGE, NOAC, KALMAN, LDE, THETHRD
COMMON/RCVR00/TTHAX, TTHAXN, TS, TR, OMEGA, TF
COMMON/RCVR01/TGMN, TGMN1, TGMN2
COMMON/RCVR02/THAX, TTHAX, TTHAX1, TTHAX2
COMMON/RCVR03/TSAMP, TSAMP2, TSAMP3, TSAMP4, TSAMP5
COMMON/RCVR04/DELTA, DELTA2, DELTA3, DELTA4, DELTA5
COMMON/RCVR05/DLOG, DLOG1, DLOG2, DLOG3, DLOG4, DLOG5
COMMON/RCVR06/PDFDAG(8), PRMT(5), PHI(5,5), PA(5,8), PI(8,5)
COMMON/RCVR07/T(130), V(130)
COMMON/RCVR08/XLOG, XLOG1, XLOG2, XLOG3, XLOG4, XLOG5
COMMON/RCVR09/BXLOG, BXLOG1, BXLOG2, BXLOG3, BXLOG4, BXLOG5
DIMENSION VPK(Z), VTH(Z), N(2), U(130), W(130), TRG(Z)
DATA GX/100./
IF (K > 0) GO TO 50
! FOLG IS INITIALIZATION
! IR = 1
NS = NSD(IR)
CALL CONT(3)
DLOGA = 2.0000
JM2 = JM2/2
JM2 = JM2/2
TSAMP = TSAMP2
JDELAY = IFIX(3.1415927 + 25000. * TSAMP + 5)
JM2 = JM2 + JDELAY
ICOUNT = 0
X113 = 0.0
X135 = 0.0
CALL CONT(4)
RETURN
50 CONTINUE
C FOLG PRODUCES T11 AND T12
TPS1 = (X112 - TTHAX) / OMEGA
IF (I = 11) THEN TTHAX = X112 / OMEGA
C FOLG PRODUCES LOG ENVELOPE SIGNAL FILTERED TO 25 KHZ
DO 70 L = 1, 15
VPEAK(L) = 0.0
DO 60 J = 1, JM2
X113(L) = I113 + (I113 - X113)
JM2 = JM2 + 1
IF (11.0 = 11.0) THEN DO 70
JL = I113 + (I113 - X113)
CALL DFTR(I113) = W(I113)
FL25 = 0.0
VPEAK = AWAX(VPEAK) + I113
IF (K < 5.0) THEN GO TO 70
END
C CONTINUE
IF (K < NE) THEN GO TO 60
NABORT = 0
SUBROUTINE RCVR

NNOM=1*IFIX(2.*5.0E-5/TSAMP+.5)
N(1)=NNOM
N(2)=NNOM
CONTINUE
GO TO 140 I=1,2
J=JM2-M(I)/2
N(I)=N(I)+1/2
D(I)=(N(I)-1)*TSAMP
TGI=TPST+D(I)
TG1=TPST+D(I)
TAUSS=TG1
IF(I.EQ.2) TAUSS=TG2
VT=VT(I)
J0=(I-1)*JM2+JJ
J1=J0+N(I)-2
L=1
ISIGN=1
CONTINUE
GO TO 100 J=JO+JL
V0=W(J)
V1=W(J+1)
TAU=TAUSS+J-J0)*TSAMP
DELTAV=(V1-VT)*ISIGN
IF(DELTAV.LT.0) GO TO 100
TOWELL=TAU+TSAMP*(VT-V0)/(V1-V0))
IF(J.NE.J0) GO TO 90
IF(V0.GT.VT) TOWELL+TAU
IF(L.EQ.2) GO TO 130
L=2
ISIGN=1
TOWELL+TOWELL
CONTINUE
IF(L.EQ.1) GO TO 190
TOWELL+TOWELL
CONTINUE
GWIDTH=TOWELL-TOWELL
IF((GWIDTH.LT.15.E-6).OR.(GWIDTH.GT.350.E-6)) GO TO 190
TRG(I)=2.*GWIDTH
TC=(TOWELL+TOWELL)*2
IF(I.EQ.2) GO TO 150
TC1=TC
CONTINUE
DELSET=TC-TC1
DDO=(.5E-6)*IFIX(DELSET+.5E-6+.5)
K1(2)=G*ONEGA/2.*(DDO-TR)
K2(2)=K1(2)
K2(1)=(VPK(1)+VPK(1))/2,
K2(2)=(K2(1))/20.1-1./EX
K2(1)=K2(1)
DO 160 I=1,2
RG=TRG(1)/TSAMP
N(I)=1.2*IFIX(RG/2.+0.5)
CONTINUE
160 NABORT=O
RETURN
193 ICOUNT=ICOUNT+1
NABORT=NABORT+1
IF(NABORT.LT.5) RETURN

THDRVR
Page 2 of 4
SUBROUTINE RCVR

N(1) = NNOM
N(2) = NNOM
XS(2) = XSI(2)
RETURN
END

410038 CM STORAGE USED ... 0.822 SECONDS
BLOCK DATA TRVRSID 73/172 TS

COMMON/IDDATA/IDNRS(6)
DATA IDNRS(3),IDNRS(4),IDNRS(6) /1,1,0/
END

STORAGE USED .023 SECONDS
PROGRAM ACQMP1

INTEGER DATIN(100)
DIMENSION X(100),Y(100),Z(100),D(100)
DIMENSION ERF(100),ET1(100),ER2(100),ET(100),
       NAME(10),NAME1(10),NAME2(10),NAME3(10),
       NAME4(10),NAME5(10)
DIMENSION NAME1,NAME2,NAME3,NAME4,NAME5,
       NAME6,NAME7,NAME8,NAME9,NAME10,
       NAME11,NAME12,NAME13,NAME14,NAME15,
       NAME16,NAME17,NAME18,NAME19,NAME20,
       NAME21,NAME22,NAME23,NAME24,NAME25,
       NAME26,NAME27,NAME28,NAME29,NAME30,
       NAME31,NAME32,NAME33,NAME34,NAME35,
       NAME36,NAME37,NAME38,NAME39,NAME40,
       NAME41,NAME42,NAME43,NAME44,NAME45,
       NAME46,NAME47,NAME48,NAME49,NAME50,
       NAME51,NAME52,NAME53,NAME54,NAME55,
       NAME56,NAME57,NAME58,NAME59,NAME60,
       NAME61,NAME62,NAME63,NAME64,NAME65,
       NAME66,NAME67,NAME68,NAME69,NAME70,
       NAME71,NAME72,NAME73,NAME74,NAME75,
       NAME76,NAME77,NAME78,NAME79,NAME80,
       NAME81,NAME82,NAME83,NAME84,NAME85,
       NAME86,NAME87,NAME88,NAME89,NAME90,
       NAME91,NAME92,NAME93,NAME94,NAME95,
       NAME96,NAME97,NAME98,NAME99,NAME100,
       NAME101,NAME102,NAME103,NAME104,NAME105,
       NAME106,NAME107,NAME108,NAME109,NAME110,
       NAME111,NAME112,NAME113,NAME114,NAME115,
       NAME116,NAME117,NAME118,NAME119,NAME120,
       NAME121,NAME122,NAME123,NAME124,NAME125,
       NAME126,NAME127,NAME128,NAME129,NAME130,
       NAME131,NAME132,NAME133,NAME134,NAME135,
       NAME136,NAME137,NAME138,NAME139,NAME140,
       NAME141,NAME142,NAME143,NAME144,NAME145,
       NAME146,NAME147,NAME148,NAME149,NAME150,
       NAME151,NAME152,NAME153,NAME154,NAME155,
       NAME156,NAME157,NAME158,NAME159,NAME160,
       NAME161,NAME162,NAME163,NAME164,NAME165,
       NAME166,NAME167,NAME168,NAME169,NAME170,
       NAME171,NAME172,NAME173,NAME174,NAME175,
       NAME176,NAME177,NAME178,NAME179,NAME180,
       NAME181,NAME182,NAME183,NAME184,NAME185,
       NAME186,NAME187,NAME188,NAME189,NAME190,
       NAME191,NAME192,NAME193,NAME194,NAME195,
       NAME196,NAME197,NAME198,NAME199,NAME200,
       NAME201,NAME202,NAME203,NAME204,NAME205,
       NAME206,NAME207,NAME208,NAME209,NAME210,
       NAME211,NAME212,NAME213,NAME214,NAME215,
       NAME216,NAME217,NAME218,NAME219,NAME220,
       NAME221,NAME222,NAME223,NAME224,NAME225,
       NAME226,NAME227,NAME228,NAME229,NAME230,
       NAME231,NAME232,NAME233,NAME234,NAME235,
       NAME236,NAME237,NAME238,NAME239,NAME240,
       NAME241,NAME242,NAME243,NAME244,NAME245,
       NAME246,NAME247,NAME248,NAME249,NAME250,
       NAME251,NAME252,NAME253,NAME254,NAME255,
       NAME256,NAME257,NAME258,NAME259,NAME260,
       NAME261,NAME262,NAME263,NAME264,NAME265,
       NAME266,NAME267,NAME268,NAME269,NAME270,
       NAME271,NAME272,NAME273,NAME274,NAME275,
       NAME276,NAME277,NAME278,NAME279,NAME280,
       NAME281,NAME282,NAME283,NAME284,NAME285,
       NAME286,NAME287,NAME288,NAME289,NAME290,
       NAME291,NAME292,NAME293,NAME294,NAME295,
       NAME296,NAME297,NAME298,NAME299,NAME300,
       NAME301,NAME302,NAME303,NAME304,NAME305,
       NAME306,NAME307,NAME308,NAME309,NAME310,
       NAME311,NAME312,NAME313,NAME314,NAME315,
       NAME316,NAME317,NAME318,NAME319,NAME320,
       NAME321,NAME322,NAME323,NAME324,NAME325,
       NAME326,NAME327,NAME328,NAME329,NAME330,
       NAME331,NAME332,NAME333,NAME334,NAME335,
       NAME336,NAME337,NAME338,NAME339,NAME340,
       NAME341,NAME342,NAME343,NAME344,NAME345,
       NAME346,NAME347,NAME348,NAME349,NAME350,
       NAME351,NAME352,NAME353,NAME354,NAME355,
       NAME356,NAME357,NAME358,NAME359,NAME360,
       NAME361,NAME362,NAME363,NAME364,NAME365,
       NAME366,NAME367,NAME368,NAME369,NAME370,
       NAME371,NAME372,NAME373,NAME374,NAME375,
       NAME376,NAME377,NAME378,NAME379,NAME380,
       NAME381,NAME382,NAME383,NAME384,NAME385,
       NAME386,NAME387,NAME388,NAME389,NAME390,
       NAME391,NAME392,NAME393,NAME394,NAME395,
       NAME396,NAME397,NAME398,NAME399,NAME400,
       NAME401,NAME402,NAME403,NAME404,NAME405,
       NAME406,NAME407,NAME408,NAME409,NAME410,
       NAME411,NAME412,NAME413,NAME414,NAME415,
       NAME416,NAME417,NAME418,NAME419,NAME420,
       NAME421,NAME422,NAME423,NAME424,NAME425,
       NAME426,NAME427,NAME428,NAME429,NAME430,
       NAME431,NAME432,NAME433,NAME434,NAME435,
       NAME436,NAME437,NAME438,NAME439,NAME440,
       NAME441,NAME442,NAME443,NAME444,NAME445,
       NAME446,NAME447,NAME448,NAME449,NAME450,
       NAME451,NAME452,NAME453,NAME454,NAME455,
       NAME456,NAME457,NAME458,NAME459,NAME460,
       NAME461,NAME462,NAME463,NAME464,NAME465,
       NAME466,NAME467,NAME468,NAME469,NAME470,
       NAME471,NAME472,NAME473,NAME474,NAME475,
       NAME476,NAME477,NAME478,NAME479,NAME480,
READ DATA FROM DISK AND PLACE IN PROPER LOCATION OR ARRAY.

READ(15) (IDENTS(I), 1-35), KSTART
READ(15) NRUNS, NRDSR, RHOD, BETA, FSC, BMLS, BRCVR, THESEP

DECODE (10,75, DOUT) NN1, IRCVR, NN2, NN3, NN4

WRITE(7,50) DOUT, DELT, TIMES, LOGAX, KM, TDDAY, JBNAM

STOP INPUT FILE ATTACH NOT SATISFACTORY.

FORMAT (20H, FILE DID NOT ATTACH/)

WRITE DATA FROM DISK ON THE LINEPRINTER.

WRITE(7, 80) DOUT, DELT, TIMES, LOGAX, KM, TDDAY, JBNAM

WRITE(7, 90) IDENTS, KSTART

WRITE(7, 100) NRUNS, NRDSR, RHOD, BETA, FSC, BMLS, BRCVR, THESEP

WRITE(7, 110) (TOTAL(KL), L-1, 5)

WRITE(7, 120) K, 35.

WRITE(7, 130) FORNAT(1H, 5(G13.6, 5X))

WRITE FIRST 35 VALUES, 5 PERIODS, THEN THE LAST 3.

WRITE(7, 140) FORNAT(1H, 5(G13.6, 5X))

PLOTTING BEGINS HERE.

CALL PLOT(-2.0, 0.O, 3)

CALL PLOT(-2.07.0, -2.0)

DRAW LEFT EDGE OF THE PAGE

WRITE FILE AND PLOT INFORMATION AT TOP OF PAGE.
115 C
    XH = -.5
    YH = 0.7 - S
    CALL SYMBOL (XH, YH, H, NAME(1), 0.0, 90).

120 C
    DO 160 I = 1, 10
    NAME(I) = BLANK
    CONTINUE

125 C
    NAME(2) = BNAME
    CALL DECODE (16, 170, DDUT) NAME(6)
    RH = YH = S
    CALL SYMBOL (XH, YH, H, NAME(6), 0.0, 100)

130 C
    WRITE PLOT INFORMATION ON BOTTOM OF PAGE

135 C
    ENCODE (81, 210, NAME) (IDENTS(I)), 1*1, 2, BNAME, DELT, XM, KSTART
    DO 210 FORMAT (10H SCENARIO: A8, 1H, A6, 7H, BMLS*1F4.1, 11H, DEG, DELT*1)
    YH = 0.0
    CALL SYMBOL (XH, YH, H, NAME, 0.0, 81)

140 C
    ENCODE (81, 230, NAME) (IDENTS(I)), 1*3, 6, BRCVR
    DO 250 FORMAT 10H RECEIVER: A7, 2H, A7, 2H, A8, 1H, A6, 8H, BRCVR*1
    YH = S
    IF (IRCVR .NE. 2) GO TO 256

145 C
    ENCODE (83, 255, NAME) (IDENTS(I), 1*3, 6, BRCVR)
    DO 255 FORMAT (FSC ESTIMATE ERROR: INITIAL*, G10.3, H, FINAL*, G10.3)
    YH = 0.7
    CALL SYMBOL (XH, YH, H, NAME, 0.0, 64)

150 C
    ENCODE (62, 255, NAME) A8, 1H, A6, 7H, BMLS*, F4, 1*11H, DEG, DELT*
    CALL SYMBOL (XH, YH, H, NAME, 0.0, 63)

155 C
    CALL SYMBOL (XH, YH, H, NAME, 0.0, 63)
    DO 250 CONTINUE

160 C
    CALL FACTOR (K)

165 C
    C FILL ARRAY WITH HORIZONTAL AXIS DATA.

170 C
    DO 260 K = 1, XM

ACQMT1
Page 3 of 5
TIM(K) = DELT*(K-1)

CALL SCALE(TIM,ALX,KM+1)

C**********290 LOOP FOR 5 PLOTS.

