Phase 2 Comprehensive Installation Plan (CIP)

University of Washington ITS4US Deployment Project

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Final Report — July 14, 2023

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ITS4US

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16. Abstract

This Comprehensive Installation Plan (CIP) provides an overview of the proposed installation approach for the University of Washington (UW) ITS4US project, the Transportation Data Equity Initiative (TDEI). The TDEI project is a software-focused project which will primarily deployed on the cloud. The TDEI project will acquire and install mobile phones that will be used to run applications that demonstrate the value of the TDEI, computers and storage to be used by TDEI staff for data processing and cloud resources for the development, deployment, and operation of the TDEI system. This document identifies the installation process for the mobile phones, computers, storage, and cloud resources that will be acquired and installed by the project.

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1 Introduction

This Comprehensive Installation Plan (CIP) provides an overview of the proposed installation approach for the University of Washington (UW) ITS4US project, the Transportation Data Equity Initiative (TDEI). This CIP incorporates information from the UW ITS4US Comprehensive Acquisition Plan (CAP) and further identifies the types and number of equipment to be configured and installed.

The TDEI project is a software-focused project which will primarily be deployed on cloud services. The TDEI project will acquire and install mobile phones that will be used to run applications that demonstrate the value of the TDEI system. In addition, the TDEI project will acquire computers and storage to be used by TDEI staff for data processing and cloud resources for the development, deployment, and operation of the TDEI system. This document identifies the installation process for the mobile phones, computers, storage, and cloud resources that will be acquired and installed by the project.

1.1 Intended Audience

This document is intended for use by the UW ITS4US project team, its partners, peer agencies, and the US Department of Transportation (USDOT). In addition, entities, such as public agencies, may refer to this document for a better understanding of the acquisition needs and processes for a project such as the TDEI.

1.2 Project Background

The project will develop a national pipeline to create, disseminate, and share standardized data about pedestrian environments, transportation environments, and on-demand transportation services to enable better use, discoverability, and data analytics of these assets and services. The goal of the UW ITS4US Deployment project is to build a sustainable, inclusive data infrastructure to enable and accelerate the future of equitable mobility and access to transportation for the benefit of all travelers. Through community leadership, this proposed system, the associated standards development, and the adoption by users (including both data generators and data consumers) will help provide a means to offer appropriate travel services, automate routing, and map out the transportation network in ways appropriate for every traveler. With this in place, previously underrepresented individuals will have tools available to make informed, customized travel decisions under any situation.

Systems developed in this project will enable users to have improved awareness of routes (specifically routes that align with their unique travel preferences) and transit services available to them. At a very high level, the TDEI system aims to achieve USDOT ITS4US Program goals by deploying the following key technology elements:

1. **Develop a Centralized Data Repository**. The UW Team will develop a centralized data repository that services many functions, including receipt/validation of data (including

sidewalk, transit station pathways, and on-demand transit), storage of data, and distribution of data through an Application Programming Interface (API) in response to requests for geographically focused data for trip making. This centralized data repository represents the focal point of the project for moving data from those who produce it to those who want to use it.

2. **Create tools to support data collection**. The UW Team will develop tools for sidewalk infrastructure owner-operators and transit agencies to collect data, translate it into the data standards supported by TDEI, and submit data to the data repository. The goal of the tools is to simplify the level of effort required to collect data, thus, encouraging agencies to undertake this data collection initiative.
3. **Demonstrate use of the data by under-represented communities through three accessibility-focused mobility applications.** This project will utilize accessible mobility applications in the evaluation and testing of the usability and efficacy of the data standards and the supporting infrastructure.

The UW Team will publish collected data for the six U.S. counties that are part of this project. The six counties, as shown in Figure 1, are King and Snohomish Counties in Washington State, Multnomah and Columbia Counties in Oregon, and Harford and Baltimore Counties in Maryland. Our pilot area focuses on regions that combine urban centers with suburban sprawl and rural areas, in order to demonstrate the use of these data in different conditions of travel networks.

Figure 1. Map. Washington, Oregon, and Maryland Counties.

Source: United States Department of Transportation, University of Washington, and Cambridge Systematics.

