From SD to HD – Video Update Challenges

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In order to support the International Space Station missions of the European Space Agency Manned Space & Microgravity a set of communications services/systems has been developed. Particularly the Video Distribution Service supports both the internal video distribution at Columbus Control Centre and the video distribution between facilities located in Europe, America (NASA) and Russia (ROSCOSMOS). This system was designed and developed in 2002-2003. At this time the broadcast industry was mainly using SD/analogue technology. It was the beginning of live streaming over IP. Today the video standard is HD/Digital. Almost all broadcasters are using IP as transmission media. New technology means new technical challenges. The video system was designed to support real time space-operations, simulations and public relation events. The user needs associated to these kind of activities are slightly different, and don't always fit with the needs of the industry. The new system must integrate the new operational wishes of the different operational teams. The standards inside the broadcast industry are still changing a lot. The industry is offering new codecs, higher video-resolution, and 3D video technology is emerging. The video capabilities inside the ISS are also evolving and will continue to evolve. The new system needs therefore to be easily maintainable and updateable in order to follow both kinds of changes (industry and ISS operations). The deployment of the new system must minimize the impact on on-going operations and minimize the costs. The challenges of updating the Columbus Video Distribution System to HD/Digital (technical, operational, maintenance and deployment) during running operations will be presented in this paper.

I. Introduction

Columbus, the European module part of the International Space Station (ISS), was successfully launched in February 2008. In this laboratory various experiments are conducted. They are controlled on the ground by the Columbus Control Centre (Col-CC) in cooperation with the User Support Operations Centers (USOC) and Engineering Support Centers (ESC) distributed across Europe. In order to conduct and support these activities a set of communications systems have been developed. Especially the Video Distribution Service (ViDS) is in charge of distributing in real time the videos coming from the ISS via NASA (Houston and Huntsville in USA) and/or via ROSCOMOS (Moscow) to all these different sites.

The ViDS was designed in 2002-2003. At this time standard definition and analogue video were the standard in the industry, digital uncompressed video (SDI – Serial Digital Interface) was just emerging. Asynchronous Transfer Mode (ATM) network technology was used to distribute the videos in real time between the different control centers. Due to cost reductions it was decided to utilize Multiprotocol Label Switching (MPLS) instead of ATM. This migration occurred in 2008-2009, during this time only a few devices were exchanged. Today the majority of the remaining equipment still continues to use Standard Definition (SD) and analogue technologies. Most of these devices reached the end of their life spam and are neither maintainable nor replaceable. This is mainly due to the fact that the broadcast industry has moved in the direction of complete digital system supporting both Standard Definition (SD) and High Definition (HD). Therefore the migration of the video system to a fully digital system was decided.

The design of the ViDS was based on requirements which were written long before the real operations started. In 2006 the ViDS successfully supported the Astrolab mission. It was the first European long duration Mission inside

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the ISS. Due to lack of experience it was not possible to foresee all future operational needs and hence the capacity of the systems was later realized to be insufficient, however for some parts of the system the inverse was also found to be true. The ISS and the dedicated resources on the ground are continuously evolving. NASA gets on regular basis HD videos coming from the ISS and Obsolescence Driven Avionics Re-Design (ODAR) will soon be deployed as results the downlink and uplink capacity from/to the ISS will drastically increase. The new Video system (called ViDS-Renewal: ViDS-R) must take into account not only the experience gathered over the past few years of operations but also adapt to the current and future changes inside the ISS and the new possibilities associated with them.

The deployment of the ViDS-R will also be a challenge. Firstly the interfaces between the remote sites and the ViDS-R must be updated. If these interfaces change then the remote sites may have to update their video system too. A system update takes time and the video system needs to be updated quickly. Configuring and monitoring the ViDS-R should stay simple so that non video specialist could still configure it.

The main challenges of updating the ViDS from an Analogue/SD video system to a Digital/HD system is presented in this paper. The first part presents an overview of the ViDS as it was in 2010 (beginning of the project). The second part presents the wishes of the different operational teams, the current and future video-capacities of the ISS and their repercussions on the design of the ViDS-R. The last paragraphs explained why the ViDS-R is much more complex than the ViDS, and why it could be an issue for operations.

II. ViDS Overview

This paragraph presents the status of the ViDS as it was in 2010 (beginning of the project). Its aim is not to provide a detail explanation of the ViDS but the necessary explanations to understand the next two paragraphs.

