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BRIEFING

Developing a Standard Update Process for the Army's Annual MOS Availability Factors (AMAFs)

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Prepared for the United States Army

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Preface

This documented briefing describes research conducted to develop a standard methodology for updating the U.S. Army's Annual Military Occupational Specialty (MOS) Availability Factors (AMAFs). An AMAF specifies the amount of direct and indirect productive time (over the course of a year) that a soldier has available to perform MOS duties. Traditionally, the Army has calculated AMAFs by measuring soldiers' non-available hours per day, treating the remainder of the 24 hours as available time, and annualizing that available time figure. Largely through field data collection, the Army identified specific "non-availability factors"—that is, the non-MOS-related activities that comprise non-available time—and measured how much time soldiers allocate to each of those activities. Because the process is costly and time-consuming, however, regular AMAF updates have not been feasible.

Through a combination of literature reviews and interviews, we examined other military services' and commercial firms' approaches to manpower availability, as well as advantages and disadvantages of various data-collection approaches. This process helped us generate an alternative methodology that may allow more regular AMAF updates—and ultimately yield more accurate calculations of manpower requirements. This document synthesizes the relevant information we gathered and presents the approach generated on the basis of that information. The proposed "three-gate" approach entails beginning with quick, low-cost, low-rigor data collection and moving sequentially to a moderate-speed/cost/rigor method—and then perhaps to a slower, high-cost, high-rigor method—if certain "triggers" indicate it is necessary to do so.

This research was sponsored by the United States Army Force Management Support Agency (USAFMSA) and conducted in RAND Arroyo Center's Military Logistics Program. RAND Arroyo Center, part of the RAND Corporation, is a federally funded research and development center sponsored by the United States Army.

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Summary

The number and specialties of personnel distributed among U.S. Army units can have a significant impact on Army operations. An insufficient number of personnel, or a mismatch between the military occupational specialties (MOSs) of personnel and unit task requirements, could affect units' readiness and overall performance. As the frequency and variety of Army operations increase, careful allocation of manpower becomes particularly critical. Thus, the U.S. Army Force Management Support Agency (USAFMSA), the organization largely responsible for calculating and documenting Army manpower requirements and authorizations, is striving to continuously improve that process to meet Army needs.

To determine the manpower requirements for a particular mission, the Army matches the estimated number of man-hours required by the mission (demand) to the estimated number of productive man-hours available to perform these tasks (supply). Currently, USAFMSA integrates data from multiple sources to measure Manpower Requirements Criteria (MARC), the set of factors used to calculate combat support (CS) and combat service support (CSS) manpower requirements. MARC components include the number of labor-hours required per task or activity, the required number of tasks or activities, and the productive time that a soldier has available to perform those tasks.

A key element in the manpower requirements calculation is the annual MOS availability factor (AMAF), which refers to the amount of direct and indirect productive time (over the course of a year) that a soldier has available to perform MOS duties. Traditionally, the Army has calculated AMAFs by measuring soldiers' non-available hours per day, i.e., the time that a soldier does *not* have available for MOS-related tasks. The remainder of the 24 hours is then treated as available time, which the Army measures on an annual basis. The AMAF is based, in large part, on field data collection that identifies specific "non-availability factors" and measures how much time soldiers allocate to each of those activities. The Army conducted AMAF studies in 1983 and 1992; however, updates are rare because of the investments of time and dollars required to carry them out.

Over the past decade, however, there have been important changes in the Army's force structure, operational concepts, and planning scenarios. Recognizing that these and other developments (e.g., new technology) could affect soldiers' available time, USAFMSA asked RAND to help assess and improve the AMAF update process. The goals of the research were to identify lessons learned from other services and commercial organizations and to develop an approach to AMAF estimation that offers the Army a more adaptive, lower-cost update process.

Lessons Learned from the Other Services and Commercial Organizations

Methods for determining non-available time can be broadly described as either "directive" or "calculation" approaches. The directive approach involves establishing a fixed amount of time per day for function/MOS duties, while the remainder of the day, i.e., the time left over after spending the required hours on function/MOS duties, is designated as non-available time. In contrast, the calculation approach involves examining how personnel actually spend their non-available time—that is, identifying specific activities within the category of "non-available time" and then measuring the time spent on each activity. This approach computes how much time personnel need for personal and unit-related activities, and then treats the remaining time in the day as available time for function/MOS duties. Traditionally, the Army has used the calculation approach, but an important question to consider is whether the directive approach might be more appropriate.

A review of other military services' treatments of non-available time suggests that their approaches are more directive than that of the Army. For example, the Navy samples productive work-hours to generate an approved standard measure of a productive workweek, which is the basis for its work-hour availability factor (WAF), the "average number of work-hours per month an assigned individual is available to perform primary duties" (Navy Manpower Analysis Center, 2000: M-22). The Air Force uses a detailed simulation model of demand to estimate the monthly labor-hours and number of personnel from each Air Force Specialty Code (AFSC) required to accomplish tasks. An implicit assumption of the model is that the requirements will leave personnel with sufficient time for activities that are not related to their functional duties,

so that detailed non-availability calculations are unnecessary. In the Marine Corps approach, neither task demands nor personnel available/non-available time is calculated. Instead, the organization relies on rules of thumb as well as input from subject matter expert (SME) groups to determine the number and types of personnel needed for a particular work area.

In the commercial sector, we found examples of both the calculation and directive approaches to non-available time. A common calculation approach, particularly in the healthcare and manufacturing sectors, is activity analysis, which entails identifying the tasks performed in an organization or organizational unit, examining the relationships among those tasks, and distinguishing between those that are primary versus secondary, value-added versus non-value-added, or productive versus nonproductive. In commercial firms that, like the Army, have "deployed" personnel who frequently reside at a worksite away from their families and homes, the directive approach to non-available time is prevalent. For example, while deployed, oil rig workers typically spend 12 hours on-duty and 12 hours off-duty per day.

Our review of military and commercial approaches to non-available time resulted in some lessons for the Army:

- The calculation approach tends to be costly and time-consuming because of the data collection required. Additionally, it is difficult to capture accurate data on some non-availability factors.
- The directive approach has the advantage of lower cost, although the resulting personnel requirements may be difficult to defend unless the organization has very well defined and substantiated task requirements, such as the Air Force and offshore drilling firms. Without clear task requirements, the risk is that personnel requirements will be subject to challenge.

A More Adaptive, Lower-Cost AMAF Estimation Method for the Army

Assuming that the Army decides to continue using a calculation approach, a key challenge of AMAF estimation is finding an update process that can be done regularly—but without each update necessarily requiring the substantial investment that prior updates required. At times, a quick, rough assessment of

one or more non-availability factors may be sufficient, while at other times, potential changes will most likely require more rigorous assessment of non-availability factors. Rather than using a single data-collection approach for all updates, the Army may find it more cost-effective to match the approach to the scope of the update. Below we list three common data-collection approaches that, together, offer a range of options.

SME judgments. This approach, used by the Marine Corps, is fast and relatively inexpensive. It involves soliciting the opinions of a small group of experts on the topic of interest, either by meeting with them in person or remotely (by email or phone). While the method typically does not yield data for a statistical analysis, it can offer reasonable answers to a small set of questions that are limited in scope, and it can take as little as a week or two to complete.

Web survey. This method involves posting a questionnaire at a website and emailing a target population to solicit their participation. The process of developing and implementing a web survey (including questionnaire design, creation of a sampling plan, tracking of responses, and analyzing results) can take as long as 2 to 4 months. Labor-hours and software requirements make this approach costlier than SME judgment, but the resulting data are generally of reasonable quality and suitable for statistical analysis. However, this method is susceptible to survey errors, including self-selection bias. Web surveys also tend to have low response rates.

Structured observation. More time-consuming and expensive is the structured observation approach, which involves direct observation and systematic recording of events, behaviors, and conditions in a setting of interest. Data obtained through this method tend to have fewer biases and thus higher quality than the self-report data captured by surveys. Structured observation can also offer a statistical sample, if enough observations are made. This approach is less susceptible to response biases than self-report methods, and allows researchers to capture context more effectively than web surveys.

AMAF Estimation Could Incorporate a "Three-Gate" Approach to Data Collection

All three data-collection methods might be used by the Army to inform AMAF updates, as described below.

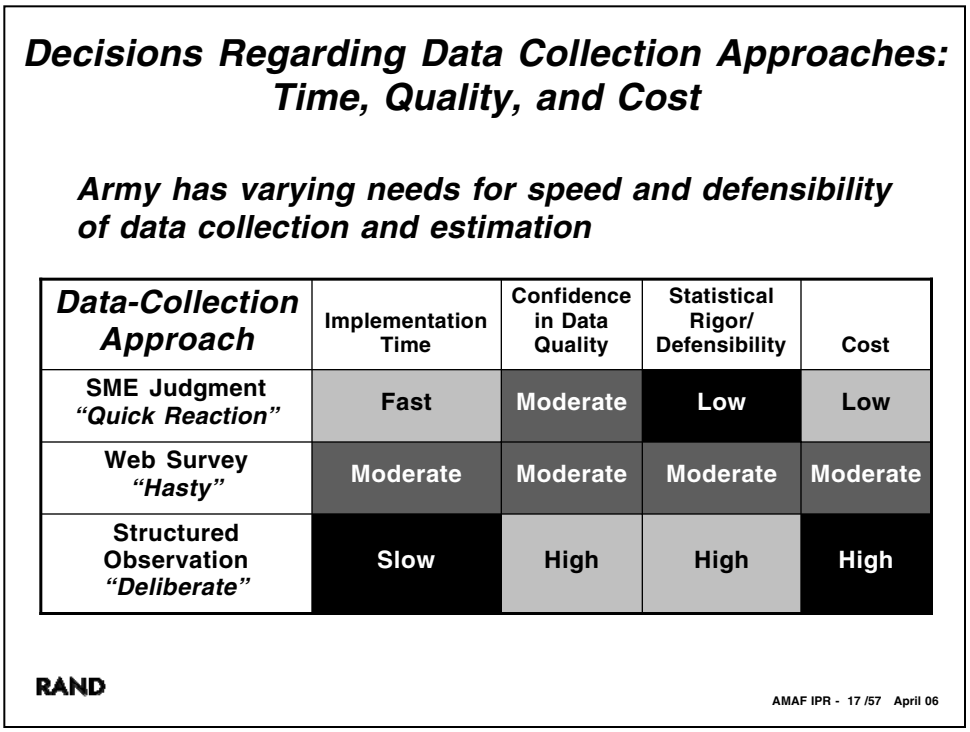
Quick Reaction Method. If a rapid, rough assessment of non-available times is required, then a data-collection approach that is fast, low-cost, and low in statistical rigor may be sufficient. The Quick Reaction Method primarily calls for SMEs but may involve limited use of the internet for gathering data from those SMEs or conducting a small-scale web survey. This method would be appropriate when reports from the field or an automated flag from a data system suggests that personnel may not have enough time to perform maintenance or other tasks and a quick assessment is needed to determine the magnitude and source of the problem.

Hasty Method. If somewhat more time is available and a broader assessment of non-availability factors is required, then a moderately costly data-collection approach involving a larger sample (and more statistical rigor) may be appropriate. This method primarily involves administering a web survey to a large sample, but it may also include supplementary, on-the-ground observations and data collection to use as a comparison to check for potential sampling biases or other sources of error. The Hasty Method may be necessary when the Quick Reaction Method indicates that a problem may be systemic (affecting more than a few units) and that more extensive data collection is required for verification and statistical analysis.

Deliberate Method. If the quality of an estimate is particularly important but speed is less critical (e.g., if results of the update will be used for long-term planning and documentation rather than for temporary adjustments to manpower), then a slower, highly rigorous, and more expensive approach may be warranted. Additionally, a substantial change in Mission, Enemy, Terrain, Troops available, Time, and Civilian considerations (METT-TC) may warrant a more thorough review of non-availability factors to ensure their relevance and accuracy; thus, METT-TC constitutes a potential trigger for use of the Deliberate Method.

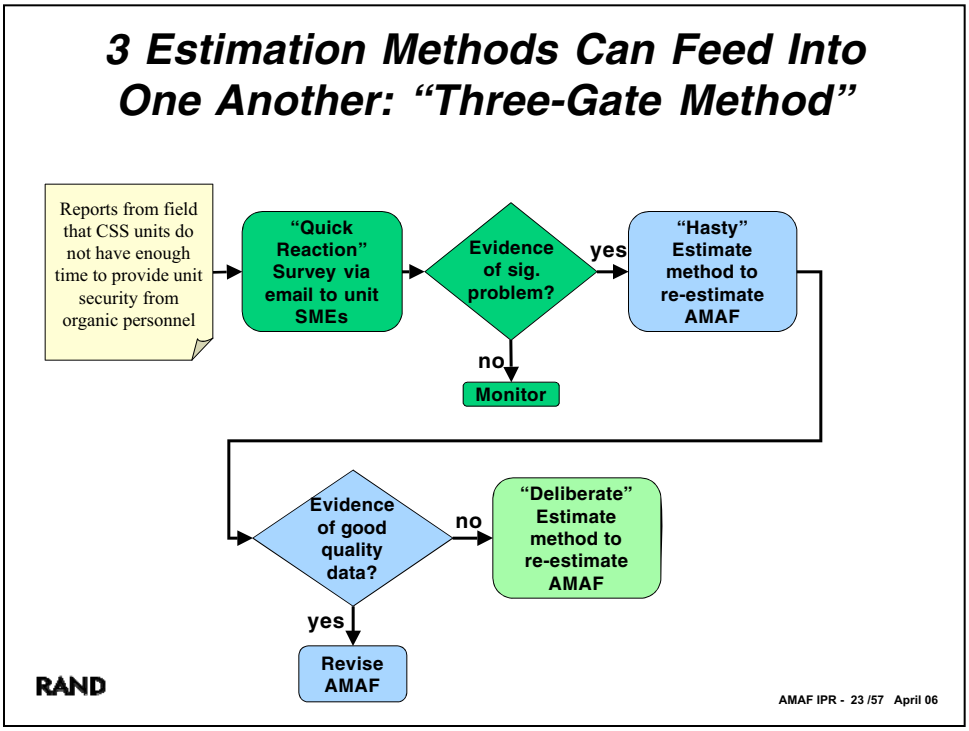
Figure S.1 summarizes some of the features of each of these data-collection approaches in terms of time required, quality (both in terms of confidence in the data quality and statistical rigor), and cost.

Figure S.1
Features of Different Data-Collection Methods



The Quick Reaction, Hasty, and Deliberate approaches to AMAF estimation, and the data-collection methods each incorporates, need not be mutually exclusive. Rather, they may feed into one another, as shown in Figure S.2. For example, if reports from the field suggest that organic personnel at CSS units do not have enough time to provide unit security, MARC planners could begin investigating the issue via the Quick Reaction approach, sending a set of questions by email to a group of SMEs. If responses to the questions suggest that the problem is minor, then AMAF adjustments may be unnecessary, and planners should simply continue to monitor the situation. But if SMEs indicate that the problem is significant and widespread, then planners can begin the Hasty Method for updating AMAFs, distributing a web survey to a larger sample, with supplementary spot checks on the ground. If the web survey yields high-quality data (e.g., reasonable response rate, representative sample, low measurement error, minimal response bias), then those data may serve as a basis for AMAF revision. If not, the Deliberate Method is warranted.

Figure S.2
A "Three-Gate Method" for Gathering AMAF Data



The Army May Also Want to Further Refine the Update Process

Additional decisions to be made about the AMAF update process include the extent to which AMAF tailoring is needed, which non-availability factors should be examined, and how frequently updates should be performed.

AMAF Tailoring. Historically, the Army tailored calculations of non-availability factors to the type of unit (i.e., Combat, CS, or CSS); the unit's location on the battlefield (i.e., Division/Brigade Combat Team, Corps/Support Brigade, or Echelons Above Corps); and the amount of unit movement. However, non-availability factors have not been tailored on the basis of other dimensions, even though such dimensions could cause non-available times to differ. While tailoring the AMAF according to numerous dimensions may be impractical, some dimensions are particularly relevant to soldier non-available time and, thus, may be natural candidates for further AMAF tailoring. These areas include different MOSs, deployment conditions and the type of contingency/mission, OPTEMPO, basing conditions, and other factors.

Inclusion of Non-Availability Factors. Another important decision for MARC planners is which non-availability factors to include in the AMAF updates. Several potentially significant factors did not appear in the 1983 and 1992 studies, including rest and recuperation, physical training, and personal digital communications. To determine which non-availability factors to exclude or include in a future data-collection process, the Army might want to adopt a threshold such as the "2 percent rule": If a factor is likely to consume more than 2 percent of a soldier's waking hours, it is probably worth measuring.

Frequency of Updates. An update process that permits more frequent data collection will help ensure that non-availability factors reflect technological or socioeconomic changes. But how frequently should the Army conduct updates? The answer is likely a function of Army preferences, the triggers being monitored, and the TOE modification process. If the Army were to implement the three-pronged approach to AMAF estimation described earlier, it would be important to define and monitor possible triggers for each method. For example, some triggers might initiate the Quick Reaction method, while others may initiate the Hasty or Deliberate method. Then, depending on the information revealed by these estimation methods, either short-term or long-term staffing adjustments may be needed.

Metrics Can Be Used to Assess the Fit of AMAFs to Units and Tasks

The Army can also use various techniques to assess the fit of AMAFs to the units and the tasks they encounter. A direct method of assessing whether there is enough time to accomplish all the duties and personal requirements in a soldier's day is to "ask the customer," e.g., use web-based surveys of soldiers to assess the fit of workload to available productive time. A second, more indirect method is to carry out exit interviews/surveys and re-enlistment surveys with soldiers. If the results from such surveys showed, for example, that the top reasons cited for not re-enlisting include responses like "excessive workload" or "burnout from too much work," this may be an indicator that there is a possible mismatch of manpower to workload.

The Army might also consider ways of formalizing estimation methods. AMAF calculations vary across factors, and the underlying logic and specific algorithms are spread across a number of publications. Having a single place

that gathers and makes accessible all the supporting information for AMAF calculations has a number of advantages. Supplying formally defined AMAF factor calculations in a locked spreadsheet, publicly available for download, provides some advantages over the current, paper-based formalization. This approach allows any interested party to inspect the calculations, assumptions, and underlying data, and allows changes to the calculations to be documented.

Conclusion

With the Army transitioning from conventional, sporadic warfare to less conventional, persistent conflict, it has become essential to create a more flexible and responsive structure. The ability to move personnel and/or reorganize units quickly, whether to manage new threats or adapt to new technology, requires a MARC process with regular reviews and adjustments. The three-pronged approach proposed in this study can give the Army a process that is adaptable to the full range of missions that the Army must be prepared to fulfill.

Acknowledgments

We would like to thank the United States Army Force Management Support Agency (USAFMSA) for sponsoring this research. COL Gerald O'Keefe, Ray Lowry, Neil Knarr, Lee Brush, and Kenneth "Mac" McDaniel (all from USAFMSA) provided us with valuable feedback during the project; their insights and suggestions contributed substantially to the project's success. Special recognition goes to Neil Knarr, Lee Brush, and Mac McDaniel, who worked in close collaboration throughout. The depth of their applied knowledge and field experience, combined with their willingness to grapple with difficult issues and be honest, patient sounding boards provided great value to the project.

Also vital to the project were the interviewees who shared their time, experiences, and insights—often on multiple occasions. Christopher Sutton of the United States Army Combined Arms Support Command (CASCOM) discussed the Quality Assurance (QA) group's experiences with web survey software as well as web survey design and administration. We greatly appreciate the cooperation of Mr. Richard Morris, Managing Editor of the U.S. Army's *PS* magazine for providing permission to use a cover from that publication. Also, Louis Datko of the Air Force Survey Office offered a thorough description of his organization's approach to web surveys, including key steps in the process and approximate timelines. Additionally, Frank Donahoe of the Marine Corps' Total Force Structure Division described how the Marine Corps determines manpower requirements. Providing a commercial perspective, Walter Luckett of Schlumberger shared his knowledge about the schedules of oil-rig workers who are "deployed" offshore.

At RAND, Eric Peltz and Rick Eden provided very helpful guidance on briefings, documentation, and the overall project direction. Donna White provided solid administrative support throughout. Additionally, Pamela Thompson helped prepare and format this document.

LTC David A. George, who participated in the RAND Army Fellows Program during FY06, shared his experiences in managing contractor work schedules as well as his thoughts on the feasibility of administering surveys to deployed personnel. LTC John Keeter, another Army Fellow during FY06,

also provided valuable insights regarding the data that are collected from soldiers on exit from Army service. Our work also benefited from manpower availability and requirements discussions with U.S. Marine Corps RAND Fellow LtCol David "Stretch" Coffman and Navy RAND Fellow LtCdr Lisa Dolan. Also, Kirsten Becker of the RAND Survey Research Group provided estimates of web survey administration costs.

Interactions with these individuals not only increased the quality of this research but also made working on the project a most enjoyable and rewarding experience.

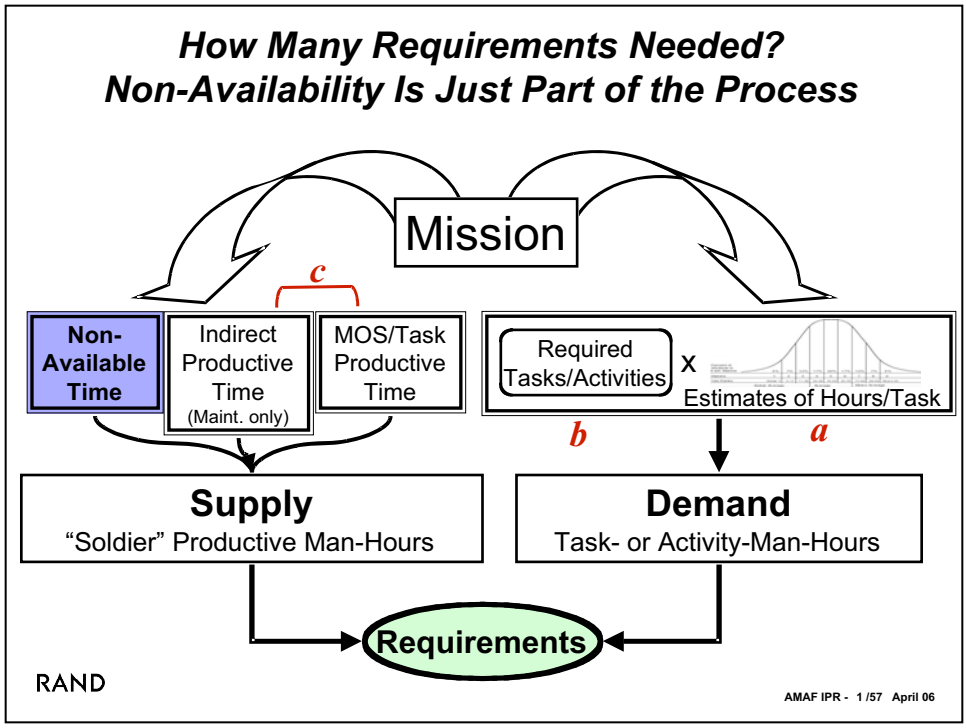
Glossary

AFSC	Air Force Specialty Code
AMAF	Annual MOS Availability Factor
AMMDB	Army MARC Maintenance Database
CASCOM	Combined Arms Support Command
CBT	Combat
CNA	Center for Naval Analysis
CS	Combat Support
CSS	Combat Service Support
DPT	Direct Productive Time
DSP	Defense Standardization Program
EAC	Echelons Above Corps
FAA	Federal Aviation Administration
FMSWeb	Force Management System Website
FOB	Forward Operating Base
GD	General Dynamics
HQDA	Headquarters, Department of the Army
IPT	Indirect Productive Time
IPT	Integrated Product Team
LCOM	Logistics Composite Model
LIW	Logistics Information Warehouse
LOGCEN	U.S. Army Logistics Center
MAJCOM	Major Command
MARC	Manpower Requirements Criteria
MCO	Major Combat Operation

METT-TC	Mission, Enemy, Terrain, Troops available, Time, and Civilian considerations
MOS	Military Occupational Specialty
MPRI	Military Professional Resources, Inc
MTOE	Modified Table of Organization and Equipment
NAVMAC	Navy Manpower Analysis Center
NCO	Non-Commissioned Officer
NTC	National Training Center
POM	Program Objective Memorandum
QA	Quality Assurance
SASO	Stability and Support Operation
SME	Subject Matter Expert
TOE	Table of Organization and Equipment
TRADOC	Training and Doctrine Command
UFC	Unit Function Code
ULC	Unit Location Code
USAFMSA	U.S. Army Force Management Support Agency
USAREUR	U.S. Army Europe
WAF	Work-hour Availability Factor

1. Background on AMAFs and Purpose of Study

The quantities and specialties of personnel distributed among Army units can have a significant impact on Army operations. An insufficient number of personnel, or a mismatch between the military occupational specialties (MOSs) of personnel and unit task requirements, could affect units' readiness and overall performance. As Army operations increase in frequency and variety, careful allocation of manpower becomes particularly critical. Thus, the U.S. Army Force Management Support Agency (USAFMSA), the organization largely responsible for calculating and documenting Army manpower requirements and authorizations, is continually striving to improve that process to meet Army needs. This documented briefing describes research aimed at facilitating these improvement efforts. Recommendations based on this research are likely to enhance the quality of decisions about personnel allocation (i.e., the number and type of personnel that work units require). By enabling more frequent reviews of a key factor used to calculate manpower requirements, the proposed process will facilitate short-term decisions (to address immediate manpower issues) as well as longer-term decisions affecting Modified Tables of Organization and Equipment (MTOEs) as well as Program Objective Memorandum (POM) budget formulations.



