Ignition – While we examined possible mechanisms for ignition of the fire: 1., electrical spark; 2., static electric spark; 3., mechanical spark; 4., impact ignition in oxygen; 5., spontaneous ignition; 6., overheated hardware; 7., pyrophoric chemicals; and 8., spontaneous combustion (delayed ignition); we could find no positive evidence of these. The Material Review Panel conducted 618 tests trying to investigate ignition and propagation phenomena. Tests included propagation rates, flash and fire point, and spark ignitions.

We knew that metal, such as titanium (sometimes aluminum) could ignite by impact in oxygen. We knew that spills of ethylene glycol can corrode electrical wires and dried spills contain conducting salts, which can short wires and which are flammable (from the stabilizers and anti-corrosion chemicals added to it), and we had a history of spills (90 oz in 6 spills), but they were all properly cleaned up. In short, we could not conclusively pin down the initiation event. Tests showed that mechanical impact ignition occurs in Velcro and Raschel Knit (used for debris bags) in standard impact testing equipment (72-ft-lb) in a 14.7 psi oxygen atmosphere. The literature shows that PVC wire insulation, when wetted with ethylene glycol and shorted, can burst into flames. We, however, used Teflon insulation, and we could not duplicate such failures with breaches in Teflon coated wires under spacecraft conditions.

Testing showed that solvents like MEK, though absorbed by Velcro, uralane foam, and couch materials would not remain in the spacecraft. Only nylon materials could generate a static electric spark. Sufficient electrostatic energy (~4 mj) could be stored in the suited astronaut to ignite MEK and methane vapors in 14.7 psi oxygen. Removal of DC electrical connector plugs could not generate a spark to ignite these gases, even at 2.5 times nominal power. No auto ignition or spark ignition of plastic materials occurred in 400°F tests, even if treated with cleaning solvents. Wire bundles were tested to see if sparking from shorting could ignite wire insulation. In a special test, the Teflon insulation on a wire was cut and intermittently sprayed with water glycol for 8 hours until it did ignite in 14.7 psi oxygen and less than 5 amps in the conductor. This test condition was considered unrealistic.

Propagation – Tests proved the burning rates in 16.7 psi oxygen typically occurred twice as fast, compared to 5 psi oxygen, and in some cases, materials sputtered or nearly exploded in this environment when set afire. No melting of aluminum tubes occurred from burning foam insulation tests. Although, water/glycol leakage was a concern, six spacecraft to date had water/glycol leakage of a total of 320 ounces, all of which were cleaned up and no wire bundle or cables failed. In 14.7 psi oxygen, dried films of water/glycol exposed to vacuum for extended periods of time will propagate a fire if ignited. The readily flammable materials: debris nets, Velcro, foams, coach materials, and nylon suits all burned in the spacecraft; whereas, Teflon coating on wires did not appear to propagate a fire. Thermal calculations indicated combustion of 3.8 ounces of either Velcro or Raschel Knit would generate sufficient heat to raise the cabin pressure from 16.7 psi to ~36 psi in less than 14 seconds, more than enough to blow the Command Module. This would use up less than 2% of the oxygen! However, in 5 psi oxygen, it would require at least 80 seconds for the cabin to fail.

Contractual Requirements – There were no specifications imposed on the Apollo contract prior to the fire with regard to material selection and flammability in oxygen. While it was known virtually all organic materials burn in oxygen, spacecraft design concentrated on avoiding ignition. There was no accounting of materials in the vehicle or control of the placement of organic material.

Summary

Although no specific cause was singled out as the "smoking gun", all indications are that the fire initiated near or below the ECU on the lower left side of the Command Module. Temperatures in this area exceeded 2,600°F.

