Numerical Analysis of Source Codes in Thales Entities

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Floating points are hard

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So what are floating point numbers?

Roughly base 2 scientific notation

$$+\ 0.6022141 \cdot 10^{24}$$

$$\downarrow$$

$$0 \quad 24 \quad 6022141$$

More formally

$$f = s * 2^{e} * m$$

Stored into 32 bits with

> 1 bit for sign

> 8 bits for exponent (able to store -126 to 127)

> 23 bits for mantissa (able to store ~6 significant digits in base 10)

> Special values of exponent are used for $\pm\infty$, NaN

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Issues: approximation of floats in machine

```c
#include <stdio.h>

int main(){
    float res = 0;

    for (int i=0; i < 1000; i++){
        res = res + 0.1;
    }

    printf("1000*0.1 = %f\n", res);
    return 0;
}
```



```
1000* 0.1 = 99.999046
```

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What can go wrong?

```c
#include <stdio.h>

int main(){
    float res = 0;

    for (int i=0;i<1000; i++){
        res = res + 0.1;
    }

    printf("%f", res);
    return 0;
}
```

99.999046

Slow loss of precision

```c
#include <stdio.h>

int main(){
    float t1 = 1000000.1f;
    float t2 = 1000000.2f;

    float pos1 = 900.0f;
    float pos2 = 910.0f;

    float speed =
        fabs(pos2-pos1)/(t2 - t1);

    printf("%f\n", speed);
    return 0;
}
```

160.00000

Quick loss of precision

```c
#include <stdio.h>

int main(){
    float a = 0.5f;
    a = a - 0.3f;
    a = a - 0.2f;

    if (a >= 0.0f){
        printf("%.10f",a);
    }
    else{
 printf("%.10f",100.0f*a+13.37);
    }
}
```

13.369998509

Unstable tests

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Thales markets
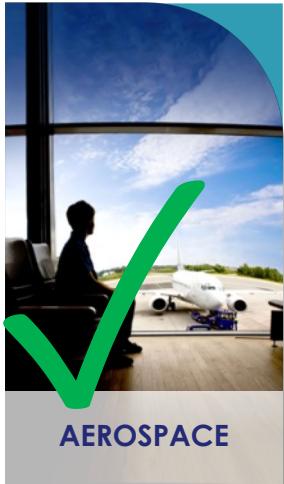
AEROSPACE

SPACE

GROUND TRANSPORT

DEFENSE

CYBERSECURITY

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But there's hope!

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13 tools tested during first year of work

