Program Trade-off and Budget Distribution Framework developed in a Digital Platform

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DELAWARE DEPARTMENT OF TRANSPORTATION

MOTT MACDONALD

Excellence in Transportation

Every Trip.

We strive to make every trip taken in Delaware safe, reliable and convenient for people and commerce.

Every Mode.

We provide safe choices for travelers in Delaware to access roads, rails, buses, airways, waterways, bike trails and walking paths.

Every Dollar.

We seek the best value for every dollar spent for the benefit of all.

Everyone.

We engage our customers and employees with respect and courtesy as we deliver our services.

Safety

2025 Delaware Total Fatalities as of 08/19/25									
	2025	2024				2023			
	Year-to-date	Year-to-Date			Total	Year-to-Date			Total
Fatalities	59	84	↓	-30%	130	89	↓	-34%	137
Delaware Residents	43	70	↓	-39%	110	69	↓	-38%	110
Person Types									
Vehicle Occupant	32	45	↓	-29%	65	62	↓	-48%	89
Pedestrian	15	16	↓	-6%	34	13	↑	+15%	28
Bicyclist	2	3	↓	-33%	5	2		0%	5
Motorcyclist	9	16	↓	-44%	21	11	↓	-18%	14
Other Person Type	1	4	↓	-75%	5	1		0%	1
Crash Types									
Curve Related	9	15	↓	-40%	23	20	↓	-55%	28
Roadway Departure	27	31	↓	-13%	42	48	↓	-44%	69
Intersection Related	16	34	↓	-53%	48	20	↓	-20%	37
Median Crossover	1	0	↑	+100%	0	7	↓	-86%	8
Wrong Way	2	3	↓	-33%	4	1	↑	+100%	1
Work Zone	4	5	↓	-20%	5	6	↓	-33%	9


DEATH AND SERIOUS INJURIES ARE UNACCEPTABLE • HUMANS MAKE MISTAKES • HUMANS ARE VULNERABLE • RESPONSIBILITY IS SHARED • SAFETY IS PROACTIVE • REDUNDANCY IS CRUCIAL •
SAFE SYSTEM APPROACH
Safer People
Safer Vehicles
Safer Speeds
Safer Land Use
Safer Roads
Post-Crash Care

The Asset Management Budgeting Problem

The Asset Management Budgeting Problem

Overview: Managing large networks of assets (facilities, roads, bridges, BMPs) is a complex task.

Objective: To maintain these assets in the best possible condition over a long period, ensuring efficient use of budgets is necessary.

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The Asset Management Budgeting Problem

- **Problem:**
  - I have a budget for maintaining my assets; how do I distribute it between districts/programs?
  - I need a quantitative method to inform how money should be distributed.

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The Asset Management Budgeting Problem

Complexity of Maintenance Budgeting: The task involves numerous variables, including different asset types, varying conditions, and diverse maintenance needs.

Introduction to the Framework: This framework will show how optimization modeling and analysis results from multiple satellite asset management software tools, across multiple scenarios, are brought into a common (and connected) data environment (CDE).

Three Levels of Risk Analysis

Frequently Flooded Roadways (FFR)

- Overall Flood Risk value for identified road segments that are determined to be vulnerable to flooding using Risk Management Framework
- Multiple event frequencies considered ranging from ‘Sunny Day flooding’ through 1:100 etc.
- Prioritizes future actions using B/C over the next 15-30 years

Asset/Location Level Risk Management Framework

- Uses quantitative risk and resilience modeling including use of the TVC (Threat Probability, Vulnerability, Consequence) framework from RAMCAP, and the quantitative definition of resilience from Frangipol et al.
- Allows for any number and type of identified threats
- Performed at asset/location level

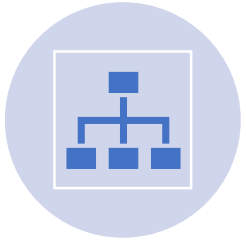
State of Good Repair (SOGR) Framework

- Program level trade-off framework
- Allows for multiple disparate analysis modelling tools ranging from PMS/BMS to spreadsheets
- Asset Stewards compile SOGR summaries annually that include SOGR metric value projections out at least 10 years under multiple funding scenarios
- Published in an Esri HUB site that enables program trade-off by Finance group

Framework Overview

Understanding Asset Management

Asset management involves identifying assets and assessing their conditions.



CFR 515.5 defines asset management as a strategic process for operating and improving assets.

Maintaining asset inventory extends beyond current condition assessments.

Effective asset management ensures long-term sustainability of physical assets.

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Asset Management Strategies Explained

- Strategies involve a sequence of maintenance and repair actions over asset lifecycles.
- Actions include maintenance, preservation, repair, rehabilitation, and replacement.
- Goal is to sustain a desired state of good repair at minimum practicable cost.
- Cost inputs influence action frequency, resulting in performance outcomes.

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Budget Curves

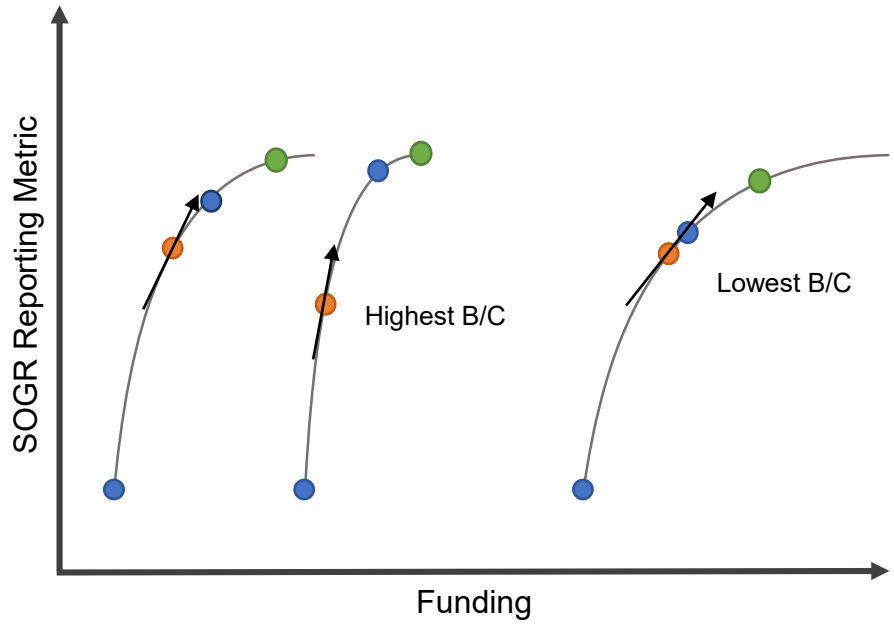
Viewing maintenance budgeting is in terms of:

- **Inputs** (Planned Budget),
- **Outputs** (Accomplishments) and
- **Outcomes** (Planned Performance/LOS/SOGR).