DO 290 L = 1,5
   AMAX = 1.E+320
   AMIN = 1.E-320

C**********270

DO 270 K = 1, KM

C FILL MIN AND MAX OF ERROR DATA.

AKIN = AMIN(TOTAL(K,L), AMIN)
AMAX = AMAX(TOTAL(K,L), AMAX)

DO 270 CONTINUE

YMAX = AMAX(ABS(AMAX), ABS(AMIN))

YMIN = YMAX
IF (L .EQ. 5) YMIN = 0.

YINC = (YMAX - YMIN) / ALY

DO 280 K = 1, KM
   YY(K) = TOTAL(K,L)

280 CONTINUE

YY(KM-1) = YMIN
YY(KM) = YINC

C DRAW Y-AXIS AND WRITE LABEL.

YH = ERROR(L)
YHM = YH
CALL AXIS(XH, YH, LABELS(L), 10, ALY, 90., YMIN, YINC)

C MAKE PLOT OF ERROR DATA.

CALL PLOT(0., YH, -3)
CALL LINE(TIM, YY(KM-1), 0., 0., YMIN, 0.)
CALL PLOT(0., YHM, -3)

C MAKE HORIZONTAL AXIS FOR ALL 5 PLOTS.

CALL AXIS(XH, YH, LIMIT, -40, ALX, 0., 0., TIM(KM+1), TIM(KM+2))

C 5 PLOTS FOR THE FILE ARE NOW COMPLETED.

C CALL FACTOR(1.)

C RESET ORIGIN AT 8.5 INCHES ALONG X-AXIS

CALL PLOT(8.5, 0., 0., -3)

C DRAW RIGHT EDGE OF FINAL PLOT.

CALL PLOT(9.5, 0., 0., -3)

ACOMP1
Page 4 of 5
CALL PLOT(-2.0,0.0,3)
CALL PLOT(-2.0,7.0,2)
CALL ENDPLOT
STOP
END

420000 dch storage used . . 2.817 seconds
SUBROUTINE CLIP

DIMENSION A(K)
LOGICAL LA, LE

C
KC=KM
LA=.FALSE.
LE=.FALSE.
ISW=0
GO TO 10
K=KM+1-KC
IF(A(K).GE.AMIN) GO TO 10
LE=.TRUE.
A(K)=AMIN
IF(ISW.EQ.0) ISW=K
GO TO 20
10 IF(LA) GO TO 20
IF(ISW.EQ.0).AND.(KC.EQ.KM) KC=K
IF(A(K).LE.AMAX) GO TO 30
A(K)=AMAX
LA=.TRUE.
IF(ISW.EQ.0) ISW=K
GO TO 100
20
30 IF(LE) GO TO 100
IF(ISW.EQ.0).AND.(KC.EQ.KM) KC=K
CONTINUE
25
100 CONTINUE
END

410008 CM STORAGE USED --- --- +171 SECONDS --- --- --- --- ---
FUNCTION GAUSS(DUMMY)

GAUSS PRODUCES INDEPENDENT PSEUDO-RANDOM NUMBERS DISTRIBUTED
C NORMALLY (0,1) BY THE DIRECT METHOD DESCRIBED IN THE FOLLOWING
REFERENCE:
C M. ABRAMOWITZ, I. A. STEGUN, HANDBOOK OF MATHEMATICAL FUNCTIONS
APPLIED MATHEMATICS SERIES #55, NATIONAL BUREAU OF STANDARD, U.S
DEPT OF COMMERCE, NOV. 1970, PAGE 953.

THIS VERSION OF GAUSS TAKES INDEPENDENT PSEUDO-RANDOM NUMBERS
UNIORMALLY DISTRIBUTED ON (0,1), FROM THE CDC-SUPPLIED FUNCTION
SUBPROGRAM RANF(X).

LOGICAL HAS
DATA HAS .FALSE./

IF(DUMY.EQ.0.0) GO TO 30

CALL RANSET(0)
HAS .FALSE.

30 IF(HAS) GO TO 40

X = SQRT(-2.*ALOG(RANFl1.0))/

T = 6.28385308*RANF(1.0)

SAVED = X*SIN(T)
GAUSS = X*COS(T)
HAS .TRUE.

40 GAUSS = SAVED
HAS .FALSE.
RETURN

END
SUBROUTINE INTIO (SYMBOL,IVAL,IVALMX,I2)
INTEGER SWITCH,SLASH,Ssymbol
DATA SLASH/1HII/
IF(I2).EQ.3 READ(10,10) IVAL
10 FORMAT(I6) WRITE(7,20) IVAL
20 FORMAT(1H16/) GO TO 30
WRITE(7,30) SYMBOL,IVAL
30 FORMAT(1H,6A6,H16) READ(10,40) SWITCH,IVAL
40 FORMAT(11,16) IF (SWITCH.EQ. SLASH) GO TO 60
WRITE(7,50)
50 FORMAT(1H16) RETURN
60 IVAL=IVAL2
WRITE(7,70) SLASH,IVAL
70 FORMAT(1H,6A6,H16) IF (IVAL.LE. IVALMX) RETURN
WRITE (7,90) SYMBOL,IVAL,IVALMX,Ssymbol,IVALMX
90 FORMAT(1H,6A6,H16,H16) MAX. VALUE (*16,H1/)
IVAL=IVALMX
RETURN
3 WRITE(7,100) SYMBOL,IVAL
100 FORMAT(1H,6A6,H16) RETURN
END

410000 CM STORAGE USED...131 SECONOS
SUBROUTINE LOGIC (SYMBOL, VALUE)
LOGICAL VALUE
INTEGER SWITCH, SLASH
DATA SLASH/"/

IF (I2) 1, 2, 3
READ (10, 10) VALUE
FORMAT (I5)
WRITE (7, 20) VALUE
FORMAT (I5, L5)
RETURN

WRITE (7, 30) SYMBOL, VALUE
FORMAT (I5, A6, B, L5)
READ (10, 40) SWITCH, VALUE
IF (SWITCH EQ. SLASH) GO TO 60
WRITE (7, 50)
FORMAT (I5, L5)
RETURN

VALUE = VAL2
WRITE (7, 70) SLASH VALUE
FORMAT (I5, A6, B, L5)
RETURN

WRITE (7, 80) SYMBOL, VALUE
FORMAT (I5, A6, B, L5)
RETURN
END

410008 CM STORAGE USED --- 104 SECONDS
SUBROUTINE MATIN

SYMBOL is a 6 CHARACTER ALPHANUMERIC, eg. *A*

A is the array name

Ml and N1 are the dimensions of the desired matrix

DIMENSION A(M1,N1)

INTEGER SYMBOL

WRITE (7,5) SYMBOL, M1, N1

5 FORMAT(14HO INPUT MATRIX, A6#ZH 012, 3H X PIOH) BY ROWS:

DO 30 I=1, M1

READ (10,10) (A(I,J), J=1, N1)

10 FORMAT(10(G13.6))

WRITE(7,20) (A(I,J), J=1, N1)

20 FORMAT(1H, 10(G13.6))

CONTINUE

RETURN

END

41т008 CH STORAGE USED .118 SECONDS
SUBROUTINE NATMUL(NRAN, ZRANC, CAN, RB, NRZRB, NGB, NRC)

DIMENSION A(NRAN), B(NRB), C(NRC)

GO TO (101) 100, 102, 103, 104

5 101 IF(NRAN .NE. NRZRB) GO TO 1000

10 DO 200 I = 1, NRAN
     DO 200 J = 1, NRB
     C(I, J) = 0
     DO 200 K = 1, NCR
     C(I, J) = C(I, J) + A(I, K) * B(K, J)
200 CONTINUE

102 IF(NRAN .NE. NCR) GO TO 1000

15 DO 400 I = 1, NCR
     DO 400 J = 1, NCR
     C(I, J) = 0
     DO 400 K = 1, NRZRB
     C(I, J) = C(I, J) + A(I, K) * B(K, J)
400 CONTINUE

20 RETURN

103 IF(NRAN .NE. NRZRB) GO TO 1000

25 DO 600 I = 1, NRZRB
     DO 600 J = 1, NRB
     C(I, J) = 0
     DO 600 K = 1, NCR
     C(I, J) = C(I, J) + A(I, K) * B(J, K)
600 CONTINUE

30 RETURN

104 IF(NRZRB .NE. NCR) GO TO 1000

35 DO 800 I = 1, NRB
     DO 800 J = 1, NRZRB
     C(I, J) = 0
     DO 800 K = 1, NCR
     C(I, J) = C(I, J) + A(I, K) * B(J, K)
800 CONTINUE

40 RETURN

END

410008 CM STORAGE USED 427 SECONDS

WRITE(7, 2000) FORMAT(5X, 'CHECK THE PROGRAM FOR MISTAKES')

RETURN
SUBROUTINE MATOUT(SYMBOL,N1,N1Z)

THE VARIABLES IN SUBROUTINE MATOUT ARE AS FOLLOWS
C$SYMBOLO$ IS A 6-CHARACTER ALPHANUMERIC EG. A*
C$M1$, AND $N1$ ARE THE DIMENSIONS(VERT,HOR) OF THE
CPRINTOUT
C$M1$ IS THE COLUMN LENGTH OF $A*$ AS DIMENSIONED IN THE
CCALLING PROGRAM
C$IZ$ CAUSES DOUBLE SPACING, OTHERWISE SINGLE SPACING
DIMENSION A($M$,N1)
INTEGER SYMBOL

WRITE(7,5) SYMBOL
5 FORMAT(*1XG12.5)
DO 10 I=1,N1
   WRITE(7,20) (A(I,J),J=1,N1)
20 FORMAT(*1XG12.5)
IF (I2.EQ.0) WRITE(7,15)
   FORMAT(*1XG12.5)
10 CONTINUE
RETURN
END

SUBROUTINE MATOUT(SYMBOL,A,M1,N1,Z)

CM STORAGE USED .098 SECONDS
SUBROUTINE MATSM

SUBROUTINE MATSM(A,B,C,M,MA,NA,M2B,NB,NC,M2C,NC,N)

DIMENSION A(MA,NA),B(MB,NB),C(MC,NC)

GO TO (101,102,102,101),L

101 IF(M2B+NE+M2C+OR.+(NB+NE+NC)) GO TO 1000

GO TO 110

102 IF(NB+NE+M2C+OR.+(M2B+NE+NC)) GO TO 1000

110 IMAX=M2B

IF(L.LE.2) GO TO 200

IMAX=NB

JMAX=M2B

200 IF(IMAX.GT.MA OR JMAX.GT.NA) GO TO 1000

DO 600 I=1,IMAX

DO 600 J=1,JMAX

A(I,J)=B(I,J)+((-1)**K)*C(I,J)

IF(L.LE.2) A(I,J)=B(J,I)+((-1)**K)*C(I,J)

IF(L.EQ.3) A(I,J)=B(J,I)+((-1)**K)*C(J,I)

600 CONTINUE

RETURN

1000 WRITE(7,10000)

10000 FORMAT(5X,9MATRICES NOT CONFORMABLE*)

RETURN

END

410008 CM STORAGE USED

.336 SECONDS
SUBROUTINE MULPLT

REAL A(NP), X(NV), Y(NV)
INTEGER MAX, MIN, ND, I, J, L, N, K
REAL EPS, EPS2, XMIN, XMAX, YMIN, YMAX

IF (NRY.LT.NP) STOP ONRY < NP, WRONGO
IF (EYMAX.E.EYMIN) PAUSE YOU MADE A MISTAKE IN PUTTING LIMITS!
DO 10 I = 1, NV
IF (YMAX(I).GT.YMAX(I-1)) YYMAX = YMAX(I)
IF (YMIN(I).LT.YMIN(I-1)) YYMIN = YMIN(I)
CONTINUE

IF (MANUAL) GO TO 41
YYMIN = YYMIN
YYMAX = YYMAX
RANGE = YYMAX - YYMIN
KAXIS = 60.*(-YYMIN/RANGE)+.5
IF(YYMIN.GT.0.0) KAXIS=1
IF(YYMAX.LT.0.0) KAXIS=61
35 DIS = RANGE/60.
40 CONTINUE
41 YYMAX = YMAX(I)
YYMIN = YMIN(I)
RANGE = YMAX - YMIN
KAXIS = 60.*(-YMIN/RANGE)+1.5
45 IF (YMIN.GT.0.0) KAXIS = 1
IF (YMAX.LT.0.0) KAXIS = 61
35 DIS = RANGE/60.
MIN = 1
XMIN = ABS(B(I))
DO 50 J = 1, NP
IF (ABS(B(J)).GE.XMIN) GO TO 50
XMIN = ABS(B(J))
50 CONTINUE
50 CONTINUE
DO 70 K = 1, 3
WRITE(7,80)
70 CONTINUE

WRITE(7,80)
WRITE(7,80)
WRITE(7,90)

WRITE(7,110) SYM(I), YNAME(I), YNAME(2, I), YMIN(I), YMAX(I)
110 CONTINUE
WRITE(7,110) SYM(I), YNAME(I), YNAME(2, I), YMIN(I), YMAX(I)
110 CONTINUE

WRITE(7,80)
WRITE(7,80)
WRITE(7,80)
WRITE(7,80)
WRITE(7,80)
WRITE(7,80)
SUBROUTINE MULPLT

WRITE(7,115) XNAME(1),YMIN,YMAX
115 FORMAT(2X,A8,5X,14HORIDENTATE AXISI,6H MIN=,G13.6,
* 7H MAX=,G13.6) WRITE(7,120) XNAME(2),DIS
120 FORMAT(3X,A8,30X,10HINCREMENT#,2X,G13.6,/) DO 130 J=1,N
LINE(J)=BLANK
65 CONTINUE DO 170 J=1,MP
IF(J.EQ.N) GO TO 180 LINE(MAXI)=DOT
70 DO 140 I=1,NV
X=60.*(A(J)-YMIN)/RANGE
KK(J)=X+1.5 IF(KK(J) .GE. 61) LINE(61)=HI
80 IF(KK(J) .LE. 1) LINE(1)=LO
DO 140 K=1,3 WRITE(7,150) B(J),LINE
150 FORMAT(1X,G13.6,6X,6A1) DO 160 I=1,NV
LINE(K)=BLANK
160 CONTINUE DO 220 K=1,3 WRITE(7,150) EYHAX,YYMAX
220 EYMIN=YYMIN
CONTINUE
180 CONTINUE GO TO 211
90 DO 200 I=1,NV
X=60.*(A(MIN(I))-YMIN)/RANGE
KP(I)=X+1.5 IF(KP(I) .GE. 61) LINE(61)=HI
95 IF(KP(I) .LT. 1) LINE(1)=LO
DO 200 K=1,3 WRITE(7,150) B(J),LINE
200 CONTINUE DO 210 J=1,61
LINE(J)=DOT
190 CONTINUE GO TO 170
210 CONTINUE GO TO 170
211 DO 220 K=1,3 WRITE(7,160) EYMAX,EYMIN
220 CONTINUE RETURN
END

