Transcript of the

Joint FAA/Industry Symposium

on

Level B Airplane Simulator Aeromodel Validation Requirements

To the Memory of Daryl Schueler

Part 6 of 7

Transcript of Day 2

Washington Dulles Airport Hilton
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Transcript of Day 2

MR. LONGRIDGE: We are going to continue with the tables.[1] Hopefully we will get through the tables today. We will get through the tables today, and once we do that, I want to open it up to some of the broader concerns. And this is really a rare opportunity for a select group of people to make input to the FAA on perhaps ideas that you might have on how we can do things better outside of specifically the tables, and I'd like to open it up to discussion in that area later this afternoon. Okay, Ed [Boothe]?

MR. BOOTHE: Let me put my administrative and logistics hat on for just a moment. If you would be kind enough to pull your original ticket receipt like this, and I'm going to give them to Judith [Bürki-Cohen] who has kindly offered to get them copied for me at break, so that I can submit an invoice to get some money and you can submit an invoice to me and, like we said yesterday, probably about a 60-day time constant. I'm sorry about that, that seems to be the way, what do they say, the epoxy oils the wheels of the bureaucracy or something like that. If you would pass the tickets around to Judith I would appreciate it.

If for some reason you don't have it now, please get it at break time because it's the only way that we can reimburse you.

Yesterday I think we got up past--did we resolve the engine issues and we are happy with them?

MR. LONGRIDGE: You were in the static control.

MR. BOOTHE: Okay, static control. I don't think we were quite through the controls, we didn't go through it all piece by piece. We stopped, we got through wheel and pedal position saying that those would be the same as column position for anything here.

And the next is nosewheel steering. I've made a suggestion here but if I could get your input on it. I've even suggested using the training device Advisory Circular to simplify this and I think you can measure break-out force with a hand held gauge, fish scale type thing, and then you could even measure the force for a bit after that. Carefully. And once you are out of break-out and trying to force gradient I think the rest could probably be predicted with sufficient accuracy.

But you tell me. I haven't built one of these, you see, so I'm just making a suggestion for your filling in the blanks here. That's 2.a.(4) on page 6. Everybody must like it.

MR. LONGRIDGE: Good. We are going to get through this in a hurry.

MR. BAILLIE: It's not a trivial thing to do but it's probably good enough.

MR. BOOTHE: Yes, I don't think it's trivial, I think it's probably going to take a learning curve till you figure out how to get it right, but I think it can be done without laying on layers of

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[1]The final tables resulting from the Symposium can be found in Part 7 - Appendix: Longridge, T., Ray, P., Boothe, E., & Bürki-Cohen, J. (1996). Initiative towards more affordable flight simulators for U.S. commuter airline training. *Royal Aeronautical Society Conference on Training - Lowering the Cost, Maintaining the Fidelity* (pp. 2.1-2.17), London, UK *(Appendix.pdf)*.

instrumentation. Frankly, I think the break-out and the beginning of the force gradient are the most important parts. Okay. We will just check that one.

MR. BAILLIE: What happens if it's a mechanical--is there such a thing as a mechanical tiller which the forces would change versus taxi speed and are tremendously nonimportant when you are sitting stationary?

MR. BOOTHE: Well, how does one normally do that? I would strongly suspect that one would base a simulator design on airplane design data there and just get a calibration point or two. Is that an erroneous assumption?

MR. DAVIS: I think that's a pretty fair statement. Then again it's something we are not addressing at Level B, it's an interesting point but if we want to include that in the discussion today, I don't know. We are not addressing it beyond this level, so maybe we should leave it at that.

MR. BAILLIE: Do most Level D simulators have mechanical connections?

MR. DAVIS: I'm not sure. Not that I'm aware of. But I'm not sure.

MR. WILLMOTT: A lot of these aircraft types that we are talking about do have a bungie that connects between the pedals and the nosewheel and its pedal forces that you get are a dynamic process, depends on the speed, depends on the forces on the nose tire which you build into the model.

When you test it when the airplane is static you really have got a very, very strong resisting torque that you are trying to twist the tire and normally can't move it very much. And often the test is additionally done on a grease plate so that you can get the basic relationship between the pedal and the nosewheel deflection. And then at speed, usually from the nosewheel response tests, they are done at a couple of speeds, and you get the dynamics of how it moves and the forces involved with that from those two things.

MR. WILLMOTT: It's quite complicated.

MR. STOCKING: The torque on the nosewheel is quite predictable. It's a mechanical equation, if you will. When you are generating a side force on the tire, you have got a moment arm that is measurable when you are in the hangar, most of the mechanical and pneumatic trail is predictable. You can calculate real close exactly what the torque is on the tire.

You feed that into your model and you can generate or know what the forces are on that mechanical tiller with a reasonable degree of certainty.

MR. BOOTHE: If we can do that with a reasonable degree of certainty for an airplane in the class we are talking about and keeping in mind a Level B simulator, do we need to do more? I mean, because Stuart [Willmott] outlined a fairly sophisticated data acquisition scheme which I think would apply to a Level D, probably a Level C simulator, but at this level do we need to go to that length? Can we just use what Chuck [Stocking] has suggested and make a couple of measurements, simplify the measurements?

MR. STOCKING: The decision maybe is to whether you want to make a dynamic loop out of it. That is the biggest shortcut, once you make it a dynamic loop you have to have in the simulator something to feed that force back, that's the biggest cost decision as to whether this class of aircraft, if you really want that honest of a tiller.

MR. WILLMOTT: I think for the purposes of doing your V_1 cuts, you were putting quite a high emphasis on that yesterday, you need to model those forces well. But I think from, probably from the ground static test on the grease plate and knowing what the forces are on the tires, which there are very good models for these days, as Chuck [Stocking] says, it's based on the arm of where the contact is between the nosewheel and the ground, and the point about which [the] nosewheel turns, and there are fairly good numbers that you can get for that and models for generation of the side force on the side.

MR. BOOTHE: So we have progressed to rudder pedals, I think, from what you are saying.

MR. WILLMOTT: I'm sorry, did I hop?

MR. STOCKING: Either way you have torque feedback from the wheel to feed the rudder pedal or the tiller.

MR. SMITH: Most tillers like the ones I have seen in the ATGs recently, the tiller basically has a break-out force and hardly any gradient to it. The rudder pedal steering, the inspectors really, subjectively that's something they squawk a lot if they don't think it's fairly representative of the airplane because it's, like you say, it's pretty noticeable.

MR. BOOTHE: I'm not suggesting it not be represented, I'm just suggesting maybe we could use the airplane design data to limit the testing. I've still got, we would have to measure some pedal force or some break-out force on the wheel. If you have got a powered system there is a flat gradient but if you have a mechanical one it's usually not so flat.

MR. SMITH: Yes.

MR. BOOTHE: So is what we have here adequate, I guess is the question?

MR. BAKER: A lot of these mechanical steer airplanes don't steer very well, they are pretty heavy so the tendency is most pilots have to thrust to steer these things, I hope that's in the equation somewhere.

MR. BOOTHE: Yes, it should be in the model.

MR. TOULA: They also vary from plane to plane, same model.

MR. BAKER: That's true.

MR. WILLMOTT: Back talking about the tiller.

MR. BOOTHE: I think we are mixing tiller and rudder.

MR. WILLMOTT: I don't know of an airplane that has a variable force on the tiller. I think it's a fixed force. With the tiller you are usually controlling it electrically.

MR. BOOTHE: In which case all you have to do is work the tiller and close the loop.

MR. WILLMOTT: It sometimes produces a different nosewheel, like the Lears at low speed, you get 55 degrees with a full tiller input as the speed profile. You put it in a computer and at high speed it's eight degrees, it doesn't affect the forces on the handle.

MR. BOOTHE: From a perspective of validating the simulator, for the nosewheel steering we just have a hand held force gauge to measure simple things like break-out force and the beginnings of the force gradient, relying otherwise on design data or prediction, and likewise with the rudder pedal, force pads on the pedals and otherwise design data. Is that going to be good enough for Level B?

MR. KOHLMAN: *(Nodding affirmative.)*

MR. BOOTHE: Considering I've got some affirmatives on this side.

MR. BAILLIE: With force pads you are also going to have to measure with pedal position.

MR. BOOTHE: Yes. That's true. I'm going to leave that one, then, for the moment and--these are always subject to reconsideration if you have more thoughts about them. But in the interest of time I think we don't want to dwell too long, so we will press on and we can always come back.

The next thing I think is not even worth mentioning, it's just a calculated value, it's like that from [Levels] A to D, and not worth spending time on here.

MR. WILLMOTT: That's item 6?

MR. BOOTHE: 2.a.(6), yes.

MR. WILLMOTT: Some of the aircraft don't have a calibration in the cockpit, like the Cessnas, they just have a little white band they put in for takeoff, so you have to put some sort of a tape or something like that in the cockpit to check that it's on the right places in extremes.

MR. BOOTHE: I don't think we need to specify that.

MR. WILLMOTT: No.

MR. BOOTHE: As long as there is a reference installed that can be used. All right.

Power lever versus engine indication. In fact I've suggested here doing just what Stu [Willmott] said for the trim, is make a scale to put on a throttle quadrant with the reference so that you can repeat, and since this is really a series of steady state events, I don't see why you couldn't make a scale for a throttle quadrant and then use a video to read engine instruments at various settings and put it together from there.

MR. BAILLIE: Do you even need a video?

MR. SMITH: You could record it.

MR. BOOTHE: If you want to record it on your knee.

MR. SMITH: If you want steady state.

MR. BOOTHE: I think everybody has a video. Except mine, every time I use it something happens.

MR. BAILLIE: I don't know who I was telling but I personally have problems with videos because most the time the lighting is bad or you can't read the scale, especially if you don't get to inspect the video until after you have done the flight.

MR. WILLMOTT: We have found you have to rehearse that in a simulator so you can see what area you can photograph and then have it when you are playing it back to a high resolution so that you can read it. We have used a Super 8 for that, doing engine stuff and it works okay.

MR. BOOTHE: I will just add there hand record steady state engine readings because all we are doing is a series of steady states, I think that's sufficient for an answer.

MR. WILLMOTT: The comment that I would have with that, Ed [Boothe], is that we probably need to do it for all three levers for prop aircraft, the throttle for the engine, the propeller and also the mixture control. I'm sorry. I don't mean mixture control.

MR. BOOTHE: I was going to say, I haven't seen one of those for a long time on a turbo prop.

MR. WILLMOTT: The condition levers.

MR. BOOTHE: Condition levers, yes.

MR. WILLMOTT: And also there is not usually design data for that. We have got in the column here aircraft design data. I don't think there is any for that.

MR. STOCKING: Or maintenance manuals, sometimes.

MR. BOOTHE: Surely somebody had to specify to design this linkage.

MR. WILLMOTT: You would think so.

MR. SCHUELER: But it doesn't relate to engine parameters.

MR. BOOTHE: Did some mechanic just go in the shop and do a fitting and make all the parts like that?

So what shall I put in that, maintenance manual, that would relate to engine power settings.

MR. STOCKING: It doesn't really relate to power settings.

MR. WILLMOTT: It may give you travel for each of the levers and what you have to make them when you are rerigging the engine or something, but it will not give you the parameters versus the position.

MR. BOOTHE: Usually fuel control has some sort of a reference gadget on it so there is a correlation between a power lever position and something on the fuel control, is there not? I know in some airplanes there is.

MR. WILLMOTT: The fuel control has a low idle and a high idle, usually, and you can usually relate that to the engine, but again--

MR. BOOTHE: There has to be a way--

MR. WILLMOTT: --how do you define the idle airplane, the idle conditions are not specified in terms of the exact torques.

MR. SCHUELER: There may be rigging points but that will be minimal, two, three points.

MR. BAKER: A lot of this depends on the engine and air frame you are looking at. There are two lever systems, three lever systems, fixed shaft engines are usually different than free turbines. You can take some condition levers and you can have a takeoff position which is typical on a Garrett like 97 percent rpm on the ground, 100 percent in flight, those are pretty well defined but it varies from engine to engine.

You have to look at individual circumstances as far as position. But on a basic power lever, unless you have got a FADEC control, or something--

MR. SCHUELER: There are no flats.

MR. BAKER: --all you have is flight idle, some have ground, some have flight idle, some have idles, it varies.

MR. SCHUELER: This is an easy test to do. We can do it with a knee board for Level D, it ought to be acceptable for--

MR. BOOTHE: We will scratch aircraft design data, since I'm told it doesn't exist, and add hand held steady state engine readings.

I guess we need to note it would also apply to other levers that control the engine.

MR. BAKER: As somebody stated earlier, jets are easier. You don't have many levers.

MR. BOOTHE: You know, I remember going to ground school on the Convair with the Allison engines, and there was--it was a coordinator on the fuel control, they beat that into my head so strongly, I guess I figured most fuel controls must have something like that. I never did understand it but they kept beating on it.

MR. WILLMOTT: I've never worked on a piston engine and I guess this class of aircraft we are also talking about piston engines.

MR. BAKER: No, not for this task I don't think.

MR. LEISTER: 421.

MR. BAKER: 421 is not a ten place [passenger seats].

MR. WILLMOTT: There are 50 DC-3 aircraft in regional carrier operation.

MR. RAY: We are not addressing those particular category of aircraft, the standards that apply to Level B would apply to any, whether it's a 727 or DC-3.

MR. WILLMOTT: I wondered if anybody worked on a piston and whether there was anything different with those things that perhaps should be included.

MR. LEISTER: Nothing different, they are certainly included but they aren't different.

MR. TOULA: You don't have to worry about nosewheel steering.

MR. WILLMOTT: Chuck [Stocking] has a question, Tom [Toula]. Does this cover Air Force One? Because it's a 20 passenger aircraft.

MR. TOULA: You have a good point. People are taking seats out, so it will apply.

MR. BOOTHE: Brake pedal position versus force, I suggested we go to the training device standard for that. And use the IATA predicted data and see if we could meet it that way, which would eliminate what's reported to be a fairly difficult measurement.

Daryl [Schueler] is shaking his head over there.

MR. WILLMOTT: It's a real tough thing to do.

MR. SCHUELER: It's a ground test, though. The difficulty is you are standing on your head in most airplanes, unless it's a Twin Otter where you open the door and reach inside.

MR. BOOTHE: I guess the question is, can this be closely enough approximated without doing measurements just from design data or is a measurement really necessary? We are talking brake pedal position versus braking force. I know in some simulators we have had a big problem with a totally unrepresentative system in that respect. And when there was a series of rejected takeoff accidents we got more interested in this, and I don't want to diminish that need, but is there some other way that we could assure that the brake pedal force is proper and that pilots could be demonstrating what maximum braking is and what it feels like?

MR. SCHUELER: I never had access to any design data, so I don't know for a braking system, so I don't know what's available.

MR. LEISTER: I don't think there is any good data available for brakes that will tell you the force you will expect, I don't think there is--at least I have never been able to find it.

MR. SCHUELER: You might be able to compute it from the geometry and work backwards.

MR. STOCKING: It's real hard to do on a stopping test, determining what is really maximum braking. I mean usually when you fly this test the pilot will not put on the braking, it will skid the tires. He backs off just a little bit less than that.

You need some measure of what that force to braking relationship is. Which is really hard to get. You have to put a sensor on the brake pedal so you can record the force. I haven't found any alternative to that.

MR. BAILLIE: In general these systems, is there a feedback force or is it a hydraulic? Generally it's a hydraulic system, so it's a non-reversible control system, so if you measure the force versus displacement on the ground then you put at most a potentiometer to measure displacement, then you have calibrated the system.

MR. WILLMOTT: The last aircraft I worked on with the brake system is the Citation 5. We tried measuring the force versus deflection with a Fokker unit and were not successful with it. It's got such a small travel, it's I think only like about a two-inch travel in the brake forces from zero up to 150 or something like that. And the Fokker just doesn't seem to be accurate enough to get that.

Once you have got the brake deflection, we use the airplane design data that relates that to the hydraulic system pressure upstream of the anti-skid system and then you have to model the anti-skid system to get the retardation forces on the airplane, and on this Citation 5 we had modeled that and we meet the stopping time and distance and the system pressures that were recorded, but for the most part, the people that fly the simulator say the airplane brakes a lot better than that. And we are still actually trying to resolve that.

But it's an area that you have to, I think, use an airplane manufacturer's data, they are helping us trying to resolve that. But I don't think that is what you really need, if you were doing the airplane test properly, you need to do one at speed that has this ground static condition and you need to get, you know, the anti-skid modulated pressure, and for whatever reason, they actually design the thing so that the anti-skid systems works on a dry runway. I have never really understood that, other than when you first touch down at real light weights, even on the ground for moderate weights the anti-skid is modulated.

You would think they would design so the brake pedal torque would be not limiting on a dry runway, but apparently they don't. But you need the pressure downstream of the anti-skid and then upstream and relate that to the toe brake force.

MR. BOOTHE: Can you do all that accurately enough without measuring anything on the airplane? Is what we are getting at.

MR. WILLMOTT: I think for this class of machine, yes.

MR. BOOTHE: Anybody else? Okay. Thank you, Stu [Willmott]. We will go with that.

Now dynamic control checks is the next entry here. There are no dynamic control checks required on Level B, as we pointed out yesterday, I think we already discussed this in-flight control sweep that Stewart [Baillie] presented up on column position versus force and unless there is some reconsideration or further thoughts on that, I think we eliminated that yesterday, did we not? So we will scratch that block, then.

Now the next several tests have to do with the dynamics resulting from a configuration change, power flaps or spoilers or landing gear, and the current requirement for Level B, I think addresses the dynamic response, and I'm suggesting that we use these steady state force response in lieu of recording the dynamics strictly as a means of reducing instrumentation requirements. But as was said yesterday, if one already has the instrumentation, certainly you are free to go back to the dynamic case, but if one is collecting data with hand held instrumentation, it's pretty hard to measure time history.

So I was just suggesting before and after here of trimmed airplane, change configuration, maintain the flight condition and measure the results steady state later. So I throw that out to you, is that good enough? Do we really need the dynamic response in this case? This really is an area where Level B is using more of a training device concept. I lost myself in the Advisory Circular here, I think this is one of those cases where we are looking at something that is currently adequate for a Level 6 training device, but can we extend that to a Level B simulator and get satisfactory results? Is the question if so--

MR. KOHLMAN: We need two things. One is the trim changes or pitching moments associated with all of these configuration changes involving power, gear, flaps, or whatever. But we also have to have an airplane that responds properly dynamically. We get that if you are going to do the phugoid and short period. That will tell us if we have the proper inertia and damping.

By doing this it greatly simplifies the number of dynamic maneuvers you have to do.

MR. BAILLIE: The power change dynamics and the like, it's the short-term effects that don't show up in the trim change. That we know--perhaps more importantly, things like gear change dynamics than power change dynamics with the aerodynamic configuration in one trim condition and the second trim condition aren't the only aerodynamic configurations the aircraft goes through. And the response of the aircraft is not the linear interpolation between those two points with dynamic inertia, there are more forces involved. I think the same is true for power and flap changes.

MR. SMITH: From an evaluator standpoint.

MR. STOCKING: I guess the question would be, is it good enough to record what happens by just observing? In other words, you've got a video of what's going on. You apply power, it pitches down two degrees and then it pitches up and stabilizes in trim five knots higher than the trim condition was before. You are taking that on a knee pad. Is that good enough, is the question? Or do you have to actually record it?

MR. DAVIS: I think either you record the stuff, or you go with the static trim before, force after test. One or the other, but just recording the video stabilized five knots above, I don't know how good that is.

MR. STOCKING: That's the trim of the aircraft, the trim of the aircraft afterward, but you need some record of what it did in between. Quite frequently airplanes will go the opposite way. The pilot says I apply power, it pitches down, it doesn't pitch up. Later on he doesn't notice what the change in trim is.

MR. BAILLIE: A video certainly would lend credence to the subjective evaluation of that maneuver. And if we are happy with just a subjective evaluation, I think that's fine. But if you are trying to match data, you have to measure attitude not with a video.

MR. STOCKING: You have the video before and after.

MR. BAILLIE: Well, for the dynamic case either you measure the dynamics or you subjectively evaluate them.

MR. SMITH: As an evaluator I would rather have the check point in the ATG for the dynamic cases although it's true that you have the gear and the flap change and the power change cases, but they are in different speed and configuration regimes, whereas if you only have the phugoid and short period in the ATG, which are at higher speeds--cruise--you don’t have good coverage; it's just a couple more points to evaluate the model and verify it.

Granted that you guys, before we look at it, check it out in many other cases, it's just a couple points we feel better about.

MR. LEISTER: Hilton [Smith] is absolutely correct. Actually you can't build a solid model unless you do the dynamics that actually describe the pitching moments and the lift and drag, you can get a first cut out of trim points, but the dynamics are really what make the whole curve solid. If we go without measuring control surfaces, then we need a lot of dynamic tests like these to allow the model builder to drive his model.

I think the dynamic tests are much more important than the force tests, frankly.

MR. BAILLIE: We are not talking about what the model builder is requiring.

MR. LEISTER: I'm thinking about that.

MR. DAVIS: The premise is we have a model.

MR. BAILLIE: How do you validate that?

MR. LEISTER: I was going to address that later, I don't think we can have it--

MR. DAVIS: I agree.

MR. BOOTHE: I'm not getting your private conversation over there. Go again, please.

MR. DAVIS: I think the point is you need this data to build your model. Is that your point?

MR. LEISTER: Exactly.

MR. DAVIS: And I tend to agree you need dynamic data to build the model but I thought the point here was we already have a model, let's define what set of data we are comfortable with to validate that model.

MR. LEISTER: The only problem I have with that is that in this type of airplane you don't have the model. Where are you going to get it?

MR. BOOTHE: Okay, that's a very important point you two have brought up. All along we have been talking about validation. And unfortunately I didn't hear the whole conversation yesterday when what to do about modeling data was discussed. But I don't think that they are independent totally, and if some of this validation data is important to feed into the modeling data, I think that's a really important consideration here.

And especially if we are dealing with a group of airplanes that the airplane manufacturer for some reason didn't see fit to produce a model themselves, so if it's important to modeling and you think that the extra effort for collecting data for validation tests feeds over into the model in an important way, then I would say we need to keep that thought in mind as we do this.

If you think that we are quite comfortable with a model and all we have to do is validate it, maybe we could get by with less. Maybe we could see what Ken [Neville] thinks about that.

MR. NEVILLE: I agree with what you are saying. You have to take into account that the model may change because when you are doing your validation tests, if it doesn't match, you have got to have enough information to know what to do or the right thing to do to improve the model. You have to keep that in mind.

MR. BOOTHE: So you are confirming my thought, I think that these are not totally independent. We have got a mutual dependency here we need to consider in the validation data collection process. That's a good thought. Stu [Willmott]?

MR. WILLMOTT: We are talking about just simplifying the validation tests, doing the force test is the old fashioned way of doing it. But if you go back to the days when we used to do that, the problems that we used to have were with these transients. You can meet these force tests within a reasonable tolerance, but you still don't have the right little change that you have when you are moving the flap or moving the power and you often do not get the correct dynamics, you often do not get the airplane pitching in the correct direction.

If there is one thing that gives us problems, particularly with pilots, it's what happens when you move the flap. And even in here it just says for two flap transients. We always do them for every single detent in the airplane. That is something that the pilot is doing all of the time and he wants to get the right direction of pitch and the right feel on the control.

MR. BOOTHE: He--

MR. WILLMOTT: So you can make this simpler and stick to the force if you want. I don't think it will give you what it is that you want. And you have to somewhere do tests that allow you to get the individual effects of each detent of the flap going up, detent of the flap going down, if there are detents. The same with the gear change.

