

Appendix M

Improved Handling of Thermal Test Results

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Abstract

Last year Intespace implemented under ESA contract in DynaWorks a number of features to improve the processing of thermal test results. This presentation will show what they were and discuss further work in this area.

The improvements focussed on:

- Simple, near-realtime import of EGSE sensor data;
- Import of ESATAN analysis predictions into DynaWorks, so that predictions and life test results could be compared interactively;
- Archiving of complete thermal test campaigns for future post-test consultation.

The improvements will be illustrated at hand of real test campaigns in which the new features were validated.

Improved Handling of Thermal Test Results

Hans Peter de Koning (ESA/ESTEC, Noordwijk, The Netherlands)

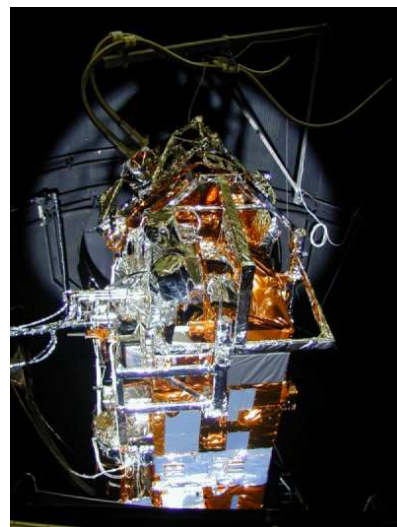
Etiènne Cavro (Intespace, Toulouse, France)



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Background

- Thermal testing is an essential activity in the development of a space system
- It is also very costly
- Need to improve process with good ICT
 - Main users are thermal engineers from customer and supplier (e.g. ESA and prime contractor)
 - Both during test and post-test
- Although many advances over the years quite a number of bottlenecks remain
- Main thermal test tools in use in ESTEC (LSS): DynaWorks® and STAMP



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Activity

"Improved access to thermal test data"

- CCN to an existing ESA contract with Intespace
- Performed mainly by Etienne Cavro
- Developed as part of DynaWorks®
- Started January 2007
- Completed January 2008



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Objectives for

"Improved access to thermal test data"

Increase effectivity and efficiency of thermal engineer performing thermal tests by:

1. Collecting all relevant test data in near-real time in a single database
 - so that simultaneous and synthesized monitoring, viewing, processing and analysis of such data can be performed in a single test data processing tool
 - in particular sensor readings coming from other sources than the test facility itself, e.g. flight sensors in spacecraft or instruments through EGSE, ...
2. Providing on-line access to an archive of thermal tests performed in the past
 - which can be browsed through user level queries
 - from which past test information and results data can be retrieved in a format that can be processed readily in the same data processing tool
3. Providing real-time access to relevant thermal analysis predictions
 - which can be loaded and viewed in the same data processing tool



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Collecting all relevant test data in near-real time in a single database (1/4)

- Test facility sensor data and EGSE mission/instrument specific sensor data
 - Test facility sensor data is routinely provided
- Original idea was to do an import interface with SCOS2000 EGSE
 - SCOS2000 is the ground station software platform used by ESOC on majority of ESA missions for TMTc, and therefore also for EGSE
- The SCOS2000 CORBA interface documentation and API turned out to be too complex
 - Too complex to implement within the frame of this limited activity
 - Also no “dry run” environment available out-of-the-box (e.g. test data server simulating EGSE)
- General problem: EGSE in isolated network – no external connection allowed
- Decided on simple fallback solution using an enhanced CSV format and FTP connection

CSV = Comma Separated Value



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Collecting all relevant test data in near-real time in a single database (2/4)

- Proof of concept with SMOS thermal balance test April 2007 in ESTEC LSS
 - Prime contractor: CASA
- Proof of concept importing from SMOS EGSE sensor data successful
 - Also thanks to simple CSV format file made available by CASA
 - Actual data file transfer using USB stick approximately two times per hour
 - DynaWorks CSV import handles a-synchronous import of sensors scans well
 - Performs bookkeeping w.r.t .timestamp of scan
 - Handles duplicate scans gracefully – warns for differences for already imported timestamp
 - Can catch up with large import intervals
- Went on to generalise the CSV format in pragmatic manner



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Collecting all relevant test data in near-real time in a single database (3/4)

- Extended CSV or TSV format with formal specification
 - Compatible with Excel .csv or tab-separated .txt

CSV = Comma Separated Value
TSV = Tab Separated Value

5. FILE FORMAT SPECIFICATION IN W3C EBNF

The following EBNF (Extended Backus-Naur Form) fully specifies the file format's syntax.

