



Performance Evaluation of Radioss-CFD on the Cray-X1

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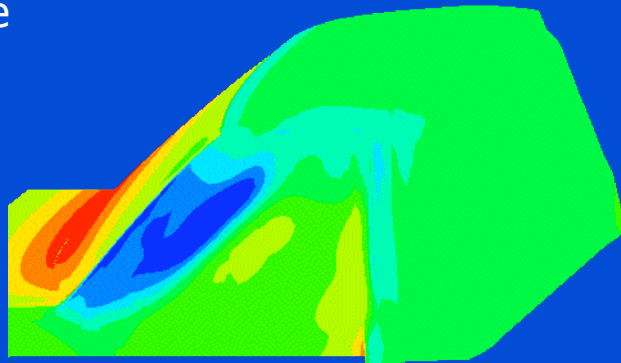


Objectives

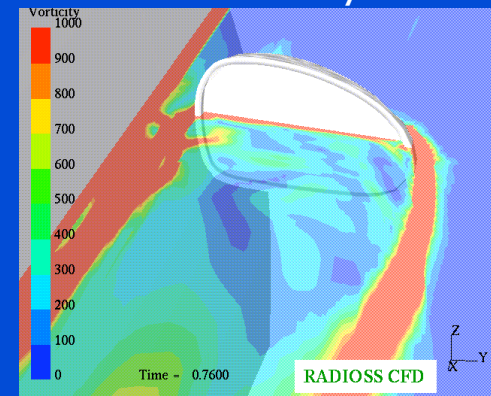
- **Introduction to Radioss-CFD**
- **A sample exhaust system model showing the accuracy of Radioss-CFD vs. experimental results**
- **Some performance results comparing the Cray X1 with the T90**
- **Code examples used to optimize Radioss-CFD**