The spacecraft fire spread rapidly by igniting nylon Velcro, Raschel Knit debris nets, insulation foams, and couch materials. When the cabin blew, flames rushed out and showed burn flow patterns from left to right. It is possible to cite 20 or 30 things that contributed to the disaster. But I will just point out the most salient that were evident to me:

1. The use of 16.7 psi oxygen on a ground test was a tremendous risk. Neither NAA nor NASA classified the test as "Hazardous". Not only did higher oxygen pressure increase combustion rates but the 2 psi delta pressure over ambient air pressure made it impossible for astronauts to remove the inner hatch, since the hatch is removed inward. Nearly 1800 pounds of force would have been required to remove the hatch.
2. NASA success with on-the-ground 16.7 psi oxygen testing on the 16 Mercury and Gemini manned vehicles brought complacency and a false sense of security.
3. I don't think anyone had calculated before the test that the burning of 3.8 ounces of plastic material would actually blow up the Command Module or that the vent was insufficient to handle a fire in 16.7 psi oxygen.
4. NASA's insistence on an inner opening hatch and rejection of an emergency explosive hatch contributed to the disaster. Also their refusal to consider a fire suppression system and to permit oxygen fire technology studies also may have contributed.
5. There was no Fire and Rescue Crew, nor was a doctor at the scene, as required by NAA in tests run in experimental aircraft when the cabin hatch is shut.
6. The aluminum soldered joints were known to be good to 190°F, above the maximum temperature allowed for the spacecraft walls. They were easily damaged by technicians grabbing on to them (causing leakage) and simply could not survive a fire of this magnitude.
7. KSC exhibited no control over materials entering the cabin. For example, they used duct tape over foam pads for providing kneeling pads. The wall-to-wall Velcro and the large debris net insured a propagation path for the fire by acting like a fuse. These were requested by astronauts who were bothered by floating tools and parts in space. The total quantity or configuration layout of plastic material was not considered in initial design in Downey.

Vehicle and Procedural Changes

Of the many changes made, the most significant were:

1. Redesigned Hatch. A new unified outward-opening hatch was designed and built which opened both hatches together within 7 seconds. It added 30 lb to the Spacecraft.
2. Launch Gaseous Environment. Procedures were changed to use a 60/40 oxygen/nitrogen mixture on the ground. As the vehicle ascended, the pressure would be reduced and the nitrogen would gradually be replaced by oxygen.
3. Highly Combustible Materials Eliminated. Nylon and other highly combustible materials were eliminated. The astronaut suits were changed to beta cloth, a fiberglass fabric coated with Teflon. Fiberglass materials were used on the seats.

   All electronics had been conformally coated with RTV 560. Complaints were that the RTV conformal coating burned in the fire, but having examined nearly 100 examples, I could only find thin whitish-gray surface flakes on the RTV. Nevertheless, Ladicote (a Viton paint plus fire retardants) and a carboxyl nitroso rubber were over-coated to protect the RTV.
4. Additional Material and Design Controls. A material selection spec with restrictions on burning rates in the oxygen atmosphere was issued. This was done by categorizing applications. For example, the couches, with a large area of organics would be rated Category A, and would have to meet some very limited burning rate requirement.

   A final walk-through inspection by NAA and NASA would pick up dangerous arrangements or proximities of materials.
5. Protection of Soldered Joints. Soldered joints on aluminum tubes were protected by bonding epoxy fiberglass clamshells over them, protecting them from the heat or aluminum lines were replaced by stainless steel lines.
6. Safety Procedures Revised. Future procedures classified this test as "Hazardous", requiring fire and rescue crews and a medical doctor's presence. Jellied water-type fire extinguishers were developed for in-spacecraft use.

   Back-up oxygen supplies were added to the spacecraft.

Epilogue

When a tragedy occurs, two kinds of investigations occur. The Apollo 204 Review Board was interested in the technical aspects of the problem-the initiation of the fire, the exacerbating circumstances, what lessons were learned, and what changes needed to be made. Congress, on the other hand is composed of lawyers who can't grasp the technical problems or the complexity of the program. Rather, they wanted to know who is at fault, so the guilty party or parties could be chastised, fired, and publically humiliated, making it appear that Congress was doing its job. It is similar to the rejection of a top coach who loses the NBA playoff game and everyone wants to fire him, regardless of his season record. So it was with this investigation. NASA was determined not to look bad and their Panels were headed by KSC and MSC Chairmen. Only the KSC and MSC Panel Chairmen were in charge of writing the final Panel reports. Many thought it was wrong that NASA was investigating itself, but I found they actually did a credible job.

