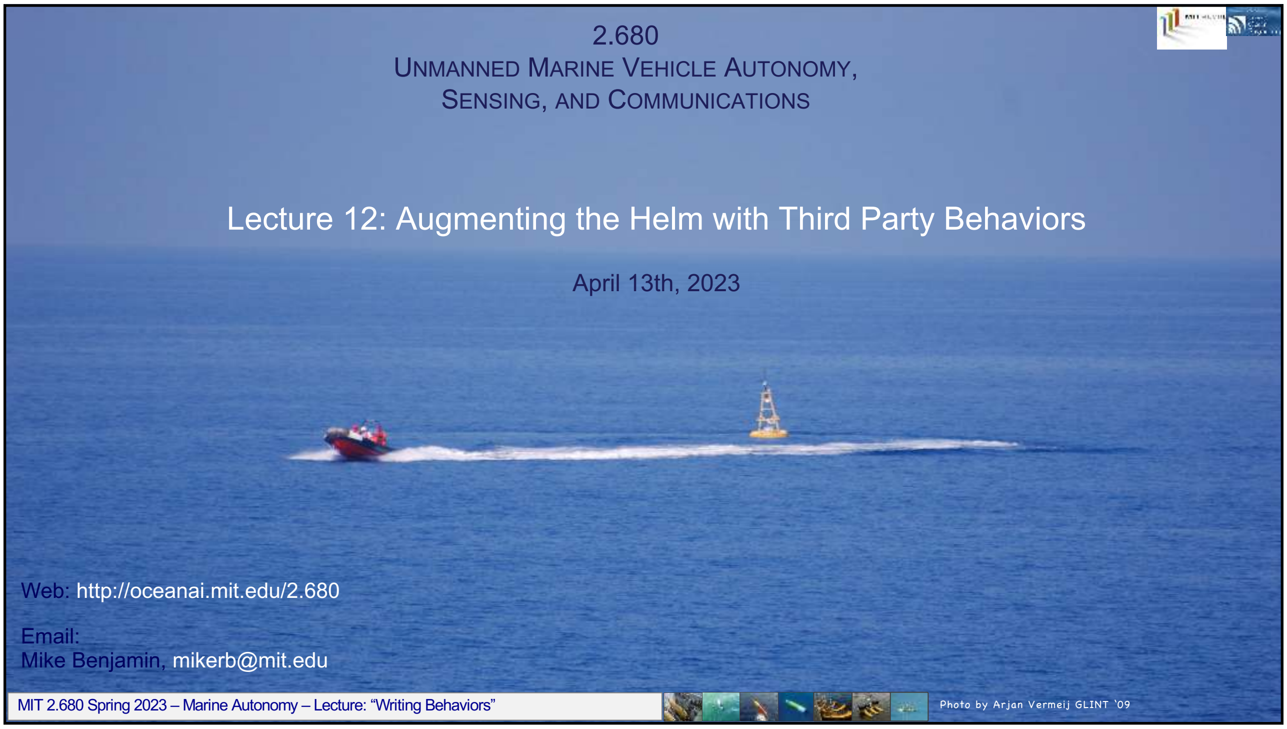

2.680

UNMANNED MARINE VEHICLE AUTONOMY,
SENSING, AND COMMUNICATIONS

Lecture 12: Augmenting the Helm with Third Party Behaviors

April 13th, 2023

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

Email:
Mike Benjamin, mikerb@mit.edu

MIT 2.680 Spring 2023 – Marine Autonomy – Lecture: "Writing Behaviors"

Photo by Arjan Vermeij GLINT '09

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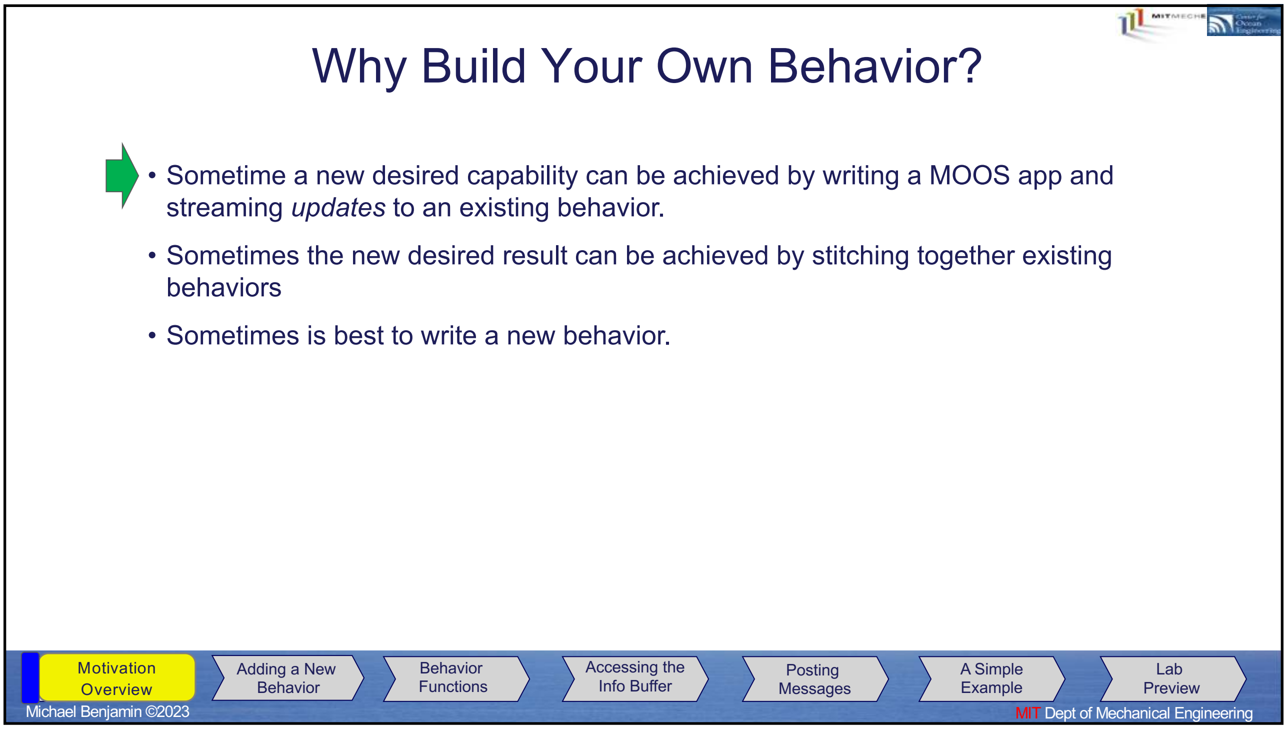

Why Build Your Own Behavior?

- Sometime a new desired capability can be achieved by writing a MOOS app and streaming *updates* to an existing behavior.
- Sometimes the new desired result can be achieved by stitching together existing behaviors
- Sometimes is best to write a new behavior.

Motivation Overview
Adding a New Behavior
Behavior Functions
Accessing the Info Buffer
Posting Messages
A Simple Example
Lab Preview

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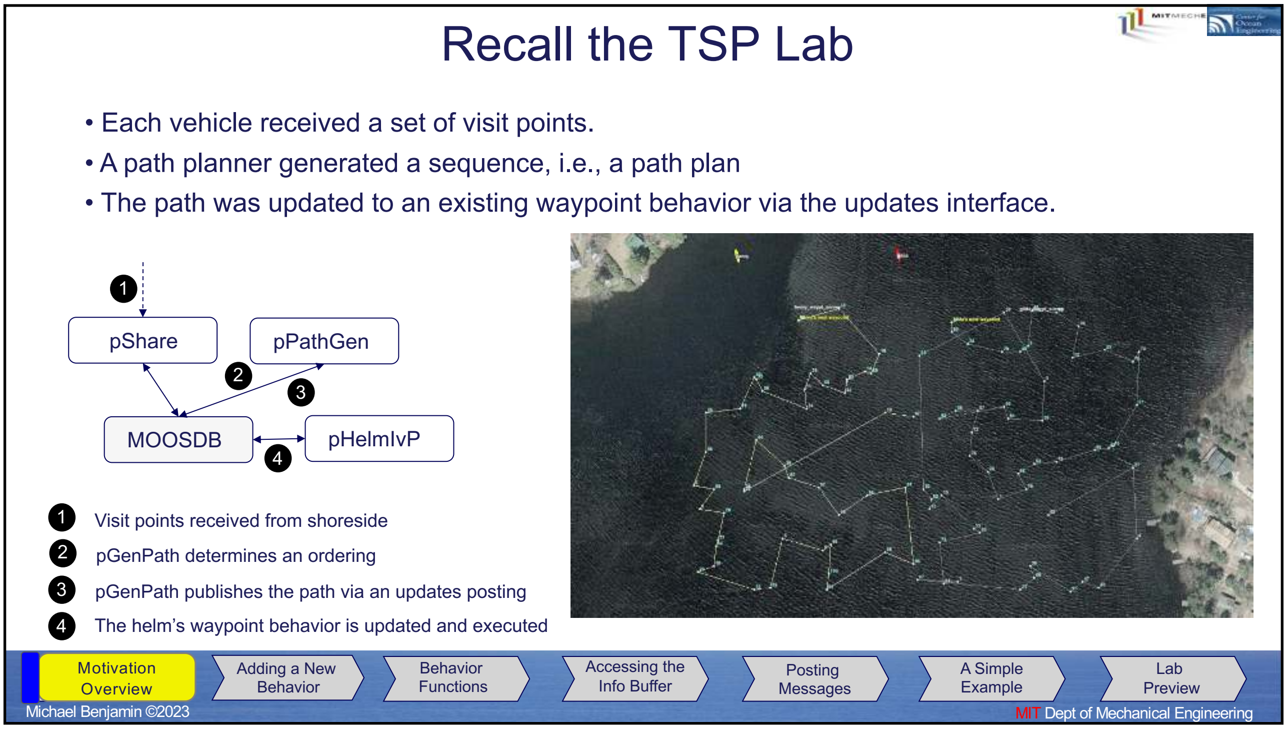


Recall the TSP Lab

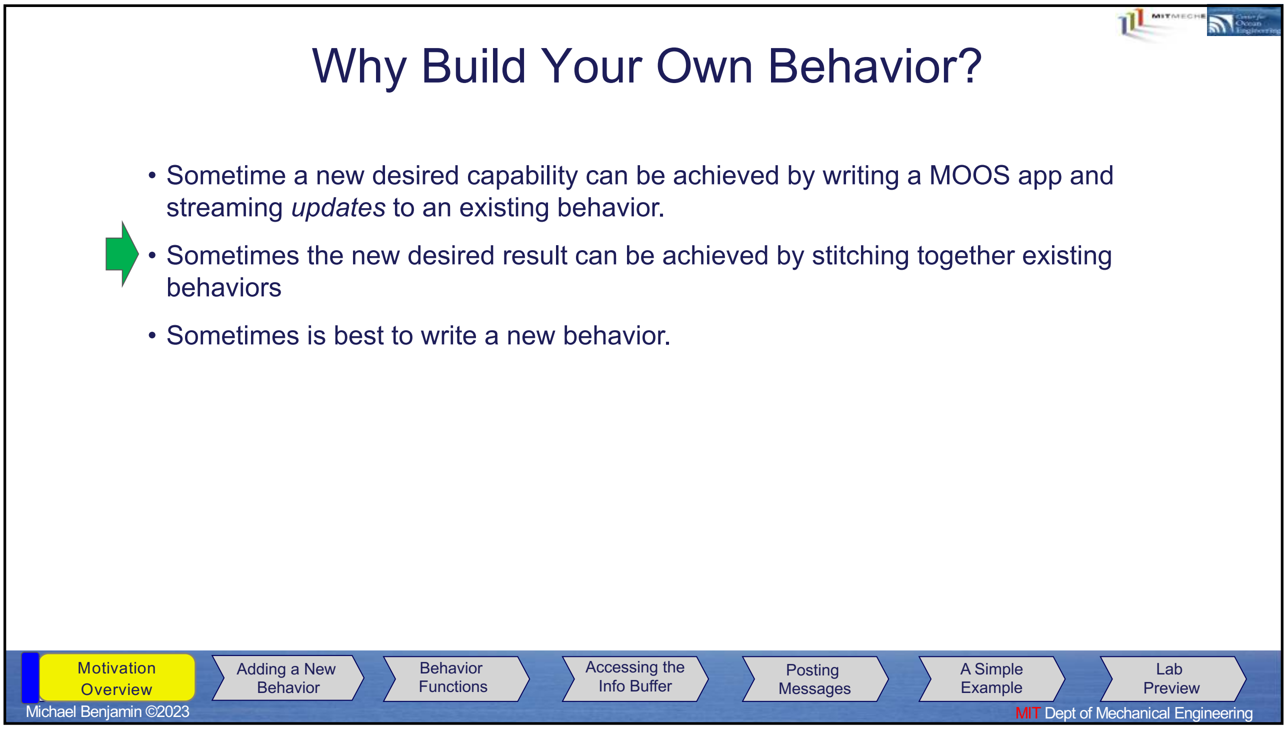
- Each vehicle received a set of visit points.
- A path planner generated a sequence, i.e., a path plan
- The path was updated to an existing waypoint behavior via the updates interface.

1 Visit points received from shoreside

2 pGenPath determines an ordering

3 pGenPath publishes the path via an updates posting

4 The helm's waypoint behavior is updated and executed



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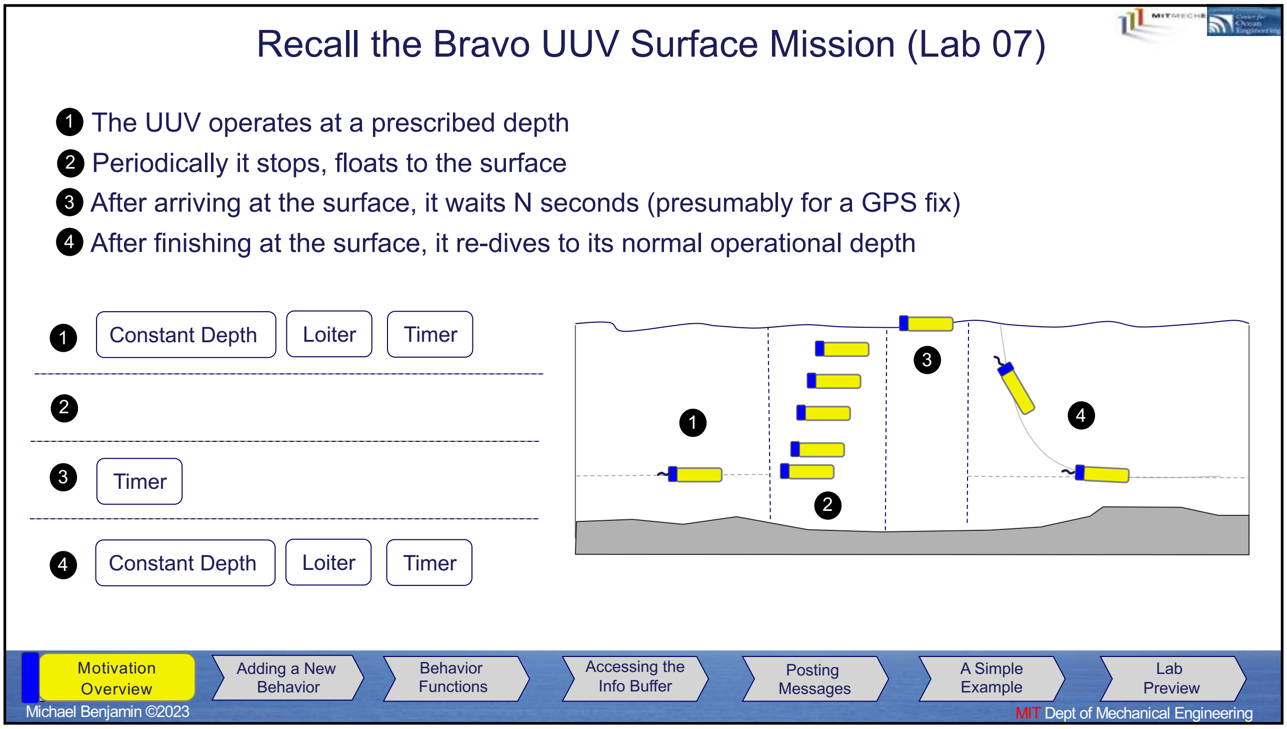


Recall the Bravo UUV Surface Mission (Lab 07)

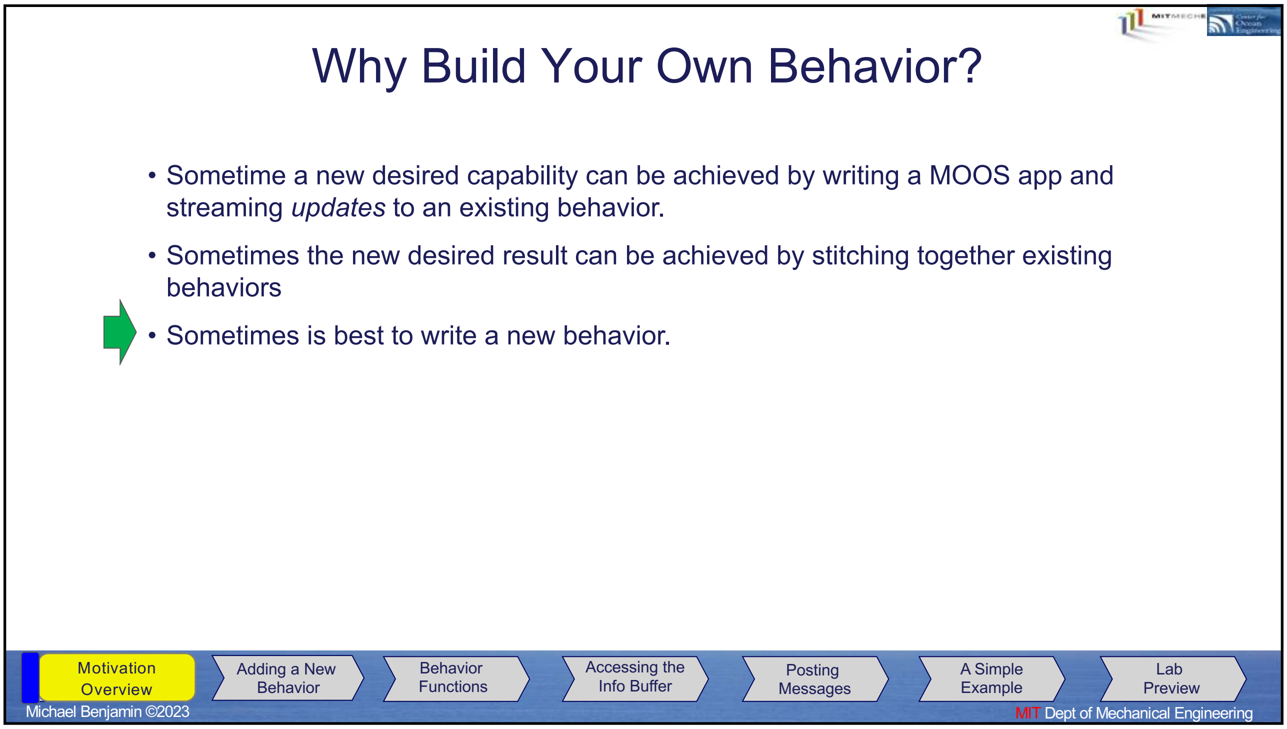
❶ The UUV operates at a prescribed depth
❷ Periodically it stops, floats to the surface
❸ After arriving at the surface, it waits N seconds (presumably for a GPS fix)
❹ After finishing at the surface, it re-dives to its normal operational depth

