

Table of Contents

Table of Contents.....	vii
Foreword.....	xvii
Introduction	xviii
1 General.....	1
1.1 Scope	1
1.1.1 Extent.....	1
1.1.2 Structure	2
1.1.3 Conformity of an Implementation with the Standard.....	4
1.1.4 Method of Description and Syntax Notation.....	5
1.1.5 Classification of Errors	7
1.2 Normative References	8
1.3 Terms and Definitions	8
2 Lexical Elements	11
2.1 Character Set.....	11
2.2 Lexical Elements, Separators, and Delimiters	13
2.3 Identifiers	14
2.4 Numeric Literals	15
2.4.1 Decimal Literals	15
2.4.2 Based Literals	16
2.5 Character Literals	16
2.6 String Literals	17
2.7 Comments.....	17
2.8 Pragmas	18
2.9 Reserved Words	20
3 Declarations and Types.....	21
3.1 Declarations.....	21
3.2 Types and Subtypes	22
3.2.1 Type Declarations	24
3.2.2 Subtype Declarations	25
3.2.3 Classification of Operations	26
3.2.4 Subtype Predicates	27
3.3 Objects and Named Numbers.....	29
3.3.1 Object Declarations	31
3.3.2 Number Declarations.....	33
3.4 Derived Types and Classes	34
3.4.1 Derivation Classes.....	37
3.5 Scalar Types	39
3.5.1 Enumeration Types	44
3.5.2 Character Types.....	45
3.5.3 Boolean Types	46
3.5.4 Integer Types	46
3.5.5 Operations of Discrete Types.....	49
3.5.6 Real Types	50
3.5.7 Floating Point Types	51
3.5.8 Operations of Floating Point Types.....	53
3.5.9 Fixed Point Types	53

3.5.10 Operations of Fixed Point Types	55
3.6 Array Types	56
3.6.1 Index Constraints and Discrete Ranges	59
3.6.2 Operations of Array Types	60
3.6.3 String Types	61
3.7 Discriminants	62
3.7.1 Discriminant Constraints	64
3.7.2 Operations of Discriminated Types	65
3.8 Record Types	66
3.8.1 Variant Parts and Discrete Choices	68
3.9 Tagged Types and Type Extensions	70
3.9.1 Type Extensions	74
3.9.2 Dispatching Operations of Tagged Types	75
3.9.3 Abstract Types and Subprograms	78
3.9.4 Interface Types	79
3.10 Access Types	82
3.10.1 Incomplete Type Declarations	84
3.10.2 Operations of Access Types	87
3.11 Declarative Parts	93
3.11.1 Completions of Declarations	93
4 Names and Expressions	95
4.1 Names	95
4.1.1 Indexed Components	96
4.1.2 Slices	97
4.1.3 Selected Components	98
4.1.4 Attributes	100
4.1.5 User-Defined References	101
4.1.6 User-Defined Indexing	102
4.2 Literals	104
4.3 Aggregates	105
4.3.1 Record Aggregates	105
4.3.2 Extension Aggregates	107
4.3.3 Array Aggregates	109
4.4 Expressions	112
4.5 Operators and Expression Evaluation	113
4.5.1 Logical Operators and Short-circuit Control Forms	114
4.5.2 Relational Operators and Membership Tests	115
4.5.3 Binary Adding Operators	119
4.5.4 Unary Adding Operators	120
4.5.5 Multiplying Operators	120
4.5.6 Highest Precedence Operators	123
4.5.7 Conditional Expressions	124
4.5.8 Quantified Expressions	125
4.6 Type Conversions	126
4.7 Qualified Expressions	131
4.8 Allocators	131
4.9 Static Expressions and Static Subtypes	134
4.9.1 Statically Matching Constraints and Subtypes	138
5 Statements	139
5.1 Simple and Compound Statements - Sequences of Statements	139
5.2 Assignment Statements	140
5.3 If Statements	142

