CFD-FE interaction
Basic questions

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Three problems have to be solved. Each of them is governed by different equations.

1. Temperatures and flows in the compartment.
2. Temperatures in the structural elements.
    1. Elements across the comp.
    2. Elements on the boundaries of the comp.
3. Behaviour of the structural elements

Two software are available

1. C.F.D. software (can perform step 1, and perhaps 2)
2. F.E. software (can perform step 2 and 3)

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Two decisions have to be taken:

1. Which software will perform step 2 ?
2. What level of coupling will be taken into account?

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1. Which software will perform step 2 ?

	C.F.D.	F.E.
+	Direct transfer of information from step 1.	Direct transfer of the results to step 3.
-	Transfer of the results to step 3 if the meshes do not coincide. Problems with thin elements. Problems with inclined surfaces. The structure MUST be in the model during step 1.	How to get information from step 1 when the meshes do not coincide?

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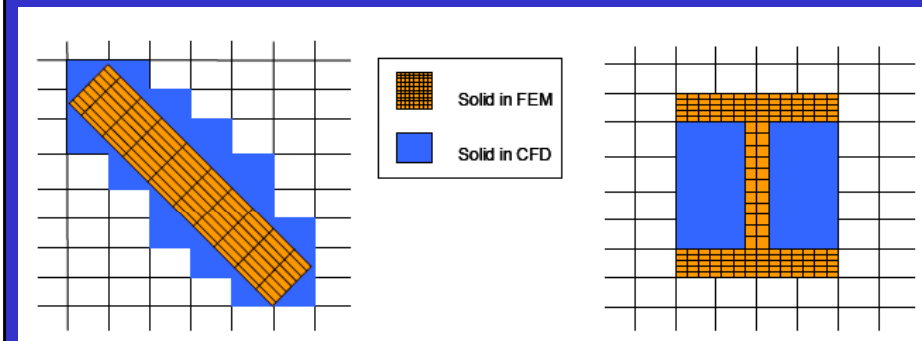

Problems with thin elements.
Problems with inclined surfaces.

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Some software allow step 2 to be performed by the C.F.D. (e.g. Ansys-CFX).

In the FIRESTRUC RFCS project, it was preferred to have it performed by the F.E.

« How to get information from step 1 » will be discussed after decision 2 (level of coupling) has been answered.

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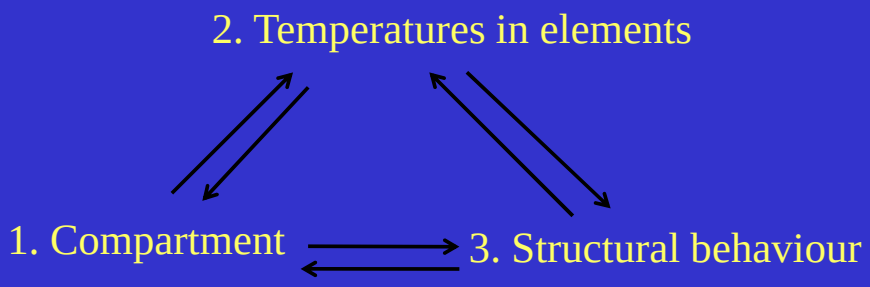
2. What level of coupling will be taken into account?

In real life, everything is coupled.



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Fire
⇒ Convection and radiation to Structural Elements (1 to 2)

Velocity of gases
⇒ Coefficients of convection (1 to 2)
⇒ Dynamic pressure on walls, windows (1 to 3)

Pressure
=> Static pressure on walls, windows (1 to 3)

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Temperatures in materials
⇒ Thermal elongation of elements (2 to 3)
⇒ Degradation of mechanical properties (2 to 3)
⇒ Absorn energy from the comp. (2 to 1)

Plasticity and cracking in elements
⇒ Generation of heat (3 to 2)
⇒ Modification of thermal properties, λ and ρ (3 to 2)

Displacements in elements
⇒ Modify the flow of gases (3 to 1)
⇒ Modify the thermal exposure of the elements (3 to 1)

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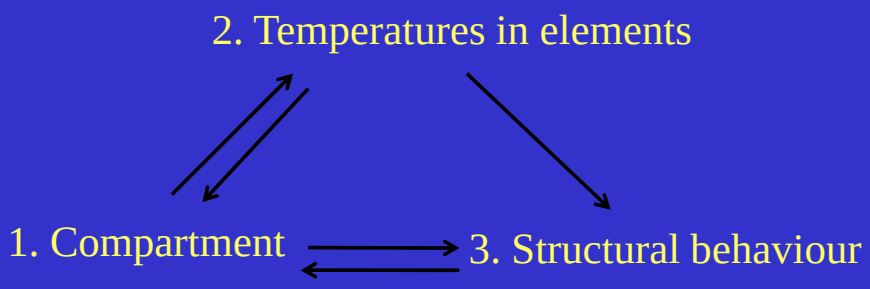
It is usually accepted to neglegt the effects 3 to 2 (this is also the case in standard F.E. calculations).



