REMARKS ON THE DESIGN, CONDUCT, AND ANALYSIS OF LARGE AIR EXERCISES

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I am a bit reluctant to stand before this group of practiced and recognized professionals in the arts of analysis and try to say something new and interesting about the conduct and study of Air Force exercises. I expect that every point I hope to make is known by one person or another in this group. Let's then approach these remarks as an attempt to systematize some of the things many of us either already know, or would soon realize if the appropriate circumstances should arise.

These remarks are not intended to be critical of analysts' past and present practices; rather, I propose to look at the practices we would all like to follow.

We are to consider large Air Force exercises. Our point of view will be that of an analyst. My thesis contains the following chain of argument:

- The attainment of an appropriately precise narrative and numerical description of what happened in an exercise--to the offense, to the defense, to the targets, in the data networks and in the several headquarters; and the environment in which these things happened--is an essential prerequisite to any correct recognition and understanding of what the exercise has to teach.

- Many of the lessons taught by the exercise can be discovered and documented only by study of the description.

- The preparation of the description demands the collection of certain kinds of information from all participating units; analysis of the description may require that further data be in hand.

- The design of the exercise missions to provide the information which

is sought, the engineering of an organization to manage the exercise, the naming of the items of information which have to be collected, the selection of sources for their collection, the preparation and distribution of suitable data forms, and the selection and training of recorders demand that a considerable amount of staff and analysis work be done during an extended period preceding the running of the exercise itself. The amount of analytical effort required represents, say, the full-time work of several good men for several months before the exercise. If this important work is ineffectively done, the exercise will be inefficient, for the added cost of this work is trivial in comparison with the aggregate cost of the exercise, and it can make possible the acquisition of tremendously more information than will otherwise be possible. In current Air Force practice, I believe this work is usually incompletely done. In order to improve this situation, the analysts should first insure their grasp of the work needed and then endeavor to persuade the commands that it would be much to their advantage to provide for its accomplishment.

• Every large exercise requires temporary organizational revisions in the command and communications structures of the forces in order to create the exercise headquarters. These headquarters never function as smoothly or well as could be desired; no organization functions well in the first hours of its operation. To help insure the smooth, efficient, and effective operation of the communications and command structures set up for an exercise, it would, most probably, be worthwhile to conduct an appropriate command post exercise, without movement of units, before the actual operating exercise is attempted.

These are some of the main points of my remarks; they show the general direction to be followed. It will be apparent as we proceed that the remarks

emphasize exercises whose purpose is the study of tactics for offense forces. This selection permits statements to be made in more definite form than would be possible if the attempt were made to discuss exercises in general.

The word "exercise" is loosely used in the Air Force to denote a rather broad band of activities; it will be worthwhile to pause here a moment to look at this band, because the kinds of information that can be drawn from a particular exercise, and the difficulty or ease of doing so, depend upon where in the band of possible exercises the particular one lies. An easy way to characterize an exercise to to observe the extent of its departure from the characteristics of an ideal test. In an ideal test the device or tactic under scrutiny is presumed to be in existence in practiced, workable form; the test is conducted under controlled conditions (that is, observations are made under specific, predetermined conditions or situations); and the data are collected by expert recorders and perhaps also by special instrumentation tailored to the test. The analysts provide most of the direction to test operations.

An exercise, on the other hand, is primarily a military show. The emphasis is on the development of tactics, techniques, or equipment, on the maintenance of proficiency in their use, or on the discovery of organisational or materiel requirements. The collection of data and the conduct of analyses are essential parts of both tests and exercises, but for exercises these activities are much more difficult and require more detailed and extended preparation. The difficulties arise from several causes, which represent departures, of greater or lesser magnitude, from the properties of an ideal test, namely: not all of the tactics or equipments under scrutiny are in hand in practiced, workable form; the conditions of the test are not closely controlled (indeed, one of the goals of an exercise may be to investigate how well can designed conditions be achieved by an operating force with incomplete specific prior practice); the data opera-

tions are frequently so numerous and far-flung that data collection everywhere by expert recorders is impossible (and hence resort must be taken to recruited recorders whose performance will reflect the temporary nature of their assignments); much special instrumentation, otherwise desirable, is inconvenient or infeasible; and the senior exercise management is perhaps less interested in adequate documentation than in other facets of the operation. These properties of an exercise place all the more premium on the quality and completeness of the staff and analysis work done before, during, and after the exercise. If this work is inadequately done, much information, potentially available, is lost.

