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**Wings & Things Guest Lecture Series**

**Battle of Britain: Three Perspectives**

*Author and aviation artist Paul Jacobs examines the Battle of Britain from three perspectives -- historical, aviation technology development and air tactics evolution.*

Paul Jacobs: Thank you. General Hudson, Marsha, members of this museum staff. I would like to say thanks for the opportunity to come and speak to you this evening. This museum has a wonderful portfolio of exhibits, they're very professionally done and they're very informative and always entertaining. And it's always a lot of fun for me to come. I've been back here off and on several times over my career in the Air Force. And it's always good to be back, I do appreciate the invitation.

I want to talk about the Battle of Britain tonight. And this is based on some research I did on a book with Bob Lightsey a few years ago. I'm one of those guys like these Civil War buffs and I'm a guy -- a Battle of Britain buff if you will. And so this is the kind of thing that I like to do. And so there were -- the Battle of Britain is a period in time which I think was really rich in aviation history. There's a lot of beautiful airplanes, a lot of elegant technologies took place at the time, a lot of interesting decisions there. And really significant profound outcome from that. If you're interested in aviation, beautiful airplanes, you've got a lot of that during the course of the battle. I think the thing that has caused me to have the most interest in it is because there is so many innovations that took place during the Battle of Britain. In fact the foundations I think of modern air warfare, a lot of them started right here with the Battle of Britain. You can see there's a number of things -- a number of things here that we still do today. It was the first use of radar and air defenses, ground control intercepts, electronic warfare, incendiary bullets, night radar intercepts. A whole bunch of things that we do now that really had their start there and they were brought to production level quality if you will.

The idea that I got for this book came from three experiences that I had during my time in the Air force. One of them was reading this poem that I'm sure a lot of you have seen, it dates back to the middle ages. And the whole idea of this was that you can have something as insignificant as a nail there and can lead to a chain of events there that can have a really catastrophic result. And this is kind of the foundation of aircraft accident investigation. I had a chance to do a little bit of that in my career. What you always try to find out is what are the cause -- after an aircraft accident happens, what is the chain of events that led up to that thing and where are the places where somebody could have stepped in there and done something different and caused a different outcome? And that's kind of what this poem gets into. The second experience I had was based on the movie Field of Dreams. And Ray Kinsella in that book said "hardly anybody recognizes the most significant moments of their life at the time that they have it." And I always thought that that was pretty interesting. Because if you think about it, most of the time if

you look back over your life, this happened and that sort of turned my life around. And this happened then I either did this or I didn't do that and because of that something in my life took a whole different change. And I think that happens a lot in military history as well as just regular history in general. So that had a profound impact on me.

And then the last one was a conversation I had at a bar at Happy Hour at Edwards Air Force Base a long time ago when I was a Captain. And so we were talking about the -- we were coming out of test file at school. And somebody had said if you find that if you're going at a flight desk, you find this airplane is not very good. And you have this moral responsibility to recommend that the airplane not be brought into service. And so we were kind of talking back and forth and this old Colonel says in I'm paraphrasing here "you may find that what you're testing that what you have there is a lousy piece of crap. And however, what you have to realize is it's probably less lousy piece of crap and the lousier piece of crap that the guys in the field have right now. And so therefore if you give it to them they will probably be able to fight better with it. They'll figure out a way to make it work." He wasn't the most elegant guy that I ran into there in my Air Force career but he had a good point. And I remember thinking, you know that's probably true. The better combat leaders will figure out a way to take the technology that they have and use it to their advantage. And the ones that aren't as good won't quite figure that out.

So based on those three experiences, I thought maybe there's a way to look at the Battle of Britain there because there were so many things that happened at the same time; technology, historical events and developmental tactics. That if you took a look at that and you started with the outcome and you traced it back through there, you might find some very interesting strings where a cause and effect type relationships. And so you might be able to find some very interesting findings with that. So that's what I'd like to talk to you about tonight. First I'll give you the highlights of the historical timeline leading up to the Battle of Britain. And then I'll talk about the technical timeline of the development of technologies and then talk about the tactical development of tactics. And then at the end maybe draw some conclusions and show how they interfaced and how the outcome of that thing happened the way it did.

My view or my thesis here is essentially most outcomes in air warfare or warfare in general are generally the result of some tactic that was used, that was dictated by a technology available at that time. And the technology available at the time was in many cases the result of some political decision or some sort of historic turn of events. And so that's what I'm trying to relate by looking at those three different timelines. Okay, so let's talk about the historical timeline. If you recall from history, back during the end of the First World War, the Treaty of Versailles was a punitive document there. It caused great hardship on Germany because of reparations involved. They weren't allowed to have an Air Force, they had to give up all of the quality aircraft that they had. And so what that did is it generated a lot of economic hardship in Germany, a lot of resentment there. And that allowed Hitler here to rise to power and take over. And so Hitler took over then he tried to use -- take over Europe and also he moves into Czechoslovakia there, the British decide to object. And so Chamberlain meets with him in Munich and he says "okay you can have Czechoslovakia but if you sign this paper and promise not to take any more

countries, we'll be happy with that." So Hitler seized that as a sign of weakness and so he invades the lowlands in Poland and then Germany. And France declared war, oh I'm sorry, France and England declared war on Germany. And so that essentially how World War II started.

