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**AUTOMATED AERIAL REFUELING
Delivery Order 0020: DC-8 Simulation Model**

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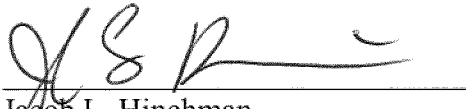
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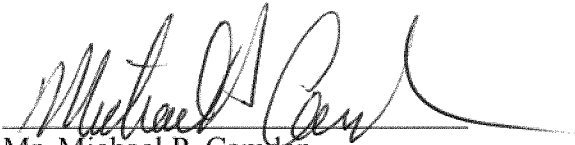
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14. ABSTRACT The purpose of this project was to provide a preliminary air refueling tanker aircraft model in the D-Six desktop simulation environment capable of flying a racetrack pattern and a small number of simple maneuvers. The aircraft used is a relatively simple DC-8 model, pictured in the simulation as a KC-135. This model will enable research to be conducted on automated aerial refueling algorithms by engineers at the Air Force Research Laboratory.						
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DC-8 Simulation Model

Chris Wilkening
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The purpose of this project was to provide a preliminary air refueling tanker aircraft model in the D-Six desktop simulation environment capable of flying a race-track pattern and a small number of simple maneuvers. The aircraft used is a relatively simple DC-8 model, pictured in the simulation as a KC-135. This model will enable research to be conducted on automated aerial refueling algorithms by engineers at the Air Force Research Laboratory.

The DC-8 can automatically fly the racetrack pattern with no user input once the following parameters for the pattern are set:

RT_heading: The commanded heading (degrees) that the system will fly. This value may be changed at any time during the flight profile.

RT_alt: The altitude (feet) that the system will maintain when (a) it is not under pilot control and (b) the flag RT_pull_out has not been activated. This value may be changed at any time during the flight profile.

RT_long: The distance (nautical miles) maintained by the tanker during phase one and three (see Figure 1). This value is measured from the first point that the heading error is less than one degree after coming out of the turn. If this value is set to zero, the aircraft will fly in a U-turn, fully skipping both long legs of the pattern. This value may be changed at any time during the flight profile.

RT_short: The distance (nautical miles) that the tanker will hold during phase two and four (see Figure 1). This value is measured from the first point that the heading error is less than one degree after coming out of the last turn. If this value is set to zero, the aircraft will fly in a U-turn, fully skipping both short legs of the pattern. This value may be changed at any time during the flight profile. If both RT_long and RT_short are set to zero, the aircraft will fly in a circle of constant bank angle with the phase numbers advancing as heading changes. Additionally, no test is performed on "RT_long" to determine if it is longer than "RT_short." Both values are independent of one another and should be non-negative.

RT_mach: The Mach number the system will try to hold if commanded to hold a set mach. This value may be changed at any time during the flight profile.

RT_vt: The speed (feet per second) that the system will try to hold if commanded to hold a set speed. This value may be changed at any time during the flight profile.

RT_bank: The bank angle (degrees) that the system will command the aircraft to hold during any turn. For right turns, this value should be positive and for left turns, this value should be negative. This value is limited to ± 30 degrees. The value may be changed at any time during the flight profile. However, if the aircraft is flying in a racetrack pattern, a sign change will cause the system to restart the pattern.

RT_psidot: The turn rate (degrees per second) that the system will command during any turn. This value is converted to a target bank angle using the current airspeed. For right turns, this value should be positive and for left turns, this value should be negative. This value is limited to ± 30 degrees. The value may be changed at any time during the flight profile. However, if the aircraft is flying in a racetrack pattern, a sign change will cause the system to restart the pattern.

Referring to Figure 1, at the start of the simulation, the racetrack pattern is initiated and the aircraft's current location is set to the location labeled "A." A phase system was deemed necessary to keep track of what the aircraft should be doing and what it should do next while in the racetrack pattern. Phase numbering is independent of turn direction or method. Additionally, the aircraft's current heading is set to ψ_1 and the parameters ψ_2 , ψ_3 and ψ_4 are determined automatically. The user may change the magnitude and method of the turns at any time. However changing the direction of the turn will cause the system to redefine both point "A" and the heading for the racetrack.

The simulation can fly the racetrack pattern with a completely arbitrary heading for ψ_1 . Phase one is the default starting phase and the phase number steps along according to the distances set by the user. The user may override and force the simulation to switch to the next phase at any time and thus cause the aircraft to start turning immediately.

