Cost Avoidance for M&S Training Systems: A Subset of Return on Investment

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Introduction

There are two major facets of Return on Investment (ROI) calculations: cost and benefit (sometimes called results - Oswalt, Cooley, et al 2011). Much of the time in modeling and simulation (M&S) to completely account for all of the benefits requires assessing qualitative metrics and collecting measures of these metrics. These studies can be time consuming, potentially complicated, and sometimes difficult to ensure the metrics developed are measurable and completely cover the ROI space. As an alternative to a complete ROI study, there are times when studying only the costs, both the actual costs of the M&S system and the costs avoided by performing the same task without M&S, demonstrates and validates the worth of the M&S system without accounting for the all the benefits.

Main Cost Avoidance Calculations

This technique can't be applied in all circumstances and to all M&S systems. In assessing the applicability of cost avoidance there are several points to consider. First, for cost avoidance to validate the worth of an M&S system, the costs avoided should be the largest benefit, as measured in terms of dollars. Additionally, data must be readily available to calculate the costs avoided due to using the M&S system. Data must also be available to calculate the costs of using the M&S system. Again, at the very least, the most significant costs of operating the system must be available. In order to substantiate the worth of an M&S system both costs expended and costs avoided must be taken into account.

Much of the time a quick pre-study is necessary to determine the applicability of some of the statements above. For example, how do you know data is available for the most significant costs of an M&S system? This requires a small bit of investigation. Let's consider an indoor marksmanship trainer and the initial investigation into whether or not a cost avoidance study would be beneficial. The first step would be to determine the configuration of the system and what data is available. It is found that the system is fielded in multiple sites and the number of simulated rounds fired by weapon is available as well as the operations and maintenance (O&M) costs for the system itself. Armed with that information, you decide to obtain the data for one site, choosing a site that would seem to have a high usage thereby giving you insight into a higher percentage of total system usage. To make it a bit easier you choose only a small sample of weapons, perhaps one that is very common, such as the M-16 and one that might be fairly expensive to fire live, such as a shoulder mounted rocket. In gathering the data for this one site and one weapon you find that for one month there were 125,000 simulated M-16 rounds fired and 500 shoulder mounted rockets fired at this site and the people that gave you the data said that is a typical month. You also find that the cost per live round fired is $0.41 for the M-16 and $2,000 for the rocket and the O&M costs for that *entire* system at that site is roughly $100,000/month. Making a quick calculation you find that 125,000 * $0.41 + 500 * $2,000 = $1,051,250.00/month that would have been expended if those munitions had been fired live. Subtract from that the O&M costs (remember these costs are for the entire system at that site, not apportioned to just these two weapons) and you have a rough net cost avoidance of $951,250.00/month. It is then relatively easy to see that the costs avoided by using simulated fire and not live fire is probably going to be the most significant cost and even though there are some operational costs not included, it is most likely that a cost avoidance study is beneficial. The other operational costs are discussed in more detail below.

Finally, before starting any cost avoidance or ROI study it is worth noting that some systems may have a positive ROI, but whether they do or not, they are going to stay because of risk to personnel. For example, the USMC has several trainers that are used to help Marines escape underwater from HMMWV and Helicopter water crashes. If the cost of crashing a helicopter or HMMWV were taken into account, these systems would be cost effective. However, a cost avoidance study would not be considered given the fact that performing both of these exercises with a live crash would unnecessarily subject US Marines to a high risk of losing life or limb. Therefore, in this case, even a pre-study is probably not worthwhile.

This cost avoidance approach has recently been applied to some Department of Defense (DoD) training systems with a fairly high level of success. In the specific case of training systems, costs avoided are typically of the nature of expenses not incurred by performing the training live. In a very simple example, to validate the worth of a flight simulator, one of the main costs avoided is the cost of flying the aircraft for the number of hours of the simulator mission. This cost is potentially substantial. Suppose each live flight hour costs $15,000[1] and the average sortie is 1.5 hours of flying time, and a squadron "flew" 60 sorties in one month. Then the total flight hour costs avoided for that month is 60 sorties x 1.5 hours/sortie x $15,000/hour or $1.35M just in one month.

