



10 gen - 10 a

MICROCOPY RESOLUTION TEST CHART NATIONAL BUREAU OF STANDARDS 1963 A

1 19 7 . 97	ACCTI	177 0
- Jak U La		1

5

SECURITY CLASSIFICATION OF	THIS PAGE

1. 00000	T 65 (110-74 -	ASSIE	TION		AL DEPTRICTUR	ABRINCE		
IN REPOR	UNT SECURITY CLASSIFICATION NCLASSIFIED		16. RESTRICTIVE MARKINGS					
2. SECUR	URITY CLASSIFICATION AUTHORITY		3 DISTRIBUTION/AVAILABILITY OF REPORT					
	CONTRACTION AUTHORITY			Approved for	nublic re	elease: die:	tributio	
26. DECLA	DECLASSIFICATION/DOWNGRADING SCHEDULE			unlimited.		cicase, dis	u ibu ci o	
4. PERFOR	IMING ORGAN	ZATION P	EPORT NUM	IBER(S)	5. MONITORING OF	GANIZATION P	EPORT NUMBER	(S)
AACE	00 056				AFOSR-	TR- 83	1274	4
MASE	AASE 83-256							
OL NAME	NAME OF PERFORMING ORGANIZATION 6. OFFICE SYMBOL (If applicable)			78. NAME OF MONI	TORING ORGAN	NIZATION -		
Miss	Mississippi State University			Air Force Of	ffice of Sc	cientific Re	esearch	
6c. ADDRE	ADDRESS (City, State and ZIP Code)			76. ADDRESS (City,	State and ZIP Co	dej		
Depa	epartment of Aerospace Engineering		Directorate	of Mathema	atical & Ind	formatic		
Miss	issippi \$	tate MS	39762	· · · · · · · · · · · · · · · · · · ·	Sciences, Bo	olling AFB	DC 20332	
	• •			•				
Sa. NAME		SPONSORI	NG	Bb. OFFICE SYMBOL	9. PROCUREMENT	INSTRUMENT IC	DENTIFICATION	NUMBER
	AFOOD				AFOST SO OTO			
-	MCUDA	and 715 C			AFUSK-80-018	Contraction of the contraction o		
	:33 (UII Y, S IGIE	una zir co	aej .		10. SOURCE OF FUI	NUING NOS.	T	
	Bolling	AFB DC	20332		ELEMENT NO.	NO.	NO.	N
L					1	1		ł
11. TITLE	Include Securit	y Classificat	tion)		7	1	1	
SEE RE	E REMARKS ARE THAT FRAME			61102F	2304	A3		
12. PERSO	NAL AUTHOR	(S)		•				
12. PERSO	NAL AUTHOR A. Warsi	(S)	136 TIME C	OVERED	14. DATE OF REPO	BT (Yr Ma Da	116 BACE	COUNT
12. PERSO 2.U. 13. TYPE Inte 16. SUPPL	NAL AUTHOR A. Warsi OF REPORT TIM EMENTARY NO	S)	136. TIME C FROM 1/	OVERED 5/30 T030/4/83	14. DATE OF REPO	RT (Yr., Ma., Das	7) 15. PAGE 12	COUNT
12. PERSO 2.U. 13. TYPE Inte 16. SUPPLI 17. FIELD	NAL AUTHOR A. Warsi OF REPORT TIM EMENTARY NO COSATI GROUP	S) DTATION CODES SUI	136. TIME C FROM 1/	DVERED 5/32T030/4/83 18. SUBJECT TERMS (Grid generatio	14. DATE OF REPOR JUL 83 Continue on reverse if m	RT (Yr., Ma., Day eccuary and iden coordinat	15. PAGE 12 11/2 11/2 11/2 11/2 11/2 11/2	COUNT en cal meth
12. PERSO 2. U. 13. TYPE Inte 16. SUPPL 17. FIELD	NAL AUTHOR A. Warsi OF REPORT rim EMENTARY NO COSATI GROUP	S) DTATION CODES SUI	136. TIME C FROM <u>1/</u> B GR	18. SUBJECT TERMS (Grid generatio computational	14. DATE OF REPO JUL 83 Continue on reverse if m on; curvilinear fluid dynamics	RT (Yr., Ma., Day eccessory and iden coordinat	15. PAGE 12 tify by block numb	count en cal meth
12. PERSO 2. U. 13. TYPE Inte 16. SUPPLI 17. FIELD	NAL AUTHOR A. Warsi OF REPORT rim EMENTARY NO COSATI GROUP	DTATION CODES	136. TIME C FROM <u>1/</u> B GR	18. SUBJECT TERMS (Grid generatio computational	14. DATE OF REPO JUL 83 Continue on reverse if m on; curvilinear fluid dynamics	RT (Yr., Ma., Day eccuary and iden coordinat	15. PAGE 12 tils by block numb res; numeric	count en sal meth
