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A Retrospective on Earth-Resource Surveys: Arguments about Technology, Analysis, Politics, and Bureaucracy

The tasks of earth-resources survey can be done easier, cheaper, sooner, better, and in a politically more palatable and manageable manner from aircraft then they can be done from satellites.

Introduction

The American Society of Photogrammetry, meeting in Washington, D. C., held a Symposium on Photointerpretation, Photogrammetry, and Public Policy on March 14, 1975. The author was one of the participants, and spoke *ad hoc*. Subsequently, when asked for a paper, he could do no more and no less than attempt a systematic collation of his several works on the subject of earth-resource surveys from space and other-ways.

This paper consists of excerpts from a series of the author's publications extending from 1948 through 1970. All were published before he was appointed to his present position in the U.S. Government. Therefore, the usual disclaimer applies: the views expressed are not necessarily those of the author's Agency. The publications out of which the text of this collation is drawn are referenced by superscript at the end of each section so reprinted.

In the Beginning

Those of us who realize the value of aerial photography as a weapon of war know that it can be successfully applied in keeping the peace. These applications, too, await our immediate attention[1].

What of the future? Not stated previously is the long-term photographic reconnaissance goal—the recording and transmission to a home station, from an uninhabited aircraft, and under all weather conditions, the ground detail below the aircraft.

Our mapping people will have no surcease from their labors until the earth is completely, accurately, and precisely mapped and until it is possible to remap quickly any portion of the earth's surface. It may not be amiss to point out that further developments of the very same philosophy so easily and successfully employed in war can be as easily and, it is hoped, as successfully employed in the maintenance of peace, in continual and continuous inspection of large areas, as required in any system of international atomic controls, and in all the other numerous activities of peaceful peoples[2].

The Neutrality of Reconnaissance Equipments: Dispersing Semantic Fog

There is an intrinsic elegance and neutrality in reconnaissance equipments and techniques. One can't tell, by looking at them, whether they are for military or nonmilitary purposes. A simple example, of many that are available, will clarify and fix this point. Let's say an aerial photograph is taken around Minot, N. D., and that the area photographed contains one or more Minuteman ICBM sites, surrounded by hundreds of square miles of agricultural crops. What do we have? A photograph of possible interest to a military analyst or a photograph of possible interest to a crop forecaster? The answer is

not to be found in the either/or process; the answer may be *yes* to both questions. The equipments, the technology, are indifferent concerning application. The aerial film developed for detecting enemy camouflage in war is useful for detecting incipient citrus diseases, as Colwell demonstrated many years ago.

It turns out that, at least so far, military reconnaissance problems have had more attention and more money applied to their solution than has been applied to the civil equivalents. The military and civil applications have perhaps converged most in mapping, where civilian mapping agencies and military mapping agencies employ substantially similar techniques. Nevertheless, bureaucracies tend to operate independently, and to seek autonomy. The NIH* factor, coupled with administrative barriers and obstacles created by security regulations, go far to explain the frequent duplication without improvement by one agency of work done by another agency. This is popularly (and, alas, frequently) referred to as "reinvention of the wheel."

An example, still with us, of forced separation of similar applications is the history of the formation of the National Aeronautics and Space Administration (NASA), created in response to the first three Soviet Sputniks. Although the Soviet Union never found it either desirable or necessary to distinguish publicly between civilian and military space programs, we went through intense debate, not all of which is finished. I cite this tendency, along with the expected bureaucratic tendencies, as examples of difficulties that may affect the problems we are here considering.

These contributions to administrative entropy have been aided, in considerable measure, by a generous helping of semantic fog that has descended upon and enveloped most discussions of the uses of space, and that will likely follow publication of this paper. This fog is characterized by an excessive prevalence of forced and factitious dichotomies, such as peaceful versus military, scientific versus military, civil versus military.

Considering the fragility and illogic of such dichotomies and their perishability when subjected to analysis, it is amazing to find them as persistent and sturdy as they are[3].

A Current Argument about Earth-Resources Surveys

Perhaps one should not be astonished to find people and organizations who are unable to contemplate or hold more than one idea at a time. The proposal and subsequent discussion and argument to do earth-resource surveys by satellite is a case in point. (References 4 through 10 can be consulted for an account of this debate.) The writer is frequently accused of "being against satellites," being "reactionary, and old fashioned," or "opposing progress." What caused pens to be lifted and voices to be raised is the conclusion of reference 4 where the writer stated:

> The tasks of earth-resources survey can be done easier, cheaper, sooner, and better, and in a politically more palatable and manageable manner from aircraft than they can be done from satellites.

