Developing Logistics Strategy using Optimization with Uncertain Data:
The Marine Corps Assault Amphibious Vehicle Return to Condition Code Alpha (RCCA)

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NDIA 19th Annual Systems Engineering Conference
27 October 2016

Purpose

- Review the methodology and results from applying Multi-Criteria Decision Making (MCDM) and Optimization to the Marine Corps logistics strategy for the Assault Amphibious Vehicle (AAV) called RCCA – Return to Condition Code Alpha.

Outline

- Background of AAV and RCCA
- Initial RCCA Activities
- Multi-Criteria Decision Making
- Approach for RCCA – Physical Programming
- Process
- Metrics
- LPP Calculation Examples
- Results

Background - AAV

- Assault Amphibious Vehicle is the Marines' combat vehicle providing a ship-to shore amphibious and expeditionary capability.
  - First fielded in 1970's
  - Planned to be replaced by the Amphibious Combat Vehicle (ACV)
  - Needs to be supported through ~2025

- Depot-level maintenance strategy is IROAN – Inspect, Repair Only As Necessary
- Plan - Every AAV to go through IROAN ~6 years.

Logistics Issues and Solutions

- Current IROAN issues:
  - IROAN costs per vehicle are rising – optemp.
  - Years between IROANs per vehicle is increasing.
  - Parts lead-time and DMSMS impacting IROAN schedule. Vehicles taking more time to go through IROAN.
  - More parts replacements taking place.
- Question: How best to affordably maintain AAV until ACV is fielded.
- Answer – Return to Condition Code Alpha (RCCA)
  - Replace key components with high maintenance history with new parts – increase reliability.
  - Goal is to have vehicles only go to depot once before ACV replacement.
  - Be able to methodically plan for parts ordering.
  - Keep within a certain budget per vehicle. Easy planning and funding.
- Problem: Limited logistics records.
  - Reliant on Field Service Representatives' (FSR) corporate knowledge.

Initial RCCA Planning

- RCCA Team - Three main groups
  - Marine Corps Systems Command – AAV Program
  - Marine Corp Logistics Command – Weapon Systems Manager (WSM) and the two Marine Corps Depots – Albany and Barstow
  - Operating Forces – Field Service Representatives (FSRs)
- BOM selection.
  - Lack of per vehicle replacement data
  - Overall Parts order history – past 3 years
  - Used Depot-level TMs to define -120 major subsystems and components
- Option Determination with SMEs (FSRs, AAV, LOGCOM)
  - Per table review (table = components of a subsystem/component from a TM figure)
  - Used SME knowledge for initial recommendations

Issues with Initial RCCA Determination

- Cost - May need to scale back the list of components to be replaced, due to cost.
- Need to decide on other options (e.g. remanufacture, repair, inspection) for some components, and prioritize the options selected for decision makers.
- Issue – How do we assess objectively on what options to modify what RCCA does, as currently defined, within an uncertain data environment?
  - Answer – Multi-criteria Decision Making (MCDM)

