

TABLE OF CONTENTS

INTRODUCTION TO THE SPECIFICATION	1
1. Introduction	3
1.1 Purpose	3
1.2 The relation between this proposal and STEP	3
1.3 Structure of the document	4
2. Approach	5
3. Basic principles	9
3.1 Use of formal languages	9
3.2 Informal description of the CAD data schema	9
3.2.1 <i>Entities and Attributes</i>	9
3.2.2 <i>References</i>	10
3.2.3 <i>Properties</i>	10
3.2.4 <i>Scope</i>	11
3.2.5 <i>World</i>	11
3.2.6 <i>Assemblies and Components</i>	11
3.2.7 <i>Geometry</i>	11
3.2.7.1 <i>Curves and Surfaces</i>	12
3.2.7.2 <i>Solid Models</i>	13
3.2.7.3 <i>Instancing and placement</i>	13
3.2.8 <i>User-defined name</i>	13
3.2.9 <i>Libraries and External References</i>	14
3.2.9.1 <i>Parametric Models and Macros</i>	14
3.2.9.2 <i>User records</i>	14
3.3 The Physical Level	15
3.3.1 <i>Strictly sequential, free format, block structure</i>	15
3.3.2 <i>Metafiles, Letters and Alphabets</i>	16
3.4 Validation of the CAD model transfer	16
3.4.1 <i>Validation of the operational behaviour of the model</i>	16
3.4.2 <i>Validation of the geometry</i>	17
REFERENCE MANUAL	19
4. The high level data specification language HDSL	21
4.1 Type declaration	21
4.2 Predefined types	22
4.2.1 <i>The type INTEGER</i>	23
4.2.2 <i>The type REAL</i>	23
4.2.3 <i>The type LOGICAL</i>	23
4.2.4 <i>The type STRING</i>	23
4.2.5 <i>The type USER_DEFINED_NAME</i>	24
4.2.6 <i>The type NIL</i>	24

4.2.7	The constants D2, D3	24
4.2.8	The type ARITHMETIC_EXPRESSION	25
4.3	Composite types	25
4.3.1	Enumeration types	25
4.3.2	Fixed structure type	25
4.3.3	Lists	27
4.3.4	Classes	28
4.4	The types REFERENCE, REF_ONLY	28
4.5	Generic types	29
4.5.1	Parametric enumeration types	30
4.5.2	Parametric structures	31
4.5.3	Parametric lists	31
4.5.4	Parametric classes	32
4.5.5	Variant structures	32
4.5.6	Variant classes	33
4.5.7	Generic structures	33
4.5.8	Generic enumerations	34
4.5.9	Generic classes	34
4.5.10	Generic lists	35
4.6	The predefined function DIMENSION	35
4.7	Rules applying to building a schema with HDSL	36
4.8	Semantics of reference models defined with HDSL	37
4.8.1	Entering entities	38
4.8.2	Interrogating the information content of the environment	38
4.8.3	Identifying entities by textual means	38
4.8.4	Identifying entities by interactive picking	39
4.8.5	Identifying properties	39
4.8.6	Creating a new entity	39
4.8.7	Creating a new property or relation	39
4.8.8	Deleting an existing entity	40
4.8.9	Deleting an existing property or relation	40
4.8.10	Modifying values of attributes	40
4.8.11	Invoking a modeling function	40
4.8.12	Invoking evaluation functions	41
4.8.13	Linear transformations	41
5.	The CAD*I reference model specification	43
5.1	Attribute types for general use	43
5.1.1	ANY	43
5.1.2	DIM	44
5.1.3	TYPE_ID	44
5.1.4	UPDATE	45
5.1.5	LIST OF predefined values	45
5.2	General data base structure	46
5.2.1	WORLD	46
5.2.2	ASSEMBLY	48
5.2.3	COMPONENT	50
5.2.4	PART_LIBRARY	50

