NSA Center for Assured Software

Information Security And Privacy Board

March 21, 2006

Software Assurance Definition

DoD Software Assurance Initiative

DoD Software Assurance Tiger Team

- The level of confidence that software is free of exploitable vulnerabilities, either intentionally designed into the software or accidentally inserted

- And that the software functions in a manner as expected.

Problem Statement (1)

"The ubiquity of software and its development and usage without consistent engineering, has resulted in ad hoc management and mitigation efforts in a race to protect systems against breaches"

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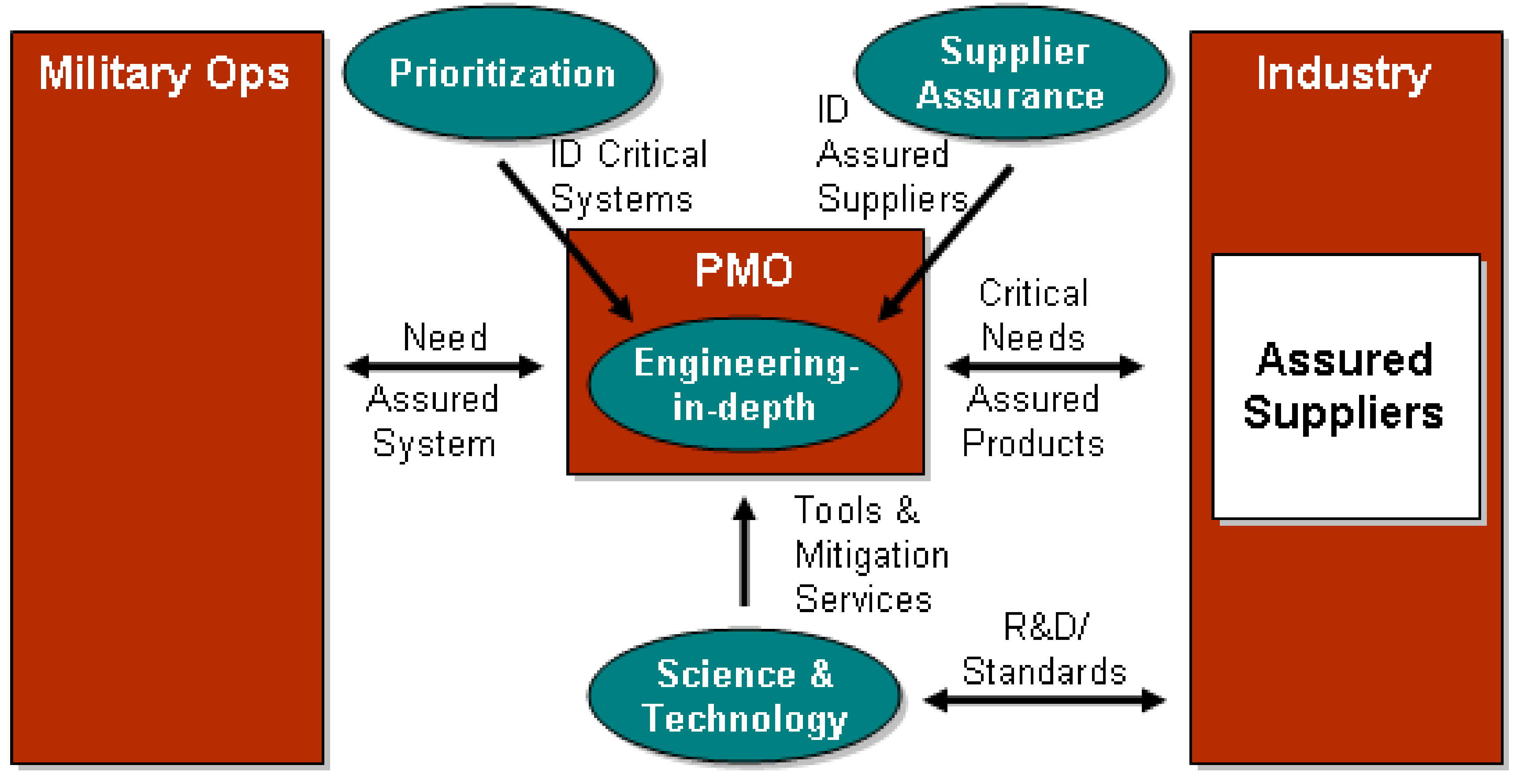
Software Assurance Tiger Team

Problem Statement (2)

There's too much software

There's too little assurance

DoD SwA CONOPS: Interacting Processes



Science & Technology

- Provide software evaluation services
- Use tools to detect vulnerabilities
- Coordinate DoD R&D for vulnerability detection and mitigation
- Work with industry to develop standards/solutions
- Recommended a DoD Executive Agent for Software Vulnerability Mitigation and Discovery
  - Establish a DoD Center for Assured Software

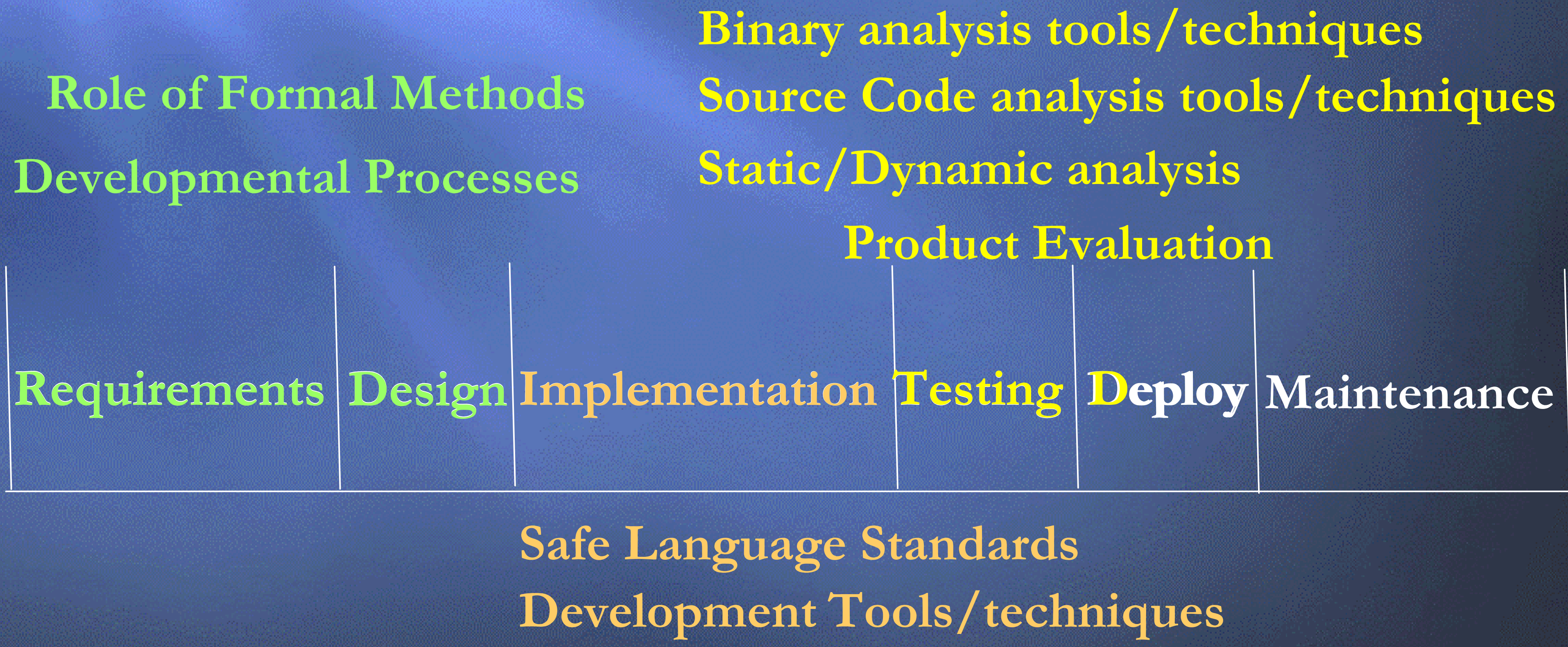
NSA Center for Assured Software (CAS)

