

PIDSC Remote Viewing Guidelines Document

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Preamble: The COVID-19 pandemic has created new realities with an increasing number of nuclear medicine physicians having to read remotely from their homes to comply with social distancing mandates. Several recent publications have described specifications and tips on how to set up viewing stations to allow reading from home (1, 2, 3, 4), but none of these focuses on nuclear medicine imaging. In this document, the Physics, Instrumentation, and Data Science Council (PIDSC) of the SNMMI provides guidelines on setting up a remote viewing station that is specific to nuclear medicine imaging. The intention of the document is to highlight components and specifications of a reading station that are necessary when setting up a remote viewing station for nuclear medicine imaging and is in response to a request from the SNMMI COVID-19 task force to that effect. This document expands upon previous guidance from SNMMI on remote nuclear medicine viewing (5).

General guidelines:

If you are reproducing a PACS station from work in your home office with identical equipment, then preferentially follow your work guidelines for which hardware to purchase. Alternatively, if you are making up your own remote viewing station with your own hardware, give consideration to the following:

Ergonomics: An ergonomic working environment is highly desirable for nuclear medicine reading stations. For example, chair and desk height, monitor height and adjustability, placement of the mouse, possible footrest should all be taken into consideration when creating a home working environment. Likewise, air circulation, temperature control and a quiet (few distractions) environment is essential to sustained comfort and alertness over prolonged working hours (4).

Computer Hardware: Required computer performance will depend on the applications to be run. Two alternative application configurations must be considered:

Thick client: The image visualization and analysis software are installed on your computer and the image data are transferred to it from the image archive server (e.g. PACS). In this configuration, your computer performs the image processing and rendering, and therefore requires more memory and processing power. Data transfer to your organization occurs only when downloading image data to review or when sending back secondary screen captures, reports, or other data. Patient sensitive data will reside locally and therefore your computer should be secured according to your hospital's policy, including hard-drive encryption, malware protection, and restrictions on applications that can be installed and websites that may be accessed. In some cases, your institutional information technology (IT) department or software vendor will require you to use computer hardware procured through them.

Thin client: The image processing and rendering is performed on a centralized server that your computer connects to using a special client (e.g. Citrix or Remote Desktop Protocol (RDP)). In this case, your computer only mirrors the image generated by the server and sends back keyboard and mouse commands. In this configuration, your computer requires relatively little processing power that even a mid-level modern laptop can provide. Network traffic is persistent throughout the viewing session requiring sufficient bandwidth and a stable connection. Patient sensitive data may not actually reside on your computer and therefore security requirements may be lax, even to the point where your personal home computer may be used.

Because a complete reporting workstation will require multiple software applications, both thin and thick client applications may reside on the computer. Regardless, a dedicated graphics card is recommended and may be required by some applications. The computer operating system may be dictated by applications that must run on the computer (e.g. viewer, electronic medical records, reporting software). It is recommended that you consult with both your institutional information technology department and software vendors for specific technical requirements prior to acquiring a computer. The computer specifications should match or exceed those posed by the most demanding application.

Security: Your hospital should provide secure access either via a cloud-based image viewing service, a virtual private network (VPN) to the hospital network, or RDP to your office PC. These may require installation of software on your home computer and authentication apps on your phone.

Ambient Light: To reduce eye strain and enable optimal image viewing, ambient lighting must be configured to eliminate glare and to allow the user to view the full grayscale range of the displayed images. The use of dimmable lighting reflecting off the wall behind the computer monitors is an effective, inexpensive and highly configurable solution, and might be considered. In a nuclear medicine reading room, ambient light should be just bright enough to read a small-text paper document (e.g. a newspaper).

Possible additional tests to be considered: Ambient light can be measured with a light reader and should be in the range of 25-50 lux in intensity (4). An android phone app has also been used to measure ambient light in radiology reading rooms (6) but has not been validated across all models of phones.

