Manual Transition Flight Design Sketch

Taxonomy

FB: Feedback action. Output of OrientaionController 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:

 $/ RC_Orientation Thrust Control System VTOL/Actuat VTOLPX4 MAVLink System/Actuation Allocator VTOL\\$

corresponding variable in code snippet: extremum angle

```
if (vtol_mode==0){ // Multirotor
    _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/ActuationAlloc

atorVT0L

corresponding variable in code snippet: extremum_angle

PITCH_CANARD_RANGE_MAX:

Location:

/RC_OrientationThrustControlSystemVTOL/VTOLFeedForward/gain_pitch_canard_range_m ax

```
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_rang e_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/ActuationAlloc atorVTOL

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

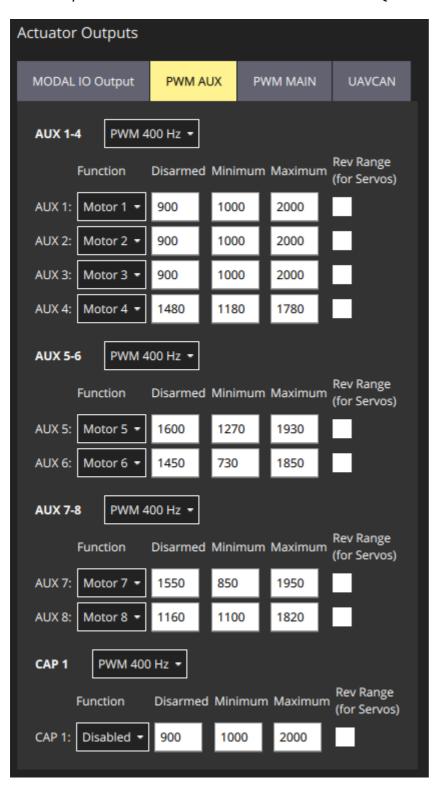
Physical Asset assignment

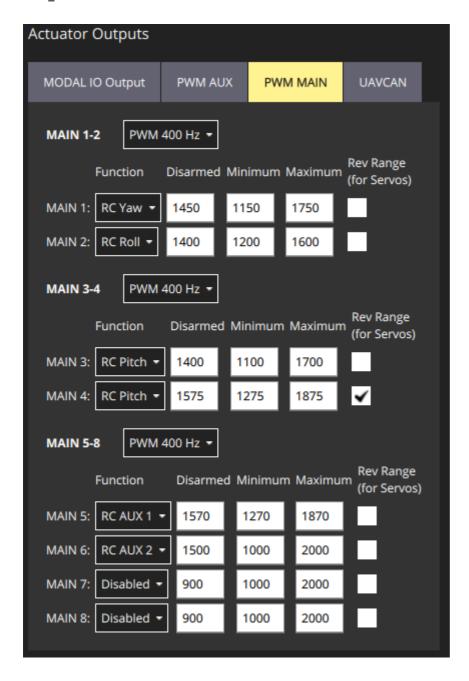
Reference	Function	Pixhawk Pin	Signal Source	
M1	Front Motor	AUX 1	OFFBOARD MAVLink 1	
M2	Rear Motor R	AUX 2	OFFBOARD MAVLink 2	
МЗ	Rear Motor L	AUX 3 OFFBOARD MAVLink 3		
S4	Canard L	AUX 4	OFFBOARD MAVLink 4	
S5	Canard R	AUX 5	OFFBOARD MAVLink 5	
S6	Vane R	AUX 6	OFFBOARD MAVLink 6	
S7	Vane L	AUX 7	OFFBOARD 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.





RC PX4 settings



RC Channel assignment

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

RC Channel	PX4 Assignment	Used in HEAR FC	Futaba T14SG Assignment
СН1	RC ROLL	Yes	J1
CH2	RC PITCH	Yes	J2
СНЗ	RC THROTTLE	Yes	J3
СН4	RC YAW	Yes	J4
СН5			
СН6		Yes (CH_number_for_forward_motion)	RS
СН7			
CH8	RC AUX 2	Yes (CH_number_for_switch_vtol_mode)	SA
СН9			
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).

 ${\tt Vanes\ closed\ HEAR-PLANE_VANES_CLOSED_TILT}$

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.