- Stood up in November, 2005
- A Focal Point for Software Assurance (SwA) Issues with the following objectives:
  - Partner with our customers, government, the private sector and academia to identify SwA Issues and resolutions
  - Develop and utilize tools and methods to analyze the trustworthiness of software

NSA Center for Assured Software (CAS) (cont)

- Objectives (cont)
  - Evaluate mission critical components
  - Establish/Identify software standards and practices to increase the availability of assured software products

CAS "domain of operation"



Binary analysis tools/techniques

Source Code analysis tools/techniques

Static/Dynamic analysis

Product Evaluation

Role of Formal Methods

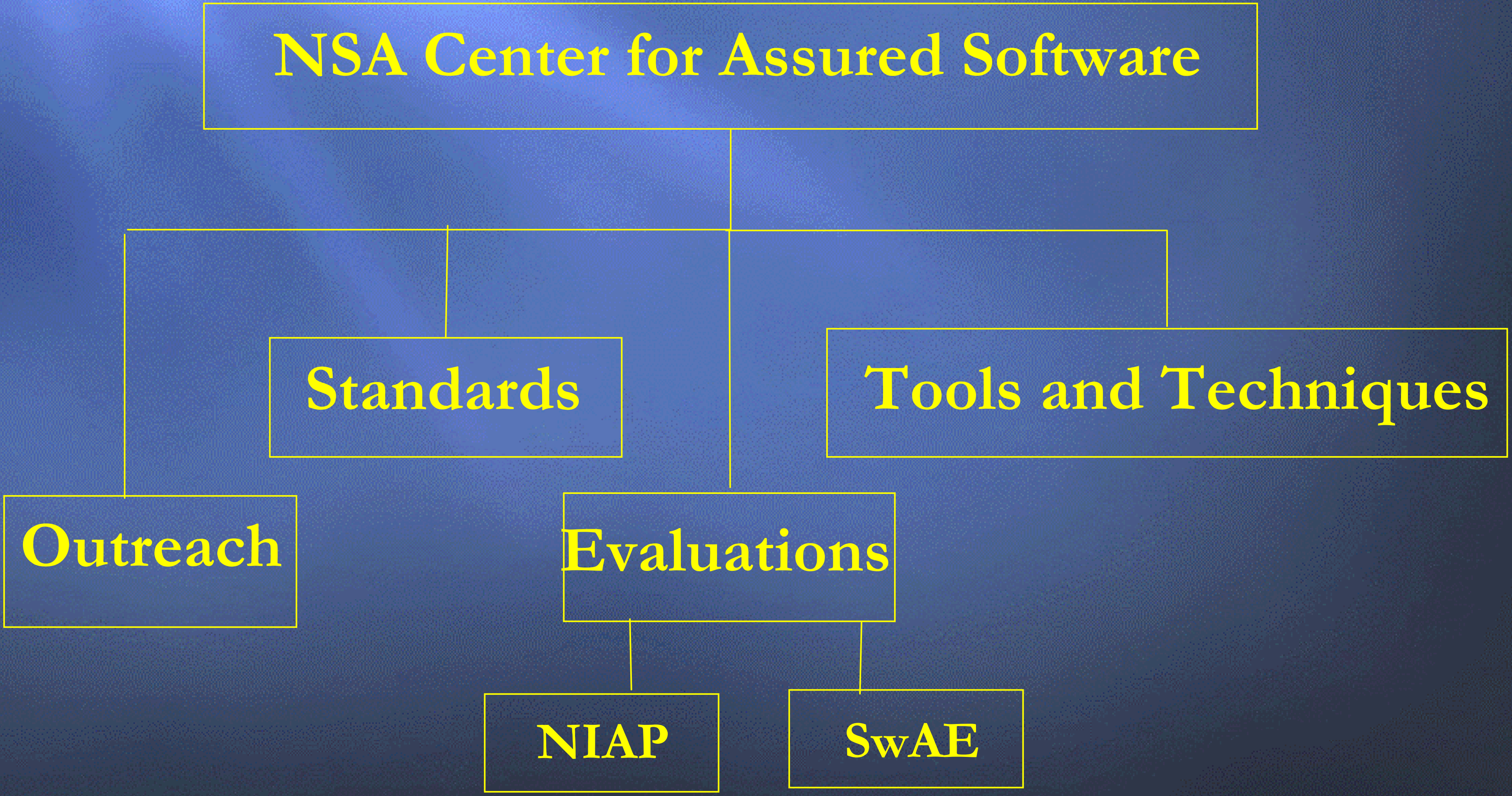
Developmental Processes

Requirements | Design | Implementation | Testing | Deploy | Maintenance

Safe Language Standards

Development Tools/techniques

What we look like today…



NSA Center for Assured Software

Standards

Tools and Techniques

Outreach

Evaluations

NIAP

SwAE

Where we are working today …

- NIAP
  - – Fully operational
  - – Beginning to address recommendations from the GAO and IDA NIAP review reports

- Software Assurance Evaluations
  - – Are evaluating some specific software of interest to NSA in the context of a pilot
    - First report due in 30 days

Where we are working today (cont) …

- A repeatable SwAE methodology based upon available tools
  - Involves a tools survey as wells as incorporating lessons learned from our pilot

- Strategies for :
  - Public Software Assurance Standards participation
  - Internal NSA Software Assurance Standards and compliance
  - Outreach
  - High Assurance

Using Tools for to gain Confidence in Software

Measuring Software Assurance

- Looking for properties of software that are indicators of the assurance level
  - Degree of confidence that software will securely and appropriately perform its intended functions
  - Degree of confidence that software will not perform any unauthorized functions
  - Degree of confidence that software does not contain implementation flaws that could be exploited.

Measuring Software Assurance

Process Phases:

- Acceptance
- Extraction/Inspection
- Analysis
- Meta-Analysis
- Reporting

Acceptance

- Are there existing tools and techniques that address the software to be evaluated?
  - Platform/Machine Language
    - x86, Sparc, ARM, etc.
  - Source Language
    - C/C++, Java, Microcode, etc.
  - File Format
    - PE, ELF, ROM Image, etc.
  - Environment
    - Windows, Real-time O/S, Linux

Measuring Software Assurance

CAS: Identify and fill capability gaps

Phase Report Card:

C+

- Acceptance
- Extraction/Inspection
- Analysis
- Meta-Analysis
- Reporting

Extraction/Inspection

- Apply tools and techniques that extract relevant metadata from the software
  - Control Flow Graphs
  - Complexity Metrics
  - Module Dependencies
  - Disassembly/Decompilation
  - Functional Extraction
  - Instruction Effects Analysis
  - Identification of Code vs. Data

