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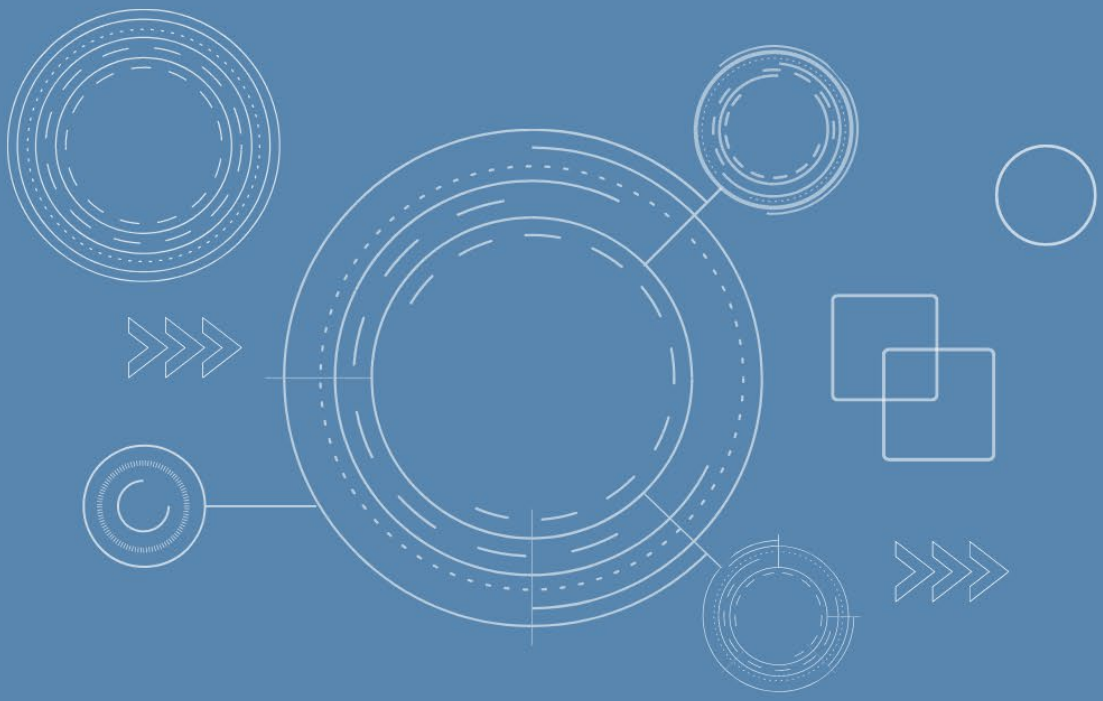

WHITE PAPER

MIGRATING NATURAL TO JAVA

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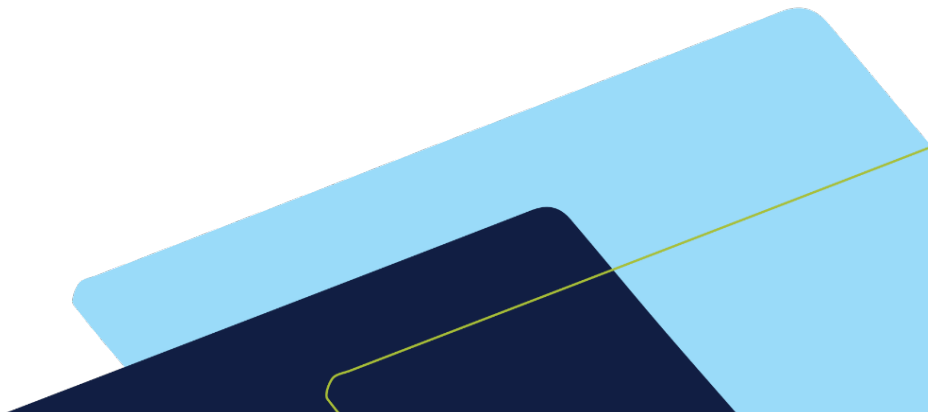

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Migrating Natural to Java

How can businesses move safely and cost-effectively from SAG Natural to Java? This document explores migration through automated code conversion, a mature approach being perfected by the software company Astadia, as an answer to this question.

