

“Kelly: More than my Share of it All,” Clarence L. “Kelly” Johnson, Chapter 16:

### “It’s No Secret”

What the Skunk Works does is secret. How it does it is not.

I have been trying to convince others to use our principles and practices for years. The basic concepts as well as specific rules have been provided many times. Very seldom has the formula been followed. One exception was the successful development of the Agena-D space vehicle at Lockheed Missiles and Space Company. Another was the Army’s management of its Division Air Defense Gun Program.

But I fear that the way I like to design and build airplanes one day may no longer be possible. It may be impossible even for the Skunk Works to operate according to its proven rules at some point in the future. I see the strong authority that is absolutely essential to this kind of operation slowly being eroded by committee and control from within and without.

The ability to make immediate decisions and put them into rapid effect is basic to our successful operation. Working with a limited number of especially capable and responsible people is another requirement. Reducing reports and other paperwork to a minimum, and including the entire force in the project, stage by stage, for an overall high morale are other basics. With small groups of good people you can work quickly and keep close control over every aspect of the project.

The lesson I learned early from Hall Hibbard about not driving people has served the Skunk Works well. People challenged to perform at their best will do so. With rare exceptions, long hours are not encouraged.

“If you can’t do it with brainpower, you can’t do it with manpower – overtime,” is axiomatic with me.

Our aim is to get results cheaper, sooner, and better through application of common sense to tough problems. If it works, don’t fix it.

“Keep it simple, stupid” – KISS – is our constant reminder.

“Be quick, be quiet, be on time,” is another of our mottos.

“Listen; you’ll never learn anything by talking. The measure of an intelligent person is the ability to change his mind.”

These concepts save time, money, and people.

The Skunk Works at Lockheed has moved four times since the first shop was constructed of engine boxes and a tent in 1943, and its first project, the XP-80 jet

fighter, was built with just 120 people in 143 days. There were only 23 engineers on the project. There were 37 engineers on the JetStar corporate transport. The U-2 many years later employed a total of 50 people on both experimental and production engineering. On the enormously more difficult SR-71, there were only 135 engineers.

The present Skunk Works No. 5 was christened by Althea in January 1963. By that time, the organization had turned out 17 major projects and participated in two others.

Another secret of the Skunk Works that is no secret is our human relations. The Skunk Works never has had any serious labor problems. We've had fine relations with the union. The union president would listen and be responsive when we told him our problems. His stewards would, too. At the test base in Nevada, I would meet with union stewards to hear their problems – which were real and many – and always try to do something about them.

On one occasion when Lockheed was threatened with a strike, Tom McNett, then president of IAM Lodge 727, told me, “Kelly, of course, we won't strike the Skunk Works.”

There was a strike, briefly. The Lockheed plant as a whole historically has had excellent labor relations. The company was used, in fact, as the example in a government booklet, “Causes of Industrial Peace,” published in the early '40s.

While the union had to make a token protest at the Skunk Works, pickets were stationed off to the side of our main gate. They let us operate.

I personally have had perhaps 20 or 30 union grievances filed against me over the years for performing work of some kind that a mechanic should have done. An example was welding a door fitting for the JetStar in my shop at home. But this has all been without hard feelings. I've always thought the employees actually enjoyed the fact that their top boss cared enough to work right along with them.

One of my challenges to employees is a standing twenty-five cent bet against anyone who wants to differ with me on anything. I keep a supply of quarters on hand. It's not the quarter, of course, but the distinction of winning it – to be able to beat the boss. It's another incentive. And I've lost a few quarters, too.

It is our practice to put the people in close contact with the airplane while it is being built so that they can follow it through-out its development. They feel responsible for the parts they make. If a part needs fixing, it will be fixed quickly.

On engineering changes, we go out of our way to explain them to all who will be working on them. WE maintain a very close liaison from me to the designer, to the purchasing agent – so that he understands the urgency in acquiring materials; to the tooling people; and to the people who actually will build any part of the plane.

That carries through from the first line I draw on paper to completion of the airplane and its first flight.

It long has been my practice to see that all those closely connected with a project witness the first flight. This dates from the days of our first Skunk Works airplane, the XP-80. We bussed our crew to the desert test base for the flight and had a party afterwards, with the Indian wrestling matches that became a sort of tradition.

Involving families of employees whenever possible is important, too. When we christened the present Skunk Works, we held an evening party in the new plant for all employees and their families. We told them as much as we could about our work. The next day we went back to strict security with no admittance without need.

