SYNOPSYS®

Managing software supply chain risk

Role of a comprehensive SBOM

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Software & Supply Chain Assurance (SSCA) Forum May 2023

#whoami

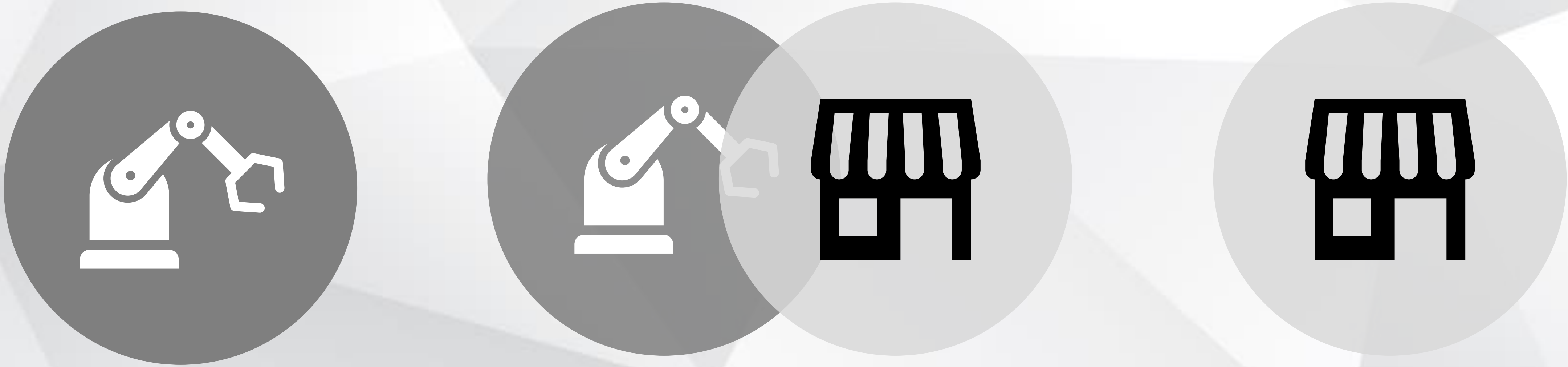
- Joined Synopsys in 2017 as part of the Black Duck acquisition
- Currently Head of Software Supply Chain Risk Strategy
  - Co-chair of DHS CISA ICT SCRM Task Force on SwA
- Previously Head of Technical Marketing and Partner Product Marketing
- Worked 13 years at Citrix
  - Virtualization and Cloud lead within Citrix Open Source Business Office
  - Dotted line to Citrix CSO with product security responsibility
  - Thought leadership in virtualization and containerization efforts

Software operators assume risk from software supply chains

Visibility into Software Supply Chain Risk

Software producers

Software operators

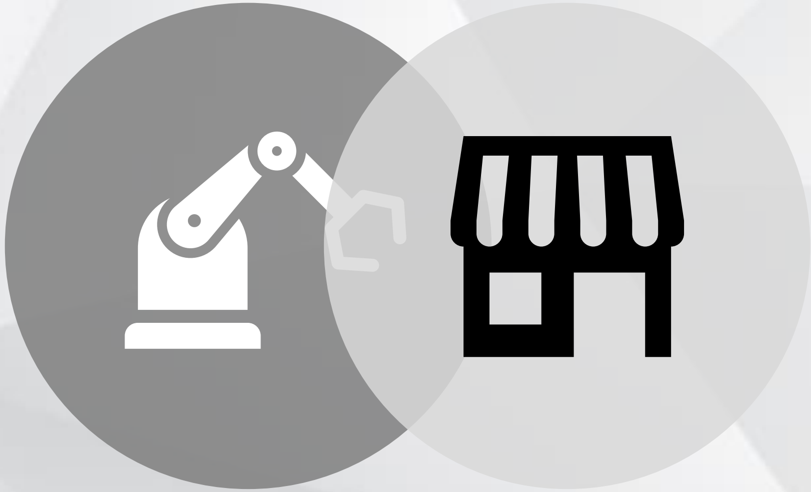


*How do we **build trust** with our customers and end users?*

*How do we **maintain visibility** and control of risks?*

Software Supply Chain Complexity and Risk

Essentials of Software Supply Chain Trust



Trust is the result of supply chain **integrity**.

Integrity is the result of consistently executed **processes**.

Effective **processes** are the result of **collaboration** between software producers and operators.

Trust objectives

□ Build and operate secure applications

□ Attest to development security efforts

□ Adhere to software license obligations

□ Verify integrity of software

Primary origins of software supply chain risk

Implementation decisions in code your teams write (proprietary code)

+

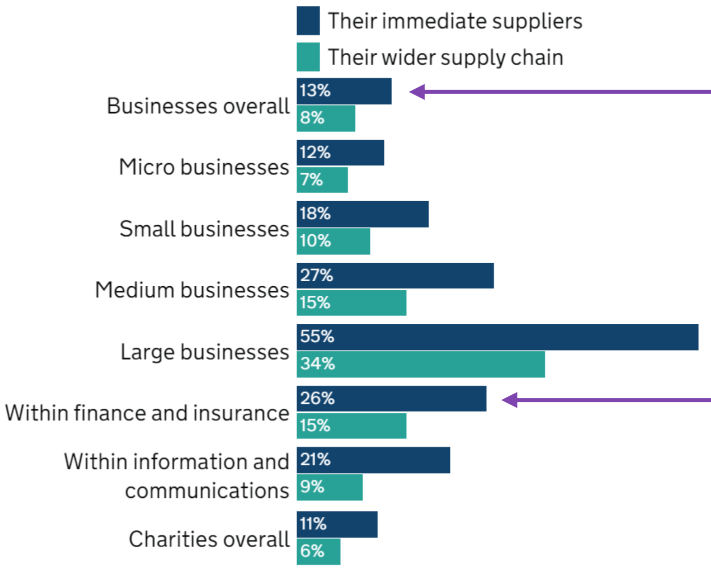
Implementation, **testing and release decisions** in code you consume (open source, container base images and 3rd party vendor libraries)

+

Implementation, testing and **deployment decisions** in cloud services (API usage and dataflows)

Cyber risk assessments within supply chains are still rare

Percentage of UK organizations that have carried out work to formally review the potential cyber security risks presented by the following groups of suppliers



Unchanged from 2022 Survey

Up 11 points since 2022 Survey

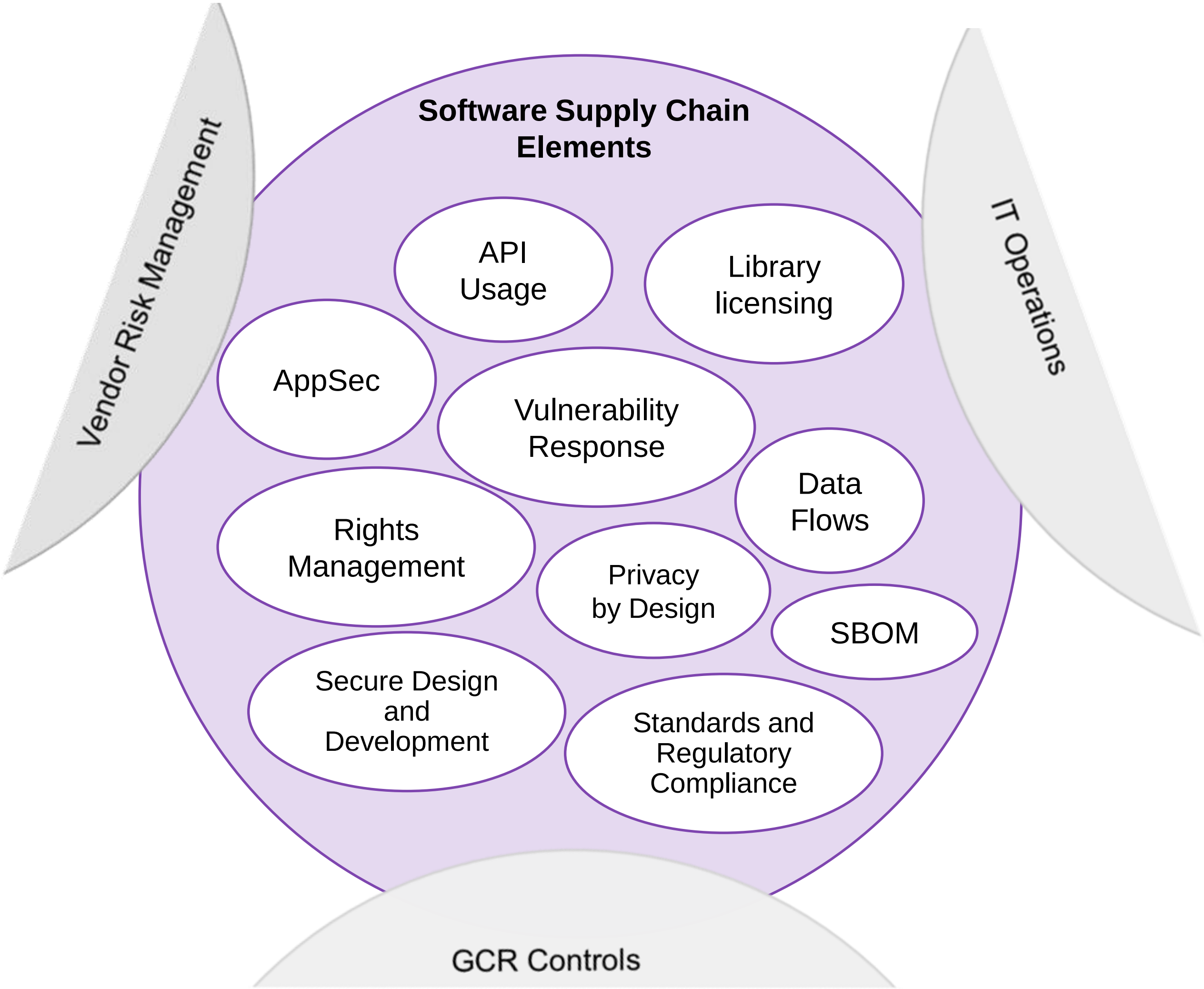
Down 8 points since 2022 Survey

Bases: 2,263 UK businesses; 1,387 micro businesses; 400 small businesses; 277 medium businesses; 199 large businesses; 178 finance or insurance businesses; 161 information and communications businesses; 1,174 charities

