AD-A044 776 FOREIGN TECHNOLOGY DIV WRIGHT-PATTERSON AFB OHIO F/G 9/4

FUNCTION OF AMBIGUITY OF RANDOM SIGNALS,(U)

MAR 77 A F TERPUGOV, V A TOLSTUNOV

UNCLASSIFIED FTD-ID(RS)I-0387-77 NL

| OF |

AD A044776

END

DATE FILMED

10-77

DDC

AD-A044776

FTD-ID(RS)I-0387-77

(1)

FOREIGN TECHNOLOGY DIVISION

FUNCTION OF AMBIGUITY OF RANDOM SIGNALS

by

A. F. Terpugov, V. A. Tolstunov

EDITED TRANSLATION

FTD-ID(RS)I-0387-77 29 March 1977

FTD-77-C-000303

CSP73115985

FUNCTION OF AMBIGUITY OF RANDOM SIGNALS

By: A. F. Terpugov, V. A. Tolstunov

English pages: 13

Source: Izvestiya Vysshikh Uchebnykh Zavedeniy Radioelektronika, Vol 15, NR 3, 1972, PP. 343-349.

Country of origin: USSR
Translated by: Marilyn Olaechea
Requester: DRDMI/YDL
Approved for public release; distribution unlimited.

U. S. BOARD ON GEOGRAPHIC NAMES TRANSLITERATION SYSTEM

Block	Italic	Transliteration	Block	Italic	Transliteration
А а	*А а*	A, a	Р р	*Р р*	R, r
Б б	*Б б*	B, b	С с	*С с*	S, s
В в	*В в*	V, v	Т т	*Т т*	T, t
Г г	*Г г*	G, g	У у	*У у*	U, u
Д д	*Д д*	D, d	Ф ф	*Ф ф*	F, f
Е е	*Е е*	Ye, ye; E, e*	Х х	*Х х*	Kh, kh
Ж ж	*Ж ж*	Zh, zh	Ц ц	*Ц ц*	Ts, ts
З з	*З з*	Z, z	Ч ч	*Ч ч*	Ch, ch
И и	*И и*	I, i	Ш ш	*Ш ш*	Sh, sh
Й й	*Й й*	Y, y	Щ щ	*Щ щ*	Shch, shch
К к	*К к*	K, k	Ъ ъ	*Ъ ъ*	"
Л л	*Л л*	L, l	Ы ы	*Ы ы*	Y, y
М м	*М м*	M, m	Ь ь	*Ь ь*	'
Н н	*Н н*	N, n	Э э	*Э э*	E, e
О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

*ye initially, after vowels, and after ъ, ь; e elsewhere. When written as ё in Russian, transliterate as yё or ё. The use of diacritical marks is preferred, but such marks may be omitted when expediency dictates.

GREEK ALPHABET

Alpha	Α	α	α	Nu	Ν	ν	
Beta	Β	β		Xi	Ξ	ξ	
Gamma	Γ	γ		Omicron	Ο	ο	
Delta	Δ	δ		Pi	Π	π	
Epsilon	Ε	ε	ϵ	Rho	Ρ	ρ	ϱ
Zeta	Ζ	ζ		Sigma	Σ	σ	ς
Eta	Η	η		Tau	Τ	τ	
Theta	Θ	θ	ϑ	Upsilon	Υ	υ	
Iota	Ι	ι		Phi	Φ	φ	ϕ
Kappa	Κ	ϰ κ	ϰ	Chi	Χ	χ	
Lambda	Λ	λ		Psi	Ψ	ψ	
Mu	Μ	μ		Omega	Ω	ω	

RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

Russian	English
sin	sin
cos	cos
tg	tan
ctg	cot
sec	sec
cosec	csc
sh	sinh
ch	cosh
th	tanh
cth	coth
sch	sech
csch	csch
arc sin	$\sin^{-1}$
arc cos	$\cos^{-1}$
arc tg	$\tan^{-1}$
arc ctg	$\cot^{-1}$
arc sec	$\sec^{-1}$
arc cosec	$\csc^{-1}$
arc sh	$\sinh^{-1}$
arc ch	$\cosh^{-1}$
arc th	$\tanh^{-1}$
arc cth	$\coth^{-1}$
arc sch	sech^{-1}
arc csch	csch^{-1}

---

rot	curl
lg	log

GRAPHICS DISCLAIMER

All figures, graphics, tables, equations, etc. merged into this translation were extracted from the best quality copy available.