There was, however, a forced bias; the word was around that, under no circumstances, could an astronaut be blamed, for they were public icons, and besides, they were killed and couldn't defend themselves. Frankly, some thought this was terribly wrong. If a driver was killed in an auto accident, he still could be determined to have been at fault. If a pilot made an error, causing an airplane to crash, should he not be held accountable? We call it "pilot error".

When Congressman William Fitts Ryan was told we didn't conclusively know the cause of the disaster, Max Faget stated that it probably started in the ECU area and that a bundle of wires was below an access door and opening the door might have caused chaffing of the electrical insulation (pure speculation)! NAA personnel inspected the bundle on the morning of the fire when they replaced air filters and there was no such chaffing of the bundle. When Ryan asked if there was another possibility, John McCarthy, a NAA Engineering Vice President, pointed out that the gas chromatograph had been removed that morning and sent back to the factory for refurbishment. The electrical connector to the gas chromatograph was "live" (had power on it). Gyro data shows that Gus Grissom left his couch. This connector was near his feet as was the ECU. Suddenly, there was a current surge recorded just before Gus got back in his couch. Shortly thereafter, fire was reported in the cabin. I tend to think this is a plausible scenario, especially since the Command Module had previously been subjected to four altitude tests at the same pure oxygen pressure level for a total of 6-1/4 hours with no problems. The only test difference was that the gas chromatograph was gone and a live connector was at its base. (If this actually did happen, Grissom had no reason to believe either a live connector existed or that it would cause any problem.) When Congressman Ryan heard McCarthy's alternate explanation, he went ballistic and condemned McCarthy for even implying Gus Grissom could be involved. Gus was a seasoned pilot who flew 100 missions in Korea, won the Distinguished Flying Cross, and flew in both the Mercury and Gemini spacecrafts. A few minutes after McCarthy's comment, Congressman Ryan publically berated NAA before the press outside the room.

The question that loomed is who would take the blame, NASA or NAA. NASA publically claimed NAA did shoddy work on the spacecraft. Several higher level management people had enough information that they could have severely embarrassed NASA in public. For example, Charlie Feltz stated that nowhere in the Apollo spec were we to design for 16.7 psi pure oxygen on the ground.

But NAA upper management had what I call a "Hamlet Moment". Hamlet said, "Whether 'tis nobler in the mind to suffer the slings and arrows of outrageous fortunes, or to take up arms against a sea of trouble, and by opposing them, end them!" We decided not to oppose them. NAA agreed to accept the blame. Many of us were disheartened. I wanted to write an article for Life Magazine telling them all the things NASA did wrong, but I didn't. I recognized there is a time to bite your lip and take the blame. I thought that if the country thinks NASA is careless or incompetent, they might cancel the Apollo Program, but if they think NAA was sloppy, NASA could either shape up NAA or put a contractor over us.

Incidentally, John McCarthy soon left NAA after the comment. Those in power tried to have Joe Shea, NASA Apollo Program Manager, examined by a group of psychiatrists. NASA removed him. Stormy was the whipping boy for NAA and was moved aside. Ironically, Bill Bergen, the Martin President, who lost the bid for the Apollo to Stormy, became our NAA Space Division President.

Finally, I think this fire saved the Apollo Program. We were being pushed too rapidly by schedule pressures in efforts to beat the Russians to the moon. Our hardware wasn't really ready, nor was that of the Lunar Module. Many glitches had to be shaken out and we spent the next 21 months making sure that the hardware was top-notch. George Low of NASA described the complexity of the lunar spacecrafts as: "two machines, 17 tons of aluminum, titanium and synthetic materials, 33 tons of propellants, 4 million parts, 40 miles of wire, 100,000 drawings, 26 subsystems, 678 switches, and 410 circuit breakers."

