VARIABLE STABILITY
FLIGHT OPERATIONS MANUAL

Prepared by the Aviation Systems and Flight Research Department

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1.1 GENERAL DESCRIPTION

The University of Tennessee Space Institute (UTSI) operates two Variable Stability Research Aircraft (VSRA), N55UT (Figure 1), and N66UT (Figure 2). N55UT is a North American Navion, and N66UT is a Ryan Navion. Both aircraft were extensively modified by Princeton University in the 1960’s, and used by Princeton until 1988, when they were acquired by UTSI. UTSI has maintained and used the Navions since then to conduct research and training for test pilots and engineers. Each aircraft is powered by a 285 hp Teledyne-Continental IO-520 BA engine driving a McCauley three-blade constant speed propeller. The aircraft allowable gross weight of both aircraft has been increased from the original 2750 to 3150 lbs.

Figure 1. North American Navion N55UT

Figure 2. Ryan Navion N66UT
N55UT is capable of six degrees of freedom, and N66UT is capable of five degrees of freedom. To facilitate six degrees of freedom, N55UT has two vertical all-moving control surfaces near the mid-span of the wing. These surfaces are modified Schweizer 2-32 sailplane horizontal tailplane assemblies. The surfaces are interconnected by a cable system to permit either surface drive actuator, located in the nacelle fairing, to drive both surfaces. Hinging and aerodynamic servo tabs also insure stable “floating” characteristics in the event of hydraulic power loss. Range of actuation is ±35 degrees. The surface area of about one-sixth of the wing area permits side force modulation of about ± 1/2 g at 105 knots. The vertical tail on this aircraft was modified with a chord wise extension and a span wise “cap” on the rudder surface. The modification provides increased sideslip control and compensates for the somewhat forward placement, relative to the center of gravity, of the side-force surfaces.

Both Navions incorporate direct lift flaps, which allow deflection over ±30 degree range, resulting in increased lift modulation authority and smaller drag changes compared to the original 0-40 deg down-only flap.

The normal Navion main landing gear struts were replaced with those designed for the Camair twin (a Navion conversion with nearly 40 percent increase in gross weight). Drop tests were conducted to optimize oleo strut inflation and orifice size. The system can be adjusted for landing tests to provide an allowable sink rate of 12.5 ft/sec.

The cockpits of each aircraft are modified with control panels for the variable stability system, control effectors for the evaluation pilot stations, and an array of panel mounted potentiometers for setting aircraft characteristics. The evaluation pilot is seated in the right seat of N55UT and controls the aircraft with a joystick arrangement (Figure 3), whereas the evaluation pilot in N66UT is seated in the left seat, and controls the aircraft with a conventional yoke arrangement (Figure 4).

![Figure 3. N55UT Evaluation Pilot Joystick (Right Seat)](image)
Figures 5 and 6 show the basic cockpit layout for each Navion. Cockpit potentiometers are located on the overhead, instrument, and center consoles, along with variable system control panels. Each aircraft has the capability of providing time histories of various sensor outputs for recording and data collection purposes.
Figure 6. N66UT Cockpit Layout

43 Channels of Output Available for Recording
1.2 VARIABLE STABILITY SYSTEM

The Navions utilize an analog “fly-by-wire” (FBW) control system, that is, hydraulic power-actuated control surfaces commanded by electrical signals. The signals come from the various cockpit controllers and motion sensors, and when appropriately processed and summed, provide a net signal to each servo-actuator, and, hence, an airplane response of a particular character and magnitude. Hydraulic power is provided by an engine-driven pump, which delivers approximately 9 gpm at 1050-psi pressure in 55UT, and 750-psi in 66UT. Figure 7 provides a simplified overview of the variable stability system, showing the important relationship of the safety pilot monitoring function.

