U.S. Gov't

Entry Date 5-12-93

Data Base HDOCNDX

Index # ~~INS.020604-8~~ INS.0206050

**ORAL HISTORY INTERVIEW**

**DATE OF DOCUMENT** [Date of Interview] = 03 - 14 - 68

**OFFICE OF PRIME RESPONSIBILITY** = JSC

**NUMBER ON DOCUMENT** = 00

**TYPE OF DOCUMENT** [Code for Interview] = 1

**PROGRAM** [3-letter Program Archive code] = INS

**AUTHOR** [Interviewee's Last Name] = NORTH

**LOCATION OF DOCUMENT** [Numeric Shelf Address] = 091-3

**SUBJECT OF DOCUMENT:** [use relevant bold-face introductory terms]

**Oral history interview with** Warren J. North
[full name of interviewee]

**about** Simulation and Crew Training; NASA
[main focus of interview]
facilities & Contractors.

**Title:** 1962 - Chief, Flight Crew Operations Div, ASPO
[interviewee's current and/or former title and affiliation]
1968 - Chief, Flight Crew Support Div, Flight Crew Oper.

**Interview conducted by** Robert B. Merrifield - Staff
[interviewer's name/position]
Historian **at** MSC.
[location of interview]

**Transcript and tape(s).** [for inventory only: # pages 17; # tapes 1]

master 1

U.S. Gov't

**CONTENTS:**

**Biographical** - [date/place of birth; family background] ______

**Education** - ______

**Career Path** - NACA-Lewis; 1958 NACA/NASA Hq, Office of Manned Space Flight

**Topics** - partic. in original astronaut selection & training; challenge of training for 3 concurrent programs; crew integration; crew training; complexity of Apollo simulators; Link Division of General Precision for simulator contract; intensive training at Cape Kennedy; relative simplicity of Mercury simulator; costs of simulators; actual hook up w/ mission control; 2 similar types: fixed base & moving base dynamic; lunar landing training vehicle; air bearing table for EVA; underwater neutral bouyancy training; docking simulator; simulation of lighting conditions; partial gravity simulator; egress training; part task simulators; Contractor Support areas (Link, McDonnell, Brown & Root, IT&T, General Electric, Lockheed); visitors views; simulators at contractor facilities; simulators at Guidance & Control Division; centrifuge at Crew Systems Div; lunar lighting simulation; crew safety panels & launch vehicle handbook; training contributions ~~from~~ by other NASA Centers

1369

April 22, 1968

Warren,

The transcript of your interview, edited to remove extraneous material is attached.

If you will, please read the statement and mark those sentences with brackets [ ] that you would not want alluded to in a Center history for reasons of embarrassment to an individual or the Center. As I mentioned during our recording session, this interview is to be part of the source material for the history, and it is doubtful that I will quote from it verbatim. Therefore, please don't worry about a sentence here or there which might not be as polished as would be desirable were it to receive public scrutiny.

If you want to add information feel free to do so. Just tack it on at the end of the statement, unless you prefer that it be inserted into the text.

After you return the transcript to me, I'll send you a copy for your personal file.

Thanks,

Bob Merrifield
BN

Bob -
Thanks for the transcript - sorry I delayed in returning it.
Warren
9/11/68

Interview with Warren North
3/14/68

3✓

I had been assigned in Headquarters in 1958 about 6 months prior to the formation of NASA as one of about 8 people brought to Washington by Abe Silverstein. Silverstein himself was brought to Washington by Dr. Dryden to help convert NACA to NASA. One of our first programs was officially announced at the formation of NASA and was the Mercury Program. Because of my background in aircraft flight test at NACA-Lewis, I was assigned to the Office of Manned Space Flight in which there were only two or three of us at the time. At one time only George Low and I were assigned to manned space flight, and we reported through Newell Sanders to Abe Silverstein. As the Mercury Program developed, I assisted in the selection of the original astronauts and was subsequently involved in their training program at Langley. As they approached the flight phase, just prior to the transfer of MSC to Houston, it was decided to establish the training operation as a division in the Center, and I was asked by Dr. Gilruth to join MSC. I transferred to Houston as Chief of the Flight Crew Operations Division, as it was then called.