Source: Cyber Security Breaches Survey 2023 – UK Department for Science, Innovation and Technology

Software supply chain risk efforts are often siloed

And risk is more than just an unpatched vulnerability



Applies to all software that is:

- Bought with hardware
- Bought as software
- Built internally
- Downloaded
- Contracted
- Modified
- Updated or patched

SBOMs are now key to software risk management

You can’t talk software supply chain risk without SBOMs

Two primary SBOM standards to be aware of – and expect both to be supported

- SPDX was created in 2010
- Is part of Linux Foundation Open Compliance Program
- Synopsys is a supporting partner
- Version 2.2.1 is international standard ISO/IEC 5962:2021
- Latest version: 2.3 - released Nov 2022
- Version 3.0 has anticipated release of summer 2023
- Six core specification contributors

- CycloneDX was created in 2017
- Is part of OWASP and intended for use with OWASP Dependency-Track
- Synopsys is a supporting organization
- Latest version: 1.4 - released January 2022
- One core specification contributor

Both formats meet the NTIA minimum requirements

SBOMs serve different markets – with different requirements

Medical devices – FDA Reg 524B* and

IMDRF/N73FINAL.2023

US Government Software Procurement – Executive Order 14028 and GSA Memo MV-23-02

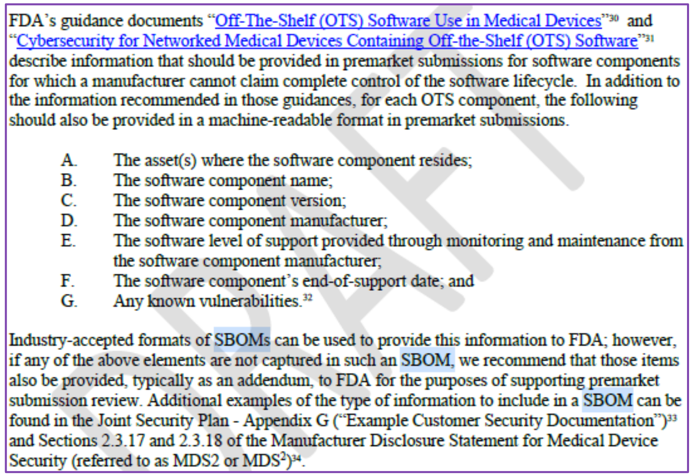
Automotive – ISO 21434, UNR 155 and NHTSA

Critical Infrastructure – IEC 62443

Same SBOM formats, different minimum fields, different supporting documentation
Requirements are global and not US centric

Note: FDA regulation 524B requires SBOM and vulnerability response plans starting March 29, 2023

Examples of SBOM definitions – more than just NTIA

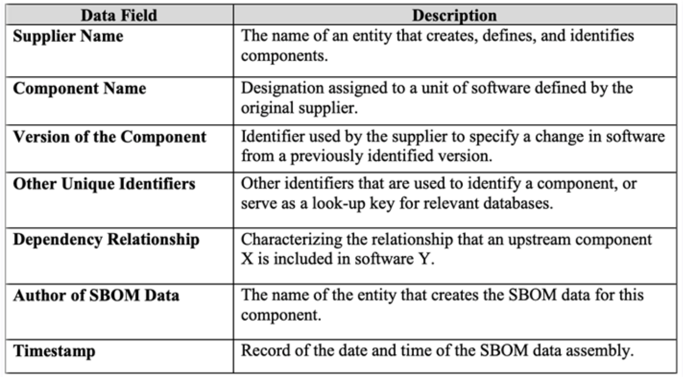


FDA's guidance documents "Off-The-Shelf (OTS) Software Use in Medical Devices"[30] and "Cybersecurity for Networked Medical Devices Containing Off-the-Shelf (OTS) Software"[31] describe information that should be provided in premarket submissions for software components for which a manufacturer cannot claim complete control of the software lifecycle. In addition to the information recommended in those guidances, for each OTS component, the following should also be provided in a machine-readable format in premarket submissions.

A. The asset(s) where the software component resides;
B. The software component name;
C. The software component version;
D. The software component manufacturer;
E. The software level of support provided through monitoring and maintenance from the software component manufacturer;
F. The software component's end-of-support date; and
G. Any known vulnerabilities.[32]

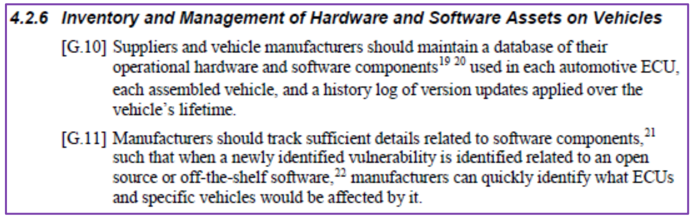
Industry-accepted formats of SBOMs can be used to provide this information to FDA; however, if any of the above elements are not captured in such an SBOM, we recommend that those items also be provided, typically as an addendum, to FDA for the purposes of supporting premarket submission review. Additional examples of the type of information to include in a SBOM can be found in the Joint Security Plan - Appendix G ("Example Customer Security Documentation")[33] and Sections 2.3.17 and 2.3.18 of the Manufacturer Disclosure Statement for Medical Device Security (referred to as MDS2 or MDS^2)[34].

FDA Requirements for SBOM[1]



Data Field	Description
Supplier Name	The name of an entity that creates, defines, and identifies components.
Component Name	Designation assigned to a unit of software defined by the original supplier.
Version of the Component	Identifier used by the supplier to specify a change in software from a previously identified version.
Other Unique Identifiers	Other identifiers that are used to identify a component, or serve as a look-up key for relevant databases.
Dependency Relationship	Characterizing the relationship that an upstream component X is included in software Y.
Author of SBOM Data	The name of the entity that creates the SBOM data for this component.
Timestamp	Record of the date and time of the SBOM data assembly.

NTIA Minimum SBOM Fields[2]



4.2.6 Inventory and Management of Hardware and Software Assets on Vehicles

[G.10] Suppliers and vehicle manufacturers should maintain a database of their operational hardware and software components[19] [20] used in each automotive ECU, each assembled vehicle, and a history log of version updates applied over the vehicle's lifetime.

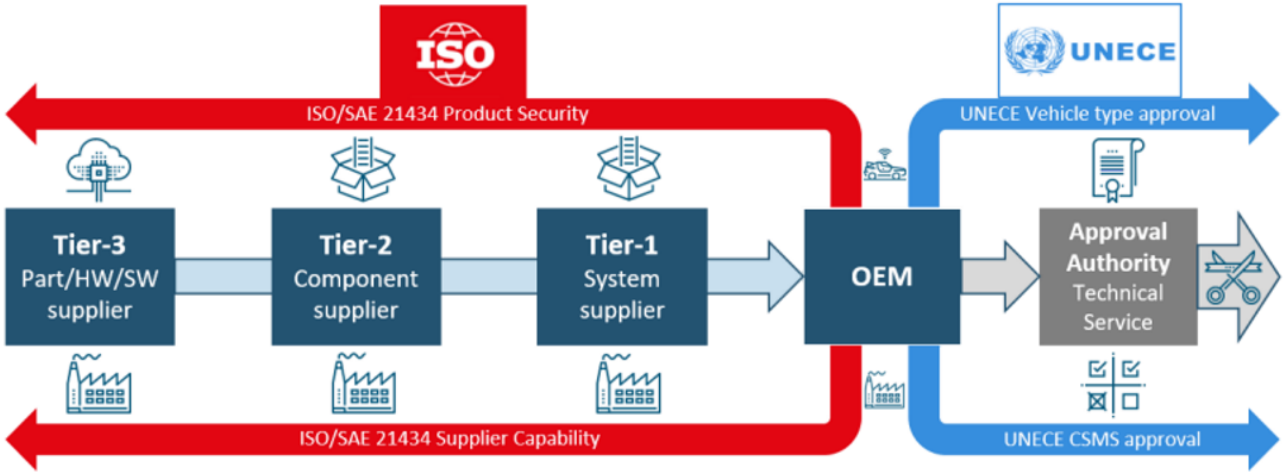
[G.11] Manufacturers should track sufficient details related to software components,[21] such that when a newly identified vulnerability is identified related to an open source or off-the-shelf software,[22] manufacturers can quickly identify what ECUs and specific vehicles would be affected by it.