Extraction/Inspection

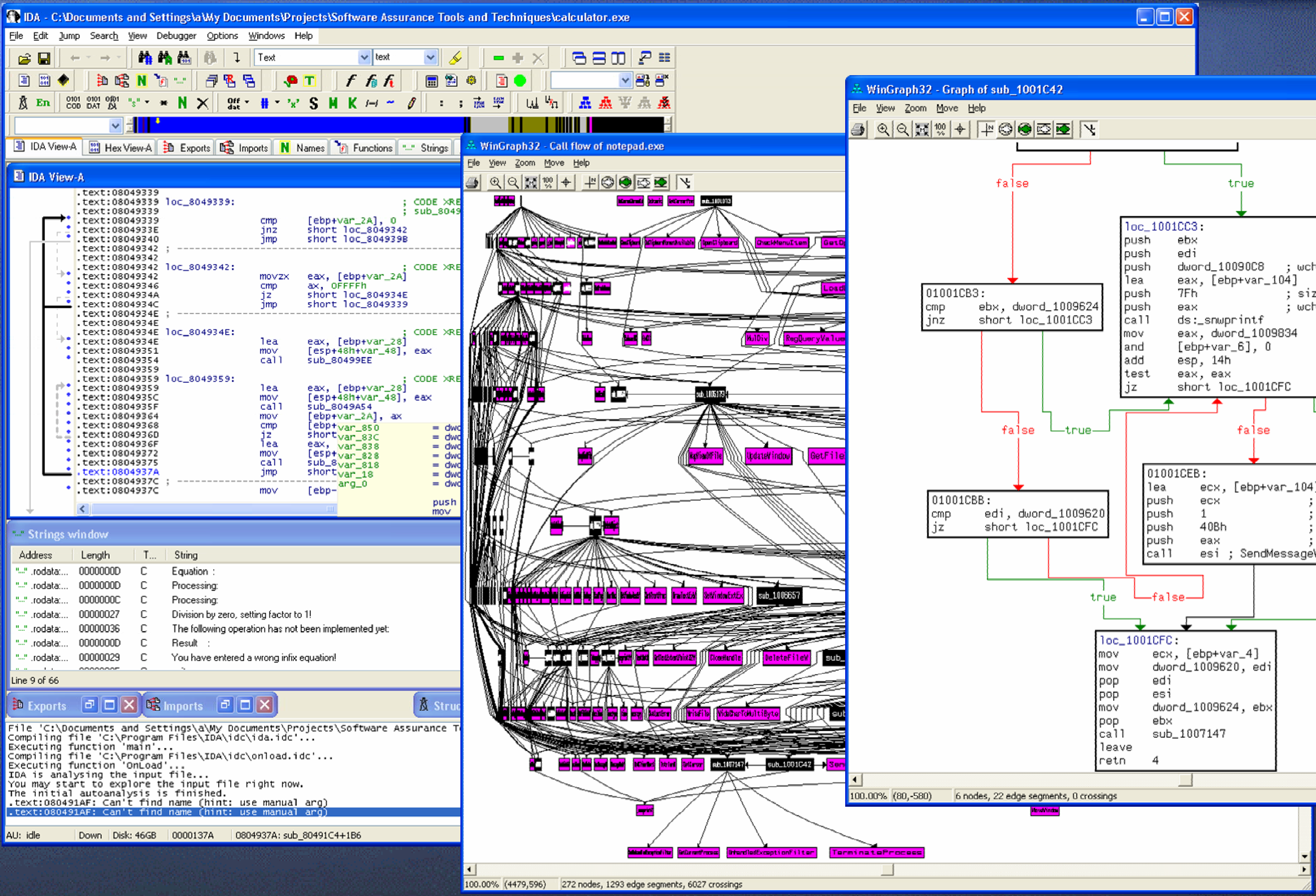
- Extraction/Inspection tools are the most sophisticated tools available today
  - Most academic and commercial research and development is in this area
  - Much of the research is driven by the need to port legacy applications to newer platforms and binary formats

Extraction/Inspection

- Extraction/Inspection tools have complex output
  - Use requires a high level of training
- Tool results create the environment for analysis, but in most cases only indirectly indicate assurance
- Integration of extraction/inspection tools with analysis tools is poor
  - Metadata formats are typically proprietary with specialized programming interfaces

Sample tool output …

Extraction/Inspection



```
.text:08049339
.text:08049339 loc_8049339:                           ; CODE XRE
.text:08049339                                        ; sub_8049
.text:08049339                 cmp     [ebp+var_2A], 0
.text:0804933E                 jnz     short loc_8049342
.text:08049340                 jmp     short loc_804939B
.text:08049342 ; ---------------------------------------------------
.text:08049342
.text:08049342 loc_8049342:                           ; CODE XRE
.text:08049342                 movzx   eax, [ebp+var_2A]
.text:08049346                 cmp     ax, 0FFFFh
.text:0804934A                 jz      short loc_804934E
.text:0804934C                 jmp     short loc_8049339
.text:0804934E ; ---------------------------------------------------
.text:0804934E
.text:0804934E loc_804934E:                           ; CODE XRE
.text:0804934E                 lea     eax, [ebp+var_28]
.text:08049351                 mov     [esp+48h+var_48], eax
.text:08049354                 call    sub_80499EE
.text:08049359
.text:08049359 loc_8049359:                           ; CODE XRE
.text:08049359                 lea     eax, [ebp+var_28]
.text:0804935C                 mov     [esp+48h+var_48], eax
.text:0804935F                 call    sub_8049A54
.text:08049364                 mov     [ebp+var_2A], ax
.text:08049368                 cmp     [ebp+var_850           = dwo
.text:0804936D                 jz      short var_83C          = dwo
.text:0804936F                 lea     eax,  var_838          = dwo
.text:08049372                 mov     [esp+var_828           = dwo
.text:08049375                 call    sub_8var_818           = dwo
.text:0804937A                 jmp     short var_18           = dwo
.text:0804937C ; ---------------arg_0                         = dwo
.text:0804937C                 mov     [ebp-
                                                            push
                                                            mov
```

Address	Length	T...	String
"..." .rodata:...	0000000D	C	Equation :
"..." .rodata:...	0000000D	C	Processing:
"..." .rodata:...	0000000C	C	Processing:
"..." .rodata:...	00000027	C	Division by zero, setting factor to 1!
"..." .rodata:...	00000036	C	The following operation has not been implemented yet:
"..." .rodata:...	0000000D	C	Result :
"..." .rodata:...	00000029	C	You have entered a wrong infix equation!

Line 9 of 66

```
File 'C:\Documents and Settings\a\My Documents\Projects\Software Assurance T
Compiling file 'C:\Program Files\IDA\idc\ida.idc'...
Executing function 'main'...
Compiling file 'C:\Program Files\IDA\idc\onload.idc'...
Executing function 'OnLoad'...
IDA is analysing the input file...
You may start to explore the input file right now.
The initial autoanalysis is finished.
.text:080491AF: Can't find name (hint: use manual arg)
.text:080491AF: Can't find name (hint: use manual arg)
```

AU: idle | Down | Disk: 46GB | 0000137A | 0804937A: sub_80491C4+1B6

```
01001CB3:
cmp     ebx, dword_1009624
jnz     short loc_1001CC3
```

```
loc_1001CC3:
push    ebx
push    edi
push    dword_10090C8    ; wchar_t *
lea     eax, [ebp+var_104]
push    7Fh              ; size_t
push    eax              ; wchar_t *
call    ds:_snwprintf
mov     eax, dword_1009834
and     [ebp+var_6], 0
add     esp, 14h
test    eax, eax
jz      short loc_1001CFC
```

```
01001CBB:
cmp     edi, dword_1009620
jz      short loc_1001CFC
```