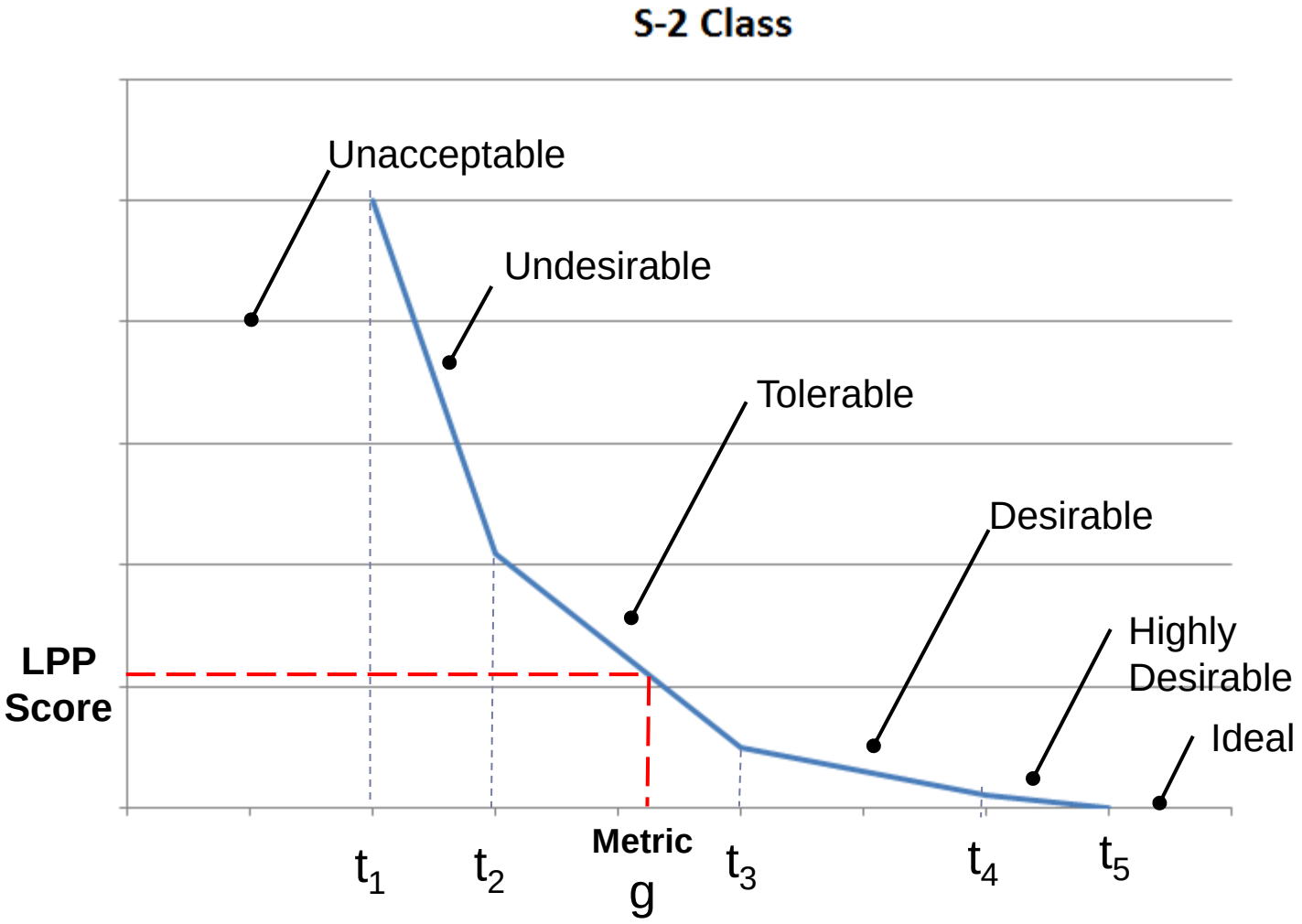
Mutli-Criteria Decision Making (MCDM)

- Most engineering problems and their COAs have many different and conflicting metrics.
- To assess different combinations of metric values, Multi-Objective Optimization (MOO) or Multi Criteria Decision Making (MCDM) are used.
  - Weighting methods are common, and the oldest:
    - Simple weighting
    - Analytical Hierarchal Process (AHP) – weighting determined through pairwise comparisons of attributes or metrics
    - Quality Function Diagrams (QFD)
  - Get a single score per option, taking all metrics into account.
- Problem with weighting: Subjective, prone to getting the answer you wanted, and can be time consuming (e.g. pairwise comparison)

