Future MCM System-of-System Study

Appendix B: Models: Maturity and Availability

Overview:

In order to compare the numerous multi-vehicle system concepts that were developed in this study with equivalent performance metrics, one of the study goals was to evaluate the systems and theirs components (vehicles, sensors, communications, …) with common performance assessments tools and common assessment methodologies. Given the scope of the study, It was understood that this goal might not have been completely achievable, but, with this goal in mind, during the course of this study, a number of specific software tools or models were selected, modified, and developed to assess these systems concepts, their components, and their tactics.

The level of maturity of the models varied from very mature models to first-time one-of-a-kind models. that The more most mature set have been used in numerous Navy system evaluations and COEA's while the later were specifically developed to assess particular concept that was being investigated during in this study. Because of the wide variety in the levels of maturity, there is a wide variety in the level of availability of the various models and software tools.

This appendix, each of the major models will be briefly discussed along with its maturity level. When appropriate, a point-of-contact (POC) is provided for either information about the model or access to use it. In general, there are four levels of maturity and availability. At the highest levels are the models that have been developed over many years and have been used in many systems evaluations and studies. At the next level are models that were either recently developed and have been used in one or two activities or are slight modifications of more established models. The next lower level are the models that were significant modifications of existing models and could be applied to other systems concepts, but would require some "local expertise". The last and lowest level of maturity and availability are those models that were developed explicitly for a specific piece of this study that would be difficult to use by anyone outside the study group.

Sensor Performance Models:

The acoustic sensor performance prediction models were some of the most mature and most available models used in the study. These are available from their parent agencies and can be used, with permission, to model a variety of

sensor configurations in a variety of applications. These models include a sensor detection sonar performance the prediction model, **Mineray3**. **Mineray3** can be used to predict the signal-to-noise ratio (SNR) and detection probability of targets in a specified environment (w/ water depth, SVP, bottom type, sea state, …) with specified sonar configurations (e.g. f_o, bandwidth, beamwidths, steering angles, ….). **Mineray3** is available from the Applied Research Laboratories at the University of Texas (ARL:UT). Information can be obtained at the website www.arlut.utexas.edu/~asdwww/xmineray/. For classification sonar prediction, NAVSEA, Panama City, Coastal System Station (CSS) has developed **SWAT** and **PCSwat**. These can be used to determine the SNR and classification probabilities of a specified sonar system in a specified environment. Information can be obtained from Gary Sammelmann at CSS.

Vehicle Endurance and Costing Model

Some of the models were adaptations of software packages that have been used in other studies or COEA's. This is particularly true for the **FMCM UUV Cost/Endurance Model** and the overall system performance models**.** The cost/endurance model is a spreadsheet that computes a UUV's endurance and cost based on user specified parameters (see Appendix A, paper 12). It calculates the endurance and cost of cylindrical UUVs given their size, energy components, and sensor selections. This model was based on the **LMRS Vehicle Endurance Spreadsheet** used in the LMRS COEA. The LMRS spreadsheet was modified to accommodate both large and small vehicle sizes used in this study, modified to accept a variety of acoustic search, classify, and identification sensor packages that were specifically design for each size option, modified to accept other standard sensor packages, and modified to accept a variety of navigation and communication packages. It was also significantly extended to incorporate costing information that was developed using **Price H**, a commercially available cost estimation software package. Together the **FMCM UUV Cost/Endurance Model** provides the endurance and costing information that is used as inputs to the overall system assessments. Information about the **LMRS spreadsheet** and **Price H** is available from Bill Kujawa at JHU/APL. The **FMCM UUV Cost/Endurance Model** is currently tailored for the FMCM Study and is not in a form that it could be widely distributed, but it is a tool that could be adapted to other vehicle and sensor configurations for other applications. Point of contact for the overall cost/endurance model is Bill Kujawa at JHU/APL and for the acoustic sensor configurations, is Rick Bailey at ARL:UT.

System-of-System Performance Models (ACR & Mission Times)

Two modeling approaches were used to assess the overall system performance including area coverage rates (ACR), mission times, and system costs. Both approaches were based in the methodology and equations defined in the PEO(MUW) Instruction 3370. This instruction uses basic MCM parameters such probability of detection, probability of classification, probability of incorrect-classification, swath width, vehicle search speeds, vehicle availability time, transit times, and reacquisition times to estimate the area clearance rates or mission times of a particular system and sensor(s) configuration. The 3370 Instruction was developed for single platform systems. In order to use it in this multi-platform system study, existing implementations of the model had to be modified or extended.

The two modeling approaches were based on two different implementations of the 3370 Instruction. The first approach used two software modules UCPLAN and NUCEVAL to calculate most of the terms in the instruction and a spreadsheet to combine the terms and calculate the final MOE's. The second approach used a newer Matlab implementation of the 3370 Instruction to calculate complete pass through the equation in a single software module call. The UCPLAN/NUCEVAL/Spreadsheet approach was the earlier implementation of the 3370 instruction and was developed to investigate one system configuration, mission, and environment scenario at time in a multi-step process. The Matlab 3370 MCM Model is a newer implementation that computes the metrics in a single step and was developed to loop thru many scenarios in one invocation of the software module. Both models were modified or adapted to assess the multiple vehicle systems concepts developed in this study. Because of the diversity of the system concepts and their tactics, no single model was developed that could handed all the concepts, rather the models were adapted for each case.

UCPLAN and **NUCEVAL** are available from CSS. POC is Curtis McVey. The **3370 MCM Matlab mode**l is available from Rick Bailey at ARL:UT. The modifications of the models are not releasable in their current configurations; however, they could be adapted to assess a variety of system and/or sensor options.

Supporting Models

Numerous models were developed during the course of this study to investigate various questions are concepts that developed during the study. These models include

- Type I, LV & Bird-dog endurance model

- Number of SVs required in a Type I, LV/Bird-dog configuration
- SV travel times in a Type I, LV/Bird-dog configuration
- Neutralization Charge Placement, Size, and SV volume calculations
- Distributed control of SVs in a parallel track search

Most if these models are engineering work code and are not in a form that is releasable; however, most could be adapted or built upon to assess other system concepts. A general POC for these models is Charles Loeffler at ARL:UT.