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# Does a Technical Education Improve Tactical Performance?

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# Executive summary

## Background

The U.S. Navy is a technological institution. Officers and enlisted personnel work on complex ships and aircraft, and operate and perform maintenance on various complex systems to accomplish their tasks. The training and skills required to complete the Navy's missions and maintain a level of readiness to meet current and future tasks is considerable. Navy work certainly requires bright minds that are able to think critically and clearly, and to make decisions with confidence. The level of technical skill, however, varies among Navy personnel—partly because of inherent talent. In other cases, the skill is nurtured in school. Officers study various fields in colleges, universities, or at the United States Naval Academy (USNA), and they graduate with different levels of technical expertise, depending on the major.

CNA is conducting a study for the Chief of Naval Personnel in support of the development of an Education Strategy for the Navy. One major issue in the study has been the undergraduate education of officers, particularly the need for a technical undergraduate education. There is a widespread belief, especially among the submarine force, that a technical undergraduate education is required for the Navy to operate proficiently. Reference [1], *Developing an Education Strategy for Unrestricted Line Officers*, discusses this topic in more detail. This research memorandum was undertaken as part of this study and reports on analysis directed at looking for empirical evidence that a technical education has an impact on tactical proficiency.

## A technical education matters

In the Navy, a technical background is valued and required in many billets, but it is difficult to quantitatively measure the value of such a background. Studies have shown that the success rate in the training pipeline is roughly 10 percent better for officers with technical backgrounds [2, 3]. A deficiency in technical skill can hamper the Navy's efforts and put a strain on resources. A lack of technically trained officers increases the reliance on senior-enlisted advice and expertise and on "black box" high-tech equipment.

The surface warfare and submarine communities specify a Master's level of expertise for many sea billets [4]. The submarine community believes in the need for technical skill to operate in an environment that requires an understanding of nuclear power and safety.

A technical background is also important in the acquisition community, which relies on technical officers transitioning from the unrestricted line (URL) to become engineering duty officers (EDOs), aviation EDOs (AEDOs), and acquisition professionals (APs). For DoD to achieve the right acquisition outcomes, the acquisition community requires people with the technical skills to develop new warfighting capabilities.

## Educational background and tactical performance

We are unaware of any previous studies of educational background and tactical performance. At a minimum, we can say that there is much that can be learned about the effects of officer background on how he or she performs in a tactical environment.

How should tactical performance be measured? Previous CNA work studied the relationship between officer background and promotion [5]. The results indicate that receiving an education from USNA and earning above-average undergraduate grades increase the probability of a promotion. However, the paper finds very little evidence that undergraduate major affects promotion for all URL communities. In this paper, a promotion is a proxy for performance, and it is a reasonable one since officers who perform well on the job are most likely to be the ones who are promoted; otherwise, the Navy might not be able to effectively complete its missions. A promotion, however, is not an explicit measure of tactical performance and may not always reflect a true picture of how an officer performed on the job. People are promoted for many reasons, and technical proficiency is but one.

As a result, a better measure of performance is necessary to study the potential link between technical education and performance. Such data are difficult to acquire, but we used two different types of performance measures. First, we have laser-guided bomb (LGB) data on combat operations during Operation Enduring Freedom (OEF) and Operation Iraqi Freedom (OIF). We know how many bombs were dropped by Navy pilots against tactical targets and how many were successful hits; one performance measure is hit percentage for each officer in the sample. On the surface and submarine side, we have data on collective, not individual, officer performance in the form of "Battle E" awards. A Battle E award annually recognizes superior ship performance and is based on a year-long review in the field. While we do not know how individual officers performed in a tactical environment, we know whether an officer served on a "winning" ship. Our second measure of performance is whether a Battle E award is won.

## Results and conclusions

Analyses of the bombing data and Battle E awards provided no evidence that a technical education enhances tactical performance. Officers with technical educations did not hit more targets in OEF/OIF than their counterparts with nontechnical educations. Similarly, destroyers and submarines that won Battle E awards did not have a higher percentage of officers with technical backgrounds. The analyses show no significant evidence of any effect—positive or negative.

The lack of a performance-enhancing effect does not nullify the value of a technical education. The results do not mean that earning a degree in a technical field is a waste of time and effort. The Navy takes pride in its officers and the training they receive. In fact, one might view the results as a testament to the valuable training that the Navy provides to all officers regardless of educational background. For example, the core curriculums at USNA and Naval Reserve Officer Training Corps (NROTC) provide strenuous training that allows its officers to succeed.

In the next section, we present the results from the analysis of the bombing data. Then we show the analysis of the Battle E data.

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# Analyzing LGB delivery success

In this section, we analyze Navy pilot success in delivering laser-guided bombs against tactical targets during OEF and OIF combat operations. We first describe the combat data. We next summarize our previous analyses of the data, which identified how elements of aircrew experience contributed to combat performance and led to a quantitative model that predicts aircrew LGB hit rates as a function of a pilot's experience. We then extend that analysis, by considering how a pilot's educational background influenced combat performance.

## Combat LGB data and analysis

CNA has analyzed the results of naval aviation LGB employment during combat operations for over a decade, including Kosovo, Afghanistan, and Iraq. We considered LGBs because they were the type of ordnance most commonly dropped during those conflicts. For example, to date, we have analyzed the results of over 5,700 deliveries from OEF and OIF. In addition, LGB results were, in general, very well documented via the bomb hit analysis (BHA) process.