Fortunately for us, three months later, on April 23, 1967, Russian Cosmonaut Vladimir Komarov was launched in his Soyuz 1 spacecraft and half of his solar cells didn't deploy. He could not stabilize the craft in orbit. After 17 orbits, he reentered, but his parachutes lines became entangled and he plunged to the ground at more than 200 mph. The Russians had to go back and do their homework. In October 1968, both the Americans and Russians finally resumed manned flights ...and the race to the moon was back on!

About the Author: Larry Korb was the Supervisor of the Apollo Metals & Producibility Group in Apollo Materials and Processes.

NAA DAY AT WESTERN MUSEUM OF FLIGHT

The Western Museum of Flight will celebrate a North American Aviation Day on Saturday, October 9th in recognition of the 70th Anniversary of the first flights of the P-51 Mustang Fighter and the B-25 Mitchell Bomber. October was the month that the first P-51 was flight tested (NA73). To make the event even more memorable, the Museum's operational P-51 will be dedicated to Edgar Schmued, the Chief Designer responsible for the design of the P-51. Also on display will be an F-86F Sabre jet fighter that should bring many memories to many of the NAA visitors.

To complete this celebration, NAA Test Pilot Bob Hoover has agreed to be the Grand Marshall. Arrangements are also being completed to display other NAA aircraft including several T-6 Texan trainers, a T-28 Trojan trainer, a B-25 Mitchell bomber, a Navion and, hopefully, a Sabreliner. The museum is located on the south side of the Torrance Airport (Zamperini Field). The address is 3315 Airport Drive, Phone No. (310) 326-9544, *www.wmof.com*. There will also be many other vintage aircraft and jets on display.

To offset the costs of flying in the various aircraft, there will be an admission charge of $10.00 per Adult, $4.00 per Student and Children under 12 for Free. Assisting the museum in this noble endeavor is our NAA Retiree, Earl Theaker. Earl can be reached at (310) 326-3180 or *etheaker@sbcglobal.net.*

REMEMBERING A PRODUCTION DEVELOPMENT LABORATORY MOMENT!

In 1951, I joined NAA as a Stressman "B" on the Navaho project in Downey. In 1954, there was an issue on the factory floor and I was invited to join Quality Control as a Material Review engineer. As an incentive to make the change, I was offered a Specialist rating which entitled me to a "Grey Badge"—at the time considered quite a coup.

One of the more interesting features on the factory floor was a huge acid bath where large sheets of metal could be placed in a metal cage and lowered into the bath to clean off the surfaces and then be brought out and hosed down.

Much of the Navaho booster consisted of two long aluminum tanks, each consisting of four long quarter sections which, when welded together, formed a large cylindrical or conical tank. A huge clamping rig was devised to hold the sections together rigidly and then to weld them together longitudinally and then circumferentially to the other tank. To attain a reliable weld, the edge of each quarter section had to be quite thick but the remainder could be thin and still comply with strength requirements at a much reduced weight. Unfortunately, since the sections had already been formed into cylindrical and conical shapes there was no means available to machine out the excessive material.

A chemist came out to the shop floor from the PDL to evaluate the situation. His name was Manuel Sanz. Manny took some notes and said, "I'll be back!"

A few days later, he returned with a plastic spray which was impervious to acid. He sprayed the entire both sides of a 20-foot quarter section. He, then, taped a pattern to the outside of the section which came inches away from the edges and ran an X-Acto knife around the pattern. He then removed the pattern and peeled off the plastic that was covered by the pattern. The section was now placed in the cage and lowered into the acid vat. Using a stopwatch, he timed the immersion in the acid and then brought up the section and had it hosed down. Removing the rest of the plastic, the quarter section emerged with thick edges suitable for welding and a perfectly fashioned thin skin.

Manuel Sanz had just invented Chem-Milling.

—Ed Rusinek

The Silent Majority

by Stan Guzy

ANDERSON, ROBERT C., 62 – died in Quinta, CA on March 20, 2010. Bob retired from Downey in 2001 where he was a property administrator.