Nevertheless, the writer first proposed the application of satellites to earth-resource surveys in the chapter on observation satellites in the Rand Corporation's *Space Handbook**, written in 1958. That chapter was condensed from a longer and more detailed paper, published later[10]. The following extract from the latter work is included here, because newcomers to satellite programs (say, past 1964) hearing of the writer's current views on aircraft find it difficult to believe the writer has ever considered satellites[3].

An Early Discussion

A brief examination of possible uses of observation of the earth from satellites must rest either on an extension of functions and purposes served by high-altitude aerial photography or on the discovery of new and unique observation opportunities characteristic of the satellite system itself.

The rapid development and application of aerial photography to exploration, earth sciences, land-use planning, and crop, soil, and forest inventories is well-documented. *Photogrammetric Engineering & Remote Sensing*, technical publication of the American Society of Photogrammetry, furnishes impressive and continuing evidence of the varied applications of aerial photography to the peaceful and civil activities of modern society.

Ecology, and geology, geography, physiography, and geomorphology and hydrography are some of the fields represented in an

* NIH—Not Invented Here.

* *Space Handbook: Astronautics and Its Applications*, Staff Report of the Select Committee on Astronautics and Space Exploration, U.S. House of Representatives, U.S. Government Printing Office, Washington, 1959, Copyright Rand Corporation 1958 and published by Random House, New York, 1959.

extensive bibliography prepared by the Library of Congress[11]. (See also [12,13,14]).

Studies of natural resources and their inventories, urban-area analysis and planning, and archeology can be assisted by data secured from observation satellites. The Gutkind and DeLause references[15,16] are two unusual and beautiful books combining selected and highly instructive examples of aerial photography, and illustrate many of the points made in this brief section.

Successful application of aerial photography to the varied fields noted above depends first upon the large view afforded, which is a match to the extent of the earth phenomena and forms represented in each of the sciences, and second on the recording of detail fine enough to permit accurate identification, measurement, and comparison.

Satellites will yield a grand view, a larger perspective than we have ever attained before. Photographs from rockets at altitudes of 150 miles have already yielded spectacular views. The possibility of seeing, as a whole, relationships, formations, and terrain features which require the perspective of distance, is an exciting prospect. The world today is still poorly mapped, its resources and far reaches still not measured.

The emergence and use of such a radically new tool as observation satellites will undoubtedly result in the development of applications and techniques not yet imagined or foreseeable. What is reasonably certain is that these applications will emerge.

A fundamental question relating to satellite use in the scientific fields briefly listed is whether sufficient detail can be recorded. The answer to this is an almost unequivocal "yes!" By and large, if sufficient detail can be recorded for detailed observation and inspection operations, and for mapping, sufficient detail can be recorded for many earth-science studies[10].

How the Aircraft Argument Started in 1967

From the standpoint of science, we live on, as Wendell Willkie put it, one world. The oceans lap all shores with impartiality, paying little heed to political lines drawn on paper maps. The Sun shines on all with differences attributable only to sines, cosines, and the calendar; And the atmosphere affects all, driven by the Sun, and responding to the earth surfaces below, but supremely indifferent to political boundaries.

As long as man has been on earth, he has responded to and been affected by these vast forces, and he has both used and abused the resources of earth. Exploited or no, they have not been ignored by consumers, scientists, industry, and governmental bureaucracies. In particular, various parties have for some time now been using aircraft, aerial cameras, and other instruments to seek earth resources and to map the terrain far and wide.

So why the excitement about an earth-resources survey from space? Is it reasonable or proper to regard this idea as heralding a new subject? Or does a new tool, the earth-orbiting satellite, make possible a new order of survey? Let us look at these question.

First, but not most important, consider the advent of the multisensor business.

Second, and more important (I might as well say it straight) NASA or, more properly, a small section of NASA, has seized the bull by the horns. In an enthusiastic, imaginative, wide-ranging synthesis, necessitating the expenditure of considerable energy and drive, NASA has made a subject out of these far-flung and disparate ideas, experiments, and aspirations. Never mind that the task could have and should have been done long ago. They did it, and now is better than later.

On the assumption, made more solid by NASA officials briefing the participants in the 1967 Woods Hole summer study on earth resources, that the first "A" in National Aeronautics and Space Administration is not there solely to facilitate pronunciation of the acronym, we should consider the use of aircraft for doing the various jobs subsumed under the title of "earth-resources survey."

There is no requirement at this time for an extended comparison and discussion of the political palatability of aircraft and satellites or of the acceptability (in bi- or multilateral cooperative arrangements) of each system. It should be pointed out that the ground tracks of earth-orbital machines, especially in high-latitude orbits (i.e., near-polar), pass over every country. And if a a bilateral arrangement is made with country A, contiguous to or near to countries B and C who might object to being observed then there can, and probably will be, unpleasant nontechnical problems. No one will believe that we are seeing and collecting data only over A, no matter how solemn the declaration. The patently poor economics of so operating would only add to the strain on everyone's credulity. Conclusion: We had better keep our political feet on the ground while getting our technical seat into space.

