Service Based Approach to Real-Time Control of the Video Distribution System in the Columbus Ground Segment

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This paper introduces a service-oriented approach for managing the Video Distribution System. The main focus lies on the service of delivering a video stream from source to destination rather than on configuring the affected devices. This service approach implements a more transparent user interface for management and uses automation of system functionalities which makes procedures faster and less error-prone than low-level configuration as it is today. Moreover, error handling can be organized more effectively using the service-oriented system design. Additionally, subsystem requirements and Service Level Agreements (SLA) are monitored for compliance which enables an overview of the stability and functionality of the subsystem.

I. Introduction

THE Columbus Control Center (Col-CC), located at Oberpfaffenhofen in Germany, is part of the German Space Operation Center (GSOC). Its goal is to administrate the day to day business of the ESA Human spaceflight, Microgravity and Exploration (HME) program for the ISS. This includes on-board and on-ground support for the Columbus project – the ESA module on the ISS. The Col-CC is responsible for the coordination and communication between the Astronauts on-board carrying out experiments inside the Columbus Module and the European scientists on ground, which lead these microgravity experiments from science centers spread over whole Europe. Observation of the Columbus module and control of the ESA ground infrastructure is also centralized in Col-CC. The second focus of the Col-CC lies in the support for ATV (Automated Transfer Vehicle), the unmanned automated space craft of ESA. ATV is operated from the ATV Control Center (ATV-CC) in Toulouse but the infrastructure and coordination runs over Col-CC.

One part of the infrastructure on-ground is the Video Distribution Subsystem (ViDS). The ViDS is in charge of delivering real-time video from the ESA partners NASA and ROSCOSMOS and from several ESA sources, mainly generated in Col-CC. A video archive is also part of the ViDS and serves as playback source. The requesters of video feeds are the European science centers, called User Support and Operations Centers (USOCs) or ESA control centers. Real-time videos are also requested by NASA and ROSCOSMOS.

The two types of Russian space crafts which approach the ISS – Soyuz and Progress – require the real-time video stream of the docking activity to be distributed to Moscow over the ViDS. The ATV docking maneuver is also being observed by using the docking video feed running over the ViDS to ATV-CC in Toulouse and to Moscow simultaneously.

Monitoring and control of the whole infrastructure on ground and of the Columbus module itself is designed on a 24/7 basis. This requires the ViDS to contribute and distribute video content around the clock. The Ground Control Team (GCT) is the operating team in Col-CC responsible for the ground segment and in charge of the day-to-day business on all subsystems. Though, these controllers are not specialists on any of the subsystems, nor do they have the permissions to perform structural configurations inside the subsystems. For many events the subsystem engineers have to be present to enable the needed functionality. In case of the ViDS this is needed for docking of spacecrafts, for public relations events and for restricted video distribution to isolated sites.

In order to allow the monitoring and controlling of all subsystems an umbrella management system was introduced for the GCT: the Integrated Management System (IMS). With this overview system it is not necessary

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for the GCT during routine operations to use detailed proprietary monitoring and control software which is available for each subsystem. The IMS gives information about the current status of devices used in the system: Is a device reachable via ping? What IP address is configured for the management network of that device?

The structure of IMS is separated into the different subsystems, which are in turn split into the different remote and local sites of the specific subsystem.

Ref. 1 gives a general overview of the IMS and also the monitoring and commanding of all subsystems at Col-CC described.

In the course of the Columbus project at Col-CC the IMS was adapted several times since subsystems were renewed or redesigned. In Ref. 2 the adaption of the network technology from ATM to the new MPLS is detailed.

Concerning the ViDS, the structure of the management software shows the ESA facilities around the world in separate windows, including most devices installed in the remote racks.

