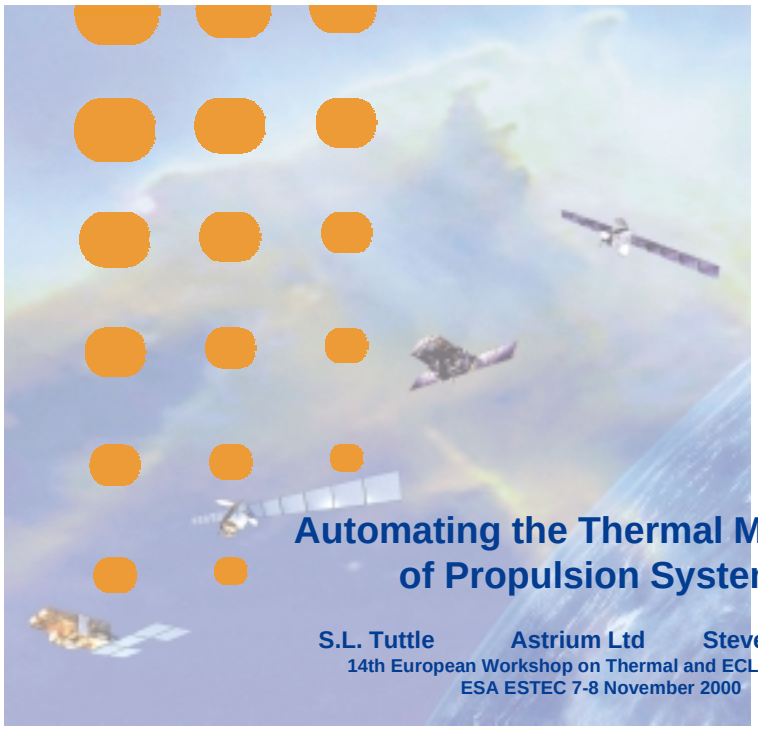
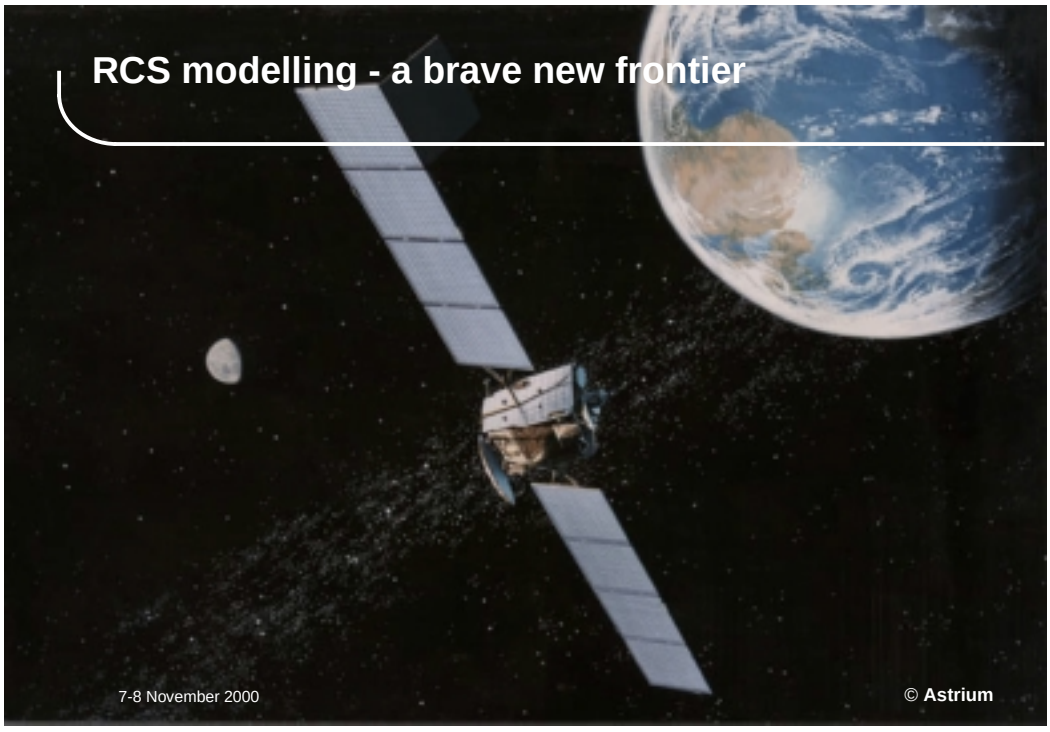


Automating the Thermal Modelling of Propulsion Systems

S.L. Tuttle Astrium Ltd Stevenage, U.K.

