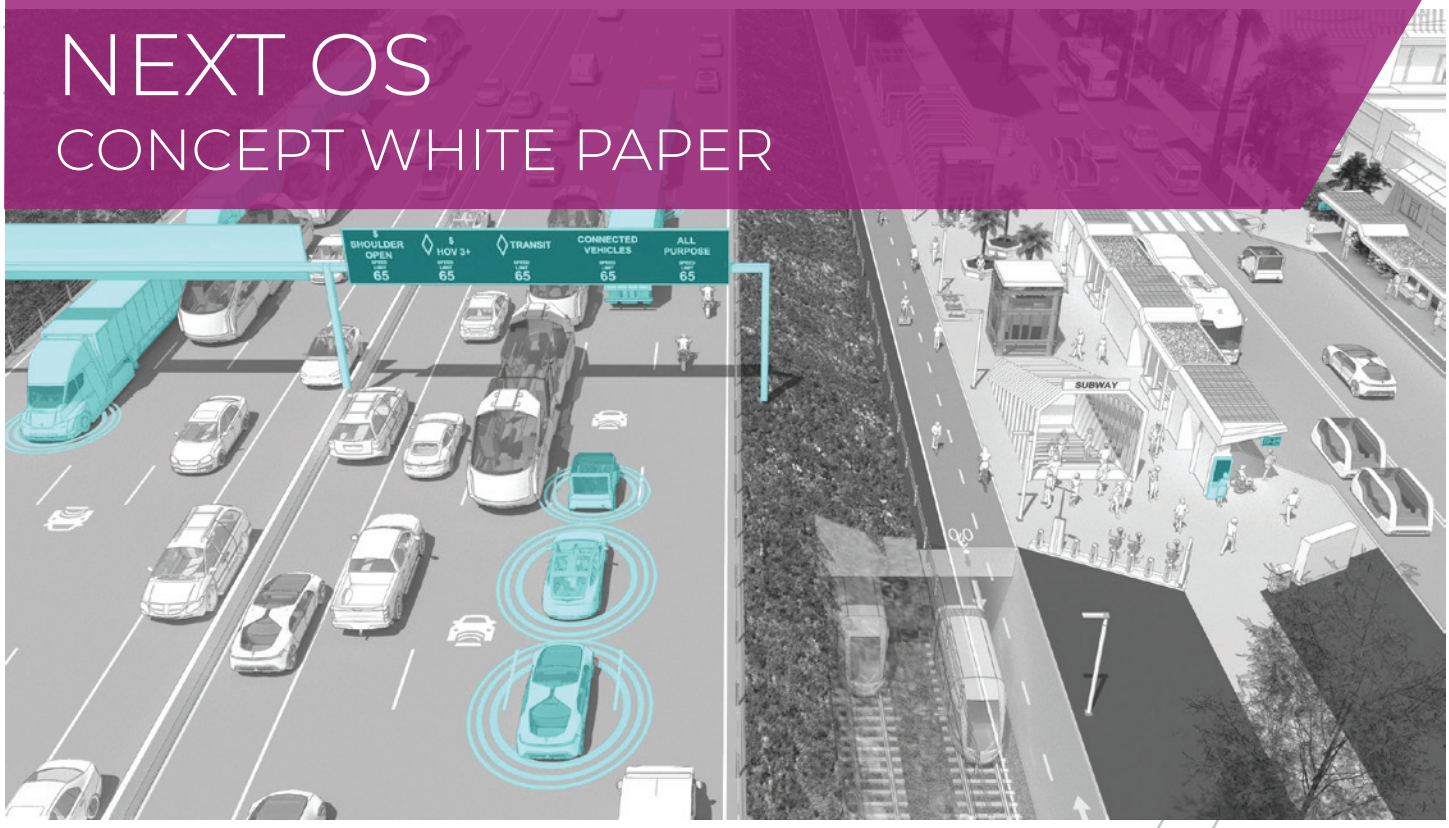
San Diego
FORWARD

# NEXT OS
## CONCEPT WHITE PAPER




## Next OS is the “brain” of the entire transportation system

Next OS technology will allow coordinated operations, management, and improved transportation services across all 5 Big Moves. The result would be a modernized transportation system with roads and transit services that operate smoothly and serve people better.

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SANDAG

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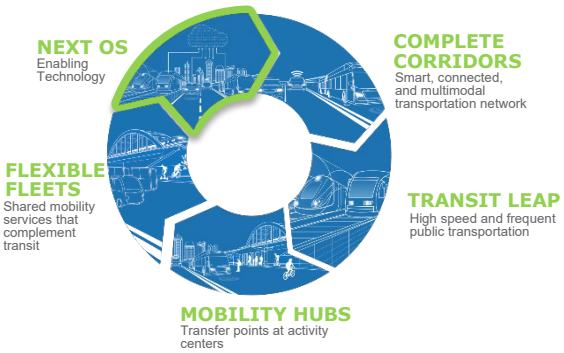
# Executive Summary

The San Diego region, like many around the world, is straining to keep pace with urbanization and population growth. The population is expected to increase 11% from 3.4 million to 3.7 million by 2050. This growth will lead to about 450,000 more jobs. The region is largely dependent on personally owned automobiles for transportation, directly contributing to an increase in greenhouse gas (GHG) emissions. Under the Sustainable Communities Act (California Senate Bill 375 [Steinberg, 2008]), the California Air Resources Board (CARB) set targets for regions around the state. For the San Diego region, the target is to reduce per capita GHG emissions to 19% below 2005 levels by 2035. Achieving these goals requires a significant reduction in vehicle miles traveled (VMT) and a fundamental shift in how people throughout the region travel.




To address these challenges, SANDAG is developing a new vision for transportation in the region. The 2021 Regional Plan envisions a more convenient, accessible, and connected transportation system enabled by 5 Big Moves—Complete Corridors, Transit Leap, Mobility Hubs, Flexible Fleets, and Next OS. Together, the 5 Big Moves will provide true alternatives to driving, meet or exceed state GHG emissions–reduction targets, and take advantage of technology solutions to make the most of our existing infrastructure and create a more efficient transportation system. The focus of this document is on one of the 5 Big Moves: Next OS, the **digital platform** that will help transform the San Diego region's current transportation system into a world-class network.

## *What is a digital platform?*

Technology continues to transform our daily lives, bringing higher levels of service, convenience, and cost-savings to many industries and economic sectors, including retail, banking, healthcare, and education. In recent years, transportation has been significantly impacted by new services that use technology to move people and goods. Ridehailing and advanced logistics services are two prominent examples. There are two common elements to how such businesses have created new products and services that ultimately benefit their customers: first, they create a new operating model, and second, they develop a digital platform that enables that model.

A **digital platform** is not a single piece of technology, but rather a set of multiple technologies that are connected to create information-sharing opportunities for businesses and public agencies and better outcomes and value for users. There are computer systems that employ a wide range of technologies that can be used to create a platform depending on business needs. At a minimum, a digital platform often includes these capabilities:

- **Data management** – a system that can collect, store, and process information from multiple sources of data
- **Analytics** – a system that can process and analyze information collected and derive value from it
- **Communications** – a system that moves information between the technologies and shares it with other systems
- **Engagement** – channels that allow users to access the information, such as applications, dashboards, and websites

A digital platform, by itself, does not directly create value for organizations or their users; it creates opportunities for changes in the way organizations operate, and it is these new ways of operating that create value. Without platform technologies, many organizations remain process-driven, relying on sets of defined manual steps to carry out business processes that can often lead to bottlenecks and siloed decision making. Digital platforms help transform organizations to become data-driven, handling end-to-end business processes that cut across traditional organizational structures to achieve improved experiences for consumers and suppliers alike.

One example of this shift from process-driven to data-driven business is the radical disruption of the taxi industry over the last decade. In order to take a taxi ride before 2010, a person needed to either place a phone call to a dispatcher or stand on a busy corner hoping to flag down an empty cab as it passed by. The rider did not know anything about the driver or their route preferences, nor did the driver know anything about the rider or where they were headed. The rider often had to pay in cash. This was a very process-driven experience, and it was rife for radical improvements in convenience, efficiency, and customer experience.

Ridehailing services, which arrived on the scene about a decade ago, combine several technologies within your mobile phone—from GPS to a common payments system—to significantly improve the customer experience in the taxi industry. At the tap of a button, a rider can be matched with a nearby ride almost instantly. Riders can choose to ride alone or with other people, specify whether they need extra seats, and even whether they want the driver to be conversational or give them peace and quiet. The driver, meanwhile, does not need to waste fuel circling busy streets in search of riders. They know where the rider is going and the fastest way to get there and accepts automatic payments using a saved payment method, further reducing friction. Riders can even earn loyalty reward points over time in a mutually beneficial relationship with the company. The entire taxi experience is now data-driven, and therefore more efficient, convenient, and cost-effective. Furthermore, it allows for new services that were not possible in the old model, such as dockless scooters and bikes.

Public agencies responsible for transportation in the San Diego region have similar opportunities for disruptive change as the organizations described above. SANDAG envisions a future of transportation in the region that reaches new levels of choice, convenience, efficiency, safety, and cost-savings.

Public agencies are in a unique position to be custodians of a public data. A digital platform that is owned and managed by a public agency is operated for the public good and in the benefit of end users. Digital platforms operated by private companies are operated with owners and shareholders as their primary beneficiary. Public agencies operate with transparency, while the data management and usage of collected data by private companies is opaque to the public. We aim to deliver on that vision by developing a digital platform, supported by streamlined processes, that will transform transportation in the region—Next OS.

## *What is Next OS?*

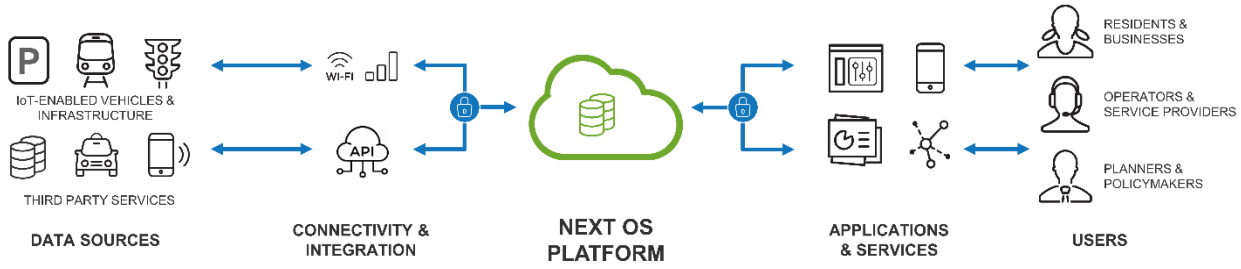



*Figure 1: Next OS Platform Overview*

As depicted in Figure 1, Next OS is an integrated platform that catalogs and offers secure and privacy-sensitive access to data from transportation infrastructure, public and private transportation services, and third-party transportation resources using standardized interfaces and interoperable protocols. Planners utilize advanced analytics to design and deploy seamless, efficient, and equitable transportation services for residents and visitors and efficient freight movement and delivery. Operators use real-time monitoring and controls to operate and manage these services and deliver seamless transportation options equitably. Public and private service providers can leverage the platform to develop and deliver new application and services. The Next OS platform allows coordination and orchestration of the operation across the other four Big Moves: Transit Leap, Complete Corridors, Mobility Hubs and Flexible Fleets.

## *Who will use Next OS and why?*

Considering the technical, operational, and institutional complexities in defining the Next OS concept, SANDAG has conducted user-centered research that places the end users of the platform at the center of all decision making. This ensures that the unmet needs of users remain the driving force behind the forthcoming design and implementation of Next OS. SANDAG led broad public outreach and applied design studies to identify those needs, engaging residents and organizations across the San Diego region through informal intercepts, formal interviews, and focus groups. The Next OS concept is being developed to provide value to three major user groups:

- **Residents, Businesses, and Visitors** – Create a seamless transportation experience by providing real-time information and integrated trip-planning tools to browse, book, and pay for any mobility service. With a network that is coordinated and responsive to real-time conditions, transportation for residents and visitors will be more efficient, flexible, safe, sustainable, and cost-effective.

- **Transportation Operators and Service Providers** – Support transportation operators, such as public transit agencies and private service providers, manage services or assets as efficiently as possible, leveraging advanced analytics and real-time data to improve operations. With a shift from process-driven to data-driven operations, operators and service providers will reduce costs and increase service levels.
- **Planners and Policymakers** – Equip planners and policymakers to make data-driven decisions using analytics tools that provide better visibility into how the transportation system is functioning and where improvements might be needed. With better-informed investment and planning decisions, planners and policymakers are better equipped to build and maintain a transportation network that achieves the region's goals of accessibility, efficiency, and sustainability.

## *Setting Next OS into motion*

Although Next OS is a technology platform, the technology itself is only one ingredient in delivering value to users. Many of the applications of Next OS will require SANDAG, local public sector agencies, transit agencies, and other organizations to move beyond traditional operational siloes and legacy governance models to form a complete regional technology network. Success of Next OS heavily depends on cross-agency and cross-sector coordination. SANDAG and our partners must commit to achieving common user, operational, and policy objectives, regardless of who owns or operates the underlying services or infrastructure.

In order to identify steps to achieve this level of collaboration, SANDAG has conducted an operational readiness assessment of public agencies in the region (including itself) to assess our collective maturity. This analysis spanned six key dimensions, including: 1) data sharing and communications, 2) systems and technologies, 3) business processes, 4) performance measures, 5) policy and regulation, and 6) organization and staffing. These insights were used to formulate guiding principles that will be leveraged at future stages of Next OS design and implementation. These principles are outlined in the figure below.

### Guiding Principles for Next OS

Next OS is more than the sum of its underlying technologies. The following overarching principles will be key to the successful design and implementation of an interoperable transportation platform:

**Establish Data Stewardship and Standards**
Identify a data steward responsible for overseeing the secure collection, responsible use, and consistent quality of data. The data steward should maintain a set of common data standards that will allow systems within and between agencies to communicate, while protecting the security and privacy of the data.

