Legacy Flight Performance Testing

30 July 2019

Version 1.5

645 Colonel Glenn Blvd

Dayton, Ohio

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Contents

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1. Introduction

The Nomad system is based heavily on the legacy Wanderer UAV system, to the extent that all relevant flight performance characteristics are identical to the previous variant. A key part of XYZ's competitive offering is the fact that no major flight performance re-designs were required to adapt the basic Wanderer vehicle to meet the OTSS-E requirements. Because of this, XYZ was able to execute an expedited flight test program using the previous Wanderer flight test article (known as Wanderer Baseline, or Wanderer-01). This article was designed with the ability to ballast as needed to emulate the various Wanderer configurations. The anticipated Nomad configurations fall within the range of existing Wanderer variants, and as such has been extensively tested. To confirm this, XYZ performed a limited series of tests to confirm the flight performance with the exact design parameters of the final Nomad configuration. These tests were conducted over 3 days (10-12 July 2019) using a legacy ground station.

2. Flight Performance

2.1. Test 01-01

Test 01-01 was designed to test the basic flight performance capability of the Nomad configuration. Test 01-01 consisted of 3 test points; maximum airspeed, maximum altitude and time to climb. Test 01-01 was conducted on 10 July 2019 in Dayton, Ohio. All testing was conducted within line of site of the operator.

TEST 01-01 METADATA	
DATE	10 July 2019
LOCATION	Dayton, Ohio
ALTITUDE	900 ft MSL
CONFIGURATION	Wanderer-01-01
WEIGHT	27.5 lbs
XCG	0.75 in
YCG	0.15 in
ZCG	1.20 in

2.1.1. Maximum Airspeed

The first test point of Test 01-01 tested the maximum airspeed of the system. The test was conducted by flying forward (in relation to the drone) at maximum speed.

TEST 01-01-01	
TIME	1400L
TEMPERATURE	78 deg F
WINDSPEED	0 knots
MAXIMUM AIRSPEED	32.15 mph

2.1.2. Maximum Altitude

Test point 01-01-02 tested the maximum altitude that the system could attain. The test was executed by climbing at a consistent power setting until the vertical velocity reached zero, then increasing power. Testing continued until zero velocity was achieved while using maximum thrust. The vehicle then maintained this altitude for 5 seconds before making a controlled descent.

TEST 01-01-02	
TIME	1500L
TEMPERATURE	81 deg F
WINDSPEED	0 knots
MAXIMUM ALTITUDE	1500 ft MSL

2.1.3. Time to Climb

Test point 01-01-03 tested how fast the vehicle could climb to 100 ft AGL. To accomplish this, the vehicle was powered on at 0 altitude and the maximum power was applied until the vehicle reached 100 ft AGL.

TEST 01-01-03	
TIME	1600L
TEMPERATURE	75 deg F
WINDSPEED	0 knots
INITIAL ALTITUDE	900 ft MSL
FINAL ALTITUDE	1000 ft MSL
ELAPSED TIME	18 seconds

2.2. Test 01-02

Test 01-02 tested the systems endurance. Testing was completed within line of system of the ground station by flying the vehicle in a circle until the system battery reached 2% (minimum safe landing condition). Testing was conducted by flying at 125 feet AGL.

TEST 01-02 METADATA	
DATE	11 July 2019
LOCATION	Dayton, Ohio
ALTITUDE	900 ft MSL
CONFIGURATION	Wanderer-01-01
WEIGHT	27.5 lbs
XCG	0.75 in
YCG	0.15 in
ZCG	1.20 in

TEST 01-02-01	
TIME	1000L

TEMPERATURE	65 deg F
MISSION ENDURANCE	23 minutes

2.3. Test 01-03

Test 01-03 tested the control capability of the vehicle. Testing was conducted using a legacy ground station; however, the control messages and control link were identical to the final Nomad configuration. All testing was conducted within line of site of the operator.

TEST 01-03 METADATA	
DATE	11 July 2019
LOCATION	Dayton, Ohio
ALTITUDE	900 ft MSL
CONFIGURATION	Wanderer-01-01
WEIGHT	27.5 lbs
XCG	0.75 in
YCG	0.15 in
ZCG	1.20 in

During Test 01-03, the control capability of the vehicle was demonstrated. For lateral speed control, the system has to different operational modes: (1) direct control of thrust vector, and (2) speed hold mode. In direct control mode, the user manipulates the control stick, and the angle and magnitude of lateral thrust is updated. As this happens, the vehicle automatically maintains the selected flight path angle, adjusting the angle of attack as needed. Assuming pitch and roll inputs are neutral (0 degrees commanded), the flight path angle will be 0 and the vehicle will maintain a constant altitude. In speed hold mode, the user selects the lateral speed using the control stick, and the presses the speed hold button. The vehicle will then maintain the selected speed and flight path angle, adjust thrust, roll and pitch as needed.

