



SMS SUMMIT 2024

SMS OPTIMIZATION

Updated: July 2024

Presentation: Thursday, Aug. 2
Plenary Session 8:00 AM—9:00 AM

Approved for Public Release; Distribution is Unlimited



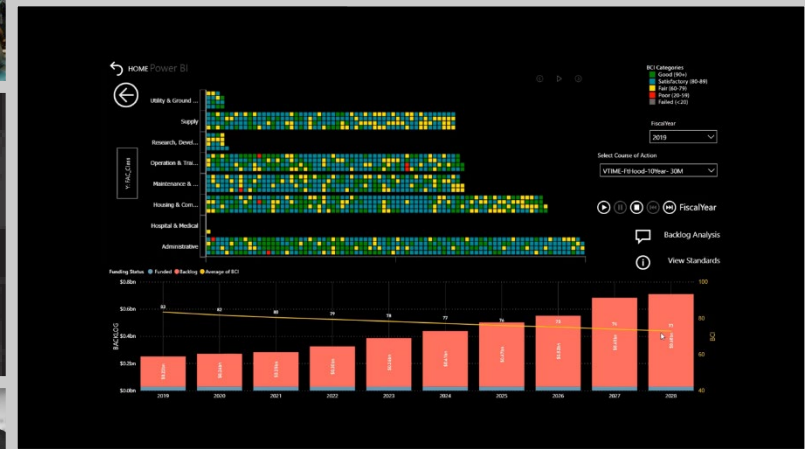
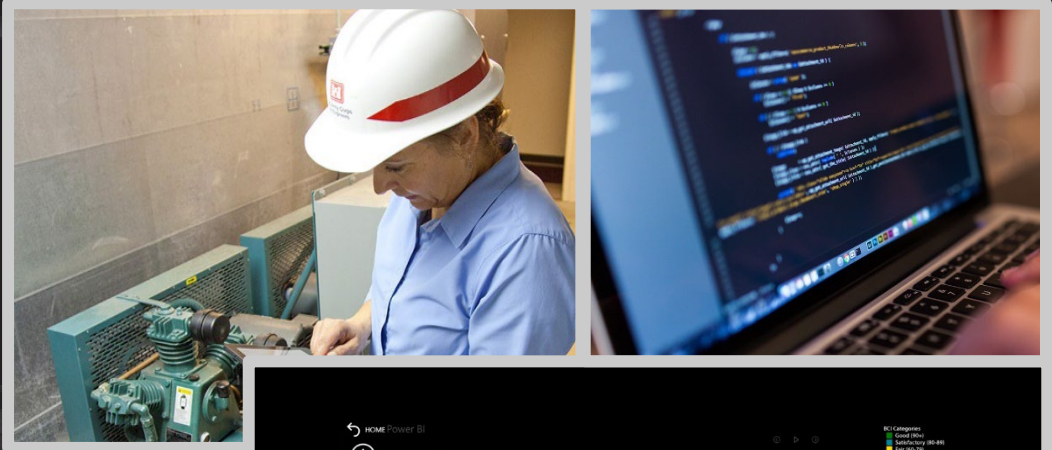
U.S. ARMY



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AGENDA



1. Programmatic Status
2. Introduction/Motivation
3. Decision Variables
4. Defining the Objective Function
5. Identifying Constraints
6. Dashboards and Visualizations
7. Other Topics

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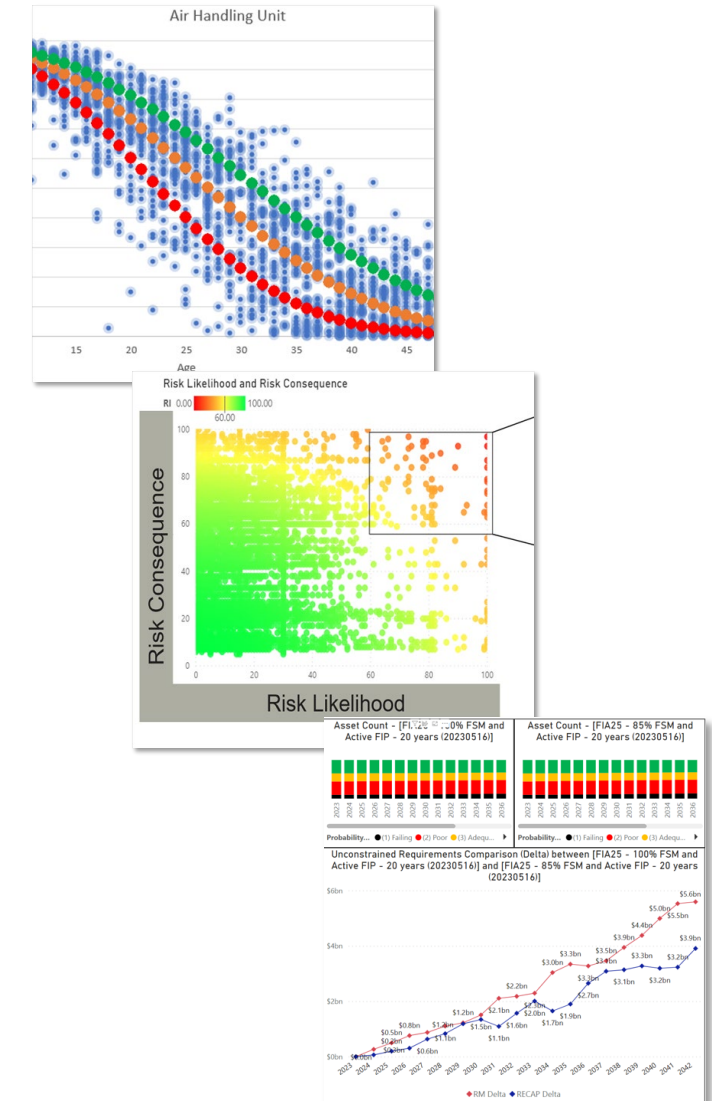
PROGRAMMATIC STATUS

Workshop #1: December 6, 2023

- ✓ Presented overview of optimization
- ✓ Components presented their tools and processes
- ✓ Discussed objective functions, constraints, and decision variables
- ✓ Discussed visualizations and data requirements

Workshop #2: March 6, 2024

- ✓ Overview of first workshop
- ✓ Discussed challenges and roadblocks
- ✓ Discussed various optimization approaches and limitations
- ✓ Solicited feedback from components



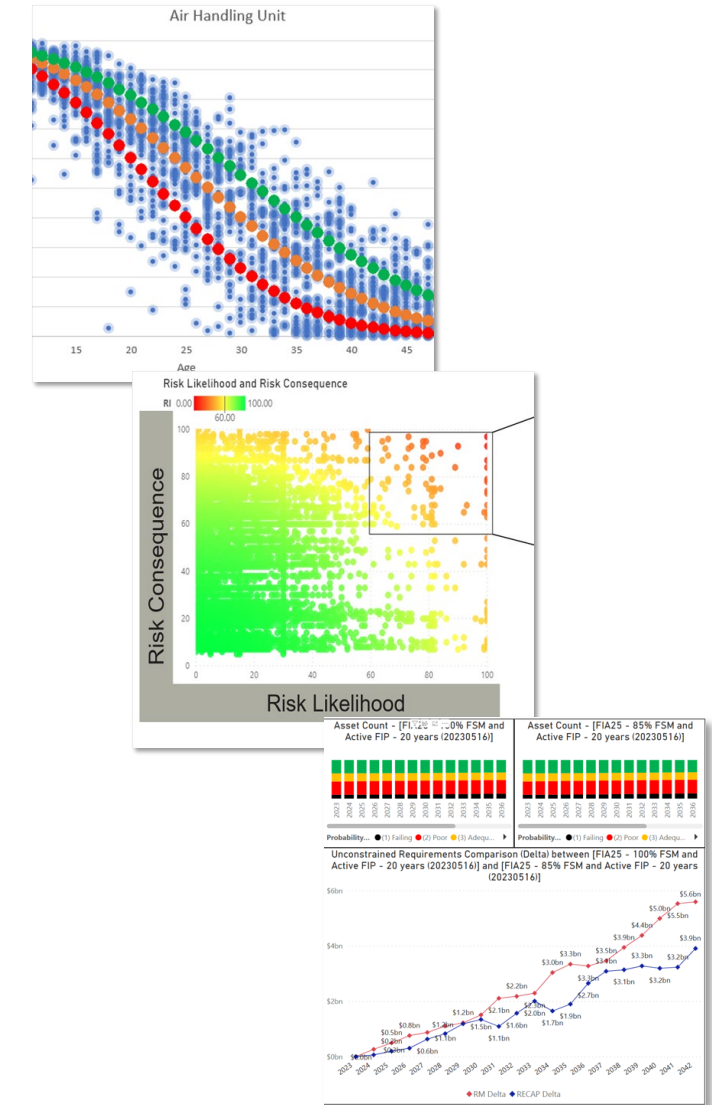


PROGRAMMATIC STATUS



Recent and Near-Term Activity:

- ✓ PMP signed with OSD on June 12, 2024
- ✓ OSD RTD&E funding received on June 26, 2024 to support phased effort through 30Sep25.
- Effort has begun. FY24-25 work will focus on:
 - Finalizing optimization requirements
 - Researching and proposing an approach
 - Initial testing/development
 - Developing data interface & exchange protocols
 - Developing user interface and visualizations
- 3rd Workshop planned for Q1-24.





INTRODUCTION / MOTIVATION

DoD installations house the facilities and infrastructure where soldiers and civilians live, work, train and fight.

The DoD facilities portfolio represents an enormous investment – with a Plant Replacement Value (PRV) of over \$1.3T

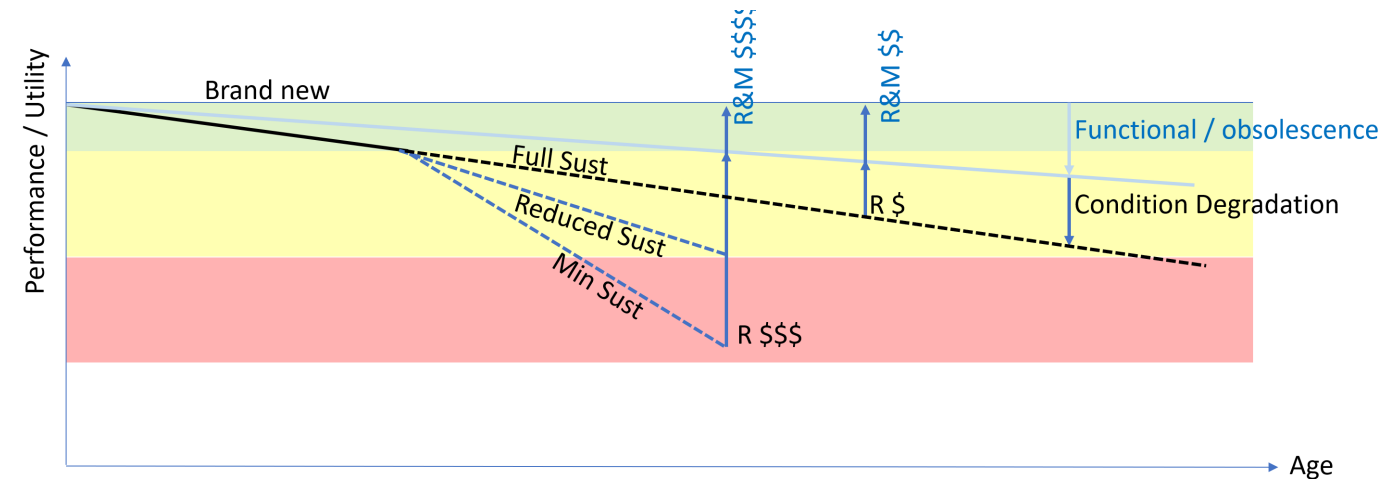
Buildings make up over 65% of this portfolio, with over 280,000 buildings encompassing more than 2.2 billion square feet

Over \$13B is required annually to sustain these facilities, in addition to the investments to construct, restore, modernize, and demolish

The services reported a total of \$137B in deferred maintenance and repair, which ultimately shortens the assets' lifespan, undercuts the investments in these facilities, and jeopardizes the ability to support mission needs

There are tools to assess the current state of a facility's component inventory, and project future state given an investment strategy, however the capabilities to perform trade-off analysis at scale across the DoD's vast portfolio are limited

- Capability is needed to optimize resource allocation across the DoD facilities enterprise in an efficient manner.
- It needs to consider the trade-offs of decisions across the facility lifecycle, to include sustainment, restoration, modernization, replacement, and disposal.
- This capability would identify the optimal investment strategy for each facility over a multi-year time horizon to achieve the highest facility performance state at lowest total cost.



Goal: Provide DoD with a strategic capability to evaluate facility investment alternatives and conduct resource programming decision-making by seeing down-range impacts on condition, performance, and mission risk



PROBLEM STATEMENT / DESIRED END STATE



Provide OSD and the Services an analysis and visualization tool to show how different facility investment decisions affect the condition and performance state of the DoD facility portfolio.

Explore impacts of varying funding levels as well as trade-offs between sustainment, restoration and modernization, demolition, and new construction at established funding levels.

