Decision Analysis - Analytical Decision Making

Problem 1: Hohman Case

At 4:00 P.M. on the 14th of July, 1972, Captain Virgil Sandford, master of the oil tanker **Nancy M. Hohman,** was considering what action he should take regarding a malfunction of his ship's engine. The **Nancy M. Hohman**, known as the **Nancy**, is a ship of British registry with 28 crew members and had been bound from Rotterdam, The Netherlands, to the Persian Gulf to take on a load of 200,000 tons of crude oil. At the time the engine malfunctioned, the **Nancy's** position was 9 miles off the coast of South Africa, just out of Port Elizabeth. Port Elizabeth, however, was too small and shallow a port for a ship the size of the **Nancy,** even when empty, to enter. The nearest port with repair facilities capable of accommodating a ship of the **Nancy's** size was Durban, South Africa, about 380 nautical miles to the east. Captain Sandford, who was known for "doing things by the book" and "running a tight ship," immediately broadcast an advisory of his ship's location and condition as a warning to other marine traffic to avoid her. Almost immediately, the captain of the **Ann-Marie**, a large seagoing tug, sent a message to Captain Sandford:

We have heard your broadcast and advise that we are standing by to offer our services to assist you to Durban. We lie at Port Elizabeth and can reach your position within an hour of your call.

Captain Sandford acknowledged the **Ann-Marie's** message without either accepting or rejecting her offer. He knew that tugboats like the **Ann-Marie** often cruised these waters hoping to find an oil tanker or other commercial vessel in difficulty. With the closing of the Suez Canal in 1967, the passage around southern Africa had become the most heavily travelled sea route in the world. Also, since the days of the legendary **Flying Dutchman**, the waters off the South African coast had been known as a graveyard for ships. Indeed, the complex currents and severe southern winter storm season from April to September had claimed a number of oil tankers in recent years with resultant loss of life and widespread pollution of the local seas by the oil cargos on board.

While Captain Sandford was relieved that the **Ann-Marie** was available, he felt that there was still a good chance of taking his ship into Durban under her own steam. This was desirable because, if he commissioned the tug to tow the **Nancy** to Durban he would be giving the **Ann-Marie** a claim to his ship. In other words, accepting the tow was tantamount to abandoning ship. Under international law, then, the **Ann-Marie** could gain legal salvage rights to the **Nancy,** a $40-million vessel less than one year old. In practice, however, salvage tugs were rarely awarded the salvaged ship in cases like this. More commonly, the owners of the towed ship paid an indemnity to the owners of the tug. This tended to avoid lengthy (and very costly) international litigation. The size of the indemnity that would be paid was subject to negotiation between the owning parties and usually took several months after the fact to settle. Some recent settlements of this sort had amounted to about 15 percent of the cost of the ship.

Captain Sandford paused to take stock of the situation. Gordon O'Donnel, chief engineer of the **Nancy**, reported that he felt that there was an 80 percent chance that he could make temporary repairs to the engine that would hold until they reached Durban. Top speed with these repairs would only be about 8 knots, about half of the normal top speed. Captain Sandford estimated that, under these conditions, he could put the **Nancy** into Durban in three days.

The weather that the **Nancy** could expect to encounter over the next three days was very important to Captain Sandford's decision. Consulting the South African weather service in Port Elizabeth, Captain Sandford found that the forecast for the next three days was for continued fair weather. His

previous experience with the reliability of nautical weather forecasting made him uneasy, however, Sandford felt that, despite the favourable forecast, there was still about one chance in five that bad weather would develop sometime during the next three days. In the event of bad weather, sufficient power was required of the engines to maintain steerage in rough seas. Captain Sandford felt that, given bad weather, the **Nancy** stood about one chance in four of being unable to maintain steerage. If she couldn't maintain steerage, the result would be the same as if the engine stopped completely in a bad storm. That is, the **Nancy** would very likely be sunk by the storm's heavy seas, with some loss of life. If steerage were lost, the probability of the ship pulling through bad weather was only about one in ten. Sandford commented on the situation to his first officer.

"If the weather holds, we'll make it to Durban if O'Donnel can get a patch job done on the engine. If he can't, we'll stand a 50-50 chance of foundering on the South African coast or drifting off into the Indian Ocean toward Australia. Of course, we could put into lifeboats if we approach the coast or otherwise, wait for a tow. If the weather turns bad, however, then I've got to decide whether to abandon her or try to ride it out. We should have enough time to make the coast in lifeboats if rough weather approaches and, if O'Donnel can't get the engine fixed, that's what we'll do. If we wait till a storm is upon us before abandoning ship, then half the crew would likely perish. Of course, if we tried to ride it out on the repaired engine and were unable to maintain steerage we'd all be lost as the ship went down. In any event, it's a good show that tug is lying in Port Elizabeth. If the weather turns or if O'Donnell can't get the engine going, I'll call her in."