But we recently had a problem with a Westwind that, you know, you are aware of, Paul [Ray]. We were not getting the correct pitching with one of the gear transients, I forgot which one it was. And we did some tests in the airplane, completely redid the longitudinal pitch aerodynamics, and we did this in fact just by a still camera with a rig ahead of the pilot and we could fire it off every one second. And we were just measuring, you know, pitch attitude, rate of climb, the altimeter, we had an angle of attack indicator in the aircraft too, that helped us and we had a simple way of measuring the control deflection. From that we were able to retune the aerodynamics.

There are two things I would say, firstly I think it's important you can either put the dynamics in here or you can put it over to the design data. You definitely need that for the design of the simulator.

And the second thing is that there are simpler ways of getting that transient data just by measuring instrumentation in the aircraft, but because these controls are reversible, you have to measure them in some way, and the simplest way is measuring the column deflection. Because the aerodynamics of what happens at the elevator often determines what happens when you move the flap or the gear.

MR. BOOTHE: Well, I thought the issue was worth discussion. And I did, though, say that if force measurements were not acceptable, then you would have to do as per [AC120-]40B, which means an instrumentation system generally would be required and the double asterisks are included. I think what you are telling me is scratch out the ifs and leave the double asterisk, as far as the gist I'm getting here. So we should do that, I think.

MR. WILLMOTT: Of course you could put under spoiler speed brake change dynamics if appropriate.

MR. BOOTHE: Oh, yes.

MR. WILLMOTT: They don't have many of those in the Beech machines.

MR. BOOTHE: Okay. That follows through really the next three squares.

2.c.(3), and (4) all fall in that exact same--they are the same test, just a different input. So there is no point in discussing those individually because if it applies to 2.c.(1), it has to apply to the next few.

Which gets us down to gear flap operating time, which I think there is lots of alternatives besides the dedicated flight test, not the least of which might just be production flight test schedule that says the gears have got to operate between certain limits and if you are between those limits it ought to be okay.

Everybody seems to be nodding okay there.

MR. BAKER: You know the flap time in particular is very important. Because that obviously affects the dynamics of the airplane. I've seen extremes on flaps during development programs you can take a flap, an extremely fast flap extension on an airplane, and it gives you a tremendous pitch, you say my God, this is unacceptable. Yet you take that same flap and slow it down by a factor of five or ten and it's a hands-off maneuver literally in the airplane. And you can do that and you can screw up a simulator the same way. It can become a hands-off maneuver because the airplane decelerates when you are on a slow flap. And it just blends right in, everything matches. It's not unusual at all.

I have seen flap times in simulators that are definitely wrong that screw up the aerodynamics.

MR. BOOTHE: The thing is, if you use the production flight test schedule to check flap times, then you are getting in-flight times. Is that not correct? That's what I would recommend, but on the other hand you could easily measure them as you do the previous four tests.

MR. KOHLMAN: The data on these previous four tests will give you the times.

MR. BAKER: You would have the data.

MR. BAILLIE: I have often wondered why that's separate from dynamic cases because it's the same test.

MR. BOOTHE: Well, I have, too.

MR. SMITH: As a matter of fact that's something I never really check on an evaluation, really that can be covered with a statement of compliance and you have done this, because like Gerry [Baker] said, you can't get it wrong if you get the dynamics right.

MR. DAVIS: The dynamics are only two detents we are looking at versus the whole range. For a flap that's a small point. Gear you are right, but for flap you need to look at the whole range.

MR. BOOTHE: Well, would it be sufficient just to say statement of compliance and refer back to these other four tests?

MR. SMITH: I could accept that. Here again, from what Tom [Davis] said, I would trust him to do the entire flap right.

MR. DAVIS: Whoa, did you get that?

MR. SMITH: That's right, the inspector will catch it.

MR. BAKER: I think every one of these items, the configuration changes, as a pilot, to me these are probably the most important things in the simulator. If you put the right characteristics of the airplane in, gear flaps power, and just stuck it in any old simulator, you would be 90 percent there, I think. Because a lot of other characteristics change, the static stability, dynamic stability changes sometimes as a function of the CG alone in the same airplane.

These are relatively constant, they change some, but you get in an airplane, you extend the flap, it pitches, the proper rate, direction, those are things the pilot, as somebody stated yesterday, really is going to recognize this is wrong. And if I were concentrating on something to make correct, those would be the ones. I think if you make those correct you are going to get a lot less squawks on a simulator.

MR. STOCKING: From the point of view of validating your math model, and not specifically just for this, that's something you routinely check in the hangar, if you have got an electrical or hydraulically actuated flap system, you need to know what it's doing at what particular time. A lot of flaps, they extend and rotate, you need to know when those events occur with your aerodynamics, know what you are looking at.

I routinely check them in the hangar or by some backup method so I know where they are at any given time. In the cockpit quite frequently you don't know what they are doing till they get there.

MR. BOOTHE: True. Okay. We will leave the double asterisk on the dynamic changes. And operating time sounds like a statement of compliance that it's right is good enough because the dynamics would have indicated whether or not it's in compliance anyway, I believe.

MR. STOCKING: You want to be careful, sometimes you can tweak the dynamics to come in right and they aren't doing what they are supposed to be doing. You are just meeting the one test.

MR. BAILLIE: Isn't it the dynamics that are important? I don't care if the light comes up a second late, that's not nearly as important as if the aircraft has a double time, time to doubling or--

MR. STOCKING: If you are looking at this particular test that's true, if you slow down 20 knots and do it at a different speed or something then it will not respond the way it does in the aircraft. I've seen simulators that are like that.

MR. WILLMOTT: I can't remember why we continually left that in as a separate test. I mean, I've been to lots of the 14 and 40 [Advisory Circular] meetings. But I think one consideration may be that some of these things do vary with air speed. And I think we were probably trying to give us another case where we could put in another air speed.

MR. STOCKING: Eliminate one uncertainty in the variables, the flap.

MR. WILLMOTT: As far as operating time.

MR. BAILLIE: If that's the intent, then the requirement for that test should be changed. In most cases you take the time off your dynamic case and say look, we matched that as well.

MR. WILLMOTT: I think we did in the international standards.

MR. BOOTHE: I don't remember.

MR. WILLMOTT: And we certainly added the alternate gear extension and alternate flap extension. And I think we had more than one speed.

MR. BAKER: Some of these times could become important. Some airplanes have no pitching limit at all. There are airplanes that don't pitch. The original Cessna 500 didn't pitch with anything. Gear flaps or power, you can do anything, it was great. You had no pitching moment associated with anything. So the times would become independent then completely.

MR. STOCKING: You have a craft like the G-3 and 4, they have a schedule on the stab that's driven by the flaps so you really need to know what that is.

MR. BOOTHE: Are we okay having written what we have? Or statement of compliance on the times assuming that they would either come from the dynamics or they would come from some other source, but that should be available rather than going out with a stopwatch and measuring it? If that's the case we will move on to longitudinal trim.

MR. WILLMOTT: Could I ask Gerry [Baker], are there any aircraft that do not have feedback or flap indication?

MR. BAKER: What do you mean by--

MR. WILLMOTT: Well, business jet type aircraft have little dials telling you where the flap is, Citations have the pointer.

MR. BAKER: Follow-up pointer.

MR. WILLMOTT: Do they all have?

MR. BAKER: Most of them have an indicator.

MR. WILLMOTT: Some of them I wondered if they had the indicator.

MR. BAKER: You see a lot of detented flaps on newer flaps but most of them still have an indicator. Citations are about the only ones that have follow-up pointer flap positions.

MR. WILLMOTT: Sorry.

MR. BOOTHE: Thank you.

Moving on to longitudinal trim. I've not tried to specify how many trim runs one may do, however I've suggested that a number be added so that we could get a trim at various configurations and various speeds within a configuration and level flight, that way we could relate angle of attack because angle of attack and pitch angle ought to be the same in that case.

I have done this with the privilege of removing angle of attack measurements from other tests because it's difficult to measure, it's difficult to calibrate, it's very important but I thought if this were a reasonable trade-off, then this would simplify some Level B data collection.

So I throw that out to you as a thought and see what you think.

MR. DAVIS: All of the 2.c.(1) through 2.c.(4), what we have is a longitudinal trim there, do we not? There is probably other areas in the test data we can look at. Do we simply call for X number of tests here?

MR. BOOTHE: I don't know how specific we want to get here. But I'll be quite frank with you, on some of those trim runs you just mentioned, I'd like to meet the guy that thought he was trimmed. Because I've seen some absolutely horrible stuff that a person said was trimmed. People just don't take the time to trim. Now if you can combine things and you can get a nice trim run prior to initiating a configuration change, if I were still evaluating this data I would be quite happy about that because I would have an opportunity then to see a period of trim flight before suddenly there is an input.

What we normally see is 43 milliseconds followed by an input. And man, you can't tell much from that. So the combination would be good. But I don't think we should say how you should do these trim runs, I think we should simply say we need enough at enough different configurations and since each airplane is different I don't know how to specify that.

Maybe you have some ideas. Sorry, I didn't mean to jump on pilots, but it's terrible some of the stuff. Being one, I guess I can do that, right?

MR. WILLMOTT: I believe for a Level B simulator, even if you don't do much flight testing, flight testing that you should do is for each flap configuration a complete speed range of trims because it gives you the basic lift, drag and pitching moment that you want to put in the model. Then you pick two or three of those tests that you put into there for the validation.

MR. BOOTHE: When you say "a complete speed range of trims," you have to tell me what that means.

MR. WILLMOTT: From the maximum flap extended speed down to probably 1.1V stall.

MR. BOOTHE: How many do I need, one every ten knots, one every--

MR. WILLMOTT: An adequate number.

MR. SMITH: Very good.

MR. KOHLMAN: But Stu [Willmott], again, are you talking about modeling tests or--

MR. WILLMOTT: Yes.

MR. STOCKING: Modeling.

MR. WILLMOTT: Absolutely. You have to get that even for the modeling, even for a Level B simulator, is what I started off saying.

MR. KOHLMAN: I agree. Those would be key data points for anybody building the model but the question here is how many are we going to require.

MR. WILLMOTT: For the validation I would recommend we stick with the same as usual, which is just--it used to be two, I think it's three now.

MR. BOOTHE: Keep in mind we used to say you must measure angle of attack through all these dynamic maneuvers, now we are saying knock that off.

MR. WILLMOTT: For the purposes of collecting the design data you have to measure pitch, which is your angle of attack--

MR. BAILLIE: There has been the suggestion in conversations both formally and informally that some people might try to meet the modeling requirements without flight testing the aircraft and relying on the ATG to validate.

MR. WILLMOTT: If that's the case, then, and we are cutting out angle of attack, we have to do more for that test.

MR. BOOTHE: That was my conclusion as well. But--

MR. WILLMOTT: I would make it so that it goes to the flap extended down to probably 1.1 and maybe one or two in between.

MR. BOOTHE: But I'm reluctant to tell a person they have to do 23 trim runs. I don't know how many they should do, I think that has to be germane to the situation. Chuck [Stocking]?

MR. STOCKING: If you are checking the absence of angle of attack I think at each flap setting you need a minimum speed, maximum speed, and normal operation range for each flap setting and then low altitude, intermediate and high altitude. If you call that three tests for each one, that's 3, 6, 9, another 9, that's 18 tests.

MR. BAILLIE: And three centers of gravity.

MR. STOCKING: Two maybe.

MR. BOOTHE: It's almost sounding cheaper to put in angle of attack.

MR. BAILLIE: What about power setting? These aircraft are different if in climb or descent.

MR. SMITH: For modeling you have to have a range of TCs for every condition.

MR. KOHLMAN: But for trim purposes you have angle of attack if you have pitch attitude.

MR. WILLMOTT: I'm just wondering about that, again. Ed [Boothe], I thought we said we didn't really need angle of attack for a lot of tests, takeoff tests and things like that, because we have pitch attitude, we have air speed, we have altitude rate of change, that gives you the flight path angle.

MR. BOOTHE: But what we said, what I said, I don't know what we said, but what I said, we can eliminate those measures of angle of attack if we compensate by doing more trim runs to get a better definition of the configurations in the first place. But in anything other than steady flight, you don't know flight paths, so how can you get angle of attack other than maneuvering around if you are not in steady state trim condition? I don't know how you--

MR. WILLMOTT: From the flight path angle, from pitch and flight path angle.

MR. BOOTHE: That's right. If you know those or can construct them, but if you are going to do that, gee whiz, you are not reducing cost.

MR. KOHLMAN: I think you can easily. Measured parameters will be rate of climb, air speed and pitch attitude, and as Stu [Willmott] is saying, you can calculate angle of attack from those.

MR. WILLMOTT: I thought that's what we were recording for virtually everything we spoke about.

MR. HEFFLEY: Recall one principle here was that if you can't see something, i.e., angle of attack or sideslip, why do you need to provide a direct measure of it?

MR. BOOTHE: Well, Bob [Heffley], we are trying to validate a model to say represents an airplane within a certain limit here. I can't see angle of attack, it's a very powerful critter that affects everything longitudinally. And while I don't see it, it sure affects, it affects what the airplane feeds back to me when I fly, I know that.

MR. HEFFLEY: That's true. But you can have equivalent variables that can be used to derive angle of attack. If you want to look at it, to the pilot it’s fictitious. It can be just as fictitious as anything else. And you can pick all kinds of different state variables.

MR. DAVIS: I don't see the difference between angle of attack and elevator position. So if we are willing to forego elevator for column position, I don't know why we are not willing to forego angle of attack--

MR. BOOTHE: Are you telling me we can eliminate angle of attack measurements and also not have to do a whole bunch of trim runs which you guys do anyway unless you use a totally predicted model?

MR. HEFFLEY: I think the idea is you can eliminate angle of attack if you are substituting that with something else that's a reasonable equivalent.

Furthermore, the angle--you know, the actual measurement of angle of attack is always a pretty doubtful thing in itself. And sideslip is even worse.

MR. BOOTHE: I know.

MR. HEFFLEY: So it's not as if giving up angle of attack is really giving up a really great thing. I mean it's kind of a nasty little variable.

MR. SMITH: I don't--

MR. WILLMOTT: They like it because they also define lift.

MR. SMITH: Your aero--

MR. BOOTHE: Hold it guys, we will never get it recorded.

MR. SMITH: Ed [Boothe], all your aero data model is is coefficients versus alpha, at constants TCs and flap setting; all your data tables, like you say, longitudinal parameters--

MR. HEFFLEY: It's strictly an engineering construction and nothing that the pilot sees.

MR. SMITH: That doesn't matter. The essential parameters, all the data is based on the program. We want to validate that.

MR. STOCKING: It depends on what type of model you are doing. The model I'm doing right now uses alpha FRL, which defines the stability axis, but that's the only reference it has, no internal meaning to the aerodynamics. I compute angle of attacks at all different places on and about the airplane. None of them are the full built up angle of attack. Angle of attack really defines what our reference is. Angle of attack.

MR. HEFFLEY: There is a way of modeling aerodynamics where you do not really use angle of attack explicitly. I typically use u, v and w velocity components. And therefore you avoid all kinds of problems that you get by using angles of attack.

MR. SMITH: If you start off with stability data--

MR. BOOTHE: You can still use u, v, w for stability axis.

MR. KOHLMAN: Angle of attack is almost always, not always, but almost always one of the primary driving variables in the aerodynamic model. It doesn't mean, though, that you have to measure and match angle of attack to prove the model is acceptable. Because if angle of attack is correctly modeled, the pitch attitude and the load factors, accelerations and pitch rates and everything else will come out within the tolerances.

So why do we have to add one more variable to match this very difficult and expensive to measure in flight? It's not that it's unimportant, it's that if you have it right all these other parameters will match. And that ought to be good enough.

MR. SMITH: We are not verifying all the other parameters, though.

MR. KOHLMAN: We are getting enough of them, we have pitch attitude, accelerations, angular rates, if we are going to have the strap-down box in here, and I don't think you can match all of those within the tolerances unless you are also modeling angle of attack appropriately.

MR. WILLMOTT: By the way, Bob [Heffley], a lot of these aircraft do have angle of attack vanes that are used to do a variety of things, and they often have a little dial that gives usually speed ratios.

MR. HEFFLEY: But that is not true angle of attack.

MR. BOOTHE: It's a reference number.

MR. HEFFLEY: So you have to go off and figure out how to calibrate that.

MR. WILLMOTT: It's the angle of attack of the vane itself. You can calibrate those and get a reasonable indication of either, you know, the body reference--

MR. BOOTHE: Can we hear from the Northwest [Mr. Neville] on this subject?

MR. SMITH: Northwest territory.

MR. NEVILLE: Well, you know this really gets down to the philosophy, what the flight test program is going to be used for. If it's only going to be used for validation data, you only need to collect the data required in the AC, and it doesn't require an angle of attack, but if you are going to use it for updating the model, you need angle of attack. In our experience when we do our flight test program there is a twofold purpose relative to simulation. One is to gather data for validation. That's actually a smaller part than the effort to go out and gather the data that we need to flight update the model, because when we go into a flight test program we have a predicted simulator model. And we use the flight test program to provide the information we need to update the model so that the simulation matches flight data within the tolerances.

And for that purpose you need to have an angle of attack or the equivalent. There may be other ways to develop a model, but angle of attack is the most important independent variable in the aerodynamic model for us. There may be some other equivalent ones, control surface deflection[s] are probably the next most important.

So I guess I don't know how you can do the full program without measuring those parameters or deriving them.

MR. DAVIS: It leaves us with are we building a model or validating a model?

MR. HEFFLEY: Validating.

MR. DAVIS: If we are building, I am uncomfortable with one of the compromises we have already made. I thought we were validating.

MR. BOOTHE: We are validating. However we said a few minutes ago that validating the model and developing a model are not mutually exclusive. We got into that discussion with the configuration change dynamics. So--but that's a question that remains to be discussed here, hopefully today, is what can we do with a totally predicted model and is that cheaper, can we--I don't want to get ahead of this, I would like to get through the tables fast so we can discuss that, but it's a valid point.

What Ken [Neville] has said, he needs that data for fine tuning, I guess, your model. But do you need it for then validating that model or would other parameters such as Dave [Kohlman] and Bob [Heffley] have discussed be adequate for that, because I think Dave has got a point, if the angle of attack is very far off, a lot of other things are going to be very far off.

I mean, it just won't work. It's either there directly or it's there implicitly, it's there.

So Ken [Neville], can we for validation purposes, can we eliminate angle of attack measurements which we have agreed to up to this point and through these--I threw the extra trim runs at you, the question is do you need the extra trim runs or can we just eliminate angle of attack as a validation measurement? That's the question.

MR. NEVILLE: When you add the additional trim runs that implies using the data for model tuning purposes. You are saying confirmation.

MR. SMITH: I think he is saying you are checking angle of attack there in lieu of checking it on all these other time history cases that we normally did.

MR. BOOTHE: That's the thought I had in mind, but now I'm being told you don't really need to do that.

MR. NEVILLE: Different parameters are interrelated. If you measure pitch attitude correctly, or if it's accurate, and climb rate is accurate, I think you can safely say that angle of attack will fall out.

MR. HEFFLEY: Yes.

MR. NEVILLE: So if you are just talking about validation purposes, I'm not sure you need angle of attack.

MR. LEISTER: You are going to be hard-pressed to build a model without a lot of trim points, but I don't think you need to show them in the approval test guide. For that matter, if you really want to validate a model you should add a lot of other things in this approval test guide. It's just a spot check. I think that's all this should be, is a spot check.

MR. BOOTHE: All right. Let's take a fallback position here. In which Advisory Circular is that? In 40B we have a trim run, is that all we need?

MR. SMITH: Just to validate the models, let's take two speed points at each flap setting instead of the one--instead of three. We have trim points in there now, we have three.

MR. BOOTHE: Well, what have we got?

MR. SMITH: And we were thinking about maybe nine a few minutes ago, three speed points at each flap setting, let's take two.

MR. BOOTHE: What I'm being--what I'm hearing, anyway, maybe it's not what I'm being told, but what I'm hearing is that it has to be in here someplace.

MR. SMITH: That's from the guys saying trust me, and I'm from the guys saying show me.

MR. BOOTHE: We have three trim points, cruise, approach and landing in 40B, and what I am hearing from the majority I think is that that is adequate without measuring angle of attack anywhere else. Is that what I'm hearing?

MR. DAVIS: Yes. An angle of attack can be calculated from those.

MR. WILLMOTT: There are a lot of other tests that we are going to be doing here for which there are effectively trim points like the landing. You have trim points for that. And even the last part of the takeoffs, you have quasi steady trims for that, the climbs, there are many trim points in there. I don't think there is any need to put more than what we have in 40B.

MR. BOOTHE: I think in terms of the objective here, proof to be seen later, that that's the most cost effective solution and it works. I know you would like more trim points but I think the majority is saying we don't need more trim points. Because of the implicit, the implicit measurements of angle of attack in almost every maneuver.

MR. HEFFLEY: Right.

MR. BOOTHE: As Dave [Leister] and some others have said, if it isn't pretty close, the only problem I have with that is some of the tolerances we have on other maneuvers, like maneuver stability.

MR. WILLMOTT: Right. That's the only exception.

MR. SMITH: Can we put a note in there, then, that all these other tests that start off with trim points that they have three or four seconds of steady trim shown?

MR. DAVIS: I think it already calls for five seconds.

MR. SMITH: How much?

MR. DAVIS: I think it calls for five seconds hands off.

MR. BOOTHE: We added that because of the problem I mentioned earlier.

MR. SMITH: Yes.

MR. BOOTHE: We weren't getting any trim.

MR. WILLMOTT: We didn't need to put in angle of attack for maneuvering stability anyway.

MR. BOOTHE: What I said, angle of attack is implicit there but I'm allowed plus or minus five pounds on maneuvering stability, so I think that gives me a pretty good margin for error on angle of attack. But that's not the only rules, so.

MR. RAY: In fact with this that test ends. One being a front end of the other tests. You have all three configurations listed, power change, flight change, et cetera. When a person does longitudinal trim cases, he is going to pick 15 seconds in front of the other test, say that's my test and repeat it.

MR. BAILLIE: Unless you define you have to have a second test.

MR. RAY: Sure.

MR. BAILLIE: In your notes here you are saying FDR sensors, surface positions.

MR. BOOTHE: Yes, I did, because I was assuming we might measure them. What I'm doing is just saying per [AC120-]40B and scratching all that at this point. This was my alternative solution that turns out that you concur is not necessary, I think. So what we do is scratch that and say per 40B, which puts us back where we were on trim. But according to consensus still permits us to not measure angle of attack, which I--tell me if I'm correct, tell me if I'm wrong, I just perceive that as a significant cost driver of gathering data. Because you have got to have some sort of sensor, whatever you use you have got to calibrate it, you can't calibrate it without flying.

You have got to fly the kinds of things we say in here to calibrate it in the first place. You don't really know how good its transient response is after you calibrate it if you don't know local flow effects.

MR. BAILLIE: Alpha isn't that bad. Especially if you put a strap-down package on it and you have some mathematics behind it you can get alpha routinely. Sideslip is the one that has all the problems we have discussed. Alpha isn't that difficult.

MR. KOHLMAN: Once a nose boom or differential pressure system is on the airplane. That's the expensive part, is modifying the airplane.

MR. BAILLIE: Or a good inertial system in the software.

MR. BOOTHE: That's not a direct measurement, then. I'm talking about a direct measurement of angle of attack.

MR. BAILLIE: You can never get a direct measurement, you are always calibrating versus inertial systems, whatever, you are never directly measuring angle of attack.

MR. WILLMOTT: I don't know what you mean by that, Ed [Boothe], there isn't any means of measuring angle of attack directly?

MR. BOOTHE: We measure something with a differential pressure system or a vane or whatever you can dream up, and we call it angle of attack. That's what I mean.

MR. BAILLIE: Anything external on an aircraft like a Dash 8 or any other turbo prop aircraft is extremely affected by power setting and slipstream effects.