For a specification of W3C EBNF itself, see <http://www.w3.org/TR/REC-xml/#sec-notation>

```

SEP ::= " " | "\t" ;
EOL ::= "\n" | "\r\n" ;
Digit ::= [0-9] ;
Alpha ::= [A-Za-z] ;
Underscore ::= "_" ;
Punctuation ::= "-" | "." | "," | ";" | ":" | "/" | "?" | "!" | "@" | "#" | "$" | "%" | "&" | "'" | "\"" | "(" | ")" | "{" | "}" | "[" | "]" | "<" | ">" | "<=" | ">=" | "<=" | ">=" ;
Operator ::= "+" | "-" | "*" | "/" | "%" ;
QuoteChar ::= "\"" | "\"" ;
GroupingChar ::= "(" | ")" | "{" | "}" | "[" | "]" | "<" | ">" | "<=" | ">=" | "<=" | ">=" ;
SpecialChar ::= "&" | "&" | "&" | "&" ;
NonAlphaNumeric ::= Punctuation | Operator ;
Underscore ::= "_" ;
PrintableChar ::= Alpha | Digit | NonAlphaNumeric ;
Identifier ::= Alpha (Alpha | Digit | Underscore | PrintableChar)* ;
RealNumber ::= [0-9] (Digit)* "." (Digit)* "E" [0-9] (Digit)* ;
RealExponent ::= [Ee] [-+] (Digit)+ ;
StringValue ::= " (" PrintableChar | ScapeChar )* " ;
File ::= HeaderSection DataSection ;
HeaderSection ::= EncodingLine (CommentLine | InfoLine | SensorLine | UnitsLine | CommentLine | ParameterLine)* ;
EncodingLine ::= "#encoding:" SEP Identifier ;
InfoLine ::= "#info:" SEP Identifier ;
SensorLine ::= "#sensor:" SEP Identifier ;
UnitsLine ::= "#units:" SEP Identifier ;
CommentLine ::= "# (" PrintableChar | ScapeChar )* ;
ParameterLine ::= "#Parameter:" SEP Identifier SEP Identifier SEP Identifier ;
ParamName ::= Identifier ;
ParamValue ::= Identifier ;

```

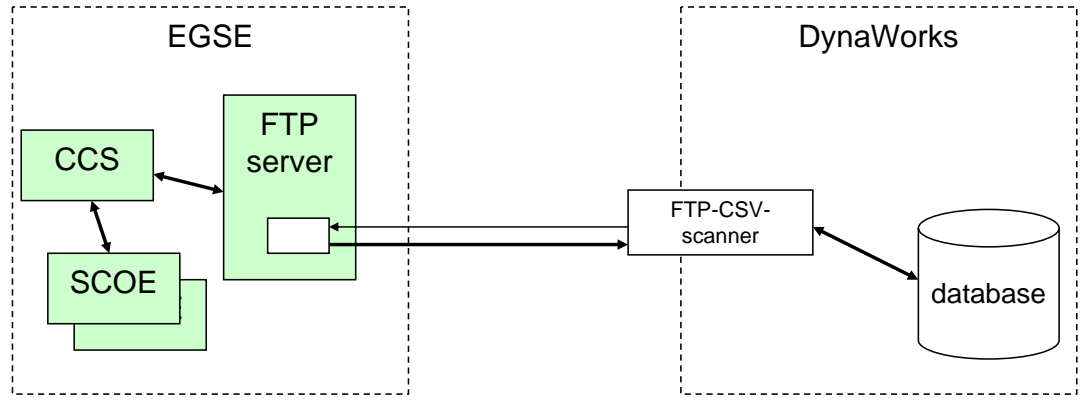
```

20071207T162003_complete.csv 20071207T162003.csv
#encoding:utf-8
#
#Parameter.Operator:"Hans Peter DE KONING, ESA/ESTEC"
#Parameter.TestName:Acceptance Test of FTPLoader Interface
#Parameter.TestPhase:Phase One
#Parameter.Facility:"Python testdata generator (csv_data_gen.py, numberOfChannels=20, sa
#Parameter.TestArticle:RandomSat
#Parameter.ProjectName:C15848-CCN6 Improved access to thermal test data
#
#Enum.HeaterMode:Off,Operational,Hibernating
#Enum.ValveStatus:Open,Closed
#
#Channels.TC_1.TC_2.TC_3.TC_4.TC_5.TC_6.TC_7.TC_8.TC_9.TC_10.TC_11.U_12.U_13.U_14.U_15.P
#Units.degC.degC.degC.degC.degC.degC.degC.degC.degC.degC.degC.mV.mV.mV.mV.W.W.-.-
#Datatypes.Real.Real.Real.Real.Real.Real.Real.Real.Real.Real.Real.Real.Real.Real.Re
2007-12-07 16:20:03.906,3,22172472256,9,66813458678,4,69157007558,13,4184548345,8,048309!
2007-12-07 16:20:05.919,3,62320887927,9,31345719501,4,85286098164,17,4392534568,8,097010!
2007-12-07 16:20:07.922,4,07719286846,9,40324884747,5,33119120587,22,5533637969,8,618448!
2007-12-07 16:20:09.935,4,16323863884,10,3074853846,5,20487896741,24,4748767257,9,317129!
2007 12 07 16:20:11.948,4,70224096290,8,17027960240,6,09701208010,27,7624522422,0,2177020!

