Despite any efforts to plan, design, integrate, install and operate high-end electronic communication systems [of any kind] in such a manner as to minimize the consequence of any failures in the actual equipment / components or in the processes that define the dynamic use of the technology components (the people / end-user portion of the equation), the fact of the matter is that it is never a question of “if” any components or processes will “fail”, it is only a matter of “when”. That being said, proper training and documented recovery procedures can go far towards minimizing the negative impact of any process or human-error, and, further, we can be comforted by the fact that the electronic systems components of today have MTBF (Mean-Time Between Failure) rates that generally fall between 6,000 and 8,000 hours of operation, rates that were unheard of just a few years ago. On the “technology-side” of these systems, the high-level of MTBF, coupled with carefully planned and integrated solutions, results in equipment and system durability and reliability that can and should be experienced and viewed as “exceptional”.

“MTBF” and “Human Error” are, however, NOT the central topics of our present discussion, they are subsidiary to our main topic. These aspects of performance characteristic and metric do not directly address the fundamental questions related to making any systems more-reliable or more fault-tolerant in and of themselves. This present discussion is focused on the concept of why and how (in what-ways) we go about making any communication system “Redundant”.

Prior to [and separate-from] actual specific discussion for the systems of technology that are addressed by general videoconference and visual communication design templates, it serves us well to explore the terms “Redundant” and “Redundancy”, and provide a little more detail for the additional concepts that, by default, underlie these terms, in order to more accurately describe the real-world levels of “reliability” and “fault-tolerance” we require from the visual communication systems of today and tomorrow.

On the following pages we will engage in a discussion of the basic issues that relate to “redundancy”, and we will provide some simple graphic illustrations to better explain the various points of our discussion. Once that over-view and description is fully complete we will detail, as closely as possible, the specific elements, including the elements within some of the readers existing spaces, that may be in-need of re-thinking and /or careful application of a planned “redundancy evaluation”.

“Glossary” note: For our purposes, “reliability” will refer to the overall performance of a collected / integrated grouping of systems and subsystems over-time as experienced by end-user perceptions and documented technical performance metrics. “Fault-tolerant” will mean the level of survivability of any system in the face of errors or malfunction, and will further refer to any mechanism that operates, directly-and-actively (through some built-in intelligent mechanism, as-in functions of an intelligent master control system) or indirectly-and-passively (for instance – a switch that changes position based on sensing current or signal on the connection), to minimize or fully ameliorate any equipment or human errors or mistakes.
REDUNDANT / REDUNDANCY: When we say that a system is “Redundant” we are actually only speaking in vague generalities. There is actually a “Range & Structure of Redundancy” that can be built into any communication solution. The typical “Range” often has a “Structure” as defined in the four (4) levels discussed below:

1. Zero Redundancy with Total Integrated Failure as a result: This means that the compliment of electronic components and the integration of these components are such that a single (1) failure in a single (1) element will render the entire system 100% unusable for anything. (This is the result of failing to design-away any “choke-points”).

If, for example, the Remote Control system interface has the only (1) Master Power “ON/OFF” button, and if the equipment compliments of many individual electronic units that make up the fully integrated communication solution are hardwired into that Master Power system with no other access to independently-power each component “ON” or “OFF”, then a failure in the Master Control system interface while the components are un-powered will render it impossible to use any of the components [total integrated failure]. There is no way to turn them “ON” for use, let alone use them.