1.3 Purpose of the Plan

The purpose of the CIP is to document the installation and configuration processes for the hardware, software, and cloud resources being used by the TDEI deployment. This CIP has been developed in accordance with the TDEI design as documented in the UW ITS4US Concept of Operations (ConOps)[1], System Requirements Specification (SyRS)[2], Emerging Technology Readiness Assessment (ETRA)[3], the Phase II Data Privacy Plan (DPP)[4], and the Phase II System Design Document (SDD). Further, the CIP leverages the plan for the TDEI system evaluation studies described in the ConOps, the Performance Measurement and Evaluation Support Plan (PMESP)[5], and the Human Use Approval Summary (HUAS)[6]. Operations and Maintenance (O&M) will be in place as each release is completed, consistent with the Comprehensive Maintenance and Operations Plan (CMOP). This document will be updated by the end of Phase II to fully capture resources used in the TDEI deployment.

[1] UW ITS4US Phase I Concept of Operations https://rosap.ntl.bts.gov/view/dot/58675

[2] UW ITS4US Phase I System Requirements https://rosap.ntl.bts.gov/view/dot/60129

[3] UW ITS4US Phase I Emerging Technology Readiness Assessment https://rosap.ntl.bts.gov/view/dot/62479

[4] UW ITS4US Phase II Data Privacy Plan https://rosap.ntl.bts.gov/view/dot/66780

[5] UW ITS4US Performance Measurement and Evaluation Support Plan https://rosap.ntl.bts.gov/view/dot/60781

[6] UW ITS4US Human Use Approval Summary https://rosap.ntl.bts.gov/view/dot/62488

2 Acquisition Overview

The TDEI will acquire four categories of items: mobile phones, computers, storage, and cloud resources. The mobile phones will be used to run demonstration applications, particularly AccessMap Multimodal, to demonstrate use of the TDEI data by under-represented communities. The computers and storage will be used by TDEI staff for processing, analysis, and storage – with the results pushed to the TDEI system hosted in the cloud. Finally, the cloud resources will be used for the development, deployment, and operation of the TDEI system, made available for others to access the data created as part of this demonstration project.

2.1 Acquisition Approach

The mobile phones, related accessories, computers, and storage will be purchased through vendors with whom the UW has existing contracts. The phones, related accessories, computers, and storage needed for this project are Commercial-Off-the-Shelf (COTS) and are readily available from these vendors. The cloud computing resources will be purchased through Microsoft Azure which is the cloud platform selected for the project. Request for Proposals (RFPs) are not necessary due to the use of vendors with whom UW has existing contracts.

The UW Team will meet Federal Acquisition Regulation (FAR) (52.204-25) for Contracts and the Code of Federal Regulations (CFR) (200.216 & 200.471) for Grants and Cooperative Agreements for the acquisitions and 2 CFR 200.317-2 CFR 200.327 (Procurement Standards) for the requirements regarding procurements. In addition, prior to acquiring an item or service from a vendor, the UW Team will complete due diligence to ensure that the vendor will not charge any costs that include covered equipment and services from restricted companies. To ensure that the item or service is not covered equipment or services from a restricted company, the System Award Management (SAM)[7] website will be reviewed prior to initiating a purchase. The team will also review the procurement plans with UW's post-award fiscal compliance team who specializes in Federal fiscal compliance questions.

2.2 Acquisition Schedule

The acquisition of the mobile phones, computers, and storage will primarily occur during the second half of Phase II of the project. The mobile phones are needed for the demonstration application testing in Phase III and will be purchased near the end of Phase II, so they are ready for use in Phase III. Mobile phones and related accessories are expected to be available within a few days or weeks of purchase; thus, a March 2024 purchase date for the mobile phones provides time for delivery, inspection, installation, and preliminary testing prior to Phase III. The

[7] Federal Contractor Registry. System Award Management. https://federalcontractorregistry.com

computers and storage will be purchased during the second half of Phase II and will be used during the second half of Phase II and into Phase III. The computers are expected to be available within weeks to up to one to two months after purchase. The team will begin the acquisition process in September 2023 to verify and adapt to the delivery time frame and accommodate any delivery delays so that the computers and storage can be in use by late 2023 or early 2024.

The cloud resources will be acquired throughout Phase II and Phase III. The acquisition of the cloud resources began in August 2022 after the cloud provider was selected and at the time that the TDEI system software development began. The acquisition will continue throughout Phase II and Phase III. It is expected that the cloud acquisition will ramp up throughout Phase II as the TDEI system development progresses and then remain relatively stable in Phase III during operation of the system. Cloud acquisition changes in Phase III would primarily be for adapting the system to changes to the number of users of and data in the system. Table 1 shows the TDEI acquisition schedule.