MR. BOOTHE: I think we have beat that to death. I have indicated we will do the trim runs per [AC120-]40B and we can move on to longitudinal maneuvering stability. I think that that can be done accurately with hand held instrumentation. See what you think.

MR. LEISTER: Well, in the course of what I do, I go on flight tests with these pilots, I will tell you I think it's extremely difficult to do this test with a hand held force gauge because if the air speed changes over three knots either way the test is invalid.

Pilots have a lot of difficulty holding constant air speed, holding something solid, but if they are holding a force gauge I think it's all over. I think you need to have a sensor to measure this. My opinion.

MR. BOOTHE: Okay. A force sensor on a wheel--

MR. LEISTER: Yes.

MR. BOOTHE: --or stick or whatever you have got?

But still it's not a test that requires an installation on an inertial system, is it? Bob [Heffley]?

MR. WILLMOTT: It's nice to have a accelerometer.

MR. BAILLIE: It's a far better--stick force per g is what everybody measures and that's what we should be trying to validate. Not stick force per air speed or bank angle.

MR. HEFFLEY: I think you need the inertial package, but I guess it's been my experience that if you have a good enough pilot, you can get some reasonable results from a hand held gauge.

MR. BOOTHE: Dave Ellis rigged up a deal one time to do this without--you had a home made accelerometer, that's what you had.

MR. ELLIS: Yes.

MR. BOOTHE: But he was doing it with wings level.

MR. ELLIS: Symmetrical--

MR. BOOTHE: Which was difficult, I must tell you.

MR. WILLMOTT: I'd like to say that one of the programs we had at SimuFlite, we tried replacing the maneuver stability by push-pull maneuvers. And that proved to be very, very difficult to accurately simulate because you have a lot of altitude changes and you have a lot of speed changes that go along with that and you can't really measure what it is that you are trying to measure, which is the force.

One of the things that these validation tests did do was if a pilot had a question about some of the characteristics of the simulator, you could pull out this test and run it in tight turns with one of the tests that the pilots do frequently as part of the training, and this gave us a check for the forces that were required in those tight turns tests, steep turn tests we called them. So having the force in the steep turn is a good thing to do still, I think.

MR. BOOTHE: What I think I'm hearing is that I've overly simplified this and we really need to use at least an accelerometer. And some more convenient way of measuring forces.

MR. KOHLMAN: We have a number of other tests that, if I recall correctly, we at least have pedal force transducer, and we may have specified some that have a force wheel. I don't remember. But if we have, then that equipment is going to have to be in the airplane. We may use it for all the points but it was installed in the airplane, then it's a very low incremental cost to go ahead and do some of these tests that you need that kind of data for.

MR. WILLMOTT: The thing with this, too, Ed [Boothe], this class of aircraft where you are involving the aerodynamics on the controls, that's very difficult to, almost impossible, to estimate the in-flight characteristics, theoretically predict them in any way. Wind tunnels are bad, this gives you a true check of the forces that are on the control surfaces.

MR. KOHLMAN: The other thing is sometimes it's very hard with a hand held gauge to know when you are stabilized at the appropriate points. If you have a time history, even though things are changing you can often look very carefully and say here is a good five-second segment where everything is stable, and use that point.

MR. WILLMOTT: What CAE does when they are plotting the maneuvers, they plot force versus g and it's scattered all over, there is considerable variation. How about that? You take the average of the result of the particular g you want to do the test for and that seems a good way of doing it.

MR. BAKER: Well, I have seen this done a lot but a hand held gauge is difficult. I mean, I've seen, talking to Daryl [Schueler], I've seen people who use just a mechanical accelerometer for steady state stuff, but it depends on the airplane. I think a lot of it, too--and capabilities of the airplane. Most the airplanes we are talking about here are fairly low altitude airplanes. You are not talking a tremendous maneuver like you might get in a high altitude jet trying to do wind up turns at 45,000 or something. But I would personally go for a control wheel input.

As Daryl [Schueler] points out, it ends up being a dynamic maneuver a lot of times where a recorded control force versus a recorder accelerometer you can pick up a multitude of points during the maneuver that way. It would be a lot simpler task.

MR. SCHUELER: It tends to be easier for a pilot to maintain a slowly increasing wind up turn type of maneuver rather than trying to stabilize at a fixed point for a period of time. It tends to be easier for them to keep a rate of change through that maneuver, slow rate of change rather than locking on a particular point.

MR. BOOTHE: Okay. I think the consensus is, I think, give up that simplistic approach and throw a double asterisk and a wheel and column force measurement here. The reason I say double asterisk, I know we really just need the accelerometer. If you are going to have some sort of inertial package I would doubt you would have a separate distinct accelerometer, it would be part of the package. So I guess that's where we are on this thing.

MR. ELLIS: Could I just note that we developed this symmetrical pull-up technique especially for the case of low speed small airplanes where you tend to, in order to produce g's you have to develop high pitch rates. And if you try to do that in a wind up turn you get, at least for the low g conditions you get a lot of air, you have to get to high g's. I agree that what you need in the simulator, probably most, is some representative force for the turns. The effort should focus on that.

MR. BOOTHE: Yes. Thank you, Dave [Ellis].

I remember using your system and it was difficult, but when I got it right it was so satisfying. Okay.

Well, we will double asterisk and go to column wheel force measurement and get us on longitudinal static stability. Again I have gone through ships instruments and a hand held force gauge. That's easier maneuvering stability. Everybody seems to agree we can do that one. Okay?

Which brings us to stick shaker air frame buffet and stall speeds. How much can we get from certification data on that? And can we simplify this test to shift calibrated systems and some video and some hand recording?

What we are really interested in is identifying that we properly model these three factors if they apply. So have I overly simplified that? What's your--

MR. WILLMOTT: My experience is that type inspection report data is very good to use for this.

MR. BOOTHE: If you can get a hold of it, as Gerry [Baker] said.

MR. WILLMOTT: If you can get a hold of it. And of course normally the simulator manufacturer or the customer pays for a data package and that's available.

MR. BOOTHE: One of the things we are addressing here is cases where there may not be a data package.

MR. WILLMOTT: Well, if there is not a data package and you want to represent that, then you have to do a whole series of stall tests.

MR. BOOTHE: True. But can you do it with just the instrumentation that I've outlined here, is the question?

MR. LEISTER: Well, you have a little difficulty identifying buffets sometimes unless someone calls out "start a buffet" or something like that, but I don't see any reason why you can't do it.

MR. WILLMOTT: The very definition of the stall test means you have to do quite a number of them, because the definition of the stall test is that it's defined as being the one knot per second entry rate and normally when you are testing the airplane you plot the minimum speed versus the entry rate between 1.1 times the minimum speed, and the minimum speed that you get, and you normally have a scattering and you draw a line across them and you read them off at one knot per second.

MR. BOOTHE: Stu [Willmott], that's why the stopwatch is in here.

MR. WILLMOTT: I--yes. I think you've got to get the TIR tests for this, otherwise you are talking about the same type of series of tests that you have to do in the airplane to define it in the first place.

MR. BOOTHE: I agree.

MR. BAILLIE: One question I have, maybe a fundamental one is, is it important to just nail the one knot per second stall speed or should you require two stalls at different deceleration rates, whatever they are, two knots, three knots, four knots, whatever, and match two so you have the right trend and the right variation of speed rather than trying to nail the one certification parameter? Once--

MR. KOHLMAN: This is not a certification test. It's just matching a known condition. I think that's an appropriate observation.

MR. BAILLIE: But it requires you have to do more than one test.

MR. DAVIS: Is that even necessary though. One test is enough if you compare apples and apples. If you have a knot and a half per second, when you go in the simulator go a knot and a half per second.

MR. WILLMOTT: But you have three or four attempts to get that.

MR. DAVIS: You have three or four attempts no matter what, in a simulator.

MR. BOOTHE: It's a pretty critical speed.

MR. BAILLIE: But is it--

MR. BAKER: Yes, it's critical for certification, yet for a simulator you've got to keep in mind nobody ever goes below stick shaker. How precise does this stall speed have to be? I've gone to airplanes, I have gone to simulators, Lears with pushers in it, the pusher doesn't represent the actual pusher at all. It's nothing like the real airplane. It's a disaster on most simulators because there is no criteria that it be like the airplane apparently, so why does the stall speed have to be so precise?

It seems to me if you want anything precise it's stall warning.

MR. BOOTHE: More so, but I think the pusher, doesn't that identify--doesn't that define the stall?

MR. BAKER: But the dynamics of a pusher are very dramatic, particularly ones with alpha-dot. I have never seen a simulator that represented the airplane very well.

MR. BOOTHE: So if we--there has got to be for these airplanes and airplane flight manual, it has to contain performance, performance has got to include stall information, is that correct? So why don't we pick numbers out of the AFM and use them?

MR. BAKER: The point is you do have defined stall speeds. And again, it's like rate of climb, I don't know why you can't use some of these things. I would be more interested in matching characteristics and warning in a simulator than the exact stall speed. I mean, it takes a lot of work, like you say, to precisely define stall speed. You go out and run half knot entry, one knot, knot and a half, cross your data and draw your line. You don't want to get into that business here.

MR. BOOTHE: Not if we can help it.

MR. KOHLMAN: I think that it's a relevant point that Gerry [Baker] raises. This is a training simulator. It's something less than a Level C and D. And if it's training you bust the ride if you go past shaker anyway. So do we have to model that precisely exactly where the airplane stalls? You don't train the pilot to stall the airplane.

MR. RAY: That's true, but it has potential implications when you realize you can also do the wind shear training that's required by [Part] 121 in one of these devices. So it has a negative--

MR. KOHLMAN: But the point is still you don't get past shaker.

MR. RAY: If the wind shear training is required, they are not required to do the wind shear in a prop, but if you go to jet.

MR. BAKER: The point is, if you went in the real world and take an airplane, take one of the airlines we have been flying recently a so-called representative Lear 35, I would have hated to use that airplane to model a simulator on. Nothing was right on it. It's been two weeks now since we flew the airplane. I would not have wanted to model it. I would have rather used the design data to model it to. Which is what we are making this guy do to get it back to configuration.

It's so far out at stall itself, at shaker no problem, you get to full stall, you have one air speed indicator that drops off dramatically, one stays where it should, it goes on and on and on. Who knows what you are going to get.

You have a better representation of a real airplane, I think, if you use the design data where somebody precisely went out and defined the stall speeds. To me you would, at least.

But characteristics I would agree. You need good characteristics. You need proper--if it's rolling tendencies or buffet, that's got to be there. The stall is not going to be far off. On certification stalls you are nit-picking. You are taking a knot or two difference in stall speeds.

MR. BOOTHE: The only problem that we have with the stall speed itself, why in the United States it's not a big issue for pilot training and certification and I don't think it's a big issue in the UK and Europe. However, the UK requires that simulators stall. And since we have got a harmonization program with the FAA, that could lead to problems for Paul [Ray]. But I still think, regardless of that, using certification and AFM data is good enough for this. Is that your position?

MR. BAKER: That's my point. I agree.

MR. BOOTHE: What I have done is changed this block that says acquire using blah, blah to use TIR and AFM. And as far as I'm concerned, issue closed.

MR. WILLMOTT: Could I ask a question of Paul [Ray]?

As far as I know, the training requirement in the simulator in this area is approach to stall, you go down to stick shaker or whatever the warning is, and you apply power and recover.

MR. RAY: Right.

MR. WILLMOTT: That's the only time you get to the stall? The wind shear requirement is not in this class of airplane?

MR. RAY: Not for maneuver training. But the side part is these standards would apply to even a turbo jet.

MR. WILLMOTT: And for that fly at stick shaker--what about unusual attitude type training, is there any requirement to have anything beyond the stick shaker modeled in that?

MR. RAY: Not that I'm aware of.

MR. BOOTHE: That's sort of industry--

MR. RAY: The industry has picked that up.

MR. TOULA: Voluntarily.

MR. RAY: It's not required.

MR. NEVILLE: They wouldn't use Level B simulators to do that.

MR. ELLIS: Related question. Is there any requirement to model stall characteristics like roll off, things like that?

MR. SCHUELER: No.

MR. BOOTHE: No. In fact that would be--they are different each time you do them, so I don't know--people do model something.

MR. STOCKING: We also have a class of aircraft here where you control stall speed with power.

MR. LEISTER: Did you say you were changing this to use TIR and/or AFM? If you don't have TIR data then you can use AFM data, don't you need to model the pitch attitude of your stall much better than just something you pick out of the air?

MR. BOOTHE: Well, it was my opinion that that gets covered in some other test and I was more relating this strictly to the pertinent speeds. If that's not right, somebody tell me.

MR. LEISTER: I know that wasn't a requirement in some of your earlier advisory circulars.

MR. BOOTHE: Let's see what this says. The only thing that--here is air speed and bank angle. While people often provide additional data, and I think that's very informative data, and certainly it's important, I think in this case if we were to take the position that those relationships are covered in other tests, while I don't know of any other tests that we really get down to speeds this low, but maybe Stewart [Baillie] can help this.

MR. BAILLIE: Bob [Heffley] and I were just suggesting you are going to have trim points at 1.1, so you have some attitude relationship, some drag relationship.

MR. BOOTHE: But that doesn't show up in the validation data, it shows up in your--

MR. BAILLIE: In your trim you have to have power setting.

MR. BOOTHE: You mean trim for the stall itself?

MR. BAILLIE: No, I'm saying in the trim data--oh.

MR. LEISTER: You are probably going to be doing power-off stalls, too. I think it's important but it may not be. It's easier for me as a modeler not to have to.

MR. BAILLIE: Chuck [Stocking] did point out in most of these aircraft the stall is completely different depending on the power settings. So getting one validated point may or may not suggest your model is good for pitch attitude and for--

MR. BAKER: You take a typical turbo prop that has a lot of prop wash across the wing, a power idle stall is going to be tremendously different than with the power on.

MR. LEISTER: The handbook shows--

MR. BAKER: One knot per second.

MR. BAILLIE: Is the training intent more for downwind turn on to final or the departure turn on takeoff?

MR. WILLMOTT: Sometimes in simulators, what they do is just let the airspeed bleed off on approach. On approach to landing demonstrate what the stall is like.

MR. BAILLIE: That's a low power stall.

MR. STOCKING: That's worst case.

MR. WILLMOTT: If we are going to use flight manual stall speeds, then we need to know the margin between stall and stick shaker, I guess that's normally seven percent.

MR. BAKER: Well, yes. I say I would still put in high speed characteristics.

MR. WILLMOTT: Also the flight manual does not give low speed, I think some of these aircraft that occurs before stick shakers.

MR. KOHLMAN: Do most of the airplanes have stick shakers?

MR. BAKER: Most have a shaker or aural warning in this category.

MR. WILLMOTT: So you can't get buffet speed--

MR. BAKER: Some airplanes in this category, some do, some of the transports, but Part 23s, no.

MR. BOOTHE: The only way you would get buffet is if it is significant enough to be the stall warning, then you would get it. But if it's not enough buffet to in and of itself be stall warning, I don't think anybody relies on that, anyway, do they Gerry [Baker]? Most people have a stall warning system.

MR. BAKER: Most of the airplanes I see some kind of artificial--

MR. WILLMOTT: The 747 flaps up. That is the buffet. You get plus or minus one g.

MR. BOOTHE: Hilton [Smith]?

MR. SMITH: Could I say I have heard a lot of words about the stall speed is not that important because we don't train to it. But if you train to stick shaker and you say the trainee busts the ride if he stalls, then if we don't have the proper stall speed represented and pitch angle brake, stall speed and load factor brake or whatever defines a stall, if he goes to stick shaker and two knots beyond and it stalls, he is going to holler foul. We have to have the stall speed properly represented to give him a proper, you know, representation of not stalling.

MR. BAKER: That's true, but I think you are going to get a better representation of proper stall speed by using certification data.

MR. SMITH: Whatever. We need to recognize, I just want to remember that it's not totally--

MR. BOOTHE: We are not suggesting not having the correct stall speed.

MR. SMITH: I realize that.

MR. BOOTHE: We are saying the source should be AFM or certification data.

MR. SMITH: Though we don't check pitch angle and load factor, they need to be properly represented.

MR. RAY: We are not going to go through there and check it mathematically.

MR. SMITH: We are not.

MR. RAY: It may be from listening to Stu [Willmott] and some others, that the AFM number is correct, supported by a video of a maneuver in the aircraft to acquire those, if you don't have comprehensive data.

MR. WILLMOTT: There is a number of things that you normally get from the TIRs that are really useful, of course one is the buffet speed that you can't get from the airplane flight manual at all. The other thing is the g break, that occurs in the cockpit, you can see that on the vertical speed indicator. If you use flight manual data you don't have any way.

MR. RAY: That's--

MR. WILLMOTT: I would find it very, very difficult to, I'm getting into modeling, do anything in this area without having the TIR data on the stall test on the aircraft.

MR. RAY: Is it reasonable to say the TIR is a reasonable source for the data?

MR. WILLMOTT: Absolutely, yes.

MR. RAY: But if you are using only AFM, then support that with another source.

MR. WILLMOTT: You have to have visual data, you can't get buffet speeds.

MR. RAY: That's my point. There are crucial items to make sure the simulator is flying properly.

MR. BAKER: I don't think there is anything wrong with what you are saying. You are still going to get some stalls, but instead of trying to take that airplane with its static system or whatever and use those numbers for stall speeds they could be way off. You would be better off in my opinion to take precise numbers that determine certification. Characteristics you define from what you saw in terms of g brake, stall warning, rolling tendency, whatever, I didn't mean to say don't go stall an airplane.

MR. BOOTHE: Well, okay. I guess what we can maybe conclude here is the TIR is available, that's the primary source. If not we can use AFM and a video to confirm these other parameters that you are concerned about. Is that fair?

MR. KOHLMAN: Yes.

MR. BOOTHE: All right. I think it's coffee time.

MR. LONGRIDGE: Let's reconvene about 20 to 11:00.

(Break taken.)

MR. BOOTHE: I guess we are down to that notorious maneuver or that notorious response mode called the phugoid. We won't have a history lesson, but what I've done here, since the phugoid is usually something on the order of a one-minute period or thereabouts which for a given airplane configuration and flight condition, is pretty much a function of speed, think we can measure the period accurately by sight.

And that's what I have indicated here, that the damping ratio, there, is another animal. So--but how close do we need it? Because with some careful recording you can probably get a pretty good handle on the damping as well. What do you think?

MR. HEFFLEY: Well, to put the phugoid into context, the phugoid is the one thing that always goes away immediately when the pilot starts flying the airplane. The mode disappears with regulation of pitch attitude. And I guess I've always wondered what the significance of really having the phugoid mode nailed very precisely, what it really adds to a training simulator or most any simulator.

MR. BOOTHE: Well, I think Dave [Leister] put a finger on it earlier. I don't think the period really tells us a whole bunch. I think the damping is pretty indicative of some longitudinal modeling, that's a validation point that's useful. That's why it's there. It's for a model validation and on the concept, you recall yesterday I said if we can convince ourselves we have a good model of the envelope, then we can support whatever training task is in an operator's program. So that's sort of why it's there.

Now if we measure only the period, then I have to agree with you, you could use it for a speed indicator, but if we measure the damping as well, then I think it's indicative of some longitudinal modeling, and particularly the drag characteristics, and I think it's important in that respect. So I hope that's not a disappointing answer, but that's--

MR. WILLMOTT: I think one of the things that it does, too, is often in simulators not being modeled properly the phugoid is quite unstable. This gives you a check for that. Particularly when you have got aerodynamically loaded controls.

MR. BOOTHE: There is one more point I would like to make why it's there. You say the pilot closes the loop, that's true. We can handle widely unstable phugoids on approach because of the closed loop. However, it almost exclusively determines the trimability of the airplane. And I think that's important. Because if the airplane has different trim characteristics--or if the simulator has significantly different trim characteristics in terms of pilot trimming capability than does the airplane, then we have messed up.

So I think that's probably even more important than is the drag characteristic indicators. It's an important mode. Bob [Heffley]?

MR. KOHLMAN: It is one of the fundamental dynamic modes, so it's a good measure of how well you have modeled some of the more prominent stability derivatives. Because of that, it's not a terribly onerous burden until you make the tolerances way too tight, because it responds relatively quickly to just a few of the primary stability groups, even though I agree with Bob [Heffley], you don't see it that often in a simulator, it's still a good measure of how good the model is. If it's very far off then you will see it in the simulator, then it will be a disconcerting characteristic.

MR. BOOTHE: But the pilot in the loop, hopefully it's totally suppressed but it still has a strong influence on trim characteristics.

MR. HEFFLEY: I really don't disagree with anything that's been said here, I guess the bottom line is how close that phugoid damping really needs to be matched.

MR. BOOTHE: That's a different question, okay. All right. I think that's open. In [AC120-]40B we have a 0.02 on the damping ratio, I believe, and we were only talking about damping ratios on the order of--that's twice as big as some of the damping ratios you get on a phugoid. So while it's a small number, an absolute value, I don't think that's a small tolerance.

MR. DAVIS: The damping ratios do tend to be very small, if not neutral.

MR. BOOTHE: Of course, that's why we need that, it's hard to get ten percent of nothing. So you have the 0.02 and the position has been taken that you may use the larger of the tolerances specified. So you think 0.02 is too tight for that?

MR. HEFFLEY: It has been in certain occasions.

MR. SMITH: Ed [Boothe], if we are going to have an inertial system for the configuration change dynamic cases, would it be unreasonable to just lump that test in with those?

MR. BOOTHE: No, it wouldn't. In fact I don't see how we can do a short period without an inertial system and those two, you know, are coupled, more or less.

MR. NEVILLE: Phugoid is something that you can measure easily with less sophisticated instrumentation because it's such a slow maneuver and I think a stopwatch would work quite well. I agree with you it is an important test of some very fundamental longitudinal characteristics. But one thing that's interesting is that I don't think there is any difference in any of the tolerances between [a Level] B and a C [or] D and this may be one area you might want to consider as a slightly wider tolerance band on it, on the damping, because it is, compared to most tolerances it is pretty tight.

MR. HEFFLEY: I would ask if that particular tolerance that we are talking about, the 0.02 value, is that really commensurate with the method of measurement that we are maybe talking about, which is just a direct observation of a couple of cycles?

MR. BOOTHE: Well, Bob [Heffley], if I were to use the airplane instruments, assuming they're calibrated, and with some help I could almost with--speed--pick something if I had a fairly well burst of speed indicator and I kept track of the variations, got a little pick of the peak each time when I'm dealing with a mode that has a damping ratio of possibly zero or 0.01, I don't think 0.02 is really that tight. Because if you can't meet that, I would say something is wrong with the dry equations. I think that's a clue. That's just my opinion.

MR. WILLMOTT: Well, with this class of airplane [you] can get into the modeling of the controls very, very significantly, it's a very, very critical thing as far as the damping is concerned, you can just blow it. [Change] some of the aerodynamic terms involved and you will change from stable to unstable. In a simulator where I changed the friction on the control column by half a pound, it changed it from stable to unstable.

And in fact one of the things I was going to say, I don't know whether I'm baring the soul of simulator manufacturers, is that one of the problems with simulators is trimability. And it still exists and I think it probably is related to the motion feel that the pilot is lacking in simulator[s], delicate motion feel, if he is not in trim. One of the ways that we used to make trimability easier is by making the phugoid very heavily damped. And in fact by including this as a test you are making it more like the airplane but you are making the trimability of the simulator harder.

MR. HEFFLEY: That's a good point.

MR. KOHLMAN: Should we make it stick fixed or stick free, stick free is where the friction and the controls--

MR. WILLMOTT: Normally it is a stick free.

MR. KOHLMAN: I know. If we are really collecting inertias and aerodynamic damping and those terms, you ought to make it stick fixed.

