

Recommended Practice

The CFD General Notation System – Standard Interface Data Structures



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Maintained by
The CGNS Steering Sub-committee of the AIAA CFD Committee on Standards

Abstract

The CFD General Notation System (CGNS) is a standard for recording and recovering computer data associated with the numerical solution of the equations of fluid dynamics. The intent is to facilitate the exchange of CFD data between sites, between applications codes, and across computing platforms, and to stabilize the archiving of CFD data.

The CGNS system consists of a collection of conventions, and software implementing those conventions, for the storage and retrieval of CFD data. It consists of two parts: (1) a standard format for recording the data, and (2) software that reads, writes, and modifies data in that format. The format is a conceptual entity established by the documentation; the software is a physical product supplied to enable developers to access and produce data recorded in that format.

The standard format, or paper convention, part of CGNS consists of two fundamental pieces. The first, known as the Standard Interface Data Structures, is described in this Recommended Practice. It defines the intellectual content of the information to be stored. The second, known as the File Mapping, defines the exact location in a CGNS file where the data is to be stored.

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Contents

Foreword	vii
1 Introduction	1
1.1 Major Differences from Previous CGNS Versions	2
1.1.1 Version 2.0, Beta 1	3
1.1.2 Version 2.0, Beta 2	3
1.1.3 Version 2.1, Beta 1	3
1.1.4 Version 2.2, Beta 1	4
1.1.5 Version 2.3	4
1.1.6 Version 2.4	4
2 Design Philosophy of Standard Interface Data Structures	6
3 Conventions	9
3.1 Data Structure Notation Conventions	9
3.2 Structured Grid Notation and Indexing Conventions	13
3.3 Unstructured Grid Element Numbering Conventions	14
3.3.1 1-D (Line) Elements	15
3.3.2 2-D (Surface) Elements	16
3.3.2.1 Triangular Elements	16
3.3.2.2 Quadrilateral Elements	17
3.3.3 3-D (Volume) Elements	17
3.3.3.1 Tetrahedral Elements	17
3.3.3.2 Pyramid Elements	18
3.3.3.3 Pentahedral Elements	20
3.3.3.4 Hexahedral Elements	21
3.3.4 Unstructured Grid Example	22
3.4 Multizone Interfaces	24
4 Building-Block Structure Definitions	27
4.1 Definition: DataClass_t	27
4.2 Definition: Descriptor_t	27
4.3 Definition: DimensionalUnits_t	28
4.4 Definition: DimensionalExponents_t	29
4.5 Definition: GridLocation_t	30
4.6 Definition: IndexArray_t	30
4.7 Definition: IndexRange_t	30
4.8 Definition: Rind_t	31
5 Data-Array Structure Definitions	32
5.1 Definition: DataArray_t	32
5.1.1 Definition: DataConversion_t	33
5.2 Data Manipulation	34
5.2.1 Dimensional Data	34

