

Accelerated Marine Vehicle Autonomy,
Sensing, and Communications



May, 2017

Introduction to the IvP Helm

Web <http://oceanai.mit.edu/2.680>

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Henrik Schmidt henrik@mit.edu

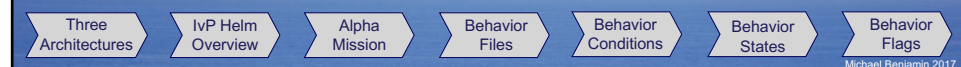
Accelerated Marine Autonomy – "Introduction to the IvP Helm"



Today's Material

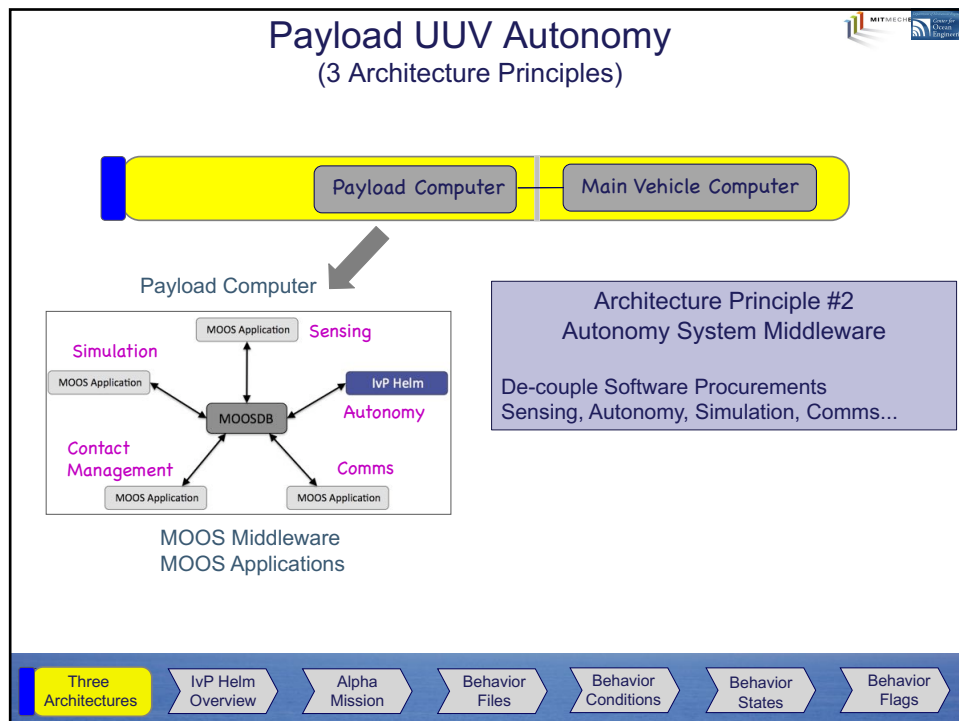
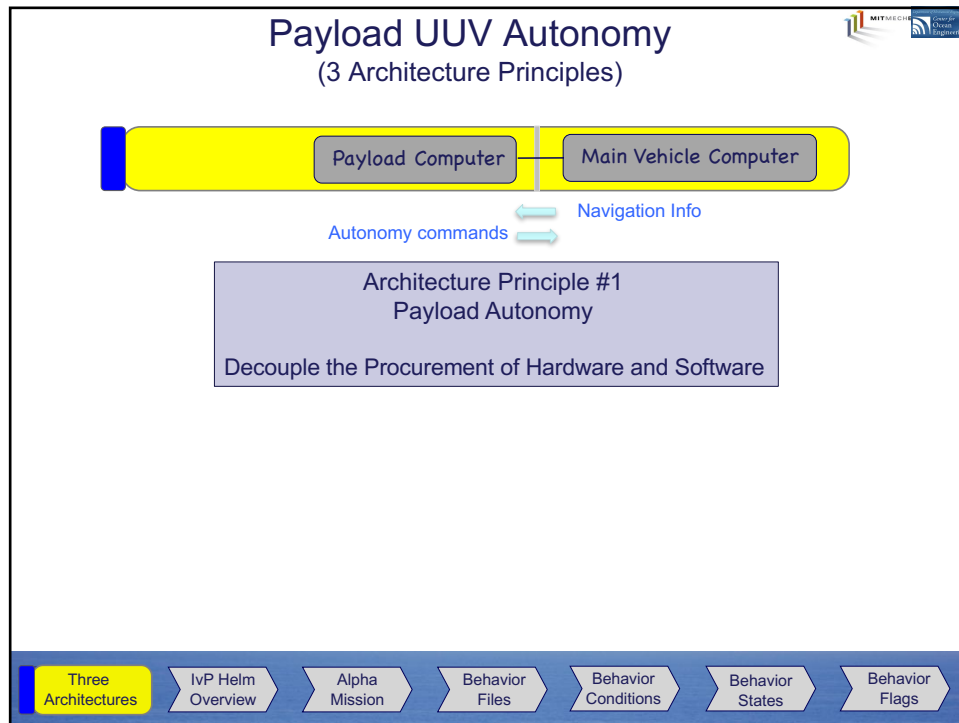
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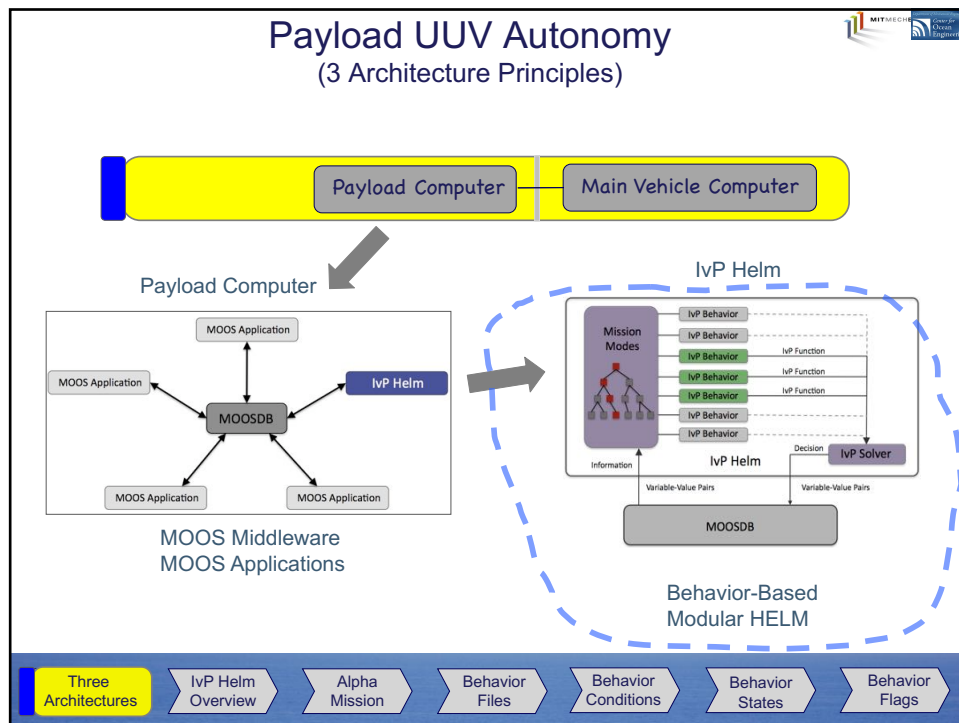
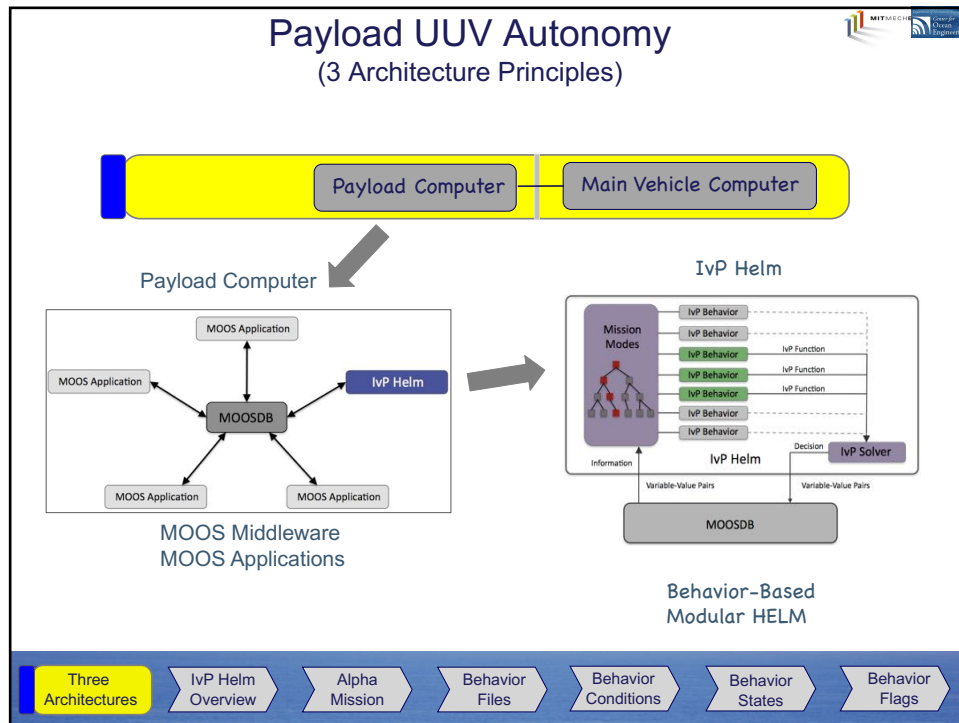
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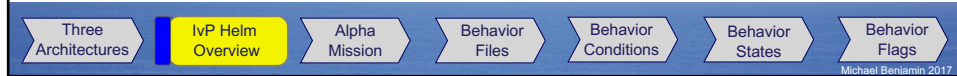
Three Architectures IvP Helm Overview Alpha Mission Behavior Files Behavior Conditions Behavior States Behavior Flags

