CORONA:

America's First Reconnaissance Satellite System.

A view from the "Land Panel"

by

Richard L. Garwin

Fellow Emeritus
IBM Research Division
Thomas J. Watson Research Center
P.O. Box 218
Yorktown Heights, NY 10598

Tel: (914) 945-2555
FAX: (914) 945-4419
Email: RLG2 at watson.ibm.com

(also
Adjunct Professor of Physics,
Columbia University)

May 23, 1995

Notes for Presentation
in Panel I
"The First Satellite Reconnaissance System.
Developing CORONA-- its technical problems,
improvements and victories."

George Washington University
Washington, DC

It is an honor to be on this panel to discuss the development of CORONA and its operational improvement, as seen by a member of the "Land Panel." I don't recall when I joined the Land Panel, but I was a member by Fall 1962, having been brought to Washington for two weeks that July by Jerome B. Wiesner, Science Advisor to President John F. Kennedy, to deal with the consequences of the detonation on July 9 of the U.S. STARFISH test, a nuclear explosion of
- 1.4 megatons yield 400 km altitude above the Pacific Ocean. My colleagues who had endorsed
- this experiment were unavailable to clean up the space mess that resulted, and so I was asked
- to understand what had happened and what might be done about it. The nuclear explosion
- created a "bubble" in the magnetic field of the Earth, and as the bubble squirted to weaker fields
- at higher altitude than expected, a large number of energetic fission product decay electrons were
- trapped in the Van Allen belts. This disturbed radio astronomers by raising the background
- noise, but the question was whether it threatened the lives or health of the Soviet cosmonauts
- in orbit after the test. The lifetime of the electrons in these belts was estimated to be some
- months to years.

- We analyzed the problem, concluding that there would be no significant impact on the
- cosmonauts, and were gratified when, as I recall, the Soviets announced the reading of the film
- badges on successfully recovering the cosmonauts, alive.

- Satellites in somewhat higher orbits were not so fortunate, and the Canadian satellite Alouette
- died as a result of radiation damage caused by the trapped electrons from this nuclear explosion. After the crisis, another problem was soon brought to my attention-- the fogging of film in CORONA by energetic electrons that penetrated the aluminum shell of the spacecraft. Naturally, it was easy enough to prescribe additional shielding, at added weight that would displace film or propellant in future missions.

- A major concern of President Kennedy was that the heightened electron content would prevent
- the safe transit of the Van Allen belts by spacecraft in the Apollo program, and thus interfere
- with his stated goal of putting an American on the Moon within the decade, with safe return to
- Earth. I sketched a system of thin uranium foils that could be lofted by rockets in order to sweep
- the electrons from the Van Allen belts more rapidly than they would normally disappear.
- Fortunately this proved not to be necessary.

In part because of my exposure to CORONA, I joined the "Land panel" that advised the President's Science Advisor and the intelligence community on overhead reconnaissance, both aircraft and satellite. So this presentation is a view from a long-time member of the Land Panel.

Edwin H. Land, inventor of polarizing film and the Polaroid instant film process and camera, was President of the Polaroid Company. He had been the Chair of "Project 3-- Intelligence Capabilities" of the TCP (Technological Capabilities Panel) activity organized July 1954 by James R. Killian in direct response to President Eisenhower's challenge of March of that year to the Science Advisory Committee of the Office of Defense Mobilization to use new technologies to counter the Soviet potential of nuclear attack on the U.S. by intercontinental bomber. Projects 1 and 2 dealt with "Continental Defense" and "Striking Power."

Din Land was an extremely ingenious, productive, and forceful person-- a genius and a showman. He did not want to be a part of a panel activity with more members than could "meet in a taxi cab" and I suppose the six-member TCP Project-3 would have held all its meetings in taxis if it had not been for the highly classified nature of its activities.

In November 1954 President Eisenhower approved the TCP Project 3 proposal to build the U-2, a jet-engined sailplane-camera system for long-range strategic reconnaissance from high altitude, and assigned responsibility for its development and operation to CIA-- all to be covert and

subject to special security procedures. The U-2 system was to use a high-resolution, small-format camera that constituted a new optimization of aerial photography that would allow the capture of enormous areas on film. In this activity relevant to overhead imagery, Land and Edward M. Purcell-- physicist of Harvard University, and James G. Baker-- inventor and designer par excellence of high-performance optics, were among the Land Panel members in its later incarnations.