Table 1. TDEI Acquisition Schedule

Item	Action	Time Frame
Mobile Phones	Acquisition	Phase II – March 2024
Mobile Phones	Installation and Preliminary Testing	Phase II – March-May 2024
Computers & Storage	Acquisition	Phase II – September 2023 - Jan 2024
Computers & Storage	Installation and Begin Usage	Phase II – November 2023 – Feb 2024
Cloud Resources	Identify Cloud Provider	Phase II – August 2022
Cloud Resources	Begin acquisition	Phase II – September 2022
Cloud Resources	Acquire cloud resources needed for system development	Phase II – May 2024
Cloud Resources	Finalize cloud resources needed for system operation	Phase II – May 2024
Cloud Resources	Acquire cloud resources needed for TDEI system operation	Throughout Phase III – June 2024 – December 2025

2.3 Vendor Outreach Plan

The UW Team will be purchasing hardware – mobile phones, computers, and storage – and cloud resources. In terms of hardware, to identify the devices to be purchased, the UW Team will research the availability of the devices to be acquired through UW's internal purchasing web site,

which lists items available from vendors with which UW has purchasing agreement. This process will identify potential vendors, product specifications, and prices. Items that meet the requirements with the lowest identified prices will be preferred. For mobile phones and related accessories, potential vendors include CDW, Office Depot, and Best Buy. For computers and storage, potential vendors include Dell, HP, and NewEgg.

The Microsoft Azure platform was selected as the cloud computing platform for the project. The UW Team assessed the Microsoft Azure and Amazon AWS platforms based on cost of expected services and UW and software development team skills and experience. Microsoft Azure was selected because it provided the best value overall – the costs were comparable to other options investigated and it will reduce staff acclimatation cost as the UW Team has significant experience with Microsoft Azure. Cloud resources will be acquired through the Microsoft Azure system.

All items will be purchased in accordance with the TDEI design as documented in the ConOps, SyRS, ETRA, and the SDD.

3 Installation Overview

The TDEI Team is acquiring and installing hardware – mobile phones, computers, and storage – and cloud resources. All hardware to be purchased is Commercial Off-the-Shelf (COTS) hardware and will be configured and installed according to manufacturer's instructions. The cloud resources are installed and configured using the Microsoft Azure platform; configuration details are provided in later sections in this CIP.

3.1 Supplier Base

For the mobile phones and related accessories, the candidate supplier is CDW, alternate suppliers including Office Depot, and Best Buy may be used if the alternate suppliers provide a lower price. For computers and storage, candidate suppliers are Dell for the computers and CDW for the storage. For cloud resources, the supplier is Microsoft Azure.

3.2 Procurement Method

The hardware – mobile phones, computers, and storage – will be acquired through the UW's internal purchasing web site. The cloud resources will be purchased through the Microsoft Azure system, the selected cloud provider for the TDEI.

3.3 Inventory Management

An inventory of the hardware devices purchased – mobile phones, computers, and storage – will be maintained by the TDEI Team and will follow UW equipment inventory and asset tracking protocols (see UW Equipment Inventory Office (EIO) procedures[8] and UW EIO Roles and Responsibilities[9] for details.

A shared spreadsheet listing the items purchased, the date of purchase and the equipment status will be maintained by the TDEI Team. The inventory of cloud resources will be maintained in the Microsoft Azure platform and kept current, as necessary, by the TDEI Team.

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[8] UW EIO General Inventory Procedures. https://finance.uw.edu/eio/sites/default/files/5000 pjv TRUNCATED GIPT FROM WEBSITE 04.30.2016.pdf

[9] UW EIO Management and Control of Inventorial Equipment and Government Owned Property - Roles and Responsibilities. https://finance.uw.edu/eio/resources/policies-procedures/university-washington/overall-roles-responsibilities

New hardware will be tagged and inventoried at the time of receipt. Inventoried items will be tagged and tracked using the UW's audited inventory system, OASIS, managed by the Equipment Inventory Office (EIO). Non-inventoried assets are tagged and tracked at the department level. At the end of the award, Inventory items will be disposed of according to federal regulations and UW's EIO and Post Award Fiscal Compliance policies.

3.4 Configuration Management

The TDEI is acquiring and installing hardware – mobile phones, computers, and storage – for the use of the UW team in its data analysis and in the project evaluation process. As such, the hardware will be configured according to manufacturer's instructions and UW team needs. The configuration of the hardware will be documented in a document stored in a shared team folder. The hardware configurations are not expected to change over time. The software to be installed on these devices, which is described in Section 3.7, will be tracked using this same method.

The cloud resources are for operating and testing the TDEI system. The TDEI system will be operated by Gaussian Solutions, the UW team's software contractor, for the majority of Phase II, and operated by the UW team in Phase III and beyond. As such, the cloud resources will be configured to meet the needs of the TDEI system.

