

Manual Transition Flight Design Sketch

Taxonomy

FB: Feedback action. Output of **OrientationController** system.

FF: Feedforward action (i.e. open-loop). Output of **VTOLFeedForward** system, and the direct connection from **PX4RCtoOrientationThrust** to **ActuatVTOLPX4MAVLinkSystem** of lateral forward command.

RC-D: commanded directly through RC. Configured in PX4.

We refer to RC inputs as CH|x| with x being the channel number. Parameters HEAR-|A||x|, HEAR-|B||x|, etc. are tunable parameters in HEAR FC with x being optional parameter index, A and B are arbitrary captions to organize parameters set.

Parameters PX4-|A||x| are tunable parameters in PX4 with x being optional parameter index, and A is arbitrary caption to organize parameters set.

General

Let CH8 be the mode selection switch, pos 1 (low): VTOL mode; pos 2 (mid or high): plane mode. Safety: CH11 is kill switch Minimum M1 command must prevent ESC stall. Speed is obtained from pitot tube and GPS.

HEAR Tunable parameters

HEAR tunable parameters specific to VTOL setup are available in the directory:

~/HEAR_Configurations/Systems/VTOL

FWD_RANGE_ANGLE_RAD_EXTREMUM:

Location:

/RC_OrientationThrustControlSystemVTOL/ActuatVTOLPX4MAVLinkSystem/ActuationAllocatorVTOL

corresponding variable in code snippet : **extremum_angle**

```
if (vtol_mode==0){ // Multicopter
    _commands[0]=_commands[0] /cos(_u[4]*extremum_angle); // This assumes
    map_for_fwd range is -1 <-> 1
}
```

COMPENSATION_FACTOR_REAR:

Location:

/RC_OrientationThrustControlSystemVTOL/ActuatVTOLPX4MAVLinkSystem/ActuationAllocatorVTOL

atorVTOL

corresponding variable in code snippet : extremum_angle

```
if (vtol_mode==0){ // Multirotor
    _commands[1]=_commands[1] /cos(_u[4]*compensation_factor_rear); //
    This assumes map_for_fwd range is -1 <-> 1
    _commands[2]=_commands[2] /cos(_u[4]*compensation_factor_rear); //
    This assumes map_for_fwd range is -1 <-> 1
}
```

PITCH_CANARD_RANGE_MAX:

Location:

/RC_OrientationThrustControlSystemVTOL/VTOLFeedForward/gain_pitch_canard_range_max

```
auto gain_pitch_canard_range_max=new Gain<float>();
gain_pitch_canard_range_max->setGain(pitch_canard_range_max);

// Pitch
this->connect(demux_ori_des->getOutputPort<float>(Demux3::OP::Y),
gain_pitch_canard_range_max->getInputPort<float>());
this->connect(gain_pitch_canard_range_max->getOutputPort<float>(),
mux_angle_u->getInputPort<float>(Mux3::IP::Y));
```

YAW_CANARD_DIFF_RANGE_MAX:

Location:

/RC_OrientationThrustControlSystemVTOL/VTOLFeedForward/gain_yaw_canard_diff_range_max

```
auto gain_yaw_canard_diff_range_max=new Gain<float>();
gain_yaw_canard_diff_range_max->setGain(yaw_canard_diff_range_max);

// Yaw
this->connect(demux_ori_rate_des->getOutputPort<float>(Demux3::OP::Z),
gain_yaw_canard_diff_range_max->getInputPort<float>());
this->connect(gain_yaw_canard_diff_range_max->getOutputPort<float>(),
mux_angle_u->getInputPort<float>(Mux3::IP::Z));
```

YAW_FB_ANGLE_U_LIMIT:

Location: /RC_OrientationThrustControlSystemVTOL/yaw_fb_angle_u_limit

```
auto yaw_fb_angle_u_limit=new Saturation3();
auto yaw_fb_angle_u_limit_val=config_ctrl->getValueFromFile<float>
(config_ctrl->getSystemSettingsFilePath("VTOL"),"YAW_FB_ANGLE_U_LIMIT");
yaw_fb_angle_u_limit->setClipValueMaxThird(yaw_fb_angle_u_limit_val);
yaw_fb_angle_u_limit->setClipValueMinThird(-yaw_fb_angle_u_limit_val);
this->addBlock(yaw_fb_angle_u_limit,"yaw_fb_angle_u_limit");
```

