RTO stands for recovery time objective, and it refers to how long it takes an organization to move from the time of disaster to the time of operating at a defined service level in a recovery environment. Defined service level does not mean back to business as usual but rather to some level of service that allows business to move forward.

The business impact analysis (BIA) is the process that helps an organization identify its most critical functions, services, assets, systems and processes, and RPO and RTO are subsequently determined to understand how much data and how quickly these systems and processes need to be recovered.

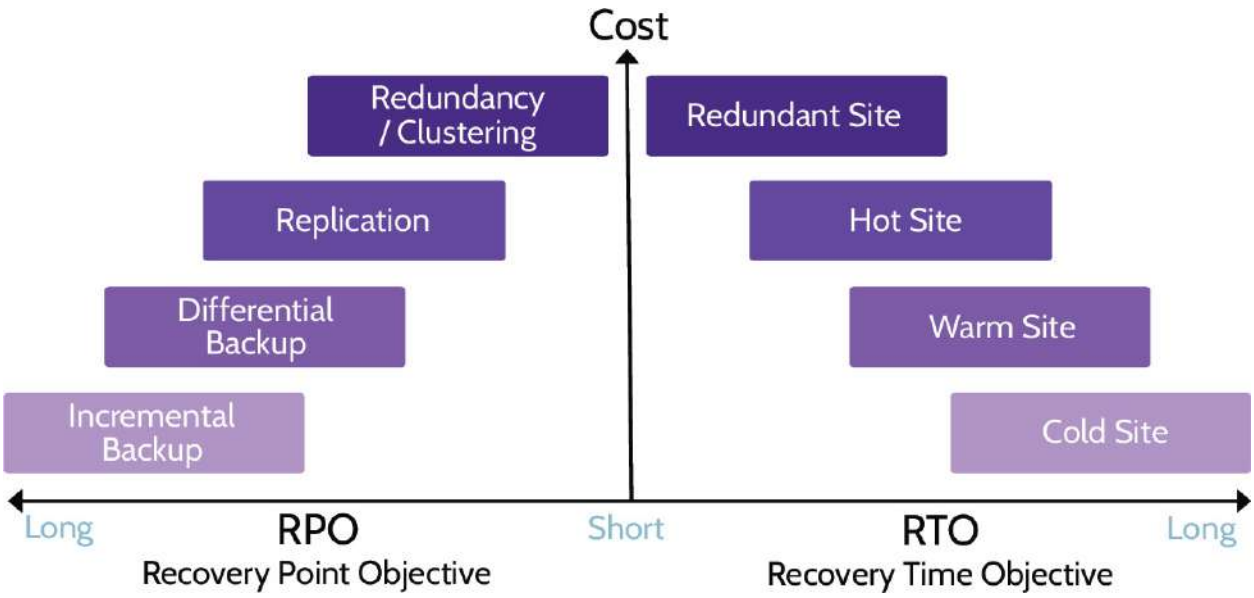


Figure 7-17: **RPO and RTO**

System Resilience, High Availability, Quality of Service (QoS), and Fault Tolerance

In addition to utilizing recovery site strategies, as noted above, system resilience, high availability, quality of service (QOS), and fault tolerance are achieved through the other means noted throughout this section: ■ Clustering ■ Redundancy ■ Replication ■ Spare parts ■ RAID

As with most security- and cost-related considerations within an organization, goals and objectives ultimately drive decisions, including those related to utilization of one, a combination of, or all of the strategies and solutions noted here.

7.11 Implement disaster recovery (DR) processes

7.11.1 BCM, BCP, and DRP

CORE **CONCEPTS**

- **A disaster is something that interrupts normal business operations**
- **BCM is the process and function by which an organization is responsible for creating, maintaining, and testing BCP and DRP plans**
- **BCP focuses on survival of the business processes when something unexpected impacts it**
- **DRP focuses on the recovery of vital technology infrastructure and systems**

- **BCP vs. DRP**
- **Understanding MTD, RTO, RPO, WRT**

The processes described in this topic all help mitigate the effects of a disaster, preserving as much value as possible. Business Continuity Management (BCM), Business Continuity Planning (BCP), and Disaster Recovery Planning (DRP) are ultimately used to achieve the same goal—continuity of the business and its critical and essential functions, processes, services, and so on.

A disaster is defined as a sudden, unplanned event that brings about great damage or loss. In a business environment, it is any event that creates an inability on an organization's part to support critical business functions for some predetermined period of time.

Simply put, a disaster is something that interrupts critical and essential business processes. Related terms, like BCM, BCP and DRP, are all listed in Table 7-18.

BCM creates the structure necessary for BCP and DRP. Where BCP is primarily concerned with the components of the business that are truly critical and essential, DRP is primarily concerned with the technological components that support critical and essential business functions. BCP focuses on the processes; DRP focuses on the systems. One important thing to note is that not all business functions are critical or essential, and this should become very clear during the BCP process. Also, even when experiencing a disaster, an organization must still adhere to laws, regulations, privacy requirements, and so on.

Business Continuity Management (BCM)

The business function and processes that provide the structure, policies, procedures, and systems to enable the creation and maintenance of BCP and DRP plans.	
Business Continuity Planning (BCP)	**Disaster Recovery Planning (DRP)**
Focuses on **survival of the business** and the capability for an effective response; **strategic**	Focuses on the recovery of vital **technology infrastructure and systems**; **tactical**

Table 7-18: **BCM, BCP, and DRP**

Steps in the BCP/DRP process

BCP is all about being able to continue performing work and delivering services at an acceptable level (often tied in with specific SLAs) after an impacting incident takes place at an organization. DRP aims at documenting a specific set of activities that will need to take place so an organization is able to recover from an incident and resume normal operations. It ultimately aims at allowing the organization to return to what is known as a Business As Usual (BAU) state of operation. The key BCP/DRP steps are included in Table 7-19.

1. Develop Contingency Planning Policy	This is a formal policy that provides the authority and guidance necessary to develop an effective contingency plan.
2. Conduct BIA	Conduct the business impact analysis, which helps identify and prioritize information systems and components critical to supporting the organization's mission/business processes.
3. Identify controls	Measures taken to reduce the effects of system disruptions can increase system availability and reduce contingency life cycle costs.
4. Create contingency strategies	Thorough recovery strategies ensure that the system may be recovered quickly and effectively following a disruption.
5. Develop contingency plan	Develop an information system contingency plan.
6. Ensure testing, training, and exercises	Thoroughly plan testing, training, and exercises. Testing validates recovery capabilities, whereas training prepares recovery personnel for plan activation, and exercising the plan identifies gaps.

7. Maintenance	Ensure plan maintenance takes place. The plan should be a living document that is updated regularly to remain current with system enhancements and organizational changes.

Table 7-19: **BCP/DRP Steps**

In addition to internal processes, assets, functions and systems, serious consideration must be given to external dependencies and how they could be impacted during a disaster. As an example, let's say we run a data center and our goal is to maintain one week of uptime, even if the power goes down. In order to accomplish this goal, we would need sufficient generator capacity and fuel. However, fuel can be costly to store, so we decide to only store enough fuel for 48 hours of generator operation. We could schedule fuel deliveries to bring in gas to cover the rest of the week. In this example, the fuel delivery company would be an external dependency. We would need to consider strategies to ensure that we can rely on this company when a disaster strikes. If there is a powerful hurricane or other disaster, will the company still be able to make its deliveries? Or should we consider backup options, like organizing an out-of-state supplier? External dependencies can go far beyond just fuel suppliers. Any external organization, individual, or service can be an external dependency, and organizations need to consider these as part of their BCP.

7.11.2 RPO, RTO, WRT, and MTD

CORE **CONCEPTS**

- **RPO, RTO, WRT, and MTD/MAD are all measurements of time.**
- **RPO = max tolerable data loss measured in time.**
- **RTO = max tolerable time to recover systems to a defined service level.**
- **WRT = max tolerable time to verify system and data integrity as part of resumption of normal ops**
- **MTD/MAD = max time critical system, function, or process can be disrupted before unacceptable/irrecoverable consequences to business.**

When dealing with BCP and DRP procedures, there are four key measurements of time to be aware of. Those are: **Maximum Tolerable Downtime (MTD)/Maximum Allowable Downtime (MAD)**

Refers to the maximum amount of time that an organization's critical process or processes can be impacted. MTD is sometimes referred to as maximum allowable downtime (MAD) or acceptable interruption window (AIW). If the MTD is reached or exceeded, the ongoing viability of the organization can be called into question, and in fact, the organization may have reached its end and will cease to operate. MTD is often considered relative to the recovery time objective (RTO). As a golden rule, the RTO should never exceed the MTD. In other words, MTD > RTO, or RTO < MTD should always be true.

Using a bank as an example, MTD measures how long their systems can be down before they're no longer in business. If the core banking systems go down and no one can access their money for any significant amount of time, the bank is likely to lose the trust of their clientele and go out of business. A bank's MTD is likely a matter of minutes.

Recovery Time Objective (RTO)

Refers to the amount of time expected to restore services or operations to a defined service level in a recovery environment. For example, if a defined and reasonable service level during a period of disruption is 75 percent and it takes four hours to reach that percentage, the RTO is four hours. RTO is a component of MTD.

In the previously mentioned example, if the bank had a backup data center in a different city, the RTO might be a measure of how long it would take to get that backup data center up and running.

- **Definitions of RPO, RTO, WRT, and MTD**
- **Cost implications of RPO and RTO**
- **MTD = RTO + WRT**

Recovery Point Objective (RPO)

Refers to the maximum amount of data that can be lost in terms of time. In other words, how much data is the organization willing to lose as a measurement of time: ten seconds worth of data, ten minutes, fifteen hours, two days, etc. The less data the organization is willing to lose, the more expensive the backup solution will need to be. If the organization is willing to lose up to twenty-four hours' worth of data, then a nightly backup is probably sufficient, but if the organization is only willing to lose a few seconds worth of data, then much more complicated and expensive solutions, like stream backups and/or replication, will be required.

For example, in the event of a massive earthquake, a bank would lose all of the information that wasn't backed up at the time of the disaster. If their maximum tolerable data loss was twenty-four hours, then a significant number of financial transactions would disappear, and the disaster would severely impact their reputation as well. As a result, banks usually have a much shorter RPO.

Work Recovery Time (WRT)

This is the time needed to verify the integrity of systems and data as they're being brought back online. Just bringing systems back online is not enough to ensure the viability and continuity of operations in an organization. There needs to be assurance that the systems are functioning properly. The WRT represents the time needed to perform this step, and it is also a component of MTD.

In order to get back to business as usual (BAU), the bank would need the information from that data center transferred to the original location. WRT would be the measure of how long it takes to ensure that the bank can return to conducting their day-to-day operations.

Figure 7-18 helps visualize how these measurements of time all fit together, while Table 7-20 provides their definitions. The horizontal axis is time, starting with business as usual, and then *kaboom!* Some sort of disaster occurs. The first measurement of time we can now look at is RPO, the maximum amount of data loss as a measurement of time. After the disaster has occurred, the next measurement of time is the RTO, the maximum amount of time to restore processes/systems to a defined service level. WRT is then the time required to validate systems as they are fully brought back online and return to business as usual. Finally, the MTD is the maximum amount of time processes/systems can be down before the business ceases to be a business. MTD is the most important measurement of time to consider when making the decision to declare a disaster.

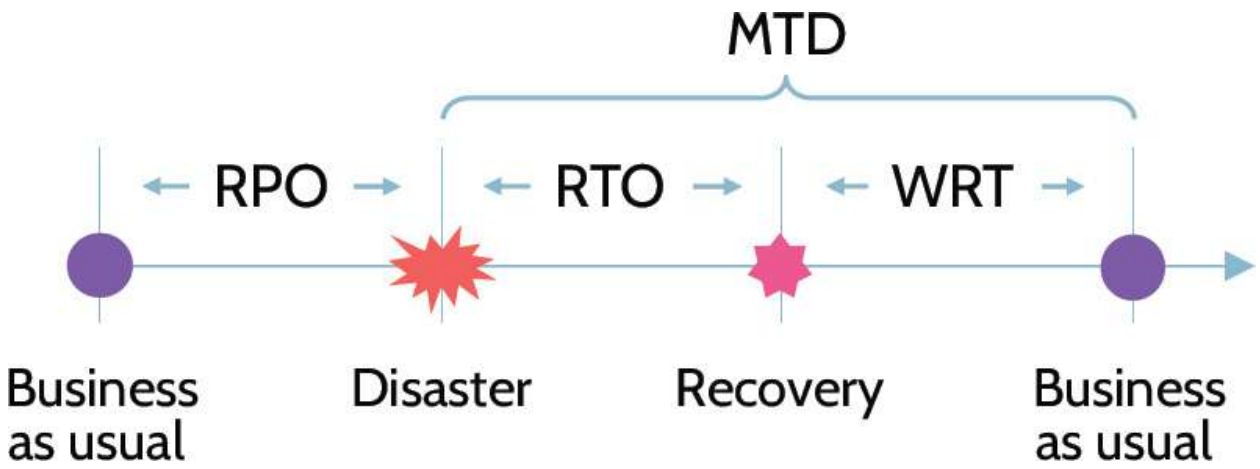


Figure 7-18: **MTD, RPO, RTO, and WRT Relationships**

RPO	**Recovery Point Objective:** Maximum tolerable data loss
RTO	**Recovery Time Objective:** Recovery time to defined service level
WRT	**Work Recovery Time:** Maximum time to verify integrity of systems and data
MTD	**Maximum Tolerable Downtime:** Maximum total time that a process can be disrupted

Table 7-20: **RPO, RTO, WRT, and MTD Definitions**

How to reduce the cost of BCP and DRP plans

When considering the cost related to implementing BCP and DRP plans, the more quickly a given process/function/system needs to be recovered, the more expensive the solution. In other words, the shorter the RPO and RTO requirements, the more significant the cost becomes. To extrapolate further, in order for an organization to make its BCP/DRP plan as cost efficient as possible, one of the goals should be to increase the RPO (more data can afford to be lost) and RTO (the time to recover can take longer) as much as it can tolerate within the acceptable bounds.

- Lower RPO/RTO = more expensive
- Higher RPO/RTO = less expensive

7.11.3 **Business Impact Analysis (BIA)**

CORE **CONCEPTS**

- **BIA process identifies:**
  - **the most critical/essential business functions, processes, and systems**
  - **potential impacts of an interruption as a result of disaster**
  - **the key measurements of time (RPO, RTO, WRT, and MTD) for each critical function, processes, and systems**

- **Purpose of the BIA process**
- **Steps in the BIA process**

The Business Impact Assessment (BIA) is the most important step in Business Continuity Planning. Its purpose is to predict the consequences of a disaster or a disruption to business processes and functions and then identify them as time parameters for the whole purpose of gathering information to develop recovery strategies for each critical and essential function and process. The output of a BIA are key measurements of time: RPO, RTO, WRT, and MTD.

The purpose of the BIA is to identify and prioritize system components by correlating them to the mission/business processes the system supports and then to use this information to characterize the impact on the processes if the system was unavailable. In the event of a disaster, having conducted a BIA ensures that security will make the right decisions about what assets to focus on and will choose the right resources for prioritization of their recovery efforts.

The BIA Process

Since many of the key systems in an organization are interdependent, creating the BIA is not a simple and quick process, and in some organizations it can take months to complete. Each critical business

process and system will have its own RPO, RTO, WRT, and MTD measurements.

Identifying and assigning values to an organization's most critical and essential functions and assets is the first step in determining what processes to prioritize in an organization's recovery efforts. Financial records, workshops, questionnaires, interviews, and observation are typically used to determine and assign values, using quantitative and qualitative methods. A crucial part in this process is involving staff from the various company functions so input can be provided about critical systems and services to allow reaching the right decisions. Making these determinations is an iterative and team-oriented effort.

Once asset values are determined, priorities can be set, and processes to protect the most important assets can be identified. Table 7-21 denotes the steps included in the BIA process.

1. Determine mission/business processes and recovery criticality	Business processes are identified, and the impact of disruption is determined, along with outage impacts and estimated downtime. The downtime should reflect the maximum that an organization can tolerate while still able to achieve the corporate mission. This downtime is reflected in the time-centric metrics discussed earlier: RPO, RTO, WRT, and MTD.
2. Identify resource requirements	Realistic recovery efforts require a thorough evaluation of the resources required to resume critical business processes and related interdependencies. Examples of critical resources may include business processes, facilities, personnel, equipment, software, data, and systems.
3. Identify recovery priorities for system resources	Based upon the results from the previous activities, system resources can be linked to critical business processes. Priority levels can be established for sequencing recovery activities and resources, typically by creating dependency.

Table 7-21: **BIA Steps**

7.11.4 Disaster Response Process

CORE **CONCEPTS**

- **A disaster should be declared when maximum tolerable downtime (MTD) is going to be exceeded.**
- **Disaster response should include all personnel and resources necessary to quickly respond to the situation and restore normal operations.**
- **Disaster response team personnel should include stakeholders from throughout the organization.**

- **Disaster communications is critical and should include all relevant stakeholders.**

Understand the role maximum tolerable downtime (MTD) plays in the declaration of a disaster

As discussed, ***a disaster is something that interrupts normal business operations.*** Prior to a disaster being declared however, the incident response process should be followed. As review, the incident response process focuses on ongoing monitoring of events and determining which events are in fact incidents. Once an incident is identified, an assessment of its severity must be made. Is the data center in flames, or did a hard drive in one of the servers fail? During the assessment of an incident, one specific variable should be carefully considered—MTD, also known as Maximum Tolerable Downtime. MTD is the maximum amount of time that a business can sustain a loss of key functionality and remain viable. So, as part of the incident impact assessment, if it's clear that the MTD will be exceeded, a disaster should be declared and the disaster recovery plan immediately initiated. If the data center is burning and the MTD is four hours, will incident response activities have everything back to normal in less than four hours? No, so the DRP should be activated, which will enable the business to remain viable by bringing a hot, mobile, or redundant site online.

Declaring a Disaster

Understand what constitutes a disaster

In the same vein used to discern an incident from an event, determining what is a disaster relative to an incident requires an understanding of what assets might be involved, how operations and processes might be impacted, and other factors that ultimately point to the risk to value and ongoing viability of an organization. The declaration of a disaster and therefore the activation of a business continuity plan needs to be done by an authoritative entity such as the CEO or a Business Continuity Board or Committee.

Assessment

As noted above, prior to a disaster being declared, the incident response process should be followed. Once an incident is identified, an assessment of its severity must be made. During the assessment of an incident, one specific variable should be carefully considered—MTD, also known as maximum tolerable downtime. ***If the MTD is going to be exceeded, a disaster should be declared, and the response process and response team should be activated.*** At this point, the response team will help manage an organization through the disaster until it is resolved. Through DR tests held as part of building a DRP, the response team should be able to quickly respond to the situation at hand and take all necessary steps to restore business operations to normal.

Personnel

The trained team—the emergency response team—should consist of stakeholders from throughout the organization. Examples might include personnel representing the following functional areas: ■ Executive/senior management ■ Legal ■ HR

- IT
- PR
- Security

Training and Awareness

Success in any endeavor typically involves significant preparation and training, and this is certainly true where the disaster recovery process is concerned. As will be discussed in more detail later in this section, disaster recovery plans should be tested often—at least annually—to best familiarize staff members and members of the emergency response team with the proper steps to follow in the event of a disaster.

Lessons Learned

After a disaster has been handled and operations restored to normal, a review of everything that took place should be conducted. This “lessons learned” exercise should focus on every facet of a BCM and especially on the DRP to determine what worked well, what needs to be improved, and what needs to be added or eliminated from the plan. As planning goes, including a “lessons learned” element could prove to be invaluable for the sake of an organization’s long-term success and viability.

Communications

As noted among the specific response components, when a disaster is occurring, communication is of critical importance and should include all relevant stakeholders, which can be a very large group of people.

Relevant stakeholders include people internal to the organization as well as people external to the organization.

- **Internal:** In the event of a disaster, internal communications are critical. Internal stakeholders could include senior management, Board members, business owners, legal, HR, and media and communications team members, among others.
- **External:** Equally critical in the event of a disaster is external communications. External stakeholders could include regulators, law enforcement, customers, the media, and others.

7.11.5 Restoration Order

CORE **CONCEPTS**

- **The BIA determines restoration order when recovering systems—the most important and critical should be recovered first.**
- **Dependency charts and mapping can help inform system restoration order.**
- **After declaring a disaster, the most critical systems should be brought online at a recovery site.**
- **When restoring systems/operations to the primary site, the least critical systems should be restored first, in order make sure the site is working properly.**

How is the order determined for restoring systems?