**Design an Open System Architecture**
Leverage an open system architecture for technical components such as schedules, congestion, signal and ramp timing, reservations, availability, timing and delays, payments, and account management to create new opportunities to build upon Next OS, compete for users, and offer innovative new services while sharing anonymized, encrypted data.

**Commit to Collaboration**
Expand transportation options via partnerships with clear service level agreements. Align on a Concept of Operations ConOps) for each use case to set clear roles and responsibilities for organizations operating and maintaining systems. Establish forums to discuss the continuous improvement of services.

**Align Performance Objectives**
Build a consensus among stakeholder agencies around collective policy and operational goals for the region. Set achievable performance targets aligned to those goals and implement key performance indicators (KPIs) to track and socialize impact.

**Establish Regional Policy Frameworks**
Develop and maintain regional policy frameworks that support Next OS use cases, including new methods to manage mobility and infrastructure with multijurisdictional collaboration. This can include permitting and regulation for new mobility services, as well as coordination of traffic engineering and parking policies.

**Form a Regional Center of Excellence**
Create a central, shared center of excellence to support technology initiatives across the region in order to maximize the ROI on technical resources, increase capacity to modernize technical systems, and quickly scale new advancements across jurisdictions.

*Figure 2: Guiding Principles for Next OS*

## *Looking Ahead*

While this document begins exploring the technical, operational, and governance implications of Next OS, more work will be needed to refine the concept. SANDAG will begin by creating a Concept of Operations (ConOps) around Next OS that will describe in greater detail the characteristics of Next OS from the point of view of our three user groups: Residents, Businesses, and Visitors; Transportation Operators and Service Providers; and Planners and Policymakers. This will be followed with detailed business requirements that will guide the design and development of key Next OS use cases. Concurrently, supporting systems

engineering elements that must be defined and documented; these elements will formalize the process, organize the development of Next OS, inform the business requirements, and lay the foundation for subsequent steps.

There are many potential use cases for a platform like Next OS, and with each application, different technologies, processes, and stakeholders will be required to make them possible. SANDAG has taken a user-centered approach to inform the development of the Next OS concept to identify high-priority use cases that will make an immediate impact in the region. Through this process, SANDAG has prioritized six use cases that align with our current priorities for the region and are extensible to future solutions. Some of these are new systems that will be piloted locally and scaled regionally. Others build off advanced transportation demand management systems that currently exist in the region, such as the Integrated Corridor Management System (ICMS) along Interstate 15 (I-15). The six use cases are:

- **Mobility-as-a-Service** – Integration and coordination of mobility systems, along with an app to plan, book, and pay for trips across public and private modes and earn loyalty rewards for transit rides
- **Curb Access Management** – Dynamic management of curb access rules for multiple uses, including freight, ridehailing pick-up and drop-off, micromobility, and parking
- **Transit Optimization** – Dynamic routing, scheduling, and vehicle-to-infrastructure communications for transit operators, with direct feedback and reporting from travelers
- **Smart Intersection System** – Traffic flow analysis and dynamic signal controls that manage traffic, improve safety, and can give priority to different users (transit, bikes and pedestrians, freight, and/or emergency vehicles)
- **Next-Gen Integrated Corridor Management System** – Cloud-based analytics and simulation system to coordinate traffic signals, ramp meters, dynamic lane assignment/management, and other technologies along the region's Complete Corridors
- **Regional Border Management System** – Cloud-based analytics and simulation solution with wait times, incident reports, and dynamic tolling to improve crossborder flow

Each Next OS use case provides unique benefits to users while contributing to the region's broader goals of economic development, connection and accessibility, and quality of life. They serve as the building blocks to implement Next OS iteratively in the coming years.

# Introduction

In spring of 2019, the San Diego Association of Governments (SANDAG) unveiled a bold new vision to deliver a fully integrated, world class transportation system in 5 Big Moves: Complete Corridors, Transit Leap, Mobility Hubs, Flexible Fleets, and Next Operating System (Next OS). Each move represents a set of concepts that will enhance connectivity, increase safety and sustainability, and improve quality of life in the San Diego region.

The purpose of this document is to define the vision for Next OS, and how it will make each of the 5 Big Moves work together by connecting users, transportation service providers and planners, and infrastructure through technology and data. This document is organized in the following sections and topic areas to be used as input for the 2021 Regional Plan and related efforts tied to the implementation of Next OS:

### Section 1: Concept Definition and Value Proposition

A detailed concept definition, value proposition, and schematic describing user groups and core capabilities for Next OS that will synchronize the 5 Big Moves via digital capabilities and better use of data.

### Section 2: Operational Readiness Assessment

An operational assessment to explore San Diego's readiness for Next OS focused on the maturity of several operational dimensions, including 1) data sharing and communications, 2) systems and technology, 3) business processes, 4) performance measures, 5) policy and regulation, and 6) organization and staffing.

### Section 3: Equity Considerations

A summary of considerations to create more equitable access and improve mobility and safety through technology and investments that are within the reach of all residents, visitors, and businesses in the San Diego region.

### Section 4: Looking Ahead and Prioritized Use Cases

A description of prioritized use cases and formal phased approach to implement the core platform and capabilities of Next OS.

Each section in this document is based on extensive industry research and study of best practices (domestic and international), interviews and surveys with public-sector executives focused on transportation across the country, consultation with the private sector, and focus groups with local residents and businesses.

# 1.0 Concept Definition and Value Proposition

## *1.0.1 What is a Digital Platform?*

Technology continues to transform our daily lives, bringing higher levels of service, convenience, and cost-savings to diverse industries such as retail, banking, healthcare, and education. In recent years, transportation has been significantly impacted by new services that use technology to move people and goods more quickly, cheaply, and sustainably. Ridehailing and advanced logistics services are two prominent examples. There are two common elements to how such businesses have created new products and services that ultimately benefit their end customer: 1) they created a new operating model and 2) they developed a digital platform that enables it.

A **digital platform** is not a single piece of technology, but rather a set of multiple technologies that are connected to create information-sharing opportunities for businesses and public agencies and better experiences for users. There are computer systems that employ a wide range of technologies that can be used to create a platform, depending on business needs. At a minimum, however, a digital platform often includes these capabilities:

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- **Engagement** – Channels that allow users to access the information, such as applications, dashboards, and websites

Next OS is a digital platform that relies on technology and data to connect users, service providers, planners, and infrastructure to improve the efficiency and accessibility for people and goods to move throughout the region. While the other four Big Moves include new technologies that enhance the management and experience of transportation in the San Diego region, Next OS is a set of underlying capabilities that will integrate and manage these solutions as a complete "system of systems."

## *1.0.2 A System of Systems*

A great example of a complex "system of systems" is an airplane. Many individual systems operate parts of a plane, but it only flies if all of those systems work together. The air traffic control centers that regulate air travel manage another system of systems, where capabilities such as radar and two-way communications are necessary to coordinate flight arrivals and departures. This case represents a *federated* system of systems—in other words, the air traffic control orchestrates multiple airplanes as a system of systems, but those airplanes still operate as their own independent sets of

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systems. Air traffic controllers do not direct passengers where to go or which airline to take, nor do they tell airlines how to operate their businesses, but they are coordinated at key points to make sure the entire system can function as efficiently and safely as possible.

Much like air traffic control, the movement of people and goods in the San Diego region is a large-scale, complex system of systems. Mobility Hubs, Complete Corridors, Transit Leap, and Flexible Fleets are systems that can be better integrated to improve the travel experience in the region. To make this happen, these individual systems must be connected and orchestrated by an overall operating system that can capture data and analyze performance across the network. Like the operating system on one's phone, Next OS will also provide new tools and information for users to navigate, manage, and continuously improve the regional transportation environment.

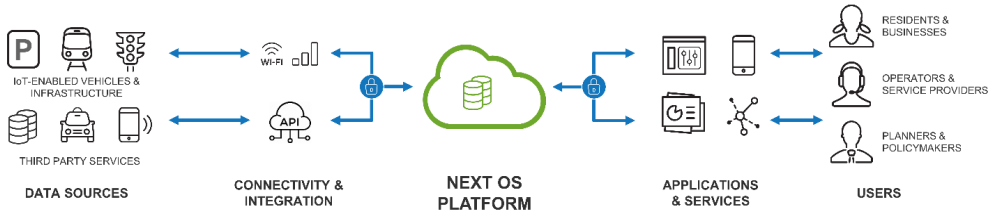



*Figure 3: Next OS and the Regional Transportation Network*

Where does Next OS sit in the regional network? As the central operational and management platform for transportation in the region, Next OS will securely ingest data captured directly from physical transportation elements—parking spaces, vehicles, signals—and indirectly from third-party sources. The platform's capabilities, described later in this section, support new applications and services that travelers, transportation operators, and planners will use to manage and navigate the coordinated system. This allows for regionwide network optimization, driving greater efficiency, safety, sustainability, and accessibility for our residents and businesses.

## 1.1 Value Proposition and Key Benefits

The value of Next OS is derived from its ability to synchronize transportation technologies in the region and create an integrated platform that serves the needs of users in the public sector, the private sector, and residents or visitors. Specifically, benefits of Next OS can be categorized into the following themes:

- **Visibility** – Enhanced data management and analytics allow for more informed and responsive planning and decision making about public infrastructure investments
- **Optimization** – Advanced analytics, combined with user incentives and engagement, balance supply and demand across modes and services
- **Collaboration** – Streamlined collaboration and operations across agencies and mobility service providers (public and private) make operations more efficient and provide a smooth transportation experience for people and goods
- **Equity** – Through partnerships, Next OS can help improve equitable access to a wide range of transportation services throughout the region

- **Cost Reduction** – Centralizing operations can lead to reduced costs that can result from efficient management of resources, improved utilization and coordination across siloed systems, and the ability to roll out services that are coordinated across agencies faster and easier. Better access to a wide range of public and private transportation services can also reduce transportation costs for users.
- **User Experience** – Travelers and operators benefit from real-time information, including the ability for travelers to seamlessly plan, book, pay for, and receive rewards for trips across multiple public and private modes of transportation.

## 1.2 Next OS Enablement of the 5 Big Moves

Next OS plays an instrumental role in the integration and management of the 5 Big Moves. Next OS core capabilities form the digital layer that the physical elements of the 5 Big Moves use to operate. When the digital capabilities of Next OS meet the physical elements (e.g., sensors, signs, and signals), they form complete concepts. To illustrate this, SANDAG identified more than 30 concepts, some of which are illustrated in Figure 4.

As part of this process, and in order to move Next OS from concept to design and implementation, key initial efforts include the completion of the Next OS ConOps, and the completion of the region's ITS Architecture and Strategic Implementation Plan update. The ITS Architecture and Strategic Implementation Plan updates will be included as key components of the 2021 RTP. These updates will provide necessary guidance while ensuring that the needs of all transportation users are considered and coordinated across immediate Next OS priority use cases and future ITS strategies, from concept development to implementation. This will include making sure that all technical platforms are appropriately integrated and meet necessary interfacing protocols and standards.

## 5 Big Moves

### NEXT OS

The "brain" of the entire transportation network, managing all services in real-time to promote sustainability, efficiency and safety

### COMPLETE CORRIDORS

Smart and connected routes that accommodate all modes of transportation to maximize the use of existing roadways

### FLEXIBLE FLEETS

Diverse services (e.g. e-scooters, bikeshare, rideshare, microtransit) that provide personalized transportation for diverse types of trips and passenger needs

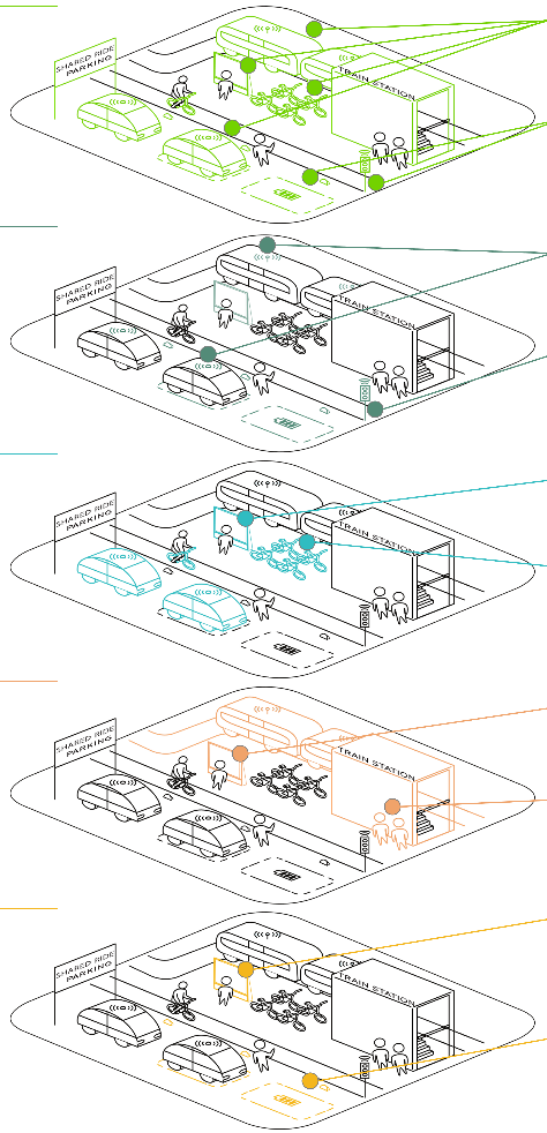
### TRANSIT LEAP

A complete network of high-capacity, high-speed, and high-frequency transit services that improve on existing services to move travelers as fast or faster than driving

### MOBILITY HUBS

Places of connectivity where a variety of travel options converge to deliver a seamless travel experience