It is unfortunate that in large-scale Air Force operations, staged for the evaluation of force tactics, the level of proficiency and familiarity required--on the part of those designing, those operating, and those recording--to make the operation a test, is rarely achieved. The briefing, the sortie of the force, the execution of the tactic, the observation, and so on are not polished and hence a host of important effects which, in any honest sense, are external to the worth of the tactic itself, either actually or seemingly assert themselves in its execution and influence the success and the reputation which the tactic achieves. Among such effects are: the coordination between individual aircraft in a formation; the coordination between formations; the pilots' ability or luck in finding the right targets, check-points, and let-down points; the force's withdrawal from the exercise area in a manner which may or may not reasonably simulate wartime behavior; the dissemination of the word on the speeds and altitudes to be followed; the reliability of people's memories of new radio call-signs and special procedures, and so on. A further effect which has little to do with proficiency, but which can very much bias the appreciation of a tactic, is the

weather. Weather influences the launching and recovery of aircraft, visibility, contrails, ground-speed, and radar performance.

There are some good reasons why the large operations are not, and perhaps should not be, tests. For one thing, the planners usually have a number of alternative tactics in mind that they want to try and, in point of time and money consumed, it would simply be infeasible to exercise the force sufficiently to polish the tactics before evaluation is attempted. Also, the consolidation of a large force for an operation necessarily involves temporary dislocations of personnel and equipment and may result in a period of reduced readiness to face actual warfare. In theaters overseas, the conduct of a large operation involves diplomatic arrangements to clear an exercise area. Furthermore, many people feel it is good for the Air Force to operate with unfamiliar orders now and then, to create and maintain a useful level of force flexibility.

There is justification for emphasizing the importance of these "external" factors to the success achieved by a tactic. The first thing which must be recognized by operation planners is that if the operation is large, it is going to be something of a first rehearsal. To some extent the force will be like a football team going into a game having studied its plays only on the blackboard. In recognition of this fact, provisions must be made in the exercise design, and later in the conduct of the exercise and its analysis, for the collection and study of information sufficient to enable the influence of the external factors to be described both qualitatively and quantitatively. One will be wholly unable to get down to a study of the tactics themselves, which the force has attempted, unless he has, during the design, conduct, and preliminary analysis, made explicit and adequate provision for the identification of, and at least partial compensation for. all those inevitable effects. This work entails at least

three important considerations: one is special provisions for collection of the essential environmental and performance data; another is the replication, if possible, of mission designs; and the last is the conduct of some analyses in order to understand how to employ the information on the influence of external factors. Far and away the most difficult of these is the arrangement for replication of mission designs. Commanders hate to drag things on. Analysts would do well to emphasize at every possibility that no single test or experiment is ever statistically decisive. They should try to underline to all who use the reports of analyses how very limited is the significance of limited data.

An operation of large forces does not have to be all novelty, however. A great deal can be, and in certain instances is, accomplished by force commanders toward sharpening the performance of their commands. Commanders should be urged to have their aircrews practice the components of force tactics: teach pilots to fly a line abreast beyond visual range (score it by radar); have them practice the precise attainment, in both space and time, of unfamiliar check-points and initial-points; teach them to take off on time and to observe radio discipline; urge offense force wing and squadron commanders to establish close cooperation with the radar stations in the vicinity of their bases, so that frequent, small, almost unofficial sub-exercises can be run and simply scored.

Let's now approach more closely the business of design, conduct, and analysis. Consider first design, and let's agree not to focus principal attention on the statistical aspects of design. We have all studied the statistical design of experiments and we know that there are good designs and bad ones, that an observed quantity is not observed exactly, that data can be sour, that statistical controls should be built into an experiment,

that the quality of our estimates is improved, in general, by repetition of experiments, and so on. We all know most of these things, whether or not we pay attention to what we know. For the present, let's focus our attention on some aspects of management of the design, on some housekeeping chores, and on some notions that have to be kept in mind in order to end up with the hope of a good exercise, one that will have a high yield of information both per hour of unit flying and per hour of analysis effort.