### Analytic approach

For each operation, we constructed comprehensive databases of sorties flown at the individual aircrew level, both during combat and before its initiation. We used smoothed squadron flight schedules, launch-recovery logs, and aircrew debriefs. For each combat LGB delivery, we analyzed all available documentation, including mission reports, aircrew debriefs, and weapon system videos.[1] We first determined whether the delivery had been influenced by system or maintenance issues. If it had, we excluded it from future consideration

1. Those combat data were provided by Navy staffs in theater, in many cases via CNA's field representatives.

because we were interested in the influence of aircrew training and experience on delivery success. We next determined whether the weapon had hit its intended target. We defined a *hit* as impacting within 50 feet of the intended aimpoint and a *miss* as impacting outside that distance.[2] If we could not determine the point of impact, we identified the delivery as an unknown. Finally, to determine the hit percentage, we took the ratio of known hits to the sum of known hits and misses (i.e., we excluded all unknowns from the calculation).[3]

We then considered the type of target, mission flown (e.g., against a preplanned target or in support of a ground terminal controller), whether the attack was during the day or at night, and the type of LGB (e.g., GBU-12 or GBU-16). References [6] and [7] document our detailed analyses of performance by two carrier airwings (CVWs) during OEF. For these factors, we did not observe consistent, strong contributions to the overall hit percentages.

## Squadron-level success

Table 1 contains squadron-level results for the CVWs participating in the major combat portions of OEF and OIF. We present aggregate percentages of LGBs delivered that hit their intended targets.

*These squadron-level weapon employment results are all generally successful by historical standards* (i.e., Operations Desert Fox, Allied Force, and Southern Watch). We also noted that there is a wide variation in the OEF/OIF squadron-level LGB results, fully 25 percentage points, between the squadron most and least successful at hitting its intended targets. We showed in [8] that we could account for this variation in hit percentages between squadrons in terms of the mix of aircrews within each squadron, considering two factors:

- The elements of *experience* held by the aircrews present in the squadron (e.g., career level, work-up level, and very recent)
- How those aircrews were *employed* in the campaign (e.g., how they were paired up into VF crews and VFA sections).

2. In the case of a dud, we followed the same criteria.
3. The number of unknowns was typically much smaller than the sum of hits and misses.

Table 1. Squadron-level percentages of LGB deliveries hitting targets: OEF and OIF CVWs

| Carrier airwing | Squadron | Percentage of LGB deliveries hitting targets |
|---|---|---|
| **Operation Enduring Freedom** | | |
| CVW-8 | VF-41[a] | 86 |
| | VF-14 | 76 |
| | VFA-15[b] | 74 |
| | VFA-87 | 65 |
| CVW-11 | VF-213 | 77 |
| | VFA-97 | 80 |
| | VFA-22 | 76 |
| | VFA-94 | 69 |
| CVW-1 | VF-102 | 79 |
| | VMFA-251 | 71 |
| | VFA-82 | 79 |
| | VFA-86 | 68 |
| **Operation Iraqi Freedom** | | |
| CVW-3 | VF-32 | 79 |
| | VMFA-115 | 85 |
| | VFA-37 | 73 |
| | VFA-105 | 79 |
| CVW-8 | VF-213 | 83 |
| | VFA-201 | 73 |
| | VFA-15 | 76 |
| | VFA-87 | 78 |
| CVW-14 | VF-31 | 88 |
| | VFA-115 | 72 |
| | VFA-113 | 81 |
| | VFA-25 | 72 |
| CVW-2 | VF-2 | 75 |
| | VMFA-323 | 67 |
| | VFA-151 | 71 |
| | VFA-137 | 89 |
| CVW-5 | VF-154 | 77 |
| | VFA-27 | 71 |
| | VFA-192 | 64 |
| | VFA-195 | 74 |

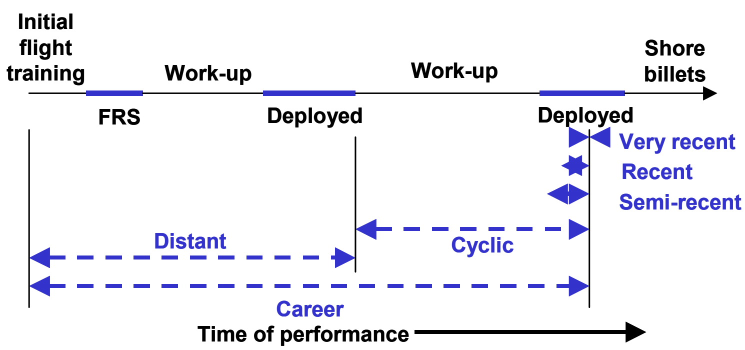
a. Fleet fighter squadron (VF).
b. Strike fighter squadron (VFA).

# Quantifying the aircrew experience-performance link

## Contribution of aircrew experience

To systematically examine the contribution of aircrew experience to performance, for each LGB-dropping sortie we looked back in time to determine flights by the participating aircrew within the past few days, within the past few months, during the current work-up, and before this training/deployment cycle [8, 9]. Figure 1 notionally illustrates the look-back process, tracking individual aircrew training and operational flights.