Problem: How do we calculate the **Input** (Planned Budget) needed to attain a specific **Outcome** (Planned Performance/LOS/SOGR)?

We assume that different Planned **Inputs** will yield different Planned **Outcomes**.

Figure: Using the Combined SOGR Budget Curves



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The Asset Management Budgeting Problem

Problem:

- I have a budget; how do I distribute it between districts/programs?
- I need a quantitative methodology to inform how money should be distributed.

Solution:

- I need to get the most benefit per dollar for any money I distribute.
- I need to get the best Benefit/Cost (B/C) ratio for any money I distribute.
- This implies investing where the steepest slope is in a graph of Benefit vs Cost.
- This B/C changes depending on current condition – typically 'diminishing marginal returns'.
- I need to figure out the B/C curve for each **'funding cell'** (e.g. District and Asset Programs).

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Historical ‘Classic’ Method

Activity-Based Budgeting:

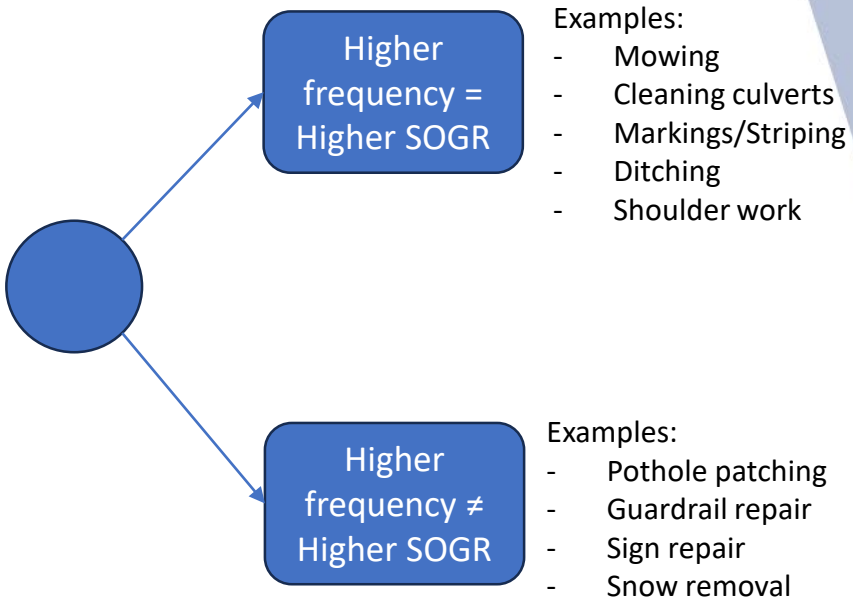
- Based on inventory, unit cost, and frequency.
- 100 acres to mow, 3 times a year = 100 x 3 = 300 acres of mowing

Frequency Based Maintenance

- Many asset management actions are frequency based.
- Higher frequency = better performance (higher %SOGR, etc.)

Frequency and Need

- Frequency implies actions – how often do we need to ‘do’ something.



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Connecting Historical Approach to Budget Curves

Frequency implies actions – how often do we need to 'do' something

- Actions are done on assets – so need to know that at least at some level.
- Actions cost money – so need to know that, as well as where the money comes from.
- If we can determine how much (what frequency) of each different activity per year translates to various LOSs, we can develop a curve/function/formula that tells us the funding needed to maintain that LOS.
- Frequency can be identified by 'expert elicitation', but…

Strategies

- If we have multiple actions on the same asset, especially if they are restoring/correcting different metrics, then the challenge is to work out the optimum strategy.

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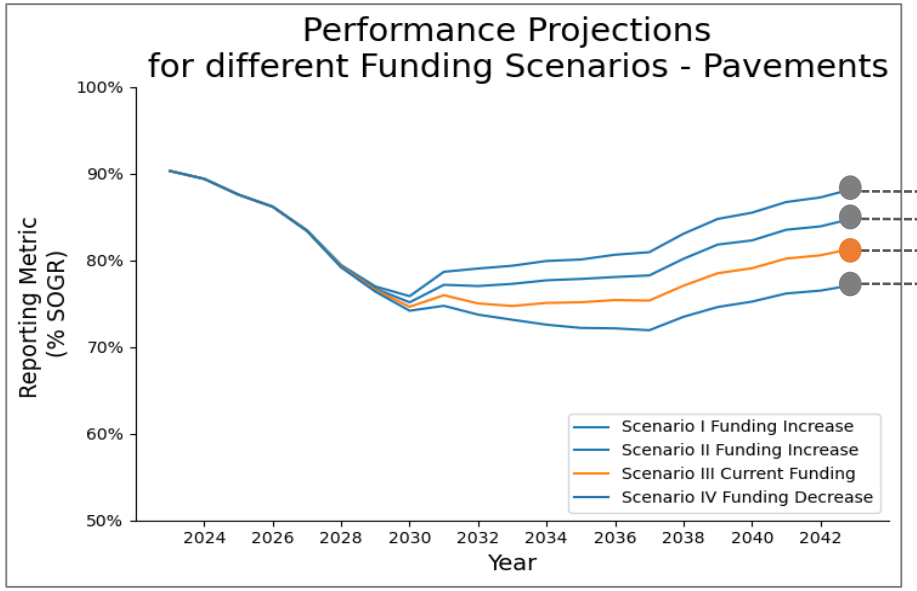
Connecting Historical Approach to Budget Curves

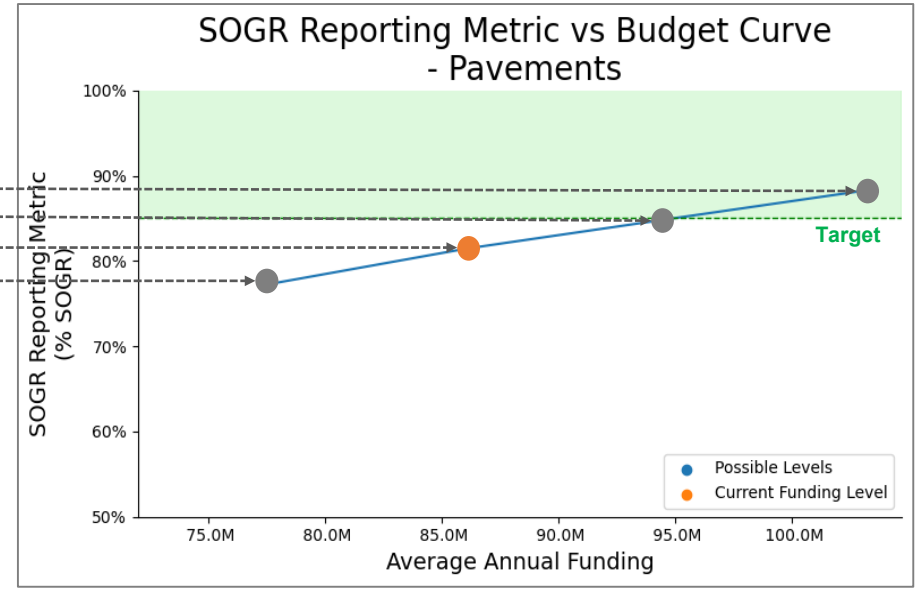
Strategies

- If we have multiple actions on same asset, especially if they are restoring/correcting different metrics, then challenge is to work out optimum strategy.
- CFR 515 Strategy = "…structured sequence of maintenance, preservation, repair, rehabilitation, and replacement actions …"
- What's the optimum lifecycle strategy for an asset?

