Costing Web App Development
for Operations Research

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Outline

1. Overview of Web Apps

2. Web Apps in Data Operations

3. Development Considerations

4. Deployment Considerations

5. DevSecOps WBS for Web App Development

6. Conclusion

7. References

Overview
of Web Apps

What Are Web Apps (*...and Why Do We Care?*)

- The ***availability of virtualized data*** and ***increase in computer processing power*** creates a need for automated data analytics, often in "real-time"

- Web applications (i.e., Web apps) ***use modern programming languages*** (e.g., Python, JavaScript, R) to output analytical results as web pages

  - Develop Web app architectures using markup languages (e.g., HTML, Markdown)

  - Programming languages can deftly ingest, transform, and output large datasets

  - Web apps can present data analysis via dynamic visualizations and dashboards

- ***Web Apps can be utilized by numerous users concurrently*** via web browsers without the need for desktop software, making them very portable and accessible
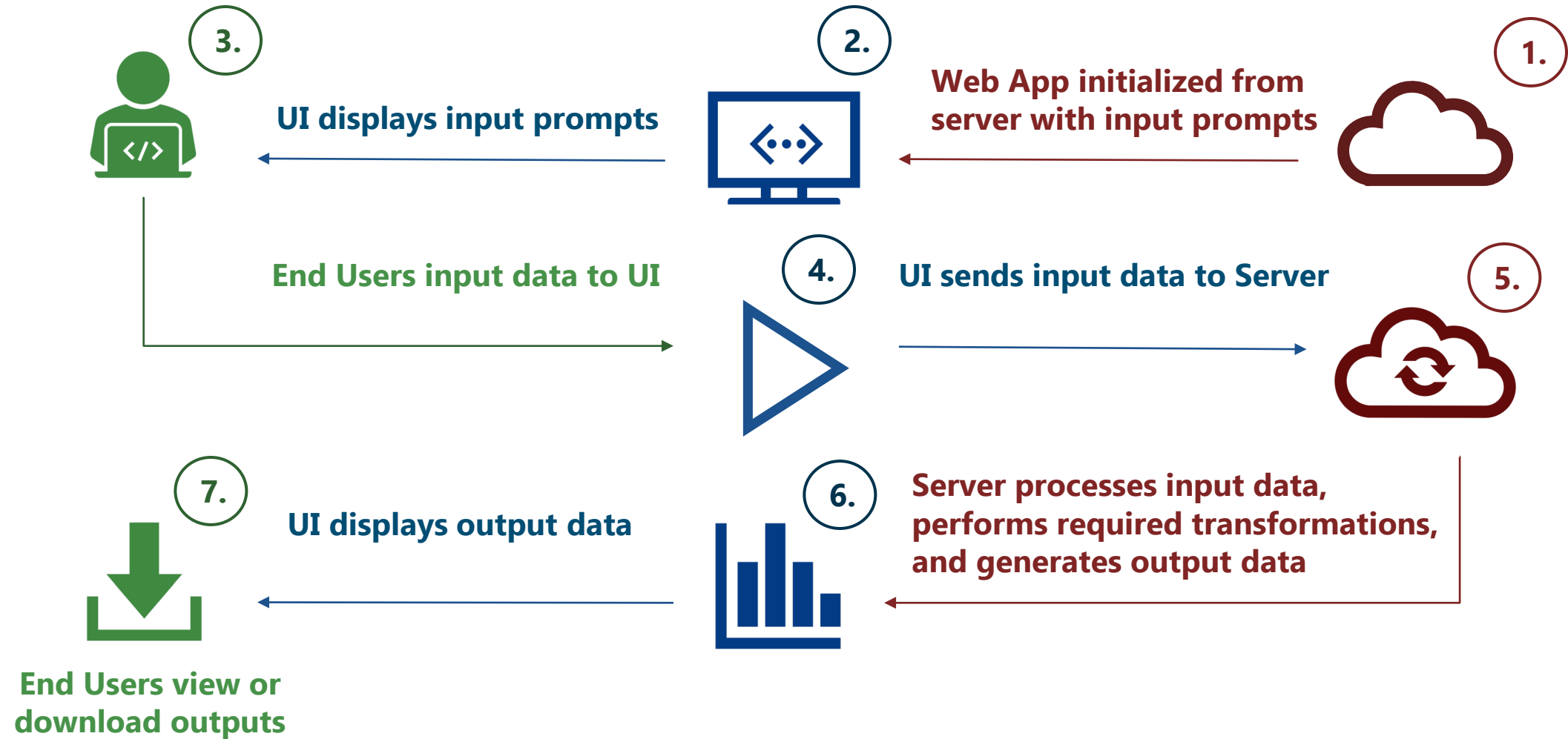
Diagram of Web App Workflow

