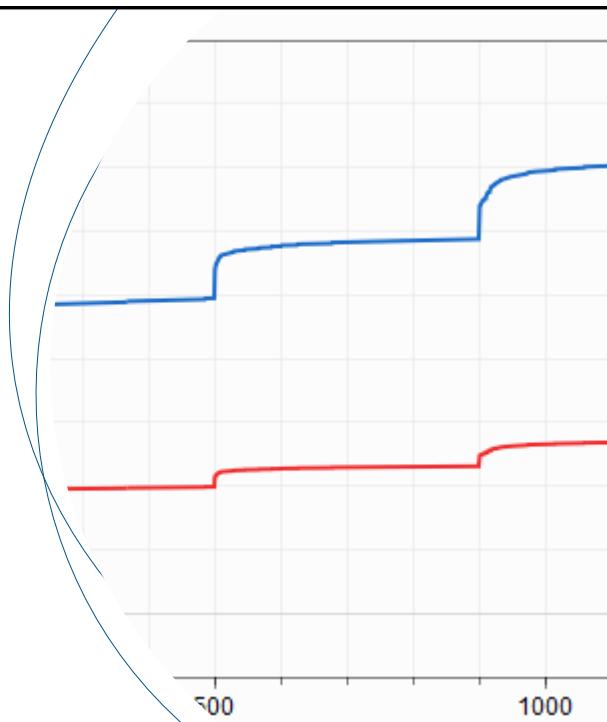




## DYMOLA 2025X HIGHLIGHTS

29 November 2024



## EXECUTIVE SUMMARY

### Model development

- Variable-length parameter arrays
- Improved parameter management
- Better Git support

### Simulation

- Faster simulation of Modelica functions
- New FMI co-simulation technology
- Dymola Modelica Compiler

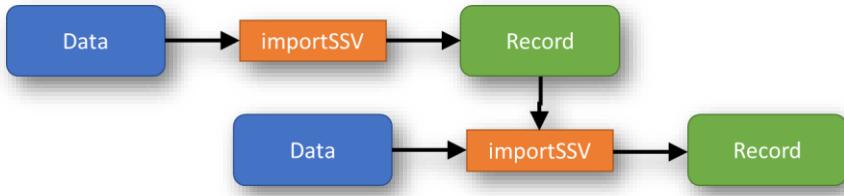
### Libraries

- ThermalSystems replaced by TIL Suite

## MODEL DEVELOPMENT

## PARAMETER MANAGEMENT IN DYMOLA

- Variable-length parameter arrays
  - No need to use external table objects
  - Initialize parameters (including arrays) at simulation initialization, not translation
  - Also supported in FMUs
- Parameter records
  - Import parameter set to create the corresponding parameter record
  - Modify one parameter set (record) with another
  - SSV and CSV supported



## VARIABLE-LENGTH PARAMETER ARRAY

- Possible to declare parameter arrays which size is not fixed at translation time
  - This is a Dymola extension controlled by an annotation
- No need to use external object (table) – directly supported in “native” Modelica
  - Can use interpolation in e.g. Modelica vectors
- Variable-length arrays are not stored in the result file

```

model Test
  parameter Real p[:] = InitializeParameters("parameterfile.txt")
    annotation(__Dymola_UnknownArray=true);
  extends Modelica.Mechanics.Rotational.Examples.CoupledClutches(
    J1(J=p[1]),
    J2(J=p[2]),
    J3(J=p[3]),
    J4(J=p[4]));
end Test;

```

5 DS CATIA



## VARIABLE-LENGTH PARAMETER ARRAY

- Can read external file to initialize at runtime
  - Trivial example reading a text file

```

function InitializeParameters "Reads initial values for parameter set"
  input String filename "File to read parameters from";
  output Real p[:] "Parameter set from file";

protected
  Integer n = Modelica.Utilities.Streams.countLines(filename);
  String data[:] = Modelica.Utilities.Streams.readFile(filename);

algorithm
  p := fill(0.0, n); // Initialization needed to get the right size
  for i in 1:n loop
    p[i] := Modelica.Utilities.Strings.scanReal(data[i]);
  end for;
end InitializeParameters;

