SKAARHOJ

Strategies for Blackmagic Design Camera Control

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Copenhagen, October 2018

Note for SKAARHOJ controllers with Blackmagic 3G-SDI Arduino Shields and Studio Fiber Converter/Camera Fiber Converter:

We have tested Blackmagics fiber converter products in general to work with SDI output. This includes the Mini Converter, ATEM Camera Converter, ATEM Studio Converter and ATEM Talkback Converter 4K. The only product we know does not work is the **Studio Fiber Converter/Camera Fiber Converter**. This product is not compatible with their own 3G-SDI shield which is the component we use inside the RCPs and other products. While the Studio Fiber Converter/Camera Fiber Converter will forward shading data from an ATEM switcher it will not do so for the 3G-SDI shield.

Bottom line is this: We cannot change this situation, only Blackmagic Design can decide to upgrade either the Studio Fiber Converter/Camera Fiber Converter or the 3G-SDI Arduino Shield to make it work. At this point we can suggest that you rather connects a controller to an ATEM switcher which will work as the master for sending out the shading data. You might employ a cheap ATEM switcher for only this purpose.

Copenhagen, September 2017

This document aims to describe typical topologies for connecting Blackmagic Design Cameras for live production to infrastructures of production switchers, intercom solutions (Blackmagic Design), tally signals, color control remote panels and monitoring solutions. The suggestions are based on our experience at SKAARHOJ combined with feedback from customers we have helped along the way. Therefore SKAARHOJ products play a central role ranging from control surfaces to tally interfacing boxes.

The document starts by introducing SKAARHOJ and Blackmagic Design products mentioned in this document. Then it moves on to describing the various topologies we have encountered and addressed with our solutions, then additional chapters on tally, monitoring and lens control. Outline:

- Topologies for intercom, tally and color control data
  - Multiple (individual camera) controllers
    - Single return feed
    - Multiple return feeds
  - Single (multi camera) controllers
- Tally over SDI
- Monitoring / “Joystick override”
- B4 Lens Control
- Various

The general assumption is that we need to address a multi camera scenario. Then a central question becomes if individual camera controllers (“RCPs”) or a multi camera controller is desired. In case of individual camera controllers it’s important to address the constraints it may impose on the return feed topology. Mixed into all of this is how options are different depending on whether the underlying

production switcher is a Blackmagic ATEM switcher or a third party product. Addressing these overall scenarios is done by detailed illustrations and considered the main focus of this document.

Acknowledgements

Thanks to Hersh Burston and Tim Schumann from Blackmagic Design for inputs to the document, feedback on Blackmagic cameras and the 3G-SDI Arduino Shield!

Thanks to Dan Slentz for sharing experiences. And thanks to countless customers for your feedback!

SKAARHOJ Products

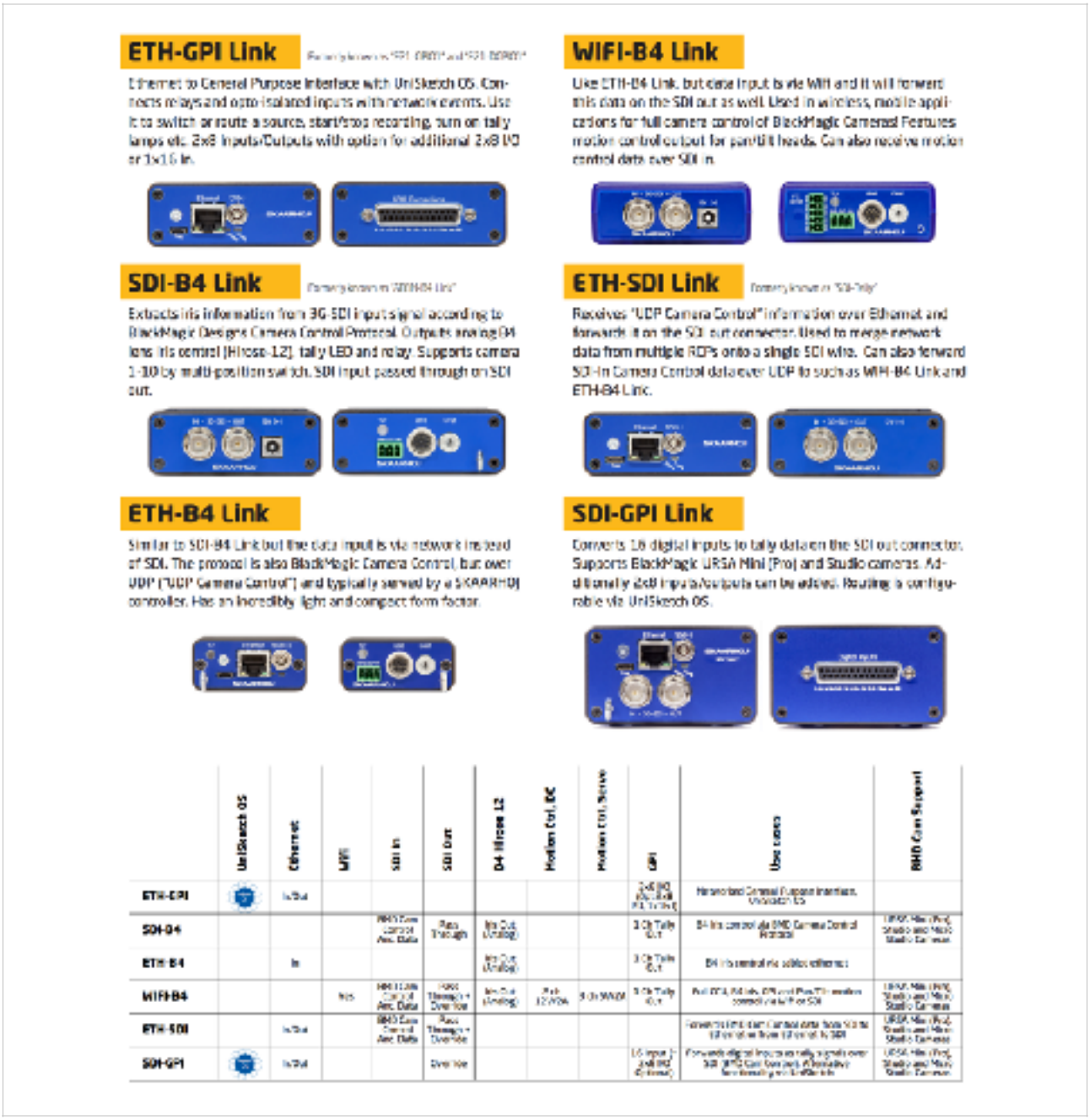
Below is an overview of SKAARHOJ products designed to address the needs of camera color control in general and Blackmagic Design cameras in particular.

RCP	RCP Mini	CCU	CCU Lite	C25
				
Classic "RCP" in a Sony RCP-1500 form factor. Drop in replacement for existing RCPs in racks in OB-vans. Includes pin compatible "EXT I/O" DB-9 GPI connector. Designed for single camera control due to the absolute position joystick as well as its familiarity with classic RCP panels. Can be delivered with encoder option instead of joystick.	Classic "RCP" in a Sony RCP-1000 form factor. 6 RCP Minis fit in the same horizontal space as 4 RCPs. Except for fewer interface components and therefore a different functional mapping to buttons, the characteristics matches that of the RCP.	Designed for camera control of multiple cameras, most typically up to 8 cameras (suggested by the 4x2 array of buttons on the left). Optionally, a GPI connector with 2x8 channel I/O and SDI connections can be added. The form factor suggests a desktop usage.	Designed for iris and black level control of 4 cameras. The form factor suggests a desktop usage.	Designed for single camera control, either over SDI or Ethernet. The form factor suggests either a hand held "field usage" or clamp mounting on tripod gear locally at a camera.

All products run on UniSketch OS and is connected with cores.skaarhoj.com for device core management. This means they can all easily be used for other camera models that we support as well as configured differently for existing cameras (see the section at the end with various configuration examples). Picking a camera control surface among the options above is mainly a question of the form factor and preferences towards single or multi camera control.

All camera control products above features 3G SDI-In and 3G SDI-Out for Blackmagic Camera Control data embedded in SDI ancillary data (either by default or by option). Some also features GPI I/O for such as joystick override and tally signals.

In addition, many of the SKAARHOJ Link IO products are included in the described topologies:



SKAARHOJ controllers with 3G-SDI In/Out can operate in a passthrough mode where incoming SDI ancillary data for tally and control is passed through the device unless the SKAARHOJ controller itself inserts data. For tally signals a SKAARHOJ controller always forwards the incoming tally data unless the controller itself has an action set up to output tally in which case the first trigger of this action will put the controller in override mode for the remaining uptime. For control data (CCU data) the default is to always override incoming data unless an option is configured that will allow it to pass through unless the controller itself actively inserts data at any time (mode is called “Momentary Override” and is described in the manual for the UniSketch “BMDCamCtrl” device core).

The SDI-In on SKAARHOJ Controllers doesn’t require an input signal. If no signal is supplied, a blank signal is generated for the output.

When SKAARHOJ products feature a 3G-SDI In/Out they hosts a Blackmagic Arduino Shield inside.

Blackmagic Design Cameras and Control Technology

SDI Ancillary Data on Return Feed

Blackmagic Design has developed a protocol for camera control that embeds data in the ancillary data of an SDI signal. The protocol is called "Blackmagic Video Device Embedded Control Protocol" and is openly documented in the ATEM Manual, in the Blackmagic Arduino Shield manual and probably other places as well. They suggest a two-way wiring with an SDI signal travelling from the camera and back to the control room (as usual) but also a "return feed" - an SDI signal travelling from the control room back to the camera. The return feed is typically the PGM signal (but can be anything) and contains the ancillary data, which includes color control data (such as iris, master black etc), tally (red, green), and talk-back (using audio channels 15+16). The ancillary data is tagged with a camera ID so even though the same data reaches all cameras, only the camera with a matching ID will pick up the data. Therefore, a camera must as a minimum receive the data tagged with its camera ID but can optionally receive (and will ignore) data for other camera IDs. The protocol is for all practical purposes one-way: There is no way to read back data from a camera/receiving device.

The promise of this method is, that only two coax cables are necessary for each camera in the studio to transport both video, control signals and talkback. With fiber it seems even more attractive since two fibers are usually bundled.

The challenge is to get the control data in and out of the SDI stream.

Devices that consumes the control data includes Blackmagic Designs own cameras of course, but also their various monitors (would display tally for instance). SKAARHOJ has products like the SDI-B4 Link which extracts the iris information and converts it into an analog voltage for B4 lens servo control.

Devices that embeds ancillary data includes the Blackmagic Design ATEM Switchers (tally and color control), Talkback and Studio converters (talkback audio on channels 15+16), but also other brands like NewTek Tricaster is now known to include tally data on their SDI out (some models, consult manual). All SKAARHOJ camera control products with SDI in/out are also able to embed tally and color control data on the SDI output, which is what constitutes their claim to be particularly useful with Blackmagic Design cameras.

It should generally be possible to let the return feed be delivered in a different resolution than the cameras output. In other words: Sending a 3G signal back to the camera with control data should work even if the camera is set up to produce 6G or 12G video.

Generally, it doesn't matter if the SDI return signal passes through SDI video routers or fiber converters as long as they only reclock the signals and otherwise doesn't modify the signals content. Even non-Blackmagic Design products will do this. However, we advice you to be cautious and test it! For instance we had a customer report back that an AJA OpenSource 2x4 HDSDI card frame DA would strip the tally and control data while an AJA Hi5 HDSDI DA would pass the data through nicely.

A side note on sync: Blackmagic Design cameras will be able to use the SDI input signal as a sync reference instead of trilevel sync, thus keeping the simplicity of a two wire topology. You must set Sync to "PGM" (instead of External or Internal) in the cameras menu.

SKAARHOJ products that support 3G-SDI in/out for Blackmagic Camera Control are using Blackmagic Designs Arduino shield internally in the hardware. All video and audio data (including talkback audio on channel 15+16) passes through and only ancillary color data and tally data may be overridden.

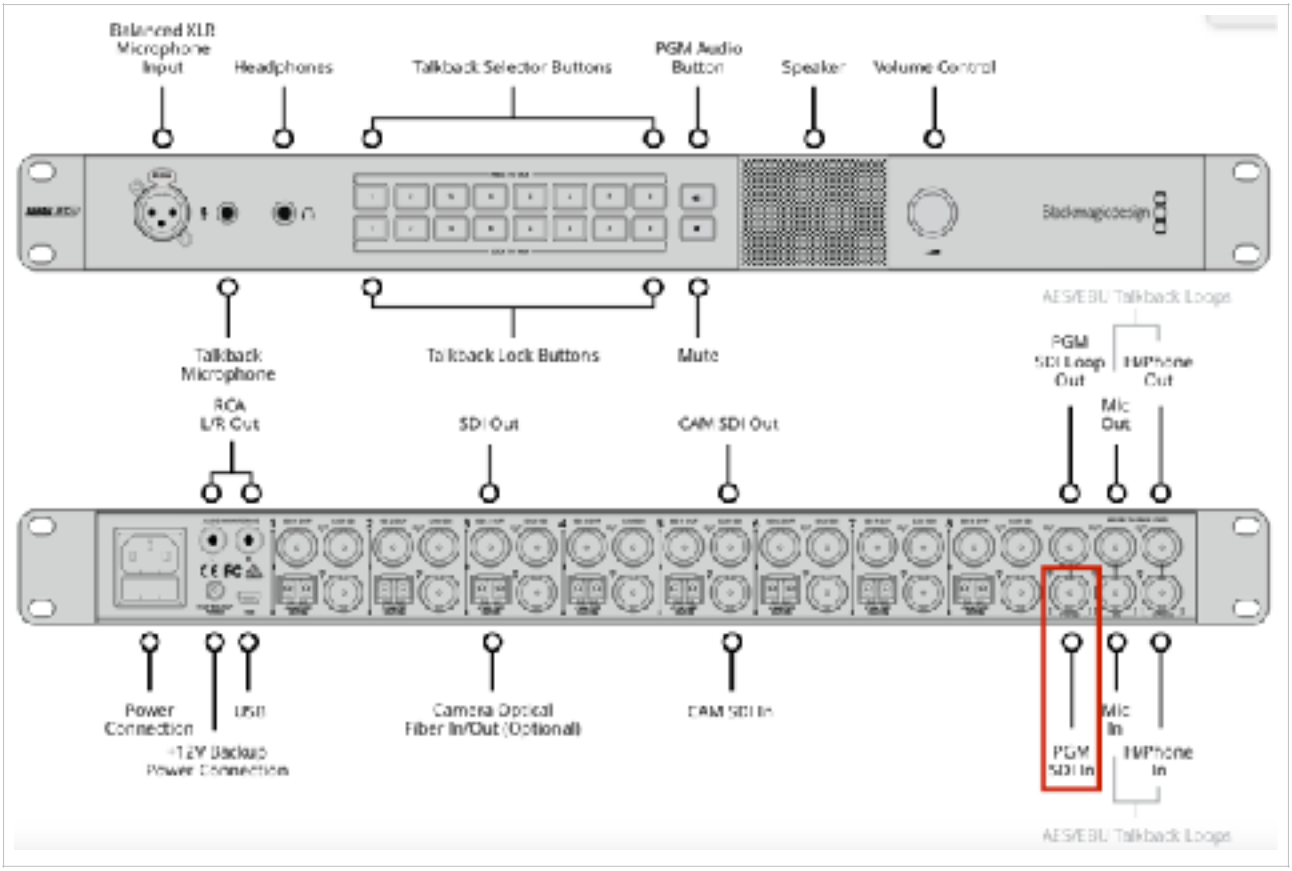
Live Production Cameras

In the following table is an overview of Blackmagic Design cameras relevant for live production usage and comments on color control relevant parameters.

