Session 17907

z/OS Debugging:
Diagnosing Loops & Hangs

z/OS Core Technologies – August 13th, 2015

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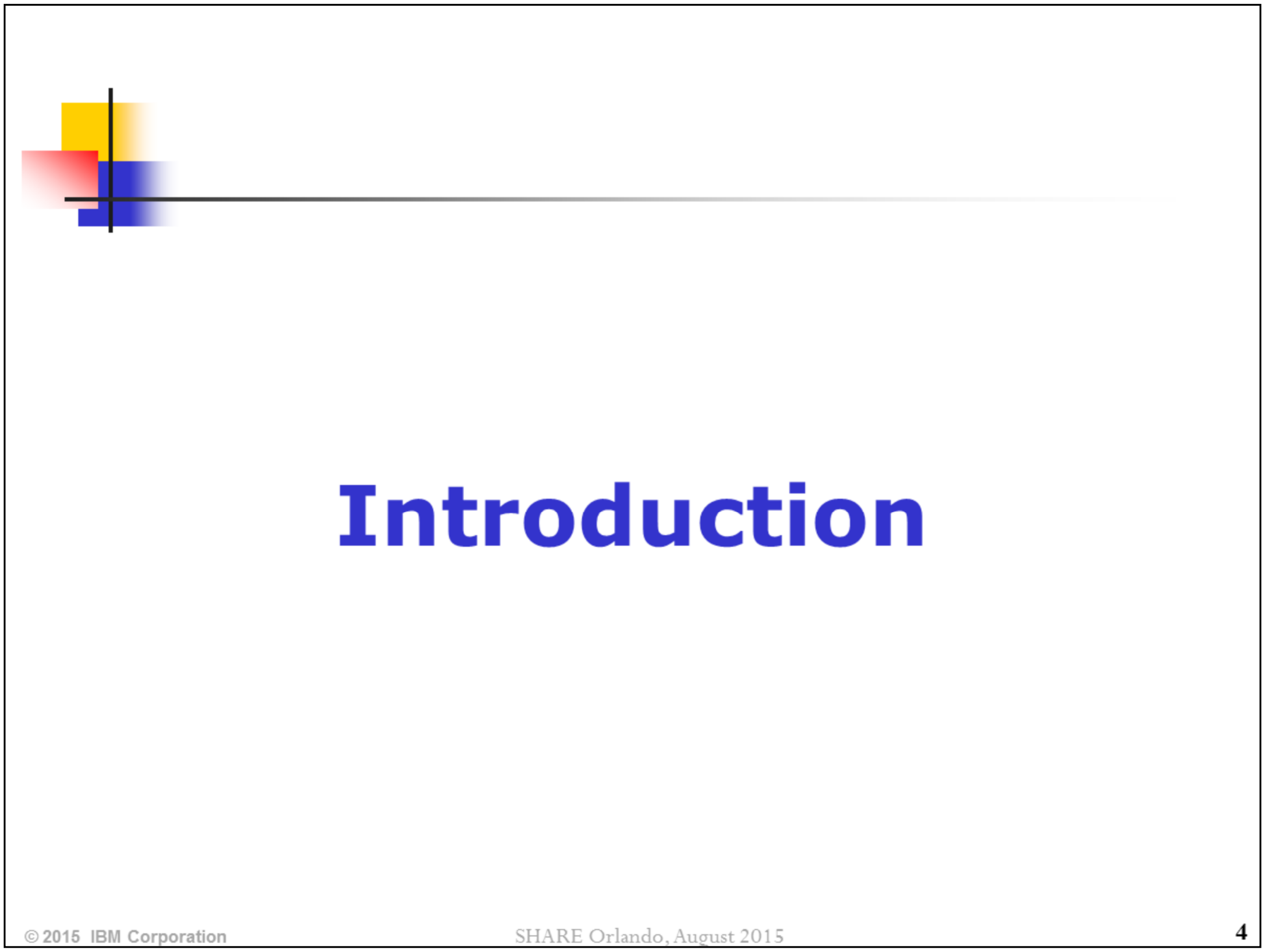
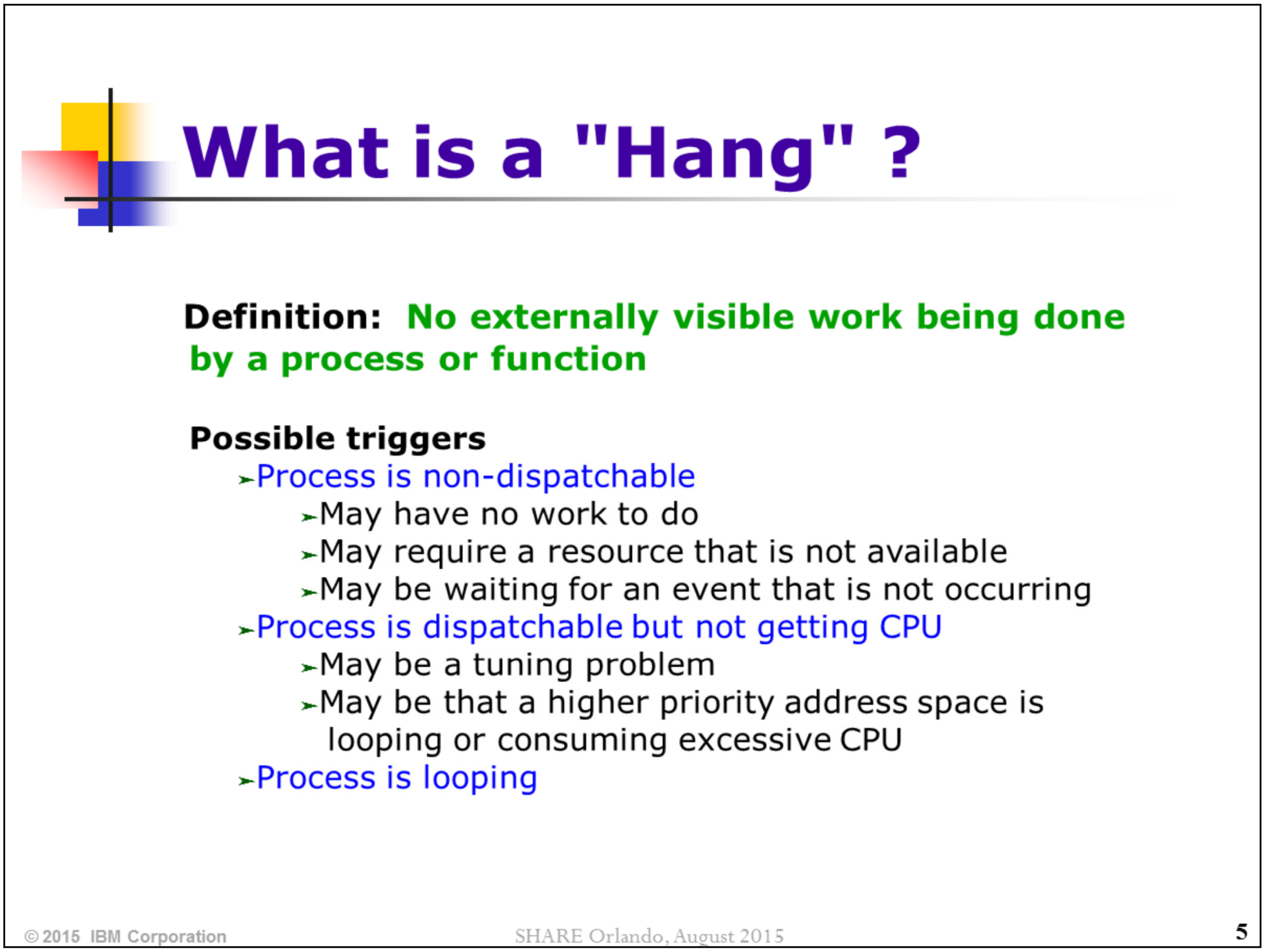


Introduction



What is a "Hang" ?

Definition: **No externally visible work being done by a process or function**

Possible triggers

- Process is non-dispatchable
  - May have no work to do
  - May require a resource that is not available
  - May be waiting for an event that is not occurring
- Process is dispatchable but not getting CPU
  - May be a tuning problem
  - May be that a higher priority address space is looping or consuming excessive CPU
- Process is looping

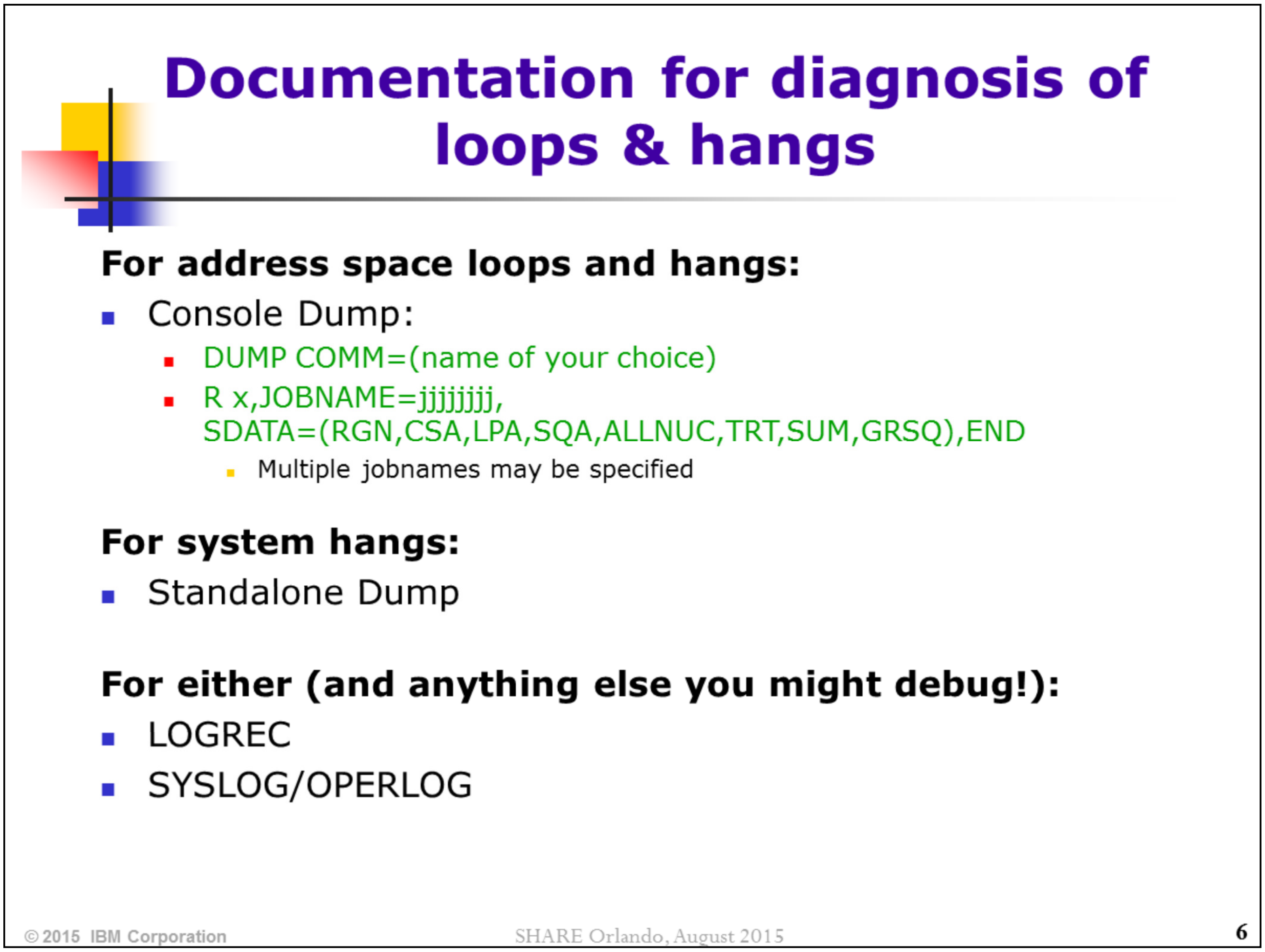
There are many ways that an application or system can appear hung. Similarly, there are many factors which can cause or contribute to a hang. This presentation provides an overview of some types of hangs (including loops) and some steps for identifying what is causing the problem.

A looping application may be perceived as hung since a looping application will not be performing any significant work.

A function can be non-dispatchable at the address space level, or at the TCB level. Non-dispatchability bits being on prevent the address space or task from being dispatched. Alternatively, an RB may be suspended. Local lock contention is another common reason for a function to be not running.

When considering a hung application, it is necessary to be familiar with the application structure. Which TCBs drive which subfunctions? Are any key subfunctions waiting or suspended? If so, what event is the TCB waiting/suspended for? What process is responsible for making this event happen?

Sometimes a hung TCB is fully dispatchable, but it is not getting dispatched due to lack of available CPU. This could be the result of a tuning problem, or this could be due to a higher priority address space being stuck in a loop, thereby consuming extra CPU and starving lower priority address spaces.



Documentation for diagnosis of loops & hangs

For address space loops and hangs:

- Console Dump:
  - DUMP COMM=(name of your choice)
  - R x,JOBNAME=jjjjjjjj, SDATA=(RGN,CSA,LPA,SQA,ALLNUC,TRT,SUM,GRSQ),END
    - Multiple jobnames may be specified

For system hangs:

- Standalone Dump

For either (and anything else you might debug!):

- LOGREC
- SYSLOG/OPERLOG

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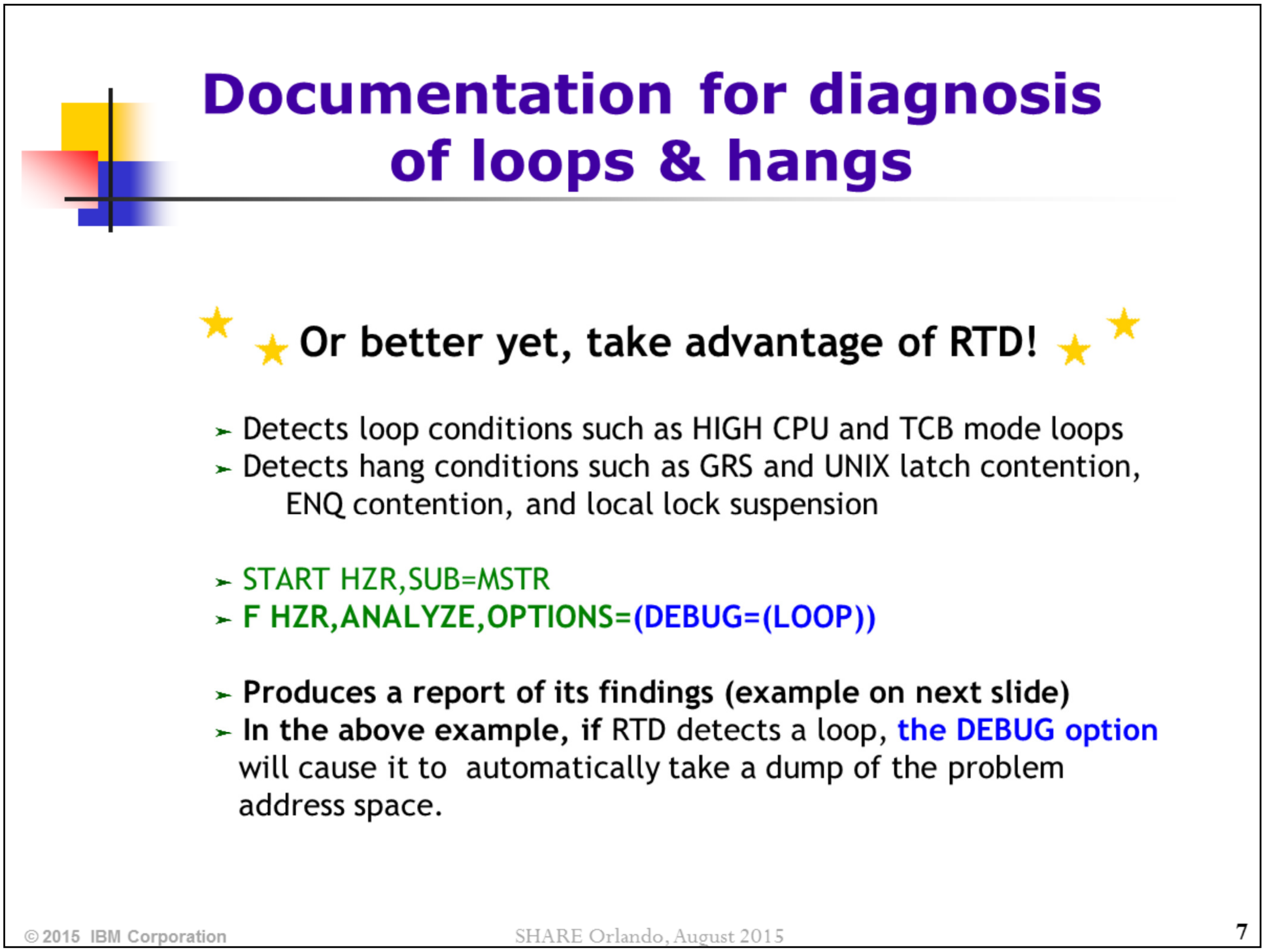
In addition to getting a dump, never overlook the importance of LOGREC and SYSLOG! Often a loop or a hang is preceded by an abend that acted as a trigger or catalyst. Always check SYSLOG for relevant messages (e.g. IEA995I "symptom dump", D GRS output) and activity around the time of the onset of the loop or hang. Always check LOGREC for errors in relevant address spaces around the time of the onset of the loop or hang.

While a standalone dump is the documentation of choice for a system hang, sometimes system hangs can be diagnosed with an SVC dump.



Documentation for diagnosis of loops & hangs

★ ★ Or better yet, take advantage of RTD! ★ ★

- Detects loop conditions such as HIGH CPU and TCB mode loops
- Detects hang conditions such as GRS and UNIX latch contention, ENQ contention, and local lock suspension

```
START HZR,SUB=MSTR
F HZR,ANALYZE,OPTIONS=(DEBUG=(LOOP))
```

- **Produces a report of its findings (example on next slide)**
- **In the above example, if** RTD detects a loop, **the DEBUG option** will cause it to automatically take a dump of the problem address space.

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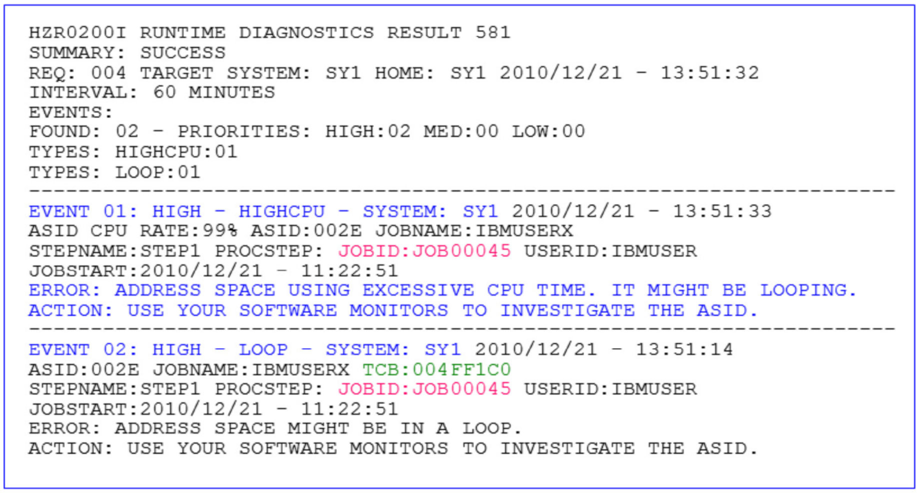
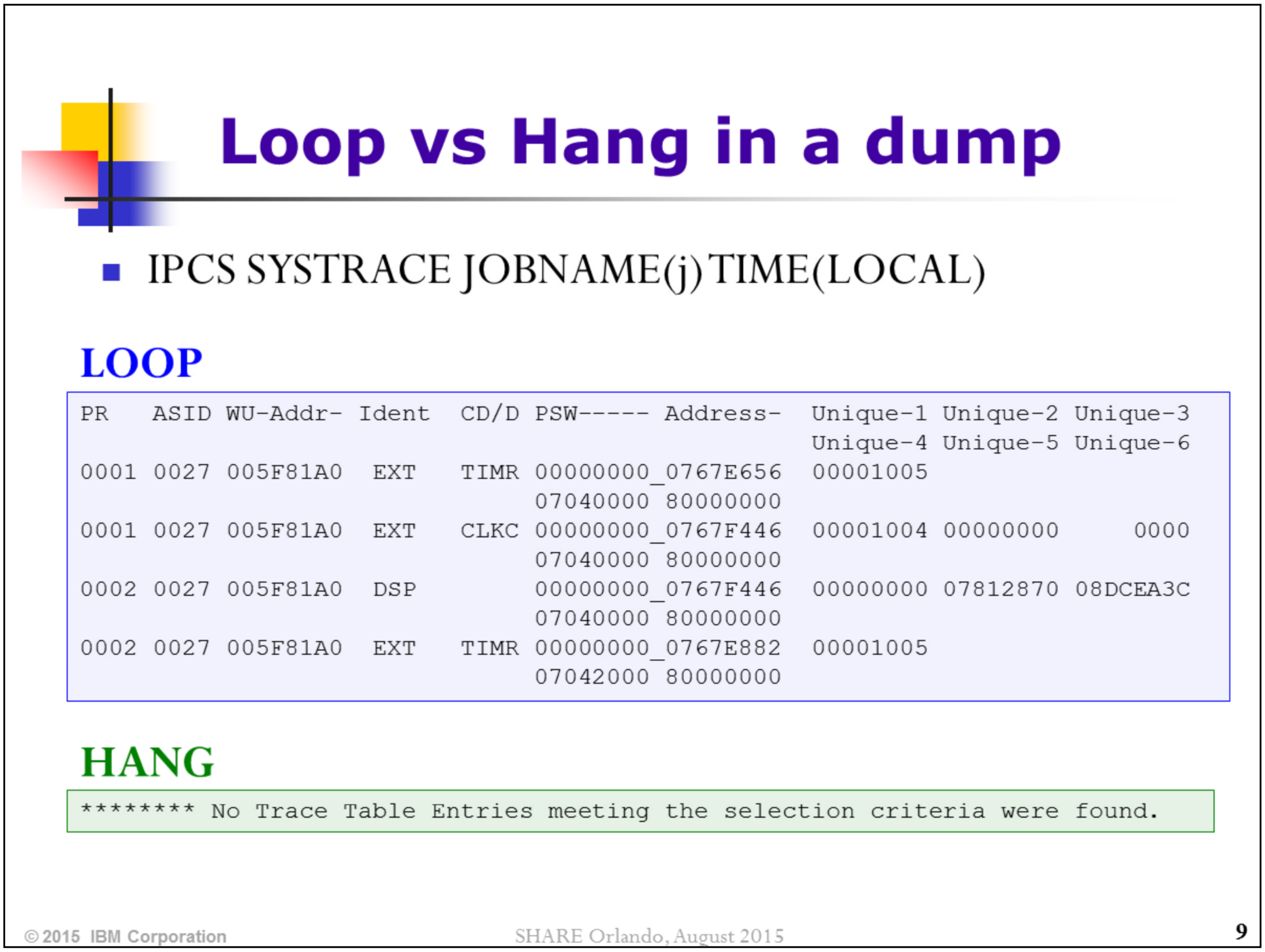
RTD = Run Time Diagnostics. Run RTD whenever your system is experiencing “sick but not dead” symptoms to do a one-minute (or less) diagnostic assessment. It checks for high CPU, loops, critical messages, GRS and UNIX latch contention, ENQ contention, and local lock suspension.

RTD report example



```
HZR0200I RUNTIME DIAGNOSTICS RESULT 581
SUMMARY: SUCCESS
REQ: 004 TARGET SYSTEM: SY1 HOME: SY1 2010/12/21 - 13:51:32
INTERVAL: 60 MINUTES
EVENTS:
FOUND: 02 - PRIORITIES: HIGH:02 MED:00 LOW:00
TYPES: HIGHCPU:01
TYPES: LOOP:01
----------------------------------------------------------------------
EVENT 01: HIGH - HIGHCPU - SYSTEM: SY1 2010/12/21 - 13:51:33
ASID CPU RATE:99% ASID:002E JOBNAME:IBMUSERX
STEPNAME:STEP1 PROCSTEP: JOBID:JOB00045 USERID:IBMUSER
JOBSTART:2010/12/21 - 11:22:51
ERROR: ADDRESS SPACE USING EXCESSIVE CPU TIME. IT MIGHT BE LOOPING.
ACTION: USE YOUR SOFTWARE MONITORS TO INVESTIGATE THE ASID.
----------------------------------------------------------------------
EVENT 02: HIGH - LOOP - SYSTEM: SY1 2010/12/21 - 13:51:14
ASID:002E JOBNAME:IBMUSERX TCB:004FF1C0
STEPNAME:STEP1 PROCSTEP: JOBID:JOB00045 USERID:IBMUSER
JOBSTART:2010/12/21 - 11:22:51
ERROR: ADDRESS SPACE MIGHT BE IN A LOOP.
ACTION: USE YOUR SOFTWARE MONITORS TO INVESTIGATE THE ASID.
```

When both a **HIGHCPU** and a **LOOP** condition are detected by RTD, the Job is very likely looping.



