

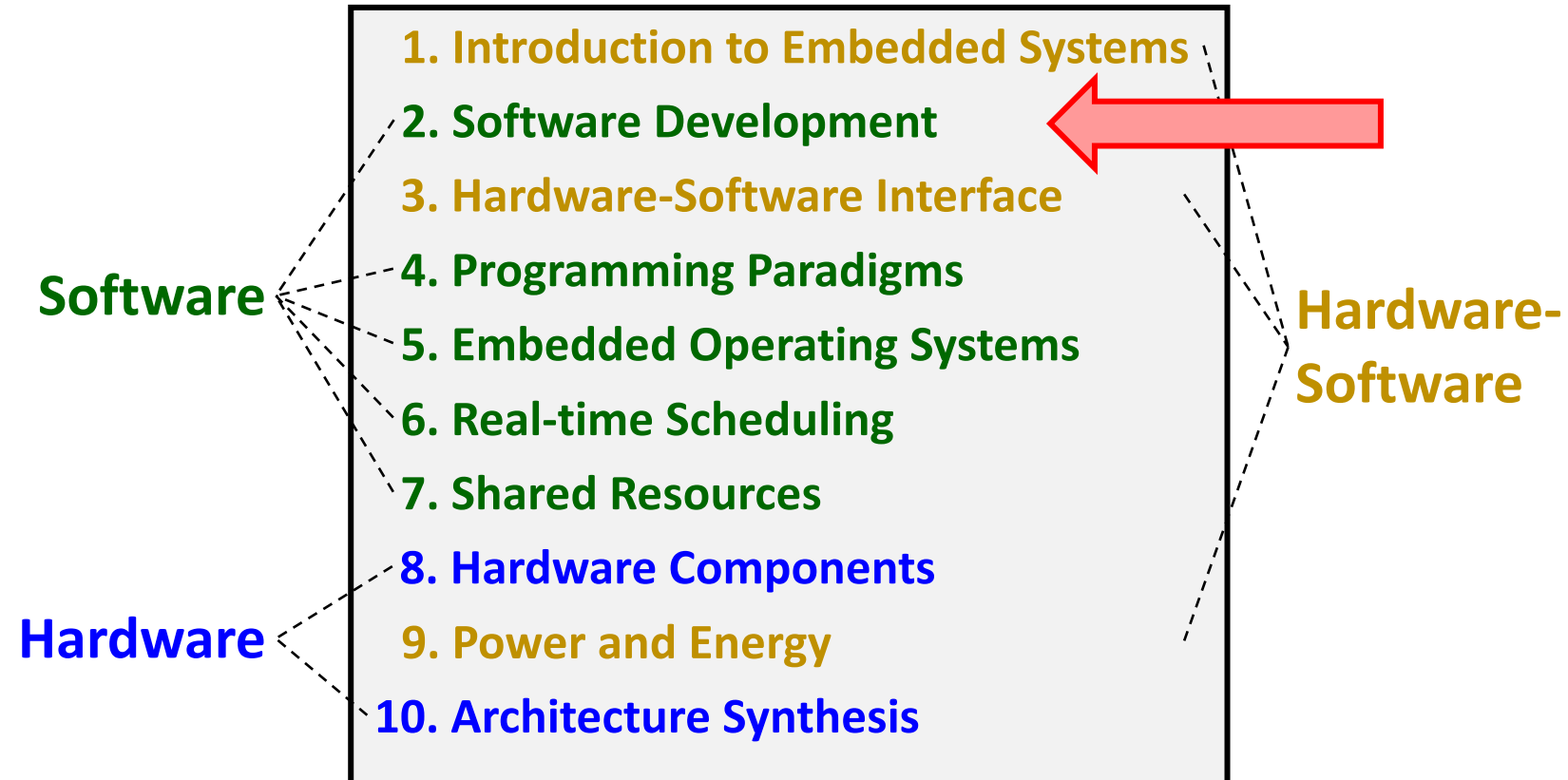
Introduction to Embedded Systems

2. Software Development