FUNCTION OF AMBIGUITY OF RANDOM SIGNALS

A. F. Terpugov, V. A. Tolstunov

ABSTRACT Presented is a generalization of the concept of the ambiguity function for random signals. The use of obtained formulas is demonstrated with two specific signals serving as an example.

The Woodward ambiguity function, which plays an important role in radar theory, was obtained for the case of determined signals, where interfering noise is white and Gaussian . Wide-band random and pseudorandom signals have recently been used in radar. The possibility of compressing such signals into a very narrow pulse in a receiver has made it possible, specifically, to resolve the contradiction between the range of action and resolution and to provide emission secrecy. For this reason the problem of the ambiguity function of random signals is of particular interest.

In [1, 2] one possible generalization of the ambiguity function to random signals is presented. Specifically the mathematical expectation of the random ambiguity functions, i.e., the mean value of the Woodward ambiguity function, written for a fixed realization of the transmitted signal, is used as the ambiguity function of random signals. The generalization thus induced is closely related to the instrument function of the radar set and has a practical significance as the measure about which the different realizations of the ambiguity function of the random signal are grouped in a statistical sense. Thus, along with the mean value we must consider the dispersion of the random ambiguity function, which introduces probability ambiguity into the determination of target parameters. Moreover, the probability sense of the plotted function becomes insufficiently clear.

In the present work a different approach to the solution of this problem is proposed.

Let the probe signal S(t) be a realization of a random process which is stored in the radar set to be later used in reception. Let us assume that θ represents the parameters, and $\hat{\Theta}$ the estimates of the parameters of this signal. If $p(\hat{\Theta}/\Theta)$ is the conditional density of the probabilities of estimates of unknown parameters, then in receiving the signal in normal white noise, we can write the expression [3, p. 149]:

$$p(\hat{\Theta}/\Theta) = Ce^{qg(\hat{\Theta}, \Theta)}, \quad (1)$$

where $g(\hat{\Theta}, \Theta)$ is the ambiguity function, q - signal/noise ratio, C - normalizing cofactor.

If the shape of the signal is known (fixed realization), then

$$p(\hat{\Theta}/\Theta, S) = Ce^{qg(\hat{\Theta}, \Theta/S)}. \quad (2)$$

If we use (1) and (2) and the known relationship

$$p(\hat{\Theta}, \Theta) = \int_{-\infty}^{\infty} p(\hat{\Theta}, \Theta/S)\, p(S)\, dS,$$

then, in the case of a weak dependence of C on S (which generally occurs) we can get the following expression for the ambiguity function:

$$g(\hat{\Theta}, \Theta) = \frac{1}{q} \ln \int_{-\infty}^{\infty} e^{qg(\hat{\Theta}, \Theta/S)} p(S)\, dS. \quad (3)$$

If we define θ as signal delay and Doppler frequency shift, then

(4) $$g(\tau, \Omega) = \frac{1}{q} \ln \int_{-\infty}^{\infty} e^{\frac{q}{T^2}\left|\int_0^{T-\tau} S(t) S^*(t+\tau) e^{j\Omega t} dt\right|^2} p(S)\, dS.$$

Here T is the length of the probe pulse. For nonrandom signals (4) is transformed into the Woodward ambiguity function.

It should be mentioned that an ambiguity function obtained in this form is not convenient for practical application, since it is not always possible to find multidimensional density p(S). However, for a broad class of signals function (4) acquires a simpler form.