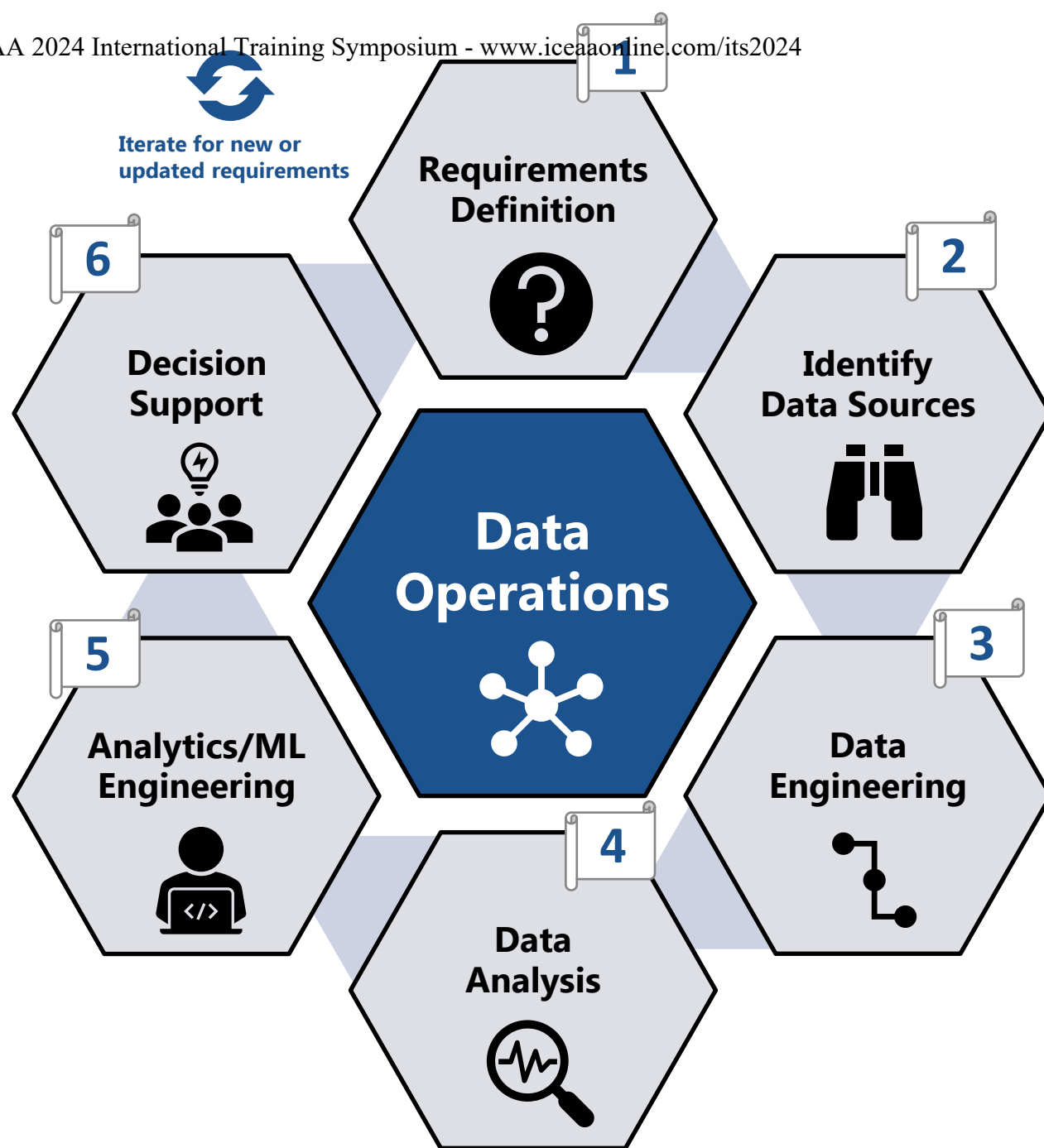# Web Apps
in Data Operations

Defining Data Operations

- Data Operations (i.e., DataOps) is a set of practices, processes and technologies that *bring structure, speed and agility to data science & analysis through the development of an operational lifecycle* [1]

- DataOps combines an integrated and process-oriented perspective on data with *automation and structured methodologies from Agile software development operations (DevOps)* to improve the efficiency of data collection, management and analytics as well as promote continuous delivery of data science solutions [2]

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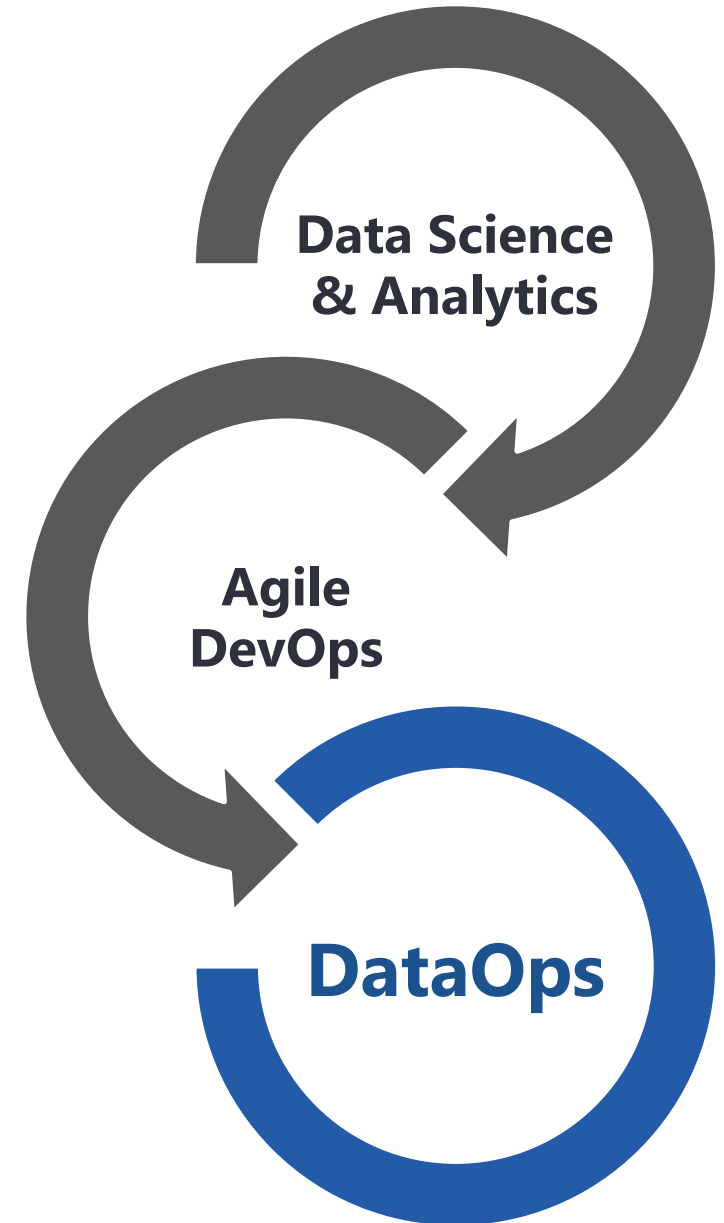
[1] **2023 DoD Data, Analytics, and AI Adoption Strategy**. *DoD Chief Digital and AI Office (CDAO)*