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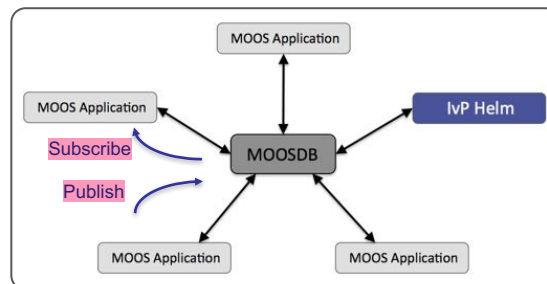


IvP Helm Overview

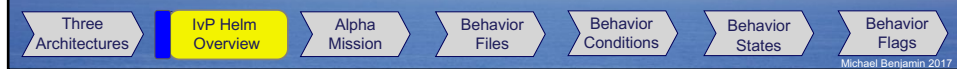


The IvP Helm

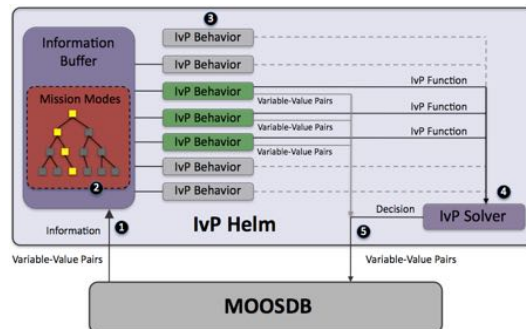
- The IvP Helm is a MOOS App, known as [pHelmIvP](#)
- The IvP Helm works with other MOOS Apps, performing sensor-processing, planning, communications.