At 10:00 P.M. about six hours after the engine malfunction occurred, the tug **Ann-Marie** pulled alongside the **Nancy** and signalled that she was sailing for Capetown to take a Liberian Freighter in tow. The message continued:

*If you want us to tow you to Durban you'd best say so now for we'll be gone several days. Also, Captain Sandford, there are no other tugboats in this area that are large enough to be of any help to your ship save the **Ann-Marie.***

With that, the **Ann-Marie** opened her throttle and moved westward toward Capetown.

Captain Sandford quickly called the engine room. He found that engine repairs would be completed within three hours - too late to recall the **Ann-Marie** if they were not successful. Further, Mr. O'Donnel was standing by his 0.8 probability estimate that repairs would be successful. Sandford knew that the master of the Ann-Marie was telling the truth about there being no other tugboats in the area to help the **Nancy** but he was not so sure about the story of a commission near Capetown. If the **Ann-Marie's** message were a ploy to get Sandford to accept a tow, then the tug might still be available in the event Mr. O'Donnel's engine repairs wouldn't hold or if the weather deteriorated unexpectedly. If the master of the **Ann-Marie** had been truthful (and Sandford felt that there was about one chance in four that the **Ann-Marie** actually have another job), then the **Nancy** was left to her own resources. As Sandford watched the receding lights of the **Ann-Marie** from the bridge of his ship, he knew that the responsibility for action in this situation was entirely his. He also knew that he would be held accountable for his decision before a ship owner's board of inquiry back in London if he either accepted a tow or if the **Nancy** were lost. For a moment he wondered how these financiers, sitting in their plush London offices, would react in this situation. Then, realizing that he had only about 30 minutes to recall the **Ann-Marie**, he began to concentrate on his decision.

Help the good Captain to make a decision. Note that some consequences of certain decisions may involve both a monetary impact and also possible losses of lives. Think of how you might deal with these two criteria by ascribing a dollar value for a human life.

Problem 2: Computer Disk Drives

You are the production manager for a firm which produces computer disk drives. You believe that, in a recent batch of drives, 10% are defective. A good drive installed nets the firm a profit of $300. If a bad drive is installed, it is reworked and replaced with a cost of $200.

The cost of reworking a drive before installation is $100, but rework yields a good drive for sure. A drive can also be tested for $25, and the test indicates "Pass" or "Fail".

Some drives which "Pass" are in fact bad, and some drives which "Fail" are good. Experience with the test indicates that a bad drive passes the test with a probability of 0.1, and a good one fails the test with a probability of 0.2.

What should you do?

Note: If you install a drive and it turns out to be defective, the cost to rework/install is 200, so the profit is 100. If you decide to rework before installation, the cost is 100, so the profit is 200 (i.e. 300-100).

Problem 3: Morris Manufacturing Company

On January 15, 2002, the monthly meeting of the Morris Manufacturing Company's Board of Directors was held at the company's offices in Hamilton. All four directors were present. From the chair, Charles Blake, the president of Morris Manufacturing began the meeting by informing the directors of the background of negotiations with the Dayton Electric Products Corporation. Dayton was a manufacturer of heavy-duty industrial equipment, and the home office and principal manufacturing facility was located in Vancouver.

"In 1995 Dayton asked us to determine whether a heavy-duty overhead crane with a 50-ton capacity could be built. The crane was needed to move one of a series of new generators from the construction area to the testing shop, a distance of about 600 feet. Our design engineer, John Stiles, did some figuring for us and wrote them that such a crane could be built for about $200,000. Dayton then decided not to make the capital investment at that time but to continue to use its old, but serviceable, crane. During the next 5 years we checked with them from time to time, and found varying degrees of interest in a new crane.

"Then last year Dayton indicated definite interest in resuming serious talks. We drew up some tentative plans based on the gauge, capacity, height, and other specifications of their overhead track, and sent the plans to Carl Mosley, Dayton's chief engineer. Mosley approved the plans and, as usual, we took this as an assurance that the track was a normal, level, industrial installation, permitting the proposed simple six-wheel design for the crane. In spite of a general increase in costs in the interim, John Stiles was able to submit again the original bid of $200,000. The order was placed, and our production costs finally turned out to be $150,000. The crane was shipped on September 25, 2001, on schedule.