Prof. Dr. Marco Zimmerling

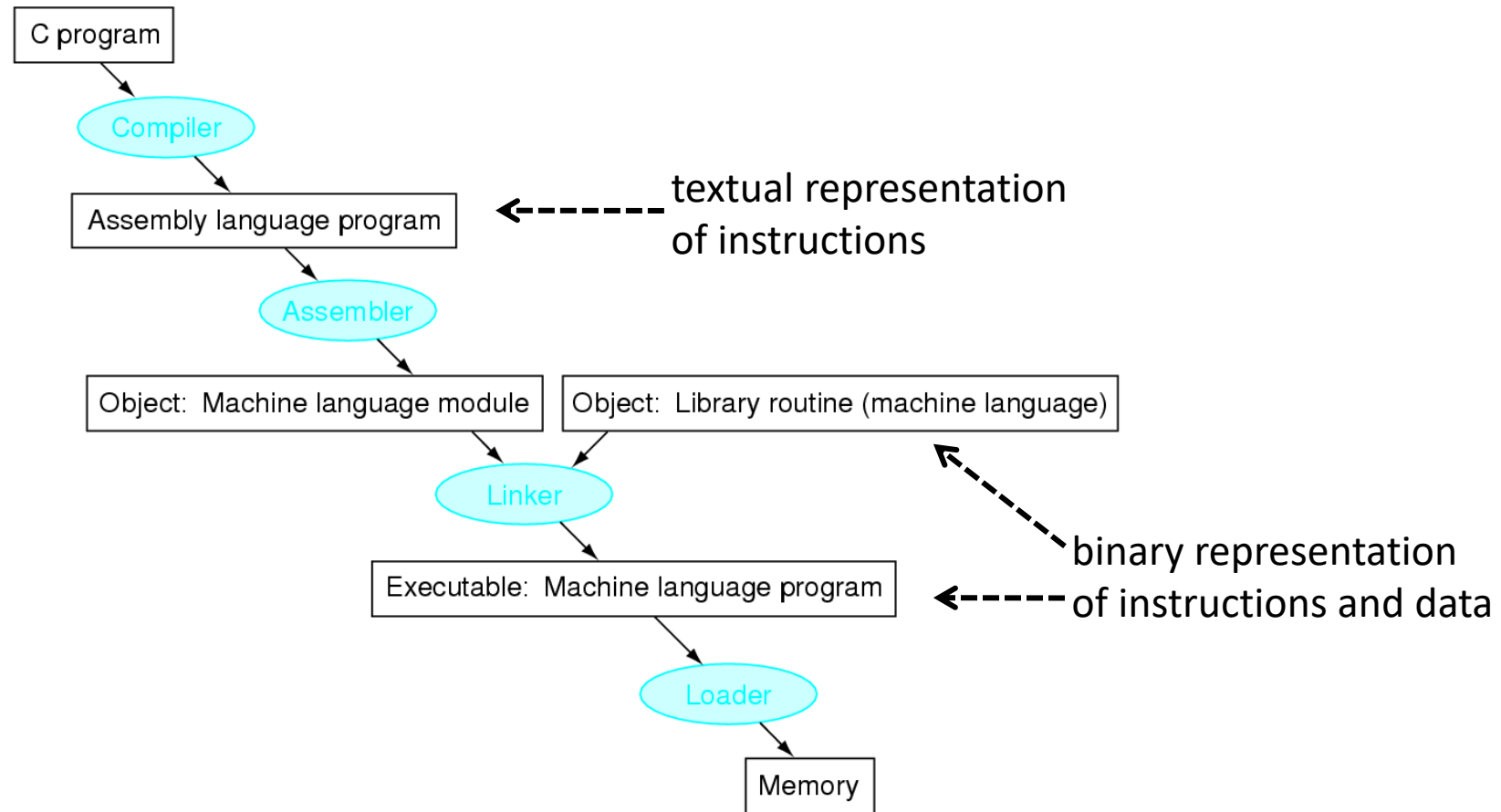


Where we are ...

