

dcapp Installation and User Guide

version 1.0

NASA Johnson Space Center



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1.0 Introduction

"dcapp" (pronounced "dee see app") is a displays and controls software package designed for UNIX platforms, specifically MacOS and Linux. It is built upon standard UNIX technologies like OpenGL for graphics, libxml2 for input file parsing, and FreeType2 for font handling. For window management and event handling, it uses Cocoa on MacOS machines and X11 for Linux-based machines. It has built-in communication libraries to communicate with external Trick-based simulations (via `trick_comm`) and EDGE graphics (via EDGE's remote commanding server (RCS)).

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2.0 Installation

2.1 Mandatory Prerequisites

dcapp is designed to run on MacOS and Linux-based machines. For all of the packages described hereafter, be sure to get "development" versions that include header files. These packages must be installed before building or running dcapp:

- OpenGL
- libxml2
- FreeType2

OpenGL is a standard environment for developing portable, interactive 2D and 3D graphics applications. It is a standard package on most MacOS and Linux installations, but it can be accessed at <http://www.opengl.org> if needed.

libxml2 is an XML file parser that is a standard package on most MacOS and Linux installations, but it can be accessed at <http://xmlsoft.org> if needed.

FreeType2 is a freely available software library for rendering fonts. It is capable of producing high-quality output (glyph images) of most vector- and bitmap- font formats. It is a standard package on most MacOS and Linux installations, but it can be accessed at <http://www.freetype.org> if needed.

2.2 Optional Prerequisites

If the user wants to use JPEG images in a dcapp display, then they should install either libjpeg or libjpeg-turbo on their computer prior to building dcapp. dcapp will build just fine without one of these packages, but it won't be able to process JPEG images unless one of the packages is properly installed.

If dcapp is to be run in conjunction with a Trick simulation, then the `trick-gte` command (or the `gte` command for Trick version 15 and earlier) must be accessible via the command line for dcapp to build correctly. Also, a stand-alone version of `trick_comm` must be successfully built prior to building dcapp. `trick_comm` is a Trick library that provides an interface to a Trick simulation via the Trick variable server. Note that Trick does not automatically build the stand-alone version of `trick_comm`. To build the stand-alone version of `trick_comm`, install Trick, `cd` to `${TRICK_HOME}`, and type "`make stand_alone`". Note that dcapp should work well with any Trick release numbered 10.2 or higher.

dcapp can be configured to monitor hardware inputs (dials, switches, etc.) via a controller area network (CAN) bus. CAN is a serial bus protocol used to connect individual systems and sensors over a single- or dual-wire networked data bus. Be sure that the CAN bus software is appropriately built and that the `CANBUS_HOME` environment variable is set to the directory containing the necessary header and library files.

2.3 dcapp

Extract the dcapp package if necessary, `cd` to the top level of the package, and type "`make`". This should build the dcapp executable within the `dcapp.app/Contents/${OSSPEC}` subdirectory, where `OSSPEC` corresponds to "MacOS" on MacOS systems or to `${OSTYPE}_${MACHTYPE}` otherwise (note that if `OSTYPE` and/or `MACHTYPE` aren't set, they are set to ``uname -s`` (converted to lower case) and to ``uname -m`` respectively). You should then add the `dcapp.app/Contents/${OSSPEC}` subdirectory to your `$PATH` environment variable if you intend to launch dcapp from the command line.

3.0 Activation

After following the instructions in section 2, simply type the following on the command line to activate dcapp:

```
dcapp file.xml [const=value...]
```

where `file.xml` is a full or partial path to a valid dcapp specfile (see section 4 for more information on dcapp specfiles). Note that the optional "`const=value`" constructs may be used as many times as needed to override the value of any constants defined within the specfile.

For instance, if a user wants to run dcapp with a specfile called myspec.xml but overriding the constants “WinWidth” and “WinHeight” with “480” and “640” respectively, the user would type the following command:

```
dcapp myspec.xml WinWidth=480 WinHeight=640
```

Note that on MacOS, an alternative to launching dcapp via the command line is to use dcapp.app, which is automatically built during the “make” step described in section 2.3. dcapp.app can be launched like any MacOS application (double clicking it, launching it from the Dock, etc.). It brings up a simple user interface that requests the information described above from the user, then proceeds to launch dcapp accordingly.

4.0 Specfile

The dcapp specfile is a standard XML file used to customize the features and capabilities of dcapp. See <http://www.w3.org/XML/> for more information about XML files, including valid file specifications, definition and usage of character entities, use of comments, etc. The elements contained within the dcapp specfile are detailed in this section.