NHSTA Recommended Software Inventory Management[3]

Sources: [1] FDA – Cybersecurity in Medical Devices: Quality System Considerations and Content of Premarket Submissions (Draft Apr 2022)
[2] NTIA – The Minimum Elements For a Software Bill of Materials (SBOM)
[3] NHTSA – Cybersecurity Best Practices for the Safety of Modern Vehicles (Draft Sept 2022)

Example: SBOM in automotive appears in multiple guidelines

Security standards and increased use of open-source libraries create a new rule book



ISO/SAE 21434 – Clause 6, Clause 7, RQ-08-07, RC-10-12

- Component reuse and usage of off-the-shelf components (***SBOM***) shall include an understanding of the suppliers' cybersecurity activities and vulnerability management practices

UNR 155 – Section 5.1.1

- Vehicle manufacturer has taken appropriate measures to collect and verify the information required through the [software] supply chain (***SBOM***) so as to demonstrate supplier related risks are identified and managed

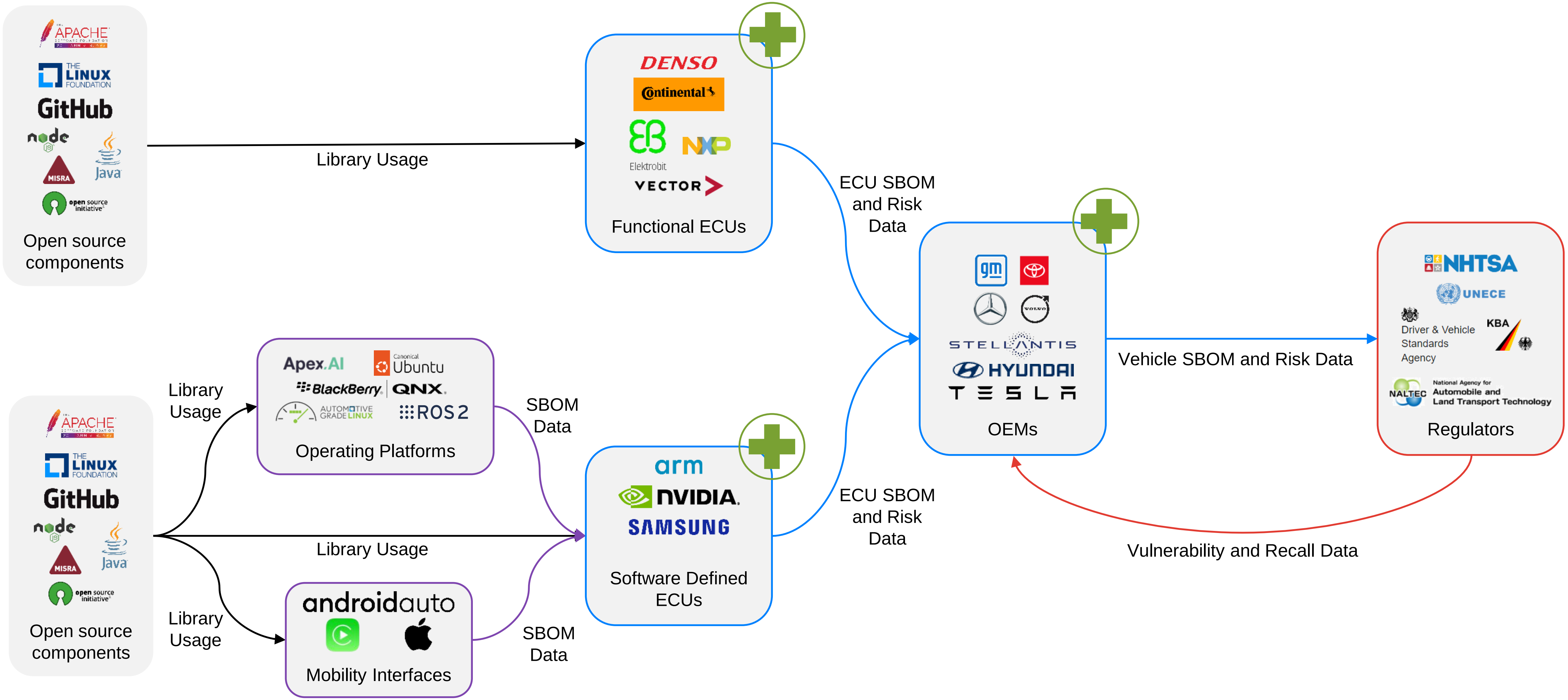
NHTSA Cybersecurity Best Practices 2022 – Section G.10

- Suppliers and vehicle manufacturers should maintain a database of their operational hardware and software components (***SBOM***) used in each automotive ECU

RQ-08-01 Cybersecurity monitoring (SBOM)

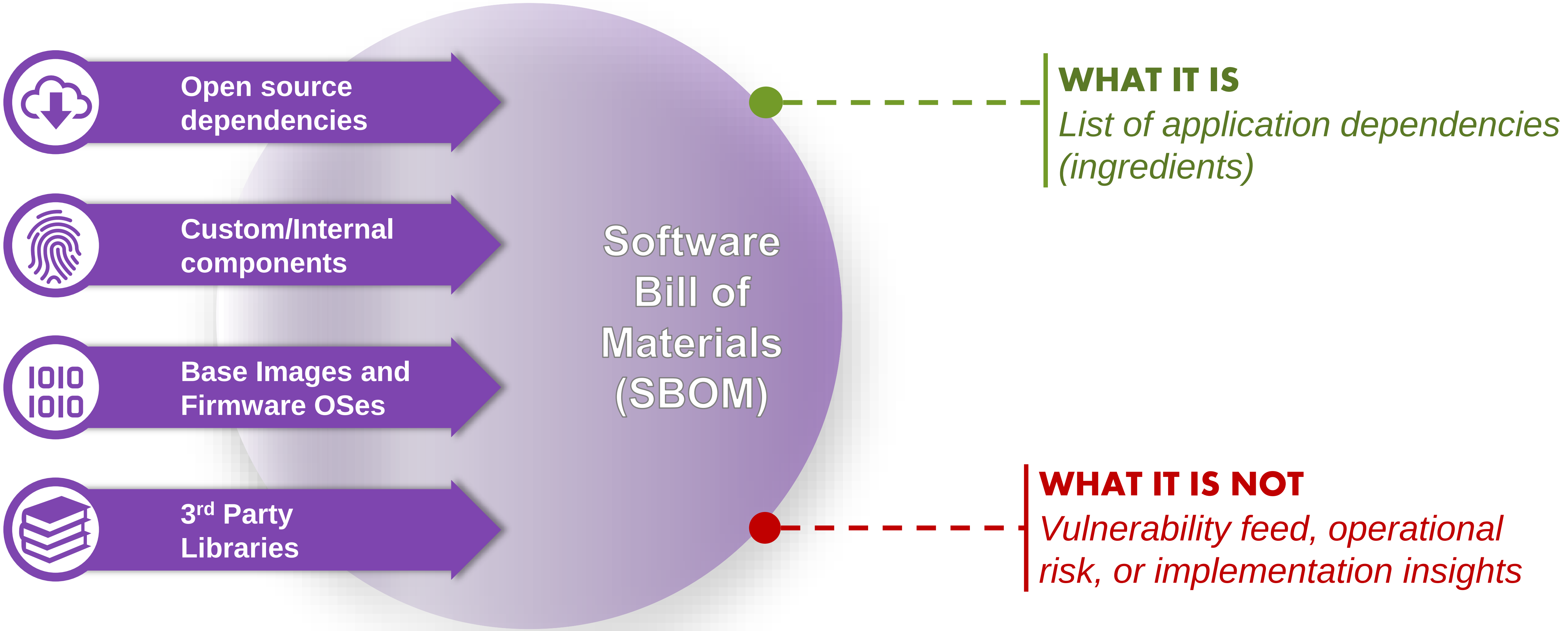
Result: SBOM responsibilities increase in the value chain

Value chain tiers add software library usage, risk and map in safety documentation



Comprehensive SBOMs identify the origin of all components

Created by software producers for the benefit of software operator/consumer



Open source dependencies

Custom/Internal components

Base Images and Firmware OSes

3rd Party Libraries

Software Bill of Materials (SBOM)