Applications

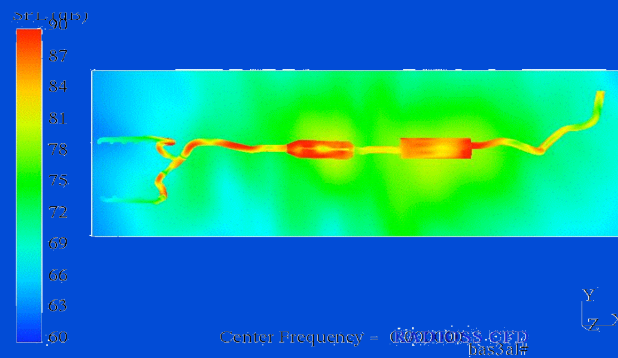
Wind Noise Analysis



Mirror Analysis



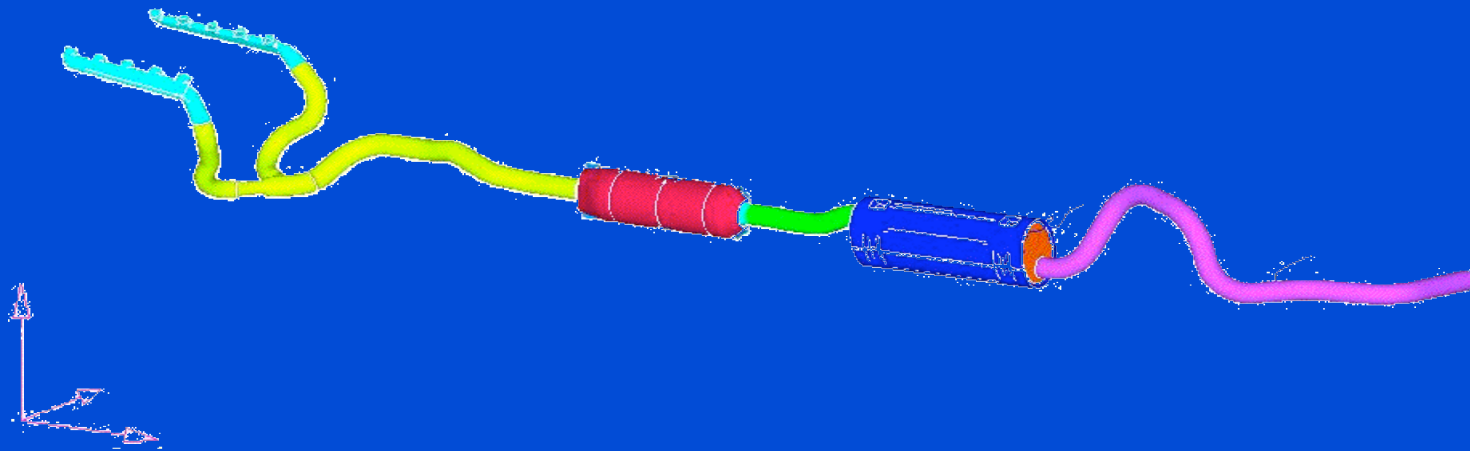
Exhaust Noise Analysis



Fan Noise Analysis

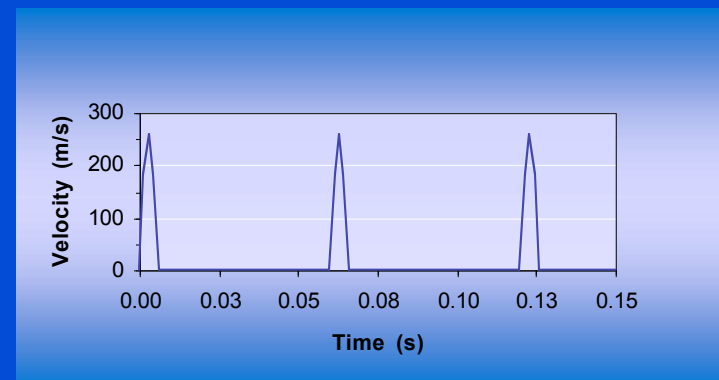