4.1 Root Element

Element	DCAPP
Parent	(none)
Children	(any)
Attributes	(none)
Description	All dcapp specfiles must contain this root element. All of the other elements, described in the following sections, must be enclosed within this root element.

4.2 Universal Elements

These elements may appear anywhere within the dcapp specfile, and they may be embedded within any element that allows children.

Element	Dummy
Parent	(any)
Children	(any)
Attributes	(none)
Description	This element does nothing besides allowing the user to group sub-elements. This is potentially useful when using XML’s <xi:include> element, which requires included files to be “well-formed”, which means, among other things, that the file must contain only one element at its root level.

Element	Include
Parent	(any)
Children	(any)
Attributes	(none)
Description	This element inserts the contents of a separate file into this portion of the specfile. The content of this element must point to a valid XML file containing valid dcapp data via an absolute path or a path relative to the specfile.

Element	If
Parent	(any)
Children	True, False, (any)
Attributes	Operator, Value, Value1, Value2
Description	This element applies the <i>Operator</i> (one of “eq”, “ne”, “gt”, “lt”, “ge”, or “le”) to <i>Value1</i> and <i>Value2</i> to evaluate a true or false condition. If no <i>Operator</i> is defined, then it simply tests <i>Value</i> to determine true or false. If the logic evaluates to true, then the sub-elements within the “True” element are processed, otherwise, the sub-elements within the “False” element are processed. If there is no “True” or “False” sub-element defined, the contents of this element are assumed to be contained within a virtual “True” element.

Element	True
Parent	If
Children	(any)
Attributes	(none)
Description	This element simply encloses sub-elements that are to be processed if the logic of the encompassing “If” element resolves to “true”.

Element	False
Parent	If
Children	(any)
Attributes	(none)
Description	This element simply encloses sub-elements that are to be processed if the logic of the encompassing “If” element resolves to “false”.

Element	Set
Parent	(any)
Children	(none)
Attributes	Variable, Operator, MinimumValue, MaximumValue
Description	This sets the value of <i>Variable</i> to a new value defined by the content of the element. The <i>Operator</i> is “=” by default, but may also be “+=” or “-=” if this element is to be used to increment or decrement <i>Variable</i> (usable only if <i>Variable</i> is a numeric type). <i>MinimumValue</i> and

	<i>MaximumValue</i> may optionally be set to bound the new numeric value.
--	---

Element	Animation
Parent	(any)
Children	Set, If
Attributes	Duration
Description	For each embedded “Set” element, this takes a snapshot of the current value and gradually sets it to the specified value over the course of the specified <i>Duration</i> . This is done linearly over each execution of dcapp until <i>Duration</i> is reached, at which point this element goes dormant until it is invoked again.

4.3 Initialization Elements

These elements typically appear near the top of the dcapp specfile. They define the behavior of subsequent elements within the specfile.

4.3.1 Settings Elements

Element	Constant
Parent	DCAPP
Children	(none)
Attributes	Name
Description	This allows a user to create a constant that can be accessed subsequently within the specfile. This is handy for setting values that are used frequently throughout the display. For instance, the user may set: <code><Constant Name="FontSize">24</Constant></code> The pre-processor will then replace all instances of “#FontSize” in the rest of the specfile with “24”.

Element	Variable
Parent	DCAPP
Children	Type, InitialValue
Attributes	(none)
Description	This allows a user to create a variable that can be accessed subsequently within the specfile. The <i>Type</i> must be either “Float”, “Integer”, or “String”. For instance, the user may set: <code><Variable Type="Integer">MyVar</Variable></code> Any subsequent elements may then use the associated value by specifying a value of “@MyVar”. Note that if <i>InitialValue</i> is not specified, the default value is 0 for float and integer parameters and an empty string (“”) for string parameters.

