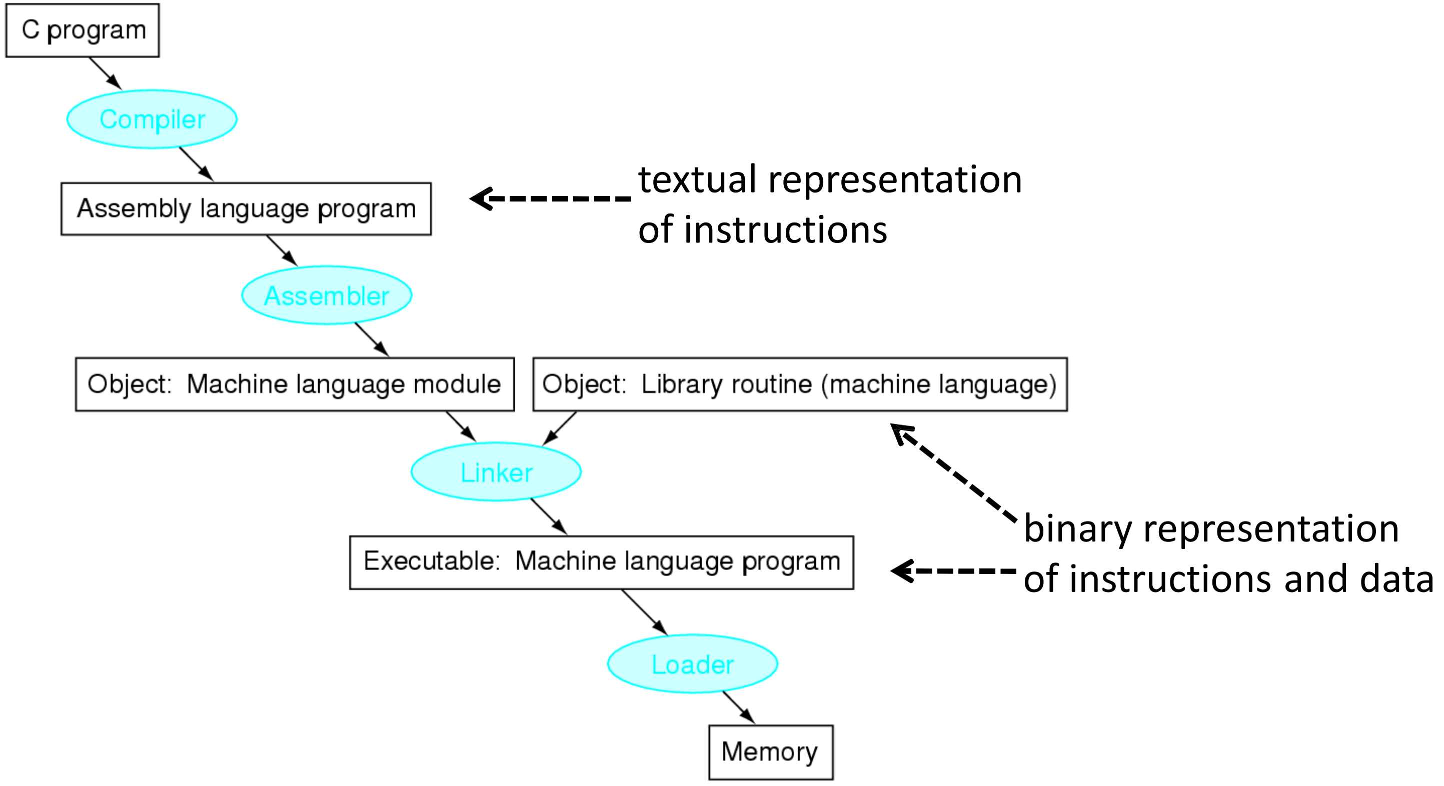
Lecture 2 – Software Development

CSE 456: Embedded Systems

Remember: Computer Engineering

Compilation of a C program to machine language program:

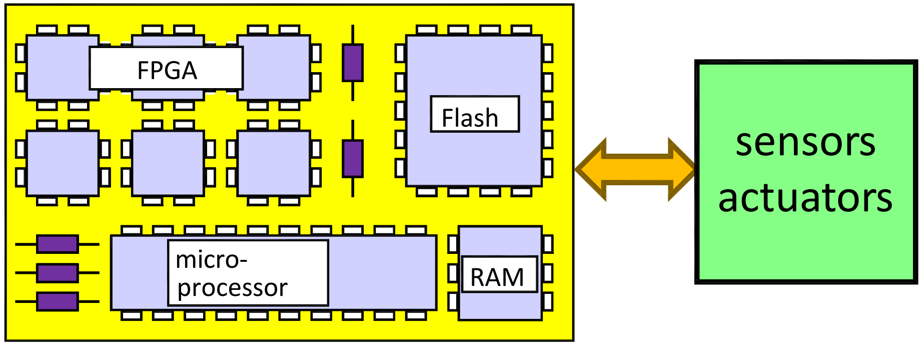


C program
Compiler
Assembly language program
Assembler
Object: Machine language module
Object: Library routine (machine language)
Linker
Executable: Machine language program
Loader
Memory

textual representation of instructions

binary representation of instructions and data

Embedded Software Development

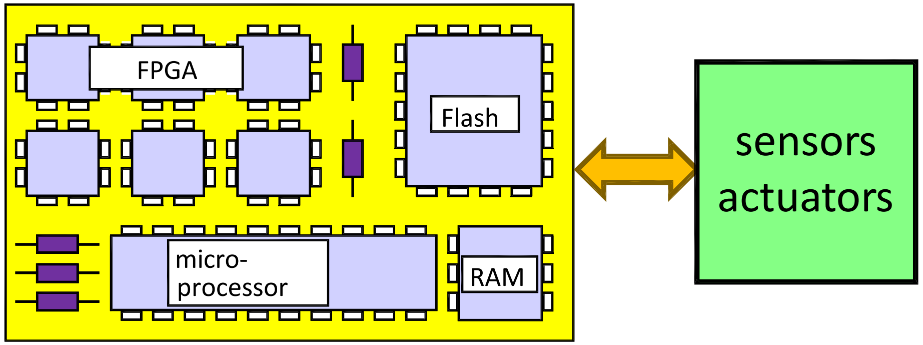


HOST

EMBEDDED SYSTEM

Embedded Software Development

Software Developer



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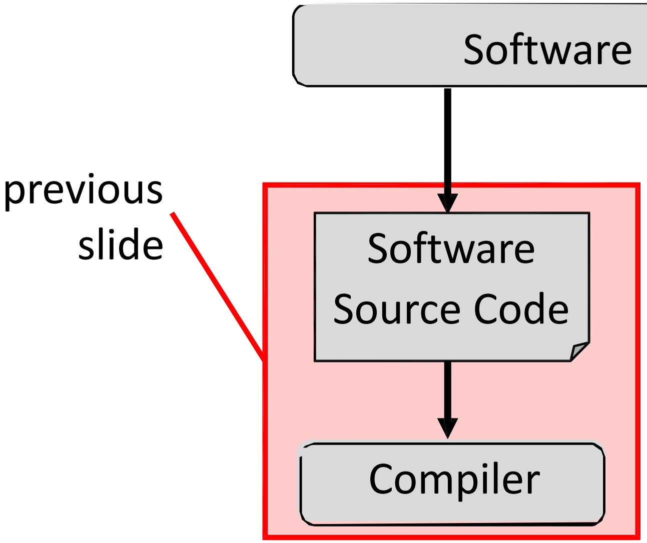