Security regulations necessarily are impersonal and unyielding. An excellent engineer, a fine and honorable person, can marry someone who might have a relative with political views unacceptable to our government, for example, and thereby become unemployable in a secret operation. It was painful, but I have had to say goodbye to a good friend for such a reason.

Most companies, while desiring the benefits, will not pay the price in revised methods and procedures for setting up a Skunk Works-type of operation. They will not delegate the authority to one individual, as Lockheed did in my case from the very first Skunk Works. It requires management confidence and considerable courage.

Without the authority assigned to the Skunk Works by our military customers and the Lockheed corporation, we would not have been able to accomplish many of the things we have done, things about which I felt we could take a risk – and did.

The theory of the Skunk Works is to learn how to do things quickly and cheaply and to tailor the systems to the degree of risk. There is no one good way to build all airplanes.

I believe that the designer and builder of an airplane also should test it. That is important to his ability to design future aircraft. I always have thought of flight testing as a method of inspection – to see how well you have engineered and built the bird. Working with pilots in testing and development has taught me a great deal over the years. Pilots are a special breed for whom I have a deep admiration and respect. When the day comes, if ever, when we do not have responsibility and authority to test the airplanes as we design them, then from that day on our design ability diminishes. We will lose competency to develop new aircraft.

There is a tendency today, which I hate to see, toward design by committee, reviews and recommendations, conferences and consultations, by those not directly

doing the job. Nothing very stupid will result, but nothing brilliant either. And it's in the brilliant concept that a major advance is achieved.

Development of some of this country's most spectacular projects – the atom bomb, the Sidewinder missile, the nuclear-powered submarine – all were accomplished by methods other than the conventional way of doing business outside the system.

Operating at its best on our Air Force programs, the Skunk Works could get an almost immediate decision on any problem. I could telephone Wright Field, Dayton, for example, talk to my counterpart who headed the small project office there for the military – and who was allowed to stay with it to conclusion – and get a decision that same morning. Now, that's just not possible in standard operating procedure. It's a difficult concept to sell for the first time, though, since it means abandoning the system.

As well as giving us the authority we needed, Lockheed also gave us the tools. The importance of a research capability is basic to advanced engineering design. Lockheed management from its earliest days has been far-seeing in this regard. The company not only built the first privately-owned wind tunnel in the industry – back when we were working on the P-38 – but today in its Rye Canyon Research Center operates the most complete advanced research and test facilities integrated at one site of any aerospace company. (It was renamed the Kelly Johnson Research and Development Center in 1983.)

In 1954, when I was chief engineer, I was able to get Messrs. Gross, Chappellet, and Hibbard to commit \$100,000 for study of such a center. Requirements outlined at the time included test tunnels of supersonic capabilities. Today, there are hypersonic, hypervelocity, and propulsion tunnels, space chambers, laboratories in electromagnetics, cryogenic, acoustics, thermal systems. The ability to “fly” an airplane on the ground through several simulated lifetimes of service using various mockups has become a science in itself. Long before an airplane ever is assembled for flight testing, we now can perform, the shortcomings of its systems, and any elements that may be likely to fail. Without these excellent research tools, the Skunk Works would not have been able to build and fly the advanced aircraft it has produced.

Before the decision was reached to locate the new research center on several hundred acres in Rye Canyon – a relatively remote and ruggedly beautiful setting in the foothills of the San Gabriel Mountains – we investigated other potential sites.

The final selection of Rye Canyon was influenced by its convenience to the Burbank and Palmdale plants, being about equidistant to both. And the surrounding foothills would provide privacy and act as sound barriers to contain the noise from out tunnels and other test facilities. An original 200 acres purchased in 1958 has been expanded to some 500 today. This research headquarters is entirely company-funded. The laboratories perform work under contract to other divisions of

Lockheed – as well as other companies and government agencies when time is available.

At Skunk Works, a typical day for me would start about 7 a.m., except in a crisis situation when I would arrive at six o'clock to make up for the three hours' time difference with military officers in Washington. Generally, I would hold a meeting with the engineers working on the key problems. Almost always the group included my three top assistants – we're short on titles in the Skunk Work: Dick Boehme, Rus Daniell, and Ben Rich, my successor as head of ADP today. Ben is one of the few persons to win one of my quarters. The bet was over how many degrees' temperature change painting the Oxcart would mean. I guessed it would lower inflight skin temperature 25 degrees. Ben, a thermodynamicist, guaranteed 50 degrees, and he was right. It was 52 degrees.

