The CÆSAR Code:  
Software Design Issues

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Available on-line at  
http://www.lanl.gov/Caesar/
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CÆSAR Description

- 3-T Photonics Diffusion (P₁) Code
- Multiple Dimensionality (1-D, 2-D, 3-D)
- Unstructured Hexahedral Cells in 3-D
- Second-Order Convergent Diffusion Discretizations
- Parallel, written in Fortran 90
- Based on earlier Augustus (P-1) and Spartan (SP₅) codes
- Future: Polyhedral Meshes, Multigroup, Tensor Diffusion, Mixed Cells, Transport
Diffusion Discretization References

- Morel-Hall Asymmetric Method
  - Described in


  which is an extension of


  to 3-D unstructured meshes, with an alternate derivation.

- Support Operator Symmetric Method:
  - Described in


  which is an extension of


  to 3-D unstructured meshes, with an alternate derivation.
Why Document A Program?

For Others:

- To Demonstrate Progress in Coding
- To Encourage Use of the Package
- To Reduce “Hit-By-A-Bus” Syndrome
- To Facilitate Technical Review

For Yourself:

- To Understand Global Logical Code Structure
- To Facilitate Computer Code “Re-Entry” For Debugging, Maintenance, and Enhancement
- To Explain Things Once, not Multiple Times, to Users
- To Allow Quick Code Access via Hypertext
- To Be Proud of Your Work
Levels of Documentation

A code can be rated according to where it falls on this sequential list:

0. Layout
   0-a. Consistency
   0-b. Logical Block Structure (Few or No Branches)
   0-c. Indentation to Show Logical Structure
   0-d. Blank Lines and Spaces for Readability
   0-e. Statements Grouped Semantically

1. Descriptive Variable and Routine Names

2. Comments throughout the Code

3. Routine Headers with
   3-a. Purpose
   3-b. Input/Output Variable Descriptions
   3-c. Internal Variable Descriptions
   3-d. Methods Employed
Levels of Documentation (cont)

4. Hardcopy Documentation
   4-a. Code Listing
   4-b. Code Manual
   4-c. User’s Manual
   4-d. Method Discussion

5. Hypertext Documentation
   5-a. Code Listing
   5-b. Code Manual
   5-c. User’s Manual
   5-d. Method Discussion
   5-e. External Links

6. Literate Programming:
   Source Code and Documentation are Generated from the Same File
Literate Programming

• Basic Idea: Combine Documentation and Source Code

• Original: WEB (Donald Knuth, of \TeX\ fame)
  
  – Weave: web file $\rightarrow$ documentation (\TeX)
  
  – Tangle: web file $\rightarrow$ source code (Pascal)

• Many WEB-related packages exist — my opinion: most are too complex or don’t support my situation (F90, \LaTeX, Unix)
The Document Package:

A Simplified Approach to Literate Programming

- Eliminate “tangle” step – files are compilable source
- Documentation is included in comments
- Small set of commands to direct output
- Formatting language independent
- Source code language independent (almost — just need to know comment characters)
- Implementation via a short perl script: Document
- Source and documentation for the Document Package are available online at:
  http://www.lanl.gov/Document
A Simple Example

This input file:

```latex
! Begin_Doc
! Some documentation for standard out.
! End_Doc
!
! This line doesn’t get output by Document.
! Begin_Doc file.tex
! This output goes to the file named file.tex.
! Comment characters are stripped by default.
!
! Begin_Verbatim
! Comment characters are included in verbatim
! environments, which are often used for code:
do i = 1, 100
   j = j+1
end do
! End_Verbatim
! End_Doc
```

when processed by Document, outputs this to standard out:
Some documentation for standard out.

and this to file.tex:

This output goes to the file named file.tex.
Comment characters are stripped by default.

```latex
! Comment characters are included in verbatim
! environments, which are often used for code:
do i = 1, 100
   j = j+1
end do
```
Making use of the capabilities of \texttt{Document}, \LaTeX\ and \LaTeX{}2\texttt{HTML}, the \texttt{CÆSAR} Code documentation has these features:

- Hardcopy \textit{and} HTML versions from a single source, which is collocated with the source code
- Graphics, equations, code listings easily included
- Automatic table of contents and semi-automatic indexing (hyperlinked in HTML)
- Automatic navigation tools for HTML (Next, Up, Previous, Contents, and Index links on every page)
- Hyper references and external HTML links

Unit Testing / Levelized Design

**Basic Idea of Unit Testing:**
Each component is tested in isolation – only components that have been previously tested may be included.

**Basic Idea of Levelized Design:**
Each component depends only on components that are at a lower level – no feedback or circular designs.

**Example:**

Bottom Line: Levelized Design is desirable because it makes Unit Testing possible.
Preliminary Levelized Design for CÆSAR
Unit Testing Implementation

- Every component contains its own specific driver routine for unit testing.

- Unit test driver routine is only compiled in when certain \texttt{gm4} macro preprocessor flags are set.

- \textsc{Caesar} uses \texttt{Document} to extract and run a unit test script imbedded in each component.
Design By Contract / Verification

**Basic Idea of Verification:**
Statements that verify that specified conditions are true are conditionally compiled into the code, allowing error checking that can be turned off completely for fast execution.

In CÆSAR, verification is implemented via gm4 macros.

**Basic Idea of Design by Contract:**
Routines satisfy a contract when they are called – input requirements are verified upon entry and output guarantees are verified prior to exit.

Design by Contract does nothing more than specify where and what to verify.
Summary

The CÆSAR 3-T photonics package employs many of the latest ideas in software design:

- **Literate Programming** — source and documentation stored together.

- The **Document** Package is used to extract documentation from code source, which is processed by \LaTeX{} into hardcopy and \LaTeX2HTML into hyperlinked HTML.

- A **Levelized Design** is used to facilitate **Unit Testing**, which is accomplished using the \texttt{gm4} preprocessor and the self-test feature of the **Document** Package.

- **Verification** \texttt{gm4} macros are used to implement **Design By Contract**.