14th European Workshop on Thermal and ECLS Software
ESA ESTEC 7-8 November 2000



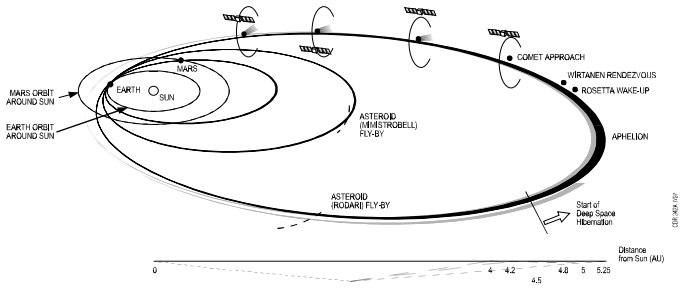
Outline

- **The ROSETTA mission & spacecraft**
- **The Propulsion System**
- **Defining the task**
- **The Solution**
  - The model generation sequence
  - Input spreadsheet
  - Interfacing
- **TCL Output**
- **Advantages of the TCL Model Generator**
- **Results**
- **Summary**

ROSETTA

ROSETTA Schedule

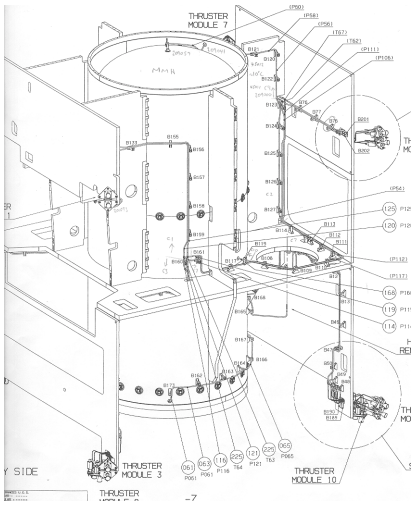
- **STM Test - March/April 2000**
- **PFM Test - November/December 2001**
- **Launch - January 2003**

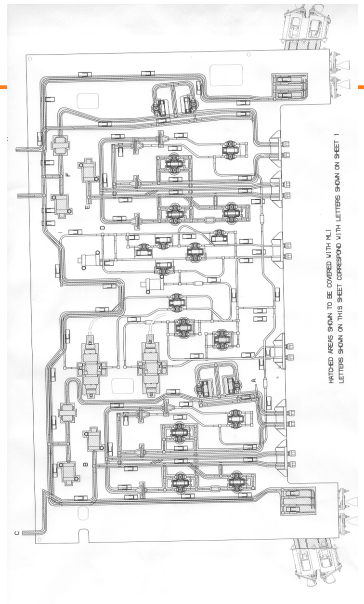


Defining the Task

- **Long periods of hibernation at 5.25AU means that a low power and autonomous design are required**
- **Need to calculate the heater power required to prevent any operating lines within the propulsion system from freezing.**
- **Purpose of Modelling**
  - Power budget refinement
  - Heater procurement
  - Thermostat placement
  - Design of the passive TCS - MLI, tapes etc

ROSETTA Propulsion System 1

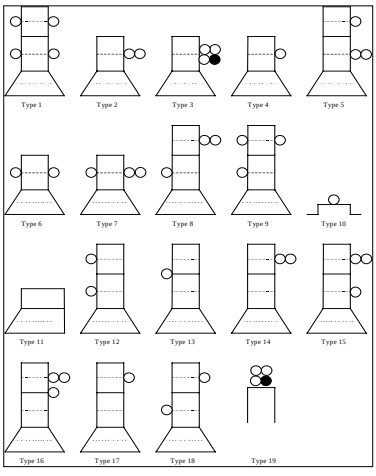




14th European Workshop on Thermal and ECLS Software
ESA ESTEC 7-8 November 2000

ROSETTA Propulsion System 2

- **Pipe Support Brackets**



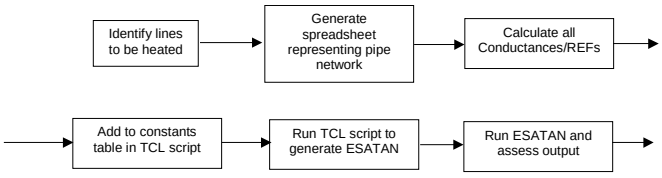
14th European Workshop on Thermal and ECLS Software
ESA ESTEC 7-8 November 2000