Let us examine the signals whose autocorrelation functions rapidly approach zero as the argument grows (this case is the most interesting from the practical standpoint). Then when the signal has a large base and the limitations [4] are sufficiently general, the law of distribution of quantity $z = \int_0^{T-\tau} S(t) S^*(t+\tau) e^{j\Omega t} dt$ can be considered approximately normal. Consequently, if we shift to random quantities u and v, so that z = u + jv, then

(5) $$p(u, v) = \frac{1}{2\pi\sigma_u\sigma_v\sqrt{1-r^2}} e^{-\frac{1}{2(1-r^2)}\left[\frac{(v-\bar{v})^2}{\sigma_v^2} - \frac{2r(u-\bar{u})(v-\bar{v})}{\sigma_u\sigma_v} + \frac{(u-\bar{u})^2}{\sigma_u^2}\right]}.$$

If we use (5) and bear in mind that for the selected class of signals σ_u^2 - and σ_v^2 - have an order of magnitude of T (see the appendix), then we can easily represent the ambiguity function (4) in the form of

(6)
$$g(\tau, \Omega) = \frac{1}{T^2}\left[\bar{v}^2 + \left(1 + \frac{q}{T^2\alpha^2}\right)\bar{u}^2\right] - \frac{1}{q}\ln\left(\sigma_u\sigma_v\sqrt{1-r^2}\times\right.$$
$$\left.\times\sqrt{4\alpha^2\beta^2-\gamma^2}\right) + \frac{q\left(2\bar{v} + \frac{\gamma}{\alpha^2}\bar{u}\right)^2}{T^4(\beta^2-\gamma^2/4\alpha^2)},$$

where

$$\alpha^2 = \frac{1}{2(1-r^2)\sigma_v^2} - \frac{q}{T^2}, \quad \beta^2 = \frac{1}{2(1-r^2)\sigma_v^2} - \frac{\bar{v}}{T^2},$$
$$\gamma = \frac{r}{(1-r^2)\sigma_u\sigma_v}.$$

If we then ignore quantities of a greater order of smallness, then after c[illegible]in simple transformations we get

(7)
$$g(\tau, \Omega) = \frac{1}{T^2}\left[\bar{v}^2 + u^2 + \sigma_v^2 + \sigma_u^2 + \frac{2q}{T^2}(\bar{v}\sigma_v + r\sigma_u\bar{u})^2\right].$$

In the limiting case, when $T \to \infty$, expression (7) acquires the form of:

(8)
$$g(\tau, \Omega) = \frac{1}{T^2}(\bar{u}^2 + \bar{v}^2).$$

Formulas (7) and (8) make it possible to rather simply calculate the ambiguity functions of random signals. Here (8), when $\Omega = 0$, determines the autocorrelation function of the signal.

As an example let us determine the ambiguity function of a random Gaussian signal with autocorrelation function $R(t_1, t_2)$. It is quite apparent that

(9)
$$\overline{u} = \int_0^{T-\tau} R(t, t+\tau)\cos\Omega t\, dt,$$
$$\overline{v} = \int_0^{T-\tau} R(t, t+\tau)\sin\Omega t\, dt.$$

If we use the known [5] relationship for Gaussian random quantities S_i

$$\overline{S_1 S_2 S_3 S_4} = \overline{S_1 S_2}\cdot\overline{S_3 S_4} + \overline{S_1 S_3}\cdot\overline{S_2 S_4} + \overline{S_1 S_4}\cdot\overline{S_2 S_3}.$$

then we find

(10)
$$\sigma_v^2 = \iint_0^{T-\tau} R(t_1, t_2) R(t_1+\tau, t_2+\tau)\cos\Omega t_1 \cos\Omega t_2\, dt_1 dt_2 + \iint_0^{T-\tau} R(t_1, t_2+\tau) R(t_1+\tau, t_2)\cos\Omega t_1 \cos\Omega t_2\, dt_1 dt_2,$$
$$\sigma_u^2 = \iint_0^{T-\tau} R(t_1, t_2) R(t_1+\tau, t_2+\tau)\sin\Omega t_1 \cdot \sin\Omega t_2\, dt_1 dt_2 + \iint_0^{T-\tau} R(t_1, t_2+\tau) R(t_1+\tau, t_2)\sin\Omega t_1 \sin\Omega t_2\, dt_1 dt_2,$$
$$r = \frac{1}{\sigma_u \sigma_v}\left\{\iint_0^{T-\tau} R(t_1, t_2) R(t_1+\tau, t_2+\tau)\cos\Omega t_1 \sin\Omega t_2\, dt_1 dt_2 + \iint_0^{T-\tau} R(t_1, t_2+\tau) R(t_1+\tau, t_2)\cos\Omega t_1 \sin\Omega t_2\, dt_1 dt_2\right\}.$$

Now let us select for the sake of deformation the autocorrelation function of the signal in the form of

$$R(t_1, t_2) = e^{-\frac{|t_1 - t_2|}{\tau_K}},$$

where $\tau_K \ll 1$ is the correlation integral.