Element	Style
Parent	DCAPP

Children	(any)
Attributes	Name
Description	<p>This allows a user to define a style, which defines attributes for any element that is used subsequently within the specfile. For instance, the user may set:</p> <pre><Style Name="mystyle"> <String Size="28" Color="0 0 1"/> </Style></pre> <p>Then, a subsequent "String" element that uses "mystyle" (<String style="mystyle"...>) will be blue and use a font size of 28 by default. Note that multiple elements may be defined within a single "Style" element.</p>

Element	Defaults
Parent	DCAPP
Children	(any)
Attributes	(none)
Description	<p>This allows a user to define default attributes for any element that is used subsequently within the specfile. For instance, the user may set:</p> <pre><Defaults> <Rectangle LineWidth="2" LineColor="1 0 0"/> </Defaults></pre> <p>Then, all subsequent "Rectangle" elements will be rendered with a red line that is 2 pixels thick by default. Note that multiple elements may be defined within a single "Defaults" element.</p>

4.3.2 Input/Output Elements

Element	TrickIo
Parent	DCAPP
Children	FromTrick, ToTrick
Attributes	Host, Port, DataRate, DisconnectAction
Description	<p>This construct specifies communication between dcapp and the Trick variable server. <i>Host</i> specifies the hostname upon which the Trick simulation is executing. If not specified, the default value is the hostname of the machine upon which dcapp is executing. <i>Port</i> specifies the port over which communication with the Trick variable server takes place. If not specified, the default value is 7000. <i>DataRate</i> specifies the data rate (in seconds) at which Trick will attempt to communicate with dcapp. If not specified, the default value is 1 second. <i>DisconnectAction</i> defines the action that dcapp takes if it loses connection with Trick. Options are "Terminate" or "Reconnect", with "Terminate" being the default action if none is specified. Note that the values for <i>Host</i> and <i>Port</i> may be overridden by the command-line arguments outlined in section 3.</p>

Element	FromTrick
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Parent	TrickIo
Children	TrickVariable
Attributes	(none)
Description	This contains a list of the “TrickVariable” elements that are used to over-write dcapp data with data from the attached Trick simulation.

Element	ToTrick
Parent	TrickIo
Children	TrickVariable
Attributes	(none)
Description	This contains a list of the “TrickVariable” elements that are used to over-write Trick simulation data with data from dcapp.

Element	TrickVariable
Parent	FromTrick, ToTrick
Children	(none)
Attributes	Name, Units
Description	This element attaches a dcapp “Variable” to the variable in the attached Trick simulation defined by <i>Name</i> . The user may optionally define the <i>Units</i> of the data within dcapp, which the Trick variable server will use to convert the data, if necessary. The <i>Units</i> must be a unit string recognizable by Trick. For instance: <TrickVariable Name="trickobj.var">MyVar</TrickVariable>

Element	EdgeIo
Parent	DCAPP
Children	FromEdge, ToEdge
Attributes	Host, Port, DataRate
Description	This construct specifies communication between dcapp and EDGE via EDGE's remote commanding server. <i>Host</i> specifies the hostname upon which EDGE is executing. If not specified, the default value is the hostname of the machine upon which dcapp is executing. <i>Port</i> specifies the port over which communication with EDGE takes place. If not specified, the default value is 5451. <i>DataRate</i> specifies the data rate (in seconds) at which EDGE will be polled by dcapp. If not specified, the default value is 1 second.

Element	FromEdge
Parent	EdgeIo
Children	EdgeVariable
Attributes	(none)
Description	This contains a list of the “EdgeVariable” elements that are used to over-write dcapp data with data from the attached EDGE instance. For instance: <EdgeVariable RcsCommand="doug.node Light set -

	<code>lit_int">LightCmd</EdgeVariable></code>
--	--

Element	ToEdge
Parent	EdgeIo
Children	EdgeVariable
Attributes	(none)
Description	This contains a list of the “EdgeVariable” elements that are used to over-write EDGE data with data from dcapp.

Element	EdgeVariable
Parent	FromEdge, ToEdge
Children	(none)
Attributes	RcsCommand
Description	This element attaches a dcapp “Variable” to the variable in the attached EDGE instance defined by <i>RcsCommand</i> .

Element	CAN
Parent	DCAPP
Children	(none)
Attributes	Network, ButtonID, ControlID
Description	This element assigns bezel keys to data associated with a CAN bus based upon <i>Network</i> , <i>ButtonID</i> , and <i>ControlID</i> of the unit associated with this instance of dcapp. The bezel keys are processed via the “Button” and/or “BezelEvent” elements.

Element	UEI
Parent	DCAPP
Children	(none)
Attributes	Host, Port, BezelID
Description	This element assigns bezel keys to data associated with a UEI controller based upon the <i>Host</i> and <i>Port</i> of the UEI and the <i>BezelID</i> of the unit associated with this instance of dcapp. The bezel keys are processed via the “Button” and/or “BezelEvent” elements.

4.3.3 Logic Element

Element	DisplayLogic
Parent	DCAPP
Children	(none)
Attributes	(none)
Description	The content of this element specifies a shared object file to be linked into dcapp at execution time. See section 5.3 for more information about the format and content of this file.

