AMAZE Autonomy

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Description

The autonomy engine is responsible for the overall mission operation. After launching the node, the autonomy will prompt the user for a predefined mission sequence. After the user confirmed a selection, the autonomy engine sequences through four main states:

- Pre-Flight Checks
- Mission Operation
- Data Clean-Up
- Error Handling

Errors that might occur during these steps are reported to the user depending on the severity. If the autonomy and consecutive nodes can solve an error without external action, a warning is published to the terminal.

Pre-Flight Checks

Pre-Flight Checks concern all aspects that are necessary to perform a successful flight. This includes:

- Communication with the WatchDog node to clarify that all ROS nodes are running, driver status are correct, and sensors provide measurements based on their defined rate. If these conditions are not met and the WatchDog node can not solve the issue, external action is required.
- Checking sensor conditions e.g. the current distance measurement of the Laser Range Finder to determine that the vehicle is placed properly on the ground.
- Checking with the state estimator that the gravity vector points downwards in the vehicle frame. This should ensure that the angles at which the vehicle is placed are within limits for the takeoff.
- At the end, the autonomy displays the result of the checks and continues with the mission generation.

Mission Operation

The mission operation starts the data recording and ensures that sufficient time has passed before the takeoff.

After this step, the mission operation sends the mission ID to the Mission Planner, which builds the mission waypoint file and sends it to the controller. At this point, the takeoff is performed.

At the end of this state, the mission planner will respond and confirm that the vehicle has landed.

Data Clean Up

The autonomy triggers the end of the data recording which leads to a wait time till all data is written and was merged between the two embedded platforms. After this, the mission has ended, which will also be displayed to the user.

Error Handling

At any time after the Pre-Flight checks, the WatchDog node can communicate an error to the autonomy. The autonomy engine is responsible for triggering an action depending on the severity of the issue. As an example, a failure of the mission camera cant be tolerated and an emergency landing is triggered immediately. On the other side, a failure of the RealSense is not critical but inconvenient for data recording. Thus, the autonomy waits until the autonomy restarted the respective node and continues. However, if a maximum restart time of the node is reached and the error was not solved, the mission can be continued.

Error Cases and Decisions

PX4 Sensors

For the PX4, generally, no restart is allowed. Otherwise the vehicle will not be controlable.

Sensor	Action	Severity
GPS		low
IMU		highest
Magnetometer		moderate
Barometer		moderate

All other Sensors

Sensor	Action	Severity
Mission Camera	Emergency Landing	Highest
RealSense Camera	Wait for a limited time	Moderate
RealSense IMU	No Restart	Low
LSM9DS1 IMU	Wait for a limited time	Moderate
LRF	Wait for a limited time	High

Interaction with the WatchDog Node

To be redefined - Work in progress

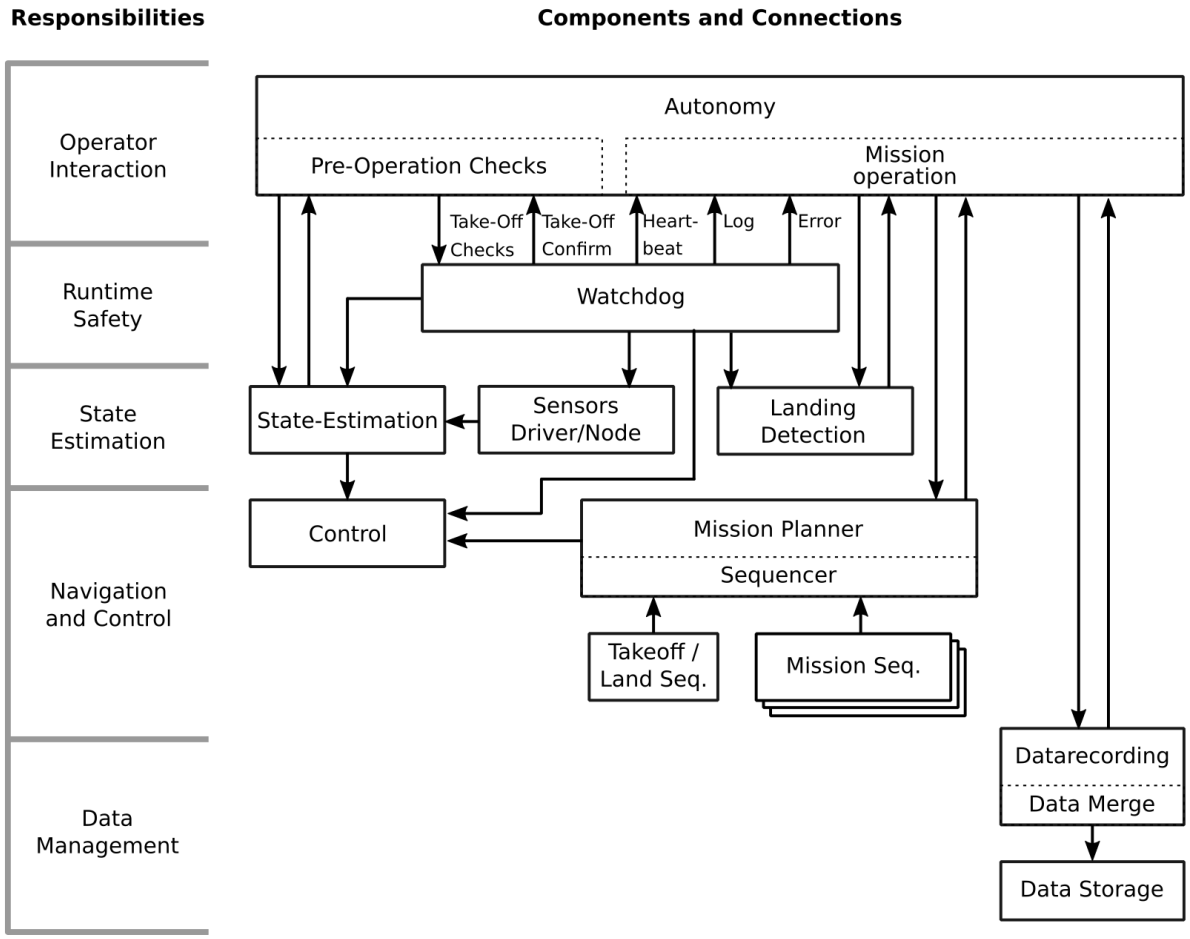
The safety node a.k.a. watchdog, only starts if the Autonomy publishes a service request to determine if the system is ready for take-off. After this, the safety node will open two streams; the action service information which will communicate the latest and highest issue of the system which will determine the most likely action of the autonomy engine, and a system info with all 'delta' sensor informations.

