Improvements in RELAP5-3D Plot and Strip Files

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Outline

- Improvements
  - On restart, plot file format automatically detected
  - Smaller size in XDR and Machine-DEpendent binary
  - Auxiliary programs modified to work w/ 4-byte
  - Comma Separated Value (CSV) format implemented

- Issue Corrections
  - XDR file had 4 GB size limit
  - Machine DEpendent format did not match pre-Beta rstplt plot records
  - Strip file also had differences from pre-Beta format

Smaller Size Plot Files

- In previous versions of F90+ RELAP5-3D (3.0.0 and 4.0.3) the plot records were written with 8-byte floating point reals
  - The machine DEpendent records were written to match the XDR records: 8-bytes
- In pre-F90 code versions, the restart-plot file used 4-byte floating point reals
- The new plot records used twice as many bytes as the old
  - These make up the bulk of the plot files
  - Plot records used nearly twice as much space as pre-Beta plot records (in the rstplt file).

Smaller Size Plot Files

- 4-byte reals can represent at least 7 significant digits
- Plots do not represent data to that degree of accuracy
  - Having 8-byte (14+ digit accuracy) is wasted accuracy for plots
- Therefore plot files with 4-byte or 8-byte reals are equivalent for plotting purposes
  - However the 8-byte records are twice the size for no improvement
- Some IRUG members requested that size of the plot file be reduced by writing only 4-bytes reals

Smaller Size Plot Files

- The 4-byte floating point real has been implemented and tested for
  - Plot records on the plot file
- The keyword on the 103 and 104 cards is XDR4
- Machine DEpendent binary plot records were also modified to produce 4-byte reals
- For legacy reasons, you still get 8-byte binary with the following keywords:
  - binary, cmpress, ncmpress

Plot Files Format Keyword

- Summary of plot record keywords available

103/104 card keyword	Outgoing plot file format
ASCII	ASCII
BINARY	8-byte machine INdependent XDR binary
CMPRESS	8-byte machine INdependent XDR binary
NCMPRESS	8-byte machine INdependent XDR binary
MBINARY	**4-byte** machine DEpendent binary
XDR4	**4-byte** machine INdependent binary

Support Programs for the Smaller Size

- RELAP5-3D auxiliary programs modified to support the 4-byte data records
    - APT Plot
    - PYGMALION
- Programs not modified
    - XMGR5

Strip File Clarifications

1. Strip files still have 8-byte reals in plot record
   - Done for legacy reasons, in pre-Beta versions strip files had 8-byte plot records
   - Some IRUG members requested this format be continued to match their legacy software

2. New Strip file format implemented in version 4.1.3, Comma Separated Value (CSV)
   - This allows many programs to import the values directly to construct tables and graphs (E.G. MS Word and Excel)

3. A decision was made to disallow XDR format for any strip file
   - PROBLEM: limitations in the PIB library for XDR do not allow two XDR files to be open simultaneously

Strip File Clarifications

- Last year we requested IRUG members who wanted strips to XDR format to inform us.
  - Received no requests
  - Thus XDR format <u>on output</u> is currently not implemented for strips
- UP 13091 – User attempted to write an XDR strip file with version 4.0.3
  - Documentation in the Vol. 2, Appendix A for the 103/104 card disallowed this, but the 100 card documentation was confusing
- The documentation in Volume 2, Appendix A, for the 100 card has been corrected
- The 100 card has been modified to warn the user if XDR strip file is requested
  - The format is changed to ASCII

Strip File Clarifications

- Plot files of any of the 4 formats can be stripped.

- Strip file has 3 allowable formats: Machine DEpendent, ASCII, or CSV

- Summary of Strip File Formats

Outgoing strip file format	Incoming Plot XDR 4- or 8-byte	Incoming Plot Machine DEpendent	Incoming Plot ASCII
CSV (Comma Separated Values)	Available	Available	Available
ASCII	Available	Available	Available
Machine DEpendent	Available	Available	Available
XDR (8-byte)	Not Allowed	Not Allowed	Not Allowed
XDR (4-byte)	Not Allowed	Not Allowed	Not Allowed

Interest in CSV Plot Files or Smaller ASCII Files?

