

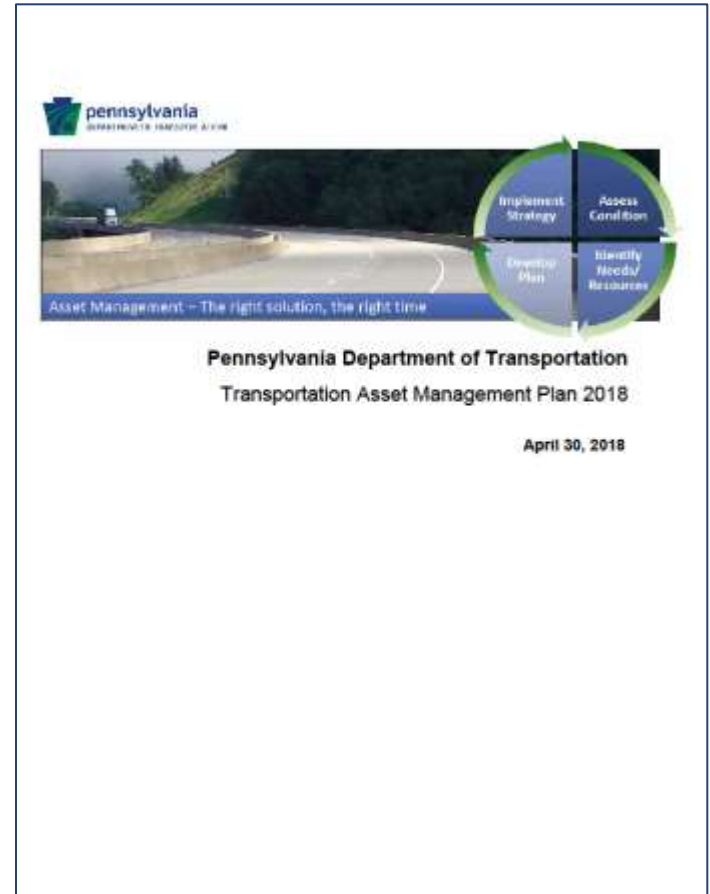
ABCD Technical Conference

Bridge Asset Management

Justin Bruner, PE

PennDOT TAMP

- 6 iterations over 5 years
- Staff turnover= fresh ideas
- Early identification of problem areas



Background

Count	
State	Poor Bridges % Ranking
RHODE ISLAND	50
IOWA	49
WEST VIRGINIA	48
PENNSYLVANIA	47
SOUTH DAKOTA	46
MAINE	45
LOUISIANA	44
OKLAHOMA	43
NORTH DAKOTA	42
ALASKA	41

Deck Area	
State	Poor Deck Area % Ranking
RHODE ISLAND	50
MASSACHUSETTS	49
WEST VIRGINIA	48
CONNECTICUT	47
WYOMING	46
IOWA	45
NEW YORK	44
ILLINOIS	43
PENNSYLVANIA	42
NORTH CAROLINA	41

Background

MILES OF PUBLIC ROAD

119,936

Roads with acceptable pavement ride quality based on International Roughness Index, 2013:

Pennsylvania	77.2%
United States	80.4%

MILES OF FREIGHT RAILROAD

5,151

BRIDGES

22,430

Bridges classified as functionally obsolete, 2013:

Pennsylvania	19.6%
United States	13.7%

Bridges classified as structurally deficient, 2013:

Pennsylvania	22.5%
United States	10.1%

MILES OF WATERWAY

260

MAJOR WATER PORTS

5

Includes ports ranked in the top 150 ports by tonnage in 2013.

NUMBER OF MPOs

20

MAJOR AIRPORTS

16

Includes Federal Aviation Administration Part-139 public use airports.