4.4 Display Setup

Element	Window
Parent	DCAPP
Children	Panel
Attributes	X, Y, Width, Height, FullScreen, ActiveDisplay, ForceUpdate
Description	This defines the position (<i>X</i> and <i>Y</i>) and size (<i>Width</i> and <i>Height</i>) of the window containing the dcapp displays. If <i>FullScreen</i> is set to “true”, “yes”, or “on”, the window will be rendered full screen regardless of <i>X</i> , <i>Y</i> , <i>Width</i> , and <i>Height</i> settings. The <i>ActiveDisplay</i> attribute allows the user to assign a variable to determine which display is active at any given time. If the value of this variable corresponds to the <i>DisplayIndex</i> of a given panel (see below), then that panel becomes the active display. By default, dcapp only updates when it senses an event (a mouse event, input data change, etc.), but the user may set <i>ForceUpdate</i> to specify an interval, in seconds, after which dcapp will automatically update.

Element	Panel
Parent	Window
Children	(display primitives)
Attributes	DisplayIndex, BackgroundColor, VirtualWidth, VirtualHeight
Description	This contains all of the display primitives for a given display panel. The <i>DisplayIndex</i> attribute is used to define when this display is the active display. <i>BackgroundColor</i> specifies the background color for the panel. See section 5.1 for information on specifying color. If not specified, the default color is black (“0 0 0”). <i>VirtualWidth</i> and <i>VirtualHeight</i> define the user-specified geometry of the display panel, which is used to render the position and size of the display primitives. If not specified, the default geometry is 100x100 units.

4.5 Display Primitives

The display primitives are the building blocks that define how the individual display panels look, feel, and react to user input. They are grouped into two primary classifications: visual primitives, which are primitives that render data to the screen, and event primitives, which are primitives that handle user input.

4.5.1 Visual Primitives

Element	Container
Parent	Panel, Container, Button, Active, Inactive, On, Transition, Off
Children	(display primitives)
Attributes	X, Y, Width, Height, HorizontalAlign, VerticalAlign, VirtualWidth, VirtualHeight, Rotate

Description	This redefines the coordinate frame for subsequent primitives by allowing the user to define a box of size <i>Width</i> by <i>Height</i> at position <i>X</i> , <i>Y</i> , and aligned by <i>HorizontalAlign</i> and <i>VerticalAlign</i> , within the current coordinate frame. The new coordinate frame can also be rotated by <i>Rotate</i> degrees from the current coordinate frame, and the new coordinate frame uses <i>VirtualWidth</i> and <i>VirtualHeight</i> to define the width and height of subsequent elements within the new frame.
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Element	Line
Parent	Panel, Container, Button, Active, Inactive, On, Transition, Off
Children	Vertex
Attributes	LineWidth, Color
Description	This attaches the enclosed “Vertex” primitives to form a single, continuous line with the specified <i>LineWidth</i> and <i>Color</i> .

Element	Polygon
Parent	Panel, Container, Button, Active, Inactive, On, Transition, Off
Children	Vertex
Attributes	FillColor, LineColor, LineWidth
Description	This attaches the enclosed “Vertex” primitives to form a polygon. The polygon is filled with <i>FillColor</i> and outlined with a line of color <i>LineColor</i> and a width of <i>LineWidth</i> . If <i>FillColor</i> is not set, then the polygon is not filled. Likewise, if <i>LineColor</i> and <i>LineWidth</i> are not set, then the polygon is not outlined.

Element	Vertex
Parent	Panel, Container, Button, Active, Inactive, On, Transition, Off
Children	(none)
Attributes	X, Y
Description	This defines the <i>X</i> and <i>Y</i> coordinates of a vertex within a “Line” or “Polygon” primitive.

Element	Rectangle
Parent	Panel, Container, Button, Active, Inactive, On, Transition, Off
Children	(none)
Attributes	X, Y, Width, Height, HorizontalAlign, VerticalAlign, Rotate, FillColor, LineColor, LineWidth
Description	This renders a rectangle based upon the location, size, alignment, and orientation specified by the user. The rectangle is filled with <i>FillColor</i> and outlined with a line of color <i>LineColor</i> and a width of <i>LineWidth</i> . If <i>FillColor</i> is not set, then the rectangle is not filled. Likewise, if <i>LineColor</i> and <i>LineWidth</i> are not set, then the rectangle is not outlined.

