

# ASL Reference Progress DDI 0623

Arm Architecture Technology Group

January 24, 2024



# Contents

<b>1</b>	<b>Non-Confidential Proprietary Notice</b>	<b>5</b>
<b>2</b>	<b>Disclaimer</b>	<b>7</b>
<b>3</b>	<b>Not implemented in ASLRef</b>	<b>9</b>
3.1	Syntax . . . . .	9
3.1.1	Constrained bitvectors . . . . .	9
3.1.2	Guards . . . . .	9
3.2	Typing . . . . .	10
3.2.1	Immutability of expressions in constraint ranges . . . . .	10
3.2.2	Sound domains for under-constrained integers . . . . .	10
3.2.3	Statically evaluable programs . . . . .	10
3.2.4	Precise implementation of parameters type-checking . . . . .	10
3.2.5	Restriction on use of under-constrained types . . . . .	11
3.3	Semantics . . . . .	11
3.3.1	Real exponentiation . . . . .	11
<b>4</b>	<b>Not transliterated in ASL reference documents</b>	<b>13</b>
4.1	Typing . . . . .	13
4.1.1	Domains . . . . .	13
4.1.2	Global storage declarations . . . . .	13
4.1.3	Statically evaluable expressions . . . . .	13
4.1.4	Polymorphism . . . . .	13
4.1.5	Calls to setters and getters . . . . .	14
4.1.6	Type inference from literals . . . . .	14
4.2	Semantics . . . . .	14
4.2.1	Base values of types . . . . .	14
4.2.2	Operations . . . . .	14
4.2.3	Standard library and primitives . . . . .	14
4.3	Side-Effects . . . . .	14



# Chapter 1

## Non-Confidential Proprietary Notice

This document is protected by copyright and other related rights and the practice or implementation of the information contained in this document may be protected by one or more patents or pending patent applications. No part of this document may be reproduced in any form by any means without the express prior written permission of Arm. No license, express or implied, by estoppel or otherwise to any intellectual property rights is granted by this document unless specifically stated.

Your access to the information in this document is conditional upon your acceptance that you will not use or permit others to use the information for the purposes of determining whether implementations infringe any third party patents.

THIS DOCUMENT IS PROVIDED “AS IS”. ARM PROVIDES NO REPRESENTATIONS AND NO WARRANTIES, EXPRESS, IMPLIED OR STATUTORY, INCLUDING, WITHOUT LIMITATION, THE IMPLIED WARRANTIES OF MERCHANTABILITY, SATISFACTORY QUALITY, NON-INFRINGEMENT OR FITNESS FOR A PARTICULAR PURPOSE WITH RESPECT TO THE DOCUMENT. For the avoidance of doubt, Arm makes no representation with respect to, and has undertaken no analysis to identify or understand the scope and content of, any patents, copyrights, trade secrets, trademarks, or other rights.

This document may include technical inaccuracies or typographical errors.

TO THE EXTENT NOT PROHIBITED BY LAW, IN NO EVENT WILL ARM BE LIABLE FOR ANY DAMAGES, INCLUDING WITHOUT LIMITATION ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL, PUNITIVE, OR CONSEQUENTIAL DAMAGES, HOWEVER CAUSED AND REGARDLESS OF THE THEORY OF LIABILITY, ARISING OUT OF ANY USE OF THIS DOCUMENT, EVEN IF ARM HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

This document consists solely of commercial items. You shall be responsible for ensuring that any use, duplication or disclosure of this document complies fully with any relevant export laws and regulations to assure that this document or any portion thereof is not exported, directly or indirectly, in violation of such export laws. Use of the word “partner” in reference to Arm’s customers is not intended to create or refer to any partnership relationship with any other company. Arm may make changes to this document at any time and without notice.

This document may be translated into other languages for convenience, and you agree that if there is any conflict between the English version of this document and any translation, the terms of the English version of this document shall prevail.

The Arm corporate logo and words marked with ® or ™ are registered trademarks or trademarks of Arm Limited (or its affiliates) in the US and/or elsewhere. All rights reserved. Other brands and names mentioned in this document may be the trademarks of their respective owners. Please follow Arm’s trademark usage guidelines at <https://www.arm.com/company/policies/trademarks>.