Determine optimal investment strategies and support Program Objective Memoranda (POM) development

Performance model computes a series of metrics that track a facility's key performance indicators over time

- Age
- Condition
- Reliability
- Risk

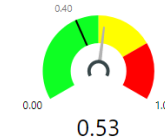
Optimization model then identifies the recommended work activity for each facility in each year to:

1. achieve a targeted level of performance most efficiently (minimal cost)
2. maximize facility performance for a given budget level

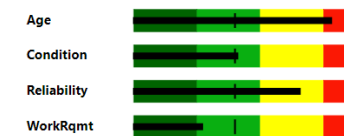
Facility Level Details

RPUID	Number	Name	Catcode	Catcode Description	Components	PRV	CRV	Age	EffAge	Condition	Repair
299710	3762	ENLISTED UPH	72111	ENLISTED UPH	186	\$24,717,049	\$45,988,650	24.33	21.92	75.38	\$12,400,000

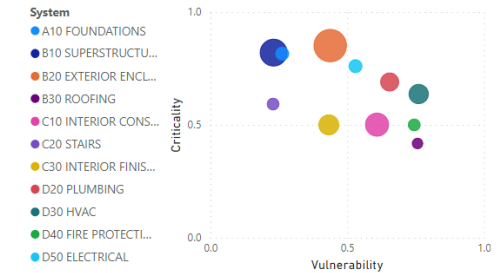
Risk Likelihood Score



Risk Likelihood Components



System Level Risk Posture



System Level Details

System	Criticality	Vulnerability	Components	CRV	Age	DLU	EffAge	SLU	Proj_Ct	AccumDet	Repair	AccumRepair
A10 FOUNDATIONS	0.43	0.26	3	\$1,324,343	43.00	0.43	42.08	0.42	90.00	0.00	\$44,006	0.43
B10 SUPERSTRUCTURE	0.02	0.00	12	\$8,897,173	36.33	0.36	36.13	0.36	90.00	0.00	\$295,641	0.36
B20 EXTERIOR ENCLOSURE	0.85	0.44	38	\$13,711,033	25.95	0.75	22.79	0.63	84.47	0.26	\$1,088,471	0.75
B30 ROOFING	0.42	0.76	3	\$523,692	23.00	0.96	20.01	0.82	60.00	0.67	\$42,487	0.58
C10 INTERIOR CONSTRUCTION	0.50	0.61	20	\$6,206,140	26.50	0.65	23.77	0.72	70.50	0.49	\$3,128,289	0.38
C20 STAIRS	0.59	0.23	1	\$1,019,592	43.00	0.34	46.56	0.37	90.00	0.00	\$33,880	0.34
C30 INTERIOR FINISHES	0.50	0.43	26	\$4,460,765	18.12	0.52	18.99	0.50	73.85	0.44	\$1,125,563	0.52
D20 PLUMBING	0.69	0.66	21	\$3,396,018	26.81	1.07	21.08	0.77	71.90	0.47	\$960,622	0.32
D30 HVAC	0.64	0.76	23	\$4,103,367	18.65	0.87	18.04	0.81	57.83	0.70	\$5,158,019	0.67
D40 FIRE PROTECTION	0.50	0.75	2	\$894,248	14.50	0.73	14.50	0.73	60.00	0.67	\$530,532	0.66



CHALLENGES/ROAD BLOCKS



- When there are thousands of optimization actions, how can these be translated to pragmatic project groupings or “bins”?
- Linking projects to asset/components is a major gap. The Components use a myriad of systems to store capital improvement plans, facility requirements data, maintenance management data and other key input that will have to be integrated into a solution
- Currently Components do not have readily accessible accounting of where their FSRM funding is spent at the installation level. Components often have multiple processes at multiple levels that determine how FSRM funding is distributed
- Linking to CMMS systems is a major hurdle
- Data availability / quality / confidence is an important issue
- Others?

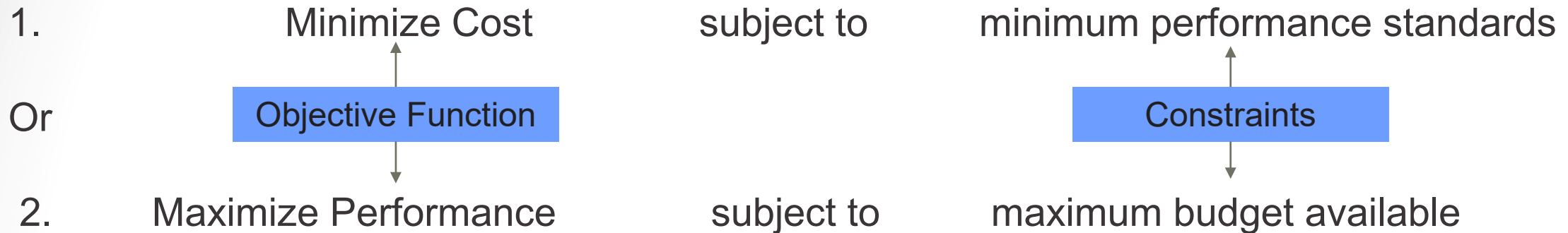


STRUCTURE OF AN OPTIMIZATION PROBLEM



Optimization problem has 3 parts:

1. Objective function
2. Decision Variables
3. Constraints



By:

Selecting the right type and timing of work actions for facilities ← Decision Variables

DECISION VARIABLES – APPLICABLE WORK ACTIONS





THE SPECTRUM OF FACILITY WORK ACTIVITIES

Traditional SMS Focus

Activity	Facility Services	Scheduled Maintenance	Emergency Repairs	Planned Component Repair	Planned Component Replacement	Major Renovation	Facility Replacement
Desc	Regular Building Service Activities	Regularly scheduled adjustments and Recurring PM Activities to maintain condition and performance	Unexpected/ unplanned activities that require immediate attention	Scheduled/ Planned repair of major facility components below condition standard	Scheduled/ Planned replacement of major facility components at failed condition or end of service life	Major Facility Restoration, Reconfiguration, or Modernization (one or more systems)	Replace with new facility built to today's standards
Examples	Grass Cutting	HVAC Seasonal Change Over	Patch leaking roof	Repair roof defects	Replace windows at failed condition	Retrofit Structural System	
	Snow Removal	Clean Gutters	Fix Broken piping	Replace Chiller compressor (subcomp)	Replace Chiller at end of service life	Upgrade HVAC System	
	Janitorial/ Cleaning	Adjust Overhead Doors	Emergency Boiler Repairs	Refinish Concrete Floor Surface	Replace Ceramic Tile Flooring	Replace Storm Damaged Roofing System	
Frequency	Continuous	Monthly, quarterly, annually	Varies, sometimes daily	Part of annual work plan	Part of annual work plan	Every 10-30 years	End of facility life
Services		Sustainment			R&M		MILCON



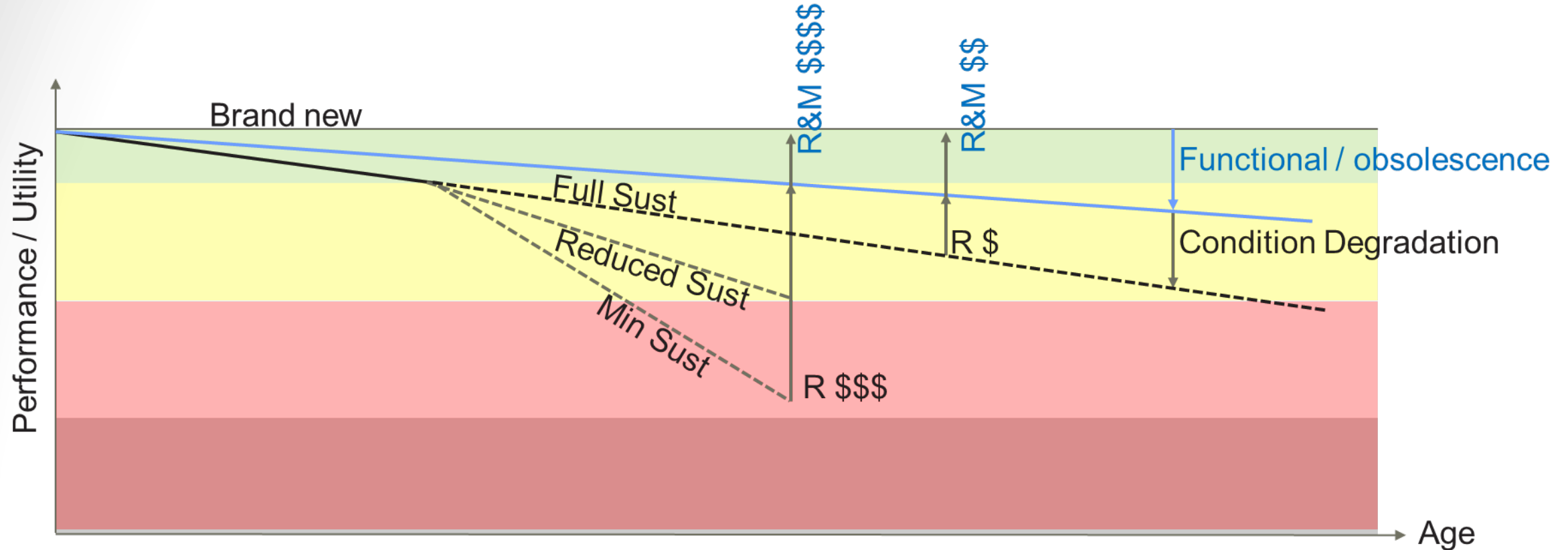
DEFINE DECISION VARIABLES



Description	Funding Class	Impact	Details
Do Nothing		No work	
Minimal Sustainment	S	Replace critical components (CII>0.75) with CI < 40	Only replace critical sustainable components if they are failing
Moderate Sustain	S	Maintain critical components to standard, replace non-critical components with CI < 40	Replace failed components, but only repair or maintain non-failed components if they are critical
Full Sustain	S	Maintain all components to standard	replacement, corrective repairs, and PM to all components
System Restore	R	replace all sustainable components regardless of component condition; repair all non-sustainable components where CI is below standard	If system CI is less than standard, replace all sustainable components and repair all non-sustainable components
Renovate	RM	Replace all sustainable components, repair all non-sustainable components to 95	Restore all system in building, and restore lost building functionality
Replace	MILCON	Replace all building components	Total replacement of building with a new building
Demolish	Demo	Deactivate building and all components	Remove building from analysis and generation of future requirements



WORK ACTION EFFECTS

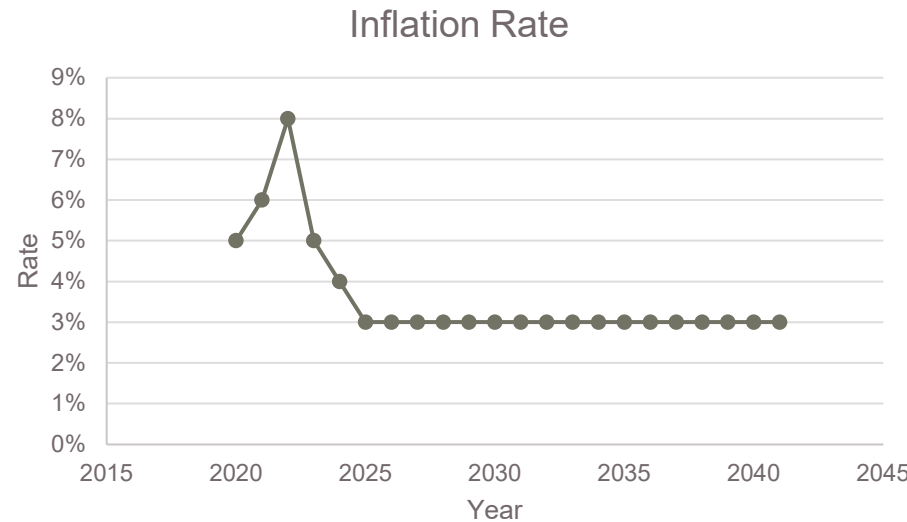




OTHER INPUTS – ESCALATION RATE ASSUMPTIONS



year	Rate
2020	5%
2021	6%
2022	8%
2023	5%
2024	4%
2025	3%
2026	3%
2027	3%
2028	3%
2029	3%
2030	3%
2031	3%
2032	3%
2033	3%
2034	3%
2035	3%
2036	3%
2037	3%
2038	3%
2039	3%
2040	3%
2041	3%



Questions:

- Allow users to adjust escalation rates and run scenarios under different assumptions?
- Just a single rate per year, or different rates for sustainment, MILCON, demo, etc?



DEFINING OBJECTIVE FUNCTION – WHAT ARE THE OPTIMIZING FOR?





PROPOSED OBJECTIVE FUNCTIONS

“What exactly are we trying to optimize?”

- Weighted average CI? Weigh by PRV, Mission Importance, Etc...?
- Proportion of facilities meeting condition/performance targets?
- Minimal cost of ownership, budget requirements, or backlog?

