ElmerSolver Input File (SIF) Explained

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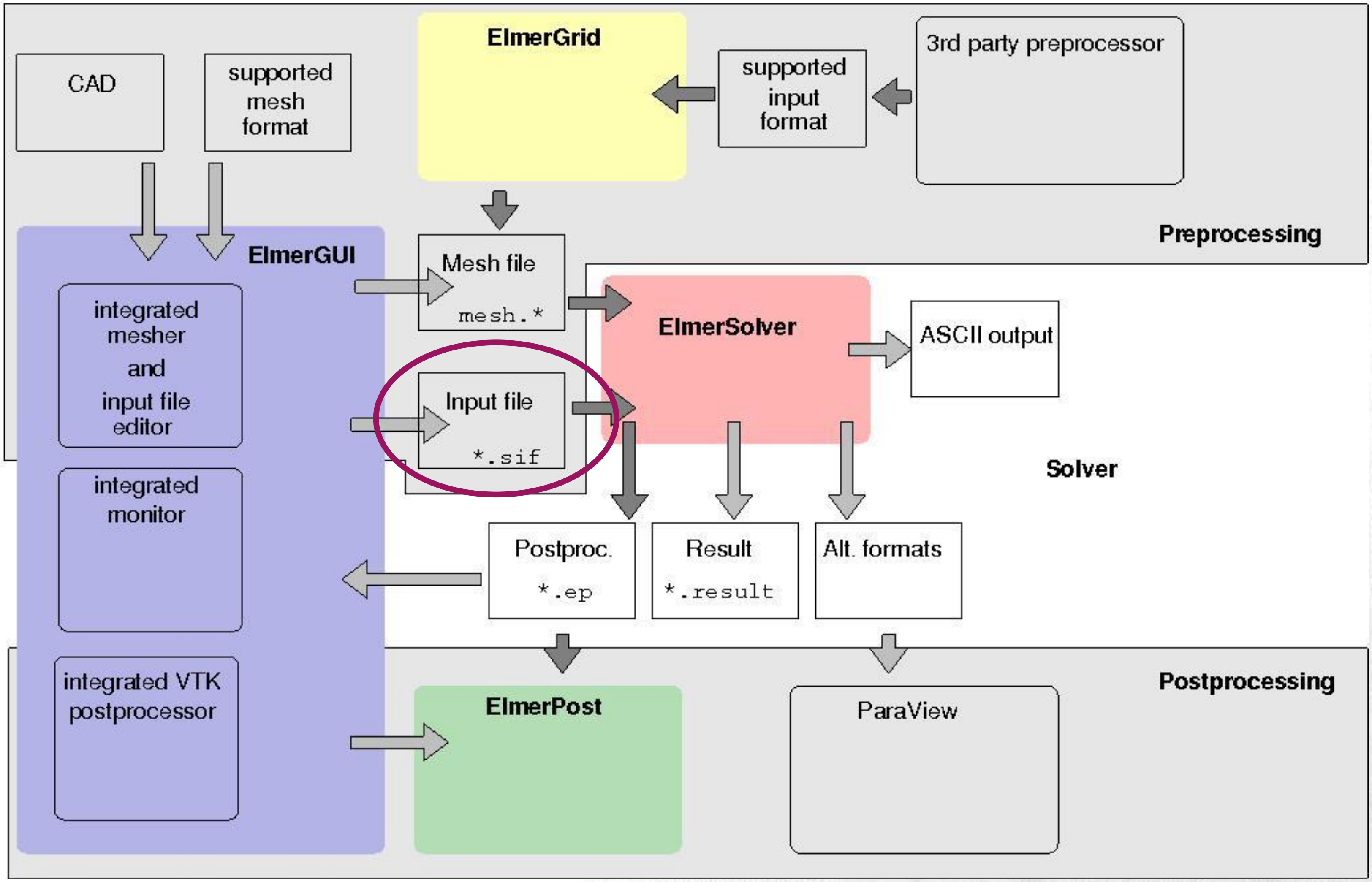
Elmer - Modules



