AIRTHIUM

https://airthium.com/

FreeFEM days 2022

Tanatloc
A FreeFEM graphical user interface

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Airthium SAS

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About us

Small enterprise – 13 team members

- 6 Ph. D., 2 in Applied Mathematics
- 4 Mechanical Engineers
- IT, Electronics, Management

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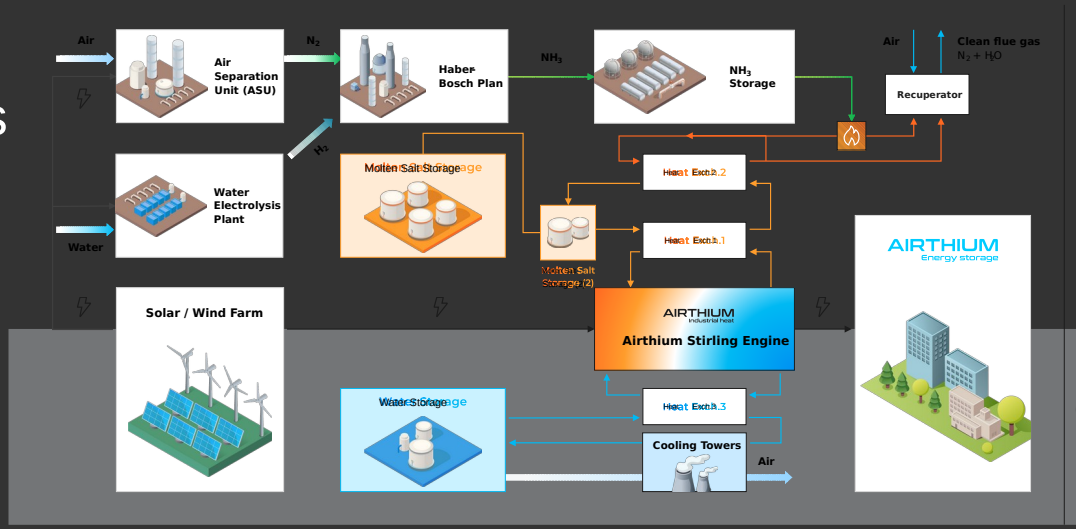
Goal

High efficiency heat pump
for seasonal energy storage



Source: https://airthium.com/

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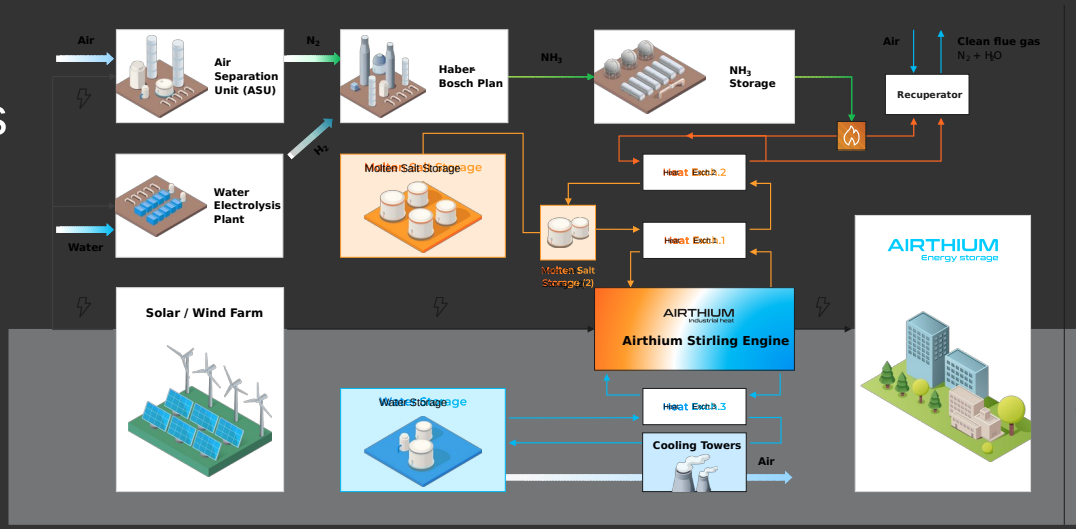

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→ Need of multiples physics simulations

1. Solid mechanics (linear elasticity, contact, ...)
2. Fluid mechanics (laminar, turbulent)
3. Couplings, …

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Framework choice

- Commercial simulation software, $$$, black box
- Open source software, $, customizable
  - → FreeFEM (using it during my Ph. D. thesis)

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Problem

Mechanical Engineers does not know maths, programming, …
Unable to write and/or modify a FreeFEM script! (without breaking all)