```

6 DS CATIA



## CREATE PARAMETER RECORD FROM DATA

- Dymola can automatically create a Modelica parameter record
  - Using a data file as template (and for default values)
  - Handles name, description, unit conversion, nested records for names with dot
  - Can modify existing parameter record
  - Supports SSV and CSV data formats

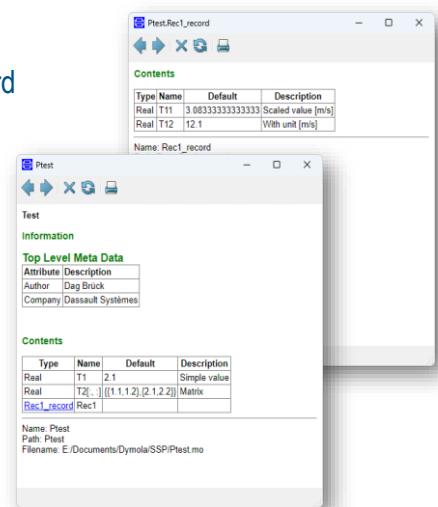
`importSSV("Partest.csv");`



```
record Partest "Test"
  parameter Real T1=2.1 "Simple value";
  parameter Real T2[:,:]={{1.1,1.2},{2.1,2.2}} "Matrix";
  record Rec1_record
    parameter Real T11(
      unit="m/s",
      displayUnit="km/h") = 3.08333333333333 "Scaled value";
    parameter Real T12(unit="m/s") = 12.1 "With unit";
  end Rec1_record;
  parameter Rec1_record Rec1;
end Partest;
```

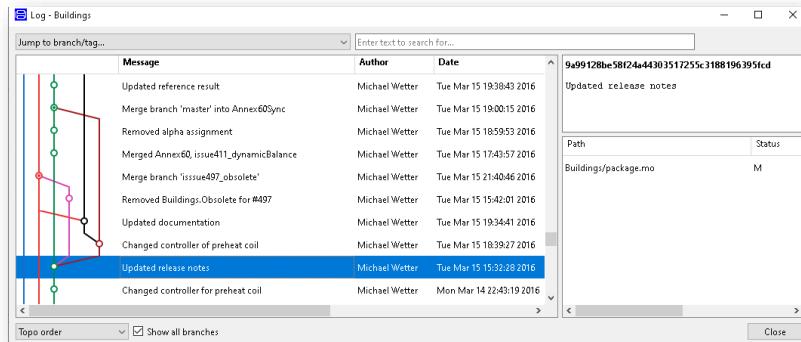
## PARAMETER RECORDS

- Best practice is to manage all global parameters as a record
  - Instead of calling file reading functions all over the model
  - More practical when variable-length arrays are supported
- SSP provides packaging of
  - Simulation model
  - Parameter sets
  - Documentation
- Improved documentation of records in Dymola



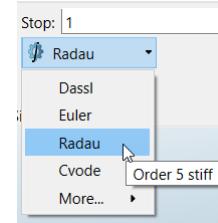
## VERSION MANAGEMENT WITH GIT

- New dialog to display the version log
  - Graphical display of branches and merges
  - Commit message, files changed by commit



