ESEIAAT
Sistemes de Propulsió d'Aeronaus

Parametrització d'un motor Jet

Eva María Urbano González
Pol Fontanes
Boyan Naydenov

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Contents

Listings

List of Figures

1 Introducció i Objectius

El present treball forma part de l'assignatura de Sistemes de Propulsió d'Aeronaus. Gran part d'aquesta assignatura consisteix en l'estudi dels tipus de motors d'una aeronau i de les possibilitats d'optimització, a més de la parametrització dels motors tant en cas ideal com en cas real.
Per tal de duu a terme un estudi més profund de les àrees de coneixement relacionades amb l'assignatura es proposa la realització d'aquest treball. L'objectiu es el disseny preliminar de la motorització d'un avió. Només es donen tres condicions de disseny, de manera que el sistema no queda definit, si no que s'han d'establir certs criteris per a aconseguir tots els paràmetres del motor. En les següents pàgines es discutirà quin tipus de motor pot ser adequat i el criteri de disseny a utilitzar. Seguidament s'implementarà aquest criteri per obtenir alguns dels paràmetres del avió i després es calcularà la resta tenint en compte que el motor es real. Un cop obtinguda la parametrització, s'afegirà al motor un mixer i un postcombustor. En cas que s'hagi decidit afegir un fan, es seleccionarà l'hèlix. Posteriorment, i un cop obtingut els flux màssic tant d'aire com de combustible, es calcularan les àrees del motor.

Sample Figure

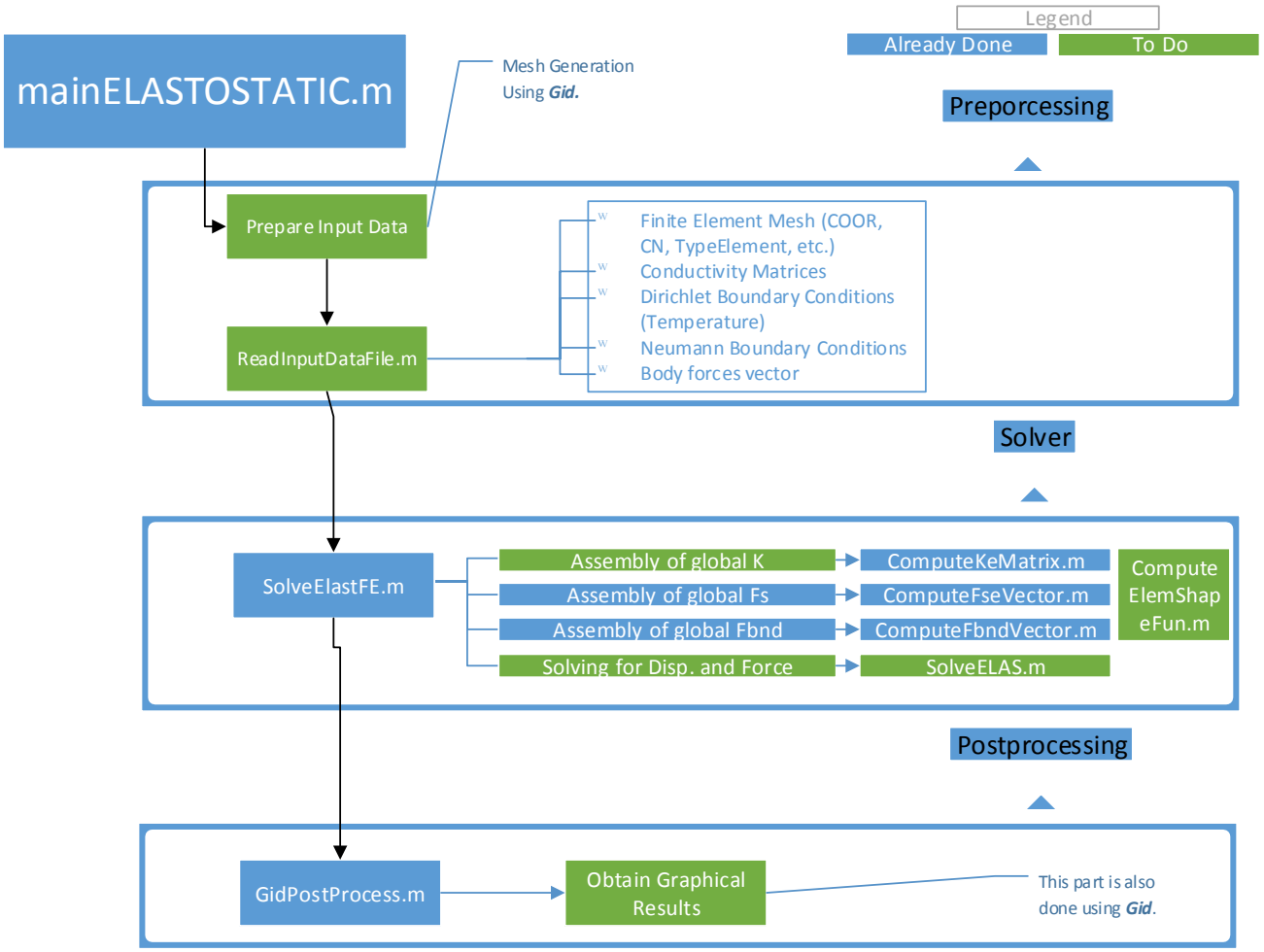

Figure 1: Sample Caption

Numbered equation:

$$K^e = \sum_{g=1}^{m} w_g (J^e B^{e^T} C B^e)_{\xi=\xi_g} \tag{1}$$

In line equation: final Global stiffness matrix K dimensions will be $n_{sd}n_{pt} \times n_{sd}n_{pt}$.