```

Collecting all relevant test data in near-real time in a single database (4/4)

- Simple FTP transfer using "directory polling handshake"



Providing on-line access to an archive of thermal tests performed in the past

- Basically this is using existing functionality in DynaWorks
- Procedure written how to perform import of existing DynaWorks post-test databases
 - Including details on “Thermal” database schema
- Can browse over a number of projects / tests / testphases
- Trials performed with Rosetta, Venus Express and SMOS data
- Should be developed into an ESA archive of tests performed
 - Not done yet due to lack of time on ESA’s side
- In future should be possible to consult results from past test campaigns through a network connection to the archive server while performing a test
 - E.g. useful in anomaly investigations



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Providing real-time access to relevant thermal analysis predictions (1/2)

- Goal: test predictions from analysis (e.g. ESATAN) available during test
 - In same database and display as actual live test results
- Analysis predictions loaded before test begins
- Provide time shift function to match transients
- Implemented proof-of-concept STEP-TAS import interface in DynaWorks
 - Uses same STEP-TAS results files as ESATAP
 - Created new DynaWorks Thermal database schema to accommodate STEP-TAS concepts
 - Shows interesting future capability to connect analysis and testing
 - Pre-cursor to component for near-real-time test correlation
- As quick intermediate solution can also use adapted ESATAN CSV format
 - For ad-hoc CSV “quick-and-dirty” converter development
 - the csv module that comes with the free Python environment proved to be excellent



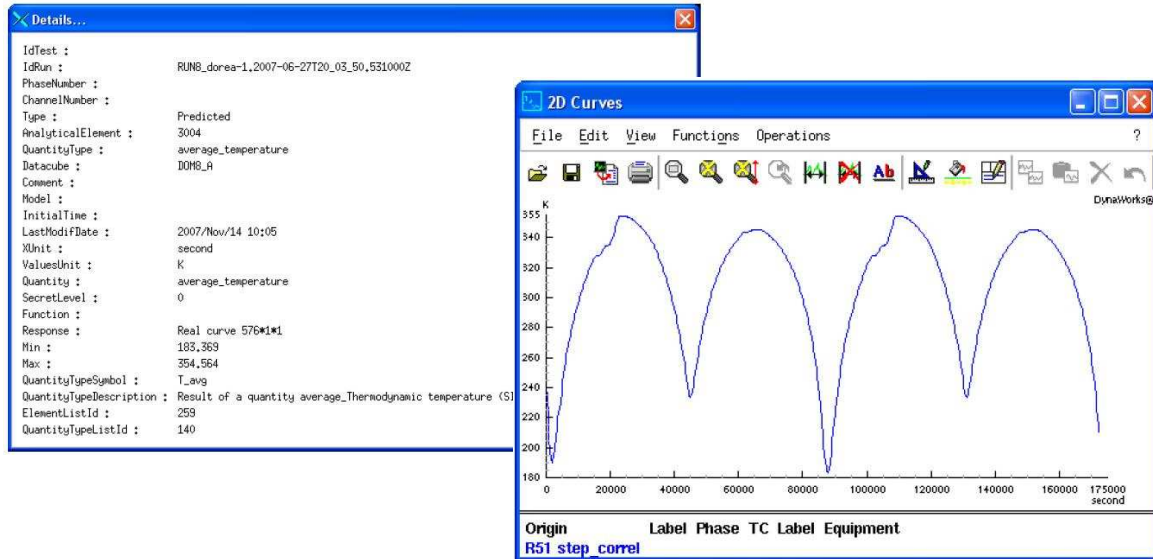
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Providing real-time access to relevant thermal analysis predictions (2/2)



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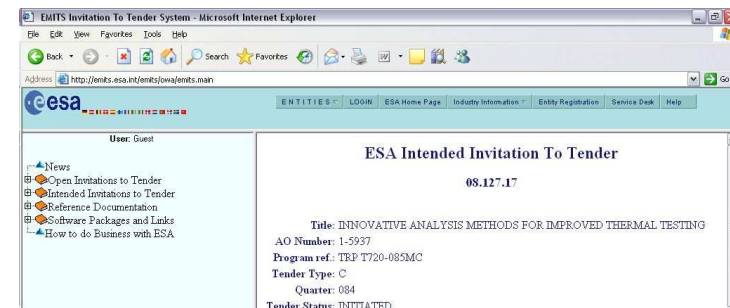
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New TRP ITT (AO 1-5937) "Innovative Analysis Methods for Improved Thermal Testing"

- ITT open this week – 300kEuro earmarked
- Critical assessment of bottlenecks in thermal testing – propose innovative solutions
 - E.g. near-real-time test correlation, sensor locations and results in 3D visualisation, early prediction of thermal equilibrium
- Implementation and validation in beta release software



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