Weighted CI Objective

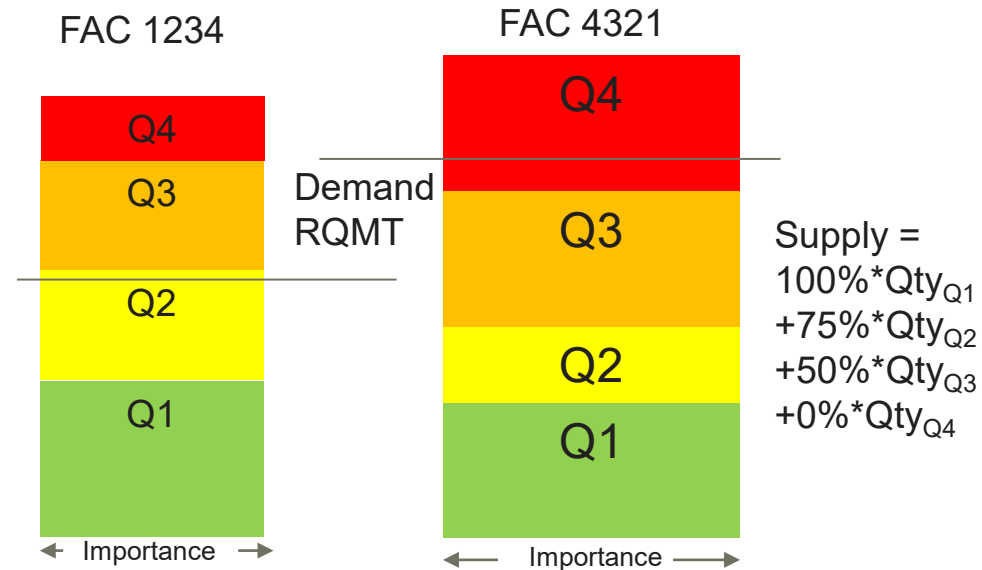
$$\text{Maximize } \frac{1}{N} \sum MDI_i * PRV_i * BCI_i$$

s.t.

$$\sum Cost_i \leq Budget$$

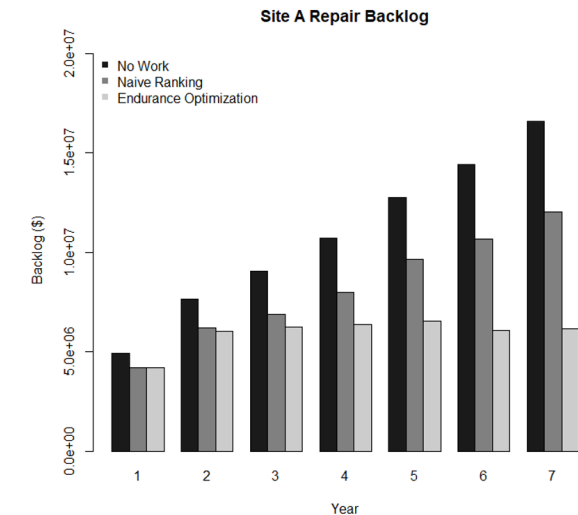
$$BCI_i \geq BCI_{minimum}$$

Facility Supply / Demand Objective



$$\text{Deficit} = \text{Sum}(MDI(\text{Demand} - \text{Supply}))$$

Minimize Cost Objective



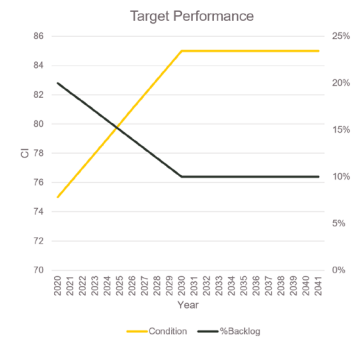


OBJECTIVE FUNCTIONS QUESTIONS

What if its more than just condition that we care about?

- Facility Performance = f (condition, functionality, reliability, efficiency, backlog, others?)
- How do we measure each factor?
- What is the relative importance of each factor?
- With multi-year scenarios, how do you weight varying performance factors from year to year?

Year	%Backlog	Condition	Functionality	Performance	Readiness	Risk Index
2020	20%	75	80	77	75	85
2021	19%	76	81	78	75	85
2022	18%	77	82	79	76	86
2023	17%	78	83	80	77	86
2024	16%	79	84	81	78	87
2025	15%	80	85	82	79	87
2026	14%	81	86	83	80	88
2027	13%	82	87	84	81	88
2028	12%	83	88	85	82	89
2029	11%	84	89	86	83	89
2030	10%	85	90	87	84	90
2031	10%	85	90	87	85	90
2032	10%	85	90	87	86	91
2033	10%	85	90	87	87	91
2034	10%	85	90	87	88	92
2035	10%	85	90	87	89	92
2036	10%	85	90	87	90	93
2037	10%	85	90	87	91	93
2038	10%	85	90	87	92	94
2039	10%	85	90	87	93	94
2040	10%	85	90	87	94	95
2041	10%	85	90	87	95	95



Instead of Maximizing Performance, what if its minimizing Cost?

- How to estimate cost?
- What's included: SRM + Milcon + Demo
- Or: Cost of Operations (energy, water), cost of disruption/failure, other external costs
- What is the discount rate to apply when aggregating across multiple years?



CONSTRAINTS – BUDGET AND PERFORMANCE THRESHOLDS/TARGETS





MODEL CONSTRAINTS

Budget Constraints

Maximum budget per year

- Sustainment
- Rest/Mod
- MILCON
- Demo

Performance Constraints

Component (could be set based on system or component type)

- CI
- RDL / RSL

Facility (could be set based on facility type / installation)

- Age/Remaining Design Life
- Condition
- Functionality
- Performance

Organization

- Condition
- Performance
- Risk
- Readiness



CONSTRAINTS: MINIMUM PERFORMANCE LEVELS



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Bldg	CRV	BCI	System	CRV	SCI	Component	CRV	BCCI	Component Type	Component Subtype	Component Name	CRV	CSCI
207 - Child Development Ctr	\$2,193,896	82	B20 - Exterior Closure	\$ 358,738	85	B2010 - Walls	\$183,923	87	B201001 - EXTERIOR CLOSURE	Exterior Wall - ExtWall_Type=Building Closure; ExtV	S01	\$111,948	90
			B20 - Exterior Closure			B2010 - Walls			B201002 - EXTERIOR WALL BACKUP CONSTR	Exterior Wall - ExtWall_Type=Backup; ExtWall_Mate	S02	\$66,776	84
			B20 - Exterior Closure			B2010 - Walls			B201006 - BALCONY WALLS & HANDRAILS	Handrail - Handrail_Material=Handrail;	Hand Rails	\$5,199	59
			B20 - Exterior Closure			B2020 - Windows		81	B202001 - WINDOWS	Exterior Window - ExtWindow_Material=Aluminum	S01	\$49,131	79
			B20 - Exterior Closure			B2020 - Windows			B202002 - STOREFRONTS	Storefront - Storefront_Type=General;	S02	\$39,182	83
			B20 - Exterior Closure			B2030 - Doors			B203001 - SOLID DOORS	Exterior Door - Door_Type=Solid; Door_Material=St	S01	\$20,487	69
			B20 - Exterior Closure			B2030 - Doors			B203002 - GLAZED DOORS	Exterior Door - Door_Type=Glazed; Door_Material=	S02	\$66,016	89
			B30 - Roofing			B3010 - Steep Slope			B301001 - STEEP SLOPE ROOF SYSTEMS	Roof Covering - RoofCovering_Type=Steep Slope; Rc	S01	\$123,850	78
			C10 - Interior Construction		62	C1010 - Partitions		81	C101001 - FIXED PARTITIONS	Interior Wall - IntWall_Type=Partition Wall; IntWa	S01	\$50,018	80
			C10 - Interior Construction			C1010 - Partitions			C101001 - FIXED PARTITIONS	Interior Wall - IntWall_Type=Partition Wall; IntWa	S02	\$14,773	83
			C10 - Interior Construction			C1010 - Partitions			C101004 - INTERIOR GUARDRAILS & SCREE	Guardrail -	Pool Hand Rails	\$75	98
			C10 - Interior Construction			C1010 - Partitions			C101005 - INTERIOR WINDOWS	Interior Window -	Interior Window	\$1,479	90
			C10 - Interior Construction			C1020 - Doors			C102001 - STANDARD INTERIOR DOORS	Interior Door - Door_Type=Solid; Door_Material=W	S01	\$77,916	48
			C10 - Interior Construction			C1030 - Partitions			C103001 - COMPARTMENTS, CUBICLES & TO	Bath Partition - BathPartition_Type=Toilet;	S01	\$2,071	69
			C30 - Interior Finishes			C3020 - Flooring		90	C302001 - TILE FLOOR FINISHES	Interior Floor Finish - FloorFinish_Type=Tile; Floor	Ceramic Tile Floor	\$22,896	92
			C30 - Interior Finishes			C3020 - Flooring			C302001 - TILE FLOOR FINISHES	Interior Floor Finish - FloorFinish_Type=Tile; Floor	Vinyl tile	\$18,457	83
			C30 - Interior Finishes			C3020 - Flooring			C302003 - WOOD FLOORING	Interior Floor Finish - FloorFinish_Type=Wood; Flo	Wood Floor	\$28,671	100
			C30 - Interior Finishes			C3020 - Flooring			C302005 - CARPETING	Interior Floor Finish - FloorFinish_Type=Carpet; Flc	Carpet	\$38,179	59
			C30 - Interior Finishes			C3020 - Flooring			C302010 - HARDENERS AND SEALERS	Interior Floor Finish - FloorFinish_Type=Hardener	Hardend Floor	\$833	100
			C30 - Interior Finishes			C3020 - Flooring			C302090 - OTHER FLOORING & FLOOR FINIS	Interior Floor Finish - FloorFinish_Type=Other;	Rollod Floor	\$91,613	100
			C30 - Interior Finishes			C3030 - Ceiling			C303001 - ACOUSTICAL CEILING TILES & PAN	Interior Ceiling - InteriorCeiling_Type=Acoustical C	Ceiling Tile	\$96,829	83
			D20 - Plumbing		83	D2010 - Plumbing Fixture		70	D201001 - WATERCLOSETS	Watercloset - Watercloset_Material=General;	S04	\$23,529	69
			D20 - Plumbing			D2010 - Plumbing Fixture			D201003 - LAVATORIES	Lavatory - Lavatory_Material=General;	S03	\$39,378	69
			D20 - Plumbing			D2010 - Plumbing Fixture			D201004 - SINKS	Sink - Sink_Type=Kitchen;	S01	\$35,603	74
			D20 - Plumbing			D2010 - Plumbing Fixture			D201004 - SINKS	Sink - Sink_Type=Service;	S02	\$10,881	69
			D20 - Plumbing			D2010 - Plumbing Fixture			D201006 - DRINKING FOUNTAINS AND COO	Drinking Fountain - DrinkingFountain_Type=Water	S05	\$7,366	69
			D20 - Plumbing			D2010 - Plumbing Fixture			D201090 - OTHER PLUMBING FIXTURES	Laundry Pan -	S06	\$5,936	54
			D20 - Plumbing			D2020 - Supply		85	D202001 - PIPES & FITTINGS	Supply Piping - Pipe_Material=Supply Piping;	S04	\$251,260	90
			D20 - Plumbing			D2020 - Supply			D202002 - VALVES & HYDRANTS	Domestic Water Valve - DomWaterValve_Type=Ger	S05	\$3,603	83
			D20 - Plumbing			D2020 - Supply			D202003 - DOMESTIC WATER EQUIPMENT	Domestic Water Heater - WaterHeater_Fuel=Electr	S01	\$2,671	47
			D20 - Plumbing			D2020 - Supply			D202003 - DOMESTIC WATER EQUIPMENT	Domestic Water Heater - WaterHeater_Fuel=Electr	S02	\$11,900	23
			D20 - Plumbing			D2020 - Supply			D202003 - DOMESTIC WATER EQUIPMENT	Booster Pump -	S03	\$7,325	82
			D20 - Plumbing			D2030 - Waste			D203001 - WASTE PIPE & FITTINGS	Waste Piping - WastePipe_Material=General;	S01	\$92,131	90
			D30 - HVAC		59	D3030 - Cooling		65	D303002 - DIRECT EXPANSION SYSTEMS	Condenser - Condenser_Type=DX; Condenser_Cooli	Exterior G NC SS-HP-CL	\$8,036	67
			D30 - HVAC			D3030 - Cooling			D303002 - DIRECT EXPANSION SYSTEMS	Condenser - Condenser_Type=DX; Condenser_Cooli	Exterior G NW SS-HP-C	\$1,476	28
			D30 - HVAC			D3030 - Cooling			D303002 - DIRECT EXPANSION SYSTEMS	Condenser - Condenser_Type=DX; Condenser_Cooli	Exterior G NW SS-HP-C	\$1,325	67
			D30 - HVAC			D3030 - Cooling			D303002 - DIRECT EXPANSION SYSTEMS	Condenser - Condenser_Type=DX; Condenser_Cooli	Exterior G W SS-HP-CU	\$24,831	67
			D30 - HVAC			D3040 - Distribution		57	D304008 - AIR HANDLING UNITS	Air Handling Unit - AHU_Type=Indoor Modular;	1st FL NC Mech Rm SS-	\$28,954	67
			D30 - HVAC			D3040 - Distribution			D304008 - AIR HANDLING UNITS	Air Handling Unit - AHU_Type=Indoor Modular;	1st FL NC Mech Rm SS-	\$28,954	67
			D30 - HVAC			D3040 - Distribution			D304008 - AIR HANDLING UNITS	Air Handling Unit - AHU_Type=Indoor Modular;	1st FL NC Mech Rm SS-	\$28,954	67
			D30 - HVAC			D3040 - Distribution			D304008 - AIR HANDLING UNITS	Air Handling Unit - AHU_Type=Indoor Modular;	1st FL NW Mech Rm SS-	\$28,954	28
			D40 - Fire Protection		85	D4010 - Alarms		82	D401001 - FIRE ALARM DISTRIBUTION	Fire Alarm System - FireDetectionSystem_Type=Ger	S01	\$90,234	83
			D40 - Fire Protection			D4010 - Alarms			D401001 - FIRE ALARM DISTRIBUTION	Fire Alarm Control Panel - Addressable=Non-addre	S02	\$17,373	83
			D40 - Fire Protection			D4010 - Alarms			D401001 - FIRE ALARM DISTRIBUTION	Fire Alarm Control Panel - Addressable=Non-addre	S03	\$5,791	80
			D40 - Fire Protection			D4010 - Alarms			D401001 - FIRE ALARM DISTRIBUTION	Fire Alarm Control Panel - Addressable=Non-addre	S04	\$23,163	80
			D40 - Fire Protection			D4020 - Piping		97	D402001 - FIRE PROTECTION WATER PIPING	Backflow Preventer - BackflowPreventer_Diameter=	S01	\$4,463	88
			D40 - Fire Protection			D4020 - Piping			D402001 - FIRE PROTECTION WATER PIPING	Fire Protection Service Piping - FireProtPipe_Materi	S01	\$14,800	100
			D40 - Fire Protection			D4040 - Suppression			D404001 - SPRINKLERS AND RELEASING DE	Sprinkler System - SprinklerSystem_Type=General;	S01	\$37,129	90
			D50 - Electrical		87	D5010 - Service		90	D501004 - PANELBOARDS	Panelboard - Panelboard_Type=General;	S01	\$52,685	91
			D50 - Electrical			D5010 - Service			D501004 - PANELBOARDS	Safety Switch -	S02	\$2,543	86
			D50 - Electrical			D5020 - Distribution			D502001 - BRANCH WIRING	Branch Wiring - BranchWiring_Type=General;	S04	\$130,180	92
			D50 - Electrical			D5020 - Distribution			D502002 - LIGHTING EQUIPMENT	Interior Light Fixture - LightFixture_Type=Fluorecen	S01	\$152,472	83
			D50 - Electrical			D5020 - Lighting		83	D502002 - LIGHTING EQUIPMENT	Interior Light Fixture - LightFixture_Type=Fluorecen	S02	\$93,435	83
			D50 - Electrical			D5020 - Lighting			D502002 - LIGHTING EQUIPMENT	Interior Light Fixture - LightFixture_Type=Incandesc	S03	\$163	80

