

Effects of a SATCOM Loss

A proposed experimental design

by Maj Arun Shankar

Military forces are more dependent on satellite communications (SATCOM) than ever before. A commander's ability to communicate with voice, video, and data beyond line of sight (BLOS) is a tremendous force multiplier. This capability has far reaching effects on all warfighting functions and certainly allows for a unique sense of flexibility and operational reach that would not otherwise be possible. The loss of this capability, even if only temporary, could have significant effects on the employment of the force. A clear understanding of these effects is a starting point for developing mitigation procedures. Consequently, an experimental design that potentially evaluates the effects of a SATCOM loss during a military operation would provide significant utility to commanders.

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The purpose of this article is to describe an approach where SATCOM capabilities are removed from a unit during a training exercise, and the subsequent effect is studied. The author proposes a method of measuring this effect through the lens of the six major warfighting functions and considers the challenges of controlling variables and defining metrics to produce the most complete and accurate results.

SATCOM has developed over time from a rare, low-bandwidth capability with reserved access to a more common, capable form of communications. In

prior years, SATCOM was only capable of sharing voice communications across long ranges. Its reliability was slightly higher than that of high frequency (HF) communications, but it did provide a redundant communications path that was enjoyed by commanders. In recent years, satellite communications have been primarily developed for the passing of voice, video, and data services. The growth of the unclassified World Wide Web and various classified networks has driven the requirement for the passage of data at every echelon of command in a deployed environment.

There is no argument against SATCOM having a positive effect on military operations. In effect, it provides a commander with an increased operational reach. Theoretically, a capability increase would not be noticed if every information exchange point within a commander's scope was within line of sight range of his unit's location. But that is highly unlikely today. Small wars and distributed operations are a wave of the future. By virtue of its geography, the American military will likely continue to fight most of its wars overseas, and communications links across the globe will be imperative.

SATCOM capabilities significantly enhance features of all warfighting functions. Feedback and reporting functions within C² loops are highly dependent upon SATCOM. Maneuver within time and space, including the distribution of



A 26th MEU Marine sets up SATCOM during deployment to Iraq. (Photo by Cpl Jason D. Mills.)

forces across the battlespace, is hinged upon communications LOS that likely rely on SATCOM. Targeting fires at critical objectives is also reliant upon a data network that uses SATCOM. The development of the enemy picture through intelligence resources is at the mercy of SATCOM networks that extend information sources across the globe. Numerous logistics capabilities are bound to communications networks and global reachback functions that depend on SATCOM. Even force protection uses SATCOM to quickly pass information about threats across the battlespace.

This increase in capability has also resulted in a critical dependence upon SATCOM. The development of data networks in recent years has increased the use of SATCOM in training and wars with little threat of cyber warfare. Future wars with conventional militaries will likely be highly focused on cyber threats, especially those that threaten SATCOM. Indications show that many nations now possess the capability to interrupt and/or destroy SATCOM capabilities. However, it is arguable that militaries are not prepared for this threat and do not fully understand its consequences.

Background

Concerns about SATCOM losses are not a new concept, but little has been formally published on the matter. Practitioners throughout the Department of Defense (DOD) are aware of the U.S. military’s high dependence on SATCOM for the exchange of critical information. This dependence could not have been more exemplified during the most recent combat operations in Iraq and Afghanistan, where even short-range voice communications often used SATCOM for ease of convenience. Some have even categorized the use of SATCOM as “overreliance.”¹ Recent use of SATCOM with little focus on redundant capabilities reinforces this assertion.

SATCOM can be lost by a variety of actions, not all of which originate with an enemy actor. Terrorists and conventional armed forces certainly maintain the capability to jam satellite signals

and even destroy key SATCOM ground transmitters.² In 2008, the People’s Republic of China demonstrated the ability to physically shoot down a satellite in orbit.³ Adversaries possess the ability to send an electromagnetic pulse via some form of space launch vehicle into orbit and damage the satellite transmitters.⁴ Additionally, solar flares, space junk, and a variety of other natural phenomena threaten the reliability of SATCOM during critical times.