Costs expended are those that are required for the operation and maintenance of the M&S system. Many DoD M&S systems are contractor operated and maintained and these costs are reported by fiscal year in different forms. Contracted Logistics Support (CLS) costs are typically delineated by site for operations and maintenance and the program and overhead costs are given for the complete simulator system. The program and overhead costs must be apportioned to each simulator in the system and then this "fair share" of the fixed costs is added to the operations and maintenance costs to obtain total operations and maintenance cost for the site. In the case above let's suppose the contractor costs to operate and maintain the family of simulators at this site are

[1] Depending upon the source and the costs included in a flight hour this number is representative of an USAF F-15 or USMC F-18. Costs of flying hours are reported differently due to some agencies rolling in initial R&D and procurement costs into the number. This cost is meant to reflect yearly average O&M cost to fly the airplane.

$80,000/month and the program and overhead costs (program management, travel, and spares) are $720,000/year across 6 sites. Then the total CLS costs/month for the simulator is $80,000 + ($720,000/year x 1year/12 months)/6 sites = $90,000/month for each site.

Costs expended to operate and maintain the simulator are subtracted to obtain net cost avoidance for the month. This net value is accrued over 12 months and reported for a fiscal year. In our example above the net cost avoidance for the example month at that site is $1.35M - $90,000 = $1.26M. The same calculations would be performed for the other 11 months of the fiscal year and total cost avoidance for that site calculated by adding up all the months. Total system cost avoidance would be calculated by performing the above for the other five sites and then adding the net fiscal year cost avoidance for all sites together to obtain the net system cost avoidance. An example table that could be used to calculate the system net cost avoidance is provided here.

Site	1	2	3	4	5	6	Total
Oct-Dec	3.12	4.15	3.34	4.11	3.31	3.64	21.66
Jan-Mar	3.06	3.96	3.66	3.34	3.24	3.50	20.76
Apr-Jun	3.70	3.20	3.91	3.63	3.18	3.13	20.75
Jul-Sep	3.81	3.33	4.07	3.76	3.02	3.26	21.24
Total	13.69	14.64	14.97	14.83	12.74	13.52	84.41

Table 1 – An Example of Net Cost Avoidance by Quarter by Site
All costs in $M

We can easily see that the total net cost avoidance for this M&S system is $84.41M for the fiscal year and in the budgetary process may well justify the value of the system.

Other Cost Avoidance Considerations

If you have read the example and discussion above and thought to yourself that there are other costs, particularly for operating the simulator you would be correct. Certainly there is electricity required to operate the simulator, perhaps a building to maintain, and potential physical security costs, just to name a few. With respect to the benefit from a simulator, there may be live range costs (if you would otherwise perform the live event on a range), cost of maintenance personnel to repair and service the live aircraft (if not included in the cost per hour to fly the aircraft), and the cost of supporting units necessary to fly a mission such as in-air refueling support. All of these are valid costs that would further enhance the cost avoidance calculation. However, gathering the data may be impossible or impossible in the time-frame given for the analysis. Additionally, the significance of these additional costs compared to the costs listed in the example above may be small.

Let’s first consider the additional simulator costs. Electricity is a valid cost and perhaps not that hard to calculate. Consider a large simulator that uses 10 kilowatts per hour when it is powered on[2]. In our example above we used 90 simulator hours in the example month. That is a total of 900 kilowatts of electricity. The average commercial cost of electricity across the United States for 2011 was $0.1032/kilowatt[3]. Therefore, the cost for the electricity to run the simulator for the month is 900 x $0.1032 = $92.88. This is an insignificant cost compared to the $90,000/month CLS cost as described above.