Understand how a dependency chart informs restoration order of systems/applications

With multiple systems and accompanying DR plans that make up the overall plan, how is the order of system recovery determined? Which systems are brought back first? Knowing that recovery resources are limited, the BIA helps determine which systems receive priority. The most critical systems, based upon the goals and objectives of the organization, should always be recovered first.

Dependency Charts

Another way to determine system/application restoration order is using dependency charts. For example, let's imagine we want to bring the primary website back online. Is this as simple as turning on the web server and then the site is up? No, because the web server might be part of a more complex architecture that includes a load balancer, a database server, and a cluster of web servers. So, to bring the website back up, each underlying component would first need to be online and available. Dependency charts, like the one shown in Figure 7-19, can map out exactly what components are required and even their initiation order.

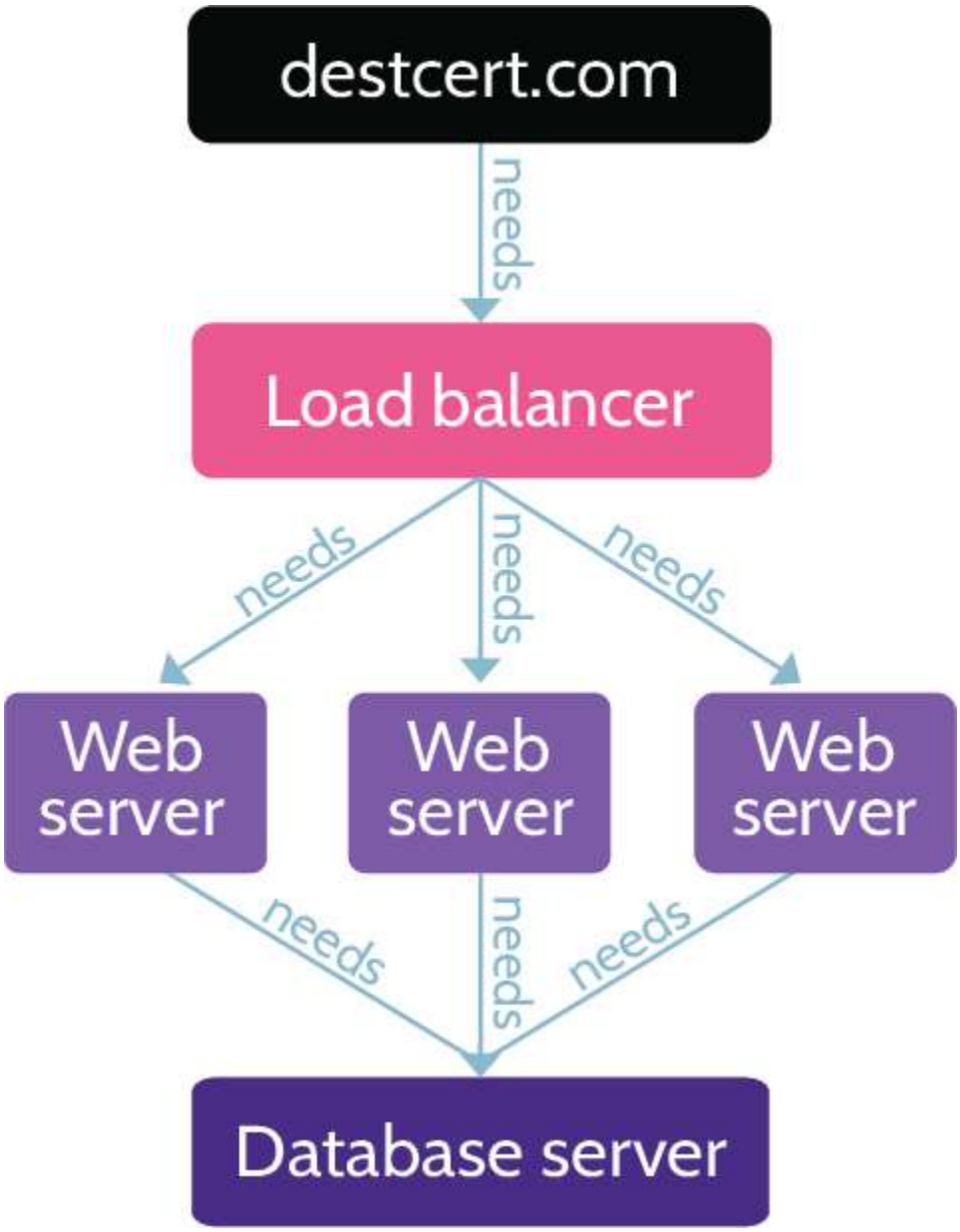


Figure 7-19: **Restoration Order Determination**

Understand the order when moving systems/operations to/from a DR site

What systems/operations should be moved first to the DR site?

After declaring a disaster, the first order of business should always be to get the most critical processes and elements of the business up and running at the recovery site.

Once the primary site is fixed, what systems/operations should be moved back first?

As time progresses, and the primary site is rebuilt and ready to once again host business operations, the processes and systems that should be restored first are the least critical. Why is this the case?

In essence, because the primary site is essentially new, it makes more sense to restore less critical processes and systems first to make sure the new site is working as expected. Once any kinks or issues are resolved, then the most critical processes and systems can be restored.

7.12 Test disaster recovery plans (DRP)

7.12.1 BCP and DRP Testing

CORE **CONCEPTS**

- **DRP testing is a critical component of plan creation and development.**
- **DRP tests include: read-through/checklist, walkthrough, simulation, parallel, full-interruption/full-scale.**
- **A full-interruption test should only be performed after management approval has been obtained and other tests have been successful.**

Know the order of DRP testing and which test is least/most impactful

After recovery plans have been created, it's imperative to test them. Tests can range from simple to complex, and each type is valuable.

The first type of test is the easiest and is known as a **read-through test**. This test simply ensures that the major components of the DRP are included, including first steps, accurate contact lists, and so on. Are all of the major pieces of information included in the plan?

The next test is what's known as a **walkthrough test**. The thinking behind a walkthrough is that all of the key stakeholders convene in a conference room and walk through the plan. Key stakeholders could include business owners, IT staff, senior management, legal, and so on. Each person receives a copy of the plan, and everybody walks through it together, thereby allowing problems and holes to be identified, so improvements can be made. The entire exercise is paper-based, but the outcome often proves very valuable.

A **simulation test** follows, and it too is paper-based. Key stakeholders are once again brought together, but this time a facilitator is also included for purposes of moderating a scenario that requires the

stakeholders to respond according to what's happening. For example, the facilitator might present a scenario that includes a major fire at a production facility or a dangerous virus outbreak. Once the scenario is presented, the stakeholders must use the DRP to help guide their response. At the same time, the facilitator can continue to throw curveballs at the situation, which requires the stakeholders to think quickly and respond accordingly.

It's important to reiterate at this point that these tests are not an "IT-only business." Whether reviewing BCPs or DRPs, all relevant stakeholders should be at the table and part of the process.

Up to this point, all of the tests have been paper-based exercises. The following section describes tests that include working with systems.

The first is known as a **parallel test**. It's very similar to a simulation test, but in this case the scenario is responded to with people located where they'd be if it was an actual situation. People would touch systems, but only backup systems, not anything in production. This is why it's known as a parallel test—people are only working with systems parallel to production systems.

The last test is what's known as a **full-interruption** or **full-scale test**. With this test, backup and production, or primary, systems are used to respond to the scenario. That is a very important point—with a full-scale test, production systems will be impacted.

Based upon the descriptions above, it's clear that the riskiest type of test—full-scale—is also the best type of test for confirming whether a DRP is going to work. Otherwise, there's really no way to know for sure how the plan, including the response of personnel, is going to function. As risky as they can be, full-scale interruption tests will often reveal the tiniest of holes in a plan and therefore are extremely valuable.

When should a full-scale, full-interruption test be conducted? *Only after every other test has been successfully conducted and with management's approval should a full-interruption test be conducted.* Because a full-interruption test can potentially take production systems down, it's important that senior management be aware of and approve the possibility of this happening. Table 7-22 contains a summary of all prementioned DRP test types.

Type	Description	Affects backup / parallel systems	Affects production systems
Read-through/Checklist	Author reviews DR plan against standard checklist for missing components/completeness		
Walkthrough	Relevant stakeholders walk through the plan and provide their		

	input based on their expertise		
Simulation	Follow a plan based on a simulated disaster scenario. Stop short of affecting systems or data.		
Parallel	Test DR plan at recovery site/on parallel systems	✓	
Full-interruption/Full-scale	Cause an actual disaster and follow DR plan to restore systems and data	✓	✓

Table 7-22: **DRP Test Types**

7.13 Participate in business continuity (BC) planning and exercises

7.13.1 Goals of Business Continuity Management (BCM)

CORE **CONCEPTS**

- **BCP and DRP = Business Continuity Management (BCM).**
- **BCM includes three primary goals: safety of people, minimization of damage, survival of business.**
- **The number one goal of BCM is safety of people.**

Understand the three goals of business continuity management (BCM)

The goals of business continuity management (BCM), which is the overall BCP and DRP process, are simple, yet important. BCM includes three primary goals: 1. **Safety of people**

2. **Minimization of damage**

3. **Survival of business**

Understand the number one goal of BCM

The number one goal of any component of BCM is safety of people. Next, the second goal is minimizing damage to facilities and the business. Finally, the third goal is ensuring the survival of the business. Within all of these goals, ***BCM should focus on the most critical and essential functions of the business.***

In addition to the material covered in this domain, the ISC2 Official Exam Outline lists: **7.14 Implement and manage physical security**

- Perimeter security controls
- Internal security controls

All physical security concepts, including the specific bullet points noted above, have been covered in Domain 3.

7.15 Address personnel safety and security concerns

As already noted, safety of humans should be the paramount consideration within any organization's security plan. Security training and awareness programs, emergency response and management training, and physical security and access controls all help in this regard.

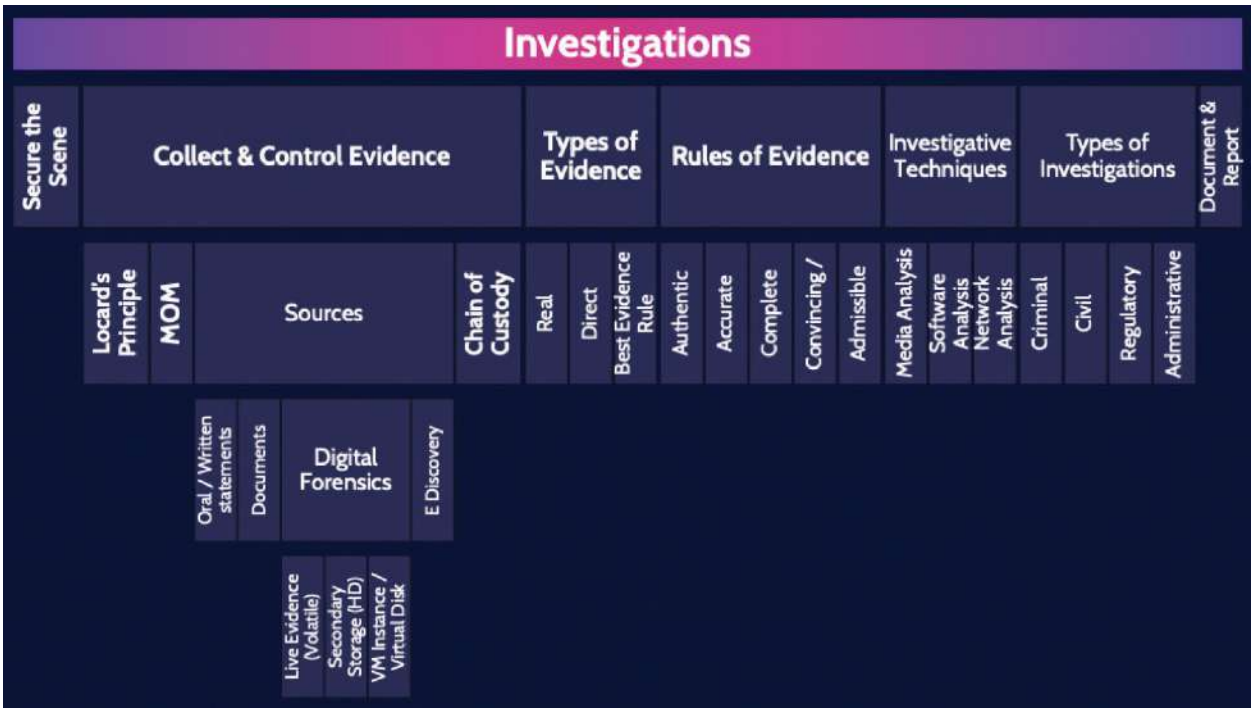
However, two additional subjects related to this topic also need to be touched upon:

- Travel
- Duress

Oftentimes employees must travel for work, and sometimes this may include visits to less safe or stable parts of the world. Even though an employee may not be physically present on a corporate campus, the organization is still responsible for ensuring the employee's safety, which might include providing additional medical coverage, travel and health insurance, and an action plan in the event of an emergency. In fact, due to the continued rise in global travel and associated security-related complexities, many organizations—especially large multinational corporations—outsource the travel logistics to companies like International SOS. International SOS acts as a single point of contact and helps design and implement integrated health and security policies and procedures that give access to 24/7 global health, security, travel, and emergency assistance to corporate subscribers.

Along with an understanding of travel-related considerations, security professionals should have a basic understanding of how to handle situations that involve employees under duress. Duress is defined as *"threats, violence, constraints, or other action brought to bear on someone to do something against their will or better judgment."* An example of duress is being held at gunpoint and forced to withdraw money from an ATM, or being threatened with violence unless some type of illegal action is taken. Regardless of the cause of duress, employees should be trained in how to respond in a pressured situation. Depending upon the context, this training might involve the use of code words to alert coworkers of a need for assistance, or perhaps it could involve pressing a silent alarm button that alerts security and other personnel. Most importantly, employees should be trained to respond with reason and to not react to the situation at hand.

MINDMAP REVIEW **VIDEOS**



Investigations

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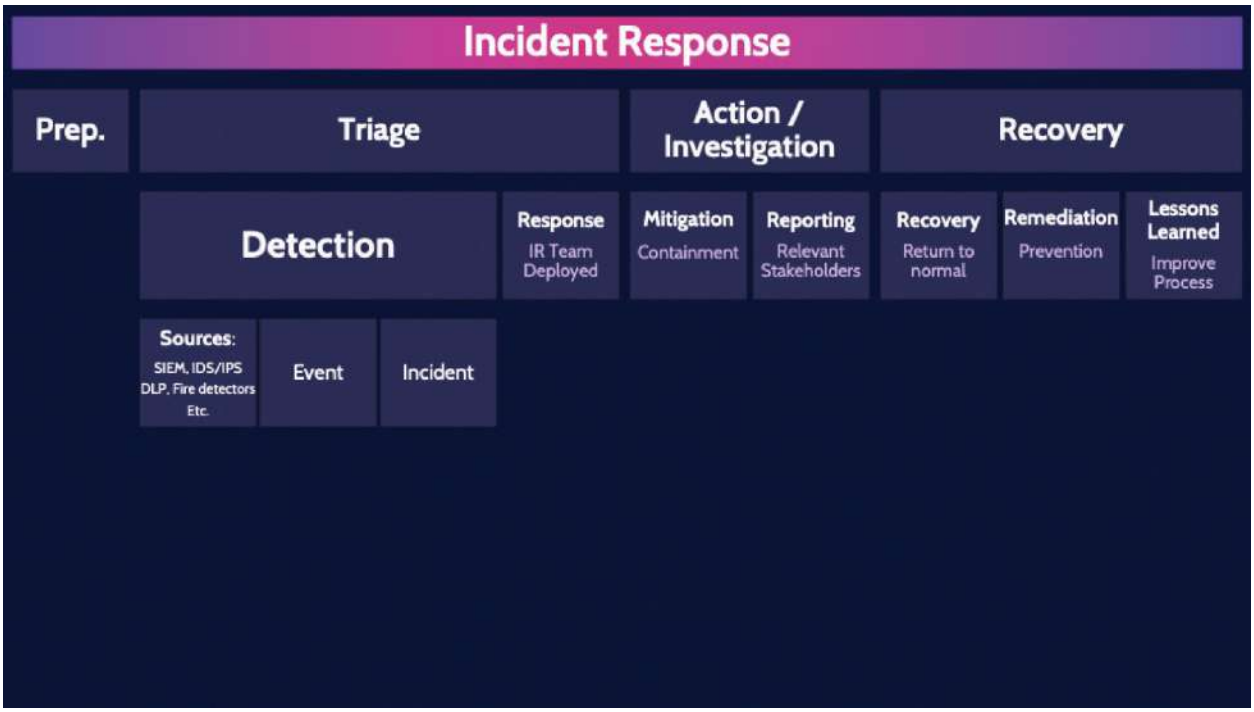

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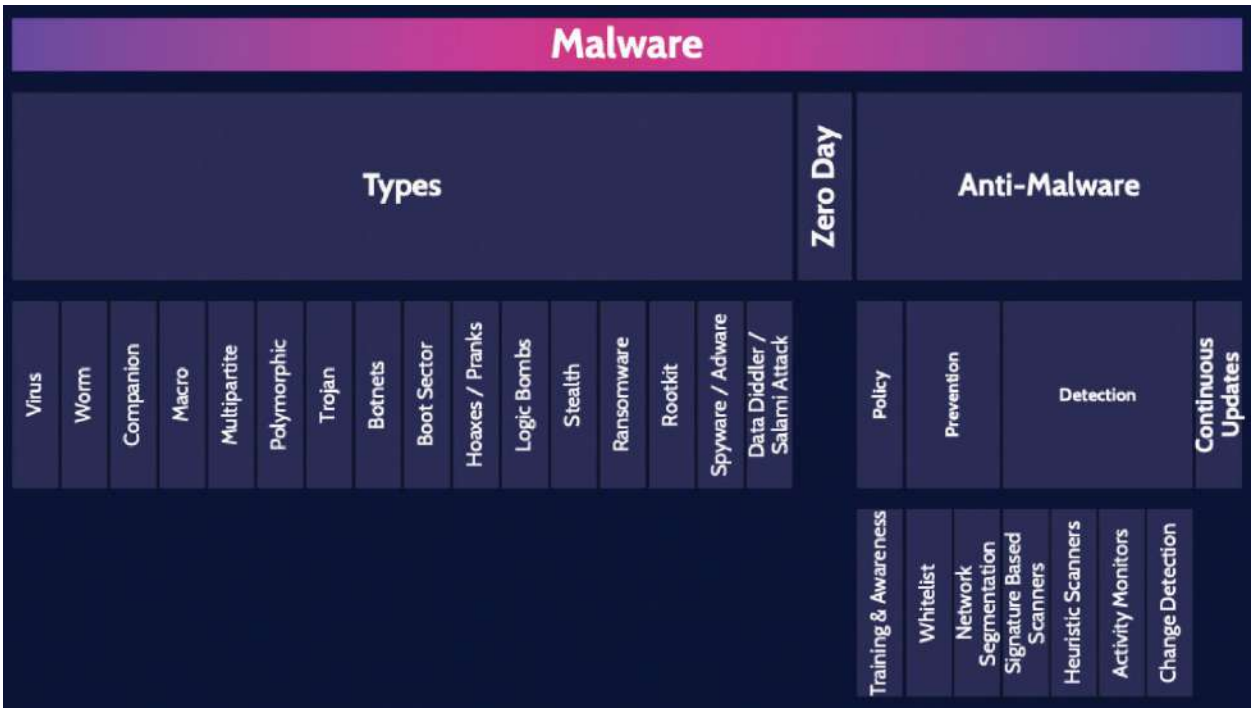

