

makes a difference in results, due to control of all factors in their statistical effect.

These comments are primarily made to encourage quantitative discussions where possible, instead of the usual qualitative discussions of the past. I trust that frankness in this matter offends no one, as many of our friends, both here and abroad, agree that this situation needed clarification.

Moderator Sharp: Our next speaker is Mr. Leon T. Eliel.

Mr. Eliel is well known to practically all of us. I personally have had many contacts with him and have received a great part of my photogrammetric education from and through him.

The title of Mr. Eliel's talk today is "How to Build a Dam." I didn't know that photogrammetrists were going into the building of dams, but Mr. Eliel has ventured to investigate that subject and will present it today. I am interested, as I know you are, to learn how he built a dam.

HOW TO BUILD A DAM

Leon T. Eliel, Fairchild Aerial Surveys, Inc.

IN BUILDING a dam one is faced with a choice of equipment. It is not unlike the choice of equipment confronting the photogrammetrist who wants to build a map. Because you are all familiar with photogrammetry, I will discuss the choice of equipment for building a dam in terms of corresponding photogrammetric problems.

If you build only a very small dam and infrequently, you would be wise to minimize your capital investment through using a wheelbarrow to haul in your cement, sand and stone. Then you could mix these in a board box with a hoe, and carry the water in a bucket. It would take a long time to do the job even though it is a small one, but it would be cheaper than buying a lot of mechanized equipment and hiring experts to run it. And when you get through you will have just as good a dam as it is possible to build.

This approach is like building a map with a Stereocomparagraph or a Contour Finder. It may be smart for an occasional small job. You can put in lots of ground control—perhaps ten or twenty points per model. Anybody who can run a wheelbarrow ought to be able to run a Stereocomparagraph, and the final product can be all right. And you have practically no money tied up in equipment.

If you build a larger dam, and think you might use the equipment you are going to buy every now and then on other projects, you would be wise to buy a small truck, perhaps a half-ton pickup. Also a small concrete mixer. Of course you will make an awful lot of trips in that little truck, and the concrete mixer will have to work hours and hours. If you want to build the dam in a hurry you will have to get dozens of these little half-ton trucks and mixers. But each unit is pretty cheap, and when you finish you will have as pretty a dam as anyone would ever want.

The preceding is something like using KEK or Wernstedt-Mahan plotters. Their cost is comparable to that of the pickup truck. While the capacity per machine is pretty small, you do get the map made. The low C factor, like the carrying capacity of the pickup, requires a lot of loads or models per map. The total labor is much greater although the investment in equipment is nominal.

If you have to build a pretty big dam, you might go in for two-ton trucks and fair-sized concrete mixers. You might even get a truck and a string of

trailers. The truck alone has a far greater capacity than the wheelbarrows, and substantially more than the pickup trucks. And it is still pretty moderate in capital cost. With the trailers you can theoretically haul ten tons at a time, with just one man driving. Even including the price of the trailers, the cost is a lot less than that of the great ten-ton trucks. Of course you can't use the trailers unless the road is pretty straight and level, and most roads to dams are crooked and steep. But it is nice to know that you could use your trailers sometimes.

What I have just described is perhaps like the Multiplex. It can carry fair-sized loads with its moderate C factor, and if you have a long bar you can bridge with a lot of projectors, although conditions are seldom favorable for doing this. So you store your extra projectors with the trailers and use your Multiplex, happy at the thought of your moderate investment, content that practically anybody can quickly learn to operate it and secure in the knowledge that the ultimate map is going to be good.