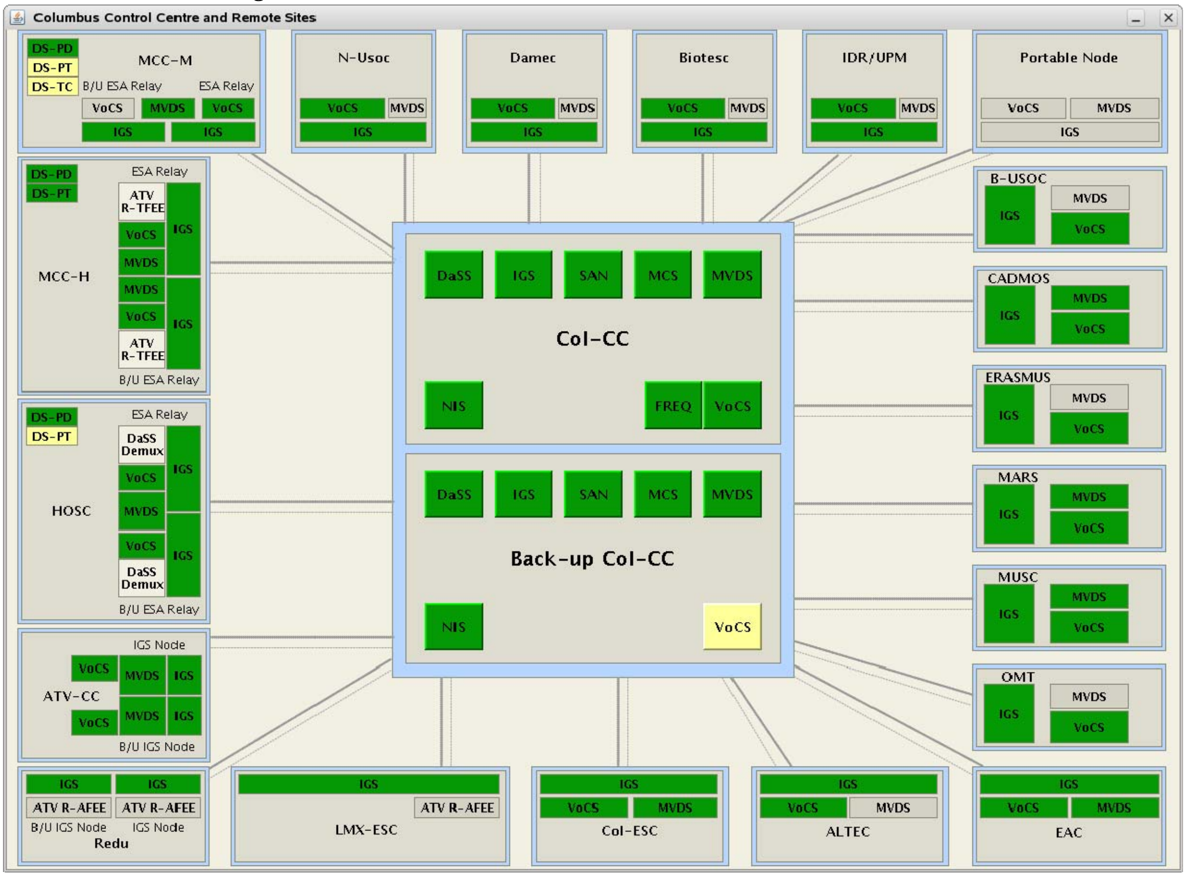


Figure 1. Main monitoring display for Col-CC. *The display shows Col-CC, its subsystems and the remote sites in the Integrated Management System IMS.*

In Fig. 1 a screenshot of the main monitoring display for Col-CC, its subsystems and the remote sites is provided. This view is available for GCT in the IMS. By clicking on a subsystem icon or on a remote site a more detailed display will open. Color coding is: green – nominal, yellow – backup, orange – warning, red – alarm.

In the following, detailed information on the current system status including monitoring and control via IMS is presented, then a new design approach using several layers is described and finally a conclusion is given.

II. System Overview

The ViDS is designed in a star topology. All data flow is centralized in Col-CC combining every remote site of the ESA ground infrastructure with a dedicated Wide Area Network (WAN). The video streams managed by the ViDS run through Col-CC where video sources can be applied to multiple destinations. In theory all destinations could receive any of the source streams. However, the streaming and receiving capabilities differ from site to site.

The number of channels to be sent out and to be received depends on the number of devices installed remotely. Also the bandwidth of the WAN reserved for a site is limited. The WAN is built upon a MPLS infrastructure allowing IP networks to be implemented between the remote sites and Col-CC. Remote sites are meant as part of the ESA ground infrastructure offering an interface to ESA partners to connect to.

Interfaces to the ESA ground infrastructure are set up with NASA in the Mission Control Center Houston (MCC-H, Prime and Backup) and in the Huntsville Operations Support Center (HOSC) and with ROSCOSMOS in the Mission Control Center Moscow (MCC-M). ESA sites are the ATV Control Center (ATV-CC, Prime and Backup) in Toulouse and the European Astronaut Center (EAC) in Cologne. Additionally about a dozen smaller ESA science

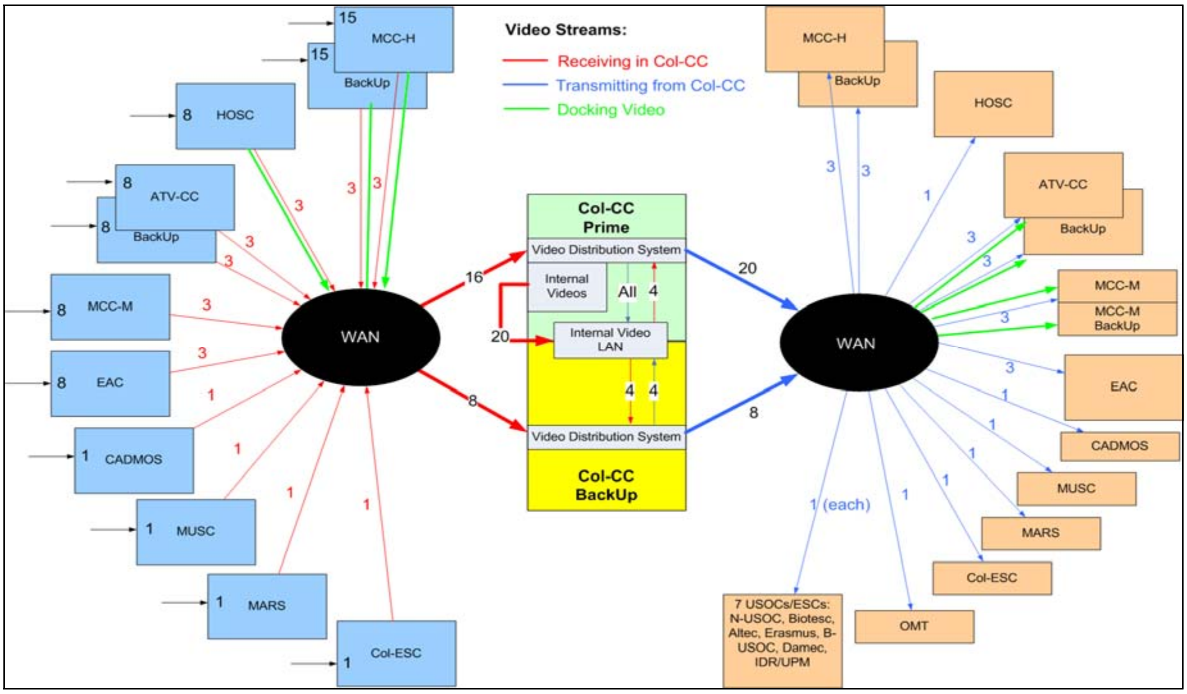


Figure 2. Design of the ViDS: *The remote sites are connected to Col-CC in a star-topology. Col-CC Prime and Backup are set up for load sharing.*[3]

and engineering support centers are connected to the network as well – the USOCs and ESCs.