The document explores the key business drivers for making the step from Natural to Java, and how Astadia tools make this transition possible. It will explain the added value Astadia migration offers over other approaches and demystify the migration process with a step-by-step look at the way Natural can be transformed into working, maintainable Java code.

1. Why Migrate from Natural to Java?

1.1. Reasons to Go to Java

There are many good reasons to make the move from Natural to Java, but the following are the largest concerns for businesses:

- High (and continuously increasing) maintenance and runtime fees for the existing Natural products.
- Shrinking availability of Natural developers and lack of interest in Natural from young developers.
- Lack of an easy transition path from the mainframe version of Natural to its Linux, Unix, and Windows platform versions.

Java offers answers to all of the above concerns:

- Maintenance fees are negligible when compared to Natural (or even nonexistent depending on the choices made).
- Java is one of the most widely used programming languages today[1] , and it is the language of choice for instruction in the IT programs of many schools. Documentation of the language, software libraries, and development tools are also available free of charge.
- Java is very formally specified, and the Java Language Specification can be accessed and downloaded over the internet free of charge. Furthermore, the Java platform has an open membership community process, with companies as diverse as HP, Cisco, IBM, Hitachi, Boeing, and Oracle working together to adapt the technology to new computing demands. The portability of the technology and its suitability to internet-computing have been defining features from the very first versions, ensuring the language is dialect-free, despite it having multiple implementations on multiple platforms.
- Its interoperability and portability are unsurpassed when compared to other technologies: it operates with practically all database and middleware technologies in use today and runs on everything from smartphones to washing machines to mainframes.

Next to that, moving to Java also means:

- Enabling the use of a state-of-the-art IDE, with extensive debugging, refactoring, profiling and (unit)testing support.
- Enabling the use of thousands of third-party libraries, covering almost all imaginable computing needs: UI-development, database interaction, mail/ftp/http/… communication, parsing, xml processing, …
- Enabling the use of modern application architectures including the use of JEE application servers, web front ends, SOA, cloud deployment, …

[1] References: https://pypl.github.io/PYPL.html, http://trendyskills.com/

1.2. Approaches: Replacement, Rewrite or Automated Migration

Once the need to move away from Natural has been established, the next big question is: how to turn a large, mature Natural code base into the Java equivalent?

Most organizations take one of three approaches:

1. Replace by third party COTS (Commercial Off-The-Shelf) software,
2. Rewrite, or
3. Migrate automatically.

Replacement by COTS software is the most cost-effective solution, but only practical if one can actually find 3rd party software that offers the same functionality as the existing Natural application (and provides a migration path for the existing data).

Rewriting on the other hand too often has led to huge costs and ultimately to project failures. According to a research note from Gartner[2] the cost for rewriting is between $6 and $26 per Line of Code (LOC), and accomplished at a rate of 160 LOC per day and per developer. Even extrapolated to a code base of only 1M LOC, it is obvious that these will become very expensive, lengthy, and risky projects.

Astadia advocates automated migration as the only realistic approach for large, legacy applications:

- It offers consistency: since all source code is translated by software, there can be no differences in quality and all existing functionality is kept as-is.
- It offers speed and continuous improvement possibilities: a complete code base can be converted in a couple of hours, meaning that this process can be repeated as often as needed or wanted.
- It offers a very large degree of testability: when keeping the converted application's functionality and user interface unchanged, the original application's behavior can effectively be used as a regression test (and running this regression test, too, can be automated).
- It offers minimal interruption: because of the speed of the conversion, any "code freeze" period before taking the migrated application into production can be kept to a minimum. The existing team can keep working on its daily tasks, including the ongoing maintenance of the Natural code, during most of the migration project.
- It gives Astadia the confidence to offer projects with fixed duration and price, equivalent functional behavior, and equivalent performance.

Like most IT projects, a migration project is a complex undertaking, one that deserves the right amount of expertise and dedication. Astadia has developed project and product methodologies, and we are happy to provide you with more information regarding these.