## Digital Concepts Enabled




**Mobility-as-a-Service**
Travelers can seamlessly plan, book, ticket, and pay for journeys across all public and private modes, reducing reliance on private automobiles

**Coordinated & Dynamic Management**
Transportation operators can dynamically adjust pricing, incentives, and policies (e.g. transit discounts, parking fees) in coordination with the entire network

**V2X Communications**
Two-way communications exist between vehicles and other entities (e.g. signals, other vehicles) to promote safety & efficiency

**Signal Prioritization & Pedestrian Safety**
Smart intersections can prioritize transit or active transportation and provide pedestrian alerts to increase safety

**Integrated Trip Planning**
Residents can plan end-to-end multimodal journeys via many platforms including kiosks and smartphones

**Fleet Management**
Real-time tracking fleets' supply, demand, and utilization guarantees residents will have a first or last mile connection

**Real-Time Information**
Residents are provided real-time, analytics-driven information on wait times, service interruptions, and conditions

**Loyalty Rewards**
Next OS' account-based multimodal booking platform allows for loyalty rewards for shared transportation such as free transit tickets and local discounts

**Mobility Kiosks**
Information gathered across the mobility network by Next OS is easily consumed by travelers along their journey through permanent or portable kiosks deployed at Mobility Hubs and other high-traffic areas

**Curb Access Management & Smart Parking**
Next OS manages access to curb space for all uses (e.g. rideshare, parking, EV charging) based on real-time demand

*Figure 4: Next OS Digital Enablement*

## 1.3 Next OS Users and Capabilities

### *1.3.1 Defining User Groups and Needs Using Human-Centered Design Principles*

SANDAG's goal for Next OS is to develop a holistic solution that addresses underlying user needs and synchronizes the 5 Big Moves. To accomplish this, SANDAG took a human-centered design approach that focused on the people who will use Next OS—residents, visitors, transportation operators, service providers, planners, and policymakers. SANDAG conducted an applied design study to uncover the unmet mobility needs of San Diego travelers, transportation operators, planners, and policymakers to define three primary user groups and the value each would see with Next OS. By engaging prospective users across the San Diego region through random in-person and on-site surveys, interviews, workshops, and focus groups, SANDAG synthesized hundreds of data points into a series of insights. Among them:

**Residents, Businesses, and Visitors**

- Commuting habits are hard to break. Once commuters start driving their car, they typically do not consider other options.
- Expectations around transportation reliability and availability have increased. With the rise of smartphones and on-demand services, travelers increasingly dislike waiting and feeling out of control of their journeys.
- The experience of cars is unmatched. The convenience and freedom of driving cars heavily influences the mode of transportation that many residents choose.

**Transportation Operators**

- Agencies share a limited amount of data. Ad-hoc data sharing exists among many agencies, but there is a lack of consistent standards and data governance.
- Complex data analysis is difficult and costly. When systems do not communicate and require their own maintenance, thorough data analysis is resource-intensive.
- Many technology projects are developed in siloes. Limited regional coordination inhibits buy-in by regional local agency and transportation system stakeholders on regional initiatives, and this makes holistic improvements to the network difficult.

**Transportation Planners**

- The quality of data used in analysis can be improved. Traditionally, planners have relied on datasets from travel surveys and other ad-hoc methods that pertain to a specific point in time that do not capture dynamic changes and situations. As a result, planners cannot plan investments and make policy decisions that reflect real-time travel patterns.
- Data management is manual and often driven by ad-hoc business processes. Without an interagency data management system, policymaking and planning for both regional and local agencies can be difficult.
- Organizations sometimes lack the resources to analyze big data. Many organizations consider these resources costly and find it difficult to hire talented data analysts and developers.

With these insights, SANDAG defined three primary user groups for Next OS and identified how it would improve their user experiences. The three groups represent a mix of residents and visitors, the public sector, and the private sector:

**Residents, Businesses, and Visitors** will be able to seamlessly browse, book, and pay for combinations of public and private services in the region. They will be able to select their routes and modes of transportation based on time, cost, and convenience, and they can book their entire trip with a few clicks.

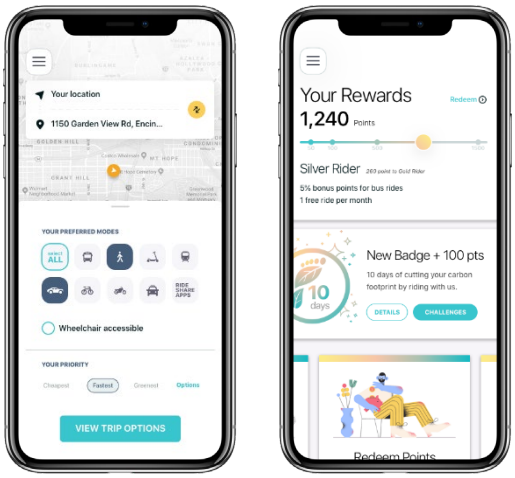



*Figure 5: Sample Resident Experience*

With Next OS, residents and visitors will access a suite of account-based applications through smartphones, kiosks, websites, and other channels (see Figure 5). While traveling, residents and visitors only pay a single price to travel on multiple modes of transportation, and Next OS handles everything else. They can also access incentives and loyalty reward points and provide feedback on the transportation network directly to local officials.

Traveling in a network that is coordinated and responsive to real-time conditions, residents and visitors will experience less friction and more flexibility and efficiency.

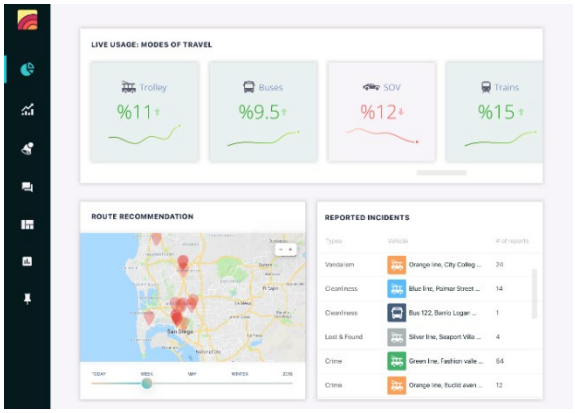



*Figure 6: Sample Custom Dashboard*

**Transportation operators and service providers** can use Next OS to shift from process-driven operations to data-driven operations using analytics software and dashboards that can be customized (see Figure 6). Next OS will provide transportation operators and service providers with these insights and tools to optimize dispatching, routing, and scheduling.

With comprehensive, accurate datasets and shared information, public transportation operators, parking authorities, traffic engineers, and other public- and private-sector transportation operators can break down siloes in their respective organizations. More collaborative business processes will improve regional coordination of transportation operations and the use of new technologies.

**Planners and policymakers** will use the wealth of data generated across the transportation ecosystem to improve the effectiveness and responsiveness of their planning, investment, and regulatory decisions. Combining artificial intelligence and machine learning with a user-friendly interface, non-technical planners and policymakers can easily use data to assess the performance of the network over time, simulate potential changes to infrastructure and policy, and clearly understand the impacts of those changes on the region. With better-informed investment and planning decisions, planners and policymakers are better equipped to build and maintain a transportation network that achieves the region's goals of accessibility, efficiency, and sustainability.

### *1.3.2 Next OS Capabilities*

As a platform, Next OS is not a single system or technology, but rather a connected set of systems and technologies with distinct purposes that work together to deliver new applications and services to users. To inform the development and configuration of the platform, SANDAG has defined a set of Next OS capabilities that can meet the needs of each of its three main user groups. By investing in these capabilities regionally for all public agencies, the region can benefit from additional economies of scale. The capabilities depicted in Figure 7 are defined further in this section and will be referenced throughout this report.

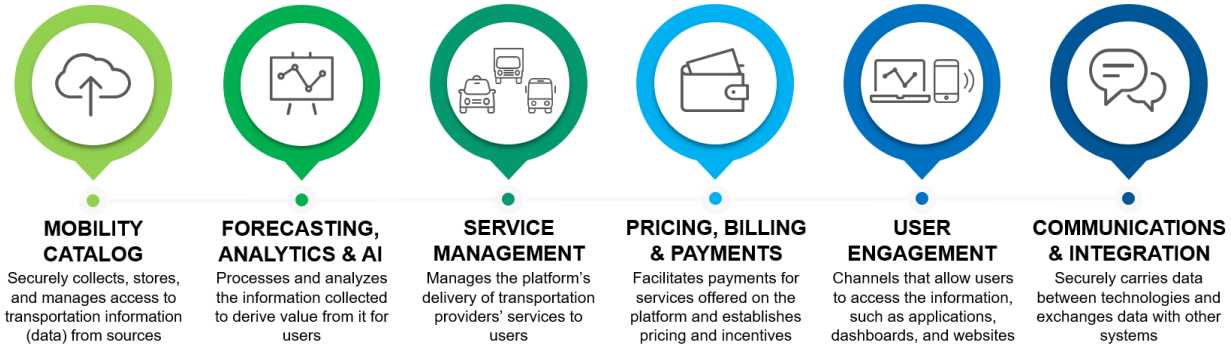



*Figure 7: Next OS Platform Capabilities*

#### *Mobility Catalog*

The Mobility Catalog is a centralized, cloud-based hub that securely collects and manages information from public and private services and assets, setting the foundation for Next OS solutions. While today most operational data are scattered between different systems (e.g., asset management or parking systems), the Mobility Catalog is a one-stop clearinghouse for regional transportation data that provides secure and privacy-sensitive access to reliable data used to deliver Next OS capabilities. SANDAG is committed to protecting the privacy of travelers and will establish firm guidelines for collecting, managing, and using mobility data responsibly. The Mobility Catalog will include datasets from all modes, including freeways, transit, local roadway and curb space data, and microtransit and micromobility transportation modes.

#### *Forecasting, Analytics, and AI*

Forecasting, Analytics, and AI use the latest technologies in analytics to derive value from the data collected by the Mobility Catalog. This value is found in how data is reported, statistically analyzed, monitored, forecast, and analyzed to make predictions and assist planning. It equips users with tools so they can use data to plan and manage policy, design and deploy infrastructure, and services while reducing operating costs.

#### *Service Management*

Service Management is the system that helps the service providers manage relationships with transportation providers and travelers. For providers, this includes the ability for policymakers to rapidly create and manage contracts, partnerships, and permits digitally, making it easy to establish data sharing and service-level agreements. For travelers, it includes the ability to manage user preferences, customer support, and notifications, delivering a personalized travel experience.

*Pricing, Billing, and Payments*

Next OS's Pricing, Billing, and Payments system will manage pricing, provide incentives, and process payments for transportation services (e.g., multimodal trips, parking, and curb access). Pricing and incentives can be static or dynamic (e.g., based on real-time congestion) to maximize efficiency. Payment systems will allow travelers to purchase both public and private services (e.g., a trip consisting of both a scooter ride and bus) with a single payment, access personalized incentives, and earn loyalty reward points.

*User Engagement and Ease of Use*

For users to gain value from Next OS, it must provide channels that allow them to interact with its applications and services. For travelers, Next OS provides information through a variety of channels, including kiosks, mobile applications, websites, and digital signs. This makes it easy for travelers to use new modes of transportation and provide valuable, direct feedback to inform improvements to the transportation network. For operators and planners, Next OS provides configurable dashboards that allow them to visualize and assess data, manage services and infrastructure, and simulate policies and incentives. This removes the need to navigate multiple systems for information and tools. It is everything they need, all in one place.

*Communications and Integration*

For any of these technologies to function, they must be able to communicate with one another as well as outside systems (e.g., third-party data sources, navigation apps, and connected vehicles). Next OS will be able to receive and distribute transportation data between systems and users in the network securely and efficiently. This requires establishing the following: 1) robust data standards, 2) Application Programming Interfaces (APIs) to make systems interoperable, and 3) streamlined collaboration with private-sector mobility providers with "plug-and-play" integration with Next OS.

*Additional Supporting Next OS Technologies*

While the above six capabilities make up the core elements of the Next OS platform, many other supporting technologies will be needed for each specific Next OS use case. Some examples include: 1) sensors to monitor various real-time conditions such as curb availability and congestion, 2) dedicated short-range communications (DSRC) systems that can exchange information between vehicles and infrastructure, and 3) edge computing systems that can bring certain computing processes closer to the locations where they are needed. These technologies and more will effectively bridge the gap between the physical transportation network and the digital capabilities of Next OS.

### *1.3.3 Next OS: A Regional Platform Driven by Common Standards*

Digital transportation technology deployed throughout the region will not be limited to Next OS. Many public-sector agencies will continue to procure and deploy solutions that meet their unique transportation management needs, and the private sector will continue to find new and innovative ways to improve the movement of people and goods throughout the region—independent of Next OS.

At the same time, Next OS can enable many regional solutions. The core platform will ingest data from across the network, analyze past and current conditions, simulate potential strategies to solve recurring or ad hoc issues (such as congestion or traffic accidents), and distribute recommendations to various local agencies and subsystems to optimize the overall regional network.

For Next OS to play this role of coordination and optimization, it must be able to communicate using a standard language. Development and/or adoption of standards for Next OS will be a key component of the regional ITS Architecture update, and these standards will follow the National Architecture ITS Framework (ARC-IT) as guidance and apply supporting development software tools such as the Regional Architecture Development for Intelligent Transportation (RAD-IT) tool. Looking back to the air traffic control analogy, it would be difficult to manage the arrivals and departures at an airport if all airplanes communicated with the tower at different times and formats. Similarly, it would be extremely challenging—and dangerous—for airlines to operate if every airport they flew to had different safety and communications requirements. So, there is enormous value in establishing consistent systems, data sharing, communications, and policy standards that encourage interoperability and a consistent user experience for civilian air travel.

