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An Approach to Communications Modeling in the SIM II Naval Engagement Model at NUSC

A Paper Presented at the Military Applications Section of the Joint National Meeting of the Operations Research Society of America and The Institute of Management Science in Milwaukee, Wisconsin, 15-17 October 1979

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Preface

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An Approach to Communications Modeling in the SIM II Naval Engagement Model at NUSC

Introduction

--First vu-graph please--

AN APPROACH TO COMMUNICATIONS MODELING IN THE SIM II NAVAL ENGAGEMENT MODEL AT NUSC

LEWIS A. STALLWORTH

This is what I'm going to talk about today. To set the stage, I'd like to put things into perspective.

The modeling I'm going to talk about was done about three years ago as part of our Naval Warfare Simulation and Analysis work at the Naval Underwater Systems Center. Since then, I have seen several other warfare simulations (Air Force and Army, as well as Navy) at the Naval War College, other government laboratories, and in industry. The people using these simulations all know that communication is a vital factor in warfare analysis. Each of those simulations is said to be capable of handling many-on-many engagements. Yet none of them include models of communications.

On the other hand, there are many models of communications by themselves — some based on queuing theory, some on networks, and even some based on numerical integration of Maxwell's equations. None of those include more than the communications signals alone. They seem to be an end unto themselves.

To do a credible simulation of a more than one-on-one engagement demands that communications be included. We added communications models to our engagement model. As far as I know, our SIM II model is the only Naval Warfare simulation that does have communications models together with platform, sensor, and weapon models.

--Next vu-graph please.--

- MOTIVATION
- SIM II
- APPROACH
- COMMUNICATIONS MODELS

What I would like to do now is to tell you how we did this. I won't go into details of the models themselves. I'll stick mainly with our approach.

These are the major items I'll cover.

The *motivation* will give you a feel for why we did what we did. We'll see the kind of operational questions we were analyzing and the measures of effectiveness that we wanted to evaluate.

Then we will briefly look at the *SIM II* engagement model -- before we added the communications models and after. The emphasis will be on the changes in SIM II.

The *approach* will describe our philosophy and general methodology for modeling the communications process. There we'll see what the models are intended to do and, equally important, what they are not intended to do.

Next, I'll briefly describe the *communications models*.

--Next vu-graph please.--

SCENARIO ELEMENTS

- PLATFORMS
- SENSORS
- WEAPONS
- TACTICS (INDIVIDUAL)
- COMMUNICATIONS
- TACTICS (COORDINATED)

In simulating a Naval engagement, we think in terms of a scenario. These are the main elements of a scenario. There are *platforms* -- ships, submarines, airplanes, sonobuoys, shore stations , et cetera. *Sensors* allow the platform to find out what is going on in the world outside the platform. If a threat is sensed, a platform may do something. A *weapon* may be thought of as a special kind of platform. *Individual tactics* in the logic that controls the actions of a single platform during a simulation -- when the threat is detected, head toward it until you think you are close enough, then deploy your weapon -- that sort of thing.

The first four elements are sufficient to simulate a one-on-one engagement. When you get to more than a one-on-one scenario, you must also think in terms of *communications* and *coordinated tactics*. If you want your analysis to be credible.

Our version of SIM II includes all of those elements. Our work is focused on submarines. A few years ago, we became interested in how submarines might be used as part of a task force. All the scenarios were more than one-on-one. Questions came up about submarine communications:

- What information should be communicated?
- How should it be communicated?
- How much time delay can be tolerated?

We looked around and could find no engagement model that had communications in it. Since we had been using SIM II for other submarine warfare studies and were familiar with it, we decided to add the communications models to SIM II.

--Next vu-graph please.--

NEW FEATURES IN POST-COMMS SIM II

- COMMUNICATIONS
- MULTISENSORS PER PLATFORM
- SONAR CLASSIFICATION MODULE
- TMA MODULE
- MISC. (INPUT/OUTPUT, MATH SUBROUTINES, ETC.)