Figure 1. Framework for connecting aircrew experience to combat performance




Each combat operation has a slightly different set of environmental and operational conditions. Such differences in conditions allowed us to identify and quantify the variables influencing combat performance. The essential conclusions from our analysis of how aircrew experience and employment contributed to LGB delivery success during OEF/OIF follow:

- *Career-level experience matters*. Seniority adds 10 to 20 percentage points to a crewmember's base LGB hit rate. This contribution reflects more senior aircrews' practice of pertinent mission tasks or skills during work-up/deployment cycles completed before the current one. Also, combat LGB drops during the last deployment add another 15 percentage points. The prior combat contribution reflects further direct practice of LGB employment skills.

- *Work-up participation matters*. Being in place in the squadron early in the work-up (i.e., before the Strike Fighter Advanced Readiness Program (SFARP)) adds 10 to 20 percentage points to the base LGB hit rate. The work-up contribution reflects participation in concentrated practice of pertinent mission skills during that phase of the work-up; late-joiners miss that opportunity for concentrated practice. However, we also observed that since those skills are perishable, aircrews need to refresh them roughly every 2 months. CVWs that followed this pattern of sustainment practice maintained their work-up contribution into combat. CVWs that were unable to follow this pattern saw this contribution lapse, with commensurately lower LGB hit rates once in combat.

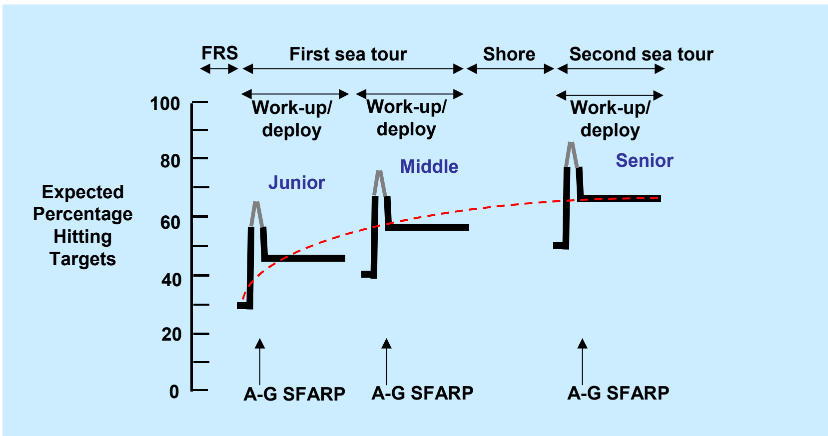
- *Very recent flying activity matters*. Frequent overland sorties within the past week add 15 percentage points to the base LGB hit rate. Such overland sorties provide practice of the many required mission tasks or skills leading up to weapon employment. LGB drops within the past week add another 5 to 10 percentage points. Such deliveries provide direct practice of LGB employment skills. For junior aircrews, initial switches in combat deliveries between weapons guided by global positioning system (GPS) and those guided by laser subtract 15 to 20 percentage points from the LGB hit rate. We hypothesize that this negative contribution reflects potential interference between two very different sets of tactics, techniques, and procedures (TTPs) for weapon employment.

- *How people are employed matters*. Junior aircrews add 10 to 15 percentage points to their base LGB hit rates when paired with seniors, either in VF crews or VFA sections. We hypothesize that this contribution reflects a senior lead's better apportionment of tasking with an accompanying junior over the course of a mission (as opposed to that of a more junior lead).

## Success across the career timeline

Combining each of these quantified elements of aircrew experience, we developed a model of how aircrew success in delivering LGBs evolves with accumulated experience (gained on different time scales) over the course of a career.[4] Figure 2 illustrates our aircrew career progression model.

Figure 2. Modeling of combat LGB success rates over the course of an aircrew career




The solid black lines in figure 2 represent the results from our analysis of all the combat data from Operation Allied Force through OIF. The broken red line represents a rough trendline of the evolution of projected LGB delivery success, as an aircrew progresses from Fleet Replacement Squadron (FRS) to the first sea tour (at the junior- and then middle-group career levels) and then on to a second sea tour (as a senior career-level aircrew).

4. We caveat our model by noting that it was derived (and validated) using combat data from operations with similar conditions: section-level air-to-ground operations in a medium- to low-threat environment. If the conditions of a future conflict differ, we recognize that our estimates may need to be revised to reflect the changes.

Starting on the left-hand edge of the progression shown in the figure, the combat data indicate that a junior aircrew's success in delivering LGBs will increase sharply with concentrated practice of relevant mission tasks or skills starting in air-to-ground SFARP. Later in the work-up, with a sustainment level of practice, success will fall off to an intermediate value, which is greater than that possessed on entering the work-up but less than that held immediately following concentrated practice. In the model, we expect late-joining FRS graduates in isolation (i.e., without a senior lead and without frequent prior overland sorties) to be about 30 percent successful on their initial combat LGB-dropping sorties. In the combat data, we see crewmembers under those conditions achieve hit rates similar to that estimate.

Similarly in the model, we expect juniors in place early in the work-up in isolation (i.e., without a senior lead and without frequent prior overland sorties) to be about 45 percent successful on their initial LGB-dropping sorties. If led by a senior aircrew and with frequent overland sorties in the week before that first dropping sortie, we expect that junior to be about 70 to 75 percent successful. In both cases, in the combat data, we see crewmembers under those conditions achieve hit rates very close to our estimates. Of note, the model estimates (and the combat data confirm) a difference of a factor of 2.5 in the performance of junior aircrews on their first LGB-dropping sorties, depending on their work-up experience, very recent flying experience, and the seniority of their section lead.