Monitor Size: The monitors must meet minimum pixel size and physical size requirements for the software you will be using. Use of multiple applications (for viewing patient charts, dictating, and image viewing) will likely require more than one monitor; 24-inch 1920x1200 or better monitors with color capability will likely be sufficient for most applications. This corresponds to 94.3 pixels per inch (0.269 mm dot pitch). Some users may prefer a higher pixel density, but it is unlikely to enhance nuclear medicine image interpretation. A single large monitor may be a substitute for multiple monitors. This has the advantage of alleviating the need to cross-calibrate monitors.

Commercial vs DICOM medical monitors: Most institutions use high-end consumer grade color monitors rather than medical grayscale DICOM monitors for reading of PET/CT, PET/MR and other nuclear medicine studies. Similar monitors may therefore be used at home, provided they meet grayscale display specifications and are calibrated (see below). Special consideration should be given if the at-home nuclear medicine physician is formally reading other modalities such as mammography, which has more stringent display requirements.

Display bit depth: If remote desktop is used, be sure the quality of the RDP connection display is set to the highest quality (32-bit) in the connection settings (see Figure 1). Use of lower bit depths may limit your grayscale to only 32 gray colors (or less). Such lower bit depths may speed access for word processing activities but are not adequate for nuclear medicine use. (Recent versions of RDP default to 32-bit depth, and some enterprise settings may force 32-bit depth regardless of user selections.)