Model	Picture	Advantages	Challenges
URSA Mini			No Hirose-12 connector for B4 Lenses on URSA Mini 4K EF and URSA Mini 4.6K EF. (The PL versions of the URSA Mini cameras both have the 12-pin B4 connector and so can be used for B4 lenses or Cine-servo PL lenses.)
URSA Mini Pro		Has “Broadcast Lens Connector” (Hirose-12) for B4 lenses	
Studio Camera			No Hirose-12 connector for B4 Lenses. Use of fibermodule may pose challenge when B4 lens control is desired.
Micro Studio Camera 4K		B4 Lens Control via breakout cable and external box from BMD.	No B4 lens control of analog lenses.

ATEM Talkback Converter and ATEM Studio Converter

The ATEM Talkback Converter and ATEM Studio Converter both integrates intercom on the 2-way SDI to/from cameras. They also work as fiber converters at the same time. The main point to make about these products is, that any SDI return signal to the cameras is taken in by a single connector, “PGM SDI In”. Therefore, any embedded tally and color control data to *all* cameras must be embedded on this signal, assuming the Talkback/Studio converters are the last device before the cable run out to the cameras.



Alternatively, video routers, distribution amplifiers and fiber products of various sorts can be used as well for signal distribution but is likely to either pose the same or less challenges than using the ATEM Converters which is why they are used in the diagrams as a sort of worst-case situation. Lets add though that we say nothing negative about these converters, in fact we think it's a brilliant idea to integrate intercom functionality the way it has been done.

ATEM Camera Converter and other fiber converters

In the camera end you may also need to convert SDI signals between coax and fiber. The ATEM Camera Converter is an option with specific support for talkback while an optical fiber converter is plain vanilla conversion. Pick whichever you prefer.

Disclaimer

The information in this document is provided with the intend to be useful and correct, but we make no guarantees about anything since we can't possibly test every single combination and firmware upgrade. We have based the writing on a mix of personal experiences, feedback from customers and statements from third parties in either written or oral form. The information may even be correct back in time and obsolete now due to developments in hardware and software. We wish to keep the information updated and relevant, therefore we also sincerely invite feedback and corrections so we can improve the accuracy!

Topologies for intercom, tally and color control data

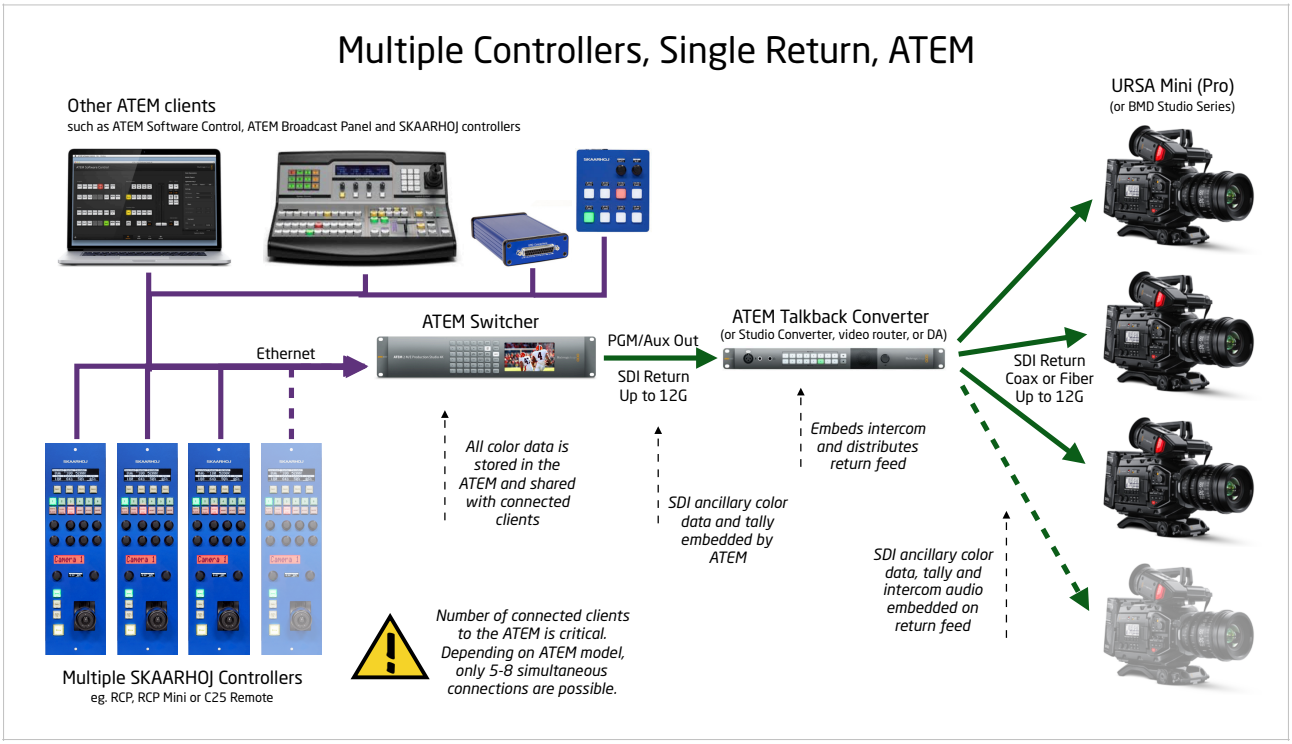
Multiple Control Surfaces with a Single Return Feed

This general scenario describes a case where multiple similar control surfaces shall control cameras through a single SDI return feed. The challenge is to channel the individual control signals from each control surface into the same SDI stream. The reason for requiring a single return feed signal could be that an ATEM Talkback or ATEM Studio Converter or simple distribution amplifier (DA) is used to transport signals to/from the cameras. These products have a common input (PGM In) that is distributed to all connected cameras.

In the cases below we only concerns ourselves with how to get control data to the camera and the camera output back to the control room is taken to be implicit.

Ethernet connections are drawn as if cables were connected directly to devices, but in reality they are of course connected to a network switch and the "direct cable" indicates simply the command flow.

ATEM Plain

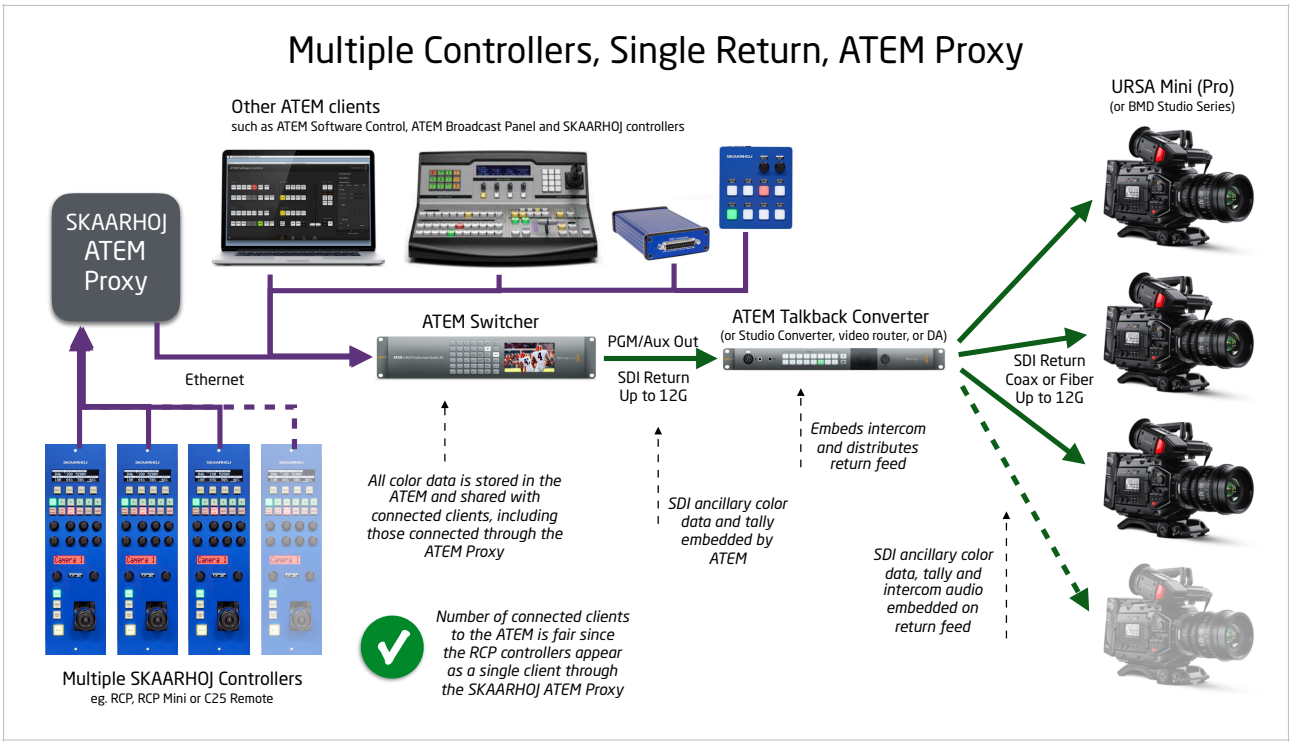


In this scenario, a SKAARHOJ RCP is taken as the control surface example. Each RCP controls a single camera and is connected via Ethernet to an ATEM switcher. The ATEM switcher embeds the control signals on the SDI outputs including tally coming from the switcher itself (assumed to be the production switcher). The return feed travels back to the cameras through an ATEM Studio/Talkback Converter, any compatible router or DI over fiber or coax. Characteristics:

- Requires an ATEM Switcher
- Embeds SDI Ancillary data on up to 12G SDI return feed.
- Parallel use of multiple controllers and software possible: Control data is located in the ATEM switcher itself and connected controllers will therefore pick up each others changes.

- Limited by number of connected clients to the ATEM (data from experiments, may have changed since)
    - ATEM Production Studio 4K (5 clients)
    - ATEM Television Studio (5 clients)
    - ATEM 2 M/E (7 clients)
    - ATEM 4K 1 M/E (6 clients)
    - ATEM 1 M/E (5 clients)
    - ATEM 4K 2 M/E (8 clients)

ATEM Proxy

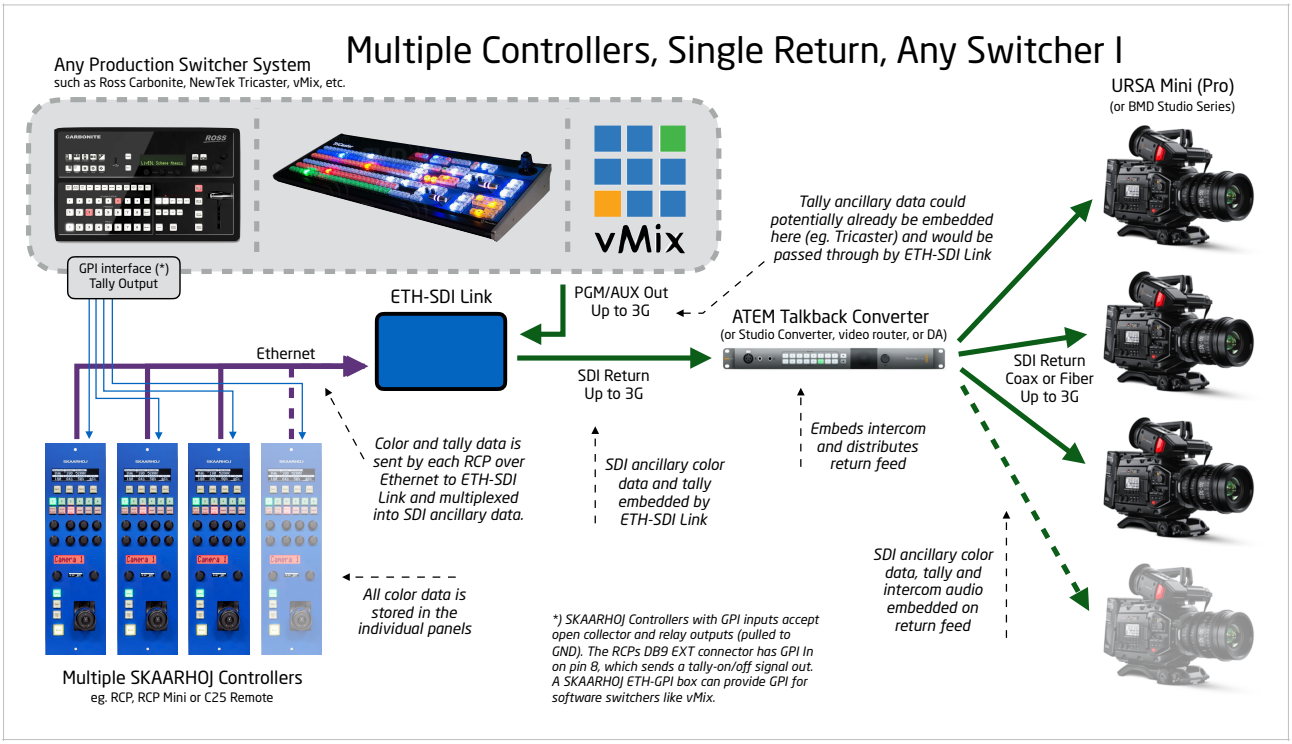


This scenario is similar to "ATEM Plain" but solves the connectivity issue of limited client connections by inserting a proxy between the RCPs and the ATEM. The Proxy is basically a Windows application (can run on anything from a real Windows computer to under Linux on a small card-PC or Raspberry Pi) that connects to the ATEM switcher as a single client using the official SDK from Blackmagic Design and at the same time exposes an interface for SKAARHOJ controllers to connect to over Ethernet in "unlimited numbers". The SKAARHOJ controllers doesn't actually know they are not connected to an ATEM switcher but a proxy that just simulates this connection by passing data through both ways. Characteristics:

- Connect unlimited number of SKAARHOJ control surfaces to ATEM switchers using only a single client connection slot on the ATEM.
- Long term ease of maintenance and support is unknown. The ATEM Proxy is an experimental/beta product at this stage. It works, and works well, but the continued development will depend on it's relevance to customers in the light of alternatives.