Continuing to the right in the figure, a middle-group aircrew's estimated success in delivering LGBs will fall off after deployment due to a lack of even sustainment practice during the first half of the work-up. Estimated success will again increase sharply with concentrated practice starting in air-to-ground SFARP. And again, later in the work-up, with a sustainment level of practice, success will fall off to an intermediate value, which is greater than that possessed on entering the work-up (and greater than that held by a junior) but less than that held during concentrated practice.

Moving even further to the right in the figure, on joining the squadron following a shore tour, the combat data indicate that a senior aircrew's success in delivering LGBs will increase sharply with concentrated practice starting in air-to-ground SFARP. Later in the work-up, with a sustainment level of practice, success will fall off to an intermediate value, which is greater than that possessed on entering the work-up (and greater than that held by either a junior- or middle-group aircrew) but less than that held during concentrated practice. In the model, we expect late-joining seniors without frequent prior overland sorties to be about 50 percent successful on their initial combat LGB-dropping sorties. In the combat data, we see crewmembers under those conditions achieve hit rates very close to that estimate. Similarly in the model, we expect seniors in place early in the work-up and without frequent prior overland sorties to be about 65 percent successful on their initial LGB-dropping sorties. With frequent overland sorties in the week before that drop, we expect that senior to be about 80 percent successful. In both cases, in the combat data, we see crewmembers under those conditions achieve hit rates very close to our estimates.

## Additional contributions to success

In our initial analysis [8], we treated the career-level experience of three aircrew career-level groups as being homogeneous. While this is a reasonable assumption for juniors (with only FRS experience before this cycle) and middle-group aircrews (with a single prior work-up / deployment cycle), it is less reasonable for seniors. Some seniors are on their second sea tour, while others are on their third, fourth, or fifth. Some seniors were tactical instructors, flying during their shore tours, while others were test pilots, staff members, or students. In later analysis [9], we extended the work to better account for varied senior career-level experience, finding two general results:

- *Cumulative experience across a career matters*. Pilots on their third (or later) sea tours achieved higher LGB hit percentages than pilots on their second sea tour (about 10 percentage points higher). In addition, juniors flying wing achieved higher LGB hit percentages with a third (or later) sea tour senior lead than when flying with a second sea tour senior lead.

- *Shore tour flying experience matters*. Pilots with instructor and test pilot backgrounds achieved higher LGB hit percentages than pilots who held other shore billets (about 10 percentage points higher). In addition, juniors flying wing achieved higher LGB hit percentages with a senior lead with an instructor or test pilot background than when flying with a senior lead with another background.

# Influence of aircrew educational background

## Analytic approach and scope

We wanted to know whether aircrew educational background also influenced success in combat LGB deliveries. Since we had already shown how elements of aircrew experience quantitatively contributed to observed LGB hit percentages, our approach was to analyze any additional contribution from aircrew educational background.

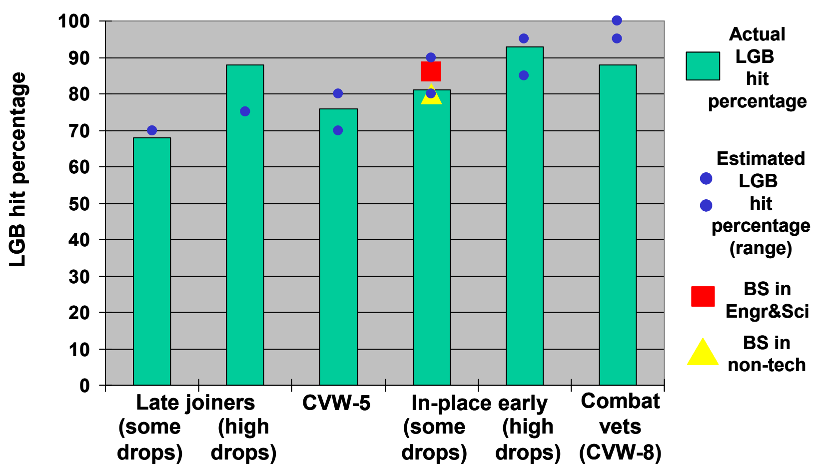
We limited our analysis to OEF and OIF combat results by F/A-18 Hornet pilots. Using the Navy Officer Master File [10], we determined the undergraduate majors of those pilots. We then classified the pilots into two broad categories based on their academic discipline; educational background is broken into three tiers. We defined a *technical* background as having an engineering or science major (i.e., Tier I or II). We defined a *nontechnical* background as a major in any other academic discipline (i.e., Tier III).[5] For VFA pilots with similar elements of career-level experience, work-up experience, and recent flying (and LGB-dropping) experience, we compared the LGB hit percentages for those with technical and nontechnical educational backgrounds. Because of the number of variables considered, we found that the number of data points became very small in many cases. Consequently, we limited our analysis to instances where the sample size was not trivial; each educational background was represented by multiple pilots, each dropping multiple weapons.

5. Because we could not determine the undergraduate educational background of some VFA pilots, we excluded their combat results from further analysis. The proportion of unknowns was typically small. For example, we excluded the results of 2 out of 32 commanding officers (COs) and executive officers (XOs) and the results of 15 of 86 junior pilots.