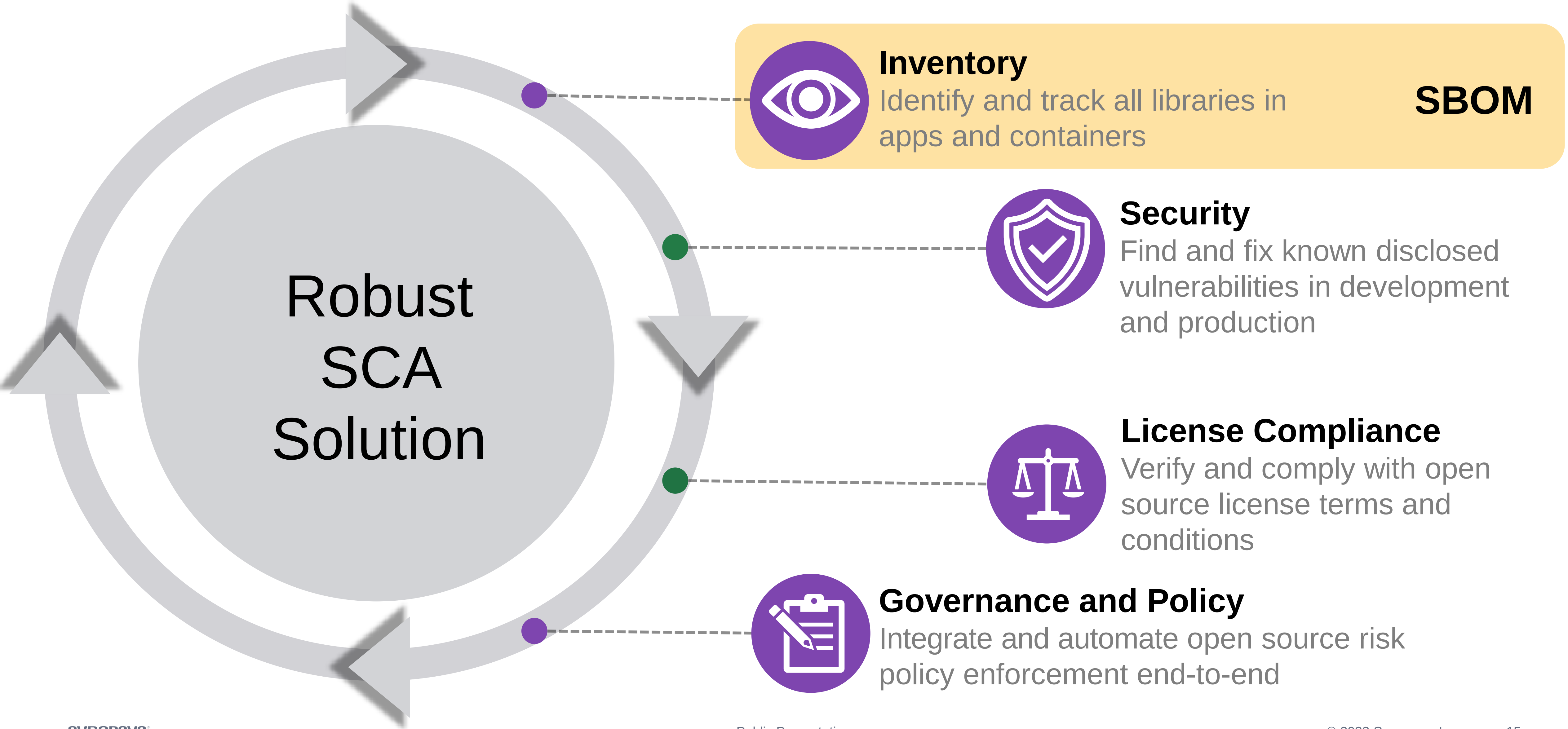
WHAT IT IS

List of application dependencies (ingredients)

WHAT IT IS NOT

Vulnerability feed, operational risk, or implementation insights

Robust SCA is a requirement for all SBOM management



Robust SCA Solution

Inventory
Identify and track all libraries in apps and containers

SBOM

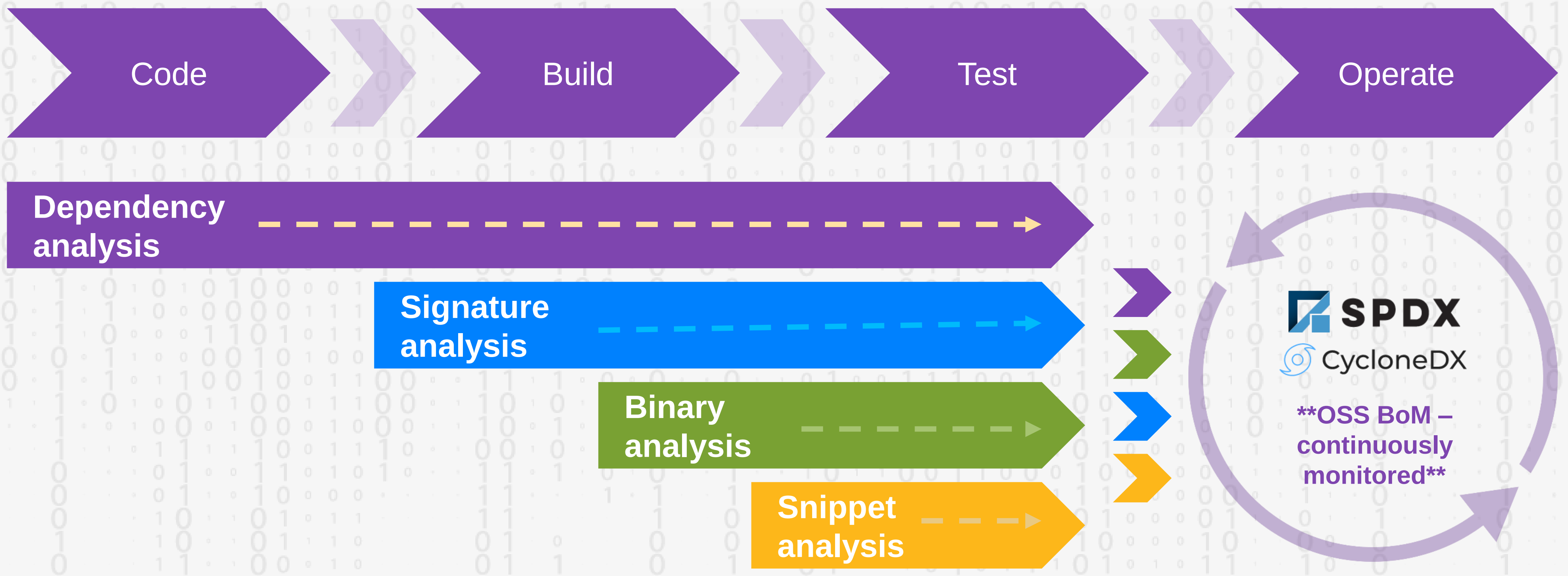
Security
Find and fix known disclosed vulnerabilities in development and production

License Compliance
Verify and comply with open source license terms and conditions

Governance and Policy
Integrate and automate open source risk policy enforcement end-to-end

Automate comprehensive SBOM generation in the SDLC

Accurate and complete SBOM generation relies upon multiple analysis techniques



Two key challenges for comprehensive SBOMs

Completeness

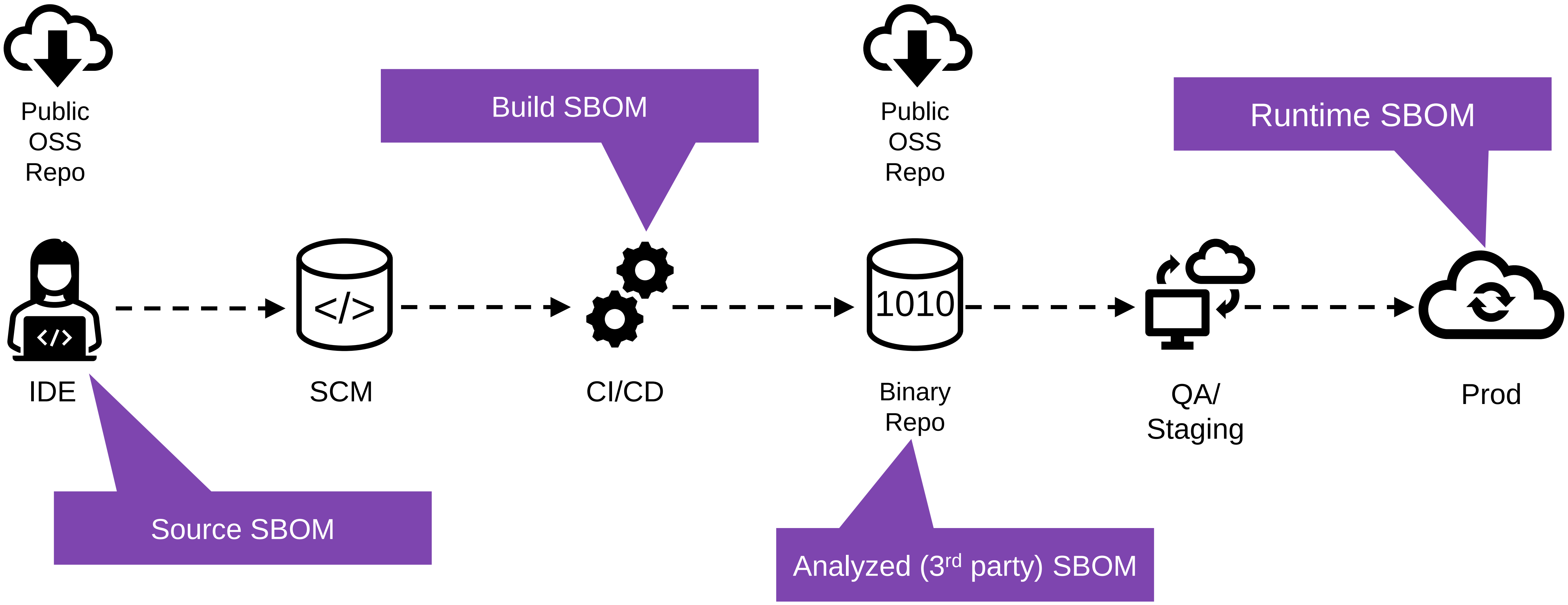
- Can the component be identified?
  - E.g. ADD, COPY, RUN in containers
- Does knowledge source contain the component?
  - E.g. missing forges or incomplete understanding of FOSS
- Does the knowledge source align to the applications' lifespan
  - E.g. Will it retain information for legacy items?
- How are internal components and 3rd party commercial non-COTS components handled?