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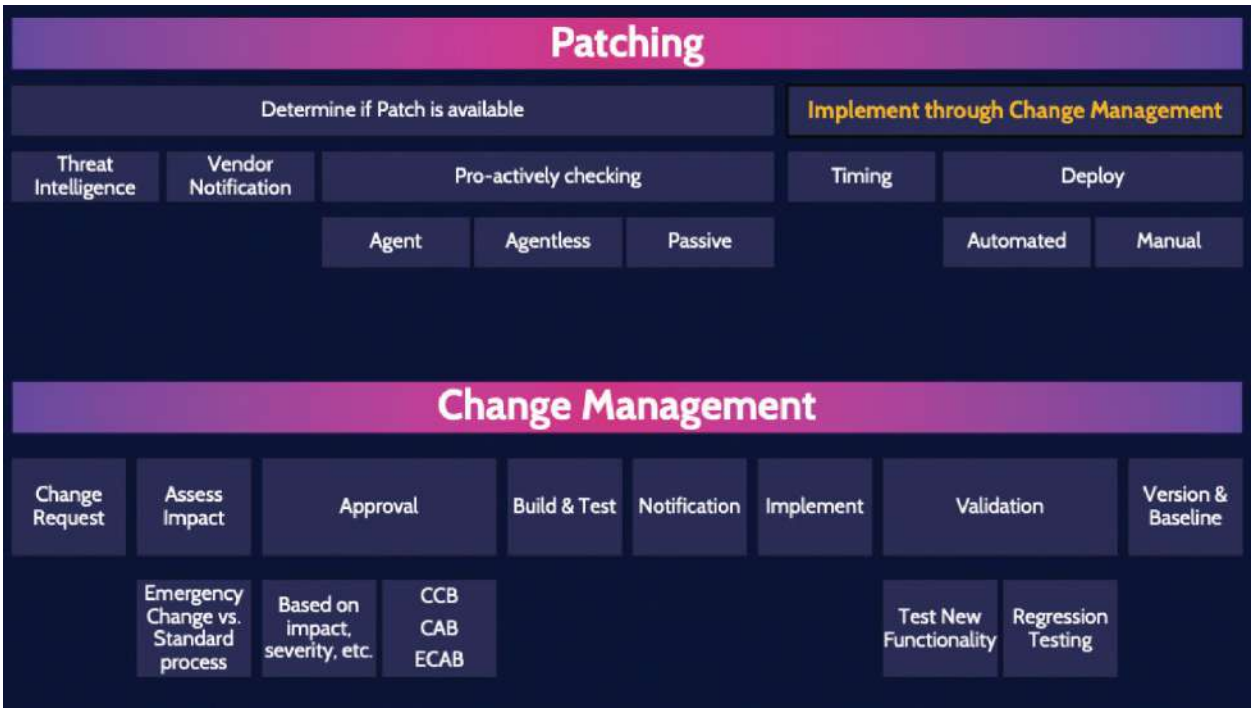

Patching & Change Management

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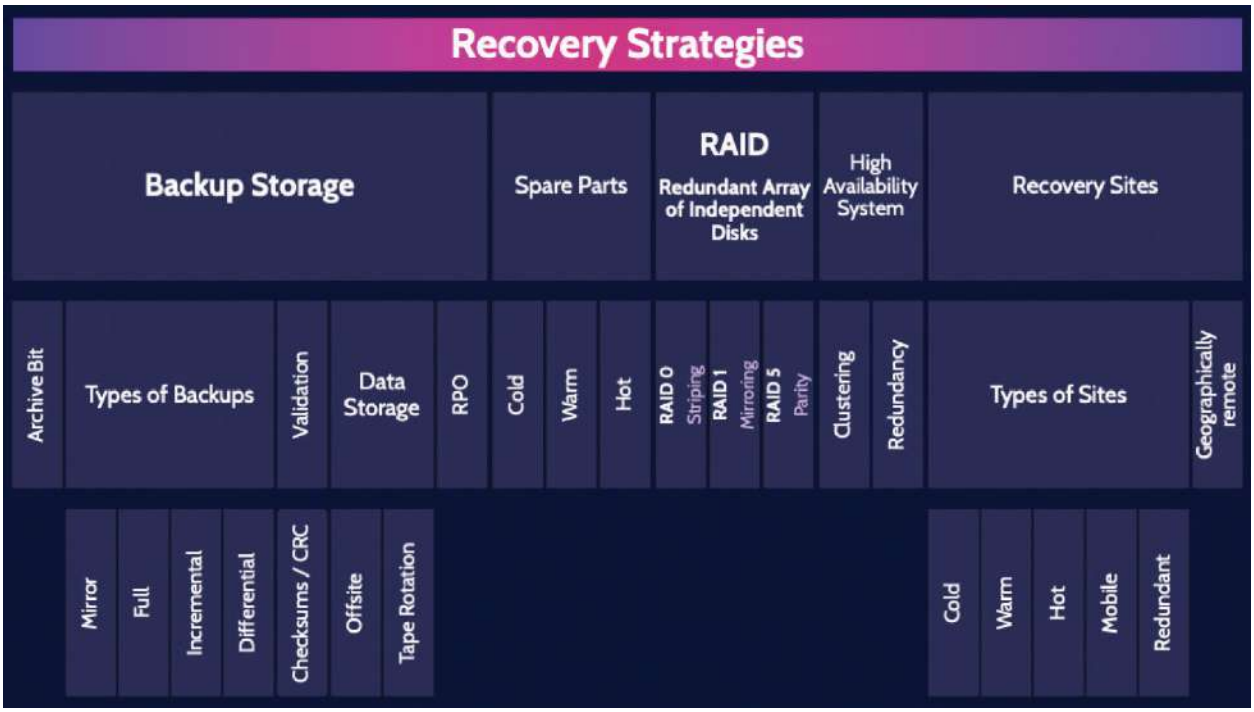

Recovery Strategies

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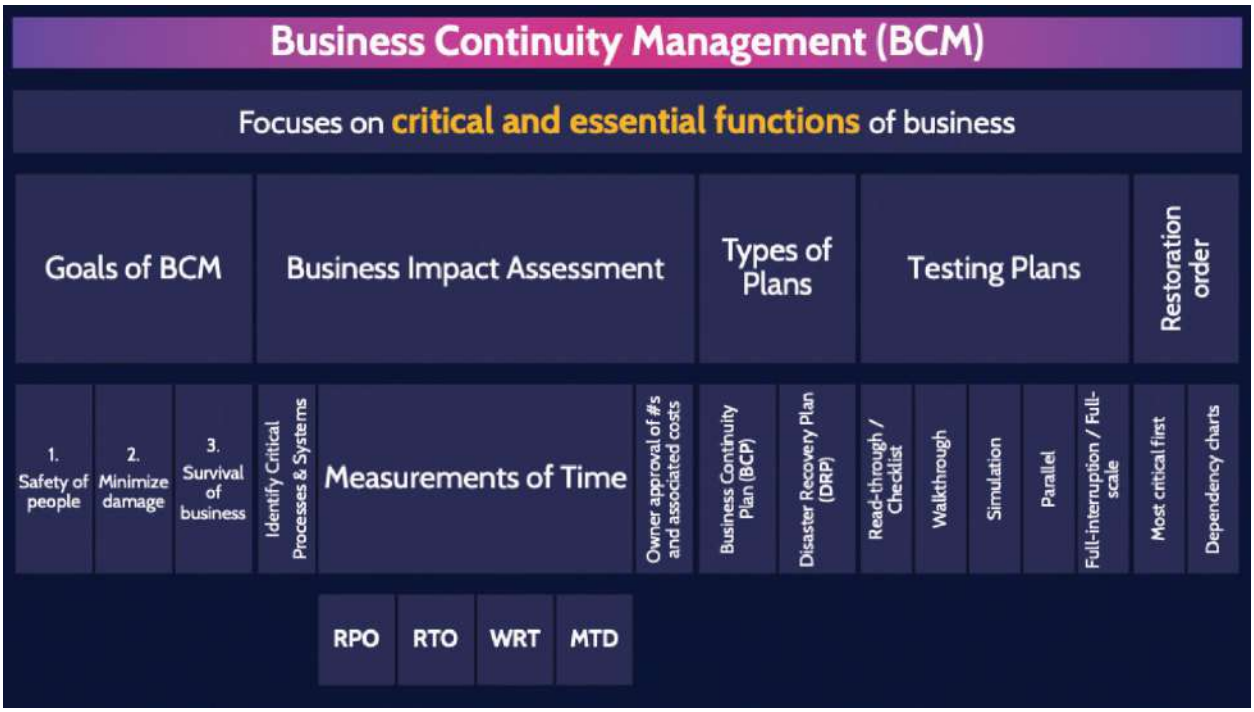

BCM

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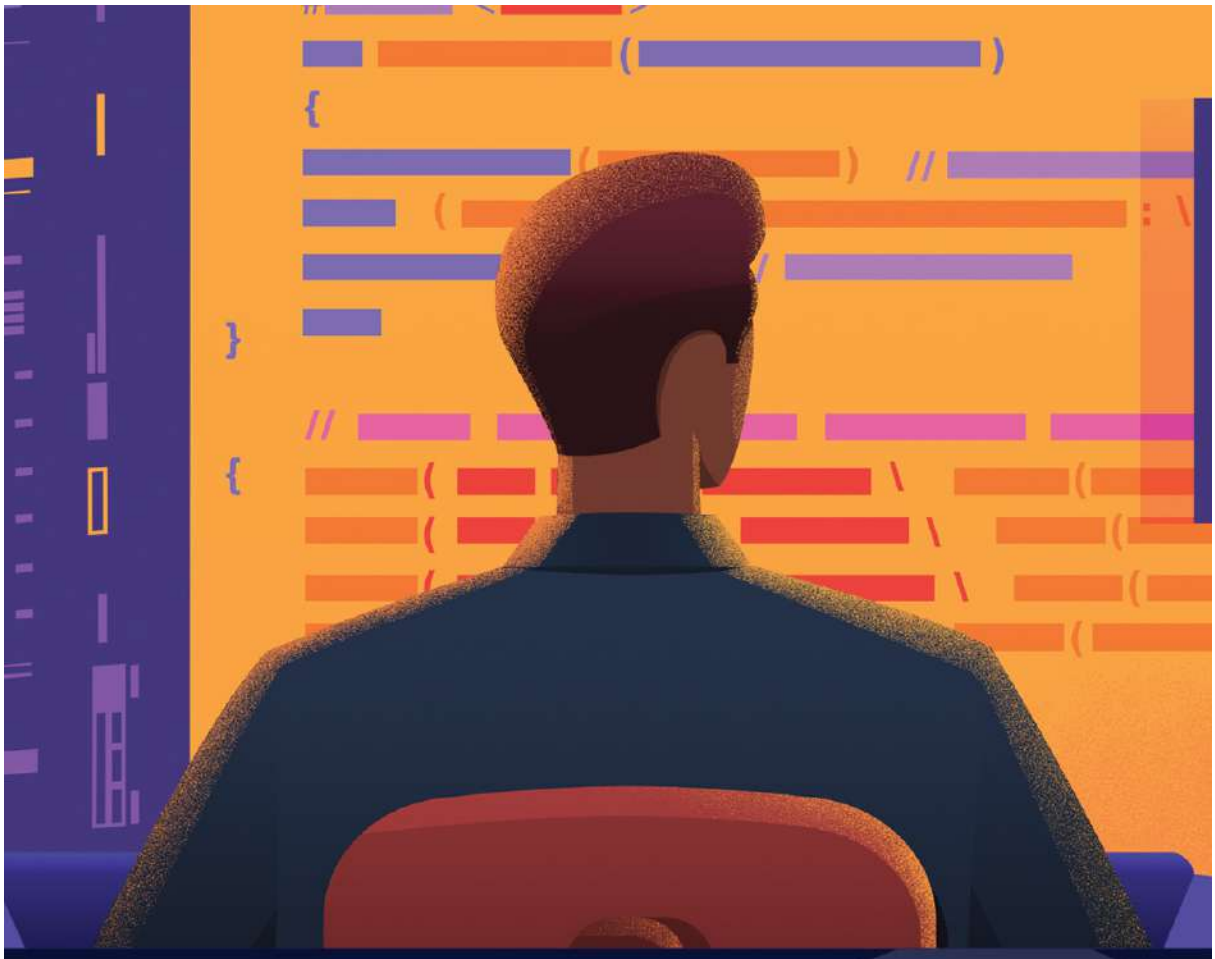


DOMAIN 8

Software Development Security

8

DOMAIN 8

SOFTWARE DEVELOPMENT SECURITY

Domain 8 is focused on helping security professionals to understand, apply, and enforce software security, otherwise referred to as “application security.” The application environment has become very complex, and organizations rely heavily on applications in every facet of the business. As applications have become more intelligent and functional, so have the challenges related to protecting and securing the application environment.

Even though this domain is titled “Software Development Security,” it not only focuses on the development life cycle of applications and how security needs to be involved right from the start and throughout the development phases of applications and systems, but also during the entire life of the applications, including the operations phases and decommissioning and disposal phases. In other words, security needs to be involved during an application’s entire life cycle, not just the development phase.

8.1 Understand and integrate security in the software development life cycle (SDLC)

8.1.1 Security's Involvement in Development

CORE **CONCEPTS**

- **Security should be involved at every phase of the development life cycle.**

As mentioned above, security needs to be an integral part of the development process, and as we've mentioned many times in this book, the best type of security is what is designed into an architecture. This is especially true for applications. Security needs to be involved from the perspective of designing the right level of protection, based on requirements, and therefore needs to be involved at the early phases of software development and throughout each of the subsequent phases.

Similar to when a system reaches end of life and is retired, when an application reaches end of life, security must also be involved to ensure proper archival and disposal. Recall from Domain 4 that quite a lot of attacks take place at Layer 7, the Application layer. This is because so much functionality in the form of applications is available at this layer. Unfortunately, during the development process this functionality is often not considered from the perspective of

an attacker, and unforeseen vulnerabilities and potential for exploit often result. Additionally, security is often not involved from inception and throughout the software development process. It typically is tacked on at the end, and this simply does not work. It's very cost inefficient for one thing, and oftentimes it fails to cover all the security needs or gaps. Security should be involved from the beginning, through the deployment and use phases, and all the way to the retirement phase. The entire life cycle should include security at each stage.

Understand when security should be considered as part of the SDLC

Many concepts covered in Domain 8 have already been covered in one manner or another in other domains. Security needs to be included as an integral part of the software development life cycle (SDLC) as well as the system life cycle (SLC). As the name suggests, the SDLC focuses on the development of an application; the SLC picks up at the point where an application is put into production and focuses on use and testing, changes, decommissioning, and disposal.

8.1.2 SDLC and SLC

CORE **CONCEPTS**

- **Security should be considered at every phase of SDLC/SLC.**
- **Risk analysis and threat modeling are very important components of the early phases of SDLC/SLC.**
- **Testing should include static, dynamic, and fuzz (a form of dynamic testing) tests.**
- **Certification and accreditation should be performed prior to release/deployment/implementation.**

Figure 8-1 depicts the SDLC/SLC and how the two relate to each other.

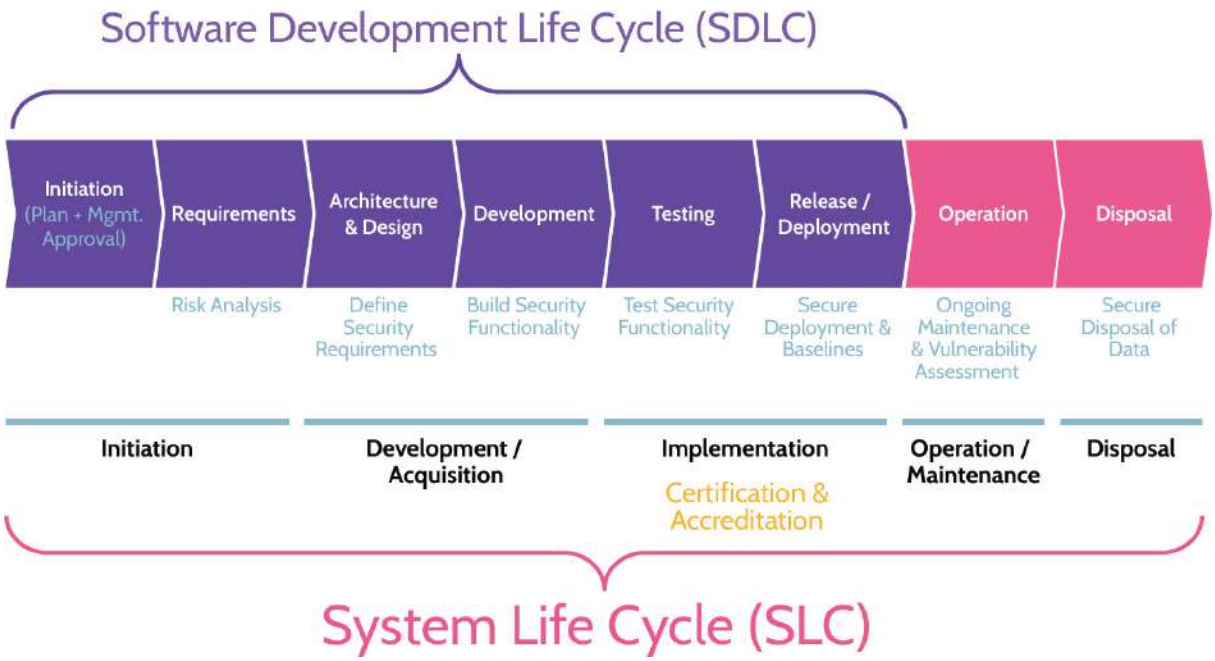


Figure 8-1: **SDLC Phases**

Understand the flow of the SDLC/SLC and what happens at each phase, specifically where

securityrelated activities are concerned

The key thing to focus on is the flow and what happens during each phase, because different methodologies use different names for the same essential steps. In fact, it's quite common for companies to mix and match software development methodologies—agile and structured development, for example, are two common approaches often used to save time and money. For similar reasons, *agile* is a term found in other contexts too, like internal audit and process development. Though the goals of agile are efficiency and cost-effectiveness, quality is not sacrificed in the process. Both goals are met through the utilization of skilled teams composed of subject matter experts, who can adapt and change quickly to meet specific needs immediately at hand. Regardless of the approach—agile or structured, or anything else—security needs to be considered, ideally as early as possible and throughout each of the phases

The SDLC/SLC include management involvement and approval as well as post-deployment activities related to operations, including decommissioning and disposal. Regardless of the phase, security should be involved. For example, during the operations phase, changes are often desired or necessary, and change management helps drive them in an orderly manner. Security in

this context helps to ensure that the desired changes meet requirements from a security perspective, and security should ultimately be part of change approval. Unfortunately, many organizations fail to include security as part of change control committees, which should also include senior management, application owners, technology representatives, and so on.

It's important to pay close attention to the text underlying each phase of the SDLC, especially where the requirements and architecture and design phases are concerned. During the requirements phase, security should be considered in the form of risk analysis related to the application being developed. Risk analysis continues through to the architecture and design phase, where the architecture of the application is considered in the context of existing infrastructure and systems. Also at this point, specifically where design is concerned, threat modeling is used to determine what security elements should be incorporated into the design of the application. At this point, the application is ready to be coded (development phase), and security can be built into it proactively. It should be noted that portions of the testing phase can overlap with the development phase—specifically static testing/code review can be conducted as units of code are completed. However, the bulk of testing—static (SAST), dynamic (DAST), and fuzz—will take place in the testing phase. This phase of the SDLC is critical and should be comprehensive to include all considerations—normal, error-prone, and malicious—related to usage of the application. Additionally, as part of the transition from testing to release/deployment (SDLC) or during the Implementation phase (SLC), certification/accreditation are performed.

Development and Maintenance Life Cycle

Historically, development methodology has typically followed what's known as a "waterfall" approach, which is simply a phased, step-by-step approach to software development. To move to the next phase, the previous phase must be completed. Sign-offs and approvals mark each phase. As seen in Figure 8-2, the process resembles a waterfall—moving from the top to the bottom in succession. This model includes an inherent flaw, however, in the fact that going backward is not possible. Similar to an actual waterfall, where water can only flow downwards, the waterfall development process only allows downward movement. To further illustrate this point, imagine an application owner wants to develop a new software application. Their first step is to contact technology. In order to best understand the application requirements and start translating those into technical and other specifications, most likely, business analysts will be engaged to effectively and efficiently facilitate the need to bridge technology and business requirements related to the application. The business analysts will spend time with the application owner, asking questions and trying to understand what the owner wants to accomplish with the application. Then the analysts will return to technology and begin the process of developing the application. Here's the problem: at this point, the owner is not involved anymore, but they're still interested in observing all phases of the development process because they're invested in the application. As this process unfolds, of course the owner is likely to come up with new ideas and other feedback.

How does the development team respond? If they're following a waterfall approach, the owner will likely be told that going backward is not possible. The design is frozen, and that's what will be built; however, all those requests can easily be accommodated later as part of change management, which costs

more time and money. This is problematic, and the software development industry has attempted to develop new methodologies to address this and other issues.

