Maritime Drug Interdiction Utilizing UAV Surveillance

Introduction

Since the mid-1970's, the U.S. has invested billions of dollars on counter-drug programs with the objective of reducing the flow of Latin American sourced illicit drugs into the U.S. Past interdiction methods included stricter cross border control and targeting crop sources in Latin America. A current counter-drug program, Operation Martillo, administered by Customs and Border Protections (CBP) Air and Maritime division utilizes 3 MQ-9 Predator Unmanned Aerial Vehicles (UAVs), seen in Figure 2, to help in the counter-drug war efforts. To increase effectiveness of programs like this, network modeling and optimization techniques have been applied to determine the best observational stationing of UAVs in the Gulf of Mexico, increasing the probability of detecting and interdicting drug cartels maritime routes used to smuggle cocaine.

Background

Operation Martillo is a partnership between the U.S. and various European and Latin American countries comprised of a multinational, interagency, and joint military operation that combats aerial and maritime drug trafficking off the coast of Central America. So far in 2013, through the efforts of Operation Martillo, forces have been able to seize approximately $571 million (street value) of cocaine.

Drug smugglers from Latin American countries can transport cocaine to the United States along maritime routes through the use of container ships, commercial fishing vessels, recreational vessels, and go-fast boats. Traffickers also have increasingly used self-propelled semisubmersibles (SPSSs) to transport cocaine from South America to Mexico. The use of SPSSs allows traffickers the ability to covertly transport large quantities of drugs making it more difficult for counter-drug units to detect.

Figure 1 – Drug Smuggling Activity

The model designed for use with the MQ-9 Predator (UAV), currently in service with the Custom and Border Protection, to detect maritime drug smuggling activity. The MQ-9 increases the probability of detection of the hard to spot SPSSs and is a key asset used to interdict drug cartels exploiting maritime routes. The endurance of the MQ-9 Predator UAV is rated up to 30 hours with a range of 400NM and maintains command and control from a network of ground control stations across the country. The MQ-9's command and control network is capable of communicating with any counter-drug unit across multiple agencies making it an ideal component for the war on drugs.


Figure 2 – MQ-9 Predator

Network Model

Targeting maritime smuggling routes is relevant due to recent intelligence showing drug traffickers shifting to Caribbean Sea routes in response to the increased pressure on trafficking in Mexico and Central America. The model objective is to minimize drug movement of cocaine and effectively position UAVs based on predicted maritime drug trafficking routes from Latin American countries. A Max Flow Network Model was utilized and modified to incorporate random shortest path properties.

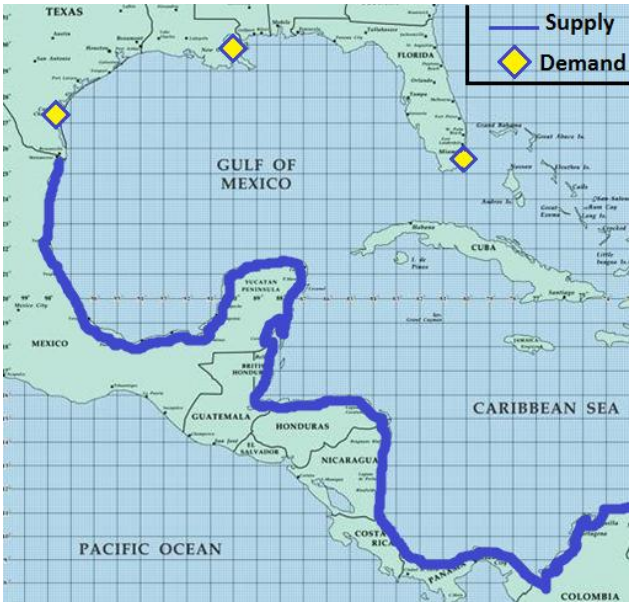

Figure 3 - Network Graph

The models nodes split into three categories, demand, supply, and transit nodes. Demand nodes include Corpus Christi, TX, Miami, FL, and New Orleans, LA, based on the assumption that U.S. demand is contained to those specific geographic areas. All demand nodes are connected to neighboring transit nodes and to an End node. Supply nodes (53 in total) are evenly distributed along the Eastern side of Mexico, Central America, and the northern edge of the South American Coast and are connected to a Start Node. Each supply node consist of any square along the Latin American coast line as illustrated with the blue line shown in Figure 3. Transit nodes are the boxes over water formed by 1x1 degree longitude and latitude lines in the Gulf of Mexico and Caribbean region. The distance between each degree of latitude and longitude is 60 nautical miles. All Transit nodes are connected to neighboring nodes unless there is a body of land that prevents a maritime route across it. For example our model does not allow maritime traffic across Cuba. The network forces maritime traffic to go around Cuba and similar bodies of land.