Loop vs Hang in a dump

- IPCS SYSTRACE JOBNAME(j) TIME(LOCAL)

LOOP

```
PR   ASID WU-Addr-  Ident  CD/D PSW----- Address-  Unique-1 Unique-2 Unique-3
                                                   Unique-4 Unique-5 Unique-6
0001 0027 005F81A0   EXT   TIMR 00000000_0767E656  00001005
                                07040000 80000000
0001 0027 005F81A0   EXT   CLKC 00000000_0767F446  00001004 00000000     0000
                                07040000 80000000
0002 0027 005F81A0   DSP        00000000_0767F446  00000000 07812870 08DCEA3C
                                07040000 80000000
0002 0027 005F81A0   EXT   TIMR 00000000_0767E882  00001005
                                07042000 80000000
```

HANG

```
******** No Trace Table Entries meeting the selection criteria were found.
```

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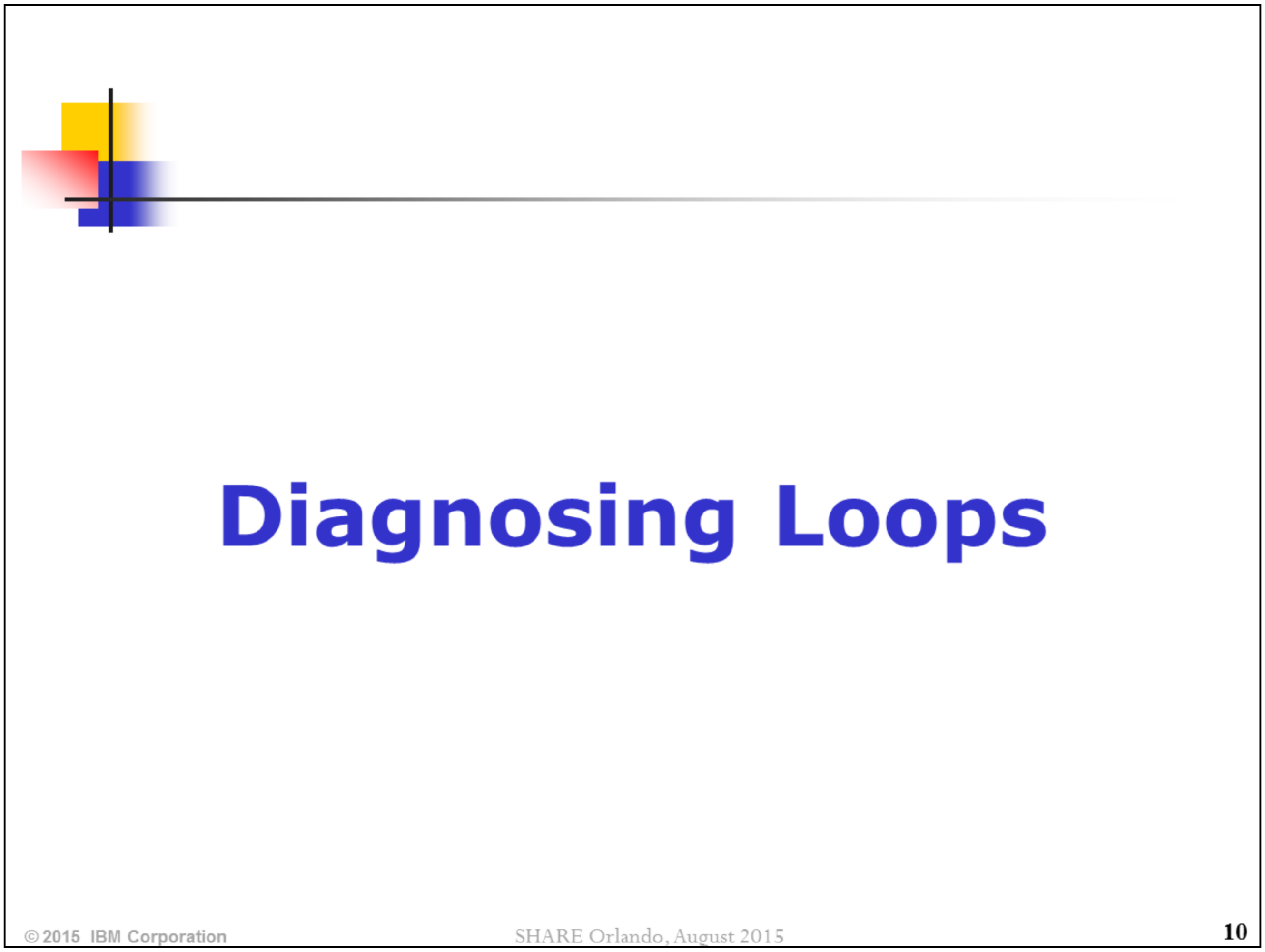
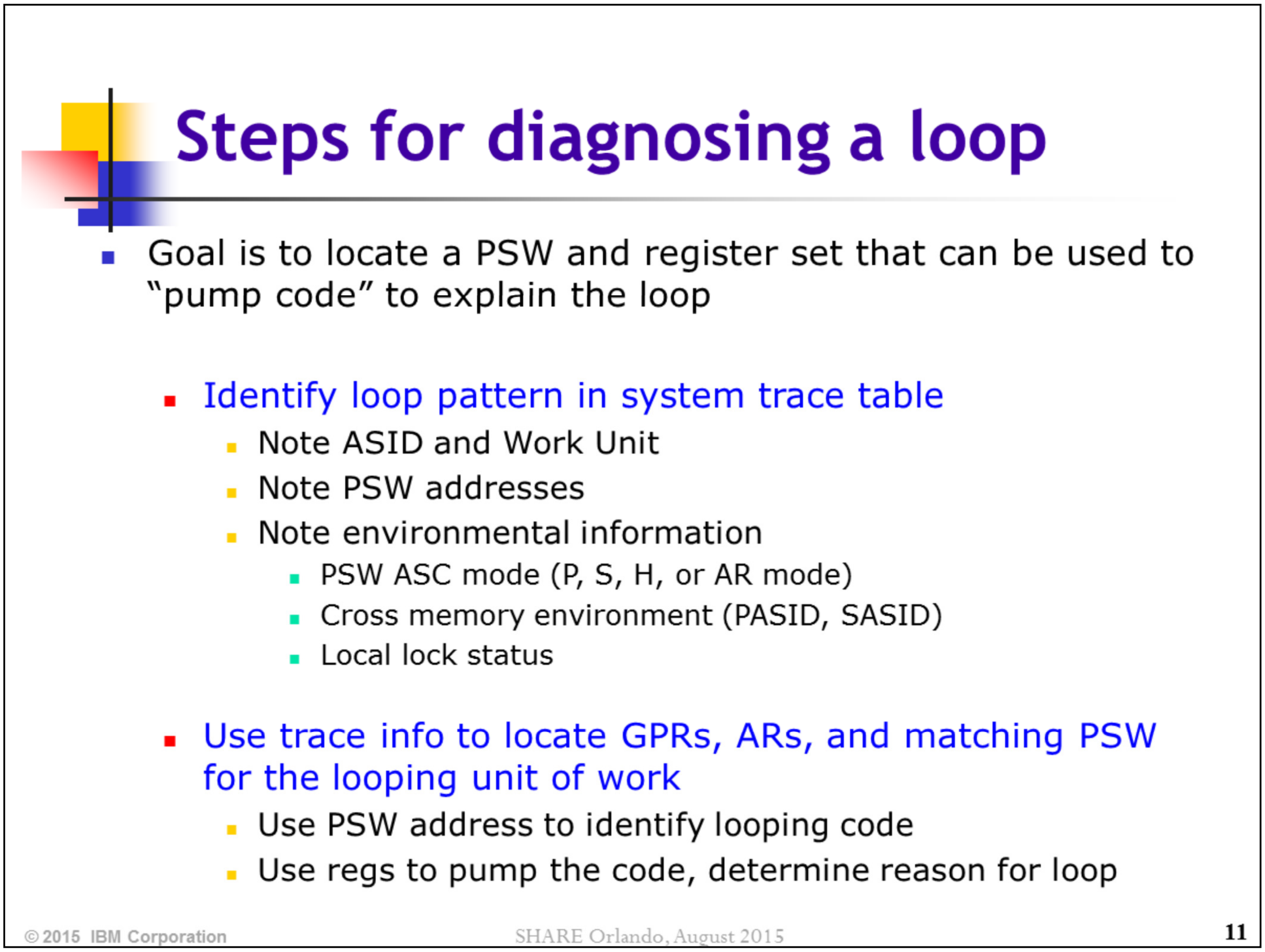
The system trace table is the best option for distinguishing a loop from a hang. A looping address space will have many entries, often composed primarily of EXT TIMR, EXT CLKC, and I/O interrupts, as well as DSP entries. A totally hung address space will have no entries in the system trace table.

Note that a hung address space may still have some work running in it. In such a case, the activity may be limited to timers being set (SVC 2F) and popping. Alternatively, there may be work running in the address space that is unrelated to the subfunction that is non-responsive. When debugging hangs, it is helpful to have a familiarity with the internal workings of the hung address space.



Diagnosing Loops



Steps for diagnosing a loop

- Goal is to locate a PSW and register set that can be used to “pump code” to explain the loop
  - Identify loop pattern in system trace table
    - Note ASID and Work Unit
    - Note PSW addresses
    - Note environmental information
      - PSW ASC mode (P, S, H, or AR mode)
      - Cross memory environment (PASID, SASID)
      - Local lock status
  - Use trace info to locate GPRs, ARs, and matching PSW for the looping unit of work
    - Use PSW address to identify looping code
    - Use regs to pump the code, determine reason for loop

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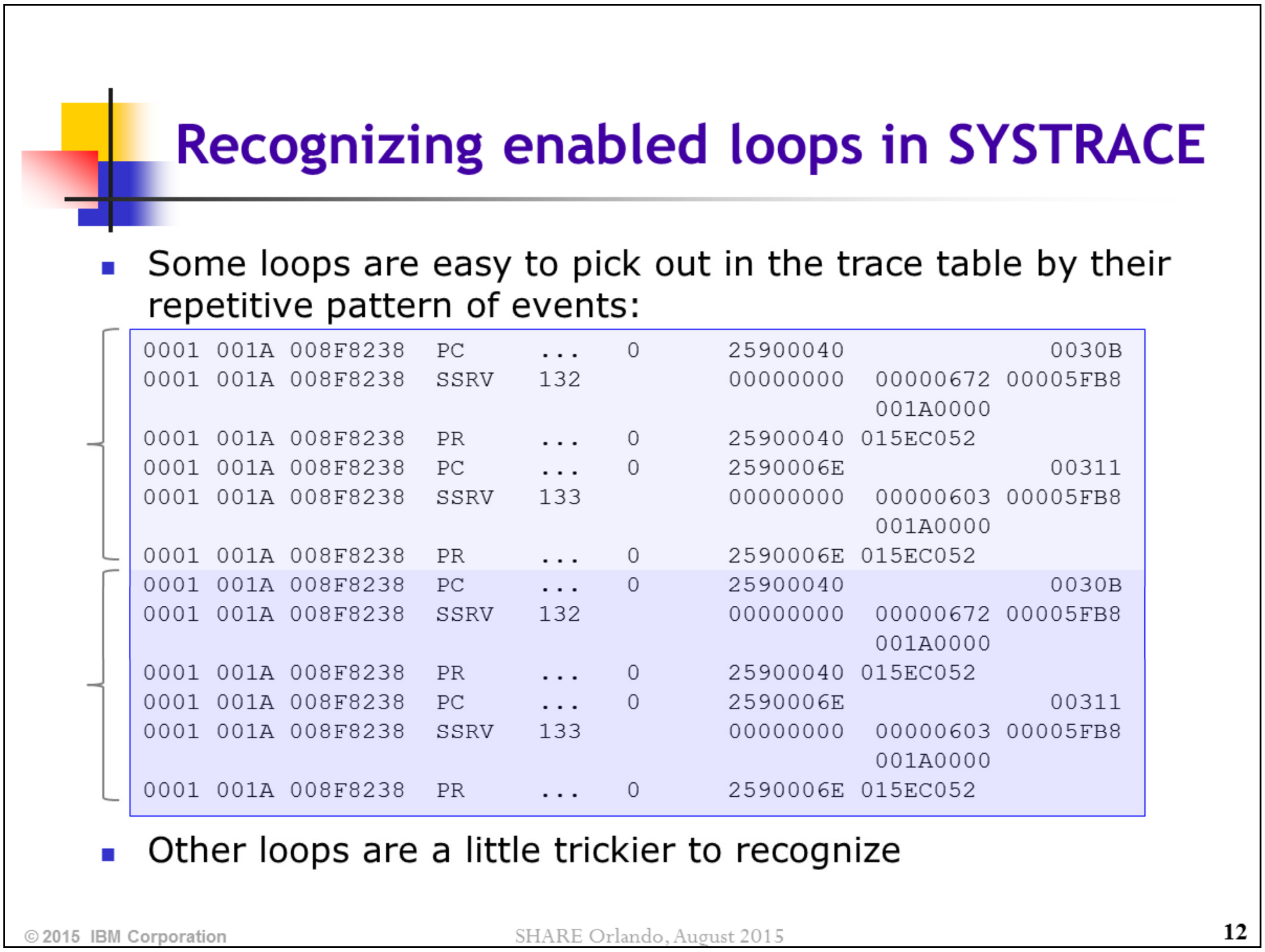
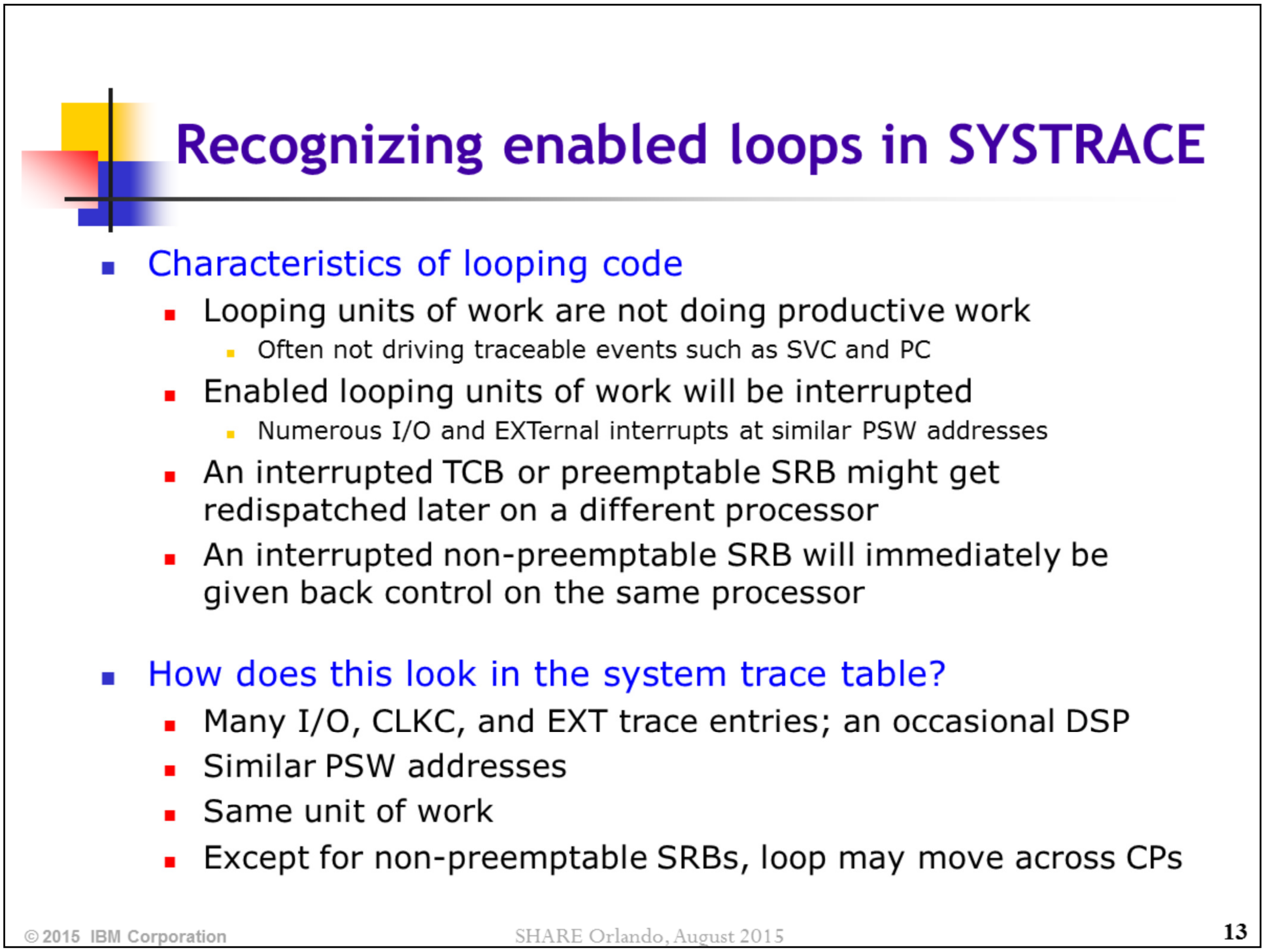


Recognizing enabled loops in SYSTRACE

- Some loops are easy to pick out in the trace table by their repetitive pattern of events:

```
0001 001A 008F8238  PC     ...   0      25900040              0030B
0001 001A 008F8238  SSRV   132          00000000  00000672 00005FB8
                                                  001A0000
0001 001A 008F8238  PR     ...   0      25900040 015EC052
0001 001A 008F8238  PC     ...   0      2590006E              00311
0001 001A 008F8238  SSRV   133          00000000  00000603 00005FB8
                                                  001A0000
0001 001A 008F8238  PR     ...   0      2590006E 015EC052
0001 001A 008F8238  PC     ...   0      25900040              0030B
0001 001A 008F8238  SSRV   132          00000000  00000672 00005FB8
                                                  001A0000
0001 001A 008F8238  PR     ...   0      25900040 015EC052
0001 001A 008F8238  PC     ...   0      2590006E              00311
0001 001A 008F8238  SSRV   133          00000000  00000603 00005FB8
                                                  001A0000
0001 001A 008F8238  PR     ...   0      2590006E 015EC052
```

- Other loops are a little trickier to recognize



Recognizing enabled loops in SYSTRACE

- Characteristics of looping code
  - Looping units of work are not doing productive work
    - Often not driving traceable events such as SVC and PC
  - Enabled looping units of work will be interrupted
    - Numerous I/O and EXTernal interrupts at similar PSW addresses
  - An interrupted TCB or preemptable SRB might get redispatched later on a different processor
  - An interrupted non-preemptable SRB will immediately be given back control on the same processor
- How does this look in the system trace table?
  - Many I/O, CLKC, and EXT trace entries; an occasional DSP
  - Similar PSW addresses
  - Same unit of work
  - Except for non-preemptable SRBs, loop may move across CPs

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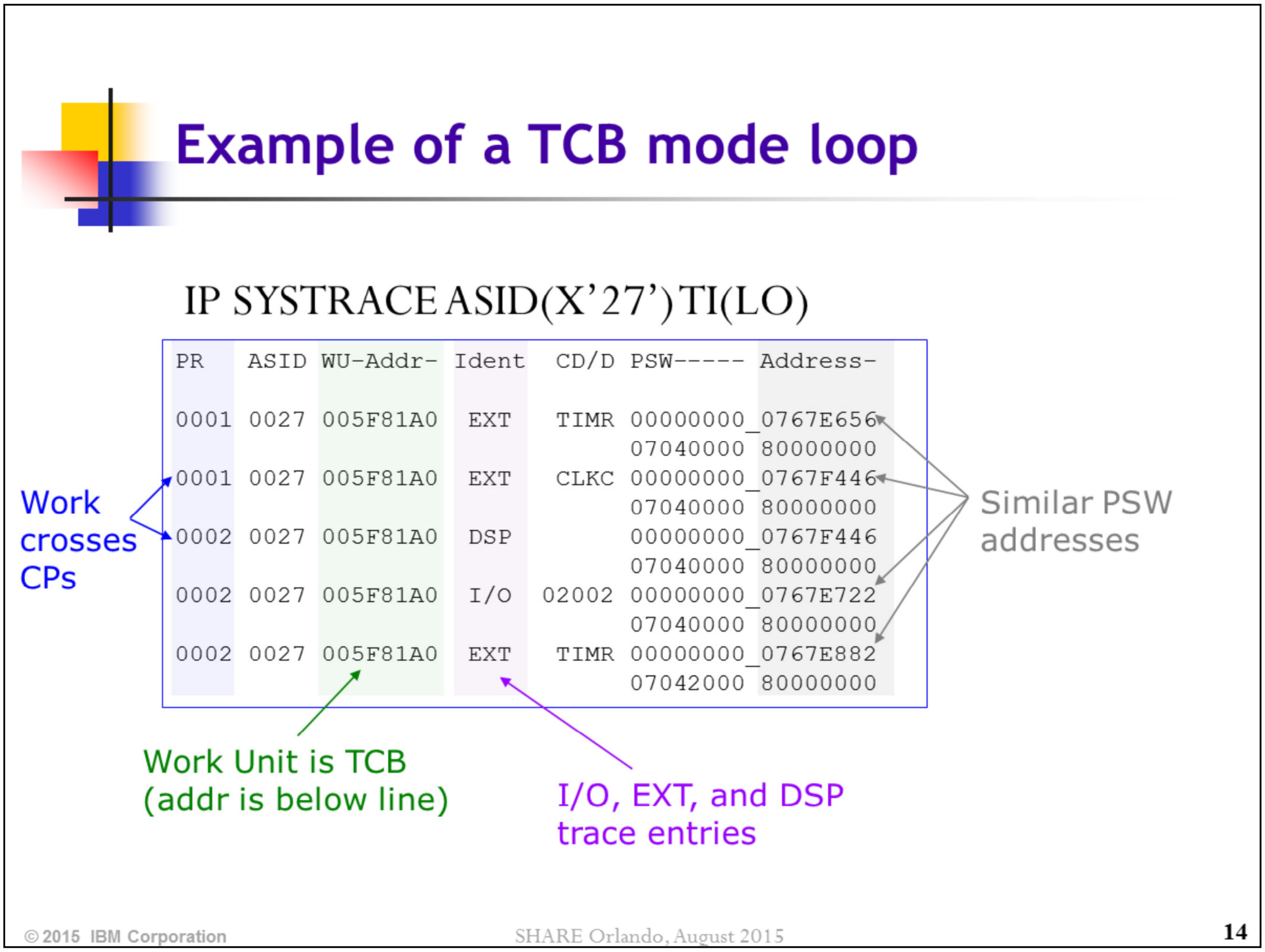
In this presentation we will not discuss how to determine whether an SRB is premptable or non-preemptable. For our purposes it is sufficient to know that if an SRB/SSRB gets interrupted and loses the processor, then it must have been a preemptable-type SRB/SSRB.



Example of a TCB mode loop

IP SYSTRACE ASID(X’27’) TI(LO)

```
PR   ASID WU-Addr- Ident  CD/D PSW----- Address-

0001 0027 005F81A0  EXT   TIMR 00000000_0767E656
                               07040000 80000000
0001 0027 005F81A0  EXT   CLKC 00000000_0767F446
                               07040000 80000000
0002 0027 005F81A0  DSP        00000000_0767F446
                               07040000 80000000
0002 0027 005F81A0  I/O  02002 00000000_0767E722
                               07040000 80000000
0002 0027 005F81A0  EXT   TIMR 00000000_0767E882
                               07042000 80000000
```

Work crosses CPs

Similar PSW addresses

Work Unit is TCB (addr is below line)

I/O, EXT, and DSP trace entries

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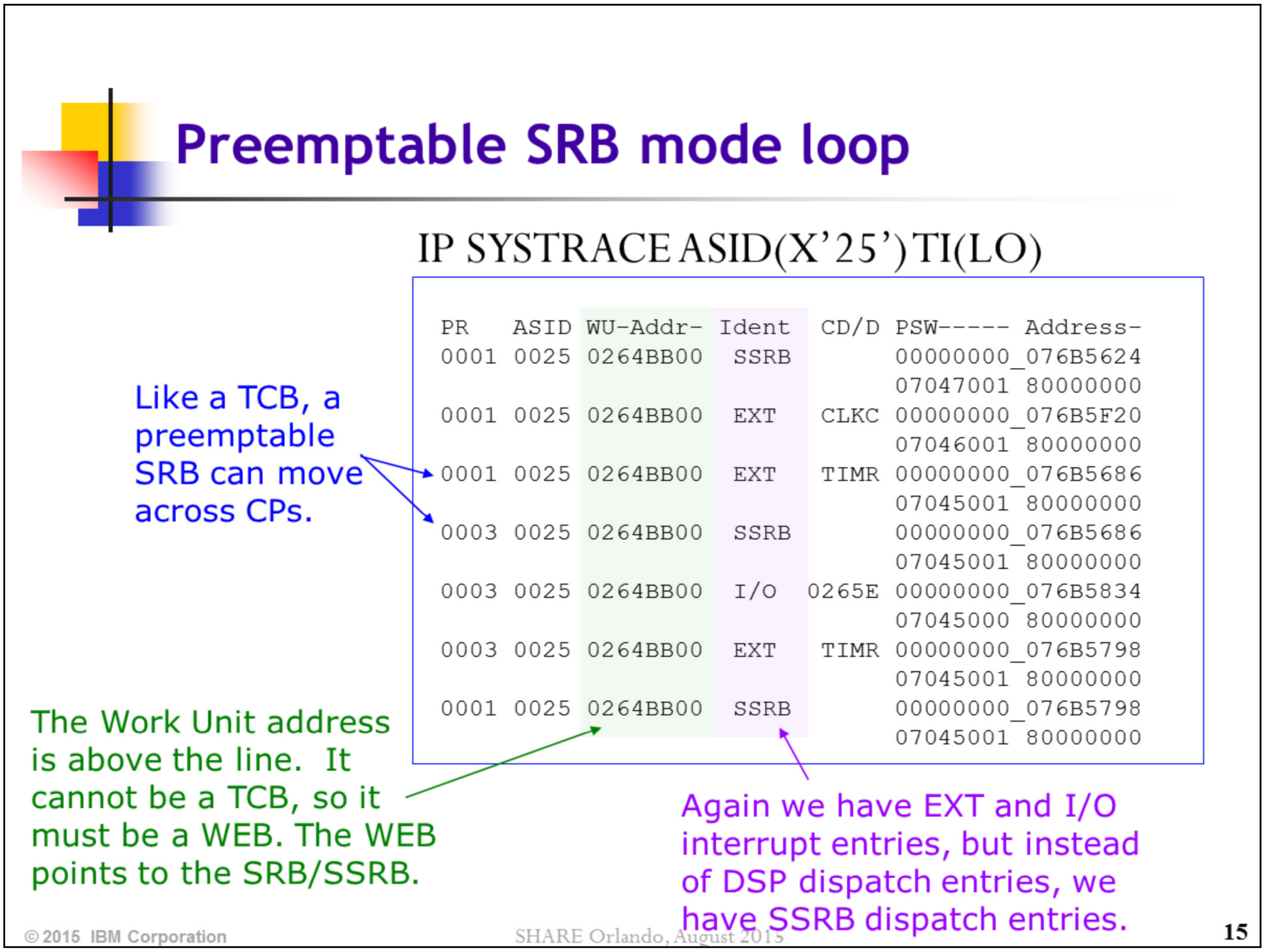
A TCB is always preemptable. This means that, when it gets interrupted, it may lose the CP and have to be redispatched before it can run again. Often when a TCB is interrupted, it does NOT lose the CP but rather is allowed to continue running on the same CP once the interrupt has been handled.

When you see a DSP entry, this means the TCB was found on the WUQ (Work Unit dispatching Queue) and has gotten redispatched. It can get redispatched on a different CP than the one on which it was running prior to the interrupt.

When a TCB is running, the Work Unit address that is traced is the TCB address. We will see that for SRBs, the traced Work Unit address is actually the address of the WEB representing that SRB/SSRB.



Preemptable SRB mode loop

IP SYSTRACE ASID(X’25’)TI(LO)

```
PR   ASID WU-Addr- Ident  CD/D PSW----- Address-
0001 0025 0264BB00  SSRB       00000000_076B5624
                               07047001 80000000
0001 0025 0264BB00  EXT   CLKC 00000000_076B5F20
                               07046001 80000000
0001 0025 0264BB00  EXT   TIMR 00000000_076B5686
                               07045001 80000000
0003 0025 0264BB00  SSRB       00000000_076B5686
                               07045001 80000000
0003 0025 0264BB00  I/O  0265E 00000000_076B5834
                               07045000 80000000
0003 0025 0264BB00  EXT   TIMR 00000000_076B5798
                               07045001 80000000
0001 0025 0264BB00  SSRB       00000000_076B5798
                               07045001 80000000
```

Like a TCB, a preemptable SRB can move across CPs.