Element	Circle
Parent	Panel, Container, Button, Active, Inactive, On, Transition, Off

Children	(none)
Attributes	X, Y, HorizontalAlign, VerticalAlign, Radius, Segments, FillColor, LineColor, LineWidth
Description	This renders a circle based upon the location, radius, and alignment specified by the user. The user may also specify the number of straight-line segments used to render the circle via <i>Segments</i> (default is 80). The circle is filled with <i>FillColor</i> and outlined with a line of color <i>LineColor</i> and a width of <i>LineWidth</i> . If <i>FillColor</i> is not set, then the circle is not filled. Likewise, if <i>LineColor</i> and <i>LineWidth</i> are not set, then the circle is not outlined.

Element	String
Parent	Panel, Container, Button, Active, Inactive, On, Transition, Off
Children	(none)
Attributes	X, Y, Rotate, Size, HorizontalAlign, VerticalAlign, Color, BackgroundColor, ShadowOffset, Font, Face, ForceMono
Description	This renders a character string based on the location, size, alignment, and rotation specified by the user. The user may also specify the <i>Font</i> and <i>Face</i> . Note that <i>Font</i> must point to a valid FreeType-accessible font file (most modern font files are FreeType-accessible) via an absolute path or a path relative to the specfile. Different font files offer different options for <i>Face</i> , but typical options include “Bold”, “Italic”, etc., and if <i>Face</i> is not specified, the default face for the font is used. The <i>ForceMono</i> optional flag accommodates three possible values: “Numeric”, “Alphanumeric”, or “All”. This allows the user to render some or all of the characters in a variable-width font as fixed width. The user may specify font <i>Color</i> with an optional <i>BackgroundColor</i> , and <i>ShadowOffset</i> allows the user to specify the offset of a shadow to be rendered behind the font (no shadow is rendered if <i>ShadowOffset</i> is not set). The content of this element is the string to be rendered, and it may contain static text, variable text, or both. dcapp variables may be accessed using the ampersand: “@MyVar”, as well as an optional C-format specifier contained within parentheses: “@MyVar(%.2f)”.

Element	Image
Parent	Panel, Container, Button, Active, Inactive, On, Transition, Off
Children	(none)
Attributes	X, Y, Width, Height, HorizontalAlign, VerticalAlign, Rotate
Description	This renders an image based on the location, size, alignment, and rotation specified by the user. The content of this element must point to a graphical file in a format usable by dcapp (see section 5.3) via an absolute path or a path relative to the specfile.

Element	PixelStream
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Parent	Panel, Container, Button, Active, Inactive, On, Transition, Off
Children	(none)
Attributes	X, Y, Width, Height, HorizontalAlign, VerticalAlign, Rotate, Protocol, Host, Port, SharedMemoryKey, File
Description	This renders a dynamic image based on the location, size, alignment, and rotation specified by the user. The dynamic image must be generated by a separate package running a compatible PixelStream writer. <i>Protocol</i> is either “File”, “MJPEG”, or “TCP” (“File” is typically best if the writer is on the same computer as dcapp, and “MJPEG” is typically best if the writer is on a remote computer). Note that “MJPEG” only works <i>IF</i> the user has installed libjpeg (or libjpeg-turbo) on their computer. For “File”, the user must specify a <i>SharedMemoryKey</i> , which provides shared memory space for hand-shaking, and a <i>File</i> , which provides disk space containing image RGB information, that matches those settings for the writer. For “MJPEG” or “TCP”, the user must provide the name of the remote <i>Host</i> (default is “localhost”) and the <i>Port</i> number (default for “MJPEG” is “8080”) used by the PixelStream writer.

Element	ADI
Parent	Panel, Container, Button, Active, Inactive, On, Transition, Off
Children	(none)
Attributes	X, Y, Width, Height, HorizontalAlign, VerticalAlign, OuterRadius, BallRadius, ChevronWidth, ChevronHeight, BallFile, CoverFile, Roll, Pitch, Yaw, RollError, PitchError, YawError
Description	This renders an attitude direction indicator (ADI), or 8-ball, used in flying vehicles to show attitude (pitch/yaw/roll) information. It is rendered with the location, size, and alignment information provided by the user. The user may also customize <i>OuterRadius</i> , <i>BallRadius</i> , <i>ChevronWidth</i> , and <i>ChevronHeight</i> . <i>BallFile</i> and <i>CoverFile</i> allow the user to specify an image to overlay on the 8-ball and an image for the instrument face. <i>Roll</i> , <i>Pitch</i> , <i>Yaw</i> , <i>RollError</i> , <i>PitchError</i> , and <i>YawError</i> point to variables used to drive the information on the ADI.