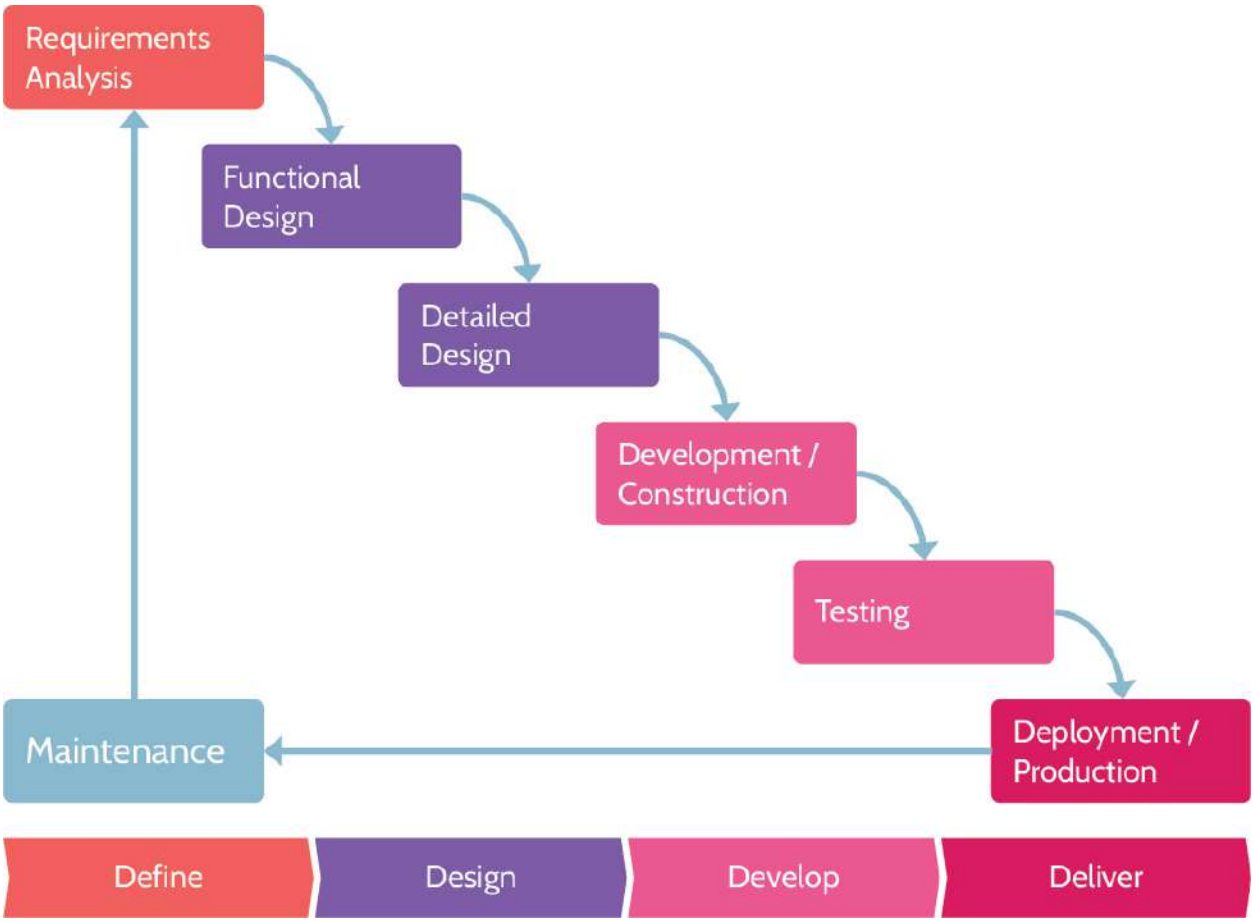


Figure 8-2: **Waterfall Model Phases**

8.1.3 Development Methodologies

CORE **CONCEPTS**

- **Development methodologies exist for the sake of efficient and effective code development.**
- **Many methodologies are a reflection of the waterfall methodology.**

- **Regardless of the methodology, security should be considered at every stage of the development process.**
- **Methodologies can be combined to utilize the best features of each of them.**
- **Agile scrum masters understand how all team efforts fit together and can therefore effectively and efficiently lead activities.**

As noted above, in response to structured and potentially timely and costly software development approaches like waterfall, the industry has developed innovative approaches to accelerate development and still produce quality code. Each of these methodologies reflects the waterfall model, simply with a variation in approach. For example, spiral is aptly named because it allows for the development process to circle back on itself to address an issue or functionality that was part of a previous phase. Similarly, agile refers to a smaller, team-based approach that allows for efficient and cost-effective parallel development. These different approaches have been summarized in Table 8-1.

The bottom line is this: *Whatever methodology or combination of methodologies is used for software development, security must be included throughout the process.*

Be familiar with various development methodologies and key characteristics of each

Waterfall	Complete each phase of development, before flowing—waterfalling—down to the next phase, until the process is complete. This model does not

	allow a previous phase to be revisited.
Structured Programming Development	A logical programming approach that is said to be foundational to object-oriented programming. Structured programming places heavy emphasis on structured control flow and aims to improve clarity, quality, and development time.
Agile	Divide the development process into multiple, rapid iterations of defining, developing, and deploying, with heavy customer interaction throughout the process.
Scaled Agile framework	A version of the Agile methodology that is designed to allow large organizations with many teams to collaborate and effectively deliver software.
Spiral Method	A risk-driven development process that follows an iterative model while also including elements of waterfall. The spiral model follows defined phases to completion and then repeats the process; this model resembles a spiral when mapped to paper.
Cleanroom	Development process intended to produce software with a certifiable level of reliability by focusing on defect prevention.

Table 8-1: **SDLC Methodologies**

Understand the different priorities of waterfall and agile methodologies

Waterfall versus Agile

Figure 8-3 depicts waterfall and agile methodologies. Don’t focus as much on the phases of waterfall but rather that it’s a phased approach. Agile, in comparison, adapts the waterfall methodology and approaches development

from the perspective of smaller, highly skilled and motivated teams. Additionally, agile is more focused on early and often delivery of code via what are known as “sprints” led by an agile scrum master.

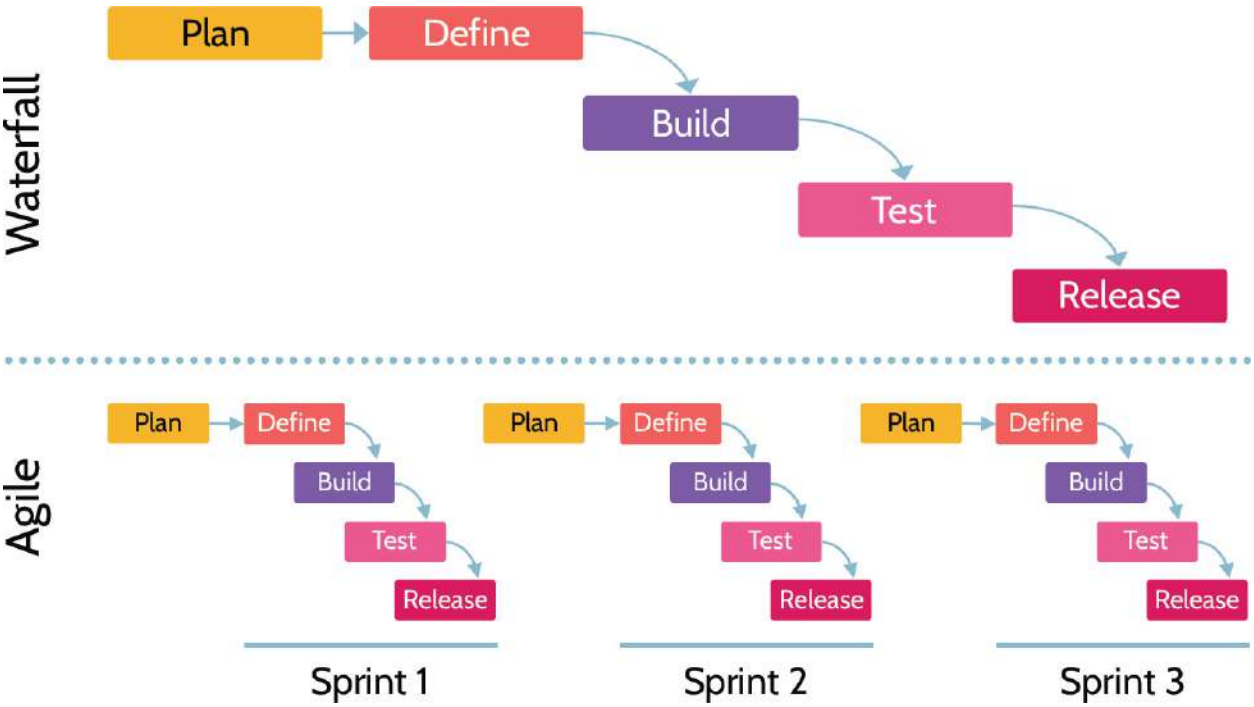


Figure 8-3: **Waterfall vs. Agile Methodology**

Agile Scrum Master

Understand the role of a scrum master in agile development

With Agile, each team works very closely and in a very time efficient manner, while all of the team’s efforts are coordinated by a person known as the Scrum Master. The Scrum Master understands how all the team efforts fit together and can therefore effectively and efficiently lead activities. Additionally, the Scrum Master shields team members from external

interruptions, which further enhances productivity. Scrum Masters are typically hyperfocused on completing tasks as quickly as possible and hopefully *not* at the expense of security. Other advantages of having a Scrum Master include the following: ▪ Shields team from external interference ▪ Enforces scrum principles ▪ Facilitator and removes barriers ▪ Enables close cooperation ▪ Improves productivity 8.1.4 **Maturity Models**

CORE **CONCEPTS**

- **Like development methodologies, maturity models also help improve the development process.**
- **Capability Maturity Model Integration (CMMI) is one of the most popular models and includes six levels of maturity: incomplete, initial, managed, defined, qualitatively managed, optimizing.**
- **Each level of maturity of the CMMI is defined by certain characteristics.**

Maturity models are another important set of methodologies that can improve the development process, including security. One of the most important maturity models is Capability Maturity Model Integration (CMMI).

Capability Maturity Model Integration (CMMI)

Know the name and characteristics of each level of the Capability Maturity Model Integration

Capability Maturity Model Integration (CMMI) is a set of best practices that focus on building key capabilities and benchmarking them to drive business performance. It essentially helps an organization to understand how mature

their processes are, what they do well and what they need to improve. CMMI includes six maturity levels, which are used to measure the maturity level of processes. The maturity levels are shown in Table 8-2 and Figure 8-4.

Maturity Level 0: Incomplete	This phase is unknown and ad hoc, indicating that work may not be getting completed.
Maturity Level 1: Initial	This is a reactive and unpredictable stage. It indicates that work is getting finished, but often coming in over budget and late.
Maturity Level 2: Managed	This stage indicates that projects are managed and planned. The tasks are performed, key metrics are taken, and the project is controlled.
Maturity Level 3: Defined	In this phase, the organization is being proactive as opposed to reactive. There are standards across the organization that guide programs, portfolios and projects.
Maturity Level 4: Quantitatively Managed	This is a controlled and measured stage. It indicates that an organization is driven by data, using it to measure performance improvement objectives. These objectives meet the needs of stakeholders and are predictable.
Maturity Level 5: Optimizing	This phase is flexible and stable. The organization is focused on continually improving and it is able to pivot when change and opportunity present themselves. The stability of the organization allows it to innovate and be agile.

Table 8-2: **The Six CMMI Maturity Levels**

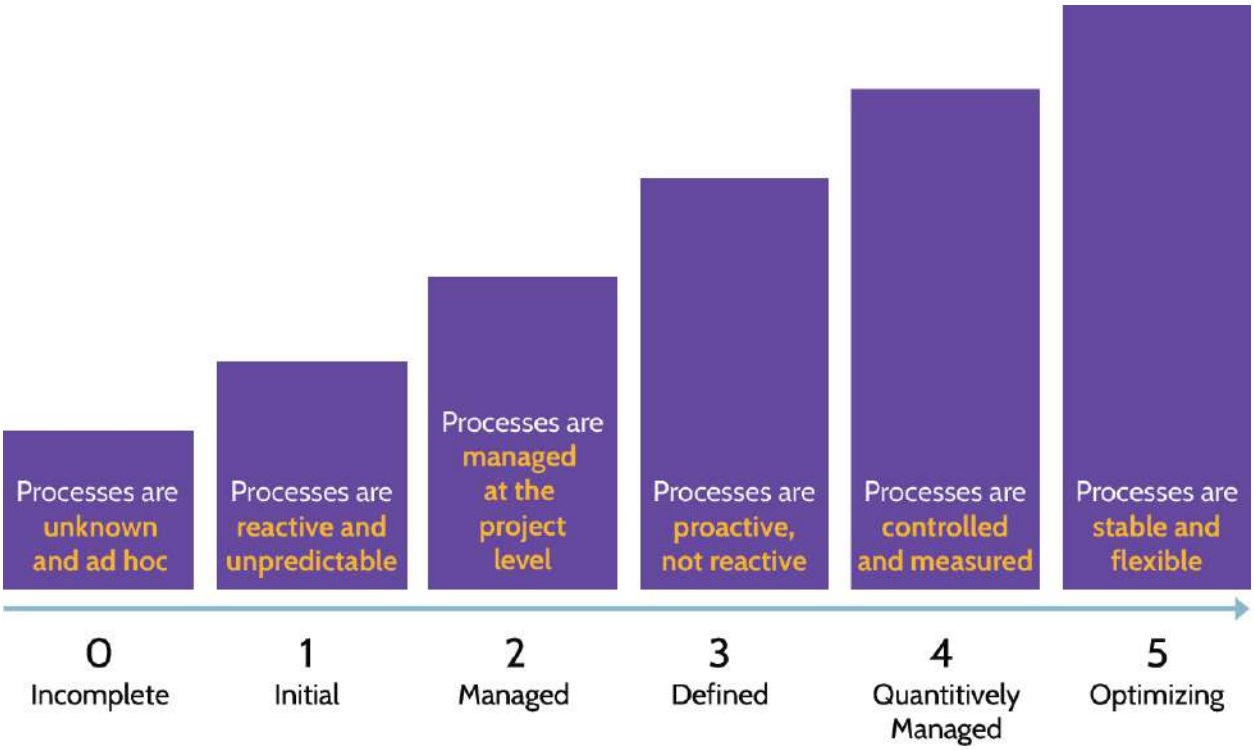


Figure 8-4: **The Six CMMI Maturity Levels**

Software Assurance Maturity Model

OWASP's Software Assurance Maturity Model (SAMM), is, in OWASP's words, *"to be the prime maturity model for software assurance that provides an effective and measurable way for all types of organizations to analyze and improve their software security posture. OWASP SAMM supports the complete software life cycle, including development and acquisition, and is technology and process agnostic. It is intentionally built to be evolutive and risk-driven in nature."* (https://owaspsamm.org/model/) SAMM consists of three maturity levels:

- Level 1—Initial Implementation
- Level 2—Structured Realization
- Level 3—Optimized Operation

Maturity levels can be measured

from a coverage and a quality perspective based upon quality criteria and a software assurance scoring model that can be referenced by auditors and organizations.

SAMM looks at software assurance from the high-level perspective of five business functions: 1. Governance

2. Design

3. Implementation

4. Verification

5. Operations

Operation and Maintenance

The success of software development is not pinned to the release of an application to production. In fact, it could be argued that long-term successful —and secure—software releases happen as a result of ongoing operation and maintenance that includes **monitoring, periodic evaluation, and patching.**

Individually and collectively, the three actions help ensure software that functions properly and is secure. Proactive monitoring can uncover security-related problems before they become widespread. Likewise, periodic evaluation that dives deeper can, among other things, confirm that the best components and coding techniques are in place to ensure continued security of the application. When monitoring and periodic evaluations are performed diligently, patching typically follows. Patching may be done for any of

several reasons, the most common being to secure a vulnerability in the code or to enhance the functionality of the application.

Change Management (Review)

Among the many topics covered in **Domain 7—Security Operations**, change management was covered in **7.9.1 Change management**. As a review, *change management ensures that costs and benefits of changes are analyzed and changes are made in a controlled manner to reduce risks.* This applies in the context of operations as well as in the context of software development. As Figure 8-5 shows, a change request might be initiated for one of several reasons. It might come in the form of a service request, as part of the incident management process, or as part of a service level agreement (SLA). Additionally, when considering software development-related changes, configuration management and release management must be integral components of the change management process to best assure stable and secure releases.

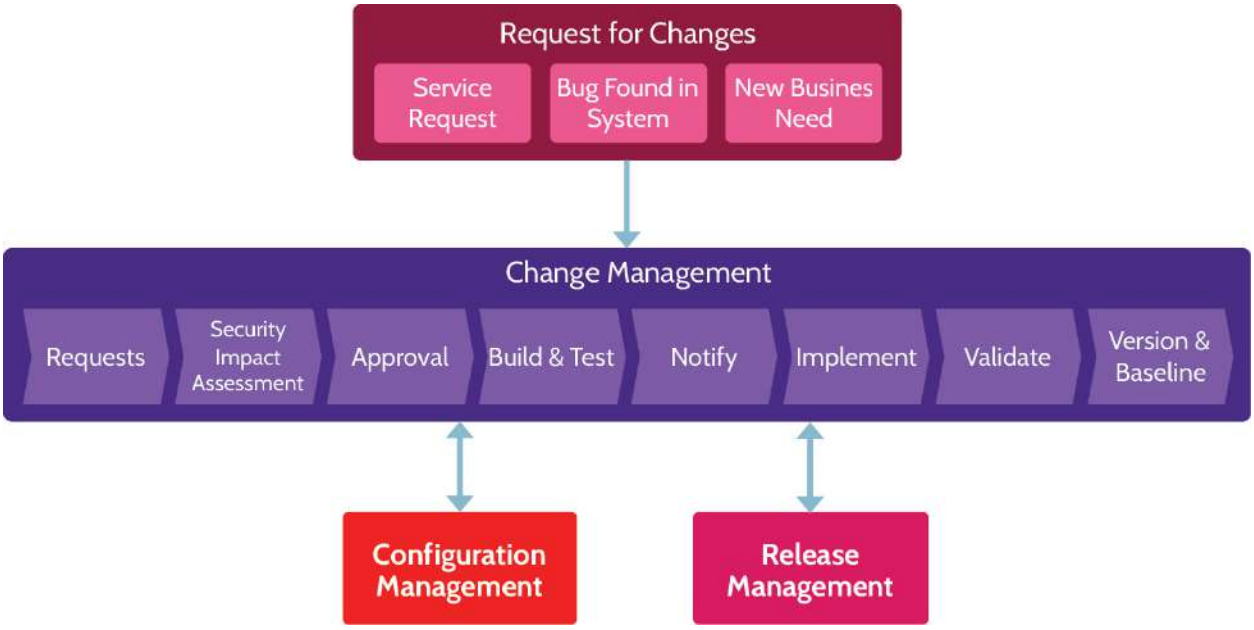


Figure 8-5: **Request for Change (RFC) Process**

8.1.5 DevOps

CORE **CONCEPTS**

- **An integrated product team is really a fancy term for DevOps: software development, operations, quality assurance (QA).**
- **Ideally, DevOps should include security as an integral part of the development process and be referred to as DevSecOps.**

Integrated Product Team (IPT)

An integrated product team (IPT) is a team of skilled professionals who each bring specific expertise and skills to a development project. At any given point in time, one or numerous members of the team may be more fully engaged with the project, but collectively the entire team is committed and

invested in delivering a secure and functional product as well as ensuring this remains the case throughout the product's life cycle.