A. Col-CC

The ViDS is mainly a contribution-distribution video system. The video sources contributed from the remote sites are received at Col-CC. These video streams are then distributed internally at Col-CC (MPEG2/IP Multicast within the Col-CC video network), and also distributed to the remote sites via MPLS (MPEG2/IP unicast). Internal video sources generated at Col-CC can also be distributed to the remote sites and internally. the ViDS also provides the video capture, distribution management and interfaces with the Col-CC SAN (Storage Area Network) for on-line archiving and retrieval. This is illustrated on the next figure.

At Col-CC the MPEG2/IP videos coming from the remote sites via the MPLS network are first converted into MPEG2/ASI streams. The video data remains untouched, only the transport layer changes. The video-streams are then forwarded to an ASI matrix. This device is able to route any video coming via an input port to any of the output ports. For example the video stream coming via input port 1 could be routed to the output port 3 and output port 25. Using this device one video can be forwarded at the same time to one or more remote sites and to the internal network at Col-CC. The ASI streams coming from the matrix are converted back to MPEG2/IP streams (Unicast for the remote sites and multicast for Col-CC).

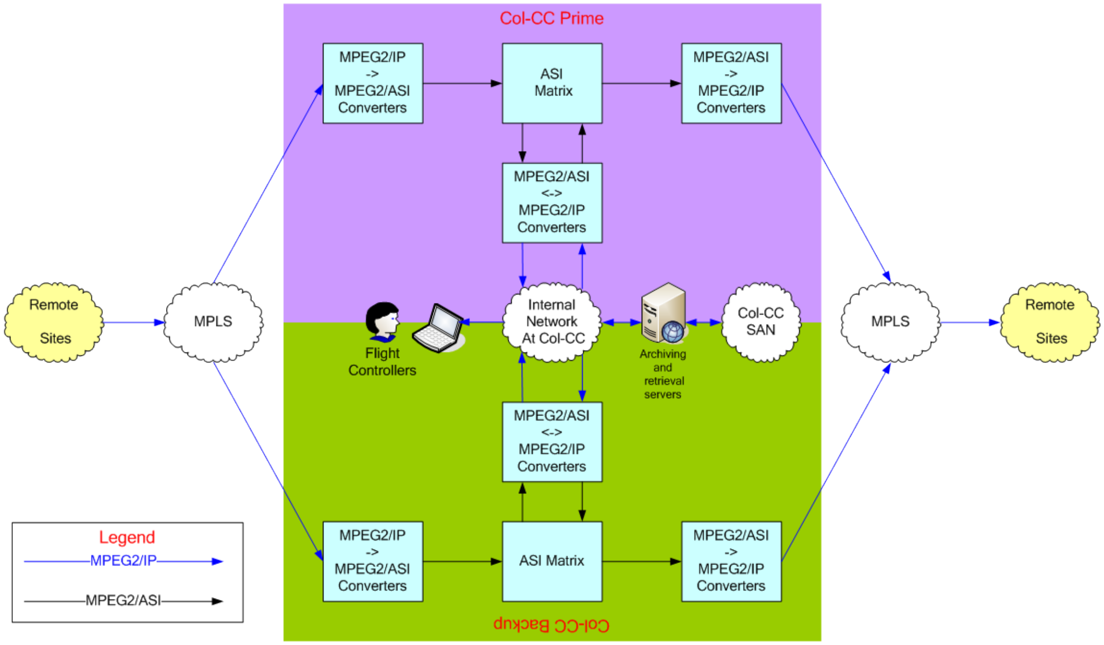

Figure 1. Remote sites interacting with the ViDS

B. Remote sites

The Next figure provides an overview of the remote sites interacting with the ViDS. The sites could be divided in three categories:

1) Redundant sites: Both the video infrastructure and the network infrastructure are redundant. These redundant facilities were originally to be used only in case of a catastrophe. However most of the time prime and backup facilities are running in parallel.
2) Non redundant sites: A few video equipments are installed in these sites. This is a non redundant setup for video but not necessarily for the network.
3) Small sites: No video equipments installed. These sites only receive video from the ViDS.