In the context of transportation, many data standards have emerged over the last two decades. In 2005, TriMet, the transit agency in the Portland region, teamed up with Google to develop the General Transit Feed Specification (GTFS). This is a standard data format for transmitting public transit data such as routes, stops, frequencies, and fares.[1] Today, more than 200 agencies in the United States use this standard format, allowing applications such as Google Maps to rapidly deploy public transit trip planning services to markets across the country. Similar standards are now emerging with other modes of transportation. Bikeshare, for instance, has the General Bikeshare Feed Specification (GBFS). Micromobility, meanwhile, can be adopted using Mobility Data Specification (MDS).

With a common data governance structure in place, Next OS will become an open data platform for the region. Anyone (e.g., public agencies, private sector organizations, and travelers) will be able to use its data standards to design new solutions while ensuring the security and privacy of personal information. This will allow new technologies deployed in the region to interface directly with Next OS without custom configurations, and it also will provide standard software tools and data sharing protocols that encourage innovation and private-sector competition.

[1] General Transit Feed Specification Background, gtfs.org/gtfs-background

## 1.4 A Sample User Journey Enabled by Next OS

To depict what users might experience while traveling through the San Diego region with Next OS in place, SANDAG has developed several illustrative user journeys. User journeys are stories of people using a service—in this case, a transportation system backed by Next OS—and describing their interactions along the way. The user journey on the next page was influenced by insights gathered by market research, focus groups, and many interviews with a diverse population of residents at key locations in the San Diego region. The user journey features a fictional person, but their needs and desires are based on interviews with actual residents in the region.

### *Setting the stage*

One journey follows Camila, a new student at San Diego State University traveling from her home in Chula Vista for her first day of classes. Camila lives at home, and as she gets ready for college, she is looking for a low-cost and reliable way to get to class. She is considering purchasing a car, but she first wants to see if her needs can be met by choosing shared transportation. Thanks to the region's new trip-planning app, she can explore a range of multimodal options.

Before Camila's journey, mobility planners from across the region have already taken the following actions to accommodate the anticipated increase in demand at the start of the new academic year:

- Planners from SANDAG, MTS, NCTD, and nearby cities meet to assess their transit capacities on routes leading to the campus. Based on Next OS forecasts, they plan to increase the frequency of service on those routes and offer incentives for shared mobility and active transportation.
- Transportation engineers and planners in the surrounding cities have met to discuss adjustments to traffic signals in order to give priority to people who have chosen active transportation options such as biking and walking.
- Local officials use Next OS to analyze forecasted demand by mode to configure curb access rules, and they share projected demand near the SDSU Mobility Hub with micromobility firms.

Follow Camila's journey on the following page. Additional user journeys that illustrate other user needs and Next OS solutions are included in Appendix A.

## *Camila's Journey*

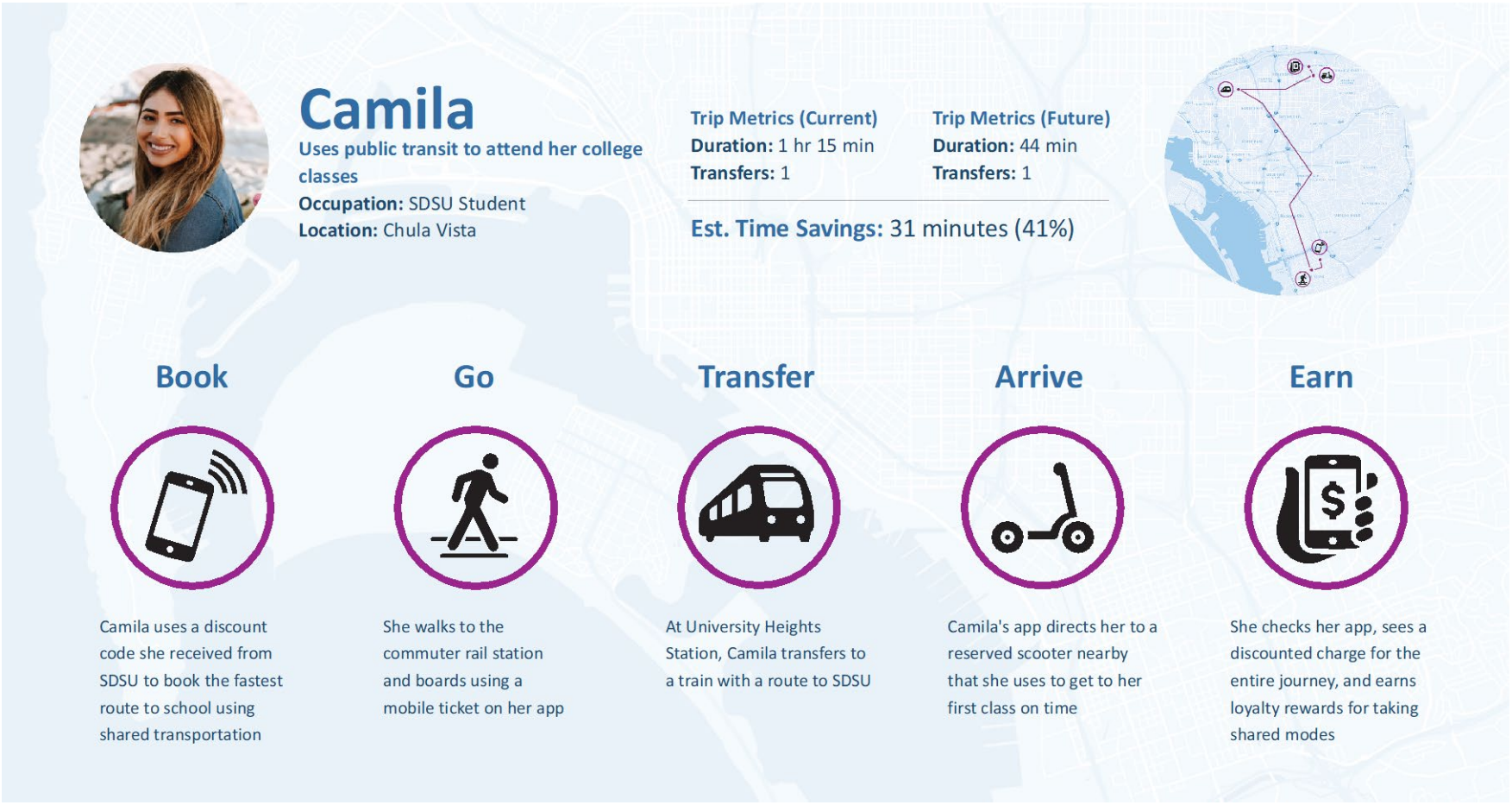



*Figure 8: Sample user journey enabled by Next OS – Camila*

# 2.0 Operational Readiness Assessment

The Next OS vision will require cooperation and collaboration among numerous public-sector agencies, private partners, and civic organizations at a scale rarely seen before in the region. The stakeholder landscape for such a vision is inherently complex, spanning 18 member public-sector agencies along with tribal nations, the county, MTS, NCTD, and numerous additional federal and state agencies (e.g., Customs and Border Protection and Caltrans). Each organization has distinct missions, responsibilities, and constituents, but in initial conversations, many have expressed an understanding of the benefits of Next OS as a regional transportation platform.

The success of funding, building, and scaling Next OS does not only depend on SANDAG. Many agencies and stakeholders will be needed to design, build, and operate the various use cases envisioned for Next OS. With such complexity, there will be understandable institutional and operational challenges to the regional deployment of the platform. Many of these challenges will be identified and addressed in the forthcoming development of a regional Next OS ConOps and the subsequent systems engineering process. SANDAG has found it important to begin assessing the region's operational readiness for Next OS, so that incremental steps can be taken across the region to begin advancing our collective digital maturity. Beginning with the development of the Next OS ConOps, SANDAG's ITS Architecture and Strategic Implementation Plan updates will help identify the Next OS user needs and technical integration elements to support and address the institutional and operational challenges and resulting strategies. Subsequent detailed steps will then be followed to reflect the next phase of the systems engineering process, once Next OS has advanced to implementation. This implementation includes completing the Next OS ConOps, System Engineering Technical Requirements (SysReqs), and the Systems Engineering Management Plan (SEMP).

Toward that end, SANDAG has conducted an assessment to gauge the region's readiness to adopt a technology platform on the scale of Next OS. This effort included surveys and interviews with local stakeholders, case study research into similar technology adoption by public agencies, and literature reviews of academic and industry best practices. Our goal was to better understand the current state of operations in the region and to identify design principles that would guide further Next OS development.

## 2.1 Capability Maturity Model Mapping

As part of the readiness assessment, SANDAG mapped the San Diego region on a capability maturity model (CMM) for a regional technology platform. This model was developed by leveraging existing frameworks set by the U.S. Department of Transportation and customizing parameters to align to a platform of this nature.[2] These models have proven to help transportation agencies self-assess their current capabilities and identify strategies for deploying new technologies. Importantly, these capabilities extend beyond the technology

[2] See FHWA's Traffic Management Framework, Transportation Research Board's ICM and Connected Vehicle CMMs.

itself and include the culture, workforce, and business processes necessary to effectively manage and operate the technology systems.

SANDAG employed a higher-order analysis to gain a picture of the region's collective maturity and readiness for Next OS. Six key dimensions were prioritized to orient the Next OS assessment, including:

- **Data Sharing and Communications** – The level of data sharing and digital communications between regional public agencies and between public and private mobility providers
- **Systems and Technology** – The application of existing design and development process for emerging technologies, including the application of system engineering process, system architecture and data standards
- **Business Processes** – Level of collaboration around operational processes and procedures
- **Organization and Staffing** – Values, expectations, and organizational structure of regional public agencies, and the position of transportation technology as a priority
- **Policy and Regulation** – Coordination around regional transportation policy and its responsiveness to changing real-time conditions
- **Performance Measures** – Calculation methods and use of performance measures for benchmarking progress against goals and objectives

These capabilities extend along a spectrum of relative maturity, from "Initial" to "Optimized," and they indicate the respective maturity of local agencies as well as the entire region.

## 2.2 Capability Maturity Model Findings and Considerations

In this section, SANDAG offers its findings and perspective on the region's readiness for adoption of Next OS, as well as principles to guide the design of Next OS and a discussion of potential governance models for the platform. This section was developed with an understanding that the development, implementation, and operations of Next OS will be a long-term, collective regional effort, with much discussion and deliberation required. As such, this analysis is intended as a living document, and it will be updated to reflect future evolutions in regional maturity and planning around Next OS.

As SANDAG moves from a concept definition for Next OS into its design phase, the principles outlined in this section should guide decision making around the platform's technical, operational, and institutional requirements and serve as initial concept study components that will be further detailed in the Next OS ConOps. Moving forward, the results of this assessment should also be examined by local agencies and guide them as they assess their own digital maturity, particularly focused on the priority use cases identified for initial deployment (described further in Section 4.0).

The 2021 Regional Plan development is an important first step toward incorporating Next OS into the transportation plans of different agencies. Throughout SANDAG's planning process, local stakeholders were engaged to identify initial priorities and objectives for the platform. SANDAG distilled a set of guiding principles (see Figure 9) to ensure the successful design and implementation of a regionally interoperable platform. Additional insights and growth

opportunities were also identified along each of the six dimensions of the maturity analysis, and these are outlined further in this section. As part of the development of the Next OS ConOps, SANDAG will coordinate with member agencies to vet these strategies and align on a plan forward.

### Guiding Principles for Next OS

Next OS is more than the sum of its underlying technologies. The following overarching principles will be key to the successful design and implementation of an interoperable transportation platform:

**Establish Data Stewardship and Standards**
Identify a data steward responsible for overseeing the secure collection, responsible use, and consistent quality of data. The data steward should maintain a set of common data standards that will allow systems within and between agencies to communicate while protecting the security and privacy of the data.

**Design an Open System Architecture**
Leverage an open system architecture for technical components such as schedules, congestion, signal and ramp timing, reservations, availability, timing and delays, payments and account management to promote transparency and encourage new organizations to build upon Next OS, compete for users, and offer innovative new services while sharing anonymized, encrypted data with planners.

**Commit to Collaboration**
Expand transportation options via partnerships with clear service level agreements. Align on a Concept of Operations (CONOPS) for each use case to set clear roles and responsibilities for organizations operating and maintaining systems. Establish forums to discuss the continuous improvement of services.

**Align Performance Objectives**
Build a consensus among stakeholder agencies around collective policy and operational goals for the region. Set achievable performance targets aligned to those goals, and implement key performance indicators (KPIs) to track and socialize impact.

**Establish Regional Policy Frameworks**
Develop and maintain regional policy frameworks that support Next OS use cases, including new methods to manage mobility and infrastructure with collaboration among multiple jurisdictions. This can include permitting and regulation for new mobility services, as well as coordination of traffic engineering and parking policies.

**Form a Regional Center of Excellence**
Create a central, shared center of excellence to support technology initiatives across the region to maximize the ROI on technical resources, increase capacity to modernize technical systems, and quickly scale new advancements across jurisdictions.

*Figure 9: Guiding Principles for Next OS*

## 2.3 Capability Maturity Model Analysis

The following section outlines SANDAG findings with regard to the operational readiness of regional agencies for Next OS. Based on agency self-assessments, follow-up interviews, and secondary research, SANDAG has identified growth opportunities across each of the assessment's dimensions, as well as a set of guiding principles to shepherd a successful regional deployment of Next OS.

The results of the capability maturity analysis are shown below in Figure 10. Generally, the region scores between stages 2 and 3 of maturity. This analysis does not discount the groundbreaking transportation technologies that have been pioneered in the San Diego region, including the ICMS along the I-15 corridor. Rather, it reflects the broad geographic and functional scope envisioned for Next OS itself. With use cases that span app-enabled transportation, transit operations, traffic engineering, and infrastructure management, this solution is the next frontier in integrated transportation technology. Therefore, it requires an even greater level of coordination.