❶ Constant Depth | Loiter | Timer

❷

❸ Timer

❹ Constant Depth | Loiter | Timer



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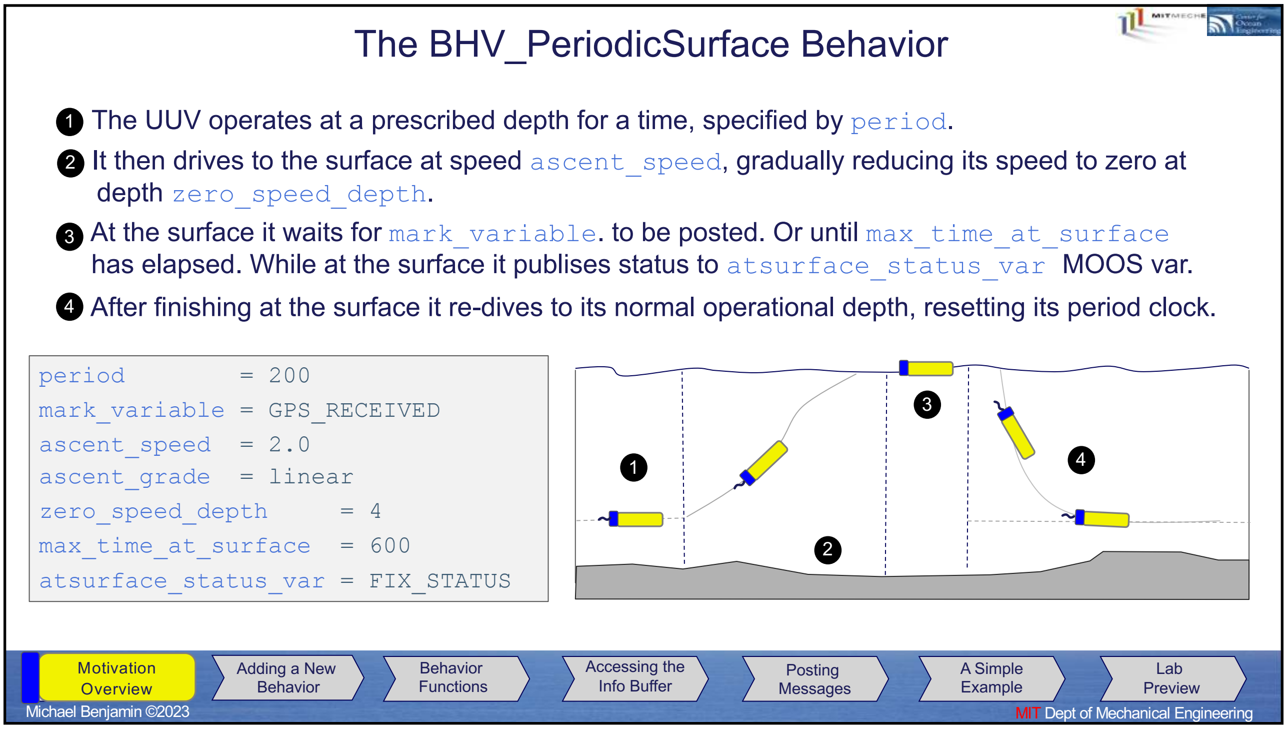

The BHV_PeriodicSurface Behavior

1. The UUV operates at a prescribed depth for a time, specified by `period`.
2. It then drives to the surface at speed `ascent_speed`, gradually reducing its speed to zero at depth `zero_speed_depth`.
3. At the surface it waits for `mark_variable`. to be posted. Or until `max_time_at_surface` has elapsed. While at the surface it publises status to `atsurface_status_var` MOOS var.
4. After finishing at the surface it re-dives to its normal operational depth, resetting its period clock.

```
period          = 200
mark_variable = GPS_RECEIVED
ascent_speed  = 2.0
ascent_grade  = linear
zero_speed_depth      = 4
max_time_at_surface  = 600
atsurface_status_var = FIX_STATUS
```

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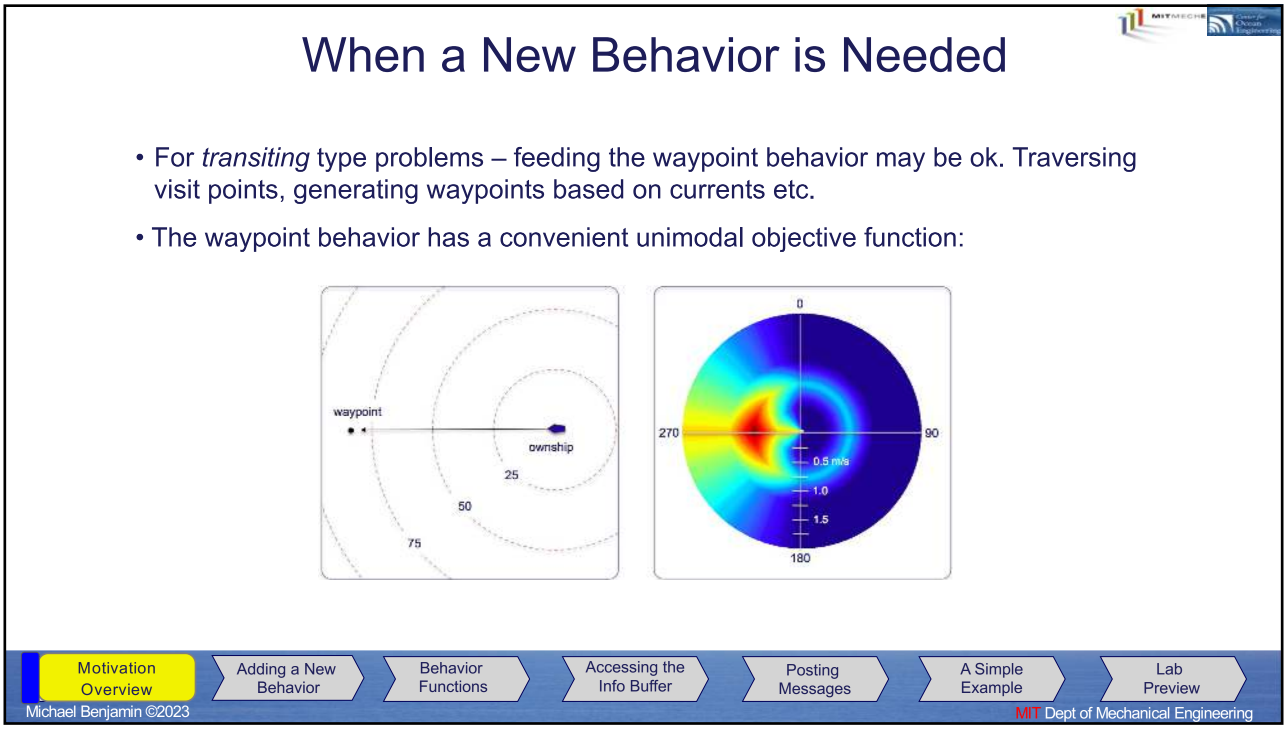

When a New Behavior is Needed

- For *transiting* type problems – feeding the waypoint behavior may be ok. Traversing visit points, generating waypoints based on currents etc.
- The waypoint behavior has a convenient unimodal objective function:

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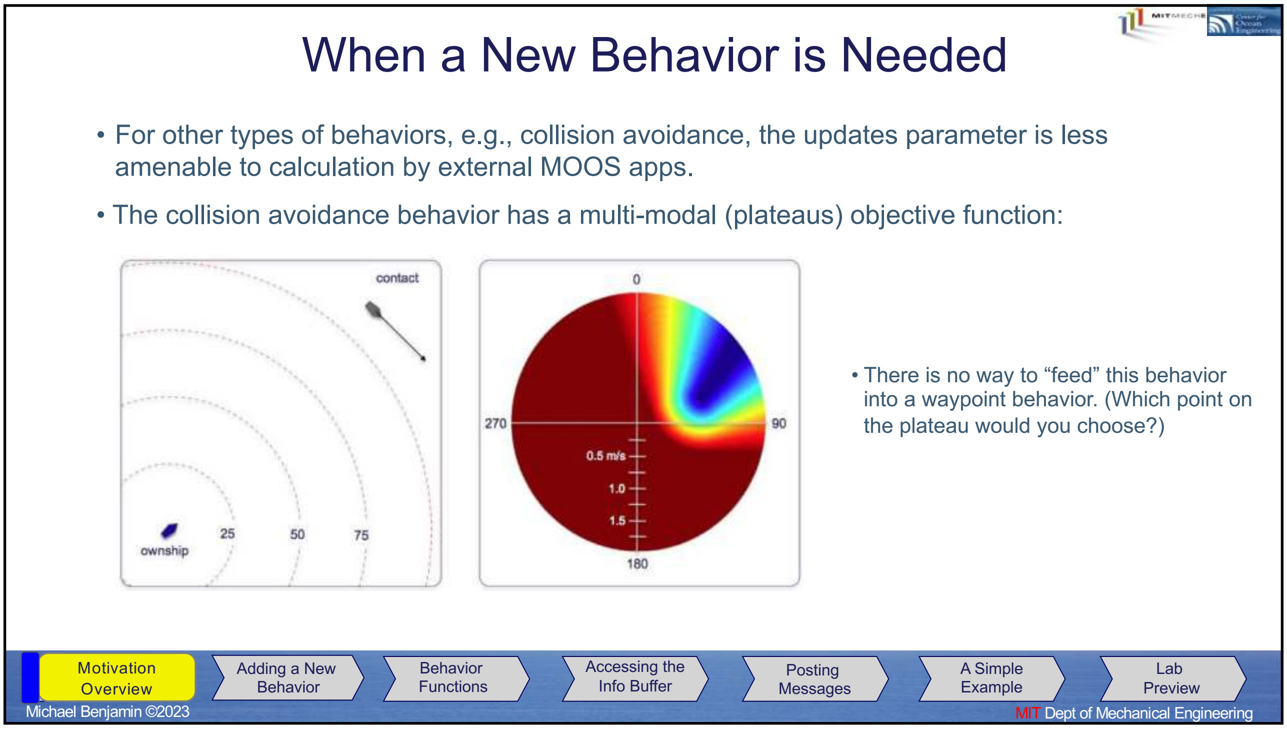

When a New Behavior is Needed

- For other types of behaviors, e.g., collision avoidance, the updates parameter is less amenable to calculation by external MOOS apps.
- The collision avoidance behavior has a multi-modal (plateaus) objective function:

contact
ownship
25
50
75
0
270
90
180
0.5 m/s
1.0
1.5

- There is no way to “feed” this behavior into a waypoint behavior. (Which point on the plateau would you choose?)

Motivation Overview | Adding a New Behavior | Behavior Functions | Accessing the Info Buffer | Posting Messages | A Simple Example | Lab Preview

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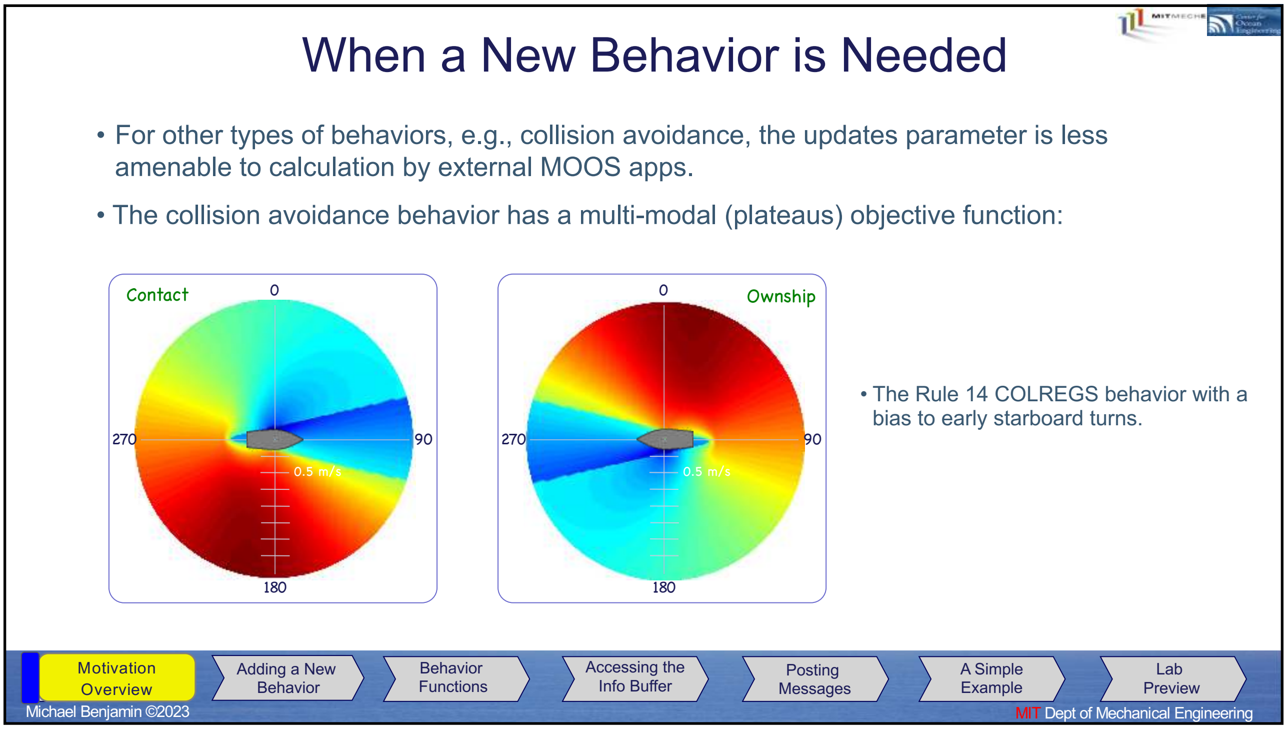

When a New Behavior is Needed

- For other types of behaviors, e.g., collision avoidance, the updates parameter is less amenable to calculation by external MOOS apps.
- The collision avoidance behavior has a multi-modal (plateaus) objective function:

Contact
0
270
90
180
0.5 m/s
Ownship
0
270
90
180
0.5 m/s

- The Rule 14 COLREGS behavior with a bias to early starboard turns.

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Adding a New Behavior

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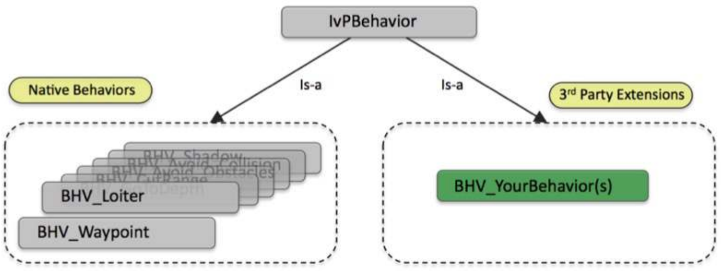
Adding a Behavior

- Your behavior will also be a subclass of the IvPBehavior superclass
- It will inherit functionality of the IvPBehavior superclass
- It will overload virtual functions of the IvPBehavior superclass.



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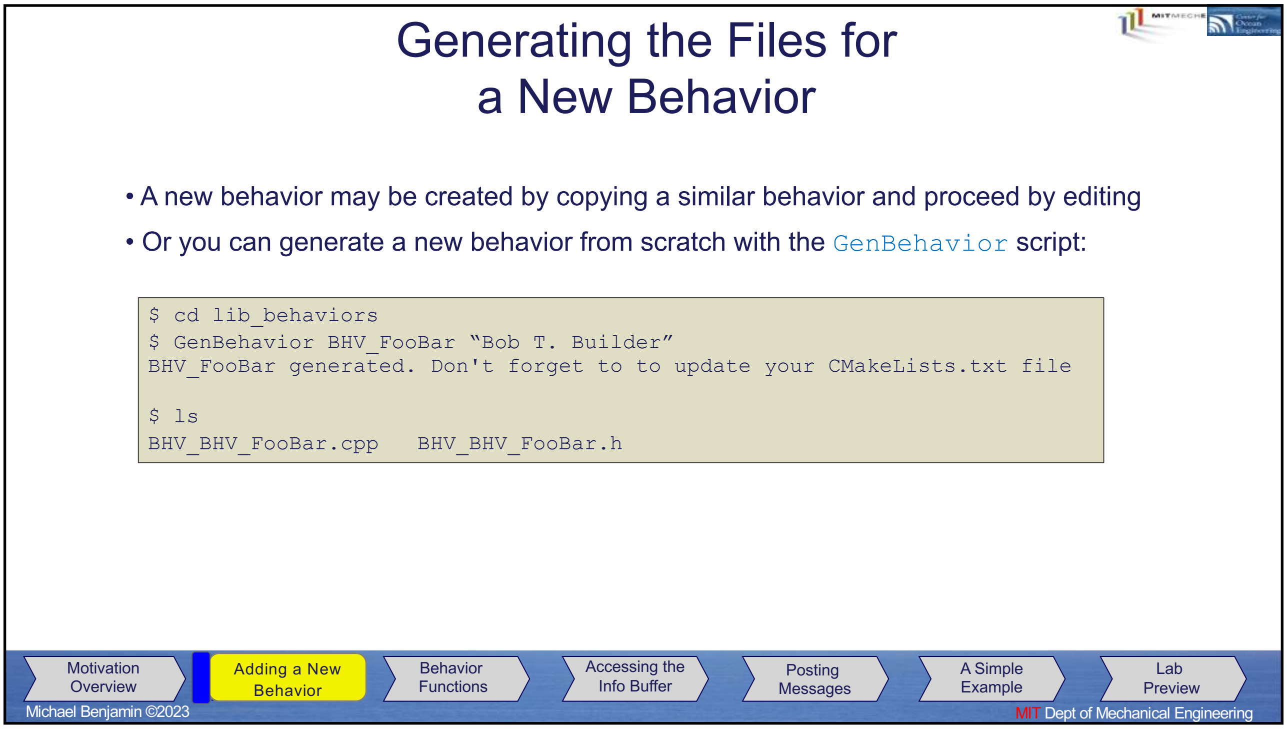
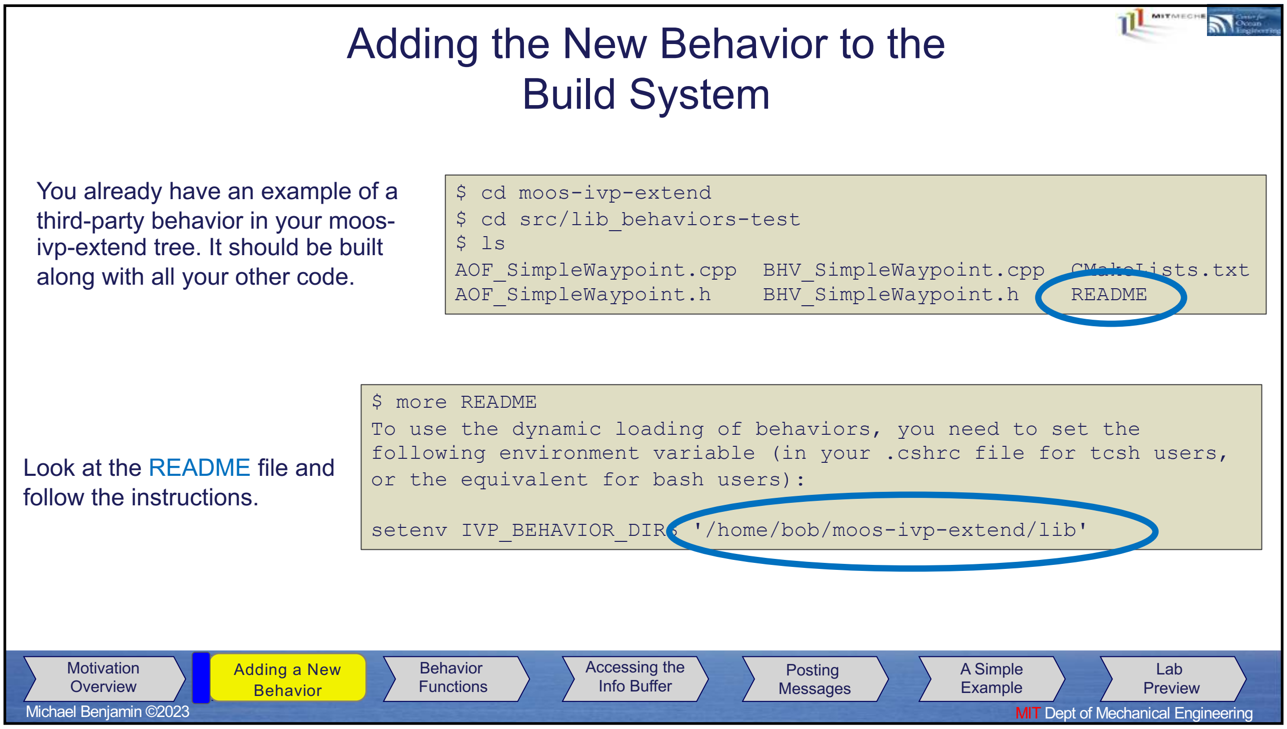


Generating the Files for a New Behavior

- A new behavior may be created by copying a similar behavior and proceed by editing
- Or you can generate a new behavior from scratch with the `GenBehavior` script:

```
$ cd lib_behaviors
$ GenBehavior BHV_FooBar “Bob T. Builder”
BHV_FooBar generated. Don't forget to to update your CMakeLists.txt file

$ ls
BHV_BHV_FooBar.cpp   BHV_BHV_FooBar.h
```



