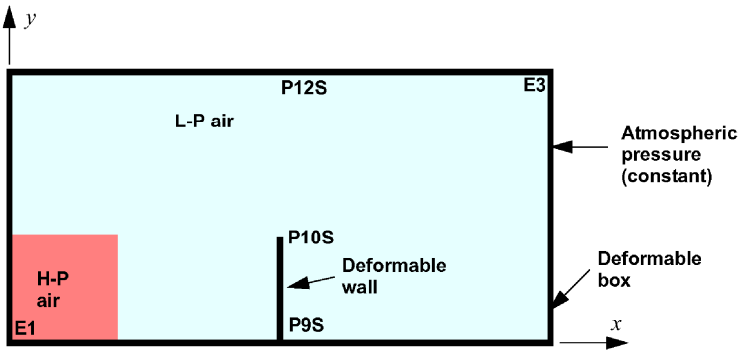
Exercise 12b – FLSR with NCFV



- The box problem of exercise 10b (Part 3) is solved with NCFV using the FLSR model for Fluid-Structure Interaction
  - Obtain solution with NCFV and FSA (reference solution) by using a fine fluid mesh and non-conforming FSA model (see Part 5)
  - Obtain solution with NCFV and basic FLSR : large spurious fluid leakage is observed
  - Add keyword **`MCFL 1`** : the spurious leakage disappears

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PROBLEM:
This is the same box problem already studied in Part 3 (exercise 10b). Now the problem is solved by NCFV using either FSA (reference solution) or FLSR. The use of optional keyword FLSR … MCFL 1 ito block spurious fluxes is illustrated.

Numerical Solutions

VFNCN2
This is the reference solution, obtained with FSA (non conforming mesh, see Part 5). The Cast3m mesh generation file reads:

```
opti echo 1;
opti titr 'VFNCN2';
opti sauv form 'vfncn2.msh';
opti trac psc ftra 'vfncn2_mesh.ps';
*
opti dime 2 elem qua4;
*
p1 = 0 0;
p2 = 2 0;
p3 = 2 1;
p4 = 0 1;
p5 = 0.4 0;
p6 = 0.4 0.4;
p7 = 0 0.4;
p8 = 0.4 1;
*
tol = 0.001;
*
c1 = p1 d 16 p5;
c2 = p5 d 16 p6;
c3 = p6 d 16 p7;
c4 = p7 d 16 p1;
expl = dall c1 c2 c3 c4 plan;
*
p9l = 1 0;
p9r = 1 0;
p10 = 1 0.4;
p11 = 2 0.4;
*
c1 = p5 d 24 p9l;
c2 = p9l d 16 p10;
c3 = p10 d 24 p6;
c4 = p6 d 16 p5;
air1a = dall c1 c2 c3 c4 plan;
*
c1 = p9r d 40 p2;
c2 = p2 d 16 p11;
c3 = p11 d 40 p10;
c4 = p10 d 16 p9r;
air1b = dall c1 c2 c3 c4 plan;
*
c1 = p6 d 24 p10 d 40 p11;
c2 = p11 d 24 p3;
c3 = p3 d 64 p8;
c4 = p8 d 24 p6;
air1c = dall c1 c2 c3 c4 plan;
*
elim tol (air1a et air1c);
elim tol (air1b et air1c);
air1 = air1a et air1b et air1c;
*
c1 = p7 d 16 p6;
c2 = p6 d 24 p8;
c3 = p8 d 16 p4;
c4 = p4 d 24 p7;
air2 = dall c1 c2 c3 c4 plan;
elim tol (air1c et air2);
elim tol (expl et air2);
elim tol (expl et air1a);
*
air = air1 et air2;
flui = expl et air;
*
e1 = expl elem cont p1;
e3 = air1 elem cont p3;
*
p1s = p1 plus p1;
p2s = p2 plus p1;
p3s = p3 plus p1;
p4s = p4 plus p1;
p9s = p9l plus p1;
p10s = p10 plus p1;
p12s = 1 1;
c1s = p1s d 10 p9s d 10 p2s;
c2s = p2s d 10 p3s;
c3s = p3s d 10 p12s d 10 p4s;
c4s = p4s d 10 p1s;
c5s = p9s d 4 p10s;
stru = c1s et c2s et c3s et c4s et c5s;
*
c1p = p2s d 10 p9s d 10 p1s;
c2p = p3s d 10 p2s;
c3p = p4s d 10 p12s d 10 p3s;
c4p = p1s d 10 p4s;
pext = c4p et c3p et c2p et c1p;
elim tol (stru et pext);
*
nfsa = cont flui;
*
mesh = flui et stru et pext et e1 et e3 et nfsa;
*
sauv form mesh;
trac qual mesh;
*
list (nbel mesh);
list (nbno mesh);
```

```
*
fin;
```