And so things don't go good for the British and the French on the continent. And so eventually the British Army gets pushed back to Dunkirk. And so they have 330,000 troops there at Dunkirk. And Herman Goering says instead of having the German wipe out the British army, he says "okay, the German Air Force this is going to be our moment of glory, we're going to destroy the British Army ourselves." So he delays for a few days and that allows this massive boat lift there to bring the most and 300,000 of the 330,000 British troops back and saves the day for England. And so at the same time Hugh Dowding has some hurricane squadrons in France and he realizes I can't just let these things go down with the French because they're not going to make it anyway. So he brings his squadrons back and more importantly his pilots back at that time. And so now at the end -- right here in June of 1940, the British are faced with defending their island. Okay and they're standing by themselves, and so the Germans decide they want to -- if they attack England they have to gain air superiority before the winter comes. Because they can't do a cross channel invasion in harsh weather, winter weather. So they have to have air superiority.

So the criteria for the Germans to win is to gain air superiority and defeat the RAF. The criteria for the RAF to win is to just be alive essentially in the middle of September, and then hope that the Germans won't attack them. So the RAF just has to deny air superiority. So that's kind of what the criteria is for winning and losing. So the Battle of Britain itself essentially takes place in four phases. And the reason it's four phases is because the Germans kept changing their objective which is part of the reason that they led to their downfall. This first phase here was called the Channel Phase and that started in -- generally agreed to have started in 10th of July. The 10th of July was the first hundred plane dog fight over the English Channel. The Germans decided that they would attack the convoys, going back and forth on the English Channel to try to starve them out, and also draw the RAF up and defeat them one-on-one in the air. So that was sort of their strategy for the beginning. So that doesn't go very well for the Germans and so they are unable to draw the RAF up into the sky to fight one-on-one. And so these all culminates in the middle of August here on Adlertag or Eagle Day. Herman Goering says "we're going to force the battle here, we're going to have one big battle and we're going to knock the RAF out for once and for all." And so he had these massive raids, the RAF comes up to meet them. And at the end of the day the RAF has shut down 45 of the Germans and they've only lost 13, so that doesn't go well.

So that begins the next phase which is the Sera Field phase. And so what Goering decides is we're going to attack the RAF at their airfields, try to knock out as many planes as we can on the ground and destroy their airfields. And so that strategy seems to be working pretty good. And they really have the RAF on the ropes and the RAF's feeling pretty bad and they have the single worst day sometime during the August year. But what happens then at the end of this thing is the German aircrew is coming back at night from bombing

in England. And they inadvertently drop a bomb on London. Okay, so that outrage's Churchill. And so what he does -- because up until this point, Berlin and London had not been bombed by anybody. So he sends a bomber, a raid over, and they drop bombs on Berlin. And so that drives Goering and Hitler out of their minds also. Because Goering had made this personal guarantee to Hitler that he wasn't going to allow any bombs to fall on Berlin. So what they do is they decide to change their objective here to London. And so they stopped bombing the airfields, they start bombing London. And that essentially is a bad decision because what happens is it allows Dowding in the RAF there to recover. So they're able to recover their airfields, they were able to recover their support system and get airplanes back in shape, and so they were better able to withstand the raid.

And so that goes on until Battle of Britain Day which is September 15th, that's this massive raids, multiple raids, where the Germans are going to try to one last push to wipeout the RAF once again. And that doesn't go well for them either. At the end of September 15th, the RAF has 60 victories, the Germans had 26. And so when they come back, Hitler decides "okay well this isn't going to work so we're going to postpone the invasion until next year, in the mean time we'll go attack Russia. Because that seems like that must going to be a better idea. What could go wrong there?" So then this last phase is essentially night bombing and the RAF or the Germans decide to just continue bombing one at a night to try to beat them in submission and break their will. So this is the historical timeline and that's kind of what the events were. And the battle really took place for about four months there during the summer.

So let's talk about the technical timeline. Because the technical timeline I think is very interesting. This is -- I'm kind of a right wing guy and a big believer in mind mapping and that thing. And so what I did is I took a look at all the technology that was developed on the British side. And all of the technology that was developed on the German side over the years and try to figure out how they got to where they did when the battle started. So let me talk about that. At the end of war, there're really multiple, technical, innovations that took place from the end of World War I which is essentially when airplanes became weapons to the beginning of the Battle of Britain. Two of these things are key, and I'll just talk about those two. Aircraft and engines were one, and then radar and battle management is the other. So let me talk a little bit about aircraft advances. At the end of World War I, you had hundred horsepower engines on these clumsy wooden fabric airplanes. And so the designer was faced with what can I do with these hundred horsepower engine? Can I get a few extra bullets? Can I get a second gun on there? Maybe two more quarts of gas? The technology development from there up thru the beginning of the Battle of Britain essentially where we had the Merlin engine which is like a squeezing a thousand horsepower engine. And that the designer had a choice of what should I do? Okay, I can put a lot of different things on here. I can put a different prop, I can put a different radio, I can put electronic equipment, I can put more guns and more gas. So the designer evolves from what could I do to what should I do. And that's essentially what happens between the two wars.