On its first flight over the Soviet Union on July 4, 1956, the U-2 was unexpectedly tracked by Soviet radar, but it continued to fly repeated missions until shot down by a Soviet SA-2 interceptor May 1, 1960. Richard Bissell, the CIA director of the U-2 CIA/Air Force project, in early 1955 asked Din Land and his TCP intelligence panel to advise him on systems for technical collection of intelligence, which included the U-2 and then the OXCART program which would produce the Mach-3 reconnaissance aircraft-- the A-12 and then the SR-71. In the film "A Point In Time," Bissell recounted how he later received from Land the news that he, Bissell, was to lead the development of the CORONA system.

As I understand it, President Eisenhower was always uneasy about the U-2 overflights, and a super secret Work Statement was issued April 25, 1958 by CIA to Lockheed, including ITEK and General Electric as major subcontractors, to develop and procure a system for satellite photoreconnaissance of the Soviet Union. The rocket launch of a satellite February 1959 began the first of a dozen failures, and successful return of film containing space imagery took place with recovery of imagery on the 20-pound film load August 11, 1960.

Din Land's Intelligence Panel continued its activities and constituted an important element of the nation's strategic reconnaissance program. It was involved then in the continuous improvement of CORONA, as well as the successor satellite systems which improved substantially on the CORONA performance. U.S. achievements in satellite imagery did not end with the 145th CORONA launch May 25, 1972 and film recovery 6 days later.

The Land Panel for most of its life reported to the President's Science Advisor, who was a member of an Executive Committee (ExCom) consisting of the Science Advisor, the DCI, and the Deputy Secretary of Defense.

Most of the recommendations of the Land Panel involved the National Reconnaissance Office, NRO, for which the two chief implementing elements belonged to CIA and to the Air Force. In addition, however, there were non-NRO activities dealing with research and development, and especially R&D that was not specific to a system but that would be of general use in improving the capability of any system.

Examples are improved image storage capability, photographic interpretation techniques, dissemination of imagery and other intelligence data, and the like.

During my years with the Land Panel, we met typically several times a year for two successive days either in Washington or in the field. In either location we would hear from the government sponsors as to the recent performance of systems in operation,, look at the status of the development of new systems, and hear proposals for systems still more advanced. We shared in much of the anguish that accompanied these programs in their early days, and also in some of the joy of success.

Occasionally the Land Panel would meet at a contractor facility, and sometimes in the magnificent board room at Polaroid, where Din Land's cook might provide us with dinner (although, as I recall, sometimes at 11 p.m.). Once our Land Panel meeting did not adjourn until dawn. That was unusual, but it was not unusual to work until midnight, and then to be invited

to Din Land's personal laboratory for a half hour demonstration of his latest work on color vision.

The Land Panel would meet sometimes in Room 206-208 of the Old Executive Office Building, next to the White House, where we would review programs, proposals, and look at some of the most recent images. Din Land both inspired us and kept us on track. Our job was not primarily to invent solutions, because there were usually plenty of those to exhaust the budget and the development resources. Rather, our job was as quickly and surely as possible to separate the wheat from the chaff, and to encourage (even to selectively breed) the wheat. We tried hard to increase the portion of intelligence community research and development effort in non-system specific areas, and occasionally, in addition to helping to choose among system or technology options, we did contribute a valuable technical innovation.

Often the recommendations of the President's Science Advisory Committee or of the Land Panel were less important than the free, informed, and open discussion (among those involved in this highly secret field) that led those present-- contractors and government personnel alike-- to a better understanding of the options and their implications.

I was also a participant in many Technical Review Panels for CIA or one of the other implementing organizations, in order to contribute technically to the programs or to solve specific problems as they arose. In this regard I followed the same principle I have always applied in my dealings with government-- help as much as I could to improve each option, and <u>then</u> help to make necessary choices among the options.

The Land Panel worked often at a very technical level, and some of these technical considerations had major impact. For instance, during the later 1960s (with Dr. Donald F. Hornig as President's Science Advisor) the Land Panel undertook a study of the potential performance and utility of the Manned Orbiting Laboratory (MOL) program for strategic reconnaissance, the primary (classified) goal of the program. We arrived at a very definite conclusion that humans in space had no beneficial and a lot of harmful effects on strategic reconnaissance, and this report, presented by Don Hornig to Secretary of Defense Robert F. McNamara, was instrumental in the later termination of the MOL program.