Adding the New Behavior to the Build System

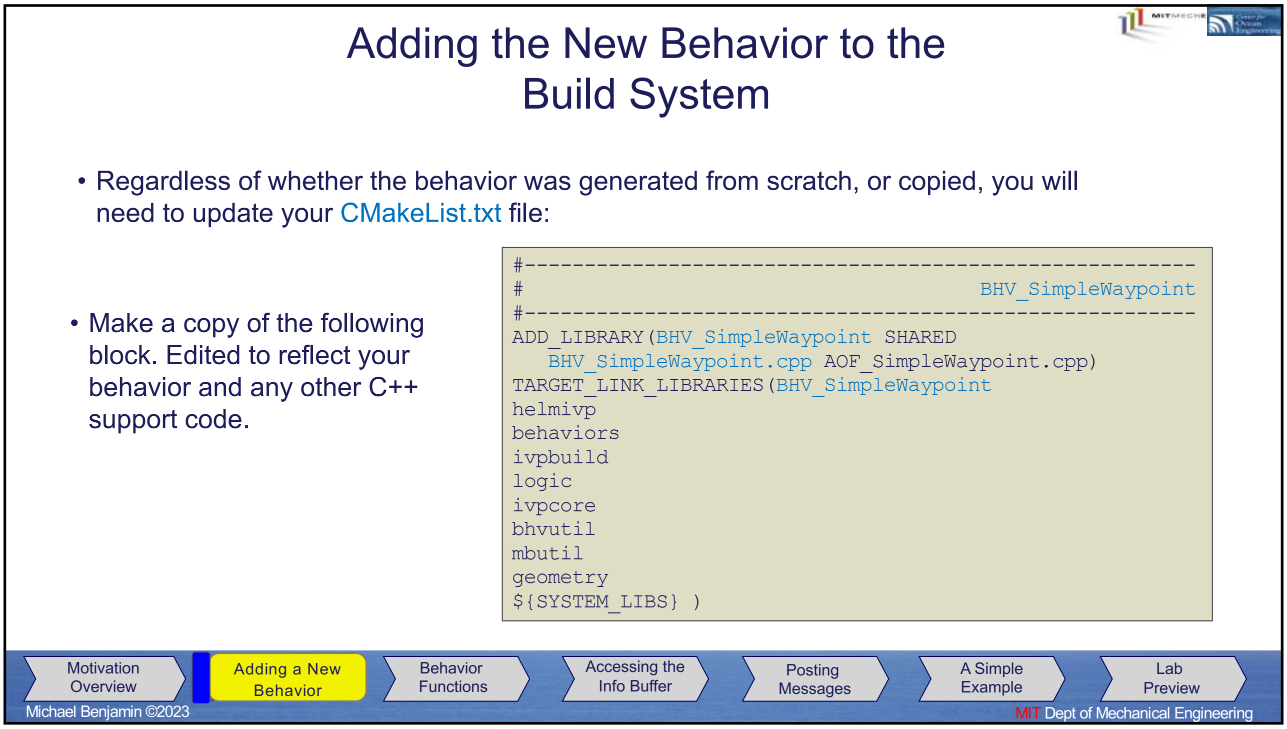
You already have an example of a third-party behavior in your moos-ivp-extend tree. It should be built along with all your other code.

```
$ cd moos-ivp-extend
$ cd src/lib_behaviors-test
$ ls
AOF_SimpleWaypoint.cpp   BHV_SimpleWaypoint.cpp   CMakeLists.txt
AOF_SimpleWaypoint.h     BHV_SimpleWaypoint.h     README
```

Look at the README file and follow the instructions.

```
$ more README
To use the dynamic loading of behaviors, you need to set the
following environment variable (in your .cshrc file for tcsh users,
or the equivalent for bash users):

setenv IVP_BEHAVIOR_DIR  '/home/bob/moos-ivp-extend/lib'
```

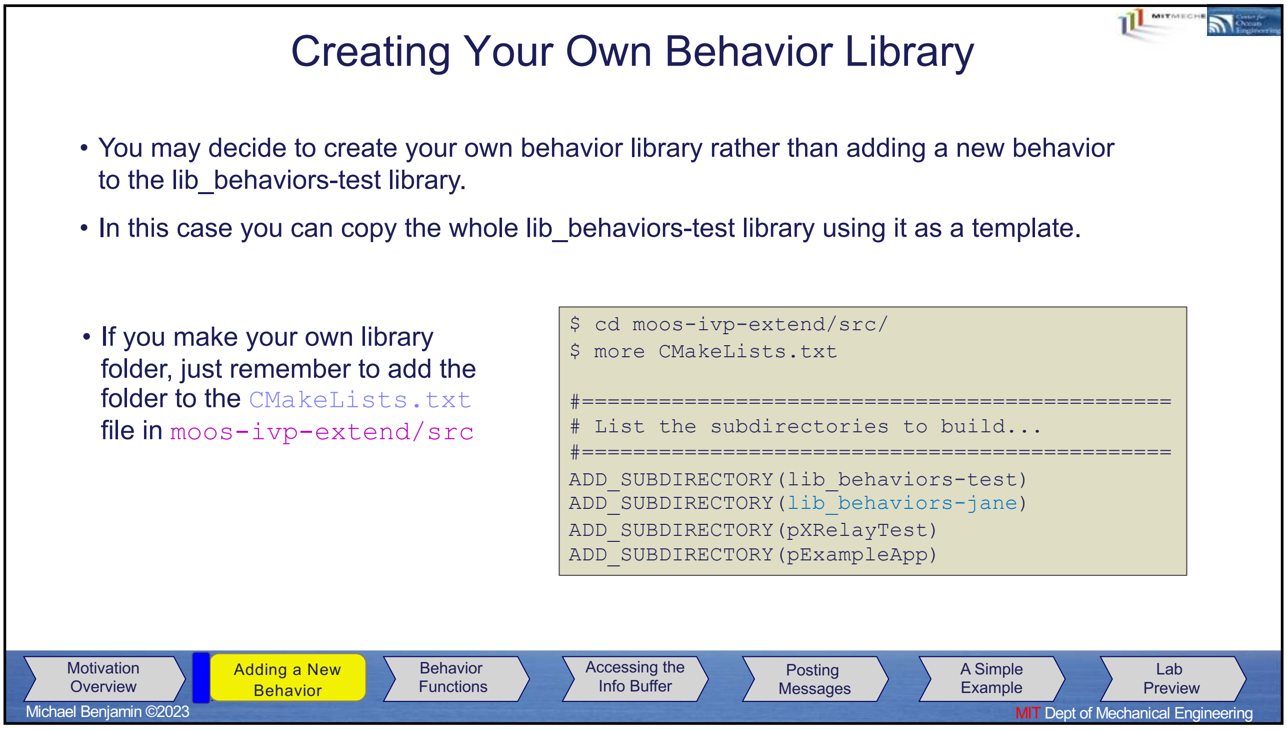


Adding the New Behavior to the Build System

- Regardless of whether the behavior was generated from scratch, or copied, you will need to update your CMakeList.txt file:

- Make a copy of the following block. Edited to reflect your behavior and any other C++ support code.

```
#--------------------------------------------------------
#                                     BHV_SimpleWaypoint
#--------------------------------------------------------
ADD_LIBRARY(BHV_SimpleWaypoint SHARED
   BHV_SimpleWaypoint.cpp AOF_SimpleWaypoint.cpp)
TARGET_LINK_LIBRARIES(BHV_SimpleWaypoint
helmivp
behaviors
ivpbuild
logic
ivpcore
bhvutil
mbutil
geometry
${SYSTEM_LIBS} )
```



Creating Your Own Behavior Library

- You may decide to create your own behavior library rather than adding a new behavior to the lib_behaviors-test library.
- In this case you can copy the whole lib_behaviors-test library using it as a template.

- If you make your own library folder, just remember to add the folder to the `CMakeLists.txt` file in `moos-ivp-extend/src`

```
$ cd moos-ivp-extend/src/
$ more CMakeLists.txt

#============================================
# List the subdirectories to build...
#============================================
ADD_SUBDIRECTORY(lib_behaviors-test)
ADD_SUBDIRECTORY(lib_behaviors-jane)
ADD_SUBDIRECTORY(pXRelayTest)
ADD_SUBDIRECTORY(pExampleApp)
```

Behavior Functions

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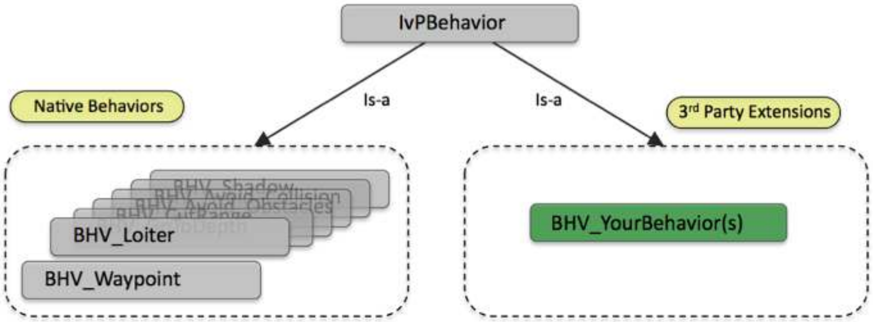
Behavior Functions
Inherited from IvPBehavior Superclass

- From a behavior **user** perspective, behaviors have common configuration parameters.
- From a behavior **author** perspective, they have common overloadable functions and callable runtime functions and libraries.
- These common behavior features are derived by inheritance from the **IvPBehavior** superclass.



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Behavior Functions are Related to Behavior State

Recall that Behaviors may be in one of four states:

`Idle` | `Running` `Active` | `Completed`

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

The running state: a behavior has met its run conditions, as defined by the condition parameter.

Solely Based on conditions

The active state: a behavior is in the running state, and it is producing an objective function over the helm's configured decision space.

The completed state: a behavior has completed. Completion is defined by the behavior author or may be due to a duration timeout defined generally for all behaviors.

Based on author implementation

Helm-Invoked Behavior Functions

- MOOS Apps have several key overloadable functions – this is where the uniqueness of the app is implemented.
- IvP behaviors also have several overloadable functions - invoked by the helm under certain specific situations

MOOSApp Overloadable functions

```
OnStartup()
{
   ...
}
OnNewMail()
{
   ...
}
Iterate()
{
   ...
}
```

IvPBehavior Overloadable functions

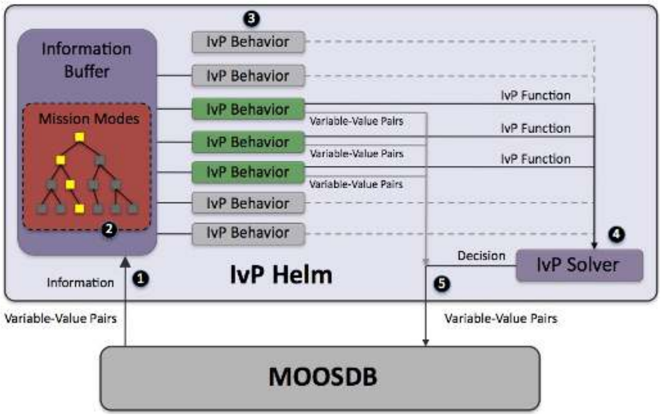
(based on *state*)

```
onRunState()
{}
OnIdleState()
{}
onCompleteState()
{}
onIdleToRunState()
{}
onRunToIdleState()
{}
onInactiveState()
{}
```

```
setParam()
{}
postConfigStatus()
{}
onSetParamComplete()
{}
onHelmStart()
{}
onRunStatePrior()
{}
```

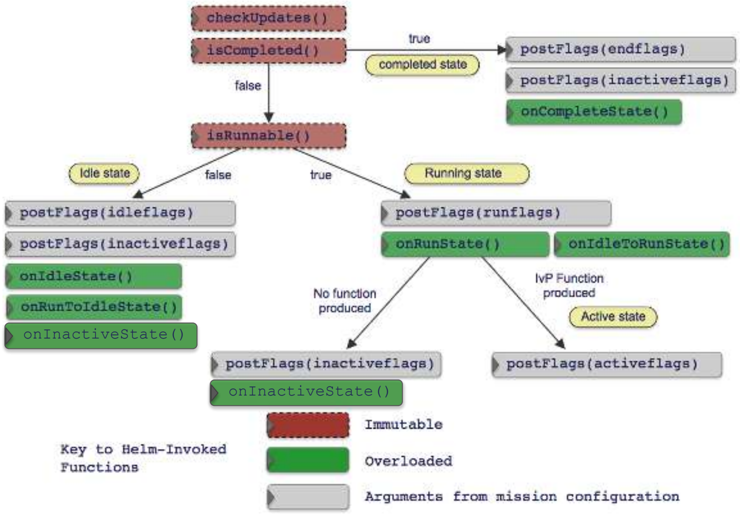
Interval Programming and the IvP Helm

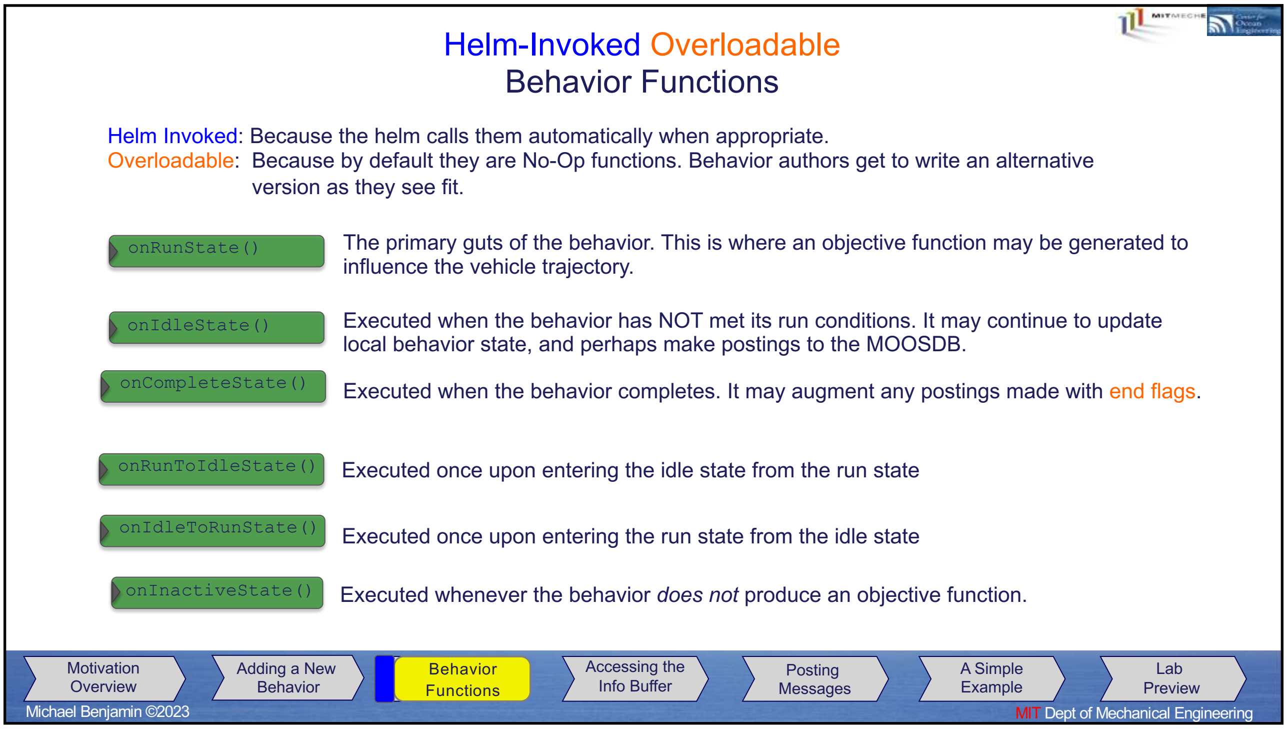
1. Mail is read in the MOOS OnNewMail() function and applied to a local buffer.
2. The helm mode is determined and set of running behaviors determined.
3. Behaviors do their thing – posting MOOS variables and an IvP function.
4. Competing behaviors are resolved with the IvP solver.
5. The Helm decision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



Helm-Invoked Behavior Functions

Chain of Contingency Events





Helm-Invoked Overloadable Behavior Functions

Helm Invoked: Because the helm calls them automatically when appropriate.
Overloadable: Because by default they are No-Op functions. Behavior authors get to write an alternative version as they see fit.

`onRunState()` The primary guts of the behavior. This is where an objective function may be generated to influence the vehicle trajectory.

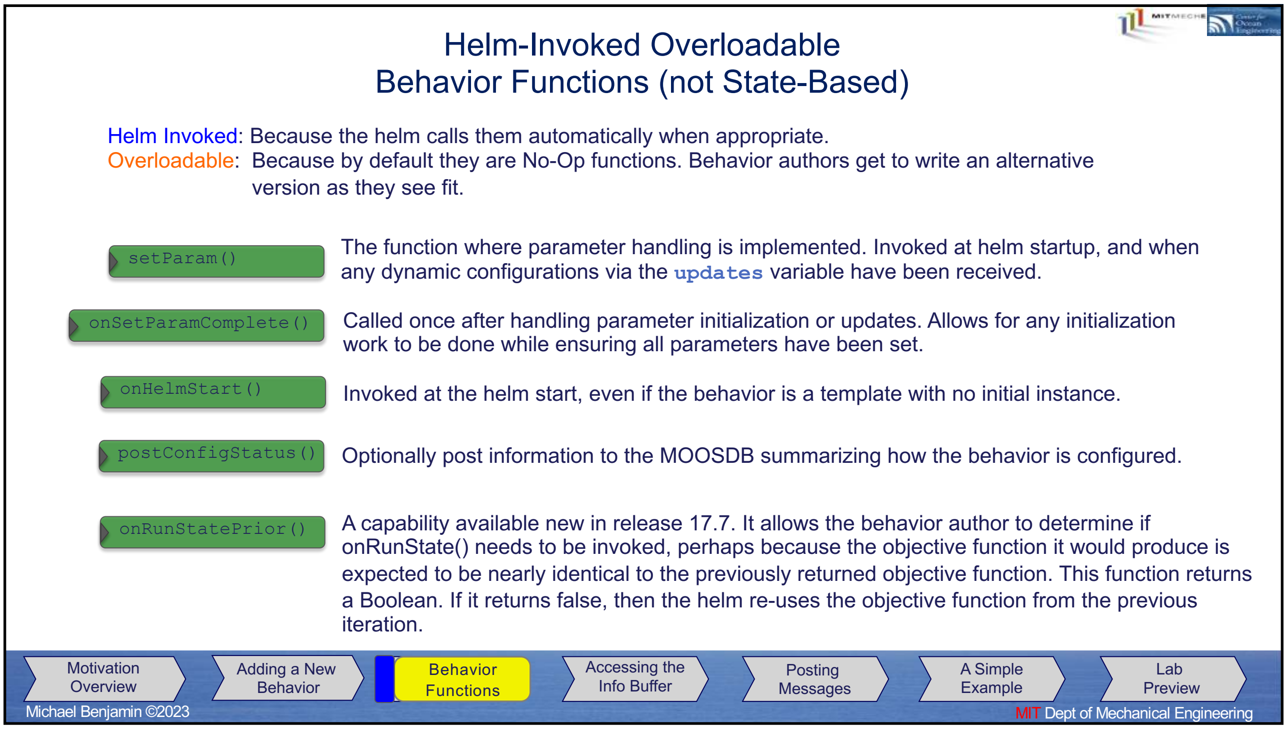
`onIdleState()` Executed when the behavior has NOT met its run conditions. It may continue to update local behavior state, and perhaps make postings to the MOOSDB.

`onCompleteState()` Executed when the behavior completes. It may augment any postings made with end flags.

`onRunToIdleState()` Executed once upon entering the idle state from the run state

`onIdleToRunState()` Executed once upon entering the run state from the idle state

`onInactiveState()` Executed whenever the behavior *does not* produce an objective function.



Helm-Invoked Overloadable Behavior Functions (not State-Based)

Helm Invoked: Because the helm calls them automatically when appropriate.
Overloadable: Because by default they are No-Op functions. Behavior authors get to write an alternative version as they see fit.

`setParam()` The function where parameter handling is implemented. Invoked at helm startup, and when any dynamic configurations via the `updates` variable have been received.

`onSetParamComplete()` Called once after handling parameter initialization or updates. Allows for any initialization work to be done while ensuring all parameters have been set.

`onHelmStart()` Invoked at the helm start, even if the behavior is a template with no initial instance.

`postConfigStatus()` Optionally post information to the MOOSDB summarizing how the behavior is configured.

`onRunStatePrior()` A capability available new in release 17.7. It allows the behavior author to determine if onRunState() needs to be invoked, perhaps because the objective function it would produce is expected to be nearly identical to the previously returned objective function. This function returns a Boolean. If it returns false, then the helm re-uses the objective function from the previous iteration.