In the process of adding the communications models to SIM II, we made some other changes. This is a list of the major changes.

We added the *communications* models (which I'll talk about later).

In the old version of SIM II, a platform could have no more than one sensor. Each platform sensor combination had its own set of tactics. If you wanted to represent a submarine with three sonars -- say, an active sonar, a hull-mounted passive sonar, and a towed passive sonar, then you were forced to create three submarines -- one for each sonar. Each of the three submarines had its own set of tactics. They were given the same initial position, course, speed, and depth. Most of the time this worked, but as you suspect, it was a monster to set up and debug. The printed outputs were not very pretty either. The new version will handle *multiple sensors per platform* with one set of tactics but the debugging and outputs are still less than optimal.

We added some logic to make it easier to model the *classification of sonar* contacts.

The *TMA module* is a set of subroutines to model the target motion analysis and localization of passive sonar contacts.

We did some odds and ends to *improve the input and output* and we added some mathematical functions needed by other parts of SIM II.

SIM II is listed in some catalogs of simulation models. The Center for Naval Analysis catalog came out in September 1974. It is available from the Chief of Naval Operations (OP 03). The seventh edition of the joint Chiefs of Staff catalog came out in August 1977. It is available through the Defense Technical Information Center (formerly the Defense Documentation Center). The descriptions of SIM II in those catalogs refer to the precommunications version. SIM II with communications is not described in any of the catalogs.

--Next vu-graph please.--

SIM II

- TIME STEP DRIVEN
- SUBMARINE ORIENTED
- UNSTRUCTURED GROWTH
- IT WORKS

These are the gross features of SIM II.

It is *time-step driven*. At each time step, everything is calculated and updated. Every sensor on every platform is evaluated against every other platform in the simulation. The size of a time step is controllable. For a one-on-one scenario, this isn't much of a problem. For more than a one-on-one, it can be a problem. If a target and a weapon are interacting in one part of an engagement, small time steps are wanted. But with each small time step you get a lot of calculations and an awful lot of output that is not wanted.

SIM II is *submarine oriented*. This is because it was created and has been used almost entirely for submarine warfare studies. It could be used for surface and air warfare studies but much work would have to be done to model non-submarine sensors and weapons. We have modeled anti-submarine warfare aircraft like P-3's in SIM II but only as platforms. Their sensors were sonobuoys.

Since SIM II was created about fifteen years ago, *it has grown* -- mostly in response to a need to do a study. SIM II was modified, the study was done but the documentation of the modifications never got done properly.

However, the bottom line is that *SIM II works*. It is a most useful and necessary tool.

--Next vu-graph please.--

COMMUNICATIONS PROCESS

- DECISION TO SEND
- ADDRESSEES AND CONTENT
- CHOOSE CHANNEL

→ ANTENNA AVAILABILITY

→ PROPAGATION PATH

→ TIME DELAYS

- ACT ON MESSAGE CONTENT
- ACT ON INTERCEPT

Now let's leave SIM II and get into communications modeling. These are the events that occur in the communications process. Some purists might argue that these events are more than the communications process. They are a subset of Cee cubed,or command, control, and communications. Be that as it may, this is how we view the communications process.

The top three and lower two events in the communications process are not explicitly included in our communications models. We use the SIM II capabilities and treat them in the tactics programming logic. The three events indicated with arrows are included in our communications models.

Now let's walk down this list of events in the communications process.

In setting up a scenario, the tactics programmers identify the circumstances that result in a *decision to send* a message. Usually, a message is generated when one platform detects a threat and a different platform should react to the threat. This includes directed intercepts and "heads up" or "look out, he's coming your way" messages. The decision to send-logic also sets up the standard *addressees and message content*.

The tactics programmers also create a communications plan for the scenario. This establishes the links and nodes by assigning communications *channels* to the various platforms.

Having composed a message and decided to send it on some channel, the first question is: Is there a transmit *antenna available*? For non-submarine platforms, this is not a problem. For submarines using electromagnetic channels, it is. There are some speed and depth conditions that must be satisfied in order for a submarine to be able to transmit. The same is true of receiving antennas on submarines. I'll say more about submarine antennas in a minute or two.