The first questions in design are: What is the exercise for? What is the exercise expected to find out? In vague terms these matters are usually suggested in the quotation of exercise objectives which comes down to the planning group from Headquarters USAF or the lesser headquarters in line. In my own experience with five or six exercises, these objectives have not been at all adequately specified. And when they are not adequately specified, there is opportunity for someone to say, after the exercise and the analysis: Why didn't you people do such and so? Surely all of you here have heard that sort of remark, and also: We wanted the distribution of the distances of early warning, not the times; now couldn't you just glance back over your sheets .... (and there go another three weeks down the rat-hole). I believe it would be a good idea for planners to prepare, for approval by the chief, a memorandum of interpretation, when an exercise objective is received, which interpretation would state exactly what the planners will endeavor to draw from the exercise. It would conclude with a remark that further information will be unobtainable since the flying schedule and the data forms will be simplified to the utmost, compatible with the objectives in the interpretation. In addition to the exercise objectives, planners should understand what the current operational prejudices are. They should recognize that exercise findings which deal with

controversial matters, in particular with matters upon which important people have adopted a position, require vastly more substantiation than non-controversial findings. You only have to prove something once to the chief if he already believes it, but he won't doubt himself until you prove it several times if it conflicts with his judgment.

Having the objectives and the prejudices in mind, the planners should "dry-lab" the analysis required to produce the information sought. Analytical experience is invaluable in this work. For those who don't remember their chemistry courses, "dry lab" means to do chemistry experiments in the library instead of the laboratory--to get precipitates from a textbook of compounds instead of at the bottom of a test tube. By "dry-labbing" the analysis, I mean here that one designs a calculation scheme, or a set of them, that can produce all of the information sought in the exercise, and from the scheme infers what input information has to be collected in the exercise in order to carry out the calculations in earnest. The "dry-labbing" has to be done in sufficient detail to guarantee that all the kinds of input information which will be required are found. It is a great mistake not to "dry-lab" an exercise long before it is flown.

With knowledge of the data requirements, as generated by the "dry-lab" work, one can begin to think of the kinds of missions that will be required to produce that data in usable amounts, and of the sorts of data-collection forms to be needed. Consider first the mission requirements. It probably happens that in most cases the grand strategy of the mission designs are directed by the chief or his deputy for operations. If, with reference to the "dry-lab" work, the mission schedule is found to be inadequate for underwriting conclusions on the questions posed in the exercise objectives, the planners should petition for revision of the schedule, and show proof that if

the schedule is not revised the analysis is going to degenerate into a salvage operation in which the staff tries to rescue what it can from chaotic information.

During the course of the exercise design, analysts would be wise to hunt for information payoffs, in addition to those primarily sought, which can be had for rather minor increase in the total exercise cost. Generally, an exercise is a tremendously expensive undertaking, and the direct cost of the design and analysis phases is practically negligible in comparison. Thus if an increase in the information payoff can be purchased by only proportional increase in the design and analysis effort, the over-all exercise cost will be negligibly affected.

And by the way, as a point of philosophy in design, I urge that in those exercises concerned with force penetration tactics, equal emphasis be given to investigation of the losses inflicted by area defenses and by local defenses. It is usually not done that way. However, in a somewhat loose sense, those tactics which are to be preferred for survival through area defenses are undesirable for penetrating local defenses, and vice versa. This statement is not to be interpreted strictly. Clearly, simple logic demands that in the study of penetration tactics, all the defenses to be penetrated must be considered before some particular mode of operation can be shown to be preferable. And, incidentally, if we are to be honest, we can consider only those local defense penetration tactics which will put the offense in position to launch weapons.

It may be appropriate at this point to say a few words about the design of missions or tactics. All of us, I think, enjoy doing the things we can do--we like to exercise our capabilities. There is tendency to throw into force tactics the equipment on hand with insufficient study of whether that equipment contributes positively to the success of the tactic: "Take those jammers out

and jam--lay a big river of chaff across in this direction so the defense won't know what's going on--Send in everything else we've got a half-hour ahead of the bombers and run their fighters out of gas." Some tactics with no more foundation than these have been taken quite seriously at times. It isn't necessary to emphasize to this audience that such planning does not necessarily guarantee efficient utilization of one's equipment and capabilities. The design of tactics should be based on a thorough study of the opposition--and I think these remarks apply as well to the design of defense tactics as to offense tactics. In the instance of offense tactics, the planners should consider in detail the essential attributes of a defense system and its components, and should study, then, their own capabilities to find out what uses of which capabilities can interfere in specific ways with the performance of the defense, and thus make positive contribution to the success of the tactic. The combing-over of one's capabilities to find out what he really wants to do can be done systematically, and will be helpful in both the perfection of present plans and the generation of legitimate requirements for future equipment.

