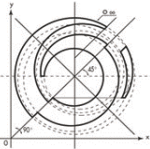




15th European Workshop on
Thermal and ECLS Software
ESTEC, The Netherlands
October 9-10, 2001

ARTIFIS / TOPIC / ThermXL

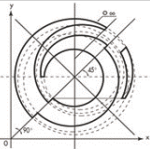
Henri Brouquet
Frédéric du Laurens d'Oiselay
ALSTOM Power Technology Centre
+44 116 284 5748
esa.support@power.alstom.com



ARTIFIS – Thermal Analyser

*A.R.T.I.F.I.S.: 'Accurate Reference Tool for
Incident Fluxes Impinging on Spacecraft'*

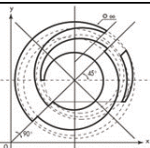
- Presented at ESTEC in 1996 (ECLS Workshop)
- Benchmarked with handbook '*Spacecraft thermal control design data*'
- Acted as reference to validate incident fluxes calculated by ESARAD v-3



ARTIFIS – Features

ALSTOM

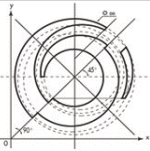
- Pre-phase A in-house *thermal analyser*
 - Fast and easy to use
 - Same ‘concept’ as ESARAD
 - Simple orbiting surfaces
 - Batch process, MS-DOS / Unix
- Incident fluxes calculated by means of analytical expressions
 - Accurate and reliable results
 - One single orbit



ARTIFIS – Current Developments

ALSTOM

- Already in use at ESTEC since 1998
- First version distributed with ESARAD v-4.2 earlier this year
- Improvements carried out over the last year by Duncan Gibson (ESTEC)
 - New code standards
 - CPU improvements
 - No new major functionality



- Flat plate
- Cylinder
- Sphere
- Cube

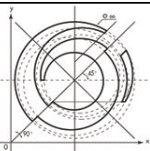
```
C:\Artifis\Artifis\Debug\Artifis.exe

***** ARTIFIS v-1.25 *****
***** Copyright ESA-ESTEC *****
***** Frederic du LAURENS *****

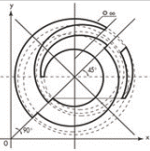
*** Geometry in Orbit ***

Flat Plate: 1
Sphere    : 2
Cylinder  : 3
Cube      : 4
Geometry choice [4]:
-
```

- Spin available for flat plate and cylinder
- Coating is assumed to be black paint



- Same standards as ESARAD v-3
 - One single orbit
 - LOCS – planet or ‘Sun’ oriented
 - Euler angles – φ , ψ and ω
- Incident fluxes calculated by means of analytical expressions
 - Simpson’s integration method
 - Accurate and reliable results



- Output Files
 - FluxResults.rpt
 - FluxResults.GFF

```

FluxResults.rpt - WordPad
File Edit View Insert Format Help
-----
ARTIFIS v-1.0 REPORT
-----
Flat Plate.

Flat plate area=1.00 m2
LOCS: Planet oriented.

Euler angles: phi=0.0 deg psi=180.0 deg omega=0.0 deg

E=1360.0 W/m2      delta=23.00 deg
Rp=6371.0 km      gc=9.80655 m/s2
Temp=288.0 K      Albedo=0.300

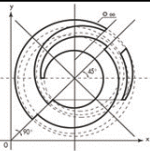
Za=800.00 km      Zp=800.00 km
a=7171.00 km      e=0.000000 i=98.0 deg
alpha=0.0 deg     Omega=135.0 deg

Beta=36.17 deg    Eclipse: Yes

  ANGLE      TIME      IS      IP      IA      IS+IA+IP
  -----
  0.00      0.00      0.000   307.928  0.000   307.928
  18.83     316.39     0.000   307.928  0.000   307.928
  19.33     324.79     620.285 307.928  0.000   928.212
  45.00     755.95     166.733 307.928  2.371   477.032
  90.00     1511.90    0.000   307.928  152.023 459.951
  135.00    2267.85    0.000   307.928  254.024 561.952
  180.00    3023.80    0.000   307.928  207.221 515.149
  225.00    3779.76    0.000   307.928  41.401  349.329
  268.14    4504.39    620.285 307.928  0.000   928.212
  268.64    4512.79    0.000   307.928  0.000   307.928
  270.00    4535.71    0.000   307.928  0.000   307.928
  315.00    5291.66    0.000   307.928  0.000   307.928
  360.00    6047.61    0.000   307.928  0.000   307.928

AVERAGE      76.499   307.928   81.959   466.386

For Help, press F1
  