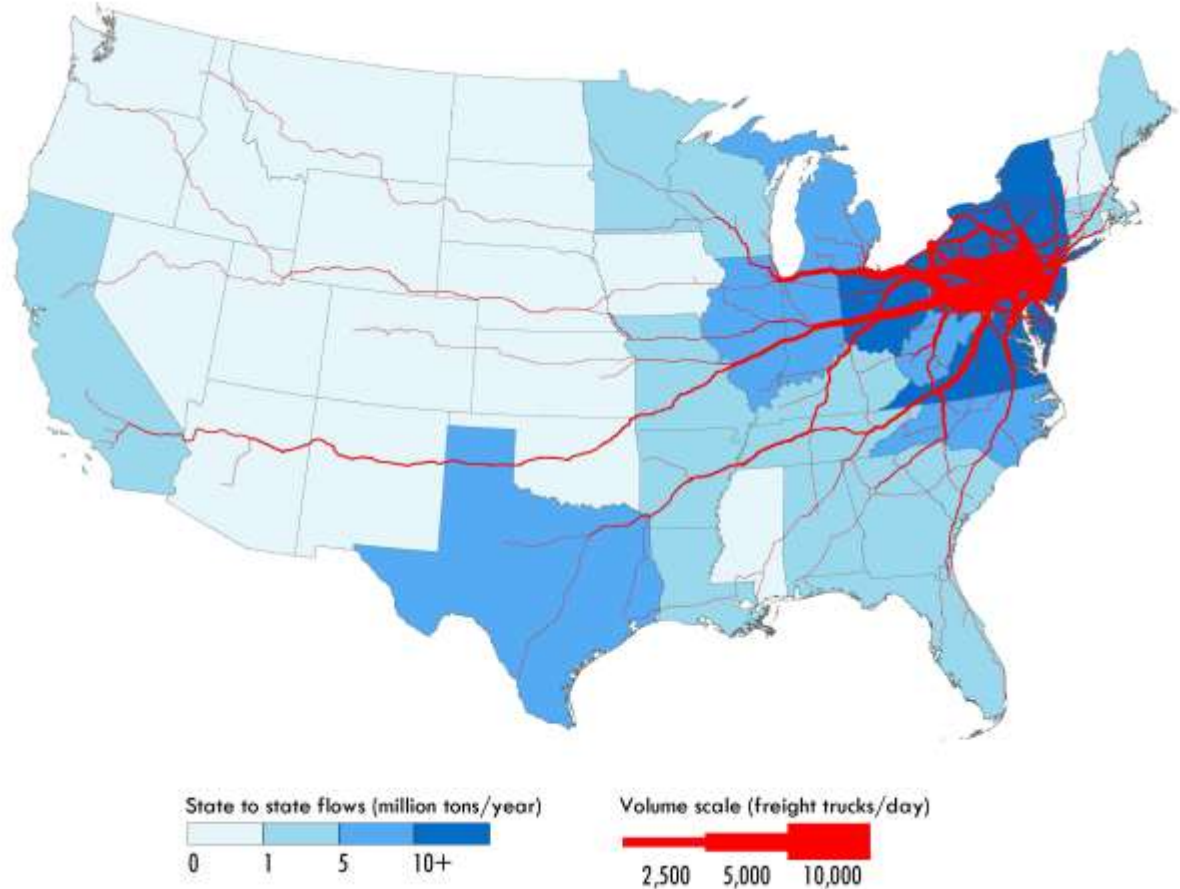
January 2016



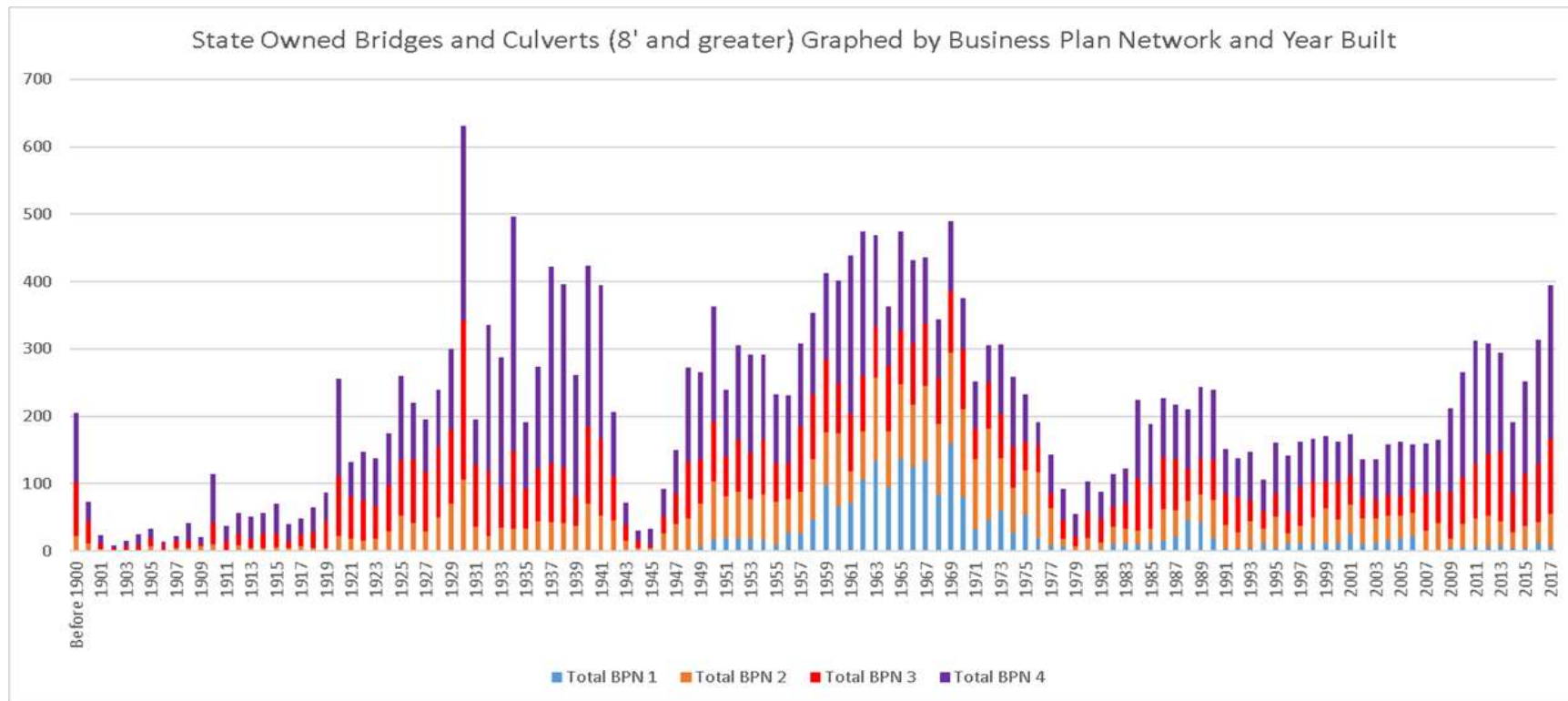
U.S. Department of Transportation
Bureau of Transportation Statistics

Background

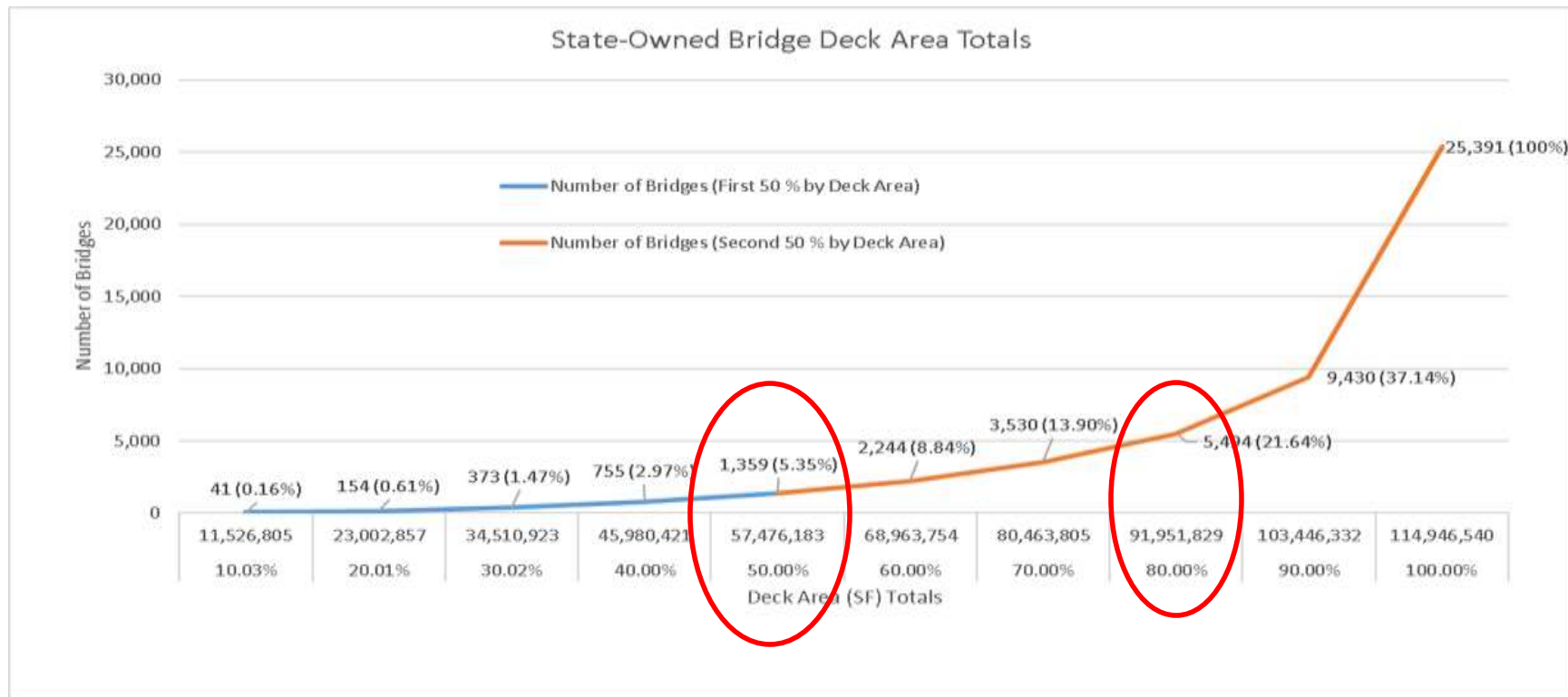
FHWA:
Trucks/day 2016



Background



Background



TAMP- Asset Management

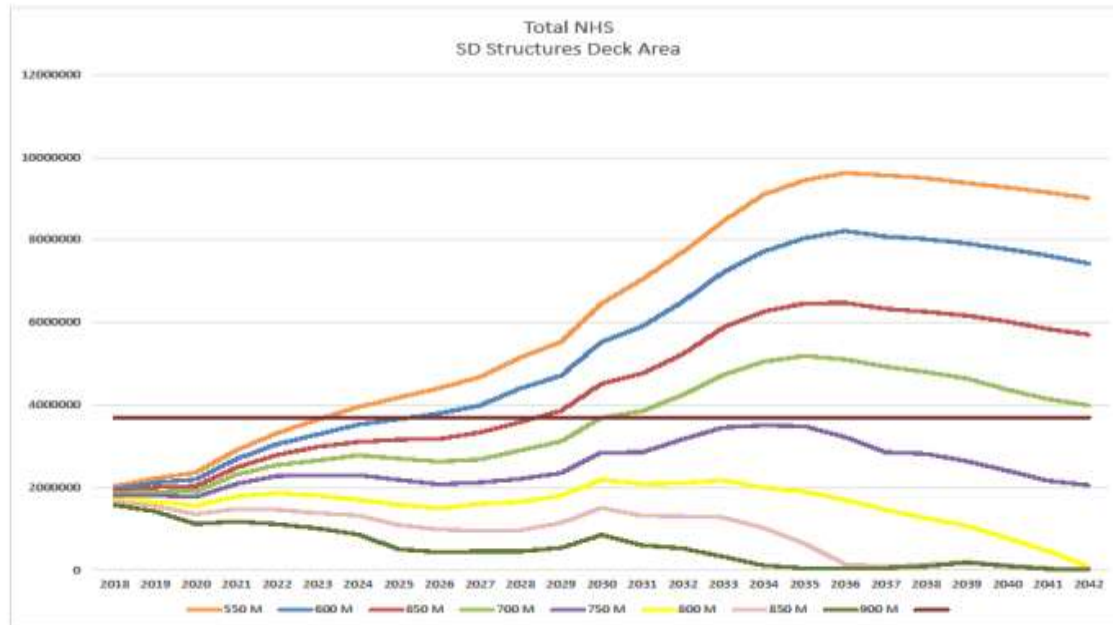


TAMP- Asset Management

We need to forecast:

- Future conditions at current funding levels for existing assets
- Investment dollars / projects to achieve future network performance goals
- Multiple iterations = “specialized” software

Asset Management



Asset Management

- Forecasting software needs:
 - Asset registry
 - Deterioration models
 - Work matrix
 - Cost matrix
 - Prioritization (risk + condition)

Asset Registry

- List of bridges, attributes and historic inspection data
- PennDOT: BMS2

The screenshot displays the Pennsylvania BMS2 Bridge Management System interface. The header includes the Pennsylvania Department of Transportation logo and the text "BMS2 BRIDGE MANAGEMENT SYSTEM". Below the header, there are navigation tabs for "Home", "Bridge", "Inspection", "Reporting", and "Administration". The main content area is a form for entering bridge data, with a "Bridge Name" field highlighted in yellow. The form includes various input fields for bridge details, a "Save" button, and a "New Bridge" button. The interface is designed for data entry and management of bridge assets.

Deterioration Modeling

- Deterministic vs probabilistic
- Limitations in data
- Limitations in durations (1/5 life)
- Expert elicitation
- Snowflake syndrome

Deterioration Modeling

Material Type	District 1	District 2	District 3	District 4	District 5	District 6	District 8	District 9	District 10	District 11	District 12	Statewide Total	% Total
Concrete(in place), Slab (solid)	226	271	185	226	292	258	592	259	313	180	296	3098	19%
Steel, I beams	195	211	253	224	234	240	343	305	156	175	286	2622	16%
P/S, Box beam - (spread)	250	229	242	251	195	225	448	226	148	112	221	2547	16%
P/S, Box beam - adj	233	177	209	165	121	196	236	168	92	61	141	1799	11%
Concrete(in place), T-beams	112	184	222	117	204	155	178	169	110	48	102	1601	10%
P/S, I beams	63	173	198	119	149	233	180	135	60	99	90	1499	9%
Steel, I-welded beams	48	80	63	61	74	267	118	68	73	177	52	1081	7%
Concr. encased steel, I beams	18	24	28	13	64	96	41	47	10	62	119	522	3%
Concrete(precast), Slab (solid)	35	16	63	23	6	0	54	35	42	3	16	293	2%
Concrete(in place), Rigid frame	5	0	1	1	6	11	112	4	0	24	2	166	1%
Steel, Truss - thru	11	13	37	12	3	5	5	15	10	16	13	140	1%
Steel, I-riveted beams	2	4	2	2	18	33	7	0	8	42	12	130	1%
Concrete(precast), Channel beams	43	8	25	4	3	4	4	1	12	1	1	106	1%
P/S, Slab (solid)	3	5	18	1	3	17	23	22	8	2	4	106	1%
Steel, Girder riv/thru	13	1	20	4	13	16	7	4	3	9	10	100	1%
Other	Combines 50 other categories of bridges. Each of these categories had less than 40 bridges statewide and breakdown by district would not provide meaningful results.											395	2%

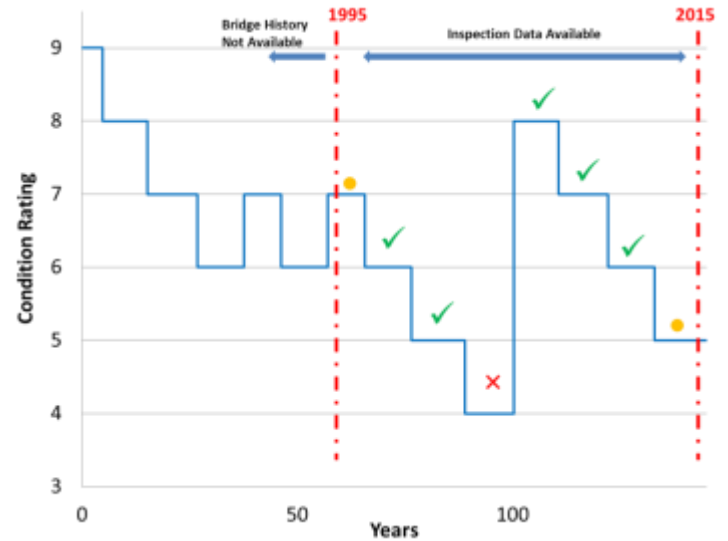
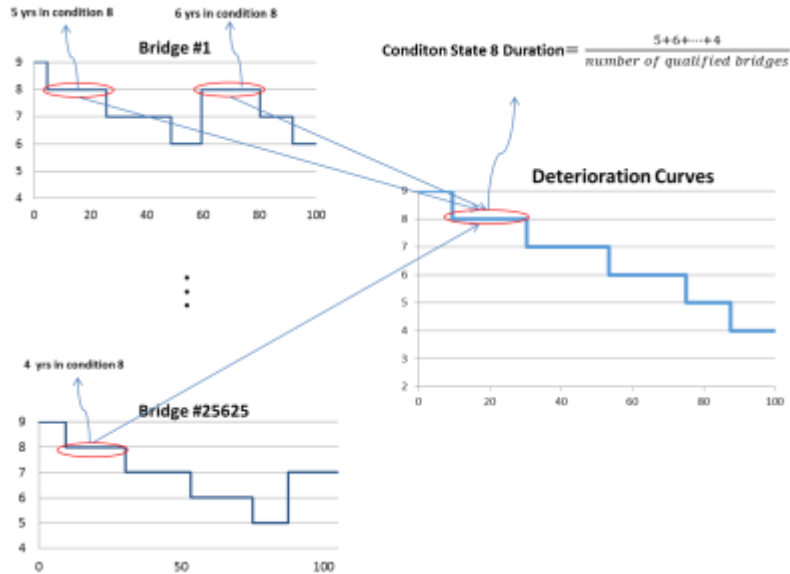
Deterioration Modeling