Each military mission generates some number of required tasks and activities. The U.S. Army and other services each use some combination of data and judgment to estimate how many man-hours a mission's work will require; this constitutes the demand for labor. The mission can also affect how people use their time, i.e., how much time is reserved for sleep and personal needs, and how much time is reserved for unit security and other organizational duties. Manpower Requirements Determination matches estimates of the available supply of productive man-hours to estimates of the tasks and activities that demand those man-hours.

Currently, USAFMSA integrates data from multiple sources to measure Manpower Requirements Criteria (MARC), the set of factors used to calculate combat support (CS) and combat service support (CSS) manpower requirements—i.e., positions in tables of organization and equipment (TOEs).[1] MARC components include (a) labor-hours required per task or activity (i.e., per "work unit"), (b) the required number of tasks or activities, and (c) the

[1] Formally defined, MARC are standards used to determine minimum mission essential wartime requirements (MMEWR) to perform CS and CSS functions (both maintenance and non-maintenance) for sustained combat operations (USAFMSA, 2002:1).

direct and indirect productive time that a soldier has available to perform those tasks (HQDA, 1997). Components (a) and (b) capture the demand for labor, and component (c) captures the labor supply. Part of the MARC process is measuring a soldier's non-available time, the time that a soldier does *not* have available for MOS-related tasks.

The manpower requirement calculation is the product of productive labor-hours required per work unit and the number of work units, divided by the annual MOS availability factor (AMAF)—i.e., (a) x (b) ÷ (c). For example, maintenance manpower requirements are calculated as follows:

$$\frac{\text{Maintenance Labor-hours per Equipment Unit per Year} \times \text{Total Quantity of Equipment from TOE}}{\text{AMAF}} = \text{Manpower Requirement}$$

The annual MOS availability factor (AMAF) refers to the amount of direct and indirect productive time (over the course of a year) that a soldier has available to perform MOS duties. Traditionally, the Army has calculated AMAFs by measuring soldiers' non-available hours per day, treating the remainder of the 24 hours as available time, and annualizing that available time figure.

Components (a) and (b) of the manpower requirement calculation are accessible via such resources as the Army MARC Maintenance Database (AMMDB) and the Force Management System Website (FMSWeb, formerly known as WebTAADs). The materiel development community provides the data for AMMDB, and multiple agencies contribute to the development, review, and modification of TOEs (USAFMSA, 2004). Component (c), the AMAF, is based on field data collection to identify specific "non-availability factors"—that is, the non-MOS-related activities that comprise non-available time—and to measure how much time soldiers allocate to each of those activities. The two previous AMAF studies, by the Army Training and Doctrine Command (TRADOC), occurred nine years apart, in 1983 and 1992, and

focused on measuring non-available time for grades E-5 and below.[2] For the 1983 study, a nine-person U.S. Army Logistics Center (LOGCEN)[3] team received training in interview techniques and conducted structured interviews with officers and senior non-commissioned officers (NCOs) in 330 units in USAREUR. The team supplemented their interview data with data from several other sources (e.g., a sleep standard provided by the Soldier Support Center) to measure several factors that the interview document did not capture (MPRI, 1993). The data collection for the 1983 study was reportedly not completed due to data-quality problems attributed to the training of the data collectors and the overall costs of data collection (MPRI, 1993).

The 1992 study did not use questionnaires or collect field data; instead, TRADOC conducted a comprehensive analysis of the 1983 factors and adjusted them based on input from the MARC community, a Council of Colonels, and other subject matter experts (MPRI, 1993). AMAF updates are rare because of the investments in time and dollars they have required.

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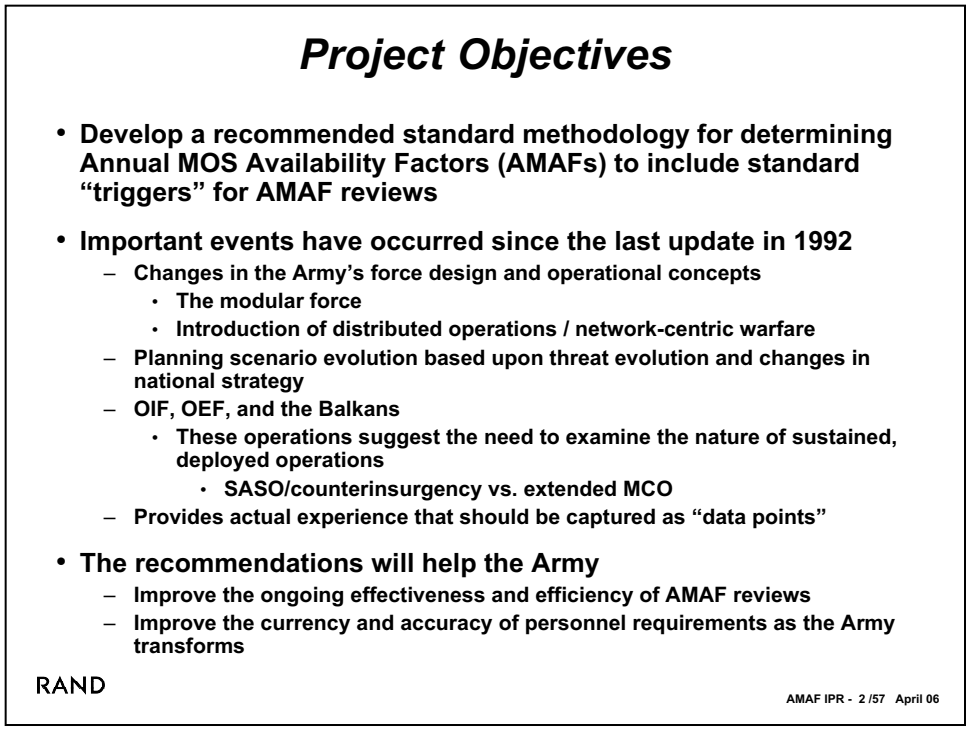
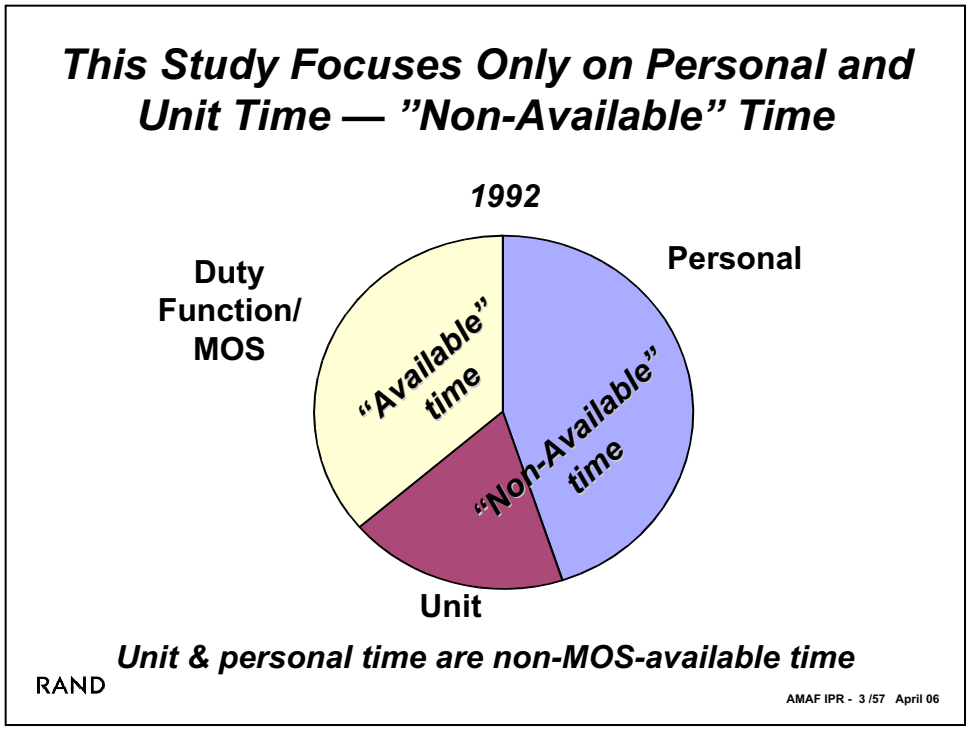
[2] The 1992 study looked at grades staff sergeant and below for unit security missions (MPRI, 1993).

[3] LOGCEN became the Combined Arms Support Command (CASCOM), a subordinate command of TRADOC.

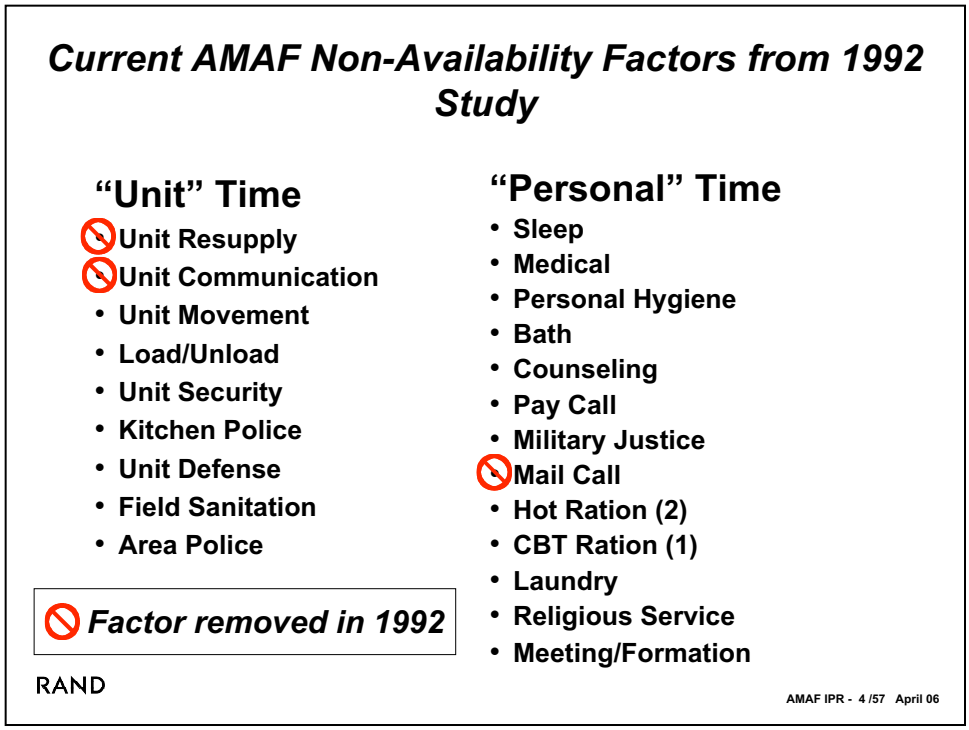


Over the past decade, however, there have been important changes in the Army's force structure, operational concepts, and planning scenario. Recognizing that these and other recent developments (e.g., new technology) could affect soldiers' available time, USAFMSA would like to improve the AMAF update process to allow more regular updates, as needed. This briefing describes research conducted in RAND Arroyo Center and sponsored by USAFMSA, with the objective of developing a recommended standard AMAF update process. Such a process will help ensure that assessments of non-available time requirements—i.e., the time needed for personal and unit (non-MOS-related) activities—remain accurate as the Army's structure and context change. That is, the proposed process will help ensure that non-available time is sufficient, but not excessive (leaving too little available time).



TRADOC's 1992 AMAF study noted that the daily activities of Army personnel fall into three broad categories: function/MOS-related duties, unit-related tasks, and personal activities (MPRI, 1993). As mentioned earlier, available time refers to the time soldiers have available for function/MOS duties (direct and indirect productive time), and non-available time refers to the time soldiers spend on unit-related tasks or personal activities. The present study focuses on non-available time, which determines available time per day (or per year—i.e., the AMAF). Available time per day = 24 hours – non-available time.

The authors of the 1992 study note that in order to get accurate estimates of manpower requirements, it is critical to have quality estimates of the non-available time to determine the "supply" or hours. However, it is also necessary to have quality estimates of the hours required for the tasks to accurately determine the "demand" for those hours.



This slide displays current Army non-availability factors that the 1992 TRADOC study identified. Factors with slashed circles next to them are those that were in the 1983 study but not in the 1992 study. Factors related to unit support—i.e., activities required to support a unit's mission—were classified as "unit" time.[4] Factors related to personal needs—i.e., regular activities performed by soldiers to meet their needs for mental and physical well-being—were classified as "personal" time. That said, in the ultimate calculation of non-available time, the distinction between unit and personal time does not come into play. That is, non-available time per day is simply the sum of those times spent on personal needs and unit support activities. Thus, while the classification of some factors may be debatable (e.g., whether meeting/formation should be classified as unit time rather than personal time), the issue is not one that affects AMAF calculations.

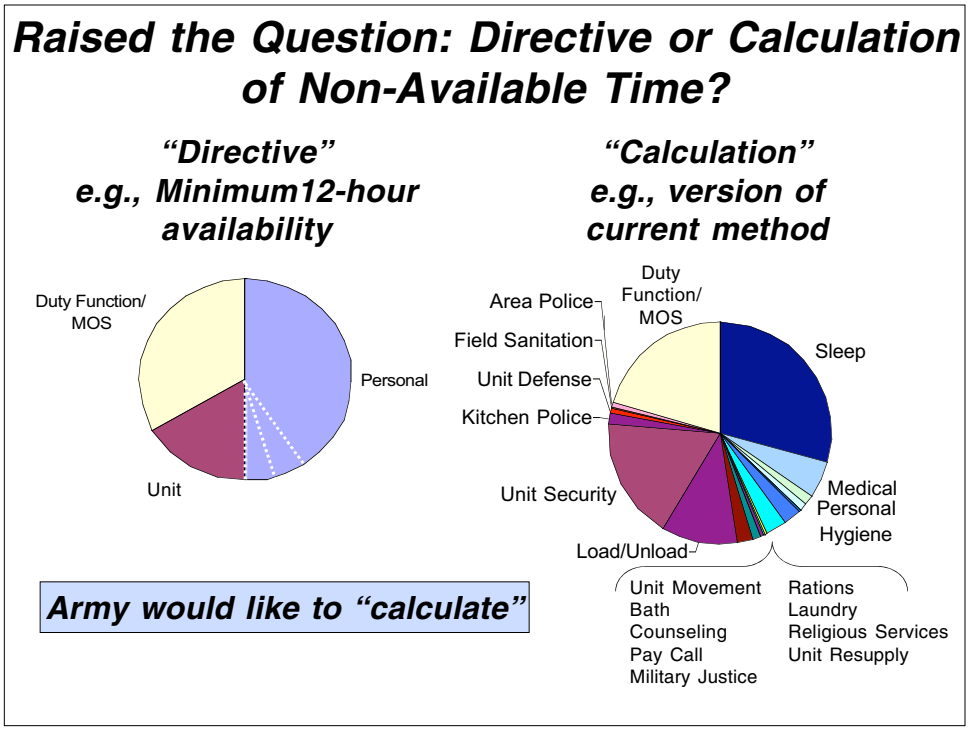
Key research questions for the present study include the following:

[4] Although unit time is spent on required tasks, it is still considered non-available time because it cannot be used for MOS duties. When determining how many soldiers of a particular MOS are needed for a task, one needs to know the time specifically available for MOS duties.

1. How do the approaches of other military services and commercial firms resemble or differ from the Army's approach to non-available time, and what are some lessons to be learned from those other approaches?
2. What general approach to AMAF estimation may provide the Army with a more adaptive, lower-cost update process?
3. What implementation guidelines are associated with the proposed approach—specifically,
    - Data-collection guidelines?
    - Guidelines for measuring effectiveness and formalizing the estimation approach?

Subsequent sections of this documented briefing address these questions.

2. Lessons on Estimating Non-Available Time from Other Services and Commercial Firms



Possible methods for determining non-available time can be broadly described as either "directive" or "calculation" approaches. The directive approach consists of requiring personnel to spend a fixed amount of time per day on function/MOS duties; the remainder of the day—i.e., the time left over after spending the required hours on function/MOS duties—is their allowed non-available time. Manpower requirements are then determined based on (a) the assumption that each worker will be available to perform tasks for the required amount of time and (b) task demands (labor-hours and specialties required).

In contrast, the calculation approach involves examining how personnel actually spend their non-available time—that is, identifying specific activities within the category of "non-available time" and then measuring the time spent on each activity. Rather than directing personnel to set aside a certain portion of the day for function/MOS duties, the calculation approach computes how much time personnel need for personal and unit-related activities, and the

remaining time in the day is treated as available time for function/MOS duties. In short, the directive approach bases non-available time on task demands, while the calculation approach bases non-available time on labor supply. Traditionally, the Army has used the calculation approach, but an important question to consider is whether the directive or calculation approach is more appropriate for Army purposes.

A review of other military services' treatments of non-available time suggests that their approaches are more directive than that of the Army. As a prior report (MPRI, 1993:2-1) stated when referring to the Navy and Air Force methods,

> neither service considers the individual non-availability tasks that are the major drivers of Army non-availability time. Both services essentially use a simplified, doctrinally defined workweek, as opposed to a 24-hour day encumbered with discrete amounts of productive and nonproductive times.

More recent documents indicate that the Navy uses work measurement to generate an approved standard productive workweek figure, which is the basis for its work-hour availability factor (WAF), the "average number of work-hours per month an assigned individual is available to perform primary duties," (Navy Manpower Analysis Center, 2000: M-22). Manpower requirements for a particular work center are determined by (a) measuring (via operational audit) the work-hours required for work center tasks and then (b) dividing that figure by the WAF. Work sampling is the basis for the WAF, and the primary focus of the Navy's work sampling effort is the measurement of productive work-hours.[5] While the work sampling process captures non-available time as well, Navy documentation suggests that non-available time measurements are not used to calculate sailors' available duty hours or a unit's staffing requirement: As Navy Manpower Analysis Center documentation (2000:4-8) indicates, "Work sampling accounts for all work-hours including non-available time; however,

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[5] Work sampling entails making brief, random observations of workers over a period of time to determine the proportion of time workers spend on various activities (Reid and Sanders, 2005). The Navy defines productive work-hours as time spent on "duties that are useful and essential to the command's mission and directly support the work center or organizational mission," (Navy Manpower Analysis Center, 2000: 4-8).

the resulting non-available work-hours are not used in the work-hour equation...."[6]

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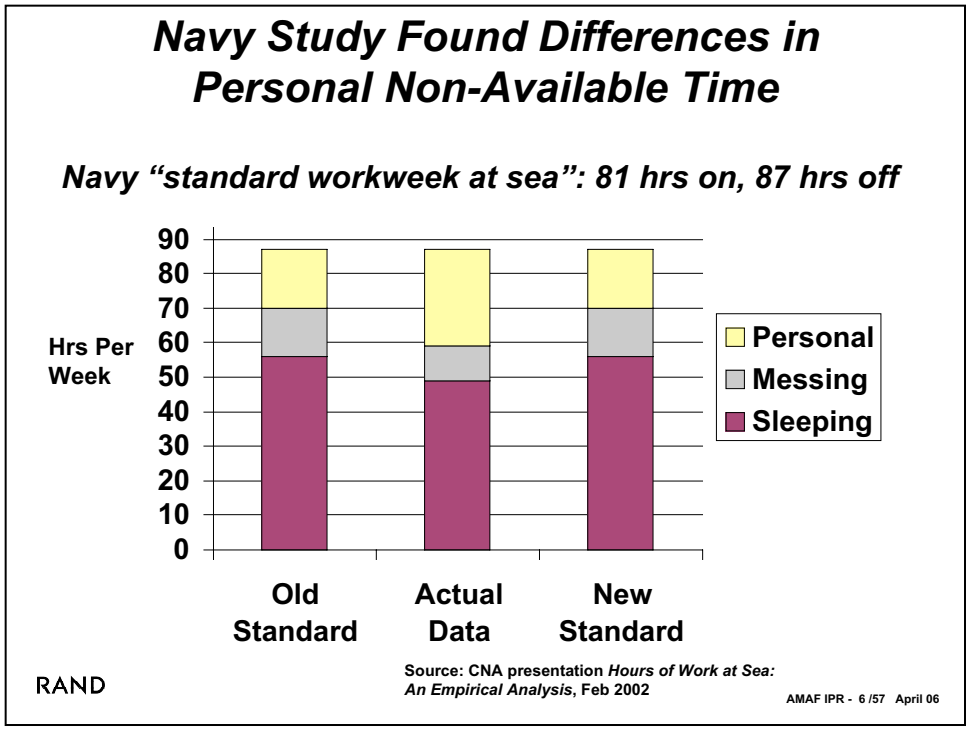
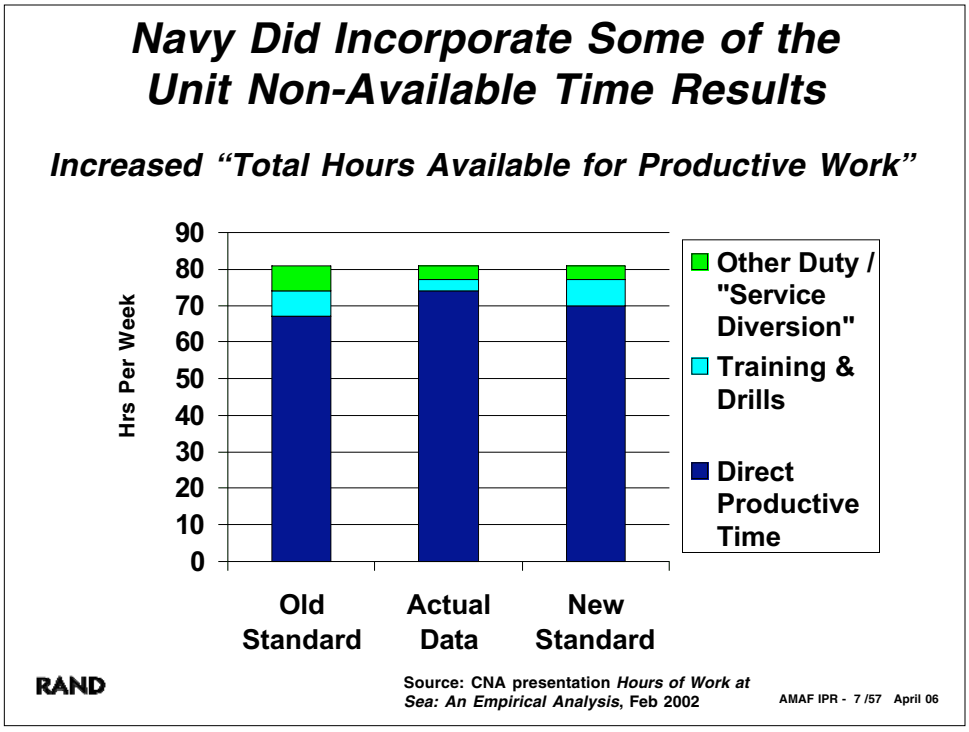
[6] NAVMAC defines non-available time as

> work-hours assigned to a work center but not available for productive effort for reasons which are essentially beyond the control of the work center supervisor (e.g., absences for leave, sick call or hospitalization, general military training, and administrative duties such as special cleanup details (external to the work center), taking a physical examination, verifying personnel records, and taking advancement exams. . .