5.4 Case Statements	143
5.5 Loop Statements	144
5.5.1 User-Defined Iterator Types	146
5.5.2 Generalized Loop Iteration	147
5.6 Block Statements	149
5.7 Exit Statements	149
5.8 Goto Statements	150
6 Subprograms	153
6.1 Subprogram Declarations	153
6.1.1 Preconditions and Postconditions	156
6.2 Formal Parameter Modes	159
6.3 Subprogram Bodies	160
6.3.1 Conformance Rules	161
6.3.2 Inline Expansion of Subprograms	163
6.4 Subprogram Calls	163
6.4.1 Parameter Associations	165
6.5 Return Statements	168
6.5.1 Nonreturning Procedures	171
6.6 Overloading of Operators	172
6.7 Null Procedures	173
6.8 Expression Functions	174
7 Packages	175
7.1 Package Specifications and Declarations	175
7.2 Package Bodies	176
7.3 Private Types and Private Extensions	177
7.3.1 Private Operations	180
7.3.2 Type Invariants	182
7.4 Deferred Constants	184
7.5 Limited Types	185
7.6 Assignment and Finalization	187
7.6.1 Completion and Finalization	189
8 Visibility Rules	193
8.1 Declarative Region	193
8.2 Scope of Declarations	194
8.3 Visibility	195
8.3.1 Overriding Indicators	198
8.4 Use Clauses	199
8.5 Renaming Declarations	200
8.5.1 Object Renaming Declarations	200
8.5.2 Exception Renaming Declarations	202
8.5.3 Package Renaming Declarations	202
8.5.4 Subprogram Renaming Declarations	203
8.5.5 Generic Renaming Declarations	205
8.6 The Context of Overload Resolution	205
9 Tasks and Synchronization	209
9.1 Task Units and Task Objects	209
9.2 Task Execution - Task Activation	212
9.3 Task Dependence - Termination of Tasks	213
9.4 Protected Units and Protected Objects	215
9.5 Intertask Communication	218

9.5.1 Protected Subprograms and Protected Actions	220
9.5.2 Entries and Accept Statements	221
9.5.3 Entry Calls	224
9.5.4 Requeue Statements	227
9.6 Delay Statements, Duration, and Time	228
9.6.1 Formatting, Time Zones, and other operations for Time	231
9.7 Select Statements	237
9.7.1 Selective Accept	238
9.7.2 Timed Entry Calls	240
9.7.3 Conditional Entry Calls	241
9.7.4 Asynchronous Transfer of Control	241
9.8 Abort of a Task - Abort of a Sequence of Statements	242
9.9 Task and Entry Attributes	244
9.10 Shared Variables	244
9.11 Example of Tasking and Synchronization	246
10 Program Structure and Compilation Issues	249
10.1 Separate Compilation	249
10.1.1 Compilation Units - Library Units	249
10.1.2 Context Clauses - With Clauses	252
10.1.3 Subunits of Compilation Units	254
10.1.4 The Compilation Process	256
10.1.5 Pragmas and Program Units	257
10.1.6 Environment-Level Visibility Rules	258
10.2 Program Execution	259
10.2.1 Elaboration Control	261
11 Exceptions	265
11.1 Exception Declarations	265
11.2 Exception Handlers	266
11.3 Raise Statements	267
11.4 Exception Handling	267
11.4.1 The Package Exceptions	268
11.4.2 Pragmas Assert and Assertion_Policy	270
11.4.3 Example of Exception Handling	273
11.5 Suppressing Checks	274
11.6 Exceptions and Optimization	277
12 Generic Units	279
12.1 Generic Declarations	279
12.2 Generic Bodies	281
12.3 Generic Instantiation	282
12.4 Formal Objects	284
12.5 Formal Types	286
12.5.1 Formal Private and Derived Types	287
12.5.2 Formal Scalar Types	290
12.5.3 Formal Array Types	290
12.5.4 Formal Access Types	291
12.5.5 Formal Interface Types	292
12.6 Formal Subprograms	292
12.7 Formal Packages	295
12.8 Example of a Generic Package	297
13 Representation Issues	299

