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11 July 1969 L-13227

Director of Space Systems
Headquarters, United States Air Force
Washington, D. C. 20330

Attention: Colonel Paul E. Worthman

Dear Paul:

Returned, belatedly, and with much thanks for its loan, is a classified report you called to my attention. How so much can be written about things we know so little about is beyond me. The report also suggests, by indirection, that the largest snowpack in the country may not be high in the mountains, but may indeed occur on the shores of the Potomac.

Enclosed as well, is a letter to the editor of ASTRONAUTICS/AERONAUTICS, consisting of my comments on a letter by one W. E. Moeckel, whose letter to the editor is also enclosed. Both of these are scheduled to be printed in the August issue of that journal. I thought you might like to have a look in advance. If you recognize pieces and snipetts in my letter it's because that letter is largely composed of pieces and snipetts from other things.

Your comments will, as always, be valued.

Sincerely yours,

Amrom H. Katz
Engineering Sciences

AHK:bg

Enclosures: CL-1449 --
"A Systems Analysis of Applications of Earth Orbital Space Technology to Selected Cases in Water Management and Agriculture (U)", Volume II - Technical Discussions, PRC R-1224, March 24, 1969, SECRET, 1 copy; Others, as mentioned above

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COMMENTS ON "LET AIRCRAFT MAKE EARTH RESOURCES SURVEYS"

by W. E. Moeckel
NASA-Lewis Research Center
Cleveland, Ohio

Mr. Katz's provocative article makes several valid points, and forms a good basis for discussion of the relative rolls of aircraft and satellites in Earth surveys. This is one of the major questions that the current Earth Surveys Program is aimed at answering. One of the most significant points in the article is that the value of Earth surveys, whether by aircraft or satellite, should not be oversold at this time; we should avoid accummulating, processing, and storing vast amounts of data which nobody wants and nobody is as yet prepared to use. Although the article makes this point, it nevertheless seems to be advocating that we start right away on just such a program but using aircraft instead of satellites.

In addition to this apparent inconsistency, there are a number of arguments in the article which seem fallacious even to someone (like myself) who is not personally involved in the Earth Surveys Program. Let us consider whether it is really true, as the article claims, that Earth resources surveys can be done "easier, cheaper, sooner, and better, and in a politically more palatable and manageable manner from aircraft than can be done from satellites."

With respect to the "easier" and "sooner" there is no argument. The technology of aerial photography is very well developed, and extensive photographic surveys could, in fact, have been started many years ago, if a demand existed. Of course, limited surveys were undertaken, for various purposes, and seemed to serve those purposes adequately. New sensors and scanners could also be used easier and sooner with aircraft than with

satellite; in fact, they are presently being evaluated with aircraft.

The point of the current program on Earth Resources Satellites is to determine, despite the greater difficulty, what information can be obtained better from satellites than with aircraft, and whether that information will be worth the cost.

This leads to the question of whether aircraft surveys are "cheaper" than satellite surveys. In his cost comparison, Mr. Katz assumes that the goal of the surveys is to obtain good images (or scans) of large areas of the Earth at the lowest possible cost per square mile. Although I question the validity of this assumption (see below) let us go along with it for a moment. It would seem obvious that a satellite survey system should be designed to make full use of those advantages which distinguish satellites from airplanes, namely, their tendency to keep circling the Earth with no further propulsion power and their repeated coverage of the Earth without additional hardware cost. Yet Mr. Katz in his cost analysis assumes that the satellite survey system will consist of a large number of photographic satellites, each of which takes pictures steadily for two weeks and is then re-entered and recovered to process the film. Obviously, this is an expensive way to take pictures! Small wonder that the cost is 18 times greater, per square mile, than mass-production aircraft surveys. But if we allow the satellite to remain active for, say, five years, the cost per square mile immediately becomes only about 15 percent of the cost of the aircraft survey! Of course, this type of satellite survey requires a non-photographic imaging system with telemetered readout and recording capability. But such systems are available, and are constantly being improved.