Okay, so let me talk about the fighters okay, or the aircraft in either side. So the RAF essentially fought with three fighters, they were in the defensive mode. So these are interceptors. They had the Hurricane here built by Hawker. They had the Spitfire built by Supermarine. And the Defiant built by Boulton Paul. Two of these are really good and very effective. One was not so good and turned out to be a failure. Now it's interesting if you take a look at the three of these how they -- the design philosophy that went into the Hurricane and Spitfire are concepts that we still do today. This was essentially a blend of old and new technology. Hawker decided to take the best of what we have from the bi-plane era and we'll just take some of this modern technology and make their better more effective fighter. And we still do that today. We just take existing designs and try to upgrade them. And the Spitfire was essentially a start from a blank piece of paper, use all the modern technology you have and make the best airplane we can.

So let's talk about the Hurricane, that was designed by Sydney Camm, he worked for the Hawker company. And the Hawker Company put out a theory here. That was the sports car of the 20s and the RAF. It's a very good bi-plane for a good fighter. So what Camm decided was let me just sort of take that and modernize it. And so what he did, here's a picture of the Hurricane here. And the blue, I don't know if you can see it, is an outline of the Fury. And so you can see he just took that same design and just made it a little bit bigger and modernized. And the Fury here was a World War I bi-plane and so its construction was -- the Hurricane's construction was the same. Wooden bulkheads, wooden stringers, maybe an aluminum truss down the middle and then fabric covering, okay. And so here's a good picture of a Hurricane that shows how this is an upgrade. Everything from here back is a World War I bi-plane. And so this is all wood back here and covered with fabric. And so these guys right here working on this thing, from the RAF standpoint, they've already been trained, that everybody knows how to fix wooden fabric airplanes. They've already got supplies, they've already got procedures, they've already got support equipment. So it's pretty cheap to have an airplane like this because half of my force is trained already. Everything from here forward is modern. Okay stressed skin construction, aluminum sheet metal, you got aluminum formers here, you got a retractable landing gear, you got a closed canopy and then eight guns in the wings here, and then a spiffy thousand horsepower engine to go up front. Everybody working on the front half of this airplane have to have new training, they have to have new parts, they have to have new procedures. And so that cost money. So you have a airplane that's cheap to maintain, half of it is cheap to maintain, and half of it is expensive to maintain. So they only can afford to buy more of these because the production and the repair situation is not too bad, and so they do. And so the Battle of Britain is fought with the two-thirds Hurricanes and one-third Spitfires.

So let's take a look at the Spitfire. So here's a picture of the Spitfire, it was designed by R.J. Mitchell, that's this guy here. He's with his buddies here at Flight Line during happy hour I think. And so the Spitfire is a start from a blank sheet of paper. It's all metal, stress skin design. It's got an elliptical wing there which is really efficient aerodynamically. Mitchell was a designer who started with Supermarine. He started working with them during the 20s and so he learned on the seaplanes that the Supermarine Company was built during the 20s. In the 20s, there were these Schneider Cup Trophy races as they

were taken place. And this was a race of seaplanes. And a fellow Frenchman named Schneider decided that the world is two-thirds covered by water, obviously the future of aircraft is seaplanes. And so I'm going to offer up a trophy every year for countries who win that. And if you win that you get to keep it until the next year. If you win it three years in a row, you get to win the trophy outright. And so England, the U.S. and the Italians were participating in the seaplane races every year. And so the Supermarine Company was with the benefit of the RAF was participating and R.J. Mitchell was the guy who was the lead designer on -- excuse me, their seaplane entries.

So here's an example of the Spitfire which evolved from the S-6B which was one of the seaplanes, the Schneider Trophy racers by Supermarine. This is the main spar of the Spitfire wing. So this is the piece that's out there that gives it the most strength, okay. And so when you turned there, it just didn't have to be strong enough so that the wing doesn't break off. So Mitchell's view is "I'll make a bunch of these leaves here, sandwich them all together into this, put a bunch of rivets in there. I'll make one for the top, one for the bottom, and then rivet a bunch of pieces in the middle." Lots of parts, lots of touch labor, lots of jigs and support equipment. Very long time to make, very expensive, very hard to repair. Now in the other side, this thing acts like the leaf spring in a car. And so when you're pulling a lot of G's, the wing can flex there and it won't tear off. And so that's the advantage of this kind of technology. So here's another example, this shows a picture of a Spitfire with the wing taken off. And so what you see here is there has to be some sort of a truss-rigged jig there to hold the airplane. You got to have to have some kind of a tractor and then you have to have some guy whose had special training on how to do this. You could tell by the look on his face, his clearly at special training.