If you have a pretty big dam to build, but fear you can't keep your equipment busy all the time, you may be wise to buy the truck with the very biggest capacity possible. A big truck is not necessarily an expensive one. You can save a lot of money if you buy the low-powered model, as you don't expect to be operating very much in steep country. However, you can save even more money and still have a truck which can do fairly well in steep country, by choosing the model without a transmission. Transmissions are, of course, a pretty expensive part of a truck. By gearing the rear axle so low that the truck can climb the steepest hill with the heaviest load, you do away with the need of a transmission but of course in other locations the travel speed will be much lower than if the truck had a transmission. Another way to save initial investment is to get the model without a power dumping attachment. This saves much expensive mechanism. When the truck arrives at the point to unload, a hand shovel is removed from the rack, machined and the driver soon has the ten tons of sand unloaded. It's a pretty back breaking job for the driver, but you can hire a good strong guy who won't care too much. And mind you, this truck has the same load capacity as the most expensive truck and you move the same tonnage of sand, or cement, in the same number of trips but with a greater expenditure of time. You can be very happy with this truck because you have a small investment per ton of capacity. You won't be eaten up by overhead when the equipment is idle, and the dam you build will be just as good as though you used the most expensive equipment. Of course you must not be unreasonable in what you expect this truck to haul in total tonnage per year, keeping in mind that it only cruises at 3 m.p.h. and takes four hours to unload at its destination.

You must be wondering if there is any kind of photogrammetric equipment which will help you understand this last truck, which is really a marvel of simplicity, considering the big load it can carry. There is a mighty sweet little plotter which will help you understand that truck. I am thinking of the Kelsh. It will carry, especially in country of low relief, about as heavy a C factor as the most expensive equipment, and the Kelsh cost is much less. Like unloading the truck with a shovel, though, the leaning over the drawing stand and pushing it around all day is a pretty slow and back breaking ordeal. And like the gearless truck, the gearless Kelsh permits drawing at only one scale. You will understand this truck best by realizing that like the Kelsh it costs so much less than other big capacity equipment, *but* because of the slowness of its operations it can only deliver one-third as much dirt in a year as the much more expensive universal machines. If the problem only requires delivering one-third as much dirt, then you can't go wrong with the Kelsh. It is sturdy like our truck and rarely needs

to go in the shop for repair, and like a Ford, any garage can fix it. On the simple truck, like the Kelsh, you have more man hours per ton and less depreciation and maintenance.

But for a steady job of hauling, twenty-four hours a day, year in and year out, it may pay to buy the universal truck.

The universal trucks have everything and cost terrifically. They have the giant engine. They have six speeds forward and three in reverse. They have power dumping. Mounted on their superstructure is a five-yard concrete mixer along with a compressor and automatic grouting attachment. They have the biggest body and four wheel drive. They also have a bed in the back of the cab, a clear vision windshield, a full swiper wiper, not to mention a two-tone horn. At a small additional cost you can get the helicopter attachment which automatically starts if the truck backs over the cliff, as soon as the rate of acceleration exceeds fourteen feet per second.

For the photogrammetrist to understand this truck he must think of the Stereoplanigraph. At \$50,000 delivered in the U.S.A. you can run it 5,000 hours a year for 10 years, and your machine still costs you half a man, or \$1 per hour. If you only operate it 10,000 hours in 10 years, then the amortization is \$5 an hour or two and a half men; and it takes two men to run it. So unless it is four and a half times more productive per hour, it won't pay. To understand that fancy truck you must think of the money invested in the Stereoplanigraph to permit you to draw from phototheodolite pictures, something you probably will never want to do; and more money goes into providing machinery to draw maps from obliques. This helps you to understand the automatic grouting attachment which is mighty nice to have on a truck even if you don't ever use it.

But to understand the use of all those gears on the truck, just think about Stereoplanigraph gears. You can draw at any scale direct, and you can shift on the handwheels to adjust the load and speed of drawing. The big truck like the big Stereoplanigraph plotter, carries the maximum load, at top speed and with the minimum of operator fatigue. The operator is always in a comfortable position. The big truck of course needs a much more skillful operator. He has to be sharp and quick to make the big investment pay off, and he has to know a lot more to operate and maintain all that fancy mechanism. But if you have a big enough job to do and good enough operators, the big truck really pays off. We wonder, however, how many jobs are big enough so the big truck will pay off.

I could tell you about other kinds of trucks and I could illustrate them for you by comparison with the A-5 and the Brock process.

But I'm sure you see by now that nearly all kinds of trucks are useful and contribute to the building of perfect dams. So there is no sense in comparing one truck against another. The truck must be chosen for the kind of dams you're going to build.

Moderator Sharp: Our next speaker is Mr. Louis A. Woodward.