## SMALLER IMPROVEMENTS

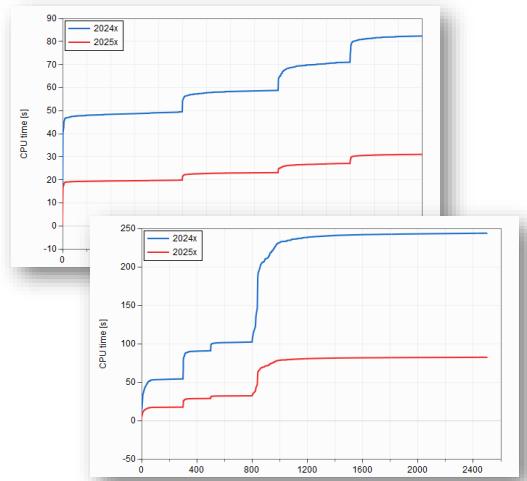
- Improved unit checking
  - Expressions, built-in functions
  - Considers value of evaluable parameters and only active equations
  - Unit checking on array elements
- Multi-lingual support for libraries
  - According to the MSL specification
- Text string expansion of description in the graphical layers (previously only name)
  - %classdescription
  - %componentdescription
- Simulation Analysis is now called Performance
- Simplified and grouped ribbon menu for integration algorithms



# SIMULATION

## SIMULATION SPEED

- Improved code generation for Modelica functions
  - Improved array handling in functions
  - Constant and parameter optimizations
  - Typically good effect in fluid systems with many function calls for media calculations
- Further optimizations by enabling
   
`Advanced.Beta.Translation.`  
`FunctionsUseConstantsInsteadOfExpressions`
  - May require setting extra start values in the model

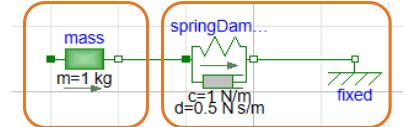


Examples from ThermoFluidStreams

## FMI CO-SIMULATION TECHNOLOGY



- New co-simulation technology aimed to
  - Improve performance of "heavy" FMUs with variable-step solvers
  - Reduces number of f-evaluations and Jacobian evaluations
  - Collaboration with partner TLK-Thermo
- Smoothing of continuous-time Real inputs
  - Linear interpolation during the next doStep
  - Integrator can continue without costly reset  
→ larger step-size, fewer evaluations
  - Predictor compensation → better error estimates
- Caveats
  - Inputs are effectively delayed
  - Not a universal cure for all co-simulation problems



| Input smoothing | # f-evals | # Jacobian evals |
|-----------------|-----------|------------------|
| Default         | 5471      | 499              |
| Enabled         | 1851      | 14               |

## SYSTEM STRUCTURE AND PARAMETERIZATION

- SSP 2.0 supported
  - Support for Modelica components in SSP
  - Better FMI 3.0 conformance (Float32 etc.)
  - Local variable can be defined as connector with kind="local"
  - Inner and outer connector positions (cf. diagram and icon)
- Initial meta-data support according to SSP Traceability
- Improved SSP conformance, cross-tool compatibility
- Black-box import of FMUs supported by `importSSP`
  - `includeAllVariables=false`



## FMI FOR EMBEDDED SYSTEMS



Functional Mock-up  
Interface for  
embedded systems

### Algorithm Code

- Support for untypical, error-case start values in manifests and initialization (NaN,  $\pm\infty$ )
- Support for many more GALEC builtin functions (3D interpolation, all integer division and remainder variants, ...)

### Behavioral Model

- Derived experiment-packages now support boolean and integer GALEC block-interface in- and outputs

### Production code checks with Cppcheck and clang-tidy

- Backed by Software Production Engineering on 3DEXPERIENCE
- MISRA C:2012, MISRA C:2023, SEI CERT C
- Strict preconfigurations, with very few exceptions and altera rules for FPGA & CUDA programming)
- HTML log with syntax highlighting for Cppcheck results
- Profiles for open source and premium Cppcheck