5.2.2	Nondimensional Data Normalized by Dimensional Quantities	35
5.2.3	Nondimensional Data Normalized by Unknown Dimensional Quantities	35
5.2.4	Nondimensional Parameters	38
5.2.5	Dimensionless Constants	39
5.3	Data-Array Examples	39
6	Hierarchical Structures	44
6.1	CGNS Version	44
6.2	CGNS Entry Level Structure Definition: CGNSBase_t	44
6.3	Zone Structure Definition: Zone_t	47
6.4	Precedence Rules and Scope Within the Hierarchy	51
7	Grid Coordinates, Elements, and Flow Solutions	53
7.1	Grid Coordinates Structure Definition: GridCoordinates_t	53
7.2	Grid Coordinates Examples	55
7.3	Elements Structure Definition: Elements_t	58
7.4	Elements Examples	60
7.5	Axisymmetry Structure Definition: Axisymmetry_t	61
7.6	Rotating Coordinates Structure Definition: RotatingCoordinates_t	63
7.7	Flow Solution Structure Definition: FlowSolution_t	64
7.8	Flow Solution Example	66
8	Multizone Interface Connectivity	69
8.1	Zonal Connectivity Structure Definition: ZonalGridConnectivity_t	69
8.2	1-to-1 Interface Connectivity Structure Definition: GridConnectivity1to1_t	70
8.3	1-to-1 Interface Connectivity Examples	73
8.4	General Interface Connectivity Structure Definition: GridConnectivity_t	75
8.5	Grid Connectivity Property Structure Definition: GridConnectivityProperty_t	78
8.5.1	Periodic Interface Structure Definition: Periodic_t	79
8.5.2	Average Interface Structure Definition: AverageInterface_t	80
8.6	Overset Grid Holes Structure Definition: OversetHoles_t	81
9	Boundary Conditions	83
9.1	Boundary Condition Structures Overview	84
9.2	Zonal Boundary Condition Structure Definition: ZoneBC_t	85
9.3	Boundary Condition Structure Definition: BC_t	86
9.4	Boundary Condition Data Set Structure Definition: BCDataSet_t	90
9.5	Boundary Condition Data Structure Definition: BCData_t	92
9.6	Boundary Condition Property Structure Definition: BCProperty_t	93
9.6.1	Wall Function Structure Definition: WallFunction_t	94
9.6.2	Area Structure Definition: Area_t	95
9.7	Boundary Condition Type Structure Definition: BCType_t	96
9.8	Matching Boundary Condition Data Sets	99
9.9	Boundary Condition Specification Data	101
9.10	Boundary Condition Examples	103

10 Governing Flow Equations	112
10.1 Flow Equation Set Structure Definition: FlowEquationSet_t	112
10.2 Governing Equations Structure Definition: GoverningEquations_t	113
10.3 Thermodynamic Gas Model Structure Definition: GasModel_t	115
10.4 Molecular Viscosity Model Structure Definition: ViscosityModel_t	116
10.5 Thermal Conductivity Model Structure Definition: ThermalConductivityModel_t	118
10.6 Turbulence Structure Definitions	119
10.6.1 Turbulence Closure Structure Definition: TurbulenceClosure_t	120
10.6.2 Turbulence Model Structure Definition: TurbulenceModel_t	121
10.7 Thermal Relaxation Model Structure Definition: ThermalRelaxationModelType_t	124
10.8 Chemical Kinetics Structure Definition: ChemicalKineticsModel_t	125
10.9 Electromagnetics Structure Definitions	127
10.9.1 Electromagnetics Electric Field Model Structure Definition: EMElectricField-Model_t	127
10.9.2 Electromagnetics Magnetic Field Model Structure Definition: EMMagneticField-Model_t	128
10.9.3 Electromagnetics Conductivity Model Structure Definition: EMConductivity-Model_t	129
10.10 Flow Equation Examples	130
11 Time-Dependent Flow	133
11.1 Iterative Data Structure Definitions	133
11.1.1 Base Iterative Data Structure Definition: BaseIterativeData_t	133
11.1.2 Zone Iterative Data Structure Definition: ZoneIterativeData_t	134
11.2 Rigid Grid Motion Structure Definition: RigidGridMotion_t	135
11.3 Arbitrary Grid Motion Structure Definition: ArbitraryGridMotion_t	137
11.4 Examples for Time-Dependent Flow	140
12 Miscellaneous Data Structures	146
12.1 Reference State Structure Definition: ReferenceState_t	146
12.2 Reference State Example	147
12.3 Convergence History Structure Definition: ConvergenceHistory_t	148
12.4 Discrete Data Structure Definition: DiscreteData_t	150
12.5 Integral Data Structure Definition: IntegralData_t	151
12.6 Family Data Structure Definition: Family_t	152
12.7 Geometry Reference Structure Definition: GeometryReference_t	153
12.8 Family Boundary Condition Structure Definition: FamilyBC_t	154
12.9 User-Defined Data Structure Definition: UserDefinedData_t	155
12.10 Gravity Data Structure Definition: Gravity_t	156
Appendix A. Conventions for Data-Name Identifiers	159
A.1 Coordinate Systems	159
A.2 Flowfield Solution	160
A.3 Turbulence Model Solution	168
A.4 Nondimensional Parameters	168