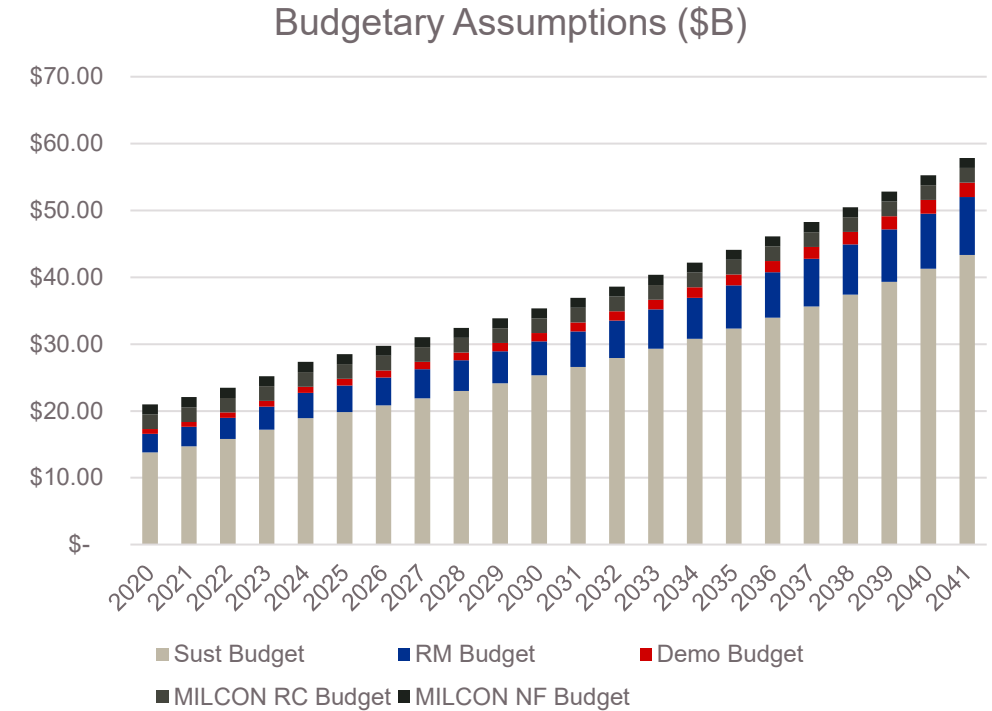
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OTHER INPUTS – BUDGET ASSUMPTIONS



Year	100% Sust (\$B)	Sust Level	Sust Budget	RM Budget	Demo Budget	MILCON RC Budget	MILCON NF Budget
2020	\$ 17.28	80%	\$ 13.82	\$ 2.76	\$ 0.69	\$ 2.20	\$ 1.50
2021	\$ 18.14	81%	\$ 14.70	\$ 2.94	\$ 0.73	\$ 2.20	\$ 1.50
2022	\$ 19.05	83%	\$ 15.81	\$ 3.16	\$ 0.79	\$ 2.20	\$ 1.50
2023	\$ 20.00	86%	\$ 17.20	\$ 3.44	\$ 0.86	\$ 2.20	\$ 1.50
2024	\$ 21.00	90%	\$ 18.90	\$ 3.78	\$ 0.95	\$ 2.20	\$ 1.50
2025	\$ 22.05	90%	\$ 19.85	\$ 3.97	\$ 0.99	\$ 2.20	\$ 1.50
2026	\$ 23.16	90%	\$ 20.84	\$ 4.17	\$ 1.04	\$ 2.20	\$ 1.50
2027	\$ 24.31	90%	\$ 21.88	\$ 4.38	\$ 1.09	\$ 2.20	\$ 1.50
2028	\$ 25.53	90%	\$ 22.98	\$ 4.60	\$ 1.15	\$ 2.20	\$ 1.50
2029	\$ 26.81	90%	\$ 24.13	\$ 4.83	\$ 1.21	\$ 2.20	\$ 1.50
2030	\$ 28.15	90%	\$ 25.33	\$ 5.07	\$ 1.27	\$ 2.20	\$ 1.50
2031	\$ 29.55	90%	\$ 26.60	\$ 5.32	\$ 1.33	\$ 2.20	\$ 1.50
2032	\$ 31.03	90%	\$ 27.93	\$ 5.59	\$ 1.40	\$ 2.20	\$ 1.50
2033	\$ 32.58	90%	\$ 29.33	\$ 5.87	\$ 1.47	\$ 2.20	\$ 1.50
2034	\$ 34.21	90%	\$ 30.79	\$ 6.16	\$ 1.54	\$ 2.20	\$ 1.50
2035	\$ 35.92	90%	\$ 32.33	\$ 6.47	\$ 1.62	\$ 2.20	\$ 1.50
2036	\$ 37.72	90%	\$ 33.95	\$ 6.79	\$ 1.70	\$ 2.20	\$ 1.50
2037	\$ 39.61	90%	\$ 35.65	\$ 7.13	\$ 1.78	\$ 2.20	\$ 1.50
2038	\$ 41.59	90%	\$ 37.43	\$ 7.49	\$ 1.87	\$ 2.20	\$ 1.50
2039	\$ 43.67	90%	\$ 39.30	\$ 7.86	\$ 1.96	\$ 2.20	\$ 1.50
2040	\$ 45.85	90%	\$ 41.26	\$ 8.25	\$ 2.06	\$ 2.20	\$ 1.50
2041	\$ 48.14	90%	\$ 43.33	\$ 8.67	\$ 2.17	\$ 2.20	\$ 1.50



Questions:

- Allow users to adjust available budgetary levels?
- Establish breakout as lower levels? (component, command, installation)
- Other funding sources to add?
- What funding constraints apply? (Only use sustainment funds if...)



OTHER INPUTS – CONDITION STANDARDS

Component	Facility Type	System	MDI	CI	RSL
Army	Maint. Fac	A10 - FOUNDATIONS	High	76	3
Army	Maint. Fac	A20 - BASEMENT CONSTRUCTION	High	90	4
Army	Maint. Fac	B10 - SUPERSTRUCTURE	High	85	4
Army	Maint. Fac	B20 - EXTERIOR ENCLOSURE	High	84	3
Army	Maint. Fac	B30 - ROOFING	High	90	3
Army	Maint. Fac	C10 - INTERIOR CONSTRUCTION	High	77	2
Army	Maint. Fac	C20 - STAIRS	High	77	2
Army	Maint. Fac	C30 - INTERIOR FINISHES	High	90	3
Army	Maint. Fac	D10 - CONVEYING	High	84	5
Army	Maint. Fac	D20 - PLUMBING	High	78	3
Army	Maint. Fac	D30 - HVAC	High	81	4
Army	Maint. Fac	D40 - FIRE PROTECTION	High	77	5
Army	Maint. Fac	D50 - ELECTRICAL	High	87	5
Army	Maint. Fac	E10 - EQUIPMENT	High	85	2
Army	Maint. Fac	E20 - FURNISHINGS	High	90	3
Army	Maint. Fac	F10 - SPECIAL CONSTRUCTION	High	88	4
Army	Maint. Fac	F20 - SELECTIVE BUILDING DEMOLITION	High	76	3
Army	Maint. Fac	G10 - SITE PREPARATIONS	High	82	3
Army	Maint. Fac	G20 - SITE IMPROVEMENTS	High	81	2
Army	Maint. Fac	G30 - SITE CIVIL/MECHANICAL UTILITIES	High	75	2

Questions:

- Minimum standards for certain systems/components?
- Can vary by component?
- Other metrics beyond CI, RSL?



OTHER INPUTS – QUALITY REQUIREMENTS



Component	FAC	Q1	Q2	Q3	Q4
Army	1311 - Communications Building	89	76	33	0
Army	1312 - Satellite Communications Building	90	79	43	0
Army	1331 - Aircraft Navigation Building	88	81	26	0
Army	1371 - Ship Navigation Building	95	83	56	0
Army	1402 - Air Defense Operations Building	86	82	49	0
Army	1403 - Missile Operations Building	91	82	61	0
Army	1404 - Emergency Operations Center / Restricted Area	85	79	27	0
Army	1411 - Airfield Fire And Rescue Station	93	76	55	0
Army	1412 - Aviation Operations Building	86	82	29	0
Army	1413 - Air Control Tower	89	75	37	0
Army	1421 - Helium Production/Storage Building	88	80	44	0
Army	1431 - Ship Operations Building	88	78	54	0
Army	1441 - Photo/TV Production Building	91	76	53	0
Army	1442 - Operations Support Lab	89	76	46	0
Army	1443 - Operations Supply Building	95	85	48	0
Army	1444 - Miscellaneous Operations Support Building	86	78	53	0
Army	1445 - Working Animal Support Building	89	75	30	0

Questions:

- Q rating breakpoints for different FACs?
- Breakdown by components?
- Other quality metrics to track?

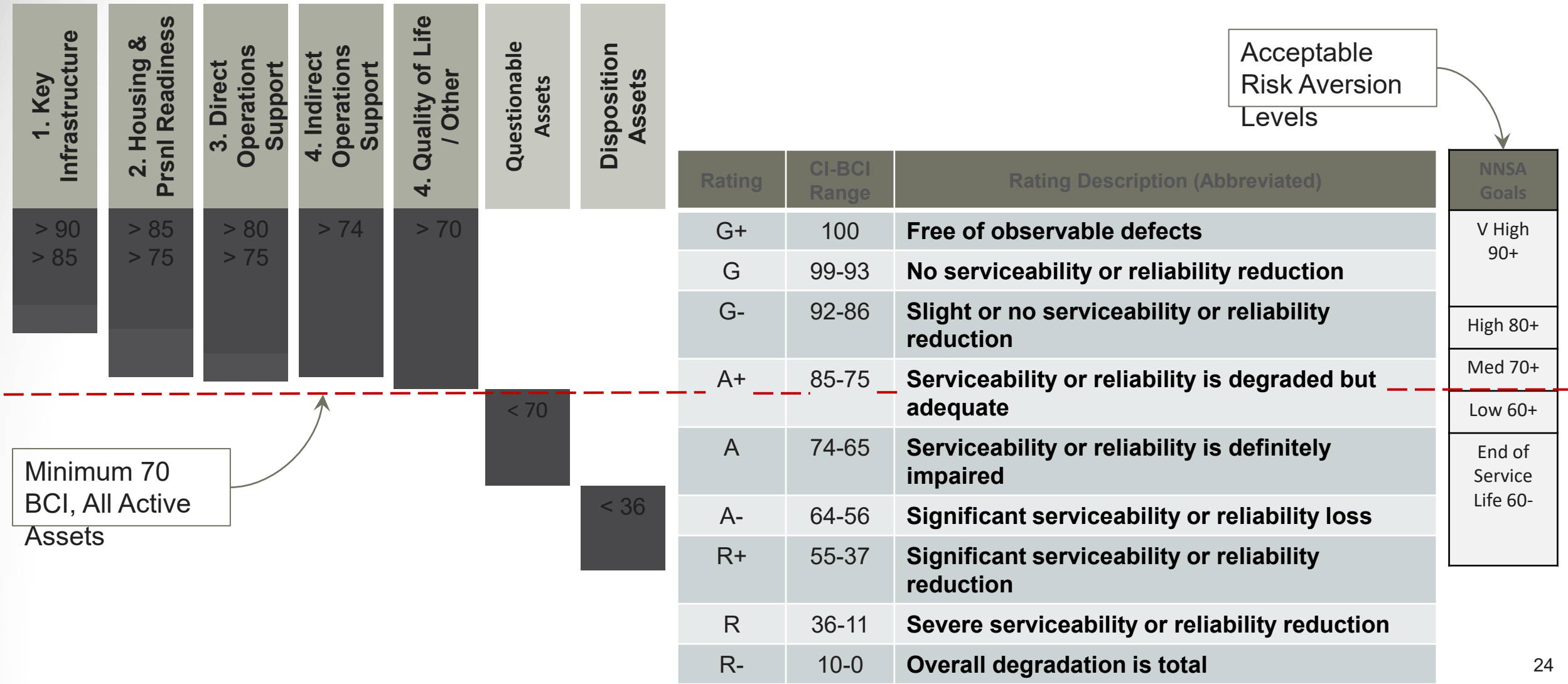


Binning – Risk-Based Asset Groups





Goals – Recommended Binning / CERL Thresholds





Binning – Risk



ERDC

Deteriorating Facilities

August 24, 2021, businessinsider.com - America's military bases are slowly falling apart; Military bases are falling apart. Deteriorating facilities contribute to maintenance delays, limiting the operational availability of ships, aircraft and vehicles across the armed forces.