Accuracy

- Was the SBOM created using tooling?
  - Manually created SBOMs are prone to being outdated
- Does SBOM adhere to schema for chosen format?
- Does tooling support precise version identification?
- Does SBOM map to known software release?
  - E.g. integrity check for release vs SBOM
- Was SBOM created from merged SBOMs?
  - Was source accuracy validated?

Knowing where an SBOM is created in the SDLC matters

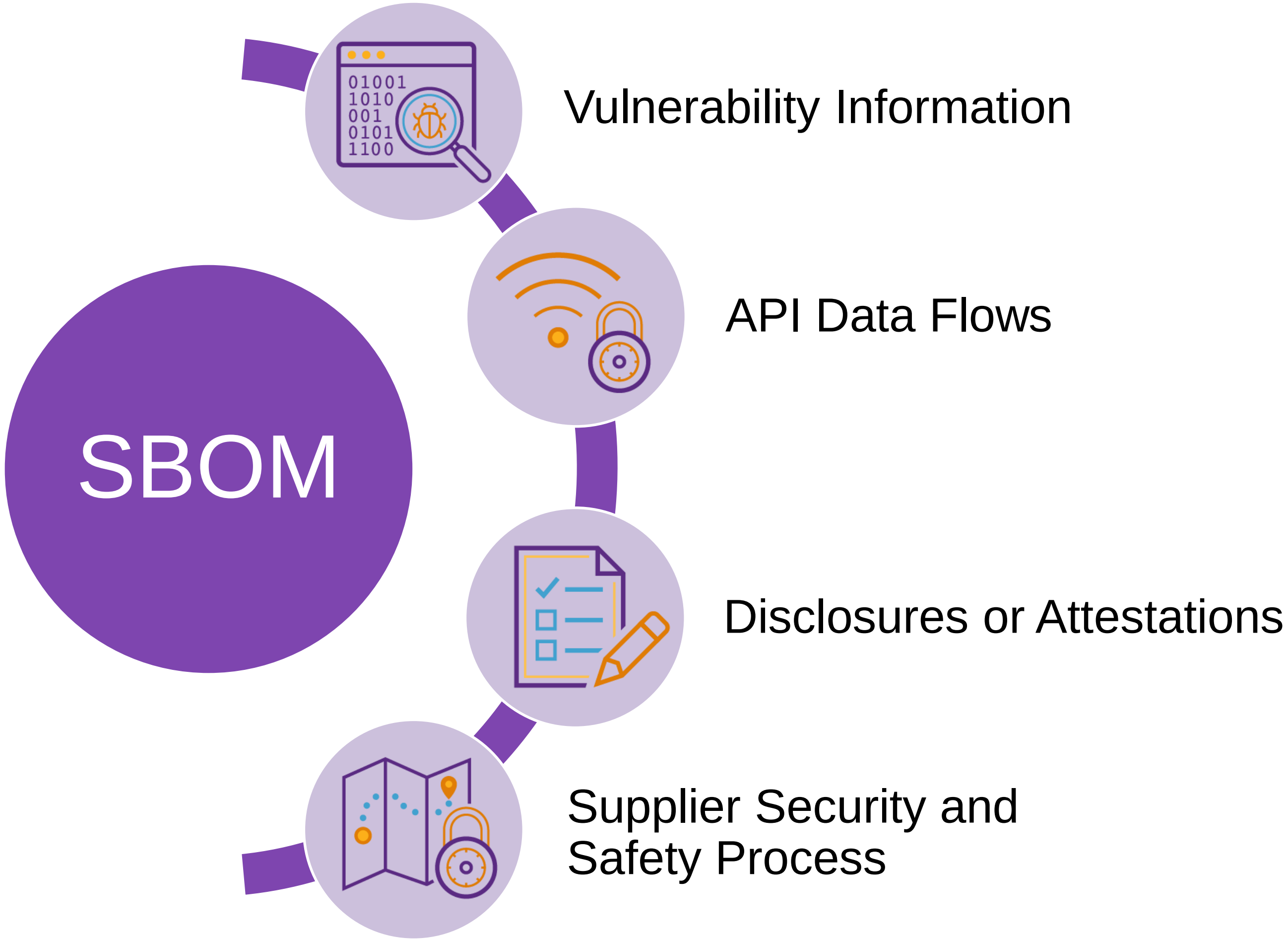
SBOM contents can vary, and data fidelity will vary accordingly



Source: Terms used are consistent with CISA SBOM Types April 2023

Comprehensive SBOMs enable supply chain risk analysis

Mapping risk elements to SBOMs is the key to extensibility and visibility


SBOM
Vulnerability Information
API Data Flows
Disclosures or Attestations
Supplier Security and Safety Process

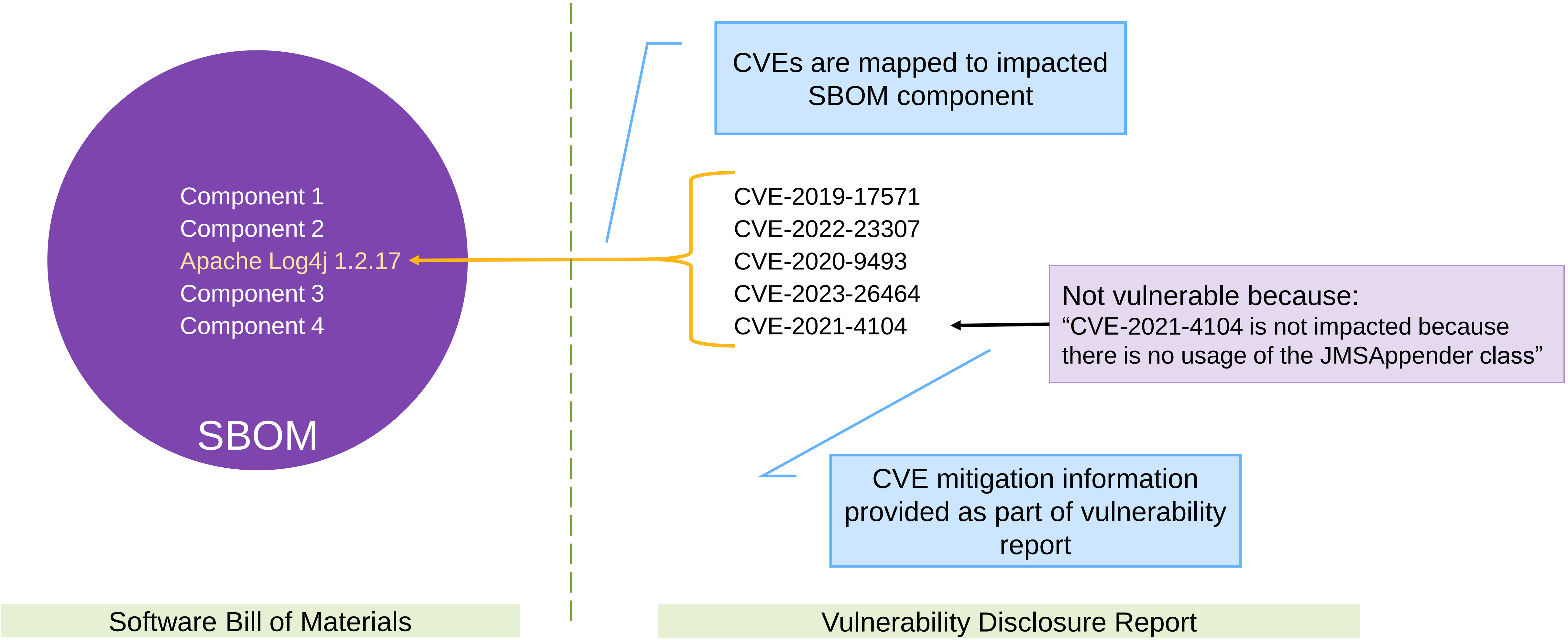
Rather than treat the SBOM as a single model for all assurance and software supply chain data, a **linkable, modular approach** is encouraged to **maximize the potential for flexibility and adoption**.

Linkability enables **SBOM data** to be **easily mapped** to other important supply chain data, while a **modular architecture supports extensibility** for more use cases as **software supply chain transparency** and **management** data and tools mature.