[2] Gartner Research Note "Forecasting the Worldwide IT Services Industry: 1999,1"

2. Natural to Java: Architecting a Migration

This section focuses on the underlying design principles that any migration from Natural to Java should consider, and how Astadia has incorporated these in its set of flexible tools.

2.1. Keys to a Successful Migration

What are the keys to a successful migration project? A primary concern in any migration is how to validate the functional correctness of the new programs. In Natural to Java migrations, this can be hard, especially if the Natural programs are driving business-critical processes and they are being adapted to evolving user requirements while a migration is running at the same time.

Under these circumstances, migrations should target:

Equivalent Program Behavior and Performance
For programs to be functionally correct, business users have to accept them. For large Natural applications that are being actively maintained, users and developers have an existing and well-tried process to specify changes, develop, test, and bring new releases into production. This familiar process should not be disturbed by migration efforts. An important best practice in migrations is targeting functional and performance equivalence with a production release and avoid whenever possible the introduction of functional changes that don't follow the standard development process. This approach makes it possible to leverage automated testing tools to reduce project costs, improve accuracy and move the project forward faster.

Automated, Iterative Processes
To manage risk, the generally accepted process in migrations is no different from that of conventional software engineering: using agile, iterative processes that can periodically align the migration project to the latest versions of the Natural programs undergoing the migration. Consistency and speed are also critical to a parallel iterative process. Using tools to automate the migration imposes rigorous consistency of transformation and brings the end goal within reach of stakeholders.

Developer Confidence
There are many differences between Natural (a procedural, business-oriented language with a very rich runtime and non-procedural statements) and Java (an object-oriented, managed, multi-purpose language). Natural developers that need to maintain the new Java programs will need to be confident in their ability to recognize the business rules and correctly implement and test the changes they make after the migration is completed.

2.2. Key Traits of a Professional Software Conversion Tool

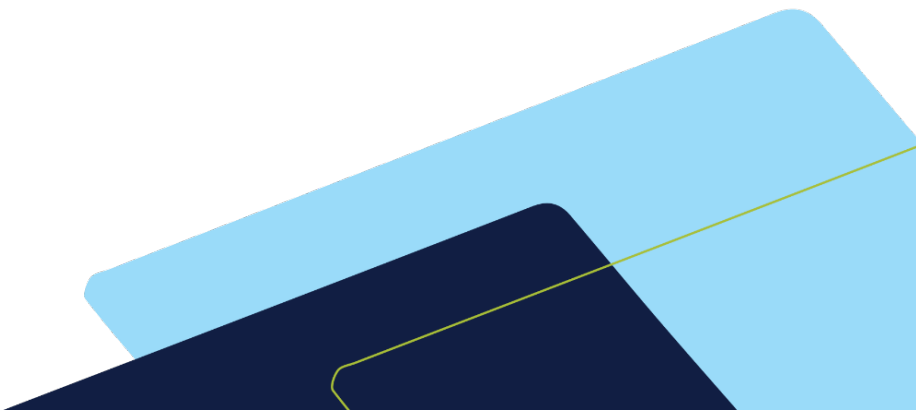
The key hallmarks of a professional language translation tool are the way it strikes a balance between three spectra of interest.

Astadia's Natural-to-Java conversion tools offer a solution to each of these areas:

Customization and Consistency
Anyone who has written software in a team before knows any program can be written in a variety of ways. A professional software conversion tool will provide the means to apply a configuration of customization options that suit the requirements of the customer. These options can be simple things like naming conventions and the formatting of comments, or they can be more sophisticated, like the efforts the conversion tool will spend to detect and optimize structural or object oriented patterns that are inherent to the Natural code. At the same time, the tool should make it possible to manage such a configuration of customization options for a consistent application in an iterative process. These management facilities should also include configuration of other aspects of the migration like the translation of scripts, screens, or databases.