But anyway, so if the airplane comes back, you have to have all these extra equipment. Somebody's got to design this, somebody's got to buy it, somebody's got to procure it, somebody's got to repair and maintain it. So everything about the Spitfire was expensive and complicated. On the other hand, the Spitfire was a 360 mile per hour airplane; the Hurricane was a 310 mile per hour airplane. So you had the trade off of upgrading and limited performance. Upgrading gives you a cheaper design with the race horse high performance, high powered airplane that cost a lot more and so you have fewer of those. So that was the situation with the British. The third one that they used was the Boulton Paul Defiant. This design came out of I'm thinking after World War I of the attacking of bombers. The idea here was we have a pilot up here and we have a gunner in the back here in an electric turret. And so the real problem was -- well actually this designed because some politicians exerted some influence and made the RAF and Defiant's specifications made the RAF buy this airplane. So who would have thought that politicians would force the Air Force to take an airplane that they didn't really want? Because I'm sure this was the only case that that has ever happened. But anyway the bad thing about this was this guy here could spend a lot of time skillfully getting on the tail of an airplane of one airplane. And the guy here in the back with the gun could be using all of his gunnery skills on some other airplane. So there was a lot of problem with crew coordination and ended up -- this airplane is really vulnerable, they took a lot of losses and they pulled them out of the fight about halfway through.

So we got three fighters there. So in the other side of the English Channel, the Luftwaffe fought battle with fighters and bombers, and there were two of them. The ME-109 and the ME-110, both of them designed by Willy Messerschmitt. One of them pretty good, one of them not so good. So this is Willy Messerschmitt here, I think he's at the Nazi company picnic with his buddy here, I think the three-legged race. The Nazi's kind of gave new meaning to three-legged races I think. But anyway, he was a really good designer and so here's the ME-109. And there's a couple of interesting features out here that kind of reveal his design philosophy. Here's the spar, if you remember the wing spar that I showed you on the Spitfire, you can see what this is essentially an I-Beam, a flat piece on the top, a flat piece on the bottom, a shear web. And so it's very strong, it's like members that are on bridges. And so this is cheap to make, cheap to repair and very easy to maintain. And so his view was to maximize that. Now Messerschmitt grew up and learned his design skills during the glider technology days of the RAF. After the First World War all the RAF was allowed to do -- I'm sorry, the Luftwaffe, all the Luftwaffe was allowed to do was have glider technology. That was the only aviation outlet for people because they weren't allowed to have an Air Force. And so you could see some glider influenced here; his got the long thin wing, his got the narrow small landing gear here. And so the wing -- about the only thing you could put in the early versions of that was bullets. You couldn't put a lot of gas in there and you couldn't put a lot of hardware for the landing gear.

Let's take a look at this, in this next picture I'll show you this firewall here. His approach was kind of interesting. This is the firewall in the front, and so what he does is he attaches the landing gear to the front, he attaches the engine, he puts the cannons in the front, he puts the machine guns up there. So everything is attached to this. Now the downside of that is the landing gear is very narrow and so it makes it hard to handle on the ground. So he lost a lot of these in training accidents and landing accidents. The positive side of that is shown here. This airplane comes back, there's something wrong with the wing and they have to pull it off and replace it, there's no extra equipment required to be able to service this thing. This thing could sit on its own landing gear and so you could move this down the flight line and maybe do some work on the engine while the wing was made fixed. So this kind of a design philosophy was much more manageable, much more maintainable, much more economically feasible to have. And so they bought a lot of these and they had a lot during the war.

Okay. This was the other fighter they had, the ME-110. And the idea here was a multi role fighter. And so what the Germans decided to do is let's combine and attack the aircraft and a fighter in one. In many cases when you do that it sounds good on paper, it sounds good when you say it fast. But what you really have is an airplane that could do two missions poorly as opposed to one that can do one really well and another that can do the other one really well. So the -- let me talk about this first. So the 110 was essentially started out as an escort fighter. It performed so poorly that eventually it had to be escorted by the escorts, and so that one wasn't very good. And that didn't go over well with the guys flying these when they were assigned to protect those guys. So this cartoon captures the bombers. The Germans also had fought this with a fleet of bombers. And so

here's a couple of significant events that happened in the bomber and the technical development of bombers with the Germans.

In the 30s, the Cleveland Air Races were being held in Cleveland obviously. But Ernst Udet was a fighter pilot who was friends with Goering during the First World War. After the First World War he was doing barn storming, going around the world and trying to make a living that way. So he goes to the 1931 air races and Al Williams has this Curtiss Gulfhawk and he's doing dive bombing demonstrations that's kind of halftime entertainment. And so Udet sees that and that makes a huge impact on him. It's like that can tell a moment when some major event in your life happens. But Udet is aware of it. And so he decides that's the way to go for bombing. Because up until this time bombing was fly at high altitude, look at the target, drop a couple of bombs and hope that the wind and the ballistics there don't blow the bomb too far off the target. And so it wasn't very accurate. The dive bombing would fly straight at the target and then you pull out at the last minute and then so there isn't much of a chance for the bomb to waiver off course. And so Udet, that makes a big impression on him. And so he eventually becomes the chief of R&D or technical development in the Luftwaffe because he and Goering are friends. Goering decides he's got a job for them. And so he essentially develops the JU-87 which was a good dive bomber for the Blitzkrieg tactics but it wasn't very good. It was slow, it was vulnerable, and eventually had to be grounded. But they thanked a lot of money in going JU-87s.