```



```

"C:\Artifis\Artifis\Debug\Artifis.exe"
Number of orbital positions, N [8]:
60
Number of orbital positions = 60
Shadow offset, offset [0.50 deg]:
Shadow offset = 0.50

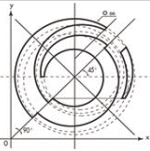
*** LOCS Orientation ***

PLANET ORIENTED: 1
SUN ORIENTED : 2
LOCS orientation choice [1]:
1
PLANET_ORIENTED. Please wait...

Solar flux:
0 10 20 30 40 50 60 70 80 90 100%
|-----|
|***** Completed!

Planet flux:
0 10 20 30 40 50 60 70 80 90 100%
|-----|
|***** Completed!

Albedo flux:
0 10 20 30 40 50 60 70 80 90 100%
|-----|
|*****
  
```

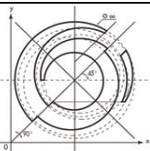


TOPIC – Thermal Designer

ALSTOM

T.O.P.I.C.: *‘Thermal and Orbital Propagated Information Calculator’*

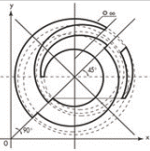
- Presented at ESTEC in 1998 (ECLS Workshop)
- Built on top of ARTIFIS
- Benchmarked with handbook *‘Spacecraft thermal control design data’*



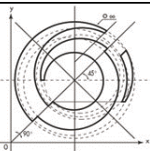
TOPIC – Features

ALSTOM

- Pre-phase A in-house *thermal designer*
 - Fast and easy to use
 - Simple Earth-orbiting surfaces
 - Analysis performed throughout a mission timeline
 - J_2 perturbation, Sun-synchronous orbit
 - Batch process, MS-DOS / Unix
- Incident fluxes calculated by means of analytical expressions
 - Accurate and reliable results



- Already in use at ESTEC since 1999
- First version distributed with ESARAD v-4.2 earlier this year
- Improvements carried out over the last year by Duncan Gibson (ESTEC)
 - New code standards
 - CPU improvements
 - No new major functionality



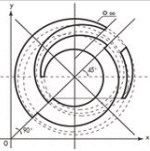
- Flat plate
- Cylinder
- Sphere
- Cube

```
C:\Topic\Topic\Debug\Topic.exe
TOPIC v-1.25
*** Copyright ESA-ESTEC ***
*** Frederic du LAURENS ***

*** Geometry in Orbit ***

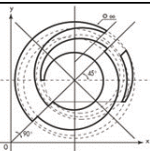
Flat Plate: 1
Sphere : 2
Cylinder : 3
Cube : 4
Geometry choice [4]:
```

- Spin available for flat plate and cylinder
- Coating is assumed to be black paint



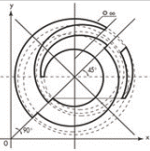
TOPIC – Thermal Design

- Same standards as ESARAD v-3
 - One single orbit
 - LOCS – planet or ‘Sun’ oriented
 - Euler angles – φ , ψ and ω
- Incident fluxes calculated by means of analytical expressions
 - Simpson’s integration method



TOPIC – Output Files

- FluxDetails.rpt
 - Flux values in detail, each orbital position
- Thermal.rpt
 - Fluxes, eclipse, β angle, solar constant...
- Solar.rpt
 - Equation of time, Julian date, solar declination...
- MinMaxESH.rpt
 - Min and max values, ESH...
- Orbits.rpt



TOPIC – Quick Demo



```

C:\Topic\Topic\Debug\Topic.exe
*** Points in Orbit ***

Number of orbital positions, N [8]:
16
Number of orbital positions == 16
Shadow offset, offset [0.50 deg]:
Shadow offset, offset, == 0.50

*** Mission Definition ***

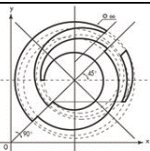
No : 0
Yes: 1
Mission from input file [0]:
1

Reading mission information from input file
File name [Orbits.rpt]:
WARNING: Orbits.rpt has been taken as default value.
Reading file Orbits.rpt
Please wait...

File read successfully.

0 10 20 30 40 50 60 70 80 90 100%
|-----|-----|-----|-----|-----|-----|-----|-----|
|-----|-----|-----|-----|-----|-----|-----|-----|
*****