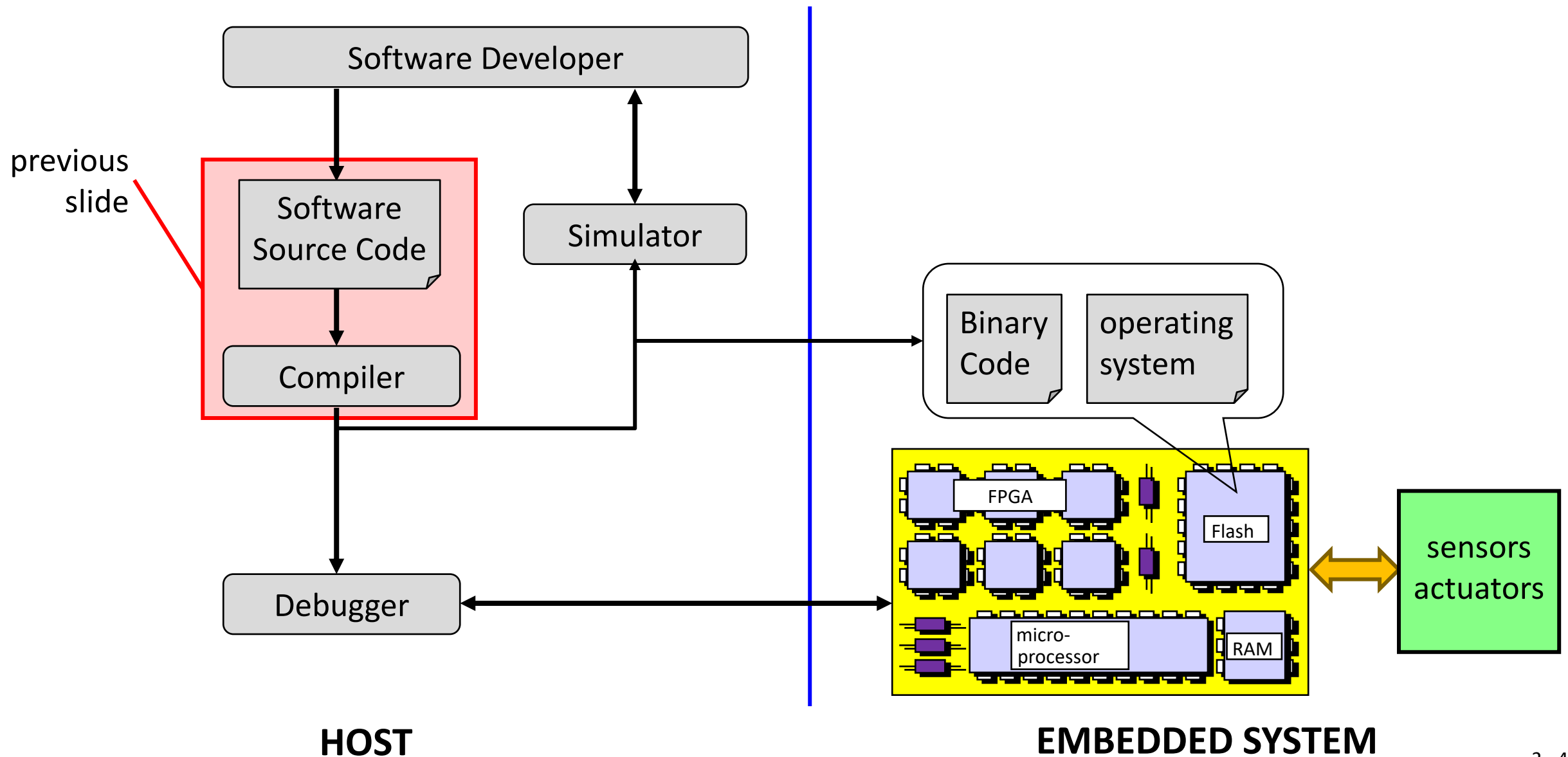


Compilation Process