12. PERSO 2. U. 13. TYPE Inte 16. SUPPLI 17. FIELD 19 ABSTR	NAL AUTHOR A. Warsi OF REPORT TIM EMENTARY NO COSATI GROUP	CODES SUI	13b. TIME C FROM <u>1</u> / B GR.	DVERED 5/92T030/4/83 18. SUBJECT TERMS / Grid generatio computational d identify by block numb	14. DATE OF REPORT JUL 83 Continue on reverse if m on; curvilinear fluid dynamics er,	RT (Yr., Ma., Day eccenary and iden coordinat	15. PAGE 12 11/2 11/2 11/2 11/2 11/2 11/2 11/2	en) al meth
12. PERSO 2.U. 13. TYPE Inte 16. SUPPLI 17. FIELD 19 ABSTR An a to b	NAL AUTHOR A. Warsi OF REPORT TIM EMENTARY NO COSATI GROUP ACT /Continue nalytical	CODES SUI	13b. TIME C FROM 1/ B GR.	18. SUBJECT TERMS (Grid generatio computational d identify by block numb generation and	14. DATE OF REPO JUL 83 Continue on reverse if m on; curvilinear fluid dynamics er; redistribution been dovalors	RT (Yr., Ma., Day eccessory and iden coordinat 	<pre>// 15. PAGE 12 //// 12 //// 12 //// 12 //// 12 //// 12 /// 12 /// 12 /// 12 /// 12 /// 12 /// 12 /// 1</pre>	en en cal moth
12. PERSO Z.U. 13. TYPE Inte 16. SUPPLI 17. FIELD 19 ABSTR An a to b the	NAL AUTHOR A. Warsi OF REPORT rim EMENTARY NO COSATI GROUP ACT (Continue nalytical e used alo developmed	(S) DTATION CODES SUI on receise i model ong wit	136. TIME C FROM 1/ B GR. Incressory and for the fu b the fu	18. SUBJECT TERMS of Grid generatio computational didentify by block numb generation and 11 3D code, has ourdinates gene	14. DATE OF REPO JUL 83 Continue on reverse if m on; curvilinear fluid dynamics er, redistribution been develope ration around	eccuary and ident coordinat of surfac d. This e multibodic	<pre>15. PAGE 12 13 14 15 by block numb 15; numeric 15; numeric 15; and narti 15; and narti</pre>	count en eal meth complet complet
12. PERSO Z.U. 13. TYPE Inte 16. SUPPLI 17. FIELD 19 ABSTR Ari a to b the arou.	NAL AUTHOR A. Warsi OF REPORT rim EMENTARY NO COSATI GROUP ACT (Continue nalytical e used alo developmen nd a wing-	CODES CODES SUI on recerse i model ong wit nt of :: -bedy c	13b. TIME C FROM 1/ B GR for the h the fu patial combination	DVERED <u>5/92</u> <u>T030/4/83</u> 18. SUBJECT TERMS / Grid generatio computational d identify by block numb generation and 11 3D code, has ourdinates gene- on in the 3D sp	14. DATE OF REPOR JUL 83 Continue on reverse if m m; curvilinear fluid dynamics er; redistribution been develope ration around ace. Numerica	eccuary and ident coordinat of surfac d. This e multibodie i results	<pre> 15. PAGE 12 ii/s by block numb es; numeric e coordinat essentially es and parti for some mu </pre>	count en eal meth complet coularly iltibody
12. PERSO Z.U. 13. TYPE Inte 16. SUPPL 17. FIELD 19 ABSTR An a to b the arou prob	NAL AUTHOR A. Warsi OF REPORT TIM EMENTARY NO COSATI GROUP ACT (Continue nalytical e used alo developmen nd a wing lems have	(S) CODES SUI on recerse i model ong wit nt of :: -body c becn o	13b. TIME C FROM 1/ B GR. for the fu patial co ombination btained.	18. SUBJECT TERMS (Grid generation computational d identify by block numb generation and 11 3D code, has ourdinates gene on in the 3D sp	14. OATE OF REPOR JUL 83 Continue on reverse if m on; curvilinear fluid dynamics er, redistribution been develope ration around ace. Numerica	RT (Yr., Ma., Day eccessory and iden coordinat cordinat do f surfac d. This e multibodie l results	<pre> 15. PAGE 12 12 14 15 by block numb 16; numeric 1</pre>	count en cal meth complet complet cularly litibody