MR. BOOTHE: At stick free you get such an overwhelming influence from bob weights and downsprings, that's what you end up measuring rather than the airplane.

MR. SCHUELER: Particularly for this class of airplane, you are going to have a lot of thrust effects as well. You have got slip stream changes occurring with changes in speed and altitude, those can be significant, those changes in the thrust model have a big input into the phugoid response.

MR. DAVIS: With respect to fixed versus free, we want the whole answer to be right, not part of the answer to be right. If there is something in the control modeling that is in error, we want to bring that out, do we not? So what's the point of having a beautiful aerodynamic model if the whole simulator isn't flying like the airplane?

MR. KOHLMAN: But if what Stu [Willmott] is saying applies across the board, that is, very small changes in the friction in the control system have a big effect in the phugoid, you are going to see the same effect on any particular airplane you test, that is, very small changes in the same airplane in friction, which I'm sure take place, are going to change a stick free phugoid.

Why not model separately, do the control sweeps within a reasonable tolerance on friction, bob weights and downsprings and all those things, then we determine the inertial effects with another test. Put them together and you will match within the tolerance bands that you see in the field.

MR. HEFFLEY: But wait now. Stu [Willmott] is bringing up a really important point here, that it's kind of beyond this matter of the goodness of the match. We are almost suggesting that this is one of those cases where as a simulator designer, you may really want to have the freedom to fudge this particular characteristic because it's something that you are in effect trying to compensate for something that is not there in the simulator.

I had a recent experience where I matched the phugoid very well. And my client did not like it because it was too tough to trim compared to the real airplane. And it was because of this lack of other cues and things were made better by adding a little bit of damping, in this case making it easier.

MR. DAVIS: How do you know it's not throughput? I'm not saying it is, there are many things that could be the source of your problem. Maybe you are covering that up.

MR. LEISTER: That's a controls problem if you can't trim it. I don't have any trouble trimming the simulators I have worked on, and pilots don't either.

The phugoid, though, you better get it very close, damping ratio or not, you better get all the peaks and valleys close to the airplane or you have done something wrong. You better go back and do some more work.

I don't ever look at damping ratio until I have to look for you guys. I just do the phugoid so it's very, very close to the data. That goes for all the phugoids induced by thrust or flaps or whatever. They are very important tests.

MR. BAILLIE: Is this maneuver conducted stick free and is the column position matched during this test?

MR. LEISTER: Yes, they better be or you really--

MR. BAILLIE: It wouldn't be if we just used stopwatch.

MR. BOOTHE: I think it's a dual answer, for validation we have not measured the elevator floating or the stick position floating, which may come from control system components. We have typically just measured the period and the damping and so we have measured the overall response in that respect. But if you get all of that right, then there has to be either something right in the model or some very strong compensating effects. And you don't know which, of course.

MR. LEISTER: But you can get the phugoid by letting elevator float in a way that was not on the flight test. You can get those matching within tolerance, you have got to get the whole thing right. You have to have the elevator float, everything right, or you might as well start again.

MR. BAILLIE: Don't you want the validation maneuvers to prove that you have it right?

MR. LEISTER: As a modeler I'm not really that concerned. But I would do it myself, I would prove it to myself, yes.

MR. BAILLIE: While we are on this discussion, before I forget, the other question I have is, the majority of simulator training in these and other simulators is in the circuit and yet the phugoid is done in the cruise. I don't understand why that's the case.

MR. LEISTER: It should be in approach or at least approach.

MR. WILLMOTT: When you are flying tests and you do them for all configurations.

MR. BAILLIE: I know. The validation maneuver, which is the one you hang your hat on and say this is a good simulator, should be at the configuration most important.

MR. WILLMOTT: Normally I think we chose the cruise because that's the place where he is going to try trimming it out and essentially let it go while he is doing other things during the cruise, see how it tends to wander in that state of flight.

MR. BAILLIE: Is that the most important configuration?

MR. WILLMOTT: In approach and other situations he is never ever going to be letting the controls alone for more than a few seconds.

MR. SCHUELER: Plus you have the change dynamic tests that provide you--

MR. WILLMOTT: Give you an excitation.

MR. BOOTHE: I must say that you folks never cease to amaze me, when I think I come to an easy one.

MR. LEISTER: We got together before the meeting.

MR. SMITH: See, Ed [Boothe], you did such a good job before you retired we are not going to break away.

MR. BOOTHE: Well, the thing is, if we have to measure it for Level B qualification, can we do it well enough by the method described here or must we have more? I guess that's the most important question to me now. Because if we need more than this, from some of the descriptions I have heard that I would indicate quite a bit more, if we were to keep track of column position and elevator position and bob weights and downsprings and all those other things that may be in airplanes of this class. But if we were simply to take what's here, measure the period in the damping, if we get that right, all of those other things are either right or somehow they have got compensating features and it could be either.

But we, traditionally, have accepted for even Level D simulators a period of damping ratio or damping, and I don't, certainly don't see that we would want to be any more stringent for Level B, but I do think if I had to flight test an airplane I have a pretty good chance of getting a decent answer, I just fly the airplane with some decent instruments.

MR. LEISTER: Most of your Level C and D simulators are, or a lot of them, they don't have elevator float, the airplane itself doesn't have an elevator float that affects it. That's the primary thing that you need the column addition for is to determine if the column is actually moving, and it does actually move quite a bit on the phugoid on these little airplanes.

MR. BOOTHE: You do see a little bit of elevator float.

MR. LEISTER: You do in a non-reversible system, it's not like a reversible.

MR. BOOTHE: No, it's not. And airplanes that have a sophisticated control system that's done by means other than bob weights and downsprings, you don't see nearly the effect that you see. But you do see an effect. Because it's still fed back through whatever affects that control system.

MR. SMITH: These C and Ds require time histories, and on airplanes with reversible controls, such as prop jets, before we asked for elevator, a time or two we found in the automatic program they were locking down elevator, I remember that on a Saab 340.

Since we are not measuring control surfaces here, I would think we would want column position and a time history and just require this data along with the configuration control dynamics data.

MR. BOOTHE: Comments on that?

MR. LEISTER: You really need that on all the transient tests. You need the column, too. I hate to say it, but I think you really do. If you are not going to record external surfaces.

MR. BOOTHE: What you are saying here, then, is you are removing my simplistic approach and saying we have got to have some kind of a position sensor on the control column and we have got to have a system to record the time history of the response.

MR. LEISTER: To be a valid check, I think you do. That's what this is about, the check on the simulator, I think without that I could play all sorts of games if you don't require me to show the elevator.

MR. STOCKING: To validate modeling itself, not to certify the machine, you have got to have a real accurate column position. Control position force and position tells you everything about your model you need to know in a reversible system.

MR. BOOTHE: But you get the model correct, then for just a validation checkpoint do I need that or can I be happy with just frequency and damping? That's all we have specified for any simulator, in fact.

MR. STOCKING: It's just like recording angle of attack. You really need it.

MR. BOOTHE: Well, the modeling is implicit, it may be wrong, and have compensating features, but it's implicit.

MR. LEISTER: In this case it isn't, really, because you can attack the problem two ways, you can make the phugoid react by making the elevator float one way or you can do it like the airplane does and then you have got to get all the other numbers correct. It's not something that proves itself with just a period and a damping in any of these phugoids.

Pardon me for talking with my mouth full.

MR. BAILLIE: If you are changing the float parameters, isn't that going to catch up with you in the longitudinal static stability test?

MR. LEISTER: It will. You can still build a model that probably passes these tests. Pilots probably won't like it but they won't know how to tell you what they don't like.

MR. BAILLIE: If the pilots don't like it, it's not going to get qualified.

MR. LEISTER: Maybe.

MR. RAY: If you don't have the right pilot, if I don't have Gerry [Baker] or someone of Gerry's caliber in there that can quantify to the engineer what's wrong with it. The worst answer in the world you would expect is comments like, “I don't like it, it's no good.” That's not a very acceptable answer.

MR. LEISTER: Doesn't fly like the airplane.

MR. RAY: Get the technician in there that can fly the test, he can make it work every time, that’s of limited value.

MR. LEISTER: I'm saying from a modeler's standpoint I would rather I didn't have to show you where the elevator or stick or anything went. But I'm saying as a validation test it's really not until you do include that one thing.

MR. BOOTHE: Sounds like we are inventing a Level E simulator.

MR. WILLMOTT: I was going to say the name of the game is to try and make this device cheaper than what the standards are right now for C and D. And going back by what we said at the start, anything that the pilot can't see is not really relevant to a validation test.

You might see the column moving a little bit, but there are lots and lots of things for all of these tests that we need to have right in order to model things correctly that we are not showing, and I don't think putting it in validation tests is the place to put it.

MR. HEFFLEY: This goes back to the relative importance, I think, of this particular characteristic. And if its importance has to do with unattended operation, trimability, then there is some of these effects such as the amount of float and column motion, that aren't very important to the pilot at that point in time.

MR. BOOTHE: Well, it looks like a solution here is to insert the infamous double asterisk and assume we are going to have a system to measure it. Because other suggestions I'm hearing even exceed that in terms of instrumentation because if we got an instrument to measure the control column movements as suggested, since we don't have the surface, and that makes a big difference on the response, but we have traditionally, we have traditionally seen it because we have that comment about having to verify flight condition and show enough data to illustrate the response, but we have never put any sort of limit on how much it should be except frequency and damping. That's the only limit we have ever had.

MR. LEISTER: I don't want to mix model and ATG that much, but I think that maybe we are all, maybe I'm not talking what you guys are talking, but to me a simplified flight test is one where you don't go out and tear up the airplane and put sensors on the surfaces and you don't measure angle of attack or sideslip, you do go in, you have force and position and transducer on all the major flight items, column, wheel, whatever. And you have to measure those positions, those forces, you have to have also a system to measure the attitudes, the pitch attitudes, roll, heading and acceleration in order to build a good model that will fly like the airplane.

Or, you have to have surface, angle of attack and all this other stuff. You can go either way, but you still have to have acceleration and attitudes for that kind of test. You can do a cheap flight test by instrumenting the internal parts of the airplane and get a very, very good model but you do have to do that.

And by going test to test here, some tests you don't have to have all those things to get the modeling data or the proof data but most the tests you do. One thing or the other.

All I'm saying is that if I don't have external position data and I don't have angle of attack and sideslip, then I want the whole system working inside the airplane on all the tests so I can use it not only for validation but for modeling. I don't know whether I have made that very clear, I can't build a model unless I have all those things. Not a good model. I can build an old time model like we used to see 20 years ago.

MR. RAY: Is it a fair question, what's the reasonable cost saving incurred by doing that?

MR. LEISTER: I don't know what the dollar amount is. But it's considerable. And you know Flight Safety used to do their tests that way, they had it on a gyro that had a precession in it, it was a modeler's nightmare. They have a laser now that's very nice and no precessions to speak of. It gets you attitude and you have positional forces, it's good flight testing.

MR. BAILLIE: I would suggest his saving would be two weeks in instrumentation time.

MR. LEISTER: And a lot of dollars.

MR. BAILLIE: Time is money.

MR. LEISTER: In the small airplane, getting in the airplane and tearing some holes in some guy's airplane that you leased, they don't somehow like that.

MR. BOOTHE: Okay. We are talking two things here, one is validation, stuff you are going to give the FAA; the other is, is finding data to fit your model. I guess I can say fit it, what you do is find responses so you can go tweak numbers to make them work; is that right?

MR. LEISTER: I didn't understand what you said.

MR. BOOTHE: You are finding responses so you can now go tweak some coefficients to make them meet those responses, so that's part of the modeling process. But it's stuff you are going to send the FAA is what I want to address right here.

MR. LEISTER: I don't think you can separate them. In all honesty, I can't look at Mr. FAA and say all we need is the period of damping, no sweat. That will prove the phugoid. It doesn't, I think you need the other thing, the elevator float characteristics.

MR. HEFFLEY: But we are getting those already in some of these dynamic and these transient maneuvers.

MR. STOCKING: If you put elevator position on this test you couldn't apply a tolerance to it because the movement is so small it's well within any--

MR. BOOTHE: Sometimes. Other times--

MR. STOCKING: I would say 99 percent of the time.

MR. BOOTHE: Let me go back to what David Kohlman said. Maybe these control system responses are seen somewhere else. We have all the transient responses for configuration changes, every last one of them will excite the phugoid, although we don't let it go very far, because we tried to but we got shot down on that. Maybe we should just look at the aerodynamic model of the airplane here and not of the control system and do a stick fixed phugoid for Level B.

MR. LEISTER: That's very hard to do. What do you define the stick fix--

MR. BOOTHE: Okay.

MR. WILLMOTT: We are really going to do tests in the validation tests that are things pilots will do and will recognize. The stick fix thing is not something that he would do.

MR. BOOTHE: But I don't want to invent a higher level simulator to do this.

MR. WILLMOTT: I'm all in favor of leaving the darn thing as it is and go on. If I wanted to do anything, I'd take it out because of what I said first. I still believe that trimability, pitch trimability is a significant problem in all simulators. That's my experience. And by taking the phugoid out I can do something to make the pitch trimability easier, but if you want it in, leave it as it is.

MR. BOOTHE: When you say "leave it as it is," do you mean leave it as it is in the current Advisory Circular?

MR. WILLMOTT: Just have the period and damping.

MR. RAY: The piece is missing, what I hear Stuart [Willmott] saying is our present ATG requirements would include the controls. In the instant case we are talking about with this particular test, we would not see controls, it goes over to Dave's [Leister] point.

MR. WILLMOTT: All the phugoids we currently do for [Levels] C and D we give you the time history of elevator, air speed, of pitch rate, pitch attitude, all of those variables are already in there. Whether they are spelled out or not. So you can see what they are doing, you can see what the elevator is doing.

MR. RAY: Correct. In this case what we are saying right here, we would not. We would neither see the control position or the surface position.

MR. WILLMOTT: I did go back and check what we needed for B.

MR. RAY: The testing requirements are the same. The tolerances are the same. It's period and time and damping ratio. But the part that will be significantly absent--

MR. WILLMOTT: I was presuming that since Dave [Leister] was talking surface position that it didn't have it in there.

MR. RAY: Didn't have surface, but Dave's point, you would have control position in lieu of surface. At least that's what I heard him say.

MR. LEISTER: Yes. If you really want a validation test. If you don't, well then don't include it. Because it's not a validation test.

MR. WILLMOTT: I'm sorry, Paul [Ray], I guess it's a bit late for me or something, I'm missing the point.

MR. RAY: Maybe I am. I think Dave's point is we need to see the control or surface. We are not going to see the surface, we already agreed to that. Before the--for the test results in the ATG, if we do it as printed in the draft tables, we will neither see surface position nor control. All we will see is a number.

MR. BOOTHE: Two numbers.

MR. WILLMOTT: A damping and altitude or a speed profile.

MR. RAY: However, it is derived. Dave's comments and some others indicate we need to see the control position in there also.

MR. STOCKING: We don't do that currently for the other.

MR. RAY: Yes, we do. Because supporting information requirements in the QTG for the varying tests we would also ask for surface position as supporting information on how that test, the test results, were derived for that tolerance we are applying on the particular item.

MR. BOOTHE: I think probably we have arrived at retaining the language in the current Advisory Circular and moving on because other thoughts I'm hearing here are inventing a higher level of qualification and we certainly don't want to do that for this application. And anything less than that is inadequate, so standing on a razor's edge here I think we better stay where we are.

MR. NEVILLE: There is a general statement in the Advisory Circular about additional parameters beyond those that are just required for tolerances, all relevant parameters related to a given maneuver or flight condition must be provided to allow overall interpretation. Providing this kind of thing, control system information, falls into that category that covers every test.

MR. RAY: My point being if we did it this way we would not have any of the other information. All we would have is a number.

MR. BOOTHE: But what we have done is delete my comment about a stopwatch and airplane instruments because we cannot do that with only those measurements, and that's why I have suggested that we simply stay with the current Advisory Circular and leave it be. Because I'm certainly not going to be popular in the industry if I raise a new level of simulator here, and I certainly don't want to not get a decent measurement and have a not good simulator.

So I'm going to be a coward and take the easy way out and leave it as printed in the Advisory Circular, and unless all your hands go up I'll take the coward position.

MR. RAY: I don't think it begs a double asterisk, I don't know.

MR. BOOTHE: It does if we are going to have time history. Good discussion. Thank you.

It doesn't leave much to talk about on the short period, I guess.

MR. SCHUELER: Knock on wood.

MR. BOOTHE: Well, we already have an inertial requirement. While I personally believe the short period is very important, very important to handling qualities, primary maneuver mode, it's hard to see, and you've got to have some decent measuring equipment, and I think that the--strap-down system is a minimum that one could really get by with for that. So I've left it that way.

Unless there is objections, we can start on lateral directional. And while I know you all have a lot to say and contribute, we've got some things to discuss that I would like to get to, and they have to do with well, the cost increment. If we can come to some estimate. So I would like to leave time for that today rather than run out of time.

And also I still think we need to discuss somewhat about what if we just use a predicted model at a Level B and don't have it adjusted from flight. Is that a possible thing to do and come up with a decent simulator? I don't expect an answer now but I would like to discuss that a little bit later.

So what I'm saying, I want to hear you out on lateral directional but I want to see if we can speed it up just a little bit. And lateral directional begins with, on page 8 of this book, with minimum control speed in the air. Can we get that from the AFM and the certification data? It's certainly something that's strongly--that's something that's tested and certainly available, I would think, but maybe I can ask Gerry's [Baker] input.

MR. BAKER: You can get the speed if you had the TIR, obviously you could. The AFM. Only you are back to the situation you don't know the specifics as to whether it was a force limited or control limited V_{MC}, for example.

MR. BOOTHE: So really it's in the TIR if we can get it.

MR. BAKER: If you are just looking for a number you can say yes, this is the way we are going to do it. How important is it? And go on from there if it's a matter of doing it that way.

MR. BAILLIE: Isn't the intent of matching V_{MCA} to be sure that the pilot in a simulated engine out condition in the simulator has to use the right forces and right cross controls? That's more than just matching a single speed number to V_{MCA}. And perhaps the Level B simulator should have OEI trim and a variety of OEI trim conditions rather than matching one V_{MCA}. That's the intent, I think.

MR. BOOTHE: So are you suggesting that perhaps we should just do a number of trims with one engine inoperative at speeds approaching V_{MC}?

MR. BAKER: They are not related.

MR. BAILLIE: But the intent of this maneuver is not to validate V_{MCA}, it is to validate the handling qualities of the aircraft in a one engine situation.

MR. BAKER: I don't relate trim at all to V_{MC}.

MR. LEISTER: Yes, trim--

MR. BAKER: Nothing to do with it.

MR. STOCKING: You can point at min control speed by taking a series of trims, increasing speed.

MR. BAKER: You don't trim in a V_{MC}, first of all. You can't use the term, you trim in a takeoff scenario, remember, for V_{MC}, not for in-flight condition. To me it's a controllability maneuver. Some airplanes are rudder limited, some airplanes are stall limited, some airplanes are aileron limited, some are force limited. You can get a lot of combinations on V_{MC}, it's a pure controllability issue.

MR. BAILLIE: But I guess the question is, for a simulator, is it as important to get that as to get the handling quality required on the climb out with one engine?

MR. BAKER: Well, it's debatable.

MR. BAILLIE: What's the training intent, is the question I have asked a number of times here.

MR. BAKER: Somebody else has to answer that.

MR. NEVILLE: The idea is to get engine out trim requirements or characteristics. There is already a test that does that. The V_{MCA} test is a more extreme condition that tests the model for full rudder. If it's a rudder limited V_{MCA}, you have maximum rudder, very low speed as well as having a maximum thrust asymmetry. So it really tests the extremes of the model.

MR. BAKER: I agree. It's the control at the extreme ends of the model is what you are looking at, which I would think would have a very important factor in the way it blends in the rest of the model.

MR. SCHUELER: It's more than a number.

MR. SMITH: I think you want the time history approach to it. Because it's very dynamic. I can remember one we just looked at, the 601, roll critical, if not limited, in that you are full wheel into it--

MR. BAKER: You can build it all wrong. Let's say you built it in as a force limited rudder problem and it's really a roll problem.

MR. BAILLIE: You don't get that from an AFM.

MR. WILLMOTT: You get that information from the TIR.

MR. BAKER: You could get it from TIR.

MR. BOOTHE: Scratch AFM, obviously that's inadequate from the discussion.

So then the question is if the TIR for some reason, and there seems to be a number of reasons, were not available, then what are we left with? If one were to have to do tests, perhaps it's not as simple as I have indicated here. From what you are saying I was just looking at speed and there is a lot more needed in here than just a speed in order to do an adequate simulation, and so therefore for validation we traditionally just looked at a speed, haven't we?

MR. SMITH: We have looked at time histories on a lot of these.

MR. RAY: Supporting data.

MR. BAKER: You can validate it in a static V_{MC} in most--most airplanes if you can meet the static V_{MC} you can meet the dynamic case. It's rarely a problem.

MR. WILLMOTT: Would you like to describe how you normally conduct the test in an airplane?

MR. BAKER: Start out with static maneuver, and just--it's everything, you know, again you need some analog instrumentation force into it, particularly for rudder force. Usually a rudder, I have never seen an aileron force limited V_{MC}, but rudder is quite frequent. It's possible you get a lateral control limit-force but I have never seen it.

But it's a matter of just slowing the airplane down, and all manufacturers are going to use the full five degrees bank. I've never seen anybody that didn't, because it's very significant. And the bank angle is extremely important. A degree of bank can make a lot of difference in V_{MC}. On some turbo props I have seen the difference in V_{MC} between wings level and five degree bank as much as 20 knots. I have personally seen that. It's a very, very important item.

I've actually run into problems where you play with it so long you get a precession on the gyro and it screws up the whole test. Usually you relate it back to some data pack or you need to make sure that the roll angle is correct. That's very important. And just progressively slow the airplane down and feed it control until you simply run out of some control or you can't slow down anymore without getting a heading change. Or reach of force limit. That's the static maneuver.

Some airplanes you can't hardly get light enough to get V_{MC}, that's an issue on some airplanes. It's very difficult to get light-weight conditions. It's important that you use takeoff trim settings in your airplane, you don't trim for a V_{MC} because you could have a force limited V_{MC}, rudder trim should be takeoff, your lateral control should be takeoff lateral control, and then normal practice is to determine the static number and then come back and validate with a dynamic cut, engine cut, actual fuel cut.

I have never seen a problem on an airplane yet as far as the dynamic cut. The dynamic maneuver becomes horrendous on some airplanes, particularly at the light-weight on some high power airplanes because of the attitude. People have looked at alternate ways of doing the dynamic cut. Slowing the airplane down and dirty up the configuration, accelerate, as you clean up you hit the speed more in level attitude.

I personally think validating with a static maneuver would be adequate and forget the dynamic cut. That could be horrendous, you could take a Lear jet, 45 degrees nose up, light weight when you are climbing out and you cut the engine the biggest problem is the speed decay, you are pushing to catch it.

That's not a very real maneuver, it does not simulate what you see on a climb out and acceleration at all. So it ends up being a horrendous push.

The other thing is you are allowed to get a 20 degree heading change on a dynamic cut. That's why I say you can almost always comply with a dynamic cut, when you let the nose turn up to 20 degrees. So the static maneuver generally sets the test.

I would think for here if you get a static V_{MC} it would be plenty adequate. You do need to instrument the forces and positions. You have to have that good--turbo props you have torque, and if you are torque limited you are in pretty good shape. You have your maximum torque available, but some of the airplanes are not as highly torque limited as others. You want to do it at a reasonable safe altitude. But some of them will be off the torque limit, then you have to correct the data somehow.

Obviously it's better if you can do it on the torque limited level. And you still may have some direction to it depending on altitude.

MR. WILLMOTT: You do it for both engines or you know which one is which?