EXAMPLE #1: Zero Redundancy

Green Line = Voice Audio Signal

Reason for Failure: Even if all of the components are able to operate properly when powered “ON” [they are all in working-order], if Master Power is “OFF” and units cannot be turned “ON” individually, the result is that our voices are not “sent-to” and heard-by the people at the far-end. Since the codec [our local link to the communications network] is one of the components in the “OFF” state, it is not even possible for us to dial the call and establish a connection with the far-end, across which any data, including audio, could then travel. In the above example the technology will not be able to intelligently or passively provide a fall-back fix, and neither will a technician following restrictive “turn it on and then touch nothing” guidelines. A creative rule-breaker who might be in possession of a pair of diagonal cutters could: cut the power leads, carefully jamb them into an un-powered AC outlet, fix the wires so they would not come loose, and then turn the power for the outlet “ON” (power the equipment). This is, however, physically dangerous, since some people take matters into their own hands without the necessary understanding of the fundamental elements involved in order to do this safely and with predictable & positive results.
2. Minimal System Fallback Redundancy that will often result in “Perceived Total 100% Failure” that, even when failure is not 100%, is “Highly Brittle”:

To begin with, what do we mean by “Brittle”? In integrated electronic systems [and, for that matter, in software design] the term “Brittle” refers to the ratio of cause-and-effect in the face of component or element failure. When a system is “Highly Brittle” we mean that a single cause [failure] in a single element or component has a greater than a one-to-one ratio in failure-and-consequential effect. (Example #1 above, for instance, had a maximum Cause-Effect failure ratio of 1: ALL [100% of all components])

For Example: Let’s say that a complex integration of ceiling-based microphones feeds an automatic microphone mixer component for the purpose of muting and un-muting selected microphones in different zones in a given space. This mixer, through selective “Zones” of microphone pickup of only the person speaking [instead of the entire room] at any one time, operates to reduce the level of general background noise fed into the conference. That is good planning and design. However: Let us suppose, for the purpose of this discussion, that the automatic mixer suddenly “fails”. In an integrated system that is “Highly Brittle” [the designer did not look-for and resolve choke-points] this will mean that everything downstream in the system flow that is dependent on the signals that are processed-by and then output-from that now-failed automatic mixer will now also “fail”, not because the other components have actually “broken” and not because they are not powered “ON” and able to perform their assigned functions but, rather, because they are no longer receiving the audio signals from the [now-failed] mixer [signals that are necessary for these downstream units to be able to perform their own functions].

More specifically: If the automatic microphone mixer was set up to feed it’s audio output signals to the echo-cancellation unit that, in turn, was connected and set-up to feed the codec which, as we know, feeds audio into the conference, in our example of a “Highly Brittle” integration, once the automatic microphone mixer ceased functioning, the echo-canceller, the audio portion of the codec and [most importantly] the audio portion of the human communication will now cease to function and, since audio is a required component of human remote communication, the meeting itself cannot be sustained. As we see in this example, a single point of failure has caused at-least 4 other elements in the “communication” process and structure to also “fail”.

Worse-Yet: Ultimately and additionally, this extensive or extended “domino-effect” of non-functioning / performing units (when the integrated solution is “Highly Brittle”) makes things much more difficult (if not at times impossible) to troubleshoot in a timely manner. When multiple units are not “performing” their [any] functions, but the human end-user perceives only that (in our example) the far-end “cannot hear us talking”, we [the people responsible for “locating and fixing any failures”] end-up with many different possible places to “look” for the source of the failure. Looking in the wrong places, in an effort to begin to eliminate variables (possible points or instances of failure), takes time and can often mis-lead anyone trying to determine the real root-cause of the stated problem of “they cannot hear our audio”. Is the failure in the microphone, the mixer, the codec, the transmission, the far-end speakers?
Exactly where should we begin to “look” in order to quickly resolve the problem? And, more importantly, even if we find a point of true failure, is the integrated design such that this knowledge even means anything to the rapid “fix” and helps us establish or restore the communications for the end-users? Unlike other things in life that we encounter, “Cause-and-Effect” in electronic systems and human communications (and, again, in software code) are not proximal. In other words, the effect of any failure may or may-not appear (physically or in terms of logical signal flow) immediately adjacent to the actual cause. (In our example, a failed Mixer at the top of our own system-flow results in a speaker that appears to display no audio in a completely separate physical location from our own room. Cause & Effect might [literally] be thousands of miles apart).