At its core, the IPT is a fancy name for DevOps, depicted in Figure 8-6, which is a software development approach that aims to unify: ▪ Software development ▪ Operations ▪ Quality assurance

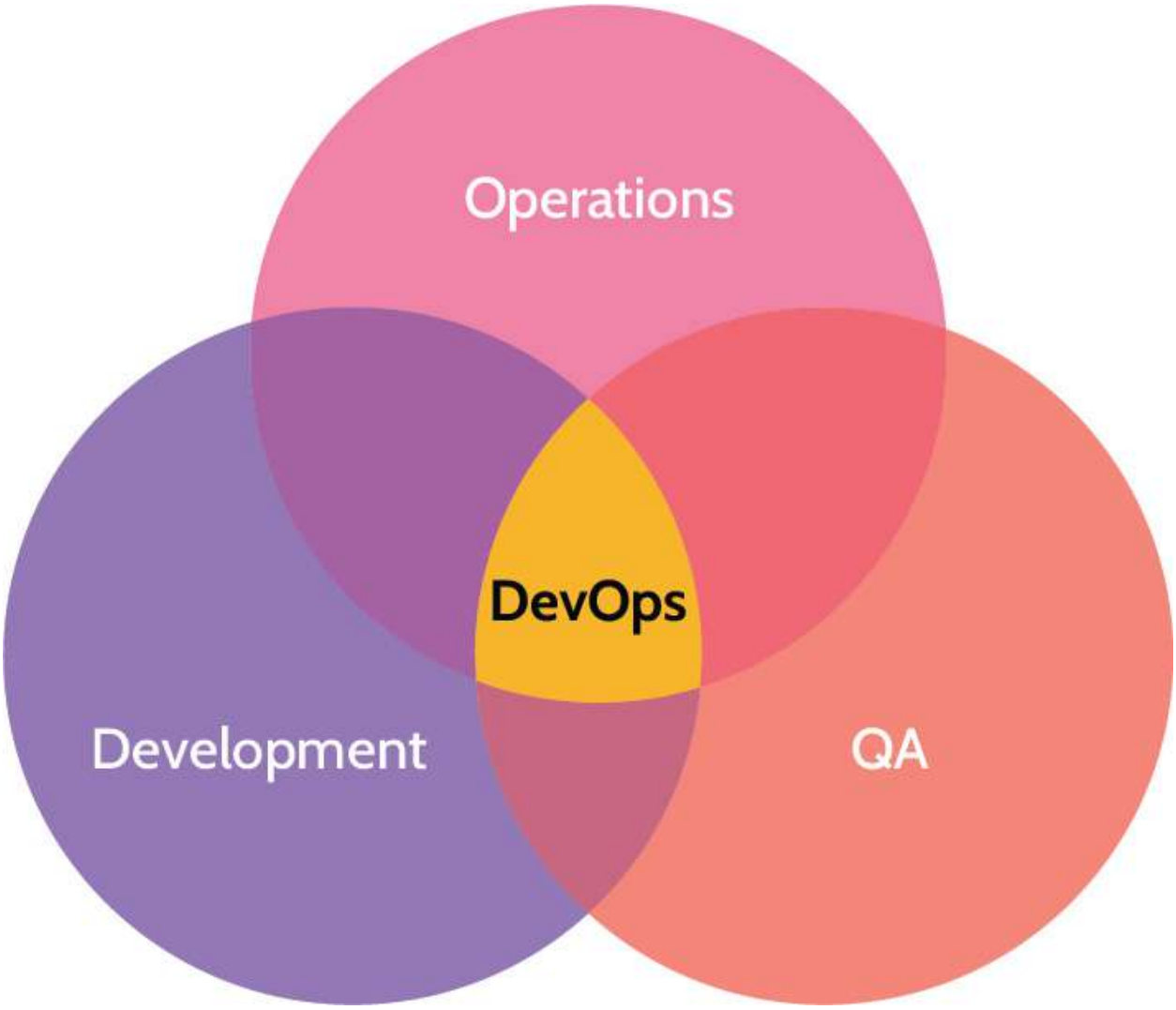


Figure 8-6: **DevOps**

DevOps refers to the integration and inclusion of team members from all relevant areas from the very beginning. The goal of this unification is to create a more agile and responsive environment, which is

ultimately more efficient and desirable than having separate teams that must complete their work before passing the project along to the next team. Separate teams often leads to a lack of collaboration and aligned pursuit of common goals. It also often leads to security being tacked on at the end of the project instead of at the beginning and throughout the project.

DevOps Security

Know when security should be involved with DevOps

As noted above, many traditional security techniques, for example, items like penetration tests, security analysis, and so on are **too slow** for rapid iteration of DevOps.

However, DevOps should ideally be referred to as DevSecOps, or even better, SecDevOps. This is where security is an integral part of the development process.

Incorporating security into DevOps should include the following components and approach: ■ Plan for security ■ Strong engagement between developers, operations, and security ■ Engage developers ■ Develop using secure techniques and frameworks ■ Automate security testing, for example, using a robust CI/CD pipeline ■ Use traditional techniques sparingly

Combining Development Methodologies

Many organizations combine methodologies to suit their specific needs, and this approach can work with DevSecOps.

8.1.6 Canary Testing and Deployments

CORE **CONCEPTS**

- **Canary testing and deployments refer to hyperfocused testing of new application code/features by pushing out the changes to a small subset of users versus pushing out to all users.**

Understand what is meant by the term *canary testing and deployment*

The phrase “canary in a coal mine” refers to a practice utilized by early miners to ensure the safety of mining teams deep underground. The teams would carry caged canaries into the tunnels, and if dangerous gases—such as carbon monoxide—collected in the mine, the canaries would begin to have trouble breathing and thus act as an early warning system so the miners could escape a similar fate. In a similar vein, *canary testing and deployments* refers to a software deployment approach where new code

and features are pushed out to a small subset of users as an initial test, before release to all users. Taking this approach allows problems to be identified and resolved before a full release.

Smoke Testing

Smoke testing is another commonly used type of testing in software development. Smoke testing focuses on quick preliminary testing after a change is made to identify any simple failures of the most important existing functionality that worked before the change was made.

8.2 Identify and apply security controls in software development ecosystems

8.2.1 Software Development Overview

It is important to have a basic understanding of how applications are written. First of all, a programming language is used, and programming languages have evolved over time to become quite powerful and even intelligent. In fact, incorporating security into applications is much easier today because of advancements in programming languages and related tools.

Programming languages have evolved over the years as generations, as depicted in Table 8-3.

Generation 1 and 2 refers to low-level programming languages, like assembly language, which allowed programmers to write programs more easily, but ultimately the CPU would be tasked with translating everything into binary code, into 0s and 1s.

From early generation languages, high-level languages evolved. Generation 3 and 4 languages, structured and object-oriented languages like COBOL, PL/1, Fortran, and BASIC, became more commonplace, and now Generation 5 languages—natural programming languages like Prolog—are coming to the forefront. Even today, however, with newer languages becoming more prevalent, legacy applications written in languages like COBOL are still in production.

Generation		Type of Language	Examples
Low-level languages	1	Machine languages	Strings of numbers that CPU can process
	2	Assembly languages	Cryptic as they use symbolic representation
High-level languages	3	Structured languages	Pascal, C, Cobol, Fortran
	4	Object oriented languages	C++, Visual Basic, Java
	5	Natural language	Prolog

Table 8-3: **Programming Language Generations**

Libraries

By simple definition, a library is a collection of resources. The collection could be resources specific to one topic, or it could be resources that cover a vast array of topics. Code libraries are frequently used in application development and include resources such as documentation, code snippets, functions, and other elements necessary to develop and configure applications that function properly and, ideally, adhere to accepted standards. Why reinvent the wheel—recreate some code that someone else has already written—when it already exists in a library?

Like a public library that houses a myriad of books, publications, and other resources that can be utilized by anybody with a library card, a software library is typically organized in a manner that allows code to be used by disparate applications that have no relationship to each other. Additionally, libraries allow elements of programs and code to be reused again and again.

Two primary types of libraries exist: static and dynamic (runtime).

If code of the library is accessed while the invoking program is being built, the library is referred to as a static library. Alternatively, if the library is called after the program is executed, the library is referred to as a dynamic or runtime library.

Tool Sets

In the context of software and application development, a tool set is a compilation of development tools and utilities that aid the creation of applications. Tool sets are more often referred to as software development kits (SDK), and tools and utilities typically include a compiler and debugger as well as application programming interfaces (APIs), documentation, libraries, and perhaps a development framework. SDKs are often tailored to the development of applications for specific hardware—desktop, laptop, mobile device, for example—and operating system platforms, like iOS, Linux, or Windows. SDKs are typically utilized in the context of larger integrated development environments.

Integrated Development Environment (IDE)

An integrated development environment is a software application that serves as an umbrella for purposes of software development. It's essentially a one-stop shop that provides the tools programmers need to perform their development tasks. Typical IDEs include the following: ■ Code editor ■ Compiler ■ Debugger ■ Automation tools By providing integrated components, an IDE allows programmers to work efficiently and effectively. Some examples of IDEs include Microsoft's Visual Studio, NetBeans, IntelliJ IDEA, Eclipse, and Code::Blocks. Factors that differentiate one IDE from another include: cost-free/open source or licenses (typically annual subscription), programming languages supported, and learning curve. Some IDEs are quite powerful but difficult to learn; others are very beginner-friendly. Determining which IDE is optimal for a given coding environment is really a matter of prioritizing required and desired features and then exploring the IDE landscape to identify the best solution.

Programming Language Translators

Even though better ways to program have evolved over time, computers have not evolved in a similar manner. In fact, computers today still only understand the language they understood fifty to sixty years ago—binary code or machine language. This explains why tools like assemblers, compilers, and interpreters exist. Their job is to take a given programming language and render it as machine language that the computer can understand.

- Assemblers read entire programs and then convert low-level assembly language into machine language.

- Compilers read entire programs and then convert high-level language into machine language.
- Interpreters convert high-level language one line at a time into machine language at runtime.

Runtime

In the context of computing and software, runtime refers to the time when code is being executed on a computer.

Continuous Integration, Delivery, and Deployment

CI/CD stands for continuous integration, continuous delivery, although sometimes sources switch out "delivery" for "deployment". **Continuous integration** involves automating many of the steps for committing code to a repository, as well as automating much of the testing. This allows code changes to be frequently integrated into the shared source code and ensures that a bunch of testing gets done easily.

Continuous delivery also involves automating the integration and testing of code changes, but it also includes delivery, automating the release of these validated changes into the repository. Continuous deployment takes things a step further and automatically releases the code changes into production so that they can be used by customers. With continuous deployment, code changes can be automatically put into production without further human intervention, as long as it passes through all of the testing and there are no issues. If there is an error in any of these steps, the changes will get sent back to the developer. Figure 8-7 highlights how these three processes overlap.

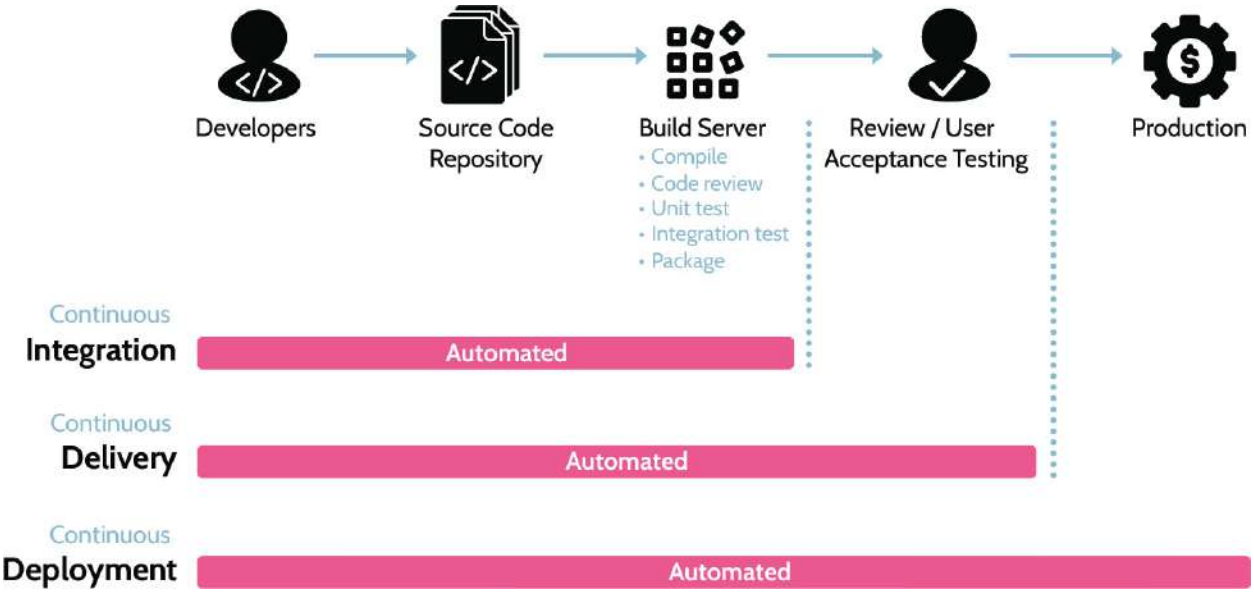


Figure 8-7: **The CI/CD Process**

Software Configuration Management (SCM)

As the name suggests, *software configuration management* specifically focuses on managing changes in software and is part of the overall configuration/change management. Like other configuration/change management activities, SCM best practices include baseline establishment and revision control, build and process management, and the facilitation of strong teamwork among the software development team. Though not comprehensive, a summary of some of the most notable benefits of SCM is below: ■ Process to systematically manage, organize, and control the changes in the documents, codes, and so on during the SDLC

■ Part of overall configuration management/change management ■ Increased productivity while minimizing mistakes

Code Repositories

A code repository is, in its simplest form, a storage location for software and application source code. Popular code repositories include Github, SourceForge, Project Locker, and SourceRepo, among others. Most code repositories support public, open source projects as well as private projects, though some, like Project Locker, focus entirely on private, enterprise-grade repositories.

Most code repositories offer much more than simple storage. In addition to hosting project code, repositories typically provide project versioning and release control, support for code review, interaction with others through discussion forums, bug tracking, document management, and patches.

Application Security Testing

Domain 6—Security Assessment and Testing—covers application security testing, and specifically **6.2.1 Testing Techniques** covers static application security testing (SAST), dynamic application security testing (DAST), and fuzz testing. Recall that each method differs from the others, as noted in Table 8-4. Thus, the most effective application security testing incorporates all three techniques.

Static (SAST)	Dynamic (DAST)	Fuzzing
■ White box ■ Examines code	■ Black box ■ Examines application itself	■ Form of dynamic testing ■ Premise is chaos

Table 8-4: **SAST, DAST and Fuzzing**

Another type of testing is Interactive Application Security Testing (IAST). It combines elements of SAST and DAST. Testing is conducted while the application is running and the source code is visible.

Secure Programming

Looking back at early programming methods, it's clear that encompassing and meeting security requirements was a difficult task. Over the years, programming methodologies have evolved—including security—and meeting related requirements has become much easier. In fact, most modern programming languages require an understanding of built-in security capabilities to code applications properly. If security requirements related to an application are understood, the inherent security capabilities of the programming language can be incorporated into the finished product.

By focusing on security from the beginning of a project that follows a SecDevOps approach, the right people can help define necessary security requirements. So, the information owners, the business people, the technology experts, and others can all help define, identify, and understand the needed security components.

This is what's important and points to security capabilities that should be incorporated into applications. As noted earlier, many newer programming tools facilitate the integration of these capabilities as part of the overall system. For example, many tools include ***inheritance*** capabilities. *Inheritance in this context refers to new objects—pieces of code—that automatically inherit characteristics of previously created objects.* This capability serves several purposes: ■ Eliminates the need to program the same characteristics into multiple objects ■ Consistent programming and security can be easily propagated to new objects This implies that the starting point must incorporate sound programming practices; otherwise, weak or missing security characteristics could result, leading to an overall very vulnerable application.

Encapsulation, discussed in the context of remote and VPN connections, is also found in programming. As a quick review, encapsulation means tunneling. In programming, encapsulation involves wrapping an object—a piece of code—to hide certain information or characteristics or to adapt to specific application needs.

From a security perspective, code can adapt and exhibit characteristics of ***polymorphism*** and ***polyinstantiation***. Like a polymorphic virus, polymorphic code can change. However, unlike polymorphic viruses, which are malicious, polymorphic code changes to meet certain needs or requirements, and it does so for the benefit of the application.

The bottom line is that addressing security to the level needed is much easier today because the tools used to create programs and applications include this functionality by default. A summary of some key terms is provided in Table 8-5.

Inheritance	The ability of an object—a piece of code—to inherit characteristics of previously created objects.
Encapsulation	The idea that an object—a piece of code—can be placed inside another. Other objects can be called by doing this, and objects can be protected by encapsulating or wrapping them in other objects.
Polymorphism	Like a polymorphic virus that can change its behavior to avoid detection, polymorphism in programming refers to code that can

	change based upon requirements. Think of it as “smart code” that can understand the environment and respond accordingly to meet the needs presented by objects in the environment.
Polyinstantiation	Polyinstantiation refers to something being instantiated into multiple separate or independent instances, and it is covered in **8.5.4 Secure Coding Practices** in detail.

Table 8-5: **Inheritance, Encapsulation, Polymorphism and Polyinstantiation**

8.2.2 Code Obfuscation

CORE **CONCEPTS**

- **Obfuscation refers to hiding or obscuring something; code obfuscation refers to hiding or obscuring code to protect it from unauthorized viewing or interpretation of the logic.**
- **Three primary types of code obfuscation: lexical, data, control flow.**

Understand the term code obfuscation and the three primary types of obfuscation

The term *code obfuscation* refers to hiding or obscuring code to protect it from those who are unauthorized to view it. More specifically, **code obfuscation is *intentionally creating source code that is difficult for humans to understand,*** which makes it difficult to reverse engineer, or it conceals the purpose of the code. The three main types of obfuscation are outlined in Table 8-6.

Lexical Obfuscation	Modifies the **look of the code** (changing comments, removing debugging information, and changing the format of the code) Easiest but weakest form of obfuscation
Data Obfuscation	Modifies the **data structure**
Control Flow Obfuscation	Modifies the **flow of control** through the code (reordering statements, methods, loops, and creating irrelevant conditional statements

Table 8-6: **Types of Obfuscation**

Understand a significant potential disadvantage of using code obfuscation

One caveat with regards to code obfuscation relates to a disaster. Specifically, what recourse does an organization have if application code has been obfuscated using one of the techniques noted above? For example, if lexical obfuscation has been used, an organization may have little to no recourse to bringing an application back online quickly. With this in mind, a software vault should be used to securely store unaltered mission critical source code, and planning around the same should be incorporated into an organization's BCM plan.

Security of the Software Environments

Within the software development environment, most organizations employ the "best practice" of separating specific components. As Figure 8-8 shows, separation of the development and production environments from each other as well as separation of the test and QA environments is prudent. In this same vein, security should be present as an advisor in each context.

Figure 8-8: **Security of the Software Environments**

8.2.3 DBMS, Concurrency, and Lock Controls

CORE **CONCEPTS**

- **Components of DBMS include: hardware, software, language (SQL, for example), users, data.**
- **Database terminology: columns/fields = attributes; records/rows = tuples.**
- **Foundation of a relational database is the concept of primary and foreign keys.**
- **Primary keys: one or more columns whose values uniquely identify a tuple (row) within a relational database.**
- **Foreign keys: one or more columns whose values in a table refer to the**

primary key in another table.

- **Concurrency: ability for multiple processes to access or change shared data at the same time.**
- **Locks prevent data corruption when multiple users try to write to the database simultaneously.**
- **ACID: atomicity, consistency, isolation, durability.**

One of the most important environments driven by applications is a database environment. Databases have been in use for decades. They allow us to store sensitive and valuable information that can be accessed and drive business decisions. It follows that database environments require attention to security to protect the information and ensure only authorized users have access to it. Security needs to exist within the database itself as well as within the applications that access the database.

The architecture is broken down into components, and each component is secured. The underlying hardware and software need to be secured, the proper tools that allow access to the data need to be secured, and users need to understand usage policies related to the information, security responsibilities, as well as how to properly use the tools that allow access to the data. Of course, the data itself must be secured and protected.

Database Management Systems (DBMS)

A database architecture is composed of several components, typically including those noted in Table 8-7.

Hardware	Hardware refers to the computer—usually a dedicated server—upon which other DBMS components reside. DBMS hardware usually includes a dedicated RAID controller and associated storage as well as redundant power, cooling, and network components.
Software	Software refers to the operating system (OS) as well as the application that supports the database and allows users to interact with database contents. Application security is very important to protect the underlying data.
Language (e.g. SQL)	Language refers to the syntax and commands that make user interaction with database contents possible. Specifically, SQL stands for “Structured Query Language,” and many dialects of SQL exist, including T-SQL, MySQL, PostgreSQL, and SQLite.
Users	Users refers to the people who need to work with data stored in a DBMS. Most often, users interact with data through a software interface; other times, super and admin users might work directly with data through a query feature built into the DBMS application.

Data	Data refers to all the important data stored in a DBMS that should be protected by a well-planned architecture that includes security in every component, including hardware, software, and user management.

Table 8-7: **DBMS Components**

Relational Database

Like most technology over time, databases have evolved too. In the past, databases were hierarchical, flat files stored on tapes. Today, relational database management systems (RDBMS) are the most frequently used database systems. As the name suggests, RDBMS allow objects and data to be stored and linked together—to be related—to drive better decision-making. Information can be related to other information and thereby drive inference and deeper understanding. A database can contain one or more tables of data as depicted in Figure 8-9.

