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Programming Practices And Standards

Michael A. Craft

Institute for Simulation and Training

Programming Practices and Standards

Third Edition
First Revision

December 21, 1994

Prepared by

Michael A. Craft

Reviewed by

Scott H. Smith

First Edition July 31, 1991
Second Edition November 11, 1992
Third Edition September 14, 1992

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1. Introduction to the Third Edition

It may not have been made sufficiently plain in prior editions, so let it be said up front: this text outlines the programming standards used by IST personal working on IST's Testbed. The amount of latitude allowed is small. Prior versions of the standard attempted to allow flexibility, but the privilege is too often abused.

In an attempt to make this document more accessible, the emphasis has changed to illustration (examples). As far as possible issues are illustrated without further explanation in the text. It is hoped this will make the standards easier to digest. Pay attention to everything: the use of white space, the use of case in identifiers, the contents of standard comment blocks, etc.

Important points in the text sections are often emphasized with the use of an arrow, especially those points that may be difficult to illustrate, for example:

⇒ Programmers may be asked to correct problems they did not introduce as part of the reviewing process.

It would seem that some elements of the standards (perhaps alignment of comments and the use of case) could be automated. This is indeed true; Ada implementations come with formatters that take care of many mechanical issues. We have solicited formatters and evaluated a few, but none have added enough value to make them worthwhile. It is practical to produce a formatter in house and someday we may do so, but the bulk of issues covered here would be difficult to automate.

1.1 Motivation

A customer has a right to expect quality code in a uniform format. It is not reasonable to expect a client (or a new staff member at IST) to deal with individual programmer's eccentricities, much less poorly laid out or designed code. The size and complexity of the IST Testbed and the number of people working with it make a standardized approach essential. These coding standards address such issues in some detail.

All procedures and standards in this document are subject to change. Such changes will be reflected in the electronic version of this document which is kept with the librarian procedure documentation (refer to section 1.4).

1.2 Terminology

The IST Testbed (usually referred to as "the Testbed") is the body of software consisting of (at least) the Simulator (DIS and SIMNET), the Operator Interface (the OI), the TDB Conversion program, the Logger, the Eagle project, and the Testbed utilities. The various Testbed executables are sometimes referred to as the Testbed "products" or "applications."

The person in charge of the Testbed libraries has the title "Software Librarian," usually referred to as "the Librarian." The Librarian's duties and procedures are not covered here except by reference to the Librarian's documentation.

1.3 Examples Used in this Text

As far as possible examples are from the Testbed. In most cases the code shown is incomplete to conserve space.

In many cases repairs had to be made to extracted code because of coding violations: the Testbed is far from perfect today. For this reason, questions about standards should be answered from this document, not from sample Testbed code.

Not every detail can be pointed out, but use the examples as a guide: pay attention to spacing and style. Some points are difficult to illustrate and are covered beginning in section 6.

1.4 Changes from Prior Editions

Unlike prior editions this paper does not cover software integration. For an up to date description of integration procedures see the system librarian. At the time of this writing the procedures are described in the various documents under delta support (DIS_SERVER\DELTA\TESTBED\SRC\DOCS\PROCEDUR).

File	Contents
Stand3.doc	This document (SW Standards Version 3).
Synch.txt	Explanation and directions for synchronizing a local copy of a project.
Delta.txt	Procedure for using Delta Software Control.
Ckin_out.txt	Procedure for checking files in and out
Bug_rpt.txt	Procedure for reporting bugs

Earlier editions of this document defined a "master to-do list." Individual projects are now too diverse to maintain their goals on a single list, although the need for overall changes to the Testbed still arises. Such global changes, and errors in the Testbed that do not fall in the purview of the project which notes the problems, are handled through the system Librarian. Refer to the Librarian's procedures for more information.

The whole flavor of this document has been turned to brief descriptions and examples. Some valuable code fragments have been, reluctantly, discarded in the process. The discussion of code complexity (and how it is hidden by non-structured constructs) is missing, but is available through the earlier editions.

2. Overall system design

Our goal is to design well-structured code that is easy to understand and modify, and which provides a solid platform on which to base further work. This requires a well thought out and complete design before coding begins.