I don't remember exactly where we were in the Mercury Program when we transferred to Houston, but before this came about, the Gemini Program became official. Because of the dual program status, there was a rapid need to expand the training and the crew integration effort. The division went from 35 civil service personnel in early 1962 to 270 today. Actually, we had 3 programs at that time, as Apollo was announced in 1961 also. Thus we had 3 programs to handle concurrently.

Our division had two major functions: crew integration and crew training. Crew integration primarily was involved with the design of the spacecraft cockpit and systems to handle the flight crew compatibility. The training aspect was directed primarily toward
198-2 ongoing flight programs such as Mercury and involved day to day astronaut training activities. Although we were organized functionally,
191 there was a lot of overlap and the crew integration people worked with the flight crews right down to launch and even during the postflight reporting cycle.

There was a bit of a struggle originally to get the other directorates(, in particular the Engineering and Development Directorate),
191 to recognize that the flight crew aspect of the design was indeed important. We also had to establish within our own division people who knew the systems from an operational standpoint. They have become the nucleus of the operations handbook effort, ~~a~~ AND support teams which work~~s~~ directly with the flight crews from the time they are assigned approximately a year before flight. They follow all the spacecraft tests at contractor facilities and at the Cape. This close relation and concern for ~~the~~ INTEGRATED systems operation that we are involved in is differentiated from the Engineering and Development Directorate interest, which is primarily concerned with INDIVIDUAL SYSTEMS AND guaranteeing a specific impulse on an engine or that an engine doesn't have rough combustion during its operation.

From an organizational standpoint the functional arrangement has
worked out very well. In the beginning there was concern that people
in the various directorates were going to overlap, but as it has
turned out the Apollo Program has been large enough so that it's been fairly
easy to define the responsibilities within the total framework of the
Apollo development and flight program. As we expanded and as we got
into this complex Apollo Program it became clear that the simulators
were going to have to be likewise much more complex. As a result,
183 they would require a lot of engineering and maintenance support which
the government wasn't in a position to staff. We established a
contract with Link to do the maintenance on the Gemini simulators. We
270 had some McDonnell engineering support to manage the configration of
the Gemini simulators, and as we got into Apollo, NAA and GAEC both
281 subcontracted their mission simulators to Link Division of General
Precision. Because Link then had the engineering and knowledge of
the simulators they were able to bid on the new contract which we had
let for both engineering and maintenance support. Because of their
engineering awareness as well as their maintenance capability, they
became the overall simulator contractor. Today they handle the
software (the computer programs) and the maintenance. They have around
384-3 570 people on this effort. Of those 570 about 150 are at Cape Kennedy.
385 About 40 of the division's civil service personnel are also located at
Cape Kennedy.

In general we try to provide training at Houston up to the point that the spacecraft is delivered to the Cape. From that point on, the flight crew does their training at Cape Kennedy. The training load has become enormous. We've established training programs which

385-1 have a nominal 55 hour week, and based on past experience and looking at the future flight crews are going to be working 6-7 day weeks for at least the last 5 months of their training cycle. Much of the~~ir~~ CREW'S

343 348 activity is in direct support of the spacecraft checkout at the Cape. There is a requirement for them to be in residence at the Cape during

352 386-1 392-1 the last 3-4 months, and consequently we have established a simulation complex at Cape Kennedy with two Apollo mission simulators and one LM mission simulator.

An example of the increased complexity of the simulators could be indicated in the number of hours we require for an Apollo mission vs

149 183 one of the Mercury missions. In Mercury we averaged about 45 hours per man on the Mercury Procedures Trainer. Mercury was a very simple spacecraft -- it had no guidance system, no onboard inertial platform. Apollo has a guidance system and is a two vehicle concept. One indication of the complexity of Apollo is the fact that we have 91 liquid and solid propulsion motors in the vehicle stack as it sits on the launch pad. The flight crew has some degree of control over all 91 of these

392-1 propulsion units. That gives some indication of the kind of training and awareness he must have to be able to handle this vehicle.