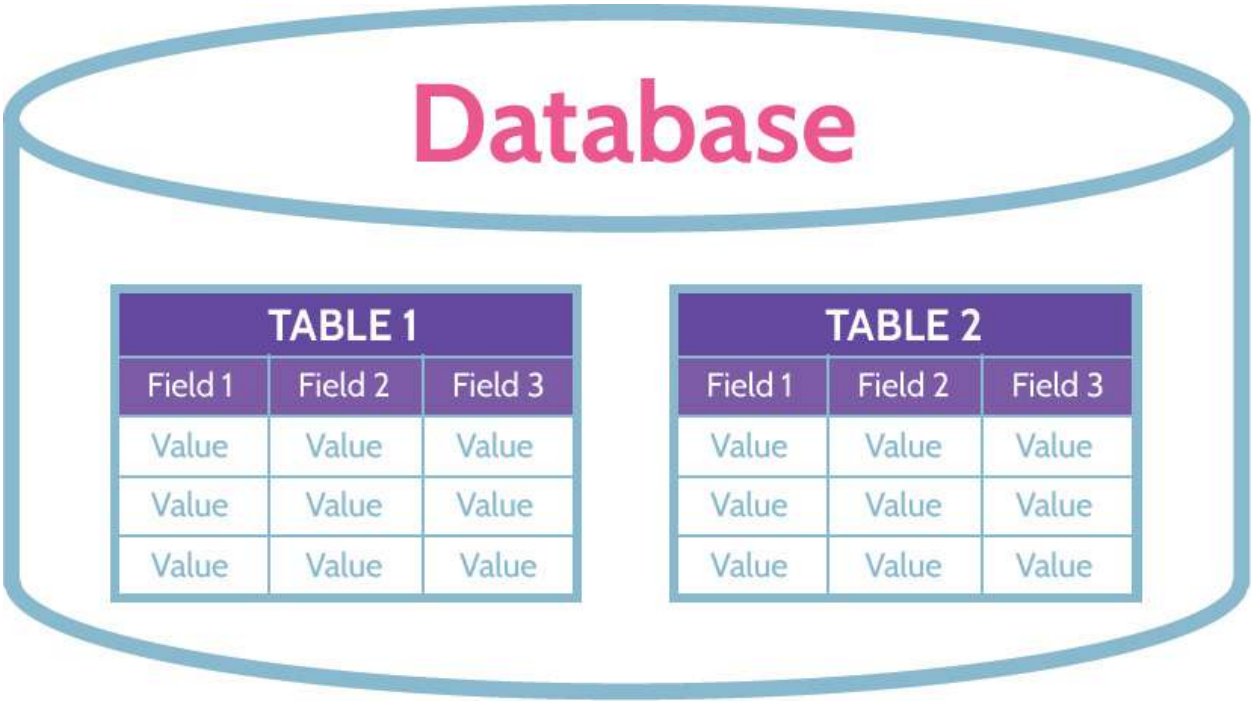


Figure 8-9: **Relational Database Table**

Attributes and Tuples

RDBMS are structured as two-dimensional tables composed of rows and columns as depicted in Figure 8-10. This structure allows tables of information to be linked together, which allows inference to take place. In addition to what might be viewed as traditional terminology, it's important to understand other words that mean the same thing as rows and columns. Columns or fields are called **attributes**, and records or rows are called **tuples**.

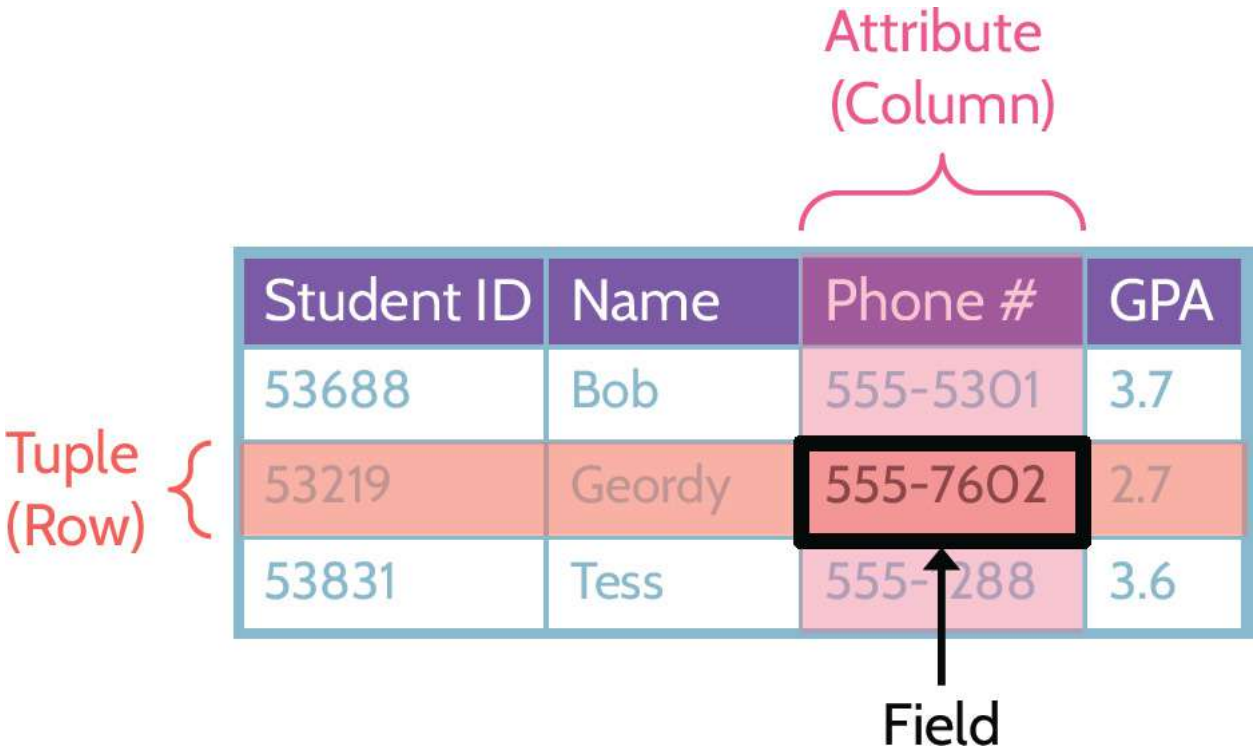


Figure 8-10: **Database Table Structure**

Primary and Foreign Keys

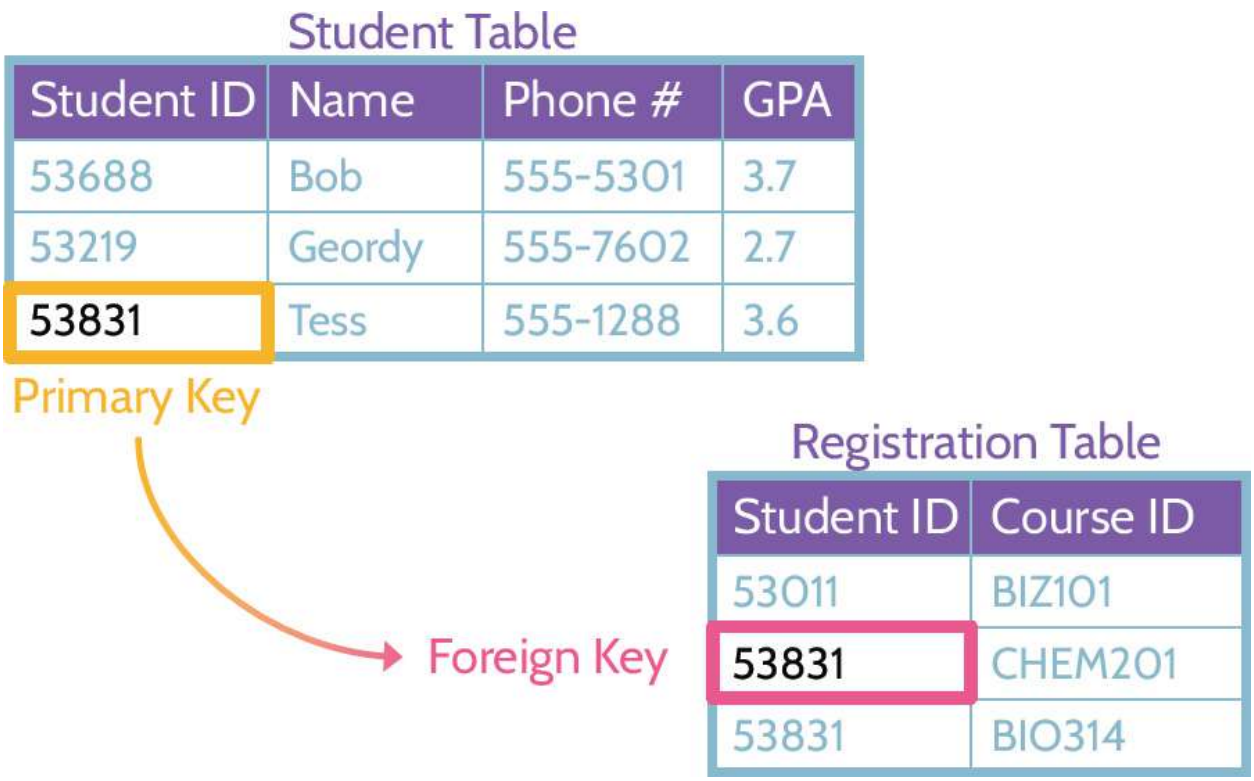


Figure 8-11: **Primary and Foreign Keys**

Understand how primary & foreign keys function together to maintain referential integrity within a database

Figure 8-11 depicts two tables: a student table and a registration table. The student table contains information that would typically relate to a student; the registration table contains information about course registrations. To gain more information about a student and their courses, it makes sense to link the tables together. To do so, some type of common denominator must exist in each table. In this example, the common denominator is "StudentID," which functions as a unique identifier and is also known as the **primary key**. The entire purpose of a primary key is to make each row—each tuple—unique. In the registration table, StudentID also exists, which allows the two tables to be linked together. When the primary key from one table references the same key in another table, the referenced key is known as the **foreign key**. In this example, the primary key is StudentID in the student table; the foreign key is StudentID in the registration table.

Understand the meaning of common database terms

Another important requirement related to primary keys is that they must be valid. In other words, validation of the primary key takes place when a record is added to a table. This typically means that the key is checked against rules to make sure the data conforms to requirements like length, data type,

uniqueness, and so on. This validation process ensures what's known as referential integrity, which is a critical component of relational database systems. In this example, referential integrity ensures that every instance of StudentID in the student table is valid and that every instance of StudentID in the registration table exists in the student table.

A summary of key database terms has been included in Table 8-8.

Tuple	Single **row** of a two-dimensional table within a relational database
Attribute	Single **column** of a two-dimensional table within a relational database
Field	The intersection of a row (tuple) and a column (attribute) is a single field of data
Primary Key	One or more columns whose values uniquely identify a tuple (row) within a relational database. For example, AuthorID in the authors table.
Foreign Key	One or more columns whose values in a table refer to the primary key in another table. AuthorID would be the primary key in the authors table. Any books in the books table by an author would have a foreign key referring to the author in the authors table.

Table 8-8: **Key Database Terms**

Concurrency and Lock Controls

Understand how concurrency and locks function to protect the integrity of databases

Among security issues that exist within the context of database environments, concurrency, locking, and controls related to each are essential to consider. Databases are valuable for several reasons, including that they contain up-to-date and relevant information for purposes of decision-making. This means that multiple people may sometimes attempt to access or update the same database element at the same time. When this happens, integrity issues could arise. As a result, the logic and controls to handle **concurrency** (the ability for multiple processes to access or change shared data at the same time) and locks are standard within DBMS. Locks are used to protect the integrity of data elements. For example, when User A accesses an element and begins making changes, the element is **locked**. Thus, another User B is prevented from updating the element. User B can only view the element. Once the

original User A is finished with their operation, the element is unlocked and released for other users to access and edit Concurrency and locks are summarized in Table 8-9.

Concurrency	Lock Controls
Ability for multiple processes to access or change shared data at the same time	***Prevent data corruption*** when multiple users try to write to the database simultaneously. A record can be locked.

Table 8-9: **Concurrency and Locks**

ACID

Understand the acronym ACID and what each term means

Related to concurrency and locks controls is specific functionality represented by the acronym ACID. ACID stands for atomicity, consistency, isolation, and durability and relates to how information and transactions in an RDBMS environment should be treated. It is important to understand what each term means, and Table 8-10, breaks down ACID in more detail.

A	**Atomicity – All** changes take effect or **None at all**
C	**Consistency –** Consistent with the **Rules**
I	**Isolation –** Transactions are **Invisible** to other users until complete
D	**Durability –** Completed changes will not be **Lost**

Table 8-10: **ACID**

8.2.4 Metadata

CORE **CONCEPTS**

- **Metadata is data about other data**

The term metadata refers to information that offers insights about other data. Essentially, it's data about data. For example, metadata about a file would include creation date, last modified date, file owner, file size, and so on.

8.2.5 Development Ecosystems

CORE **CONCEPTS**

- **CI/CD, SOAR, and SCM are development ecosystems.**
- **Though the focus of each is different, they each share common characteristics.**

Different types of development ecosystems exist, and several of them were noted at the beginning of Section 8.2. They are: continuous integration; delivery and deployment (CI/CD); security orchestration, automation, and response (SOAR —this is covered separately in section 7.2.3); and Software Configuration Management (SCM). Though each of these has a different focus, they share similar characteristics: ■ The use of automation to ensure consistency and quality ■ Efficient and effective delivery of product, results, and protection ■ Protection of the organization and partners/customers

through a proactive focus on security

8.3 Assess the effectiveness of software security

8.3.1 Software Security Assessment Methods

CORE **CONCEPTS**

- **Software security effectiveness can be determined through auditing and logging of changes and risk analysis and mitigation, among other methods**

This section is really a short review of Domain 6, Security Assessment and Testing; for more details, refer to Domain 6.

In order to assess the effectiveness of application security, testing should be conducted, and logs should be reviewed, among other things. Testing could include white box testing and black box testing as well as items like threat modeling and penetration testing. Security should be involved with: ■ Risk analysis and mitigation ■ Auditing and logging of changes ■ Logging and monitoring ■ Internal and external audit ■ Procurement process ■ Certification and accreditation ■ Testing and verification ■ Code signing As noted above, certification and accreditation are parts of this process.

Certification is the comprehensive and technical analysis of something—an application in this case—to make sure requirements and needs are met. Accreditation is management's official decision and sign-off to implement a solution. Both activities relate to security's goal of providing confidence and assurance.

As noted earlier, this topic is a quick review of Domain 6, Security Assessment and Testing, and it covers both bullet points noted in the Official CISSP Certification Exam Outline: ■ Auditing and logging of changes ■ Risk analysis and mitigation **8.4 Assess security impact of acquired software**

Does purchasing software preclude the need for security to be assessed? Many organizations do not have the time or resources to develop their own software, so they contract the development to a third party, or they purchase the software from a vendor. Regardless of the source of software—internally developed or externally purchased—security should always be involved with the process. Whether testing functionality or assessing potential vulnerabilities, security must be included.

When purchasing software, oftentimes the seller will not provide the source code—only the finished product. In cases like this, the purchasing company might ask that the source code be stored in escrow to provide ongoing access, regardless of what may happen with the seller over time (e.g., going out of business).

8.4.1 Acquiring Software

CORE **CONCEPTS**

- **Acquiring software should be taken as seriously as developing software, and security should be considered at every step in the process.**
- **Software assurance phases for acquisition include: planning/requirements, contracting, acceptance, monitoring and follow-on.**
- **Common ways to acquire software is via: COTS, open source, third party, managed services.**

Software development should be underpinned by a strong focus on security from inception to deployment to retirement. The acquisition of software should require and receive the same level of attention and scrutiny. At a high level, the software acquisition process should follow a similar process as noted.

Software Assurance Phases for Acquisition

■ Planning/requirements ■ Contracting ■ Acceptance ■ Monitoring and follow-on

Software may be acquired in a multitude of legal and illegal ways. Some of the more common legal means of acquiring software include COTS, open source, third party, and managed services.

Commercial-Off-the-Shelf (COTS)

Among most organizations, COTS software is typically used, because it is often readily available to the general public, and it is user friendly. Additionally, active user communities often develop around COTS software that allow user support, software use scenarios and examples, troubleshooting, and bug reports to become a dynamic and collective community-based effort versus isolated user dependence upon the COTS provider. Examples of COTS software include Microsoft 365, antivirus, and security software as well as numerous other types of software, including enterprise resource planning (ERP), customer relationship management (CRM), point of sale (POS), billing, accounting, and invoicing, among many other COTS solutions.

Use of COTS software offers pros and cons.

Pros include:

■ Functionality of the product can be more easily verified/confirmed ■ Comparisons of similar products can be made ■ Third-party evaluation of the product can be made ■ Existing customers can be contacted ■ Software updates and patches are likely more readily available

Cons include:

■ Inability to conduct white box testing, due to code base not being available for examination ■ Possibility of the vendor going out of business ■ Support and related issues ■ Missing features and functionality ■ Vulnerabilities being identified and taken advantage of by malicious users as widely used software is more likely to be probed for weaknesses due to larger user base Like when software is developed in house, the acquisition of COTS software should result from a correspondingly rigorous application of the SDLC, despite things like white box testing not being possible.

Understand how COTS and open source are similar and different from each other and pros and cons of each method of procuring software

Open Source Software

In many respects, open source software is very similar to COTS software, with one significant exception: unlike COTS, open source software is software with source code that anyone can inspect, modify, and enhance. As a general rule, open source software licenses invite collaboration among a user community. Furthermore, modification of code and incorporation of changes into projects can lead to enhanced functionality and new uses of the software. An organization may choose to use open source software for any of a number of reasons, including those noted below: ■ **Control:** the organization can thoroughly examine the code to make sure it is safe, and they can choose to modify or omit parts of the software.

- **Training:** programming students can use open source software as a learning tool and invite feedback and scrutiny from a much wider audience.

- **Security:** due to the "open" nature of open source software, vulnerabilities and issues that may impact the stability of the software are typically identified and corrected much more quickly. Additionally, missing functionality can be added just as quickly.

Additionally, open source software typically provides a level of stability not always found with COTS or proprietary software, because the ongoing viability of open source software is not dependent on the original creators. Rather, open source software—like larger COTS platforms—typically leads to the growth of communities around it and these communities provide ongoing care, support, and upkeep.

With all of this in mind, however, prior to using open source software in an organization, the software should be examined and treated as if it was being developed in house. The SDLC, or a similar security-centric approach, should be applied, and the code confirmed to be safe for use. Otherwise, due to the community-based nature of open source software, vulnerabilities—accidental or malicious in origin—could exist. A classic example of this centered around a popular piece of software called OpenSSL. Due to a simple programming error, a security hole was opened and later exploited in what became known as Heartbleed. Due to widespread use of OpenSSL around the globe, Heartbleed affected millions of devices.

Third Party

In the context of software development and acquiring software, third-party code is code developed by programmers not employed by the organization. Whether acting as an independent contractor or as an employee of a software development company, third-party programmers and their code should be held to the same level of scrutiny as other vendors and their software products. The SDLC process should be applied to the extent possible, in order to ensure that the application is secure and functions as expected.

Managed Services (e.g., Enterprise Applications)

Managed service providers (MSPs) offer IT infrastructure and support for businesses. They can install and manage a range of technologies, allowing their customers to focus on their core businesses. MSPs often provide things like network monitoring, security, backup and recovery, technical support and even things like enterprise applications. For small-to-medium businesses, it's often much more cost effective

for them to engage an MSP than to run their IT infrastructure themselves. These days, many MSPs act as brokers and bundle cloud services for their customers.

Organizations should always properly assess the managed service provider to ensure that organizational goals and objectives are met, especially where security and privacy are concerned. Proper assessment would typically include: ■ Evaluation of SOC reports prepared by an independent auditor.

- Site visits by senior management and key stakeholders to assess the managed service provider.
- Discussions with existing customers of the managed service provider.
- If applicable, industry and regulatory assessments of the managed service provider for the sake of specific needs relevant to the organization.

Cloud Services (e.g., Software as a Service (SaaS), Infrastructure as a Service (IaaS), Platform as a Service (PaaS)

We discuss the cloud service models in section 3.5.9. In this more specific context, the security function needs to be involved in the process of acquiring cloud services. Just like an organization's other stakeholders, security should be part of the process of choosing cloud services, as well as when assets are moved to the cloud. Organizations must conduct their due diligence whenever they are moving data or applications to the cloud. Another key thing to remember is the shared responsibility model. While the customer always remains accountable, they share both control and responsibility with the provider. Both parties must understand their responsibilities and the risks that they face. All of this should be written up as part of the agreement between the two parties.

8.5 Define and apply secure coding guidelines and standards

8.5.1 Secure Coding Guidelines

To produce consistently secure software, it is important to define and apply secure coding guidelines and best practices. As noted earlier, programming tools today offer significant functionality, including the ability to include security as part of the process. This is what needs to be enforced. Several frameworks and sources exist to aid with these efforts, including Open Web Applications Security Project (OWASP). Every few years, OWASP publishes a Top 10 Web Application Security Risks document that includes a list of risks, their descriptions, and mitigation strategies. Similarly, other organizations, like NIST and CIS, also offer secure software development frameworks and resources devoted to best software development practices. Table 8-11 contains a list of the most common security weaknesses and vulnerabilities present at the source code level.