The system should not be considered a large, monolithic, single entity, but rather should be considered a group of interacting modules (or objects).

Modules (objects) should be self-contained, and should rely as little as possible on other modules. The use of global data is prohibited; the interface to a module is achieved through its functions.

2.1 File types

Files fall into two categories, "headers" and "source." The header files have a ".h" extension whereas source files are compilable files (and so this excludes makefiles) which do not have a ".h" extension; the usual extension for source files is ".cpp" although exceptions exist.

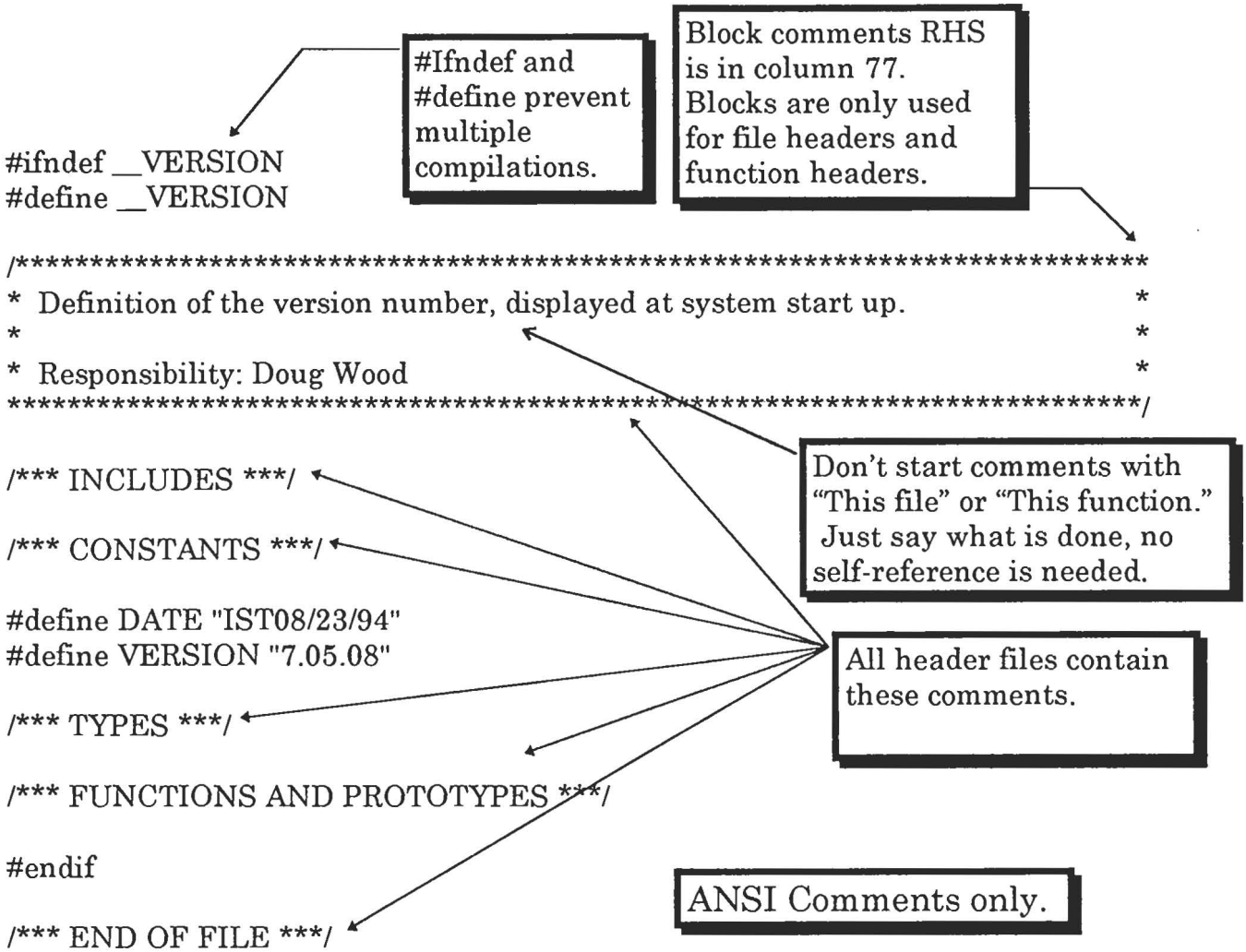
A module consists of an interface header file with a .h extension and one or more source files. If there is more than one source file in a module, a local header file may be required. Such local headers are kept in "include\local" and use names beginning with "loc_" (this may seem redundant, but this identifies the locals when included in source files). Local headers are *only* included in the module for which they are defined: they are for in*tra*-module binding. Non-local headers (inter-module binding) are kept in "include\global."

