VDOT

Virginia Department of Transportation

2015 AASHTO SCOM

Using Current Valuation to Direct Maintenance Decisions

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Maintenance Prioritization Process

General Formula for Prioritization:

Rank = a(*IF*) + b (*Condition*) +c(*CE*) + d(*Risk*) +e(*Function*)

Where:

- ***IF*** **= Importance Factor – measuring the importance of the structure**
- ***Risk*** **= Factor measuring the risk to the structure**
- ***Function*** **= Variable ranking the (geometric) functionality of the structure**
- ***Condition*** **= Virginia Health Index – variable measuring condition**
- ***CE*** **= Cost-Effectiveness of Action**

All five variables will have a 0 to 1.0 scale

- **a, b, c, d, e are coefficients that may be selected to suit the particular evaluation being performed**
- **a + b + c + d + e = 1.0**

By separating the five variables users can readily understand why one project has a higher priority than another

Description of Variables – Importance Factor

IF = Importance Factor. Measures *relative* importance of the structure to the roadway network

Uses these variables:

- **Traffic**
- **Truck traffic**
- **Proximity to schools, hospitals and emergency facilities**
- **Detour vs. traffic**
- **Functional class of roadway**
- **Predicted future ADT growth**

Description of the Variables - Risk

Risk = Factor measuring the risk to the structure, with an emphasis on redundancy but also taking into account financial and functional risk of inaction

$Risk = .5 * Risk_a + .5 * Risk_b$

- **$Risk_a$ measures the likelihood of problems if the work is not performed**
- **$Risk_b$ measures the potential consequences of the problems if the work is not performed**
- **Each of the two risk categories is calculated using risk factors for Safety, Traffic, and the Value of the Structure**
- **Risk factors address redundancy, scour and earthquake susceptibility**
- **All risk factors are weighted equally on a scale of 0 - 1.0 to determine an overall risk score**

Description of the Variables - Function

Function = Measures the geometric adequacy of the structure

Function = .25 * (Accidents) + .25 * (Deck Width) + .25 * (Vertical Clearance) + .25 * (Posting)

- ***Accidents:*** **variable (0 -1.0) measuring the # of accidents at the site**
- ***Deck Width:*** **variable (0 -1.0) based on the Desired/Provided deck width ratio**
- ***Vertical Clearance:*** **variable (0 -1.0) based on the Desired/Provided vertical clearance ratio**
- ***Posting:*** **variable (0 -1.0) based on the Desired/Provided load limit**

Description of the Variables - Condition

Condition is measured using the Virginia Health Index (VAHI)

- **VAHI provides a measurement of the current value of a structure as a percentage of its original value**
- **Example: If a structure has lost 34% of its value, VAHI = 66**
- **Allows for quick determination of Current Valuation (Equity).**
  - **A structure with a $1M replacement value and 66 VAHI has a Current Valuation of: .66 * $1M = $660,000**
- **In business, success is measured through profits and volume**
- **Bridges have value but no revenue, so Current Valuation allows for fiscally-based decision making in inventory management**

Description of the Variables – Cost-Effectiveness of Actions

CE= Increase in Valuation due to Maintenance Intervention

Example for a structure with VAHI = .32

- **Repair Option 1 will increase VAHI to .92, so CE = .92 - .32 = .60**
- **Repair Option 2 will increase VAHI to .74, so CE = .74 - .32 = .42**
- **Replace Option will increase VAHI to 1.00, so CE = 1.00 - .32 = .68**

Determining VAHI

VDOT has a good understanding of the condition of each element of every structure

Virginia Health Index: Example Equation

If a structure has the following characteristics:

- 0 to 100 scale
- 0 means no health left (failed)
- 100 for a new (ideal) structure
- Example: If a structure has deteriorated 32%, the VAHI = 68 (68 = 100 - 32)

$$VAHI = \frac{\Sigma\ (VAHI_{Element} * Replacement\ Value_{Element})}{\Sigma\ Replacement\ Value_{Elements}}$$

If Σ Superstructure Value = 0, then deck = 0

If Σ Substructure Value = 0, then deck and superstructure = 0

Element Data Collected During Inspections

Component	Number	Title
Deck	801	Sidewalk
	802	Deck Drains
Superstructure	811	Beam/Girder End
	812	Reinforced Concrete Frame
Substructure	821	Steel Abutment
	822	Steel Wingwall
	823	Reinf.\ Concrete Abutment
	824	Reinf.\ Concrete Wingwall
	825	Timber Abutment
	826	Timber Wingwall
	827	Masonry Abutment
	828	Masonry Wingwall
	829	MSE Abutments
	830	MSE Wingwall
Culverts	831	Concrete Culvert Endwall/Headwall
	832	Concrete Cuvlert Wingwall
	833	Roadway Over Culvert
Joints	841	Asphalt Plug Joint
	842	Elastomeric Concrete Plug Joint
	843	Link Slab
	844	Slab Extension
	845	Joint Effectiveness
Slopes & Channels	851	Unprotected Slope
	852	Protected Slope - Paved
	853	Protected Slope - Riprap
	854	Channel
Protective	881	Wearing Surface - Unprotected Asphalt Wearing Surface
	882	Wearing Surface - Protected Asphalt Wearing Surface
	883	Wearing Surface - Thin Overlay
	884	Wearing surface - Rigid Overlay
	885	Wearing Surface - Other

