

# Recent Advances in the TARP Post Processing Program

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## Abstract

Recent updates have been made to the Thermal Analysis Results Processor (TARP) program allowing the user greater flexibility in data analysis from thermal model results. TARP is a dedicated post-processor that reads standard thermal model output from various solvers and produces a Microsoft Excel® workbook with objects defined by the user at the TARP Main Interface. Previous versions of TARP included DataSets, Plots, Tables, Groups, Parameters, and HeatMaps as available objects and features. Four new object types have now been added: Graphical Tables, Radk Manipulations, Backloads, and Binary HeatMaps. The Graphical Table object shows each table entry as a Max/Min error bar within a bar chart, including the limits. Radk Manipulations allow the user to post process radiation couplings by specifying an action and the criteria to determine on which conductors to operate. Backloads provide a means for representing a complex radiative environment by a simple heat load or a sink temperature and view to the sink. Lastly, the Binary HeatMaps move the necessary heatmap data to an external file and greatly improves the performance of heatmaps for very large models. Further advances have also been made in the capabilities of the output workbook. The addition of these new features further reduces the time needed by a thermal analyst to evaluate and create presentation quality data.

## Introduction

TARP is a Windows® based program that provides an interface where a user defines various types of objects related to the post processing of thermal model results. The resulting product is a Microsoft Excel® workbook. The main interface is shown in Figure 1. From here, the user may add and define object in the session. Once all the desired objects have been defined, the Make XL button is used to generate the output workbook.

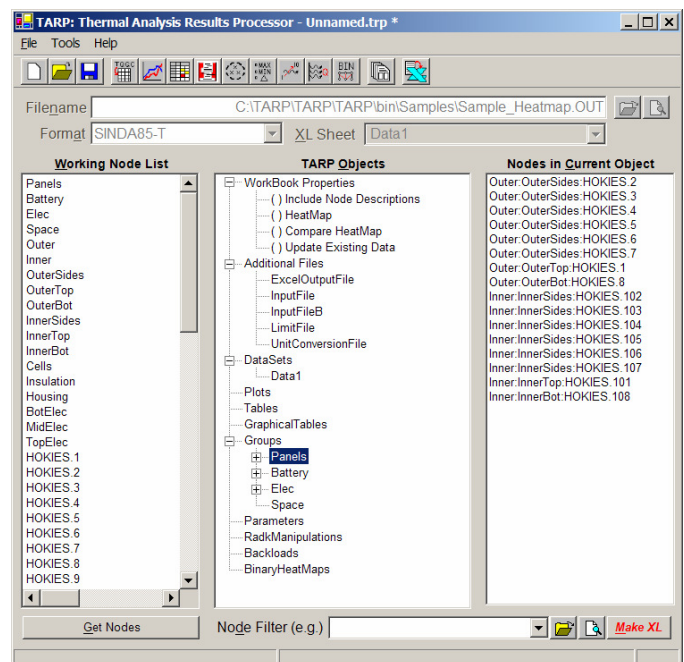


Figure 1 – TARP Main Interface

## Existing Features Review

Existing objects and features in TARP include DataSets, Plots, Tables, Groups, Parameters, and HeatMaps. Each of these will be described very briefly for those unfamiliar with TARP. DataSets include the raw data from the output file which may be a subset of nodes and or timesteps. Plots show the 2-D trend of data vs. time for DataSets/Nodes specified in the Plot definition. Tables list key values (e.g. Min, Max, etc) for the specified nodes and may include node descriptions, if desired. Groups and Parameters create additional datapoints that may be plotted or tabulated. Lastly, HeatMaps produce an interactive workbook which dynamically displays the heat flow between nodes and/or groups for the timestep specified by the user within the workbook.

## New Features Overview

Four new objects have been added to TARP for further post processing abilities: Graphical Tables, Radk Manipulations, Backloads, and BinaryHeatMaps. Each of these will be described in detail after a brief overview.