Now the other significant event that happens is the first Germany chief of staff is Walter Weber. And he is a very capable general. And so that he understands, he's a forward thinking guy, and he says "okay we got to have big bombers, long range, if we want to project power." So he starts these two four-engine bomber programs, the DO-19 and the JU-89. And those are going along pretty good, but Weber is one of these guys who likes to fly and he likes to travel around. He likes to fly himself if he's going to go somewhere. So he's on a meeting, he's a hurry to get to the next meeting in 1936. And so he doesn't follow the checklist to this airplane or he sort of looks at it very quickly and he forgets the step to take the aileron locks of the wings before you take off. So he gets to the end of the runway and he has no control and he crashes that he kills himself. And so that's a bad deal for the Germans because Erhard Milch is out of town. Erhard Milch is the Nazi party member for Air. He's an advocate of four-engine bombers too. But he's out traveling somewhere and so Albert Kesselring replaces Webber. Kesselring is a World War I cavalry officer and his view is that airplanes are just horses okay with motors on them. And so we need two engine bombers, and this four-engine bomber is too expensive and we don't need those. He has a conversation with Goering and he agreed that the Fuhrer is not going to ask how big our bombers are, his going to ask how many we have. And so what Kesselring does is he cancels these two. And starts developing two-engine bombers, okay and so the Dornier DO-17, HE-111 and JU-88 are the ones that go into production that the Germans fight that battle with.

This one is called the Flying Pencil, because of that long narrow fuselage. Any bomber that's called the Flying Pencil is probably not big enough or can't carry a big enough payload there do any damage. And so that's what's really the problem is, they're slow and



the range limited, and they can't carry enough of a payload to be effective. Furthermore, Udet tells these guys I want you to design in almost after the fact, a dive bombing capability. And so what that really means for Heinkel is I have to make the airplane that I have stronger which means less fuel and less payload. So he takes a reasonably decent airplane and makes it worse by his being enamored here with the dive bombing.

Okay, so let's talk about radar or early warning. The story on radar here kind of starts back here around the turn of the century. Somebody realized that if a ship goes by and I'm listening to music on the radio, the music gets interrupted for a second. And so that led to some people realizing that okay maybe we can do something with radar waves in a weapon area. And so what the British do is they put together a group of really smart guys led by Lord Tizard. And they put this committee together to try to come up with a "death ray,, today we call it a Directed Energy Weapon. But they realized very quickly there isn't enough power so we can't have a death ray but maybe we can use radar to find airplanes and that might be useful. And so what they do is they conduct an experiment here where they take a Hafer bomber out, they fly, and low and behold they can find this bomber. And so that leads to the development of radar. And the reason that that happens and here's one of those can "tell a moments." Hugh Dowding, the guy who eventually becomes Chief of Staff of the fighter command -- or Air Marshall Fighter Command, he's the doing a tour of duty here as the air member for R&D. And so he understands that this stuff is a big deal when it happens. And so he funds the development of radar and pushes it. And that's probably the most significant thing. Because it's one thing to understand technology but to put money to it and do some experiments and follow through as another.

So they set up some experiments here at Biggin Hill, which is an airfield there in the south of England. So they set up a tower, they set up a command center and then telephone lines to the squadrons. And so the bombers or the targets come in, they're detected by the radar, the people in the command center figure out "okay that squadron is the closest and say launch them to intercept it." And those experiments go very well. And so what happens is that the RAF commits to a chain of radars. Okay, so they have a netted air defense system. And so this is kind of a cartoon of England here in the English Channel. And so a whole bunch of this chain home system, radar system is set-up along the coast line. And they organize in groups and they have airfields and sectors for each one. And so they set up a system so that when attackers are coming across, they can find them and they can get the closest squadrons to engage. And so that's the significant event with -- excuse me let me take a sip here. And so that's the significant technology and the story with radar and battle management.

So let's take a -- let's switch now to the tactical timeline. Okay, so the tactical timeline is different. That essentially goes from World War I, fairly primitive tactics, to the Battle of Britain where things are happening a lot quicker. So at the end of World War I, the British came out of that and their basic fighter formation was the Vic or the Three-Ship. That was largely driven because of technology considerations. They didn't have radios in airplanes. And so the wingmen had to be positioned so that they could see the leader because all of communication was being done with hand and arm signals. So the Three-

Ship Vic is the basic formation that evolves out of World War I. Another tactic that evolved out of World War I was the Lufbery Circle. So Raoul Lufbery was the Captain in the U.S. Air Force or Air Corps or Air Service I guess it was called. Anyway he decided that if you're -- he comes up with this idea that if you're being attacked and you need to go to a defensive position, everybody get in the line and then just fly in a circle. And that way if somebody comes on your tail, this guy coming around behind will be able to get on his tail. So that's a good way to defend. So that becomes a basic tactic also. On the German side, Oswald Boelcke is the guy who comes up with the first effort to capture best practices for air warfare. And so he comes up with what he called Dicta Boelcke and that says some things like always fly together, be aggressive, come in out of the sun, fly with another guy so you can mutually support each other and some basic ideas. Unfortunately he gets killed during World War I so he can't really develop that too much more.