## Results for senior pilots

Figure 3 illustrates our results for VFA COs and XOs, the pilots in those squadrons who usually have the most career-level experience. We first divided the pilots into two groups based on predeployment work-up participation: early arrivals (i.e., before SFARP) and later joiners (i.e., after SFARP). We further divided each group based on recent LGB-dropping experience: high drops (i.e., two or more LGB-dropping sorties in the past week) and some drops. We also broke out two additional pilot groups with special experience. We broke out the results for CVW-5 pilots separately because their work-up differed from the standard. We also broke out the results for combat LGB-dropping veterans because they had more career-level experience in performing the task operationally.

Figure 3. OEF/OIF LGB hit percentages for VFA COs and XOs




The blue dots indicate our model's estimate for LGB hit percentage for each group of pilots. The expectation for success increases from left to right in the figure, ranging from 70 percent hits for pilots joining late in the work-up and not dropping LGBs very frequently to 95 to 100 percent hits (i.e., essentially system limited) for veterans of prior combat.

The green bars show the actual hit percentages observed for each group of pilots. Note that, in general, our model (i.e., a mathematical expression combining terms for elements of aircrew experience and employment, developed in [8]) is good at predicting hit percentages.[6] For example, our model estimated that pilots joining late in the work-up and not dropping LGBs very frequently would hit their targets 70 percent of the time. We observed that they actually hit about 68 percent of the time.

The most numerous combat data were for pilots in place early in the work-up and dropping LGBs infrequently. We estimated that those pilots would hit their targets on 80 to 90 percent of deliveries. We observed that overall they hit their targets 81 percent of the time (on 154 out of 189 deliveries). We then broke this group down according to educational background. We found that technical pilots achieved a hit rate of 86 percent (101 out of 118 deliveries). We denoted their result with a red box in the figure. We also found that nontechnical pilots achieved a very similar hit rate of 80 percent (47 out of 59 deliveries). We denoted their result with a yellow triangle in the figure.

Figure 4 illustrates our results for other senior VFA pilots, including department heads. Here we consider only pilots who were in place in their squadrons early in the work-up. We again divided the pilots into two groups based on recent LGB-dropping experience: high drops (i.e., two or more LGB-dropping sorties in the past week) and some drops. We also broke out two additional pilot groups with special experience. We broke out the results for CVW-5 pilots separately because their work-up differed from the standard. We also broke out the results for combat LGB-dropping veterans because they had more career-level experience in performing the task operationally.

The results again show that, in general, our model is good at predicting hit percentages. We found that the most numerous combat data were for the general case pilots dropping LGBs frequently or infrequently. We estimated that those two groups of pilots would hit their targets on 85 to 95 percent of deliveries and on 80 to 90 percent of

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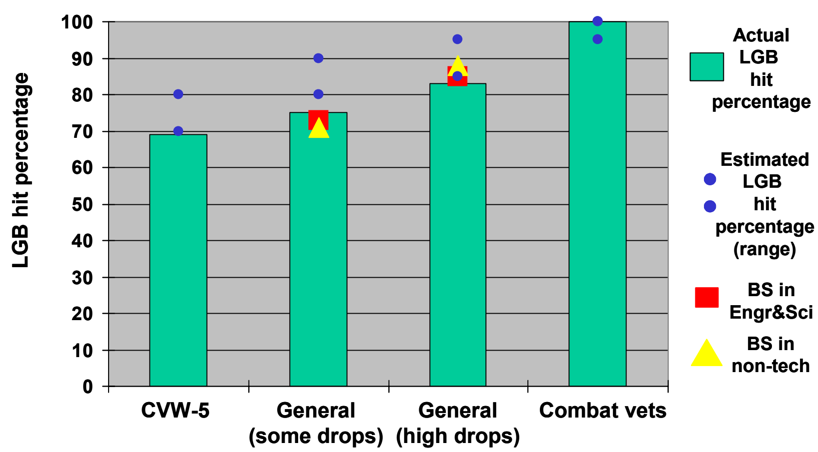
6. We developed our quantitative model estimates from combat data gathered through OEF. We validated them using combat data from OIF.

deliveries, respectively. We observed that, overall, pilots dropping LGBs frequently and infrequently hit their targets 75 and 83 percent of the time, respectively. We then broke down each group according to educational background. For pilots dropping LGBs frequently, we found that technical pilots achieved a hit rate of 85 percent and that nontechnical pilots achieved a very similar rate of 88 percent. For pilots dropping LGBs infrequently, we found that technical and non-technical pilots achieved very similar hit rates of 73 and 71 percent, respectively.

Figure 4. OEF/OIF LGB hit percentages for early-arriving VFA senior pilots

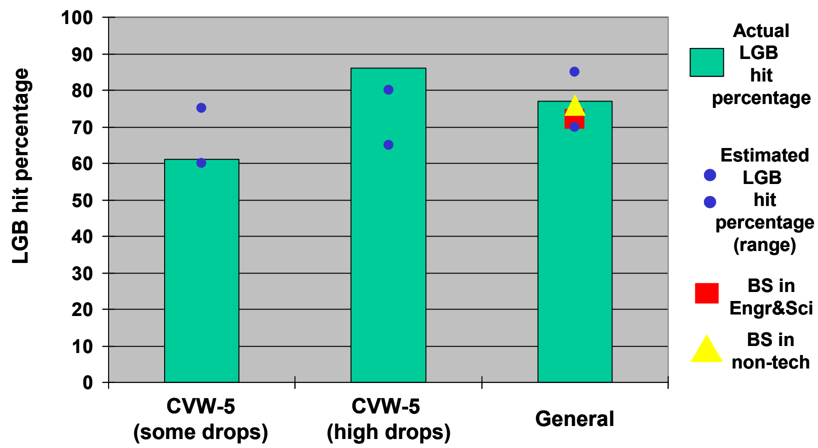



## Results for junior pilots

Figure 5 provides a final example of our results, this time for VFA junior pilots (i.e., those on the first deployment of their first sea tour). Again, we consider only pilots who were in place in their squadrons early in the work-up. Again, we broke out the results for CVW-5 pilots separately because their work-up differed from the standard. We also further divided the CVW-5 results based on recent LGB-dropping experience.