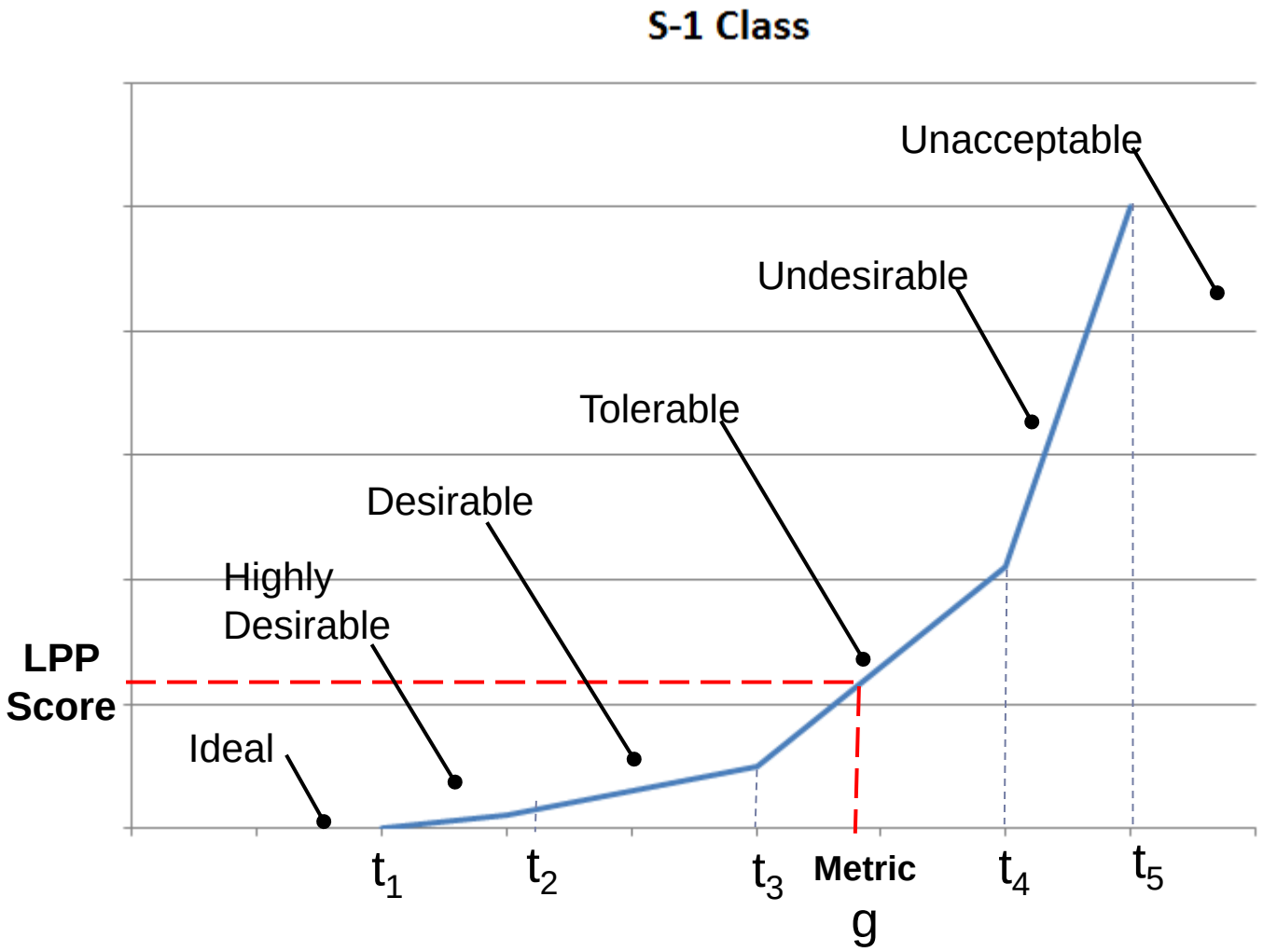
Linear Physical Programming

- Does not use the weighting of metrics
  - No discussions like cost more important than reliability
- Avoiding weighting subjectivity (e.g. Cost is weighted x3, reliability x2)
- Requires less stakeholder involvement. (e.g. pairwise comparison – 10 metrics would require 45 comparisons, 20 requires 180)
- Focuses on each individual metric, scoring how well a metric lands within various pre-defined ranges (ideal range down to unacceptable). Easier to be more objective.
  - E.g. CPD requires functionality provided to be between 85% (T) to 95% (O).
  - User preferences can be very granular.