The EUROPLEXUS input file reads:

```
VFNCN2
ECHO
!conv win
CAST mesh
DPLA ALE
DIME
 NALE 148 NBLE 3065 NDVC 13072
TERM
GEOM MC24 flui ED01 stru CL22 pext TERM
COMP EPAI 0.01 LECT stru TERM
     COUL turq LECT air  TERM
          roug LECT expl TERM
          bleu LECT stru TERM
          jaun LECT pext TERM
GRIL LAGR LECT stru TERM
     EULE LECT nfsa TERM
     AUTO AUTR
MATE MCGP NCOM 1 R 8.3143E3
          COMP 'Air' PM 29.0 CV1 2.07585E4 CV2 0 CV3 0
          LECT flui TERM
     VM23 RO 7800. YOUNG 1.6E11 NU 0.333 ELAS 1.05E8
          TRAC 2 1.05E8 .656256E-3 1.6105E10 1.00066
          LECT stru TERM
     IMPE PIMP RO 1.1897 PRES 1.E5 PREF 0
          LECT pext TERM
INIT MCOM COMP 'Air' MFRA 1.0 LECT flui TERM
          PRES 1.E6 LECT expl TERM
          PRES 1.E5 LECT air  TERM
          TEMP 586.36 LECT expl TERM
          TEMP 293.16 LECT air  TERM
          VEL1 0.0 LECT flui TERM
          VEL2 0.0 LECT flui TERM
LINK COUP FSA NCFS LECT nfsa TERM
ECRI DEPL VITE ACCE FINT FEXT CONT ECRO MCVA TFRE 1.E-3
          POIN LECT p1 p5 p6 p7 p3 TERM
          ELEM LECT e1 e3 TERM
     FICH ALIC TFRE 5.E-5
     FICH ALIC TEMP FREQ 1
          POIN LECT p1 p4 p5 p6 p7 p3 p1s p2s p3s p4s p9s p10s p12s TERM
          ELEM LECT e1 e3 TERM
OPTI NOTE LOG 1
     CSTA 0.5
     MC ORDR 2 NUFL ROE
CALC TINI 0.0 TFIN 5.E-3
*=================================================================
PLAY
CAME   1 EYE   1.00000E+00  5.00000E-01  5.03115E+00
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
sler cam1 1 nfra 1
scen geom navi free
          face hfro
     vect scco fiel vite scal user prog 10 pas 10 140 term
          SUPP LECT air  TERM
     text vsca
     colo pape
freq 0 tfre 2.5e-3
go
trac offs fich bmp rend
go
trac offs fich bmp rend
ENDPLAY
*=================================================================
SUIT
Post treatment
ECHO
 conv win
RESU ALIC GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=================================================================
PLAY
CAME   1 EYE   1.00000E+00  5.00000E-01  5.03115E+00
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
sler cam1 1 nfra 1
scen geom navi free
     iso  fili fiel mcpr scal user prog 0.61E5 pas 0.2E5 3.21E5 term
          SUPP LECT flui TERM
     text isca
     vect scco fiel vite scal user prog 10 pas 10 140 term
          SUPP LECT flui TERM
     text vsca
     colo pape
trac offs fich avi     nocl nfto 101 fps 10 kfre 10 comp -1 rend
freq 1
gotr loop 99 offs fich avi cont nocl rend
go
trac offs fich avi cont rend
ENDPLAY
*=================================================================
```

```
SUIT
Post treatment
ECHO
 conv win
RESU ALIC GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=================================================================
PLAY
CAME   1 EYE   1.00000E+00  5.00000E-01  5.03115E+00
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
sler cam1 1 nfra 1
scen geom navi free
     iso  fili fiel mcpr scal user prog 0.61E5 pas 0.2E5 3.21E5 term
          SUPP LECT flui TERM
     text isca
     vect scco fiel vite scal user prog 10 pas 10 140 term
          SUPP LECT flui TERM
     text vsca
     colo pape
freq 50
go
trac offs fich bmp rend
go
trac offs fich bmp rend
ENDPLAY
*=================================================================
SUIT
Post treatment
ECHO
 conv win
RESU ALIC GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=================================================================
PLAY
CAME   1 EYE   1.00000E+00  5.00000E-01  5.03115E+00
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
sler cam1 1 nfra 1
scen geom navi free
     iso  fili fiel mcpr scal user prog 0.61E5 pas 0.2E5 3.21E5 term
          SUPP LECT flui TERM
     text isca
     colo pape
freq 50
go
trac offs fich bmp rend
go
trac offs fich bmp rend
ENDPLAY
*=================================================================
SUIT
Post-treatment (time curves from alice temps file)
ECHO
*
RESU ALIC TEMP GARD PSCR
*
SORT GRAP
*
AXTE 1.0 'Time [s]'
*
COUR  1 'dt1'     DT1
COUR  3 'p_e1'    MCPR COMP 1 NOEU LECT p1 TERM
COUR  4 'p_e3'    MCPR COMP 1 NOEU LECT p3 TERM
COUR  5 'dx_p10s' DEPL COMP 1 POIN LECT p10s TERM
COUR  6 'dy_p12s' DEPL COMP 2 POIN LECT p12s TERM
COUR  7 'dx_p9s'  DEPL COMP 1 POIN LECT p9s TERM
COUR  8 'dy_p9s'  DEPL COMP 2 POIN LECT p9s TERM
COUR 101 'p_p4'    MCPR COMP 1 NOEU LECT p4 TERM
COUR 102 'r_p4'    MCRO COMP 1 NOEU LECT p4 TERM
COUR 103 't_p4'    MCTE COMP 1 NOEU LECT p4 TERM
COUR 104 'yl_p4'   MCMF COMP 1 NOEU LECT p4 TERM
*
TRAC 1   AXES 1.0 'DELTAT [S]'
TRAC 3 4 AXES 1.0 'PRESS [PA]'
TRAC 5 6 AXES 1.0 'DISPL. [M]'
TRAC 7 8 AXES 1.0 'DISPL. [M]'
TRAC 101 AXES 1.0 'PRESS. [PA]'
TRAC 102 AXES 1.0 'DENS. [KG/M3]'
TRAC 103 AXES 1.0 'TEMP. [K]'
TRAC 104 AXES 1.0 'FRAC. [-]'
LIST 3 4 AXES 1.0 'PRESS [PA]'
LIST 5 6 AXES 1.0 'DISPL. [M]'
LIST 7 8 AXES 1.0 'DISPL. [M]'
*
QUAL MCPR COMP 1 LECT p1 TERM REFE  1.56554E+5 TOLE 5.E-3
     MCPR COMP 1 LECT p3 TERM REFE  2.02150E+5 TOLE 5.E-3
*=================================================================
FIN
```