Sample Listing:

Listing 1: ComputeK.m

```
clc;
clear all;
close all;
plot1=[0 0
1 -0.00087300001
2 -0.0024590001];

plot100=[0 0
0.2 -0.000239
0.40000001 -0.00080500002
0.60000002 -0.001642
0.80000001 -0.0026809999
1 -0.0038689999
1.2 -0.0051589999
1.4 -0.006513
1.6 -0.0079009999
1.8 -0.0093019996
2 -0.010703];

plot900=[0 0
0.133333 -0.000137
0.26666701 -0.00043700001
0.40000001 -0.00089600001
0.533333 -0.001482
0.66666698 -0.002177
0.80000001 -0.002961
0.93333298 -0.003817
1.0666699 -0.0047280001
1.2 -0.005682
1.33333 -0.0066669998
1.46667 -0.0076720002
1.6 -0.008688
1.73333 -0.0097110001
1.86667 -0.010734
2 -0.011756];

plot4=[0 0
0.1 -9.4000003e-005
0.2 -0.00028099999
0.30000001 -0.00056999997
0.40000001 -0.00094400003
0.5 -0.001392
0.60000002 -0.001907
0.69999999 -0.002478
0.80000001 -0.0030990001
0.89999998 -0.003762
1 -0.0044590002
1.1 -0.0051850001
1.2 -0.0059329998
1.3 -0.006699
```

```
1.4 -0.0074780001
1.5 -0.0082660001
1.6 -0.0090589998
1.7 -0.0098559996
1.8 -0.010654
1.9 -0.011451
2 -0.012247];

figure
hold on
plot(plot1(:,1),plot1(:,2),'-.g',...
    'LineWidth',2)
plot(plot100(:,1),plot100(:,2),'--k',...
    'LineWidth',2)
plot(plot900(:,1),plot900(:,2),'-.r',...
    'LineWidth',2)
plot(plot4(:,1),plot4(:,2),'--b',...
    'LineWidth',2)
axis([0 2 -0.02 0.02])
xlabel('BEM x axis',...
'FontSize',12,...
'FontName','Helvetica')

ylabel('nodal y-displacement',...
'FontSize',12,...
'FontName','Helvetica')

legend('MESH1','MESH2','MESH3','MESH4',...
'FontUnits','points',...
'interpreter','normal',...
'FontSize',14,...
'FontName','Helvetica',...
'Location','NorthEast')


hold off
print -depsc2 myplot.eps
% legend('900 elements','100 elements','1 element')
```

2 Descripició del/s motor/s

Les característiques que ha de complir el motor son les següents:

- Empenta de creuer: $F = 25000N$
- Alçada de vol: $h = 9500m$
- Velocitat de creuer: $v = 600km/h$

A més de tot això es tracta d'un disseny real, per la qual cosa s'han de tenir en compte els següents ratis i temperatura màxima d'entrada a la turbina:

- Rati de pressió al difusor: $\pi_d = 0.96$
- Rendiment al compressor: $\eta_c = 0.88$
- Rati de pressió a la cambra de combustió: $\pi_b = 0.94$

- Eficiència de combustió: $\eta_b = 0.99$
- Rendiments de turbina: $\eta_{tH} = \eta_{tL} = 0.87$
- Rati de pressió a la tovera: $\pi_n = 0.98$
- Rendiment mecànic: $\eta_{mec} = 0.99$
- Temperatura d'entrada a la turbina: $T_{t4} = 1780$

Sample Figure

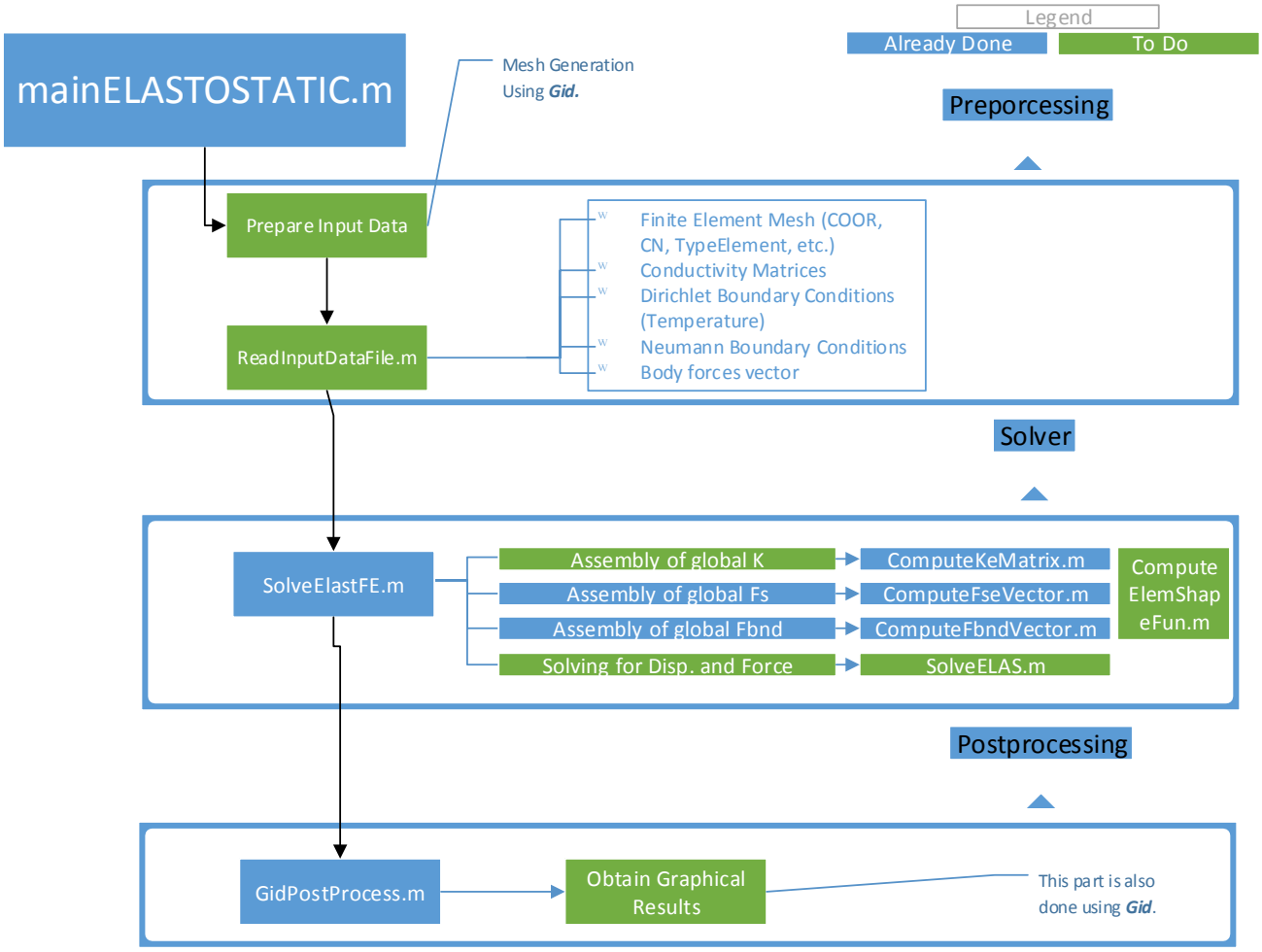

Figure 2: Sample Caption

Numbered equation:

$$K^e = \sum_{g=1}^{m} w_g (J^e B^{e^T} C B^e)_{\xi=\xi_g} \tag{2}$$

In line equation: final Global stiffness matrix K dimensions will be $n_{sd}n_{pt} \times n_{sd}n_{pt}$. Amb les dades disponibles de velocitat de creuer i altitud podem assimilar que el tipus d'aeronau per al qual va destinat es un avió de negocis lleuger, com pot ser el Cessna 510 Citation Mustang.

Sample Listing:

Listing 2: ComputeK.m

```
clc;
clear all;
close all;
plot1=[0 0
1 -0.00087300001
2 -0.0024590001];

plot100=[0 0
0.2 -0.000239
0.40000001 -0.00080500002
0.60000002 -0.001642
0.80000001 -0.0026809999
1 -0.0038689999
1.2 -0.0051589999
1.4 -0.006513
1.6 -0.0079009999
1.8 -0.0093019996
2 -0.010703];

plot900=[0 0
0.133333 -0.000137
0.26666701 -0.00043700001
0.40000001 -0.00089600001
0.533333 -0.001482
0.66666698 -0.002177
0.80000001 -0.002961
0.93333298 -0.003817
1.0666699 -0.0047280001
1.2 -0.005682
1.33333 -0.0066669998
1.46667 -0.0076720002
1.6 -0.008688
1.73333 -0.0097110001
1.86667 -0.010734
2 -0.011756];

plot4=[0 0
0.1 -9.4000003e-005
0.2 -0.00028099999
0.30000001 -0.00056999997
0.40000001 -0.00094400003
0.5 -0.001392
0.60000002 -0.001907
0.69999999 -0.002478
0.80000001 -0.0030990001
0.89999998 -0.003762
1 -0.0044590002
1.1 -0.0051850001
1.2 -0.0059329998
1.3 -0.006699
1.4 -0.0074780001
1.5 -0.0082660001
1.6 -0.0090589998
1.7 -0.0098559996
1.8 -0.010654
1.9 -0.011451
2 -0.012247];

figure
```

```
hold on
plot(plot1(:,1),plot1(:,2),'-.g',...
    'LineWidth',2)
plot(plot100(:,1),plot100(:,2),'--k',...
    'LineWidth',2)
plot(plot900(:,1),plot900(:,2),'-.r',...
    'LineWidth',2)
plot(plot4(:,1),plot4(:,2),'--b',...
    'LineWidth',2)
axis([0 2 -0.02 0.02])
xlabel('BEM x axis',...
'FontSize',12,...
'FontName','Helvetica')

ylabel('nodal y-displacement',...
'FontSize',12,...
'FontName','Helvetica')

legend('MESH1','MESH2','MESH3','MESH4',...
'FontUnits','points',...
'interpreter','normal',...
'FontSize',14,...
'FontName','Helvetica',...
'Location','NorthEast')


hold off
print -depsc2 myplot.eps
% legend('900 elements','100 elements','1 element')
```