This brings us to the question whether aircraft surveys are better than satellite surveys. Mr. Katz defines better primarily in terms of image resolution, but includes also the possibility of more complete coverage. The coverage limitation with satellites is easily disposed of if one rejects the 2-week photographic satellite system. A group of long-life polar-orbit satellites can eventually cover the entire Earth, even though in some areas it may be a long time between breaks in cloud cover. But high-flying aircraft would also have difficulties in those areas.

With regard to image resolution, the advantage is clearly with aircraft, because they can fly as low as necessary to achieve any desired ground resolution. One can, of course, point out a corresponding advantage of satellite surveys, which is not attainable with aircraft, namely, the large-scale, synoptic single-image coverage, which defines and clarifies many Earth features.

But one should not give up too easily on ground resolution from satellites either. Some non-photographic imaging systems (such as vidicons and photosensitive transistors) are approaching the 80 lines per millimeter resolution quoted for photographic film. The main difficulty with achieving high ground resolution from satellites is the need for an optical system with large focal length (several feet), together with excellent pointing accuracy and satellite motion compensation. But again, all of these features are becoming available, although not all in a single system. The current ground resolution goal for satellite surveys is in the neighborhood of 300 feet but there is no fundamental reason why this should not be reduced to 10 feet or less eventually. Such a resolution would be of the same order

as that obtainable with high-flying aircraft. A greater effort to develop a high-resolution non-photographic satellite imaging system would seem to be warranted.

Turning now to the question of political palatability, Mr. Katz points out that some nations may not like continuous overflights by our observational satellites. So far, this difficulty has not arisen, despite the wide variety of satellites and sensors already in orbit. The problem may, of course, become more serious as high-resolution satellite systems become operational. However, all nations are probably aware that observations could just as easily be done with secret satellites as with unclassified ones. In any case, the possibility of objections from abroad is no reason to forego development of a new and useful capability.

I am not sure what the author meant by the statement that aircraft survey is more manageable than the satellite survey. If this means the job of accummulating, processing, analyzing, storing, retrieving and disseminating the vast quantities of data that would result from a large-area Earth Resources Survey, the article correctly assumes that this job is of the same magnitude for aircraft and satellites. The job is certainly an awesome one, and should not be undertaken in one swoop.

This information management problem raises the question whether the implied goal of accummulating and processing vast quantities of data for all conceivable future uses is a proper one for an Earth Surveys Program. Admittedly, there will be a need, eventually, for Earth survey data banks and libraries, but the program should not be directed primarily toward mere accummulation of information, most of which might never, or only rarely, be

used. Instead, an Earth survey system would probably be more beneficial if it were aimed toward development of a versatile, user-oriented command and response capability, which would produce rather quickly, on request, and at reasonable cost, a color image or multi-spectral scan of any area of the Earth in which a prospective customer may be interested. In this way, the system avoids the need to acquire, process, analyze and store vast quantities of data in a wide variety of forms for possible future use. In addition, such a system may attract users who have so far not been identified by the various study groups. For example, news media or publishers may wish to obtain images of a particular area to enhance interest or increase the information content of news or feature programs or publications. Or a private citizen may wish to have a satellite image of his neighborhood or his vacation spot. The secret of economic payoff, whether for survey satellites or for old movies, is massive and repeated use. If, for example, 20 million users per year, throughout the world, found it worthwhile to pay an average of five dollars each for a satellite image or scan, the Earth survey program would more than pay for itself in a short period of time. With television rights, copyrights, and the many other previously identified commercial and governmental users for Earth observations, perhaps we could eventually finance a manned exploration of the planets with the proceeds from the Earth observation satellites alone.