PLANE_FRT_SERVO_TILT AND PLANE_VANES_CLOSED_TILT

Location:
/RC_OrientationThrustControlSystemVTOL/ActuatVTOLPX4MAVLinkSystem/ActuationAllocatorVTOL

```
_commands[5]=plane_vanes_closed_tilt;
_commands[6]=plane_vanes_closed_tilt;
_commands[7]=plane_frt_servo_tilt;
```

Physical Asset assignment

Reference	Function	Pixhawk Pin	Signal Source
M1	Front Motor	AUX 1	OFFBOARD MAVLink 1
M2	Rear Motor R	AUX 2	OFFBOARD MAVLink 2
M3	Rear Motor L	AUX 3	OFFBOARD MAVLink 3
S4	Canard L	AUX 4	OFFBOARD MAVLink 4
S5	Canard R	AUX 5	OFFBOARD MAVLink 5
S6	Vane R	AUX 6	OFFBOARD MAVLink 6
S7	Vane L	AUX 7	OFFBOARD MAVLink 7
S8	M1 Tilt Servo	AUX 8	OFFBOARD MAVLink 8
S9	Rudder R	MAIN 1	RC YAW
S10	Rudder L	MAIN 1	RC YAW
S11	Aileron R	MAIN 2	RC ROLL
S12	Aileron L	MAIN 2	RC ROLL
S13	Elevator R	MAIN 3	RC PITCH
S14	Elevator L	MAIN 4	RC PITCH
S15	Steering	MAIN 5	RC AUX 1
S16	Door RF	MAIN 6	RC AUX 2

Reference	Function	Pixhawk Pin	Signal Source
S17	Door RR	MAIN 6	RC AUX 2
S18	Door LF	MAIN 6	RC AUX 2
S19	Door LR	MAIN 6	RC AUX 2

Actuation PX4 settings

Maximum/Minimum limits for each actuator are set in the QGC. See QGC screenshots below.

Actuator Outputs

MODAL IO Output

PWM AUX

PWM MAIN

UAVCAN

AUX 1-4

PWM 400 Hz

	Function	Disarmed	Minimum	Maximum	Rev Range (for Servos)
AUX 1:	Motor 1	900	1000	2000	
AUX 2:	Motor 2	900	1000	2000	
AUX 3:	Motor 3	900	1000	2000	
AUX 4:	Motor 4	1480	1180	1780	

AUX 5-6

PWM 400 Hz

	Function	Disarmed	Minimum	Maximum	Rev Range (for Servos)
AUX 5:	Motor 5	1600	1270	1930	
AUX 6:	Motor 6	1450	730	1850	

AUX 7-8

PWM 400 Hz

	Function	Disarmed	Minimum	Maximum	Rev Range (for Servos)
AUX 7:	Motor 7	1550	850	1950	
AUX 8:	Motor 8	1160	1100	1820	

CAP 1

PWM 400 Hz

	Function	Disarmed	Minimum	Maximum	Rev Range (for Servos)
CAP 1:	Disabled	900	1000	2000	

4 / 7

Actuator Outputs

MODAL IO Output

PWM AUX

PWM MAIN

UAVCAN

MAIN 1-2

PWM 400 Hz

	Function	Disarmed	Minimum	Maximum	Rev Range (for Servos)
MAIN 1:	RC Yaw	1450	1150	1750	<input type="checkbox"/>
MAIN 2:	RC Roll	1400	1200	1600	<input type="checkbox"/>

MAIN 3-4

PWM 400 Hz

	Function	Disarmed	Minimum	Maximum	Rev Range (for Servos)
MAIN 3:	RC Pitch	1400	1100	1700	<input type="checkbox"/>
MAIN 4:	RC Pitch	1575	1275	1875	<input checked="" type="checkbox"/>

MAIN 5-8

PWM 400 Hz

	Function	Disarmed	Minimum	Maximum	Rev Range (for Servos)
MAIN 5:	RC AUX 1	1570	1270	1870	<input type="checkbox"/>
MAIN 6:	RC AUX 2	1500	1000	2000	<input type="checkbox"/>
MAIN 7:	Disabled	900	1000	2000	<input type="checkbox"/>
MAIN 8:	Disabled	900	1000	2000	<input type="checkbox"/>

RC PX4 settings

Radio Setup

Radio Setup is used to calibrate your transmitter. It also assigns channels for Roll, Pitch, Yaw and Throttle vehicle control as well as determining whether they are reversed.