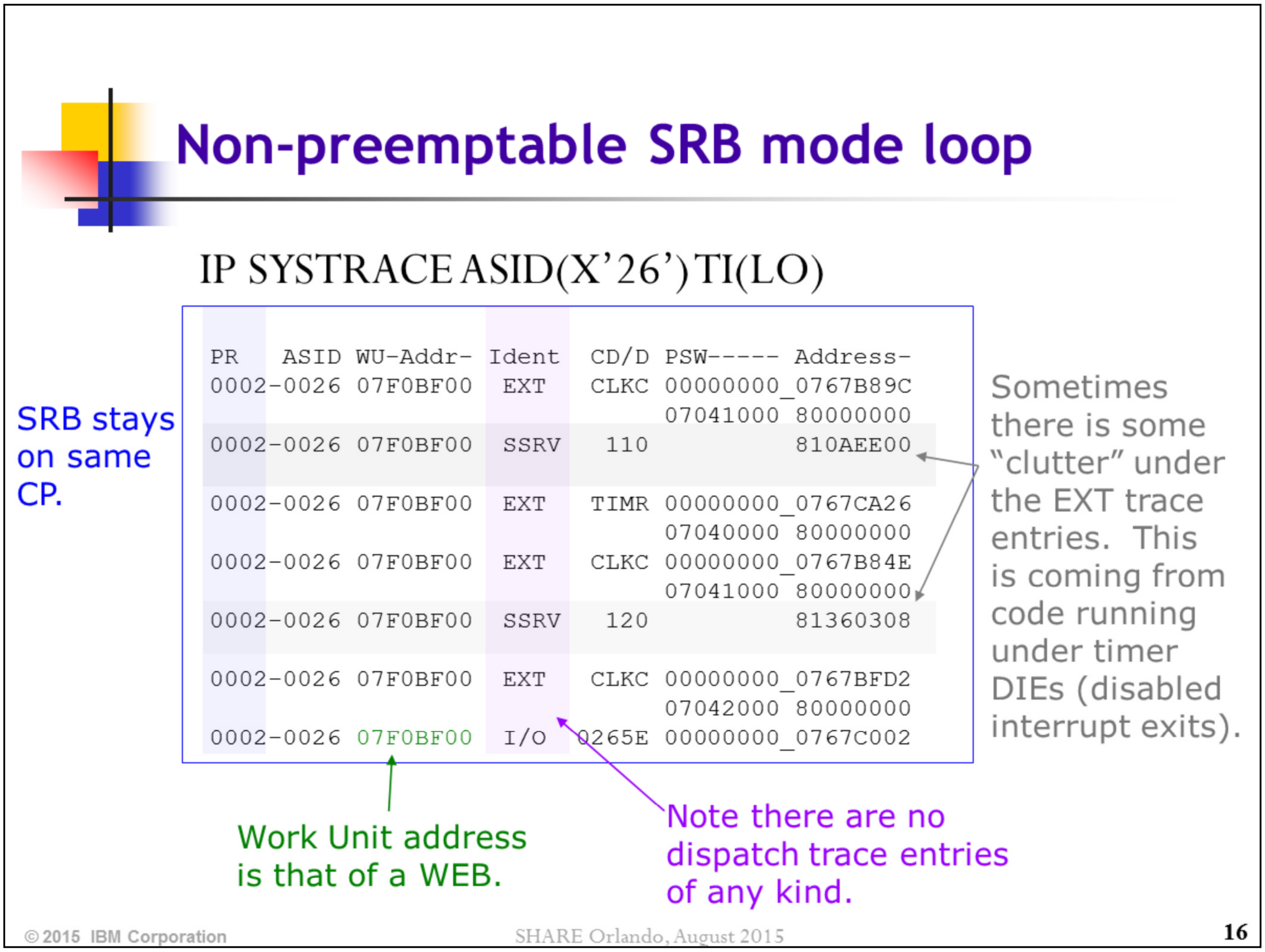
The Work Unit address is above the line. It cannot be a TCB, so it must be a WEB. The WEB points to the SRB/SSRB.

Again we have EXT and I/O interrupt entries, but instead of DSP dispatch entries, we have SSRB dispatch entries.

A preemptable SRB, as its name implies, may have to give up the processor on an interrupt, and wait in line on the WUQ dispatching queue for another opportunity to be dispatched. Therefore, like TCBs, when a preemptable SRB is looping, the loop will travel across processors.

When a preemptable SRB gets interrupted, its status (PSW, registers, cross memory environment) needs to be saved. The operating system obtains an SSRB control block to hold this information. (This is the same type of control block as is used for an SRB, preemptable or non-, when it gets suspended.) This is why we are seeing SSRB entries rather than SRB entries in the system trace output.

WEB = Work Element Block. WEB control blocks represent units of work. They will point to a TCB, an SRB, or an SSRB. WEBs representing ready units of work get queued to a WUQ dispatching queue in priority order. When an SRB (preemptable or non-) is running, the Work Unit address that is traced is the WEB address for that SRB/SSRB.



Non-preemptable SRB mode loop

IP SYSTRACE ASID(X'26') TI(LO)

```
PR   ASID WU-Addr- Ident  CD/D PSW----- Address-
0002-0026 07F0BF00  EXT   CLKC 00000000_0767B89C
                               07041000 80000000
0002-0026 07F0BF00  SSRV   110          810AEE00

0002-0026 07F0BF00  EXT   TIMR 00000000_0767CA26
                               07040000 80000000
0002-0026 07F0BF00  EXT   CLKC 00000000_0767B84E
                               07041000 80000000
0002-0026 07F0BF00  SSRV   120          81360308

0002-0026 07F0BF00  EXT   CLKC 00000000_0767BFD2
                               07042000 80000000
0002-0026 07F0BF00  I/O  0265E 00000000_0767C002
```

SRB stays on same CP.

Sometimes there is some "clutter" under the EXT trace entries. This is coming from code running under timer DIEs (disabled interrupt exits).

Work Unit address is that of a WEB.

Note there are no dispatch trace entries of any kind.

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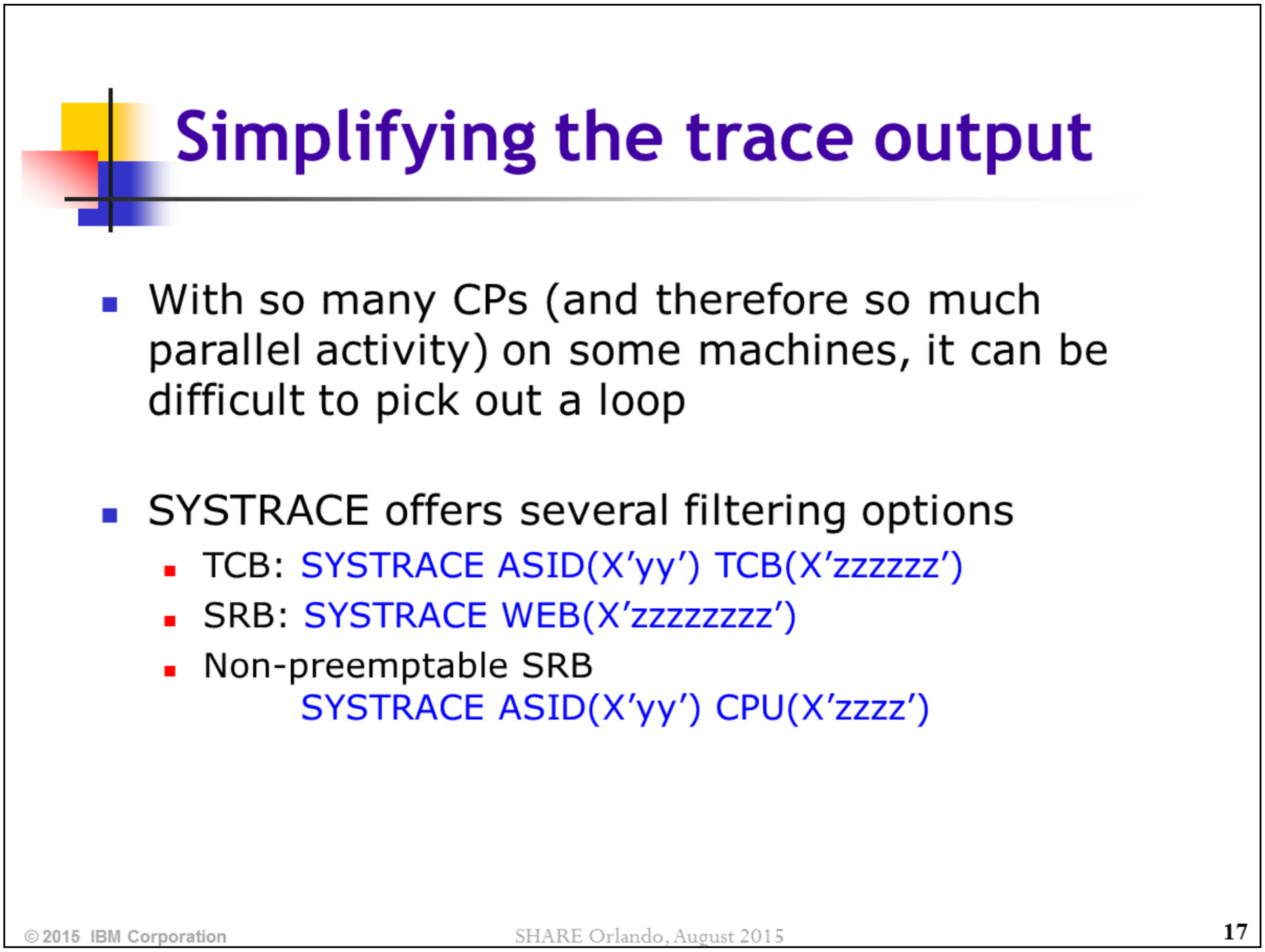
Non-preemptable SRBs cannot lose the processor. You will not see DSP or SSRB trace entries in the pattern of the loop. The SRB will never get preempted and have to be redispatched; therefore, the loop will stay on the same CP rather move around as was the case with the TCB and preemptable SRB mode loops.



Simplifying the trace output

- With so many CPs (and therefore so much parallel activity) on some machines, it can be difficult to pick out a loop
- SYSTRACE offers several filtering options
  - TCB: SYSTRACE ASID(X'yy') TCB(X'zzzzzz')
  - SRB: SYSTRACE WEB(X'zzzzzzzz')
  - Non-preemptable SRB
    SYSTRACE ASID(X'yy') CPU(X'zzzz')

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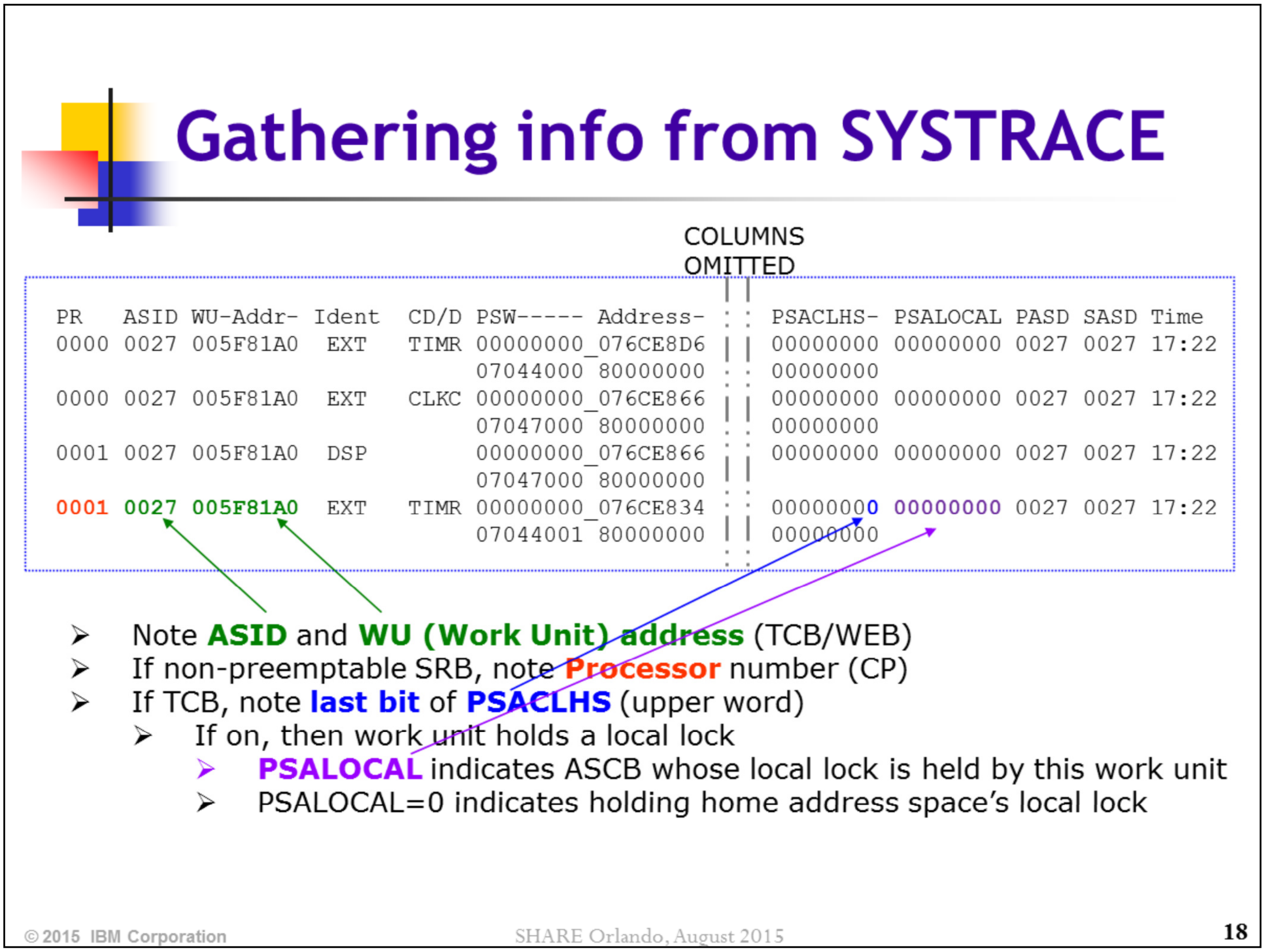

Gathering info from SYSTRACE

COLUMNS OMITTED

```
PR   ASID WU-Addr- Ident  CD/D PSW----- Address-     PSACLHS- PSALOCAL PASD SASD Time
0000 0027 005F81A0  EXT   TIMR 00000000_076CE8D6     00000000 00000000 0027 0027 17:22
                               07044000_80000000     00000000
0000 0027 005F81A0  EXT   CLKC 00000000_076CE866     00000000 00000000 0027 0027 17:22
                               07047000_80000000     00000000
0001 0027 005F81A0  DSP        00000000_076CE866     00000000 00000000 0027 0027 17:22
                               07047000_80000000     00000000
0001 0027 005F81A0  EXT   TIMR 00000000_076CE834     00000000 00000000 0027 0027 17:22
                               07044001_80000000     00000000
```

- Note **ASID** and **WU (Work Unit) address** (TCB/WEB)
- If non-preemptable SRB, note **Processor** number (CP)
- If TCB, note **last bit** of **PSACLHS** (upper word)
  - If on, then work unit holds a local lock
    - **PSALOCAL** indicates ASCB whose local lock is held by this work unit
    - PSALOCAL=0 indicates holding home address space’s local lock

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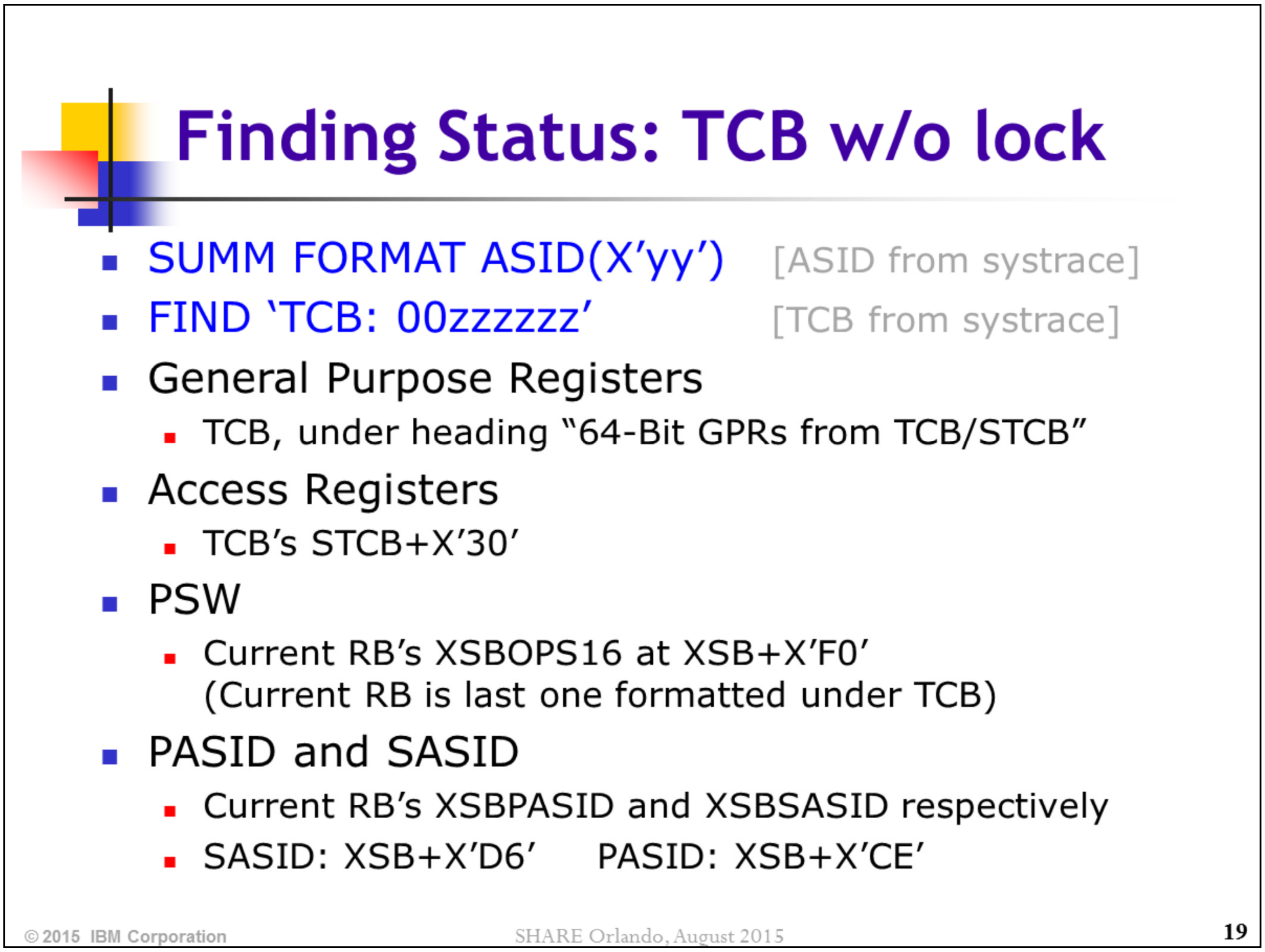
The last bit of PSACLHS can also be used to determine whether an SRB is holding a local lock. However, this information is not needed to locate the status information of an SRB.

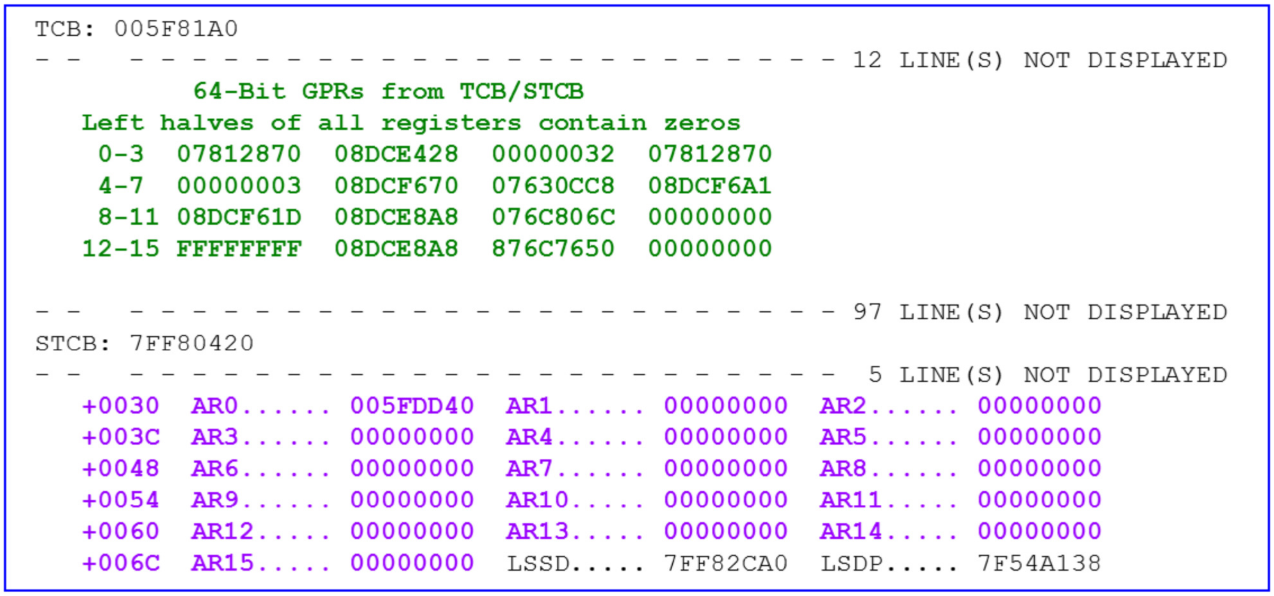


Finding Status: TCB w/o lock

- SUMM FORMAT ASID(X’yy’) [ASID from systrace]
- FIND ‘TCB: 00zzzzzz’ [TCB from systrace]
- General Purpose Registers
  - TCB, under heading “64-Bit GPRs from TCB/STCB”
- Access Registers
  - TCB’s STCB+X’30’
- PSW
  - Current RB’s XSBOPS16 at XSB+X’F0’
    (Current RB is last one formatted under TCB)
- PASID and SASID
  - Current RB’s XSBPASID and XSBSASID respectively
  - SASID: XSB+X’D6’ PASID: XSB+X’CE’

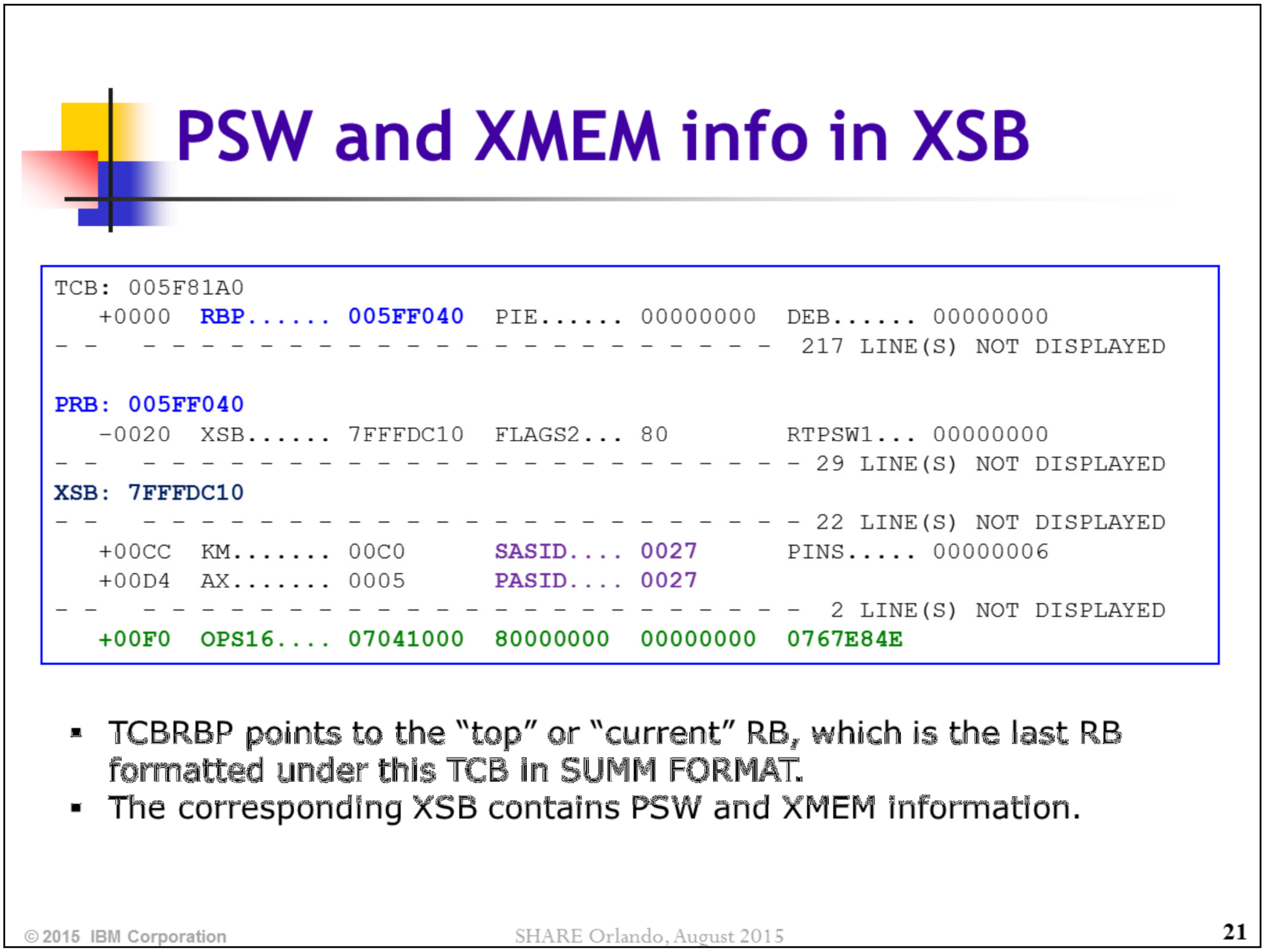
Status: PSW, General Purpose Registers, Access Registers, Cross Memory environment. PASID and SASID stand for Primary ASID and Secondary ASID respectively.