5.2.5	<i>ROUTINE_LIBRARY</i>	50
5.3	Referencing mechanisms	51
5.3.1	<i>INDEX_ENTRY</i>	52
5.3.2	<i>REF_EXTERNAL</i>	52
5.3.3	<i>REF_PART_LIBRARY</i>	53
5.3.4	<i>REF_ANY</i>	53
5.4	Geometric model entities	54
5.4.1	<i>GEOMETRIC_MODEL</i>	54
5.4.2	<i>WIREFRAME_MODEL</i>	54
5.4.3	<i>SURFACE_MODEL</i>	55
5.4.4	<i>SOLID_MODEL</i>	56
5.5	Points and curves	56
5.5.1	<i>Attribute types related to curves</i>	56
5.5.1.1	<i>CURVE_TRANSITION_CODE</i>	56
5.5.2	<i>DIRECTION</i>	57
5.5.3	<i>POINT</i>	58
5.5.4	<i>Curve classes</i>	58
5.5.4.1	<i>CURVE</i>	58
5.5.4.2	<i>ELEMENTARY_CURVE</i>	59
5.5.4.3	<i>BOUNDED_CURVE</i>	59
5.5.4.4	<i>CLOSED_CURVE</i>	60
5.5.5	<i>Elementary curves</i>	61
5.5.5.1	<i>LINE</i>	61
5.5.5.2	<i>LINE_SEGMENT</i>	62
5.5.5.3	<i>CIRCLE</i>	62
5.5.5.4	<i>ELLIPSE</i>	64
5.5.5.5	<i>HYPERBOLA</i>	65
5.5.5.6	<i>PARABOLA</i>	67
5.5.5.7	<i>POLYGON</i>	67
5.5.5.8	<i>B_SPLINE_CURVE</i>	68
5.5.6	<i>Derived curve entities</i>	76
5.5.6.1	<i>TRIMMED_CURVE</i>	76
5.5.6.2	<i>COMPOSITE_CURVE</i>	77
5.5.7	<i>Curves with functional dependency</i>	78
5.5.7.1	<i>OFFSET_CURVE</i>	78
5.6	Surfaces	79
5.6.1	<i>Surface classes</i>	79
5.6.1.1	<i>SURFACE</i>	79
5.6.1.2	<i>RECTANGULAR_SURFACE</i>	79
5.6.1.3	<i>ELEMENTARY_SURFACE</i>	79
5.6.2	<i>PLANAR_SURFACE</i>	80
5.6.3	<i>SPHERICAL_SURFACE</i>	81
5.6.4	<i>CONICAL_SURFACE</i>	81
5.6.5	<i>CYLINDRICAL_SURFACE</i>	82
5.6.6	<i>TOROIDAL_SURFACE</i>	83
5.6.7	<i>B_SPLINE_SURFACE</i>	84
5.6.8	<i>SURFACE_OF_REVOLUTION</i>	87
5.6.9	<i>SURFACE_OF_TRANSLATION</i>	89

5.6.10	RECTANGULAR_TRIMMED_SURFACE	90
5.6.11	RECTANGULAR_COMPOSITE_SURFACE	91
5.6.12	CURVE_BOUNDED_SURFACE	91
5.6.13	OFFSET_SURFACE	92
5.7	Geometry on surfaces	93
5.7.1	SURFACE_CURVE	93
5.7.2	Classes of curves on surfaces	94
5.7.2.1	CURVE_ON_SURFACE	94
5.7.3	POINT_ON_SURFACE	94
5.7.4	Curves on surfaces	95
5.7.5	Elementary curves on surface	95
5.7.5.1	ELEMENTARY_CURVE_ON_SURFACE	95
5.7.5.2	LINE_SEGMENT_ON_SURFACE	95
5.7.5.3	B_SPLINE_CURVE_ON_SURFACE	96
5.7.6	INTERSECTION_CURVE	96
5.7.7	Derived curves on surfaces	97
5.7.7.1	TRIMMED_CURVE_ON_SURFACE	97
5.7.7.2	COMPOSITE_CURVE_ON_SURFACE	98
5.8	Boundary representations	98
5.8.1	Standard boundary representation	98
5.8.1.1	B_REP	98
5.8.1.2	SHELL	101
5.8.1.3	FACE	102
5.8.1.4	FACE_SURFACE	104
5.8.1.5	LOOP	104
5.8.1.6	EDGE_LOOP	105
5.8.1.7	EDGE	106
5.8.1.8	EDGE_CURVE	107
5.8.1.9	VERTEX_LOOP	107
5.8.1.10	VERTEX	107
5.8.2	The POLYHEDRON: a boundary representation with planar faces	108
5.8.2.1	POLY_HEDRON	108
5.8.2.2	POLY_SHELL	109
5.8.2.3	POLY_FACE	109
5.8.2.4	POLY_LOOP	110
5.8.3	An experimental compound boundary representation	110
5.8.3.1	COMPOUND_B_REP	110
5.8.3.2	REGION	112
5.9	Constructive solid geometry	112
5.9.1	CONSTRUCT	112
5.9.2	BOOLEAN	113
5.9.3	BOOL_OPERAND	114
5.9.4	BOOL_OPERATOR	115
5.9.5	PRIMITIVE	115
5.9.6	Primitives for constructive solid geometry	116
5.9.6.1	PLANAR_HALFSPACE	116
5.9.6.2	REGULAR_PRISM	117
5.9.6.3	BOX	119