12. PERSO 2.U. 13. TYPE Inte 16. SUPPL 17. FIELD 19 ABSTR An a to b the arou: prob	NAL AUTHOR A. Warsi OF REPORT TIM EMENTARY NO COSATI GROUP ACT (Continue nalytical e used alo development nd a wing- lems have	(S) CODES SUI on receive i model ong wit nt of :: -bcdy c been o	136. TIME C FROM 1/ B GR. for the fu patial co ombination btained.	18. SUBJECT TERMS (Grid generatio computational didentify by block numb generation and 11 3D code, has ourdinates gene on in the 3D sp	14. DATE OF REPO JUL 83 Continue on reverse if m on; curvilinear fluid dynamics er, redistribution been develope ration around ace. Numerica	RT (Yr., Mo., Day eccuary and iden coordinat coordinat do f surfac d. This e multibodie i results	15. PAGE 12 11/2 11/2 11/2 11/2 15. PAGE 12 15. PAGE 12 15. PAGE 12 15. PAGE 12 15. PAGE 12 15. PAGE 12 15. PAGE 12 15. PAGE 12 15. PAGE 12 16. PAGE 12 17. PAGE 12 17. PAGE 12 17. PAGE 12 17. PAGE 12 17. PAGE 12 17. PAGE 12 17. PAGE 12 17. PAGE 17. PAGE	COUNT eal meth complet complet cularly
12. PERSO Z.U. 13a TYPE Inte 16. SUPPLI 17. FIELD 19 ABSTR Ari a to b the arou. prob	NAL AUTHOR A. Warsi OF REPORT rim EMENTARY NO COSATI GROUP ACT (Continue nalytical e used alo developmen nd a wing- lems have	(S) CODES SUI on recerse i model ong wit nt of :: -bedy e been o	13b. TIME C FROM 1/ B GR. for the fu patial co ombination btained.	18. SUBJECT TERMS (Grid generatio computational didentify by block numb generation and 11 3D code, has ourdinates gene on in the 3D sp	14. DATE OF REPO JUL 83 Continue on reverse if m n; curvilinear fluid dynamics er; redistribution been develope ration around ace. Numerica	eccewary and ident coordinat of surfac d. This e multibodie l results	if s. PAGE 12 if y by block numb ies; numeric ie coordinat issentially is and partific for some muticity DTLC	count eal meth complet coularly litibody
12. PERSO 2.U. 13. TYPE Inte 16. SUPPLI 17. FIELD An. a to b the arou: prob	NAL AUTHOR A. Warsi OF REPORT TIM EMENTARY NO COSATI GROUP ACT (Continue nalytical e used alo developmen nd a wing- lems have	(S) CODES SUI on receive (model ong wit nt of () -body c been of	13b. TIME C FROM 1/ B GR. for the fu patial co ombination btained.	IB. SUBJECT TERMS (Grid generation computational didentify by block numb generation and 11 3D code, has ourdinates generation in the 3D sp	14. DATE OF REPOR JUL 83 Continue on reverse if m on; curvilinear fluid dynamics er, redistribution been develope ration around ace. Numerica	RT (Yr., Ma., Day eccessory and ident coordinat do of surfac ed. This e multibodie il results	15. PAGE 12 12 12 12 12 13 14 15 by block numb 15 12 12 12 12 12 12 12 12 12 12	count eal meth complet coularly ultibody
12. PERSO Z.U. 13. TYPE Inte 16. SUPPLI 17. FIELD 19 ABSTR An a to b the arou prob	NAL AUTHOR A. Warsi OF REPORT TIM EMENTARY NO COSATI GROUP ACT /Continue nalytical e used alo developmen nd a wing lems have	(S) CODES SUI on receive (model ong wit nt of () -bedy e been o	136. TIME C FROM 1/ B GR. /nccessary and for the , h the fu patial co ombination btained.	18. SUBJECT TERMS (Grid generatio computational didentify by block numb generation and 11 3D code, has ourdinates gene on in the 3D sp	14. DATE OF REPO JUL 83 Continue on reverse if m on; curvilinear fluid dynamics er, redistribution been develope ration around ace. Numerica	RT (Yr., Mo., Day eccewary and iden coordinat coordinat do f surfac d. This e multibodie il results	15. PAGE 12 12 13 14 15 by block numb res; numeric res; n	count cal moth complet coularly litibody