To summarize my comments, although the subject article contains some excellent viewpoints, the arguments in favor of using aircraft for Earth Resources Surveys rather than satellites are not convincing, because none of the potential advantages of satellites over aircraft are used in the comparisons. Furthermore, the restriction of the discussion to Earth

Resources Surveys is unwarranted, because the so-called Earth Resources Satellites will have a wide variety of other uses and functions. Many of these have been identified, but there will undoubtedly be others that we do not now foresee.

COMMENTS ON W.E. MOECKEL'S COMMENTS ON "LET AIRCRAFT MAKE EARTH RESOURCE SURVEYS"

by

Amrom H. Katz

The RAND Corporation

July 1, 1969

I appreciate the opportunity to comment, however briefly and hastily, because of deadlines, on W. E. Moeckel's comments on my June 1969 piece in ASTRONAUTICS AND AERONAUTICS.

It is flattering to note that although he is uninvolved in the Earth Resources Program, and is, by both profession and geography, removed from the mainstream of tension and contention, he was moved to take pen in hand. Would that those directly concerned, and ardent advocates of the program, in both government and industry; would have responded in the past two years. Not a peep from them!

Instead of trying a jerky line by line rebuttal, I will attempt to put my arguments in strong form. Of course, where Moeckel agrees with me, I do not disagree with him.

In my paper, I gave NASA full credit for making a subject out of the disparate, fragmented disciplines, and elements of earth resource studies. It was, and remains, a bold, innovative, far reaching synthesis--and whether the data collection job is to be done by aircraft, satellites, or a mixture of both is irrelevant to giving deserved credit to NASA for the grand conception.

Having said that, it is not unfair for me to add that, as far as I know, the earliest published suggestion that collecting earth resources data from space was both feasible and desirable--and a description of advantages, tasks, and promise--was made in the RAND Corporation SPACE HANDBOOK, (1958) and greatly expanded on in my 1959 paper "Observation Satellites -- Problems, and Prospects." My record is clear and open.

However, Moeckel seriously misunderstood both me and the program when he says:

> Katz assumes that the goal of the surveys is to obtain good images (or scans) of large areas of the earth at the lowest possible cost per square mile.

What we need is data, not pictures. Sometimes, but not always, the results of the program may be superimposed on a photograph. The purpose of the earth resources program and the expectations raised around the world--will not be fulfilled if photographs alone are produced. They are not the final product. The goal is the production of information and data--data useful and usable to enhance, enlarge, and help direct man's use of this planet. Data collection, as I've stressed in my article (but apparently I've not stressed it enough!) is only first step. The history of the International Geophysical Year (IGY) -- written properly -- would be a monument to nearly pure data collection. The object of the Earth Resources Program begins with photographs; it better not end with photographs only.

It is impossible to compare costs of surveys performed by aircraft with those performed by satellite -- unless both systems deliver useful data.

Let us now, once and for all, face up to what the long life TV system can do compared to what aircraft can do. Specs for the ERTS call for three Return Beam Vidicons (RBV) operating in three separately filtered bands of the job. The 2 inch RBV has an imaging surface about one inch square, and early promises were to be 6,000 TV lines across the tube face. There is reason to believe that this specification will be lowered, and considerably. To image a 100 mile square onto this tube face implies that 100 feet on the ground equals the width of one line. Going from TV resolution to equivalent photo resolution usually takes a preliminary negotiation at any meeting where both kinds of engineers are present. But the answer, neglecting such esotericia as the Kell factor, is that 100 feet per TV line is 200 feet, in photo resolution terms. Superimposing TV pix for three different cameras (to make color pix) will not improve resolution. One can only hope that it doesn't degrade resolution too much.

What all this boils down to is that we can expect about 400-500 feet ground resolution out of the first system. Now go back and read the applicable paragraph from my June paper (p. 64, June ASTRONAUTICS/AERONAUTICS), where after discussing my aircraft proposal -- using photo, infra-red, and radar, I say:

> No direct comparison with a satellite system can be made, because no one dares design a satellite system that will deliver this volume, type, or quality of data. (To those who argue the case for a long-life TV satellite system of,

> say 300-ft ground resolution, I suggest a hard look at the resolution requirements stipulated as necessary by users of data. Comparison with the data system I propose, to be fair, should be based on proposals that deliver the goods at quality levels specified, at sufficient volume, and over the spectrum.