BEERER, JOSEPH G. "JOE", 96 – of Santa Barbara, passed away on May 31, 2010. After graduating from New York University in 1936, Joe went to work for the Glenn L. Martin Company in Baltimore, MD before joining the new McDonnell Aircraft Corp. in St. Louis, MO as an expert in aircraft engine cooling systems. In 1940, he was hired by NAA as the Chief Thermodynamicist with the assignment to solve the complex coolant problems with the P-51 Mustang fighter. He went on to become the president of the NAA Missile Division, responsible for the Navaho and the Hounddog missiles. Joe retired in 1962 as corporate vice president of engineering. He is survived by his loving wife of 71 years, Virginia.

BISHOP, C. R. "RON", 77 – died in Fountain Valley, CA on August 4, 2010. He joined the NAA Production Development Laboratory on the X-15 program. Ron gained recognition in the Industry for his expertise in Non-Destructive Testing. He progressed through management on the B-70, Saturn/Apollo and Space Shuttle programs. He retired from Space Division in 1990 as Director of Quality Assurance with 32 years of service. Ron is survived by his loving wife of 51 years, Irmgard. He was a good friend. Good night Ron.

BROWN, GEORGE H., 85 – passed away on May 22, 2010 in Little Company of Mary hospital in San Pedro, CA. George was an electrical engineer with NAA for 36 years until his retirement. He is survived by his wife Maxine.

CHAVEZ, RAY, 86 – Bulletin returned, later notified that he passed away in Long Beach, CA in January 2010. Ray retired from Autonetics in 1987 with 40 years of service.

CHRISKE, JOHN "JACK", 75 – passed away in Riverside, CA on March 17, 2010 from a cerebral hemorrhage. Jack attended Michigan State University on a baseball scholarship and joined the U.S. Navy. He qualified to serve aboard nuclear submarines and was involved in covert operations with the U.S. Navy SEALs off the China coast during those critical Cold War years. After the service; he completed his education at Cal Poly San Luis Obispo, earning degrees in Electrical Engineering and Advanced Mathematics. Jack joined Autonetics, working on the F-105 fighter program. He later transferred to the Space Division to join the Apollo Ground Support Equipment (GSE) management team. He subsequently moved to the Shuttle Program as Engineering Manager of GSE before retiring in 1991. He was recalled to provide his expertise on the Soviet MIR/Space Station Program. Jack is survived by his loving wife of 52 years Patricia.

COOPER, WIL – Bulletin returned stamped "DECEASED". Our records indicate Wil retired from the Space Division, Seal Beach Facility in 1983 after 21 years of service.

DANIEL, PHILLIP G., 90 – of Hawthorne, CA passed away on May 12, 2010. Phillip was an engineer and retired in 1980 from LAD with 40 years of service. He is survived by his loving wife Helen.

EVANS, EDWIN T. "TED", 91 – succumbed to cancer in Newhall, CA on June 5, 2010. Ed retired as Vice President of Manufacturing at LAD in 1970 after 33 years of service.

FOURNIER, F. "FRENCHY" – a note from Frenchy's wife indicated he had passed away on January 7, 2009. He had retired from Autonetics in 1984 after 36 years of service.

GAMBLE, LAVERN R., 82 – passed away on July 28, 2010 in Redondo Beach, CA. After serving in the Navy, he joined NAA as a Flight Simulator engineer technician for 38 years. Vern is survived by his wife Shirley.

GATTO, ANTHONY R. "BOB", 80 – of Torrance, CA passed away on July 10, 2010. Following his discharge from the U.S. Marine Corps Bob joined Rockwell International as a manufacturing engineer. He retired after 33 years of service and started a second career in the television and film industry as a stand-in double. Bob was preceded in death in 1992 by his wife, Verna.

HANSEN, ROBERT M., 91 – of Palmdale, CA passed away June 26, 2010. Bob joined NAA in 1936 as a riveter and served 43 years until he retired in 1979. In that time, he worked on the B-25, P-51, F-86, X-15, B-70, B-1, Apollo, and Space Shuttle. Bob spent 5 years in Spain, helping a Spanish company modify F-86s and F-100s for the USAF. During this period, he advanced to General Foreman of the Machine Shop at LAD and Director of Final Assembly in Palmdale. He was preceded in death by his loving wife Audrey.

