Model-based Approach in Defense Portfolio Management: Data Preparation, Analysis, and Visualization of Decision Spaces

20th Annual Acquisition Research Symposium
Naval Postgraduate School

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Acknowledgment

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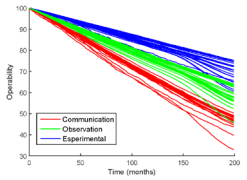
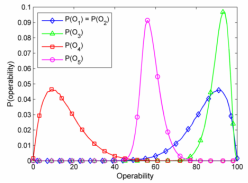
Research Question and Issues

- **Question**: How can we develop prototype tools to enhance <u>data-driven decision-making</u> for the DoD's Integrated Acquisition Portfolio Review (IAPR) process?
  - Utilize the portfolio-centric approach
  - Enhance and adapt an existing research product called the System-of-Systems Analytic Workbench (AWB), which consists of various tools

System Operational Dependency Analysis (SODA)

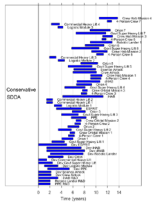
- Which systems are critical to SoS performance?
- What is the impact of system failures during operations?

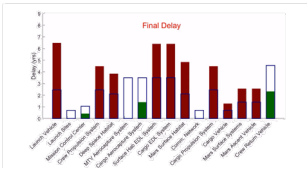




System Developmental Dependency Analysis (SDDA)

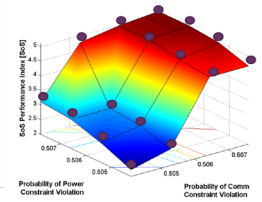
- What is the impact of delays?
- Which technologies need to be prioritized?





Robust Portfolio Optimization (RPO)

- Treat SoS as a portfolio of systems
- Mathematical programming to identify best portfolio

