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"STATISTICS IN WAR"

Lecture by

Colonel Leonard P. Ayres.

May 2, 1929.

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I think we shall be entirely safe if we infer that in the event of another emergency military statistics will play an important part. I say that simply because of our experience in the war. I am sure no one in the Army planned ahead that there was going to be any large development of statistics, particularly any development in the Army itself of any statistical unit or branch. So the large development that did come was not any result of pre-vision, but was the result of what circumstances as they developed forced upon the Army.

Personally, I came to Washington at the very outbreak of the war, not to aid in any statistical development but to help in some of the problems of organization and administration of the Council of National Defense. Almost immediately - in April of that year - it became evident that some source of general information was needed about the developing war activities and we began shortly to get out a weekly report, at first consisting only of five copies and of not very many pages, perhaps a dozen or so, telling all sorts of things that were not necessarily statistical in nature. As this was a confidential document, we began to include actual figures about orders placed, deliveries promised, deliveries under way, et cetera. It was very informal and rudimentary.

As that summer came on, there developed a marked difference of opinion in regard to calling the first draft. The question was when it should be called - when the men should be called to the colors - and responsible opinion varied over a surprisingly great range of time. Some officers held that they should be called in the summer of 1917, others as far ahead as the spring of 1918. One day, General Palmer Pierce, who represented the War Department as the military member of the Council of National Defense and was also a kind of liaison officer between the Army and civilian organizations, asked me if I would take the available information and begin to project ahead the deliveries of goods necessary for bringing an Army into being and into uniform, and so give an impartial view as to when that first draft might be called. We began what I suppose was the first of this long series of projecting ahead the probable deliveries and finding out when you would have the essentials at the place needed so you could take a military step based upon them. We began to think in terms of the controlling factors - which we had not done before - and we began thinking of minimum essentials. I asked myself what was it we would have to have to bring an army into being. What are the least terms on which you can take a half million men from civilian life and make them into soldiers? I made a decision in this matter which I decided to state to the Army authorities - a decision as to when we should actually have a sufficient amount of delivery of the goods that were the minimum essentials for calling an Army into being. I decided that the first week in September was going to be the date, and still being statistician of the Council of National

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Defense and the War Industries Board, I submitted my report. The Army,- the General Staff - decided it was the right solution and that the draft would be called for the 5th day of September. Now the main essential which I decided was going to be present in sufficient quantities to have these men called was one pair of pants, olive drab, per man, because it seemed to me that you could not start a man off as a soldier until he had pants. He could wait for a greater or less time for any other article of equipment. We had enough blankets - such as they were - we decided that they could wear the shoes they already had, but it was going to be necessary to have one pair of pants for each man, and the actual facts are that the first important piece of statistical work done in the war was that done to decide when the draft should be called. It was finally decided on that basis - by projecting the groups of the important organizations and deciding which was the controlling factor or factors. That date was decided by the pants curve. That seems and is a very crude beginning. It illustrates the condition of military statistics at that time and the way in which the thing evolved, and the necessity for having controls of a statistical nature in time of a major emergency.

While this was going on, and before September came, there arose another interesting question which related to shoes. To the great surprise of all of us, we found that there was no schedule of sizes that was sufficiently dependable and definite to use as the basis for ordering shoes by so many of this size, so many of the next size, et cetera. Of course, it would seem that the Quartermaster

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records for some time back, put together, would be an adequate guide in this matter. That was not so. The different posts and supply depots had ordered shoes as the supply of any given size ran out. They ordered more of the size they needed and no one ever put together a large enough number of requisitions to constitute a guide for the number of shoes of each size. That is an extraordinary fact. When we had to begin to order shoes by the millions and three and four millions, nobody knew how many 8's, or 9's, or 10's there ought to be. They asked us if there was any recorded experience or theory in statistical method that would help solve that problem, and after short investigation among large shoe companies we found there was nothing, and so we went back into the first piece of theoretical statistics brought into operation during the war and tried to solve our military problems.

There is a rare piece of statistical theory used by biologists and pschydologists which relates to the distribution of facts relating to human beings and other organisms. Let me illustrate. Suppose you were to get outdoors late in the summer and pick up the leaves from a tree and measure them. You would find a few dwarf leaves and a few giant leaves, but a large number of average sized leaves. Most of them would be average. That is true of men. If you drafted all the adult men of a given age in a homogeneous population, you would get a few dwarfs and a few giants. Most of them would be average. From a number of years experience we found the proportion of people of very small size to those a little larger than that, and on up to the giant size, is always about uniform in any homogeneous population.