In the case of building maintenance and security issues, these costs can be attributed to the simulator(s) if the simulator(s) are housed in a separate building containing nothing else and used for no other purpose but the simulators. If the building houses other uses then the costs can be apportioned to the simulators by taking the same percentage of maintenance/security costs as the percentage of the building used by the simulators. For example, if the building is 8,000 sq ft and the simulators occupy 6,000 sq ft of the building then 75% (calculated by taking 6,000 and dividing by 8,000) of the costs could be attributed to the simulator. However, one can argue whether the building is completely utilized or not, outside maintenance still has to be performed. Therefore, if the building is not dedicated to the simulator(s), one could argue that there is no increase in outside maintenance and "charging" outside maintenance to the simulator is incorrect. Either way, the experience of the authors is that building maintenance data is difficult to obtain and that the resulting costs are insignificant compared to the CLS costs listed above.

Similarly, the costs of security for the building fall under the same argument. Site/base security costs are not delineated by building, and the incremental cost for one additional building, if it could be captured, is insignificant.

If there are significant costs associated with operating and maintaining the simulator, such as dedicated training personnel, scenario generation personnel, or significant network costs, then these costs should be calculated and added to the other costs of simulation operation. However, the author's experience is that CLS costs cover virtually all of the operations and maintenance costs for the simulation system.

With respect to the additional costs avoided, the situation is slightly different. In our example above we are showing $84.41M costs avoided just by not flying the live hours. Any additional costs avoided will only further justify the simulator's worth. If the data is readily available then one would want to add the calculated costs avoided to the analysis. However, the experience of the authors is that much of the data for these types of avoided costs is difficult to obtain. For example, the hourly cost of a live range can be calculated, but typically the bombing run for your sortie is only one of several in an exercise or event. Again, we are faced with apportioning the fair cost of one bombing run out of several in the event and the incremental cost may be relatively inexpensive, if even obtainable. There is a similar argument with air refueling costs. Since a tanker rarely would re-fuel one aircraft the cost of the tanker would have to be allotted over all re-fueled aircraft. This is possible, but one can argue that the incremental cost of refueling that one aircraft pales in comparison to the $84.41M especially considering the cost of the fuel is already considered in the hourly rate for the aircraft.

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[2] This is a significant power load and roughly equivalent to the power consumption of a 2000 sq ft residence. See http://www.nfpa.org/assets/files/PDF/Research/PowerConsumption.pdf accessed 25 Mar 2012.

[3] See http://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_3 accessed 25 Mar 2012

Again, if there are significant costs avoided in addition to the most obvious ones then these costs should be included in the analysis. Certainly, there are times when the data to calculate the amount of the avoidance is not readily available and if obtaining the data is impossible or highly unlikely, then an estimation of these costs may be required. Either way, all significant costs avoided should be included in the cost avoidance analysis.

Data Considerations

One of the main challenges to performing a thorough cost avoidance study is the availability of the necessary data. The data for these studies can be segregated into two different kinds of data: cost data, and usage data. Both of these, with their challenges, are described below.

Cost data is the cost per item for the live items that would have been expended had the M&S system not existed. For example, for a flight simulator one "item" that would have been expended had the training been performed live is flight hours. Then the cost data required is the cost of flying that aircraft for one hour. While that may seem to be a simple data point, the author's experience is that finding a definitive value for the flight hour costs is somewhat problematic. A search reveals at least four different values for the cost of flying an F/A-18 for one hour. Certainly, one part of this issue is that none of these values list what is included in the cost for that flight hour. Does it include: the cost of spare parts? Personnel costs for operators and maintainers? The cost of hanger or aircraft carrier space? This exact issue applies to other cost data as well such as vehicle costs per mile, ship costs per hour, etc. On the other hand, the cost of some items is well established and unambiguous. For example, the cost of an M-16 round is reported as $0.41 (FY11). There aren't a lot of questions as to what is included and what is not since it is a well defined product, a physical item that can be purchased, and not an item that is closer to a service.