MR. BAKER: Generally you know, depending on rotation of the engines you can make that assumption.

MR. BOOTHE: Okay. So that was a good description, Gerry [Baker]. I appreciate it.

Now we have come down, we have to have force and position measurements of the controls. What other measurements do we need? Do we need to put the whole inertial system in to [get] enough information or if we have control information and speed do we have enough?

MR. BAILLIE: Attitude.

MR. BAKER: Attitude.

MR. BOOTHE: We do need attitude, right?

MR. BAKER: If you have got a good attitude system, I mean inertial or AHRS system or whatever it is.

MR. HEFFLEY: Given what Gerry [Baker] just described, though, I guess, I guess it sounds to me like you really can come back to what Stewart [Baillie] just suggested, was an engine out trim that sufficiently approaches V_{MCA}.

MR. BAILLIE: That's the same--

MR. BOOTHE: I think what Stewart [Baillie] was suggesting was a series of measurements as you approach.

MR. HEFFLEY: Yes. So you get close enough so you get a reasonable match in controls--control forces.

MR. BAILLIE: Could I maybe reiterate or clarify what I was suggesting? The idea that I had which makes it easier to conduct the test, given that we don't have certification pilots usually on board, makes it more repeatable to do the tests, is to take the aircraft at a variety of speed conditions, both engines operating, get a trim point, pull one engine back, measure the forces and accelerations on the aircraft to keep heading zero. Or heading rate zero. So you measure asymmetric thrust, high thrust on the one engine and you can predict V_{MCA} by the extrapolation of those points.

MR. BOOTHE: But you are going to measure control force and control position.

MR. BAILLIE: Exactly. And acceleration.

MR. BOOTHE: At a number of points as you approach critical speed.

MR. BAKER: It will take twice as long.

MR. BAILLIE: It's not a time history matching which takes twice as much effort to do in simulator time. You are right however, the flight test does take longer.

MR. SCHUELER: It's not really significant whether you do it statically or time history. The measurement requirements that you have are such that it's--I don't see a huge difference between doing it either way.

MR. BOOTHE: What I think I'm hearing is what Stewart [Baillie] is saying has merit, I think, I think it has more merit for modeling than it does validation. And it would increase the validation requirements over what are now required.

MR. BAILLIE: The maneuver ties in a bunch of things, no. You need that level trim, anyway, so you are there. Then you pull an engine back, zero up the heading and you got the second data point. Then you clean up the aircraft, go to your next trim point anyway. It's not like you are adding tests here, you are just combining the longitudinal trim with a lateral trim.

MR. SCHUELER: I think it's a valid approach. I think it makes more sense to trim once, slow down to a speed, stabilize that, slow down some more, stabilize that. You know, hit several speeds in that manner, record your required inputs, your attitudes at each of those points and you have accomplished the same thing.

I'm not sure what retrimming at new air speeds accomplishes for you. It actually increases your variables.

MR. RAY: Depends on what you mean by retrimming. To get back to the definition where you talk about retrimming, as Gerry [Baker] indicates, zero trim, using that term, as opposed to configuration of controls being in trim.

MR. BAKER: That's a better definition.

MR. STOCKING: In my comments I meant a static trim, not--

MR. WILLMOTT: The purpose of the check is to check the V_{MCA} in the simulator is the same as the airplane at a very critical speed. That's really what it is we need to check. If you do a trim check that's away from that speed, you don't know whether you are going to meet that speed. Particularly with the turbo prop aircraft where everything is so dependent on slip stream and a few knots down a low speed is going to significantly affect control forces, control effectiveness and everything else.

I think we need to set up the test and do it like the airplane, which is the way we currently do it.

MR. BAILLIE: I know that's the way we currently do it. I would suggest the majority of the time in the simulator is not spent at V_{MCA}, it's a pilot trying to avoid getting to V_{MCA}. He is pitting forces and inputs to stay away from that. Being at V_{MCA} matching it isn't as relevant as being close to matching it.

MR. WILLMOTT: Ground rule one, we want to stick with the requirements of [Level] B if we can.

MR. DAVIS: Either which way it's double asterisks, right? If somebody wants to do it differently, they can go to the FAA and pose it differently. For now it's double asterisks.

MR. RAY: The critical point from a training viewpoint, is that there is the potential, the potential, I think Stu [Willmott] would agree, with the critical impact of V_{MC}. If you don't get close, how close is close enough? I don't have the answer to that.

In the simulation if the pilot does something wherein he should fail, fail due to controls, that simulator should fail as the aircraft should. I think there is more comfort factor, if that's the right word, with the classic approach to that, to ensure that does in fact happen.

MR. BOOTHE: Okay. I think moving right along here that we are right where we started from, if not having invented a more severe test, which we don't want to do, I appreciate Stuart's [Willmott] approach. I think it's a good one. But for our purposes here, if I think if we were to attempt validation by that method, in fact I think that would give quite valid modeling numbers, too, if we were to attempt validation by a method we are actually increasing the requirements that we currently have across the board. And if we want to do that, then by all means let's speak up. But I don't think that was one of our objectives, for sure.

MR. STOCKING: Many of this category of aircraft have min control speed below stall speed, in which case you have to back up to something that points to the right speed.

MR. RAY: Right.

MR. STOCKING: It's only an alternative.

MR. BOOTHE: Is stall not a valid--

MR. BAKER: That varies.

MR. BOOTHE: V_{MC} if it stalls before it gets there.

MR. BAKER: It varies the way it's done by manufacturers.

MR. NEVILLE: It's one of the tests that was originally included because it's a cert test, it's one that's already done anyway. To call it V_{MCA} maybe isn't appropriate. What's needed, perhaps, is a low speed engine out trim. And as Gerry [Baker] pointed out, you have got to get the airplane very light, to even be able to fly a V_{MCA} test the way it's defined, which includes five degrees bank angle.

But if you can't get there without stalling the airplane you could perform it at three degrees or two degrees and still have very low speed maximum thrust asymmetry trim. I think that's the point Stewart [Baillie] is trying to make.

MR. BAKER: If you can find the control required to get to the lowest point you could. The thing I failed to mention, I assumed everybody realized it, you are in a prop, you are at an aft CG, you are at light weight, whatever configuration it's going to windmill again, whether autofeather or NTS or just a plain old windmill, if you don't have either one of these devices, it's in the takeoff configuration, you are up.

MR. BOOTHE: Well, if we were to do what you suggest, which I think is a good idea, we would have to do that for all levels of simulators. I don't think we could--well, we wouldn't have to.

Do you want to change this so we don't actually do a V_{MC} or we do a low speed asymmetric thrust test?

MR. NEVILLE: We run into the same problem at any level. I know my experience with Boeing airplanes with a flight test airplane, because of all the flight test equipment that's fixed weight you can't get light enough to perform a true V_{MCA}, and we have had questions from the simulator operators and manufacturers complaining that our V_{MCA} test is not really a V_{MCA} because it's not five degrees bank angle. We have had to say it's four degrees, but it satisfies the intent. But people get hung up on the name V_{MCA} where it's really just a low speed engine out trim with maximum thrust.

MR. BOOTHE: I have to defer this one to you. Do you want to invent a new test for Level B?

MR. RAY: Stewart's [Baillie] approach is reasonable if you are down at that point where you are close to V_{MCA}. I'm not talking 15 or 25 knots above, I'm talking on the edge of it. It's a reasonable approach we have accepted before. Rather than invent another case for the alternative of tests like that, which may be supportive of V_{MCA}, I think is a more realistic approach to point to the existence of TIR data. If someone has it, they can match it, then it's truly a V_{MCA} test. I believe it goes back to Stu [Willmott] and the Dallas approach, if you want to call it that, where we invented the terms, in one case low speed engine out ground handling characteristics, in the other case it was engine out in the air.

MR. WILLMOTT: Low speed engine inoperative handling characteristics in the air. It's already in the [AC120-]40B.

MR. RAY: That alternative has been there for many, many years. I don't think we are reinventing anything. But to delete it could mislead someone.

MR. BOOTHE: Okay. Another test left where it is, is that the conclusion? Is that also stick a double asterisk in the right-hand column?

MR. SMITH: A couple of times you said 40B and sometimes you say double asterisk. Do you mean the same thing?

MR. BOOTHE: No. Double asterisk means we need inertial platform to measure stuff.

MR. RAY: Including controls.

MR. SMITH: That doesn't mean you are not going to measure anything else. You are going to do normally what you would do in 40B.

MR. BOOTHE: Whatever 40B required.

MR. RAY: Except for surface.

MR. BOOTHE: Moving on to roll response, again I have tried to, while I would prefer to have a roll response, in the interest of simplification I have digressed, I guess, to the old measurement of bank angle from some predetermined initial condition in one direction to some bank angle in the other direction.

A question is, then, is that good enough? We see things done both ways these days, roll response measuring roll rate, but we also still see these full wheel roll rates, which I don't think really tell us much except full wheel roll rates. I have attempted to simplify to that extent. The question is, is that good enough for Level B?

MR. WILLMOTT: The one area where you have the problem is the amount of wheel that you are putting in, and for Level B I would suggest that what could be done is that you put aileron trim of a given magnitude holding the wheel so that it isn't rolling, and when you are ready to time it, you let the wheel go and time it to 30 degrees of bank. Do the same thing [in] the other direction so you have got consistency in doing the test.

MR. BOOTHE: To get anything meaningful out of that response you have got to have a time history because you have the initial roll. What I have suggested and we just measure steady state roll rate.

MR. WILLMOTT: But that's the way of--well, I don't know how you can measure steady state roll rate. In all the time histories I see these days there is a lot of yawing that goes on which gives you from the slip roll from the slip and there is no such thing as steady state roll rate.

MR. DAVIS: How accurately can you measure with a stopwatch? You see a start plus 30, putting your wheel any time from [plus] to minus 30, however I'm a little worried how accurately you can get that with a stopwatch. You could do it with a video better.

MR. KOHLMAN: I would suggest you have the video on this. As a matter of fact, it's spelled out there. Then you can--the way we do it, we always have a digital stopwatch in the frame and you can stop it anywhere you want, read the time, read roll angle and plot it out. Maybe a little scatter but I think you get reasonable tolerances.

MR. HEFFLEY: Yes, I mean all you are really looking for here is a time to roll to a given angle. And if you do it where, for example, you put into the limit aileron that establishes the amount of control, then it seems to me it would be quite simple to get a validation point while still avoiding an explicit time for a single event. Is that what you are describing in this, Ed [Boothe]?

MR. BOOTHE: Yes, maybe I didn't do a very good job. When I say stopwatch I don't mean necessarily going clickity, clickity, but something in a video, a time recorder I should have said. I guess my brain is fixed to the old days or something. But a time measurement.

Certainly you couldn't be clicking a stopwatch in this maneuver and get anything worth getting, but with the video clock in it you could.

MR. KOHLMAN: To answer another point that Stu [Willmott] raised, you are going to get some yaw, and I forgot the other point, but you never do get a pure roll about longitudinal axis but still you try to fix things. I would say you hold the rudders neutral, put in a step and you record it, and whatever the airplane does the simulator should do. There will be some adverse yaw in there, yaw due to roll rate, but they should all be the same within reasonable tolerances.

MR. BOOTHE: To do that, Dave [Kohlman], we need to record more than just bank angle, don't we?

MR. KOHLMAN: You need to know the input.

MR. BOOTHE: You need to know the input and the bank angle change, but if I'm going to take this as an overall response, which obviously is going to involve yaw rate, generation of sideslip, which means I'm rolling from things other than aileron and not rolling because of other things than aileron, I don't know anything about those if I just measure roll rate.

MR. KOHLMAN: Well, except the assumption is if the roll rate, which is the primary match, matches over a number of inputs at several speeds.

MR. BOOTHE: We can assume the other stuff is modeled correctly.

MR. KOHLMAN: That's correct, we want to minimize the number of parameters.

MR. BOOTHE: That's what I was hoping you would say.

MR. SMITH: I disagree with that. Well, I mean this is a validation test, it's to validate the model in the lateral axis. What you want to know, you want to know if a particular airplane has a yaw characteristic, when it rolls you want to verify that, you want to verify the roll, you want to know the aileron effectiveness, you want to know if roll damping is right, you validate all that with one test if you have these parameters.

MR. RAY: Doesn't rudder response cover that to a large degree?

MR. LEISTER: That's roll. If you go roll response--Ray?

MR. KOHLMAN: This is a test primarily to measure aileron roll power. And roll response.

We will get all the other parameters with cross control tests, with V_{MC} tests, we have so many others that will find out if there is another, C_{L_β}.

MR. BOOTHE: Right. If I could address that. I agree with what Dave [Kohlman] is saying, if the response in roll is not correct, then you don't know what's causing it, but if the response in roll is correct and you do have the other measurements, then I think you are in pretty good shape.

MR. RAY: If you isolate the others.

MR. SMITH: The initial yaw due to aileron, are you going to pick up the roll--

MR. BAILLIE: You pick it up in steady state slips.

MR. SMITH: You get a static. If--well--

MR. BOOTHE: We don't measure that now as an independent parameter, yaw due to aileron.

MR. SMITH: It's built into this test.

MR. BOOTHE: What Dave [Kohlman] is saying, if you have yaw due to aileron that generates sideslip which generates rolling moment which may oppose the aileron, if you get the right roll rate then you have accounted for it.

MR. SMITH: With a time history we get the time history data, we before have gotten sideslip, we wouldn't here, we wouldn't ask for it. We may ask for yaw rate.

MR. BOOTHE: We are trying to simplify.

MR. SMITH: I know but you want the same fidelity. You want to validate the model.

MR. BOOTHE: I'm not even sure we want the same fidelity. We want a simulator that supports--we want a simulator that stimulates a pilot response that is correct. I don't know what fidelity that takes, quite honestly, and I don't think any of us do, really. I still make--if you make an aileron input of known size and you measure roll rate and it is correct, you are halfway convinced those other variables are also correct, and then we have other tests which will confirm that. Like Dutch roll and so on. So I think for a Level B we don't need to do all that. I think a simple roll rate will suffice.

MR. RAY: Eliminate the rudder parameter.

MR. KOHLMAN: Yes, eliminate the parameter, the rudder response.

MR. HEFFLEY: The other extreme is if you start breaking these model characteristics into so many components you really are checking every stability control derivative in your model, then you really increase scope. The idea of making a check that takes into account several effects all at once, you know, it's consistent with what you all have been doing for a long time.

MR. BAILLIE: That would be fine if we could say okay, we are going to do a roll step response, we are going to match yaw rate, roll rate all the accelerations, but then we are throwing out this maneuver, this maneuver, this maneuver and we are not, so at least minimizing the effort to match each maneuver does reduce some cost. You are still going to be measuring yaw rate because you need it for Dutch roll and pedal response. But let's not put it onto the roll response, let's check it.

MR. BOOTHE: So if we do a full wheel deflection roll rate, then we can eliminate this need for measuring the control wheel deflection because we are on the stop as soon as somebody has done a confirmation check on the airplane and stops in the right place which should be done anyway. And we just have a full wheel roll response.

MR. SCHUELER: There are ways to do partial.

MR. WILLMOTT: You want the wheel deflection typical of what a pilot is going to use, you are trying to check the simulator to see if it is like the airplane as far as the pilot is concerned.

MR. BOOTHE: In that case I have to go back to something to measure wheel deflection.

MR. HEFFLEY: Control system.

MR. BOOTHE: I couldn't hear you.

MR. HEFFLEY: The use of a control stop fixture allows you to intermediate without going to a full throw.

MR. BOOTHE: I agree, I'm trying to figure out what to write.

MR. LONGRIDGE: We have to stop. She is running out of tape, the sandwiches are set up as yesterday.

MR. BAKER: I hate to bring this up, there are hard roll requirements for commuter airplanes. Right now the Beech 1900 has a single engine roll rate requirement at 1.2 V_S.

MR. BOOTHE: That's more critical than this.

MR. BAKER: That's not all airplanes, I am telling you that. But Part 25 is getting the roll rate requirement. It is coming. They are critical in landing flap configuration. In fact their V_{MC} is a whole new ball game. With V_{MC} you can have a V_{MCL} which we didn't touch on. Some airplanes do have V_{MCL} already. They are actually defining V_{MCL} as the ability to do certain roll rates, so there is all kind of stuff coming.

MR. BOOTHE: Okay. Maybe we can pick it up there after lunch.

MR. BAKER: I wanted you to be aware of that.

MR. BOOTHE: Paul [Ray] needs to really be aware it sounds like some of the requirements that are already here may be addressed.

MR. BAKER: The Europeans may be ahead of you.

MR. BOOTHE: I like Tom's [Longridge] suggestion.

MR. LONGRIDGE: Reconvene at 1:00.

(Lunch break taken.)

MR. BOOTHE: Did we agree on roll response pretty much? We didn't quite have a concluding remark. My memory is that we would do known wheel or aileron controller input deflections using some sort of a stop mechanism to define the wheel deflection. And measure a bank angle to bank angle roll response assuring that that's a steady state response so we have got the transient and that would satisfy this requirement?

MR. RAY: Is it reasonable to add at that point to limit, maybe I shouldn't say limit. Perhaps less than half wheel deflection?

MR. WILLMOTT: My suggestion would be to make sure that the test is repetitive, is to put in a specified amount of wheel trim and then to release the wheel and that would normally be no more than if you used maximum trim, probably no more than halfway.

MR. SCHUELER: [AC120-]40B says about 30 percent.

MR. RAY: Right. You know where I'm leaning, isn't that a better validation as opposed to an absolute full wheel throw?

MR. BAILLIE: Yes.

MR. DAVIS: Yes.

MR. RAY: You want something to roll for 2.5 seconds, what does it prove? I understand it proves something.

MR. BOOTHE: That's important. Full wheel deflection is not a frequently used thing, although I've landed in crosswinds where I wish I had more. But Gerry [Baker] has brought up an important point, that maybe isn't something we write in here today, but commuter category airplanes in particular have roll, minimal roll requirements in some specified configurations, particularly with an engine inoperative. Did I say that correctly?

MR. BAKER: *(Nodding head.)*

MR. BOOTHE: While we aren't here to revise the simulator qualification standards in general today, I think that's something that I would recommend that Paul [Ray] take under consideration for the future, because if that's deemed necessary for airplane certification and roll is, we all know roll is limited in asymmetric low speed conditions, that that seems to me a critical point we would want to make sure the simulator did correctly. So I would like to recommend that for a--

MR. RAY: I agree.

MR. BOOTHE: --future consideration for the overall simulation requirement. Okay.

So we will move on, I have added the word stop, and wheel deflection stop here to be left to the ingenuity of the person developing the test procedure. But you have to have some defined way, or you could do it Stu's [Willmott] way, except you have got to--you have got to go a little past the bank you want to measure so you are out of the transient by the time you cross some point. Unless you can measure roll rate, then we would like to see the transient, so leave that to the testers, I guess.

MR. STOCKING: You'd better pass it.

MR. KOHLMAN: Don't we get the transient in the next one?

MR. BOOTHE: Yes, we do. Which brings up the next question, do we need to do both of those for Level B?

MR. KOHLMAN: Right. I think in one maneuver we do a step input like Stu [Willmott] is suggesting, you get the transient and steady state both.

MR. BOOTHE: Which means would we prefer then to retain 2.d.(3) and throw out 2.d.(2)? 2.d.(3) requires more instrumentation, but it gives you a much better result.

MR. HEFFLEY: Yes.

MR. BOOTHE: I spent 15 minutes before lunch for nothing?

MR. HEFFLEY: Yes.

MR. WILLMOTT: I never knew why 2.d.(3) became to be that. It used to always be the rollover, for [Level] B it was changed and I was never sure why, what really is the difference between 2 and 3?

MR. BOOTHE: A lot. Let me just say I did it and we will talk about it later because it's too much to add to this meeting. I really think 2.d.(3) is a more informative response and I would certainly choose that any day over 2.d.(2). If we think we can make money on a Level B by eliminating one I would go for eliminating 2.d.(2).

I see positive head shakes; are there any negative head shakes?

MR. HEFFLEY: I guess I wondered way back when whether the reason for these things, one was basically a maximum roll control power and the other was simply the roll transient response, roll trim, $L_{\delta a}$ and L_p.

MR. BOOTHE: That's what I envision 2.d.(3) to be, the latter thing that you mentioned, and the other one was pretty much a maximum roll rate.

MR. STOCKING: It's origin was in the TIR.

MR. BOOTHE: The question is, do we need them both? If we do the roll response to a reasonable size wheel input will we get a steady state of roll rate for the wheel input? That's not the maximum roll rate necessarily, so do we need that?

MR. DAVIS: Just keep in mind the roll response test calls for two configurations where the d., 2.d.(3) does not, so we have to cover that somehow. 2.d.(2) calls for approach and/or landing.

MR. RAY: 2.d.(3) is only one case. The recommendation would be to eliminate 2.d.(2), but add a cruise case. Right now we are running three cases, one for 2.d.(2) two for 2.d.(3). Eliminate one of those.

MR. BOOTHE: Okay. We will do that.

As far as instrumentation for the roll response to a stepped input, you have to have a time history to make any sense out of it, so I think we are stuck with an instrumentation requirement.

So we can move on to spiral stability. I've never liked the way we do spiral stability, but I won't tell you why until we discuss it. How important is it to you?

MR. HEFFLEY: Do you need to say how you should measure it? As Stu [Willmott] just mentioned here, it's something that can be altered depending on how you perform the maneuver. Spiral time constant is difficult to back out.

MR. WILLMOTT: I think its real purpose is to tell, to find out, whether the airplane has a tendency to roll further into a bank or to come out of a bank when a pilot is flying a bank in a simulator and that was its original purpose. But it's hard to set everything up symmetrically, so when you roll into the bank what you are measuring is how accurate you got it in trim in level flight, so it's usually good to do it in both directions.

MR. BOOTHE: Well, I think it needs to be convergent or divergent as the airplane is convergent or divergent. There is no arguments on that, and reasonably the same rate. But, to roll over 30 degrees and see what it does is not very meaningful to me. I've never been able to get that changed, but I would really rather see what the airplane does on its own when disturbed from level flight. But getting it disturbed sometimes--

MR. WILLMOTT: Thirty degrees is a typical bank angle that the transport category aircraft use when they are turning with passengers. So it's seeing what tendency the airplane has in that condition.

MR. BAILLIE: The test is probably more repeatable and less sensitive if you go to a lesser bank angle. Less sensitive.

MR. LEISTER: You need to do it in both directions, too.

MR. BAILLIE: Yes.

MR. SCHUELER: Particularly for a slip stream airplane.

MR. BOOTHE: Well, what I have suggested here is from a simplistic test point of view, in this case we could use a real watch that goes tick tick tick, this ought to be a slow response, ships calibrated instruments, some sort of crude resolution on attitude indicator which a person can really make up a scale and perhaps a video, and I think we ought to be able to get adequate results that way on spiral if we do it carefully.

Is there any objection to that technique?

MR. WILLMOTT: No. Not really.

MR. BOOTHE: Okay, gee.

It should be or--that's something a person could really measure by watching attitude, so--or engine inoperative trim. Again I just looked at adding some scales to the trim controls and doing a ground calibration of the surfaces, but we have already decided not to measure surfaces, so that's sort of redundant at this point.

It's a steady state condition that we are simply measuring what trim inputs are required to maintain the condition, so I think if we, if we add whatever scales are necessary and calibrate them for the trim controls, it's hard to make a general rule because airplanes vary a lot, but I think that could give adequate data for trim conditions.

Stewart [Baillie], you had some thoughts on that earlier.

MR. BAILLIE: Yes. You do a lot of trade-offs in OEI trims, we all know to get a zero heading rate state. And my suggestion originally was to acquire inertial measures and to match the accelerations and control inputs. That's a lot more detailed test than here.

