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MEMORANDUM

Lyndon B. Johnson Space Center — NASA

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SUBJ: Comments on the Terminal Configured Vehicle (TCV) Program

This note is to document some of the observations made by Jack Lousma, Bob Crippen, and me concerning the Boeing 737 TCV airplane and simulator that we flew at Langley Research Center. The aircraft and simulator are being used in a multi-purpose study that involves demonstrating the microwave landing system (MLS) and reducing pilot workload through better flight deck design and automation.

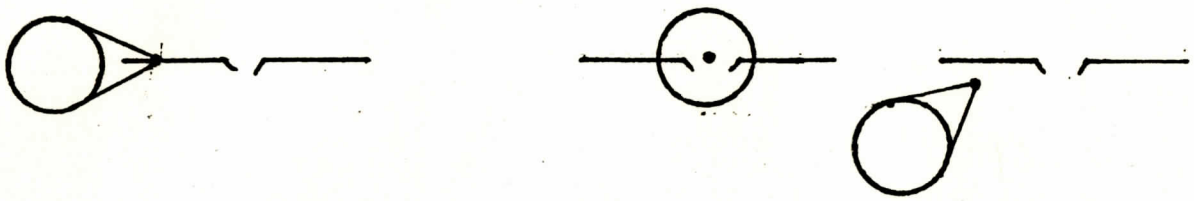
Finding out how the TCV displays work is worth the trip to LRC from the standpoint of gaining background in at least one advanced CRT display concept by flying it for awhile. Flying the TCV simulator and TCV airplane displays allows a pilot not familiar with advanced display concepts to understand some of the ideas that are being tried right now.

The TCV simulator was a typical 737 fixed base simulator with the improved displays. The TCV airplane was unusual in concept as a full "second cockpit" was built in the 737's midsection. This is where the TCV pilot and instructor fly the basic 737. This "second cockpit" provides a great deal of flexibility as it allows for modification and maintenance without tampering with the basic equipment. It also allows for easier changing of simulation pilots than working on the actual flight deck would have. There was reduced contact between the safety pilot (in the front cockpit) and simulation pilot, but this did not appear to adversely affect safety. Indeed there may have been some enhancement because the safety pilot did not also have to be the simulation instructor. Forward flight visibility for the second cockpit was provided by a black and white TV system. Flight dynamics in the midsection seemed realistic, although this was not significant as far as the things to be learned were concerned.

The TCV had an electronic attitude director indicator (an ADI display on a CRT) that some have jokingly referred to as an HDD (Heads Down Display). It used some basic display concepts many of which are incorporated in today's Heads Up Displays (HUD). All of us felt that a HUD would have provided a much better tool for flying than the HDD. Somehow superimposing the right information over the real world appears to be the way to go rather than creating an artificial world on a little CRT set down among a bunch of other instruments. I think we all feel that if the Shuttle could get a HUD we would be able to fly the vehicle both landing and on-orbit much more precisely and safely. We can do nothing about that now, but we should put it at the top of the improvements desired list for after OFT.

A very interesting concept of displaying a desired flight path was used that involved a conical section. The pointed cone end was the checkpoint (where one ultimately wanted to go), and the large end (represented by a circle) was what you wanted to fly the aircraft into to fly along a prescribed path in space to the checkpoint.

Examples



Right and Level On Flight Path Right and High

This idea may have major application to the Shuttle, especially for entry displays, RTLS, and possibly launch. Instead of providing "plan and elevation" views of a desired flight trajectory, the actual trajectory, limits (boundaries), etc., as a mission controller or GCA controller might see them, this concept provided a "pilot's-eye" view. Additional pertinent info was also displayed on the CRT. This whole idea of providing a forward-looking view rather than a side and top view made sense and should be pursued for Shuttle displays. The computer could digest the data and present it on the CRT in terms of pilot corrective action rather than require the pilot to integrate side and top view displays and then decide on what action to take; i.e., why not have a flight director system rather than merely providing raw data?

The TCV displays appeared to have an abundance of data displayed on the CRT some of the time which made it difficult to find and concentrate on the important data. It probably increased their training time and made it easier to become confused. At the same time other important information that might have been presented close by on a dedicated instrument (altitude for example) was not included on the CRT display. Because one spends most of his time looking at the CRT displays there was a tendency to forget to scan the other instruments. This might be eliminated by training, but points up a problem of balance between CRT and dedicated display information. The CRT does not provide a magic answer to the total instrument problem.

The TCV display used a line that moved to predict the future path of the airplane the same way the Shuttle displays use a series of three symbols. There was a feeling that the line display was superior in that there was not the need to mentally connect the three data points as we have to do on our display. This refinement may cost additional software words, though.

Another good TCV display consisted of an energy line to indicate where the airplane would go if the crew maintained the present energy level; i.e., airspeed, powersetting, and configuration. This concept might be useful in

Shuttle for approach and landing to better understand where we would land if we did not change anything. If we were not satisfied with that spot we could make appropriate changes. Incorporated into a HUD, this would be a super approach and landing aid.

The crewman's interface with the computer was straightforward and depended heavily on dedicated keys. The number of options available to the crewmen made it too easy for the novice to sometimes forget what mode was selected.

A means of reprogramming the desired ground track was available, but from a brief introduction appeared somewhat complex. It appeared easier to take manual control and fly than to reprogram the computer. If the concept was to have the ground datalink your new flight plan to you it might have some merit. Still it would leave me uncomfortable as to insuring that I knew exactly where the aircraft should be going. The concept is not bad, but it needs some work. I do not believe it has application to the Shuttle.

On three of the approaches at the airport the MLS glideslope did not lock up, and the aircraft would not have landed on the runway. In fact, with the present TCV logic and no lockup the software would not have provided autoflare. This was a subtle point that all the pilots did not completely understand.

The TCV demonstrated that these pilot displays have a "ways-to-go" before routine zero-zero landings should be made with it, and that it might be a long time before anybody ought to think about landing the Shuttle in IFR conditions, not to mention zero-zero.

Recommendations - All of us believe that a person comes away from a day flying the TCV display concept in the simulator with a better understanding and feeling for the sorts of things that we do and that we do not want to see on the Shuttle CRT. It is recommended that we send all our guys who have any input into our Shuttle displays for a couple of days to Langley.

Flying just the simulator was as good for our purposes as flying the airplane. The additional motion of the airplane did not appear to add a lot to what one could learn. Future attendees might want to go up to LRC by T-38 in the morning and fly the simulator the rest of the afternoon. On the next morning they could fly the simulator again and return to Houston in the afternoon. It would be cost-effective and educational.

Jack Lousma suggested sending along some of our FOD troops who work on displays to give them some fresh perspectives and ideas. Good idea. His basic thought is that we are still in the "dark ages" with respect to some pilot displays, whereas we should be the leaders in the field.