dcapp Installation and User Guide

version 2.1

NASA Johnson Space Center

Table of Contents

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. Building dcapp requires a compiler that can accommodate the C++11 programming language. 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 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.

Much of the PixelStream functionality associated with the MJPEG and VSM protocols is built upon curl. If the user needs this functionality, then they should install curl prior to building dcapp. dcapp will build without curl, but most of the MJPEG and VSM PixelStream capabilities will be unavailable to the user unless curl 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 some older versions of Trick do not automatically build the stand-alone version of trick_comm. If this is the case, 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.

dcapp can also monitor hardware inputs via a Hagstrom device. This requires the IDF package to be properly built and for the IDF_HOME environment variable to be set. If IDF_HOME isn't set, then dcapp will look for the IDF package at the same level in the directory tree as the dcapp package. If it still can't find IDF, then IDF functionality will not be available to the user.

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 is defined by the returned value of "dcapp.app/Contents/dcapp-config --osspec". On MacOS systems, OSSPEC is "MacOS". On other systems, it is typically set to a combination of `uname -s` (converted to lower case) followed by an underscore ("_") followed by `uname -m` (for instance, "linux_x86_64"). You should then add the returned value of

"dcapp.app/Contents/dcapp-config --exepath" 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

If a user chooses to run in debugging mode, which provides a wealth of debugging information to the console screen, the user may include a "-debug" argument anywhere on the command line after the specfile (file.xml).

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 current file.

Element	If
Parent	(any)
Children	True, False, (any)
Attributes	Operator, Value, Value1, Value2
Description	This element applies the *Operator* (one of "eq", "ne", "gt", "lt", "ge", or "le") to *Value1* and *Value2* to evaluate a true or false condition. If no *Operator* is defined, then it simply tests *Value* 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 *Variable* to a new value defined by the content of the element. The *Operator* is "=" by default, but may also be "+=" or "-=" if this element is to be used to increment or decrement *Variable* (usable only if *Variable* is a numeric type). *MinimumValue* and *MaximumValue* 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 *Duration*. This is done linearly over each execution of dcapp until *Duration* 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:

<Constant Name="FontSize">24</Constant>

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 *Type* must be either "Decimal", "Integer", or "String" (note that "Float" is a valid but deprecated type that is functionally identical to "Decimal"). For instance, the user may set: <Variable Type="Integer">MyVar</Variable> Any subsequent elements may then use the associated value by specifying a value of "@MyVar". Note that if *InitialValue* is not specified, the default value is 0 for decimal and integer parameters and an empty string ("") for string parameters.

Element	Style
Parent	DCAPP
Children	(any)
Attributes	Name
Description	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: <Style Name="mystyle"> <String Size="28" Color="0 0 1"/> </Style> 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.

Element	Defaults
Parent	DCAPP
Children	(any)
Attributes	(none)
Description	This allows a user to define default attributes for any element that is used subsequently within the specfile. For instance, the user may set: <Defaults> <Rectangle LineWidth="2" LineColor="1 0 0"/> </Defaults> 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.

4.3.2 Input/Output Elements

Element	TrickIo
Parent	DCAPP
Children	FromTrick, ToTrick
Attributes	Host, Port, DataRate, DisconnectAction
Description	This construct specifies communication between dcapp and the Trick variable server. *Host* 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. *Port* specifies the port over which communication with the Trick variable server takes place. If not specified, the default value is 7000. *DataRate* specifies the data rate (in seconds) at which Trick will attempt to communicate with dcapp. If not specified, the default value is 1 second. *DisconnectAction* 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 *Host* and *Port* may be overridden by the command-line arguments outlined in section 3.

Element	FromTrick
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 *Name*. The user may optionally define the *Units* of the data within dcapp, which the Trick variable server will use to convert the data, if necessary. The *Units* 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 server. *Host* 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. *Port* specifies the port over which communication with EDGE takes place. If not specified, the default value is 5451. *DataRate* 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 –`
	`lit_int">LightCmd</EdgeVariable>`

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 *RcsCommand*.

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 *Network*, *ButtonID*, and *ControlID* 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	Port, BezelID
Description	This element assigns bezel keys to data associated with a UEI controller based upon the *Port* of the UEI and the *BezelID* of the unit associated with this instance of dcapp. The bezel keys are processed via the "Button" and/or "BezelEvent" elements.