Sections of SIF

- The SIF is structured into sections
  - `Header`
  - `Constants`
  - `Simulation`
  - `Solver`
  - `Body`
  - `Equation`
  - `Body Force`
  - `Material`
  - `Initial Condition`
  - `Boundary Condition`

The contents of each section is between the keyword above and an **`End`**-statement

Sections of SIF: Header

- Declares search paths for mesh

```
Header
 Mesh DB "." "dirname"
End
```

- preceding path + directory name of mesh database
- Replace path and ***dirname*** to fit your case

Sections of SIF: Constants

- Declares simulation-wide constants

```
Constants
  Gas Constant = Real 8.314E00
  Gravity(4) = 0 -1 0 9.81
End
```

- a casted scalar constant
- Gravity vector, an array with a registered name

Sections of SIF: Simulation

- Declares details of the simulation:

```
Simulation
  Coordinate System = "Cartesian“
```

- choices: **Cartesian{1D,2D,3D}, Polar{2D,3D}, Cylindric, Cylindric Symmetric, Axi Symmetric**

```
  Coordinate Mapping(3) = Integer 1 2 3
  Coordinate Scaling = Real 0.001
```

- Permute or scale coordinates

```
  Simulation Type =“Transient“
```

- **Steady State, Transient or Scanning**

```
  Output Intervals(2) = 10 1
```

- Interval of results being written to disk

Sections of SIF: Simulation

- Declares details of the simulation:

```
Steady State Max Iterations = 10
Steady State Min Iterations = 2
```

- How many min/max rounds on one timelevel/in a steady state simulation (see later)

```
Timestepping Method = ″BDF″
```

- Choices: **`BDF`**, **`Newmark`** or **`Crank-Nicholson`**

```
Timestep Intervals(2) = 10 100
```

- Has to match array dimension of **`Timestep Sizes`**

```
Timestep Sizes(2) =  0.1 1.0
```

- The length of one time step

```
Output File = "name.result"
```

- Contains data for restarting

```
Post File = "name.ep‟ ! Or ‟name.vtu″
```

- Contains ElmerPost data

Sections of SIF: Simulation

- Declares details of the simulation:

```
  Restart File = "previous.result"
  Restart Position = 10
  Restart Time = 100

  Max Output Level = 5
End
```

- Restart from this file at file-entry (not necessarilly timestep!) no. 10 and set time to 100 time-units
- Level of verbosity.
  1 = errors,
  3 = warnings,
  4 = quite silent,
  …
  10 = very verbose

Sections of SIF: Solver

- Declares a physical model to be solved

```
Solver 3
 Equation = "Navier-Stokes"
 Exec Solver = "Always"


 Linear System Solver = "Iterative"


 Linear System Iterative Method = BiCGStab
 Linear System Convergence Tolerance =1.0e-6



 Linear System Abort Not Converged = True


 Linear System Preconditioning = "ILU2"
```

- Numbering from 1 (priority)
- The name of the equation
- **`Always`** (default), **`Before/After Simulation/Timestep`**
- Choices: **`Iterative`**, **`Direct`**, **`MultiGrid`**
- Lots of choices here
- Convergence criterion
- If not True (default) continues simulation in any case
- Lots of choices