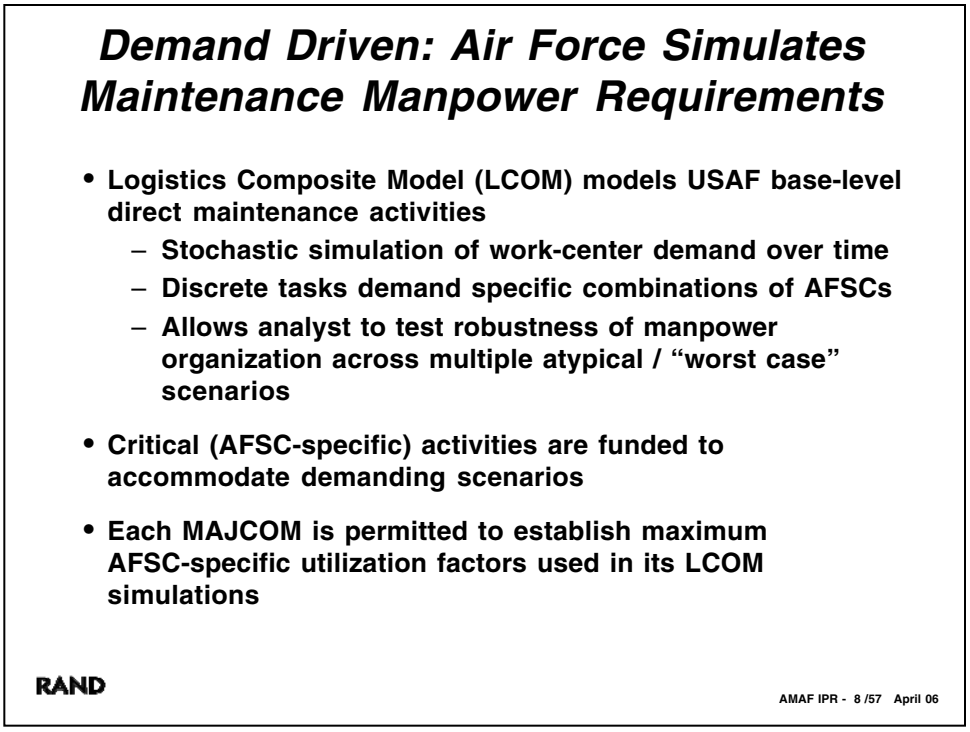
and it uses the term *non-productive time* to capture other types of non-available time—specifically, "time expended in either personal, rest, unavoidable delay, standby, or idle (avoidable delay) status" (Navy Manpower Analysis Center, 2000:M-19). Together, NAVMAC's non-available time and non-productive time essentially capture unit and personal non-available time. (In fact, the Center for Naval Analysis (Moore, Gasch, Hattiangadi, Quinton, and Schriver, 2002; Moore, Hattiangadi, Sicilia, and Gasch, 2002) referred to sleeping, messing, and personal needs as non-available time, rather than non-productive time.)



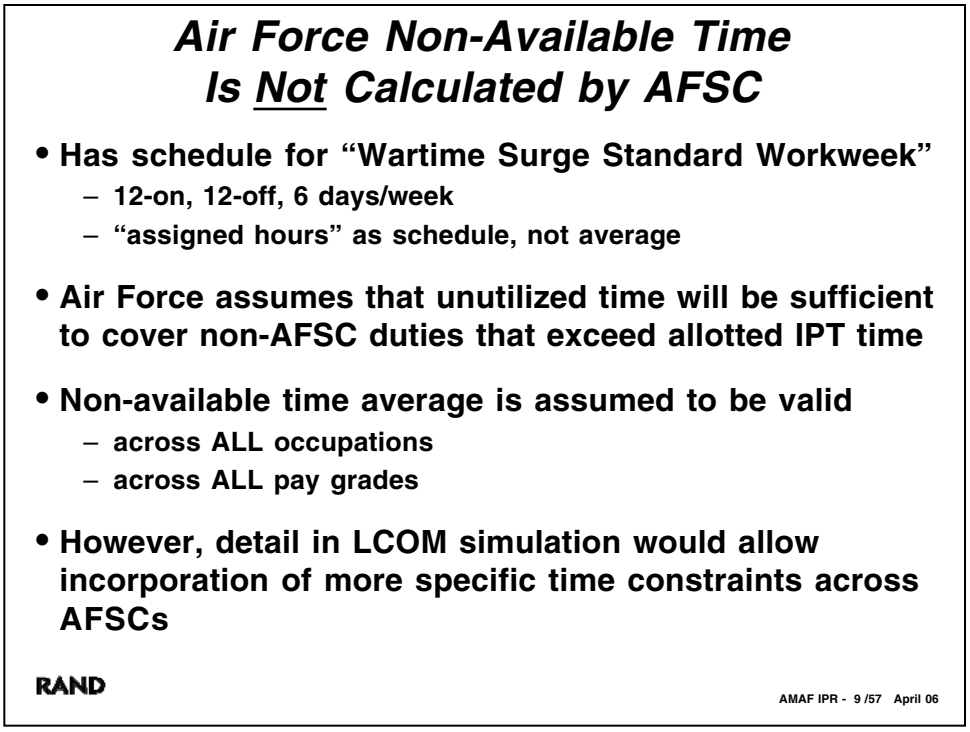
When the Center for Naval Analysis (Moore, Hattiangadi, Sicilia, and Gasch, 2002) conducted a study to assess the validity of the Navy's standard workweek figure and its subcategories, its findings differed from the standard figures. For example, personal time was higher than the standard, while sleep was lower than the standard. Also, productive work time was higher than the standard, while training time was lower than the standard.



As the above two slides indicate, the Navy responded to this new information with a mild reduction in other duty (service diversion) time (3 hours per week) to allow slightly more direct productive time. The Navy chose not to modify personal time and training time, perhaps because the overall workweek figures (81 hours of on-duty time, 87 hours of non-available time) in the Center for Naval Analysis (CNA) study were the same as the standard figures. Additionally, informal interactions with Navy personnel suggest that there may be "slippery slope" concerns associated with modifying personal or training time. Specifically, the concern is that if the Navy were to adjust expected personal time—i.e., making it longer and reducing the time allocated to sleep, it might send an undesirable message, encouraging sailors to sacrifice too much of their sleep time (to the detriment of health and performance). In short, the Navy's standard workweek, and the resulting WAF, tend to be fairly stable and are minimally affected by measurements of non-available time.



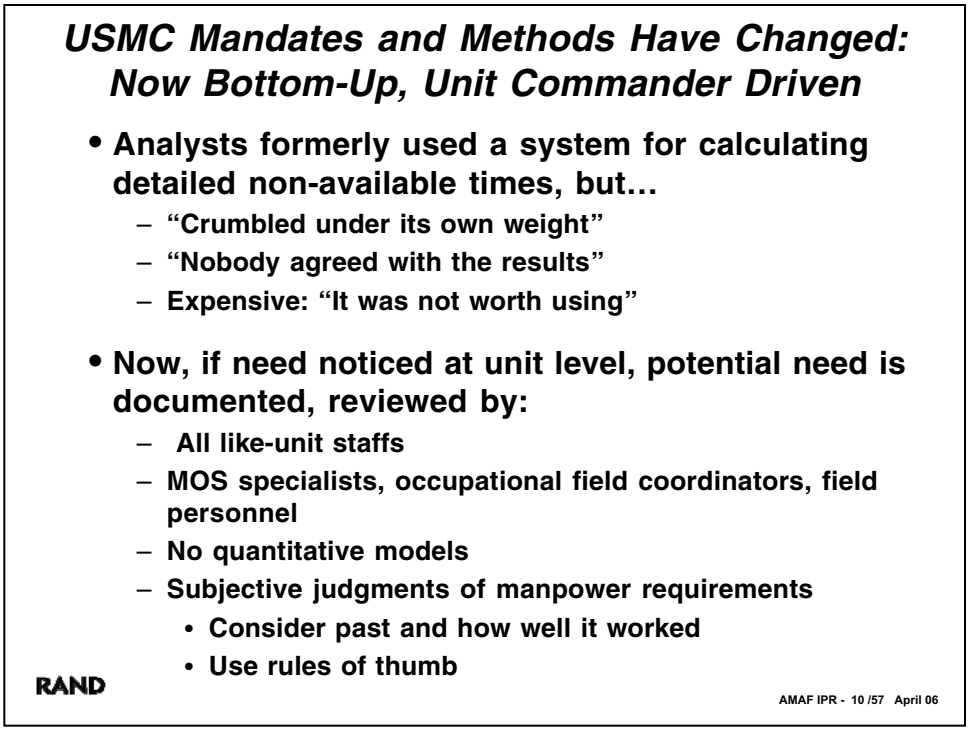
Non-available time also plays a minimal role in the process the Air Force uses to determine manpower requirements. The Air Force has a stochastic simulation model, the Logistics Composite Model (LCOM)(Dahlman, Kerchner, and Thaler, 2002), for estimating task requirements for maintenance positions—that is, the monthly labor-hours and number of personnel from each Air Force Specialty Code (AFSC) required to accomplish tasks. The model determines task requirements under peak-demand scenarios (those with the highest operational requirements), not average demands. This method ensures that given a wide set of conditions, maintenance units will be staffed to meet peak demands.



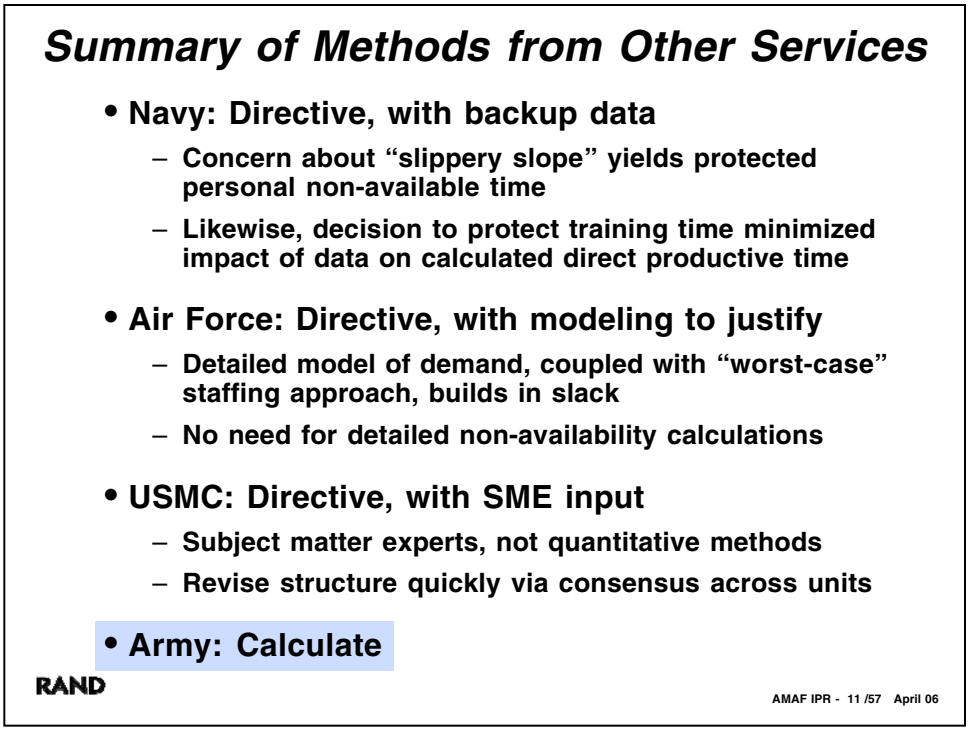
The detailed, data-driven LCOM model of task demands, coupled with a "worst case" staffing approach, tends to build slack into manpower requirements. An implicit assumption is that the requirements will leave personnel with sufficient time for activities that are not related to their functional (AFSC) duties, so detailed non-availability calculations are unnecessary. Thus, rather than measuring categories of non-available time, Air Force regulations dictate how much non-available time is expected of personnel. During a wartime surge, personnel are expected to spend 12 hours on-duty and 12 hours off-duty (non-available time), 6 days per week. As Dahlman, Kerchner, and Thaler (2002:iii) noted in their review of the Air Force process for determining maintenance manpower requirements, the Air Force has

> major command (MAJCOM)-wide standards and policies that prescribe the average number of monthly hours individuals can be expected to be away from their primary duties. The associated regulations state the average number of hours individuals are unavailable (holidays, weekends, sick leave, etc.) and specify a number of overhead tasks they are expected to accomplish during duty hours, thereby setting the ceilings for the hours available for primary duties…

Compared to the other services, the Marine Corps has a more subjective, less data-driven approach to manpower requirements: neither task demands nor personnel available/non-available time are calculated. Instead, the organization relies on rules of thumb as well as input from subject matter expert (SME) groups to determine the number and types of personnel needed for a particular work area. A rule of thumb may, for example, suggest how many administrators are needed to support a certain number of personnel. The SME groups vary in size and tend to include MOS specialists, occupational field coordinators, and field personnel.



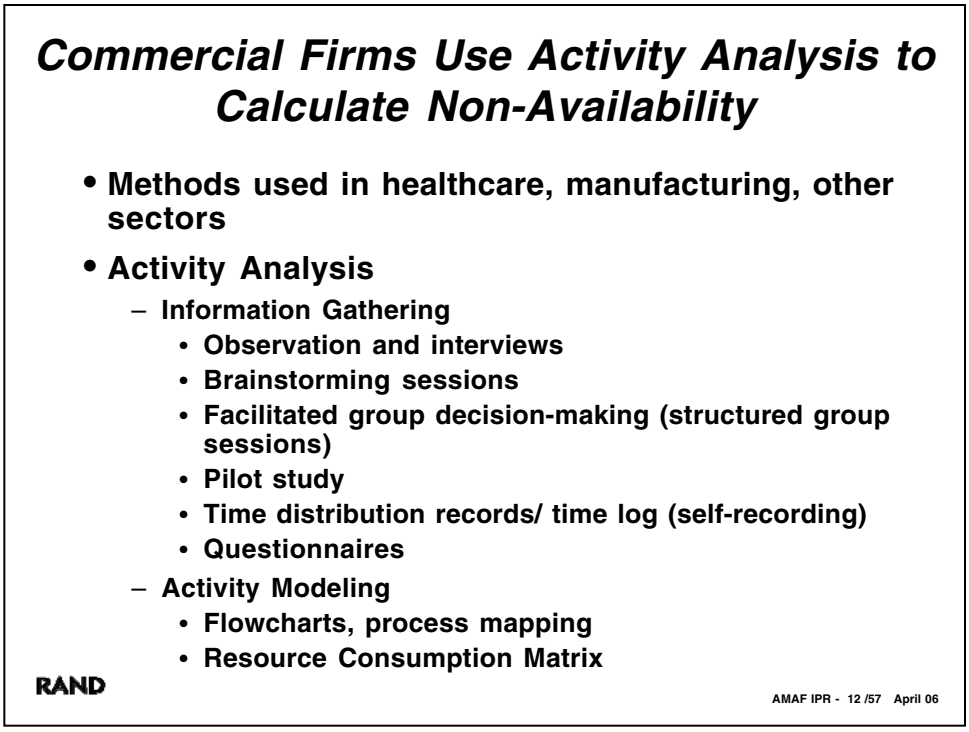
The Marine Corps used to have a detailed model for assessing specific categories of non-available time, but the model "crumbled under its own weight, was out of date, and nobody agreed with the results" (Donahoe, personal communication, January 12, 2006). Thus, the Army's calculation approach to non-available time is now unique among the military services.



In summary, while the Army's AMAF estimation approach entails calculation of non-available time based on intensive—but infrequent—data collection, other military services have variations of the directive approach to non-available time. Using an approach we call "directive, with backup data," the Navy measures productive work-hours via work sampling and uses that figure as the basis for its work-hour availability factor; data on non-available time are collected but not used. In an approach we call "directive, with modeling to justify," the Air Force uses the detailed LCOM model of task demands to determine labor-hour and personnel requirements, and based on that model, they specify how much non-available time is expected of personnel. The Marine Corps takes a more qualitative approach, which we call "directive with SME input"; their approach is to use expert judgment to determine how many personnel should be assigned to a particular type of unit, rather than measuring how many hours various tasks require or how much time workers spend on specific activities.

As in the military, both the calculation and directive approaches to non-available time exist among commercial firms. A common calculation approach, particularly in the healthcare and manufacturing sectors, is activity analysis.

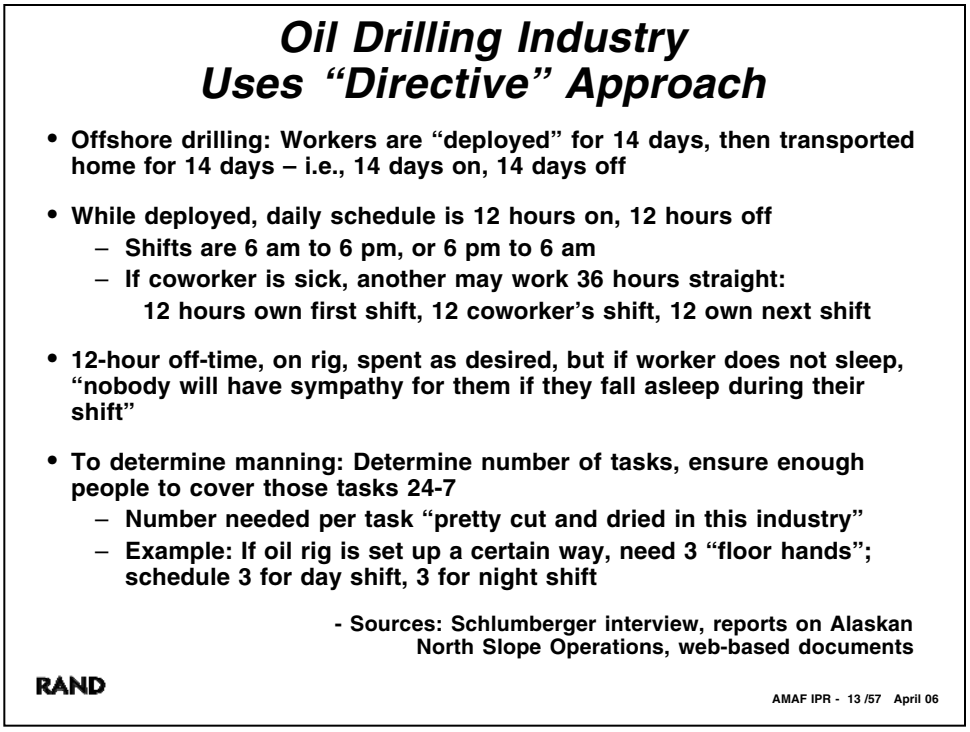
Typically implemented as a continuous improvement or cost accounting tool, activity analysis entails identifying the tasks performed in an organization or organizational unit, examining the relationships among those tasks, and distinguishing between those that are primary versus secondary, value added versus non-value-added, or productive versus nonproductive (Barfield, Fisher, and Goolsby, 2004; Canby, 1995; FAA Office of Information Technology (AIT), 1995). Activity analysis is often accompanied by assessments of the resource (e.g., time) consumption and output of each task.



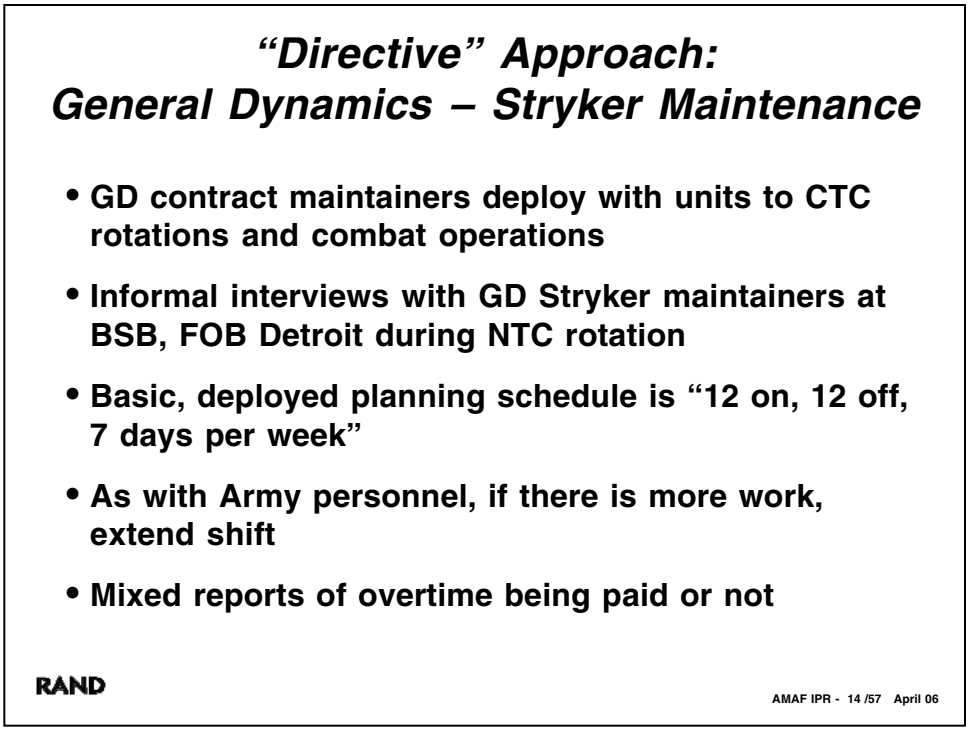
This slide highlights the two major components of activity analysis: information gathering and activity modeling. Information gathering consists of using one or more data-collection techniques (e.g., observation and interviews, brainstorming, structured group sessions, questionnaires) to identify activities and gather data on their purpose, sequence, and absolute resource consumption. Activity modeling consists of using one or more tools (e.g., flow charts, process mapping) to gain a better understanding of the activities' interrelationships, their relative importance, and their relative resource consumption.