Registers in TCB/STCB



```
TCB: 005F81A0
- -   - - - - - - - - - - - - - - - - - - - - - - - - - 12 LINE(S) NOT DISPLAYED
          64-Bit GPRs from TCB/STCB
   Left halves of all registers contain zeros
    0-3  07812870  08DCE428  00000032  07812870
    4-7  00000003  08DCF670  07630CC8  08DCF6A1
    8-11 08DCF61D  08DCE8A8  076C806C  00000000
   12-15 FFFFFFFF  08DCE8A8  876C7650  00000000

- -   - - - - - - - - - - - - - - - - - - - - - - - - - 97 LINE(S) NOT DISPLAYED
STCB: 7FF80420
- -   - - - - - - - - - - - - - - - - - - - - - - - - -  5 LINE(S) NOT DISPLAYED
   +0030  AR0...... 005FDD40  AR1...... 00000000  AR2...... 00000000
   +003C  AR3...... 00000000  AR4...... 00000000  AR5...... 00000000
   +0048  AR6...... 00000000  AR7...... 00000000  AR8...... 00000000
   +0054  AR9...... 00000000  AR10..... 00000000  AR11..... 00000000
   +0060  AR12..... 00000000  AR13..... 00000000  AR14..... 00000000
   +006C  AR15..... 00000000  LSSD..... 7FF82CA0  LSDP..... 7F54A138
```

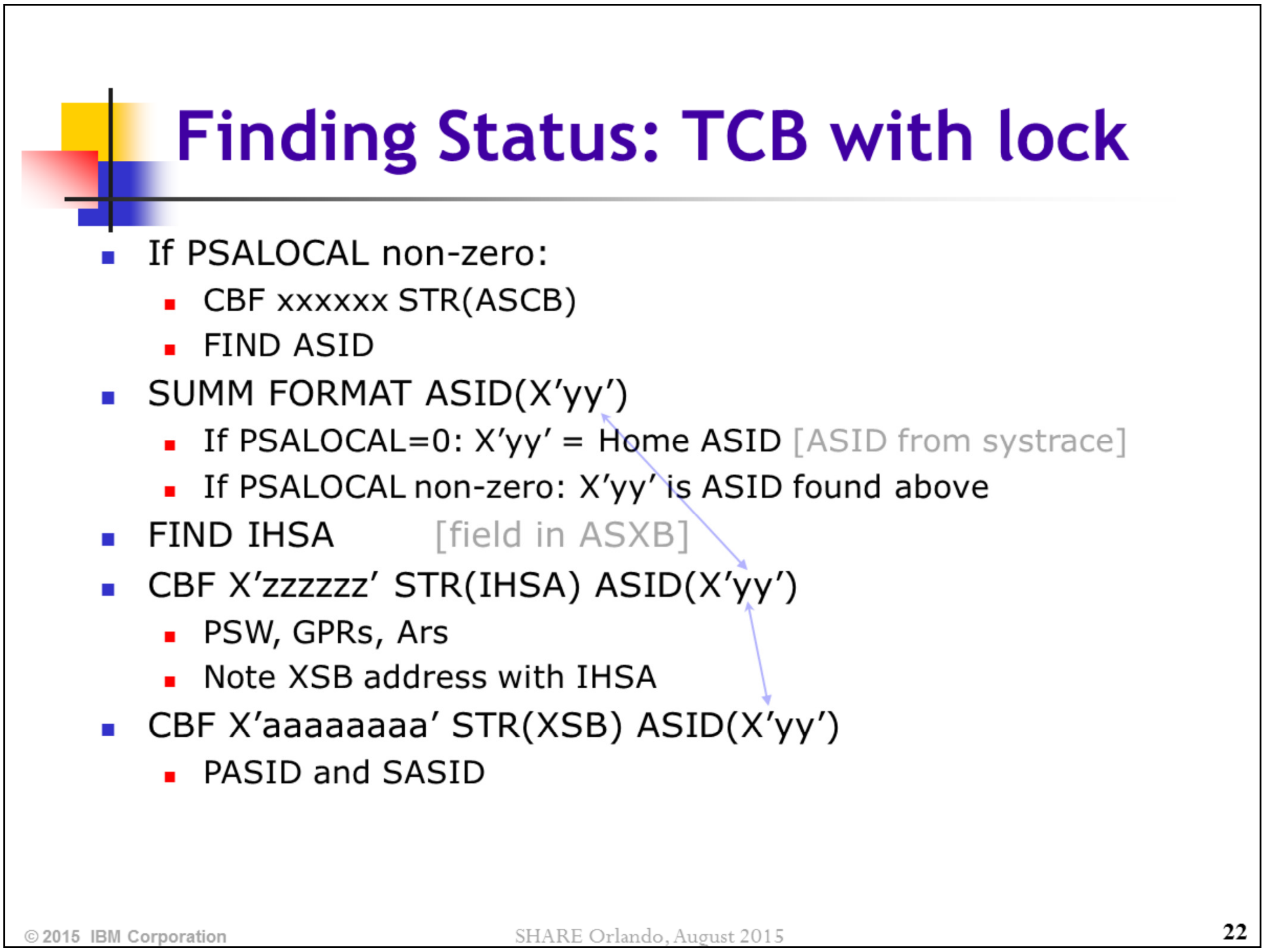
General purpose registers are formatted under the TCB, access registers under the STCB



PSW and XMEM info in XSB

```
TCB: 005F81A0
   +0000  RBP...... 005FF040  PIE...... 00000000  DEB...... 00000000
- -   - - - - - - - - - - - - - - - - - - - - - - -  217 LINE(S) NOT DISPLAYED

PRB: 005FF040
   -0020  XSB...... 7FFFDC10  FLAGS2... 80        RTPSW1... 00000000
- -   - - - - - - - - - - - - - - - - - - - - - - - - 29 LINE(S) NOT DISPLAYED
XSB: 7FFFDC10
- -   - - - - - - - - - - - - - - - - - - - - - - - - 22 LINE(S) NOT DISPLAYED
   +00CC  KM....... 00C0      SASID.... 0027      PINS..... 00000006
   +00D4  AX....... 0005      PASID.... 0027
- -   - - - - - - - - - - - - - - - - - - - - - - - -  2 LINE(S) NOT DISPLAYED
   +00F0  OPS16.... 07041000  80000000  00000000  0767E84E
```

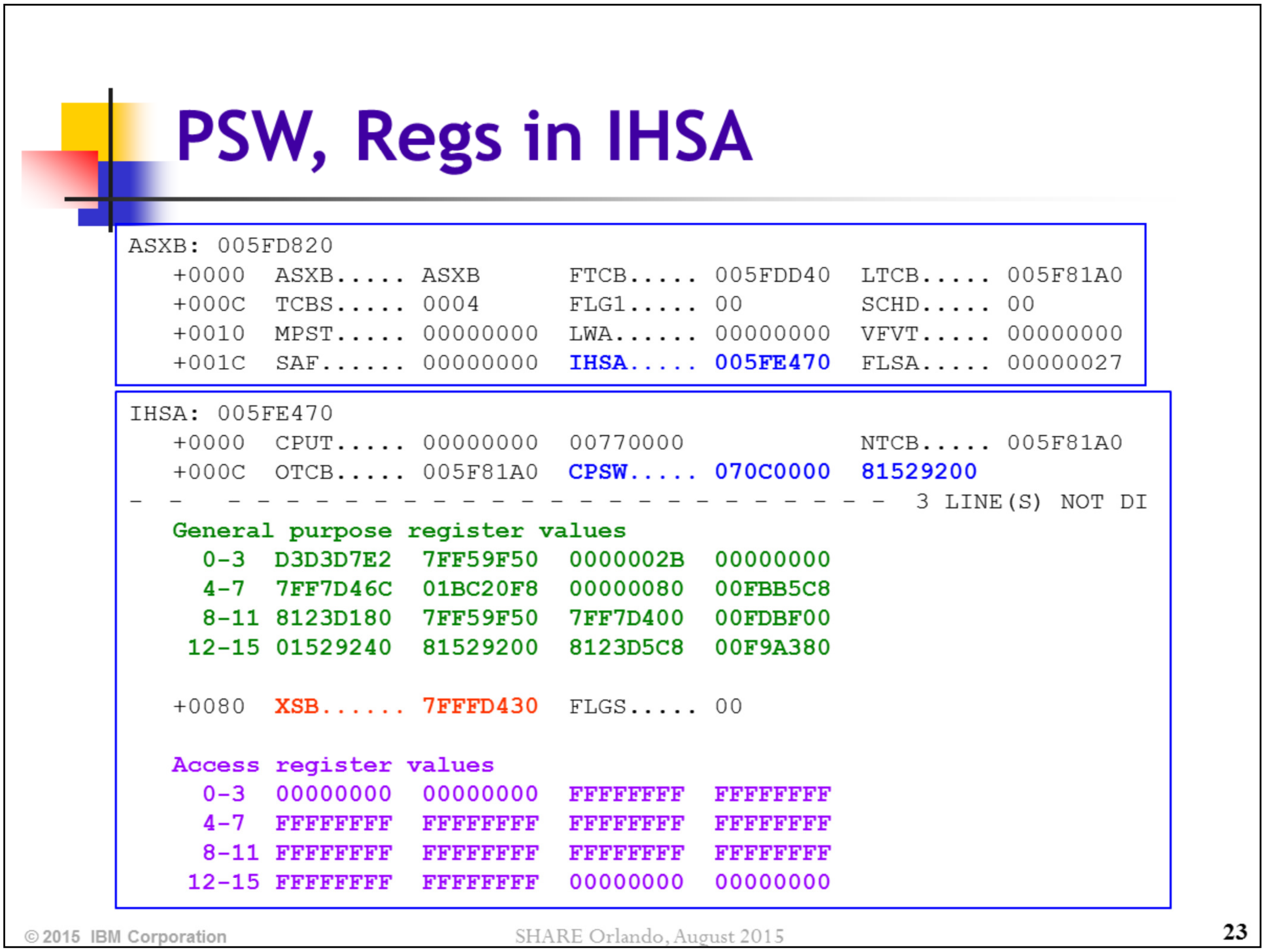
- TCBRBP points to the “top” or “current” RB, which is the last RB formatted under this TCB in SUMM FORMAT.
- The corresponding XSB contains PSW and XMEM information.



Finding Status: TCB with lock

- If PSALOCAL non-zero:
  - CBF xxxxxx STR(ASCB)
  - FIND ASID
- SUMM FORMAT ASID(X’yy’)
  - If PSALOCAL=0: X’yy’ = Home ASID [ASID from systrace]
  - If PSALOCAL non-zero: X’yy’ is ASID found above
- FIND IHSA [field in ASXB]
- CBF X’zzzzzz’ STR(IHSA) ASID(X’yy’)
  - PSW, GPRs, Ars
  - Note XSB address with IHSA
- CBF X’aaaaaaaa’ STR(XSB) ASID(X’yy’)
  - PASID and SASID

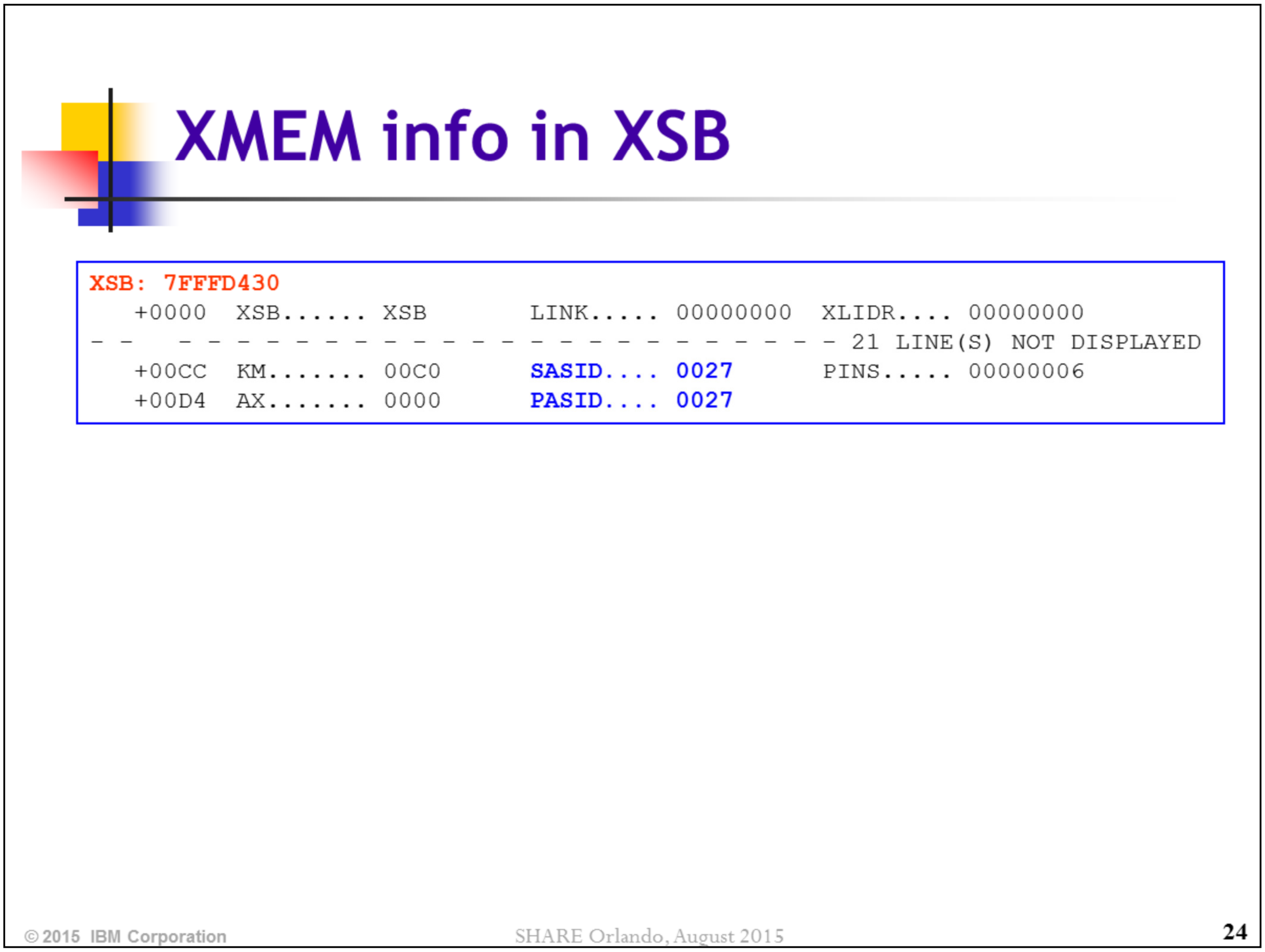
Status: PSW, General Purpose Registers, Access Registers, Cross Memory environment



PSW, Regs in IHSA

```
ASXB: 005FD820
    +0000  ASXB..... ASXB      FTCB..... 005FDD40  LTCB..... 005F81A0
    +000C  TCBS..... 0004      FLG1..... 00        SCHD..... 00
    +0010  MPST..... 00000000  LWA...... 00000000  VFVT..... 00000000
    +001C  SAF...... 00000000  IHSA..... 005FE470  FLSA..... 00000027
```

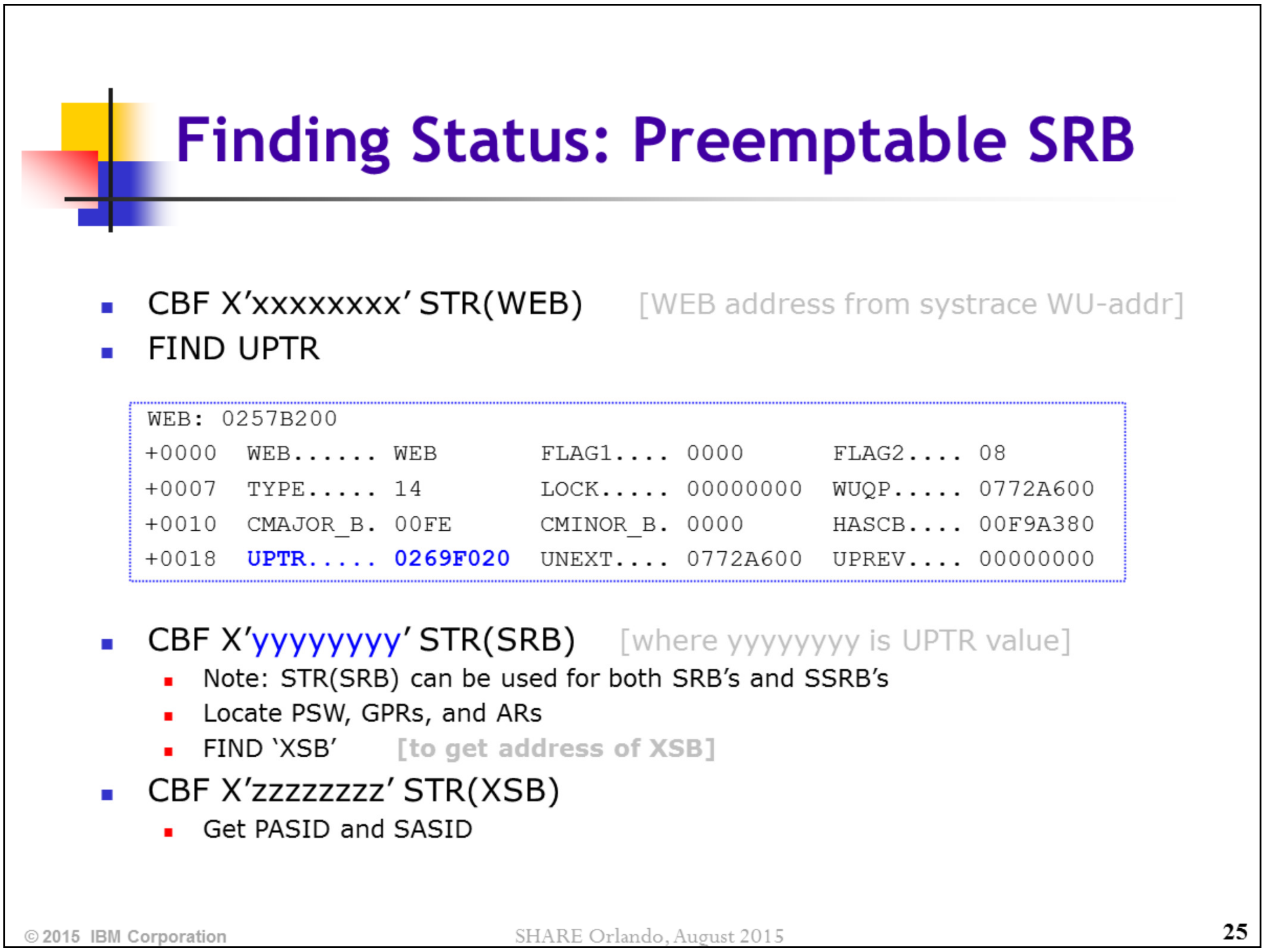
```
IHSA: 005FE470
    +0000  CPUT..... 00000000  00770000            NTCB..... 005F81A0
    +000C  OTCB..... 005F81A0  CPSW..... 070C0000  81529200
 -  -   - - - - - - - - - - - - - - - - - - - - - - -   3 LINE(S) NOT DI
    General purpose register values
      0-3  D3D3D7E2  7FF59F50  0000002B  00000000
      4-7  7FF7D46C  01BC20F8  00000080  00FBB5C8
      8-11 8123D180  7FF59F50  7FF7D400  00FDBF00
     12-15 01529240  81529200  8123D5C8  00F9A380

    +0080  XSB...... 7FFFD430  FLGS..... 00

    Access register values
      0-3  00000000  00000000  FFFFFFFF  FFFFFFFF
      4-7  FFFFFFFF  FFFFFFFF  FFFFFFFF  FFFFFFFF
      8-11 FFFFFFFF  FFFFFFFF  FFFFFFFF  FFFFFFFF
     12-15 FFFFFFFF  FFFFFFFF  00000000  00000000
```



XMEM info in XSB

```
XSB: 7FFFD430
   +0000  XSB...... XSB       LINK..... 00000000  XLIDR.... 00000000
- -   - - - - - - - - - - - - - - - - - - - - - - - - 21 LINE(S) NOT DISPLAYED
   +00CC  KM....... 00C0      SASID.... 0027      PINS..... 00000006
   +00D4  AX....... 0000      PASID.... 0027
```

This XSB lives in the same address space as the IHSA.



Finding Status: Preemptable SRB

- CBF X'xxxxxxxx' STR(WEB) [WEB address from systrace WU-addr]
- FIND UPTR

```
WEB: 0257B200
+0000  WEB......  WEB       FLAG1....  0000      FLAG2....  08
+0007  TYPE.....  14        LOCK.....  00000000  WUQP.....  0772A600
+0010  CMAJOR_B.  00FE      CMINOR_B.  0000      HASCB....  00F9A380
+0018  UPTR.....  0269F020  UNEXT....  0772A600  UPREV....  00000000
```

- CBF X'yyyyyyyy' STR(SRB) [where yyyyyyyy is UPTR value]
  - Note: STR(SRB) can be used for both SRB's and SSRB's
  - Locate PSW, GPRs, and ARs
  - FIND 'XSB' **[to get address of XSB]**
- CBF X'zzzzzzzz' STR(XSB)
  - Get PASID and SASID

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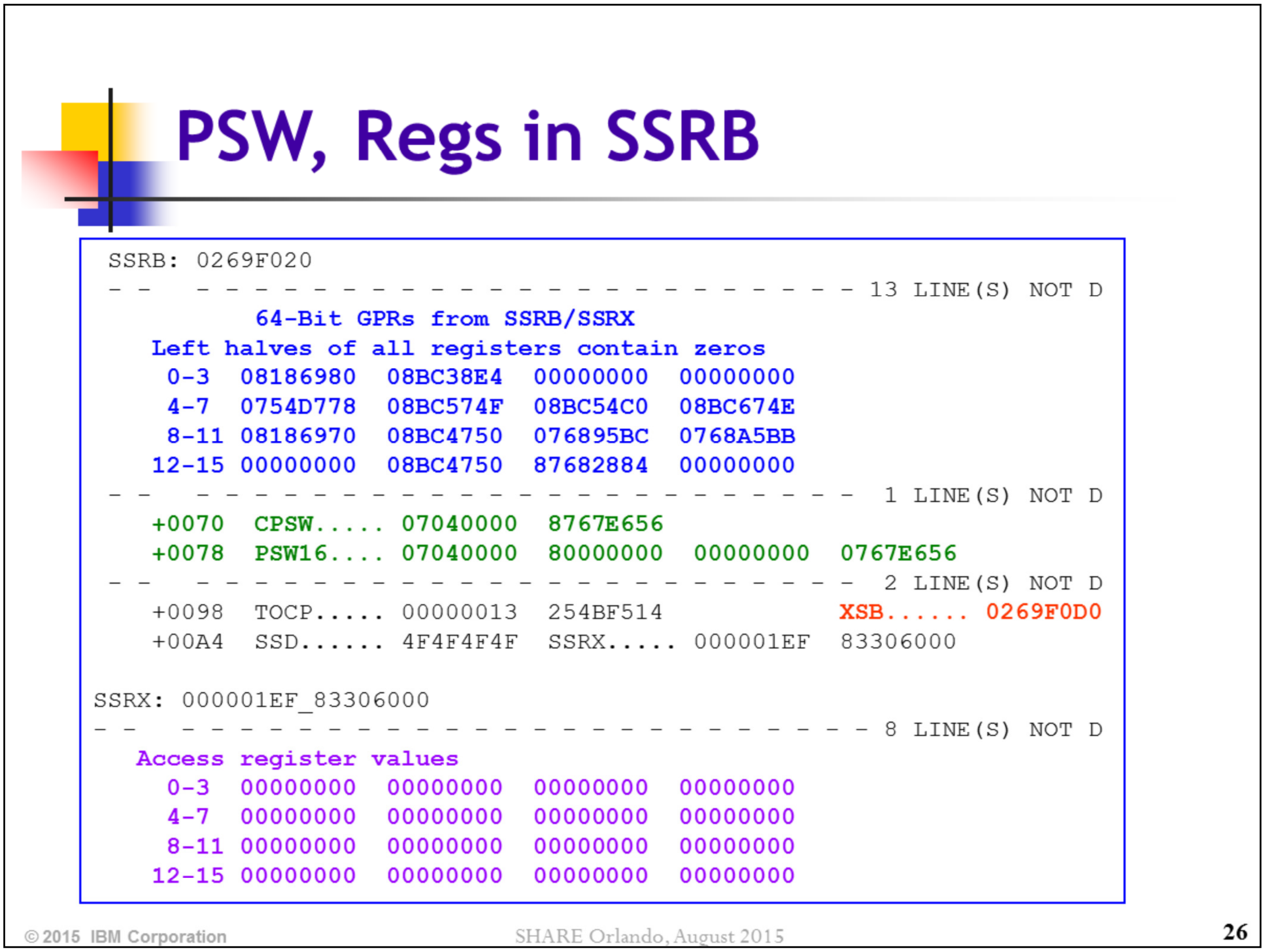
Status: PSW, General Purpose Registers, Access Registers, Cross Memory environment



PSW, Regs in SSRB

```
 SSRB: 0269F020
 - -   - - - - - - - - - - - - - - - - - - - - - - - - 13 LINE(S) NOT D
           64-Bit GPRs from SSRB/SSRX
    Left halves of all registers contain zeros
     0-3   08186980   08BC38E4   00000000   00000000
     4-7   0754D778   08BC574F   08BC54C0   08BC674E
     8-11  08186970   08BC4750   076895BC   0768A5BB
    12-15  00000000   08BC4750   87682884   00000000
 - -   - - - - - - - - - - - - - - - - - - - - - - - -  1 LINE(S) NOT D
    +0070  CPSW.....  07040000   8767E656
    +0078  PSW16....  07040000   80000000   00000000   0767E656
 - -   - - - - - - - - - - - - - - - - - - - - - - - -  2 LINE(S) NOT D
    +0098  TOCP.....  00000013   254BF514              XSB...... 0269F0D0
    +00A4  SSD......  4F4F4F4F   SSRX.....  000001EF   83306000

SSRX: 000001EF_83306000
- -   - - - - - - - - - - - - - - - - - - - - - - - - - 8 LINE(S) NOT D
   Access register values
     0-3   00000000   00000000   00000000   00000000
     4-7   00000000   00000000   00000000   00000000
     8-11  00000000   00000000   00000000   00000000
    12-15  00000000   00000000   00000000   00000000
```

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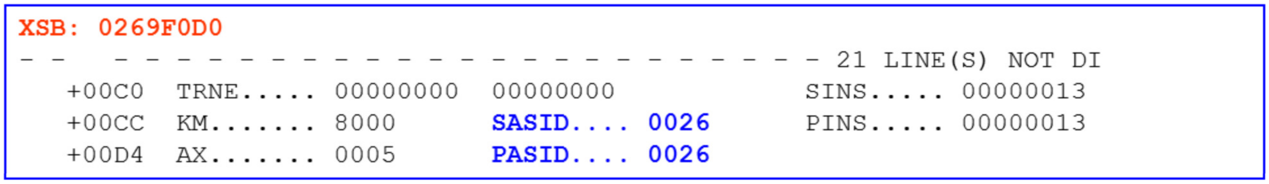
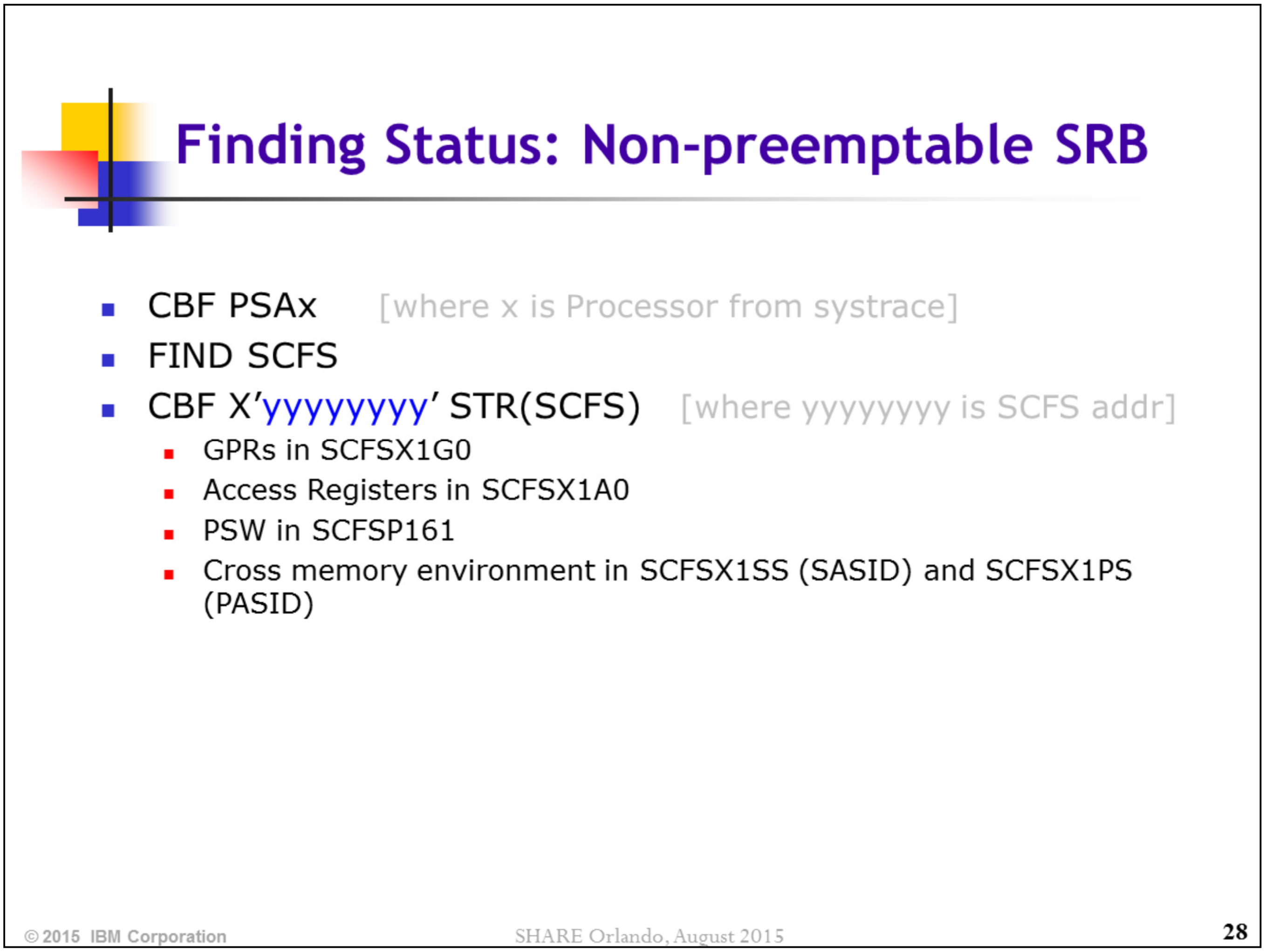
SSRBCPSW is the “scrunched” version of SSRBPSW16. Technically SSRBPSW16 is the correct PSW to use now that there is limited execution allowed above the bar. However, the number of exploiters is in fact so small that debuggers can get away with still using SSRBCPSW virtually 100% of the time. Several IPCS reporting execs still format SSRBCPSW instead of SSRBPSW16.

