ADA LOG

Thinking about Ada...

Introduction to Ada
for
Beginning or Experienced Programmers

J-P. Rosen
Adalog
www.adalog.fr

Who's that lady?

Ada Augusta Byron,
countess of Lovelace
(1815-1852)

- Poet Lord Byron's daughter
- A Mathematician
- Worked with Charles Babbage on the Difference Engine
- Invented the first program for Babbage's Difference Engine
- First “computer scientist” in history

Brief history of Ada-the-language

- 1983: The basis
  - ☞First industrial language with exceptions, generics, tasking
- 1995: OOP, protected objects, hierarchical libraries
  - ☞First standardized object-oriented language
- 2005: Interfaces, improving existing features
  - ☞Putting it all together

A free language

- An international standard
  - ISO 8652:1995, freely available
  - Does not belong to any company
  - Entirely controlled by its users
- Free (and proprietary) compilers
- Many free resources
  - Components, APIs, tutorials…
  - http://www.adapower.com, http://www.adaworld.com
- A dynamic community
  - comp.lang.ada, fr.comp.lang.ada

Who uses Ada?

Who uses Ada?

Who uses Ada?

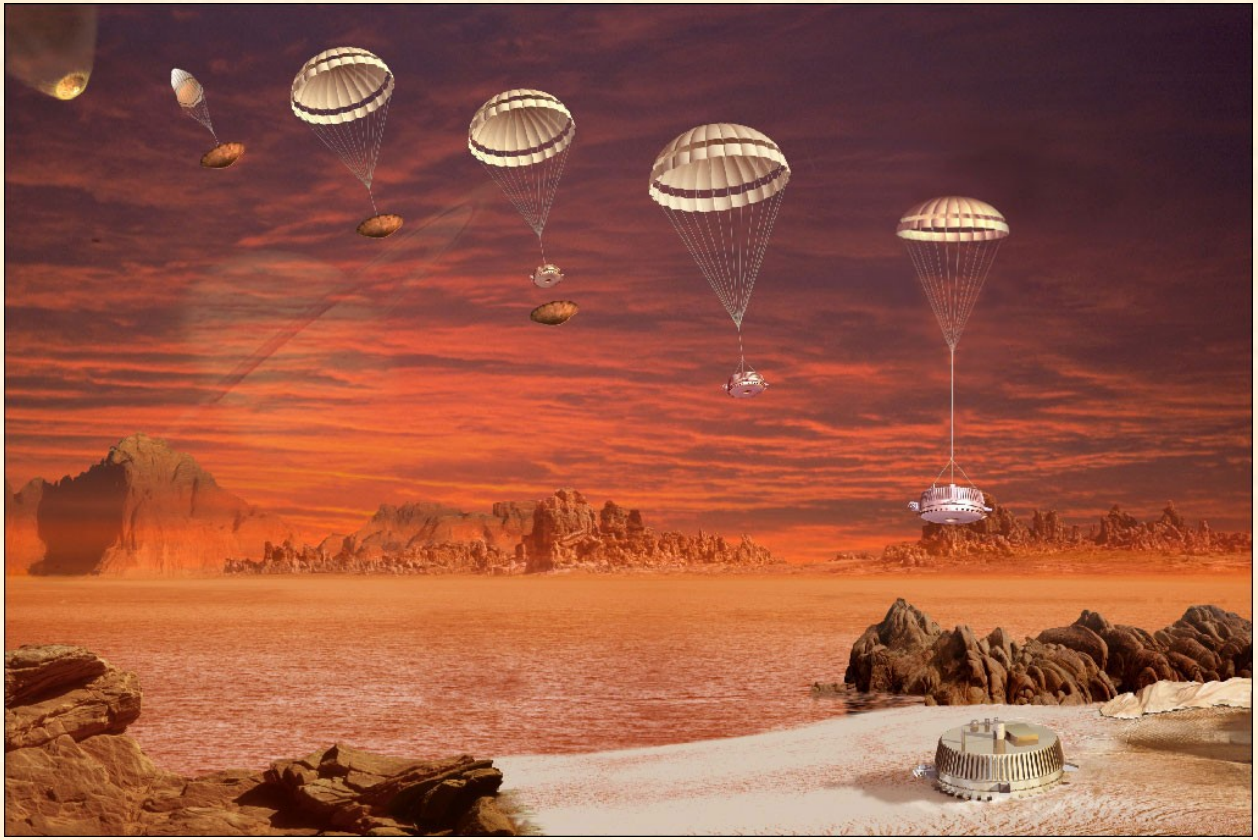


Photo ESA

Who uses Ada?