LABELIB
Page 10 of 17
SUBROUTINE PLOTRCBA,NPPXNAMEPYNAME,EINEMAXISC3
  DIMENSION BCNP#A(NP),LINE(6)...
  INTEGER HILOLINEBLANK,DOTSTAR
  LOGICAL MANUAL,SYME
  INTEGER XNAME(E),YNAME(Z)
  DATA BLANK,DOTSTAR/1H1HnslH*/*HI/94/,LO/IH/...
  SYME=.FALSE.
  MANUAL=.TRUE.
  IF(EMAX.EQ.EMIN) MANUAI=.FALSE.
  IF(EMIN.GT.EMAX) STOP 'YOU MADE A MISTAKE INPUTTING EMIN & EMAX'
  IISC-IISC
  IF(MANUAL) IISC ----.
  DO 10 If-l NP
    IF(A(I).GT.YMAX) YMAX=A(I)
    IF(A(I).LT.YMIN) YMIN=A(I)
  10 CONTINUE
  ZO' GO TO 21
  11
  19 YMIN=ABS(B(I))
  DO 20 J-2,NP
    IF(ABS(B(J)).GE.XMIN) "GO TO 20
    XMIN=ABS(B(J))
  20 CONTINUE
  35 IF(XISC.EQ.0) GO TO 21
  RANGE=YMAX-YMIN
  KAXIS=60.*(YMIN/RANGE)+1.5
  IF(YMIN.GT.0.0) KAXIS=1
  DIS=RANGE/60.
  GO TO 30
  21 IF(YMIN.GT.0.0) GO TO 22
  IF(YMAX.LT.0.0) GO TO 23
  KAXIS=31
  SYME=.TRUE.
  ABY=ABS(YMIN)
  RANGE=ABY*YMAX
  DIS=RANGE/30.
  GO TO 30
  45 KAXIS=1
  RANGE=YMAX
  DIS=RANGE/60.
  GO TO 30
  23 KAXIS=61
  RANGE=YMIN
  DIS=RANGE/60.
  CONTINUE
  30 DO 40 K=1,3
  40 WRITE(7,50)
  50 FORMAT(1H0)
  WRITE(7,60) XNAME(I),YNAME(I),YMIN,YMAX
SUBROUTINE PLOTR

60 FORMAT (2X, A8, 7X, A9, 3X, 3X, 20HORDINATE AXIS: G13.6)     MIN=G13.6, 3X, 4HMAX=+

60 WRITE (7, 70) INAME(2), YNAME(2), 515

70 FORMAT (2X, A8, 7X, A8, 25X, 10HINCREMENT=G13.6 /)

DO 80 J = 1, 61
LJNE(J) = BLANK

80 CONTINUE

DO 100 J = 1, 61
IF(J2.EQ., MIN) GO TO 110
X = (A(J) - YMIN) / RANGE

70 K = K + 1.5
LINE(K) = DOT
IF(K.GT.61) LINE(61) = BLANK

72 IF(K.LT.1) LINE(1) = DOT
IF(K.LT.1) KMAX = K
IF(K.GT.61) GO TO 89

80 IF(K.LT.1) KMAX = K
IF(K.GT.61) GO TO 89

85 IF(K.LT.1) GO TO 100
LINE(K) = BLANK
CONTINUE

90 110 CONTINUE

90 120 J = 1, 61
LINE(J) = DOT

120 CONTINUE

95 IF(J2.EQ., MIN) GO TO 110
X = (A(J) - YMIN) / RANGE

100 IF(K1.GT.61) LINE(61) = HI
IF(K1.LT.1) LINE(1) = LO
LINE(K1) = STAR
IF(K1.GT.61) GO TO 129

129 IF(K1.GT.1) GO TO 129
LINE(K1) = STAR
WRITE (7, 50) X, Y

130 FORMAT (1X, G13.6, 2X, G1.6, 7X, A30)

do 140 j = 1, 61
LINE(J) = BLANK

140 CONTINUE

140 CONTINUE

145 DO 150 K = 1, 61
WRITE(7, 50)

150 CONTINUE

EMIN = YMIN
CONTINUE

RETURN
SUBROUTINE PLOT " 73/172" TS

END

410000 CM STORAGE USED .817 SECONDS
FUNCTION PVALUE(X,P,DEL)
C THIS ASSUMES X RANGES ON THE REAL LINE, MODULO 2P AND
C REDUCES X TO THE INTERVAL (-P;DEL,P-DEL), EXCLUSIVE OF A SMALL
C INTERVAL ABOUT THE ORIGIN, (-DEL,DEL).

B*X/P
C*P*(AMOD(ABS(B)+1.,2.*)=1.)
IF (DEL,.NE. 0.) C=SIGN(AMAX1(ABS(A),P-DEL),DEL),C
IF (B.LT. 0.) C=0.
RETURN
END

41000B CM STORAGE USED .092 SECONDS
SUBROUTINE REALIO( SYMBOL, VALUE, IZ )
  INTEGER ISW, ISLASH, SYMBOL
  DATA ISLASH /1H//
  IF(IZ) 1,2,3
  READ(10, 10) VALUE
  10 FORMAT(G13.6)
  WRITE(7, 20) VALUE
  20 FORMAT(1H I, G13.6/)
  RETURN
  10 FORMAT(2H 7, S0)
  WRITE(7, 30) SYMBOL, VALUE
  30 FORMAT(1H , A6, 3H * G13.6)
  READ(10, 40) ISW, VAL2
  40 FORMAT(Al, G13.6)
  IF(ISW .EQ. ISLASH) GO TO 60
  15 WRITE(7, 50)
  50 FORMAT(1H )
  RETURN
  60 VALUE = VAL2
  WRITE(7, 70) ISLASH, VALUE
  70 FORMAT(1H , 2X, A1, G13.6/)
  RETURN
  3 WRITE(7, 80) SYMBOL, VALUE
  80 FORMAT(1H , A6, 3H * G13.6/)
  RETURN
  END

410008 CM STORAGE USED .098 SECONDS
SUBROUTINE RETURN

DIMENSION FIT(1)

IX = INOXFIT(LP) 

CALL STOREF(FIT(IX),ZLCF,LU)

CALL CLOSER(FIT(IX))

RETURN

END

41000B CM STORAGE USED ... +047 SECONDS
FUNCTION SATU(X, XL)
IF (ABS(X).LE.XL) GO TO 2
SATU=SIGN(XL,X)
RETURN
5
2
SATU=X
RETURN
END

41000B CM STORAGE USED ....... 0.046 SECONDS
PROGRAM PCRMPI

*TAPE0*

INTEGER DATIN(4)
DIMENSION TIM(102),YY(102), TODAY(3),PKXL(3),YYK(3), ALYSNR(3)
DIMENSION ENCM(3), RMS(3), ESTDEV(3), TCOUNT(3), YEMP(3), YMAX(3)
DIMENSION IDENT(63), CSNRTD(102), THESEP(102), JBNAM(3), CSNRF(102)
DIMENSION DOUT(3), ADDBRT(100), THESER(100), 3
DIMENSION NAME(10), NAME2(10), NAME(3), YPEAK(3), AYERR(3)
DIMENSION NAMSEP(3), NAMSNR(2), NAMTIM(4)

10 DIMENSION YORERR(3, 3)
EQUIVALENCE (RNAME2, NAME2(10)), (RNAME2, NAME(10))
DATA YMAX, 1.0, 0.6, 0.5, 0.12
DATA NAMEL/10HSIM. JOB., 3*IH, 10 FILE NO: *3*IH
--------
--------
DATA NAME/10HPLTS, JOB., 3*IH
--------
--------
DATA NAME/10*ZH
--------
--------
DATA DATIN/10HMLT DATA, 3*I0/
--------
--------
DATA NAMSNR/10HCSNR, (TD-SPI, CAN)
20 DATA NAMSEP/10H SEPARAT, 10HION ANGLE, 10HDEG, /
DATA NAMTIM/10H TIME SINCE 10H FIRST SCAN, 10H (SECONDS, /
30 CALL CALCO(20)
CALL FACTOR (1,)
CALL PLOTZ.00, 1.50,-3)
40 READ(10,10) ,.....
10 FORMAT(I2)
LWRITE(7,20) NAME2(2), RNAM2, NPLDTS
45 FORMAT(1I5, JOBNAME:, A10, 15X, THDATES lAO//, lH .13,
*17 HPLOTS TO BE DONE)
80 DO N-I, FILES
20 READ(10,40) DATIN(2)
40 FORMAT(53XA10)
80 WRITE(7,50) NPNPLOTS, (DATIN(II-1, Z), NNFILES
50 FORMAT(6H PLOT I2, 4H OF *IZ/Z4
*4H OF *Z/4)
IF(IR.EQ.0) DO
60 STOP INPUT FILE ATTACH NOT SATISFACTORY..
C READ FILE INTO NTH ELEMENTS OF ARRAYS, WHERE NECESSARY
60
C
70 READ(15) DOUT(N),DELT,MTIMES,LMAX,KM,TODAY,N,JBNAM(N)
C READ(15) (IDENTS(I),I=1,6)
C READ(15) NRUN,DSNROD,RHD,BETA,FSC,MLS,BRCVR
C
65 DO 80 K1,KM
C READ(15) CSNRTO(K),CSNRFR(K),THESER(K),ABBORT(K),THESEP(K)
80 CONTINUE
C READ(15) EMEAN(N),ERMS(N),ESTDEV(N),TCOUNT(N),YMIN(N),YMAX(N)
C CALL RETURN(6LTAPE15)
70 C WRITE DATA ON LPRINT AS IN CONTROL
C
75 WRITE(7,90) DOUT(N),DELT,MTIMES,LMAX,KM,TODAY(N),JBNAM(N)
90 FORMAT(1H10,A10,6X,G13.6,5X,3(5X,I3,10X),A10,8X,A10/)
70 WRITE(7,100) (IDENTS(I),I=1,6)
100 Format(1H10,6X,A5,9X/)
70 WRITE(7,110) NRUN,DSNROD,RHD,BETA,FSC,MLS,BRCVR
110 FORMAT(1H5X,12,6X,6(5X,G13.6)/)
C
80 DO 130 K1,KM
C WRITE(7,120) CSNRTO(K),CSNRFR(K),THESER(K),ABBORT(K),THESEP(K),K
120 FORMAT(1H5X,3(G13.6,5X),6X,11X,G13.6,5X,17)
130 CONTINUE
C
85 DO 140 K1,KM
C WRITE(7,140) CSNRTO(K),CSNRFR(K),THESER(K),ABBORT(K),THESEP(K),K
140 FORMAT(1H5X,5(6X,1H,11X))
150 CONTINUE
C
90 DO 160 K1,KM
C WRITE(7,160) CSNRTO(K),CSNRFR(K),THESER(K),ABBORT(K),THESEP(K),K
160 CONTINUE
C
95 DO 170 K1,KM
C WRITE(7,170) EMEAN(N),ERMS(N),ESTDEV(N),TCOUNT(N),YMIN(N),YMAX(N)
170 CONTINUE
C
C DRAW LEFT EDGE OF THE PAGE
C CALL PLOT(-2.0,0.0,3)
C CALL PLOT(-2.0,7.0,2)
C
C WRITE INFORMATION ON THE TOP OF THE PAGE
C
100 YH=8.8-S
105 XH=0.5
110 CALL SYMBOL(XH,YH,NAME1,0.0,90)
120 NAME1=IBLANK
C
100 DO 200 N1,NFILES
110 NAME(2)=JBNAM(N)
190 CONTINUE
PROGRAM PCRMP1 73/172 TS FTN 4.6+452 05/17/79 16.20.35 PAGE 3

115  195 DECDEODO*195,DWUT(H)) NAME(6),
FORMAT(A10)
   RNAME=TODAY(N)
   YIN=0,N=PS
   CALL SYMBOL(XH,YH+H,NAMEXO+0,100)
120  200 CONTINUE
   CALL SYMBOL(XH,YH+H,NAME2,0,100)
C ORIGINATE TIME DELAY
C
125  KMK*KM+1
   KMK2=KM+2
   *************210
   DO 210 K=1,KM
   TIM(K)=DEL*K
130  CONTINUE
   CALL SYMBOL(XHY1HHNAME1,0,0,100)
C FIND MAX,MIN, AND INCREMENT FOR CSNTRD
C
135  210 CONTINUE
   CSNRTD(KM1)=0.0
   SNRINC=1.0F0(CSNRTD(K)+5)
   CSNRTD(KM2)=SMINC
   YH=NMAX
   YP2=1.0E+320
   ALX=ALTIM/1
   CALL SCALE(TIM,ALX,KM)
   *************220
   DO 220 N=1,NFILES
   YPEAK(N)=AMAXI(1-NMIN(N),YMAX(N))
   YMAX=AMAX1(YMAX,TVMAX)
140  CONTINUE
   YMIN=LMIN(YH,YMIX)
   *************230
   DO 230 K=1,KM
   YY(K)=THESER(N,K)
   ZS=SIGN(YMIN,YY(K))
145  IF(ABS(YY(K)).GE.YMM)
150  CONTINUE
   YY(K)=ZS*YMM
   *************230
   DO 230 K=1,KM
   YY(K)=THESER(N,K)
   ZS=SIGN(YMIN,YY(K))
155  CONTINUE
   YY(K)=ZS*YMM
150  CONTINUE
   YY(K)=ZS*YMM
160  CONTINUE
   CALL FACTOR(1,1)
   CALL PLOT(0.0,YORM2(N,NFILES),-3)
   XB=-3.0*S
   YB=YPK(NFILES)
   CALL SYMBOL(XBYB,H,PKVAL,90.0,23)
   CALL FACTOR(SIZE,ALY-ALYERR(NFILES)/SIZE
   ENCODE(17,250,NAMERR)
   IDENT(3,N)
165  CONTINUE
   YPK=MEM(NFILES)
   CALL SYMBOL(XB,YB,PKVAL,90.0,23)
   CALL FACTOR(SIZE
   ALY=ALYERR(NFILES)/SIZE
   ENCODE(17,250,NAMERR)
   IDENT(3,N)
170  CONTINUE
   CALL FACTOR(1,0)

PCRMP1
Page 3 of 4
CALL PLOT(0.0, YORERR(NFILES) = 3)
CONTINUE
CALL PLOT(0.0, YORSNR = 3)
CALL FACTOR(1.0)
CALL FACTOR(SIZE)
CALL AXIS(0.0, EPS + 0.0, NAME = 'SNR', SIZE = 1.0)
CALL LINE(TIM, EPS + 0.0, SNR, 1.0, 0.0, 0.0)
CALL PLOT(-2.0, 0.0, 3)
CALL PLOT(-2.0, 7.0, 2)
END
STOP

42000B CM STORAGE USED
4.12B SECONDS
PROGRAM RLOGSW

(OUTPUT#TAPE1#TAPE7#OUTPUT)

C THIS READS <SWA>, <SWB>, % <RAB>
REAL NC(1000), NS(1000)
INTEGER FNA(4)

COMMON /DATA1/GA,x,WA,WA1,WA2,WA3,WA4,WA5,WA6,WA7,WA8,WA9,WA10,
       /DATA2/LMAX,OSO,JHMAX,NC,NS,ALMX,JHMAX
DIMENSION QA(25),BJ(J),BULK(J,J),3,DATA(9),COSB(10)

EQUIVALENCE (WA,DATA(1))
DATA PI/3.1415927/,LMAX/100/,JHMAX/1000/,JHMAX/12/
DATA FNA/100,MSSLOGSWCDILC,2*O/,...