It should be noted that communications requirements often simply seek the maximum capacity available through the present technology. Unlike other equipment requirements, the greatest speed and bandwidth available can almost always be justified by a military requirement. Others claim that the present dependence on SATCOM is unnecessary. A different approach is required to truly determine the importance of SATCOM during a military operation. One approach would be to remove the SATCOM capability from a unit during a training exercise and determine the subsequent effects on the mission. Such a scenario will likely force troops to employ their innate behaviors to adapt and overcome. Consequently, a true metric describing the degradation to the mission can be measured.

Experimental Design

This process begins by first understanding the purpose of the experiment or the dependent variable that is to be measured. This variable is an “effect” on the military force, but a more specific description of this is required for an experiment. This “effect” can be decomposed into several metrics related to the effectiveness of a military. Depending on the mission, militaries can perform a vast range of functions. An appropriate starting point is the well-known six warfighting functions described within official publications throughout the U.S. military. The six warfighting functions “encompass all military activities performed in the battlespace.”⁵ They are C², maneuver, fires, intelligence, logistics, and force protection. The decomposition of the earlier described effect variable can be broken down along these six lines.

The effect of a SATCOM loss on a military force largely depends on the circumstances and employment of the force during the outage. Weather, terrain, mission, and distance all play a significant role in the use of SATCOM. In this article, these circumstances are defined as controlled variables. Controlled variables should not change during the conduct of the experiment. It is typical to begin with the simplest controlled variables of the most common circumstances. For instance, an experiment may begin assuming a clear day on flat terrain with a routine fire support mission. Once these results are tabulated, further investigation can be conducted through sensitivity analysis or the adjustment of these variables.

The remaining variable to be defined in the conduct of the experiment is the independent variable. This variable is altered by the conductor of the experiment to study the impact on the dependent variable. In the case of this experiment, this binary variable is simply defined as whether or not SATCOM is available.

With variables identified, the next step is to define the experimental scenario. This is largely accomplished by defining the controlled variables. It is difficult to enumerate an exhaustive list of these variables for the experiment, but those that will likely have significant effects on the results of the experiment, if altered, can be noted. An optimal scenario would be to evaluate the dependent variable by changing the independent variable with absolutely all other factors remaining the same. However, such a scenario might be unrealistic, and the experimenter should have awareness of the non-negotiable set of control variables. These may include weather, terrain, time of day, mission, operational tempo, force type, and force laydown.

Once controlled variables are established, the independent variable is specified in relation to the experimental scenario. The independent variable is a binary condition as to whether SATCOM is available to the military force or not. For this experiment, SATCOM is defined as a unit’s ability to communicate with a satellite, whether it is

through relays or a direct link. Communications is defined as a successful transfer of information across a digital or analog medium. Consequently, when a unit's SATCOM capability is turned off, it cannot communicate with satellites, but all other forms of communications remain accessible.

Finally, measurement of the dependent variable is specified. As noted earlier, the effect of the SATCOM loss is the dependent variable, and this effect is decomposed into the six warfighting functions. Therefore, the effect on the six warfighting functions needs to be measured before and after the loss of SATCOM. The difference of the effect between these two levels of the independent variable produces the result of the experiment.

Elements of the six warfighting functions must be examined to measure the change in the dependent variable. These can include features of the targeting process, collections efforts, or logistical movements. In an optimal scenario, systems would exist that collect these measurements automatically, whether it is through user-provided reports or electronic event monitoring. For instance, in measuring the effect of the SATCOM outage on C², a system might exist that could observe the timeliness of reporting and responses. The concern with strictly quantitative measurements is that they are reliant upon mature data collection systems that will likely never exist. The dynamic nature of the military does not lend itself to structure in this area.