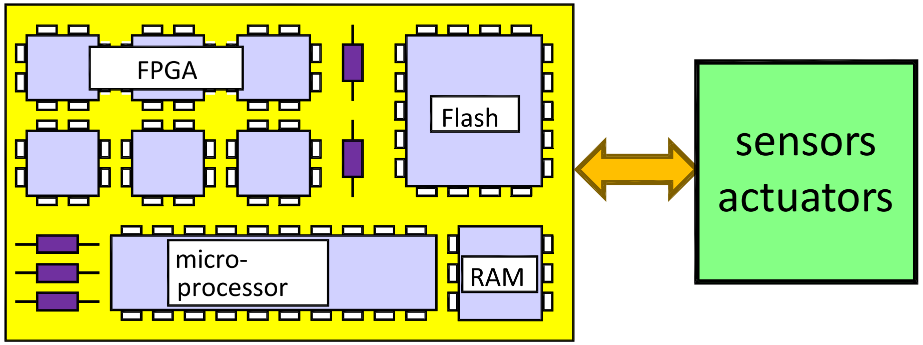
Software Developer

previous slide

Software Source Code

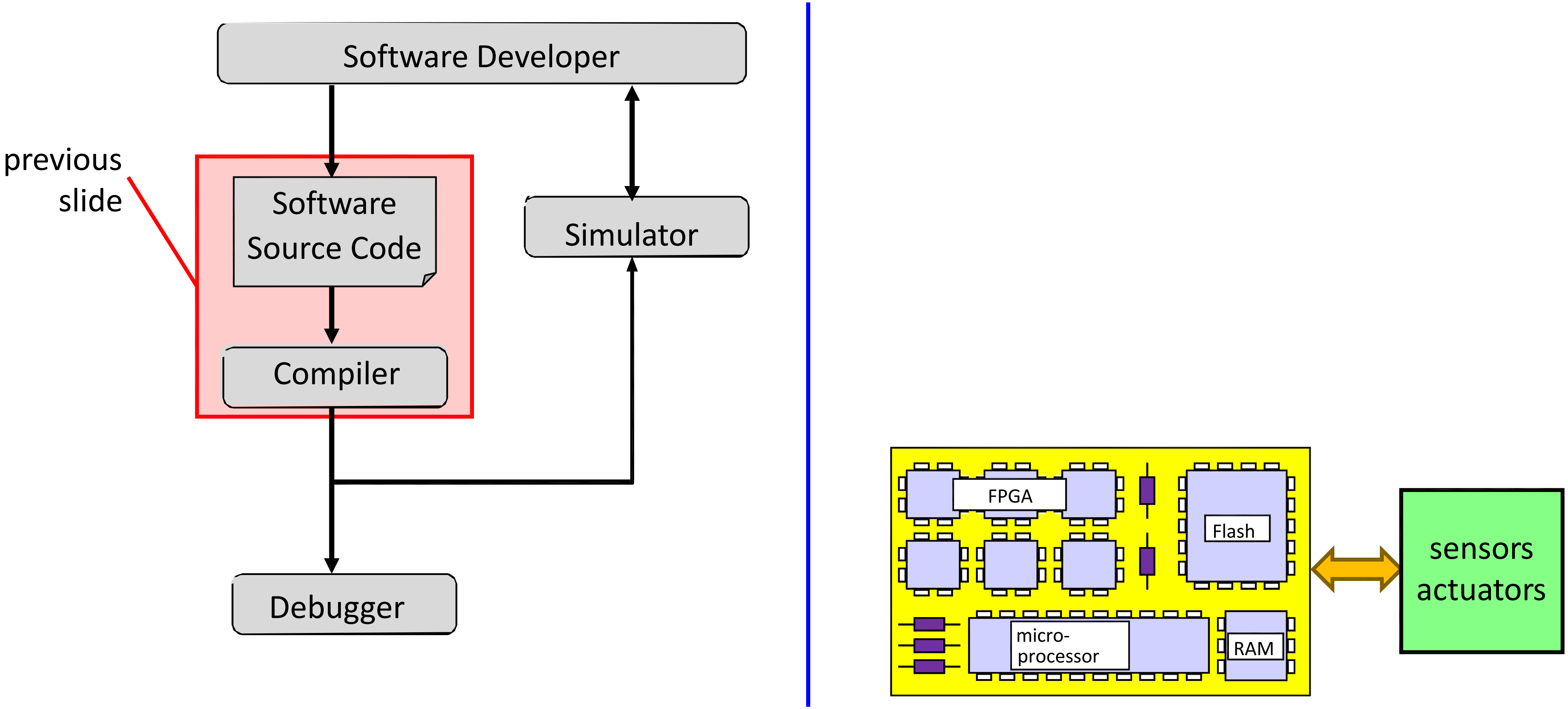
Compiler

HOST



EMBEDDED SYSTEM

Embedded Software Development



previous slide

Software Developer

Software Source Code

Compiler

Simulator

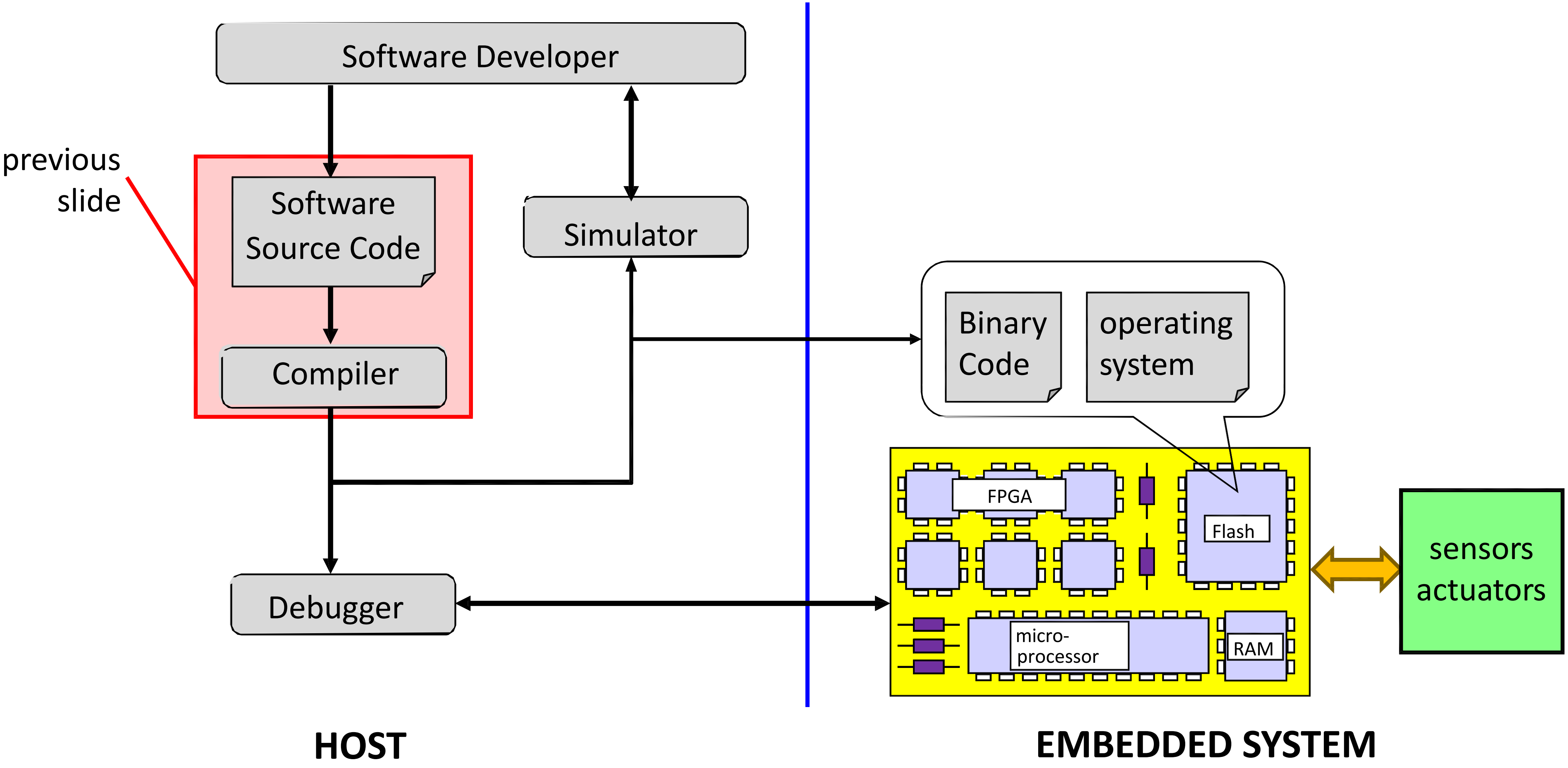
Debugger

sensors actuators

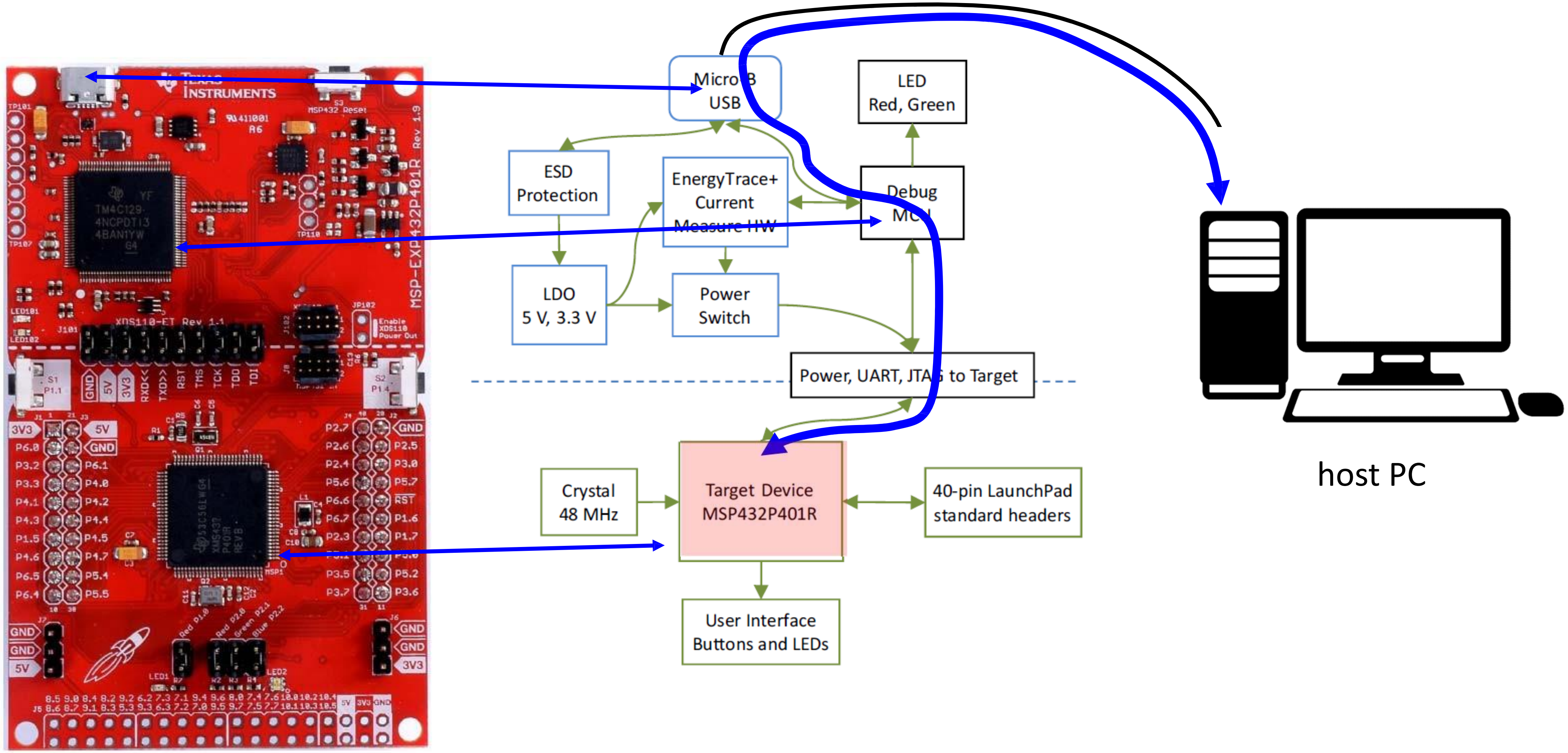
HOST

EMBEDDED SYSTEM

Embedded Software Development



Software Development with MSP432



Micro B USB

LED Red, Green

ESD Protection

