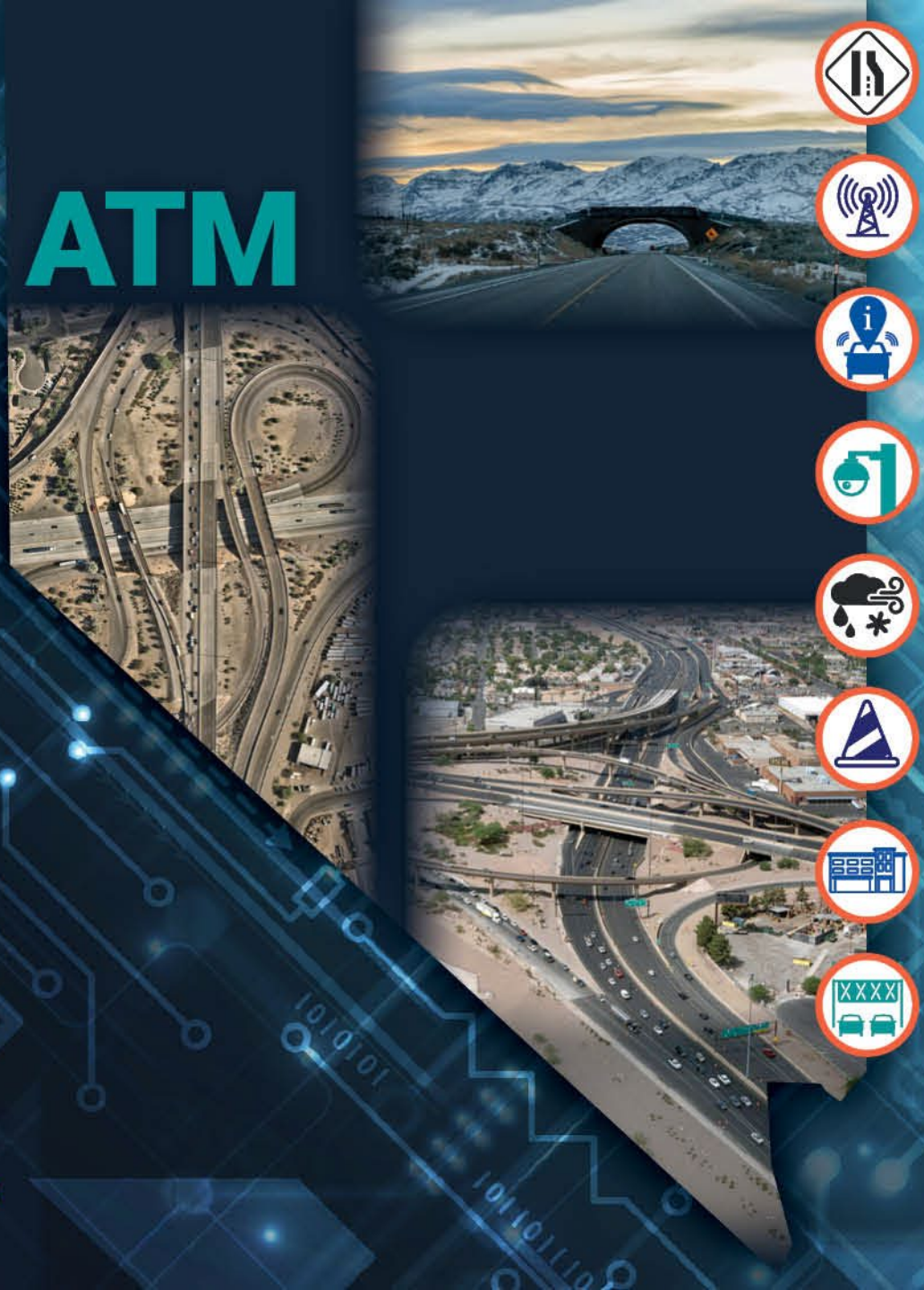
NEVADA
Statewide ITS & ATM
Master Plan



NEVADA DOT
SAFE AND CONNECTED

Kimley»Horn

AtkinsRéalis

What is this plan?

What is this plan?

The Nevada Statewide ITS & ATM Master Plan is a data driven planning document which identifies ITS needs and provides data-supported solutions. Nevada D.O.T. (NDOT) defines ATM as "Active Traffic Management" and uses this term to describe a series of overhead gantries with dynamic message signs that span the width of the roadway and convey dynamic lane assignments, dynamic speed limits, and critical traveler information (pictured on slide 6). NDOT defines Intelligent Transportation Systems (ITS) as any technology which is used to improve the transportation system.

Previously, NDOT installed ITS equipment on an ad hoc basis – based on the opinions of decision makers and what they thought might be best, with little data or evidence to make the decision.

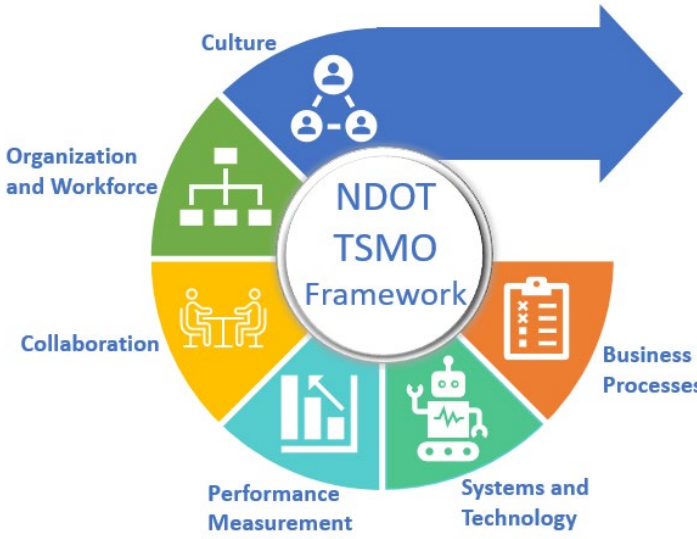
This plan improves the efficiency of Nevada's decision- making process by recommending the strategic deployments of technologies that will maximize the efficiency of our transportation operations.

Where did this plan come from?

NDOT TSMO Program

TSMO Planning creates the BLUEPRINTS

ITS are the TOOLS



Strategy
Implementation

NDOT TSMO Program

- Nevada DOT's Transportation Systems Management and Operations (TSMO) program began in 2018 and was formally adopted in 2020.
  - Quick definition: TSMO is a philosophy aimed to manage and operate transportation systems with an emphasis on maximizing efficiency through improved processes, coordination, and utilization of existing infrastructure, money, and resources.
- Our Director and upper management "saw the light" and prioritized the benefits of maximized efficiency of operations through technologies that were more cost effective than roadway expansions.
- This led to the install of our first ATM corridor in 2020….

ATM Corridors

- Successful pilot of first ATM corridor: 2020 in downtown Las Vegas
- How/where do we expand?
- Need justifiable reasons for new locations
- Why do we not have a data-driven approach for all ITS?
- Reason for plan name

ATM Corridors

- The corridor is now successful in managing traffic during incidents, peak hours, and major Las Vegas events.
- Our upper management was interested in expanding the use of ATM, but these corridors are very expensive and it was clear that the Department would not be able to install them everywhere. So where should we install them? With a TSMO philosophy in mind, our upper management asked us to look at the data to determine the best locations to install additional ATM corridors. We agreed that it would be best to create a new data-driven plan to analyze all existing data we had access to and then allow those findings to identify areas that would benefit most. If we were going to go through all this work for ATM corridors, it was decided that we should also look at all other ITS devices and produce data-driven recommendations for them as well.
- Side note – this is the purpose for the somewhat redundant name of the plan. The impetus was regarding ATM corridors, and we decided to keep "ATM" in the title to easily connect those dots for upper management, but we wanted the title to accurately convey that the plan included other ITS recommendations also.
- Thus, the ITS & ATM Master Plan was theorized! As with all good plans, we started by identifying our goals….

Vision and Strategic Focus Areas

TSMO Vision:

- Improve efficiency
- Maximize financial value
- Prioritize travelers' experiences

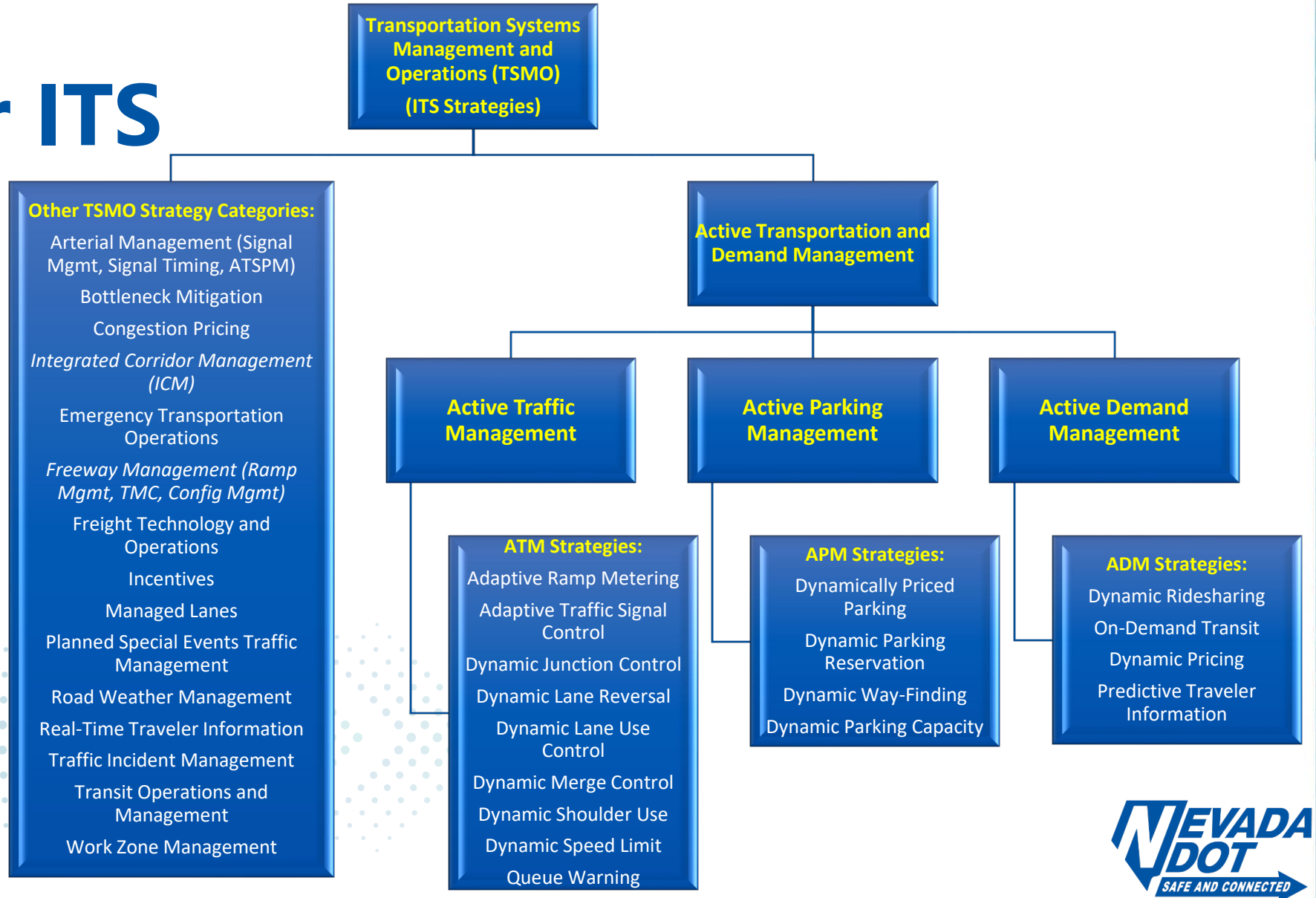
For each focus area:

- Goals and Objectives to work toward
- Strategies being developed

Vision and Strategic Focus Areas

- NDOT decided to align the goals of this data-driven plan with the goals of our TSMO program, which prioritizes efficiency, cost savings, safety, improved partnerships, and traveler experience.
- Note that these goals include more than just an increase in ITS device installations. We wanted this plan to identify all areas within the process of scoping, planning, designing, building, operating, and maintaining our ITS equipment that could use improvement. This includes improvements to the systems that run the devices, the processes that utilize the devices, and the coordination between all personnel who interact with the devices or their data.
- With that said, we did identify some technological strategies that we desired to pursue where needed…

Evaluating Options for ITS Strategies



Evaluating Options for ITS Strategies

- NDOT decided that we wanted certain TSMO strategies considered – instead of just waiting to see what the data and consultant recommended, NDOT wanted to specifically evaluate several technology-based strategies to see if any of these strategies would provide benefit to a given situation. These strategies can be seen in the "Other TSMO Strategy Categories" category on this slide.