A strictly qualitative measurement also has its drawbacks. Historically, military organizations focused on lessons learned and staff training have performed similar evaluations in the field or on deployments in an attempt to measure success and determine needed improvements. These evaluations are principally based on free text responses from relatively unscreened participants. The responses are then proofread and summarized into a final product. Concerns about this process include a lack of structure, a shortage of quantitative measurements, and the absence of a determined focus on removing bias from the evaluation.



Testing a field expedient SATCOM antenna during training. (Photo by Sgt Tammy Himeline.)

A common compromise to these challenges is the use of surveys (grading rubrics). Surveys allow the collection of the necessary data in a practical manner without the implementation of expensive data collection systems. The survey can be carefully designed to charge the respondent with the responsibility of considering the unintended influences of varying controlled variables, such as an unexpected shift in mission tempo. Respondents should be carefully selected—much like those in

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a marketing research focus group—to provide a useful response to decision makers. Survey respondents would evaluate particular criteria across the six primary warfighting functions. The use of warfighting functions within the evaluation provides a universal, well-known, comprehensive structure to the survey that respondents can understand. It also allows commanders to draw ho-

listic conclusions about the effectiveness of the force from a complete evaluation of its combat capabilities.

One method of design is through the use of a Likert scale, or a ratings scale. In this model, respondents are asked to attach a numerical rating, typically 1 through 4, to characterize the level of preference or agreement with the particular assertion within the survey. For instance, a survey may ask the respondent to rate the effectiveness of unmanned aerial system feeds before and after the SATCOM loss. A rating of 1 might equal “not effective,” and a rating of 4 could equal “fully effective.” Though there is still subjective judgment involved in determining effectiveness, choosing mature respondents should assist in this matter. Additionally, respondents will set a baseline score before the SATCOM loss is executed. The scores provided after the SATCOM loss will be tabulated in comparison to the baseline score rather than stand alone. This relative value will assist in reducing a respondent's potential bias toward a particular topic.

Topics within each warfighting function are evaluated in the survey. The development of these topics should be determined by parties of interest, to include the local commander and/or an evaluation team. Surveys might have slight differences for different types

of units, depending on their mission and scope but should remain consistent among a group that is compared. Infantry units might have several specific topics determined under fires and maneuver, while support units could be more focused on logistics and force protection. An example of a survey is shown in Figure 1.

Execution of the Experiment

In essence, the foundation of the experiment is simple. A military unit deploys to a simulated combat zone. After a specified period, SATCOM capabilities are disabled (both relay and direct access). The effect on the force is measured before and after the outage. However, further investigation reveals a more complex interaction of circumstances that need to be addressed before

the experiment can be executed.

SATCOM allows for the transfer of information (data, voice, video, etc.) beyond the capabilities of line of sight (LOS) communications. On the earth's surface, the maximum LOS distance across flat terrain is 30 miles, or the approximate distance at which the Earth's horizon is met, and two transmission terminals can no longer be pointed directly at one another. The distance is increased when both terminals are suspended in the sky via aircraft, as there is no horizon and transmission distances are solely based on the power output of the transmitter and the sensitivity of the receiver.

Tropospheric scatter and HF transmissions allow the transfer of information BLOS, but the reliability and flexibility of these capabilities remain

inadequate. Nevertheless, in the event of a SATCOM loss, these are some of the few existing capabilities for communications beyond LOS. More creative solutions like the transfer of printed messages or disk storage via aircraft and the employment of VHS aerial retransmission are also possibilities for mitigation.

Present designs of communications network redundancy stress the use of LOS, tropospheric scatter, and HF transmission paths in the absence of SATCOM. In fact, these transmission paths are generally designed as the preferred route of information if the destination can be reached without SATCOM. This is because SATCOM links usually have lower bandwidth than LOS links, and SATCOM availability is more limited than alternative

