ENERGY SYSTEM MODEL INCUBATOR

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Incubator - definition

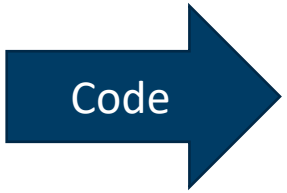
An insulated enclosure in which all environmental conditions can be regulated for optimal growth

(Britannica encyclopedia)

Model incubator - motivation

- Internal initiative in SINTEF
  - Responsibility to manage the knowledge that clients have invested in over many years
- Goals
  - Contribute to long-term strategy for model development
  - Increase our ability to use IT professionals in software devlopment
  - Establish quality-assured software development processes
- Budget 1MNOK
- Start in May 2020, end in September 2020

Software management



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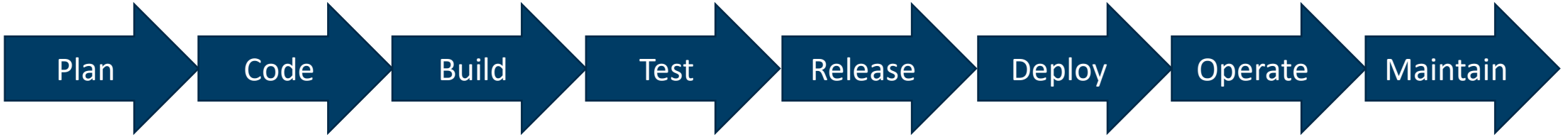
Software management



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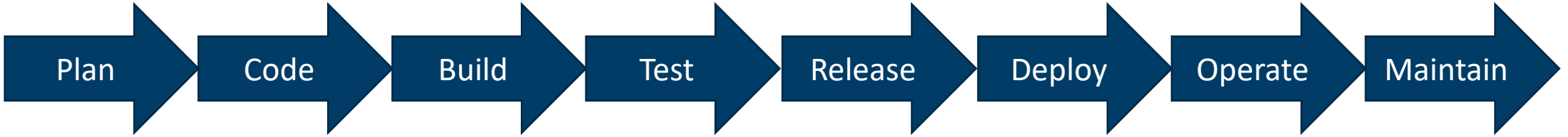
Software management



Programming language

Interoperability

Code standards

Data structuring

Version control

Test frameworks

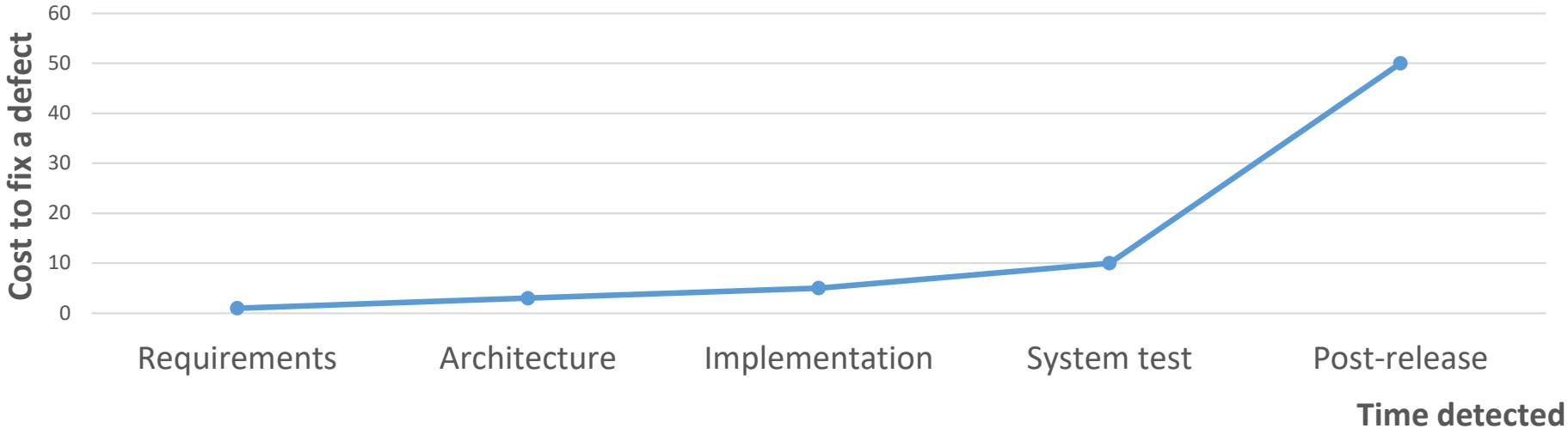
Release pipeline

Documentation

Customer portal

Ticket system

Software management



Plan → Code → Build → Test → Release → Deploy → Operate → Maintain

Programming languages

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Up and coming programming languages

