Volume grid for CRM (Common Research Model) - Wing/Body/Horizontal tail configuration

1. Grid description

These are 4 block H-type structured, point matched multiple block grids for CFL3D or TLNS3D type of codes. The geometry defined by the grid is the NASA CRM Wing/Body/Horizontal-tail configuration with open TE on the wing and horizontal-tail. Please refer to the attached sketch for the block layout.

Block 1: upper surface region
Block 2: lower surface region
Block 3: block downstream of finite wing trailing edge region
Block 4: block downstream of finite h-tail trailing edge region

2. Boundary conditions

All solid surfaces (i.e., wing upper and lower surfaces, h-tail upper and lower surfaces, fuselage surface) are treated as viscous surfaces, except the base of blunt trailing edges which are treated as inviscid surfaces due to the use of grid which is not adequate to resolve the viscous layer.

3. Volume grid files:

Coarse grid (W/B/H): vgrd_WBH0_cRe5M.bin ← coarse grid - CRM W/B/H configuration (iH = 0.0°, Re=5M)

Grid dimensions:

Block	I_{max}	J_{max}	K_{max}
1	377	65	97
2	377	65	97
3	25	57	65
4	41	57	25

I	streamwise direction
J	normal to wing surface
K	spanwise direction

Medium grids (W/B/H): vgrd_WBH0_mRe5M.bin ← medium grid - CRM W/B/H configuration (iH = 0.0°, Re=5M)
vgrd_WBHp2_mRe5M.bin ← medium grid - CRM W/B/H configuration (iH =+2.0°, Re=5M)
vgrd_WBHm2_mRe5M.bin ← medium grid - CRM W/B/H configuration (iH = -2.0°, Re=5M)
vgrd_WBH0_mRe20M.bin ← medium grid - CRM W/B/H configuration (iH = 0.0°, Re=20M)

Grid dimensions:

Block	I_{max}	J_{max}	K_{max}
1	469	81	145
2	469	81	145
3	25	65	97
4	57	65	33

I	streamwise direction
J	normal to wing surface
K	spanwise direction

Med-fine grid (W/B/H): vgrd_WBHNo_mRe5M.bin ← medium-fine grid - CRM W/B/H configuration (iH = 0.0°, Re=5M)

Grid dimensions:

Block	I_{max}	J_{max}	K_{max}
1	657	97	201
2	657	97	201
3	25	73	133
4	81	73	45

I	streamwise direction
J	normal to wing surface
K	spanwise direction

Fine grid (W/B/H): vgrd_WBH0_fRe5M.bin ← fine grid - CRM W/B/H configuration (iH = 0.0°, Re=5M)

Grid dimensions:

Block	I_{max}	J_{max}	K_{max}
1	873	105	257
2	873	105	257
3	25	81	173
4	101	81	53

I	streamwise direction
J	normal to wing surface
K	spanwise direction

Extra-fine grid (W/B/H): vgrd_WBH0_xRe5M.bin ← extra-fine grid - CRM W/B/H configuration (iH = 0.0°, Re=5M)

Grid dimensions:

Block	I_{max}	J_{max}	K_{max}
1	-	-	-
2	-	-	-
3	-	-	-
4	-	-	-

I	streamwise direction
J	normal to wing surface
K	spanwise direction

Medium grid (W/B): vgrd_WBHNo_mRe5M.bin ← medium grid - CRM W/B configuration (Re=5M)

Grid dimensions:

Block	I_{max}	J_{max}	K_{max}
1	469	81	145
2	469	81	145
3	25	65	97

I	streamwise direction
J	normal to wing surface
K	spanwise direction

The grids have also been split for running on multiple CPU's for optimal load balance on a cluster. The number of cpus specified below will give an optimum load balance for a cluster when using the split grids. The split grids and mapf files contain ".splt" in their name.

Grid	Coarse	Medium	Medium-Fine	Fine	Extra-Fine
# CPU	26	38	52	66	-

The map file (connectivity file) is the standard form of TLNS3D multi-block grid type, it tells the boundary conditions to use, and the connectivity information among different blocks. When running CFL3D, there is a tlns3d to cfl3d conversion program to convert this map (or connectivity) file to cfl3d input file. See CFL3D user manual and TLNS3D paper by Dr. V. Vatsa. The grid format is in CFL3D standard format, available in the CFL3D User's Manual, NASA TM-1998-20844, or http://cfl3d.larc.nasa.gov/Cfl3dv6/cfl3dv6.html under the Version 5 Manual.

The grid file is an unformatted 64 bit binary file of the PLOT3D multiple grid form generated on workstation or PC, it consists of number of grid zones (blocks) and their dimension size, follows by the coordinates of each grid point, block by block, written out in PLOT3D three dimensional multiple grid format.