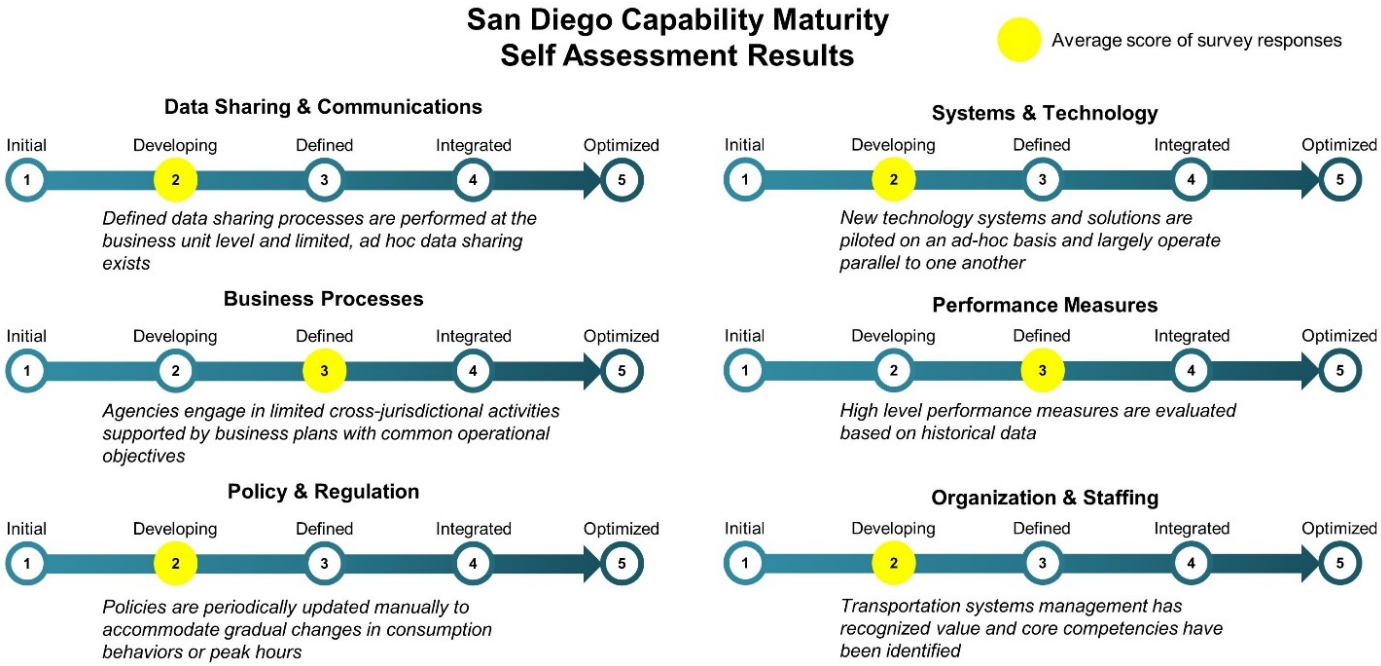



*Figure 10: Operational Assessment Maturity Scores*

### *2.3.1 Data Sharing and Communications*

**58%** of survey respondents said that data compilation is a manual, non-standardized process with ad-hoc reports from different systems.

Given the numerous technology solutions present in local agencies, it is difficult for many organizations to standardize and share data, which is critical to drive operational improvements. This dimension analyzes the San Diego region's current data-sharing and communications practices and provides a path forward for regional agencies to improve data sharing between public and private mobility service providers.

*"Our data goes back years…we get data from the consultant team, but it sits on our S Drive in Excel or PDF."*

Currently in San Diego, defined and documented data-sharing processes are performed at the business unit level. Data sharing and communication within and across agencies is limited or ad hoc. Data is often recorded manually using Excel or even paper-based documents, resulting in limited ability for historical analysis and subpar data quality. Strict protocols and a lack of data-sharing agreements restrict interagency cooperation in the region. There are also few frameworks or agreements to share data with private service providers.

*"We've tried repeatedly to get baseline TNC data from [other government agency], but without some kind of legal documents or MOU, no one wants to play ball."*

Going forward, establishing data stewardship that drives standards and ensures the responsible and secure use of data will improve data management and governance. Detailed further in Section 2.3.2, data stewardship involves establishing a trusted third party to manage cross-organizational data sharing including setting standards, ensuring privacy and security, and providing frameworks for what data should be shared for different purposes. As Next OS is designed for its various user groups, an analysis of existing data standards will help standardize both intergovernmental and public–private data protocols for data sharing agreements. As regional data sharing is catalyzed by a data steward, all agencies will be able to conduct holistic analysis and make more informed decisions.

#### I-15 Integrated Corridor Management System

Since 2010, SANDAG has been working with five partner agencies (Caltrans, the Metropolitan Transit System, and the cities of San Diego, Poway, and Escondido) to operate and manage individual transport systems along I-15 as a unified corridor, including the highway network, toll lanes, the surrounding arterials, and the public transport network.

The ICMS was designed to optimize capacity and efficiency, reducing delays and obtaining more reliable journey times without the need for investment in additional infrastructure (e.g., more lanes for private traffic).

Like the Next OS, the ICMS allows multiple systems to communicate and coordinate operations, improving efficiency regardless of who owns or operates the individual system. It analyzes changing conditions and congestion based on real-time information, and its Decision Support System (DSS) generates automated response plans predicted to best optimize the corridor traffic efficiency.

Rather than reacting to traffic conditions, managers can anticipate problems before they arise and take preventative action using ICMS strategies such as responsive traffic light synchronization, coordinated ramp metering or transit priority on arterial roadways.

To establish these response plans, project teams and agency managers had to develop and agree to specific tactics—the alternate routes to be considered, the technologies to be activated, etc.—and capture them as rules to be analyzed and simulated by the DSS. Nearly ten years later, the ICMS system is maintained by regional SANDAG staff, with regular input and performance evaluation by partner agencies in monthly working group meetings.

*Figure 11: The I-15 ICMS Story*

### 2.3.2 Systems and Technologies

As investment in new physical infrastructure has been constrained by a limited funding environment, it has become critical for transportation agencies to use technology to support an efficient, reliable, and safe transportation network. However, technology expansions have led to a new set of challenges, including managing a disparate set of systems across transportation agencies and keeping up with rapidly evolving commercial technologies. This theme explores the San Diego public sector's technology systems' effectiveness, cohesiveness, and conduciveness to emerging capabilities, all of which will be critical to successful transportation management and developing key features of Next OS.

*"Everyone is able to get capital investments for new solutions, but no one thinks about maintenance costs."*

Today in San Diego, most new technology systems and solutions are explored, designed, and piloted on an ad hoc basis for target purposes, but they largely operate parallel to one another. Many transportation management systems in the region such as the freeway management systems, arterial management systems, and transit management systems do not communicate or interact with each other.[3] Maintaining these disparate systems results in high operational costs and reduces opportunities for future integration.

Going forward, Next OS should use an Open System Architecture, aligned to a regional and federal level ITS Architecture guidance and standards, to ensure interoperability and promote transparency and innovation. An open Next OS system architecture will allow systems design and development to be performed at any level of its hierarchical structure (from local to regional) using the central capabilities of Next OS. Furthermore, once updated, the regional ITS Architecture will help guide ITS investments by member agencies that support local agency project needs while aligning with Next OS investment priorities. The regional ITS Architecture update will denote current and future ITS systems as well as the underlying institutional agreements and technical integrations necessary to form the complete system of systems and follow guidance established by the U.S. Department of Transportation and Federal Highway Administration.

### 2.3.3 Business Processes

It is important to remember that a platform alone does not create value—value is created by the new, cooperative operating models that the platform supports. Technology projects can only be successful if they are supported by the necessary business processes. This dimension explores the current processes in place within the San Diego transportation landscape for planning, policymaking, budgeting, programming, and project activities.

[3] I-15 Integrated Corridor Management System Requirements, USDOT, July 2011

**58%** of planning and programming activities solve immediate, targeted problems or are based on plans that are contained to a single subset of the transportation network with no regional coordination.

Today, regional agencies engage in limited cross-jurisdictional transportation management activities supported by business plans, concepts of operations, or other documentation with common operational objectives. Regional coordination is present in certain ad hoc initiatives, but many projects operate in siloes. The Regional Arterial Management System (RAMS) is an example of once-localized transportation operations coordinating at the regional level, allowing agencies to view their peers' traffic signal timing plans to coordinate across jurisdictions and improve overall traffic flow. Meanwhile, other projects continue in siloes or with limited coordination, such as MTS's new trip-planning app, GoMTS. A new regional ITS architecture is pending release, but it has not yet influenced interagency collaboration and there remain many processes with regional impacts that are not part of a coordinated regional vision.

### Obtaining Buy-In for a Digital Platform by Government Agencies

"A Digital Government Technology Platform is Essential to Government Transformation," published by Gartner, offers numerous insights around obtaining buy-in for a similar platform to Next OS.

Buy-in for the platform can be obtained by demonstrating benefits realized by other governments who have successfully adopted similar systems, particularly in terms of cost reduction and operational efficiencies gained. In addition, strong executive sponsorship for adopting the platform can provide incentives to business units who participate, and disincentives for those that chose not to participate (e.g. Agile training, resources). For an information technology group to deliver the value of the platform, Gartner recommends it be structured around business capabilities, with skill gaps addressed prior to development and operations.

*Figure 12: Obtaining Buy-in for a Digital Platform (Gartner)*

In addition, limited budgets and long backlogs keep digital solutions from becoming a priority and create barriers for regional coordination. There is currently low confidence in the ability of digital solutions to solve pressing transportation challenges. Transit agencies want to prevent—and not just monitor—criminal behaviors. City traffic engineers, meanwhile, who are only responsible for their own jurisdiction's roadway performance (as opposed to the broader region's), will advocate for lane expansion over other regional digital solutions because it provides immediate relief from congestion. Long public-sector planning and procurement cycles are not conducive to implementation of rapidly obsolete technologies.

Going forward, a commitment to collaboration by the leadership of member agencies is necessary to successfully implement the Next OS platform. Most public-sector agencies want quick wins that fit into budget cycles. Establishing a long-term digital strategy as a high priority requires inspiration and education on the value of Next OS in terms of business or mission. Additionally, funding, resources, and training can incentivize the participation by agencies in Next OS, as outlined in the Gartner article in Figure 12.[4] The Next OS ConOps, currently under development, should clearly outline the roles and responsibilities of organizations operating and maintaining systems and establish forums to gather input on the continuous improvement of the platform. Public agencies should be encouraged to form responsible partnerships that further advance their ability to offer new or expanded services.

[4] Obtaining Buy-In for a Digital Platform by Government Agencies, Gartner, 2018

### *2.3.4 Organization and Staffing*

Leading transportation agencies make information systems management a central part of their mission and organizational structure. This dimension explores the San Diego region's values, expectations, and organizational structures, including staff training and development, recruitment and retention, and collaboration, in order to provide recommendations on how to better support and prioritize technology functions of regional public agencies.

*"We're not in the business of big data analytics—we don't have the resources and have a tough time hiring developers."*

**Embracing Next-Generation Digital Organization Structures**

"Embrace Next Generation Digital Organization Structures," published by Forrester, offered additional insights into organizational change and digital technologies.

New organizational structures should align with technology capabilities, shifting investment and human resources to drive efficiency and scale. In the future, many digital organizations will transition from owning and producing to orchestrating a partner ecosystem around clear, customer-centric goals. This may require changes to established workflow cadence and embracing tools that assist in performing work in shorter cycles can accelerate that shift and drive digital innovation. Certain technologies can drive open and agile organizational transformations, such as microservices and open APIs.

*Figure 13: Embracing Next-Generation Digital Organization Structures*

Today in San Diego, transportation systems planning, operations, and management have recognized value, and core supporting competencies have been identified. Certain agencies in the region have set up cross-functional, integrated initiatives focused on innovation.

However, limited resources and outdated organizational structures place technology initiatives in siloes and limit organizations' ability to invest in IT systems development and management. In many cases, organizations remain low-tech, struggling to hire and retain talented technology personnel due to limited resources, and often place interdependent functions (e.g., IT and planning) in siloes, making it difficult to coordinate between stakeholders for successful technology implementations. See Figure 13 for further research on how organization structures must evolve to encourage technological innovation.[5]

Going forward, a regional Center of Excellence can cost-effectively provide analytics and technology support to local transportation efforts. A centralized and shared center of excellence supporting technology initiatives across the region should be considered to maximize ROI on technical resources. A center of excellence would increase capacity to modernize technical systems that stakeholders in the region use for daily operations and increase capacity to quickly scale new advancements across jurisdictions.

[5] Embracing Next-Generation Digital Organization Structures, Forrester, 2019

### *2.3.5 Policy and Regulation*

For Next OS to truly optimize the regional transportation network, it is critical to enact dynamic policies that respond to our changing transportation environment. This analysis explores the San Diego region's level of policy coordination and responsiveness to real-time conditions and provides recommendations on how to establish flexible, dynamic, and effective policies.

> *"Public–private partnerships with ridehailing providers have to be a larger policy question on the regional level, because it is not productive for the agencies to address individually."*

Currently in San Diego, transportation and infrastructure policies are periodically updated to accommodate gradual changes in consumption behaviors or peak hours, and there is need for regional coordination on policies with respect to private mobility providers. SANDAG is effectively influencing policy on the state level (e.g., California Senate Bill 1151), but member agencies remain hesitant to engage private mobility providers for several reasons, including apprehension to have conversations around data sharing, lack of clarity on engagement strategies, or recognition that regional standards need to exist first.

> *"Our policy frameworks are in place for multimodal corridor management, and through this policy we share the data. However, these policies need to be expanded to the other corridors and not just two."*

Going forward, regional policy frameworks should be established for private mobility providers. Using data analysis and human-centered design to develop and maintain regional policy frameworks will set the bounds on how technologies dynamically manage mobility, encourage multijurisdictional coordination, and make private mobility providers more likely to share data. SANDAG can play several roles in creating these standards, including hosting forums between member agencies, documenting policy guidelines, and facilitating productive conversations with between public agencies and private providers.