Figure 2 describes the video distribution network. On the left hand side all incoming connections into the ViDS (the source streams) are listed. On the right hand side all destinations are shown. The center of the picture is the central point of the subsystem – Col-CC, separated into Prime and Backup.

To enable streaming over the WAN, the video source needs to be compressed to MPEG2 for Standard Definition and MPEG4 for High Definition format. The encoded signal is packetized into the MPEG transport stream format which runs over UDP/IP.

There are limitations in the distribution and contribution from and to Col-CC as well. The WAN connector devices allow only a certain number of channels for receiving and sending unicast UDP streams.

The most frequently requested video sources are provided by NASA over the interface in MCC-H. 15 channels are directed through the interface in Houston to the ESA facility in parallel. Due to the limited hardware and bandwidth up to six streams can be routed over the WAN to Col-CC. Switching matrices allow the Ground Controller to select the requested streams remotely.

In Col-CC all incoming IP streams are converted to the Asynchronous Serial Interface (ASI) and are fed into the "heart" of the ViDS – the switching matrix in Col-CC Prime and for specific sources into the one in Col-CC Backup. Col-CC Prime and Backup are both used in the nominal system configuration by load-sharing operations.

Several sources are generated in Col-CC itself. These include cameras from the control rooms and replays out of the video archive. Other centers deliver control room feeds and occasionally videos from public events.

Inside Col-CC videos are distributed over a dedicated LAN. The videos serve as visual communication between the control center and the space station.

Because of a reduced bandwidth allocation at many USOCs the original streaming bit-rate has to be down-converted. Only one stream is available on their WAN connections, whereas other remote sites may receive up to six streams in parallel. The feed for the USOCs is used as a visualization channel to follow the on-board experiments in real-time.

Requesters of the streams in the Mission Control Centers are Ground and Flight Control Teams. The ATV Control Center (ATV-CC) has a high priority for the docking video stream of ATV docking. The same applies for the Russian Control Center together with the docking videos of the Russian space crafts and scientific experiments. Public Relation events have to be routed to ESA in Noordwijk, Netherlands, and to the European Astronaut Center in Cologne, Germany.

The ViDS is composed of hardware devices with focus on low latency. While the distribution between Col-CC and the remote sites is based on IP, the contribution interface between an ESA facility and the control centers is uncompressed video in digital or analogue format. The encoding and decoding process is done by established broadcasting equipment. The list of devices includes encoders, decoders, switching matrices for compressed and uncompressed formats (analogue, SDI and ASI) and converters of the transportation interface (ASI and IP). All devices are managed remotely from Col-CC over a dedicated management network using the Simple Network Management Protocol (SNMP). The older analogue equipment is managed via telnet or HTTP.

The SNMP interface offers monitoring data of the device's management subsystem as defined in its Management Information Base (MIB). Data like the streaming bit-rate, the device temperature and video engineering parameters can be requested. Configuration settings are done remotely via SNMP as well. The current layout of the ViDS management in IMS offers several of these monitoring parameters.

III. Current Situation

The monitoring and control tool used today for ViDS is part of the Integrated Management System (IMS). The ViDS part of the software is separated in a stand-alone application which is called “Element Manager”.

This application offers an overview of the full subsystem by displaying the global state of the ESA video facilities on each site. Figure 3 shows the ViDS overview – including the status of every remote site and Col-CC.

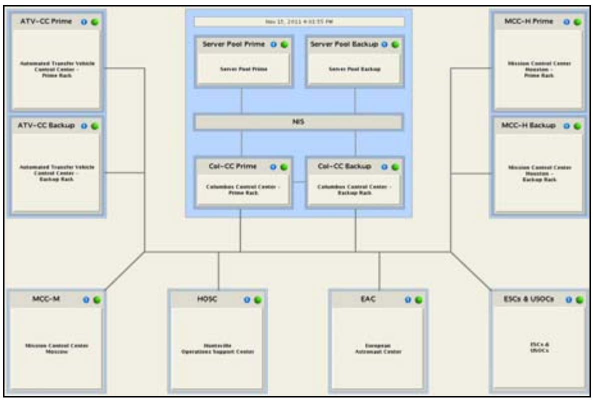


Figure 3. Main monitoring display for ViDS. *The display shows the overview of the Video Distribution System (ViDS).*

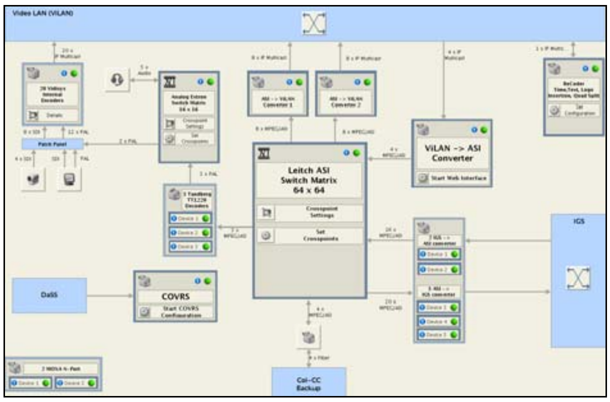


Figure 4. Main monitoring and control display for Col-CC Prime. *The display shows the overview of the equipment at Col-CC Prime.*

All remote sites and Col-CC are displayed in their dedicated windows. The integrity of the subsystem on-site is, thus, visible at a glance. Controlling of the ViDS in this management setup is only needed for the switching matrices. Remote matrices serve to switch the content coming from the external interface connected to the ESA facility.