Helm-Invoked *Parameterized* Behavior Functions

Helm Invoked parameterized: Called by the helm, users and behavior authors cannot change or overwrite them. But their functionality is largely determined by how they are parameterized by the user in the mission file.

```
postFlags(activeflags)
postFlags(runflags)
postFlags(inactiveflags)
postFlags(idleflags)
postFlags(endflags)
```

Augmentable: Behavior authors can introduce similar functions, specific to their behavior.

For example, the Waypoint behavior also has:

```
postFlags(cycleflag)
postFlags(wptflags)
```

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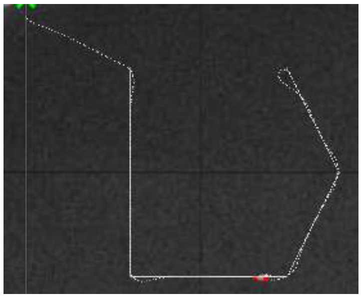
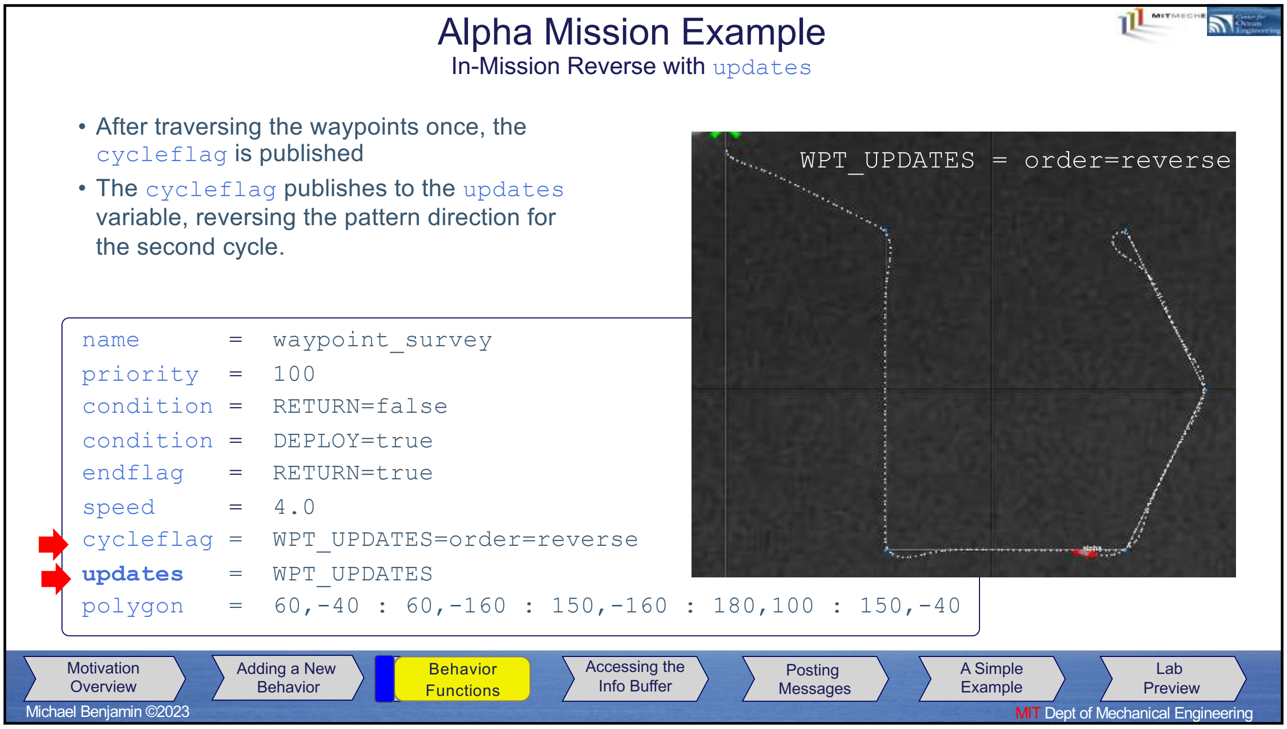


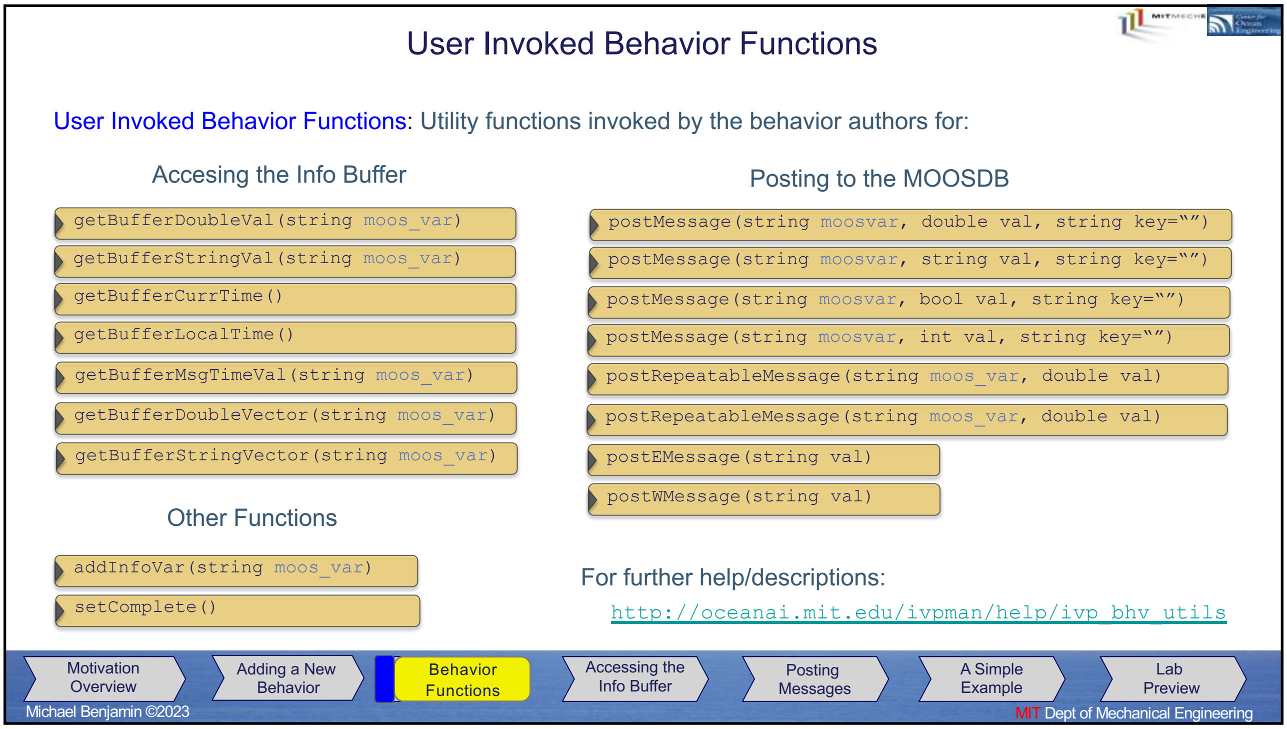


Alpha Mission Example

In-Mission Reverse with updates

- After traversing the waypoints once, the cycleflag is published
- The cycleflag publishes to the updates variable, reversing the pattern direction for the second cycle.

```
name       =  waypoint_survey
priority   =  100
condition  =  RETURN=false
condition  =  DEPLOY=true
endflag    =  RETURN=true
speed      =  4.0
cycleflag  =  WPT_UPDATES=order=reverse
updates    =  WPT_UPDATES
polygon    =  60,-40 : 60,-160 : 150,-160 : 180,100 : 150,-40
```



User Invoked Behavior Functions

User Invoked Behavior Functions: Utility functions invoked by the behavior authors for:

Accessing the Info Buffer

```
getBufferDoubleVal(string moos_var)
getBufferStringVal(string moos_var)
getBufferCurrTime()
getBufferLocalTime()
getBufferMsgTimeVal(string moos_var)
getBufferDoubleVector(string moos_var)
getBufferStringVector(string moos_var)
```

Posting to the MOOSDB

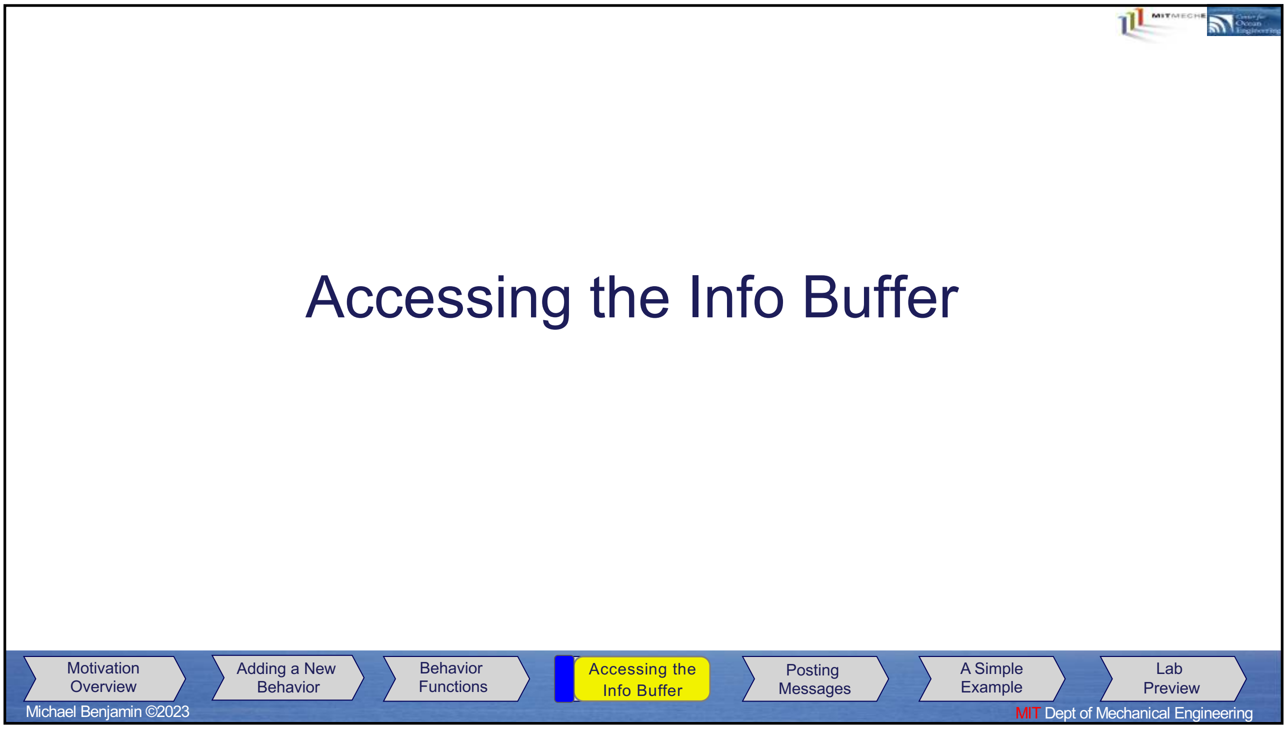
```
postMessage(string moosvar, double val, string key="")
postMessage(string moosvar, string val, string key="")
postMessage(string moosvar, bool val, string key="")
postMessage(string moosvar, int val, string key="")
postRepeatableMessage(string moos_var, double val)
postRepeatableMessage(string moos_var, double val)
postEMessage(string val)
postWMessage(string val)
```

Other Functions

```
addInfoVar(string moos_var)
setComplete()
```

For further help/descriptions:

http://oceanai.mit.edu/ivpman/help/ivp_bhv_utils



Accessing the Info Buffer

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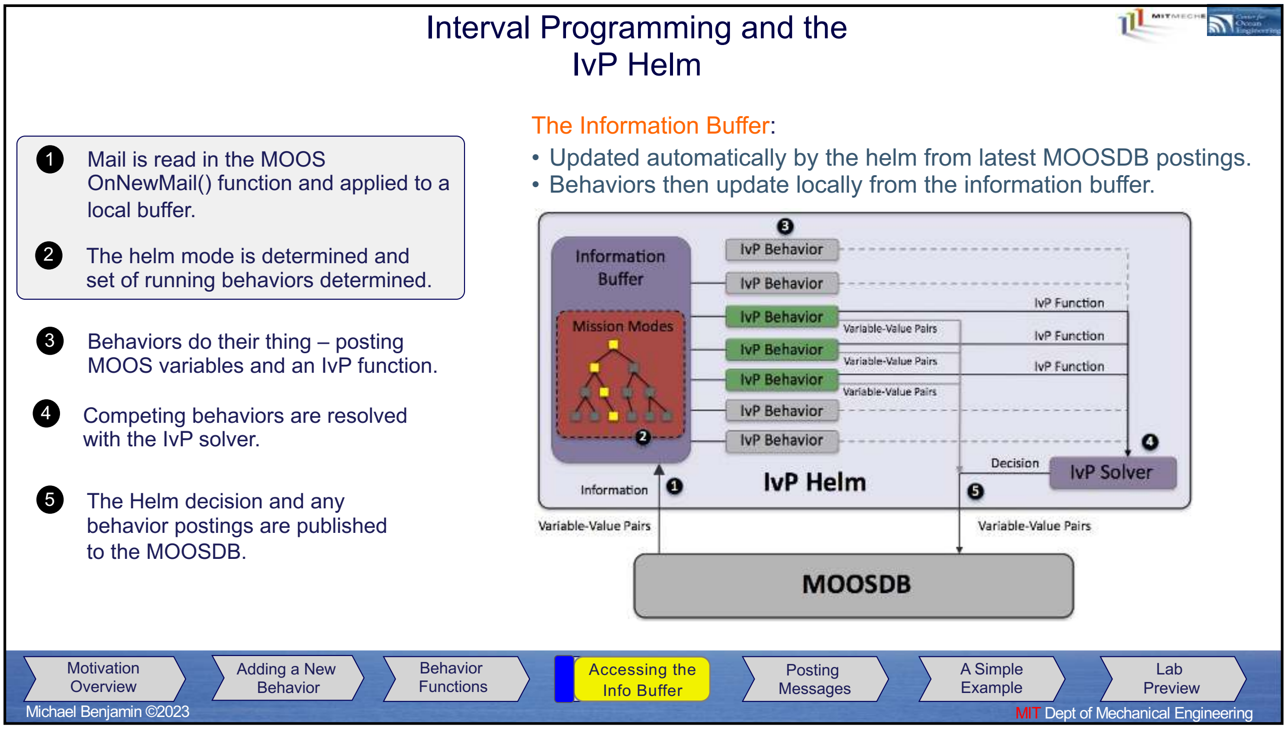

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3. Behaviors do their thing – posting MOOS variables and an IvP function.

4. Competing behaviors are resolved with the IvP solver.

5. The Helm decision and any behavior postings are published to the MOOSDB.

The Information Buffer:

- Updated automatically by the helm from latest MOOSDB postings.
- Behaviors then update locally from the information buffer.

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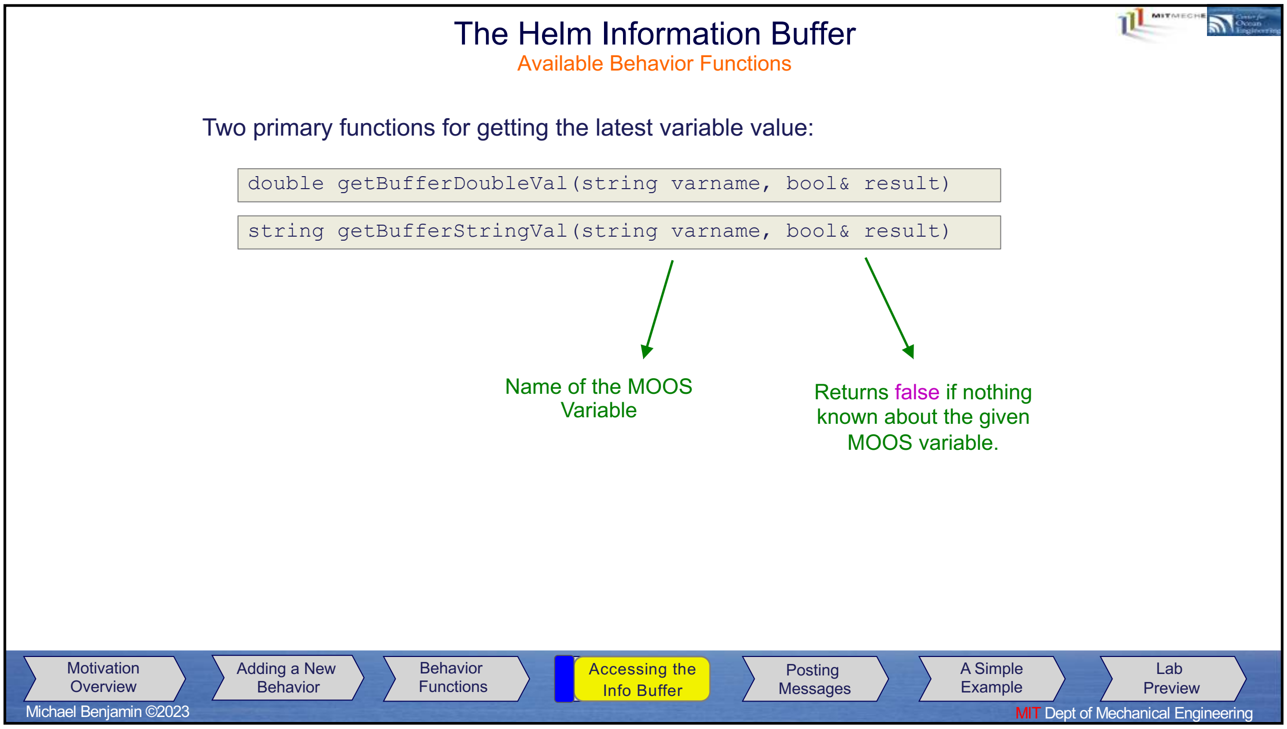


The Helm Information Buffer

Available Behavior Functions

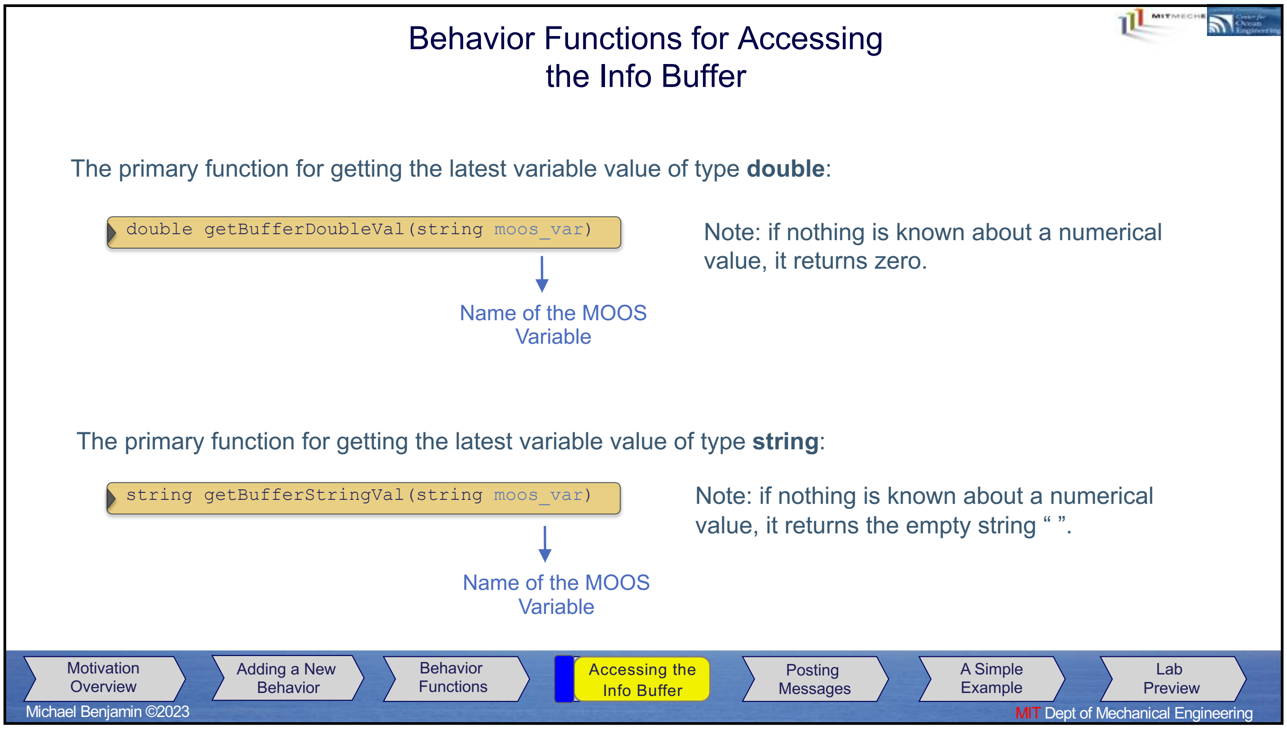
Two primary functions for getting the latest variable value:

```
double getBufferDoubleVal(string varname, bool& result)
```

```
string getBufferStringVal(string varname, bool& result)
```

Name of the MOOS Variable

Returns false if nothing known about the given MOOS variable.