StructureType	# Bridges	StructureType	# Bridges
Concrete(in place), Slab (solid)	3409	Alum, Iron, Pipe culvert	7
P/S, Box beam - (spread)	2990	Alum, Iron, Truss - thru	7
Steel, I beams	2477	Concr. encased steel, Girder rv/deck	7
Concrete(in place), Box culvert	2238	Steel, Girder weld/thru	7
P/S, Box beam - adj	1873	Concrete(precast), Box beam - (spread)	6
Concrete(precast), Box culvert	1864	Steel, Arch deck - closed	6
P/S, I beams	1596	Steel, Box beam - (spread)	6
Concrete(in place), Arch culvert	1463	Steel, Box culvert	6
Concrete(in place), T-beams	1441	Steel, Other	6
Steel, I-welded beams	1442	Timber, glue-lam timber	6
Steel, Pipe-arch culvert	760	Concrete(precast), Rigid frame	4
Concr. encased steel, I beams	514	Other, Arch deck - closed	4
Concrete(precast), Slab (solid)	384	Other, Box culvert	4
Steel, Pipe culvert	359	Other, Other	4
Concrete(in place), Arch deck - closed	346	P/S, Slab (hollow)	4
Masonry, Arch deck - closed	285	Concr. encased steel, T-beams	3
Masonry, Arch culvert	200	Masonry, Tied arch culvert	3
Concrete(in place), Rigid frame	199	Steel, Channel beams	3
Concrete(precast), Pipe culvert	174	Concrete(in place), Pipe-arch culvert	2
Concrete(in place), Tied arch culvert	153	Concrete(precast), I beams	2
Steel, Truss - thru	142	Concrete(precast), Tied arch culvert	2
Steel, Arch culvert	127	Other, I beams	2
P/S, Slab (solid)	122	Other, Pipe-arch culvert	2
Steel, I-riveted beams	121	Steel, Box beam - single	2
Concrete(precast), Channe beams	112	Steel, Movable - bascule	2
Concrete(precast), Arch culvert	97	Timber, Truss - thru	2
P/S, T-beams	94	Alum, Iron, Arch deck - open	1
Steel, Girder rv/thru	94	Alum, Iron, Frame culvert	1
Concrete(in place), Frame culvert	74	Concr. encased steel, Arch deck - open	1
Steel, Girder weld/deck	60	Concr. encased steel, Other	1
Steel, Girder rv/deck	38	Concr. encased steel, Rigid frame	1
Concrete(in place), Arch deck - open	37	Concr. encased steel, Truss - thru	1
Concr. encased steel, Slab (solid)	28	Concrete(in place), Box beam - (spread)	1
Other, Pipe culvert	25	Concrete(in place), Tunnel	1
Steel, Truss - deck	25	Concrete(precast), Tunnel	1
Steel, Girder rbr/deck	23	Masonry, Pipe culvert	1
Concrete(in place), Other	16	Masonry, Pipe-arch culvert	1
Concrete(precast), Frame culvert	15	Masonry, Tunnel	1
Concr. encased steel, I-riveted beams	14	Other, Arch culvert	1
Steel, Girder wbr/deck	14	Other, Slab (solid)	1
Concr. encased steel, Girder rv/thru	13	Other, Tunnel	1
Concrete(precast), Arch deck - closed	13	P/S, Box beam - single	1
Concrete(precast), Pipe-arch culvert	12	P/S, Channel beams	1
Steel, Arch - thru	12	Steel, Frame culvert	1
Steel, Rigid frame	12	Steel, Orthotropic	1
Alum, Iron, Pipe-arch culvert	11	Steel, Slab (solid)	1
Alum, Iron, Box culvert	10	Steel, Suspension	1
Concrete(precast), Box beam - adj	10	Steel, Tied arch culvert	1
Alum, Iron, Arch culvert	9	Timber, Solid timber beams	1
Concrete(in place), Pipe culvert	8	Timber, Tunnel	1
Steel, Arch deck - open	8		

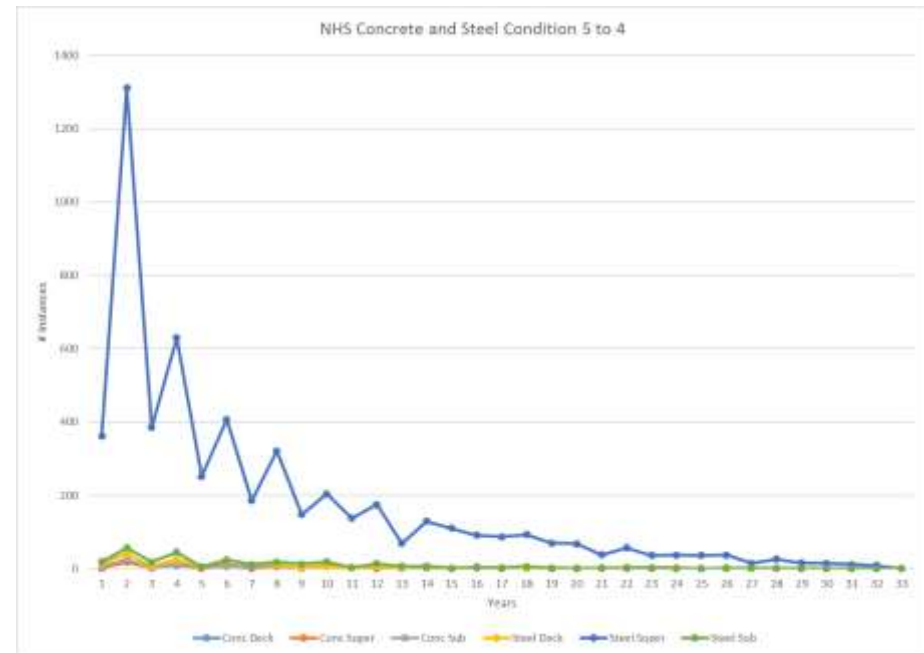
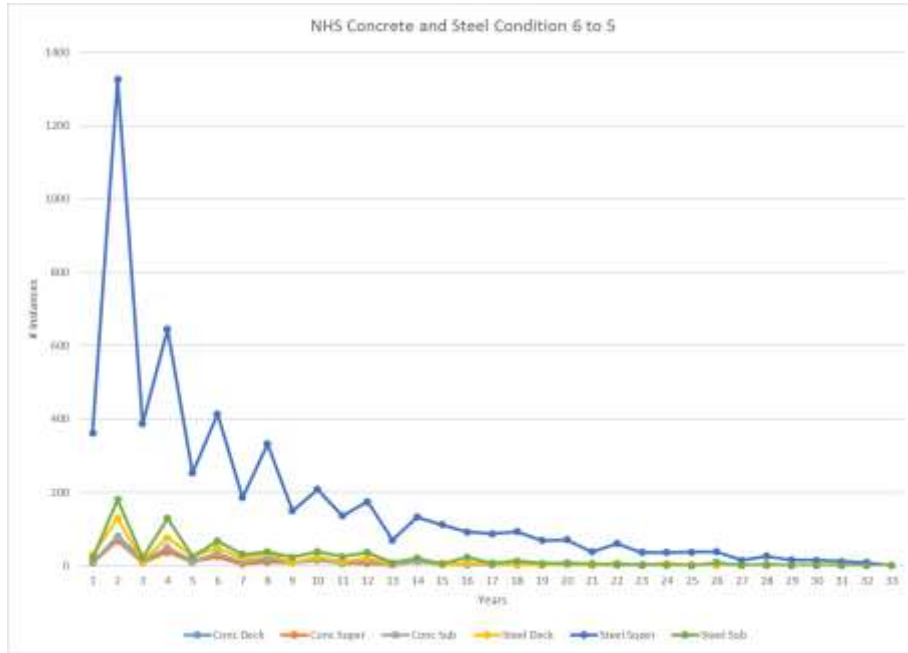


FamilyID	Family Name	# of Bridges
B01	General Concrete	5758
B02	General Steel	4298
B03	PS Concrete	4804
B04	PS Composite	1846
B05	PS NCAB	479

