

MANAGING SYSTEM OF SYSTEMS RISKS: CAPABILITY PLANNING WITH UAF

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SYSTEM ENGINEERING V-MODEL



My System of Interest



ARCHITECTURE OF SYSTEM OF SYSTEMS

System of systems (SoS) key characteristics:

- Operational independence of constituent systems
- Managerial independence of constituent systems
- Geographic distribution
- Emergent behavior
- Evolutionary development process





AC/DC Converter

Electric Bus



To describe a System of Systems architecture, an architecture framework is needed.



UAF IS A STANDARD...

• To develop architectural descriptions



- in commercial industries, federal governments and military organizations
- Applied for many different use cases:
 - System of Systems engineering,
 - Enterprise as a System engineering
 - Cyber-Systems engineering
 - enabling Digital Transformation Planning
- Developed by Object Management Group (OMG) with the leadership from Dassault Systemes and Lockheed Martin
- Is an international ISO standard ISO/IEC 19540:1 and ISO/IEC 19540:2
- Current version of UAF specification is 1.2
 <u>https://www.omg.org/spec/UAF/1.2/About-UAF/</u>



OMG UNIFIED ARCHITECTURE FRAMEWORK M	Motivation Mv	Taxonomy Tx	Structure Sr	Connectivity Cn	Processes Pr	States St	Sequences Sq	Information ^c If	Parameters ^d Pm	Constraints Ct	Roadmap Rm	Traceability Tr
Architecture Management ^a Am	Architecture Principles Am-Mv	Architecture Extensions Am-Tx ^e	Architecture Views Am-Sr	Architecture References Am-Cn	Architecture Development Method Am-Pr	Architecture Status Am-St		Dictionary Am-If	Architecture Parameters Am-Pm	Architecture Constraints Am-Ct	Architecture Roadmap Am-Rm	Architecture Traceability Am-Tr
					Sum	mary & Overview Sr	m-Ov					
Strategic St	Strategic Motivation St-Mv	Strategic Taxonomy St-Tx	Strategic Structure St-Sr	Strategic Connectivity St-Cn	Strategic Processes St-Pr	Strategic States St-St		Strategic Information St-If		Strategic Constraints St-Ct	Strategic Deployment, St-Rm-D Strategic Phasing St-Rm-P	Strategic Traceability St-Tr
Operational Op		Operational Taxonomy Op-Tx	Operational Structure Op-Sr	Operational Connectivity Op-Cn	Operational Processes Op-Pr	Operational States Op-St	Operational Sequences Op-Sq			Operational Constraints Op-Ct		Operational Traceability Op-Tr
Services Sv		Services Taxonomy Sv-Tx	Services Structure Sv-Sr	Services Connectivity Sv-Cn	Services Processes Sv-Pr	Services States Sv-St	Services Sequences Sv-Sq	Operational Information Op-lf	Environment	Services Constraints Sv-Ct	Services Roadmap Sv-Rm	Services Traceability Sv-Tr
Personnel Ps	Requirements Rq-Mv	Personnel Taxonomy Ps-Tx	Personnel Structure Ps-Sr	Personnel Connectivity Ps-Cn	Personnel Processes Ps-Pr	Personnel States Ps-St	Personnel Sequences Ps-Sq	Resources	En-Pm-E and Measurements Me-Pm-M	Competence, Drivers, Performance Ps-Ct	Personnel Availability Ps-Rm-A Personnel Evolution PS-Rm-E Personnel Forecast Ps-Rm-F	Personnel Traceability Ps-Tr
Resources Rs		Resources Taxonomy Rs-Tx	Resources Structure Rs-Sr	Resources Connectivity Rs-Cn	Resources Processes Rs-Pr	Resources States Rs-St	Resources Sequences Rs-Sq	Information es Rs-If	Risks Rk-Pm-R	Resources Constraints Rs-Ct	Resources evolution Rs-Rm-E Resources forecast Rs-Rm-F	Resources Traceability Rs-Tr
Security Sc	Security Controls Sc-Mv	Security Taxonomy Sc-Tx	Security Structure Sc-Sr	Security Connectivity Sc-Cn	Security Processes Sc-Pr					Security Constraints Sc-Ct		Security Traceability Sc-Tr
Projects Pj		Projects Taxonomy Pj-Tx	Projects Structure Pj-Sr	Projects Connectivity Pj-Cn	Projects Processes Pj-Pr						Projects Roadmap Pj-Rm	Projects Traceability Pj-Tr
Standards Sd		Standards Taxonomy Sd-Tx	Standards Structure Sd-Sr								Standards Roadmap Sd-Rm	Standards Traceability Sd-Tr
Actual Resources Ar			Actual Resources Structure, Ar-Sr	Actual Resources Connectivity, Ar-Cn		Simulation ^b				Parametric Execution/ Evaluation ^b		