3 Càlcul paramètric del motor i optimització per a les condicions de disseny

Sample Figure

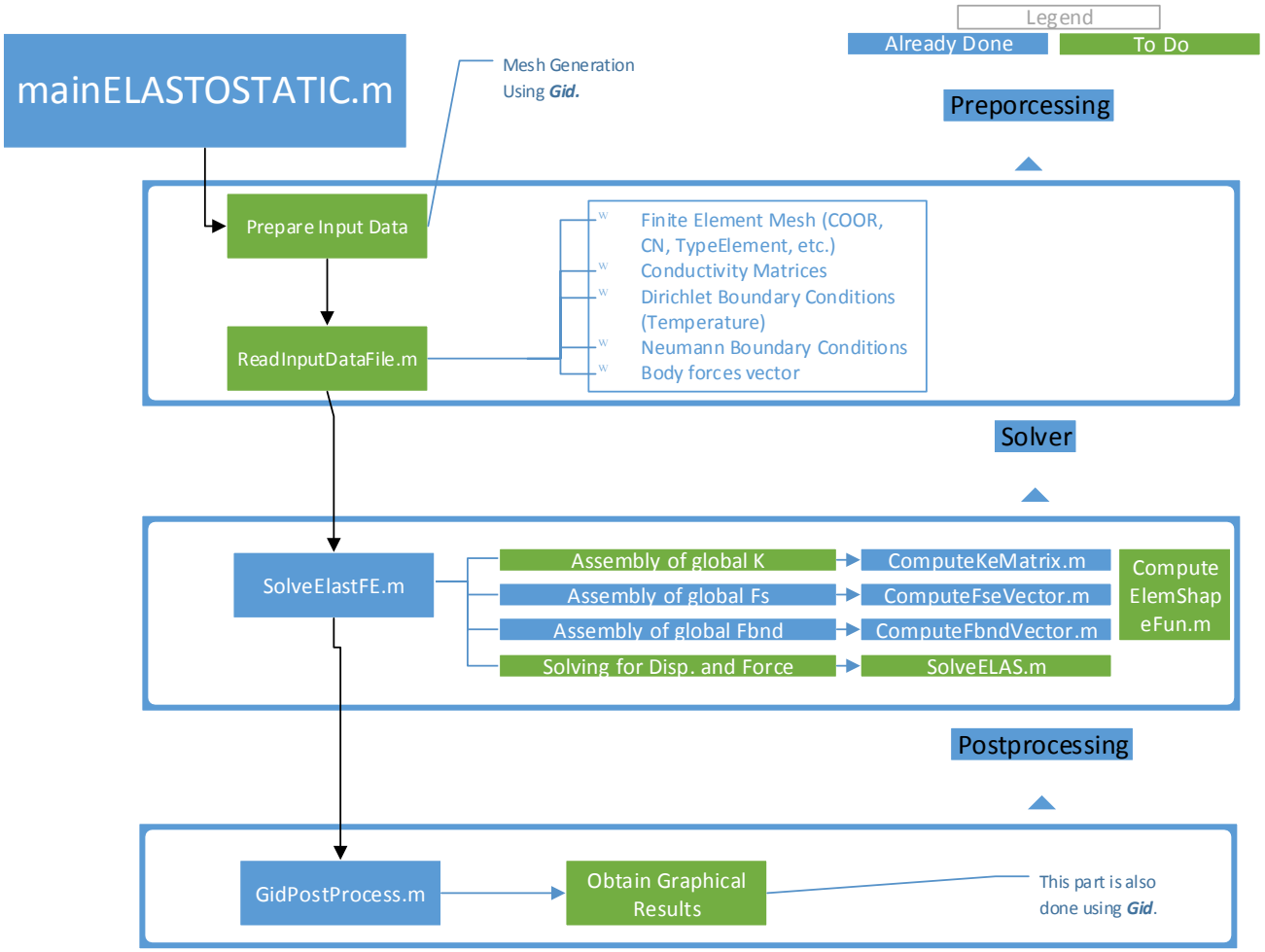

Figure 3: Sample Caption

Numbered equation:

$$K^e = \sum_{g=1}^{m} w_g (J^e B^{e^T} C B^e)_{\xi=\xi_g} \tag{3}$$

In line equation: final Global stiffness matrix K dimensions will be $n_{sd}n_{pt} \times n_{sd}n_{pt}$.

Sample Listing:

Listing 3: ComputeK.m

```
clc;
clear all;
close all;
plot1=[0 0
1 -0.00087300001
2 -0.0024590001];

plot100=[0 0
0.2 -0.000239
0.40000001 -0.00080500002
0.60000002 -0.001642
0.80000001 -0.0026809999
1 -0.0038689999
```

```
1.2 -0.0051589999
1.4 -0.006513
1.6 -0.0079009999
1.8 -0.0093019996
2 -0.010703];

plot900=[0 0
0.133333 -0.000137
0.26666701 -0.00043700001
0.40000001 -0.00089600001
0.533333 -0.001482
0.66666698 -0.002177
0.80000001 -0.002961
0.93333298 -0.003817
1.0666699 -0.0047280001
1.2 -0.005682
1.33333 -0.0066669998
1.46667 -0.0076720002
1.6 -0.008688
1.73333 -0.0097110001
1.86667 -0.010734
2 -0.011756];

plot4=[0 0
0.1 -9.4000003e-005
0.2 -0.00028099999
0.30000001 -0.00056999997
0.40000001 -0.00094400003
0.5 -0.001392
0.60000002 -0.001907
0.69999999 -0.002478
0.80000001 -0.0030990001
0.89999998 -0.003762
1 -0.0044590002
1.1 -0.0051850001
1.2 -0.0059329998
1.3 -0.006699
1.4 -0.0074780001
1.5 -0.0082660001
1.6 -0.0090589998
1.7 -0.0098559996
1.8 -0.010654
1.9 -0.011451
2 -0.012247];

figure
hold on
plot(plot1(:,1),plot1(:,2),'-.g',...
    'LineWidth',2)
plot(plot100(:,1),plot100(:,2),'--k',...
    'LineWidth',2)
plot(plot900(:,1),plot900(:,2),'-.r',...
    'LineWidth',2)
plot(plot4(:,1),plot4(:,2),'--b',...
    'LineWidth',2)
axis([0 2 -0.02 0.02])
xlabel('BEM x axis',...
'FontSize',12,...
'FontName','Helvetica')

```

```
ylabel('nodal y-displacement',...
'FontSize',12,...
'FontName','Helvetica')

legend('MESH1','MESH2','MESH3','MESH4',...
'FontUnits','points',...
'interpreter','normal',...
'FontSize',14,...
'FontName','Helvetica',...
'Location','NorthEast')


hold off
print -depsc2 myplot.eps
% legend('900 elements','100 elements','1 element')
```