Element	Hagstrom
Parent	DCAPP
Children	(none)
Attributes	SerialNumber
Description	This element assigns bezel keys to data associated with a Hagstrom device. The user may specify a *SerialNumber* of the Hagstrom device it wants to associate with in case multiple devices are connected to the computer. If *SerialNumber* isn't specified, then dcapp will attach to the first Hagstrom device it discovers. 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 (*X* and *Y*) and size (*Width* and *Height*) of the window containing the dcapp displays. If *FullScreen* is set to "true", "yes", or "on", the window will be rendered full screen regardless of *X*, *Y*, *Width*, and *Height* settings. The *ActiveDisplay* 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

DisplayIndex 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 *ForceUpdate* 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 *DisplayIndex* attribute is used to define when this display is the active display. *BackgroundColor* 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"). *VirtualWidth* and *VirtualHeight* 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, OriginX, OriginY, 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 *Width* by *Height* at position *X*, *Y* (with respect to *OriginX* and *OriginY*), and aligned by *HorizontalAlign* and *VerticalAlign*, within the current coordinate frame. The new coordinate frame can also be rotated by *Rotate* degrees from the current coordinate frame, and the new coordinate frame uses *VirtualWidth* and *VirtualHeight* to define the width and height of subsequent elements within the new frame.

Element	Line
Parent	Panel, Container, Button, Active, Inactive, On, Transition, Off
Children	Vertex
Attributes	LineWidth, Color, Pattern, Factor

Description	This attaches the enclosed "Vertex" primitives to form a single, continuous line with the specified *LineWidth* and *Color*. *Pattern* is an optional 16-bit hexadecimal number used to determine the pixel pattern of the line (e.g. solid [default] = 0xFFFF, dashed = 0xFF00). *Factor* is an optional multiplier for each bit in the line. For example, scale factor 3 will repeat each bit 3 times before the next bit in the pattern is used (default is 1).

Element	Polygon
Parent	Panel, Container, Button, Active, Inactive, On, Transition, Off
Children	Vertex, OnPress, OnRelease
Attributes	FillColor, LineColor, LineWidth, LinePattern, LineFactor
Description	This attaches the enclosed "Vertex" primitives to form a polygon. The polygon is filled with *FillColor* and outlined with a line of color *LineColor* and a width of *LineWidth*. If *FillColor* is not set, then the polygon is not filled. Likewise, if *LineColor* and *LineWidth* are not set, then the polygon is not outlined. *LinePattern* is an optional 16-bit hexadecimal number used to determine the pixel pattern of the outline. *LineFactor* is an optional multiplier for each bit in the outline. Note that this primitive works well for convex polygons, but the behavior for polygons with concave vertices is undefined.

Element	Vertex
Parent	Panel, Container, Button, Active, Inactive, On, Transition, Off
Children	(none)
Attributes	X, Y, OriginX, OriginY
Description	This defines the *X* and *Y* coordinates (with respect to *OriginX* and *OriginY*) of a vertex within a "Line" or "Polygon" primitive.

Element	Rectangle
Parent	Panel, Container, Button, Active, Inactive, On, Transition, Off
Children	OnPress, OnRelease
Attributes	X, Y, OriginX, OriginY, Width, Height, HorizontalAlign, VerticalAlign, Rotate, FillColor, LineColor, LineWidth, LinePattern, LineFactor
Description	This renders a rectangle based upon the location, origin, size, alignment, and orientation specified by the user. The rectangle is filled with *FillColor* and outlined with a line of color *LineColor* and a width of *LineWidth*. If *FillColor* is not set, then the rectangle is not filled. Likewise, if *LineColor* and *LineWidth* are not set, then the rectangle is not outlined. *LinePattern* is an optional 16-bit hexadecimal number used to determine the pixel pattern of the outline. *LineFactor* is an optional multiplier for each bit in the outline.

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

Children	OnPress, OnRelease
Attributes	X, Y, OriginX, OriginY, HorizontalAlign, VerticalAlign, Radius, Segments, FillColor, LineColor, LineWidth, LinePattern, LineFactor
Description	This renders a circle based upon the location, origin, radius, and alignment specified by the user. The user may also specify the number of straight-line segments used to render the circle via *Segments* (default is 80). The circle is filled with *FillColor* and outlined with a line of color *LineColor* and a width of *LineWidth*. If *FillColor* is not set, then the circle is not filled. Likewise, if *LineColor* and *LineWidth* are not set, then the circle is not outlined. *LinePattern* is an optional 16-bit hexadecimal number used to determine the pixel pattern of the outline. *LineFactor* is an optional multiplier for each bit in the outline.

