Managing the Interface Between ThermXL and Esarad

Presented by

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Summary

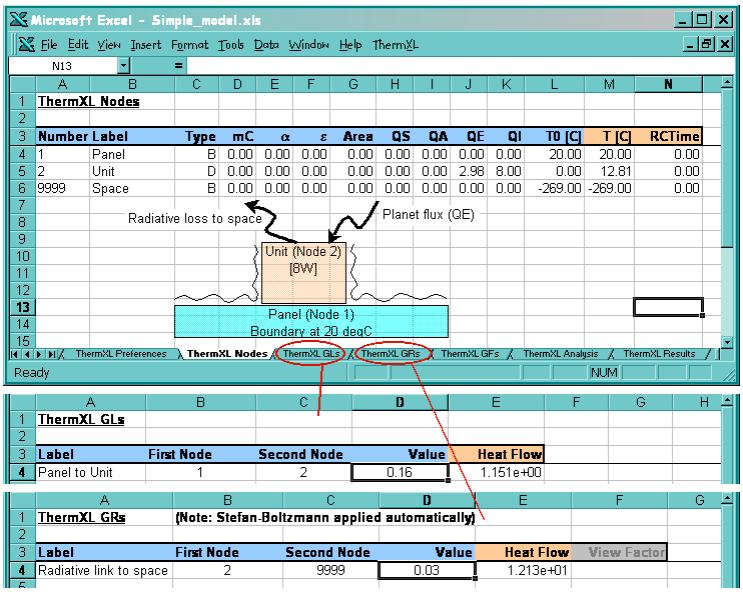
- Thermal Modelling Tools
- ThermXL Overview
- The Thermal Modelling Process
- Esarad Interface
- Other Interface Issues
- Conclusion

Thermal Modelling Tools

ANALYSIS TOOLS			GEOMETRY TOOLS		
	PROs	CONs		PROs	CONs
ESATAN or SINDA	Powerful and flexible.	Too cumbersome for early study phases	ESARAD	Integrates well with Esatan	Does not interface with any other analysis tools
THERMXL	Simple, Powerful and flexible	Not appropriate for detailed analysis. No interface with other tools	SYSTEMA	Integrates well with Esatan and SINDA	Does not interface with ThermXL
HAND CALCULATION	Quick answers to simple problems	No use for analysis of more than 2 or 3 nodes	HAND CALCULATION	No interface issues	Simple geometry only

What is ThermXL?

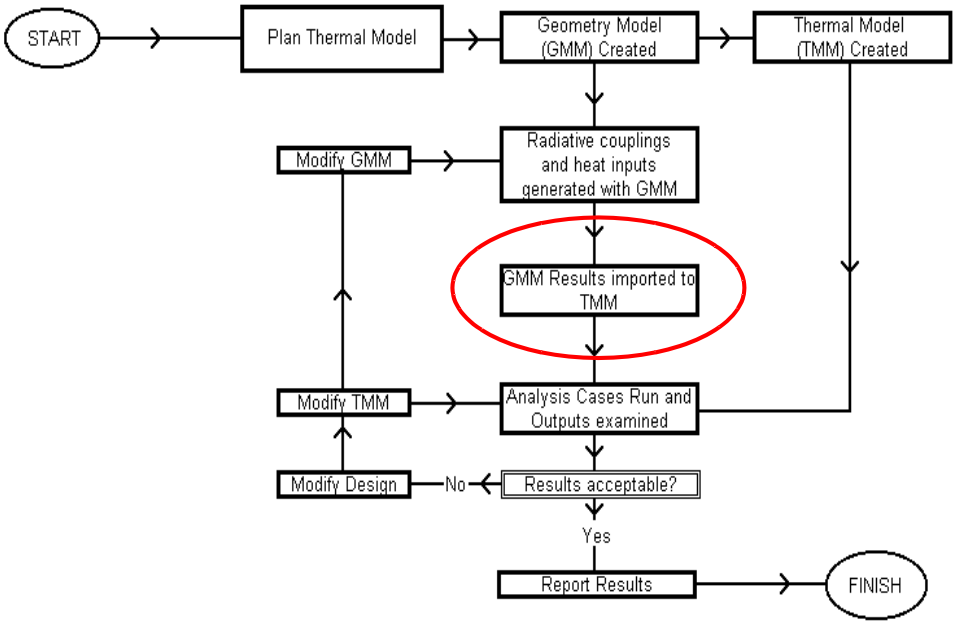
- An add-in for MS Excel that provides Thermal modelling and analysis capabilities in a spreadsheet environment.



Why ThermXL?