A MOOS Community



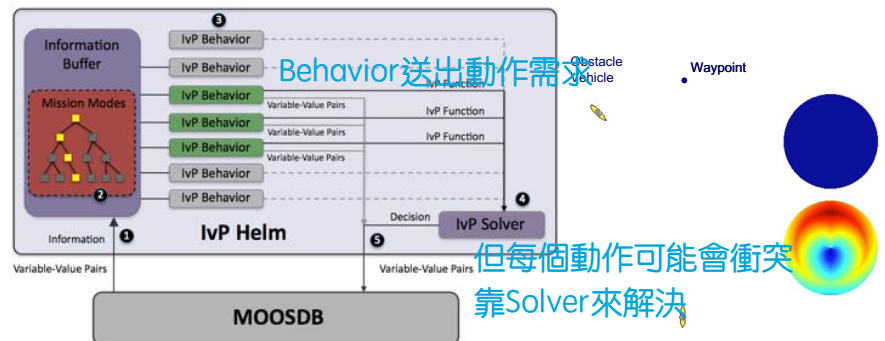
The IvP Helm Execution Loop



- ① Mail is read in the MOOS OnNewMail() function and applied to a local buffer.
- ② The helm mode is determined, and set of running behaviors determined.
- ③ Behaviors do their thing – posting MOOS variables and an IvP function.
- ④ Competing behaviors are resolved with the IvP solver.
- ⑤ The Helm decision and any behavior postings are published to the MOOSDB.

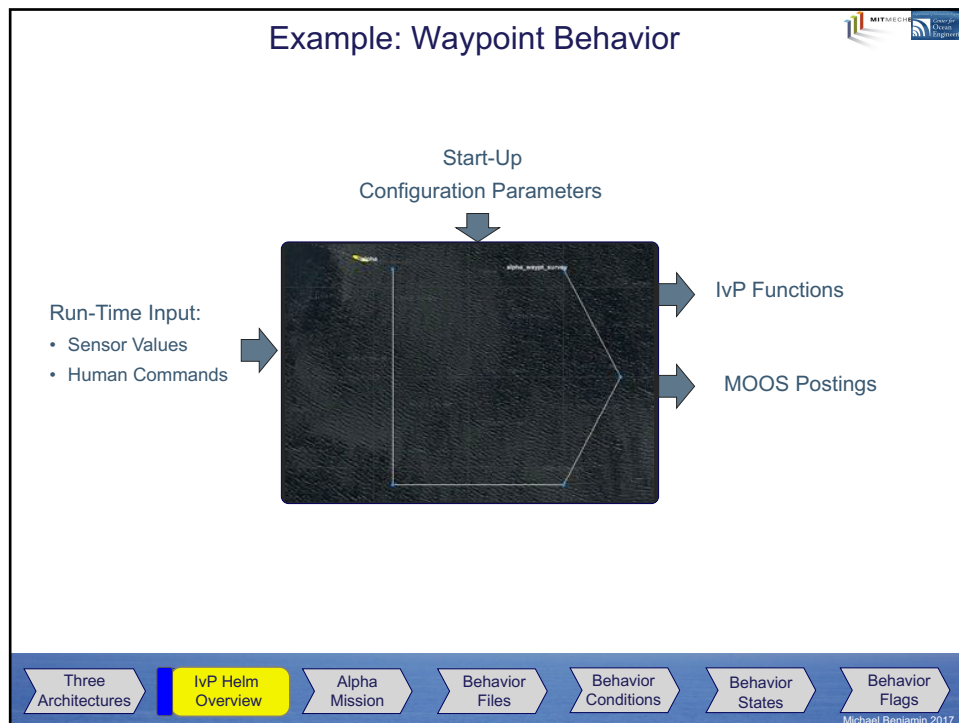
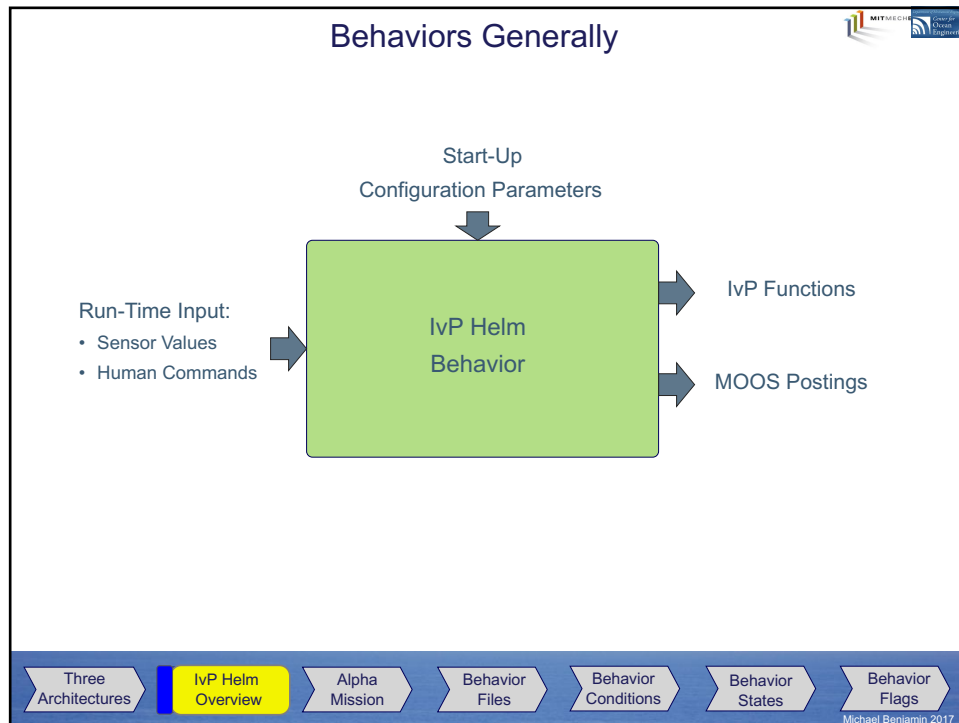
Three Architectures | **IvP Helm Overview** | Alpha Mission | Behavior Files | Behavior Conditions | Behavior States | Behavior Flags