A.5	Characteristics and Riemann Invariants Based on 1-D Flow	170
A.6	Forces and Moments	170
A.7	Time-Dependent Flow	173

Annex B. Structured Two-Zone Flat Plate Example 175

B.1	Overall Layout	176
B.2	Grid Coordinates	177
B.3	Flowfield Solution	178
B.4	Interface Connectivity	180
B.5	Boundary Conditions	183
B.6	Global Reference State	186
B.7	Equation Description	188

List of Figures

1	Sample Topologically Based CFD Hierarchy	7
2	Structured-Grid Multizone Interface Types	25
3	Example Interface for 1-to-1 Connectivity	74
4	Hierarchy for Boundary Condition Structures	85
5	Boundary Condition Implementation Levels	103
6	Two-Zone Flat Plate Test Case	175

List of Tables

1	Element Types in CGNS	15
2	Simple Boundary Condition Types	97
3	Compound Boundary Condition Types	99
4	Associated Boundary Condition Types and Usage Rules	100
5	Data-Name Identifiers for Perfect Gas	116
6	Data-Name Identifiers for Molecular Viscosity Models	118
7	Data-Name Identifiers for Thermal Conductivity Models	120
8	Data-Name Identifiers for Turbulence Closure	121
9	Data-Name Identifiers for Chemical Kinetics Models	126
10	Defined Names (Symbols) for Commonly Used Mixtures	126
11	Data-Name Identifiers for Electromagnetics Models	130
12	Data-Name Identifiers for Rigid Grid Motion	137
13	Data-Name Identifiers for Grid Velocity	139
14	Data-Name Identifiers for Reference State	147
15	Data-Name Identifiers for Coordinate Systems	160
16	Data-Name Identifiers for Flow Solution Quantities	162
17	Data-Name Identifiers for Typical Turbulence Models	168
18	Data-Name Identifiers for Nondimensional Parameters	169
19	Data-Name Identifiers for Characteristics and Riemann Invariants	170
20	Data-Name Identifiers for Forces and Moments	172
21	Data-Name Identifiers for Time-Dependent Flow	173

Foreword

This document contains the Standard Interface Data Structures (SIDS) definitions for the CFD General Notation System (CGNS) project. This project was originally a NASA-funded contract under the AST program, but control has now been completely transferred to a public forum known as the CGNS Steering Committee, a sub-committee of the AIAA CFD Committee on Standards.

The purpose of this document is to scope the information that should be communicated between various CFD application codes; the target is 3-D multizone, compressible Navier-Stokes analysis. Attention in this document is not focused on I/O routines or formats, but on the precise description of data that should be present in the I/O of a CFD code or in a CFD database.

This document therefore contains a precise definition of information pertinent to a CGNS database. Specifically, the following information is addressed:

- grid coordinates and elements
- flow solution data, including nondimensional parameters
- multizone interface connectivity, including abutting and overlap
- boundary conditions
- flow equation descriptions
- time-dependent flow
- reference states
- dimensional units and nondimensionalization information associated with data
- convergence history
- association to geometry definition
- topologically based hierarchical structures

This information is encoded into C-like data structures.