Element Data Collected During Inspections

Table 1. Bridge Elements.

Element	Units	Element Number					
		Steel	Prestressed Concrete	Reinforced Concrete	Timber	Masonry	Other
Deck/Slab							
Deck	SF		13	12	31		60
Open Grid Deck	SF	28					
Concrete Filled Grid Deck	SF	29					
Corrugated or Orthotropic Deck	SF	30					
Slab	SF			38	54		65
Top Flange	SF		15	16			
Superstructure							
Closed Web/Box Girder	LF	102	104	105			106
Girder/Beam	LF	107	109	110	111		112
Stringer	LF	113	115	116	117		118
Truss	LF	120			135		136
Arch	LF	141	143	144	146	145	142
Main Cable	LF	147					
Secondary Cable	EA	148					149
Floor Beam	LF	152	154	155	156		157
Pin, Pin and Hanger Assembly	EA	161					
Gusset Plate	EA	162					
Substructure							
Column	EA	202	204	205	206		203
Column Tower (Trestle)	LF	207			208		
Pier Wall	LF			210	212	213	211
Abutment	LF	219		215	216	217	218
Pile Cap/Footing	LF			220			
Pile	EA	225	226	227	228		229
Pier Cap	LF	231	233	234	235		236
Culvert							
Culvert	LF	240	245	241	242	244	243
Bridge Rail							
Bridge Rail	LF	330*		331	332	334	333
Joint							
Strip Seal	LF	300					
Pourable	LF	301					
Compression	LF	302					
Assembly with Seal (Modular)	LF	303					
Open	LF	304					
Assembly without Seal	LF	305					
Other	LF	306					
Bearing							
Elastomeric	EA	310					
Movable (roller, sliding, etc.)	EA	311					
Enclosed/Concealed	EA	312					
Fixed	EA	313					
Pot	EA	314					
Disk	EA	315					
Other	EA	316					

Equity Determination: Example Equation

Equity = VAHI * Structure Replacement Cost

Example Structure:

VAHI= 78

Replacement Value = $2,000,000

Equity = .78 * 2,000,000 = $1,560,000

Virginia Health Index: Example Calculation #1

Element Name	$VAHI_{Element}$	Element Replacement Value	VAHI * Replacement Value
Columns	63	$25,000	$15,750
Pier Caps	54	$30,000	$16,200
Abutments	75	$60,000	$45,000
Girders	83	$160,000	$132,800
Diahragms	86	$30,000	$25,800
Deck	92	$180,000	$165,600
Joints	65	$30,000	$19,500
Parapet	92	$40,000	$36,800
Sum	**-**	**$555,000**	**$457,450**