Deterioration Modeling

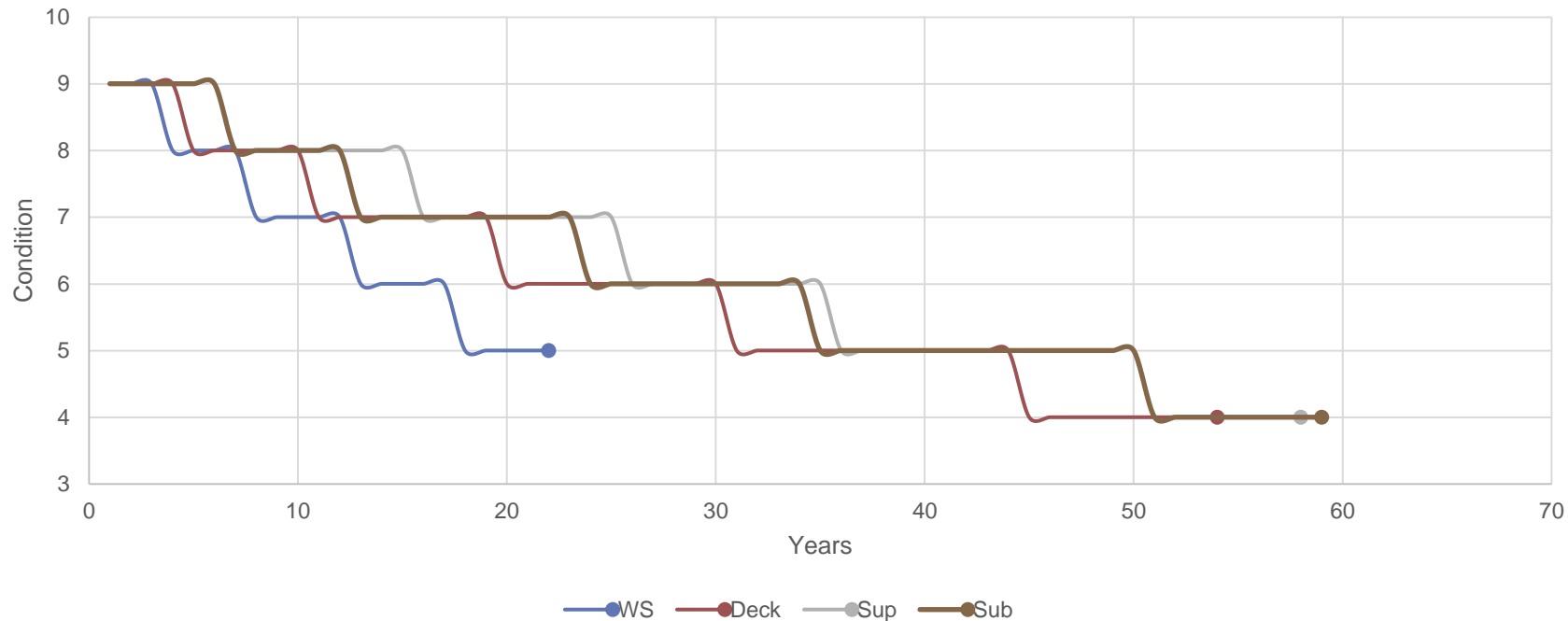


- Transition instances of 6-5 and 5-4

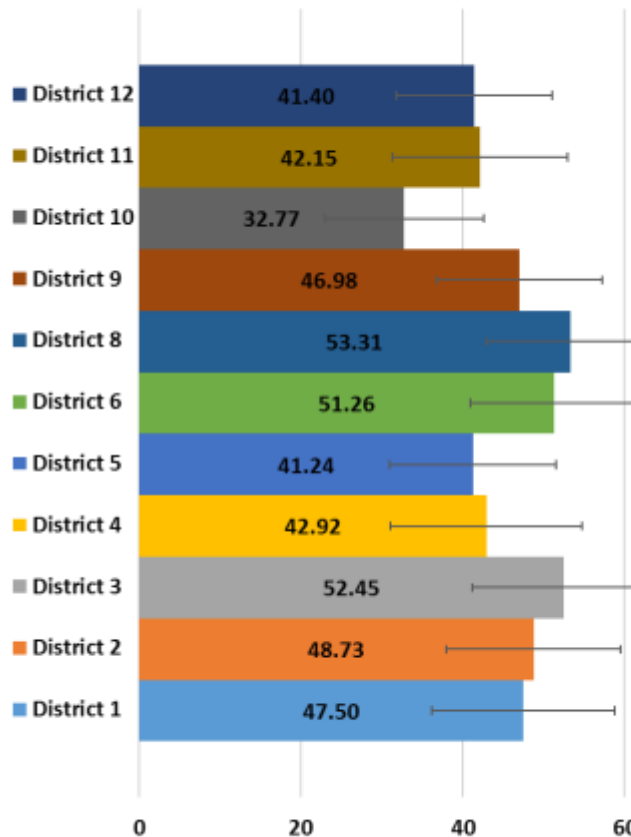


Deterioration Modeling

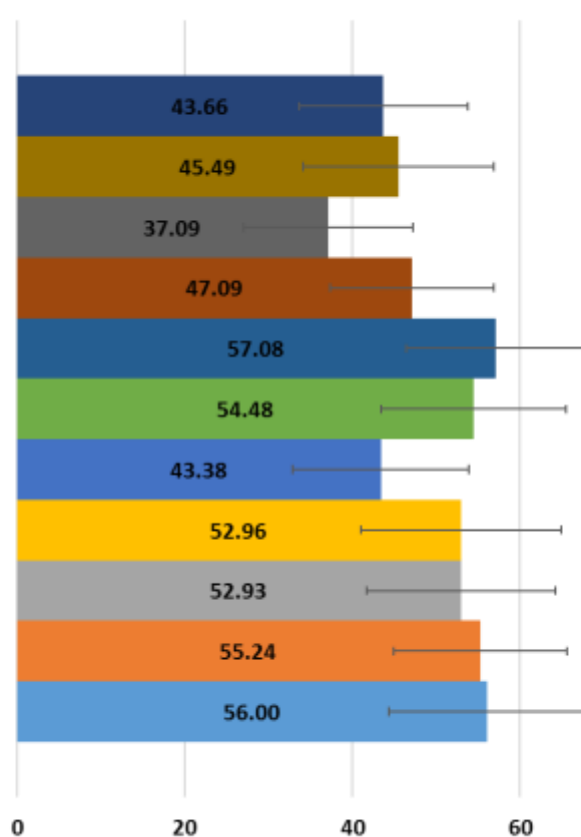
Deterioration District 7



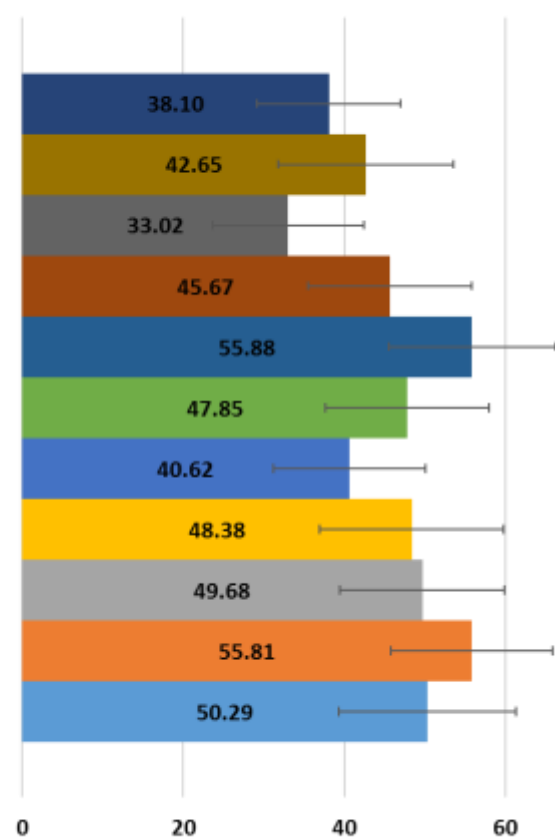
Deck



Superstructure



Substructure



Time to Structural Deficiency (Years)