- Systems programming language
- Performance like C
- Designed for safety
  - Prevents memory errors
  - Prevents concurrency issues

- High-level language
- High performance
- Designed for scientific computing
  - Large mathematical function library
  - Easy to call C code

Evaluation of languages

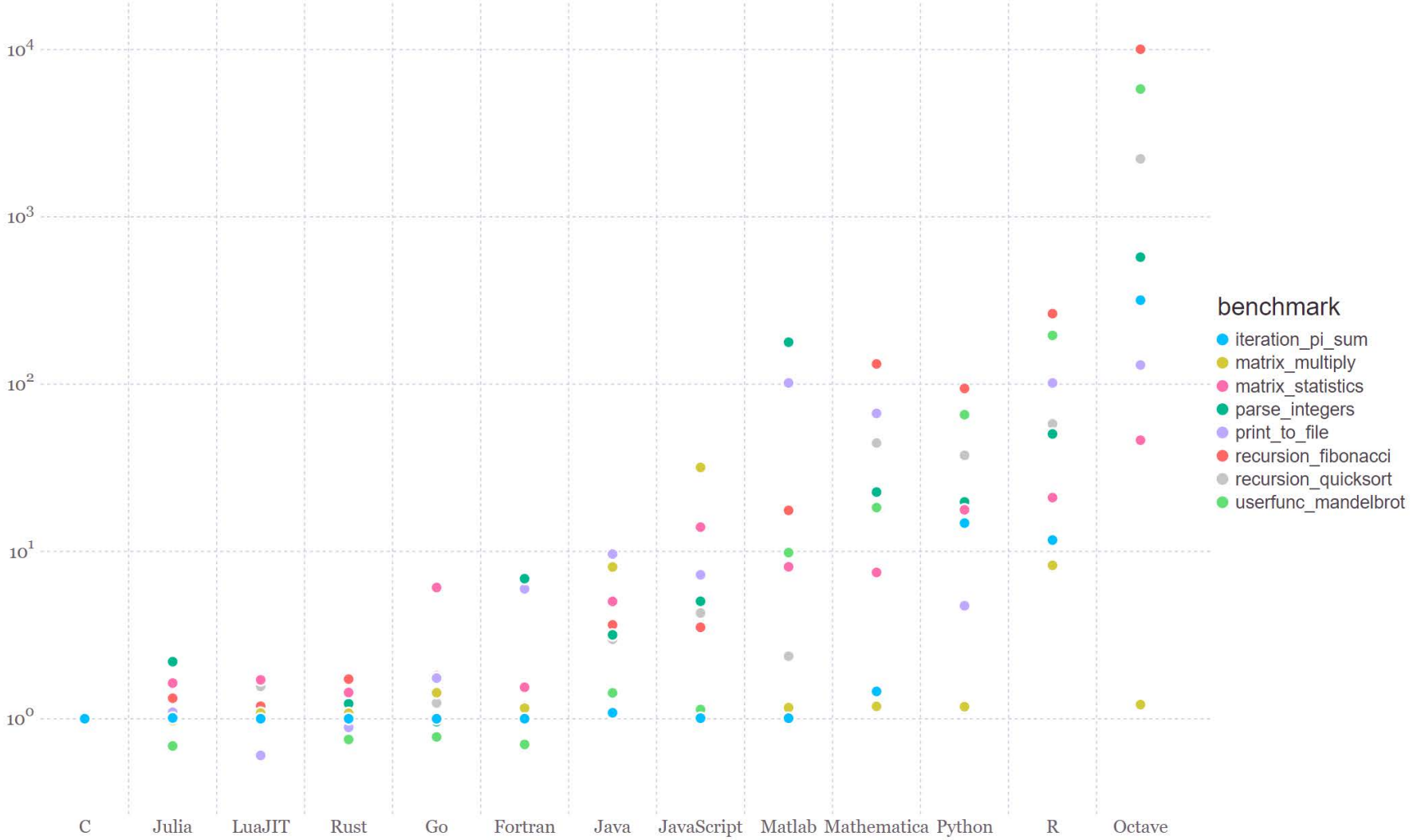
TIOBE Programming Community index
https://www.tiobe.com/tiobe-index/