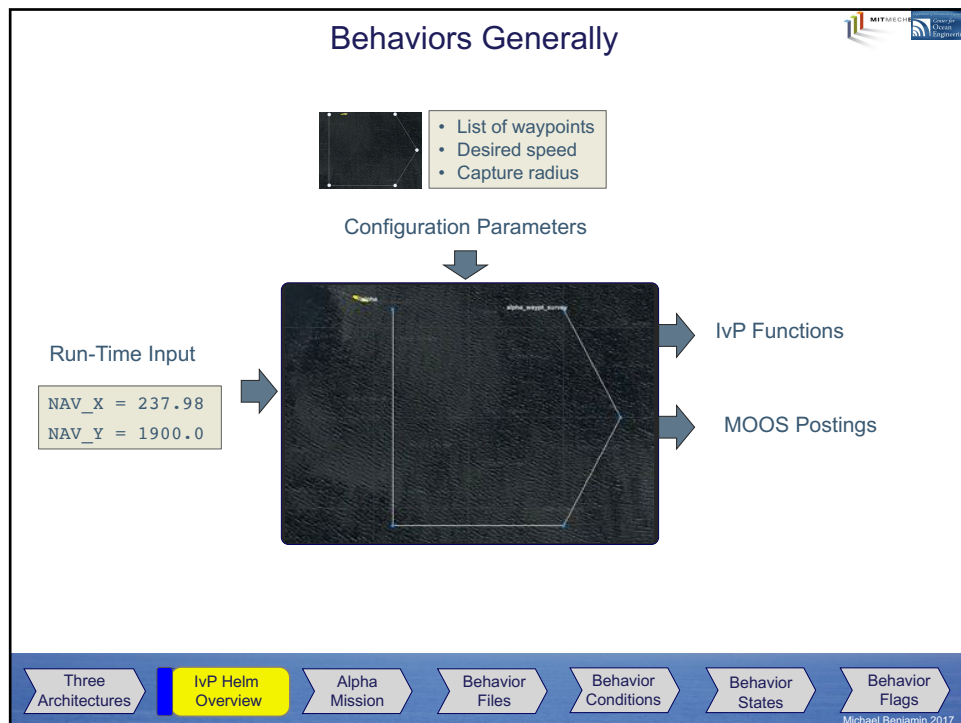
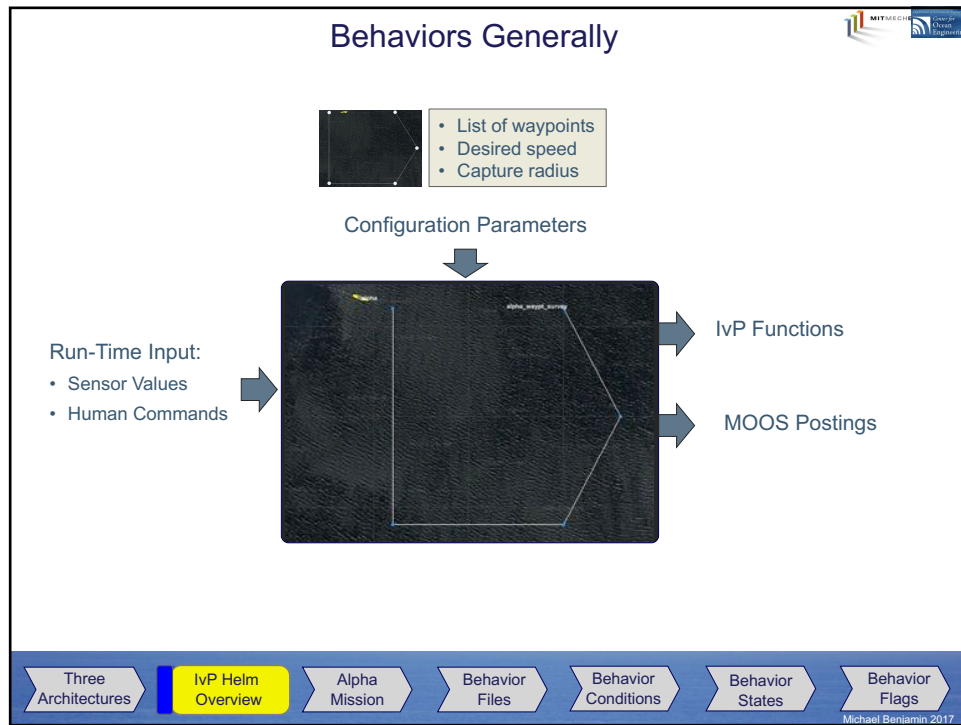
The IvP Helm Execution Loop