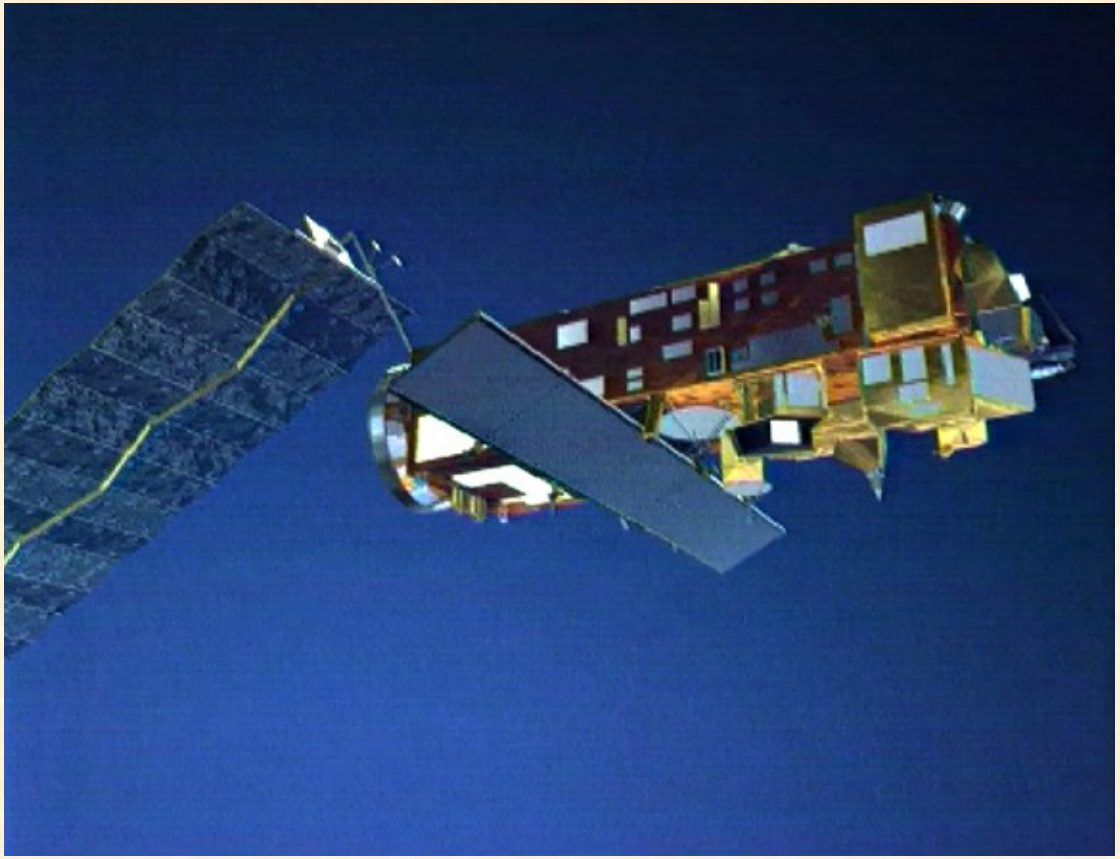


Photo ESA

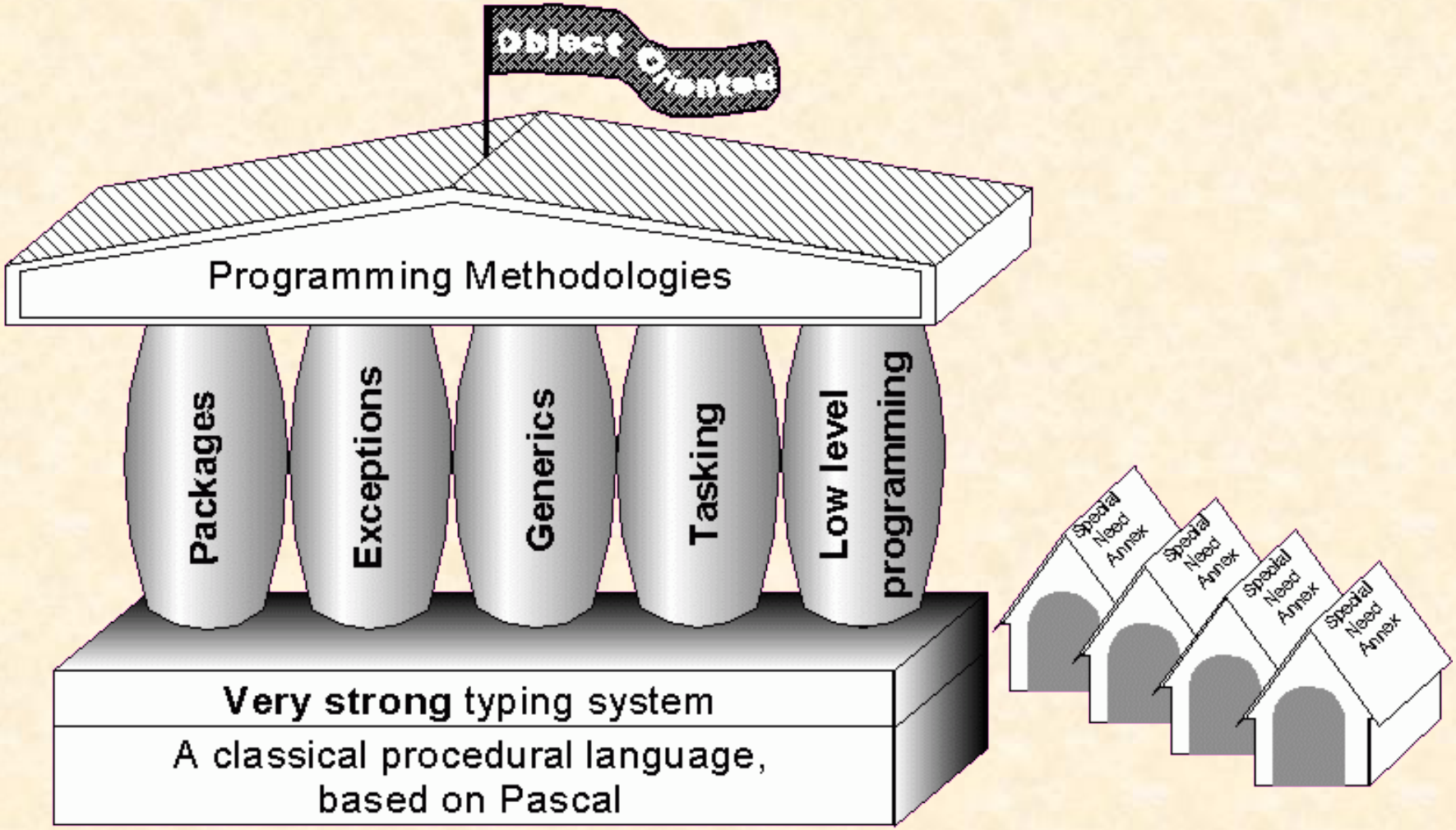
Why use Ada?

- When failure is not an option
  - Of course, Ada is used in safety critical systems...
- Other systems should not fail!
  - Buffer overflows are still the most common origin of security breaches
- Ada checks a lot at compile time
  - Bad design doesn't compile!