Work Matrix



Component	Condition Rating Ranges	Treatment Options	How Many Times Can it Be Performed?	Frequency of Treatment (Years)	Expected Increase in condition rating with treatment	Expected Life Extension due to Condition Rating Increase (Years)*	Expected Life Extension due to Preservation (Years)	Total Expected Life Extension with Treatment (Years)	Maximum Possible Life Extension (Years)	Special Conditions	Detailed Treatment Description
Deck	9 to 5	No Treatment (no problems noted)	No Limit	-	-	-	-	-	-	-	N/A
	7 to 6	Polyester Polymer Concrete Overlay	3	25	0	0	25	25	75	-	Polyester Polymer Concrete overlay protects the deck from water penetration.
		Epoxy Based Surface Treatment	6	10	0	0	10	10	60	-	Epoxy Resin overlay with fine aggregate added for skid resistance. This protects the deck from water penetration.
		Latex Modified Concrete Overlay	3	20	0	0	20	20	60	-	Place Latex Modified Concrete Wearing surface after scanning the entire surface. This is performed prior to significant deck deterioration, prevents water penetration, and improves the ride quality of the deck.
		Place waterproofing membrane & Bituminous wearing surface	6	10	0	0	10	10	60	-	A waterproofing membrane is installed per Pub 406 section 600 and a bituminous asphalt wearing surface is placed and compacted. Ride quality will be improved and the membrane will prevent water penetration into the concrete deck. The actual concrete deck condition will NOT be improved with this treatment. This treatment increases the dead load of the deck.
	5	Latex Modified Concrete Overlay	3	15	0	0	15	15	45	-	Place Latex Modified Concrete Wearing surface after scanning the entire surface. This is performed prior to significant deck deterioration, prevents water penetration, and improves the ride quality of the deck.
	4	Deck Repair Type 2	2	15	2	15	0	15	30	-	Concrete deck repair to 3/4" below the top mat of reinforcing bars. Reference BC-765(h).
		Hydro-Demolition and Variable Depth LMC Overlay	1	-	2	15	15	30	30	Typically performed in lieu of Type 2 Deck Repairs and LMC Overlay	Hydro-demolition is used to scan surface and remove any deteriorated concrete and a variable depth LMC wearing surface is applied. The "variable depth" LMC will replace any deteriorated concrete removed by the hydro-demolition eliminating the need for Type 2 deck repairs. This improves the condition of the deck and the LMC prevents water penetration and improves ride quality.
3 to 2	Full Deck Replacement	1	-	3	40	0	40	40	Do not perform any conditions 5&4 treatments if this is done.	Total deck replacement. Expected life of new deck is about 40 years.	

Work Matrix

- Important values
 - Expected life extension due to treatment
 - Expected condition rating increase due to treatment
 - Expected life extension due to preservation treatment
 - Maximum number of treatments

Cost Matrix

Component	Condition Rating Range	Treatment Options	How Many Times Can It Be Performed?	Frequency of Treatment (Years)	Expected Increase in Condition Index with Treatment	Expected Life Extension due to Condition Rating Increase (Years)*	Average Cost of Repair
7 to 6	3	25	0	0	\$ 47.31		
	6	10	0	0	\$ 19.09		
	3	20	0	0	\$ 46.77		
	6	10	0	0	\$ 16.55		



Component	Condition Rating Range	Treatment Options	How Many Times Can It Be Performed?	Frequency of Treatment (Years)	Expected Increase in Condition Index with Treatment	Expected Life Extension due to Condition Rating Increase (Years)*	Average Cost of Repair
Deck	8 to 6	No Treatment (no penalties noted)	No limit	-	-		\$ -
	7 to 6	Polyester Polymer Concrete Overlay	3	25	0	0	\$ 47.31
		Epoxy Based Surface Treatment	6	10	0	0	\$ 19.09
		Latex Modified Concrete Overlay	3	20	0	0	\$ 46.77
		Place waterproofing membrane & bituminous wearing surface	6	10	0	0	\$ 16.55
	6	Latex Modified Concrete Overlay	3	15	0	0	\$ 46.77
	4	Deck Repair Type 2	2	15	2	0	\$ 30.09
Hydro-Demolition and Variable Depth UAC Overlay		1	-	2	0	\$ 83.80	
3 to 2	Full Deck Replacement	1	-	5	0	\$ 170.79	

Risk

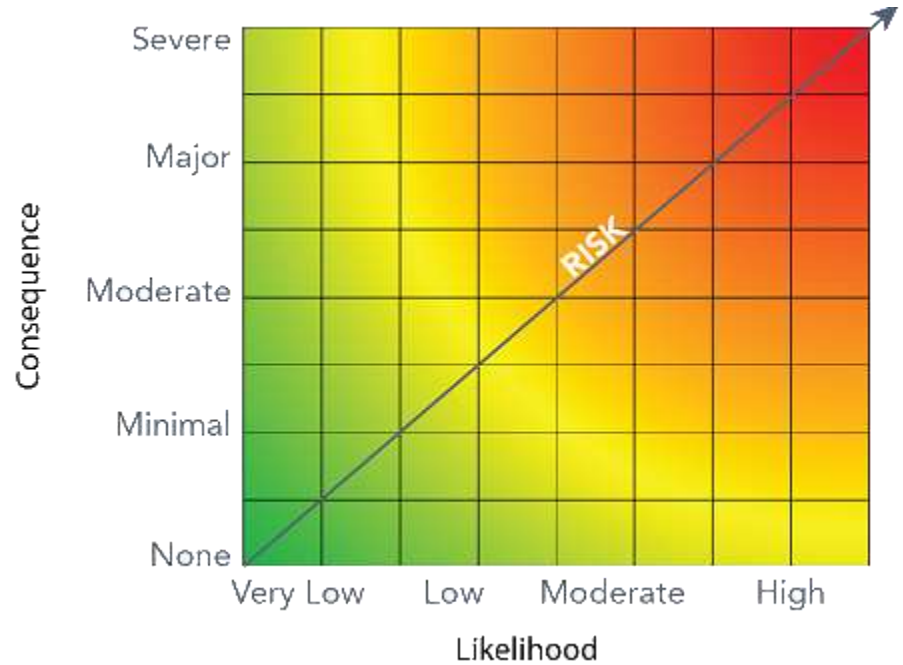
- Risk based enterprise bridge prioritization

$$= (\sqrt{\text{Deck area} * ADT}) * Fs * Ffc * Fdet * Fadtt * Fflood$$

- Risk alone is not prioritization
- **Prioritization = risk + condition**

Risk

- Risk levels:
 - Enterprise
 - Program
 - Project
 - Task
- Risk requires context



RISK



New Risk
score:
34264.8

Attribute*	Interstate Bridge	Culvert
BR Key	20445	32548
Length (ft)	198	18
Deck Area (sf)	9,801	288
ADT	31,798	287
Deck Condition	5	N
Superstructure Condition	5	N
Substructure Condition	4	N
Culvert Condition	N	2
Structurally Deficient?	Yes	Yes
Risk Score	5,330	5,995

New Risk
score:
598.6

Despite carrying more than 100 times the traffic volume, the SD interstate bridge has a lower risk score than the SD culvert.

*Bridge attributes were selected from BMS2. Attributes may have changed since they were selected.