Such a heap of problems need not arise with aircraft.

Another important factor makes aircraft preferable. For the United States to engage in

a bilateral assistance agreement with country A, that country must do something itself aside from being the (un)grateful recipient of assistance (Foreign Policy Axiom No. 2). It should participate as much as possible. Suppose we tell A that we've got a satellite that will fly over and deliver data about A. The people of A never taste, smell, hear, see, or touch the satellite, before or after launch. The "political participation benefit quotient" for the satellite comes close to zero, if it does not come in negative.

On the other hand, an aircraft system can be based in country A. (To the writer's knowledge, there is no country in the world where we cannot land a 707-type aircraft. If an exception exists, that place had better get about joining the jet set.) Nationals from A can fly in the aircraft—and it can be made the object of press releases and other publicity. For aircraft, the "political participation benefit quotient" will be measurable, positive, and large. It reflects an operation neither so distant as to be imperceptible nor so omnipresent as to be fear-inducing (negative quotient).

However, the argument will not be settled, nor even made conclusive, without some cost estimates. So I now turn to that topic with a detailed description and specification, including costs, of an aircraft system and its instrumentation to do very large area-resource surveys[4].

(The next section of reference 4 is a detailed description and specification, including costs, of an aircraft system and its instrumentation to do very large area resource surveys.)

Facing the Analysis Problem

It is one thing for a briefer to project a few Gemini photos and then expound at length on what can be seen. It is quite another to contemplate what will happen when the floodgates are opened and new data pour from the sky.

The analysis and data handling problem is usually ignored, and when not ignored is always played down and underestimated.

(The next section of ref. 4 is a lengthy discussion of the dimensions and costs of the data analysis problem.)

To sum up, analysis (getting and presenting usable, timely answers) is usually disregarded, left to chance, or underestimated. We don't need one more sad example to cast on the stockpile of history. Making a new mistake is regrettable, but making an old one over again is stupid. If mistakes are to be made, let them be new ones.[4]

How to Start

The application of a new technique such as measuring, exploring, or mapping earth resources from data secured by spaceborne sensors usually requires that the realizable benefits exceed the cost of securing them. The "usually" in the preceding statement is not deployed frivolously because some tasks need doing for the sake of extrinsic considerations, in which the task at hand is necessary to spark or catalyze other developments and thus to act as a multiplier.

Further, given a series of countries in various states of development, one might develop a weighting system (confessedly simple-minded) that would reflect both the absolute value of the operation (for instance, using the GNP of the country) and the ease with which improvements in the country's economy can be made through the use of the proposed system.

The first of these two factors merely argues the obvious: that, all other things being equal (they seldom are), a fixed percentage of a big amount is larger than the same percentage of a small amount. The second factor is simply the marginal utility. If a country is well-mapped, well-explored, well-inventoried, well-reported, etc., it is unlikely that an additional tool, such as that afforded by space-sensing gear, will make as much difference as it would in another country less-developed if, in the second country, there are ways and people on a taut leash ready to use the information, ready to go.

Despite the protestations of the various specialists, the United States, to take a country at hand, is well-developed, well-mapped, etc. Certainly this is true by comparison with what are called "less-developed countries." (There has been an escalation in nomenclature. Some countries used to be described as "backward," but this pejorative description was replaced by "underdeveloped countries," a phrase replaced in turn by "less-developed countries." This phrase enjoyed wide enough usage to be abbreviated "LDC." But now the "in" phrase is "developing countries," which has blurred all distinctions, because practically all nations are "developing."

It might be argued that the marginal utility of spacecraft sensors is lower for the United States than for a less-developed country.

Even if this conservative assumption is so (and taking India as an example of a less-developed country, one is hard-pressed to believe that in the foreseeable future India could better exploit resource surveys than could the United States), the economic mul-

tiplier of the United States is so huge that one will almost always come up with weighting factors that give the United States highest priority.

This result is not uncongenial. For a long time the equivocality of space-derived data and its interpretation will require much ground truth to check and to supplement them. Much experimentation will be needed before international commitments of any kind can be made on a sound basis. (This suggests that we hold our tongues internationally and do not force a country into the role of Tantalus by holding out benefits that we cannot deliver.) We will have to shake the system down, debug it, and probably engage in uneconomic operations for a while. The United States can better afford operations in which cost exceeds benefit than can anyone else.

All this argues for doing in the United States what we think we are going to want to do on a global basis. It is much better to have private and internal difficulties than public and international difficulties.

Consider the Limiting Case: The biggest problem area outside the United States (subject to the constraint that the U.S. has an active interest in helping the country and the country be "willing" to be helped) is India. Let us take India.