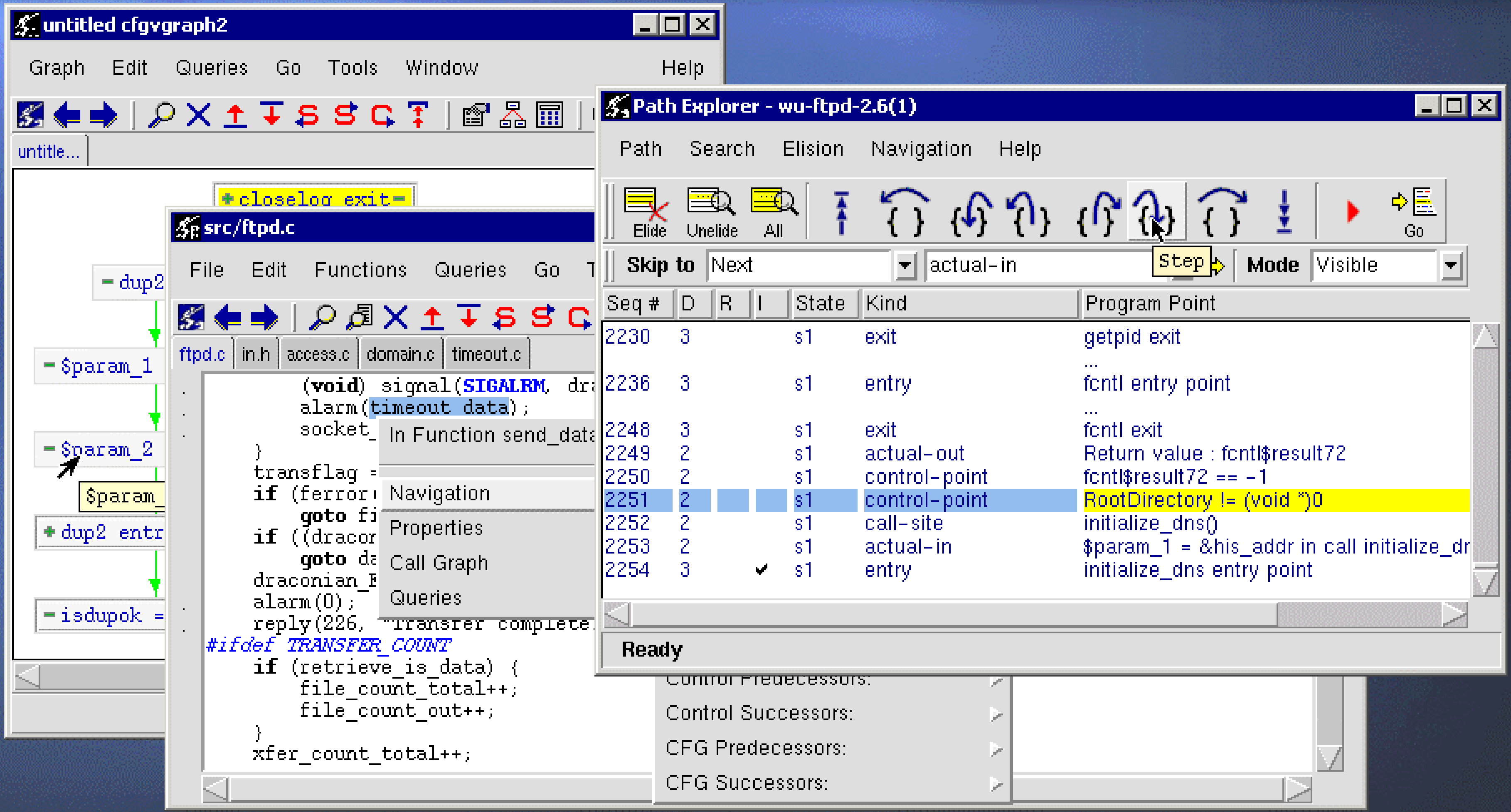
```
01001CEB:
lea     ecx, [ebp+var_104]
push    ecx              ; lParam
push    1                ; wParam
push    40Bh             ; Msg
push    eax              ; hWnd
call    esi  ; SendMessageW
```

```
loc_1001CFC:
mov     ecx, [ebp+var_4]
mov     dword_1009620, edi
pop     edi
pop     esi
mov     dword_1009624, ebx
pop     ebx
call    sub_1007147
leave
retn    4
```

100.00% (80,-580) 6 nodes, 22 edge segments, 0 crossings

100.00% (4479,596) 272 nodes, 1293 edge segments, 6027 crossings

Extraction/Inspection

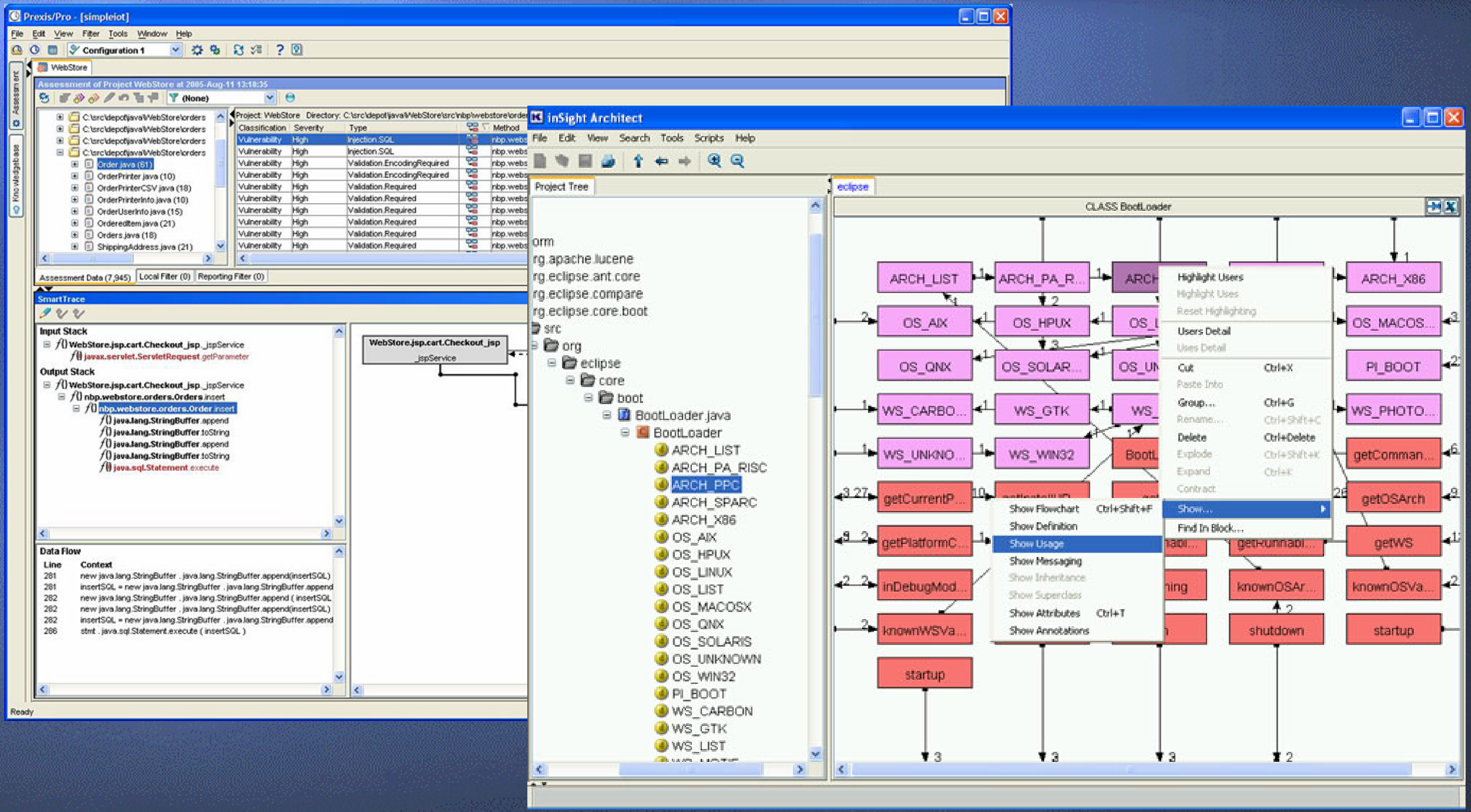


```
        (void) signal(SIGALRM, dra
        alarm(timeout_data);
        socket_
    }
    transflag =
    if (ferror(
        goto fi
    if ((dracor
        goto da
    draconian_F
    alarm(0);
    reply(226, "Transfer complete
#ifdef TRANSFER_COUNT
    if (retrieve_is_data) {
        file_count_total++;
        file_count_out++;
    }
    xfer_count_total++;
```