VAHI = $457,450 ÷ $555,000 = 82

Virginia Health Index: Example Calculation #2

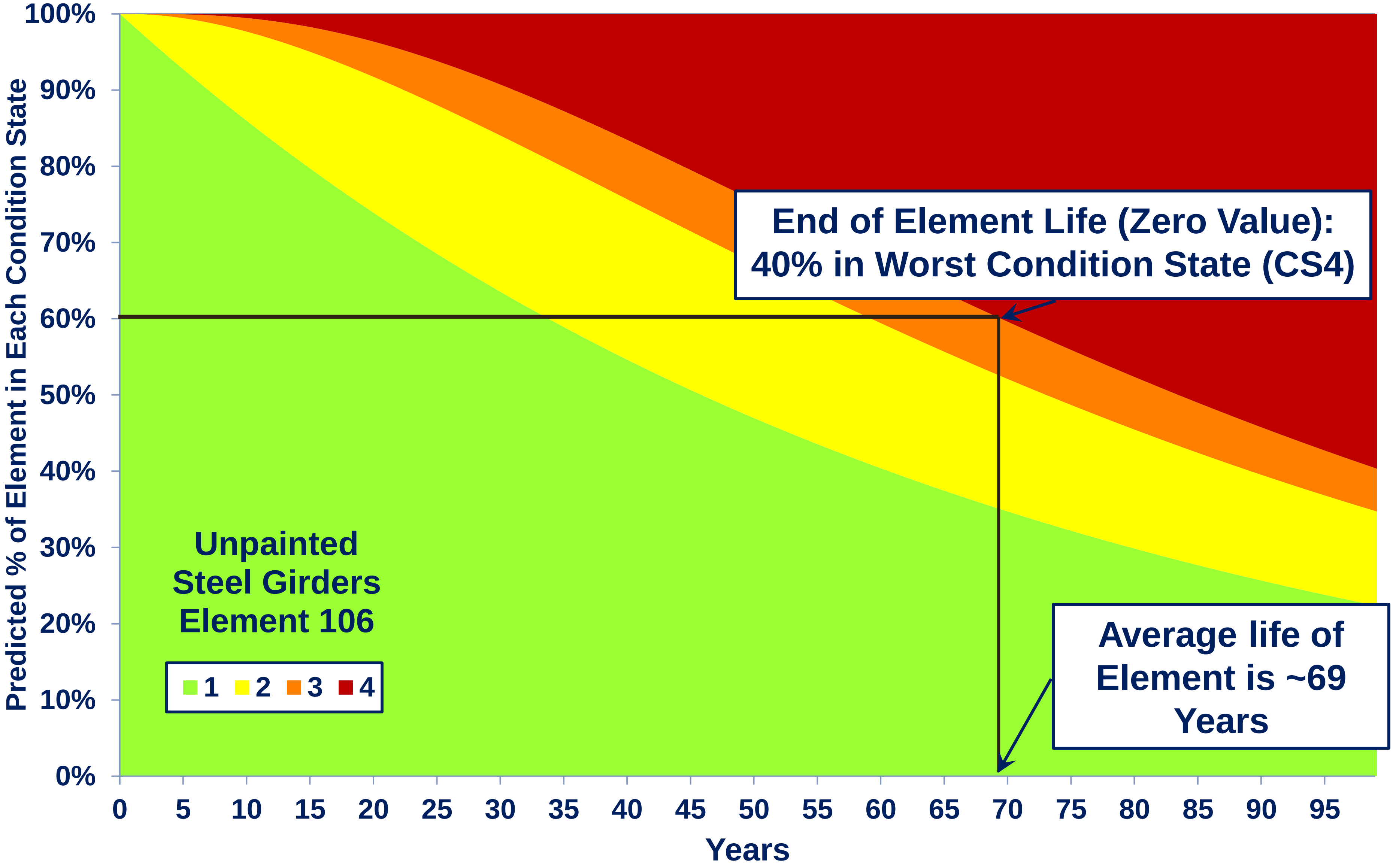
Element Name	$VAHI_{Element}$	Element Replacement Value	VAHI * Replacement Value
Columns	63	$25,000	$15,750
Pier Caps	54	$30,000	$16,200
Abutments	75	$60,000	$45,000
Girders	83	$160,000	$132,800
Diahragms	86	$30,000	$25,800
Deck	0	$180,000	$0
Joints	0	$30,000	$0
Parapet	0	$40,000	$0
Sum	**-**	**$555,000**	**$235,550**