HEARN, BOB LEE, 75 – Bob was born in Tulsa, OK and migrated with his family to California during the dustbowl years. He passed away on July 20, 2010. After serving in the U.S. Army in the Korean War, he joined NAA/RI and served for nearly 40 years before retiring. After retiring, he became interested in California Impressionist art and was active in community charity work. Bob is survived by his wife of 49 years, Lynn.

HENDERSON, JOHN L., 90 – of Ventura, CA passed away on May 31, 2010. John served with the Army Air Force Technical Training Command before joining NAA in 1946. He became leadman-crew chief in Production on the FJ-1 Fury and F-86A Sabre. Transferring to Field Service, he became a Tech Rep supporting newly equipped F-86A squadrons assigned to the 4th Fighter Group at Langley, VA. This tour lasted 30 months, including 13 months in Korea. He was the first F-86 tech rep to participate in the support of the first air-to-air engagements between the Soviet built MiG-15 and the F-86 in December 1950. John provided this bio with the article he submitted to the NAAR Bulletin in 2001. He is survived by his loving wife of 66 years, Barbara. Good night John.

HEYWOOD, WILLIAM – Bulletin returned stamped "DECEASED". Nothing further available, his mailing address was Hemet, CA.

HODGETTS, KELLEY, 60 – passed away on July 8, 2010 in Burbank, CA. Kelley worked on the GPS systems in the laboratories at Seal Beach. He is survived by his wife Darlene.

HULICK, RALPH – Bulletin returned marked "DECEASED". No further information available.

HUSTER, HOWARD H., 93 – passed away in Chicago Ridge, IL on March 23, 2010. Howard retired from the Sabreliner Program in 1981 with 41 years of service.

KNOWLDEN, FLOYD H., 83 – passed away from undisclosed causes on April 11, 2010. He served in the U.S. Army

Air Forces during WWII. Floyd obtained his engineering education at UCLA and worked at NAA/RI for 30 years on a variety of Space Programs, including Saturn, Apollo and Shuttle Orbiter. He retired at the age of 82. He leaves behind his loving wife of 35 years, Joanne.

KRAGH, JAMES "JIM", 81 – of Torrance, CA passed away on April 17, 2010. Jim was a hydraulics engineer on the F-86, B-1, and B-70 before retiring from LAD in 1990 with 39 years of service. He is survived by his loving wife Evalyn.

KULUSCH, LOUIS "LOU", 84 – died at his home in Newport Beach, CA on July 26, 2010. He retired from Rocketdyne in 1988 with 22 years of service. He is survived by his wife Joyce.

MEADE, JEROME J. "JERRY", 74 – of Westminster, CA passed away on June 18, 2010 in Duluth, MN. Jerry started his life in California as a roughneck in the oil fields. He obtained a degree and joined RI as a safety engineer and advanced to supervision in human resources. After retirement, he had a very active role in Westminster civic affairs.

MEYER, LESLIE C. "LES", 78 – passed away at home in Pismo Beach, CA on February 2, 2010. Les joined NAA in 1958 as a structural engineer and computer specialist, conducting structural tests on several classified projects. He retired from Space Division in 1988 with 29 years of service. He is survived by his loving wife of 52 years, Dorothy.

MICHEL, VICTOR J., 83 – of Saint Peters, MO passed away peacefully at home of respiratory failure on June 2, 2010. Vic retired from Defense Electronics Operations at Autonetics as Manager of the Technical Information Center in 1984 with 30 years of service. He is survived by his loving wife of 59 years, Margaret.