Proponents of the activity analysis approach point out that it helps reveal how workers are spending their time, leads to elimination of activities that do not contribute sufficiently to the organization's goals, reduces resource consumption and costs, and can identify sources of quality problems (Carolfi, 1996; Howard, 1993). Caveats, however, are that it is itself a time-consuming and labor-intensive process (Canby, 1995; Sharman, 1994). Additionally, some argue that while activity analysis may help a company tighten operations in the short term and "improve how it does business as usual," it does not help the company determine whether a significant shift in direction is needed for

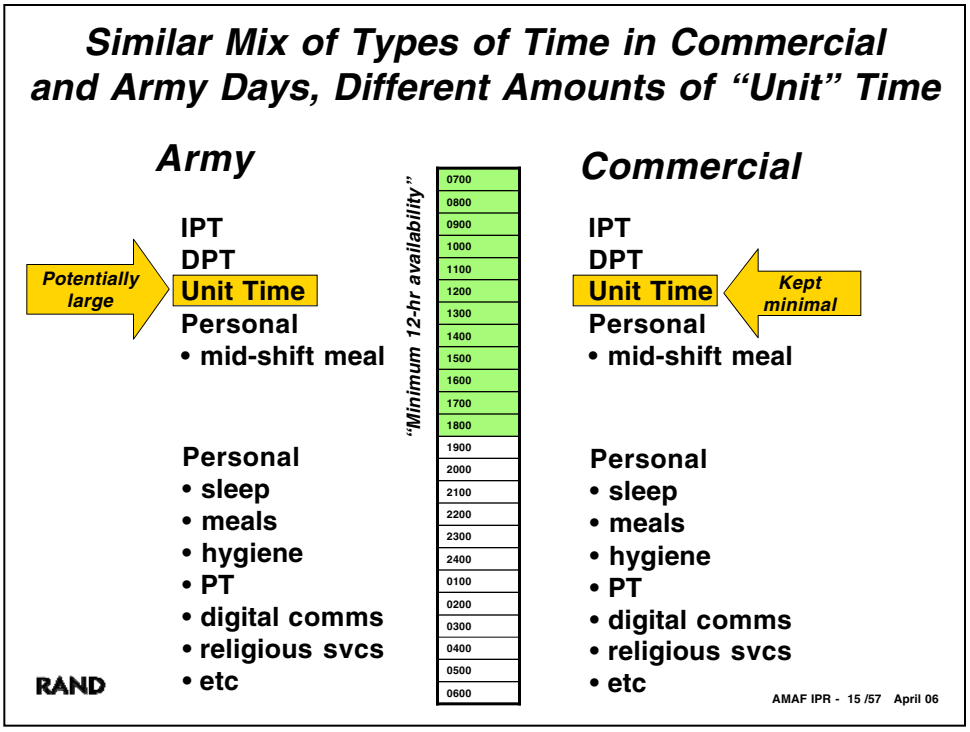
long-term competitiveness (Johnson, 1992:33). By the same token, in a military context, refining the Army's approach to calculating non-available time is helpful if the calculation approach continues to be appropriate, but it may sometimes be necessary to revisit the question of whether calculation should be done at all.



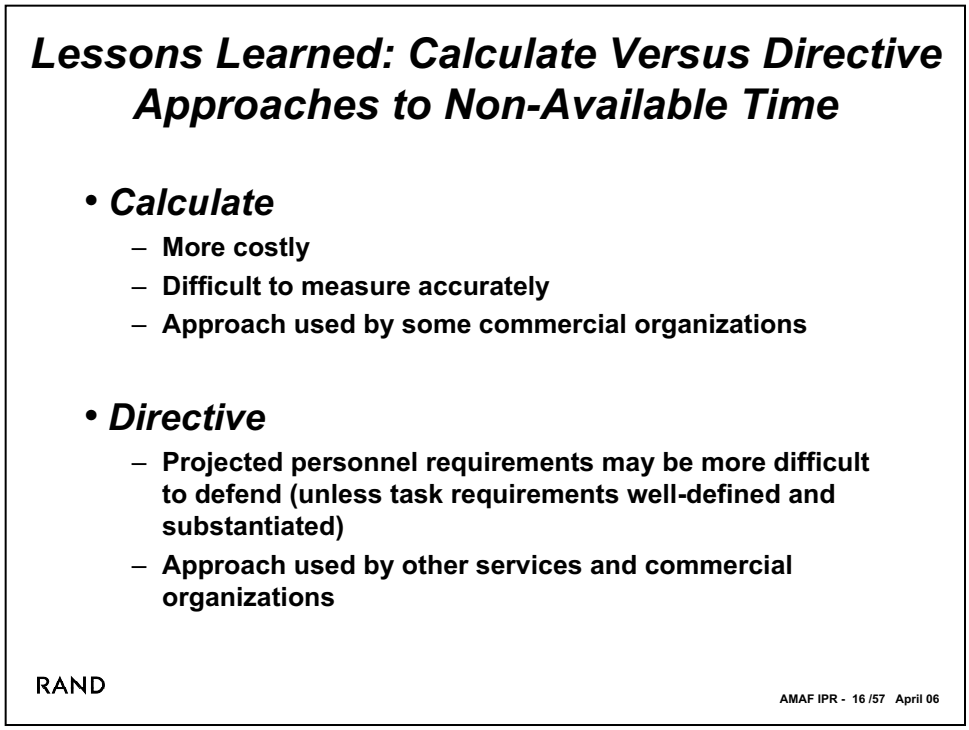
In commercial firms that—like the Army—have "deployed" personnel who frequently reside at a worksite away from their families and homes, the directive approach to non-available time is prevalent. For example, in offshore drilling, task demands dictate the available and non-available time of workers. For oil-rig workers, the standard while deployed (for two weeks at a time) is to spend 12 hours on-duty and 12 hours off-duty per day (Luckett, personal communication, March 22, 2006; rigworker.com, 2006; Skolnik, Holleyman, and Schwochert, 2002). If a coworker is ill, a worker may need to cover that additional shift, working 36 hours straight: his/her own shift (e.g., 6 AM to 6 PM), the coworker's shift (6 PM to 6 AM), and then his/her own shift once again (6 AM to 6 PM) (Luckett, 2006).



Similarly, when General Dynamics (GD) Land Systems workers deploy to an Army Stryker forward repair activity, they have a "12-on, 12-off, 7-day-per-week" schedule, and task demands sometimes require reduction of the 12-hour-per-day non-available time allotment.



Non-availability factors applicable in commercial firms with deployment resemble those in the Army, but the unit non-available time of commercial workers tends to be minimal, while Army soldiers potentially spend a large amount of time on such activities as unit security and unit defense (particularly with contractors in the battlefield).



Some key features of the calculation and directive approaches to non-available time are important to consider when choosing which to adopt. While some commercial organizations—and currently the Army—calculate non-available time, the challenge is that the data-collection process tends to be costly and time-consuming. Additionally, it is difficult to capture accurate data on some non-availability factors. The Marine Corps dropped the calculation approach, in part, because the non-available times were frequently criticized as invalid, and the Army has faced similar criticisms about some of its 1983 and 1992 results.[7]

The directive approach to non-available time, used by other military services as well as commercial firms with deployed workers, has the advantage of lower cost, but the resulting personnel requirements may be difficult to defend unless the organization has very well defined and substantiated task requirements, such as the Air Force and off-shore drilling firms. Luckett (2006,

[7] A General Accounting Office (GAO) review of the 1983 TRADOC study suggested that some of the estimates—particularly of unit movement times—may not be valid (GAO, 1984).

personal communication) noted that determining "how many tasks there are and making sure they have enough people to cover those tasks" is

> pretty cut-and-dried in [the off-shore drilling] industry. For example, consider "rough necks" (floor hands), the people that handle the pipe. If a rig is set up one way, you need three floor hands. If a rig is set up another way, you need two. If you need three, that means you need to schedule three on day shift and three on night shift.

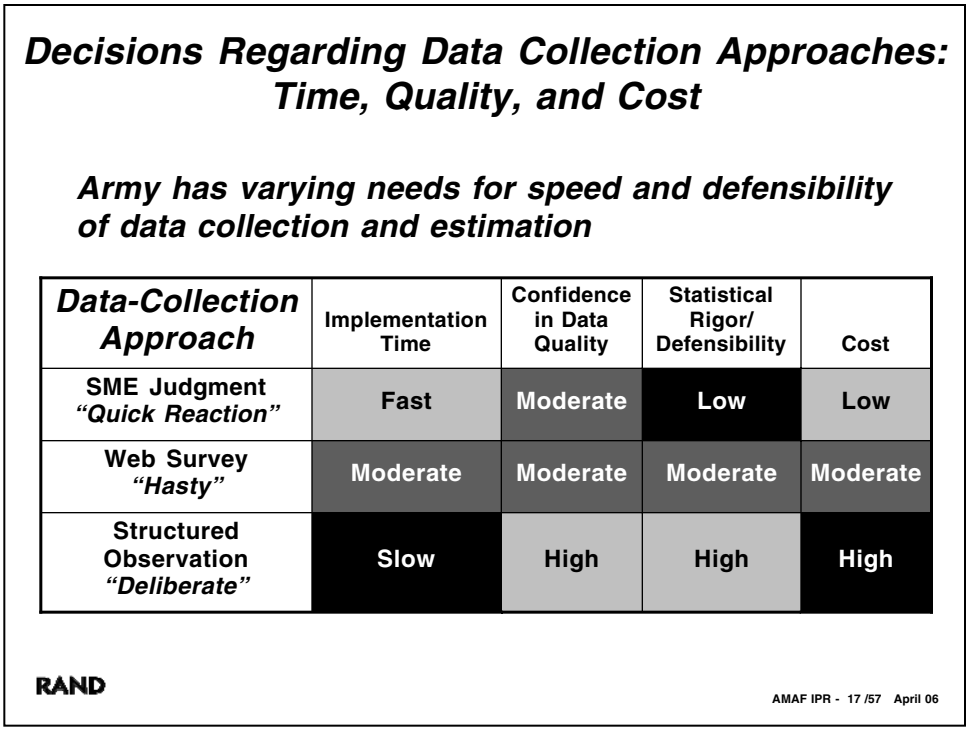
Without such clear task requirements, the risk is that personnel requirements will be subject to challenge—i.e., that units will be pressured to accomplish more with fewer personnel. Indeed, even in the Air Force, the Dahlman, Kerchner, and Thaler (2002:95) study observed that

> The lack of focused oversight over the direction of a significant portion of the maintainer's day is leading to a form of "mission creep": The uncontrolled addition of tasks that is creating an overtasked workforce, especially among midlevel and senior personnel.

Because Army tasks tend to be wide-ranging and fluctuating, it may be difficult to defend personnel requirements on the basis of task demands alone; for this reason, the calculation approach may be more appropriate—provided that an adaptive, lower-cost version can be implemented. The remainder of this document focuses on a proposed alternative calculation approach for determining AMAFs; nevertheless, at some point the Army may want to conduct a detailed assessment of the potential costs and benefits of adopting the directive approach, rather than the calculation approach it has historically taken.

3. General Methods for More Adaptive, Lower-Cost AMAF Estimation

For the Army, the key challenge of AMAF estimation is finding an update process that can be done regularly—but without each update necessarily requiring the substantial investment that prior updates required. We hope to identify a flexible AMAF updating approach that will yield short-term as well as long-term solutions to manpower issues. At times, a quick, rough assessment of one or more non-availability factors may be sufficient to address the need for limited, minor changes in manpower requirements. At other times, potential changes are wider in scope and call for more rigorous assessments of non-availability factors. Thus, rather than a single data-collection approach for all updates, it may be more cost-effective to match the data-collection approach to the scope of the update. Three common data-collection approaches that, together, offer a range of options include (1) gathering SME judgments, (2) a web survey, and (3) structured observation. More specifically, SMEs can provide expert judgments of times required for a set of activities (or the number of personnel required in a particular unit); soldiers can provide approximate time requirements based on their recollection and experiences; and/or observers can record the amount of time they see soldiers spending on particular activities—and whether the time appears to be sufficient or excessive. We elaborate on these options below.

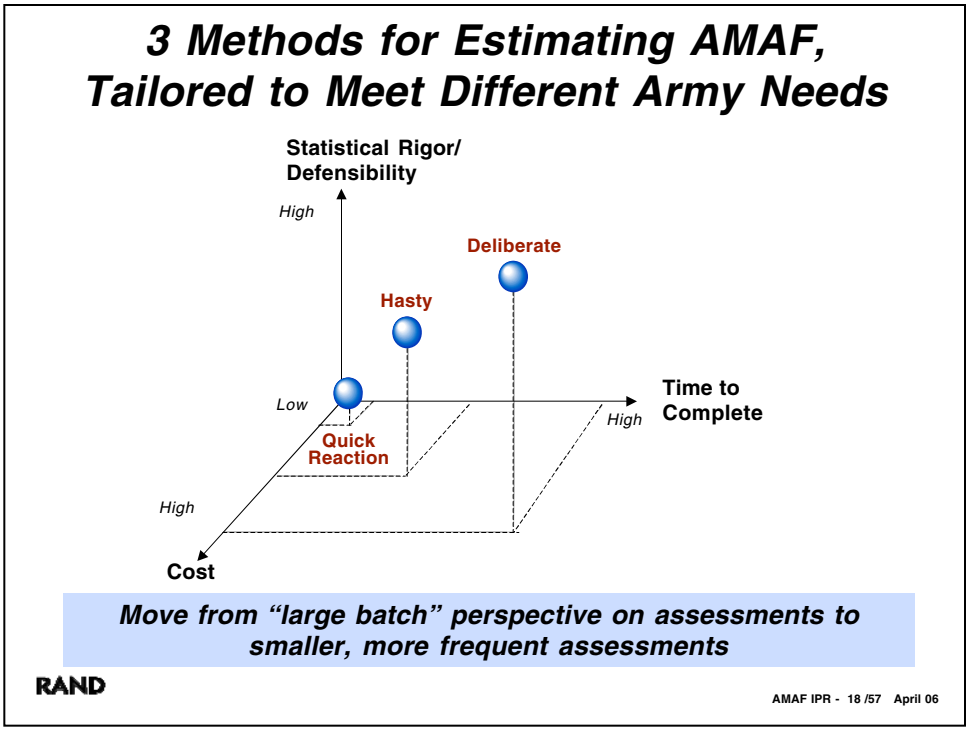


Writings on data-collection methodologies often provide qualitative comparisons of these approaches (e.g., Bouffard and Little, 2004; Iyengar et al., 2004). SME judgment, the approach used by the Marine Corps, is the fastest and lowest-cost of the three methods. It involves soliciting the opinions of a small group of experts on the topic of interest, either by meeting with them in person or remotely (by email or phone). The group may be interacting or non-interacting. While the method typically does not yield data for a statistical analysis (i.e., it has low rigor), it can offer reasonable answers to a small set of questions that are limited in scope, and it can take as little as a week or two to complete.

The web survey is a somewhat slower, moderate-cost approach, which involves posting a questionnaire at a website and sending a target population emails with a link to that site. Careful design of a questionnaire, determining of a sampling plan (including selecting a target population and accessing their email addresses), tracking responses, sending follow-up emails, and analyzing the resulting large dataset can take 2–4 months. The labor-hours for the task and the software requirements make it costlier than SME judgment, but the resulting data are generally of reasonable quality and suitable for statistical

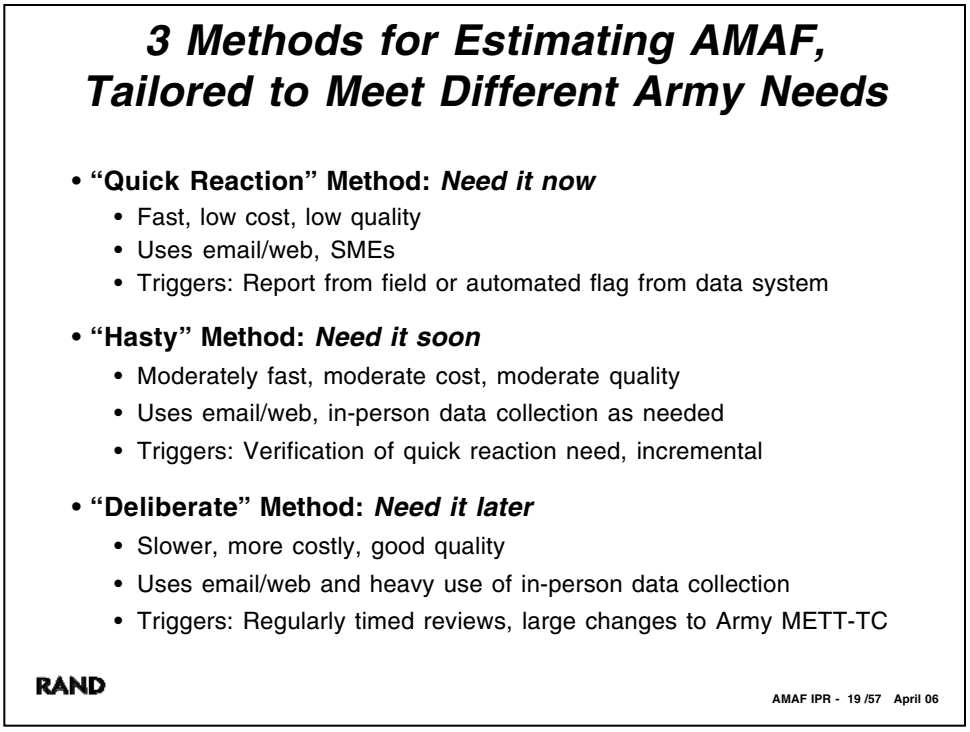
analysis. Web surveys may be an appropriate option when potential non-availability factor changes are more substantial and wider in scope.

The most time-consuming and expensive of the three approaches, structured observation, involves directly observing, systematically noting, and recording events, behaviors, and conditions in a setting of interest, and facilitating that process with a worksheet or checklist to be completed by the observer (Marshall and Rossman, 1995). Data obtained by an independent observer tend to have fewer biases—and, thus, higher quality—than the self-report data captured by surveys, and structured observation can also offer a statistical sample, if enough observations are made.



Each of these data-collection approaches may be appropriate for AMAF estimation, depending on the needs of the Army at a particular time. If a rapid, rough assessment of non-available times is required, then a data-collection approach that is fast, low-cost, and low in statistical rigor may be sufficient. We refer to such an approach as the "Quick Reaction Method." If somewhat more time is available and a broader assessment of non-availability factors is required, then a data-collection approach involving a larger sample (and more statistical rigor) may be appropriate, incurring moderate costs. We refer to such an approach as the "Hasty Method." If the quality of an estimate is particularly important but speed is less critical—for example, if results of the update will be used for long-term planning and documentation rather than for temporary adjustments to manpower, then a slower, highly rigorous, and more expensive approach may be warranted. We refer to this third approach as the "Deliberate Method." The Army has previously used the terms "Quick Reaction," "Hasty," and "Deliberate" in other contexts. For example, a manual describing urban platoon operations (FM 7-8, HQDA, 1992) differentiates between hasty and deliberate attacks, noting that the chief difference is the time available for preparation. Similarly, a recent Army Field Manual on

counterinsurgency operations differentiates between hasty and deliberate checkpoints (HQDA, 2004). In adapting this terminology for AMAF-related purposes, our intent is to be consistent with prior Army terminology.

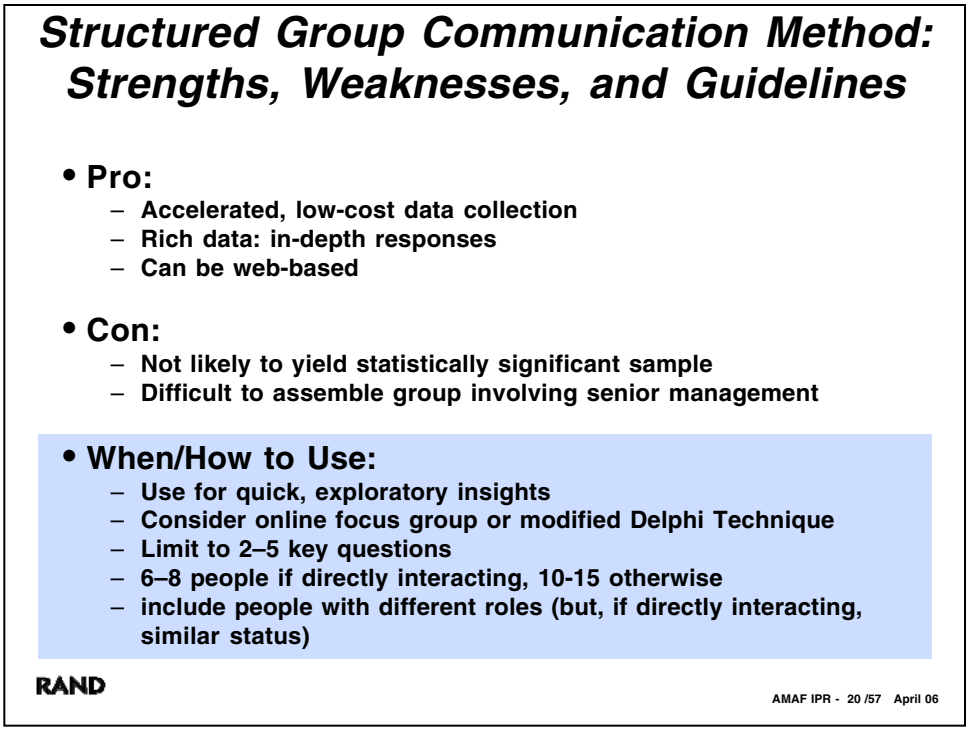


This slide summarizes the Quick Reaction, Hasty, and Deliberate methods, highlighting their relative speed, cost, and quality (as illustrated in the previous slide), suggesting possible combinations of data-collection approaches for each method, and identifying triggers that may indicate when to use each method. The Quick Reaction Method primarily calls for subject matter experts but may involve limited use of the internet for gathering data from these individuals (or conducting a small-scale web survey). If (a) reports from the field or an automated flag from a data system suggest that personnel may not have enough time to perform maintenance or other tasks—e.g., if the Logistics Information Warehouse (LIW) shows a sudden decrease in the mission-capable rates of certain units' equipment, and (b) a quick assessment is needed to determine the magnitude and source of the problem, then the Quick Reaction Method is appropriate.

If the Quick Reaction Method indicates that a problem may be systemic (affecting more than a few units) and that more extensive data collection is required for verification and statistical analysis, the Hasty Method may then be necessary. The Hasty Method primarily involves administering a web survey to a large sample, but it may also include supplementary, on-the-ground

observations and data collection to use as a comparison to check for potential sampling biases or other sources of error.

If the need for an update is less immediate and quality is critical (for example, if the update is part of a regularly scheduled review of non-availability factors and their accuracy), then the Deliberate Method may be most suitable. Additionally, a substantial change in Mission, Enemy, Terrain, Troops available, Time, and Civilian considerations (METT-TC) may warrant a more thorough review of non-availability factors to ensure their relevance and accuracy.