[2] *"What is DataOps?"*. *IBM*

Data Science & Analytics

Agile DevOps

DataOps

The Data Operations Lifecycle

The Data Operations Stack

CYBER SECURITY

Decision Support
Web App End-Product
Analytics / ML Engineering
Data Analysis / Modeling
Data Engineering
Data Architecture
IT Infrastructure & Tools

DATA GOVERNANCE
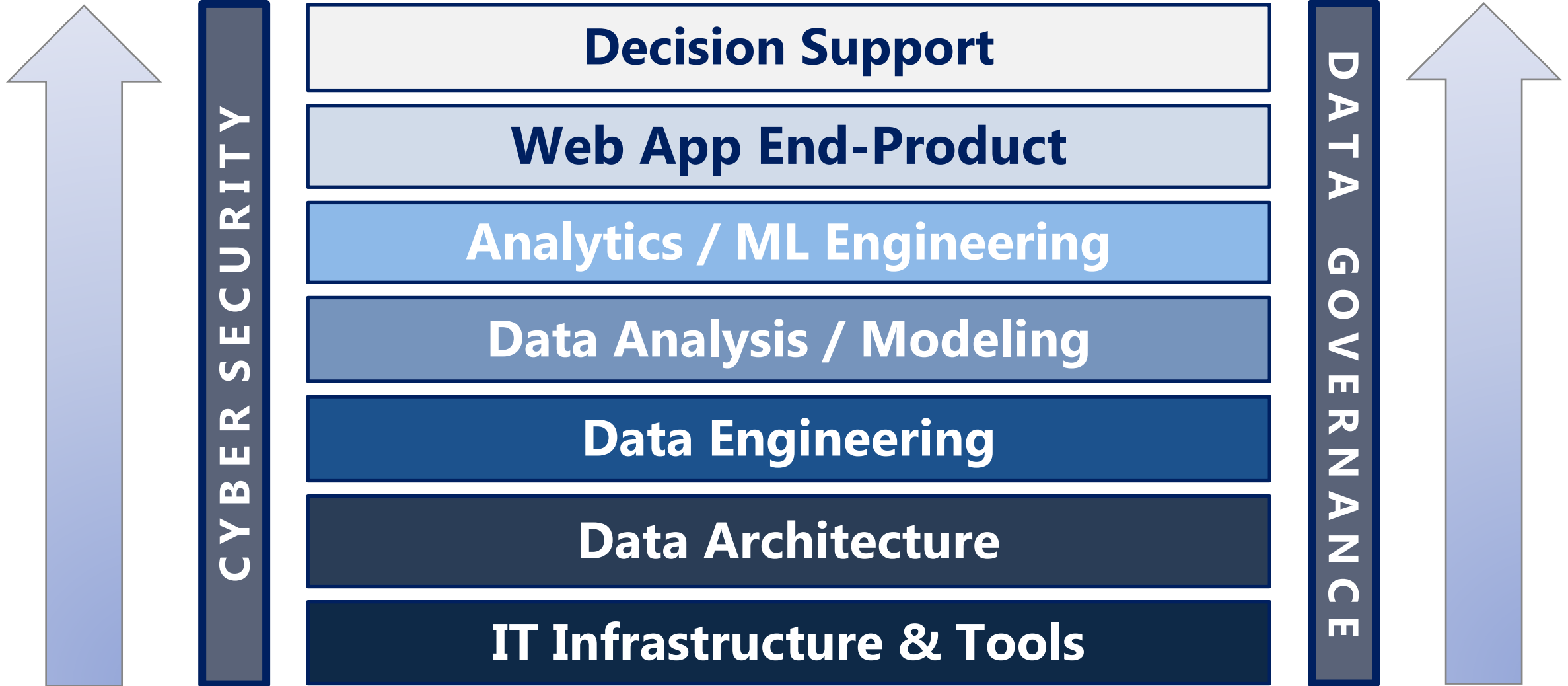
Web Apps
Development Considerations