VFNCF2S

This is the solution with (basic) FLSR. The Cast3m mesh generation file reads:

```
opti echo 1;
opti titr 'VFNCF2S';
opti sauv form 'vfncf2s.msh';
opti trac psc ftra 'vfncf2s_mesh.ps';
*
opti dime 2 elem qua4;
*
p1 = 0 0;
p2 = 2 0;
p3 = 2 1;
p4 = 0 1;
p5 = 0.4 0;
p6 = 0.4 0.4;
p7 = 0 0.4;
p8 = 0.4 1;
*
pa = -0.2 -0.2;
pb =  2.2 -0.2;
pc =  2.2  1.2;
pd = -0.2  1.2;
*
tol = 0.001;
*
c1 = pa d 96 pb;
c2 = pb d 56 pc;
c3 = pc d 96 pd;
c4 = pd d 56 pa;
flui = dall c1 c2 c3 c4 plan;
elim tol (flui et p1 et p2 et p3 et p4 et p5 et p6 et p7 et p8);
```

```
abso = c1 et c2 et c3 et c4;
*
el1 = flui elem appu larg p1;
el3 = flui elem appu larg p3;
*
p9s = 1 0;
p10s = 1 0.4;
p11s = 2 0.4;
p12s = 1 1;
p1s = p1 plus p1;
p2s = p2 plus p1;
p3s = p3 plus p1;
p4s = p4 plus p1;
c1s = p1s d 10 p9s d 10 p2s;
c2s = p2s d 10 p3s;
c3s = p3s d 10 p12s d 10 p4s;
c4s = p4s d 10 p1s;
c5s = p9s d 4 p10s;
stru = c1s et c2s et c3s et c4s et c5s;
*
mesh = flui et stru et abso et el1 et el3;
*
sauv form mesh;
trac qual mesh;
*
list (nbel mesh);
list (nbno mesh);
*
fin;
```