(Emphasis added this time around. This seems to be an elusive point - AHK)

The questions arise: (a) whether I propose producing too much data at too good quality, and/or (b) whether TV systems, at 300-500 feet resolution will be good enough.

Here I fell back on experience, and even better, on the user requirements as stated by NASA to the 1967 Summer Study, and as reproduced in summary form on p. 47 of the July 1968 issue of SPACE/AERONAUTICS. 100 foot (photo) ground resolution is the worst usable. All users want better resolution. The quality of the collection system I proposed is close to what the users specified.

NASA people are not at all surprised by this; because, as is readily demonstrable, the technical competence to make these calculations is not an asset unique to me alone. The widely advertised requirements of the users, and such experience as I am familiar with, all suggest that this particular satellite will not be able to deliver data which can be processed to deliver the various goodies in the several fields of agriculture, forestry, etc. In fairness to NASA, they never said it would. Their testimony is properly conservative. Their view, and it's entirely in order, is that this is the first of a series of satellites, that it is experimental, and that there is much to learn. I share this opinion, but I hasten to add that Congress and the media in turn have been feeding on (and generating) publicity, magic and expectation suggested by others who do not have this scientific, conservative, and cautious view point.

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, say like 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.

On a recent trip to Israel I discovered, experimentally, that aerial photography over Israel is not permitted. Casual and incomplete investigation has turned up the fact that this prohibition on aerial photography is true for France, Sweden and India as well. This list is far from exhausted; it would be interesting to have a complete list. The four I found are numbered among the free nations; I thought it pointless to list the communist countries. Difficulty arises because objects of security interest are sprinkled among crops, trees and rocks. For purposes of the earth resource 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 that nature and man have co-conspired. The kinds of satellite photographs that would be good for crops, etc., would be plenty adequate to get other nations aroused about these other matters. It has been observed that there has been little adverse reaction to the Gemini, Apollo and other space photography made public thus far. Well, either by design or inadvertence the released photographs have been taken over places like Tibet, West Africa, etc., and have shown such sparce detail as to make complaints premature. Take and release a few good shots over France, for example, and stand back. Those nations who might object to being looked at would not believe (nor would I) that we are cooperating by shutting down satellite operations over their countries. Nor would they trust a shut-off switch that we gave them to operate because they (like I) wouldn't believe it works. Again, all these problems can be avoided by use of aircraft.

So what if, as Moeckel suggests, TV satellites can stay up a long time? If they don't cut the mustard, who cares about their longevity? And by the way, the 6000 line RBV was to perform at 50% better than Moeckel's hoped for 80 lines/mm. Resolution in lines/mm on the image tube isn't the problem. It's the tiny, lonely, one inch square image tube, up at 500 miles, so far way. Even so, because of bandwidth limitations, available readout time, etc., this tiny image collector can collect more than it can send back! Sure, one can, in principle, exchange the 5 inch focal length lens on a RBV camera at 500 mile altitude for a 500 inch focal length lens. And presumably the ground

resolution could improve by a factor of 100. But the area covered (per photograph) would decrease by a factor of 10,000!

There is a widespread belief, skillfully, enthusiastically, repetitively spread by government agencies, Congress, the aerospace industry, and others at technical meetings, symposia, international meetings, and in the 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 sentence itself--that our enhanced understanding directly increases our ability to deal more effectively, etc. 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 has been used. The implications that effective management of resources is a prize to be delivered by these sensing mechanisms raises false hopes. In brief, there is one tremendous jump from elegant demonstrations of the detection of plant diseases from low-altitude aerial photography over selected areas to an ability to do this from space on a wholesale basis. This is not to say that these tasks will never be done. I am suggesting that it may not be done within the time limits of the expectations aroused in the popular press, the Congress, and international meetings.