Sep 2020	Sep 2019	Change	Programming Language	Ratings	Change
1	2	↑	C	15.95%	+0.74%
2	1	↓	Java	13.48%	-3.18%
3	3		Python	10.47%	+0.59%
4	4		C++	7.11%	+1.48%
5	5		C#	4.58%	+1.18%
6	6		Visual Basic	4.12%	+0.83%
7	7		JavaScript	2.54%	+0.41%
8	9	↑	PHP	2.49%	+0.62%
9	19	⇈	R	2.37%	+1.33%
10	8	↓	SQL	1.76%	-0.19%
11	14	↑	Go	1.46%	+0.24%
12	16	⇈	Swift	1.38%	+0.28%
13	20	⇈	Perl	1.30%	+0.26%
14	12	↓	Assembly language	1.30%	-0.08%
15	15		Ruby	1.24%	+0.03%
16	18	↑	MATLAB	1.10%	+0.04%
17	11	⇊	Groovy	0.99%	-0.52%
18	33	⇈	Rust	0.92%	+0.55%
19	10	⇊	Objective-C	0.85%	-0.99%

Evaulation of languages – architecture

	Python	Julia	Rust	C	C++	Fortran
Compiled?	No	JIT	Yes	Yes	Yes	Yes
Binary distribution	Many 3. Party libs	PackageCompiler Limited usage, Some problems	Yes, inherent	Yes, Inherent	Yes, Inherent	Yes, Inherent
Binary size	…	LARGE!	Small/medium	Small	Small	Small
Binary, protected source code	…	Not well protected	Protected	Protected	Protected	Protected
Run time reqs	Python	Julia	Optional C/C++ libs	Optional C/C++ libs	Optional C/C++ libs	Optional C/C++ libs
Community	Large, Growing	Small/Moderate, Growing	Small/Moderate, Growing	Moderate, Slowly decreasing	Moderate, Stable	Small, Slowly decreasing
Memory model	GC	GC	Unique ownership model	User managed	User managed	User managed

Evaluation of languages - performance



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Evaluation of languages - interoperability

Callee\Caller	Python	Julia	Rust	C	C++	Fortran
Python		Yes (built in)	Yes	Yes	Yes	
Julia	Yes (package)		Systemcall	Yes? (hassle)	Yes? (hassle)	Systemcall
Rust		Yes (ccall)		Yes (C api)	Yes (C api)	No? (via C?)
C	Yes (slow!)	Yes (fast, ccall)	Yes (unsafe)			Yes
C++	Yes (slow!)	No? (C api)	No? (C api)			No? (C api)
Fortran	Limited (F2PY)	Yes (fast, ccall)	Yes (iso c)	Yes (iso c)	Yes (iso c)	

Code examples - Initialization

Rust

```rust
#[derive(Clone, Copy)]
struct XY {
    x: Option<u32>,
    y: Option<u32>
}

struct ProdriskCore {
    value_a: Option<XY>
}

impl ProdriskCore {
    pub fn set_xy(&mut self, x: u64, y: u64) {
        let xy = XY{x: Some(x), y: Some(y)};
        self.value_a = Some(xy);
    }

    // Extraction from nested option can be simplified by ?
    pub fn get_a_x(&mut self) -> Option<u64>{
        self.value_a?.x
    }
}

fn main() {
    let mut prodrisk = ProdriskCore {value_a: None};
    println!("Err {:?}", prodrisk.get_a_x());
    prodrisk.set_xy(1, 2);
    let x = prodrisk.get_a_x();
    println!("Err {:?}", x);

    match x {
        Some(i) => prodrisk.set_xy(i*2, 1),
        _ => (),
    }
}
```