Overarching Web App Considerations

- ## What is the purpose of the web app?
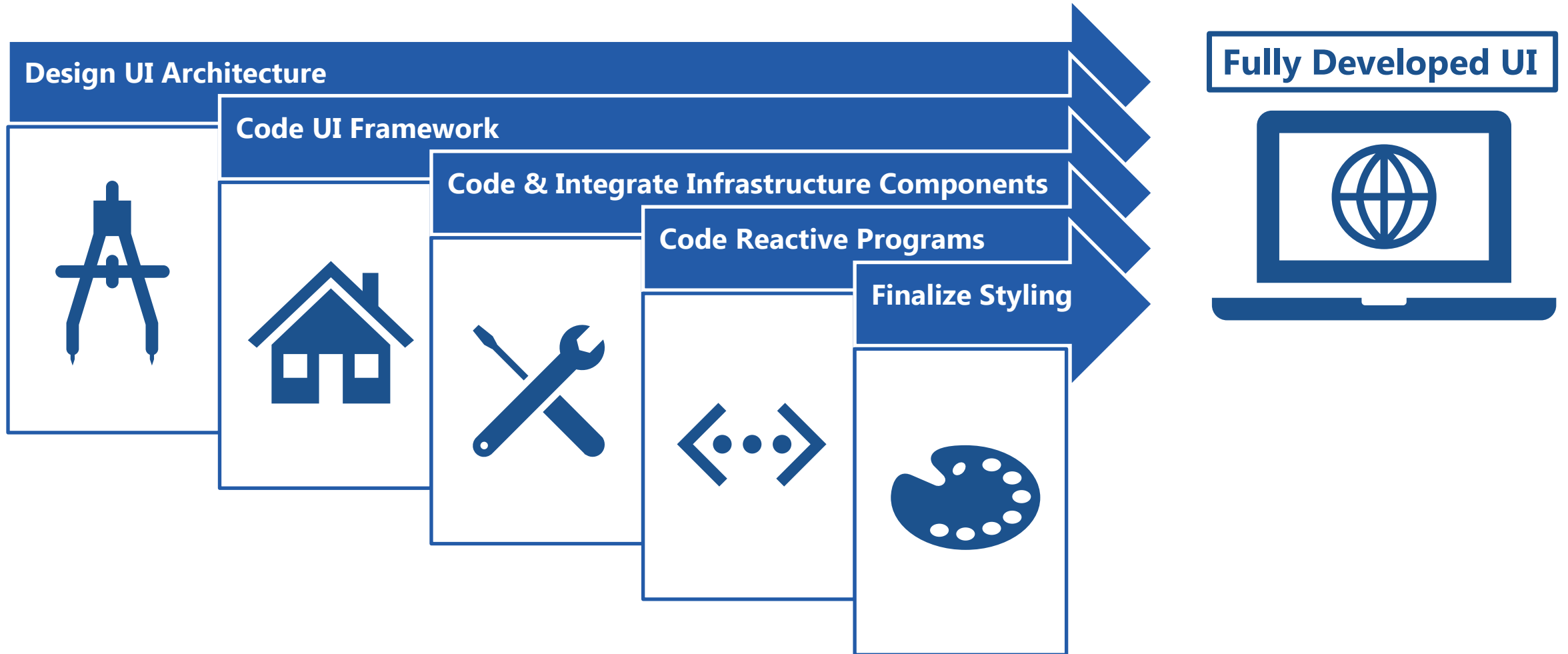 - Data Analytics?
  - Machine Learning?
  - Web Form?
  - Other?

- ## Who is the audience?
  - Will the web app be designed for **technologists** (e.g., software engineers, data scientists, cybersecurity analysts) or **management professionals** (e.g., program analysts, cost estimators, systems engineers)?

- ## Is a custom web app the best idea?
  - If dashboard analytics are a requirement, are tools like Tableau or Power BI better options?
  - If developing a web-based form, are tools like Microsoft Forms or Survey Monkey better options?

- ## What Resources are Available?
  - Will COTS web app development tools address my requirements (e.g., Python Dash, R Shiny)?
  - Based on available resources and operational constraints, what can I realistically develop?