As we progressed from Mercury into Apollo we increased the number of simulators as well as their complexity. In Mercury A SPECIAL ~~the Procedures~~ ~~Trainer~~ trainer consisted of an air bearing unit with a COMPRESSED AIR ~~reasonable degree of fidelity response to the~~ reaction control system. It ~~was mounted upon~~ ROTATED ABOUT a center support air bearing. We also had a separate, crude display of the earth scene, which was not driven through a computer but was simply a film strip to give the pilot a veiw of the earth and its horizon during the critical retrofire maneuver. This training helped prepare Gordon Cooper for manual mode reentry on the last of Mercury flights, since he had a failure of the automatic control system. The cost of the Mercury trainers was modest--on the order of 1/2 million dollars for the two Mercury Procedures Trainers, as I recall. In Apollo we have a total investment of about 100 million dollars in the mission simulators and the part task trainers. ~~This simulation effort has been intensive from a configuration standpoint, as~~ ~~the~~ The simulators have to be at least as sophisticated as the spacecraft. They must simulate not only the spacecraft operation but that of the booster as well. They also must be continually updated in order to conform to the configuration of the upcoming mission. This has required the maintenance of close ties with the prime contractor, so that whenever he makes a spacecraft change, we are immediately informed and can then program that change into the hardware and software of the simulator. Today we have several outstanding modifications to make at the Cape to get into perfect configuration for the upcoming 205 flight with Captain Schirra. It's very similar to Gemini in that the STAFF ~~crew~~ works a 3 SHIFT ~~step~~ operation 7 days a week to both train ing and configuration-update ~~of~~ the simulators. A crew trains

770

348

386-1
392-1

5 days a week about 8 hours a day- the remaining 16 hours of that day plus the weekends are used to update the simulator, configuration-wise, both from a hardware and software (computer) standpoint.

Another reason why the simulators are so complex is that in addition to providing a realistic environment for the flight crew from a total mission standpoint, they also are linked with the mission control center during the training phase. They send to the Control Center the telemetry signals which during an actual flight would be received from the spacecraft in flight, which means that the system simulation must be of high fidelity. We could cut some corners and make some simplifications on systems performance from a training standpoint, but this is unrealistic because we have to provide systems operations which look realistic to the monitors on the ground ~~as well as the flight crew in space~~.

The simulators are two basic types - one type is the fixed base simulator in which the crew station is static and only the displays and controls are dynamic. The other type is the moving base dynamic simulators which provide the motion cues to the flight crew. In the later category the dynamic crew procedure simulator has become a fairly important training device for the launch phase of the mission and the reentry aborts immediately following launch. In all 3 flight programs; Mercury, Gemini, and Apollo there are failure modes at the booster which require rapid crew response in terms of detection and abort action. In a dynamic simulator which has gross pitch motion and short period vibration motions in yaw and roll, we are able to simulate the motions of the launch vehicle. By using these motion cues in conjunction with the displays within the spacecraft, the pilots are able to anticipate failures and perform aborts or guidance switchovers to insure mission completion and crew safety.

Another dynamic simulator which has been in development for some time is the lunar landing training vehicle. This was originally
340 managed by our Flight Research Center at Edwards which subcontracted to Bell Aerosystems in Buffalo to build two lunar landing preflight vehicles. These are 4000 pound vehicles which have a center turbojet engine gimballed to the local vertical so that the remaining motions of the vehicle create the same sort of dynamic situation as the lunar module would during a lunar landing. It was realized very early by the operations people that a good landing ~~simulator preflight~~ FREE FLIGHT simulator was a mandatory requirement. People involved in aircraft simulators for many years knew that the big void in simulation capability was a realistic landing simulation using visual displays which portrayed the landing, ~~but these d~~ D isplays were never quite good enough to provide high fidelity landing training. Consequently in the beginning of the Apollo Program we justified this device before top management and I think the flight history to date has certified the need for this type of vehicle because the lunar landing in the 1/6 environment has associated with it some fairly unique vehicle performance characteristics. I think the thing that Joe Walker had mentioned (he was the first man to fly the vehicle at Edwards) was the extreme attitudes the vehicle has to attain in order to decelerate ~~to~~ AND arrest any horizontal velocity. This is particularly critical because as you come in for the lunar landing you are moving forward over the ground and you want to arrest this velocity and land in a strange field as quickly as possible.

Unfortunately the only way to arrest velocity is to pitch up and back to kill off any horizontal motion. At this point the visibility of your landing site is washed out because of the pitchback attitude. That kind of experience the crew must become familiar with before the actual trial lunar landing.