Usage data is data that depicts the operations of the M&S system. In the flight simulator example discussed earlier, the number of simulator hours is usage data. Number of pilots trained would also be usage data. For a marksmanship trainer, the number of simulated rounds fired or munitions expended by type of ammunition/munition is usage data. This data is multiplied by the appropriate cost data if the event was performed live to calculate the cost avoidance. The problem with this data is that it can be difficult to obtain for a number of reasons. First, it may be that the data is not collected. For instance, perhaps the flight simulator doesn't track actual flight hours or the marksmanship trainer tracks total number of shots fired, but it is not broken down by ammunition type. These types of issues require simulator changes either to hardware or software, or both. Another possibility is that the data is available but, it is not in a form that is easy to read and the current operational concept is that it is reported in aggregate, or not at all. In this case, operational procedures need to be changed and/or software modifications may need to be made to the simulator software to produce the report in an easier to read format. Last, it may be that the data is collected and in an easily accessible format but, the keeper of the data will not release it. Unless this situation can be remedied, the success of the cost avoidance report is in jeopardy.

Significant Findings

In addition to calculating the cost avoidance, the process can yield other interesting results. For example, a cost avoidance study is able to show that while an M&S system can overall have positive cost avoidance; there may be some sites where the cost avoidance is negative. This may lead to reallocation of assets to where they might be more efficiently utilized[4]. Other system performance reports may show different system behavior. For example, one analysis may show that between two sites the number of personnel trained is the same, but one site uses twice the number of hours to perform the training. There may be solid reasons for this, but these studies are able to show areas that need further investigation. Another indicator that could appear is that one site may have lower cost avoidance than another site yet produce the same system output. In this case, it may mean the costs are higher at that site for some reason (geographic wage differences, more system maintenance actions leading to more parts replaced, etc) or that the other site may be more efficient. Either way, this is another situation that requires additional examination. There are other M&S system behaviors that may be uncovered from a cost avoidance study, depending upon the type of system. Each of these behaviors, with proper review, could lead to actions that will increase the efficiency and effectiveness of the M&S system which is a substantial benefit of a cost avoidance study.

While the authors believe that a complete ROI study on an M&S system is the best way to determine the ***complete*** value for the investment, a cost avoidance study can be used to show the value of an M&S system and is a necessary stepping stone to a complete ROI calculation. Cost avoidance only considers the dollar amounts involved and not the more qualitative results from the system such as reduction of risk, increased readiness, task proficiency, etc., as noted in both Oswalt, Cooley, et al 2011, and Waite, et al, 2008. However, the monetary piece of complete ROI is essentially the result of a cost avoidance study and a necessary part of the ROI calculation. One could use the cost avoidance study not only to justify the benefit and value of an M&S system, but as a pre-study to determine if an ROI study is desired or warranted. Therefore, we see worth in performing cost avoidance studies both for use in justifying M&S systems and as a preliminary step to an ROI study.

M&S System Design Considerations with respect to Cost Avoidance and ROI

The authors' experience has been with performing cost avoidance studies on existing systems. However, it becomes apparent that these types of studies should be planned and conceived while the M&S system is in the design stage. If ROI and cost avoidance are considered as the M&S system is designed then the ability to collect and provide the correct usage data, such as types of units, munitions, vehicles, aircraft, type of tasks trained, number of students using the system, number of hours the system is used, and system availability, to name a few, can be built into the system. By identifying these data requirements at the design phase the "hooks" can be built into the system at a fairly minimal cost (or perhaps no additional cost at all) rather than a software modification after the system has been fielded which can be relatively costly. Additionally, designing the usage data report such that the data is correctly categorized and delineated, and in a way that is easy to use for cost avoidance/ROI calculations is much simpler and less costly in the

[4] The authors have experienced this situation in their recent studies. However, the details are not releasable from the DoD due to ongoing analysis in the decision process.

design phase of the M&S system. Our experience has been that some of the greatest cost, longest time, and most difficult tasks revolve around data collection on existing systems.

Conclusions

There are times when a complete, full, ROI study is too time-consuming or the requisite data is unavailable. In these times, a cost avoidance study may be a viable substitute. Assuming you can obtain cost and usage data (data which is needed for an ROI study as well), the study may provide insight into other system behaviors in addition to cost avoidance. These behaviors may lead to actions which have the potential to increase efficiencies for the M&S system. Additionally, if data for a cost avoidance study on the M&S system is researched when the system is designed the cost to obtain the data in a useful format could be considerably reduced. The experience of the authors is that cost avoidance studies are useful to show the value of an M&S system in a quick and reasonably non-complex manner.

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