# User Interface (UI) | Development Process

Design UI Architecture

Code UI Framework

Code & Integrate Infrastructure Components

Code Reactive Programs

Finalize Styling

Fully Developed UI

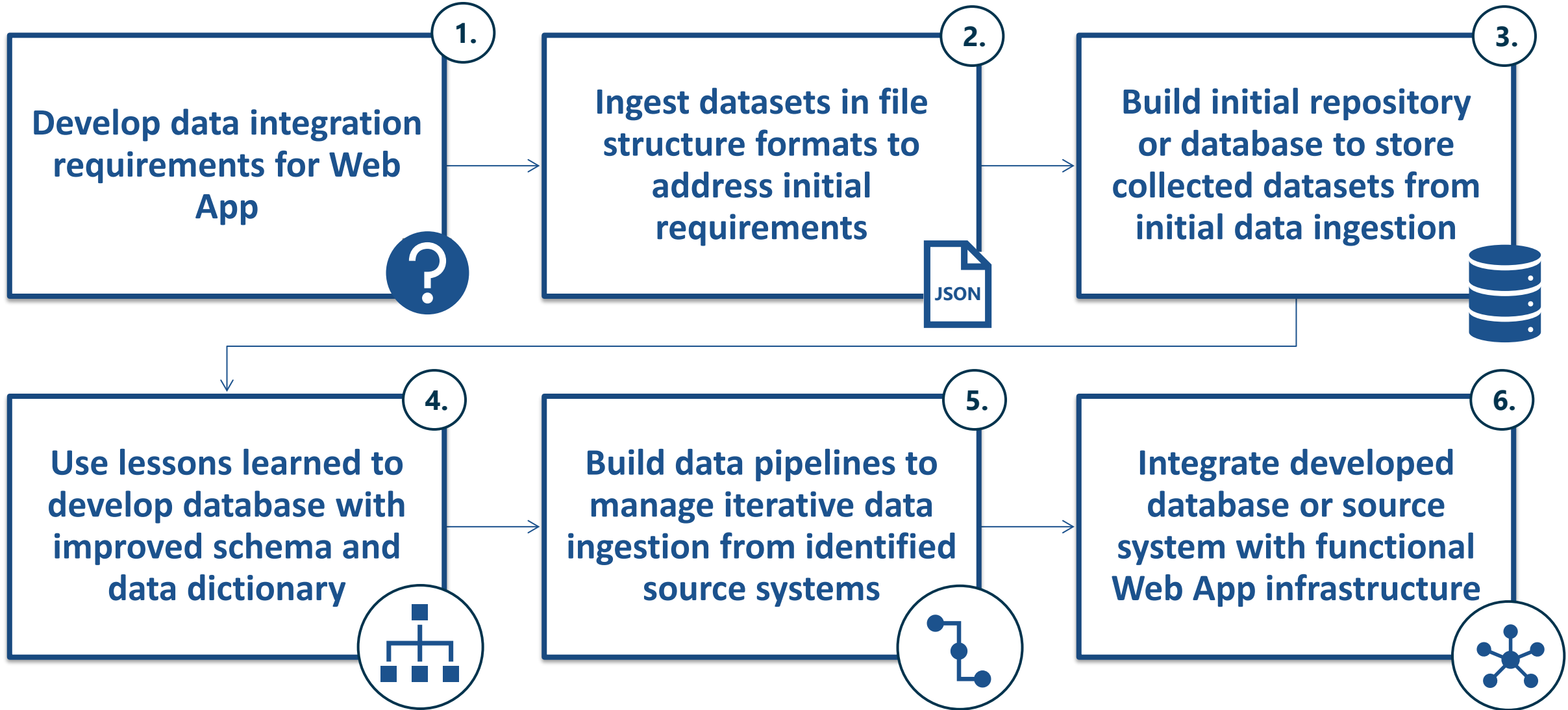# Data Architecture | Development Considerations

Data Ingestion / Storage

- Where will data be physically stored?
- In what format will data be stored?
- How will lifecycle requirements for data collection be defined?
- How often will data need to be updated?
- Will data uploaded by end-users need to be ingested into databases or repositories integrated and/or connected to web apps?
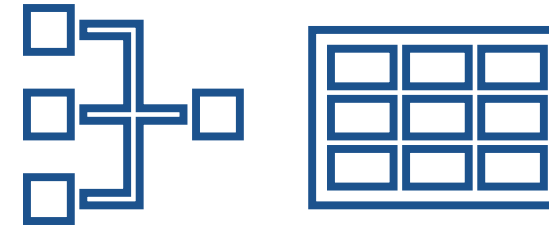
Data Management

- What schema should be used to organize and store ingested datasets?
- How well is this schema defined prior to web app deployment?
- Is there a need for data dictionaries and/or data tagging?
- How are data schemas implemented to determine web app features such as data relationships, file structures, table structures?

Data Integration | Development Process

1. Develop data integration requirements for Web App

2. Ingest datasets in file structure formats to address initial requirements

JSON

3. Build initial repository or database to store collected datasets from initial data ingestion

4. Use lessons learned to develop database with improved schema and data dictionary

5. Build data pipelines to manage iterative data ingestion from identified source systems

6. Integrate developed database or source system with functional Web App infrastructure

Web Apps
Deployment Considerations

Platform Integration | Deployment Considerations
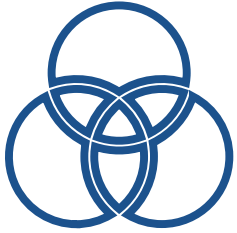
Determine Hosting Environment

- Determine web app compute and storage requirements
- Stage database or repository for web app data storage needs
- Procure PaaS or develop custom platform that meets web app compute and storage requirements

Deploy Hosting Environment

- Load datasets into web app via automated upload or source system connections
- Finalize necessary API integrations
- Deploy functional web app along with associated data connections and APIs for system testing

Test in Non-Production Staging Environment

- Test deployed web app functionality, resiliency, and security within closed-network testing environment
- Complete User Acceptance Testing (UAT) to fulfill end-user requirements
- Deploy web app to production phase

Publish to Production Environment

- Ensure published web app is accessible to end users and fully functional
- Troubleshoot design flaws and bug fixes using end-user feedback loops
- Maintain web app functionality and monitor vulnerabilities