Another dynamic simulator is the air bearing table for EVA. ~~I think~~ We learned a lot from the Gemini Program regarding extravehicular
348 activity. The air bearing table provides the ability to train the crew in ~~6°~~ 5° of freedom. The air bearing itself provides $2^{\circ}$ of freedom and by adding a platform on an air bearing pad you can in effect get $5^{\circ}$
343 of freedom. This was used effectively in training the Gemini 4, 8, and 10 crews for EVA procedures. Half way through the Gemini Program we realized the extravehicular activity was causing exhaustion to a much greater extent than had been anticipated from any ground training. ~~We discovered that~~ Most of the EVA activities were being trained FOR by piecing together simulations which we were accomplishing in the KC-135 aircraft during 30 sec of zero g parabulas. As it turned out the airplane was an ideal place to simulate short period activities such as opening and closing of hatches, but when it came to a long term activity outside the spacecraft, the airplane could not simulate this, as it provided a long rest period for the flight crew between the parabulas. We were overlooking the real problem in the simulation technique, which is that in space you are continually fighting to hang on to a spacecraft or continually fighting the pressure of the spacesuit which has a neutral position somewhat awkward for EVA activity. ~~But~~ Because of this inability

to simulate the end to end timeline of EVA, we went to the underwater 35✓ neutral bouyancy type of training which for Gemini 11 and 12 proved to be extremely effective. Because of this training, Col Aldren found no surprises in flight as compared to predecessors who had not had this end-to-end type continuous training in the zero gravity environment.

Another dynamic training facility ~~we use~~ is the docking simulator. We used the McDonnell-built Gemini docking simulator during the Gemini 34? 35✓ Program and it showed that the docking operation for Gemini would be quite straight forward, much more so than flying close formation in aircraft. Again, because we had this good simulator built by McDonnell and installed at Houston, the Gemini flight crews found no surprises when they attempted the same operation in space. As we went to Apollo we converted this same facility to meet requirements of Apollo DOCKING ~~hardware~~ training. We installed a lunar module spacecraft where the Gemini spacecraft was and we put in an unmanned command module where the Agena target vehicle was mounted. This is fullscale hardware, but lightweight from a mass standpoint, and gives $6^{\circ}$ of freedom in movement. The target command module vehicle has $2^{\circ}$ of translational freedom and the active LM vehicle has $1^{\circ}$ of translation and $3^{\circ}$ of rotation. This facility is flown through an analog computer system in a darkened room where we can simulate the various lighting conditions experienced during a docking maneuver. It was made for the LM active case since

we thought that was the most difficult type of docking. In Apollo we can dock with either the command module or the LM. We feel that LM should be primary ACTIVE ~~use~~ vehicle, because in lunar orbit it will be important to conserve reaction fuel in the command module for the subsequent trip home, and use LM fuel first since that vehicle will be left in lunar orbit. Also the LM active docking involves a maneuver in which the pilot approaches the command module head-on looking directly at the command module. Then he has to pitch down 90° and perform the docking with the LM top hatch while looking out a very small top window and at the same time operating controls that are 90° orthogonally out of phase with the direction of his line of sight. It turned out that some of the visual simulations of this maneuver which were performed several
39v-1 years ago were fairly difficult because of the nonrealism of the entire setup. However the dynamic fullscale simulator made considerable
38b-1 difference in the ease of this maneuvering. Pilots have been able to ~~fairly~~ accurately perform this maneuver with very little practice.

The other dynamic simulator which is just becoming operational is the partial gravity simulator involving an overhead pneumatic servo
39v-1 which ~~operates from a~~ METERS AIR pressure ~~standpoint~~ to offset any portion of the pilot's weight. In particular we are looking at the 1/6-g simulations, in which the overhead servo takes up 5/6 the weight of the man and his spacesuit. The man is held in a lightweight body suspens~~e~~ION system and attached to this overhead servo in such a fashion that he is able to exercise a full 6° of freedom in walking and performing lunar tasks.

The unique aspect of this simulator is that the low inertia of the suspension gimbals do not result in any adverse feedback~~ when the trainee makes various motions~~.

Another aspect of the Division's program is egress training.
33-V Working with the Recovery Division we have taken all the flight crews
343 into the Gulf of Mexico for egress training. There they experience
386-1 actual wave conditions as they affect their particular spacecraft
392-1 (Mercury, Gemini, or Apollo), and practice egress~~ing~~ from the spacecraft~~,~~
266 ~~in actual sea conditions~~.

