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An Installed Nacelle Design Code Using a Multiblock Euler Solver

Volume II: User Guide

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1.0 Summary

This is a user manual for the general multiblock Euler design (GMBEDS) code developed under NASA contract NAS1-18703. The code is for the design of a nacelle installed on a geometrically complex configuration such as a complete airplane with wing/body/nacelle/pylon. It consists of two major building blocks: a design module developed by NASA Langley using direct iterative surface curvature (DISC) approach; and, a general multiblock Euler (GMBE) flow solver. The flow field surrounding a complex configuration is divided into a number of topologically simple blocks to facilitate surface-fitted grid generation and improve flow solution efficiency. This user guide provides input data formats along with examples of input files and a Unix script for program execution in the UNICOS environment.

2.0 Introduction

This overview focuses on the use of the general multiblock Euler design (GMBEDS) code (Vol. I, Ref. 1) for the design of an installed nacelle on complex airplane configurations. From a user perspective, this code requires the combined input for the DISC design module (Ref. 2) and the general multiblock Euler (GMBE) flow solver (Refs. 3, 4, 5). The required input files have increased from the four for GMBE to six for GMBEDS.

The grid file, block relationship file (which establishes the flow field communication between adjacent blocks), the block-boundary condition file (which provides information on the type of boundary condition to be applied on each face of each block) and flow analysis input file are required by the flow solver and can be used to "seed" the design for GMBEDS.

Two additional input files specify the target pressure on the nacelle surface for design. Target pressure information is provided by configuration aerodynamic engineers and designers who are familiar with the design requirements as well as the CFD code. The flow analysis input file has flags and controlling parameters for design.

This volume is the user guide for the GMBEDS code. Guidelines for job deck preparations using UNICOS script files are given in Section 4.0. The script files are specific to the Cray Y-MP (reynolds) at the Numerical Aerodynamic Simulation (NAS) facility. However, the FORTRAN source for the GMBEDS code should be portable to other super computers

The output files are discussed in Section 5.0.

3.0 Input File Description

The original descriptions for the block relationship and block-boundary condition files are given in Reference 4. However, because of some newly developed options, the current descriptions for these files are given in Appendices A and B respectively. These two files are required for GMBEDS execution in either design or analysis mode.

The two additional design input files, the design patch identification file "desin" and the target pressure specification file "cptin" are required for GMBEDS execution in design mode. The specification of the target pressure is done in a block-by-block manner. These two files are described below. The flow analysis/design input file called "gmbdsin", described in the sub-section 3.3, is required for GMBEDS execution in either design or analysis mode.

3.1 Preparation of input file desin

The design is only allowed on J and K faces and the block topology should be set up with this restriction in mind. This input file identifies the design patches on the J and K faces of relevant blocks. The data structure of this file is similar to the block boundary condition file discussed in Appendix B. The difference is that "desin" contains only the faces where design boundary conditions will be imposed.

Within a block, the local indexing coordinates I, J, and K follow the right-hand rule. The inherent assumption is that each index numbers the grid points starting from two. Grid points with index one are reserved for the extra-layer outside the block. Faces three and four are constant-J faces, that is, J = JMINB = 2 on face three and J = JMAXB on face four. Faces five and six are constant-K faces with K = KMINB = 2 on face five and K = KMAXB on face six.

Input preparation for a typical block is presented. The same process can be repeated for the other blocks. For a typical block, input preparation for the J-face is described in Card 3 to Card 6. Description for the K-face is given in Card 7 to Card 10. An example of a desin file is presented following the description of the format of the file.

Column	Code	Format	Description
Card 1:			
1-80		1x	Header card.
Card 2:			
1-10	NBA	Free	Block number.
11-20	NFT	Free	Number of faces that contain design patch. For examples, if there is one design patch on face-3, and another design patch on face-5, then NFT is equal to two.
Card 3:			
1-80		1x	Header card.
Card 4:			
1-10	NFA	Free	Face number. = 3 or 4
11-20	NBCA	Free	Number of design boundary condition patches for the face.
Card 5:			
1-80		1x	Header card.

Card 6: Repeat this card NBCA (see Card 4) times.

1-10	NTYPE	Free	Boundary condition type for a design patch. = 7 for surface transpiration.
11-20	IMIN	Free	The minimum I-index for the patch.
21-30	IMAX	Free	The maximum I-index for the patch.
31-40	KMIN	Free	The minimum K-index for the patch.
41-50	KMAX	Free	The maximum K-index for the patch.
51-60	KINC	Free	Increment in the K-index. Recommended value = 1

Card 7:

1-80		1x	Header card.

Card 8:

1-10	NFA	Free	Face number. = 5 or 6
11-20	NBCA	Free	Number of design boundary condition patches for the face.

Card 9:

1-80		1x	Header card.

Card 10: Repeat this card NBCA (see Card 8) times.

1-10	NTYPE	Free	Boundary condition type for a design patch.

			Please see descriptions in Card 6.
11-20	IMIN	Free	The minimum I-index for the patch.
21-30	IMAX	Free	The maximum I-index for the patch.
31-40	JMIN	Free	The minimum J-index for the patch.
41-50	JMAX	Free	The maximum J-index for the patch.
51-60	JINC	Free	Increment in the J-index. Recommended value = 1

Repeat cards 1 through 10 for the other design blocks.

Example of File desin

NBA	NFT				
2	1				
NFA	NBCA				
3	1				
NTYPE	IMIN	IMAX	KMIN	KMAX	KINC
7	30	78	2	10	1

3.2 Preparation of input file cptin

This input file prescribes the distributions of the target pressure coefficients on the design patch on the J and K faces of the relevant blocks. The specification of the design patches must be consistent with the "desin" file. The target pressure coefficients are prescribed at the grid points, along a streamwise strip, in a strip-by-strip manner, for each design patch, on the surface of the seed configuration.

Input preparation for a typical block is presented. The same process can be repeated for another block. For a typical block, input preparation for the J-face is described in Card 3 to Card 8. Description for the K-face is given in Card 9 to Card 14. An example of the cptin input file is presented at the end of this sub-section.

Column	Code	Format	Description
Card 1:			
1-80		1x	Header card.
Card 2:			
1-5	NN	I5	Block number.
6-10	MM	I5	Face number.
11-15	L	I5	Number of design boundary condition patches for the face, this number is equal to the number of sets of Cards 3 to 8 plus the number of sets of Cards 9 to 14.

Card 3:

1-80		1x	Header card.

Card 4:

1-5	KA	I5	The minimum K-index for the patch.
6-10	KB	I5	The maximum K-index for the patch.
11-15	KINC	I5	Increment in the K-index. The number of sets of Cards 5 through 8 = (KB-KA)/KINC + 1 Recommended value = 1

Card 5:

1-80		1x	Header card.

Card 6:

1-5	IA	I5	The starting I-index for the patch.
6-10	IB	I5	The ending I-index for the patch. The number of Card 8 = IB - IA + 1
11-15	K	I5	The K-index.

Card 7

1-80		1x	Header card.

Card 8:

1-5	I	I5	The I-index.
6-15	X	F10.4	x-coordinate.
16-25	CPT	F10.6	Target pressure coefficient.

Card 9:

1-80		1x	Header card.

Card 10:

1-5	JA	I5	The minimum J-index for the patch.
6-10	JB	I5	The maximum J-index for the patch.
11-15	JINC	I5	Increment in the J-index. The number of sets of Cards 11 through 14 = (JB-JA)/JINC + 1 Recommended value = 1

Card 11:

1-80		1x	Header card.

Card 12:

1-5	IA	I5	The starting I-index for the patch.
6-10	IB	I5	The ending I-index for the patch. The number of Card 14 = IB - IA + 1
11-15	J	I5	The J-index.

Card 13:

1-80		1x	Header card.

Card 14:

1-5	I	I5	The I-index.
6-15	X	F10.4	x-coordinate.
16-25	CPT	F10.6	Target pressure coefficient.

Repeat Cards 1 through 14 for the other blocks that contain design patches.