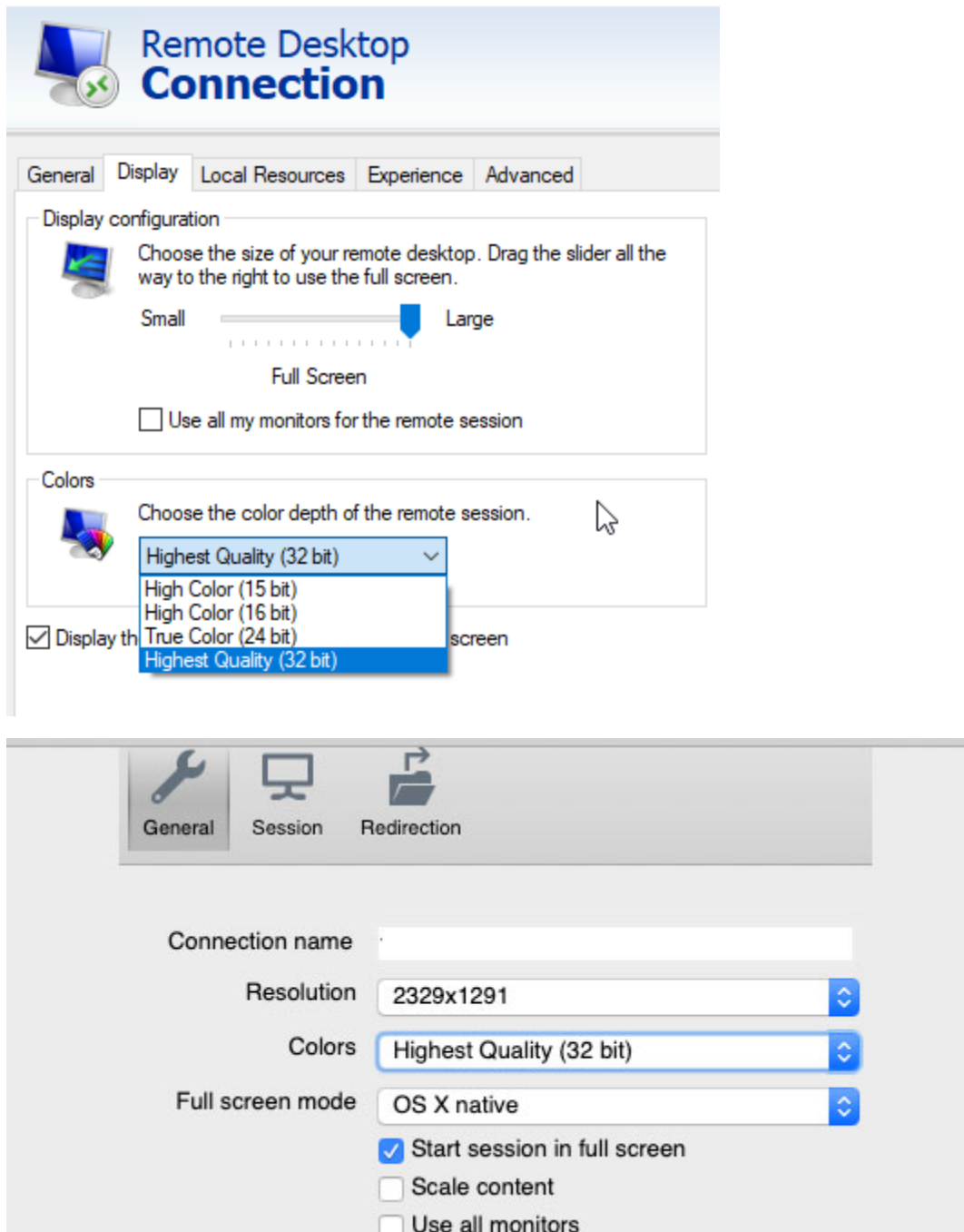


Figure 1 Choosing the color depth in RDP settings on a PC (top) and Mac (bottom).

Similarly, on your home computer the display quality should be set to the maximum number of colors. Modern operating systems and display cards now typically default to 32-bit depth and may no longer allow setting to lower (inadequate) bit depths. Bit depth can be visually assessed using the gray sphere test pattern at <http://gamma.wustl.edu/images/bwhtest.gif> (5). If you see a smooth gray range, you have the desired bit depth (see Figure 2). If you see circular bands in the gray sphere, you have an inadequate bit depth setting.

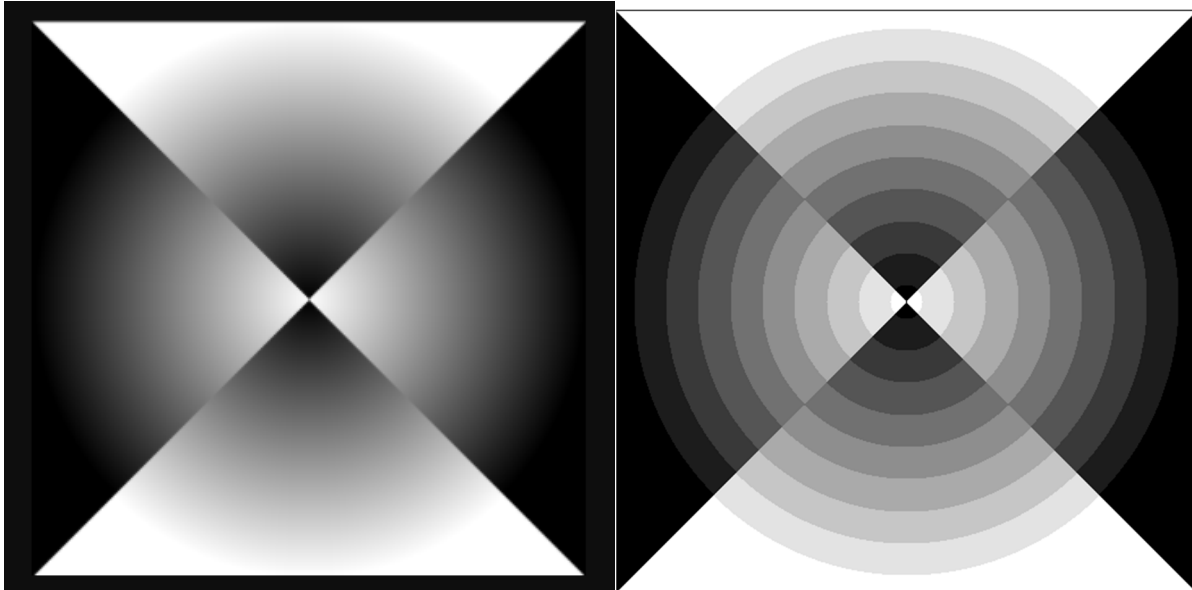


Figure 2. The left image was created with a smooth grayscale range, which should not have visible rings. The right image demonstrates the rings that might be seen if the display depth is not properly set. Test pattern courtesy of J. Anthony Parker, MD, Beth Israel Deaconess Medical Center, Boston Mass.