The results again show that, in general, our model is good at predicting hit percentages. We found that the most numerous combat data were for the general case pilots. We estimated that those pilots would hit their targets on 70 to 85 percent of deliveries. We observed that overall they hit their targets 78 percent of the time. We then broke them down according to educational background. We found that technical pilots achieved a 72-percent hit rate and that nontechnical pilots achieved a very similar 75-percent rate.

Figure 5. OEF/OIF LGB hit percentages for early-arriving VFA junior pilots




## Conclusions

Based on the results of our analysis of the combat data, we concluded that VFA pilot educational background did not influence LGB hit percentages during OEF/OIF. We observed no overall difference in delivery success between pilots with degrees in technical academic disciplines and those from nontechnical disciplines. After taking the contributions of aircrew experience (and the pattern of employment) into account, we did observe slight differences between the two groups. In all cases, however, those differences were small (i.e., only a few percentage points), not statistically significant, and not consistent.

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# Battle E analysis

One way the Navy awards exceptional performance is through Battle Effectiveness/Efficiency Awards, commonly known as the "Battle E." For submarines, it is called the Battle Efficiency Award; for ships and crews, it is the Battle Effectiveness Award. The Battle E is awarded annually, based on a year-long evaluation, to a small number of ships, submarines, and aviation and other units that exhibit an overall readiness of the command to carry out its various tasks and missions. It acknowledges superior performance in an operational environment. A submarine must excel in four combat areas (Maritime Warfare, Engineering/Survivability, Command and Control, and Logistics Management) to be eligible for a Battle E [11]. Likewise, a ship must excel in six areas—the four just listed plus Commander, Naval Surface Force Safety Award and the Efficiency Excellence Award [12].

To see if there is a connection between performance and technical education background, we selected a sample of destroyers (DDGs) and submarines (SSNs) from the Submarine Force, U.S. Atlantic Fleet (SUBLANT) and used the Battle E award as a measure of superior performance.[7] Each ship class was divided into two groups: Battle E winners and other ships. For each group, we show the percentage of officers with a technical degree in each year. We have the list of DDG Battle E winners from 1999 through 2006 and SSN Battle E winners from 2002 through 2006. The number of Battle E winners in the sample varied each year. Table 2 shows the number of ships that won a Battle E award, as well as the number of officers in each group.

We recognize that it is difficult to determine exactly which officers contributed most to a ship or submarine winning the Battle E. At any point in time, some officers will have been on board for a relatively

7. We were unable to obtain a list of Battle E winners in the Submarine Force, U.S. Pacific Fleet (SUBPAC).

long time, while others will not. In addition, there will be other officers no longer on board whose service had a lasting positive impact that contributed greatly to the success of the ship.

Table 2. The sample sizes of Battle E awards and officers on DDGs and SSNs[a]

| Year of award | Number of DDG Battle E's | Number of officers | | Number of SSN Battle E's | Number of officers | |
|---|---|---|---|---|---|---|
| | | On winning DDGs | On other DDGs | | On winning SSNs | On other SSNs |
| 1999 | 4 | 146 | 874 | n/a | n/a | n/a |
| 2000 | 4 | 152 | 932 | n/a | n/a | n/a |
| 2001 | 2 | 73 | 1,083 | n/a | n/a | n/a |
| 2002 | 8 | 303 | 990 | 5 | 99 | 557 |
| 2003 | 9 | 362 | 1,109 | 5 | 106 | 560 |
| 2004 | 11 | 418 | 1,147 | 5 | 96 | 564 |
| 2005 | 8 | 292 | 1,335 | 4 | 78 | 562 |
| 2006 | 10 | 330 | 1,324 | 5 | 90 | 521 |

a. The number of officers reflects those records that have educational background information. Officers with no information on education were omitted (approximately 20 percent of the officers did not have this information).

As a result, we choose an 18-month window before the Battle E award date (announced in June) to represent the time period that influenced the ships' performances. We analyzed the education background of all officers who served on the ships during the 18 months. We treated officers who were on board for only 1 month the same as those who served all 18 months; we assumed that every officer played a role in determining whether his or her ship earned a Battle E Award. We obtained education data from the Officer Master Files, maintained by the Navy's Bureau of Naval Personnel (BUPERS).

## Undergraduate technical background

First, we look at the undergraduate background of the officers who served on the DDGs and SSNs to see if there is any evidence that a technical education positively affects ship performance. In the following graphs, the x-axis presents the year of the award, but year *x* represents the entire preceding 18-month time period—from January of year *x-1* to June of year *x*.

## All officers

Figures 6 and 7 show the percentages of officers with undergraduate technical degrees on board DDGs and SSNs, respectively. As mentioned, a technical degree is defined as a Tier I or Tier II education.