It is expected that the configuration of the cloud resources may change over time as the needs of the TDEI system evolve and are better understood; these changes are a normal part of the evolution of the TDEI system. The configuration of the cloud resources is managed and maintained in the Microsoft Azure platform. Snapshots of the cloud resources configuration will be created periodically to document the cloud configuration and changes in that configuration. These snapshots will also be stored in the shared team folder.

3.5 High Level Equipment Inventory

The hardware to be acquired and installed for the TDEI includes mobile phones and associated Subscriber Identity Module (SIM)[10] cards and Global Positioning System (GPS) [11] units, computers and storage devices and cloud resources. Tables 2, 3, and 4 in the CAP for this project provide details on the hardware to be acquired. In addition, cloud resources will be acquired and Tables 5 and 9 in the CAP provide details on the cloud resources to be acquired. Table 2, below, provides the TDEI Equipment Inventory.

In Table 2, in the Total # Procured column for cloud resources (prefixed with "Cloud"), each entry has a number followed by "x3". The "x3" indicates that the TDEI system will operate in three

[10] Subscriber Identity Module (SIM) https://csrc.nist.gov/glossary/term/subscriber_identity_module

[11] GPS: The Global Positioning System. U.S. Government. https://www.gps.gov

environments: development, staging and production, and so at least three copies of each type of cloud resources will be required.

The development environment will be used for software development, e.g., testing and deployment by software developers, the staging environment will be used for internal testing prior to deployment to production, e.g., by quality assurance staff, and the production environment will run the operational TDEI that is accessible and visible to the public. All three environments will generally have the same structure and the same types and quantities of resources; however, the resources in the production environment will be more powerful (more powerful processors, more memory) than the development and staging environments to handle the expected greater use compared to the other environments.

Furthermore, for the “Cloud: Compute” equipment type, a range of 20-25 is given. The exact number of Cloud: Compute resources to be acquired for each environment is currently estimated to be 20-25; the exact number will be determined based on the final system design as defined by the Agile process being used for TDEI software development and documented in the SDD.

Table 2. Equipment Inventory

Equipment Type	Total # to be Procured	Total # to be Configured & Installed
Mobile Phone	42	42
SIM Cards	42	42
GPS Units	42	42
Computer	2	2
Storage Devices (Disk Drives)	6	6
Storage Box (Computer)	1	1
Cloud: Compute	20-25x3	20-25x3
Cloud: Databases	1x3	1x3
Cloud: Integration	1x3	1x3
Cloud: Storage	3x3	3x3
Cloud: Containers	1x3	1x3
Cloud: DevOps	1x3	1x3

3.6 Installation Schedule

The installation of the mobile phones, computers, and storage will primarily occur during the second half of Phase II of the project, so they are ready for the demonstration application testing to occur in Phase III of the project. Mobile phones and related accessories are expected to be available within a few days or weeks of purchase; thus, there is limited lag between the acquisition and delivery date for the mobile phones.

The computers and storage will be purchased during the second half of Phase II. The computers are expected to be available within weeks to up to one to two months after purchase; the team has planned for a one-two month lag between acquisition and delivery with computers and storage expected to be in use by late 2023 or early 2024.

The acquisition of the cloud resources will occur throughout Phase II and Phase III. The acquisition of the cloud resources began in August 2022 and will continue through Phase III. Cloud resources are available immediately after acquisition thus acquisition and delivery time are the same for cloud resources. Table 3 shows the TDEI installation schedule.

Table 3. TDEI Installation Schedule

Item	Action	Time Frame
Mobile Phones	Acquisition	Phase II – March 2024
Mobile Phones	Delivery	Phase II – March 2024
Mobile Phones	Installation and Preliminary Testing	Phase II – March-May 2024
Computers & Storage	Acquisition	Phase II – September 2023 – Jan 2024
Computers & Storage	Delivery	Phase II – October 2023 – Jan 2024
Computers & Storage	Installation and Begin Usage	Phase II – November 2023 – Feb 2024
Cloud Resources	Identify Cloud Provider	Phase II – August 2022
Cloud Resources	Begin acquisition	Phase II – September 2022
Cloud Resources	Acquire cloud resources needed for system development	Phase II – May 2024
Cloud Resources	Finalize cloud resources needed for system operation	Phase II – May 2024

Cloud Resources	Acquire cloud resources needed for TDEI system operation	Throughout Phase III – June 2024 – December 2025

3.7 Installation Plan

The mobile phones will be installed according to manufacturer's instructions and will be stored in a secure location in the Taskar Center for Accessible Technology (TCAT). The computers and storage will be installed at TCAT and will be installed according to manufacturer's instructions. The cloud resources are installed based on a specified configuration in the Microsoft Azure platform, developed by UW or its contractors.