Find more information about the ATEM Proxy at http://skaarhoj.com/support/atem-proxy/

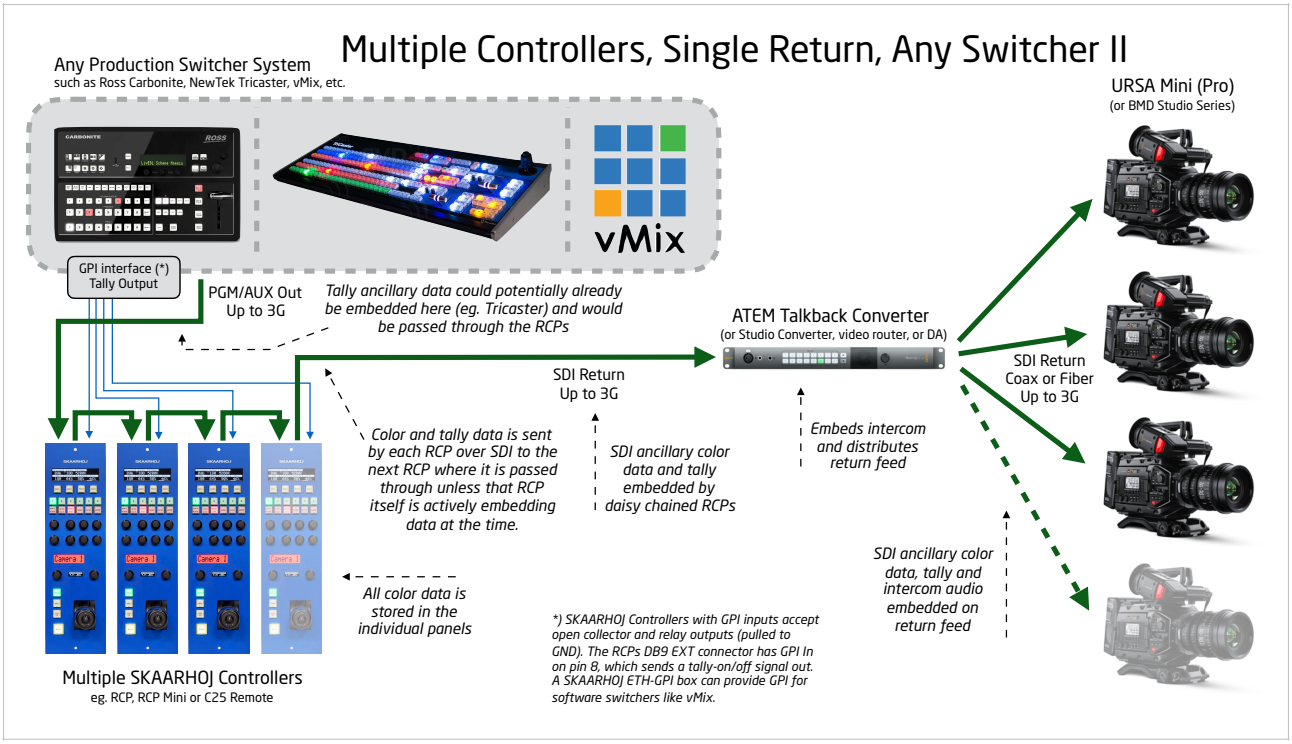
Any Production Switcher



In this setup multiple SKAARHOJ panels connect with a SKAARHOJ ETH-SDI Link over ethernet which in turn multiplexes this into the 3G-SDI output. On the 3G-SDI input of the ETH-SDI Link any 3G-SDI input can be supplied and may even contain ancillary data for tally on its own which will be passed through unless incoming ethernet tally data takes priority and disables the pass through behaviour. For example, if a Newtek Tricaster supplies a PGM out with tally data to the 3G SDI-in, the tally data will be passed through, but may be overridden if tally data is passed to the ETH-GPI Link over Ethernet from an RCP. Color data is always overridden.

Characteristics:

- 3G-SDI return feed
- Best for 1:1 controller-camera designs: The original data is located in the controllers, not in the ETH-SDI Link (unlike the ATEM scenarios) so if multiple controllers try to address the same camera, they will do so using individual (and competing) sets of data. This will most likely yield confusing results if two or more controllers try to adjust the *same* parameter, but it should work fine if they address strictly different parameters.
- Embeds color control and tally data on any 3G-SDI input. Any tally data on SDI-In is passed through when the ETH-SDI Link is not embedding tally data itself. Any incoming color control data is overridden.
- SKAARHOJ RCPs will allow an external GPI to send tally data into the ETH-GPI over ethernet (configuration dependent)



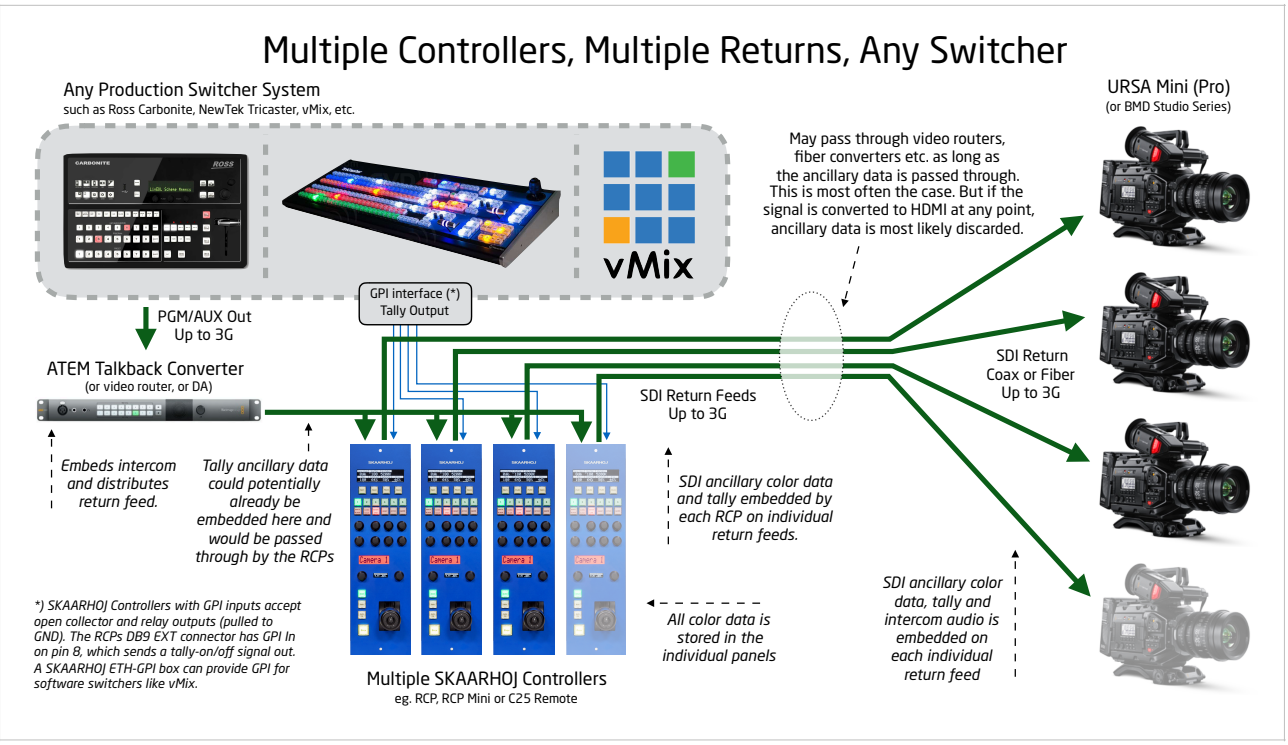
An alternative design is to daisy chain the RCPs. This will work when the RCPs are configured to pass on incoming tally and color SDI ancillary data to the output in case the controller itself does not produce data output to be embedded ("Momentary Override" option). Thus there is a chance of data loss in a case where two or more RCPs are sending data simultaneously. Additionally the topology is more fragile to failures in just one RCP or cable that will immediately interrupt the daisy chaining.

Characteristics in addition to the previous scenario:

- No need for ETH-SDI Link to multiplex data onto SDI
- Fragile to cable failures and power loss in the daisy chain.
- Potential for data loss when simultaneously operating more RCPs.

Multiple Control Surfaces with Multiple Return Feeds

Any Production Switcher



In this setup each RCP has its SDI output connected "directly" to the receiving camera. By directly we mean it may pass through video routers and fiber converters as long as the ancillary data is not filtered out. But the main characteristic is that each return feed contains color and tally data for that camera only.

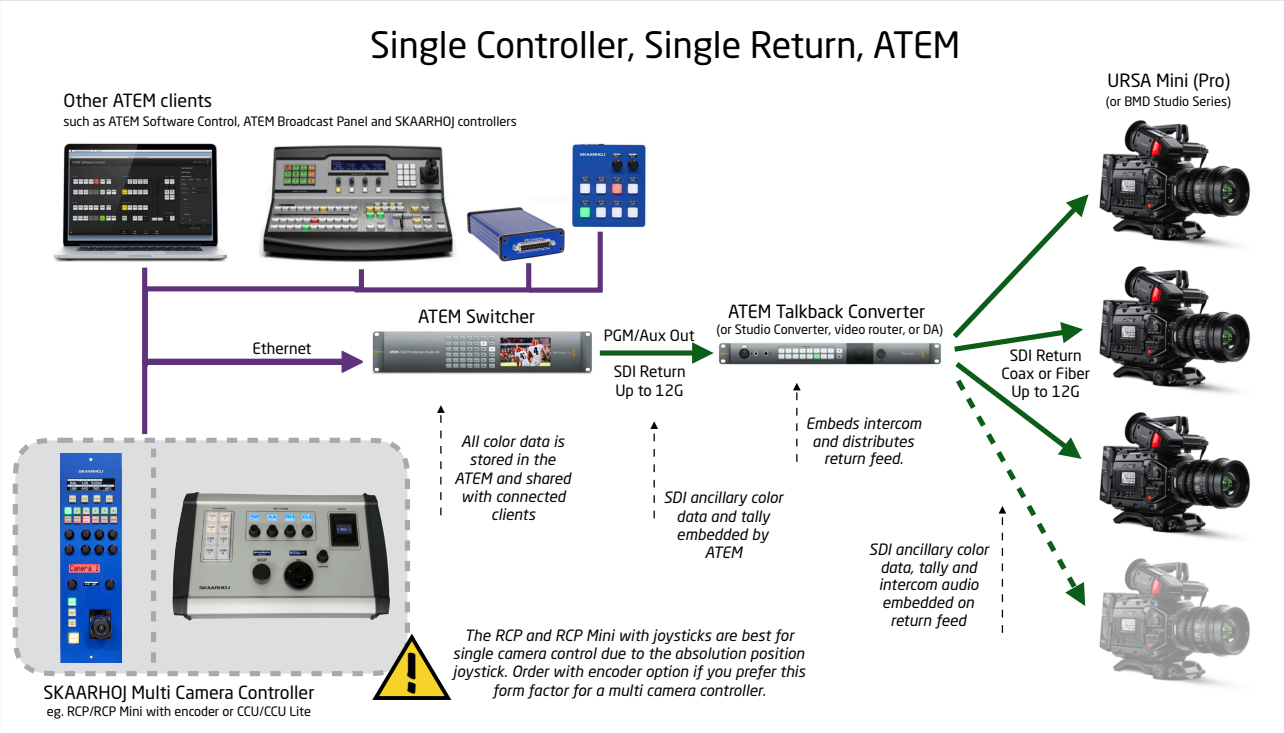
Specifically with this solution, an ATEM Talkback Converter is not an obvious component since it cannot be placed after the RCPs and used as the distribution point to/from cameras. Rather, if an ATEM Talkback/ Studio Converter is to be used at all in this set up, it will be before the RCPs SDI-In.

This solution is also available for use with any production switcher. The return feed would be such as the PGM output from the switcher, going into a DA or a Talkback Converter, then distributed out to each RCP which in turn embeds color control and tally data before it sends the signal on to the camera. The SDI input to the RCPs may even contain ancillary data for tally on its own which will be passed through unless incoming GPI triggers is set up to override it. For example, if a Newtek Tricaster supplies a PGM out with tally data to the 3G SDI-in, the tally data will be passed through by default, but may be overridden if the GPI input is triggered and set up to output tally data in that event.

Single (Multi Camera) Control Surfaces

Some workflows call for a single control surface to adjust all cameras on the set. In particular the CCU and CCU Lite products from SKAARHOJ are very useful for such scenarios. They are designed to accommodate selection of one or more cameras, and adjusting their parameters. The RCP and RCP Mini products can be set up to do the same, but the absolute mechanical position of the iris joystick makes them better designed for single camera control. However, fitted with the encoder options, the RCP and RCP Mini can be set up with a camera selection as well and work efficiently as multi camera controllers.

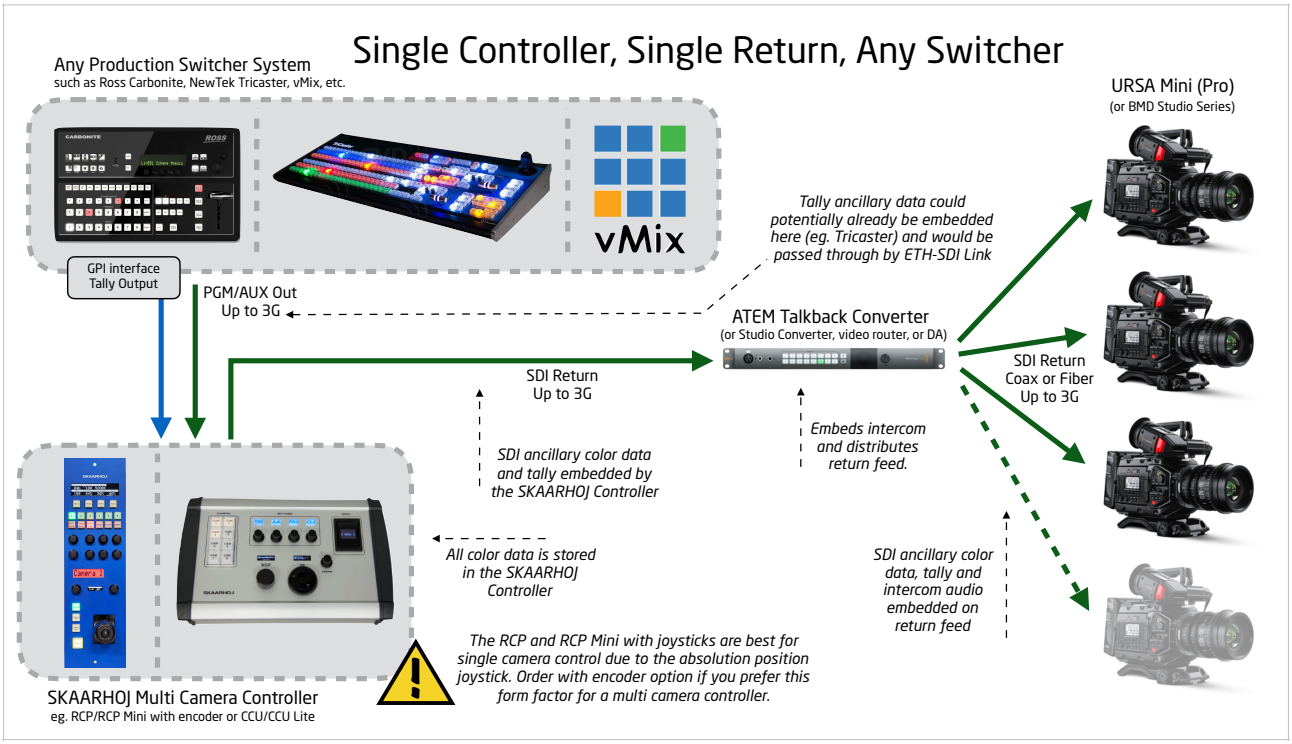
Via ATEM Switchers



A single control surface is connected to an ATEM switcher. Most typically it would be a SKAARHOJ CCU or CCU Lite since they are designed for multi camera control. The RCP and RCP Mini could also be used, but it would be highly recommended to choose the encoder option and in any case they need to be configured with a scheme for camera selection. The ATEM Switcher inserts the control data on the SDI output that is fed back to the cameras.