| Cppcheck report - [project name]  |      |  |         |   |   |
|---|------|--|---------|---|---|
|   | Line | id   | CWE     | Severity  | Message   |
| Defect summary  |      |  |         | information   | Active checkers: 504/1055   |
| <input checked="" type="checkbox"/> Toggle all  |      |  |         |   | Common libraries/Conda embedded libraries/embedded_for_resources/build_includes/include.h.c |
| Show # Defect ID  |      |  |         |   |   |
| <input type="checkbox"/> 39 premium-misra-c-2023-8.7  | 89   | premium-misra-c-2023-10.1                  | style   | Operands shall not be of an inappropriate essential type.                   |   |
| <input type="checkbox"/> 36 misra-c-2023 8.7  | 589  | premium-misra-c-2023-10.1                  | style   | Operands shall not be of an inappropriate essential type.                   |   |
| <input checked="" type="checkbox"/> 5 premium-cet-ds19-c-<br>premium-cet-ds19-interpolationID | 627  | premium-misra-c-2023-10.1                  | style   | Operands shall not be of an inappropriate essential type.                   |   |
| <input checked="" type="checkbox"/> 5 premium-cet-ds19-c-<br>SPE_interpolationID              | 681  | premium-misra-c-2023-10.1                  | style   | Operands shall not be of an inappropriate essential type.                   |   |
| <input checked="" type="checkbox"/> 5 premium-cet-ds19-c-<br>SPE_interpolationID              | 1421 | misra-c2023-14.1                           | style   | A loop counter shall not have an essentially negative type.                 |   |
| <input checked="" type="checkbox"/> 5 premium-cet-ds19-c-<br>SPE_interpolationID              | 1728 | premium-cet-ds19-c-<br>SPE_interpolationID | style   | Avoid information leakage when passing a structure across a trust boundary. |   |
| <input checked="" type="checkbox"/> 4 premium-misra-c-2023-10.1                               | 1730 | premium-misra-c-2023-10.1                  | warning | Ensure that unsigned integer operations do not wrap.                        |   |
| <input checked="" type="checkbox"/> 2 premium-misra-c-2023-10.1                               | 1736 | premium-cet-ds19-c-<br>SPE_interpolationID | style   | Avoid information leakage when passing a structure across a trust boundary. |   |
| <input checked="" type="checkbox"/> 1 misra-c-2023-14.1                                       | 1772 | premium-cet-ds19-c-<br>SPE_interpolationID | style   | Avoid information leakage when passing a structure across a trust boundary. |   |
| <input type="checkbox"/> 1 premium_licenseExpiresSoon   | 1791 | premium-cet-ds19-c-<br>SPE_interpolationID | style   | Avoid information leakage when passing a structure across a trust boundary. |   |
| 94 total  | 1798 | premium-cet-ds19-c-<br>SPE_interpolationID | style   | Avoid information leakage when passing a structure across a trust boundary. |   |
| Statistics  |      |  |         |   |   |
|   |      |  |         |   |   |

Created by Cppcheck 24.0.1 Generation (RC)

```

if (((Integer)1) == _M_saturated) /* no interpolation needed */
{
    result = SPE_interpolation1D();
    error_mSignal
    .+ x2_data
    .+ x2_saturated
    .+ x2_size
    .+ x2_saturated<=x2_size) /* Ensure that until
    .+ x2_size
    .+ M_size
}

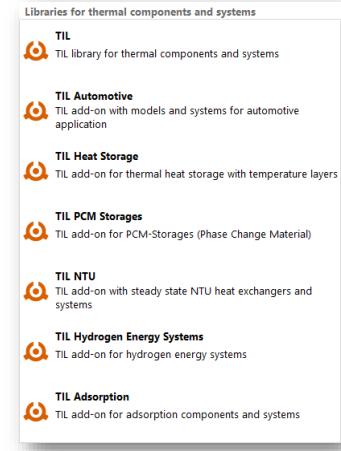
```