Altitude Controls

Roll

Pitch

Yaw

Throttle

Skip

Cancel

Calibrate

Mode 1

Mode 2

Channel Monitor

Additional Radio setup:

Flaps channel

AUX2 Passthrough RC channel

PARAM2 tuning channel

Spektrum Bind

Copy Trims

Unassigned

AUX1 Passthrough RC channel

Channel 8

PARAM1 tuning channel

PARAM3 tuning channel

Channel 10

Channel 6

Channel 7

RC Channel assignment

See "Systems/RC/general.json" for updated HEAR configuration.

RC Channel	PX4 Assignment	Used in HEAR FC	Futaba T14SG Assignment
CH1	RC ROLL	Yes	J1
CH2	RC PITCH	Yes	J2
CH3	RC THROTTLE	Yes	J3
CH4	RC YAW	Yes	J4
CH5			
CH6		Yes (CH_number_for_forward_motion)	RS
CH7			
CH8	RC AUX 2	Yes (CH_number_for_switch_vtol_mode)	SA
CH9			
CH10	RC AUX 1		LD
CH11	Kill switch		SF
CH12			

VTOL Mode

- CH1: Throttle commanding M1, M2, M3 (FF). M1 is the frontal motor.
- CH2: Yaw commanding the vanes differentially (FB) (HEAR-YAW_VANES_RANGE_MAX), and canard differentials (FF) (HEAR-YAW_CANARD_DIFF_RANGE_MAX); rudder together (FF) (RC-D).
- CH3: Roll commanding M2 and M3 in a differentially (FB), AND ailerons differentially (FF) (RC-D).
- CH4: Pitch commanding M1 and (M2+M3) differentially (FB), elevators together (FF) (RC-D), canard together (FF) (HEAR-PITCH_CANARD_RANGE_MAX). Both elevators and canards are differential (PX4 settings).
- CH6: Forward lateral commanding vanes (FF) (range HEAR-FWD_RANGE_MIN - HEAR-FWD_RANGE_MAX | parametrized angles HEAR-FWD_RANGE_ANGLE_RAD_EXTREMUM), frontal servo (FF) (range HEAR-FWD_RANGE_MIN - HEAR-FWD_RANGE_MAX), and canard (canard phase leads frontal servo phase by a factor of HEAR-CANARD_FWD_SCALE >= 1) in the same direction . Frontal servo angle theta modifies M1 thrust by $M1=M1*/\cos(\theta)$.

Plane mode

- At the event of transition
- The frontal servo drives M1 to HEAR-PLANE_FRT_SERVO_TILT. The canard is also trimmed to HEAR-PLANE_FRT_SERVO_TILT.
- M2 and M3 are switched off.

Doors of M2 and M3 closed (RC-D).

Vanes closed HEAR-PLANE_VANES_CLOSED_TILT

Post-transition control

CH1: Throttle directly commanding M1. No front servo angle compensation.

CH2: Yaw commanding rudder together (FF) (RC-D).

CH3: Roll commanding ailerons differentially (FF) (RC-D).

CH4: Pitch commanding elevators together (FF) (RC-D), and canard together (FF) (HEAR-PITCH_CANARD_RANGE_MAX). Both elevators and canards are differential (PX4 settings).

Known Issues

RC inputs and servo outputs are not in SI units.

Proposed solution: prepare a calibration and trimming procedure based on manual angle measurements. Manually obtained angle measurements + angle specifications are input into `HEAR_Configurations`. A special subsystem in `RC_OrientationThrustControlSystemVTOL` picks up angle specifications and updates all `RC_OrientationThrustControlSystemVTOL` parameters accordingly.