Then, by calculating integrals (9) and (10) and ignoring terms of a greater order of smallness, we get

$$g(\tau, \Omega) = \frac{1}{T^2}\left\{e^{-2\tau/\tau_K}\frac{4}{\Omega^2}\sin^2\frac{\Omega(T-\tau)}{2} + \left[e^{-2\tau/\tau_K}\frac{\sin\Omega\tau}{\Omega} + \frac{2\tau_K}{4+\tau_K^2\Omega^2}\right]\times\right.$$

(11)

$$\left.\times\left[2(T-\tau) + \frac{8q}{\Omega^2}e^{-2\tau/\tau_K}\sin^4\frac{\Omega(T-\tau)}{2}\,\frac{\left(1-\frac{\tau}{T}+\frac{\sin\Omega(T-\tau)}{\Omega T}\right)^2}{T-\tau-\frac{\sin 2\Omega(T-\tau)}{2\Omega}}\right]\right\}.$$

As one might expect, the ambiguity function depends substantially on the correlation interval, where the lower the value of τ_K, the better the form acquired by $g(\tau, \Omega)$. From (11) we find the ambiguity function section with plane $\Omega = 0$

$$g(\tau, 0) = \left(1-\frac{\tau}{T}\right)\left[\left(1+\frac{\tau}{T}\right)e^{-2\tau/\tau_K} + \frac{\tau_K}{T}\right], \quad (12)$$

which, when $T \to \infty$ is transformed into the autocorrelation function of the signal.

As another example let us look at a phase-manipulated signal, represented by a random quantity, which with equal probability acquires one of two values ±1. Here the latter sign change is described by the Poisson process with parameter

$$\Lambda(t_1, t_2) = \int_{t_1}^{t_2} \lambda(x)\, dx.$$

In order to calculate the ambiguity function of (7) we must determine the mean value of the products S (t) S (t + τ) and S (t_1) •S (t_1 + τ) •S (t_2) X S (t_2 + τ).

Now let us look at the product of S (t) S (t + τ). It is equal either to +1 or to -1, depending on whether the number of transitions through zero on the interval (t, t + τ) is even or odd. Thus,

(13) $$\overline{S(t)\,S(t+\tau)} = P_{ч}(t, t+\tau) - P_{н}(t, t+\tau),$$

where

$$P_{ч}(t, t+\tau) = \frac{1}{2}[1+e^{-2\Lambda(t, t+\tau)}],\quad P_{н}(t, t+\tau) = \frac{1}{2}[1-e^{-2\Lambda(t, t+\tau)}]$$

represents the probabilities of the even and odd number of transitions through zero, respectively.

In order to find the mean value $A(t_1, t_2, \tau) = S(t_1) S(t_1 + \tau) S(t_2) S(t_2 + \tau)$, we introduce events determined by the following relationships:

(14)
$$\begin{aligned} B &= (t_1 < t_2), \\ B_1 &= (t_1 + \tau < t_2), \\ B_2 &= (t_1 + \tau > t_2), \\ C &= (t_2 > t_1), \\ C_1 &= (t_2 + \tau > t_1), \\ C_2 &= (t_2 + \tau < t_1), \end{aligned}$$

where

$$0 \leqslant t_1,\ t_2 \leqslant T - \tau.$$

These events can be regarded as random, or, if we assume that from the domain $0 \leqslant t_1, t_2 \leqslant T - \tau$ random quantities $A(t_1, t_2, \tau)$ are arbitrarily selected. Then

(15)
$$\begin{aligned} P[A = \pm 1] = P(B)\,[P(A = \pm 1/BB_1)\, P(B/B_1) + P(A = \pm 1/BB_2)\, P(B/B_2)] + \\ P(C)\,[P(A = \pm 1)/CC_1)\, P(C/C_1) + p(A = \pm 1/CC_2)\, P(C/C_2)]. \end{aligned}$$