Graphical Tables present the requested nodes and/or groups as an error bar (Min to Max) within a bar chart including limits. Two sets of limits may be included and the error bar will clearly show any limit violations as well as margin. Radk Manipulations take a query like approach to radk postprocessing. A subset of radks is first selected based on being connected to Node Range A and/or Node Range B. Actions are defined for this range and the file is post processed with each Query-Action instruction applied sequentially to produce the resulting output. Backloads (and Equivalent Sinks) reduce a complex radiative environment down to simple heat loads (or temperatures and radks) for the specified nodes. The stand alone model produces larger radks to space, where other surfaces exist in the integrated model. However, adding the backload term compensates and provides an environment representative of the integrated model. Lastly, Binary HeatMaps address performance issues in HeatMaps when processing large models (> 200,000 conductors). The critical bottleneck in the calculations was the data retrieval from the

conductor worksheet. This time was greatly reduced by moving the necessary data into a binary file and retrieving the data from the file instead of from the embedded worksheet.

## GraphicalTables

The input form for a Graphical Table is shown in Figure 2 with the corresponding output in Figure 3.

Figure 2 – Graphical Table Input Form

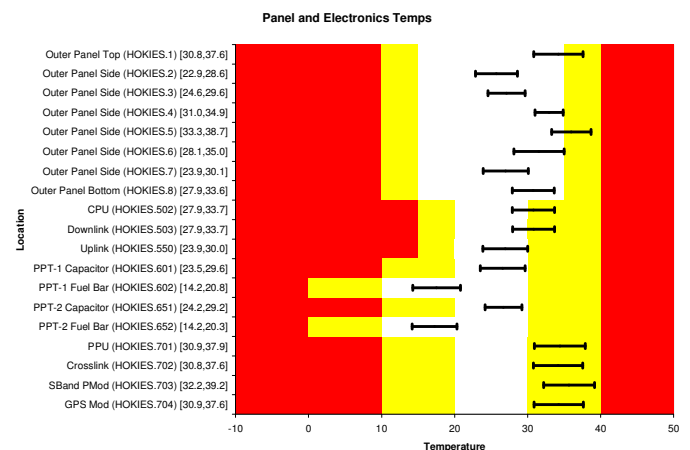


Figure 3 – Graphical Table Output

The limits to be used are specified for the Upper/Lower Inner/Outer values. Also, the source sheet(s) for the minimum and maximum temperature prediction are also specified. An option exists inside the generated workbook to include or exclude the Max/Min values as part of the node label. Furthermore, if a Group object is included in the Graphical Table and a MaxGroup or MinGroup Parameter is defined for that Group, then the Parameter value will be used. The difference is that a Parameter would yield the Maximum or Minimum *nodal* temperature of all nodes in the group over time, whereas the Group would return the maximum *average* temperature of all nodes in the group over time.

## RadkManipulations

The Radk Manipulation input form is shown in Figure 4 with the corresponding output in Figure 5. Input and output radk files are specified as well as a series of Query-Action instructions and formatting options.