EnergyTrace+ Current Measure HW

Debug MCU

LDO 5 V, 3.3 V

Power Switch

Power, UART, JTAG to Target

Crystal 48 MHz

Target Device MSP432P401R

40-pin LaunchPad standard headers

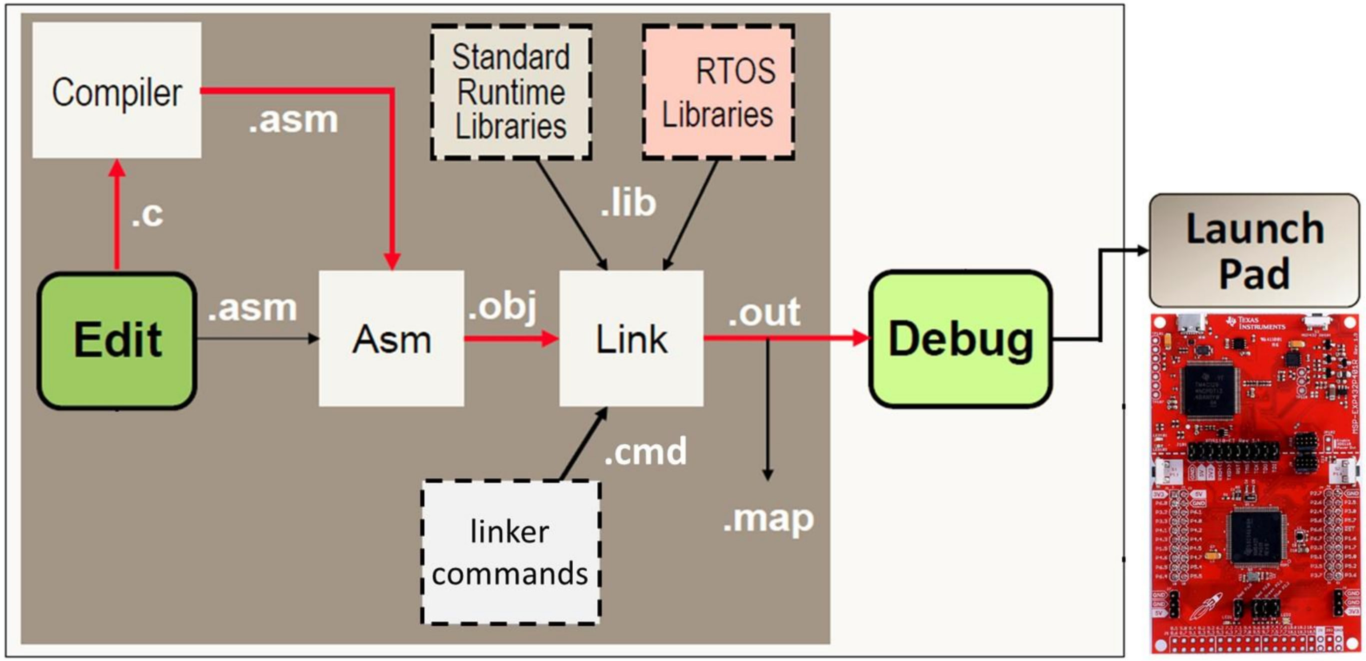
User Interface Buttons and LEDs

host PC

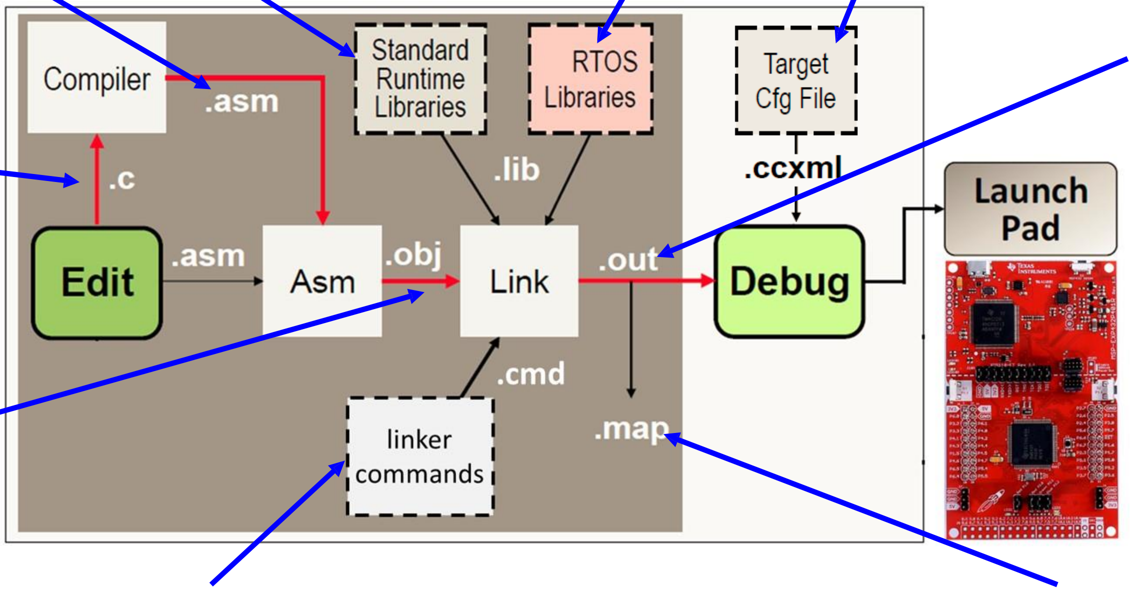
Software Development

Software development is nowadays usually done with the support of an IDE (Integrated Debugger and Editor / Integrated Development Environment)

- edit and build the code
- debug and validate



Software Development



assembly code

object libraries that are referenced in the code

object libraries that contain the operating system (if any)

target configuration file specifies the connection to the target (e.g. USB) and the target device

source code file in C

the executable output file that is loaded into flash memory on the processor

relocatable object file

Linker command file that tells the linker how to allocate memory and to stitch the object files and libraries together.

report created by the linker describing where the program and data sections are located in memory.