The Solution

CONSIDERATIONS:

- **The key is to allow FLEXIBILITY**
  - FM design is complex
  - Design typically evolves through a series of many changes
- **Ability to perform design studies / trade-offs**
  - Should be easy to make global changes to parameters
  - Should be easy to make local changes to parameters

The Model Generation Sequence



Input Spreadsheet

Number	Node	Node	Node	Code	Label	Node	Code	Code	Code
39	95197	99197	75041	B	MMHWetLine	97039	3	1	1
	95198	99198	75041	A	MMHWetLine		3	1	1
	95199	99199	75041	A	MMHWetLine		3	1	1
	95200	99200	75041	A	MMHWetLine		3	1	1
40	95201	99201	80013	E	MMHWetLine	97040	3	1	1
	95202	99202	80013	A	MMHWetLine		3	1	1
	95203	99203	80013	A	MMHWetLine		3	1	1
41	95204	99204	80013	B	MMHWetLine	97041	3	1	1
	95205	99205	80013	A	MMHWetLine		3	1	1
	95206	99206	80013	D2	TANK-MMHLOWEREND		3	1	1
	95211	99211	80021	D2	PRESSURANTTANK		3	1	0
	95212	99212	6039	A	GasLine		3	2	0
	95213	99213	6039	A	GasLine		3	2	0
42	95214	99214	6039	B	GasLine	97042	3	2	0
	95215	99215	6039	A	GasLine		3	2	0
	95216	99216	6039	A	GasLine		3	2	0
	95217	99217	6039	A	GasLine		3	2	0
	95218	99218	6039	A	GasLine		3	2	0
43	95219	99219	6039	B	GasLine	97043	3	2	0
	95220	99220	6039	A	GasLine		3	2	0
	95221	99221	6039	A	GasLine		3	2	0
	95222	99222	6039	A	GasLine		3	2	0
	95223	99223	6039	A	GasLine		3	2	0
44	95224	99224	45003	B	GasLine	97044	3	2	0
	95225	99225	45003	A	GasLine		3	2	0

TCL Script

```
#####################################################################
# Calculated GLs etc (note GL, GR for MLI = 2.25*test results) #
#         *** Make all changes here ! ***           #
#####################################################################
#*****
set K_thruster 0.0000258D0
set K_FDV 0.001D0
set K_tank 0.068D0
set K_free 0.0D0
set K_pipe_to_pipe 0.153
set K_pipe_brktB 0.00132D0
set K_brktB_panel 0.001443D0
set K_pipe_brktC 0.0008427D0
set K_brktC_panel 0.0007394D0
set K_pipe_brktE 0.0001805D0
set K_brktE_panel 0.00011D0
set GL_RCSMLI 0.018675D0
set GR_RCSMLI 0.009D0
set gaspipe_to_compmt 6.765D-5
set fuelpipe_to_compmt 6.765D-5
set doublepipe_to_compmt 8.835D-5
set gaspipe_to_panel 2.775D-5
set fuelpipe_to_panel 2.775D-5
set doublepipe_to_panel 3.643D-5
#*****
#####################################################################

# Boundary Temperatures - average for compartment

set B101 "-1.74D0"
set B102 "-2.95D0"
set B103 "-1.94D0"
set B104 "-3.28D0"
set T_thruster 10.0D0

# Node surface areas and number of nodes per heater (when spirally-wound)
# and CHNGQR control variable

set singlepipe 0.0009975D0
set doublepipe 0.001895D0
set fuelpipe 0.001496D0
set singleMLI 0.002934D0
set doubleMLI 0.002356D0
set talltype 0.005945D0
set tophat 0.0014015D0
set nodes_per_htr 8
set ctrl_var 0.0001D0
```

Interfacing

- **The windows environment allows various reporting**
  - which lines are heated
  - the values of all GLs & GRs currently used

TCL Output

Advantages of TCL Model Generator

- **By changing values at top of file, you can:**
  - Change heater length
    - This helps the physical implementation of the model
  - Change thermostat set points
    - Again, helps match the hardware
- **By changing codes in the spreadsheet, you can:**
  - Change types/numbers of brackets
  - Add equipment such as valves
  - Change which lines are heated and which are not
  - Add / delete sections of pipe

Summary

- **Because design is represented by spreadsheet**
  - User friendly
  - Can cater for a continually evolving RCS network design
- **With the TCL model generator**
  - Can change parameters such as conductance easily
  - Can produce a new model quickly and look at design drivers
  - Can vary heater lengths so hardware definition is simplified