UNITED STATES AIR FORCE

FLYING Safety

MAGAZINE

August 2002

AIR FORCE RECURRING PUBLICATION 91-1 August 2002, VOL 58, NO 8

This Issue:

4

16

22

Cover: HQ AFSC Photo by CMSgt Jeff Moening
Photo Illustration by Dan Harman

UNITED STATES AIR FORCE
FLYING Safety
MAGAZINE

Air Force Safety Center web page:
http://safety.kirtland.af.mil/
***Flying Safety* Magazine on line:**
http://safety.kirtland.af.mil/magazine/htdocs/fsmfirst.htm

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Commercial: (505) 846-0931

DEPARTMENT OF THE AIR FORCE — THE CHIEF OF SAFETY, USAF

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DISTRIBUTION — One copy for each three aircrew members and one copy for each six maintainers and aircrew support personnel.

POSTAL INFORMATION — ***Flying Safety*** (ISSN 00279-9308) is published monthly except combined Jan/Feb issue by HQ AFSC/SEMM, 9700 G Avenue, SE, Kirtland AFB NM 87117-5670. Periodicals postage paid at Albuquerque NM and additional mailing offices. **POSTMASTER:** Send address changes to ***Flying Safety***, 9700 G Avenue, SE, Kirtland AFB NM 87117-5670.

CONTRIBUTIONS — Contributions are welcome as are comments and criticism. The editor reserves the right to make any editorial changes in manuscripts which he believes will improve the material without altering the intended meaning.

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MORE FROM THE MAINTENANCE SIDE

Courtesy ASRS *Callback* #249, Mar 00
NASA's Aviation Safety Reporting System

ASRS continues to receive valuable safety suggestions from the maintenance community. We'd like to share a recent submission that highlights the importance of both visual and procedural "markers" for the completion of maintenance tasks.

I was assigned to perform the #9 "A" Check on the engine of an A-320. I followed the job card procedures, which require the deactivation of the hydraulic thrust reverser control unit by installing a safety pin in the control unit. While I continued with the engine service, I found a couple of discrepancies that would need to be addressed. As time passed, it was near to push-out and run the engines for leak checks. It was at this point I became rushed and missed reactivating the thrust reverser hydraulic control unit.

I did not realize my mistake until I was on my way home and the aircraft was already airborne. At once I called the station maintenance controller and explained the problem. I learned the next day that the aircraft landed safely at its destination, but that the #1 engine thrust reverser did not deploy, resulting in diminished stopping capability.

Aside from obviously paying more attention to my work, it would have been helpful if a "Remove-Before-Flight" streamer was installed on the deactivation pin of the control unit. I would likely have seen the streamer prior to closing the fan cowls.

ASRS learned in a callback to this reporter that he had followed maintenance instructions on a job card for the thrust reverser lockout procedure. The job card directed the technician to install the lockout pin on the reverser, but did not direct removal of the pin—instead, it instructed the technician to "restore aircraft to normal." Nor did it require an operational check of the thrust reverser. The absence of explicit instructions for completing the job deprived the technician of a memory jogger that apparently was much needed in the time-pressure situation involved. 🛠

Aircraft Maintenance Chiefs' Advisory Board (AMCAB)

HQ AFSC Photo by CMSgt Jeff Moening

CMSGT JEFF MOENING
HQ AFSC/SEMM

I had the pleasure of attending the March 2002 meeting of the Aircraft Maintenance Chief's Advisory Board, otherwise known as AMCAB. The AMCAB is a functional advisory board chartered by the HQ USAF Director of Maintenance, and reviews aircraft maintenance, armament and munitions maintenance issues from an Air Force-level perspective. It provides independent assessments and recommendations to/for the Director of Maintenance. The members represent the entire aircraft, armament and munitions maintenance community, regardless of the AMCAB members' assigned command. This interview was of the entire group, and you will not see references to any specific Chief. The views expressed are their personal opinions and viewpoints on the questions asked, and reflect *their* knowledge of what is happening in the aircraft, armament and munitions maintenance career fields.

FS: *Throughout the Air Force, many people complain about low manning levels and low skill levels. Where is the Air Force right now in regard to manning and skill levels, and what does the future hold?*

AMCAB: "We do have a lot of 3-levels, but that is the only way to fill the 5-level holes we have at the senior airman and staff sergeant levels. We have to grow the skill levels and this creates a large training burden for all the wings. It's tough out there, but we have to start fixing it now, so we can grow our way out of the manning problems."

"Currently we are at about 76-77 percent 5-level manning. That's where our big shortfall is, too many 3-levels, not enough 5-levels. For the most part, with few exceptions, we are over-manned in 7- levels, but it isn't enough to make up for the 5-level shortfall. In my mind, the Air Force (AF) has done a lot for retention in the form of pay raises, selective reenlistment bonuses and that sort of thing. If you look at the last few years and what has been done for retention, it's a good time to be in the AF. Along with that, we are undertaking a few functional initiatives to try and help things out as well. Once this current bow wave of 3-levels evens out, it is up to us to continue and try to retain them. I think the fact that we are focused on retention, and making things happen, eventually we will pay ourselves large dividends."

How are we doing on career field retention, and what are we doing to improve retention of skilled workers?

"One key program is the Keep Enlisted Experience Program (KEEP) initiative. One aspect of KEEP is the Airmen Retention chapter recently published in AFI 21-101. I think we all agree that the details of the mandatory commanders retention call should be in a Personnel AFI, but it's great that the program is somewhere and is mandatory. One of the basic complaints you hear from the airmen is communication, that communication doesn't flow. Here is the opportunity for the commander, and Chiefs, to stand up and tell the airmen, 'Here is what's going on in the Air Force,' and what the AMCAB and others are doing for them. Advertising opportunities and providing a chance for airmen to voice their concerns to leadership."

"I'm not sure our retention shortfall is strictly related to pay. I just performed a KEEP brief in USAFE, and of the over one hundred airmen there, only one stated he wasn't satisfied with his pay. Pay is not the issue in keeping people in right now."

If pay isn't the issue in keeping airmen in, what is the main issue?

"If it were possible to put a finger on it, I would say ops tempo. I think it comes down to stability in order to figure out and let the young folks know what they have to be doing next, and what's coming down the road. If they can see it coming, they are a lot more apt to stick around. Giving our airmen the tools and support they need, day in and day out, is another issue. Some of the legacy airframes are not being supported as well as they should be. The funds are not available, and when you have to decide on whether to put the majority of your funds on the future or on the past, the decisions are tough. Look how old the B-52 and some of the F-15s are. We have some old aircraft that we have to keep flying."

"One thing we have to understand about retention in our career fields, and probably most others, is what I read in a trade magazine article. Not only are we having this problem, but also the airlines, the aircraft manufacturers and the depots. This industry is not as attractive as it used to be, and what I found from the airlines is that a lot of the people are leaving to pursue careers in information technology. Hence, you are seeing phenomenal pay raises being negotiated by the mechanics' unions. Mainly because the industries are trying to be competitive with other industries."

The maintenance career field has had a great run on promotions in the last few years. Has this helped or hurt our experience levels?

"That depends on your definition of experience. The way I read your question is that we didn't get experience; we got people with more stripes and more money in their pocket. Experience is grown over time. We can force them into certain positions where they have to accelerate that experience level, because they can't sit dormant or stagnant in another rank as they sometimes do, but the experience level hasn't been raised."

"The number one complaint I have is 'I don't have experienced people to work the airplanes.' Especially if you look at how many years certain crew chiefs have on certain weapons systems, especially overseas. The promotions probably did more for retention than for experience, but in the long term the higher pay will make them more likely to stay and take a little more pain. We can't just increase the promotion rate and say 'I fixed the experience problem, because I now have extra tech sergeants.' They need more time on the aircraft or piece of equipment. It's not an overnight fix. The key is to dedicate a little more time to the training program."

"That all falls back to ops tempo. You can have all the people in the world you want, if the ops tempo is up and you can't get them trained right, then what? We are now rolling qualified 3-levels into AEF, and the AEF is an ideal time to train them. What is the 3-level doing on their off time at the deployed location?

continued on next page

They aren't going downtown partying or anything else. That person has more opportunities to train. There are training centers in the theaters where airmen can take their CDC tests and everything else. What an ideal time to train and gain operational experience."

"Everyone knows that we work closer together when deployed, so a person can learn more about their weapon systems. I still think we don't have enough dedicated time at home station for certain training situations. Heck, we don't even have enough time to dedicate to our infrastructure for aircraft delayed discrepancies."

"Just look at our airmen's time in service. Recently, in AMC, I looked at our current age groups and compared them to 1996. I found that AMC has 400 fewer faces than 1996. Out of what is remaining we have 300 more 21-year-olds and 200 less 34-year-olds. That should tell you something about experience. We have a lot more young airmen and a lot less older experienced ones. If you look at the rank structure, we probably are fairly close to the same numbers we had back in 1996. We are promoting the people, but like mentioned earlier, you can't promote experience. You have to grow it."

"Conceptually, with the promotion rate as high as it is, we have raised expectations: 'You are now an NCO, because we promoted you.' But is the person actually experienced and ready for the increased responsibility? As long as we keep explaining to everybody how important it is, and how critical it is to be part of the NCO corps, I see them stepping up to the plate and performing very well."

For Senior NCOs, there is talk about putting more MSgts back on the flightline. Some like this; some don't. What are the benefits and will it hurt their chances for promotion?

"If we do it corporately, across the board, it won't hurt anyone's chance of promotion. If we do it selectively, we take that chance. The whole concept is to put experience back on the flightline. There is a tendency in maintenance that you get to a certain rank, then you get a radio, or a desk, or a truck, or a bench or whatever. We need the MSgts to be doing the training, because they are among the most knowledgeable, and in current times, it's the right thing to do."

Is this being applied corporately?

"I don't think it is yet, but it's getting there. This issue was submitted at the first AMCAB and it was brought on 10 years ago as our 7- and 3-level numbers were reversed. The initiative was intended to reduce the tempo placed on 5-levels by putting MSgts in positions to get them promoted. A sole staff-type job. To take the tempo off the 5-levels, we need to put the experience back on the line but also recognize the MSgts as technical experts. The career field Chiefs that sit on promotion boards should recognize this."

"If you want to say that, then we should recognize the MSgt who is being one-third manager, one-third craftsman and one-third supervisor. That MSgt is doing what their responsibility dictates and is ready to assume SMSgt responsibilities. We need to control that aspect. 'I'm not going to get promoted' seems to be the negative feedback we get. We are not asking them to be craftsman 100 percent of the time, just look at their duties. Does this job need to be a full-time additional duty or can a person go back and do that one-third craftsman role? Go out on the flightline and take the corporate experience with you. Not only retain the experience, but also help train the future MSgts. Help them obtain the knowledge and experience they need to work those aircraft. We need to recognize them for the job they are doing as well."

"I sometimes think we look too much at the all-around individual. Must do so much of this and that, including off-duty involvement. If I am spending 12-14-hour days on the flightline, guess what I am not capable of doing on the backside, especially if I have a family? I can be involved in my kid's activities, but it is very tough. I have to be promotion competitive at the wing level, with people who aren't on the line 12-14 hours a day, and that's a tough part of our career field. Look at our awards and decorations programs right now. What blocks do you need to fill out to have that full package? A lot of people are saying 'I would be glad to go out and bend wrenches all day long, but will I be recognized for that?' How do you recognize them?"

"That brings up a key point. We as a group must document that the MSgt on the flightline is doing an outstanding job on a day-to-day basis, versus a three-deep MSgt or second person on swing shift. Is that person on swings making a difference for the mission? The person leading people out on the ramp is making a difference. Some of our SNCOs have the impression that they need to be that second or third person for the duty title. That is what will get them somewhere, and they have actually fooled themselves. We are coming full circle on this issue. We took training records away from the MSgt, and soon we will give them back. Are we correcting something that shouldn't have even happened?"