LPP – "Bigger is Better" Metric



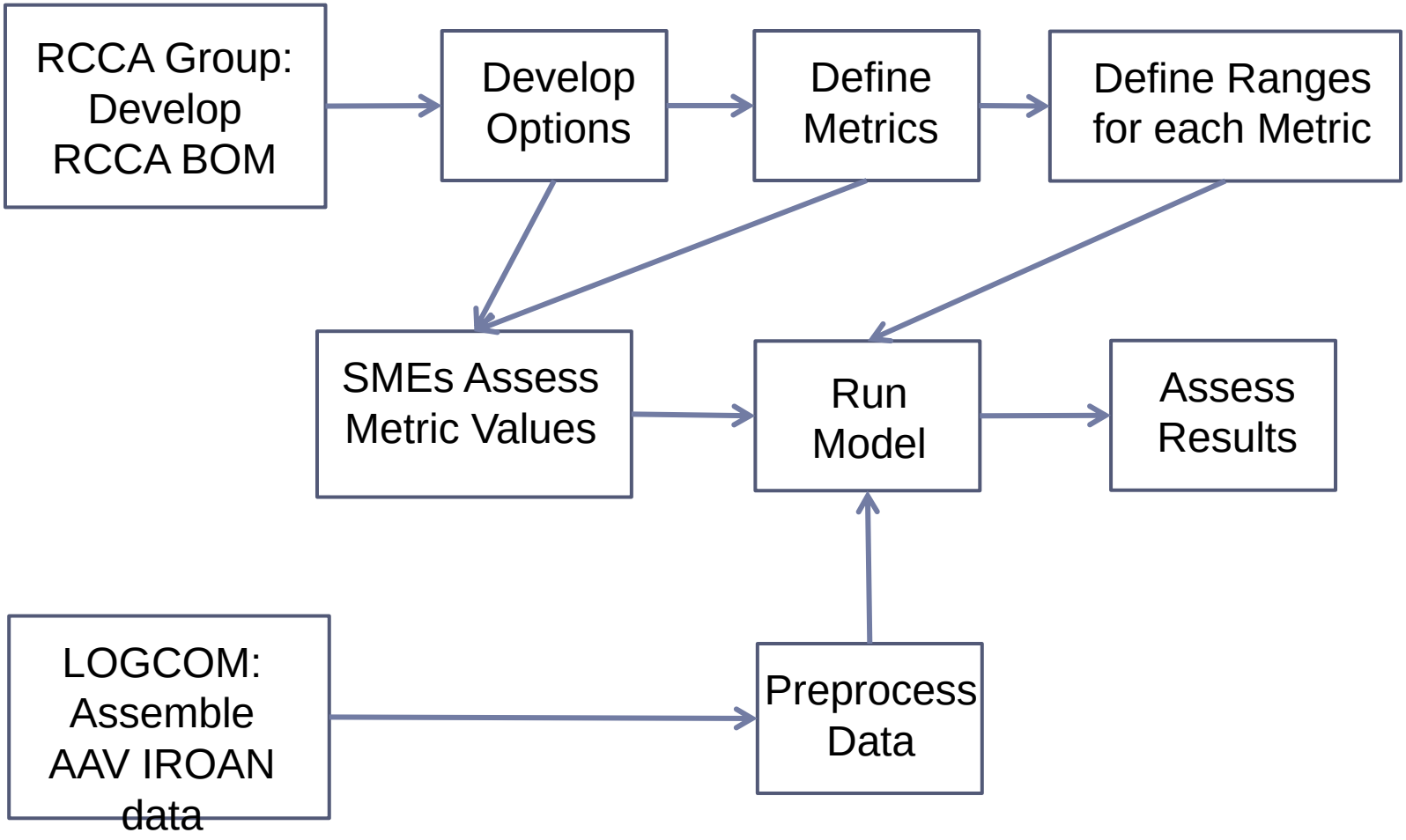
LPP – “Smaller is Better”