C FOLLOWING READS DATA FROM FILE
IX=IATTACH(6,TAPE1,FNA)
READ (10) LMAX1,JHMAX
READ (10) IQMAX,(QA(I)),I=1,IQMAX)
READ (10) JBMAX,(BJ(J),J=1,JBMAX)
READ (10) ((BULK(J,J),J=1,JBMAX),I=1,IQMAX),X=1,3)

DO 80 K=1,3
     IF (K.EQ.1) WRITE (7,870)
     IF (K.EQ.2) WRITE (7,871)
     IF (K.EQ.3) WRITE (7,872)

870 FORMAT (1X,///,SHOSW)
871 FORMAT (1H1,///,SHOSW)
872 FORMAT (1H1,///,SHORAB)

WRITE (7,880) (BJ(J),J=1,JBMAX)
880 FORMAT (1H1,///,SHOSW)

WRITE (7,885)
885 FORMAT (4HQA1)

DO 10 I=1,IMAX
     WRITE (7,890) QA(I)
10 CONTINUE

DO 10 J=1,JMAX
     WRITE (7,892) (BULK(J,J),J=1,JMAX)
10 CONTINUE

STOP
END

410008 CM STORAGE USED ······ 300 SECONDS
PROGRAM WLOGSW

C THIS COMPUTES <WGA>, <WGB>, <WA>, <SWA>, <SWB>, X <RA8>

REAL NC(IOOO),NS(IOOO)

COMMON DATAI(IO,T),DBU(WA),WAX(WA),WAXA(WA),WAXB
COMMON DTAI2/MAI1/CUSB,JMAX,NC,NS,ALNI1,RJMAX

DIMENSION GAI(25),BII(12),DAI(25),NIA(5)

DIMENSION DATA3(12,25,3),BULK(12,25,3),CUSB(101),DATA4(937)

EQUIVALENCE (WAI,DATA1(1)),(GAI(1),DATA4(11)),(BJ(I),DATA4(20))

EQUIVALENCE (DATA4(30),DATA3(1,1,1))

DATA PI/3.1415927/,LMAX/100/
DATA JMAX,XMAX/100/25/,JMAX/12/
DATA QAI(1),OATA4(1),OATA3(I,1),OATA2/SQRT(0.5)/
DATA BH(5),BH(6),BH(7),BH(8),BH(9),BH(10),BH(11),BH(12),BH(13)

WRITE(7,9) LIAX,JNMAX
FORMAT(1H LMAX=,I5/8H JNMAX=,I5/)
CONTINUE

DO 100 1=1,IQMAX
  DO 100 J=1,JBMAX
  DATA3(J,1,K)=ALOG(SQRT(BULK(J,1,K)))

CONTINUE

DO 200 J=1,JBMAX
  DATA3(J,1,3)*=BULK(J,1,3)/SQRT(BULK(J,1,1)*BULK(J,1,2))

CONTINUE

CONTINUE

CONTINUE

STOP
END

410008 CM STORAGE USED: 827 SECONDS
SUBROUTINE WAWB
CTHIS COMPUTES A SAMPLE EACH OF THE PROCESSES WA & WB
REAL NCCIOOO), NSI00)
COMMON/OATALIOA, [UWAA, WBA, WA2A, WB2A, WAAB, WBAB, WA, WB
COMMON/GDATA2/LHAXL1, CSBO, JMMAx+NCNSALNLMX, RLMAX
DIMENSION HA(1011), HB(1011), COS(1011), G(1011), H(1011)
C
GMAX=-1.E+322
HMAX=1
HABAX=1
HBMAX=1
DO 20 L=1,LMAX1
COSBL=COSBL(L)
BCBL1=AMAX1(1x+9*COSBL+0.)
AABC+UB*BCBL1
UABC=U*ABC
RAD2=SORT(1,ABC)
RAD1=SORT1+(UABC)
GLZ=(RAD1-1./((1+RAD1)*ABC
GLZ=GL
HL=1./SORT((1+6.2091646*RAD)
H(L)=HL
HAL=(-1+U/RAD1)*HL
HBL=HAL*COSBL
HBL=HAL*HBL
HBL=HAL*COSBL
GMAX=AMAX1(GL, GMAX)
HMAX=AMAX1(HL, HMAX)
HABAX=AMAX1(ABS(HAL), HABAX)
HBAX=AMAX1(ABS(HBL), HBAX)
CONTINUE
GZ=GMAX-741.1
FZ=ALOG(HMAX)+GZ
FZ=ALOG(HMAX)+GZ
GZ=2*ALNLNX
GZ=2*ALNLNX
GZ=GZ=ALOG(HABAX)
GZ=GZ=ALOG(HBAX)
FZ=0.
FZ=0.
DO 30 L=1,LMAX1
GL=GL(L)
GLM=GL-GL
GLMA=GL-GL
GZ=2*ALNLNX
GZ=2*ALNLNX
GZ=GZ=ALOG(HABAX)
GZ=GZ=ALOG(HBAX)
FZ=0.
FZ=0.
DO 30 L=1,LMAX1
GL=GL(L)
GLM=GL-GL
GLMA=GL-GL
IF(GLM+GE-674.) FS=FS+EXP(GLM)*H(L)
IF(GLMA+GE-674.) FSA=FSA+EXP(GLMA)*H(L)
IF(GLMB+GE-674.) FS=B+EXP(GLMB)*H(L)
CONTINUE
WA=(HABAX/HABAX)*(FSA/FS)
WA=HMAX/HMAX*(FSB/FS)
RETURN
END
410008 CM STORAGE USED 399 SECONDS
SUBROUTINE WAVGS
C GIVEN QA % B, THIS COMPUTES VARIOUS AVERAGES OF WA' & WB OVER U''
REAL NCJ,NSJ,NC(1000),NS(1000)
DIMENSION DATUM(5)
COMMON/DATA1/QA,B,UA,WAA,WA2A,WBA,WA,WA
COMMON/DATA2/LMAX1,CSE(101),JNMAX,NC,NS,ALNL,HX,RIJMAX
EQUIVALENCE (WA,DATA1),(IBUMAX,LMAX1)
C
DO 10 K=1,5
10 CONTINUE
DO 10 I=1,IBUMAX
COSBUI=COSB(I)
QU=QA+MAX1(1.+B*COSBUI,Q)
SQRQUZ=2.*SQR(QU)
DO 20 J=1,JNMAX
NCJ=NC(J)
NSJ=NS(J)
U*QU+NCJ*SQRUZ+NCJ*NCJ+NSJ*NSJ
20 CONTINUE
CALL WAWB ..
WAA=WAA+WA
WBA=WBA+WB
WA2A=WA2A+WA
WBA=WBA+WA
WA=WBA+WA
WBA=WBA+WA
WBA=WBA+WA
WBA=WBA+WA
DO 40 K=1,5
30 CONTINUE
40 CONTINUE
S DO 40 K=1,5
DATUM(K)=DATUM(K)*RIJMAX
30 CONTINUE
RETURN
END
41000B CM STORAGE USED .175 SECONDS
APPENDIX B

EXPERIMENTAL SYSTEM DATA ACQUISITION

PDP-11/03 DEV 11 Parallel Line Unit signals which will be used:

Outputs: OUT 00 through OUT 15*
NEW DATA READY*
DATA TRANSMITTED*
CSR0*

Inputs: IN 00 through IN 09*
REQ A*
REQ B*

Signals which will be generated by the data acquisition hardware:

BIT 0 through BIT 9*
START CONVERT*
STATUS*
CLEAR CONTROLLER*
TO SCAN IN (DECODE 33)*
tF RECEIVED
COMPARISON MATCH*
COUNTER ENABLE
COUNTER DISABLE
ID RECEIVED \ne ID REQUESTED
tS * TO SCAN IN
ID RECEIVED = ID REQUESTED
tS * TO SCAN IN
S0 through S5*

Signals which are expected from the BENDIX receiver:

tF*
Log Video(+) * and Log Video(-)*
Elevation*
Azimuth*

Signals which will be supplied from front panel switch: Basic Wide (BW)
or Basic Narrow (BN)*

Quick Overview of Normal Operation

After initialization, the hardware will ask the PDP 11/03 to select the

Note: * indicates that the signal will be transmitted via the backplane of the VERO rack.
type of scan (Azimuth or Elevation), which should next be sampled. In response
the PDP will read out the samples from the previously sampled scan which were
stored in a semiconductor memory; then, the PDP will select the next type of
scan to be sampled. This selection is referred to as "ID REQUESTED" (ID REQ).

Now, the hardware waits for the \( t_R \) signal from the BENDIX receiver which
indicates the beginning of the next scan. (Note: \( t_R \) must come shortly after
Bit 5 of the BARKER code (data Bits 1 through 5); however, scan function identi-
fication is associated with data bits 6 through 11. The current design
assumes that Azimuth or Elevation scans are the only type being transmitted
from the airport. If this is not the case design changes must be made. This
problem will be discussed further in relation to the Function ID logic.) After
receipt of the \( t_R \) pulse, the hardware waits for either the Azimuth or the
Elevation line from the BENDIX receiver to be raised. This is referred to as
the "ID RECEIVED" (ID REC).

If the ID requested is unequal to the ID received, then the hardware
waits until the desired scan is received. When the desired scan is received,
(ID requested = ID received), the hardware asks the PDP to tell it when to
start sampling the TO scan. The PDP sends a 16-bit \( t_s \) word to the hardware.
When a hardware timer operating at 3.84 MHz counts up to the \( t_s \) word, TO scan
sampling commences. The \( t_s \) word measures time with respect to the \( t_R \) refer-
cence, but there are some delays which are involved which must be compensated
for by adjusting the \( t_s \) word sent to the hardware. These adjustments will be
discussed later.

The data samples have 10-bit resolution and are stored in a 256 x 12
semiconductor memory. After 33 samples are taken, the hardware asks the PDP to
send a \( t_s \) word to tell it when to start FRO scan sampling. When the hardware
timer counts up to this \( t_s \) word, FRO scan sampling commences. Then, 34 samples
are taken (the last one will be ignored when data are read out for processing).

Finally, the hardware returns to the state in which it asks the PDP to select the next type of scan to be sampled. The PDP reads out the 66 samples and sends out the next ID requested.

Detailed Description of the Data Acquisition Hardware

The detailed description will come in two parts. First, the hardware will be divided into functional units which will be described as separate entities. Second, a step-by-step description of the operation of the hardware will be given to show how the functional units interact by passing signals through the backplane of the VERO rack. The backplane wiring will be described after all of the functional units have been presented. The descriptions are most meaningful if they are read along with the logic diagrams of the hardware.

Functional Units

The hardware is divided into separate functional units, each of which has its own Vero Finger Board. These boards will be mounted in a Vero rack, and the backplane will provide the necessary interconnections from board-to-board and from the rack to the PDP 11/03 computer. The functional units are:

- a. POWER SUPPLY
- b. OSCILLATOR (3.84 MHz Clock)
- c. A/D and Sample/Hold
- d. STATE CONTROLLER and FUNCTION ID LOGIC
- e. SCAN TIMER
- f. SAMPLE TIMER & BUFFER MEMORY

Power Supply (Figure B-1)

The power supply is a Datel Systems BPM 15/150-D5, which converts +5 volts to ±15 volts with COMMON. The supply has been mounted on a PC board with an aluminum plate for heat dissipation. Note: It is very important in a
Figure B-1  Power Supply
system with both analog and digital signals present to maintain the correct
distinction between analog and digital ground. However, these must ultimately
be tied together -- preferably, as close to the power supply as possible.
Therefore, GROUND and COMMON have been wired together on the power supply
board. [Note: second thoughts suggest the two supplies should be tied together
at the A/D Converter (see below); this will be considered further]

Inputs: +5 Volts, GROUND   Outputs: +15 Volts, -15 Volts, COMMON

Oscillator

The oscillator is a 3.84 MHz crystal oscillator which has been mounted on
a special PC board which provides a ground plane underneath the entire unit.

Inputs: +5 Volts, GROUND   Outputs: CLOCK

A/D and Sample/Hold (Figure B-2)

This board will include an AD509J Op Amp and an ADC1109 Analog-to-Digital
Converter, both by Analog Devices, plus an SHM-12 Sample and Hold by Datel.
The op amp is used in the standard noninverting configuration, with high-
frequency compensation, to provide a gain of four. This gain will boost the
0 - 2.5 Volts swing of the Log Video input to 0 - 10 Volts, which is the uni-
polar range of the A/D converter.

The board will operate as follows. The A/D converter will receive a
START CONVERT command, via the backplane, from the SAMPLE TIMER & BUFFER MEMORY
board. The converter will then raise its STATUS output signal, which will make
the SHM-12 hold the current value of the Log Video input. Approximately four
microseconds later, when the conversion is completed, the STATUS line will drop
low. The 10 bits of digitized data are then valid. The negative-going edge of
the STATUS signal will cause the 10 bits to be written into the buffer memory
via the backplane. Note: While the schematic diagram for this board shows the

B-5
Figure B-2  A/D and Sample/Hold
ADC 1109 with trim pot adjustments for the zero adjust (Pin 21) and the gain adjust (Pin 23), these should be replaced ultimately with precision resistors. Also, it is assumed that Log Video will be brought to the backplane from the BENDIX receiver through a shielded cable.

Inputs: +5 Volts, GROUND, +15 Volts, -15 Volts, COMMON, START CONVERSION, Log Video(+), Log Video(-)

Outputs: STATUS, Bit 1(MSB) through Bit 10(LSB)

State Controller and Function ID Logic (Figures B-3 and B-4)

The state controller design is based on the control-state counter, presented in Section 5.11 of Thomas R. Blakeslee's book, Digital Design with Standard MSI and LSI. The controller consists of two 74151 data multiplexers, a 74193 presettable binary counter, and a 7442 demultiplexer. The inverters on the outputs of the demultiplexer are used for buffering and also establish positive logic; thus, when a line, such as S1, goes high, the controller is in State 1. The operation of the controller is discussed in Blakeslee's book and will not be described here. However, we may summarize its performance with the state diagram on the following page (Figure B-3).

The signals which cause the transitions from one state to another are produced at several different points in the data acquisition system:

<table>
<thead>
<tr>
<th>Signal</th>
<th>Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLEAR CONTROLLER</td>
<td>SAMPLE TIMER &amp; BUFFER MEMORY LOGIC; the signal goes high at initialization when CSR0 is raised and, also, after PRO scan sampling.</td>
</tr>
<tr>
<td>NEW DATA READY</td>
<td>PDP 11/03 DRV 11; this signal is raised when the DRV 11 places data in its output buffer. The data in this case is a code indicating the type of scan which the computer wants to sample next. BENDIX receiver.</td>
</tr>
</tbody>
</table>
Figure B-3 State Diagram for State Controller
Figure B-4 State Controller and Function ID Logic
Signal | Origin
-------|----------------------------------
ID received = ID requested | FUNCTION ID LOGIC; these signals are produced on the same board that contains the state controller. The Function ID logic is discussed below.
ID received ≠ ID requested |
TO SCAN IN | SAMPLE TIMER & BUFFER MEMORY LOGIC; after 33 samples have been taken, this signal is raised to indicate that TO scan sampling is completed.
$t_s \cdot \text{TO SCAN IN}$ | STATE CONTROLLER & FUNCTION ID LOGIC; when the PDP sends out the first $t_s$ word, the NEW DATA READY signal is pulsed to indicate that data is in the DRV 11 output buffer. The TO scan samples have not yet been taken, so TO SCAN IN is true. We use the trailing edge of the NEW DATA READY signal to fire a one-shot, whose output is logically ANDed with TO SCAN IN to produce $t_s \cdot \text{TO SCAN IN}$. By using the trailing edge, we insure that the data is stabilized in the output buffer before we accept it as valid.
$t_s \cdot \text{TO SCAN IN}$ | Similar to above; however, when the PDP sends out the second $t_s$ word, TO scan sampling has already been completed and TO SCAN IN is true. Thus, TO SCAN IN and TO SCAN IN are used by the hardware to differentiate between TO and PRO scans.