13.1 Operational and Representation Aspects	299
13.1.1 Aspect Specifications	302
13.2 Packed Types	305
13.3 Operational and Representation Attributes	306
13.4 Enumeration Representation Clauses	312
13.5 Record Layout	313
13.5.1 Record Representation Clauses	314
13.5.2 Storage Place Attributes	316
13.5.3 Bit Ordering	317
13.6 Change of Representation	318
13.7 The Package System	319
13.7.1 The Package System.Storage_Elements	321
13.7.2 The Package System.Address_To_Access_Conversions	322
13.8 Machine Code Insertions	322
13.9 Unchecked Type Conversions	323
13.9.1 Data Validity	324
13.9.2 The Valid Attribute	326
13.10 Unchecked Access Value Creation	326
13.11 Storage Management	327
13.11.1 Storage Allocation Attributes	330
13.11.2 Unchecked Storage Deallocation	331
13.11.3 Default Storage Pools	332
13.11.4 Storage Subpools	333
13.11.5 Subpool Reclamation	335
13.11.6 Storage Subpool Example	336
13.12 Pragma Restrictions and Pragma Profile	338
13.12.1 Language-Defined Restrictions and Profiles	340
13.13 Streams	342
13.13.1 The Package Streams	342
13.13.2 Stream-Oriented Attributes	343
13.14 Freezing Rules	348
The Standard Libraries	351
Annex A (normative) Predefined Language Environment	353
A.1 The Package Standard	356
A.2 The Package Ada	360
A.3 Character Handling	360
A.3.1 The Packages Characters, Wide_Characters, and Wide_Wide_Characters	361
A.3.2 The Package Characters.Handling	361
A.3.3 The Package Characters.Latin_1	364
A.3.4 The Package Characters.Conversions	369
A.3.5 The Package Wide_Characters.Handling	371
A.3.6 The Package Wide_Wide_Characters.Handling	373
A.4 String Handling	374
A.4.1 The Package Strings	374
A.4.2 The Package Strings.Maps	374
A.4.3 Fixed-Length String Handling	377
A.4.4 Bounded-Length String Handling	386
A.4.5 Unbounded-Length String Handling	393
A.4.6 String-Handling Sets and Mappings	398
A.4.7 Wide_String Handling	399
A.4.8 Wide_Wide_String Handling	401
A.4.9 String Hashing	404

A.4.10 String Comparison	405
A.4.11 String Encoding	406
A.5 The Numerics Packages	411
A.5.1 Elementary Functions	412
A.5.2 Random Number Generation	415
A.5.3 Attributes of Floating Point Types	420
A.5.4 Attributes of Fixed Point Types	424
A.6 Input-Output	425
A.7 External Files and File Objects	425
A.8 Sequential and Direct Files	426
A.8.1 The Generic Package Sequential_IO	427
A.8.2 File Management	428
A.8.3 Sequential Input-Output Operations	430
A.8.4 The Generic Package Direct_IO	430
A.8.5 Direct Input-Output Operations	431
A.9 The Generic Package Storage_IO	432
A.10 Text Input-Output	433
A.10.1 The Package Text_IO	434
A.10.2 Text File Management	439
A.10.3 Default Input, Output, and Error Files	440
A.10.4 Specification of Line and Page Lengths	441
A.10.5 Operations on Columns, Lines, and Pages	442
A.10.6 Get and Put Procedures	445
A.10.7 Input-Output of Characters and Strings	447
A.10.8 Input-Output for Integer Types	449
A.10.9 Input-Output for Real Types	450
A.10.10 Input-Output for Enumeration Types	453
A.10.11 Input-Output for Bounded Strings	454
A.10.12 Input-Output for Unbounded Strings	456
A.11 Wide Text Input-Output and Wide Wide Text Input-Output	457
A.12 Stream Input-Output	458
A.12.1 The Package Streams.Stream_IO	458
A.12.2 The Package Text_IO.Text_Streams	460
A.12.3 The Package Wide_Text_IO.Text_Streams	461
A.12.4 The Package Wide_Wide_Text_IO.Text_Streams	461
A.13 Exceptions in Input-Output	461
A.14 File Sharing	463
A.15 The Package Command_Line	463
A.16 The Package Directories	464
A.16.1 The Package Directories.Hierarchical_File_Names	472
A.17 The Package Environment_Variables	474
A.18 Containers	477
A.18.1 The Package Containers	477
A.18.2 The Generic Package Containers.Vectors	477
A.18.3 The Generic Package Containers.Doubly_Linked_Lists	495
A.18.4 Maps	506
A.18.5 The Generic Package Containers.Hashed_Maps	513
A.18.6 The Generic Package Containers.Ordered_Maps	517
A.18.7 Sets	521
A.18.8 The Generic Package Containers.Hashed_Sets	529
A.18.9 The Generic Package Containers.Ordered_Sets	534
A.18.10 The Generic Package Containers.Multiway_Trees	540
A.18.11 The Generic Package Containers.Indefinite_Vectors	554