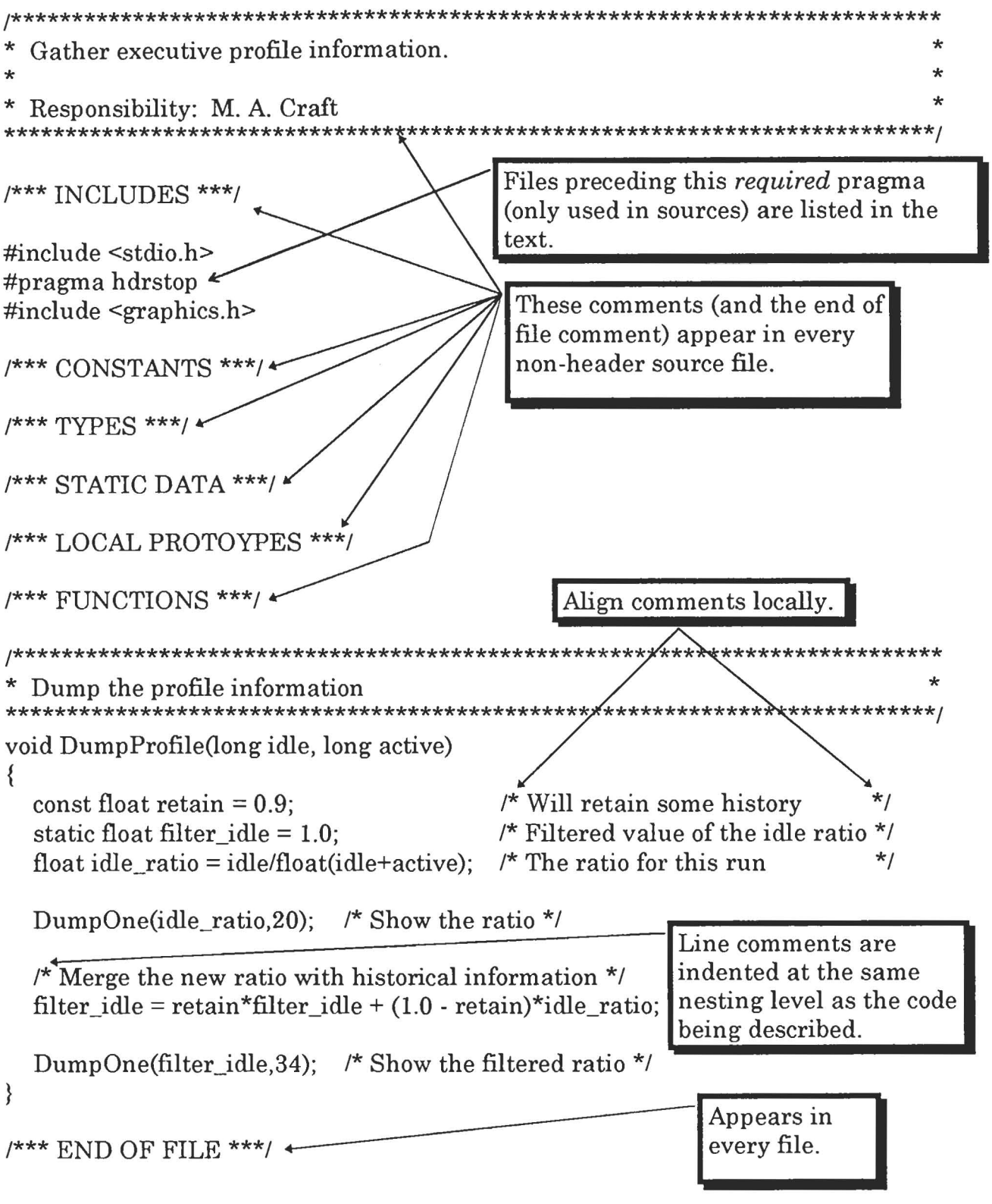
The requirements for the two file types are different and their respective organizations are covered by this document.