Example of File cptin

```
NN   MM     L
 2    3     1
KA   KB  KINC
 2   10     1
IA   IB     K
30   78     2
 I    X         CPT
30    0.0000  0.844700
31    0.5298  0.658000
32    1.5997  0.141600
33    3.0684 -0.293900
34    4.8621 -0.591100
35    6.9388 -0.734800
36    9.2704 -0.816200
37   11.8386 -0.857200
38   14.6295 -0.871200
39   17.6296 -0.876800
40   20.8319 -0.879500
41   24.2259 -0.878600
42   27.8044 -0.874600
43   31.5622 -0.868500
44   35.4929 -0.861000
45   39.5913 -0.852300
46   43.8533 -0.842000
47   48.2734 -0.827600
48   52.8486 -0.800000
49   57.5757 -0.743900
50   62.4493 -0.649500
51   67.4685 -0.524300
52   72.6291 -0.393100
53   77.9277 -0.288700
54   83.3635 -0.228700
55   88.9322 -0.205600
56   94.6327 -0.201700
57  100.4618 -0.201900
58  106.4187 -0.199200
59  112.5000 -0.191500
60  118.7058 -0.179700
```

```
61   125.0319 -0.165500
62   131.4793 -0.150400
63   138.0438 -0.135500
64   144.7255 -0.121100
65   151.5233 -0.107000
66   158.4339 -0.093000
67   165.4584 -0.078900
68   172.5937 -0.064500
69   179.8385 -0.049700
70   187.1927 -0.034300
71   194.6544 -0.017800
72   202.2233  0.000300
73   209.8971  0.020800
74   217.6746  0.044600
75   225.5547  0.072000
76   233.5360  0.105700
77   241.6192  0.139800
78   249.8000  0.218600
IA   IB     K
30   78     3
 I    X        CPT
30     0.0000  0.845300
31     0.5298  0.658700
32     1.5997  0.142200
33     3.0684 -0.293400
34     4.8621 -0.590900
        .
        .
        .
74   217.6746  0.044300
75   225.5547  0.071700
76   233.5360  0.105500
77   241.6192  0.139600
78   249.8000  0.218500
        .
        .
        .
        .
        .
IA   IB     K
30   78    10
```

I	X	CPT
30	0.0000	0.844700
31	0.5298	0.658000
32	1.5997	0.141600
33	3.0684	-0.293900
34	4.8621	-0.591100
	.	
	.	
	.	
74	217.6746	0.044600
75	225.5547	0.072000
76	233.5360	0.105700
77	241.6192	0.139800
78	249.8000	0.218600

3.3 Preparation of the Input File gmbdsin

This file is required by the multiblock Euler design code and specifies the flow conditions and miscellaneous control parameters. Two examples of input files are presented at the end of this subsection for easy reference. The first file "gmbdsin-1" is for the analysis of the baseline configuration (pre-design analysis). The second file "gmbdsin-2" is for nacelle design starting from the pre-design solution.

For design updates, the installed nacelle is described locally by a cylindrical coordinate system (x, r, θ) where the nacelle centerline is the x-axis, r and θ are the radial and circumferential coordinates respectively.

Column	Code	Format	Description
Card 1:			
1-80	TITLE	10A8	Title to describe the run output data. The title should include sufficient information for the user to identify his run at a later time (e.g., the configuration identification, the flight conditions, M_∞, α, etc.).
Card 2:			
1-80		1x	Header card. Header cards are essentially dummy cards provided for identification of the data in the following cards. Typically the fields in the header cards should include the generic names of the variables to be included in the field in the following card (s). The header cards are read in with format (1x), which means that they may contain any legal characters including blanks.

Card 3:

1-10	FCYC	F10.0	Number of multigrid cycles. Typical value = 500.0 for analysis = 302.0 for design if it is restarted from an analysis run. This allows for six design cycles with FCYD2 = 50.0 (FCYC = FCYD2*6 + FCYD1). FCYD1 and FCYD2 are defined in the same input card. = 800.0 for design if it is started from scratch.
11-20	FCYD1	F10.0	Number of initial time steps before beginning design. FCYD1 should be greater than FCYC for analysis run. Recommended value = 2.0 if the design is restarted from an analysis run. Recommended value = 500.0 if the design is started from scratch.

The restart file (see Ref. 5) for the baseline configuration analysis should be saved for subsequent design runs at various different target C_p.

21-30	FCYD2	F10.0	Number of time steps per design cycle. Recommended value = 50.0

The next two variables on this card are for local design, see sub-section 3.2 of Volume I.

31-40	FCYD3	F10.0	Number of initial time steps within each design cycle in which Runge-Kutta time-stepping is applied to every block (complete flow field update) Recommended value = FCYD2

41-50	FCYD4	F10.0	After FCYD3 time steps within a design cycle, FCYD4 is the number of time-stepping between two complete flow field updates. For example, FCYD4 = 2.0 implies alternating between local flow field update (applied only to blocks with design surface) and complete flow field update. Recommended value = 1.0
51-60	GMESH	F10.0	Multigrid levels for each block. Recommended value = 2.0
61-70	FNFIC	F10.0	Nacelle surface fictitious point indicator = 0.0 there are fictitious points on the nacelle surface = 1.0 there is no fictitious point on the nacelle surface

Card 4:

1-80		1x	Header card

Card 5:

1-10	CFAC	F10.0	Nose region design accelerator (exponent B in Eq. (7) in Vol. I), 0.0 < CFAC < 0.5 Recommended value = 0.20
11-20	DCPMX	F10.0	Magnitude of maximum change in pressure coefficient allowed for each design cycle. 0.0 < DCPMX < 0.5 Recommended value = 0.20

21-30	YPCHK	F10.0	Airfoil slope limiter, the magnitude of the computed airfoil slope is not allowed to go over this limit. This is to circumvent infinite slope near the leading edge. Recommended value = 5.0
31-40	FMONO	F10.0	Option parameter to reshape the leading edge to keep a monotonic nose = 0.0 no reshape = 1.0 has reshape Recommended value = 0.0
41-50	FSSSW	F10.0	Controlling parameter to choose a switching Mach number from subsonic design algorithm [Eq. (7) in vol. I] to supersonic design algorithm [Eq. (11) in Vol. I]. = 0.0 switch to supersonic algorithm at M = 1.0 = 1.0 switch to supersonic algorithm at M = 1.05 = 2.0 switch to supersonic algorithm at M = 1.15 Recommended value = 1.0
51-60	FINICY	F10.0	Number of initial design cycles in which the geometry closure procedure described in Appendix A in volume I is used. Recommended value = 0.0
61-70	CUTOF	F10.0	This number corresponds to the upper limiter S_u described in Appendix A in volume I. This variable will not be used if FINICY < 1.0. Recommended value = 5.0

Card 6:

1-80		1x	Header card

Card 7:

1-10	FMSFX	F10.0	Option parameter to select transpiration velocity or transpiration mass flux. = 0.0 use transpiration velocity = 1.0 use transpiration mass flux Recommended value = 0.0
11-20	QNLIM	F10.0	Cut-off magnitude for transpiration velocity (when FMSFX=0.0) or transpiration mass flux (when FMSFX=1.0). Recommended value = 0.10
21-30	SSFIN	F10.0	The coefficient C in Equation (11) in Vol. I for design algorithm in the supersonic region. Recommended value = 0.16
31-40	XSMO3	F10.0	Number of chordwise smoothings for the surface transpiration quantities after they are evaluated from flux balance. Recommended value = 5.0
41-50	FTRB	F10.0	This number corresponds to the lower limiter S_l described in Appendix A in volume I. This variable will not be used if FINICY < 1.0 in Card 5. Recommended value = 0.2
51-60	FNNAX	F10.0	Block number of any one of the blocks that have a degenerated face on the nacelle center line. When FNNAX is non-positive then the code assumes

			that block one is adjacent to the nacelle center line.
61-70	CNSTN	F10.0	Option to repeatedly apply the geometry closure procedure described in Appendix A in Volume I, CNSTN number of times. This variable will not be used if FINICY < 1.0 in Card 5. Recommended value = 1.0