Approximate grid sizes for Wing-Body-Tail with open TE are:

	Unsplit grid	Split grid
Coarse	4.9 million	5.4 million
Medium	11.3 million	12.6 million
Medium-fine	26.1 million	29.2 million
Fine	47.9 million	53.6 million
Extra-fine	-	-

Surface/Volume grids generated by T.J. Kao and N.J. Yu for Ben Rider and Ed Tinoco
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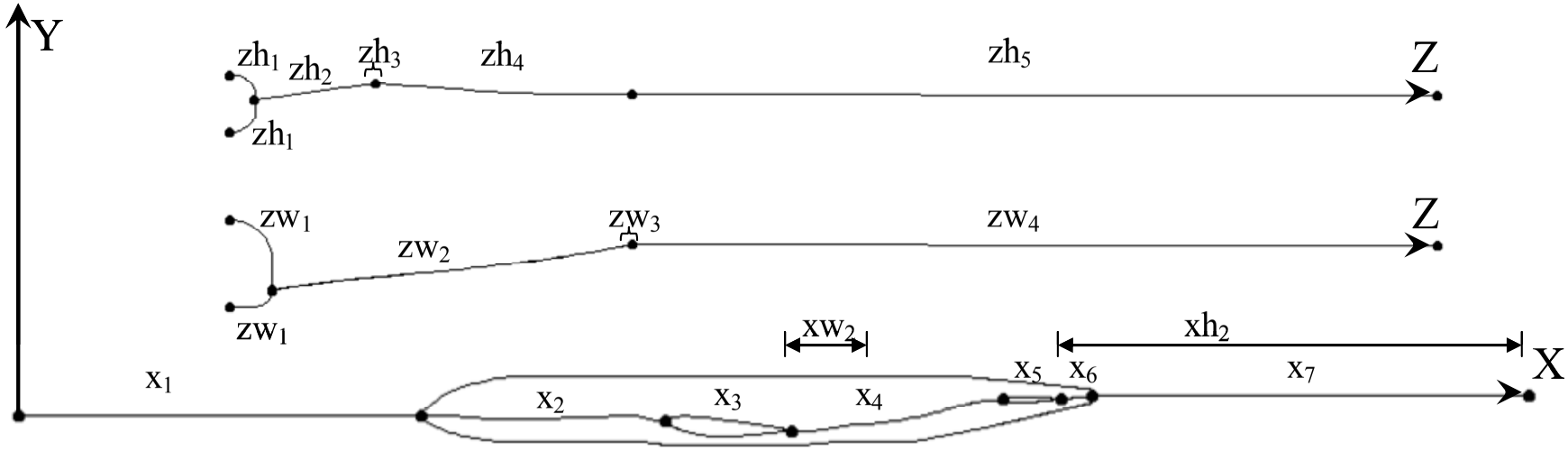
Here is the segment of code to write the grid files:

```
      open (10,file='Gfile',form='system')
      write(10) ngrids
c
      write(10) ((mm(j,i),j=1,3),i=1,ngrids)
c
      do 20 ig=1,ngrids
      nr = mm(1,ig)*mm(2,ig)*mm(3,ig)
      do 10 i=1,nr
      x(i) = xdum(i)
      y(i) = ydum(i)
      z(i) = zdum(i)
 10   continue
      write(10)(x(i),i=1,nr),(y(i),i=1,nr),(z(i),i=1,nr)
 20   continue
      close(10)
c
```

where ngrids: number of blocks
m(1,n),mm(2,n),mm(3,n):I,J,K grid size in the block n, respectively
x(i),y(i),z(i): x,y,z coordinates for ith point in the block



	x_1	x_2	x_3	x_4	x_5	x_6	x_7	y
Coarse: 5M RE	16	72	88	80	80	24	16	64
Medium: 5M RE	24	80	112	100	96	32	24	80
Medium-Fine: 5M RE	32	96	168	136	144	48	32	96
Fine: 5M RE	36	160	224	160	192	64	36	104
Extra fine: 5M RE	-	-	-	-	-	-	-	-
Medium: 20M RE	24	80	112	100	96	32	24	80
Medium WB: 5M RE	24	80	112	168			24	80