Maintainability by Natural and Java Developers
Consistent translation improves the maintainability of the generated Java, but for the Java code to be easy to work with for the Natural developers, it also needs to be based around simple design principles. This means the migration should generate code that provides (as much as possible) a 1:1 relationship between the number of lines of Natural code and the number of lines of Java, and keeps identifiers (variable names, program names, …) as close as possible to the original ones. This will facilitate the recognition of business entities and rules in Java by the Natural developer. At the same time, Java developers with limited exposure to Natural should be able to pick up the programs and be optimally productive in the shortest possible timeframe. Simple design principles improve the understandability of the converted programs also by Java developers. Typical Natural constructs that are unknown in Java (like `REDEFINES`, or `ESCAPE` handling, or `BREAK` handling) are transformed into their closest Java-style equivalents.

Functional Equivalence with Natural and Full Support for the Target Platform
The basic requirement of a conversion tool is that the programs it produces are 100% functionally equivalent (including side effects encountered at runtime) with the original Natural programs. At the same time, the code that is produced should enable full use of the richness of the target platform. This means some Natural language syntax will be replaced with calls to Java SE and EE platform APIs. It also means that the code should be fully usable in Visual Studio and support execution in debug mode. It also means that the code should be fully usable in modern Java development tools like Eclipse or NetBeans and support execution in debug mode. And also, the converted programs should easily be integrated with newly written Java programs and vice versa.



2.3. Flexible Migration Tools

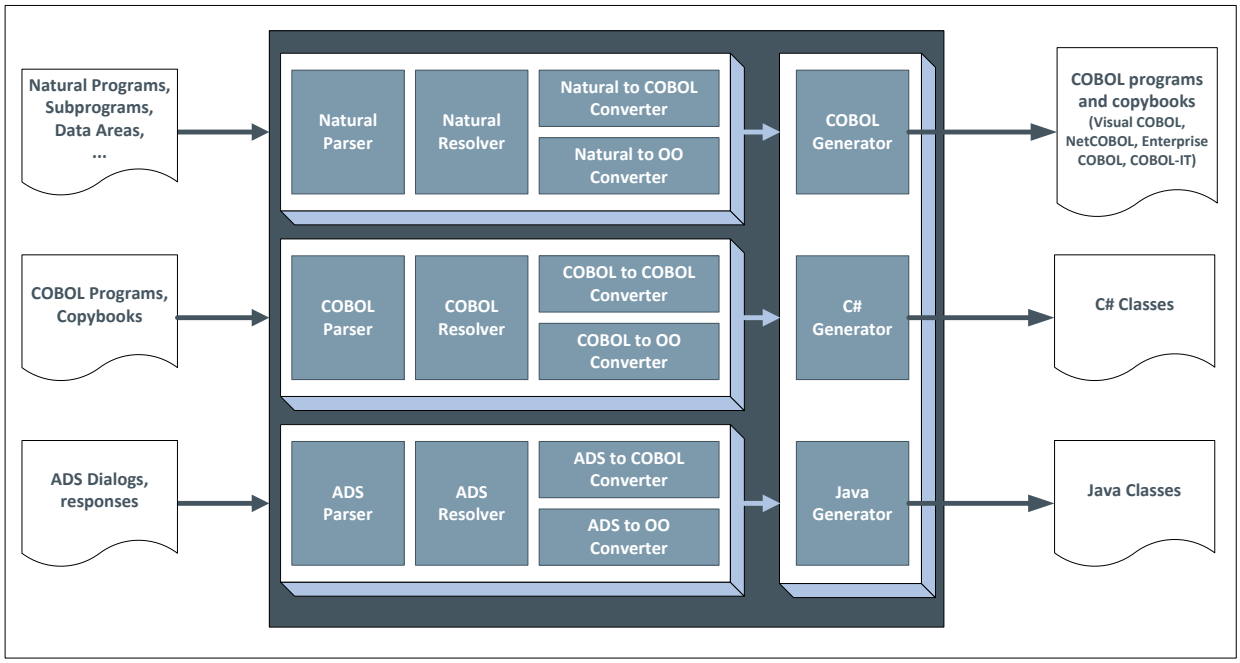
2.3.1. Rationale

For conversions from one programming language to another, Astadia has built a set of tools, collectively called the Language Convertor, with one important consideration in mind: each customer is different, and each migration is different. Every organization for example has its own development and design standards, patterns, and frameworks. Some prefer all data access in a separate layer, others choose for embedded data access.