Long term stable optimum lifecycle

- We can do a lot through expert elicitation to develop SOGR budget curves.
- But ideally, we would like to model total cost of ownership for assets and identify optimum long- term stable 'mix of fixes' for asset classes at any funding level.





PAVEMENTS

DelDOT is responsible for managing approximately 6,000 directional centerline miles of state-maintained roadway, 750 of which are on the NHS, and 1,600 of which are Suburban routes.

DelDOT is unique in that they are responsible for over 90% of the road network in the state. This SOGR Summary Sheet applies to the 4,400 miles of non-suburban roadways. See the State Maintained Suburban Pavements SOGR Summary Sheet for a more detailed look at that network.

Annual Budget:

The total expected average annual budget for the next 10 years is $68 million. This is a combination of State ($13-55.2 million), and Federal ($20-40.5 million).

Asset Valuation:

NHS Pavement Value:
Weighted $/Sq Yd = $235.17
Total Lane Miles = 1,655.87
Total Sq Yds = 12,675,385.07
Value = $2,980,874,365.04

*Centerline miles is a measure of the length of a road regardless of the number of lanes it has.

Lane miles is a measure of the total length of each individual lane in a stretch of roadway.

STATE OF GOOD REPAIR

A pavement section with an Overall Pavement Condition (OPC) rating of 50 or above is considered to be in a SOGR. The OPC ratings are determined by combining individual distress indices into a calculated value that defines the health of a pavement section.

TARGETS AND MEASURES

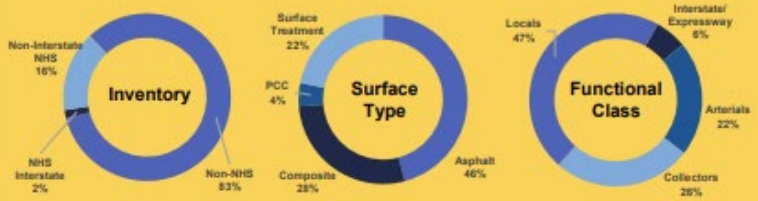
STATE:
75% of all pavements in a state of good repair.

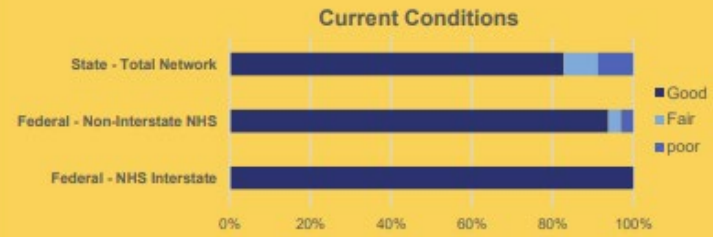
FEDERAL:
Interstate % Good – at least 50%
Interstate % Poor – no greater than 5%
Non-Interstate % Good – at least 40%
Non-Interstate % Poor – no greater than 5%
[Good, Fair, and Poor defined by 23 CFR 490.313(c)]

INVENTORY & CONDITION

STATE: Collecting federal plus additional pavement distresses to roll up into functional, structural, and non-structural indices which are in turn rolled up into an OPC value.

FEDERAL: Collecting data every year on IRI, rutting, cracking, and faulting to determine good, fair and poor at a tenth mile level.





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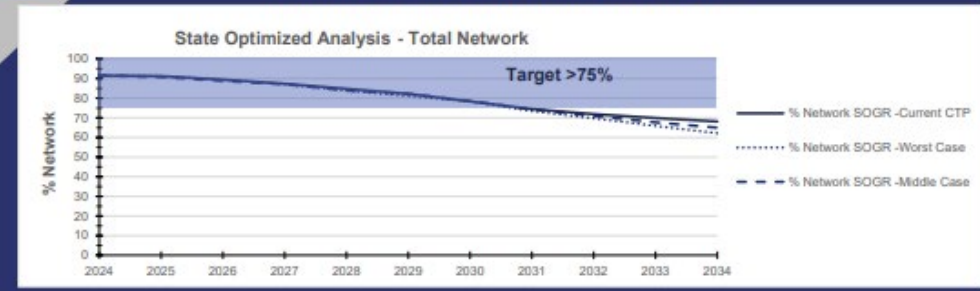
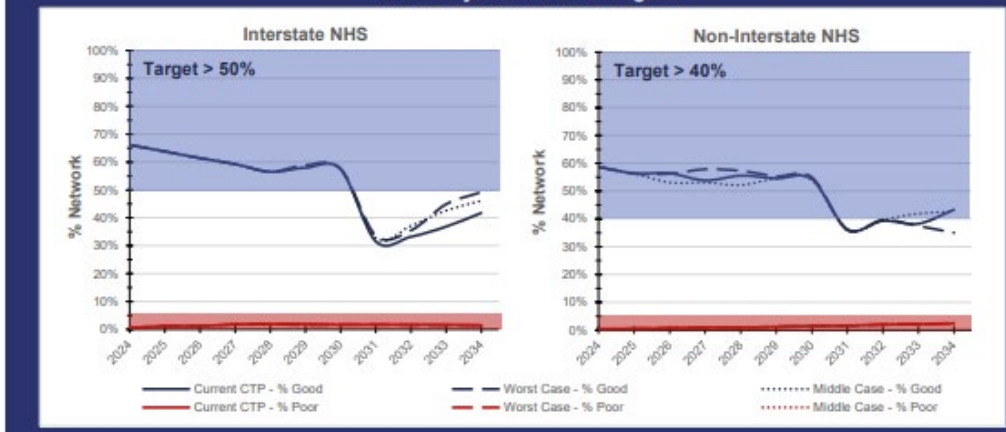
PERFORMANCE PROJECTIONS

Total Network SOGR Projections and Targets



NHS Projections and Targets



Funding Scenario	Average State Funds/Year	Average Federal Funds/Year
Current CTP	$39.3M	$27.75M
Middle Case	$28.8M	$31.9M
Worst Case	$15.3M	$31.9M

POTENTIAL RISKS

Risks to the management of Delaware's pavement netowrk include financial risks in unexpected price increases for materials, labor, and equipment, budget constraints that can effect how much work can be scheduled and performed, environmental risks, such as coastal flooding and other extreme weather, which can accelerate pavement deterioaration, and operational risks such as limited contractor availablitity and other construction delays.