MR. BOOTHE: Okay. You have to, if you don't mind, elaborate a little bit. I'm not with you.

MR. BAILLIE: Well, for a given steady state condition, asymmetric thrust, given that it is steady state matching the lateral acceleration and matching the control inputs. You are not measuring beta, but at least this way you have beta is implicitly then being matched.

MR. SMITH: You are verifying the trim. Verifying the steady state condition.

MR. BAILLIE: Yes. Well, it's an accelerated trim condition in that the lateral force is not zero, so you should probably be measuring those acceleration forces.

MR. WILLMOTT: The way that it would normally be run is that for this class of airplane you would zero the ball with the engine symmetric, which means it needs both rudder and aileron trim to do that, then you do the asymmetric engine, pull the engine back, zero the ball doing that. That means you have zero acceleration, so you are suggesting that you use an accelerometer laterally to give you a better ball centering capability.

MR. BAILLIE: Or accepting the fact in most cases the pilot may trim with a non-zero ball or may accept steady state flight with a non-zero ball. It doesn't matter if you have zero a_y or a measured a_y, so long as you matched a_y and a little bit of ball deflection can make a fairly big impact in where your rudder has to be. So measure it lateral acceleration rather than just zero.

MR. WILLMOTT: Is that the way you would normally fly, zeroing the ball?

MR. BAKER: Depends on where you are doing it at. What speed. What speed you are doing this at.

MR. WILLMOTT: Unspecified, I guess.

MR. STOCKING: Second segment and approach and landing low speed.

MR. BAKER: There is no certification requirement in trim the second segment.

MR. LEISTER: If you combine it with engine out climbs--

MR. BAKER: Something--heck, most airplanes will not trim at second segment. A Part 25 airplane has the same requirement to trim as a Part 23 airplane. Clean configuration. Second segment is not a requirement to trim to, most airplanes won't trim to it.

MR. BOOTHE: What should be there is measuring the required control forces rather than trim.

MR. BAKER: That's very well what it could be. You could have an airplane that you will not trim there.

MR. BAILLIE: So it becomes measuring controlled inputs to forces and lateral acceleration if you can't get the ball setting.

MR. BOOTHE: I guess--

MR. BAKER: We require climb performance to be demonstrated at first and second segments, beyond that it's--

MR. BAILLIE: There are lots of variables.

MR. BAKER: There are lots of variables.

MR. BAILLIE: What I was suggesting is a minor change in any variables can make a big difference in dynamics, so the trick is just rather than specifying that you must be exactly level, which is always difficult to achieve, specify that you must measure these things and just match all the measurements and you have done the same dynamic validation.

MR. BOOTHE: So what you are suggesting really is that we have an inertial system and a control, cockpit controller position, and force measures which drives this requirement up considerably. So let's see if we can get--

MR. BAILLIE: That's my role here.

MR. SMITH: Thank you.

MR. BOOTHE: But since only two guys are applauding each other, let's see what the rest of us think here.

MR. WILLMOTT: Engine out trim and engine out capability in the simulator in my experience is somewhat of a problem. In the Lear jet, for instance, with takeoff power and V_2 speed you need full rudder trim and you need pedal force, quite a lot of pedal force at lower speeds, and the pilots know about 170 knots they can do it all with just rudder trim. So it's a check for that type of characteristic. And I think the engine out trims that most of our simulator tests perform, we don't use full power, we use a condition where the pilot does not need force, so it's checking out the full trim capability.

MR. BOOTHE: Do we need to go to the instrumentation level that Stewart [Baillie] is suggesting, though, or do--or are we content to measure just the trim positions and not measure the acceleration?

MR. WILLMOTT: Well, bearing in mind that we are trying to make this simpler to do, I would suggest that we do it where you can basically use the cockpit instrumentation. You use the trim controls and you use the ball. And you do it at a speed whereby the trim capability will be able to give you zero ball. Which, you know, is very easy to set up in the airplane.

MR. BOOTHE: I think by silence you are outvoted, Stewart [Baillie].

MR. BAILLIE: Okay. I don't mind being outvoted, I'm just raising the questions.

MR. RAY: I think it's probably more repeatable.

MR. WILLMOTT: I keep thinking back to our basic purpose. We definitely need really good instrumentation for [Level] C and D devices, but again there are lots and lots of tests that the pilot can perform at a Level 3, 4, 5, 6 device, we are talking about a Level B that is somewhere in between in sophistication and I think doing a simple test like that is adequate for this level of simulation.

MR. LEISTER: Which is this test in the ATG, then?

MR. WILLMOTT: I'm sorry?

MR. LEISTER: Why is a simulator required to do this?

MR. RAY: It's a validation really of what the pilot would need for training. What's a better validation? I tend to agree with Stewart [Baillie].

MR. LEISTER: Well, yes.

MR. RAY: The force, position of controls is a much better validation I think. You can get too many, I shouldn't say too many, other variables in it, such as the accuracy of the slip indicator and the control assembly. We all know the difficulties of the accuracy of the trim indicator in the cockpit. Measuring the force and the controls in the airplane, matching that in a sim, I believe is considerably more valid.

MR. LEISTER: The pilot is not going to be flying at a speed where he doesn't need any additional input, on some airplanes he is going to be flying at speeds where he is trying to climb out and get away, he is trying to trim an engine out at best climb speed probably, that's probably going to require additional input.

MR. WILLMOTT: We are also doing circuits with engine out as part of the training engine failure at takeoff, leveling off, circling and, coming back and doing the landing. This is a check that you can use for the trimming required in the circuit. And we are already doing, as you said, an engine out rate of climb, although I guess we are doing that from the flight manual, so I better be careful.

But you are checking the capability of the simulated airplane to be able to trim out, you know, full engine power condition in your climbs.

MR. BOOTHE: Keeping in mind the objectives that you acknowledged as well, I'm content to leave that like it is, while I totally agree with Stewart [Baillie], if we wanted to get a better measurement he has certainly outlined a way that's certainly an improvement over what's here. But keeping in mind we are trying to find a way to validate something at a lower cost, which is as I said earlier, Dave Kohlman reminded me it may not be the same fidelity as a Level C simulator.

So I think I will leave that one and move on to the next two, which are rudder response and Dutch roll, both of which require rather significant instrumentation to get any reasonable result from them. On the rudder response I would say that we should measure the cockpit or the rudder pedal position or the rudder pedal input. We have to know that, otherwise we don't know what we are measuring.

And on the Dutch roll, I don't see that we do anything differently, I don't know that we need to measure--if we measure rudder response and measure the rudder pedal input, the Dutch roll then is an open loop response and we don't need to know the input if we are only interested in the Dutch roll response.

MR. NEVILLE: Is there any reason those two tests couldn't be combined? You excite the Dutch roll with rudder input anyway, so you get rudder response in a Dutch roll test.

MR. BOOTHE: I see no reason why you can't. You could still cull them out separately if you needed to, but in fact I don't see why you couldn't do one test and get both outputs.

MR. SMITH: Typically they are done differently, rudder response and the Dutch roll--the rudder response you put the rudder in and hold it, whereas the Dutch roll you do it with a doublet, typically. If it's a free response here again--

MR. BOOTHE: True.

MR. SMITH: --you need the rudder positioning.

MR. BOOTHE: But the first half of the doublet input when I push the rudder and I see the response I can continue the doublet and get a free response. I'm only interested in the initial response for the rudder after a brief transient there is other stuff going on.

MR. KOHLMAN: I think you are measuring the same things two different ways. You do a pure rudder response to hold the step in and you will get both the yaw and the $C_{L\beta}$ pretty clearly. And if you do--sometimes we will do the Dutch roll with a cross control and get it out there to a nice big sideslip, then release and that will get your Dutch roll, which gets the dynamics plus a number of other derivatives.

MR. BOOTHE: In which case you would not combine them.

MR. KOHLMAN: That's right.

MR. NEVILLE: For the response to a steady rudder input you get that in the sideslip.

MR. KOHLMAN: You do get a lot of overlap here, if you do cross control steady sideslip then you are getting $C_{L\beta}$, aileron power, rudder power. All of those.

MR. BOOTHE: Okay. I think the answer is yes. We can leave them as separate responses. But I have seen on a number of occasions where people have used the same test to demonstrate both effects. And I don't think there is a problem with that. To me the rudder response, if I'm just interested in rudder response, and it's a real short period, if I'm interested in the subsequent effects that Dave [Kohlman] described, then I definitely need a rudder step input to get that. So what are we interested in, I guess is the question?

And if it's just the initial response to rudder, you can combine them. But for our purpose I would just leave them as they are because in either case we need to instrument the airplane or we get nothing.

MR. WILLMOTT: Right.

MR. BOOTHE: That's really the cost driver.

MR. KOHLMAN: I can certainly see somebody taking the first second or two of Dutch roll initiation saying let's match the rates and accelerations, that will satisfy that condition.

MR. BOOTHE: I have seen that done. For better or worse.

MR. ELLIS: You can also excite it with an aileron, too. Look at some other.

MR. RAY: Could that comment on the Dutch roll for larger airplanes "it might be possible to," et cetera, could that be misleading? Do you leave that in there? Under Dutch roll it says "strap-down inertial system," the latter part of that first sentence, because we know what that means.

MR. BOOTHE: That's stretching it a bit, I guess. Keep in mind I was trying to pull out every thought I could to see how could I do this cheaper?

MR. RAY: Agreed. I just recommend striking that part.

MR. BOOTHE: Okay.

MR. SMITH: I'm not sure we don't need the rudder position, because like the phugoid with a reversible control system, the response can be different.

MR. RAY: That's true, it can. We talked about that earlier. I think the fidelity of that maneuver is based upon the premise to all this that we would not have rudder position for any of this.

MR. SMITH: Control. I mean rudder control pedal.

MR. RAY: I think that's embedded in this.

MR. SMITH: Okay.

MR. BOOTHE: Could be, but it's not showing other than verification of the flight condition and test, it's not something that is mentioned in the Advisory Circular. And I don't think the rudder is--well, to do this you ought to have a rudder deflection, what's going to be important about rudder on most airplanes other than the float.

MR. LEISTER: I will tell you this, to build a solid model you need the rudder pedal input position. But this is modeled.

MR. BOOTHE: For rudder response definitely the input, but for Dutch roll?

MR. LEISTER: For Dutch roll you need it. You literally can derive seven derivatives from a Dutch roll test alone.

MR. DAVIS: Those are validation, though.

MR. LEISTER: No, for a model.

MR. BOOTHE: We are going to--

MR. LEISTER: The response you are going to get are about the same with any kind of rudder.

MR. SMITH: I think you need it, though. Especially since we backed off on roll response, I think we need it.

MR. WILLMOTT: Suggestion, Ed [Boothe], for consideration for simplicity. Where you can combine the Dutch roll and the rudder instead of input you trim the airplane up for level flight zero ball, you then do a test similar to what I was suggesting for the wheel. In other words, you hold the rudder pedals where they are, you put in an amount of rudder trim. Then when you are ready, take your feet off the pedal, that gives you the step input of rudder and also excites the Dutch roll.

I guess you are not quite sure how much banking that you are going to get when you do that, you have to select a rudder trim input that would give you a satisfactory bank.

MR. BOOTHE: Well, it excites an asymmetric Dutch roll, which you can deal with.

MR. SMITH: But you are not going to save anything, I don't think.

MR. LEISTER: In a prop airplane I recently worked on we had a pretty large input of rudder, it rolled over very smoothly, no Dutch roll that you could tell. That may not be applicable to all planes, I don't know.

MR. STOCKING: We need stabilizing gyros.

MR. BOOTHE: I tell you, gentlemen, in the interest of time what I would like to do, if we could come back to steady state sideslip, if we can. Normal landing, cross landing, inoperative landing, all are fully instrumented events. I don't know how to make that any simpler or cheaper, except to remove angle of attack and sideslip, which we have already done, and say we will measure cockpit controllers instead of surfaces, which gets us to, I think, probably an important area of ground effect.

I would like to spend a little time on ground effect, then I would like to spend some time on this broader issue of predicted data and see if we can't also discuss costs a little bit. So could we just skip to ground effect for now and I guess there is lots of ways to do ground effect, but what is a recommended, a recommended alternative for us? For this application? And how can we minimize instrumentation? Again, remember now we have already said angle of attack is out, and with angle of attack out of the picture, we have to do something neat here. I don't quite know what it is.

MR. SMITH: If these are level flybys, I think it would be acceptable to compute it from data, pitch angle.

MR. BOOTHE: That takes--that would be acceptable, but that's a Level D technique and--it's not a Level D technique, it's a Level D requirement. But is there an easier and simpler and cheaper way?

MR. HEFFLEY: Ed [Boothe], I guess the most effective thing I've seen for this sort of an airplane or something where you really have a lot of power lift effect, are these constant attitude approaches all the way down, the very shallow approach, all the way down to the point of nosewheel contact, but you need, you need precise h and h-dot measurement to really make sense out of it. And given that you know you--I guess radar altimeter--

MR. BOOTHE: Is that high enough resolution to get what we need?

MR. ELLIS: We have one, it was really good.

MR. BOOTHE: Was it high enough resolution?

MR. ELLIS: Yes.

MR. BOOTHE: Is the standard installation on an airplane these days high enough resolution--you had a special one, didn't you?

MR. ELLIS: No, it was pretty standard. There was a Honeywell which had been around for some years, it was a standard on P-3s, I think. But we got convinced that it was very accurate down to just a matter of a few feet.

MR. BOOTHE: You could extract rate from it?

MR. ELLIS: Yes.

MR. HEFFLEY: Are you suggesting a baro-altimeter?

MR. BOOTHE: I don't think we could get much with a baro-altimeter.

MR. HEFFLEY: I was just wondering.

MR. WILLMOTT: There are changes in the pitot static errors going into ground effect and you can't rely on the pressure altimeter. I was going to suggest essentially the same thing that we did in the original landing maneuver approval, which is to fly an approach with as low a rate of descent as you can, so you give as long a time as possible to see what the ground effect does to the airplane.

MR. LEISTER: Hands-on.

MR. WILLMOTT: It was called hands-off and I think because it was called hands-off that scared everybody off that test, but it's a real low rate of descent approach, so you get into ground effect and you are giving the ground effect time to do something to the airplane that you can see.

MR. LEISTER: Right.

MR. WILLMOTT: In the case of the 727, when we first did that when it got into ground effect, we came in at 250 feet per minute, it pitched down very strongly and it would rise out of the ground effect and it continually did a phugoid and it never touched the ground.

MR. BOOTHE: Most of them I saw suffered from pilot intervention, that there wasn't much there. Probably with good reason.

MR. HEFFLEY: The one effective one I saw was from the Bréguet 941. It was flown with attitude-hold autopilot on. The pilot in effect was out of the loop except for being close to the controls, and it was flown at a very, very shallow pitch attitude. You got very good resolution of what was happening with the pitch controls (the elevator) as well as what was happening to the flight path. Therefore you measured both pitching moment and lift ground effect with good resolution.

MR. BOOTHE: The ground effect can be so subtle, and we have already thrown out elevator measurements here, it seems to me we need a measurement of control deflection somehow.

MR. HEFFLEY: If you want pitching moment, yes.

MR. BAILLIE: I think you are going to have to measure the inertial parameters plus perhaps a radio altimeter plus column as a minimum, to get any description of the ground effect. And the idea of a reduced rate approach you are already at some level validating ground effect in each of your approaches. Already having a markedly different descent rate gives you another point to validate ground effect, not the only point but another point.

MR. WILLMOTT: Of course if you do what Bob [Heffley] is saying, you have to measure the elevator surface anyway.

MR. HEFFLEY: Yes.

MR. BOOTHE: Okay. So we need a radio altitude, a radio altitude rate. You say we need inertial measurements so we have a full blown, fully instrumented test.

MR. BAILLIE: It's another landing, just a reduced rate landing.

MR. SCHUELER: Then it doesn't matter if you do flybys or shallow approaches, whichever technique.

MR. KOHLMAN: It really doesn't. The problem with constant attitude approach is you are changing ground effect during the ground effect event. The way we derive ground effect is do a constant angle of attack approach. The pilot is monitoring angle of attack.

MR. HEFFLEY: Pilot tracking angle of attack?

MR. KOHLMAN: Yes.

MR. BAILLIE: I wasn't suggesting constant pitch attitude or angle of attack, I was saying set up and do an approach. A pilot control intervention is part of it. But you are going to go through ground effect at a different rate than you do in a normal three degree approach, and to match the control inputs and angular rates of both that maneuver and a standard approach maneuver means you need a ground effect model. Because you have got a different onset--

MR. HEFFLEY: Aren't all these techniques more or less equivalent from the standpoint they all expose ground effect, they all pretty much require these basic measurements?

MR. SCHUELER: You can look at the changes in the airplane trim or whatever you want to call it, through that transition with any of the approaches. But you need the instrumentation.

MR. KOHLMAN: If we have one test really looking at ground effect rather than landing and takeoffs it would be better to limit the number of variables as much as possible. You are not going to have angle of attack, but I like Bob's [Heffley] suggestion, constant attitude.

Because as you were saying, Ed [Boothe], the effects are very subtle, if you put some controls in there we just may blank out or at least overwhelm the small changes we are looking for. If you hold constant attitude ground effect is going to--

MR. HEFFLEY: Let me add that by holding constant pitch attitude you have something that's inherently a bit easier to be flown manually.

MR. KOHLMAN: You should hold constant elevator, keep the wings level.

MR. HEFFLEY: Of course you can do that, too. Again, all of these are essentially equivalent if in fact you are matching the states.

MR. NEVILLE: Ed [Boothe], you mentioned the level flight flybys are a Level D requirement. But there is no reason they couldn't be used for Level B.

MR. BOOTHE: Absolutely not.

MR. NEVILLE: The way it's described in the AC it says "a test." You can show an acceptable ground-effect test, including flybys. There has to be more than one test, one near the ground, one at an intermediate height, and one in free air. You don't need angle of attack. If you get rid of the flare problem--

MR. BOOTHE: You still need the instrumentation?

MR. HEFFLEY: Yes.

MR. NEVILLE: Do you need as much?

MR. SCHUELER: Whichever technique you use you need instrumentation.

MR. BOOTHE: We've eliminated angle of attack.

MR. KOHLMAN: Still it's our most instrumented low cost Level B, which is inertial and control and control forces.

MR. BOOTHE: We need those. That's more or less a conclusion, not necessarily the one I was looking for, but the kind of conclusion I'm looking for, we can't cheapen this test, because it's--I mean, that's the very reason we are talking about Level B for Tom's [Longridge] application and we have to land and we have got to do in ground effect maneuvers. And I think it's important to do that right. So I think we arrive at Dave's [Kohlman] conclusion, we have to instrument pretty much completely with the exception of angle of attack, which if you did level flybys of course you've got that involved. All right?

So we will just leave that technique as you want the instrumentation will be required, write it up that way. Back to [AC120-]40B.

MR. WILLMOTT: A test to demonstrate longitudinal ground effect. The words in 40B.

MR. BOOTHE: We skipped a couple of things kind of lightly here. I would like to leave them for the moment. One of the considerations for Level B to present a lower cost simulator from the point of the aeromodel was to consider the use of predicted data by whatever means, but to me that means any data short of being like validated.

You know where you get predicted data better than I know where you get it. Couldn't we take the approach to a Level B simulator which we could do the aerodynamic program with predictive data and eliminate some of the cost associated with the flight tests? When I say validation, I have to watch my words, put simulator validation aside for a moment, couldn't we get a good enough simulator in Level B for doing a pilot recurrency check without doing initial training in it, programmed with predicted data, with validations of the kind that we have been talking about, or could we not, I guess is the first question?

MR. LEISTER: I would just like to say that 20 years ago or 15 years ago that's exactly what happened, people took predicted aircraft data and put it in a simulator and the simulator didn't fly like the airplane for some reason.

MR. BOOTHE: Like some reason?

MR. LEISTER: For a lot of reasons. Making a model work in a simulator is a game with very, very small numbers. And predicted data just is not that good. I wish it were. I could build models at home with my PC and then take them outside and make them work, but they don't work that well. So I don't think you can, but Mr. Stocking is going to tell us.

MR. STOCKING: What I said yesterday about the change that we have in computer capacity now. I can now implement DATCOM and turn it into a simulator program which has about ten times the number of variables, the complexity as the models that we had 20 years ago. As long as you take advantage of that change in 20 years, there is no question in my mind whatsoever that we can meet that objective. It's just how much time is going to be allocated to the particular device to do it?

The only way I can see to do that is to spread the cost of development of these larger models over a number of devices. And you can do that by making programs more generic, then populating it with the type of data that you need to do that. So regulating that or guaranteeing that you have that type of model in place really is the question. And I don't know how to do that.

MR. RAY: If I could interject, Ed [Boothe], the question is potentially not can it be done, but who can do it?

MR. SMITH: And has it been done?

MR. STOCKING: I have done the concept on a lower device. I have not done this with a higher device.

MR. BOOTHE: But the device you did, did it require validation to some set of validation parameters?

MR. STOCKING: Absolutely, yes. I had to go out--as a matter of fact, I did far more than what's required under the regulation as a proof of concept.

MR. NEVILLE: So was it altered based on flight data? I mean you started out with a DATCOM derived model.

MR. STOCKING: But the DATCOM got me within one and a half degrees of elevated trim tab, for example, I tweaked it the rest of the way.

MR. NEVILLE: It wasn't--the end result was not purely predicted data, it was--

MR. STOCKING: No. The end result was a validated model. I started with a predicted.

MR. RAY: But it's a subset of what we just went through.

MR. LEISTER: You still had to tweak, though.

MR. STOCKING: Yes.

MR. KOHLMAN: I agree with Chuck [Stocking]. With the sophistication that we have now and the computer programs plus the increasing database that we have, with a great many Level C and D packages of various airplanes, whatever configuration we want to simulate, I think you can get reasonably close with a predictive model. Then we are going to have to do a flight test for the validation data, and with a great many of these validation tests I can extract stability derivatives and aerodynamic coefficients to help me fine tune that predictive model to the point where then a program of fine tuning will get me within the Level B requirements.

MR. LEISTER: That's not different from what we are doing right now. What I do, anyhow.

MR. BOOTHE: In that process have we eliminated cost factor?

MR. KOHLMAN: What we eliminated is 30, 40, 50 hours of flight testing to get parameter identification data and all of the heavily instrumented data we are using to build Level C models now. We eliminated flight testing as well as a substantial amount of instrumentation.

MR. BOOTHE: Not to put you on the spot, which I seem to often do, what sort of cost increment in the overall data package would you guess we are eliminating by this?

MR. KOHLMAN: This is just a very broad guess, but I would say you are eliminating 50 percent of your flight test time to begin with. You're eliminating a pretty large amount of your analysis time that is spent doing a very detailed parameter identification matching program, and extracting a lot of data from flight test that you would instead do with a predictive program. And you replace some flight test analysis with predicted analysis.

But you are looking at not trivial savings in your initial costs getting a model ready for validation.

MR. DAVIS: I would ballpark it at about a half million dollars. A half million is a ballpark figure.

MR. KOHLMAN: That's certainly a reasonable order of magnitude, in my estimation.

MR. BOOTHE: I see Stewart [Baillie] wincing and grinning.

MR. BAILLIE: The only danger I see--I agree with Dave [Kohlman] and Tom [Davis] that you could save based on the instrumentation that we have discussed for these tests and a reduction in the extent of flight test you could save that order of magnitude. The danger is, not that Chuck [Stocking] would do it, but someone else will, they will come up to developing a model that the only real data that they have used are those tests. And the question has to be is how is the FAA going to determine whether that is sufficient?