Imagine the most favorable outcome of the earth-resources satellite program. We have run the program, and it has worked. All desirable and needed data have been secured, reduced, analyzed and put in usable form. Maps, land-use patterns, hydrologic, geologic, demographic data all are available, as are any data that one can conceive of wanting or using. Suppose further that we have an Indian Data, Information, and Analysis Center (IDIAC), that the data are kept up-to-date, and that they are readily accessible and available in map, graphical, digital, or any other form.

Now what? What can we (or India) do that will be significantly different than could be done with present data? How could such a cornucopia of new data be used? Will it make a difference? Are these data genuinely important, or will their importance and impact be vitiated by national habits, customs, mores, institutional problems, religious factors and ineptitudes of various sorts?

These questions are raised not to prevent programs from getting off the ground, but to make sure that expectations are not raised unduly, and that the narrow perspective forced by technological blinders does not obstruct the full field of the problem.

These questions, of course, raise broader questions. Can we expect India to take advice? Can we design and erect cooperative bilateral training centers? What does our cumulative experience with India to date suggest? More directly, do we even understand the process of foreign aid to less-developed countries, when our understanding is based on happy but mainly irrelevant models drawn from our experiences with western, sophisticated, Marshall Plan countries?

Going to the limits, as in this example, can help clarify assumptions, moderate expectations, and illuminate otherwise dark corners, and thus help chart a smooth passage. This is not a plea for scientists to stop working on scientific problems and start working on socio-political problems any more than it is the reverse. But if there is to be mutual benefit, the efforts on these two axes had better not be at right angles or the net effect will be zero.

The point of this article and my argument is simple. The tasks of earth-resources survey can be done easier, cheaper, sooner, better, and in a politically more palatable and manageable manner from aircraft than they can be done from satellites. We should start, quietly, with a portion of the United States as the target. The problem of discovering new resources, of helping developing countries help themselves, of the dimensions of the world food problem are real, large, serious and consequential. The sooner we get to work with the better instrument system, the better for all involved. The partly teasing, partly plausible, partly demonstrable solutions offered by technology are exciting. But a good heart and generalized pieties are not enough. Much, and harder, work remains.[4].

The Debate Heats Up

The systems being proposed for the earth-resource satellite will be good enough to raise all sorts of questions of propriety and security without, I argue, being good enough to do the jobs that have been advertised. When I talk to the people who are doing this work in data reduction and attempting to automate it, I find that they are more conservative than are others who are talking about their work. For example, not long ago I asked one of the key figures in this work when he would be ready to take a contract to reduce the agriculture data from some foreign country like, say, Liberia or Tanzania. He said that he is far from ready to do it for the U.S.; and that in about 10 years, with luck, they would have it down pat for the Wabash Valley. (He's at Purdue and so is the Wabash Valley.)

The problem of prematurely and greatly raised expectations is, typically, one of our own making. But national sensitivities to being photographed is not a problem we originated.

Difficulty arises because objects of security interest are sprinkled among crops, trees, and rocks. For an earth-resources program it would be better if the crops did not surround airfields, nuclear power stations, and related man-made artifacts but, alas, that's the way nature and man have conspired. The satellite photographs that would be good for crop evaluation and other surveys would be plenty adequate to arouse other nations.

There is a widespread belief skillfully, enthusiastically, and repetitively spread by government agencies, Congress, the aerospace industry, and others at technical conferences, symposia, international meetings, and in media such as *Fortune* and *National Geographic* to the effect that we are on the threshold of a great leap forward in our understanding, and hence our ability to deal more effectively with earth resources.

The biggest leap in this proposition is in the notion itself, that our enhanced understanding directly increases our ability to "deal more effectively with." I claim that it's not the shortage of data which has inhibited our abilities to deal more effectively with the earth's resources. There is, I am assured, more data in existence than have been used. The implication that effective management of resources is a prize to be delivered by these sensing mechanisms raises false hopes.

It is not completely relevant to refer to secret satellites as Moeckel does. What about the ones we are here considering? If there were some overwhelming one-sided advantages to doing the earth-resource job by satellite, advantages so large that we'd be willing to incur the political problem, perhaps I'd reconsider. But here, as in other areas, we'd have the disadvantage without the advantages, the worst of both worlds.

Warren Kornberg, editor of *Science News*, published an article on the space program in the *Los Angeles Times* on March 30, 1969. I quote from that article:

> But even without a massive effort at earth surveys from space, U.S. companies have been accused already by their foreign competitors of being able to get the jump in overseas resources investments and development, on the basis of casual photography done from space. The suggestion is, in fact, that resources information from classified military photo-intelligence missions has been leaked to U.S. industry.

The French journal *Air et Cosmos*, No. 270, 30 November 1969, quoted Pardoe of Hawker-Siddeley Dynamics and O'Hagan of Standard Telephone and Cable of London as claiming that the United States is using satellites for economic espionage.