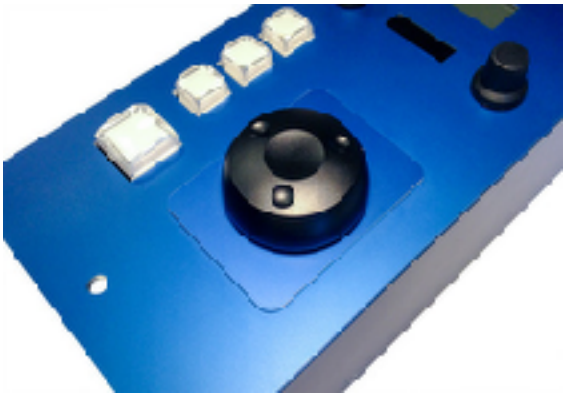
- Allows multiple, synchronized control panels because they all pull information from the ATEM switcher.
- Subject to limits in number of connected clients to the ATEM (but here it would probably be OK since the assumption is a single control panel).
- Will allow 12G return feed to cameras.
- Tally is provided from the ATEM Switcher.

Via Any Production Switcher



A single control surface receives the 3G-SDI PGM out from a production switcher. The SKAARHOJ Controller inserts the color and tally control data on the SDI output that is fed back to the cameras. Most typically it would be a SKAARHOJ CCU or CCU Lite with SDI option since they are designed for multi camera control. The RCP and RCP Mini could also be used, but it would be highly recommended to choose the encoder option and in any case they need to be configured with a scheme for camera selection. Tally can be inserted on the SDI if the CCU has the GPI option, but notice how this is not practically possible with the RCP since it has only a single channel GPI input. See SDI-GPI Link for a solution to this challenge.

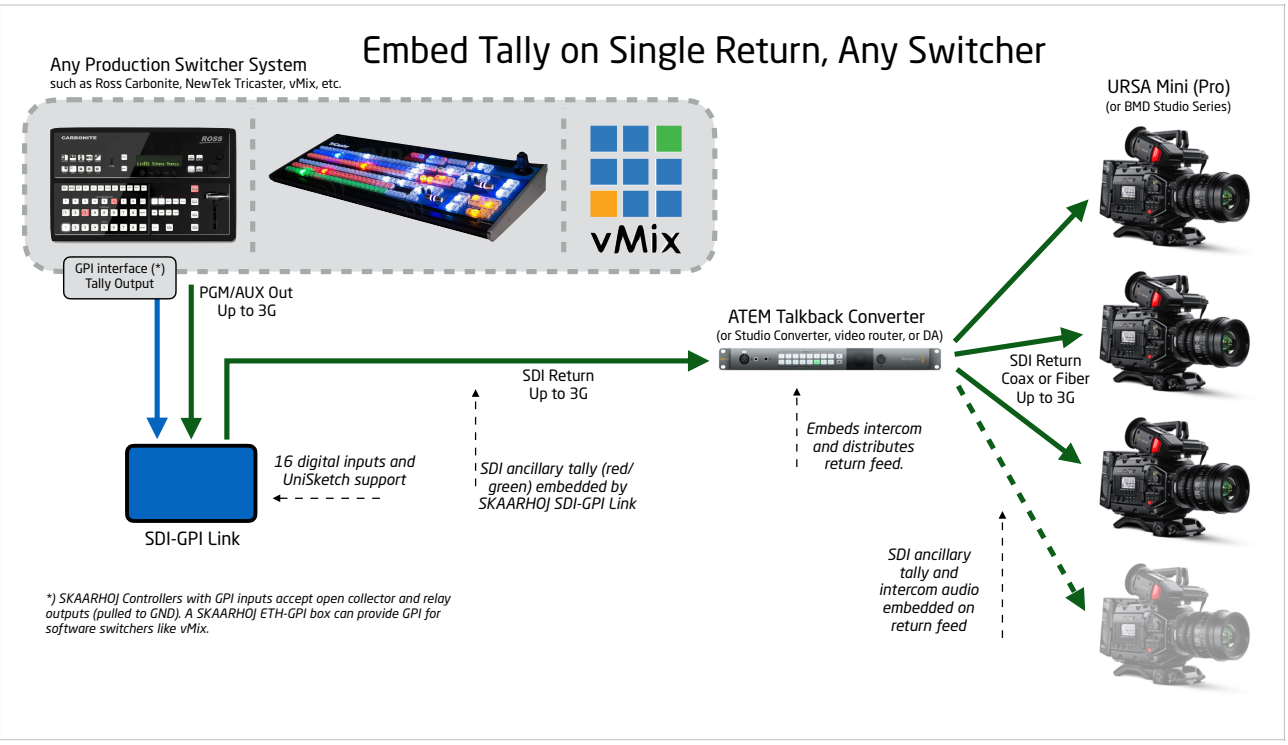
- Single control panel for all cameras.
- 3G-SDI return feed.
- Tally embedded by controller via GPI triggers from production switcher.



Multi Turn Dial (“Encoder”) option for the RCP

Tally over SDI

Tally over SDI can be embedded by the SKAARHOJ SDI-GPI Link in case there is no such function found elsewhere in the signal chain. For example, RCPs can embed tally signals for single cameras and the CCU can embed signals for multiple cameras via GPI triggers. With the SDI-GPI Link you get even more power since it has 16 inputs by default and options to add more. They are configurable by UniSketch OS, so you can assign the 16 inputs to either 16 channels of "red" tally or 8 channels of "red" and "green" tally. (See the section in the back of the document about SKAARHOJ Controller configuration for more insights).



In general, a tally signal is embedded on SDI only when an event to the GPI trigger happens. For example when the trigger is activated/closed, "red" tally could be sent to camera 1, and when the trigger is released again, clear tally could be sent to camera 1. But no tally signals are embedded on the SDI in the meantime between triggers. This means the system may need to receive at least one trigger signal before tally states are correctly reflected on cameras and monitors in the receiving end. On the other hand this is also the reason why all SKAARHOJ controllers can operate in a passthrough mode that lets tally data flow through the SDI In-Out connectors unless the controller itself is triggered to insert data in the SDI stream.

Tally from SDI to Relays

An SDI-GPI Link with the 2x8 GPI options (having 8 relay outputs) can work in reverse too! You can set up the output relays to trigger based on red and green tally signals on the incoming SDI stream. This is useful if the final recipient of the SDI carried tally signals is not a Blackmagic camera or monitor but a traditional tally lamp system.

Monitoring / “Joystick Override”

Color Control Monitoring

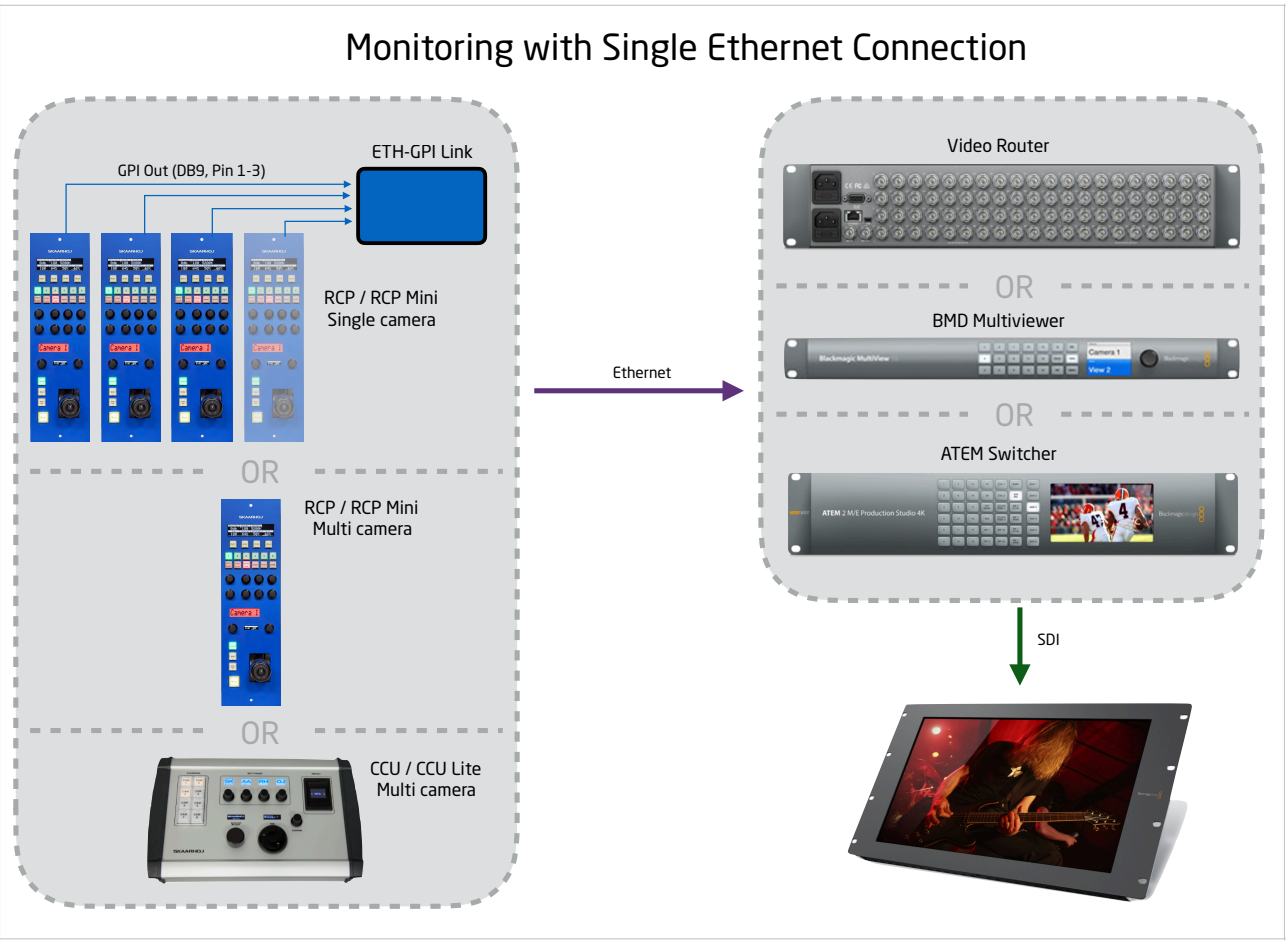
With any coloring controller it is necessary to provide a reasonable solution to local monitoring; the shading artist usually needs a dedicated monitor to preview the inputs he or she is controlling. Most SKAARHOJ camera controllers have buttons that are designed to trigger inputs on a preview monitor. Generally, such a button can operate in different modes:

- Set: Pressing the button simply sets or routes a given input to the monitor.
- Toggle: Pressing the button sets the input on the first press and on a second press it falls back to the previously shown source.
- Hold down: Pressing down the button sets the input but when it’s released it falls back to the previously shown source.
- Hold Groups: A special mode that takes other buttons pressed state into account; as long as any of a group of buttons remain pressed down, the last pressed buttons source is shown and when the last button is released it falls back to the source shown before any buttons in the group were pressed.
- Special device adapted approaches: For example for a Blackmagic Design Multiview show a single selected source in solo mode but multiple sources in a 2x2 or 3x3 grid view.

In the above text, the word “button” is used, but all the same facts apply for GPI inputs on SKAARHOJ controllers: They are both considered “binary triggers” - either they are on/pressed or not.

Which scheme applies best depends on a mix of operator preference and the type of controller you apply.

Single Ethernet Connection



In this case a single ethernet connection to a video router, BMD Multiviewer or ATEM Switcher is used for monitoring. There are two subcases here: a) When individual camera controllers of the type RCP is used and when b) an RCP or CCU is used for multi camera control.

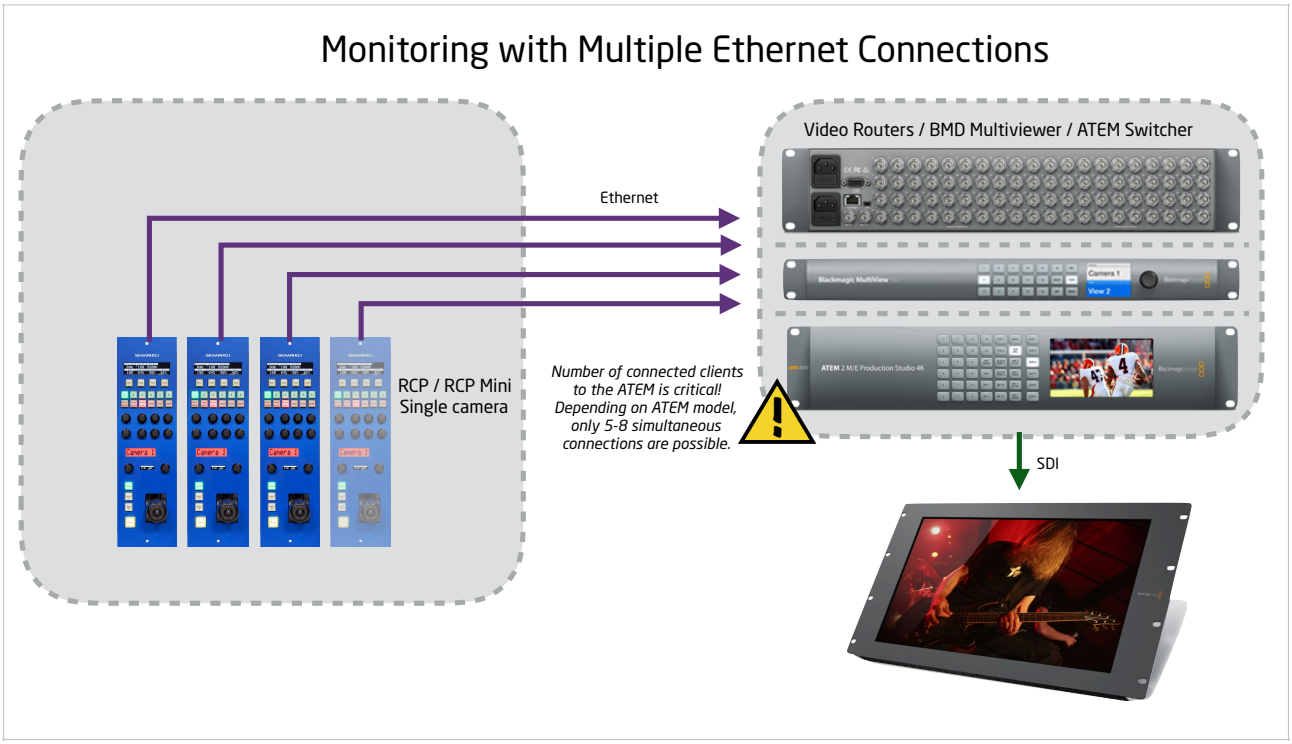
In the first case, multiple RCPs are connected to a SKAARHOJ ETH-GPI Link box by the GPI interface. The ETH-GPI Link establishes the connection to the monitor router. This scenario is very typical and applies beyond the use of SKAARHOJ RCPs - could be any RCP really. In this case Hold Groups is really well suited: As an RCP operator holds down the joystick push button, the camera is routed to the monitor and as he releases, it drops back to the previous source (could also be a fixed default), but if two or more joysticks are operated simultaneously as is often the case, the routing will change between the sources represented by the joysticks so comparison is easily done - and eventually everything will fall back to the original source. This concept requires a single controller (like ETH-GPI Link) because it requires knowledge about all sources. Hold Groups is a feature found in SKAARHOJ device cores for BMD Videohub, Aja Kumo, BMD Multiview and BMD ATEM Switchers (AUX, Program, Preview).

In the second case where an RCP or CCU is used for multi camera control, a number of buttons are used for camera selection. On the CCU, an array of 4x2 buttons on the left side are designed for this purpose while on the RCP, user buttons U1-U6 are the most likely choice. The camera selector buttons on a multi camera controller is usually not used in any Hold-scheme because pressing the button primarily functions to set the destination of changes made on the controller itself. Therefore in the most simple case, a button in the camera selector array simply sets a route when pressed (and for BMD Multiviewer may also enable solo mode) in addition to selecting that camera as a destination.