Fortran

```fortran
program main

implicit none

    ! type declarations
    type xy
        integer :: x
        integer :: y
        logical :: x_flag
        logical :: y_flag
    end type xy

    type prodriskcore
        type(xy), pointer :: value_a
        logical :: defined
    end type prodriskcore

    ! local variable declarations
    type(prodriskcore), pointer :: prodrisk
    logical :: prodrisk_defined
    integer :: xval

    ! code
    allocate(prodrisk)
    prodrisk_defined = .true.
    prodrisk%defined = .false.

    if (prodrisk_defined) then
        xval = get_prodrisk_a_x(prodrisk)
    else
        xval = -1
    end if

    call print_positive (xval)

    if (prodrisk_defined) then
        call set_prodrisk_xy(prodrisk, 1, 2)
        xval = get_prodrisk_a_x(prodrisk)
    else
        xval = -1
    end if
    call print_positive(xval)

    if (xval > -1 .and. prodrisk_defined) then
        call set_prodrisk_xy(prodrisk, xval*2, xval)
    end if

    if (prodrisk_defined) then
        if (prodrisk%defined) then
            deallocate(prodrisk%value_a)
        end if
        deallocate(prodrisk)
    end if

contains
    function get_prodrisk_a_x (prodrisk)

    implicit none

        ! dummy arguments
        integer :: get_prodrisk_a_x
        type(prodriskcore), pointer, intent(in) :: prodrisk

        if (prodrisk%defined) then
        ! short circuit logic not guaranteed in fortran
            if (prodrisk%value_a%x_flag) then
                get_prodrisk_a_x = prodrisk%value_a%x
            else
                get_prodrisk_a_x = 0
            end if
        else
            get_prodrisk_a_x = -1
        end if
    end function get_prodrisk_a_x


    subroutine set_prodrisk_xy (prodrisk, x, y)

    implicit none

        ! arguments
        type(prodriskcore), pointer, intent(in) :: prodrisk
        integer, intent(in) :: x
        integer, intent(in) :: y

        if (.not. prodrisk%defined) then
            allocate(prodrisk%value_a)
            prodrisk%defined = .true.
        end if
        prodrisk%value_a%x = x
        prodrisk%value_a%y = y
        prodrisk%value_a%x_flag = .true.
        prodrisk%value_a%y_flag = .true.
    end subroutine set_prodrisk_xy

    subroutine print_positive (x)
    implicit none

        integer :: x

        if (x > -1) then
            print*, x

        else
            print*, 'None'
        end if

    end subroutine print_positive

end program main
```


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Toolchains

Git

SVN (Subversion)

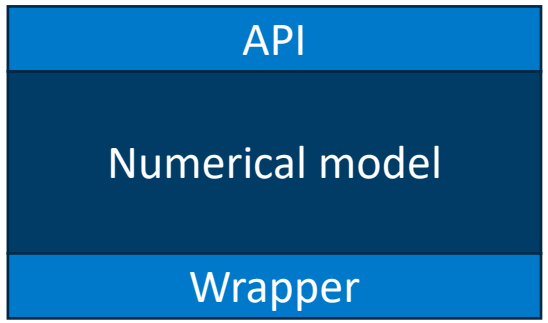
TeamCity build server

Markdown documentation

Model architecture

Numerical model

Model architecture



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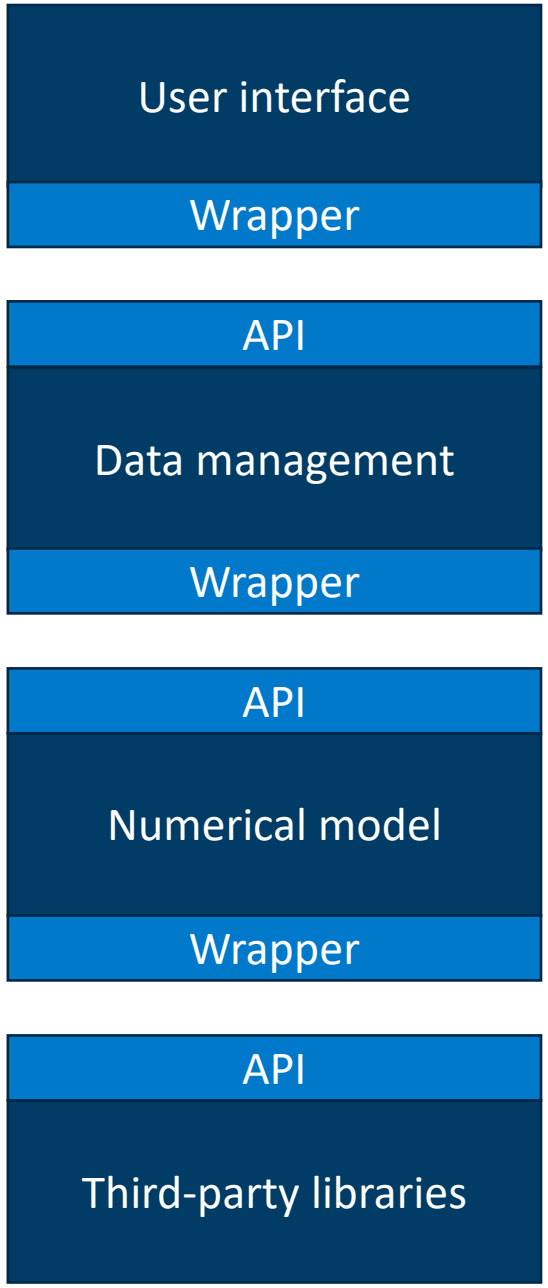
Model architecture