2.2 Code Organization by File

The general design rule is to not combine logically independent software in the same file. If a set of routines is completely subservient to another set, by all means keep them together. But, if they are logically independent, separate them.

3. Comment Basics




/**********
* Gather executive profile information. *
* *
* Responsibility: M. A. Craft *
**********/
/*** INCLUDES ***/
#include <stdio.h>
#pragma hdrstop
#include <graphics.h>
/*** CONSTANTS ***/
/*** TYPES ***/
/*** STATIC DATA ***/
/*** LOCAL PROTOYPES ***/
/*** FUNCTIONS ***/
Files preceding this *required* pragma (only used in sources) are listed in the text.
These comments (and the end of file comment) appear in every non-header source file.
Align comments locally.
/**********
* Dump the profile information *
**********/
void DumpProfile(long idle, long active)
{
const float retain = 0.9; /* Will retain some history */
static float filter_idle = 1.0; /* Filtered value of the idle ratio */
float idle_ratio = idle/float(idle+active); /* The ratio for this run */
DumpOne(idle_ratio,20); /* Show the ratio */
/* Merge the new ratio with historical information */
filter_idle = retain*filter_idle + (1.0 - retain)*idle_ratio;
DumpOne(filter_idle,34); /* Show the filtered ratio */
}
/*** END OF FILE ***/
Line comments are indented at the same nesting level as the code being described.
Appears in every file.

4. File Layout

```
#ifndef __LOC_TERR
#define __LOC_TERR

/*****************************************************************************
* These definitions are used within the terrain module to perform:           *
*     - (FileIO) reading database file and closing file                      *
*     - Current database specific operations                                 *
*                                                                            *
* Responsibility: Doug Wood                                                  *
*****************************************************************************/

/*** INCLUDES ***/

#include "hx.h"
#include "tdb_type.h"
#include "terrain.h

/*** CONSTANTS ***/

/*** TYPES ***/

/* The DB map is followed by the patch indices and the patch elevation       */
/* minima/maxima. The patch minima/maxima are organized as patch guards.     */
/* These guards allow intervisibility to avoid some processing. This data is read */
/* into memory if intervisibility is in use. The hope is that we will avoid reading */
/* the patch altogether, saving an expensive disk access.
```

The name (LOC) indicates this is a local header file.

Local headers always include their global equivalent (so prototypes can be checked by the compiler). No pragma for hdrstop is used in header files. Includes do not incorporate path information. Whether source or header, only include what is needed.

A block comment would be inappropriate here as this is not a file or function header comment. Nonetheless, the comment edges are aligned. A single space separates the lead asterisk and the first character of the verbiage.

```
typedef struct
{
   float min_z_left_edge;      /* Min z along left edge      */
   float min_z_bottom_edge;    /* Min z along bottom edge */
   float max_z_polygon;        /* Max polygonal elevation */
   float max_z_object;         /* Tallest object             */
   float max_z_trees;          /* Tallest tree on the patch */
   float max_z_treelines;      /* Tallest treeline on patch */
   float max_z_canopies;       /* Max z in a tree canopy     */
} PATCH_GUARD;

/*** FUNCTIONS AND PROTOTYPES ***/

/*****************************************************************************
* Using the values in the DB_HEADER, calculate the indices of the 8 patches  *
* bordering the patch indicated by "center_index".                            *
*****************************************************************************/
void GetBorderIndices
(
   long center_index, /* Index for the center patch of the new region.      */
   long *this_index   /* Array to store the calculated patch index values. */
);

/*****************************************************************************
* Dereference a patch handle. Bail out of the system if anything goes wrong.  *
* This routine should only be called via the macro getPatchHeader             *
*                                                                             *
* Returns: the patch header pointer corressponding to the patch handle.       *
*****************************************************************************/
PATCH_HEADER *GetPatchHeaderDebug
(
   HX_HND handle,      /* The patch handle to be dereferenced*/
   char *file,         /* File from which the call was made   */
   int line            /* Line on which the call was made     */
);

#endif

/*** END OF FILE ***/
```

Indentation is on 4 space boundaries and increases 4 spaces at a time.