Source: NTIA - The Minimum Elements For a Software Bill of Materials (SBOM)

Example: Disclosing unpatched CVEs present at release

Use NIST Vulnerability Disclosure Report (VDR) process mapped to SBOM data



CVEs are mapped to impacted SBOM component

Component 1
Component 2
Apache Log4j 1.2.17
Component 3
Component 4

SBOM

CVE-2019-17571
CVE-2022-23307
CVE-2020-9493
CVE-2023-26464
CVE-2021-4104

Not vulnerable because:
“CVE-2021-4104 is not impacted because there is no usage of the JMSAppender class”

CVE mitigation information provided as part of vulnerability report

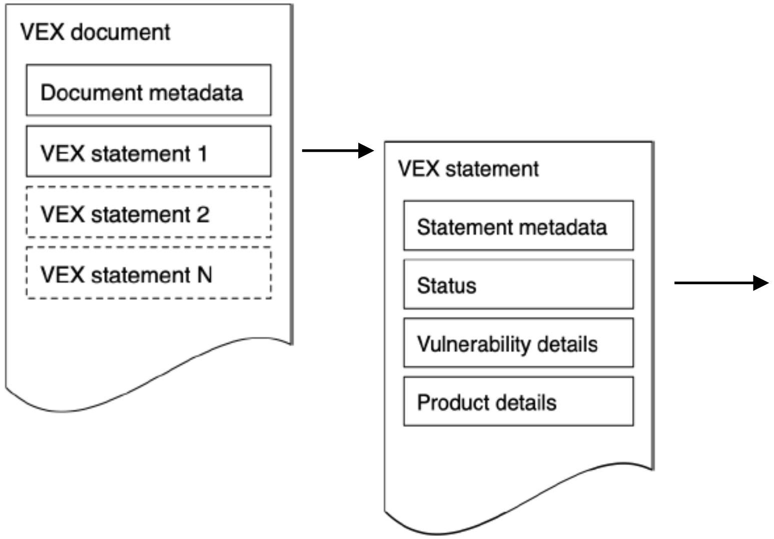
Software Bill of Materials

Vulnerability Disclosure Report

Sidebar: Vulnerability Exploitability eXchange (VEX) process

Not directly connected with SBOMs, but part of the SBOM ecosystem

- **Goal**: Provide transparency of vulnerability data to software operators
- **Core requirement**: Identify in automation or tooling what isn't impacted by a CVE
- **Mature implementation**: Common Security Advisory Framework (CSAF) 2.0
- **Minimum requirements published**: April 21, 2023 by DHS CISA*



Example VEX statement

```
"product_status": {
  "fixed": [
      "8Base-RHOSE-4.11:openshift4/ose-etcd:v4.11.0-202301041324.p0.gc50e9aa.assembly.stream"
  ],
  "known_not_affected": [
       "8Base-RHOSE-4.11:openshift4/cloud-network-config-controller-rhel8:v4.11.0-202301051554.p0.g5dd318b.assembly.stream",
       "8Base-RHOSE-4.11:openshift4/network-tools-rhel8:v4.11.0-202301070325.p0.g4e87286.assembly.stream",
       "8Base-RHOSE-4.11:openshift4/ose-baremetal-installer-rhel8:v4.11.0-202301042055.p0.gf746e45.assembly.stream",
       "8Base-RHOSE-4.11:openshift4/ose-cluster-baremetal-operator-rhel8:v4.11.0-202301091615.p0.g1f1ea53.assembly.stream",
[...full list truncated...]
  ]
}
```

CVE in NVD can answer this

Only vendor can answer this

https://www.cisa.gov/resources-tools/resources/minimum-requirements-vulnerability-exploitability-exchange-vex

Twelve essential elements for assuring trust in software supply chain

1	**Asset inventory**	*Know what software you have (and perhaps don't want!)*
2	**SBOM**	*Produce a Software Bill of Materials (SBOM) on demand*
3	**Provenance of software**	*Know the origin of your software*
4	**Secure dev environment**	*Secure the development pipeline and artifacts*
5	**Integrity attestation**	*Attest to integrity of a software artifact (e.g. component, zip file, container, API connection, database connection)*
6	**Quality**	*Identify bugs and reliability issues*
7	**Security**	*Identify security issues*
8	**Regulatory noncompliance**	*Determine noncompliance with regulations and standards*
9	**Licensing noncompliance**	*Ensure software is legally licensed*
10	**Unexpected functionality**	*Identify malware and other hidden or unexpected functions*
11	**Policy compliance**	*Show evidence that security policies are followed*
12	**Risk management reporting**	*Measure and communicate supply chain risks*

Only part of solution

Importance of each element depends on role and responsibility

Twelve essential elements for assuring trust in software supply chain

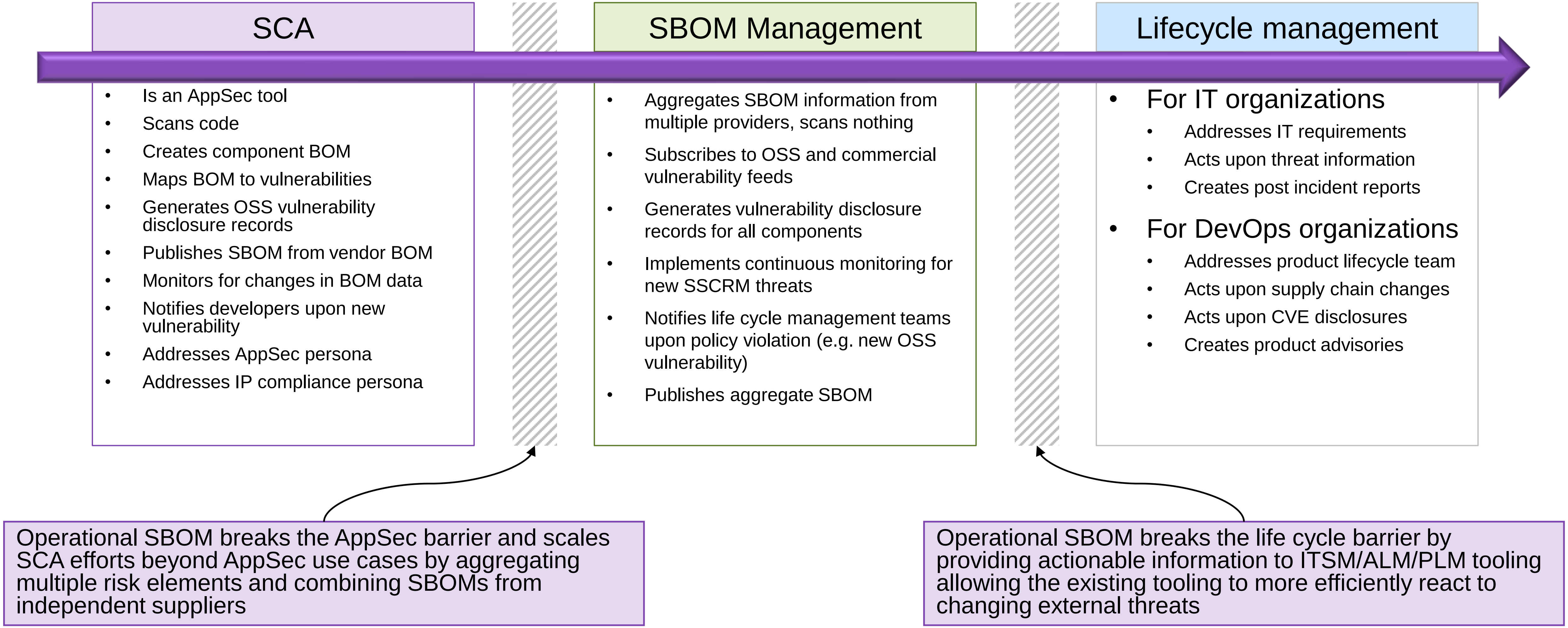
1	**Asset inventory**	*Know what software you have (and perhaps don't want!)*	Inventory & Operations
2	**SBOM**	*Produce a Software Bill of Materials (SBOM) on demand*	
3	**Provenance of software**	*Know the origin of your software*	
4	**Secure dev environment**	*Secure the development pipeline and artifacts*	Secure SDLC
5	**Integrity attestation**	*Attest to integrity of a software artifact (e.g. component, zip file, container, API connection, database connection)*	
6	**Quality**	*Identify bugs and reliability issues*	
7	**Security**	*Identify security issues*	
8	**Regulatory noncompliance**	*Determine noncompliance with regulations and standards*	Verification, Compliance, Attestation
9	**Licensing noncompliance**	*Ensure software is legally licensed*	
10	**Unexpected functionality**	*Identify malware and other hidden or unexpected functions*	
11	**Policy compliance**	*Show evidence that security policies are followed*	
12	**Risk management reporting**	*Measure and communicate supply chain risks*	

A Secure Software Development Lifecycle is a necessary part of all software supply chains

Crystal ball:
What an SBOM focused world might look like

Scenario: Operationalized SBOMs

Creating a continuum scaling SCA to meet InfoSec and product lifecycle requirements



SCA

- Is an AppSec tool
- Scans code
- Creates component BOM
- Maps BOM to vulnerabilities
- Generates OSS vulnerability disclosure records
- Publishes SBOM from vendor BOM
- Monitors for changes in BOM data
- Notifies developers upon new vulnerability
- Addresses AppSec persona
- Addresses IP compliance persona

SBOM Management

- Aggregates SBOM information from multiple providers, scans nothing
- Subscribes to OSS and commercial vulnerability feeds
- Generates vulnerability disclosure records for all components
- Implements continuous monitoring for new SSCRM threats
- Notifies life cycle management teams upon policy violation (e.g. new OSS vulnerability)
- Publishes aggregate SBOM

