CALIFORNIA
High-Speed Rail Authority

REPORT

Update to Peer Review Group of work in progress on O&M cost modeling and projections

Model Enhancement and Validation of Projected O&M Costs

San Francisco,
July 9th, 2013

FINAL

Disclaimer

All results presented in this report are based on preliminary model runs with final inputs and assumptions still being developed. All numbers should be considered draft and subject to change as the model is finalized.

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Over the past year, there has been increased interest in and scrutiny of the O&M cost estimates

- CPUC Section 185033.a mandates that the Authority's biannual Business Plan include a forecast of the anticipated operating and maintenance costs of the system
- In its comments on the 2012 Revised Business Plan, the Peer Review Group called the results of the O&M model, "a critical determinant of the ability of the system to generate positive cash flow for use in financing future parts of the system beyond the IOS." and urged the Authority to upgrade its existing model
- SB 1029, the legislation authorizing the Authority to issue bonds to fund the start of construction, requires the 2014 Business Plan to include "a proposed approach for improving [operations and maintenance cost models]"
- The GAO found that the Authority's cost estimates substantially met best practices for producing accurate cost estimates. However, they confirmed that the modeling could be further improved by adding more detailed cost categories, increasing the amount of documentation, and further evaluating risk and uncertainty.
- The UIC provided 19 findings and recommendations to enhance the O&M cost estimating process and supplied international benchmarks for typical Maintenance of Infrastructure (MoI) and Maintenance of Equipment (MoE) costs

We took these requirements/criticisms/suggestions to heart in developing the 2014 model

- The 2014 model…
  - Provides a detailed bottom-up approach based on guidance from the USDOT Inspector General (DOT IG)
  - Incorporates the feedback received from the PRG and UIC
  - Addresses the recommendations provided by the GAO
  - Takes into account the current level of program definition and development and is flexible to further refinements in the future.
  - Uses the current Concept of Operations as its technical baseline and includes full documentation of all inputs and assumptions.
  - Uses the UIC benchmarks, recommendations, and philosophies for validation and cross-checking purposes.
  - Was used to validate the top-down cost estimates produced from the 2012 model

The 2014 model produces a robust estimate of the system's O&M costs based on applicable recommendations and guidance

The operations and maintenance cost model provides a comprehensive estimate of the cost of running the system

- This includes:
  - Running the trains (including labor and energy)
  - Staffing the stations
  - Dispatching the trains
  - Maintenance and inspection of the track and infrastructure
  - Maintenance and inspection of the rolling stock
  - Commercial costs of operations (such as credit card fees, marketing costs, etc.)
  - Insurance
  - General and Administrative Costs
  - Contingencies for potential uncertainties

This report includes information on model development, structure, and results

- The report includes the following sections:
  - Introduction
  - Context and Objectives
  - Model structure and functionality
  - Model results
  - Analysis

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The Legislature's Peer Review Group was concerned about the level of detail in the model and proposed UIC involvement

PRG Conclusion

- 2012 O&M model is simplistic and does not reflect the relationship between costs and level of operations as well as it could
- Concerns that the model appears optimistic relative to US Amtrak HSR operations in the Northeast Corridor*
- The O&M model does not reveal major errors in the individual components
- International comparisons show that the forecasts seem realistic, but comparisons with systems operating at the same speed do not exist
- The Authority did perform a series of sensitivity tests on the O&M cost estimates suggesting that the financial performance of the project is robust over a reasonable range of assumptions

PRG Recommendations

- The PRG recommendations were incorporated into SB-1029:
  - The High-Speed Rail Authority shall, as part of its January 1, 2014, Business Plan, include: a proposed approach for improving (a) demand projections, (b) operations and maintenance cost models, and (c) benefit-cost analysis as applied to future project decisions
  - The authority shall also submit a copy of the study by the Union Internationale des Chemins de Fer (the international union of railways) examining how the authority's estimated operating costs for high-speed rail compare to high-speed rail systems in other countries

*As previously discussed with the PRG, Amtrak's existing NEC operations are not a good comparator for the CA system. However, the publicly available data on Amtrak's NextGen demonstrates that our estimated operating ratio is line with theirs. We are working with Amtrak to gather other relevant and comparable data.

The GAO strongly recommended further refinements to the O&M model following DOT-IG and international guidance

GAO Conclusion

- The GAO report concluded that the cost estimates substantially met best practice for accurate forecasts and were updated regularly
- The O&M model cost categories are not as detailed as those of the Capital Cost Estimation
- The cost estimates could be improved to better match DOT-IG guidelines
- Contingencies could be improved by conducting more risk/uncertainty analysis
- There was no ICE performed to establish an independent cost validation of the forecasts
- Documentation of some costs in the O&M model was difficult to trace back to existing source documents

GAO Comments

- Continue developing and refining the O&M cost model to integrate additional level of details in line with the recommendations from the DOT-IG guidance
- Develop additional sensitivity analyses to test the responsiveness of the model to key changes in model inputs
- Incorporate allocated and unallocated contingencies based on uncertainty and risk analysis
- Provide international comparisons and benchmark to help validate the model output
- Use international expertise such as the UIC to further refine the model and gain buy-in for the model results
- Develop a clear set of documentation such as a User's Guide and a Record of Assumptions

The UIC has endorsed the O&M cost modeling approach and has outlined a series of improvements

UIC Conclusion

- In September 2012, as required by SB 1029, the Authority commissioned the Union Internationale des Chemins de Fer (UIC) – International Union of Railways – to conduct a review of the operations and maintenance cost estimates that were developed to support the 2012 Business Plan
- The experts reviewed the methodology and the procedures developed by the Authority and assessed the resulting O&M cost estimates for reasonableness
- UIC and its experts concluded that the model and the processes had no fatal flaws and that the O&M estimates were reasonable at the current stage of the program development
- The review also provided best practice guidelines and some European benchmark values in order to improve the O&M cost modeling process

UIC Recommendations

- The experts identified 5 primary areas for recommendations for the next generation O&M modeling :

1. Further detail cost categories (e.g. marketing and advertising costs, distribution and sales costs, …)
2. Account for International private sector practices to offer a suitable alternative to US public sector costs
3. Further adjust MoI, MoE and energy cost to reflect the impact of train operations at 220 mph
4. Account for seasonality of the demand to refine operating plans
5. Further optimize the program and the operations plan to identify sources of cost savings and efficiencies

The goal is to create an O&M Cost Model that is...

1. In line with federal guidance including the DOT IG and the recommendations from the GAO
2. Consistent with the current status of system design, concept of operations, service planning, and ridership forecasting
3. Flexible to further changes in design, phasing, operating scenarios, service plans, etc.
4. A bottom-up estimate with detailed inputs
5. Comprehensive, accurate, well-documented, and credible
6. Capable of testing the ability of different scenario's ability to operate without a subsidy

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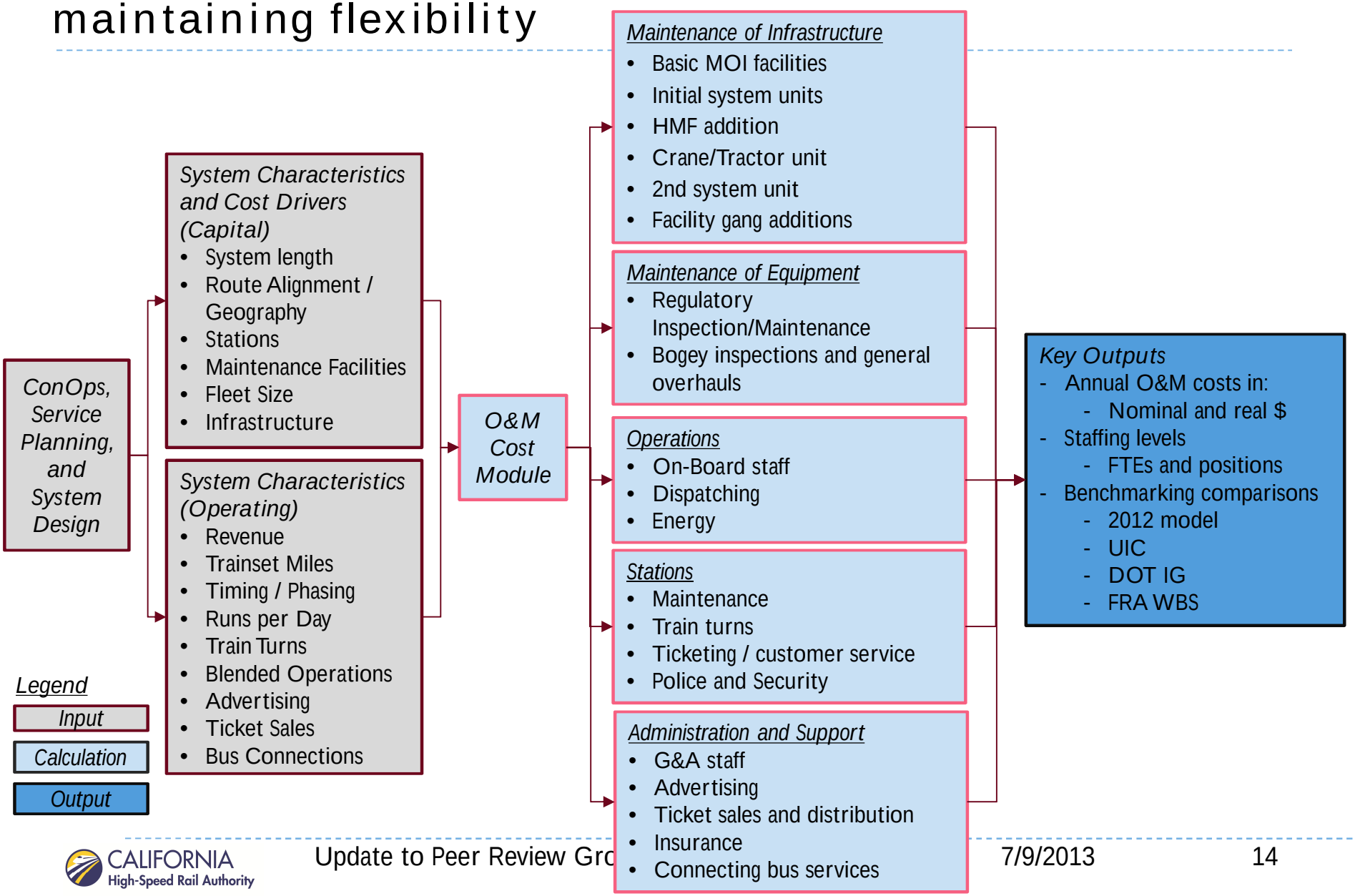
The 2014 model structure is much more detailed while maintaining flexibility



The bottom-up 2014 model addresses the criticisms of the top-down 2012 model and provides validation for previous O&M cost estimates

2012 O&M Model

- Top-down model with six cost drivers
- Inputs based on simplification of previous model and validation from international data
- Majority of costs driven completely by ridership leading to very high variable costs
- Some assumptions not fully consistent with ConOps
- High/low scenarios based purely on ridership high/low scenario, not high/low O&M costs
- Cumbersome model leading to slow scenario turnaround times
- Model can be classified as "Preliminary" by DOT IG standards

2014 O&M Model

- Bottom-up model with dozens of cost drivers
- Inputs developed based on existing rail practices, costs, and other credible sources of information
- Ability to conduct the sensitivity tests and risk analyses recommended by the GAO
- Much more diverse set of cost drivers leading to greater percentage of fixed costs and less elasticity to ridership (consistent with UIC findings)
- ConOps and O&M model/documentation directly linked as "living documents"
- Results validated against previous model, UIC values, and DOT IG values
- Risk-adjusted range of costs being developed based on O&M variables
- Flexible model with built-in scenario testing capability leading to faster turnaround times
- Built-in high and low scenarios independent of ridership
- Model classified as "Intermediate" by DOT IG standards

The 2014 O&M cost model was developed in accordance with the Concept of Operations

ConOps Input

- Requirements Document for Operations and Maintenance Methodology and Scope
- Contains Detailed Descriptions of Operations including:
  - Phased Implementation of the HSR System
  - Station Operation and Configurations
  - Facilities
  - Rolling Stock
- Appendices Include:
  - Command and Control - Staffing and Facilities
  - On-Board Train – Staffing and responsibilities
  - Maintenance Methodologies for Rolling Stock and Infrastructure
  - Service Plans to Support Phased Implementation

- The ConOps is a primary driver to the O&M cost model input and assumptions

Detailed Assumptions

Cross-walk between ConOps and O&M model

Section	Title	Description	Relevant to O&M Estimate	Type of input	Relevant to O&M Estimate
5.1	PHASED IMPLEMENTATION	This introduces the staged development and implementation of the project in a three step plan.	Y	2	Length of main track by segment: IOS = 250 miles long Bay to Basin = 390 miles Blended Phase I = 470 miles
5.3	THE INITIAL OPERATING SECTION (IOS)	This provides a description of the IOS infrastructure, service plan, infrastructure maintenance plan, and rolling stock maintenance plan.	Y	2	Consistent with the phasing applied in the O&M model 4 Trains/hr each direction = peak; 1-2 Trains/hr each direction = off peak; 68 Trains in daily schedule; 27 Train sets, 250 miles of double main track; 2 Terminal stations and 4 Intermediate stations; Shafter MOI Facility, Divide and Palmdale MOI facilities plus three sidings; 30-Track HMF in Central Valley, SFV Level 3 Maint. Facility, car wash, wheel inspection device. Starting costs indicated in section 5.3.1 are included in the O&M model
5.4	THE BAY TO BASIN SECTION	This provides a description of the Bay to Basin infrastructure, service plan, infrastructure maintenance plan, and rolling stock maintenance plan.	Y	2	Consistent with the phasing applied in the O&M model. 4 Trains/hr each direction, SJ to SFV and 2 Trains/hr each direction Merced to SFV = peak; 5 Trains/hr each direction = off peak; 142 Trains in daily schedule; 47 train sets, 390 miles of double main track includes tangent and elevated track, tunnels, bridges, aerial structures; 3 Terminal stations and 5 intermediate stations;
6.3	INFRASTRUCTURE	List and description of infrastructure elements	Y	1	Limited reference to : • 5-hour overnight work window (6.3.3) • Inspection schedule (6.3.3.5, Table 6-1)
6.5	ROLLING STOCK	Description of rolling stock requirements	Y	2	Reference to 400-500 psgrs per trainset (6.5.2)
6.6	EQUIPMENT SERVICING, MAINTENANCE, AND REPAIR – PROGRAMS AND FACILITIES	Description of various rolling stock cleaning and maintenance plans and facilities	Y	2	Reference to : • 72 trainsets for Phase 1 (6.6.3.1) • List of storage yard track capacities by phase (6.6.3.3, Table 6-2)
6.7	PASSENGER STATIONS	Description of station requirements, types of stations, list of stations, station infrastructure and elements, station operations	Y	2	Reference to : • Terminal stations (6.7.3.1) • Intermediate stations (6.7.3.2) • Key intermediate stations (6.7.3.3)
6.8	TRAIN MOVEMENT AND CONTROL FACILITIES	Description of train control facilities and responsibilities	Y	2	Reference to : • Yard Operating Center headcount (6.8.5)
7.3	THE PHASED IMPLEMENTATION CONCEPTUAL SERVICE PLAN	Description of CHST service plan over course of phased implementation	Y	2	Reference to : • 6 stations/64-68 revenue trips/21-27 trainsets in IOS (7.3) • 8 stations/142 revenue trips/50 trainsets in B2B (7.3) • 13 stations/203 revenue trips/72 trainsets in Phase 1 (7.3) • Double consist trainset ridership assumption – 500-1000 psgrs (7.3.1) • 72 trainsets in Phase 1 (7.3.2)
7.12	THE TRACK AND INFRASTRUCTURE MAINTENANCE PROGRAM	General description of this plan	Y	1	Reference to: • MOI on-track vehicles • 5-hour overnight maintenance window
7.14	HIGH-SPEED OPERATING STRATEGY	List and description of operating control centers, functions, responsibilities and overall operational control strategy. Description of ATC system, wayside signals, operation on different type of track, operating rules.	Y	1	Reference to: • List of types of control centers • Locations of TCFs by phase (Table 7-1)

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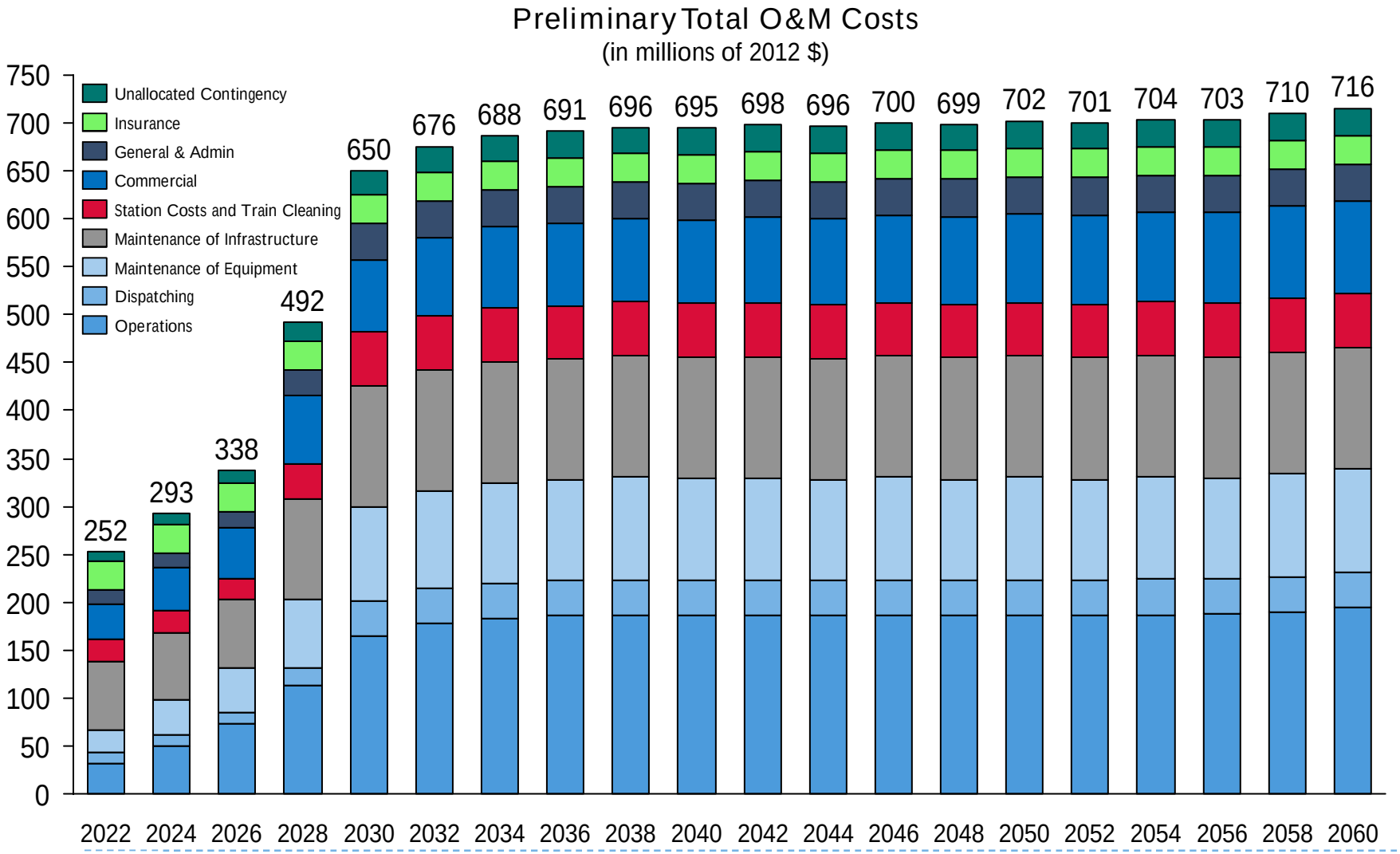
O&M costs increase with ramp-up in service and addition of new phases



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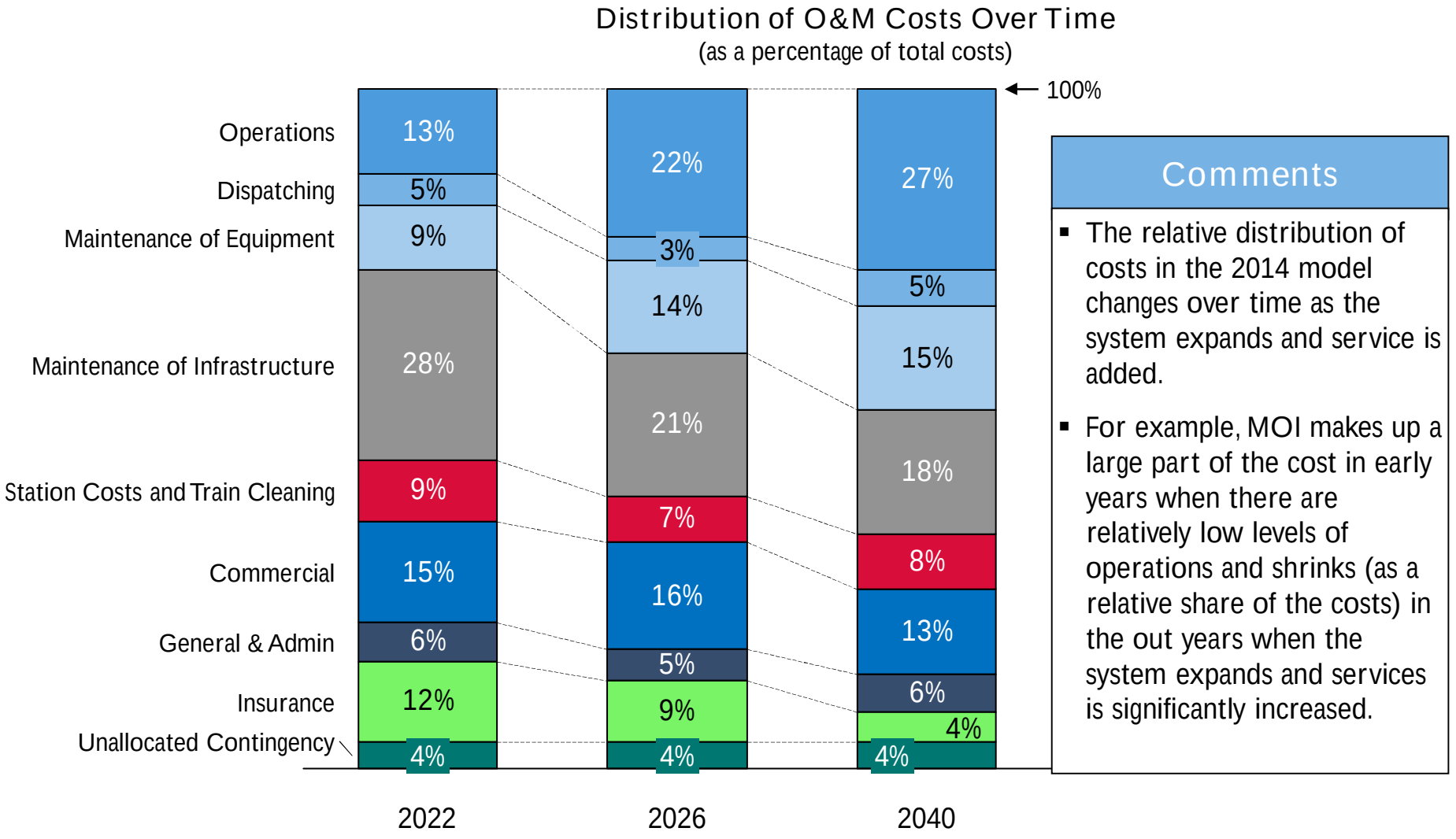
The contribution of various cost components changes as the system evolves



Comments

- The relative distribution of costs in the 2014 model changes over time as the system expands and service is added.
- For example, MOI makes up a large part of the cost in early years when there are relatively low levels of operations and shrinks (as a relative share of the costs) in the out years when the system expands and services is significantly increased.