"We took a lot of the tools out of their hands, and we corporately threw titles at them. People are striving for titles. People are asking, how does this title sound? I always ask, 'How does the job sound to you?' The duty description will get you promoted, not the title."

"Truth is, we are not promoting the guy who is doing the great job on the flightline, but the guy with 47 different job titles. We write in the job descriptions this big breadth of experience and they have done all this stuff. Shame on us. We are saying one thing, 'This is what we want,' but who are we promoting? The guy who has gone everywhere and done everything. If you really look at the guys we promote, it's not the guy who is an F-15 crew chief his whole career and out on the ramp with a toolbox. However, if that same guy went to the propulsion branch and/or EMS, then we will promote him. We have to be careful with what we are saying, as it's nice to make all the speeches, but it's not what we are doing. The one problem we have is that we are promoting positions, not the guys who are out there making a difference on the flightline."

Is the MSgt on the flightline who is following the intent being hurt for promotion?

"I think it is a cultural change that will not happen overnight. Initially, you may unintentionally do that, because it will take a while for the board members to recognize it. I think we're doing the right thing, but it will be painful for a couple of years."

"I sat on the E-8 promotion board this year and I did not see one MSgt in the 2A3 career field that had a dedicated crew chief (DCC) duty title, or a duty title representative of the issue we are talking about. Everyone had a supervisory or creative duty title. The ones that caught the most attention were the ones that had the most scope of responsibility--production superintendent, flightline expeditor, and quality assurance supervisory type of duties. Does this say they were not out there turning wrenches and fixing airplanes and training young airmen? From what I saw in the records, the good folks are going to do that anyway. That's a natural part of our culture as aircraft maintainers. I didn't see it reflected on the duty title or duty block."

"A good case in point is when you read the duty title and job description and then read the EPR. Then you say, 'Wait a minute, hold it, that doesn't sound like the front of this EPR.' People are being carried away with the duty title and job description, thinking it is everything they need to ride them over. Now, when I have to put some hard bullets in the EPR, sometimes the two don't match. That's what folks need to understand. The back of the EPR must support the front."

"I sat on the supplemental board and I think I read two of the EPR fronts, and after that I quit. They were all fluff. Then I read what was actually written on the back and looked for discriminators. We aren't asking them to be a DCC. We are asking them to use one-third of their time turning wrenches being craftsman. If they are 100 percent craftsman, then you aren't utilizing a SNCO's responsibilities of supervising and managing. It's up to leadership, the Chiefs, to let them fill in for them when they go on leave and such. That gives more back to the Air Force."

Some young airmen and NCOs today make the comment that they are a totally different kind of airman, facing different challenges than the SNCOs did as young airmen. Do you believe this, and if so, what makes them different, and is this having an effect on our maintenance culture?

"They are the same airmen we were when we came along. We were the ones greasing our hair back and patting it

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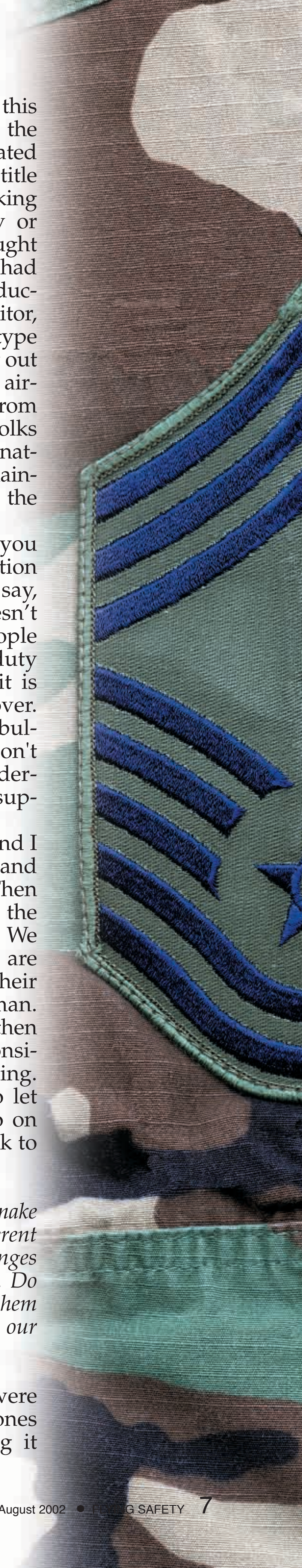

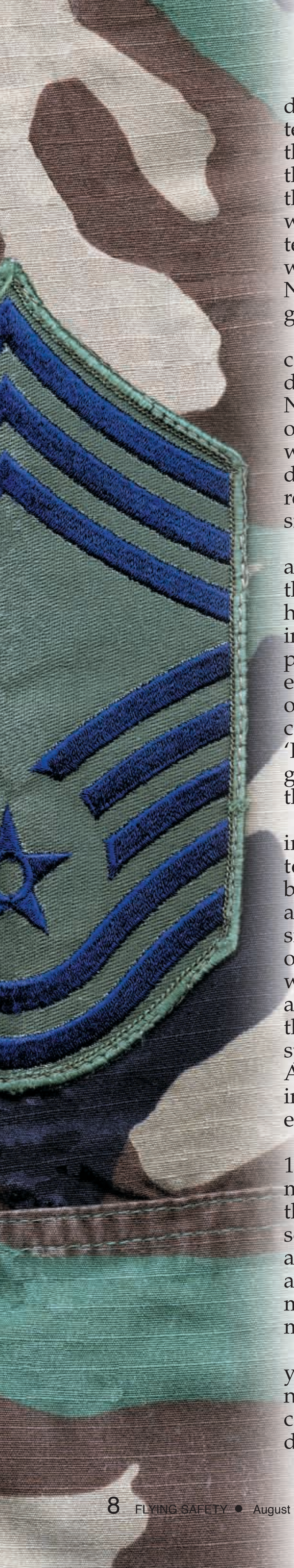

down because the establishment was telling us our hair was too long. While this group has different challenges and the times are different, you can't take this group and compare them to what we did. This group will ask why we patted our hair down, because that was our way of going against the establishment. Now, they are finding their ways of going against the establishment."

"I would say that compared to when I came in, our manning was not much different than it is today. We had few NCOs and loads of airmen. I do say that our AF is structurally different than it was 20+ years ago. We have drawn down tremendously, closed bases and realigned things, while I think our mission requirements have only increased."

"From that viewpoint, today's airmen are facing different challenges. Some of the challenges are just a result of not having the opportunity to get the training we had years ago. You had more people and more time. You had time to explain the 'why' and the mechanics of the philosophy behind the aircraft/equipment. Versus today it's 'Here is how you do it, do you got it, good,' and then move on. We don't have the time we used to."

"I think the biggest effect we are seeing and hearing from units is that today's technology is different than before. We all grew up taking things apart and putting things back together simply to see how things work and operate. Today that is different. Today we find a non-mechanical inclination in a lot of our young airmen who go through basic and get drafted, so to speak, into the maintenance career field. As soon as they get the careers retraining opportunity to go do something else, they go."

"We are struggling to get people in the 18-21-year-old population with a mechanical or electronics aptitude into the service. We are looking at doing some things way outside the box to accommodate that shortfall. We are creating different prep courses for the airmen, and so forth, to increase their mechanical and electrical knowledge."

"We grew up working on cars, and you don't touch cars anymore, as you need a PHD and a computer. You could always find the OMS or AGS dorm in the old days as you drove on the base. You found the dorm with the cars tore apart, hoods off and up on jacks. That was where the mechanics lived, as they had everything they owned tore apart. They worked on aircraft at work and cars after work. Now you can't tell the difference between the communications/electronics and the maintenance dorms."

"Today's airmen have better quality of life, pay and living conditions than we did, but they are saddled with some responsibilities that we didn't have. Just look at the environmental issues that are out there today and the paperwork they have to do. As a whole, we worked a little harder, but we got to play a whole lot harder. Due to money constraints and how the civilian populace looks at us, we have had to change a lot of our rules. It is very hard and difficult for today's airmen, and it's not a one-mistake Air Force, but they don't get away with the things we used to. It is tougher on them, as we had a better chance of recovering from our mistakes."

Training is a major factor facing the AF today, especially with the current manning and experience levels. Where do we stand on ensuring our people are correctly trained?

"I think we have a good training program and we are much more structured than a lot of other AFSCs. Given the fact that we have an experience shortfall, it will drive the need for more training, and it's a difficult nut to crack. With the ops tempo the way it is and manpower not growing, there are always going to be challenges and we must stay engaged and concerned."

"What's interesting is most of the maintainers coming into the field now, which is hard to believe, probably have two to three times the amount of training we did. Many of us came in with six weeks of training, then to the base. Now we have the Mission Ready Airmen programs that lasts six to seven months."

"We have training courses that run from four to 88 weeks depending on AFSC. There are a lot of training opportunities out there. Look at the quality training devices we are getting now. New technology aircraft have outstanding training devices. On the C-17 trainer, you can program in discrepancies and allow the students to troubleshoot it out.

The C-17 was one of the first airplanes where the acquisition community realized that if they put enough money into high fidelity trainers, they could buy fewer airplanes and still meet the mission. Even if you are talking decimals, because we won't have to dedicate as many aircraft to training. We are doing the same thing with the F-22, JSF and CV-22. We put a lot of money in training."

"I agree that's one thing we are doing right with future weapons systems. We are putting more money into training and better planning for it when it happens. A downside to that is the ops tempo. We are forced to the point where we have to make the sortie rate and flying hours. Sometimes when we need to spend that extra time, we can't. I know when I came in, there was a SSgt with me all the time. He showed me everything I needed to do. Now we don't have that luxury because we are trying to fly, and that takes away from training."

What is the status of the Avionics restructure?

"When we talk avionics restructure, it's really 12 separate initiatives. We have already completed some and started others. The big school changes occur this October, when we start moving large amounts of schoolhouse TPR from the old conventional 2A4, 2A1 Avionics AFSCs to the 2A3 AFSCs. We have already done the F-16, F-15, UAV, U-2 and B-52 communications/navigation. The big change really is not here yet. The remainder of the changes will begin in October 2002 and end in October 2003 with the backshop side of the large airframe and helicopter integrated avionics."

"That's the training side of the change. It's also the personnel side. We have already started and turned in the first classification changes that take effect October 2002. Some of the positions are being recoded as we speak. We are already moving some of our students around and things like that. The plan is on track and it is the right thing to do."

"Conventional avionics is dead. All the airplanes out there have, or have funded, an Avionics Modernization Program to put integrated suites in the aircraft. Before we started the restructure we were teaching students conventional systems for large airframes and helicopters that are no longer out there. Take a student and teach them conventional avionics on a B-52 radio or T-39 for GAC, and then they go to a Pacer Craig-modified C-135 or C-17 unit. It's not going to happen, as their training is not compatible with the airframe they are assigned. It took a couple of years to get all commands to agree on how we were going to restructure, and we finally did this in December 1998. We have held 10 training workshops since then to figure out all the details. It all comes this October."

We document everything we do in CAMS or GO81, and there has been talk for many years on a new integrated maintenance documentation system. Is there one in the works?

"The Air Force is going to one system. I think CAMS going to a centralized database is going to help a lot, because that is one of the things that AMC needs. If you look at AMC's mission, the world is our AOR. When you are sitting at Incirlik, Turkey, and a C-5 comes in, you need to be able to know what was done to that aircraft in Hickam, Hawaii. You can do that in GO81. When CAMS gets a centralized database, and we have that capability, I see AMC moving towards CAMS. I think we will get there, but it will take us some growing pains."