4 Càlcul i elecció de l'hèlix

Sample Figure

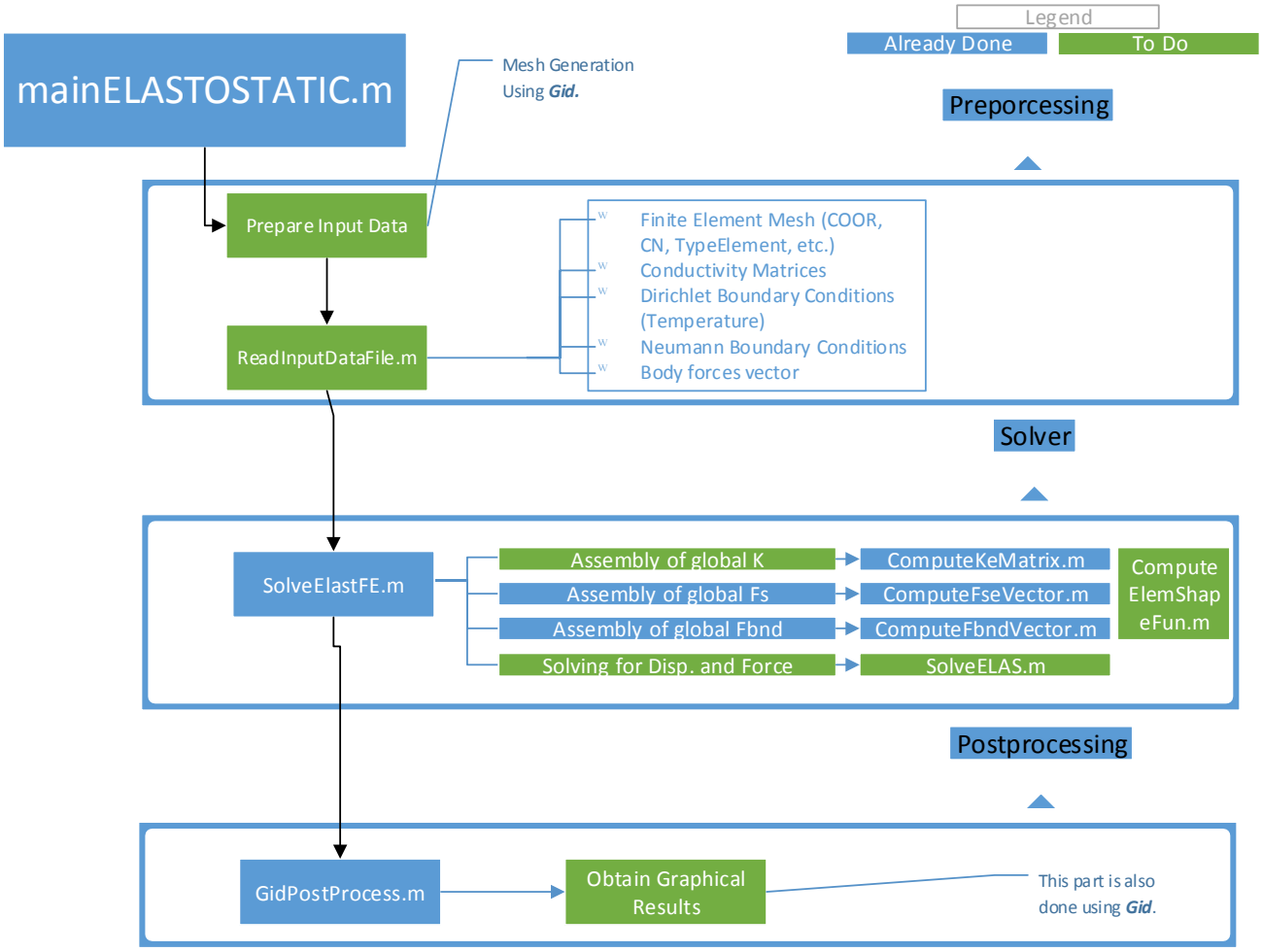

Figure 4: Sample Caption

Numbered equation:

$$K^e = \sum_{g=1}^{m} w_g (J^e B^{e^T} C B^e)_{\xi=\xi_g} \tag{4}$$

In line equation: final Global stiffness matrix K dimensions will be $n_{sd}n_{pt} \times n_{sd}n_{pt}$.

Sample Listing:

Listing 4: ComputeK.m

```
clc;
clear all;
close all;
plot1=[0 0
1 -0.00087300001
2 -0.0024590001];

plot100=[0 0
0.2 -0.000239
0.40000001 -0.00080500002
0.60000002 -0.001642
0.80000001 -0.0026809999
1 -0.0038689999
1.2 -0.0051589999
1.4 -0.006513
1.6 -0.0079009999
1.8 -0.0093019996
2 -0.010703];

plot900=[0 0
0.133333 -0.000137
0.26666701 -0.00043700001
0.40000001 -0.00089600001
0.533333 -0.001482
0.66666698 -0.002177
0.80000001 -0.002961
0.93333298 -0.003817
1.0666699 -0.0047280001
1.2 -0.005682
1.33333 -0.0066669998
1.46667 -0.0076720002
1.6 -0.008688
1.73333 -0.0097110001
1.86667 -0.010734
2 -0.011756];

plot4=[0 0
0.1 -9.4000003e-005
0.2 -0.00028099999
0.30000001 -0.00056999997
0.40000001 -0.00094400003
0.5 -0.001392
0.60000002 -0.001907
0.69999999 -0.002478
0.80000001 -0.0030990001
0.89999998 -0.003762
1 -0.0044590002
1.1 -0.0051850001
1.2 -0.0059329998
1.3 -0.006699
```

```
1.4 -0.0074780001
1.5 -0.0082660001
1.6 -0.0090589998
1.7 -0.0098559996
1.8 -0.010654
1.9 -0.011451
2 -0.012247];

figure
hold on
plot(plot1(:,1),plot1(:,2),'-.g',...
    'LineWidth',2)
plot(plot100(:,1),plot100(:,2),'--k',...
    'LineWidth',2)
plot(plot900(:,1),plot900(:,2),'-.r',...
    'LineWidth',2)
plot(plot4(:,1),plot4(:,2),'--b',...
    'LineWidth',2)
axis([0 2 -0.02 0.02])
xlabel('BEM x axis',...
'FontSize',12,...
'FontName','Helvetica')

ylabel('nodal y-displacement',...
'FontSize',12,...
'FontName','Helvetica')

legend('MESH1','MESH2','MESH3','MESH4',...
'FontUnits','points',...
'interpreter','normal',...
'FontSize',14,...
'FontName','Helvetica',...
'Location','NorthEast')


hold off
print -depsc2 myplot.eps
% legend('900 elements','100 elements','1 element')
```