MR. RAY: I appreciate you saying that. It goes back to what we are attempting to do in the case of the Boeing 737-6[00], -7[00], -800 family of airplanes. In a reduced set of data for the 6[00] and 800 we hope we can, at least we are going to try. The international community has gotten together under the auspices of the Royal Aeronautical Society and put together a fence. I call it a fence for lack of a better term, which says if you do this then you may be able to do that. I think that's what I hear Stewart [Baillie] saying.

And the feeling I'm getting from Dave [Kohlman] and also from Chuck [Stocking] is that, is it reasonable for someone to come to a regulator, whether us or the MoT or CAA or JAA, for that matter, and present your case, that based on this process that we have agreed upon to get to the point that Dave [Kohlman] is with his program with Stewart's [Baillie] approach and meet acceptable standards. I believe you will be able to do this. Is that a reasonable approach?

MR. HEFFLEY: Are you suggesting that that mitigates or that takes the place or that removes the requirement for some of this validation data?

MR. RAY: No. We are saying it may succeed in eliminating what Dave [Kohlman] mentioned as far as all the additional flight tests that they would need to do to acquire sufficient data to build their model from scratch.

MR. HEFFLEY: So you are suggesting some sort of a requirement for a credible modeling approach. You want to know, you all want to know what the basis is for this math model along with the validation test points.

MR. RAY: I believe that's what I said.

MR. KOHLMAN: That is what is done today for Level C and D or do you, rather, even though you know how we get the data, come in and look at the simulator, make sure the test guide data was obtained in the proper manner from the proper airplane and if those all come together, then the stamp of approval is given without sitting in on the model data analysis gathering process or analysis process. Are we doing something that isn't done for C and D at this point?

MR. BAILLIE: I would say what you have done, though, is you have brought down the cost of flight test, so whereas before people that got in this game had the capital invested so they would do the well-founded development, now you brought it down to a cost level where maybe the guys that aren't going to do the well-founded development can get in the ball game.

I think the--I like the concept of if this is the only aircraft data involved, which it could be in a lot of cases, I think either having a description of how the model was developed or making sure that the guys don't tweak the model to this until you are involved. Like if you--it's the classic case of a seventh order curve with seven test points. And both of those are an increase in the requirement, I'm aware of that. But I think if you are going to deal with an unknown model that just comes and meets these, you are going to have a problem unless you somehow understand how the model was built.

MR. DAVIS: I think that's a fair compromise. All that's being said, we will let you get away with doing all this testing but tell us how the model came about. Versus Level D, they don't ask for that but you go a hell of a lot farther in terms of proving objectively it meets the level of the airplane. It's a fair compromise.

MR. LEISTER: You are speaking as though the approval test guide, those tests are the whole story.

MR. DAVIS: It may be, though.

MR. LEISTER: The subjective part is a very big part.

MR. RAY: That's true.

MR. LEISTER: You can't make the simulator fly well if you don't do your job up front. I've actually wondered why you guys haven't asked in the past just what model you are using in the simulators, I have seen some crude simulators that doesn't re--

MR. RAY: We have too.

MR. KOHLMAN: This is not the sole source of in-flight data. We have talked about the flight manual, certification testing, TIR; if we have access to those, certainly I'm going to use those as part of my predictive model. It's not as if this is a skimpy amount of data.

MR. LEISTER: I think it would be difficult to build a model based on those tests. I don't know how you could do that.

MR. DAVIS: Well, with something like that DATCOM you can get pretty close. Those tools, AAA, DATCOM, whatever you want.

MR. STOCKING: I bet a poor model wouldn't get certified.

MR. BOOTHE: Let me see if we understand this. Are you suggesting that you would develop a model based on DATCOM and other predictive techniques, whatever that might be?

MR. KOHLMAN: Data from whatever source you are going to get it.

MR. BOOTHE: Then having developed the model you would do flight testing to acquire the types of validation data that we need for validation and you might also collect--not everybody can collect parameter identification data and do something with it. Did you indicate that you would also collect parameter identification data with this qualification data?

MR. KOHLMAN: No. What I'm saying is each one of these tests that are test guide type points have enough data in them that I can extract some derivatives, for instance steady state cross controls. You can extract quite a bit of information. The trim points, you can extract a lot of information. And I don't want to get the cart before the horse, if I'm doing this job I'm going to do these flight tests very early in the game and I will probably add some additional points with this minimally instrumented airplane. That gives me other isolated data points and derivatives that help me fine tune a DATCOM type model much closer to the final product.

MR. BOOTHE: Okay. So what is the danger or the risk of winding up with a predicted model that is kludged to fit the validation points and maybe erroneous in other parts of the envelope if you do this any more than we have now?

MR. KOHLMAN: The danger is you will match all the data points and the pilot who comes in to evaluate says yes, it trims fine right here but ten knots higher it's not anything like the airplane; or you do a maneuver and the pilot says this doesn't fly like the airplane. That's the danger.

MR. BOOTHE: So we are really placing then a greater reliance on some subjective evaluations instead of we are now relying on them, or are we?

MR. KOHLMAN: I don't think so. I don't see how you can build a model that doesn't use standard equations and aerodynamic components. I don't see how you can do that. That's why it may be a misplaced faith that I have, but I think if you are able to match this many test guide points with a model that has all of the standard mathematical components that we are using today, that it's going to fly in the rest of the envelope in a proper manner. Even when we have these $500,000 flight test programs and then we deliver them to SimuFlite or Flight Safety there is fine tuning that goes on; they still have to adjust and tweak the model. So the process is no different.

MR. BOOTHE: Except we have skipped some portion of the flight testing that seems to be a high dollar.

MR. BAILLIE: We skipped all the tricky installations, we no longer have oleo, you no longer have string test, you no longer have all the things that make the last increment on the fidelity.

MR. BOOTHE: Bob [Heffley] was trying to say something for 15 minutes.

MR. HEFFLEY: It's been changing from minute to minute. The one thing, Ed [Boothe], I don't see what the increased risk is here over how it's been done in the past. And some of these things that Stewart [Baillie] just mentioned in terms of the little finishing touches are things that I guess I really believe are pretty much invisible, or at least very difficult to see from the standpoint of a pilot in the simulator unless you are using the same basic list of validation requirements. And I think in all the discussion we have had, we kept coming back around to the point where there we really didn't make any real compromises in the quality of the data that are being gathered here. In the final analysis really I don't see where there have been real compromises in the quality of the data.

MR. BOOTHE: You mean the validation data?

MR. HEFFLEY: The validation data.

MR. BOOTHE: I don't either, we didn't simplify a lot.

MR. HEFFLEY: Yes. So you wind up really where you were except for the fact that now we are talking about maybe some additional offerings of words on approach used for the math modeling to make the FAA feel better about the quality of the basic math model, which is something that apparently has not really been subject to much question.

MR. BOOTHE: The math model has not been subject to question. In fact I often used the expression when I was there we really didn't look behind the curtain. I still, in terms of what kind of instruments were behind the instrument panel, I never really cared as long as they looked right and worked right. And I never looked behind the curtain of modeling as long as the validation and the test guide demonstrated what we asked. I mean, that was really all we asked. So I don't see that difference, either.

But I think there was always some comfort factor in having some idea that people were doing a considerable amount of flight testing and were adjusting their models to meet that flight testing over and above the validation tests that the FAA asked for. But when looking at this from a perspective now of a regional airline who is training in the airplane, while I don't think we should make an impulsive step here, I think we need to find out how to do this, maybe even figure out how to do a trial run somewhere.

I cut you off Hilton [Smith], I'm sorry.

MR. SMITH: That's okay.

MR. BOOTHE: You had something you wanted to say?

MR. SMITH: It seems like we came up with a whole other question. I believe what Paul [Ray] was saying, yes, we might do this if. My opinion is that if we, you know, now we don't really look at the model, like you say, but the advice is to use flight test data to program a simulator. However, we take that away and just don't say what is used to program the simulator. I think we [have] got to have validation data according to [AC120-]40B requirements.

MR. BOOTHE: We have almost wound up at that point, not quite.

MR. SMITH: I mean, I admit that we struck out alpha and beta, which we can do, but then everything else has to be rigorous because you are then relying on all the other measurements to derive those. And there is no question about it. I have seen the quality of data go all the way from aircraft manufacturer data down to--I remember questioning an operator about some questionable buffet data for a Level D machine, he finally admitted they went out and obtained it in a thunder storm.

MR. BOOTHE: Warped buffet data.

MR. SMITH: It was that. There is data and there is data and there is data.

MR. BOOTHE: No, I don't think anybody here is suggesting any degradation in data integrity, now we all know there are people out there who would.

MR. SMITH: No.

MR. BOOTHE: That's just real world. But I think--I mean, I'm also--I think we have been aware that at least in my experience I never saw much work without a lot of inputs from the artist of their dynamics. And I think it's still at that state. You can do all the drilling of the coefficients in your equations that you want the first time, but the aerodynamic artist has to operate with those to meet the conditions.

If you know better than that, I want to patent it, maybe we can get a co-agreement here. But if this has an opportunity to or this presents an opportunity to lower the cost of the simulator from the aerodynamic program perspective by as much as I thought I don't know if you meant Canadian dollars or American dollars, but in either case it's a bunch of money. It's a lot of money. And shouldn't we somehow try this out? And so then how do we do that? I don't know how we do that. But somehow it seems to me we should be able to get our heads together and come up with a definitive plan on paper, here is how we are going to program the simulator, here is how we adjust the parameters, here is how we validate it, here is the validation data we are going to collect and we are going to try it out on this device. That's what I would like to see happen. And that's a test concept, that doesn't mean that it couldn't be abused, but we have to work with that.

MR. LEISTER: I just don't think there are good predictive models for a lot of things. These little prop jobs I'm working on, there is no method, it wouldn't do any good at all to sit for hours and try to come up with a predicted model for a prop type airplane because we just don't know the prop that well. I can take a 747 model and start and build any kind of model you want out of it. It just doesn't matter what you start with, really.

MR. SCHUELER: What prevents me from going out and taking a predictive approach today? There is nothing that prevents me from doing that other than my engineering judgment or someone's engineering judgment that that's not the best or the safest approach.

MR. STOCKING: That has been done. McDonnell-Douglas on the DC series aircraft uses an all predictive model.

MR. SCHUELER: There is nothing here that says I can't do that today for a Level D device.

MR. SMITH: Well, I think it--you are encouraged to use flight test data, it's indicated that you can use some predicted but I think you are encouraged to use flight test data.

MR. SCHUELER: Not for modeling.

MR. RAY: Not for modeling.

MR. SCHUELER: As long as I provide flight test data to fulfill the validation tests--

MR. RAY: Correct.

MR. SCHUELER: --for a Level D device, I can come up with a model any way I want to.

MR. RAY: Very true.

MR. KOHLMAN: If we get into the situation of the FAA wanting to somehow approve, and I'm not sure how you write the specifications for that, how the model was developed, where it came from, how you came across all this nice data, then you are faced with the situation of somebody, just as a hypothetical case, inviting you in to approve a simulator. And they show you all of the flight test data, maybe invite you to participate in the test guide flight test data and it meets all of the requirements within the tolerances and the FAA sends its best pilot to evaluate the simulator and it flies great.

But then you say, just for my comfort I want to know how you got this model, where did it come from? And the guy says you can't see behind the curtain, it's proprietary, I don't want you to know how I got it. You say well, if you are not going to show me, I'm not going to approve your simulator. I think that puts the FAA in a very difficult position.

MR. RAY: As far as the sequence, it would never occur that way. It's backwards. Before anybody came in--

MR. BOOTHE: I don't work there anymore.

MR. RAY: It would be in the initial application that you come up with your approach had you never done this before. That gets back to the B-737 process we developed. You have to have been there before you can get there now, really. In a nutshell. But it's a front end, you come in and make your case for presenting this simulator based upon something. Explain how you got from the conceptual idea to where you want to go with it.

MR. BOOTHE: Stewart [Baillie]?

MR. BAILLIE: We have spent two days in detailed discussions about particular minimum sensors for a given test. Perhaps one thing that should be done by this group is to take an existing simulator that's out there, approach the company that owns it, and with them get the minimum Level B data package so even though you have got a tremendous wealth of information, only give, for instance, the period and damping of the phugoid, only develop this minimum ATG case. And then regardless of this, go through it page by page and say is this enough? As a second look at this. Because we have gone back and forth through a lot of the tests but until you pull it all together I might not really understand the depth that you validate. I think we have probably validated more than I personally think we have. If that makes sense.

MR. BOOTHE: Maybe. But it's break time, so let me just--if we were to follow the scheme that Dave Kohlman outlined, you yourself have said we could save an awful lot on instrumentation and flight time, it seems to be the major area of cost reduction. And if we can get to the same end by doing that, then I don't have a means to try this out, but I think somebody ought--we ought to figure out how to do that. Because while I know we have discomfort right now, I can see the discomfort on Hilton's [Smith] face. And doubts in the room. I think that that's not unusual. I think we need to really consider this, and if there are those kinds of savings that you are describing, that can go a long way towards getting these folks out of airplanes and into simulators if it works. I'd be really thrilled to see something like that happen. I don't know what the next step is, but I think having that conclusion is really something I'm happy about right at the moment.

MR. KOHLMAN: I want to say, just to make it clear, I don't question or disagree with the policy or the desire of the FAA to have a comfort level about what this model is built of. Because that's reasonable. I have trouble understanding how we are going to define how you get the comfort level you need and how you define that you are at that comfort level.

But I have had the experience myself of going into a simulator of a prominent manufacturer of lower level simulators. I think it was a Seneca, and it flew really great, it was nice. But then I did the Kohlman test on it, I rolled it 90 degrees and I was able to hold altitude and air speed just fine. That told me there is something wrong with that model or the equations of motion.

MR. SMITH: I'd like to ask Dave [Kohlman] one thing that really, I've heard some numbers like, when you do a flight test program a certain percentage is for modeling data and a certain percentage is for validation data. What would be the effect on the half million dollars cost savings we talked about here if you just got 40B validation data and like you said, no modeling data, but just say 40B validation data as opposed to what we discussed here?

MR. KOHLMAN: I'm going to kick that over to Daryl [Schueler]. I think he has a better handle on it in recent tests than I do.

MR. SCHUELER: Test guide maneuvers are probably on the order of a third of the testing that would be accomplished. You could typically accomplish, if you are reasonably aggressive, the full set of data for Level D in no more than three calendar weeks. Two calendar weeks for instrumentation. For Level D.

MR. KOHLMAN: Right. But that's of course after you already have a fully instrumented airplane.

MR. SCHUELER: No, two weeks instrument, two, two and a half weeks is doable. It's aggressive but it's doable. So maybe you cut airplane time down to three weeks from five weeks, I don't know.

MR. DAVIS: You go back to Stewart's [Baillie] original slide from the first day.

MR. BAILLIE: The IQTG for a simulator company that will remain nameless took six weeks of aircraft time. Nine days was flying, the rest was instrumentation.

MR. SMITH: That was validation data.

MR. BAILLIE: That's all that was. The addition of modeling is usually seven hundred 3211 inputs. [That] is the only difference. [That] is basically what we have been doing; that's a week of flying.

MR. SCHUELER: You can come up with it [in] different ways, you know different sets of maneuvers, a little bit different time for instrumentation. I don't agree completely on which ones are difficult parameters, which ones are easy ones, but the numbers are in the right ballpark. So if you pull out--if you reduce five to six weeks of airplane time down to three weeks, you know, maybe.

MR. BAILLIE: I think the saving here has been that the modeling, the flight test for modeling per se, a lot of it doesn't add much more flight time. But it--it's the instrumentation of the subtleties in the aircraft and the instrumentation to meet the requirements of the [AC120-]40B test maneuvers that add the biggest chunk of time to a flight test program.

MR. SMITH: Isn't the quality of the data directly proportional to the quality of the instrumentation?

MR. BAILLIE: I am saying that--no. I am saying that if you need oleo displacement it's going to take time. If you don't need it, it's not a quality issue, it's just either you have it or you don't.

MR. BOOTHE: Can we--that's something I want to mention, anyway. Can we pick that up after a ten-minute break?

MR. LONGRIDGE: Let's just take ten minutes. We are going to break at 3:30, so we need to get started again in about ten minutes.

(Break taken.)

MR. BOOTHE: Sorry to rudely yank you back to your seats, but unfortunately time comes marching in and we promised you would be out of here by 3:30 so you could connect with your flights back to California and places like that.

I think that last discussion that led us up to an approach to modeling and validation that promises significant cost reduction is a very important result of our being here for these two days. I know that's not what we spent most of the time on, but we, in deciding what to discuss first, thought that the FAA has a much larger influence over the validation than they do modeling and we ought to get through the validation stuff.

But I think the big payoff might be in what we just discussed the last hour. And I'd like to extend that a little bit. One thing I would like to ask, would all the discussion we did on the validation, do any of you see any significant cost reduction there? Have we really accomplished anything or are we, when you really put your validation hat on and you have got to go flight test, are we really saving anything or are we really just sort of looking at Level B as it exists in the current Advisory Circular?

MR. DAVIS: You are saving in terms of instrumentation, I think that's clear. I mean, if not you have to fly, we haven't removed any tests.

MR. BOOTHE: Is there an increment that you would care to guess at there?

MR. DAVIS: Myself, maybe Stewart [Baillie] is in a position to guess at that, but in terms of time--

MR. BAILLIE: In the test of just gathering that data, you probably saved two weeks.

MR. BOOTHE: Are you talking just validation data?

MR. BAILLIE: That's all I'm talking, yes. The gathering validation data, I think that takes me six weeks.

MR. BOOTHE: What takes you six weeks now is both validation and modeling or just validation data?

MR. BAILLIE: Compared to a Level D version data set I think I could do a Level B in two weeks less.

MR. BOOTHE: That's really a third reduction in time. Does that equate to a third reduction in cost, approximately, then?

MR. BAILLIE: That depends on the size of the aircraft. And how much it costs to fly per hour versus how much it costs to sit in a hangar for an hour. But in manpower it's a saving.

MR. SCHUELER: Manpower during the flight test phase, but you haven't significantly changed data reduction time or any of that time, which can be--those are cheaper hours but there is a lot of hours there. So--

MR. DAVIS: Your data reduction costs would be reduced some, you are measuring a lot less parameters, the pain in the ass ones, I'm not sure how significant it is, but it has to be some reduction.

MR. BAILLIE: You don't have to do angle of attack calibration, that saves time.

MR. SCHUELER: You still have to do air speed.

MR. KOHLMAN: However, we are making some data gathering less efficient, because if we have all that stuff instrumented, we would run through a computerized flight test analysis program, print out engineering units. Whereas now somebody has to sit and read points off of videotape or other knee board type data.

MR. BAILLIE: When I suggested two weeks reduction, I would approach this by having the column and force control inceptor and control force and inertial package on all tests and do it all that way. I don't think--if you are going to instrument for the takeoff you do all of them that way.

MR. SCHUELER: If you are going to collect a whole data set, video doesn't save you anything because the reduction is so much more labor intensive.

MR. BAILLIE: If after you have put all this to bed the aircraft is gone and then you realize you need a data point, the video, the minimum stuff that we have defined, is of great importance.

MR. HEFFLEY: Right.

MR. BOOTHE: So that's really the only place it would really pay off, is what I hear you say. If you are going to do a data collection and you need the instrumentation for some test, if I were doing it, using the instrumentation for all tests, I think that's what you are feeding back to us anyway. So that really says if there is a cost increment it's that two weeks you mentioned. And that's preparation time and that could be, that could be on the order of 20 percent, though, couldn't it?

MR. BAILLIE: Two out of six, 30 percent.

MR. BOOTHE: I'm being conservative.

MR. BAILLIE: Fine.

MR. BOOTHE: So there is a potential, then, for some, because of the some of the changes we did make, namely instrumentation, I think primarily angle of attack and sideslip, where that comes in for something on the order I say 20 and you say 30, so 25 percent. And but then there is this big cost savings in the approach that we covered before the break. So does this mean that we could probably do all this work, which I assume it will, we could do a Level B aerodynamic modeling and validation for half of what we are doing it now?

MR. BAILLIE: I've never done a predictive model, so I don't know what the cost would be of doing that.

MR. WILLMOTT: When you are talking about validation, too, you are talking about what's required for the Level B validation plus all of the other validation data that you need to verify the predictive model; is that correct?

MR. BAILLIE: No. I think the only data you are required is the stuff we have discussed.

MR. DAVIS: That's it. You have AFM--

MR. WILLMOTT: I'm not sure Chuck [Stocking] was thinking the same thought.

MR. BAILLIE: You might do, rather than just one V_{MCA} case, you might do two or three.

MR. WILLMOTT: Normally you know if you are collecting validation data and you want to do every single flap transient, you want to do a phugoid at each of the five configurations, you want to do Dutch rolls, probably at each of the configurations, so those things are not included in what you are talking about.

MR. DAVIS: I don't think so. If you want to look at the model you want the minimum amount of data and rely on predictive techniques.

MR. WILLMOTT: If Gerry [Baker] comes along to the simulator after we have done the predicted package and modified it appropriately to what is in the Level B validation tests, and then says Dutch roll isn't right, in some configuration or the airplane pitches the other direction when I move the flap from here to here, that's not in that.

MR. BAILLIE: You have trouble.

MR. WILLMOTT: What do we do?

MR. HEFFLEY: But then you have the ability to come back and more cheaply get additional flight test points. I mean, you are still better off, it seems to me.

MR. KOHLMAN: If you need one more flight test data point to solve a problem, then that's where video--

MR. HEFFLEY: Pays off.

MR. KOHLMAN: And fish scale comes into--

MR. WILLMOTT: I think Chuck [Stocking] was thinking to validate the model he was talking about that there are additional validation things that aren't covered by what we were talking about here. I just wanted to check what you were talking about as far as validation data is concerned. It's Level B only.

MR. BAILLIE: The one premise that I have probably implicitly at the moment is to really look at this you expect, or considering the guy that has the Level 5 standard turbo prop model who thinks it flies like a given type and you can just gather this amount of data and prove that it does fly like that type. Subjectively everybody already, in some cases everybody already says that flies like the real aircraft. So it's just to get over the documentation hurdle. There is where you save the money.

If you are starting from scratch, you probably want to take more data.

MR. SCHUELER: Part of the fallacy of saying hey, if I need one more data point I can do it cheaply, it depends on what that data point is. Dutch roll being the example, we have said it needs inertial data. Didn't save me anything.

MR. BOOTHE: That's true.

MR. SCHUELER: If it's a climb point, okay, yes, I can--I can run out with a stopwatch, but realistically today if I ran into that situation I'd call Paul [Ray] and say hey, I need one more data point. And it's this one and how about if we go do it this way? And work out some reasonable approach to fill in that piece of data. And more than likely--and if it was that kind of data point, that would be acceptable today for a Level D device.

MR. RAY: In most cases that's, as we talked about outside, that's with the foreknowledge that you required all of this other data, you just happened not to have a particular case that's spelled out. It's not that you can't pull a test from somewhere to validate performance in a different configuration, it's to fill in the configuration requirements.

MR. SCHUELER: Right.

MR. BOOTHE: Okay. I don't know where else we can go with that subject today. I personally am delighted at the outcome. I think it offers some real opportunities for exploration, I guess is the way to put it. But I do think a demonstration program of some kind would be very informative on it. I would like to see that happen. I don't know how if it can be, but we need to figure out if this can significantly reduce this particular cost and add it to other possible cost reductions in other parts of simulator construction. It could go a long way towards the goal of getting people who now say they can't afford simulation out of airplanes and training in simulators.

I think everybody here would agree that is an honorable goal. So if something contributes to that, Stewart [Baillie] was mentioning before we broke about modeling an oleo, and I've often questioned why we bother. Why don't we have a model that goes from wheel in the pilot seat one big transfer function, if you will, if I can describe it that way, instead of having to model? Is it important to model each of these little components of landing gear and structure or could all that be lumped parameter system, say here you go, here is what you feel when this happens, and I know I'm overly simplifying, but something I've thought about.