Figure 6. Percentage of officers with undergraduate technical degrees—DDGs

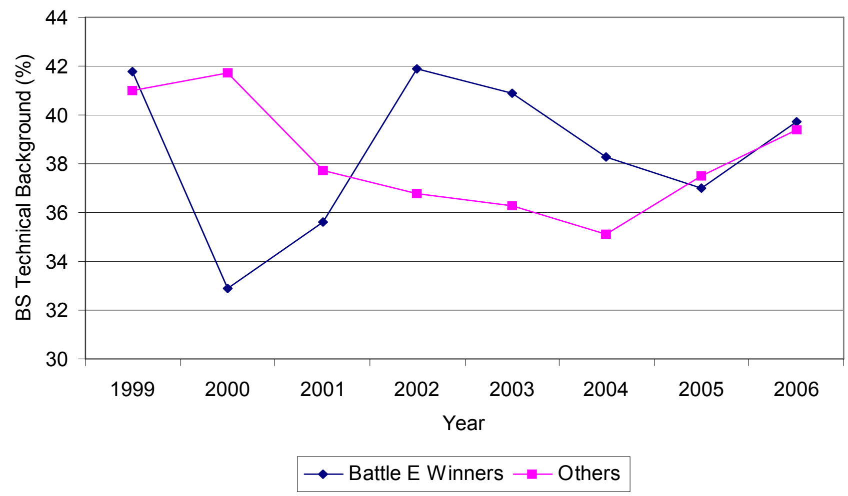
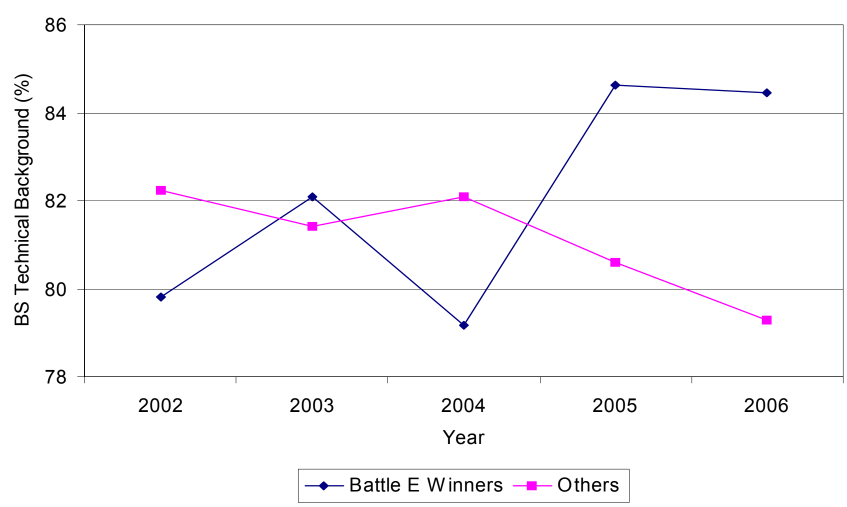



Figure 7. Percentage of officers with undergraduate technical degrees—SSNs



Overall, there is no evidence that DDGs that were awarded a Battle E tended to be manned by a higher percentage of officers with undergraduate technical degrees. From 1999 through 2006, Battle E winners exhibited a higher percentage in only five of the eight years, but there is no consistent pattern. Despite having a greater proportion of undergraduate technical degrees from 2002 through 2004, the result is not consistently observed during the entire sample time period. Furthermore, the percentage of technical undergraduate degrees varies from year to year, ranging from about 33 percent to 42 percent for the Battle E winners and from about 35 percent to 42 percent for the other DDGs.

A similar result is seen in the analysis of SSNs. Overall, there is no evidence that SSNs that were awarded a Battle E tended to be manned by a higher percentage of officers with undergraduate technical degrees. From 2002 through 2006, Battle E winners exhibited a higher percentage in only three of the five years. Except for a decline in 2004, Battle E winners experienced an increasing trend in the percentage of officers with undergraduate technical degrees over the sample period—from about 80 percent in 2002 to more than 84 percent in 2006. The other SSNs, however, collectively, show a decreasing trend—from about 83 percent in 2002 to under 80 percent in 2006.

As expected, the overall degree of technical background is higher on SSNs than on DDGs. In general, on SSNs, more than 80 percent of officers had undergraduate technical degrees, while roughly 30 to 40 percent of officers on DDGs had similar educational backgrounds. A larger proportion of SSN billets require a technical background because of the requirement to understand nuclear power and safety.

## Senior officers

Figures 8 and 9 show the percentages of lieutenant commanders, commanders, and captains with undergraduate technical degrees on board DDGs and SSNs, respectively. While there was no evidence of technical background leading to better performance when all officers were included, a different result may be present when only the more senior officers are included in the sample. It is possible that a technical background is more important at the higher leadership positions than for the other officers on DDGs and SSNs. We look at the impact of senior officer undergraduate education on winning a Battle E in the next two figures.