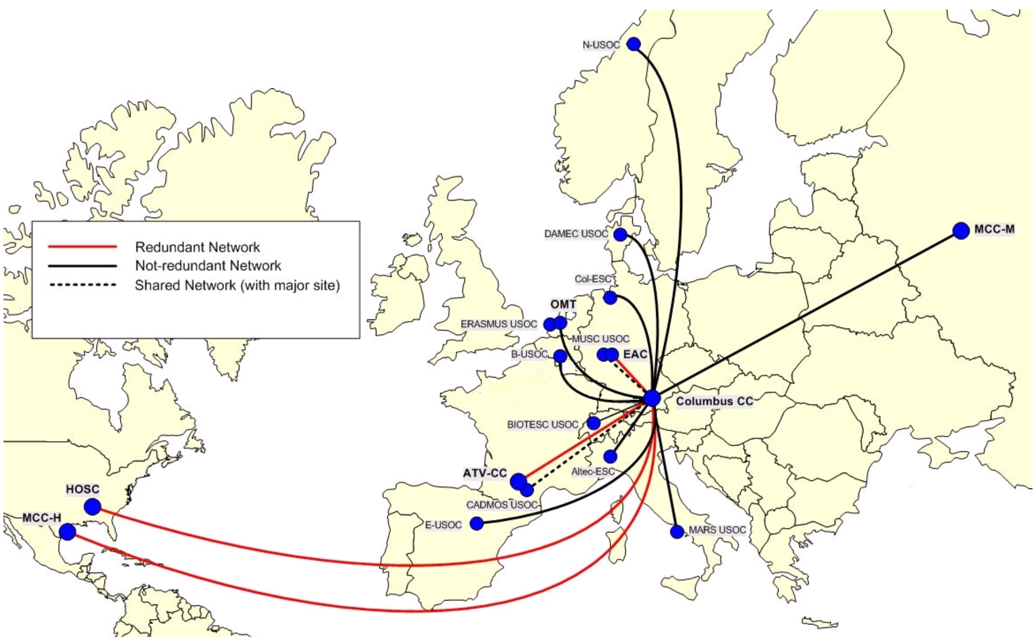

Figure 2. Remote sites interacting with the ViDS

C. Interfaces between the ViDS and the remote sites

1. Analogue Interface

The sites (categories one and two only) provide analogue videos to the ViDS. The video signals are firstly processed (e.g.: video format conversion NTSC to PAL) using analogue devices, encoded (3Mbit/s, Constant Bit Rate - CBR) and finally these encoded signals are forwarded to Col-CC via the MPLS network. In the other direction, the videos coming from Col-CC are first decoded, the analogue signals are then processed and finally the analogue video signals are transmitted to the remote sites. The decoders are also able to provide a MPEG2/ASI signal to the remote sites, but this only used by a few centers. The number of ViDS devices installed at a remote site is varying, for example around 50 devices are installed at Mission Control Center Houston (MCC-H) and only 3 devices are installed at Col-ESC (Columbus Engineering Support Center). The ViDS is only able to process PAL video signal. If a site (e.g.: NASA) provides a NTSC video then the ViDS will transform it directly into PAL.

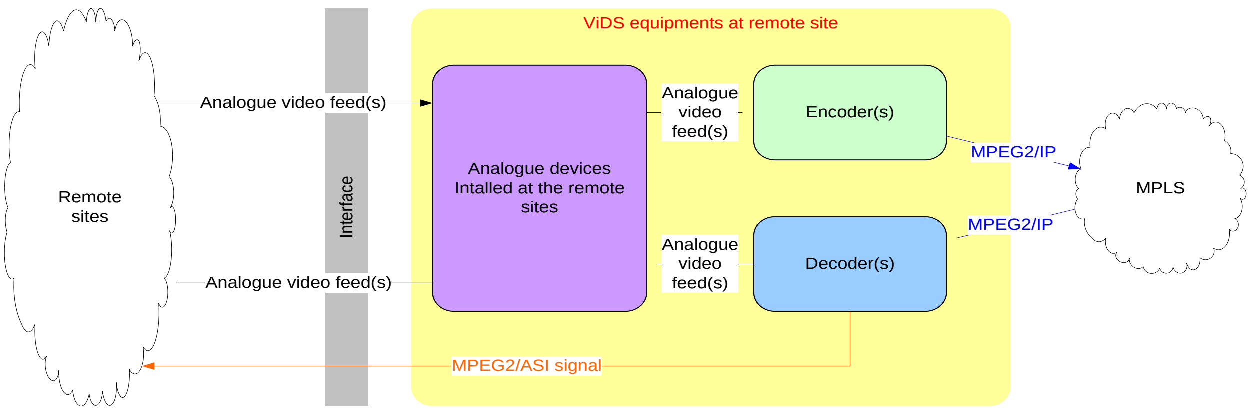

Figure 3. Remote sites interacting with the ViDS

2. Docking interface

In order to support docking video activities an IP interface has been developed between MCC-H and the ViDS and between VIDS and Mission Control Centre Moscow (MCC-M). The video signal is encoded on board (4,2Mbit/s) and transported to MCC-M without any format conversion and without being decoded or re-encoded. The MPEG2 video is received at the MCC-H via IP multicast. The ViDS transform this multicast into a unicast and sends it directly to Col-CC, which forwards the video to ViDS devices installed at MCC-M. These devices transform the unicast stream back into a multicast for further distribution at MCC-M. The design has been optimized to keep the end-to-end delay as low as possible. This interface was originally to be used for ATV (Autonomous Transfer Vehicle) docking video. Today this interface supports also SOYUZ, Progress, some Russian experiments and PR events.