Let us turn briefly to the political problems. I would ask Moeckel and others to consider the pairs of problems located almost everywhere.

Take the antagonisms in the Middle East, and the war still going on there. How would the UAR like Israel to have easy access to comparatively good pix of Egypt? And how about Israel?

And this is only one situation out of many. 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 30 March 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 competitive advantage problem is built into the satellite system, and exists, but at much smaller scale and in more manageable form, even with aircraft.

The French journal, Air Et Cosmos, #270, 30 November 1969, quoted K. C. Pardoe of Hawker Siddley Dynamics and Mr. O'Hagan of Standard Telephone and Cable of London as claiming that the USA is using satellites for exonomic espionage. They were participating in a seminar sponsored by the Conservative Party. Neither the speakers nor the forum

are irresponsible. It is useful to quote more extensively from this article:

> According to these two specialists "there is absolutely no doubt that the Americans are utilizing photographs taken from satellites in order to delimit the terrestrial zones which would justify prospecting for minerals and oils." To support this thesis Mr. Pardoe cites the "surprising success achieved by the American prospecting company in North Africa, in the Middle East, in zones which no one long had thought of up until then."
>
> Mr. O'Hagan goes even farther since he declares "Americans have purchased in foreign countries, lands containing minerals riches, based on information furnished by photographs from satellites for the study of terrestrial resources. Mr. Pardoe for his part affirmed that only 13 photos of the 8,000 taken during the flight of Apollo 7 have been published as of now (cf. Air et Cosmos, n° 268, p. 18) the others having been "classified" because of their too great resolution.

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 #274, 28 December 1968) doubts may linger, because of the difficutly of providing negative proof. The article containing the original charges goes on:

> One certain fact is that up until now satellites for the study of terrestrial resources fly over -- or have flown over -- a great part of the globe, but that they are not controlled in any way by the countries flown over. The only controlling authority is the one who puts them in orbit; and it's only that one which decided to communicate to the third country, information received of interest on a national scale.

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 satellites programs as a way of sharing costs.

This notion reflects what I consider to be a widespread and strongly held fallacy. 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.

That costs may increase, is of course, also true with respect to other proposals for international cooperation, such as joint U.S./Soviet space exploration. But that's another matter, and I mention it only in passing.

Other countries will want and expect benefits but may not be willing to share the full cost.

Of course there are jobs for which satellites are preferable to aircraft. In my original memo (unfortunately for this debate, not reprinted in my paper) to the 1967 Summer Study Group, (included in RAND P-3753, December 1967) I stated, in part:

> As I listened, read, and talked, it seemed to me that two huge areas were unlikely to receive adequate treatment -- the role of aircraft and the need for a BIG analysis center. Further, it seemed fairly clear that meteorology and oceanography (except for coastal areas) are not "natural" applications for photographic techniques (again, in the case of meteorology, where pictures are relevant, that subject is in good shape).
>
> Hence the concentration on land use and earth resources. The land is where the people are, and where most of the money in the business of this summer study is likely to be made.
>
> The mapping/cartographic group here is both capable and autonomous; hence nothing of what I've written is directly about their work.

This should help clarify both the record and my positions. In my early papers on satellites I <u>proposed</u> mapping from satellites and discussed it at least as accurately as any of the current discussions do. Further, in my earth resources paper I deliberately excluded mapping from the subject. I didn't do this by omission or neglect, but by positive statement. Mapping is different.

The honest-to-God 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. So much for mapping. A couple of definitions will help distinguish mapping

from observation. Mapping from space or aerial platforms will tell you about the character of the terrain. Aerial (or space) observation tells you about the characters on the terrain. Mapping is hi-fi geometry. For all other purposes, such as all the other purposes of the earth resource program, geometrical fidelity is of second or lower priority. An ideal mapping satellite would look and behave differently than would an earth resource satellite.