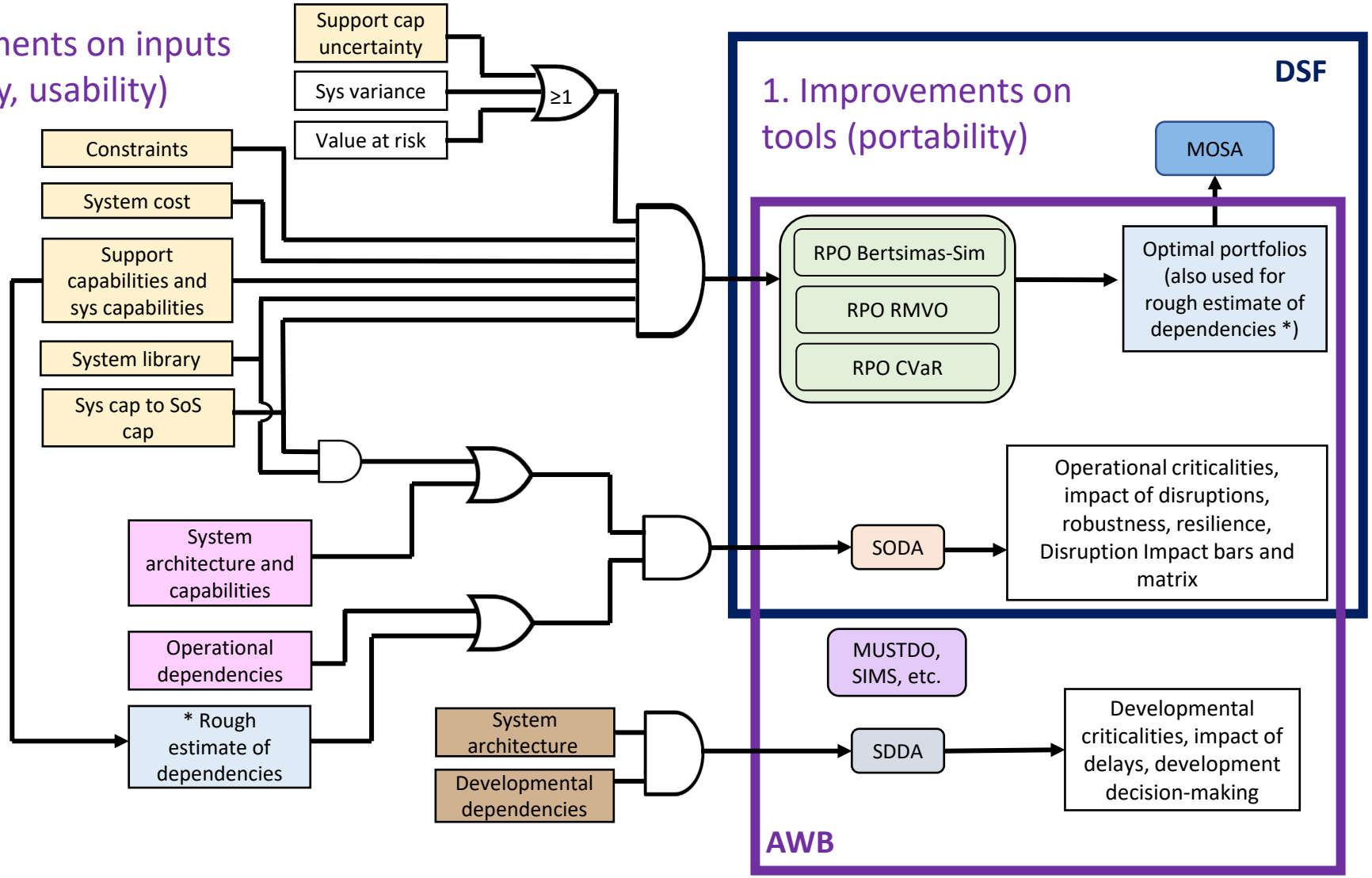


Multi-Stakeholder Dynamic Optimization (MUSTDO)

- How do we coordinate planning between local and SoS-level stakeholders?

Prototype Tools I/O and relationships

2. Improvements on inputs (extensibility, usability)



3. Improvements on outputs (usability)

Legend

- Method
- All input required
- Input from RPO/DSF Excel spreadsheet
- Input from SODA Excel spreadsheet
- Input/output
- Alternative input
- Rough estimation of SODA parameters based on support capabilities
- Input from SDDA Excel spreadsheet