12. PERSO 2.U. 13. TYPE Inte 16. SUPPL 17. FIELD 19 ABSTR An a to b the arou prob	NAL AUTHOR A. Warsi OF REPORT TIM EMENTARY NO COSATI GROUP ACT (Continue nalytical e used ald developmen nd a wing- lems have	(S) CODES Sur on reverse i model ong wit nt of :: -body c been o	136. TIME C FROM 1/ a GR. for the fu patial co ombination btained.	18. SUBJECT TERMS (Grid generatio computational didentify by block numb generation and 11 3D code, has ourdinates gene on in the 3D sp	14. DATE OF REPO JUL 83 Continue on reverse if m on; curvilinear fluid dynamics er redistribution been develope ration around ace. Numerica	RT (Yr., Ma., Day eccuary and ident coordinat coordinat d. This e multibodie il results	15. PAGE 12 11/2 11/2 11/2 11/2 11/2 12 12 12 12 12 12 12 12 12 1	count eal meth complet coularly litibody
12. PERSO 2.U. 13. TYPE Inte 16. SUPPLI 17. FIELD Ari a to b the arou prob	NAL AUTHOR A. Warsi OF REPORT rim EMENTARY NO COSATI GROUP ACT (Continue nalytical e used alo developmen nd a wing- lems have	(S) CODES SU on recerse i model ong wit nt of :: -bedy c been o	136. TIME C FROM 1/ B GR. Incressory and for the fu patial co ombination btained.	18. SUBJECT TERMS (Grid generatio computational didentify by block numb generation and 11 3D code, has ourdinates gene on in the 3D sp	14. DATE OF REPO JUL 83 Continue on reverse if m n; curvilinear fluid dynamics er; redistribution been develope ration around ace. Numerica	RT (Yr., Ma., Day eccenary and ident coordinat coordinat d. This e multibodie l results	15. PAGE 12 11/2 11/2 11/2 11/2 12 12 12 12 12 12 12 12 12 1	count eal meth complet coularly dtibody
12. PERSO Z.U. 13. TYPE Inte 16. SUPPLI 17. FIELD An a to b the arou prob	NAL AUTHOR A. Warsi OF REPORT TIM EMENTARY NO COSATI GROUP ACT (Continue nalytical e used alo developmen nd a wing- lems have	(S) CODES SUI on recerse (model ong wit nt of :: -body c been o	13b. TIME C FROM 1/ B GR. for the fu patial combination btained.	18. SUBJECT TERMS Grid generation computational didentify by block numb generation and 11 3D code, has ourdinates gene on in the 3D sp	14. DATE OF REPO JUL 83 Continue on reverse if m in; curvilinear fluid dynamics er, redistribution been develope ration around ace. Numerica	eccenary and ident coordinat of surfac d. This e multibodie i results	15. PAGE 12 12 12 12 12 13 14 15 by block numb 15 12 12 12 12 12 12 12 12 12 12	count eal meth complet coularly litibody
12. PERSO 2.U. 13. TYPE Inte 16. SUPPLI 17. FIELD 19 ABSTR An a to b the arou. prob	NAL AUTHOR A. Warsi OF REPORT TIM EMENTARY NO COSATI GROUP ACT (Continue nalytical e used alo developme) nd a wing- lems have	(S) CODES SUI on receive i model ong wit nt of :: -bcdy c been o	136. TIME C FROM 1/ B GR. for the fu patial co ombination btained.	18. SUBJECT TERMS (Grid generatio computational didentify by block numb generation and 11 3D code, has ourdinates gene on in the 3D sp	14. DATE OF REPO JUL 83 Continue on reverse if m on; curvilinear fluid dynamics er redistribution been develope ration around ace. Numerica	RT (Yr., Ma., Day eccenary and ident coordinat coordinat d. This e multibodie il results	IS. PAGE 12 12 13 14 12 14 15 12 14 15 15 15 15 15 15 15 15 15 15	count cal moth complet coularly litibody