NUNNALLY, JACKSON L., COL. USAF, 85 – a patriot to the end, Jackson passed away on July 4, 2010 in Huntsville, AL. Jackson flew P-40s and P-51s during WWII as a fighter pilot. He received his aero engineering degree from the University of Florida and then became a fighter pilot in the Korean War, flying F-80s. Between wars, he flew acrobatics as a member of the Florida Rockets. Jackson joined NAA in 1956 as a test pilot. He was the F-100 chase pilot for the Hounddog WS-131B Program, later ferried NAA personnel aboard a C-54. Retiring from the USAF in 1976 with the rank of Colonel, he retired from Rockwell International in 1987 with 13 years of service. Jackson is survived by his loving wife Eva Mae.

PATTON, W. GLENN, 87 – died on May 1, 2010 in Santa Ana, CA. Glenn retired from B-1 Division in 1986 with 26 years of service. He is survived by his wife Eva.

PEARCE, CHARLES W., 94 – of Terre Haute, IN passed away on June 10, 2010. After graduating from Curtiss Wright Technical Institute in 1942, Charles joined Bell Aircraft where he worked on the first American jet fighter, the P-59. He joined NAA in 1944 and was assigned to the design of the P-82, which consisted of two P-51s connected by an airfoil. Subsequently, he was assigned to the F-86 designs, Models A through H. Charles volunteered to move to the new Columbus facility in 1952. With contract cancellations, his career spanned service with Lockheed in Marietta, GA, Fairchild Hiller in Hagerstown, MD, and LTV at NASA Langley Research Center. He retired from the Columbus Division in 1974 with 24 years of service. He is survived by his wife Ruby.

PRICE, WILLIAM E. "BILL", 78 – passed away in Kurten, TX on June 24, 2010. Bill joined NAA in 1964 as a member of the NAA Test Team at NASA-Houston on the Apollo Thermal Vacuum Program testing of S/C-008 and 2TV-1. Later, he moved to the Shuttle Avionics Integration Laboratory (SAIL) as a test conductor. He then transferred to the Rockwell KSC Test Team, working on the Orbiter test and checkout teams preparatory for launch. He retired from Rockwell with 28 years of service. He is survived by his loving wife Alandra.

PURPURA, FRANK A., 90 – of Placentia, CA passed away on August 11, 2010 after a long battle with cancer. After serving in the Navy during WWII, Frank joined Autonetics where he served as a project administrator in Logistics. He retired in 1990 with 37 years of service. Frank is survived by his wife, Gerry.

SANBORN, MORGAN W. "SANDY", COL. USAF, 78 – passed away in San Antonio, TX on June 21, 2010 after a protracted struggle with Parkinson's disease. Entering the Air Force in 1954, his career spanned many stations and assignments including flying F-89s over Panama City, FL, flying F-102s over Newfoundland, industry liaison at Vandenberg AFB, base commander of a radar installation on Eleuthera Island in the Bahamas, being a forward air controller over Vietnam flying the OV-10 Bronco, and lastly, "flying a desk" in the Pentagon. After retiring in 1979, he joined Rockwell International as project engineer on the Space Shuttle. Sandy retired from Rockwell in 1990 with 11 years of service.

SCARFONE, LAWRENCE L., – passed away on June 7, 2010 from undisclosed causes. He proudly served as a paratrooper in the U.S. Army Airborne Divisions during WWII in Europe. He retired from NAA/RI after many years of service. He is survived by his wife, Doris.

SHORT, DORIS J. – of South Gate, CA. Notified by the executor of her estate that she passed away in September 2009. Doris retired from Space Division with 38 years of service.

WELCH, JOHN L., 89 – of Anaheim, CA passed away on June 17, 2010. John served in the Pacific during WWII where he received the Bronze Star. Graduating from the University of Missouri, he joined Autonetics in Procurement and Quality Assurance and served for 25 years before retiring.

ZUG, DONALD L. 78 – of Fullerton, CA passed away on June 3, 2010. Don joined Autonetics as a fireman and retired as a fire chief in 1994 with 34 years of service. He is survived by his wife Carole.

LOST SHEEP – BULLETIN RETURNED WITH NO FORWARDING ADDRESS

ROBERT A. BROWN – SEYMOUR, TN

KENNETH L. PIERCE – YUMA, AZ

W. E. THIBODEAU – BOZEMAN, MT