Budget Curves Summary

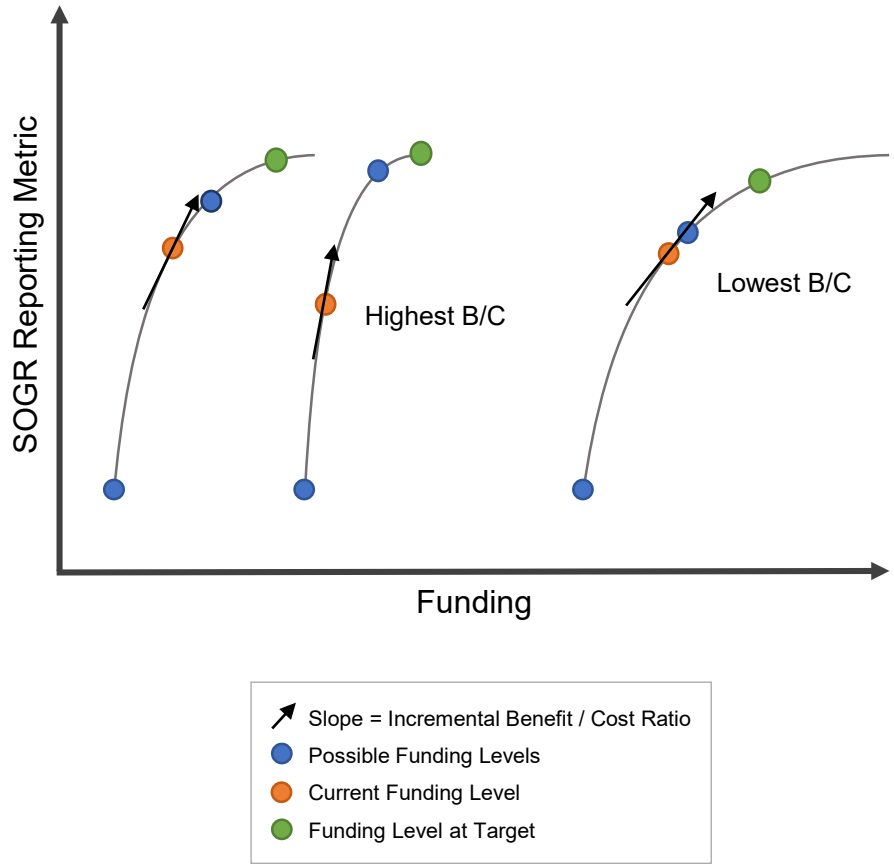
Long term stable optimum lifecycle

- So ideally, we would like to model total cost of ownership for assets and identify optimum long-term stable 'mix of fixes' for asset classes at any funding level.
- There are sometimes billions of different possible strategies – we need to find the optimum strategy at each level of funding.
- This generates an efficient frontier curve.
- This is essentially:
  Life Cycle Planning (LCP) ++

What level is needed for curves?

- One curve per funding cell.

Figure: Using the Combined SOGR Budget Curves



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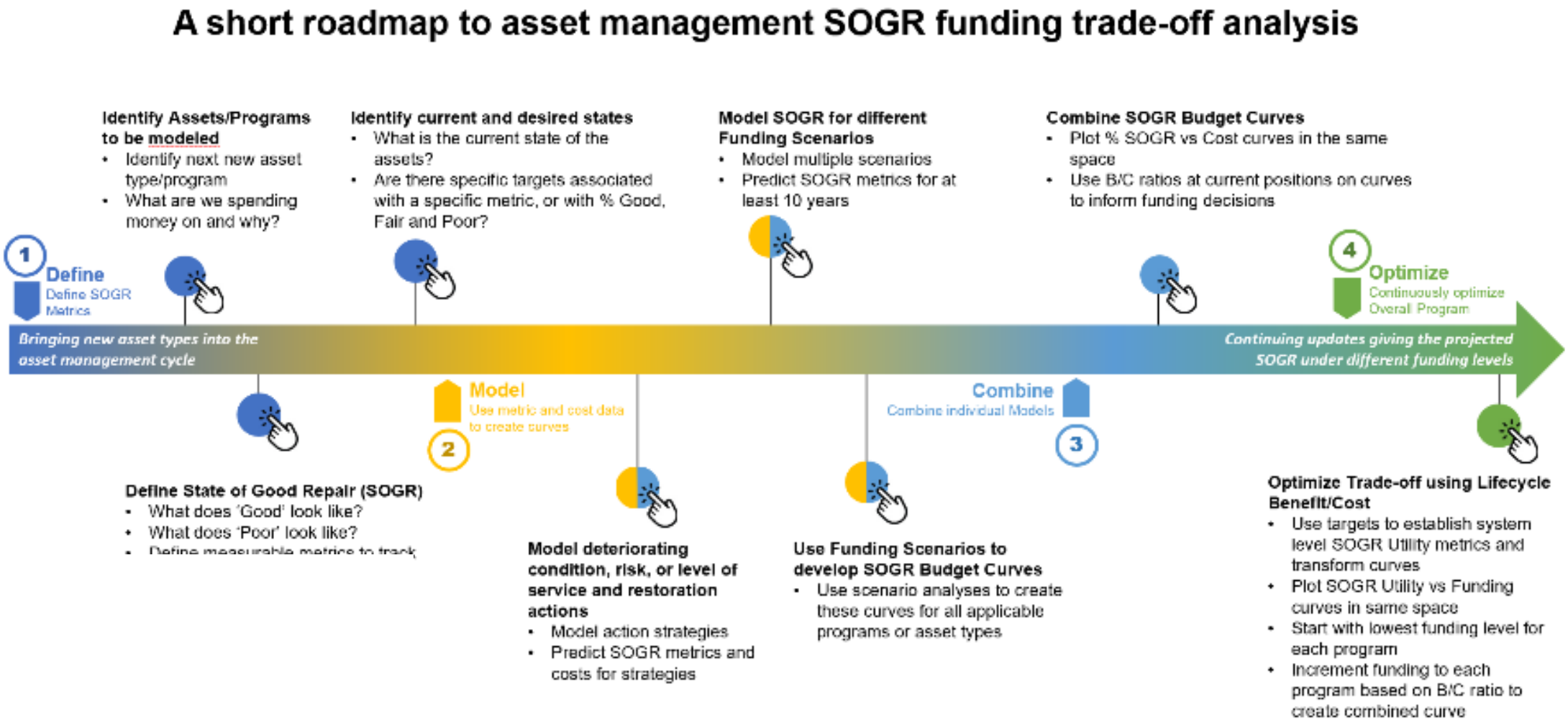
Framework Roadmap