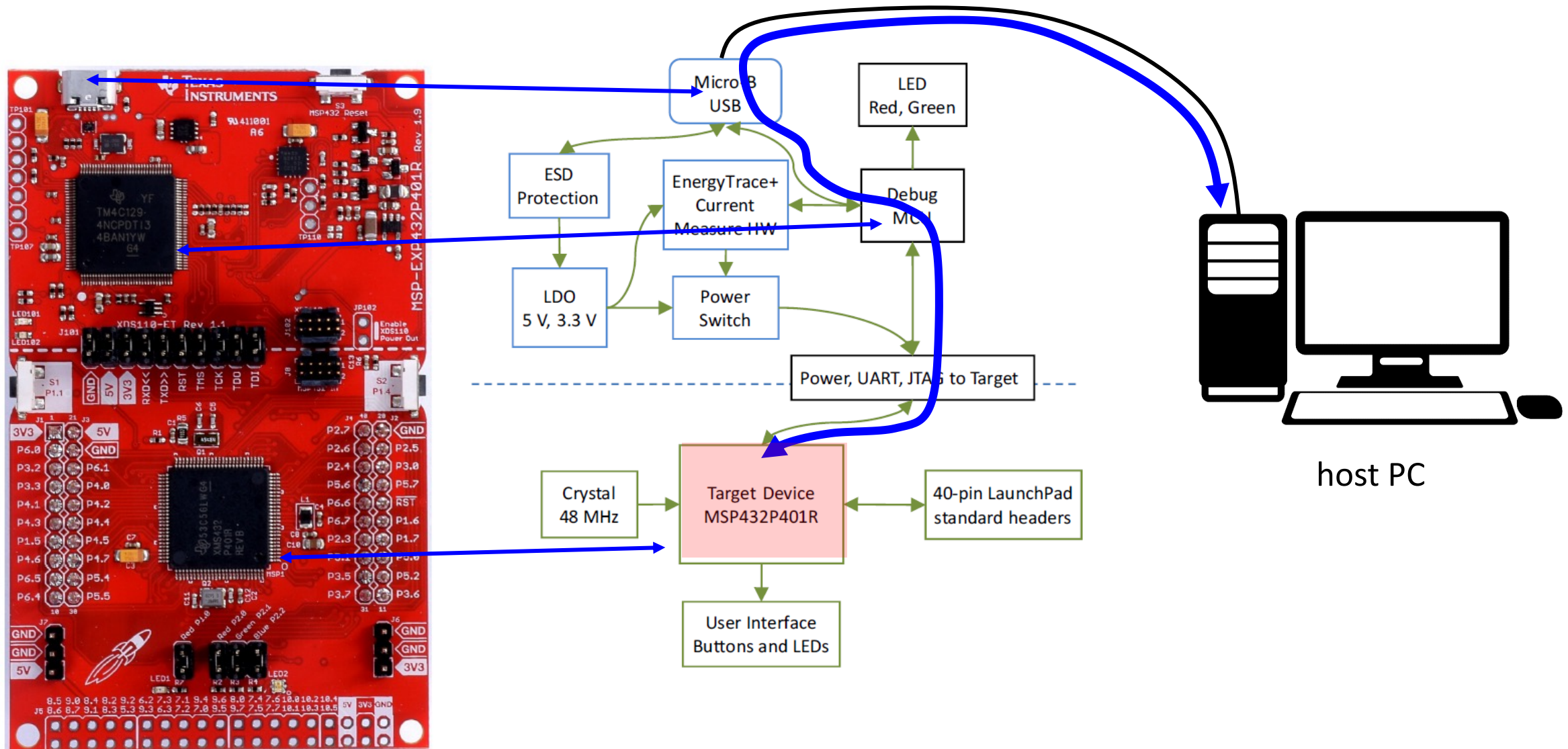
Compilation of a C program to a machine language program:



Embedded Software Development



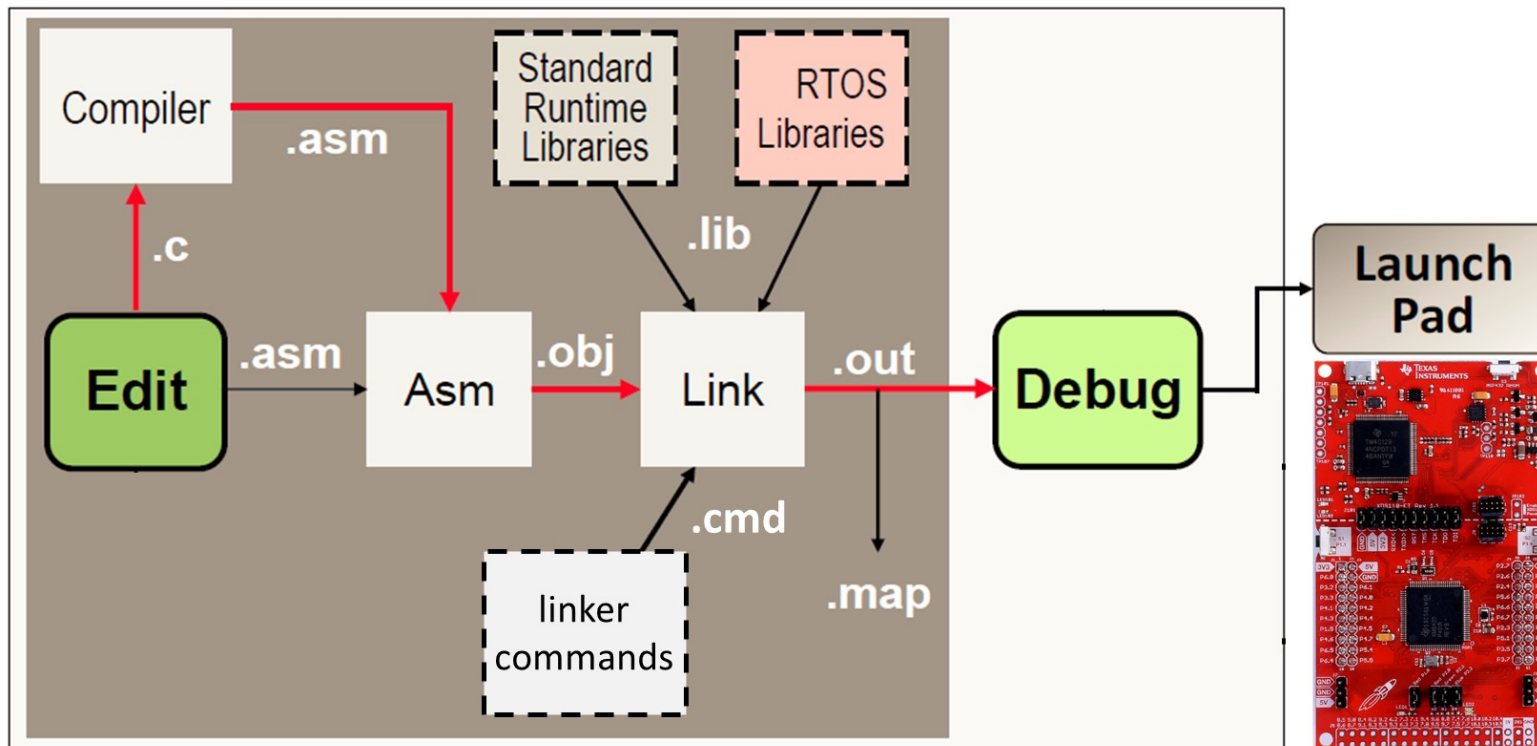
Software Development with the TI LaunchPad