- One does not make a system like the OXCART aircraft or a costly satellite system in an
- empirical fashion-- "Let's just build one and see whether it works. We can always improve it
- later." Far from it! Actually, CORONA with an orbital life never exceeding a month did
- (fortunately) provide an opportunity for learning by doing, and for continuous improvement that
- was not available for the successor, longer-life space systems. At the "point in time" of its
- initiation, the CORONA program was exactly the right approach, and the video testifies to the
- major improvements over the 12 years of flight, with CORONA launches averaging one per
- month.

- For the satellite systems of longer life, as with CORONA, one needs to begin with a few people
- of vision, even dreams. Then it is necessary to identify and select candidate technologies for
- each one of the major subsystems and to see how far they can practically be pushed, while still
- retaining a good chance of meeting schedule, weight margin, and budget. Subsystem choices
- can't be made in the abstract, and "proof of principle" activities need to be undertaken, followed
- by "risk reduction" programs.

- Finally (it seems like finally, but it isn't), the system is ready for some kind of decision and takes
- on a life of its own as a program. Then follows the necessity to pass the Preliminary Design
- Review PDR, Critical Design Review CDR, etc. Such stages are typical of all large, complex
- programs and must be carried out with integrity and technical oversight, if the program is not
- to fail either because of excessive conservatism or excessive optimism. The conservative failure

- occurs when one "absolutely" insists on meeting schedule and budget, with all aspects of the
- program defined from the beginning. After all, the only way to be sure something works is to
- do what has already been done (and even then one can't be certain). The other pole of failure
- is to have faith that unspecified or promised advances in every field will all be available in time
- to be integrated.

In a draft of a Land Panel report (March 1, 1965) I tried to reflect the Panel's philosophy,

> "The Panel is very much disturbed that continuing low-level research is not performed at the necessary scale in this field... Conservatism is certainly a virtue in the later stages of development of an operational system, but if it is to be practised there, then there must be a venturesome exploratory development and advanced development program, and a short feedback cycle to address problems that appear during the development phase."

Parenthetically, full fare on the Eastern Air Shuttle from New York to Boston was $16 thirty years ago.

The amazing level and rate of progress in the satellite reconnaissance capabilities during the CORONA era was due in large part to the openness within this tightly secured community. When problems are reported quickly rather than concealed, they can be attacked with effort appropriate to ensuring the success of the entire program (rather than what would appear to be warranted by the value of the component or the subsystem) by a technical task force, review panel, or "Tiger Team" drawing on resources outside the specific sub-program.

- Meeting at one of the contractor facilities in conjunction with a CORONA-era satellite imagery
- program, the Land Panel was shown the diagnosis of a problem in the film transport system,
- caused by a transient in film motion as the film was brought up to speed for each image. It
- seemed to us that the onboard controller could command a speed wiggle that would largely
- compensate this effect. The contractor agreed and at a later visit the Panel was proudly shown
- the compensation system.

- Experimental physicists know how many things can go wrong between design and
- implementation, so we asked for evidence that this "improvement" really worked. When we
- returned from lunch we had the experimental results, showing that the compensation had been
- introduced with the wrong sign, so that the transient error was now twice as large as it had been!
- It was easy to correct this on the ground, and it worked in space as well.

At a particular time during the CORONA era, Edward E. David was Presidential Science Advisor and the Land Panel Executive Secretary was John J. Martin. Land Panel members were Edwin H. Land, James G. Baker, Sidney D. Drell, Richard L. Garwin, Marvin L. Goldberger, Donald P. Ling, Allen E. Puckett, Edward M. Purcell, and Joseph F. Shea. I was entrusted by Din Land to be Acting Chairman of the Land Panel, to put into final form and to gain Panel agreement on the detailed wording of a panel report and recommendation for a major program change. This was no easy task for a report that had to be distributed by courier and viewed without retaining a copy, and with the 9 members of the Panel dispersed over the United States. Another error of sign: I carefully timed my call from the East Coast to Allen Puckett, who was visiting Hawaii, so that it would reach him at 5:30 pm, but I miscalculated and woke him at 5:30 am!

- The topic and recommendation were both controversial, so much so that Prof. Sidney D. Drell
- and I, both members of the Land Panel and the President's Science Advisory Committee, were
- requested to ensure that the President's National Security Advisor was fully aware of the
- recommendation and its basis.

These strategic reconnaissance programs were among the blackest of the "black" programs, often vilified as "wasteful and inefficient", if not worse. Not so for most of them, in my experience. I was extremely pleased with the quality of the technical program leadership and their willingness to listen to advice and criticism from the (relatively) outside and to do something about it.