Skip to Next | actual-in | **Mode** Visible

Seq #	D	R	I	State	Kind	Program Point
2230	3			s1	exit	getpid exit
						...
2236	3			s1	entry	fcntl entry point
						...
2248	3			s1	exit	fcntl exit
2249	2			s1	actual-out	Return value : fcntl$result72
2250	2			s1	control-point	fcntl$result72 == -1
2251	2			s1	control-point	RootDirectory != (void *)0
2252	2			s1	call-site	initialize_dns()
2253	2			s1	actual-in	$param_1 = &his_addr in call initialize_dr
2254	3		✓	s1	entry	initialize_dns entry point

Extraction/Inspection



Prexis/Pro - [simpleiot]

WebStore

Assessment of Project WebStore at 2005-Aug-11 13:18:35

C:\src\depot\java\WebStore\orders
C:\src\depot\java\WebStore\orders
C:\src\depot\java\WebStore\orders
C:\src\depot\java\WebStore\orders
Order.java (61)
OrderPrinter.java (10)
OrderPrinterCSV.java (18)
OrderPrinterInfo.java (10)
OrderUserInfo.java (15)
Ordereditem.java (21)
Orders.java (18)
ShippingAddress.java (21)

Project: WebStore Directory: C:\src\depot\java\WebStore\src\nbp\webstore\order

Classification	Severity	Type	Method
Vulnerability	High	Injection.SQL	nbp.webs
Vulnerability	High	Injection.SQL	nbp.webs
Vulnerability	High	Validation.EncodingRequired	nbp.webs
Vulnerability	High	Validation.EncodingRequired	nbp.webs
Vulnerability	High	Validation.Required	nbp.webs
Vulnerability	High	Validation.Required	nbp.webs
Vulnerability	High	Validation.Required	nbp.webs
Vulnerability	High	Validation.Required	nbp.webs
Vulnerability	High	Validation.Required	nbp.webs
Vulnerability	High	Validation.Required	nbp.webs

Assessment Data (7,945) Local Filter (0) Reporting Filter (0)

SmartTrace

Input Stack
```
⊟ f() WebStore.jsp.cart.Checkout_jsp._jspService
      f() javax.servlet.ServletRequest.getParameter
```
Output Stack
```
⊟ f() WebStore.jsp.cart.Checkout_jsp._jspService
   ⊟ f() nbp.webstore.orders.Orders.insert
      ⊟ f() nbp.webstore.orders.Order.insert
            f() java.lang.StringBuffer.append
            f() java.lang.StringBuffer.toString
            f() java.lang.StringBuffer.append
            f() java.lang.StringBuffer.toString
            f() java.sql.Statement.execute
```

Data Flow
```
Line    Context
281     new java.lang.StringBuffer . java.lang.StringBuffer.append(insertSQL)
281     insertSQL = new java.lang.StringBuffer . java.lang.StringBuffer.append
282     new java.lang.StringBuffer . java.lang.StringBuffer.append ( insertSQL
282     new java.lang.StringBuffer . java.lang.StringBuffer.append(insertSQL)
282     insertSQL = new java.lang.StringBuffer . java.lang.StringBuffer.append
286     stmt . java.sql.Statement.execute ( insertSQL )
```

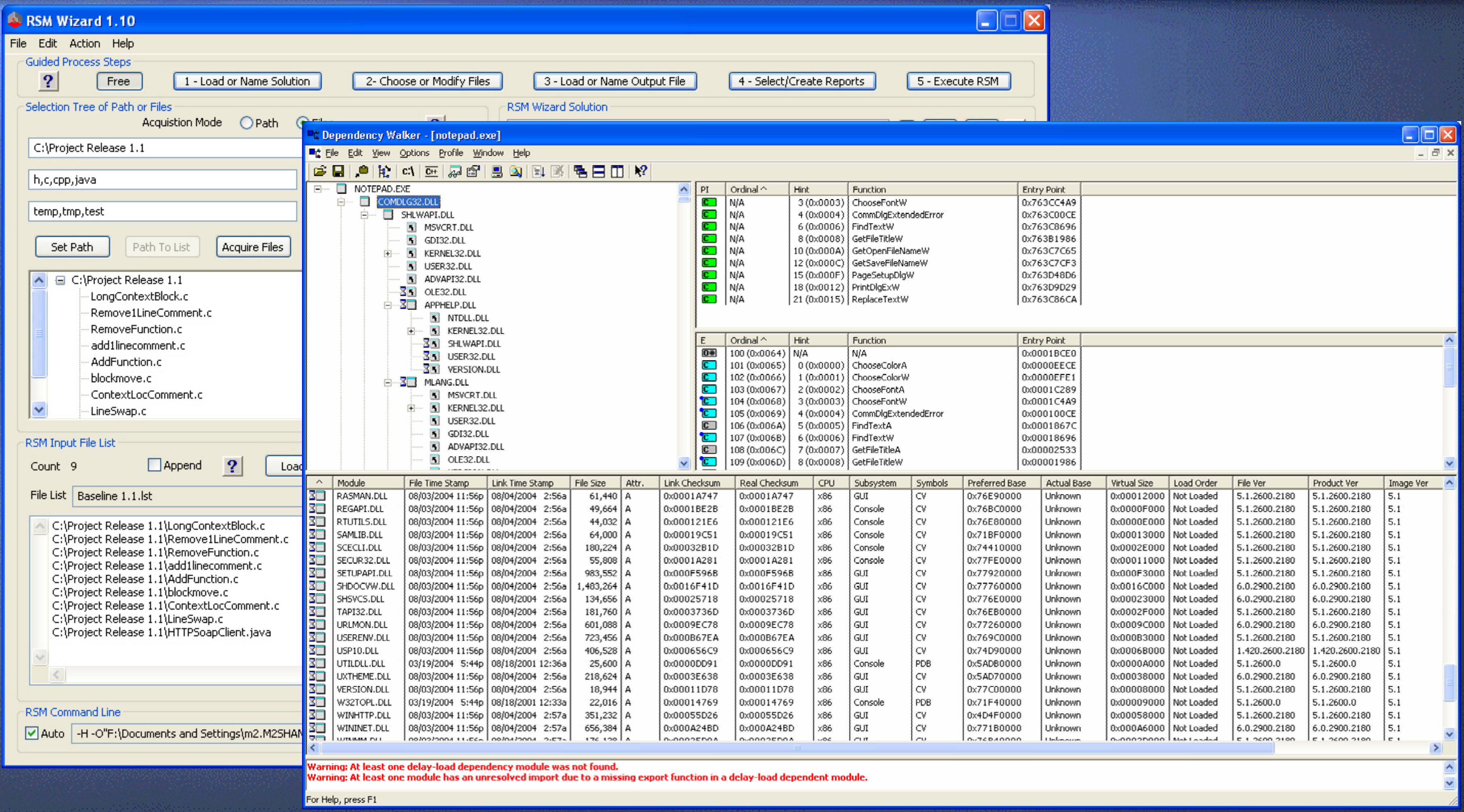
WebStore.jsp.cart.Checkout_jsp
_jspService

Ready

inSight Architect

Project Tree
```
orm
rg.apache.lucene
rg.eclipse.ant.core
rg.eclipse.compare
rg.eclipse.core.boot
src
⊟ org
   ⊟ eclipse
      ⊟ core
         ⊟ boot
            ⊟ BootLoader.java
               ⊟ BootLoader
                    ARCH_LIST
                    ARCH_PA_RISC
                    ARCH_PPC
                    ARCH_SPARC
                    ARCH_X86
                    OS_AIX
                    OS_HPUX
                    OS_LINUX
                    OS_LIST
                    OS_MACOSX
                    OS_QNX
                    OS_SOLARIS
                    OS_UNKNOWN
                    OS_WIN32
                    PI_BOOT
                    WS_CARBON
                    WS_GTK
                    WS_LIST
```