Assume now that the mission or flying schedule is approaching final form. Before the planners admit that they are as little dissatisfied with it as they can honestly expect, the schedule should be searchingly examined again by the "dry-lab" technique. Also, the schedule ought to be padded a bit to provide some flying that can, grudgingly, be cancelled because of weather or other causes, without making the exercise data hopelessly incomplete.

The next step in the design is the preparation of the operations orders, including the data collection forms. Thousands of matters have to be accounted for in the orders; some of these are particularly important to the smooth conduct and analysis of the exercise, and insuring their presence in the orders is

worth special effort:

First, a central, over-all command headquarters with full authority is extremely desirable. This headquarters should be responsible for all forces involved to the extent it is feasible to arrange this responsibility. This headquarters should be responsible for both making and disseminating to all participating forces all decisions in regard to any facet of the exercise. It would be most wise to train this headquarters by a command post exercise some time before the operational exercise. Otherwise this somewhat ad hoc group is not likely to function as well as would be desirable.

Next, the orders should require an exercise critique to be held within a few days following the end of flying. The critique must be attended by the exercise commander and his staff and well-informed representatives of all participating units and organizations. The critique should direct its discussions toward the performance of the command and communications structure set up for the exercise and the exercise environment, and should specifically avoid trying to anticipate the results of the exercise analysis. The critique proceedings should be private, informal, sincere, and off the record, with only summary remarks officially recorded. In this way people will be more free in their airing of congratulations and complaints. The critique must have a strong chairman, and he should make it his business to see that people do not use the forum of the critique as a sounding board from which to advance preconceived notions. Those who are to analyze the exercise can collect much valuable information in a critique, for it involves people from all the spheres and levels of activity involved, and all the points of view.

Next, the orders should help provide motivation for the complete execution of all the data collection forms, and detail the machinery for the collection of all the data records to some single place.

When the orders are all prepared, the analysts should procure a complete deck of them and study them in detail for consistency. All courses, briefed check-points, and targets, with the associated times, should be plotted for guidance during the exercise touring, and for later use during the analysis.

Consider now the data collection forms. From earlier work the planners know all the data items that have to be collected. It is necessary to find at least one, and preferably three or four sources from which each item can be obtained. Redundancy of the data is desirable because the capability of people who are filling out forms for becoming inactive or inaccurate is almost beyond description or belief. You people are all familiar with this human characteristic. When an observation is recorded independently by several sources, sour observations can frequently be spotted. Also if there are multiple data sources, chances are that not all of them will be inactive simultaneously.

Data must be collected from the sources on prepared forms. The subject of data forms is worth a full-dress study course in its own right. A few remarks on the design and use of forms are in order here:

First, the execution of data forms takes time, and if this time is taken by people who are actual links in the system under study, then the system is disturbed. Consequently it is worthwhile to have data collected by special recorders who are not themselves linked into the system. It is infeasible to have special recorders collect all data, of course--only the pilot of a fighter can observe his airplane throughout its flight. Special data recorders are usually much more reliable than recorders who are in the system. Pilot reports are particularly unreliable and should never be taken as primary data unless they are otherwise corroborated. The usefulness of pilot reports probably would be increased if, in some way, pilots could be assured, truthfully, that

they would be immune from retribution should they frankly record their actual actions, specifically including their mistakes. I am convinced that much of the unreliability of pilot reports stems from their fear of looking bad on their records, and fear of being reprimanded or otherwise penalized for mistakes. Pilots need both protection from this sort of thing, and motivation to do good flying and reporting. It should be impressed on pilots that incorrect mission reports can lead the command staff into an improper appreciation of the relative effectiveness or desirability of alternative tactics, and thus may lead to a preference for inferior tactics. The inferior tactics could, in combat, force the unnecessary loss of pilot lives or result in other disaster.