A Highly Brittle system is, then, one that has a ratio that is far-from 1-to-1, and such a system is generally very time consuming to troubleshoot and repair (it takes time to isolate the point or points of actual failure and then recover from the failure) and, as such, this level / lack of Redundancy is more devastating to the activities of end-users of the systems. Worse yet — these types of systems will often generate, over time, palpable fear within the user community. The end-users will not only fear that something might fail, but also fear that any failure [“large” or “small”] will result in a complete loss of any ability to communicate important and time sensitive information at a distance.

EXAMPLE #2: Minimal Fallback Redundancy that is “Highly-Brittle”

Green Line = Voice-Audio Signal     Blue Line = DVD Audio Signal

Reason for Failure: This system is “Highly Brittle” – One component failure causes a ripple effect...it seems, to the people at the far-end, that our microphones, our microphone-mixer, our echo-controller or our codec [or any combination-of or all of these components], or maybe even their own codec or speaker unit(s) “failed” in terms of conveying voices from our location to the people at the far-end of the connection. The ratio of “cause-effect” is not 1:1 but is rather, at a minimum, 1:4 [and probably higher when we add the complete failure in any ability to meet and discuss, since voice communication is a requirement for this activity]. There is not, however, “100%” system-failure even in this “Highly Brittle” integrated flow, since there is some audio making it to the far-end from our location (our DVD is heard by them, but no microphones / live-voices are heard). Unfortunately - This generally serves only to complicate and confuse any attempts to diagnose and resolve the real difficulty, and is especially frustrating and confusing to the non-technical end-users.
3. Good Fallback Redundancy – minimally Brittle: This means that the compliment of electronic components [and the integration of these components] is such that a single failure in any one element will reduce the performance of the system, but the system will remain minimally able to perform. One example of this is known as “Safe Mode” in the MS-Windows operating system software that “runs” your PC or laptop. If the main MS-Windows operating system on a PC has a “dramatic failure”, the software will generally drop-back-to or fail-over to what is known as “Safe Mode”. The PC will remain functional (you can run most of the basic individual applications, you can usually continue to use print functions and network access to servers, etc) with little or no actual “basic downtime” for the person using the machine [there may be no complete / 100% loss of utilization time with the machine], but - the PC will now operate with quite dramatically reduced capabilities in elements such as color-depth, screen resolution, rapid data processing and the ability to maintain multiple open & active software applications.

When it comes to “Good Fallback Redundancy – minimally Brittle” in video communications, an example might look like this: Let’s say (keeping with our previous illustration and examples) that a complex integration of ceiling-based microphones feeds an automatic microphone mixer component for the purpose of muting and un-muting selected microphones in different zones in a given space and this was done because it reduces the level of general background noise fed into the conference (only the microphone closest to the person speaking at that moment is active, the others are muted when there is not sufficient sound-pressure from someone speaking-up at general meeting level conversation). With fewer microphones “hot” at one time, there is less ambient or random background noise fed into the conference. As previously noted in Example #2 above, this is good design practice. Further suppose that the automatic mixer suddenly “fails”. In a carefully planned and integrated system that is “minimally Brittle”, this might mean that the microphones will all continue to operate (they will still feed the voices from the local room into the audio portion of the connected conference and the people at the far-end will continue to hear our voices completely uninterrupted), but at a reduced level of performance [the automatic muting or attenuation function that the now-failed mixer was performing will no longer be present]. As a result, instead of only the single zone for the person speaking supplying audio into the meeting, all of the separate microphone zones / all of the room spoken audio is now fed at all times into the conference. This might mean that, to the end-users, there is actually no perception-of or knowledge-of any “failure” of any individual component. This also means, however, that while the system can still function to provide voice communication into the meeting, and can do this with proper fidelity and clarity and volume, there is now an increased and required burden on the participants / occupants of the room to be careful not to speak or make any noise until it is their turn to speak. Otherwise, the random unwanted ambient general “noise” in our local space, which was being minimized by the [now failed] mixer, may overtake the intended voice audio of the person in our room who is speaking in the conference and make it extremely difficult for people at remote locations to hear (intelligibly comprehend) the resulting words that are being sent to them from our system or space. In other words – in this example, we do not completely lose our ability to communicate, and all of the components in our system, except for the failed microphone mixer, will continue to perform their job properly. The
only danger is that the resulting quality may be perceived to be “poorer” than normally experienced from this system if the humans involved do not cooperate to minimize random talking and unnecessary / unwanted noise (pens tapping, rustling papers, squeaking chairs, soda cans opening, laughter, doors being slammed shut, etc).