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Solution

Build a FreeFEM graphical interface to allow engineers to parameterize, select the boundary conditions, run a simulation and post-process the results

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Needs - Final user

- **Only click**
- **No code**
- Geometry integration from STEP, DXF (CAD software format)
- Automatic meshing
- Easy parameterize (material, physics parameters, mesh adaptation, solver parameters, finite element choice)
- Easy boundary conditions definition and selection
- Easy run (meshing + simulation)
- Post-processing (warp, stream lines, isolines, …)

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Framework

Web-based application (React (javascript) client, NodeJS server)

→ Cloud deployment, Cluster deployment, Electron (desktop) app

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Needs - Expert user

- **Custom model**
- **Custom code**
- Additional data
- Parallel run

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Features addition

Custom model editor, sensors, …

FreeFem++-mpi support, Slurm interface (coming soon)

On request developments, first collaboration with **DENSO** and **Pr. A. Suzuki**

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Basic behavior

A word of templates

Meshing tool: Gmsh

→ Gmsh script templ

```
SetFactory("OpenCASCADE");

Geometry.OCCScaling = 1.e-3;
V() = ShapeFromFile("<%= geometry %>");

Mesh.Optimize = 1;

// Compute minimal distance on the bounding box
// this is used for automatic size of the mesh
lmin = 0;
lmax = 0;
For i In {0:#V[]-1}
    bb() = BoundingBox Volume{V[i]};

    xmin = bb[0];
    xmax = bb[3];
    ymin = bb[1];
    ymax = bb[4];
    zmin = bb[2];
    zmax = bb[5];

    lx = xmax - xmin;
    ly = ymax - ymin;
    lz = zmax - zmin;

    llmin = (lx < ly) ? lx : ly;
    llmin = (llmin < lz) ? llmin : lz;
    llmax = (lx > ly) ? lx : ly;
    llmax = (llmax > lz) ? llmax : lz;

    If (i == 0)
        lmin = llmin;
        lmax = llmax;
    Else
```

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Basic behavior

A word of templates

Meshing tool: Gmsh
- → Gmsh script template

Simulation tool: FreeFEM
- → FreeFEM script template
- → Model description

```
try {
<%# Headers -%>
<%- helpers.indent(include('/blobs/headers.edp.ejs'), 1) -%>

<%# Dimension -%>
<%- helpers.indent(include('/blobs/dimensioning.edp.ejs', {
    dimension
}), 1) -%>

<%# Mesh -%>
<%
const mesh = geometry.mesh
mesh.name = 'Mesh'
-%>
<%- helpers.indent(include('/blobs/mesh.edp.ejs', {
    dimension,
    mesh
}), 1) -%>

<%# Finite element space -%>
<%
const finiteElementSpace = parameters.finiteElementSpace.children[0]
finiteElementSpace.name = 'Uh'
-%>
<%- helpers.indent(include('/blobs/fespace.edp.ejs', {
    mesh,
    dimension,
    finiteElementSpace
}), 1) -%>

<%# Finite element function -%>
<%- helpers.indent(include('/blobs/fespaceFunction.edp.ejs', {
    finiteElementSpace,
    finiteElementFunction: ['u']
```

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Basic behavior

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Post-processing tool: Paraview (pvpython)
- → Python script

```python
import sys
import math
from paraview.simple import CleantoGrid, PointSource, StreamTracerWith(

# Arguments
# 1. string: InFileName
# 2. string: OutFileName
# 3. string: Vector

args = sys.argv

# Read
VTU = XMLUnstructuredGridReader(FileName=args[1])
VTU.UpdatePipeline()

# Check vector
NumberOfComponents = VTU.GetPointDataInformation().GetFieldData(
).GetArrayInformation(args[3]).GetNumberOfComponents()
if NumberOfComponents != 3:
    raise ValueError('Wrong vector number of components')

# Bounds
Bounds = VTU.GetDataInformation().GetBounds()

# Center
Center = [(Bounds[0] + Bounds[1]) / 2., (Bounds[2] + Bounds[3]) /
          2., (Bounds[4] + Bounds[5]) / 2.]

# Max length
MaxLength = max([Bounds[1] - Bounds[0], Bounds[3] -
                 Bounds[2], Bounds[5] - Bounds[4]])

# Radius
Radius = MaxLength / math.sqrt(2.)
```