Display brightness/Luminance: on Reading Monitors: No strict guidelines for display brightness are available, but 300 cd/m^2 (nits) is regarded as reasonable minimum specification when purchasing a monitor. This level of brightness will allow enough excess range to permit for some dimming during monitor aging and adjustments during grayscale calibration. Equally (or more) important is the ability to darken the room in which the interpretation is being done, since these are inter-related.

Possible additional tests that should be considered: Display brightness should be at least 150 cd/m^2 (nits) after monitor calibration. These measurements can be done by dedicated light meter. It has been suggested that smart phone applications might be used for this purpose, but they have not been adequately validated against true light meters (7,8).

Grayscale range: The monitor should be able to be calibrated to display the small 5% and 95% boxes within the larger boxes of the SMPTE test pattern in the lighting conditions under which you will be reading (Figure 3). Multiple copies of this pattern are available on the internet (see table in Resource Section for SMPTE web links and a downloadable SMPTE DICOM image, as well as links to other test images). Calibration should be performed upon installation using the monitor brightness and contrast controls, and periodically at 6 to 12-month intervals or when major hardware and software components have been replaced or modified. If the monitor has a third “black level” control, this will greatly facilitate calibration and will make it much more likely that the monitor can be calibrated adequately (since some monitors cannot be adequately calibrated for nuclear medicine use). LCD monitors utilizing the IPS technology are more likely to display the full grayscale range compared to older/cheaper TN technology, and will also have better color stability at wide viewing angles. Other newer display technology may also be considered if it has the appropriate grayscale range, viewing angles, and color stability. Some nuclear medicine display software (e.g. MIM) has the ability to perform secondary calibration to further customize the

gray/color tables employed in the viewing program to match the monitor characteristics. If such capability is present, its use is recommended.

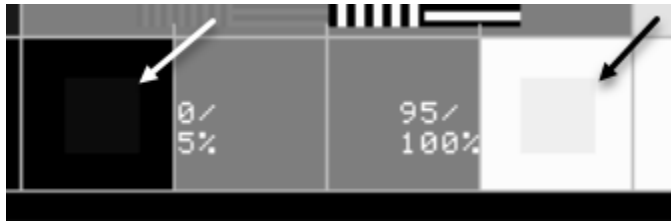


Figure 3. Reproduction of a small portion of the SMPTE pattern, with arrows indicating the small 5% and 95% boxes that should be visible after monitor calibration.

Resolution: Monitors should be set to their native resolution (typically, the highest resolution available in the monitor settings on your home computer). In Windows 10 this Display Resolution setting is located in your computer “Display Settings” under “Scale and Layout,” while on the Mac OS it is shown under “Display Preferences” (see Figure 4). Likewise, this should also be considered for RDP application settings (see Figure 1).

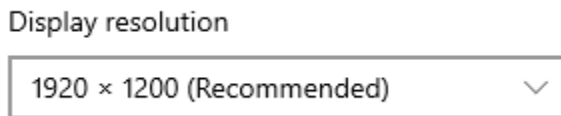


Figure 4 Windows (above) and Mac (below) settings for screen resolution, in each case set for the maximum available resolution setting for that monitor.

Color calibration: Consistent color between multiple monitors and over the life of the monitor is important for semi-quantitative interpretation of images. Full-screen uniform color images should be viewed simultaneously on all monitors for red, green, blue, and white, and visual evaluation of color consistency and uniformity should be performed periodically. Links to such color images are in the Resource Section).

Possible additional tests that should be considered: Color calibration can be achieved using a colorimeter which often comes with calibration software. The chromaticity coordinates of a white point can be measured for absolute color accuracy or for consistency between monitors.