I do not share their beliefs. The point is that they hold them, and have expressed them. A belief doesn't have to be true to be widespread and operational. Even though NASA has refuted these charges (see *Air et Cosmos* No. 274, 28 December 1968) doubts may linger because of the difficulty of providing negative proof.

Many economic and technical problems need solution before a viable earth-resources program emerges. However, and this may come as a surprise to the doubtful reader, I think that a strong effort on cost-effectiveness is *not* to be encouraged. Cost-effectiveness analysis is certainly applicable to things we understand. We don't understand earth-resource surveys well enough at this time to let them be carved up by this powerful clinical tool. If we can start small and quietly, in what perhaps will be an uneconomic fashion, I suspect that we will find unanticipated uses of the surveys and that benefits will be obtained once removed from the actual and proximate results. This does not mean that given a choice of two ways of doing a job we should favor the less economic one. It is in this area that aircraft have it, as I've demonstrated.

It is in this context that one must consider the various ideas for international cooperation in earth-resource-satellite programs as a way of sharing costs.

Broad participation may be a desirable end in itself and, if so, we should be willing to pay for it and not expect to get this benefit and also save money. It may cost more, not less. If we want cooperation, let's pay for it[5].

Just One of the Resolved Problems: Resolution Requirements

The pursuit of truth is always difficult, often fun, and sometimes successful. Logic, I find, is not always the preferred tool to pry bureaucracies off their self-chosen roads to destiny, or wherever. Archimedes thought he could move the world given a lever and a fulcrum. That is the rub. Leverage without a fulcrum yields frustration.

There have been symposia on the subject *ad "infinauseam."* the Harlem Globetrotters get around, but the wandering road show featuring discussions of earth-resource surveys must run a close second. So it was at the AIAA Earth Resources and Information Sys-

tems Meeting at Annapolis, March 2-4, 1970. (Remember the dates: this is important.)

This meeting demonstrated anew what many have observed: Meetings occur at a higher frequency than does new work.

The issues, and the real problems, were hidden, like strawberries in a bowl of viscous yogurt, cliche-ridden, and made up of "in" words and religious references to environment, priorities, third world needs, population, resources, etc. This particular pie from the sky I entitled "Celestial Transcendentalism."

It seemed to met that the problems were

1. *Technical:* Will ERTS meet officially stated requirements? Is there a need for film recovery? Who will collect and analyze huge amounts of data? Where? How?

2. *Political:* Are we going to "do" earth-resource surveys for countries if they do not want us to? Do we understand the development process for non-Western-European countries? Are we going to make more problems than we solve?

3. *Economic:* Have we forgotten the fundamental assumption underlying cost/benefit calculations? I call this dimensional balance. Stated more formally, there should be a decent overlap and some identity between those who pay the costs and those who get the benefits. In other words, the numerator should have some members from those in the denominator.

4. *System/Strategic:* How do we get started? Earth-resource surveys cannot become, let alone remain, illustrated lectures. Why not start with a piece of the U.S.? Who is going to operate the system? An old, established agency or a new one with a new charter?

Of all these points, the one that NASA's Leonard Jaffe chose to respond to was my argument on resolution requirements (see pp. 13-14 of *Astronautics and Acronautics* April 1970).

A good part of my arguments had been based on actual user requirements as stated in documents made available by NASA. Practically all the acceptable resolution values for various tasks were under 100 ft. (A lower number means higher resolution.)

Jaffe publicly disputed these official statements, saying, as correctly quoted in the April *Astronautics and Aeronautics* (pp. 12-14), that user agencies have repudiated the old 1967 specifications. Thus, inferentially, Katz's argument went down the tubes. (I refer to the Hearings on NASA Authorization for FY 1971.) More specifically, these are the "hearings before the Committee on Aeronautical and Space Sciences, U.S. Senate, 91st Congress, 2nd Session, on S.3374, March 5, 6, and 18, 1970, Part 2." (Remember the dates of the Annapolis Symposium, March 2-4, 1970!)

Page 838 of Part 2, reproduced above,* hit me and I did a double-take. Here is the same old-fashioned, obsolete, discarded, superseded, product of (to use Jaffe's phrase) "a naive community" that I had been quoting and using since 1967, and which, before the date of the hearings, Jaffe told all of us were no longer valid.

The worst resolution tolerable in the table reproduced above, and that for only four of 30 tasks, is 50 meters! Most of the tasks call for better than 10 meter resolution!

The questions for NASA are obvious. I have a set of requirements stated by NASA, Naval Oceanographic Office, U.S. Department of Interior, and U.S. Department of Agriculture. If these are the products of "a naive community," where are their replacements?

I rest my case.