The last of our training equipment in this category is the part
348 task simulators. One is operated by McDonnell Aircraft Co. It is actually a conversion of the Gemini simulator visual system and computer system into a part task guidance and navigation simulator for Apollo. Another trainer, the LM part task simulator, also uses visual equipment obtained from the Gemini simulators. It is run entirely, however, by our civil service engineers inhouse.

The maintenance and operation of these many simulators (there are
347-V about 10 major simulators used in Apollo alone) involve more effort than
395 the civil service employees can handle, and as a result we have had to have contractor support. The major contractor is Link with about 570 employees. We have about 62 McDonnell engineers who are working on the rendezvous procedures for the Apollo mission. ~~The third~~ Another contractor supporting us is Brown and Root. Their people are experienced safety divers used in the underwater facilities for extravehicular training. We have a small group of IT&T people doing checklist typing for us, and

in the simulation area we have some General Electric and Lockheed people working on the interpreter guidance computer which takes the MIT guidance program and interpret it into language which can be used by our mission simulator computers. BOEING IS PROVIDING EXPERT SUPPORT FOR SEVERAL BRANCHES IN THE DIVISION.

350 391 A high degree of interest is shown in the simulation facilities by visitors. We have endeavored to provide them with viewing areas. Of course we have ground rules that specify that there will be no direct access to the simulators during the actual training operation. We have an overhead balcony from which people can observe the LM and command module mission simulators and the 2 part task simulators. We also have a glassed-in observation room at the docking simulator which is removed from the trainer itself, but enables visitors to view the operation. At Cape Kennedy we have a similar provision to provide for visitors. The two command module and one LM simulators are lined up in a row and we have a glassed in balcony that runs parallel. We made a tape recording which can be played for visitors. Again, visitors are allowed access only during periods when the flight crew is not training. We realize the taxpayer has a right and a need to observe what's going on and we attempt to provide a good balance of observation and briefings for visitors.

There are simulators which are used for crew integration, crew familiarization, and training which are not under our division management. 352 392-1 These are at the contractor facilities at NAA, GAEC, and MIT. These are primarily for verification of the hardware and software, however, and the crew will utilize them only when they are at the contractor facilities for spacecraft checkout activities as sort of a by-product of being at the facility. These facilities are also useful to us as they provide us with a check on the performance of our own inhouse simulators for various part task operational phases. Another simulator not under our Division control exists here in the Guidance and Control Division. It simulates the command module and LM in the guidance and navigation mode and enables the crew and our own engineers to get experience on this unique aspect of the mission and also to be able to compare the performance of that simulator with our own. The Crew Systems Division has the centrifuge which was built here to provide for both crew training and biomedical research. ~~From our standpoint, its primarily value is in biomedical research.~~ Each Flight Crew is expected to experience 1 session of acceleration ~~g's~~, however, we found in both Mercury and Gemini that as long as crews experienced the acceleration once or twice, there wasn't much to be gained by repeated training in this kind of facility. Another reason why its use is limited, is that we have learned that during the high acceleration portions of the abort or reentry periods, not much crew activity is required. The main requirement at that time is to remain conscious and to know what to expect in terms of blackout or grayout tendencies. That is primarily the reason why that facility is located in the Crew Systems Division. There they can do research on the biomedical aspects - research on high g forces.

35V
245
3/13-1

The mission phase which the division is just getting into to a major extent is the training for activities on the lunar surface. This involves the fullscale LM mockup on the site. We considered this mockup in conjunction with the Crew Systems Division and the Science and Applications Directorate in designing the lunar scientific package.

We are concerned about the lighting conditions on the moon and are currently negotiating to set up a fullscale facility where we can have a simulated lunar surface with realistic sun shafting to get the correct sun-shadow relation. This may require a building as big as Building 9 or our new building for both the part task simulators AND mockups ~~and the new larger water tank for underwater activities.~~

Another aspect of our operation which I haven't touched on is our training support for the nonflight environment TEST spacecraft, 2 TV-1 command module, and the LTA-8 lunar module. We discovered when we used the 008 Block I command module in the environmental chamber that many operational systems interfaces needed modifications prior to the manned flight. This environmental vacuum and heat chamber has been extremely useful in getting some early information on crew procedures required to deal with the problems of low vacuum and extreme temperature ranges. The pilot report from the 008 chamber test was voluminous, and there were many many meetings with the program manager after that test in which anomalies discovered resulted in operational and hardware changes for the command module. These two spacecraft are extremely important, but since they are nonflight hardware the tendency is to overlook their importance. ~~We have had some difficulty in getting the contractors and even our own program people to consider them as having essentially the same importance as the flight spacecraft.~~ Certainly from a crew safety standpoint, they can be equally critical in a vacuum on the ground as in space. We have formalized training programs for the crews who will be manning these spacecraft with the same degree of concern that we have formalized the training programs for the pilots who man the flight hardware.