> From academia, PMEs

> Open source benchmarks, Thales entities code

> Objective criteria: level of guarantee, scalability, …

> « Thales » criteria: easy to use, insert in test suites, …
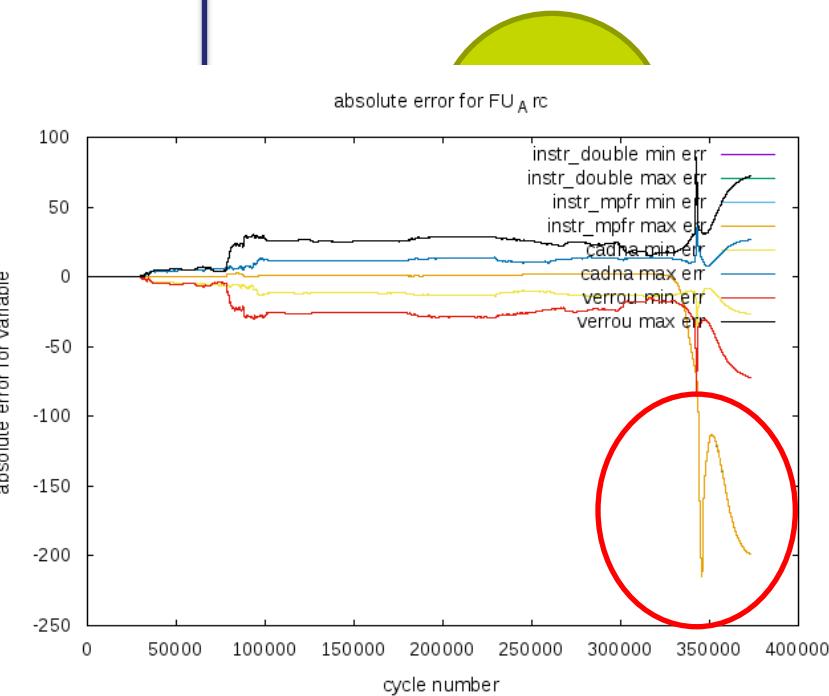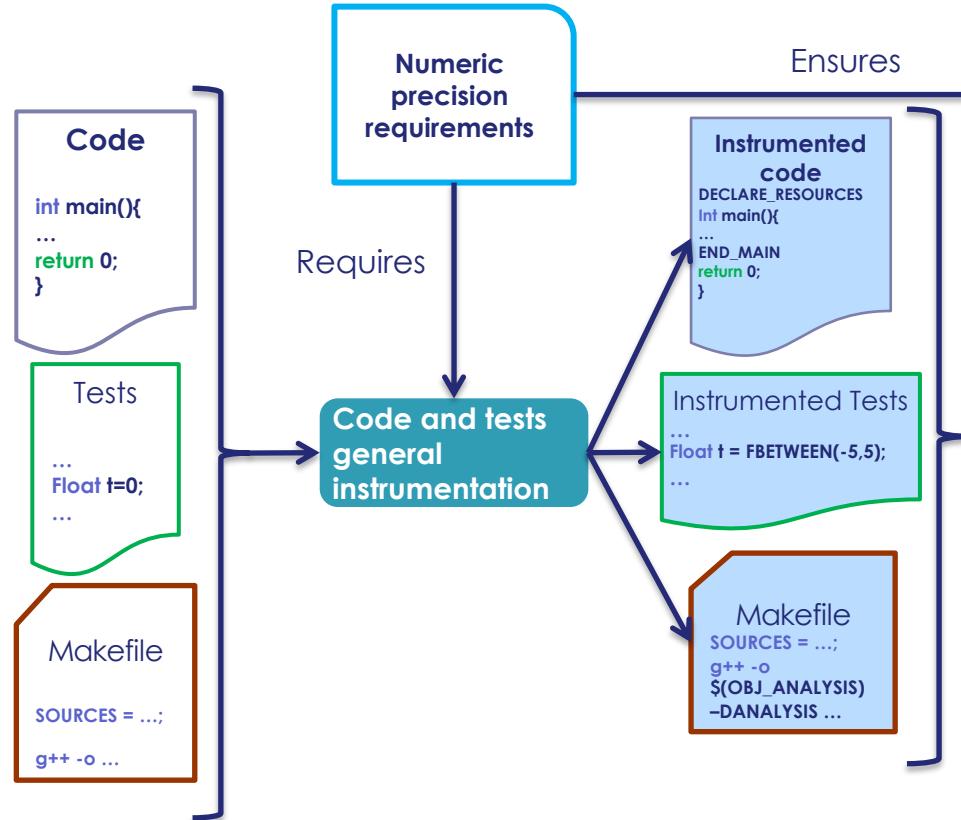
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General Toolchain

Numeric precision requirements

Ensures

Code

```
int main(){
…
return 0;
}
```

Requires

Tests

```
…
Float t=0;
…
```

Makefile

```
SOURCES = …;

g++ -o …
```

Code and tests general instrumentation

Instrumented code
DECLARE_RESOURCES
```
Int main(){
…
END_MAIN
return 0;
}
```

Instrumented Tests
```
…
Float t = FBETWEEN(-5,5);
…
```

Makefile
```
SOURCES = …;
g++ -o
$(OBJ_ANALYSIS)
–DANALYSIS …
```


absolute error for FU$_A$rc

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Analysis as a Service
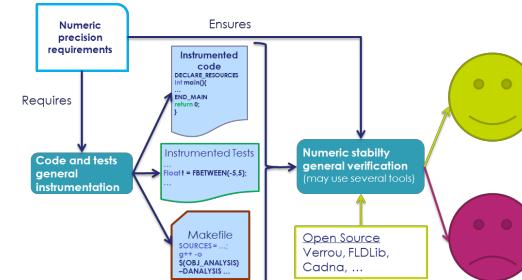
VM with toolchain

All open source tools installed

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