Prototypes get a block header. In header files, discuss use, not implementation.

Describe every parameter

5. File Layout (Section Contents)

```
/*****************************************************************************
* Memory Debugging Support
*
* Responsibility: M.A.Craft
*****************************************************************************/

/*** INCLUDES ***/

#include <stdio.h>
#include <stdlib.h>
#pragma hdrstop
#include <alloc.h>
#include <assert.h>

/*** CONSTANTS ***/

#define LIST_SIZE 2048
#define CHECK_SIZE      sizeof(char)

/* Returned pointers must be aligned on valid boundaries.                  */
#define ALIGNMENT_SIZE      4     /* Valid byte boundary size.             */
#define CHECK_BIT_OFFSET    24    /* Bit shift to add first check byte.    */

#define BEGINNING_CHECK     '@'   /* Set values to be used for boundary */
#define ENDING_CHECK        '!'   /* checks.                               */

/*** TYPES ***/

/* Values to determine if memory allocation should exit on failure. */
enum FAIL_ENUM
{
   CONTINUE,
   QUIT
};
```

Any general information about the file contents not specific to any function is included here.

Contains #define'd constants and anonymous enum's (not macros). Named constants are used in place of raw numbers unless meaning is obvious (e.g., 0). The Testbed does not use "const" globals.

Contains struct defs, ***named*** enumerations, and typedef's (**anonymous** are listed with **constants).**

Use enumerations whenever appropriate: typically classification values, especially when the values are unimportant or when the values are consecutive.

```
typedef struct
{
   void   *address; /* Address of memory allocated.          */
   char   *file;    /* File name where allocation occured.   */
   int     line;    /* Line number where allocation occured. */
   UINT amt;        /* Amount of memory allocated.           */
} MALLOC_LIST_ENTRY;


/*** STATIC DATA ***/

static int
   debugging  = TRUE,  /* Is debugging on?              */
   first_free    = 0;  /* First free malloc list index. */

static MALLOC_LIST_ENTRY *malloc_list = NULL;

/*** LOCAL PROTOTYPES ***/

void DumpMalloc (void);

/*** FUNCTIONS ***/

/*****************************************************************************
* Set up space for memory debugging.                                         *
*****************************************************************************/
static void InitializeDebugMemory(void)
{
   ...
}

/*****************************************************************************
* Begin tracking pointers to malloc'd memory                                 *
*****************************************************************************/
void EnableDebugMemory(void)
{
   InitializeDebugMemory();
   use_debug_mem = TRUE;
}

/*** END OF FILE ***/
```

Independent fields are on separate lines. Logically related variables may be declared and described together (x,y; /* Location */).

Only found in source files. In most cases this section is empty, but occasionally functions share data which is declared, as static, here.

In headers, prototypes are module interface definitions and have *usage* documentation. In sources this section contains forward references.

For header files, the function and prototype sections are combined. Functions in a header are only in the form of macros.

Macros, inline functions (only allowed by special permission), and, for source files, function bodies appear here. Macros and inline functions may use a block or non-block comment depending on their complexity.

5.1 Header files

#Ifndef and #define prevent multiple compilations.

Header's block comments state the purpose of the ***module*** and who is the main source for information about the module. Information pertinent to the use of the module but not specific to any function is also here.

```
#ifndef __LOC_DYNA
#define __LOC_DYNA

/*****************************************************************************
* Module supports:                                                           *
*   1. Checking for object collisions                                        *
*   2. ...                                                                   *
*                                                                            *
* Responsibility:  Sumeet Rajput                                             *
*****************************************************************************/

/*** INCLUDES ***/

#include "dynamics.h"

/*** CONSTANTS ***/

/* We handle speed calculations for three types of entities.    */
/* These values are used to index into the speed table.         */
enum
{
   SPEED_TABLE_DI = 0,
   SPEED_TABLE_VEHICLE,
   SPEED_TABLE_LANDED_FIXEDWING
};
```

Header files never contain code or variable declarations.