EXAMPLE #3: Good Fallback Redundancy – minimally Brittle

Green Line = Voice-Audio Signal
Blue Line = DVD Audio Signal

Failure without End-User communication being interrupted: This system is “minimally Brittle” – One component failure (the Mixer) causes NO hard-negative “ripple-effect”...it seems, to the people at the far-end, that our microphones, our microphone-mixer (even though broken), our echo-controller or our codec [or any combination of or all of these components] all seem to be working properly in terms of conveying voices from our location to the people at the far-end of the connection.

The ratio of “Cause-and-Effect” is now 1:1. One component fails, and only one component performance metric is impacted. The remainder of the integrated system continues to operate as planned and desired. This is the result of the introduction of the Signal Splitter and the Auto-Sensing Switch for the signals from the microphones, allowing us to feed the microphone signals to either the Mixer (which will then feed the Echo Controller - preferred) OR allowing us to feed the microphones directly to the Echo Controller (bypassing the Mixer). If the Mixer fails and the Auto-Sensing Switch is aware of the failure (the Auto-Sensing Switch sees a change in the Fail-over reference signal), then the instant the failure occurs the Auto-Sensing Switch will toggle from it’s Primary Feed (that was coming to it through the now-failed Mixer as the Fail-over reference signal) to the Fail-Over Feed coming to the Auto-Sensing Switch directly from the Signal Splitter. The audio signal from all microphones is, as a result, now being sent directly to the Echo Controller, bypassing the [now failed] Mixer. To the end-user, there is virtually no interruption of the flow of audio from one site to the other and, if noise is controlled within the room, no change in audio quality. HOWEVER: Since ALL microphones are now “hot” at all times, there is no “Zone” structure that can minimize random unwanted room and participant noise. All sound from all microphones is now being sent at all times, and the end-user must take care to minimize unwanted room-noise, since the Mixer [having failed] can no-longer help to minimize any “noise”. This means that we must rely on an educated and cooperative end-user base as part of the “Redundancy” solution and the hardening of the communications.
4. Full Redundancy – Zero Loss and 100% Failure-Tolerant: This is a level rarely implemented or achieved in any communication system. Let’s discuss why that is the case. On the equipment or component side of the equation this level of fail-over and reliability means an intricate fail-over architecture where every element – components, cables, controllers, software, inputs, outputs etc – EVERYTHING – has a secondary and [ideally] mirror-tertiary component, cable, controller, software, input, output etc. It also generally means complete failover for the humans involved in the communication or activities. If any one or any combination of components or elements or any humans involved in the activities “fail” at any time [either hardware failure or incorrect action on the part of the human involved], the backup element or person(s) takes over immediately with no interruption to the communication flow. This means, at the very least, that the “hardware” and resulting integration costs will be doubled or tripled for any electronic or component system. In the real-world, it is clear that certain applications can require this level of performance. For instance: Any application in which a loss of human life may occur as a result of even a temporary failure is often all but required to have >100% component redundancy. I [Scott Sharer] witnessed this first-hand as a specialist consultant working on a contract in the 1990’s working with EG&G at [then] Cape Kennedy and the Shuttle Launch Control program. At the Launch Block at [now] Cape Canaveral / Shuttle Command Launch Control, there were / are three (3) rooms that are identical configurations of 200 networked Command Consoles. All three rooms each are fully staffed by 240 people (fully redundant operators and operational managers x 3). During the launch phase of a Shuttle, if any element in the first Launch Control System fails, the second room [and second staff of 240 people] takes over. If there is any failure in that second room, the third room and third staff of 240 people takes over the launch process. Additionally, every action (a keystroke on a computer or button-press on any device) and every word spoken by anyone working on that launch gets recorded in real-time in 1/1000th of-a-millisecond intervals (a key-press on any of the Operations Consoles can be reviewed down to the 1/1000th-of-a-milli-second of when it occurred during the launch sequence), and all of the 300 video feeds and all of the data and voice communications from the Cape Canaveral Launch Block Command Center are shared in real-time between the Cape and the Johnson Space Center. In case the third room at the Cape actually fails, the JSC has to take-over the mission early (usually only after the launch does Johnson Space Center take-over operations). This vast layering of failover and real-time communication capability acts to provide reliability and safety to humans (though, as we have tragically seen, not 100%), and makes it faster and easier to finely pin-point potential root-causes for any problems. With a multi-billion-dollar machine, on-board astronauts and populated local areas nearby, and with the very public nature of the launch events and perceptions of the world resting on the level of the performance of this process, this level of redundancy makes very good sense. It also costs many billions of dollars just to send a single craft into space [just for the launch, not for the full mission] once or twice a year [the Johnson Space Center has a completely separate budget]. Another example might be the need for multiple link-communication redundancy in a tele-medicine / tele-surgical system. If, as a medical team, you have a human life in your hands in a surgical suite and you are performing a highly dangerous and unique procedure, you probably do not want to rely on having only one data-link to the remote surgical expert talking you through the procedure in real-time.
Redundancy in either of the above illustrations becomes critical because of human-life and the potential liability and monetary exposure if anything were to cause a loss-to or degradation-of that life. In the final analysis it is [coldly] a cost-cost equation that can be (and usually is) carefully calculated by an Actuary. A simple “if-then” statement usually serves to define the cost necessity for double and triple redundant systems. If the cost of a single random failure, calculated on a low-probability of occurrence over-time, is less than the cost of implementing the double-or-triple-redundant systems, then the expenditure may not be worthwhile (and, frankly, most of the time is not worthwhile).