These morning meetings were short and informal. I liked to sketch on a pad of unlined yellow paper the specific work we should do and outline the program for the day or week. The pads of lined paper that most engineers use I find inhibiting. It was nine years before I discovered that my loyal secretary, Verna Palm, was having these pads of unlined yellow paper made up especially for me. I had thought I was being frugal and using inexpensive scratch paper. Verna was my first secretary when I became chief research engineer. Hibbard, with typical generosity, let her leave his office and work for me because he knew it would help me in my new position to continue to work with the secretary we had shared. She stayed with me for 18 years, until her retirement.

When Skunk Works principles really are applied, they work. An example of their successful application was development of the Agena-D launch vehicle. The Rand Corporation has recorded it in a report available to anyone interested.

The satellite that was to become this country's workhorse in space was in trouble in terms of design and cost but especially in reliability, which stood at an incredibly low 13.6 percent. I was drafted, in effect, to go up to the Lockheed missiles and Space Company and fix it. We set up a Skunk Works operation with the company's design project engineer, Fred O'Green, as head. Air Force Col. "Hank" Cushman was the customer's counterpart.

O'Green's excellent performance later attracted the attention of Litton Industries, where he became president, and then chairman of the board. Cushman was promoted to general and put in charge of the Air Force's Armament Division at Eglin Field, Fla.

It proved again our axiom: If you have a good man and let him go, he'll really perform. In terms of today's world, that axiom should apply to women as well.

When I first reviewed the Agena project, I discovered that 1,206 people were employed in quality control alone, achieving only that 13 percent reliability factor! It should have been the world's most reliable vehicle just using the inspection department. That was enough people to design and build the thing.

At the Baird Atomic Company, which made the vehicle's horizon sensor, Lockheed had 40 people inspecting, coordinating, and reporting. Yet Baird had only 35 people building the instrument. We resolved that situation by returning responsibility for the product to the vendor. For example, I telephoned Walter Baird personally since he and I had worked together on a number of other Skunk Works projects. He immediately agreed to pick up his end of the log.

The same understanding was reached with the other vendors. It's a basic principle of delegating authority. Suppliers and others associated with a project must be extended the same kind of rules and permissions that are given us for the entire program. This cuts red tape and costs and allows all participants to concentrate on the product instead of a system. It is so simple.

Other measures taken saved the government at least \$50 million on costs. This application of Skunk Works methods completed in nine months what had been scheduled for 18. Some 350 drawings were created against a projected 3,900, and quality control personnel were slashed to 69. Tooling costs were reduced from a projected \$2,000,999 to \$150,000, and procedures were established to turn out design drawings in a single day instead of one month. These measures demonstrated results. In the first twelve launches, reliability was 96.2 percent.

Attempts to apply Skunk Works techniques, however, have not always met with success. One example was the U.S. Army's Cheyenne rigid-rotor helicopter program.

The Army became interested in the Skunk Works approach because it promised quicker deliveries, greater flexibility, and lower costs than a conventional operation.

In preparation, I took Jack Real, a very able engineer and manager who was to be in charge of the program for Lockheed, plus six of his top supervisors, into the Skunk Works for six months' study of our operation.

At Van Nuys Airport, they had at their disposal a large hangar, well-lighted drafting rooms, and anything else they might need. I imposed on Real the requirement that he try to design the helicopter so that it could be serviced with six simple tools – any six of his choice. This was more a challenge than an arbitrary decision. I think most good designers want to keep things simple, but sometimes, for the sheer engineering delight of creating, things become unnecessarily complex and cumbersome.

The rigid motor concept, pioneered by Lockheed's Irv Culver and Frank Johnson, was much simpler and safer than conventionally designed helicopter propulsion systems and had been proven successful on smaller-scale flying machines. The Cheyenne AH-56A would be its first application to a large military vehicle. The Cheyenne was designed for high performance, maneuverability, evasive operation, and was to be ideal for nap-of-the-earth flying.

Real and his team began with great enthusiasm to apply our operating methods to meet the Army's design specifications. But within six months, the satellite Skunk Works had a purchasing department larger than my entire engineering department working on seven projects. They had become buried in the usual paperwork already.

Despite the best of intentions, the Army had at the time ten different test centers and bases involved in the procurement of new weapon systems. And when you have that many representatives involved in design and development, with no single person in charge to represent the customer, the Skunk Works concept cannot work.