Behavior Functions for Accessing the Info Buffer

The primary function for getting the latest variable value of type **double**:

```
double getBufferDoubleVal(string moos_var)
```

Name of the MOOS Variable

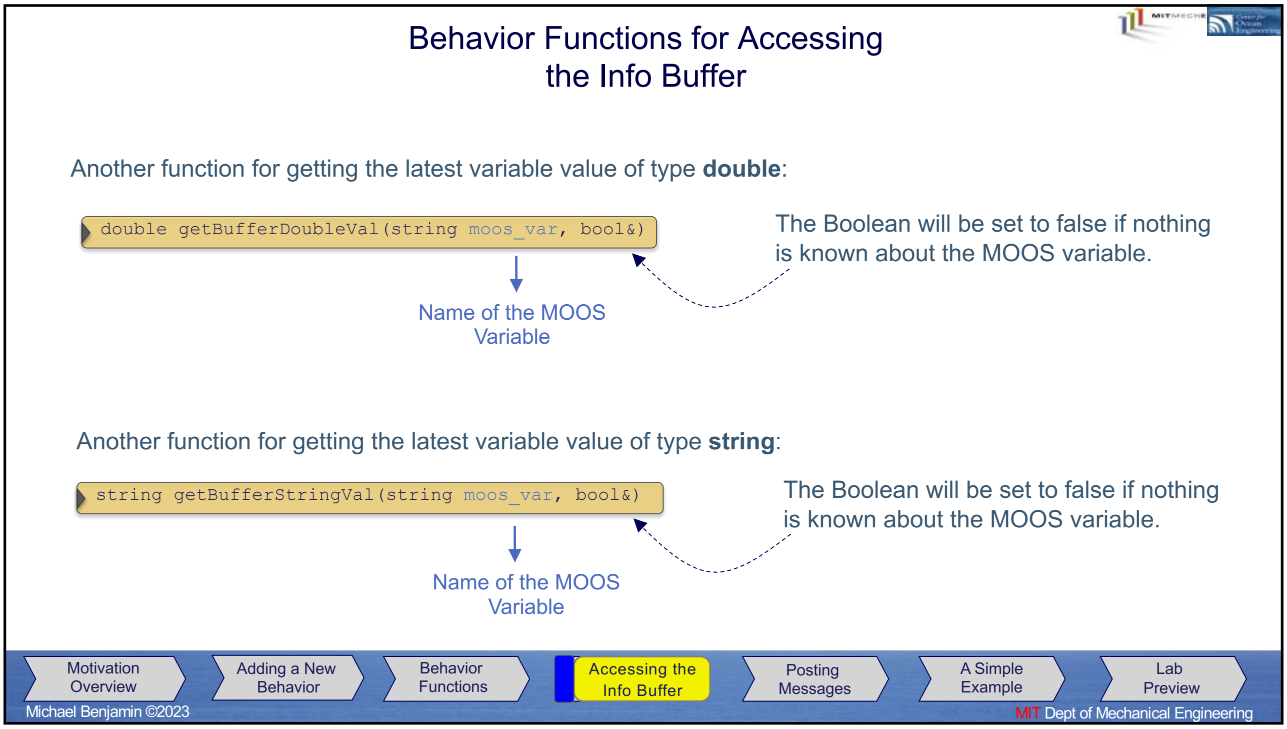
Note: if nothing is known about a numerical value, it returns zero.

The primary function for getting the latest variable value of type **string**:

```
string getBufferStringVal(string moos_var)
```

Name of the MOOS Variable

Note: if nothing is known about a numerical value, it returns the empty string “ ”.



Behavior Functions for Accessing the Info Buffer

Another function for getting the latest variable value of type **double**:

```
double getBufferDoubleVal(string moos_var, bool&)
```

Name of the MOOS Variable

The Boolean will be set to false if nothing is known about the MOOS variable.

Another function for getting the latest variable value of type **string**:

```
string getBufferStringVal(string moos_var, bool&)
```

Name of the MOOS Variable

The Boolean will be set to false if nothing is known about the MOOS variable.

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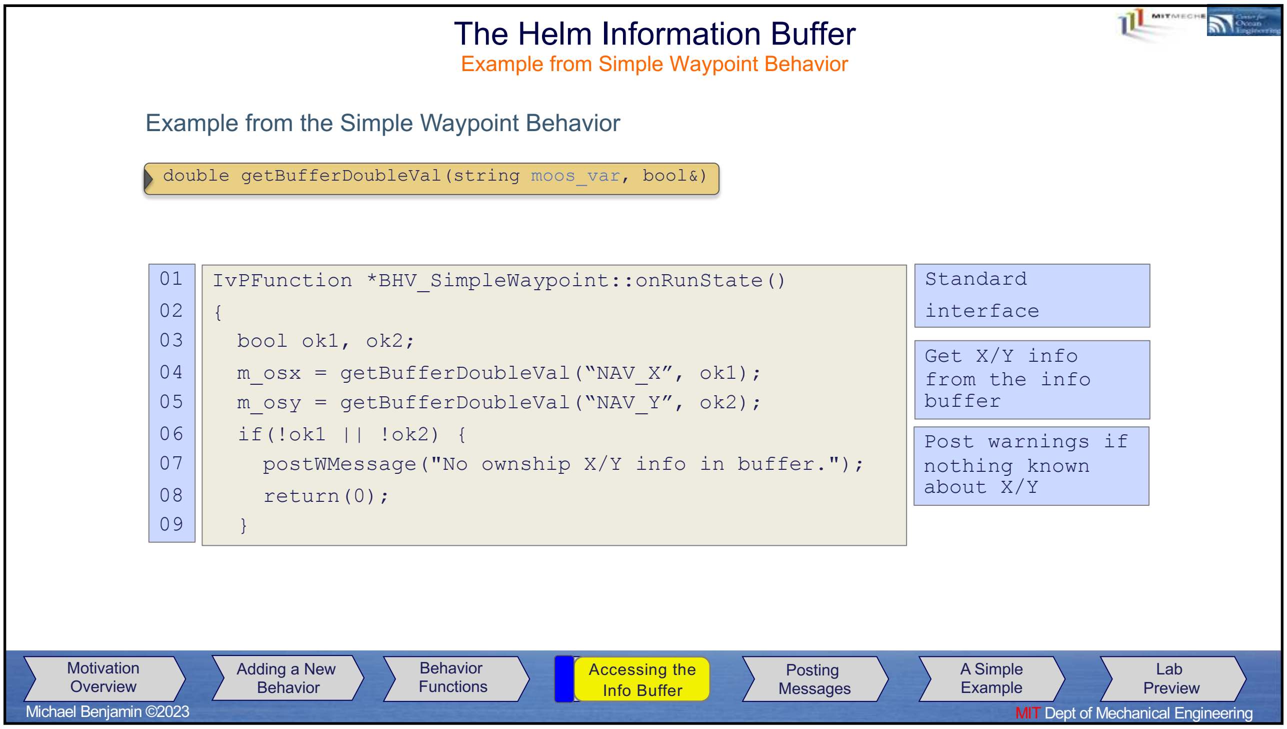

The Helm Information Buffer

Example from Simple Waypoint Behavior

Example from the Simple Waypoint Behavior

```
double getBufferDoubleVal(string moos_var, bool&)
```

```
IvPFunction *BHV_SimpleWaypoint::onRunState()
{
  bool ok1, ok2;
  m_osx = getBufferDoubleVal("NAV_X", ok1);
  m_osy = getBufferDoubleVal("NAV_Y", ok2);
  if(!ok1 || !ok2) {
    postWMessage("No ownship X/Y info in buffer.");
    return(0);
  }
```

Standard interface

Get X/Y info from the info buffer

Post warnings if nothing known about X/Y

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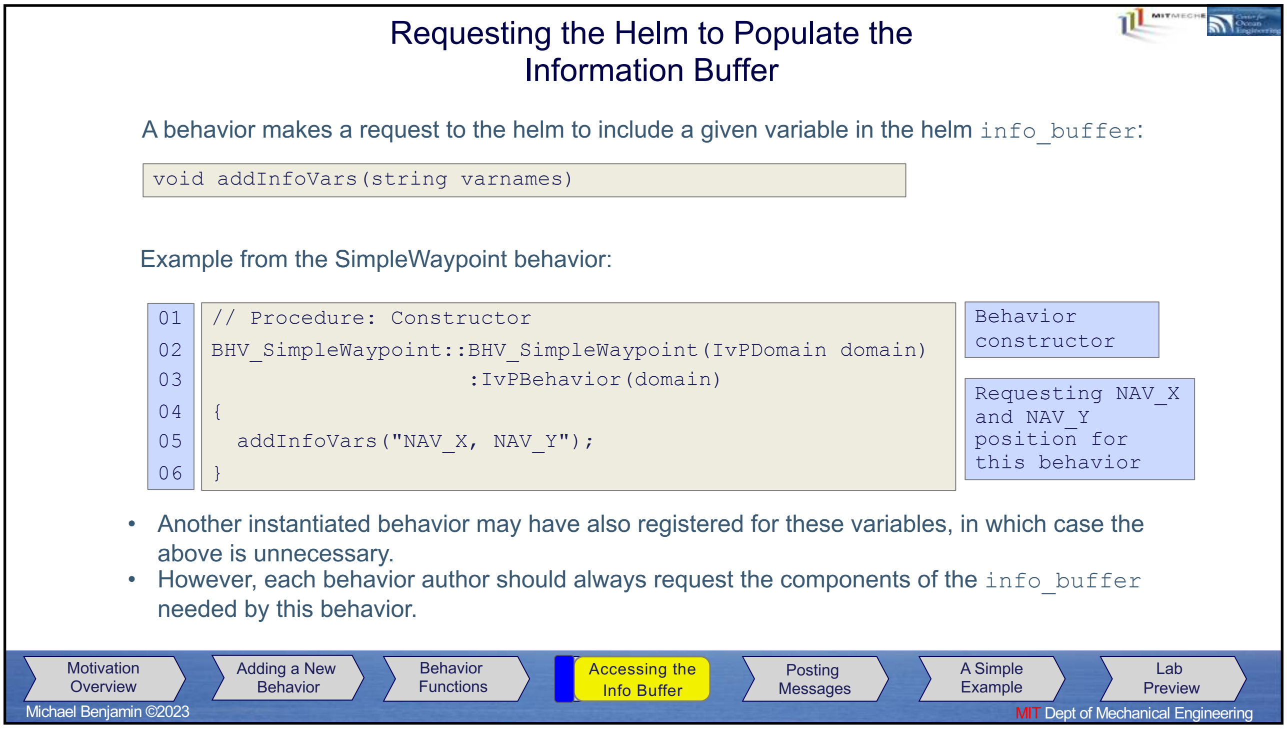

Requesting the Helm to Populate the Information Buffer

A behavior makes a request to the helm to include a given variable in the helm `info_buffer`:

```
void addInfoVars(string varnames)
```

Example from the SimpleWaypoint behavior:

```
// Procedure: Constructor
BHV_SimpleWaypoint::BHV_SimpleWaypoint(IvPDomain domain)
                    :IvPBehavior(domain)
{
  addInfoVars("NAV_X, NAV_Y");
}
```

Behavior constructor

Requesting NAV_X and NAV_Y position for this behavior

- Another instantiated behavior may have also registered for these variables, in which case the above is unnecessary.
- However, each behavior author should always request the components of the `info_buffer` needed by this behavior.

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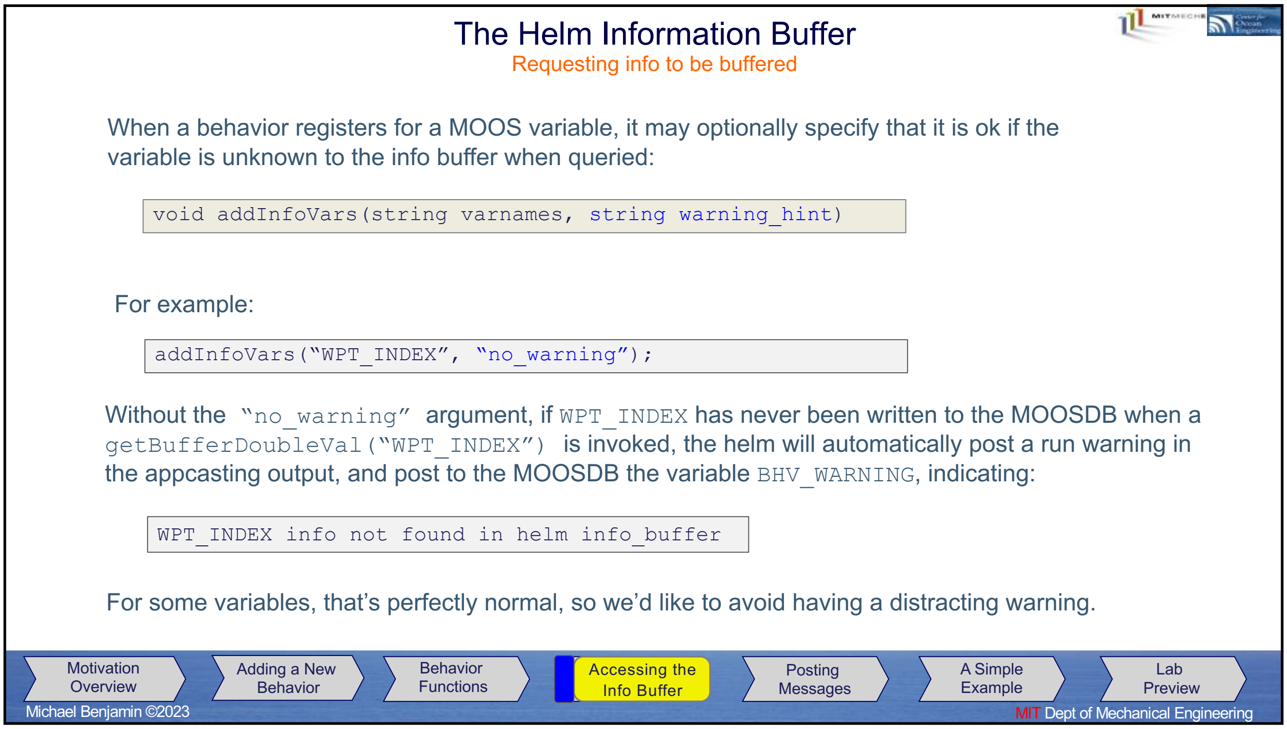

The Helm Information Buffer

Requesting info to be buffered

When a behavior registers for a MOOS variable, it may optionally specify that it is ok if the variable is unknown to the info buffer when queried:

```
void addInfoVars(string varnames, string warning_hint)
```

For example:

```
addInfoVars(“WPT_INDEX”, “no_warning”);
```

Without the `“no_warning”` argument, if `WPT_INDEX` has never been written to the MOOSDB when a `getBufferDoubleVal(“WPT_INDEX”)` is invoked, the helm will automatically post a run warning in the appcasting output, and post to the MOOSDB the variable `BHV_WARNING`, indicating:

```
WPT_INDEX info not found in helm info_buffer
```

For some variables, that’s perfectly normal, so we’d like to avoid having a distracting warning.

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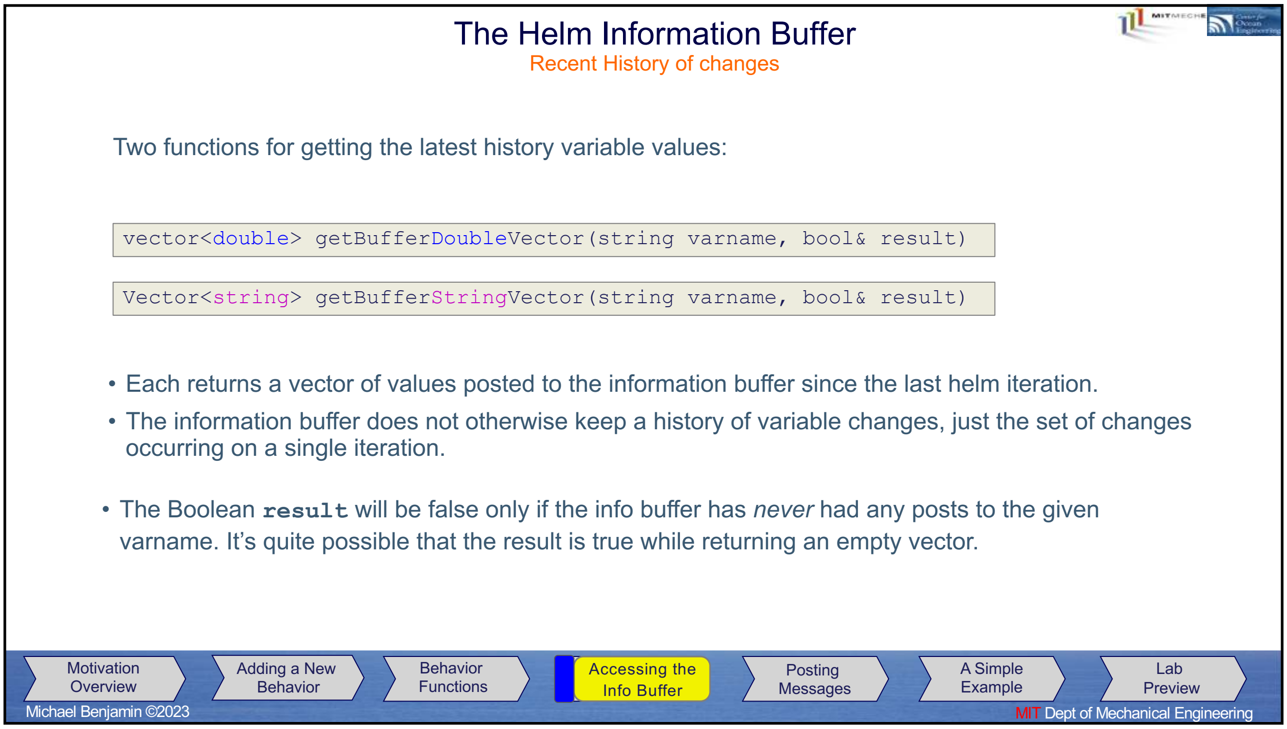

The Helm Information Buffer

Recent History of changes

Two functions for getting the latest history variable values:

```
vector<double> getBufferDoubleVector(string varname, bool& result)
```

```
Vector<string> getBufferStringVector(string varname, bool& result)
```

- Each returns a vector of values posted to the information buffer since the last helm iteration.
- The information buffer does not otherwise keep a history of variable changes, just the set of changes occurring on a single iteration.

- The Boolean **`result`** will be false only if the info buffer has *never* had any posts to the given varname. It's quite possible that the result is true while returning an empty vector.