5 Càlcul i elecció de postcombustor

Sample Figure

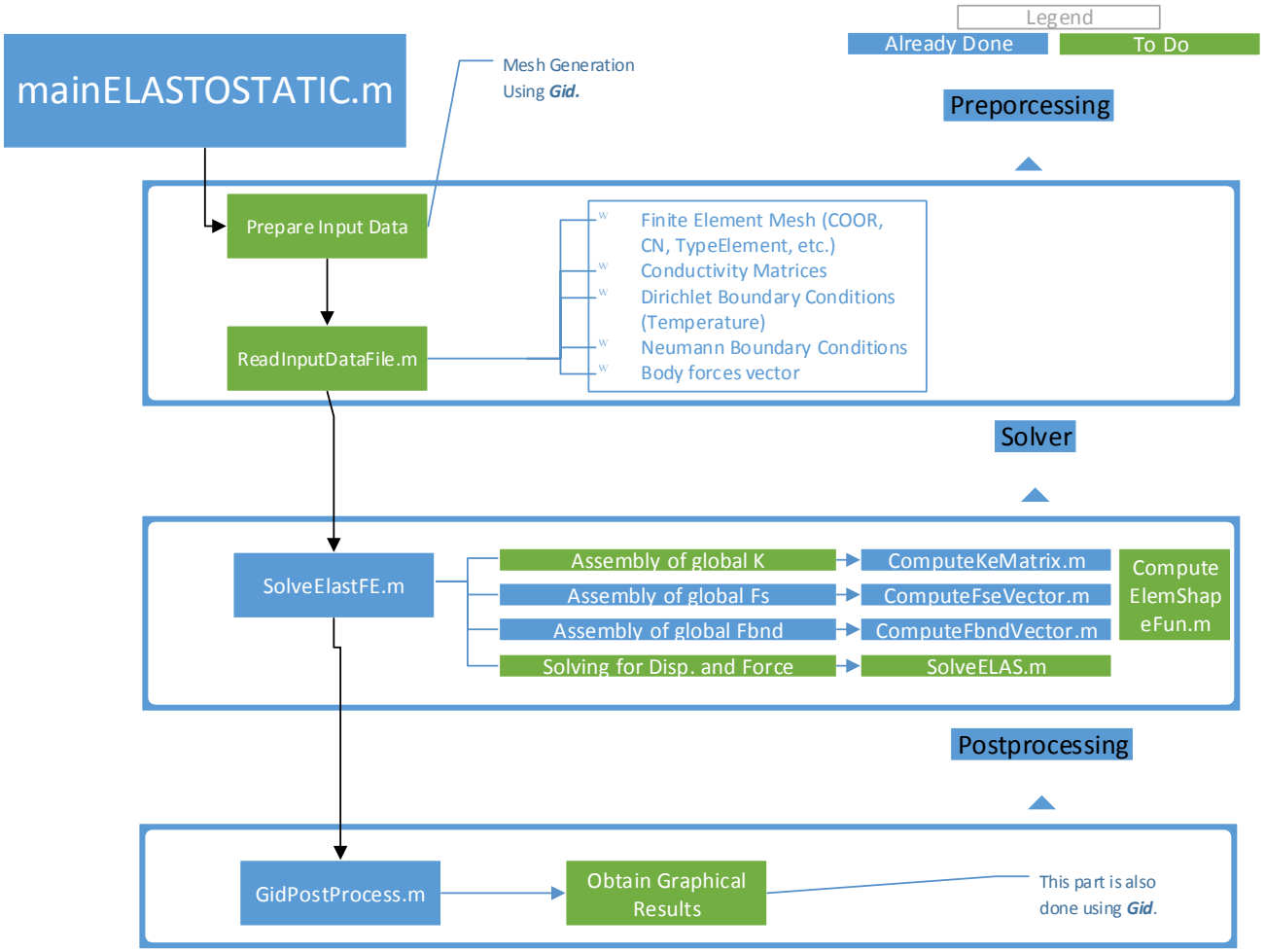

Figure 5: Sample Caption

Numbered equation:

$$K^e = \sum_{g=1}^{m} w_g (J^e B^{e^T} C B^e)_{\xi=\xi_g} \tag{5}$$

In line equation: final Global stiffness matrix K dimensions will be $n_{sd}n_{pt} \times n_{sd}n_{pt}$.

Sample Listing:

Listing 5: ComputeK.m

```
clc;
clear all;
close all;
plot1=[0 0
1 -0.00087300001
2 -0.0024590001];

plot100=[0 0
0.2 -0.000239
0.40000001 -0.00080500002
0.60000002 -0.001642
0.80000001 -0.0026809999
1 -0.0038689999
```

```
1.2 -0.0051589999
1.4 -0.006513
1.6 -0.0079009999
1.8 -0.0093019996
2 -0.010703];

plot900=[0 0
0.133333 -0.000137
0.26666701 -0.00043700001
0.40000001 -0.00089600001
0.533333 -0.001482
0.66666698 -0.002177
0.80000001 -0.002961
0.93333298 -0.003817
1.0666699 -0.0047280001
1.2 -0.005682
1.33333 -0.0066669998
1.46667 -0.0076720002
1.6 -0.008688
1.73333 -0.0097110001
1.86667 -0.010734
2 -0.011756];

plot4=[0 0
0.1 -9.4000003e-005
0.2 -0.00028099999
0.30000001 -0.00056999997
0.40000001 -0.00094400003
0.5 -0.001392
0.60000002 -0.001907
0.69999999 -0.002478
0.80000001 -0.0030990001
0.89999998 -0.003762
1 -0.0044590002
1.1 -0.0051850001
1.2 -0.0059329998
1.3 -0.006699
1.4 -0.0074780001
1.5 -0.0082660001
1.6 -0.0090589998
1.7 -0.0098559996
1.8 -0.010654
1.9 -0.011451
2 -0.012247];

figure
hold on
plot(plot1(:,1),plot1(:,2),'-.g',...
    'LineWidth',2)
plot(plot100(:,1),plot100(:,2),'--k',...
    'LineWidth',2)
plot(plot900(:,1),plot900(:,2),'-.r',...
    'LineWidth',2)
plot(plot4(:,1),plot4(:,2),'--b',...
    'LineWidth',2)
axis([0 2 -0.02 0.02])
xlabel('BEM x axis',...
'FontSize',12,...
'FontName','Helvetica')

```

```
ylabel('nodal y-displacement',...
'FontSize',12,...
'FontName','Helvetica')

legend('MESH1','MESH2','MESH3','MESH4',...
'FontUnits','points',...
'interpreter','normal',...
'FontSize',14,...
'FontName','Helvetica',...
'Location','NorthEast')


hold off
print -depsc2 myplot.eps
% legend('900 elements','100 elements','1 element')
```