Life, Health & Safety

November 2021, US Environmental Protection Agency – Red Hill Fuel Releases; 93,000 U.S. Navy water system users were impacted by fuel-contaminated drinking water, many of whom were relocated to temporary housing for the duration of the water crisis

Manpower Quality of Life

January 21, 2023, Military.Com - HASC Subcommittee to Focus on Quality of Life; New HASC focus on military quality of life issues like, military housing conditions, and day care waiting lists, indicated its chair, Rep. Don Bacon (R-Neb.)

Ageing Inventory

January 2022, GAO Report – Manage Risks Posed by Deferred Facility Maintenance; DOD does not fully account for the costs of sustaining facilities that exceed lifespans; underestimates funding requirements; 30 percent of facilities exceed expected lifespans

Dated Functionality

May 2021, Senate Armed Services Committee – Shipyard Infrastructure, K. Cramer, ND; Navy shipyards have storied histories. Each is over 100 years old and showing its age. The poor condition of these shipyards is having a serious negative effect on fleet operations

Climate Agenda

January 30, 2018, Science.org - Half of U.S. military facilities vulnerable to extreme weather and climate risks; Half of DoD's infrastructure has been affected by extreme weather and climate risks

Regional Climates

July 21, 2021, Defense.gov - Navy Confronts Climate Change in Southern Virginia; Naval Station Norfolk, the world's largest naval facility, experienced 18 inches of sea-level rise in 100 years; Expects 1-3 feet by 2050 (NOAA)

READINESS BINNING

- 1 CRITICAL INFRASTRUCTURE
- 2 HOUSING / PERSONNEL READINESS
- 3 DIRECT OPERATIONAL SUPPORT
- 4 INDIRECT OPERATIONAL SUPPORT
- 5 QUALITY OF LIFE – OTHER

RISK PREMIUMS

- MISSION DEPENDENCY
- FACILITY AGE
- FUNCTIONAL USE
- REGIONAL CLIMATE



OTHER INPUTS – QUANTITY REQUIREMENTS



Component	Installation	FAC	UM	Qty Rqmt
Army	INSTA	1311 - Communications Building	SF	214,924
Army	INSTB	1312 - Satellite Communications Building	SF	246,223
Army	INSTC	1331 - Aircraft Navigation Building	SF	171,352
Army	INSTD	1371 - Ship Navigation Building	SF	216,339
Army	INSTE	1402 - Air Defense Operations Building	SF	139,564
Army	INSTF	1403 - Missile Operations Building	SF	105,810
Army	INSTG	1404 - Emergency Operations Center / Restricted Area	SF	130,089
Army	INSTH	1411 - Airfield Fire And Rescue Station	SF	134,810
Army	INSTI	1412 - Aviation Operations Building	SF	108,577
Army	INSTJ	1413 - Air Control Tower	SF	155,912
Army	INSTK	1421 - Helium Production/Storage Building	SF	179,276
Army	INSTL	1431 - Ship Operations Building	SF	233,081
Army	INSTM	1441 - Photo/TV Production Building	SF	168,428
Army	INSTN	1442 - Operations Support Lab	SF	144,830
Navy	INSTO	1311 - Communications Building	SF	165,904
Navy	INSTP	1312 - Satellite Communications Building	SF	204,496
Navy	INSTQ	1331 - Aircraft Navigation Building	SF	212,585
Navy	INSTR	1371 - Ship Navigation Building	SF	143,210
Navy	INSTS	1402 - Air Defense Operations Building	SF	190,078
Navy	INSTT	1403 - Missile Operations Building	SF	183,601
Navy	INSTU	1404 - Emergency Operations Center / Restricted Area	SF	125,589
Navy	INSTV	1411 - Airfield Fire And Rescue Station	SF	181,868
Navy	INSTW	1412 - Aviation Operations Building	SF	198,440
Navy	INSTX	1413 - Air Control Tower	SF	183,845
Navy	INSTY	1421 - Helium Production/Storage Building	SF	151,653
Navy	INSTZ	1431 - Ship Operations Building	SF	230,345

Questions:

- Quantity requirements per CATCODE/FAC by installation?
- Considered a hard or soft constraint?



OTHER INPUTS – PLANNED PROJECT LIST



Component	P#	RPUID	Year	Activity	Cost
Army	P61077	82530	2021	MILCON RC	\$ 5,570,914.00
Army	P84736	82009	2027	MILCON RC	\$12,717,833.00
Army	P47454	16955	2030	MILCON RC	\$ 9,643,075.00
Army	P28119	15899	2028	MILCON RC	\$12,372,377.00
Army	P75389	14667	2026	MILCON RC	\$20,944,554.00
Army	P31822	43796	2021	MILCON RC	\$ 9,950,672.00
Army	P94665	73507	2021	MILCON RC	\$17,871,244.00
Army	P12278	45841	2027	MILCON RC	\$14,329,643.00
Army	P63421	89589	2029	MILCON RC	\$17,245,337.00
Army	P74949	58517	2023	MILCON RC	\$ 9,683,049.00
Army	P63957	13739	2020	MILCON RC	\$17,722,528.00
Army	P91300	11267	2021	MILCON RC	\$21,342,774.00
Army	P76741	11794	2025	RM	\$ 2,962,763.00
Army	P33807	27503	2028	RM	\$ 3,316,568.00
Navy	P12836	14390	2020	RM	\$ 2,604,455.00
Navy	P98269	12397	2022	RM	\$ 3,758,690.00
Navy	P73338	90843	2026	RM	\$ 2,320,746.00
Navy	P45562	18125	2028	RM	\$ 4,894,082.00
Navy	P53345	63842	2029	RM	\$ 3,934,744.00
Navy	P38153	34294	2027	RM	\$ 3,901,370.00
Navy	P47983	80447	2024	RM	\$ 2,896,608.00
Navy	P64863	68472	2029	RM	\$ 2,623,154.00
Navy	P96401	65587	2027	RM	\$ 2,588,109.00
Air Force	P54035	90899	2021	RM	\$ 4,104,318.00
Air Force	P90345	47452	2020	RM	\$ 3,895,532.00
Air Force	P62200	66033	2023	RM	\$ 4,824,087.00
Air Force	P64709	16832	2030	RM	\$ 4,911,241.00
Air Force	P11493	58945	2026	DEMO	\$ 1,790,440.00
Air Force	P49457	92939	2029	DEMO	\$ 1,242,235.00
Air Force	P12640	92217	2024	DEMO	\$ 959,234.00
Air Force	P73542	14418	2028	DEMO	\$ 1,933,702.00
Air Force	P89018	13442	2020	DEMO	\$ 1,760,924.00
Air Force	P46738	85835	2022	DEMO	\$ 1,420,874.00
USMC	P15856	53072	2020	DEMO	\$ 1,248,989.00
USMC	P72755	90389	2022	DEMO	\$ 582,825.00
USMC	P21805	35020	2027	DEMO	\$ 839,883.00
USMC	P30227	53599	2023	DEMO	\$ 707,696.00
USMC	P76597	41606	2025	DEMO	\$ 640,695.00
USMC	P44197	44224	2025	DEMO	\$ 597,581.00
USMC	P21417	10884	2026	DEMO	\$ 1,374,572.00

Projects in progress, previously approved, or locked into investment plan



OUTPUTS – DASHBOARDS AND VISUALIZATIONS





OUTPUTS – PERFORMANCE METRICS BY YEAR



Installation	Asset Count	Total PRV	Total SF	Average Age	Ave Qual	Average FI	Average PI	Ave Readiness	Total Backlog
InstA	1,365	\$2,047,500,000	6,825,000	43	91	93	67	93	\$ 128,665,341
InstB	2,144	\$3,216,000,000	10,720,000	44	89	66	72	75	\$ 651,962,358
InstC	1,339	\$2,008,500,000	6,695,000	25	67	65	91	75	\$ 9,440,896
InstD	2,441	\$3,661,500,000	12,205,000	30	83	91	92	73	\$ 325,739,554
InstE	2,304	\$3,456,000,000	11,520,000	31	87	95	89	72	\$ 590,733,169
InstF	1,281	\$1,921,500,000	6,405,000	41	84	90	88	88	\$ 539,497,767
InstG	1,957	\$2,935,500,000	9,785,000	32	77	83	93	83	\$ 795,511,983
InstH	1,739	\$2,608,500,000	8,695,000	36	76	95	67	87	\$ 628,814,672
InstI	1,456	\$2,184,000,000	7,280,000	45	81	78	71	70	\$ 634,789,679
InstJ	2,367	\$3,550,500,000	11,835,000	39	87	69	82	66	\$ 36,672,341
InstK	939	\$1,408,500,000	4,695,000	33	83	91	71	82	\$ 162,783
InstL	2,073	\$3,109,500,000	10,365,000	26	77	73	81	89	\$ 422,958,619
InstM	753	\$1,129,500,000	3,765,000	33	73	79	86	66	\$ 32,698,333
InstN	768	\$1,152,000,000	3,840,000	34	85	89	81	74	\$ 272,001,722
InstO	1,237	\$1,855,500,000	6,185,000	34	70	90	77	86	\$ 541,650,413
InstP	711	\$1,066,500,000	3,555,000	25	88	71	88	86	\$ 272,321,815
InstQ	1,058	\$1,587,000,000	5,290,000	43	75	65	84	70	\$ 157,495,073

- PI = Performance Index: Combination of Condition and Functionality Index
- Readiness: Mission-weighted condition or performance aggregate score



OUTPUTS - SPENDING



Component	Region	Installation	FAC	Year	S	RM	MILCON RC	MILCON NF	Demo
Air Force	MAJCOM1	INSTC	4200	2023	\$ 15,286,473	\$ 1,638,758	\$ 1,280,293	\$ 1,609,492	\$ 235,191
Air Force	MAJCOM1	INSTG	4600	2023	\$ 13,387,784	\$ 1,500,473	\$ 1,573,040	\$ 912,444	\$ 102,963
Air Force	MAJCOM1	INSTK	5000	2023	\$ 14,837,897	\$ 1,944,215	\$ 879,102	\$ 852,537	\$ 204,490
Air Force	MAJCOM2	INSTO	5400	2023	\$ 20,742,415	\$ 553,305	\$ 1,016,329	\$ 2,160,431	\$ 161,826
Air Force	MAJCOM2	INSTS	5800	2023	\$ 8,524,416	\$ 838,448	\$ 1,559,264	\$ 1,105,034	\$ 107,519
Air Force	MAJCOM2	INSTW	6200	2023	\$ 24,114,632	\$ 934,605	\$ 886,616	\$ 2,392,809	\$ 132,671
Army	Region1	INSTA	4000	2023	\$ 20,779,264	\$ 2,072,638	\$ 2,464,467	\$ 1,944,583	\$ 123,038
Army	Region1	INSTE	4400	2023	\$ 7,825,044	\$ 1,771,260	\$ 2,438,468	\$ 1,701,206	\$ 60,162
Army	Region1	INSTI	4800	2023	\$ 10,406,213	\$ 1,157,458	\$ 1,064,421	\$ 1,036,331	\$ 165,398
Army	Region2	INSTM	5200	2023	\$ 22,794,561	\$ 864,663	\$ 1,118,802	\$ 1,082,680	\$ 232,045
Army	Region2	INSTQ	5600	2023	\$ 18,472,297	\$ 1,304,500	\$ 2,057,003	\$ 2,061,771	\$ 93,984
Army	Region2	INSTU	6000	2023	\$ 22,895,959	\$ 724,266	\$ 958,434	\$ 2,278,728	\$ 240,291
Army	Region2	INSTY	6400	2023	\$ 24,479,647	\$ 1,338,969	\$ 1,317,772	\$ 750,101	\$ 77,923
Army	Region2	INSTZ	6401	2023	\$ 10,664,164	\$ 1,328,376	\$ 1,837,286	\$ 1,063,206	\$ 113,516
Navy	Region1	INSTB	4100	2023	\$ 22,083,086	\$ 2,094,411	\$ 2,429,359	\$ 953,854	\$ 100,787
Navy	Region1	INSTF	4500	2023	\$ 17,702,668	\$ 2,498,177	\$ 2,439,862	\$ 552,467	\$ 175,925
Navy	Region1	INSTJ	4900	2023	\$ 8,976,025	\$ 1,464,905	\$ 1,206,565	\$ 1,299,695	\$ 69,118
Navy	Region2	INSTN	5300	2023	\$ 24,595,572	\$ 1,534,312	\$ 1,780,641	\$ 1,086,103	\$ 52,485
Navy	Region2	INSTR	5700	2023	\$ 18,111,395	\$ 1,272,621	\$ 555,364	\$ 716,635	\$ 155,179
Navy	Region2	INSTV	6100	2023	\$ 9,935,443	\$ 833,279	\$ 1,674,859	\$ 1,493,360	\$ 86,487
USMC	Region1	INSTD	4300	2023	\$ 19,020,149	\$ 545,112	\$ 2,466,319	\$ 2,030,072	\$ 167,028
USMC	Region1	INSTH	4700	2023	\$ 13,188,960	\$ 1,272,012	\$ 884,221	\$ 1,476,218	\$ 236,198



OUTPUTS – PROJECT RECOMMENDATIONS



Component	P#	RPUID	Year	Activity	Cost
Army	P96107	35294	2028	MILCON RC	\$ 12,160,608.00
Army	P49535	64151	2027	MILCON RC	\$ 11,584,424.00
Army	P67753	13070	2026	MILCON RC	\$ 22,685,582.00
Army	P59703	13776	2027	MILCON RC	\$ 6,228,758.00
Navy	P32367	14266	2028	MILCON RC	\$ 21,195,828.00
Navy	P20584	97266	2025	MILCON RC	\$ 12,461,711.00
Navy	P93923	19185	2027	MILCON RC	\$ 22,182,053.00
Navy	P76190	38492	2025	MILCON RC	\$ 21,351,644.00
Navy	P54323	51050	2025	MILCON RC	\$ 10,052,857.00
Air Force	P34251	80933	2026	MILCON RC	\$ 11,335,224.00
Air Force	P35162	23488	2029	MILCON RC	\$ 11,401,835.00
Air Force	P13639	86654	2029	MILCON RC	\$ 14,649,623.00
Air Force	P31892	96854	2027	RM	\$ 4,301,803.00
Air Force	P74296	48343	2028	RM	\$ 2,846,120.00
USMC	P32975	72636	2030	RM	\$ 4,542,932.00
USMC	P27097	50063	2026	RM	\$ 2,647,543.00
USMC	P95145	98387	2029	RM	\$ 4,965,811.00
USMC	P82984	21856	2028	RM	\$ 3,143,401.00