![Image of the variable stability system]

**Figure 7. Variable Stability System**

1.2.1 Moment Controls

Control over pitching, rolling, and yawing are through conventional elevator, aileron, and rudder control surfaces. The full authority (that is, maximum travel) of each surface is available, and the maximum deflection rate in each case is about 70 deg/sec. The hydraulic servos are modified units originally designed for the B-58 and incorporate built-in solenoids and pilot force-override disengage features. The inputs to each channel and the function they vary are shown in Table A-1.
<table>
<thead>
<tr>
<th>CHANNEL</th>
<th>INPUT</th>
<th>FUNCTION VARIED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pitch</td>
<td>Control Stick Displacement</td>
<td>Control Sensitivity</td>
</tr>
<tr>
<td></td>
<td>Thrust Lever</td>
<td>Simulated moment due to thrust</td>
</tr>
<tr>
<td></td>
<td>Column thumbwheel</td>
<td>Simulated DLC moment</td>
</tr>
<tr>
<td></td>
<td>Radar Altitude</td>
<td>Ground effect moment</td>
</tr>
<tr>
<td></td>
<td>Airspeed</td>
<td>Speed stability</td>
</tr>
<tr>
<td></td>
<td>Angle of attack</td>
<td>Static stability</td>
</tr>
<tr>
<td></td>
<td>Pitch attitude</td>
<td>Attitude hold sensitivity</td>
</tr>
<tr>
<td></td>
<td>Pitch rate</td>
<td>Pitch damping</td>
</tr>
<tr>
<td></td>
<td>Flap angle</td>
<td>Trim change from flap</td>
</tr>
<tr>
<td></td>
<td>Flap rate</td>
<td>Moment from flap rate</td>
</tr>
<tr>
<td></td>
<td>Simulated turbulence</td>
<td>Turbulence response</td>
</tr>
<tr>
<td>Roll</td>
<td>Lateral stick displacement</td>
<td>Control sensitivity</td>
</tr>
<tr>
<td></td>
<td>Sideslip</td>
<td>Dihedral effect</td>
</tr>
<tr>
<td></td>
<td>Roll rate</td>
<td>Roll damping</td>
</tr>
<tr>
<td></td>
<td>Yaw rate</td>
<td>Roll due to yaw rate</td>
</tr>
<tr>
<td></td>
<td>Rudder pedal displacement</td>
<td>Roll due to rudder</td>
</tr>
<tr>
<td></td>
<td>Simulated turbulence</td>
<td>Turbulence response</td>
</tr>
<tr>
<td>Yaw</td>
<td>Rudder pedal displacement</td>
<td>Control sensitivity</td>
</tr>
<tr>
<td></td>
<td>Sideslip</td>
<td>Directional stability</td>
</tr>
<tr>
<td></td>
<td>Yaw rate</td>
<td>Yaw damping</td>
</tr>
<tr>
<td></td>
<td>Roll rate</td>
<td>Yaw due to roll rate</td>
</tr>
<tr>
<td></td>
<td>Wheel displacement</td>
<td>Yaw due to aileron</td>
</tr>
<tr>
<td></td>
<td>Simulated turbulence</td>
<td>Turbulence response</td>
</tr>
</tbody>
</table>

Table A-1. Inputs of Moment Controls

1.2.2 Normal Force Control

Independent control over normal acceleration is by means of the Navion flap system, modified to deflect up, as well as down, through a ± 30 deg range. The upward motion provides increased lift modulation authority and tends to minimize the problems of drag and angle of zero lift changes.

Actuation is hydraulic, with a maximum available surface rate of 110 deg/s. At 105 kt the available authority is slightly more than ± 1g. Inputs and function varied are shown in Table A-2.
### Table A-2. Inputs to Normal Force Control

<table>
<thead>
<tr>
<th>INPUT</th>
<th>FUNCTION VARIED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control stick displacement</td>
<td>Lift due to control (simulated elevator lift, or</td>
</tr>
<tr>
<td></td>
<td>direct lift control integrated with column)</td>
</tr>
<tr>
<td>Thrust lever displacement</td>
<td>Lift due to thrust, direct lift control integrated</td>
</tr>
<tr>
<td></td>
<td>with throttle</td>
</tr>
<tr>
<td>Radar altitude</td>
<td>Ground effect lift; wind gradients</td>
</tr>
<tr>
<td>Angle of attack</td>
<td>Lift response to angle of attack, lift change at</td>
</tr>
<tr>
<td></td>
<td>stall</td>
</tr>
<tr>
<td>Simulated turbulence</td>
<td>Turbulence response</td>
</tr>
</tbody>
</table>

#### 1.2.3 Thrust Control

Thrust and drag modulation is by a hydraulic actuator on the engine throttle. The engine rpm is maintained by the propeller governor which adjusts the blade pitch (constant speed propeller). Inputs to the thrust/drag modulation system are shown in Table A-3.