```

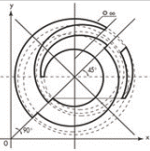


TOPIC – Future Developments

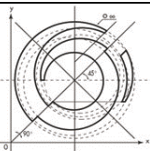


File Edit View Satellite Help

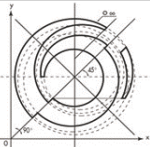
<p>Satellite Parameters</p> <p>Geometry</p> <ul style="list-style-type: none"> <input checked="" type="checkbox"/> Flat Plate Side Length: <input type="text" value="1.0"/> <input checked="" type="checkbox"/> Sphere Radius: <input type="text" value="1.0"/> <input checked="" type="checkbox"/> Cube Side Length: <input type="text" value="1.0"/> <input checked="" type="checkbox"/> Cylinder Side Length: <input type="text" value="1.0"/> Radius: <input type="text" value="1.0"/> 	<p>Euler Angles</p> <ul style="list-style-type: none"> Phi axis X: <input type="text" value="0.0"/> Psi axis Y: <input type="text" value="0.0"/> Omega axis Z: <input type="text" value="0.0"/> <p>Spin</p> <ul style="list-style-type: none"> Positions: <input type="text" value="1"/> Spin Axis X: <input type="text" value="1.0"/> Spin Axis Y: <input type="text" value="0.0"/> Spin Axis Z: <input type="text" value="0.0"/> <p>Orientation</p> <ul style="list-style-type: none"> <input checked="" type="checkbox"/> Planet Oriented <input type="checkbox"/> Sun Reference Line Oriented <input type="checkbox"/> True Sun Oriented 	<p>Planet Parameters</p> <ul style="list-style-type: none"> Radius: <input type="text" value="6378.140000"/> Gravity: <input type="text" value="9.810000"/> Temperature: <input type="text" value="256.400000"/> Albedo: <input type="text" value="0.325400"/> <p>Solar Parameters</p> <ul style="list-style-type: none"> Declination: <input type="text" value="0.000000"/> Solar Constant: <input type="text" value="1371.450000"/> alphaS: <input type="text" value="0.000000"/> omegaG: <input type="text" value="0.000000"/> 	<p>Orbit Parameters</p> <ul style="list-style-type: none"> Apogee: <input type="text" value="40000.000000"/> Perigee: <input type="text" value="800.000000"/> Inclination: <input type="text" value="0.000000"/> alpha: <input type="text" value="0.000000"/> Initial time: <input type="text" value="0.000000"/> Period: <input type="text" value="34759.618721"/> <p>Eclipse Parameters</p> <ul style="list-style-type: none"> Eclipse?: <input checked="" type="checkbox"/> Eclipse Entry Angle: <input type="text" value="168.632608"/> Exit Angle: <input type="text" value="191.367392"/> Duration: <input type="text" value="7821.868232"/> Percentage: <input type="text" value="22.502745"/> 	<p>Orbital Points Info</p> <ul style="list-style-type: none"> Number of Points: <input type="text" value="8"/> Eclipse Offset: <input type="text" value="0.500000"/> Start Angle: <input type="text" value="0.000000"/> End Angle: <input type="text" value="360.000000"/> <p>Orbit Preview</p>
-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------



- Final testing currently on-going
 - Actual release expected late October 2001
- Four major enhancements
 - Heat balance calculation for each node
 - Worksheet 'User Results' automatically generated
 - ESATAN file export
 - Possibility of using Visual Basic (macros...)



Number	Label	Type	mC	α	ϵ	QE	QI	T0 [C]	T [C]	RCTime	Imbalance
1	End bar 1	D	3.89e+01				7.00e+01	26.67	57.15	3.5	8.70e+00
2	bar	D	7.79e+01					26.67	51.72	3.5	1.74e+01
3	bar	D	7.79e+01					26.67	47.84	3.5	1.74e+01
4	bar	D	7.79e+01					26.67	45.51	3.5	1.74e+01
5	End bar 2	D	3.89e+01					26.67	44.72	3.5	8.68e+00
999	space	B	0.00e+00					-273.15	-273.15	0.0	4.70e-01



ThermXL v-2.0 – User Results



Microsoft Excel - case02.xls

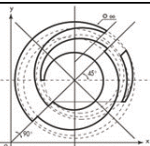
File Edit View Insert Format Tools Data Window Help ThermXL

Transient Arial 10

E6

Time	HF(GR(1,999))	Imbalance 1	convergence
0	0.171828733		
5	0.184409009	26.07576941	0.000372465
10	0.190973123	17.29384297	0.009305017
15	0.195916963	13.85379713	0.008118463
20	0.200115355	11.97919621	0.007343894
25	0.203886112	10.8283983	0.006838126
30	0.207395385	10.09182143	0.006507284
35	0.210744417	9.613292426	0.006290642
40	0.213998515	9.300688226	0.006148679
45	0.217200655	9.096005041	0.006055582
50	0.220379321	8.961804752	0.005994467

ThermXL Analysis ThermXL Results ThermXL User Results



ThermXL v-2.0 – ESATAN Export



Microsoft Excel - case02.xls

File Edit View Insert Format Tools Data Window Help ThermXL

Transient Arial 100%

E38

Parameter	Value	Unit
Max. No. Iterations		
Convergence Criterion	1.00e-02	
Damping Factor	1.00e+10	
Start Time	0.0	Time_s
End Time	50.0	Time_m
Output Interval	5.0	Time_e
Initial Timestep	1.0	Current Timestep
Min. Timestep	0.0	
Max. Timestep	50.0	
Max. No. Iterations	100	
Convergence Criterion	1.00e-02	
Max. Delta T [C] per Timestep	1.00e+10	
Damping Factor	1.00	

ThermXL Analysis ThermXL Results ThermXL User Results