- As previously mentioned, Active Traffic Management (ATM) was the driving factor, so it was broken out separately in this diagram to more clearly identify the strategies being considered for this topic. We recognized that ATM is a part of the broader topic of Active Transportation Management and listed the other categories of "Active Parking Management" and "Active Demand Management" to acknowledge that NDOT was intentionally NOT considering these strategies at this time – due to current resources and capabilities.

Project Milestones

Late 2022 — Existing Conditions

Early 2023 — Needs & Gaps Assessment

Spring 2023 — Deployment Recommendations

End 2023 — Implementation Plan

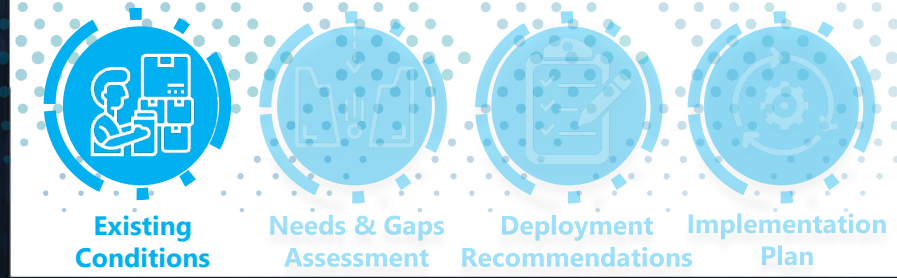
Stakeholder Engagement and Coordination

Project Milestones

- Once we had our goals established, we entered into an agreement with Kimley Horn (who recruited assistance from Atkins Realis) and got started!
- The process produced 4 Technical memos (ranging from 79 – 173 pages each) shown on this slide.
- The next several slides will detail the research, the analysis, the data-driven recommendations (and utilization of engineering judgment), the final product, and how it is being implemented today….

Stakeholder Engagement

- NDOT District 1
- NDOT District 2
- NDOT District 3
- NDOT Traffic Operations – ITS Planning and Operations
- NDOT Traffic Operations – Technology Services
- NDOT Traffic Operations – Signals, Lighting, & ITS Design
- NDOT Traffic Operations – Signs, Striping, and T.C. Design
- NDOT Traffic Operations – Operations & Network Analysis
- NDOT Planning
- NDOT Freight
- NDOT Sustainable and Emerging Transportation (SET)
- NDOT Structures
- NDOT Construction
- Regional Transportation Commission (RTC) of Southern Nevada (RTC SNV)
- RTC of Washoe County (RTC Washoe)
- Carson Area Metropolitan Planning Organization (CAMPO)
- Nevada National Oceanic and Atmospheric Administration Weather Forecast Offices in Elko, Reno, and Las Vegas
- Nevada State Police Highway Patrol (NHP) Northern Command, Central Command and Southern Commands
- A variety of local public agencies (city and county agencies) in proximity to state-owned facilities



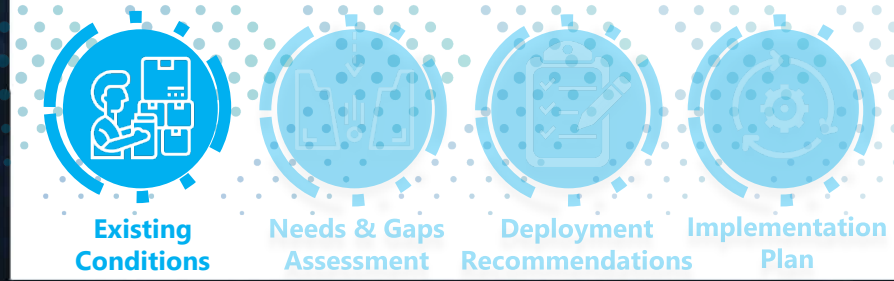
Stakeholder Engagement

- This slide lists all agencies/divisions/offices that were contacted for this effort.
- The Kimley Horn team conducted a thorough round of interviews to:
- Gather input/perspective from all stakeholders regarding the current processes and views of needs.
- Gather all the relevant documents and data….. Speaking of relevant documents….

Collection of Information

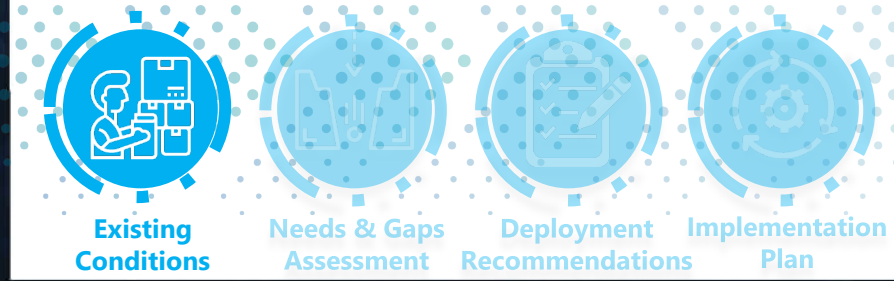
- Existing ITS infrastructures
- Conditions of existing infrastructures
- Nevada Citation and Accident Tracking System (NCATS) statewide crash data (KABCO severity index)
- Fatality Analysis Reporting System (FARS) data
- Rekor (formerly WayCare) data
- Regional Integrated Transportation Information Systems (RITIS) traffic congestion data
- State and federal laws/regulations

- 93 planning documents/transportation studies
  - NDOT programs and SOPs
  - NDOT plans
  - Local agency programs and plans
  - TSMO program documents and CMM
  - Wildlife migration pattern studies
  - Weather data and patterns
  - Freight patterns
  - Funding sources and incentive programs
  - Currently programmed projects
  - Nationwide and non-Nevada studies
  - Innovative technologies (AI, EV, AV, Drones, etc.)
  - Incident responders' systems



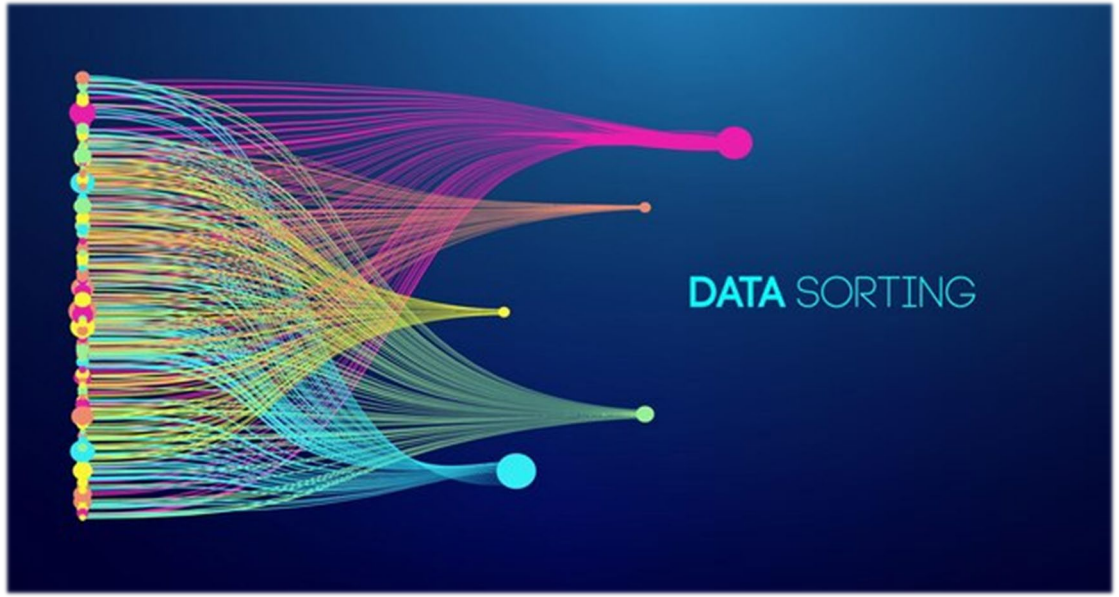
Collection of Information

- Existing ITS infrastructures
  - All existing ITS devices and associated infrastructure currently in the field (at time of study)
- Conditions of existing infrastructures
  - Some of this was estimated for the purposes of this plan. A robust asset management program is still being developed.
- NCATS, FARS, Rekor, KABCO severity index
  - Crash location
  - Crash severity (Fatal, Serious, Minor, Possible/Unknown, Property Only)
  - Crash type
  - Vehicle factors
  - Driver factors
  - Most harmful event
  - Driver age
  - Weather conditions
  - Lighting conditions
  - Date
  - Time

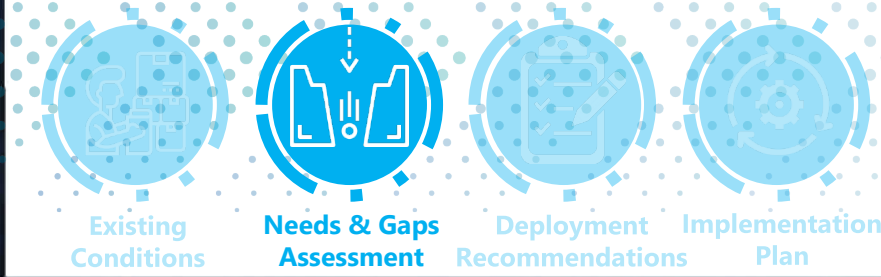


- RITIS traffic congestion data
  - Speed data
  - Travel time Index (TTI)
    - TTI = Travel time/free-flow travel time
  - Travel time reliability
  - Traffic Counts
  - Congestion data
    - Speed reduction factor = (av. peak period speed/ free-flow speed) x 100
  - Queue lengths
  - Bottleneck ranking
  - Total delay
    - Delay = (observed travel time – free-flow travel time) x AADT x day-of-week factor
- State & federal laws/regulations + incentives
  - License plate capture
  - Shoulder running
  - Drones
  - EV/Alternative fuels

Data Analysis



- Started with road segments
  - Based on Regional Integrated Transportation Information System (RITIS).
- Classified types of roadways
  - Urban
  - Urban Lite
  - Rural
- Created hundreds of categories for evaluation
  - We will look at some examples on next several slides.
- Evaluated based on:
  - Risk of injury
  - Time delay
  - Environmental impact
  - Cost to NDOT and public
- Qualitative criteria
  - Will be discussed in later slides
- Evaluated against NDOT goals
  - Discussed on previous slides



Crash Analysis

- Are all crashes created equal?
- KABCO Scale from National Highway Traffic Safety Administration (part of U.S.D.O.T.)