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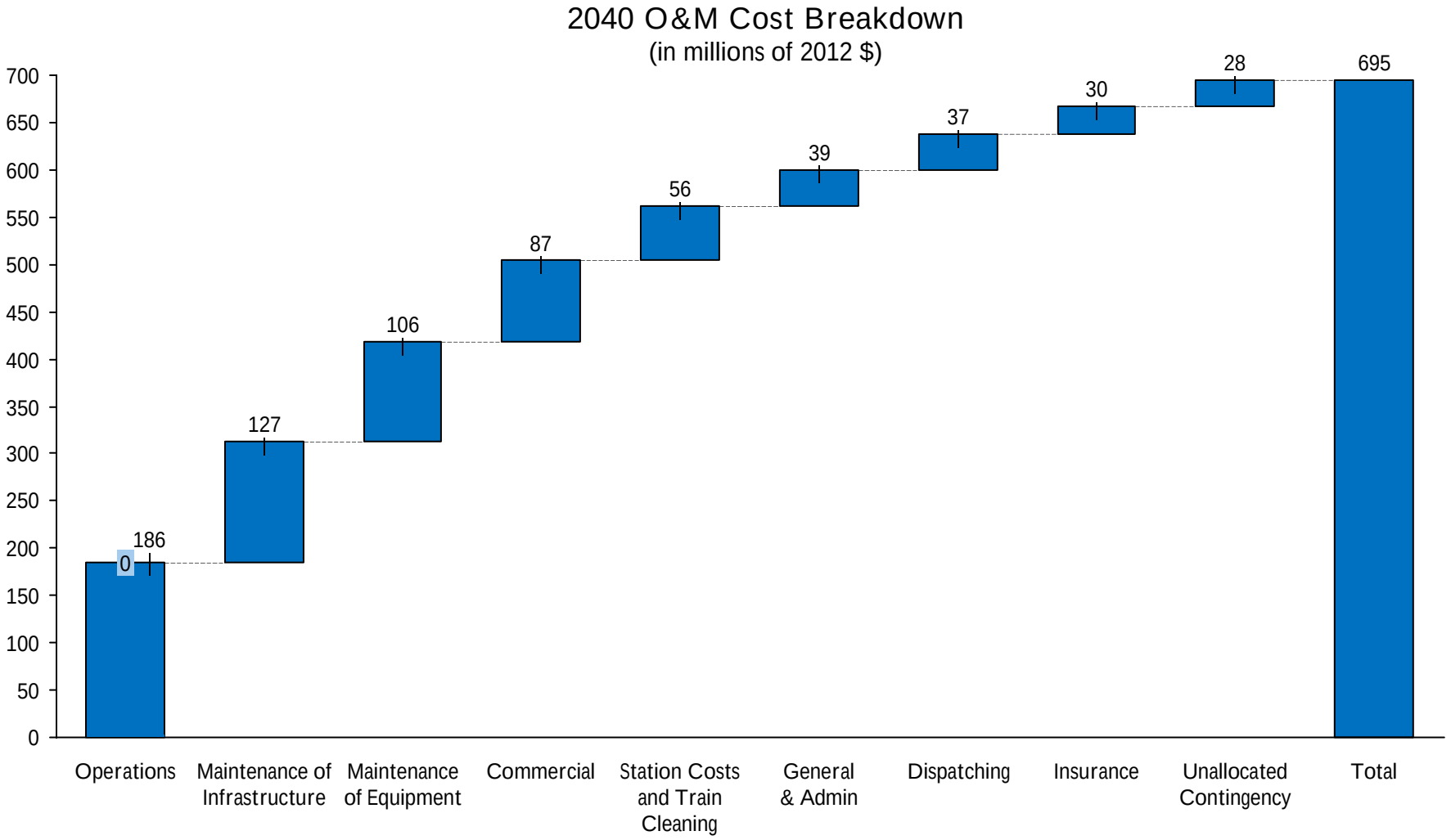
In year 2040, preliminary results show that operations, MoI, MoE, and commercial costs make up almost 75% of costs



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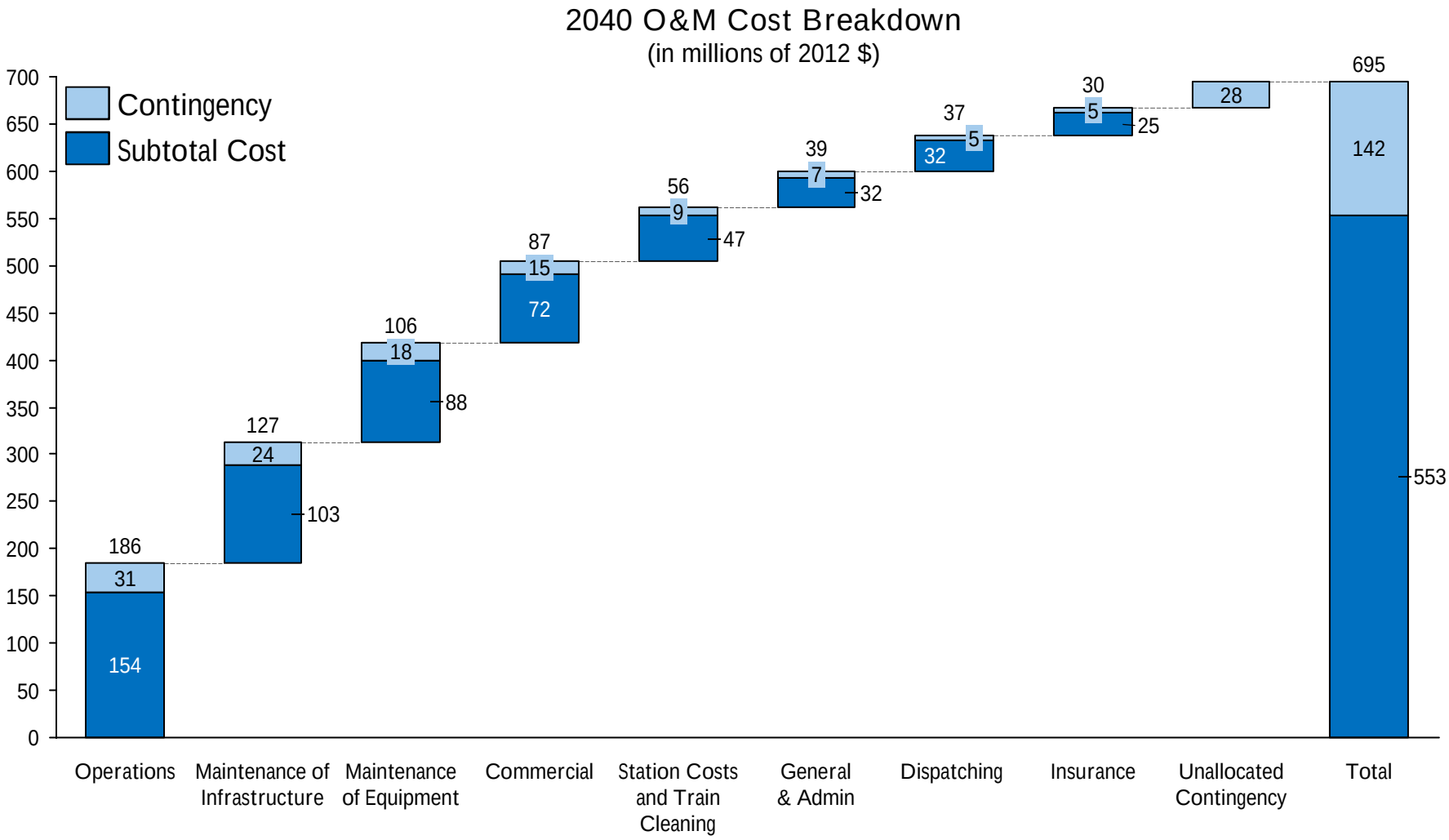
The 2014 model includes both allocated and unallocated contingency, which add up to 26% of subtotal costs



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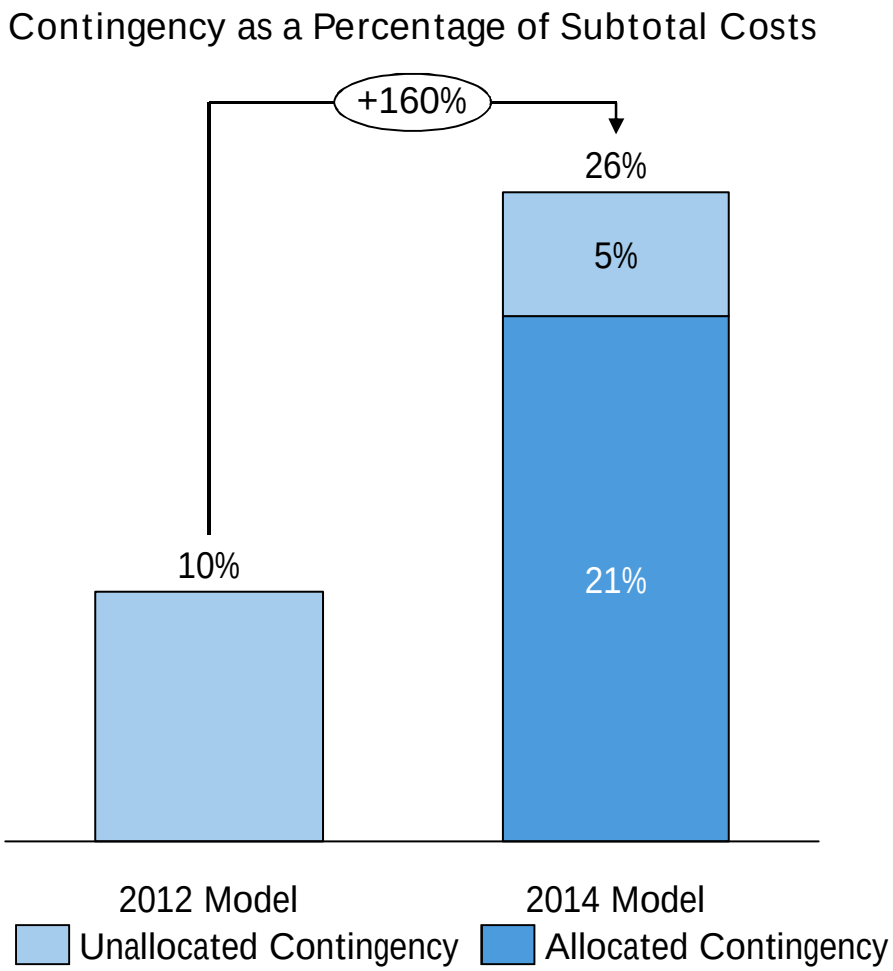
Contingency increased from 10% of subtotal costs in the 2012 model to 26% in the 2014 model



(1) The 16% increase in contingency is not a net increase on the total cost as some reallocation is included.The net difference in costs is indicated on page 22.

Comments

- The 2012 model included only unallocated contingency and did not break out levels of conservatism or allocated contingency in its unit costs.
- For the 2014 model, individual cost elements' uncertainties and risks were analyzed to create a range of allocated contingencies for each set of variables.(1)
- Total contingency for each cost element was set between 20% and 40% depending on the risk associated with the cost element, based on guidance from DOT IG on intermediate stage cost estimates.
- The UIC also recommended that O&M contingencies be set at least at levels consistent with the capital cost estimate. The capital cost contingencies are 5% unallocated, 16% allocated, broadly in line with the O&M contingencies.

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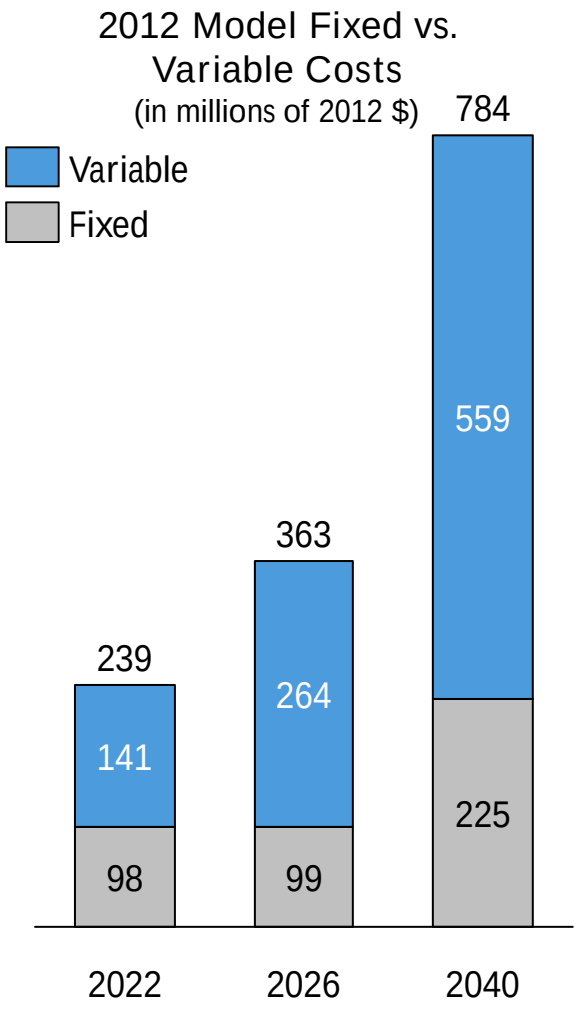
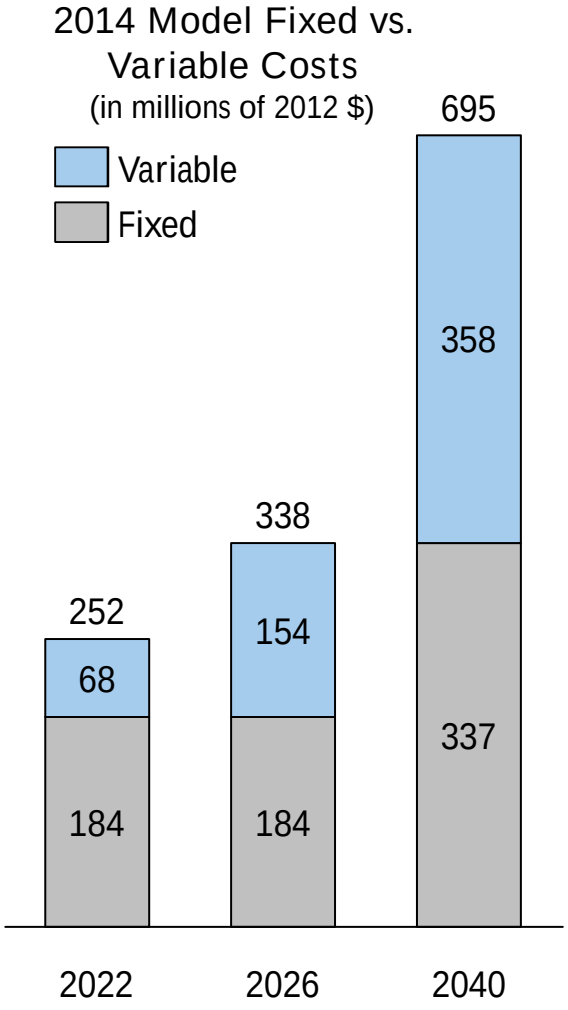
The 2014 model has more fixed costs relative to ridership than the 2012 model (consistent with UIC finding)

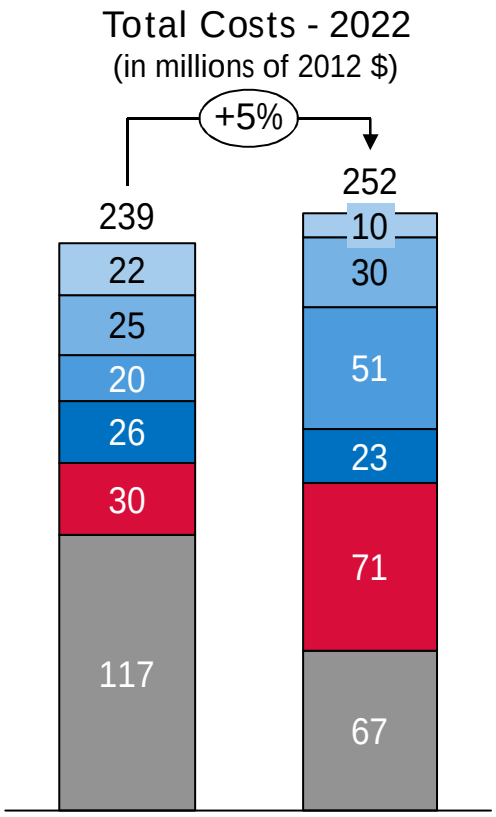


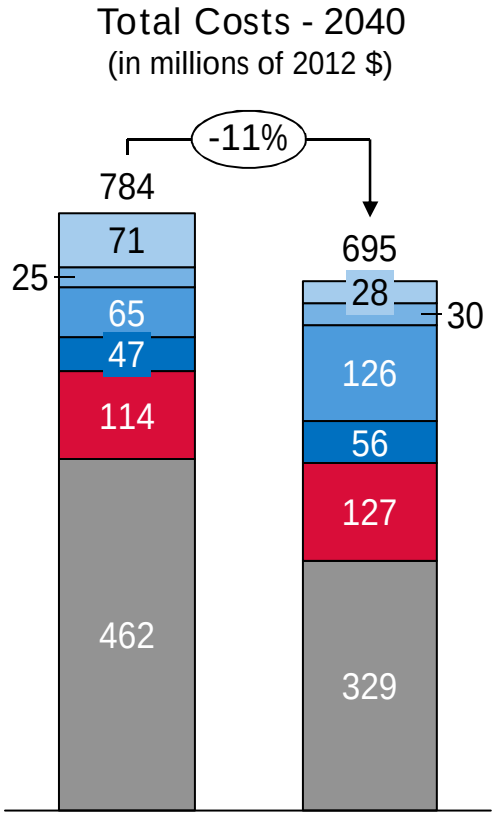


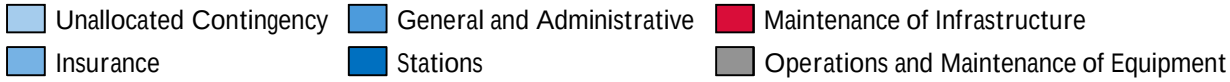
Comments

- The UIC commented that the top-down approach of the 2012 model made the model more reactive to changes in ridership (higher elasticity) than expected.
- The 2014 model has more detailed cost drivers so only costs directly tied to service/operating characteristics vary with ridership.
- The 2014 model's higher share of fixed costs is consistent with UIC's experience with HSR systems around the world.

Preliminary results from the 2014 model validate the results of the 2012 model but the higher percentage of fixed costs in the 2014 model lead to higher costs in early years and lower costs in out years







Comments

- The bottom-up approach for the 2014 model resulted in similar bottom-line total O&M costs as the top-down approach from the 2012 model.
- Higher fixed costs (relative to operating characteristics) in the 2014 model lead to higher costs in the early years and lower costs in the out years.
- G&A and MoI accounted for most of the higher costs in the 2014 model while Operations and MoE and unallocated contingency decreased.

All results presented in this report are based on preliminary model runs with final inputs and assumptions still being developed. All numbers should be considered draft and subject to change as the model is finalized.