VIEWPOINTS FOR CAPABILITIES DEPLOYMENT PLANNING



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STRATEGIC VIEWPOINT



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STRATEGIC VIEWPOINT: DEFINING SOS PHASING

Phases for city bus depot modernization:





STRATEGIC VIEWPOINT: IDENTIFY REQUIRED CAPABILITIES



S DASSAULT SYSTEMES

DEVELOP SYSTEM OF SYSTEMS ARCHITECTURE



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SYSTEM OF SYSTEMS ARCHITECTURES

- Architectures for SoS:
- **Operational Architecture**: define requirements for capabilities implementation
- **Resource Architecture**: design solution architecture that enables capabilities and implements operational architecture
 - Service Architecture: capture service-oriented or functional architecture if needed
- Security Architecture: identify possible risks and threats in the architectures above and design how to mitigate them







SOLUTION ARCHITECTURE

- Defined in Resources viewpoint of UAF
- Individual **Solution Architectures** are created for each of actual enterprise phases
- Multiple alternative architectures may be created for the same phase, to experiment with possible solutions



Resource Architecture for Diesel and Tolleybus fleet

Resource Architecture for Electric Bus Fleet

SOLUTION ARCHITECTURE

Defined resource cofigurations enable capabilities from Strategic viewpoint



PLANNING CAPABILITIES DEPLOYMENT



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PROJECTS VIEWPOINT: PROJECTS AND MILESTONES

• Projects and their milestones enable capabilities deployment

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Project Name	Start Date	End Date	2017	2018	2019	2020	2021	2022	2 0 23	2024	2025	2026	2027	2 0 28	2029	2030	2031
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🖂 🚸 Electric Bus Infrastructure : Infrastructure Depl	Jan 1, 2023	Dec 31, 2024			, , , , , , , , , , , , , , , , , , ,	⊱ Electric B	us Infrastru	cture 🕻	Y								
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🚸 Train Staff : Infrastructure Deployment	Jun 3, 2024	Dec 31, 2 0 24						······	Train Staff	<	ç						
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5 🔶 Utilize Electric Buses : Infrastructure Retiremen	tJan 1, 2030	Feb 10, 2031											+\$\$+ Uttil	ize Electric	Buses 🧹	\searrow	×

PLANNING CAPABILITIES DEPLOYMENT



RESOURCES VIEWPOINT: RESOURCES EVOLUTION

- Versions of configuration timeline for urban transportation
- Separate resources architectures are defined for each of them



RESOURCES AVAILABILITY: APPLYING MILESTONES

• Project milestones assigned to resources define for what period of time resource is

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1	🔗 Bus Yard Deployed	liService	2024-11-02	💩 Electric Bus Maintenance	
2	🔗 Charging Stations Deployed	InService	2025-05-15	Charging Station	
3	🛷 Diesel Bus Maintenance OutOfService	OutOfService	2025-01-01		🔊 Die el Bus Maintenance
4	🔗 Electric Bus Staff Trained	InService	2024-12-31	餐 Park Operator Ph2	
5	🛷 Elecric Bus Staff Retired 📊	OutOfService	2030-01-01		餐 Park Operator Ph2
6	🔗 Electric Buses InService 📕	InService	2025-01-01	🐟 Urban Transportati in Ph2	
- 7	🗇 Electric Buses Obtained	InService	2024-10-03	💿 Electric Bus Fleet	
8	🛷 Electric Buses OutOfService	OutOfService	2029-12-31		👋 Urban Transportation Ph2
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			2000 01-01		Charging Station
					🕅 Park Operator Ph2



STRATEGIC PHASING

- Resource configurations implement capabilities
- Resource availability is defined by applied project milestones

Full Electric Bus Fleet		💷 🗹 Show Capabi	lity Icons		
Start: Jan 1, 2025		Show Horizo	otal Grid Lines		
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C Transportation by Electric Bus			🔉 Electric Bus Fleet 🛭 🐟 Urb	an Transportatio	
C Dispatch and Operate Electric Bus			🕅 Park Operator Ph2		
C Maintain Electric Bus			🕈 Electric Bus Maintenanc	e	
Charge Electric Bus			Charging Station		
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IMPACT ANALYSIS

- Changes of the milestone dates impact availability of resources
- This may cause delay of capabilities deployment



Capability is not available when needed



TAKE AWAYS

- SysML does not provide enough tools for system of systems (SoS) modeling
- Unified Architecture Framework (UAF) is widely used for SoS and Enterprise Architecture modeling
- UAF is used not only to define SoS architecture, but also for capabilities deployment planning
- UAF can help understanding SoS milestones, resources availability, plan capability deployment