"Unfortunately, Dayton's track foundation was not adequate for a six-wheeled crane of this capacity, and began to bend and crack. Dayton would not accept the crane and returned it at a cost of

$5,000 to us. John then undertook an engineering study and concluded that the cost of rebuilding the crane with a 12-wheel design would be about $160,000. A further review of the costs developed no useful shortcuts. On October 15, a revised total price of $350,000 was offered to Dayton.

"No firm reply was received by the end of October, so I arranged for a meeting with Dayton's general manager, Bob Hendricks, and Carl Mosley. John Stiles went to Vancouver with me, and the first thing we did was look at the damaged rails. They had already repaired the track and were again operating their old crane. Right away, we could see that the rail structure was completely inappropriate for the six-wheel design, and that it could not stand the pounds-per-square-inch loads generated by six wheels. Apparently that had not occurred to Carl Mosley, since their existing crane was of an "antique" 10-wheel design, and he figured that we would know how many wheels a crane should need. Well, we really should have inspected the tracks, since this rail design is as old as Dayton's crane.

"Hendricks said that he thought that $350,000 was a greater investment than Dayton couldconsider. He felt that a suitable crane should cost about $280,000, and thought that he could get a competitive bid for about that much. We left the meeting with the understanding that we would review the design to see if costs could be reduced enough to get below the quotation of October 15. Both Hendricks and Mosley indicated that there was "no big rush" for us, and I suspect that they may be willing to keep plugging along with that old dinosaur.

There was a knock at the door, and John Stiles entered. "I've asked John to give us some further information on this matter," Blake said, "and I would like to give the floor to him at this time."

"Thank you, Mr. Blake. We quoted Dayton a figure of $350,000 based on our present estimate of the costs of modification and the production cost of the original crane. Now, though, with an indication that a suitable crane at $280,000 would probably be acceptable to them, we could reconsider. But I would like to remind you that it would have been impossible to have built a 12-wheeled crane originally for $280,000. I would say that there is an even chance that we'd get the order at $280,000, since nobody else could build a 12-wheel for any less. At a lower figure of $220,000, say, I'd bet on a 90% chance of getting the order. At the higher price of $350,000 I'd say we'd have only a 25% chance of getting the order".

"What about trying to sell the crane to someone else, instead of trying to sell it to Dayton?" asked one of the directors.

"There's some chance of that." Stiles replied. "I know of another company, Stern Industries, that might take the crane off our hands. I'd guess there is a 30% chance they would purchase it-but the price we could get is a different matter. I'd say that three prices are possible: $100,000, $150,000, and $180,000. Presuming that Stern does, in fact, purchase the crane, I think the most likely sales price is $150,000; we have about a 7 out of 10 chance of getting that figure. The chances of only getting a price of $100,000 are about 2 in 10, and there is about a 1 in 10 chance we'd see the $180,000 figure. In addition to a lower selling price, another drawback is that just to get a salesman out there and to prepare the sale would cost us about $10,000, and *then* we're at the point I mentioned above of either getting the sale or losing it. Also, if we try initially to sell to Stern, we will eliminate any chance of selling the crane to Dayton.

"If we do decide to go all out in trying to sell the crane to Dayton, we're going to have to develop a good, revised design. I figure that this will cost us about $20,000. No matter what bid price we try, if they reject it, we can always try to sell the crane to Stern. With the time delay I'd guess that we'd have only a 15% chance of selling the crane to Stern. If we can sell it, I think that the price and chances that I mentioned earlier would be the same."

"How about scrapping this turkey, John?" asked Blake.

"I've been thinking about that, too. I think we should consider scrapping the crane at any point that things start looking too expensive and risky. We could salvage at least $50,000 from it, and we would certainly avoid a lot of uncertainty"

At this point Charles Blake thanked John Stiles, excused him from the meeting, and turned to the other directors. "As you might suspect, there is the possibility of pressing Dayton on the legal point that they studied and approved our plans for the initial crane, and that they, therefore, must accept the crane as designed. However, I think that this is a very poor idea, since the last thing we want to do is become involved in a lawsuit over this thing. There is the possibility that a growing company like Dayton will be a source of future business for us, but not if we sue them."

Perform a decision tree analysis of Morris Manufacturing decision situation using expected value, and indicate the appropriate decision(s) with this criterion.