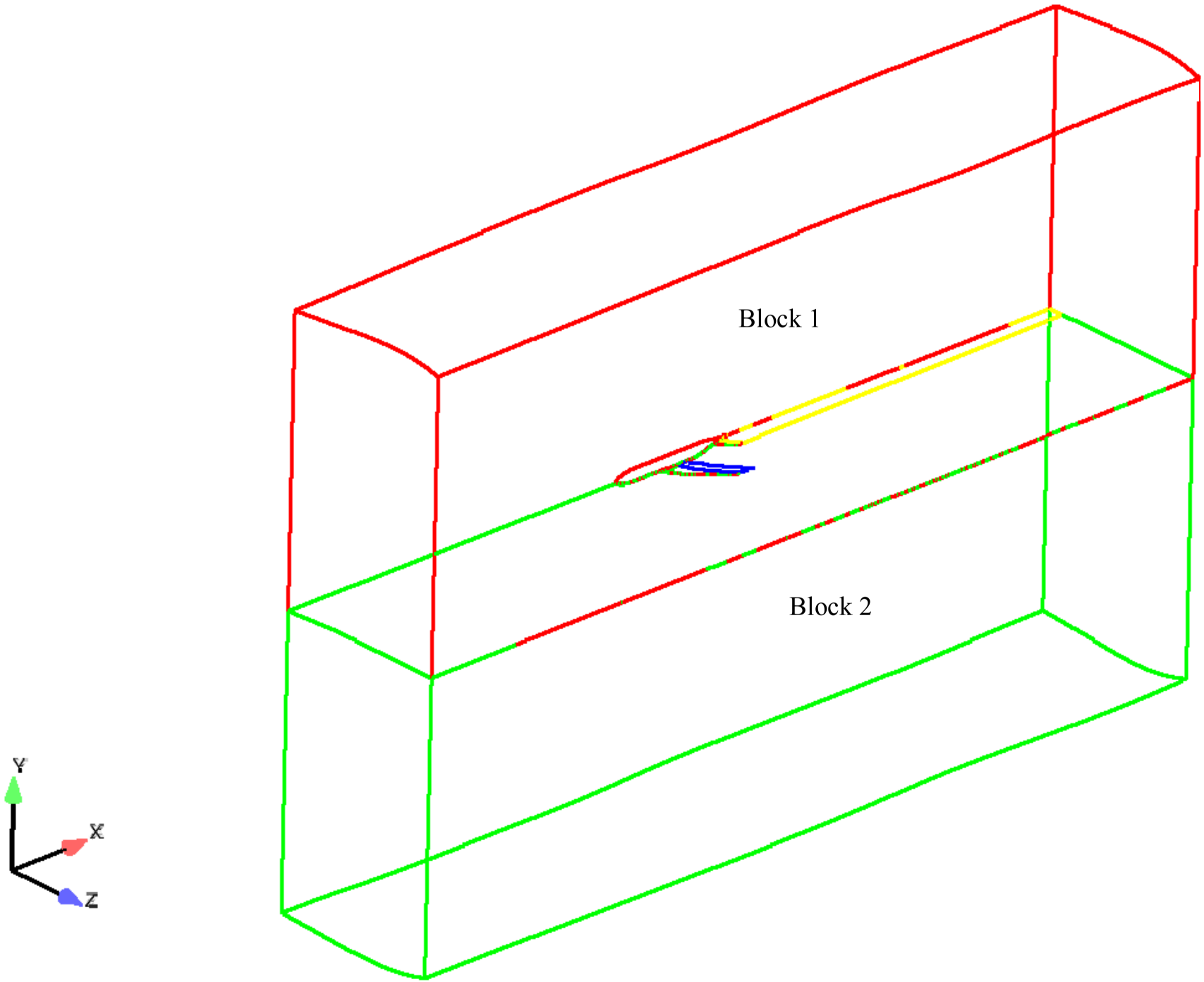
Total Split Grid Size
5.4M
12.6M
29.2M
53.6M
-
12.6M
12.6M

	zw_1	zw_2	zw_3	zw_4	zh_1	zh_2	zh_3	zh_4	zh_5	y
Coarse: 5M RE	24	60	4	8	24	20	4	40	8	64
Medium: 5M RE	32	92	4	16	32	28	4	64	16	80
Medium-Fine: 5M RE	48	128	4	20	48	40	4	88	20	96
Fine: 5M RE	64	168	4	20	64	48	4	120	20	104
Extra fine: 5M RE	-	-	-	-	-	-	-	-	-	-
Medium: 20M RE	32	92	4	16	32	28	4	64	16	80
Medium WB: 5M RE	32	92	4	16	32	28	4	64	16	80

Blunt TE Block	xw_2	y	zw_2	xh_2	y	zh_2
Coarse: 5M RE	24	56	64	40	56	24
Medium: 5M RE	24	64	96	56	64	32
Medium-Fine: 5M RE	24	72	132	80	72	44
Fine: 5M RE	24	80	172	100	80	52
Extra fine: 5M RE	-	-	-	-	-	-
Medium: 20M RE	24	64	96	56	64	32
Medium WB: 5M RE	24	64	96	56	64	32

Boundary Layer	Δy_1	Ave y+
Coarse: 5M RE	0.000835530	0.5652
Medium: 5M RE	0.000835530	0.5652
Medium-Fine: 5M RE	0.000557020	0.3768
Fine: 5M RE	0.000417765	0.2826
Extra fine: 5M RE	-	-
Medium: 20M RE	0.000139255	0.33975
Medium WB: 5M RE	0.000835530	0.5652

Block Layout



Block Layout