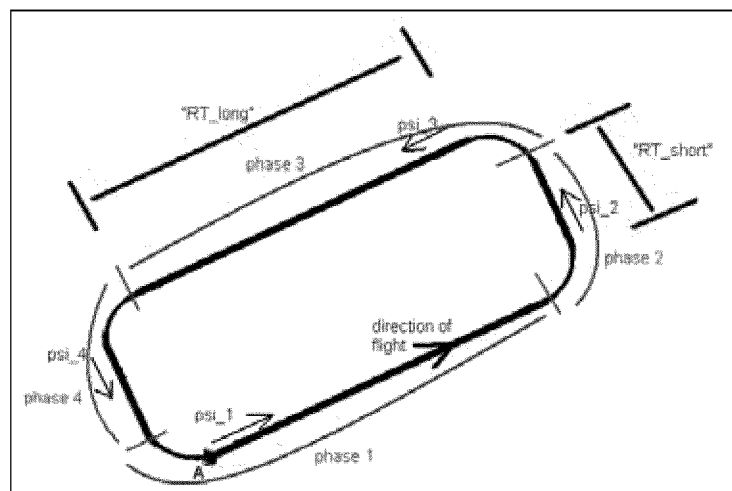


Figure 1 – Racetrack pattern and corresponding parameters

In addition to the racetrack parameters, six input flags are utilized for determining system behavior:

RT_turn_now: Setting this value to 1 while the aircraft is in the racetrack pattern will cause the system to advance to the next phase of the pattern. This flag suppresses the distance requirement and will return to zero automatically.

RT_do_what: This value controls the system objectives. It has five settings that may be selected using the keyboard or other means of setting simulation variables. Changing this value will cause the system to exit the current objective. Valid settings are the following:

0: Human controlled flight. The system directly passes joystick commands to the aircraft control surfaces and the throttle is under human control.

1: Racetrack pattern.

2: Acquire heading. This will cause the aircraft to fly to the heading supplied in "RT_heading."

3: Hold heading. This will command the aircraft to hold the heading that is currently being flown. This is accomplished by over writing "RT_heading" with the current heading and switching to system 2.

4: Circle indefinitely. This will cause the aircraft to fly in a circle until "RT_do_what" is changed. This flag should not be used to command the aircraft to circle while in the racetrack pattern as this will cause the system to exit the racetrack subsystem.

RT_circle_now: While in the racetrack pattern, a value of one will cause the aircraft to complete one full 360 degree circle and then reestablish the pre-circle heading to continue in the racetrack pattern. This flag should not be set during a turn. No phase change will occur during the circle. This flag will return to zero automatically.

RT_pull_out: This flag can be used to simulate an emergency situation in which the aircraft must rapidly gain altitude. A value of one will suppress the altitude hold system. The aircraft will apply full throttle and will pitch up to gain altitude. This flag does not suppress lateral or directional control while in the racetrack pattern. Phase and heading changes will occur as normally determined. This flag may be used only when in the racetrack subsystem.

RT_how_speed: When this value is set to 1, the system will control the thrust to track the mach set in "RT_mach." When this value is set to 2, the system will control the thrust to track the speed set in "RT_speed."

RT_how_turn: When this value is set to 1, the system will turn to the bank angle set in “RT_bank.” When this value is set to 2, the system will turn at the heading rate set in “RT_psidot.”

The aircraft is controlled by manipulating thrust, longitudinal stick, lateral stick, and rudder pedal position. The stick, throttle, and rudder commands are directly applied to the aircraft plant as actuator deflections. Also, in addition to the standard set of simulation output variables, a number of additional parameters specific to the racetrack maneuvering system and its other modes are also output from the simulation:

psi_1, psi_2, psi_3, psi_4: These values correspond to the headings (degrees) along the four sides of the racetrack pattern. They are limited to the range of ± 180 degrees.

psi_error: This value represents the angular error (degrees) from the current heading to the heading the system is working to reach and hold. This variable is limited to ± 180 degrees.

Leg_distance: The distance (nautical miles) flown along the leg during the current phase. The starting point for this distance is set when the heading error becomes less than one degree.

phase: This flag identifies the phase of the racetrack currently being flown by the system.



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28 December 2006

MEMORANDUM FOR: Defense Technical Information Center/OMI
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