Extraction/Inspection



RSM Wizard 1.10

Acquistion Mode ○ Path ●

C:\Project Release 1.1

h,c,cpp,java

temp,tmp,test

```
⊟ C:\Project Release 1.1
    LongContextBlock.c
    Remove1LineComment.c
    RemoveFunction.c
    add1linecomment.c
    AddFunction.c
    blockmove.c
    ContextLocComment.c
    LineSwap.c
```

Count 9 □ Append

File List Baseline 1.1.lst

```
C:\Project Release 1.1\LongContextBlock.c
C:\Project Release 1.1\Remove1LineComment.c
C:\Project Release 1.1\RemoveFunction.c
C:\Project Release 1.1\add1linecomment.c
C:\Project Release 1.1\AddFunction.c
C:\Project Release 1.1\blockmove.c
C:\Project Release 1.1\ContextLocComment.c
C:\Project Release 1.1\LineSwap.c
C:\Project Release 1.1\HTTPSoapClient.java
```

☑ Auto -H -O"F:\Documents and Settings\m2.M2SHAN

Dependency Walker - [notepad.exe]

```
⊟ NOTEPAD.EXE
  ⊟ COMDLG32.DLL
    ⊟ SHLWAPI.DLL
        MSVCRT.DLL
        GDI32.DLL
      ⊞ KERNEL32.DLL
        USER32.DLL
        ADVAPI32.DLL
        OLE32.DLL
      ⊟ APPHELP.DLL
          NTDLL.DLL
        ⊞ KERNEL32.DLL
          SHLWAPI.DLL
          USER32.DLL
          VERSION.DLL
      ⊟ MLANG.DLL
          MSVCRT.DLL
        ⊞ KERNEL32.DLL
          USER32.DLL
          GDI32.DLL
          ADVAPI32.DLL
          OLE32.DLL
```

PI	Ordinal ^	Hint	Function	Entry Point
C	N/A	3 (0x0003)	ChooseFontW	0x763CC4A9
C	N/A	4 (0x0004)	CommDlgExtendedError	0x763C00CE
C	N/A	6 (0x0006)	FindTextW	0x763C8696
C	N/A	8 (0x0008)	GetFileTitleW	0x763B1986
C	N/A	10 (0x000A)	GetOpenFileNameW	0x763C7C65
C	N/A	12 (0x000C)	GetSaveFileNameW	0x763C7CF3
C	N/A	15 (0x000F)	PageSetupDlgW	0x763D48D6
C	N/A	18 (0x0012)	PrintDlgExW	0x763D9D29
C	N/A	21 (0x0015)	ReplaceTextW	0x763C86CA

E	Ordinal ^	Hint	Function	Entry Point
O#	100 (0x0064)	N/A	N/A	0x0001BCE0
C	101 (0x0065)	0 (0x0000)	ChooseColorA	0x0000EECE
C	102 (0x0066)	1 (0x0001)	ChooseColorW	0x0000EFE1
C	103 (0x0067)	2 (0x0002)	ChooseFontA	0x0001C289
C	104 (0x0068)	3 (0x0003)	ChooseFontW	0x0001C4A9
C	105 (0x0069)	4 (0x0004)	CommDlgExtendedError	0x000100CE
C	106 (0x006A)	5 (0x0005)	FindTextA	0x0001867C
C	107 (0x006B)	6 (0x0006)	FindTextW	0x00018696
C	108 (0x006C)	7 (0x0007)	GetFileTitleA	0x00002533
C	109 (0x006D)	8 (0x0008)	GetFileTitleW	0x00001986

Module	File Time Stamp	Link Time Stamp	File Size	Attr.	Link Checksum	Real Checksum	CPU	Subsystem	Symbols	Preferred Base	Actual Base	Virtual Size	Load Order	File Ver	Product Ver	Image Ver
RASMAN.DLL	08/03/2004 11:56p	08/04/2004 2:56a	61,440	A	0x0001A747	0x0001A747	x86	GUI	CV	0x76E90000	Unknown	0x00012000	Not Loaded	5.1.2600.2180	5.1.2600.2180	5.1
REGAPI.DLL	08/03/2004 11:56p	08/04/2004 2:56a	49,664	A	0x0001BE2B	0x0001BE2B	x86	Console	CV	0x76BC0000	Unknown	0x0000F000	Not Loaded	5.1.2600.2180	5.1.2600.2180	5.1
RTUTILS.DLL	08/03/2004 11:56p	08/04/2004 2:56a	44,032	A	0x000121E6	0x000121E6	x86	Console	CV	0x76E80000	Unknown	0x0000E000	Not Loaded	5.1.2600.2180	5.1.2600.2180	5.1
SAMLIB.DLL	08/03/2004 11:56p	08/04/2004 2:56a	64,000	A	0x00019C51	0x00019C51	x86	Console	CV	0x71BF0000	Unknown	0x00013000	Not Loaded	5.1.2600.2180	5.1.2600.2180	5.1
SCECLI.DLL	08/03/2004 11:56p	08/04/2004 2:56a	180,224	A	0x00032B1D	0x00032B1D	x86	Console	CV	0x74410000	Unknown	0x0002E000	Not Loaded	5.1.2600.2180	5.1.2600.2180	5.1
SECUR32.DLL	08/03/2004 11:56p	08/04/2004 2:56a	55,808	A	0x0001A281	0x0001A281	x86	Console	CV	0x77FE0000	Unknown	0x00011000	Not Loaded	5.1.2600.2180	5.1.2600.2180	5.1
SETUPAPI.DLL	08/03/2004 11:56p	08/04/2004 2:56a	983,552	A	0x000F596B	0x000F596B	x86	GUI	CV	0x77920000	Unknown	0x000F3000	Not Loaded	5.1.2600.2180	5.1.2600.2180	5.1
SHDOCVW.DLL	08/03/2004 11:56p	08/04/2004 2:56a	1,483,264	A	0x0016F41D	0x0016F41D	x86	GUI	CV	0x77760000	Unknown	0x0016C000	Not Loaded	6.0.2900.2180	6.0.2900.2180	5.1
SHSVCS.DLL	08/03/2004 11:56p	08/04/2004 2:56a	134,656	A	0x00025718	0x00025718	x86	GUI	CV	0x776E0000	Unknown	0x00023000	Not Loaded	6.0.2900.2180	6.0.2900.2180	5.1
TAPI32.DLL	08/03/2004 11:56p	08/04/2004 2:56a	181,760	A	0x0003736D	0x0003736D	x86	GUI	CV	0x76EB0000	Unknown	0x0002F000	Not Loaded	5.1.2600.2180	5.1.2600.2180	5.1
URLMON.DLL	08/03/2004 11:56p	08/04/2004 2:56a	601,088	A	0x0009EC78	0x0009EC78	x86	GUI	CV	0x77260000	Unknown	0x0009C000	Not Loaded	6.0.2900.2180	6.0.2900.2180	5.1
USERENV.DLL	08/03/2004 11:56p	08/04/2004 2:56a	723,456	A	0x000B67EA	0x000B67EA	x86	GUI	CV	0x769C0000	Unknown	0x000B3000	Not Loaded	5.1.2600.2180	5.1.2600.2180	5.1
USP10.DLL	08/03/2004 11:56p	08/04/2004 2:56a	406,528	A	0x000656C9	0x000656C9	x86	GUI	CV	0x74D90000	Unknown	0x0006B000	Not Loaded	1.420.2600.2180	1.420.2600.2180	5.1
UTILDLL.DLL	03/19/2004 5:44p	08/18/2001 12:36a	25,600	A	0x0000DD91	0x0000DD91	x86	Console	PDB	0x5ADB0000	Unknown	0x0000A000	Not Loaded	5.1.2600.0	5.1.2600.0	5.1
UXTHEME.DLL	08/03/2004 11:56p	08/04/2004 2:56a	218,624	A	0x0003E638	0x0003E638	x86	GUI	CV	0x5AD70000	Unknown	0x00038000	Not Loaded	6.0.2900.2180	6.0.2900.2180	5.1
VERSION.DLL	08/03/2004 11:56p	08/04/2004 2:56a	18,944	A	0x00011D78	0x00011D78	x86	GUI	CV	0x77C00000	Unknown	0x00008000	Not Loaded	5.1.2600.2180	5.1.2600.2180	5.1
W32TOPL.DLL	03/19/2004 5:44p	08/18/2001 12:33a	22,016	A	0x00014769	0x00014769	x86	Console	PDB	0x71F40000	Unknown	0x00009000	Not Loaded	5.1.2600.0	5.1.2600.0	5.1
WINHTTP.DLL	08/03/2004 11:56p	08/04/2004 2:57a	351,232	A	0x00055D26	0x00055D26	x86	GUI	CV	0x4D4F0000	Unknown	0x00058000	Not Loaded	5.1.2600.2180	5.1.2600.2180	5.1
WININET.DLL	08/03/2004 11:56p	08/04/2004 2:57a	656,384	A	0x000A24BD	0x000A24BD	x86	GUI	CV	0x771B0000	Unknown	0x000A6000	Not Loaded	6.0.2900.2180	6.0.2900.2180	5.1

```
Warning: At least one delay-load dependency module was not found.
Warning: At least one module has an unresolved import due to a missing export function in a delay-load dependent module.
```