When migrating from Natural to Java, some organizations will prefer to keep the resulting Java relatively close to the original Natural, for reasons of readability and maintainability by the existing developers. Other organizations will choose a more radical approach and prefer Java that uses more Object-Oriented design patterns.
In order to be able to accommodate these considerations, standards, and frameworks the Astadia tools are parameterized and customized for each project.

To address the stringent requirements listed in the above two sections, Astadia have selected a modular approach to building migration tools for all of its supported source platforms (Natural, IDMS, COBOL, …).
For language to language conversion tools, such as Natural to Java, the architectural overview of the internals of these tools looks like this:

- A parser that supports the complete Natural syntax.
- A resolver that links together the AST[3] that is produced by the parser with control-flow and data-usage information.
- Conversion rules for Natural syntax, from single statements to complex patterns of code, implemented in function of the target language.
- Code generators for Java, Java, and various COBOL dialects, enabling any desired coding style.



[3] Abstract Syntax Tree, a hierarchical representation of source code

2.3.2. Intelligent Conversion

To keep up with the design principle of a fully automated migration, conversion rules have been implemented in the Natural to OO Converter module to cover all possible edge cases. From time to time this could lead to relatively complicated Java code. Therefore, the conversion tools also recognize coding patterns (by static code analysis) that indicate where simpler, more elegant Java code can be generated while still staying 100% functionally equivalent to the Natural original.

Examples of such optimization can be found in the example code of the migration of the Natural loop statements to Java, and in the handling of the `DECIDE` statements.

3. Natural to Java: A High-Level Tour

This section first lists the main challenges involved in converting Natural to Java. Next, some examples will be shown of converted Natural code. These examples use the default conversion settings and are provided as-is, except that line breaks may have been added or removed in order for the code to fit on the page.

3.1. Challenges

When converting Natural, with both its procedural syntax and rich runtime, to a modern OO language such as Java, there are a lot of architectural and behavioral mismatches that need to be overcome:

- While Natural data items have an associated type (alphanumeric, date, logical, …), they can also be redefined and treated as a completely difference data type. This makes it possible to store "illegal" values (for example, the value "HELLO" could be stored in an alphanumeric redefinition of a numeric field, resulting in an invalid[4] number).
  Java on the other hand is a strongly typed language, which makes it impossible to assign a number to a String variable or vice versa.

- Natural programs typically use copycodes as a means to re-use code in multiple programs. Java on the other hand does not have the concept of an "include file".

- Some Natural control-flow instructions, such as `REINPUT` and `RETRY`, simply don't have a counterpart in Java.

- Some Natural control-flow instructions, such as `ESCAPE`, map rather nicely to exception handling, but this incurs an overhead that may not be desirable (e.g. if used in tight loops).

- Natural is known for its high-precision arithmetic (29 digits). While Java offers a `BigDecimal` type, its behavior is not quite the same as that of a Natural numeric field.

- Natural programs can import database fields using only their name, with types taken from the corresponding DDM module. This means that a data dictionary change, such as extending a text field from 20 to 30 characters, does force a recompilation but no actual code change.

3.2. Target Java Version

The migration targets Java 8 or later, because this produces the most readable and compact code (thanks to the use of lambdas and method references).

[4] Strictly speaking, "HELLO" is a valid value for a Natural numeric field (format length "(N5)"); on EBCDIC systems, "HELLO" corresponds to hexadecimal value X'C8C5D3D3D6', and Natural would interpret this as a valid numeric value (-85336).

3.3. Hello World

Natural program objects get mapped to Java classes that extend a corresponding base class (Program, Subprogram, Map, …); and the top-level program code is located in the "`run()`" method.
A NaturalObject annotation is used to mark classes representing migrated program objects, in order to support dynamic steplib-based lookup at runtime (and to avoid any forced correlation between the class/package name and the original library/object names).