LPP

- The LPP methods favors a COA that has acceptable metric values for all metrics, rather than a COA that has a few outstanding metric values but many other metrics that have undesirable metrics results.
  - Acquisition Friendly: Reinforces COAs that meet all requirements, and helps avoid “gold-plating” at the expense of poor performance in other areas.
  - Analogy: LPP favors the all-around good basketball team, rather a team with a couple of superstars but the rest of the team being bad.
- Can use metrics where “smaller is better” (e.g. cost) or “bigger is better” (e.g. reliability)
- No special tools – implemented in MS Excel

Process


RCCA Group: Develop RCCA BOM
Develop Options
Define Metrics
Define Ranges for each Metric
SMEs Assess Metric Values
Run Model
Assess Results
LOGCOM: Assemble AAV IROAN data
Preprocess Data

Metrics

- Seven metric types developed by the group:
  - Per subsystem/table
    - Procurement Cost (Smaller is Better)
      - New Parts Acquisition
    - Labor (Smaller is Better)
      - Relative scale (0-10: No labor to extreme labor required)
    - Longevity (Bigger is Better)
      - Measured in Years.
    - Risks (Smaller is Better)
      - 0-3 low, 4-6 Medium, 7-10 High
      - Mission Performance Risk
      - Safety Risk
      - Supply Risk (Avg)
      - Supply Risk (Max)

Used after initial model run

All but the Procurement Cost metric was SME-

Proposed Metrics

- The seven metric types can be associated for specific subsystems or the overall vehicle.
  - (Radiator – Cost) and (Transmission – Cost) are two separate metrics
  - Ended with 532 metrics
- Can decide at any time what metrics you want to include or exclude in calculations to determine an overall score for each option.
- All options under consideration need to have the same metrics chosen for a consistent comparison.

Metric LPP Scales

	t1	t2	t3	t4	t5	Comment
Parts Cost	-2σ	-σ	μ	σ	2σ	The mean and stddev are calculated from the costs for components in that table for the various options (e.g. RCCA, IROAN, and "Do Nothing")
Labor	2	4	5	7	8	Across all tables, 2 is the best (Objective) value and 8 is the worst (threshold)
Longevity	1	2	3	4.5	6	Across most tables, 6 is the best (Objective) value and 1 is the worst (threshold) value. In some instances (e.g. engine), the objective can go up to 10.
Mission Risk	2	4	5	6	8	Across all tables, 2 is the best (Objective) value and 8 is the worst (threshold)
Safety	2	4	5	6	8	Across all tables, 2 is the best (Objective) value and 8 is the worst (threshold)

Ranges for the metrics was done by SME consensus. The ranges do not limit what the actual metric values may be. For instance, a component may have a longevity of 10 years, but the max the group saw needing optimally was 6 years

Major Options

- The model has assessed the following RCCA COAs/Options, considering all 532 metrics:
  - RCCA – used the RCCA BOM that replaced all components on the list
  - Min IROAN – Conducted IROAN, using average parts costs mined from depot data. Sometime RCCA options are used on a table-by-table basis if metric values do not meet the predetermined threshold.
  - Optimal – Per table, the optimal option is selected using the 5-7 metrics associated with a table.
  - Optimal with Longevity (2-6) – Using the optimal COAA as a basis, the optimal per table option is selected that meets or exceeds the longevity target. This provides 5 different RCCA COAs/Options.