Function ID Logic (Figure B-4)

As mentioned in the quick overview, the function ID logic, as currently designed, will work only if Azimuth and Elevation scans are the only scans being transmitted from the airport. The logic works as follows. When making an ID request, the computer will use signals OUT 15 and OUT 14 of the DRV 11. OUT 15 will be raised to request Azimuth; OUT 14 for Elevation. The NEW DATA READY pulse associated with this output will strobe the request into a 7475 buffer latch. Now, when the BENDIX receiver decodes the scan function ID, either the Azimuth flag or the Elevation flag will be raised. A DM8160 comparator will compare the ID received with the ID requested. It takes approximately 20 nsec for the comparator output to become valid. In order to prevent premature generation of invalid ID RECEIVED ≠ ID REQUESTED or ID RECEIVED = ID
REQUESTED signals, the rising edge of either the Azimuth or Elevation flag is passed through a delay line and is used to gate the comparator output and its complement on to the state controller. Thus, both of the signals ID REQUESTED \( \neq \) ID RECEIVED and ID REQUESTED = ID RECEIVED remain low until the comparator output is valid, at which time only one of the signals goes high. This is necessary for the correct operation of the state controller (see Figure B-5).

If the airport were to broadcast more than just Azimuth and Elevation scans, the hardware as currently designed would not work. The BENDIX receiver would have to send out a \( t_R \) pulse at the beginning of each scan as it decodes the BARKER code; it has no way of knowing if the scan to follow is Azimuth, Elevation, or otherwise. Upon receipt of the \( t_R \) pulse, the state controller would enter STATE 2. Now, however, the controller would be stuck if neither the Azimuth nor Elevation flags were raised, as neither of the signals ID REC = ID REQ or ID REC \( \neq \) ID REQ would be enabled to take the controller to another state. There are two ways around this problem. One solution would be to have the Bendix receiver provide additional flag signals for the other scans and to expand on the current design using some of the extra inputs to the DM8160 comparator. The raising of any of the flag signals could be used to gate the comparator output on to the state controller. A second solution would be to obtain precise information about the delay between the output of the Bendix \( t_R \) pulse and the output of the Azimuth or Elevation flags. Since the \( t_R \) pulse starts a 3.84 MHz counter, logic could be designed around this counter to provide a pulse after this delay had elapsed. This pulse could be used to gate the comparator output on to the state controller.

Inputs: +5 Volts, GROUND, CLEAR CONTROLLER, TO SCAN IN, CLOCK
        BENDIX \( t_R \), Azimuth, Elevation
        NEW DATA READY, OUT 14, OUT 15

Outputs: S\( \phi \), S1, S2, S3, S4, S5
Figure B-5  Timing Diagram for Function ID Logic
Scan Timer (Figure B-6)

The purpose of the scan timer is to initiate sampling of the TO and PRO scans at the times specified by the 16-bit t_s words sent from the PDP. The scan timer uses four 7475 four-input latches to hold the t_s word. Four 7493 binary counters are wired to provide a 16-bit binary counter. The combination of a DM8130 10-bit comparator and a DM 8160 6-bit comparator will be used for a 16-bit comparison between the latches and counters. Cross-coupled NOR gates are used to implement classic Set-Reset flip-flops. Two flip-flops are used and will be referred to as the clock flip-flop and the comparator flip-flop. The clock flip-flop controls the flow of the 3.84 MHz clock signal to the binary counter. The comparator flip-flop controls the passage to the backplane of the ANDed comparator outputs (referred to as COMPARISON MATCH).

The scan timer will operate as follows. When the state controller enters STATE 0, both flip-flops are reset. This will prevent the counter from being incremented and will disable the COMPARISON MATCH signal from reaching the backplane. When the controller enters STATE 1, the binary counter is cleared. Now, upon receipt of the BENDIX t_R pulse, the state controller enters STATE 2. This sets the clock flip-flop, and the binary counter begins counting at 3.84 MHz. If the ID received ≠ ID requested signal is produced by the function ID logic, the controller re-enters STATE 1; and the counter is again cleared. It will remain cleared as long as the controller sits in STATE 1, even though the 3.84 MHz clock signal still flows to the counter input. On the other hand, if the ID received = ID requested signal is produced, then the controller enters STATE 3. Note that the t_s word has not yet been loaded into the latches; therefore, any matching between the counter and the latches cannot be valid. So STATE 3 is used to reset the comparator flip-flop, preventing the COMPARISON MATCH signal from being raised.
Figure B-6 Scan Timer Logic

Words from PDP 11/03
STATE 3 is used to signal an interrupt request (REQUEST B) to the PDP. In response, the PDP will output a 16-bit \( t_s \) word which indicates when TO scan sampling should start. As mentioned in the quick overview, this \( t_s \) word will measure time from the \( t_R \) pulse but must be corrected for a constant delay time which will be discussed in the next section. The NEW DATA READY signal associated with the output of the \( t_s \) word is used to strobe the 16 bits into the 7475 latches. The trailing edge of the NEW DATA READY signal is used to generate the \( t_s \) TO SCAN IN signal which will make the controller enter STATE 4. At this point, the latches contain a valid \( t_s \) word; so STATE 4 is used to set the comparator flip-flop. Now, when the counter counts up to the \( t_s \) word, the comparator outputs go high. The comparator flip-flop is set; thus, the COMPARISON MATCH signal is raised. This signal is passed via the backplane to the SAMPLE TIMER & BUFFER MEMORY board and enables sampling to commence.

After 33 samples have been taken, the state controller re-enters STATE 3. The Request B line to the PDP is raised to request the FRO scan \( t_s \) word. Since the \( t_s \) word has not yet been received, STATE 3 resets the comparator flip-flop to prevent the COMPARISON MATCH signal from going high. When the \( t_s \) word is received, the \( t_s \) TO SCAN IN signal will make the controller enter STATE 5. STATE 5 sets the comparator flip-flop to allow the COMPARISON MATCH signal to go high. Meanwhile, the counter continues to count at 3.84 MHz. When it counts up to the FRO scan \( t_s \) word, the comparator outputs again go high; and the COMPARISON MATCH signal is raised. This allows FRO scan sampling to commence. After the 67th sample is taken, the controller returns to STATE $\emptyset$.

Inputs: +5 Volts, GROUND, OUT $\emptyset$(LSB) through OUT 15(MSB), New Data Ready, CLOCK, S$\emptyset$ through S5

Output: COMPARISON MATCH
Sample Timer and Buffer Memory (Figure B-7)

The purpose of this board is to control the operation of the A/D and Sample/Hold board and to store the samples as they are taken so that they may be read back by the PDP 11/03. Three Intel 2101 256 x 4 Static MOS RAM's provide the memory storage. Although only 66 samples with 10-bit resolution need to be stored, space is at a premium on the VERO boards and the 2101's provide the necessary storage with only three 22-pin I.C. packages. The samples are taken at a rate of 160 KHz. This frequency is obtained from the 3.84 MHz clock by a divide-by-24 counter which consists of the series combination of a 7492 counter and a 7493 counter. The memory address logic for 2101 RAM's is provided by an 8-bit binary counter consisting of two 7493 counters. These will be referred to as the address counters. Additional logic is wired to the outputs of the address counters to provide signals which go high when the counters point to the 33rd and to the 67th locations in memory. This additional logic consists of two 7421 dual 4-input AND gates along with some inverters and 7408 AND gates.

NOTE: As was mentioned previously, the $t_s$ words sent by the computer to the SCAN TIMER must be adjusted for a constant delay factor. This delay is due to two primary sources. One source of delay is the divide-by-24 counter.

![Diagram of counter operation]

A detailed analysis of the operation of this counter, based on its internal logic, yields the following result: the counter provides
Figure B-7 Sample Timer and Buffer Memory
the proper frequency division, but the output is shifted in phase. The first output pulse comes at the end (trailing edge) of nine input pulses. At 3.84 MHz, this delay is approximately 2.34 microseconds.

A second source of delay will be the Bendix receiver. The receiver is to output the leading edge of its $t_R$ pulse no later than 100 microseconds after reception of Bit 5 of the five-bit Barker code. The actual delay will have to be obtained from Bendix. Note that this delay will be compensated for partially or wholly by the delay in transmission of the Log Video envelope.

Other delays associated with gating and signal propagation are measured in nanoseconds and are insignificant when compared to the sources of delay above. Thus, the total delay may be expressed as:

$$\text{TOTAL DELAY} = (\text{COUNTER DELAY}) + (BENDIX t_R \text{ DELAY}) + (BENDIX \text{ Log Video DELAY})$$

This total delay must be subtracted from the $t_s$ words which are calculated by the computer before they are sent to the SCAN TIMER board.

The sample timer and buffer memory board will operate as follows. During the initialization following power-up, the computer will raise and then lower the CSR0 signal of the DRV 11 Parallel Line Unit (DRCSR Bit 0). This pulsing of CSR0 will do three things: (1) it will raise the CLEAR CONTROLLER signal, thus placing the state controller in STATE 0; (2) it will clear the divide-by-24 counter; (3) it will clear the address counter so that it points to memory location zero of the buffer memory.
Now, STATE 0 is the state in which the computer reads out the samples from the previously sampled scan. It does this by repeatedly reading the contents of the DRV 11 input buffer, DRINBUF. After each read operation, the DRV 11 automatically pulses the DATA TRANSMITTED signal. This signal will be used by the hardware to increment the address counter so that the next sample may be read. Thus, to read out the 66 samples the computer must do the following. First, it must read DRINBUF once and ignore this sample. This sample, stored in buffer memory location zero, is actually the 67th sample and that is why it is ignored. The 66 samples of interest are stored in Locations 1 through 66. So the computer now does 66 successive reads to obtain the 66 samples. The data is in the lower 10 bits of the 16-bit input buffer, with Bit 0 as the Least Significant Bit.

After the 66th sample has been read (67 read operations), the hardware automatically clears the address counters in preparation for the next set of samples to be taken. The hardware also raises the CLEAR CONTROLLER signal (this has no effect here since the controller is already in STATE 0) and fires a one-shot (the purpose of the one-shot will be explained later).

No more activity occurs on the board until the COMPARISON MATCH signal from the SCAN TIMER board is raised, signifying that sampling is to begin. The COMPARISON MATCH signal is fed into a one-shot (E8). The output of this one-shot, labeled COUNTER ENABLE, is normally high and is used to prevent the divide-by-24 counter from incrementing. When COMPARISON MATCH goes high, COUNTER ENABLE goes low for an interval somewhat longer than the time necessary to take 33 samples at 160 KHz. Thus, the divide-by-24 counter is allowed to start incrementing. Each output pulse of the counter fires a one-shot whose output is the START CONVERT signal. This signal causes the A/D and Sample/Hold board to take a sample and also increments the address counter so that it
addresses the location in the buffer memory where the sample will be stored. When the A/D conversion is completed, the STATUS line goes low. This transition fires a one-shot (E4) which provides a low-true write pulse for the buffer memory. The 10-bit digitized sample is thus written into the buffer memory at the address indicated by the address counters.

When the 33rd sample is taken, logic wired to the outputs of the address counters decodes the 33 and raises the TO SCAN IN signal. A one-shot (E7) is fired which raises the COUNTER DISABLE signal. This signal remains high for the duration of the TO scan and clears and disables the divide-by-24 counter, thus preventing any more samples from being taken during the scan. The raising of TO SCAN IN takes the state controller back to STATE 3.

The board is now inactive until the COMPARISON MATCH signal goes high, signifying that sampling for the FRO scan must begin. The COUNTER ENABLE signal goes low, and samples are taken and stored as before. However, during the FRO scan, 34 samples are taken, the last of which will be ignored. This is done so that the 66 samples of interest will be stored in consecutive memory locations, while still providing a self-clearing address counter. Thus, when the 67th sample is taken, logic wired to the outputs of the address counters decodes the 67 and clears the address counter so that the 67th sample gets written into memory location zero. A one-shot (E6) is fired whose output raises the COUNTER DISABLE line, thus preventing anymore samples from being taken during the FRO scan. The CLEAR CONTROLLER line is also raised, so the state controller is sent back to STATE 0.

STATE 0 is used to signal the PDP 11/03 with an interrupt (Request A). The PDP responds by reading out 67 samples (ignoring the first) and then by sending out the code for the next type of scan to be sampled.

Note: The Basic Wide/Basic-Narrow option will be transmitted to the
buffer memory from a front panel switch. The option will be stored in memory along with the data samples and may be checked by looking at Bit 15 of the input buffer after any of the data samples have been read.

Inputs: +5 V; GROUND, Bit 0 (LSB) through Bit 9 (MSB), BW/BN, COMPARISON MATCH, CLOCK, STATUS CSR 0, DATA TRANSMITTED

Outputs: START CONVERT, TO SCAN IN, CLEAR CONTROLLER, IN 00 (LSB) through IN 09 (MSB), IN 15

**Backplane Wiring**

The table on the following page gives terminal pin assignments for each of the VERO FINGER BOARDS which will be used to implement the functional units described above (Figure B-8).

## II. Step-by-Step Operation

We may now summarize and clarify all of the previous discussion by giving a step-by-step description of the operation of the data acquisition hardware. The state transitions of the state controller will provide a convenient outline structure for the description.

**Power Up**

During the initialization following power-up, the computer must pulse the CSR 0 signal. On the sample timer and buffer memory board this pulse will clear the divide-by-24 counter and the address counter and will also raise the CLEAR CONTROLLER signal. The CLEAR CONTROLLER signal is transmitted to the state controller and function ID logic board, where it places the state controller in STATE 0.

**State 0**

The STATE 0 line is connected to the Request A line of the DRV 11; so
Figure B-8 Terminal Pin Assignments
when STATE 0 occurs, an interrupt is generated. The STATE 0 signal also is transmitted to the scan timer board, where it resets the clock flip-flop and comparator flip-flop, thus preventing the COMPARISON MATCH signal from being raised.

**Response to Interrupt Request A**

The computer must respond to the Request A interrupt by reading its input buffer 67 times. The first read will be ignored and is used merely to increment the address counter so that it points to buffer memory location one, which holds the first sample. The DATA TRANSMITTED signal generated by each read operation is transmitted to the buffer memory to increment the address counter.

After reading in the samples, the computer will send out a code for the type of scan that it wants to have sampled. To request Azimuth the OUT 15 signal will be raised; to request Elevation the OUT 14 signal will be raised. The NEW DATA READY signal generated by this output will latch the ID requested on the STATE CONTROLLER & Function ID Logic board and will take the state controller to STATE 1.

**State 1**

The STATE 1 signal is transmitted to the scan timer board, where it clears a 16-bit binary counter which will operate at 3.84 MHz. Now, the controller waits until the Bendix receiver generates a TR pulse. This pulse will take the controller to STATE 2.

**State 2**

The STATE 2 signal is transmitted to the scan timer board, where it sets the clock flip-flop. This makes the 16-bit binary counter begin to count at 3.84 MHz.
Meanwhile, the Bendix receiver will be decoding the function ID of the current scan. It will raise either the Azimuth or Elevation flag. The function ID logic, in turn, will generate either the signal "ID received ≠ ID requested" or the signal "ID received = ID requested." If ID rec ≠ ID req is generated, the state controller goes back to STATE 1, thus stopping and clearing the 16-bit counter. If ID rec = ID req is generated, the state controller goes to STATE 3.

**State 3**

The STATE 3 line is connected to the Request B line of the DRV 11; so when STATE 3 occurs, an interrupt is generated. The STATE 3 signal is also transmitted to the scan timer board, where it resets the comparator flip-flop, thus preventing the COMPARISON MATCH signal from being raised.