This revision “A” of AIAA R-101 replaces in whole AIAA R-101-2002. Changes made to the document since the last release are outlined in Section 1. At the time of approval, the members of the CGNS Steering Committee were:

Chris Rumsey, Chairman	NASA Langley
Steve Allmaras	Boeing Commercial
John Alonso	Stanford University
Bob Bush	Pratt & Whitney
Thierry Chevalier	AM-Airbus
Armen D. Darian	Pratt & Whitney Rocketdyne
Dan Dominik	Boeing Rocketdyne
Steve Feldman	CD-ADAPCO

Pankaj Gupta	Fluent
Richard Hann	ANSYS / CFX
Thomas Hauser	Utah State
Steve Legensky	Intelligent Light
Todd Michal	Boeing Integrated Defense Systems
Marc Poinot	ONERA
Greg Power	ATA / AEDC
Charles Towne	NASA Glenn
Kurt Weber	Rolls Royce / Allison
Bruce Wedan	Ansys / ICEM CFD Engineering
Nick Wyman	Pointwise, Inc.

The above consensus body approved this document in December 2005.

The AIAA Standards Executive Council (Mr. Amr ElSawy, Chairman) accepted the document for publication in December 2005.

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Questions and comments on this document are welcome and should be directed to:

Charlie Towne
MS 86-7
NASA Glenn Research Center
Cleveland, OH 44135-3191
(216) 433-5851
(216) 977-7500 (FAX)
e-mail: town@nasa.gov

1 Introduction

CGNS (CFD General Notation System) is a collection of conventions, along with software implementing those conventions, for the storage and retrieval of CFD (computational fluid dynamics) data. The CGNS system is designed to facilitate the exchange of data between sites and applications, as well as to help stabilize the archiving of fluid dynamic data. In today's environment, it is important in many technical arenas to maintain detailed records of scientific computations. CGNS was designed to help promote a long-lasting and extensible standard for this purpose. Many companies and institutions choose to adopt the CGNS standard in order to increase productivity, by (1) reducing the time required to translate between data created and used by different applications, and (2) increasing the quality, longevity, and re-usability of archived data.

The CGNS standard is a conceptual entity established by the documentation. The CGNS software is a physical product supplied to enable writing and reading data according to this standard. All CGNS software is completely free and open to anyone. By using the supplied software, it is relatively easy for users to adhere to most of the standard described in detail in this document.

The CGNS project originated during 1994 through a series of meetings that addressed improved transfer of NASA technology to industry. A principal impediment in this process was the disparity in I/O formats employed by various flow codes, grid generators, and other utilities, and CGNS was conceived as a means to promote "plug-and-play" CFD. Agreement was reached to develop CGNS at Boeing, under NASA Contract NAS1-20267, with active participation by a team of CFD researchers from NASA's Langley, Lewis (now Glenn), and Ames Research Centers, McDonnell Douglas Corporation (now part of Boeing), and Boeing Commercial Airplane Group. This team, which was joined by ICEM CFD Engineering Corporation of Berkeley, California in 1997, undertook the core of the development. However, in the spirit of creating a completely open and broadly accepted standard, all interested parties were encouraged to participate; the US Air Force and Arnold Engineering Development Center were notably present. From the beginning, the purpose was to develop a system that could be distributed freely, including all documentation, software and source code. This goal has now been fully realized; further, control of CGNS has been completely transferred to a public forum known as the CGNS Steering Committee.

The principal target is the data normally associated with compressible viscous flow (i.e., the Navier-Stokes equations), but the standard is also applicable to subclasses such as Euler and potential flows. The initial release addressed multi-zone grids, flow fields, boundary conditions, and zone-to-zone connection information, as well as a number of auxiliary items, such as non-dimensionalization, reference states, and equation set specifications. Extensions incorporated since then include unstructured meshes, connections to geometry definition, time-dependent flow, and support for multiple species and chemistry.

It is worth noting that extensibility is a fundamental design characteristic of the system, which in principle could be used for other disciplines of computational field physics, such as acoustics or electromagnetics, given the willingness of the cognizant scientific community to define the conventions.

The standard format, or paper convention, part of CGNS consists of two fundamental pieces. The first, known as the Standard Interface Data Structures (SIDS), describes in detail the intellectual content of the information to be stored. It defines, for example, the precise meaning of a "boundary