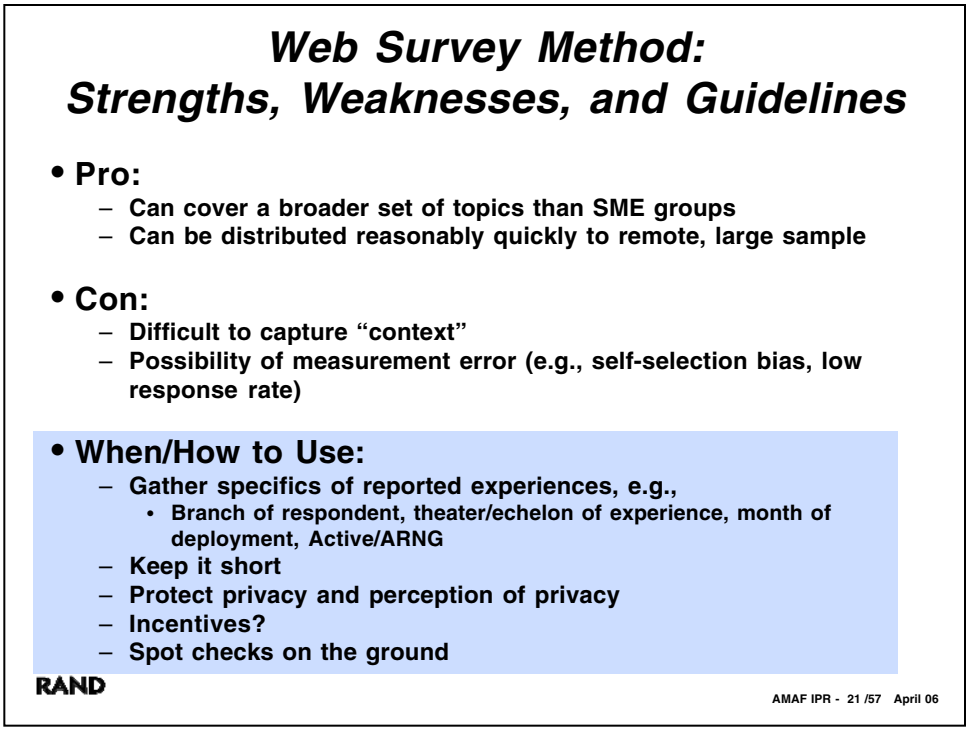
This slide and the following two elaborate on the data-collection approaches that the Quick Reaction, Hasty, and Deliberate Methods are likely to incorporate; specifically, the slides identify strengths, weaknesses, and guidelines of each approach based on a review of relevant literature. As noted in the above slide, Structured Group Communication (subject matter experts) has several advantages. The method can "generate focused insights more quickly and generally more cheaply than . . . formal social surveys" (Guijit and Woodhill, 2002). Additionally, it allows participants to explain their responses to questions, offering greater insights and reducing the chance that poorly worded or misinterpreted questions will affect the data gathered. Group interactions can also occur via internet-based teleconferences, avoiding the inconvenience and cost of travel. A limitation of the approach is that it is not likely to yield a statistically significant sample.[8] Also, if SMEs are senior managers, there may be scheduling difficulties.

Two common structured group communication methods are focus groups and the Delphi technique. Focus groups typically involve gathering a small

[8] One structured group communication technique, the Delphi method, sometimes involves enough participants to allow simple statistical summaries of responses.

group of stakeholders (6–8 persons) to discuss a set of issues—either in person or online (often the preferred approach). The Delphi technique, in contrast, involves little or no interaction among SMEs. Instead, each expert responds independently to a set of questions. Responses are then aggregated, summarized, and returned to experts along with a set of follow-up questions.

The traditional Delphi technique included four rounds of such data collection, typically accomplished via postal mail. More recent, modified versions include only one or two rounds of data collection via email (Snyder-Halpern, Thompson, and Schaffer, 2000). Because its participants are non-interacting, Delphi group sizes tend to be larger, ranging from about 10–50 members; however, a group of 10–15 SMEs is generally sufficient for "a Delphi study that is focused and where the participants do not vary a great deal" (Stitt-Gohdes and Crews, 2004:62). If structured group members are interacting directly (as in a focus group), they should ideally have similar status; otherwise one or two people with a higher rank may dominate discussions and have too much influence on other participants (Iyengar et al., 2004).

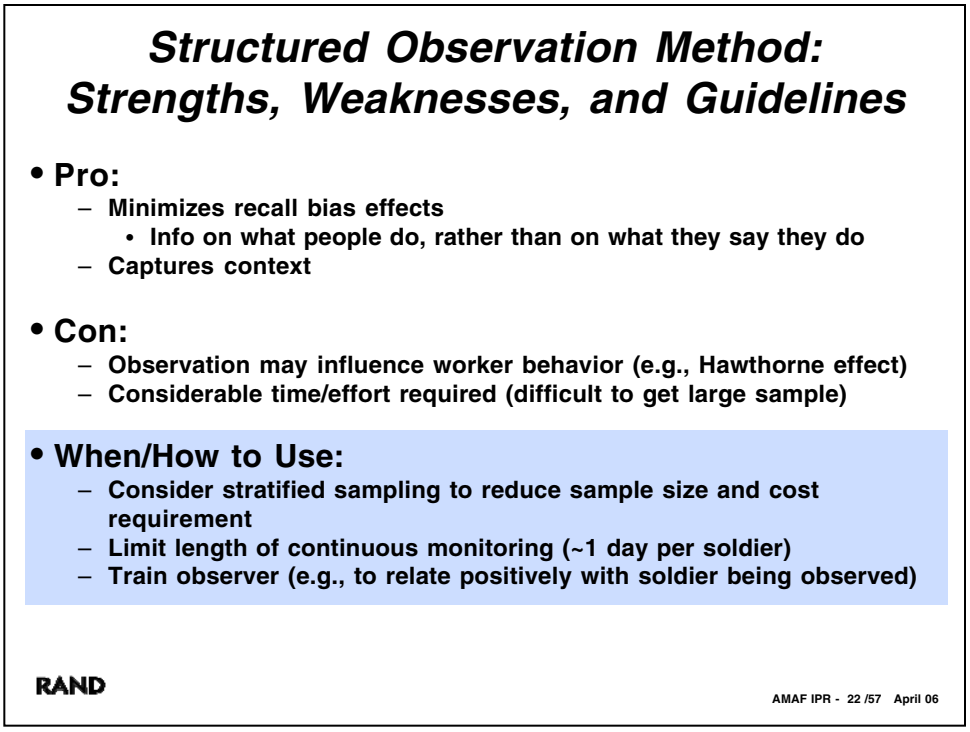


Web surveys have become quite popular over the past decade, as they allow researchers to gather data on a broad set of topics and can be distributed quickly to a large group of geographically dispersed individuals, typically yielding sufficient data for multivariate statistical analyses (Iyengar et al., 2004; Kraut et al., 2004; Schaefer and Dillman, 1998). Key drawbacks of the method are its limited ability to capture the context of responses and its susceptibility to survey errors. For example, there may be a self-selection bias, in which persons who choose to respond to the questionnaire are those who hold strong opinions about the subject; consequently, the sample may not be representative. Additionally, web surveys tend to have low response rates, typically ranging from 7 to 44 percent (Schonlau, Fricker, and Elliott, 2002), which also reduces representativeness. If the target population has unequal access to (or comfort with) the internet, then that condition may contribute to lower response rates. Another risk is measurement error, gathering inaccurate responses to questions due to poor questionnaire design (causing respondents to misunderstand questions) or because respondents are uncomfortable responding truthfully (Manfreda, Batagelj, and Vehovar, 2002).

Adding questions about respondents' background and experiences may improve the survey's ability to capture context. For example, a web survey of Army personnel could request such information as the respondent's branch, theater and echelon of experience, and month of deployment. A second guideline for minimizing the problems associated with web surveys is to keep the survey relatively short and simple, as respondents are more likely to abandon a survey that takes a long time to complete. Studies of web survey design have not yet recommended a specific, optimal survey length, but survey software companies sometimes offer advice on the subject. For example, one well-known survey software company reported, "On surveys exceeding a couple of pages (with multiple questions per page), we have seen a 6 to 10% dropout rate for each additional page of questions" (StatPac, Inc., 2006). Deployed military personnel may not have the opportunity to complete a survey that takes longer than 10 minutes to finish.

A third guideline is to protect the privacy of respondents, as well as the perception of privacy, to encourage honest answers as well as higher response rates. Incentives for survey completion can increase responses as well. If material incentives such as coupons are not permissible in an organization, "another completely different way of rewarding a respondent is to send survey results via email after the survey is completed" (Schonlau, Fricker, and Elliott, 2002:49). After respondents complete a web survey, some survey software allows them to see how their responses compare with the average responses of others who completed the survey so far. This feature can serve as a reward for participation (Sutton, personal communication, February 9, 2006).

To help interpret responses and assess the quality of web survey data, occasional, supplementary observations—i.e., "spot checks on the ground"—may be helpful. Additional suggestions for designing and implementing web surveys can be found in detailed literature reviews on the subject (e.g., Andrews, Nonnecke, and Preece, 2003; Schonlau, Fricker, and Elliott, 2002).



As mentioned earlier, the primary advantage of structured observation data is their quality. More specifically, they are less susceptible to response biases than self-report methods, and they allow the researcher to capture context more effectively. Disadvantages of the method are that it is expensive and time-consuming. Also, it is more obtrusive than other methods, and subjects may behave differently when they know they are being watched. Some may respond by working harder—a phenomenon known as the Hawthorne effect (Mayo, 1933; Roethlisberger and Dickson, 1939,)[9] while others may become distracted and find the observation process intrusive.

Although developing a sampling plan is necessary for both the web survey and structured observation approaches, it is particularly challenging for the latter. An excessively large sample size may have little impact on web survey costs, but it could have a substantial impact on observation costs. Stratified random sampling is an approach well-suited to structured observation, as "the sampling size can usually be smaller than for [simple random sampling or

[9] Although in recent years some have challenged the validity of the conclusions from the Hawthorne experiments, the Hawthorne effect remains widely cited and accepted as a tendency.

systematic sampling]. Therefore, a stratified sample is often considered the best choice for structured observations . . ." (Bentley et al., 1994:14).[10] That said, when observation is to occur in a remote war zone, gathering a representative sample may be infeasible—not only because of the cost of sending a sufficient number of observers, but also because of the risk of interference with a mission and the challenge of ensuring observers' security.

Extended observation, the most common type of structured observation, consists of monitoring a subject or subjects continuously over a period of time—typically hours (Bentley et al., 1994). To maintain observer concentration and reduce the burden on subjects, it is important to limit the length of the observation period per subject. An observer could, for example, spend one day observing a soldier's behavior and a second day gathering relevant records from the soldier's unit and asking follow-up questions, an approach similar to that of McVea's (1996) study of healthcare providers.

Another guideline for structured observation is to train observers carefully, giving them not only a structured observation guide/worksheet, but also the chance to role-play in hypothetical situations (Arhinful et al., 1996). Training observers to be inconspicuous may minimize subjects' reactions to being observed—i.e., behavioral changes in response to the observation process. Also, making observers fully aware of the kinds of activities, events, and situations they should document (including ones that may not be on the observation worksheet) can enhance the quality of observation data.

It is important to note that there are also more technologically intensive methods that can provide quantitative data on human activities, but which also have weaknesses. Examples include

- Hand-held barcode scanners with data-collection capability carried by individuals and used to, in essence, clock in and out of tasks by scanning appropriate barcodes at activity sites. These data are then downloaded to central servers via a variety of communication methods, including radio and infrared transmission.

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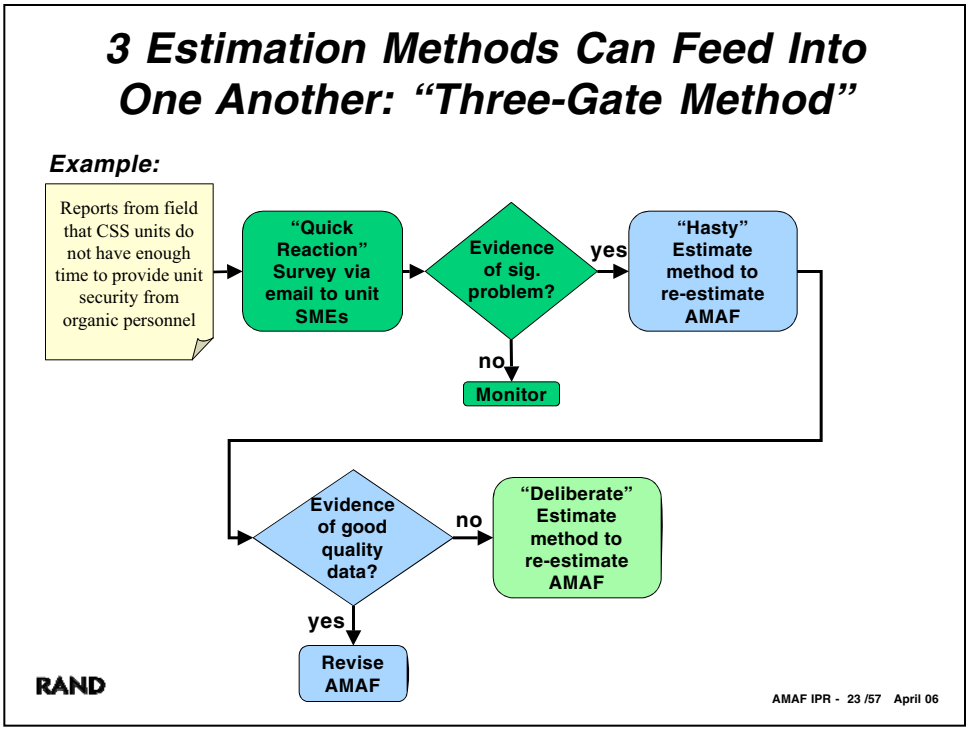
[10] The approach entails dividing the target population into subgroups based on one or more attributes and then sampling a number of individuals within each subgroup. Later in this paper we describe how to calculate an appropriate sample size based on stratified sampling.

- Use of radio frequency identification (RFID) technology with passive transmitters (cards to wave in front of readers) or active transmitters (battery-powered fobs that transmit to base stations) to track the movement of individuals within instrumented areas (Smith et al., 2005).

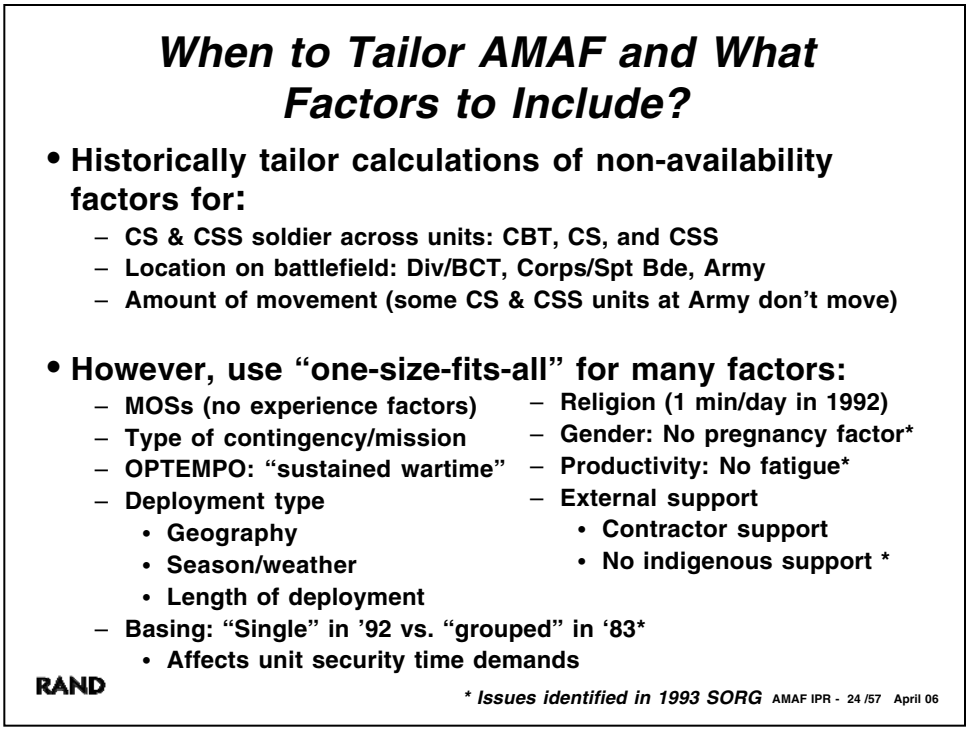
Such technologies can provide detailed tracking of activities, but they also put a certain amount of "response burden" on the people whose activities are being tracked. The response burden of having to remember to scan barcodes at the start and end of activities or carry/wear a fob can amount to significant compliance problems with the data collection. This, in turn, can lead to data-quality problems.

Although the benefits of potentially providing high-quality, quantitative measures of human activities are significant, the costs and risks are significant as well. The financial costs, implementation and maintenance challenges in austere environments, and lingering compliance issues for such technology-supported approaches suggest that they would not be appropriate solutions to field in-theater at this time. However, the Army should consider experimenting with such technologies with units at home station to develop the experience, processes, and appropriate technologies that could be fielded to deployed units in the future.



The Quick Reaction, Hasty, and Deliberate approaches to AMAF estimation, and the data-collection methods each incorporates, may not be mutually exclusive. Rather, they may feed into one another. For example, if reports from the field suggest that organic personnel at CSS units do not have enough time to provide unit security, MARC planners could begin investigating the issue via the Quick Reaction approach, sending a set of questions by email to a group of SMEs. If responses to the questions suggest that the problem is minor, then adjustments may be unnecessary, and planners should simply continue to monitor the situation. But if SMEs indicate the problem is significant and widespread, then planners can begin the "Hasty Method" for updating AMAFs, distributing a web survey to a larger sample, with supplementary spot checks on the ground. If the web survey yields high-quality data (e.g., reasonable response rate, representative sample, low measurement error, minimal response bias), then those data may serve as a basis for AMAF revision. If not, the "Deliberate Method" is warranted.[11]

[11] This project focused on updating the current AMAF estimates, as opposed to getting new, complete data to use for new estimates of AMAFs. The authors acknowledge that starting with the collection of high-quality data for each MOS via a "deliberate"



Before gathering data for AMAF purposes, regardless of the data-collection approach, two important up-front choices are the extent of AMAF tailoring needed and the specific non-availability factors to examine. Historically, the Army tailored calculations of non-availability factors to (a) the type of unit—i.e., Combat (CBT), CS, or CSS; (b) the unit's location on the battlefield—i.e., Division/Brigade Combat Team, Corps/Support Brigade, or Echelons Above Corps (EAC); and (c) the amount of unit movement. For example, the 1992 AMAF study, the "unit security" non-availability factor was 2 hours and 10 minutes per day for CSS Corps units, 1 hour and 46 minutes per day for CSS EAC units, and 27 minutes per day for CBT EAC units. The "unit movement" non-availability factor was 5 minutes for CS EAC units and, as one might expect, 0 minutes for CS EAC "no movement" units (MPRI, 1993).

Yet non-availability factors have not been tailored on the basis of other dimensions, even though such dimensions could cause non-available times to

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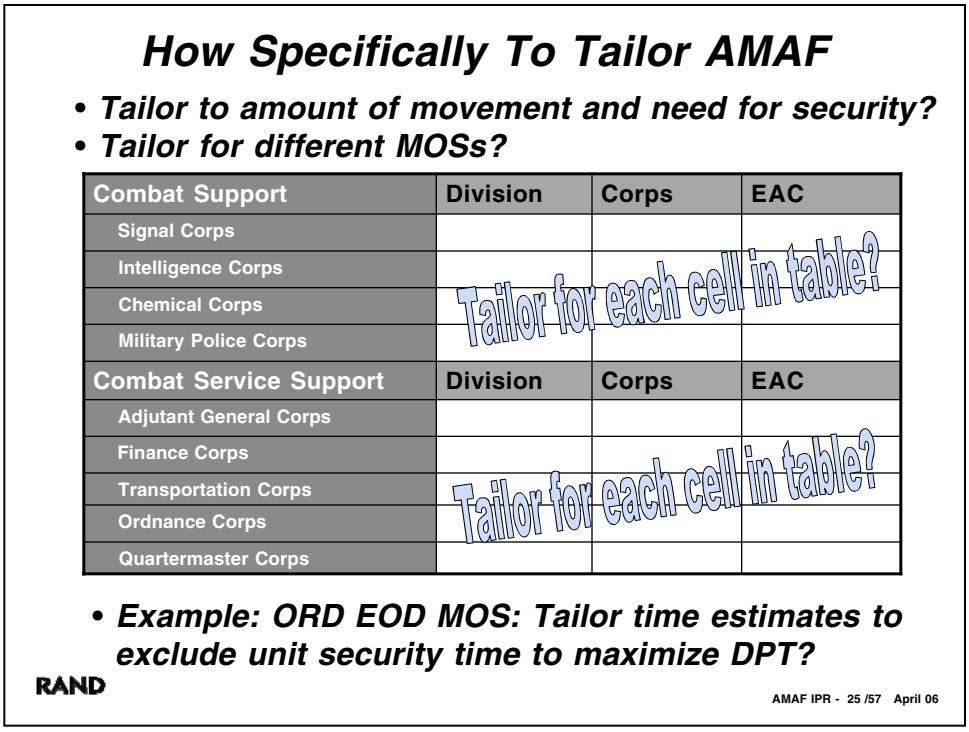
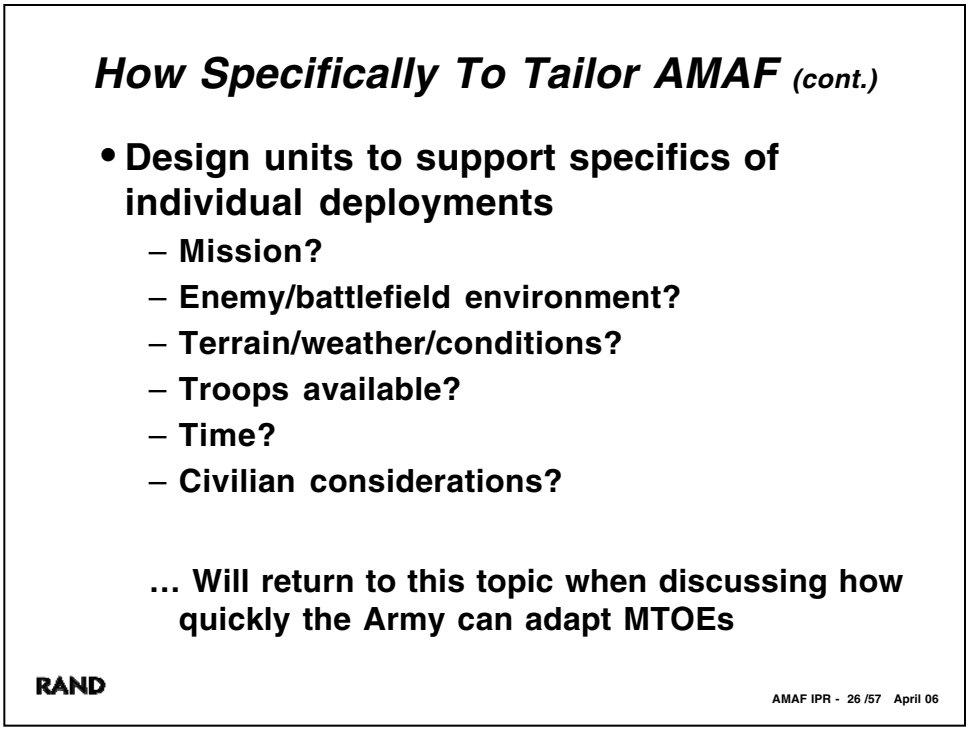
method, with subsequent follow-ups via the other two, less-resource-intensive methods would provide better estimates. However, the cost of such an exhaustive effort may make this approach untenable in the near term.

differ. This "one-size-fits all" approach has been applied across MOSs, missions, OPTEMPOs, religion, gender, and other attributes.