Software Development

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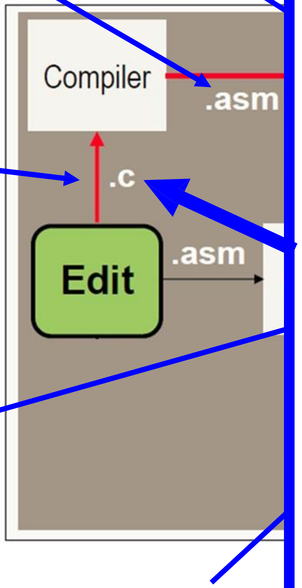

Linker command file that
how to allocate memory
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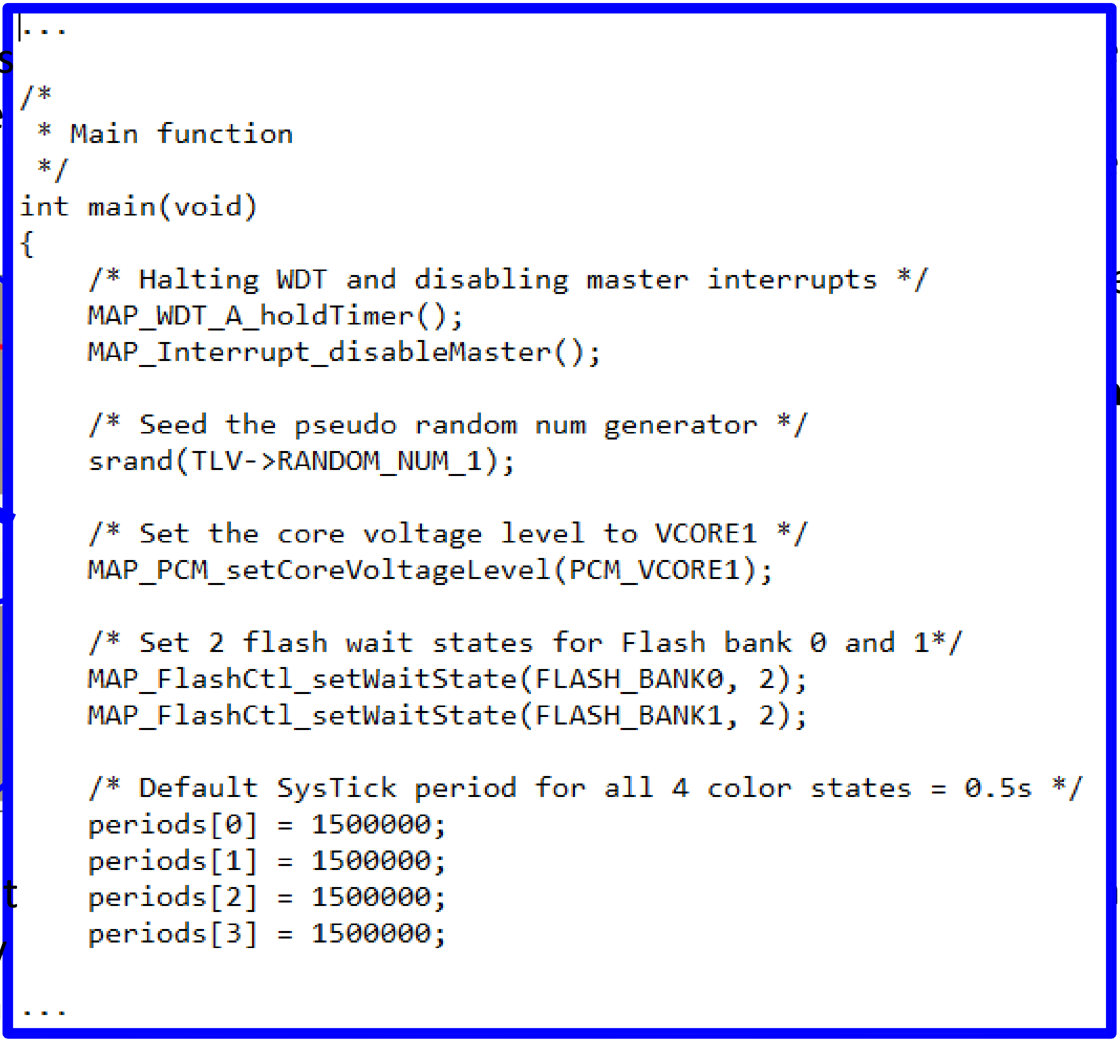

```
...

/*
 * Main function
 */
int main(void)
{
    /* Halting WDT and disabling master interrupts */
    MAP_WDT_A_holdTimer();
    MAP_Interrupt_disableMaster();

    /* Seed the pseudo random num generator */
    srand(TLV->RANDOM_NUM_1);

    /* Set the core voltage level to VCORE1 */
    MAP_PCM_setCoreVoltageLevel(PCM_VCORE1);

    /* Set 2 flash wait states for Flash bank 0 and 1*/
    MAP_FlashCtl_setWaitState(FLASH_BANK0, 2);
    MAP_FlashCtl_setWaitState(FLASH_BANK1, 2);

    /* Default SysTick period for all 4 color states = 0.5s */
    periods[0] = 1500000;
    periods[1] = 1500000;
    periods[2] = 1500000;
    periods[3] = 1500000;

...
```

to the
target device

e output file
into flash
ne processor

g

Software Development

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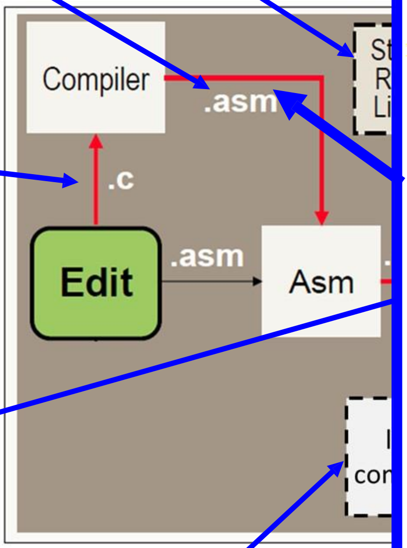

Linker command file that tells how to allocate memory and t

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are located in memory.