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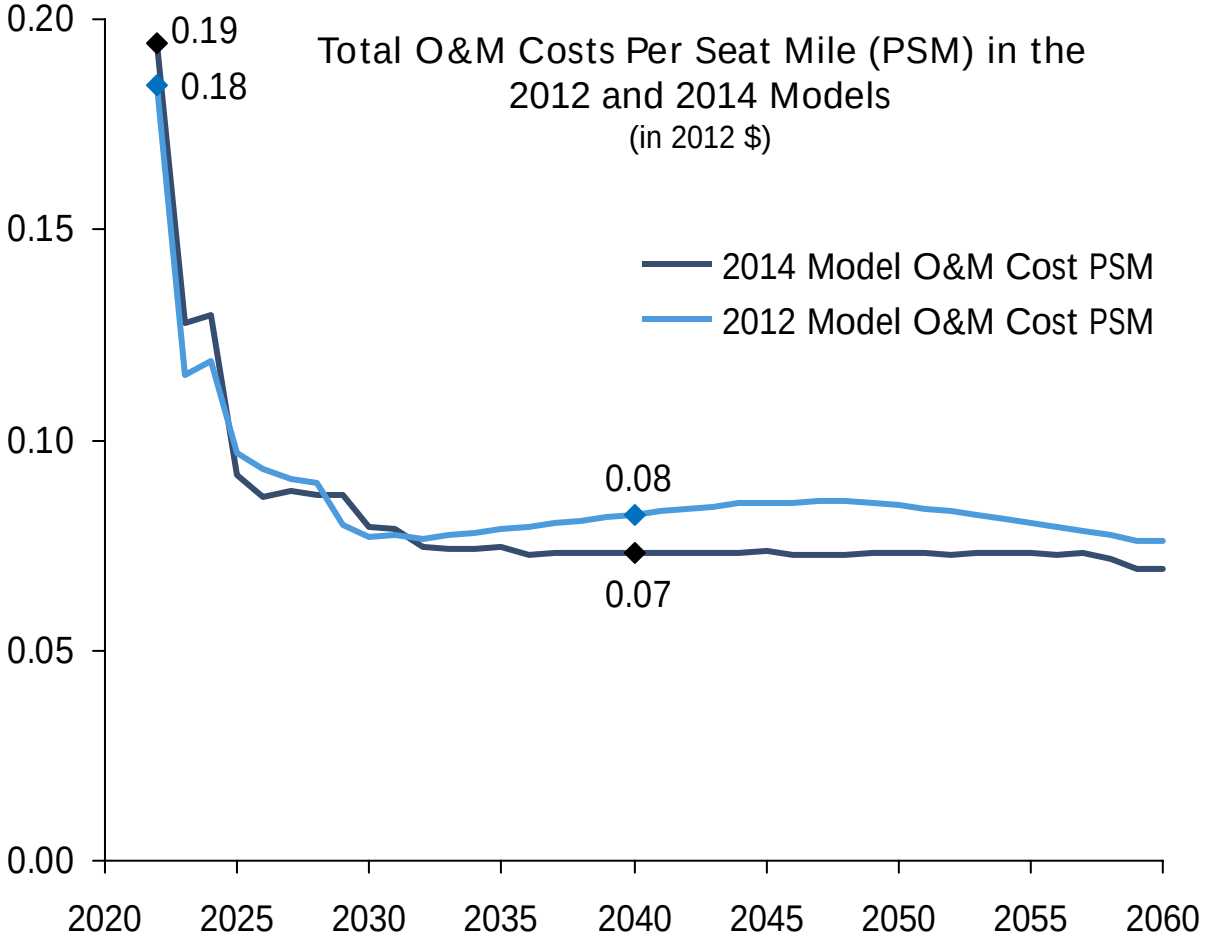
The preliminary 2014 O&M Model cost per seat-mile is almost identical to the results of the 2012 O&M Model



Cost per PSM	2022	2040
2014 Model	0.19	0.07
2012 Model	0.18	0.08

Comments

- The 2014 O&M Model cost per seat-mile is very close to the 2012 O&M Model cost per seat-mile
- The 2014 Model costs are slightly higher in the early years and slightly lower in the out years due to the more accurate representation of fixed costs in the model (due to system expansion and service growth)
- The out year average of $0.07 per seat-mile is consistent with international HSR experience (1)

(1) Source: Average international HSR experience cost per seat-mile I $0.06; "Relationship between rail service operating direct costs and speed", UIC (2010)

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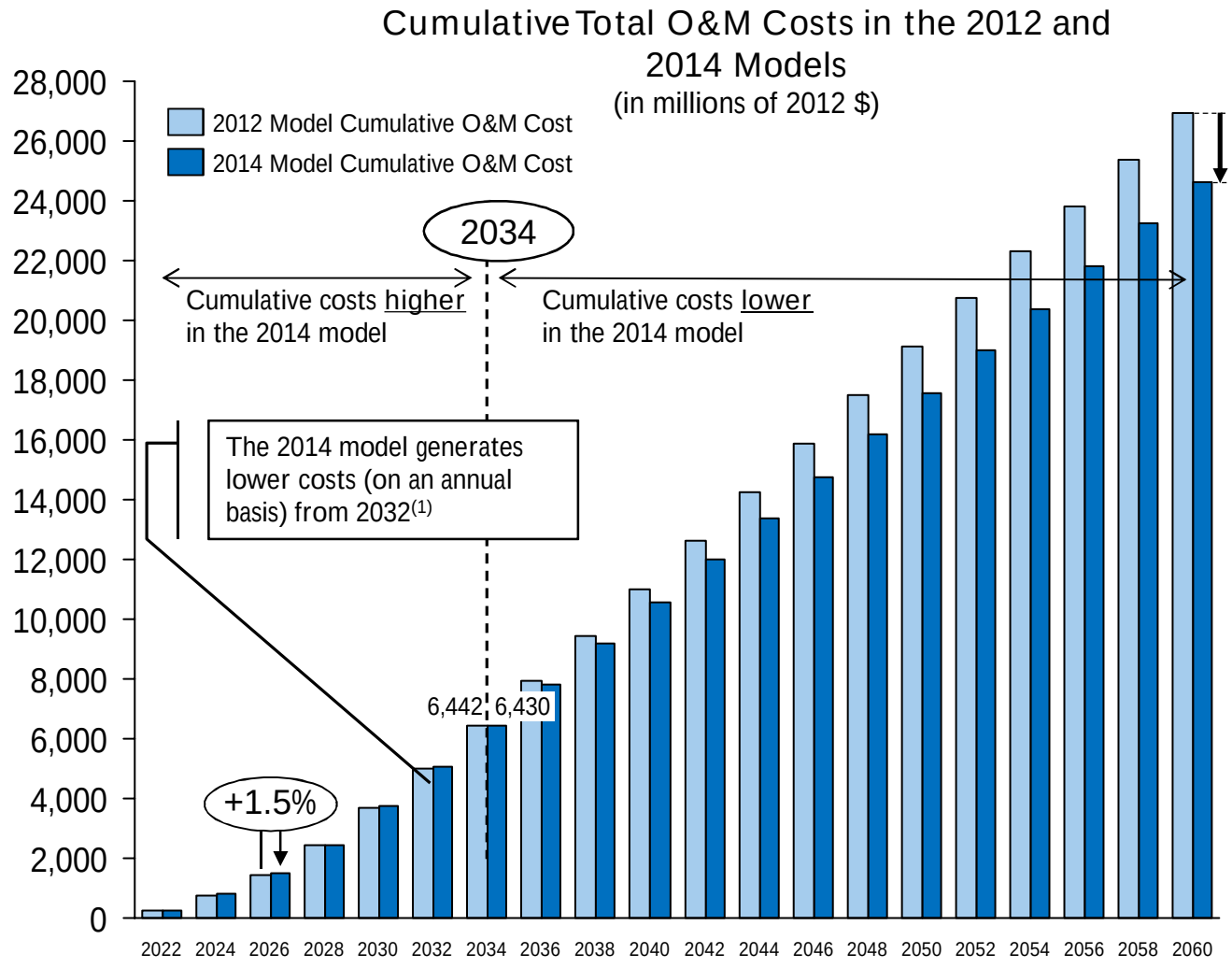
Over the course of the analysis period, the preliminary 2014 Model has over $2 billion less in total O&M costs than the 2012 Model



Comments

- Over the analysis period, from 2022 to 2060, the 2014 Model has $2.284 billion less in costs than the 2012 Model. By 2040 the savings is over $430 million.
- This amounts to 8.5 percent of total costs over the analysis period
- The difference is driven by the 2014 Model's relatively lower costs in the out years, due to the shift from variable to fixed costs between the models.

(1) There are also some years prior to 2032 in which the costs in the 2014 model are lower than the 2012 model but they are higher for most years

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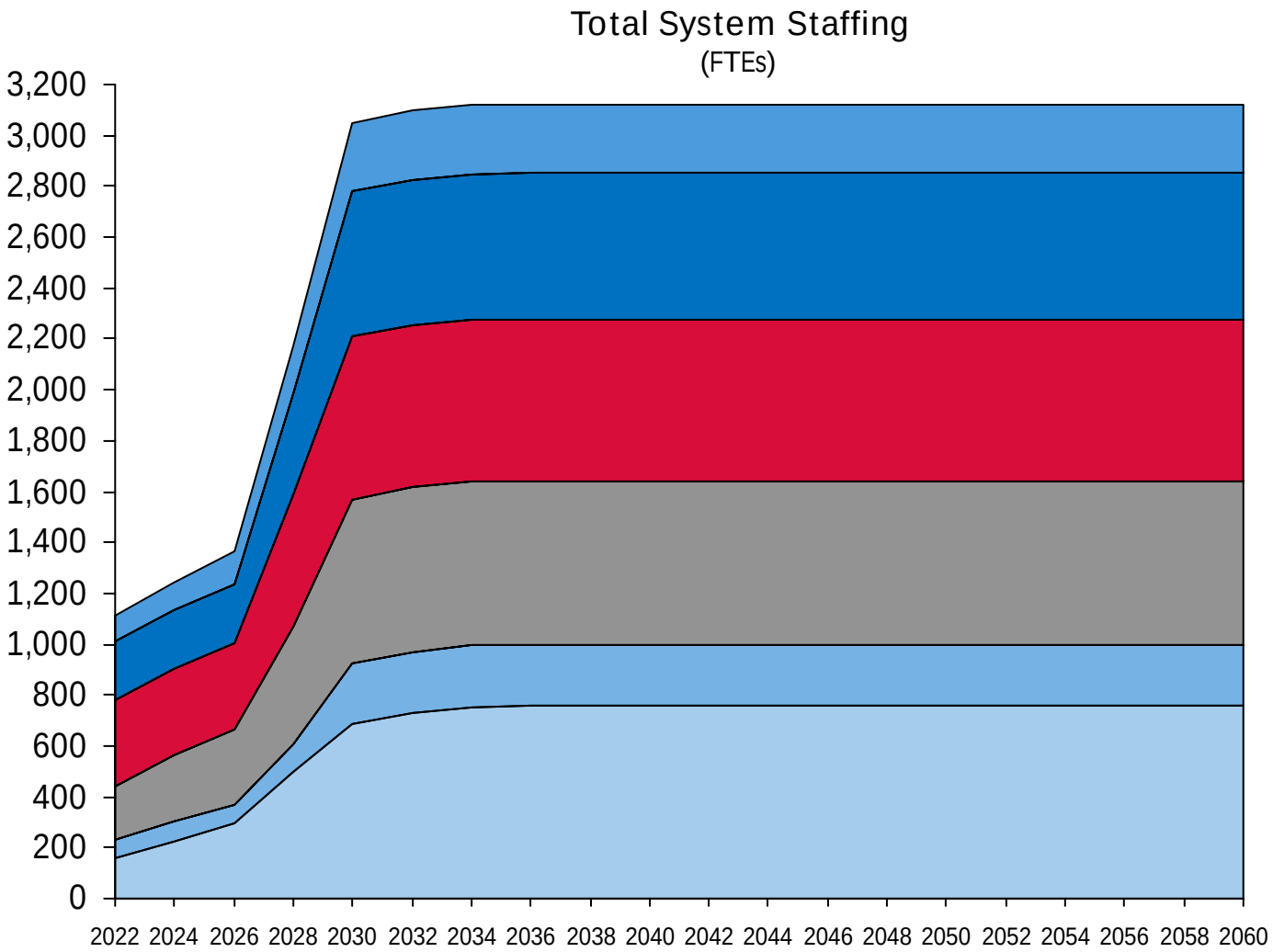
Staffing levels follow a similar pattern to costs



Comments

- Staffing levels increase over time as the system matures and progresses.
- Each staff category has a set of separate drivers (e.g. on-board staff is driven mostly by the service plans)
- The balance of the various drivers leads to the distribution and total number of staff required at each phase

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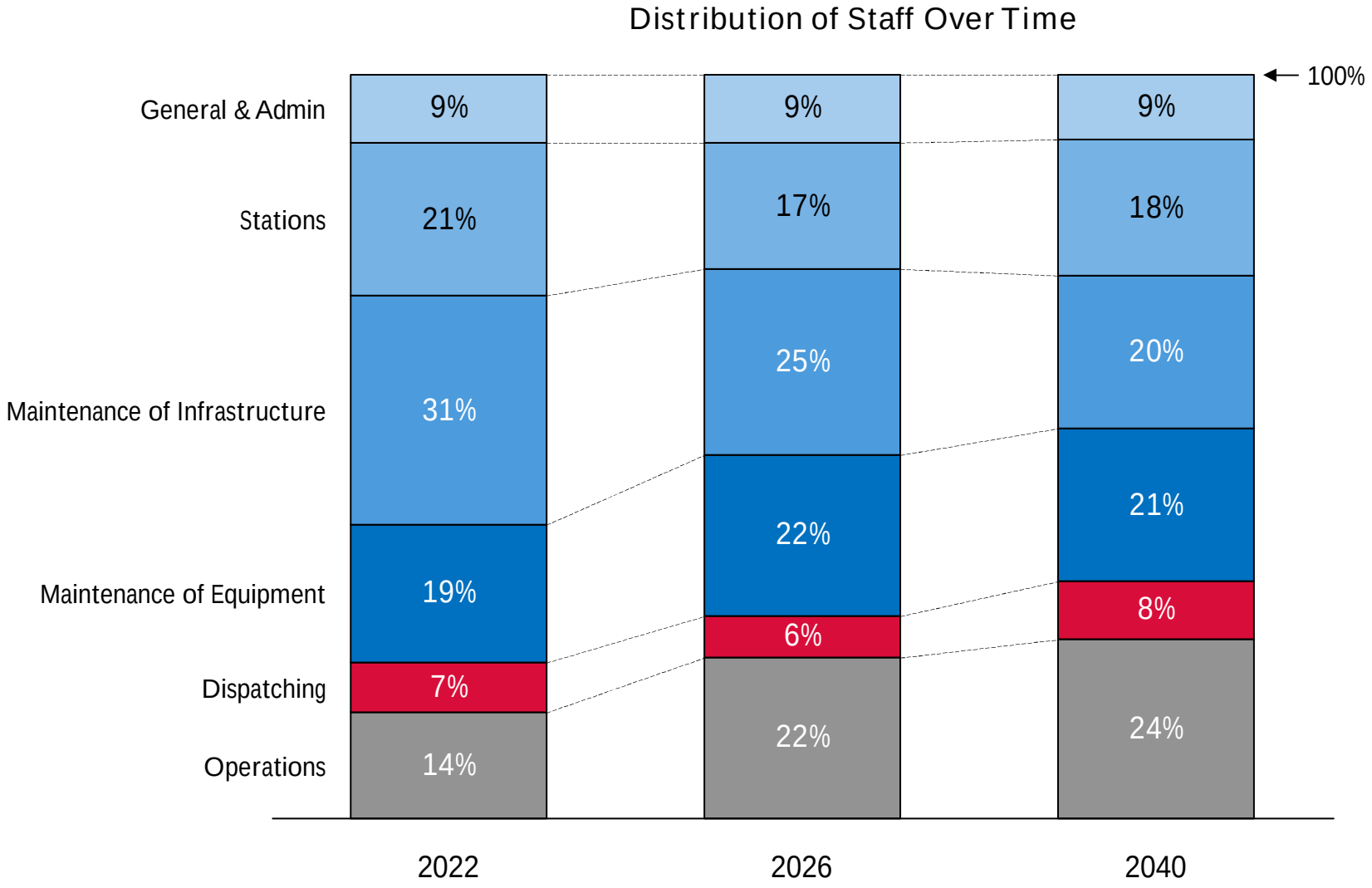
The relative distribution of staff is more fluid to system development than costs



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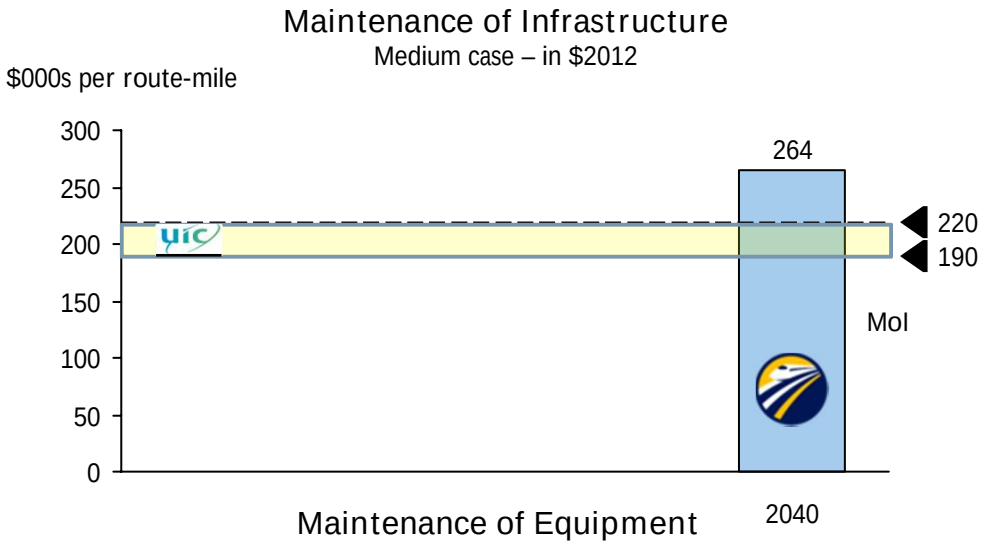
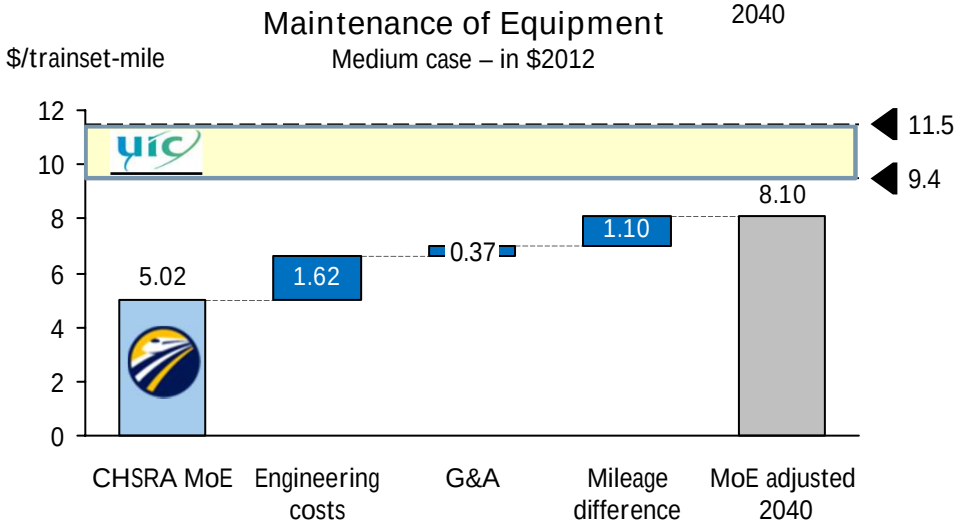
Our forecasts are in line with UIC benchmarks on MoI and MoE based on European experience





Comments

- UIC provided cost comparisons for MoI and MoE based on European HSR experience
- The range of $190-220k per route-mile compares lower to our medium case mostly because of the additional contingencies built into our estimates
- For MoE, a direct comparison with European practices is difficult due to a number of differences with CHSRA anticipated services:
  - Most European operators include a dedicated engineering cost in MoE that was not assumed for CHSRA operations (estimated 20%)
  - G&A costs are distributed within each cost category in Europe and needed to be adjusted (estimated 10% of direct MoE costs) for comparison purposes
  - Fleet utilization in Europe is lower than what can be achieved on a single corridor such as CHSR; on average SNCF TGV fleet run 220,000 miles per trainset per year while our service plan has an average utilization of 300,000 miles per train et per year
  - Assuming a 60% maintenance cost directly related to mileage, we adjusted our maintenance cost to level of utilization in Europe for comparison purposes
- Fleet diversity leads to higher costs in Europe, while CHSRA will benefit from a single fleet type and lower costs

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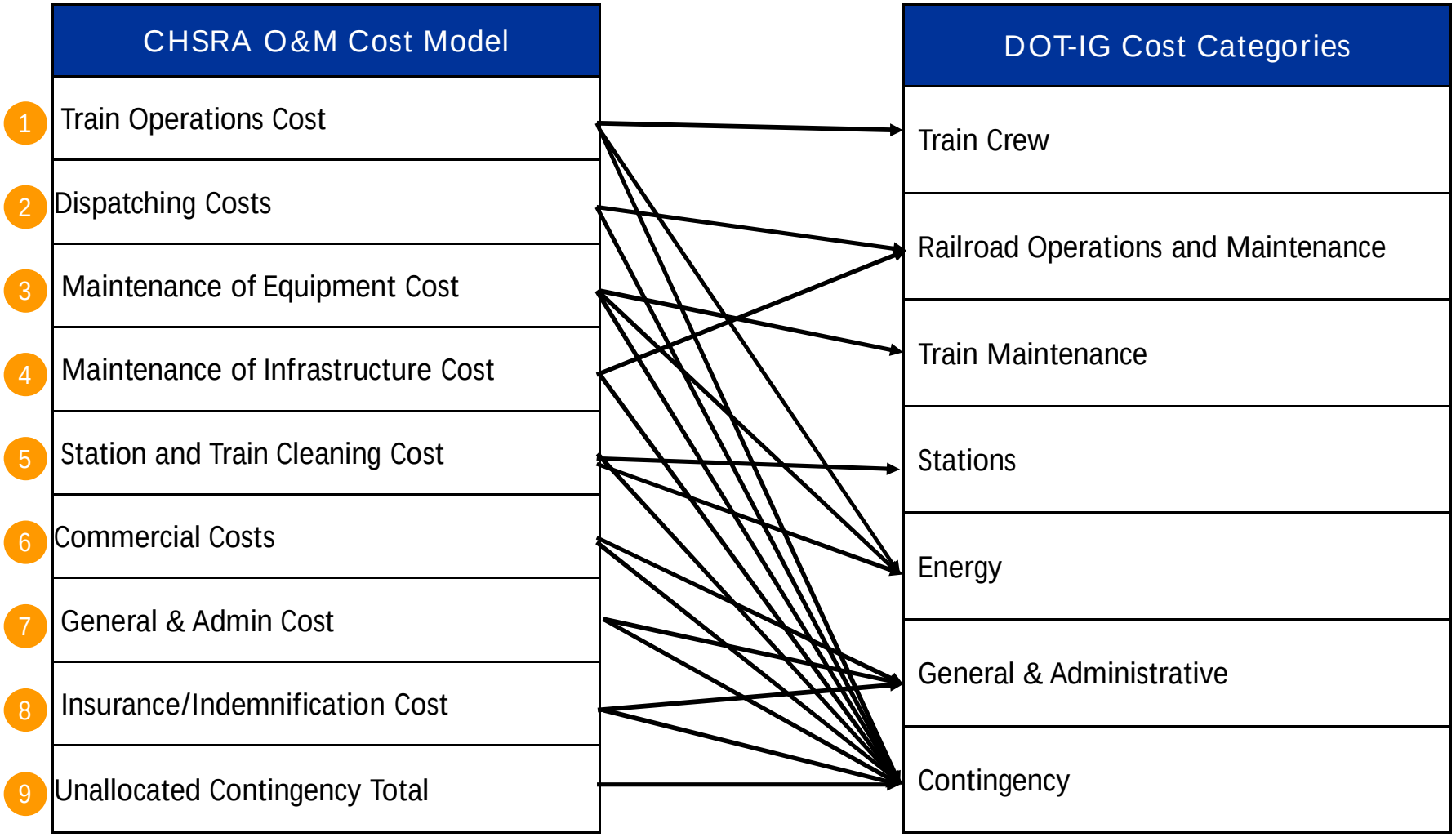
The DOT IG guidance provided a series of general benchmarks, many of which the preliminary 2014 model results mirror

Cost Category	DOT IG[1]	2014 model in 2022	2014 Model in 2040
MoE Cost per TSM	$4.00 - $7.00	$8.22	$5.02
MoI Cost per Track Mile	$110,000 - $130,000	~$119,000	~$134,000
Marketing and Advertising Costs	$3 million - $15 million	$5 million	$8 million
Energy Usage (kWh per TSM)	25 – 50 kWh	41.5 kWh	43 kWh
MoE, MoI, and Dispatch costs as percent of total	~50%	42%[2]	39%[2]
MoE, MoI, Dispatch, and Energy costs as percent of total	~66%	48%[2]	54%[2]
Staff costs as percent of total	~50%	50%	51%
On-board staff salary relative to train engineer	40% less	42% less (for OBA)	42% less (for OBA)
Train cleaning staff salary relative to train engineer	40% - 50% less	48% less	48% less
Contingency (at the intermediate stage)	20% - 40%	26%[3]	26%[3]

(1) The DOT IG Report is available at http://www.oig.dot.gov/sites/dot/files/OIG-HSR-Best-Practice-Operating-Cost-Report.pdf.
(2) The model's share of MoE, MoI, Dispatch, and Energy costs is slightly lower than the approximate benchmarks from the DOT IG due to the Authority's estimates including greater commercial costs (including buses), and relatively high levels of staffing for stations.
(3) As described by the DOT IG, when estimates advance through levels of design, contingencies will generally be reduced. For many of the cost categories, the 2014 Model has greater levels of detail (more advanced design) than the DOT IG guidance for estimates at the Intermediate stage so it is appropriate that the contingency attached to those estimates is lower than the average for Intermediate stage estimates.