Model Set-up

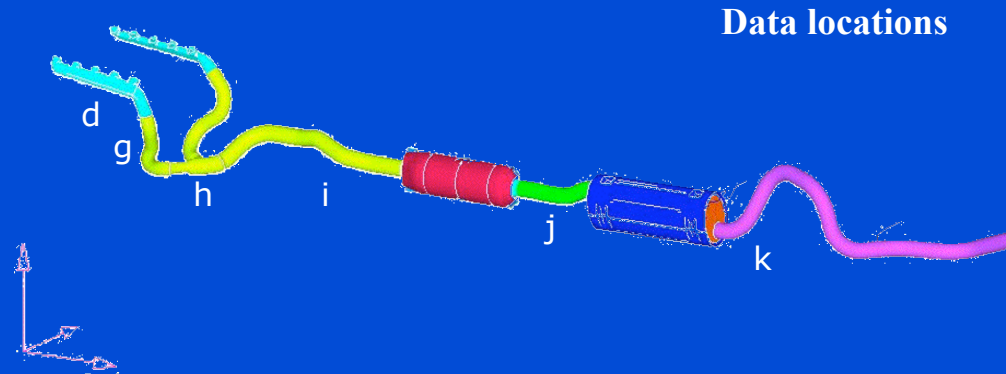


110,000 Nodes
120,000 Elements
200 milliseconds

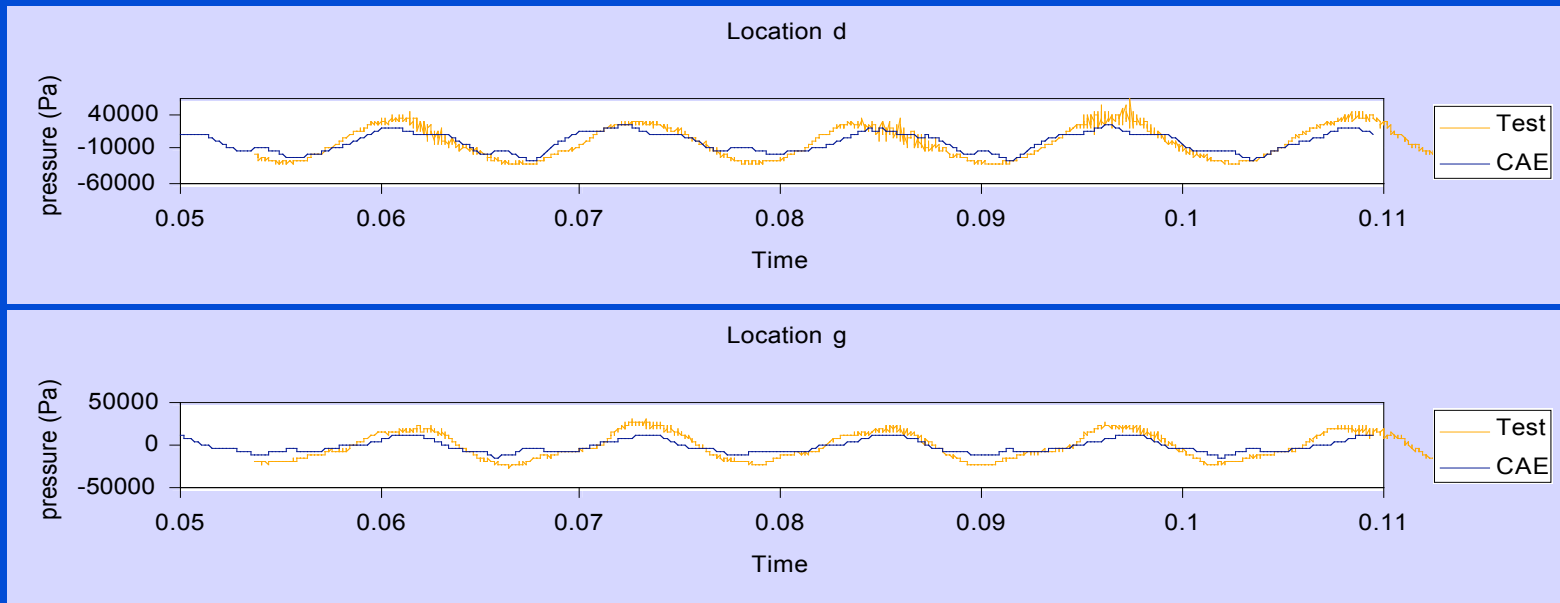
Input condition:
gas velocity profile at exhaust ports