Now, let me say once and for all, clearly and unequivocally, that whatever anybody has proposed doing for the various earth resources tasks, I argue can be done easier, quickly, sooner, and in a more politically palatable fashion from aircraft.

Again let me be specific so as to minimize chances of misinterpretation. I proposed an equipment load for the aircraft consisting of 6 cameras, a multichannel infrared recording spectrophotometer (like the University of Michigan system) and two side-looking radars (as proposed by the University of Kansas team). This equipment can be bought, installed, and made to work from aircraft cheaper, sooner, better than it can from satellites; and it will give better results. No one has chosen to dispute this with me. How much clearer can I mkae this simple idea?

Maybe satellites will be useful in an earth-resource mission sometime. But we'ver got to find out what data is needed, how frequently it is needed, how to get it, how to analyze it, and how to exploit it.

Some of us, (as I indicate in the last portions of my paper) have more doubts now about our understanding of foreign aid than we used to. Further, the political problems, noted in my report, 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 going--such as my proposal to do it with aircraft--some people prefer to take refuge in a more distant and less available prospect. Why? I leave the job of remote make-sensing to others, more gifted than I am in the black art of telepsychoanalysis.

Occasionally people arguing for better resolution from space borne cameras murmur about the 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 individual researchers in the small, must not be the subject of high-voltage sales pitches no matter how camouflaged they are in scientific garb.

High resolution? I'll give anyone more detail than he can digest. Higher resolution? We can always fly the aircraft at 5000 feet and get better than 6 inch ground resolution! Is this what everyone wants? Hell, no! They want it <u>from space</u>. Why? Do the rocks or vegetables

care? Do the farmers, geologists care? Do the underdeveloped countries care? No! If I could find out where this slippery, elusive advocacy and its constituency resides, I'd be happy to enter into direct argument.

There seem to be two kinds of people interested in this earth resources business. If I may be pardoned for the highly dichotomous caricature, they are astronauts and farmers. The astronauts want to fly and the farmers want data. The farmers could care less whether I gave it to them from an airplane, a satellite, or the Farmer's Almanac. They could 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. The reader will recognize, I am sure, the over-drawn character of these remarks; however, in essentials, I argue they are true.

But again, I come back to the hard theorem that most of these guys want to experiment and when I ask the question "suppose I give you all the damn 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. And I continue to argue that we ought to stop teasing (or conning) the world till we know what we're talking about.

The airplane system I "designed" incorporated more and better hardware than anyone would dare put in a satellite for many years to come. Why don't we do it? Why don't we say to ourselves (as I said in the paper) that the U.S. is the only place where we can try experimental

and possibly uneconomic techniques. Let's set aside a state, California, Texas, Rhode Island--I don't care which one--and do the earth resources, geology, soils, urban area analysis, forestry, etc., etc. for that state. Let's get a measure of the job, and thus get ready to do the international job!

I still argue that 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.

I state again that international sensitivity, state of the art, the preference to fail privately rather than publicly (or at least hedge against public failure) -- all these and many more factors argue for starting the job with aircraft starting in the U.S., building up analysis centers. Then, after we have demonstrated a capability instead of a plausibility, we can go public and international, starting with bilateral arrangements. There is a fundamental difference between this satellite and weather and communications satellites. Communications and meteorology are "naturals" for satellites. The latter have little meaning unless they are international. But this is not true for the earth resource problem.

I choose not to comment on Moeckel's notions that economic payoffs for the earth resource satellite are to be found in the entrepreneurial aspects--that individuals could order particular photographs to be taken. This idea falls afoul of the political problem I raised earlier. Besides, and more to the point, this is a diversion from the central argument about how to conduct a meaningful and significant earth resources program.

But Moeckel is to be given points for his ingenious, inventive ideas.

It is good that he wrote, thus forcing me to answer. Let's keep it up!