The cost categories from the 2014 model can be reorganized to fit the DOT IG cost categories



The 2014 model represents a substantial step forward in the understanding and estimation of the system's projected O&M costs

- The 2014 model…
  - Implemented the changes necessary for the O&M estimates to meet all legislative requirements, follow DOT IG guidance, be consistent with UIC benchmarks, and provide estimates consistent with the current level of system design.
  - Incorporates the feedback on the model from the PRG and GAO.
  - Validates the costs developed using the top-down 2012 model while greatly improving model detail and functionality.
  - Can serve many purposes including, but not limited to, testing the system's ability to operate without an operating subsidy, evaluating risk and uncertainty associated with specific cost elements, analyzing the O&M cost implications of design and operating decisions, and more.
  - Includes high and low cost ranges and sensitivity analyses to look at the impacts of a range of various exogenous and endogenous factors.
  - Maintains the ability to add/modify modules and components as system design advances and/or decisions still on the table are finalized.
  - Can be used to present costs in accordance with cost ledgers from the FRA, DOT IG, the 2012 model, and new ways that can answer specific questions as they arise.

Table of Content

The high and low scenarios in the preliminary 2014 model represent sensitivity tests of the medium cost scenario

- The 2012 model's high and low cost scenarios were driven entirely by variations in ridership, representing essentially a point estimate for various ridership levels.
- The 2014 model includes separate high and low cost estimates based on changes in assumptions and inputs to create a range and test the model's sensitivity to individual factors allowing the model to develop high, medium, and low costs for the high, medium, and low ridership scenarios.
- The high scenario addresses areas where costs are less predictable/certain and makes assumptions about potential higher cost scenarios.
- The low scenario represents an "efficient operator" running the system, which shows the system's upside potential if an operator is given more leeway than traditional legacy rail operators.

All results presented in this report are based on preliminary model runs with final inputs and assumptions still being developed. All numbers should be considered draft and subject to change as the model is finalized.

The high scenario is designed by adding costs in specific categories

Cost Category	Rationale
Marketing	• Advertising extended to all California counties, not just those close to route. • Marketing campaigns expanded from 3 to 4 per year
G&A	• G&A staffing percentage increased by 10%
Fuel	• Bus fuel cost assumed to be 25% of total costs (model uses a total cost per mile) • Increased the fuel cost by 20%
Wage Increase	• Increased wages by 10% across the board
Real Inflation on Wages	• Increased real inflation on wages to 0.5% p.a.
Station Staff	• Double number of ticket clerks at minor stations, increased from 3 to 8 for terminal stations
MoI	• Added two additional Facility Gang Additions
MoE	• Increased frequency of bogey inspections from every 600k trainset miles to every 500k • Increased general overhaul frequency from every 1.2m trainset miles to every 1m • Daily inspection frequency increased from every 48 hours to every 24 hours
Real Inflation on Energy	• Assumed 0.5% real inflation p.a.

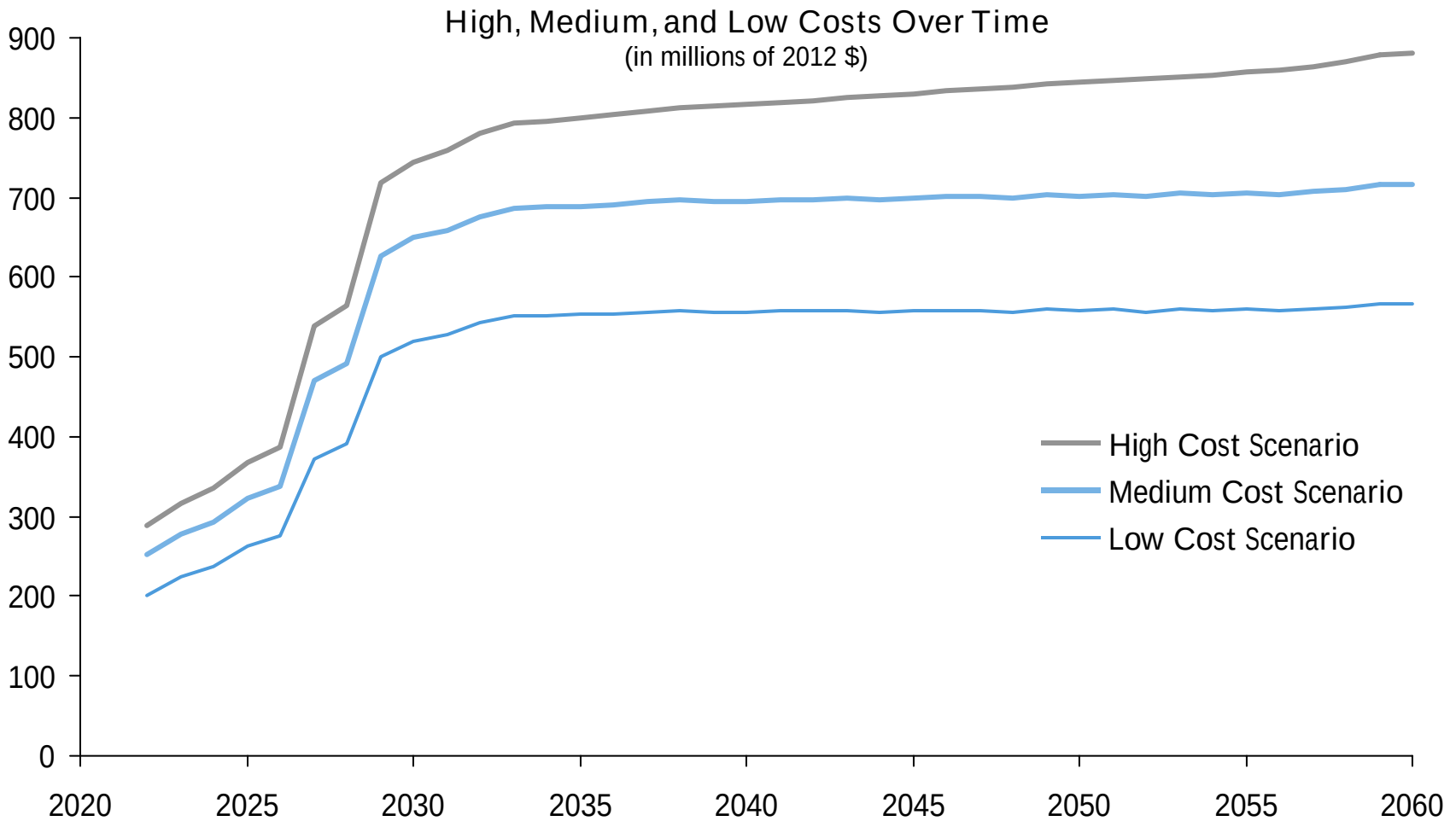
All results presented in this report are based on preliminary model runs with final inputs and assumptions still being developed. All numbers should be considered draft and subject to change as the model is finalized.

The low cost scenario reduces costs by applying practices that may be employed by an "efficient operator"

Cost Category	Rationale
Maintenance Vehicles	• Cut 35% of costs because assumed to be bought and owned by maintenance contractor (as opposed to wet lease cost)
Bus Contracts	• Assumed a private operator will get a better negotiated contract than Amtrak – reduced cost by 20%
Fringes & Benefits	• Cut the retiree health plan, reduced employee health plan cost by 30%
Wages	• Reduced wages by 10%
G&A	• Reduced G&A staffing from 10% to 9%
Real Inflation on Energy	• Assumed an annual real inflation rate of -0.5% in energy costs based on improved technology and real reduction in renewable energy prices
Stations	• Reduced minor station staffing from 3 ticket clerks to 2 based on anticipated advances in technology
Drill crew	• Got rid of drill crews and assumed roustabouts can cover both functions
Staffing Levels	• Cut maintenance Staff by 20% and commensurate materials and tools savings
On-Board Flexible Staffing	• Increased efficiency by 20% to 2.4 roundtrips per crew per day
Fewer Sick Days	• Eliminated all but 3 sick days
One fewer Facility Gang Addition	• One less Facility Gang Addition

All results presented in this report are based on preliminary model runs with final inputs and assumptions still being developed. All numbers should be considered draft and subject to change as the model is finalized.

The high and low cost scenarios bracket the medium case



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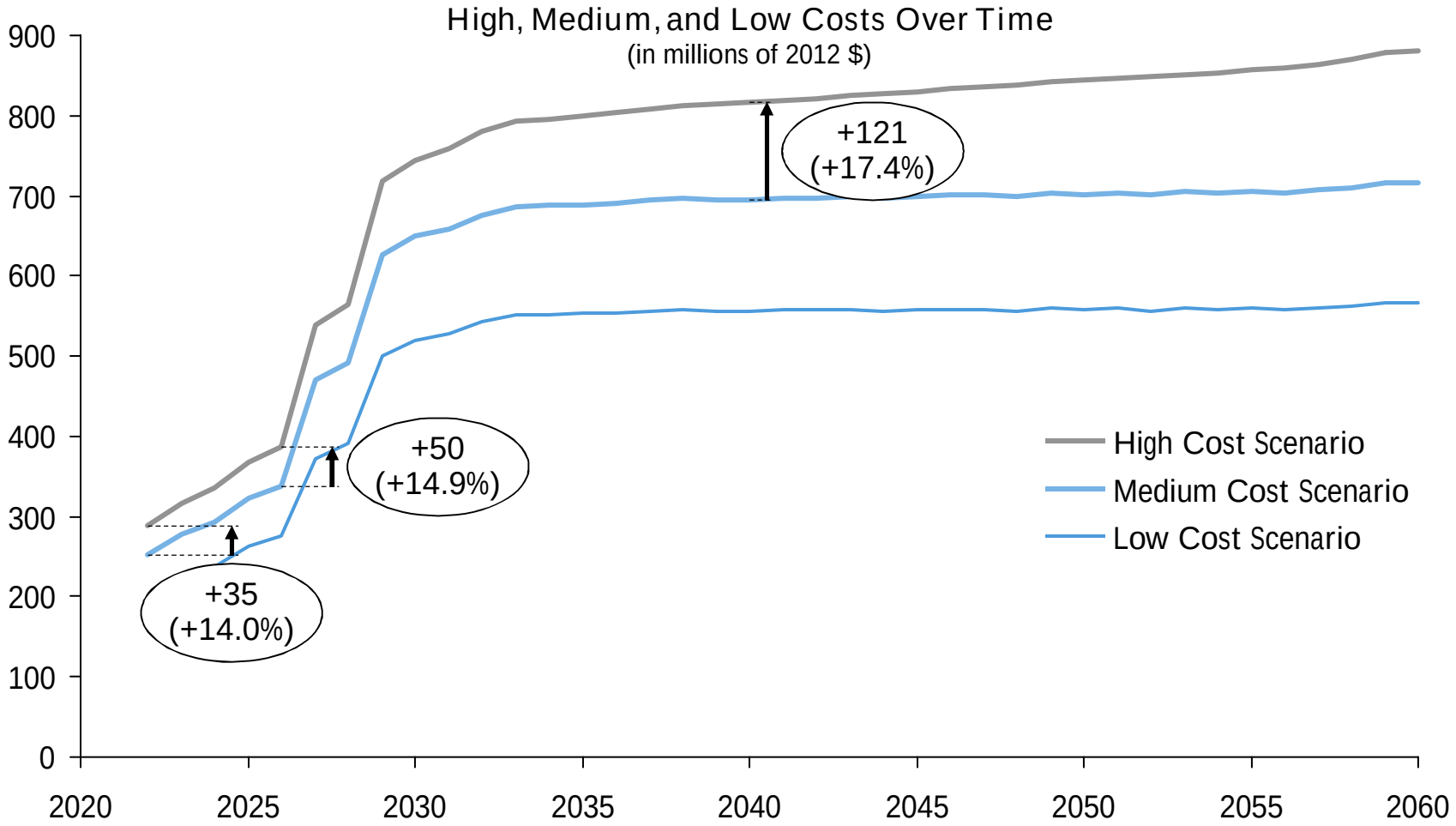
The high scenario's impact on the cost provides a relatively stable increase over the medium for the analysis period



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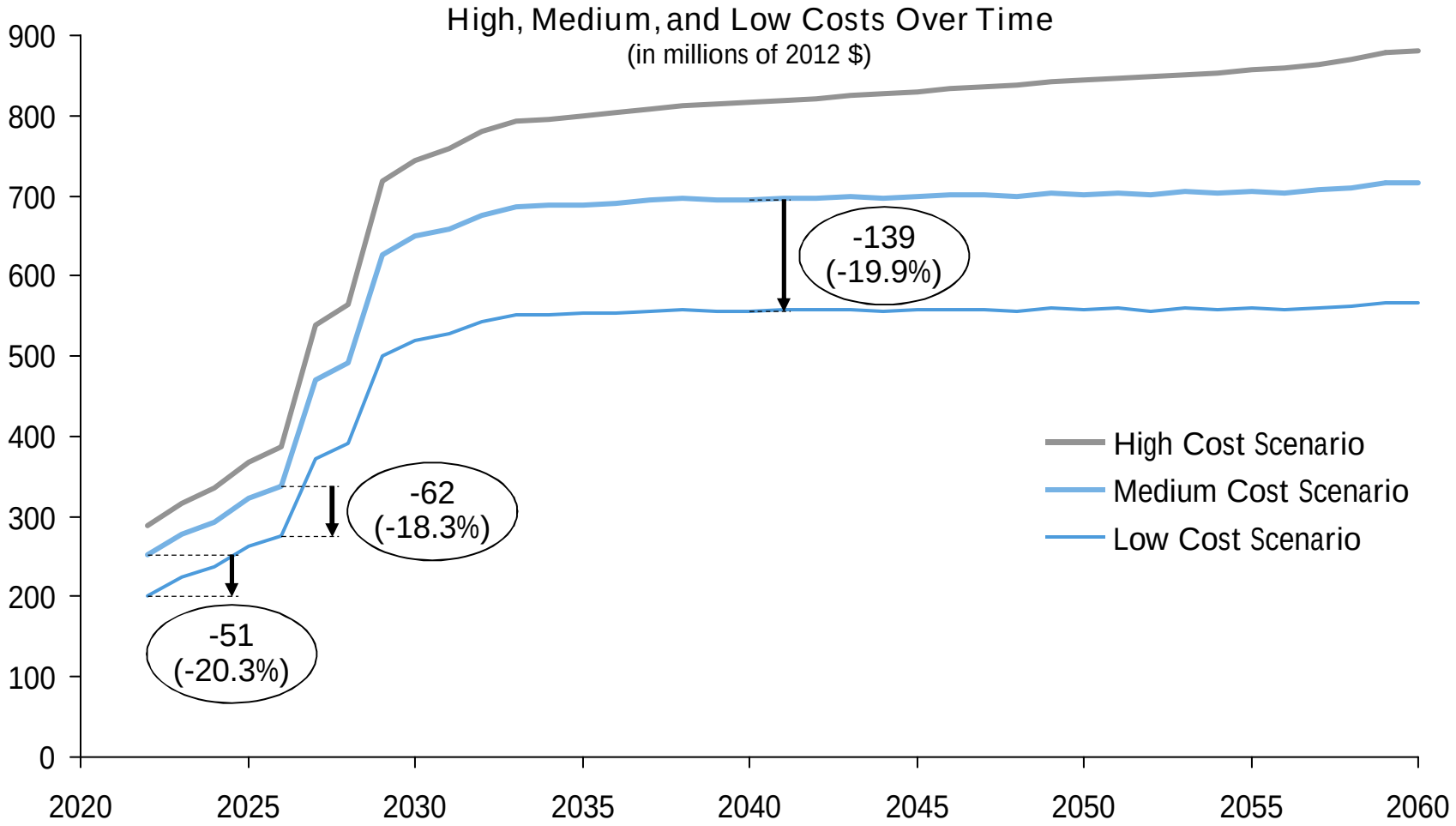
The low scenario's impact on the cost provides a relatively stable decrease over the medium for the analysis period



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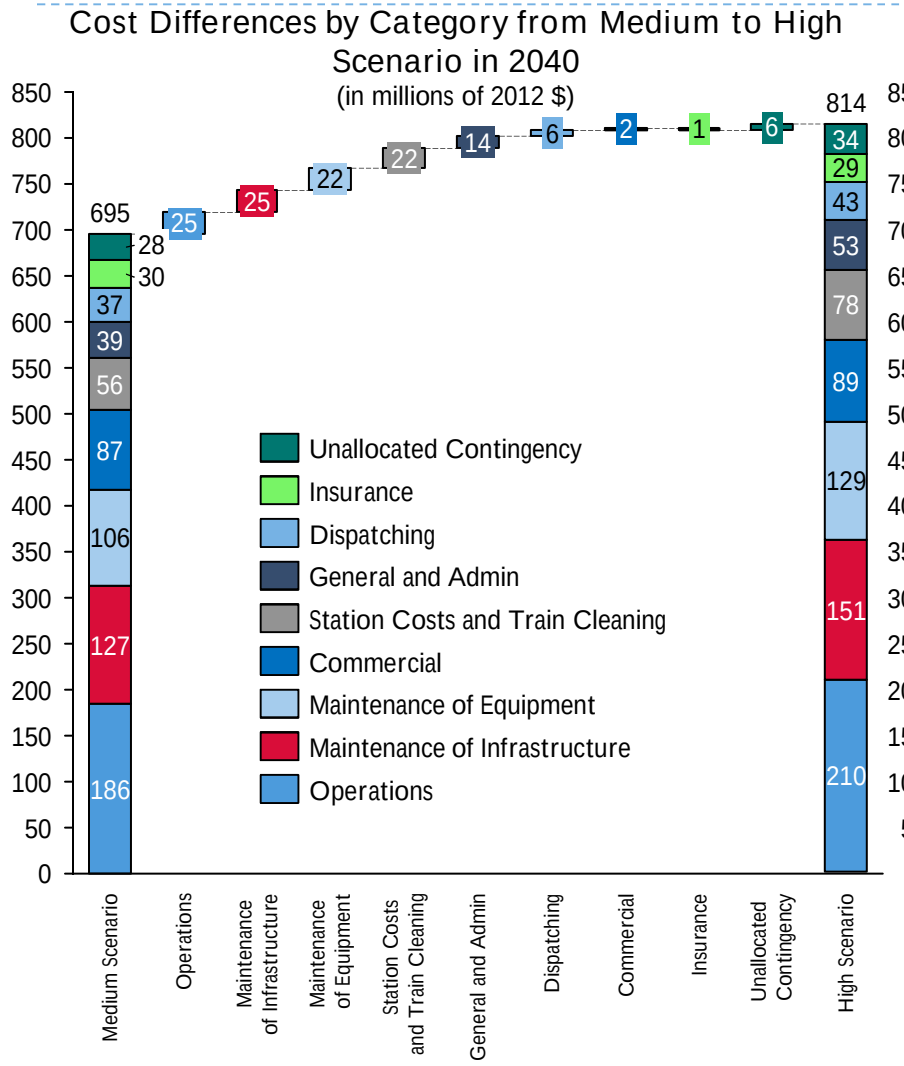
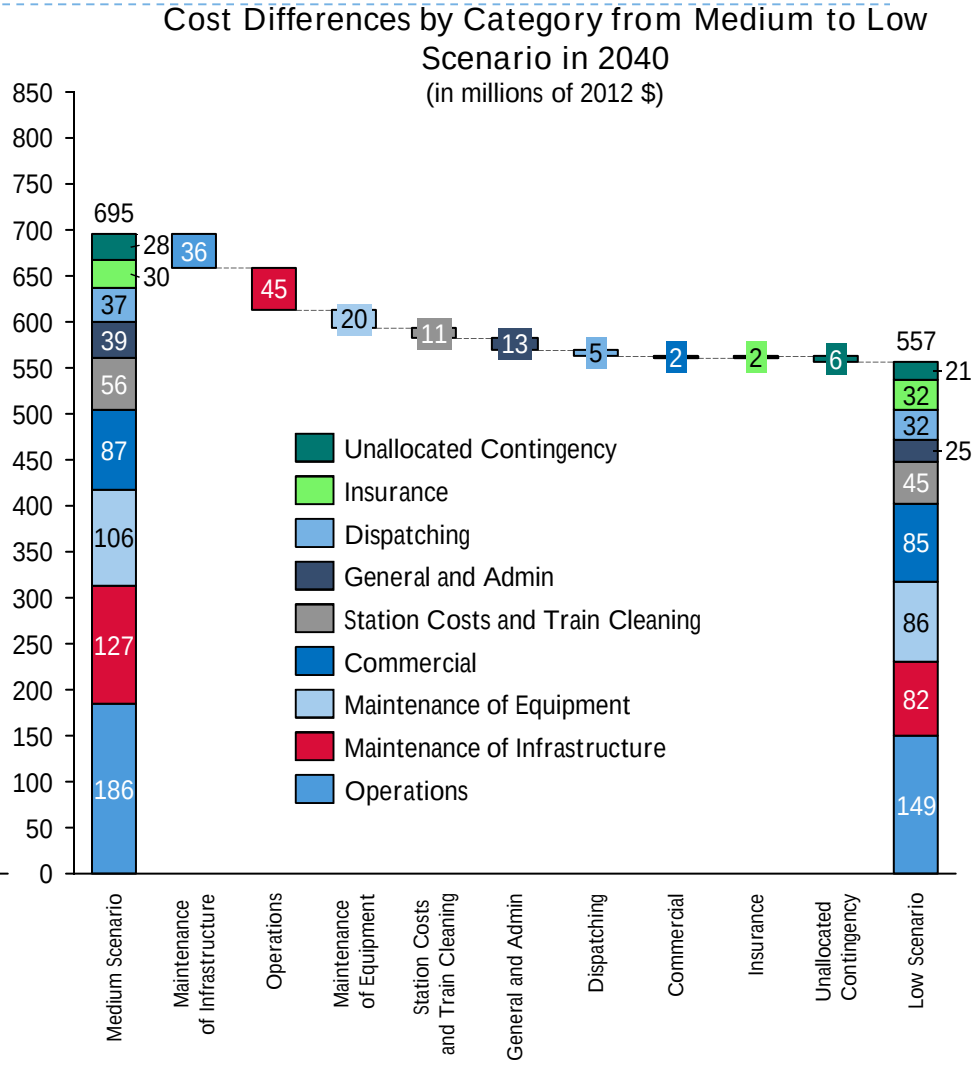
The high and low cost estimates provide a range of costs for each cost component category