Covert Channels	***Unintentional*** communications path that has the opportunity of disclosing confidential or sensitive information. Two types of covert channels exist: timing and storage.
Buffer Overflows	Buffer overflows take place when application input information exceeds the storage space—the buffer—allocated to store that information. Buffer overflow conditions are not uncommon and typically can only be fixed through application of a software patch.
Memory/Object Reuse	The ability to overwrite storage where secure and sensitive information has been written or stored. Most applications don't have the ability to overwrite storage where sensitive information has been written, which can lead to this information being available or viewable by other applications.
Executable Mobile Code	Executable mobile code is code that is downloaded to a system and then run on the system. This may happen because of clicking a link on a webpage or in an email. Once the link is clicked, the code downloads to the machine and runs locally, and therefore it is referred to as "mobile" code. If the code is malicious, serious harm could follow. A protective measure is to test the code in a sandbox environment first.
TOCTOU	TOCTOU refers to time-of-check time-of-use, and it may also be referred to as "race condition." This occurs when a time gap exists between when a value is checked/enforced and when the value is used. This gap leaves room for malicious activity to occur.

Backdoors/Trapdoors	Backdoors/trapdoors are intentionally put in place by developers so they can quickly access an application to perform legitimate work. They're sometimes also referred to as maintenance hooks. A problem arises, however, when these backdoors/trapdoors still exist after development is finished. Numerous examples of backdoors found in operating systems and applications exist, and oftentimes they can only be identified by examining the source code.
Malformed Input	Malformed input means exactly that—input that does not meet certain criteria or rules. Data or input validation functionality should exist in applications and check data before it is accepted. In fact, inadequate input validation is one of the leading causes of attacks on web applications, and it routinely shows up in OWASP's Top 10 vulnerabilities list.
Citizen Developers	Citizen developers is a term that politely refers to normal users having access to powerful programming and similar tools. A perfect example of this is giving users access to SQL query tools, so they can perform their own queries against the contents of a database instead of relying on somebody to do the work for them. As a result, these users often have access to very functional and powerful tools without commensurate security skills to protect their activities. Policies, security awareness, training, and education can help alleviate and bridge this gap.

Table 8-11: **Security Weaknesses and Vulnerabilities at the Source Code Level**

8.5.2 Buffer Overflow

CORE **CONCEPTS**

- **Buffer overflow is a common problem with applications and happens when information sent to a storage buffer exceeds the capacity of the buffer.**
- **Buffer overflow vulnerabilities can be exploited to elevate privileges or launch malicious code.**
- **Address space layout randomization (ASLR) can be used to protect against buffer overflows.**
- **Parameter/bounds checking is another way to protect against buffer overflows.**

Understand what is meant by the term *buffer overflow* and how a buffer overfl ow works

Let's examine the concept of buffer overflows more closely. As described above, a buffer overflow happens when information sent to a storage buffer exceeds the capacity of the buffer, especially in applications. At a high level, applications accept input, process it, and provide output. When designing applications, buffers—temporary memory storage areas—are included to handle the input, processing, and output functionality. Buffer sizes are often determined ahead of time and don't dynamically change. Thus, if an application somehow sends more information than a buffer can handle, an overflow condition results.

The inability of a buffer to dynamically change size points to the way an attacker could creatively use a buffer overflow to exploit a system. An attacker could create a situation where the overflow data that contains executable code is placed into a storage area where the code is then executed. For example, this could allow the attacker to elevate their system privileges.

Understand how a buffer overflow situation can be mitigated through ASLR

Though the buffer overflow problem has been around for decades, ways to mitigate or prevent buffer overflows do exist. **Address Space Layout Randomization (ASLR)** is one of the best techniques to protect against buffer overflows. In essence, it works by randomizing the locations of where system executables are loaded into memory. In other words, without ASLR, an attacker could learn how a program operates and what parts of a buffer are utilized by a given program, and this knowledge can lead to the creation of an attack. With ASLR enabled, because the location of system executables is randomized, it makes it very difficult for the attacker to guess the locations and therefore launch a successful attack.

Another software development technique commonly used to prevent buffer overflows is **bounds checking.** The input to a variable should be checked to ensure it is within some bounds, before it is used. For example, that a string is of a certain length, a number fits into a given type, or an array index is within the bounds of the array.

In addition to ASLR, understand other ways to protect against buffer overflow situations

In addition to ASLR & bounds checking, other ways to protect against buffer overflow situations include: ■ Parameter/**bounds checking**

■ Improve software development process, including thorough code review ■ Runtime checking of array and buffer bounds ■ Use safe programming languages and library functions 8.5.3 **Application Programming Interfaces (APIs)**

CORE **CONCEPTS**

- **Application programming interfaces (APIs) provide a way for applications to communicate with each other; APIs act as translators.**
- **Two of the most common APIs are Representational State Transfer (REST) and Simple Object Access Protocol (SOAP).**
- **APIs should be secured along with other components of an application; security can include authentication and authorization mechanisms, TLS encryption for data traversing insecure channels, API gateways, and data validation, among others.**

Due to the proliferation of use of the internet and the way applications are programmed and operate today, many of the programs in use today are disparate components that talk to and work with each other. A perfect example of this fact is web application environments, where many different components might exist and need to communicate with each other. This communication is facilitated by standards that allow components to understand each other. These standards are better known as application programming interfaces or APIs.

Understand what the term *application programming interface* means and what function an API provides to applications

Here's an example to better illustrate: Imagine walking into a restaurant and sitting down at a table to order a meal. After looking at the menu, a server takes the order and relays it to the kitchen, where the cooking team will prepare the food. In this context, the server is like the API that relays information from the customer to the kitchen in such a way that a meal will be prepared as the customer specified. Like the language used to communicate between servers and kitchen staff, APIs provide a way for applications to communicate with each other. If the goal is for two applications to communicate, regardless of the language they speak, a translator must exist. APIs act as translators and facilitate this communication. The two most used API formats are REST and SOAP, and each format has strengths and weaknesses.

Application Programming Interfaces (APIs)

As noted above, how to access web services really boils down to the question of which API should be used, as both REST and SOAP are viable options. Table 8-12 outlines differences between the two standards.

Understand the two most common API formats and characteristics of each

Representational State Transfer (REST)	Simple Object Access Protocol (SOAP)
■ Representational State Transfer ■ Newer ■ More flexible and lighter weight alternative to SOAP ■ HTTP based ■ Easy to learn and use ■ Fast in processing ■ Output can take several forms, including CSV, JSON, RSS, and XML	■ Simple Object Access Protocol ■ Older, originally developed by Microsoft ■ More rigid and standardized ■ XML-based ■ Extensible through use of WS standards ■ Strong error handling

Table 8-12: **REST vs SOAP**

Security of Application Programming Interfaces

Understand techniques commonly used to secure APIs

Among ways to protect APIs, best industry recommendations include: ■ Authentication and authorization (access tokens/OAuth) ■ Encryption (TLS) ■ Data validation ■ API gateways ■ Quotas and throttling ■ Testing and validation 8.5.4 **Secure Coding Practices**

CORE **CONCEPTS**

- **Secure programming can help prevent software vulnerabilities.**
- **Secure coding practices include: input validation, authentication and password management, session management, among others.**
- **Coupling and cohesion are relational terms that indicate the level of relatedness between units of a code base (coupling) and the level of relatedness between the code that makes up a unit of code (cohesion).**
- **Low coupling (meaning units of code can stand alone) and high cohesion (meaning the code that makes up a unit of code is highly related) are optimal.**
- **Polyinstantiation refers to something being instantiated into multiple separate or independent instances and can be used to prevent unauthorized inference.**

Secure coding practices refers to steps and techniques taken to minimize or eliminate vulnerabilities in software that could lead to exploitation. In addition to some that were mentioned earlier, other steps and techniques are noted below: ■ Input validation ■ Authentication and password management ■ Session

management ■ Cryptographic practices ■ Error handling and logging ■ System configuration ■ File/database security ■ Memory management

Coupling and Cohesion

Understand the terms *cohesion* and *coupling* and which combination (low or high) is ideal for purposes of coding

Coupling and cohesion are relational terms that indicate the level of relatedness between units of a code base (coupling) and the level of relatedness between the code that makes up a unit of code (cohesion). Low **coupling** (meaning units of code can stand alone and are not dependent on other units of code to function) and high **cohesion** (meaning the code that makes up a unit of software is highly related) are optimal, whereas high coupling and low cohesion is typically indicative of poorly written code.

Polyinstantiation

Understand the term *polyinstantiation* and what it can help prevent

The word *poly* means many. The word *instantiation* refers to an instance or example of something. Put together, *polyinstantiation* refers to something being instantiated into multiple separate or independent instances. A better way to illustrate this is through an example.

Imagine a military environment—an army base—where one of the systems is used to track and manage military units. One day, a General requests that a new military unit—Charlie Company 6—be added to the system. Upon trying to enter information about this unit to the system, the system operator receives the error message: “Unable to add unit Charlie Company 6.” Simply based upon this transaction and error message, unauthorized inferences can be made—that error message is essentially saying that a unit named “Charlie Company 6” already exists in the system.

If polyinstantiation techniques had been designed into the system, the system would have recognized that Charlie Company 6 already existed in the system at a higher classification level than what the operator was allowed to see. The system would then know that when anybody at the lower level refers to Charlie Company 6, it will be mapped to something else at that lower level. In other words, technology will handle the management of data using polyinstantiation techniques based upon classification and clearance levels, which will prevent unauthorized inference from taking place.

Unauthorized inference can be a particular issue where people and databases are concerned. Most of the time, inference is a good thing. This is why databases and similar repositories exist, to facilitate queries that can lead to the discovery of information valuable to an organization and thereby drive better decisions. However, some types of information should only be viewed by certain people. Otherwise, more unauthorized inference of more sensitive information might result.

Polyinstantiation can be used to ***prevent unauthorized inference***, and it allows the same data to exist at different classification levels.

Software-Defined Security

As the name suggests, software-defined security is security in a computing environment that is implemented, controlled, and managed by software. As with other software-defined functions, the development and growth of software-defined security has coincided with continued growth of cloud and virtualization. Specific functionality of software-defined security can mimic that found with traditional hardware-based solutions; firewalls, intrusion detection and prevention, access control and management, among others, can all be instantiated, configured, and managed through software-defined security solutions. Furthermore, functionality of software-defined security is typically driven by policy that supports an organization's overall goals and objectives in a cost-effective manner.

8.5.5 Software Development Vulnerabilities

CORE **CONCEPTS**

- **Insecure coding practices and citizen developers writing code usually leads to software development vulnerabilities.**
- **Backdoor/trapdoor attacks often result from software vulnerabilities.**
- **Between-the-lines attack = attacker intercepts/modifies communication between devices/people over a network; also known as a man-in-the-middle attack.**

Software development vulnerabilities often arise because of:

- Use of insecure coding practices.
- Citizen developers writing code.

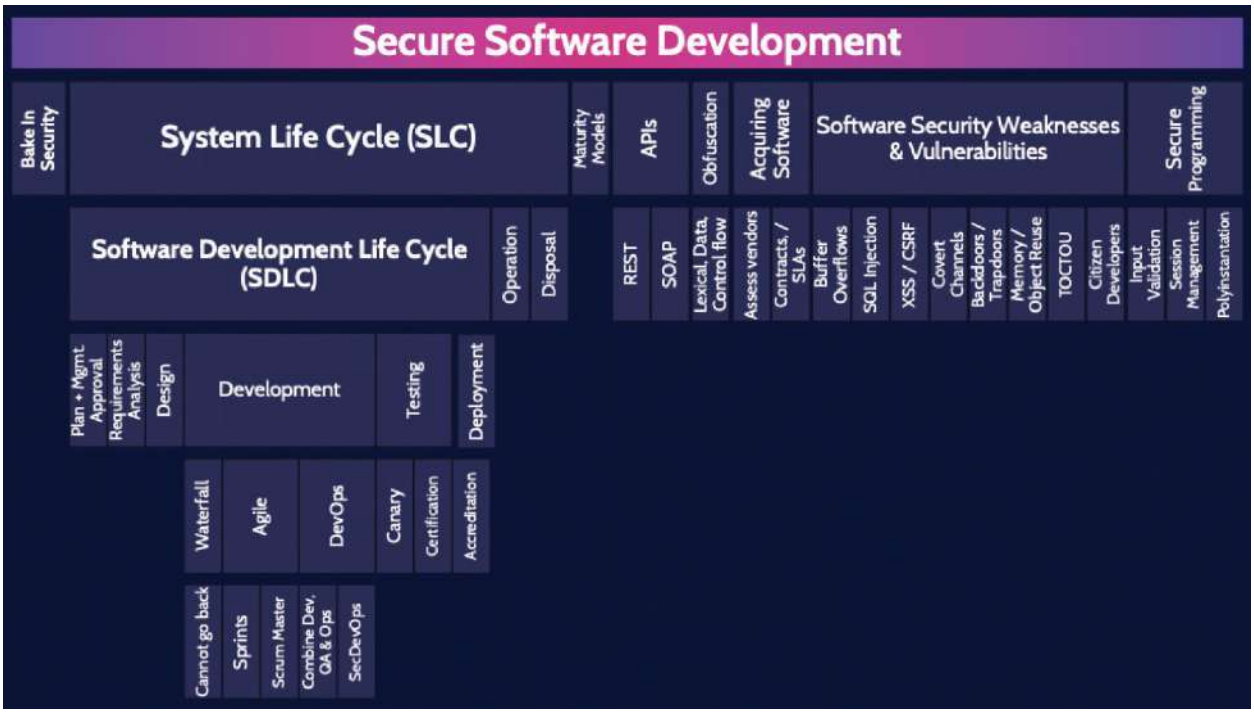
Understand the primary reasons that lead to software development vulnerabilities

As noted earlier, ***citizen developers*** often have access to powerful programming tools, but they're typically self-taught and unskilled with regards to secure coding practices, which can lead to insecure and unreliable application development , as well as insecure technology use. Insecure coding practices can lead to backdoor or trapdoor situations, whereby an attacker is able to bypass normal authentication mechanisms as a result of installing remote access software on a computer as well as attacks like: ■ **Between-the-lines attack,** where an attacker intercepts or modifies communication between

devices/people communication over a network. This type of attack is also known as a man-in-the-middle attack.

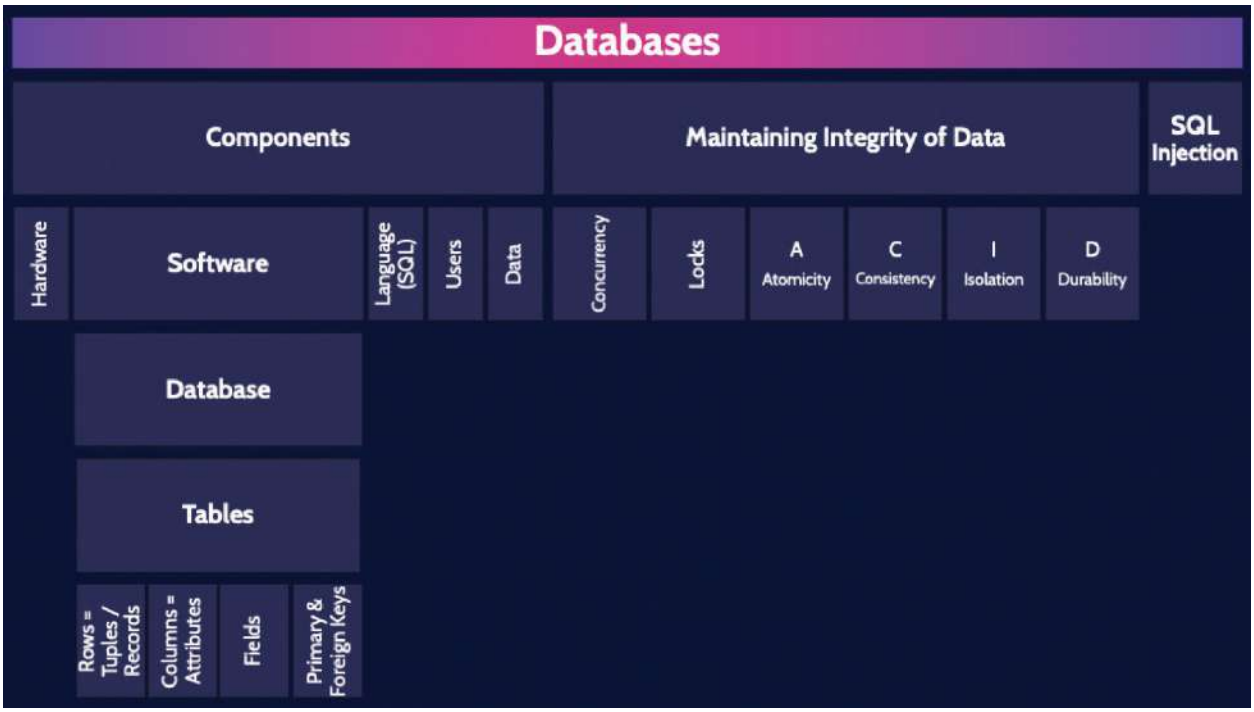
- **Memory reuse (object reuse)**, where remnants of data that relate to a previous operation are accidentally or intentionally read, used, or otherwise disclosed. In practice, residual data should be cleared from memory before another operation is performed.

MINDMAP REVIEW **VIDEOS**



Secure Software Development

dcgo.ca/CISSPmm8-1



Databases

dcgo.ca/CISSPmm8-2

REFERENCES AND FURTHER READING

Resource	Link
ISC2 Code of Ethics	https://www.isc2.org/Ethics
ISC2 CISSP Exam Outline (effective April 15, 2024)	https://www.isc2.org/certifications/cissp/cissp-certification-exam-outline
California Privacy Rights Act of 2020	https://iapp.org/resources/topics/ccpa-and-cpra/
COPPA	https://www.ftc.gov/legal-library/browse/rules/childrens-online-privacy-protection-rule-coppa
COBIT	https://www.isaca.org/resources/cobit
CVE	https://www.cve.org/
CVSS	https://www.first.org/cvss/
DMCA	https://www.gpo.gov/fdsys/pkg/PLAW-105publ304/pdf/PLAW-105publ304.pdf
DREAD	https://en.wikipedia.org/wiki/DREAD_%28risk_assessment_model%29
FedRAMP	https://www.fedramp.gov/
FIPS 140-3	https://csrc.nist.gov/pubs/fips/140-3/final
GDPR	https://gdpr.eu/tag/gdpr/

GLBA	https://www.govinfo.gov/link/plaw/106/public/102?link-type=pdf&.pdf
HIPAA	https://www.hhs.gov/hipaa/index.html
ISO 15408	https://www.iso.org/standard/72891.html
ISO 27001 & 27002	https://www.iso.org/standard/27001 https://www.iso.org/standard/75652.html
ISO 29134	https://www.iso.org/standard/86012.html
ITIL	https://www.axelos.com/certifications/itil-service-management
ITSEC	https://op.europa.eu/en/publication-detail/-/publication/f06fe0df-1d9b-430e-bc82-f8c63ea1c394/language-en/format-PDF/source-search
Kerckhoff's Principle	https://en.wikipedia.org/wiki/Kerckhoffs%27s_principle
Locard's exchange principle	https://en.wikipedia.org/wiki/Locard%27s_exchange_principle
NIST Cloud Computing Forensic Science Challenges	https://csrc.nist.gov/publications/detail/nistir/8006/final
NIST SP 500-241	https://nvlpubs.nist.gov/nistpubs/Legacy/SP/nistspecialpublication500-241.pdf
NIST SP 800-12 Rev 1	https://csrc.nist.gov/publications/detail/sp/800-12/rev-1/final

NIST SP 800-34 Rev 1	https://csrc.nist.gov/publications/detail/sp/800-34/rev-1/final
NIST SP 800-37 Rev 2	https://csrc.nist.gov/publications/detail/sp/800-37/rev-2/final
NIST SP 800-41 Rev 1	https://csrc.nist.gov/publications/detail/sp/800-41/rev-1/final
NIST SP 800-53 Rev 5	https://csrc.nist.gov/publications/detail/sp/800-53/rev-5/final
NIST SP 800-61 Rev 2	https://csrc.nist.gov/publications/detail/sp/800-61/rev-2/final
NIST SP 800-63	https://pages.nist.gov/800-63-3/sp800-63-3.html
NIST SP 800-88 Rev 1	https://csrc.nist.gov/publications/detail/sp/800-88/rev-1/final
NIST SP 800-115	https://csrc.nist.gov/publications/detail/sp/800-115/final
NIST SP 800-122	https://csrc.nist.gov/publications/detail/sp/800-122/final
NIST SP 800-124 Rev 2	https://csrc.nist.gov/pubs/sp/800/124/r2/final
NIST SP 800-125	https://csrc.nist.gov/publications/detail/sp/800-125/final
NIST SP 800-137A	https://csrc.nist.gov/publications/detail/sp/800-137a/final
NIST SP 800-153	https://csrc.nist.gov/publications/detail/sp/800-153/final