Next, controllers should never be their own recorders, since they are very busy, usually, and also have a universal tendency to assign their failures to quirks of their equipment. All analysts know that "target fade" is meaningless in a controller's logbook.

Next, one should try hard to obtain from routine forms used in regular operations most of the data to be required. Special new forms always add to the already considerable burden of paper flowing through the force, they are not readily understood, and frequently meet hostility.

If new forms must be used, they must be carefully and cleverly worked out in order to be easy to understand, difficult to misunderstand, easy and fast to fill out, and easy to read by those who will use the information. The forms should, to the maximum possible extent, be composed either of questions with given multiple-choice answers, for which the correct answer can be indicated by a check-mark, or of data entries which can be given by writing a number in a box. Avoid asking a data collector to write a sentence. Never tell him to "cross out those answers which do not apply" for this instruction is invariably

confused. Never state questions in the negative. Never ask a recorder to make a calculation. Avoid having a recorder draw diagrams; if diagrams are essential, provide printed coordinate grids and be particularly careful that the recorders are properly instructed and exercised.

Finally, a data recorder has to be motivated to do his work properly. Motivation goes beyond either instruction or command. The recorders must be shown how to fill in the forms, what they are used for (in broad terms), be made to feel that the time he spends on the forms is well invested, and he must be given cause to want to fill in the forms properly. He must believe that every data entry on the forms is important. Accomplishing these things is a difficult but essential part of successful force exercising. The only way I know of whereby recorders can be adequately motivated is through personal contact. It is helpful to show recorders the results achieved in previous analyses using their records.

Consider now a few remarks on the behavior of analysts and commanders during the conduct of an exercise.

The commander should have at his elbow a statistician who knows the exercise plan inside and out. This arrangement may require clever selling. The commander will be less interested in the data than will the analyst, but the analyst can nevertheless keep him posted on how the information situation is developing. For one reason or another, missions are always being shuffled around, revised, postponed, and sometimes cancelled during large exercises. An analyst wired-in at the sanctum of command can sometimes provide useful advice to the chief on which missions are the more vital to the completeness of the data scheme. Thus if some flying has to be cancelled, the analyst can attempt to insure that nothing crucial is lost.

The analysts should see everything they can during the exercise, and take

copious notes. The human memory is unreliable. It is a good idea for everyone in the analysis team to write up his notes into memoranda for circulation within the team. In this way, each can profit from the experiences of all in the group.

It is important for each observer and analyst to visit, some time before the exercise, the place or places he will be during the exercise. The purposes are to learn where the place is, how it is laid out, how it operates, to meet and chat with the people and enlist their cooperation, and to arrange for a place to sit or stand where one will be able to keep track of proceedings without disturbing the system. These things must be done beforehand to avoid disturbing the system during the exercise. One should be careful during an exercise not to give away information to those who shouldn't have it. For example, an analyst bursting into a JCI at 5 a.m. with an expectant look in his eye could alert the watch that something is about to happen.

It would be a good thing if the command staff could be persuaded to keep a record of incoming information and to permit a recorder to take notes on staff discussions during an exercise. The records kept are usually only a log of outgoing printed messages; the discussions and verbal commands are lost. A rather complete staff log would be invaluable in the untangling of some of the knots of inconsistent data that may be discovered during an analysis. Analysts are well-advised to snatch up opportunities to interview commanders, staff, and crews when doing so does not disturb the system.

Now the exercise is over but, for the analysts and some of the command staff, the work continues.

It was suggested before that there should be held a critique of the command and communications operations during the exercise.

The analysis staff would be well-advised to ignore the fact that the operations orders, if well written, will have set up machinery for the prompt assembly at some one place of the complete records collected in the exercise by all participating units. The machinery may be helpful, but to insure its action the analysts should disperse to each of the source points and hound them for the records until all have been accounted for. The exercise headquarters should persist long enough to help this work. The analysts should be emotionally prepared for the realization that many of the reports will not have been made out according to the letter, to say nothing of the spirit, of the instructions. Using the records will still be difficult if all the recorders were properly instructed and motivated before the exercise. If they were not so instructed, long hours of frustration are in prospect for the analysts.

We turn now to a few remarks on analysis.