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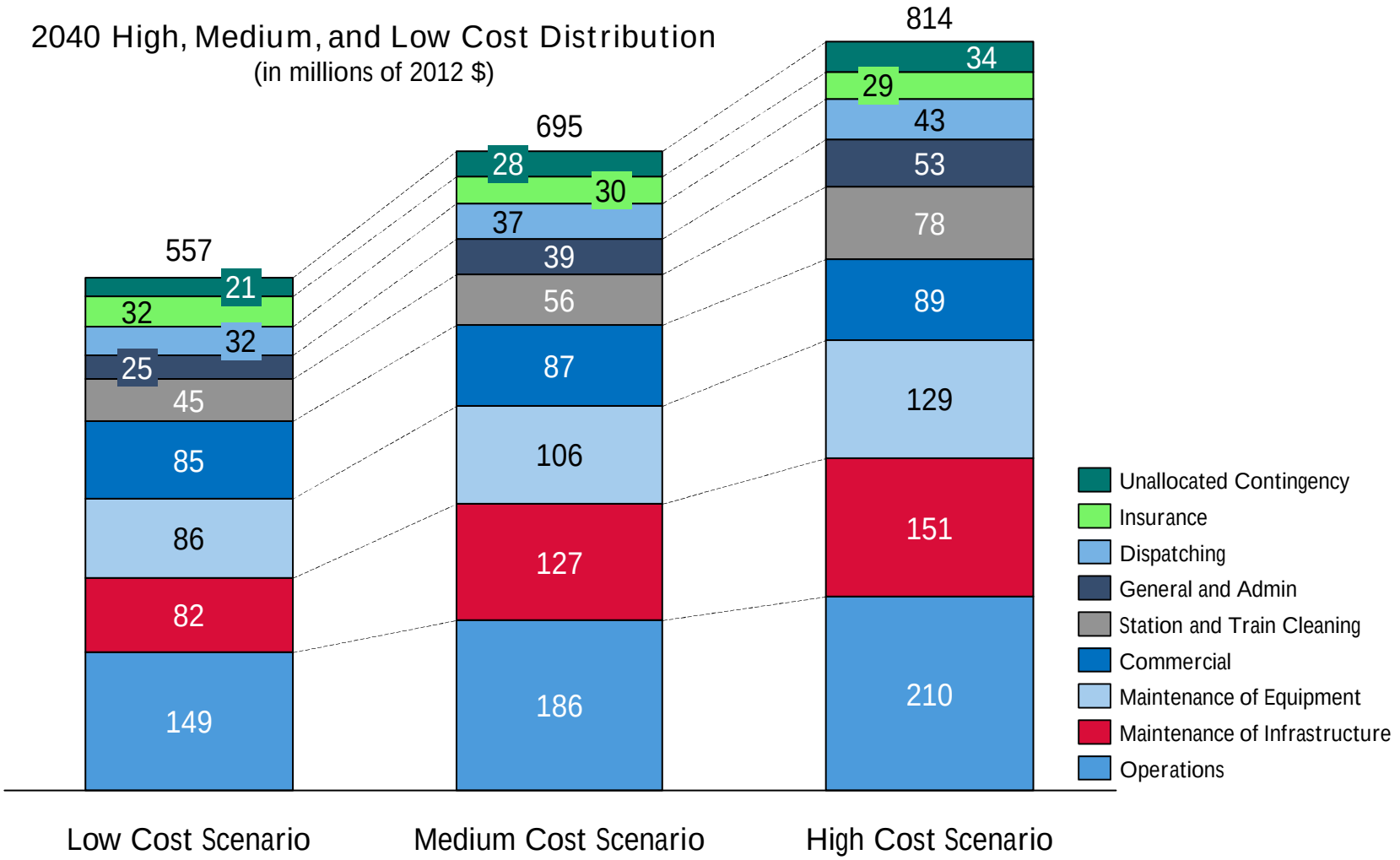
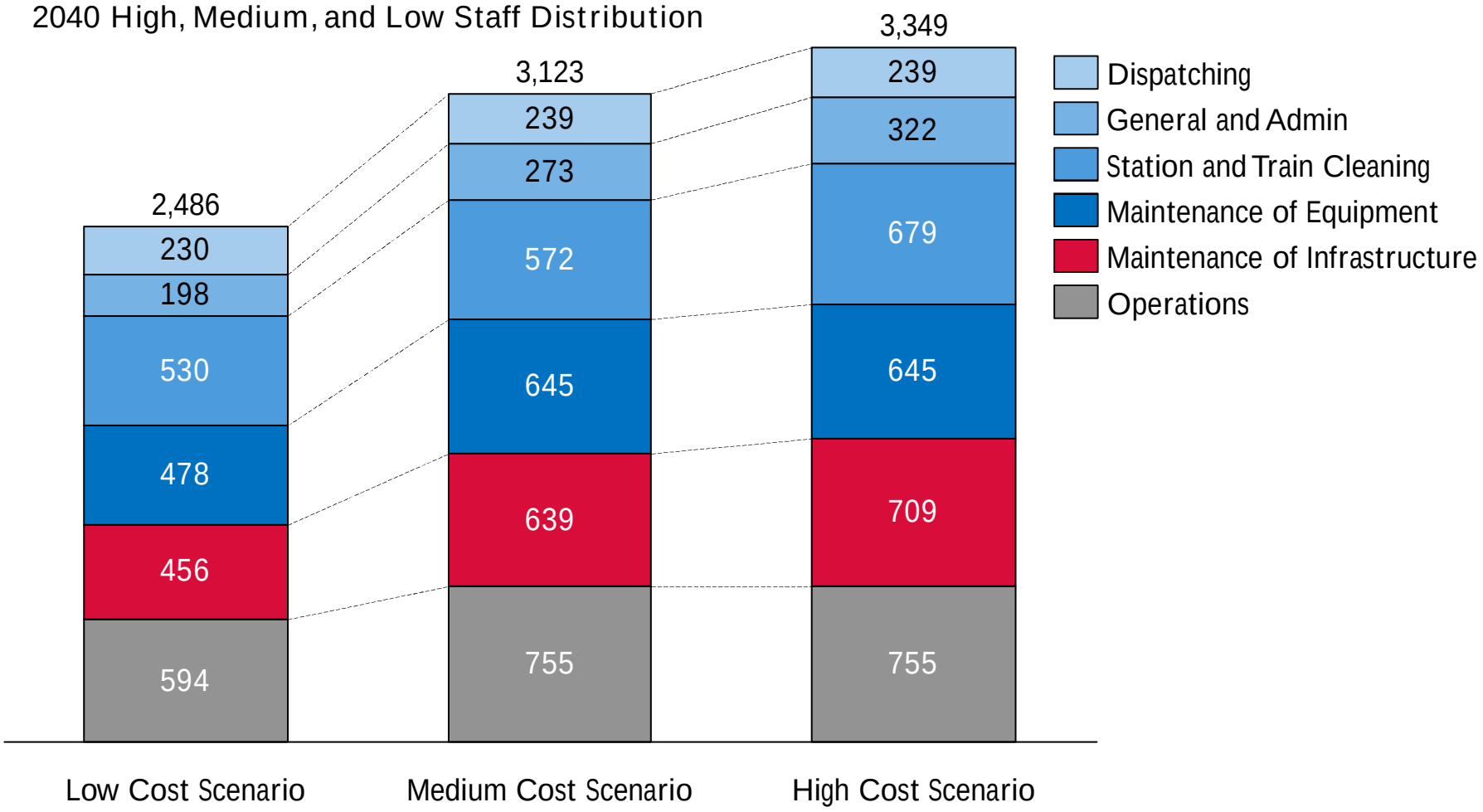
The high and low scenarios include increases and decreases in costs across almost all categories



All results presented in this report are based on preliminary model runs with final inputs and assumptions still being developed. All numbers should be considered draft and subject to change as the model is finalized.

For some cost categories, the low and high scenarios are driven by changes in staff numbers while others are driven by changes in costs



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The high and low cases provide a reasonable range of potential costs under various scenarios around the medium case

- The high and low scenarios bracket the medium (base scenario).
- The high ranges from 14% to 23% above the medium while the low ranges from 18% to 21% below the medium.
- The peaks and valleys of the high and low scenarios match up with the biggest gap (difference in percent change from medium to high and low scenarios) being 6.4% in 2022 and the smallest gap being just 0.05% in 2051.
- The high and low scenarios include changes in assumptions about staffing levels, wages, and cost inputs to account for various possibilities and to create a reasonable range.
- The medium scenario is considered the “most likely” or base case scenario.

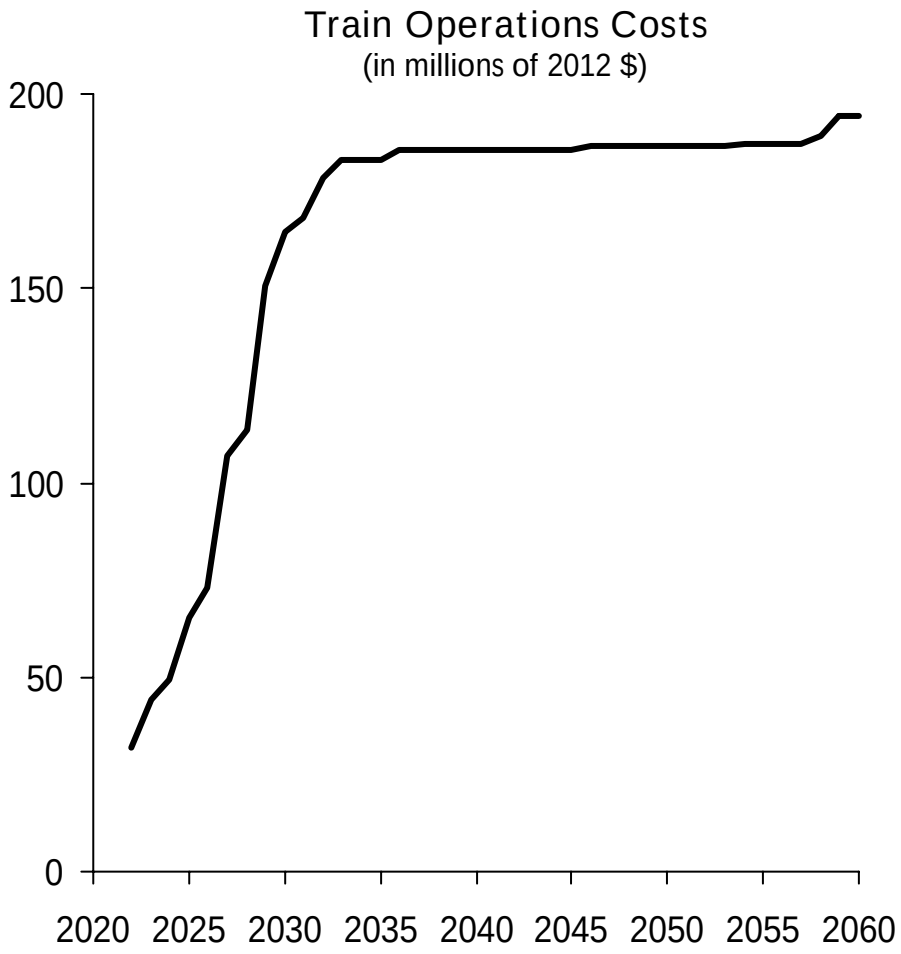
Table of Content

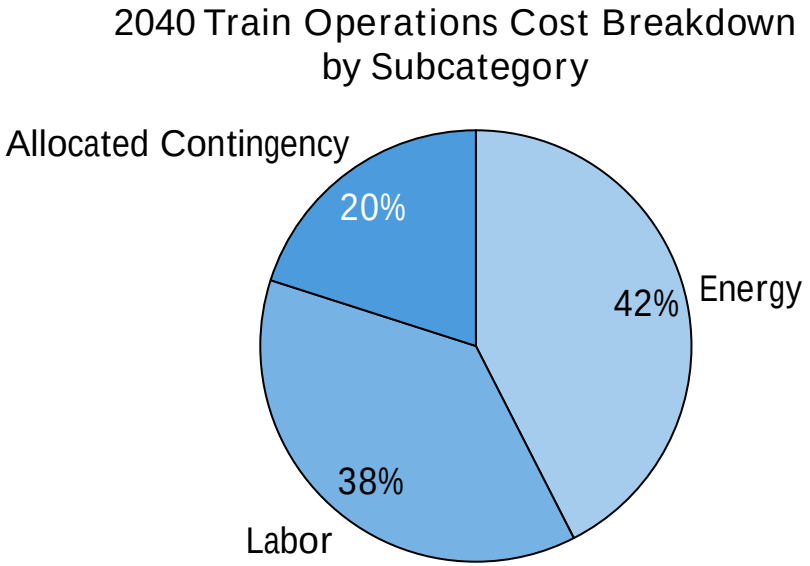
The following section includes detailed information for the 9 major cost categories

- This section includes the detailed cost estimates, methodologies, and analyses for each of the 9 major cost categories (table at right) for the medium scenario.
- We will repeat the same analysis for each of the 9 cost categories
- Each category represents a separate estimate of the system's operations and maintenance needs in each area.
- The methodologies to estimate each area's needs are separate but the overall philosophies, sources of some data, work rule assumptions, and other inputs are applied uniformly.
- For further details on the methodologies, assumptions, and inputs please see the Technical Memo for the model.

	2014 CHSRA O&M Cost Model
1	Train Operations Cost
2	Dispatching Costs
3	Maintenance of Equipment Cost
4	Maintenance of Infrastructure Cost
5	Station and Train Cleaning Cost
6	Commercial Costs
7	General & Admin Cost
8	Insurance/Indemnification Cost
9	Unallocated Contingency Total

Train operating costs increase gradually as service is added





Comments

- Train operations costs include regular on-board crews, protect crews, roustabouts crews, drill crews, energy costs, and allocated contingencies.
- Most of the labor costs and the energy costs are driven by the service plan

All results presented in this report are based on preliminary model runs with final inputs and assumptions still being developed. All numbers should be considered draft and subject to change as the model is finalized.

Train Operations Costs include on-board staff and energy related to train operations

General Description

- Train Operations costs include two major cost categories modeled individually and each including further sub-categories:

1. On-board train crews consisting of locomotive engineers, conductors, assistant conductors, and on-board attendants (OBA), roustabout crews, protect crews, and drill crews
2. Operational energy costs are based on the usage of energy for the movement of trains (the Authority has committed to using 100% renewable energy so the price for energy is based on the cost of renewables)

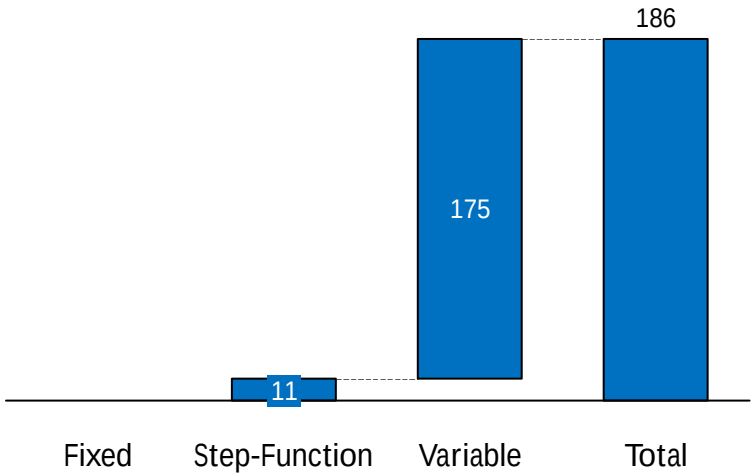
Primary Drivers

- The primary driver affecting escalation of on-board personnel headcount is assumed to be the total number of runs that trains make each day and the efficiency of the crews. It is assumed that each crew will be able to cover one round trip per day (two legs) and crew changes will be used, where necessary, to maintain this efficiency
- The number of OBAs will increase if on-board refreshment services are added. It is assumed that no on-board refreshment service will be provided under any of the phases. However, one OBA will be on board trains without food service to respond to passenger needs and assist the core train crew in case of an emergency. An extra OBA will be added if on-board services are added
- The cost of renewable energy has been estimated using the California Public Utilities Commission's Renewable Portfolio Standard Quarterly Report from the fourth quarter of 2012. The renewable energy cost from the report is $0.09 per kWh for contracts approved in 2012
- Based on energy use simulation modeling, rolling stock energy consumption at the pantograph is assumed to be 41.5 kWh per trainset mile during IOS and Bay to Basin and 43.0 kWh per trainset mile during Phase 1 Blended

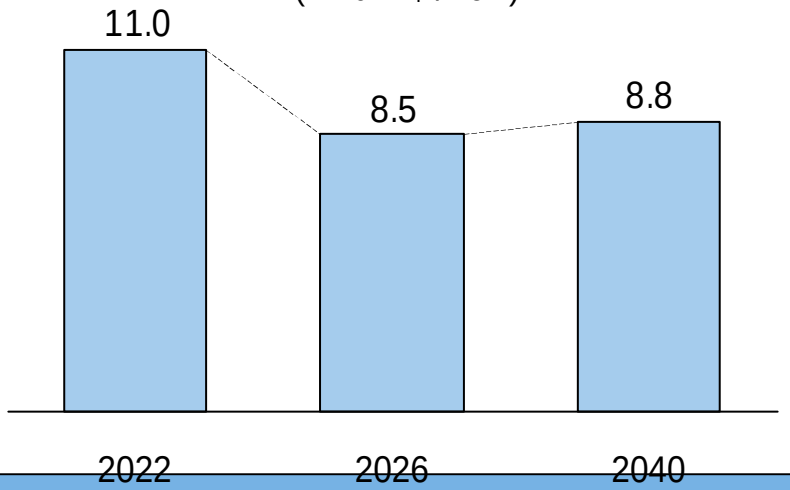
Note: Detailed description , staff categories, wages and benefits and relative assumptions are presented in the TM " Operations and Maintenance Cost Model Documentation"

Operations costs vary almost completely with the service and operating plans

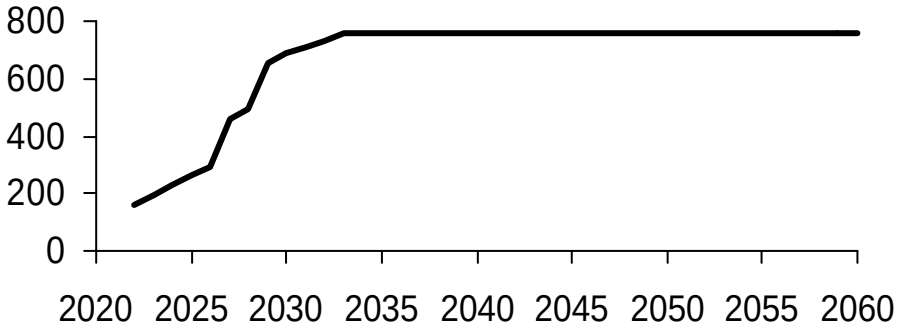
2040 Fixed vs. Variable Operations Costs
(in millions of 2012 $)



Operations Cost per Train Set Mile
(in 2012 $ / TSM)



Operations Staff Level Over Time



Comments

- Operations costs are mostly dependent on the levels of ridership and service.
- Only roustabout, protect, and drill crews increase as a step-function of phasing.
- Operations cost per TSM decreases over time as the step-function costs are distributed over a larger service base.

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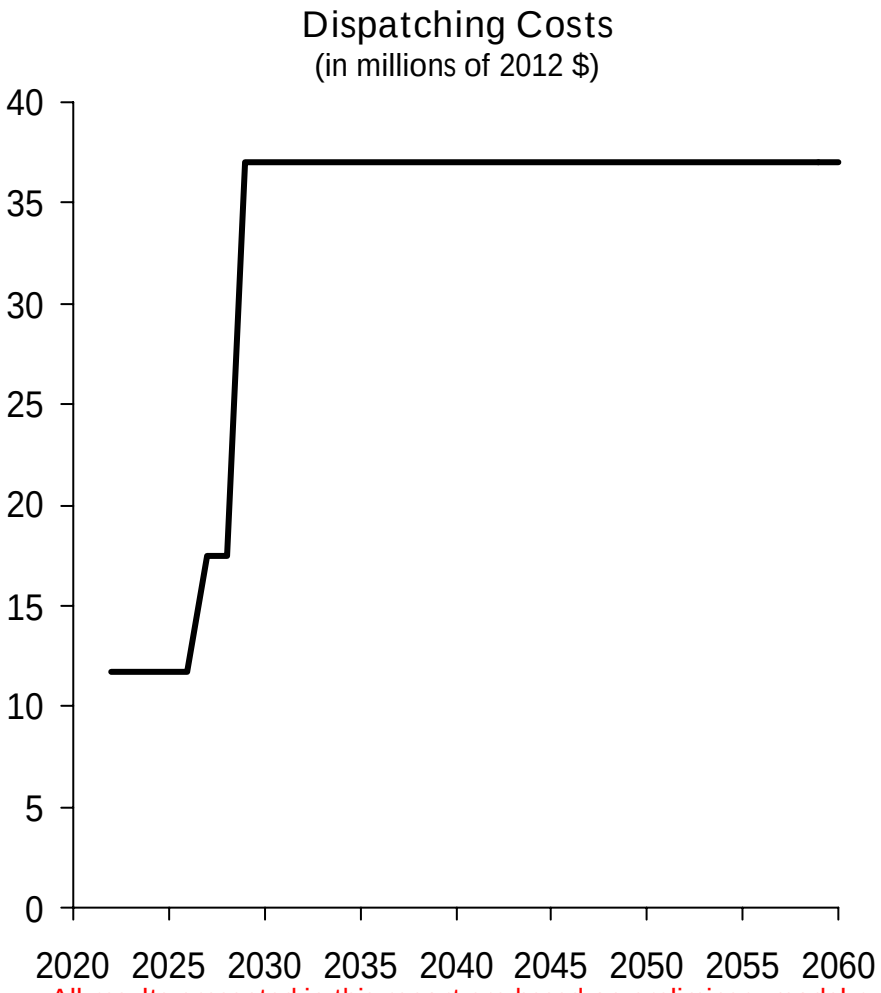
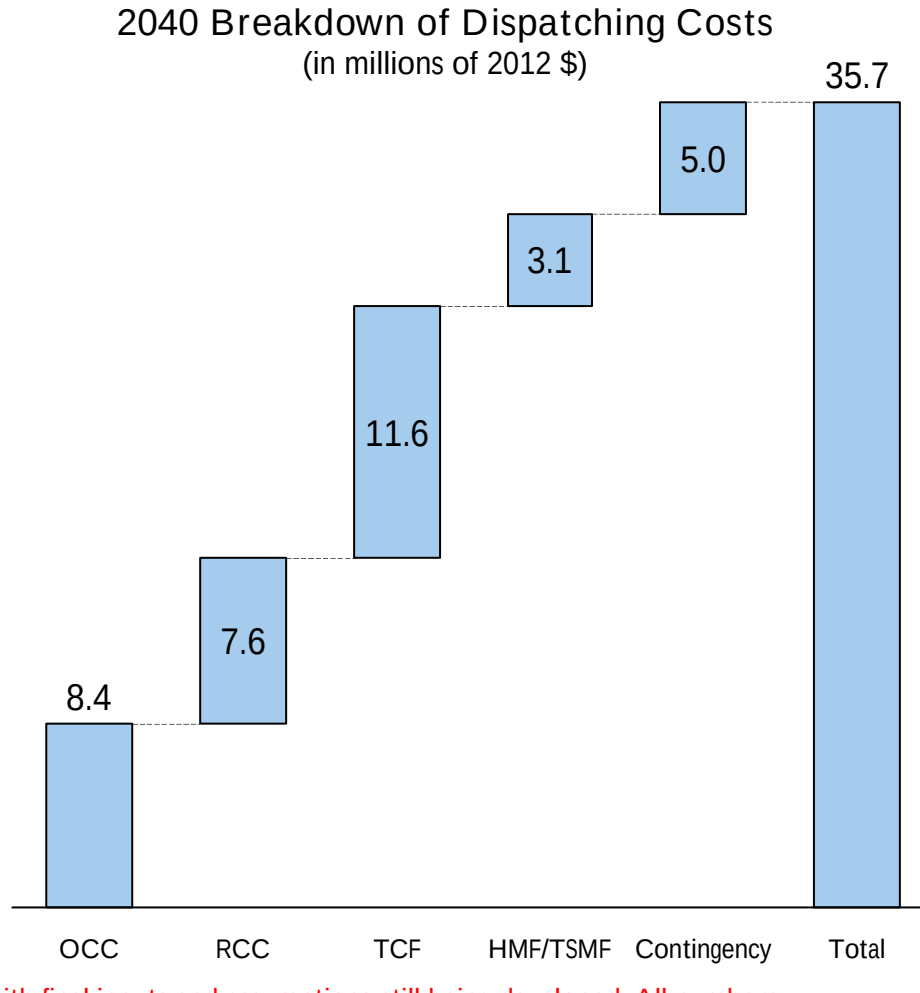
Dispatching costs vary with the size/complexity of the system