## MODELICA LIBRARIES



## TIL-SUITE LIBRARIES

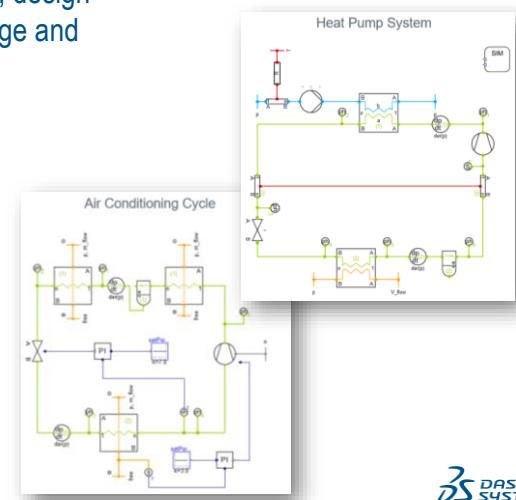
- ThermalSystems library is replaced by TIL-Suite
  - More complete range of libraries, extended functionality
- Divided into four library products at Dassault Systèmes
  - TIL Base Library (FNY-x)
  - TIL Mobile Air Conditioning Library (HMY-x)
  - TIL Hydrogen Library (HNY-x)
  - TIL Thermal Storages Library (TTY-x)
- Free upgrade for existing customers of ThermalSystems
  - ThermalSystems → TIL Mobile Air Conditioning Library
  - Contact your sales channel (not automatic)



## TIL BASE LIBRARY



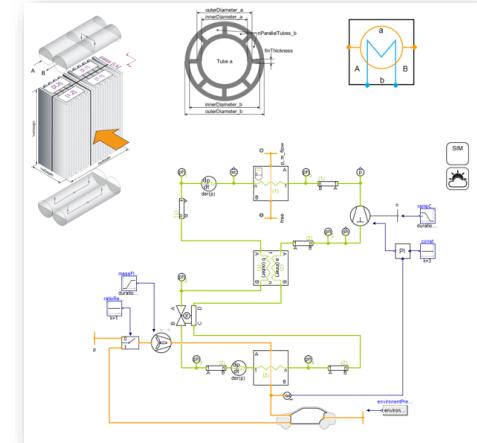
- Intended for the stationary and transient simulation, design and optimization of individual components up to large and complex systems
  - Refrigeration cycles, including refrigeration mixtures
  - Heat pump systems e.g. with ejectors
  - Hydraulic networks
  - Rankine cycles
  - Heating, ventilation and air-conditioning systems
- Includes the TIL Media library
- Foundation for all the other TIL-Suite libraries



## TIL MOBILE AIR CONDITIONING LIBRARY

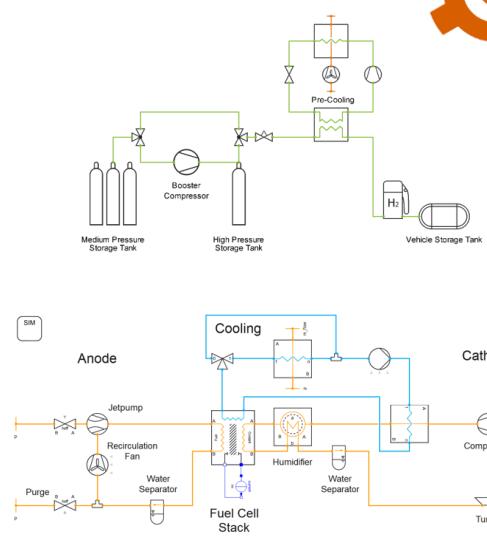


- Focuses on mobile air conditioning systems with models for
  - Car, coach and train cabins
  - Detailed MPET heat exchanger (configurable flow patterns)
  - Internal heat exchanger
  - Common example systems for mobile AC cycles with different refrigerants
  - Steady-state heat exchangers using a “Number of Transfer Units” (NTU) method
- Includes all of TIL Base



## TIL HYDROGEN LIBRARY

- Simulate systems of the entire hydrogen value chain
  - $H_2$  production and utilization
  - $H_2$  storage and distribution
  - Applications – fuel cell systems
- Simulation and analysis of adsorption processes
  - Drying applications, gas separation or direct air capture
  - Models are based on the physical principle of adsorption
  - Extendable with material data for different adsorbents