So we go through the post warfare at the end of World War I to the beginning of World War II. And the RAF isn't really doing much, they're kind of trading water during that period of time because of peace reigns. But on the other side of the English Channel, the Germans are building an Air Force and they are developing an army and so they decided they want to have a practice war in Spain. Because they got the Spanish Civil War going on down here in 1936. So they sent all their troops down there and try out some tactics. And so what they did is they developed Blitzkrieg tactics during the Spanish Civil War. And the air piece of that had a number of ideas. Rapid troop transport, so we'll take troops from here to there by airplane instead of having them march. We'll use close air support tactics, so when the enemy is up here close to the front lines, our airplanes will be close to them and they will attack the enemy that's engaged there. We'll attack the rear areas with our aircraft so that they can't reinforce or re-supply. But the most important thing I think or one of the most significant things that come out of the Spanish Civil War is this Schwarmm or finger-four formation. Werner Molders was one of the only pilots down there in the Condor Legion. And he realized that this Three-Ship Vic thing wasn't going to cut it there, it wasn't the most efficient way to deploy. And so his view was let's fly in formations of four and we'll shape -- and we'll position them like the tips of a finger, two two-ships. Okay, so there'll be a leader and a wingman, and a leader and a wingman. And this guy will do the shooting and he'll protect him, and this guy will do the shooting and he'll protect it. And so that becomes the standard fighter formation for the Luftwaffe. And then eventually the British, and in fact everybody, figures that out eventually.

With regard of the bombing, the Germans used what they called "Crocodile Tactics." And so that was lining the bombers up in rows of three or five in a long line which sort of resembled the crocodile. When you see all these green airplanes there with all these lumps on them. And so the idea was fly close together so that you guns, everybody's guns could mutually support each other. And when you drop the bombs they'd all fall at the same place and do a lot more damage. So the British understood that the crocodile tactics were pretty formative. The aircraft that they were using had armor in the back of the pilots and around the engines. And so they couldn't attack very effectively from the rear, but they could attack from the front. And wait let me back up here, sorry. I'll figure out

how to use this in a second. So what the British decide is if I attack them in the front there, there is less armor. Since I'm facing a guy eyeball-to-eyeball there's a good chance in here I could be more effective with my gunfire or I might be causing panic and break up the formations. The other tactic that evolved here at the beginning of the battle was Lufbery Circle. The one tenths became -- they realized that they were vulnerable and so oftentimes they will go out on this escort mission and end up flying in Lufbery Circles to protect themselves. What the Hurricanes did is they realized that we can't attack them from the rear but we can dive on them. Come down take a few shots, go under the circle and then come back up, take a few shots and go up and down. And so what they did was kind of translate it into a corkscrew. They called that "Corkscrew Tactics," where you're diving and going back up all the way around the circle.

The one tactic or the one element not really a tactic that caused a lot of problems here or I think was a missed opportunity was the use of drop tanks. Okay this was an HE-51 that was used during the Spanish Civil War and they realized it was range limited so they developed drop tanks to put on this to extend the range. So the Germans had drop tanks at the beginning of the Battle of Britain but they just never bother to use them and there isn't any real good reason why they never did that. So here's a picture of an HE-111 and you can see that this is all glass up front and the engines are pretty much exposed here. So they attack from the front, it's going to take a lot of courage on this guys behalf to watch a guy come in right at him with eight machine guns and just keep charging forward.

Okay, so let me talk a little about some of the tactics that evolved during the course of the battle, during the three months there. The RAF at the beginning at Dunkirk decided to deploy in large rings. And so they would send everybody out at the same time, lots of fire power with the idea of doing a lot of damage. The downside of that is everybody runs out of gas at the same time and so they have to go back at the same time and Luftwaffe is sitting there looking "okay there's nobody in the air, let's attack now." And so they attacked during the gaps, that's a lesson that we just never learn. Okay that happened in Vietnam and it happened as late as Bosnia. Where the enemy figured out if you're going to fly at the same time everyday and go out and then come home, and leave gaps in protection, that's where we'll take advantage of that. In Vietnam you had the thinking there that okay there's a 7 o'clock go, and 11 o'clock go, a 2 o'clock - go. So if I wait I can move my people or my trucks around there at 9 o'clock and 12 o'clock and 3 o'clock. And that lesson for some reason or another was first learned during the Battle of Britain still hasn't registered in a lot of cases.