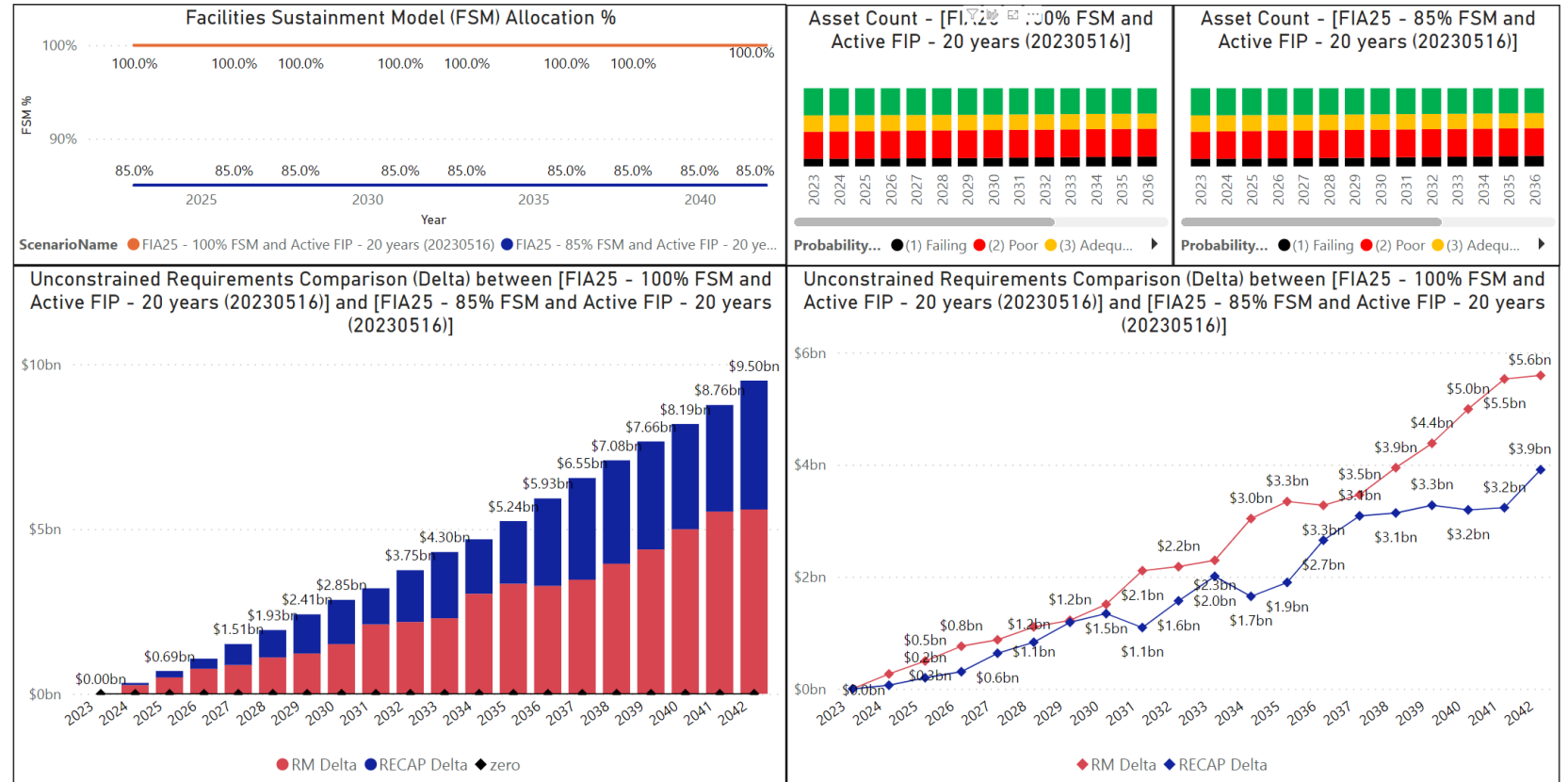


UNCLASSIFIED VISUALS



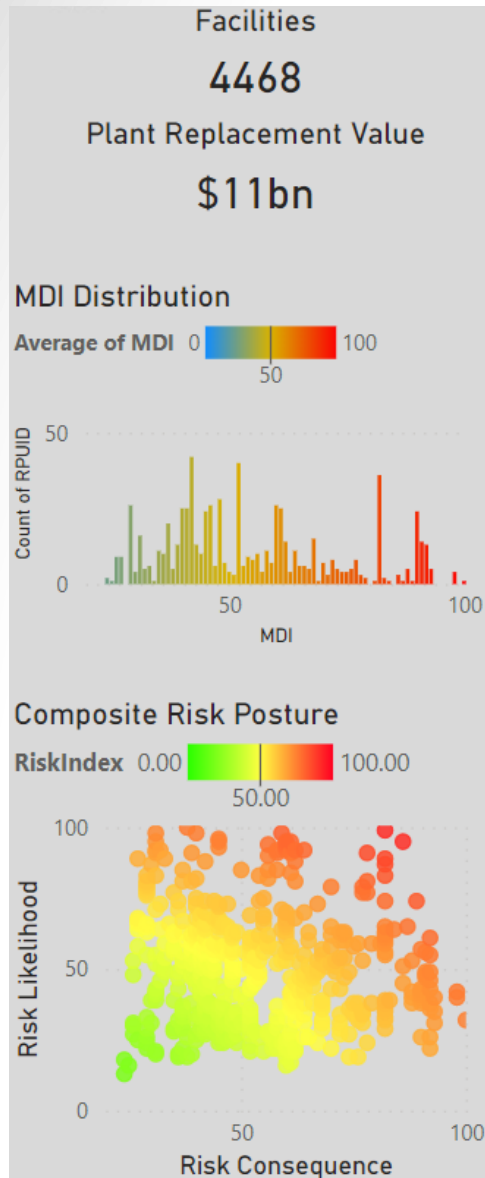
Graphs / Charts / Visuals
to interpret results and
make comparisons

- Budget / Spending over time
- Condition state distribution over time
- Backlogged Requirements
- Average Condition over time
- MDI vs CI or readiness over time
- Others?

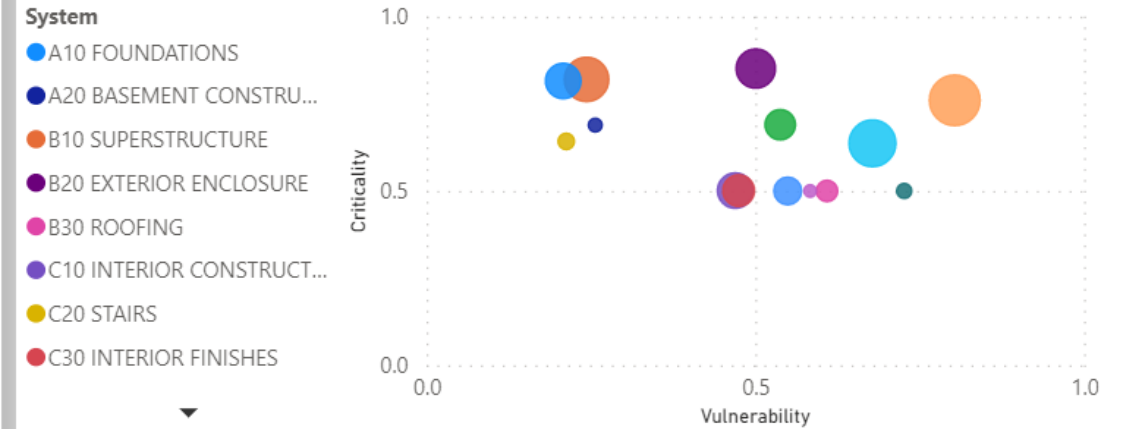




INSTALLATION LEVEL DASHBOARDS



System Level Risk Posture



Facility Level Details

Number	Name	Catcode	Catcode Description	PRV	CRV	Year	CI	Risk Consequence	Risk Likelihood	Risk
1882	VEH MNT SHOP ORG	21410	VEH MAINT SHOP	\$11,696,381	17,165,343.14	1984	58	82	99	
8030	VEH MNT SH DS	21410	VEH MAINT SHOP	\$95,008,640	101,522,392.00	1981	67	86	95	
1982	READINESS CENTER	21410	VEH MAINT SHOP	\$6,546,393.2027	7,211,297.45	1986	72	82	89	
8930	USAR VEH MNT	21409	USAR VEH MAINT	\$15,485,614	19,747,668.50	1982	70	78	91	
8152	VEH MNT SH ORG	21410	VEH MAINT SHOP	\$12,631,152	19,300,876.68	1984	55	82	87	
9628	VEH MNT SH ORG	21410	VEH MAINT SHOP	\$12,709,540	11,122,754.79	1987	68	82	83	
1853	RELIGIOUS EDUCATION FACILITY	73018	RELIG ED FAC	\$4,977,979	12,168,565.33	1975	68	89	74	
R145B	RANGE OPNS BLDG @ RANGE 145 FRMLY P14202	17122	RANGE OPNS BLDG	\$144,347	138,898.64	1970	64	59	98	
R057I	GENERAL INSTR BLDG @ RANGE 57	17123	RG SPT FAC	\$566,030	472,927.67	1992	69	61	95	



FACILITY TYPE ANALYSIS

Organization / Installation / Site

- ☐ ANC
- ☐ ARCENT
- ☐ ARMY RESERVE
- ☐ ARNG
- ☐ BRAC/EXCESS
- ☒ IMCOM
- ☐ ID EUROPE
- ☐ ID PACIFIC
- ☒ READINESS
- ☐ SUSTAINMENT
- ☐ TRAINING
- ☐ USACE
- ☐ USAREUR

Facility Type

Administrative

Administrative Buildings

Administrative Structures Other

Hospital & Medical

Dental Clinics

Dispensaries and Clinics

Medical and Medical Support Faci

Medical Centers and Hospitals

Housing & Community

Family Housing

Indoor Morale, Welfare, and Recr

Museums And Memorials

Outdoor Morale, Welfare, and Rec

Personnel Support and Services F

Unaccompanied Personnel Housing

Maintenance & Production

Maintenance Facilities

Production Facilities

Operation & Training

Airfield Pavements

Communications, Navigation Aids

Harbor and Coastal Operational F

Land Operational Facilities

Liquid Fueling and Dispensing Fa

Training Facilities

Waterfront Operational Facilitie

Research, Development, Test, and Evaluation

RDT&E Facilities Other Than Bui

RDT&E Buildings

RDT&E Range Facilities

Supply

Facilities

PRV Total

Ave Risk
ConsequenceAve Risk
Likelihood

Ave Risk Index

Administrative Buildings	2775	\$23,406M		48.03		55.65		53
Administrative Structures Other	545	\$44M						
Dental Clinics	34	\$415M		33.00		54.00		45
Dispensaries and Clinics	194	\$2,009M		36.70		51.78		42
Medical and Medical Support Faci	85	\$217M		34.93		47.94		42
Medical Centers and Hospitals	27	\$7,611M		58.00		46.00		52
Family Housing	26661	\$28,784M		51.28		45.65		48
Indoor Morale, Welfare, and Recr	929	\$2,655M		37.82		56.15		49
Museums And Memorials	515	\$202M		30.88		48.07		39
Outdoor Morale, Welfare, and Rec	3094	\$1,175M		9.33		18.33		15
Personnel Support and Services F	2573	\$5,829M		47.02		54.34		52
Unaccompanied Personnel Housing	2272	\$21,400M		74.91		51.39		64
Maintenance Facilities	3125	\$14,406M		60.22		54.16		58
Production Facilities	27	\$43M		30.13		52.30		42
Airfield Pavements	961	\$4,910M						
Communications, Navigation Aids	1201	\$10,199M		63.18		52.50		59
Harbor and Coastal Operational F	2	\$0M						
Land Operational Facilities	4566	\$3,748M		55.94		87.54		80
Liquid Fueling and Dispensing Fa	1290	\$449M						
Training Facilities	5081	\$10,669M		54.02		47.24		50
Waterfront Operational Facilitie	54	\$54M						
RDT&E Facilities Other Than Bui	1028	\$659M						
RDT&E Buildings	597	\$1,069M		22.29		59.17		46
RDT&E Range Facilities	643	\$775M		47.98		61.44		56

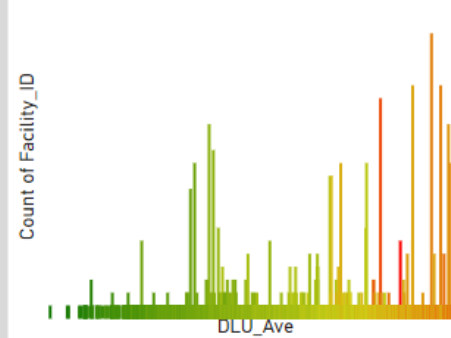


FACILITY PERFORMANCE INDICATORS

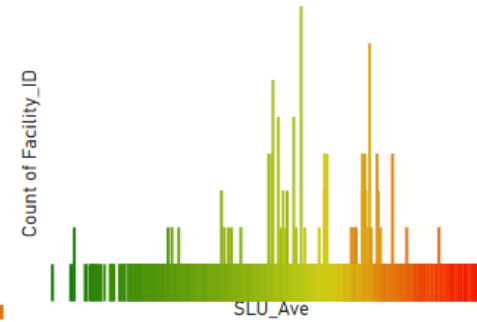
Organization / Installation / Site

- ☐ ANC
- ☐ ARCENT
- ☐ ARMY RESERVE
- ☐ ARNG
- ☐ BRAC/EXCESS
- ☒ IMCOM
- ☐ ID EUROPE
- ☐ ID PACIFIC
- ☒ READINESS
- ☐ SUSTAINMENT
- ☐ TRAINING
- ☐ USACE
- ☐ USAREUR