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Dispatching costs follow a step change function in line with the system phased implementation

General Description

- Train dispatching consists of four sets of functions

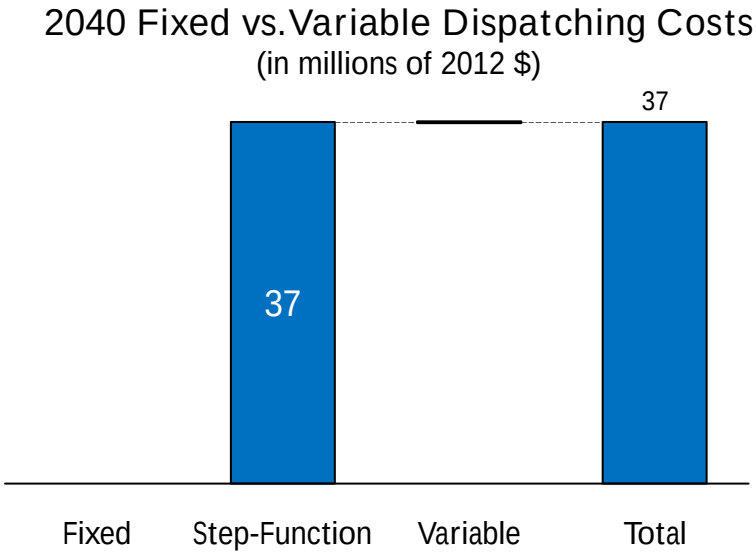
1. Operations Control Center (OCC) responsible to the daily tactical operations the HSR system
   - The OCC facility is the base of operations for train dispatchers, SCADA and Traction Power control, public address and messaging, security, MoI and Rolling Stock deployment and repair
2. Regional Control Center (RCC) responsible to carry out the functions of an OCC on Joint Usage Corridors like Caltrain
3. Terminal Control Facility (TCF) responsible for station operations at large terminal such as LA or SF
   - Responsible for crews and equipment dispositions and passenger operations. Interface with RCC or OCC
4. Yard dispatcher – responsible to dispatch trains in the facilities' yards

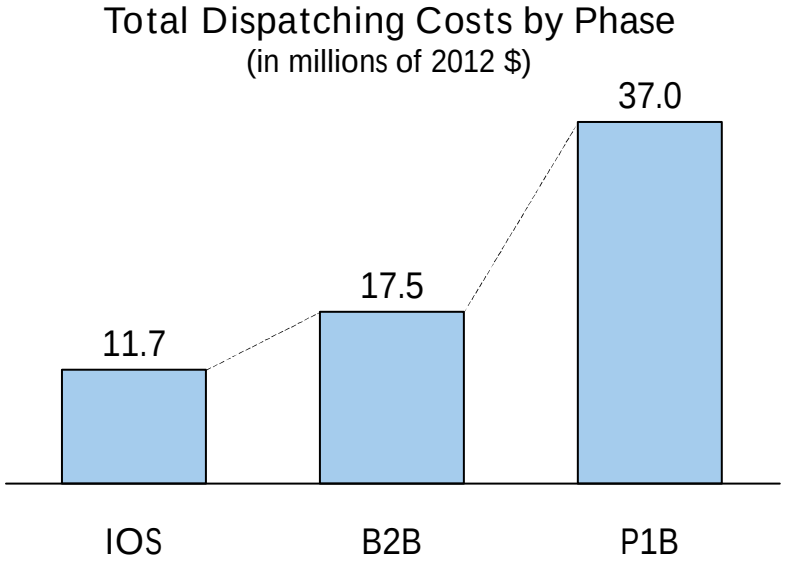
Primary Drivers

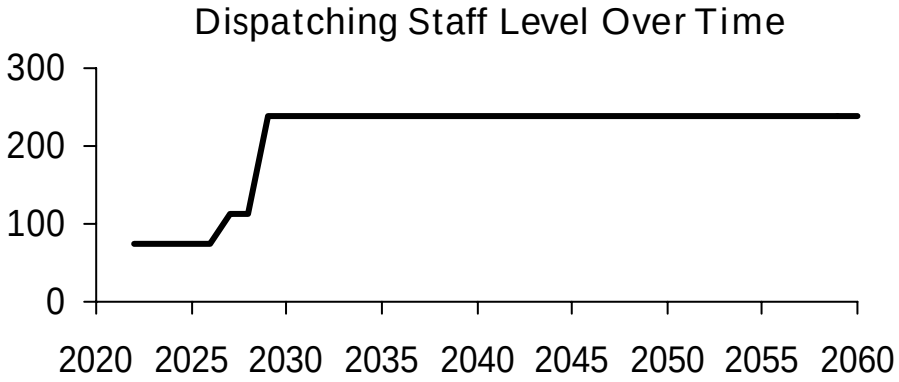
- The OCC staffing is based on the number of miles of track in operation ranging from 7 to 12 staff for each of the 3 tours and are present in all phases
- RCCs that are in charge of each section of blended operations are in operation for 2 tours per day, have 11 staff, and are added whenever new blended operations come online
- TCF staffing depends on the Level A (ultimate terminal) and B (interim terminal) stations that are on the system
  - Staffing is dependent on the size of the station
  - Once a station achieves a certain level (even for interim phased operations) it retains its TCF staff even when it no longer serves the same function (such as being a terminal)
  - The TCFs are staffed while trains are in operations, which is 2 tours per day.
- Yard dispatching is needed for each yard and maintenance facility and consists of 2 train dispatchers per yard
- Yard dispatchers are assumed to be on for 3 tours per day at the HMF and 2 tours per day at each of the other facilities

Note: Detailed description , staff categories, wages and benefits and relative assumptions are presented in the TM " Operations and Maintenance Cost Model Documentation"

Dispatching costs are a step-function of the phasing of the system





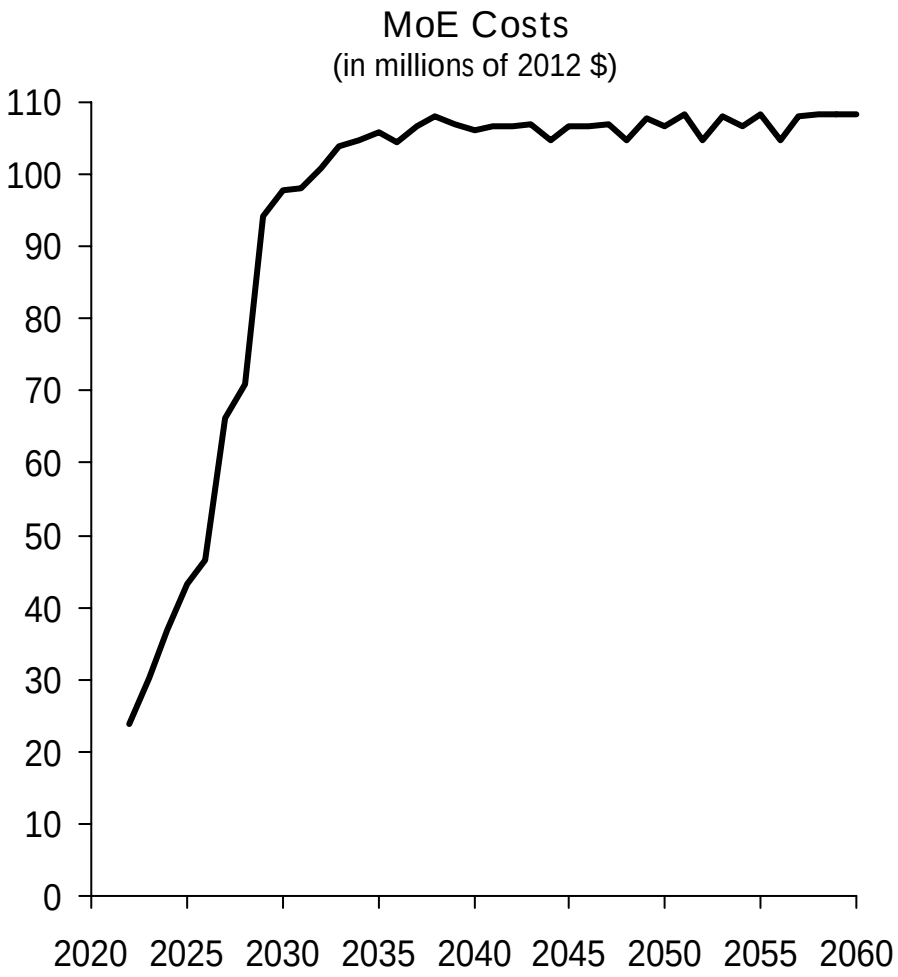


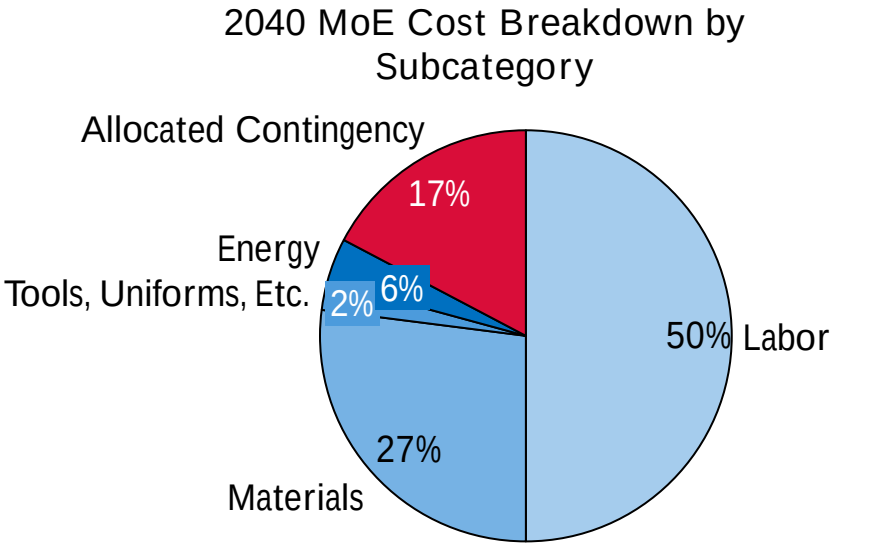
Comments

- Dispatching costs and labor are a step-function of the phase the system is in.
- The addition of new sections of track and stations lead to the need for more dispatchers.

All results presented in this report are based on preliminary model runs with final inputs and assumptions still being developed. All numbers should be considered draft and subject to change as the model is finalized.

Labor and materials make up the majority of MoE costs





Comments

- MoE costs include regulatory maintenance/inspection and smoothed bogey inspection and general overhaul costs.
- For details on how smoothing is applied, please see the Tech. Memo.

All results presented in this report are based on preliminary model runs with final inputs and assumptions still being developed. All numbers should be considered draft and subject to change as the model is finalized.

Train maintenance follows the Code of Federal Regulations based on both time and distance run by the fleet

General Description

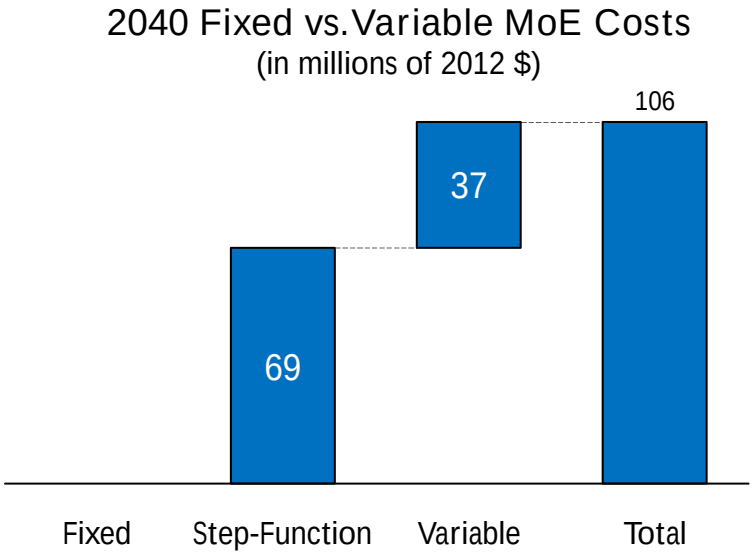
- Maintenance of Equipment costs are essentially related to the cost of undertaking current maintenance activities on the fleet at a maintenance facility (or Heavy Maintenance Facility) including:
  - Regulatory inspections (guided by the Code of Federal Regulations) carried out by dedicated staff
  - Major component overhauls carried out by dedicated staff
  - Material cost for regulatory inspections and overhauls
- Regulatory inspections are carried out at the maintenance facilities but overhauls occur only at the HMF
- For the purpose of the modeling, a typical maintenance regime was assumed based on both time and distance run by the trainsets
- The costs are built up from a number of teams and a number of tours required to carry out routine maintenance activities on the fleet
- Additional personnel are added when renewal operations are scheduled in the trainset lifecycle

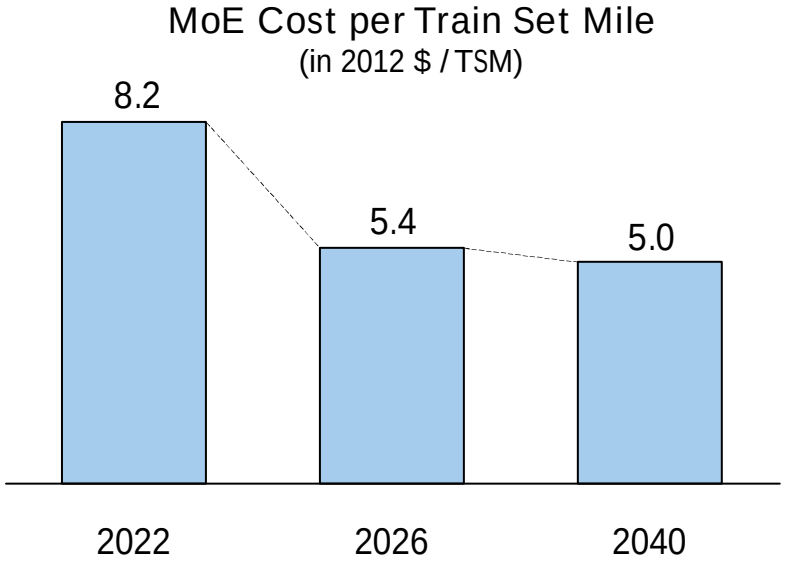
Primary Drivers

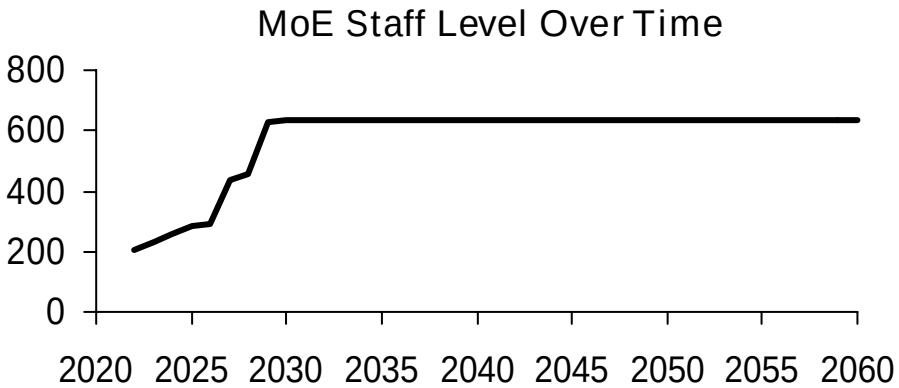
- Staffing levels are determined by regulatory requirements for Short and Long Term Inspection and Maintenance of rolling stock as well as daily cleaning, toilet servicing and cleaning between runs. MOE staffing levels are documented in the Concept of Operations. Survey of current HSR systems as well as consultation with UIC conducted to develop strategy and approach to MOE
- Regulatory maintenance inspections are carried out by a team of 13 staff based on 2 or 3 tours per day depending on the location of the facility
- The model differentiates between Level1-5 maintenance facilities and MOE functions vary with both distance and time (daily, monthly and annual inspections)
- During the IOS Phase, two MOE Facilities are anticipated and staff assigned according to the number of trains assigned to be maintained at each facility according to the Service Plan.
- Wage rates determined from survey of major railroads

Note: Detailed description , staff categories, wages and benefits and relative assumptions are presented in the TM " Operations and Maintenance Cost Model Documentation"

Maintenance of equipment combines step-function and variable costs





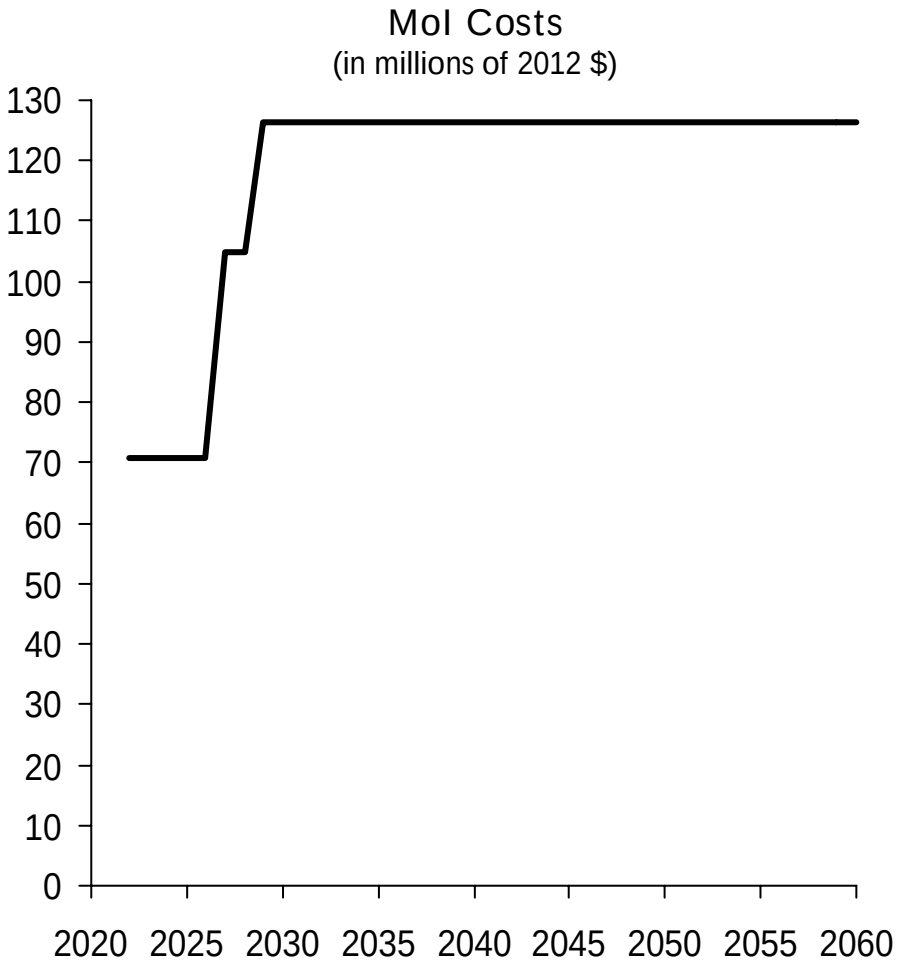


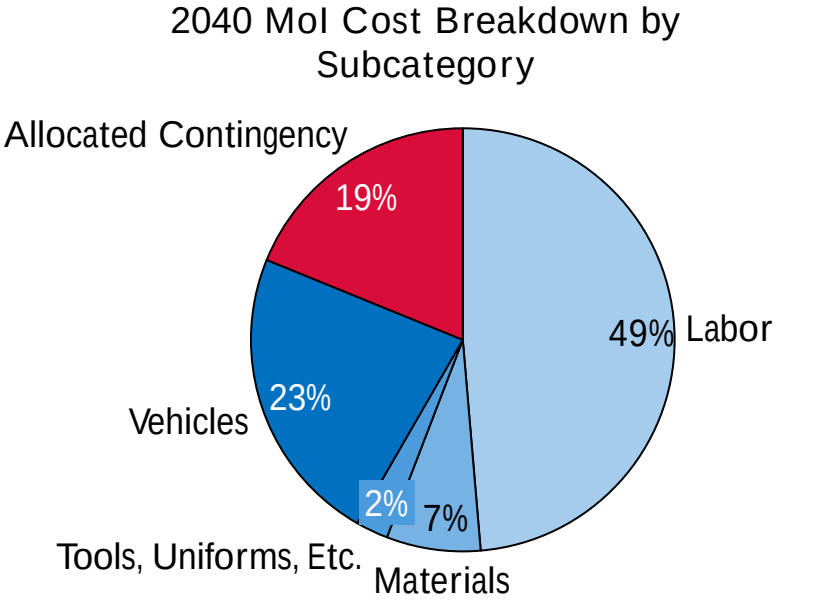
Comments

- Regulatory inspection costs act as a step-function with the fleet size
- Bogey inspections and general overhauls are variable costs driven by the TSM so they flatten out after full ramp-up
- MoE cost per TSM varies from $8.22 in 2022 to $4.72 in the out years

All results presented in this report are based on preliminary model runs with final inputs and assumptions still being developed. All numbers should be considered draft and subject to change as the model is finalized.

MoI costs grow as a step-function based on the phasing





Comments

- MoI costs are comprised of a series of gangs that operate either from an MoI base or systemwide.
- Labor and vehicle costs are tied closely together.

All results presented in this report are based on preliminary model runs with final inputs and assumptions still being developed. All numbers should be considered draft and subject to change as the model is finalized.