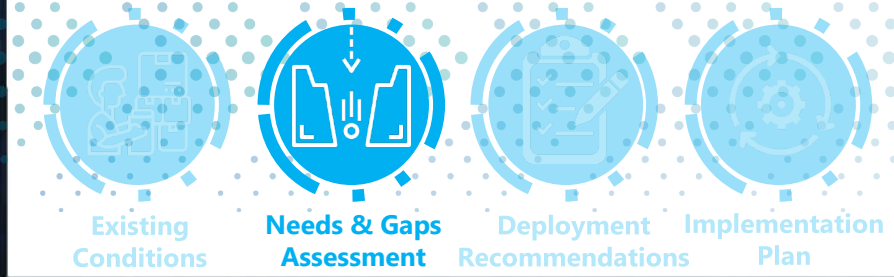
K – Kill (Fatality)

A – Injury Type A (Serious)

B - Injury Type B (Minor)

C - Injury Type C (Unknown/Potential)

O – Only Property Damage



Crash Analysis

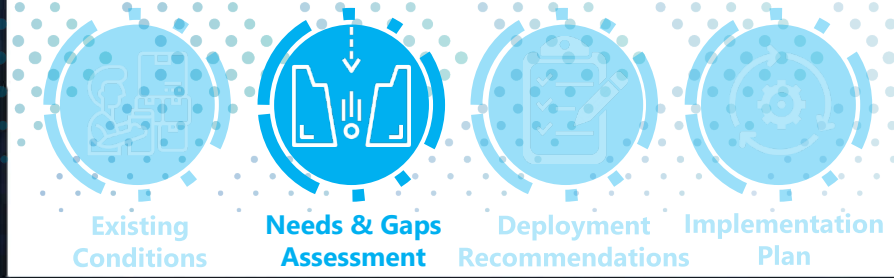
Crash Severity	Severity Weight	EPDO Index
Fatal	568.00	2272.00
Injury Type A	30.00	390.00
Injury Type B	11.00	1177.00
Injury Type C	6.00	4416.00
PDO	1.00	1597.00

- It was determined that a fatal crash is 568 times more impactful than a Property-Damage-Only crash.
- Equivalent Property Damage Only (EPDO) Index equates all crashes to the lowest severity crash to compare apples to apples.

Table 3 – Safety (EPDO) Priority Corridor Statewide Summary

Rank	Route	DIR	TMC Segment Cross Street in Proximity	Functional Classification	NHS	% NHS	County	EPDO Score
1	I-15	NB	I-15/WILBER CLARK DESERT INN WEST RD	1 - Interstate	Yes	100	CLARK	12545.34201
2	I-15	SB	I-15/W RUSSELL RD	1 - Interstate	Yes	100	CLARK	10901.53164
3	NV-582	SB	E RUSSELL RD	3 - Principal Arterial: Other	Yes	100	CLARK	7352.869491
4	I-15	NB	CHARLESTON BLVD/EXIT 41	1 - Interstate	Yes	100	CLARK	6656.869812
5	NV-589	WB	NV-604/LAS VEGAS BLVD	3 - Principal Arterial: Other	Yes	100	CLARK	6394.218166

- Each crash was multiplied by the corresponding EDPO Index value then the sum of all crashes provided an EPDO score that compares the overall impact of crashes within each segment.



Crash Analysis

Project No.	Sum of EPDO Index	EPDO Index	Normalized Sum of EPDO Index
D1-001	9852	9852.00	0.32
D1-002	4903	4903.00	0.16
D1-003	12298	12298.00	0.40
D1-004	30908	30908.00	1.00
D1-005	5999	5999.00	0.19
D1-006	12694	12694.00	0.41

- Once we had an EPDO total for each segment, the number was normalized to a ratio that made it comparable to other crash data values.

Table 1 – Crash Score (EPDO Score) Ranking Thresholds

EPDO Score		Distribution of Total Weight for Safety
At or Below Average	0	0%
Above Average and Below 90 Percentile	1	40%
At or Above 90 Percentile	2	60%

- These values were then weighted based on their severity compared to an average roadway segment so we could focus on the most severe issues.

Animal-Related Crashes

- Compiled all animal-related crashes and analyzed how many resulted in human injuries or property damage only.
- Determined probabilities of each animal causing injury or property damage.
- This data is used in combination with probability that a driver will encounter an animal to determine overall risk and cost levels.

Table 2 – Animal-Related Crashes Adjustment Factor

Animal Type	Injury	PDO	Total Crashes	Injury Probability	PDO Probability	Animal Type Probability	Injury and Animal Type Probability	Injury and Animal Type Probability Percent Total	Animal Adjustment Factor
Deer	32	511	543	5.89%	94.11%	61.92%	3.65%	47.76%	0.477612
Horse	13	107	120	10.83%	89.17%	13.68%	1.48%	19.40%	0.194030
Elk	8	43	51	15.69%	84.31%	5.82%	0.91%	11.94%	0.119403
Other Animal	5	25	30	16.67%	83.33%	3.42%	0.57%	7.46%	0.074627
Antelope	3	12	15	20.00%	80.00%	1.71%	0.34%	4.48%	0.044776
Big Horn Sheep	2	8	10	20.00%	80.00%	1.14%	0.23%	2.99%	0.029851
Cattle	2	28	30	6.67%	93.33%	3.42%	0.23%	2.99%	0.029851
Dog/Coyote	2	67	69	2.90%	97.10%	7.87%	0.23%	2.99%	0.029851
Bear		9	9	0	1	1.03%	0.00%	0.00%	0.000000
Total	67	810	877	7.64%	92.36%	100%	7.64%	100.00%	

Table 5 - Safety (Wildlife) Priority Corridor Statewide Summary

Rank	Route	DIR	TMC Segment Cross Street in Proximity	Functional Class	NHS	% NHS	County	Total Animal Crossing Crashes	Most Common Animal Type	Wildlife Issue Level
1	US-93	NB	ACE DR	3 - Principal Arterial: Other	Yes	100	ELKO	29	Deer	13.851
1	US-93	SB	6TH ST	3 - Principal Arterial: Other	Yes	100	ELKO	29	Deer	13.851
2	US-93	NB	BEAVER DAM RD	3 - Principal Arterial: Other	No	0	LINCOLN	13	Deer	6.209
2	US-93	SB	ANTELOPE CANYON RD	3 - Principal Arterial: Other	No	0	LINCOLN	13	Deer	6.209
3	US-93	NB	MT WILSON RD	3 - Principal Arterial: Other	No	0	LINCOLN	11	Deer	5.254
3	US-93	SB	UNNAMED STREET 3	3 - Principal Arterial: Other	No	0	LINCOLN	11	Deer	5.254
4	US-395	NB	NV-206/SUNRIDGE DR/JACKS VALLEY RD	3 - Principal Arterial: Other	Yes	100	DOUGLAS	10	Deer	4.776

Weather-Related Crashes

- Collected data on current weather at time of every crash.
- Evaluated the likeliness and extent that weather influenced a crash – as well as the severity of a crash.

Table 9 – Crashes by Weather Type and Injury Severity

Weather Type	K	A	B	C	O	Total
Clear	1,180	3,530	17,993	54,898	98,319	**175,920**
Cloudy	228	564	3,307	10,025	19,117	**33,241**
Blowing Sand, Soil, Dirt, Snow	3	7	39	156	521	**726**
Blowing Snow	2	1	16	145	1,161	**1,325**
Fog, Smog, Smoke	2	4	81	161	713	**961**
Not Reported	20	6	32	374	2,688	**3,120**
Other	1	6	26	30	153	**216**
Rain	41	110	684	2,171	5,004	**8,010**
Severe Crosswinds	3	9	68	94	323	**497**
Sleet, Hail (Freezing Rain or Drizzle)	0	5	14	46	138	**203**
Snow	7	16	112	390	1,770	**2,295**
Total	**1,487**	**4,258**	**22,372**	**68,490**	**129,907**	**226,514**

Weather-Related Crashes

- The probabilities of each possible weather event causing a crash were combined to provide an overall weather risk score for each segment (Weather Issue Level).

Table 4 - Safety (Weather) Priority Corridor Statewide Summary

Rank	Route	DIR	TMC Segment Cross Street in Proximity	Functional Class	NHS	% NHS	County	Roadway Surface Crashes	Visibility Crashes	Severe Wind Crashes	All Weather Related Crashes	Crash Score	Roadway Surface Issue Level	Visibility Issue Level	Severe Wind Level	Weather Issue Level
1	I-15	NB	I-15/WILBER CLARK DESERT INN WEST RD	1 - Interstate	Yes	100	CLARK	84	16	2	140	2	168	32	4	280
2	I-15	SB	I-15/W RUSSELL RD	1 - Interstate	Yes	100	CLARK	65	14	2	113	2	130	28	4	226
3	US-395	NB	I-80/EXIT 68	3 - Principal Arterial: Other	Yes	100	WASHOE	39	3	0	54	2	78	6	0	108
4	I-15	NB	SPRING MOUNTAIN RD/EXIT 39	1 - Interstate	Yes	100	CLARK	27	3	0	52	2	54	6	0	104
5	US-395	SB	US-395 ALT/NV-429	3 - Principal Arterial: Other	Yes	100	WASHOE	35	0	1	50	2	70	0	2	100
6	US-395	NB	US-395/I-580	3 - Principal Arterial: Other	Yes	100	WASHOE	16	5	4	42	2	32	10	8	84

Data Weights

- Safety was considered most important factor.
- We allowed the outcomes to be influenced slightly by local agency's opinion of priority.
- Table 18 shows the exact breakdown of factors that creates the overall "Enhanced Mobility" weight.
- Table 19 shows (again) the breakdown of the weighted score for safety.

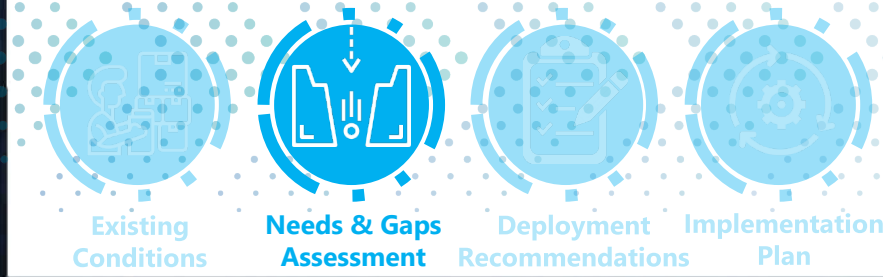


Table 17 – Priority Corridor Weights

Prioritization Category	Weight
Enhanced Mobility for All Users	45%
Improves Safety	50%
Local Agency Priority Level	5%
Total	100%

Table 18 – Enhanced Mobility Criteria and Weights

Criteria	Weight
% Congestion	14%
Bottleneck	24%
Average Queue Length	24%
TTI	14%
Total Delay	24%
Total	100%

Table 19 – Improved Safety Criteria and Weights

EPDO Score	Weight
At or Below Average	0%
Above Average and Below 90 Percentile	40%
At or Above 90 Percentile	60%
Total	100%

Data Buckets

- All categories were bucketed and then weighted to emphasize most severe issues.