### Table A-3. Inputs to Thrust/Drag Modulation System

<table>
<thead>
<tr>
<th>INPUT</th>
<th>FUNCTION VARIED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control stick displacement</td>
<td>Drag due to control (simulated control surface</td>
</tr>
<tr>
<td></td>
<td>drag; drag due to direct lift controls integrated</td>
</tr>
<tr>
<td></td>
<td>with column</td>
</tr>
<tr>
<td>Thrust lever displacement</td>
<td>Thrust command/throttle sensitivity</td>
</tr>
<tr>
<td>Radar altitude</td>
<td>Ground effect drag change; wind gradients</td>
</tr>
<tr>
<td>Airspeed</td>
<td>Drag change with speed</td>
</tr>
<tr>
<td>Angle of attack</td>
<td>Drag change with angle of attack</td>
</tr>
<tr>
<td>Flap displacement</td>
<td>Drag due to flap deflection</td>
</tr>
</tbody>
</table>

#### 1.2.4 Side Force Control

Direct control of side force is obtained by dual vertical surfaces mounted on nacelles on the wing. The location chosen was based on NASA wind tunnel studies which indicated a minimum cross-coupling effect. Although the upper and lower surface areas are not equal, the rolling moment induced by deflection is very nearly zero. The position forward of the c.g. is favorable with respect to obtaining some additional force from the vertical tail fin. In addition to direct side force control, the surfaces provide a means to simulate crosswinds. At 105 kt, the available authority is slightly more than ±.5g. The presently available inputs are shown in Table A-4.
Table A-4. Inputs to Side Force Control

<table>
<thead>
<tr>
<th>INPUT</th>
<th>FUNCTION VARIED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sideslip</td>
<td>Crosswind force</td>
</tr>
<tr>
<td>Bank angle</td>
<td>Side force due to bank</td>
</tr>
<tr>
<td>Lateral control stick</td>
<td>Side force due to aileron</td>
</tr>
<tr>
<td>Rudder pedal</td>
<td>Side force due to rudder</td>
</tr>
<tr>
<td>Yaw rate</td>
<td>Side force due to yaw rate</td>
</tr>
<tr>
<td>Thumb controller</td>
<td>Direct side force control</td>
</tr>
<tr>
<td>Simulated turbulence</td>
<td>Turbulence response</td>
</tr>
</tbody>
</table>

1.2.5 Servo-Actuator Response

The hydraulic servo-actuator rate limits and approximate second order frequency response are shown in Table A-5. The hydraulic pump capacity is sufficient to permit two-thirds maximum on side force and maximum rate on all other servos simultaneously (without accumulator supplement).

<table>
<thead>
<tr>
<th>Control</th>
<th>Displacement Limit, deg</th>
<th>Rate Limit, deg/sec</th>
<th>Bandwidth, Flat, (6 db down) Hz</th>
<th>Maximum Specific Force or Moment (IAS=105)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pitch</td>
<td>-30 +20</td>
<td>70</td>
<td>5(10)</td>
<td>9.9 rad/sec²</td>
</tr>
<tr>
<td>Roll</td>
<td>±20</td>
<td>70</td>
<td>5(10)</td>
<td>9.2 rad/sec²</td>
</tr>
<tr>
<td>Yaw</td>
<td>±20</td>
<td>70</td>
<td>5(10)</td>
<td>4.2 rad/sec²</td>
</tr>
<tr>
<td>Thrust</td>
<td>-</td>
<td>-</td>
<td>0.6*</td>
<td>.05g</td>
</tr>
<tr>
<td>Side Force</td>
<td>±35</td>
<td>60</td>
<td>2(3)</td>
<td>.5g</td>
</tr>
<tr>
<td>Normal</td>
<td>±30</td>
<td>110</td>
<td>2(3)</td>
<td>1.1g</td>
</tr>
</tbody>
</table>