- Plot files with CSV format similar to CSV strip files.
- Smaller ASCII plot file and strip files concept:
  - Most of the data occurs in plotrec records which have format:
    - ("plotrec", 5x, 1p, 4e15.6),:/(5e15.6)
  - W/ one space between values, could be reduced from 15.6 to 13.6
  - Could be reduced to: 13.6, 12.5, 11.4, or 10.3
    - 103/104 card keyword = ASCIIx
    - x = # digits after decimal point in the format statement
    - ASCII = ASCII6
- Note that a plot/strip file with ASCII3 format would be 2/3 the current plot/strip file size.
- Same could apply to CSV. Keyword CSVx.

Plot/Strip User Problems/Requests

- The following slides present User Problems and requests regarding plot and strip files
  - 13010
  - Plot File Format on Restart
  - 13020
  - 13089

UP 13010 - XDR Plot File 4GB Limit Error

- User Problem 13010 - any XDR file larger than 4 GB would begin to overwrite itself
    - The resulting file was unusable
    - Unacceptable for long-running transients
- This problem does not occur for machine DEpendent and ASCII plot files
- This was traced to an error in the PIB library for XDR caused large plot files to fail.

UP 13010 - XDR Plot File 4GB Limit Error Solved

- The author of the PIB library was informed and the bug was fixed
  - A 32-bit integer can index 2^{32} = 4,294,967,296 bytes = 4 GB
  - Changed 32-bit indexing to 64-bit indexing
- The modified PIB library allows huge plot files (2^{64} bytes) with the XDR format
- This capability was introduced into RELAP5-3D and tested.
- XDR files may now exceed 4 GB in version 4.1.3

Plot File Format on Restart

- An IRUG member requested a simplification in plot file specification for restart problems.

- New subroutine <u>findPlotFormat</u> determines format of an existing input plot file
  - Via open and read statements, it determines plot file format.
    - Tries to open as XDR first,
    - If that fails, tried to open as machine Dependent second
    - If that fails, it is ASCII, so it opens that
    - If it has a comma on the plotinf line, it is CSV.
  - Located in plotmod

- The plot file remains open for writing new plot records, there is no need to specify its format.

Legacy Machine DEpendent Plot Record Format

- UP 13020 V&V'ed software could not read the machine DEpendent binary plot file produced by 4.0.3.

- In Version 4.0.3, machine DEpendent binary the plot records were not the same as in pre-F90 versions

- After several exchanges with the IRUG member, the exact format that their software required was determined

- RELAP5-3D version 4.1.3 now produces plot records that match those on the pre-F90 restart-plot file

Strip File Issues

- UP 13020 continued – legacy software could not read the strip file.
  - The strip coding that read machine Dependent binary plot files and wrote machine Dependent binary was modified:
    - Plotinf records have four 32-bit integers
    - Read 4-byte reals from plot file plotrec records
    - Write 8-byte reals on strip file plotrec records
- UP 13089 The ASCII strip file format had an extra space in one record
- This extra space disagreed with the description in Volume 2, Appendix A, 100-card description and affected legacy software.
  - Workaround: modify ASCII strip file with a text editor
  - The IRUG member requested a permanent solution
  - The space has been removed and the legacy software now works without post-processing

Summary

- The binary plot files can be made about half as large as in 4.0.3
    - XDR4 for machine INdependent binary
    - mbinary for machine DEpendent binary

- The strip file has a new format, CSV

- Machine DEpendent plot file matches the pre-F90 form for legacy software

- Much work has been done to improve the performance of the plot and strip file capabilities

- Question was asked to IRUG Members, "interest in CSV plot or smaller ASCII plot/strip files?"