Mobility

	Rank		Queue Length	Definition
Average Max Queue Length	1st Priority	1	67.16	The average max queue length experienced on segments due to bottleneck locations
		50	15.69	
	2nd Priority	51	15.47	
		300	4.09	

	Rank		% Free Flow	Definition
Congestion	1st Priority	1	35.97%	Percent of free flow speed (peak hours)
		51	67.96%	
	2nd Priority	52	68.24%	
		300	86.43%	

	Rank		Base Impact	Definition
Bottleneck Rank	1st Priority	1	54462	Ranked by base impact using Total delay, Speed dif, congestion, and AADT. Base impact is determined by queue length and queue duration. (Peak Hours)
		50	12757	
	2nd Priority	51	12736	
		300	2068	

	Rank		Index	Definition
TTI	1st Priority	1	2.911111111	Travel time divided by free flow travel time (peak hours)
		50	1.3	
	2nd Priority	51		
		300		

	Rank	
Total Delay	1st Priority	1
		50
	2nd Priority	51
		300

	Rank	
LOTTR	1st Priority	1
		49
	2nd Priority	50
		300

1st Priority Point Value	1
2nd Priority Point Value	0.5
No Priority Point Value	0
Total Mobility Priority	45%
Total Safety Priority	45%
ELT Priority	10%

*Adjust the above values and the rank number for each priority only

Safety

	Rank	Crash Score	Definition
Crashes	1st Priority	2	Calculated EDPO score by summing the product of crashes for each KABCO severity type and the crash weighting factor. Applied score (2 points = 90th percentile/60% ditribution, 1 point = above average/40% distribution, 0 points = at or below average). 1st priority is all segments with 90th percentile score.
	2nd Priority	1	

	Rank		Issue Value	Definition
Weather-Related Crashes	1st Priority	1	280	Issue value represents number of weather-related crashes on a TMC roadway segment multiplyied by the segment crash score received in crash analysis (2 points = 90th percentile/60% ditribution, 1 point = above average/40% distribution, 0 points = at or below average)
		49	29	
	2nd Priority	50	28	
		200	11	

	Rank		Issue Value	Definition
Wildlife-Related Crashes	1st Priority	1	13.85074627	Issue value represents the number of wildlife-related crashes on a TMC roadway segment multiplied by the animal adjustment factor. The animal adjustment factor accounts for the average severity of incidents involving each animal type and is applied to each segemnt for the animal most commonly encountered.
		56	1.910447761	
	2nd Priority	57	1.432835821	
		283	0.029850746	

Data Analysis

- After data is broken down, sorted, normalized, and weighted –

Each segment is measured based on all categories to determine which roadway segments have the most severe issues, and therefore the greatest need for improvement. This is conveyed by the "Weighted Score" on the right side of the table.

Table 20 – Statewide Weighted Ranking of Priority Corridors

Rank	Route	DIR	TMC Segment Cross Street in Proximity	Functional Classification	NHS	% NHS	County	Urban/ Rural	Queue Length	Congestion	Bottleneck	TTI	Total Delay	Mobility Score	Crash Rate	Priority Level	Event	Weighted Score
1	I-15	NB	I-15/WILBER CLARK DESERT INN WEST RD	1 - Interstate	Yes	100	CLARK	Urban	0.96	0.14	0.96	0.28	1.2	3.59	12545.34	0	0	6274.287
2	I-15	SB	I-15/W RUSSELL RD	1 - Interstate	Yes	100	CLARK	Urban	0.96	0	0	0.14	0	1.15	10901.53	0	0	5451.283
3	NV-582	SB	E RUSSELL RD	3 - Principal Arterial: Other	Yes	100	CLARK	Urban	0.72	0	0	0	0	0.77	7352.869	0	0	3676.781
4	I-15	NB	CHARLESTON BLVD/EXIT 41	1 - Interstate	Yes	100	CLARK	Urban	0.96	0.14	0.48	0.28	0.72	2.63	6656.87	0	0	3329.618
5	NV-589	WB	NV-604/LAS VEGAS BLVD	3 - Principal Arterial: Other	Yes	100	CLARK	Urban	0.96	0.14	0.72	0.14	0.72	2.73	6394.218	0	0	3198.338
6	NV-582	SB	E LAKE MEAD DR	3 - Principal Arterial: Other	Yes	100	CLARK	Urban	0.96	0	0	0	0	1.01	6393.831	0	0	3197.37
7	NV-582	SB	E FLAMINGO RD	3 - Principal Arterial: Other	Yes	100	CLARK	Urban	0.72	0	0	0	0	0.77	6356.367	0	0	3178.53
8	NV-582	SB	I-515/US-93/US-95/VEGAS VALLEY DR	3 - Principal Arterial: Other	Yes	100	CLARK	Urban	0.72	0	0	0	0	0.77	6282.797	0	0	3141.745
9	NV-159	WB	LAMB BLVD	3 - Principal Arterial: Other	Yes	100	CLARK	Urban	0.72	0	0.48	0	0.48	1.68	6080.472	0	0	3040.992
10	NV-159	EB	NELLIS BLVD	3 - Principal Arterial: Other	No	0	CLARK	Urban	0.72	0	0	0	0	0.72	6076.905	0	0	3038.776

Finding Solutions

- Once the needs were determined, we had to identify strategies to mitigate/improve circumstances.
  - Strategies are defined in this plan as systems of technologies working together to accomplish a specific goal.

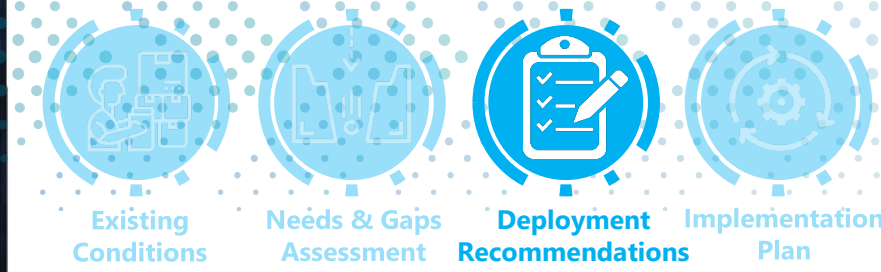
Performance Data Recommended Strategy	Safety Data		Mobility Data						NDOT Front Office Priority	
	EPDO Score	Weather Crash	Bottleneck	Congestion	Average Max Queue Length	TTI	TTR	Delay	Mountain Pass	Las Vegas/ Reno ATM
Adaptive and Advanced Traffic Signals	Included		Included	Included		Included	Included	Included		Included
Dynamic Junction Control System			Included			Included	Included	Included		Included
Dynamic Lane Use System			Included		Included	Included	Included	Included		Included
Dynamic Merge Control System			Included			Included	Included	Included		Included
Enhanced Chain Warning System		Included				Included				
Express Lane System	Included	Included	Included	Included		Included	Included	Included		Included
Flood or Ice Detection System		Included	Included			Included	Included	Included		
Predictive Traveler Information System	Included			Included			Included			Included
Queue Warning System			Included		Included		Included			
Reversible Lane System	Included	Included	Included	Included		Included	Included	Included		Included
Safety Warning System	Included					Included	Included			
Smart Priority Traffic Signals System			Included	Included			Included	Included		
Smart Signals System			Included	Included		Included		Included		
Tourist Information System			Included				Included	Included	Included	
Variable Speed Limit System			Included			Included	Included			Included
Virtual Traveler Information System	Included		Included			Included	Included	Included	Included	
Weather Warning System	Included	Included	Included	Included		Included	Included	Included		
Adaptive Ramp Metering System			Included	Included	Included		Included	Included		
Dynamic Transit Shoulder Use System				Included			Included			Included

Geographic Data Recommended Strategy	Safety Data	NDOT Front Office Priority		
	Wildlife Crash	Rain/ Snow	Wind Speeds	Visibility
Flood or Ice Detection System		Included		
Variable Speed Limit System		Included		Included
Weather Warning System			Included	Included
Wildlife Migration System	Included			

Finding Solutions (Cont.)

- The table to the right shows the combination of technologies included for some strategies.

Performance Data Recommended Strategy	Application	Performance Data Recommended Technologies											
		Vehicle detection	CCTV	DMS	Flashing Beacon	Dynamic Speed Limit Sign	RWIS Station	Visibility Sensors	Lane Control Sign	Ramp Meters	CV Device	Adaptive Signals	Adaptive Lighting
Adaptive and Advanced Traffic Signals	Single Location	2	1									1	
Dynamic Junction Control System	Per Mile	2	1	2		2				1			
Dynamic Lane Use System	Per Mile	2	1	2		or 2			or 4	1	1		
Dynamic Merge Control System	Per Mile	2	1	1		or 2			or 4	1	1		
Enhanced Chain Warning System	Single Location	1	1		1						1		
Express Lane System	Per Mile	2	1	2					2		1		
Flood or Ice Detection System	Single Location	2	1		1	2					1		
Predictive Traveler Information System	Single Location	2	or 1	1	or 2 or 4	or 2					1		
Queue Warning System	Per Mile	2	1	1		or 2			or 4		1		
Reversible Lane System	Per Mile	4	1		8	8					1		
Safety Warning System	Single Location	2	1	1	or 1				or 0, 2, or 4		1		
Smart Priority Traffic Signals System	Single Location	1	1		1						1	1	or 1
Smart Signals System	Single Location	2	1						2				1
Tourist Information System	Single Location	2	1	1		4							
Variable Speed Limit System	Per Mile	2	1	or 1 or 2	or 1	or 1 or 2			or 4		1		
Virtual Traveler Information System	Single Location				1						1		1
Weather Warning System	Single Location	2	1	1	1		1		or 4		1		
Adaptive Ramp Metering System	Per Mile	1								1	1	1	
Dynamic Transit Shoulder Use System	Per Mile	2	1	1		2					1		



General Benefits

- It was determined through the evaluation of nationwide studies that some technologies created a net benefit to the transportation system based on traffic volumes and complexity of the roadway network.

Project Package Types	Permanent Detection	CCTV	Overhead DMS	Side Mounted DMS	Speed Feedback Signs	Side Mounted VSL	RWIS Station	Overhead Lane Control Gantries	Ramp Meters	CV Devices	Adaptive Signal	Adaptive Lighting	Wrong Way Driving Detection	Fiber Communications	3rd Party Data	Sample Recommendations	
																Northern Nevada	Southern Nevada
Urban – Freeway ATM	●	●	●					●	●	●			●	●		I-80 within Reno/ Sparks City Limits	I-15 adjacent to Las Vegas Strip
Urban – Non-Freeway ATM	●	●		●		●				●	●			●		Virginia Street from SR 659 to I-80	N/A
Urban Lite – Permanent Full	●	●		●	●	●	●		●	●	●	●	●	●		Virginia Street from McCarran Boulevard to US 395	Tropicana Avenue from Valley View to I-515
Urban Lite – Permanent Lite	●	●		●	●		●			●			●	●		US 50 from I-580 to Stagecoach Drive	I-15 from Nevada/ California State Line to Sloan Lane
Urban Lite – Hybrid Full		●		●		●	●			●					●	N/A	Blue Diamond Road from I-15 to MM CL 26.
Urban Lite – Hybrid Lite		●		●	●	●	●			●			●	●	●	I-80 from Nevada/Utah State Line to US 93	US 95 from Silverpeak Road to SR 82
Rural (Spot Improvements)	●	●		●	●	●	●			●		●	●		●	US 95 from I-80 to Nevada/Oregon State Line	Lee Canyon Road, Kyle Canyon Road, and Deer Creek Road (loop) from US 95 to US 95

NEVADA DOT SAFE AND CONNECTED

Rural Classification

- To the right is an excerpt from the Recommendations Tech Memo detailing the general recommendations for rural areas.