The EUROPLEXUS input file reads:

```
VFNCF2S
ECHO
 conv win
CAST mesh
DPLA ALE
DIME
 NALE 148 NBLE 3065 NDVC 21808
TERM
GEOM MC24 flui ED01 stru CL22 abso TERM
COMP EPAI 0.01 LECT stru TERM
     GROU 3 'expl' LECT flui TERM COND BOX X0 0.0 Y0 0.0 DX 0.4 DY 0.4
            'flin' LECT flui TERM COND BOX X0 0.0 Y0 0.0 DX 2.0 DY 1.0
            'air'  LECT flui TERM COND COMP LECT expl TERM
     COUL turq LECT air  TERM
          roug LECT expl TERM
          bleu LECT stru TERM
          jaun LECT abso TERM
GRIL LAGR LECT stru TERM
MATE MCGP NCOM 1 R 8.3143E3
          COMP 'Air' PM 29.0 CV1 2.07585E4 CV2 0 CV3 0
          LECT flui TERM
     VM23 RO 7800. YOUNG 1.6E11 NU 0.333 ELAS 1.05E8
          TRAC 2 1.05E8 .656256E-3 1.6105E10 1.00066
          LECT stru TERM
     MCFF BDFO 1 TEMP 293.16 PRES 1.E5
          VEL1 0. VEL2 0.
          COMP 'Air'      MFRA 1.
          LECT abso TERM
INIT MCOM COMP 'Air' MFRA 1.0 LECT flui TERM
          PRES 1.E6 LECT expl TERM
          PRES 1.E5 LECT air  TERM
          TEMP 586.36 LECT expl TERM
          TEMP 293.16 LECT air  TERM
          VEL1 0.0 LECT flui TERM
          VEL2 0.0 LECT flui TERM
LINK COUP FLSR STRU LECT stru TERM
               FLUI LECT flui TERM
               R    0.036 ! = gamma*delta*h_fluide = 1.01*1.41*0.025
!fc            R    0.018 ! = gamma*delta*h_fluide = 1.01*1.41*0.025
                          !   [delta = sqrt(2) en 2D, = sqrt(3) en 3D]
               HGRI 0.110
               DGRI
ECRI DEPL VITE ACCE FINT FEXT CONT ECRO
     MCVC MCVS MCFL MCEF MCMU MCVM TFRE 1.E-3
          POIN LECT p1 p5 p6 p7 p3 TERM
     FICH ALIC TFRE 5.E-5
     FICH ALIC TEMP FREQ 1
          POIN LECT p1 p4 p5 p6 p7 p3 p1s p2s p3s p4s p9s p10s p12s TERM
OPTI NOTE LOG 1
     CSTA 0.5
     MC ORDR 2 NUFL ROE SYNC 1
CALC TINI 0.0 TFIN 5.E-3
*=================================================================
PLAY
CAME   1 EYE   1.00000E+00  5.00000E-01  5.03115E+00
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
sler cam1 1 nfra 1
scen geom navi free
     face hfro
     vect scco fiel vite scal user prog 10 pas 10 140 term
          SUPP LECT air  TERM
     text vsca
     colo pape
freq 0 tfre 2.5e-3
go
trac offs fich bmp rend
go
trac offs fich bmp rend
ENDPLAY
*=================================================================
SUIT
Post treatment
ECHO
 conv win
RESU ALIC GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=================================================================
PLAY
CAME   1 EYE   1.00000E+00  5.00000E-01  5.03115E+00
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
sler cam1 1 nfra 1
scen geom navi free
     iso  fili fiel mcpr scal user prog 0.61E5 pas 0.2E5 3.21E5 term
          SUPP LECT flui TERM
     text isca
     vect scco fiel vite scal user prog 10 pas 10 140 term
          SUPP LECT flui TERM
     text vsca
     colo pape
trac offs fich avi     nocl nfto 101 fps 10 kfre 10 comp -1 rend
freq 1
gotr loop 99 offs fich avi cont nocl rend
go
trac offs fich avi cont rend
ENDPLAY
*=================================================================
SUIT
Post treatment
ECHO
 conv win
RESU ALIC GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*=================================================================
PLAY
CAME   1 EYE   1.00000E+00  5.00000E-01  5.03115E+00
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
sler cam1 1 nfra 1
scen geom navi free
     iso  fili fiel mcpr scal user prog 0.61E5 pas 0.2E5 3.21E5 term
          SUPP LECT flui TERM
     text isca
     colo pape
freq 50
go
trac offs fich bmp rend
go
trac offs fich bmp rend
ENDPLAY
*=================================================================
SUIT
Post-treatment (time curves from alice temps file)
ECHO
*
RESU ALIC TEMP GARD PSCR
*
SORT GRAP
*
AXTE 1.0 'Time [s]'
*
COUR  1 'dt1'     DT1
COUR  3 'p_e1'    MCPR COMP 1 NOEU LECT p1 TERM
COUR  4 'p_e3'    MCPR COMP 1 NOEU LECT p3 TERM
COUR  5 'dx_p10s' DEPL COMP 1 POIN LECT p10s TERM
COUR  6 'dy_p12s' DEPL COMP 2 POIN LECT p12s TERM
COUR  7 'dx_p9s'  DEPL COMP 1 POIN LECT p9s TERM
COUR  8 'dy_p9s'  DEPL COMP 2 POIN LECT p9s TERM
COUR 101 'p_p4'    MCPR COMP 1 NOEU LECT p4 TERM
COUR 102 'r_p4'    MCRO COMP 1 NOEU LECT p4 TERM
COUR 103 't_p4'    MCTE COMP 1 NOEU LECT p4 TERM
COUR 104 'yl_p4'   MCMF COMP 1 NOEU LECT p4 TERM
*
TRAC 1   AXES 1.0 'DELTAT [S]'
TRAC 3 4 AXES 1.0 'PRESS [PA]'
TRAC 5 6 AXES 1.0 'DISPL. [M]'
TRAC 7 8 AXES 1.0 'DISPL. [M]'
TRAC 101 AXES 1.0 'PRESS. [PA]'
TRAC 102 AXES 1.0 'DENS. [KG/M3]'
TRAC 103 AXES 1.0 'TEMP. [K]'
TRAC 104 AXES 1.0 'FRAC. [-]'
LIST 3 4 AXES 1.0 'PRESS [PA]'
LIST 5 6 AXES 1.0 'DISPL. [M]'
LIST 7 8 AXES 1.0 'DISPL. [M]'
*
QUAL MCPR COMP 1 LECT p1 TERM REFE  1.10708E+5 TOLE 5.E-3
     MCPR COMP 1 LECT p3 TERM REFE  1.36705E+5 TOLE 5.E-3
*=================================================================
FIN
```