Probably the best solution with a multi camera controller using memory groups to select camera destination(s) is to add a “Memory Group AutoRouter” action to the controller. This exists for device cores such as ATEM, VideoHub, Kumo and BMD Multiviewer. Based on the assumption that a memory group is used for camera selection, it will automatically route the input corresponding to the selection to a

destination such as an auxilary output. For the BMD Multiviewer it becomes even more functional since a multiple selection of destinations will create a 2x2 or 3x3 grid with the selected sources instead of only a solo display of the last selected camera.

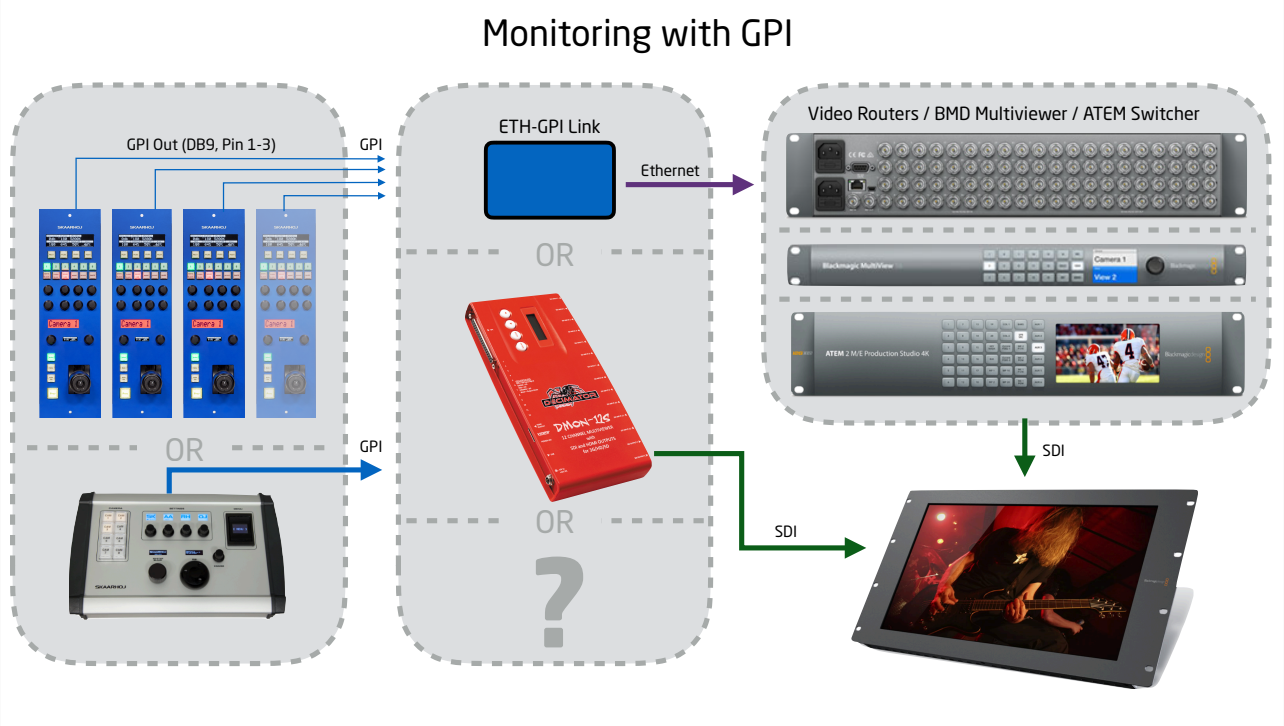
Multiple Ethernet Connections



In this case, a Set action is the most relevant. The Hold Down and Toggle modes are problematic because they pick up the fall-back source when they are first pressed and assuming the fall-back source should theoretically always be the same (like PGM), this will easily get "out of sync". Hold Groups on each controller combined with a "Hold Group Default" action can provide the proper behaviour though (giving the function of a single Hold Down with fixed fall-back).

However, this approach requires individual ethernet connections for each camera controller and while this is likely to work for video routers up to a reasonable amount of controllers, we know for sure it will not work with ATEM switchers - they can accept only a limited number of client connections as has already been described a number of times. Use of the ATEM Proxy can however alleviate this challenge.

Monitoring with GPI



Finally, monitoring with GPI outputs from the camera controllers is a classic. It has already been described how the ETH-GPI Link can be used for this purpose, but many other products exist that can function as routers or multiviewers based on GPI triggers. Therefore, not only the RCPs has a GPI output, also the CCU can be delivered with GPI outputs that enable them to trigger routing in this way.

	General	RCP / RCP Mini (Single camera)	CCU / CCU Lite (Multicamera)	C25 (Single camera)
BMD ATEM	You can route an input to an AUX output and let it fall back to the previous source or a particular predefined source.	Beware of limited client connections of ATEM if RCPs are used in single camera modes.	Popular with the CCU products because they are designed for multi camera usage and takes up only one client connection to the ATEM for a single multi camera controller.	The C25 will probably fall into the category of the RCP/ RCP Mini products in this case.

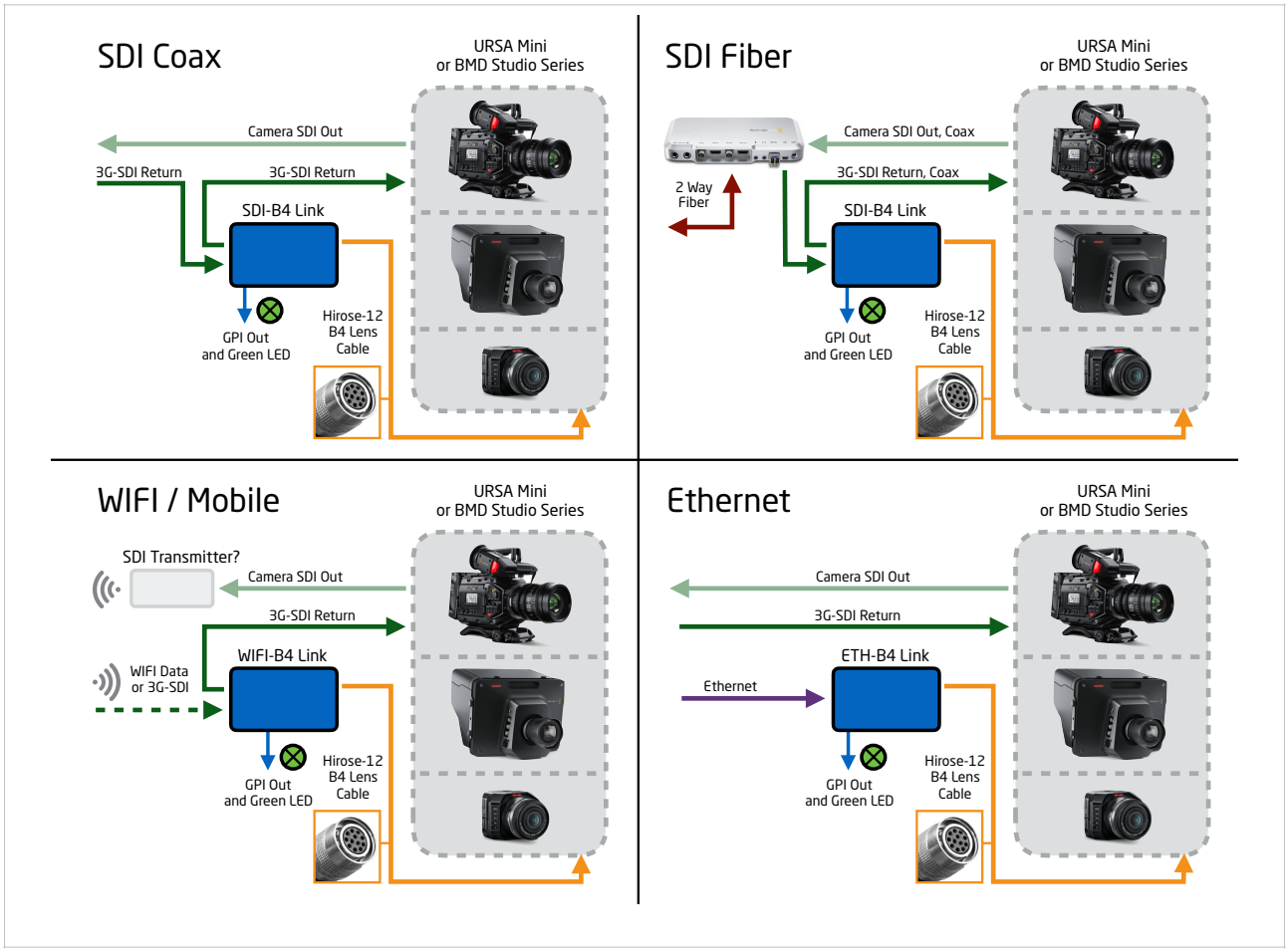
	General	RCP / RCP Mini (Single camera)	CCU / CCU Lite (Multicamera)	C25 (Single camera)
Video routers	You can connect to a video router over IP (such as a BMD Videohub or Aja Kumo) and route a source to an input and let it fall back to the previous source or a particular predefined source. Generally video routers are relaxed about the number of simultaneous client connections so this is likely to work well in many cases.	If a particular fall-back scheme for hold-down functionality is desired it may not be feasible this way.	Because the same controller controls multiple cameras, you can use advanced fall-back schemes such as Hold Groups that are sensitive to what other cameras are selected	
BMD Multiview 16	With a BMD Multiview you can route a source to the Solo output and enable Solo mode on hold to bring up a single source	If a particular fall-back scheme for hold-down functionality is desired it may not be feasible this way.	Because the same controller controls multiple cameras, you can use advanced layouts: For example solo mode if one camera is selected or 2x2 or 3x3 views if multiple cameras are selected.	
Decimator DMON 12S	Uses GPI trigger inputs to route sources on the multiview output.	The joystick override output is wired to the DMON for each RCP	If the GPI option is selected, you connect the outputs to the GPI inputs to route sources on the multiviewer	N/A
ETH-GPI	Uses GPI trigger inputs to route sources on ATEMs, video routers, multiviewers etc.	The joystick override output is wired to the ETH-GPI for each RCP. The use of Hold-Groups queuing will be fully available.	If the GPIO option is selected, you connect the outputs to the ETH-GPI and let it handle the routing schemes.	N/A

B4 Lens Control

One of the most glaring omissions on Blackmagic Designs cameras available for live production is the poor support for broadcast lenses. The ancillary camera control data has provisions for controlling lenses, including focus, zoom and most importantly, the iris. While focus and zoom is typically a local concern of the camera operator and therefore not a big deal in terms of remote control, iris is a concern of the CCU operator in the control room. The lens mounts of Blackmagic Designs cameras does have some means of controlling focus, zoom and iris on some lenses. For example, at SKAARHOJ we have a MFT lens from Olympus that has these features and receives all that data through the lens mount. However, that lens is far from a classic broadcast lens with a B4 mount and Hirose-12 connector.

Lately, the URSA Mini Pro camera has received such a lens connector on the camera body itself, and as far as we know it works fine, but for the URSA Mini, older Studio Cameras and somewhat also the Micro Studio Camera, the need for external means to control the lens iris is obvious.

We have a number of solutions for those, who for whatever reason needs iris control of their broadcast lens and don't get it directly from their cameras.



SDI Coax

The SKAARHOJ SDI-B4 Link is a box you place close to the camera lens and which provides analog servo control of the iris (voltage from 2.5V to 7.5V) through a Hirose-12 connector. It works by intercepting the 3G-SDI return feed to the camera and extracting the iris information, then converting this to an analog control voltage. From the SDI-B4 Link the SDI output is connected to the camera SDI input so the color data still reaches the camera. The SDI-B4 Link has a camera selector switch that sets it's camera ID filter

and the iris data it receives is output on the Hirose-12 connector. It also features a tally lamp (red/green) and a relay output (PGM tally out).

SDI Fiber

In case you run the SDI signals between the camera and control room in a duplex fiber, you may face the issue of how to insert the SDI-B4 Link box in that signal flow. This would in particular be true if you wish to use the Studio Cameras with their fiber port. The answer is: You can't. You will have to purchase another fiber to/from SDI converter such as the ATEM Camera Converter (includes talkback features) or Optical Fiber 4K mini converter. From these you will connect the camera with regular coax cables and thus follow the workflow suggested in the previous section for "SDI Coax".

Ethernet

With SKAARHOJ ETH-B4 Link the iris control data is sent separately out to the lens through ethernet, thereby requiring an additional wire as compared to a dual SDI/Fiber solution. This option is partly historic since it existed before the SDI-B4 Link product was available but it may still be relevant if it's not an option to interrupt the fiber to the camera as described under "SDI Fiber" or if the return feed needs to be 12G. The ETH-B4 Link has a camera selector switch that sets it's camera ID filter as well as its IP address and the iris data it receives is output on the Hirose-12 connector. It also features a tally lamp (red/green) and a relay output (PGM tally out).

WIFI / Mobile

With SKAARHOJ WIFI-B4 Link you have a fairly powerful solution, not only by the fact that it is wireless but also by the many ways it can output data. Basically it receives Blackmagic Camera Control Protocol packages over WIFI and does a number of things with these:

- Like ETH-B4 Link it will output iris values for the selected camera as an analog voltage on the Hirose-12 connector.
- Additionally it will forward any received data on the SDI output connector, thereby proposing a solution for wireless color control of Blackmagic Cameras.
- Received data on the SDI input will likewise be forwarded on the output and used for lens control (on the Hirose-12 output). It's assumed that the box will typically receive data only on either SDI in or over WIFI.

It's highly recommended to consider the robustness of the WIFI-B4 Link solution in relation to your venue: Will the WIFI network perform sufficiently well during a live show (with a room full of audience with wifi enabled mobile devices) as it did during your test? Experiences with mobile usage (cable cameras) show that it may work just fine, but could also be challenging. You are encouraged to consider means such as directional antennas etc.

SKAARHOJ Controller Configuration

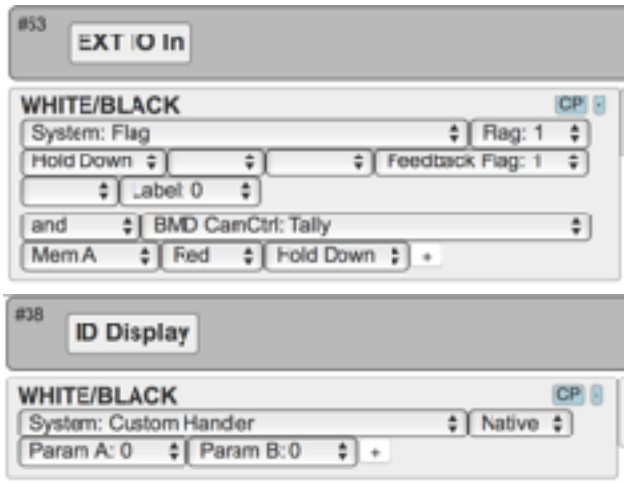
SKAARHOJ Controllers are so flexible that you can completely reconfigure them any way you want. For a number of typical cases we give examples of how you could configure your controller to achieve certain results.

In the tables in this chapter you will find screenshots from the UniSketch interface and in the text on the right side we will describe how the configuration works. In the text we use "HWC" (short for HardWare (interface) Component) to refer to configuration entries for buttons, knobs, displays, GPIs and even "virtual" components used in UniSketch.