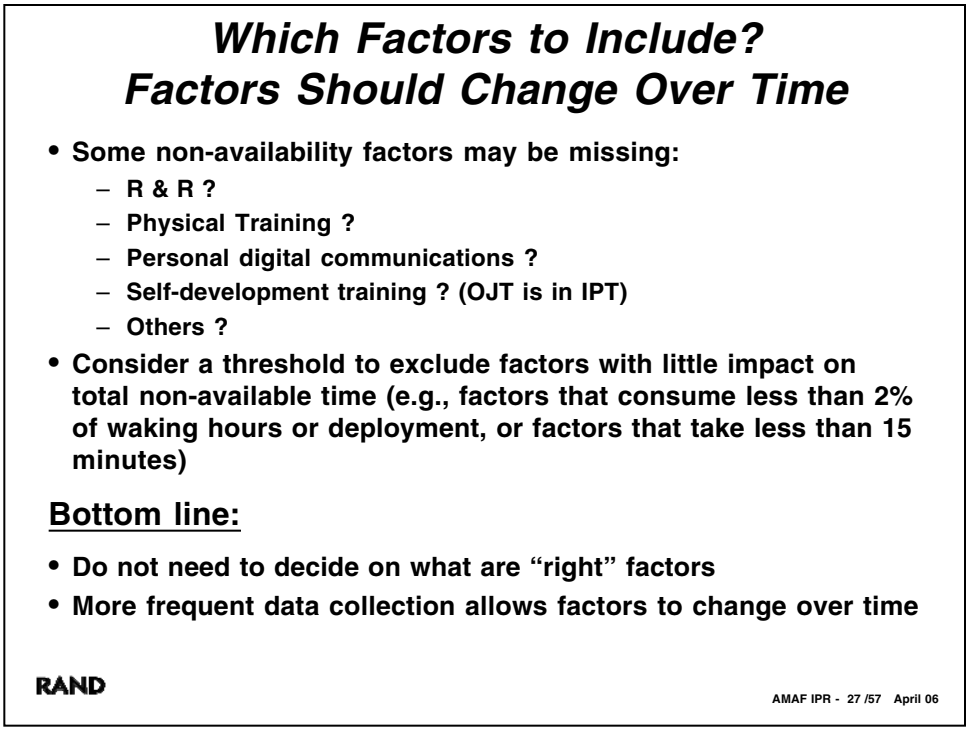


An important factor influencing AMAF tailoring is the decision being supported by the update process. If the goal is to clarify and quickly address an immediate problem affecting a small number of units, then the question of how much to tailor the AMAF may not be relevant. That is, administering a brief set of open-ended questions to SMEs may reveal that a problem is narrow in scope and can be addressed without AMAF revision. On the other hand, if the decision is broader in scope and longer term, calling for the Hasty or Deliberate method, then it is appropriate to consider how much AMAF tailoring is needed and which factors should be included.

While tailoring the AMAF according to numerous dimensions may be impractical, some dimensions are particularly relevant to soldier non-available time and, thus, may be natural candidates for further AMAF tailoring. MARC planners may want to consider whether to tailor unit movement and unit security times to different MOSs within CS and CSS units. For example, excluding unit security time from AMAF estimates for the Explosive Ordnance Disposal (EOD) MOS may help ensure that EOD teams, who have provided extensive support during OIF (Meneses, 2005), have sufficient direct productive time.



Deployment conditions may also constitute natural bases for further AMAF tailoring. For example, if only a modest number of troops are available for a particular deployment (because other troops are committed elsewhere), non-available times may need to be shorter than they would otherwise, as each soldier needs to carry a heavier task-load. Additionally, if a deployment is in an urban environment, then non-availability factors may need to account for additional time required to interact with local civilians. The slide above lists these and other METT-TC deployment features that may serve as a basis for AMAF tailoring.

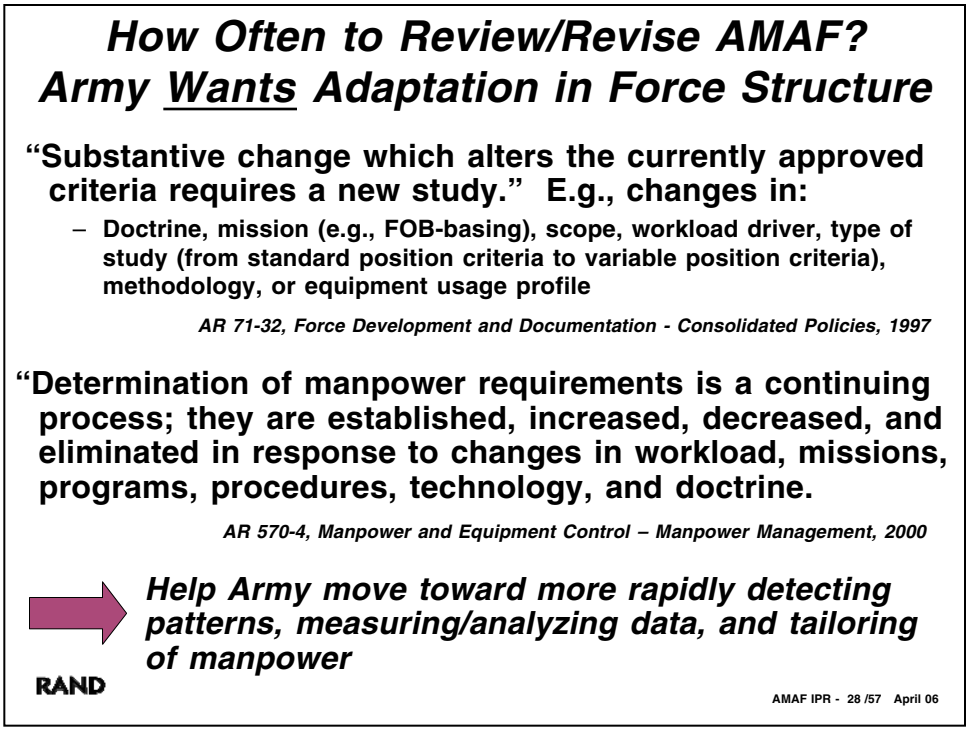


Like the extent of (and bases for) AMAF tailoring, another important decision for MARC planners is which non-availability factors to include in the AMAF updates. This slide points out some potentially significant factors that did not appear in the 1983 and 1992 studies. Some were missing simply because they did not exist at the time—at least not in their present form. The current Rest and Recuperation (R&R) leave program, approved in late 2003, allows troops on 12-month tours of duty in Iraq (and who have served between 3 and 11 months of their tour) "to take up to 15 days, excluding travel time, to visit family or friends in the United States or Europe" (Well-Being Liaison Office, 2003:4). Personal digital communication (e.g., email) is another relatively new activity for deployed soldiers.

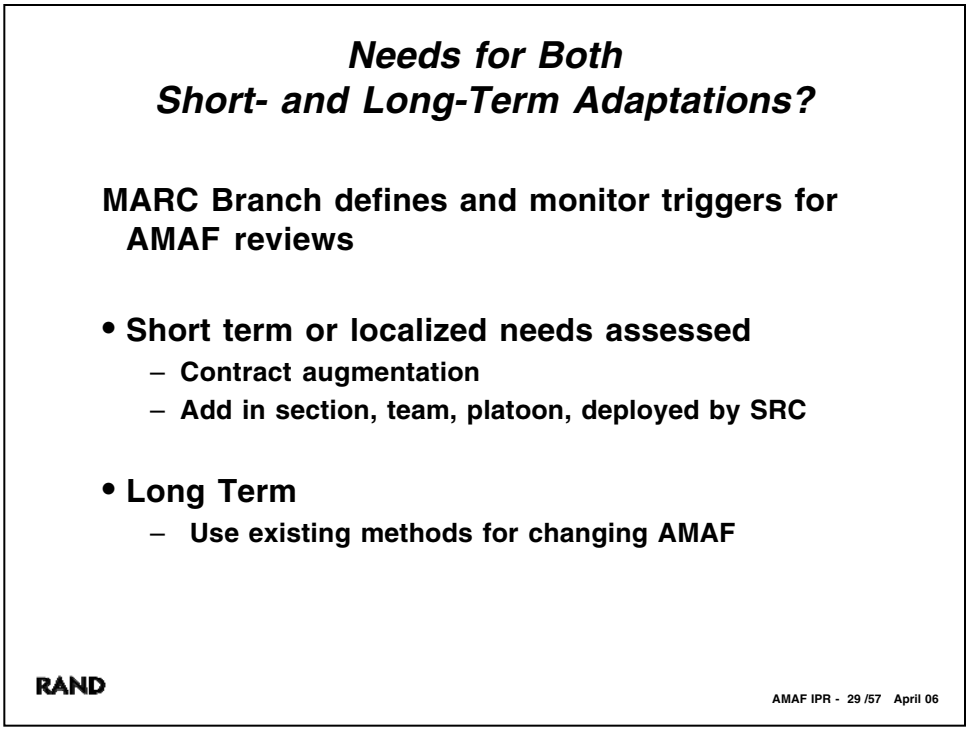
To determine which non-availability factors to exclude or include in a data-collection process, it may be useful to apply a rule of thumb—that is, a threshold that excludes factors with little impact on total non-available time (e.g., excluding factors that consume less than 2 percent of waking hours, or perhaps excluding factors that take less than 15 minutes).

Just as internet use has spread to the battlefield in recent years, other technological or socioeconomic changes may, over time, alter the way soldiers

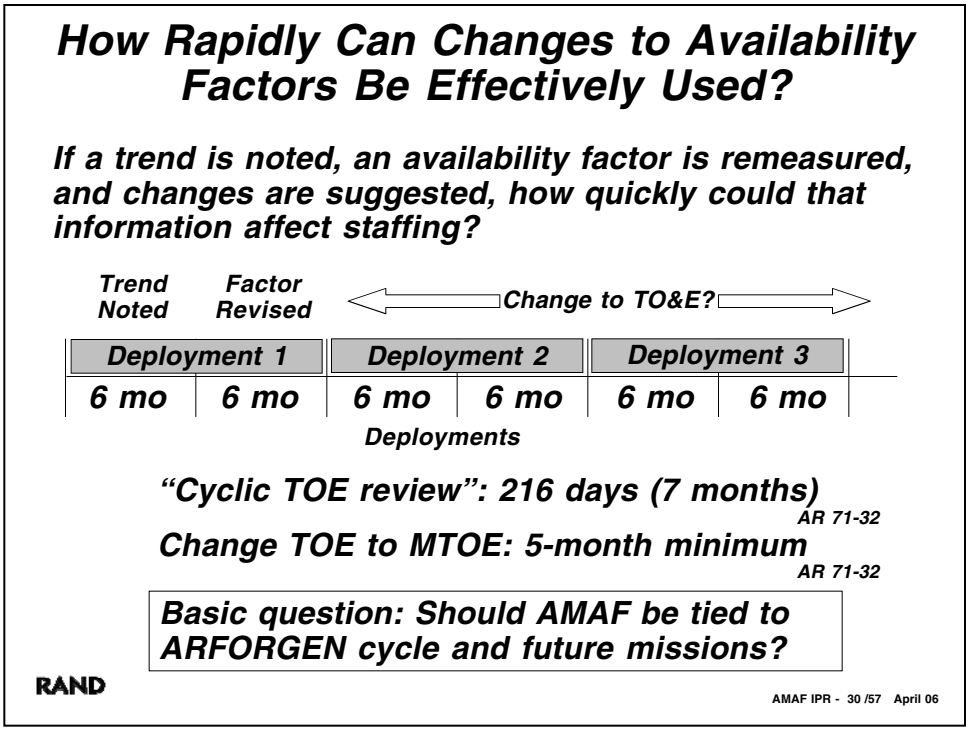
spend their days (Wong and Gerras, 2006). An update process that permits more frequent data collection will help ensure that non-availability factors reflect such changes.



But how frequent is "frequent," or "frequent enough"? Several Army regulations (shown above) underscore Army officials' preference for an adaptable force structure. They also point out circumstances that warrant new studies pertaining to manpower requirements—e.g., substantive changes in doctrine, mission, equipment usage, procedures, and technology. In an earlier slide, a brief overview of the three-gate method introduced the idea that certain triggers might initiate the use of the Quick Reaction Method, initiate a shift from the Quick Reaction Method to the Hasty Method, or initiate a shift from the Hasty Method to the Deliberate Method. The above slide, and the two that follow, further develop the concept of triggers, offer examples of some that could be monitored, and discuss the timing associated with updates and the implementation of AMAF changes.



If the Army were to implement a three-pronged approach to AMAF estimation, of the kind described earlier, then some triggers may initiate the Quick Reaction Method, while others may initiate the Hasty or Deliberate Method. It is important to define and monitor possible triggers for each method. Then, depending on the information revealed by these estimation methods, either short-term or long-term staffing adjustments may be needed. If the Quick Reaction Method indicates that a personnel shortfall is limited in scope—i.e., that the problem is localized or temporary, the solution may be contract augmentation or deploying an additional section, team, or platoon. If the Hasty or Deliberate Method reveals a more pervasive problem, then AMAF modification may be necessary.



AMAF changes are relatively long-term solutions to personnel allocation issues. The above slide illustrates the process: about six months to note a trend (via data collection and analysis), six months for formal revision of an availability factor, and roughly 12–24 months to complete a cyclic TOE review and change a TOE to a modification TOE (MTOE) (HQDA, 1997). (The cyclic TOE review takes about seven months, while changing the TOE to an MTOE takes at least five months.) Thus, the total time between initiating the data collection for an AMAF update and changing a TOE based on that update could range from two to three years. Given that Active Component Army units will be progressing through a three-year readiness cycle known as Army Force Generation (ARFORGEN), MARC planners may want to consider whether AMAF updates should be linked to the ARFORGEN cycle.

4. Guidelines and Specifications for Collecting Data

In the process of describing the Quick Reaction, Hasty, and Deliberate methods, the previous section offered some general guidelines for three data-collection approaches, including subject matter experts, web surveys, and structured observation. In this section we present more specific guidelines for the web survey and structured observation approaches, as well as rough costs associated with those approaches. As mentioned earlier, these approaches would ultimately be used to modify AMAFs and support medium- to long-term decisions about manpower requirements and POM budget plans.

To encourage participation, most web surveys begin by concisely stating their goals and potential benefits. Dillman, Tortora, and Bowker (1998) indicate that such a message is necessary, but they recommend keeping it brief and using much of the first screen to "help people get to the content of the questionnaire as quickly as possible and with as little effort as is practical."

Protecting respondents' privacy—and pointing out that one is doing so—tends to make individuals more willing to complete a survey. Andrews et al. (2003) suggest that managing privacy concerns quickly in opening statements is critical. If a survey must request the respondent's name at some point (e.g., to access records data and conduct analyses that correlate questionnaire data with records data), then a second, brief assurance at that point may be necessary.

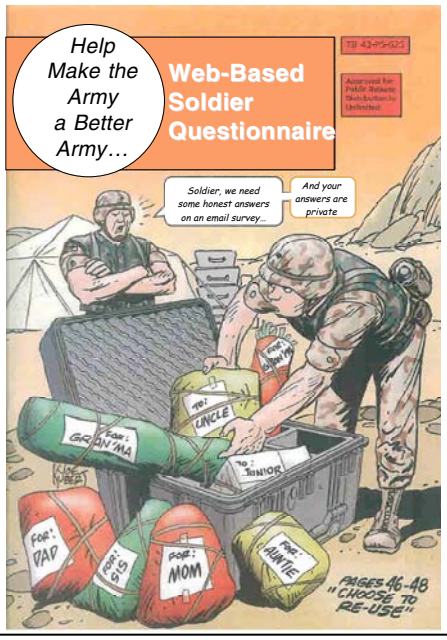
Web Survey: Commercial Best Practices for Increasing Data Quality Apply to Army

Intro, motivate, and assure
- Communicate goals of questionnaire and benefits
- Motivate responders
- Assure privacy of data

Communicate effectively
- Use graphics and cartoon style, where appropriate - but in moderation
- Consider "thin animations and audio"
- In case of low-speed internet connections, allow respondent to choose "with" or "without" graphics

Think like a marketer
- Plan for incentives

Consider "carrot and stick"
- Incentives and mandate with consequences



Graphic from *PS, The Preventive Maintenance Monthly,* Issue 625, December 2004. Used with permission.

Graphics and a cartoon style such as the one shown here (a graphic from the U.S. Army publication *PS, The Preventive Maintenance Monthly,*[12] modified to refer to a survey) may help capture the attention of respondents and motivate them to complete the survey by "generating a valuable feeling of having a 'good time' or 'fun' while answering the Web questionnaire" (Manfreda, Batagelj, and Vehovar, 2002). An important caveat, however, is to use graphics in moderation; studies of web survey design have found that slow downloads, which can result from graphics, tend to frustrate respondents and lead them to abandon the survey (Dillman et al., 1998; Schonlau, Fricker, and Elliott, 2002). Schonlau et al. suggest providing a "no graphics" option for those who have low-speed internet connections. They also point out that incentives are helpful for increasing response rates.

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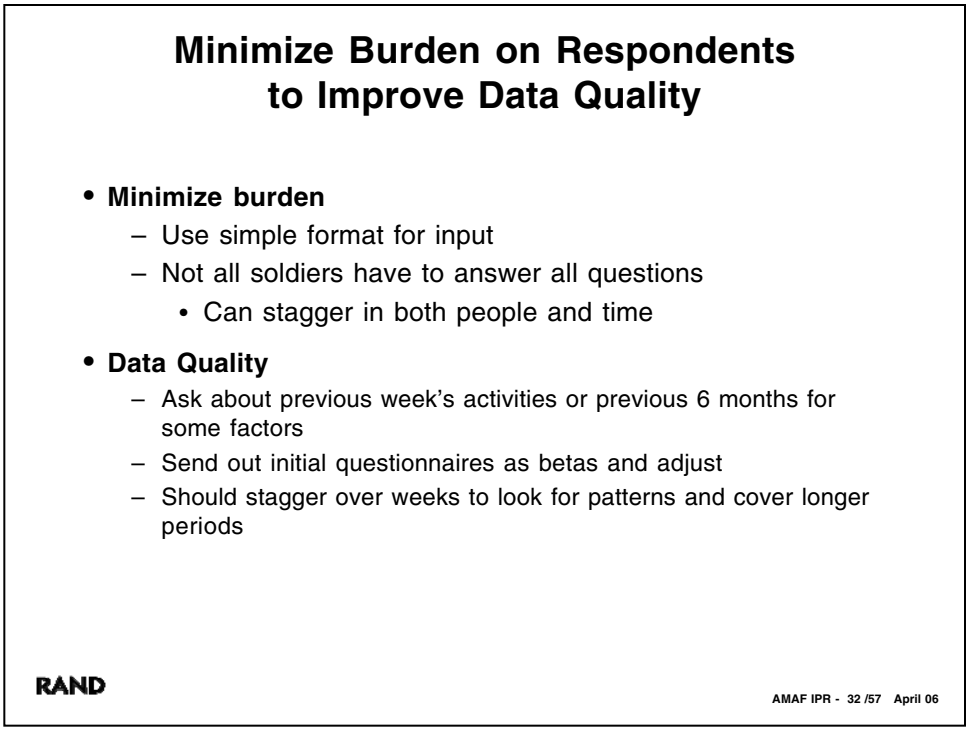
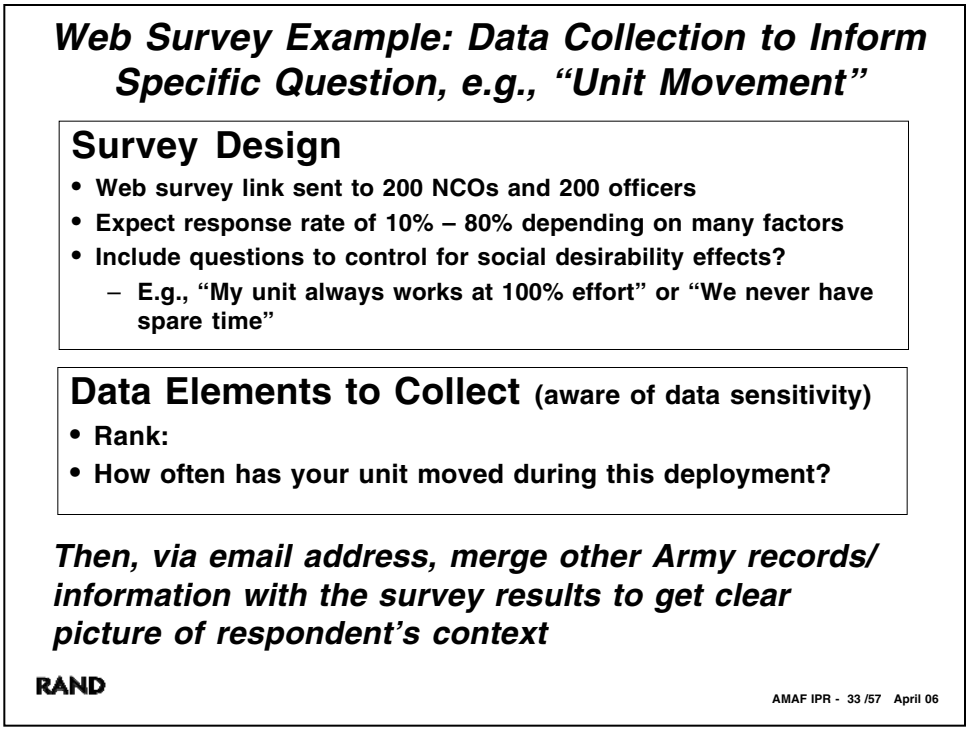
[12] *PS, The Preventative Maintenance Monthly,* Issue 625, December 2004. Cover image modified and used with permission from the managing editor of that publication.



While the above-mentioned features help motivate potential subjects to participate in the study, other survey features can help reduce the likelihood of measurement error. Minimizing the burden the survey places on the soldier will help increase response rates and allow more time for soldiers to read and respond to questions carefully. The survey instructions and administration process can also contribute to higher-quality data. The survey format and procedures should be simple to follow. Pilot tests can help ensure that questions are clear to respondents. Also, when designing the survey it is important to keep in mind that asking about the previous week's activities is appropriate for some non-availability factors, but for other factors (such as medical leave), a longer retrospective period is appropriate.



This slide describes a possible design for a brief survey focusing on a single non-availability factor, such as unit movement. The sample size requirement depends largely on the confidence level and precision desired; in this example, the web survey link is sent to 200 NCOs and 200 officers.

A common source of response bias in survey data is the "social desirability effect," a tendency to respond to sensitive questions with answers that reflect favorably on the respondent.[13] More specifically, the

> social desirability effect is a well-documented phenomenon in which survey respondents indicate that they have done something because they think it is the socially desirable response . . . . That is, a certain percentage of respondents may say they have [for example] taken [preparedness] measures because they think it would cast a negative light on their character if they indicated that they did not (Opinion Research Corporation, 2005:7).