It is important to get this matter clarified but it is important, and fundamental, to get a sensible, viable earth-resources-survey program started. The recommendations I made in my earlier articles that we start with a high-altitude aircraft system (707-type aircraft, or, say, surplus U-2s) still holds. We should start in the U.S., with a section of the U.S. as the area being surveyed, set up an analysis center, study the operation, and attempt to find benefits and to analyze costs.

There is much support for these ideas, but those who whisper encouragement cannot say it publicly for bureaucratic or commercial reasons, and other understandable if unfortunate reasons.

Far from urging NASA to slow down, as stated in the photo caption in *Astronautics and Aeronautics* (April 1970, p. 13), I have been urging them to speed up, and get out of the cul-de-sac they are steering into[8].

After my article in the August *Astronautics and Aeronautics*, "ERTS Resolution: Old Numbers in Again?", had been readied for publication, I received a letter from Leonard Jaffe, NASA Deputy Associate Administrator for Space Sciences and Applications. (See reference 9 for text of Jaffe's letter.)

The main thrust of Jaffe's letter, as I see it, is the new line: the satellite cannot do it alone. In other words, if we are going to have an international program, we are going to need aircraft to go to each foreign country, as

* See reference 8 for this chart and tables.

well as satellites. The problem of coordinating these two systems is enormous, as is the cost. I return to my statement of 1967, "Those jobs worth doing for the good of mankind can be better done with aircraft." To Jaffe, aircraft are necessary; to me they are sufficient.

If we take a camera, commercially available at modest price, to 65,000 ft in, say, a U-2 type aircraft, one vertical shot covers about 1000 square miles (statute).* We can do it in color, false color or in multispectral bands and this system would yield about 25-ft. resolution on the ground. We could store coverage of the U.S. in a file cabinet.

Jaffe makes a powerful point about telemetry and data-volume problems, concluding that one should favor minimizing resolution in the synoptic scale view. This is true, and I agree, only if one is stuck with the band width problem and data storage on tape. The real point is that if one takes a 9 by 9 in. high-resolution photo and looks at it with the naked eye, he has already done his data filtering because of the visual limitation of about 8-10 lines per mm. On the other hand, buried in these photographs is high-density information, the extraction of which requires higher magnification. Were I to write a specification describing this system, without using the word "photograph," NASA would be eager to obtain this remarkable development. But it is here, and available. It is not too late for earth-resource-survey enthusiasts to avoid the ride in the tumbril[9].

About Mapping and Satellites

In my early papers on satellites I proposed mapping from satellites and discussed it at least as accurately as any of the current discussions do. Mapping is different. The fact of the matter is that mappers are a curious and separate breed; they are driven by a consuming passion to map, remap, revise, and measure, sometimes for purposes that are obscure and sometimes for purposes that are their own. They are neat people, who hate the thought that somewhere there remains an unmapped area. Worldwide mapping has little, if anything, to do with the earth-resources program.

Mapping is hi-fi geometry. For all other purposes, such as all the other purposes of the earth-resources program, geometrical fidelity is of second or lower priority. An ideal mapping satellite would look and behave differently from an earth-resources satellite[5].

* Omitted in Reference 9 is the data that the camera I refer to here has a 9 by 9 in. format with a super-wide-angle lens of 3 in. focal length. At 65,000 ft., the scale number is 260,000.

Astronauts and Farmers

Some of us (as I indicate in the last portions of my *Astronautics and Aeronautics* article) have more doubts now about our understanding of foreign aid than we used to. Furthermore, the political problems, noted in my article, are real enough. It is inappropriate by any measure for technical people skilled in earth sensing to utter gratuitous fatuities about problems they never heard of, don't understand, and that they regard only as a nuisance. Experts on the political side, when confronted with nonsense, be it errant, arrant, or aberrant, are liable, perhaps wrongly, to mistrust the technical types in other things as well.

Perverse insight suggests that when confronted with a real proposal for getting through, such as my proposal to do it with aircraft, some people prefer to take refuge in a more distant and less available prospect. Why?

Occasionally people arguing for better resolution from space-borne cameras murmur about the Department of Defense (DOD) and classification. The hobgoblin of classification is no impediment or threat to carrying out my proposal. Whatever has held up the application of remote sensing techniques, it's not the DOD's classification policies, but rather the unwillingness to face the magnitude of the analysis jobs, the production character of the job, and the fact that earth sensing, if it's to do good for mankind in the large instead of (for) individual researchers in the small, must not be the subject of high-voltage sales pitches no matter how camouflaged they are in scientific garb.

There seem to be two kinds of people interested in this earth-resources business. If I may be pardoned for a slight caricature, they are astronauts and farmers. The astronauts want to fly and the farmers want data. The farmers couldn't care less whether I give it to them from an airplane, a satellite, or the *Farmer's Almanac*. They couldn't care less whether I dug it out of a hole in the ground or from a hole in the wall. The astronauts want to fly in space, or build gadgets from space, and they are hitching on to this mission to get themselves launched.