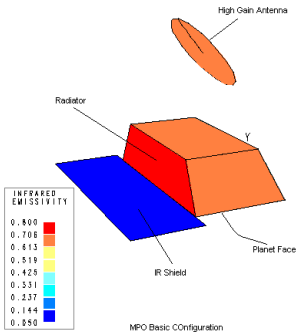
- **ThermXL provides a flexible and simple environment for performing early study thermal design and analysis.**
- **Fast turn-around of analyses**
- **Spreadsheet functionality**
  - Ability to define time and/or temperature dependent values using Excel formulae or macros
  - Direct plotting facility using Excel charts as required
- **Flexibility**
  - Ability to change parameters easily and see instant results

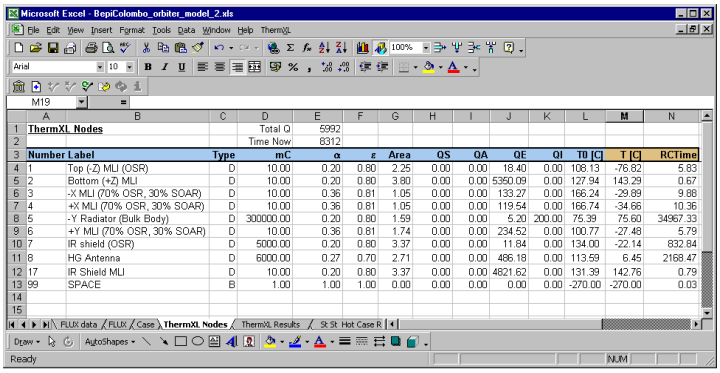
The Thermal Modelling Process



The ThermXL Model

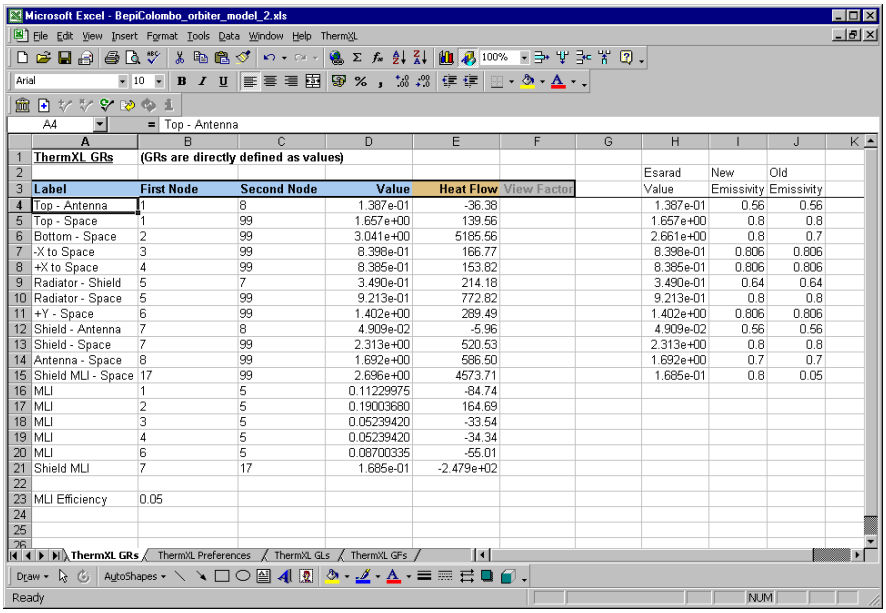
- ThermXL used by Astrium UK for preliminary Bepi Colombo model development
- ESARAD used for geometry modelling
- Steady state fluxes for interplanetary cruise phases and for the Mercury Surface Element (MSE) in situ
  - no problem inserting ESARAD results into ThermXL
- Transient fluxes for orbiting elements, such as the Mercury Planetary Orbiter (MPO), and the descent phase of the MSE with its Chemical Propulsion Module (CPM)
  - Interfacing tools required to import Esarad results into ThermXL





Importing ESARAD generated GRs

- Fixed GRs are manually imported from ESARAD, with Excel formulae to modify optical properties during design iterations



Importing ESARAD Generated Fluxes

Importing the data is an issue for two reasons:

- **Esatan output format not compatible with ThermXL, so importing tool required.**
  - Tool written with Visual Basic macros to deal with the format
- **Excel does not support interpolation**
  - Interpolation performed using a sequence of Excel formulae with the spreadsheet