Element	String
Parent	Panel, Container, Button, Active, Inactive, On, Transition, Off
Children	(none)
Attributes	X, Y, OriginX, OriginY, Rotate, Size, HorizontalAlign, VerticalAlign, Color, BackgroundColor, ShadowOffset, Font, Face, ForceMono, LineColor
Description	This renders a character string based on the location, origin, size, alignment, and rotation specified by the user. The user may also specify the *Font* and *Face*. Note that *Font* 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 current file. Different font files offer different options for *Face*, but typical options include "Bold", "Italic", etc., and if *Face* is not specified, the default face for the font is used. The *ForceMono* 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 *Color* with an optional *BackgroundColor*, and *ShadowOffset* allows the user to specify the offset of a shadow to be rendered behind the font (no shadow is rendered if *ShadowOffset* 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)". The user may also specify an *UpdateRate*, in seconds, which reduces the rate at which data is rendered to the screen, thereby eliminating unnecessarily fast updates that are difficult to read. The user may also specify a *ZeroTrim* value. If the absolute value of the data to be displayed is below this threshold, it will display as "0". This can eliminate things like "-0" or unrealistically small numbers on the display.

Element	Image

Parent	Panel, Container, Button, Active, Inactive, On, Transition, Off
Children	OnPress, OnRelease
Attributes	X, Y, OriginX, OriginY, Width, Height, HorizontalAlign, VerticalAlign, Rotate, File
Description	This renders an image based on the location, origin, size, alignment, and rotation specified by the user. The *File* 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 current file. If the *File* element isn't specified, the path to the graphical file may be specified within the content of this element, but this is a deprecated capability.

Element	PixelStream
Parent	Panel, Container, Button, Active, Inactive, On, Transition, Off
Children	(none)
Attributes	X, Y, OriginX, OriginY, Width, Height, HorizontalAlign, VerticalAlign, Rotate, Protocol, Host, Port, Path, SharedMemoryKey, File, TestPattern
Description	This renders a dynamic image based on the location, origin, size, alignment, and rotation specified by the user. The dynamic image must be generated by a separate package running a compatible PixelStream writer. *Protocol* is either "File", "MJPEG", "TCP", or "VSM" ("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. "VSM" is designed specifically for use with the video stream manager (VSM) application). Note that "MJPEG" and "VSM" only work *IF* the user has installed libjpeg (or libjpeg-turbo) and curl on their computer. For "File", the user must specify a *SharedMemoryKey*, which provides shared memory space for hand-shaking, and a *File*, 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 *Host* (default is "localhost") and the *Port* number (default for "MJPEG" is "80") used by the PixelStream writer. Also for "MJPEG" the user may specify a *Path* in addition to *Host* and *Port*. "VSM" requires the user to specify a *Host* and *Port* for the VSM application as well as *Camera*, which specifies the name of the camera to be requested from VSM (this is typically a variable name). A user may also specify a *Path* for VSM that overrides the default path passed back by VSM. If the user specifies a *TestPattern* file in a graphical format usable by dcapp (see section 5.3) via an absolute path or a path relative to the current file, then the image associated with this file will be displayed if the PixelStream is not currently connected to a PixelStream source.

Element	UPSMap
Parent	Panel, Container, Button, Active, Inactive, On, Transition, Off
Children	Textures, Points, MapTexture, MapImage, MapString

Attributes	X, Y, Latitude, Longitude, PolarAxisOffset, LatOrigin, LatOuter, Zoom, Width, Height, HorizontalAlign, VerticalAlign, EnableIcon, EnableTrail, TrailColor, TrailWidth, FnClearTrail, TrailResolution, EnableInverseTheta, IconFile, IconWidth, IconHeight, IconRotationOffset, ZoneLon1, ZoneLat1, … ZonLon4, ZoneLat4, Yaw, YawOffset, EnableCircularMap, EnableTrackUp
Description	This renders a UPS map based on the location, origin, size, alignment, and rotation specified by the user. The *File* 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 current file. If the *File* element isn't specified, the path to the graphical file may be specified within the content of this element, but this is a deprecated capability. Latitude and Longitude are the current position on the map being rendered. PolarAxisOffset specifies the longitude at which the polar axis is set. LatOrigin and LatOuter specify the latitude range of the map. EnableIcon and EnableTrail enable a positional icon and trail showing the current position and traverse path. FnClearTrail clears the trail through incrementing the an integer. TrailResolution is a value which increases the resolution with a smaller value (0..1). EnableInverseTheta inverts the direction in which the longitude increases. IconFile allows the user to specify a custom positional icon image. IconRotationOffset allows the user to rotate the image to align with the traverse path. ZoneLonN and ZoneLatN creates a custom quadrilateral zone rendered on the map. Yaw and Yawoffset are used as a variable input to set the yaw orientation of the user, instead of backtracking latlong. EnableTrackUp positions the user so they are always facing up, and the map rotates underneath. Textures is a child consisting of MapTexture elements, which allows the user to set multiple map textures to change between. Points consist of MapImage and MapString elements, both of which allow the user to specify images and strings at a latlong to render graphics within the map. See samples/maps/maps.xml for an example.