3. MPEG2/IP video

Like previously mentioned no video devices are installed at the small sites (category 3). These sites are getting directly one MPEG2/IP unicast signal (2Mbit/s). A trans-rating has been implemented at Col-CC: the video-streams coming from the remote sites at 3Mbit/s (4,2Mbit/s for docking video) are first decoded and then re-encoded at 2 Mbit/s.

III. Operational needs, ISS video-capacities and impact on the ViDS-R design

A. Delay, quality and bandwidth

When configuring an encoder the engineer must find the best compromise between the following factors: (encoding) delay, bandwidth (which has a big influence on the MPLS-costs) and quality. Fixing two factors will determine the third one. E.G.: If a user wants a video with a good quality, and he wants to keep the delay low then the bandwidth will be high. If the user wants anyway to decrease the bandwidth, he could either buy a better encoder or changes his codec and chooses a more competitive one. Inside the video system one of the “fixed” factor is bandwidth, the bandwidth must be kept low in order to keep the communication costs relatively low. As a consequence either the delay will be low and the quality poor or the quality will be high but the delay great.

At the beginning of the project a questionnaire has been send to the different European sites to determine their real needs and to identify new possibilities for saving costs without impacting the operational needs. All possibilities were envisaged from removing completely the video system and provide video only via DVDs to update the system to a full HD system. One of the subjects addressed by the questionnaire was: "delay and quality of the video stream(s) delivered by the ViDS". The answers have been analyzed, discussed and assessed by the different operational teams located at Col-CC. It was found out that:

1) Video is important for operations. The video must be transported in real-time to the operational teams
2) Delay is the most important factor. Especially when on-board activities are conducted inside Columbus, the end-to-end delay must be minimized.
3) The quality of the video provided to them by the ViDS is sufficient, but must not decrease. With lower quality it won't be possible to properly conduct operations.
4) HD video is highly desirable but not necessary.
5) There is only one exception to the three previous statements: Public Relation Event. For this kind of event the video quality was barely acceptable. Moreover HD was required. The delay could be an important factor, especially if during a public relation event a discussion is taken place between VIPs on the ground an astronaut on-board, but it stays secondary to quality.

The ViDS-R must support both real time operations and public relation events. These two kinds of activities have radically different needs and constraints. Due to the fact that bandwidth is already a "fixed factor" it is not possible to use the same encoders to support both activities. In this case the only technical solution is to create at least one channel dedicated to public relation events. This channel will stream HD video and the settings of the different devices will be optimized to provide the best possible video-quality.

Some HD capacities have been developed by ESA and NASA over the past few years to stream HD video from the ISS to the ground. One example is the MPC (Multi-Protocol Converter) video, this video is a HD video encoded at 27Mbit/s and downloaded to the ground either in real-time or in playback. In the next future with the new possibilities offered by ODAR, particularly the increase of bandwidth of the up/down link between the ISS and the ground, the number of live HD channels will most probably increase. But currently the ISS is mostly streaming SD video. As consequence the ViDS-R must then support both HD and SD, and it should be easy to increase the number of HD channels later on.

Taking into account all this feed-back and in order to keep the costs relatively low it was decided to perform the migration in 2 phases. During the first phase the old analogue devices will be replaced, the system will be updated to a full digital system. The encoders and decoders will be kept, they can already support digital video (SDI) and can still be maintained. The new devices will be able to support both SD and HD. Technically it's possible to have a video system which is both supporting SD and HD, it's coming from the fact that the industry and the different TV broadcasters haven't yet fully migrated to HD. In 2011 in "theibcdaily" journal (IBC: International Broadcast Conference) dated from 09.09.2011 Joe Zaller explained that the most important budget item this year for broadcast industries will be upgrading their infrastructure for HD/3Gbps operations[3]. As consequence there is a large panel of devices which can support both SD and HD videos. One point which will not be explained in this paper is that the number of channels (from remote sites to Col-CC) will be drastically reduced during phase 1. The main point was to reduce the number of encoders (and to prepare phase 2), in fact encoders are extremely expensive. During phase 2 the encoders will be replaced and the system will be migrated to a full HD digital system.

B. Reduce the delay: no many possible solutions

For real time operations the end-to-end delay needs to be kept as low as possible. Therefore the streams coming from a remote site should be transmitted as fast as possible to the end user. In the current system the video streams received at a remote site have been many times processed, the transport layers changed many times and in worse case scenario the streams have been decoded and re-encoded. Each process, each transport layer change and each re-encoding add delay. In order to reduce the delay they need to be reduced and ideally completely removed.