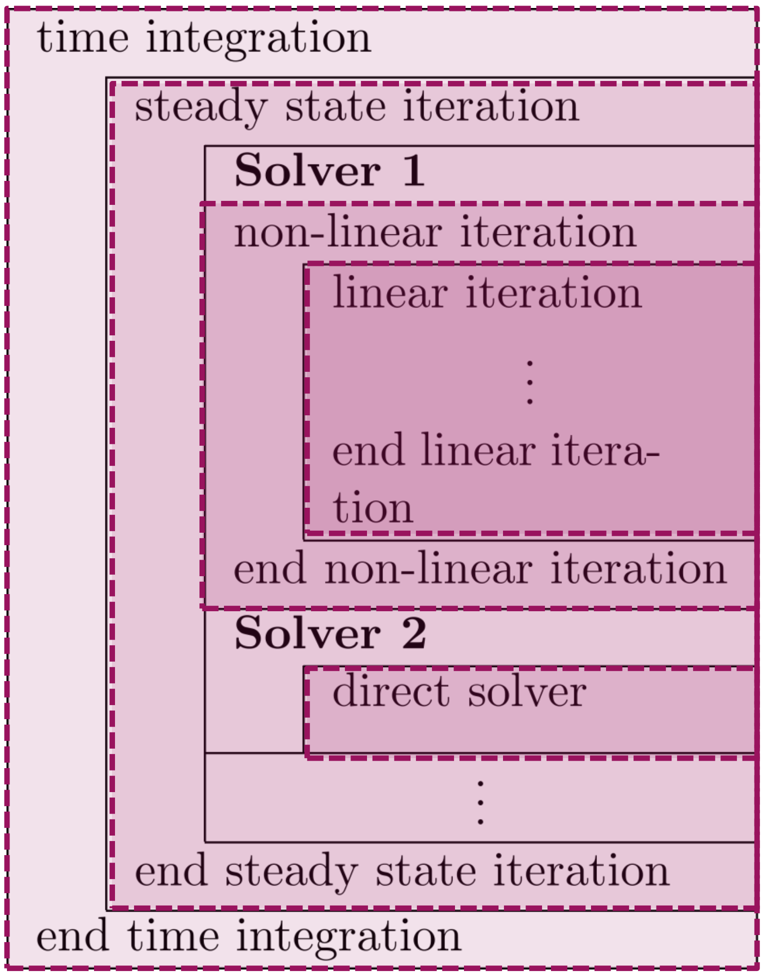
Sections of SIF: Solver

- Declares a physical model to be solved

```
 Nonlinear System Convergence Tolerance=1.0e-5

 Nonlinear System Max Iterations = 20
 Nonlinear System Min Iterations = 1

 Nonlinear System Newton After Iterations=10

 Nonlinear System Newton AfterTolerance=1.0e-3


 Steady State Convergence Tolerance = 1.0e-3

 Stabilization Method = Stabilized
End
```

- Convergence criterion for non-linear problem
- The maximum rounds
- The minimum rounds
- Switch from Picard to Newton scheme after 10 iterations ...
- ... or after this criterion (NV.: has to be smaller than convergence criterion ot hit)
- The convergence on the time-level
- Convection needs stabilization. Alternatives: **`Bubbles, VMS, P2/P1`**

Sections of SIF: Solver



1. `Timestep Intervals`

2. `Steady State Max Iterations`

3. `Nonlinear Max Iterations`

4. `Linear System Max Iterations`

4. `Linear System Convergence Tolerance`

3. `Nonlinear System Convergence Tolerance`

2. `Steady State Convergence Tolerance`

1.