Internal Table Optimal Choice

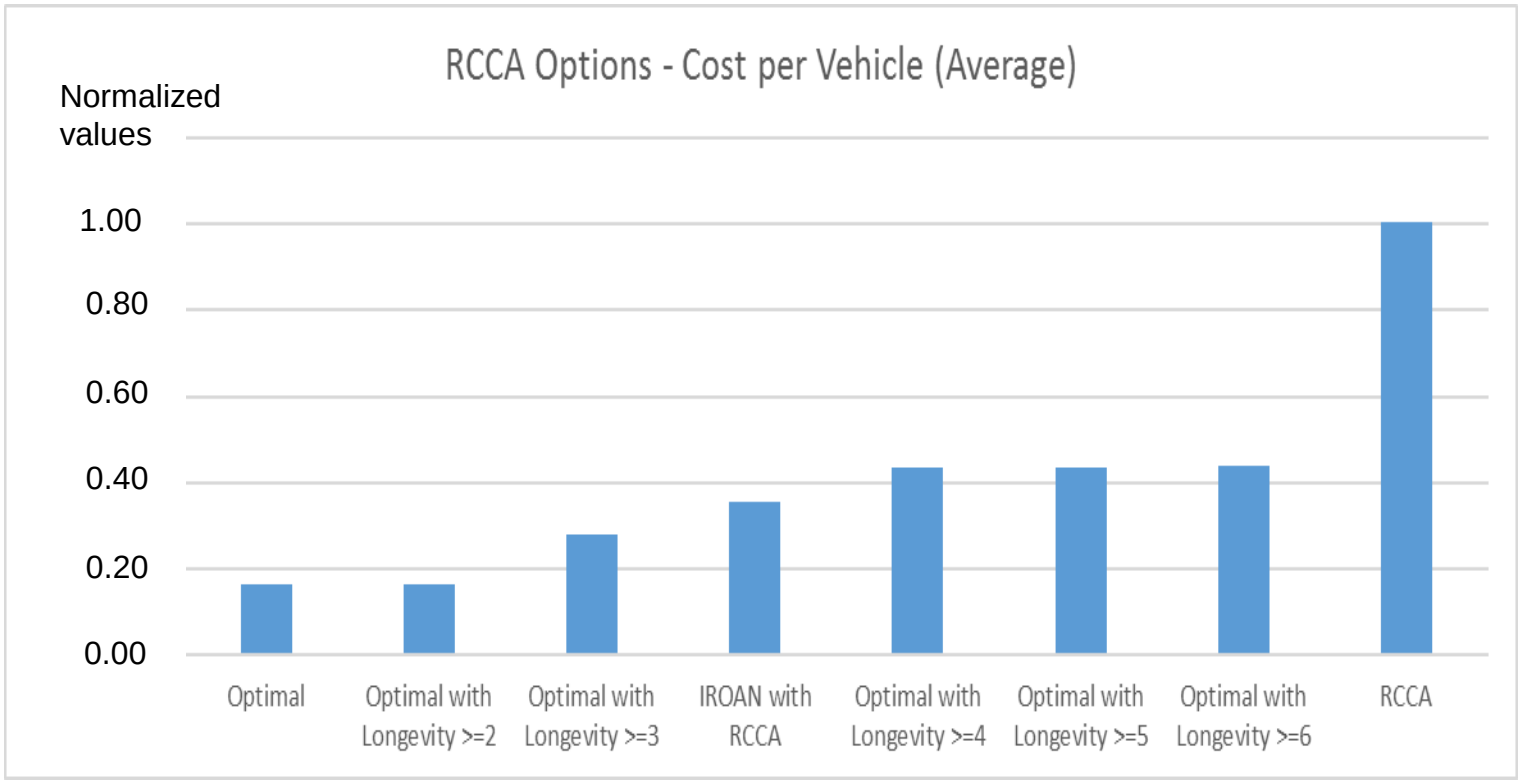
				RCCA BOM		MIN IROAN		Do Nothing	
#	Table	Metric Name	Description	Metric Value	LPP Value	Metric Value	LPP Value	Metric Value	LPP Value
1	Table 3-1	Cooling System Hoses, Tubes, and Fittings-Cost-Parts	Parts Cost	$150.43	1.21	$247.65	4.02	$0.00	0.09
2	Table 3-1	Cooling System Hoses, Tubes, and Fittings-labor	Labor	1.00	0.00	5.00	0.70	0.00	0.00
3	Table 3-1	Cooling System Hoses, Tubes, and Fittings-Longevity	Longevity	6.00	0.00	6.00	0.00	2.00	4.30
4	Table 3-1	Cooling System Hoses, Tubes, and Fittings-Mission-Risk	Mission Risk	1.00	0.00	1.00	0.00	7.00	15.10
5	Table 3-2	Radiator-Cost-Parts	Parts Cost	$5,755.33	7.23	$1,101.66	0.47	$0.00	0.25
6	Table 3-2	Radiator-labor	Labor	1.00	0.00	8.00	25.90	0.00	0.00
7	Table 3-2	Radiator-Longevity	Longevity	6.00	0.00	6.00	0.00	2.00	4.30
8	Table 3-2	Radiator-Mission-Risk	Mission Risk	1.00	0.00	3.00	0.05	7.00	15.10