What's important in a language is not what it allows

What's important in a language is what it forbids

What's in Ada


Object Oriented
Programming Methodologies
Packages
Exceptions
Generics
Tasking
Low level programming
Special Need Annex
Special Need Annex
Special Need Annex
Special Need Annex
Very strong typing system
A classical procedural language, based on Pascal

Readable, Pascal-like syntax

```
for C in Colour loop
   I := I + 1;
end loop;

while I > 1 loop
   I := I - 1;
end loop;

Main_Loop :
loop
   I := I + 1;

   exit Main_Loop when I = 100;
   I := I + 2;
end loop Main_Loop;
```

```
if I in 1 .. 10 then
   Result := Red;
elsif I in 11 .. 20 then
   Result := Green;
elsif I in 21 .. 30 then
   Result := Blue;
end if;

case I is
   when 1 .. 10  =>
      Result := Red;
   when 11 .. 20 =>
      Result := Green;
   when 21 .. 30 =>
      Result := Blue;
   when others   =>
      Result := Red;
   -- all cases must be handled
end case;
```

```
Mat := ((1, 0),
        (0, 1));

Head := new Node'(Value=> 10_000,
                  Next => new Node'(Value=> 2009, Next=> null);
```

Strong typing system

```
type Age   is range 0..125;
type Floor is range -5 .. 15;

My_Age  : Age;
My_Floor: Floor;
  ...
My_Age   := 10;          -- OK
My_Floor := 10;          -- OK
My_Age   := My_Floor;    -- FORBIDDEN !
```

Problem level Age, Floor...

You do the mapping

Machine level Byte, Int...

Language level

Strong typing system

```
type Age   is range 0..125;
type Floor is range -5 .. 15;

My_Age  : Age;
My_Floor: Floor;
  ...
My_Age   := 10;          -- OK
My_Floor := 10;          -- OK
My_Age   := My_Floor;    -- FORBIDDEN !
```

Problem level Age, Floor... Ada level

The compiler does the mapping

Machine level Byte, Int...

User defined elementary types

- Enumeration:

```
type State is (Idle, Waiting, Active);
```

- Signed integer:

```
type Age is range 0..125;
```

- Modular integer:

```
type Hash_Index is mod Hash_Size;
```

- Floating point

```
type Length is digits 5 range 0.0 .. 4.0E6;
```

- Binary fixed point:

```
type Voltage is delta 0.1 range 0.0 .. 100.0;
```

- Decimal:

```
type Euros is delta 0.01 digits 11;
```

Packages (1)

```
package Colour_Manager is
   type Colour is private;
   type Density is delta 1.0/256.0 range 0.0 .. 1.0;

   Red, Green, Blue : constant Colour;

   function "+" (Left, Right : Colour) return Colour;
   function "*" (Coeff: Density; Origin : Colour) return Colour;

private
   type Colour is
      record
         R_Density, G_Density, B_Density : Density;
      end record;
   Red   : constant Colour := (1.0, 0.0, 0.0);
   Green : constant Colour := (0.0, 1.0, 0.0);
   Blue  : constant Colour := (0.0, 0.0, 1.0);
end Colour_Manager;
```

```
package body Colour_Manager is
   ...
end Colour_Manager;
```

Packages (2)

```
with Colour_Manager;
procedure Paint is
   use Colour_Manager;
   My_Colour : Colour := 0.5*Blue + 0.5*Red;
begin
   -- Make it darker
   My_Colour := My_Colour * 0.5;
   My_Colour := My_Colour / 2.0; -- Forbidden (or define "/")
   ...
end Paint;
```

Abstractions are enforced

Dependences are explicit
➔ no makefiles!

Derived types

```
with Colour_Manager;
procedure Mix_Paints is
   use Colour_Manager;

   type Water_Paint is new Colour;
   type Oil_Paint   is new Colour;

   W : Water_Paint;
   O : Oil_Paint;
begin
   W := Red;   -- OK
   O := Red;   -- OK
   W := O;

   W := W + O;
   W := W + Blue;   -- OK
end Mix_Paints;
```

Error! Inconsistent types

Use the language to add more controls

Discriminated types

```
type Major  is (Letters, Sciences, Technology);
type Grade is delta 0.1 range 0.0 .. 20.0;

type Student_Record (Name_Length : Positive;
                     With_Major  : Major)
is record
   Name    : String(1 .. Name_Length); --Size depends on discriminant
   English : Grade;
   Maths   : Grade;

   case With_Major is      -- Variant part, according to discriminant
      when Letters =>
         Latin : Grade;
      when Sciences =>
         Physics   : Grade;
         Chemistry : Grade;
      when Technology =>
         Drawing : Grade;
   end case;
end record;
```

Discriminants

Discriminants are to data
what parameters are to subprograms

Object Oriented Programming

- Is Ada object oriented?