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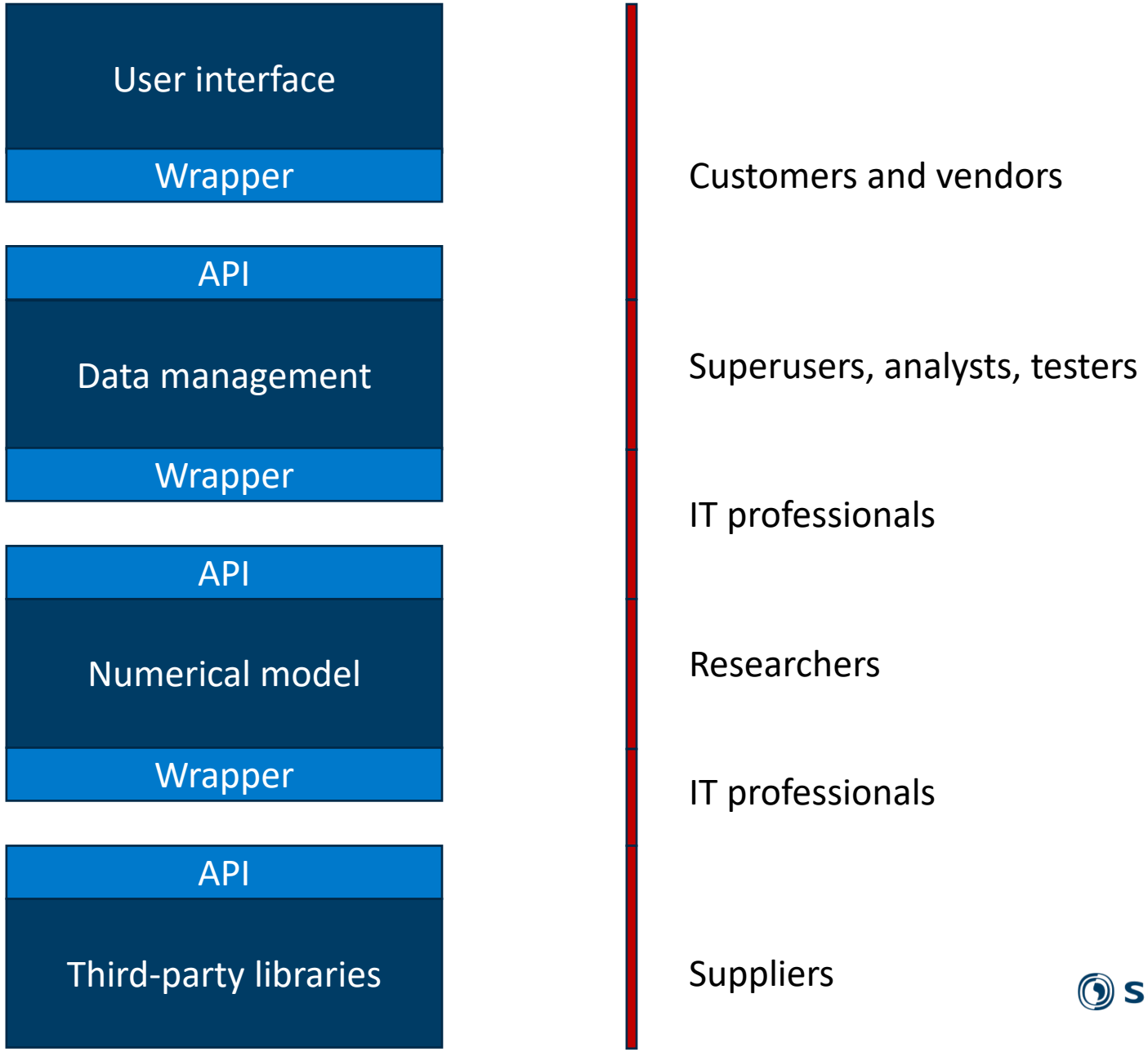
Model architecture