A.18.12 The Generic Package Containers.Indefinite_Doubly_Linked_Lists	555
A.18.13 The Generic Package Containers.Indefinite_Hashed_Maps	555
A.18.14 The Generic Package Containers.Indefinite_Ordered_Maps	556
A.18.15 The Generic Package Containers.Indefinite_Hashed_Sets	556
A.18.16 The Generic Package Containers.Indefinite_Ordered_Sets	556
A.18.17 The Generic Package Containers.Indefinite_Multiway_Trees	557
A.18.18 The Generic Package Containers.Indefinite_Holders	557
A.18.19 The Generic Package Containers.Bounded_Vectors	561
A.18.20 The Generic Package Containers.Bounded_Doubly_Linked_Lists	562
A.18.21 The Generic Package Containers.Bounded_Hashed_Maps	563
A.18.22 The Generic Package Containers.Bounded_Ordered_Maps	564
A.18.23 The Generic Package Containers.Bounded_Hashed_Sets	565
A.18.24 The Generic Package Containers.Bounded_Ordered_Sets	567
A.18.25 The Generic Package Containers.Bounded_Multiway_Trees	568
A.18.26 Array Sorting	570
A.18.27 The Generic Package Containers.Synchronized_Queue_Interfaces	571
A.18.28 The Generic Package Containers.Unbounded_Synchronized_Queues	572
A.18.29 The Generic Package Containers.Bounded_Synchronized_Queues	573
A.18.30 The Generic Package Containers.Unbounded_Priority_Queues	574
A.18.31 The Generic Package Containers.Bounded_Priority_Queues	575
A.18.32 Example of Container Use	576
A.19 The Package Locales	578
Annex B (normative) Interface to Other Languages	581
B.1 Interfacing Aspects	581
B.2 The Package Interfaces	584
B.3 Interfacing with C and C++	585
B.3.1 The Package Interfaces.C.Strings	593
B.3.2 The Generic Package Interfaces.C.Pointers	596
B.3.3 Unchecked Union Types	599
B.4 Interfacing with COBOL	601
B.5 Interfacing with Fortran	607
Annex C (normative) Systems Programming	611
C.1 Access to Machine Operations	611
C.2 Required Representation Support	612
C.3 Interrupt Support	612
C.3.1 Protected Procedure Handlers	614
C.3.2 The Package Interrupts	616
C.4 Prelaboration Requirements	618
C.5 Pragma Discard_Names	619
C.6 Shared Variable Control	620
C.7 Task Information	622
C.7.1 The Package Task_Identification	622
C.7.2 The Package Task_Attributes	624
C.7.3 The Package Task_Termination	626
Annex D (normative) Real-Time Systems	629
D.1 Task Priorities	629
D.2 Priority Scheduling	631
D.2.1 The Task Dispatching Model	631
D.2.2 Task Dispatching Pragmas	633
D.2.3 Preemptive Dispatching	634
D.2.4 Non-Preemptive Dispatching	635

D.2.5 Round Robin Dispatching	637
D.2.6 Earliest Deadline First Dispatching	638
D.3 Priority Ceiling Locking.....	640
D.4 Entry Queuing Policies.....	642
D.5 Dynamic Priorities	644
D.5.1 Dynamic Priorities for Tasks	644
D.5.2 Dynamic Priorities for Protected Objects	645
D.6 Preemptive Abort	646
D.7 Tasking Restrictions.....	647
D.8 Monotonic Time	649
D.9 Delay Accuracy	653
D.10 Synchronous Task Control.....	654
D.10.1 Synchronous Barriers.....	655
D.11 Asynchronous Task Control.....	656
D.12 Other Optimizations and Determinism Rules	657
D.13 The Ravenscar Profile	658
D.14 Execution Time	659
D.14.1 Execution Time Timers	661
D.14.2 Group Execution Time Budgets.....	663
D.14.3 Execution Time of Interrupt Handlers	665
D.15 Timing Events.....	666
D.16 Multiprocessor Implementation	668
D.16.1 Multiprocessor Dispatching Domains.....	669
Annex E (normative) Distributed Systems	673
E.1 Partitions.....	673
E.2 Categorization of Library Units	675
E.2.1 Shared Passive Library Units	676
E.2.2 Remote Types Library Units	676
E.2.3 Remote Call Interface Library Units.....	678
E.3 Consistency of a Distributed System	679
E.4 Remote Subprogram Calls.....	679
E.4.1 Asynchronous Remote Calls.....	681
E.4.2 Example of Use of a Remote Access-to-Class-Wide Type.....	682
E.5 Partition Communication Subsystem	684
Annex F (normative) Information Systems.....	687
F.1 Machine_Radix Attribute Definition Clause	687
F.2 The Package Decimal.....	688
F.3 Edited Output for Decimal Types	689
F.3.1 Picture String Formation.....	690
F.3.2 Edited Output Generation	694
F.3.3 The Package Text_IO.Editing.....	698
F.3.4 The Package Wide_Text_IO.Editing.....	701
F.3.5 The Package Wide_Wide_Text_IO.Editing	701
Annex G (normative) Numerics	703
G.1 Complex Arithmetic.....	703
G.1.1 Complex Types	703
G.1.2 Complex Elementary Functions	708
G.1.3 Complex Input-Output	711
G.1.4 The Package Wide_Text_IO.Complex_IO	714
G.1.5 The Package Wide_Wide_Text_IO.Complex_IO.....	714
G.2 Numeric Performance Requirements	714