Currently the ViDS is a "centralized network", the streams are first sent to Col-CC and Col-CC forward them to the remote sites. The first idea was to change this concept and to create a "decentralized network", in this case Col-CC will be seen as a normal remote site, and all the processes performed at Col-CC will then be removed. Since one

[3] Theibcdaily, 09.09.2011, „European broadcast technology budgets on the rise 2011-2012", by Joe Zaller, Devoncraft Partners

stream could be seen at the same time by many different operational teams at many different locations, multicast appeared to be a good solution. The MPLS network could be compared to a giant multicast network. It was not technically possible to implement this setup however. The MPLS provider does not support a multicast-enabled MPLS core. Therefore all multicasts have to be converted into a couple of unicasts before being sent through the MPLS Backbone. This means that sending the streams over IP directly from e.g. Houston (MCC-H) to the external sites would multiplicate the Atlantic Bandwidth by the number of unicasts to be generated. In general sending a stream directly from a site to the end users will increase the overall bandwidth and as result the communication cost. The provider did not announce to change to a multicast enabled MPLS core in the foreseeable future. Secondly within Cisco devices the setup and even more the troubleshooting of multicast traffic are categories more complicated than unicast. The multicast routing is a complete separate entity from unicast routing, there are significantly less debugging possibilities and the extra setup to support multicast increase the management workload significantly, reduce the trouble-shooting capabilities and as result could impact operations. Some studies have been performed to check if it was possible to use Internet instead of MPLS, in this case Internet could be compare to a "multicast network". It quickly appears that Internet won't be able to fulfil the needs of the different operational teams and that delay will increase drastically (over 1 minute instead of 3-4 seconds currently). The new system will remain a centralized network, and the transport layer changes at Col-CC will remain.

The streams coming from the remote sites (via the analogue interfaces) are encoded by encoders which belong to the ViDS. The only exception is the docking video, the encoder is on-board, and on the ground this video is forwarded to the ViDS via an IP interface (MPEG2/IP). The ViDS only transform the multicast stream into a Unicast stream. The delay associated to this transformation (around 100ms) is less important that the encoding time (around 600-700ms). Another idea was then to extend this interface. This was technically possible to do it but it won't neither decrease the delay nor save costs and could cause additional issues. In fact the video engineers need to be able to control the bandwidth, not only because of the costs but also because of technical reasons. On the MPLS the available bandwidth between a remote site and Col-CC are shared by all the video-streams. If the total video-bandwidth, sum of the bandwidth of each individual stream in a direction (in this case remote site to Col-CC), is over the limit, all the streams in this direction will be affected and as result distorted. This is one of the main reasons why the ViDS-Encoders are CBR (constant Bit Rate) and not VBR (Variable Bit Rate). NASA also informed Col-CC that some video coming from the ISS are encoded at 27Mbit/s (instead of the 3Mbit/s, normal bandwidth used inside the ViDS) and that all their streams are not CBR. So in order to be able to control the bandwidth trans-rating capabilities will be needed, this means that the IP videos coming from a remote site will be first decoded and then re-encoded

The docking interface is an exception. Col-CC was in fact part of the development team of the on-board encoder and could right at the beginning of the project provide a list of important parameters (for the ViDS) with their associated values. Since receiving directly IP videos from the remote sites can increase the delay, causes a number of issues as well as increasing costs, it was decided to use SDI and HD-SDI as interface (Contribution), and to keep the encoding-capabilities inside the ViDS.

In order to improve the end to en delay only the following changes were integrated inside the ViDS-R:

1) No format conversion in the ViDS anymore. Some couple of 100ms could be saved and the video quality will increase too.
2) Remove the trans-rating at Col-CC. The sites present in the category 3 will receive a MPEG2/IP stream at 3 Mbit/s (instead of 2Mbit/s). The network infrastructure at the remote sites will require a small update. In fact all the data are encrypted on the MPLS. The encryption is performed by the routers located at Col-CC and the decryption by the routers installed at the remote sites. For most of the small sites a software encryption is currently in place. For these devices to be able to decrypt a higher amount of data additional encryption/decryption cards will be needed. These cards need to be installed inside the routers.

IV. ViDS-R a complex system

A. HD: a new codec and more bandwidth

As described before HD was only required for public relation events. In this case HD (and especially Space to ground HD Video) was only needed for ERASMUS and Col-CC Bringing HD to these two sites were decided extremely quickly (end of 2010, beginning of 2011) long before the acceptance of the ViDS-R (Phase 1 was officially accepted in April 2012). This decision was driven by the presence on-board of a European astronaut: Paulo Nespoli.