Software to be installed on the mobile phones are the demonstration applications AccessMap Multimodal[12] and Audiom [13], the e-mission[14] software for route tracing and the Garmin Connect[15] app to connect the GPS devices to the phones. All software is freely available on the Internet via the links referenced in this document. Research participants will use phones provided by the TDEI and will not need to install software on their personal phones.

The latest version of the GNU/Linux Operating System[16,17] available at the time of purchase and installation will be installed on the computers and on the storage box. The GNU/Linux Operating System is freely available. In addition, standard data processing software including Python[18]and JavaScript[19], and the PostgreSQL[20] database will be installed on the computers. All of these are freely available under open-source licenses.

The cloud resources will run a variety of software ranging from software developed by the TDEI team, to open-source software deployed on the cloud resources, to software managed by the

[12] AccessMap Multimodal https://tcat.cs.washington.edu/2021/12/03/accessmap/

[13] Audiom. https://www.audiom.net

[14] e-mission software https://github.com/e-mission

[15] Garmin Connect. https://connect.garmin.com

[16] GNU Operating System. https://www.gnu.org

[17] The Linux Kernel Archives. https://www.kernel.org

[18] python https://www.python.org

[19] JavaScript. Mozilla Developer Network. https://developer.mozilla.org/en-US/docs/Web/JavaScript

[20] PostgreSQL https://www.postgresql.org

cloud provider, Microsoft Azure. An overview of this software is provided in Section 6.1.1.4, a more complete description of the software to be installed on the cloud resources is provided in the SDD.

4 Mobile Devices

The UW Team will acquire mobile phones to be used to run the AccessMap Multimodal and Audiom demonstration applications to demonstrate and evaluate the value of the TDEI and its data. The use of the phones in the evaluation studies is described in the ConOps, the Performance Measurement and Evaluation Support Plan (PMESP)[21], and the Human Use Approval Summary (HUAS)[22].

4.1 Mobile Phones

The UW Team will acquire mobile phones and ancillary equipment, including SIM cards, to provide a data connection for the phones and GPS units to improve location collection accuracy.

4.1.1 Installation Information

4.1.1.1 Suppliers

The mobile phones will be Android and are expected to be supplied by Samsung. The SIM cards are expected to be supplied by AT&T and the GPS units and are expected to be supplied by Garmin. All are expected to be purchased through CDW using the UW's purchasing system.

4.1.1.2 Inventory Control Method

As described in Section 3.3, an inventory of these devices will be maintained by the TDEI team in a shared document.

4.1.1.3 Installation Procedures

For each mobile phone, the manufacturer's instructions, typically included on-screen on the phone, will be followed for phone set up. The SIM card will be inserted in the phone's SIM card slot to establish a data connection for the phone. The Garmin Connect app will be installed on each phone and each phone will be paired with a GPS unit using a Bluetooth[23] connection.

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[21] UW ITS4US Performance Measurement and Evaluation Support Plan https://rosap.ntl.bts.gov/view/dot/60781

[22] UW ITS4US Human Use Approval Summary https://rosap.ntl.bts.gov/view/dot/62488

[23] Bluetooth https://www.bluetooth.com

4.1.1.4 Quality Assurance and Quality Control Processes

Following the installation of the phone, SIM card, and GPS unit, a TDEI team member will verify that the phone's data connection is working by accessing a web page on the Internet from the phone. Subsequently, a TDEI team member will verify the GPS unit is connected with the Garmin Connect app and can be utilized with the TDEI demonstration applications.

4.1.1.5 High-level Installation Schedule

The mobile phones, SIM cards and GPS units will be installed and connected within one month of receipt of the mobile phones.

4.1.1.6 Hardware and Software Configuration Control Processes

As described in Section 3.7, several pieces of software will be installed on each phone including AccessMap Multimodal, Audiom, e-mission and Garmin Connect. Garmin Connect will be tested during the quality assurance process described above. A TDEI team member will test the installation of AccessMap Multimodal by requesting and obtaining a route using the AccessMap Multimodal application. This test will follow the same process that the participants in the demonstration application evaluation will be asked to follow. Audiom will be similarly validated by following the process that will be used to evaluate the Audiom application.