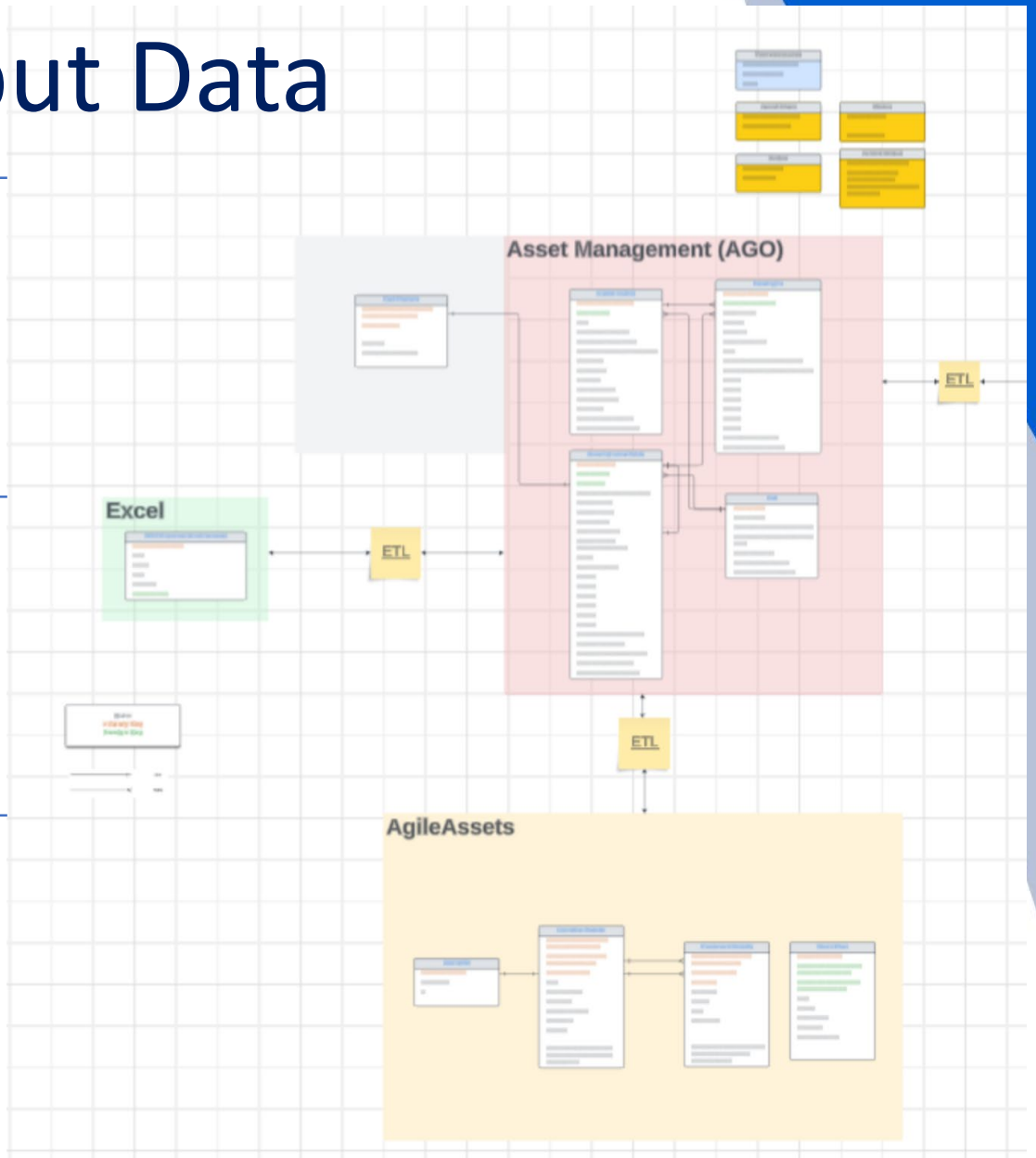
Framework Implementation: Handling Input Data

Framework Implementation: Handling Input Data

Asset inventory and scenario projection data originates from various sources including Excel and asset management systems (PMS and BRM).

Scenario projections developed by asset stewards illustrate funding impacts.

Data heterogeneity requires standardized processing for integration.



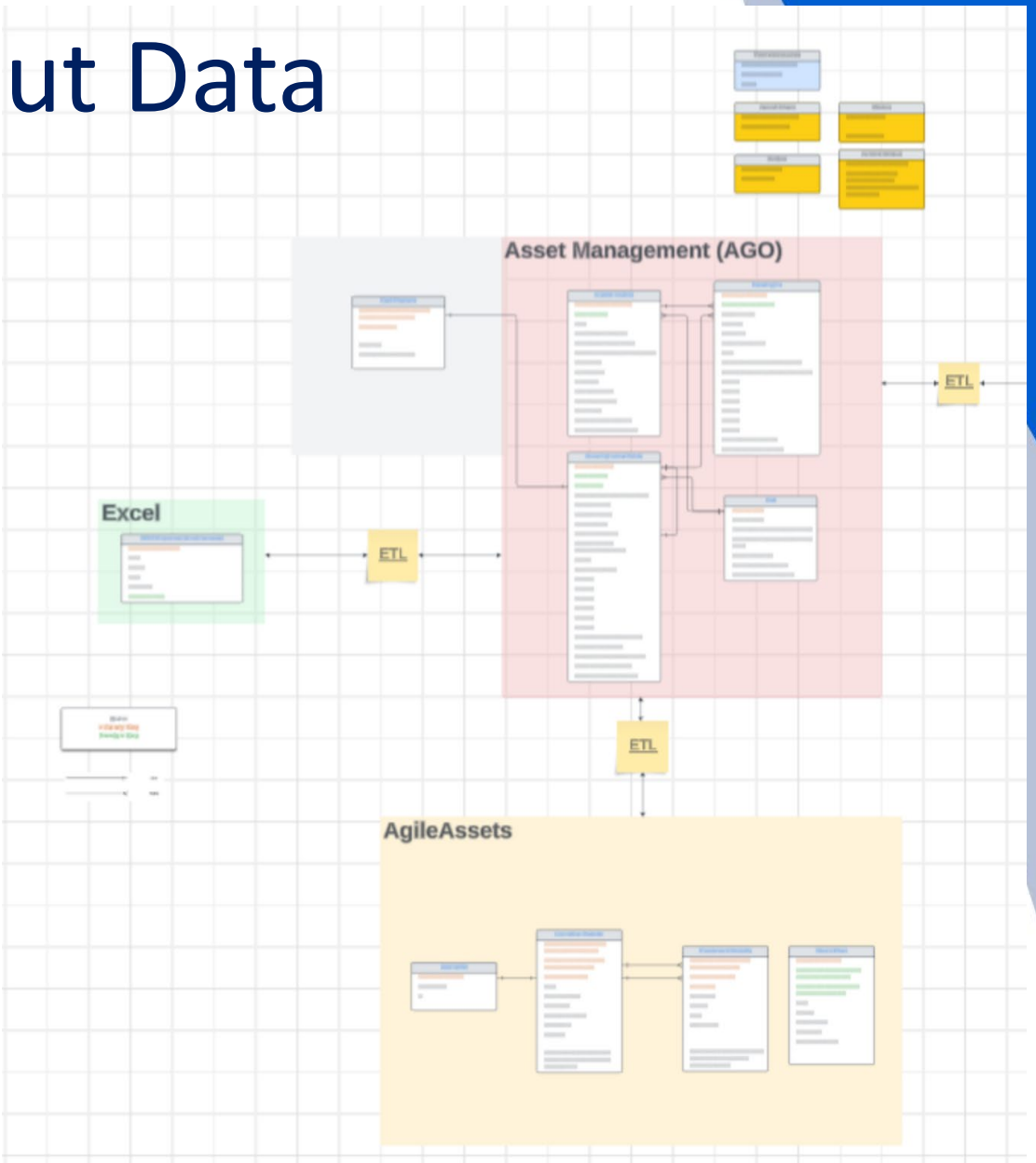
Framework Implementation: Handling Input Data