In Fig. 4 the main monitoring and control display for the devices at Col-CC Prime is provided. The Col-CC matrices are used to switch the incoming streams to remote destinations. The device-oriented overview helps detecting local issues. In combination with other subsystems like the IGS Relays and Nodes (for Local Area Networks) and IGS WAN (for the Wide Area Networks), which are also managed by the IMS, the root cause of a problem affecting more subsystems can be identified. Though, the overview does not show the impact of an isolated issue on the system.

Furthermore, even though several device parameters are available in the Element Manager (e.g. the streaming bit-rate, the destination IP address, etc.) the controller has no additional use out of them without setting them into a relation with data from devices which are connected to the same stream – or to be more precise – to the same service.

The most important parameter for daily operations is the on-line status of devices. The Element Manager performs a ping command on the management network interface of the device and takes the response as proof of availability. The handling of SNMP data is performed by an additional management server called Dataminer. This device is used by the video subsystem only and serves as an advanced management interface for the ViDS engineers.

This subsystem consists of hundreds of hardware devices. Many of them offering hundreds of parameters to be adjusted for the system requirements. System setups for special events may require changes on several devices on different sites in parallel. The docking setup, private video requests and public relation events need modifications of the default configuration.

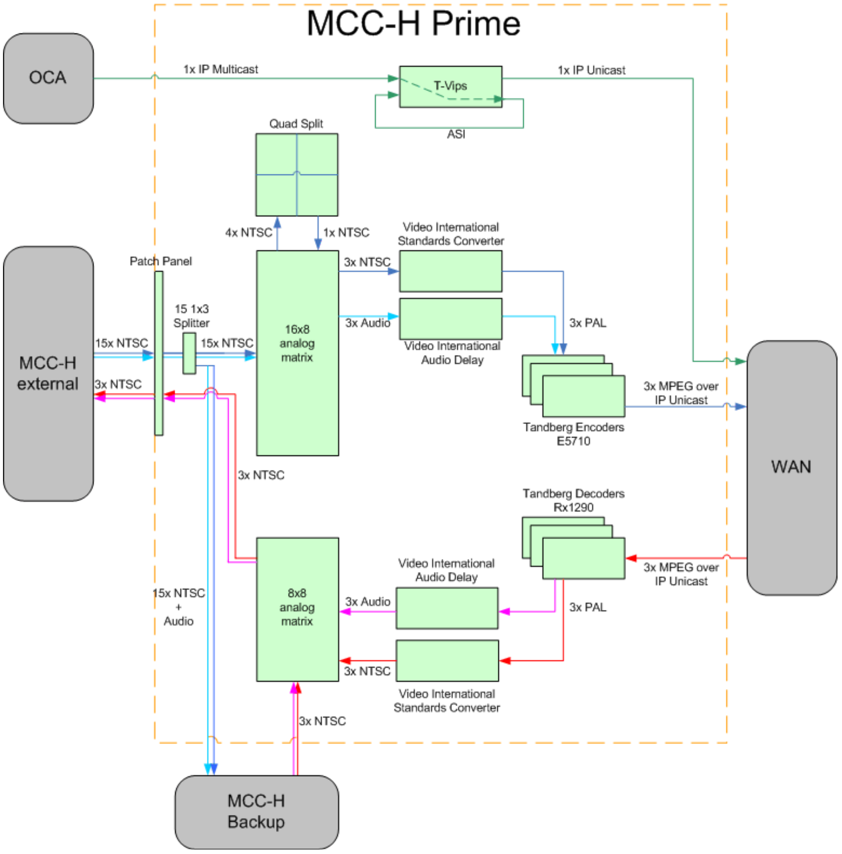


Figure 5. Device implementation at MCC-H Prime. *The display shows the overview of the equipment at MCC-H Prime.*[3]

The monitoring approach of the current system is designed to be on device level. Consequently, for the Ground Controller it is difficult to follow the route of a video stream from its source to its destination. Moreover, it is challenging for a GC to assess the impact of an error occurring somewhere in the subsystem since hundreds of devices and software parameters have to be considered.

Figure 5 displays as an example the device implementation at the remote site MCC-H Prime. From this schematic drawing the displays for the monitoring are created and provided for the Ground Control Team in the IMS.

IV. New design – introducing service layers

An abstraction of the current design enhances the device-oriented layout by a service-oriented layout. Service-oriented means combining devices and software settings logically rather than locally. Two levels of abstraction are needed.

The first one serves the Ground Controller for his daily business in observation and control. A service on this level is the combination of system elements (hardware and software settings) following the

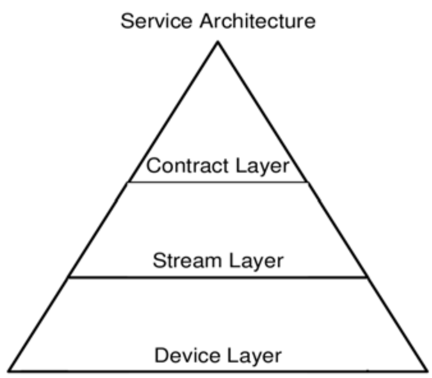


Figure 6. Abstraction model of the new design. *One layer serves as an abstraction of the layer beneath.* [3]

actual stream flow.

The second layer builds a “proof of design” for the subsystem engineers by tracking the availability of the services defined in the first layer. This provides the tracking of the Service Level Agreements and a logging of the compliance of requirements.

As displayed in Fig. 6 the different layers are each an abstraction of the layer beneath. The stream layer is an abstraction of the device interface. The contract layer groups information of the stream layer for another abstraction.