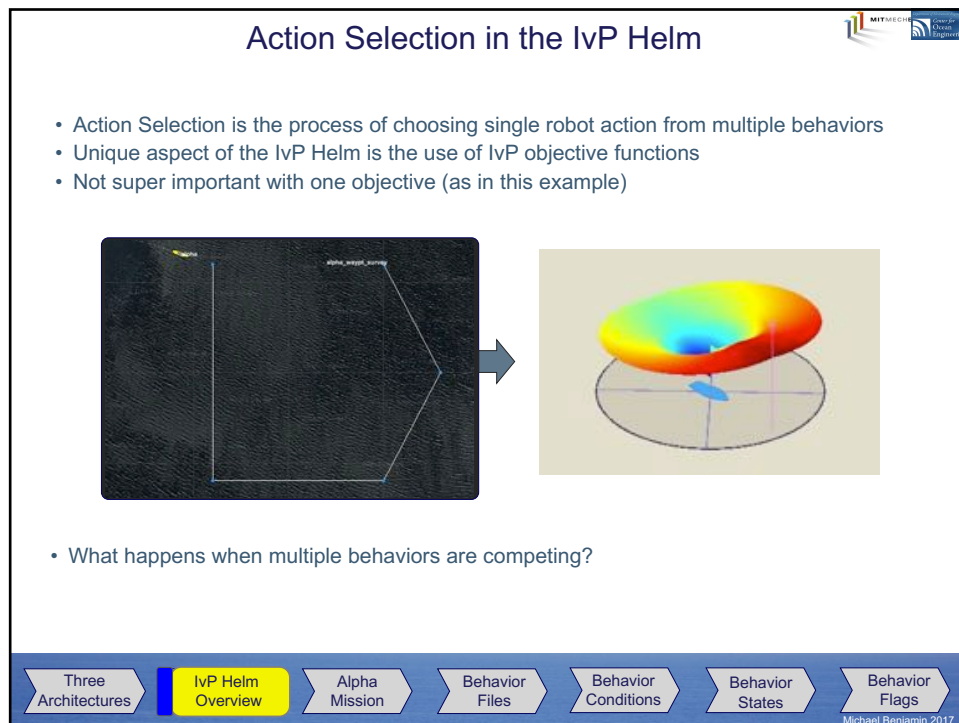
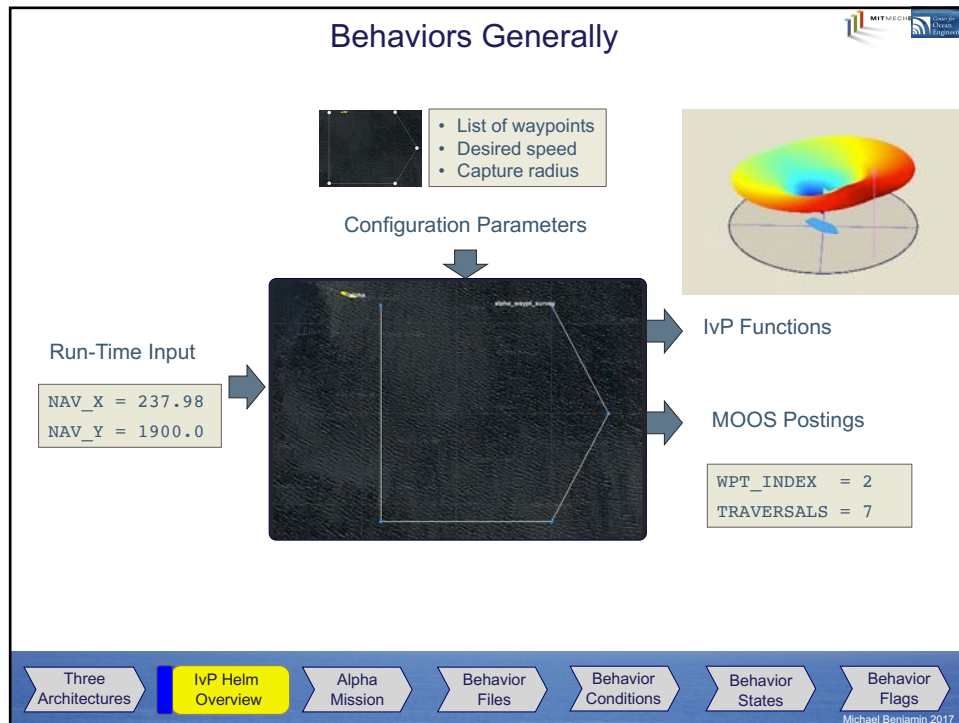


- ① Mail is read in the MOOS OnNewMail() function and applied to a local buffer.
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- ③ Behaviors do their thing – posting MOOS variables and an IvP function.
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Three Architectures | **IvP Helm Overview** | Alpha Mission | Behavior Files | Behavior Conditions | Behavior States | Behavior Flags



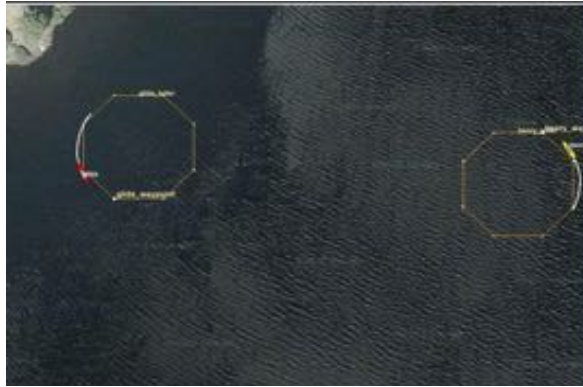




Competing Objective Functions



- An example of competing behaviors (1) Transiting and (2) Collision Avoidance



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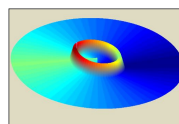
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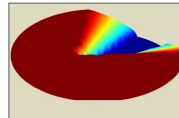
Competing Objective Functions



- Each vehicle is running two behaviors
- Each produces its own objective function



Transiting
Objective Function



Collision Avoidance
Objective Function

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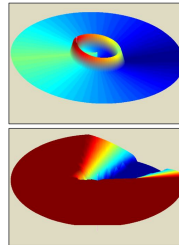
Behavior
Flags

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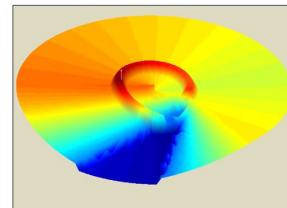
Competing Objective Functions



- Each vehicle is running two behaviors
- Each produces its own objective function



Individual
Objective Functions



Collective
Objective Function

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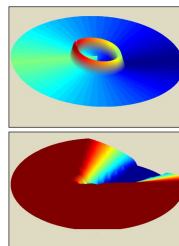
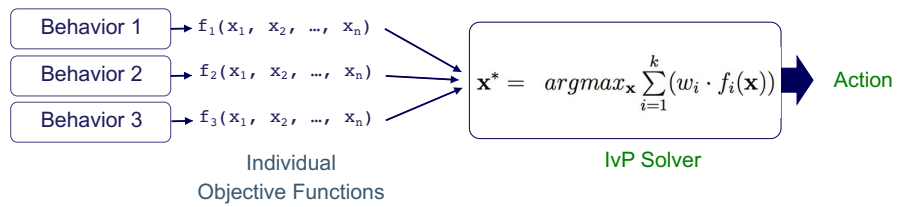
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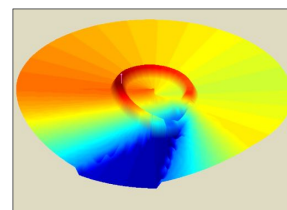
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Competing Objective Functions



Individual
Objective Functions



Collective
Objective Function

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Competing Objective Functions