Possible states for the action and info streams, are:

Value	Description	Action	Info	Continue Mission
1	Nominal Condition		x	x
2	Non-Critical Failure		x	x
4	Inconvenient Failure	x	x	x
8	Severe Failure / Mission Hold	x	x	
16	Error / Mission Abort	x	x	

Nominal Failure	Description
Nominal Condition	The component is operating as intended
Non-Critical Failure	The component has failed but is not system critical OR a frame rate is not as intended
Inconvenient Failure	The component has failed and is not critical to the system but losing the data stream for recording is very inconvenient (e.g., the stereo camera).
Severe Failure / Mission Hold	A severe failure occurred, the safety node tries to restart the component, the mission should hold meanwhile.
Error / Mission Abort	A severe failure could not be resolved, the system needs to land immediately

System Block-Diagram



Autonomy Sequence

```
@startuml

skinparam monochrome true
scale max 1000*1000

'title Autonomy Routine

actor User
participant Autonomy
participant Watchdog

participant LandingDetection
participant StateEstimation
participant MissionPlanner
participant Control
participant Datarec
participant AutoPilot

User->Autonomy++: Select&Start Mission

Autonomy->Watchdog++: Vehicle in nominal condition?
Watchdog->Watchdog: All nodes & driver running?
Watchdog->Watchdog: Sensor meas. rate ok?
Watchdog->Autonomy--: Confirm
```

```
Autonomy->AutoPilot++: Check battery level
AutoPilot->Autonomy--: Confirm


Autonomy->LandingDetection++: Vehicle on ground?
LandingDetection->Autonomy--: Confirm

Autonomy->StateEstimation++: State valid?
StateEstimation->StateEstimation: Gravity pointing down?
StateEstimation->Autonomy--: Confirm

Autonomy->User: Display "Ready"

Autonomy->Datarec++: Start Rec.
Autonomy->MissionPlanner++: Send Mission ID
MissionPlanner->Autonomy: Confirm
MissionPlanner->MissionPlanner++: Run Sequencer
MissionPlanner->Control++: Send Waypoints
Control->MissionPlanner--: Got last Waypoint
MissionPlanner->MissionPlanner--: Confirm end of mission
MissionPlanner->Autonomy--: Confirm end of mission

Autonomy->Datarec: Stop Rec.
Datarec->Datarec++: Merge Data
Datarec->Datarec--: Done
Datarec->Autonomy--: Done

Autonomy->User--: Mission Ended

@enduml
```

Autonomy Activity Diagram

```
@startuml

skinparam monochrome true
scale max 1000*1000

'title Autonomy Activity

(*) -down-> "Mission Input"

if "Mission Valid" then
  -down->[true] "Watchdog Checks"

  if "Watchdog Checks Passed?"
    -right->[true] "Check Battery level"

    if "Level ok for next Mission?"
      -->[true] "Check LRF Data"

      if "Vehicle on the Ground?"
        -->[true] "Check State Estimation"

        if "Are States Valid?"
         -->[true] "Display ready to User"
        else
         -->[false] "Outreach"
        endif

      else
        -->[false] "Outreach"
      endif

    else
    -->[false] "Outreach"
    endif

  else
    -->[false] "Evaluate the Severity"
    if "Can WD fix the Issue?"
      -right->[true] "Watchdog Checks"
      else
      -->[false] "Outreach"
    endif
  endif

else
  ->[false] "Display Error"
  -up->"Mission Input"
endif

"Display ready to User"-->"Start Recording\n Mission Data"
-->"Send Mission ID\nto Mission Planner"
if "Mission Planner Confirm?"
  -->[True] "Send Takeoff Signal"
  --> "Wait for\nMission Completion"
```

```
  if "Mission Complete?"
    -->[True] "Stop and Merge\nData Recording"

    if "Data Complete"
      -->[True] "Display\nMission Completed"
    endif

  endif

else
  -->[False] "Outreach"
endif

@enduml
```