**Response to Interrupt Request B**

The computer must respond to the first Request B by sending out a 16-bit \( t_s \) word (with adjustments as noted before) which tells the hardware when to begin TO scan sampling. In response to the second Request B (STATE 3 is generated twice), the computer must send out a 16-bit \( t_s \) word which tells the hardware when to begin FRO scan sampling.

If the TO scan has not been sampled, then the TO SCAN IN signal from the sample timer board will be low. The state controller board will use the trailing edge of the NEW DATA READY signal associated with the first \( t_s \) word output to generate the signal \( t_s \cdot \text{TO SCAN IN} \); this signal will take the controller to STATE 4.

On the other hand, if the TO scan has already been sampled, then the state controller board will generate the signal \( t_s \cdot \text{TO SCAN IN} \); this signal will take the controller to STATE 5.
State 4

The STATE 4 signal is transmitted to the scan timer board, where it sets the comparator flip-flop, thus allowing the COMPARISON MATCH signal to go high when the 16-bit counter counts up to the TO scan $t_s$ word. When the COMPARISON MATCH signal is raised, sampling begins as described in Section I. After 33 samples have been taken, the TO SCAN IN signal from the sample timer board is raised. This signal takes the state controller back to STATE 3.

State 5

The STATE 5 signal is transmitted to the scan timer board, where it sets the comparator flip-flop, thus allowing the COMPARISON MATCH signal to go high when the 16-bit counter counts up to the FRO scan $t_s$ word. When COMPARISON MATCH is raised, sampling begins as described in Section I. After 34 additional samples have been taken, the sample timer board raises the CLEAR CONTROLLER signal, which takes the state controller back to STATE 0.

Test Program

The computer program used to test the completed data acquisition system is shown in Figure B-9.
Figure B-9 Data Acquisition System Test Program
APPENDIX C

A 6D LOE OPTIMAL RECEIVER

In this design, a 6th component, $\omega_{sc}$, is appended to the definition of $\gamma$, requiring basically only two changes:

1. Appending a 6th row to matrix $D(\gamma)$ so that instead of (2.103)

\[
D(\gamma) = \begin{pmatrix}
-2\alpha^2 p_j(\hat{\theta}) + 2\alpha^2 p_j(\hat{\theta}) p_j(\hat{\theta}_R) \cos x_j \\
-2\alpha^2 p_j(\hat{\theta}) p_j(\hat{\theta}_R) + 2\alpha^2 p_j(\hat{\theta}) p_j(\hat{\theta}_R) \cos x_j \\
-2\alpha^2 p_j(\hat{\theta}) p_j(\hat{\theta}_R) \cos x_j + 2\alpha^2 p_j(\hat{\theta}_R) \cos x_j \\
-2\alpha^2 p_j(\hat{\theta}) p_j(\hat{\theta}_R) \sin x_j \\
-2\alpha^2 p_j(\hat{\theta}) p_j(\hat{\theta}_R) \sin x_j
\end{pmatrix}
\]

where, as indicated in (3.10a), the quantity

\[
\hat{\beta}_j = \hat{\beta} + \omega_{sc} \tau_j
\]

is one which has already been in use in the SD LOE (see PLOPT, Appendix A) (in spite of the assumption (2.90) used in the derivation of the LOE that all the $\beta_j$ are equal); and

2. Changing the dimensions of all affected arrays in the programs.

Both changes affect module PLOPT, the latter additionally affects modules MLSSIM, OPRVR and CTLACQN, the (interference acquisition) version of CONTRL which was selected for this study. Listings of the modified versions of these modules, CTLACQ6, MLSIM6, OPRVR6 and PLOPT6 follow below. Two options of this basic design were provided in the programs.
1. $N_s = 8$, and the state vector $x$ is as defined for the Optimal design;

2. $N_s = 9$, and an additional component, $\omega_{sc}$, is appended to the end of the state vector definition.

It was not possible to run any simulation studies involving the 6D LOE, the computing resources having practically been exhausted at this point (including the $4700 University grant); as a debug exercise, however, the programs, by parameter inputs, were specialized to the prior SD LOE OPTRVR design and an earlier interference acquisition run with OPTRVR duplicated.
SUBROUTINE CONTRL(ISW)

C THIS CONDUCTS THE MLS SIMULATION THROUGH A
C INTERFERENCE ACQUISITION SCENARIO.

REAL LAMDA
INTEGER XNAME, YNAME, DATIN, DATOUT

DIMENSION IDNRS, IDASCI, IDENTS, RMSVAL
DIMENSION ALFAX, EALFA, ETHER, ETHERO, XFOUR
DIMENSION EBETA, EFSC(100)
DIMENSION EFSCOT(100)
EQUIVALENCE (ALFAX(1), ISW, IDNRS(1), DATOUT(2))

DATA ABORT/1HA/, SPACE/1H /, NFIRST/.FALSE./, ADAPTV/.TRUE./
DATA DATINI/I0HLSSIMDATA/1O,H500000DF000/20/0/
DATA DATOUT/I0HMLSIMDATA/34/0/
DATA IDASC/THCRSSRP/THRMSE(E)/THRMSE(F)/THACQTYN/
DATA THGEMPL, 0H PMLS1, 0H PMLS2
DATA THI, OHTHRD, 0H OPTML, 0H SUBOPT, 0H = 3 DB, 0H ADAPTV
DATA HNMDADAP, 0HNTREAD, 0H,NH1 , 0H, 0H P0PT3
DATA NSTART/3/, IRSIGN/1/, KSTART/26/, FILOUT/.FALSE./
DATA PCFNCT/THAZMUTH, 0H,THELEVAT/
DATA GGCT0/17,3/, GGCT9/1.0/
DATA C, 0H ALFA, 0H EHTETA, 0H EHTEDOT, 0HALFA, 0H EHTETA
DATA CONTROT/0H, 0H WSC, 0H WSCOT/
DATA XNAME/8H SCAN, 8H NUMBER, /YNAME, 8H ETHER, 8H DEGREES/
DATA YNAME/8H EALFA, 8H /YNAME, 8H EALFA, 8H
DATA YNAME/8H ETHER, 8H DEGREES, 8H YNAME, 8H RH, 8H
DATA YNAME/8H HREDSET, 8H DEGREES/
DATA YNAME/8H EHEADFSC, 8H HERT /
DATA YNAME/8H EHEADFSCOT, 8H HZ/SEC/

GO TO (100,200,300,400,500,600,700,800,900,1000,1100,1200), ISW

FORMAT(1H )

CTEACQ6
Page 1 of 8
SUBROUTINE CONTRL

C THIS IDENTIFIES THE SCENARIO AND REINITIALIZES, AS NECESSARY.
CTHE FOLLOWING RECEIVER PARAMETERS
CSIGMA, AE, DSNR0, RHOMAX, FSC, BETA, JM, BNL

IF(NFIRST) GO TO 155
NOAC=.FALSE.

NFIRST=.TRUE.

ISIM=5

WRITE (7,110)

110 FORMAT (1H)

IF(NFIRST) GO TO 155

WRITE (7,115)

115 FORMAT (35H THIS IS NOT FOR THRESHOLD RECEIVER)

STOP # ABORTED--NOT FOR THRDVR*

CONTINUE

CALL LOGIO(6HFILEIN,FILEINO)

IF(.NOT.FILEIN) GO TO 122

IF(IX.NE.0) CALL INTIO(6H' ',IXIP)

CALL LOGIO(6HTETHR,TETHRO)

IF(TETHRO) ITETHR=2

IF(AADAPTV) GO TO 135

IRSIGN=-1

135 CONTINUE

145 CONTINUE

GO 145 I=2,6

155 CONTINUE

ENCODE(8,150,IDENTS(1)) IDASC(IASC)

150 FORMAT(A7,11)

WRITE (7,152) IDNR,INGD

152 FORMAT (1H+612*)

WRITE (7,153) IDENT

153 FORMAT (1H+61)

CALL INTIO(6H'. ',IR,IR+6,0)

CALL REALIO(6H'RHOMAX',RHOMAX,0)

CALL REALIO(6H' DTHD',DTHD,0)

CALL REALIO(6H' TORD',TORD,0)

BETA=BD+20.*PI

FSC=FSC*1.1/(2.*PI)
SUBROUTINE CONTRL

NOTE

MULTIPLY BY 1 --- IGNORED

CALL REALID(6H BETAO,BETAO,0)
CALL REALID(6H FSCO,FSCO,0)
IF (IR.GE.5) CALL REALID(6H GSNO,GSTB,0)

115

WSCO=FSCO*1/PI
NRUN=NRUN+1
OSNROBS=0,
BETA=45.

120

FSC+0,
BMLS=1.
BRCVR=1.
THESEP=1.88
FSCCDOT=XC0(9*IAE)*1.5/PI

125

CONTINUE

130

IF (FILEIN) GO TO 198

135

CALL INTIO(6H NRUNX,1,1)
CALL REALID(6H OSNROB,OSNROB,0)
CALL REALID(6H RHO,RHO,0)
CALL REALID(6H BETA,BETA,0)
CALL REALID(6H FSCO,FSCO,0)
IF (IR.EQ.6) CALL REALID(6H FSCDOWT,FSCDOWT,0)

140

CALL REALID(6H BMLS,BMLS,0)
CALL REALID(6H BRCVR,BRCVR,0)
CALL REALID(6H THESEP,THESEP,0)

145

CONTINUE

150

READ (15,160) NRUN,DSNRDB,RHD,BETAO,FSCDOWT,BMLS,BRCVR,

155

CONTINUE

160

FORMAT (15,6G10.5)
IF (NRUN.GT.NSTART) GO TO 158

165

IF (NRUN.LT.NSTOP) MORE*FALSE.

170

RETURN

STOP*EOF REACHED ON INPUT FILE

180

C

190

C THIS OUTPUTS BASIC SIMULATION DATA OF INTEREST, SUCH AS
C THE ANGLE FUNCTION, INITIAL STATE, ETC.

200

WRITE (7,210) NRUN,DSNRDB,RHD,BETAO,FSCDOWT,BMLS,BRCVR,

210

CONTINUE

220

FORMAT (56X,15F10.5)
WRITE (7,209) NRUN,DSNRDB,RHD,BETAO,FSCDOWT,BMLS,BRCVR,

225

Page 3 of 8
SUBROUTINE CONTLE-73/172 TS FTN 4.6+452 05/18/79 13:43:29 PAGE 4

210 FORMAT(1HO,14,8(ZX,610.3),2X,14)
IF(.NOT.FILOUT) GO TO 245
IF(NRUN.LE.9) ENCODE(10,220,DOUT) IDNS,1HU,1MOD,1H0,NRUN
220 FORMAT(611,A11,11,12)
IX=IREST(6LTAPE1,3L*PF)
IF(IX.NE.0) CALL INTDX6(HIX(RO),IX,1,1)
IF(IX.NE.0) STOP OUTPUT FILE REQUEST NOT SATISFACTORY
240 FORMAT(25H OT THIS WRITES OUTPUT FILE,1A10)
245 CALL DATE(TODAY)
246 FORMAT(1HO,AT,15H FUNCTION CIAE-I1,1H))
250 FORMAT(6I1,AL,11,11)
X(4)=XO(4,IAE)-O.
255 WRITE(7,260) ((IX(I)),11,p9)
260 FORMAT(15HOINITIAL STATE://(,I1,4H)
265 WRITE(7,270) IDENTS(2)
270 FORMAT(1HO,A7)
RETURN
300 CONTINUE
C******************************************************************************
195 C THIS IDENTIFIES THE BASIC RECEIVER STRUCTURE (THMLDO,OPT,SUBOPT)
C AND REINITIALIZES AS NECESSARY, THE FOLLOWING RCVR DATA
CIR (NEGATE ONLY), NCAC=NCACLH=NOACLE,rcvr=DELAL*TETHAO
CNEGATE IR WITH THE FOLLOWING FOR NONADAPTIVE RECEIVER
CR=SIGN(IR,IRSIGN)
200 IF(IR.GE.5) GGTV9(1,9)=GGTV99
205 ITER=MIND(1RCVR+2)
C***********
210 C THIS OUTPUTS BASIC RECEIVER DATA OF INTEREST
C***********
215 WRITE(7,410) (IOENTS(I),I-3,4),IRNGNS
410 FORMAT(1HO,B/1HO,AB,6HDESIGN/SH (IR-I2,4HNS-,1,4HNS-,11H))
220 WRITE(7,420) (IDENTS(I)*I.5,6-------------------------------)
225 C***********
226 C THIS SETS-UP THE MSET-LOOP
C***********
230 CONTINUE
235 C THIS SETS-UP THE MG-LOOP FOR THE (MSET)TH SERIES OF SETS
C***********
240 C THIS IDENTIFIES THE BASIC RECEIVER STRUCTURE (THMLDO,OPT,SUBOPT)
C AND REINITIALIZES AS NECESSARY, THE FOLLOWING RCVR DATA
CIR (NEGATE ONLY), NCAC=NCACLH=NOACLE,rcvr=DELAL*TETHAO
CNEGATE IR WITH THE FOLLOWING FOR NONADAPTIVE RECEIVER
CR=SIGN(IR,IRSIGN)
245 IF(IR.GE.5) GGTV9(1,9)=GGTV99
250 ITER=MIND(1RCVR+2)
C***********
255 C THIS OUTPUTS BASIC RECEIVER DATA OF INTEREST
C***********
260 WRITE(7,410) (IOENTS(I),I-3,4),IRNGNS
410 FORMAT(1HO,B/1HO,AB,6HDESIGN/SH (IR-I2,4HNS-,1,4HNS-,11H))
265 WRITE(7,420) (IDENTS(I)*I.5,6-------------------------------)
270 C***********
275 C THIS SETS-UP THE MG-LOOP FOR THE (MSET)TH SERIES OF SETS
C***********
280 CONTINUE
C***********
285 C THIS IDENTIFIES THE BASIC RECEIVER STRUCTURE (THMLDO,OPT,SUBOPT)
C AND REINITIALIZES AS NECESSARY, THE FOLLOWING RCVR DATA
CIR (NEGATE ONLY), NCAC=NCACLH=NOACLE,rcvr=DELAL*TETHAO
CNEGATE IR WITH THE FOLLOWING FOR NONADAPTIVE RECEIVER
CR=SIGN(IR,IRSIGN)
290 IF(IR.GE.5) GGTV9(1,9)=GGTV99
295 ITER=MIND(1RCVR+2)
C***********
300 C THIS OUTPUTS BASIC RECEIVER DATA OF INTEREST
C***********
305 WRITE(7,410) (IOENTS(I),I-3,4),IRNGNS
410 FORMAT(1HO,B/1HO,AB,6HDESIGN/SH (IR-I2,4HNS-,1,4HNS-,11H))
310 WRITE(7,420) (IDENTS(I)*I.5,6-------------------------------)
315 C***********
320 C THIS SETS-UP THE MG-LOOP FOR THE (MSET)TH SERIES OF SETS
C***********
325 CONTINUE
C***********
330 C THIS IDENTIFIES THE BASIC RECEIVER STRUCTURE (THMLDO,OPT,SUBOPT)
C AND REINITIALIZES AS NECESSARY, THE FOLLOWING RCVR DATA
CIR (NEGATE ONLY), NCAC=NCACLH=NOACLE,rcvr=DELAL*TETHAO
CNEGATE IR WITH THE FOLLOWING FOR NONADAPTIVE RECEIVER
CR=SIGN(IR,IRSIGN)
335 IF(IR.GE.5) GGTV9(1,9)=GGTV99
340 ITER=MIND(1RCVR+2)
C***********
345 C THIS OUTPUTS BASIC RECEIVER DATA OF INTEREST
C***********
350 WRITE(7,410) (IOENTS(I),I-3,4),IRNGNS
410 FORMAT(1HO,B/1HO,AB,6HDESIGN/SH (IR-I2,4HNS-,1,4HNS-,11H))
355 WRITE(7,420) (IDENTS(I)*I.5,6-------------------------------)
360 C***********
365 C THIS SETS-UP THE MG-LOOP FOR THE (MSET)TH SERIES OF SETS
SUBROUTINE CONTRL