Again, I come back to the proposition that most of the space enthusiasts want to experiment; and when I ask the question "Suppose I give you all the data you want from satellites or airplanes, which one of you is ready to take the contract to do the job for any country?" everyone falls silent. Nobody is ready to put these plausible, interesting, heuristic experiments on a production line. So, I continue to

argue that we ought to stop teasing (or conning) the world till we know what we're talking about.

We ought to proceed quietly within the U.S. with an aircraft system which can be used to find out how to do the international job, if indeed that job ever becomes ours for the doing[5].

International Politics Again

With respect to Doyle's remarks on the comparative political acceptability of aircraft versus satellite photography, I simply refer to my August *Astronautics and Aeronautics* letter. I claim he's wrong. If we have a bilateral or other arrangement with a country that wants an earth-resource survey, and it doesn't allow the aircraft to fly over its country, clearly it doesn't want the data badly enough. If it doesn't want the data, that's okay with me, and I hope with Doyle. We shouldn't, can't, and don't force-feed anyone with technological, scientific, or political progress. We want digestion, not regurgitation.

Doyle says, "The USGS has had inquiries from 30 countries all wanting satellite coverage when it becomes available."

I've tried this sentence out on a dozen people. All believed that Doyle implied that 30 governments wanted satellite coverage when it becomes available. Now let's see what really happened.

Dr. Pecora, Director of the USGS, testifying before a congessional committee, said:

> As I mentioned earlier, my counterparts in some 30 countries have expressed interest in EROS, many of these have spoken directly to me about some form of participation. . .
> . . .I think what we are facing here is, at the scientific and technical working level, a general enthusiasm for getting on with the job. How this is transferred upward to the political level is beyond my ken. All I can say is my counterparts in these other countries have been anxious to participate in receiving the data and participating in the future development of any system that may come out of the successful experiment.

Doyle's comments on the Mercury, Gemini, and Apollo photographs were answered in my August *Astronautics and Aeronautics* letter. He says:

> True enough, future satellites may produce resolutions that could be considered compromising, but as the Central Review Committee stated, "institutional arrangements can be adapted easily and rapidly to functional requirements as they evolve with the technology. Imaginative organizational and political innovation may be as crucial as technical innovation in this sphere, especially where national systems interface with international ones."

The two sentences quoted are interesting, but not consistent. I would differ about the ease and speed with which institutional arrangements can be adapted. I do agree with the second statement, that "imaginative organizational and political innovation may be as crucial as technical innovation." However, as often happens, restatement of the problem is often mistaken for a solution. Because political innovation is as crucial as technical innovation doesn't mean that political innovation is as tractable a problem as is technical innovation. We've got enough problems, many of which are not of our devising. Why should we make another problem, especially for ourselves?

Einstein was once asked, in effect, "How come there are so many geniuses in physics and so few, if any, in political science?" He answered, "I guess physicists work on easier problems."

As I think about the problem of getting started, it is becoming clear that the earth-resources-survey mission is altogether different from the Apollo lunar mission. Putting man on the moon and getting him back, a magnificent accomplishment, was an almost 100 per cent technical task. Failure or happily (as it turned out) success would be obvious, speedily observable. With earth-resource surveys most of the work is tedious, on the ground, in data-analysis centers. There is hardly any failure mode. Certain things won't get done, and they won't make prime time on TV, or page one of the papers, whether they get done or not. Research and development will continue, briefings and presentations will be dusted off and replayed. The problem as just outlined is far too urgent to permit this dreary prospect.

NASA, as an organization that delivered the goods and performed so flawlessly on the MOM (Man-on-Moon) project, should realize that, in developing space hardware and activities, it also developed managerial skills and techniques that can be and perhaps should be turned to other big projects having little to do with space. For example, because there seems to be no agency in the U.S. presently chartered to run the aircraft system I proposed, why not NASA, under a broadened charter? Or why not ESSA? Or the United States Air Force?[6]

On Technology Transfer

The transfer of technology from highly developed societies to those far less developed has been one of the more fashionable subjects of study and discussion for the past decade,

and it remains so. By now we have all learned, the hard way, what some had suspected all along, that technology that flourishes in one environment cannot be transferred to another environment without careful preparation. Sometimes technology can't be transferred at all.

This is precisely the kind of problem we are addressing at this symposium. Whereas the problems I referred to above are *international,* the problem of transferring technology from U.S. military to U.S. civilian applications is *intranational* or, if you prefer, *intramural.*

Underlying this symposium, even if not explicitly stated (or even agreed to) by its sponsor, is a concept of national defense broadened in scope and geography from whatever definition may have been acceptable a few years ago. If the objective of national defense is security, surely and certainly whatever strengthens, preserves, and defends our home base, our people, and our land can be considered to be a legitimate task of national defense.