Research Methodology

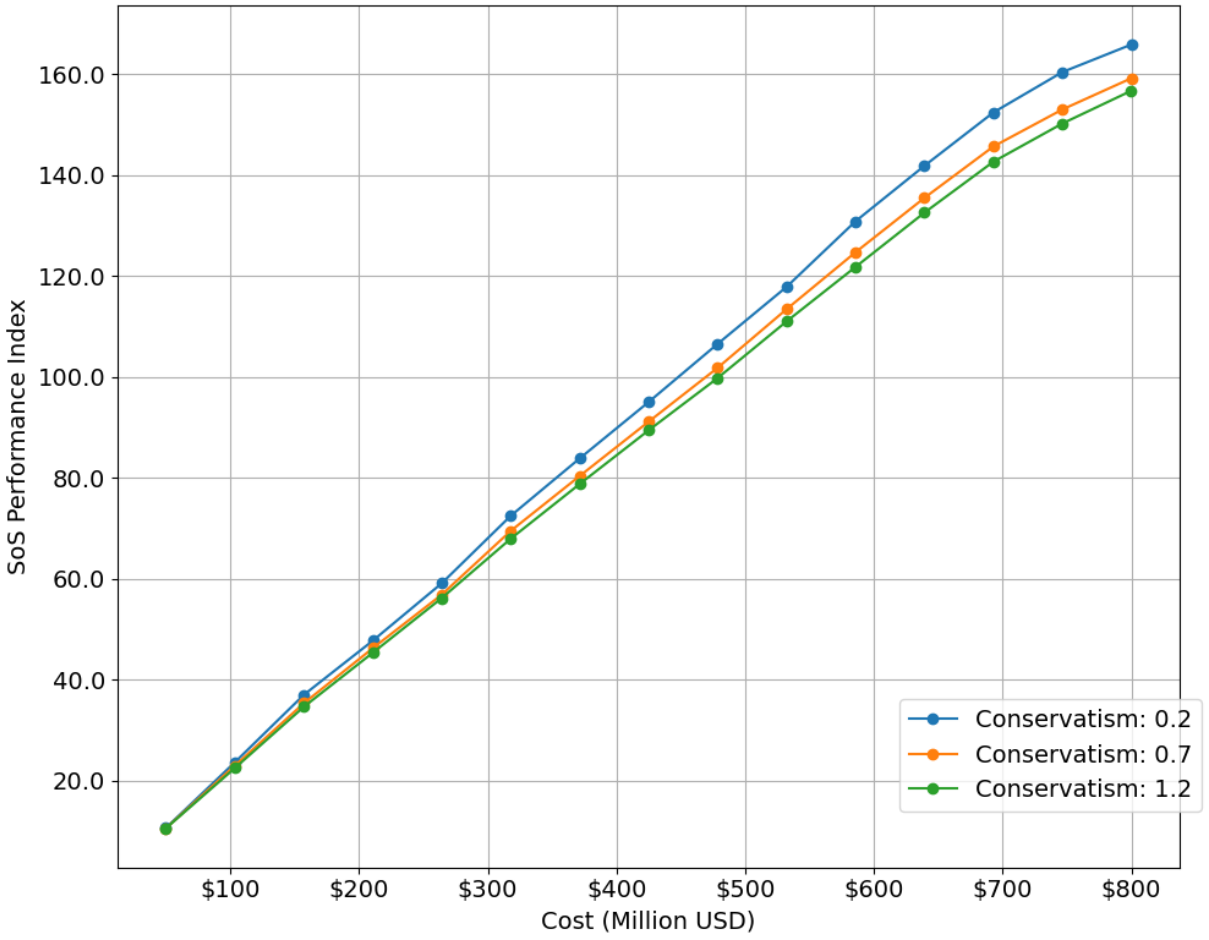
AWB interoperability, extensibility, and usability upgrades:

- RPO
  - Migrate RPO to a fully Python-based application (previously, MATLAB license required)
  - Provide I/O data control and validation methods
  - Integrate RPO into a controlled Python product with available pip and Anaconda packages
  - Add unit and integration testing, static code analysis, and implementation of CI/CD
  - Convert the input for RPO into compact JavaScript Object Notation (JSON) file (previously, MS Excel)
  - Provide interactive interface for I/O using Jupyter Notebooks
- SODA
  - Integrate SODA into a controlled Python product with available pip and Anaconda packages
  - Add unit and integration testing, static code analysis, and implementation of CI/CD
- SDDA
  - Integrate SDDA into a controlled Python product with available pip and Anaconda packages

Application

- Apply a notional anti-surface warfare (ASuW) scenario to demonstrate the application of the prototype tool