12. PERSO Z.U. 13. TYPE Inte 16. SUPPLI 17. FIELD 19. ABSTR An a to b the arou prob	NAL AUTHOR A. Warsi OF REPORT TIM EMENTARY NO COSATI GROUP ACT /Continue nalytical e used alo developmen nd a wing lems have	(S) CODES SUI on recerce i model ong wit nt of :: -bedy c been o	13b. TIME C FROM 1/ B GR. / necessary and for the fu patial co ombination btained.	18. SUBJECT TERMS (Grid generatio computational didentify by block numb generation and 11 3D code, has ourdinates gene on in the 3D sp	14. DATE OF REPOR JUL 83 Continue on reverse if m in; curvilinear fluid dynamics er, redistribution been develope ration around ace. Numerica	RT (Yr., Ma., Day eccessory and ident coordinat coordinat do f surfac d. This e multibodie il results	15. PAGE 12 12 13 14 12 14 15 12 14 12 14 12 14 12 14 12 14 12 14 12 14 12 14 12 14 12 14 12 14 12 14 12 14 12 14 14 15 16 16 16 16 16 16 16 16 16 16	count cal meth es which complet cularly litibody
12. PERSO Z.U. 13. TYPE Inte 16. SUPPLI 17. FIELD 19 ABSTR Ari a to b the arou: prob 20 DISTRI UNCLASSI 22. NAME	NAL AUTHOR A. Warsi OF REPORT TIM EMENTARY NO COSATI GROUP ACT (Continue nalytical e used alo developmen nd a wing- lems have	CODES CODES SUI on recerse i model ong wit nt of is -body c been of been of EABILITY red Z SA	136. TIME C FROM 1/ B GR. I necessary and for the fu patial of ombination btained.	18. SUBJECT TERMS (Grid generatio computational didentify by block numb generation and 11 3D code, has oordinates gene on in the 3D sp	14. DATE OF REPOR JUL 83 Continue on reverse if m m; curvilinear fluid dynamics er; redistribution been develope ration around ace. Numerica 21 ABSTRACT SEC UNCLASSIFIED 722 TELEPHONE N Unclude Area Co	RT (Yr., Ma., Day eccessory and ident coordinat dof surfac d. This e multibodie d results URITY CLASSIF	15. PAGE 12 12 13 14/5 by block numb 12 12 12 12 12 12 12 12 12 12	COUNT eal meth complet oularly litibody
12. PERSO Z.U. 13. TYPE Inte 16. SUPPLI 17. FIELD 19. ABSTR An a to b the arou prob 20. DISTRI UNCLASSI 22. NAME CPT	NAL AUTHOR A. Warsi OF REPORT TIM EMENTARY NO COSATI GROUP ACT /Continue nalytical e used alo developmen nd a wing lems have FIED UNLIMIT OF RESPONSI	CODES CODES SUI on recerter model ong wit hong wit been of been of been of BLE INDIV	13b. TIME C FROM 1/ B GR. / necessary and for the fu patial co ombination btained. // of ABSTRAC ME AS RPT	IB. SUBJECT TERMS (Grid generatio computational d identify by block numb generation and 11 3D code, has oordinates gene on in the 3D sp	14. DATE OF REPOR JUL 83 Continue on reverse if m in; curvilinear fluid dynamics er, redistribution been develope ration around ace. Numerica 21 ABSTRACT SEC UNCLAUGIFIED 721 TELEPHONE N (Include Are Co	RT (Yr., Ma., Day eccessory and ident coordinat do of surfac ed. This e multibodie il results URITY CLASSIF	15. PAGE 12 12 13 14 12 14 15 15 15 15 15 15 15 15 15 15	COUNT eal meth eas which complet oularly litibody