It is not unkind and certainly not untrue to suggest that the civilian agencies, looking at the vast resources of the DOD, suspect that somewhere in that colossus lurk hardware "solutions" to their problems.

It's the technology transfer problem again. No one can make use of technology alone, just like that. One needs people, organization, training, purpose. To the civilian agencies, let me say that reconnaissance is more, yes much more, than a collection of black boxes. It is a system with organization, equipments, techniques, and people, with libraries, laboratories and procedures. All these pieces are related to and serve the larger purposes of military operations. Reconnaissance (or recce, to use a more convenient, if "in", short form) is a subject with a history (largely unwritten!) that records both successes and failures, a history sprinkled with heroes and superstars, living and dead. Recce operations continue to become increasingly mechanical, harvesting and digesting the fruits of modern technology at its very frontiers. But recce successes would be impossible without the wit, brain, and eyes of the people involved in these operations. *Gadgets are necessary but insufficient.*

Civilian agencies have much to learn about the totality of recce before they are ready to reach into its vineyard for ripe grapes[3].

On the Role of Government

No one disputes the assignment of responsibility for national defense in its traditional meaning to the federal government. The bizarre idea of letting private industry, or the several states, bid on a contract to run the U.S. Air Force, so far has appealed only to Art Buchwald and a few other kindred or cynical spirits. But the job of "defending" our environment, our land, air, and water, our cities and rivers and forests, where there has been interest and activity at all, has been either the object of jurisdictional argument, or of not-too-benign neglect by the various layers of government and industry. These very large problems cut across the government departments, and what is done by one department may adversely affect the problems, values, and interests of another department.

There is here briefly displayed an important difference in assignment between the two kinds of defense. Reconnaissance systems for the military problems and survey systems for the non-military applications are part of the corresponding intelligence systems leading to understanding, decision, and action. As such, there is no obvious or even carefully argued case for assigning the "reconnaissance systems" as non-military problems to any one civil agency.

Professor R. V. Jones of the University of Aberdeen, and Churchill's Chief of Scientific Intelligence in World War II, described the role of government in the following elegant conclusion of his summing-up address at the 1962 Aspen Conference on Man and His Environment.*

> Now the case for the government to act is when it is not to any one man's advantage to do the right thing. This is where government must be imposed. One can think of many examples, river pollution for example. The pollution produced by any one man obviously has an almost infinitesimal effect on the river, so he has no compunction about it. He probably doesn't even realize he's doing something wrong; but in entirety, the amount of pollution which is produced by a community is such as to ruin our rivers. Air pollution, the same thing. Traffic, the extinction of game—the amount of game that any one man can kill is probably quite small but in total the effect may result in the extinction of a species. In these circumstances, there is a great case for government.
>
> The other case for government, I think, is when something can be done jointly which could not be achieved by one man alone. The whole design problem in government is to create conditions in which these two aspects of control or creation can be followed up without, at the same time, restricting the liberty of the individual more than is absolutely necessary. The solution depends on circumstances. In

* Private communication; full citation unavailable.

emergencies, we found by experience, there is a lot to be said for concentrating power in the hands of one man or in the hands of a small group of men. Sir Winston Churchill once discussed this with me after World War II. He said. "You know, Socrates said that there would only be good government when kings were philosophers and philosophers were kings." And, he said, during World War II, in Britain, he was effectively a king. He had absolute power; he solved the problem of bringing in the philosophers by his friendship with one or two of us. He said, "Yours was the philosophy; and with my power and your philosophy, we won."[3]

Conclusion

This planet, this wrinkled old ball, this almost spherical space ship named earth, is our home. Successful and orderly work on domestic problems here at home, as well as export of our techniques and procedures, require concurrent stability and comparative peace on earth.

Many long-range, difficult, important problems face us now. Some are but dimly perceived while others already loom large. Problems of hunger, disease, population, education, development and conservation of resources—control of environment, and the long-standing but just discovered problems of ecology and despoilation of our air, water, and land—all these, and more not listed, demand and deserve our attention and the application of our energies and resources.

The American philosopher William James formulated the notion of and stated the need for "the moral equivalent of war", some way of focusing and organizing national resources onto huge problems other than war.*

The problems just stated certainly are that; they are as well the *financial equivalent of war,* and can take more resources than we dare think about. Let us hope that that happy era will soon arrive which will permit and encourage further attention to and massive work on the problems listed above[3].

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* See the otherwise hard-to-find James essay in which he formulates this concept, along with other ideas that are forerunners of the Civilian Conservation Corps (CCC), the Peace Corps, and the concept of Universal National Service!

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