ETL codes extract, transform, and load data into the connected data environment.

Transformations standardize diverse data into asset-agnostic tables.

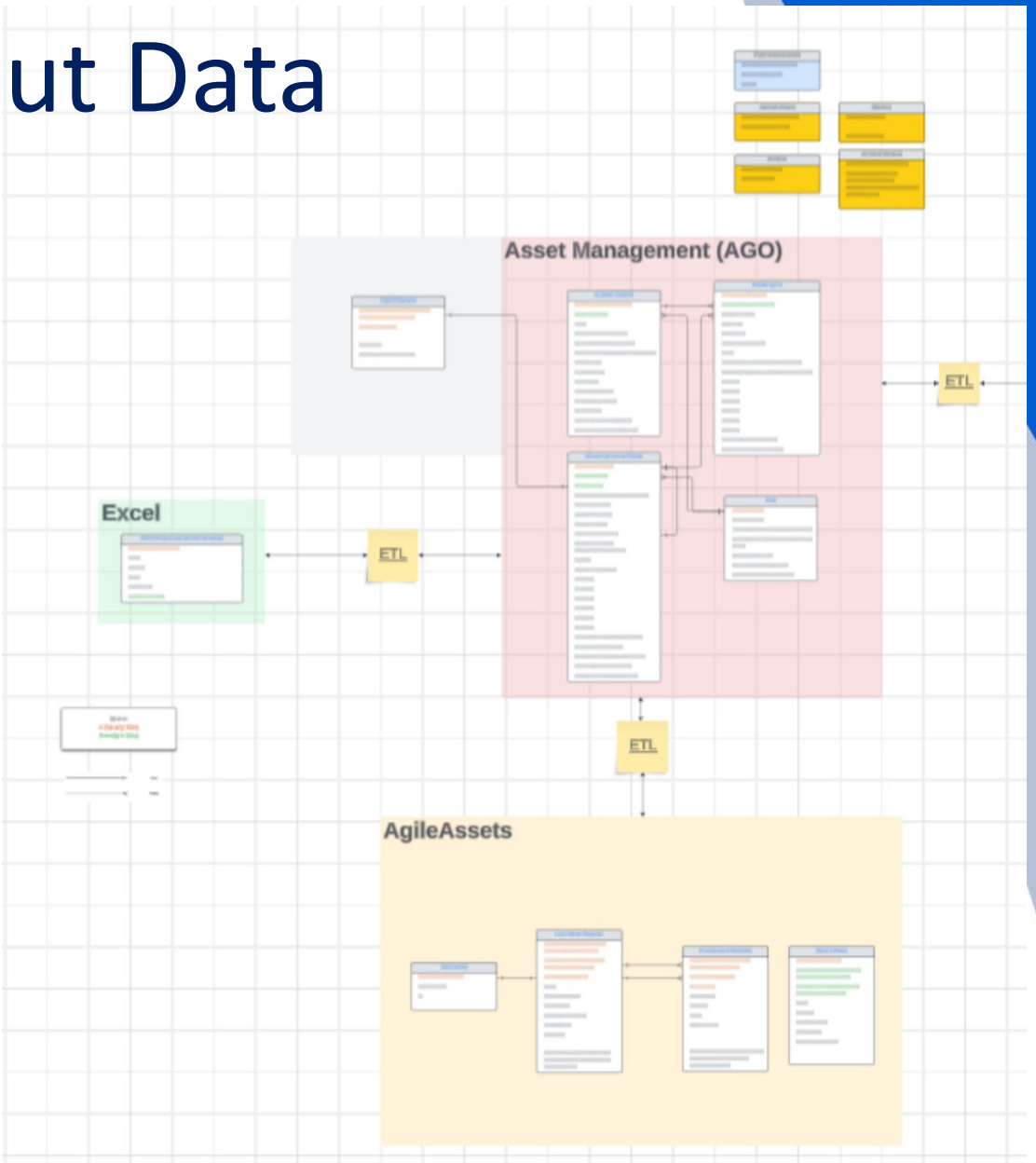
ETL processes handle discrepancies and ensure data quality.

Unified data (CDE) supports consistent analysis across multiple asset classes.