A. The Stream Layer

The first service layer can be seen as operational layer. All operations a GC has to perform can be monitored and executed from one single view. The system integrity is visible in one screen. The linkage of distribution and contribution channels is being made visible by tables. Special subsystem settings like the ViDS configuration for docking or the isolated private video distribution can be executed by one click and is highlighted during the time of activation.

Therefore stream services need to be defined. Since the conceptual design of the ViDS follows a star-topology two kinds of stream services exist: Source streams and destination streams. The end point of the first is the starting point of the second kind – the input and output port of the switching matrices in Col-CC (in prime and backup in parallel). A source stream service groups all system devices which affect the flow of a stream from its entry into the ViDS up to the Col-CC switching matrix input port. Similarly a destination stream service groups the devices starting at one of the matrices in Col-CC and its own output port up to the output interface where the stream exits the ViDS. The IMS overview of the subsystem knows three status types of a stream service: nominal, warning and critical. Potential errors and misconfigurations of a stream service must be analyzed in how they affect the integrity of a stream. If a stream service is still running nominal even though devices in the service group throw errors, the service receives the warning state. As soon as an error impacts the stability of a stream the stream service state gets the status critical.

Of course, this stream layer does not give details on occurring errors. Solely the current state of a stream is being displayed. The error analysis in this layer works top-down instead of bottom-up as in the device-oriented layout. At first occurrence of an error the impact on a stream gets visible. The root cause of that error can be searched for by analyzing the device level.

The different services of the ViDS are discussed in the following paragraphs.

1. *Source Stream Service*

The most popular distributed source stream is the first channel from the ESA facility in Houston. The name of the stream service is 'Src MCC-H Pr 1'. 'Src' stands for 'source', MCC-H Pr is the abbreviation of the remote site and more precisely from the Prime facility (Pr). The trailing number is the channel number.

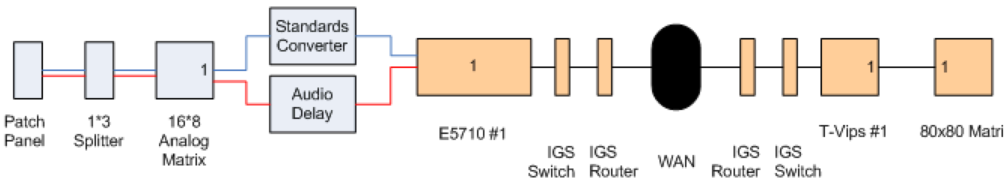


Figure 7. Src MCC-H Pr 1. *All devices of the source stream are displayed. The elements at the left hand side of the analogue matrix define the content service of that stream.*

Figure 7 describes the stream flow through the ViDS from its starting point to its end. The starting point of this service is the first output port of the analogue matrix in MCC-H. Audio is not embedded in the video stream. Thus, two cables are connecting the matrix port to the second device: a format converter with integrated audio delay. The signal sent by NASA is NTSC, while inside the ESA facilities analogue video is distributed in the PAL format. Since NTSC comes with a frame-rate of 29.98 frames per second the audio signal has to be slow down to be kept synchronous to the PAL format in 25 frames per second. The analogue video and audio streams are now connected to the first encoding device in MCC-H prime. The video stream is compressed by the MPEG2 encoder. Standardized system configurations define the settings of all necessary parameters of a stream. Thus, compatibility of all system devices and the streams running through can be guaranteed. The audio stream is compressed to the MPEG1 Layer 2 format at 64 kbit/s. Both streams are multiplexed into a MPEG Transport Stream (MPEG TS), which is the industry standard for unreliable transmission (in comparison to reliable media like discs) [5, 3]. The MPEG TS packets are transported over IP networks. The Maximum Transmission Unit (MTU) of IP is 1500 bytes[5]. One TS packets is specified by a length of

188 bytes[5] (the ViDS does not use Forward Error Correction, which would add another 16 bytes to each TS packet). The maximum number of MPEG TS packets to be encapsulated into one IP frame is therefore 7. The transport layer protocol is UDP. The network interface of the encoder device is connected to a switch, which belongs to the IGS Relays and Nodes subsystem. The IGS R&N is in charge of the network devices on the remote and local sites. Thus, monitoring of these elements is out of scope of the ViDS. However, the ViDS is enabled to request information via SNMP GET commands from those switches and routers the ViDS equipment is connected to. This allows the ViDS engineers to monitor the bit-rate input on the involved switch port.

From the switch the stream is directed to the IGS R&N router and is handed over to the next subsystem, the IGS WAN. This subsystem is responsible for the MPLS network – the wide area connection between Col-CC and all remote sites. The entry point in Col-CC is again an IGS R&N router followed by a switch, which is again monitored by ViDS. The next video device in the stream service is a transportation format converter (a device called "T-Vips"). It removes the IP/UDP headers and encapsulates the MPEG TS packets into the Asynchronous Serial Interface (ASI). ASI is a streaming data format which carries compressed video streams multiplexed into MPEG TS packets. The conversion from IP to ASI is needed for security reasons to separate the IGS WAN connection from the local network in Col-CC. The converter devices have either 4 or 8 ASI output connectors. Thus, up to 8 streams can be received on one device.

Concerning the stream service only one channel of this device must be grouped into the source stream service. Potential errors on different channels do not impact the service in question. The source stream from 'MCC-H Pr 1' is routed through the first channel of the first converter device. The ASI outputs are connected to the input ports of the Col-CC ASI matrix. Either the prime or the backup device is the last device in each source stream service. Like before, not all ports are of relevance for a service but only the individual input port, which is connected to the right channel of the converter. For 'Src MCC-H Pr 1' it is the first input port of the Col-CC Prime ASI matrix.