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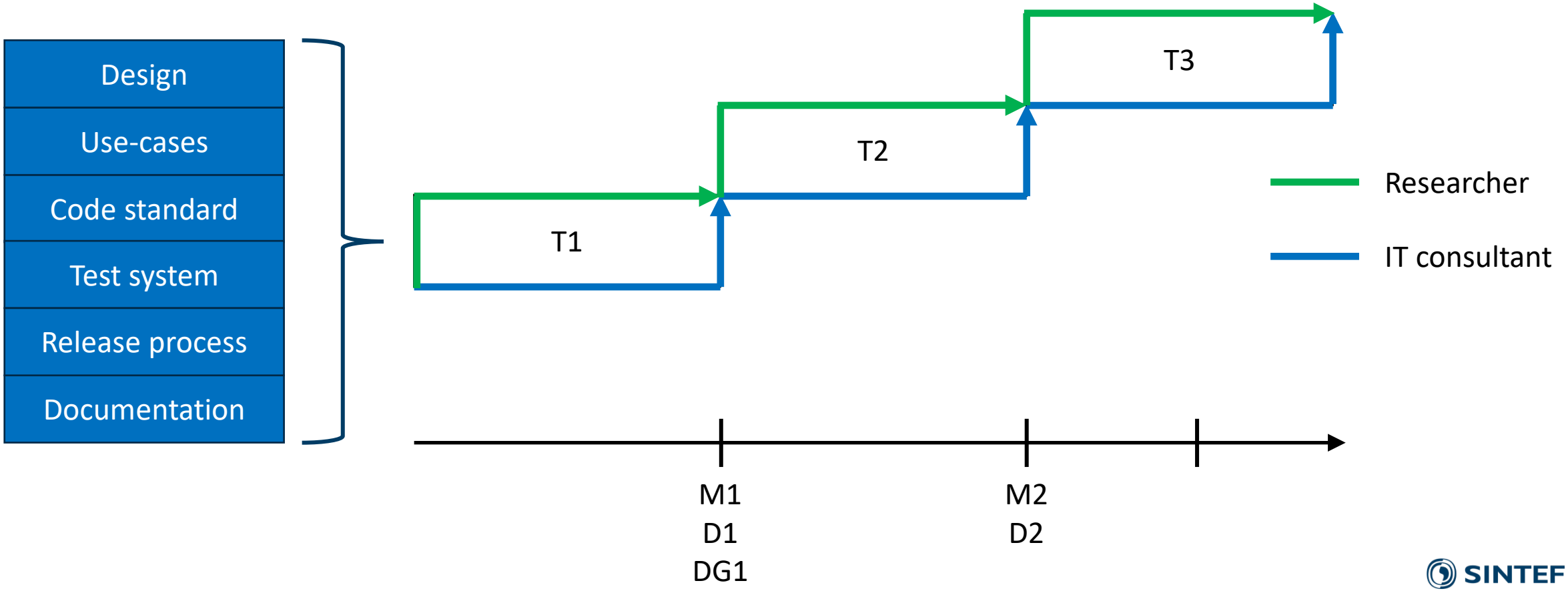
Realization in practice



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Results from the Model Incubator project

- Recommended usage areas for different programming languages
- Roadmap for management and restructuring of legacy code
- Evaluation of toolchains for version control, testing and release
- Strategy for integration of IT professionals in the development process
- Assessments on actual code to demonstrate feasibility and impact

SINTEF

70 år

1950-2020

Teknologi for et bedre samfunn