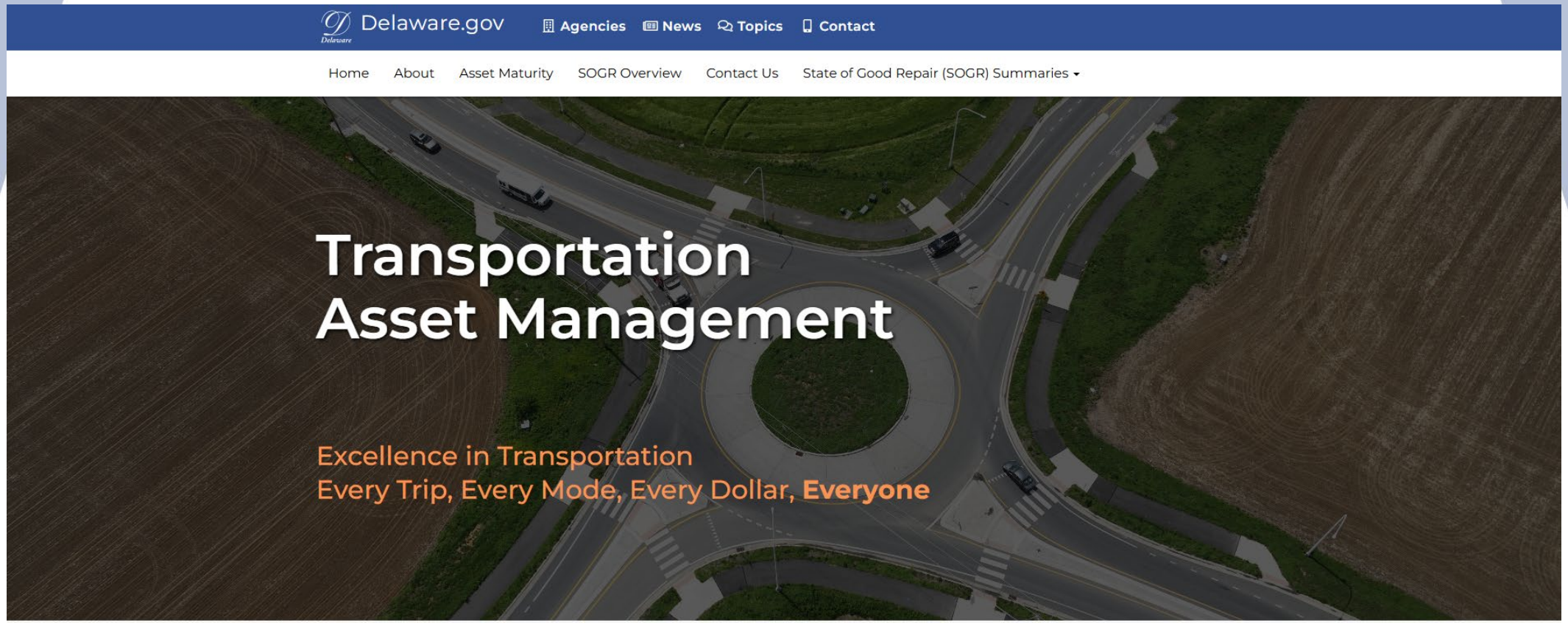


Framework Implementation: Handling Input Data

- CDE stores inventory and scenario projection data in a unified structure.
- Asset-agnostic tables enable cross-asset class data integration.
- Supports scalable data updates and scenario comparisons.
- Seamless integration with visualization tools like Esri Hub Site.



Framework Implementation: Esri Hub Site



Framework Implementation: Esri Hub Site

Enables spatial visualization of asset conditions and funding scenarios.

Supports informed decision-making with interactive dashboards.

Enhances ability to analyze funding distribution decisions across asset classes.

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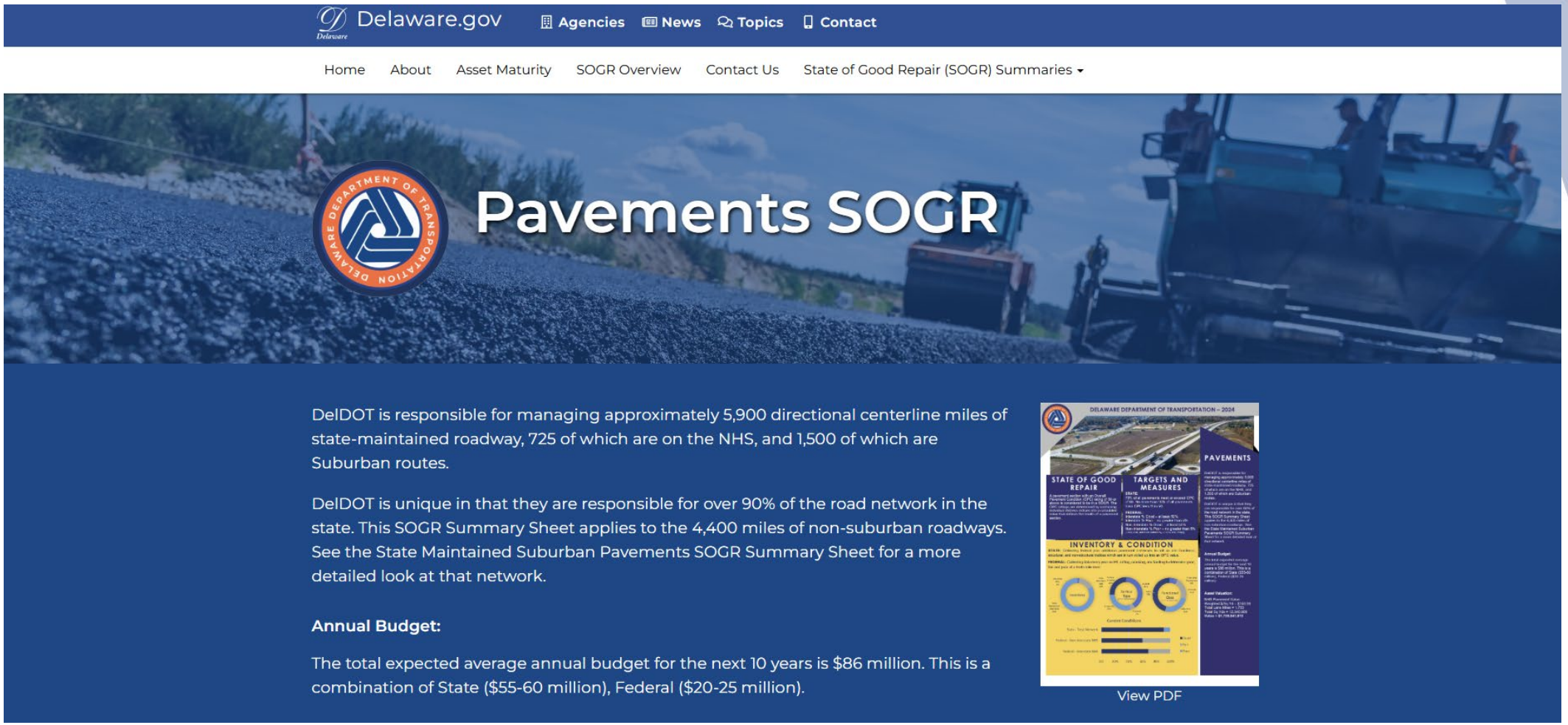
Framework Implementation: Esri Hub Site