C THIS SETS-UP THE K-LOOP FOR THE (LG)-TH SET OF KM SCANS
CALL INTOI6H KM,KM1,1)
WRITE(7,710) (STITLE(I),I=1,9)
FORMAT(4H8 K,3X,6HCSNRTO,5X,6HCSNRFR,3X,9(HQTY3X,9(ZXA6SX))
RETURN

C THIS INITIALIZES THE K-TH SCAN
IF(K.EQ.KSTART) XN10=RHO*X1
RETURN

C THIS SAVES/PREPROCESSES DATA FROM THE K-TH SCAN
THEX=X(2)-X(5)
CFO=SQRT(PPDIAG(2))
ES(I)*X(I)-X(I)
RMSVAL(I)=SQRT(PPDIAG(I))
CONTINUE
IF(NS.GE.7) ES(7)=ABS(X(7))-ABSXS(7)
IF(NS.GE.8) ES(8)=ABS(X(8))-ABSXS(8)
IF(NS.GE.9) ES(9)=ABS(X(9))-ABSXS(9)
SCAHR(K)-K
ETA(K)=ES(I)
ETHET(K)=ES(2)
ETHER(K)=ES(4)
XFOUR(K)=X(4)/X(1)
IF(NS.GE.7) ETA(I)=0.5*ES(7)/PI
IF(NS.GE.8) EFSC(I)=0.5*ES(8)/PI
IF(NS.GE.9) EFSCD(I)=0.5*ES(9)/PI
IF(KRUNNEI NSTART.AND.KNEKM) RETURN
WRITE(7,920) K,
FORMAT(1H1,2(1X,G10.3))
WRITE(7,930) X(1:NS)
WRITE(7,940) 1H
WRITE(7,950) EXP(I)
RETURN

C THIS SAVES/OUTPUTS DATA FROM THE (LG)-TH SET OF KM SCANS
WRITE(7,1060) (GQGT(II),I=1,NS2
RETURN

CONTINUE
SUBROUTINE CONTRL

CALL PLOT(SCANNR, ELFA, KM, XNAME, YNAM3, YMIN, YMAX)
CALL REALIO(6H YMIN, YMIN)
CALL REALIO(6H YMAX, YMAX)
YMIN=YMAX=0.
WRITE (7,11)
CALL INTO (6H NRUN, NRUN, 1, 1)

CALL PLOT(SCANNR, XFOUR, KM, XNAME, YNAM4, YMIN, YMAX)
CALL REALIO(6H YMIN, YMIN)
CALL REALIO(6H YMAX, YMAX)
YMIN=YMAX=0.
WRITE (7,11)
CALL INTO (6H NRUN, NRUN, 1, 1)

CALL PLOT(SCANNR, EBEA, KM, XNAME, YNAM7, YMIN, YMAX)
CALL REALIO(6H YMIN, YMIN)
CALL REALIO(6H YMAX, YMAX)
YMIN=YMAX=0.
WRITE (7,11)
CALL INTO (6H NRUN, NRUN, 1, 1)

CALL PLOT(SCANNR, EFSC, KM, XNAME, YNAM8, YMIN, YMAX)
CALL REALIO(6H YMIN, YMIN)
CALL REALIO(6H YMAX, YMAX)
YMIN=YMAX=0.
WRITE (7,11)
CALL INTO (6H NRUN, NRUN, 1, 1)

CALL PLOT(SCANNR, ESCT, KM, XNAME, YNAM9, YMIN, YMAX)
CALL REALIO(6H YMIN, YMIN)
CALL REALIO(6H YMAX, YMAX)
IF (NS.LE.6) GO TO 1065

WRITE (7,11)
CALL INTO (6H NRUN, NRUN, 1, 1)

CALL PLOT(SCANNR, EDEL, KM, XNAME, YNAM10, YMIN, YMAX)
CALL REALIO(6H YMIN, YMIN)
CALL REALIO(6H YMAX, YMAX)
IF (NS.LE.8) GO TO 1065

YMIN=YMAX=0.
WRITE (7,11)
CALL INTO (6H NRUN, NRUN, 1, 1)

CALL PLOT(SCANNR, EBLX, KM, XNAME, YNAM11, YMIN, YMAX)
CALL REALIO(6H YMIN, YMIN)
CALL REALIO(6H YMAX, YMAX)
IF (NS.LE.10) GO TO 1065

YMIN=YMAX=0.
WRITE (7,11)
CALL INTO (6H NRUN, NRUN, 1, 1)

CALL PLOT(SCANNR, EBRD, KM, XNAME, YNAM12, YMIN, YMAX)
CALL REALIO(6H YMIN, YMIN)
CALL REALIO(6H YMAX, YMAX)
IF (NS.LE.12) GO TO 1065

YMIN=YMAX=0.
WRITE (7,11)
CALL INTO (6H NRUN, NRUN, 1, 1)

CALL PLOT(SCANNR, EBCD, KM, XNAME, YNAM13, YMIN, YMAX)
CALL REALIO(6H YMIN, YMIN)
CALL REALIO(6H YMAX, YMAX)
IF (NS.LE.14) GO TO 1065

CONTINUE

IF (.NOT. FOUT) RETURN
WRITE (7,11)
WRITE (7,1070) (DATOUT(I), I = 1, 2)

FORMAT(13H OUTPUT FILE \2A10,1H/) WRITE(7,1072) OUTX, DELT, TIMES, LMAX, KM, TODAY, JBNAM
SUBROUTINE CONTRL

1072 FORMAT(1H,A10,6X,G13.6,5X,3(5X,13.10X),A10,6X,A10/)
WRITE(7,1074) IDENTS,KSTART
1074 FORMAT(1H,6(I1),6X,13/)
WRITE(7,1076) NRUNS,DSNROD,RK,THESIS
1076 FORMAT(1H,12X,3X,8(3X,G13.6)I)
DO 1077 I=1,KM
1077 WRITE(7,1078) EALFA(I),ETHET(I),EALFR(I),ETHER(I),XFOUR(I)
1078 FORMAT(1H,6(1X,A0,9X),I3/)
DO 1079 I=1,KM
1079 WRITE(7,1080)------------------.
1080 FORMAT(1H,5(6X,1H.,1lX))
DO 1081 I=KM1,KM
1081 WRITE(7,1083) RHOMAX,DTHOT,DRBETADEBETADEBETAKM,EFSCEFSC(KM)
1083 FORMAT(1H,9(G13.6#ZX))
DO 1085 I=1,36
1085 WRITE(7) DOUTDELTMTIMES,LGMAXKMTODAYJBNAM
WRITE(7) NRUNOSNRDBRHUBETAFSCFSCDOTBMLSBRCVTHESEP
1090 CONTINUE
WRITE(7) IDENTSKSTART
WRITE(17) NRUNOSNRDBRHUBETAFSCFSCDOTBMLSBRCVTHESEP
1099 FORMAT(1H,9(G13.6,5X))
DO 1090 IF(I.X.E.0) GO TO 1095
1095 IF(I=1) CALL INTIO(6HIX(CA),IXf,1I)
1096 IF(I=1) STOP#OUTPUT FILE CATALOG NOT SATISFACTORY
1097 IF(I=1) RETURN(6LTAPE17)----
1100 CONTINUE
C THE saves/processes/outputs data from the (NSET)th series of
C RHOMAX sets of KM scans
C THIS EFFECTS CLOSURE OF THE SIMULATION RUN
WRITE(7)-------------------------------.
END

CTLACQ6
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SUBROUTINE CONTROL   73/172 TS   FTN 4.6+452   05/18/79   13.43.29   PAGE 8

450000 CM STORAGE USED   11.349 SECONDS
PROGRAM MLSSIM(INPUT,OUTPUT,TAPE10=INPUT,TAPE12,TAPE15,
                 TAPE7=OUTPUT,TAPE17,TAPE20)
REAL LAMDA
LOGICAL NOKLHHH,LOGORE,NOAC,KALMAN,LDE,TETHRD,MORE

COMMON /IOTDATA/IDNRS(6)
COMMON/RCVRO0/THAMAX,THAMIN,TS,TR,DMEGA,TF
COMMON/RCVRO1/HMIN,HMAX,DEBL,CHN,IR,IAE
COMMON/RCVRO2/RHMAX,DTHMA,TDRO,BS,WSCO,XSO(6),NGIO(6)
COMMON/RCVRO3/FI(9,9),FL25(4),FSAMP,K,THETHRO,NGN,JS
COMMON/RCVRO4/DELTA,ED(9),GDOT(9,9),H(9,9),ICOUNT,SIGMA
COMMON/RCVRO5/NOLOG,NOKLH,NOKL,NCORES(6),ROIALG(6),PMIALG(9)
COMMON/RCVRO6/PDIALG(9),RHA(6,6),PHI(6,6),PA(9,9),LAMDA(6)
COMMON/RCVRO7/T(130),V(130)
COMMON/RCVRO8/VSDE(9),ESDE(9),ES(9)
COMMON/RCVRO9/RCVRATM,RCVRATC
COMMON/RCVRO10/XS1(9),XS(9)
COMMON/MLSU00/ALFA,THET,THETDOT,ALFAR,THETR,THETDOTB,WSC,WSCDOTT
COMMON/MLSU01/CSHRT,CSHRF,DSHDB,RNG,BETA,FSC,LGMAX
COMMON/MLSU02/DCSNR,CSNR,ALG,TPKT,TPKF
COMMON/MLSU03/FL10AE(4,2),FL10(4),DELTAT(2),XO(9,2),YO(4,2)
COMMON/MLSU04/BNL,THRES,THET,MORE

CONTINUE..........

CALL MLSUB

IF(MORE) GO TO 10

STOP
END

41000B CM STORAGE USED 131 SECONDS.
SUBROUTINE MLSSUB 73/172 TS

PEAL LANDA
LOGICAL NOKLMNNODOE, NOAC, KALMANLOE, TETHRD, MORE
COMMON/RCVROO/THAMAX, THAMIN, TS, TR, OMEGA, TP
COMMON/RCVRO1/NGMAX, NGMAXDEL, NGM, IA
COMMON/RCVRO2/RHOMAX, DTHG1, DTHG2, B0, WSGC, NSD(4), NGD(4)
COMMON/RCVRO3/PI2(9,9), FL25(4), PSMAP, K, K, TETHRD, NG, NS, J, JM
COMMON/RCVRO4/DELT, ED(9,2), GQ(10,9), H(6,9), ICOUNT, SIGMA
COMMON/RCVRO5/NGLDE, NOKL, NOAC, GAMES(6), ROIG(6), PMOIAG(9)
COMMON/RVCVR06/PMOIA(9), RMAT(6,6), PHI(6,6), PMOIA(9), LAMDA(6)
COMMON/RCVRO7/THAT(130), V(130)
COMMON/RCVRO8/XSLOE(9), ESOE(9), ES(9)
COMMON/RCVRO9/RCVRB, BCR, BCR, BCR, BCR
COMMON/RCVRO10/XS(19), ES(19)
COMMON/MLSO00/ALFATH, TETHD, OTHER, THROOT
COMMON/MLSO01/CSNR, DSNRDB, RH0BET, FSCLG, MAX
COMMON/MLSO02/FLIOAE(4,2), FL10(4), DELTAT(2), XU(2), Y(2)
COMMON/MLSO04/EMS, BMS, TIMES, MEET, MORE
COMMON/MLSO03/FLIOAE(4,2), FL10(4), DELTAT(2), XU(2), Y(2)

C GENERAL SIMULATION: OPTIMIZATION OF MLS RECEIVERS FOR C

C MULTIPATH ENVIRONMENTS C

DIMENSION X(9), INDEXCZ), Yf4), X(9)
EQUIVALENCE (THAMAX, THAMIN, TS, TR, OMEGA, TP)

C FOLLOWING BEGINS EXECUTABLE STATEMENTS C

PI2=2.*PI
S022=SOR(4,4)

C FOLLOWING Initializes THE DIAGONAL OF F(0,0)

DO 10 I=1,9
 F(I,I)=1
10 CONTINUE
CALL CONTROLL() 
SSQN=SIGMA*SQRT(2.)

C FOLLOWING Completes INITIALIZATION AND COMPUTES SECONDARY

C PARAMETERS.

DO 15 I=1,4
 FLDO(I)=FLIOAE(I,IAE)
 CONTINUE
 DO 20 I=1,4
 Y(1)=Y(I,1,IAE)
 CONTINUE
OMEGA=(THAMAX-THAMIN)/TS
SECPD=1./OMEGA
TF=TS+TR- TS*SECPD

C FOLLOW ARE CONSTANT PARAMETERS USED BY P

BB2=2./MLS
 DUM=GAUSS(1,0)
ALPHA=10.***DSNRDB/20.0
X(1,IAE)=ALPHA
ALPHAR=RHO*ALPHA

C25

C GENERAL SIMULATION OPTIMIZATION OF MLS RECEIVERS FOR C

C MULTIPATH ENVIRONMENTS C

DIMENSION X(9), INDEXCZ), Yf4), X(9)
EQUIVALENCE (THAMAX, THAMIN, TS, TR, OMEGA, TP)

C FOLLOWING BEGINS EXECUTABLE STATEMENTS C

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S022=SOR(4,4)

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10 CONTINUE
CALL CONTROLL() 
SSQN=SIGMA*SQRT(2.)

C FOLLOWING Completes INITIALIZATION AND COMPUTES SECONDARY

C PARAMETERS.

DO 15 I=1,4
 FLDO(I)=FLIOAE(I,IAE)
 CONTINUE
 DO 20 I=1,4
 Y(1)=Y(I,1,IAE)
 CONTINUE
OMEGA=(THAMAX-THAMIN)/TS
SECPD=1./OMEGA
TF=TS+TR- TS*SECPD

C FOLLOW ARE CONSTANT PARAMETERS USED BY P

BB2=2./MLS
 DUM=GAUSS(1,0)
ALPHA=10.***DSNRDB/20.0
X(1,IAE)=ALPHA
ALPHAR=RHO*ALPHA

C25
SUBROUTINE MLSSUB

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XC(4,IAE) = ALPHAR

XU(7,IAE) = PI*BETA/I8O.

DELT = DELTATT(IAE).

F(2,3) = DELT

F(5,6) = DELT

F(7,8) = DELT

F(7,9) = 0.5*DELT**2

JM2 = JM2+1

THW = 0.5*TSAMP*(JM2+1)

DO 30 I = 1,9

X(I) = XO(I,IAE)

30 CONTINUE

CALL CONTRL(2)

C FOLG CALLS RECEIVER FOR INITIALIZATION

CALL RCVR

C FOLLOWING BEGINS SIMULATION PER SE, LGMAX RUNS OF KM SCANS EACH

CALL CONTRL(5)

DO 777 MSSET = 1, MTIMES

MSSET = MSSET

CALL CONTRL(6)

DO 1 LGG = 1, LGMAX

LG = LGG

CALL CONTRL(7)

DO 2 HR = 1, HR

K = K

CALL CONTRL(8)

IF (K .EQ. 1) GO TO 122

C FOLLOWING ADVANCES THE TRUE STATE AND SAVE PRIOR VALUE

DO 100 I = 1,9

X(I) = X(I)

100 CONTINUE

DO 120 I = 1,9

DO 110 J = 1,9

X(I) = X(I) + F(I,J)*X(J)

110 CONTINUE

120 CONTINUE

B = VALUE(B,F,P,0.)