- All too often in normal programs, the most serious technical problems to be overcome are not
- given prominence, while routine development continues that would be wasted if the prime
- technical problem were not solved. A tradition of Technical Review Panels and Tiger Teams
- evolved in the NRO activity to bring visibility to these programs. Most of the problems were
- identified and solved by the contractors themselves, but a visit by the Land Panel or some other
- technical review panel helped to ensure that technical management had properly prepared by its
- own review of the status and problems.

- I was saddened to see key government personnel in these programs struggling not only with their
- work but to support a family at salaries that might have been 1/5 the salaries of the corporate
- vice presidents with whom they dealt, and I explored ways to alleviate this burden, but most of
- them would have been illegal, it seemed.

- In reality I had had a small brush with strategic reconnaissance many years before, when in 1950
- or thereabouts, I proposed to my colleague and mentor Enrico Fermi that one mount cameras
- on balloons that would drift across the Soviet Union at 100,000 foot altitude or higher,
- photographing both down and up. The "up" image of stars would give the location on Earth,
- and one could obtain in this way not only imagery of objects but also mapping and intelligence
- imagery.

- Fermi made discreet inquiries and then told me that I didn't need to think about this any more.
- As we know, such balloons were flown, but apparently without great success.

Din Land made his own ideas freely available to the government agencies and programs with which we were involved, as did the rest of us. But he was careful not to talk about Polaroid business.

As noted by Cargill Hall, President Eisenhower's memoirs do not mention the satellite technical reconnaissance innovations for which Eisenhower deserves such credit, beyond the publicly known U-2 program. Many of our satellites still require the protection of secrecy, but secrecy is not enough. Soviet rejection of Eisenhower's "Open skies" proposal of July 1955 was followed by the initiation of covert U-2 flights and by the satellite reconnaissance program. Despite Soviet diplomatic protests of U-2 overflights, it was the Soviet Union that initiated satellite overflight with the launch October 4, 1957 of Sputnik I, and that must have been some relief for those who feared eventual Soviet destruction of U.S. satellites.

As I testified November 9, 1991, in a celebration of the contributions of Edwin H. Land to public policy and national security,

> "I believe it would be foolish-- no, it would be tragic-- to follow the siren song urging that we put actual weapons into space, or that we must be ready to destroy photographic satellites launched by some nation not friendly to our cause. We depend heavily on our own satellites to gather vital information, and it is far easier to destroy a satellite than to build another highly capable one. Sadly, 'a (satellite) eye for a (satellite) eye' would be no consolation for us and little deterrent for an opponent; we can hardly organize the wrath of nations against a power using an antisatellite weapon (ASAT) against one of our satellites while maintaining that our own use of ASAT against other satellites would be legitimate. Our course should be that of conviction and leadership toward the early

conclusion of a universal Treaty banning satellite destruction or tests of such antisatellite systems, and a Presidential declaration would go far toward realizing that goal."

- In the early 1980s I tried hard to bring about an International Treaty to Ban Weapons in Space
- and Antisatellite Tests (and Use), and I still believe this to be an urgent task.

When President Richard Nixon dismissed his Science Advisor in 1973, and with him the President's Science Advisory Committee, much was lost-- not least the Land Panel in its longstanding role. Through the efforts of Land Panel member Sidney Drell and Donald H. Steininger, who had been for some years the Executive Secretary of the Land Panel in the Office of the President's Science Advisor, some similar independent technical panel activities continued, I believe for a while with the NRO, the DCI, and more recently with the Senate Select Committee on Intelligence.

Acknowledgments[1] In these brief unclassified remarks I have not been able to do justice to the contributions of my fellow members of the Land Panel Team-- indeed, for the most part, so collegial were our activities that it may not be meaningful to ask who originated an idea, who recast it, and who polished it so that it might be persuasive and implemented. I think we shared the view of Jerry Wiesner, which I heard from him in 1953-- that one could either accomplish something or get credit for it, but not both.

But tough choices had to be made, as with the cancellation of the MOL or the choice of system technology, and Din Land and his panel did not shrink from calling the shots as it saw them.
- The saga of the CORONA era, as distinguished from CORONA itself, remains to be told.

---

[1] For those events in which I was not personally involved (and which I have not included in the oral presentation) I have drawn on the formerly TOP SECRET "Corona" history declassified for this event, and on an essay "The Eisenhower Administration and the Cold War: Framing American Astronautics to Serve National Security" by R. Cargill Hall, in PROLOGUE, Quarterly of the National Archives of the U.S., Vol. 27, No. 1, pp. 59-72 (Spring 1995).