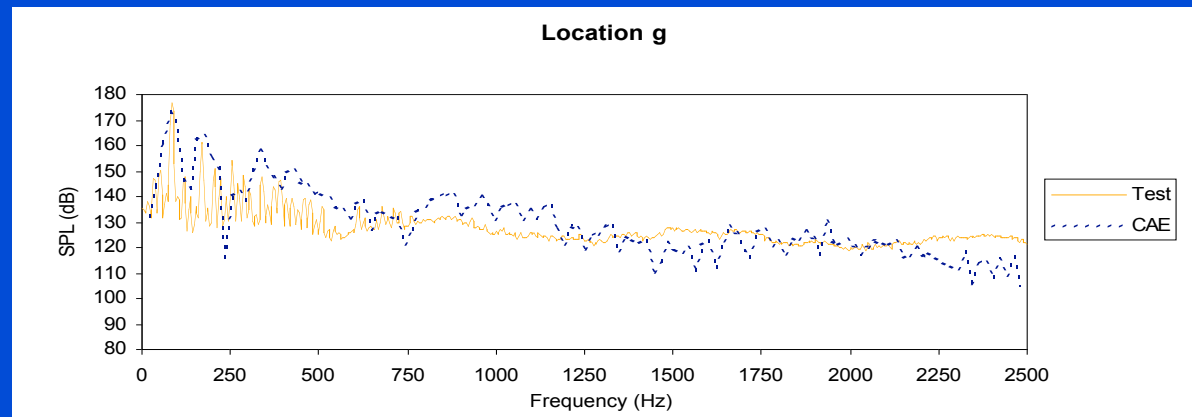
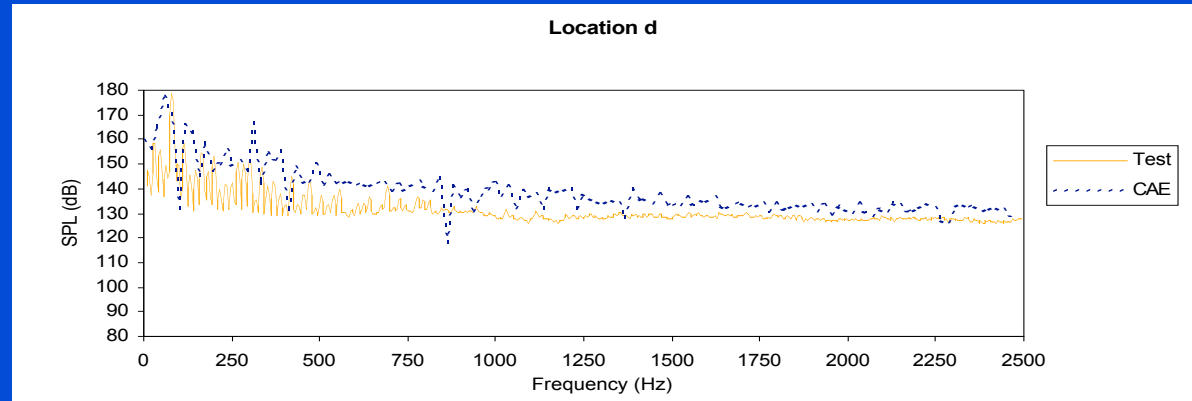
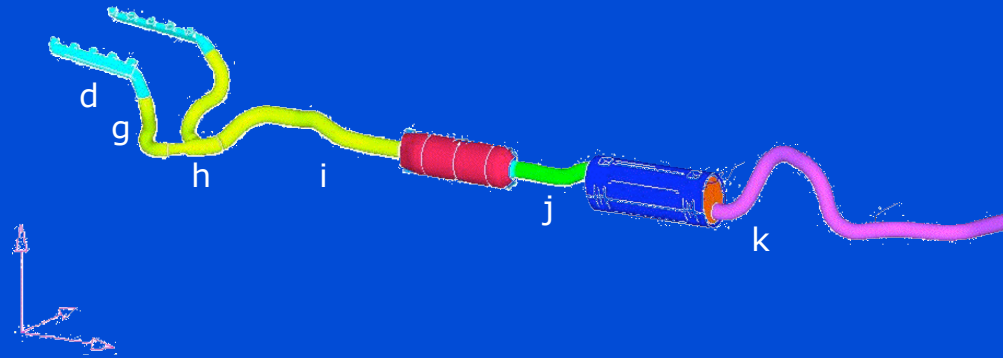
Time Domain Comparison



Data locations



Frequency Domain Comparison





Code Example 1

```
integer ndim
real a0(3,ndim),a1(3,ndim),a2(3,ndim),a3(3,ndim)
MV--< do 100 j=1,ndim
MV      a0(1,j) = a1(1,j) + a2(1,j) + a3(1,j)
MV      a0(2,j) = a1(2,j) + a2(2,j) + a3(2,j)
MV      a0(3,j) = a1(3,j) + a2(3,j) + a3(3,j)
MV--> 100 continue
```

```
integer ndim
real a0(3,ndim),a1(3,ndim),a2(3,ndim),a3(3,ndim)
C-----< do 110 j=1,ndim
C MV--< do 100 i=1,3
C MV      a0(i,j) = a1(i,j) + a2(i,j) + a3(i,j)
C MV--> 100 continue
C-----> 110 continue
```