t

,

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE

.

ITEM #11, TITLE: THE GUNERATION OF THREE-DIMENSIONAL BODY-FITTED COORDINATE SYSTEMS FOR VISCOUS FLOW PROBLEMS.

Acces	sion For	
NTIS	GRA&I	X
DTIC	TAB	Ľ,
Unan	iounced	
Just	ification_	
By Dist:	ribution/	
Ava	ilability	Codes
Dist	Avail au Special	i/or L
R.		

.....

AFOSR-TR. 83-1274

THE GENERATION OF THREE-DIMENSIONAL BODY-FITTED COORDINATE SYSTEMS FOR VISCOUS FLOW PROBLEMS

H Z

by

Z. U. A. Warsi Department of Aerospace Engineering Mississippi State University Mississippi State, MS 39762

> Interim Report May 1982 - April 1983

Submitted to the Air Force Office of Scientific Research

Bolling Air Force Base, D. C. 20332

Grant No. AFOSR 80-0185

Approved for public release; distribution unlimited.

July 1983

84 01 04 101

The Generation of Three-Dimensional Body-Fitted Coordinate Systems For Viscous Flow Problems

by Z. U. A. Warsi

Abstract

An analytical model for the generation and redistribution of surface coordinates, which is to be used along with the full 3D code, has been developed. This essentially completes the development of spatial coordinate generation around multibodies and particularly around a wing-body combination in the 3D space. Numerical results for some multibody problems have been obtained.

Introduction

The problem of numerical grid generation for three-dimensional configurations through elliptic PDE's has been pursued under this grant for the last several years. Various reports and journal publications have explained the mathematical model in detail. This model, which is based on the numerical solution of three nonlinear PDE's has been programed on Cray 1, and has been tested for single and two-body configurations as enclosed in a single outer boundary.

In the period of this report it was found necessary to have the capability of generating those surface coordinate systems which simplify the procedure of 3D coordinates generation through those equations which have already been developed in the previous reporting years. The main thrust for this development has come from the problem of wing-body

Department of Aerospace Engineering, (Principal Investigator) IFIC RESIGNER (AFSC) DITC OT LON NOTICE CT . has been reviewed and is

This term

So release IAWANA 190-12. approved " malimited. Distribut MATTHEW J. KELLYER Chief, Technical Information Division

combination. In the wing-body configuration we must, first of all, generate a suitable surface coordinate system which provides the Dirichlet boundary conditions for the full 3D code. Therefore a coordinate system is needed which reflects the trace of the body and wing intersection as one of the coordinates, and the coordinate along the wing as the outgoing coordinate from the fuselage. The developed analytical model which has been described in the next section generates those surface coordinates on the fuselage in which the trace of wing and body intersection is one of the surface curves. Based on the data so generated, the 3D equations as described in References 4-8 have been solved. Some results of the 3D coordinates for various multibodies are shown in Figures 1-5. Equations For The Transformed Coordinates In A Surface

Let (u,v) be a coordinate system in a surface (say a fuselage) on which the coordinate $\eta = \text{const.}$, and which has been generated by some means, e.g., from Craidon's routine (Ref. 9). We now wish to introduce other coordinates $\xi = \xi(u,v)$ and $\zeta = \zeta(u,v)$ in the same surface. From Warsi (Ref. 4), the fundamental equations for the generation of the cartesian coordinates r = (x, y, z) as functions of (ζ, ξ) , are

$$Lr + Pr_{\zeta} + Qr_{\xi} = nR , \eta = const., \qquad (1)$$

where

$$L = g_{11}^{\partial} \zeta \zeta - 2g_{13}^{\partial} \xi \zeta + g_{33}^{\partial} \xi \xi$$

$$n = (X, Y, Z,), \text{ surface normal.}$$

$$g_{11} = r_{\xi} \cdot r_{\xi} , g_{13} = r_{\xi} \cdot r_{\zeta}, g_{33} = r_{\zeta} \cdot r_{\zeta},$$