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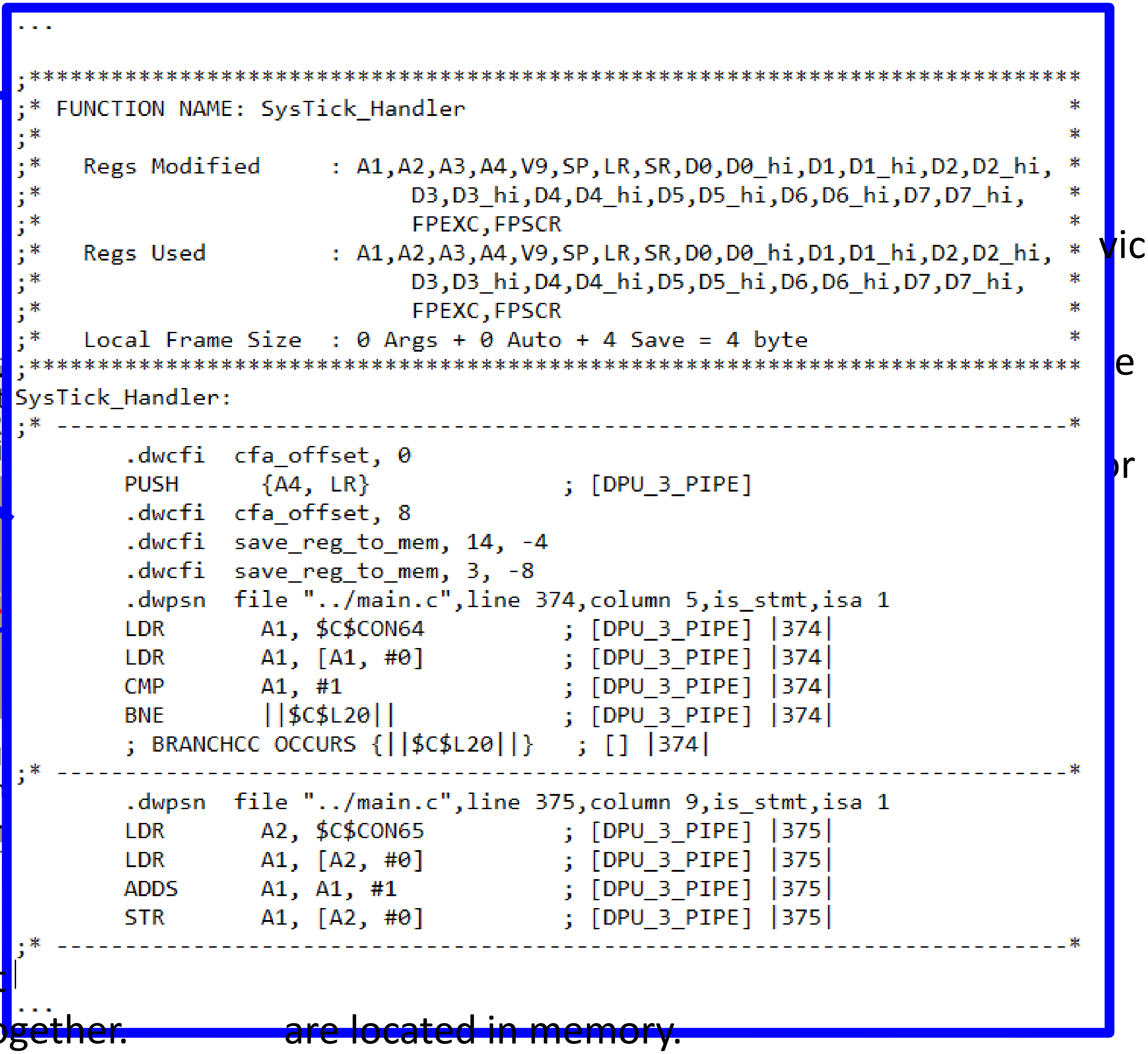
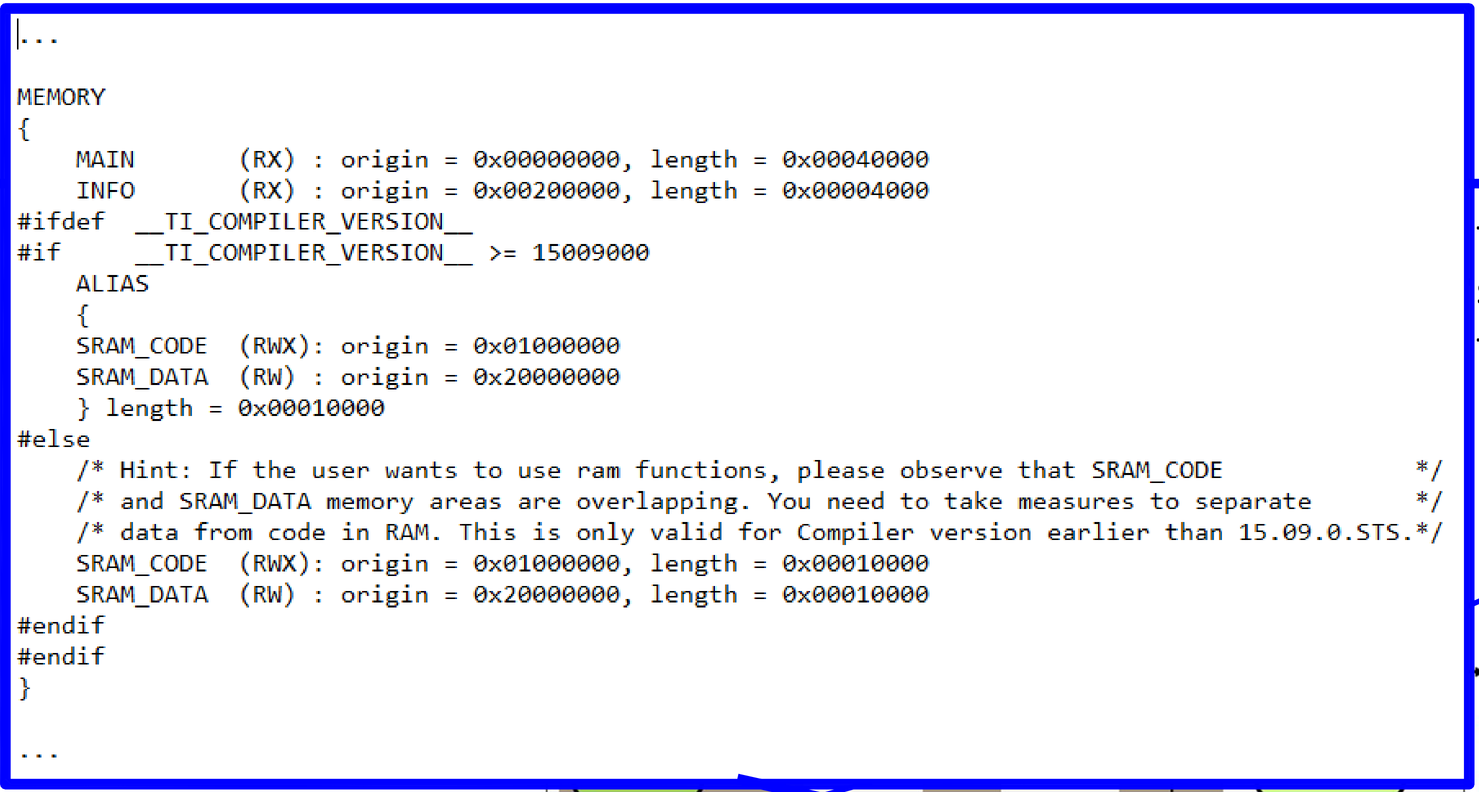


```
...

;**************************************************************************
;* FUNCTION NAME: SysTick_Handler                                         *
;*                                                                        *
;*   Regs Modified     : A1,A2,A3,A4,V9,SP,LR,SR,D0,D0_hi,D1,D1_hi,D2,D2_hi, *
;*                          D3,D3_hi,D4,D4_hi,D5,D5_hi,D6,D6_hi,D7,D7_hi,   *
;*                          FPEXC,FPSCR                                    *
;*   Regs Used         : A1,A2,A3,A4,V9,SP,LR,SR,D0,D0_hi,D1,D1_hi,D2,D2_hi, *
;*                          D3,D3_hi,D4,D4_hi,D5,D5_hi,D6,D6_hi,D7,D7_hi,   *
;*                          FPEXC,FPSCR                                    *
;*   Local Frame Size  : 0 Args + 0 Auto + 4 Save = 4 byte                *
;**************************************************************************
SysTick_Handler:
;* ----------------------------------------------------------------------*
        .dwcfi  cfa_offset, 0
        PUSH      {A4, LR}               ; [DPU_3_PIPE]
        .dwcfi  cfa_offset, 8
        .dwcfi  save_reg_to_mem, 14, -4
        .dwcfi  save_reg_to_mem, 3, -8
        .dwpsn  file "../main.c",line 374,column 5,is_stmt,isa 1
        LDR       A1, $C$CON64           ; [DPU_3_PIPE] |374|
        LDR       A1, [A1, #0]           ; [DPU_3_PIPE] |374|
        CMP       A1, #1                 ; [DPU_3_PIPE] |374|
        BNE       ||$C$L20||             ; [DPU_3_PIPE] |374|
        ; BRANCHCC OCCURS {||$C$L20||}    ; [] |374|
;* ----------------------------------------------------------------------*
        .dwpsn  file "../main.c",line 375,column 9,is_stmt,isa 1
        LDR       A2, $C$CON65           ; [DPU_3_PIPE] |375|
        LDR       A1, [A2, #0]           ; [DPU_3_PIPE] |375|
        ADDS      A1, A1, #1             ; [DPU_3_PIPE] |375|
        STR       A1, [A2, #0]           ; [DPU_3_PIPE] |375|
;* ----------------------------------------------------------------------*

...
```



```
...

MEMORY
{
    MAIN       (RX) : origin = 0x00000000, length = 0x00040000
    INFO       (RX) : origin = 0x00200000, length = 0x00004000
#ifdef  __TI_COMPILER_VERSION__
#if     __TI_COMPILER_VERSION__ >= 15009000
    ALIAS
    {
    SRAM_CODE  (RWX): origin = 0x01000000
    SRAM_DATA  (RW) : origin = 0x20000000
    } length = 0x00010000
#else
    /* Hint: If the user wants to use ram functions, please observe that SRAM_CODE         */
    /* and SRAM_DATA memory areas are overlapping. You need to take measures to separate   */
    /* data from code in RAM. This is only valid for Compiler version earlier than 15.09.0.STS.*/
    SRAM_CODE  (RWX): origin = 0x01000000, length = 0x00010000
    SRAM_DATA  (RW) : origin = 0x20000000, length = 0x00010000
#endif
#endif
}

...
```