In order to keep the MPLS bandwidth low, MPEG4 Part 10 is used as codec. This codec provides up to 40% bandwidth-gain in comparison to MPEG2. MPEG-4 has also the following advantages, as "open standard" most of the software player can decode it and display it. This is also the case of the software used at Col-CC Moreover during the MPLS migration (2008) the decoders have been replaced by new ones which are able to decode MPEG-4 and are supporting HD. The decoders only need a key update. Even if the first request was to bring HD only to Col-CC and the European Space Research and technology Centre (ESTEC) everything was done to be able to provide HD video relatively easily (with only few changes) to the other remote sites.

In June/July 2010 some HD Video tests in cooperation with NASA have been performed in order to find out the best compromise between bandwidth, delay, video quality, CPU usage and memory utilization on the computers installed at Col-CC. The next figure shows the variation of the delay (encoding time) with the video-bandwidth. 6 Mbit/s seems to be the best compromise: the bandwidth stays acceptable, video quality is good, the encoding time is bellow 1 sec, on workstations the CPU usage stays below 20%

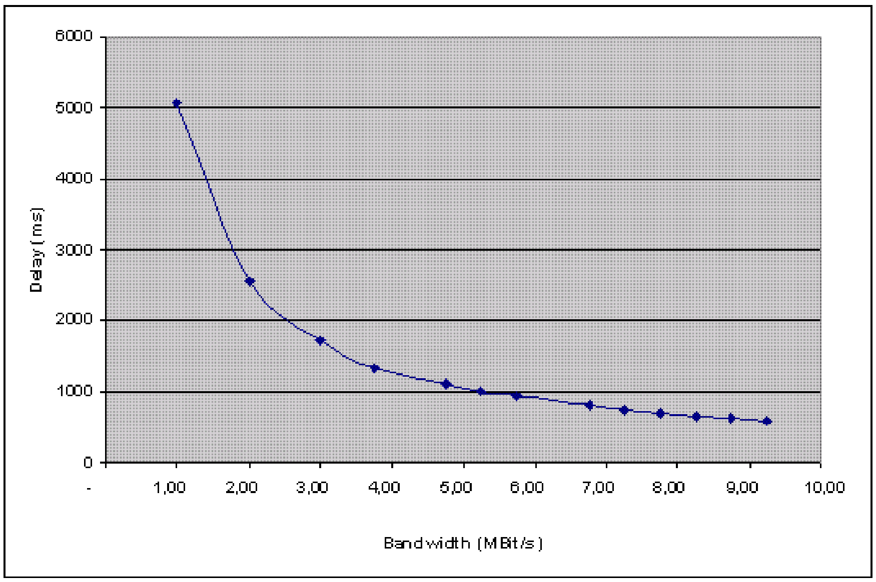

Figure 4. MPEG-4: variation of the delay with the bandwidth

B. HD, digital: new interfaces

A video format is defined by a few parameters: the number of pixels in the image, the number of frames per second, and the scanning, Progressive (P) or Interlaced (I). "Progressive or non-interlaced scanning is a method for displaying, storing or transmitting moving images in which all the lines of each frame are drawn in sequence. This is in contrast to the interlacing used in traditional television systems where only the odd lines, then the even lines of each frame (each image now called a field) are drawn alternately"[4]. E.G.: 720p50 means: 720 lines per frame (usually only the number of lines are used); 50 frames per second, the scanning is progressive.

There are two SD digital format, 576i50 (which corresponds to Pal) and 480i59.94 (which corresponds to NTSC). These two formats are well known and all the video-devices can easily support them. But HD video format is much more complicated, there are more than 20 official video formats (720p25, 720p29.97, 720p30, 720p50, 720p59.94, 720p60, 1035i59.94, 1035i60, 1080i50, 1080i59.94, 1080i60, 1080psf23.98, 1080psf24, 1080psf25, 1080psf29.97, 1080psf30, 1080p23.98, 1080p24, 1080p25, 1080p29.97, 1080p30….). The broadcast industry seeks for more and more video-quality, and new standards with higher resolution are regularly appearing. The resolution of most of the new camera is not 1920*1080 anymore but 4096*2160 (this resolution is named 4K, 4 times HD). Ultra High Definition (7680x4380) is under development. This format will even be used during the Olympic Games 2012. Most of the standard video-formats are not compatible. Some devices can support few of them and other devices few others… After lots of investigations, it appears that the following HD formats need to be supported by the ViDS-R 720p50, 720p59.94, 1080i50 and 1080i59.94. The other formats are either used in the cinema and in

[4] www.wikipedia.org

post productions industry (and not in the broadcast industry) or the video resolutions are too high (1080p formats), the ISS is not supporting this video format and only few encoders (very expensive) are able to encode in real time this kind of format. For contribution-distribution the EBU (European Broadcast Union) recommends to use 720p formats. It was also observed that some devices only work with 1080i or only provide a 1080i signal even if they receive a 720p input-signal. In order to have bigger choices and to avoid compatibility problems between devices, it is needed to support these formats too. Moreover some of the ISS HD channels are 1080i59.94 too.