$$G_{2} = g_{11}g_{33} - (g_{13})^{2} \cdot$$

Now

ģ

$$\mathbf{r} = \mathbf{r} \mathbf{u} + \mathbf{r} \mathbf{v}_{\zeta},$$

$$\mathbf{r}_{\xi} = \mathbf{r}_{u} \boldsymbol{\xi} + \mathbf{r}_{v} \boldsymbol{\xi},$$

so that on substituting the terms $r_{\zeta\zeta}$, $r_{\xi\zeta}$, $r_{\xi\xi}$ in (1) and collecting terms, we get after some manipulations

$$au_{\zeta\zeta} - 2bu_{\xi\zeta} + cu_{\xi\xi} + Pu_{\zeta} + Qu_{\xi} = J_2^2 \Delta_2 u$$
, (2)

$$av_{\zeta\zeta} - 2bv_{\xi\zeta} + cv_{\xi\xi} + Pv_{\zeta} + Qv_{\xi} = J_2^2 \Delta_2 v$$
, (3)

where

$$J_2 = u_{\zeta} v_{\xi} - u_{\xi} v_{\zeta}$$

and a,b,c are the coefficients which have the derivatives u_{ξ} , u_{ζ} , v_{ξ} , v_{ζ} , also x_{u} , x_{v} , etc. and $\Delta_{2}u$, $\Delta_{2}v$ are the Belramians. By imposing the appropriate boundary conditions on u and v the equations (2) and (3) can be solved as a 2D grid generation problem for the new coordinates ξ and ζ . This routine can therefore be used to redistribute the surface coordinates in any manner from any given surface coordinates u and v.

The preceding equations have been programed as a subroutine with the general 3D program and is used when the coordinates for a wingbody combination are to be generated. The trace of the wing with the fuselage is considered to form an inner closed curve and the outer curve is any arbitrary closed curve near the mid section of the fuselage (Fig. 6). Equations (2) and (3) then provide the curves which are consistent with the 3D routine for the generation of space coordinates.

References

- (Note: Papers and reports written under the contract have been marked by an asterisk)
- 1. "A Method for the Generation of General Three-Dimensional Coordinates Between Bodies of Arbitrary Shapes", MSSU-EIRS-80-7, October (1980).
- 2. "Tensors and Differential Geometry Applied to Analytic and Numerical Coordinate Generation", MSSU-ELRS-81-1, January (1981).
- "A Non-Iterative Method for the Generation of Orthogonal Coordinate in Doubly-Connected Regions", <u>Mathematics of Computation</u>, Vol. 38, No. 158, (1982), pp. 501-516.
- "Basic Differential Models for Coordinate Generation", Numerical Grid Generation, Edited by J. F. Thompson, Elsevier Science Publishing Co., (1982), pp. 41-77.
- 5. "Numerical Generation of Three-Dimensional Coordinates Between Bodies of Arbitrary Shapes", Ibid, pp. 717-728.
- 6. "Boundary-Fitted Coordinate Systems for Numerical Solution of Partial Differential Equations - A Review", <u>J. Computational Physics</u>, Vol. 47, No. 1, (1982), pp. 1-108.
- 7. "A Note on the Mathematical Formulation of the Problem of Numerical Coordinate Generation", <u>Quarterly of Applied Mathematics</u>, to be published.
- 8. "Three-Dimensional Grid Generation from Elliptic Systems", to be presented at the AIAA 6th Computational Fluid Dynamics Conference at Danver, MA July 1983.
- 9. "A Computer Program for Fitting Smooth Surfaces to an Aircraft Configuration and Other Three-Dimensional Geometries", by C. B. Craidon, NASA TMX-3206, (1975).







I





- 1.

(b)

Fig. 2 Three-dimensional coordinates between a thick ellipsoid surrounded by an ellipsoid. (a) Front section, (b) Meridinal section.

7

Ł





Fig. 3 Two-dimensional surface coordinates on the surface formed of two intersecting spheres.





Fig. 4 caption on next page.





Fig. 4 Three-dimensional coordinates between the surface of Fig. 3 and an outer sphere. (a) Front section of the small sphere,
(b) Front section at the junction, (c) Front section of the large sphere, (d) Meridinal section.





t