Copyright © [2023,2024] Arm Limited (or its affiliates). All rights reserved.

Arm Limited. Company 02557590 registered in England. 110 Fulbourn Road, Cambridge, England CB1 9NJ. (LES-PRE-20349)

## Chapter 2

# Disclaimer

This document is part of the ASLRef material. It is a snapshot of: <https://github.com/herd/herdtools7/commit/6dd15fe7833fea24eb94933486d0858038f0c2e8>

This material covers both ASLv0 (viz, the existing ASL pseudocode language which appears in the Arm Architecture Reference Manual) and ASLv1, a new, experimental, and as yet unreleased version of ASL.

The development version of ASLRef can be found here `~/herdtools7/asllib`.

A list of open items being worked on can be found here `~/herdtools7/asllib/doc/ASLRefProgress.tex`.

This material is work in progress, more precisely at Alpha quality as per Arm's quality standards. In particular, this means that it would be premature to base any production tool development on this material.

However, any feedback, question, query and feature request would be most welcome; those can be sent to [asl-support@arm.com](mailto:asl-support@arm.com) or by raising issues or PRs to the herdtools7 github repository.





## Chapter 3

# Not implemented in ASLRef

This chapter describes what is not yet present in the executable version of ASLRef.

### 3.1 Syntax

#### 3.1.1 Constrained bitvectors

Constrained bitvectors are not yet implemented in ASLRef.

For example, the following function is not understood by ASLRef:

```
func foo(x: bits({3, 5})) => integer
begin
  return Len(x) * 2;
end
```

Here the length of the formal argument `x` needs to be declared as a parameter, for example as follows:

```
func foo {N: integer {3, 5}} (x: bits(N)) => integer
begin
  return Len(x) * 2;
end
```

This also applies to bitvectors constrained by a type.

This is related to `R_FHYZ`, `R_VBMX`, `R_XVWK`, `R_PMQB`, `R_VCZX`, `I_TZVJ`, `I_GLWM`, `I_MTWL`, `R_QYZD`, `I_NFBN`, `R_LJBG`, `I_YBHF`, `R_FZSD`.

#### 3.1.2 Guards

Guards are used on `case` and `catch` statements, to restrict matching on the evaluation of a boolean expression. They are not yet implemented in ASLRef.

This relates to  $R_{WGSY}$ .

## 3.2 Typing

Note that as it stands, the type system of ASL is not sound. Our proposal can be found at: <https://github.com/herd/herdtools7/pull/747>

This is related to  $I_{JSKW}$ .

### 3.2.1 Immutability of expressions in constraint ranges

The constraints of an integer type should be *constrained, statically evaluable expressions*, i.e. the variables used by expressions describing an integer constraint should be immutable and of a constrained type, and those expressions should be side-effect-free.

Furthermore, those constraints should not include Checked Type Conversions.

This also applies to bitvector widths.

This is related to  $R_{BSMK}$ ,  $R_{LSNP}$ ,  $R_{GHRP}$ ,  $R_{LVTH}$ ,  $I_{ZLZC}$ ,  $R_{RHTN}$ ,  $R_{XNBN}$ ,  $I_{GQYG}$ .

### 3.2.2 Sound domains for under-constrained integers

Under-constrained integers have for the moment the same domain. This makes the type-system unsound, as one can assign one under-constrained integer to another.

This is related to  $I_{JSKW}$ .

### 3.2.3 Statically evaluable programs

Side effects analysis has not been implemented yet. This makes detection of statically evaluable subprograms impossible.

Furthermore, non-execution time subprograms, expressions, and types have not been implemented.

This is related to  $I_{LZCX}$ ,  $I_{NXJR}$ ,  $R_{CSFT}$ ,  $I_{HYBT}$ ,  $D_{CCTY}$ ,  $I_{LYKD}$ ,  $I_{ZPWM}$ ,  $D_{KCKX}$ ,  $I_{NTYZ}$ ,  $I_{MSZT}$ ,  $D_{QNHM}$ ,  $I_{XYKC}$ ,  $D_{ZPMF}$ ,  $I_{XSDY}$ ,  $D_{XRBT}$ ,  $I_{WVGG}$ ,  $D_{JLJD}$ ,  $I_{KKDY}$ ,  $D_{MTQJ}$ ,  $I_{YBGL}$ ,  $I_{YMRT}$ ,  $I_{QJTN}$ ,  $I_{GFZT}$ .