*Limited by aircraft engine to a first order time constant of .25 seconds

Table A-5. Servo-Actuator Response

1.2.6 Interconnects

It may be noted in the lists of inputs for the system (Tables A-1 – A-4) that several coupling functions are provided. These are used to remove the interacting effects in the basic airframe: for example, pitch and drag changes due to flap deflection may be eliminated with interconnects between the flap position sensor and the elevator and throttle servos.

Simulated interacting effects are handled using inputs from various cockpit controllers: pitching moments and lift changes due to power are provided by interconnecting the elevator and the flap with the thrust lever. Other controllers may be similarly connected.
1.3 STABILITY DERIVATIVES AND INFLIGHT SIMULATION

The VSRA’s can be used to simulate known aircraft characteristics, or to provide desired stability and control cases for evaluation or training. This is accomplished by changing the basic dimensional stability and control characteristics of the Navion through the cockpit mounted potentiometers. Each potentiometer is labeled in accordance with the dimensional derivative value it affects. Settings for replicating known aircraft characteristics are determined by using potentiometer settings, which provide the same dimensional derivative values of the aircraft being simulated. Figures 8 and 9 provide the list of stability derivatives that can be controlled in each aircraft.

<table>
<thead>
<tr>
<th>Force or Moment Derivative (Y)</th>
<th>Pitching Moment (Elevator)</th>
<th>Rolling Moment (Aileron)</th>
<th>Yawing Moment (Rudder)</th>
<th>Normal Force (Flaps)</th>
<th>Side Force</th>
<th>Longitudinal Force (Thrust, Drag)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elevation Deflection $\delta_e$</td>
<td>$M_{\delta_e}$</td>
<td></td>
<td></td>
<td>$Z_{\delta_e}$</td>
<td></td>
<td>$D_{\delta_e}$</td>
</tr>
<tr>
<td>Aileron Deflection $\delta_{\alpha}$</td>
<td>$L_{\delta_{\alpha}}$</td>
<td>$N_{\delta_{\alpha}}$</td>
<td></td>
<td>$Y_{\delta_{\alpha}}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rudder Deflection $\delta_r$</td>
<td>$L_{\delta_r}$</td>
<td>$N_{\delta_r}$</td>
<td></td>
<td>$Y_{\delta_r}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Side Force $\delta_{SF}$</td>
<td></td>
<td></td>
<td></td>
<td>$Y_{SF}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Angle of Attack $\alpha$</td>
<td>$M_{\alpha}$</td>
<td>$M'_{\alpha}$</td>
<td></td>
<td>$Z_{\alpha}$</td>
<td></td>
<td>$D_{\alpha}$</td>
</tr>
<tr>
<td>Sideslip $\beta$</td>
<td>$M_{\beta}$</td>
<td>$L_{\beta}$</td>
<td>$N_{\beta}$</td>
<td>$Z_{\beta}$</td>
<td>$Y_{\beta}$</td>
<td></td>
</tr>
<tr>
<td>Pitch $\theta$</td>
<td>$M_{\theta}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pitch Rate $\dot{\theta}$</td>
<td>$M'_{\theta}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roll Rate $P$</td>
<td>$L_P$</td>
<td>$N_P$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yaw Rate $R$</td>
<td>$L_R$</td>
<td>$N_R$</td>
<td></td>
<td></td>
<td>$Y_R$</td>
<td></td>
</tr>
<tr>
<td>Ground Effect $H$</td>
<td>$M_H$</td>
<td></td>
<td></td>
<td>$Z_H$</td>
<td>$Y_H$</td>
<td>$D_H$</td>
</tr>
<tr>
<td>Thrust $TH$</td>
<td>$M_{\delta_{TH}}$</td>
<td></td>
<td></td>
<td>$Z_{\delta_{TH}}$</td>
<td></td>
<td>$D_{\delta_{TH}}$</td>
</tr>
<tr>
<td>Direct Lift $DL$</td>
<td>$M_{DL}$</td>
<td></td>
<td></td>
<td>$Z_{DL}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Velocity $V$</td>
<td>$M_V$</td>
<td></td>
<td></td>
<td>$Z_V$</td>
<td></td>
<td>$D_V$</td>
</tr>
</tbody>
</table>