2. Content Stream Service

The entry point of the source stream service is the output port of the analogue matrix in MCC-H Pr. However, figure 7 outlines additional elements on the left hand side of the source stream. The way from the ESA patch panel up to the output of the matrix is still missing.

This first route of the stream is carrying the content to a source stream. A temporary list (maintained by the Col-CC GCT in arrangement with the NASA GCT) defines which content is available on which patch panel port. Even if some operations need a change of the temporary list to access the required content, some inputs stay constantly the same. Port 9 through 12 transmit the Ku downlink videos from the station. Port 1 contains NASA TV and port 7 is reserved for public relations events.

The patch panel is connected to analogue amplifiers offering two outputs on each channel. One is connected to the corresponding input port of the analogue matrix in Prime, the other similarly to the corresponding input port of the Backup Matrix. During the ViDS migration to a digital system[4] this interface will be replaced by a SDI matrix which is also configurable and monitorable via SNMP. Today this is not possible, which makes the content service unavailable for now.

3. Destination Stream Service

A destination stream service defines the group of system elements to transmit a video stream from Col-CC to a remote site. Two types of remote requesters have to be differentiated: the standard sites, which accept the streams as originally provided by the ViDS and the sites with reduced bandwidth capabilities. The default streaming bit-rate is 3 Mbit/s for SD streams and 7 Mbit/s for HD streams. The sites with reduced bandwidth (which are most of the USOCs) are limited to a bandwidth of 2 Mbit/s for the video streaming interface.

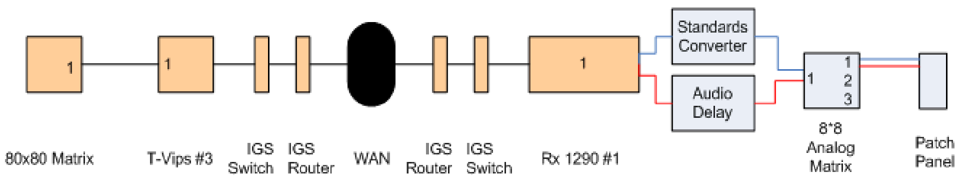


Figure 8. Dest MCC-H Pr 1. *The components of the destination stream to MCC-H Prime 1.*

As a demonstration, the first destination stream to MCC-H Prime will be explained (see Fig. 8). The stream service of this destination is called 'Dest MCC-H Pr 1' (Dest stands for Destination). The entry point is as mentioned before the output port of the Col-CC matrix. The first stream to Houston is connected to the first output port on the prime ASI matrix. Afterwards, the T-Vips converter takes the ASI input on channel 1 and generates an IP/UDP stream with the destination IP address and port of the first decoder in MCC-H Prime. The network interface of this device is once again connected to an IGS R&N switch, where the ViDS monitoring system receives information about the input bit-rate on the specific port. This is, of course, the total bit-rate the T-Vips sends out on its network card. As before, the IGS subsystems are in charge of the stream now. The stream is sent to the IGS R&N router and from there transmitted over the MPLS network to MCC-H. The MCC-H Prime switch is the first monitorable device for ViDS after the WAN router at the remote site. Connected to the switch is the decoder, which is already the last monitored device in the destination stream. The analogue video and audio feeds are converted from PAL to NTSC before they are fed into another analogue matrix in MCC-H, which brings the separated signals to the patch panel of the NASA interface (the analogue interface will be replaced by SDI during the ViDS migration[4]).

Only the control centers and a few USOCs are equipped with decoders. The majority of the remote sites receive the IP stream on a dedicated PC and a software decoder, such as the VLC player (Video LAN Client). The ESA facilities at EAC and OMT are connected to the digital output of their decoder.

4. Col-CC Services

Col-CC adds additional services to the concept. Besides the source services of Col-CC – the control room cameras, the Columbus camera and video streams from the archive – four transrating services and four Backup-Prime connection services are in place. With the ViDS migration new SDI connections are included into the system. These serve as video feeds for external companies. The SDI interfaces are integrated as new services as well. In Fig. 9 a transrating stream is demonstrated. Transrating means decoding the incoming stream and encoding with a different bit-rate again. This stream is linked from Col-CC Pr to Col-CC Bu.

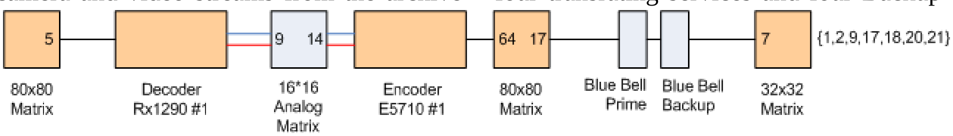


Figure 9. Col-CC Transrating 1. [3]

5. Automation: settings for docking, private and cutoff

The service concept introduces another feature which eases the configuration part of the system. As already mentioned in the introduction chapter certain events require a configuration of several system components that differs from the default. These configurations can only be done by the ViDS engineers. The new service concept also adds the possibility to automate complicated procedures. The docking configuration is thus an additional service which gets activated (and deactivated) by triggering the needed automation scripts. The scripts perform all SNMP settings on the