Sailor Milan was a prominent fighter pilot at the RAF and he's the guy who figured out that okay this Three-Ship thing isn't working so I'm going to switch the figure-four also. And so the RAF eventually moved over to that Schwarmm or figure-four formation also. Milan published his ten rules for air fighting. And so he captured some ideas in there that are still used today. Come in high, harmonize your guns at 200 or 400 meters, or yards, so that you're all pinning at the same place at the same time. Don't fly straight level for more than 30 seconds at the time when you're in the combat area, you need to be weaving. Be aggressive, stay above the enemy, come in out of sun and so forth. And so

the ten rules for air fighting are kind of a formalized way to be able to conduct operations. Okay, Keith Park was the commander of 11th Group in the south. And so he realized the Hurricane is a real stable gun platform but it's not all that fast. The Spitfire is not quite a stable gun platform but it's a lot faster and a lot more maneuverable. So he assigned the Hurricanes to attack the bombers and the Spitfires to attack the 109s. And so that was an adaptation of limited technology to a tactical situation. The Germans did realize later in war that they could -- that radar there was having some sort of an effect and so they could come in at low level. And if they did that they could a lot times not be detected by the radar. So coming in low level, under the radar was something the Germans tried there during the Battle of Britain for the first time.

The last major tactical issue there had to do with this "big wing" concept. The two groups that were fighting for the RAF was 11th Group in the south which is closest to the battle and then 12th Group which was in the north. 12th Group was led by Lee Mallory and 11th Group was led by Park. Park's view was to ditch your squadrons in the air and attack as soon as you can and try to prevent the bombers from getting their targets. Lee Mallory's view was take the time to form up in large and big wings and then attack in mass. And if you have to get them on the way out after they have dropped the bombs that's okay. They will just don't want to have that bomber to come back the next day. That became a politically charged episode if you will. And it involved people like Douglas Bader. Douglas Bader was this heroic character in Lee Mallory's group who had lost both legs in an aircraft accident in the 20s and thru sheer willpower got artificial legs and then talked his way back into the RAF and became a squadron leader there. And he was a big wing advocate. There were also a couple of members of parliament in the squadron, I think like Captain-level officers who decided to pull a few political cards. And so there was a big tactics meeting essentially well they hashed out this big wing theory. In the end, Lee Mallory prevailed there, he managed to outmaneuver Park and Park was sort of cast aside at the end of the war and Lee Mallory became the Commander in Chief of the fighter command.

Okay, so we've talked about the historical timeline, the technical timeline and the tactical timeline. So let's take a look now, I think it'll be a lot of fun, I think it's very interesting to take a look at how strings of events happen that interwove those three timelines and resulted in the outcome. And if you recall, I think that there's a lot of places where we kind find that these outcomes are dictated by tactics. Which were dictated by technology and the result of political decisions. So there's two ways to look at how the Battle of Britain ultimately turned out with the RAF winning. One of them is to consider why did the British win and another is to consider why did the Germans lose. The answer to that is not necessarily the same. So what I did is I tried to trace from Hitler making this decision not to invade England or to postpone it. All the reasons why and how that happened and what were the interactions that caused that -- what was the chain of events? And where are there places where somebody could have made a different decision or just by the luck of the draw something could have turned out differently. And there's so much interesting points there. So let me talk about a couple of those.

Let's consider why they RAF won the Battle of Britain. Two of the keys I think are they had effective use of the limited number of fighters that they had. And they had effective interceptors to fight with. So let's take a look at that effective use of the fighters that they had. In other words, they had limited number of airplanes but because of that radar network they had, every airplane could be committed to battle and could have a high degree of probability of finding an attacker and having success with them. Because if they hadn't have the RAF or hadn't have the chain home network setup, the RAF would have had put patrols up in the air, wandering around just hoping that they stumbled across a bomber. And they probably would have missed it most of the time or they would not have had enough airplanes to go around. The reason that the RAF had was able to do effective use of the limited number of airplanes is because they had early warning. They had an early warning because they developed and fielded radar. One of the places where that could have taken a better turn for the Germans was in 1939, they loaded up a Zeppelin with electronic gear and they saw these structures being built on the coast. And they flew over there and they tried to figure out what frequency these guys were operating on to try to get an idea of what those structures were. They were unable to find the frequency that they operating on which is like 20 megahertz which is 20 to 50 megahertz which is fairly low. So the Zeppelin comes back and said hey we couldn't find it. So the best and brightest over there decided that those towers or air tracking control towers probably just to keep people from managing the traffic pattern. So the Germans didn't realize that this netted air defense system was a formative weapon. All of that was a result of the success of these experiments, success with the technology, putting together a group of smart guys to try to figure out how we can exploit that technology. And this one was I think the key there.

Dowding, before he became Commander in Chief of the fighter commander, was smart enough to recognize critical technology at the time that he saw it and do something about it. So you could make an argument that the Battle of Britain was won because if you walk all the way back through here, is because some guy got mad because his radio music was being interfered with when a ship went by back in 1905 or 1906. Okay, so let me talk a little about having enough fighters. One of the reasons that the Germans had, or the RAF had enough fighters are, there're several reasons. One of them was the Luftwaffe stopped bombing factories and so production was maintained. They stopped bombing factories essentially because the Germans switched targets. The Germans switched targets ultimately because some guy dropped a bomb on London early on the battle or in the middle of the battle. And he did that because he had an inadequate bombsite for conducting night bombing operations. So there's a place where technology led to a mistake, a mistake led to a emotional reaction, an emotional reaction led to a change in tactics and strategy and the house of cards came rumbling down.