NIST SP 800-207	https://csrc.nist.gov/publications/detail/sp/800-207/final
OECD Privacy Guidelines	https://legalinstruments.oecd.org/en/instruments/OECD-LEGAL-0188
OWASP Mobile Security Testing Guide	https://mas.owasp.org/MASTG
OWASP Mobile Top 10	https://owasp.org/www-project-mobile-top-10/
OWASP Software Assurance Maturity Model	https://owaspsamm.org/model/
PASTA	https://versprite.com/blog/what-is-pasta-threat-modeling/
PCI DSS	https://docs-prv.pcisecuritystandards.org/PCI%20DSS/Standard/PCI-DSS-v4_0.pdf
Privacy by Design	https://www.ipc.on.ca/wp-content/uploads/2018/01/pbd.pdf
Sarbanes–Oxley Act (SOX)	https://www.govinfo.gov/link/plaw/107/public/204?link-type=pdf&.pdf
STRIDE	https://docs.microsoft.com/en-us/azure/security/develop/threat-modeling-tool-threats
TCSEC (Orange Book)	https://csrc.nist.gov/csrc/media/publications/conference-paper/1998/10/08/proceedings-of-the-21st-nissc-1998/documents/early-cs-papers/dod85.pdf
The Wassenaar Arrangement	https://www.wassenaar.org/

TPM Standard	https://www.iso.org/standard/66510.html
USML	https://www.ecfr.gov/current/title-22/chapter-I/subchapter-M/part-121

ACRONYMS

AAA	Authentication, Authorization and Accounting
AAL	Authentication Assurance Levels
AES	Advanced Encryption Standard
AH	Authentication Header
AICPA	American Institute of Certified Public Accountants
ALE	Annualized Loss Expectancy
API	Application Programming Interface
APPs	Australian Privacy Principles
APT	Advanced Persistent Threat
ARO	Annualized Rate of Occurrence
AS	Authentication Service
ASLR	Address Space Layout Randomization
ATM	Automated Teller Machine
ATM	Asynchronous Transfer Mode
AV	Asset Value
AV	Anti-Virus
BAU	Business as Usual
BC	Business Continuity

BCM	Business Continuity Management
BCP	Business Continuity Procedure
BCP	Business Continuity Plan
BGP	Border Gateway Protocol
BIA	Business Impact Analysis
CA	Certificate Authority
CaaS	Containers as a Service
CAB	Change Advisory Board
CAM	Content Addressable Memory
CAPTCHA	Completely Automated Public Turing test to tell Computers and Humans Apart
CBC	Cipher Block Chaining
CBK	Common Body of Knowledge
CCTV	Closed Circuit Television
CD	Compact Disc
CDMA	Code Division Multiple Access
CEO	Chief Executive Officer
CER	Cross over Error Rate
CFB	Cipher Feedback
CHAP	Challenge Handshake Authentication Protocol
CI/CD	Continuous Integration, Continuous Delivery

CIO	Chief Information Officer
CIP	Critical Infrastructure Protection
CISO	Chief Information Security Officer
CISSP	Certified Information Systems Security Professional
CMM	Capability Maturity Model
CORPA	Consumer Online Privacy Rights Act
COSO	Committee of Sponsoring Organizations of the Treadway Commission
COTS	Commercial-Off-The-Shelf
CPE	Continuing Professional Education
CPTED	Crime Prevention Through Environmental Design
CPU	Central Processing Unit
CRC	Cyclic Redundancy Check
CRL	Certificate Revocation List
CRM	Customer Relationship Management
CRT	Cathode-Ray Tube
CSMA	Carrier Sense Multiple Access
CSMA/CA	Carrier Sense Multiple Access (Collision Avoidance)
CSMA/CD	Carrier Sense Multiple Access (Collision Detection)
CSO	Chief Security Officer
CSP	Cloud Service Provider

CSR	Certificate Signing Request
CSRF	Cross Site Request Forgery
CTR	Counter
CVE	Common Vulnerability and Exposures
CVSS	Common Vulnerability Scoring System
CWE	Common Weakness Enumeration
DAC	Discretionary Access Control
DAST	Dynamic Application Security Testing
DBMS	Database Management System
DCS	Distributed Control System
DDoS	Distributed Denial of Service
DES	Data Encryption Standard
DFS	Distributed File Systems
DLP	Data Loss Prevention
DMCA	Digital Millennium Copyright Act
DMZ	Demilitarized Zone
DNS	Domain Name System
DNSSEC	Domain Name System Secure
DoS	Denial of Service
DPIA	Data Protection Impact Assessment
DPO	Data Protection Officer

DR	Disaster Recovery
DRM	Digital Rights Management
DRP	Disaster Recovery Protocol
DRP	Digital Rights Protection
DRP	Disaster Recovery Plan
DVD	Digital Versatile Disc
EAL	Evaluation Assurance Level
EAP	Extensible Authentication Protocol
EAR	Export Administration Regulations
ECB	Electronic Codebook
ECC	Elliptic Curve Cryptography
EF	Exposure Factor
ERP	Enterprise Resource Planning
ESP	Encapsulating Security Payload
FaaS	Function as a Service
FAR	False Acceptance Rate
FCoE	Fibre Channel over Ethernet
FERPA	Family Educational Rights and Privacy Act
FIA	Fault Injection Attack
FIM	Federated Identity Management
FIM	Federated Integrity Management

FIM	File Integrity Monitoring
FISMA	Federal Information Security Modernization Act
FISMA	Federal Information Security Management Act
FRR	False Rejection Rate
FTP	File Transfer Protocol
GDPR	General Data Protection Regulation
GLBA	Gramm–Leach–Bliley Act
GPS	Global Positioning System
GRE	Generic Routing Encapsulation
GSM	Global System for Mobiles
HIPAA	Health Insurance Portability and Accountability Act
HIPS	Host Intrusion Prevention System
HMAC	Hash Message Authentication Code
HSM	Hardware Security Module
HTTP	Hyper Text Transfer Protocol
HTTPS	Hyper Text Transfer Protocol Secure
HVAC	Heating, Ventilation and Air Conditioning
IaaS	Infrastructure as a Service
IAM	Identity and Access Management
IAM	Identity Access Management
IANA	Internet Assigned Numbers Authority

IAST	Interactive Application Security Testing
ICMP	Internet Control Message Protocol
ICS	Industrial Control Systems
IDaaS	Identity as a Service
IDE	Integrated Development Environment
IDS	Intrusion Detection System
IEEE	Institute of Electric and Electronic Engineers
IGMP	Internet Group Management Protocol
IKE	Internet Key Exchange
IoT	Internet of Things
IP	Intellectual Property
IPSec	Internet Protocol Security
IPT	Integrated Product Team
iSCSI	Internet Small Computer Systems Interface
ISO	International Organization for Standardization
IT	Information Technology
ITAR	International Traffic in Arms
ITSEC	Information Technology Security Evaluation Criteria
IV	Initialization Vector
JIT	Just In-Time
KDC	Key Distribution Center

KEK	Key Encrypting Keys
KPI	Key Performance Indicator
KRI	Key Risk Indicator
L2F	Layer 2 Forwarding
L2TP	Layer 2 Tunneling Protocol
MAC	Mandatory Access Control
MAD	Maximum Allowable Downtime
MAM	Mobile Application Management
MASVS	Mobile Application Security Verification Standard
MD5	Message Digest 5
MDM	Mobile Device Management
MIC	Message Integrity Check
MOM	Motive Opportunity Means
MPLS	Multi-Protocol Label Switching
MSTG	Mobile Security Testing Guide
MTBF	Mean Time Between Failures
MTD	Maximum Tolerable Downtime
NAC	Network Access Control
NAT	Network Address Translation
NCA	Non-Compete Agreement

NDA	Non Disclosure Agreement
NetBIOS	Network Basic Input/Output System
NIDS	Network Intrusion Detection System
NIPS	Network Intrusion Prevention System
NIST	National Institute of Standards and Technology
NTP	Network Time Protocol
OCSP	Online Certificate Status Protocol
OECD	Organization of Economic Cooperation and Development
OFB	Output Feedback
OSI	Open Systems Interconnection
OSPF	Open Shortest Path First
OUI	Organizational Unique Identifier
PaaS	Platform as a Service
PAP	Password Authentication Protocol
PASTA	Process for Attack Simulation and Threat Analysis
PAT	Port Address Translation
PbD	Privacy by Design
PBX	Private Branch Exchange
PCI DSS	Payment Card Industry Data Security Standard
PDPL	Personal Data Protection Law
PEAP	Protected Extensible Authentication Protocol

PGP	Pretty Good Privacy
PIA	Privacy Impact Assessment
PII	Personally Identifiable Information
PIPA	Personal Information Protection Act
PIPEDA	Personal Information Protection and Electronic Documents Act
PKI	Public Key Infrastructure
PLC	Programmable Logic Controller
POA&M	Plan of Actions and Milestones
POS	Point of Sale
PPTP	Point to Point Tunneling protocol
PSTN	Public Switched Telephone Network
PtH	Pass the Hash
PVC	Permanent Virtual Circuit
QA	Quality Assurance
QoS	Quality of Service
RA	Registration Authority
RADIUS	Remote Authentication Dial-In User Service
RAID	Redundant Array of Independent Disks
RAM	Random Access Memory
RBAC	Role Based Access Control

RDBMS	Relational Database Management Systems
REST	Representational State Transfer
RFID	Radio Frequency Identification
RIP	Routing Internet Protocol
RMC	Reference Monitor Concept
RPC	Remote Procedure Call
RPO	Recovery Point Objective
RSA	Rivest–Shamir–Adleman
RTO	Recovery Time Objective
RUM	Real User Monitoring
S/MIME	Secure/Multipurpose Internet Mail Extensions
SA	Security Association
SaaS	Software as a Service
SABSA	Sherwood Applied Business Security Architecture
SAML	Security Assertion Markup Language
SAMM	Software Assurance Maturity Model
SAST	Static Application Security Testing
SCADA	Supervisory Control And Data Acquisition
SCM	Software Configuration Management
SDK	Software Development Kit
SDLC	Software Development Life Cycle

SDN	Software Defined Network
SESAME	Secure European System for Applications in a Multi-Vendor Environment
SETI	Search for Extraterrestrial Intelligence
SHA-1	Secure Hash Algorithm 1
SHA-3	Secure Hash Algorithm 3
SIEM	Security Information and Event Management
SIP	Session Initiation Protocol
SLA	Service Level Agreement
SLC	Software Life Cycle
SLE	Single Loss Expectancy
SLIP	Serial Line Internet Protocol
SLR	Service Level Requirements
SMART	Specific, Measurable, Achievable, Relevant, Timely
SMTP	Simple Mail Transfer Protocol
SNMP	Simple Network Management Protocol
SOAP	Simple Object Access Protocol
SOAR	Security Orchestration, Automation, and Response
SOX	Sarbanes-Oxley
SPML	Services Provisioning Markup Language
SQL	Structured Query Language

SRTP	Secure Real-time Transport Protocol
SSD	Solid State Drive
SSH	Secure Shell
SSID	Service Set Identifier
SSL	Secure Sockets Layer
SSN	Social Security Number
SSO	Single Sign-On
STP	Shielded Twisted Pair
SVC	Switched Virtual Circuit
TACACS	Terminal Access Controller Access-Control System
TCB	Trusted Computing Base
TCP/IP	Transport Control Protocol/Internet Protocol
TCSEC	Trusted Computer System Evaluation Criteria
TGS	Ticket Granting Server
TGS	Ticket Granting Service
TGT	Ticket Granting Ticket
TKIP	Temporal Key Integrity Protocol
TLS	Transport Layer Security
TOCTOU	Time-of-check Time-of-use
TOGAF	The Open Group Architecture Framework
TOR	The Onion Router

TPM	Trusted Platform Module
UBA	User Behavior Analytics
UEBA	User Entity Behavior Analytics
UPS	Uninterrupted Power Supply
UTP	Unshielded Twisted Pair
VESDA	Very Early Smoke Detection Apparatus
VLAN	Virtual Local Area Network
VM	Virtual Machine
VMM	Virtual Machine Manager
VoIP	Voice over Internet Protocol
VPN	Virtual Private Network
WEP	Wired Equivalent Privacy
WRT	Work Recovery Time
WSUS	Windows Server Update Services
XACML	eXtensible Access Control Markup Language
XML	Extensible Markup Language
XSS	Cross Site Scripting

INDEX

Note: Entries in this index, carried over verbatim from the print edition of this title, are unlikely to correspond to the pagination of any given e-book reader. However, entries in this index, and other terms, are easily located by using the search feature of your e-book reader.

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Zigzag cipher. See Rail fence cipher

Proven Exam Strategies

The CISSP exam—What to expect

- The majority of questions will be in a multiple-choice format—four possible answers, and you must select one answer.

- You may see drag-and-drop questions and these questions require matching a list of terms or steps in a process with their corresponding definition or description. Partial scores are not awarded for these types of questions. You must get all items correct to score the points associated with a particular drag-and-drop question.

- You will likely see questions on material you never studied or heard about. Be prepared, and don't let it psyche you out. Use our guidance and strategies for selecting the best possible answer, even if you don't fully understand the question.

- The Computer Adaptive Test (CAT) algorithm is good at finding weak topic areas. If any are identified, you will likely see multiple questions related to the topic(s). Be prepared and don't let this psyche you out.

- The CISSP exam requires careful comprehension of the questions as it is a test of security-focused knowledge. Understanding context and semantics is critical to success. This requires careful reading of the question multiple times.

- If taking the CAT (English) version of the exam, approach each question as if it is its own exam. Totally focus on each question. You can't mark questions for review or go back to see previous questions.

How to read and understand the question

- **Read each question at least three times**—the exam is not a speed-reading exam. Read each question slowly and carefully, at least three times.

- **Pick out the keywords**—every question includes keywords that will help you determine the best answer.

- **Simplify the wording of the question**—focus on exactly what is being asked and remove extraneous details.

- **Look for qualifiers**—questions will often use qualifiers—terms like ALL, LEAST, MOST, BEST,

EXCEPT, NOT. The meaning of a question can be completely changed with one of these qualifier words.

- **What does the answer have to be?** Think about everything you know about the topic in relation to the question. Ask yourself, “What does the answer have to be?” What is the ideal answer you will be looking for in the answers?

- **Don’t add information or make assumptions**— everything needed to answer a question is included in the question.

How to select the BEST answer

- **Do not look at the answers** until you have fully read and understood the question.

    - Three of the four possible answers can be thought of as being misleading or poisonous answers if you have not yet considered the question and keywords and asked yourself, “What does the answer have to be?”

    - Use your hand or the whiteboard to cover the answers until you are ready to look at them to avoid being influenced by the wrong answers.

- Most questions include multiple answers—distractor answers—that look correct and very appealing, especially if you have not fully read and understood the question.

- **Think Like A CEO**

  - How would the CEO or a member of senior management answer the question?

  - What would a risk advisor recommend?

  - You are a thinker, not a "doer" or "fixer"—think first, act second.

  - Think "end game"—don't focus on the immediate or near term.

- After selecting your answer, confirm that it BEST meets the criteria specified in the question.

- If one answer encompasses other answers, the more encompassing answer is usually correct.

- If an answer includes the word "policy," that's likely the correct answer.

- Safety of humans ALWAYS takes precedence.

- Security should always be considered as early as possible in a process; it's more effective and less costly to add early versus bolting on later.

The CISSP mindset

- **Think like a CEO**.

- Focus on understanding concepts and be able to apply them to given scenarios.

- Though the exam is not highly technical, it is important to understand the technology associated with the concepts and be able to apply this understanding.

- Assuming proper preparation, be confident and optimistic that you'll pass the exam.

Final preparations and exam day

- Schedule your exam for a time when you function most effectively. If you're a "morning" person, schedule your exam in the morning; if you're a "night" person, schedule your exam in the afternoon.

- The most important sleep is the sleep two nights before your exam. The night before, you'll likely be a

bit keyed up and on edge; so, a good night's rest two nights prior to your exam is important.

- Eat normally on exam day, but nothing too heavy, and stay hydrated. Healthier food and good hydration will allow your body and mind to function optimally during the exam.

- Just like an athlete warms up prior to a competition, warm up for your exam with ten to fifteen practice questions to engage your mind and get in "test mode."

- Before taking your exam, look yourself in the mirror and give yourself a positive pep talk—remind yourself of the time and effort you've put into preparing, the people who believe and support you, and why you're going to pass the exam. **You've got this!**

Destination Certification CISSP MasterClass

Brief description of the CISSP MasterClass – this will be a one page ad for our class

We're the co-founders and master instructors at Destination Certification.

We love teaching. We find it incredibly rewarding to help folks like yourself learn, become better security professionals, and achieve your CISSP certification!

Between us, we've been teaching CISSP classes for over 35 years and working directly with ISC2 leading many of their initiatives and programs, as well as teaching and guiding thousands of professionals to confidently pass the CISSP exam.

We've written this book to concisely provide the knowledge you need to pass the CISSP exam.

If you memorize and understand every word and concept in this book, you could pass the exam. However, that is a daunting task despite our great efforts to make this book as concise as possible. As you study for the exam, it's difficult to know which parts to focus on, keep yourself motivated, ensure you've learned everything you need to, and create or find other important study materials and support such as a study plan, flashcards, insightful answers to your questions, and practice tests.

The easiest way to get your CISSP certification

Our CISSP MasterClass provides you with the same knowledge as this book. In fact, this book is an important part of our class. Above and far beyond, this book our MasterClass provides: ▪ an intelligent learning system that guides you to focus on what you need to study most ▪ a clear study plan throughout the process that adjusts to your schedule ▪ a personal CISSP mentor who will guide you ▪ direct answers to your questions from us — expert CISSP instructors ▪ exam testing strategies and lots of examples of how to apply these strategies, so you know how to find the BEST answer to each exam question You could potentially save hundreds of hours of studying by focusing only on what you need to learn — and by having access to a complete integrated training system which provides everything you need to confidently pass the CISSP exam: MasterClass video lessons, your own personal CISSP mentor,

live calls with expert instructors, our student workbook, flashcard app, and the most realistic CISSP practice test in the world.

If you'd like to have a clear study path laid in front of you, you can join our CISSP MasterClass here:
destinationCISSP.com

DESTINATION CISSP

The goal of this concise study guide is simple: to help you confidently pass the CISSP exam and to provide you with a foundation of security knowledge that will equip you to be a better security professional as you navigate your career.

This Second Edition of our CISSP guide has been fully updated to reflect the April 2024 exam outline.

We have written this guide to be as concise as possible while still providing sufficient, valuable and relevant information to help you understand the concepts behind each domain that makes up the CISSP certification.

We have created hundreds of diagrams and summary tables and highlighted the core concepts to know for each section - all to make the daunting task of CISSP exam preparation as easy as possible.

Our collective wisdom from decades in the trenches of security, working with ISC2, developing official curriculums and official guides, teaching thousands of CISSP classes, and guiding tens of thousands of students to passing the CISSP exam has been distilled to create this concise guide to the CISSP exam.

Rob Witcher, CISSP, CCSP, CCSK, CISM, CISA, CSX-P, Security+, Network+, A+, and CIPM, is the co-founder of Destination Certification. He has over 20 years of intense security & privacy experience guiding some of the world's largest companies through major breaches and leading security implementations. Rob spends much of his time developing learning materials and systems and teaching CISSP and CCSP classes.

John Berti, CISSP, CCSP, SSCP, and CISM, is the co-founder of Destination Certification. He has over 30 years of experience in the security field and an exceptional ability to make complex topics simple. He has worked closely with ISC2 for over 20 years, developing materials for the official CISSP curriculum, the CCSP curriculum, and CISSP exam questions. John has facilitated hundreds of CISSP & CCSP classes worldwide. He was one of the original authors of the 'Official ISC2 Guide to the CISSP Exam'.

Lou Hablas, CISSP, has more than 25 years of experience working in the technology industry. He is passionate about helping people learn and confidently pass the CISSP exam. Lou is an exceptional CISSP mentor and guide.

Nick Mitropoulos, CISSP, has more than forty-five security certifications and fifteen years of experience in security, threat intelligence, data loss prevention, and incident response. He is a published author, Certified ISC2 instructor and holds numerous accolades and distinctions in the security industry, including winning the CEH Hall of Fame 2021 and United Nations Hall of Fame awards.

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CERTIFICATION

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