Headers are the interface spec's for modules. They contain all info needed for programmers to use the module resources.

Anonymous enums appear in the CONSTANTS section.

```
#if 0
/* For demonstration only. */
enum
{
   ACC_TABLE_DL = 0,
   ACC_TABLE_VEHICLE,
   ACC_TABLE_LANDED_FIXEDWING
};
#endif


/*** TYPES ***/

/*** FUNCTIONS AND PROTOTYPES ***/

/*****************************************************************************
* Determines if the vehicle identified by e_cb has collided with an object or *
* another vehicle. Return indicates whether collision occurred or not. If the *
* return indicates a collision with a vehicle, the ID of that vehicle is supplied in *
* thing_hit. If a collision with a terrain object INVALID_ID is returned in *
* thing_hit.                                                                  *
*                                                                             *
* Return: did a collision occur?                                              *
*****************************************************************************/
BOOL CheckCollision
(
   ENTITY_CB *e_cb,          /* pointer to Entity Control Block      */
   VEHICLE_ID *thing_hit     /* address of a VehicleID structure     */
);

/*** END OF FILE ***/

#endif
```

Out of date code should be removed, but if code is to be compiled out pending a removal decision, use conditional compilation directives, NEVER comment out code.

A function prototype is preceded by a block comment. This does ***not*** include the function name. In headers, contains information pertinent to the *use* (not implementation) of the function. If the function returns void, there is no need state this.

All functions within a module <u>used</u> in other modules MUST be prototyped in a header file. The prototype includes the return type (possibly void), the function name, and the parameter list including parameter names

Comments do not contain redundant information (such as the function name). State the use or implementation directly without self references (avoid saying "this function").

Functions are preceded by a block comment. For source files, discuss implementation, particularly if it is unusual or complicated; information in header files is not duplicated here. For static functions (no prototype) both use and implementation may be discussed.

```
/*****************************************************************************
* Process a list of information to be stored. The list contains sub-lists of numeric *
* data consisting of a range and the damage probabilities for that range. The      *
* number of sub-lists is counted and stored, ...                                   *
*****************************************************************************/
static int StoreIFInfo
(
  CHAIN_HEAD *head,
  int *veh_list,
  int vehicle_number,
  int *mun_list,
  int munition_number,
  char **error_string        /* pass error message */
)
{
  LIST_NODE *old_node;   /* save old current node          */
  int readin_ok = TRUE;  /* assume all will go well.       */

  ...

  /* Count the number of elements in the list */
  while (current_node = (LIST_NODE *)GetNextNode(current_node))
    num_elements++;

  /* Malloc IF damage info space for these vehicle and munition types */
  for (vtmp=0; vtmp<vehicle_number; vtmp++)
  for (mtmp=0; mtmp<munition_number; mtmp++)
  {
    if_table[veh_list[vtmp]].detonator[mun_list[mtmp]].damage_list =
      (IF_DAMAGE_DISTANCE *)
        calloc(num_elements, sizeof(IF_DAMAGE_DISTANCE));
  }

  return readin_ok;
}
```

Unless used outside of a module, functions should be static..

Declarations of important variables appear on their own lines, normally with a descriptive comment.

A reasonable notion of what is going on should be available through comments alone. They do not echo the code, they explain it.

Lines are limited to 8(characters. When necessary, split statements over multiple lines.