The first big problem of the analysis is to obtain a complete description, in documented numbers and narrative, of what each airplane and group of airplanes, the ground networks, and the command actually did in the exercise, and of what happened to them while doing it. This work must precede any attempt at numerical analysis, discussion, drawing of conclusions, and the like. If the exercise design has been competently done, if the data forms were well engineered, and were distributed, filled-out, and collected, and if there were no major upheavals during the conduct of the exercise, then this task is rather straightforward, though at best it is laborious. On the other hand, should one of the preceding "if" statements not be realized, the job of description may degenerate into the salvage operation mentioned before.

For those who have not experienced what this job of description can entail, let me create an only slightly exaggerated example. Suppose we are dealing with

an exercise designed to evaluate the relative reliability of a set of alternative mission designs for getting an attack force through an area defended by radar-controlled interceptors. The sequence of the main events is: the offense forces approach the defended area, some or all of them are seen by radar, the radar information is evaluated and scramble orders are given, interceptors rise and engage some or all of the offense, the surviving offense aircraft continue to target and turn homeward.

Ideally, the offense could provide, within the accuracy of navigation logbooks, a minute-by-minute record of the location, course, speed, and altitude of each of its aircraft, along with a notation of its base, type, time of take-off, call-sign, side markings, briefed IP's and target, briefed profile, the points where each is attacked, where each sights interceptors, the influence of radio jamming on communication, and the existence or absence of contrails at all points along the route. That would be the offense's picture of things.

The defense network gets a different picture. They see pips on radar scopes, they estimate speeds, altitudes, courses, and positions for the aircraft the pips represent. But the defense isn't positive who are friend and foe, it doesn't know for sure which aircraft are weapon carriers and which are not--maybe none or all are--and they don't know the intended targets. The defense is unsure how many aircraft are present; they worry about being deceived. The defense gives each track it sees a number, and records loads of information on each one, from their viewpoint. Decisions are made, disseminated, and recorded.

Now interceptors leave the ground. An interceptor pilot sees many things, and records some of it. If he sees an offense airplane, he has no sure way of knowing if it is the one he was dispatched and vectored to find. He knows his

position only approximately, and can only guess the heading of the aircraft he sees. Sometimes he can read the markings on his target, sometimes not.

The point of these paragraphs has been to indicate how the offense, the defense ground network, and the defense squadrons each build up stores of more or less inaccurately recorded information about aircraft sent, aircraft detected and tracked, and about aircraft sighted or attacked. But there is no immediate identification of a particular offense sortie with a particular radar track and with a particular interceptor sighting. Obviously this three-sided correlation is essential to the bringing together of all the information recorded on the actions of, and responses to, each offense aircraft. One procedure for approaching this correlation involves the use of plotted overlay maps of aircraft tracks.

Eventually, the narrative and numerical description of the exercise is achieved and the analysis proper can get under way. This task, too, can be rather straightforward if the "dry-lab" work, so helpful in the design stages, was well carried out.

Let me close these remarks by recalling to your memories a few of the arguments advanced in the previous paragraphs:

1. The conclusions from an exercise can be documented only if one knows and can document what happened in the exercise.
2. Only if the influence of the "external factors" can be adequately appreciated and isolated can the conclusions reflect the influence, on the results achieved, of the components of force tactics, or can whole-force tactics be fairly ranked in order of preference. To accomplish this isolation to a useful extent, very

careful and explicit preparations are required.

3. The proper design of an exercise, to be statistically efficient, conclusive, possible to describe and to analyze, and to make possible the collection of all the data and other information sought, requires a large amount of analysis and staff work to be done before the exercise is flown.

4. The command and communications structures set up for an exercise should be given practice beforehand in order to increase the likelihood that these structures will function smoothly.

5. Force commanders can contribute much to the capability of their forces by a continuous program of scored and analyzed small exercises.

6. There are a number of important steps that have to be taken in order to collect useful and adequate data. Among these are:

   The data requirements must be deduced.

   The missions must be appropriately designed.

   The data sources must be found and the personnel be trained.

   Clever collection forms must be engineered, reproduced, distributed, executed, and collected together.

7. In the design of an exercise, analysts should search carefully for information payoffs, beyond those originally required, which can be attained for negligible or minor increase in the over-all exercise cost.

8. In considerations of exercises concerned with force penetration tactics, analysts are urged to give equal emphasis to investigation of the losses inflicted by local defenses and by area defenses.