Cybersecurity | Deployment Considerations

Malicious Code

- Upload of malicious open-source or external code by end-users can result in compromised web platform/app
- Compromised data ingestion from connected source systems poses a significant risk

User Access

- All users (i.e., developers and end-users) must have registered profiles with associated access permissions
- User authentication for access is strongly recommended
- Framework needed to avoid unauthorized access to classified, proprietary, or otherwise sensitive data

Data Governance

- Establish policies for environment and dataset access according to registered profiles and access permissions
- Educate end-users to avoid loading data into open-source systems (e.g., uploading data to open-source LLMs)

Legal Copyright

- Need permission to use proprietary and/or copyrighted data
- Includes ingestion and storage of proprietary datasets for extrapolated analysis or modeling
- Copyright issues associated with AI tools such as ChatGPT and DALL-E provide relevant examples

DevSecOps WBS
for Web App Development

Using a WBS to Cost Web App Development

- Web Apps can represent a *small project* or a component of a *large project*:

Small Project	Large Project
Stand up web portal to host custom web apps, where end-users upload data through app interfaces to perform automated analytics	Custom web apps hosted on an analytics platform that connect to various source systems in order to iteratively ingest data and perform automated analytics

- As with any cost estimating task, it's important to breakdown Web App Development into *defined cost elements that are discrete and easily traceable*
  - No matter how simple or complex, a standard framework such as a Work Breakdown Structure (WBS) can be used to define the full-scope of Web App requirements as well as the detailed tool, service, and labor costs necessary to meet these requirements

DevSecOps WBS | Web Platform / App Development

WBS Number	WBS Element	Web Platform / App Development
1.1	Software Mission Applications	Web App Development
1.2	Developer Facility by Site	On-Premise Facility Costs
1.3	User Site Hardware/Support	End-User Hardware / Furnished Equipment
1.4	Platform Development	Web Platform Development
1.5	Infrastructure Services	Cloud Service Provider / On-Premise IT Hardware
1.6	Systems Engineering	Web Platform / App Architecture
1.7	Program Management	Agile Delivery Management
1.8	System Test & Evaluation	User Acceptance / Cybersecurity Testing
1.9	System Training	User Training
1.10	System Data	Data Governance

WBS 1.1 | Software Mission Applications

WBS Number	WBS Description	WBS Definition
1.1	**Software Mission Applications**	All the software and associated effort needed to analyze, design, build, test, and release a custom software application.

Small Project	Large Project
• **Small team of Developers tasked to design Web App architecture** and associated workflows, integration points, and user interfaces • **Use programming languages to build Web App user interfaces and functions** via design specifications and standard frameworks to ensure successful deployment/integration to platform environment • **Primarily concerned with addressing functional requirements** and ensuring Web Apps meet performance and usability standards • **Responsible for designing and performing basic testing strategies** to ensure Web App functionality, performance, and reliability • **May be responsible to develop formal technical documentation** for software evaluation and debugging	• **Medium to large team of Software Engineers responsible for designing and developing Web App** architectures and associated workflows, integration points, and user interfaces • **Use programming languages to build Web App infrastructure and functions** to include back-end server logic, integration nodes, API endpoints, and other middleware components as well as front-end UI/UX interfaces, reactive programming, and platform and/or cross-device compatibility • **Responsible for iterative Web App testing and debugging** in the form of back-end/front-end unit, integration, and endpoint testing for coded infrastructure and functions, as well as troubleshooting design flaws through error logging and versioning

WBS 1.2 | Developer Facility by Site

WBS Number	WBS Description	WBS Definition
1.2	**Developer Facility by Site**	Physical infrastructure needed for planning, designing, and building attributed to all functional business areas at the developer location(s).

Small Project	Large Project
• **Operations costs associated with facility development and maintenance for dedicated project space**, to include property development, facility construction and/or leasing to physically store on-premise IT hardware and perform on-site business operations • **Typically out-of-scope for a small project focused on Web App development**, as these resources are developed and maintained by facility operations components	• **Operations costs associated with facility development and maintenance for dedicated project space**, to include property development, facility construction and/or leasing to physically store on-premise IT hardware and perform on-site business operations • **Large DevSecOps program may be responsible for allocating funding to develop and/or maintain dedicated facilities** to address on-premise IT infrastructure, on-site support, and/or Sensitive Compartmented Information Facility (SCIF) requirements • **Facility operations components responsible for developing and/or maintaining dedicated facilities**, even if DevSecOps program is responsible for funding

WBS 1.3 | User Site Hardware / Support

WBS Number	WBS Description	WBS Definition
1.3	User Site Hardware / Support	The costs associated with deploying the mission applications/PMP at the user site(s). Should cover only those efforts that are incurred at the user site.