Behavior 1 → $f_1(x_1, x_2, \dots, x_n)$

Behavior 2 → $f_2(x_1, x_2, \dots, x_n)$

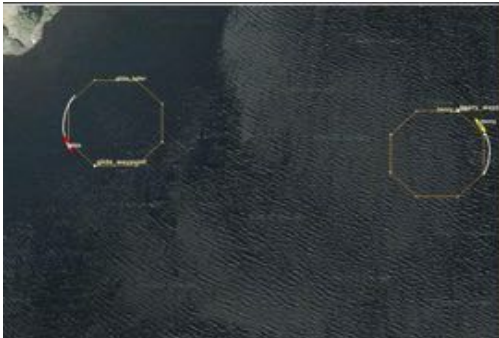
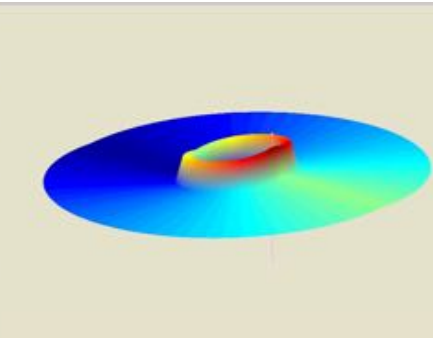
Behavior 3 → $f_3(x_1, x_2, \dots, x_n)$

Individual
Objective Functions

$$x^* = \underset{x}{\operatorname{argmax}} \sum_{i=1}^k (w_i \cdot f_i(x))$$

IvP Solver

→ Action

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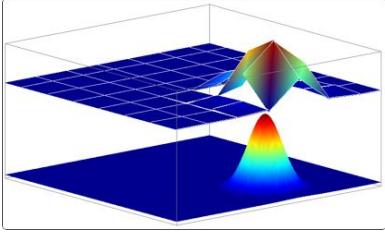
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Interval Programming

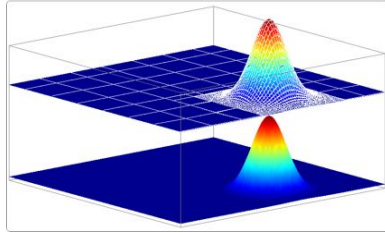
- IvP is Interval Programming
- It is a format for representing objective functions
- It is a solver that capitalizes on that format – fast, globally optimal

每一個方格都是linear func

IvP Functions are piecewise linear



Piece distribution need not be uniform



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近似

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The Alpha Mission

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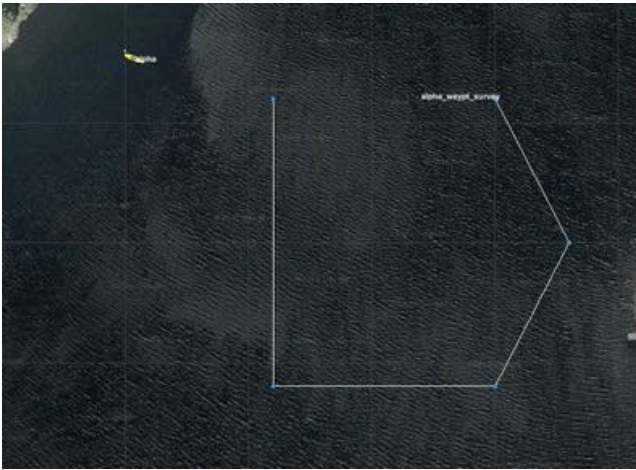
Behavior States

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The Alpha Mission



To launch yourself:

```
$ cd moos-ivp/ivp/missions/s1_alpha  
$ ./launch.sh 10
```

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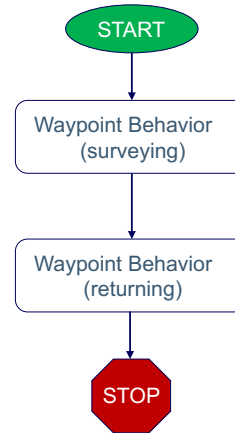
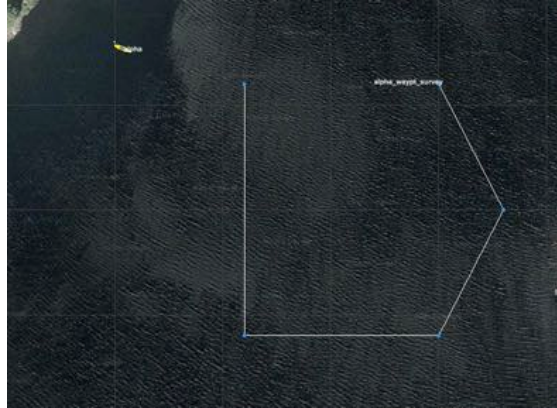
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Alpha Mission Has Two Behaviors



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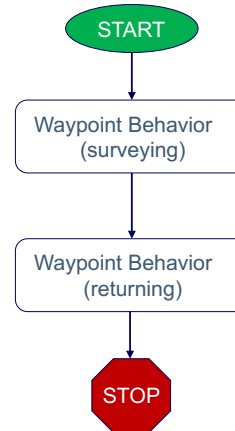
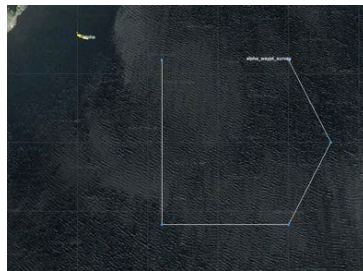
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Alpha Mission Has Two Behaviors



Three questions discussed next:

- How is this mission configured?
- What initiates this mission?
- How does the helm transition to return?