Card 8:

1-80		1x	Header card

Card 9:

1-10	RELXC	F10.0	Relaxation factor. Equals one half of the value of the adjustable constant ω in Equations (A3, A4) in Appendix A in Volume I. This variable will not be used if CNSTN < 1.0 in Card 7 and FINICY < 1.0 in Card 5. Recommended value = 0.75
11-20	FFCTE	F10.0	Number of points that will retain the starting local curvature. Start from the point before the trailing edge on the outer surface of the fan cowl. Count towards the leading edge. This is to prevent the convergence problem of the design iterations when the computed surface pressure is not smooth near the trailing edge. Recommended value = 0.0
21-30	FFCLE	F10.0	Number of points that will retain the starting

			local curvature. Start from the point after the leading edge on the outer surface of the fan cowl. Count towards the trailing edge. This is to prevent the convergence problem of the design iterations when the computed surface pressure is not smooth near the leading edge. Recommended value = 0.0
31-40	ALLP	F10.0	Option to use six or seven points in the least-squares fitting for data smoothing using Equation (14) or (15) in Vol. I. = 0.0 six points are used = 1.0 seven points are used Recommended value = 1.0
41-50	FNUPD	F10.0	Option in smoothing. Choice to use either the most current value as soon as it becomes available, or to use the old value and update all points simultaneously after finishing a sweep (see Appendix B in Vol. I). = 0.0 use the current value = 1.0 use the old value Recommended value = 1.0
51-60	SMPSM	F10.0	Option to use either the least-squares smoothing or smoothing by averaging (see Appendix B in Vol. I). = 0.0 use least-squares smoothing = 1.0 smoothing by averaging Recommended value = 1.0

Card 10:

1-80		1x	Header card

Card 11:

1-10	FSMOO	F10.0	Number of least-squares smoothings of r distribution in the chordwise direction for the updated nacelle. Recommended value = 3.0
11-20	TSMO1	F10.0	Number of smoothings for the Δr distribution in the circumferential direction for the updated nacelle. The smoothing is done block-by-block. Recommended value = 0.0
21-30	XSMO1	F10.0	Number of smoothings for the Δr distribution in the chordwise direction for the updated nacelle before the global circumferential smoothing is applied. The smoothing is done in a block-by-block manner. Recommended value = 3.0
31-40	SMPAS	F10.0	Number of global smoothing passes. Each pass consists of TSMO2 circumferential smoothings and XSMO2 chordwise smoothings of Δr. Recommended value = 3.0
41-50	TSMO2	F10.0	Number of circumferential smoothings in Δr within each pass of global smoothing. Recommended value = 1.0
51-60	XSMO2	F10.0	Number of chordwise smoothings in Δr within each pass of global smoothing.

			Recommended value = 1.0

Card 12:

1-80		1x	Header card

Card 13:

1-10	CFLF	F10.0	CFL number for the fine (original) mesh. Negative CFL implies the use of local time-stepping. Positive value implies global time-stepping (see also variable CFLC in Card 21). Recommended value = -6.0
11-20	VISO	F10.0	Dissipation coefficient for coarse grid. Recommended value = 1.0
21-30	QFIL	F10.0	Filter evaluation flag = 1.0 evaluate two times for every time step if SN53 = 0.0 in column 61-70 in this card. evaluate three times for every time step if SN53 = 1.0 in this card. = 0.0 evaluate once for every time step. Recommended value = 1.0
31-40	VIS2	F10.0	Coefficient for second order dissipation. Recommended value = 4.0
41-50	VIS4	F10.0	Coefficient for fourth order dissipation. Recommended value = 2.0

51-60	HMF	F10.0	Coefficient for enthalpy damping for the fine mesh. Recommended value = 0.2 if total energy level is uniform. Recommended value = 0.0 for flow field with different total energy levels.
61-70	SN53	F10.0	Option to evaluate dissipation terms different number of times in Runge-Kutta integration. = 0.0 use 5-2 scheme, five-stage Runge-Kutta with two evaluations of dissipation terms. = 1.0 use 5-3 scheme, five-stage Runge-Kutta with three evaluations of dissipation terms. Recommended value = 1.0 Some minor code changes are required to activate the six-stage Runge-Kutta option.
71-80	SNSFIL	F10.0	Option to use different sensor terms in the 2nd order dissipation. = 0.0 use pressure sensor. = 1.0 use entropy sensor. Recommended value = 0.0 for transonic flow calculation. Recommended value = 1.0 for low speed flow calculation.

Card 14:

1-80		1x	Header card

Card 15:

C1 to C6 in this card are coefficients for multistage Runge-Kutta integration steps. The following values are recommended for the five stage scheme.

1-10	C1	F10.0	= 0.25
11-20	C2		= 0.166667
21-30	C3		= 0.375
31-40	C4		= 0.5
41-50	C5		= 1.0
51-60	C6		= 0.0

Card 16:

1-80		1x	Header card

Card 17:

1-10	SMOPI	F10.0	Implicit smoothing parameter in the I-direction. Recommended value = 2.0
11-20	SMOPJ	F10.0	Implicit smoothing parameter in the J-direction. Recommended value = 2.0
21-30	SMOPK	F10.0	Implicit smoothing parameter in the K-direction. Recommended value = 2.0
31-40	START	F10.0	Euler analysis or design start option (see also variable FIRUN in Card 23). = 0.0 start from scratch. = 1.0 continuation analysis run, or a design run starting from an analysis solution, or a design run as a continuation from an previous design run.

Card 18:

1-80		1x	Header card

Card 19:

1-10	FIBCN	F10.0	Solid surface boundary condition whenever a patch of a constant-I face is a solid surface. = 1.0 use normal momentum relation to compute the solid surface pressure. = 0.0 use cell center value to approximate the solid surface pressure. Recommended value = 0.0 for non-smooth grid.
11-20	FJBCN	F10.0	Solid surface boundary condition whenever a patch of a constant-J face is a solid surface. = 1.0 use normal momentum relation to compute the solid surface pressure. = 0.0 use cell center value to approximate the solid surface pressure. Recommended value = 0.0 for non-smooth grid.
21-30	FKBCN	F10.0	Solid surface boundary condition whenever a patch of a constant-K face is a solid surface. = 1.0 use normal momentum relation to compute the solid surface pressure. = 0.0 use cell center value to approximate the solid surface pressure. Recommended value = 0.0 for non-smooth grid.
31-40	FICEN	F10.0	Method of differencing along a JK face on solid surface for the pressure and the three

			components of the momentum. = 1.0 central difference everywhere along both directions. = 0.0 central difference everywhere along both directions but one-sided differences in I-direction normal to an edge of the face. Recommended value = 1.0
41-50	FJCEN	F10.0	Method of differencing along an IK face on solid surface for the pressure and the three components of the momentum. = 1.0 central difference everywhere along both directions. = 0.0 central difference everywhere along both directions but one-sided differences in J-direction normal to an edge of the face. Recommended value = 1.0
51-60	FKCEN	F10.0	Method of differencing along an IJ face on solid surface for the pressure and the three components of the momentum. = 1.0 central difference everywhere along both directions. = 0.0 central difference everywhere along both directions but one-sided differences in K-direction normal to an edge of the face. Recommended value = 1.0

Card 20:

1-80		1x	Header card

Card 21:

1-10	FITDO	F10.0	Number of Euler integrations in each grid level in a V-cycle multigrid from the finest grid to the coarsest grid. Recommended value = 1.0
11-20	FITUP	F10.0	Number of Euler integrations in each grid level in a V-cycle multigrid from the coarsest grid to the finest grid. Recommended value = 0.0. This means interpolation only.
21-30	CFLC	F10.0	CFL number for the coarse grids. Negative value implies the use of local time-stepping. Positive number implies global time-stepping (see also variable CFLF in Card 13). Recommended value = -6.0
31-40	HMC	F10.0	Enthalpy damping coefficient for the coarse grid. Recommended value = 0.0

Card 22:

1-80		1x	Header card

Card 23:

1-10	FMACH	F10.0	Freestream Mach number.
11-20	ALPHA	F10.0	Angle of attack (degrees).