PSW, Regs, XMEM info in XSB



```
XSB: 0269F0D0
- -   - - - - - - - - - - - - - - - - - - - - - - - 21 LINE(S) NOT DI
   +00C0  TRNE..... 00000000  00000000            SINS..... 00000013
   +00CC  KM....... 8000      SASID.... 0026      PINS..... 00000013
   +00D4  AX....... 0005      PASID.... 0026
```

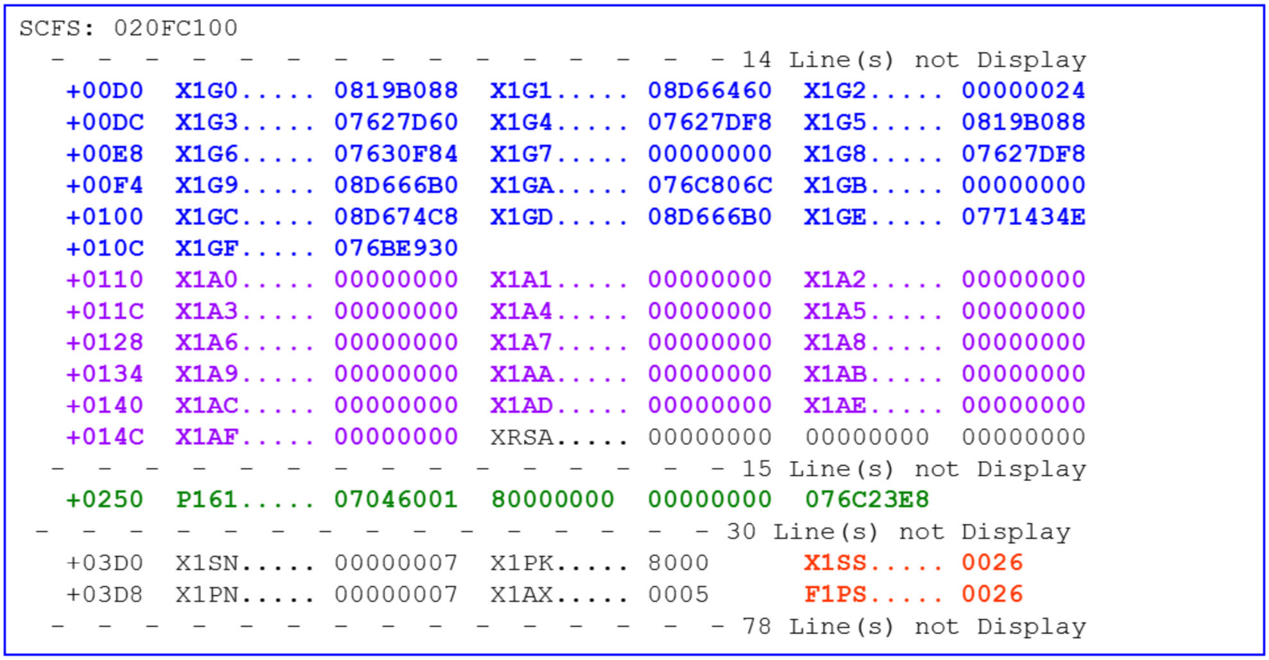


Finding Status: Non-preemptable SRB

- CBF PSAx [where x is Processor from systrace]
- FIND SCFS
- CBF X'yyyyyyyy' STR(SCFS) [where yyyyyyyy is SCFS addr]
  - GPRs in SCFSX1G0
  - Access Registers in SCFSX1A0
  - PSW in SCFSP161
  - Cross memory environment in SCFSX1SS (SASID) and SCFSX1PS (PASID)

Status: PSW, General Purpose Registers, Access Registers, Cross Memory environment

PSW, Regs, XMEM info in SCFS



```
SCFS: 020FC100
  -  -  -  -  -  -  -  -  -  -  -  -  -  -  - 14 Line(s) not Display
    +00D0  X1G0..... 0819B088  X1G1..... 08D66460  X1G2..... 00000024
    +00DC  X1G3..... 07627D60  X1G4..... 07627DF8  X1G5..... 0819B088
    +00E8  X1G6..... 07630F84  X1G7..... 00000000  X1G8..... 07627DF8
    +00F4  X1G9..... 08D666B0  X1GA..... 076C806C  X1GB..... 00000000
    +0100  X1GC..... 08D674C8  X1GD..... 08D666B0  X1GE..... 0771434E
    +010C  X1GF..... 076BE930
    +0110  X1A0..... 00000000  X1A1..... 00000000  X1A2..... 00000000
    +011C  X1A3..... 00000000  X1A4..... 00000000  X1A5..... 00000000
    +0128  X1A6..... 00000000  X1A7..... 00000000  X1A8..... 00000000
    +0134  X1A9..... 00000000  X1AA..... 00000000  X1AB..... 00000000
    +0140  X1AC..... 00000000  X1AD..... 00000000  X1AE..... 00000000
    +014C  X1AF..... 00000000  XRSA..... 00000000  00000000  00000000
  -  -  -  -  -  -  -  -  -  -  -  -  -  -  - 15 Line(s) not Display
    +0250  P161..... 07046001  80000000  00000000  076C23E8
 -  -  -  -  -  -  -  -  -  -  -  -  -  -  - 30 Line(s) not Display
    +03D0  X1SN..... 00000007  X1PK..... 8000      X1SS..... 0026
    +03D8  X1PN..... 00000007  X1AX..... 0005      F1PS..... 0026
  -  -  -  -  -  -  -  -  -  -  -  -  -  -  - 78 Line(s) not Display
```

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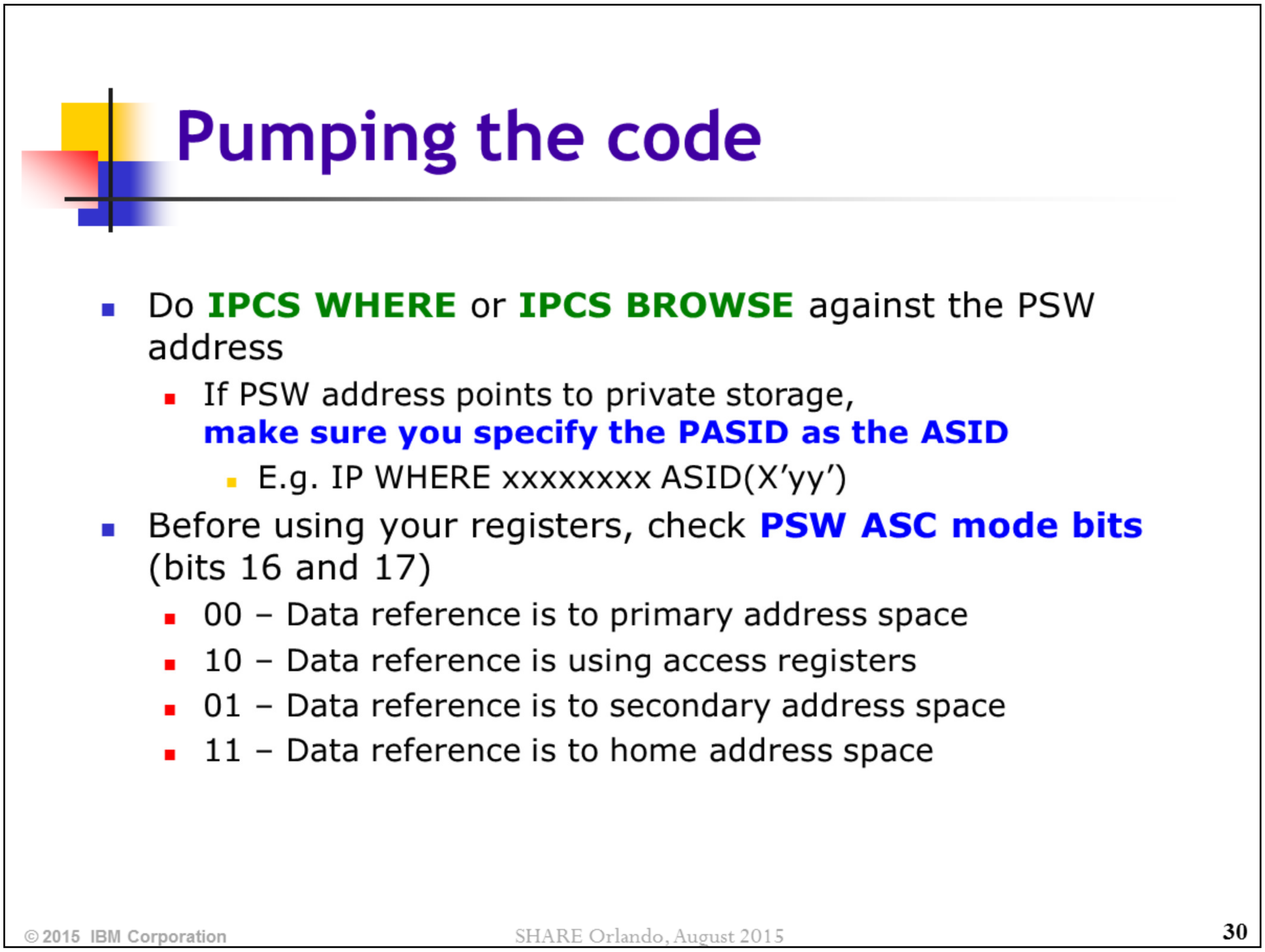
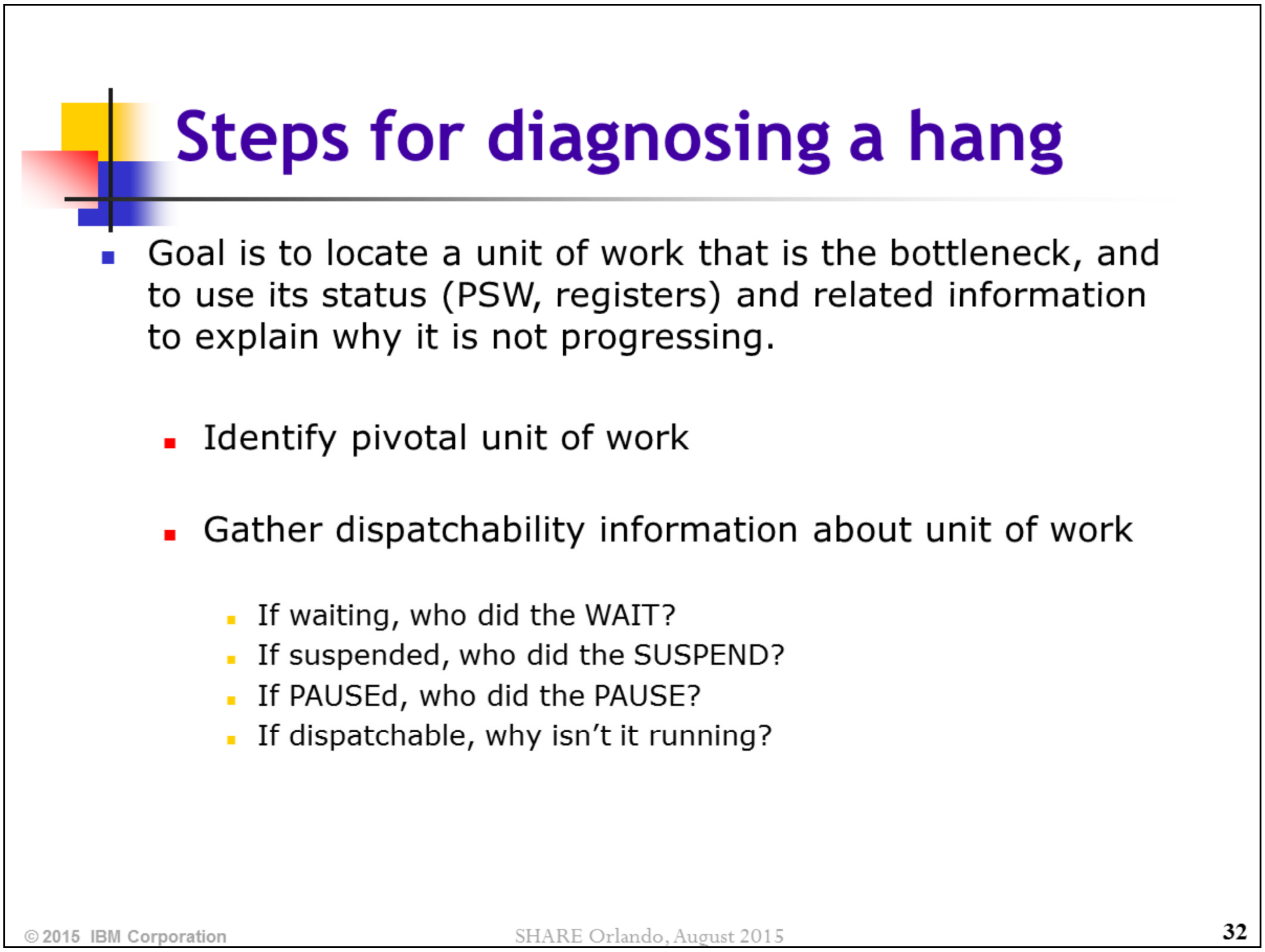


Pumping the code

- Do **IPCS WHERE** or **IPCS BROWSE** against the PSW address
  - If PSW address points to private storage, **make sure you specify the PASID as the ASID**
    - E.g. IP WHERE xxxxxxxx ASID(X'yy')
- Before using your registers, check **PSW ASC mode bits** (bits 16 and 17)
  - 00 – Data reference is to primary address space
  - 10 – Data reference is using access registers
  - 01 – Data reference is to secondary address space
  - 11 – Data reference is to home address space

Diagnosing Hangs



Steps for diagnosing a hang

- Goal is to locate a unit of work that is the bottleneck, and to use its status (PSW, registers) and related information to explain why it is not progressing.
  - Identify pivotal unit of work
  - Gather dispatchability information about unit of work
    - If waiting, who did the WAIT?
    - If suspended, who did the SUSPEND?
    - If PAUSEd, who did the PAUSE?
    - If dispatchable, why isn’t it running?

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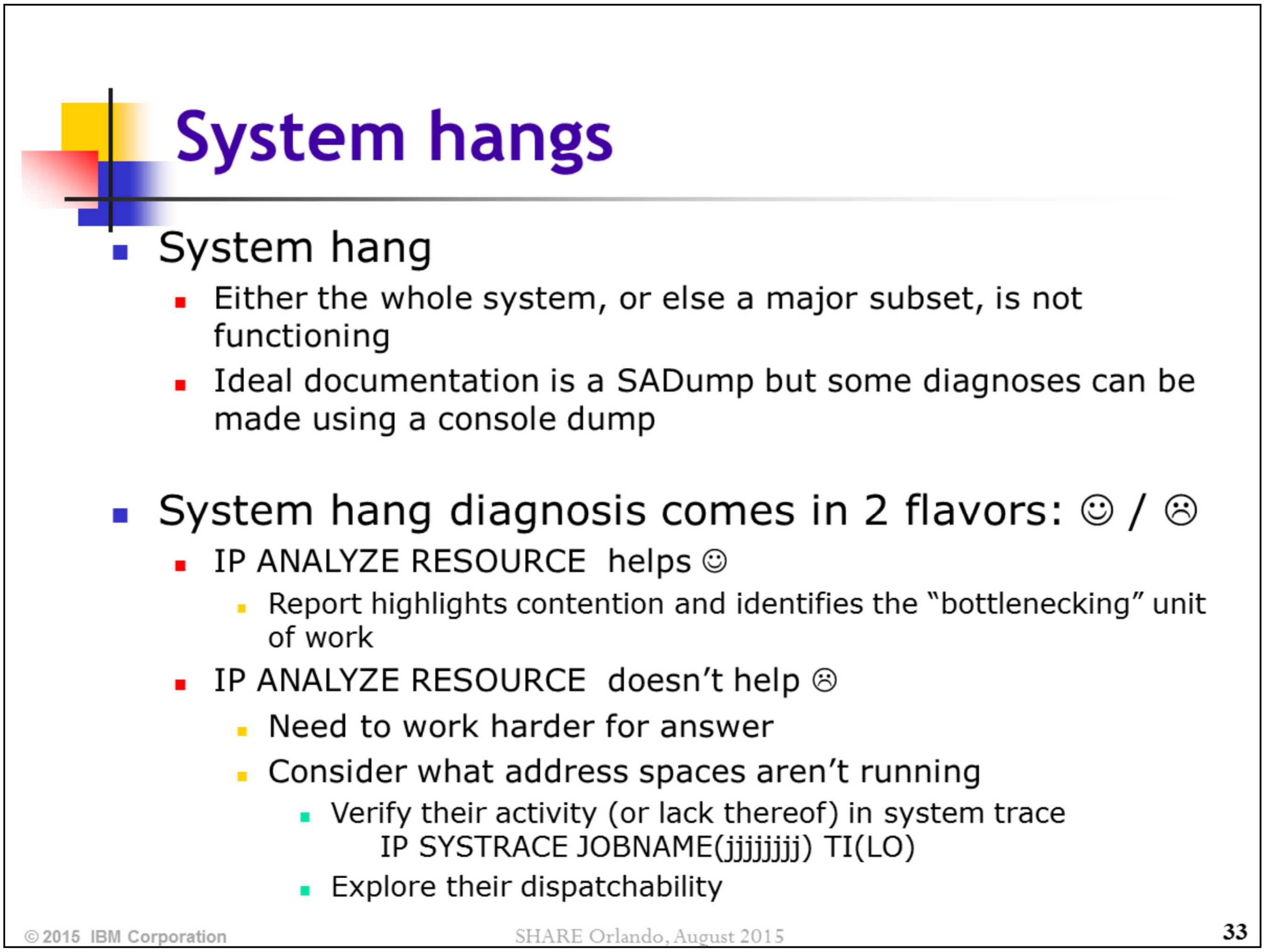
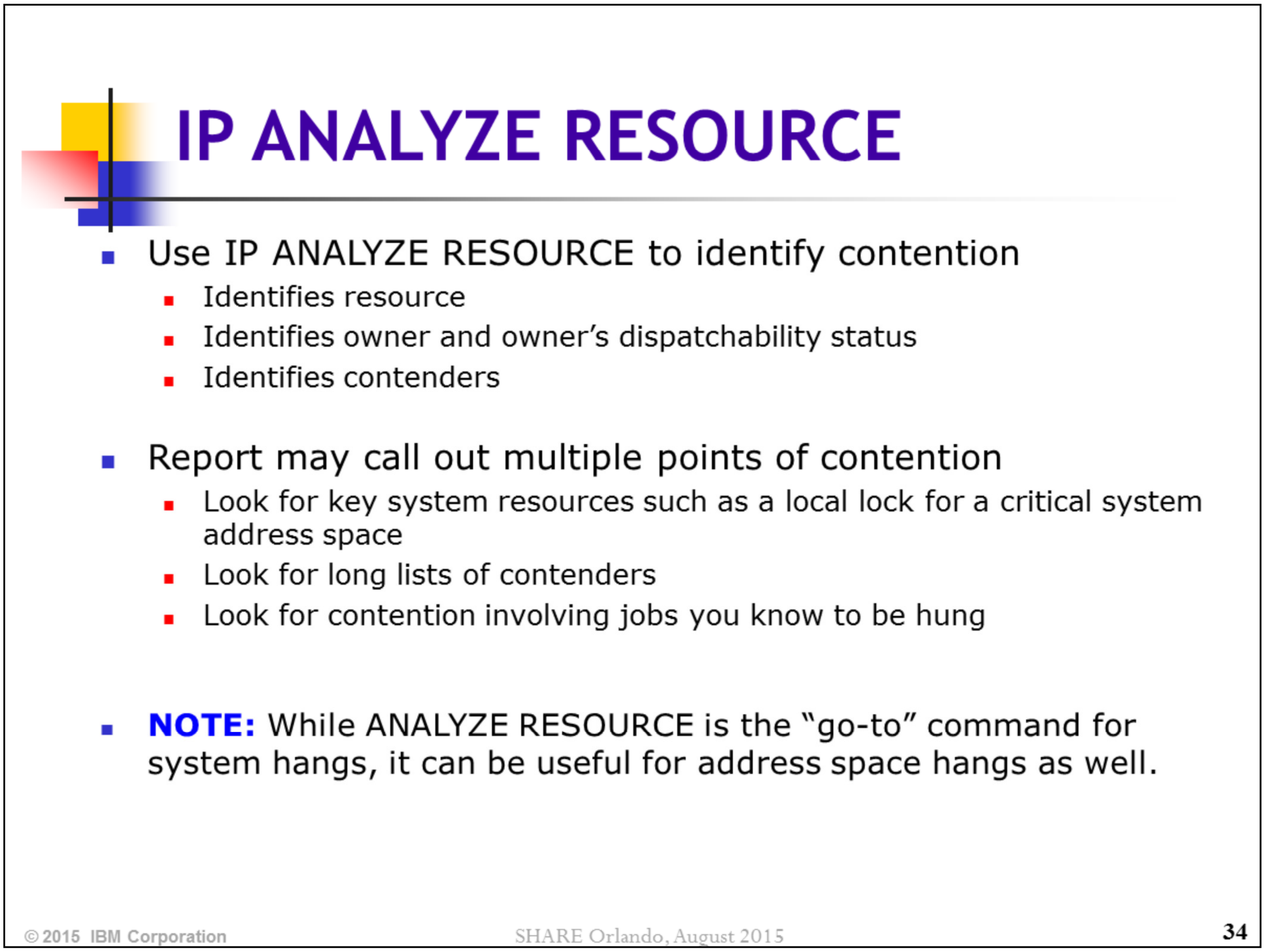


System hangs

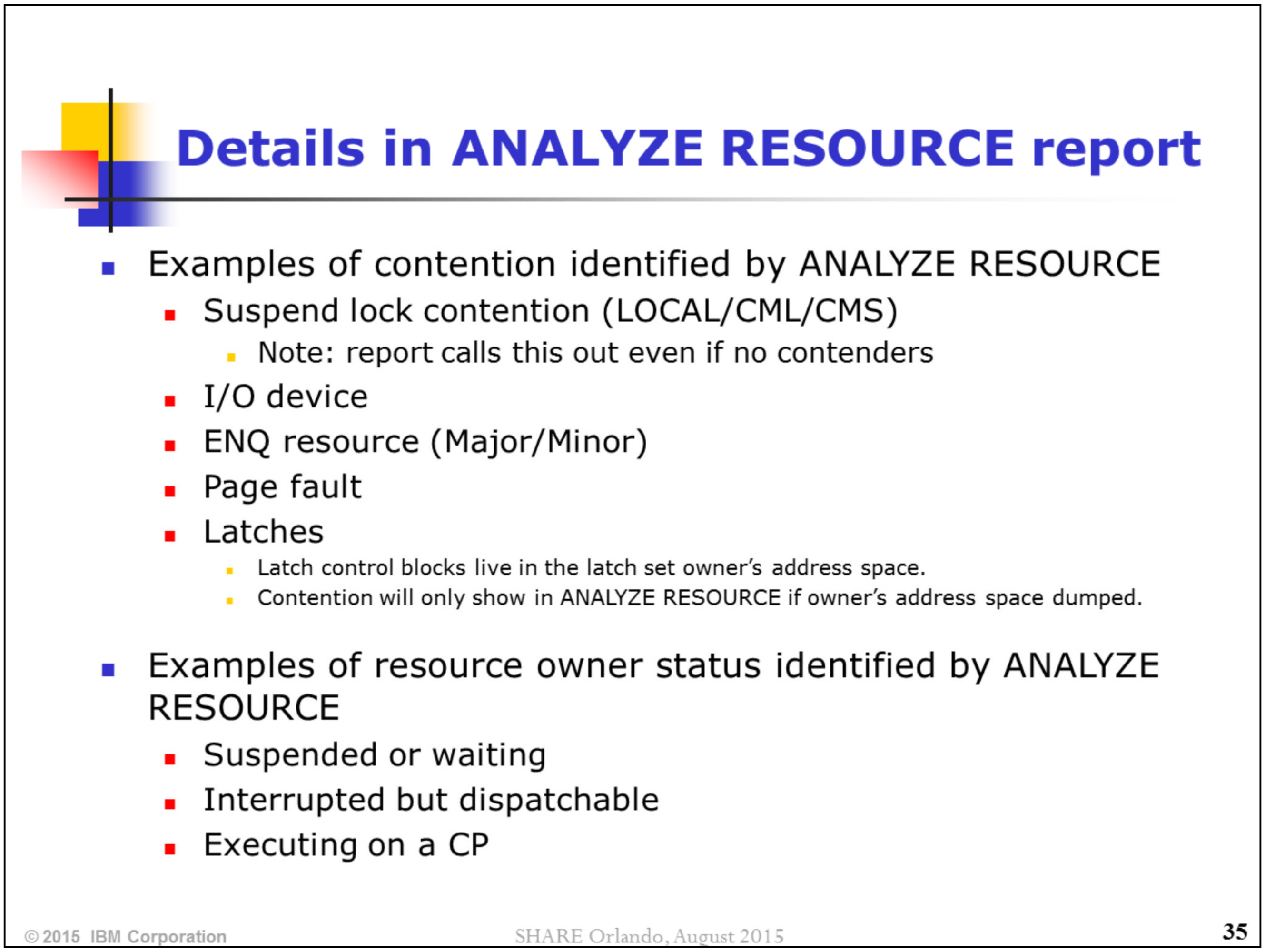
- System hang
  - Either the whole system, or else a major subset, is not functioning
  - Ideal documentation is a SADump but some diagnoses can be made using a console dump

- System hang diagnosis comes in 2 flavors: ☺ / ☹
  - IP ANALYZE RESOURCE helps ☺
    - Report highlights contention and identifies the "bottlenecking" unit of work
  - IP ANALYZE RESOURCE doesn't help ☹
    - Need to work harder for answer
    - Consider what address spaces aren't running
      - Verify their activity (or lack thereof) in system trace
        IP SYSTRACE JOBNAME(jjjjjjjj) TI(LO)
      - Explore their dispatchability



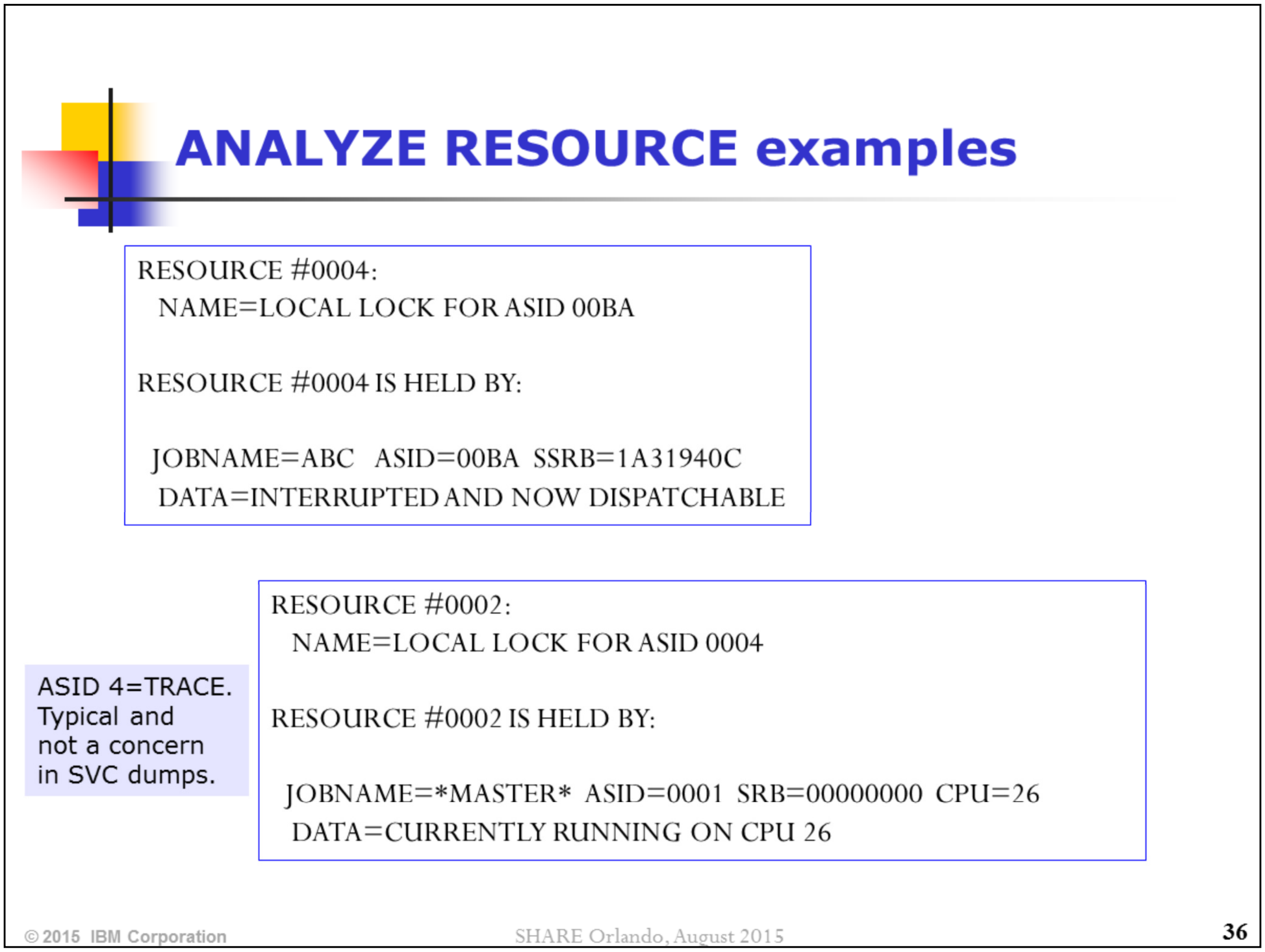
IP ANALYZE RESOURCE

- Use IP ANALYZE RESOURCE to identify contention
  - Identifies resource
  - Identifies owner and owner's dispatchability status
  - Identifies contenders
- Report may call out multiple points of contention
  - Look for key system resources such as a local lock for a critical system address space
  - Look for long lists of contenders
  - Look for contention involving jobs you know to be hung
- **NOTE:** While ANALYZE RESOURCE is the "go-to" command for system hangs, it can be useful for address space hangs as well.