We found that the proportions of men as to size were about the same as leaves, or clam shells, et cetera, or anything that is of the same family and goes through the development from youth to maturity. So, taking into account the rules that have been evolved by those observations, which are known to statisticians as rules of the normal distribution, we worked out the proportions of shoes of different sizes that, according to pure theory, the homogeneous body of men such as the Army of this country ought to want. I went out to Fort Myer and looked up some of the records of the purchase of shoes in the Civil War and made inquiry to find out if size 8 meant the same thing as size 8 at the present time, and applied this distribution to the actual purchase orders of contractors during the Civil War. What the Civil War Army had done was what our curves indicated and we worked out schedules by sizes and letters for the ordering of shoes for the Army. We submitted these and after a little experimentation it was found that that was the way to order shoes, adding of course something to size because it is the experience of all armies that the sizes are certain to be somewhat larger after the men have been in service for a while. We found that if the Army had gone ahead ordering shoes on the schedules that it began to use at the beginning of the war, we would have had an excess of small size shoes sufficient to supply an Army of 23 million men. So the importance of this becomes very evident.

After the ordering had gone on for a while we began to get complaints that this did not fit in every case - the result did not agree with the needs. We found that while it was true that the shoe

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sizes showed a large number of medium sizes coming out to a small number of large sizes, nevertheless there seemed to be something in there that was throwing it out. Statistically speaking, we had what was called a bi-modal distribution, as though we were dealing with two races. There was an average size of one group which apparently was not fitting the average of another group. We found that was true - that we had two entire series of shoe sizes to consider, for the average for the colored troops was different from the white as they have to be stepped up a bit. We found that instead of doing all this ordering on the basis of one curve we had to have another curve for the colored troops, and we found that had to be stepped up because of the surprising increase in the size actually needed by the men when they changed from civilian to military life. That explains why so many men trying to order shoes they were accustomed to wearing were told "Out of 8's, take a 10". I cite that to illustrate a curious combination of plain straightforward statistical practice relating to a practical purpose and statistical theory which may come in and solve a problem when the commonsense, ordinary straightforward method will not suffice. In general, military statistics is a straightforward, non-theoretical, practical subject requiring ingenuity, adaptability and close contact rather than statistical theory, yet lurking in the background are these curious problems which apparently can not be solved except by having a statistical theorist somewhere in the force, so I would suggest that if, in time of emergency, you are called upon to help establish a statistical unit, you include, not many, but one or more people of thoroughly

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good training in statistical theory as well as in statistical practice, and by that I mean able mathematicians and experienced statisticians, because from time to time you will need them.

About the time we were working on the shoes we had worked up our weekly report until it had become something we people in the War Department and its accessory organizations, such as the War Industries Board and the Council of National Defense, had learned to rely upon. The number of copies had grown, the number of pages had increased, and the Army found that this thing was becoming too intimately connected with its own operations and too confidential in nature, so they asked me if I would take some of my assistants and go over into the War Department where complete confidence and secrecy could be maintained. We did that on a civilian status - coming into the Army not directly but edging in sidewise. One day they called me in and asked me if I would draw up an order by which this force would be militarized and become a unit of the Army organization. I said that of course I should be glad to do that. No one knew just how a statistical army should be organized. So I tried to draw up a General Order creating a statistical organization which we decided would be a statistical unit of the General Staff. I had been around long enough to get some insight into Army methods, so when I finished writing the order I had a happy thought - one of the happiest thoughts I ever had - and I added the sentence which said "Communications between the Chief Statistical Officer and the Secretary of War and Chief of Staff shall be direct and not through military channels "

The Chief of Staff signed the order. From that time on, whenever it

seemed advisable to talk with the Chief of Staff or the Secretary of War I went in, and that worked very well except one time when I walked into the office of the Chief of Staff and found that he was in consultation with the President, who was somewhat peevish, but in general it was a good plan.

Quite seriously, I want to suggest that in time of emergency military statisticians be located in such a way that they will have close contact with the people in top control. They are a little different from almost anything else from an organization standpoint. Military statistics are, I think, in reality a staff function for the staff. They are a staff staff function. They have the mission of trying to weed out the essential from the great mass of incidental and make it clearly and easily available for those people who are charged with the planning and producing. While what I did was un-military, its working out was extremely fortunate and the principle is sound.