After the antenna tests are passed, we then check to see if a *propagation path* between the transmitter and each applicable receiver exists. This includes the addressees of the message as well as ESM equipped platforms on the other side of the engagement. For ESM, the communications signals is only available for a preselected length of time. This represents the on-the-air time. The content of messages detected by ESM is not revealed to the interceptor.

Having passed the propagation path test, addressees get the message after an appropriate *time delay*. This time delay is intended to represent the processing time of the originator and the addressee. It is the brain-to-brain delay. The time delay can be different for each channel. For each message on a channel, the time delay may be fixed or it may be perturbed.

When a message is *received or intercepted*, the tactics logic takes over again to cause the recipient to do something.

Roughly speaking, our communications models deliver the mail. They do not write the mail and they do not read the mail. The fact that the communications models do not automatically create messages was a big disillusionment to our analysts. However, they recovered and have become proficient in using SIM II with communications.

--Next vu-graph please.--

SUBMARINE ANTENNAE

- MAST MOUNTED
- TRAILING WIRE
- BUOY SYSTEMS
- ACOUSTIC

As I mentioned earlier, SIM II is submarine oriented. We use four broad categories to describe submarine antennas.

To use a *mast-mounted antenna*, a submarine must be at periscope depth or less. At that depth, a mast is raised to get the antenna out of the ocean. Being at the surface to communicate on a mast-mounted antenna means that the submarine is not at the best depth for use of his sonar sensors.

***Trailing wire antennas* are streamed out behind and above the submarine. They have less communications ability than mast-mounted antennas but they allow the submarine to be deeper. They also impose some restrictions on the submarine's maneuvering freedom.**

***Buoy systems* come in a variety of forms. They all wind up floating on the ocean surface and using electromagnetic means to communicate through the atmosphere. Some broadcast a tape recorded message. Some have an acoustic link in the water. Some are tethered to the submarine and have an antenna lead to the submarine. The communications models in SIM II can handle any buoy system.**

***Acoustic* communications uses sonar sensors to send and receive messages.**

--Next vu-graph please.--

COMMUNICATION CHANNEL MODELS

- SATELLITE
- LINE OF SIGHT
- HIGH FREQUENCY
- VERY LOW FREQUENCY
- EXTREMELY LOW FREQUENCY
- ACOUSTIC
- PERFECT

This is the menu of communications channels. In any scenario, more than one of each can be used. Each channel is assigned a time delay when the scenario is set up. The time delay may be fixed or it may be calculated from a pre-assigned probability function each time a message is sent on that channel.

The *satellite channel* assumes that a communications satellite is properly positioned so that a path always exists.

The *line-of-sight channel* is just that. Altitude adjusted lines of sight are calculated. If the communicating platforms are within line-of-sight distance, a path exists. If they are not, communications are not possible at that time.

The *high frequency channel* is a cookie cutter for mobile platforms. The size of the cookie is adjusted for aircraft altitude. Shore stations are assumed to always be able to communicate on the high frequency channel.

The very *low frequency model* assumes that the transmitter is a shore station. The receivers are submarines using a trailing wire or a mast-mounted antenna. The signal strength at the ocean surface in the scenario is input from another model. Reception is affected by sea state.

The *extremely low frequency model* is similar to the very low frequency model -- a shore transmitter and a trailing wire receiving antenna.

The *acoustic channel* uses our sonar sensor models and I won't go into that.

The *perfect channel* is just that -- perfect communications with no time delays. We use perfect communications together with no communications to assess the sensitivity of the outcome of a simulation to communications.

--Vu-graph off please.--

This SIM II engagement model with communications has been used for quite a few studies. The results were found to be very useful. Much of this usefulness would not have been possible without the communications models as part of the total simulation. I suspect that other places will find a need to include communications in their simulation models and that some of you will be involved in the development or will have to use what is developed. I hope that these remarks will be useful for you then.

Are there any questions?

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