### 3.2.4 Precise implementation of parameters type-checking

The code handling parameter type-checking at a function declaration is not safe: some checks are missing.

Furthermore, the handling of formal arguments that should be considered as parameters is also not finished.

This is related to  $I_{BLVP}$ ,  $R_{RKBV}$ ,  $I_{TQGH}$ .

### 3.2.5 Restriction on use of under-constrained types

#### As storage types

Restrictions on use of under-constrained types as storage element types are not implemented.

This is related to  $R_{ZCVD}$ .

#### As expression with a constrained type

Restriction on the use of under-constrained parameters as left-hand-side of a Checked Typed Conversion is not implemented in ASLRef. For example, the following will not raise a type-error:

```
    return N as integer {0..2*N};
end
```

```
func main () => integer
begin
  assert foo ('100') == 3;
```

This is related to  $I_{TBHH}$ ,  $R_{ZDKC}$ .

## 3.3 Semantics

### 3.3.1 Real exponentiation

The exponentiation operation `exp_real` has not been implemented. Note: this would construct non-rational numbers which are not supported by ASLRef, e.g.  $2^{\frac{1}{2}} = \sqrt{2}$ .

This is related to  $R_{BNCY}$ .



## Chapter 4

# Not transliterated in ASL reference documents

### 4.1 Typing

#### 4.1.1 Domains

The transliteration of the notion of domains will be made more complete in the future.

#### 4.1.2 Global storage declarations

Global storage declarations are not transliterated.

This is related to  $R_{FWQM}$ .

#### 4.1.3 Statically evaluable expressions

The part of statically evaluable expressions that has been implemented in ASLRef (see Section 3.2.3) has not been transliterated.

Equivalence of statically evaluable expressions has been implemented in a restricted setting (see Section 3.2.3). Mainly, expressions that reduce to polynomials can be checked for equivalence. This has not been transliterated either.

This is related to  $R_{PKKK}$ ,  $D_{YYDW}$ ,  $D_{CWVH}$ ,  $D_{HLQC}$ , and  $I_{LHLR}$ ,  $R_{RFQP}$ ,  $R_{VNKT}$ .

#### 4.1.4 Polymorphism

Polymorphism in ASL is the ability to have multiple subprograms with the same name that do not have the same signature.

Although polymorphism is implemented in ASLRef, it has not yet been transliterated.

This is related to  $D_{BTBR}$ ,  $I_{FSFQ}$ ,  $I_{FCTB}$ ,  $I_{PFGQ}$ ,  $R_{PGFC}$ ,  $I_{BTMT}$ .

### 4.1.5 Calls to setters and getters

The replacement of implicit calls to getters and setters (written for example as slices) to explicit calls to subprograms has not been transliterated. In terms of abstract syntax, this corresponds to the translation between a `E.Slice` and a `E.Call`.

This is related to `IYQX`, `ILJLW`, `IMFBC`.

### 4.1.6 Type inference from literals

Finding the type of a literal value, or a compile-time constant expression, is not yet transliterated.

This is related to `RZJKY` and `IRYP`.

## 4.2 Semantics

### 4.2.1 Base values of types

Finding the base value of a type is not transliterated.

This is related to `RNJDZ`, `RCFTD`, `RQGGH`, `IWVQZ`, `RGYCG`, `RWKCY`, `RLCCN`, `RCPCK`, `RZVPT`, `IQFZH`, `RZGVR`, `IPGSS`, `RQWSQ`, `RHMRK`, `RMBRM`, `RSVJB`.

### 4.2.2 Operations

Operations are not transliterated from ASLRef.

This is related to `RNCCW`, `RVGZF`, `RTHSV`, `RCRQJ`, `RZTJN`, `RSVMM`, `RWWTV`, `RGHXR`, `INBCT`.

### 4.2.3 Standard library and primitives

The standard library is not transliterated.

This is related to `RRXYN`.

## 4.3 Side-Effects

Side-Effects are not yet considered in ASLRef.