The other one was the RAF had capable fighters to prosecute that war with. The reason they did if you look at that chain of events they had the Spitfire and the Hurricane. Both of those were available because advance fighter technology was available. One part of that was the Merlin engine. And the Merlin engine and the Spitfire both descended from the S-6B which won the 1931 Schneider Trophy Race. The 1931 Schneider Trophy Race and the S-6B only occurred because just prior to that the Schneider Trophy Race is like

the Daytona 500 for cars. And so just prior to that the RAF was deciding okay this cost us a lot of money, I think we had to drop out of it and spend the money somewhere else. Lady Houston was a widow of a shipping magnate who was a millionaire and she thought the RAF was pretty cool and these Schneider Trophy Races were pretty impressive. And so she said rather than have the RAF drop out I'll give you 100,000 pounds so you guys can go ahead and enter the race next year. Just step forward, just thought it was a good idea. So there's one of those I can tell a moments where somebody -- one of the most significant events in maybe that whole battle just happens. And a lot of people just weren't aware of that. She did that because Britain had had success with the Schneider Trophy Races. The Schneider Trophy Races were there to develop technology because essentially the world was two-thirds covered by water. So the RAF won the Battle of Britain because the world was two-thirds covered by water. Another argument you can make.

Okay, so let's talk about why the Germans lost. Okay, and they really there's a number of interactions here that led to that. And there are really two reasons. Poor leadership was one of them and the poor leadership essentially caused one bad decision after another after another to be made. And all of those cascaded into a poor outcome for the Germans. The other one was inadequate fighters. The 109 was pretty good but it was inadequate for the mission it was being used for. So let's talk about that poor leadership chain first of all. The poor leadership was essentially resulted in a number of bad decisions, one of them was they didn't understand what a netted air defense system could do. And they stopped bombing the radar sites. And part of the reason they stopped bombing the radar sites is because they kept switching targets. You know from convoys, to the airfields, to London. And they did that because they didn't have a good strategy for attacking Britain at the beginning of the war. They were just sort of making it up as they went. And that's an indicator of poor leadership. The reason they had poor leadership is because the Luftwaffe was formed before people making decisions, Goering, Udet, Kesselring and Walther Weber. Of the four, the only really capable guy was Weber and he managed to get himself killed in 1936. So you have these three guys who are just not up to the task at leadership positions making bad decisions. Part of those bad decisions including poor materiel decisions. Okay, Udet having this dive bombing thing impressed on him from the 1931 Cleveland Air Races decides dive bombing is the way to go. Kesselring, completely misunderstanding the importance of four-engine bombers and decided to kill that program and go ahead with the two-engine bombers.

And so all of that was a result of Hitler coming into power and bringing his buddy Goering in there to run the Air Force, and Goering bringing his World War I Ace Udet along with him. So that chain of events you could see how that traces all the way back to the Treaty of Versailles and having bad leadership in position to make bad decisions. The other one was inadequate aircraft. The Germans lost because they had unacceptable losses to the bomber fleet. They had unacceptable losses because the bombers they were fighting with had light pay loads and they would go over and drop bombs on the target but have to back again and again. And so if you have more -- you'd like to be able to go over there, drop bombs and target one time, take that target out. If you have to do it multiple times, you're putting yourself in harm's way and eventually the law of averages

is going to catch up with you. So the two-engine bombers were essentially not up to that task. They also had inadequate fighter escort because the 109s were range limited. They're range limited because Messerschmitt designed them the way he did heavily influenced by glider technology and a failure to use drop tanks. They were led down that path because they had success with the Blitzkrieg tactics which is essentially close land warfare. And that gave the Germans a small sense that the Air Force was configured to be able to be successful. Because it was successful in Poland and Spain that it would be successful in England and that was a different kind of a war and they were fighting over with different kinds of weapons.

And all of that was essentially could be traced back to the Treaty of Versailles with no Air Force and limited technology and of course Hitler coming to power. Okay, so there's two kind of two conclusions that I -- two significant conclusions I think come out of all this. We take a look at the three timelines and take a look at how those things interact with each other, and see what that chain of events is even if you pull on that thread in many cases it goes way back. It goes all the way back to the World War I era where you find that nail that came out of the horseshoe. And in some cases that's a very small nail. And some things happened that some people realized and some people didn't. I think that two of this most significant conclusions to me were you have to have leaders to be successful. You have to have leaders in the military who recognize critical technology when they see it and they act upon it. And then they act upon it by funding it and pushing and advocating programs. The Luftwaffe did not have that and the RAF did have that. We also have to have leaders in place that can understand technology and how to adapt their tactics to that. So if you have some technology that's limited, don't put it in a position where it will cause you to fail. If you have some parts of your technology that is strong like the Hurricanes and the bombers, use that technology with the tactics that will give them the best chance to succeed. So I think those are the two conclusions there.

I do appreciate you paying attention and everybody staying for the whole time and not walking out. If you have any questions, I would be more than happy to answer those and if not, I would be also willing to stay afterwards and chat a little bit about the subject. It's an exciting subject and I am always thrilled to have the opportunity to talk about. Thank you.

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