21-30	ALYAW	F10.0	Angle of yaw (degrees).
31-40	FIRUN	F10.0	Option to initialize the Euler calculation with a computed solution obtained at a different freestream condition. = 0.0 start from scratch or restart from a run with the same freestream condition. = 1.0 start from a run with a different freestream condition. See also variable "START" in Card 17.
41-50	RMOLD	F10.0	Freestream Mach number for previous run.
51-60	ALOLD	F10.0	Angle of attack (degrees) for previous run.
61-70	AYOLD	F10.0	Angle of yaw (degrees) for previous run.
71-80	CD0	F10.0	Estimation of the viscous drag coefficient. Default value = 0.0

Card 24:

1-80		1x	Header card

Card 25:

This card defines the reference length and reference area in the Euler calculations. The units should be consistent with the geometry data for the configuration. For example, if the geometry data is given in meters, then the reference length will be in meters, and the reference area will be in square meters.

1-10	AREF	F10.0	Wing reference area.

11-20	XREF	F10.0	Longitudinal location of the moment reference point.
21-30	YREF	F10.0	Spanwise location of the moment reference point.
31-40	ZREF	F10.0	Vertical location of the moment reference point.
41-50	CREF	F10.0	Pitching moment reference length.
51-60	SREF	F10.0	Yawing and rolling moments' reference length.

Card 26:

1-80		1x	Header card

Card 27:

1-10	FMIN	F10.0	Option flag for the fan inlet face boundary condition. This option is irrelevant for the analysis of a flow through nacelle. = 1.0 normal velocity boundary condition at fan inlet face = 2.0 pressure boundary condition at fan inlet face = 3.0 mass flux boundary condition at fan inlet face
11-20	QIN	F10.0	Normal flow speed at the fan inlet face normalized by the freestream flow speed (FMIN=1.0), or pressure at the fan inlet face normalized by the freestream flow speed (FMIN=2.0), or mass flux at the fan inlet face normalized by the

			freestream flow speed (FMIN=3.0).
21-30	FEXT	F10.0	Total number of different exhaust boundary conditions. FEXT is limited to two. Card 28 and 29 must not be present if FEXT is less than one. When FEXT equals one or two, then Card 28 and 29 are required input and the number of data sets in Card 29 equals FEXT. FEXT < 1.0 implies a flow through nacelle.

Card 28:

1-80		1x	Header card

Card 29:

1-10	FMOUT	F10.0	Option flag for fan exhaust boundary condition for each set. = 1.0 freestream exhaust = 2.0 freestream total temperature with a specified total pressure PSTG0 = 3.0 specify both total temperature TSTG0 and total pressure PSTG0
11-20	PSTG0	F10.0	Total pressure (normalized by freestream static pressure) at the nacelle exhaust plane. Value used only if FMOUT = 2.0 or 3.0
21-30	TSTG0	F10.0	Total temperature (normalized by freestream static temperature) at the nacelle exhaust plane. Value used only if FMOUT = 3.0
31-40	FBEHT1	F10.0	Block number for the blocks that contain the

41-50	FBEHT2		nacelle exhaust plane.
51-60	FBEHT3		

Card 30:

1-80		1x	Header card

Card 31:

1-10	FMDSK	F10.0	Propeller disk option. = 0.0 propeller disk-off, Card 32 to Card 37 are not required. = 1.0 propeller disk-on (4(a) in Appendix C, Ref. 3) = 2.0 propeller disk-on (4(b) in Appendix C, Ref. 3)
11-20	FIRDSK	F10.0	Number of radial points at which propeller loading is described for each θ station. This number should equal to the number of numerical data cards in each data set in Card 37.
21-30	FITDSK	F10.0	Number of θ stations at which propeller loading is described. This number should be no less than three and should be equal to the number of data sets in Card 35.

Card 32:

1-80		1x	Header card

Card 33:

1-10	XDSK0	F10.0	The x-coordinate of the propeller disk's center.
11-20	YDSK0	F10.0	The y-coordinate of the propeller disk's center.
21-30	ZDSK0	F10.0	The z-coordinate of the propeller disk's center.
31-40	RDSK	F10.0	The radius of the disk.

Card 34:

1-80		1x	Header card

Card 35:

1-10	TDS	F10.0	θ station in degrees measured counter-clockwise (looking aft) from a horizontal axis originating from the center of the propeller disk and pointing to the right.

Card 36:

1-80		1x	Header card

Card 37:

1-10	RDS	F10.0	Dimensional radial distance, measured from propeller disk center, at which loading is defined.
11-20	PSTG1	F10.0	Total pressure input (normalized by the freestream static pressure) immediately downstream of propeller disk (FMDSK=1.0), or thrust coefficient of the propeller disk (FMDSK=2.0).

21-30	TSTG1	F10.0	Total temperature input (normalized by the freestream static temperature) immediately downstream of propeller disk (FMDSK=1.0), or normal force coefficient of the propeller disk (FMDSK=2.0).
31-40	ALP1	F10.0	Swirl input in degree immediately downstream of propeller disk, looking aft, clockwise swirl is positive (FMDSK=1.0), or side force coefficient of the propeller disk (FMDSK=2.0).

Flow Analysis Input File

Example 1: gmbdsin-1

```
Pre-design Analysis for NASA Wing/Body/Underwing Nacelle/Pylon
FCYC      FCYD1     FCYD2     FCYD3     FCYD4     GMESH     FNFIC
  500.0    600.0      50.0      50.0     1.0       2.0       0.0
CFAC      DCPMX     YPCHK     FMONO     FSSSW     FINICY    CUTOF
 0.2       0.2       5.0       0.0       1.0       0.0       5.0
FMSFX     QNLIM     SSFIN     XSMO3     FTRB      FNNAX     CNSTN
 0.0       0.10      0.16      5.0       0.2       1.0       1.0
RELXC     FFCTE     FFCLE     ALLP      FNUPD     SMPSM
 0.75      0.0       0.0       1.0       1.0       1.0
FSMOO     TSMO1     XSMO1     SMPAS     TSMO2     XSMO2
 3.0       0.0       3.0       3.0       1.0       1.0
CFLF      VIS0      QFIL      VIS2      VIS4      HMF       SN53      SNSFIL
 -6.0      1.0       1.0       4.00      2.0       .20       1.0       0.0
C1        C2        C3        C4        C5        C6
 .2500     .166667   .375      0.5000    1.0000    0.0000
SMOPI     SMOPJ     SMOPK     START
 2.00      2.00      2.00      0.0
FIBCN     FJBCN     FKBCN     FICEN     FJCEN     FKCEN
  0.0       0.0       0.0      1.0       1.0       1.0
FITD0     FITUP     CFLC      HMC
 1.0       0.0       -6.0      0.0
FMACH     ALPHA     ALYAW     FIRUN     RMOLD     ALOLD     AYOLD     CD0
 0.77      0.500     0.0       0.0       0.7700    0.0000    0.0       0.0
AREF      XREF      YREF      ZREF      CREF      SREF
 294.00    41.8      0.0       0.0       8.176     80.0
FMIN      QIN       FEXT
 1.0       0.60      0.0
FMDSK     FIRDSK    FITDSK
 0.0
```