5.9.6.4	SOLID_CYLINDER	119
5.9.6.5	SOLID_SPHERE	120
5.9.6.6	TRUNCATED_CONE	121
5.9.6.7	TRUNCATED_PYRAMID	123
5.9.6.8	SOLID_TORUS	123
5.9.6.9	SWEEP	125
5.9.6.10	CONTOUR_ELEMENT	125
5.9.6.11	LINEAR_SWEEP	126
5.9.6.12	ROTATIONAL_SWEEP	128
5.10	HYBRID_SOLID	129
5.11	General grouping mechanism	131
5.11.1	ASPECT	131
5.11.2	GEOMETRY_ASSOCIATION	131
5.12	Placement and instancing	132
5.12.1	GEOMETRIC	132
5.12.2	INSTANCE	132
5.12.3	ROTATION	133
5.12.4	ROT_AXIS	133
5.12.5	ROT_GLOBAL	134
5.12.6	ROT_MATRIX	135
5.12.7	PLACEMENT	137
5.13	Test data elements	137
5.13.1	TEST_RELATION_FOR_D2_WIREFRAME	137
5.13.2	TEST_RELATION_FOR_D3_WIREFRAME	138
5.13.3	TEST_RELATION_FOR_SURFACE_MODEL	138
5.13.4	TEST_RELATION_FOR_SOLID_MODEL	139
5.14	Miscellaneous	139
5.14.1	MATERIAL	139
5.14.2	Private record structures attached to CAD data	140
5.14.2.1	RECORD	140
5.14.2.2	RECORD_TYPE	140
5.14.3	Interfacing with other data bases (not CAD data bases)	141
5.14.3.1	DATA_BASE_BRIDGE	141
5.14.3.2	DATA_BASE_LINK	141
5.15	Parametric modeling	141
5.15.1	PREDEFINED	142
5.15.2	INTEGER	142
5.15.3	INTEGER_EXPRESSION	142
5.15.4	REAL	143
5.15.5	REAL_EXPRESSION	143
5.15.6	MACRO	144
5.15.7	ROUTINE	145
5.15.8	FORMAL_PARAMETER	146
5.16	Extensions of the reference model under consideration	146
5.16.1	POLY_CURVE	146
5.16.2	POLY_SURFACE	147
5.16.3	Presentation of line geometry	149

6. Levels of schema implementations	151
6.1 The geometric modeling levels	151
6.1.1 Two-dimensional wireframes	151
6.1.2 Three-dimensional wireframes	151
6.1.3 Surface models	152
6.1.4 Single modeling type solids	152
6.1.4.1 Pure CSG models	152
6.1.4.2 Pure POLY_HEDRON models	152
6.1.4.3 Pure boundary representation models	152
6.1.5 Hybrid models	152
6.1.6 Full geometric capabilities	153
6.2 The assembly structure	153
6.2.1 No assembly structure	153
6.2.2 Assembly structure with three levels	153
6.2.3 Full assembly structure	153
6.3 Parametric models and macros	154
6.3.1 No parametric models, no macros	154
6.3.2 Only one parametric capability	154
6.3.2.1 Parametric models only	155
6.3.2.2 Macro capabilities only	155
6.3.3 Full parametric capabilities	155
6.4 References	155
6.4.1 No external references, no library references	155
6.4.2 No external references	155
6.4.3 No library references	155
6.4.4 Full referencing capabilities	156
7. The Physical Layer	157
7.1 The physical level	157
7.1.1 Tape characteristics	157
7.1.2 File transfer via computer networks	157
7.2 The metafile level	158
7.3 The alphabet level	159
7.4 Tokens of the neutral file language	160
7.4.1 Arithmetic expressions	162
7.5 The statement level	163
7.5.1 Basic statement productions	163
7.6 Rules for translating from the HDSL into BNF	164
7.7 Structure of the neutral file language	168
IMPLEMENTATION GUIDELINES	171
8. Definition of the finite state machine post-processor	173
8.1 The finite state machine approach	173
8.2 Interpreter	174
8.2.1 Begin interpretation of the neutral file	174
8.3 World	175
8.3.1 Open world	175

8.3.2 Close world	176
8.4 Entity with scope (except WORLD)	176
8.4.1 Open entity	176
8.4.2 Begin scope definition	177
8.4.3 End scope definition	177
8.4.4 Close entity	177
8.5 Entity without scope	178
8.6 Property definition	178
8.7 Interpretation of argument lists (except references)	178
8.8 References	179
8.9 Examples of error messages	179
9. State lists	181
10. Relationships between operating systems and CAD	183
10.1 Data bases and libraries	183
10.2 Binding of objects from the receiving world and part libraries	184
11. Programming rules for CAD*I processors	187
11.1 Programming language	187
11.1.1 Determination of the programming language	187
11.1.2 Requirements of structured programming	187
11.2 Software design	189
11.2.1 Organisation of the program	189
11.2.2 Software commenting	190
12. Programming interface	193
12.1 Mapping of HDSL data types onto FORTRAN	193
12.2 Application program interface routines	193
13. Comments on pre-processors	195
13.1.1 Implementation of level 1 and level 2 pre-processor routines	197
13.1.1.1 Level 1 routines	197
13.1.1.2 Level 2 routines	198
13.1.1.3 An example of a level 3 routine	199
14. Comments on post-processors	201
15. The interface of the CAD*I parser	203
15.1 Parse Tree	203
15.2 EXAMPLE	209
Appendix A. The graphical alphabet	213
Appendix B. The escape sequences	215
B.1 The Latin alphabet (ISO6937)	215
B.2 The Greek alphabet	216
B.3 The Kanji alphabet	217

Appendix C. Alphabet translation into a private alphabet	219
Appendix D. A neutral file for fixed format letters	225
Appendix E. Examples of CAD*I neutral files	227
Index	247