"Integrated Maintenance Data System (IMDS) is still the future. According to the folks at SSG/ILM, IMDS is an evolutionary incremental development that will re-engineer and modernize the existing maintenance information systems (MIS) into a single integrated maintenance enterprise. The CAMS modernization effort will be done in spirals. The first spiral was the graphical user interface, which occurred 1 March 2002. That is the Windows-based environment versus the current green screen. The next spiral is the centralized database. There is also a Maintenance Information Technology Working Group that's purpose is to evaluate information technology solutions within maintenance for adoption as AF solutions. The idea is to share knowledge and reduce duplication of effort. Currently, they are working agenda items with maintenance control center, scheduling and quality assurance (QA)."

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HQ AFSC Photo by TSgt Michael Featherston

The Air Force has started on a very bad year safety-wise, both in the air and on the ground, so much that the CSAF declared a down day in February. What are we doing to help units turn this trend around?

"In USAFE we have a tasker to figure out an objective way to determine if we break the line on Ops Tempo on our people. In other words, when is enough, enough? We have to come up with a way to quantify this, and it's tough. We have some good people working on getting the numbers, but we aren't there yet. We have to show how to do it because of incidents, ops tempo, and from our people visiting the field. I think it's also a leadership function."

"At my last operational base we had a rash of mishaps. Perception was that ops tempo was causing people to do things in a hurry, skip steps and that sort of thing. As Chiefs, we basically decided that we are going to tell our folks, 'Slow down, follow the book and do it right.' If we don't get the jet off on time, and/or we don't make our sorties, then I will stand in front of the boss and take the heat. I think that has to be, and I'm sure it's done at many bases. We as Chiefs at the wing level need to stand up and face the music and force the issue. It's the leader's responsibility to ensure a safe workplace."

"I can tell you from an operational unit: That is, in fact, what we do. We had an exercise last week and I went to every shop, at the beginning of every shift, on the first day, to make sure that everyone understood the importance of safety. I tell people that if you can't do it, then you just don't do it. There is a reason why it doesn't feel right, or the hair is standing up on the back of your neck. There is nothing we do that is worth losing a finger, poking an eye out, getting killed or losing an aircraft over. If it means it doesn't fly, then it doesn't fly. Then I will go answer to the boss why it didn't fly. I think, at least I hope, this is happening at every unit. Because what we do can't replace a life."

"I haven't met too many Chiefs in the maintenance world who do not say 'no' when we need to say 'no,' but all the time? We carry that message all the time, and you have to be cautious and not jump to conclusions about an increase of mishaps. It is not a steady line. You will have increases and decreases in mishaps. We evaluate what is happening and try to figure out the bottom line of why these mishaps are occurring, and then tackle the problem."

"I would like to see the items that young airmen bring up on safety days dealt with a little faster. Case in point: The young airmen at Mildenhall brought up airfield lighting as a safety hazard. It took two years to get it fixed. It was the number one issue, where several parking spots had no lighting or had ground lighting that shined in their eyes. We had guys bumping into aircraft and other objects. It wasn't a safe environment, and it was brought up two years in a row. When we come up with a list, we need to look at it hard, and we need to put some bucks behind it."

What advice can you give the force on the flightline, the backshops, or in the weapons storage areas to keep the safety trend going in the right direction?

"No excuse to have to do the job twice. If you can't do it right the first time, then you have to sit down and review what your process is. It's all part and parcel to the mission. Young folks have to understand right from the beginning, there is no deviation from safety. Once the foundation is laid that a safe environment is the only environment they are going to operate in, then you are okay."

"We get caught up on ops tempo and we have to hurry. It was never intended for our tempo to be greater than the safety factor would allow. That is the one assumption that most of our leaders actually make. It's understood that everyone was going to do his or her part right the first time. If you don't do it right the first time, then you have to do it twice. That's double the manpower and double the work."

"One thing I'm seeing that I like is we are bringing back QA and giving it more of an active role in what is going on. QA used to be more TQM 'love-in' type of guys. Now we are actually giving them some power and teeth, and they are fixing things."

"Getting back to one word and that is compliance. We are focusing more on compliance and tech data. Mostly what QA gives us is data to let us know how often things are going wrong on the flightline, or how often people aren't following the book. It doesn't put any more teeth in the program. It just gives us more ammunition to convince the supervisors that they need to take a closer look at what the people are doing. Nothing drives me crazier than having QA report something, but my supervisors aren't finding it on the flightline. I want the supervisors finding the same thing and stopping it on the spot."

"That is why we are emphasizing putting MSgts back on the flightline and in the shops."

Last question: What is the one major factor or issue facing aircraft/munitions maintenance today, and how are we addressing this issue?

"I would say, and we have said it before, that it's experience. Manning and retention is part of it, but getting the right experience levels in the right places would solve a lot of our problems. This isn't going to happen overnight, but we are heading in the right direction."

"We need to fix our experience problems for the long term this go-around and stick with it. We have to keep that constant emphasis there for retention. Long-term fixes will keep our experience on the line."

"You probably will get a whole bunch of different answers from these Chiefs on that question. I agree that experience is the key, but as far as maintenance right now, I am working airplanes that are over 30 years old–we got BUFFs around here that are 50 years old and '56-model tankers. The age of the airplanes, and the undue stress we put on them from cycling them so much, is probably our biggest problem. You are seeing problems and corrosion you never saw before, and of course, you are going to require more people than before to keep them flying."

"What I'm seeing right now, from when I came in the AF, is the small number of mechanics that are the 18-year-olds from the family farm and/or rural America that are actually very adept at the mechanical trait. That manpower pool isn't there today. We are going to have to develop the prep schools and invest in the front side to actually teach these young folks how to be a mechanic, and teach the basic fundamentals that we came in with."

"These same young people can sit down at the computer with no problem, while we couldn't understand CAMS. They are angry because our computers are so antiquated compared to what's out there right now. They want something new, and we should give it to them. The point being is what they are skilled and very good at is not necessarily aircraft maintenance."

"When it comes right down to it, it's the person where the rubber meets the road and knows how to change the tire, change the part, fix the wires and do all of those things that are important. That is a skill we are going to have to build into our airmen from day one. We have to create that experienced maintenance technician."

My thanks to the AMCAB Chiefs for their candor and openness, for allowing *Flying Safety* the opportunity to participate in the meeting, and for the great work they are doing to improve safety and the aircraft/munitions maintenance environment. If you have an issue that you think affects the aircraft, armament or munitions maintenance community, contact your Chief, MAJCOM functional manager, any AMCAB member or the AMCAB chairperson. You can find the AMCAB on the Air Force Aircraft Maintenance Home page at:: http://www.il.hq.af.mil/ilm/ilmm/acmaint/index.html.

USAF Photo

Yesterday and Today

CMSGT JEFF MOENING
HQ AFSC/SEMM

In 1992 *Flying Safety* published an article by CMSgt Robert Holritz entitled "Aircraft Maintenance—Yesterday and Today." In 1998 we reprinted the article with a short statistical update. It is time for us to really update the article and take a look at how Air Force aircraft maintenance has changed over the last ten years. The Air Force has changed the aircraft we fly, the tools and methods we use to repair the aircraft and keep them flying, plus the people who maintain them. The latter is the real key to our maintenance success. Let's start by taking a look at what aircraft were and are still flying.

Since 1992 the types of aircraft we are flying hasn't really changed much. The A-7D Corsair II, the F-111 variants, and the F-4 Phantom finally left our inventory. The C-141 is headed for the boneyard, and many of the venerable B-52s are already there. The F-16 and F-15 are still the premier air superiority aircraft, as well as a major part of the ground attack fleet. The A-10 is the forward air controller mainstay, while still playing an active role in the ground attack mission. The F-117 Stealth has held center stage on many occasions and is one of the first on target. The B-52H and the B-1B are still the bomber backbone, while the B-2 Spirit came on line and is playing a key role in today's air campaigns. The heavy lifters have seen the C-17 Globemaster III hit the runways around the world, while the C-5 is still the ultimate heavy lifter. The "Herc" is still in the theaters around the world moving everything and anything. The KC-135 is still the main air-refueler, only with newer engines on most models, while the KC-10s continue hauling aircraft, people and equipment around the world.

The Air Force has so many variants of the aircraft that were flying in 1992 still active today that it would take an issue all by itself to highlight their achievements, but we are a safety magazine, not "The History Channel." We have touched on just a few of the heavy hitters that make us the premier Air Force in the world. The fact that they are still around is a great tribute to all the men and women who maintain them, from the flightline to the depots. So what has changed in how we maintain them?

The biggest change over the last ten years is how we organize the maintenance community. The days of 66-1 and 66-5 have given way to the Objective Wing. The DCM, or "God Of The Logistics World," gave way to maintainers belonging to the operations squadrons, and the longtime champion of maintenance was no longer there. There is much discussion on whether this works or not, but the mission was completed thanks to a lot of hard working airmen. Today, we have a mix of organizations. Some wings have the maintenance folks back under the LG, while others are still under the OG. Either way, the current Chief of Staff Logistics

Review is looking at what works best to ensure our multi-million dollar aircraft are maintained the way they should be. Regardless, the flightline is still run by the production supervisor, the crew chief still owns the airplane, and the specialists are out there fixing the highly technical systems that make everything happen. Don't forget, no matter what patch you wear, the key to our Air Force successes is the quality of maintenance we perform.

While all this was going on, the old black hat Quality Assurance (QA) went away with the DCM, and Quality Assessments came online. Was this good or bad for the maintenance world? Depends on your viewpoint. We are going back to the old black hat QA days when QA had some bite and power. You never know; SAC MSET may be on the road again soon.

We became a lot smarter and are using technology to make aircraft maintenance more efficient and effective. One area that has greatly improved is our supply channel. We now have more computer-based supply systems that allow the technician to look up the part on the computer and see if any are available, and then order it and have it delivered without having to go through anybody else. When the part is delivered, the new Supply Asset Tracking System (SATS) allows the airmen to sign for the part without paper, just an ID card that tells the supply computer who signed for the part and when. This system provides supply 100 percent accountability and an instant record. Plus, the supply squadrons now have a better handle on what is on the shelf. This reduces the inventory cost of stocking our bases, and reduces downtime.