Figure 4 – Radk Manipulation Input Form

```

C TARP RadkManipulation performed the following actions:
C REMOVE SUBMODEL for all conductors where Node I/J is in range: * and Node J/I is
C COMMENT for all conductors where Node I/J is in range: 77777 and Node J/I is in
C DELETE for all conductors where Node I/J is in range: 88888 and Node J/I is in
C LIST TO FILE C:\Program Files\TARP\Samples\To_101.rdk for all conductors where N
C LIST TO EXCEL SHEET 101 for all conductors where Node I/J is in range: 101 and N
C SCALE BY 1.15 for all conductors where Node I/J is in range: 1 and Node J/I is i
C RENUMBER STARTING WITH 100000 for all conductors where Node I/J is in range: * a
C
C *** Area units are          feet^2
C *** Multiplier              = 1.00000
C *** Bij cutoff fraction     = 0.00000
C *** Bij minimum fraction    = 0.00000
C *** Bij sum fraction        = 0.00000
C
-100000, 1, 99999, 0.0039628 * 1.15
-100001, 2, 99999, 0.039910
-100002, 3, 99999, 0.039910
-100003, 4, 99999, 0.043327
-100004, 5, 99999, 0.043658
-100005, 6, 99999, 0.040810
-100006, 7, 99999, 0.039740
-100007, 8, 99999, 0.0054124
-100008, 9, 99999, 0.27667
-100009, 10, 99999, 0.0063218
-100010, 102, 99999, 0.58230
-100011, 103, 99999, 0.58230
-100012, 104, 99999, 0.58230
-100013, 105, 99999, 0.58230
-100014, 106, 99999, 0.58230
-100015, 107, 99999, 0.58230
-100016, 108, 99999, 0.0080378
-100017, 109, 99999, 0.091952
-100018, 502, 99999, 0.12249
-100019, 503, 99999, 0.0098125
-100020, 550, 99999, 0.0072625
-100021, 601, 99999, 0.16828
-100022, 602, 99999, 0.038713
-100023, 651, 99999, 0.14126
-100024, 652, 99999, 0.039897
-100025, 701, 99999, 0.033636
-100026, 702, 99999, 0.025442
-100027, 703, 99999, 0.018700
-100028, 704, 99999, 0.0052347
-100029, 1501, 99999, 0.0029910
-100030, 1502, 99999, 0.0042117
-100031, 1503, 99999, 0.0085071
-100032, 1504, 99999, 0.0036410
-100033, 1505, 99999, 0.0032634
-100034, 1506, 99999, 0.0031090
-100035, 1, 2, 8.2108e-05 * 1.15
-100036, 1, 3, 0.00014425 * 1.15
-100037, 1, 4, 0.00015402 * 1.15
-100038, 5, 0.00015337 * 1.15
-100039, 1, 6, 0.00013622 * 1.15

```

Figure 5 – Radk Manipulation Output

Eight actions are available to the user:

1. Remove Submodel
2. Comment Out
3. Delete
4. Sum
5. List to File
6. List to Excel Sheet
7. Scale By
8. Renumber Starting With

To select the radks on which to operate, a combination of Node  $i/j$  and Node  $j/i$  criteria are used. If all conductors are to be operated on, then an \* is entered for both of these fields. If all conductors connected to a node (or range of nodes) is to be operated on, then the range is entered for Node  $i/j$ , and Node  $j/i$  is \*. Lastly, if conductors between specific nodes (or ranges) are to be operated on, then the ranges are specified for Node  $i/j$  and Node  $j/i$ .

Finally, the user may select some formatting options to control the spacing, header inclusion, and variable radk inclusion in the output file.

## Backloads and Equivalent Sinks

The Backload input form is shown in Figure 6 with the corresponding output in Figure 7. Backloads are computed by summing the  $\sigma * \text{Radk} * T_j^4$  terms for all J values in the field of view of the Backload Node. Equivalent sinks follow a similar derivation, but also include the heating terms in the calculations. Options exist to include or exclude other Node J's which are also in the Backload Node range. This is known as with or without self view.