Details in ANALYZE RESOURCE report

- Examples of contention identified by ANALYZE RESOURCE
  - Suspend lock contention (LOCAL/CML/CMS)
    - Note: report calls this out even if no contenders
  - I/O device
  - ENQ resource (Major/Minor)
  - Page fault
  - Latches
    - Latch control blocks live in the latch set owner's address space.
    - Contention will only show in ANALYZE RESOURCE if owner's address space dumped.
- Examples of resource owner status identified by ANALYZE RESOURCE
  - Suspended or waiting
  - Interrupted but dispatchable
  - Executing on a CP



ANALYZE RESOURCE examples

```
RESOURCE #0004:
  NAME=LOCAL LOCK FOR ASID 00BA

RESOURCE #0004 IS HELD BY:

 JOBNAME=ABC   ASID=00BA  SSRB=1A31940C
  DATA=INTERRUPTED AND NOW DISPATCHABLE
```

ASID 4=TRACE. Typical and not a concern in SVC dumps.

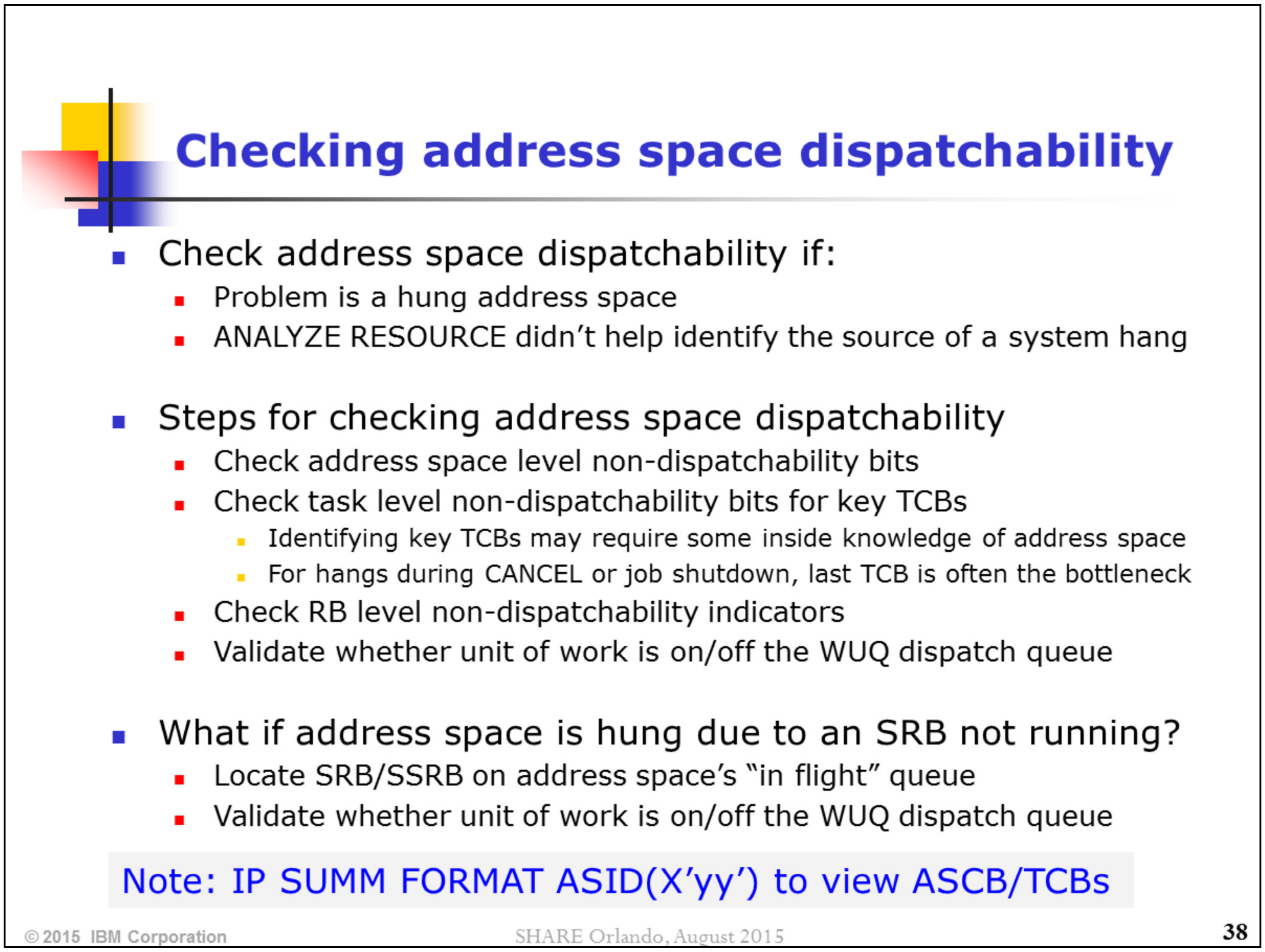
```
RESOURCE #0002:
  NAME=LOCAL LOCK FOR ASID 0004

RESOURCE #0002 IS HELD BY:

 JOBNAME=*MASTER*  ASID=0001  SRB=00000000  CPU=26
  DATA=CURRENTLY RUNNING ON CPU 26
```

ASID 4 is the TRACE address space. A trace table is “snapped” as part of dump processing, and doing this requires the local lock of the TRACE address space.

ANALYZE RESOURCE examples

```
RESOURCE #0002:
  NAME=MAJOR=CATLGRES MINOR=CAS SCOPE=SYSTEM

RESOURCE #0002 IS HELD BY:

 JOBNAME=CATALOG   ASID=0031 TCB=008AC680

RESOURCE #0002 IS REQUIRED BY:

 JOBNAME=PBLPROG  ASID=0117 TCB=008D1210
```

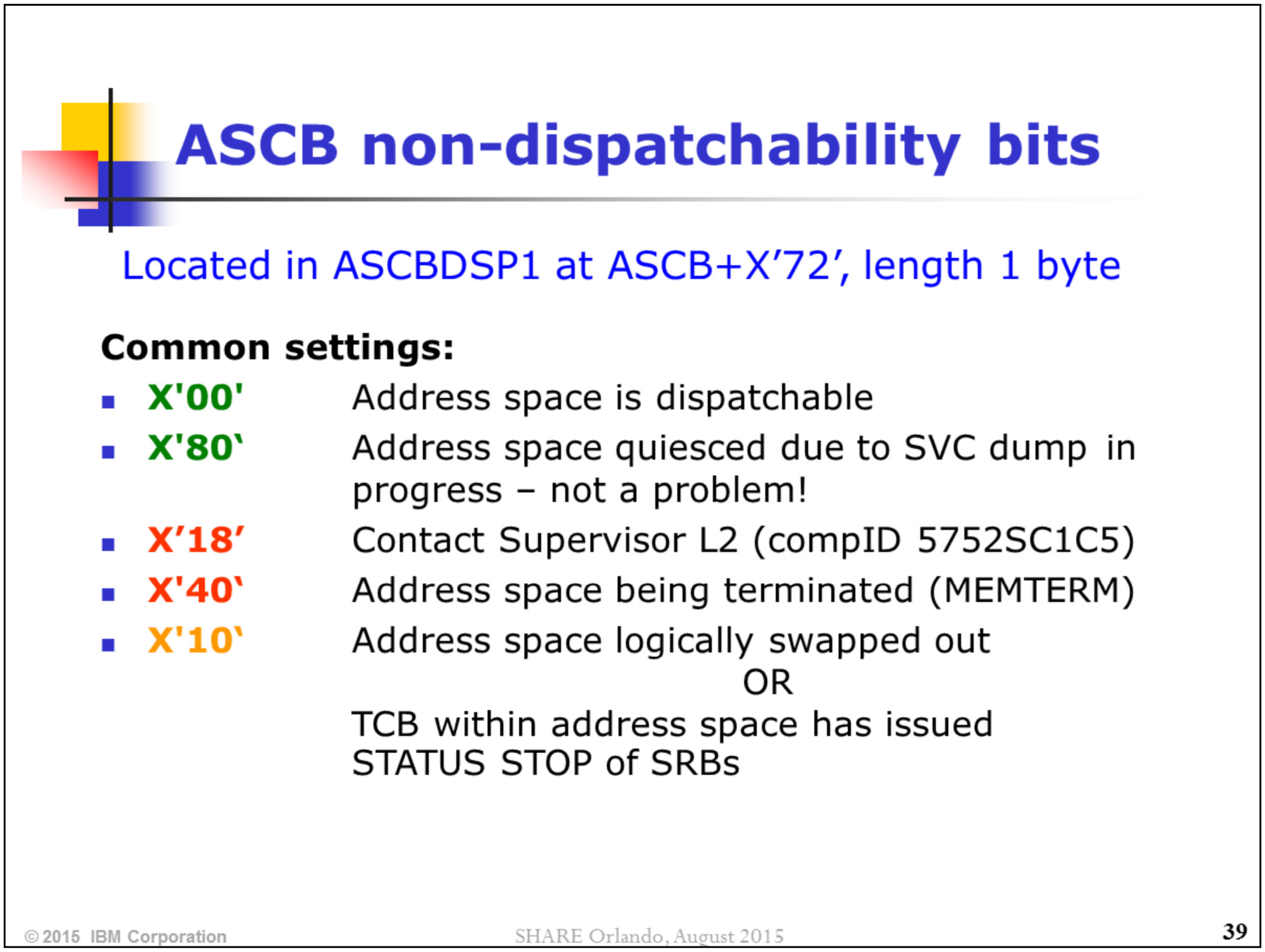
No dispatchability status;
Perhaps CATALOG job was
not in dump.



Checking address space dispatchability

- Check address space dispatchability if:
  - Problem is a hung address space
  - ANALYZE RESOURCE didn’t help identify the source of a system hang
- Steps for checking address space dispatchability
  - Check address space level non-dispatchability bits
  - Check task level non-dispatchability bits for key TCBs
    - Identifying key TCBs may require some inside knowledge of address space
    - For hangs during CANCEL or job shutdown, last TCB is often the bottleneck
  - Check RB level non-dispatchability indicators
  - Validate whether unit of work is on/off the WUQ dispatch queue
- What if address space is hung due to an SRB not running?
  - Locate SRB/SSRB on address space’s “in flight” queue
  - Validate whether unit of work is on/off the WUQ dispatch queue

Note: IP SUMM FORMAT ASID(X’yy’) to view ASCB/TCBs

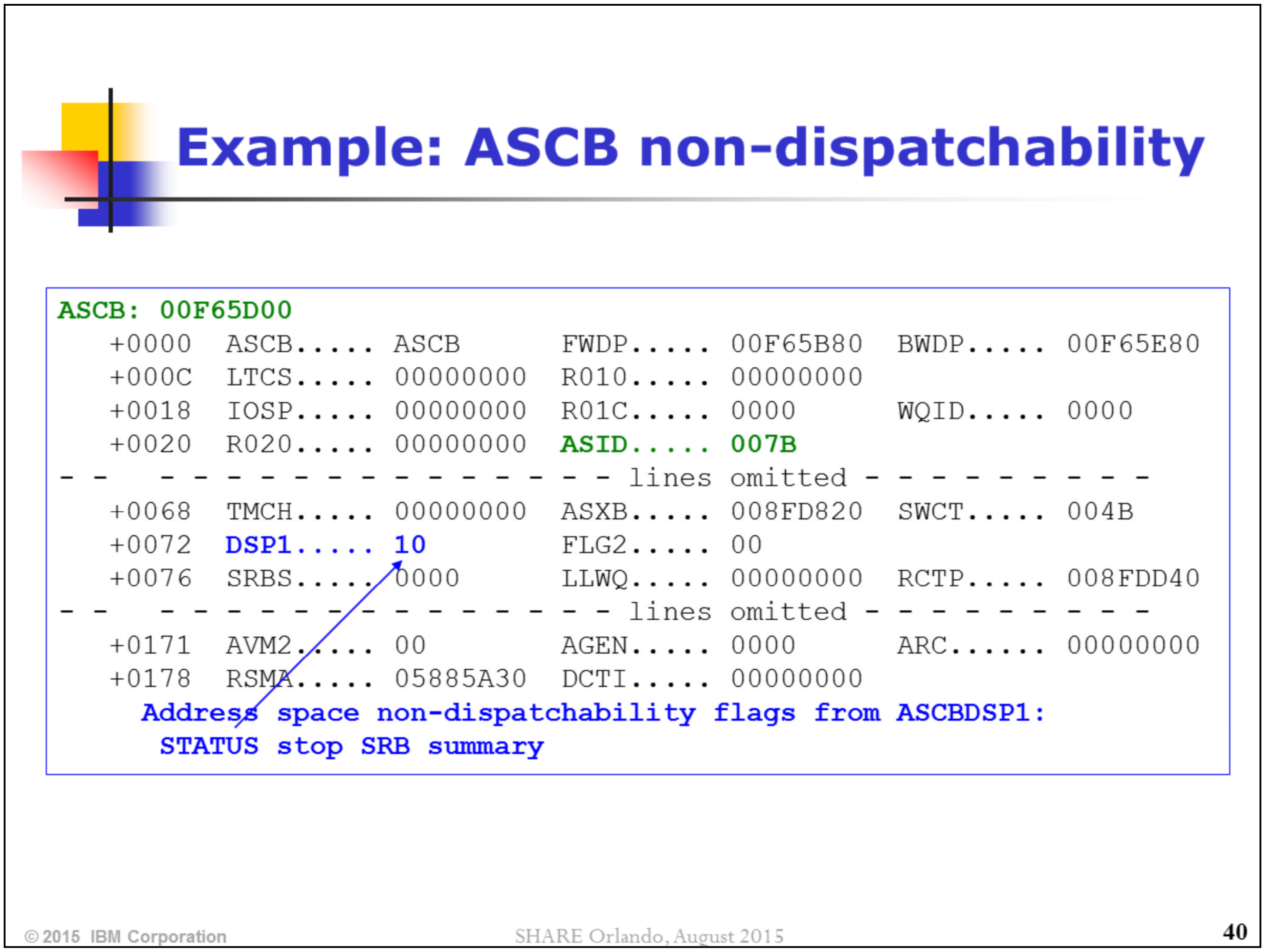


ASCB non-dispatchability bits

Located in ASCBDSP1 at ASCB+X’72’, length 1 byte

Common settings:

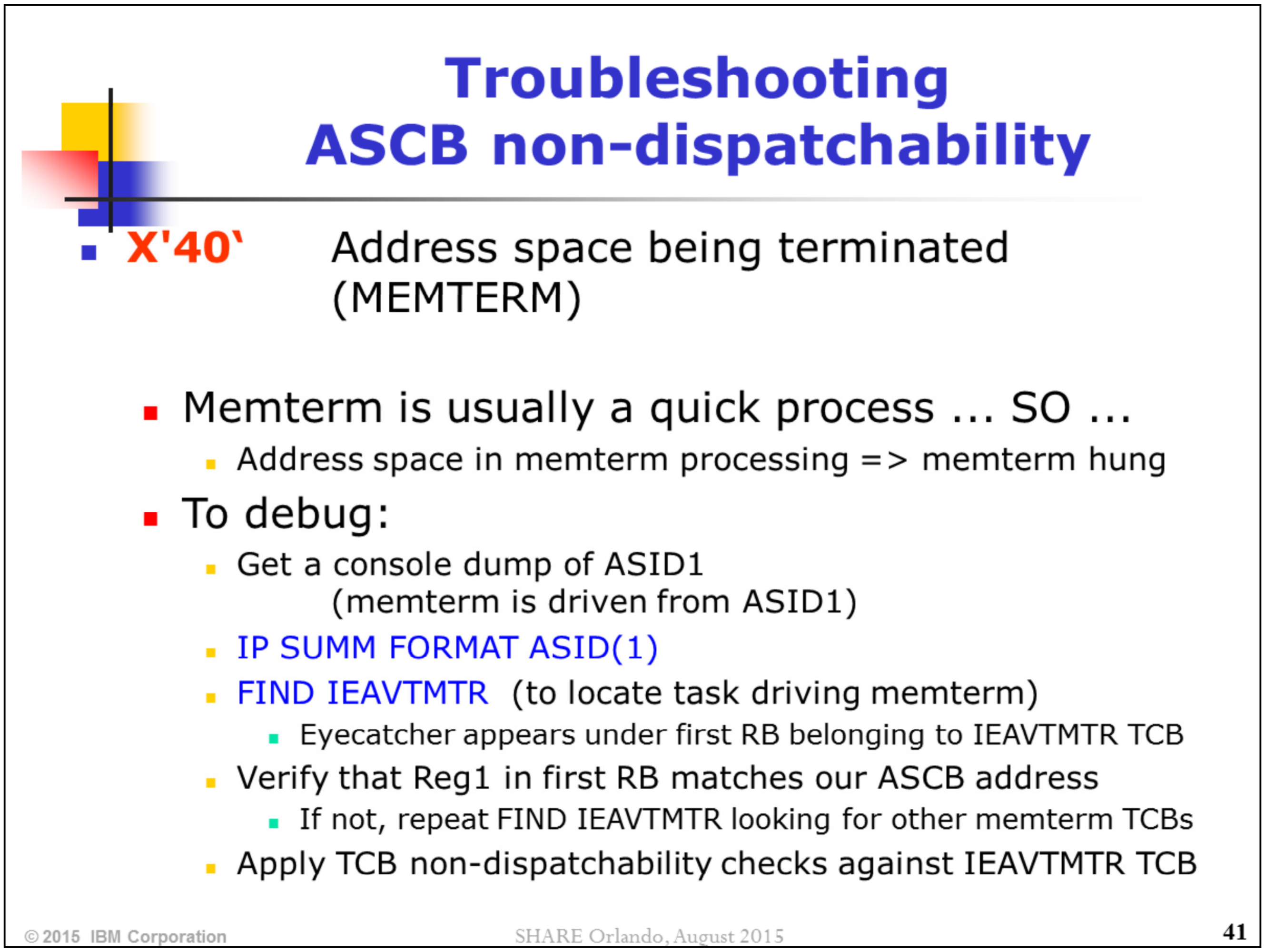
- **X'00'** Address space is dispatchable
- **X'80‛** Address space quiesced due to SVC dump in progress – not a problem!
- **X’18’** Contact Supervisor L2 (compID 5752SC1C5)
- **X'40‛** Address space being terminated (MEMTERM)
- **X'10‛** Address space logically swapped out
  OR
  TCB within address space has issued STATUS STOP of SRBs



Example: ASCB non-dispatchability

```
ASCB: 00F65D00
    +0000  ASCB..... ASCB      FWDP..... 00F65B80  BWDP..... 00F65E80
    +000C  LTCS..... 00000000  R010..... 00000000
    +0018  IOSP..... 00000000  R01C..... 0000      WQID..... 0000
    +0020  R020..... 00000000  ASID..... 007B
- -   - - - - - - - - - - - - - - lines omitted - - - - - - - - -
    +0068  TMCH..... 00000000  ASXB..... 008FD820  SWCT..... 004B
    +0072  DSP1..... 10        FLG2..... 00
    +0076  SRBS..... 0000      LLWQ..... 00000000  RCTP..... 008FDD40
- -   - - - - - - - - - - - - - - lines omitted - - - - - - - - -
    +0171  AVM2..... 00        AGEN..... 0000      ARC...... 00000000
    +0178  RSMA..... 05885A30  DCTI..... 00000000
     Address space non-dispatchability flags from ASCBDSP1:
      STATUS stop SRB summary
```

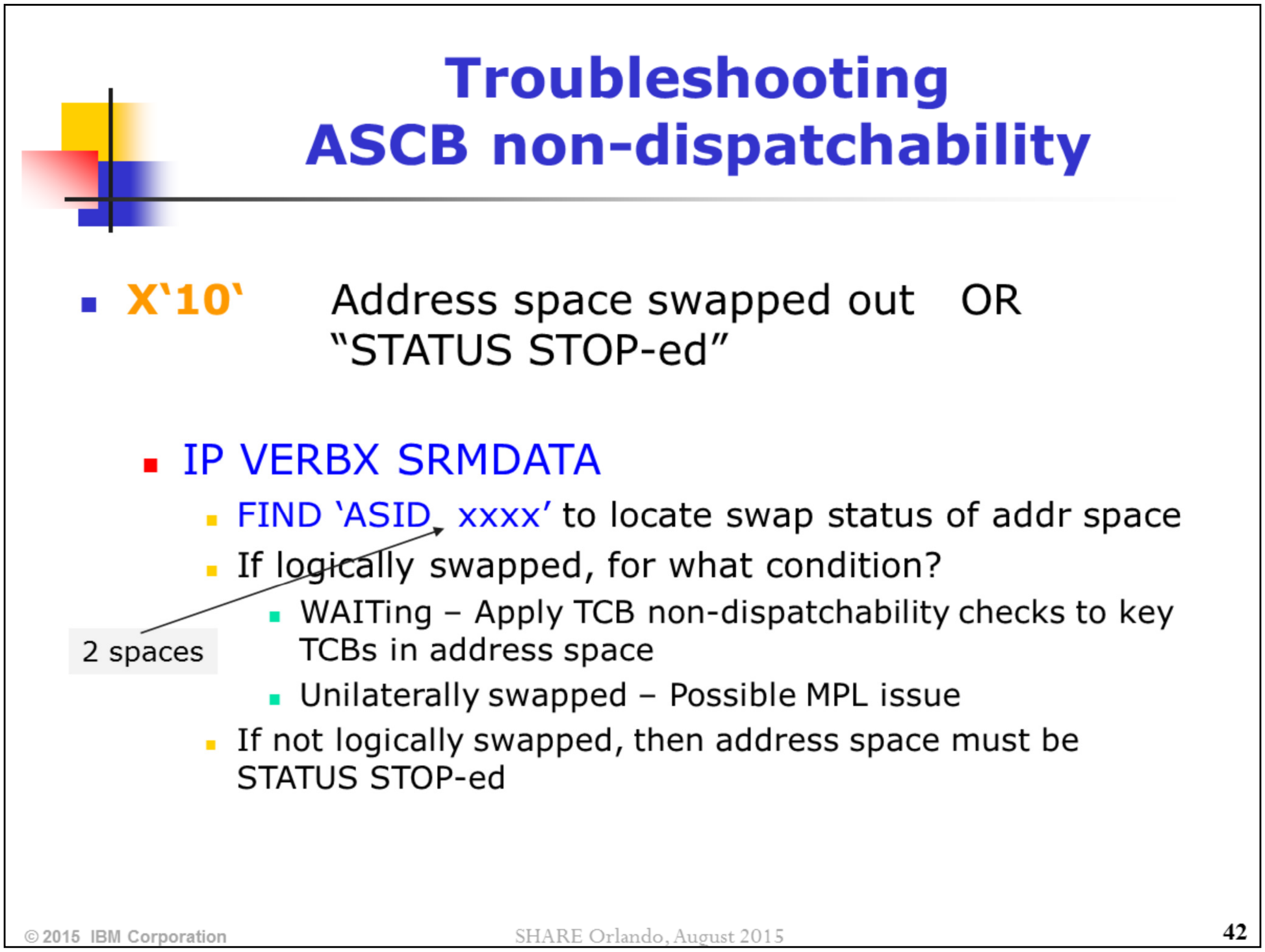
Address space nondisatchability bits in ASCBDSP1 are described verbally immediately underneath the formatted ASCB. Note that if no bits are on, no verbiage will appear.