Results

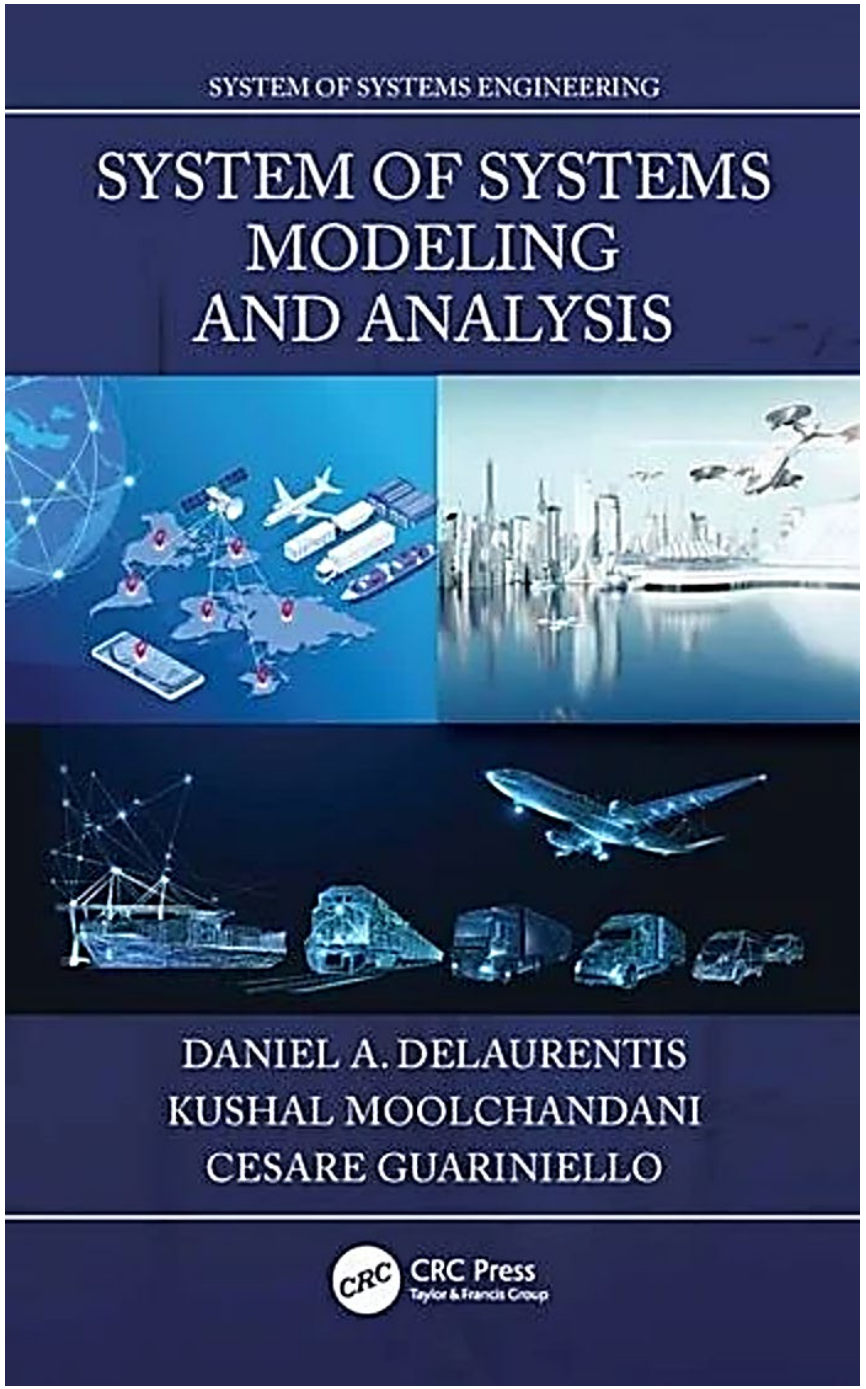


Alternative	0	1	2	3	4	5		39	40	41	42	43	44
Objective Value	10.7	10.7	10.7	22.6	22.2	21.8		159.6	157.6	156.5	169.5	166.7	164.6
Cost	$ 50.00	$ 49.94	$ 49.96	$ 103.53	$ 103.53	$ 103.57		$ 746.40	$ 746.36	$ 746.42	$ 800.00	$ 800.00	$ 800.00
Max Conservatism	0.2	0.7	1.2	0.2	0.7	1.2		0.2	0.7	1.2	0.2	0.7	1.2
Legacy SAR Satellite	0	0	0	0	0	0		1	1	0	0	0	0
Small SAR Satellite	1	1	1	2	2	2		5	5	8	8	8	8
EO/IR Satellite	0	0	0	0	0	0		0	0	0	0	0	0
Comm Satellite	2	2	2	4	4	4		20	20	20	20	20	20
MQ-4C	12	12	12	15	15	20		20	20	20	7	1	0
P-8A	4	4	4	3	4	4		4	4	4	4	4	4
EA-18G	0	0	0	0	0	0		0	0	3	1	1	1
F/A-18E/F	0	0	0	0	0	0		83	114	107	92	88	87
MH-60S	0	0	0	0	0	1		1	1	0	0	1	0
F-35B	0	0	0	8	8	0		0	0	0	0	0	0
F-35C	0	0	0	0	0	0		77	46	50	67	71	72
INDEPENDENCE (LCS-2)	0	1	1	0	0	1		0	0	0	0	0	0
FREEDOM (LCS-1)	1	0	0	0	0	0		0	0	0	0	0	0
ARLEIGH BURKE (DDG-51)	1	1	1	1	1	2		3	2	2	3	3	3
MAHAN (DDG-72)	0	0	0	0	0	0		0	0	0	0	0	0
OSCAR AUSTIN (DDG-79)	0	0	0	0	0	0		1	0	0	1	0	0
JACK LUCAS (DDG-125)	0	0	0	0	0	0		0	0	0	0	0	0
ZUMWALT (DDG-1000)	0	0	0	0	0	0		0	0	0	0	0	0
TICONDEROGA (CG-47)	0	0	0	0	0	0		0	0	0	0	0	0
BUNKER HILL (CG-52)	0	0	0	1	1	0		2	3	3	2	3	3
WASP (LHD-1)	0	0	0	1	1	0		0	0	0	0	0	0
AMERICA (LHA-6)	0	0	0	0	0	0		0	0	0	0	0	0
FORD (CVN-78)	0	0	0	0	0	0		2	2	2	2	2	2
AGM-84H/K	0	0	0	0	0	0		0	0	0	0	0	0
BGM-109 Blk V	5	5	5	0	0	28		145	174	179	211	228	230
RIM-174	0	0	0	0	0	0		0	0	0	0	0	0