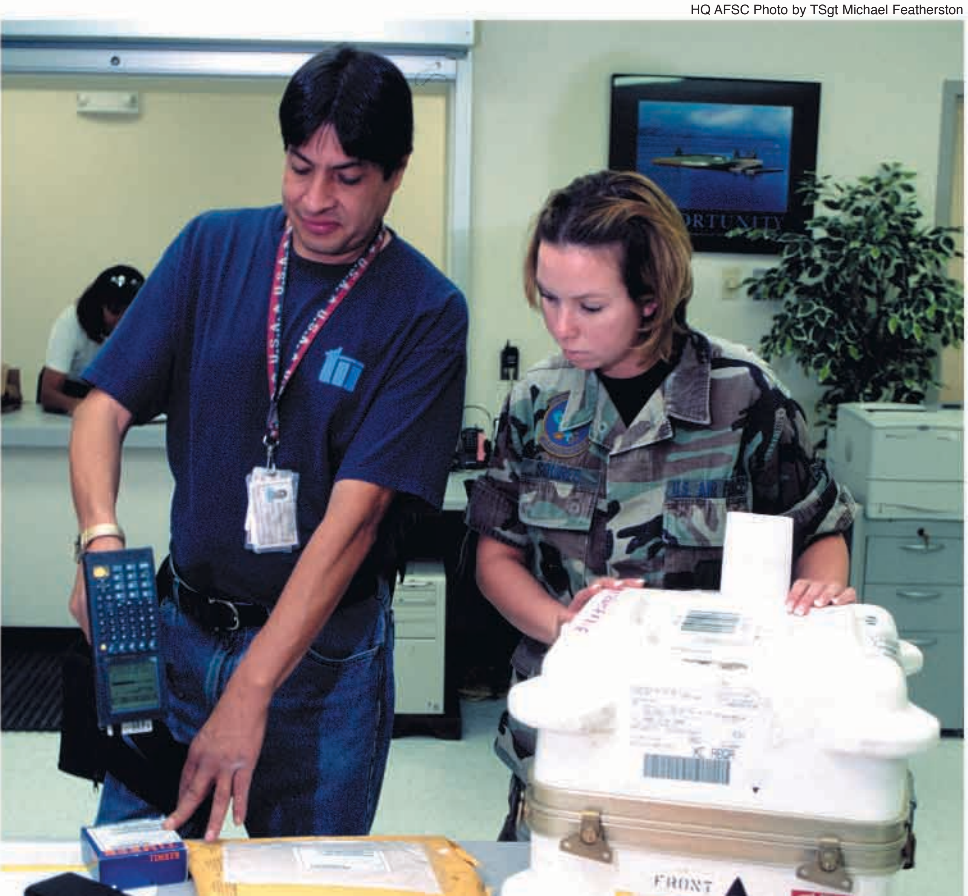
In the old days, it took weeks or months to move a part from the base to the depot for repair and back again. Now it takes an average of two days for a part to leave a base as we utilize two-level maintenance, or Agile Logistics as it is called today. One of the major changes was the two-level maintenance concept. We no longer have the elaborate back-shop structure to repair parts at every base, but rely on the depots to quickly repair parts, and the transportation system to move them back and forth in days versus weeks. The process now consists of three steps:

- The asset is ordered and delivered to the user who installs the part.
- The part is returned to a local backshop to see if there is any base-level repair, and if not the part is returned to supply.
- If the asset cannot be repaired at the base then supply has the part prepped and to transportation which arranges shipment to the repair depot.

Nice process, right? Just remember, the standard to have the part from supply to customer and out to depot for repair is two days or less. This process has greatly improved aircraft safety by standardizing maintenance practices, reducing spare part costs and ensuring the right part is in the right place at the right time.

Another area that supply has reduced our workload is in the Air Force Equipment Management System or AFEMS. This is where the Air Force tracks all of the equipment items. It still is a lot of work, but through the use of a user-friendly computer system, the flightline user can track and make changes to the system a lot easier. Plus, the system has increased our ability to better forecast and determine unit equipment requirements.

HQ AFSC Photo by TSgt Michael Featherston



Computers, computers and more computers. When I joined the Air Force in 1980 we used keypunch cards. I used my first computer, a Zenith 100, in 1989, and now I can't think of using anything less than a Pentium. I knew nothing of computers and most of us older folks in uniform are self-taught. Today's young airmen know the inner workings and can build their own computer, while navigating the Web with ease. Computers have helped the engineers design test equipment that is faster and more efficient, while reducing troubleshooting time. We have computer analyzers to troubleshoot engine vibrations and track and balance helicopter rotors—a large manpower savings.

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HQ AFSC Photos by TSgt Michael Featherston

We do all of our aircraft maintenance documentation on a computer versus the old printed 781 series forms, which are still around today, just computer-generated. One of the major factors affecting us today is the proper documentation of all the maintenance actions we must accomplish. In days gone by, we hand-wrote everything. Now we load a job standard in the computer and print out a job package for an entire inspection or a tire change. When we are done, we document what we did in the computer to have a complete historical record of how well we took care of the aircraft. This capacity has also allowed our depots to more effectively track what parts are breaking and how often. This helps ensure we have the right number of spare parts on the shelf and the depots have the capacity to repair the parts. The Air Force is trying to improve our maintenance information system with the implementation of the Integrated Maintenance Documentation System, and do away with the multiple systems we use today. Going to one Windows-based system will take care of our future documentation needs.

Maintainers today enjoy the benefits the computer technology has given them. Besides the technical advances of the aircraft systems, one of the best uses of technology on the flightline and in our engine repair shops is the borescope. It has given us unprecedented capabilities in engine troubleshooting. Now we can look inside an engine and see just what is going on and even videotape the results for others to see, or print out digital pictures. Many versions have the capability to measure the damage, or possible damage, to see if limits are exceeded. The technology used and developed for engines is also used to help other areas, as the borescope can be used to inspect any otherwise inaccessible area.

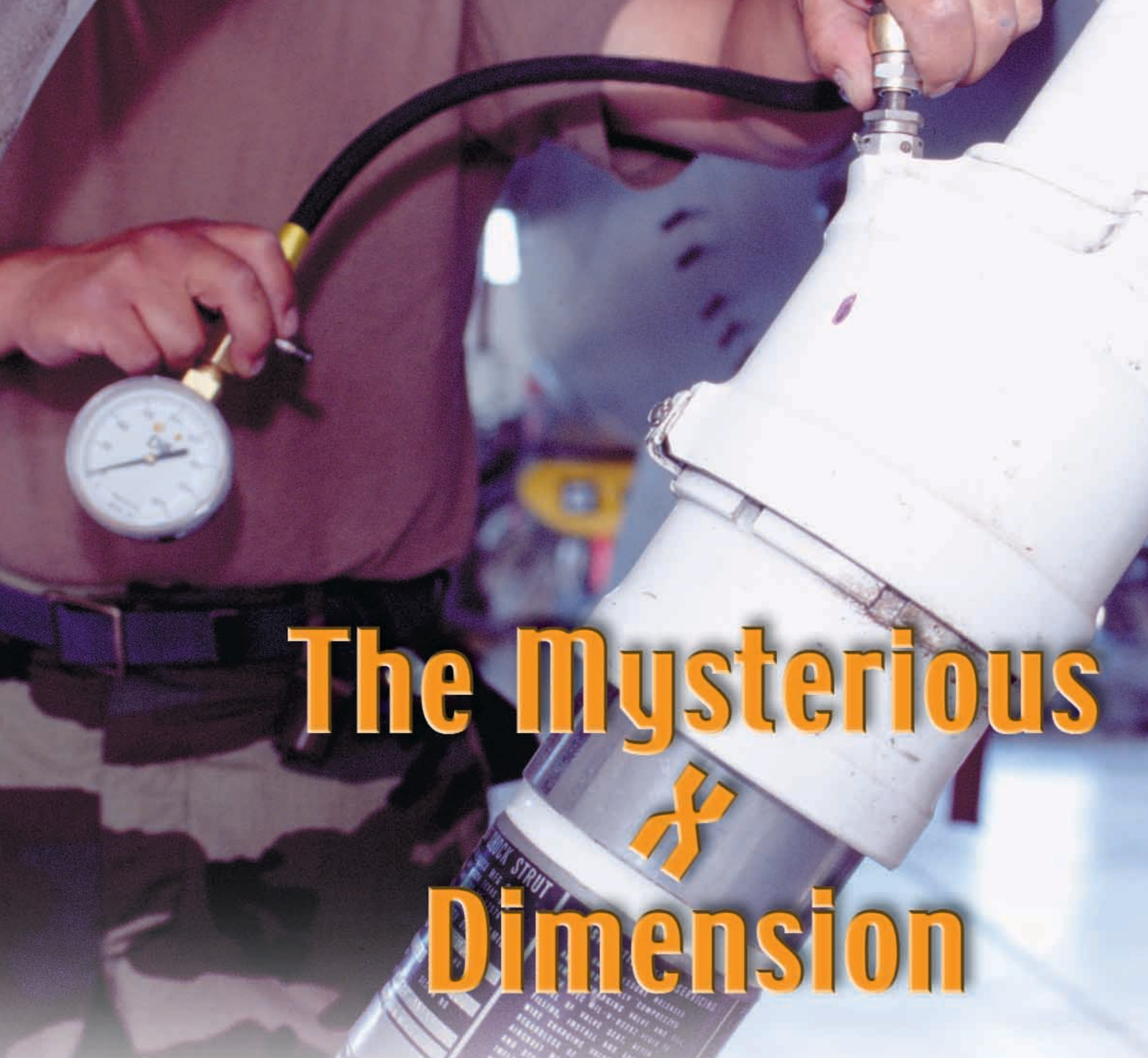
Another benefit is the use of today's digital cameras to look at damage. We can photograph the damaged areas and send the picture via e-mail to the depot engineers for evaluation. They in turn can make assessments on how to repair the aircraft from home instead of using limited travel funds to travel to the aircraft. Plus, they can determine what a repair team needs before they travel, instead of after they have arrived. This saves limited funds and more valuable time in repairing a valuable and much needed Air Force asset.

Let's talk about one of the biggest issues facing us yesterday and today: training. The aircraft have changed, a little, the methods used have changed, and the airmen seem to be getting younger. How do we train them? Each career field has their Career Field Education and Training Plan (CFETP) to guide them from the 3- to 7-level. The big difference is the path we take to get there. In days of old, you could be upgraded in months; now we have longer set time periods that a person must be trained in order to ensure we have an experienced individual working on our aircraft. We have the Mission Ready Airmen program that delivers a qualified 3-level crew chief to the unit after six to seven months of training. We use computer-based training to cover many of the tasks, so the troops can see the task before they go to the aircraft. We use the Command Aircraft System Training program to give SNCOs and officers an idea of the aircraft they are managing when they change weapon systems. We utilize Cross-Utilization Training (CUT) on every Air Force base that I know of to help with manning shortfalls and to fully utilize the people we have. The bottom line on training: It is still the effort our supervisors around the world put into their troops that ensures we have quality-trained individuals on our flightlines.

What is in our future? We have more fly-by-wire aircraft. By that I mean electrical wire, not flight control cables. We have aircraft squadrons that fly nothing but unmanned aircraft. Takes a big piece out of the maintenance puzzle, doesn't it? The aircraft of the future are stealthy and made of composite material—no more soda-can-sheet-metal repairs. The aircraft utilize more "off-the-shelf" technology that makes repairs easier and parts resupply faster. Our depots are leaner and the flightline is still the heartbeat of a flying squadron. No matter how much technology improves, it will still take a professional maintainer turning a wrench, installing a black box and just taking tender loving care of a high-tech multi-million dollar machine to keep our aircraft flying safely. I have no doubt that today's maintainers will not falter and carry the sword to the enemy. With improved aircraft reliability and better maintenance practices, the safety rate for our weapons systems will only improve.

Editor's Note: I would like to thank all the maintenance chiefs and officers I have talked to for their inputs to this article. Couldn't have done it without them!

USAF Photo



The Mysterious X Dimension

HQ AFSC Photo by TSgt Michael Featherston

CHAD HOGAN, P.E.
CRAIG PESSETTO, P.E.
OO-ALC Hill AFB, Utah

In the past six years the USAF has had at least seven mishaps where improperly serviced landing gear shock struts have played either a direct or contributing role. This article is to help field maintenance crews understand the importance of properly servicing shock struts. Improper servicing can cause damage to the shock strut, adjacent landing gear and airframe. In the worst case, it can cause the shock strut to fail completely, resulting in the loss of aircraft and crew.

The Basic Design Of A Shock Strut

Most Air Force aircraft use an oleo-pneumatic (oil/gas) shock strut. The main purpose of the shock strut is to alleviate load on the airframe and to cushion impact during landing. The oleo-pneumatic shock strut is the most efficient of all shock absorbers and is the best in energy dissipation.

Most oleo-pneumatic shock struts have an upper and lower chamber. The shock strut is filled with fluid (oil such as MIL-PRF-5606 or MIL-PRF-83282). Shock struts are designed such that filling a strut to the top servicing port with oil while it is fully compressed sets the oil volume to the correct level before it's pressurized. The strut is then extended and the space above the fluid is pressurized with gas (nitrogen or dry air). An oil metering system is used to control the rate at which oil moves from one area of the strut to the other on compression. On extension, another system (termed a snubbing system) controls the rate of extension by metering the return flow. The metering system and strut are designed to accomplish two things. First, the strut is designed to convert some of the aircraft's kinetic energy into heat energy (a brake does the same thing). This way, the aircraft structure does not see full landing loads and the absorbed energy dissipates as heat energy after the aircraft has landed. Second, struts can effectively reduce the peak load an airframe experiences by spreading out the total landing energy over the time it takes to complete a compression stroke.