Table	Name	RCCA	MIN IROAN	Do Nothing	1st	2nd	3rd
Table 3-1	Cooling System Hoses, Tubes, and Fittings-Cost-Parts	0.020848	0.168411	0.322473	RCCA	MIN IROAN	Do Nothing
Table 3-2	Radiator-Cost-Parts	0.214826	0.355473	0.323347	RCCA	Do Nothing	MIN IROAN

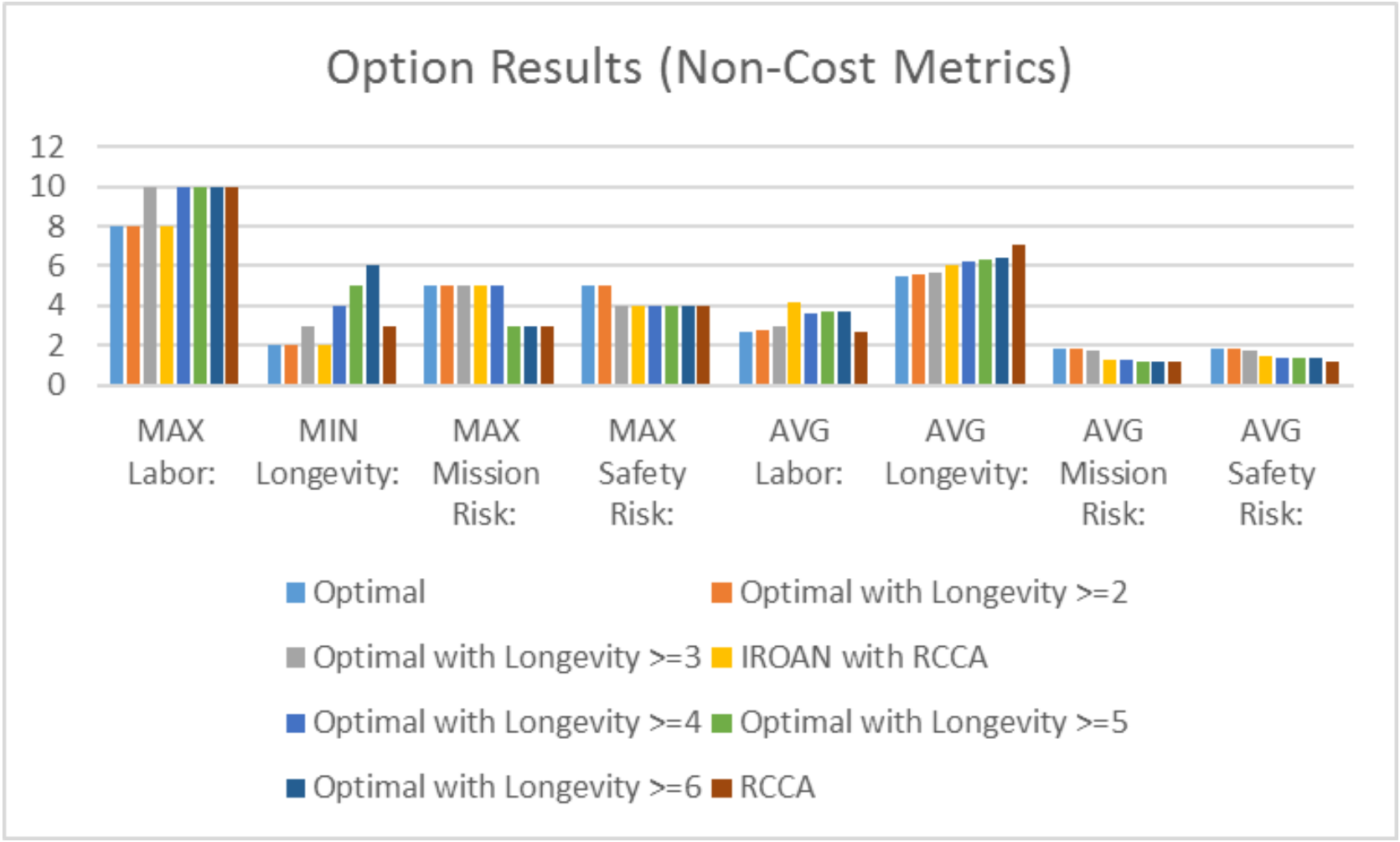
Example: Optimal Option Results

Table	Metric Name	RCCA	IROAN with RCCA	Optimal	Optimal with Longevity >=2	Optimal with Longevity >=3	Optimal with Longevity >=4	Optimal with Longevity >=5	Optimal with Longevity >=6
Table 11-1	ELECTRICAL SYSTEM INSTALLATION	RCCA	RCCA	RCCA	RCCA	RCCA	RCCA	RCCA	RCCA
Table 11-3	INSTRUMENT DISTRIBUTION BOX	RCCA	MIN IROAN	MIN IROAN	MIN IROAN	MIN IROAN	MIN IROAN	MIN IROAN	MIN IROAN
Table 11-4	LIGHTS AND HORN	RCCA	MIN IROAN	MIN IROAN	MIN IROAN	MIN IROAN	MIN IROAN	MIN IROAN	MIN IROAN
Table 11-4a	VANEAXIAL FANS	RCCA	MIN IROAN	Do Nothing	Do Nothing	Do Nothing	MIN IROAN	MIN IROAN	MIN IROAN
Table 11-5	ELECTRIC BILGE PUMP	RCCA	MIN IROAN	MIN IROAN	MIN IROAN	MIN IROAN	MIN IROAN	MIN IROAN	MIN IROAN
Table 11-6	INDICATOR PANEL	RCCA	MIN IROAN	MIN IROAN	MIN IROAN	MIN IROAN	RCCA	RCCA	RCCA
Table 11-7	POWER TRAIN CONTROL ASSEMBLY	RCCA	MIN IROAN	OPT 2	OPT 2	OPT 2	OPT 2	OPT 2	RCCA