## TIL THERMAL STORAGES LIBRARY

- Hot water storage tank
  - Stratified temperature layers
  - Used for example in residential heat pump systems
  - Optional internal and mantle heat exchangers
  - Models for buoyancy, walls and insulation
- Phase Change Material (PCM) Storages library
  - Different types of geometries and fluid combinations for thermal PCM storages / heat exchangers
  - Properties of solid-liquid equilibrium (SLE) media, such as cold ice storage



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21 DS CATIA

## TIL-SUITE LIBRARY / PRODUCT MATRIX

| TIL Suite                   | TIL Base Library (FNY-x) | TIL Mobile Air Conditioning Library (HMY-x) | TIL Hydrogen Library (HNY-x) | TIL Thermal Storages Library (TTY-x) |
|-----------------------------|--------------------------|---|------------------------------|--------------------------------------|
| TIL                         | X                        | X   | X                            | X                                    |
| TIL Automotive              |                          | X   |                              |                                      |
| TIL Heat Storage            |                          |   |                              | X                                    |
| TIL PCM Storage             |                          |   |                              | X                                    |
| TIL NTU                     |                          | X   |                              |                                      |
| TIL Hydrogen Energy Systems |                          |   | X                            |                                      |
| TIL Adsorption              |                          |   | X                            |                                      |
| TIL Cabin                   |                          | X   |                              |                                      |
| TIL Media                   | X                        | X   | X                            | X                                    |

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## DYMOLA MODELICA COMPILER

23 DS CATIA

 DASSAULT SYSTEMES

## DYMOLA MODELICA COMPILER

- Command-line Dymola
  - Dymola compiler without any graphical user interface
  - Supports non-gui toolchains
  - For people who like black&white movies
- Limited in what it can do
  - Translates and simulates models
  - Runs scripts
  - Supports Python/Java/JavaScript interface via network port
- Uses normal Dymola license



24 DS CATIA

 DASSAULT SYSTEMES

## DYMOLA MODELICA COMPILER

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| Command         | Meaning                   |
|-----------------|---------------------------|
| -h              | Print help                |
| -o <file-name>  | Open named Modelica file  |
| -t <model-path> | Translate the named model |
| -x <command>    | Execute the command       |
| -r <file-name>  | Run a script file         |
| -p <port>       | Start the HTTP server     |
| -nosettings     | Do not read settings file |

```
Q8K> dmc -t Modelica.Mechanics.Rotational.Examples.CoupledClutches
License information found. DS AR (e41d4)
Selected "DYMOLA" environment variable: E:/WS/ibk8a27/win_64/resources/Dymola
Successfully loaded settings file C:/Users/Q8K/AppData/Roaming/DassaultSystems/Dymola/2025x/setup.dymx
= true
Parameters::translateModel("Modelica.Mechanics.Rotational.Examples.CoupledClutches")
Translation of Modelica.Mechanics.Rotational.Examples.CoupledClutches
The DAE has 106 scalar unknowns and 106 scalar equations.

Statistics
Original Model
Number of components: 14
Variables: 21 (21 scalars)
Parameters: 53 (56 scalars)
Unknowns: 106 (106 scalars)
Differentiated variables: 14 scalars
Equations: 98
Nontrivial: 79
Translated Model
Number of components: 14
Free parameters: 39 scalars
Parameter depending: 6 scalars
Outputs: 2 scalars
Continuous states: 8 scalars
Time-varying variables: 51 scalars
Alias variables: 51 scalars
Number of mixed real/discrete systems of equations: 1
Size of the linear systems of equations: (1)
Sizes after manipulation of the linear systems: (4)
Sizes of nonlinear systems of equations: ( )
Sizes after manipulation of the nonlinear systems: ( )
Number of numerical Jacobians: 0

Settings
OutputContinuous = true
Continuous continuous time states
Statically selected continuous time states
clutch1.phi_rel
clutch1.w_rel
clutch2.phi_rel
clutch2.w_rel
clutch3.phi_rel
clutch3.w_rel
...
31.w
= true

Q8K> |
```

25 DS CATIA

DS DASSAULT SYSTEMES

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