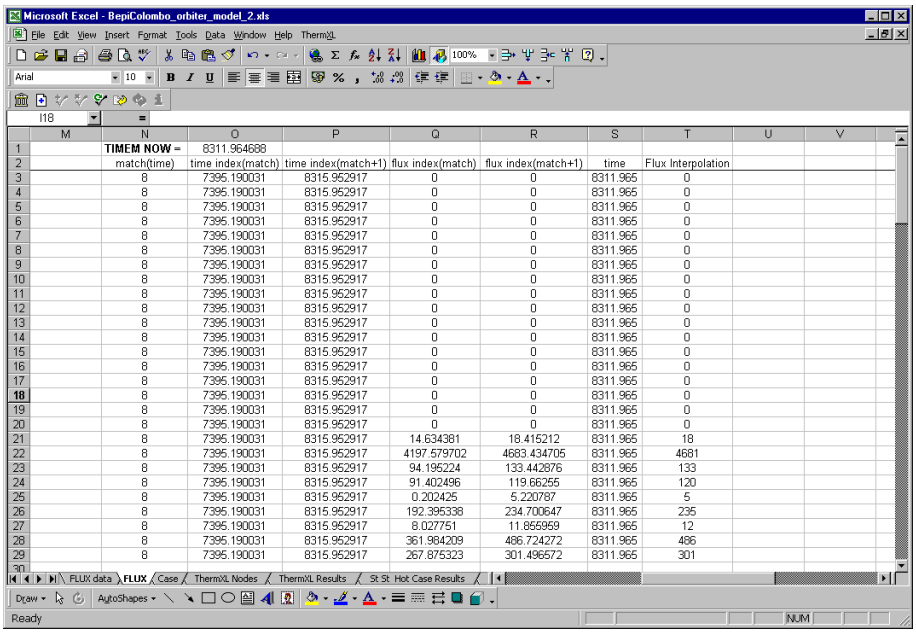
Flux data after importing to ThermXL

Microsoft Excel - BepiColombo_orbiter_model_2.xls

	A	B	C	D	E	F	G	H	I	J	K	L
1											Mean	End of table
2	Time	0	921	930	2184	4158	5529	7386	7395	8316	50000	51000
3	QS1	0	0	224	2473	3851	4097	207	0	0	2005	2005
4	QS2	0	0	22325	0	0	0	22325	0	0	1971	1971
5	QS3	0	0	2760	5475	2226	0	2	0	0	1792	1792
6	QS4	0	0	0	0	2219	5118	2741	0	0	1789	1789
7	QS5	0	0	0	0	0	0	0	0	0	0	0
8	QS6	0	0	21	1398	3641	2593	16	0	0	1453	1453
9	QS7	0	0	86	3710	9693	6868	80	0	0	3869	3869
10	QS8	0	0	1965	1302	3402	2857	1959	0	0	1908	1908
11	QS17	0	0	7069	0	0	0	7069	0	0	624	624
12	QA1	0	0	0	1	2	2	0	0	0	1	1
13	QA2	0	0	0	734	1517	1215	0	0	0	675	675
14	QA3	0	0	0	5	1	1	0	0	0	1	1
15	QA4	0	0	0	0	6	7	0	0	0	3	3
16	QA5	0	0	0	0	0	0	0	0	0	0	0
17	QA6	0	0	0	11	9	10	0	0	0	6	6
18	QA7	0	0	0	0	2	2	0	0	0	1	1
19	QA8	0	0	0	16	23	20	0	0	0	12	12
20	QA17	0	0	0	235	479	391	0	0	0	214	214
21	QE1	18	15	15	7	6	6	15	15	18	10	10
22	QE2	4683	4198	4188	3065	2459	2730	4188	4198	4683	3348	3348
23	QE3	133	94	93	22	5	14	93	94	133	49	49
24	QE4	120	91	91	34	22	27	91	91	120	55	55
25	QE5	5	0	0	0	0	0	0	0	5	1	1
26	QE6	235	192	191	95	38	58	191	192	235	118	118
27	QE7	12	8	8	6	4	4	8	8	12	7	7
28	QE8	487	362	360	152	98	116	360	362	487	223	223
29	QE17	301	268	267	196	155	175	267	268	301	214	214