Only 1 return per function; none for void functions. No parenthesis for return value

```
switch (add_data->entity_type)
{
   case EGL_MGR_TYPE:
   {
      if (!(created = CreateDynamicCB(&new_entity,...))
         TraceOutput(ERROR,"Unable to create CGF Eagle Manager.\a\n");

      break;
   }

   default:
   {
      created = FALSE;
      TraceOutput(ERROR,"Can't create unknown Eagle entity type\n\a");

      break;
   }
}


if (created)
{
    /* The entity was successfully created, send an initialize   */
    /* message to the new entity.                                */

    MsgBuildAndSend(&new_entity,
            INITIALIZE,
            sizeof(VEHICLE_ID),
            &add_data->immediate_sup,
            NO_DELAY,
            RESPONSE_NOT_NEEDED,
            IncGcbSeq());
}
```

The bodies of cases include braces. { and } line up with their associated control construct (if, for, switch, etc.).

If a single statement is controlled then braces are not required, though the indentation must still illustrate the control (exception: consecutive for's may be at the same level, viewed as an extended loop construct).

Rather than precede the test with a rewording of what is to be tested ("if the vehicle was created"), state positively what has happened to arrive in the block. Braces are required here as the if "controls" both the comment and another statement.

Given room, make the comments complete sentences: start with a capital and end with a period.

```
/*****************************************************************************
* The Aggregation FSM of the Eagle Manager.                                  *
*                                                                            *
* Responsibility: David Stober                                               *
*****************************************************************************/

/*** INCLUDES ***/

#include "core.h"
#pragma hdrstop
#include <assert.h>
#include "init_mgr.h"

/*** CONSTANTS ***/

/* The status of an aggregation request in the aggregation list. */
enum
{
   AGG_WAITING,    /* Aggregation waiting for the unit's disagg to complete  */
   AGG_READY,      /* Ready for aggregation                                  */
   AGG_ACTIVE,     /* Aggregation currently running for this unit.           */
};

#define MAX_ EM_AGG_LIST 20      /* Phoney define for demo only */

/*** TYPES ***/

/* Aggregation list element */
typedef struct
{
   CHAIN_LINK link;    /* The links to the nodes in the list.     */
   MESSAGE *msg;       /* The aggregate request.                  */
   int status;         /* Status of the element in the            */
                       /* aggregation list.                       */
} AGG_LIST_ELEMENT;

/*** STATIC DATA ***/

static CHAIN_HEAD em_agg_list; /* The Eagle Manager's aggregation list. */

/*** LOCAL PROTOTYPES ***/
```

Identifiers (types, structures, constants) of only local interest should only appear in the file that uses them. If identifiers are module bound, put them in the module's local header.

enumerated values: ALL_CAPS_AND_UNDERSCORES
#defines: ALL_CAPS_AND_UNDERSCORES

defined types: ALL_CAPS_AND_UNDERSCORES

variable names: all_lower_case_and_underscore

```
static void RemoveC2Node(FSM_RECORD *fsm);

/*** FUNCTIONS ***/

/*****************************************************************************
* Retreive the Eagle Manager's AGG FSM data from an FSM record.              *
* fsm should be the FSM record of the Eagle Manager's Aggregation FSM.       *
*****************************************************************************/
#define EMAggFSMData(fsm)((EM_AGG_FSM_DATA *)(EglFSMData(fsm)->data))

/*****************************************************************************
* The start state of the Eagle Manager Aggregation FSM.                      *
*                                                                            *
* Determines the root C2 Node of the disaggregated unit and sends it an      *
* aggregation message.                                                       *
*****************************************************************************/
void EglMgrAgg(FSM_RECORD *fsm)
{
   CHAIN_LINK *c2_list = CLink(&EglMgr(fsm->cb)->c2_node_list);

   TraceOutput(DEMO,"Eagle Manager Aggregation Beginning\n");

   /* Search the list of C2 nodes for this unit. */
   while (!found && (c2_list = GetNextNode(c2_list)))
   {
      found = ((C2_NODE_ENTRY *)c2_list)->unit_id == unit_id;
   }
```

macros: EachWordIsCapitalized

function names: EachWordIsCapitalized

Variable names are to be meaningful.

A blank line precedes and follows control constructs (if, switch, while, etc.) so the construct stands out from surrounding code.