Small Project	Large Project
• **User site hardware costs associated with deployed Web Apps and maintenance for dedicated hardware**, if applicable • **Typically out-of-scope for a small project focused on Web App development**, as Web Apps and associated tools are typically accessible via standard furnished equipment	• **User site hardware costs associated with deployed Web Platform/Apps and maintenance for dedicated hardware**, if applicable • **Large DevSecOps program may be responsible for allocating funding to procure and/or maintain dedicated hardware** to address on-premise IT infrastructure, on-site support, and/or Sensitive Compartmented Information Facility (SCIF) requirements • **IT operations components are typically responsible for maintaining dedicated hardware**, even if DevSecOps program is responsible for funding

WBS 1.4 | Platform Development

WBS Number	WBS Description	WBS Definition
1.4	**Platform Development**	Software and services required to develop and maintain the software platform, defined as a multi-tenet environment that integrates total software supply chain

Small Project	Large Project
• **Small team of Developers responsible to deploy and configure Web Platform architecture** to facilitate Web App hosting • **Typically use Platform-as-a-Service (PaaS) deployment model for Web App hosting**, requiring minimal Web App integration and configuration efforts. Otherwise, on-site platform development may be the responsibility of a separate team due to unique and comprehensive requirements as well as engineering complexity • **Responsible for deploying and integrating functional Web Apps to configured platform**, implementing CI/CD pipelines for consistent deployment of new Web App features, upgrades, integrations, and configurations to the cloud or on-site hosted platform	• **Small team of Platform Engineers responsible for designing, deploying, and configuring Web Platform architecture** to facilitate Web App hosting capabilities • **May use PaaS deployment model or tools such as Docker and Kubernetes** to develop platform performance, resource utilization, and user scaling policies for hosted Web Apps. Typically develop APIs that integrate hosted Web Apps with external services and source systems to facilitate access control and CI/CD pipelines • **Responsible for iterative Fault Tolerance testing for Web Platforms**, testing platform reliability, redundancy, and scalability as well as execution of failover mechanisms testing data recovery and backup deployment protocols to measure platform resiliency

WBS 1.5 | Infrastructure Services

WBS Number	WBS Description	WBS Definition
1.5	**Infrastructure Services**	Management of IT infrastructure providing compute, storage, and network resources to enable functional capabilities.

Small Project	Large Project
• **Small team of Developers responsible to define IT infrastructure requirements for Web Platforms/Apps**, to include virtual machine (VM), container and server instances necessary to support Web Platform/App architecture, run-time, and workflow compute • **Business Analyst responsible to define and monitor incurred Web Platform/App resource consumption**, specifically analyzing and monitoring historical VM compute and data storage to optimize resource allocation for improved cost management and estimation • **Typically use Infrastructure-as-a-Service (IaaS) deployment model for infrastructure resources**, Otherwise, on-site IT infrastructure management is typically the responsibility of dedicated IT support staff with domain knowledge that is out-of-scope for smaller teams	• **Small team of Infrastructure/Cloud Engineers responsible for deploying and configuring IT infrastructure architecture** and associated networks, compute, and storage • **May use IaaS deployment model** to provision and manage cloud-based VM, storage, and container compute resources **or deploy physical networks and servers on-site** to provision and manage dedicated CPUs, disk storage, and network bandwidth • **If provisioning physical IT infrastructure, typically responsible for iterative Fault Tolerance testing** for processing and bandwidth reliability, redundancy, and scalability as well as execution of failover mechanisms testing data recovery and backup deployment protocols to measure infrastructure resiliency

WBS 1.6 | Systems Engineering

WBS Number	WBS Description	WBS Definition
1.6	Systems Engineering	Technical Management effort of designing, directing and controlling a totally integrated engineering effort of a system or platform.

Small Project	Large Project
• **Business Analyst responsible for defining and managing all functional requirements and workflows** for Web Apps • **Develops concept of operations (CONOPs)** supporting anticipated deployment and enhancement requirements for Web Apps • **Primarily concerned with addressing business requirements** and ensuring Web Apps meet quality assurance and user acceptance • **May be responsible for identifying and managing technical risks** related to Web App usability and quality • **System architecture, integration, configuration and cybersecurity management are typically out-of-scope** due to the complexity of managing these integrated tasks, requiring specialized skill-sets	• **System Engineer(s) responsible for defining and managing full-scope of Web Platform/App lifecycle requirements**, from design, development, deployment, enhancements, and maintenance • **Develops comprehensive portfolio of Web Platform/App technical documentation** to include system architecture, integration, and configuration diagrams as well as system interface, test & evaluation, cybersecurity, quality assurance, and data engineering, storage, and analytics requirements • **Responsible for documenting and mitigating all technical risks** to include Web Platform/App design flaws, functional drivers for integrated system dependencies, security vulnerabilities, and performance degradation due to server/compute limitations

WBS 1.7 | Program Management

WBS Number	WBS Description	WBS Definition
1.7	Program Management	The business and administrative planning, organizing, directing, coordinating, controlling, and approval actions designated to accomplish overall program objectives

Small Project	Large Project
• **Team Lead responsible for managing a small team** of developers and analysts dedicated to Web App development • **Facilitates regular stand-ups** to develop/refine story points • **Primarily concerned with managing and delivering story point completion and user acceptance**, as well as managing programmatic risks associated with Web App development • **May be responsible for managing Platform deployment** depending on schedule constraints and available labor resources • **Web App hosting, data governance, and security compliance are typically out-of-scope** due to the complexity of managing these integrated tasks, requiring specialized skill sets	• **Project Manager responsible for managing a medium/large team** of software engineers in addition to systems engineers, platform engineers, cloud engineers, data engineers, and business analysts • **May implement Agile management processes** such as team stand-ups, feedback loops, and retrospectives to facilitate sprint planning for improved adaptability, scalability, and risk management related to successful Web Platform/App development and delivery • **Responsible for managing and refining all business and programmatic Platform/Web App requirements** to include story point completion, hosting capabilities, formal user acceptance & security compliance, data governance, end-user training services, and full operational Web Platform/App delivery

WBS 1.8 | System Test & Evaluation

WBS Number	WBS Description	WBS Definition
1.8	System Test & Evaluation	The iterative use of a pilot, prototype or fully developed system to obtain or validate engineering data on system performance, resilience and security prior to deployment.