Like shown in the next table the digital format and the video format are strongly related. 3G-SDI won't be supported because this digital format is used to transport 1080p videos

Standard	Common Name	Bitrates	Example of Video Format
SMPTE 259M	SD-SDI	270Mbit/s, 360Mbit/s, 143 Mbit/s, 177 Mbit/s	480i, 576i
SMPTE 292M	HD-SDI	1,485Gbit/s, 1,485/1.001 Gbit/s	720p, 1080i
SMPTE 424M	3G-SDI	2.970 Gbit/s, 2.970/1.001 Gbit/s	1080p

Table 1: Digital formats[5]

SD-SDI and HD-SDI will be used as interface for contribution (except for docking video). This interface could also be used for distribution, but rather than using this kind of format the engineers are trying to extend the MPEG2/IP interface.

Currently, the ViDS is only distributing Pal video to the remote sites (except NASA centres), via either analogue interface or MPEG2/IP video. Since in the future the ViDS-R will get and deliver different video-formats to the remote sites, via either digital interfaces or IP interfaces, the interfaces with the remote sites must be renegotiate. Negotiation takes time and in worse case scenario some of the partners must update their video-infrastructure too, and this will most probably require even more times. The ViDS needs to be updated soon, so a transition phase must be implemented, during this phase part of the current interface will be kept up and running and the new interface will be deployed. Keeping an analogue interface is not an issue, since the decoders and the encoders can support both SDI and analogue at the same time.

C. Operational aspect: new management interface

The video-system is only a small part of the ground infrastructures which have been developed to support Columbus activities. The system is running 24 hours a day, 7 days a week, 365 days a year. The video engineers are only present during normal office hours (8:00-17:00, 5 days a week). They are in charge of the maintenance and design of the video-systems. The ground controllers sitting on console and present all the time are performing the day-to-day configurations (mainly routing a video from a site to another and scheduling a recording) and also the monitoring of this system. Not only they are monitoring and configuring the video system but also the other systems part of the ground infrastructure. Moreover they are in charge of the coordination of the ground resources between the operational centers. They are not specialists on any specific subsystem.

The old system was rather easy to understand, one video-format (Pal), one codec (MPEG-2), and 3 different bandwidths (3 Mbit/s for "normal video", 4,2Mbit/s for docking video, and 2Mbit/s for the trans-rating video). At the remote sites the video were analogue, and after the encoding-process the resulting MPEG2 streams were transported via IP to Col-CC. For the ViDS-R it's another story, and especially during the transition phase: 6 Video-formats (576i50, 480i59.94, 720p50, 720p59.94, 1080i50, 1080i59.94), 2 codec (MPEG2 for SD and MPEG-4 for HD), at least 4 bandwidths (2Mbit/s, 3Mbit/s, 4.2Mbit/s and 6Mbit/s for HD video). At the remote sites analogue video (during the transition phase) and digital video will be mixed; IP video will still remain. Since HD was not required yet and to keep the cost low the old encoders and decoders will be reused (phase 1), but on the other side they cannot support HD (a key update is required for the decoders). Moreover in the next future the ViDS will continuously change, as soon as phase 1 will be completed phase 2 will start. Due to all the previous constraints the ViDS-R will be rather difficult to understand and rather difficult to configure and will keep changing. By performing some pre-configurations and by providing detailed procedures to the ground controllers, the

[5] www.wikipedia.org

configurations could be simplified and some miss-configurations could be avoided but this is not enough and the system will remain too complicated. Therefore another solution was required: a software solution.

The Ground Controllers are currently using the IMS (Integrated Management System) to monitor and configure all the different subsystems. Basically inside each subsystem a dedicated server named “Element Manager” gather the status information of all the software and hardware inside this subsystem and forward part of this information to the IMS. In order to configure the system the ground controller sends via the IMS a command to the Element Manager which then forward this command to the proper software/hardware. In the special case of the ViDS, the ground controllers monitor and configure each device individually. In the current setup they are rather free and they are able to route any video to any centre. In order to help them and in order to avoid miss-configuration, it was decided to implement a new user-interface and to provide to them a “service oriented view”. In this case the ground controllers will monitor/configure a group of devices/software which provides a service (E.G.: all the software/hardware which is used to forward the first video coming from MCC-H to Col-CC). The video element manager will automatically perform all the needed checks and will be able to perform all the needed configurations on all the software/hardware. Therefore the video element manager will be exchanged and his interface to the IMS will be extended in order to be able to send additional commands and to receive additional status. These status and commands are valid for “services” and not only for one single device.