Note: Replacement Cost of Bridge < ΣElement Replacement Values

VAHI = $235,550 ÷ $555,000 = 42

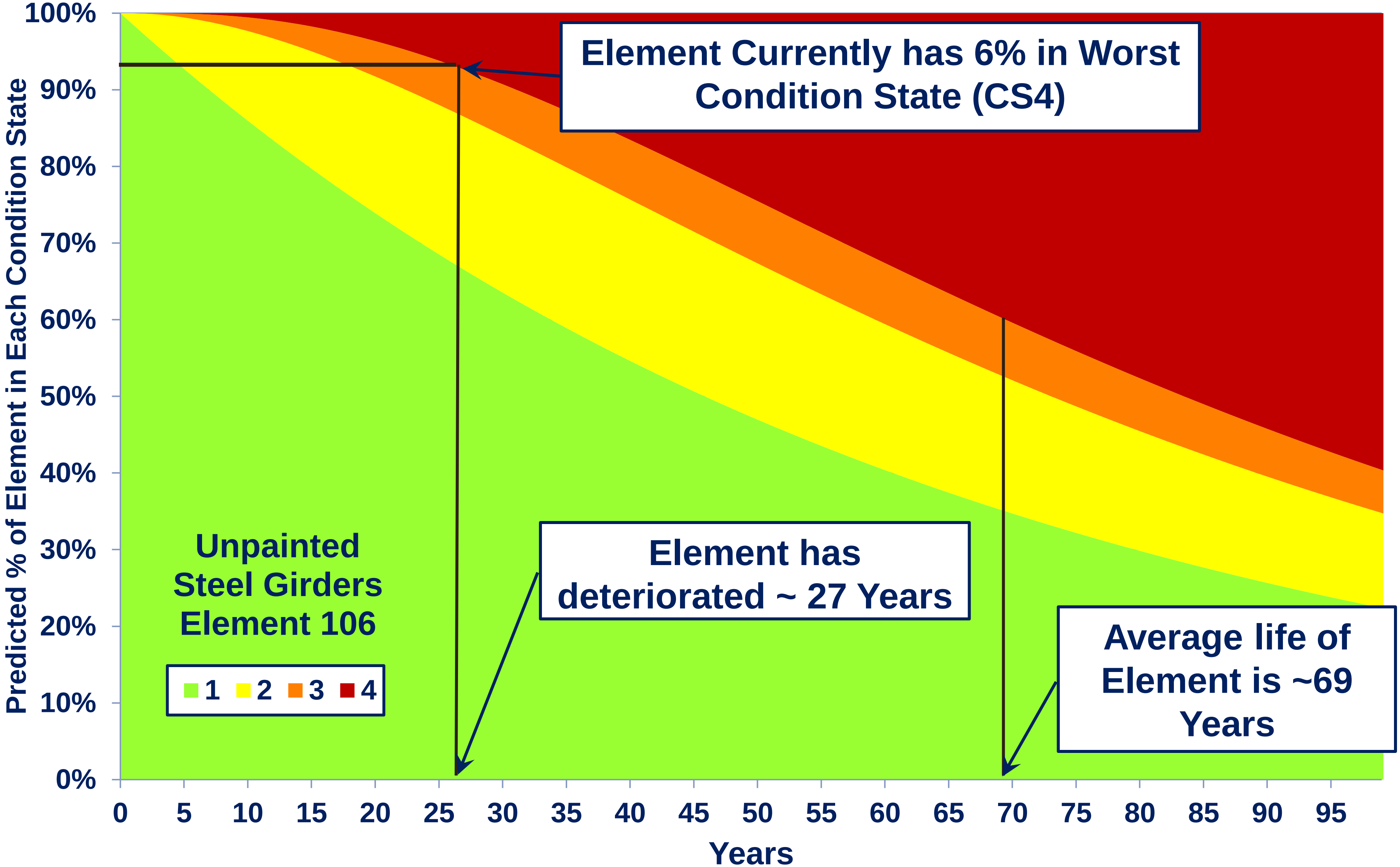
Using Deterioration Models to Determine Current Value:

Step 1: Define End of Life of Elements in Terms of Condition States



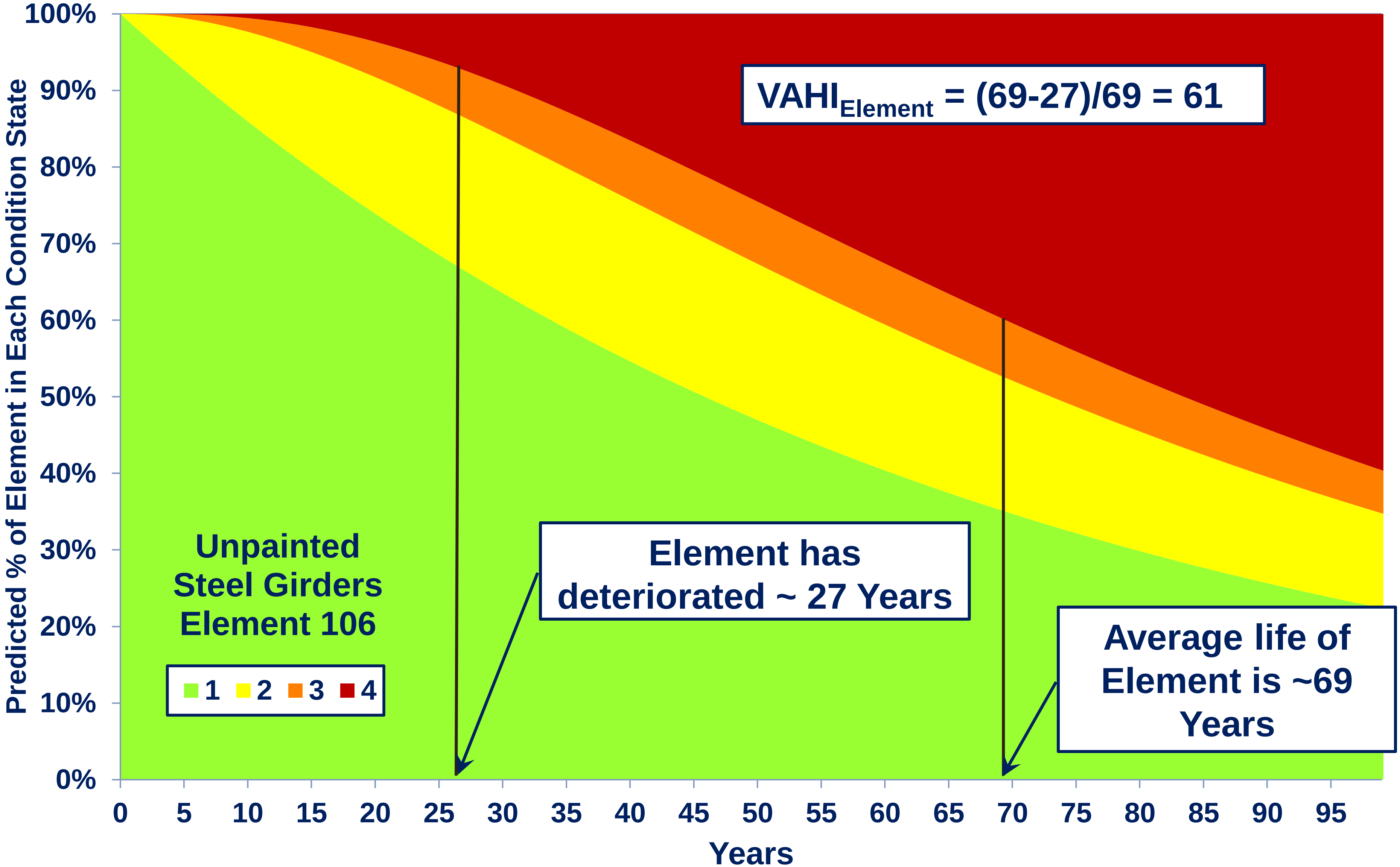
Using Deterioration Models to Determine Current Value:

Step 2: Determine Current Value in Terms of Current Condition

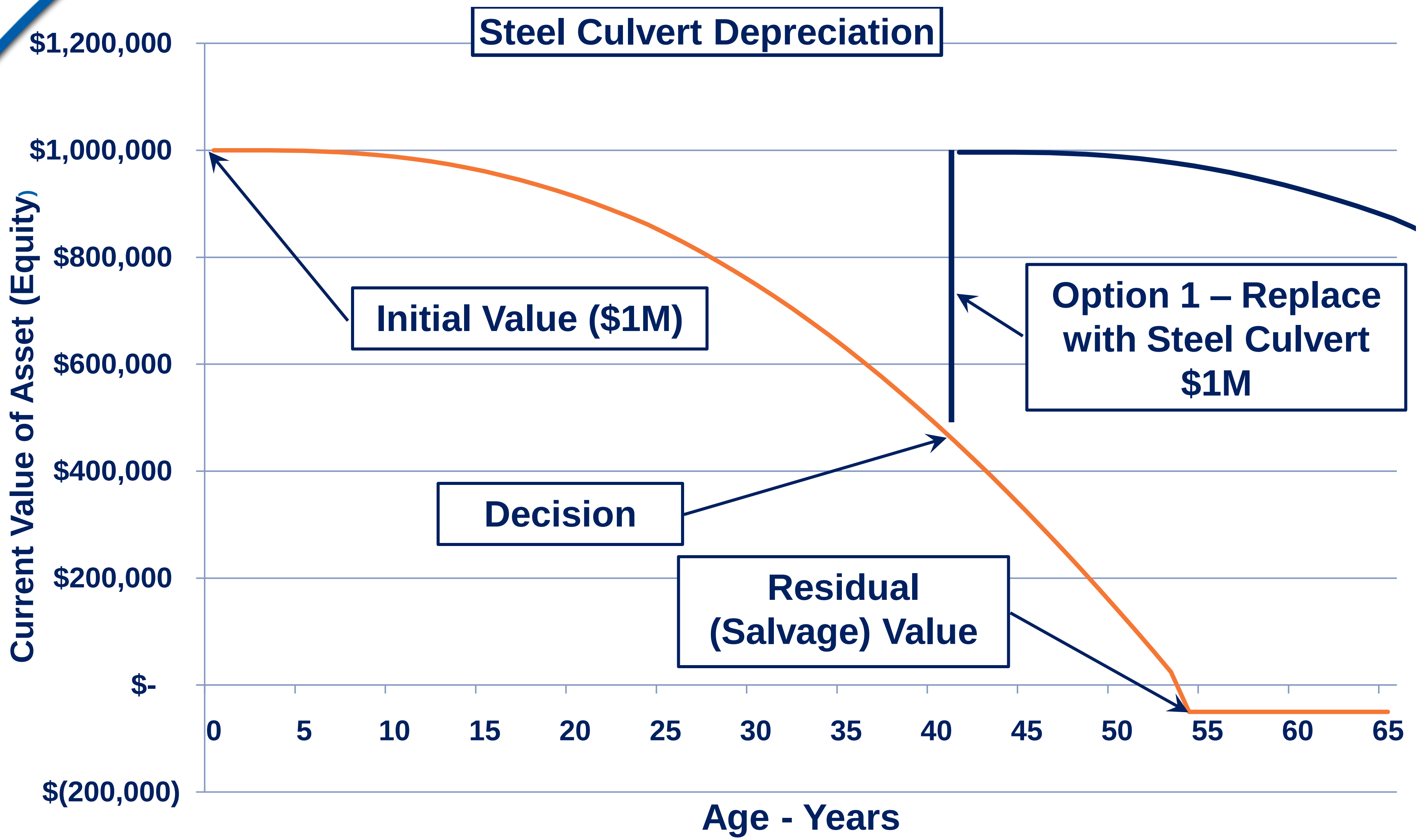


Using Deterioration Models to Determine Current Value:

Step 3: Determine VAHI for Each Element



The Benefits of Using Equity as the Basis for Engineering Decisions



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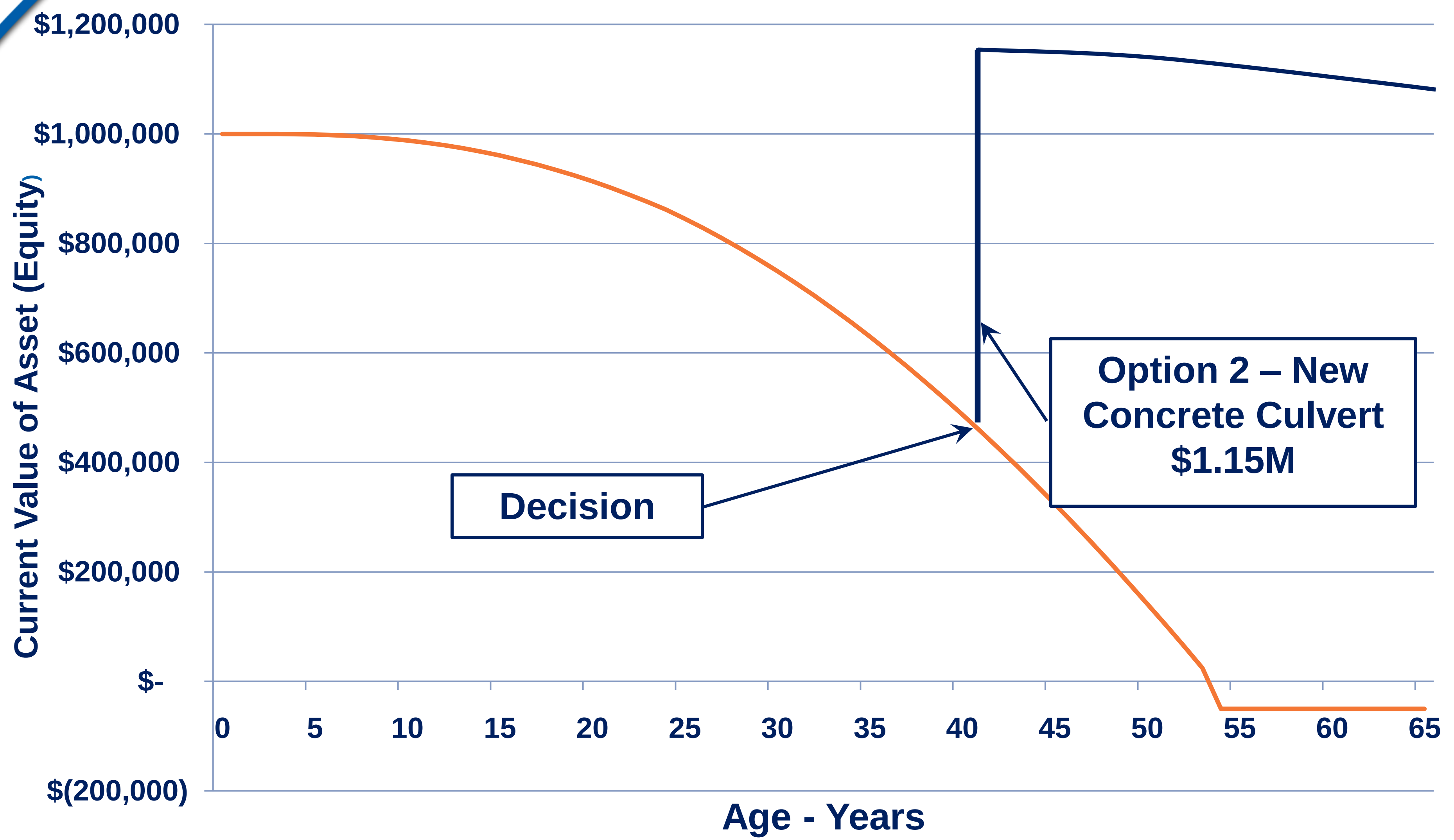