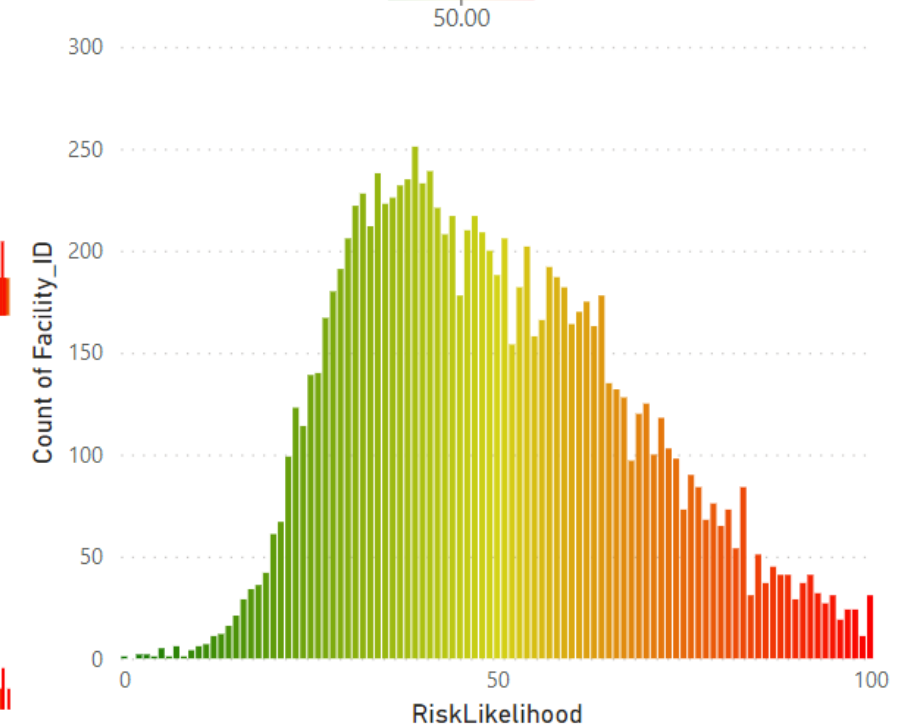
Age Factor



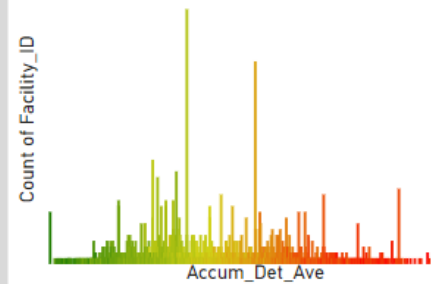
Reliability Factor



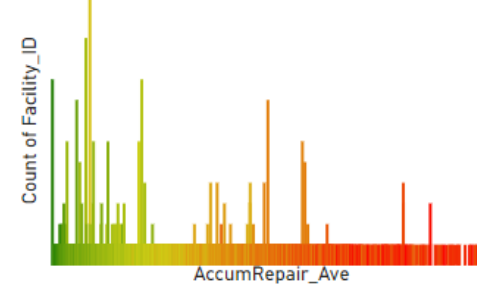
Average of RiskLikelihood 0.00 50.00 100.00



Condition Factor



Repair Factor



Facility Level Details

Number	Name	Catcode	Catcode Description	Components	PRV	CRV	Year	CI	RiskLikelihood	DLU_Ave
1	ADMIN GEN PURP, 1	61050	ADMIN GEN PURP	167	\$14,120,200	10,967,626.83	1916	61.37	61.00	
1	BARTSOW OUTREACH CENTER	74033	ACS CTR	38	\$595,378	1,290,730.04	1993	84.75	40.00	
1	FIRE STATION	73010	FIRE STATION	144	\$10,649,463	14,262,331.10	2017	83.10	27.00	
1	GEN INST BLDG	17120	GEN INST BLDG	54	\$681,541	859,190.16	1986	75.59	64.00	
1	HUTMENT	72510	HUTMENT	31	\$73,096	1,172,730.04	1995	46.83	63.00	
<	US G... ..	14100	FAB CSE	215	\$181,046,870	150,000,000.00	2010	81.00	20.00	



PORTFOLIO LEVEL RISK POSTURE

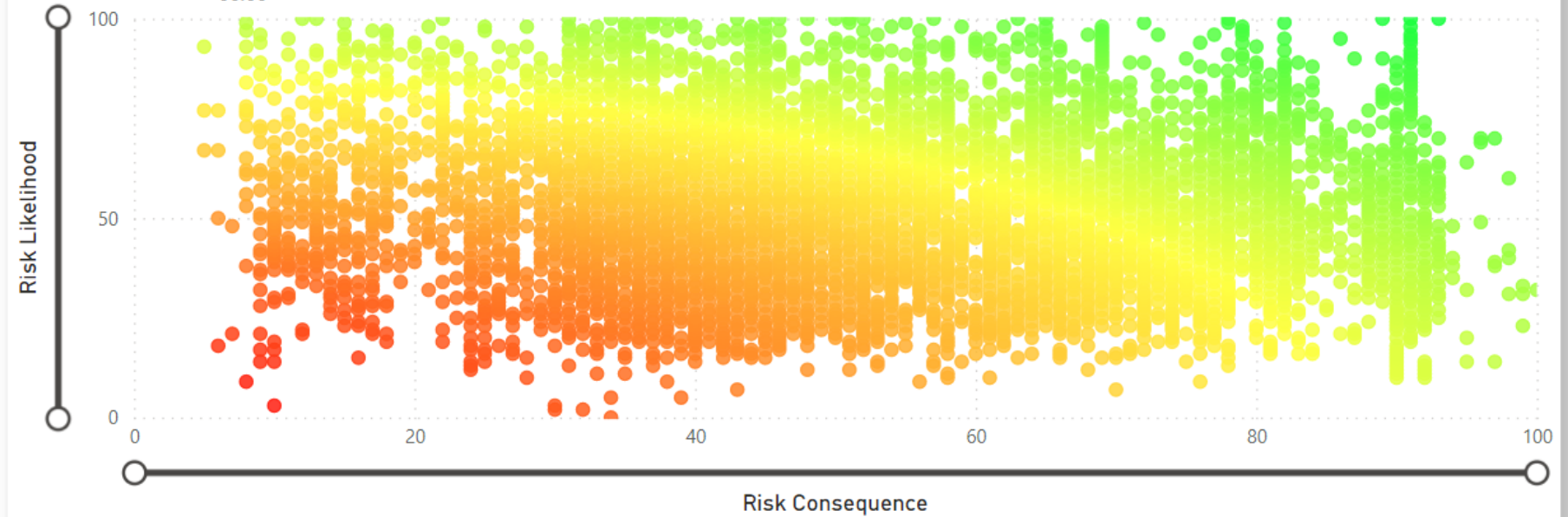


Organization / Installation / Site

- ☐ ANC
- ☐ ARCENT
- ☐ ARMY RESERVE
- ☐ ARNG
- ☐ BRAC/EXCESS
- ☒ IMCOM
- ☐ ID EUROPE
- ☐ ID PACIFIC
- ☒ READINESS
- ☐ SUSTAINMENT
- ☐ TRAINING
- ☐ USACE
- ☐ USAREUR

Composite Risk Posture

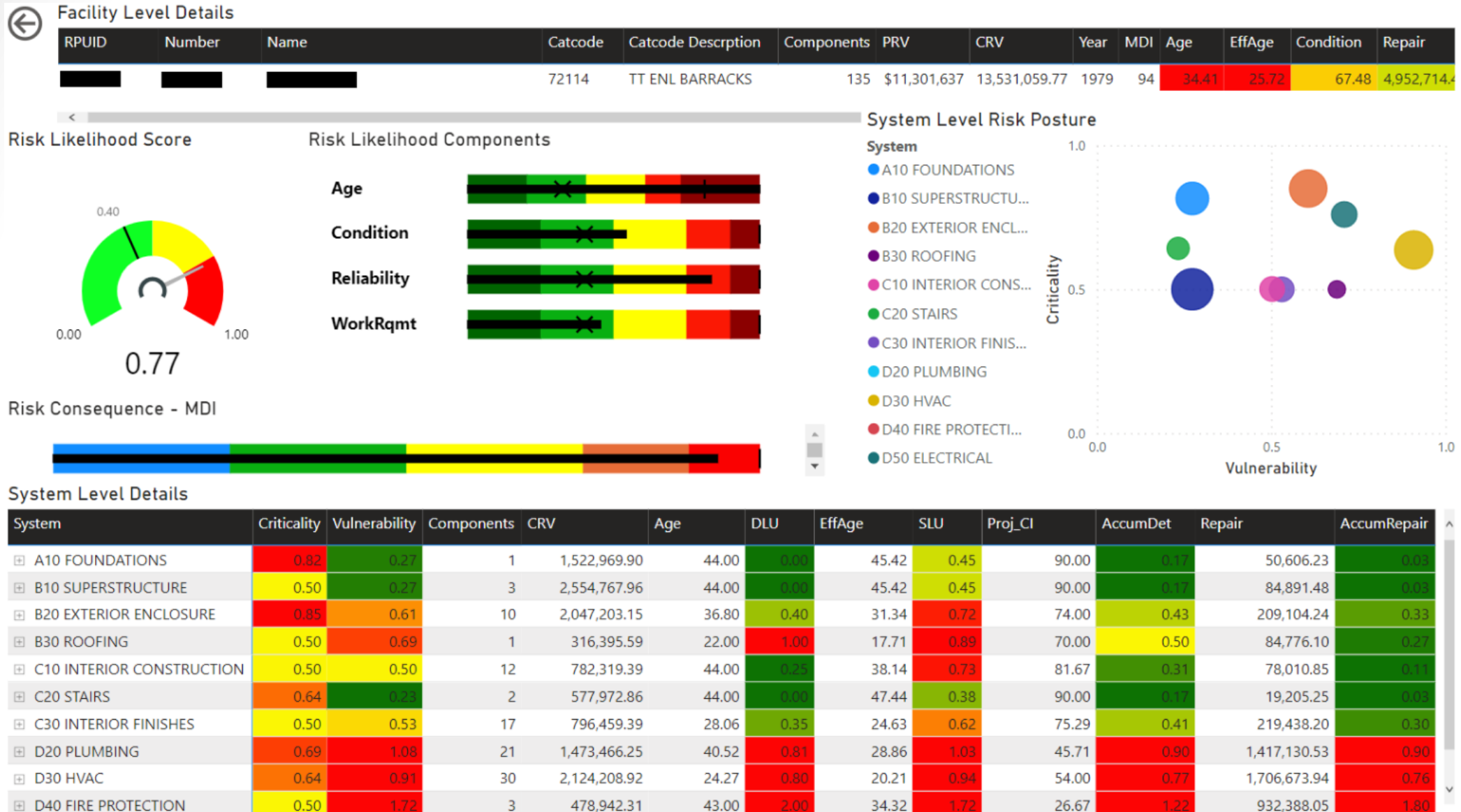
RiskIndex 0.00 100.00
60.00



RPUID	Site	Facility Number	Facility Name	Status	Year	Catcode	Risk Index	Risk Consequence	Risk Likelihood
1047660	Fort Stewart	10508	13115 - INFO SYS FAC	ACT	2010	13115	39	52	
1061761	Fort Hood	56411	INFORMATION SYSTEMS FACILITY	ACT	2008	13115	54	72	
1061762	Fort Hood	7030	INFORMATION SYSTEMS FACILITY	ACT	2008	13115	55	72	
1061763	Fort Hood	88021	INFORMATION SYSTEM BLDG (RSC)	ACT	2008	13115	55	72	
189400	Fort Polk	7840	NORTH FORT INFORMATION SYSTEM FACILITY...	ACT	1966	13115	58	73	
288238	Fort Bliss	56	INFO SYS FACILITY, 56	ACT	1961	13115	60	76	
289349	Fort Bliss	1022	INFO SYSTEM FAC, 1022	ACT	1957	13115	66	73	



FACILITY LEVEL DETAIL





MAP BASED VISUALIZATIONS

Color code sites or assets by:

- Average Age
- Average Quality
- Average FI
- Average PI
- Average Readiness
- Total Backlog

Vary metrics by Year





UNCLASSIFIED

OTHER TOPICS



UNCLASSIFIED



MODEL DATA REQUIREMENTS

Objective function(s)

- Maximize facility performance
- Minimize facility cost
- Maximize facility readiness

Subject to constraints

- Maximum yearly budget
- Acceptable performance state
- Target Risk profile

Currently Available Data

- Facility real property data
 - Facility type, size, age, PRV, MDI
- Component condition data
 - Component type, quantity, age
- Cost data
 - Facility replacement and sustainment unit cost
 - Component repair/replacement costs
- Metrics
 - Component condition index, facility condition / functionality / performance index, facility risk likelihood

Additional Data Needs

- Facility demo costs
- Historic R&M costs
- Component-level PM costs
- Emergency repair costs
- Current Planned facility projects
- Quantity Requirements: Facility space/quantity requirements by building type and site
- Quality Requirements: Q rating breakpoints by facility type
- Standards and policies: minimum acceptable condition levels by system/component type