Figure 6 – Backload Input Form

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-----
Backloads generated by TARP v2.1.0
Files:
Radk : C:\Program Files\TARP\Samples\Sample_Heatmap.rdk (TSS)
Temp : C:\Program Files\TARP\Samples\Sample_Heatmap.OUT (SINDA85)
Heat1: C:\Program Files\TARP\Samples\Sample_Heatmap.hrt (TSS)
Parameters:
Sigma: 1.71E-09
Toffset: 460
Self View not included (where Nodes i and j both in Backload Node List)
-----
Backload Arrays from Radk File: C:\Program Files\TARP\Samples\Sample_Heatmap.rdk
Temp File: C:\Program Files\TARP\Samples\Sample_Heatmap.OUT
1 = $ Backload Time Array
0.00, 0.063265, 0.16653, 0.249795, 0.33306
0.416325, 0.49959, 0.582855, 0.66612, 0.749385
0.83265, 0.915915, 0.999179, 1.08244, 1.16571
1.24897, 1.33224, 1.4155, 1.49877, 1.58203
1.6653, 1.66531
2 = $ Backload Array for Node HOKIES.1501
0.8157217, 0.8277131, 0.8326434, 0.8276911, 0.8137955
0.7917555, 0.7744631, 0.7637633, 0.7730696, 0.7811651
0.7898009, 0.7954515, 0.7959425, 0.7896727, 0.7779213
0.7619958, 0.7547652, 0.7619739, 0.7777795, 0.7975104
0.8156582, 0.8156675
3 = $ Backload Array for Node HOKIES.1502
0.3887772, 0.3949135, 0.3976558, 0.3955868, 0.3891148
0.3786698, 0.3702353, 0.3678169, 0.3692012, 0.3728459
0.3767422, 0.3792651, 0.3793495, 0.3762845, 0.3706514
0.3630537, 0.3594644, 0.3628114, 0.3703701, 0.3799049
0.3887479, 0.3887516
4 = $ Backload Array for Node HOKIES.1503
0.0075385, 0.0076655, 0.0077259, 0.007691, 0.0075698
0.0073733, 0.0072318, 0.0072211, 0.0072937, 0.0074104
0.0075232, 0.007594, 0.0076013, 0.0075259, 0.0073816
0.0071824, 0.0070566, 0.007078, 0.0071982, 0.0073707
0.0075363, 0.0075363
5 = $ Backload Array for Node HOKIES.1504
0.4456515, 0.4526522, 0.455749, 0.4533248, 0.445908

```

Figure 7 – Backload Output

At a minimum, the temperature and radk file must be entered. Heat Rate files may also be included, with two entries available if UV and IR sources are to be separated. Heat loads are passed through “as is” for Backloads, but included in the calculations for Equivalent Sinks.

The output is provided in a format that is directly usable by the thermal model, including: nodes, conductors, arrays, steady state calls, and transient call statements. To use the backloads, radks must first be run for the stand alone model containing all the nodes for which backloads were calculated (e.g. for a particular instrument or subsystem). This produces larger views to space than the corresponding integrated model. To compensate for the larger view, the backload is applied as heat loads to the various nodes in the subsystem. This is the same approach used by radiation codes to compute the radiative backloading from environmental sources (planet, solar, etc.), which are independent of the temperature of the receiving nodes.