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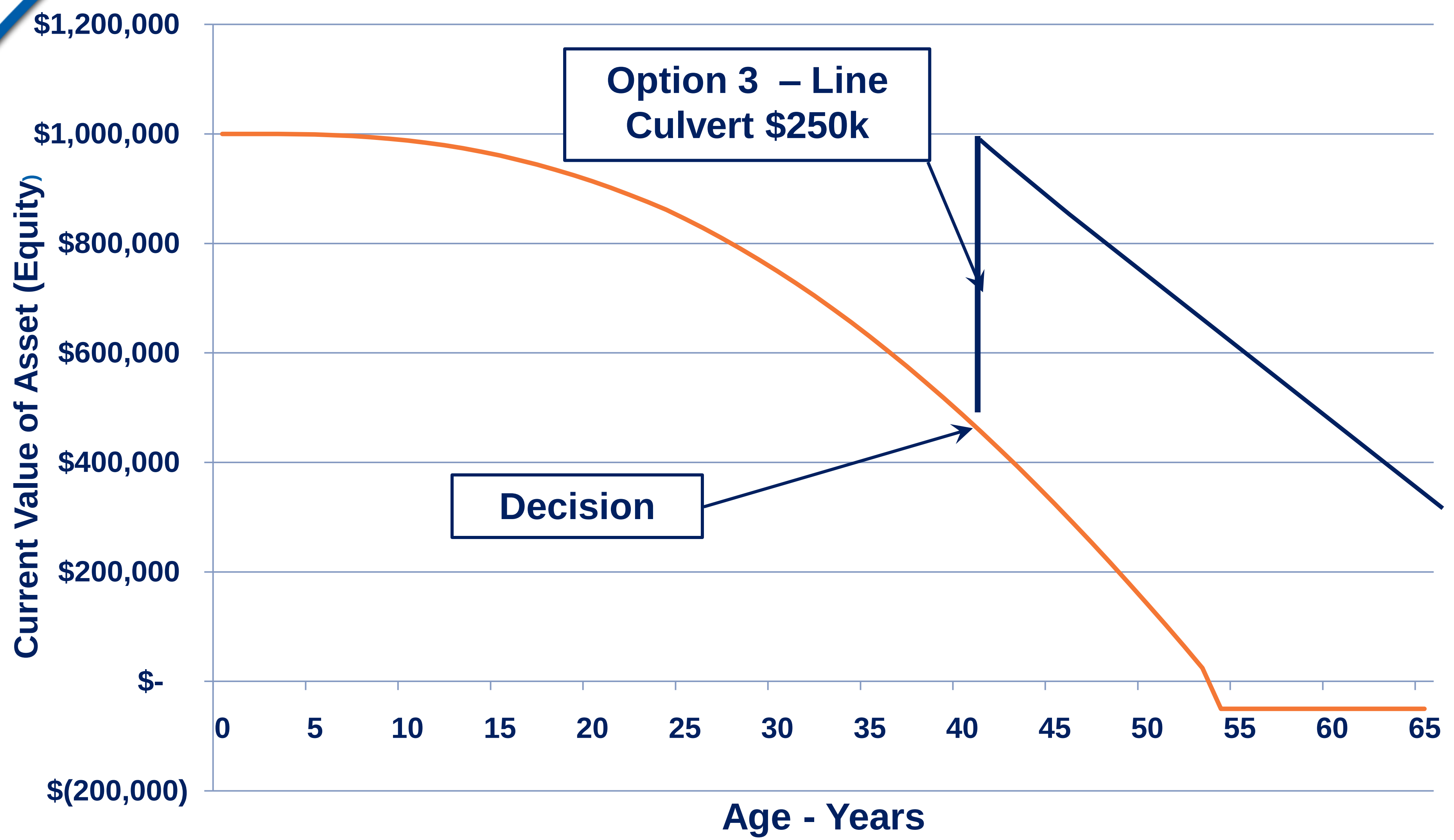