V. Conclusion

This paper presented various challenges which were faced by the engineers during the design of the ViDS-R. Even if there are more and more HD videos coming from the ISS, SD video is still present and will still be used in the next future. Therefore the new system will need to support both HD and SD. The new system must support both operations and public relation events. For operations the delay should be kept as small as possible, which means remove all the video-format conversions and remove the trans-ratings. For public relation events a new HD channel was integrated, video-quality was the most important factor.

Digital and HD mean new codec, more bandwidth, new video formats and finally new interfaces between the ViDS and the remote sites. For these new interfaces agreements must first be found, and this takes time. Therefore a transition phase is required and part of the old interfaces need to be kept for the time-being. Due to these new technical constraints the new system will be complex. The system is continuously used for operations and the ground controllers need to be able to monitor and configure it without being specialist and without the presence of video engineers. A new management interface is therefore required. The new interface shall rather use the concept of services and not look at each device individually.

Col-CC decided to perform his update in two phases, in phase 1 all the analogue devices will be removed, the system will be migrate to full digital system. Originally one HD should be developed too but this capability was deployed at the beginning of 2011, long before the acceptance of phase1. In phase 2 the video system will be migrate to a full HD system. Phase 1 was urgent because the engineers were a serious obsolescence issue. The strategy for phase 2 has not been clearly defined yet, is a full HD system really required? Would it be better to buy additional spares and to wait for the end of the ISS program?

Appendix A
Acronym List

ALTEC	Advanced Logistics Technology Engineering Center
ASI	Asynchronous Serial Interface
ATM	Asynchronous Transfer Mode
ATV-CC	Autonomous Transfer Vehicle Control Centre
B-USOC	Belgian User Support and Operations Centre
BIOTESC	Biotechnology Space Support Centre
CADMOS	Centre d'Aide au Développement des activités en Micropesanteur et des Opérations Spatiales
CBR	Constant Bit Rate
Col-CC	Columbus Control Center
Col-ESC	Columbus Engineering Support Centre
DAMEC	Damec Research Aps
EBU	European Broadcast Union
ERASMUS	Erasmus User Support and Operations Centre
ESA	European Space Agency
ESC	Engineering Support Centre
ESTEC	European Space Research and Technology Centre
E-USOC	Spanish User Support and operations Centre
HD	High Definition
HOSC	Huntsville Operations Support Centre
IBC	International Broadcast Conference
IMS	Integrated Management System
ISS	International Space Station
MARS	Microgravity Advanced Research and Support Centre
MCC-H	Mission Control Center – Houston
MCC-M	Mission Control Center – Moscow
MPEG	Moving Picture Experts Group
MPLS	Multiprotocol Label Switching
MSM	Manned Space & Microgravity
MUSC	Microgravity User Support Centre
MPC	Multi-Protocol Converter
NTSC	National Television System Committee
N-USOC	Norwegian User Support Operations Centre (N-USOC)
NASA	National Aeronautics and Space Administration
ODAR	Obsolescence Driven Avionics Re-Design
PAL	Phase Alternating Line
SAN	Storage Area Network
SD	Standard Definition
SDI	Serial Digital interface
SMPTE	Society of Motion Picture and Television Engineers
USOC	User Support Operations Centre
VBR	Variable Bit Rate
ViDS	Video Distribution Service

Appendix B
Glossary

ASI	Is a streaming data format which often carries MPEG Transport Stream (MPEG-TS)
MPEG-TS	Designed for use in environments where errors are likely, such as transmission over long distances or noisy environments, transport streams are used by TASC and DVB standards. A transport stream combines one or more programs, with one or more independent time bases, into a single stream. [6]
SD-SDI/HD-SDI/3G-SDI	These standards are used for transmission of uncompressed, unencrypted digital video signals (optionally including embedded Audio and/or Time code) using 75Ohm coaxial cable (or optical fibre cable).

[6] Keith Jack, "Video 4th edition demystified," Newness, 2005, pp. 667

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[4]Matthias Urban, "Design and implementation of a services concept for monitoring and controlling an automated Columbus Ground Video Distribution System," Master-Thesis to obtain the academic degree: Master of Engineering at Deggendorf University of Applied Sciences, March 10th, 2010.