Troubleshooting ASCB non-dispatchability

- **X'40‛** Address space being terminated (MEMTERM)

- Memterm is usually a quick process … SO …
  - Address space in memterm processing => memterm hung
- To debug:
  - Get a console dump of ASID1
    (memterm is driven from ASID1)
  - IP SUMM FORMAT ASID(1)
  - FIND IEAVTMTR (to locate task driving memterm)
    - Eyecatcher appears under first RB belonging to IEAVTMTR TCB
  - Verify that Reg1 in first RB matches our ASCB address
    - If not, repeat FIND IEAVTMTR looking for other memterm TCBs
  - Apply TCB non-dispatchability checks against IEAVTMTR TCB



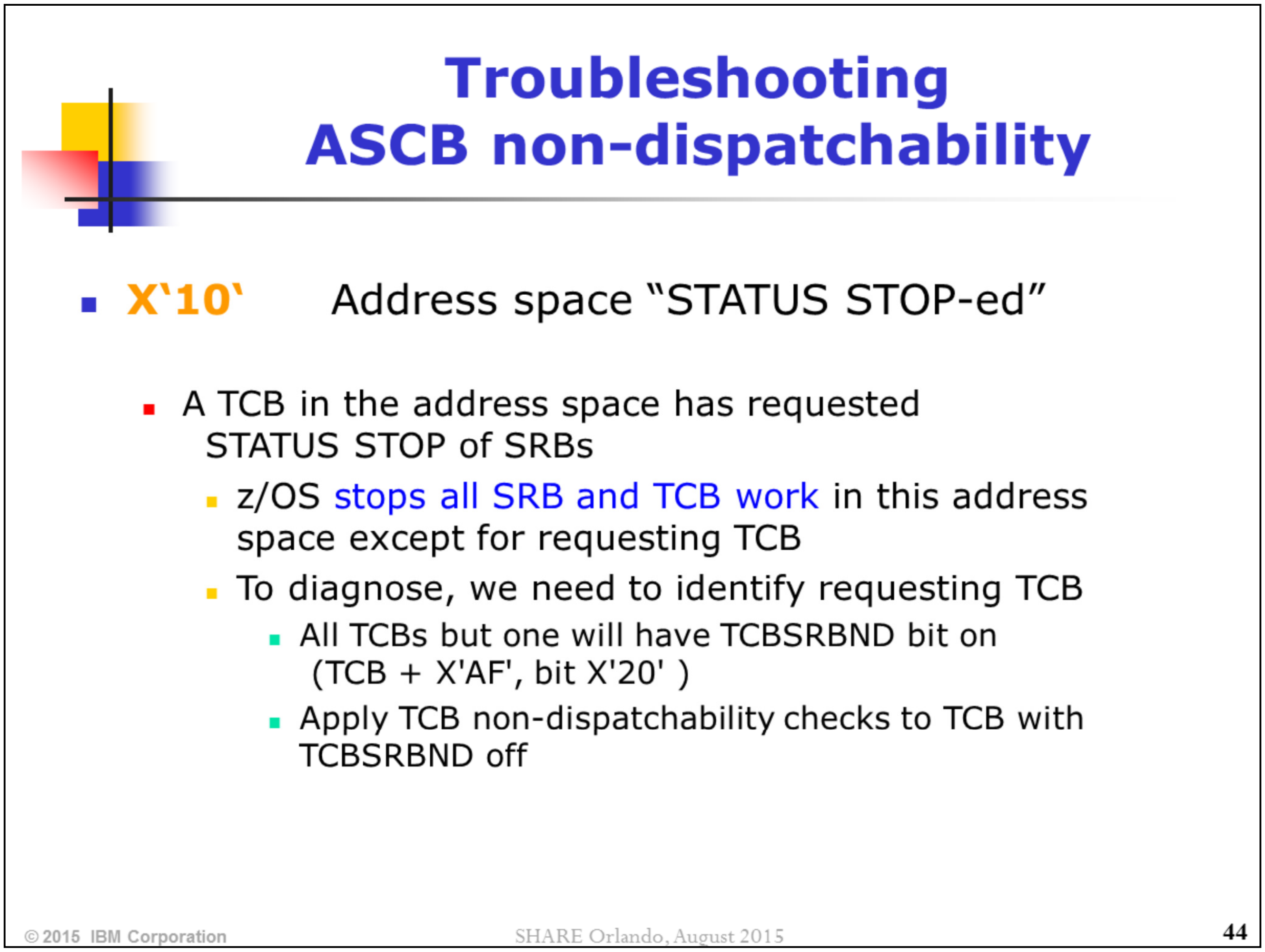
Troubleshooting ASCB non-dispatchability

- **X'10'** Address space swapped out OR "STATUS STOP-ed"
  - IP VERBX SRMDATA
    - FIND 'ASID xxxx' to locate swap status of addr space
    - If logically swapped, for what condition?
      - WAITing – Apply TCB non-dispatchability checks to key TCBs in address space
      - Unilaterally swapped – Possible MPL issue
    - If not logically swapped, then address space must be STATUS STOP-ed

2 spaces

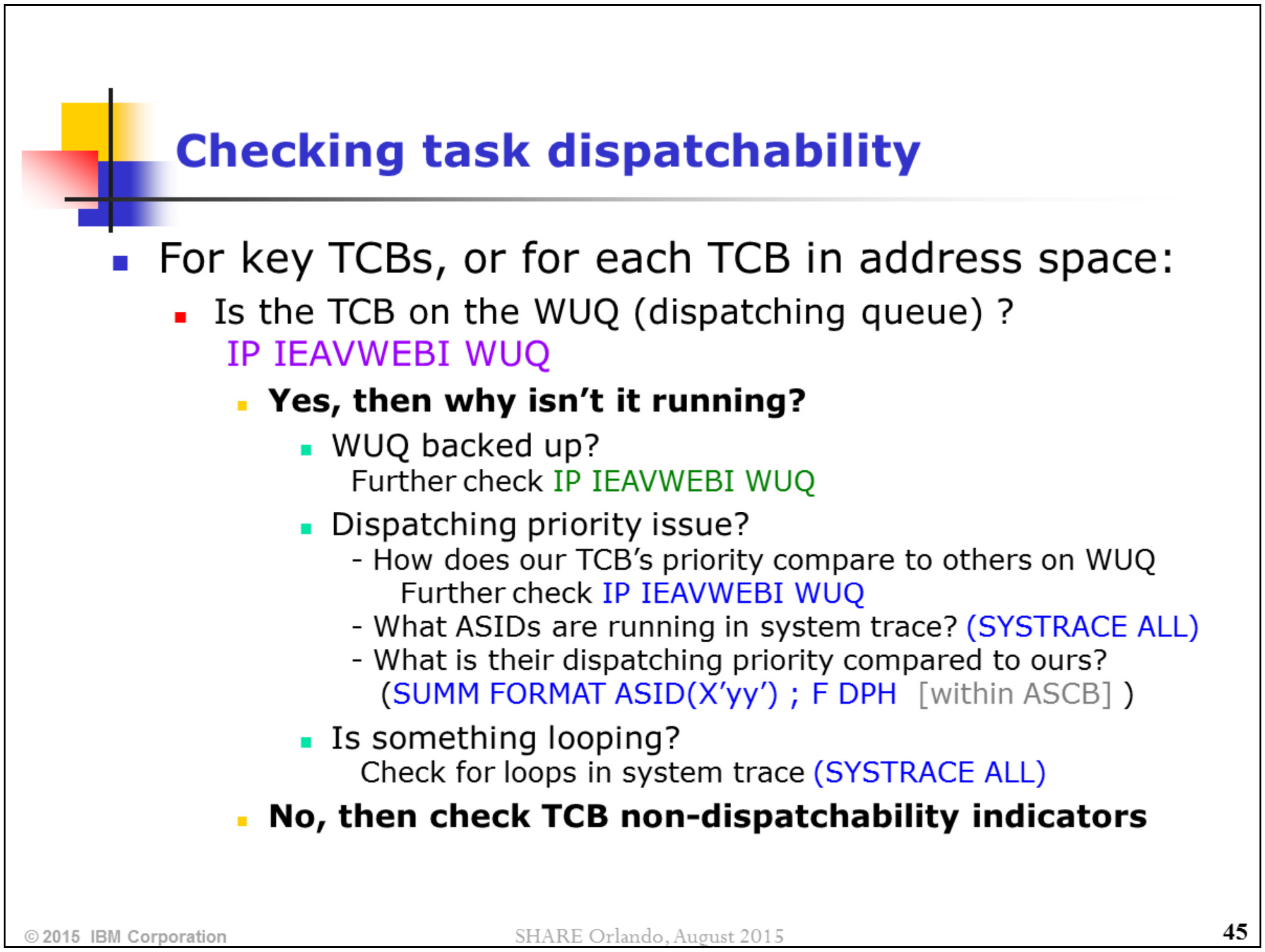
Example: VERBX SRMDATA

```
JOB   INIT
ASID  007B
OUCB  04FCB500 LS WAIT QUEUE
                +10 (LSW)  LOGICALLY SWAPPED
                +11 (PVL)  PRIVILEGED PROGRAM
                +29 (SRC)  SWAP OUT REASON: LONG WAIT
                (ASCBRSME) RAX ADDRESS IS 05885BA8
                           SERVICE CLASS = SYSSTC
                           WORKLOAD = SYSTEM
                           INTERNAL CLASS= $SRMGOOD
                           PERIOD = 01
```



Troubleshooting
ASCB non-dispatchability

- **X‘10‘** Address space “STATUS STOP-ed”
  - A TCB in the address space has requested STATUS STOP of SRBs
    - z/OS stops all SRB and TCB work in this address space except for requesting TCB
    - To diagnose, we need to identify requesting TCB
      - All TCBs but one will have TCBSRBND bit on (TCB + X'AF', bit X'20')
      - Apply TCB non-dispatchability checks to TCB with TCBSRBND off



Checking task dispatchability

- For key TCBs, or for each TCB in address space:
  - Is the TCB on the WUQ (dispatching queue) ?
    IP IEAVWEBI WUQ
    - **Yes, then why isn't it running?**
      - WUQ backed up?
        Further check IP IEAVWEBI WUQ
      - Dispatching priority issue?
        - How does our TCB's priority compare to others on WUQ
          Further check IP IEAVWEBI WUQ
        - What ASIDs are running in system trace? (SYSTRACE ALL)
        - What is their dispatching priority compared to ours?
          (SUMM FORMAT ASID(X'yy') ; F DPH [within ASCB])
      - Is something looping?
        Check for loops in system trace (SYSTRACE ALL)
    - **No, then check TCB non-dispatchability indicators**

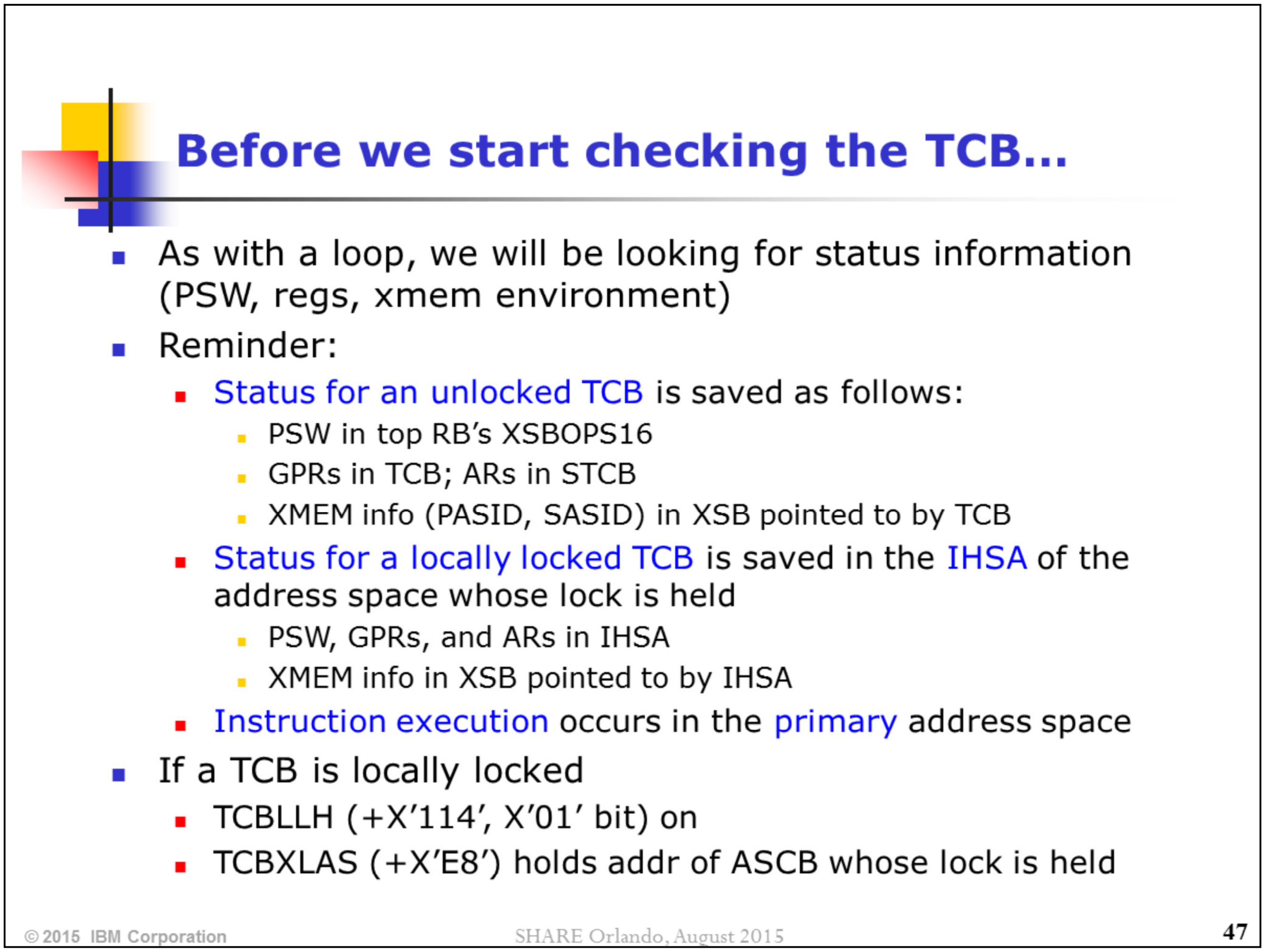
IP IEAVWEBI WUQ report

```
SUMMARY BY WUQ. SORTED BY TOTL:
----------------------------------------
|  WUQ@   | TOTL |PROC|      CPUMASK     |
----------------------------------------|
|0309A800|    156| CP |FE000000 00000000|
|0309A200|      2| CP |80000000 00000000|
|0309AA00|      2|ZIIP|01840000 00000000|
 - -  - - - - - - - - - - - - - - - - - - - - - - - - - - lines omitted - - - - - - - -
SUMMARY BY ASID. SORTED BY TOTL:
-------------------------------------------------------------------------------------
|ASID|JOBNAME | TOTL| ZAAP| ZIIP|TCB  |SSRB |SRB  |MSRB |ESRB |PSRB |FSRB |EXIT |CMLP
|----|--------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|----
|0254|WXYZ    |    8|    0|    0|    0|    0|    8|    0|    0|    0|    0|    0|
 - -  - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
|006F|ABCD    |    1|    0|    0|    1|    0|    0|    0|    0|    0|    0|    0|
|====|========|=====|=====|=====|=====|=====|=====|=====|=====|=====|=====|=====|====
|TOTL|********|  160|    0|    2|   48|    0|   95|    1|    4|    2|    0|    0|
-------------------------------------------------------------------------------------
 - -  - - - - - - - - - - - - - - - - - - - - - - - - - - lines omitted - - - - - - - -
DETAILED INFORMATION FOR WUQ 0309A200, SORTED BY WEB DPH:
---------------------- DATA FROM WEB ----------------------------||--- ASCB DATA ----|
----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8----+
|  WEB@   |TYPE| WEB DPH|  WUQ@   |CLAS| ASCB@   |  WU@    |PROMOTE || JOBNAME|ASID| DPH|
|--------|----|--------|--------|----|--------|--------|--------||--------|----|----|
|045C3100|SRB |40FF8000|0309A200| CP |00FA5200|02157FA0|00000000||XCFAS   |0006|00FF|
|1390BE80|TCB |00F240FF|0309A200| CP |00F12480|008A2CF0|04000000||W1234567|01E1|00F2|
 - -  - - - - - - - - - - - - - - - - - - - -              es omitted - - - - - - - - -|
```

There are actually multiple WUQs. Section shows number of ready-to-run work units on each WUQ; in this example, 156 indicates a busy system with some backup.

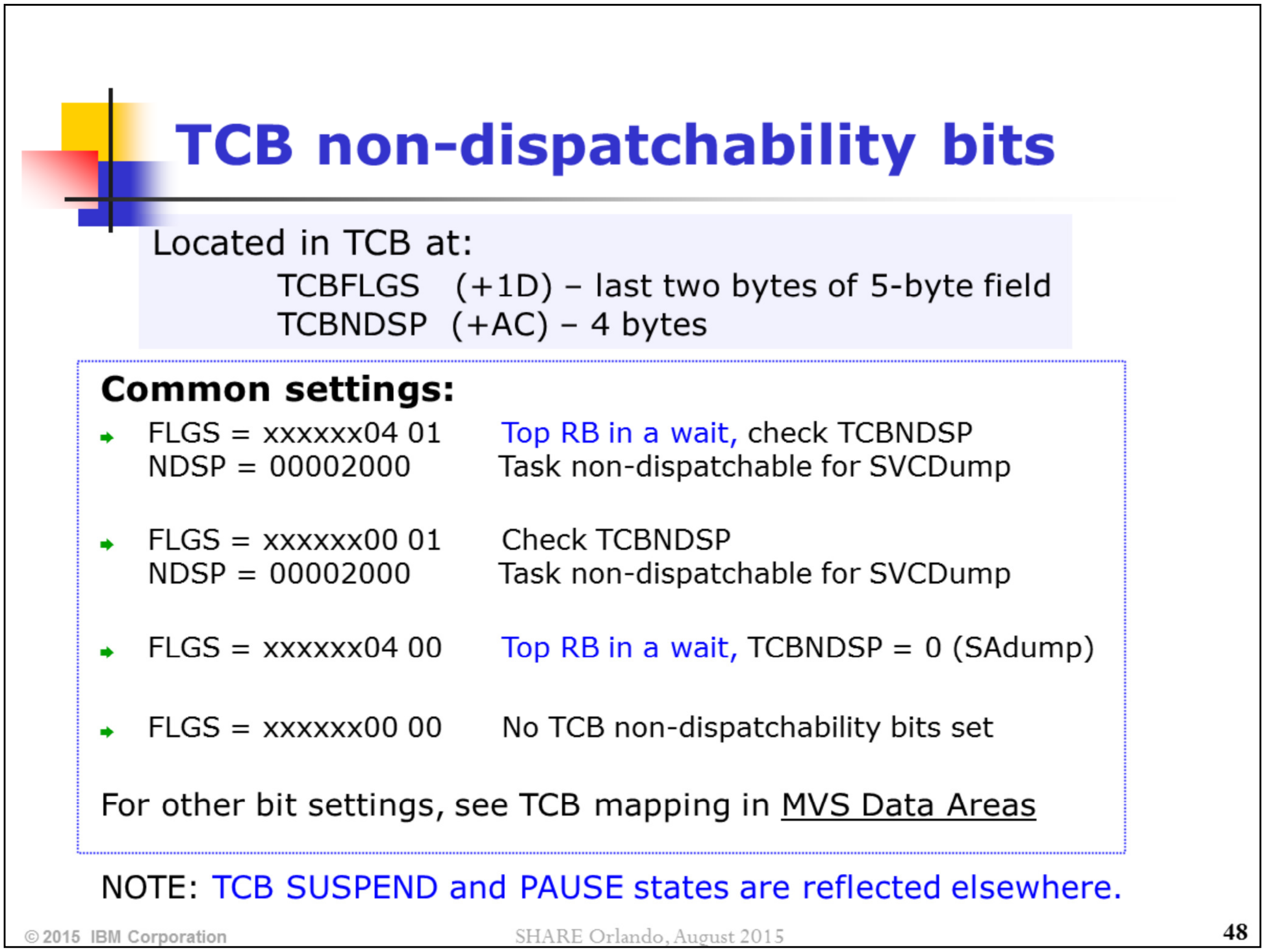
WXYZ has 8 ready SRBs (across all WUQs)

TCB's address



Before we start checking the TCB…

- As with a loop, we will be looking for status information (PSW, regs, xmem environment)
- Reminder:
  - Status for an unlocked TCB is saved as follows:
    - PSW in top RB's XSBOPS16
    - GPRs in TCB; ARs in STCB
    - XMEM info (PASID, SASID) in XSB pointed to by TCB
  - Status for a locally locked TCB is saved in the IHSA of the address space whose lock is held
    - PSW, GPRs, and ARs in IHSA
    - XMEM info in XSB pointed to by IHSA
  - Instruction execution occurs in the primary address space
- If a TCB is locally locked
  - TCBLLH (+X'114', X'01' bit) on
  - TCBXLAS (+X'E8') holds addr of ASCB whose lock is held



TCB non-dispatchability bits

Located in TCB at:

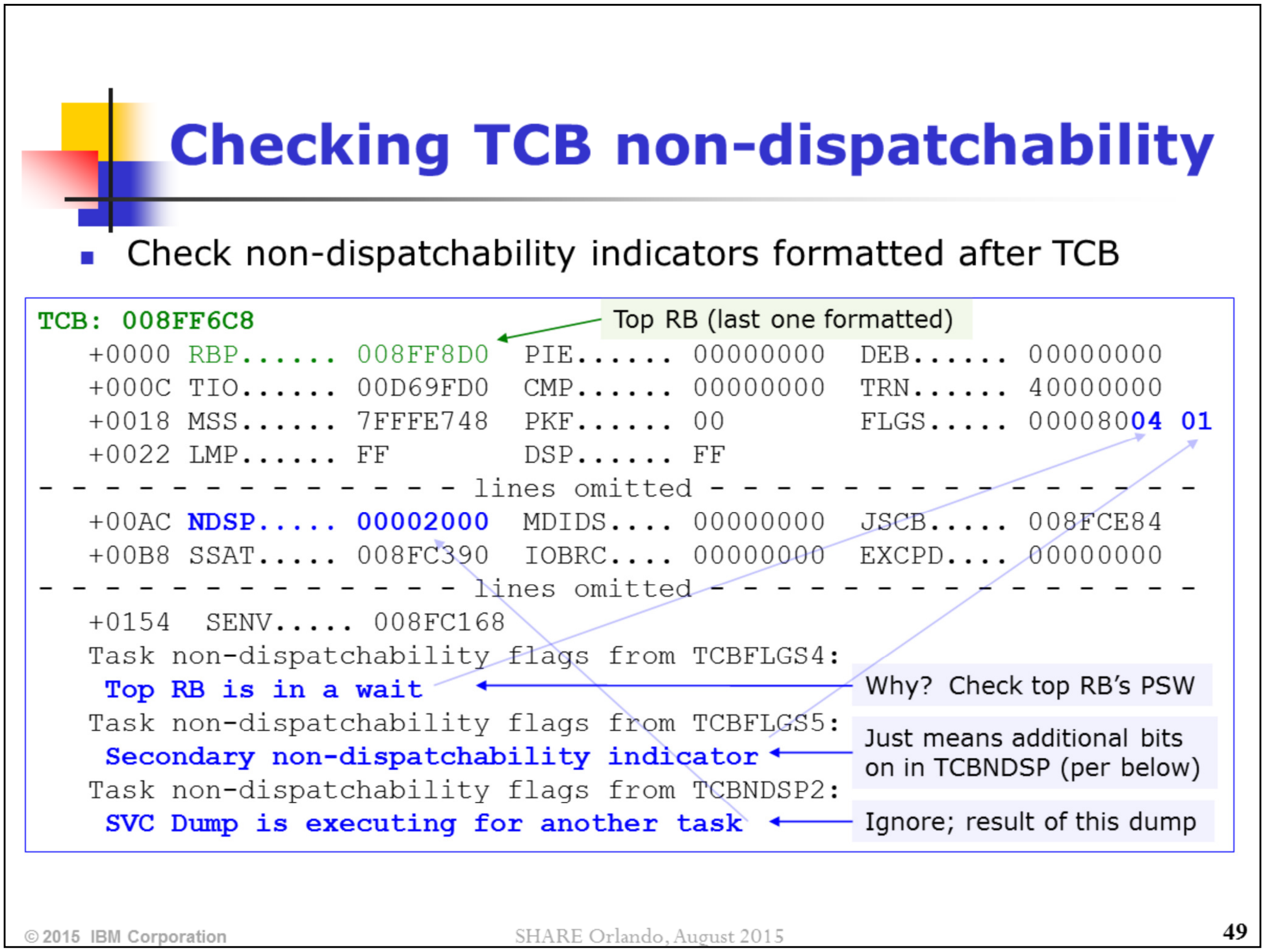
TCBFLGS (+1D) – last two bytes of 5-byte field
TCBNDSP (+AC) – 4 bytes

Common settings:

- FLGS = xxxxxx04 01 Top RB in a wait, check TCBNDSP
  NDSP = 00002000 Task non-dispatchable for SVCDump
- FLGS = xxxxxx00 01 Check TCBNDSP
  NDSP = 00002000 Task non-dispatchable for SVCDump
- FLGS = xxxxxx04 00 Top RB in a wait, TCBNDSP = 0 (SAdump)
- FLGS = xxxxxx00 00 No TCB non-dispatchability bits set

For other bit settings, see TCB mapping in MVS Data Areas

NOTE: TCB SUSPEND and PAUSE states are reflected elsewhere.



Checking TCB non-dispatchability

- Check non-dispatchability indicators formatted after TCB

```
TCB:  008FF6C8
   +0000 RBP...... 008FF8D0  PIE...... 00000000  DEB...... 00000000
   +000C TIO...... 00D69FD0  CMP...... 00000000  TRN...... 40000000
   +0018 MSS...... 7FFFE748  PKF...... 00        FLGS..... 00008004 01
   +0022 LMP...... FF        DSP...... FF
- - - - - - - - - - - - - - lines omitted - - - - - - - - - - - - - - -
   +00AC NDSP..... 00002000  MDIDS.... 00000000  JSCB..... 008FCE84
   +00B8 SSAT..... 008FC390  IOBRC.... 00000000  EXCPD.... 00000000
- - - - - - - - - - - - - - lines omitted - - - - - - - - - - - - - - -
   +0154  SENV..... 008FC168
   Task non-dispatchability flags from TCBFLGS4:
    Top RB is in a wait
   Task non-dispatchability flags from TCBFLGS5:
    Secondary non-dispatchability indicator
   Task non-dispatchability flags from TCBNDSP2:
    SVC Dump is executing for another task
```

Top RB (last one formatted)

Why? Check top RB's PSW

Just means additional bits on in TCBNDSP (per below)

Ignore; result of this dump

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The last bit of TCBFLGS5 (which is the last byte in TCBFLGS) is a summary bit. If any bits are on in TCBNDSP, then this summary bit is turned on.

When SVC dump processing gathers local storage, it sets TCBs non-dispatchable in order to get a more stable picture. To make then non-dispatchable, dump processing calls a system service called STATUS who turns on the X'20' bit at TCB+x'AE' in each TCB. Therefore, when you see a X'00002000' in the TCBNDSP field at +AC, this is an effect of the dump in progress and is not relevant to debugging of the hang.

If TCB is waiting….