[13]Modern writings on the social desirability effect typically define it as a "tendency of [study] participants to overstate a socially desirable position, especially in the presence of researchers" (Shaheen, 1999:82). A more traditional definition states, "Social desirability effects refer to distortions related to the impressions the respondent wishes to make on the interviewer or misinterpretations of his own behavior that permit him to maintain or enhance a positive self-image and reduce cognitive dissonance" (Bahr and Houts, 1971:376).

To minimize the impact of this bias on findings, researchers sometimes include decoy questions or measures of social desirability in their surveys and then control for those variables in statistical analyses. For example, the Marlowe-Crowne Social Desirability Scale (Crowne and Marlowe, 1964) consists of 16 items that researchers have previously used to measure and control for social desirability effects.

In this example, several decoy questions help determine whether a respondent's answers suffer from social desirability effects. If a soldier strongly agrees with certain extreme statements such as "My unit always works at 100% effort" or "We never have spare time," then that signals he/she may be trying to create a favorable impression with his/her responses, rather than answering truthfully.

For information sensitivity and security reasons, the information acquired from the soldier in the field about their location, unit, etc., is kept to a minimum. This sensitive information can be later tied back to an individual's responses via the responding soldier's email address and other Army records.

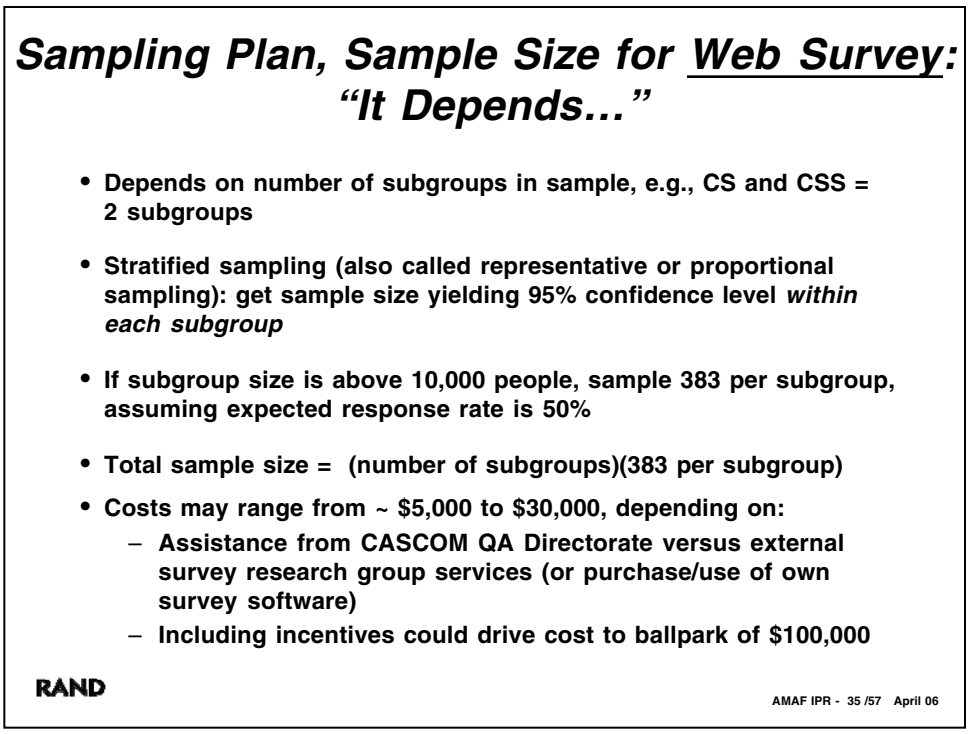
Example of Web-Based Questionnaire Format to Assess Multiple Factors

- How much time did you spend over the last week on different parts of your day?
- We're asking you to fill in the amount of time you recall for each activity, below, on each specific day…
- Think back and be as accurate as you can be for each day.
- There are definitions of each activity that will pop up as you roll your mouse over them…

	Sun	Mo				Fri	Sat
Activity	*19 Feb*	*20*				*24 Feb*	*25 Feb*
Number of minutes doing area policing							
Number of minutes getting to, eating, and getting back from hot rations							
Number of minutes getting and eating MREs							
Number of minutes with laundry							
Number of minutes doing physical training							
Number of minutes doing self-development training							
Number of minutes reading and sending personal email							
Number of minutes surfing the web							
OTHER ACTIVITIES THAT YOU SPENT MORE THAN 20 minutes doing on any single day							
… Soldier fills in activity here.…							

Definition: All time to get MRE, open, eat, clean up, get back to worksite

This slide illustrates a web survey designed to measure multiple non-availability factors. Note that this format keeps the survey concise while still capturing a lot of information. The soldier reports how much time he/she spent on each activity during the past week. If the definition of an activity is unclear, he/she has the option of viewing that definition.

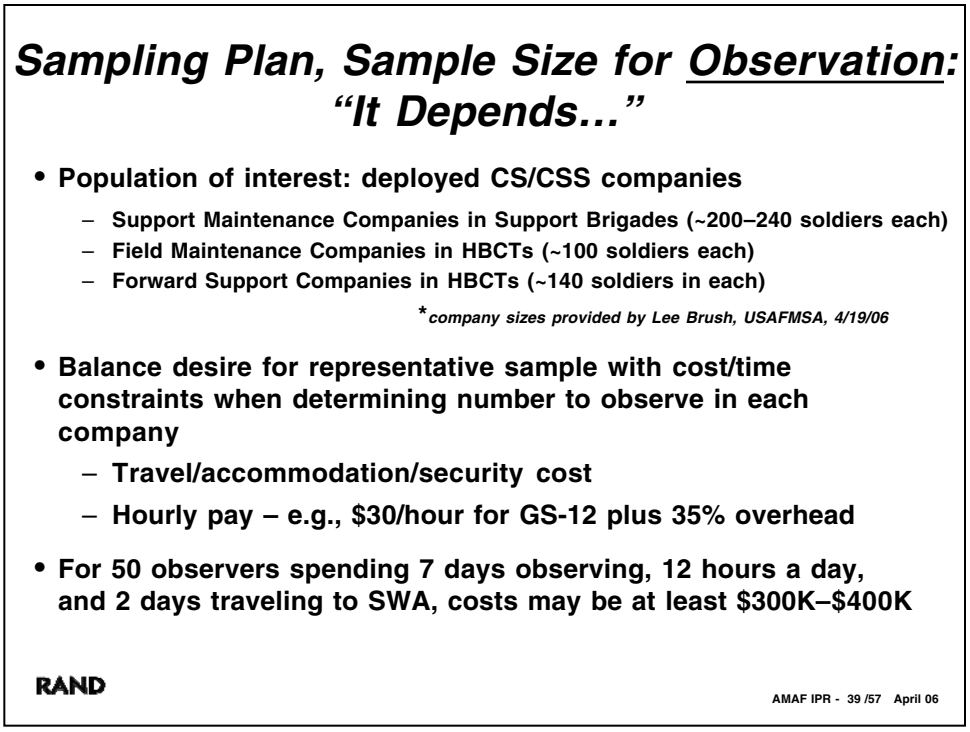


This slide presents a possible stratified sampling plan, and approximate costs, for a web survey. The process begins by defining population subgroups based on one or more attributes. For example, CS versus CSS may be one defining attribute, and Division versus Corps versus EAC may be a second attribute. Together, they define six subgroups: CS-Div, CS-Corps, CS-EAC, CSS-Div, CSS-Corps, and CSS-EAC. The Air Force Survey Office typically calculates sample size requirements based on the number and size of subgroups, a 5 percent margin of error, a 95 percent confidence level, and an assumed response rate of 50 percent (Lou Datko, Air Force Survey Office, March 8, 2006, personal communication).[14] Air Force survey subgroups tend to have sizes on the order of 10,000 people. The sample size requirement for a subgroup of that size, under the aforementioned assumptions, is about 383 people per subgroup. The Air Force Survey Office typically over-samples by a factor of 2.3 in case the response rate is below 50 percent (a common occurrence with web surveys). An "Army-Led Outreach Integrated Product

[14] The confidence level is the percentage certainty "that the true proportion of the total population's answer to any survey question would be [within the margin of error] of the estimated sample proportion" (Army-Led IPT, 2001).

Team" (Army-Led IPT, 2001) advocated the same approach to determining sample size (without mentioning oversampling) when it recommended that the Defense Standardization Program (DSP) prepare a comprehensive survey instrument.

With six subgroups, a sample of 383 per subgroup and an oversampling factor of 2.3, the total sample size would be (383)(6)(2.3) = 5,285. When we calculated approximate costs for administering and analyzing a web survey with a sample of that size (for the purpose of AMAF updates), we found that they ranged from $5,000 to $30,000. The Combined Arms Support Command (CASCOM) Quality Assurance (QA) directorate, which often administers surveys, recently offered to assist MARC planners with administering a web survey for AMAF updates. If MARC planners accept that offer rather than hiring an external survey group or purchasing survey software, then costs are likely to be on the low end of the range.



For structured observation, the sample needs to be considerably smaller than 5,285, so population subgroups should be defined more narrowly. In the case of AMAF updates, the population subgroups of interest are, according to USAFMSA (Brush, April 19, 2006, personal communication) likely to be Support Maintenance Companies in Support Brigades and both Field Maintenance Companies and Forward Support Companies in Heavy Brigade Combat Teams (HBCTs),

Given the relatively small size of those subgroups (on the order of 100–200 soldiers in each) and cost/time constraints, a practical stratified sampling plan may simply select a small percentage of each subgroup to observe, such that 40–50 observers could gather observation data on the total number of subjects (across subgroups) within a reasonable period of time (perhaps 1–2 months). (We are assuming that 40–50 observers is a feasible number to send, given that the U.S. Army Materiel Systems Analysis Activity (Kratzmeier, 2005) recently reported that it has ~40 data collectors in the area of responsibility—i.e., Baghdad, Balad, Tikrit, Taji, Talafar, Talil, Mosul, Arifjan, Kandahar.) When we calculated rough costs for structured observation, based on sending 50 observers to collect data in Southwest Asia

over several weeks, we computed costs ranging from $300,000 to $400,000—most likely a considerable underestimate, for reasons we later discuss.

Primary Bases of Rough Cost Approximations

Sources: Air Force Survey Directorate, Web-based companies, CASCOM group, RAND Survey Research Group

FACTOR	MAGNITUDE	SOURCE
Cost of hiring survey research group to administer survey to sample of 5,000	~$17,600, not including fees	RAND Survey Research Group
Cost of having survey research administer survey incentive (assuming 50% response rate)	~$9,000, not including fees or cost of incentive	RAND Survey Research Group
Purchasing Perseus web-survey software	~$30,000	CASCOM QA Directorate
Having CASCOM QA Directorate administer survey	no charge, but cannot do more frequently than every 2–3 years	CASOM QA Directorate
Roundtrip airfare from Texas to Doha	~$1,500 per person	British Airways
Hourly Base Rate, GS-12 (similar to overtime rate)	~ $30/hour + 35% overhead	Office of Personnel Management (opm.gov)
Rough sample size for web survey	(383/subgroup) x (6 subgroups) x (oversampling factor of 2.3) =5,285.4	Air Force Survey Group; Schwartz (1999) *Government Manager's Guide to Satisfaction Surveys and Performance Improvements*

RAND

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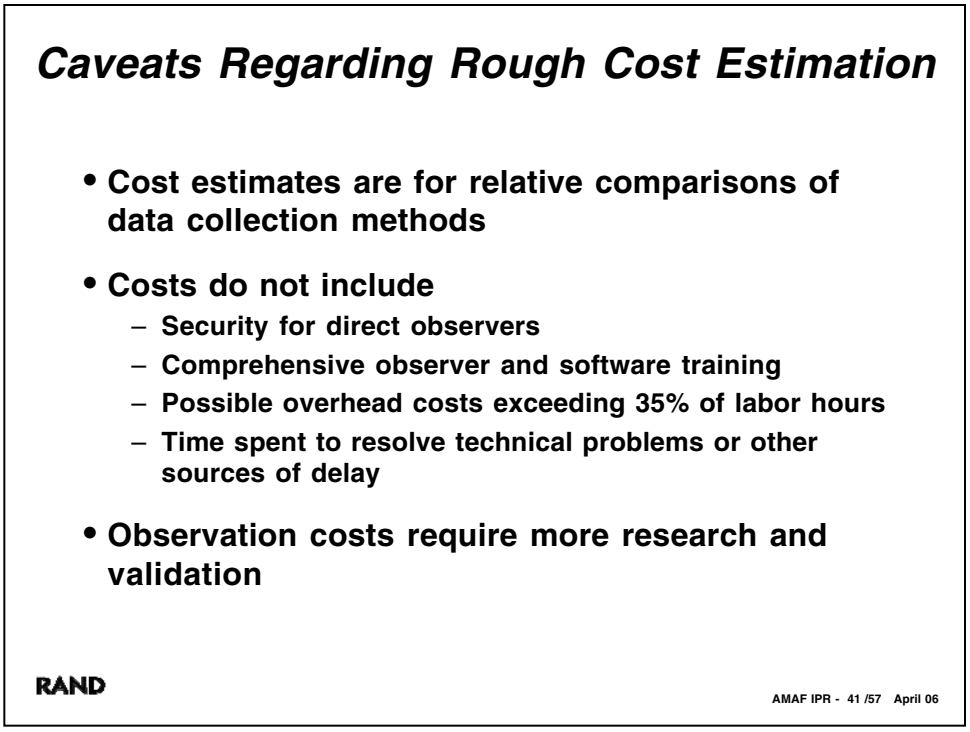
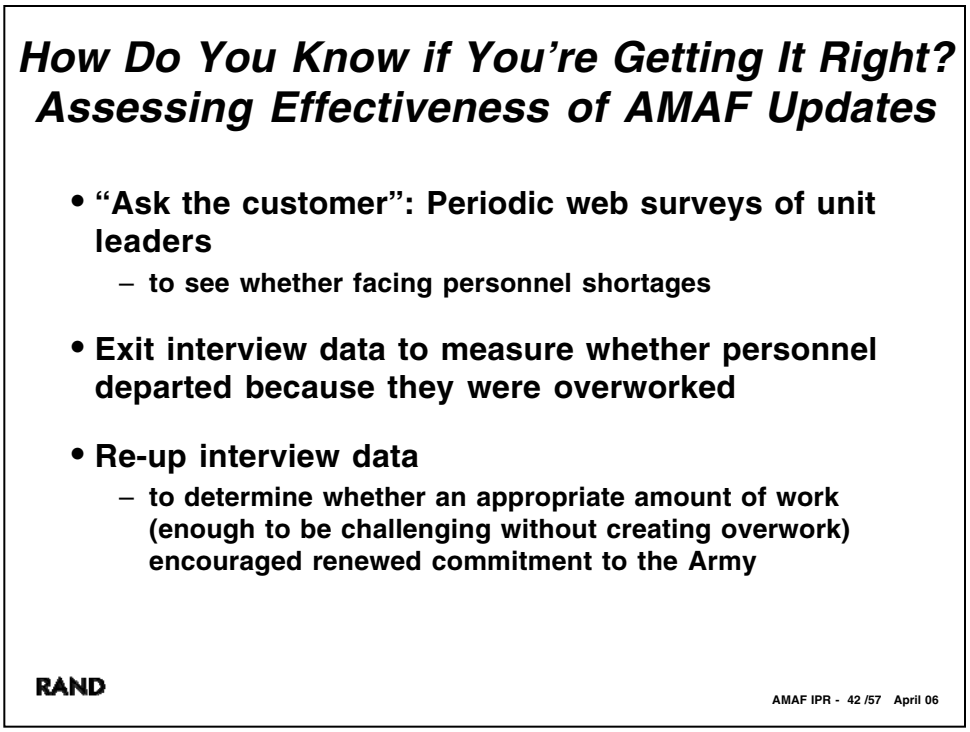
This table shows the major factors we used to calculate rough costs of the web survey and structured observation methods. The RAND Survey Research Group (SRG) provided a "back of the envelope" estimate of what they would charge for administering (not analyzing data from) a 2–3 page survey with (a) a sample size around 5,000, (b) a list of email addresses already prepared (not made by SRG), (c) only one administration of the survey, (d) two follow-up email reminders, and (e) a one-month data-collection period. The estimate did not include RAND administrative fees of 8%–10% or the cost of an incentive (other than the administrative cost of including an incentive). CASCOM's QA directorate provided an approximate cost of purchasing survey software—but also offered to administer the survey for MARC planners every 2–3 years at no charge. Other costs were largely from on-line sources.



It is important to keep in mind that the rough cost estimates mentioned in this paper are only to make relative comparisons of costs associated with different data-collection methods. They are likely to be underestimates, as they exclude a number of possible additional expenses.

5. Appropriate Metrics and Formalizing Estimates



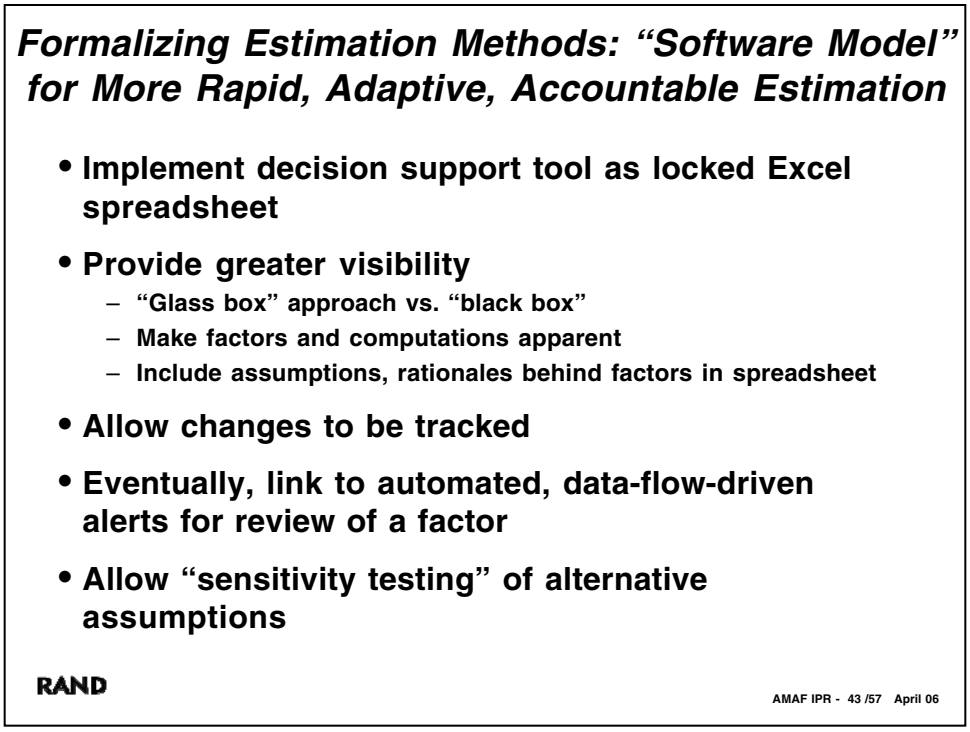
Once AMAFs have been updated based on web survey or structured observation findings, several additional steps may further ensure the quality of the revised estimates. First, MARC planners can follow up to determine whether the revisions resulted in appropriate manpower allocations among the units. Second, making AMAF calculations more transparent and accessible will facilitate review and continuous improvement of current estimation processes.

The slide above focuses on the first of these steps, suggesting formal methods for assessing the fit of AMAFs to the units and tasks they encounter. The method(s) selected should be reliable and potentially frequent.

A direct method of assessing if there is enough time to accomplish all the duties and personal requirements in a soldier's day is to "ask the customer": Use web-based surveys of soldiers to assess the fit of workload to available productive time. A second, more indirect method is to carry out exit interviews/surveys and re-enlistment surveys with soldiers. Assessing the underlying reasons that enlisted soldiers are leaving or re-enlisting could provide insights into fit of manpower to workload. In such a survey item there

would be a broad range of reasons for separation, and the ability to attribute the separation decision to more than one reason. These reasons would include both positive (e.g., "I fulfilled my duty to my country" or "I have learned skills that will allow me to get a good-paying job outside the Army") and negative reasons (e.g., "The Army lifestyle did not fit with my own" or "I am burned out from working too many hours during deployments").

If the results from such surveys showed that, for example, the top reasons cited for not re-enlisting include responses like "excessive workload" or "burn-out from too much work" this may be an indicator that there is a possible mismatch of manpower to workload. Such exit and re-enlistment interviews are reportedly not done for enlisted personnel, but are reportedly done for officers who are exiting the Army.



As mentioned above, formalizing and elucidating how AMAFs are calculated may also contribute to higher-quality updates. Currently, descriptions of the underlying logic and specific algorithms in AMAF calculations are spread across a number of publications. Having a single place where all the supporting information for AMAF calculations is gathered and made accessible has a number of advantages.

If AMAF calculations are formally defined in a locked spreadsheet that is publicly available (within the Army) for download, any interested party can inspect the calculations, assumptions, and underlying data. This "glass box"[15] approach fosters a more widespread understanding of the AMAF estimation process, as well as greater quality control. In addition, any changes to the calculations, over time, can be documented in the spreadsheet with explanations for why the change occurred and who or what organization approved the change.

[15] The term "glass box" refers to the opposite of a "black box" approach: in the former the contents of the underlying data, assumptions, and calculations are made explicit and easily inspectable. In a "black box" approach, the underlying data, assumptions, and calculations are not explicit or easily inspectable.

This locked spreadsheet approach also provides a way to carry out some "sensitivity testing" of potential changes to the AMAFs. For example, analysts can assess how changes in assumptions (e.g., the amount of time for medical leave or hot rations) affect the estimated availability of soldiers.

Tables in Paper Publications Versus Digital Tools: Example of Adaptive Calculation Methods

AR 71-32, Table C-1
Basic MARC AMAF

UFC/ULC	UMC A	B
11	4161	--
12	4380	--
13	4380	--
21	3176	--
22	3760	--
23	4307	4380
31	3230	--
32	3778	--
33	4295	4380

RAND

EXAMPLE . . .

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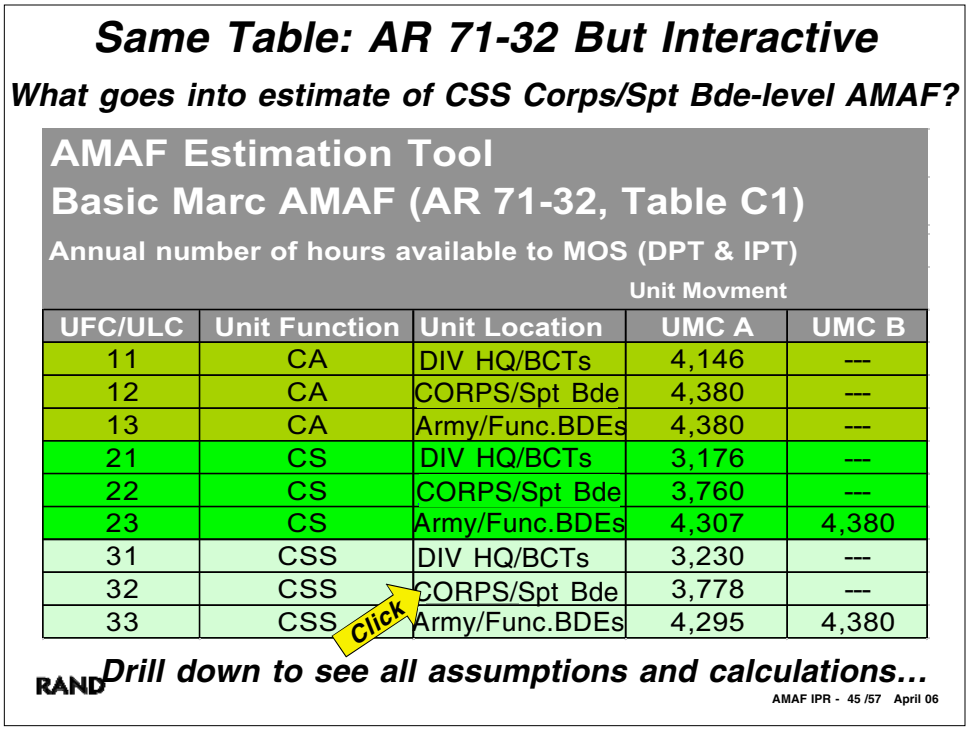
A spreadsheet-based decision support tool that formalizes and clarifies AMAF calculations could, for example, explain how the factors in the above slide are derived. The slide shows Table C-1, as it currently appears in Army Regulation 71-32. The purpose of the table is to show the annual hours of available time corresponding to each CS/CSS unit function code (UFC) or unit location code (ULC) in the list. For example, UFC/ULC 12 has an AMAF of 4,380 hours.