N-55 UT Stability Derivatives, e.g., $M_{\delta_e} = (1/l_{yy}) (\partial M/\partial \delta_e)$
<table>
<thead>
<tr>
<th>Variable (X)</th>
<th>Force or Moment Derivative (Y)</th>
<th>Yawing Moment (Rudder)</th>
<th>Longitudinal Force (Thrust, Drag)</th>
<th>Pitching Moment (Elevator)</th>
<th>Rolling Moment (Aileron)</th>
<th>Normal Force (Flaps)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elevation Deflection $\delta_e$</td>
<td>$X_{\delta_e}$</td>
<td>$M_{\delta_e}$</td>
<td>$Z_{\delta_e}$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aileron Deflection $\delta_{\alpha}$</td>
<td>$N_{\delta_{\alpha}}$</td>
<td></td>
<td>$L_{\Delta_{\alpha}}$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rudder Deflection $\delta_r$</td>
<td>$N_{\delta_r}$</td>
<td></td>
<td>$L_{\delta_r}$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Angle of Attack $\alpha$</td>
<td>$X_{\alpha}$</td>
<td>$M_{\alpha}$</td>
<td>$Z_{\alpha}$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sideslip $\beta$</td>
<td>$N_{\beta}$</td>
<td>$M_{\beta}$</td>
<td>$L_{\beta}$</td>
<td>$Z_{\beta}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pitch $\theta$</td>
<td></td>
<td>$M_{\theta}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pitch Rate $\dot{\theta}$</td>
<td></td>
<td>$M_{\dot{\theta}}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roll Rate $P$</td>
<td>$N_{P}$</td>
<td></td>
<td>$L_{P}$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yaw Rate $R$</td>
<td>$N_{R}$</td>
<td></td>
<td>$L_{R}$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ground Effect $H$</td>
<td>$X_{H}$</td>
<td>$M_{H}$</td>
<td>$Z_{H}$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Direct Lift DL</td>
<td>$X_{DL}$</td>
<td>$M_{DL}$</td>
<td>$Z_{DL}$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thrust $TH$</td>
<td>$X_{\delta_t}$</td>
<td>$M_{\delta_t}$</td>
<td>$Z_{\delta_t}$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Velocity $V$</td>
<td>$X_{V}$</td>
<td>$M_{V}$</td>
<td>$Z_{V}$</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

N-66 UT Stability Derivatives, e.g., $M_{\alpha} = (1/I_{yy})(\partial M/\partial \alpha)$

Figure 9. N 66UT Dimensional Derivatives

1.4 SAFETY PILOT FUNCTION

FUNDAMENTAL TO THE SAFE OPERATION OF VARIABLE STABILITY AIRCRAFT IS THE CONCEPT THAT A SAFETY PILOT WILL CONTINUALLY FOLLOW THE MOVEMENTS OF THE BASIC AIRPLANE CONTROLS, MONITOR THE SYSTEMS AND THE FLIGHT PATH, AND BE READY TO DISENGAGE OR OVERRIDE THE EVALUATION PILOT IN CASE OF MALFUNCTION OR TO PREVENT AN UNSAFE
CONDITION FROM DEVELOPING. For disengaging, a disconnect switch on the safety pilot’s control wheel is the primary cutout, with the main electrical and hydraulic controls providing secondary means of deactivating the system.