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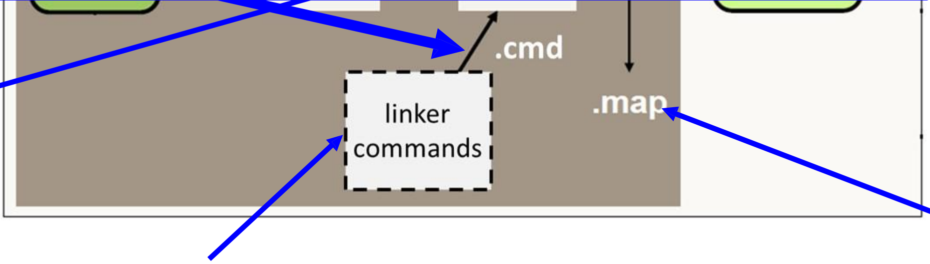

relocatable object file

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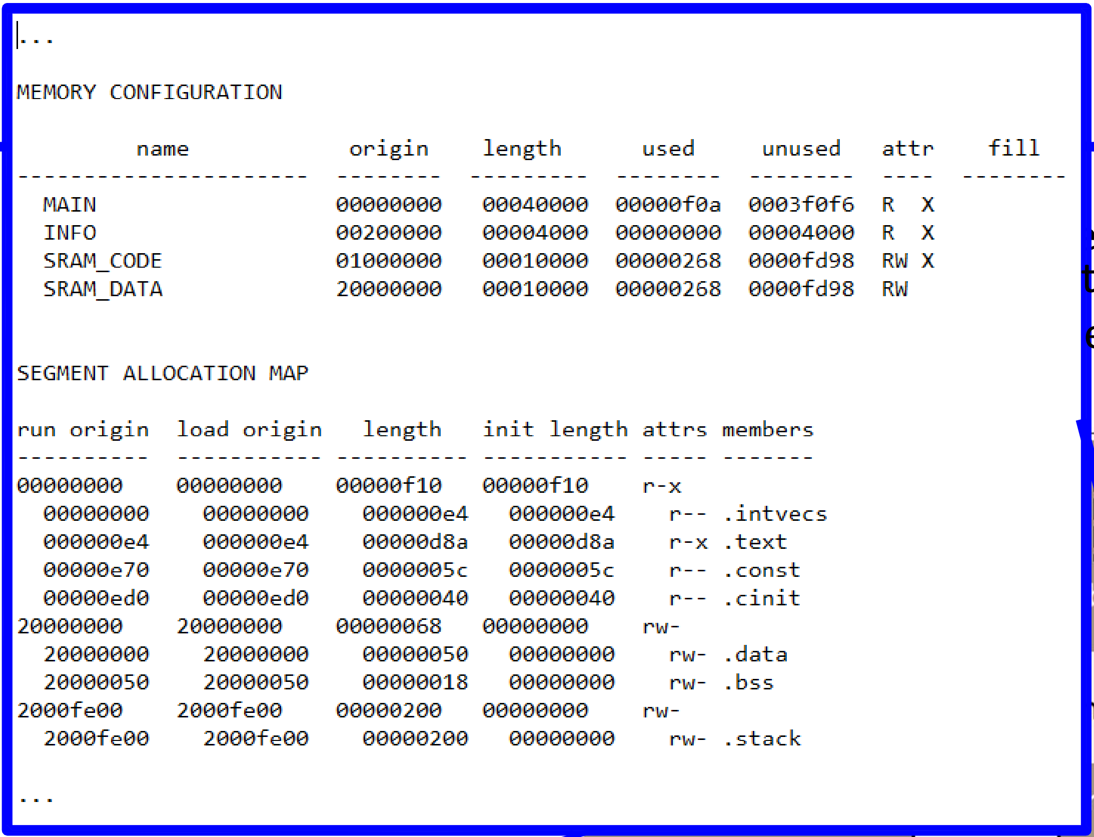

```
...

MEMORY CONFIGURATION

         name            origin    length      used     unused   attr    fill
----------------------  --------  ---------  --------  --------  ----  --------
  MAIN                  00000000   00040000  00000f0a  0003f0f6  R  X
  INFO                  00200000   00004000  00000000  00004000  R  X
  SRAM_CODE             01000000   00010000  00000268  0000fd98  RW X
  SRAM_DATA             20000000   00010000  00000268  0000fd98  RW


SEGMENT ALLOCATION MAP

run origin  load origin   length   init length attrs members
----------  ----------- ---------- ----------- ----- -------
00000000    00000000    00000f10   00000f10    r-x
  00000000    00000000    000000e4   000000e4    r-- .intvecs
  000000e4    000000e4    00000d8a   00000d8a    r-x .text
  00000e70    00000e70    0000005c   0000005c    r-- .const
  00000ed0    00000ed0    00000040   00000040    r-- .cinit
20000000    20000000    00000068   00000000    rw-
  20000000    20000000    00000050   00000000    rw- .data
  20000050    20000050    00000018   00000000    rw- .bss
2000fe00    2000fe00    00000200   00000000    rw-
  2000fe00    2000fe00    00000200   00000000    rw- .stack

...
```