The next few slides illustrate how a spreadsheet tool could facilitate interpretation and, if necessary, modification of figures in the table.



This table presents information found in Table C-1 from Army Regulation 71-32 but adds other information and is set up as a spreadsheet. It expands the definitions of UFC and ULC to "Unit Function" and "Unit Location," with values for those variables, and shows that Unit Movement changes only for CS and CSS units above Corps level. This table in spreadsheet form also contains active links to other, underlying spreadsheets from which the values are calculated. Clicking on the link to the CORPS/Spt Bde for CSS units allows an interested party, in this case an analyst, to "drill down" to the underlying spreadsheet that generates the total AMAF of 3,778 hours.

Okay… But Why Is Unit Movement So High Before, and Now So Low?

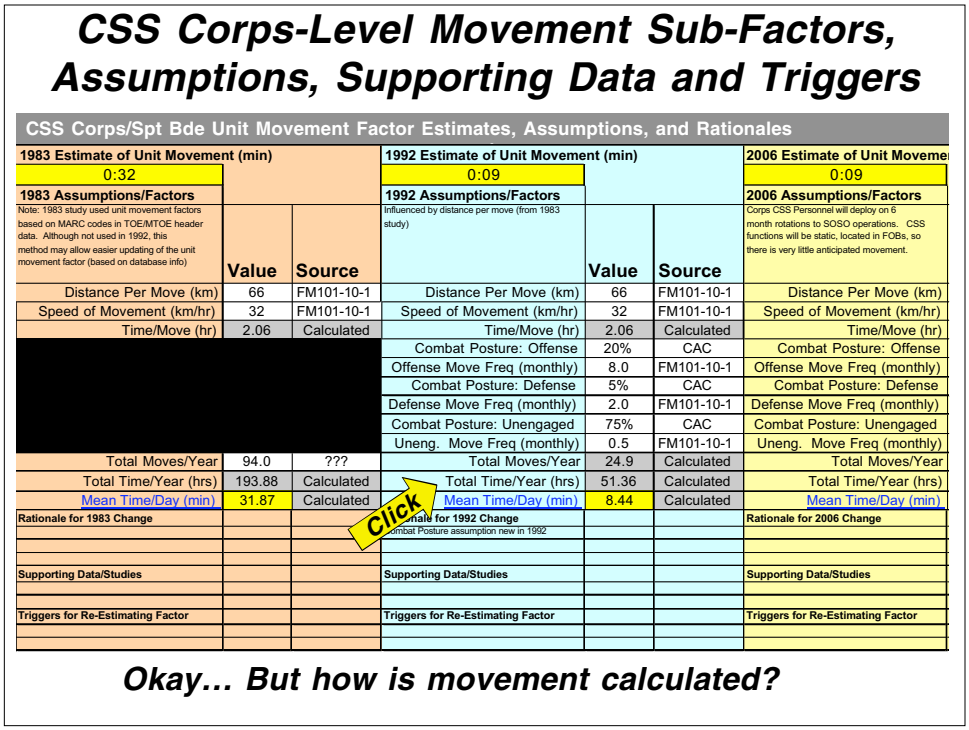
Non-Availability : CSS Corps/Spt Bde

Availability Factor	Type	Pre-1984	1983	1992	2006
Sleep	Pers	12:00	7:00	7:00	
Medical	Pers	0:20	1:20	1:20	
Personal Hygiene	Pers	0:30	0:22	0:22	
Bath	Pers		0:13	0:13	
Counseling	Pers		0:01	0:01	
Pay Call	Pers		0:01	0:01	
Military Justice	Pers		0:01	0:01	
Mail Call	Pers		0:03		
Hot Ration (1)	Pers	0:45	0:34	0:45	
CBT Ration (2)	Pers		0:45	0:15	
Laundry	Pers		0:03	0:01	
Religious Service	Pers		0:03	0:01	
Unit Resupply	Unit		0:09		
Unit Commo	Unit				
Meeting/Formation	Unit		0:15	0:20	
Unit Movement	Unit	2:16	0:32	0:09	
Load/Unload	Unit		2:43	0:38	
Unit Security	Unit	0:35	4:16	2:10	
Kitchen Police	Unit	0:15	0:20	0:10	
Unit Defense	Unit		0:10	0:09	
Field Sanitation	Unit		0:06	0:01	
Area Police	Unit	0:24	0:06	0:02	
		17:05	**19:03**	**13:39**	**0:00**

Click

The underlying spreadsheet is shown in the above slide and contains a number of elements. First, all the factors that make up the AMAF of 3,778 hours are included separately. Second, the earlier AMAFs are also included to allow the analyst to see what values changed between revisions.

In this example, the analyst is interested in the "unit movement" factor and chooses to drill down on that factor to understand why that value dropped to nearly a quarter of the value in the most recent revision. The drill down is accomplished via an active link in the spreadsheet that, when clicked, takes the analyst to the spreadsheet underlying that specific calculation.



CSS Corps-Level Movement Sub-Factors, Assumptions, Supporting Data and Triggers

CSS Corps/Spt Bde Unit Movement Factor Estimates, Assumptions, and Rationales

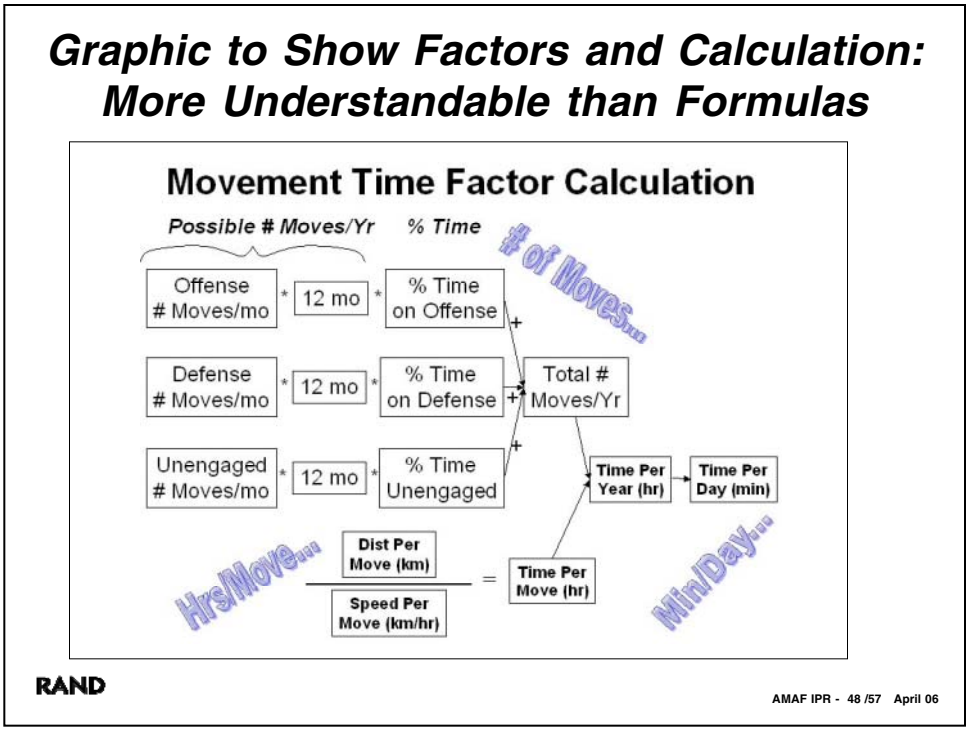
1983 Estimate of Unit Movement (min)			1992 Estimate of Unit Movement (min)			2006 Estimate of Unit Movemer
0:32			0:09			0:09
1983 Assumptions/Factors			**1992 Assumptions/Factors**			**2006 Assumptions/Factors**
Note: 1983 study used unit movement factors based on MARC codes in TOE/MTOE header data. Although not used in 1992, this method may allow easier updating of the unit movement factor (based on database info)	**Value**	**Source**	Influenced by distance per move (from 1983 study)	**Value**	**Source**	Corps CSS Personnel will deploy on 6 month rotations to SOSO operations. CSS functions will be static, located in FOBs, so there is very little anticipated movement.
Distance Per Move (km)	66	FM101-10-1	Distance Per Move (km)	66	FM101-10-1	Distance Per Move (km)
Speed of Movement (km/hr)	32	FM101-10-1	Speed of Movement (km/hr)	32	FM101-10-1	Speed of Movement (km/hr)
Time/Move (hr)	2.06	Calculated	Time/Move (hr)	2.06	Calculated	Time/Move (hr)
			Combat Posture: Offense	20%	CAC	Combat Posture: Offense
			Offense Move Freq (monthly)	8.0	FM101-10-1	Offense Move Freq (monthly)
			Combat Posture: Defense	5%	CAC	Combat Posture: Defense
			Defense Move Freq (monthly)	2.0	FM101-10-1	Defense Move Freq (monthly)
			Combat Posture: Unengaged	75%	CAC	Combat Posture: Unengaged
			Uneng. Move Freq (monthly)	0.5	FM101-10-1	Uneng. Move Freq (monthly)
Total Moves/Year	94.0	???	Total Moves/Year	24.9	Calculated	Total Moves/Year
Total Time/Year (hrs)	193.88	Calculated	Total Time/Year (hrs)	51.36	Calculated	Total Time/Year (hrs)
Mean Time/Day (min)	31.87	Calculated	Mean Time/Day (min)	8.44	Calculated	Mean Time/Day (min)
Rationale for 1983 Change			**nale for 1992 Change**			**Rationale for 2006 Change**
			mbat Posture assumption new in 1992			
Supporting Data/Studies			**Supporting Data/Studies**			**Supporting Data/Studies**
Triggers for Re-Estimating Factor			**Triggers for Re-Estimating Factor**			**Triggers for Re-Estimating Factor**

Click

Okay… But how is movement calculated?

Clicking on the active link that is the "Unit Movement" factor in the previous spreadsheet takes the analyst to this underlying Unit Movement spreadsheet for CSS units in Corps or Spt Bde roles. This spreadsheet contains the subfactors and calculations to produce the appropriate unit movement factor. Note that each of the subfactors, such as "Distance Per Move" and "Speed of Movement," are included here with references for the source of these factors in Army Field Manuals or from organizations. The sheet also contains the history of the earlier calculations that allows an analyst to immediately see the changes in calculations between earlier and later estimates.

The mean time per day for unit movement is calculated to be 8 minutes and 44 seconds, which rounds up to 9 minutes, the current estimate. However, the underlying calculation for the source of this number is available only as a formula in the formula window of the spreadsheet. Such formulas, written in the language of Excel, are often difficult to parse and understand. In this example, the analyst can click on an active link in the spreadsheet and drill down to a graphical representation of how the factors are combined to give the overall unit movement estimate.



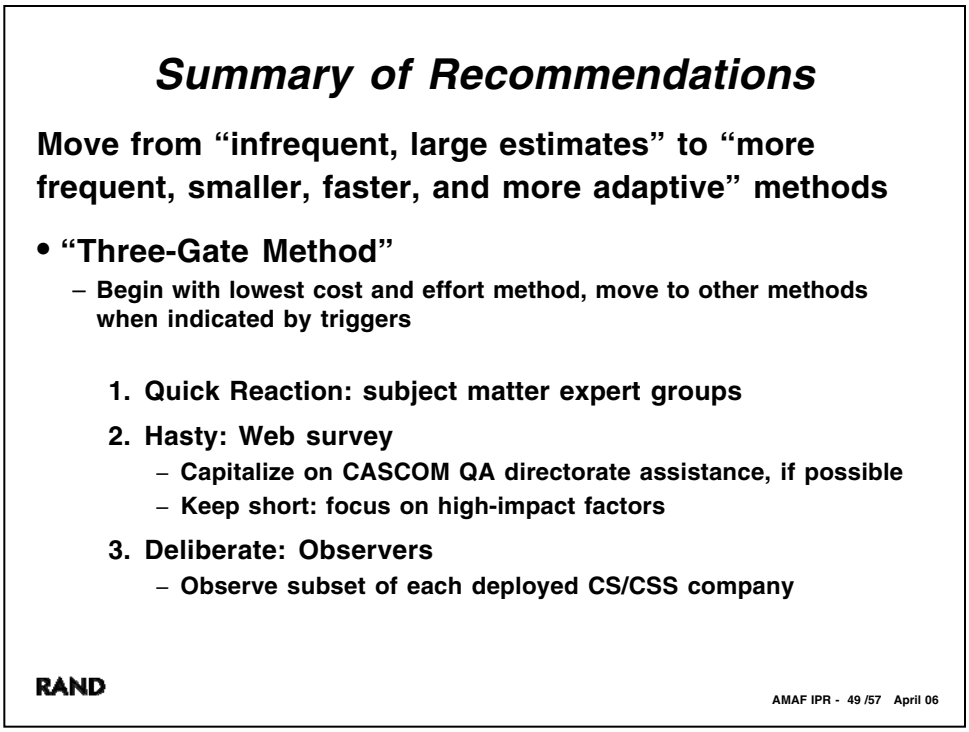
The graphical picture of the subfactors and their combination is stored as a separate spreadsheet. A click on the active link shown in the previous slide brings the above spreadsheet graphic to the fore. This graphic quickly summarizes that the number of moves per year is multiplied times the hours per move to provide the hours per year—or the number of minutes per day that is the target of the estimate.

In sum, formalizing the estimation methods for availability factors can benefit Army planners in a number of ways by providing:

- A single location to access the AMAF estimates as well as the underlying calculations, data, and assumptions;
- A "glass box" approach to make the estimate inspectable;
- A place where not only the current methods are documented, but past methods are included as well for comparison;
- A tool for carrying out "sensitivity testing" of potential changes to the AMAFs and their effects on availabilities.

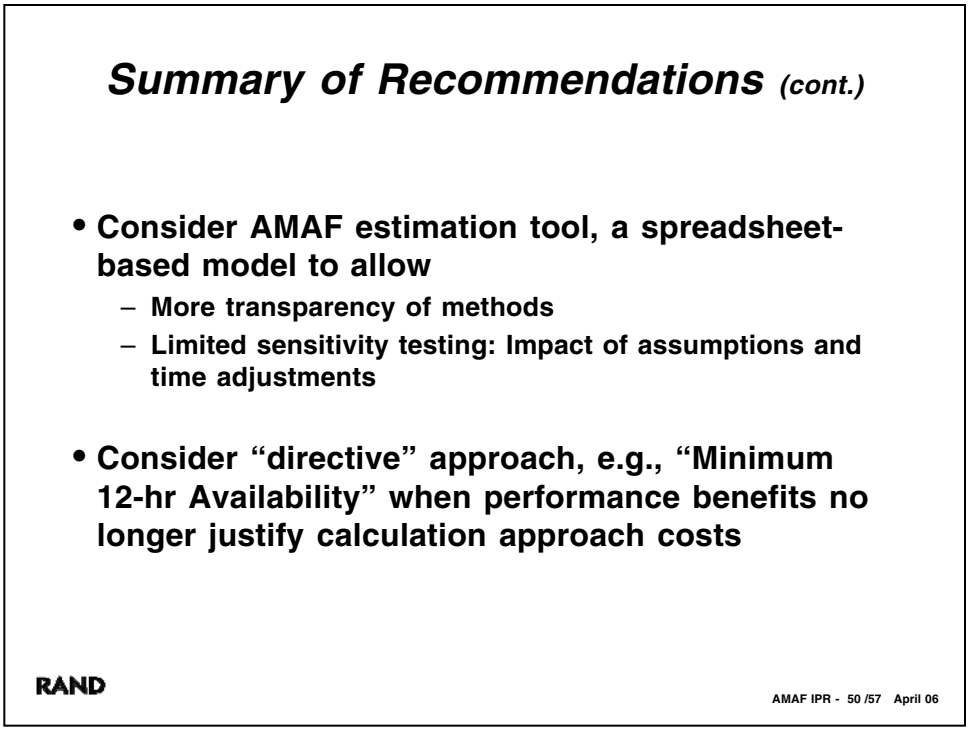
Such benefits could help the Army better understand the genesis of current and past AMAFs, as well as the possible costs and benefits of changes to those estimates.

6. Closing Remarks



With the Army transitioning from conventional, sporadic warfare to less conventional, persistent conflict, achieving a more flexible and responsive structure has become paramount. The ability to move personnel and/or reorganize units quickly, whether doing so to manage new threats or adapt to new technology, requires a MARC process that involves regular reviews and adjustments. While some components of the MARC process have been updated regularly, AMAF updates have not, largely because prior methods for estimating AMAFs have been costly and time-consuming. Our research entailed synthesizing multiple sources of information—specifically, lessons learned from other services and commercial organizations, research findings on data-collection methodologies, and personal communication with those who use such methodologies—to propose a more adaptive, lower-cost approach to AMAF estimation. The approach is essentially a three-pronged or "three-gate" process: It begins with the lowest-cost, least-effort method—i.e., the Quick Reaction Method (primarily relying on subject matter experts), and if a problem such as a personnel shortfall or mismatch of specialties proves to be

significant and widespread, it progresses to the Hasty Method (involving a web survey with spot checks on the ground). If the web survey yields poor-quality data, or if the update process is more pressed for quality than for time, then the Deliberate Method (structured observation) is used.



The proposed approach calls for identifying and monitoring a set of triggers that indicate when to begin with the Quick Reaction Method, when to initiate the Hasty Method, and when to move on to the Deliberate Method. These triggers may include informal reports (e.g., persistent rumors or email from unit commanders), database elements (e.g., readiness rates or equipment downtime reports from LIW, casualty rates), or signs that a particular method is not sufficient (e.g., a problem proved to be too widespread to resolve via SMEs, or a web survey did not get an adequate response rate).

Other recommendations include developing a spreadsheet-based AMAF estimation tool that not only enhances understanding of the MARC process (by making it more transparent) but also allows sensitivity testing to see the effects of potential changes in non-availability factors.

Finally, if the calculation approach to non-available time eventually proves to be cost-ineffective despite proposed changes, the MARC planners should reconsider whether adopting the directive approach—that of other services—would be more advantageous.

Appendix A. Sample Size Calculation for Web Survey

Alternative Sample Sizes per Population Subgroup

Population size	Expected response rate	Confidence Level	Z	SAMPLE SIZE per subgroup	
				3% margin of error	5% margin of error
100,000	0.5	0.99	2.58	1815	661
100,000	0.5	0.95	1.96	1056	383
100,000	0.5	0.90	1.65	746	270
100,000	0.5	0.85	1.44	573	207
100,000	0.5	0.80	1.28	453	164
100,000	0.5	0.70	1.04	300	108

NOTE: Calculations based on a smaller subgroup size (on the order of 10,000, rather than 100,000) yield similar sample sizes per subgroup.

RAND

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The above slide and the following two elaborate on the sample size calculation for stratified sampling. Above we see the effect of the desired confidence level on the sample size requirement. If the Army were willing to be only 70 percent confident that the true population's responses would be within 5 percent of the sample's responses, then a sample size of 108 per subgroup would suffice, rather than 383 per subgroup.

Calculating Sample Size Requirement per Subgroup

- **Assumes normal distribution, random sample**
- **Notation**
  - p = expected response rate from sample
  - Z_c = z-value (from a normal distribution table) corresponding to confidence level of c
  - e = precision
- **For example,**
  - p = 50%
  - c = 95% $\rightarrow Z_c = 1.96$
  - e = 3%

In this example, sample size will allow us to be 95% confident that the proportion of the sample giving a certain response is within 3% of the proportion of the population that would give that response.

- **unadjusted sample size requirement**

  $n_0 = [(Z_c)^2 \, p(1-p)] / [e^2]$

- **after adjusting for population of N**

  $n = n_0 / [1 + (n_0 - 1) / N]$

RAND

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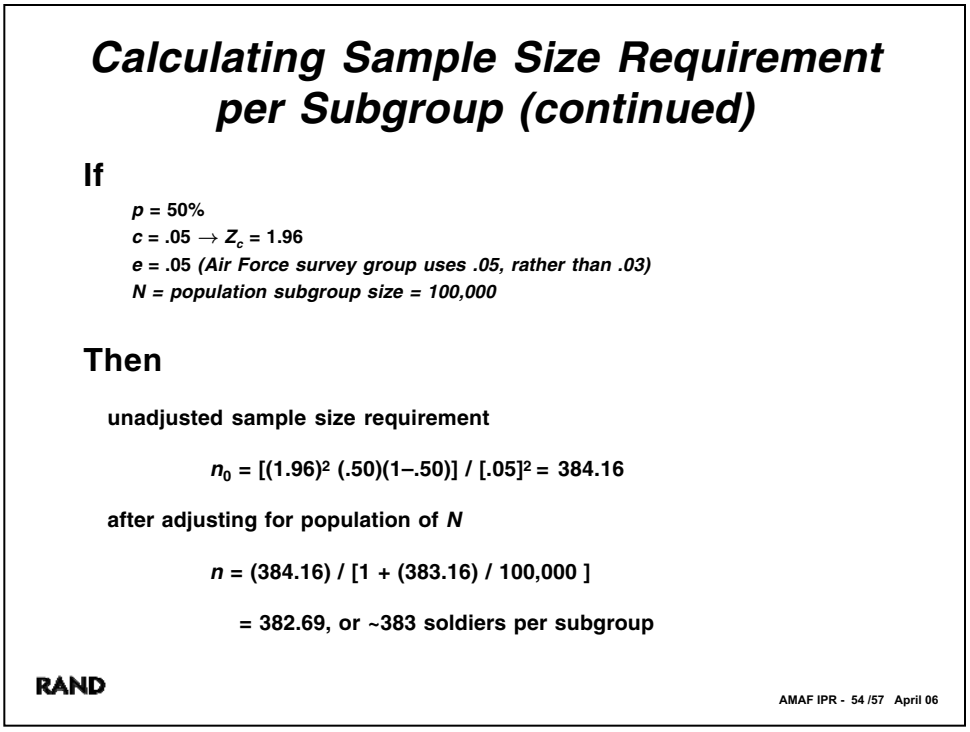
This slide shows the equation used to calculate the sample size requirement for a given response rate, confidence level, and precision (margin of error). It also shows how to adjust that sample size requirement to account for the size of the population subgroup. For a more detailed explanation of these equations, see Israel (1992).



Here we see how the sample size equations yield 383 soldiers per group, given a 50 percent response rate, a 5 percent margin of error, and a 95 percent confidence interval.

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