6 Càlcul de consum d'aire i fuel en vol

Sample Figure

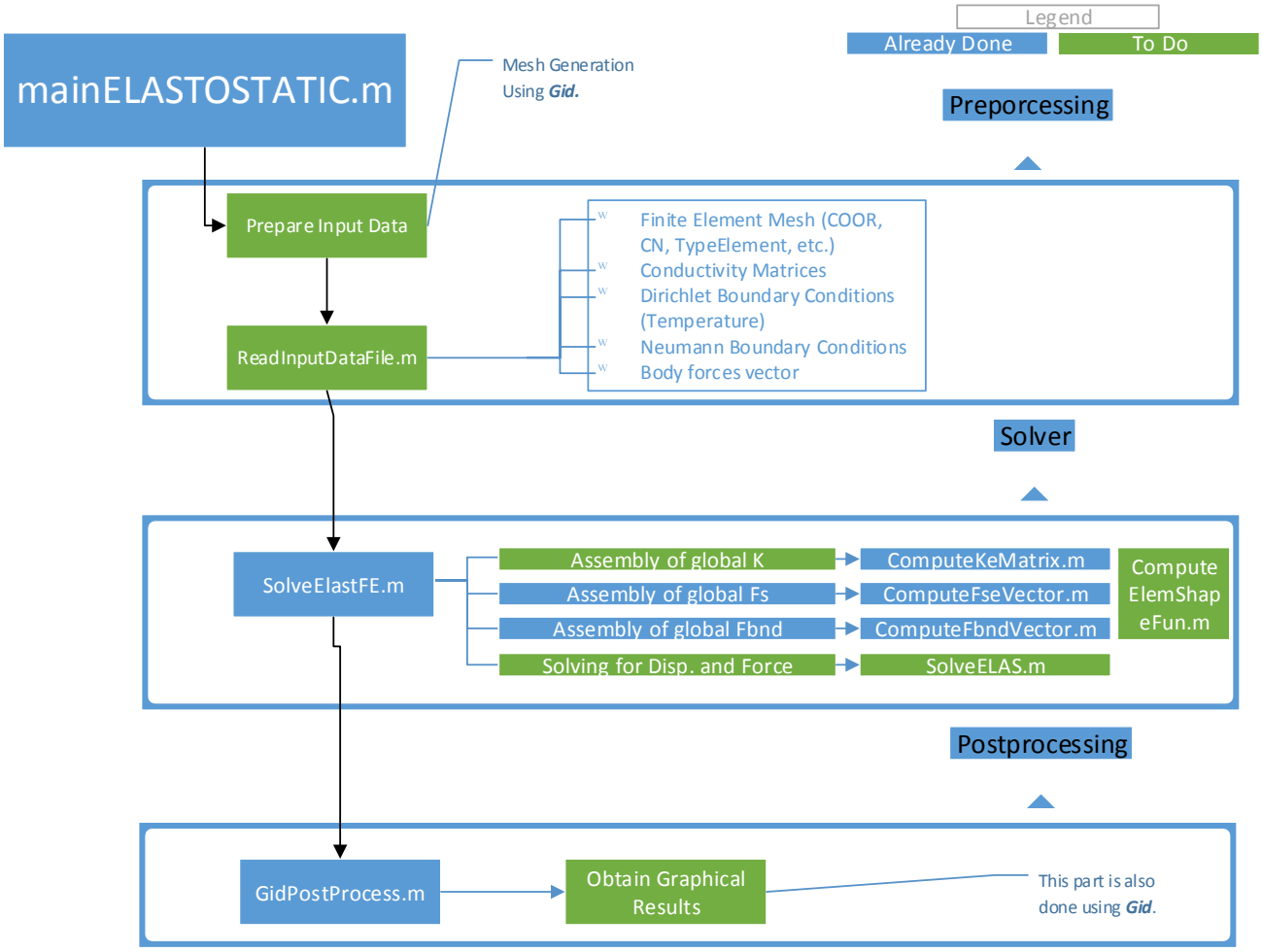

Figure 6: Sample Caption

Numbered equation:

$$K^e = \sum_{g=1}^{m} w_g (J^e {B^e}^T C B^e)_{\xi=\xi_g} \tag{6}$$

In line equation: final Global stiffness matrix K dimensions will be $n_{sd}n_{pt} \times n_{sd}n_{pt}$.

Sample Listing:

Listing 6: ComputeK.m

```
clc;
clear all;
close all;
plot1=[0 0
1 -0.00087300001
2 -0.0024590001];

plot100=[0 0
0.2 -0.000239
0.40000001 -0.00080500002
0.60000002 -0.001642
0.80000001 -0.0026809999
1 -0.0038689999
1.2 -0.0051589999
1.4 -0.006513
1.6 -0.0079009999
1.8 -0.0093019996
2 -0.010703];

plot900=[0 0
0.133333 -0.000137
0.26666701 -0.00043700001
0.40000001 -0.00089600001
0.533333 -0.001482
0.66666698 -0.002177
0.80000001 -0.002961
0.93333298 -0.003817
1.0666699 -0.0047280001
1.2 -0.005682
1.33333 -0.0066669998
1.46667 -0.0076720002
1.6 -0.008688
1.73333 -0.0097110001
1.86667 -0.010734
2 -0.011756];

plot4=[0 0
0.1 -9.4000003e-005
0.2 -0.00028099999
0.30000001 -0.00056999997
0.40000001 -0.00094400003
0.5 -0.001392
0.60000002 -0.001907
0.69999999 -0.002478
0.80000001 -0.0030990001
0.89999998 -0.003762
1 -0.0044590002
1.1 -0.0051850001
1.2 -0.0059329998
1.3 -0.006699
```

```
1.4 -0.0074780001
1.5 -0.0082660001
1.6 -0.0090589998
1.7 -0.0098559996
1.8 -0.010654
1.9 -0.011451
2 -0.012247];

figure
hold on
plot(plot1(:,1),plot1(:,2),'-.g',...
    'LineWidth',2)
plot(plot100(:,1),plot100(:,2),'--k',...
    'LineWidth',2)
plot(plot900(:,1),plot900(:,2),'-.r',...
    'LineWidth',2)
plot(plot4(:,1),plot4(:,2),'--b',...
    'LineWidth',2)
axis([0 2 -0.02 0.02])
xlabel('BEM x axis',...
'FontSize',12,...
'FontName','Helvetica')

ylabel('nodal y-displacement',...
'FontSize',12,...
'FontName','Helvetica')

legend('MESH1','MESH2','MESH3','MESH4',...
'FontUnits','points',...
'interpreter','normal',...
'FontSize',14,...
'FontName','Helvetica',...
'Location','NorthEast')


hold off
print -depsc2 myplot.eps
% legend('900 elements','100 elements','1 element')
```