Forecasting Software

- Options:
 - BrM
 - COTS
 - Excel / Access
- All have pros and cons
- All have same inherent forecasting issues

Bridge AM software (BAMS)

- BAMS Lite (excel)
- BAMS Bridge Care (RoadCare)

The screenshot displays the BAMS software interface with four main data sections:

Model Input	
Model Duration (Yrs)	0
1 Year Years	292,143,333
10 Year Years	133,567,200
10 Year Years	281,133,000
Additional Funding Per Yr (\$)	0
Additional Funding (Yr)	0
Assessment Percentage	10%
Assessment Funding (\$)	0
Flotation Value (%)	0%

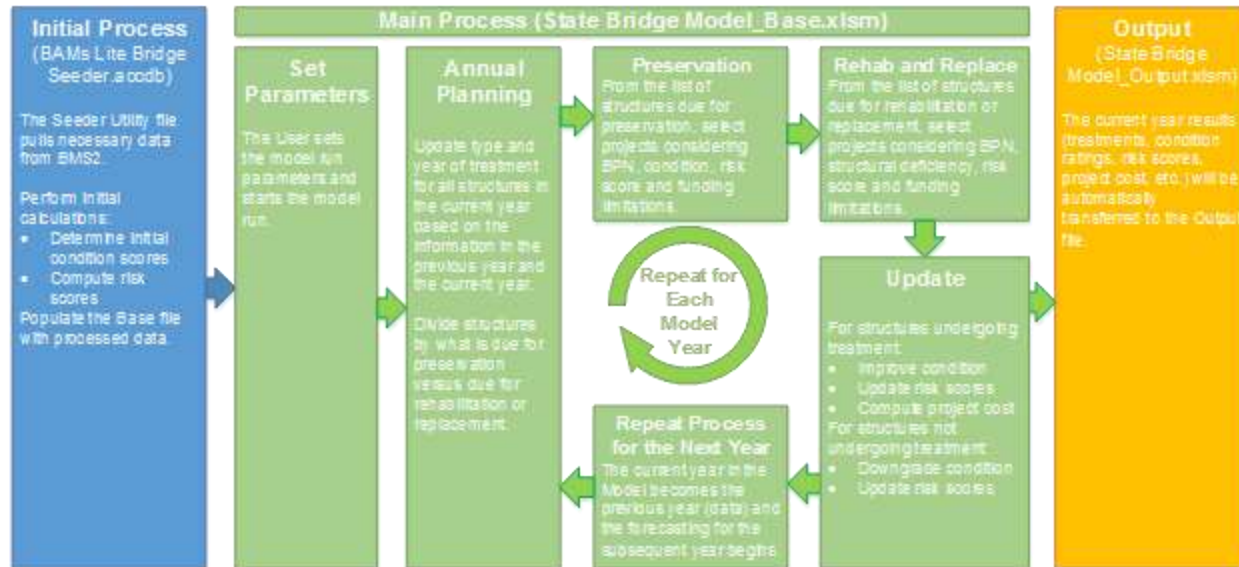
Funding Breakdown		
Assessment BPN 1-2	100%	\$ 30,218,333.00
Assessment BPN 3-4	0%	0
PN 1-2	100%	\$ 302,183,333.00
PN 3-4	0%	0

Deck Percentile		
PN 1-2	10%	2286
PN 3-4	0%	0

Funding Breakdown by Deck Percentile		
PN 1-2 - 1	Structures with deck area above 90% percentile	40%
PN 1-2 - 2	Structures with deck area below 90% percentile	40%
PN 3-4 - 1	Structures with deck area above 90% percentile	40%
PN 3-4 - 2	Structures with deck area below 90% percentile	40%