AGM-158D JASSM-XR	0	0	0	27	25	0		99	61	60	77	66	61
AGM-158C LRASM	0	0	0	0	0	0		0	0	0	0	0	0
AGM-84D	6	6	6	6	7	7		174	236	221	191	183	113
AGM-84F	2	2	2	0	1	1		0	0	1	1	1	69
RGM-84F	8	8	8	16	16	16		48	40	40	48	48	48
AGM-119	0	0	0	0	0	0		0	0	0	0	0	0
RGM-184A (NSM)	1	1	1	0	0	1		0	0	0	0	0	0
AGM-114L	19	19	19	0	0	26		0	0	0	0	0	0
Navy Officer Personnel	64	66	67	133	137	109		864	847	863	849	851	854
Navy Enlisted Personnel	439	419	420	1277	1285	747		6668	6395	6409	6630	6655	6633
Navy Flight Personnel	9	11	12	15	19	15		171	173	180	183	175	174

Alternatives 6-38 were omitted from this figure

Conclusions and Future Work

- The research team adapted a previously developed SoS-AWB to inform decisions in IAPRs.
  - Improvements in usability and interfaces
  - Adaptation to various inputs
  - Modularization
- These advanced prototypes provide broader insights (e.g., resource tradeoffs, cost-sensitivity analysis, and the most robust ASuW systems to be acquired in specific portfolios) for the stakeholder's decision-making process.
- Future work will improve the tools to identify the following: how risk aversion affects portfolio optimization; technical dependencies among systems; developmental dependencies; and portfolio performance effects from stakeholder decisions.



Thank you

If interested, detailed description of AWB in:

DeLaurentis, Moolchandani, Guariniello
“System of Systems Modeling and Analysis”

(The first System of Systems college textbook)