Code Example 2

```
integer ndim
real a0(3,ndim),a1(3,ndim),a2(3,ndim),a3(3,ndim)
logical cond1
C-----< do 110 j=1,ndim
C          if(cond1) then
C MV--<    do 100 i=1,3
C MV      a0(i,j) = a1(i,j) + a2(i,j) + a3(i,j)
C MV--> 100 continue
C          endif
C-----> 110 continue
          :
          :
C-----< do 310 j=1,ndim
C          if(cond1) then
C MV--<    do 300 i=1,3
C MV      a0(i,j) = a1(i,j) + a2(i,j) + a3(i,j)
C MV--> 300 continue
C          endif
C-----> 310 continue
```


Code Example 2

```
integer ndim
real a0(3,ndim), a1(3,ndim), a2(3,ndim), a3(3,ndim)
logical cond1
MV----< do 100 j=1,ndim
MV      if(cond1) then
MV          a0(1,j) = a1(1,j) + a2(1,j) + a3(1,j)
MV          a0(2,j) = a1(2,j) + a2(2,j) + a3(2,j)
MV          a0(3,j) = a1(3,j) + a2(3,j) + a3(3,j)
MV      endif
MV----> 100 continue
      :
      :
f-----< do 300 j=1,ndim
f      if(cond1) then
f          a0(1,j) = a1(1,j) + a2(1,j) + a3(1,j)
f          a0(2,j) = a1(2,j) + a2(2,j) + a3(2,j)
f          a0(3,j) = a1(3,j) + a2(3,j) + a3(3,j)
f      endif
f-----> 300 continue
```

Code Example 3

```
integer ndim
real a0(ndim), a1(ndim), a2(ndim), a3(ndim)
logical cond1(3,ndim)
1-----< do 120 i=1,ndim
1 2----<     do 100 j=1,3
1 2      ml = 11
1 2      if(cond1(j,i)) ml = 52
1 2      if (ml.ne.11) goto 110
1 2----> 100  continue
1      110  continue
1      if(ml.ne.11) then
1          a0(i) = a1(i) + a2(i) + a3(i)
1      else
1          a0(i) = a0(i) * 20.0
1      endif
1-----> 120 continue
```

Code Example 3

```
real      a0 (ndim) , a1 (ndim) , a2 (ndim) , a3 (ndim)
logical  cond1 (3, ndim)
integer  count_mline11=0, list_mline11 (ndim)
integer  count_mleq11=0, list_mleq11 (ndim)
V-----< do 100 i=1, ndim
V          ml = 11
V          if (cond1 (1, i)) ml=52
V          if (ml.ne.11) goto 110
V          if (cond1 (2, i)) ml=52
V          if (ml.ne.11) goto 110
V          if (cond1 (3, i)) ml=52
V          if (ml.ne.11) goto 110
V          count_mleq11 = count_mleq11 + 1
V          list_mleq11 (count_mleq11) = i
V          110 continue
V          if (ml.ne.11) then
V              count_mline11 = count_mline11 + 1
V              list_mline11 (count_mline11) = i
V          endif
V-----> 100 continue
```

Code Example 3

```
integer ndim
real      a0(ndim), a1(ndim), a2(ndim), a3(ndim)
logical  cond1(3, ndim)
integer  count_mln11, list_mln11(ndim)
integer  count_mleq11, list_mleq11(ndim)
count_mleq11 = 0
count_mln11 = 0
      :
      :
      :
CDIR$ CONCURRENT
Mvr---<      do 200 idrive=1, count_mln11
Mvr          i = list_mln11(idrive)
Mvr          a0(i) = a1(i) + a2(i) + a3(i)
Mvr---> 200 continue
      CDIR$ CONCURRENT
Mvr----<      do 300 idrive=1, count_mleq11
Mvr          i = list_mleq11(idrive)
Mvr          a0(i) = a0(i) * 20.0
Mvr---> 300 continue
```



Summary

- **Radioss-CFD correlates well with experimental results**
- **The Cray X1 provides high enough performance to make these simulations practical**
- **Further performance improvements are necessary to address much larger simulations**