Equivalent sink temperatures are also calculated in parallel with Backloads. If an entire nodal view is to a single, perfect emissivity, isothermal surface, the equivalent sink temperature is the necessary temperature to produce the same radiative heat flow as in

the integrated model. These values can be particularly useful for determining settings to be used in a thermal vacuum test where surface views are blocked by a controlled heater panel or cryopanel. The outputs from Backloads and Equivalent Sinks can be directly output to an Excel worksheet for further plotting or analysis within Excel®, if needed. Lastly, a Validation File may be output, which includes the contributions of each node in the field of view of the backload node list. This data may be used to verify the values computed by TARP.

## Binary HeatMaps

The Binary HeatMap input form is shown in Figure 8. It requires the same outputs from the thermal model as a regular Heatmap, namely Temperatures, Heat Loads, and Conductances at all output timesteps.

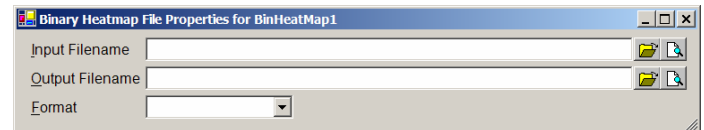


Figure 8 – Binary HeatMap File Input Form

The BinaryHeatMap file is linked to a HeatMap workbook by the filename. When the workbook is opened, if a bhf file with the same basename is found in the workbook folder, then data from this file is loaded and processed to generate the HeatMaps. The performance improvement is significant, with a 300K+ conductor model taking about 1.5 hours to process a single heatmap and less than 8 minutes with binary data, a 10:1 ratio.

Furthermore, some model may become too large to even load into an Excel workbook (> ~500K conductors), but may be loaded in the Binary HeatMap format. Lastly, some model may even be too large (> ~2,000K conductors) to store all of the heat paths in memory. For these cases, all heat paths are processed and their contributions stored in the appropriate internal Node-To-Group and Group-to-Group structures, but the Node-to-Node paths needed for output of a nodal HeatMap are read from the file at request time and then output.

## Workbook Capabilities

Some additional capabilities have also been added to the output workbook, primarily the

ability to modify the Group Definitions and to output transient heat flows for all timesteps. The Group Modification form is shown in Figure 9. At this form, groups may be moved, created, or deleted and nodes may be moved into, or assigned to, the groups. These updates are then propagated throughout the Group Definitions and formulas on the DataSets to calculate the group values. Lastly, the updates may be saved to an external file for later use in TARP to load the updated group definitions into another session.

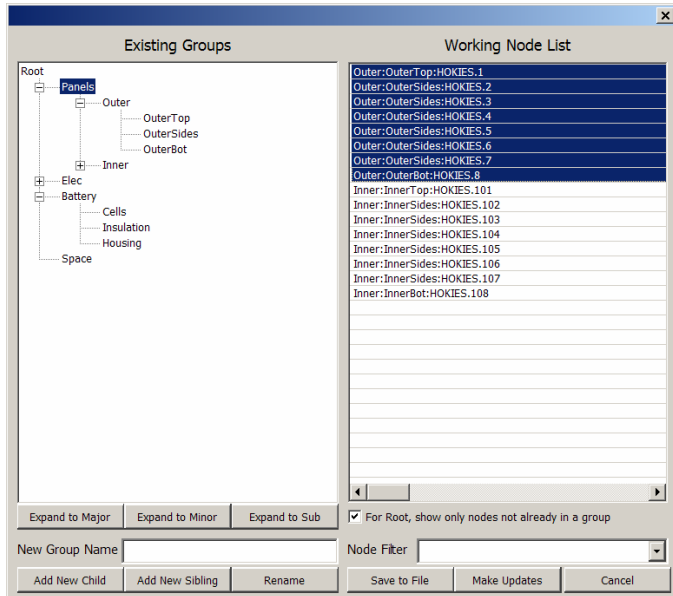


Figure 9 – Group Modification Form

An option was also added to the HeatMaps to allow for the creation of transient heatflows. The input form is shown in Figure 10 and the resulting output in Figure 11.

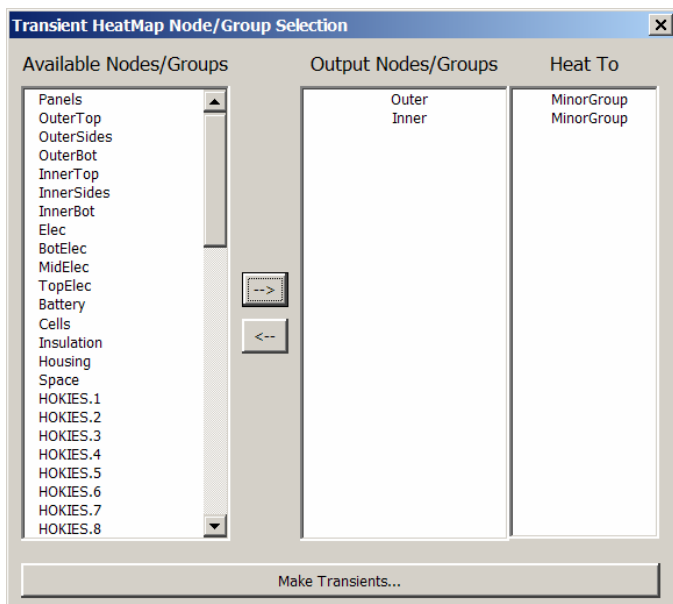