VFNCF3S

This is the solution with FLSR and MCFL 1. The Cast3m mesh generation file is identical to the previous case. The EUROPLEXUS input file reads:

```
VFNCF3S
ECHO
 conv win
CAST mesh
DPLA ALE
DIME
 NALE 148 NBLE 3065 NDVC 21808
TERM
GEOM MC24 flui ED01 stru CL22 abso TERM
COMP EPAI 0.01 LECT stru TERM
     GROU 3 'expl' LECT flui TERM COND BOX X0 0.0 Y0 0.0 DX 0.4 DY 0.4
            'flin' LECT flui TERM COND BOX X0 0.0 Y0 0.0 DX 2.0 DY 1.0
            'air'  LECT flui TERM COND COMP LECT expl TERM
     COUL turq LECT air  TERM
          roug LECT expl TERM
          bleu LECT stru TERM
          jaun LECT abso TERM
GRIL LAGR LECT stru TERM
MATE MCGP NCOM 1 R 8.3143E3
          COMP 'Air' PM 29.0 CV1 2.07585E4 CV2 0 CV3 0
          LECT flui TERM
     VM23 RO 7800. YOUNG 1.6E11 NU 0.333 ELAS 1.05E8
          TRAC 2 1.05E8 .656256E-3 1.6105E10 1.00066
          LECT stru TERM
     MCFF BDFO 1 TEMP 293.16 PRES 1.E5
          VEL1 0. VEL2 0.
          COMP 'Air'      MFRA 1.
          LECT abso TERM
INIT MCOM COMP 'Air' MFRA 1.0 LECT flui TERM
          PRES 1.E6 LECT expl TERM
          PRES 1.E5 LECT air  TERM
          TEMP 586.36 LECT expl TERM
          TEMP 293.16 LECT air  TERM
          VEL1 0.0 LECT flui TERM
          VEL2 0.0 LECT flui TERM
LINK COUP FLSR STRU LECT stru TERM
               FLUI LECT flui TERM
               R    0.036 ! = gamma*delta*h_fluide = 1.01*1.41*0.025
!fc            R    0.018 ! = gamma*delta*h_fluide = 1.01*1.41*0.025
                          !   [delta = sqrt(2) en 2D, = sqrt(3) en 3D]
               HGRI 0.110
               DGRI
               MCFL 1 MCCP 1
ECRI DEPL VITE ACCE FINT FEXT CONT ECRO
     MCVC MCVS MCFL MCEF MCMU MCVM TFRE 1.E-3
          POIN LECT p1 p5 p6 p7 p3 TERM
     FICH ALIC TFRE 5.E-5
     FICH ALIC TEMP FREQ 1
          POIN LECT p1 p4 p5 p6 p7 p3 p1s p2s p3s p4s p9s p10s p12s TERM
OPTI NOTE LOG 1
     CSTA 0.5
     MC ORDR 2 NUFL ROE SYNC 1
CALC TINI 0.0 TFIN 5.E-3
*=================================================================
PLAY
CAME   1 EYE   1.00000E+00  5.00000E-01  5.03115E+00
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
```

```
        RIGH  1.00000E+00  0.00000E+00  0.00000E+00
        UP    0.00000E+00  1.00000E+00  0.00000E+00
        FOV   2.48819E+01
sler cam1 1 nfra 1
scen geom navi free
          face hfro
     vect scco fiel vite scal user prog 10 pas 10 140 term
          SUPP LECT air  TERM
     text vsca
     colo pape
freq 0 tfre 2.5e-3
go
trac offs fich bmp rend
go
trac offs fich bmp rend
ENDPLAY
*================================================================
SUIT
Post treatment
ECHO
 conv win
RESU ALIC GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*================================================================
PLAY
CAME   1 EYE   1.00000E+00  5.00000E-01  5.03115E+00
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
sler cam1 1 nfra 1
scen geom navi free
     iso  fili fiel mcpr scal user prog 0.61E5 pas 0.2E5 3.21E5 term
          SUPP LECT flui TERM
     text isca
     vect scco fiel vite scal user prog 10 pas 10 140 term
          SUPP LECT flui TERM
     text vsca
     colo pape
trac offs fich avi     nocl nfto 101 fps 10 kfre 10 comp -1 rend
freq 1
gotr loop 99 offs fich avi cont nocl rend
go
trac offs fich avi cont rend
ENDPLAY
*================================================================
SUIT
Post treatment
ECHO
 conv win
RESU ALIC GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*================================================================
PLAY
CAME   1 EYE   1.00000E+00  5.00000E-01  5.03115E+00
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
sler cam1 1 nfra 1
scen geom navi free
     iso  fili fiel mcpr scal user prog 0.61E5 pas 0.2E5 3.21E5 term
          SUPP LECT flui TERM
     text isca
     vect scco fiel vite scal user prog 10 pas 10 140 term
          SUPP LECT flui TERM
     text vsca
     colo pape
freq 50
```

```
go
trac offs fich bmp rend
go
trac offs fich bmp rend
ENDPLAY
*================================================================
SUIT
Post treatment
ECHO
 conv win
RESU ALIC GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
*================================================================
PLAY
CAME   1 EYE   1.00000E+00  5.00000E-01  5.03115E+00
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
sler cam1 1 nfra 1
scen geom navi free
     iso  fili fiel mcpr scal user prog 0.61E5 pas 0.2E5 3.21E5 term
          SUPP LECT flui TERM
     text isca
     colo pape
freq 50
go
trac offs fich bmp rend
go
trac offs fich bmp rend
ENDPLAY
*================================================================
SUIT
Post-treatment (time curves from alice temps file)
ECHO
*
RESU ALIC TEMP GARD PSCR
*
SORT GRAP
*
AXTE 1.0 'Time [s]'
*
COUR  1 'dt1'     DT1
COUR  3 'p_e1'    MCPR COMP 1 NOEU LECT p1 TERM
COUR  4 'p_e3'    MCPR COMP 1 NOEU LECT p3 TERM
COUR  5 'dx_p10s' DEPL COMP 1 POIN LECT p10s TERM
COUR  6 'dy_p12s' DEPL COMP 2 POIN LECT p12s TERM
COUR  7 'dx_p9s'  DEPL COMP 1 POIN LECT p9s TERM
COUR  8 'dy_p9s'  DEPL COMP 2 POIN LECT p9s TERM
COUR 101 'p_p4'    MCPR COMP 1 NOEU LECT p4 TERM
COUR 102 'r_p4'    MCRO COMP 1 NOEU LECT p4 TERM
COUR 103 't_p4'    MCTE COMP 1 NOEU LECT p4 TERM
COUR 104 'yl_p4'   MCMF COMP 1 NOEU LECT p4 TERM
*
TRAC 1   AXES 1.0 'DELTAT [S]'
TRAC 3 4 AXES 1.0 'PRESS [PA]'
TRAC 5 6 AXES 1.0 'DISPL. [M]'
TRAC 7 8 AXES 1.0 'DISPL. [M]'
TRAC 101 AXES 1.0 'PRESS. [PA]'
TRAC 102 AXES 1.0 'DENS. [KG/M3]'
TRAC 103 AXES 1.0 'TEMP. [K]'
TRAC 104 AXES 1.0 'FRAC. [-]'
LIST 3 4 AXES 1.0 'PRESS [PA]'
LIST 5 6 AXES 1.0 'DISPL. [M]'
LIST 7 8 AXES 1.0 'DISPL. [M]'
*
QUAL MCPR COMP 1 LECT p1 TERM REFE  1.00000E+5 TOLE 5.E-3
     MCPR COMP 1 LECT p3 TERM REFE  1.00000E+5 TOLE 5.E-3
*================================================================
FIN
```