Flow Analysis Input File

Example 2: gmbdsin-2

```
Installed Nacelle Design for NASA Wing/Body/Underwing Nacelle/Pylon
FCYC      FCYD1     FCYD2     FCYD3     FCYD4     GMESH     FNFIC
  302.0     2.0      50.0      50.0     1.0       2.0       0.0
CFAC      DCPMX     YPCHK     FMONO     FSSSW     FINICY    CUTOF
 0.2       0.2       5.0       0.0       1.0       0.0       5.0
FMSFX     QNLIM     SSFIN     XSMO3     FTRB      FNNAX     CNSTN
 0.0       0.10      0.16      5.0       0.2       1.0       1.0
RELXC     FFCTE     FFCLE     ALLP      FNUPD     SMPSM
 0.75      0.0       0.0       1.0       1.0       1.0
FSMOO     TSMO1     XSMO1     SMPAS     TSMO2     XSMO2
 3.0       0.0       3.0       3.0       1.0       1.0
CFLF      VIS0      QFIL      VIS2      VIS4      HMF       SN53      SNSFIL
 -6.0      1.0       1.0       4.00      2.0       .20       1.0       0.0
C1        C2        C3        C4        C5        C6
 .2500     .166667   .375      0.5000    1.0000    0.0000
SMOPI     SMOPJ     SMOPK     START
 2.00      2.00      2.00     1.0
FIBCN     FJBCN     FKBCN     FICEN     FJCEN     FKCEN
  0.0       0.0       0.0      1.0       1.0       1.0
FITD0     FITUP     CFLC      HMC
 1.0       0.0      -6.0       0.0
FMACH     ALPHA     ALYAW     FIRUN     RMOLD     ALOLD     AYOLD     CD0
 0.77      0.500     0.0       0.0       0.7700    0.0000    0.0       0.0
AREF      XREF      YREF      ZREF      CREF      SREF
 294.00    41.8      0.0       0.0       8.176     80.0
FMIN      QIN       FEXT
 1.0       0.60      0.0
FMDSK     FIRDSK    FITDSK
 0.0
```

4.0 Program Execution

A Unix script file, "jgmbeds" is listed at the end of this section. This script file is used to execute the GMBEDS code on the NAS Cray Y-MP (reynolds) in the UNICOS environment. To submit the job to NQS, use the command line:

reynolds.me% qsub jgmbeds

NQS provides computing resources for several different job queues based on the machine resources requested for each job (Ref. 6). A job requiring less machine resources would generally have quicker turn around time. It is, therefore, beneficial to make a good estimate of machine resource utilization. A typical test case using one million grid points would use up to 16 MW of central memory and under 24 MW of SSD space. Approximately 3 hours and 40 minutes of (single) CPU time are required to run the 500 multigrid steps typically required for a pre-design analysis to converge. The example input file gmbdsin-2 on page 36 requested six design cycles. Each cycle takes 50 multigrid steps. Such a run would take approximately 2 hours and 20 minutes. The currently CPU time limit in NQS is four hours (14,400 seconds).

As discussed in Reference 5, for a general flow field simulation, it would be very useful to adjust the memory requirement to each grid in the GMBEDS analysis or design. Following the same approach described in Reference 5, a pre-processor (spds.f on pg. 40) of the GMBEDS code is used for managing the central memory requirement in the Euler calculations. The procedure to run this pre-processor is integrated into the example script file.

The permanent file disk space is generally very limited for a typical NAS account while the scratch file disk space is usually adequate for a run. The example script file shows that only the program source files are fetched from the permanent file disk. All other input files are fetched from the scratch file disk. The output from GMBEDS analysis or design are temporarily stored in the SSD space. Details are given in the script file.

The command line

QSUB -lr 'FASTDIR,24Mw'

on page 40 requested that 24 Mw of SSD space be allocated and another command line on the same page

cd $FASTDIR

directs all output generated from program execution to the SSD space. This is the working space for program execution. This method of program execution has an advantage over the use of the scratch disk space as the working space. Program execution on the scratch disk can lead to the problem of disk overflow from any unexpected large program output. For example, a core dump from a user error. In the situation of multiple jobs running on the same user disk, one bad job can fill-up the disk space and kill all other jobs. The use of SSD prevents this kind of inadvertent kill. However, at the end of the run, the SSD files that contain essential information, such as the restart file fort.10, and design surface q_n file fort.17 (see section 5 on output analysis) must be copied back to the user disk. At least 15,000 blocks must be available in scratch space for a typical one million grid point run.

There are two modes to run the GMBEDS code; the analysis mode and the design mode. Within each mode, there are two ways to run the code. One is a start-up run. The other is a continuation run or restart from a previous solution. The design patch identification file fort.9 (pg. 42) and blocked target C_p file fort.12 (pg. 42) are required input when executing the code in design mode.

The example script file was prepared for a design mode started from a previous analysis run. To modify this script file for a design run starting from scratch. The command line to move the flow field solution file must be de-activated (see the line containing 'fort.10' on pg. 42). The script file so modified shall referred to as jgmbeds-2. In addition, the variable START in Card 9 of the flow analysis/design input file "gmbdsin" must be set to 0.0.

For a design run continued from another unconverged design run, two changes to the basic script file will suffice. The restart file of the previous design run should be copied to fort.10 and the design surface q_n file (fort.17 output from the previous design run) should be copied to fort.12.

The jgmbeds-2 script can be modified for a start-up analysis run by changing Card 3 in the "gmbdsin" file. Simply set FCYD1 to be greater than FCYC. The fort.9 and fort.12 are no longer required. The change from this script to an analysis run restart from another analysis run is self-evident.

At the end of Euler analysis or design run, fort.10 will be over-written by a new flow field solution. Using the same I/O unit for both input and output of the restart file implies that only one copy of the restart file is written on the scratch disk or SSD space. This allows for a much better disk or SSD space utilization. Discussion on this flow field solution file can be found in Reference 5.

Example of Unit Script

File: jgmbeds

```
# QSUB -eo
# QSUB -o /scr8/hchen/wbnsm/jgmbeds.log          # destination logfile
# QSUB -lM 16Mw                                  # memory requested
# QSUB -lT 14400                                 # time limit for job
# QSUB -lr 'FASTDIR,24Mw'                        # allocate 24 Mw SSD
#
# This is an example UNICOS script file to compile and execute the
# GMBE code on NAS Cray Y-MP
#
# In this example
# FORTRAN source files are fetched from permanent file directory
# /u/re/hchen/soce
#
# The grid file, the block-to-block relation and the block boundary
# condition files are fetched from scratch file directory
# /scr8/hchen/in
#
# Flow analysis input file is fetched from scratch file directory
# /scr8/hchen/wbnsm
# this is also the directory where this script file is stored
#
# Files created during program execution are stored in the
# SSD space
# At the end of the program execution, temporary files in the
# SSD space will be deleted
#
cd $FASTDIR                                    # SSD for program execution
#
echo "compile of /u/re/hchen/soce/spds.f"
#
# Compilation of a pre-processing code spds.f
# Grid information are read in and processed by this code
# to specify the memory requirement for general multiblock
# Euler (GMBE) calculation
```

```
#
# Link the grid file to fort.1
#
ln /scr8/hchen/in/gfthc.nw fort.1
#
# Copy the block-to-block relation file to fort.3
#
cp /scr8/hchen/in/relo.dat fort.3
echo "execution of sprm"
#
# Executing the pre-processing code using the flow analysis
# input file
#
parex < /scr8/hchen/wbnsm/gmbdsin-2 > parout
#
# The pre-processing code creates an update file in fort.7
# which will be used to update the program library of the
# GMBEDS code
#
mv fort.7 mdbq01
echo "update from source for update"
#
# Create GMBEDS program library from source for update
#
update -i /u/re/hchen/soce/gmben -n npl01 -f
echo "update using mod file"
#
# Update the GMBEDS program library using fort.7 (mdbq01)
# created by the pre-processing code for memory management
#
update -p npl01 -i mdbq01 -c gmbeu -f
echo "compile of gmbeu"
#
# compile the GMBE FORTRAN source file gmbeu.f
#
cf77 -Wf"-l gmbeu.l -e mpqrsxz" -c gmben.f
cf77 -o gmbex gmben.o
```

```
#
cf77 -o parex /u/re/hchen/soce/spds.f
#
# copy the block boundary condition file to fort.2
#
cp /scr8/hchen/in/bco.dat fort.2
#
# copy the design patch identification file to fort.9
#
cp /scr8/hchen/in/desin fort.9
#
# copy the blocked target cp file to fort.12
#
cp /scr8/hchen/wbnsm/cptin fort.12
#
# If this is a restart run then copy the restart file to fort.10
#
cp /scr8/hchen/wbnsm/fnbq01 fort.10
#
echo "execution of gmbex"
#
# Execution of GMBEDS code using the flow analysis input file
#
gmbex < /scr8/hchen/wbnsm/gmbdsin-2 > /scr8/hchen/wbnsm/obq01
echo "save files"
#
# Move some output files back
#
mv fort.3 /scr8/hchen/wbnsm/cvbq01
mv fort.50 /scr8/hchen/wbnsm/cpbq01
mv fort.10 /scr8/hchen/wbnsm/fnbq01
mv fort.15 /scr8/hchen/wbnsm/cpqn01
mv fort.17 /scr8/hchen/wbnsm/cpty01i
mv fort.90 /scr8/hchen/wbnsm/grd01
#
# End of job
```

5.0 Output Analysis

A successive flow analysis or design will generate several output files. Many of these files are inherent to the Euler solver (Ref. 5). The primary output is a flow field solution file that is stored in fort.10 in binary format. The surface pressure file and the convergence history file are stored as fort.50 and fort.3 respectively. Discussions on these two ascii files can also be found in Reference 5.