### *2.3.6 Performance Measures*

Today, Next OS's stakeholder organizations each measure their own performance to continuously improve operations. Success for Next OS depends on many organizations aligning their operational objectives toward common goals for the region. This final CMM dimension analyzes the region's use of performance measures for benchmarking progress against transportation objectives and provides the next steps for promoting collaborative performance measures.

**63%** of respondents said that high-level performance measures are based on historical data.

Today, the San Diego region is focused on performance measurement with an ambition to manage the region's performance against clear goals. Current efforts include the development of a Regional Transportation Performance Management Framework. Under this effort, SANDAG will examine possible opportunities for establishing a performance-based management process to improve existing transportation-planning business processes, monitoring, and reporting. SANDAG will also examine ways to align with transportation management and operational objectives and goals in order to shift toward integrated performance management and real-time operations.

*"Manual processes are used to count passengers, which leads to an inaccurate measure of performance."*

However, high-level performance measures are currently evaluated based on historical rather than real-time data, and the data for measuring performance is sometimes collected manually or from third parties. Manual data-collection processes can lead to inaccurate performance measurements. Progress against regional goals is reported to other agencies and to the public infrequently. Due to the lack of real-time data and monitoring, consistently measuring performance within the region is a challenge.

Going forward, the design of Next OS use cases should outline collective operational goals that draw a clear line from street-level performance to regional outcomes. By placing an emphasis on breaking silo mentalities for performance measurement and focusing on building consensus around collective operational goals, it will be easier to collaborate regionally around Next OS use cases. These operational goals should have clear, measurable Key Performance Indicators (KPIs) to track and socialize impact beyond initial deployments and establish achievable performance targets aligned to those KPIs.

## 2.4 Next OS Governance and Operational Considerations

### *2.4.1 A Distributed Governance Model*

Prior to the design of Next OS, there are several governance and operational questions that must be addressed to help guide the activities of SANDAG and member agencies to prepare for Next OS.

There are several common governance structures used for multijurisdictional technology efforts that are like Next OS, with regulatory authority varying across regional and local agencies. Given that Next OS is not a single solution but rather a "system of systems," or a platform on which other solutions are built, a distributed governance model is likely the most appropriate for the San Diego region.

A distributed governance model would assign authority for developing and operating the Next OS platform itself at the regional level while distributing operating responsibilities of the solutions built on the Next OS platform to other agencies (e.g., local public-sector agencies and transit authorities) based on the nature of those individual solutions. This distributed model allows different stakeholders to own and operate distinct solutions while empowering the region to drive collaboration across organizations, departments, and business functions.

SANDAG has experience leading the development and coordination of regional technologies such as the ICMS. Given that SANDAG is made up of representation from most local agencies, it is a natural forum to host the Next OS platform and resolve associated policy, technical, and process issues. Relevant solutions would still sit with their respective agencies but would share data with and receive policy inputs from Next OS. For example, the business owners and operators of a transit-optimization solution built on the Next OS platform would be NCTD and MTS, and SANDAG would serve both as the forum to discuss maintenance and operations as well as manage the underlying technologies that support the solution.

**Distributed Governance Models for Government Operating Systems**

In "A New City O/S," by Stephen Goldsmith, former Mayor of Indianapolis and professor at Harvard's Kennedy School, and New York University professor Neil Kleiman, present a practical and theoretical perspective on the use of operating systems in the government environment.

The book proposes a distributed governance model to rapidly address needs of citizens. Such a transformative operational reform can produce enhanced public services, in turn generating more citizen trust. For distributed governance to be successful, a city should serve as a hub for civic work and enable openness that supports deep communications, coordination, and connections across the government and a range of third parties. Universities and foundations are becoming increasingly relevant resources to drive changes in local governance and should be involved in future steps taken to drive innovative change in mobility. Goldsmith and Kleiman argue that a new operating system is not just a technology fix but can drive new principles into practice for government agencies, including customization, speed, and collaboration.

*Figure 14: Distributed Governance Models for Government Operating Systems*

SANDAG's Board of Directors would set regional policies necessary to operationalize Next OS, and the Cities/County Transportation Advisory Committee (CTAC) would expand its current charter to oversee the platform's development. This might include procurement, convening stakeholder experts to provide guidance on technical and operational matters, coordination of regional Next OS solutions' policies, prioritization of Next OS projects, and funding. CTAC's existing charter and membership puts it in a good position to act in this role.

Supporting CTAC would sit a new Next OS Center of Excellence (CoE). This would include technical resources that support the design, development, and integration of Next OS solutions, such as data scientists that train predictive models and provide analytics expertise to local agencies. The CoE would be responsible for operations and maintenance of the platform's underlying technologies, and it could leverage SANDAG's existing Service Bureau to provide analytics and modeling to third party organizations.

As new use cases for Next OS are conceived, CTAC, the Next OS CoE, and stakeholder member agencies will work together to develop concepts and gather business requirements to be designed by the CoE. As solutions move into operation, new or existing working groups will manage the maintenance and enhancements for solutions that are being used by multiple agencies.

It is important to acknowledge that member agencies will continue to procure their own transportation technology solutions outside of the scope of this governance structure. However, this governance structure will drive regional standards that support the interoperability and accelerated adoption of new transportation technology solutions that are deployed throughout the San Diego region. The proposed Next OS governance structure would complement the respective strengths of local agencies while maximizing the return on investment of the overall platform. Overarching institutional frameworks can further support the governance structure, including interagency agreements and technical or policy steering committees.

This proposed governance structure requires further in-depth analysis of its implications on the governance of data and policies—an effort currently underway by SANDAG.

### *2.4.2 Data Stewardship*

Next OS will generate enormous amounts of transportation data that must be standardized, shared, securely stored, and analyzed. Therefore, a system must be put in place to ensure that this is done responsibly and respects data privacy and proprietary concerns. To accomplish this, SANDAG should consider the role of a data steward, or a trusted third party such as a national lab or university, to govern and manage Next OS data. The data steward's responsibilities could include assisting in fostering voluntary agreements for data standards, developing clear data-sharing requirements for providers and agencies, overseeing the structured access to the Mobility Catalog, and ensuring that data is used responsibly and fairly in the interest of the region at large. Such a system could help encourage consensus and collaboration among stakeholders, as well as protect the data and interests of SANDAG constituents.

SANDAG has recently developed a data-governance strategy for the agency, but similar efforts should be pursued on a regional scale as we progress with the Next OS ConOps and systems engineering process.

**Mobility Data Sharing Policies and Recommendations**

"Mobility Data Sharing: Challenges and Policy Recommendations" is a white paper published by UC Davis' Policy Institute for Energy, Environment, and the Economy, and provides an overview of the top needs and challenges surrounding mobility data sharing.

The white paper argues that, to allow planners and policymakers to access data that informs transportation policy and investment decisions, data should be managed by a trusted third party to capture the benefits of data sharing while minimizing risks. The four policy strategies that follow include fostering voluntary agreement among mobility providers for a set of standard data specifications, developing clear data-sharing requirements designed for transportation network companies (TNCs) and other mobility providers, establishing publicly held big-data repositories, managed by third parties, to securely hold mobility data and provide structured access, and leverage innovative land-use and transportation planning tools using this data.

*Figure 15: Mobility Data Sharing Policies and Recommendations*

### *2.4.3 Formalizing the Governance Model*

In order to establish the governance model described above, agreements must be put in place that represent a commitment of stakeholders to their roles and responsibilities in operationalizing Next OS. These agreements will be further defined as a result of the Transportation Systems Management and Operations (TSMO) strategy that is currently being developed by SANDAG. However, given the complexity of the technology and stakeholder environment, four types of interagency agreements will likely be necessary for Next OS:

- Institutional agreements should define the roles and responsibilities of the various agencies with respect to the Next OS platform and field solutions, and they should articulate the mutual obligations of each party for data privacy and cybersecurity.
- Funding agreements should identify the cost-sharing or matching requirements of different agencies for Next OS technologies or support from the regional Center of Excellence.
- Operations agreements should define the criteria and processes through which Next OS recommendations should be deployed or modified at a local subsystem level.
- Data-sharing agreements and data specifications should be developed to facilitate communications and integration between agency partners, as well as private service providers (e.g., GTFS and MDS).

*Figure 16: Types of interagency Agreements*

As SANDAG completes its 2021 Regional Plan, the Next OS ConOps, TSMO strategy, and data-governance strategy, this governance model and the supporting agreements outlined above will evolve to include their outputs.

# 3.0 Equity Considerations

Improving access to transportation is vital to our region's economic prosperity, health and well-being, education and opportunity, and overall quality of life.

Without proper planning and development, transportation systems can actually harm communities, degrading the quality of life in them. The construction of roads, freeways, and rail transit systems may place health burdens on many low-income and minority communities. New transportation projects may physically divide communities, resulting in long-lasting social and economic costs. Like physical infrastructure, information infrastructure systems could also result in inequities.

SANDAG and its member agencies are committed to addressing the equity barriers that exist in the region today. Overcoming them will require deep coordination with regional and local partners, both in the public sector and throughout our communities. In conjunction with the other 5 Big Moves, Next OS offers both the technological and operational basis for such cooperation. To guide the development and deployment of Next OS toward this goal, SANDAG has identified the potential challenges and opportunities that the platform presents for equity issues in the region.

### Equity Considerations for Next OS

As SANDAG prepares for the design and deployment of Next OS, there are several steps the region should take to guide its development to improve transportation equity and accessibility, including:

**Inclusive Mobility Management**
Ensure Next OS technology designs respond to the needs of the entire community (e.g., voice-activated mobile apps, multilingual interfaces, wayfinding kiosks, and cash payments).

**Pilots and Service Expansion**
Demonstrate early benefits of Next OS with pilots and projects in disadvantaged communities (e.g., microtransit in areas that are low-density or underserved by public transit).

**Algorithmic Bias Prevention**
Enshrine neutral decision making as a principle in the platform's machine learning and analytics capabilities, with pre-processing, operational KPIs, and post-processing reviews to avoid implicit algorithmic biases.

**Transparent Revenue Allocation**
Develop transparent investment plans for funds raised from dynamic pricing (e.g., mobility subsidies or service expansion). Ensure equitable infrastructure investment and service coverage across the region.

**Continuous Improvement**
Set KPIs that are focused on equity, and leverage user feedback as well as community forums, surveys, etc. to identify additional needs or opportunities until equity goals are met.

*Figure 17: Equity Considerations for the Next OS*

This includes recommendations for transportation policymakers and operators to address existing barriers in the region, and it concludes by identifying new opportunities for Next OS to improve equity as the platform is designed, developed, and deployed.

There are a number of potential equity challenges—and opportunities—directly related to the Next OS platform. SANDAG's findings focused on three distinct phases of the technology lifecycle: 1) the design of the platform, 2) the deployment of Next OS and its associated technologies, and 3) the management and operations of the platform. As part of the solution to these challenges, SANDAG will employ a Systems Engineering Process, but it will ensure that unconcious bias in this process is illuminated, addressed, and mitigated. The Systems Engineering Process focuses on users first by defining customer needs and required functionality early in planning and throughout the design and development of the system.

## 3.1 Equity Challenges and Opportunities

### *3.1.1 Next OS Design*

**Requirements**

While becoming more mainstream, most new transportation services, such as ridehailing, tend to be used by people who are younger, wealthier, more educated, and less diverse than the population at large. SANDAG is committed to developing engineering and technical requirements that ensure that the Next OS platform will be accessible to and inclusive of all members of all communities. Special attention will be provided to develop requirements that overcome technological barriers and meet the needs of the region's most vulnerable populations, including seniors, people with physical disabilities, those who are unbanked/underbanked, low-income individuals, minorities, non-English-speakers, and anyone impacted by the digital divide. System requirements will also reflect the needs of rural communities and tribal nations as part of SANDAG's commitment to bridge the digital divide. These efforts will also be supplemented in a forthcoming regional strategy for digital inclusion.

Addressing the digital divide can lead to economic growth and wage increases, alongside easier access to medical care, lower-cost online education, and job opportunities.[6] Ensuring that the needs and concerns of vulnerable populations remain at the center of the design process, particularly the system requirements definition, will ensure that the digital divide is addressed within the domain of Next OS.

**User Interfaces**

A key equity issue for Next OS will be the simple accessibility of its user interface. Because much of the end-user functionality envisioned for Next OS revolves around mobile phones, it will be important that users without a smartphone, credit card, or other modern technologies, or those who are elderly or physically disabled can still access Next OS solutions planned for the region. The digital divide is still a concern, and it continues to impact lower-income and rural households and users more persistently. Although technology adoption is increasing, roughly three in ten adults with household incomes below $30,000 annually do not own a smartphone. More than four in ten do not have home broadband services or a traditional computer.[7] With

[6] Bridging the Digital Divide, University of Pennsylvania, Wharton School, April 2018

[7] Digital divide persists even as lower-income Americans make gains in tech adoption, Pew Research, 2019

fewer options for online access at their disposal, many lower-income people are relying more on smartphones to access the internet and other digital services.[8]

Three percent (3%) of San Diego residents are unbanked, while 19% are underbanked (i.e., they lack access to mainstream financial institutions).[9] A key design element of Next OS will involve kiosks to provide payment options for users without phones or credit cards. Also available will be alternative access methods to wayfinding or travel-time information (e.g., SMS text booking) that do not require a smartphone, as well as account-based payments systems to allow transit subsidies to be used with other mobility services.

The percentage of people in the region aged 65 or older is projected to grow significantly in coming decades. By 2050, this demographic is projected to account for 25% of the region's population—up from about 15% today. Ten percent (10%) of the regional population has a disability.[10] To ensure that these groups are able to access Next OS functionality and solutions, voice-activated digital interfaces will be in place for travel planning and booking, along with related non-visual design elements (e.g., Bluetooth-enabled audio alerts).