To control roll and pitch, the user manually controlled the vehicle flight path angle. As the control stick moved further from neutral, the vehicle increased the target flight path angle up to a maximum of 45 degrees at maximum control deflection. Roll and pitch rate were determined by two factors: (1) speed the stick changed position, and (2) control limits built into the software. When the stick was released, the vehicle returned to steady level flight. Yaw control behaved differently: the yaw controls commanded yaw rate, rather than angle. As the control triggers were depressed, the yaw rate increased up to a maximum of 20 degrees per second. If both triggers were depressed simultaneously, then the resulting yaw rate equaled the difference between the two commands, down to 0 degrees per second if both were depressed equally. When the controls were released, the yaw rate returned to zero, enabling movement along a consistent heading without yaw input.

3. Control Communications

3.1. Test 02-01

Test 01-03 was design to test the control communications system, including the operational range and the lost link capability.

TEST 02-01 METADATA	
DATE	11 July 2019
LOCATION	Springfield, Ohio
ALTITUDE	900 ft MSL
CONFIGURATION	Wanderer-01-01
WEIGHT	27.5 lbs
XCG	0.75 in
YCG	0.15 in
ZCG	1.20 in

3.1.1. Control Link Operational Range

Test point 02-01-01 was designed to test the control link operational range. To accomplish this, testing was moved to Springfield, Ohio where additional range space was available. Testing consisted of flying the vehicle directly away from the ground station at a constant speed and altitude (300 feet AGL). During this time, the vehicle moved outside of visual range of the ground station. Positive visual control was maintained by helicopter.

TEST 02-01-01	
TIME	1500L
TEMPERATURE	75 deg F
GROUND RANGE TO BASE STATION	12 miles

3.1.2. Lost Link Detection and Behavior

To test lost link detection, the vehicle was flown to 300 feet AGL and the control link was physically disabled at the ground station. Prior to takeoff, the battery was discharged to 15%, ensuring that the vehicle would remain on the test range if unanticipated behavior occurred. The vehicle remained within line of site during the entire test.

The tests showed that the vehicle successfully detected when the link was disabled, with a latency of 5 seconds. This delay was intentional to account for intermittent communications outages. Upon detection of link loss, the vehicle entered a stable hover at the target altitude. When link was re-enabled, the vehicle detected, authenticated and re-established full control. When the link remained in-operational, the vehicle maintained hover until battery life was calculated at less than 5 minutes, upon which the vehicle initiated a controlled descent.

4. Navigation

4.1. Test 03-01

Test 03-01 tested the basic navigation accuracy of the legacy Wanderer system.

TEST 03-01 METADATA	
DATE	12 July 2019
LOCATION	Dayton, Ohio
ALTITUDE	900 ft MSL
CONFIGURATION	Wanderer-01-01
WEIGHT	27.5 lbs
XCG	0.75 in
YCG	0.15 in
ZCG	1.20 in

4.1.1. Stationary Error

During testing, the legacy Wanderer navigation system showed less than expected performance, especially during stationary testing where the inertial navigation capability could not be effectively utilized. Testing was conducted by holding the vehicle steady at a constant altitude (300 ft AGL).

TEST 03-01-01	
TIME	1400L
TEMPERATURE	75 deg F
LATITUDE ERROR	11 ft
LONGITUDE ERROR	11 ft
ALTITUDE ERROR	15 ft
ABSOLUTE VELOCITY	0.1 ft/s

4.1.2. Moving Error

Test point 03-01-02 showed that combining the inertial capability with the GPS improved accuracy, but not enough to meet the originating requirements. Testing was conducted by moving at a constant velocity (2.5 ft/s) at a constant altitude (300 ft AGL).

TEST 03-01-02	
TIME	1500L
TEMPERATURE	75 deg F
LATITUDE ERROR	7 ft
LONGITUDE ERROR	7 ft
ALTITUDE ERROR	10 ft
ABSOLUTE VELOCITY	2.5 ft/s