The MoI costs are determined relative to the system's length and complexity

General Description

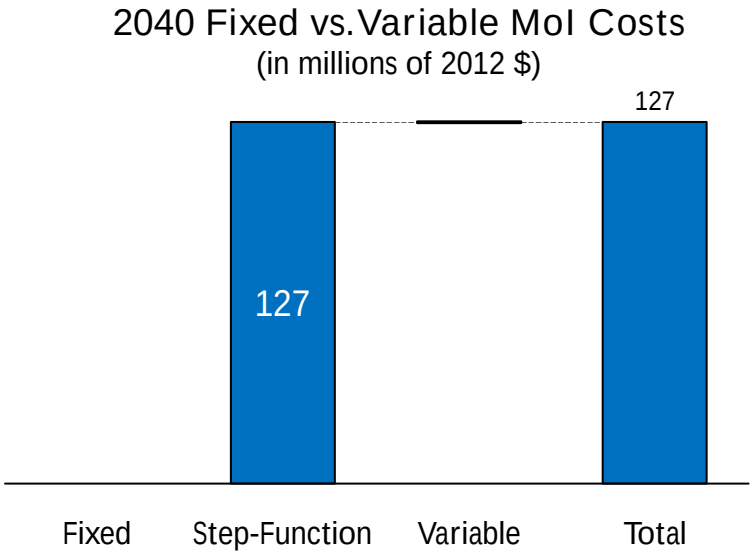
- Maintenance of Infrastructure portion of the model includes the personnel, materials, tools, and equipment required to maintain the tracks and other infrastructure
- 6 areas of duties and responsibilities of the MOI staff have been identified:
  - Basic MOI Facility
  - Initial System Units
  - HMF Addition
  - Crane /Tractor Unit
  - 2nd System Unit
  - Facility Gang Addition
- The second component of the MoI costs is made of materials and other costs based on UIC's International Benchmarking and estimated at 15% of the total MoI labor cost
  - An additional 5% of the total labor cost (including front-line management) is assumed for miscellaneous tools, uniforms, and so forth
- The third component is constituted with rubber tired and on-track vehicles required to perform maintenance activities

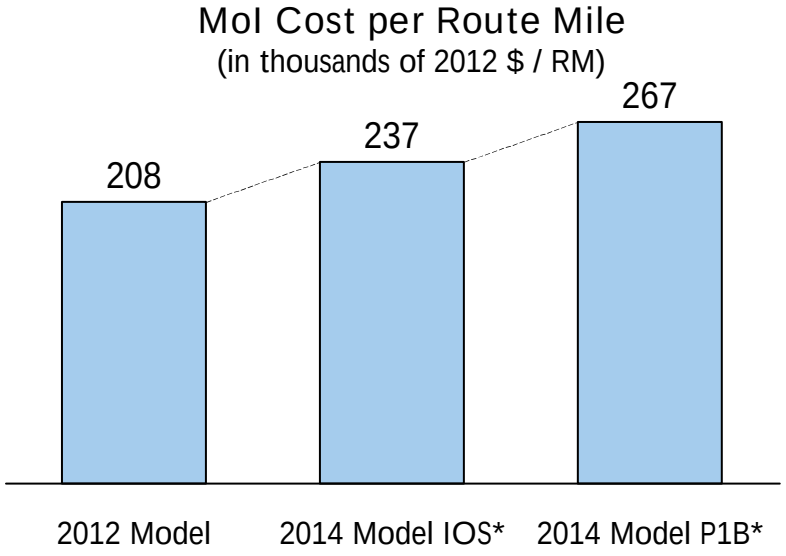
Primary Drivers

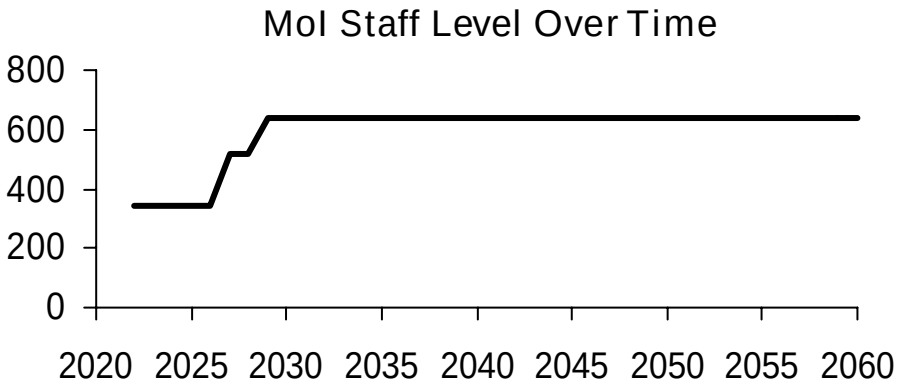
- It is assumed that most MOI activities will occur during one tour at night and that daytime MOI staffing will be aimed at maintenance that does not negatively impact train service and responding to unscheduled outages as they occur
- Basic MOI Facility (BMF) will be commissioned when one segment of the system is in operation for construction, equipment testing or other purpose
  - Additional BMFs are required as each segment of 100 - 150 route miles is added.
  - An Initial System Unit (ISU) is required when two line segments are in operation
- The HMF Addition (HMFA), and Facility Gang Additions (FGA) will be added as those components of the system are brought online
- The 2nd System Unit and the Crane / Tractor Unit will be added when the Gilroy / San Jose segment is added to the original route from Merced to San Fernando Valley
- All vehicles are assumed to be leased with their costs based on Metrolink's actual wet costs for similar equipment where available

Note: Detailed description , staff categories, wages and benefits and relative assumptions are presented in the TM " Operations and Maintenance Cost Model Documentation"

Maintenance of infrastructure is purely a step function of the phasing and system characteristics







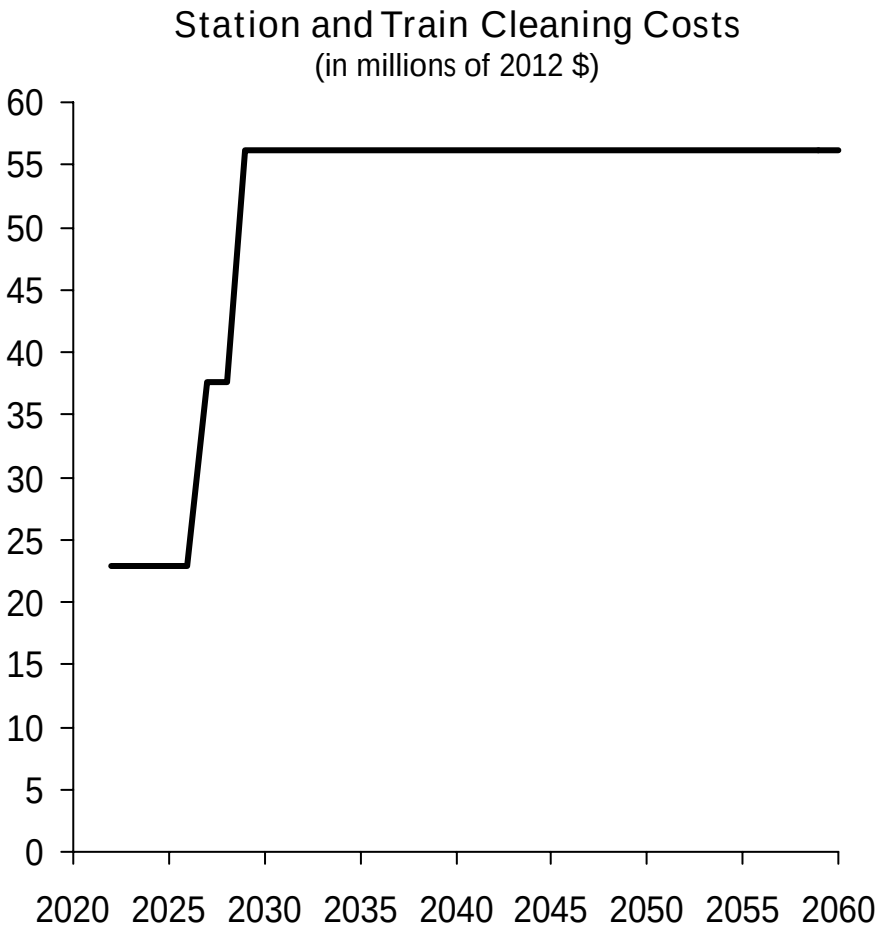
Comments

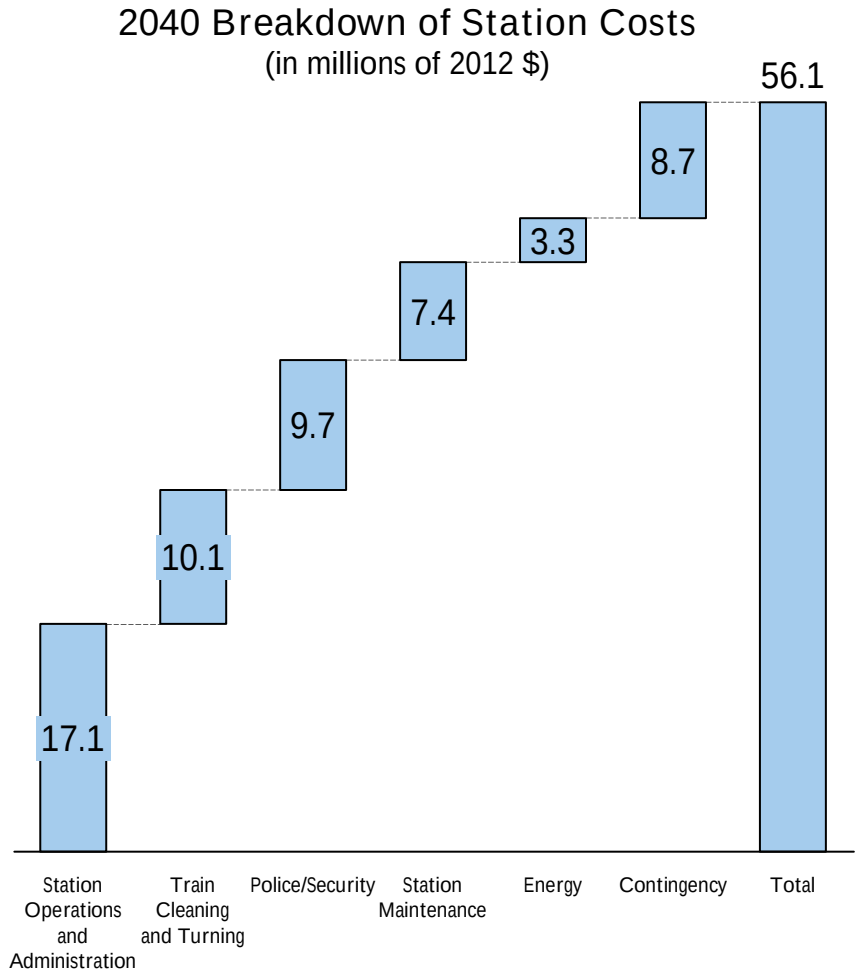
- MOI costs include systemwide and localized maintenance gangs for each phase of the system creating a step-function.
- Costs will vary by a segment's components, geography, and other unique characteristics.

*2014 model cost estimates include allocated contingency

All results presented in this report are based on preliminary model runs with final inputs and assumptions still being developed. All numbers should be considered draft and subject to change as the model is finalized.

Station costs are roughly evenly divided between maintenance, operations and administration, train cleaning, and police/security





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This cost category regroups costs related to station management, station cleaning and train cleaning

General Description

- Stations fall under a 3-level classification and costs (level of staffing) vary according to station levels and its role on the system

Level	Description	Stations
Level A	Final system configuration terminals	• Los Angeles Union Station • San Francisco Transbay Transit Center
Level B	Stations that serve as terminals under some phases of development or other major stations that are not Level A stations.	• Merced • San Jose • San Fernando Valley
Level C	Intermediate stations that never serve as system terminals	All Other Stations

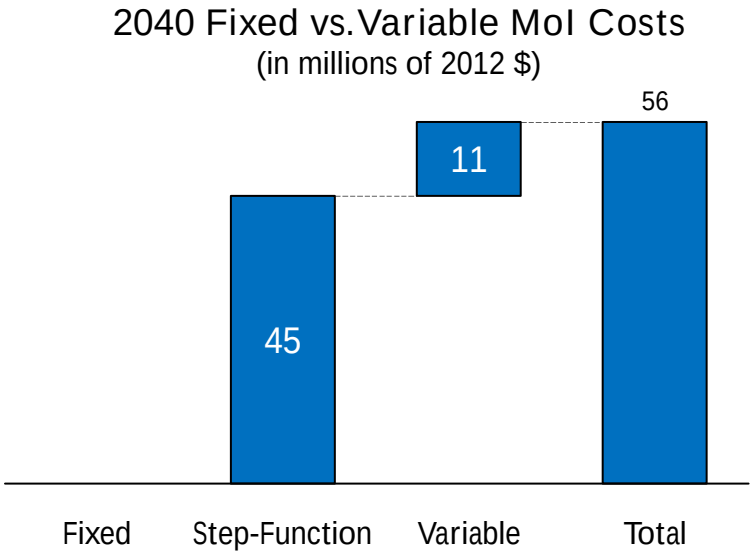
- Station personnel consist of an agent/station manager, a building systems manager, ticket clerks, and customer service representatives
- Stations also require personnel to clean them with staff varying with station levels (including part time positions for additional flexibility)
- Train cleaning is done at the stations or at the facilities
  - Trains going from revenue service to revenue service will be cleaned in the stations where they are being turned
  - Trains going from revenue service to deadhead or from deadhead to revenue service will be cleaned in the facilities
- Each station will have one deputy on duty 24 hours a day, 7 days a week. The deputy will be responsible for policing their station and patrolling the right-of-way
- Security personnel will be positioned at each station, maintenance facility, and the operations control center (but not the regional control center)

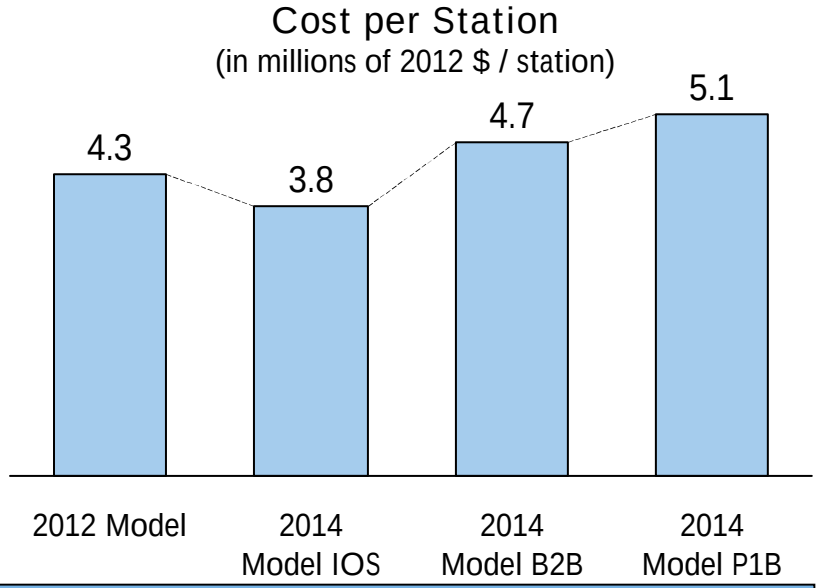
Primary Drivers

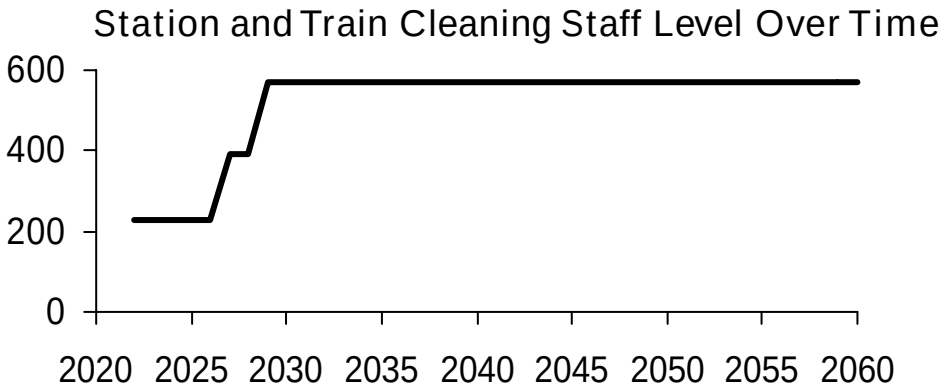
- The primary drivers affecting escalation of station personnel headcount is assumed to be the number of stations in the system and station ridership in each phase
- Each station is assumed to be staffed for customer operations utilizing 2 tours per day
- Depending on station levels, headcount per tour ranges from 4 to 7 staff
- Stations may be open for customer operations for up to 18 hours with tours of station personnel staggered in order to provide the required coverage
- Staff for station cleaning is assumed to be 8, 5 and 2 per tour for station levels A, B and C respectively
- Stations that have trains that terminate there and start a new revenue run there will have a contracted train cleaning teams of 10 people
- The number of teams that will be used to clean trains will be one team per 15 trains being turned from revenue to revenue service in that station rounded to the nearest half-team with no cleaning staff if three of fewer trains are turned
- The train cleaning that will be carried out at the maintenance facilities are included in the MoE costs
- Police and security personnel are a function of planned number of facilities and passenger stations (depending on level) for each segment, and the total route miles of the system
- Police and Security positions are assumed to be 24 hours, 365 days per year for all segments

Note: Detailed description , staff categories, wages and benefits and relative assumptions are presented in the TM " Operations and Maintenance Cost Model Documentation"

Station maintenance and admin staff behave a step-function while train cleaners vary with service levels







Comments

- Station maintenance, administration (ticketing, management, etc.), and energy are step functions of the size/type of stations on the system while train cleaners vary with levels of service.
- The Phase 1 Blended cost per station is almost identical to the 2012 Model.

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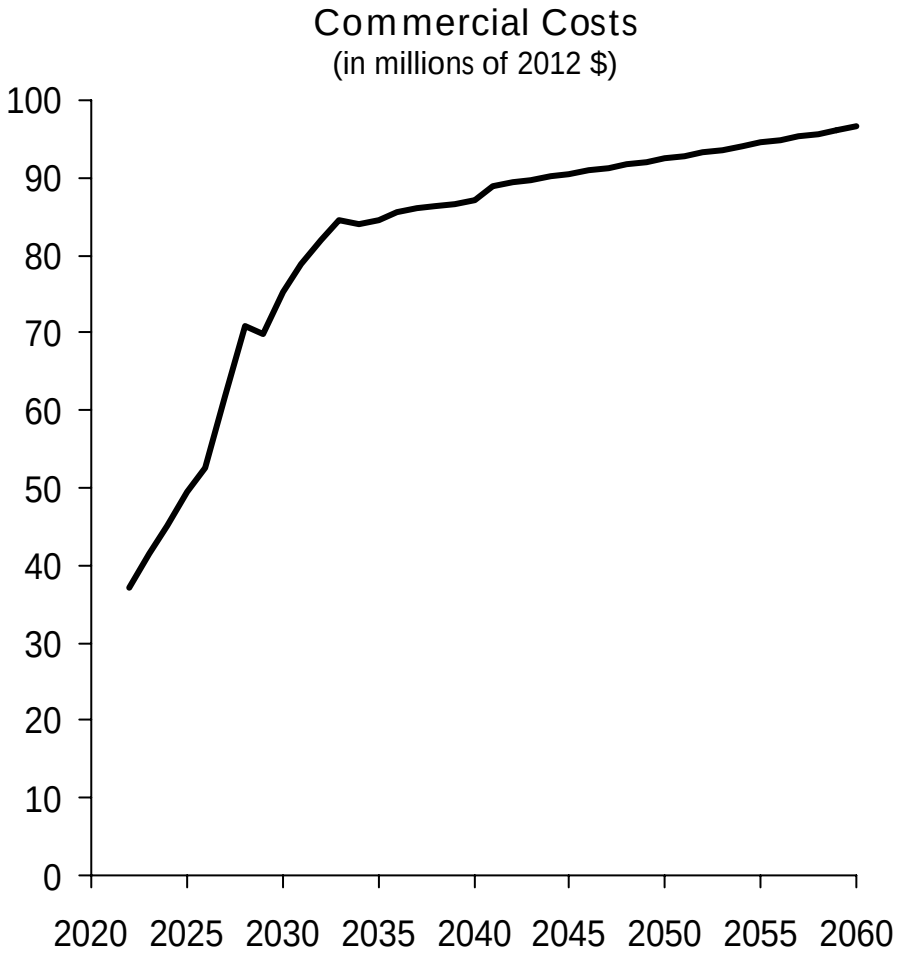
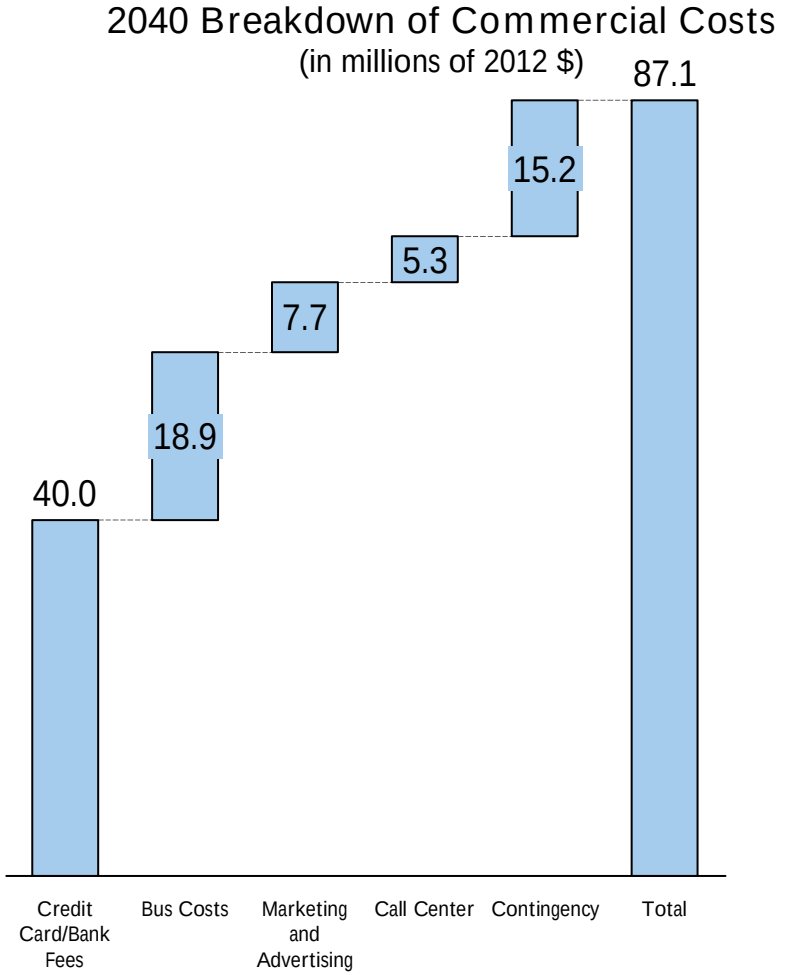
Commercial costs grow as the system expands and as socioeconomic conditions change over time





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Commercial costs include marketing, distribution costs, credit cards and bank fees, and buses operation costs