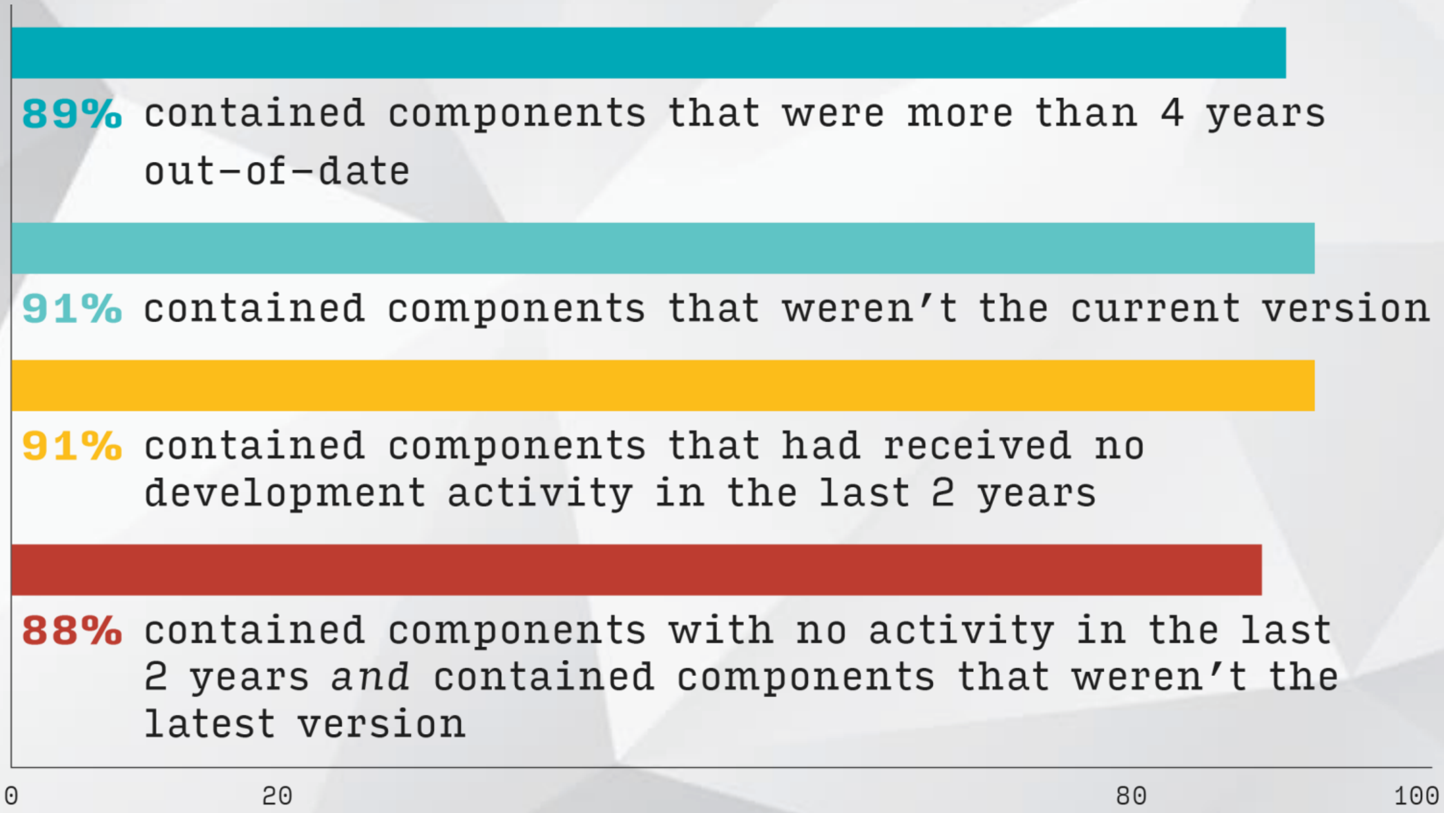
Lifecycle management

- For IT organizations
  - Addresses IT requirements
  - Acts upon threat information
  - Creates post incident reports
- For DevOps organizations
  - Addresses product lifecycle team
  - Acts upon supply chain changes
  - Acts upon CVE disclosures
  - Creates product advisories

Operational SBOM breaks the AppSec barrier and scales SCA efforts beyond AppSec use cases by aggregating multiple risk elements and combining SBOMs from independent suppliers

Operational SBOM breaks the life cycle barrier by providing actionable information to ITSM/ALM/PLM tooling allowing the existing tooling to more efficiently react to changing external threats

Scenario: Find the “Sleeping Beast” in “stable code”



89% contained components that were more than 4 years out-of-date

91% contained components that weren’t the current version

91% contained components that had received no development activity in the last 2 years

88% contained components with no activity in the last 2 years *and* contained components that weren’t the latest version

of codebases contained components that had no new development in the past two years

of codebases contained open source more than four years out-of-date

Source: 2023 Synopsys Open Source Security and Risk Analysis report

Scenario: Identify if patch processes allow malicious code in?

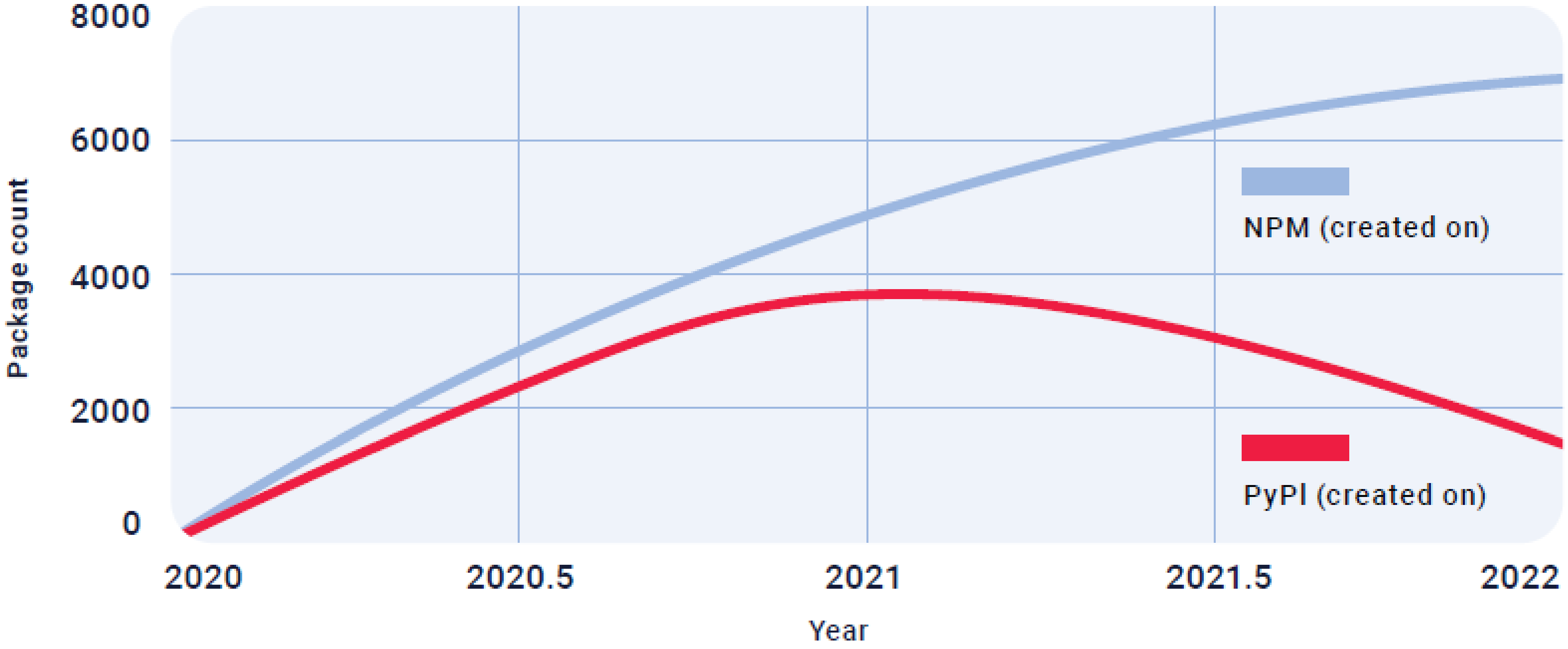
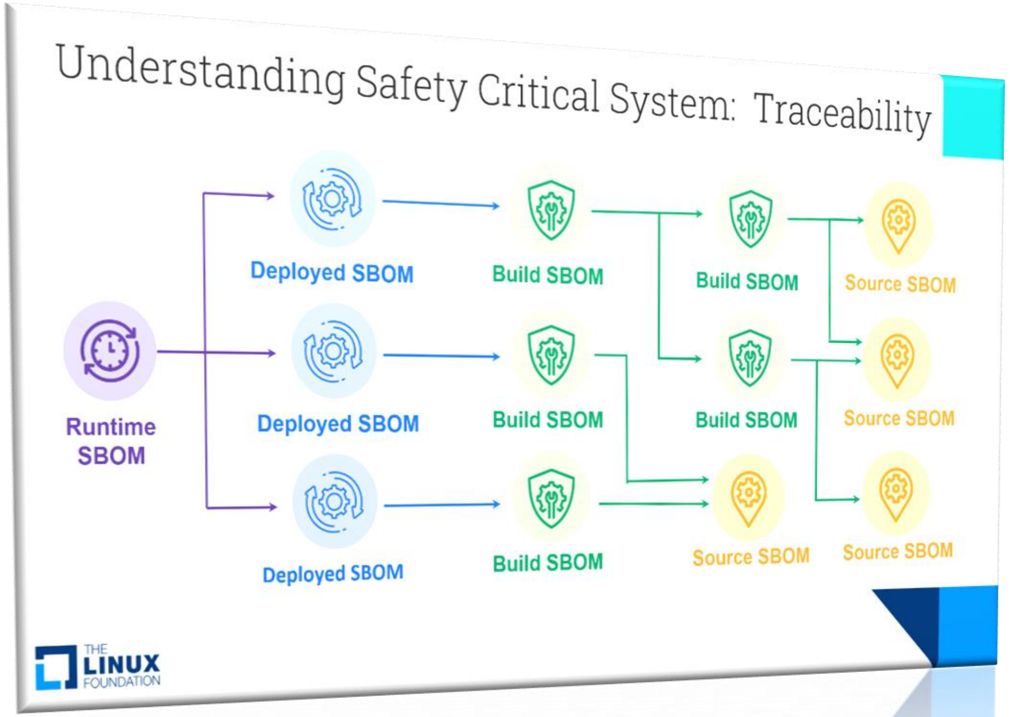