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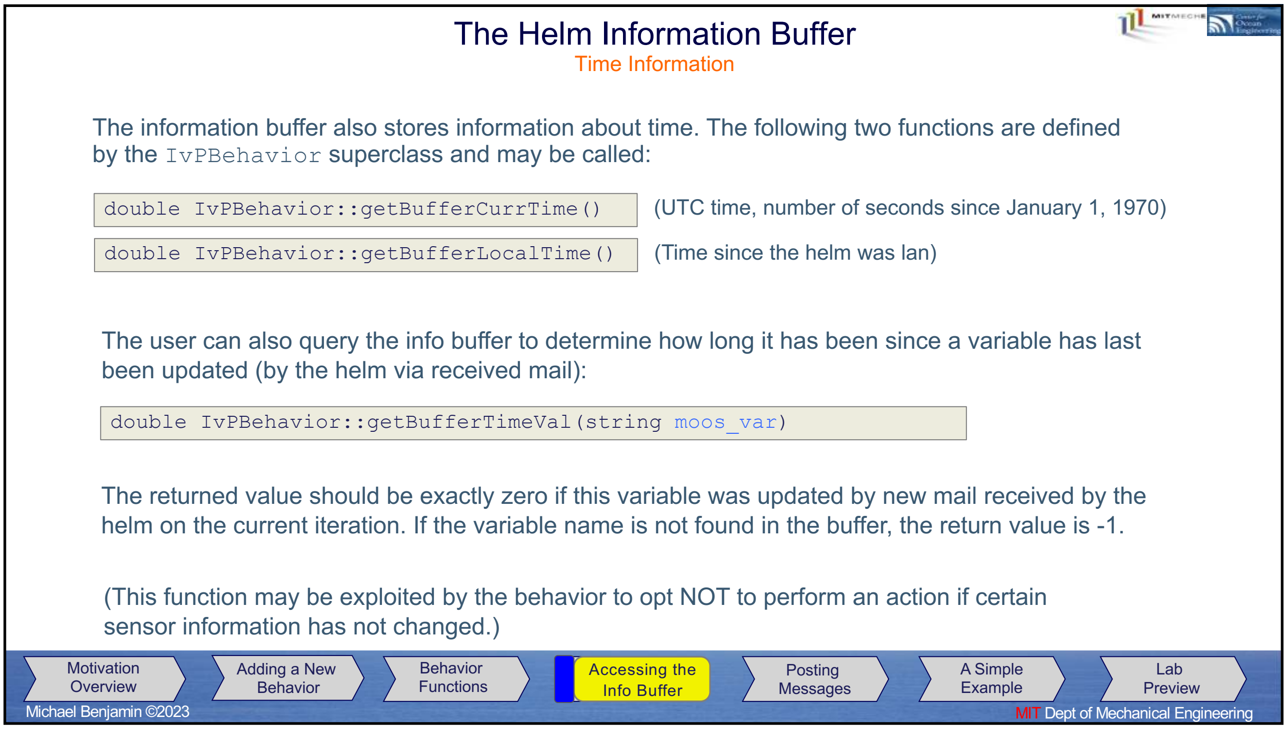

The Helm Information Buffer

Time Information

The information buffer also stores information about time. The following two functions are defined by the `IvPBehavior` superclass and may be called:

```
double IvPBehavior::getBufferCurrTime()
```

(UTC time, number of seconds since January 1, 1970)

```
double IvPBehavior::getBufferLocalTime()
```

(Time since the helm was lan)

The user can also query the info buffer to determine how long it has been since a variable has last been updated (by the helm via received mail):

```
double IvPBehavior::getBufferTimeVal(string moos_var)
```

The returned value should be exactly zero if this variable was updated by new mail received by the helm on the current iteration. If the variable name is not found in the buffer, the return value is -1.

(This function may be exploited by the behavior to opt NOT to perform an action if certain sensor information has not changed.)

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Posting Messages

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The IvP Helm Iterate Loop
Posting Messages

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.

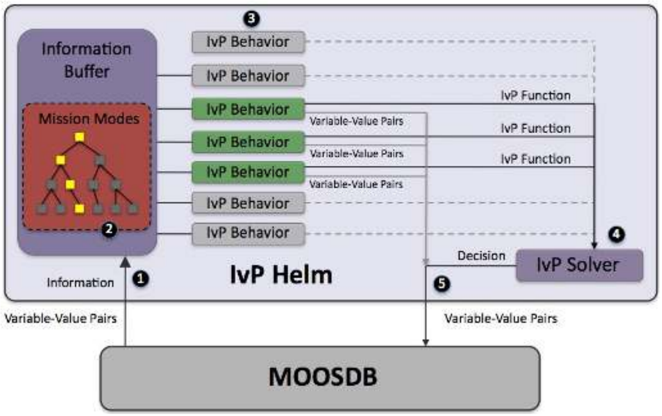
3. Behaviors do their thing – posting MOOS variables and an IvP function.

4. Competing behaviors are resolved with the IvP solver.

5. The Helm decision and any behavior postings are published to the MOOSDB.

The Information Buffer:

- Updated automatically by the helm from latest MOOSDB postings.
- Behaviors then update locally from the information buffer.



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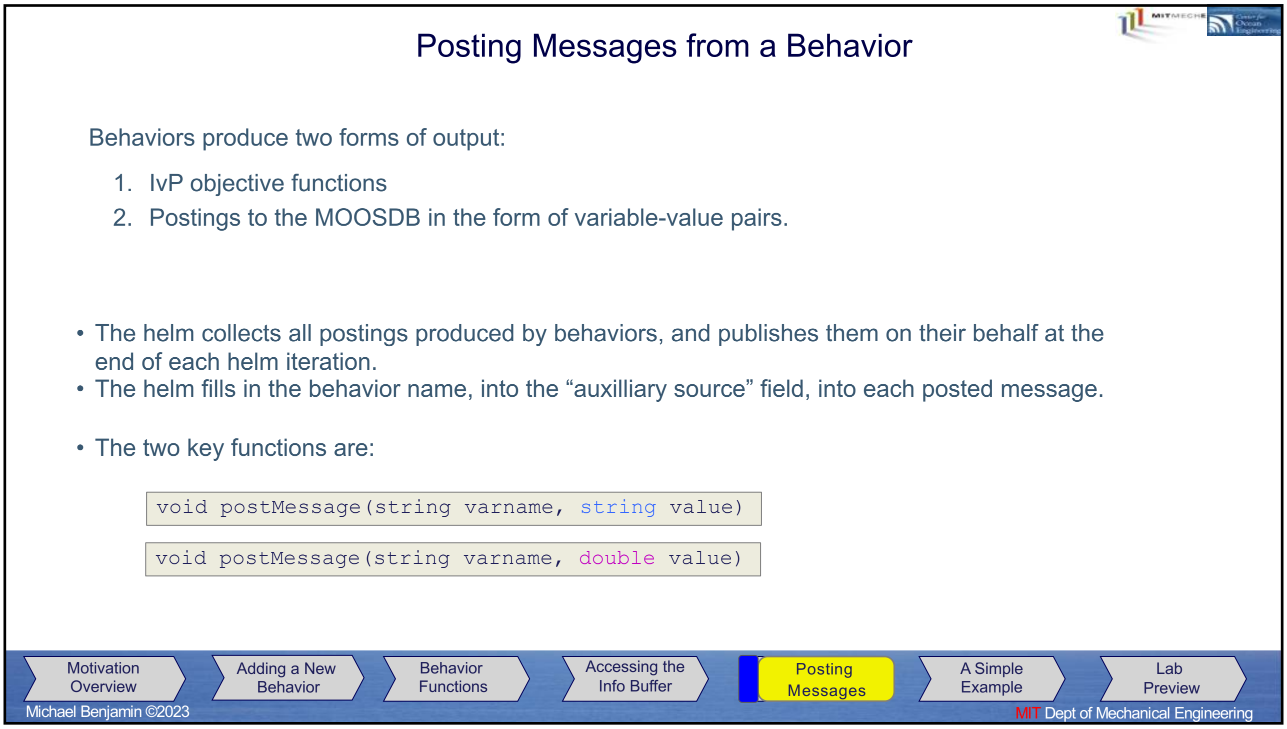

Posting Messages from a Behavior

Behaviors produce two forms of output:

1. IvP objective functions
2. Postings to the MOOSDB in the form of variable-value pairs.

- The helm collects all postings produced by behaviors, and publishes them on their behalf at the end of each helm iteration.
- The helm fills in the behavior name, into the “auxilliary source” field, into each posted message.

- The two key functions are:

```
void postMessage(string varname, string value)
```

```
void postMessage(string varname, double value)
```

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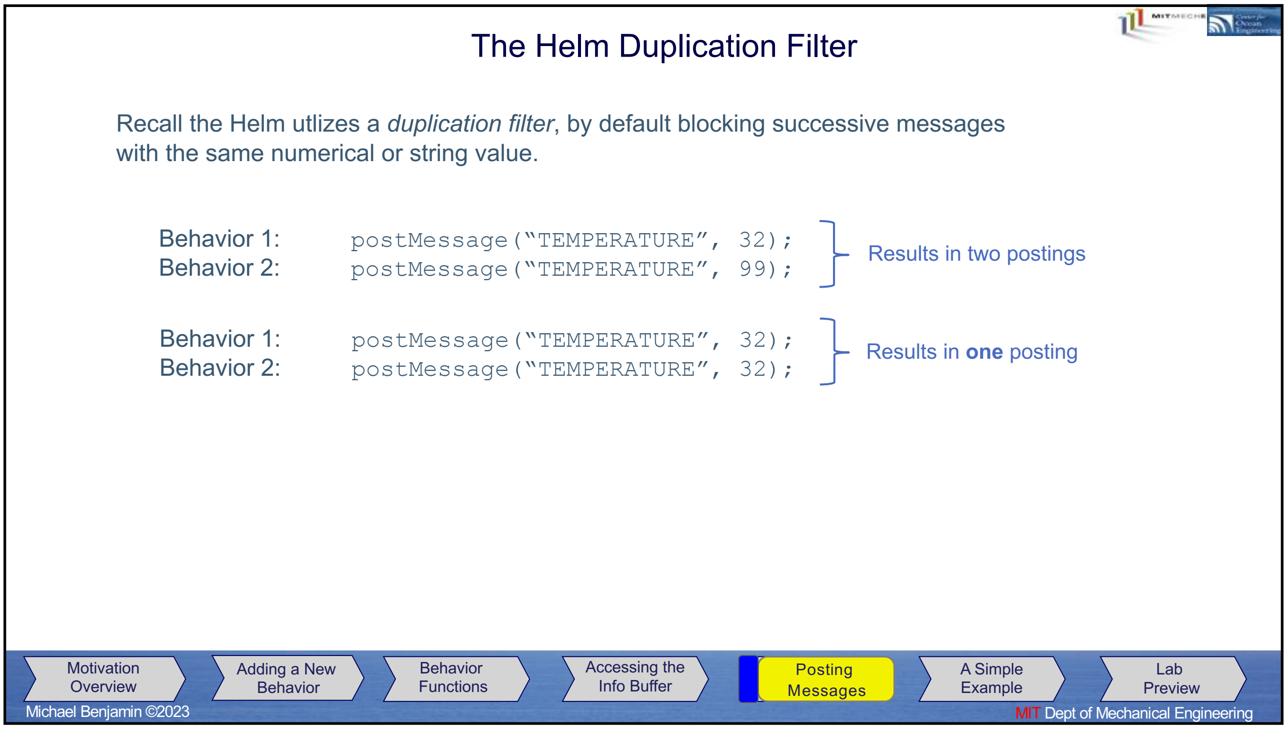

The Helm Duplication Filter

Recall the Helm utlizes a *duplication filter*, by default blocking successive messages with the same numerical or string value.

```
Behavior 1:     postMessage(“TEMPERATURE”, 32);
Behavior 2:     postMessage(“TEMPERATURE”, 99);
```

Results in two postings

```
Behavior 1:     postMessage(“TEMPERATURE”, 32);
Behavior 2:     postMessage(“TEMPERATURE”, 32);
```

Results in **one** posting

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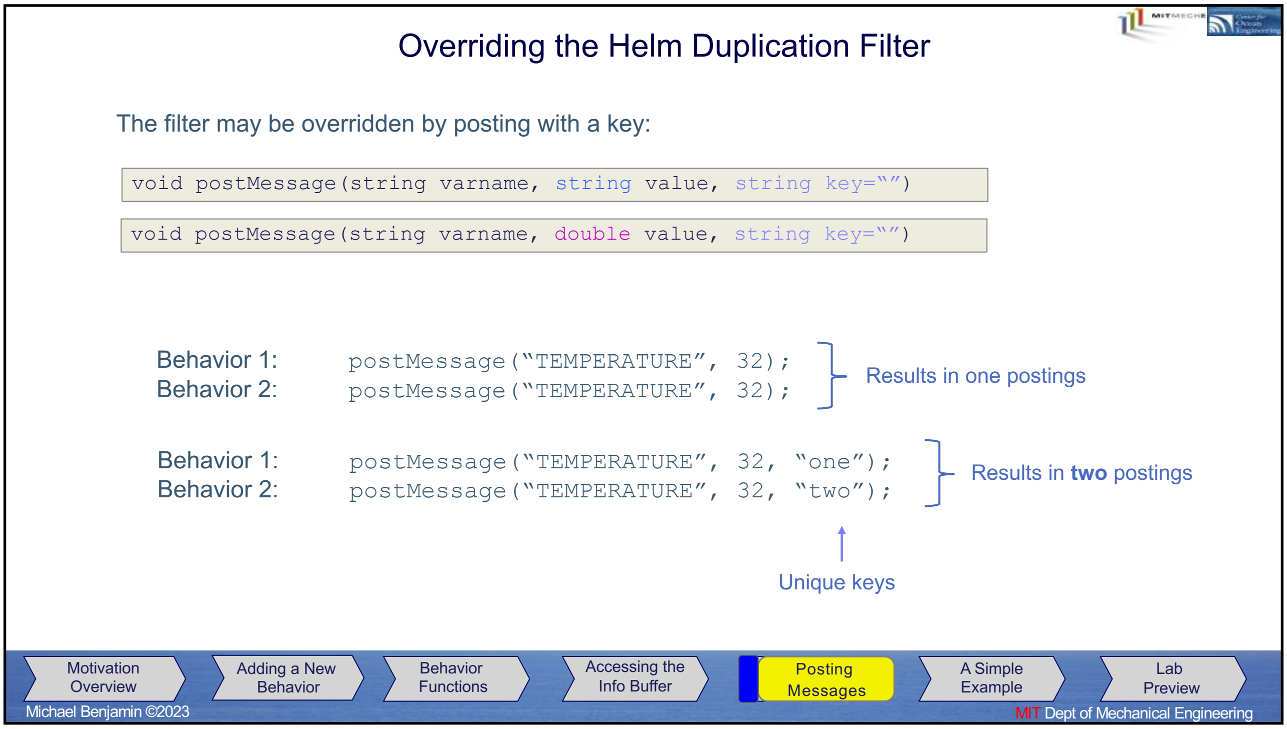

Overriding the Helm Duplication Filter

The filter may be overridden by posting with a key:

```
void postMessage(string varname, string value, string key=“”)
```

```
void postMessage(string varname, double value, string key=“”)
```

```
Behavior 1:     postMessage(“TEMPERATURE”, 32);
Behavior 2:     postMessage(“TEMPERATURE”, 32);
```

Results in one postings

```
Behavior 1:     postMessage(“TEMPERATURE”, 32, “one”);
Behavior 2:     postMessage(“TEMPERATURE”, 32, “two”);
```

Results in **two** postings

Unique keys

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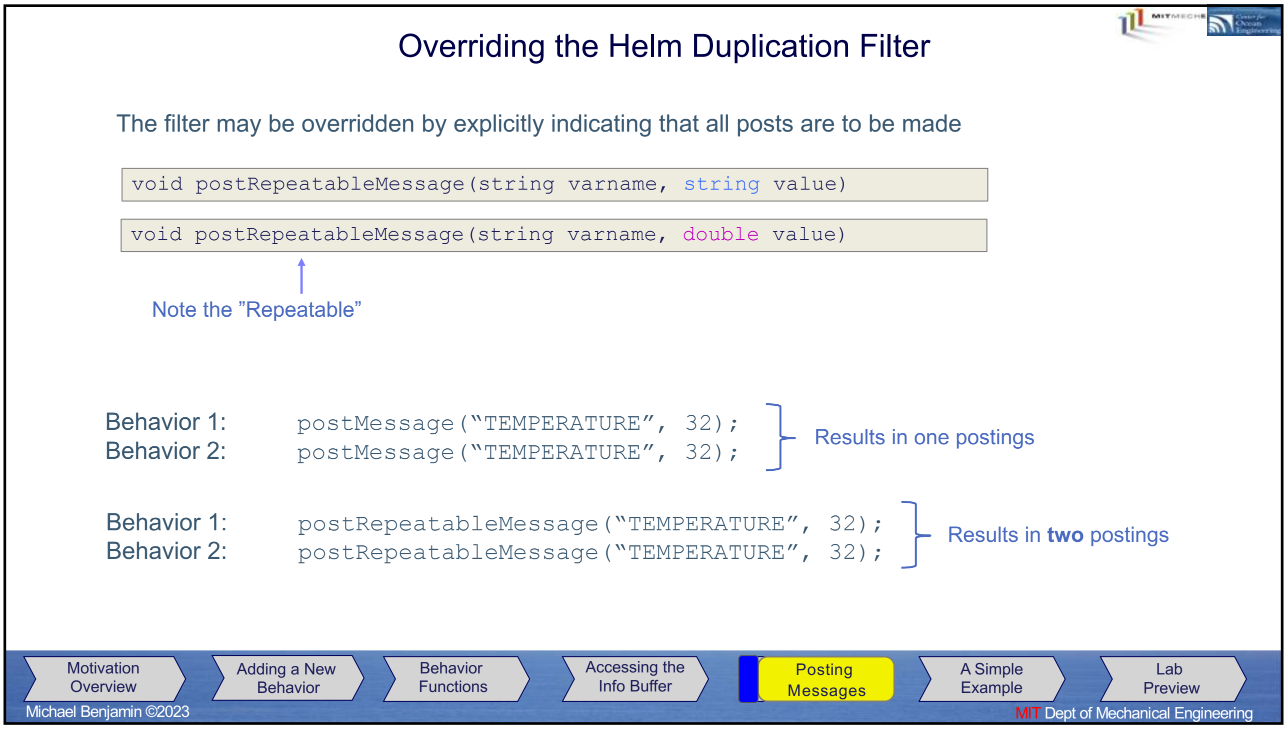

Overriding the Helm Duplication Filter

The filter may be overridden by explicitly indicating that all posts are to be made

```
void postRepeatableMessage(string varname, string value)
```

```
void postRepeatableMessage(string varname, double value)
```

Note the ”Repeatable”

```
Behavior 1:     postMessage(“TEMPERATURE”, 32);
Behavior 2:     postMessage(“TEMPERATURE”, 32);
```

Results in one postings

```
Behavior 1:     postRepeatableMessage(“TEMPERATURE”, 32);
Behavior 2:     postRepeatableMessage(“TEMPERATURE”, 32);
```

Results in **two** postings

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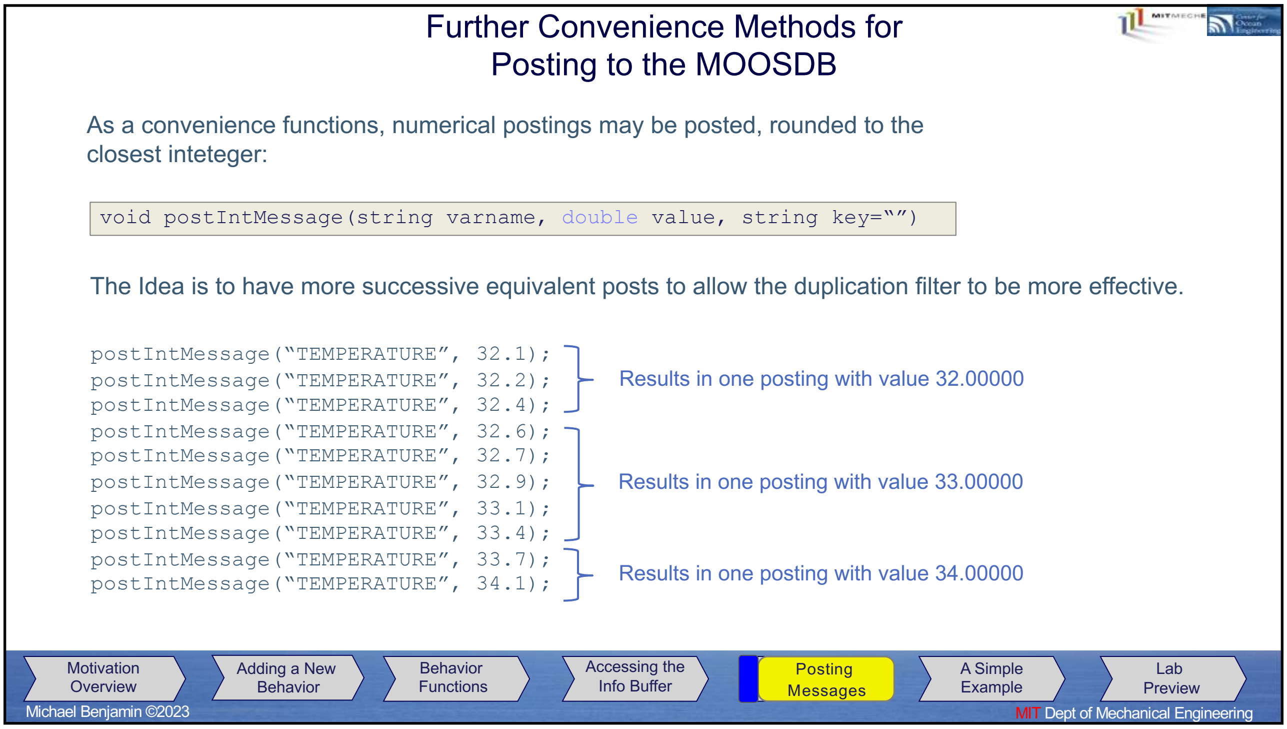