There is also a log file containing diagnostic and timing/resource utilization information associated with each GMBEDS run. When design is completed, a new computational grid is generated (fort.90) based on the final designed geometry. The new nacelle surface geometry may be extracted from this volume grid.

Two additional ascii files pertinent to design runs, the design history surface C_p and q_n file stored in fort.15 and the final designed surface q_n and target C_p file stored in fort.17, are described below.

5.1 Design History Surface C_p and q_n File

The surface C_p and q_n on each grid point on the design surfaces is stored in this file in a block-by-block manner for each design cycle. This allows a user to examine the evolution of design surface C_p and q_n during design iterations. The radius of the nacelle outer fan cowl, normalized by the fan cowl chord length, are also stored for the initial geometry (YU0) and designed geometry (YU). The un-normalized designed radius is stored as YUT.

5.2 Final Designed Surface q_n and target C_p File

At the end of a design run, the design surface transpiration velocity q_n together with the corresponding target C_p (CPT) are stored in this file in a block-by-block manner. This file and the restart file (Ref. 5) are required to continue the design iteration from a previous design run. The normalized radius for the final designed nacelle outer fan cowl is also stored (YU). The data structure of this file is the same as that of the target C_p input file discussed in sub-section 3.2. There is a difference in content in that the Cards 8 and 16 of the file are expanded to include the q_n and YU.

6.0 Glossary

Input Files

File No.	File Name	File Type	Description
fort.1	gfthc	Binary	Computational grid file for the baseline configuration.
fort.2	bco.dat	Ascii	Block boundary condition file.
fort.3	relo.dat	Ascii	Block relationship file.
fort.9	desin	Ascii	Design patches specification.
fort.10	fnbq01	Binary	Restart file.
fort.12	cptin	Ascii	Target pressure specification.

Intermediate Files

File No.	File Name	File Type	Description
fort.7	mdbq01	Ascii	File to update the parameter statements in the GMBEDS code. This allows GMBEDS to allocate the right amount of memory for design and analysis according to the baseline computational grid file fort.1.
fort.4 fort.8 fort.16 fort.18 fort.51 to fort.89		Ascii	Scratch files.

Output Files

File No.	File Name	File Type	Description
fort.3	cvbq01	Ascii	Convergence history file (over writes input fort.3, see previous page).
fort.10	fnbq01	Binary	Restart file (over writes input fort.10, see previous page).
fort.15	cpqn01	Ascii	Design history surface C_p and q_n file.
fort.17	cpty01i	Ascii	Final design q_n and target C_p file.
fort.50	cpbq01	Ascii	Surface C_p file.
fort.90	grd01	Binary	New computational grid file based on the final designed geometry.

7.0 Acknowledgement

Mainframe computing has been provided by the Numerical Aerodynamic Simulation Complex at NASA Ames Research Center.

8.0 References

1. Chen, H. C., "An Installed Nacelle Design Code Using Multiblock Euler Solver, Volume I: Theory Document," NASA CR-189652, Volume I, 1992.
2. Smith, L. A. and Campbell, R. L., "A Method for the Design of Transonic Flexible Wings," NASA Technical Papper 3045, December, 1990.
3. Chen, H. C., Su T. Y., and Kao, T. J., "A General Multiblock Euler Code for Propulsion Integration, Volume I: Theory Document," NASA CR-187484, Volume I, May 1991.
4. Su, T. Y., Appleby, R. A., and Chen, H. C., "A General Multiblock Euler Code for Propulsion Integration, Volume II: User Guide for BCON, Pre-Processor for Grid Generation and GMBE, " NASA CR-187484, Volume II, May 1991.
5. Chen, H. C., "A General Multiblock Euler Code for Propulsion Integration, Volume III: User Guide for the Euler Code," NASA CR-187484, Volume III, May 1991.
6. NAS Systems Division, "NAS User Guide, Version 5.1," NASA Ames Research Center, October 1990.

Appendices

Appendix A

Description of Input File relo.dat

This file specifies the block-to-block relationship on the six faces of each block. It allows for proper data communication between neighboring blocks during multiblock Euler calculation. Within a block, the local indexing coordinates I, J, and K follow the right-hand rule. The flow solver requires a communicating layer of ghost cells around each block. These ghost cells are not generated by the user. There are automatically generated by the flow solver. In this scheme, faces one and two are constant-I faces and correspond to I = IMINB = 2 and I = IMAXB respectively. Faces three and four are constant-J faces and correspond to J = JMINB = 2 and J = JMAXB respectively. Faces five and six are constant-K faces and correspond to K = KMINB = 2 and K = KMAXB respectively.

The multiblock Euler design code requires that the local I-index be consistent. An I-face is always connected to another I-face and the I-direction is maintained between neighboring blocks. This allows great simplification in storing the face information for data communication.

Input preparation for a typical block is presented. The same process can be repeated for the other blocks. For a typical block, input preparation for the I-faces is described in Card 3 to Card 10. Similar description is given in Card 11 to Card 18 for the J-faces and in Card 19 to Card 26 for the K-faces.

The original write type option NWTP for constant-I faces, Card 6 for face-1 and Card 10 for face-2, had to be set to unity for the GMBE code (Ref. 3). The current GMBEDS code can accept an additional option of NWTP = 3 for these two faces. This new option is explained in Card 6.

For constant-J and -K faces, option NWTP = 5 was unavailable in the GMBE code (Refs. 4, 5). This new option allows for reflecting boundary condition at a vertical plane. In GMBE a vertical plane is treated as solid wall. Consequently, for an axi-symmetric nacelle, the solution is slightly off from its axi-symmetric value on the vertical plane. The new option NWTP = 5 (Cards 14, 18, 22, and 26) ensures the axi-symmetry of such a flow.

Take Card 14 as an example, when NWTP = 5, in the same card, the record number from neighboring face, NRB must take the same value as, the face record number, NRA. This allows two layers of data to be reflected along the face. In addition, the NTYPE option (Card 14, in file "bco.dat" Appendix B) must be set to unity for the corresponding faces. This allows GMBEDS code to impose an interblock boundary condition on the face using the reflected data. An example input file, which allows for the reflection boundary condition on faces five and six of each block, is presented at the end of this appendix.

Column	**Code**	**Format**	**Explanation**
Card 1:			
1-80		1x	Header card.
Card 2:			
1-10	NBLK	Free	Block number.
Card 3:			
1-80		1x	Header card.
Card 4:			
1-10	NFAC	Free	Face number. = 1
11-20	NREC	Free	Number of records for face-1.

Card 5:

1-80		1x	Header card.

Card 6: Repeat this card NREC (see Card 4) times.