Internet connection: A reasonably high-speed internet connection is desirable. At least 100 Mbps home connection is recommended, especially if large datasets need to be downloaded or rapid scrolling/video is used as part of interpretation. Connection speed to the internet can be assessed using publicly available tools (9,10,11). Note that the speed to the hospital over an encrypted network connection may be several-fold slower than that measured to public server over a non-encrypted connection. As an example, for a thin client viewer with a 2-monitor system using Citrix or RDP connectivity to a reliable end-to-end (home computer-to-server) transfer, download speed of >30 Mbps and latency <150 ms are recommended over the encrypted connection to the hospital, but specifications will depend on multiple factors and should be reviewed with the hospital IT and/or vendor. A wired (rather than WIFI) connection to your home router is strongly recommended. The connection quality is also important since a poor-quality connection may result in frequent drops in VPN access. Connection quality is difficult to assess, but some speed test sites (9) provide insight into the connection quality.

Image compression will likely be employed as part of a remote viewing solution. Lossless compression preserves full image quality, and can be used in radiology to speed image transmission by reducing file sizes by a factor of about 2-3-fold. Lossy compression results in yet smaller file sizes, but induces small irreversible changes to the image. Lossy compression of about 10-fold has been accepted for radiology use in many imaging settings (12). Limited data is available regarding standards for lossy compression of nuclear medicine imaging, but given the lower resolution of nuclear medicine compared to other imaging modalities, it is likely that standards for nuclear medicine will be no more stringent than other radiology fields.

If the user is reading images at home on a thin or thick client, it is likely that the compression will be handled by the viewing software, and should be identical to that used in the hospital setting. If the user is viewing a remote image by first connecting to a computer at the hospital and then launching the viewing program on that computer, it is possible that the remote connection (e.g., Citrix (13) or RDP (14)) may impose *additional* image compression. Because of the uncertainty of the effects of further compression, it is recommended that any additional compression be lossless in nature when possible. Future assessment of lossy image compression of nuclear medicine images may be useful to clarify its role in remote image viewing.

Possible additional tests that should be considered: The hospital IT department may be able to perform more accurate tests and monitor network performance over prolonged time intervals to diagnose connectivity issues, using tools such as that provided at <https://iperf.fr/>.

The SNMMI Physics, Instrumentation, and Data Science Council hopes these guidelines will facilitate creation of home interpretation stations for nuclear medicine. These guidelines are based on available literature and consensus of opinions rather than exhaustive tests by the Council; however, they do address a number of key issues for at-home nuclear medicine viewing.

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(13) Citrix compression is set by the server administrator. The ability to use lossless compression may depend on the Citrix version and the specific video cards, since compression/decompression may be offloaded to video cards for greater speed.

(14) When connecting to a centralized RDP server, the settings for compression and quality can be accessed under 'Group Policy\Computer\Windows Components\Remote Desktop Services\Remote Desktop Session Host\Remote Session Environment'. Any changes should be discussed with the hospital IT department. When connecting via RDP directly to a specific desktop PC client, the compression settings cannot usually be modified.

Resource Section – Under the PIDSC Webpage Resource Tab

	Web link to GIF or PNG	Downloadable DICOM image
SMPTE test pattern	http://gamma.wustl.edu/images/smpte.gif also available as first image of https://parker.bidmc.harvard.edu/TestPatterns.html	SMPTE DICOM Image
Gray Sphere test pattern	http://gamma.wustl.edu/images/bwhetest.gif also available as second image of https://parker.bidmc.harvard.edu/TestPatterns.html	BHW Test Pattern
RGB and White uniform images	Red Uniform Image Blue Uniform Image Green Uniform Image White Uniform Image	Red Uniform Dicom Image Blue Uniform Dicom Image Green Uniform Dicom Image White Uniform Dicom Image

Disclosure: These guidelines are designed to assist practitioners in providing appropriate care for patients. They are not inflexible rules or requirements of practice and are not intended, nor should they be used, to establish a legal standard of care. For these reasons and those set forth below, the SNMMI caution against the use of these guidelines in litigation in which the clinical decisions of a practitioner are called into question. The ultimate judgment regarding the propriety of any specific procedure or course of action must be made by the physician or medical physicist in light of all the circumstances presented. Thus, there is no implication that an approach differing from the guidelines, standing alone, is below the standard of care.