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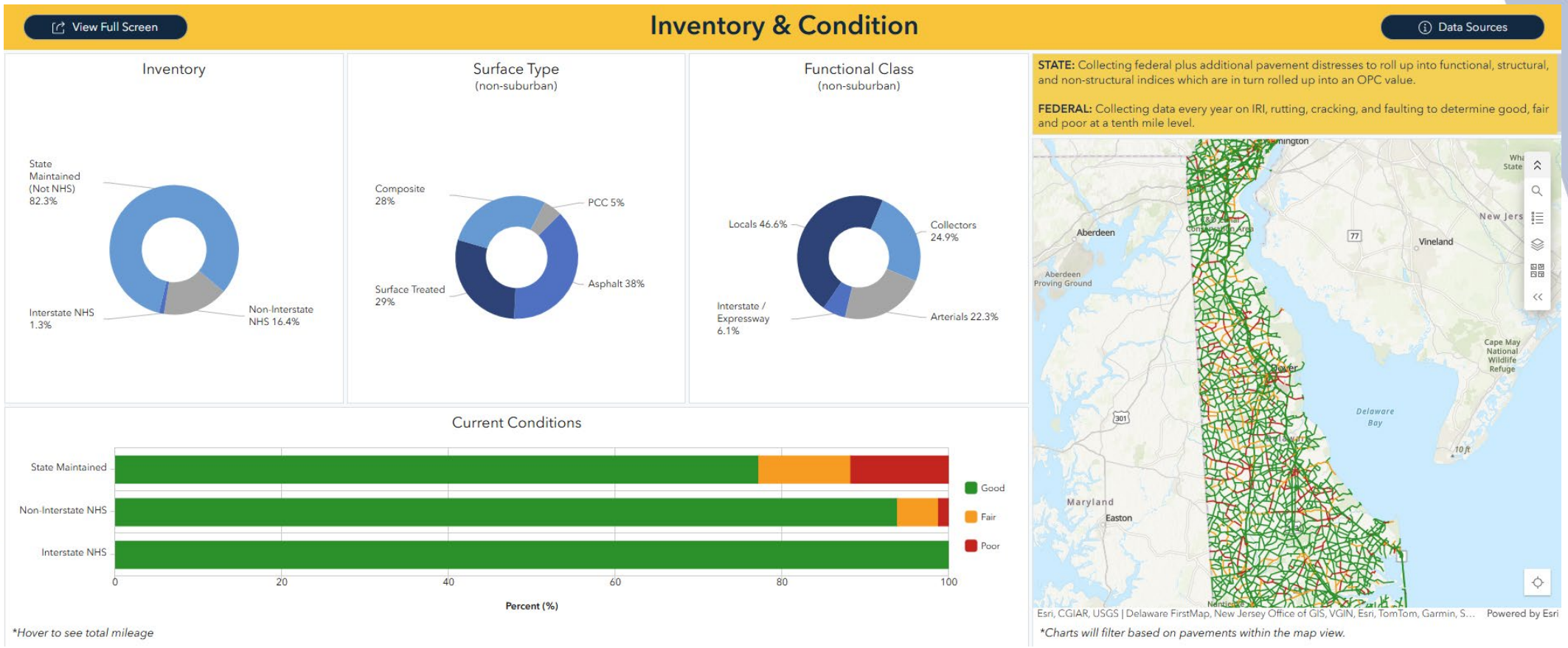
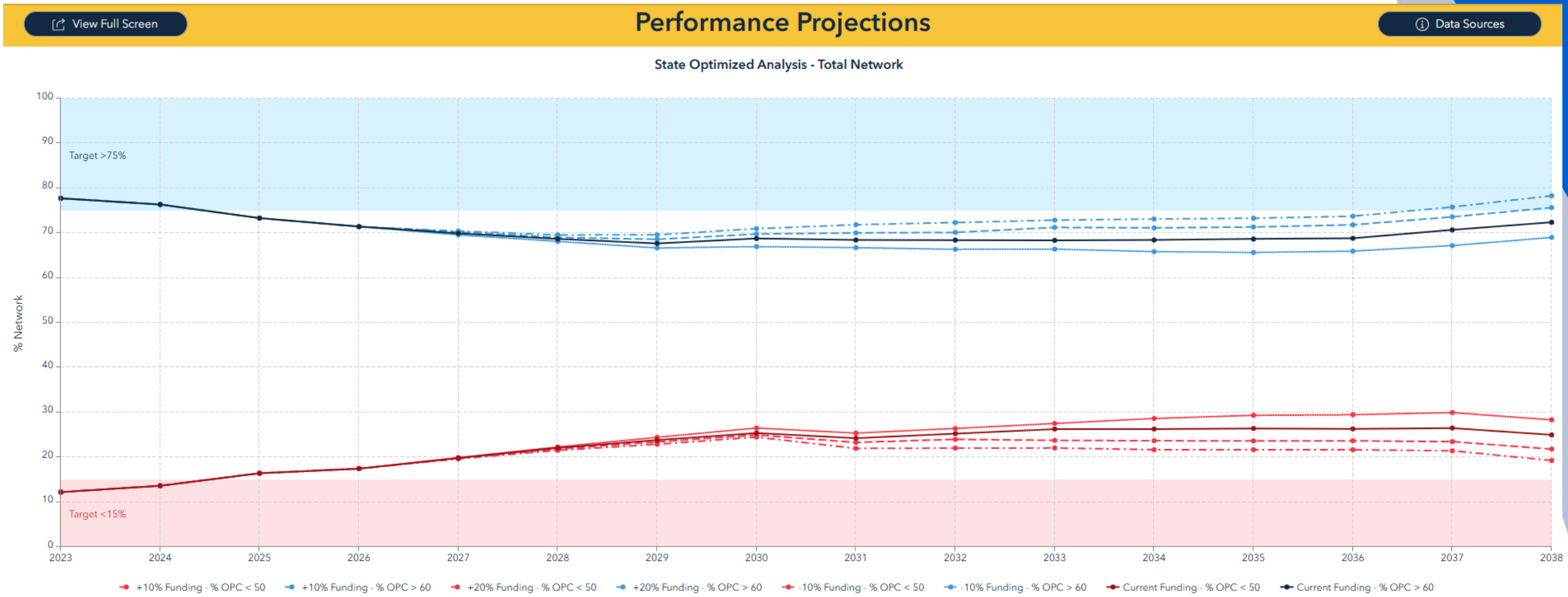


Framework Implementation: Esri Hub Site



Summary

- Effective budgeting maximizes asset performance for the best cost.
- Quantitative framework method guides optimal fund distribution across cells.
- Framework allows for assessment of all assets in a CDE.
- Visualization of framework implementation is performed through the Hub Site.

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QUESTIONS &
COMMENTS

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THANK YOU!

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