With Equity Curves Simple Life Cycle Analysis is Practical

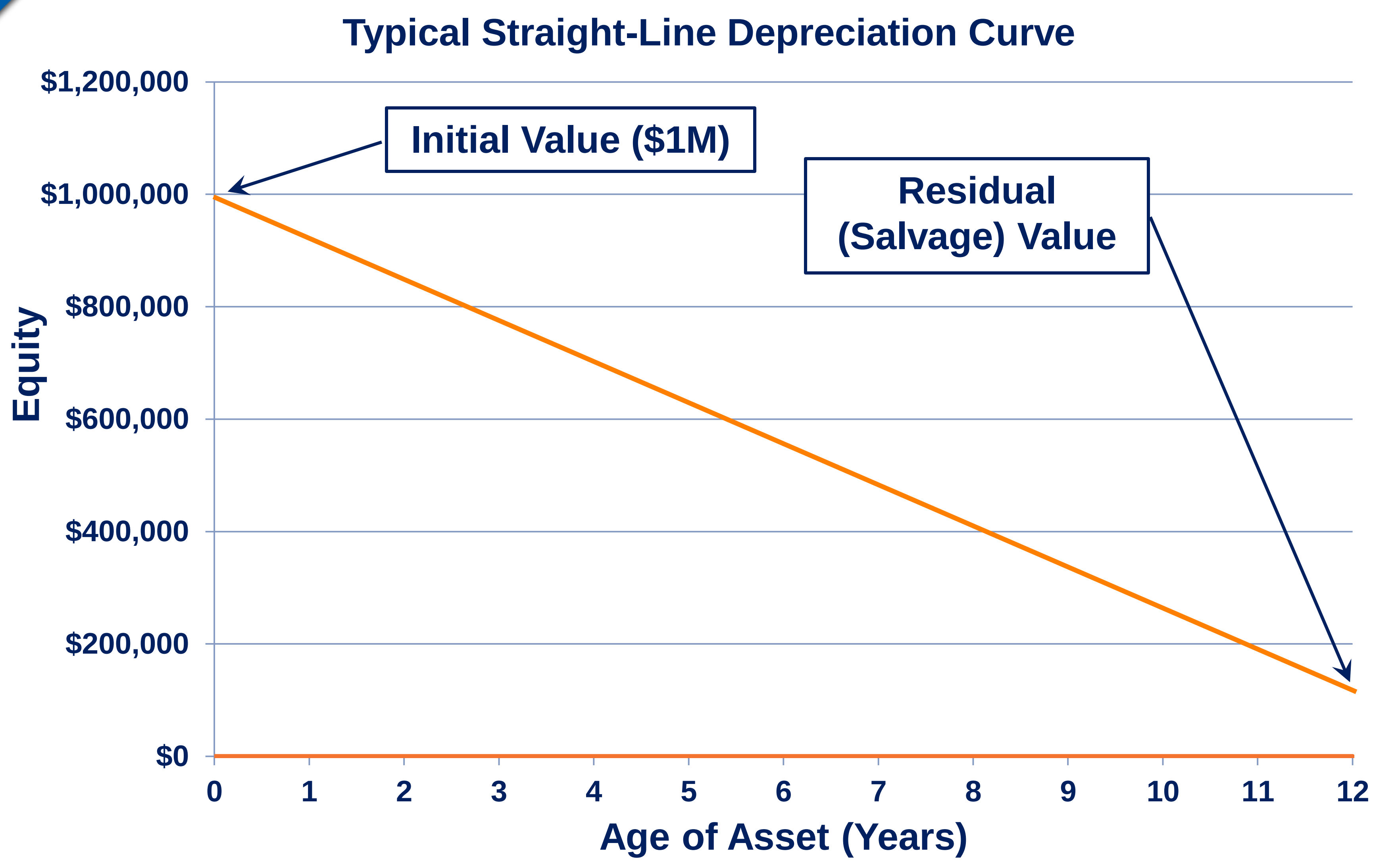
		Initial Costs						
	Name	Initial Construction	Traffic Control	Engineering, Inspection, R/W	Total Initial Cost	Estimated Maintenance Costs Per 10 Year Interval	Replace ment Year	Present Value (calculated)
Option 1	Coated Steel	$748,400	$64,500	$187,100	$1,000,000	$4,000	53	-$1,131,192
Option 2	Precast Concrete	$850,240	$87,200	$212,560	$1,150,000	$6,000	110	-$893,554
Option 3	Steel Liner	$190,000	$12,500	$47,500	$250,000	$4,000	30	-$1,380,666

Discount Rate	1.50%

Suggested PE, CEI, R/W Factor	0.25

Steel Liner Option Assumes New Steel Culvert Required in 25 Years

Measuring Equity – Common Practice: Time Based Depreciation



Equity – Multiple Uses

Equity can be a powerful tool in guiding bridge management

- **Can determine the most cost-effective actions on a given structure**
- **Helpful in selecting which structures should be worked on**
- **Can be used to measure effectiveness of various work programs**
- **Helpful as a measurement of progress**

Thank you for your time and attention

Questions??

2015 SCOM
VDOT's use of Current Valuation to Inform Maintenance Decisions

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