Element	UTMMap
Parent	Panel, Container, Button, Active, Inactive, On, Transition, Off
Children	Textures, Points, MapTexture, MapImage, MapString
Attributes	X, Y, Latitude, Longitude, LonMin, LonMax, LatMin, LatMax, Zoom, Width, Height, HorizontalAlign, VerticalAlign, EnableIcon, EnableTrail, TrailColor, TrailWidth, FnClearTrail, TrailResolution, IconFile, IconWidth, IconHeight, IconRotationOffset, ZoneLon1, ZoneLat1, … ZonLon4, ZoneLat4
Description	This renders a UTM map based on the location, origin, size, alignment, and rotation specified by the user. The *File* 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 current file. If the *File* element isn't specified, the path to the graphical file may be specified within the content of this element, but this is a deprecated capability. Latitude and Longitude are the current position on the map being rendered LatMin, LatMax, LonMin, LonMax, specify the bounds of the latlong of the map. EnableIcon and EnableTrail enable a positional icon and trail showing the current position and traverse path. FnClearTrail clears the trail through incrementing the an integer. TrailResolution is a value which increases the resolution with a smaller value (0..1). IconFile allows the user to specify a custom positional icon image. IconRotationOffset allows the user to rotate the image to align with the traverse path. ZoneLonN and ZoneLatN creates a custom quadrilateral zone rendered on the map. Yaw and Yawoffset are used as a variable input to set the yaw orientation of the user, instead of backtracking latlong. EnableTrackUp positions the user so they are always facing up, and the map rotates underneath. Textures is a child consisting of MapTexture elements, which allows the user to set multiple map textures to change between. Points consist of MapImage and MapString elements, both of which allow the user to specify images and strings at a latlong to render graphics within the map. See samples/maps/maps.xml for an example.

Element	ADI
Parent	Panel, Container, Button, Active, Inactive, On, Transition, Off
Children	(none)
Attributes	X, Y, OriginX, OriginY, Width, Height, HorizontalAlign, VerticalAlign, OuterRadius, BallRadius, ChevronWidth, ChevronHeight, BallFile, CoverFile, Roll, Pitch, Yaw, RollError, PitchError, YawError, RollRate, PitchRate, YawRate, RateMax, NeedleColor, HideNeedles, HideRateIndicators, RateIndicatorColor
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, origin, size, and alignment information provided by the user. The user may also customize *OuterRadius*, *BallRadius*, *ChevronWidth*, and *ChevronHeight*. *BallFile* and *CoverFile* allow the user to specify an image to overlay on the 8-ball and an image for the instrument face. *Roll*, *Pitch*, *Yaw*, *RollError*, *PitchError*, and *YawError* point to variables used to drive the information on the ADI. Optionally, RollRate, PitchRate, and YawRate can be used to drive rate indicators on the outside of the ball. NeedleColor and RateIndicatorColor may be used to customize the color of the markers.

4.5.2 Event Primitives

Element	Button

Parent	Panel, Container
Children	Active, Inactive, On, Transition, Off, OnPress, OnRelease, (display primitives)
Attributes	X, Y, OriginX, OriginY, 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	This contains a list of primitives to be rendered when a Button is in the "active" state (when ActiveVariable is set to the ActiveOn value).

Element	Inactive
Parent	Button
Children	(display primitives)
Attributes	(none)
Description	This contains a list of primitives to be rendered when a Button is in the "inactive" state (when ActiveVariable is not set to the ActiveOn value).