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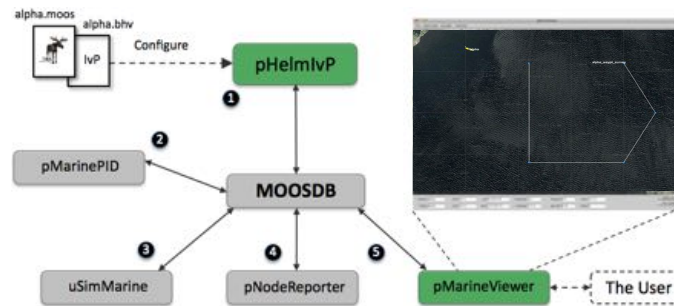
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Configuring the Helm for a Mission

A mission is configured with two files:

`alpha.moos` – configures all MOOS apps, including general helm parameters

`alpha.bhv` – configures all Helm behaviors



To launch yourself:

```
$ cd moos-ivp/ivp/missions/s1_alpha
$ ./launch.sh 10
```

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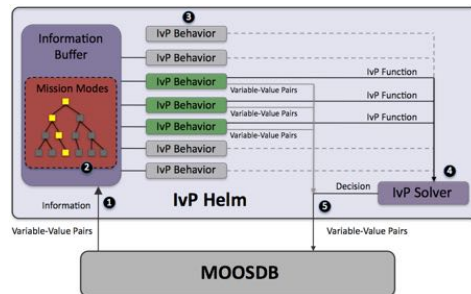
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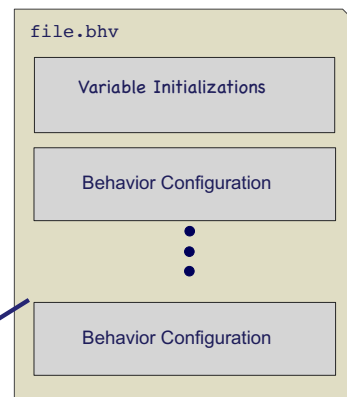
Behavior
Flags

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Behavior Files



Helm configuration file structure:



```
Behavior = <behavior_name>
{
  parameter = value
  ...
  parameter = value
}
```

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Alpha Mission Behavior File

```

initialize  DEPLOY = false
initialize  RETURN = false

Behavior = BHV_Waypoint
{
  name      = waypt_survey
  pwt       = 100
  condition = RETURN = false
  condition = DEPLOY = true
  endflag   = RETURN = true

  speed = 4
  capture_radius = 5.0
  slip_radius = 15.0
  polygon = 60,-40:60,-160:150,-160:180,-100:150,-40
  repeat = 1
}

Behavior = BHV_Waypoint
{
  name      = waypt_return
  pwt       = 100
  condition = RETURN = true
  condition = DEPLOY = true
  endflag   = DEPLOY = false

  speed = 2.0
  capture_radius = 2.0
  slip_radius = 8.0
  points = 0,-2
}

```

結束時會執行的

```

graph TD
    START([START]) --> Surveying[Waypoint Behavior (surveying)]
    Surveying --> Returning[Waypoint Behavior (returning)]
    Returning --> STOP{{STOP}}

```

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Helm Initial MOOSDB Pokes

alpha.bhv file

```

initialize  DEPLOY = false
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Behavior = BHV_Waypoint
{
  name      = waypt_survey
  pwt       = 100
  condition = RETURN = false
  condition = DEPLOY = true
  endflag   = RETURN = true

  speed = 4
  capture_radius = 5.0
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  polygon = 60,-40:60,-160:150,-160:180,-100:150,-40
  repeat = 1
}

Behavior = BHV_Waypoint
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  condition = DEPLOY = true
  endflag   = DEPLOY = false

  speed = 2.0
  capture_radius = 2.0
  slip_radius = 8.0
  point = 0,-2
}

```

When pHelmIVP launches,
it will write to the MOOSDB:

```

DEPLOY = false
RETURN = false

```

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Behavior Types vs. Names

alpha.bhv file

```

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  speed = 2.0
  capture_radius = 2.0
  slip_radius = 8.0
  point = 0,-2
}

```

Both behaviors are the same type.

Each behavior has a unique name.

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Waypoint Behavior Points

alpha.bhv file

```

initialize  DEPLOY = false
initialize  RETURN = false

Behavior = BHV_Waypoint
{
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  condition = RETURN = false
  condition = DEPLOY = true
  endflag   = RETURN = true

  speed = 4
  capture_radius = 5.0
  slip_radius = 15.0
  polygon = 60,-40:60,-160:150,-160:180,-100:150,-40
  repeat = 1
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  name      = waypt_return
  pwt       = 100
  condition = RETURN = true
  condition = DEPLOY = true
  endflag   = DEPLOY = false


  speed = 2.0
  capture_radius = 2.0
  slip_radius = 8.0
  point = 0,-2
}

```



The waypoint behavior accepts either:

- a polygon
- a single point

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Behavior Conditions



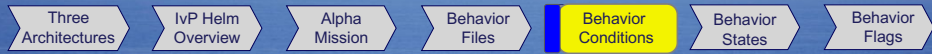
Behavior Conditions

- Each condition involves one or more MOOS variables
- A behavior may have more than one condition
- If multiple conditions, all conditions need to be satisfied.

Example:

```
condition = RETURN = false
condition = DEPLOY = true
```

- Both **RETURN** and **DEPLOY** are MOOS variables
- Both are of type string (not double)
- The condition is true if the current variable value matches the string



Behavior Conditions

- Each condition involves one or more MOOS variables
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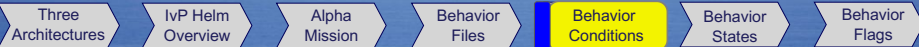
alpha.bhv file

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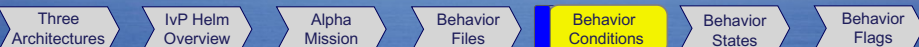
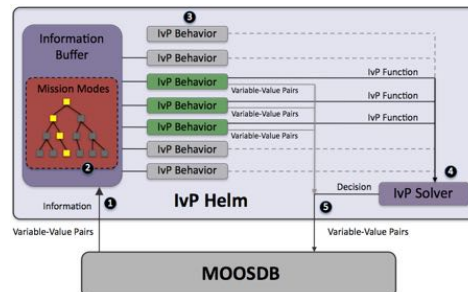
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  polygon = 60,-40:60,-160:150,-160:180,-100:150,-40
  repeat = 1
}
```

優先權數字小的營



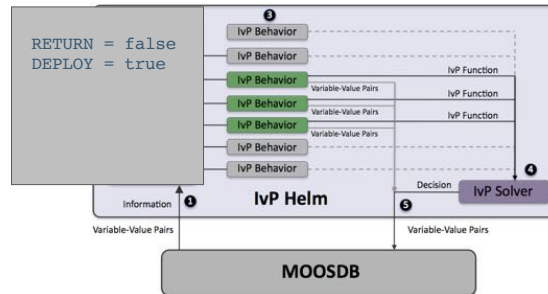
The Helm Information Buffer

- The helm maintains an information buffer, a cache of MOOS Variable Values
- It is updated by reading MOOS mail on each iterate loop
- Behavior Conditions are checked against this buffer



The Helm Information Buffer

- The helm maintains an information buffer, a cache of MOOS Variable Values
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Behavior Logic Conditions

Simple logic condition with one component