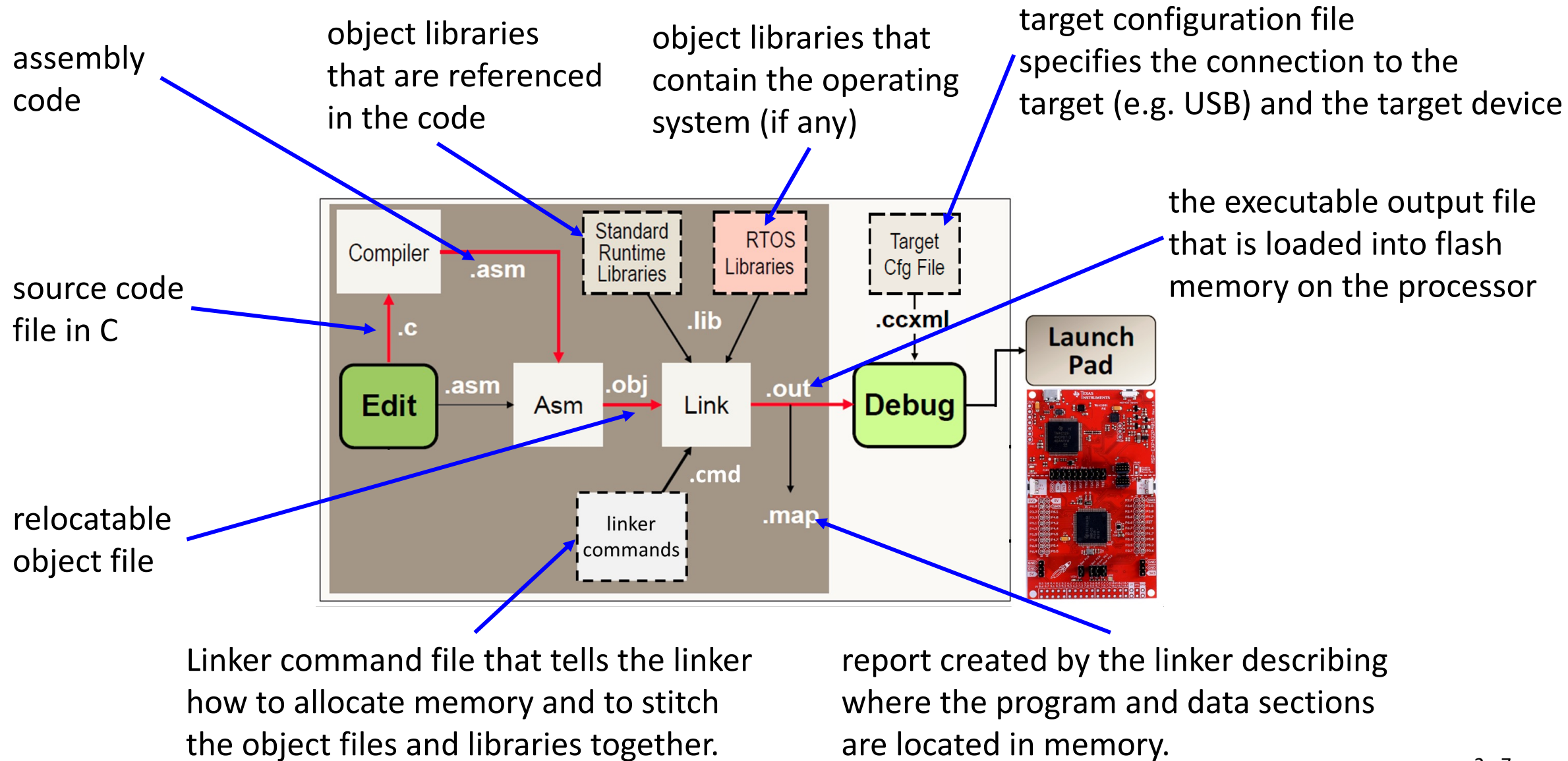
Software Development

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



Software Development

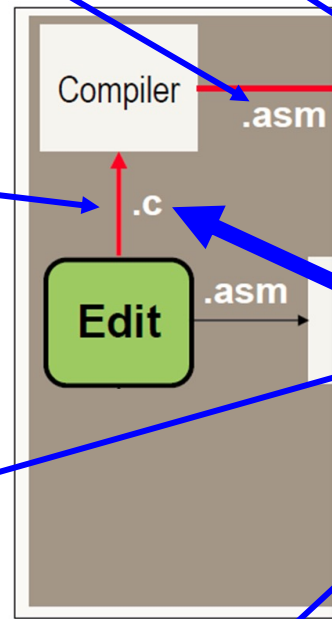
assembly
code

object libraries
that are referred
in the code

source code
file in C

relocatable
object file

Linker command file that
how to allocate memory
the object files and libra...



```
...  
/*  
 * 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

the output file
into flash
the processor

Software Development

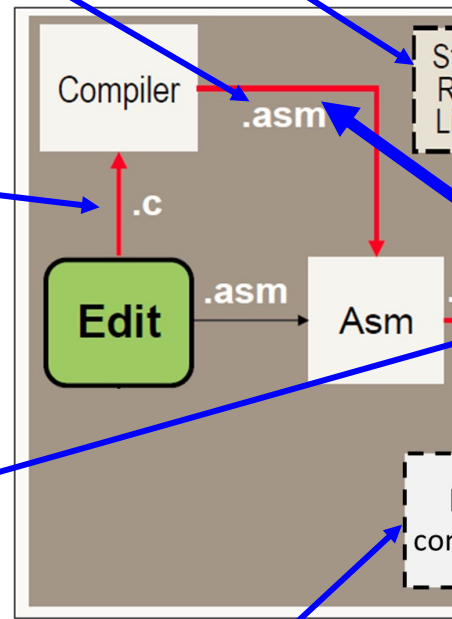
assembly code

object libraries that are referenced in the code

source code file in C

relocatable object file

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



```
...
;*****
; * 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, $$CON64              ; [DPU_3_PIPE] |374|
; *   LDR     A1, [A1, #0]             ; [DPU_3_PIPE] |374|
; *   CMP     A1, #1                   ; [DPU_3_PIPE] |374|
; *   BNE     ||$C$L20||               ; [DPU_3_PIPE] |374|
; *   ; BRANCHCC OCCURS {||$C$L20||}   ; [] |374|
; * -----
; *   .dwpsn file "../main.c",line 375,column 9,is_stmt,isa 1
; *   LDR     A2, $$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__ >= 15090000
    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
}
...