**Language**

A final design consideration will be made for non-English-speaking residents. The San Diego region contains a diverse population with a variety of cultures, languages, and traditions. Nearly 40% of San Diego residents speak a non-English language, and about 15% of the population has limited English proficiency.[11] Multilingual interfaces will be designed for all Next OS solutions, and the rollout of specific technologies will be accompanied by targeted outreach and educational marketing, specifically to low-income, minority, tribal, and non-English-speaking communities.

### *3.1.2 Next OS Deployment*

SANDAG has previously identified several regional transit "gaps" occurring in geographic areas that lack adequate public transit and have low private automobile ownership rates. This lack of transit is particularly challenging for individuals with disabilities, those with limited means, and seniors. As Next OS is deployed across the region, it will be important to include all cities, neighborhoods, and rural communities in the region, regardless of characteristics such as population density or income level. As SANDAG has undertaken the 2021 Regional Plan process, there are two planning considerations we have made with regard to equitable deployment of Next OS: 1) equity-focused analysis of data and information and 2) policy, incentive, and partnership models.

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[8] Ibid

[9] 2017 FDIC National Survey of Unbanked and Underbanked Households

[10] San Diego Coordinated Plan, SANDAG, 2018

[11] Data USA, San Diego Region, California, datausa.io/profile/geo/san-diego-county-ca

**Equity-focused Data Analysis and Information**

SANDAG has analyzed supply–demand, origin–destination, employment and demographic, and traffic data across the region to ensure that the planning process is equity-driven and expands transportation service coverage across the region. SANDAG has also consistently gathered resident feedback from travel surveys, informal intercepts, focus groups, and community forums to understand local needs, and this resident feedback has been incorporated into the planning process. It has been a similar priority for SANDAG to develop a deployment plan for Next OS technologies that accounts for the entire region and targets gaps in transportation services. To that end, certain advanced use cases of Next OS could be piloted first in areas currently underserved by the public transportation network before they scale to the rest of the region. Microtransit services, for example, can expand public transit access and provide a first-mile/last-mile link to traditional fixed-route services. They are a natural focus for initial demonstration pilots in underserved areas.

**Policy, Incentive, and Partnership Models**

Beyond the planning process, SANDAG has explored policies, incentives, and partnership models that can complement Next OS technologies to ensure adequate service levels in the future. For example, local incentives for private mobility providers can be set to encourage service for low-income users or low-density areas, with ridership origin–destination data verified by Next OS. Shared mobility subsidies for qualified residents and pre-tax benefits for commuters can improve regional connectivity to employment centers, healthcare, and education. Discounts and offsets for pricing can be allocated for qualified users with incentives for using public transit during peak periods. Partnerships with businesses, nonprofits, universities, tribal nations, and consolidated transportation service agencies should also be encouraged, with Next OS APIs allowing them to offer their customers multimodal travel options as part of their own product offerings (e.g., a shared mobility trip bundled with a medical appointment).

By setting key performance indicators (KPIs) for community participation and equity goals, SANDAG can help ensure that equity is a continuing priority for policymakers and service operators as they use Next OS in their communities.

### *3.1.3 Next OS Management and Operations*

Once deployed, there are additional equity considerations that must be addressed around the future management and operation of Next OS. Much of the promise of the platform is focused on its powerful data analysis and machine learning capabilities, as well as its related ability to manage infrastructure and transportation services more dynamically. However, there are risks that should be acknowledged and mitigated well in advance of the platform's rollout.

**Algorithmic Bias Prevention**

As machine learning has been applied to real-life scenarios, from banking to retail to media, researchers have praised its ability to derive new insights from massive datasets. Recently, there also has been a growing caution against the risk it can pose in reproducing and even expanding upon human biases in what is known as "algorithmic bias."[12] Machine learning algorithms are trained to sift through massive datasets and discover the "correct" answer. They then construct a model that can be applied to other datasets to make predictions about a correct output. However, because the algorithms are trained by humans with their own implicit biases, or because their training data can be unrepresentative or incomplete, machine learning has been found to sometimes make recommendations or predictions that reflect historical inequities. If training data is inaccurately collected, an error or unjust rule can become part of the algorithm. For example, an algorithm directed to sift through online résumés for the best job candidate—but trained on what qualifications for "best candidate" might mean based on the company's current leadership—may identify recommended candidates on the basis that they are white and male.

**Decision Support System and Data Fairness**

Recent studies have found that such bias can occur in transportation, where many of the datasets around transportation network design and service provision implicitly favor men over women. As SANDAG plans for the management and operations of Next OS, it will enshrine fairness as a doctrine in its decision–support systems to ensure that the machine learning algorithms do not discriminate against people on the basis of race, gender, disability, or other designations. This principle can be applied to the platform's analytics and simulation capability in several ways.[13] Data can be "pre-processed" to reduce differences between non-protected and protected classes, therefore avoiding biases becoming inadvertently incorporated into the algorithms. The algorithms can also be made to operate fairly by design by incorporating equity KPIs directly into their decision-making process. Finally, there should be post-processing measures that include regular, cross-functional review and monitoring of platform decisions to avoid algorithmic biases.

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[12] "Algorithmic bias detection and mitigation: Best practices and policies to reduce consumer harms," Brookings Institution, May 2019

[13] "How fair algorithms can help building better transport systems for women," Diamond, September 2019

## 3.2 Additional Equity Opportunities

As Next OS is designed, deployed, and managed, SANDAG expects that its powerful data ingestion and analytics capabilites can be leveraged to uncover new opportunities to improve transportation equity in the region.

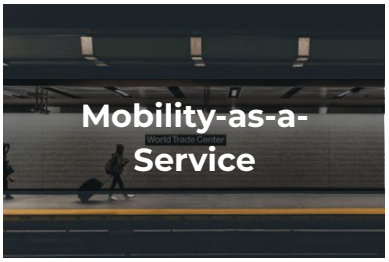
For example, by making historical (and anonymous) transportation datasets open to the public, SANDAG can offer local students, data scientists, and developers the opportunity to build new civic solutions to address mobility needs in their own communities. For example, a hackathon hosted in 2017 by “Smart City Hack” generated participation across 22 cities and led to the creation of an app that allowed homeowners and businesses to post open parking spaces and a location and assistance app for people with disabilities. Columbus, Ohio held a hackathon in 2018 that focused on transportation challenges such as parking and transit access in low-income neighborhoods. These initiatives can offer incentives to local programmers or private citizens to help make the San Diego region “smarter” while jumpstarting our local entrepeneurial ecosystem.

Meanwhile, the improved fidelity and variety of data collected by the Next OS will allow SANDAG to better plan transportation investments in the region that meet all of our residents’ needs. It also offers new channels for SANDAG and our partners to engage with residents. As other Next OS use cases and solutions are deployed—or as-yet-unknown civic solutions are built upon the platform—new opportunities to expand transportation equity in the region will continue to unfold.

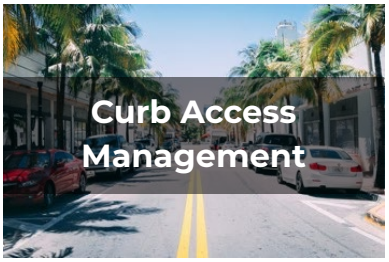
# 4.0 Looking Ahead and Prioritized Use Cases

To plan for the long-term deployment of Next OS and guide the initial development of the platform, SANDAG prioritized six use cases—specific ways in which Next OS will enhance mobility across the region. These use cases align with current priorities for the region at SANDAG,  and they can be used to solve future transportation challenges. Some of these use cases are new systems that will be piloted in specific areas of the region and then scaled regionally. As they are, they will be continually improved and evaluated. Other use cases will build off cutting-edge transportation demand management systems that already exist in the region, such as the Integrated Corridor Management System (ICMS) along I-15.

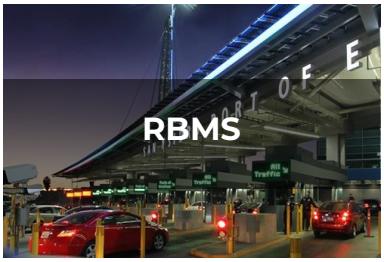
Each use case requires different capabilities of the Next OS platform, and each one will be designed and developed so it is compatible with the architecture of the regional Next OS platform. The completion of the Next OS ConOps and the regional ITS Architecture update will guide the initial development of the use cases and move Next OS from concept to implementation.



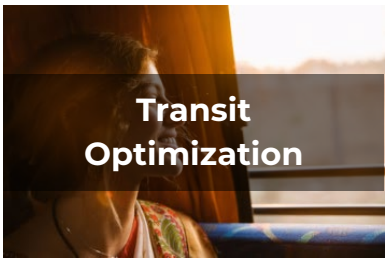

An integrated app to plan, book, and pay for trips across public and private modes and earn loyalty rewards




Dynamic management of curb access rules for flexible use in freight (un)loading, passenger pick-up/drop-off, and micromobility

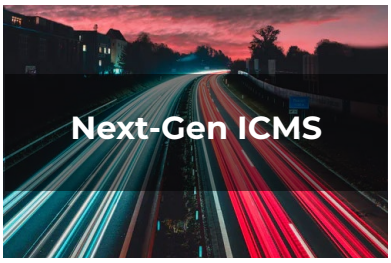



Regional Border Management System with wait times, incident reports, and dynamic tolling to improve crossborder travel flow




Dynamic routing, scheduling, and vehicle-to-infrastructure communications for transit operators with direct feedback and reporting from travelers


Traffic flow analysis and dynamic signal controls that manage traffic and can give priority to different users (transit, bikes, pedestrians, freight, and/or emergency vehicles)




A cloud-based analytics and simulation system to coordinate traffic signals, ramp meters, and other technologies along the region's Complete Corridors

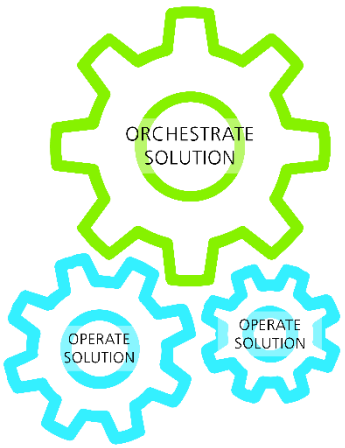
*Figure 18: Next OS Use Cases and Projects*

Next OS offers the promise of a digitally connected transportation network that moves people and goods more safely, sustainably, efficiently, and cost-effectively throughout the region. The magnitude and complexity of Next OS requires careful planning to define how this digital platform will encompass existing services, infrastructures, and systems in the San Diego region as well as those planned for the future.

SANDAG recognizes that Next OS is more than a single solution, but rather a system of systems, as described in this document. The platform provides the digital infrastructure needed for all the region's 5 Big Moves to be fully realized. At the same time, it will also enable new solutions for orchestrating the entire regional transportation system. This has led SANDAG to define two categories of Next OS solutions that will be pursued in parallel: **operate solutions** and **orchestrate solutions**.

## *Operate Solutions*

**Operate solutions** refer to the many existing and new systems that manage a single isolated element (e.g., traffic signals and parking spaces) of the overall transportation network, and have stand-alone value in doing so. One example of an operate solution existing today is the ramp metering system along I-15, which dynamically controls the rate at which vehicles merge onto the highway. Ramp metering is, in isolation, a powerful tool to manage congestion. Since implementing ramp metering, cities around the U.S. have seen up to 170% increases in traffic speeds and up to 150% decreases in travel time.[14] This operate solution and others have been shown to be effective, and they will help the 5 Big Moves, including Next OS, achieve their planned outcomes.




In the context of the 5 Big Moves, the operate solutions for Next OS account for many of the technology features present in Mobility Hubs, Complete Corridors, Flexible Fleets, and Transit Leap. This includes solutions such as curb access management, smart parking, dynamic routing, smart intersections, and micromobility management—solutions that have inherent value as standalone systems and therefore can be piloted, tested, and deployed that way.

[14] ops.fhwa.dot.gov/publications/fhwahop14020/sec1.htm

### *Orchestrate Solutions*

**Orchestrate solutions** refer to the system of systems that connect several operate solutions and apply advanced simulation and analytics capabilities to continuously optimize the configurations of those solutions based on various real-time and forecasted conditions. An example of an orchestrate solution present in San Diego is the I-15 ICMS, which connects various operate solutions—ramp metering, signal timing, transit routing, and tolling—along the corridor. By connecting these operate solutions and continuously running simulations based on real-time conditions, the ICMS can orchestrate the configurations of the operate solutions in real time to mitigate the impacts of traffic incidents and special events. Preliminary results from the I-15 ICMS indicate a 12.6% improvement in travel time reliability.[15]

This is where Next OS will offer a big part of its value. While accelerating the deployment of operate solutions throughout the region, Next OS will also orchestrate them regionwide, because they are all integrated into a common digital platform. The I-15 ICMS is a local example of how Next OS can become the "brain" of the entire regional transportation network.