(Please note – we are not interested-in or taking any position-on, for the purpose of this document, the moral and ethical debate of the “value of a single human life”. We are merely noting that these types of cold monetary business calculations are made every day in many walks of life for the purpose of managing a business, evaluating insurance risk and exposure, judging investment risk, etc). For this, our layout might now look like:

EXAMPLE #4: “Triple Redundant”

Result: 100% Up-Time, Zero “Lost communications” + BIG $$$$$$$
Conclusions so far:

As we are able to see from the examples given above, there are many levels-of, and multiple considerations related-to, making any communication system “Redundant”. We are also able to see that there is a blend of design calculation and common-sense required in order to maintain a balance between “Required Redundancy” and “Cost-Effectiveness”.

On a more granular scale, it seems clear that every communication system can benefit from good design practice that avoids any hard choke-points or that offers alternate modes of operation in the face of common or anticipated failures. It is also clear that almost no applications and solutions can reasonably, realistically or affordably reach 100% Redundancy and Fault-Tolerance. In fact, it may be impossible to actually achieve that 100% level, no matter how much money is spent.

That being said, there are certain elements [discussed below] that simply make good-sense as additions to any communication system. These elements generally help avoid choke-points through minimal expense and proper end-user training and incident recovery processes* (*this applies to support technicians and actual day-to-day users).

It is not possible to provide a list of technology elements and training modules that apply to each and every communication application out there. We can, however, begin by providing some guidance for designers, system managers, trainers and users in isolating and assessing risks and selecting and applying certain solutions.