These topics are very general and apply to all struts, but there are some distinct differences in various aircraft types. Some struts, like those on the A-10 and C-5, have oil over air, but the principle is the same. Oil is still forced from one area to the other through a metering system. All struts on the F-15 and F-16 have dual gas chambers in addition to a single low-pressure oil/gas chamber. This is also the case in the B-1, C-5 and B-2 nose gear. Dual chambered struts are slightly more difficult to service properly.

The Operation Of A Strut

In order for the shock strut to function properly, it must have the correct gas-to-fluid ratio. Physical laws dictate that when a strut is serviced with the correct volume of gas/oil, it will follow a specific air curve while being compressed. When a strut has the wrong fluid-to-gas ratio, the following can happen.

1. *Not enough fluid*:

When the fluid level is significantly low due to improper servicing or leaks, the shock strut will not be able to absorb landing energy effectively. The airframe will experience higher peak loads because of a shortened stroke interval. Increased loads represent a greater chance of damage to the airframe and strut. Occasionally, depending upon strut geometry, this can allow the strut to bottom out with metal-to-metal contact during normal landings. This impactive loading can lead to failure of the shock strut or supporting structure.

If the fluid level is extremely low, it will also have reduced snubbing (rebound dampening) capabilities. This can result in a violent extension. When the aircraft takes off or bounces on landing, the piston assembly will slam against the gland nut, which could result in damage to the shock strut. A common effect of snubbing loss is for internal strut components to deform, causing struts to bind in a certain position. Another result is a separation of the piston, wheel and brake assembly from the shock strut. An important fact to remember is that in even the smallest struts there is enough explosive pressure energy to equal one to three sticks of dynamite.

This condition is exacerbated when continued "re-servicing" at preflight to meet the X-dimension requirement at that given weight yields an improper gas to fluid ratio. Doing this can increase gas pressure to a dangerous level. The topic of "re-servicing" is discussed in depth below.

2. *Too much fluid:*

When fluid levels are high, the gear becomes too stiff. This results in a decreased ability to absorb energy and may cause the strut to rupture under heavy aircraft gross weights or hard landings. High fluid levels also decrease the allowable stroke of the strut, reducing its ability to dampen peak loading. This condition is less common and is usually a result of confusing or inadequate technical data for initial strut servicing.

The methods used to determine proper X-dimension values vary between aircraft. X-dimension can be generally defined as the amount of chrome showing on the strut. Every maintainer who works with landing gear should be familiar with the strut servicing instruction decal on the outside of each shock strut. There are three basic types of instruction decals:

- X-dimension vs. aircraft gross weight.
- X-dimension vs. pressure.
- X-dimension vs. both pressure and gross weight.

Some technical data may only give aircraft gross weight vs. X-dimension, like the KC-135. Care should be exer-

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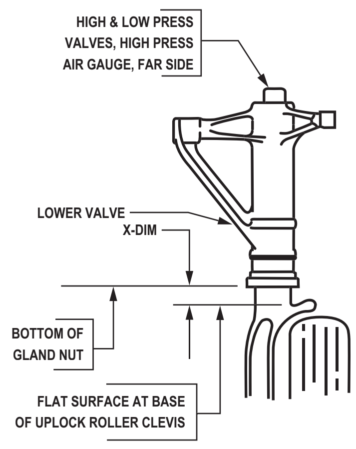
X-dimension can be generally defined as the amount of chrome showing on the strut.



SERVICING		APPROX. AIRCRAFT WEIGHT
XDIM	PSIG	
.16		COMPRESSED
4-1/8	2200	81000
4-3/8	1840	68000
4-5/8	1520	56000
4-7/8	1330	49100
5-1/8	1220	45100
5-1/4	1130	41800
5-1/2	1050	38800
9.19	480	EXTENDED

Figure 1

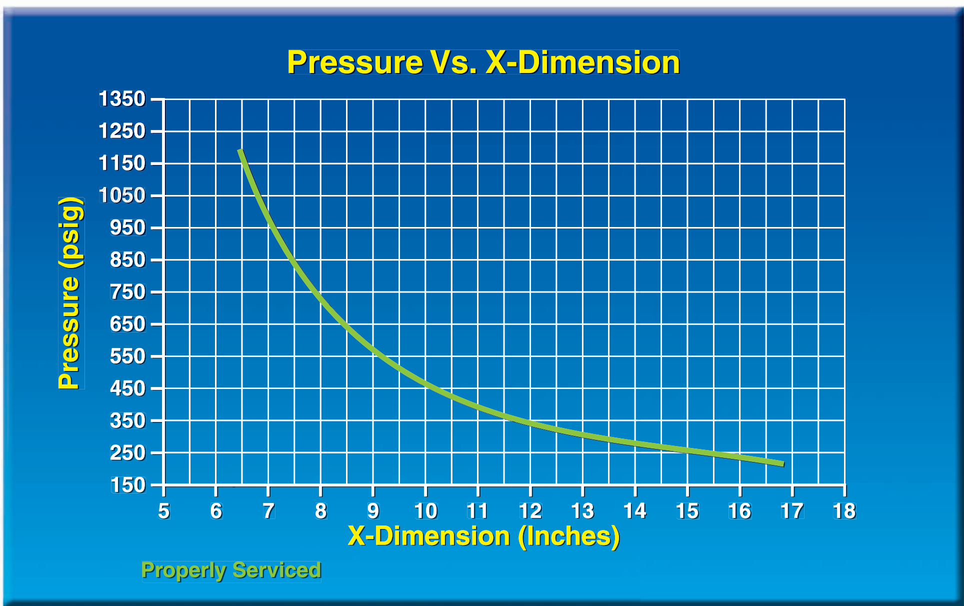


Chart 1

cised when using gross weight to determine X-dimension, because the aircraft center of gravity may not be in the center of the aircraft, depending upon the loading condition. Using gross weight as the only method for checking strut servicing is also prone to error because of binding effects.

Aircraft like the F-16 check X-dimension during preflight by using strut pressure. Using X-dimension vs. pressure is a good way to check the X-dimension, because aircraft CG or strut binding effects are of little or no concern. With the F-15, gross weight vs. X-dimension is given for preflight checks, and pressure vs. X-dimension is also given for other instances when a pressure gauge is available (see figure 1). If the proper procedure is not clear, crews will try to service F-15 struts using gross weight and pressure simultaneously. This usually does not work because of CG and strut binding effects. Pressure or gross weight should be used individually but never together. Pressure readings always produce the most accurate results.

Basic Conceptual Physics Of Strut Operation and Proper Servicing Of A Shock Strut

Now that we have discussed the design and operation of a shock strut, we would like to focus on the physics of operation and proper servicing of a shock strut. A question maintainers always seem to ask landing gear engineers is, "Why doesn't the landing gear ever seem to extend to the proper X-dimension?" It is a common frustration that landing gear engineers are constantly answering. The typical short answer to this question is, "The strut hasn't been serviced properly." This answer is not intended to be an accusation but a statement of physical laws. The following information is an attempt to explain these physical laws and how they relate to getting a proper X-dimension. For simplicity, this discussion omits the transient effects of altitude and temperature.

The three basic main drivers of strut servicing are gross aircraft weight, X-dimension and internal strut pressure. Once a strut is serviced with fluid and gas, it is a closed fluid and gas system, and some intuitive things happen. X-dimension decreases when the aircraft gets heavier, and increases when the aircraft gets lighter. A heavier aircraft produces higher internal strut pressure than a lighter aircraft. As the volume of the internal strut chamber decreases due to external forces, internal pressure increases (i.e., pressure is inversely proportional to volume). Regardless of what is going on outside of the strut, in a closed system, the internal strut pressure is affected only by changes in strut internal volume.

Once a strut is considered a closed system, physical laws dictate that a certain X-dimension correlates to a volume of gas in the strut, which always produces a corresponding pressure. X-dimension and internal strut pressure are only loosely related to gross aircraft weight because of center of gravity (CG) and binding effects. For example, assume a half-compressed strut has an X-dimension of eight inches and an internal pressure of 725 psi. No matter how many times you extend and compress that strut (if proper gas-to-fluid ratio exists), or how you load the aircraft, an X-dimension of eight inches will always produce an internal pressure of 725 psi, because the internal volume of the strut defines the strut pressure. Considering this fact, it is a simple thing to pull a strut out of an aircraft, compress it, record X-dimensions vs. pressure and then put the data on a chart. A sample curve is shown in chart 1. For simplicity, the three charts in this discussion disregard aircraft weight and consider only pressure vs. X-dimension.

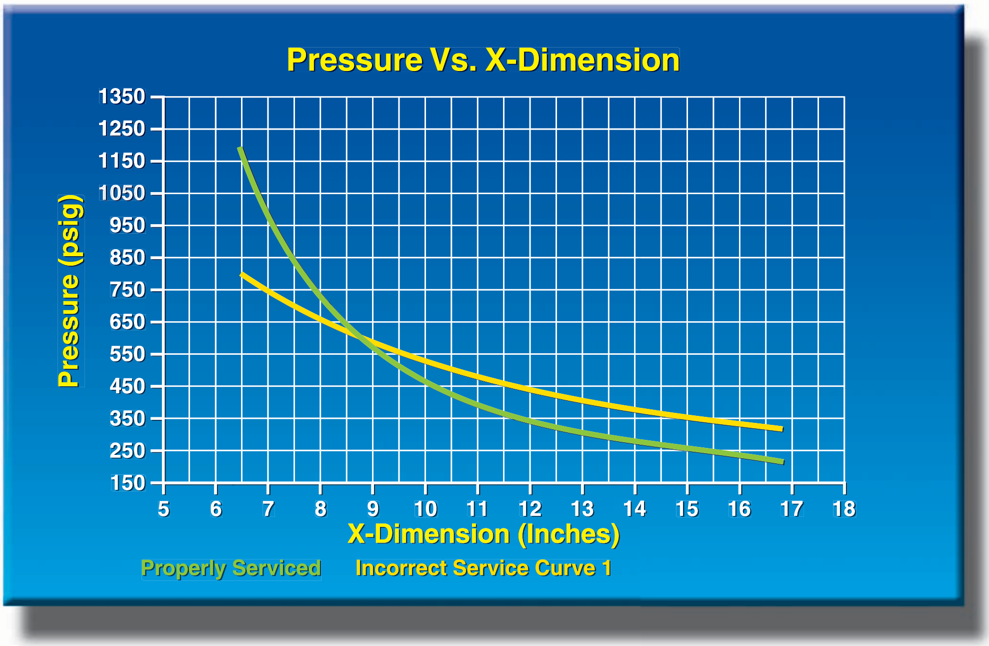


Chart 2

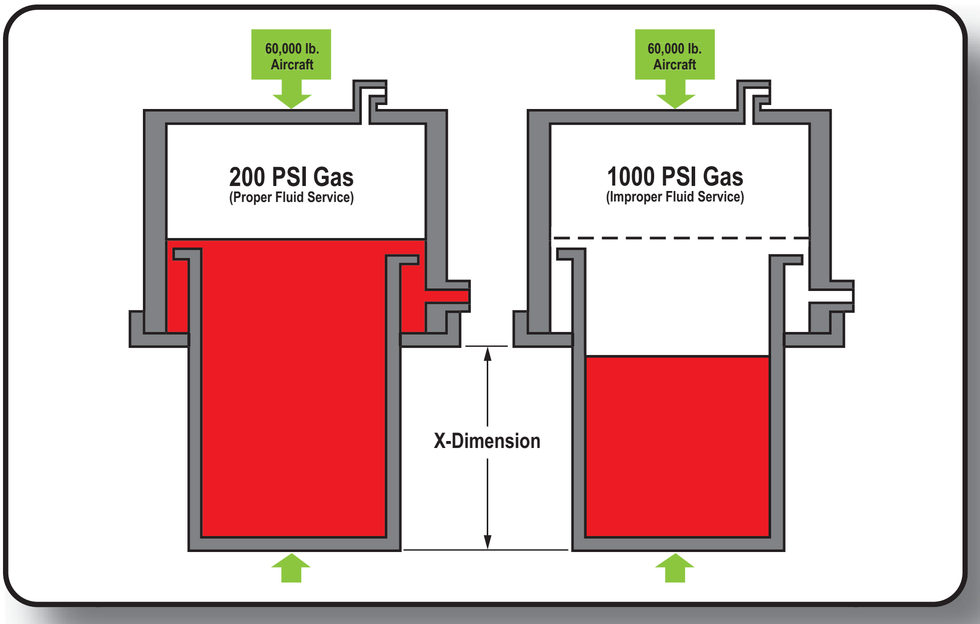


Figure 2

Chart 1 shows how X-dimension changes vs. pressure. If no fluid or gas is removed or added, this chart will always be correct because the unbreakable laws of physics govern it. When all struts are designed, engineers go to great lengths to ensure they can be serviced with the correct proportions of gas and fluid every time. Filling a compressed strut with fluid and ensuring that no air bubbles are trapped inside sets the proper fluid volume. The proper air volume is set when the strut is pressurized to the proper pressure corresponding to an X-dimension established by the servicing plate.