## 4.1 Phased Approach to Deploying Next OS Solutions

Next OS solutions will generally be deployed in several phases:

| Phase | Description |
|---|---|
| **Phase 0**<br>System Engineering Design | Before any deployment, thorough analysis must be conducted, including a detailed current-state gap analysis, operational requirements (ConOps), impact analyses, and feasibility studies to further justify the need for each use case. |
| **Phase 1**<br>Pilot | The first phase includes piloting the operate solution at a small scale for a predetermined period. In this phase, a pilot location is determined, the solution is designed and built, data is collected on its use, and performance is measured. |
| **Phase 2**<br>Scale and Extend | Upon a successful pilot deployment, the solution is then scaled to additional geographic locations and extended to accommodate additional operational objectives by piloting new features. |
| **Phase 3**<br>Integrate | The solution continues to expand geographically, extend its functionalities, and now integrates with orchestrate solutions, which can use the solution as an effective lever in managing the complete network |

[15] fhwa.dot.gov/publications/publicroads/10novdec/02.cfm

## *Putting the Next OS in Motion*

The next steps required to move Next OS toward implementation are largely planning and technical in nature. That said, it is important to acknowledge the underlying complexity with some steps that require iteration or repetition in order to prepare for and realize the integration and operation of Next OS across multiple projects, multiple systems, and multiple jurisdictions. These next steps, tasks, and activities will require momentum, collaboration, and enthusiastic leadership. They will be a heavy lift for SANDAG and regional stakeholders. To provide structure and organization for the upcoming effort, the development of Next OS will follow an established formal system engineering process as illustrated in the V-diagram in Figure 19. We are currently in the Concept Exploration and Regional Architecture phases (the left wing of the V). SANDAG's Regional ITS Architecture update and Next OS ConOps will be developed in parallel and will guide future deployments of Next OS. In addition, recognizing that communications infrastructure plays a pivotal role towards the implementation of the Next OS, a near-term effort is the completion of a regional communications digital strategy in an effort to address the digital divide. The strategy will set forth a regional roadmap that will focus on identifying communications infrastructure improvements including examining private partnership opportunities to bring affordable, reliable, and high-speed broadband internet access to underserved and rural populations.

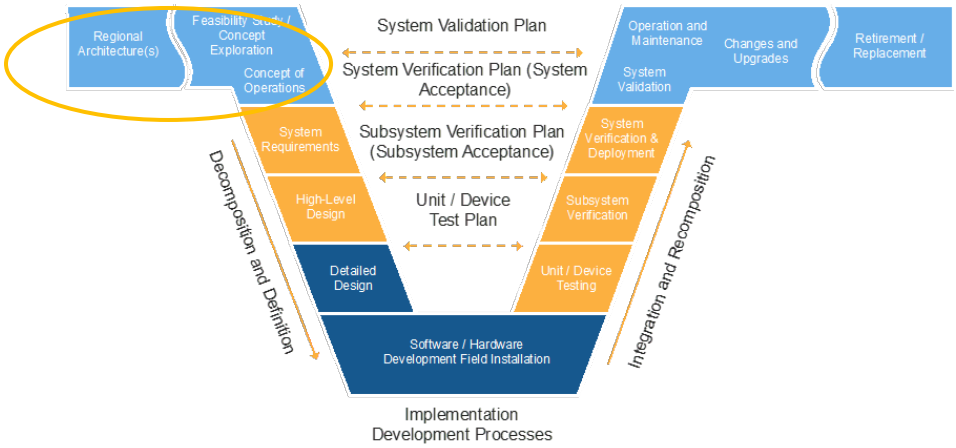



*Figure 19: FHWA V-Diagram Systems Engineering Process Model*

# Appendix A – Additional User Journeys

The following pages include additional user journeys that illustrate ways in which Next OS would enhance the region's transportation experience for residents and businesses.

# Carrie

**Drives her children to school on her way to work**
**Occupation:** Sales Executive
**Location:** El Cajon

**Trip Metrics (Present)**
**Distance:** 25 mi
**Duration:** 1 h

**Trip Metrics (Future)**
**Distance:** 25 mi
**Duration:** 41 min

**Est. Time Savings:** 20 minutes (33%)

## Plan

Carrie opens her navigation app, enters her daughters' school as a drop-off destination, and selects the fastest route along the I-8 and I-805

## Re-Route

En route, she receives notification that she can reach the school faster by paying to use the Express Lane

## Alert

Carrie's car receives a pedestrian warning. She slows down as a child walking to school emerges from her blind spot

## Drop-Off

Carrie arrives at the school, and the navigation app directs her to a curb space marked by an LED light where she can safely drop off her daughters

## Arrive


Carrie drives to work and since her office's lot is full, parks in a reserved street parking spot. Her navigation app shows the total cost of her trip including curb access and parking

San Diego FORWARD

# Daniel

**Relies on on-demand services for visits to his specialist at UCSD Medical (Hillcrest)**
**Occupation:** Retired
**Location:** Escondido

**Trip Metrics (Present)**
**Duration:** 1 hr 35 min
**Transfers:** 1

**Trip Metrics (Future)**
**Duration:** 1 hr 10 min
**Transfers:** 1

**Est. Time Savings:** 25 minutes (26%)

## Book

Daniel obtains a referral code from his clinic to book a discounted trip on a Next-Gen Rapid route online

## Go

Daniel walks to the Escondido Transit Center and boards a Next-Gen Rapid that uses a bus-only lane to bypass heavy I-15 traffic

## Transfer

At the mobility hub, Daniel taps his Compass Card at a kiosk that directs him to a nearby pick-up location where an ambassador helps him board the autonomous shuttle

## Ride

As the autonomous shuttle is heading toward the medical center, traffic signals stay green to keep Daniel's vehicle on schedule

## Arrive

Daniel rides the shuttle to the UC San Diego Medical Center and books his return trip with reception upon check-in

San Diego FORWARD

# Greg & Silvia

**Truck drivers bringing in and distributing goods from Mexico**
**Occupation:** Truck Drivers
**Location:** Ensenada & San Diego

**Trip Metrics (Present)**
**Distance:** 92 mi
**Duration:** 4 hr 5 min

**Trip Metrics (Future)**
**Distance:** 92 mi
**Duration:** 2 hr 25 min

**Est. Time Savings:** 1 hr 40 min (41%)

## Plan

After picking up fresh strawberries near Ensenada, Greg uses his navigation app to select a preferred truck route to cross the border for drop off at a warehouse in Otay Mesa

## Cross

While driving, Greg receives a notification that he can save two hours by crossing at the new Otay Mesa East Port of Entry (POE), so he decides to cross there

## Pass

After arriving in the U.S., Greg pays the Otay Mesa East access toll on State Route 11 (SR 11) and heads toward the Otay Mesa distribution warehouse to complete his delivery

## Transfer

Silvia, a driver for a local distributor, drives to the Otay Mesa warehouse to pick up a load of strawberries. While driving south on I-5, a lane is designated for freight, allowing Silvia to pick up her load ahead of schedule.

## Drop-Off

Silvia drives to her company's warehouse to drop off the load and restock with orders for local restaurants. She uses her navigation app to reserve a curb space where she can safely unload her first delivery in Hillcrest

San Diego FORWARD

# Appendix B – Glossary, Acronyms, and Abbreviations

| Acronym | Definition |
|---|---|
| AI | **Artificial Intelligence** is the simulation of human intelligence processes by machines, especially computer systems. AI algorithms are designed to make decisions, often using real-time data. |
| API | **Application Programming Interface** is a set of routines and protocols which allow two or more applications to talk to each other and share information between their respective software programs. |
| ATDM | **Active Transportation and Demand Management** is a DOT program intended to support agencies and regions considering moving toward an active management approach. The support is provided via customized workshops, tools, guidance documents, resources, and peer exchanges, and to assist with technical support to implement ATDM strategies. |
| CARB | **California Air Resources Board** is one of six boards, departments, and offices under the umbrella of the California Environmental Protection Agency. CARB focuses on California's unique air quality challenges by setting the state's own stricter emissions standards for a range of statewide pollution sources including vehicles, fuels, and consumer products. |
| CMM | The **Capability Maturity Model** is a methodology used to develop and refine an organization's system or software development process. The **model** describes a five-level evolutionary path of increasingly organized and systematically more mature processes. It has been used extensively worldwide in the public sector and private industry. |
| CoE | **Center of Excellence** refers to a team, shared facility, or an entity that provides leadership, best practices, research, support, and/or training for a focus area. It may also be aimed at revitalizing stalled initiatives, or describe a network of institutions collaborating with each other to pursue excellence in a particular area. |
| ConOps | **Concept of Operations** is a document describing the characteristics of a proposed system from the viewpoint of an individual who will use that system. The ConOps describes how a set of capabilities may be employed to achieve desired objectives, and it is written to communicate the quantitative and qualitative system characteristics to all stakeholders. |

| Acronym | Definition |
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| DSRC | **Dedicated Short-Range Communications** is an open-source protocol for wireless communication, similar in some respects to WiFi. While WiFi is used mainly for wireless Local Area Networks, DSRC is intended for highly secure, high-speed wireless communication between vehicles and the infrastructure. |
| DSS | A **Decision Support System** is a computerized program used to support determinations, judgments, and courses of action in an organization or a business. It analyzes massive amounts of data, compiling comprehensive information for use in problem solving and decision-making. |
| FHWA | The **Federal Highway Administration** (FHWA) provides stewardship over the construction, maintenance, and preservation of the nation's highways, bridges, and tunnels. FHWA also conducts research and provides technical assistance to state and local agencies to improve safety, mobility, and to encourage innovation. |
| FMLM | **First-Mile/Last-Mile** refers to that portion of a journey for a public transportation rider where he or she must travel to and return from the public transportation stop or terminal. The FMLM can be walked, driven or even bicycled. The further the FMLM distance is from public transportation, the more people may perceive it as an impediment to using public transportation. |
| GBFS | **General Bikeshare Feed Specification** is the open data standard for **bikeshare**. GBFS will make real-time data feeds publicly available online in a uniform format, so that map- and transportation-based apps can easily incorporate this data into their platforms. |
| GTFS | The **General Transit Feed Specification** is a data specification that allows public transit agencies to publish their transit data in a format that can be consumed by a wide variety of software applications. Today, the GTFS data format is used by thousands of public transport providers. |
| ICM | **Integrated Corridor Management** is a process to improve the movement of people and goods along metropolitan corridors through a multimodal, integrated, transportation management approach. The corridor is viewed as a system, rather than individual transportation networks. |
| ICMS | The **Integrated Corridor Management System** allows individual transportation systems to be operated and managed as a unified corridor network. SANDAG's ICM system went live in early 2013. |
| IT | **Information Technology** is the study or use of systems (especially computers and telecommunications) for storing, retrieving, and sending information. |

| Acronym | Definition |
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| ITS | An **Intelligent Transportation System** is an advanced application that aims to provide innovative services relating to different modes of transport and traffic management, and enable users to be better informed and make safer, more coordinated, and 'smarter' use of transport networks. |
| KPI | A **Key Performance Indicator** is a measurable value that demonstrates how effectively a company is achieving key business objectives. Organizations use KPIs at multiple levels to evaluate their success at reaching targets. |
| MaaS | **Mobility-as-a-Service** describes a shift away from personally owned modes of transportation and toward mobility provided as a service. |
| MDS | **Mobility Data Specifications** is a standard for exchanging data between mobility operators and cities or other regulators. Consisting of several APIs, it allows agencies to analyze data from mobility operators in a standardized format and implement regulation digitally. |
| MPO | A **Metropolitan Planning Organization** is the policy board of an organization created and designated to carry out the metropolitan transportation planning process. MPOs are required to represent localities in all urbanized areas (UZAs) with populations that exceed 50,000 people, as determined by the U.S. Census. |
| MTS | **Metropolitan Transit System** (San Diego County) is the public transit service provider for Central, South, Northeast, and Southeast San Diego County, in the United States. |
| NCTD | The **North County Transit District** is the agency responsible for public transportation in North San Diego County, California, United States. |
| Next OS | The **Next Operating System** (OS) is the "brain" of the entire transportation system. It is a digital platform that uses technology and data to connect and manage different modes of transportation – passenger vehicles, buses, ride-sharing vehicles, delivery trucks, autonomous vehicles, bikes and scooters, and more – to improve overall efficiency and accessibility for people and goods to move throughout the region.<br>Next OS will modernize the existing transportation system by using technology to better manage supply and demand. The result will be roadways and transit services that operate more smoothly and serve people better. |
| PeMS | The **Freeway Performance Measurement System** collects real time traffic data from sensors and generates performance measures of vehicle miles traveled, hours traveled, and travel time. |
| RAMS | A **Regional Arterial Management System** used for interjurisdictional signal coordination as well as local advanced traffic and event management. RAMS Integrates with cameras, signals, vehicle sensors, and message signs. |

| Acronym | Definition |
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| RBMS | The **Regional Border Management System** will provide fast, predictable, and secure border crossings by constructing a four-lane tolled road connecting directly to a state-of-the-art Customs and Border Protection Land Port of Entry and a California Highway Patrol Commercial Vehicle Enforcement Facility. |
| ROI | **Return on Investment** is a financial ratio used to calculate the benefit an investor will receive in relationship to their investment. |
| SANDAG | **San Diego Association of Governments** serves as the forum for decision-making in the San Diego region. SANDAG builds consensus; makes strategic plans; obtains and allocates resources; plans, engineers, and builds public transportation; and provides information on a broad range of topics pertinent to the region's quality of life. |
| SCOS | **Smart City OS** is an open platform that platform brings cities to life, visualizing real-time data on large displays and mobile apps. The system uses artificial intelligence to measure citizen responses and amasses massive amounts of data to improve public sector decision making. |
| SLA | A **Service Level Agreement** is a contract that establishes a set of deliverables that one party has agreed to provide another. This agreement can exist between a business and its customers, or between one department that delivers a recurring service to another department within that business. |
| TDM | **Transportation Demand Management** is the application of strategies and policies to reduce travel demand, or to redistribute this demand in space or in time. Integrating the TDM philosophy into the delivery of a sustainable urban transportation system is a crucial part of urban transportation planning, as well as the daily management and operation of transportation services and infrastructure. |
| TNC | A **Transportation Network Company** is a business model that offers prearranged rides or car rentals for a fee, using an online application (app) via a mobile device to connect passengers or car renters with drivers/car owners. Examples include Uber and Lyft, |
| USDOT | **United States Department of Transportation** is a federal cabinet department of the U.S. government. It was established by an act of Congress on October 15, 1966, and it began operating on April 1, 1967. It is governed by the United States Secretary of Transportation. |
| VMT | **Vehicle Miles Traveled** is a measure used in transportation planning for a variety of purposes. It measures the amount of travel for all vehicles in a geographic region over a given period, typically one year. |