C FOLG SETS THESE PRIOR TO COMPUTING SAMPLE TIMES

THES = XS(2) + DELT*XS(3)

IF (NOT.THIRD) GO TO 124

C CONTINUE

DO 123 I = 1,9

123 CONTINUE
SUBROUTINE MLSSUB  73/172 TS

CONTINUE THE-$B$112)

CONTINUE

C FOLG BEGINS COMPUTATION OF SIGNALS AND RELATED QUANTITIES
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SUBROUTINE MLSSUB

BLOCAL = PVALUE(B + (WSC + O.5 + WSCDOT + TJVAL) * TJVAL * P1 + O.)
QJ + AL2*(PJ**2) + AA2*PJ*PRJ*COS(BLOCAL) + ARZ*(PRJ**2)

QJ = AMAX1(QJ, 0.0)

SQRTQZ - 2 - SQRT(OJ)

UJ = QJ + SQRTQZ**2 + XNC**2 + XNS**2

V(JVAL) = SQZ**2 + SQ(ZUJ)

175 CONTINUE
127 CONTINUE
130 CONTINUE

FOLLOWING COMPUTES RECEIVER RESPONSES

CALL RCVR

105 CALL ASSIMILATES DATA FROM THIS SCAN FOR FUTURE EVALUATION

190 CALL CONTROL(9)

195 CALL CONTROL(10)

199 CALL CONTROL(11)

200 CALL CONTROL(12)

RETURN

END

C STORAGE USED 1.465 SECONDS
FUNCTION THA(T)

C THIS COMPUTES THE ANTENNA SCAN ANGLE AT LOCAL SCAN TIME T.
C THE PARAMETERS OF THE SCAN WAVEFORM HERE THE IDENTITY OF
C THE ANGLE FUNCTION ARE PASSED THROUGH COMMON AND ARE DEFINED
C AS FOLLOWS:
C T = TIME BETWEEN TRAVERSAL OF ZERO DEGREES IN A TO-FRO SCAN
C TS = DURATION OF THE TO SCAN
C TF = DURATION OF THE TO SCAN + INTERSCAN REST INTERVAL
C THAMAX = ANTEANA ANGLE AT BEGINNING OF TO SCAN
C THAMIN = ANTEANA ANGLE AT END OF TO SCAN
C OMEGA = ANTEANA ANGULAR SCAN RATE, DEG/SEC, DURING TO SCAN

C COMMON / RCVR00 / THAMAX, THAMIN, TS, TF, OMEGA, TF

I3 = TS + TF
IF (I3 .GT. 0.0) GO TO 50

THA = THAMAX
RETURN

IF (T .GT. TS) GO TO 100

THA = THAMAX + OMEGA * T
RETURN

THA = THAMIN
RETURN

IF (T .GT. TF) GO TO 200

THA = THAMIN + OMEGA * (T - TF)
RETURN

THA = THAMAX
RETURN

END

410008 CM STORAGE USED
.114 SECONDS
SUBROUTINE DFLTR1(X,Y,C)
DIMENSION C(4)
S=X-C(1)*C(4)
Y=C(1)+S+C(2)+C(4)
RETURN
END

410000 CM STORAGE USED
5946 SECONDS

OF POOR QUALITY
SUBROUTINE RCVR
REAL LAMOA,MJM2
LOGICAL NOKLMN
COMMON/RCVR01/NGMIN
COMMON/RCVR02/RHOMAX,DINH,TORH,BW
COMMON/RCVR03/P1,F129(9),FSAMP,KX,THRD,HG,NS,LM
COMMON/RCVR04/DEL,T0(9),GQGT(9,9),H(6,9),ICOUNT
COMMON/RCVR05/NOLOG,NKLN,MGAMES,RD_DIAG,RM_DIAG
COMMON/RCVR06/PPICRIT,PHI(6,6),PA(9,9),LAMDA(6)
COMMON/RCVR07/PPICRIT(130),PS(130)
COMMON/RCVR08/XSLE(9),ESL0E(9),ES(9)
COMMON/RCVR09/XSLE(9),PPICRIT,CC
COMMON/RCVR10/XS(9)
DIMENSION TPAL(9,9),TPA(9,9),TPZ(6,9)
DIMENSION RVNG(6),GAIN(9,6)
IF(K.GT.0) GO TO 40
C FOLG IS INITIALIZATION
PI2.3*PI
SS2.5/I(SIGMA**2)
CALL PHILM
NS=NSO(IR)
NG=NGO(IR)
COMMON/NGD(9,6)
COMMON/NGD(9,6)
GQGT(3,3)=GQGT33
GQGT(6,6)=GQGT33
GQGT(8,8)=GQGT33
DO 20 J=1,NS
DO 10 I=1,NS
CALL CONT(3)
IF(IR.GT.0) GO TO 30
NS=NSO(4)
NG=NGO(4)
CONTINUE
NG=NGMIN
IF(NOKLMN) NGM=HG
LDE=.NOT. NOLOG
RETURN
C DIAGNOSTIC OUTPUT_OF_INPUT_DATA_FOR_K=1_GOES_HERE
C
GO TO 60
CONTINUE
C FOLG EXTRAPOLATES_STATE_ESTIMATE_AS_REQD
C
SUBROUTINE RCVR

IF (IETHRO) GO TO 60

DO 70 I=1,NS

XSI(I)=0.

DO 60 J=1,NS

XSI(I)=XSI(I)+F(I,J)*XSI(J)

60 CONTINUE

CONTINUE

70 CONTINUE

C  

GOGT(I)=AMAX1(.25,0.1*(XSI(I)**2))

C  

GOGT(I,I)=GOGTI

GOGT(I,I)=GOGTI

C  

FOLLOWING COMPUTES VECTORS 0(JM), W(JM), LAMDA(NG) AND MATRICES DT(JM), 

C. NC, PH(ING,NS) ALSO SQUARED AMPLITUDE ENVELOPE VECTOR U(JM) AND 

C INOVATION PROCESS VECTOR W(JM)

75 CALL PHILM

IF (NLDE) GO TO 120

C  

FOLLOW COMPUTES R innovation=inverse and the lde 

CALL MATINV(RMAT,6,NG,IVNG,RVNG)

DO 100 I=1,NG

RDIAG(I)=RMAT(I,I)

100 CONTINUE

C  

CALL MATMUL(6,NG,6,NG,1,6,1,RMAT,LAMDA,GAMAES,1)

DO 110 I=1,NS

XSLGE(I)=XSI(I)+ESLOE(I)

110 CONTINUE

CALL MATMUL(6,NS,6,NG,1,9,1,H,GAMAESESLOE,2)

DO 120 I=1,NS

XSLGE(I)=XSI(I)+ESLOE(I)

120 CONTINUE

IF (NLKMN) GO TO 170

C  

FOLLOWING EXTRAPOLATES STATE ESTIMATES, ERROR 

COVARIANCE MATRIX PA(NG,NS)

95 CALL MATMUL(9,NS,9,NG,9,9,PA,F,TPA1,3)

CALL MATMUL(9,NS,9,NG,9,9,PA,F,TPA1,PA,3)

CALL MATMUL(9,NS,9,NG,9,9,PA,GOGT,TPA1,PHT,3)

DO 130 I=1,NS

PMdiag(I)=PA(I,I)

130 CONTINUE

C  

FOLLOWING COMPUTES MODIFIED-KALMAN GAIN MATRIX GAIN(NG,NS)

105 CALL MATMUL(9,NS,6,NG,9,9,PA,F,PHT,3)

CALL MATMUL(9,NS,6,NG,9,9,PA,F,PHT,PA,3)

CALL MATMUL(9,NS,6,NG,9,9,PA,GOGT,PHT,PHT,3)

DO 140 I=1,NG

TPAZ(I)=TPA2(I,1)

140 CONTINUE

CALL MATINV(TPA2,9,IVNG,RVNG)

CALL MATMUL(9,NS,9,NG,9,9,PA,F,TPA2,GAIN,1)

C  

FOLLOWING UPDATES STATE ESTIMATE
SUBROUTINE RCVR

CALL MATMUL (9,NS+NG,6,NG,1,9,1,9,NS+1,9,NS,9)

CALL MATSM (XS,XSIES,1,9,1,9,NS,1,9,NS,1,0)

115 CALL MATMUL (X5,X51,ES,1,9,1,9,NS,1,9,NS,1,ES)

120 FOLLOWING UPDATES STATE ESTIMATE ERROR COVARIANCE MATRIX

C

P(NS)

125 CALL MATMUL (9,NS,NS,9,NG,9,NS,9,9,NS+1,TPA1,TPA2,3)

DO 150 I=1,NS

TPA2(1,1)=TPA2(1,1)-1.

150 CONTINUE

CALL MATMUL (9,NS,NS,9,NS,9,NS,9,NS,9,1,TPA2,TPA2,1)

CALL MATMUL (9,NS,NS,9,NS,9,NS,9,NS,9,TPA1,TPA1,3)

130 CALL MATMUL (9,NS,NS,9,NS,9,NS,9,NS,9,NS,9,NS,0)

DO 160 I=1,NS

PP01AG (I)*PA(I,1)

160 CONTINUE

170 CONTINUE

X5(1)=ABS(X5(1))

AN=(THAMAX-THAMIN)/2.

135 X5(2)=SATU(X5(2),AN2,AN-THAMAX/2.,AN)

IF(NG.EQ.3) X5(3)=SATU(X5(3),1,1)

140 IF(NG.EQ.4) X5(4)=SATU(ABS(X5(4)),2*X5(1))

THWW2=NUM2=OMEGA/(2.*PSAP)

AMX=X5(2)+THWW2

145 AMN=X5(2)-THWW

ANZ=(AMX+AMN)/2.

IF(NG.EQ.5) X5(5)=SATU(X5(5),ANZ,2,ANZ-AMX/2.,AN)

150 IF(NG.EQ.6) X5(6)=SATU(X5(6),1,1)

IF (NS.EQ.7) X5(7)=PVALUE(X5(7),PI,0.)

155 IF (NG.EQ.5) X5(8)=PVALUE(X8(8),PI,DEL,0.)

RSMA2=800.

160 IF (NG.EQ.9) X5(9)=SATU(X5(9),RSMA2,

RETURN

170 END

410008 CM STORAGE USED

1.412 SECONDS
BLOCK DATA ORVRID 73/172 TS

BLOCK DATA ORVRID
COMMON/IDDATA/IDNRS(6)
DATA IDNRS(4)/2/
END

41000B CM STORAGE USED .012 SECONDS
SUBROUTINE PHILM 73472 TS

THIS OPTIMAL VERSION OF PHILM IS FOR ALL SCALLOPING RATES
AND PROVIDES A CRUDE SEARCH AND ACQUISITION FUNCTION.

SEARCH MODE: NGM = NGMIN
ACQUISITION MODE: NGMIN < LT < NGMAX
FULL TRACK MODE: NG = NGMAX

THIS NEEDS NGMIN < LE < NG < LE < NGMAX.

REAL LAMDA
LOCKAL MGKLM, MLODE, NODAC, KALHAML, LGAB, TETHRD
COMMON/RCVR/NGM, NGMAX, DETL, NGL, NREX
COMMON/RCVR02/NGM, NGMAX, DIVD, BD, WSCD, NGD, NGM, NGM
COMMON/RCVR03/F1, F2(5, 4), FSMP, K3, TETHRD, NG, NS, JN
COMMON/RCVR04/DELTD, S0(9), SGT0(9), NS, NGM, NGM, ICOUNT, SIGMA
COMMON/RCVR05/NGM, NOLM, NOLM, NOLM, NOLM, NGM, NGM, NGM
COMMON/RCVR06/NGM, NGM, NGMAX, DAG, NMAX, TETHRD, TETHRD
COMMON/RCVR07/NGM, NGM, NGM, VMAX
COMMON/RCVR08/NSM, NSM, NSM, NSM, NSM, NSM, NSM, NSM
COMMON/RCVR09/RCR, BS, PDCRIT, CC
COMMON/RCVR10/ALFA, THES, THESDT, ALFA, THES, THES
COMMON/RCVR11/ALFA, THES, THES
DIMENSION INDEX(2), DT(130, 6), HW(130)

FOLLOWING EFFECTS INITIALIZATION

IF(K > 0) GO TO 10
JMN = JR/E
K = JR1
S2 = SIGMA + 2
RETURN

FOLLOWING PROGRAMS THE SEARCH

IF (NGM > NGMIN) GO TO 30.
ALFA = ALFA * RHOMAX
THES = THES
B = BD
WSC = WSCD
THES = THES - DTHO
CONTINUE

FOLLOWING COMPUTES CONSTANTS FOR PRESENT SCAN

AL2 = ALFA
AL2 = ALFA
AR2 = AR2
AR2 = ALFA
AA2 = AA2

FOLLOWING INITIATES LOOP AND COMPUTES FUNCTIONS

PLOPT6
Page 1 of 4
SUBROUTINE PHILM

FOR EACH J

DO 60 J=1,JM2
INDEX(1)=J
INDEX(2)=J+JM1
THAj=THA(T(JJ))
THEE=THEE-THAJ
PJ=P(THEE)
PDJ=PDOT(THEE)
P2J=P/J**2
CM=RJ+THERS-THAJ
PRJ=P(ITEM)

65 INDEX(1)=JI
INDEX(2)=JM1-JI
THAJ=THA(JI)
THEE=THEE-THAJ
PJ=P(THEE)
PDJ=PDOT(THEE)
P2J=P/J**2
CM=RJ+THERS-THAJ
PRJ=P(ITEM)

70 D1NET=ALZ*P2J
C1=ARZ*P
C2=AZ*PDJ
D3=ALZ*PPPJ
D4=ARZ*PRZJ
D5=AAZ*PPPJ

C FOLG COMPLETES CALCULATIONS FOR TO,FRO SCANS, RESP.

65 DO 50 I=1,Z
INDEX(I)=J
TJ=T(I)
BLOCAL=PVALUE(JB+WSC+0.5*WSCDOT*TJ)*TJ**3.1415927,00ELBLISB-SIN(BLOCAL)
COS(BLOCAL)
QJ-QNRJ

50 IF (NGH.LT.NGMAX) GO TO 40

C FOLG IS FOR A 60 LDE DESIGN

C FOLLOWING COMPUTES VECTOR HW(JM), AND INNOVATIONS PROCESS VECTOR W(JM)

110 HW(J)=1./((1.+Z.*QJ)
UJ+V(J)
UJ+S2*(UJ**2)
V(J)=U/J/5QT(1.+QJ*UJ))**1.

CONTINUE
SUBROUTINE PHILN 73/172 TS

FOLLOWING COMPUTES VECTOR LAMDA(NG) AND MATRICE PHI(NG,NG)

CONTINUE -

DO 110 I=1,NG

LAMDA(I)=0.0

DO 120 J=1, JM

LAMDA(I)=LAMDA(I)*DT(J,I)+W(J)

120 CONTINUE

DD 100 L=1,1

PHIL=0.0

DO 80 J=1, JM

PHIL=PHIL+HW(J)*DT(J,I)*DT(J,L)

80 CONTINUE

130 IF (NLOEL) GO TO 90

RMAT(L,I)=PHIL

90 CONTINUE

CONTINUE

135 CONTINUE

CONTINUE

RETURN

END

CM STORAGE USED 823 SECONDS
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