Manual override of the hydraulic servo actuators is possible for all controls except the flap. The force required is set through an adjustable poppet valve on each servo, 40 lbs being typical. Warning of system failures is provided by a flashing master warning light on the upper edge of the instrument panel in front of the safety pilot; with individual channel disengage warning lights slightly lower on the variable stability system (VSS) panel. THE SAFETY PILOT WILL GUARD THE FLIGHT CONTROLS AND MONITOR THE EVALUATION PILOT CONTROL INPUTS DURING ALL LOW ALTITUDE OPERATIONS (BELOW 1000’ AGL). IF AT ANY TIME A CONTROL SYSTEM ANOMALY OCCURS, A FAILURE IS ANNUNCIATED ON THE VSS CONTROL PANEL, OR IF AN UNSAFE FLIGHT CONDITION IS DEVELOPING, THE SAFETY PILOT WILL IMMEDIATELY DISENGAGE THE SYSTEM AND ASSUME MANUAL CONTROL OF THE AIRCRAFT.

1.5 SYSTEM REUNDANCY FEATURES AND FAILURE MODES

The elevator, aileron, and side force systems incorporate redundant control channels. The philosophy here is that anomalous control inputs (runaway, hard-over) resulting from system failures is particularly dangerous in a low-speed, low-altitude situation, and should be guarded against. With the redundant channels, any substantial error between the commanded and actual control position is detected, and a switchover to a second servo is made. The evaluation pilot retains control during this process, but all inputs to the switched channel, except those from the control column are eliminated, thus reducing the possibility that a defective transducer or signal path is causing the problem. Redundant sensors for the control input signal are incorporated; the other transducers are not duplicated. The fact that a channel has switched to the secondary servo is communicated to the safety pilot by warning lights.

The elevator is clearly critical with regard to failures which result in sudden full deflection, with the ailerons only slightly less so. If the elevator is switched to the standby channel (secondary servo), it operates on a fixed gain schedule, and utilizes a backup power supply in the standby computer. This feature permits continued fly-by-wire elevator operation at all times, unless disconnected by the safety pilot. The aileron channel also switches to a secondary servo in the event of a failure, but will automatically disconnect if there is a subsequent failure in the switched channel. Redundancy is also incorporated in the side force channel. In the case of a detected error in a channel, the surfaces are driven to the safety pilot command point – normally set for faired or zero deflection angle. Redundancy is not incorporated in the rudder or throttle channels, because inadvertent disengages are less critical, and the safety pilot can very effectively override large-deflection failures. If there is a failure in the flap channel, or if a malfunction drives the flap to full up, the safety pilot will shut off 28 VDC power and the flaps will trail to a 10 deg down position. Down-flap deflections clearly pose no safety problem; up-flap hardovers could be hazardous due to the large lift loss, but this has proved to be a failure mode so instantly recognized by the safety pilot that a disengage (with subsequent down-float of the flap) is effected with very small altitude loss.
Control surface potentiometer failures can also cause a variable system failure. These failure cases are recognized by the anomalous control response characteristics of the aircraft, depending on whether the failure occurred before engaging the VSS, or if it occurred during variable stability operations. The indications of a possible potentiometer failure are a diverging tendency in pitch, yaw, or roll, an abnormal amount of control input to effect an aircraft response, or a sudden disconnect in a control surface during a control application. In all cases, the failure is immediately recognizable, requiring the safety pilot to disengage the VSS and control the aircraft with the mechanical flight controls.

1.6 WAVEOFF AUTOMATION

To aid the safety pilot in recovering from an excessive sink rate situation, an “abort mode” system disengage can be used. The switch is located on the variable stability control panel and when the switch is turned to the arm position, pressing the disengage thumb switch causes the flap to travel at a maximum rate to a 20 deg down position and power is automatically advanced to a climb setting; primary control reverts to the safety pilot. Using this system, recovery from a 70 kt, 6 deg approach (sink rate of 12.5 ft/s) with a simulated up-flap failure can be made with less than 10 ft altitude loss.

1.7 LIMITATIONS

The following flight limitations are imposed on the operation of UTSI’s variable stability aircraft. Waivers for some limitations based on mission need may be requested after completing a Comparative Safety Assessment analysis through the UTSI airworthiness and safety process.