Although Marshall Space Flight Center was not involved in Gemini - they were involved in Mercury Redstone in the same fashion as they are in Apollo. The primary interface between personnel in my Division and the Marshall group is in work done by the crew safety panels. I've been on the crew safety panels since the beginning of Mercury and I've been extremely impressed with the thoroughness of their activity and their concern for crew safety. We are currently jointly publishing an Apollo launch vehicle handbook for the flight crews. I say jointly-- it is being primarily written by Marshall with a minimum input from us, except from an editorial standpoint.

The Marshall interface on Apollo Applications Program, has been considerably different than for Mercury or Apollo, as Marshall has had a much bigger role in the design phases of the SIV-B workshop, and the multiple docking adapter. We've had to work with them from the crew integration standpoint. It has been a fairly inefficient way to function because of the logistics involved, the location of the two Centers and Marshall's lack of familiarity with the flight crew problems. Marshall is building a large neutral buouyancy water tank which is extremely well designed and is going to be an excellent facility. It is expected to be of great value in the design of space station-type vehicles, but will require a lot of travel on our part to attend design review meetings and participate in some of the underwater activities. I think as we go into AAP there will be a management problem to resolve insofar as exactly how we share the responsibility for these crew integration-type tasks and the training which will follow. It is difficult to separate design and training activities. Not only are we going to have to physically divide our time between Marshall and Houston as we approach the launch phase we'll have to further subdivide our time between Marshall, Houston, and Cape Kennedy. The need for high mobility in terms of the astronauts is going to increase as we get into progressively more advanced programs.

We have utilized all the centers to some degree in our crew integration and training program. The Lewis Research Center provides a facility where the pilot ~~is~~ WAS able to actually control ~~a few~~ THE ANGULAR degrees of freedom with the aid of multiple-gimbal system. ~~With various~~ FROM COMBINATIONS OF rotational motions he ~~can~~ learned the best way to arrest TUMBLING ~~a tumbled~~ spacecraft motion which might develop from a control system failure.

The Ames Research Center has provided some extremely valuable work in terms of what is feasible from a manual booster control standpoint. The boosters for the~~se~~ EARLY manned spacecraft programs obviously were originally designed as military weapons which required fully automatic guidance systems, but as we get into Apollo and beyond we have boosters which were primarily designed for manned programs. Consequently we should take advantage of the ability of the man to simplify and make the control system more reliable, and also provide ability for the man to enhance mission reliability and crew safety from a manual control standpoint. The Ames Research Center has been extremely active for over 6 years in doing work to improve pilot ability to enhance the overall mission success through manual takeover of the booster guidance system. They are currently working with us to show the feasibility of a manual takeover of the Saturn V, either the 1st, 2nd, or 3rd stage. Such a takeover, because of a booster platform failure, would enable the pilot to fly the booster into orbit and even make the translunar injection burn.

The Langley Research Center has been extremely helpful in many difficult areas. In Gemini, LRC personnel provided fixed base rendezvous studies. For Mercury they prepared simulations on the spacecraft reentry control system. For Apollo they built a fullscale docking simulator for both command module active docking and for the LM extraction maneuver which follows the transposition and docking. This rig is somewhat similar to our fullscale docking simulator except that theirs is ca~~lbe~~le-suspended. They constructed an outdoor lunar landing facility, which again is a cable suspended lunar module. It operates within an envelope roughly 200' high by 400' long and 40' wide. We are using that facility as a pre-checkout simulator for all the flight crew people who fly the FREE ~~pre~~flight lunar landing training vehicle. ~~Actually~~ They go through Langley first, get some feel for the dynamics on the tethered simulator, then they go through our fixed base lunar landing trainer simulator in Bldg 4 here at Houston, where they get detailed procedures type training~~,~~ prior to flying the FREE ~~pre~~flight vehicle at Ellington.

272
333-4
405