To begin with, the designer or system manager will benefit from looking over their global systems and asking, “Are there any functional elements that provide a required performance feature present in this system without which the system(s) could not provide the minimum required performance for the end-users?” For instance – in our examples above, the Automatic Microphone Mixer was designed and configured to work in “Zones” in an effort to minimize unwanted general-background and user-induced noise and, therefore, provide better emphasis for the spoken words of only one or two people at one time. If, for the purpose of assessment, we determine that Zone operation is preferred but, in the event of failure in this component, we can operate and communicate perfectly well with just a little cooperation from an educated end-user base, then we do not have to spend the money to have a full failover backup unit to the Automatic Microphone Mixer. We, instead, merely need to assure that the signals that were being processed by the Mixer are sent to other components in the flow if the Mixer fails. In our 3rd Example above we achieved this with the Signal Splitter and Auto-Sensing Switch. These units together would probably cost less than half the price of a full second Automatic Microphone Mixer. HOWEVER – If we determine that the end-users cannot or will-not act in such a manner as to minimize noise and random chatter themselves, and if we further determine that the level of noise from the uncooperative end users will be so great as to regularly overwhelm the spoken words of an individual in the room, then we may determine that we must incur the additional higher expense of a full failover secondary Automatic Microphone Mixer and the programming necessary to make it come on-line
automatically and instantly in the event of the failure of the primary unit. This type of “what-if?” and “what is the negative impact of?” and “what are the chances of failure in xyz unit in the first place?” and “what type of user guidelines must be published-provided-delivered in order to enlist the end-user in helping to improve the quality of the communications and handle the anomalies that always occur?” must be made on a user-by-user, system-by-system and design-by-design basis, and these questions must be made within the context of the technology or component compliment and the level of ability, education and cooperation of the typical end-user of the systems, along with the “cost” of either full redundancy or the “cost” of the damage done if the systems fail and the end-users cannot accommodate a particular set of system malfunctions or anomalies. Quite frankly, the answers are different for every application and every user-community.

I may believe that asking people not to engage in noisy side conversations and not to constantly tap on a microphone surface with their papers or pens is a reasonable request, done in the interest of improving the communication experience for everyone and reducing the costs necessary for the communication in the first place. All that being said, others may say (and they have precisely said to me) that this is unreasonable - - it’s “too much to ask of end users”, and that the people they work with are “not able to learn to be quiet during a meeting and, besides, their colleagues can only function when everything around them in their professional and personal lives is 100% perfect” with no problems or challenges at any time in any way for any reason and when there are no guidelines that the user has to follow in order to work cooperatively with others in any endeavor. O.K.

Moving On: The assessments for cost-effective and reasonable levels of “Redundancy” must be made at every step along the way when deploying advanced communications, including visual video communications of all kinds. The constant “what-if” questions [examples given in the above paragraphs] should be raised during the conceptual phase, the design process, creation of the specification, the procurement and the installation of the systems. These questions and assessments must be made by the end-users, the technical system managers, the designers and the integration firm or firms who are engaged to implement the solutions. These questions must also be asked by the training and development person or group within the context of the known business process and the profile of the user community that will use the systems. Remember- this is a group effort. The “wisdom of the counsel of many” applies here, and all points of view should be sought-out and considered when looking for elements or layers of “brittleness” in a communication system. This is also a group effort in that the questions and the decisions must be shared with everyone so that each person or group is able to understand their own [and others] responsibility when operating and using the finished systems, and understand this BEFORE being required to individually contribute as the result of a malfunction or failure in the systems or processes. Additionally – Do everyone a favor and keep this process of evaluation, accommodation and selection within the realm of things that can be achieved in the known universe. Ultimately, common-sense must rule. Any failover or performance demand that is based-on things like “violating the space-time continuum” or “keeping a single technician awake and on-duty for 6 months straight with no food and no sleep” should be discarded immediately. There is no reason to agonize over the completely ridiculous.
For anyone who is interested in reviewing for or implementing Redundancy and Fault-Tolerance into their systems we would strongly recommend that the following guidelines become part of the review consideration for “Brittleness” and hardening of the systems and solutions.