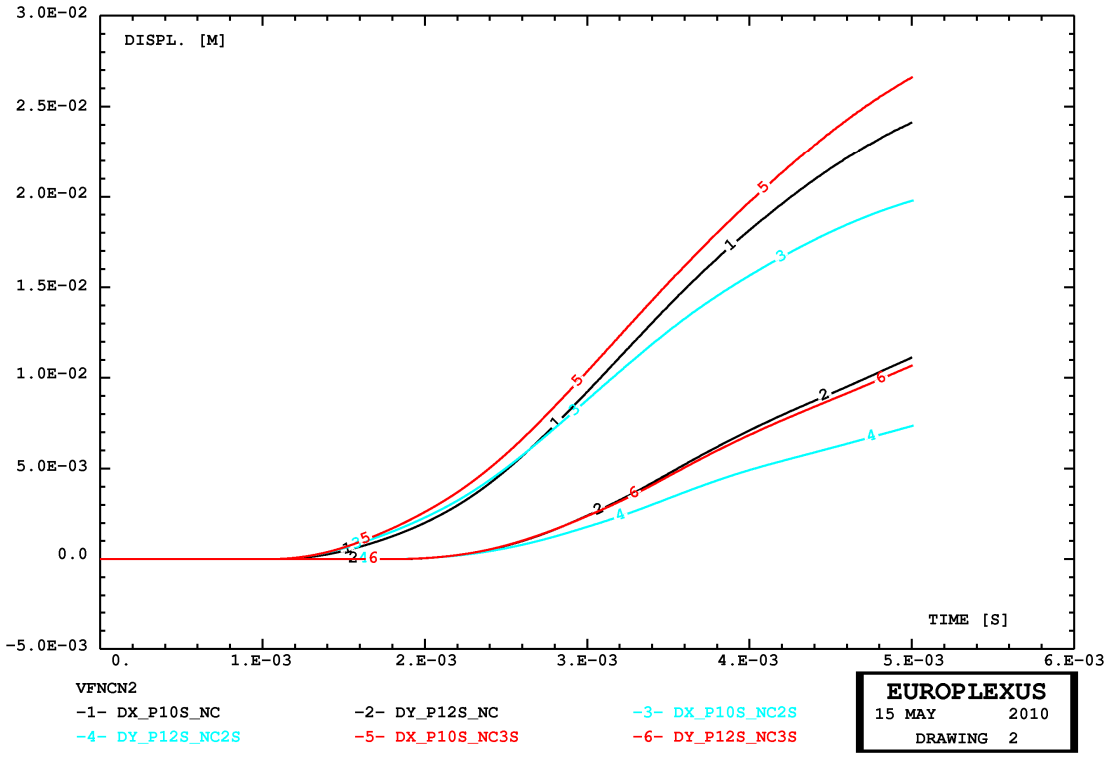
EFVFC2

This is an input file used to compare the various solutions:

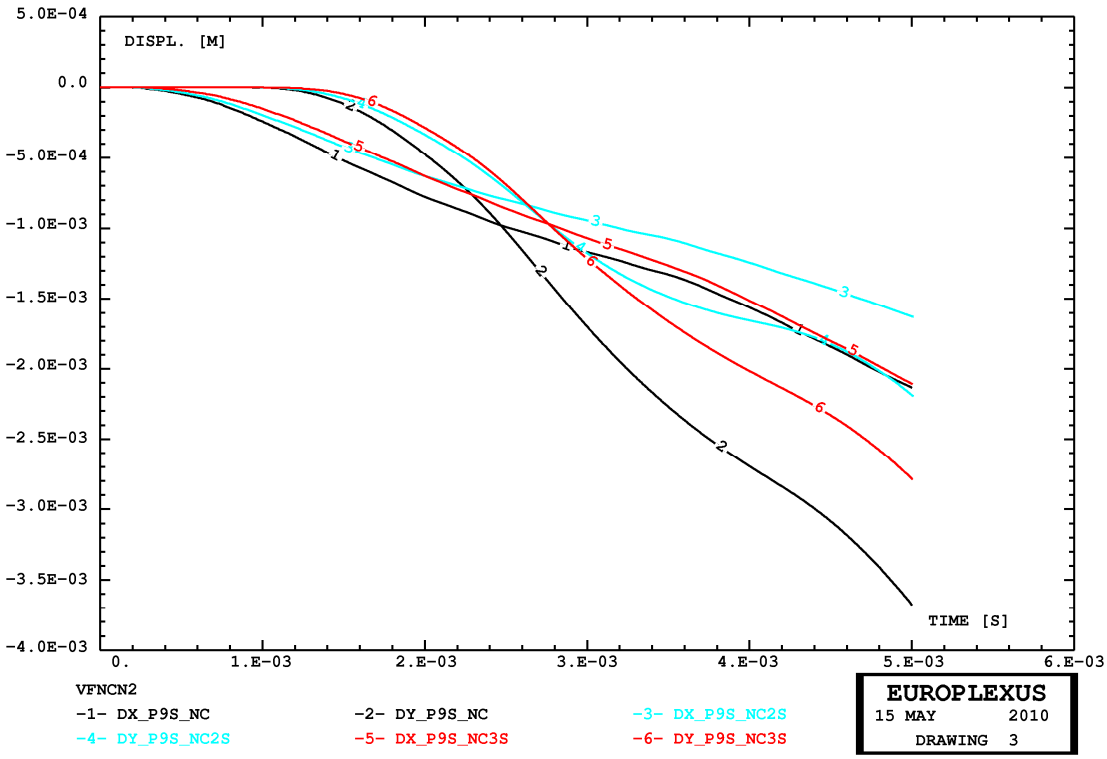
```
EFVFC2
ECHO
*
RESU ALIC TEMP 'vfncn2.alt' GARD PSCR
*
SORT GRAP
*
AXTE 1.0 'Time [s]'
*
COUR 13 'p_e1_nc'    MCPR COMP 1 NOEU LECT p1 TERM
COUR 14 'p_e3_nc'    MCPR COMP 1 NOEU LECT p3 TERM
COUR 15 'dx_p10s_nc' DEPL COMP 1 POIN LECT p10s TERM
COUR 16 'dy_p12s_nc' DEPL COMP 2 POIN LECT p12s TERM
COUR 17 'dx_p9s_nc'  DEPL COMP 1 POIN LECT p9s TERM
COUR 18 'dy_p9s_nc'  DEPL COMP 2 POIN LECT p9s TERM
*
RCOU 23 'p_e1'    FICH 'vfncf2s.pun' RENA 'p_e1_nc2s'
RCOU 24 'p_e3'    FICH 'vfncf2s.pun' RENA 'p_e3_nc2s'
RCOU 25 'dx_p10s' FICH 'vfncf2s.pun' RENA 'dx_p10s_nc2s'
```

```
RCOU 26 'dy_p12s' FICH 'vfncf2s.pun' RENA 'dy_p12s_nc2s'
RCOU 27 'dx_p9s'  FICH 'vfncf2s.pun' RENA 'dx_p9s_nc2s'
RCOU 28 'dy_p9s'  FICH 'vfncf2s.pun' RENA 'dy_p9s_nc2s'
*
RCOU 43 'p_e1'    FICH 'vfncf3s.pun' RENA 'p_e1_nc3s'
RCOU 44 'p_e3'    FICH 'vfncf3s.pun' RENA 'p_e3_nc3s'
RCOU 45 'dx_p10s' FICH 'vfncf3s.pun' RENA 'dx_p10s_nc3s'
RCOU 46 'dy_p12s' FICH 'vfncf3s.pun' RENA 'dy_p12s_nc3s'
RCOU 47 'dx_p9s'  FICH 'vfncf3s.pun' RENA 'dx_p9s_nc3s'
RCOU 48 'dy_p9s'  FICH 'vfncf3s.pun' RENA 'dy_p9s_nc3s'
*
TRAC 13 14 23 24 43 44 AXES 1.0 'PRESS [PA]'
     COLO noir noir turq turq roug roug
TRAC 15 16 25 26 45 46 AXES 1.0 'DISPL. [M]'
     COLO noir noir turq turq roug roug
TRAC 17 18 27 28 47 48 AXES 1.0 'DISPL. [M]'
     COLO noir noir turq turq roug roug
*================================================================
FIN
```

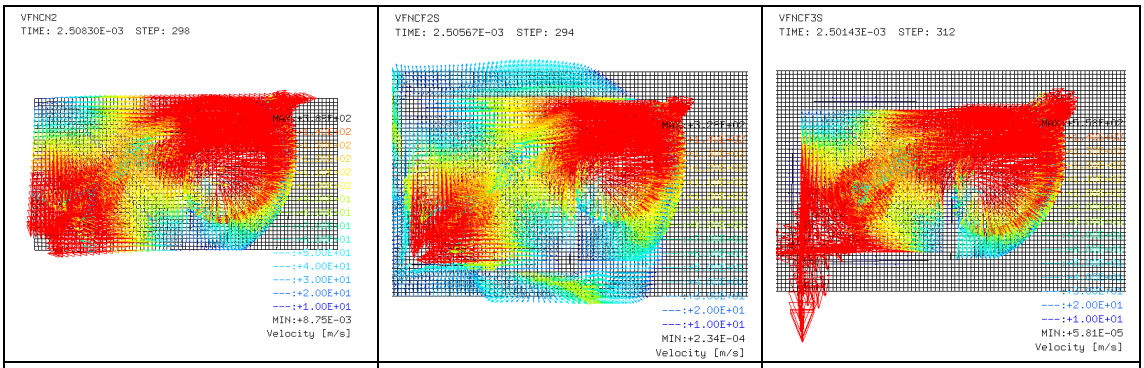
Here are some results. Structural displacements at points P10S and P12S