Figure 10 – Transient HeatMap Input Form

	A	B	C	D	E	F	G	H	I	J	K	L
1		Node/Group I		Temperature i	5	87.77563	87.77563	91.43413	93.02263	92.58225	90.4075	86.61588
2		INNER		Linear Heat In:	0	97.42988	97.42988	116.2695	112.3089	101.1733	85.74775	74.97237
3				Linear Heat Out:	0	-36.9794	-36.9794	-36.8521	-37.0014	-37.6088	-39.7232	-48.4222
4		What to Show	SUMMARY	Radiative Heat In:	0	2.7E-05	2.7E-05	3.34E-05	3.29E-05	3.08E-05	2.75E-05	2.34E-05
5		HeatFlow		Radiative Heat Out:	-280.471	-536.557	-536.557	-550.926	-557.228	-555.498	-547.041	-532.528
6				Source:	476.9368	476.9368	493.8171	491.788	488.8384	483.5721	478.0499	472.1959
7				Imbalance:	196.4662	0.830244	17.71054	20.27969	6.918033	-8.36131	-22.9667	-33.7824
8												
9												
10	description	Node/Group J	Type	Max / Min	SS	SS	0	8.33E-02	0.16663	0.249796	0.33306	0.416325
11		BOTELEC	Lin	6.03E+01 / 0.00E+00	0.00	35.32	35.32	29.18	27.27	24.32	21.75	19.96
12		HOUSING	Lin	1.06E+01 / -3.48E+00	0.00	4.84	4.84	-1.21	0.76	4.23	6.80	9.67
13		MIDTELEC	Lin	0.00E+00 / -3.82E+01	0.00	-35.68	-35.68	-35.64	-37.00	-37.61	-37.32	-36.32
14		OUTER	Lin	1.42E+01 / -1.72E+01	0.00	-1.30	-1.30	9.90	10.10	5.50	-2.40	-12.10
15		TOPELEC	Lin	7.91E+01 / 0.00E+00	0.00	57.27	57.27	77.18	74.18	67.13	57.19	45.34
16		BOTELEC	Rad	2.98E-06 / -6.08E-05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17		HOUSING	Rad	1.68E-06 / -3.12E-05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18		MIDTELEC	Rad	9.19E-06 / -9.27E-04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19		MISC	Rad	9.04E-04 / -1.29E-01	0.00	-0.11	-0.11	-0.12	-0.12	-0.12	-0.12	-0.11
20		OUTER	Rad	4.48E-09 / -1.89E-04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21		SPACE	Rad	-3.57E-01 / -5.65E-02	-280.47	-536.45	-536.45	-550.80	-557.10	-555.37	-546.92	-532.42
22		TOPELEC	Rad	3.42E-05 / 0.00E+00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Figure 11 – Transient HeatMap Output

The transient heat map output includes the heat flow to each connected node or group at each timestep. Any connections where no heat flow exists at any timestep are removed. A summary of the heat balance (Conduction In/Out, Radiation In/Out, and Applied Source) is also shown for each timestep. The user may also opt to display the Temperature of or the Conductance to, the connected Node/Group. As many sheets as desired can be created for different nodes, groups or group levels.

### Conclusions

The new features added in TARP as well as the existing features allow the thermal analyst to post-process data faster and more efficiently. The new objects allow for alternate ways to display data for reports and presentations, process radiation results, simplify environments, and examine heat flows in very large models. TARP will continue to evolve as further post-processing needs are identified.

### Contact Information

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