4.5.2 Event Primitives

Element	Button
Parent	Panel, Container
Children	Active, Inactive, On, Transition, Off, OnPress, OnRelease, (display primitives)
Attributes	X, Y, Width, Height, HorizontalAlign, VerticalAlign, Rotate, Type, Key, KeyASCII, BezelKey, Variable, On, Off, SwitchVariable, SwitchOn, SwitchOff, IndicatorVariable, IndicatorOn, ActiveVariable, ActiveOn
Description	

Element	Active
Parent	Button
Children	(display primitives)
Attributes	(none)
Description	

Element	Inactive
Parent	Button
Children	(display primitives)
Attributes	(none)
Description	

Element	On
Parent	Button
Children	(display primitives)
Attributes	(none)
Description	

Element	Transition
Parent	Button
Children	(display primitives)
Attributes	(none)
Description	

Element	Off
Parent	Button
Children	(display primitives)
Attributes	(none)
Description	

Element	MouseEvent
Parent	Panel, Container
Children	OnPress, OnRelease, Set, If, Animation
Attributes	X, Y, Width, Height, HorizontalAlign, VerticalAlign
Description	This element sets up a listener to react when the mouse is pressed or released in a bounding volume specified by this element's attributes. The listener then executes the elements contained within its "OnPress" and "OnRelease" elements. If there is no "OnPress" or "OnRelease" sub-element defined, the contents of this element are assumed to be contained within a virtual "OnPress" element.

Element	KeyboardEvent
Parent	Panel, Container
Children	OnPress, OnRelease, Set, If, Animation
Attributes	Key, KeyASCII

Description	This element sets up a listener to react when a specified key on a keyboard is pressed or released. The key can be specified either with <i>Key</i> (for instance “a”, “b”, “Q”, “3”, “\$”, etc.) or with <i>KeyASCII</i> if the user wishes to specify a key that is not easily specifiable in an XML file (for instance, “8” to represent the “backspace” key). The listener then executes the elements contained within its “OnPress” and “OnRelease” elements. If there is no “OnPress” or “OnRelease” sub-element defined, the contents of this element are assumed to be contained within a virtual “OnPress” element.
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Element	BezelEvent
Parent	Panel, Container
Children	OnPress, OnRelease, Set, If, Animation
Attributes	Key
Description	This element sets up a listener to react when a specified bezel <i>Key</i> is pressed or released. The listener then executes the elements contained within its “OnPress” and “OnRelease” elements. If there is no “OnPress” or “OnRelease” sub-element defined, the contents of this element are assumed to be contained within a virtual “OnPress” element.

Element	OnPress
Parent	Button, MouseEvent, KeyboardEvent, BezelEvent
Children	Set, If, Animation
Attributes	(none)
Description	This element defines a list of actions to take if the parent element senses a “press” condition.

Element	OnRelease
Parent	Button, MouseEvent, KeyboardEvent, BezelEvent
Children	Set, If, Animation
Attributes	(none)
Description	This element defines a list of actions to take if the parent element senses a “release” condition.

5.0 Technical Details

5.1 Color Format Specification

When specifying color formats for any dcapp display elements, the following format must be used:

```
red_level green_level blue_level alpha_level
```


where each level is expressed as a number between 0 (full off) and 1 (full on). Note that if `alpha_level` isn't specified, `dcapp` assumes a value of 1 (fully opaque). Examples may include: black specified as "0 0 0", white specified as "1 1 1", blue specified as "0 0 1", grey specified as "0.5 0.5 0.5", etc.

5.2 Alignment Specification

Options for *HorizontalAlign* attributes are "AlignLeft", "AlignCenter", and "AlignRight". Options for *VerticalAlign* attributes are "AlignBottom", "AlignMiddle", and "AlignTop". If a user doesn't specify alignment, "AlignLeft" and "AlignBottom" are used as default values.

5.3 Graphic File Formats

`dcapp` can currently handle graphic files in TARGA (.tga) and bitmap (.bmp) formats. TARGA files should be saved uncompressed with a "bottom left" origin. Bitmap files should be saved in 24-bit format, although files saved in other valid bitmap formats may work. `dcapp` also handles JPEG (.jpg or .jpeg) formats *IF* the user has installed libjpeg (or libjpeg-turbo) on their computer.

5.4 Display Logic File

5.5 Element Values

5.5.1 Constants

5.5.2 Variables

5.5.3 Environment Variables