Elements that may constitute dead-end alleys and choke-points and that may not allow for any recovery or repair in a useable & timely manner often will include:

a. Display Technology - This refers to the actual display devices. In the event that CRT, LCD or Plasma direct-view systems are used, these have known and documented high MTBF. There is little or no need to have a redundant unit as a hot-backup available as part of each system. That being said, a tracking mechanism must be used in order to determine when these devices may be reaching their end-of-useful life so that they can be placed on an upgrade or replacement cycle and removed from service before any actual malfunction occurs. In the event of the use of projection-style devices (LCD or DMD), there are lamps and lamp-filters for the fan cooling units that have predicted service requirements and known MTBF. Since these are more difficult to “drop into place” in many integrated designs, it may be necessary, in certain high-level and mission-critical spaces or applications, to have a hot-standby operating at all times while also tracking and cycling lamps and units and providing cleaning services on a regular basis.

b. Video processing technologies - This is a vast area. Suffice it to say that any processor that performs a necessary function (for instance - a “windowing” device that permits display of multiple images on a single display, without which the meeting flow would be dramatically diminished to [possibly] an unacceptable level) should have a hot-standby present in the system at all times or the system should be designed with patch-points and racking that allow for a replacement unit (stored on-site and immediately available for use) to be installed & configured in a matter of minutes in the event of failure in the primary. For any processors for which there is no “required function without which the meeting will fail entirely”, it is best to provide a sophisticated signal routing and distribution solution that enables automatic and immediate bypass of the malfunctioning unit or units so that the signals continue to flow to the remaining functional devices. This means a series of auto-switches, distribution amplifiers, video-equalizers and signal “scalers” [and other specialty video signal modification and adjustment devices] may be required to back-up a more sophisticated processor. This will also mean an increased cost in the cabling plant, and care must be taken to associate this cabling requirement with the available runways and conduits supplied from the Facilities group(s) or contractors.

c. Audio - It is possible to have a conference with audio and no video, but you cannot have it the other way around. Audio is not only the most important element, it is one of few required elements for human distant communications. Care should be taken to provide full failover for the audio processing components, and recovery mechanisms for alterations to those components through the controllers in the space(s). Additionally – these elements must be known-by and available-to a master control suite for the purpose of providing technical operators means to remotely adjust and manage the audio elements within one or more spaces engaged in a conference. Likewise- every effort must be made to take all audio adjustment functions out of the hands of the end-users, providing them only with the “Mute - Un-mute” functions for the purpose of altering the privacy at any
time during their calls. Levels of devices and systems should be set and stored in master files, able to be restored with a simple click of a mouse by a centralized operator using the management software tools. Likewise – the audio elements that are used within a space or application, even if that application is set-up in various locations on a temporary basis, **MUST** be dedicated to that space or application, not pulled from a general pool of technology components. This will help to avoid the manufacturing “plus-or-minus” performance spec. that is present in every equipment type or line.

d. **Control** - Master or Main Control frames generally have very long MTBF statistics. Failures related to the main control frames / central processors or the interface to those processors are generally associated with one of two (2) causes: 1. The interface panel or unit (touch-panel or button interface) fails and, 2. The Central-Frame / main-processor fails as a result of power fluctuations or complete temporary loss of power (even if for only a few milliseconds). It is strongly recommended here, for the Control portion and ALL processor point / units, that, in highly critical systems, there be two (2) active and fully operational touch-panel or button interfaces available, usually one for the end-users and one for the support technicians, as well as TCP/IP access into the control unit main processor frame. *(The power issue is discussed below)*. In addition, the complete system, as well as the individual components, should be specified and installed in such a manner as to be accessible through external network interface (PC via Ethernet, generally) for the purpose of individual TCP/IP interface and management of any one component and collective or individual management through a centralized management software system (the main management suite). Likewise, along with network connection and access, the unit or units should be loaded into the database of elements for the management software.