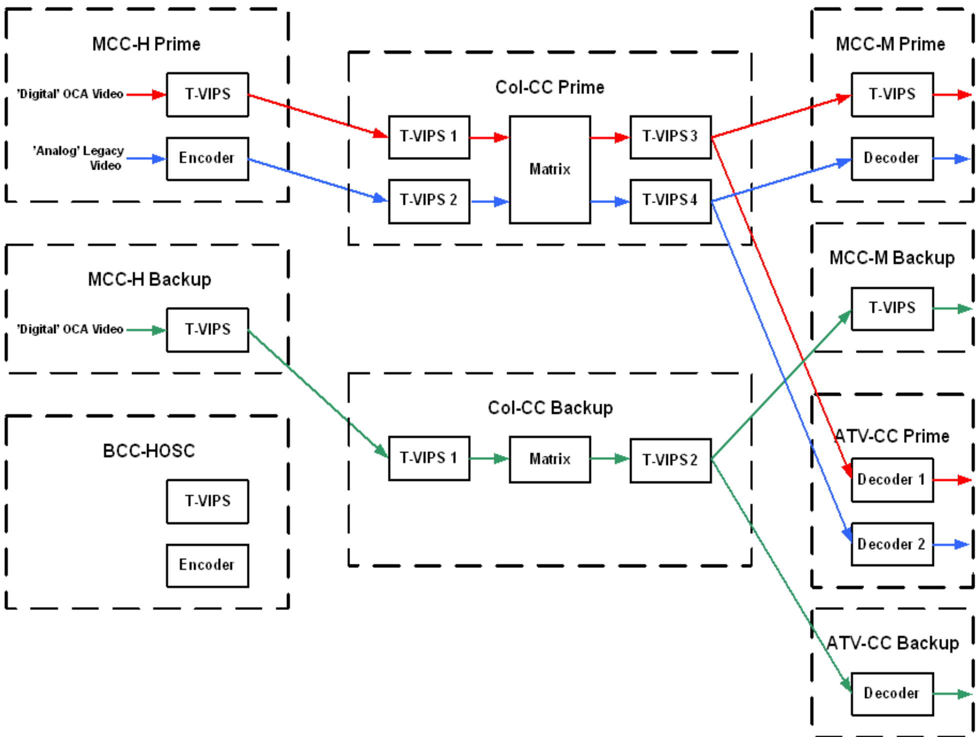


Figure 10. Docking service. *Three docking streams are linked to MCC-M in parallel.*[6]

devices involved in the service. As displayed in Fig. 10 the docking services (prime, backup and one analogue feed) include devices in Houston, Col-CC and Moscow. The default system configuration disables these services by switching off the source in MCC-H. By activating the service, however, all parameters have to be verified and adjusted. The MCC-H T-Vips which is the entry point of the service, receiving a Multicast UDP stream from NASA, two T-Vips devices in Col-CC and another one in MCC-M are needed for each docking stream (prime and backup). On all devices IP addresses and ports have to be verified, the channels have to be activated and the streaming bit-rate has to be logged. Additionally the IGS switches in MCC-H, Col-CC and MCC-M have to log the input and output bit-rate of the affected switch ports. The Col-CC matrices (prime for docking prime service, backup for docking backup service) need to be switched from the MCC-H docking input port to the corresponding MCC-M docking output port. Streaming into the dedicated Video LAN in Col-CC has to be enabled as well. Moscow does not only receive the digital streams from the T-Vips devices. Also the analogue format gets streamed from the second decoder in MCC-M – this service has to be activated and correctly switched as well.

Another automated service is the cutoff service. This is realized by an emergency button. For unexpected incidents which are not allowed to be seen by a public audience (i.e. fire in the station) the cutoff service interrupts all destination stream services from Col-CC and replaces the streams with a “service not available” placeholder.

The private video service is the third configuration tool, which can be automated. The private video streams do not enter the ViDS again when leaving MCC-H. The encoders in MCC-H backup are configured to stream directly to the destinations in CADMOS (France) and DAMEC (Denmark). The private video feeds are highly restricted and may not be seen by any other person than the authorized individuals at those two sites. The private video service has to verify the correct settings on the encoders 2 and 3 at MCC-H Bu: IP addresses and ports, the input selecting SDI instead of analogue video. The standard video streams ‘Dest CADMOS’ and ‘Dest DAMEC’ have to be deactivated for bandwidth reasons. Only the two private streams can be transmitted simultaneously. The outputs of the encoders have to be activated now. Monitoring is available by logging the bit-rate of the switches in MCC-H Bu and in CADMOS and DAMEC.

Figure 11 shows the different buttons for automated services.

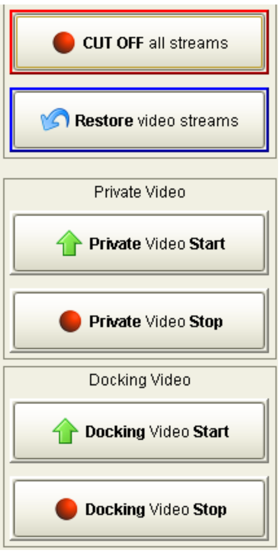
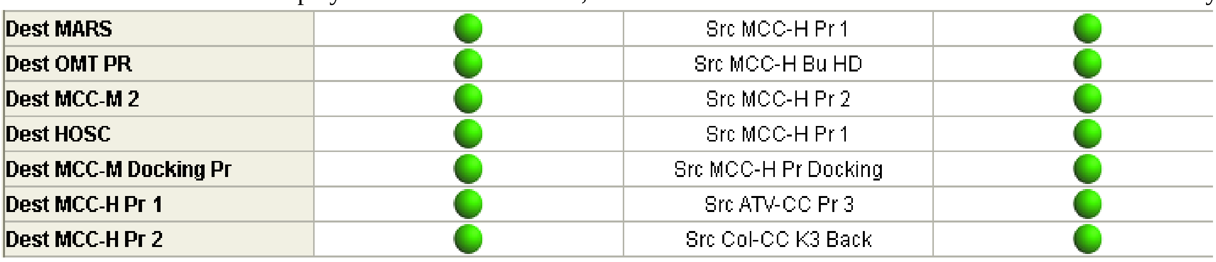


Figure 11. Buttons for automated services.