2.2.4.3. Rural Areas

The rural areas of the state have less population, more distance between NDOT facilities, less total connecting arterials, but more focused areas where the arterials may be NDOT facilities serving as main thoroughfares of smaller communities. The rural areas of the state need to be managed where there are safety or mobility issues or concerns, but NDOT should be careful about where to deploy infrastructure because of limited power service and higher cost of infrastructure to connect in a rural setting. Use of alternative options for physical infrastructure, such as third party data monitoring, are priority in the rural areas where there can be a combination of physical infrastructure where it makes sense and third party data where it can supplement effectively.

"**Rural**" deployment of infrastructure will generally include:

- Spot locations for technology (such as a RWIS station, CCTV, DMS, flashing beacons, SFS, CV devices) to serve the need for data collection at specific areas to support safety or mobility needs.
- Radio communications to infrastructure where fiber communications do not exist, or fiber infrastructure is not planned in the long-term (as defined in Section 18.2.4.4 Priority Corridors).
- Third party data situational awareness where physical infrastructure is not cost-effective or maintainable.
- Robust 511 to support all movement across state and marketed to be a central point of resource for any data needs for travelers within and through the state regardless of facility type (NDOT or non-NDOT).
- Strong and active partnerships with local agencies along NDOT-routes.
- Types of project concepts recommended for NDOT:
  - **Rural** – Includes spot deployments of RWIS station, flood, weather, speed, VSL, ice detection, etc., as needed and determined by data evaluation. Along these corridors, third-party data can also support real-time condition reporting.

Alternative situational awareness technologies that are not included in this plan, but NDOT could consider as part of rural deployments to improve the situational awareness include dashboard cameras on emergency responders or maintenance vehicles or Unmanned Aerial System tethered cameras. Those deployments would be considered pilots of these kinds of technologies.

Technology Recommendations

- Some examples of technology recommendations based on location classification.
- Additional examples on next few slides.

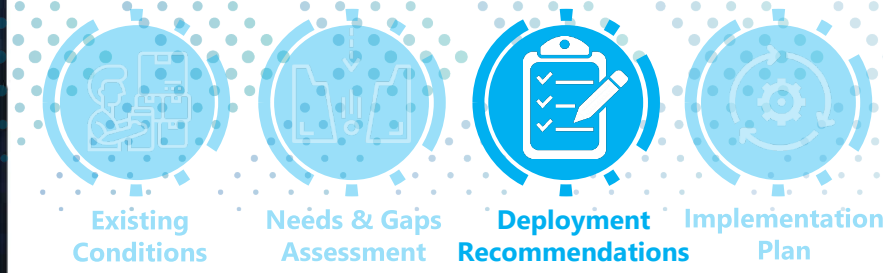


Table 7 – Systems and Technology Guidelines

Technology	Urban Application Threshold	Urban Lite Threshold	Rural Application Threshold
Vehicle Detection	• Every third to half mile in both traveling directions • At mainline freeway and on-ramps	• Every three to five miles (in permanent applications) in both traveling directions • Not needed if third party data is used • At mainline freeway and on-ramps	• Location specific based on case by case evaluation completed by Traffic Operations prior to funding
Closed Circuit Television Camera (CCTV)	• Every one mile on freeways • Typically located at interchanges • Every traffic signal • Near DMS	• Every three to five miles • Typically located around interchanges • Near DMS	• Every traffic signal • Near DMS • NDOT-owned roadway interchanges • Location specific based on case by case evaluation completed by Traffic Operations prior to funding
Dynamic Message Sign (DMS) (Overhead or Side-Mounted)	• Every mile on freeways in both traveling directions on freeways • Every system to system interchange to inform traffic entering onto the NDOT roadway • Typically Type 1 DMS • In advance of major decision points • Every 15 minutes on freeways based on typical travel times at free flow	• Every three to five miles in both traveling directions • Every system to system interchange to inform traffic entering onto the NDOT roadway • Typically, side-mounted DMS	• Every system to system interchange to inform traffic entering onto the NDOT roadway • Major decision points • Travel restriction areas • Weather issue areas • Every 60 minutes on freeways based on typical travel times at free flow
Flashing Beacons (With Accompanying Signage)	• Not recommended in urbanized areas in this Plan (may be implemented separately as part of other projects)	• Location specific based on case by case evaluations completed by Traffic Operations prior to funding • Safety concern areas due to high incidents, speed, visibility, traction conditions, slopes, concern of drowsy driving, sight distance issues, and where the roadway is entering communities from high-speed rural highways	• Location specific based on case-by-case evaluations completed by Traffic Operations prior to funding • Safety concern areas due to high incidents, speed, visibility, traction conditions, slopes, concern of drowsy driving, sight distance issues, and where the roadway is entering communities from high-speed rural highways

Technology Recommendations

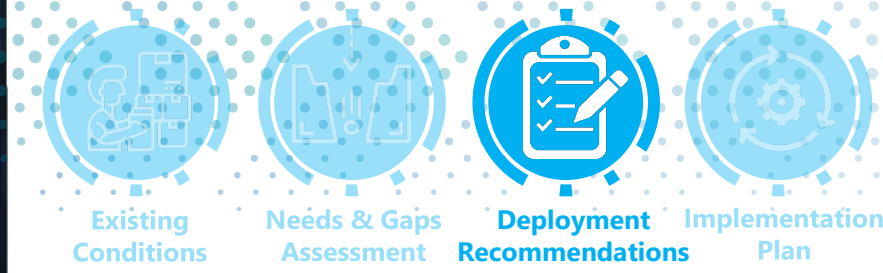
Technology	Application Thresholds	Intended Uses	Unacceptable Uses
Closed Circuit Television Camera (CCTV) Camera mounted on pole, mast arm, or other structure to provide monitoring capability in real-time	• Locations should be chosen where there are crash, weather, or geography issues, maintenance/emergency response staff needs, road closures or detours, unplanned events where they frequently occur which have negative impacts on progression and cause severe delays, and where there is additional information needed to support truck parking or freight movement would benefit from current condition information (such as rest areas or truck parking lots) • Should be chosen so that all approaches to the intersection can be seen with pan/tilt/zoom (PTZ) capability – in some cases, a bucket truck survey may be beneficial to check sight distance and visibility • **Urban** o Every one mile o Typically located at interchanges o Every traffic signal o Near DMS • **Urban Lite** o Every three to five miles o Typically located around interchanges o Near DMS • **Rural** o Every traffic signal o Near DMS o NDOT-owned roadway interchanges o Location specific based on case by case evaluation completed by Traffic Operations prior to funding	• CCTV is to be used to monitor real time traffic conditions and events, and assist in decision making and traffic management • Pan, tilt, and zoom permissions control shared privileges with other departments or agencies should remain very limited with the NDOT ROC maintaining priority use and central control • Establish agreements with other Departments for viewing and/or control of cameras, as permissible • Police should have viewing privileges only of viewing technology under incident conditions, or special event conditions as warranted • Video can be recorded by other Departments that want to hold liability for that video • CCTV real time images or screenshots can be shared with traveling public	• Camera pre-sets on the transportation network need to be set to limit extenuating use of camera beyond traffic or incident management purposes • CCTV control should not be granted to any public person, institution, or media • CCTV should not be used to gain personal information or be used for personal use

Technology	Application Thresholds	Intended Uses	Unacceptable Uses
Dynamic Message Sign (DMS) (Overhead or Side-Mounted) DMS communicate information about travel time between locations or other important warnings to road users to improve the flow of traffic and safety	• Strategic locations prioritized for high volume corridors, in advance of population center or traffic generators, in advance of route decision points, to inform travelers of traffic or flood/emergency conditions particularly in areas where unanticipated events occur regularly that delay traffic, to indicate evacuation routing, and to provide travel time data • **Urban** o Every mile in both traveling directions on freeways o Every system to system interchange to inform traffic entering onto the NDOT roadway o Typically Type 1 DMS o In advance of major decision points o Every 15 minutes on freeways based on typical travel times at free flow • **Urban Lite** o Every three to five miles in both traveling directions o Every system to system interchange to inform traffic entering onto the NDOT roadway o Typically side-mounted DMS • **Rural** o Every system to system interchange to inform traffic entering onto the NDOT roadway o In advance of major decision points o Travel restriction areas o Weather issue areas o Every 60 minutes on freeways based on typical travel times at free flow	• DMS are to be used primarily to provide roadway information including but not limited to roadway conditions, travel time and delays, weather, and warnings/hazards • DMS can be secondarily used for amber alerts and public safety messages • Develop standard message library as well as basic message design standard operating procedures for use to display on signs: problem, location of problem, and (if warranted) recommended driver action under normal use and emergency use of DMS • State should establish an approval procedure prior to implementing messages outside of the message library	• DMS should not be used for personal messages or advertisements • If connecting to an existing sign or a sign that is being installed as a partnership, the State will need to develop an agreement with the entity (property owner, school district, etc.) dictating guidelines for usage, operations and maintenance

Technology Recommendations

Technology	Urban Application Threshold	Urban Lite Threshold	Rural Application Threshold
Dynamic Speed Limit Sign (DSL) (or Variable Speed Limit [VSL] Sign)	• Can be combined with overhead lane control gantries in the urban freeway core area • Side mounted VSL (where ATM is not implemented) • VSL deployments need to have multiple consecutive locations to support speed harmonization	• Side mounted VSL along specific portions as determined by data evaluation • VSL deployments need to have multiple consecutive locations to support speed harmonization	• Location specific based on case by case evaluation completed by Traffic Operations prior to funding • VSL deployments need to have multiple consecutive locations to support speed harmonization • Typically spaced at between one and three mile frequency on both sides of a length of the road
Road Weather Information System (RWIS) Station	• No new RWIS are recommended in urbanized areas because of the existing weather monitoring capabilities (may be implemented separately as part of other projects)	• Location specific based on case by case evaluations completed by Traffic Operations prior to funding • Focus on where weather conditions cause safety or access issues such as road closures, flooding, landslides, or other restriction	• Location specific based on case by case evaluations completed by Traffic Operations prior to funding • Focus on where weather conditions cause safety or access issues such as road closures, flooding, landslides, or other restriction

Lane Control Sign (for additional information, see *ATM Deployment Guidelines* in Attachment K)	• Every half mile as part of ATM implementation on freeways
	• Informed by detection or ROC/TMC operator
	• Incorporated into freeway software system for management
	• Overhead lane control signs mounted on structures over all lanes
	• For determining application of individual recommended device locations:
	  ○ Where a single LCS is recommended in the GIS map, it shall be a Site Type 2 deployment as shown in the *ATM Deployment Guidelines*.
	  ○ Where a LCS and a DMS is recommended in the GIS map in proximity to one another, that location shall be a Site Type 1 deployment as shown in the *ATM Deployment Guidelines*.
		• Location specific based on case by case evaluations such as special events or slow climbing lanes completed by Traffic Operations prior to funding
		• May only be needed over single lane or shoulder as required
			• Location specific based on case by case evaluations such as special events or slow climbing lanes completed by Traffic Operations prior to funding
			• May only be needed over single lane or shoulder as required