Conditional probability $P(A = 1/BB_1)$ is represented as the sum of the probabilities of all such combinations of values of the signal S for which A = 1, and we examine the first term

$$P[S(t_1) = 1,\ S(t_1 + \tau) = 1,\ S(t_2) = 1,\ S(t_2 + \tau) = 1/t_1 < t_1 + \tau < t_2 < t_2 + \tau].$$

Since the time intervals do not overlap, and the appearance of +1 or -1 does not depend on the number of possible transitions on an interval, then

$$P[S(t_1)=1, S(t_1+\tau)=1, S(t_2)=1, S(t_2+\tau)=1/t_1<t_1+\tau<t_2<t_2+\tau]=$$
$$=\frac{1}{2}P_q(t_1, t_1+\tau)P_q(t_1+\tau, t_2)P_q(t_2, t_2+\tau).$$

Such relationships can also be obtained for other terms. Then, by calculating (15), we get

(16)
$$P(A=\pm 1)=\begin{cases}\frac{1}{4}[2\pm e^{-2\Lambda(t_1, t_1+\tau)-2\Lambda(t_2, t_2+\tau)}], & t_1<t_1+\tau<t_2<t_2+\tau.\\ \frac{1}{4}[2\pm e^{-2\Lambda(t_1, t_2)-2\Lambda(t_1+\tau, t_2+\tau)}], & t_1<t_2<t_1+\tau<t_2+\tau,\\ \frac{1}{4}[2\pm e^{-2\Lambda(t_2, t_1)-2\Lambda(t_2+\tau, t_1+\tau)}], & t_2<t_1<t_2+\tau<t_1+\tau,\\ \frac{1}{4}[2\pm e^{-2\Lambda(t_1, t_1+\tau)-2\Lambda(t_2, t_2+\tau)}], & t_2<t_2+\tau<t_1<t_1+\tau.\end{cases}$$

Further, the finding of the ambiguity function with (13) and (16) considered leads to awkward expressions. Thus, we examine here only a particular case, where $\Omega = 0$, $\lambda(x) = \lambda_0$. Then

$$g(\tau, 0)=\iint_0^{T-\tau}\overline{S(t_1)S(t_1+\tau)S(t_2)S(t_2+\tau)}\,dt_1dt_2.$$

By using (16), after certain simple calculations we will get:

(17)
$$g(\tau, 0)=\left(1-\frac{\tau}{T}\right)^2 e^{-4\lambda_0\tau}+\frac{1}{4\lambda_0 T}\left[\frac{1}{4\lambda_0 T}(e^{-4\lambda_0(T-\tau)}-1)+1-\frac{\tau}{T}\right].$$

From (17), when $T \to \infty$, we get the autocorrelation function of the studied signal in the form of

$$g(\tau, 0) = e^{-4\lambda_0 \tau},$$

which is the well known result of [7].

CONCLUSION

1. As the ambiguity function for random signals we should generally use the expression

$$g(\hat{\Theta}, \Theta) = \frac{1}{q} \ln \int_{-\infty}^{\infty} e^{q g(\hat{\Theta}, \Theta/S)} p(S)\, dS.$$

2. If the unknown parameters are range and target velocity, then

$$g(\tau, \Omega) = \frac{1}{q} \ln \int_{-\infty}^{\infty} e^{\frac{q}{T^2}\left|\int_0^{T-\tau} S(t) S^*(t+\tau) e^{j\Omega t} dt\right|^2} p(S)\, dS.$$

3. In the case where the autocorrelation function of the signal rapidly declines to zero as the argument grows, it is possible to use an approximate formula as the ambiguity function:

$$g(\tau, \Omega) = \frac{1}{T^2}\left[\bar{u}^2 + \bar{v}^2 + \sigma_u^2 + \sigma_v^2 + \frac{2q}{T^2}(\bar{v}\sigma_v + r\sigma_u \bar{u})^2\right],$$

where

$$u + jv = \int_0^{T-\tau} S(t)\, S^*(t+\tau)\, e^{j\Omega t} dt.$$

APPENDIX

Let us show that σ_u^2 and σ_v^2 have an order of magnitude of T. For convenience let us switch to references at intervals of Δt = 1/2F, where 2F is the width of the spectrum of the studied signal. Then

$$u=\frac{1}{2F}\sum_{i=1}^{n}u_i,$$

where $u_i=S_iS_{i+m}\cos i\frac{\Omega}{2F}$, $n=B-m-1$, $m=2F\tau$, $B=2FT$ is the signal base. Consequently

$$\sigma_u^2=\frac{1}{4F^2}\left|\sum_{i=1}^{n}\sum_{j=1}^{n}R_{ij}\sigma_i\omega_j\right|.$$