6. New IMS GUI

The new IMS GUI for ViDS would fit on one single page compared to the 16 pages used today (each displaying one remote site). The stream services are the main part of the interface – these are the most important controls for daily operations. The stream services are separated into five different tables. For each destination stream service a source stream can be selected. The selection of source stream services is limited for each destination stream table as defined by the technical restrictions. Fatally wrong connections cannot be set over this interface anymore. Special services (see chapter IV.1.5) can be started and stopped by easy to use buttons.

The success or failure of service settings is displayed in a response message string, tagged with a time stamp. Figure 12 is an example of the destination table for some of the services connected to Col-CC Prime. The current state of each destination stream service is indicated in the second column. The current connection to the destination's source stream service is displayed in the third column, while the last column indicates the state of the source. By



Dest MARS		Src MCC-H Pr 1	
Dest OMT PR		Src MCC-H Bu HD	
Dest MCC-M 2		Src MCC-H Pr 2	
Dest HOSC		Src MCC-H Pr 1	
Dest MCC-M Docking Pr		Src MCC-H Pr Docking	
Dest MCC-H Pr 1		Src ATV-CC Pr 3	
Dest MCC-H Pr 2		Src Col-CC K3 Back	

Figure 12. Display of new interface. *Source streams can be connected to destination streams and the current configuration can be monitored in one table.*

right-clicking on a row a selection of possible sources for the destination service in question pops up. This limits the potential combinations to legal values only and misconfigurations can be prevented. In a future design a tab for the content services will be added. The content will be linked to the selected source stream service.

B. The Contract Layer

The contract layer serves as a proof of the system stability. The ViDS engineers are responsible for the fulfillment of the contract details defined by ESA[3]. The contract layer enables monitoring and logging as defined within the requirements as well as the achievement of all Service Level Agreements (SLA).

By the implementation of the stream services logging of those services becomes feasible. For the automated events, e.g. the docking service certain breakpoints are of interest: the incoming bit-rate on the entry point, where the Multicast stream from NASA is received and the outgoing bit-rate at the interface to the Russian segment verify the stream flow through the system. If the entry signal is already corrupted, the reliability of the service can still be proven by the logs. On the other hand, if an error occurs inside the ViDS, the logs of the stream service give information about the outage time and the root cause of the problem.

The contract layer shows if a service still meets the requirements or the Service Level Agreements with ESA.

V. Conclusion

In this paper a new management concept for the ViDS was introduced. The management software used today offers status information from system components and allows minimal configurations on devices. Correlations of system events are hidden in diverse system layouts. An analysis of the global functionality of the Video Distribution Subsystem is not foreseen. The fulfillment of contract agreements is not stated inside the management software but must be carried out by the analysis of single data sources by the ViDS engineers.

Routine operations of the Ground Controllers demand complicated procedures for retrieving and distributing video content. However, misconfigurations in the subsystem cannot be prevented. In addition, wrong settings are not easy to detect since several look-ups may be required to sort out an error.

A different approach of management does not focus on the actual devices and their geographical relationship but rather on services those individual elements are forming. Two additional layers are required to abstract the device-oriented management structure of the ViDS.

The first layer offers fast monitoring and control of the operational services like stream connections and specific system configurations. The second layer opens up tools for system analysis. Monitoring of subsystem requirements and service level agreements is available. The logging of service components during events serves as proof of SLA achievement.

The new design is already partly implemented at Col-CC. The management tools still do not allow the switching of content stream services as long as the old analogue hardware is in place. With the completion of the ViDS migration[4] this operational service will also be activated.

Since several subsystems in the Col-CC Ground Segment are covered by SLAs the presented approach could be of interest also for other subsystems. The operational business can be made more secure and easier to handle by offering a transparent and abstract tool-set to the GCT instead of a low-level management application as today.

Appendix A
Acronym List

ALTEC	Advanced Logistics Technology Engineering Center
ASI	Asynchronous Serial Interface
ATV	Automated Transfer Vehicle
ATV-CC	Automated Transfer Vehicle Control Center
B-USOC	Belgian User Support and Operations Center
BIOTESC	Biotechnology Space Support Center
CADMOS	Centre d'Aide au Développement des activités en Micropesanteur et des Opérations Spatiales
Col-CC	Columbus Control Center
DAMEC	Danish Aerospace Medical Center of Research
EAC	European Astronaut Center
ERASMUS	Erasmus User Support and Operations Center
ESA	European Space Agency
ESC	Engineering Support Center
GC	Ground Controller
GCT	Ground Control Team
GSOC	German Space Operations Center
GUI	Graphical User Interface
HD	High Definition
HOSC	Huntsville Operations Support Center
IGS	Interconnection Ground Subnetwork
IGS-R&N	IGS Relays and Nodes
IMS	Integrated Management System
ISS	International Space Station
IP	Internet Protocol
MARS	Microgravity Advanced Research and Support Center
MCC-H	Mission Control Center – Houston
MCC-M	Mission Control Center – Moscow
MPEG	Moving Picture Experts Group
MPEG-TS	MPEG Transport Stream
MPLS	Multiprotocol Label Switching
MUSC	Microgravity User Support Center
N-USOC	Norwegian User Support Operations Center (N-USOC)
NASA	National Aeronautics and Space Administration
NTSC	National Television System Committee
OMT	Operations Management Team
PAL	Phase Alternating Line
SD	Standard Definition
SDI	Serial Digital interface
SLA	Service Level Agreement
SNMP	Simple Network Management Protocol
UDP	User Datagram Protocol
USOC	User Support Operations Center
ViDS	Video Distribution Service
WAN	Wide Area Network

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