MR. SCHUELER: You get into robustness and ability to handle failure modes and some of those kinds of questions. Some things it might be reasonable to model as a black box, if you will, [an] input-output model, but other things may--that approach may drive you into a corner.

MR. BOOTHE: Well, let's go back to Level B for a minute, and maybe we would have to review as Stewart [Baillie] has so often reminded us, what are we going to do with this thing? Are we going to do tire and landing gear failures or is that part of it done somewhere else? I think that's an important consideration. But it seems to me we use the same ground reaction model on everything, of course if you've got one that's fine. And you can fill in the numbers.

MR. STOCKING: The place where we model ground reactions where we are concerned with, it is in the air to ground, ground to air transition, it needs to push back on the airplane. Just like it does in the airplane. And so we want that spring curve in there just like it was in the airplane. It goes away and it comes in like it does on the aircraft. And we have made enough generic models that we can estimate that data real close at minimum cost by using our models.

MR. BOOTHE: So you already have models that you can use, but--

MR. STOCKING: That's correct.

MR. BOOTHE: --suppose he doesn't.

MR. WILLMOTT: The oleo itself is a very simple model because it's a pressurized system, it's adiabatic when you compress it, it's a very simple model, knowing the cross-sectional area of the oleo and the pressure it's precharged to. Usually everything in the airplane that we know of is simulated, so we are simulating the aircraft.

As far as the struts are concerned, when sometimes people like landing on one gear and getting the right effects, if they were to do that we even have to represent a one gear up landing malfunction sometimes. We have tire burst malfunctions and we have to represent banking due to this.

MR. BOOTHE: That's more Level C and D stuff.

MR. RAY: As far as failure it doesn't preclude--

MR. BAILLIE: Perhaps we forgot one thing, with a Level C and D you want to know exactly when the nosewheel leaves the ground and the best way to do that is oleo deflection. You want to know exactly where the wheels first touch, the best way to do is oleo deflection. In a crosswind you want to know where when the tires touch, again oleo deflection. That's the reason why, not to model but to know what wheel touches first.

MR. STOCKING: You need to know the forces before you leave the ground. That's the other part of it.

MR. WILLMOTT: And also, the model normally works out the deflection of the bottom of the tire and you have a tire spring rate and you don't start deflecting the oleo until you get the preload at the oleo, it's part of the model.

MR. STOCKING: You also model the tire so you get the slalom handling characteristics--

MR. BOOTHE: I think you all have a good reason why it's needed.

MR. KOHLMAN: How much of this applies to Level B?

MR. WILLMOTT: Also there is normally a hydraulic damping mechanism within the oleo with a metering pin in there that gives you different flow rates depending on the deflection of the oleo, so the damping actually varies.

MR. BOOTHE: My thought was it seems like there is lots of components there to model. If we can bypass any of them for somebody developing a model it might be worth consideration. But I hear that it isn't.

MR. RAY: It could be an issue between an A and a B though, because of the credit you can receive in a B, but then if you had a B would you really go and pull that piece out just to create an A? Probably not.

MR. DAVIS: Again, this parameter we drop in a Level D if we want to, it's just something when we build a high fidelity simulator we want the information for our own insight. We don't need to know it for a Level D so we don't need it for a Level B. It doesn't go into development, it goes into the validation process. There isn't savings to be had there, we are making the choice to get it.

MR. BOOTHE: Okay, thank you.

MR. LONGRIDGE: I would like to return to an issue that was raised earlier, that was the question of whether or not there is an adequate model for the predictive data purposes for this class of aircraft. It seems to me the cost savings that we hope to achieve is very much dependent on whether or not we can use predictive modeling. Because if there isn't, the FAA may want to consider paying for the development of such a model and making it available to everybody.

What is your feeling with regard to the availability of a sufficiently sophisticated model to do what we are trying to do?

MR. HEFFLEY: I think there is the availability of models for this class of aircraft that have been around for a while that can be used as a basis if you don't have a basis already. And you need something that structurally contains the right things. Namely propellers, slip stream, airfoils and the rest of the usual things.

MR. NEVILLE: So this really brings up the possibility of a generic aerodynamic model for a class. I mean it could even be as specific as a high wing T tail twin turbo prop, for example, that would cover all airplanes in that category.

MR. HEFFLEY: There have been models built for this class of aircraft in the past not in use right now necessarily.

MR. LONGRIDGE: The question is, are they good enough to talk about what we have been talking about doing? Dave [Leister] is shaking his head.

MR. LEISTER: They are absolutely not.

MR. STOCKING: I agree.

MR. LEISTER: Stocks, you and I have disagreed for a long time.

MR. BAILLIE: About the case where you have a simulator for a similar type which now has three feet added on the wings and a plug, but in the fuselage we can certainly make the adaptations to the stability derivatives, et cetera, using classical techniques to probably make that model fit the test maneuvers for the type and all the ATG data does is say make sure you have made those extrapolations reasonably well. That's a good example where you could save a big amount of money.

MR. DAVIS: I think that's fair. To do a 100 from a blank page and DATCOM, I am a little more skeptical about that.

MR. STOCKING: If you would like I will read you the effects that are in the current model that we derived from DATCOM or a textbook, they are--

MR. DAVIS: I acknowledge there could be a million terms, that's not really what's relevant. What's relevant is how accurate the terms are.

MR. STOCKING: They are quite accurate.

MR. LEISTER: Do they drive the simulation to fly like the airplane?

MR. STOCKING: The problem is not all the effects have ever been put in a simulator. People have grabbed bits and pieces to get what they want. They have not gone a back and done a full-up stretch of how the propeller affects the surfaces on the aircraft.

MR. LEISTER: On the ratings we haven't had the computing power up to just now to do that.

MR. STOCKING: That's my point. When I was sitting down doing this model I modeled practically the rest of the airplane and then I sat down and modeled the prop effects. It was almost an equal test. It was extensive. But it was available, and the reason why it's not been used in the past is because of how extensive it is.

MR. BOOTHE: That's just propeller effects, you said?

MR. STOCKING: Just prop effects.

MR. HEFFLEY: On an airfoil.

MR. STOCKING: Yes. Any place it impinges on the airframe itself.

MR. HEFFLEY: If we go back 30, 40 years people were doing that. It's a matter of going back in the literature. Models of this class of aircraft have been handled, successfully, and there are fairly good theoretical models for effects of power lift on airfoils.

MR. STOCKING: The tables I'm using came off a Bearcat.

MR. LEISTER: World War II.

MR. BOOTHE: What about the power lift that was done at NASA-Ames?

MR. HEFFLEY: We mentioned Bréguet 941, it's a rather extreme power lift aircraft, you simply back off on the extremity of that. But models of propellers and powered-lift effects on airfoils exist, and can be included in the sort of system that Chuck [Stocking] has been--is talking about.

MR. STOCKING: They are extensive, they look at what the wing is doing, then modify what the wing is doing accordingly.

MR. LEISTER: Have you taken this model and flown it against the flight test or tried to make it--

MR. STOCKING: No.

MR. LEISTER: That's--

MR. STOCKING: Well, yes, but with qualifications. The proof of concept that I did it was only partially in there, I used this portion of it, an estimate, everything went in the right direction, there is nothing that makes me believe that it isn't a good accurate model.

MR. LEISTER: Someone should let you cook up a model like that for one of the known--well, a Dash 8 or something like that, and see how it rides in a sim. You may have something.

MR. STOCKING: It's not me, I'm just rolling over what's been there for a long time that we haven't used because of our limited computation problems.

MR. HEFFLEY: That's right. And further you know there is a body of existing wind tunnel data that has been gathered on aircraft such as light twins.

MR. BOOTHE: So is this existing data that's lying in the archives that current modelers are not taking advantage of? Or--

MR. HEFFLEY: It's there. And I think it would be the logical basis, if one really were starting from scratch. At the same time contemporary commuter aircraft, as a class of aircraft, is not terribly extreme in terms of powered-lift effects. The effects of propellers are significant. But there are existing data and models to draw from.

MR. LEISTER: Those effects are modeled but I guess what Stu--I'm sorry, what Chuck [Stocking] is saying, is that perhaps using predictive methods you can come up with a model that would play in a simulator. Is that what you are saying?

MR. STOCKING: You have to realize when I take stuff from DATCOM it's more than predictive, this has been contributed to by the experiences of researchers.

MR. HEFFLEY: You do not have to go to the extreme of just starting from DATCOM, you don't have to start with totally analytic functions.

MR. STOCKING: No.

MR. HEFFLEY: You start with whatever you can find. And some of that is existing wind tunnel.

MR. STOCKING: The air frame manufacturers have gone far beyond what's available to me in DATCOM or another source, a public source, I have to rely on public sources.

MR. HEFFLEY: Same here.

MR. STOCKING: The volume of data.

MR. LEISTER: Hilton [Smith] and I worked on a C-130 derivation years ago, the prop effects--Hilton Smith? He is gone.

MR. HEFFLEY: That's another example where there is some decent NASA test results on powered lift (on the NC-130).

MR. WILLMOTT: A thought that occurred to me, Ed [Boothe], that maybe you have thought of, too. Is it reasonable to consider taking what Chuck [Stocking] has done, which is the process that we are talking about, to reduce the costs, and try and put that into a simulator somewhere, additionally do the flight testing that is necessary, we have come up with the validation tests for B, and to use it as a proof of concept? You are asking if there is something that you could do like come up with models or something like that, maybe something like that is beneficial.

MR. LONGRIDGE: There is no question, I think we are moving in the direction of a demonstration program for this particular effort. And I think it's quite feasible that we might as part of that program do something like that.

MR. WILLMOTT: I mean, the proof of the pudding is in the eating, they say across the way.

MR. BOOTHE: I think that it is feasible and I think it's more than feasible, I think it's quite desirable, and I even would go so far as to say it's necessary to at least gain the confidence that's needed to say yes, this is a viable method and we can do this.

I just want to spend a couple of minutes on the Level B issue, and Tom [Longridge] has some concluding remarks. But a couple of things we never got to the steady state sideslip, I will let you read that yourself and you can shoot me through CompuServe or something, but these other tables we never got to talk about and I guess the conclusion was we didn't want to talk about them.

But I tell you that Microsoft Word does a nice job doing it, so I guess we just leave them to be and those are just as I said, yesterday's is pretty much a redo of the IATA tables and use them or throw them out or whatever you find them useful for.

But this Level B issue, there is intention beyond just the data, we know we can't reduce the cost of the simulator just on the data as a start. So we are going to be looking at, at motion systems and visual systems, and I don't think that necessarily means we are going to be looking at can we use cheaper, smaller visual systems, I think we are going to be looking at what kind of visual system does one need to accomplish what we need to accomplish and what needs to be in it. I mean, do we need photo texture and pretty clouds and waves? I don't know. Those are some things that I'm sure we will be addressing.

And the old question of motion goes on and on and probably we could split this room fifty-fifty and half of us believe in motion and the other half don't. And it's something that's going to be unresolved until the community decides to do some work to find out how needed it really is and if it's needed and--which I think it is, but that's all right, I've got an open mind, I'll be convinced it isn't if you show me the data.

But what motion is needed? I think that's important. Can that cost be reduced? Do we need a one degree of freedom sidekick error, do we need a six degree [of] freedom 72 stroke system, and those questions need to be answered, and I think that's all part of the equation of lower cost simulation.

But I think that needs to be done in such a way that we still accomplish the goal and that's not--that is to not degrade the pilot certification function. So that has to be kept firmly in mind as we do all this. We recertify pilots periodically, if we can recertify them periodically in a Level B they still go out and fly in air transportation service perhaps with you riding in back. So the simulation still has to be of high integrity and it has to support that task.

So I think as we continue, that's really what happens. As we continue we have to keep that thought in mind. Even with the modeling. So if we can do it cheaper we ought to. But we still have to keep in mind that the idea is to certify pilots, and I think we all have a concept of what that means. So I think that's the important aspect and I don't want to lose those in the process of cutting costs here and cutting costs there. But I certainly don't want to do more than is necessary to accomplish that task, accomplish it properly, and accomplish it with integrity.

So I want to thank you all for your contributions. I think this has been one of the best discussions on simulation I have ever been involved with. And it's just been so open and all of you have contributed beyond my best hopes. And I'm just really pleased with what you brought with you and what you have given us. And thank you all very much. Tom [Longridge]?

MR. LONGRIDGE: I certainly second those comments.

There is one other issue I would like some further clarification on. It was brought up at one point that it might be fruitful to the extent we are going to rely more heavily on predictive modeling for the FAA to require some type of description of the model development process. And is it the recommendation of this group that the FAA come up with some type of criteria for such a description? Or do you feel that that's probably not necessary?

MR. STOCKING: I really feel you can do it through training requirements. If you have a training requirement to fly forward CG, that implies the simulator is going to have a fair representation of forward and aft CG.

MR. LONGRIDGE: Let me ask by show of hands how many people would recommend that we not require, not establish criteria for such a description of model development.

MR. RAY: And a model development would be something in the order of what we were talking about earlier. How did you get from point A to point B, not a full description of your model development, something along the lines we are working with now.

MR. KOHLMAN: Rephrase that again, Tom [Longridge].

MR. WILLMOTT: Not get involved, right?

MR. LONGRIDGE: The question is, do you recommend that the FAA establish criteria for description of model development?

MR. KOHLMAN: Okay.

MR. LONGRIDGE: Yes or no, raise your hand if you recommend.

MR. RAY: Can I ask a follow-up question?

MR. BOOTHE: Let's answer this one.

MR. RAY: That's right. Answer this one first. It passed, your question was no, don't fool with it.

MR. LONGRIDGE: Don't fool with it. I'm not surprised.

MR. RAY: I'm not surprised either.

MR. LONGRIDGE: Yes.

MR. BAILLIE: Rather than putting forward a criteria which somebody is going to figure a way to get around anyway, requesting some level of explanation is a different approach.

MR. LONGRIDGE: The point is, if you are going to require a description we need to specify the nature of that description. What I mean by criteria. What would be a satisfactory description to the FAA? If we don't specify that, we might as well not ask for it.

MR. WILLMOTT: Your subjective evaluation of the simulator covers the things that aren't really specifically spelled out in those validation tests. The purpose of the subjective evaluation is that you can fly it wherever you want, do other things and you are effectively checking the simulation, you are checking all of the models, you are checking aerodynamics, checking the controls, checking weight and balance, checking the engine, all of that is being done by your subjective evaluation.

MR. LONGRIDGE: I understand that. I also understand that we don't presently require any such description but it's also understood that the people that are doing this model development are in fact doing those tests and the FAA knows that and we are talking about going perhaps to a regime where that's no longer the case. You may have new people doing this who may not have the integrity of the present group.

MR. RAY: That's where I was coming from with my follow-up question. Where I thought we were going earlier when I saw a head or two nod saying yes, to what's reasonable.

In answer to Tom's [Longridge] question, I would have answered the same way that you did. Within this room with the way everyone in this room I believe perceives the way simulators should be built, have been built in the past, will continue to be built hopefully tomorrow. There is no need for that. Hopefully the industry opens up to other people, assuming the computer simulation market opens up. I see a lot more folks, as I referred to earlier, who we don't know, haven't the foggiest idea what their capabilities are, will come in and ask us to qualify a simulator. Putting yourself in the same position, is it reasonable to ask at least what process, that's the wrong word, what approaches did you take in development, whether it's of a model or the data, whatever the case may be, similar to what we do today with the Level 2, Level 3 and Level 5 devices as far as the generic aero behind it. They come in and present their case, this is how we develop our generic aeromodel and our validation set or data that confirms it is representative. When they come in and present that, it's a rather a straightforward process.

The only question is, is that reasonable to ask for those who haven't done this before particularly getting into the idea of the issue of expanded--is it a reasonable thing to ask? If it's not, I'll stop.

MR. HEFFLEY: What would you use to rule out an approach that somebody says "Hey, this is the way I'm going to do it." You have got to be prepared to say "Well, I sure don't like that for such and such a reason."

MR. RAY: Exactly what we ask to put together a similar group of what's sitting here right now. The exact same way we did it with the international scene with Boeing, Boeing participating in the process on what was reasonable. What would be reasonable to the experts in the room if they were to come to you. They built a process and it seems to work. We hope it works, anyway.

MR. WILLMOTT: One of the things about this, Paul [Ray], is you are right now addressing presumably the six aerodynamic coefficients.

MR. RAY: Presumably.

MR. WILLMOTT: The next step with this class of aircraft are the three control hinge moment coefficients, the next thing the downspring, the bob weight, the whole control system itself. The next thing is the engine, and how you model it, and as I was saying to Tom [Longridge] last night, sometimes somebody gets in a simulator and it flies badly, it's got nothing to do with any of that. It's the flight director.

So now you want to see all of the laws and the logic of the flight director? It's very difficult to pick out one thing of all of the simulation and say that this is what really matters as far as the flying qualities are concerned. And you know if you start down the path--

MR. RAY: We certainly don't want to get into that chart. The other chart we didn't talk about. We would not want that at all. It's not a reasonable question. You want us to try to work it out the way we typically have, that's fine. I just think there is some--gut instinct tells me, particularly with some of the inquiries we have had recently, that it's reasonable to ask someone to sit down and explain how you are doing what you are doing, not at this detail level, but do they seem to have a reasonable grasp about what they are doing? Have they addressed some of the simplistic pieces of putting their simulation together, whether it's motion, visual, the aero, whatever?

MR. WILLMOTT: Maybe one of the long-term solutions and suggestions is to get the regional aircraft, commuter aircraft manufacturers to do what the major airline manufacturers do, and that's produce the packages and then, you know, they are available for you to see.

MR. RAY: That's one of Tom's [Longridge] points I think he is going to be making or wanted to ask that question before we adjourn.

MR. WILLMOTT: They really are the best qualified people to do that. But it means that they have got to do things perhaps that they didn't do before even with the sort of class of aircraft you might have to develop aeroelastics which they may not do right now.

MR. RAY: It's a good time to ask the question.

MR. WILLMOTT: And all sorts of other things.

MR. RAY: Sorry.

MR. WILLMOTT: Go ahead.

MR. RAY: It's a good time to perhaps ask that question. Is it reasonable, would it be the recommendation of this group that we take from this meeting the idea that the FAA should somehow mandate the incorporation of data for simulation in the initial certification of an airplane?

MR. WILLMOTT: Well, if I were to say yes, I'm putting various people out of work.

MR. RAY: Actually you may--

MR. WILLMOTT: The answer is yes, really.

MR. RAY: If you look at it pragmatically perhaps you are increasing business.

MR. BAILLIE: In general we are working with a lot of companies to get that data to them.

MR. SCHUELER: I don't think the FAA has to regulate or demand that. The market can cause that to happen.

MR. RAY: True.

MR. ELLIS: That would be the best case if the customers for the airplane said manufacturer, we want simulators and we want you to provide the data package, otherwise we won't buy your airplane.

MR. SCHUELER: If the market forces aren't strong enough to force it then is the need great enough--

MR. LONGRIDGE: They haven't been strong enough to force it in the commuter market. We do have an NTSB recommendation in so many words.

MR. RAY: Everyone is aware of the '94 NTSB recommendation which essentially said it should be a requirement. We recommended, when that came out, the alternative should be that simulator training is required. And airplane training is an alternative. If you require simulator training, then the market forces come to bear where you are not going to buy the airplane unless the manufacturer produces the data. I think the end result may be the same, but it may not. I don't know all the answers to it, that's your recommendation. If you require the simulator training to the manufacturers obviously that will have some impact. They will be forced somehow, to provide data.

MR. SCHUELER: I think the FAA would be very hard pressed to regulate into existence the kind of package developed today for the regulatory agency. To define and regulate what that package is I think would be an enormous task and I don't think we could do a very good job of getting it right, at least not for quite a while.

MR. STOCKING: And the cost?

MR. SCHUELER: But the marketplace can do that, it can bring the forces to bear to say, you know, to cause someone even like Boeing to change and modify and update what they develop because we have learned and found new ways and whatever.

MR. BAILLIE: Can I revisit an issue which I feel compelled to talk about? I was probably one of the people who first said you should look at how people build the model. And as we discussed it I agreed with all the can of worms that come up from making it a requirement. But similarly in AC120-40B right now there is a requirement that either you use aircraft manufacturers' flight test data or data from a source that you have approved. Something of that level might get you over that comfort hump that you want to have in terms of aeromodel time where you take a look at the person not based on the architecture of the given model but based on his or her own personal competence; has this person got the competence to model an aircraft? That might be an out that doesn't bother the majority of people who are in the industry right now but allows the door to be opened with a gate on it so you can watch who is walking in.

MR. LONGRIDGE: There again you have criteria.

MR. BAILLIE: What's the criteria for the data?

MR. KOHLMAN: That's broad enough to allow the sort of thing that I have been thinking could come along and I have asked myself how would the FAA handle that. I have been reading about new ways of modeling, such as neural networks. I don't pretend to understand, but what I do know about it, it's a new way of modeling complex systems in which we don't have the traditional C_{L_α}, C_{L_β}, all those terms. Instead it's a rather complex transfer function.

What if somebody says here is how I'm going to model the airplane? What do we do then? Then we fall back on the competence and experience question. And the source of the data.

MR. SCHUELER: There are also some things that come in from the certification side where the FAA as a regulatory agency applies control: data collection, data process, data analysis--[all that] has to be documented. Validated, if you will. Or shown to be sound. In some manner. Calibration of the instrumentation has to be documented. There isn't currently any requirement on data for simulators. From that--in that same way. There is a requirement that the data come from an improved source. But in certification there is actually a regulation that specifies that that data collection will be documented and approved by the agency.

So there is some--there is some tools and methods that, some avenues, that might apply without.

MR. BOOTHE: Maybe we ought to get simulators mentioned in Part 21, which is where I think that information is.

MR. BAKER: Yes, it's 21.

MR. BOOTHE: That would be a big step in the right direction if we could just get them recognized in that concept that you have just outlined.

MR. BAILLIE: We aren't trying to make it more difficult to gather data, we are trying to look at people who build the models.

MR. SCHUELER: I guess part of what I'm trying to say, is that some of those concepts without--without regulating how it's done or who can do it or whatever, there is some examples again in other areas of how that might be done, how you might open the door to allow you the insight that I think you are looking for, and that's appropriate in certain cases, but without saying you have to show me all of your equations or something.

MR. RAY: Don't say that.

MR. SCHUELER: Right. That's not what you want.

MR. ELLIS: Just I hate to see us get into a rigid "this is how we do it now, this is how it's going to ever be." Dave [Kohlman] mentioned earlier something coming along called object oriented programming. Chuck [Stocking] is into, we are into it. It's very, very promising for this simulation field. We need to give it a chance.

MR. BAKER: One thing to me maybe that's what the NTSB was saying, I don't recall the recommendation but it would seem logical, I think it's what forces Boeing to support simulators as you said earlier, that the customers that the airplane hits the street on for training. If you could somehow try simulation to any of these airplanes in scheduled passenger carrying service I think you have to look at it from that direction. Schedules aside, if somehow you could tie that together that there is--there should be simulation provided at the time of delivery of the airplane.

MR. LONGRIDGE: That was exactly the NTSB recommendation. Yes.

MR. RAY: The way they phrased it--

MR. BAKER: The only way it's going to happen is if the manufacturer provides it. That's a fact.

MR. LONGRIDGE: It's just my impression it's going to take a bit of a push to make that happen. I'm not so confident the market forces are going to be adequate, at least in the near term.

We are out of time, I would like to thank all of you. I think from my perspective we have definitely accomplished the objectives the FAA had in calling this meeting. I appreciate your input, it's clear the input streams to maintain the quality of flight simulators, I can tell you we will act on this input, we are moving towards a demonstration program in this area.

Thank you all.

(Time Noted: 3:30 p.m.)