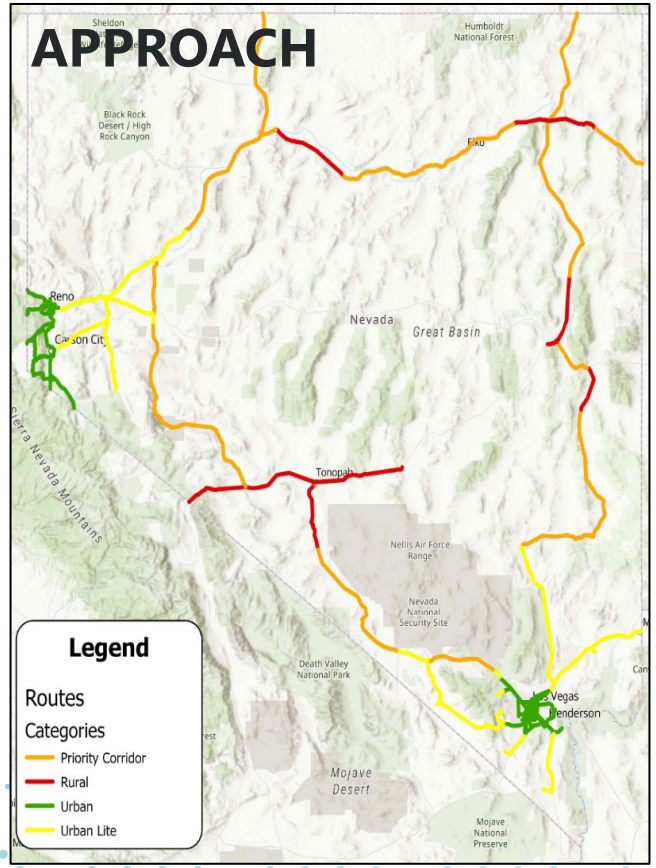


Technology Recommendations

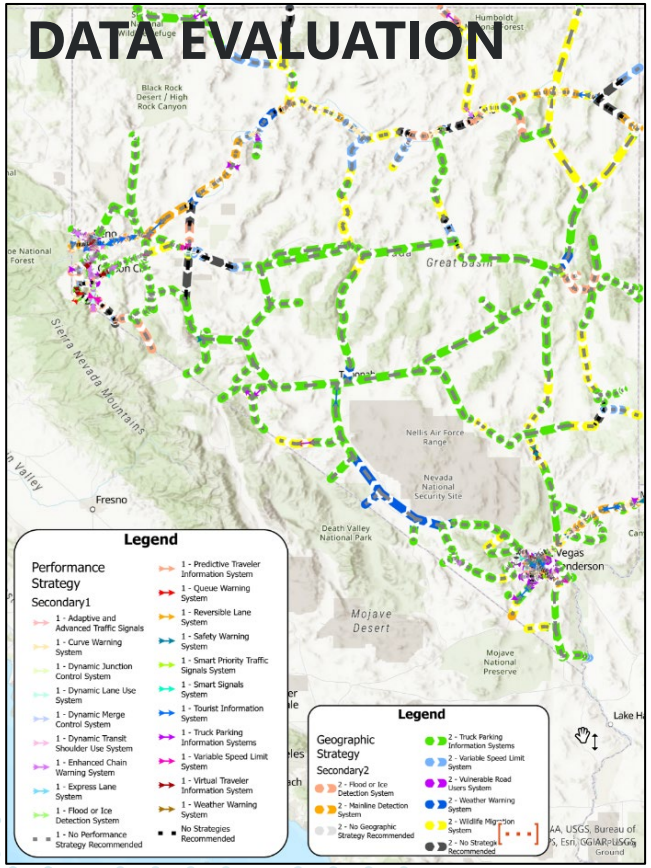
Technology	Urban Application Threshold	Urban Lite Threshold	Rural Application Threshold
Ramp Metering	• Every interchange on freeway (applied per the ramp meter warrant process) • Informed by detection or ROC/TMC operator • Incorporated into freeway software system for management	• Not recommended in urban lite areas unless it is determined through evaluation completed by Traffic Operations prior to funding	• Not recommended in rural areas unless it is determined through evaluation completed by Traffic Operations prior to funding
CV Infrastructure	• Every traffic signal • Every two miles on freeways • Typically located at interchanges	• Every five miles on freeways • Typically located at interchanges	• Every traffic signal • NDOT-owned roadway interchanges • Location specific based on case by case evaluation completed by Traffic Operations prior to funding
Adaptive Signals	• Along non-freeway facilities with multiple traffic signals that experiences safety or mobility issues or consistently used for event traffic	• Not recommended in outside of the urban areas unless it is determined through evaluation completed by Traffic Operations prior to funding	• Not recommended in rural areas unless it is determined through evaluation completed by Traffic Operations prior to funding
Adaptive Lighting	• No adaptive lighting is recommended in urbanized areas because of the existing roadway lighting; however, specific case by case evaluations completed by Traffic Operations prior to funding could be done to improve safety, if warranted	• Location specific based on case by case evaluation completed by Traffic Operations prior to funding • Focus on where intersections or interchanges exist to increase visibility and safety when vulnerable road users or vehicles are present and where there are locations/intersections that experience high incidence of crashes	• Location specific based on case by case evaluation completed by Traffic Operations prior to funding • Focus on where intersections or interchanges exist to increase visibility and safety when vulnerable road users or vehicles are present and where there are locations/intersections that experience high incidence of crashes
Wrong-Way Driver Detection System	• Every freeway off ramp as defined by separate NDOT study • Higher priority to locations that have crash evidence of an issue	• Every freeway off ramp as defined by separate NDOT study • Higher priority to locations that have crash evidence of an issue	• Every freeway off ramp as defined by separate NDOT study • Higher priority to locations that have crash evidence of an issue

Project Concept Packages

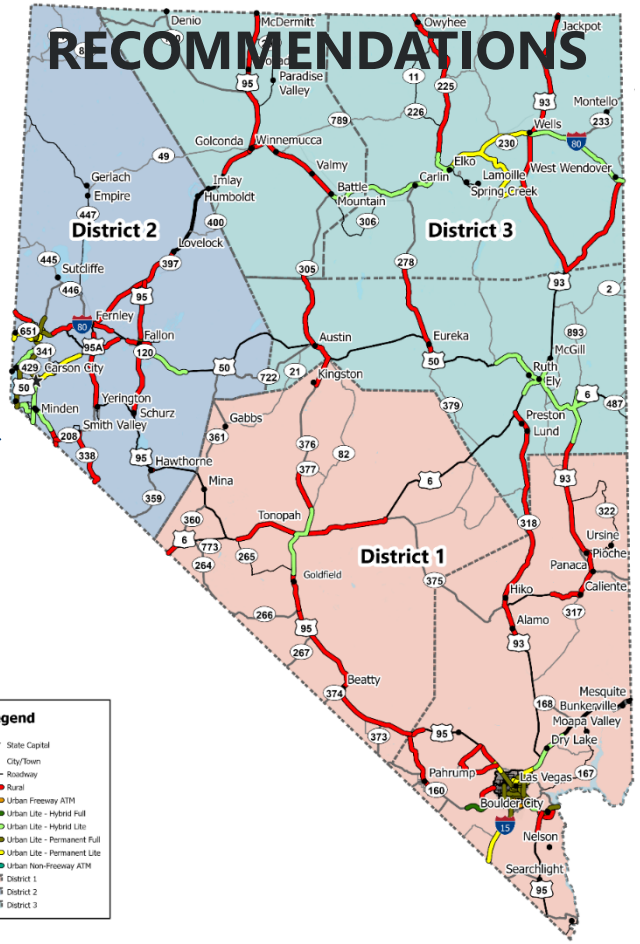
APPROACH



DATA EVALUATION



RECOMMENDATIONS



Existing Conditions | Needs & Gaps Assessment | **Deployment Recommendations** | Implementation Plan

Project Concept Packages

- Recommendations were provided based on roadway classification (Urban, Urban Lite, Rural), AND recommendations were provided based on particular locations where data identified specific need(s).
- These recommendations were combined, and then evaluated manually to ensure that the combination of technologies were compatible and not redundant.
- The collection of final recommendations for a given roadway segment were termed “Project Concept Packages.”

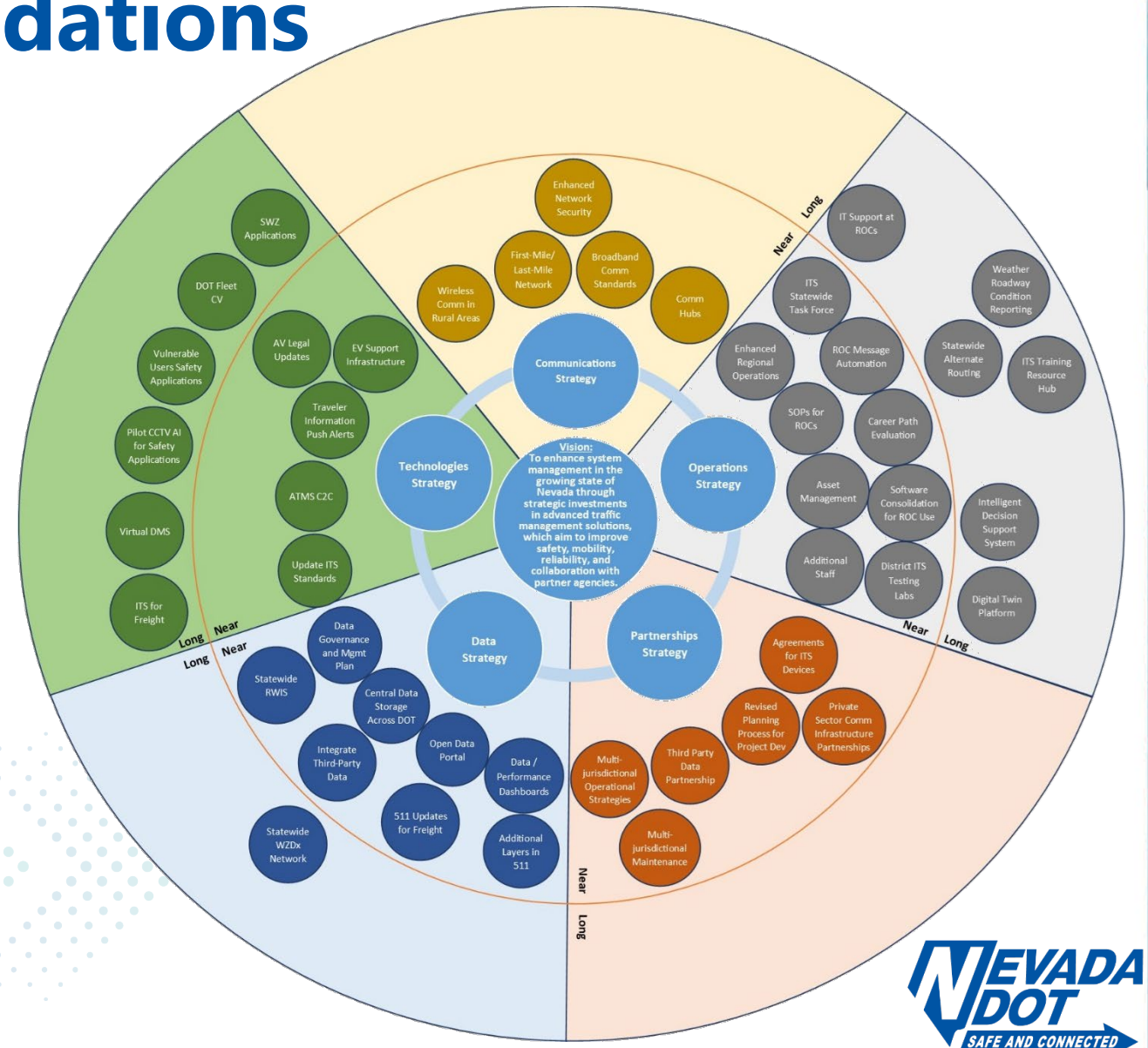
Priority Corridors

- Priority Corridors are defined as roadway segments which already have an approved and published plan to install at least one kind of technology. It was determined by NDOT management that these plans were priorities and would be completed regardless of this Master Plan's findings, and therefore did not need to be evaluated in this plan.