For Help, press F1

Measuring Software Assurance

Phase Report Card:

- C+ Acceptance
- B+ Extraction/Inspection
- Analysis
- Meta-Analysis
- Reporting

CAS: Identify and fill capability gaps

CAS: Foster integration and promote further research

Analysis

- Apply tools and techniques that query the metadata for properties or indicators of assurance
  - Existence of Buffer Overflows
  - Improper Memory Management/Object Reuse
  - Insecure Storage of Cryptographic Keys
  - Lack of Authentication
  - Race conditions
  - Covert Channels
  - Unexpected Functionality

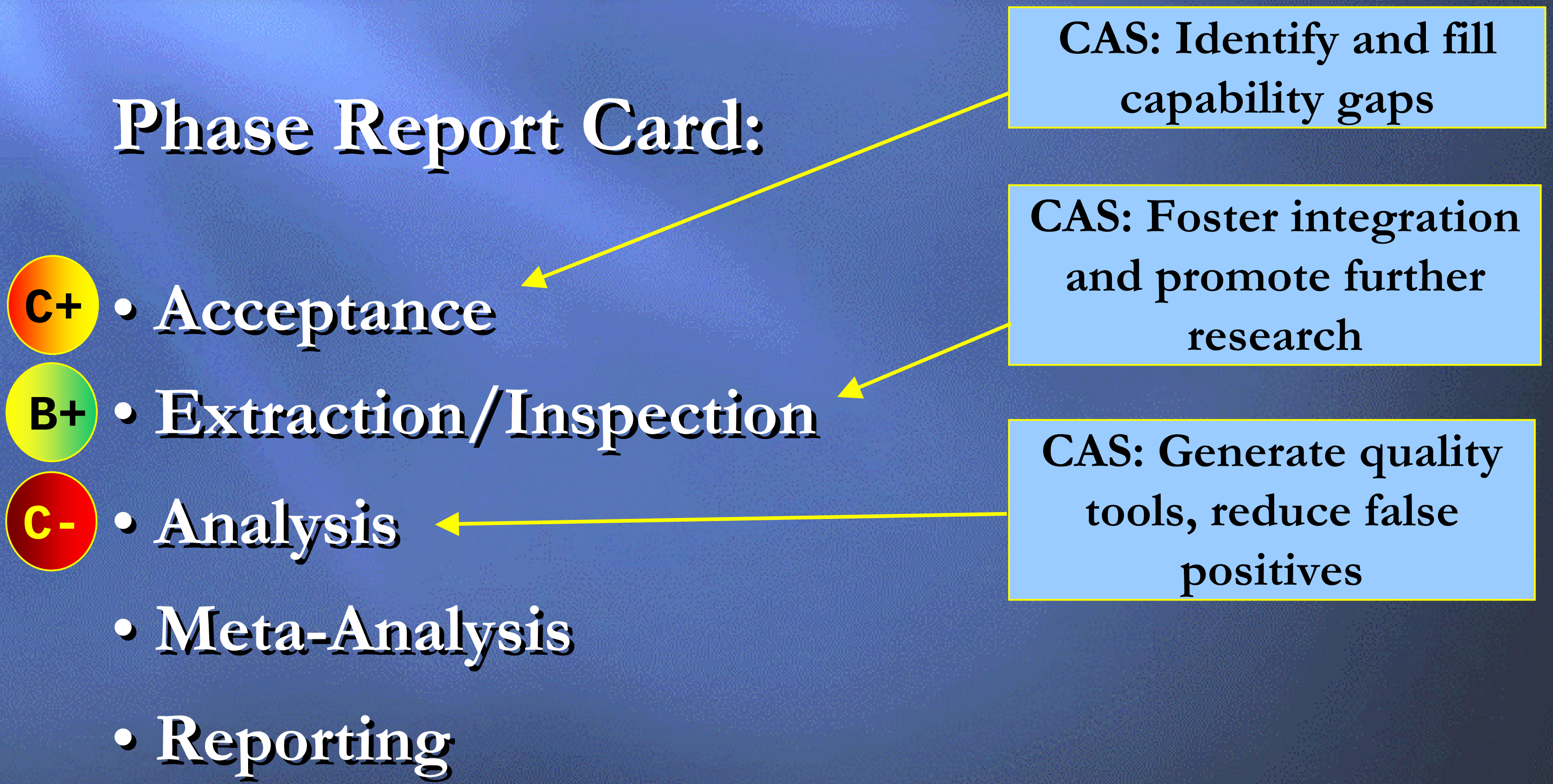
Analysis

- Existing analytical tools:
  - Relatively primitive
  - Typically tailored to a specific sets of bugs
    - Not easily modified to address new questions
  - Typically highly coupled to a particular extraction/inspection tool
    - Simple analytic capability carries with it the cost of sophisticated tool
  - Lots and lots of false positives

Analysis

- Analysts typically create small programs on the fly to answer specific questions
  - Custom tools generally aren't refined to cover all relevant cases
  - Limited distribution and support of tool
  - Tools themselves are not well-engineered or extensible
  - No integration into an overall evaluation methodology

Measuring Software Assurance



Phase Report Card:

- C+ Acceptance
- B+ Extraction/Inspection
- C- Analysis
- Meta-Analysis
- Reporting