AccessMap Multimodal is an application developed by UW and will be published on the Google Play store. The app will be downloaded and installed onto the mobile phones by the UW Team. Any AccessMap Multimodal patches will be uploaded to the Play Store and the apps on the mobile phones will be updated through the Play Store. Testing will be done with Android phones hence the focus on the Google Play store. Audiom is a web application and will be accessed through the phones' browsers.

4.1.1.7 Warranty and Contingency Plan

A warranty of at least one year will be purchased for the mobile phones. Warranties will not be purchased for the SIM cards and GPS units.

The evaluation studies which use the mobile phones will involve forty participants as described in the ConOps, PMESP and HUAS. As a contingency for a hardware failure, the project will acquire forty-two of each device (mobile phones, SIM cards, GPS units). Due to the limited time these devices will be used in the demonstration application evaluation process and the limited impact of a potential equipment failure, two spare sets of devices has been deemed to be adequate. In addition, UW purchasing rules allow for a device to be purchased directly from a retailer, thus the team can quickly replace any device that has failed.

5 Data Management & Analysis Equipment

The UW Team will acquire computers to process and analyze data collected as part of the TDEI project and to generate sidewalk network data. This data analysis will be done outside of the cloud environment to reduce the amount of cloud resources needed and for convenience for the data analyst. Network Attached Storage (NAS)[24] will be acquired to store the inputs and outputs of this data analysis.

5.1 Computers

The UW Team will purchase computers to support the data analysis associated with the TDEI project. In addition, these computers provide an alternative option for operating the TDEI system should cloud costs become excessive.

5.1.1 Installation Information

5.1.1.1 Suppliers

The computers are expected to be supplied by Dell as described in the CAP and are expected to be purchased through CDW using the UW's purchasing system.

5.1.1.2 Inventory Control Method

As described in Section 3.3, an inventory of these devices will be maintained by the TDEI team in a shared document.

5.1.1.3 Installation Procedures

The computers will be set up according to manufacturer's instructions and connected to the UW network for Internet access. The latest version of the GNU/Linux Operating System available at the time of purchase and installation will be installed on the computers as well as required data processing software including Python and JavaScript, and the PostgreSQL database. Accounts will be created for appropriate TDEI team members to have access to the computers.

[24] What is NAS? Seagate. https://www.seagate.com/blog/what-is-nas-master-ti/

5.1.1.4 Quality Assurance and Quality Control Processes

The UW team will verify that the computers are functional by running a short data analysis task and by connecting to the Internet from the computers.

5.1.1.5 High-level Installation Schedule

The computers will be installed and configured within one month of their receipt.

5.1.1.6 Hardware and Software Configuration Control Processes

The hardware configuration of these computers is not expected to change. The software on the computers will be kept up to date through automated software updates using the GNU/Linux operating system.

5.1.1.7 Spare Parts/Warranty Contingency Plan

A three-year warranty will be purchased with the computers to provide for equipment failure. Data other than the operating system and software program installations will not be stored locally on the computers, thus needed backup of the computers is limited to documenting the system configurations. The team considered the option of purchasing a spare computer however that option was decided against. The team is purchasing two computers and in addition TCAT possesses a previous version of this machine that could further serve as backup if needed. Importantly, the computers that are being acquired are covered by a warranty, ensuring that any potential failures would be addressed by the manufacturer. Further, the intended use of these computers is data analysis – these computers are not planned to directly support the functioning of the TDEI system as the TDEI system is being deployed in the cloud. A downtime of a few days is acceptable for data analysis computers; thus, this arrangement was deemed suitable. It was noted in the CAP, that these computers provide an alternative option for operating the TDEI system should cloud costs become excessive. While it is possible the computers would be used in this way, it is unlikely. Should that change, the purchase of an additional spare or spares will be reconsidered.

5.2 Network Attached Storage

The UW Team will purchase Network Attached Storage devices primarily to store data that is used and generated by the offline data analysis (outside of the cloud system). The NAS consists of a storage box (computer) and storage devices (disks) as more fully described in the CAP.

5.2.1 Installation Information

5.2.1.1 Suppliers

The NAS storage box is expected to be supplied by Intel® and the storage devices are expected to be supplied by Western Digital as described in the CAP. Both are expected to be purchased through CDW using the UW's purchasing system.

5.2.1.2 Inventory Control Method

As described in Section 3.3, an inventory of these devices will be maintained by the TDEI team in a shared document.