Table 12-1	FUEL SYSTEM INSTALLATION	RCCA	RCCA	Do Nothing	Do Nothing	Do Nothing	RCCA	RCCA	RCCA
Table 13-1	COMMUNICATION SYSTEM COMPONENTS	RCCA	RCCA	RCCA	RCCA	RCCA	RCCA	RCCA	RCCA
Table 13-2	EPLRS Components	RCCA	MIN IROAN	MIN IROAN	MIN IROAN	MIN IROAN	MIN IROAN	MIN IROAN	MIN IROAN
Table 13-3	TACTICAL NAVIGATION DIGITAL SYSTEM - LITE	RCCA	MIN IROAN	MIN IROAN	MIN IROAN	MIN IROAN	MIN IROAN	MIN IROAN	MIN IROAN
Table 13-4	DAGR	RCCA	MIN IROAN	MIN IROAN	MIN IROAN	MIN IROAN	MIN IROAN	MIN IROAN	MIN IROAN

Initial Option Results - Cost



Option Results – Non-Cost Metrics



Observations

- The key metric types that show the most variation in the results are cost and minimum longevity.
- Average IROAN costs, per NSN, are usually much lower than RCCA replacement costs.
- The group was able to provide metric values for items, like labor, for which current hard data has not been processed to use in a model that uses individual NSNs.
- There is a large mix of replacement, IROAN, and “Do nothing” selections when assessing actions at the table level.
- There is not much cost difference between COAs with a minimum longevity from 4-6 years.