When fluid and gas exist in the strut in improper proportions, problems arise. If a strut is sealed with improper proportions of fluid, gas or both, the strut follows a different curve. An example of this is shown in chart 2. Once a strut has the wrong ratios of fluid and gas, the new curve that it operates on can only touch the properly-serviced strut curve once. This means, a strut can be improperly serviced and still have the proper X-dimension for one given instance of pressure. However, many people fail to realize this simple fact and its unintended consequences. Figure 2 illustrates this condition.

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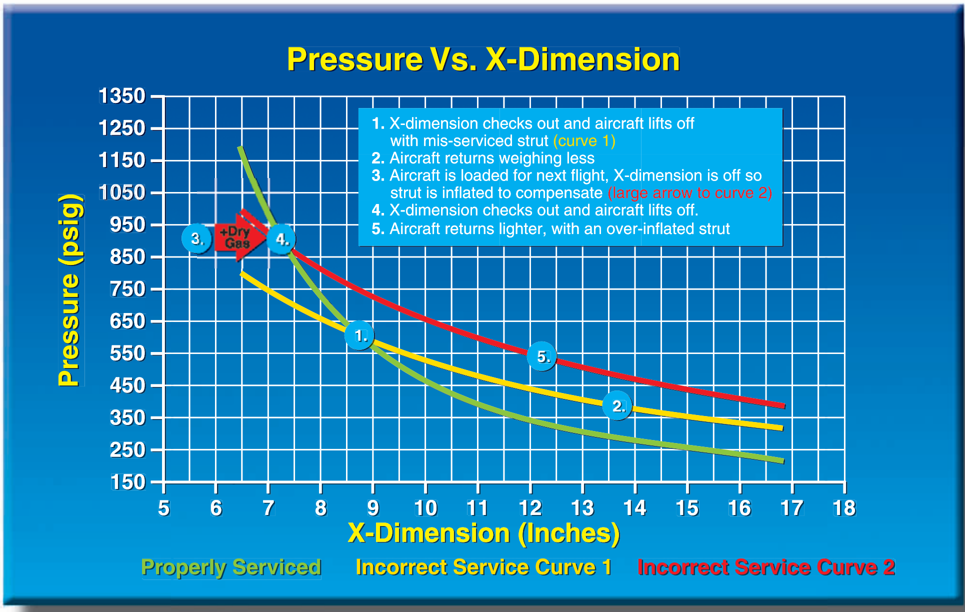
Chart 3



Every time any gas or fluid is released or introduced, the strut follows another curve. In the real world, when an aircraft X-dimension is checked during pre-flight and found to be wrong, gas is either added or released by the maintenance crew. As a result of this action, the maintenance crew changes the operating curve of the strut. Chart 3 shows how a strut mis-serviced with fluid can cause a vicious cycle of inflation and deflation once mis-serviced.

An easy way to determine if a strut has an incorrect volume of fluid is if it requires an X-dimension adjustment more than once between fluid servicing. If this happens, the strut has an improper fluid level and it should be re-serviced IAW current tech data. Improper fluid levels can be caused by an incorrect or unclear TO procedure, a fluid leak or human error. If you believe the tech data is incorrect or unclear, contact your local Quality Assurance office to obtain clarification or submit a change.

Dangers Of Using Standard Compressed Air

The final topic of discussion concerns using the proper type of gas to pressurize the strut. Technical data on landing gear universally requires that either dry air or nitrogen shall be used to inflate struts. If standard compressed air is used, it will introduce moisture into the interior of the strut. This can be an expensive and dangerous condition.

Struts are made of high strength metals (i.e., aluminum, steel and titanium). This allows designers to get the best performance from landing gear while incurring the lowest weight penalty. The tradeoff is that these high strength metals are extremely susceptible to corrosion and its effects. Weapon system and design engineers work very hard to ensure high-quality corrosion control coatings cover all exposed areas of the strut. The interior components of a strut are not normally treated because they have mechanical wear surfaces, and the strut is supposed to be filled with oil and a dry gas.

In addition, the effects of corrosion are accelerated inside of a strut because the strut is constantly under stress. Stressed metals can experience the effects of corrosion much faster than unstressed components. When moisture is introduced into a strut via standard atmospheric air, it collects at interior notches and ledges where stress concentrations are highest. Corrosion begins in these areas and if left unchecked, landing gear can develop corrosion pits that lead to cracks. A crack only has to be about .01 to .02 inches deep to cause a landing gear component to fail. The big problem is that shock struts have no redundant load paths like most other aircraft structures. As a result, shock strut failures have a high potential to result in aircraft damage, injury or even death when they occur.

Another corrosion-related issue is cost. Shock strut components like outer cylinders and pistons can cost between $30K and $500K depending upon the weapon system. If the corrosion pits and cracks are in critical locations, these components will have to be condemned when they come in for overhaul. Bottom line, many components are discarded long before they have reached their intended service life because standard air was used to service the strut.

In summary, if you take the time to service landing gear shock struts properly IAW applicable technical data using the correct amount of fluid and dry gas, it will function properly, be easy to maintain and last its intended designed life.

Editor's Note: Mr. Pesseto is currently the Lightweight Landing Gear lead engineer at OO-ALC, and Mr. Hogan is an engineer assigned to the section.

The Aviation Well Done Award is presented for outstanding airmanship and professional performance during a hazardous situation and for a significant contribution to the United States Air Force Mishap Prevention Program.

Capt. Tony D. Bauernfeind
15 SOS
Hurlburt Field FL

On 10 January 2001, 3.5 hours into an overwater flight, the MC-130H became uncontrollable due to a failure of the elevator trim system. The resultant nose-down pitch disengaged the autopilot and the aircraft immediately began losing altitude. While countering the excessive nose-down pull, the aircraft commander, Capt Bauernfeind, noticed the aircraft's trim gauge was indicating 25 degrees nose up (even though the yoke was commanding nose down). The trim was not responsive to any trim switch inputs (in either the normal or emergency modes). As the nose down pull was in excess of what he expected, he directed the copilot to assist in handling the aircraft.

All attempts to troubleshoot the trim malfunction failed to correct the problem. Since the effort to control the aircraft on brute force alone for an extended time was more than they could handle, Capt Bauernfeind ordered that a cargo strap be brought to the cockpit to help secure the yoke. With the 5000 lb. strap wrapped around the copilot's seat and yoke, they tightened it until most of the pressure was alleviated, and Capt Bauernfeind and his copilot were able to trade time at the controls and rest their arms. The crew began dumping fuel to decrease the weight of the aircraft, and the loadmasters moved cargo as far aft as practical, to shift the center of gravity and help alleviate the nose-down condition.

The closest suitable airfield was over 220 NM to the west of their position, and due to the slower flight required to minimize the airload on the elevator, this location was about an hour away. After a controllability check at 11,000 feet MSL, they deemed the aircraft controllable down to 100% flap touchdown speed. The controllability check was accomplished without the cargo strap around the yoke, and afterward the strap was reapplied and flaps were brought to 50% to quicken the enroute time. When they descended to 1200 MSL they broke out of the clouds approximately 20 NM away from the airfield.

Capt Bauernfeind flew a 100% approach and landing with both hands on the yoke while the copilot controlled the throttles. A very sizable pull was required to achieve a safe flare and landing. On rollout, Capt Bauernfeind resumed control of the throttles and taxied the aircraft to the military ramp and the engines were shut down.

A maintenance inspection revealed that the trim motor had catastrophically failed, driving the elevator trim tabs past the electronic stops (6 degrees) and the mechanical stops (8 degrees), and had overtorqued the four jack screws attached to the elevator trim tabs in driving the trim tabs downward.

The Perfect Engine Run

SMSGT BARRY TROUBA
3rd Component Repair Squadron
Elmendorf AFB, AK

With a combined experience of over 60 years repairing and operationally testing jet engines, this was just another "regular" day for this experienced run team. The long Alaskan winter was almost over and spring was in the air. The team members busied themselves looking at the engine's maintenance records to ensure everything was in order. The T56 turboprop engine had been removed for metal on the magnetic drain plug and had required a reduction gearbox change earlier in the week. After the gearbox assembly was replaced with a new unit from depot, the Jet Engine Intermediate Maintenance (JEIM) shop technicians performed a pre-Test Cell inspection and called Test Cell for the test run. After another careful inspection, Test Cell technicians towed the engine to the facility for loading, initial leak check and functional checks.

This experienced run team had worked together for several years and were confident in their abilities. Communication headsets kept the team aware of each member's movements and tasks, even though they were well aware of each other's routine from experience. After the required engine preparation, intake and exhaust inspections were completed, and the team proceeded with servicing

HQ AFSC Photo by TSgt Michael Featherston
Photo Illustration by Dan Harman
Inset Photos courtesy of Author

the engine oil and propeller hydraulic systems. Next, the engine was motored over in order to purge air from the oil and hydraulic systems. The run supervisor energized the start switch and motored the engine for approximately 30 seconds. All indications seemed fine until the start switch was released and the engine started to coast down.

The engine run supervisor noticed the engine seemed to spool down faster than normal, and the propeller didn't spin as long as usual. The ground man did an intake inspection, and much to his surprise he found damage to the first and second stage compressor areas. Several shreds of red cloth material entwined between the compressor blades made the cause of the fast spool- down readily apparent.

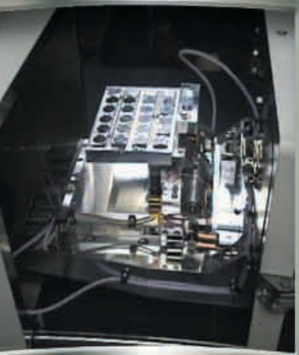
The engine was impounded and an investigation was launched to identify the extent of damage and determine how and why it happened. After a complete engine teardown, the JEIM shop gave investigators the good and bad news. The good news was the damage was isolated to the compressor section of the motor. The bad news was that *extensive* compressor damage from a single rag would require depot-level repair. The really bad news was that all of the damage was *self-inflicted* and could easily have been prevented. Price tag to repair this Class C mishap, approximately $40,000. The maintenance investigation revealed that all of the required foreign object damage inspections, in-process inspections and supervisory inspections had been performed and documented in accordance with directives during each step of repair and reassembly. Investigation also revealed that the test cell technicians had performed inlet and exhaust inspections prior to motoring the engine. The mystery of how the rag ended up in the engine inlet was discovered during a look-back on how the Composite Tool Kit (CTK) was inventoried prior to the technicians motoring the engine for servicing.