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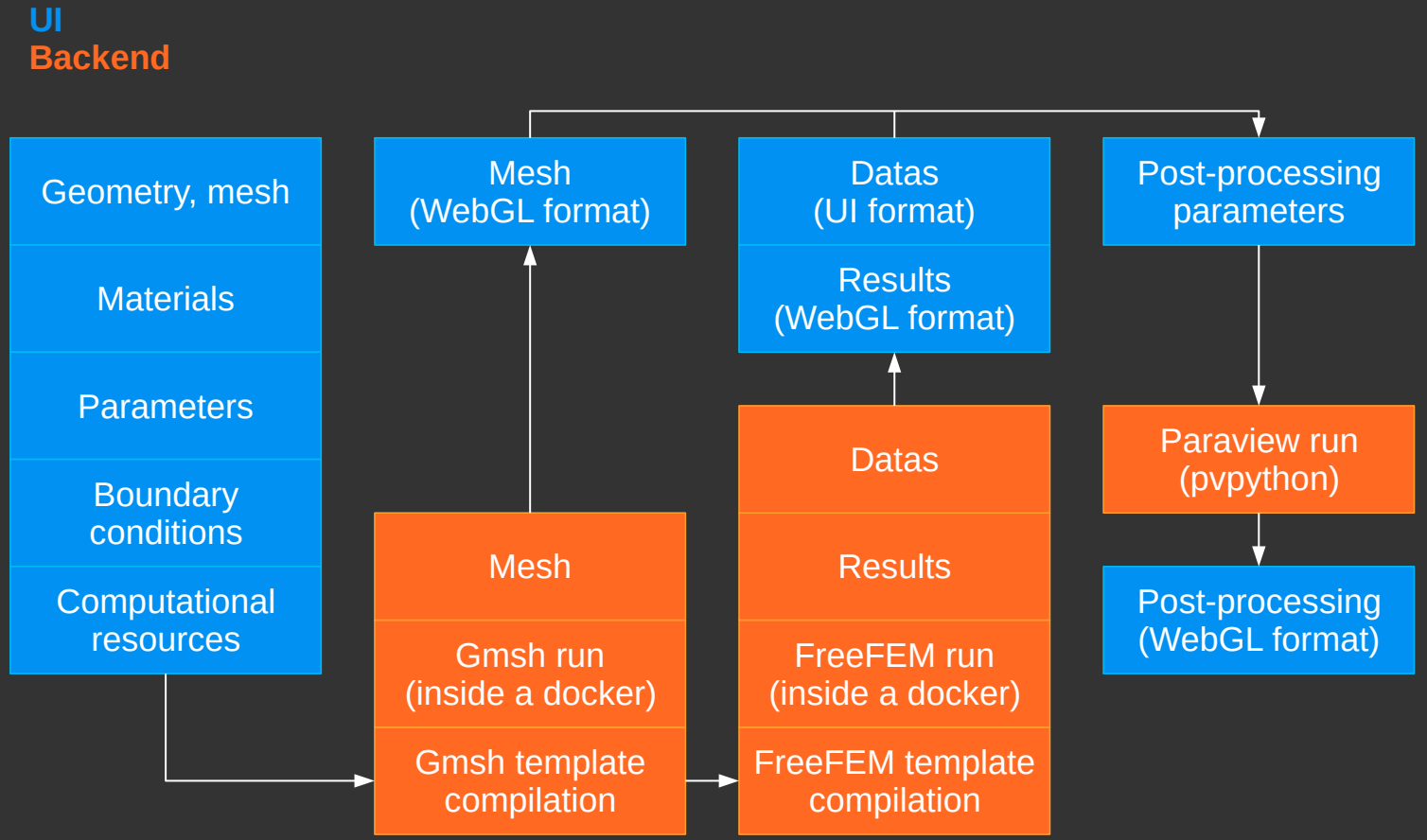
Workflow



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Main targets:

- Engineers
  - Easy access to simulations
- Academics (students, teacher, researcher)
  - Customizable model, interface, ...

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Features

- Integrated simple models (linear elasticity, modal analysis, stokes, navier-stokes, …)
- Easy simulation setup from geometry to results
- Result visualization and post-processing tools
- Data visualization and sensors additions
- Code template editor
- Collaborative tools: share, organizations (Web only)

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https://tanatloc.com
Electron app available on Linux, MacOS and Windows

Some more informations

- AGPLv3+ license
- We are open to pull requests
  https://github.com/Airthium/tanatloc/pulls
- Or just suggestions
  https://github.com/Airthium/tanatloc/issues
- Public repositories: Tanatloc (core), Electron (desktop app), Docker
- Private repositories (pay features): Rescale, Sharetask

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TODO list

- Documentation !
- Algorithm description and validation (blog?)
- Editor improvement
- Slurm interface
- A lot of bugs to fix, …

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Thank you
for your attention
and let’s see a demo