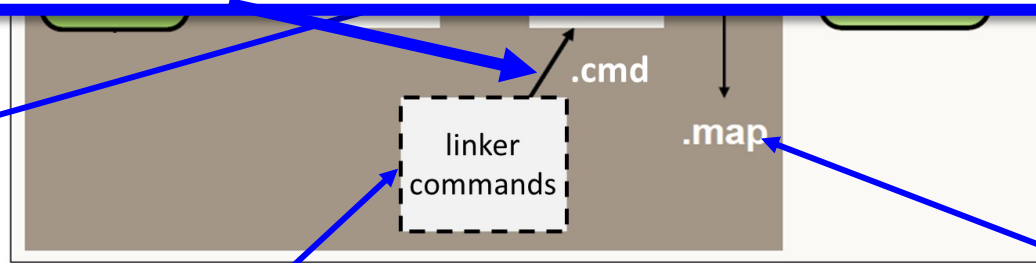
```

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

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.

...

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

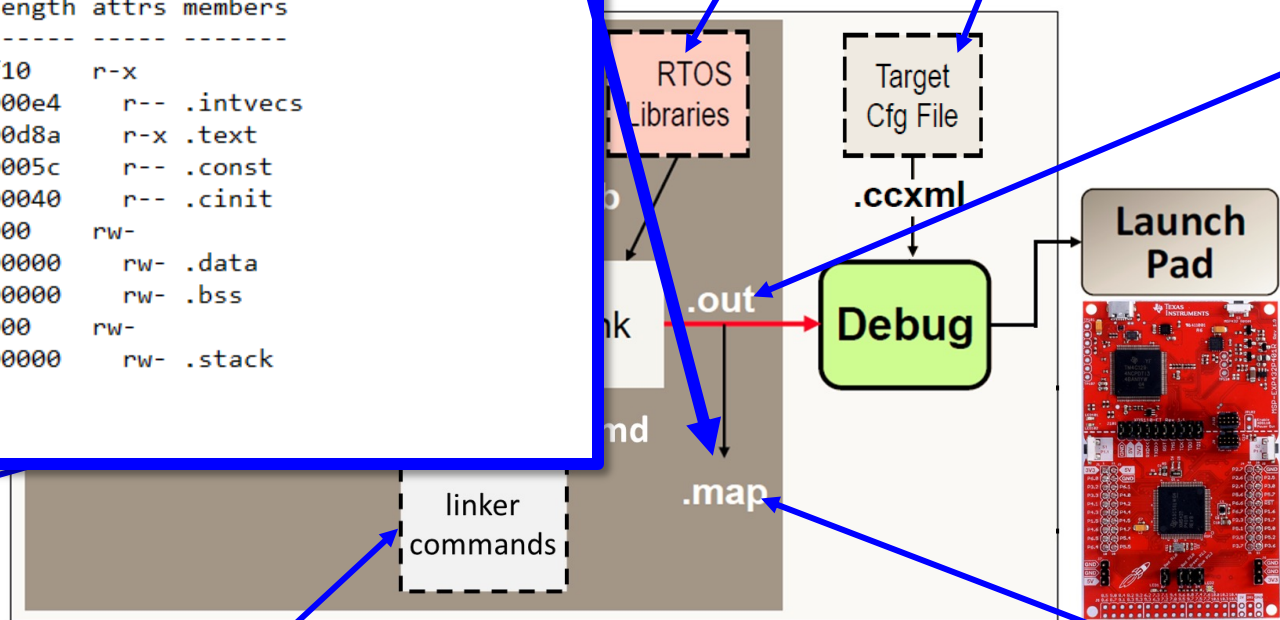
run origin	load origin	length	init length	attrs	members
00000000	00000000	00000f10	00000f10	r-x	
00000000	00000000	000000e4	000000e4	r--	.intvecs
000000e4	000000e4	00000d8a	00000d8a	r-x	.text
00000e70	00000e70	0000005c	0000005c	r--	.const
00000ed0	00000ed0	00000040	00000040	r--	.cinit
20000000	20000000	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

...

select libraries that contain the operating system (if any)

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

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

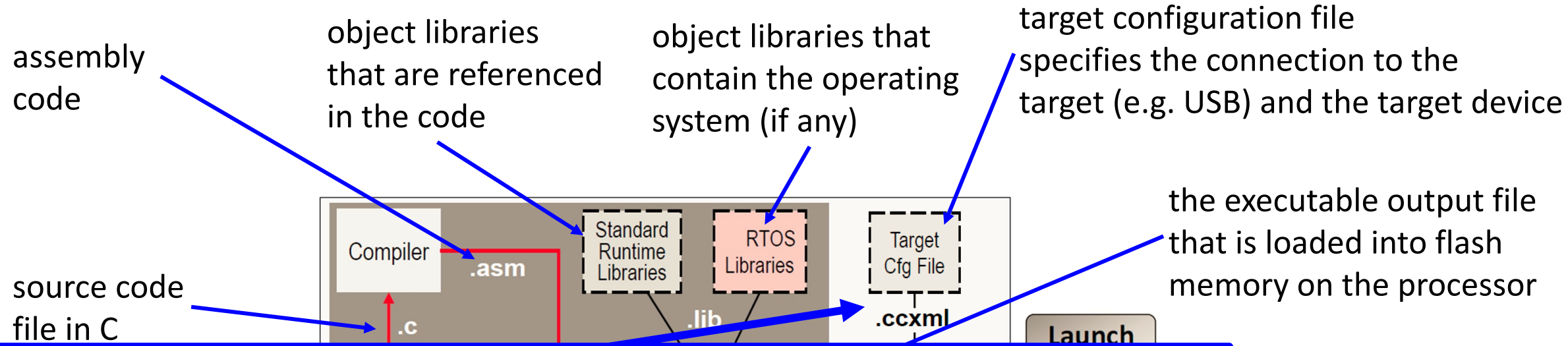


relocatable object file

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



```
<?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>
```

describing
a sections

Much more in ...

- Mikrocontroller-Praktikum
- Hardware-Praktikum (summer)
 - Microcontroller programming using Arduino IDE
 - FPGA programming
 - *From the schematics to a real embedded application*