RCP / RCP Mini

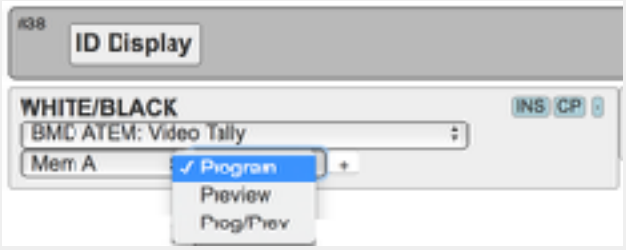
In this section we present configurations based on the RCP and RCP Mini and which mostly deal with specifics of how these controllers are normally used.

Tally Embedding and Local Tally on Display



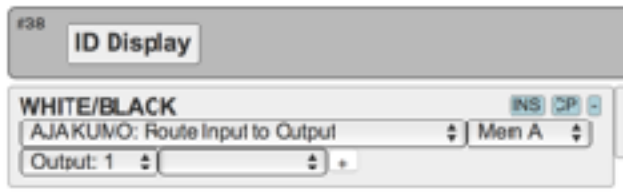
Tally in via GPI, embedded on SDI out

HWC #53 is the "EXT IO In" which is the binary trigger found on pin 8 of the DB-9 plug on the RCP and RCP-Mini. If this pin is shorted to GND, this behaviour consisting of two actions is triggered. The first action sets system flag 1 true for as long as the GPI input is held low after which it returns the flag to false (used for the display tally backlight), and with the second action it sends red tally on SDI out when triggered, and when released it will clear the red tally on SDI out again.
The display on the RCP is also red when the GPI is triggered. This is handled by a custom handler that also writes the camera ID in the display based on the value of Mem A. Basically it looks after the state of system flag 1 to determine if the display should be white or red. This is the only reason for setting flag 1.



Tally and Camera Name via ATEM

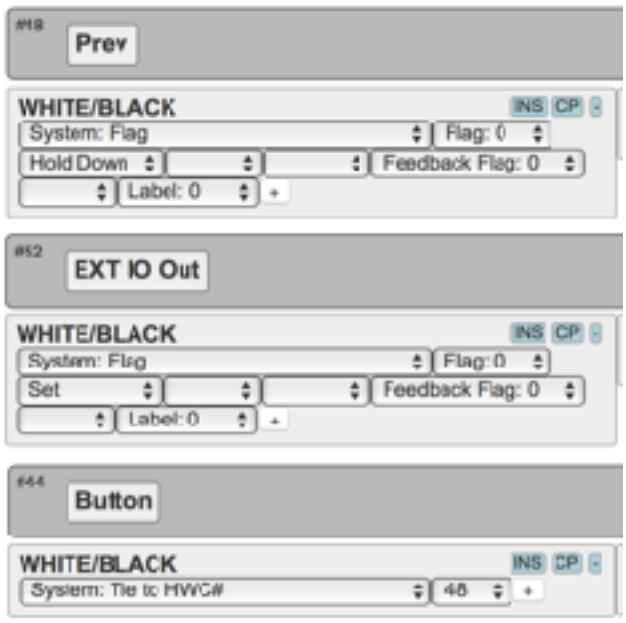
If the RCP is connected via an ATEM switcher you can configure the display to show red and/or green tally in response to the tally state of the camera in the switcher. In addition you will enjoy the name of the input being taken from the ATEM switcher.



Tally and Camera Name via Videohub

The RCP can also extract the input name from a video router such as a BMD Videohub or Aja Kumo. If the input is routed to the selected output, it will light up red, otherwise white. Input numbers must correspond to camera numbers.

Monitoring by Prev button

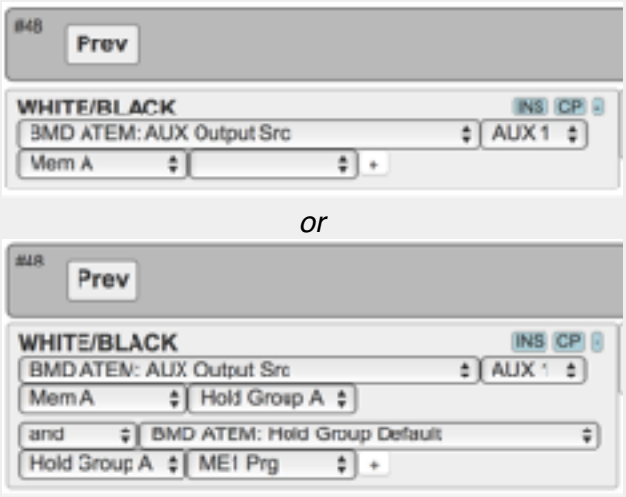


Preview via GPI out (DB-9, pin 1 and 2 shorted)

The Prev button (HWC #48 on RCP) is configured to set system flag 0 to true for as long as the button is held down. The state of system flag 0 is then picked up by the relay output on the DB-9 plug by the HWC "EXT IO Out". The essential setting here is that the "Feedback Flag" is set to 0. This means that pin 1 and 2 will be shorted on the DB-9 plug when Prev is held down. Otherwise pin 1 and 3 will normally be shorted in the inactive state.

Notice how the top button of the joystick is simply tied to the "Prev" button so it follows the exact same behaviour.

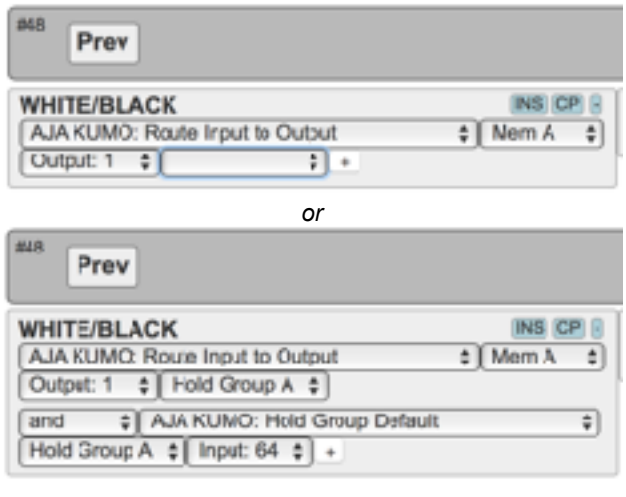
This is the default configuration of the RCPs and basically how they should work if they are set up for the scenario "Monitoring with Single Ethernet Connection" or "Monitoring with GPI".



Preview with ATEM switcher (single camera, ATEM Proxy)

This configuration simply routes the input in memory A to AUX1. There is no fallback to another source when released.

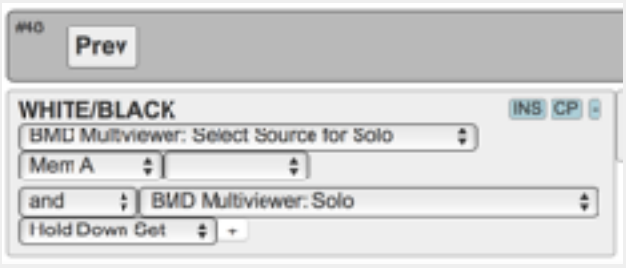
The alternative configuration shows how you can secure a fall back to PGM when the joystick is released.



Preview with a AJA Kumo video router (single camera)

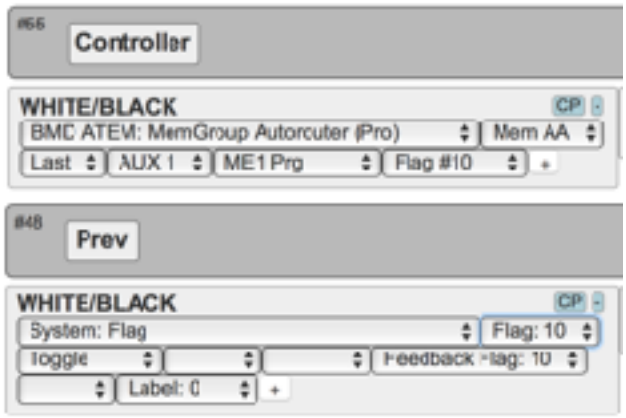
This configuration simply routes the input in memory A to Output 1. There is no fallback to another source when released.

The alternative configuration shows how you can secure a fall back to Input 64 when the joystick is released.



Preview with a BMD Multiview (single camera)

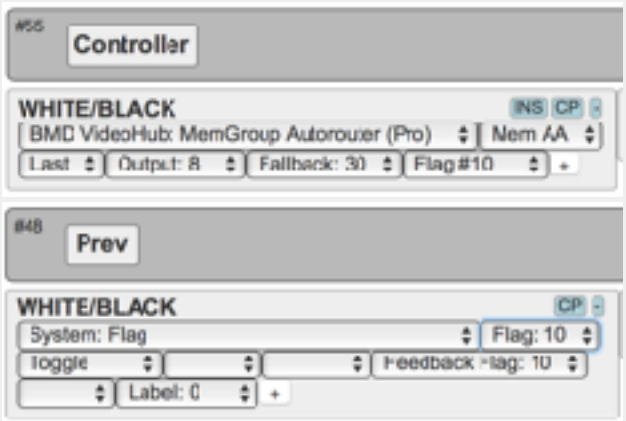
This configuration routes the input in memory A to the Solo output and enables Solo mode for as long as the trigger is held down after which it reverts to grid view.



Preview with ATEM switcher (multi camera)

Assuming that Memory Group A is used for a multi camera controller, adding the "MemGroup Autorouter" to the Controller virtual HWC will let you start an automatic routing scheme on AUX 1 that goes like this: The last selected camera in the memory group will be routed to AUX1 and if the Memory Group is empty, ME1 PRG is routed there. System flag 10 is used to enable/disable the auto router.

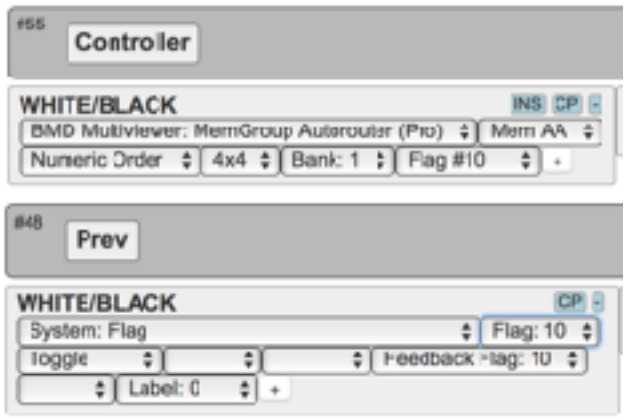
Since system flag 10 is used to start/stop the router, we set up the Prev button to toggle this flag on and off. Instead of "Toggle", "Hold Down" could be selected.



Preview with BMD Videohub (multi camera)

Assuming that Memory Group A is used for a multi camera controller, adding the "MemGroup Autorouter" to the Controller virtual HWC will let you start an automatic routing scheme on output 8 that goes like this: The last selected camera/input in the memory group will be routed to output 8 and if the Memory Group is empty, input 30 is routed there. System flag 10 is used to enable/disable the auto router.

Since system flag 10 is used to start/stop the router, we set up the Prev button to toggle this flag on and off. Instead of "Toggle", "Hold Down" could be selected.

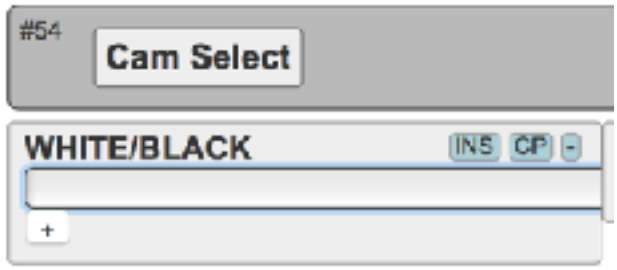


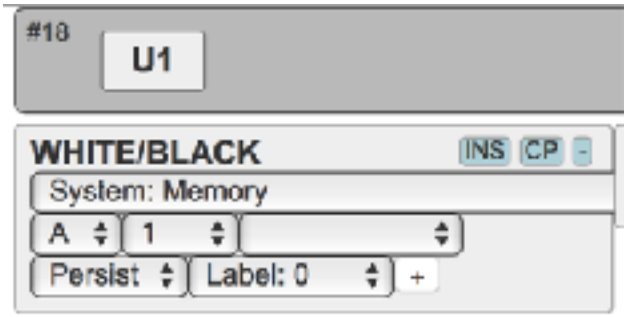
Preview with BMD Multiview 16 (multi camera)

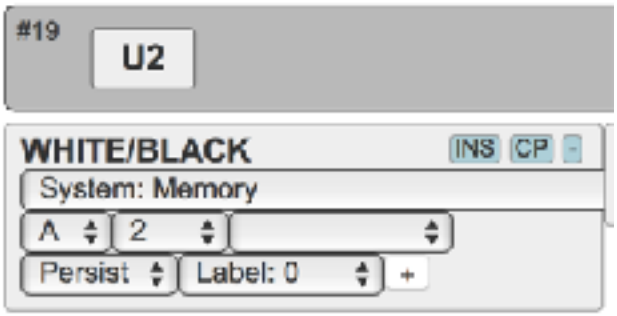
Assuming that Memory Group A is used for a multi camera controller, adding the "MemGroup Autorouter" to the Controller virtual HWC will let you start an automatic routing scheme: If any camera is selected in the memory group, that input from the Multiview is routed to the Solo output and the Multiview is put in solo mode. In case multiple cameras are selected in the memory group, they will be arranged in numeric order on the multiviewer in either a 2x2 or 3x3 grid depending on whether the number exceeds 4 or not. The original multiviewer configuration is stored in bank 1 and when no cameras are found in the memory group or if flag 10 is going false, the Multiview will be restored to the routing saved in Bank 1 and a 4x4 grid is shown.

Since system flag 10 is used to start/stop the router, we set up the Prev button to toggle this flag on and off.

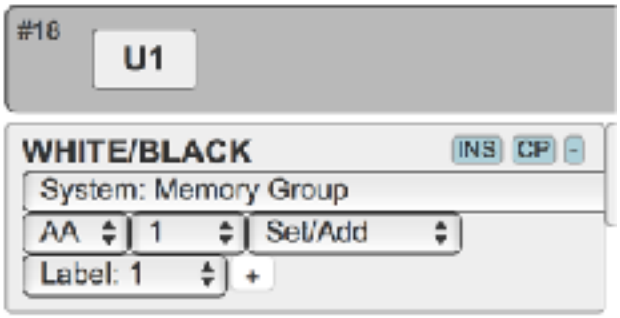
Camera selector: DIP or buttons?