1-10	NRA	Free	Record number for the face.
11-20	NRB	Free	Record number for the face in the neighboring block.
21-30	NWTP	Free	Record write type. = 1 both the J- and K- indices are consistent and retain the same directions with those in the neighboring block adjacent to the face-1. = 3 both the J- and K- indices are consistent but the directions are reversed from those in the neighboring block adjacent to the face-1.
31-40	JMIN	Free	The minimum J-index for the record including the ghost point.
41-50	JMAX	Free	The maximum J-index for the record including the ghost point.
51-60	KMIN	Free	The minimum K-index for the record including the ghost point.
61-70	KMAX	Free	The maximum K-index for the record including the ghost point.

Card 7:

1-80		1x	Header card.

Card 8:

1-10	NFAC	Free	Face number. = 2
11-20	NREC	Free	Number of records for face-2.

Card 9:

1-80		1x	Header card.

Card 10: Repeat this card NREC (see Card 8) times.

1-10	NRA	Free	Record number for the face.
11-20	NRB	Free	Record number for the face in the neighboring block.
21-30	NWTP	Free	Record write type. = 1 Both the J- and K- indices are consistent and retain the same directions with those in the neighboring block adjacent to the face-2. = 3 Both the J- and K- indices are consistent but the directions are reversed from those in the neighboring block adjacent to the face-2.

31-40	JMIN	Free	The minimum J-index for the record including the ghost point.
41-50	JMAX	Free	The maximum J-index for the record including the ghost point.
51-60	KMIN	Free	The minimum K-index for the record including the ghost point.
61-70	KMAX	Free	The maximum K-index for the record including the ghost point.

Card 11:

1-80		1x	Header card.

Card 12:

1-10	NFAC	Free	Face number. = 3
11-20	NREC	Free	Number of records for face-3.

Card 13:

1-80		1x	Header card.

Card 14: Repeat this card NREC (see Card 12) times.

1-10	NRA	Free	Record number for face-3.
11-20	NRB	Free	Record number for the face in the neighboring block.

21-30	NWTP	Free	Record write type. = 1 when the J-index is consistent with that in the neighboring block adjacent to the face. = 2 the neighboring block adjacent to the face retains the same J-index, but the direction is reversed. = 3 the J-index changes to K-index in the adjacent neighboring block, and the direction is reversed. = 4 the J-index changes to K-index in the adjacent neighboring block, but the direction is the same. = 5 the face is a vertical reflection plane. Note: this is a new option. It requires that the corresponding NTYPE be set to unity in bco.dat in Appendix B.
31-40	IMIN	Free	The minimum I-index for the record including the ghost point.
41-50	IMAX	Free	The maximum I-index for the record including the ghost point.
51-60	KMIN	Free	The minimum K-index for the record including the ghost point.
61-70	KMAX	Free	The maximum K-index for the record including the ghost point.

Card 15:

1-80		1x	Header card.

Card 16:

1-10	NFAC	Free	Face number. = 4
11-20	NREC	Free	Number of records for face-4.

Card 17:

1-80		1x	Header card.

Card 18: Repeat this card NREC (see Card 16) times.

1-10	NRA	Free	Record number for the face.
11-20	NRB	Free	Record number for the face in the neighboring block.
21-30	NWTP	Free	Record write type. Please see descriptions in Card 14.
31-40	IMIN	Free	The minimum I-index for the record including the ghost point.
41-50	IMAX	Free	The maximum I-index for the record including the ghost point.
51-60	KMIN	Free	The minimum K-index for the record including the ghost point.
61-70	KMAX	Free	The maximum K-index for the record including the ghost point.

Card 19:

1-80		1x	Header card.

Card 20:

1-10	NFAC	Free	Face number. = 5
11-20	NREC	Free	Number of records for face-5.

Card 21:

1-80		1x	Header card.

Card 22: Repeat this card NREC (see Card 20) times.

1-10	NRA	Free	Record number for the face.
11-20	NRB	Free	Record number for the face in the neighboring block.
21-30	NWTP	Free	Record write type. = 1 when the K-index is consistent with that in the neighboring block adjacent to the face. = 2 the neighboring block adjacent to the face retains the same K-index, but the direction is reversed. = 3 the K-index changes to J-index in the adjacent neighboring block, and the direction is reversed.

			= 4 the K-index changes to J-index in the adjacent neighboring block, but the direction is the same.
			= 5 the face is a vertical reflection plane (see note on pg. 55).
31-40	IMIN	Free	The minimum I-index for the record including the ghost point.
41-50	IMAX	Free	The maximum I-index for the record including the ghost point.
51-60	JMIN	Free	The minimum J-index for the record including the ghost point.
61-70	JMAX	Free	The maximum J-index for the record including the ghost point.

Card 23:

1-80		1x	Header card.

Card 24:

1-10	NFAC	Free	Face number. = 6
11-20	NREC	Free	Number of records for face-6.

Card 25:

1-80		1x	Header card.

Card 26: Repeat this card NREC (see Card 24) times.

1-10	NRA	Free	Record number for the face.
11-20	NRB	Free	Record number for the face in the neighboring block.
21-30	NWTP	Free	Record write type. Please see descriptions in Card 22.
31-40	IMIN	Free	The minimum I-index for the record including the ghost point.
41-50	IMAX	Free	The maximum I-index for the record including the ghost point.
51-60	JMIN	Free	The minimum J-index for the record including the ghost point.
61-70	JMAX	Free	The maximum J-index for the record including the ghost point.

Repeat Cards 1 through 26 for the other blocks.

Example of File relo.dat

```
NBLK
1
NFAC    NREC
1       1
NRA     NRB     NWTP    JMIN    JMAX    KMIN    KMAX
1       0       1       1       15      1       11
NFAC    NREC
2       1
NRA     NRB     NWTP    JMIN    JMAX    KMIN    KMAX
2       0       1       1       15      1       11
NFAC    NREC
3       1
NRA     NRB     NWTP    IMIN    IMAX    KMIN    KMAX
3       0       1       1       99      1       11
NFAC    NREC
4       1
NRA     NRB     NWTP    IMIN    IMAX    KMIN    KMAX
4       11      1       1       31      1       11
5       0       1       29      79      1       11
6       13      1       77      99      1       11
NFAC    NREC
5       1
NRA     NRB     NWTP    IMIN    IMAX    JMIN    JMAX
7       7       5       1       99      1       15
NFAC    NREC
6       1
NRA     NRB     NWTP    IMIN    IMAX    JMIN    JMAX
8       8       5       1       99      1       11
NBLK
2
NFAC    NREC
1       1
NRA     NRB     NWTP    JMIN    JMAX    KMIN    KMAX
9       0       1       1       27      1       11
NFAC    NREC
2       1
NRA     NRB     NWTP    JMIN    JMAX    KMIN    KMAX
10      0       1       1       27      1       11
```

NFAC	NREC					
3	3					
NRA	NRB	NWTP	IMIN	IMAX	KMIN	KMAX
11	4	1	1	31	1	11
12	0	1	29	79	1	11
13	6	1	77	99	1	11
NFAC	NREC					
4	1					
NRA	NRB	NWTP	IMIN	IMAX	KMIN	KMAX
14	0	1	1	99	1	11
NFAC	NREC					
5	1					
NRA	NRB	NWTP	IMIN	IMAX	JMIN	JMAX
15	15	5	1	99	1	27
NFAC	NREC					
6	1					
NRA	NRB	NWTP	IMIN	IMAX	JMIN	JMAX
16	16	1	1	99	1	27

Appendix B

Description of Input File bco.dat

This file specifies the boundary condition on the six faces of each block. It allows for the imposition of different boundary conditions on sub-faces. Within a block, the faces and the local indexing coordinates I, J, and K follow the right-hand rule. Faces one and two are constant-I faces and correspond to I = IMINB = 2 and I = IMAXB respectively. Faces three and four are constant-J faces and correspond to J = JMINB = 2 and J = JMAXB respectively. Faces five and six are constant-K faces and correspond to K = KMINB = 2 and K = KMAXB respectively. These are the same conventions as those described for file relo.dat in Appendix A.

Input preparation for a typical block is presented. The same process can be repeated for the other blocks. For a typical block, input preparation for the I-faces is described in Card 3 to Card 10. Similar description is given in Card 11 to Card 18 for the J-faces and in Card 19 to Card 26 for the K-faces.