It is absolutely imperative that the customer have a small, highly-concentrated project office as a counterpart to the Skunk Works manager and his team. It is not a concept easily adopted after years of working within the system. There has to be an all-out commitment, or the method will not work.

The Cheyenne program was cancelled, I think unwisely, when it encountered a rotor problem. We lost a test vehicle when a rotor shed its parts. We were able to determine the cause – it was in the whirl mode – and knew how to fix it. But the Army decided to cancel the program and start from scratch.

For the money later spent in development of a helicopter with lesser capabilities, the service could have had some 450 Cheyennes. At the time the Cheyenne contract was cancelled, 145 Army personnel were involved in the program. In contrast, the total at the Skunk Works for both CIA and Air Force representatives in our U-2 and SR-71 programs did not exceed six people.

I am convinced of the military's intention to improve weapon systems development through faster and cheaper means. Taking on a major new project requires bold decisions. It is extremely difficult to predict technology problems five to ten years ahead and commit to solutions.

The Army did decide again to work by Skunk Works rules, and this time they made it work. In initial planning for development of the Division Air Defense gun and radar, I was asked for and gave a personal briefing, extended to about six companies competing as suppliers for the project. Representatives from the companies spent several days at the Skunk Works. They had been informed by the Army that they were to prepare their bids for a project of potentially several billion dollars on the basis of our "14 points."

The basic operating rules of the Skunk Works are:

1. The Skunk Works manager must be delegated practically complete control of his program in all aspects. He should report to a division president or higher.
2. Strong *but small* project offices must be provided both by the military and industry.

3. The number of people having any connection with the project must be restricted in an almost vicious manner. Use a small number of good people (10 percent to 25 percent compared to the so-called normal systems).
4. A very simple drawing and drawing release system with great flexibility for making changes must be provided.
5. There must be a minimum number of reports required, but *important* work must be recorded thoroughly.
6. There must be a monthly cost review covering not only what has been spent and committed but also projected costs to the conclusion of the program. Don't have the books ninety days late and don't surprise the customer with sudden overruns.
7. The contractor must be delegated and must assume more than *normal* responsibility to get good vendor bids for subcontract work on the project. Commercial bid procedures are very often better than military ones.
8. The inspection system as currently used by ADP, which has been approved by both the Air Force and Navy, meets the intent of existing military requirements and should be used on new projects. Push more basic inspection responsibility back to subcontractors and vendors. Don't duplicate so much inspection.
9. The contractor *must* be delegated the authority to test his final product in flight. He can and must test it in the initial stages. If he doesn't, he rapidly loses his competency to design other vehicles.
10. The specifications applying to the hardware must be agreed to in *advance* of contracting. The ADP practice of having a specification section stating clearly which important military specification items will not knowingly be complied with and reasons therefore is highly recommended.
11. Funding a program must be *timely* so that the contractor doesn't have to keep running to the bank to support government projects.
12. There must be a mutual trust between the military project organization and the contractor, with very close cooperation and liaison on a day-to-day basis. This cuts down misunderstanding and correspondence to an absolute minimum.
13. Access by outsiders to the project and its personnel must be strictly controlled by appropriate security measures.
14. Because only a few people will be used in engineering and most other areas, ways must be provided to reward good performance by *pay not based on the number of personnel supervised*.

My early definition of the Skunk Works holds true today: "The Skunk Works is a concentration of a few good people solving problems far in advance – and at a fraction of the cost – of other groups in the aircraft industry by applying the simplest, most straightforward methods possible to develop and produce new

projects. All it is really is the application of common sense to some pretty tough problems.”

My promise then to Skunk Works employees still applies now: “I owe you a challenging, worthwhile job, providing stable employment, fair pay, a chance to advance, and an opportunity to contribute to our nation’s first line of defense. I owe you good management and sound projects to work on, good equipment to work with and good work areas....”

Our employees could tell, I think, that I really believed in the Skunk Works and in them. The bottom line is integrity, and I’ve never built a plane in which I did not believe. Examples: The liquid-hydrogen design already mentioned; a nuclear-powered plane in the ‘50s; and an experimental vertical-rising aircraft, XFV-1 which we advised the Navy was so underpowered with the engines available at the time, in the ‘50s, that it was dangerous. The Navy agreed to abandon the development effort.

Three times I was offered a company presidency at Lockheed and three times declined it. To me, there was no better job within the corporation than head of Advanced Development Projects – the Skunk Works. I was doing what I’d wanted to do since I was 12 years old.

MARS DIRECT: COWARD RETURN TO THE MOON

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