Further Convenience Methods for Posting to the MOOSDB

As a convenience functions, numerical postings may be posted, rounded to the closest inteteger:

```
void postIntMessage(string varname, double value, string key="")
```

The Idea is to have more successive equivalent posts to allow the duplication filter to be more effective.

```
postIntMessage("TEMPERATURE", 32.1);
postIntMessage("TEMPERATURE", 32.2);
postIntMessage("TEMPERATURE", 32.4);
```

Results in one posting with value 32.00000

```
postIntMessage("TEMPERATURE", 32.6);
postIntMessage("TEMPERATURE", 32.7);
postIntMessage("TEMPERATURE", 32.9);
postIntMessage("TEMPERATURE", 33.1);
postIntMessage("TEMPERATURE", 33.4);
```

Results in one posting with value 33.00000

```
postIntMessage("TEMPERATURE", 33.7);
postIntMessage("TEMPERATURE", 34.1);
```

Results in one posting with value 34.00000

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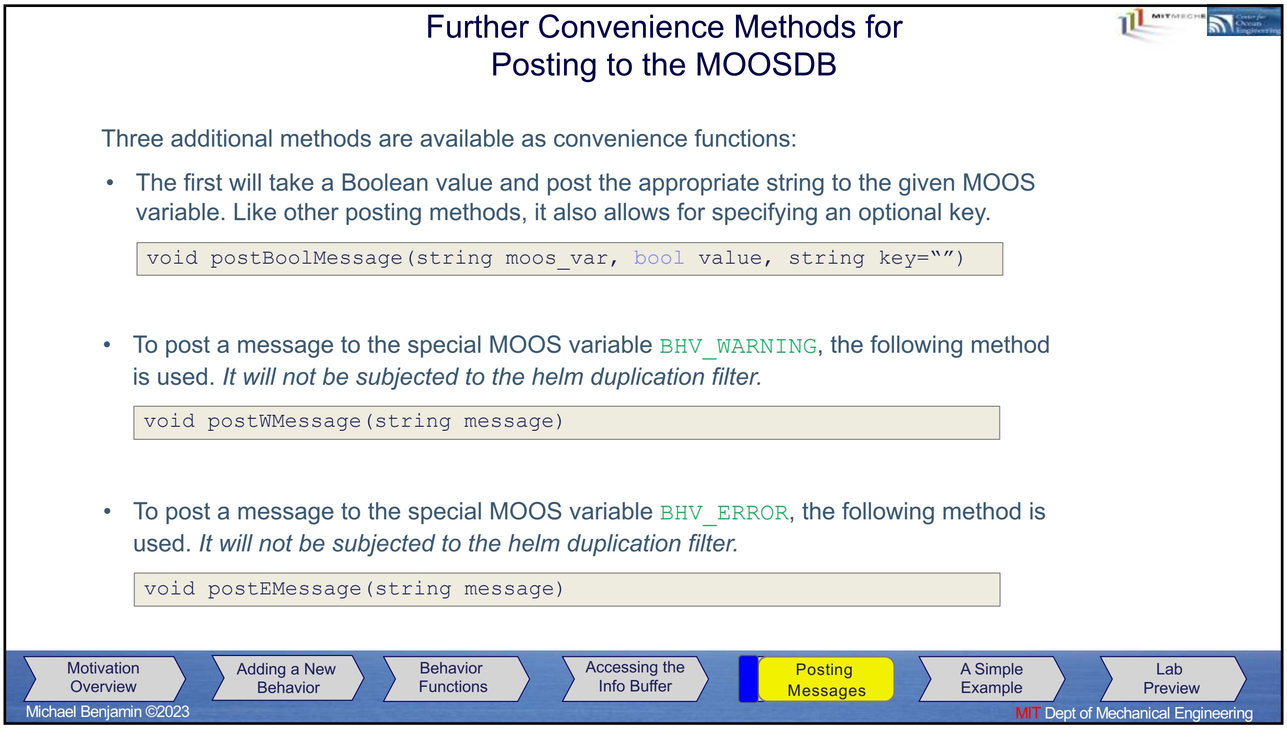

Further Convenience Methods for Posting to the MOOSDB

Three additional methods are available as convenience functions:

- The first will take a Boolean value and post the appropriate string to the given MOOS variable. Like other posting methods, it also allows for specifying an optional key.

```
void postBoolMessage(string moos_var, bool value, string key="")
```

- To post a message to the special MOOS variable `BHV_WARNING`, the following method is used. *It will not be subjected to the helm duplication filter.*

```
void postWMessage(string message)
```

- To post a message to the special MOOS variable `BHV_ERROR`, the following method is used. *It will not be subjected to the helm duplication filter.*

```
void postEMessage(string message)
```

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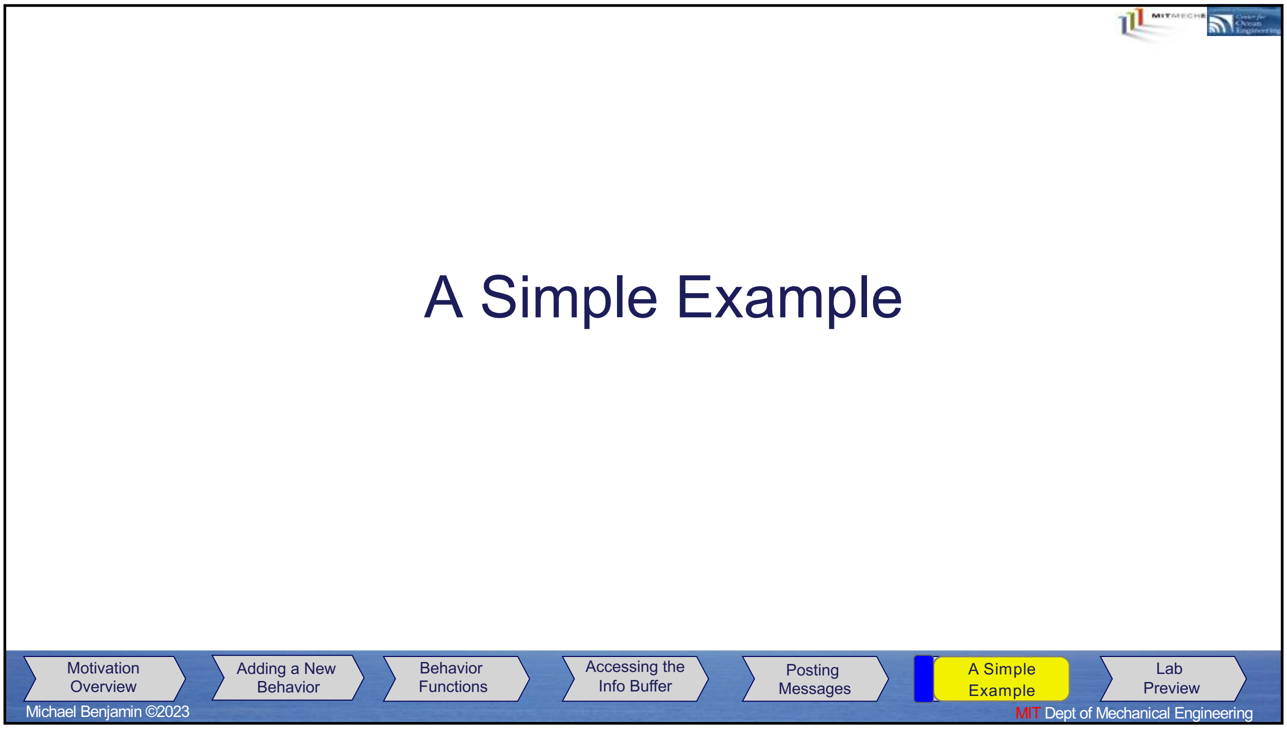

A Simple Example

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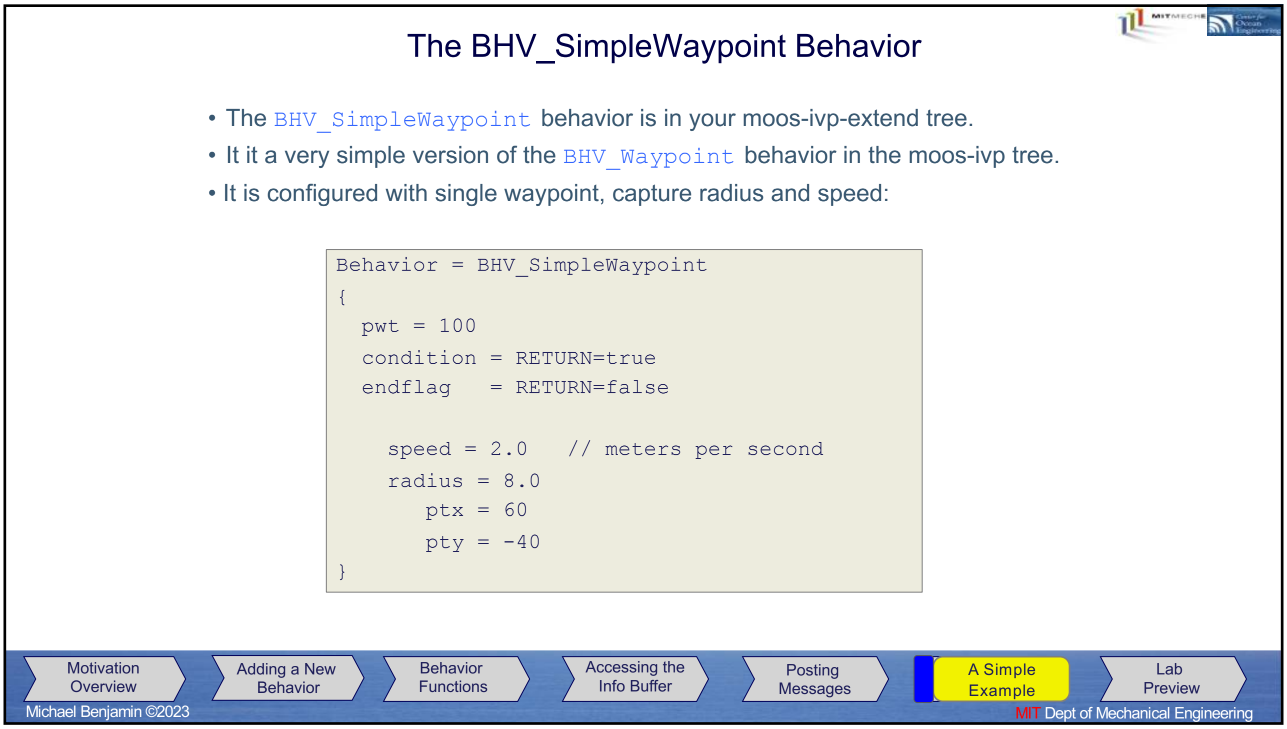

The BHV_SimpleWaypoint Behavior

- The BHV_SimpleWaypoint behavior is in your moos-ivp-extend tree.
- It it a very simple version of the BHV_Waypoint behavior in the moos-ivp tree.
- It is configured with single waypoint, capture radius and speed:

```
Behavior = BHV_SimpleWaypoint
{
  pwt = 100
  condition = RETURN=true
  endflag   = RETURN=false

    speed = 2.0   // meters per second
    radius = 8.0
       ptx = 60
       pty = -40
}
```

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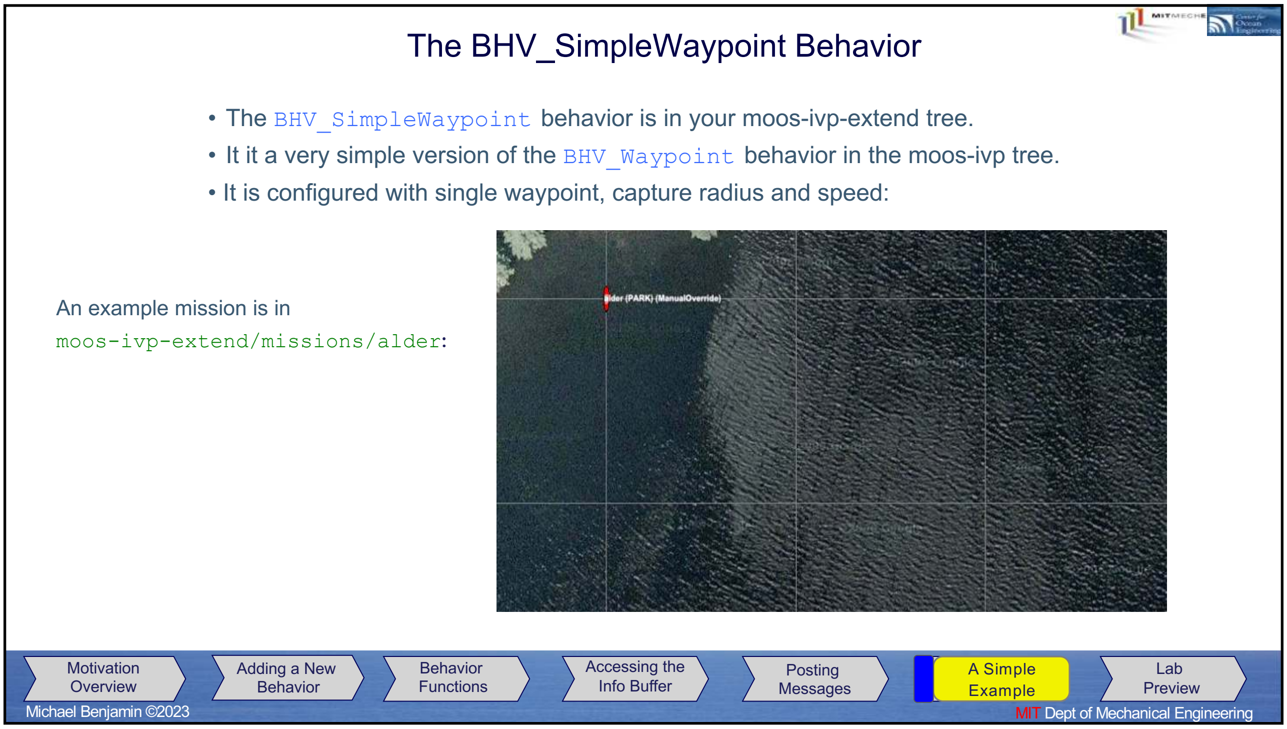

The BHV_SimpleWaypoint Behavior

- The `BHV_SimpleWaypoint` behavior is in your moos-ivp-extend tree.
- It it a very simple version of the `BHV_Waypoint` behavior in the moos-ivp tree.
- It is configured with single waypoint, capture radius and speed:

An example mission is in `moos-ivp-extend/missions/alder`:

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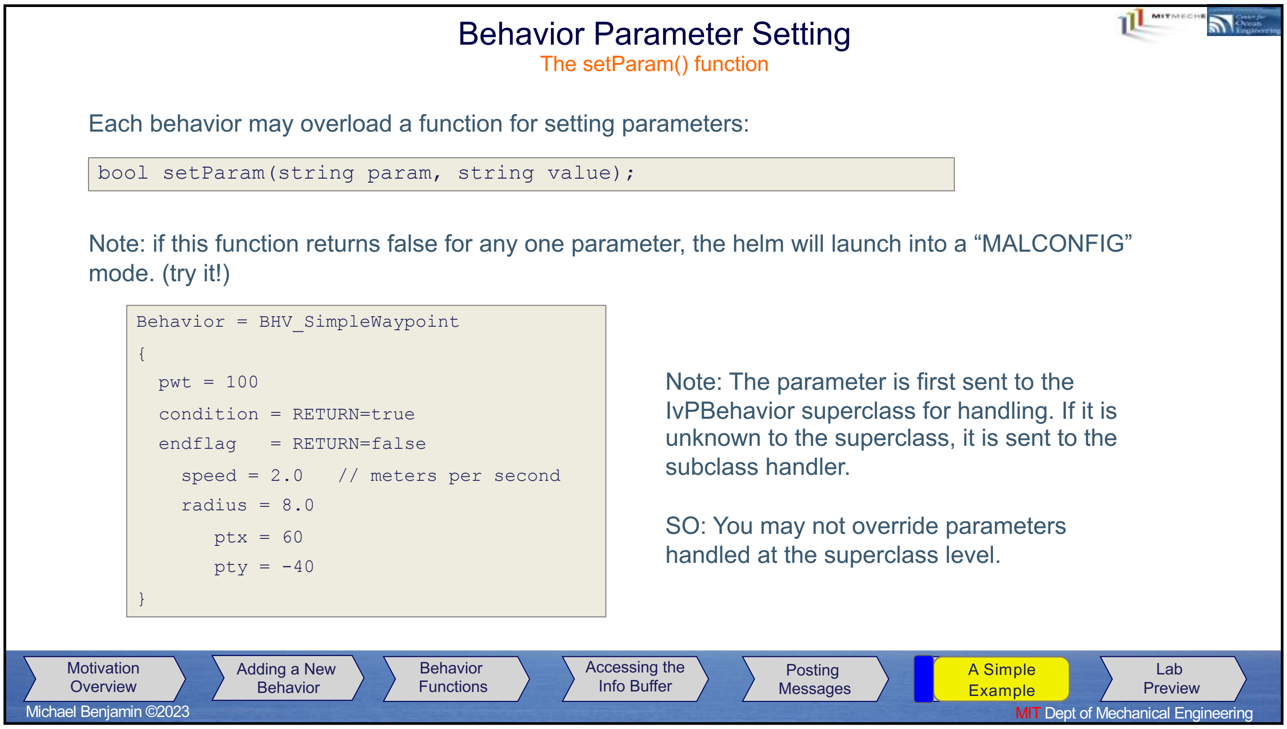

Behavior Parameter Setting

The setParam() function

Each behavior may overload a function for setting parameters:

```
bool setParam(string param, string value);
```

Note: if this function returns false for any one parameter, the helm will launch into a “MALCONFIG” mode. (try it!)

```
Behavior = BHV_SimpleWaypoint
{
  pwt = 100
  condition = RETURN=true
  endflag   = RETURN=false
    speed = 2.0   // meters per second
    radius = 8.0
       ptx = 60
       pty = -40
}
```

Note: The parameter is first sent to the IvPBehavior superclass for handling. If it is unknown to the superclass, it is sent to the subclass handler.

SO: You may not override parameters handled at the superclass level.