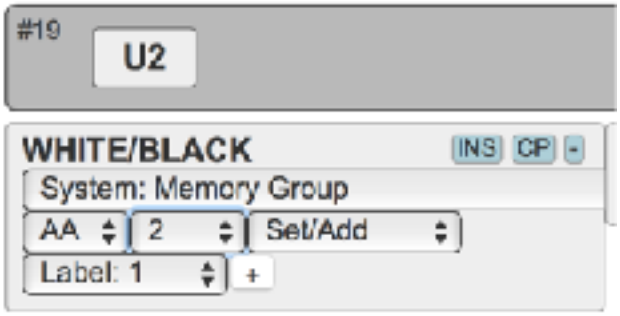






or with memory groups:





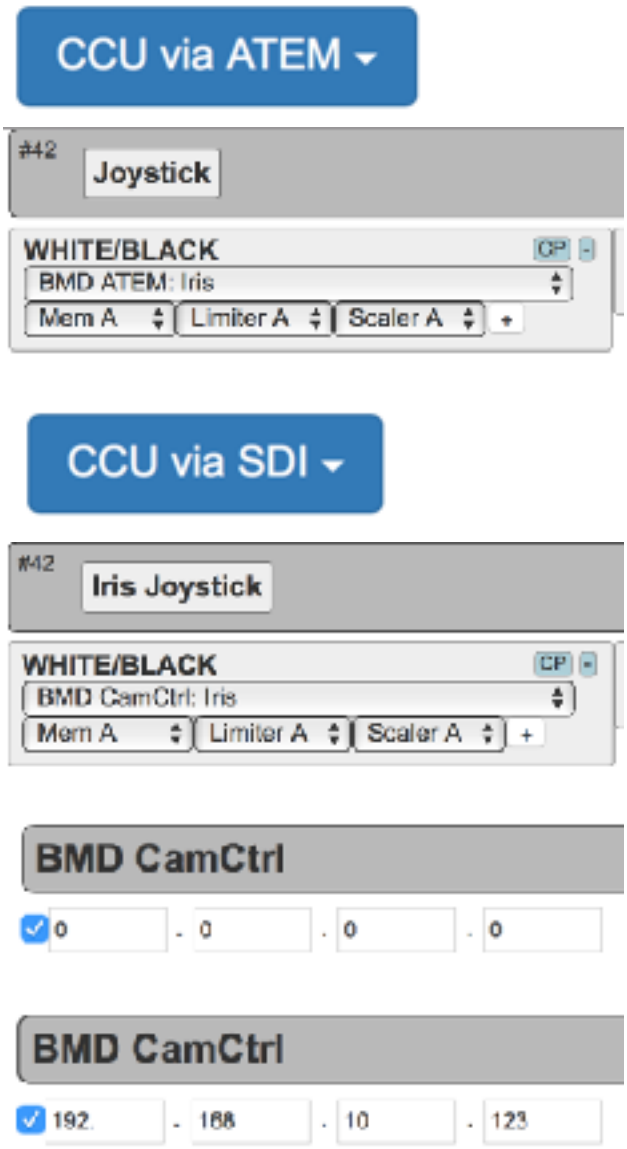
Making a multi camera controller out of an RCP

First, disable the "Cam Select" dip switch by clearing the actions for it.

Then you could use buttons U1-U6 for setting Memory A instead. If you set "Persist" the value will be stored in memory and available when you boot the controller again.

Alternatively, use "System: Memory Group" as a camera selector. This allows not only to add more than one camera at a time, but also allows you to get tally down on the camera selector, if you choose the "sister" action to "System: Memory Group" found in other device cores such as ATEM, VideoHub and AJA Kumo.

ATEM, SDI out or ETH-SDI Link?

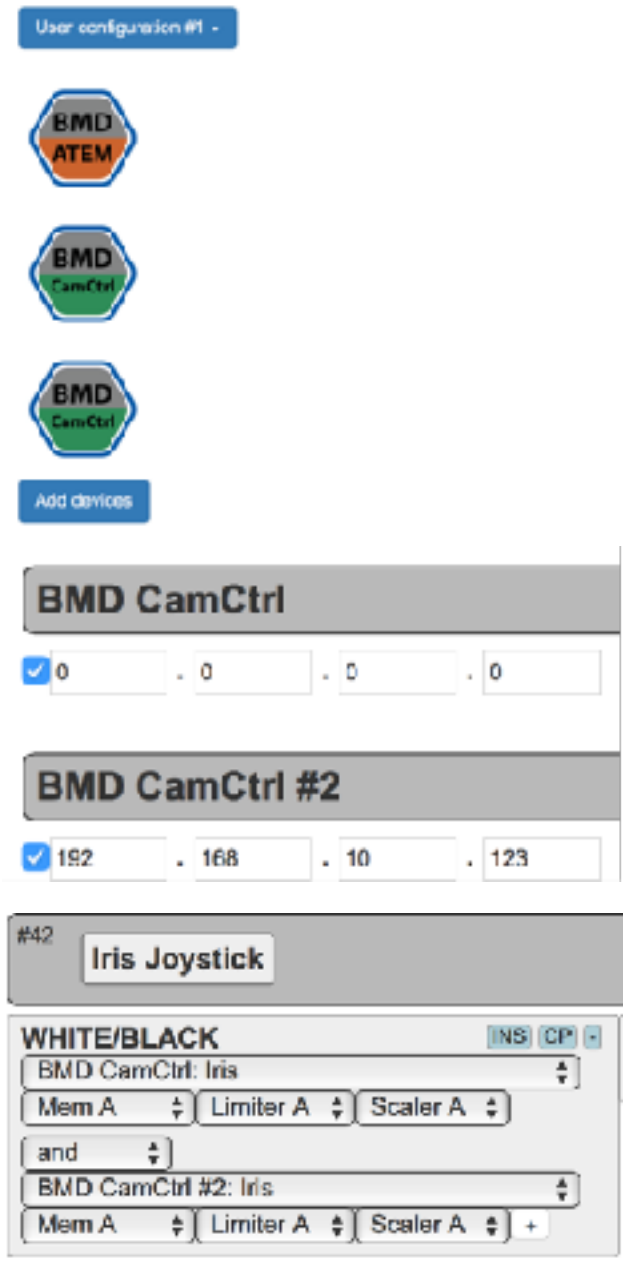


ATEM, SDI or ETH-SDI Link?

With the default configuration "CCU via ATEM" you will find that all HWCs are calling camera control actions through the ATEM switcher.

If you change to the default configuration "CCU via SDI" you will see all the same actions, but via the device core called "BMD CamCtrl" which uses the 3G-SDI output of the controller. However, this is easily changed to the use of the "ETH-SDI Link" because all you need to send out the packages over ethernet is setting the IP address! In other words: If the IP address is 0.0.0.0, control packages will get sent over the SDI output, if the IP address is filled in, the packages will be sent to that IP address (and we assume there sits a SKAARHOJ ETH-SDI Link, WIFI-B4 Link or ETH-B4 Link box ready to receive the information).

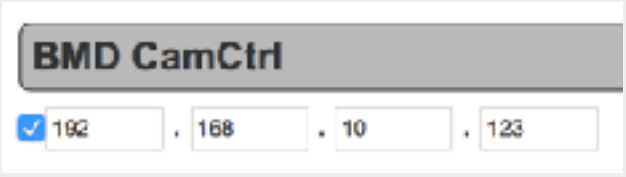
Control with ETH-B4 Link or WIFI-B4 Link



Direct Iris control with ETH-B4 Link or WIFI-B4 Link

Assuming you start with the RCP configuration for "CCU via SDI", you add another device core for "BMD CamCtrl", but instead of just enabling it, you also add an IP address - the IP address of your ETH-B4 Link or WIFI-B4 Link. Notice how this device core is suffixed with "#2"
In the behaviour for the Iris Joystick you add an action to set iris on "BMD CamCtrl #2" with all the same settings.

Notice, this will only work with an RCP that controls a single camera because there is no change of IP address of the ETH-B4 Link or WIFI-B4 Link box in the other end - it will always send the iris values to that box. However, it will do so with proper camera ID so in case you have multiple cameras but only one of them using this box, it will work fine because that box will only (as always) react to values addressed for the camera ID set on its DIP switch.



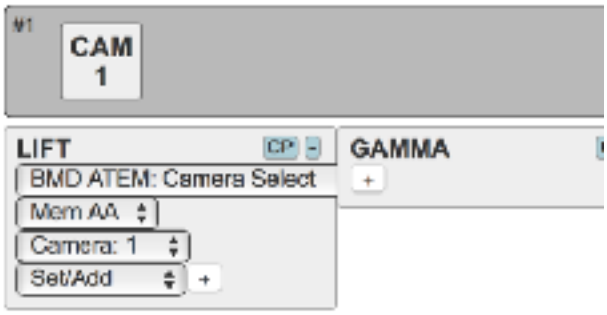
Full control with WIFI-B4 Link

For full control with a WIFI-B4 Link (or ETH-B4 Link) in the other end, simply set an IP address for the "BMD CamCtrl" device core.

(In case you have a multi camera controller and wish one of the cameras to receive the information over a WIFI-B4 Link or ETH-SDI Link you will have to duplicate all actions like in the example above, but for all behaviours, not just the Iris Joystick.

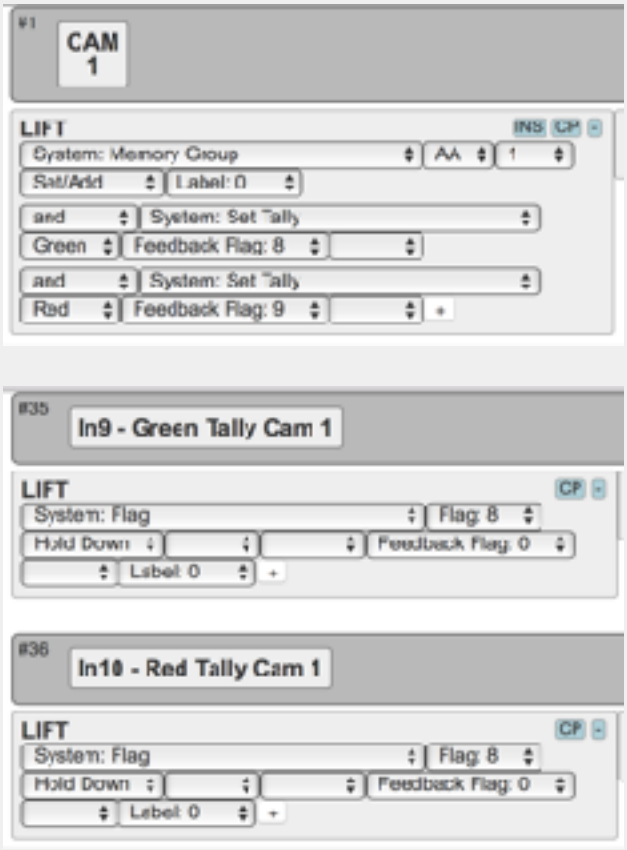
CCU / CCU Lite

Tally Embedding and Local Tally for Camera Selector



Camera Selector with ATEM

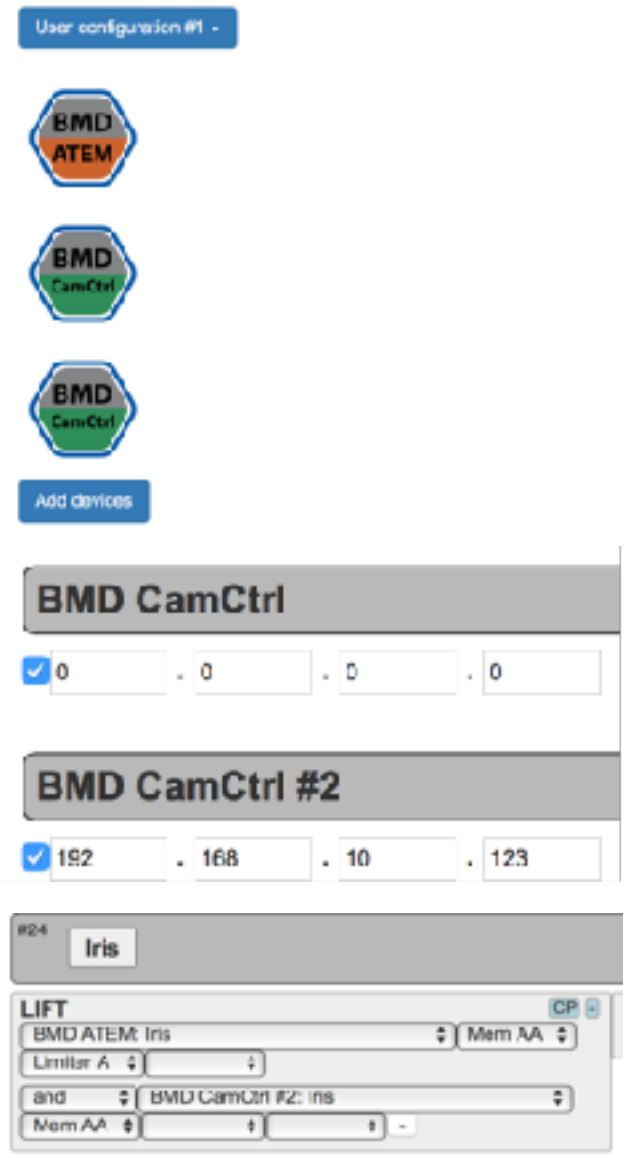
With a configuration like this for every button in the camera selector array, you will have a nice multi camera selector (hold down a button to add the camera to the group, just press the button shortly if you want only that camera selected). The action corresponds to a similar action, "Systems: Memory Group", but when this one is used, the buttons will assume red/green tally instead of just being highlighted if the camera is on program or preview.



Camera Selector with GPI Tally

This configuration creates a traditional memory group selector, but then overrides the "on" state with red or green tally based on the value of memory flags 8 and 9. Those memory flags are controlled by GPI inputs.

Control with ETH-B4 Link or WIFI-B4 Link



Iris control with ETH-B4 Link or WIFI-B4 Link

You add another device core for "BMD CamCtrl", but instead of just enabling it, you also add an IP address - the IP address of your ETH-B4 Link or WIFI-B4 Link. Notice how this device core is suffixed with "#2"
In the behaviour for the Iris encoder you add an action to set iris on "BMD CamCtrl #2" with all the same settings.
In case you don't need the iris value to go out on SDI or via the ATEM you can simply change the "BMD ATEM: Iris" action to the "BMD CamCtrl #2: Iris" action.
Also, if you have many ETH-B4 Links you need to make a configuration setting that will change the mode from "direct" to "base" which means the IP address will now be the base address for a whole array of ETH-B4 Link boxes for each camera. This is documented in the manual for the "BMDCamCtrl" device core.

Full control with WIFI-B4 Link

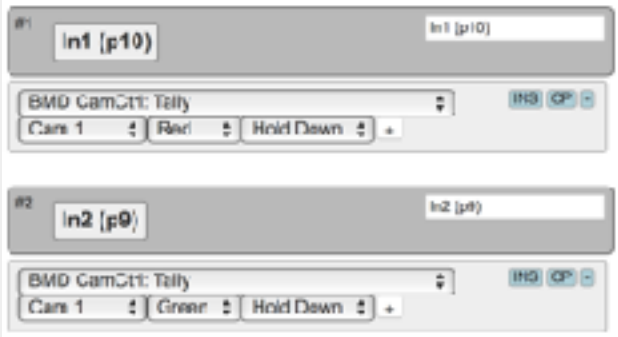
Since the CCU is designed to be a multi camera controller and even though we wish only one of the cameras to receive the information over a WIFI-B4 Link or ETH-SDI Link you will have to duplicate all actions like in the example above.

SDI-GPI Link

Embedding Tally from GPI

Red tally

This configuration shows how GPI input 1 and 2 (and up to 10) can be set up to send a signal for red tally out on the SDI output of the SKAARHOJ SDI-GPI Link.