- **Fast charging electric and alternative fueling stations** – Nevada's National Electric Vehicle Infrastructure planning for 2,446 miles of Nevada roadways (6th highest in the country) includes the Nevada State Plan for Electric Vehicle Infrastructure Deployment. The plan includes Phase 1 (I 11, I 15, I 80, I 580, I 215, and I 515) and Phase 2 (SR 28, US 50, US 93, US 95, and US 395) infrastructure that is:
  - One mile from the highway
  - 50 miles between stations
  - Direct Current fast charging stations with at least four ports with combined charging system Combined Charging Station connector
  - Power output of at least 150kW per port
- **Broadband fiber communications** – High Speed Nevada (HSNV) Initiative and the Office of Science, Innovation & Technology (OSIT) are focusing as part of their Phase 1 effort to connect to 1,000 government facilities and community anchor institutions to create that first mile fiber connection to internet service providers to support the statewide broadband network. Once fiber is brought to a government or school facility, other federal funding streams will be used to extend connectivity to surrounding areas. Fiber communications is being recommended for Urban and Urban Lite project concepts where there is permanent vehicle detection recommended for installation. Project concepts where there is minimal ITS and ATM infrastructure being recommended for Urban Lite – Hybrid and Rural applications, it is recommended that fiber communications not be included as it would drive up the cost of the project significantly which would remove the ITS and ATM focus and put the focus rather on an extension of broadband capabilities statewide. If the state desires to deploy broadband statewide along priority corridors, that should be identified as individual fiber communication project concepts separately. It is noted that it may be desired for NDOT to consider broadband communications where there are ITS or ATM technologies recommended. However, for the purposes of this ITS & ATM Master Plan, project concepts are structured where ITS and ATM technologies are the focus rather than broadband being the focus of this plan. The state has a separate broadband master plan in place to utilize for broadband expansion planning efforts.

Qualitative Recommendations

- Priority strategy areas
- Near and long term recommendations
- Influence area of each of these recommendations is included in the GIS file
- ***Qualitative seeks to improve processes, procedures, capability maturity, and resource support for an effective and comprehensive statewide ITS and ATM technology program***



Existing Conditions | Needs & Gaps Assessment | **Deployment Recommendations** | Implementation Plan

Qualitative Recommendations

RURAL
Insufficient traffic monitoring capabilities approaching rural tourist destinations like Laughlin.
Existing legacy equipment is aging and needs replacement (RWIS, CCTV cameras, chain warning, detection).
Limited number of users that can access signs to display information.
Insufficient and unreliable chain warning equipment.

- Some qualitative recommendations were identified specifically for rural areas based on these gaps.

Planning Level Cost Estimates

- Components
  - Unit prices
  - Communication costs
  - Project administration costs
  - Operations and maintenance costs
  - Inflation costs

- Qualitative
  - $6,550,000
- Quantitative
  - District 1 - $132,740,000
  - District 2 - $107,540,000
  - District 3 - $23,170,000
- Total = $263,450,000 (*2023 dollar value)

What about emerging technologies?

- Vehicle Electrification
- Connected Vehicles
- Vehicle Automation
- Mobility as a Service (Maas)
- Artificial Intelligence (AI)
  - These topics have little-to-no data to evaluate. Some general recommendations were provided based on existing research documents.

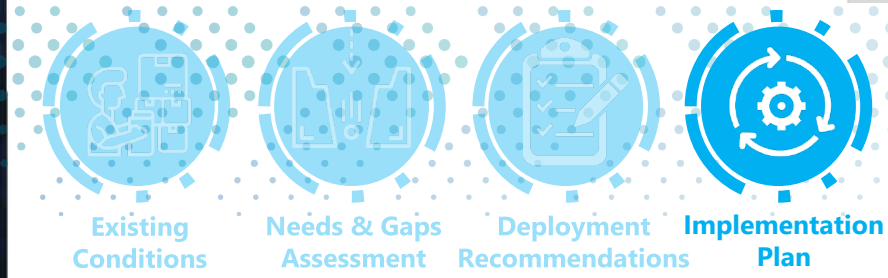
Limitations

- State-maintained routes only
- Not all state-maintained routes were identified for a project
  - Data analysis informed which segments of the roadways had “issues” to consider
- NDOT to compare recommendations to other plan documents
- Does not include NDOT Fiber Plan, NDOT Freight Plan, Nevada Electric Highway Plan
- Does identify “Priority Corridors”
- Provides recommendations only
- Not a living document

Plan Update Plan

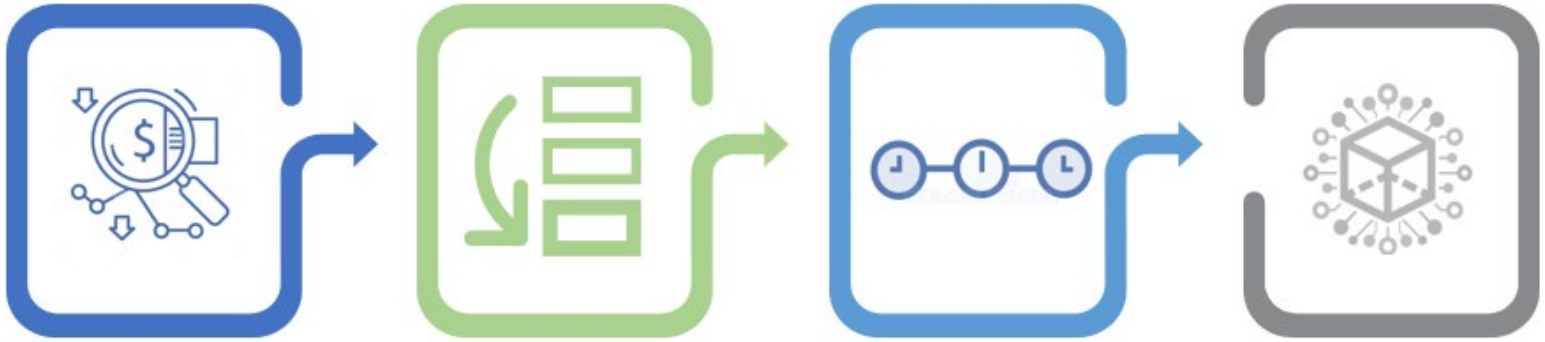
- Critical to maintaining useful recommendations

	Annual	3rd Year	5th Year
NDOT Annual Activities	1 Update SDP 2 Update ITS and ATM in GIS Platform (Existing and Planned) 3 ITS Device/Project Package Selection 4 Finalize Project Scopes	1 Update SDP 4 Update ITS and ATM in GIS Platform (Existing and Planned) 6 ITS Device/Project Package Selection 7 Finalize Project Scopes	5 Update SDP 6 Update ITS and ATM in GIS Platform (Existing and Planned) 8 ITS Device/Project Package Selection 9 Finalize Project Scopes
Additional Activities to Update Data and Plan		2 Extract Data Integration Into POWER BI Dashboard 3 Identifying Needs and Gaps from SME Interviews 5 Review and Update Project Concepts (Optional)	1 Conduct Stakeholder Engagement 2 Review Project Goals and Objectives *Align with:* ➢ *One Nevada Plan* ➢ *TSMO Program Plan* ➢ *TAMP* ➢ *TSMO PMPP* 3 Document and Report 4 Communicate with Stakeholders 7 Review and Update Project Concepts



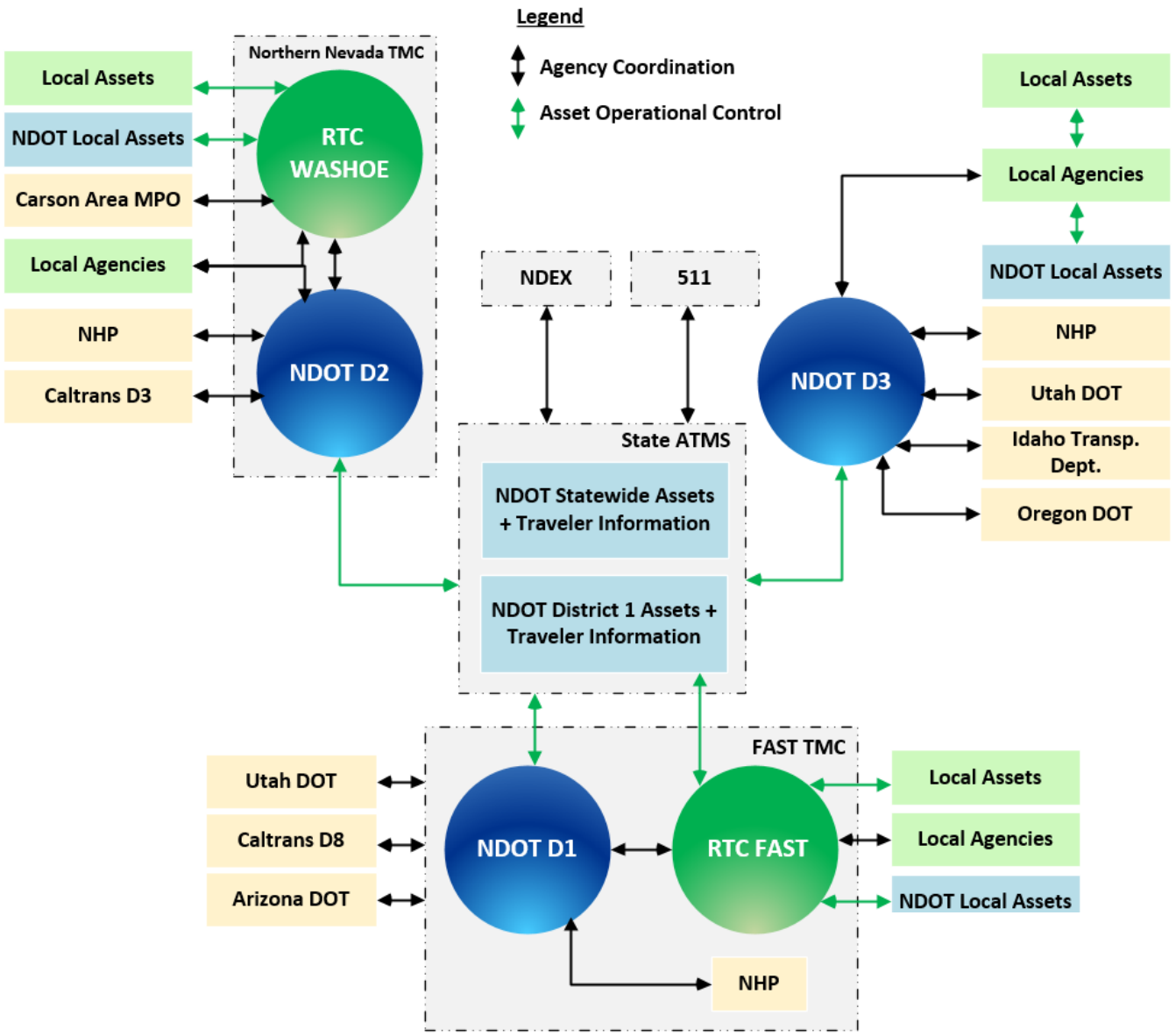
Implementation Process

- Review of Segment Project Packages
- Segment Prioritization Tool
- Investment Prioritization Tool
- One Nevada Process
- Includes Qualitative Recommendations!