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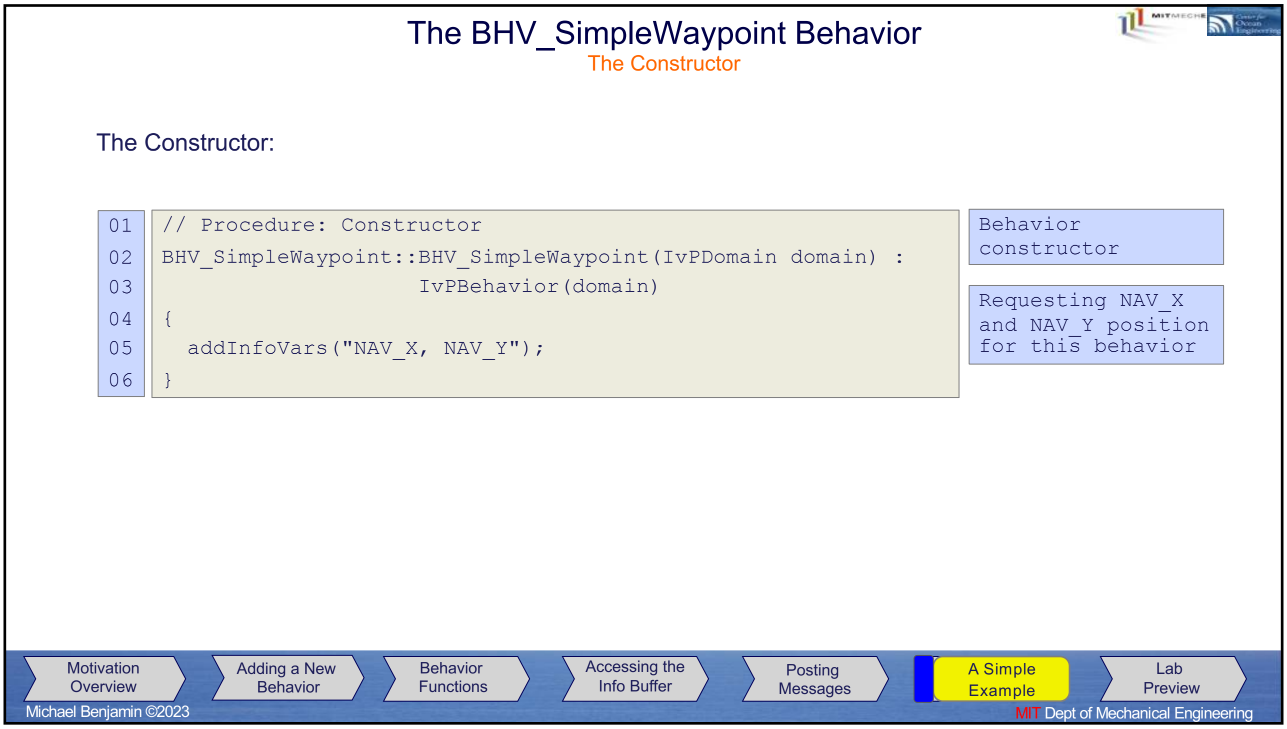

The BHV_SimpleWaypoint Behavior

The Constructor

The Constructor:

```
// Procedure: Constructor
BHV_SimpleWaypoint::BHV_SimpleWaypoint(IvPDomain domain) :
                    IvPBehavior(domain)
{
  addInfoVars("NAV_X, NAV_Y");
}
```

Behavior constructor

Requesting NAV_X and NAV_Y position for this behavior

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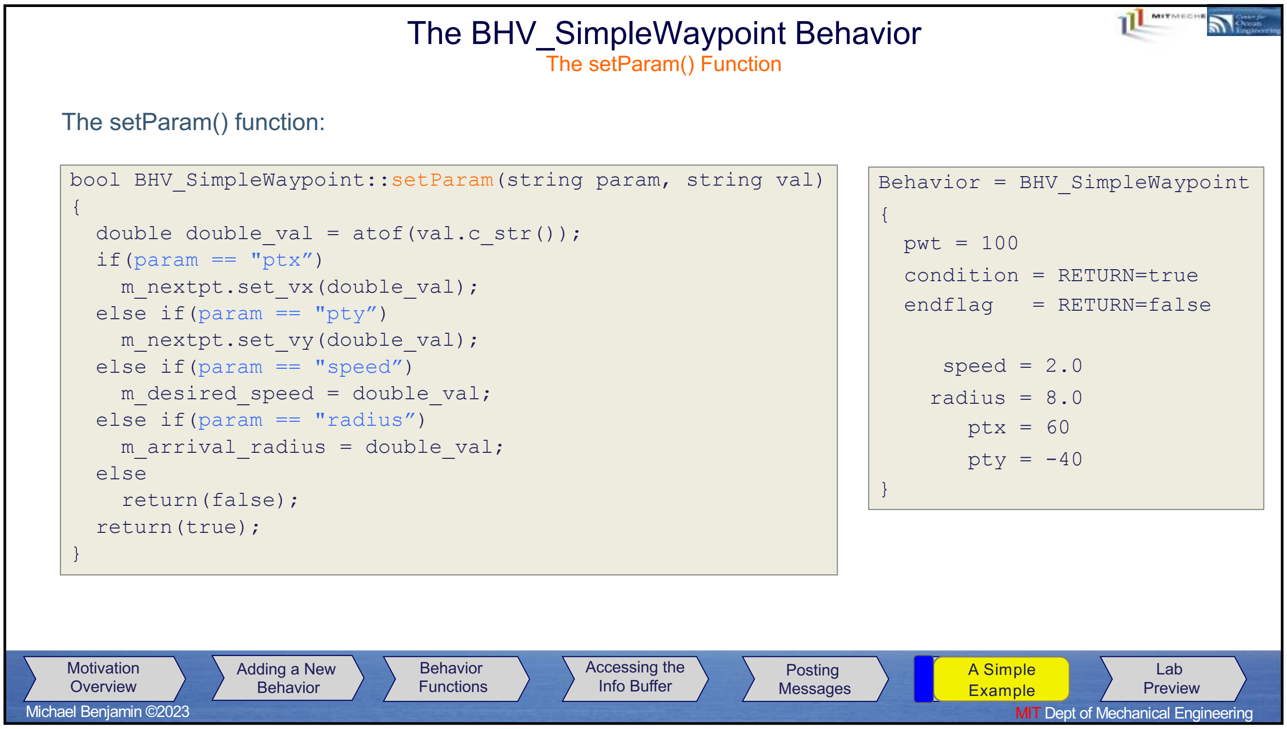

The BHV_SimpleWaypoint Behavior

The setParam() Function

The setParam() function:

```
bool BHV_SimpleWaypoint::setParam(string param, string val)
{
  double double_val = atof(val.c_str());
  if(param == "ptx”)
    m_nextpt.set_vx(double_val);
  else if(param == "pty”)
    m_nextpt.set_vy(double_val);
  else if(param == "speed”)
    m_desired_speed = double_val;
  else if(param == "radius”)
    m_arrival_radius = double_val;
  else
    return(false);
  return(true);
}
```

```
Behavior = BHV_SimpleWaypoint
{
  pwt = 100
  condition = RETURN=true
  endflag   = RETURN=false

     speed = 2.0
    radius = 8.0
       ptx = 60
       pty = -40
}
```

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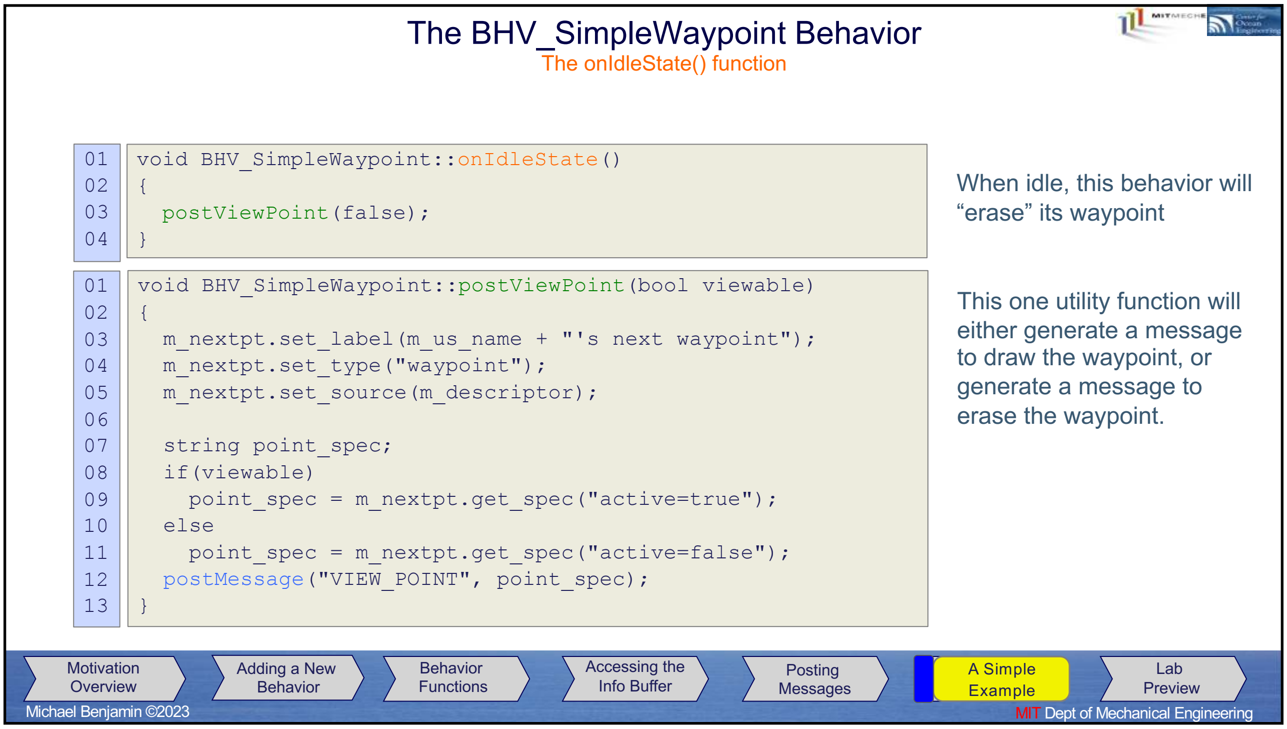


The BHV_SimpleWaypoint Behavior

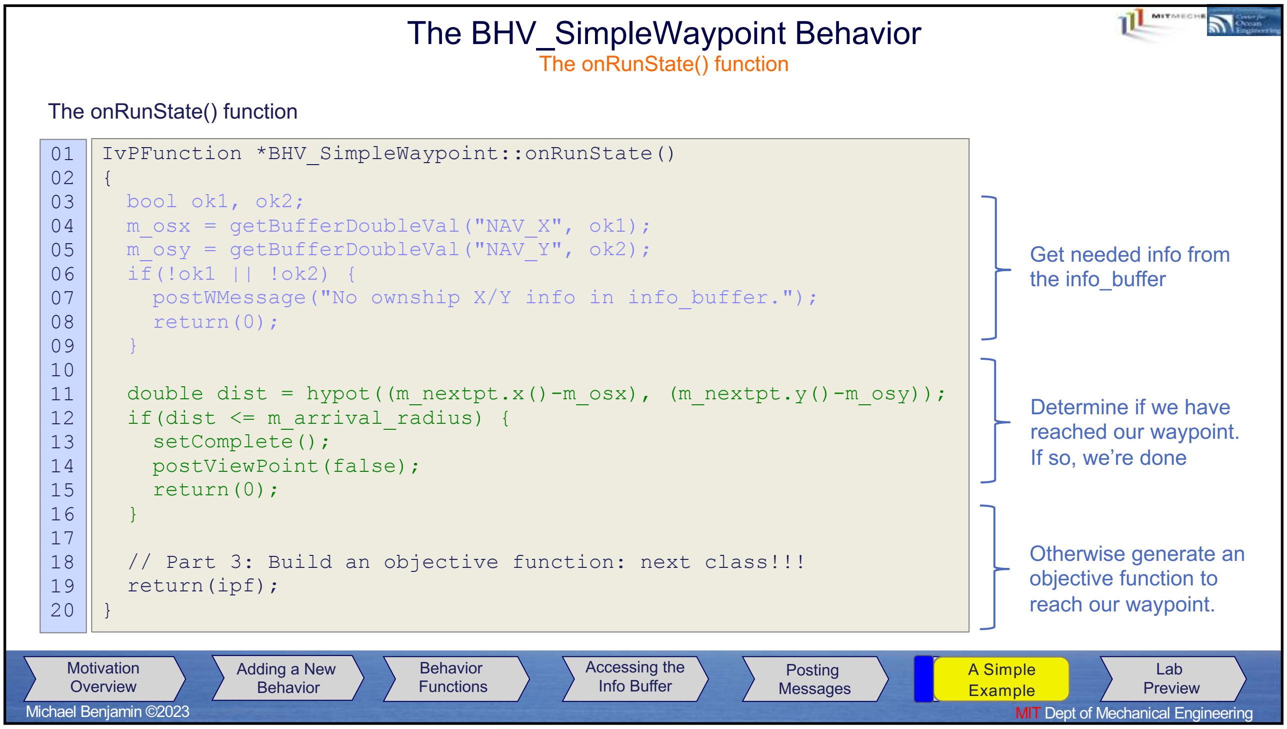
The onIdleState() function

```
void BHV_SimpleWaypoint::onIdleState()
{
  postViewPoint(false);
}
```

When idle, this behavior will "erase" its waypoint

```
void BHV_SimpleWaypoint::postViewPoint(bool viewable)
{
  m_nextpt.set_label(m_us_name + "'s next waypoint");
  m_nextpt.set_type("waypoint");
  m_nextpt.set_source(m_descriptor);

  string point_spec;
  if(viewable)
    point_spec = m_nextpt.get_spec("active=true");
  else
    point_spec = m_nextpt.get_spec("active=false");
  postMessage("VIEW_POINT", point_spec);
}
```

This one utility function will either generate a message to draw the waypoint, or generate a message to erase the waypoint.



The BHV_SimpleWaypoint Behavior

The onRunState() function

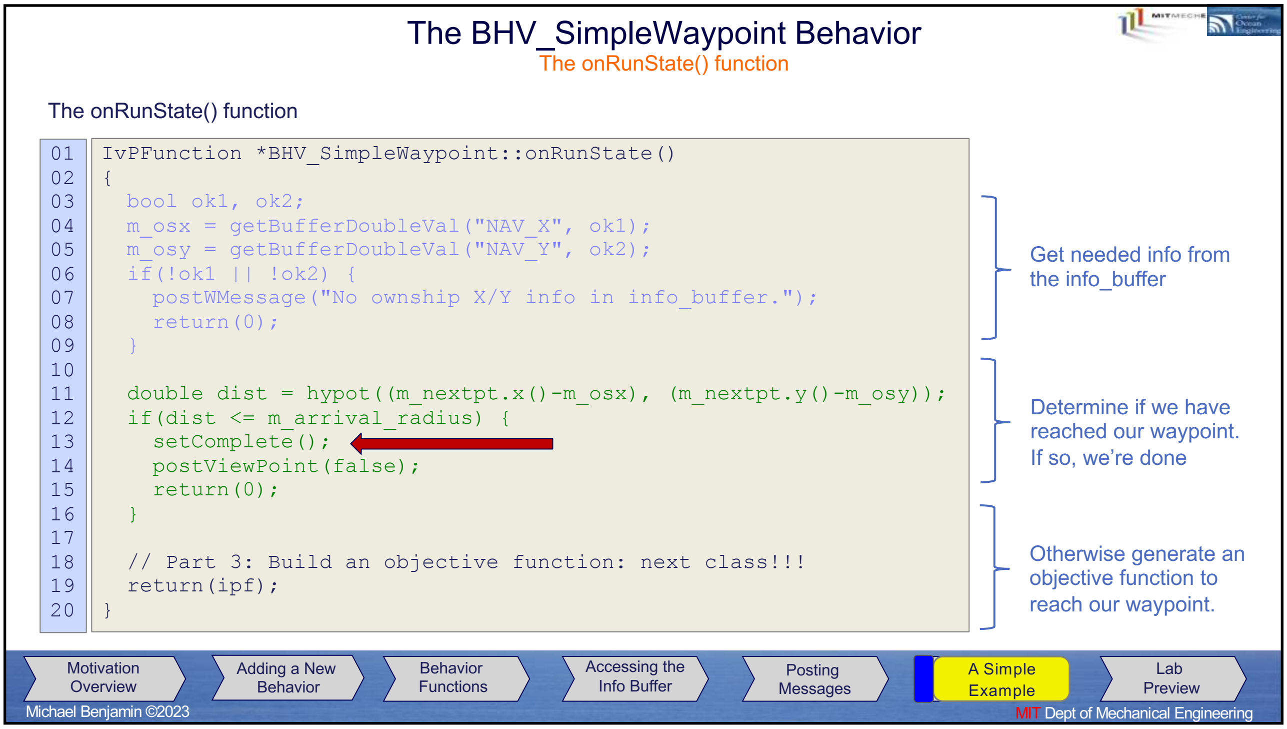
The onRunState() function

```
IvPFunction *BHV_SimpleWaypoint::onRunState()
{
  bool ok1, ok2;
  m_osx = getBufferDoubleVal("NAV_X", ok1);
  m_osy = getBufferDoubleVal("NAV_Y", ok2);
  if(!ok1 || !ok2) {
    postWMessage("No ownship X/Y info in info_buffer.");
    return(0);
  }

  double dist = hypot((m_nextpt.x()-m_osx), (m_nextpt.y()-m_osy));
  if(dist <= m_arrival_radius) {
    setComplete();
    postViewPoint(false);
    return(0);
  }

  // Part 3: Build an objective function: next class!!!
  return(ipf);
}
```

Get needed info from the info_buffer

Determine if we have reached our waypoint. If so, we're done

Otherwise generate an objective function to reach our waypoint.



The BHV_SimpleWaypoint Behavior

The onRunState() function

The onRunState() function

```
IvPFunction *BHV_SimpleWaypoint::onRunState()
{
  bool ok1, ok2;
  m_osx = getBufferDoubleVal("NAV_X", ok1);
  m_osy = getBufferDoubleVal("NAV_Y", ok2);
  if(!ok1 || !ok2) {
    postWMessage("No ownship X/Y info in info_buffer.");
    return(0);
  }

  double dist = hypot((m_nextpt.x()-m_osx), (m_nextpt.y()-m_osy));
  if(dist <= m_arrival_radius) {
    setComplete();
    postViewPoint(false);
    return(0);
  }

  // Part 3: Build an objective function: next class!!!
  return(ipf);
}
```

Get needed info from the info_buffer

Determine if we have reached our waypoint. If so, we're done

Otherwise generate an objective function to reach our waypoint.

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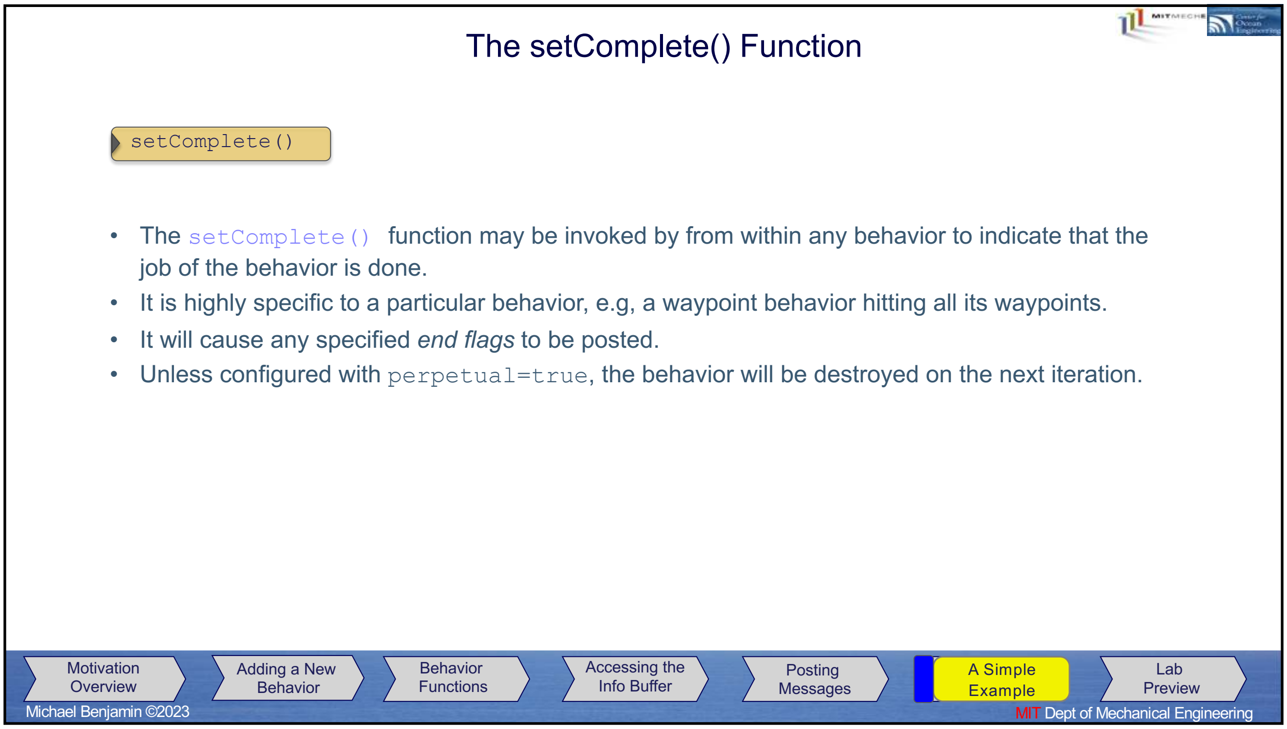

The setComplete() Function

`setComplete()`

- The `setComplete()` function may be invoked by from within any behavior to indicate that the job of the behavior is done.
- It is highly specific to a particular behavior, e.g, a waypoint behavior hitting all its waypoints.
- It will cause any specified *end flags* to be posted.
- Unless configured with `perpetual=true`, the behavior will be destroyed on the next iteration.

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Lab Preview

Lab 10 Introduction to Behavior Writing

- Generate of a new behavior class
- Add a behavior to the build system
- Obtain information from the information buffer into your behavior
- Overload general behavior functions to suit your needs
- Handle the setting of behavior parameters set by the user

https://vimeo.com/91971985

Lab 10 Introduction to Behavior Writing

- Modify / Extend the first behavior to produce a zig-zag leg each time it arrives at a waypoing.
- Learn how to use basic functionality of the IvPBuild Toolbox.

https://vimeo.com/91975349

THE END