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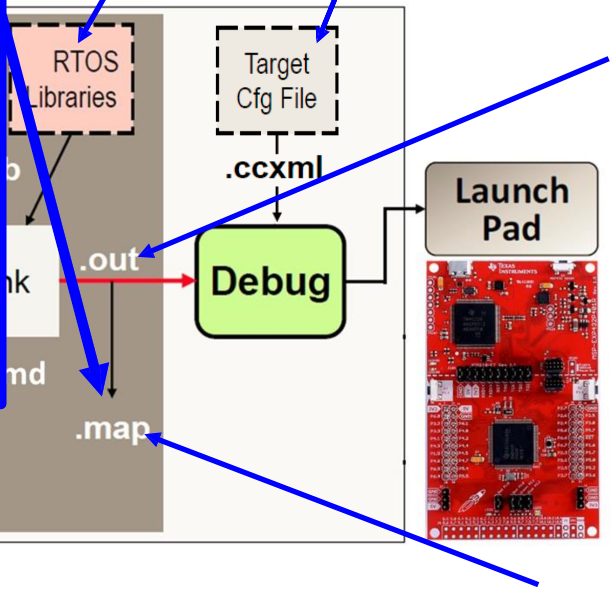

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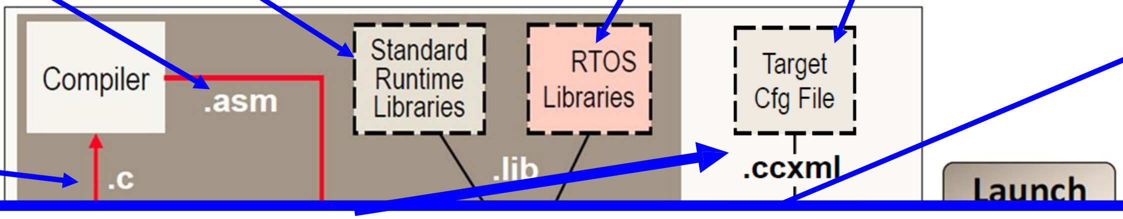

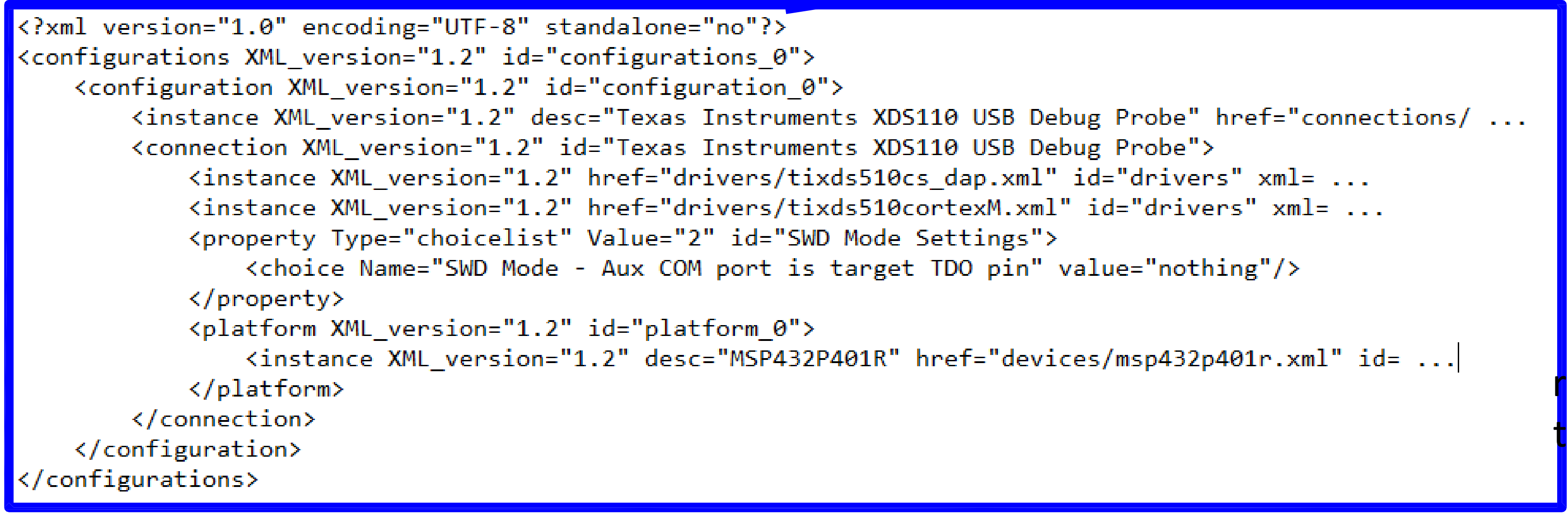

```
<?xml version="1.0" encoding="UTF-8" standalone="no"?>
<configurations XML_version="1.2" id="configurations_0">
    <configuration XML_version="1.2" id="configuration_0">
        <instance XML_version="1.2" desc="Texas Instruments XDS110 USB Debug Probe" href="connections/ ...
        <connection XML_version="1.2" id="Texas Instruments XDS110 USB Debug Probe">
            <instance XML_version="1.2" href="drivers/tixds510cs_dap.xml" id="drivers" xml= ...
            <instance XML_version="1.2" href="drivers/tixds510cortexM.xml" id="drivers" xml= ...
            <property Type="choicelist" Value="2" id="SWD Mode Settings">
                <choice Name="SWD Mode - Aux COM port is target TDO pin" value="nothing"/>
            </property>
            <platform XML_version="1.2" id="platform_0">
                <instance XML_version="1.2" desc="MSP432P401R" href="devices/msp432p401r.xml" id= ...
            </platform>
        </connection>
    </configuration>
</configurations>
```

r describing
ta sections