The boundary condition option indicator NTYPE = 7 is used in Cards 14, 18, 22, and 26 for imposing the transpiration boundary condition on the design patches of the block faces. This option was not available in the GMBE code in Reference 5.

Also, when NWTP = 5 in Cards 14, 18, 22 or 26 of file relo.dat (Appendix A), then NTYPE must be set to 1 in Cards 14, 18, 22 or 26 of file bco.dat. This implies the use of reflection boundary condition on a vertical plane. An example of an input file using such a reflection boundary condition is presented at the end of this Appendix.

Column	Code	Format	Explanation
Card 1:			
1-80		1x	Header card.
Card 2:			
1-10	NBA	Free	Block number.
Card 3:			
1-80		1x	Header card.
Card 4:			
1-10	NFA	Free	Face number. = 1
11-20	NBCA	Free	Number of boundary condition patches for face-1.
Card 5:			
1-80		1x	Header card.

Card 6: Repeat this card NBCA (see Card 4) times.

1-10	NTYPE	Free	Boundary condition type for a patch. = 1 interblock = 2 solid surface = 3 inlet = 4 exhaust one (typically the fan exit)

			= 5 exhaust two (typically the core exit) = 6 far field = 7 unused = 8 center line = 9 downstream side of the propeller disk =10 upstream side of the propeller disk
11-20	JMIN	Free	The minimum J-index for the patch not including the ghost point.
21-30	JMAX	Free	The maximum J-index for the patch not including the ghost point.
31-40	KMIN	Free	The minimum K-index for the patch not including the ghost point.
41-50	KMAX	Free	The maximum K-index for the patch not including the ghost point.

Card 7:

1-80		1x	Header card.

Card 8:

1-10	NFA	Free	Face number. = 2
11-20	NBCA	Free	Number of boundary condition patches for face-2.

Card 9:

1-80		1x	Header card.

Card 10: Repeat this card NBCA (Card 8) times.

1-10	NTYPE	Free	Boundary condition type for a patch. Please see descriptions in Card 6.
11-20	JMIN	Free	The minimum J-index for the patch not including the ghost point.
21-30	JMAX	Free	The maximum J-index for the patch not including the ghost point.
31-40	KMIN	Free	The minimum K-index for the patch not including the ghost point.
41-50	KMAX	Free	The maximum K-index for the patch not including the ghost point.

Card 11:

1-80		1x	Header card.

Card 12:

1-10	NFA	Free	Face number. = 3
11-20	NBCA	Free	Number of boundary condition patches for face-3.

Card 13:

1-80		1x	Header card.

Card 14: Repeat this card NBCA (Card 12) times.

1-10	NTYPE	Free	Boundary condition type for a patch. = 1 interblock or symmetry plan. For the latter also set NWTP=5 in relo.dat (see pg. 55). = 2 solid surface = 3 inlet = 4 exhaust one (typically the fan exit) = 5 exhaust two (typically the core exit) = 6 far field = 7 surface transpiration (this is a new option for the design surface) = 8 center line
11-20	IMIN	Free	The minimum I-index for the patch not including the ghost point.
21-30	IMAX	Free	The maximum I-index for the patch not including the ghost point.
31-40	KMIN	Free	The minimum K-index for the patch not including the ghost point.
41-50	KMAX	Free	The maximum K-index for the patch not including the ghost point.

Card 15:

1-80		1x	Header card.

Card 16:

1-10	NFA	Free	Face number. = 4
11-20	NBCA	Free	Number of boundary condition patches for face-4.

Card 17:

1-80		1x	Header card.

Card 18: Repeat this card NBCA (Card 16) times.

1-10	NTYPE	Free	Boundary condition type for a patch. Please see descriptions in Card 14.
11-20	IMIN	Free	The minimum I-index for the patch not including the ghost point.
21-30	IMAX	Free	The maximum I-index for the patch not including the ghost point.
31-40	KMIN	Free	The minimum K-index for the patch not including the ghost point.
41-50	KMAX	Free	The maximum K-index for the patch not including the ghost point.

Card 19:

1-80		1x	Header card.

Card 20:

1-10	NFA	Free	Face number. = 5
11-20	NBCA	Free	Number of boundary condition patches for face-5.

Card 21:

1-80		1x	Header card.

Card 22: Repeat this card NBCA (Card 20) times.

1-10	NTYPE	Free	Boundary condition type for a patch. Please see descriptions in Card 14.
11-20	IMIN	Free	The minimum I-index for the patch not including the ghost point.
21-30	IMAX	Free	The maximum I-index for the patch not including the ghost point.
31-40	JMIN	Free	The minimum J-index for the patch not including the ghost point.
41-50	JMAX	Free	The maximum J-index for the patch not including the ghost point.

Card 23:

1-80		1x	Header card.

Card 24:

1-10	NFA	Free	Face number. = 6
11-20	NBCA	Free	Number of boundary condition patches for face-6.

Card 25:

1-80		1x	Header card.

Card 26: Repeat this card NBCA (Card 24) times.

1-10	NTYPE	Free	Boundary condition type for a patch. Please see description in Card 14.
11-20	IMIN	Free	The minimum I-index for the patch not including the ghost point.
21-30	IMAX	Free	The maximum I-index for the patch not including the ghost point.
31-40	JMIN	Free	The minimum J-index for the patch not including the ghost point.
41-50	JMAX	Free	The maximum J-index for the patch not including the ghost point.

Repeat Cards 1 through 26 for the other blocks.

Example of File bco.dat

```
NBA
1
NFA      NBCA
1        1
NTYPE    JMIN     JMAX     KMIN     KMAX
6        2        14       2        10
NFA      NBCA
2        1
NTYPE    JMIN     JMAX     KMIN     KMAX
6        2        14       2        10
NFA      NBCA
3        1
NTYPE    IMIN     IMAX     KMIN     KMAX
8        2        98       2        10
NFA      NBCA
4        3
NTYPE    IMIN     IMAX     KMIN     KMAX
1        2        30       2        10
2        30       78       2        10
1        78       98       2        10
NFA      NBCA
5        1
NTYPE    IMIN     IMAX     JMIN     JMAX
1        2        98       2        14
NFA      NBCA
6        1
NTYPE    IMIN     IMAX     JMIN     JMAX
1        2        98       2        14
NBA
2
NFA      NBCA
1        1
NTYPE    JMIN     JMAX     KMIN     KMAX
6        2        26       2        10
NFA      NBCA
2        1
NTYPE    JMIN     JMAX     KMIN     KMAX
6        2        26       2        10
```

```
NFA       NBCA
3         3
NTYPE     IMIN      IMAX      KMIN      KMAX
1         2         30        2         10
1         30        78        2         10
1         78        98        2         10
NFA       NBCA
4         2
NTYPE     IMIN      IMAX      KMIN      KMAX
6         2         98        2         10
NFA       NBCA
5         1
NTYPE     IMIN      IMAX      JMIN      JMAX
1         2         98        2         26
NFA       NBCA
6         1
NTYPE     IMIN      IMAX      JMIN      JMAX
1         2         98        2         26
```

Note: For convenience a starting index specified as unity will be reset to two. For example, consider face one of block one which is of dimension 13 by 9. Although the specification JMIN=2 and JMAX=14 is correct, specification of JMIN=1 would be reset to correct value JMIN=2.

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This is a user manual for the general multiblock Euler design (GMBEDS) code developed under NASA contract NAS1-18703. The code si for the design of a nacelle installed on a geometrically complex configuration such as a complete airplane with wing/body/nacelle/pylon. It consists of two major building blocks: a design module developed by NASA Langely using direct iterative surface curvature (DISC) approach; and, a general multiblock Euler (GMBE) flow solver. The flow field surrounding a complex configuration is divided into a number of topologically simple blocks to facilitate surface-fitted grid generation and improve flow solution effiency. This user guide provides input data formats along with examples of input files and a Unix script for program execution in the UNICOS environment.

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