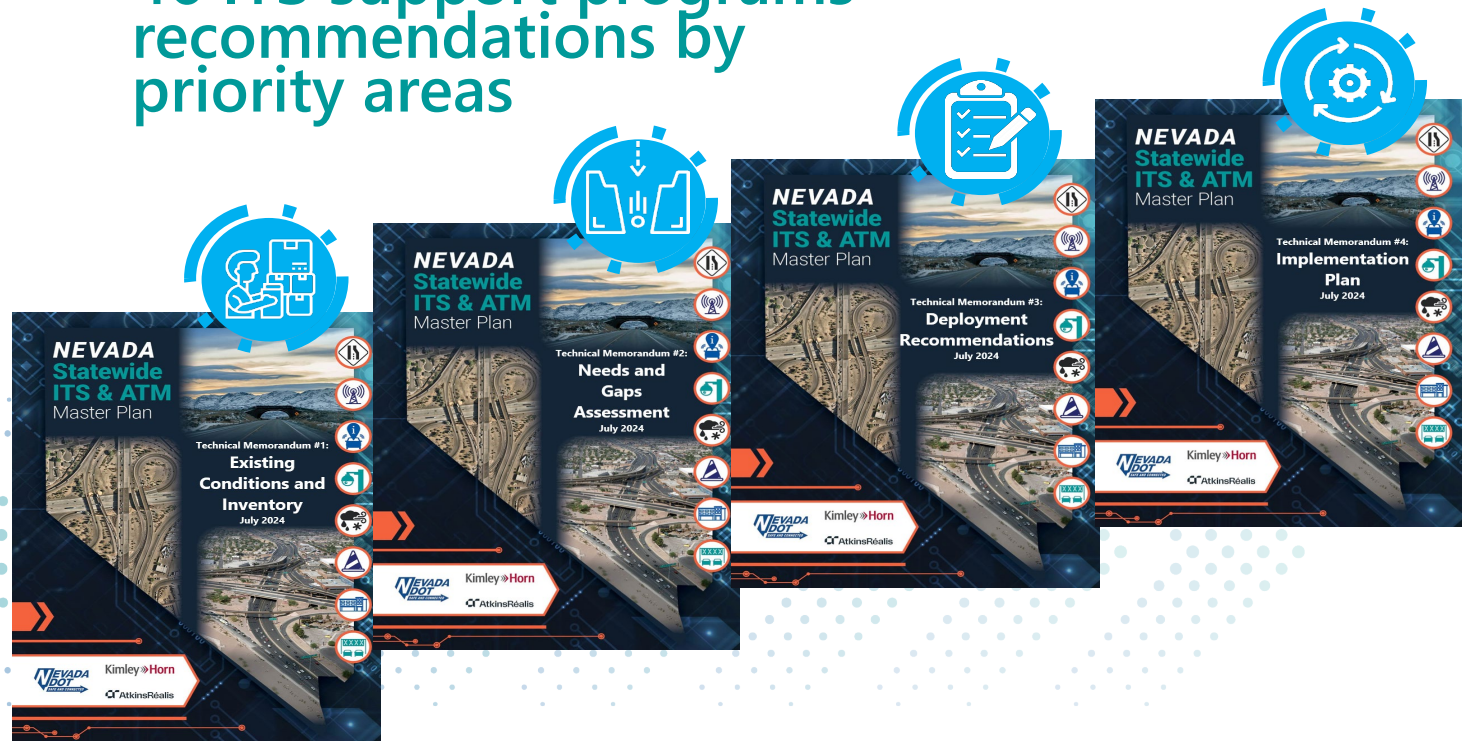
High-Level Operational Concept

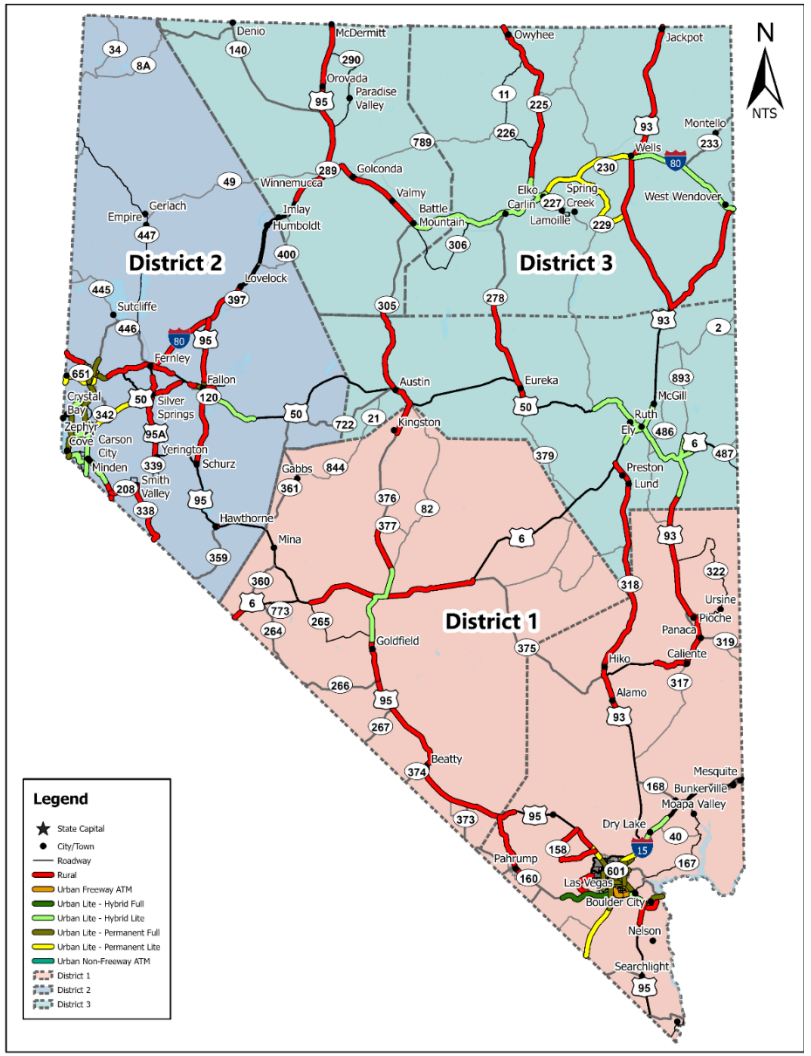
- Trends in Technology
- Recommended District Operations for each of the 3 Districts
- Operations Staffing
- System and Technology Guidelines
- Device and Data Permissions
- Operational Scenarios



ITS & ATM Master Plan

- 83 infrastructure project concept recommendations
  - District 1 - 40
  - District 2 - 31
  - District 3 - 12
- 46 ITS support programs recommendations by priority areas





Review of Master Plan Document

- Attachment A – One-on-One Meeting Key Takeaways
- Attachment B – ITS and ATM Strategy Summary
- Attachment C – Review of Existing Studies (Detail)
- Attachment D – Actions to Mature the Capabilities of ATM
- Attachment E – ITS and ATM Statewide Approach: District Maps
- Attachment F – Summary of the Data Recommendation Tool
- Attachment G – Deployment and No Deployment Risks for Primary Strategy Types
- Attachment H – Current and Suggested ITS and ATM Funding Sources
- Attachment I – Staffing and Resource Needs KSAs
- Attachment J – Qualitative and Quantitative Recommendations Including Factors for Consideration
- Attachment K – Systems and Technology Guidelines
- Attachment L – Qualitative Benefit-Cost Analysis Questionnaire for ITS & ATM Master Plan

TM#1: Existing Conditions and Inventory

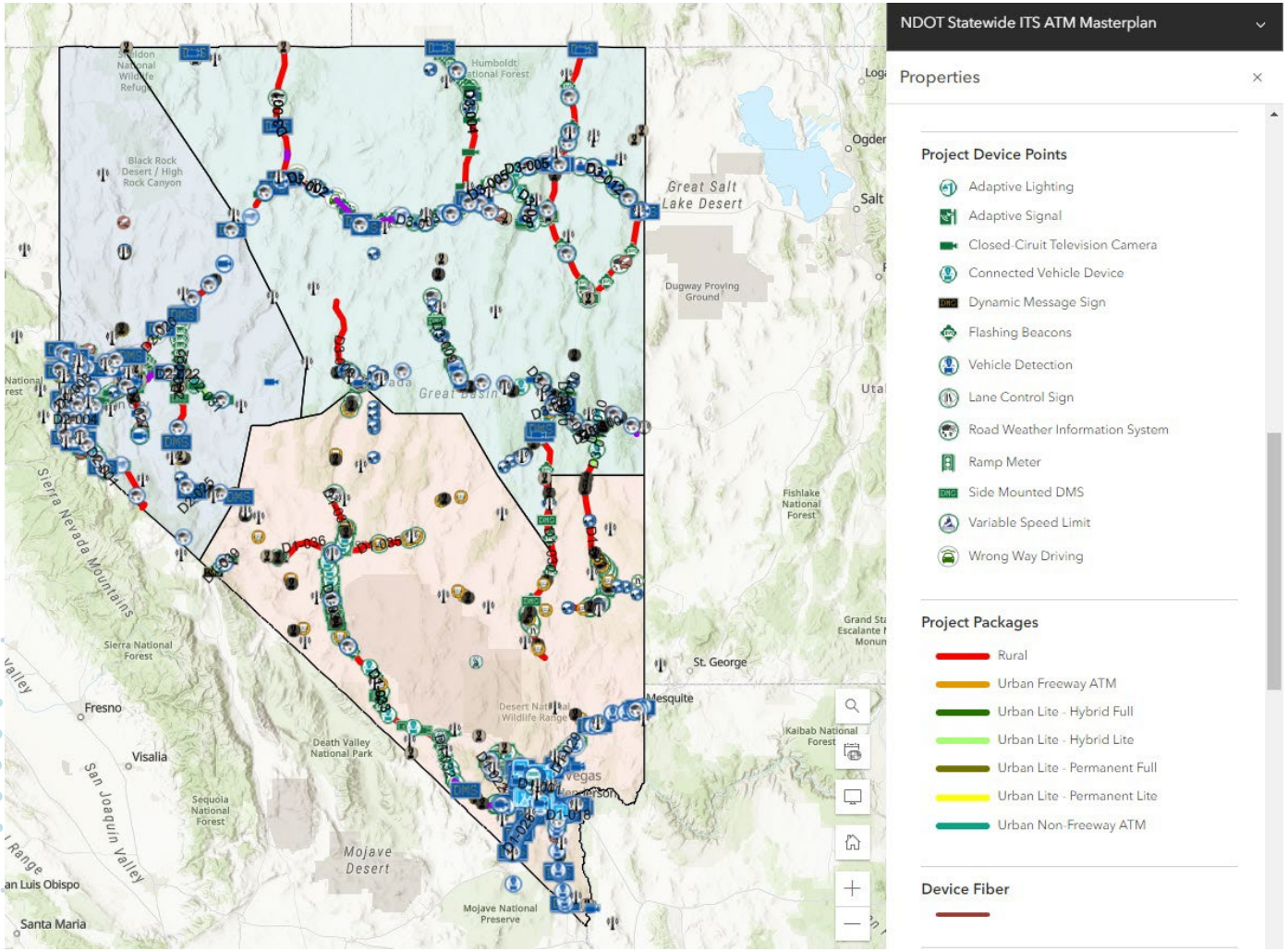
TM#2: Needs and Gaps Assessment

TM#3: Deployment Recommendations

TM#4: Implementation Plan

Recommendations Available on NDOT's GeoHub

https://geohub-ndot.hub.arcgis.com/ → search for "ITS" or "ATM" for the map and all relevant data layers



For more information, please visit the NDOT website:

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