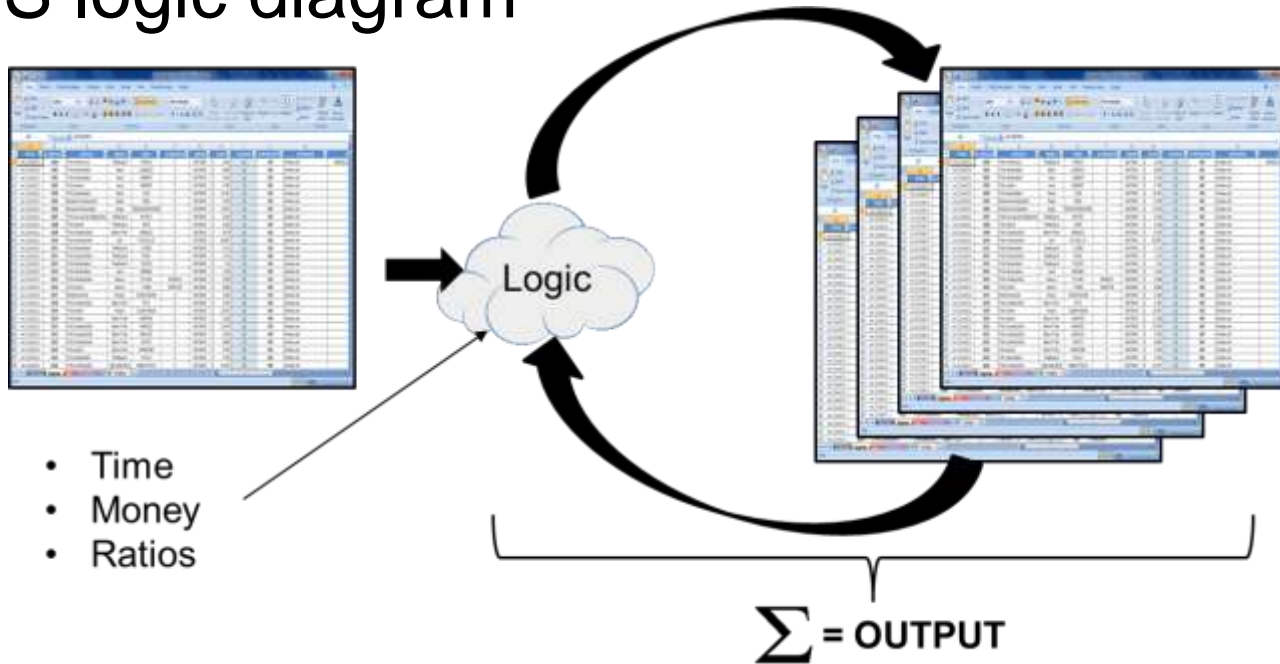
BAMS Light

Process flow chart



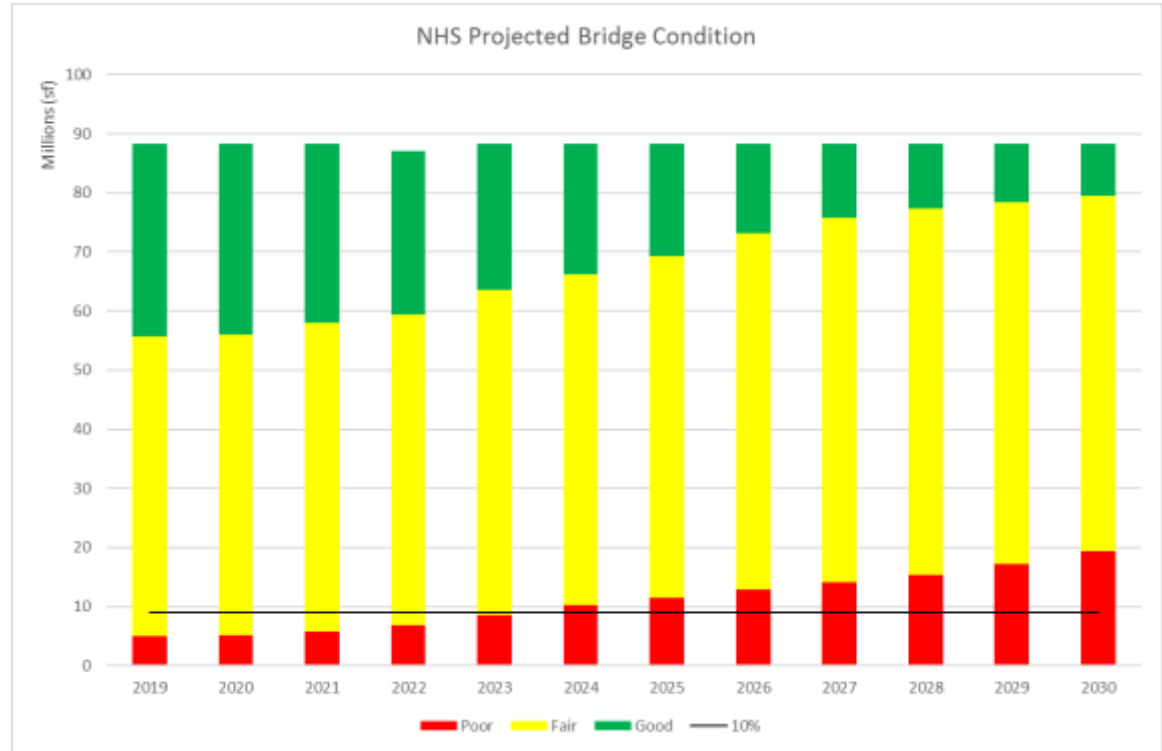
BAMS

- BAMS logic diagram



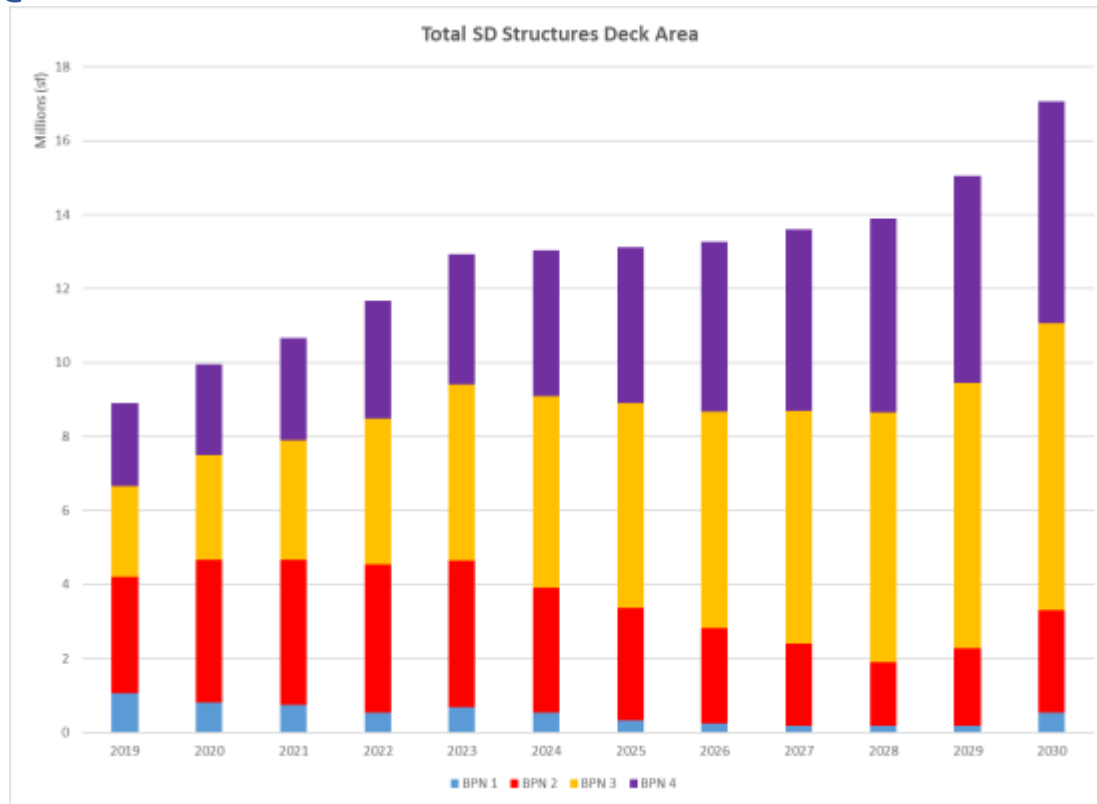
BAMS Light

- TAMP
output:
NHS



BAMS Light

- TAMP
Output:
All
Networks



BAMS Lite

- Limitations

- Speed
- Data precision
- Logic loop limits
- Treatment matrix

- BAMS Lite

- Think google earth vs google street view

The screenshot displays the BAMS Lite software interface with four data tables:

Model Input		
Model Duration (Yrs)		0
0 Year Years	100%	30,228,338.00
10 Year Years	0%	0
20 Year Years	0%	0
Additional Funding Per Yr (%)		0
Additional Funding (Yr)		0
Assessment Percentage	10%	
Assessment Funding (\$)		0
Flotation Value (%)	2%	

Funding Breakdown		
Assessment BPN 2-2	100%	30,228,338.00
Assessment BPN 2-4	0%	0
PN 2-2	100%	3,352,925,586.20
PN 2-4	0%	0

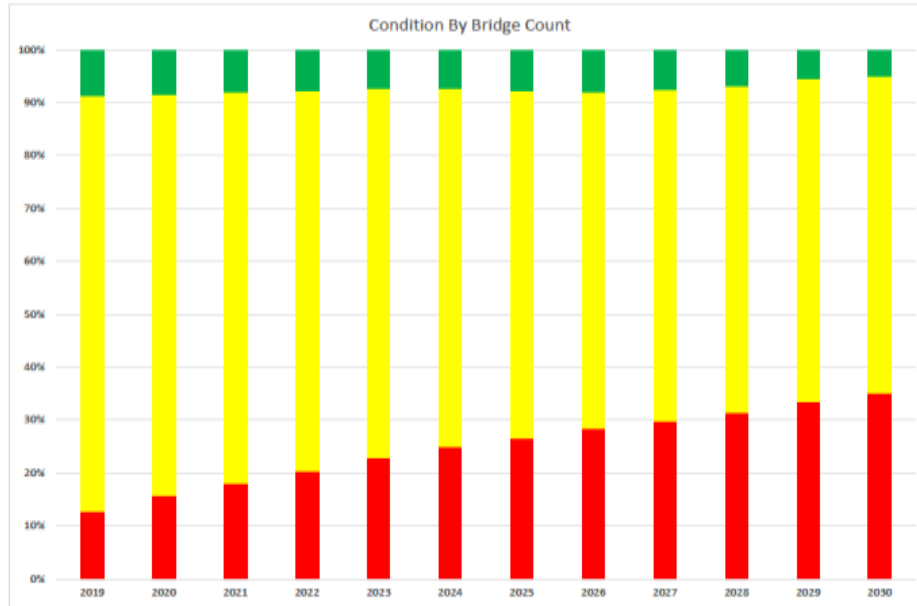
Deck Percentile		
	Percentile	Deck Area (ft)
PN 2-2	90%	22866
PN 2-4	10%	0

Funding Breakdown by Deck Percentile		
PN 2-2 - 1	Structures with deck areas above 90th percentile	40%
PN 2-2 - 2	Structures with deck areas below 90th percentile	40%
PN 2-4 - 1	Structures with deck areas above 90th percentile	40%
PN 2-4 - 2	Structures with deck areas below 90th percentile	40%

Bridge Care

- COTS-MODM decision engine
- ARA RoadCare software
 - “Level 3” forecasting
 - Addresses 0-5 year forecast through force
 - Sum of MODM and force make for more accurate forecasting

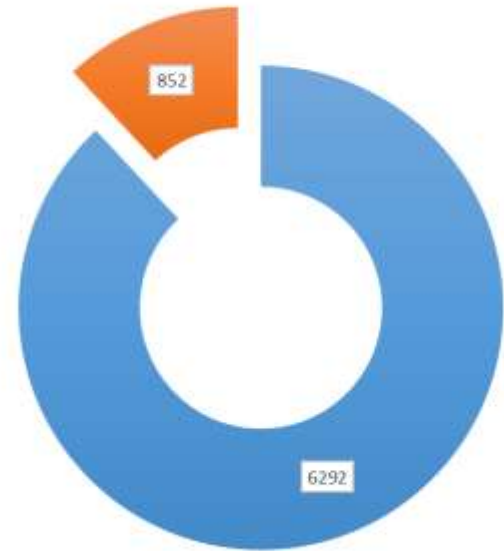
Bridge Care



Bridge Care

- Force forecasting 0-7 yr population
- CS 5>15yrs
- Average of 70 per District

NHS Bridges in Contion State 5 more than 15 Years



Summary

- Improvements to condition forecasting:
 - Multiple cycles of element level data
 - Integration of maintenance, construction and inspection data
 - Goal of deterioration model per key structure

Questions?