Figure 8. Percentage of senior officers with undergraduate technical degrees—DDGs

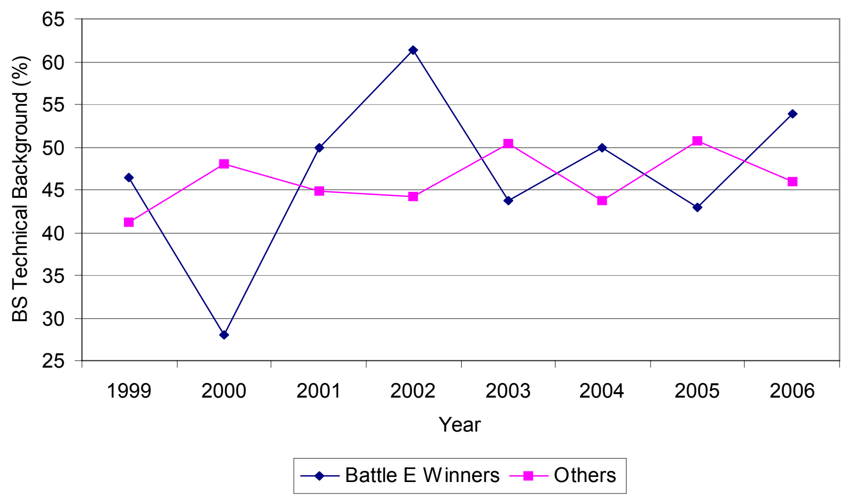
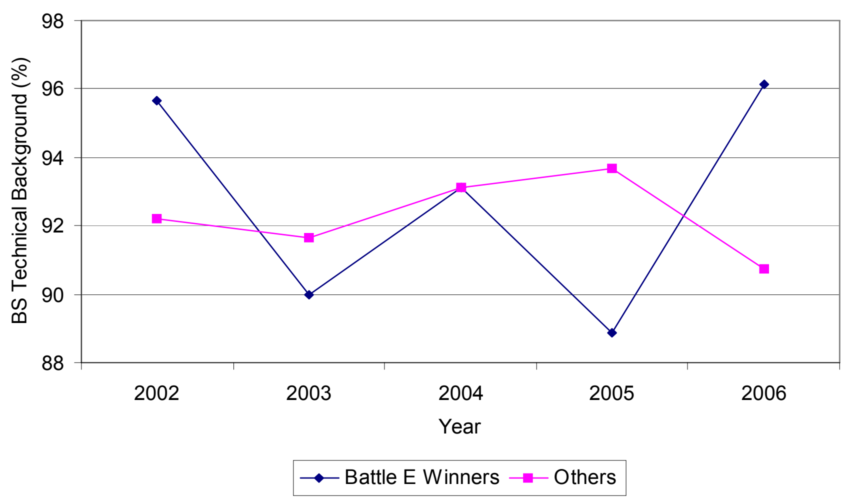



Figure 9. Percentage of senior officers with undergraduate technical degrees—SSNs



The results suggest a story similar to what we found with the full sample of officers. Overall, there is no evidence that DDGs that were awarded a Battle E tended to be manned by a higher percentage of senior officers with undergraduate technical degrees. From 1999 through 2006, Battle E winners exhibited a higher percentage in only five of the eight years. In fact, the Battle E winners and other DDGs mostly alternate having the higher percentage from year to year. The percentage of technical undergraduate degrees varies from year to year, especially with the Battle E winners, ranging from about 28 percent to more than 60 percent. The percentage of senior officers with undergraduate technical degrees is less variable in the group of other DDGs, fluctuating between about 40 and 50 percent.

Again, we have a similar result with the SSNs. Overall, there is no evidence that SSNs that were awarded a Battle E tended to be manned by a higher percentage of senior officers with undergraduate technical degrees. From 2002 through 2006, Battle E winners exhibited a higher percentage in only two of the five years, and the other SSNs had the higher percentage from 2003 to 2005. Similar to the DDG results, the percentage of technical undergraduate degrees varies from year to year, especially with the Battle E winners, ranging from about 89 percent to more than 96 percent. The percentage of senior officers with undergraduate technical degrees is less variable in the group of other SSNs, fluctuating between about 91 and 94 percent; an overall increasing trend also occurred from 2002 to 2005.

The analyses of senior officers are based on smaller sample sizes. In any year, the number of senior officers on winning DDGs or SSNs ranged from 18 to 56. The number of senior officers on the other DDGs or SSNs ranged from 151 to 222.

It is interesting to note that a higher percentage of senior officers earned undergraduate technical degrees than their lower-ranked counterparts—as seen in both the DDG and SSN samples. This suggests that a technical background is more likely to be required if an officer hopes to be promoted to lieutenant commander (or higher) and serve a high leadership role on board a DDG or SSN.

## A quick look at graduate education

We also analyzed the graduate-level educational background of the officers: Can it help explain whether a Battle E Award was won? Similar to the undergraduate results, we find no evidence that the percentage of officers with graduate degrees or graduate technical degrees has an effect of the performance of DDGs and SSNs.

The results are not surprising because the number of officers with graduate degrees is small, and the number with graduate technical degree is even smaller. The sample size is simply too small for any effect to be significant. Most junior officers on the DDGs and SSNs will not have graduate degrees—since they are not far enough along in their careers to have had the time to complete a graduate program. In addition, when URL officers go to graduate school, they are usually not there to earn a technical degree.

## Conclusions

Based on the results of our analysis, we concluded that officer educational background was not a determining factor in whether a Battle E Award was won by a DDG or SSN. Differences between the percentages of officers with technical undergraduate degrees were not consistent, often not large (none were statistically significant), and did not reveal any evidence that the Battle E winners tend to have more technically skilled officers. If technical skill does really matter, the effect cannot be captured by Battle E Awards. A better measure of ship and submarine performance would be needed to study this issue further.

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