1. The VSS will not be engaged after initial take off until a minimum altitude of 400’ AGL is reached.
2. Initial engagement of the VSS on the first flight of the day will be with the basic Navion settings to verify nominal system operation. If this check is satisfactorily completed, research or training settings may then be used. If the check is unsuccessful, the variable stability system will be disengaged and the mission aborted.
3. All maneuvers with the VSS engaged will be planned at speeds below 108 KCAS to avoid a possible overstress in the event of a VSS malfunction.
4. The VSS may not be operated below 200’ AGL. During approaches, the VSS will be disengaged between 400’ AGL and 200’ AGL.
5. Large amplitude aircraft maneuvers are limited to chandelles and lazy – eights.
6. Normal acceleration is limited from -1 to +2.5 g.
7. Maximum airspeed is limited to 130 KIAS.
8. Flight operations are limited to day VFR.
9. Center of gravity must be within normal limits for all variable stability flights.
2.1 STANDARD OPERATING PROCEDURES

UTSI Standard Operating Procedures or SOP’s are provided to ensure that evaluation pilots and safety pilots are aware of their roles and responsibilities during flight research or training operations. Crew coordination is vital to the safe conduct of variable stability operations, and it is particularly important in the event of system malfunctions. Before each flight, the safety pilot will conduct a briefing with the evaluation pilot(s). This briefing will include an overview of the variable stability system, aircraft or mission limitations, evaluation profile, and SOP’s. This briefing may be given en mass or individually.

2.1.1 Preflight Briefing

Variable stability system
   Normal and abnormal operation
   Transfer of control procedures
Mission profile
   Maneuvers and techniques
   Evaluation methods (Cooper – Harper, etc)
   Local area operations, frequencies, controlling agencies
In-flight emergency procedures
   Aircrew responsibilities and functions
   Emergency airfields
   Communications

2.1.2 Flight Operations

The safety pilot is responsible for completing normal and VSS checklist items.

The aircrew will verify that the VSS is off for takeoff and landing.

During takeoff and landing, the safety pilot will closely monitor wing flap position.

After takeoff the VSS will be engaged when reaching a minimum of 400’ AGL.

On the first flight of the day, the VSS will be initially operated with baseline Navion settings to confirm normal system operation. Following this check, all cockpit potentiometers will be returned to zero, and the test card will be referred to for all subsequent mission settings.

The Safety Pilot will monitor the movement of control surfaces during variable stability flight operations, and will guard the controls during all variable stability operations below 1000’ AGL.
Variable stability system set up procedures:
  a. VSS - DISENGAGED
  b. Cockpit potentiometers and respective sense switches – SET
  c. Settings verify - CHALLENGE AND RESPONSE. Example, the evaluation pilot calls out “M alpha 35 and down”, and the safety pilot verifies “M alpha 35 and down”. This process continues until all settings are verified.
  d. Aircrew initiates transfer of control procedures

Transfer of control procedures:
  a. Cockpit settings verified
  b. Safety Pilot calls “Ready?”
  c. Evaluation Pilot responds “Ready” (hands/feet positioned, no control input)
  d. Safety Pilot engages variable stability system while guarding mechanical controls
  e. Safety Pilot calls “You have control”
  f. Evaluation Pilot responds “I have control”
  g. Test complete or if taking control, Safety Pilot calls “I have control”, and disengages the VSS
  h. Evaluation Pilot responds “You have control”

2.1.3 Emergency Procedures

Tullahoma is the primary recovery airfield in the event of an in-flight emergency. The Safety Pilot will notify Tullahoma traffic on VHF 123.0 MHz, and UTSI operations on 123.40 MHz. Crash fire and rescue may be requested on either frequency if needed.

If the variable stability system malfunctions during flight, annunciates a failure, or if an unsafe flight condition develops: the
  a. Safety Pilot yoke mounted disengage button – DEPRESS
  b. Variable stability 28 VDC power switch – OFF
  c. Reset/disengage switch - PRESS
  d. Hydraulic power – OFF
  e. Aircraft alternator and battery – OFF

The aircrew will review emergency egress and canopy opening procedures before making an emergency landing.

If the wing flaps runaway at any time during flight, the Safety Pilot will:
  a. Variable stability system - DISENGAGE
  b. 28 VDC variable stability system power switch - OFF