7 Càlcul de dimensionat d'àrees

Sample Figure

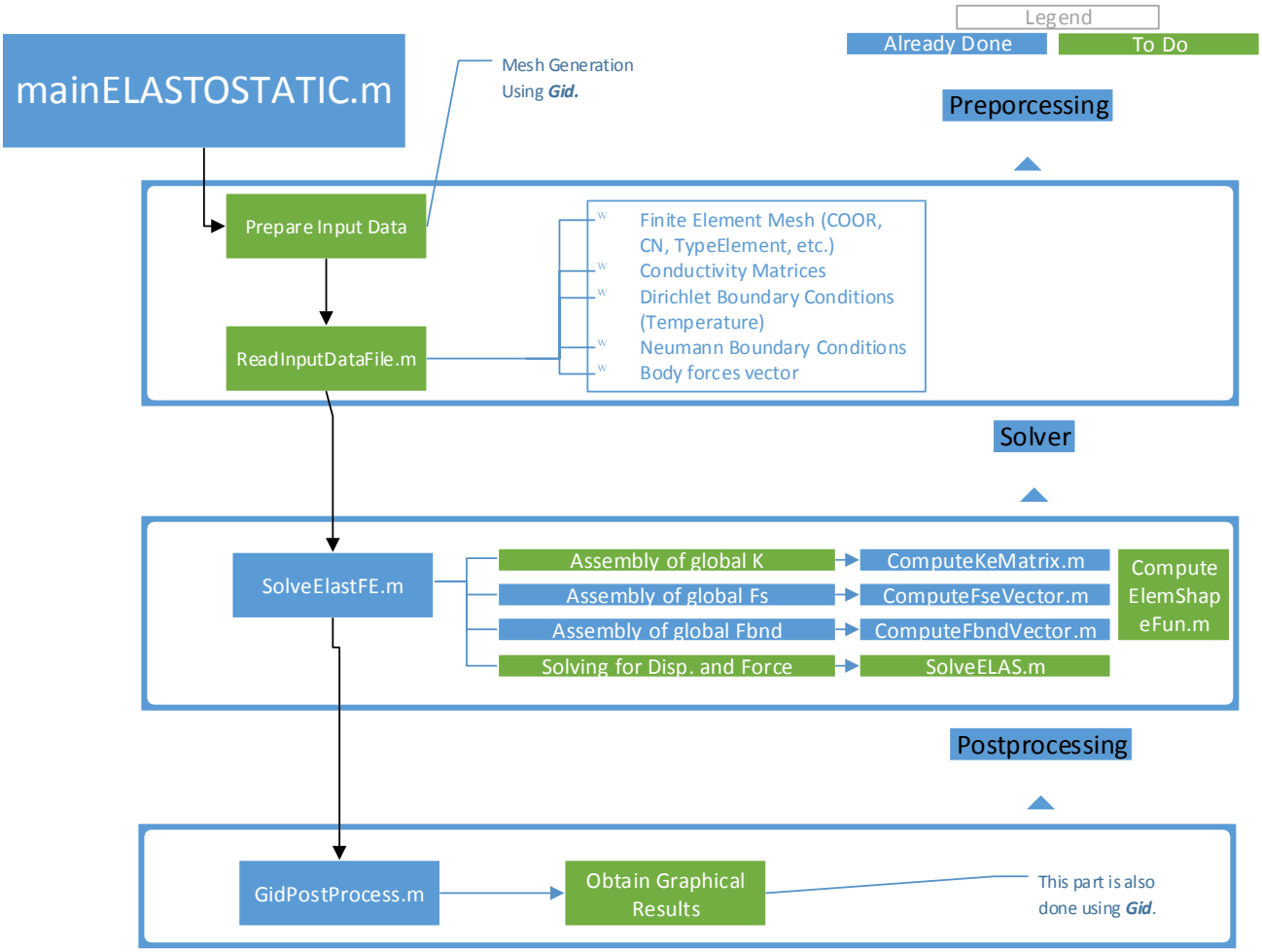

Figure 7: Sample Caption

Numbered equation:

$$K^e = \sum_{g=1}^{m} w_g (J^e B^{e^T} C B^e)_{\xi=\xi_g} \tag{7}$$

In line equation: final Global stiffness matrix K dimensions will be $n_{sd}n_{pt} \times n_{sd}n_{pt}$.

Sample Listing:

Listing 7: ComputeK.m

```
clc;
clear all;
close all;
plot1=[0 0
1 -0.00087300001
2 -0.0024590001];

plot100=[0 0
0.2 -0.000239
0.40000001 -0.00080500002
0.60000002 -0.001642
0.80000001 -0.0026809999
1 -0.0038689999
```

```
1.2 -0.0051589999
1.4 -0.006513
1.6 -0.0079009999
1.8 -0.0093019996
2 -0.010703];

plot900=[0 0
0.133333 -0.000137
0.26666701 -0.00043700001
0.40000001 -0.00089600001
0.533333 -0.001482
0.66666698 -0.002177
0.80000001 -0.002961
0.93333298 -0.003817
1.0666699 -0.0047280001
1.2 -0.005682
1.33333 -0.0066669998
1.46667 -0.0076720002
1.6 -0.008688
1.73333 -0.0097110001
1.86667 -0.010734
2 -0.011756];

plot4=[0 0
0.1 -9.4000003e-005
0.2 -0.00028099999
0.30000001 -0.00056999997
0.40000001 -0.00094400003
0.5 -0.001392
0.60000002 -0.001907
0.69999999 -0.002478
0.80000001 -0.0030990001
0.89999998 -0.003762
1 -0.0044590002
1.1 -0.0051850001
1.2 -0.0059329998
1.3 -0.006699
1.4 -0.0074780001
1.5 -0.0082660001
1.6 -0.0090589998
1.7 -0.0098559996
1.8 -0.010654
1.9 -0.011451
2 -0.012247];

figure
hold on
plot(plot1(:,1),plot1(:,2),'-.g',...
    'LineWidth',2)
plot(plot100(:,1),plot100(:,2),'--k',...
    'LineWidth',2)
plot(plot900(:,1),plot900(:,2),'-.r',...
    'LineWidth',2)
plot(plot4(:,1),plot4(:,2),'--b',...
    'LineWidth',2)
axis([0 2 -0.02 0.02])
xlabel('BEM x axis',...
'FontSize',12,...
'FontName','Helvetica')

```

```
74 ylabel('nodal y-displacement',...
75 'FontSize',12,...
76 'FontName','Helvetica')
77
78 legend('MESH1','MESH2','MESH3','MESH4',...
79 'FontUnits','points',...
80 'interpreter','normal',...
81 'FontSize',14,...
82 'FontName','Helvetica',...
83 'Location','NorthEast')
84
85
86 hold off
87 print -depsc2 myplot.eps
88 % legend('900 elements','100 elements','1 element')
```

References