At that time one of the most important problems was that of getting the supplies overseas. Not merely a problem of getting vessels, of securing supplies or of training men, but a corresponding Navy problem of how the available vessels could best perform their function of getting the supplies over to the other side. There was an organization - a Joint Board of Navy and Army officers charged with the duty of computing the carrying capacity of the shipping that was available, adding new ships as fast as they could be secured and figuring ahead by months and weeks how much of what was available on this side in terms of man power and material could be moved to the

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other side by the shipping available. You can see that the functioning of the military machine on this side was really controlled by that operation. One of the first observations I made when I got into the Army was that the work of the Army and Navy Embarkation Board was not going satisfactorily. It was done very carefully and very secretly but the actual operations were always different from the computed operations. The first day I was in uniform I went to look over that material and being still quite unabashed by Army procedure I observed that I thought it was worthless. The next morning an orderly appeared and requested that I report to the War Council. I did not know what it was about. I found that the Council had been reenforced for that meeting by not merely the usual formidable array of army generals but also naval officers including the Chief of Staff and a number of admirals. The Chief of Staff of the Army said that it had been reported to him that I had made critical remarks about the work of the Embarkation Board. He said, "Please tell this Board what you would advise concerning the work that Board is doing." I said, "I would recommend that it be abandoned." He said, "Why?" I said, "Because the methods used are producing results that are deceptive and will continue to do so until the methods are changed."

I will tell you why. Of course, the operation of an Army transport is recorded in terms of the "turn-around", which is the time necessary to load the vessel on this side, sail it to the other side, unload it and bring it back, completing one unit of the work of the transport. What the Board had been doing was to record the

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the turn-arounds of all vessels in the Army and Navy transport service and to estimate on the basis of the time that each vessel took how much cargo and how many men could be carried over in the next week, month, et cetera. It is not a straight piece of work. Let us suppose you have three vessels - one slow one and two fast ones. The slow one makes its turn-around in 50 days and the two fast ones make a turn-around in 25 days, and that was all the fleet you had. You would say the sum is 100 and the average is $33\frac{1}{3}$. That means they would make three trips every 100 days and for the three vessels, nine trips. That is correct and straightforward. But you have already said that one vessel makes its turn-around in 50 days, which is two in 100, and the other two vessels make four in 100, and four and four and two are 10, so one way you have 9 trips and the other way 10. All of our vessels were slow so the operations were always behind schedule and the material was piling up on the wharves and the whole thing was running badly. The Chief of Staff said, "What would you substitute for the methods now used?" I said, "I would substitute the effective average", and when he asked what the effective average was I said it was the harmonic mean. General March said, "Define the harmonic mean." I said, "That is the reciprocal of the mean of the reciprocal of the several observations." General March said, "Precisely so, and it will be computed that way from this time on." It was computed that way from that time on and we began to have our results gibe with the estimates.

While most of this work is routine, from time to time you are going to have more technical questions come in. They are perhaps 1% of the volume, but much more in importance.

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The routine work of the organization went forward. It was then a considerable unit of the General Staff. It occupied offices close to the office of the Chief of Staff and the Secretary of War. There was thrown around it every precaution of secrecy. Reports were made by the photostatic process by enlisted personnel who worked in the basement of the State, War and Navy Building, and rigorously maintained guards were thrown around it night and day, which, of course, was essential.

About that time General Pershing having heard that this form of reporting was going on on this side, asked me to have copies of those reports forwarded to him, which was done. Shortly thereafter, he cabled the request that a similar unit be organized and trained and sent to his headquarters to get out the same kind of report from there, so we organized a short course in military statistics and I went over there in 1918 with that statistical unit and organized a unit similar to the one here at general headquarters and the headquarters of the Services of Supply. It would take too long to go into the details of the work there. In the main it was the same sort of thing we had done here. The work at the S.O.S. constituted a weekly report of procurement and delivery, very similar fundamentally to the one made for the War Department on this side. The one over there was a daily report that General Pershing required to have on his desk each morning at eight o'clock. Eight o'clock meaning eight o'clock - a very inconvenient hour for a daily report. That was largely a personnel and fighting equipment report. The other report was a materiel report in the main.

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One very disagreeable, rainy night not long after our arrival, the Adjutant General in person came to my billet and gave me orders to report at Versailles at daybreak the next morning. It was a long way from Chaumont and the orders were imperative, but blind, of course. It seemed to me it must be something very important that the Supreme War Council wanted so I gathered such material as I thought might be useful, rode all night and got there the next morning. I was met by an American officer who explained what the mission was. He said they had gathered there the artillery ordnance officers selected from all the allied armies because of their knowledge of artillery and had constituted them a board under orders to wait until there was a dud from Big Bertha and to draw up plans and specifications for artillery like Big Bertha so the allies might begin its manufacture. At that time Paris was under continual 20-minute bombardment and the Board had been sitting a long time. Somebody had told them there was a statistical officer at Chaumont and if they would send for him he could compute how long the Board would have to wait before there would be a dud. All of you have probably had some experience in computation and you will recall that it is not possible to compute the probability of an occurrence of which there has never been a single instance. However, that was the first time the Statistics Unit had been called upon to do anything for the Supreme War Council, and it was the only military statistics unit in the Army, although now I believe all armies have such units. I asked them if they had any samples of Big Bertha's shells. They had a large table there entirely covered with portions of those shells. There was an order