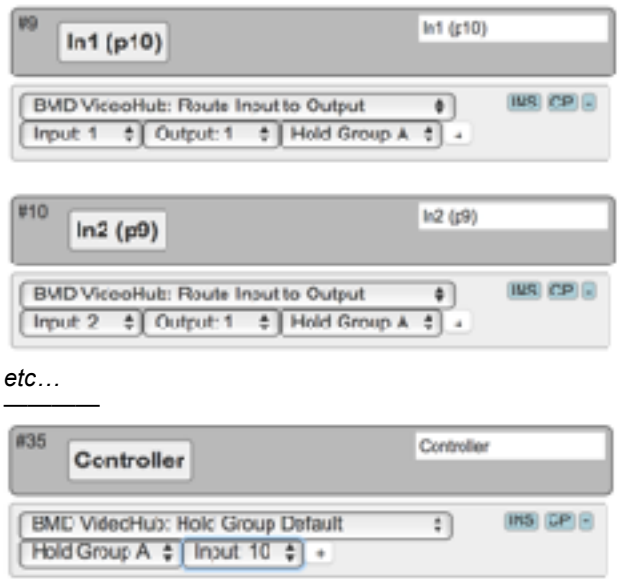


Red and Green tally

This configuration shows how GPI input 1 and 2 (and up to 16) can be set up to send a signal for red and green tally out on the SDI output of the SKAARHOJ SDI-GPI Link.

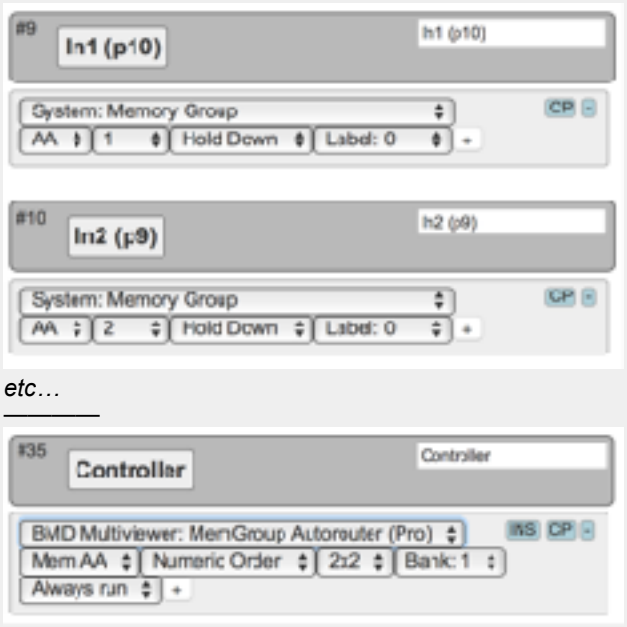
ETH-GPI Link

Monitoring



Videohub with Hold Groups

GPI input 1 (In1 (p10)) and 2 (In2 (p9)) each routes Input 1 and Input 2 on a videohub to output 1, using Hold Group A. This means when the GPI for Input 1 is active, Input 1 is routed, but when it becomes inactive it falls back to the previous item in the hold group queue. The same for input 2 (and you can set it up for more of course).
If you experience that the Hold Groups do not always eventually fall back to the previous source that existed before any triggers in the hold group were active, you may want to set a Hold Group Default in the "Controller" element - that will set an always fixed fall back input.

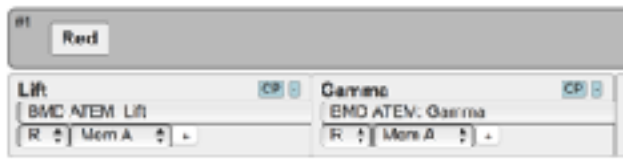


Multiviewer with Auto Router

In this example we "simulate" a camera selector in the ETH-GPI link where multiple cameras can be selected. Each GPI trigger will add a value to the memory group but only for as long as the trigger is held after which point the value is removed again.
The "BMD Multiviewer: MemGroup Autorouter" is then used to create an output scenario based on the memory group.

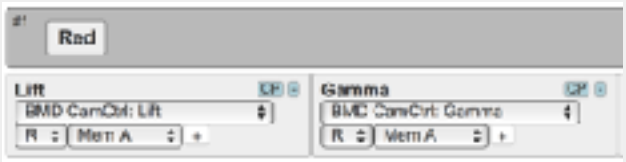
C25

ATEM or SDI out



Control via ATEM

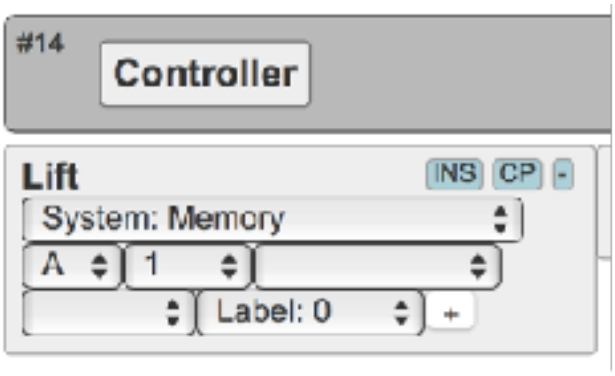
Here we see the configuration of red Lift and Gamma via the ATEM switcher.



Control via SDI output (Shield)

Here we see the configuration of red Lift and Gamma via the 3G-SDI output..

Change camera



Setting fixed camera

This configuration sets the value “1” in memory A when the controller boots up (because it’s placed in the virtual Controller HWC.

Setting camera with encoder

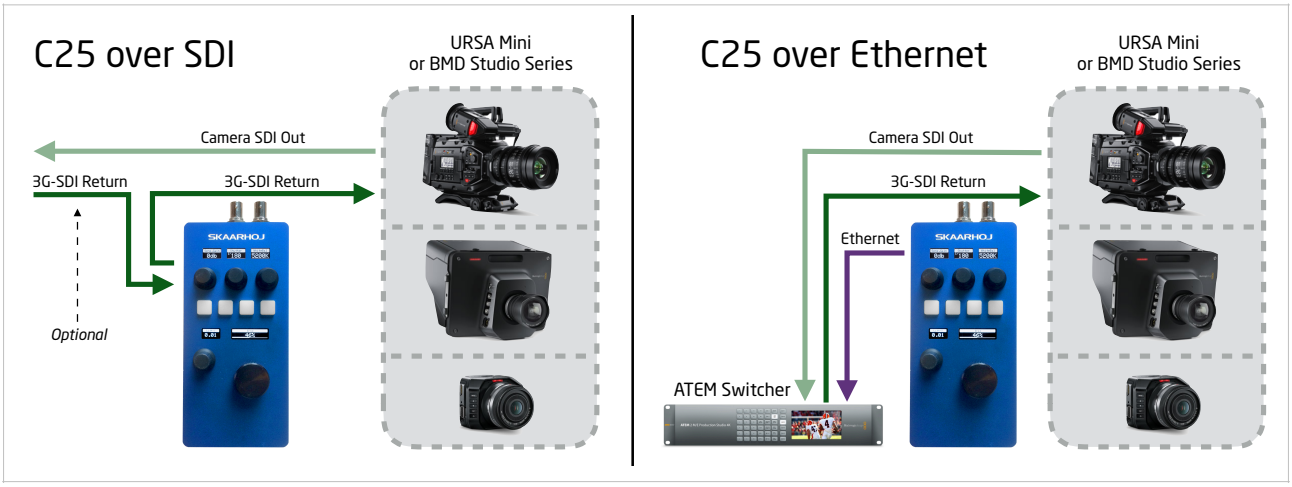
One of the encoders could be set up to set the camera by cycling value. This is the default case with the Master Black encoder when in “Other” mode.

Various

Local Color Control with C25

The C25 belongs in the SKAARHOJ remote series which are uniquely relevant for local use close to cameras and other on-location places. The C25 has interface components designed for color control usage which is why we address it in this document. So far it has just been mentioned by name but no example has been given. So to put it in context, we will describe two use cases.

1. The C25s 3G-SDI output is connected to a camera directly and it exercises color control over that camera. The Camera ID has to match (as is always the case) of course. The camera ID is set inside UniSketch web interface of the C25.
2. The C25s is connected by ethernet to an ATEM switcher which in turn has its PGM Out distributed to the cameras. The Camera ID has to match (as is always the case) of course. The camera ID is set inside UniSketch web interface of the C25. Notice: This scenario is subject to all those design parameters mentioned for individual RCPs connected to an ATEM switcher, including limited number of clients.



Wireless / Mobile CCU control

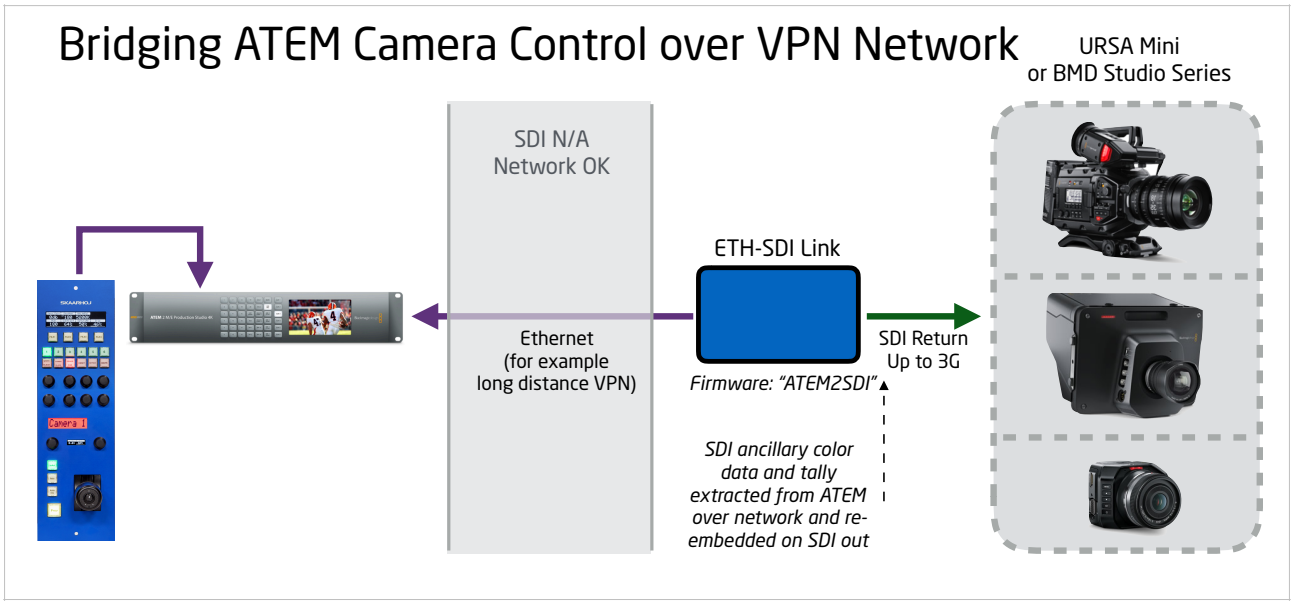
The WIFI-B4 Link is useful for mobile color control of Blackmagic Cameras. Such a case could be a Blackmagic Micro Studio camera in a wire rig.

Alternative firmwares for ETH-SDI Link

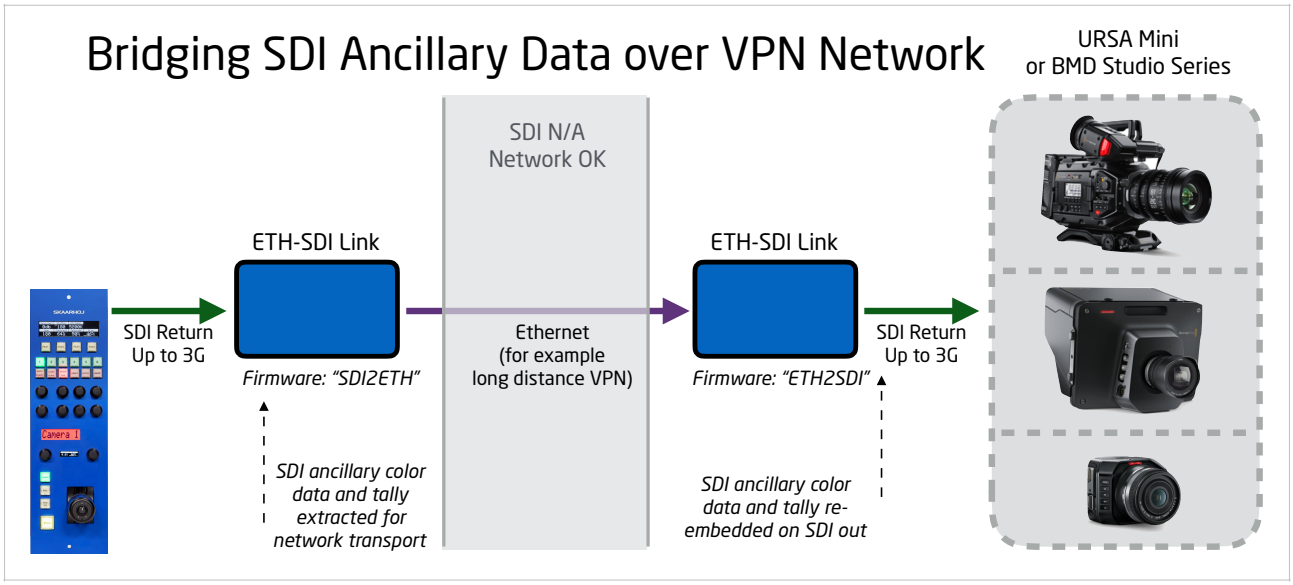
The SKAARHOJ ETH-SDI Link mainly functions as a device that receives Blackmagic Camera Control data over UDP and embeds it on SDI ("ETH2SDI" Firmware). However, a number of other firmwares are possible.

- "ATEM2SDI" firmware: Embeds color data on SDI in a situation where a network connection to an ATEM switcher is feasible while an SDI connection is not, for instance if there are thousands of kilometers between the ATEM and the camera and a VPN can be used to channel the network data through. In such

a scenario, the ETH-SDI Link would establish a network connection to the ATEM and use it to extract the data otherwise embedded on SDI out of the switcher and embed it "locally".



- "SDI2ETH" firmware: Extract Camera Control data from incoming SDI and forward it over network to another ETH-SDI Link for re-embedding. This approach would be agnostic to the original source of the SDI Ancillary data, but otherwise aims to bridge the ancillary data transport over network for whatever reason.



ATEM Proxy

The ATEM Proxy is a windows application that uses the official Blackmagic Design SDK to connect to an ATEM switcher and at the same time it exposes an interface that SKAARHOJ controllers can connect to as if the ATEM Proxy application is in itself an ATEM switcher. In other words: It's an invisible middle-man between the ATEM switcher and the controller. The main advantage of this is that the number of simultaneous clients is not limited for any practical purpose and thus it's a very useful tool when it's desirable to keep an ATEM switcher the heart of the color control for Blackmagic Design cameras. All that

is needed for the SKAARHOJ controllers is to connect to the IP address of the ATEM Proxy instead of the physical ATEM switcher.

A number of limitations also apply:

- The DLL ("ATEM SDK driver") will have to be updated anytime the Blackmagic Switchers firmware is updated
- Likewise, the ATEM Proxy application will have to match the ATEM Arduino Library implementation promoted by SKAARHOJ at any time.
- The ATEM Proxy application has to run on a Windows or Linux computer (under a windows emulator) on the network. This can potentially be a small mini-PC/micro-PC hidden nicely in the infrastructure - or it can be any Windows workstation with a static IP address. Relying on "yet another" network device to be turned on and functioning may be considered a weakness.
- Not all of the ATEM protocol is supported, we have had to focus on those features most useful, in particular for camera control as well as other popular features.
- Generally, a solution like this may be subject to some latency in support for protocol updates in either end, so the necessity of checking thoroughly that things work before firmware upgrades is even more real.

With all that being said, it's likely that the ATEM Proxy will be a sufficient and functional solution, in particular if firmwares are kept fairly stable.