5.2.1.3 Installation Procedures

The storage box will be set up according to manufacturer's instructions and connected to the UW network for Internet access. The latest version of the GNU/Linux Operating System available at the time of purchase and installation will be installed on the storage box. The storage devices (disks) will be inserted into slots in the storage box as specified by the manufacturers. The NAS will be configured as Redundant Array of Independent Disks (RAID) using the RAID 10 configuration[25].

5.2.1.4 Quality Assurance and Quality Control Processes

The UW team will verify that the storage box and devices are functional by storing and retrieving a small amount of data on the storage boxes.

5.2.1.5 High-level Installation Schedule

The storage box and devices will be installed and configured within one month of their receipt.

5.2.1.6 Hardware and Software Configuration Control Processes

The hardware configuration of these computers is not expected to change. The software on the computers will be kept up to date through automated software updates using the GNU/Linux operating system.

5.2.1.7 Spare Parts/Warranty Contingency Plan

The intended storage box for the NAS, an Intel® NUC 11 Pro Mini PC; NUC11TNKv7[26], has a three-year warranty. The intended storage devices, Western Digital (WD) Red Pro NAS Hard Drive. Part#: WD121KFBX[27], come with a five-year warranty. Spare parts are not being acquired as doing so would significantly increase costs while providing minimal benefit as both items have warranties and replacements are expected to be readily available. As a contingency plan, the data on this NAS will be backed up to a second NAS that is owned by TCAT at UW.

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[25] What is RAID Storage? Western Digital. https://www.westerndigital.com/solutions/raid

[26] Intel® NUC 11 Pro Mini PC. Intel. https://www.intel.com/content/www/us/en/products/sku/205608/intel-nuc-11-pro-mini-pc-nuc11tnkv7/specifications.html

[27] WD Red Pro NAS Hard Drive. Western Digital. https://www.westerndigital.com/products/internal-drives/wd-red-pro-sata-hdd#WD121KFBX

6 Cloud Infrastructure

This section describes the installation and configuration of cloud resources that are being utilized for deployment and operation the TDEI system, which is being developed and operated on the Microsoft Azure Cloud.

6.1 Cloud Services

The cloud resources to be used for the operation of the TDEI have been divided into six categories: compute, databases, integration, storage, containers, and DevOps. The CAP describes the cloud services, their connection to the TDEI architecture which is described in the Phase II System Architecture Document (SAD) and describes the specifications of the cloud services to be acquired. Full details of the cloud system architecture are provided in the SDD.

All cloud services will be supplied by Microsoft Azure and will be installed, tested, and maintained in a similar fashion. Thus, there is one installation information section which describes the installation of all these services. Where there are minor differences between management of different services, those are called out in the appropriate section. Table 9 in the CAP contains a Bill of Materials for the TDEI cloud services and provides a list of all cloud services to be acquired and their configurations.

Note: DevOps is a term derived from the terms development and operations, it is a practice of integration and collaboration, usually around cloud resources, between software development teams (Dev) and information technology teams (Ops)[28].

6.1.1 Installation Information

6.1.1.1 Suppliers

Cloud services will be supplied by Microsoft Azure; the Microsoft Azure platform was selected as the cloud computing platform for the TDEI project.

6.1.1.2 Inventory Control Method

The inventory of cloud resources will be maintained in the Microsoft Azure platform. The Azure platform maintains an inventory of cloud resources for the purposes of billing, thus that inventory

[28] What is DevOps? Microsoft. https://learn.microsoft.com/en-us/devops/what-is-devops

captures the TDEI resource usage. Snapshots of this inventory will be created periodically to document the cloud resources inventory and changes in that inventory.

6.1.1.3 Configuration

The cloud resources will be configured to meet the needs of the TDEI system. It is expected that the configuration of the cloud resources may change over time as the needs of the TDEI system evolve and are better understood; these changes are a normal part of the evolution of the TDEI system. The configuration of the cloud resources is managed and maintained in the Microsoft Azure platform. Table 9 in the CAP provides the TDEI cloud resources configuration. Snapshots of the cloud resources configuration will be created periodically to document the cloud configuration and changes in that configuration.

6.1.1.4 Installation and Update Procedures

The cloud services used by the TDEI will run three types of software:

- Software managed by Microsoft Azure (also called Managed Services)
- Software developed by the TDEI team which is developed, maintained, installed, and managed by the TDEI team
- Software that is developed and maintained by external entities, but installed and managed by the TDEI team

These three types of software have three different installation and update processes.