Sections of SIF: Body

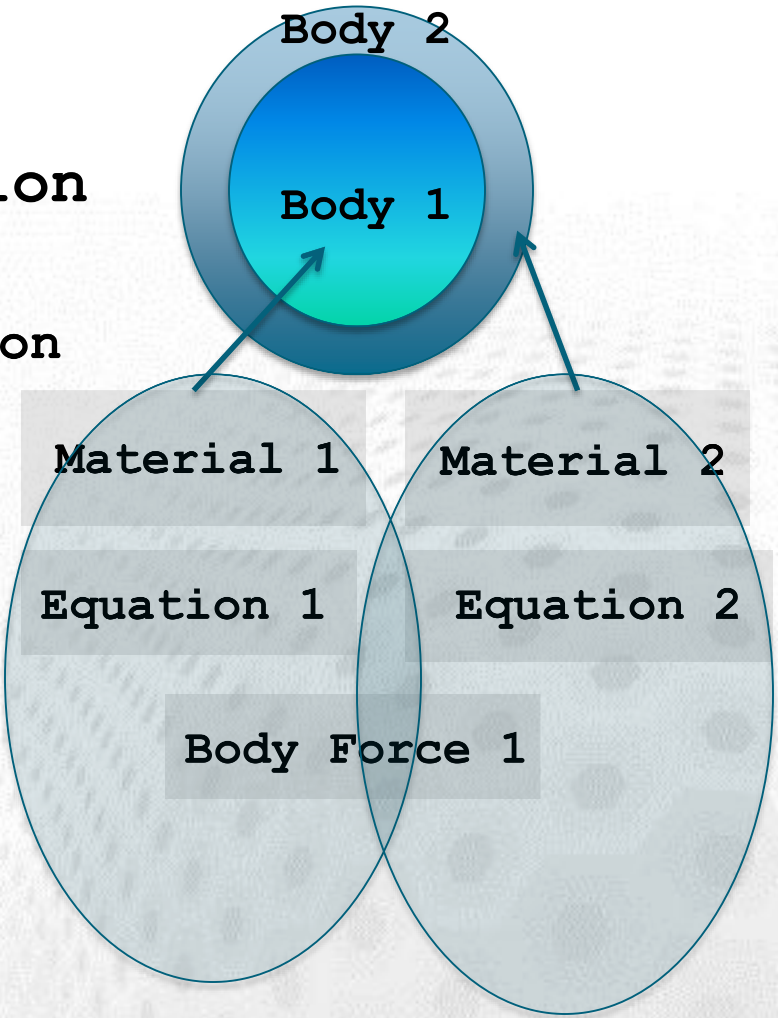
- Declares a physical model to be solved

```
Body 2

 Name = "pipe"
 Equation = 2
 Material = 2
 Body Force = 1
 Initial Condition = 2
End
```

- Numbering from 1 to number of bodies
- Identifier of the body
- The assigned set of equations
- The assigned material section
- The assigned body force
- The assigned initial condition

Sections of SIF: Body

- Each **Body** has to have an **Equation** and **Material** assigned
  - **Body Force**, **Initial Condition** optional
- Two bodies can have the same **Material/Equation/ Body Force/Initial Condition** section assigned



Sections of SIF: Equation

- Declares set of solvers for a body

```
Equation 2

 Active Solvers(2) = 1 3

 Convection = Computed



 NS Convect = False


End
```

- Numbering from 1 to number of equation sets
- Declares the solvers (according to their numbers) to be solved within this set
- Important switch to account for convection term. Alternatives: None and Constant (needs Convection Velocity to be declared in the Material section)
- Sets no convection for Navier-Stokes (=Stokes) alternative:

  `Flow Model = Stokes`

  in the Solver section of Navier-Stokes

Sections of SIF: Body Force

- Declares body forces and bulk and execution conditions for a body

```
Body Force 3

 Flow Body Force 1 = 0.0
 Flow Body Force 2 = -9.81

 MyVariable = Real 0.0

 Heat Source = 1.0
End
```

- Numbering from 1 to number of body forces
- Gravity pointing in negative x-direction applied to Navier-Stokes solver
- A Dirichlet condition for a variable set within the body
- Heat source for the heat equation

Sections of SIF: Material

- Declares set of material parameters for body

```
Material 1

 Density = 1000.0
 Heat Conductivity(3,3) = 1 0 0\
                          0 1 0\
                          0 0 2
 Viscosity = Variable Temperature
    Real MATC ”viscosity(tx)”
 MyMaterialParameter = Real 0.0

End
```

- Numbering from 1 to number of material
- Always declare a density (mandatory)
- Parameters can be arrays
- Or functions of other variables
- Non-keyword DB parameters have to be casted