Survey				
Warfighting Function	Topic	Effectiveness Score (1-4) (Before SATCOM loss)	Effectiveness Score (1-4) (After SATCOM loss)	+/-
C2	Reporting	3	3	0
	Commander's Feedback	3	3	0
	Unity of Command	4	3	-1
	Planning	4	3	-1
	Information Management	3	2	-1
Maneuver	Space	3	3	0
	Time	3	3	0
	Psychological	N/A	N/A	N/A
	Technological	N/A	N/A	N/A
Fires	Targeting Process	3	2	-1
	Battle Damage Assessment Process	3	2	-1
	Fires Asset Allocation Process	3	2	-1
Intel	Collections	3	2	-1
	Topographic Functions	4	2	-2
	Enemy Picture	3	2	-1
	Meteorology	4	2	-2
Logistics	Transportation	4	2	-2
	Maintenance	4	2	-2
	Supply	4	2	-2
	Engineering	3	2	-1
Force Protection	Services (PX, Postal, Legal, Disbo)	3	2	-1
	Chemical/Biological Protection	N/A	N/A	N/A
	Entry Control Points	4	3	-1

Figure 1. Survey example.

transmission paths. Therefore, in the event of a SATCOM loss, information will automatically be routed over redundant paths with limited human intrusion.

Consequently, the loss of SATCOM will immediately reduce, but not necessarily eliminate, a unit's ability to communicate BLOS. A good experiment will ensure that the tested unit is reliant upon this capability. Distributing subordinate units throughout a training area beyond 30 miles or requiring communications with higher headquarters in another region of the world could satisfy this requirement.

It must be ensured that the tested unit is under realistic wartime conditions. Rather than being a staged exercise solely devoted to the test of a SATCOM outage, a unit performing realistic training should be interrupted with the SATCOM outage, and training should then continue under the constrained conditions. Measurements under both conditions will provide the necessary results.

Units that vary in mission and capability will have different dependencies on SATCOM. For instance, an intelligence battalion might have a high reliance on SATCOM for imagery and signals. Contrarily, a base security unit might depend highly upon LOS communications within a safety perimeter. An infantry unit with a security mission might have different communications requirements than one with a more offensive mission. An evaluation of multiple units with different missions and capabilities will increase the confidence of the results from this experiment and provide a greater understanding of the effects of a SATCOM loss on the force as a whole.

Conclusion

Past emphasis on SATCOM vulnerabilities have been solely focused on the military's present use of SATCOM and assume very little mitigation in the event of an outage. Recent events have brought clarity to the risk of SATCOM and an enemy force's ability to disable this capability. However, no research has been provided that accurately assesses the true effects of a SATCOM



Marines setting up a SATCOM system at Camp Leatherneck, Helmand Province, Afghanistan, April 2013. (Photo by Cpl Alejandro Pena.)

outage. This article suggests that different units have varying SATCOM requirements, and some might be more affected than others by an outage. This experimental design will allow stakeholders to better understand the military's reliance on SATCOM and how it is truly affected by a loss of the capability.

Such an experimental design is not simply limited to SATCOM evalua-

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tions. A similar design can be developed to evaluate the loss of other communications capabilities. In some cases, the design can even be used to evaluate the loss of capabilities beyond those of communications. Perhaps a training unit is deprived of a logistics or maintenance capability. Or maybe a headquarters staff is notionally killed during training. Similar variables and surveys can be quickly developed to obtain the re-

sults of these effects using the structure provided in this article.

Future warfare will almost undoubtedly face obstacles in the area of cyber warfare that have not yet been seen. It is the responsibility of commanders to foresee these concerns and develop realistic training for troops to overcome these obstacles. SATCOM is just one of many critical communications capabilities that are at risk in the future. Experimental designs similar to those developed in this article will greatly assist military forces in adapting to these challenges.

Notes

1. Maj Christopher Tsirlis, "Overreliance on SATCOM," *Marine Corps Gazette*, (Quantico, VA: September 2011).
2. Capt Eric Mitchell, "A Critical Vulnerability: Satellites May Eventually Become a Major Threat," *Marine Corps Gazette*, (Quantico, VA: March 2014), 44-47.
3. Ibid.
4. Tsirlis.
5. United States Marine Corps, *Marine Corps Doctrinal Publication 1-0, Marine Corps Operations*, (Quantico, VA: 2011).