Let's start with a simple example: a main program called HELLO from library WHITEPPR, which prints "HELLO WORLD".

Natural

```
0010 WRITE 'HELLO WORLD'
0020 END
```

Java

```
package com.customer.whitepaper.code.programs;

import com.Astadia.naturalservices.*;
import com.Astadia.naturalservices.objects.*;

@NaturalObjectName("HELLO")
public final class HELLO extends Program {

  @Override
  protected void run() {
    Natural.write().text("HELLO WORLD").execute();
  }

}
```

Notes:

- The formatting of the Java code can be customized to a certain degree. For more advanced formatting rules, dedicated tools and/or IDE features are expected to be used. The samples in this document use the default settings.
- The package used for migrated code is configurable. The samples in this document will use a fixed prefix ("com.customer") and have the WHITEPPR library configured to use "whitepaper" as package name. The final component of the package name is a classification of the original Natural object (e.g. "code.maps" for maps, "db" for DDMs, "data.parameter" for PDAs, …).
- The mapping for most Natural names (library name, object name, subroutine name, field name, …) is fully configurable, whether via general rules (e.g. "use lower camel case") or explicit specification. The default for Java class names is "same as the Natural name, with invalid characters mapped to underscores", which is why HELLO remained HELLO (and ABC-DEF would have become ABC_DEF).

The second example is a subprogram and includes a subroutine:

Natural

```
0010 DEFINE DATA
0020   PARAMETER USING MYPDA
0030 END-DEFINE
0040 PERFORM WRITE-GREETING
0050 DEFINE SUBROUTINE WRITE-GREETING
0060   WRITE (2) #GREETING 'WORLD'
0070 END-SUBROUTINE
0080 END
```

Java

```java
package com.customer.whitepaper.code.subprograms;

import java.util.stream.Stream;

import com.Astadia.naturalservices.*;
import com.Astadia.naturalservices.objects.*;

import com.customer.whitepaper.data.parameter.MyPDA;

@NaturalObjectName("HELLO2")
public final class Hello2 extends Subprogram {

  private final MYPDA_Area mypda = new MYPDA_Area();

  @Override
  protected Stream<DataArea> getDataAreas() {
    return Stream.of(this.mypda);
  }

  @Override
  protected void run() {
    Natural.perform(this::writeGreeting);
  }

  @InternalSubroutine("WRITE-GREETING")
  private void writeGreeting() {
    Natural.write(2)
            .field(this.mypda.xgreeting)
            .text("WORLD")
            .execute();
  }

}
```

Notes:

- The `DEFINE DATA PARAMETER` block is represented by a private field matching the type of the referenced PDA. Note that for data areas, the default name mapping includes an "_Area" suffix. This is because data areas commonly contain a group item of the same name as the area, which would otherwise cause clashes.
- The `getDataAreas()` method returns all areas set up via `DEFINE DATA`, which allows the framework to apply proper initialization and parameter matching behind the scenes.
- The mapping for the `PERFORM` statement uses a reference to the method created for the `DEFINE SUBROUTINE`, instead of calling it directly. This allows the framework to apply pre/post processing around the method call behind the scenes (e.g. handling `ESCAPE`s, updating system variables, …).
- The default mapping for field names is used; this converts "`#GREETING`" to "`xgreeting`", because '#' is not a valid identifier component in Java.

3.4. Additional examples

Our extended Natural to Java Transformation Research Paper delves deeper into the main challenges of Natural to Java migration, with examples of Java equivalents of converted Natural code, with the tools configured to their current defaults which produce OO-style Java code, with many other mappings and configurations possible. Next to the short code snippets like the one above, a more comprehensive program sample is also provided.

Further examples include Natural **loop statements**, **data items**, the different types of **basic control flow**, and **REINPUT** and **RETRY statements**.

Request the Natural to Java Transformation Research Paper at info@astadia.com.

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For nearly three decades, Astadia has performed mainframe modernization projects for government agencies and enterprises throughout the world:

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