  Yes, of course...

  .. But the model is quite original

- See you tomorrow
  - ☞Same place, 11:00
  - ☞Same speaker...

Exceptions

- Every run-time error results in an exception
  - Buffer overflow
  - Dereferencing null
  - Device error
  - Memory violation (in C code!)
  - ...
- Every exception can be handled

Take care of the unexpected unexpected

Generics

- Provide algorithms that work on any data type with a *required* set of properties

```
generic
   type Item is private;
procedure Swap (X, Y : in out Item);

procedure Swap (X, Y : in out Item) is
   Temp : Item;
begin
   Temp := X;
   X    := Y;
   Y    := Temp;
end Swap;
```

```
   procedure Swap_Age is new Swap (Age);
   My_Age, His_Age : Age;
begin
   Swap_Age (My_Age, His_Age);
```

Tasking

- Tasking is an integral part of the language
  - Not a library
- Tasks (*threads*) are high level objects
- High level communication and synchronization
  - Rendezvous (client/server model)
  - Protected objects (passive monitors)
- Tasking is easy to use
  - Don't hesitate to put tasks in your programs!

Tasking example

```
with Ada.Text_IO; use Ada.Text_IO;
procedure Task_Example is
   task Server is
      entry Are_You_Here;
   end Server;

   task body Server is
   begin
      Put_Line ("Server starting");
      accept Are_You_Here;
      Put_Line ("Server going on");
   end Server;

begin
   Put_Line ("Main starting");
   Server.Are_You_Here;
   Put_Line ("Main going on");
end Task_Example;
```

Server waits for client

Client calls server

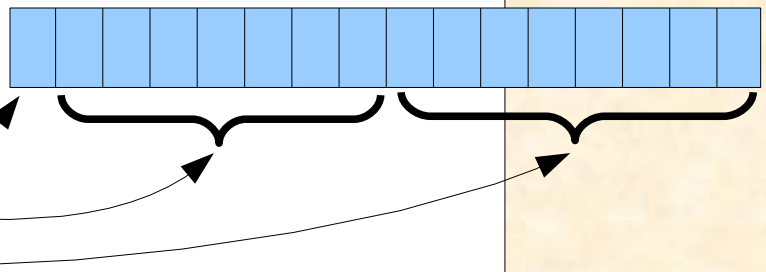
Protected example

```
protected type Barrier is
  entry Wait;

  procedure Signal;

  function Count return Natural;

private
  Arrived : Boolean := False;
end Barrier;
```

Access to low level

- Let the compiler do the hard work
  - ☞You describe the high level view
  - ☞You describe the low level view
  - ☞You work at high level, and get what you want at low level

```
type BitArray is array (Natural range <>) of Boolean;
type Monitor_Info is
   record
      On     : Boolean;
      Count  : Natural range 0..127;
      Status : BitArray (0..7);
   end record;

for Monitor_Info use
   record
      On     at 0 range 0 .. 0;
      Count  at 0 range 1 .. 7;
      Status at 0 range 8 .. 15;
   end record;
```

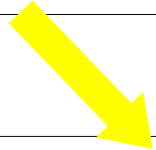


Access to low level

- Let the compiler do the hard work
  - ☞You describe the high level view
  - ☞You describe the low level view
  - ☞You work at high level, and get what you want at low level

```
type BitArray is array (Natural range <>) of Boolean;
type Monitor_Info is
   record
      On     : Boolean;
      Count  : Natural range 0..127;
      Status : BitArray (0..7);
   end record;

for Monitor_Info use
   record
      On     at 0 range 0 .. 0;
      Count  at 0 range 1 .. 7;
      Status at 0 range 8 .. 15;
   end record;
```

```
   MI : Monitor_info;
begin
   MI.Status(3) := False;
```



```
ANDB [BP-11],-9
```

Really low level

```
KBytes : constant := 1024;

Memory : Storage_Array (0..640*KBytes-1);
for Memory'Address use To_Address(0);

procedure Poke (Value : Byte; Into : Storage_Offset) is
begin
  Memory (Into) := Value;
end Poke;

function Peek (From : Storage_Offset) return Byte is
begin
  return Memory (From);
end Peek;
```

- You can include machine code...
- You can handle interrupts...