Figure 1. Malicious package uploads to the npm code repository showed a 41% increase in 2022 over 2021, when researchers detected 4,940 packages. And the 2022 numbers represent more than a 9,000% increase over 2020, when researchers detected just 75 malicious npm packages. *Source: ReversingLabs*

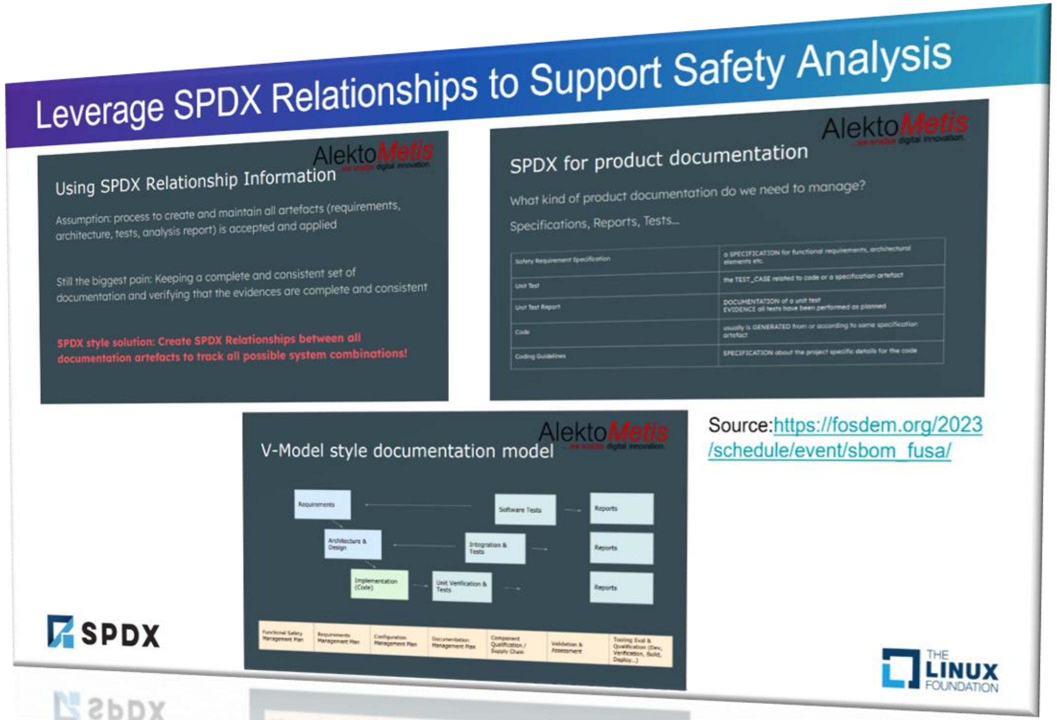
Source:2022 ReversingLabs The State of Software Supply Chain Security

Scenario: Functional Safety and Traceability

SBOM enables software analysis beyond vulnerability management



Understanding Safety Critical System: Traceability



Leverage SPDX Relationships to Support Safety Analysis

Using SPDX Relationship Information

Assumption: process to create and maintain all artefacts (requirements, architecture, tests, analysis report) is accepted and applied

Still the biggest pain: Keeping a complete and consistent set of documentation and verifying that the evidences are complete and consistent

SPDX style solution: Create SPDX Relationships between all documentation artefacts to track all possible system combinations!

SPDX for product documentation

What kind of product documentation do we need to manage?

Specifications, Reports, Tests…

Safety Requirement Specification	a SPECIFICATION for functional requirements, architectural elements etc.
Unit Test	the TEST_CASE related to code or a specification artefact
Unit Test Report	DOCUMENTATION of a unit test EVIDENCE all tests have been performed as planned
Code	usually is GENERATED from or according to some specification artefact
Coding Guidelines	SPECIFICATION about the project specific details for the code

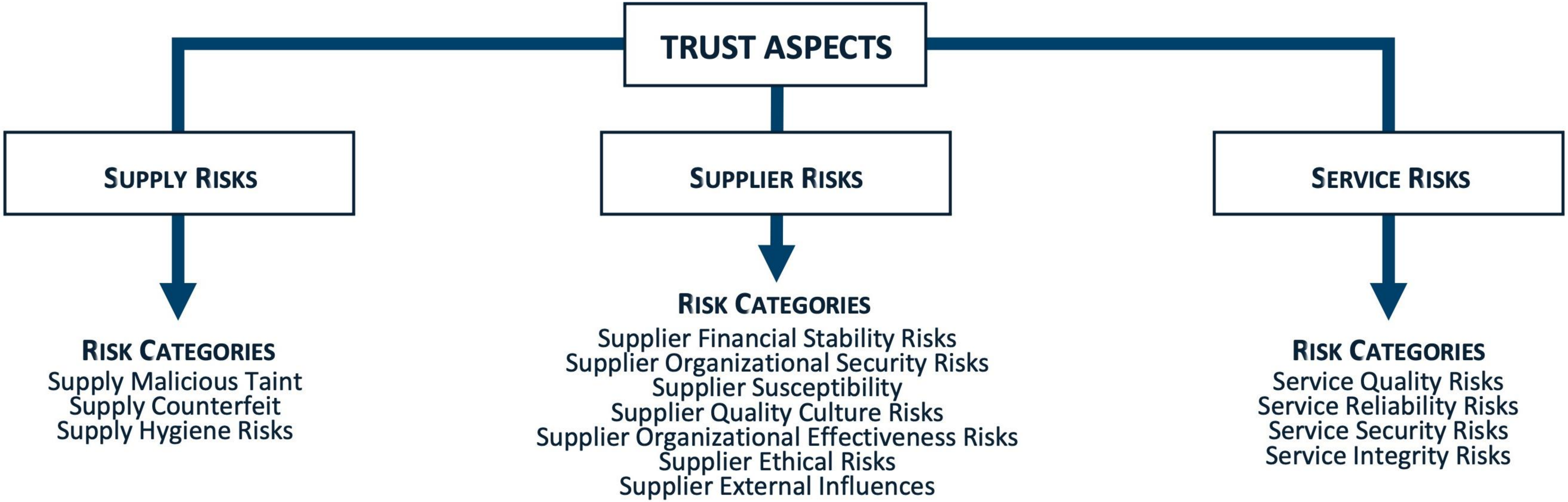
V-Model style documentation model

AlektoMetis
…we enable digital innovation
Requirements
Architecture & Design
Implementation (Code)
Unit Verification & Tests
Integration & Tests
Software Tests
Reports
Reports
Reports
Functional Safety Management Plan
Requirements Management Plan
Configuration Management Plan
Documentation Management Plan
Component Qualification / Supply Chain
Validation & Assessment
Tooling Eval & Qualification (Dev, Verification, Build, Deploy…)
SPDX
THE LINUX FOUNDATION

Source:https://fosdem.org/2023/schedule/event/sbom_fusa/

Source: SPDX community

Scenario: MITRE System of Trust Framework



TRUST ASPECTS

SUPPLY RISKS

RISK CATEGORIES
Supply Malicious Taint
Supply Counterfeit
Supply Hygiene Risks

SUPPLIER RISKS

RISK CATEGORIES
Supplier Financial Stability Risks
Supplier Organizational Security Risks
Supplier Susceptibility
Supplier Quality Culture Risks
Supplier Organizational Effectiveness Risks
Supplier Ethical Risks
Supplier External Influences

SERVICE RISKS

RISK CATEGORIES
Service Quality Risks
Service Reliability Risks
Service Security Risks
Service Integrity Risks

Source: MITRE System of Trust

Core takeaways

- SBOMs are becoming a requirement, but you need a robust SCA solution to create them
  - Single SCA analysis technique rarely identifies all software
- Robust comprehensive SBOMs include all code: internal, 3rd party and open source
  - Advanced SBOM scenarios rely on deeper analysis of software risk from all software
- SBOM workflows are mostly focused on vulnerability management today
  - SCA vendors solved the problem of OSS vulnerability and license compliance years ago
- Products don’t have one single SBOM
  - The type of SBOM and how it was generated are key pieces of metadata
  - Cyber-physical devices may have many vendors requiring aggregation of SBOM data
- Having an SBOM doesn’t directly solve problems, but it does enable solutions
  - Push vendors to use SBOMs to solve critical problems not solved by SCA

Thank You