Sections of SIF: Initial Condition

- Declares initial conditions for a body

  By default restart values are used

```
Initial Condition 2

 Velocity 1 = Variable Coordinate 2
    Real MATC "42.0*(1.0 – tx/100.0)"
 Velocity 2 = 0.0

  MyVariable = Real 20.0

End
```

- Numbering from 1 to number of IC's
- Initial condition as a function of a variable ...
- ... and as a constant
- Non-keyword DB parameters have to be casted

Sections of SIF: Boundary Condition

- Declares conditions at certain boundaries

```
Boundary Condition 3

 Target Boundaries(2) = 1 4

 Velocity 1 = Variable Coordinate 2
    Real MATC "42.0*(1.0 - tx/100.0)"
 Velocity 2 = 0.0

 Normal-Tangential Velocity = Logical True
End
```

- Numbering from 1 to number of BC's
- The boundaries of the mesh the BC is assigned to
- Variable as a function and ...

  ... as a constant
- Set velocities in normal-tangential system

Tables and Arrays

- Tables (piecewise linear or cubic):

```
Density = Variable Temperature
Real cubic
     0 900
   273 1000
   300 1020
   400 1000
End
```

- Arrays:

```
Target Boundaries(3) = 5 7 10

MyParamterArray(3,2) = Real 1 2\
                            3 4\
                            5 6
```

- Expresions:

```
OneThird = Real $1.0/3.0
```

Input options for Real valued keywords

- Most Real valued keywords are fetched using a method that allows multiple functional dependency styles
  - Constant value
  - Dependence via linear (or spline) loop-up table
  - Dependence via MATC in-line function
  - Dependece via User Defined Function (UDF)
- This related to all command file sections
  - Body Force
  - Material
  - Boundary Condition

MATC

- Syntax close to C
- Even if-conditions and loops
- Can be use for on-the-fly functions inside the SIF
- Documentation on web-pages
- Do <u>not</u> use with simple numeric expressions:

```
OneThird = Real $1.0/3.0
```

is much faster than

```
OneThird = Real MATC "1.0/3.0"
```

MATC

- Use directly in section:

```
Heat Capacity = Variable Temperature
 Real MATC "2.1275E3 + 7.253E0*(tx - 273.16)"
```

- Even with more than one dependency:

```
Temp = Variable Latitude, Coordinate 3
 Real MATC "49.13 + 273.16 - 0.7576*tx(0) - 7.992E-03*tx(1)”
```

- Or declare functions (somewhere in SIF, outside a section)

```
$ function stemp(X) {\
  _stemp = 49.13 + 273.16 - 0.7576*X(0) - 7.992E-03*X(1)\
}
```

being called:

```
Temp = Variable Latitude, Coordinate 3
   Real MATC “stemp(tx)”
```

User Defined Functions (UDF)

- Written in Fortran 90
- Dynamically linked to Elmer
- Faster, if more complicated computations involved
- Compilation command **elmerf90**

```
elmerf90 myUDF.f90 –o myUDF.f90
```

- Call from within section:

```
MyVariable = Variable Temperature
  Real Procedure ”myUDF” ”myRoutine”
```

User Defined Functions (UDF)

- Example: $\rho(T[K]) = 1000.0 \cdot \left[1 - 1 \times 10^{-4} \cdot (T - 273.15)\right]$

```
FUNCTION getdensity( Model, N, T ) RESULT(dens)
 USE DefUtils !important definitions
 IMPLICIT None
 TYPE(Model_t) :: Model
 INTEGER :: N
 REAL(KIND=dp) :: T, dens
 dens = 1000.0_dp*(1.0_dp - 1.0d-04*(T - 273.0_dp))
END FUNCTION getdensity
```

- Definitions loaded from **`DefUtils`**
- Header: **`Model`** access-point to all ElmerSolver inside data; Node number **`N`**; input value **`T`**