Element	On
Parent	Button
Children	(display primitives)
Attributes	(none)
Description	This contains a list of primitives to be rendered when a Button is in the "on" state (when IndicatorVariable is set to the IndicatorOn value).

Element	Transition
Parent	Button
Children	(display primitives)
Attributes	(none)
Description	This contains a list of primitives to be rendered when a Button is in the "transition" state (when IndicatorVariable and SwitchVariable are in different states).

Element	Off
Parent	Button
Children	(display primitives)
Attributes	(none)
Description	This contains a list of primitives to be rendered when a Button is in the "off" state (when IndicatorVariable is not set to the IndicatorOn

value).

Element	MouseMotion
Parent	Panel, Container
Children	(none)
Attributes	XVariable, YVariable
Description	This element provides the user with the current X and Y position of the mouse within the context of the Panel or Container within which it exists. Note that if this element is active, it will sense any mouse motion as an event, which will trigger a display update, which can be computationally expensive.

Element	MouseEvent
Parent	Panel, Container
Children	OnPress, OnRelease, Set, If, Animation
Attributes	X, Y, OriginX, OriginY, 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 *Key* (for instance "a", "b", "Q", "3", "$", etc.) or with *KeyASCII* 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.

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 *Key* 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 Origin Specification

The origin attributes (*OriginX* and *OriginY*) specify which side of the current region to establish as the base for *X* and *Y*. For instance, if a user wants a primitive 10 units from the left, they would set *OriginX* to "Left" and *X* to "10". Likewise, if they want a primitive 10 units from the right, they would set *OriginX* to "Right" and *X* to "10". Options for *OriginX* are "Left" and "Right". Options for *OriginY* are "Bottom" and "Top". If a user doesn't specify an origin, "Left" and "Bottom" are used as default values.

5.3 Alignment Specification

The alignment attributes (*HorizontalAlign* and *VerticalAlign*) specify the direction in which a primitive is rendered with respect to the specified *X* and *Y* values. Options

for *HorizontalAlign* are "Left", "Center", and "Right". Options for *VerticalAlign* are "Bottom", "Middle", and "Top". If a user doesn't specify alignment, "Left" and "Bottom" are used as default values.

5.4 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.

Additionally, dcapp supports precompressed texture files using S3 Texture Compression (.s3tc). The file is required to have a 64 byte header followed by the raw binary data. The header consists of a uint32_t format (macro standard defined by OpenGL), int32_t n level, uint32_t width, uint32_t height, uint32_t size in bytes of the texture, and 44 bytes of padding. DXTn is supported on all modern GPUs and both Linux/MacOS, but other formats have not been verified.

5.5 Display Logic File

While dcapp sets the value of its variables automatically based upon user specifications provided within the XML specfile, it also provides the capability for a user to modify those variables using custom C++ software. This is useful if the user wants the display to operate in non-standard or complex ways. To facilitate this, dcapp provides a command-line tool called dcapp_genheader, which is activated with the following syntax:

dcapp_genheader file.xml [output_file]

where file.xml is a full or partial path to a valid dcapp specfile and output_file is the name of the C++ header file to be created (the default value is "dcapp.h"). This tool mines the specfile, finds all of the dcapp variables, and provides them to the user as pointers (double *, int *, or std::string *, depending upon how they're defined in the specfile) in output_file.

From there, the user may create one or more C++ files to manipulate these variables. The user must #include output_file in the C++ files and include C++ logic within one of these three "void" routines:

- DisplayInit
- DisplayLogic
- DisplayClose

Note that these routines do not accept arguments, and the user need only include the ones that are needed for their logic. DisplayInit is executed once at dcapp

startup and DisplayClose is executed once at dcapp shutdown. DisplayLogic is executed whenever dcapp senses that a display should be updated, which includes a keyboard or mouse event, a variable update, etc.

Once the user creates the logic files, they should be compiled into a shared object. Doing so can differ per operating system but typically looks something like:

```
c++ -fPIC -shared mylogic.cc -o mylogic.so
```

From there, the user instructs dcapp to use this customized logic by using the DisplayLogic element (see section 4.3.3) within the specfile.