General Description

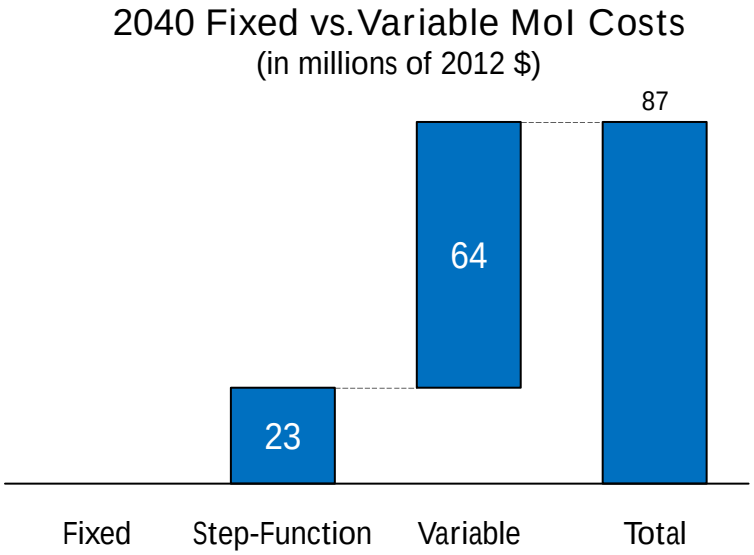
- Marketing and advertising costs are based on the number of people that the advertising campaign is trying to reach and the number of impressions that will be required for the campaign to have an impact
- The model assumes that the campaign will reach every person in a select number of counties in California.
  - Specific counties are targeted in accordance to the phasing of the system
  - For purposes of the model, it is assumed that no advertising will take place in other states
- Distribution costs include costs that will be incurred to sell tickets and operate other customer-centered functions such as call centers, website and credit card fees on ticket sales
  - The website is assumed to be able to generate advertising revenue and be cost neutral
- The cost of dedicated feeder bus service was estimated from a review of data and discussions with contract operators including the supply of coaches, operation, and establishment / operation of depot and maintenance facilities

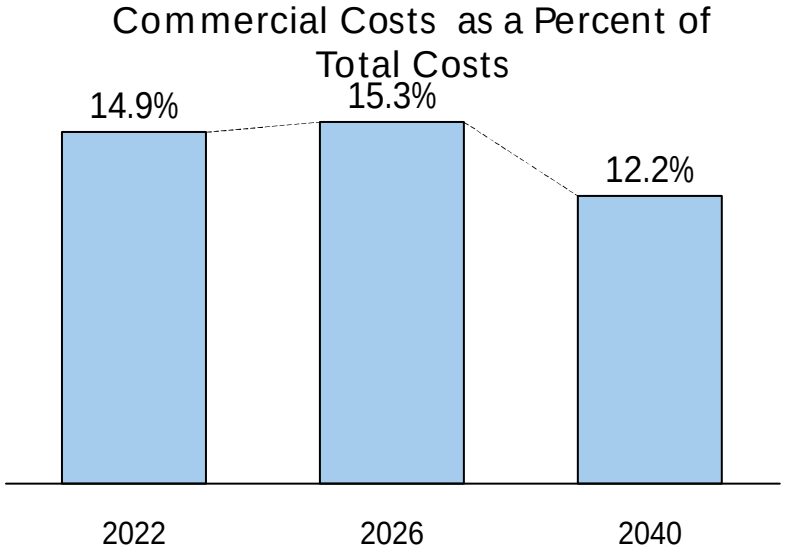
Primary Drivers

- Costs for marketing and advertising are based on counties population forecasts
- Based on eMarketer's Online Brand Management Report, we assumed that the advertising cost will be equal to the highest cost in eMarketer's data, which is $10.77 (in 2012 dollars) per 1,000 impressions for broadcast television
- Based on SNCF's experience, 2 percent of ticket purchases are assumed to be through call centers in all but the first two years where 4 percent was assumed (all other sales are assumed to take place over the Internet and in stations)
- The model assumes a 15 percent commission to be applied to the sales conducted through the call center to cover both cost for sales (two thirds) and costs for information (one third)
- Credit card sales costs are calculated as a percentage of total revenue generated based on Amtrak's ticket sales and using an average fee of 2.27 percent
- The model uses $3.16 per mile based on Amtrak Thruway buses as it is more representative of the service that would be needed to meet HST trains
- The number of bus miles is determined by the number of riders at each station that use the bus connections for station access increased by deadhead miles

Note: Detailed description , staff categories, wages and benefits and relative assumptions are presented in the TM " Operations and Maintenance Cost Model Documentation"

Socioeconomic conditions, phasing, and ridership/revenue growth drive changes in commercial costs





Comments

- Marketing, credit card fees, and call center costs are variable with revenue and population growth.
- Bus costs are a step-function of phasing with some additional buses needed in out years for ridership growth.
- Buses are a major driver of commercial costs and they decrease as a percentage of total costs as phases are added and other costs grow.

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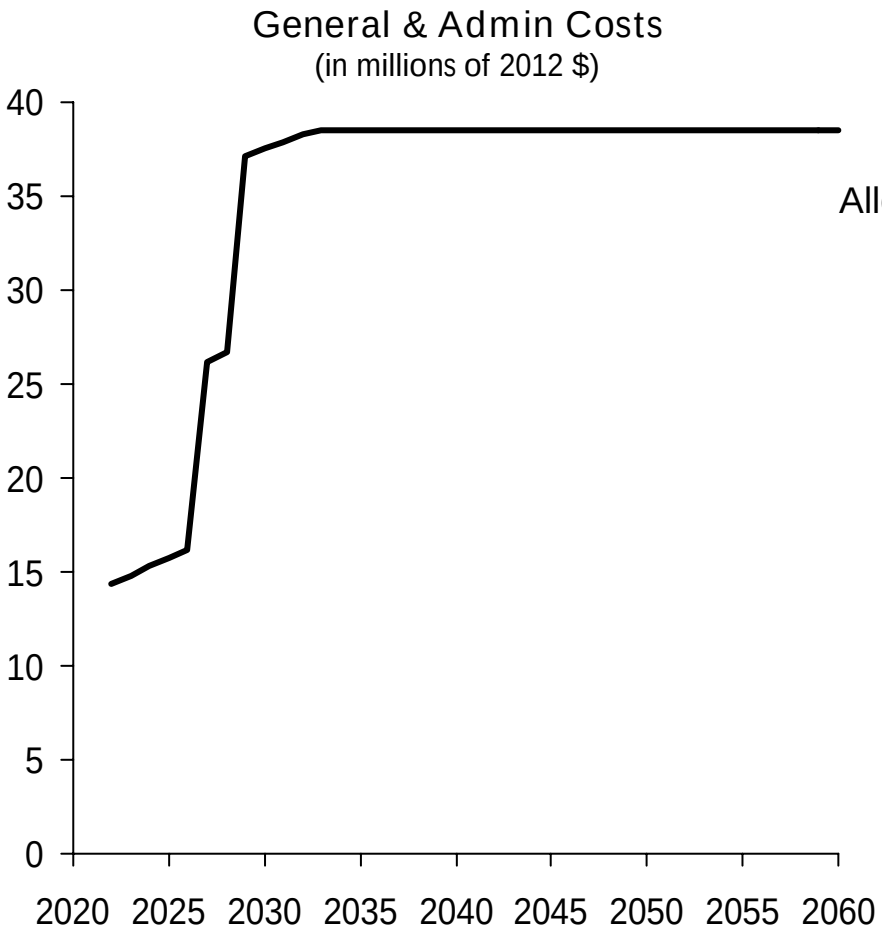
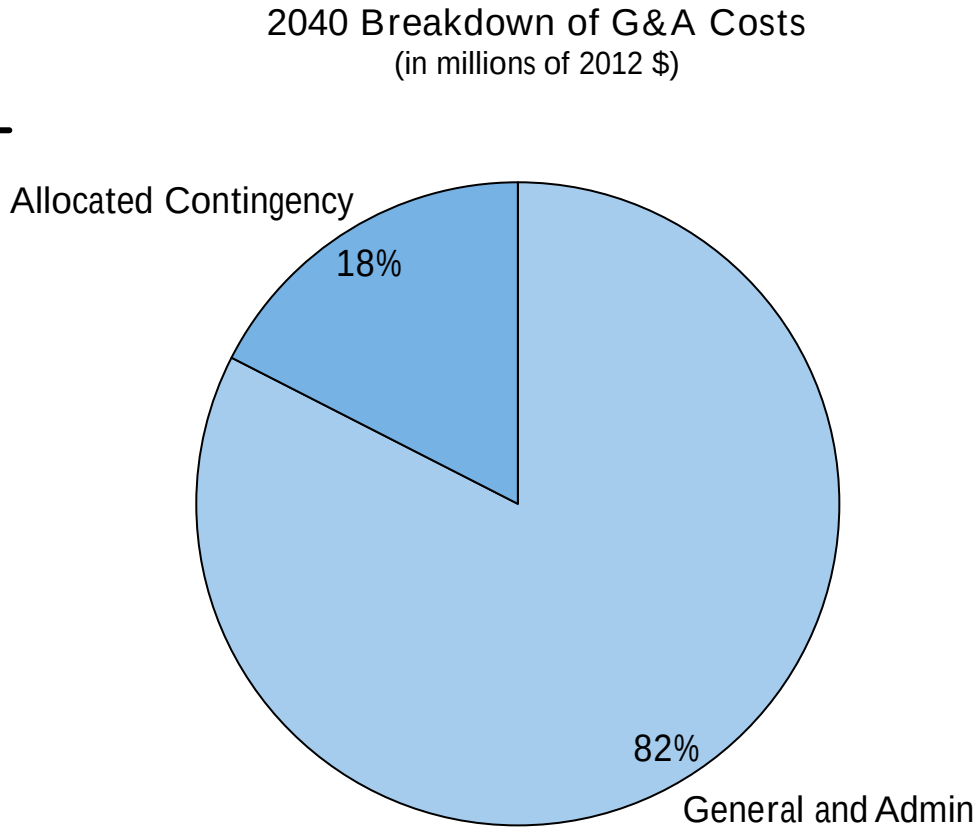
G&A costs increase with the growth of the system's operations and ridership





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The General & Admin category covers overhead executive and admin staff.

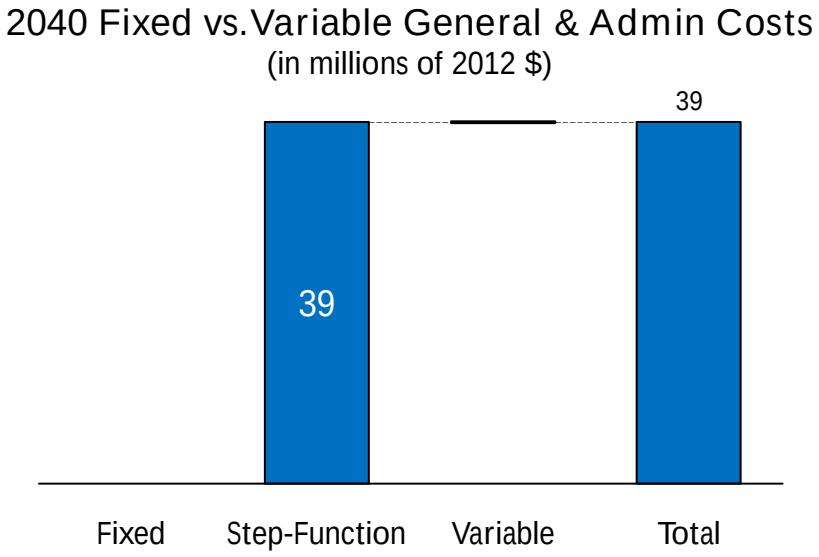
General Description

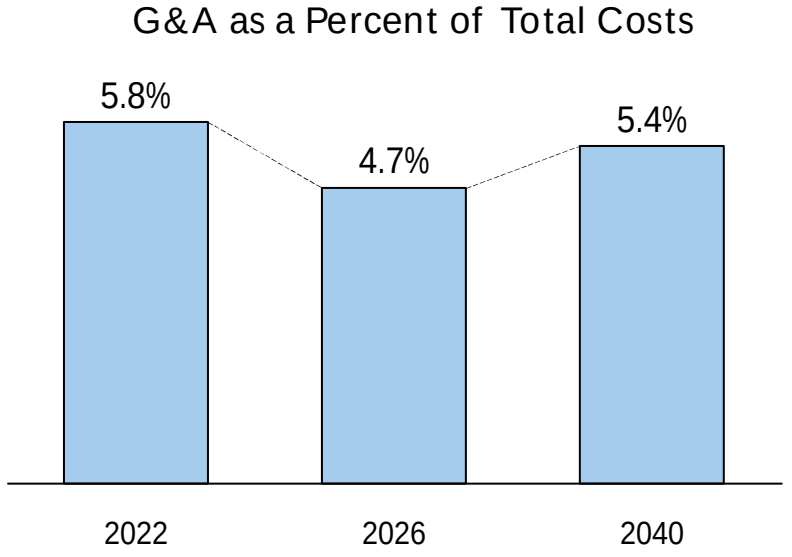
- This category covers administrative cost items and overhead staff, including: executive and corporate organization, police and security.
- The executive and corporate organization is comprised of senior level personnel and experienced support staff who lead and direct the organization at the command and policy level. The number of personnel required to fill corporate functions is calculated as a percentage of the total personnel employed at the system

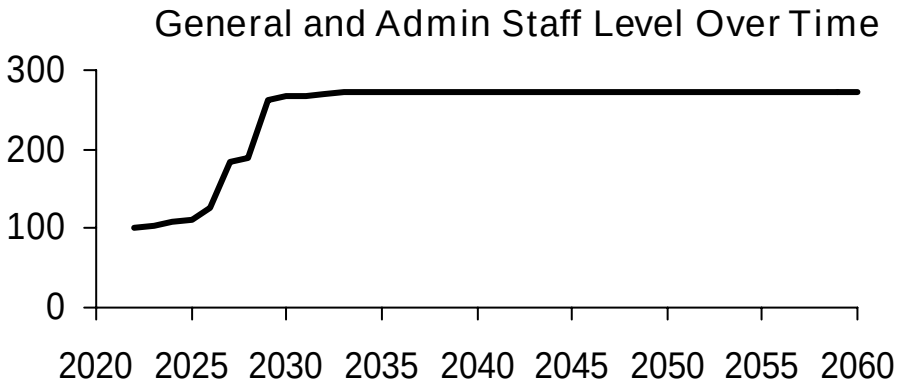
Primary Drivers

- The total headcount for management and administration of the system is assumed to be 10 percent of the organization below this level.
- Executive positions are estimated to comprise 5 percent of this subtotal and are assumed to be compensated at senior executive rates.
- Senior manager positions below executives are estimated to comprise 10 percent of the subtotal and are assumed to be compensated at a rate 25 percent below executive rates.
- Mid-managers are estimated to comprise 25 percent of the subtotal and are assumed to be compensated at a manager's/supervisor's rate.
- Administration and other lower level corporate staff are estimated to comprise 60 percent of the subtotal and will be compensated accordingly.
- The allocation of positions with the G&A staffing is based on a comparison with other railroad properties in the U.S. and high-speed rail systems abroad.

G&A Costs are relatively stable once the system ramps up







Comments

- G&A costs are a step function of the labor force associated with the system.
- G&A as a share of total costs fluctuates between 4.5 percent and 6 percent of the total cost

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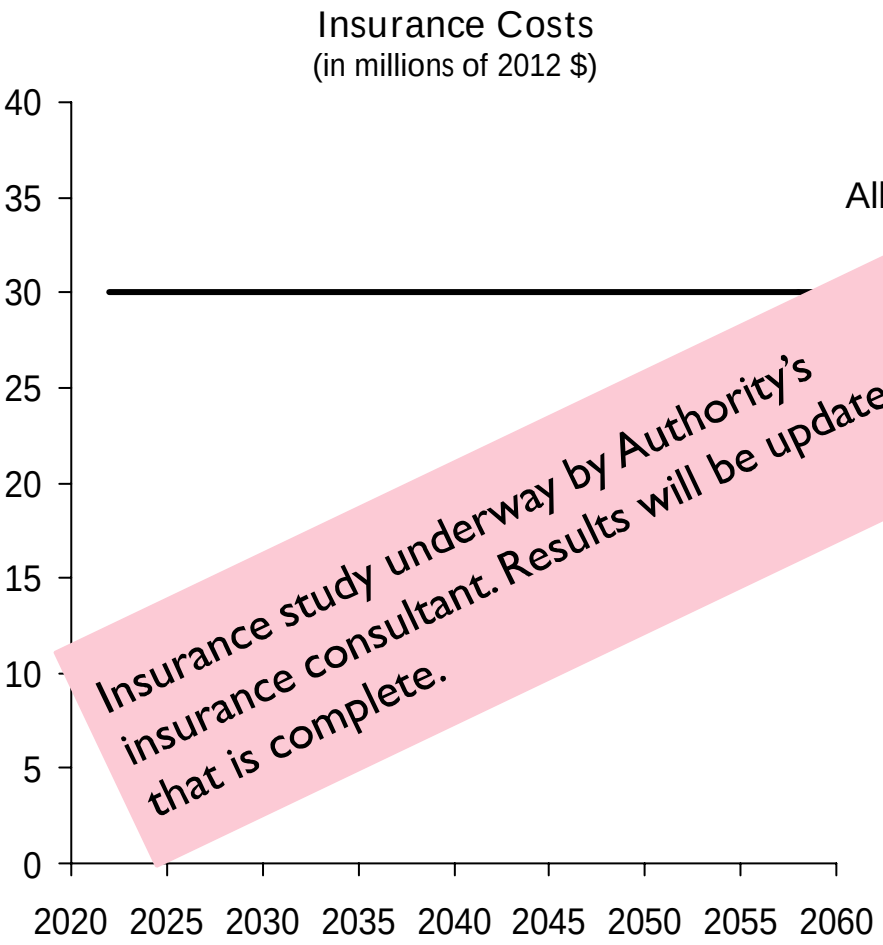
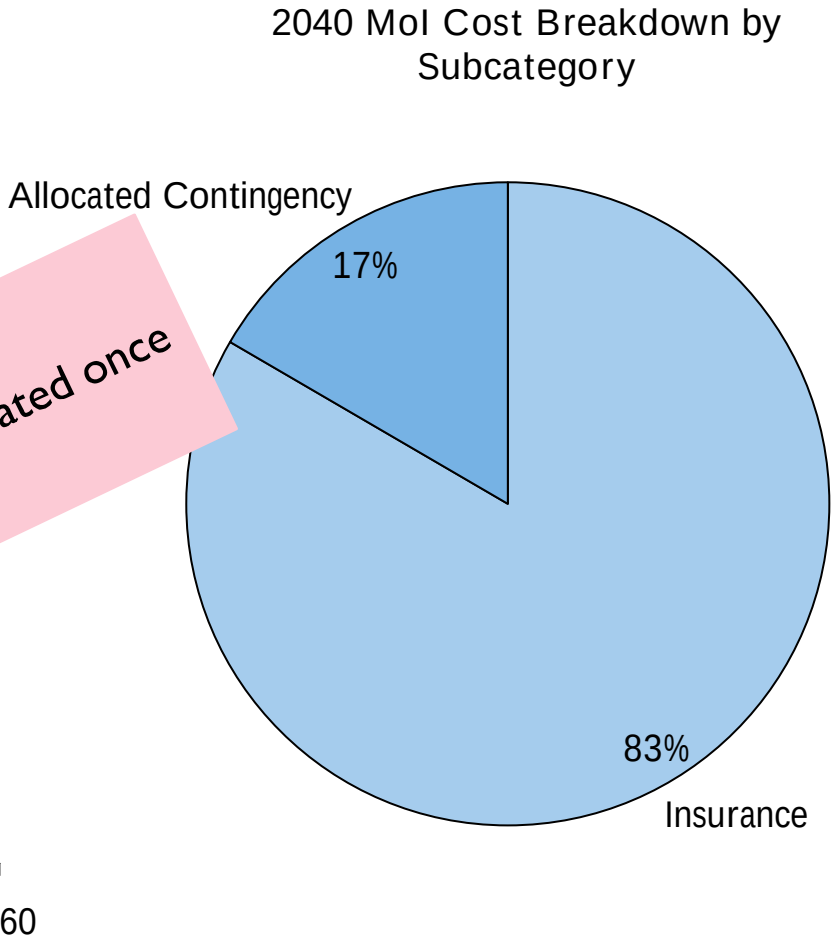
Insurance costs are a placeholder that will be updated by the Authority's insurance consultant





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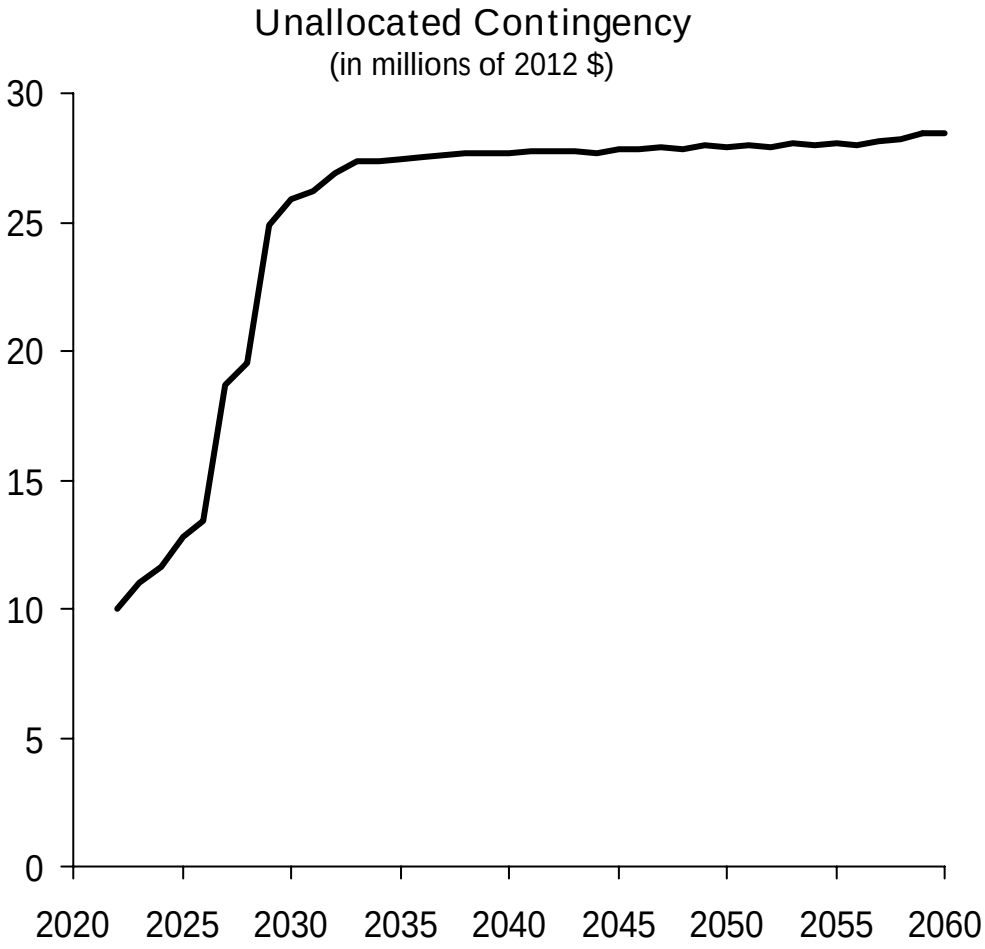
Cost forecast by major cost category



Comments

- 2014 model includes unallocated contingency for “unknown” unknowns and allocated contingency for “known” unknowns.
- Unallocated contingency makes up 5% of the subtotal costs, consistent with the capital cost estimate.

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