G.2.1 Model of Floating Point Arithmetic	715
G.2.2 Model-Oriented Attributes of Floating Point Types	716
G.2.3 Model of Fixed Point Arithmetic	717
G.2.4 Accuracy Requirements for the Elementary Functions	719
G.2.5 Performance Requirements for Random Number Generation	721
G.2.6 Accuracy Requirements for Complex Arithmetic	721
G.3 Vector and Matrix Manipulation	723
G.3.1 Real Vectors and Matrices	723
G.3.2 Complex Vectors and Matrices	728
Annex H (normative) High Integrity Systems	741
H.1 Pragma Normalize_Scalars	741
H.2 Documentation of Implementation Decisions	742
H.3 Reviewable Object Code	742
H.3.1 Pragma Reviewable	742
H.3.2 Pragma Inspection_Point	743
H.4 High Integrity Restrictions	744
H.5 Pragma Detect_Blocking	746
H.6 Pragma Partition_Elaboration_Policy	747
Annex J (normative) Obsolescent Features	749
J.1 Renamings of Library Units	749
J.2 Allowed Replacements of Characters	749
J.3 Reduced Accuracy Subtypes	750
J.4 The Constrained Attribute	751
J.5 ASCII	751
J.6 Numeric_Error	752
J.7 At Clauses	752
J.7.1 Interrupt Entries	752
J.8 Mod Clauses	754
J.9 The Storage_Size Attribute	754
J.10 Specific Suppression of Checks	754
J.11 The Class Attribute of Untagged Incomplete Types	755
J.12 Pragma Interface	755
J.13 Dependence Restriction Identifiers	755
J.14 Character and Wide_Character Conversion Functions	756
J.15 Aspect-related Pragmas	756
J.15.1 Pragma Inline	756
J.15.2 Pragma No_Return	757
J.15.3 Pragma Pack	757
J.15.4 Pragma Storage_Size	757
J.15.5 Interfacing Pragmas	758
J.15.6 Pragma Unchecked_Union	759
J.15.7 Pragmas Interrupt_Handler and Attach_Handler	759
J.15.8 Shared Variable Pragmas	760
J.15.9 Pragma CPU	760
J.15.10 Pragma Dispatching_Domain	761
J.15.11 Pragmas Priority and Interrupt_Priority	761
J.15.12 Pragma Relative_Deadline	762
J.15.13 Pragma Asynchronous	762
Annex K (informative) Language-Defined Aspects and Attributes	763
K.1 Language-Defined Aspects	763
K.2 Language-Defined Attributes	766

Annex L (informative) Language-Defined Pragmas..... 783

Annex M (informative) Summary of Documentation Requirements 787

M.1 Specific Documentation Requirements 787

M.2 Implementation-Defined Characteristics 789

M.3 Implementation Advice 796

Annex N (informative) Glossary 805

Annex P (informative) Syntax Summary 811

Annex Q (informative) Language-Defined Entities 845

Q.1 Language-Defined Packages..... 845

Q.2 Language-Defined Types and Subtypes 848

Q.3 Language-Defined Subprograms..... 852

Q.4 Language-Defined Exceptions 863

Q.5 Language-Defined Objects 864

Index..... 869