Small Project	Large Project
• **Small team of Developers and Business Analyst responsible for iteratively testing/validating Web App performance** via formal or informal user acceptance, resilience, and security testing • **Developers primarily concerned with testing standard technical requirements** and evaluating how Web App architecture and workloads respond to user and data ingest traffic, performance response time, vulnerability scanning, and data recovery protocols • **Business Analyst primarily concerned with testing business requirements** and evaluating how Web App interfaces and workflows address user acceptance criteria, data governance and security standards, and other enterprise compliance requirements	• Medium to large team of **Quality Assurance (QA) and Cybersecurity Engineers responsible for defining and managing formal Web Platform/App testing requirements**, to include the full-scope of performance, resilience, security, user acceptance, regression, scalability, load, and compliance testing • **QA and Cybersecurity Engineers concerned with evaluating and documenting enterprise-level user acceptance testing (UAT) and cybersecurity compliance**, such as Web Platform/App response times, simulated network/server failure, access controls, data encryption, penetration testing, and load balance testing • **Mitigate all Web Platform/App deployment risks** including performance degradation, disaster scenarios, and security breaches

WBS 1.9 | System Training

WBS Number	WBS Description	WBS Definition
1.9	System Training	Deliverable training services and equipment used to facilitate instruction through which personnel will learn to operate and maintain the system with maximum efficiency.

Small Project	Large Project
• **Business Analyst responsible for developing Web App training plan and materials to support end-user adoption,** as well as feedback/assessment resources and continuous learning support • **Primarily concerned with facilitating efficient Web App utilization by end-users.** Depending on available resources, Business Analyst may develop standard training materials such as user guides, video recordings, and training datasets to facilitate end-user adoption • **Training delivery may take form of instructor-led sessions or self-paced resources.** Regular on-site training sessions or workshops may require skillsets or funding that is out-of-scope for Web App development team, but Developers and Business Analyst typically have skillsets to develop user guides such as recordings or wikis	• Small to medium team of **dedicated Trainers responsible for designing and developing formal Web Platform/App training courses and modules,** to include knowledge gap analyses, training plans, user guides, video recordings, training datasets, system simulations, and associated courseware if needed • **Trainers likewise responsible for efficient training delivery,** to include on-site and/or virtual training sessions as well as workshops, self-paced modules, user labs, and formal examinations • **Responsible to provide recurring training support, resources, and access to additional materials,** such as training module updates and refresher courses to ensure that Web Platform/App skillsets are maintained, enhanced, and disseminated over time

WBS 1.10 | System Data

WBS Number	WBS Description	WBS Definition
1.10	System Data	Acquisition and subsequent management and control of prepared data for both internal program purposes and for delivery to external customers.

Small Project	Large Project
• **Business Analyst responsible for managing Web App data pipelines and repositories**, such as articulating data governance requirements as well as iterative data collection, structuring, normalization, modeling, and analysis of required datasets • **Primarily concerned with curating required datasets as well as repositories and pipelines for Web App analytics.** Comprehensive data operation infrastructure and tools may be out-of-scope due to the complexity of managing these integrated capabilities and required datasets, requiring specialized skill-sets • **Responsible to ensure that developed Web Apps enable advanced analytics support** to facilitate effective operations research and comprehensive data delivery and reporting	• Small to medium team of **Data Engineers and Scientists responsible to design and develop Web Platform/App data operations** to include data architecture, governance, ingestion, transformation, storage, analytics, modeling, and delivery • **Data Engineers concerned with managing data staging requirements**, such as database schemas, source system integration, ETL pipelines, data format normalization, development of data dictionaries, and metadata tagging • **Data Scientists responsible for designing and developing Web App analytics requirements**, using programming languages to develop reactive analytical functions, models, dashboard visualizations, and/or machine learning algorithms

Conclusion

Web App Development | Key Takeaways

Before Starting
- Define the enterprise requirements to address
- Consider if a web app is the best option
- If so, consider available resources (skilled labor, funding, schedule, security)

Develop Web App
- Determine minimum viable datasets and begin coding on local computers
- Define web platform/app architecture and build UI framework
- Implement reactive programming to address end-user input/output criteria

Deploy Web App
- Establish appropriate databases, repositories, or pipelines for required data storage
- Design, deploy and configure hosting environment and web app integrations
- Establish security protocols and monitor web platform/app for system vulnerabilities

Further Discussion

- **Web applications are great as live dashboards**
  - Professionally transitioning to a more virtual society
  - Ability to extract live data from various sources
  - Online tools for modeling
  - Reactive programming

- **Web applications do require effort to develop and maintain**
  - The more reactive the program or complex the styling, the longer this takes
  - Versioning may be important
  - Enterprise-level hosting and security are challenging

- **For data visualization associated with business analytics, BI tools (e.g., Tableau, Power BI, etc.) may be more practical**

- **Reactive web forms are more complex to develop than dashboards!**

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