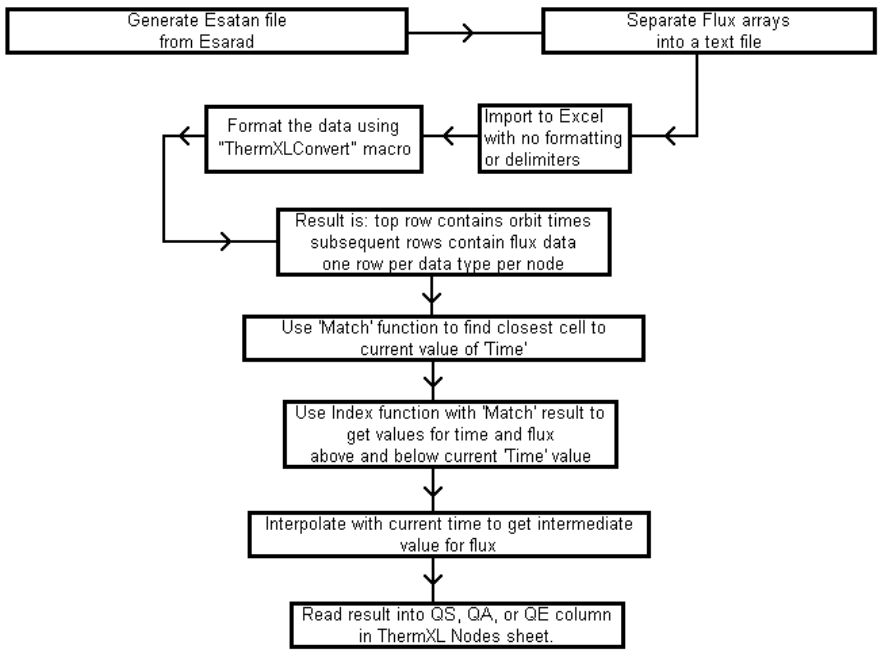
Interpolating the Data

- A series of Excel formulae are used to interpolate the data during the solution, to give a QS value for any specified time during the analysis.



	M	N	O	P	Q	R	S	T	U	V
1		TIMEM NOW =	8311.964688							
2		match(time)	time index(match)	time index(match+1)	flux index(match)	flux index(match+1)	time	Flux Interpolation		
3		8	7395.190031	8315.952917	0	0	8311.965	0		
4		8	7395.190031	8315.952917	0	0	8311.965	0		
5		8	7395.190031	8315.952917	0	0	8311.965	0		
6		8	7395.190031	8315.952917	0	0	8311.965	0		
7		8	7395.190031	8315.952917	0	0	8311.965	0		
8		8	7395.190031	8315.952917	0	0	8311.965	0		
9		8	7395.190031	8315.952917	0	0	8311.965	0		
10		8	7395.190031	8315.952917	0	0	8311.965	0		
11		8	7395.190031	8315.952917	0	0	8311.965	0		
12		8	7395.190031	8315.952917	0	0	8311.965	0		
13		8	7395.190031	8315.952917	0	0	8311.965	0		
14		8	7395.190031	8315.952917	0	0	8311.965	0		
15		8	7395.190031	8315.952917	0	0	8311.965	0		
16		8	7395.190031	8315.952917	0	0	8311.965	0		
17		8	7395.190031	8315.952917	0	0	8311.965	0		
18		8	7395.190031	8315.952917	0	0	8311.965	0		
19		8	7395.190031	8315.952917	0	0	8311.965	0		
20		8	7395.190031	8315.952917	0	0	8311.965	0		
21		8	7395.190031	8315.952917	14.634381	18.415212	8311.965	18		
22		8	7395.190031	8315.952917	4197.579702	4683.434705	8311.965	4681		
23		8	7395.190031	8315.952917	94.195224	133.442876	8311.965	133		
24		8	7395.190031	8315.952917	91.402496	119.66255	8311.965	120		
25		8	7395.190031	8315.952917	0.202425	5.220787	8311.965	5		
26		8	7395.190031	8315.952917	192.395338	234.700647	8311.965	235		
27		8	7395.190031	8315.952917	8.027751	11.855959	8311.965	12		
28		8	7395.190031	8315.952917	361.984209	486.724272	8311.965	486		
29		8	7395.190031	8315.952917	267.875323	301.496572	8311.965	301		

Flow chart to import Esarad data to ThermXL



Other Interface Issues

- **Inactive Nodes.**
  - ThermXL does not support 'inactive' nodes. ThermXL users must therefore delete the ESARAD generated node and all the couplings to it as part of the process of importing to ThermXL.
- **Couplings Between a Node and Itself.**
  - ThermXL does not support ‘Self Couplings’, where a node is connected to itself. While such links have no impact on the heat balance, they are retained by ESARAD for information, so they must be manually removed.
- **Export to Esatan format**
  - There is no function to export ThermXL models into ESATAN format. This step will always be necessary when the scale of the model exceeds the practical limits of ThermXL.
  - It would be a simple matter to generate an Excel macro to format the nodes, couplings, fixed heat sources, and analysis control into ESATAN form. However, this would not deal with any functions and macros used during the analysis for time or temperature varying properties, functions to vary fluxes and couplings according to thermo-optical properties, and so on.

Conclusion

- **The BepiColombo proposal analysis was successfully completed and ThermXL was found to be a very suitable tool for early phase thermal design and analysis.**
  - Short model development time
  - Simple and Intuitive to build and develop the model
  - Very quick to analyze parameter changes
  - Simple to plot results on Excel charts
- **The most significant issue with using ThermXL is the amount of work needed to import the results from ESARAD. Astrium UK has developed a solution to this interface which results in much faster turn-around of analysis.**