e. **Power** – Despite the unflagging belief by many who speak with me that there are “no real power issues within the physical plants for this company” [this is what I am often told], the fact of the matter is that we have entered a realm of not merely having to deal with potential full-loss of power, but full and careful conditioning of the power that remains present. The high-speed processors that are used throughout systems that are deployed for computing and communication derive their clock cycles from the power (60 cycles or 60Hz in this country). The higher the speed of the processor, the more devastating even the slightest fluctuation in the power that is supplied to that system. This is especially true for any high-speed video devices and any device that will be connected-to and communicate-across a LAN or WAN or telecommunication network enterprise. Drifts-in or mismatches-of various clock cycles as the signals propagate from one device and one network to another device and another network have devastating consequences on the integrity of the resultant signals. It is even possible to have completed network connections tear-apart for no apparent reasons in the face of the most minor power fluctuations. Care must be taken to provide any systems backup-and-conditioning for all power, and the power must be carefully phased in order to avoid introducing visual and auditory anomalies into the signals, since that will result in an unusable signal stream to the end-user.

f. **Network Connectivity and Interface** – These elements generally have quite long MTBF statistics, and, once “burned-in” over a 30-day period, can be expected to operate without failure for up to 8,000 hours commonly. That being said, these elements are required if a connection is to be made between one or more locations for the purpose of sending and receiving audio and video (discussed elsewhere above). Care should be taken
to isolate those very exceptional situations where a failure in the network interface and the encoder-decoder (codec), even if that failure could be recovered-from within a matter of only a few minutes, is unacceptable. In those exceptional cases, there must be a hot failover unit or unit(s) present in the integrated system, and the configuration should be such that if the first connection or encoder goes off-line, the second takes over immediately with no interruption. In those cases where a few minutes (less than 5) can be accommodated there must be great care taken to make certain that there are backup units available, that these units can be rapidly configured to fit that specifically integrated space or solution, and that the units can be deployed within the cabling structure in the rack or equipment area with complete ease. This will generally mean some additional planning and cost related to patch-panels, properly labeled secondary cables, distribution amplifiers and auto-sensing switches in order to minimize the down-time while the backup unit is put into place and energized, then “dialed” / connected into the meeting.

g. Processes – Careful data collection and entry must be done in order to understand the fallback elements that are immediately available, track the utilization of the individual and collective components, and allow for remote management and corrective actions to be taken in the face of any failures. Protocols (business process, security related, etc) must be re-visited to permit remote maintenance, control and call setup & tear-down without requiring the end-users to supply technical assistance or requiring a technician to be present in the room for every meeting that is being held. Regular testing, break-fix trial scenarios and constant professional development programs must be put in place and delivered to the technical groups and individuals who are responsible for operating and maintaining the technology systems on a day-to-day and event-to-event basis. Authority lines must be set and consistently applied to eliminate cross-over and under-cutting of the established professional processes by well-intentioned people who are not informed-of and skilled-in the broader process protocols and management of the technical systems.

h. Professional Development – This applies to the technical specialists that are responsible for daily operations AND to the end-users of these new technologies and systems. The technology specialists must continuously be brought up to speed on the technical and process elements for handling systems (INFOCOMM is a good place for this to happen), especially in the face of some element of system anomaly or failure. End-users MUST be trained in the effective use and reasonable expectation of these solutions. NOTE: Review of many call-logs and system anomalies sent in to CDG Inc. have shown that at least 30% of “technical problems” were related to the lack of understanding and cooperation on the part of the end-user community as they begin-to or continue-to-use these systems for visual communications. A program of synchronous live delivery and asynchronous self-paced delivery must be developed to aid in this effort, and the management of any organization must now and in the future continue to require people (everyone) to take advantage of these supportive development elements.

Final Conclusion: These steps, taken within the context of the guidelines listed in the section “Conclusions So Far…”, blended with support from management for the professional development of ALL of the professional staff members within an organization, will provide a cost effective and reasonable “minimally Brittle” set of solutions that can deliver reliable high quality audio and video communications, now and well into the future.

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