Here R_{ij} is the correlation coefficient between u_i and u_j; ; σ_i^2 is the dispersion of random quantity u_i. For signals which can be realized in practice the following limitation is natural

$$\sigma_i^2\leqslant C<\infty.$$

Then

$$\sigma_u^2\leqslant\frac{C}{4F^2}\sum_{i=1}^{n}\sum_{j=1}^{n}|R_{ij}|.$$

Since for the selected class of signals $R_{ij}\to 0$ and $|i-j|\to\infty$,, for any value $\varepsilon>0$, no matter how small, when $|i-j|>N$ we get $|R_{ij}|<\varepsilon$ (for definition we will assume that $\varepsilon\leqslant 1/n$). This means that in the matrix $\|R_{ij}\|$. containing n² elements not more than (2N + 1) n elements exceed ε, and the remaining are smaller than ε. From this it follows that

$$\sigma_u^2 \leqslant \frac{C}{4F^2}[n^2\varepsilon + n(2N+1)(1-\varepsilon)] \leqslant \frac{C}{4P^2}[n + n(2N+1)],$$

i.e., when $n \to \infty$ $\sigma_u^2 \to \infty$ - no faster than n, this means that σ_u^2 - has the order of magnitude of T. It is precisely this way that we prove that $\sigma_0^2 \sim T$.

Received 30 November 1970, revised 3 May 1971

BIBLIOGRAPHY

1. Сифоров В. И., Туркельтауб Р. М., О функции неопределенности случайного процесса, Радиотехника, 1968, 23, № 8, 1.

2. Garampon G., Boonet G., Extension de la notion de fonction d'ambiguité a des signaux aleatoires, Ann. télicommun. 1968, 23, № 5—6.

3. Вакман Д. Е., Сложные сигналы и принцип неопределенности в радиолокации, Изд-во «Советское радио», 1965.

4. Сарманов О. В., Распространение предельной теоремы теории вероятностей на сумму почти независимых величин, удовлетворяющих условию Линдеберга, Изв. АН СССР, Сер. математ., 1947, 2, № 6.

5. Давенпорт В. Б., Рут В. Л., Введение в теорию случайных сигналов и шумов, Изд-во ин. лит-ры, 1960.

6. Цифровые методы в космической связи, под ред. С. Голомба, Изд-во «Связь», 1969.

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER FTD-ID(RS)I-0387-77	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) FUNCTION OF AMBIGUITY OF RANDOM SIGNALS		5. TYPE OF REPORT & PERIOD COVERED Translation 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) A. F. Terpugov, V. A. Tolstunov		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Foreign Technology Division Air Force Systems Command U. S. Air Force		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE 1972 13. NUMBER OF PAGES 13
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED 15a. DECLASSIFICATION DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

09

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

DISTRIBUTION LIST

DISTRIBUTION DIRECT TO RECIPIENT

ORGANIZATION		MICROFICHE
A205	DMATC	1
A210	DMAAC	2
B344	DIA/RDS-3C	8
C043	USAMIIA	1
C509	BALLISTIC RES LABS	1
C510	AIR MOBILITY R&D LAB/FIO	1
C513	PICATINNY ARSENAL	1
C535	AVIATION SYS COMD	1
C557	USAIIC	1
C591	FSTC	5
C619	MIA REDSTONE	1
D008	NISC	1
H300	USAICE (USAREUR)	1
P005	ERDA	2
P055	CIA/CRS/ADD/SD	1
NAVORDSTA (50L)		1
NAVWPNSCEN (Code 121)		1
NASA/KSI		1
544 IES/RDPO		1
AFIT/LD		1

ORGANIZATION		MICROFICHE
E053	AF/INAKA	1
E017	AF/ RDXTR-W	1
E404	AEDC	1
E408	AFWL	1
E410	ADTC	1
E413	ESD	2
	FTD	
	CCN	1
	ETID	3
	NIA/PHS	1
	NICD	5