The engine run supervisor did a full inventory of the CTK and had accounted for all ten rags that were signed out. Nine rags in possession, and the tenth rag with the ground observer for servicing. What the supervisor didn't know was that the ground observer had serviced hydraulic fluid to the propeller and left a rag on top of the motor. Subsequently, the rag was pulled into the engine inlet during the motoring process, causing the compressor damage. After all the checks and inspections were performed, the 10th rag was missed. The three experienced members of this run team are still pondering the following question over and over in their minds: How could we have overlooked this?

The run supervisor knew the ground man had the tenth rag and *never questioned* where the rag was. The ground man knew the run supervisor would not operate the engine without ensuring the CTK was accounted for, and *assumed* the supervisor had taken the rag from the top of the engine. This couple of assumptions led to an expensive result.

As the engine run supervisor, you're ultimately responsible for everything that happens during the engine run. You can't assume everything is where it's supposed to be. The only sure way–and authorized way–is to visually verify that every tool, rag or loose object is accounted for.

Needless to say, this engine run turned this team's "just another regular day" into one they will never forget. Remember, assuming anything can make a really good day go really bad, even for the most experienced technician.



Engine Bearing Failure
Detection Improved With NewTechnology

Debris
Light debis or fuzz-like particles observed during normal day-to-day operations.

New technology has equipped man and machine to better detect impending component failure. This machine (pictured left), called a JetSCANTM, uses X-Rays to detect and analyze tiny metal particles that the maintainer may not see with the naked eye. Strict T.O. guidance and proper use of this machine will reduce engine-related mishaps.

Photos Courtesy of General Electric
Photo Illustration by Dan Harman

ANDY RODWELL
GE F-110-100/F110-129
Model Engineer
Cincinnati OH
Courtesy, *Airscoop*, Spring '02

The detection of the spalling debris in the oil system...

The modern jet engine operates at the very limits of mechanical technology. The speeds and temperatures of the components are pushed to maximum performance at minimum weight, while being able to deliver that performance with reliability that will maintain safety and mission capability. The main engine bearings that support the high speed rotating shafts of the engine operate in a particularly challenging environment, needing to support the loads of the internal engine speeds and pressures in addition to larger maneuver and gyroscope loads generated by the aircraft. These engine loads, as much as 15,000 pounds on each bearing, are supported on the minute contact areas between the balls or rollers and the bearing races they run against while riding an oil film just microns thick.

The unavoidable result of the repeated stress cycling of the bearing's surface metal created by the passing balls or rollers is metal fatigue which, in highly loaded bearings, can ultimately lead to the surface of the bearing breaking off flakes of material, normally referred to as "spalling." If the bearing continues to run after this spalling has initiated, then the rough contact surfaces will ultimately result in breakup of the bearing and seizure of the engine.

Most jet engine bearings operate at loads that will result in fatigue failure of some of the bearings, and the detection of the spalling debris in the oil system is essential to prevent the effects of full failure. In single-engine aircraft this becomes critical, as undetected failures typically result in engine failure with high potential for loss of the aircraft.

Although a joint oil analysis program (JOAP), which focuses on the number of tiny wear particles present in the oil, has been successful in detecting bearing failure on certain engine types, it is typically nonsuccessful with detecting spalling failure debris, because this type of debris is too large to be detected by JOAP. This means that this critical detection of bearing debris has been exclusively dependent on a visual inspection of the engine master chip detector. Unfortunately, some bearings located deep within the engine have a long and obstructed path to get the debris from the bearing to the chip detector, with the result that very little debris may be available at the chip detector to announce the impending failure. This requires extremely tight limits on chip detector debris, with a particle as small as 20 thousandths of an inch indicating potential failure. These small particles are required to be evaluated on a chip detector of the same color, while covered in oil, in less than ideal conditions that sometimes exist on the flightline. An additional problem with these tight debris limits is that routine maintenance can introduce many particles of the same size from sources outside the engine which are visually impossible to differentiate from the bearing debris, often resulting in unnecessary maintenance engine runs or engine removal and teardown.

Recently the USAF began implementing a new technology solution to the

Slivers
Appear as hairlike slivers or magnetic material. Normally this indicates wear interference on new or rebuilt engines.

Curls
Spiral curls of machining debris that may be found in new engines.

Flakes
Paper thin chips, probably shiny, may indicate that a bearing is spalling.

Chunks
Three dimensional particles may indicate that a gear is failing.

bearing failure detection problem in the form of an automated debris detection and classification system that is intended to improve both safety and maintenance by the early and correct diagnosis of bearing failure. Currently, the system is being installed to monitor all GE F110 engines in the F-16, while other potential applications are under consideration.

The system, which goes by the JetSCAN™ trade name, employs an SEM/EDX system, standing for Scanning Electron Microscope with Energy Dispersive X-ray. As this name suggests, the system is essentially a highly accurate electron microscope. The EDX part of the system is used to detect the material composition of the particle it is examining. This type of detection solution was selected as it was already available, had been in use with the U.K. Royal Air Force and required no modification to the existing fleet of engines.

While this is a complex piece of equipment, it has been developed and "ruggedized" to tolerate the normal conditions where it might be installed and to be movable to deployed locations. Just as importantly, it has been developed for ease of use with minimal training requirements. At the flightline nothing is changed except that following visual inspection of the chip detector, the chip detector is bagged and submitted for JetSCAN™ analysis and a clean chip detector is installed that has been returned from the analysis location. The visual inspection is still required and remains critically important, as the analysis may not always be conducted prior to the next flight.

To conduct the analysis, the chip detector is de-greased in solvent and any debris removed by pressing it onto an adhesive tab. Up to 24 separate engine samples can then be loaded into the machine and the corresponding engine details entered into the computer. The analysis begins with the operator stepping through the automated calibration, following which the system will perform the analysis with no further input or oversight. The system examines each sample for any particles, then each particle is measured and the elemental composition by the EDX sensor. The composition of each particle can then be compared to known alloys used in the engine bearings, gears and other oil system components and compared against programmed limits for each material. This allows small amounts of important materials to be detected in amongst less important or foreign debris, and limits are set accordingly to prevent unnecessary maintenance. On conclusion of the analysis, which typically takes around one minute per sample, a report is generated for each engine, and if debris is detected that exceeds the limits, a maintenance warning is generated for which direction is provided by the technical manuals, depending on the type of material detected.

Currently thirteen systems have been fielded at USAF bases, with eight more expected by the end of Aug 02. This includes a number of systems at the most frequently deployed locations. Frequency of SEM/EDX sampling is currently aligned with JOAP criteria. Already, impending failures have been detected and maintenance actions avoided demonstrating the intended double benefit of both enhanced safety and operational readiness.

...is essential to prevent the effects of full failure.

Editor's Note: The following accounts are from actual mishaps. They have been screened to prevent the release of privileged information.

Situational Awareness On A Different Level — All aircrew know about situational awareness when it comes to flying. SA applies when you are on the ground as well as when you are in the air. Lack of SA can cause maintenance a lot of extra work.

Ahead Of The Game

After returning from a cross-country instructor-pilot upgrade sortie, a T-38A blocked into their parking spot. After engine shutdown, maintenance found pieces of a helmet visor cover on the ramp and later in the mishap engine. Further inspection found the engine experienced numerous damaged compressor blades. Damage was so severe that the engine needed to be removed and sent to the backshop for repair.

How did this happen? How could a visor cover get sucked into an aircraft engine inlet? At this location, the local operation instruction states "aircrews remove and stow the HGU-55 visor cover *prior* to engine start. Replace it only *after* engine shutdown." Maybe this crew forgot what stage of the game they were in when the canopy was opened.

Maintenance Dust Off

Two HH-60Gs were returning to base after an uneventful but successful night sortie, and were cleared to land on the taxiway abeam base operations. Now the taxiway runs parallel to the runway and the tower is midfield. Base operations is located approximately 850 feet from the control tower. Tower advised the aircrew to use caution on their approach, as men and equipment were on the taxiway abeam the tower. The vigilant aircrew then acknowledged that they had a visual on the men and equipment. Sounds good so far, right?

The men and equipment were local fighter-type maintainers performing periodic radar warning receiver checks on those crazy fixed-wing-type aircraft. Tower noticed the HH-60 flight appeared to be descending right on top of the maintenance crew. A call from the tower to the aircraft advised them to not descend any lower, and the aircraft stopped their descent. The aircraft then continued straight in until they were past the tower. Unfortunately they *overflew* the men and equipment on the taxiway by about 60 feet. Luckily, no one was injured and no equipment was damaged.

Why and how could a helicopter crew overfly a maintenance crew? Maybe the crew didn't really have the men and equipment in sight due to their NVGs, or they lost situational awareness of their location. Make sure when you acknowledge cautions from the tower that you have someone in sight, or ask for clarification on your landing zone.

Where Is That Checklist?

Returning to home station on the third sortie of a cross-country mission, the event O/A-10 pilot had a hard time keeping track of his checklists. During the third flight, while performing some basic fighter maneuvering, the publications storage bag opened and four checklists *fell* out into the cockpit behind the ejection seat. Nice place to store pubs during flight, seeing as how the pilot can't see them there.

After the flight was complete, and as the aircraft taxied into dearm, the canopy was raised and checklist number one proceeded to fall out onto the dearm ramp. The dearm crew did not notice the dropped checklist until the aircraft had left, so they gave the checklist to another pilot to return to the event pilot. Checklist number two fell out of the aircraft as the event pilot taxied back to the parking ramp via the main taxiway. The second pilot, who was given the first checklist, noticed the second checklist on the taxiway and notified base operations to retrieve it from the taxiway. A FOD hazard it was. Now the third checklist, a 5"x8" plastic-sleeved 12-page checklist with two plastic-coated metal rings, fell out sometime between the canopy opening and engine shutdown. The event pilot noticed all four checklists missing at debrief and notified maintenance. Maintenance then found the fourth checklist in the cockpit. Unfortunately, during the post-flight engine inspection maintenance found the third checklist in the number 2 engine.

Pieces of the checklist were found in the first stage fan blades and the compressor inlet. This required the engine to be removed and sent to the regional repair facility for repair. What happened in this safety chain? Do you know how many pubs you have in your pubs bag? How secure is your storage bag in flight? When do you check your pubs bag to ensure you have everything? Before or after you raise the canopy, before or after engine shutdown, at debrief or just before the next flight? Maintenance relies on *YOU* to help prevent FOD in the cockpit and the engines.

What Clear Zone?

A C-141 was returning to home station and experienced some confusion on which runway to land. At the home drome they have two runways, 36 and 6, less than a quarter-mile apart, and the approach ends are offset by 1300 feet. This normally isn't a problem. Aircraft one (A1) was cleared to land on Runway 36, which is the preferred runway as it is closer to the parking apron. However, the crews also like to use Runway 36 to back taxi to takeoff on Runway 6. Aircraft two (A2) was given permission to back taxi to Runway 6 and hold short in the clear zone for traffic on Runway 36. The pilot of A2 read back the clearance to the tower, but not the clear zone part. A2 then taxied to the end of Runway 6, and was asked by the tower if they were ready for takeoff. They replied no, as they were still running the checklist. Tower once again advised A2 to hold short of the clear zone. A2 read back the instruction, but again did not mention clear zone. Do you see a situation developing here?