CAS: Identify and fill capability gaps

CAS: Foster integration and promote further research

CAS: Generate quality tools, reduce false positives

Meta-Analysis

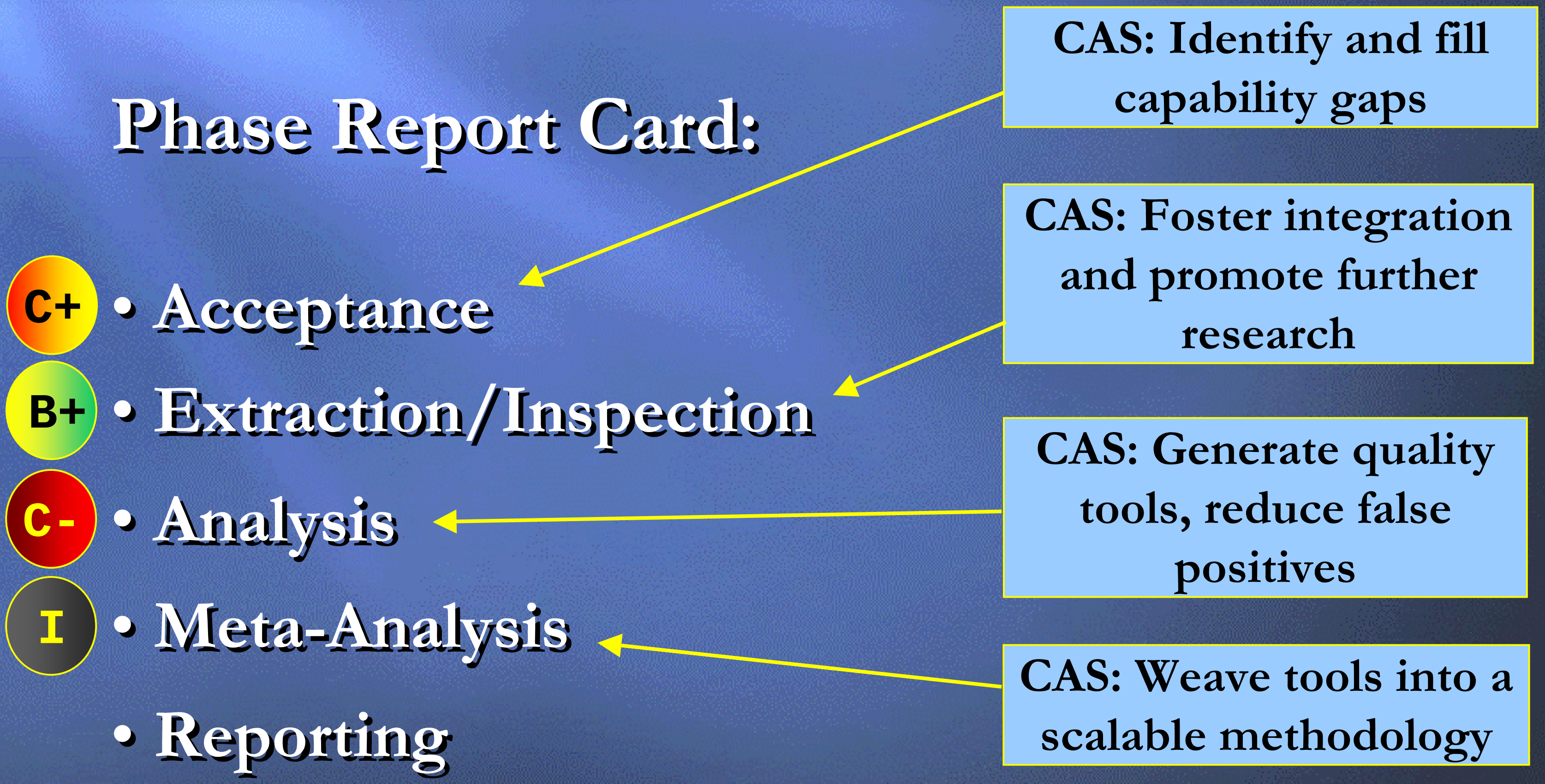
- Integrate output from multiple analytical tools and techniques to discern higher-order assurance indicators
  - Some tools may increase the confidence in the results from another tool
  - Use one tool to focus the analysis of a following tool or filter the results of a preceding tool
  - Independent indicators help rank results
  - Perform analytical tests not within the capability of any one tool

Meta-Analysis

- No technological methodology currently exists that:
  - Leverages the strengths of multiple tools
  - Contains the technological “glue” to connect tools from different vendors
  - Models software assurance through a diverse set of direct and indirect indicators
  - Is repeatable, scalable, and well-documented

Measuring Software Assurance

Phase Report Card:



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CAS: Identify and fill capability gaps

CAS: Foster integration and promote further research

CAS: Generate quality tools, reduce false positives

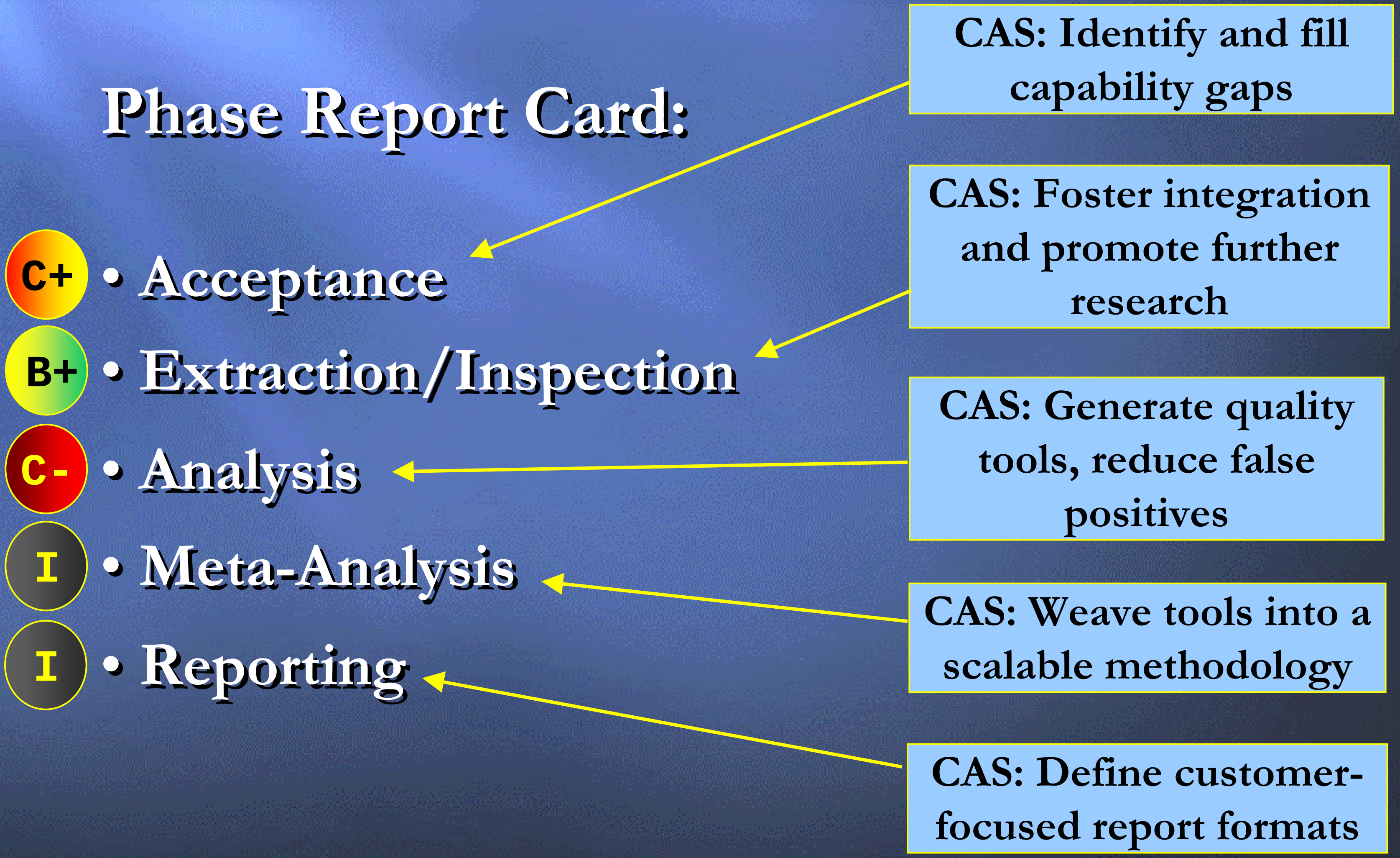
CAS: Weave tools into a scalable methodology

Reporting

- Transform analytical results into comprehensible reports
  - Ranked “raw” data for follow-on deep analysis
  - Comparative results for systems design decisions
  - Summary results linked to standardized evaluation criteria for use as part of a larger evaluation process
  - Formal evaluation report for technology-only evaluations
- Report formats are not currently defined

Measuring Software Assurance

Phase Report Card:



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CAS: Identify and fill capability gaps

CAS: Foster integration and promote further research

CAS: Generate quality tools, reduce false positives

CAS: Weave tools into a scalable methodology

CAS: Define customer-focused report formats

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