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that when a shell fell its pieces should be recovered and turned in, with a report as to the hour and place it fell. These pieces ranged from the size of a half dollar to a whole side of one of the shells. Looking over these and wondering what I was going to say, I noticed some fragments of fuzes and I asked if each shell had a single fuze or two or more fuzes. Some of you who have brushed up against the theory of probabilities will realize that what I was groping for was an independent cause and it took a long time to decide that they had two independent fuzes. I had thought that would be the case. Then I asked if they could tell by further examination whether the two fuzes came from the same manufacturer or arsenal or whether they originated in different manufacturing plants. That took well into the next day when they reported that it was pretty clearly evident that each shell had two fuzes and they came from two arsenals. Then I asked them if they had tables showing the number of duds found in ordinary shells carrying these fuzes. They had. I was then able to make a statistical reply. In any problem of probabilities, when you are dealing with perfectly independent causes, the probability of such a result as we are considering would be not in proportion to adding the probabilities, but in proportion to multiplying them, so if you had one fuze that would produce one dud in 1,000 shots and you had another fuze not likely to contain some defect, this probability was also one in 1,000, and the probability that both would fail at the same time was not one in 2,000, but one in a million. So I told them that there was not going to be any dud in that war. I took a chance on that because even if there was going to be only one in ten

years it might happen to be the next day. However, I did not explain that. I thought that, coming from the Statistical Unit, the answer had better be definite. The war ended without there being a dud from Big Bertha.

That shows that your Statistical Unit in time of war is going to have to do a great mass of perfectly routine gathering of information in which the essential purpose is to sift out the necessary from the contingent, the essential from the insignificant and make available the important information to the people in top control. From time to time it is going to be called upon to do extraordinary things, entirely different in nature, frequently requiring mathematical statistics of an abstruse sort so your organization must be competent to do the routine job competently and efficiently and it must be a fast working organization and have within it two or three or more people who can take care of the extraordinary demand. Sometimes they do not require any mathematics. Some of you will recall that when it was decided to let each man receive from home one of those Christmas packages about the size of a brick, there was a great question as to what the people should be permitted to send and what the boys wanted to receive. Some battalions were furnished with little ballots on which the men wrote what they would like to receive. Some 10,000 of these were sent to the Statistical Unit which would report to headquarters and they would report to the newspapers over here. That did not require any higher mathematics but it was an interesting insight into dughboy pschycology. We tabulated those 10,000 combinations of wishes. They came out perfectly definitely. What those

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men wanted first by a long majority were unmounted snapshots of people and things at home - family, sweethearts, sights around town, et cetera. The second wish by a definite majority was for home-made fudge. I think it was simply another manifestation of the desire shown in the first request. The third was the cause of this statistical report not being published in this country. Very, very definitely the thing they wanted next was rye whiskey. The typical Christmas package that was wanted consisted of a layer snapshots and rye whiskey packed all around with fudge. The Commander in Chief received the report and directed that it be suppressed.

I should be sorry if I had misled you into thinking that the things I have been talking about are the typical features of military statistical work. These are the high point illustrations of the range of statistical work that has to be done and some explanation of the reason why in time of emergency it is well to have a unit devoted to doing just such extraordinary things. In the main the military statistician needs to be quick, adaptable and practical.

Colonel Coward told me that at the beginning of the war he was at the military training camp at Fortress Monroe and gave an examination. One of the questions was "How would you ascertain the height of a tower by means of an aneroid barometer?" One cadet said, "I would lower the barometer from the top of the tower by a string and measure the string." He was right. I hope he got his commission because that was really the practical answer. What needs

to be done is to remember in military statistics, with all its aid and adjuncts, to use the practical method unless you are forced to use some other.

When the time comes that an emergency is upon the Army, you may be sure that there will be need of military statistical work. No one can foretell along what lines that work will have to be done. The important thing about the organization of a statistical unit of the army is that it must fit in with the organization you have got in the Army and you have got to organize it so it will have contact with responsible people in the procurement divisions of the Army. In so far as is possible, work of this sort ought to be in close contact with the policy-making bodies at the top. The men assigned to work in the statistical branch or unit should be selected for their adaptability, quickness and ingenuity rather than for their paper qualifications. Among them there must be a few people of technical accomplishment in theoretical statistical work. It is a very interesting thing that of the men who came through in the statistical work during the war and have gone on to distinguished statistical accomplishment since, one was a lawyer, one a biologist, one a sanitary engineer and one a regular officer. You can not tell where they are coming from. They come through in that kind of work because of innate ability to do quick, ingenious thinking. I think the statistical work of the army is to be regarded as a staff function for the Staff, rather than an integral part of Military Intelligence. I think it could be operated by the Military Intelligence Division, although in reality it seems to be a specialist staff function to be greatly expanded during an emergency and very much contracted during ordinary, normal times.