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First option: full coupling.

Advantages:

- All phenomena are taken into account.
- Exact results obtained.
- General field of application

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First option: full coupling.

Difficulties:

1. A CFD sofwtare « A » must communicate with an FE software « X ».
   - Modifications have to be made in both codes.
   - Questions about different time steps must be adressed.
   - Intervention of specialists in A, in X and in informatic is required.
   - Will not work with a CFD software « B » or an FE software « Y ».
   - What when a new release of A or X is produced?
   - What when the O.S. is changed on the computer, or when the computer is changed?

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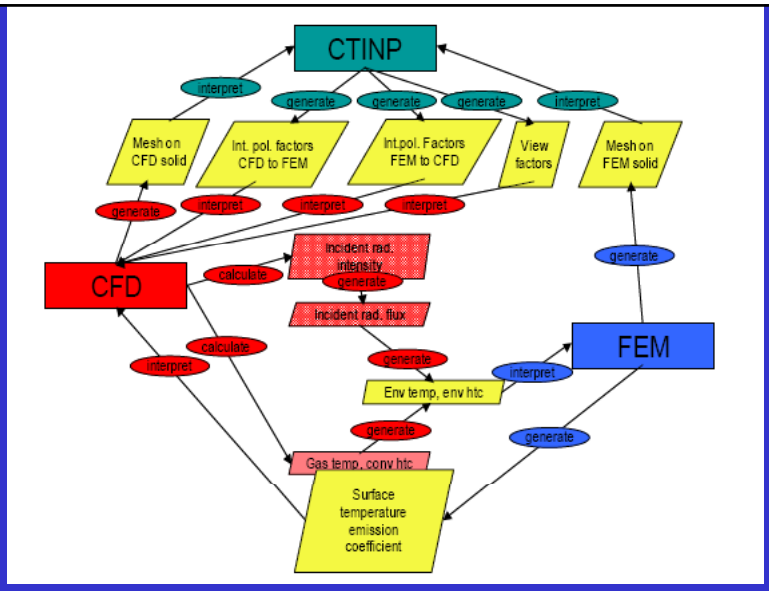
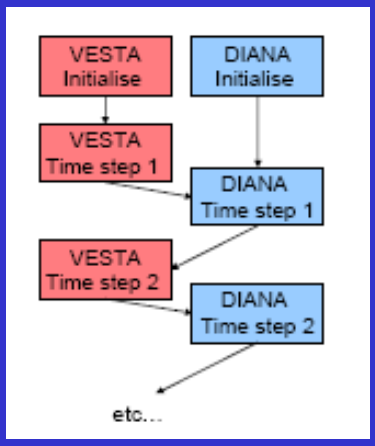


A CFD sofwtare « A » must communicate with an FE software « X ». Example VESTA <-> DIANA



Questions about different time steps must be adressed

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First option: full coupling.

Difficulties:

2. Each run requires a specialist in CFD and a specialist in FE (or someone who is specialist in both).
3. Capacity demand of the hardware and CPU time increase, especially during the debugging of the model.
4. If the structure must be changed (either because it does not satisfy the fire resistance requirement, or because the architect changes the project), everything has to be recalculated.

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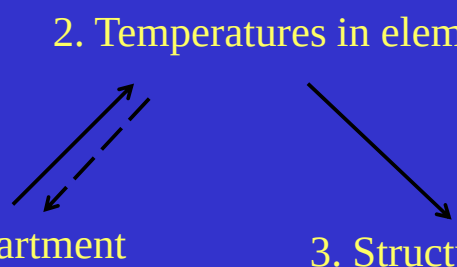
Second option: one way coupling



Note:interaction 2 to 1

- is complete if step 2 is performed by the CFD,
- is limited to the boundary of the compartmen if step 2 is performed by the FE.

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Second option: one way coupling

Advantages:

- The CFD calculation can be performed before and separately of the FE analysis. A result file is produced by « A » that will be read by « X ».
- Can be used with different combinations of CFD and FE software.
- Les demanding in CPU and hardware.

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Second option: one way coupling

Difficulties:

- How to judge whether the interactions between 1 and 3 are really negligible?

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Thank you.