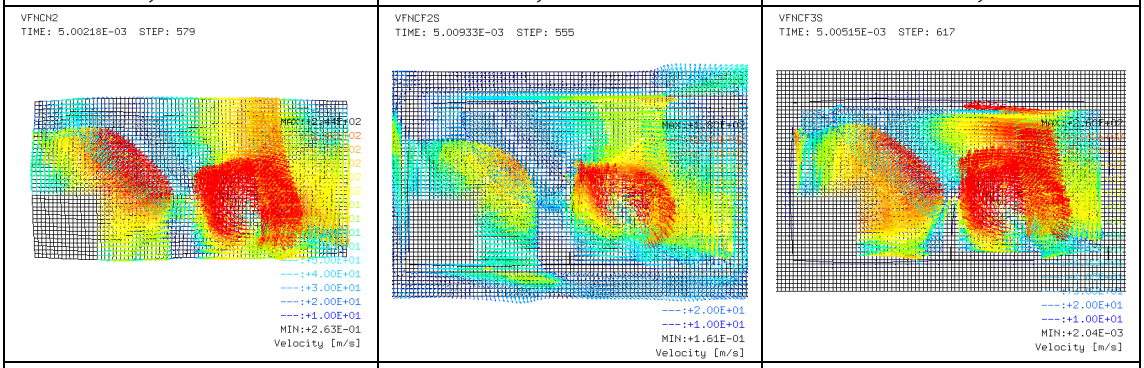
Structural displacements at point P9s:



Fluid velocities:

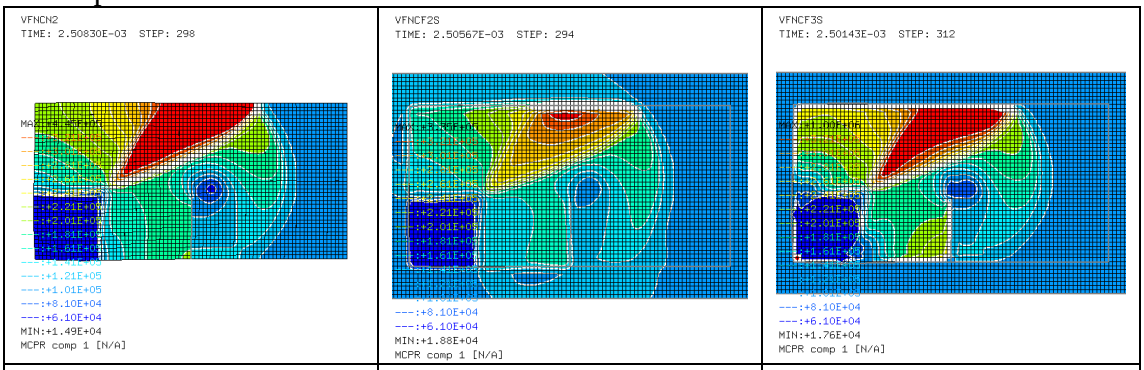


FSA, t = 2.5 ms	FLSR, t = 2.5 ms	FLSR MCFL 1, t = 2.5 ms

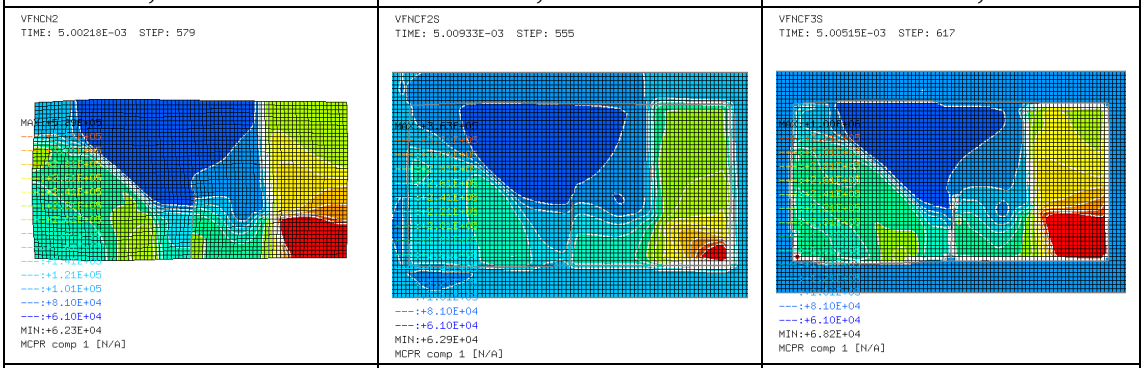


FSA, t = 5.0 ms	FLSR, t = 5.0 ms	FLSR MCFL 1, t = 5.0 ms

Fluid pressures:



FSA, t = 2.5 ms	FLSR, t = 2.5 ms	FLSR MCFL 1, t = 2.5 ms



FSA, t = 5.0 ms	FLSR, t = 5.0 ms	FLSR MCFL 1, t = 5.0 ms

The large leakages observed with the standard FLSR model disappear when MCFL 1 is added, and the solution is overall in good agreement with the reference.