Software managed by Microsoft Azure, which includes the Azure Database for PostgreSQL[29], Azure Cosmos DB[30], Azure Service Bus[31], Azure Blob Storage[32], Azure Container Registry[33], and Azure Monitor[34] (as described in Table 9 in the CAP) are installed and configured by Microsoft

[29] Azure Database for PostgreSQL. Microsoft. https://azure.microsoft.com/en-us/products/postgresql/

[30] Azure Cosmos DB. Microsoft. https://azure.microsoft.com/en-us/products/cosmos-db/

[31] Azure Service Bus. Microsoft. https://azure.microsoft.com/en-us/products/service-bus

[32] Azure Blob Storage. Microsoft. https://azure.microsoft.com/en-us/products/storage/blobs

[33] Azure Container Registry. Microsoft. https://azure.microsoft.com/en-us/products/container-registry/

[34] Azure Monitory. Microsoft. https://learn.microsoft.com/en-us/azure/azure-monitor/overview

Azure when they are acquired. All updates to this category of software are managed by Microsoft Azure.

Software developed by the TDEI team will be run using Microsoft Azure AppServices[35]. AppServices is the virtual equivalent of a computer, in other words, a virtual machine. The TDEI-developed software will be installed on the AppServices using a Continuous Integration / Continuous Delivery (CI/CD)[36] process which is being developed by the TDEI team and which will automatically install software and deploy software updates once those updates have passed tests and are approved for deployment as described in the STP.

The final category is software that is developed and maintained by external entities. In the TDEI, this is Keycloak[37], which is part of the authorization service. Keycloak will be manually installed on an AppService by the TDEI team, updates will also be handled manually by the TDEI team.

6.1.1.5 Quality Assurance and Quality Control Processes

The cloud services will be regularly tested as part of the TDEI system testing as described in the UW ITS4US System Test Plan (STP).

6.1.1.6 High-level Installation Schedule

Cloud services are installed by the cloud provider, Microsoft Azure, upon purchase of those services. In terms of timing, the cloud resources will be acquired throughout Phase II and Phase III of the TDEI project. The acquisition of the cloud resources began early in the project after the cloud provider was selected and at the time that the TDEI system software development began. The acquisition will continue throughout Phase II and Phase III. It is expected that the cloud acquisition will ramp up throughout Phase II as the TDEI system development progresses and then remain relatively stable in Phase III during operation of the system.

6.1.1.7 Warranty and Contingency Plan

Cloud resources are maintained by Microsoft Azure thus equipment failure is the responsibility of Microsoft and thus there is no need for a hardware warranty or acquisition of spare parts. Service levels, including uptime, are governed by Microsoft's Service Level Agreement (SLA) for Online Services[38].

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[35] AppService. Microsoft. https://azure.microsoft.com/en-us/products/app-service/#overview

[36] What is CI/CD? Redhat. https://www.redhat.com/en/topics/devops/what-is-ci-cd

[37] Keycloak. https://www.keycloak.org

[38] Microsoft Service Level Agreement for Online Services https://www.microsoft.com/licensing/docs/view/Service-Level-Agreements-SLA-for-Online-Services?lang=1

Appendix A Definitions, Acronyms, and Abbreviations

Acronym	Definition
API	Application Programming Interface
BLOB	Binary Large Object
CAP	Comprehensive Acquisition Plan
CFR	Code of Federal Regulations
CI/CD	Continuous Integration / Continuous Delivery
CIP	Comprehensive Installation Plan
CMOP	Comprehensive Maintenance and Operations Plan
ConOps	Concept of Operations
COTS	Commercial Off the Shelf
DOT	Department of Transportation
EIO	Equipment Inventory Office
ETRA	Emerging Technology Readiness Assessment
FAR	Federal Acquisition Regulation
GB	Gigabyte
GPS	Global Positioning System
GTFS	General Transit Feed Specification
HUAS	Human Use Approval Summary
ITS	Intelligent Transportation System
ITS JPO	Intelligent Transportation System Joint Program Office
LRS	Locally Redundant Storage
NAS	Network Attached Storage
O&M	Operations & Maintenance
OSW	Open Sidewalks
PMESP	Performance Measurement and Evaluation Support Plan
RAM	Random Access Memory
RFP	Request for Proposal
SAD	System Architecture Document
SDD	System Design Document
SAM	System Award Management
SIM	Subscriber Identity Module
SNI	Server Name Indication

Acronym	Definition
SSL	Secure Socket Layer
SyRS	System Requirements
Taskar Center or TCAT	Taskar Center for Accessible Technology
TDEI	Transportation Data Equity Initiative
TRAC	Washington State Transportation Center
U.S.	United States
USDOT	United States Department of Transportation
UW	University of Washington
WCF	Windows Communication Foundation

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