Model Assumptions

Some assumptions were made to simplify the construction of the network model. The first assumption applied was that drug smugglers travel from multiple supply nodes to three demand nodes via a random shortest feasible path, as describe above. The second assumption was that the predicted flow pattern represents an average flow through the area based on the amount supply pushed through by the model. The third model assumption was that the distribution of cocaine along all supply nodes along the Latin American coast line was equally distributed. This assumption is quite flexible and simple to adjust to current intelligence, but in a base model allows for a wider flow spread pattern of possible routes for analysis. Additionally, a Profit verses Distance argument applies that drug smugglers who bring the cocaine larger distances, receive bigger profit shares. The fourth model assumption made was that UAVs are available to be on station 24/7 and that the UAVs assigned to only one node have a 100 percent detection effectiveness of drug running vessels transiting through the UAVs' station. The fifth assumption is that the UAVs fly at undetectable attitudes decreasing drug smugglers' ability to react and change routes quickly. The last and final important assumption was that an interdiction cannot take place within a distance less than 60nm off the coast; this allows time for an interdiction team to be notified and respond to an intercepting location.

The Interdiction

The Interdiction portion of the analysis aimed at applying the Max Flow model to actual applications as if making recommendations to the task force directly. In the advancement of this effort, a short list of "rules" limiting some abilities of the responding force as well as the behavior and effectiveness of the UAVs.

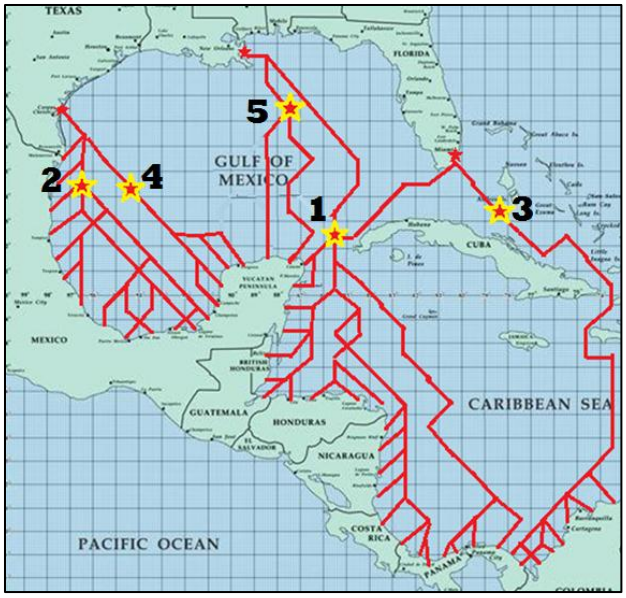

Figure 4: Drug flow and the 5 best interdictions in order

Interdiction Rules

- UAVs can be assign 1 to multiple nodes to survey
- Probability of detection is assumed as 1 when assigned a single node and is reduced to 1 divided by number of nodes assigned if more
- UAVs never participate in apprehension and remain undetectable
- Apprehensions occur away from UAV station
- No Interdictions with 60 miles of US Coastline
- UAV yearly mission cost is $18.4 Million per UAV

The initial results from interdicting with one thru five UAVs, is depicted in Figures 4 thru 6. Figure 4, shows the location and order of the UAV placement. Figures 5 and 6 show the cost per pound of cocaine seized and the marginal/total effectiveness of each additional UAV. The specific results in Figure 4 only are important as the starting point; the real benefit is in the actual application. The specific locations identified, if used singularly, would be soon avoided by drug runners after some time period.

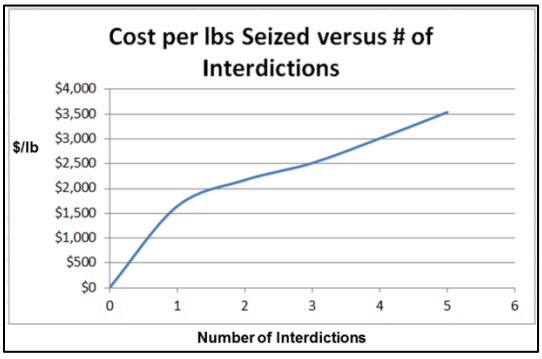

Figure 2:

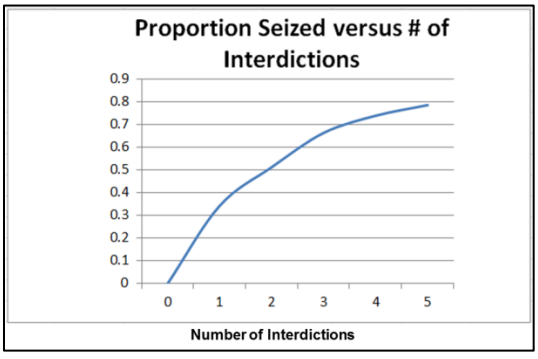

Figure 3:

The real strength in the entire analysis and model is its robust nature, ease of adjusting the "rules," ability to then complete follow up analysis, and then compensate for drug running path changes. For example the shortest path property for large systems is not a unique property. Thus multiple high probability locations could be generated iteratively and game theory applied to create random stationing that would provide best a possible stationing/interdiction plan, which in turn would be difficult for drug runner to avoid. Although this analysis is still in the infancy stage, it is very easy to see how with a little effort an extremely useful tool has been developed to deal with a real life application.