5.6 Element Values

5.6.1 Constants

A constant is a value that is set at pre-processor time when the XML specfile is initially processed. It does not change while dcapp is executing. Note, however, that the user may reassign a Constant to a new value as often as needed within the specfile. The user accesses the value of the Constant after it has been set by using the hash or pound sign ("#"). For instance, if a user sets a constant as follows:

```
 <Constant Name="MyConst">3.14159</Constant>
```

...then the user may subsequently use the Constant as follows:

```
<Set Variable="MyVar">#MyConst</Set>
```

5.6.2 Variables

A variable is a value that can change while dcapp is executing. The user accesses the value of the Variable after it has been set by using the at sign ("@"). So, if a user sets variables as follows:

```
<Variable Type="String" InitialValue="Michael">MyName</Constant>
<Variable Type="Decimal" InitialValue="6">MyHeight</Constant>
```

...then the user may subsequently use the Variable as follows:

```
<String>My name is @MyName and I am @MyHeight feet tall.</String>
```

5.6.3 Environment Variables

The user may access the value of any available environment variable from within the specfile by prepending the name of the environment variable with a dollar sign ("$"). For instance, the following String element shows the value of the USER environment variable:

<String>my user name is $USER</String>

Note that dcapp makes the following environment variables available to the user:

- dcappOSTYPE
- dcappOSSPEC
- dcappOBJDIR
- dcappBINDIR

These values are set to the return values of the dcapp.app/Contents/dcapp-config script with the following arguments respectively: --ostype, --osspec, --objdir, and --bindir. Note that using the above environment variables in the specfile in conjunction with the corresponding return values from the dcapp.app/Contents/dcapp-config script in build files are a great way of ensuring that the specfile and build files are pointing to the same files and directories.

Other environment variables provided by dcapp include:

- dcappDisplayHome
- dcappVersion

The dcappDisplayHome variable is set to the directory containing the specfile. It is useful for specifying a path to a Font, Image, etc., with respect to the specfile instead of to the current file, which may change if Include elements are used. The dcappVersion provides a way to test the current version of dcapp from within the specfile in the event that a display needs to run with two or more versions of dcapp that may or may not be fully compatible from a programming interface perspective.

Besides the above variables, dcapp makes the following environment variables available to the user from within the specfile by setting them if they haven't already been set:

- USER
- LOGNAME
- HOME
- OSTYPE
- MACHTYPE
- HOST

5.7 Logic Utilities

5.7.1 General Utilities

Class	Blinker
Header	blinker.hh

Constructor	Blinker(int* dcapp_var, int repetitions, float duration)
Parameters	dcapp_var: pointer to DCApp variable being toggled repetitions: number of repetitions (on-off or off-on) to execute before ending duration: duration of each repetions in seconds
Methods	start(): start blinking stop(): stop blinking
Description	Class for handling an individual blink. Toggles a DCApp integer variable between 0 and 1 for a specified number of repetitions at a specified interval

Class	BlinkerManager
Header	blinker.hh
Constructor	BlinkerManager()
Parameters	None
Methods	addBlinker(string name, blinker b): add blinker *b* mapped to key *name* startBlinker(string name): start blinker with key *name* stopBlinker(string name): stop blinker with key *name* processAllBlinkers(): execute process() for all blinkers attached to this manager. Recommended to execute this in *DisplayLogic()*
Description	Class for handling multiple blinker objects. Access each blinker with a string keyword and process all of them in one function

6.0 Release Information

Below is a brief summary of changes associated with each release of dcapp. While dcapp strives to maintain full compatibility between releases, there are often changes from release to release that require a user to make modifications to their specfiles and/or logic files. These items are also documented below:

- 1.0:
  - Initial release
  - **Compatibility note:** The pre-release versions of dcapp provided the user with "String" variables of type "char *" for use in their logic files. With this release, those variables are now of type "std::string", so some re-writing of logic files may be needed since calls like strlen, strcmp, etc. do not work with variables of type std::string.
- 1.1:
  - Improved XML parsing now handles nested Constants
  - Implemented an improved data model to improve code maintenance
  - Geometry now utilizes OriginX and OriginY to specify values from right and top, respectively (see compatiblity note below)

- o Added support for IDF and Hagstrom devices
- o Improved loading time on most systems
- o Improved error handling, which should result in fewer crashes
- o **Compatibility note:** Prior to dcapp 1.1, a user could use negative values for X and Y to render primitives from the right or top of the current region, which was often confusing and non-intuitive. This is no longer the case. This release provides the explicit attributes OriginX and OriginY to achieve this instead.
- 1.2
  - o Several primitives, including Rectangle, Circle, Polygon, and Image, now provide OnPress and OnRelease functionality when a mouse is pressed within their respective bounds.