- Get PSW from XSBOPS16 of top RB’s XSB
- IP WHERE or IPCS Browse the PSW address, making sure you use the correct PASID
  - IEAVEWAT? Then WAIT was PC-entered
    - Find last LSE linkage stack entry (between TCB and STCB)
    - LSE TARG field should contain 0000030D
    - LSE PSWE will point to who issued the PC 30D WAIT
  - Otherwise, WAIT was SVC- or branch-entered
    - XSBOPS16 points to the issuer of the WAIT

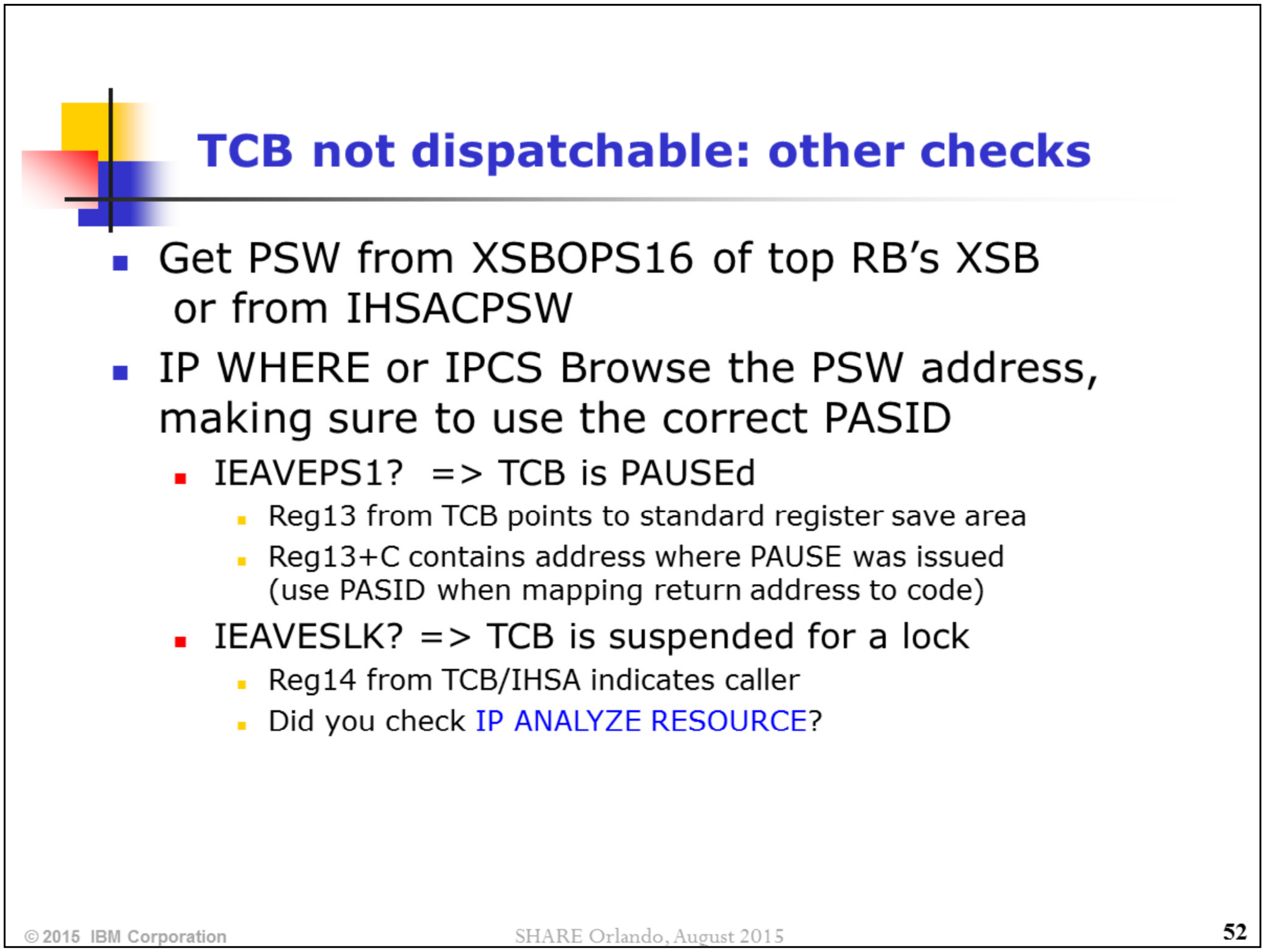
TCB suspended?

Is TCB suspended?

- Get first byte of RBLINK from TCB's top RB
  - If X'01' then TCB is suspended
    - If TCB is unlocked, get suspend PSW from top RB's XSBOPS16
    - If TCB is locked, get suspend PSW from IHSACPSW
    - IP WHERE or IPCS Browse the PSW address, making sure to use the correct PASID

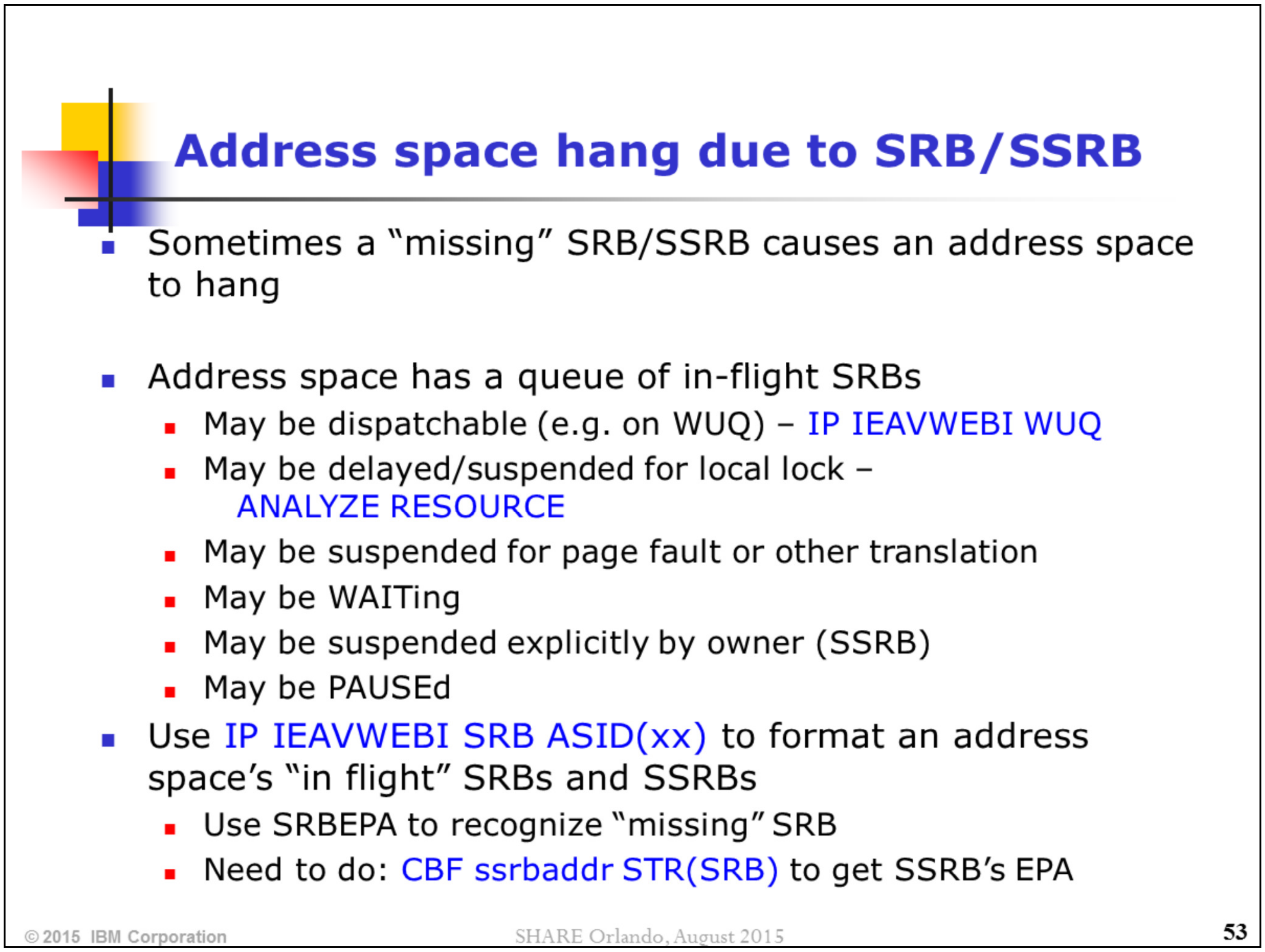
X'01' can also mean TCB is waiting, but we've already verified that this is not the case

NOTE: The SUSPEND PSW typically points right after a BALR instruction. If this is not the case, the SUSPEND could be due to a translation exception (e.g. page fault). Check for a non-zero XSBRTRNE (XSB+X'C0') that matches the instruction base register or the instruction address.



TCB not dispatchable: other checks

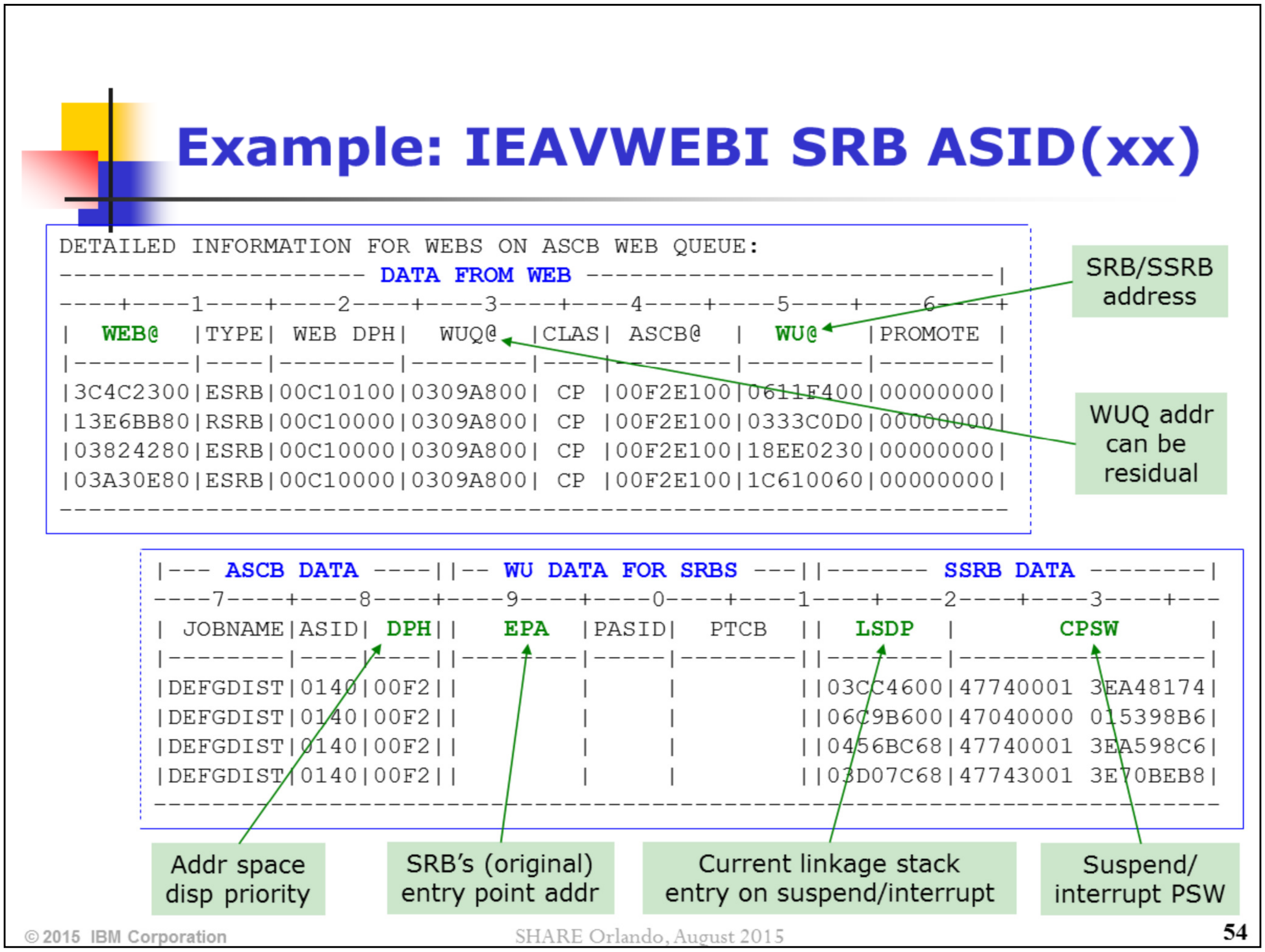
- Get PSW from XSBOPS16 of top RB's XSB or from IHSACPSW
- IP WHERE or IPCS Browse the PSW address, making sure to use the correct PASID
  - IEAVEPS1? => TCB is PAUSEd
    - Reg13 from TCB points to standard register save area
    - Reg13+C contains address where PAUSE was issued (use PASID when mapping return address to code)
  - IEAVESLK? => TCB is suspended for a lock
    - Reg14 from TCB/IHSA indicates caller
    - Did you check IP ANALYZE RESOURCE?



Address space hang due to SRB/SSRB

- Sometimes a “missing” SRB/SSRB causes an address space to hang

- Address space has a queue of in-flight SRBs
  - May be dispatchable (e.g. on WUQ) – IP IEAVWEBI WUQ
  - May be delayed/suspended for local lock – ANALYZE RESOURCE
  - May be suspended for page fault or other translation
  - May be WAITing
  - May be suspended explicitly by owner (SSRB)
  - May be PAUSEd
- Use IP IEAVWEBI SRB ASID(xx) to format an address space’s “in flight” SRBs and SSRBs
  - Use SRBEPA to recognize “missing” SRB
  - Need to do: CBF ssrbaddr STR(SRB) to get SSRB’s EPA



Example: IEAVWEBI SRB ASID(xx)

```
DETAILED INFORMATION FOR WEBS ON ASCB WEB QUEUE:
--------------------- DATA FROM WEB ----------------------------|
----+----1----+----2----+----3----+----4----+----5----+----6----+
|  WEB@   |TYPE| WEB DPH|  WUQ@   |CLAS| ASCB@   |  WU@    |PROMOTE |
|--------|----|--------|--------|----|--------|--------|--------|
|3C4C2300|ESRB|00C10100|0309A800| CP |00F2E100|0611F400|00000000|
|13E6BB80|RSRB|00C10000|0309A800| CP |00F2E100|0333C0D0|00000000|
|03824280|ESRB|00C10000|0309A800| CP |00F2E100|18EE0230|00000000|
|03A30E80|ESRB|00C10000|0309A800| CP |00F2E100|1C610060|00000000|
-----------------------------------------------------------------
```

SRB/SSRB address

WUQ addr can be residual

```
|--- ASCB DATA ----||-- WU DATA FOR SRBS ---||------- SSRB DATA --------|
----7----+----8----+----9----+----0----+----1----+----2----+----3----+---
| JOBNAME|ASID| DPH||    EPA   |PASID|  PTCB   ||  LSDP   |       CPSW       |
|--------|----|----||--------|-----|--------||--------|-----------------|
|DEFGDIST|0140|00F2||        |     |        ||03CC4600|47740001 3EA48174|
|DEFGDIST|0140|00F2||        |     |        ||06C9B600|47040000 015398B6|
|DEFGDIST|0140|00F2||        |     |        ||0456BC68|47740001 3EA598C6|
|DEFGDIST|0140|00F2||        |     |        ||03D07C68|47743001 3E70BEB8|
-------------------------------------------------------------------------
```

Addr space disp priority

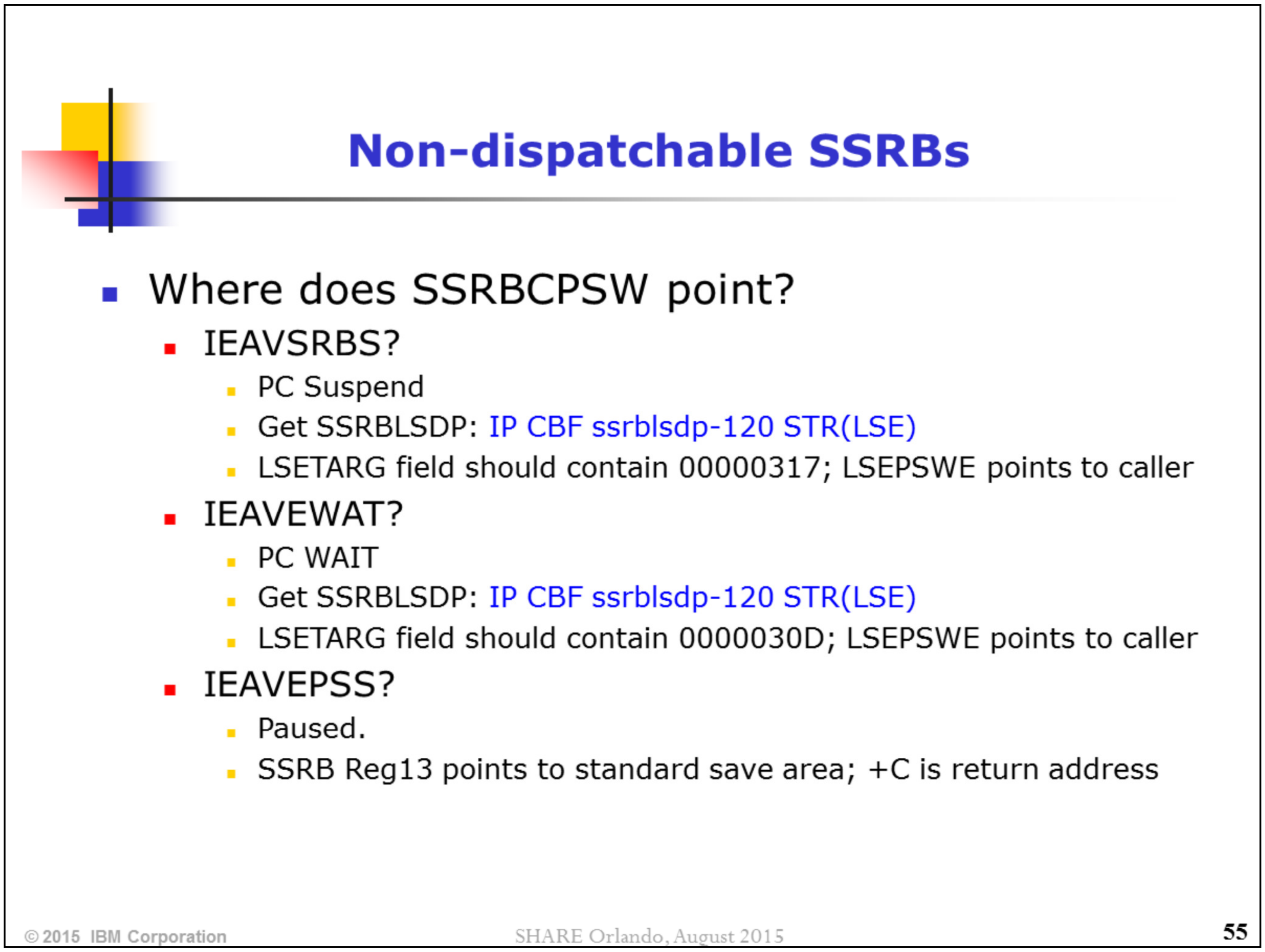
SRB's (original) entry point addr

Current linkage stack entry on suspend/interrupt

Suspend/ interrupt PSW

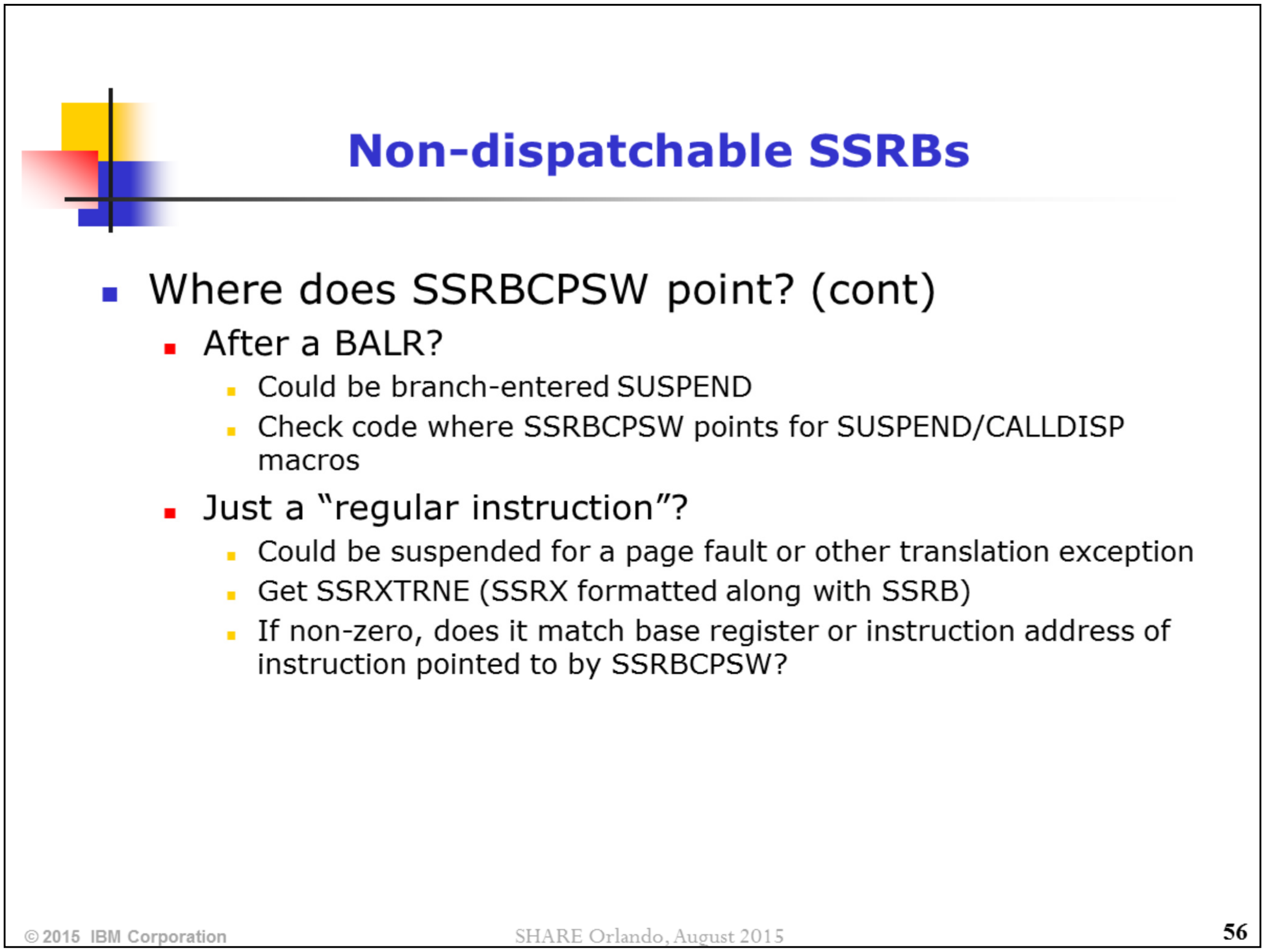
This is output from the IPCS command: IEAVWEBI SRB ASID(140) where 140 is a hexadecimal ASID number. This report shows in flight SRBs/SSRBs associated with ASID X'140'. When SRBs/SSRBs are not hung, their status is changeable. This means that in an SVC dump, you may see inconsistent data between the IEAVWEBI SRB ASID(xx) report which formats in flight SRBs/SSRBs, and the IEAVWEBI WUQ report which formats work units on a WUQ dispatch queue. For example, you may find an address space has SRBs on a WUQ waiting to be dispatched per IEAVWEBI WUQ, but the IEAVWEBI SRB ASID(xx) report may show no WEBs on the "in flight" queue because the pointer (ASSBSAWQ) to this queue was zero at the time the ASSB was dumped.

The IEAVWEBI SRB ASID(xx) report excerpt shown above shows each WEB having a non-zero WUQ address. The presence of a non-zero WUQ address in a WEB does not imply that the WEB is currently on a WUQ. To determine whether a WEB is on a WUQ, use IEAVWEBI WUQ.



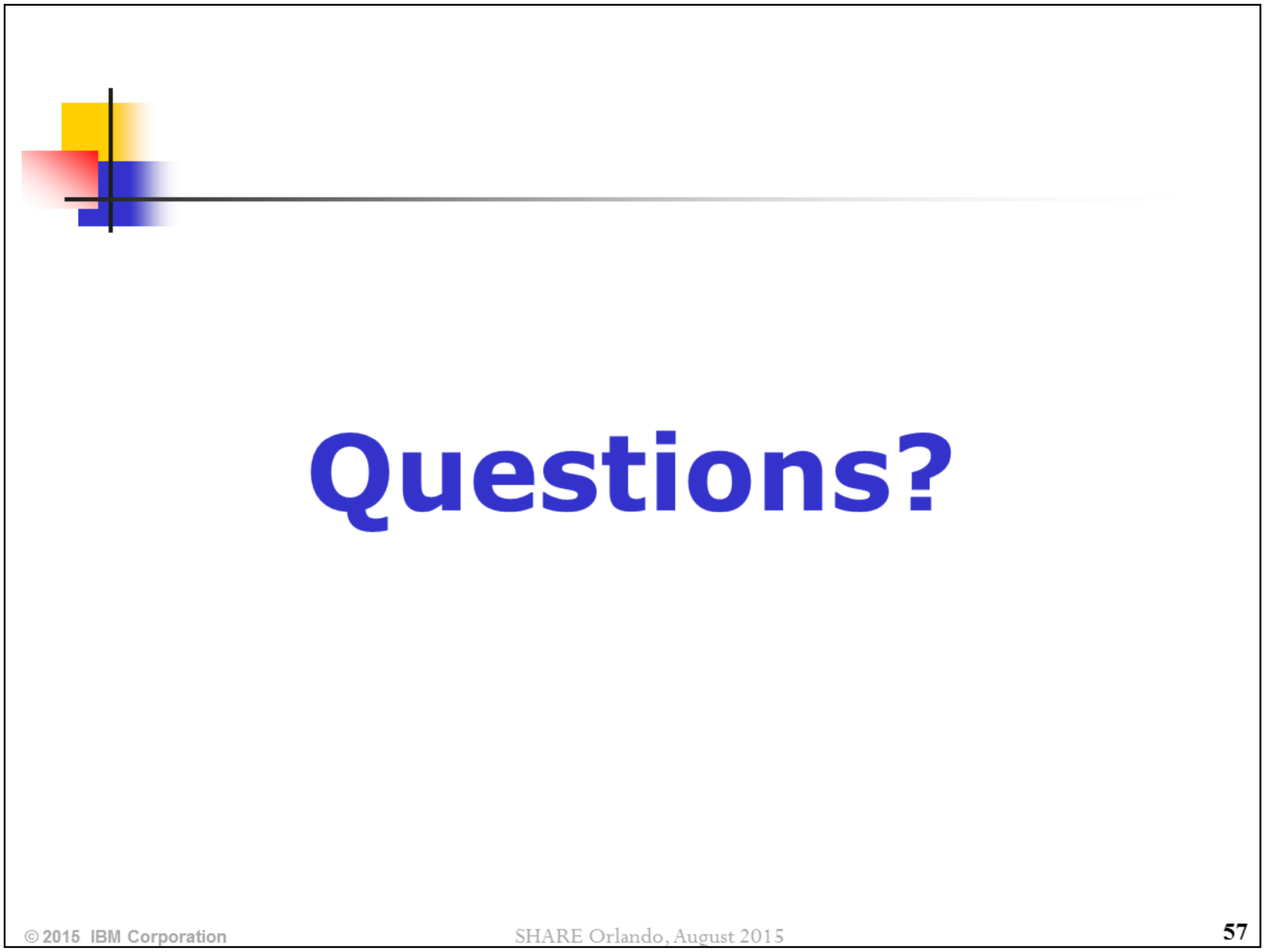
Non-dispatchable SSRBs

- Where does SSRBCPSW point?
  - IEAVSRBS?
    - PC Suspend
    - Get SSRBLSDP: IP CBF ssrblsdp-120 STR(LSE)
    - LSETARG field should contain 00000317; LSEPSWE points to caller
  - IEAVEWAT?
    - PC WAIT
    - Get SSRBLSDP: IP CBF ssrblsdp-120 STR(LSE)
    - LSETARG field should contain 0000030D; LSEPSWE points to caller
  - IEAVEPSS?
    - Paused.
    - SSRB Reg13 points to standard save area; +C is return address



Non-dispatchable SSRBs

- Where does SSRBCPSW point? (cont)
  - After a BALR?
    - Could be branch-entered SUSPEND
    - Check code where SSRBCPSW points for SUSPEND/CALLDISP macros
  - Just a “regular instruction”?
    - Could be suspended for a page fault or other translation exception
    - Get SSRXTRNE (SSRX formatted along with SSRB)
    - If non-zero, does it match base register or instruction address of instruction pointed to by SSRBCPSW?



Questions?