As A1 was turning right base, the tower cleared them to land on Runway 36. A1 *saw* A2 on the end of Runway 36 and asked the tower if they should go to Runway 6 because they might overfly A2. Tower told A1 that A2 was holding short in the clear zone and to land on Runway 36. Now might be a good time to mention that the tower could not accurately see if the aircraft at the end of the runway was actually in the clear zone or not, but relied upon the *aircrew* to know where they were. In addition, there were no signs to indicate to the aircrew where the clear zone actually was.

As A1 continued their approach, A2 called out *"Aircraft on short final, go around, go around."* A2 then reported to the tower that A1 had flown right over the top of him. After the go-around, A1 requested, and was granted, permission to land on Runway 6. A2 was told to taxi into position and hold for IFR release. A2 said he would wait a few minutes and asked the controller what clear zone he was supposed to be in. Tower responded with "Runway 36's." The pilot had *thought* he was to be in Runway 6's clear zone. Once again we have an example of what is said and what is understood are two different things.

Both parties, the tower and aircrew, did not ensure they understood the instructions the same way. In addition, the base instruction states, "Aircraft will not be taxied into the Runway 18/36 clear zone enroute to Runway 6 when aircraft are landing on Runway 36 or departing Runway 18…" The Aeronautical Information Manual under 4-3-18 stipulates that pilots understand clearly the clearance or instruction. The tower controller assumed the pilot understood and complied with the clearance given. Without ever being questioned, why should the tower think otherwise? The pilot never read back the clearance as it was given, "Hold short of the clear zone." The AIM also states that controllers are to obtain from the pilot a readback of *all* runway hold short instructions. There is no stipulation to obtain a hold short clearance for a clear zone.

Bottom line of all this? An aircraft almost landed on another aircraft at home station. The failure to communicate, by both sender and receiver, could have caused a catastrophic event for a lot of people. A1 and A2 had eyes open and made the right calls, but how did they get into that position in the first place? Pilots and controllers, make sure you don't *assume* and completely understand the instruction you receive.

Maintenance Matters

Editor's Note: The following accounts are from actual mishaps. They have been screened to prevent the release of privileged information.

Finishing the Job — When we do our critical maintenance actions, do we finish the job? Sometimes we take care of the major parts but forget to clean up after ourselves, or assume someone else will. We also may use workarounds that are standard practice, but should they be? Be safe and finish the entire job!

Which Way Does It Go?

An F-16 completed its scheduled 300-hour phase, and during the inspection the "A" sump lube and scavenge oil manifold line was replaced. This line is the feed and return line for all engine oil to the Number 1 engine bearing, so it is kind of important. On the first flight after phase, the aircraft was scheduled for two sorties, with hot pit in between. Unfortunately, the pilot didn't get to complete both sorties. On the second sortie, the aircraft had problems during climbout and returned to base, where the pilot engaged the departure end cable and shut down the aircraft.

Maintenance then had to remove the engine and send it to the backshop for teardown. The engine troops found the Number 1 engine bearing had failed due to oil starvation. When the bearing failed, the engine fan lost forward support and contacted the fan stator cases and affected fan rotation. The digital engine control sensed the fan speed versus core speed relationship, and since it was out of tolerance, it automatically transferred to secondary mode. Disruption of the airflow and vibration caused the high-pressure oil line to be severed, resulting in no engine oil pressure.

The moral of the story? On the F110 engine, the lube and scavenge pump/manifold gasket is composed of soft metal and has a manifold alignment pin at each end of the gasket. This gasket is used not only on the F110 engine but on other military engines as well, and only *one* of the alignment holes is used on the F110 engine. T.O. 1F-16CJ-2-79JG-00-1, page 2-104, contains a caution stating that misalignment of the gasket will cause oil blockage to the front frame, but only in respect to a loose, distorted or missing manifold alignment pin. Figure 2-8-2 also does not clearly identify which gasket alignment pin hole is used for the F110 engine. Do you know which way to install the gaskets on your engine? Is the tech data you use clear on how to ensure proper alignment of gaskets? If not, see your supervisor for more training or quality assurance to change the tech data.

BUFF Strut Wins, Finger Loses

A B-52 landing gear strut required the seals to be replaced, and a crew of four removed the inner cylinder from the aircraft and replaced the seals with no problems. Now the fun part starts. The crew was reinstalling the inner strut and was using an MHU-83 bomb loader to apply the pressure to compress the inner strut into the outer strut cylinder. T.O. 1B-52-2-10JG-4 calls for a 10-ton axle jack for this task, but the bomb lift has a much higher reach than the axle jack. Think of the size of a BUFF strut and how high the aircraft will be to remove the inner strut. The axle jack required by the T.O. would not reach high enough to put the inner strut back in, due to this height. To overcome this height mismatch, the unit had been using the bomb lift to provide the height and capacity to completely reinstall the inner strut. One major problem with using the bomb lift instead of the T.O.-required axle jack is that the workers can't readily tell if the strut becomes jammed during installation.

Back to the story. The workers were progressing with the reinstall, and as they were raising it into place, Worker 1 placed the strut alignment tool into position. He also placed his right thumb and index finger at the top of the alignment tool. Do you see what is going to happen next? As the strut was being compressed into the outer cylinder, it jammed (surprise, surprise!). Worker 2, who was operating the bomb lift, noticed this and stopped the bomb lift, but left pressure on the strut. The strut immediately came free and jerked upward into the outer cylinder. Unfortunately, Worker 1's finger was still in the way and the tip of the index finger was severed completely.

What could have prevented the lost fingertip? *First*, how about keeping your fingers and other body parts out of danger areas? *Second*, are you using the right tool for the job that is specified in the tech data? *Third*, if you are using an alternate piece of equipment, is it an approved piece of equipment? It's a fact of life in the Air Force: We all use workarounds at times to get the task at hand completed, but we need to formalize the workarounds and correct the tech data to ensure we don't damage equipment or our people.

What's That Smell?

A KC-135 was attempting to fly and after numerous maintenance problems finally got the engines started. The ground crew then noticed smoke and hydraulic fluid coming from the Number 4 engine. The crew shut it down, followed by the other engines. Troubleshooting the engine revealed that the fluid and smoke were coming from the Number 4 starter bleed air duct. Everything was inspected and found in working order. Maintenance then concluded that the fluid was residual from an earlier maintenance action.

The crew was asked to run the engine again with cowlings open. No smoke or fluid was noticed, so the crew shut it down and maintenance closed the cowlings. The crew then restarted all four engines and ran things through one more time. The crew did notice a light mist of condensation from the pressurization ducts, but it abated after 60-90 seconds. Since no smoke or fumes were noticed, they proceeded to the runway. During the takeoff roll the crew aborted the sortie and requested fire coverage.

Once the aircraft was cleared by the fire department and towed clear of the taxiways, maintenance went to work. After replacing the Number 1 and 2 tires and brakes (the brakes developed leaks and a fuse plug blew during the abort), maintenance determined that the hydraulic reservoir check valve which failed eight days earlier had leaked fluid into the bleed air ducts. This fluid was not totally removed during the repair and subsequent maintenance engine runs after the check valve change, and the water separator sock was also contaminated with fluid. Bottom line on this incident…bad cleanup after the task. When you complete a task, do you completely clean the work area and any other associated equipment? The job guide for a hydraulic check valve will not tell you to check the water separator sock for contamination, but common sense and/or experience might.

Landing Gear Explodes

A C-5 was on takeoff roll when it experienced a catastrophic nose gear failure. The high-pressure piston on the nose landing gear (NLG) failed and the NLG *separated* from the aircraft. Now we have this somewhat large C-5 on the roll with no nose gear. When the gear exploded, the packing nut and various other internal parts became projectiles, and the force broke the NLG torque link scissors, freeing the NLG piston axle and wheel assembly. The wheel assembly then struck the underside of the aircraft fuselage, the Number 3 main landing gear bogie and the aircraft keel beam, causing additional damage. The force of the failure also threw pieces and parts into the Number 2 engine.

How could a strut explode? The metallurgical analysis found that the high-pressure piston experienced an instantaneous rupture failure due to *over-pressurization*, with no fatigue or latent defects. I don't know about you, but there aren't too many ways a strut can become over-pressurized that I know of. Make sure you read the article in this issue about strut servicing, and make sure you follow the book *every time* you service your struts. ✈

FY02 Flight Mishaps (Oct 01-Jun 02)

24 Class A Mishaps
11 Fatalities
14 Aircraft Destroyed

FY01 Flight Mishaps (Oct 00-Jun 01)

14 Class A Mishaps
5 Fatalities
12 Aircraft Destroyed

14 Oct ♣	An HH-60 crashed into a river while flying a low-level training mission.
17 Oct	An F-16CG was severely damaged following an aborted takeoff.
25 Oct	An F-16C departed the runway after landing.
02 Nov ♣	An MH-53 crashed while performing a mission.
05 Nov ✶	An F101 engine undergoing Test Cell maintenance sustained severe fire damage.
12 Dec ♣	A B-1B crashed into the ocean shortly after takeoff.
21 Dec ♣✶	A C-141B sustained a collapsed wing during ground refueling operations.
30 Dec ♣✶	An RQ-4A Global Hawk unmanned aerial vehicle crashed while returning to base.
08 Jan	A C-17 was damaged during landing.
10 Jan ♣	An F-16C crashed during a surface attack training mission.
10 Jan	An MH-53J crashed during a search and rescue mission.
17 Jan ♣♣	Two A-10As were involved in a mid-air collision. Only one pilot ejected safely.
24 Jan	An MH-53 crashed while performing a mission.
25 Jan ♣✶	An RQ-1 Predator crashed on landing.
31 Jan ♣	A T-37 crashed during a training mission. The two crewmembers suffered fatal injuries.
02 Feb ♣	A C-21 crashed while landing. The two crewmembers suffered fatal injuries.
12 Feb	An F-15 was severely damaged due to an engine fire.
13 Feb ♣	An MC-130P crashed during a mission.
18 Mar	An MH-53 crashed during landing.
20 Mar ♣	An F-16 crashed during a training mission and the pilot did not survive.
10 Apr	A KC-10 experienced FOD damage to an engine. (Upgraded to Class A 08 May 02.)
15 Apr ♣	An F-16 crashed into the sea during a training mission.
22 Apr ✶	An F-22 suffered a birdstrike that severely damaged the right engine.
30 Apr ♣	An F-15C crashed during a test mission. The pilot did not eject.

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13 May	An E-4B experienced damage when the HF wire broke loose and struck the fuselage.
15 May ✶	A B-2 suffered major damage when a main landing gear collapsed.
18 May ✶	An RQ-1 Predator crashed returning from a routine mission.
29 May ♣✶	An F-16CJ crashed during a training sortie.
30 May	An HH-60 crashed during a rescue mission.
12 Jun ♣	An MC-130H crashed shortly after takeoff. Three crewmembers suffered fatal injuries.
27 Jun ♣	An A-10A crashed during a training mission and the pilot did not survive.

- A Class A mishap is defined as one where there is loss of life, injury resulting in permanent total disability, destruction of an AF aircraft, and/or property damage/loss exceeding $1 million.
- These Class A mishap descriptions have been sanitized to protect privilege.
- Unless otherwise stated, all crewmembers successfully ejected/egressed from their aircraft.
- Reflects only USAF military fatalities.
- "♣" Denotes a destroyed aircraft.
- "✶" Denotes a Class A mishap that is of the "non-rate producer" variety. Per AFI 91-204 criteria, only those mishaps categorized as "Flight Mishaps" are used in determining overall Flight Mishap Rates. Non-rate producers include the Class A "Flight-Related," "Flight-Unmanned Vehicle," and "Ground" mishaps that are shown here for information purposes.
- Flight and ground safety statistics are updated frequently and may be viewed at the following web address: http://safety.kirtland.af.mil/AFSC/RDBMS/Flight/stats/statspage.html
- **Current as of 28 Jun 02.**

USAF Photos
Photo Illustration by Dan Harman