Control statements are not functions: leave a space between the control word (if, while, switch, etc.) and the parenthesis. No space is required after the opening parenthesis or before the closing parenthesis.

```
    if (!found)
    {
        TraceOutput(ERROR,
            "Unit %lu not in list "
            "of units that it is maintaining.", unit_id);

        NewState(fsm,DoneAgg, STD_DELAY);
    }
    else
    {
        /* Found the C2 node for this unit, so remember its ID  */
        /* and send it a message to aggregate.                  */
        EglFSMData(fsm)->data = malloc(sizeof(EM_AGG_FSM_DATA));

        /* Release all the manned simulators associted with this unit. */
        MsgBuildAndSend (&(EglMgr(fsm->cb)->man_mgr_id),
                    RELEASE_SIMULATORS,
                    sizeof(UNIT_ID),
                    &unit_id,
                    NO_DELAY,
                    RESPONSE_NOT_NEEDED,
                    0);

            fsm->current_state = RemoveC2Node;
    }
}

/*** END OF FILE ***/
```

Shorter block of if/else comes first, even if a boolean must be negated to do so.

Do NOT separate an else from its if by white space or comments.

6. Other Points

The examples cannot capture everything. Here are other important items.

⇒ Use standard functions, don't write your own equivalents.

⇒ (char *) is not used as a generic pointer type, use (void *).

⇒ Inline assembly code is not permitted.

⇒ The comma operator is disallowed

⇒ Floating point comparisons for equality are suspect: use Zero, Tiny, Small or Close.

⇒ Remove tabs before integration (a utility is available from the Librarian).

⇒ Non-structured constructs are disallowed. These include goto's, continue's, break's (with the exception of breaks in cases), and returns (except at the end of a function).

⇒ As functions are developed, they are given a scope as local as makes sense. Adding function prototypes to a global module header is a serious step.

6.1 Include Order

The #include order before the pragma hdrstart is:

CORE	SIM	OI	EAGLE
<stdlib.h>	<stdlib.h>	<graphics.h>	"core.h"
<string.h>	<sting.h>	<stdlib.h>	
"core.h"	"core.h"	<string.h>	
"coreutil.h"	"coreutil.h"	"core.h"	
"exec.h"	"ent_mgr.h"	"operator.h"	
"simaddr.h"	"fsm.h"	"map.h"	

The files above the "#pragma hdrstop" must appear as indicated; any of these files not required can be omitted, but other header files should not be added above the #pragma.

If none are required, the #pragma must appear anyway (with nothing above it). After the #pragma, the ordering (if possible) is system header files in alphabetical order followed by our header files in alphabetical order.

6.2 File Length

Source files may not exceed 1200 lines. Any file longer than 1000 lines is considered too long, and steps should be taken to break it into smaller files. Removing white space and documentation are not legitimate methods of reducing file size. At the other extreme unnecessary file splits are discouraged and very small files should be combined with logically related files whenever appropriate.

6.3 Arithmetic comparisons and DeMorgan's Laws

When checking that a value is in, or out, of a range, a number line ordering is recommended:

```
if (A <= x && x <= B)
```

not, for example,

```
if (x >= B && x <= A).
```

If x is to be out of the span, write it as "if (x < A || B < x)."

Many very complex tests can be simplified with the application of DeMorgan's Laws:

(Not (A and B)) ⇔ ((Not A) or (Not B))
(Not (A or B) ⇔ ((Not A) and (Not B))

6.4 Assertions

Occasionally a programmer will recognize a condition would cause a problem, but the condition should not occur.

If in doubt, include an assertion. For example, if dt should never be zero, but its computation is complex (or depends on parameters), the developer should consider including "assert(!zero(dt));" before dividing by dt.

6.5 Code factoring

Using an editor to copy code is seductive, but usually inappropriate. Rather than copy code, create a function.

6.6 Boolean expressions

Booleans are not tested simply to set booleans. For example,

```
boo = TRUE;

if (a < b)
    boo = FALSE;
```

is written boo = b <= a.

6.7 Type casting

Type casting is done only when necessary. Casting an identifier to its own type is not done. Casting is not used when a formal parameter is (void *) and the actual parameter is a pointer.

6.8 Compilation Errors and Warnings

The Librarian will refuse integration of any file which fails to compile and may refuse any file which generates a warning. Pragmas to disable warnings of unused parameters may be allowed on a case by case basis.