Now



Future



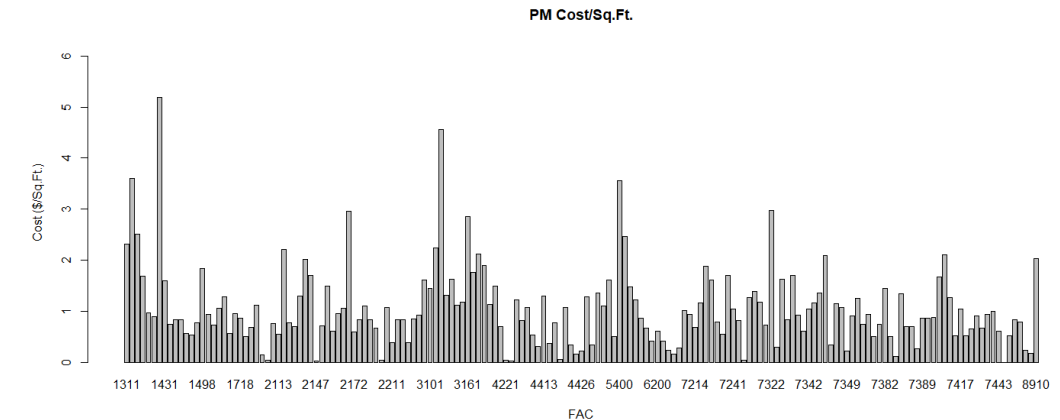
PREVENTATIVE & EMERGENCY MAINT. COSTS



PM and Emergency maintenance costs are not current captured with SMS data

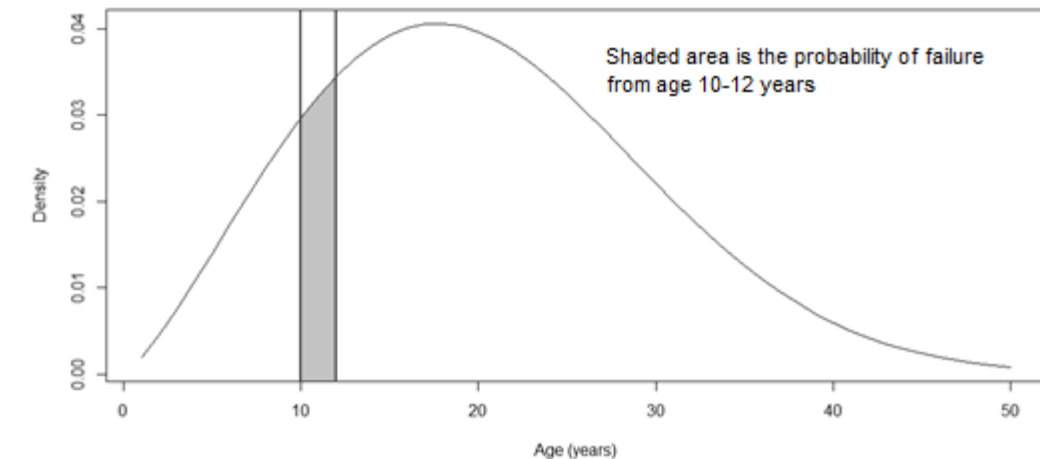
Preventative Maintenance Costs:

1. Short-term: Use a \$/sqft approach, based on RSMeans data
2. Medium-term: Use inventory and recommended PM actions to estimate costs
3. Long-term: Model costs from historical PM data



Emergency Repair Costs:

1. Use historical data to develop probability functions based on equipment age
2. Use probability, component value, and emergency repair premium to estimate cost





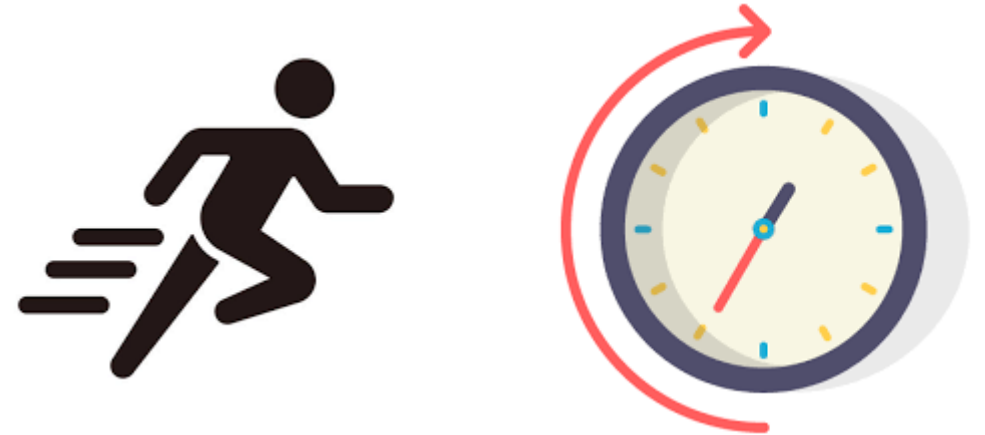
RUNTIME CONSIDERATIONS

What are the runtime requirements?

- At what level does the analysis need to run? (Facility, Installation, Service...?)
- How quickly does it need to return a solution? (Minutes, Hours, Days, Weeks...?)
- How far into the future will the model make projections? (3 years, 7 years, 10 years...?)

What are some ways to adjust run time?

- Algorithm selection ('optimal' vs. 'near-optimal')
- Different data structure
- Level of analysis (facility vs. component)
- Asynchronous calculation
- High-performance computing

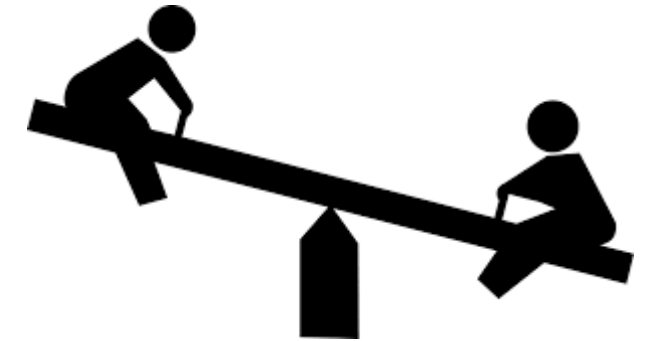




RUNTIME TRADEOFFS

What priorities are most important? These may conflict with each other:

- Speed
- Optimality
- Scope



Example: we may have to sacrifice speed for optimality or scope

- A nonlinear optimization approach may require longer runtimes (**speed**) to reach 'near-optimal' solution (**optimality**)
- **Scope** may need to be reduced (e.g., 5 years instead of 10 years) to have a reasonable runtime **speed**



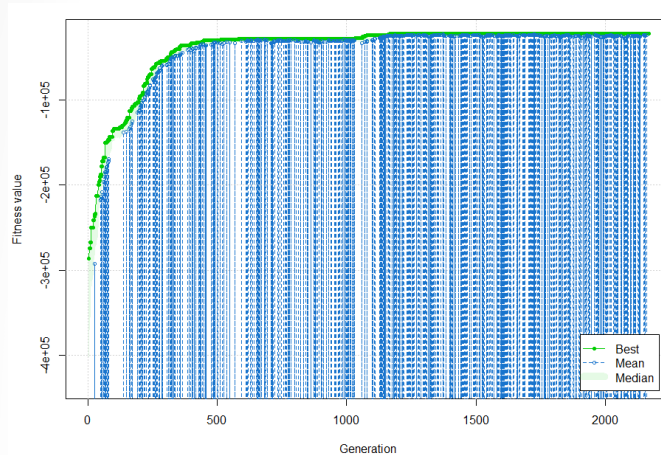
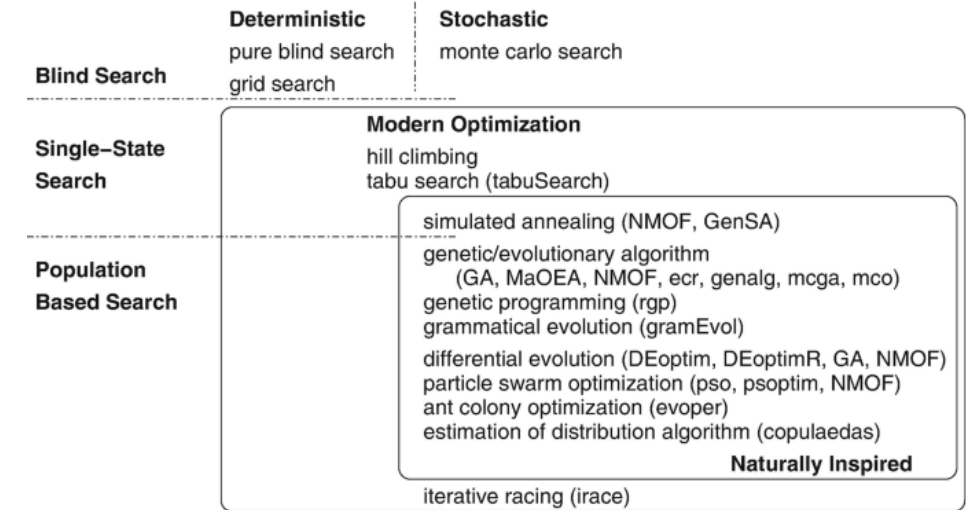


COMPUTATIONAL OPTIMIZATION METHODS



Many different approaches to optimization, each with tradeoffs

- **Linear program:**
 - Fast, guarantees optimal solution
 - Often difficult to frame complex problems into a LP
- **Mixed integer linear program**
 - Guarantees optimal solutions w/ discrete decisions (repair, replace, etc.)
 - Tends to not scale well
- **Nonlinear program**
 - Lends itself to complex problems
 - “Near-optimal” and depends on runtime allowance
- **Machine learning**
 - May generate clear policy decisions (renovate when BCI=X)
 - May be data and runtime extensive



Define metrics of interest using same data and computing platform

- **Scalability metric:** runtime to find a solution
- **Performance metric:** convergence to the same solution on multiple runs



REINFORCEMENT LEARNING

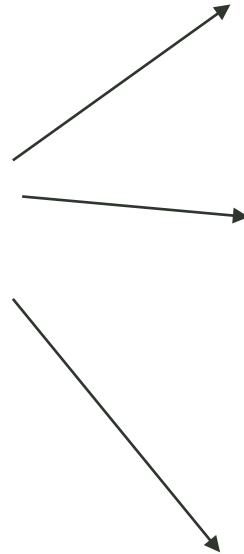
Observation

Action

Reward



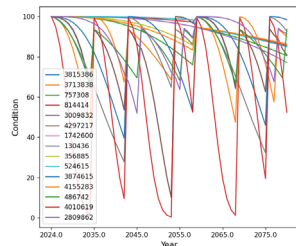
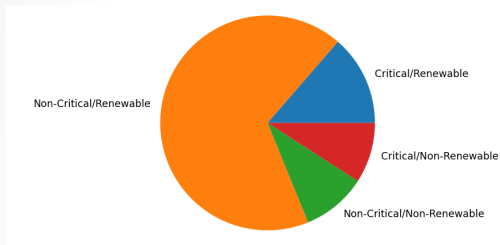
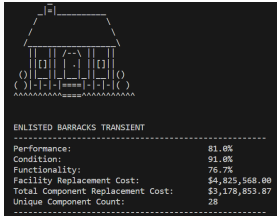
“Sit!”





REINFORCEMENT LEARNING

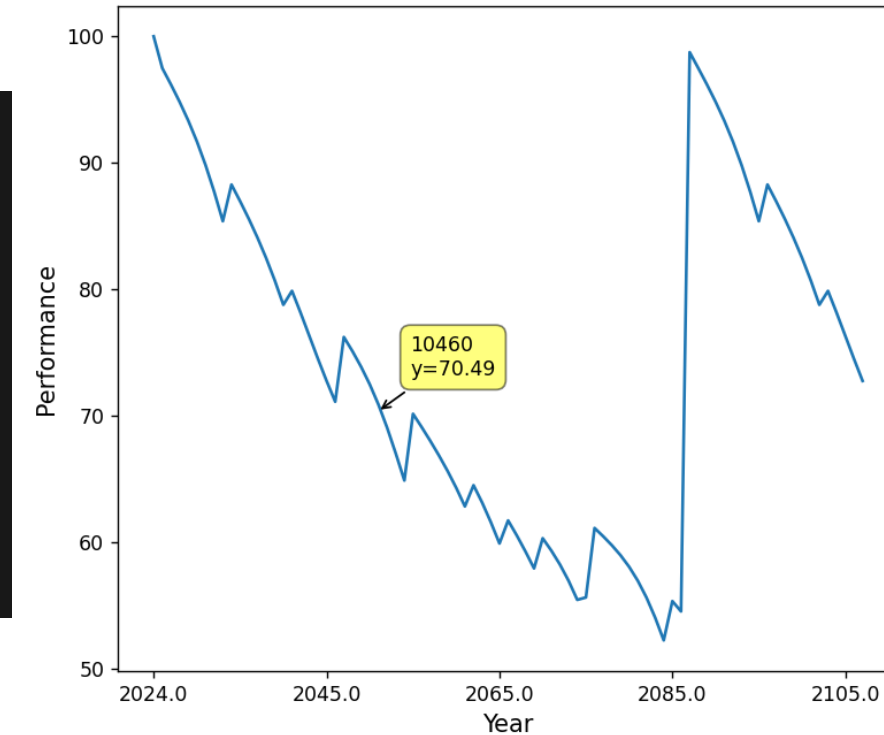
Observation



Action

Do Nothing
Facility Demolition
Facility Replacement
Facility Restore and Modernize
System Restore
>> Full Sustainment
Reduced Sustainment
Minimum Sustainment

Reward



THANK YOU!

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