```
condition = RETURN = false
```

true if the MOOS variable **RETURN** has the string value "false"

```
condition = DEPLOY != true
```

true if the MOOS variable **DEPLOY** has a string value other than "true"

因為是string 要小心用not!

WARNING: this condition is fail if the MOOS variable **DEPLOY** has never been written to.

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Disjunctive (OR) Logic Conditions



A logic condition may have more than one component

```
condition = ((RETURN = false) or (DEPLOY != true))
```

True if

- the MOOS variable **RETURN** has the string value "false", **OR**
- the MOOS variable **DEPLOY** has a string value other than "true"

WARNING: this condition will fail if the MOOS variable **DEPLOY** has never been written to – even if the first component (RETURN = false) is true

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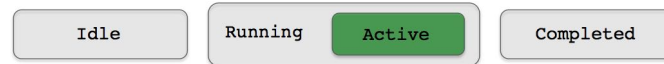
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Behaviors may be in one of four states:

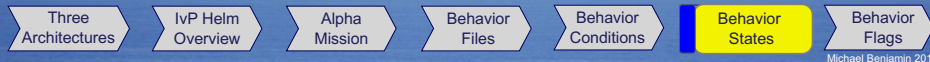


The **idle** state: a behavior has **not met** its **run condition**, as defined by the **condition** parameter.

The **running** state: a behavior has **met** its **run conditions**

The **active** state: a behavior is running state and is producing an objective function

The **completed** state: Completion is specific to a behavior, or may be due to a **duration** timeout defined generally for all behaviors.



Active vs. Running States



What's the difference between **running** and **active**?



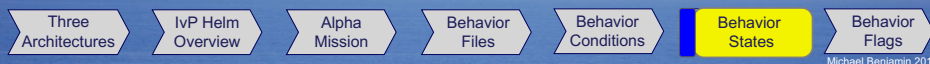
The **running** state: behavior has **met its run conditions**.

The **active** state: behavior is running and **producing an objective function**.

The helm's primary job is to produce a helm decision. A behavior is participating in that decision only if it is producing an objective function.


The choice to participate in the helm decision is made at two points:

- (1) The run conditions (mostly dependent on an external decision process)
- (2) The behavior's own logic (a local decision based on a more nuanced / domain-expert understanding of the situation).



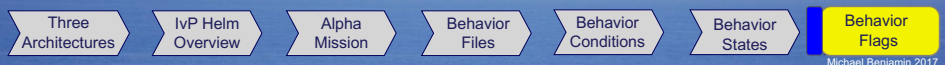


Behavior Flags



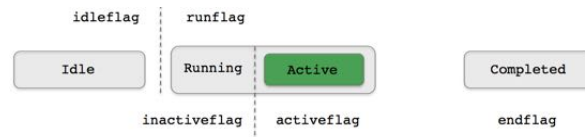
Behavior Flags

- Flags are MOOS Pokes triggered by behavior state
- They are mission configuration parameters (not behavior source code)
- They are critical tools for structuring a mission



Behavior Flags

- Flags are MOOS Pokes triggered by behavior state
- They are mission configuration parameters (not behavior source code)
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- endflag:** posted when the behavior **completes**.
- idleflag:** posted when the behavior is in the **idle** state.
- runflag:** posted when the behavior is in the **running** (or **active**) state.
- activeflag:** posted when the behavior is in the **active** state.
- inactiveflag:** posted when the behavior is **not** in the **active** state.
- activeflag:** posted when the behavior is in the **active** state.

End Flags

- End Flags are posted when a behavior completes
- An endflag may trigger the condition of another behavior
- Alpha mission as an example

```

Behavior = BHV_Waypoint
{
  name      = waypt_survey
  pwt       = 100
  condition = RETURN = false
  condition = DEPLOY = true
  endflag   = RETURN = true

  speed = 4
  capture_radius = 5.0
  slip_radius = 15.0
  polygon = 60,-40:60,-160:150,-160:180,-100:150,-40
  repeat = 1
}

```

結束時發出poke

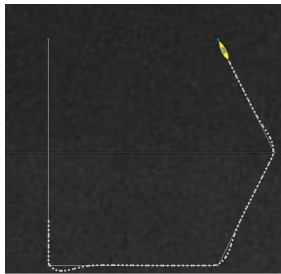
```

Behavior = BHV_Waypoint
{
  name      = waypt_return
  pwt       = 100
  condition = RETURN = true
  condition = DEPLOY = true
  endflag   = DEPLOY = false

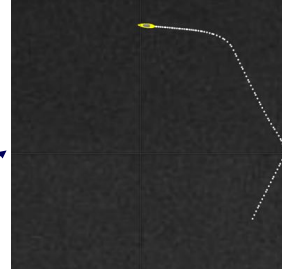
  speed = 2.0
  capture_radius = 2.0
  slip_radius = 8.0
  point = 0,-2
}

```

Alpha Mission End Flag Example



- ① survey waypoints completes
- ② endflags posted RETURN=true
- ③ return waypoint behavior begins



```
Behavior = BHV_Waypoint
{
  name      = waypt_survey
  pwt       = 100
  condition = RETURN = false
  condition = DEPLOY = true
  endflag   = RETURN = true

  speed      = 4
  capture_radius = 5.0
  slip_radius = 15.0
  polygon    = 60,-40:60,-160:150,-160:180,-100:150,-40
  repeat     = 1
}
```

把自己關了

```
Behavior = BHV_Waypoint
{
  name      = waypt_return
  pwt       = 100
  condition = RETURN = true
  condition = DEPLOY = true
  endflag   = DEPLOY = false

  speed      = 2.0
  capture_radius = 2.0
  slip_radius = 8.0
  point      = 0,-2
}
```

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END



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