Everything can be done in Ada, provided it is stated **clearly**

Special Needs Annexes

- An annex is an extension of the standardisation for specific problem domains.
  - ☞ An annex contains no new syntax. An annex may define only packages, pragmas or attributes.
- System Programming Annex
- Real-Time Annex
- Distributed Systems Annex
- Information Systems Annex
- Numerics Annex
- Safety and Security Annex

A portable language

- Really portable!
  - Configure/automake.. only compensate for lack of portability
  - The virtual machine concept is just a workaround for the lack of portability of programming languages.
  - But there are compilers for the JVM and .net as well…
- All compilers implement *exactly* the same language
  - and are checked by passing a conformity suite
- High level constructs protect from differences between systems

Linux, Windows: 100% same code

Ease of writing

- Try GNAT's error messages!

```
procedure Error is
   Lines : Integer;
begin
   Line := 3;
   Lines = 3;
end Error;
```

error.adb:4:04: "Line" is undefined
error.adb:4:04: possible misspelling of "Lines"

error.adb:5:10: "=" should be ":="

- The language protects you from many mistakes
  - Strong typing is not a pain, it's a help!
  - If it compiles, it works...
  - Spend your time on *designing*, not chasing stupid bugs

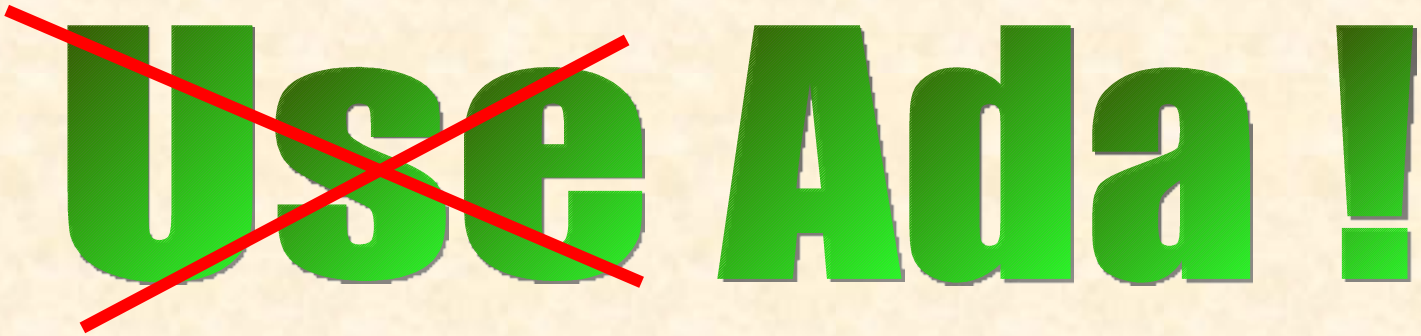
An efficient language

- The compiler is very fast
  - … it is written in Ada!
  - Especially considering the services provided by the language
- Generated code is very fast
  - Try it!
  - High level semantics allow the compiler to remove unnecessary checks
- To be honnest…
  - It was not the case of early compilers
  - Beware of old tales!

Components and Tools

- Ada interfaces easily with other languages
  - Bindings are available for most usual components
    - Posix, Win32, X, Motif, Gtk, Qt, Tcl, Python, Lua, Ncurses, Bignums, Corba, MySQL, PostGres…
- Unique to Ada:
  - AWS (Ada Web Server)
    - A complete web development framework
  - ASIS (Ada Semantic Interface Specification)
    - Makes it easy to write tools to process and analyze Ada sources
  - Many more…

Conclusion



Conclusion

Try Ada !

…and discover what higher level programming means