RFI NNA15544624L
Draft Statement of Work
Videography and Photography Services
NASA Ames Research Center
Moffett Field, CA 94035

1. Introduction/Background

The NASA Ames Video and Photo Groups provide primary responsibility for video production, photography, image archiving and audio-visual requirements at Ames Research Center. Currently located within Public Affairs, the groups also support the Director's Office, NASA Headquarters, external media requests, special events, as well as requirements for the entire Ames science and institutional community. The purpose of this procurement is to secure support for all types of video production, photography, image archiving, and audio-visual requirements as necessary.

Both groups are based on small core staff who work on-site at Ames full-time. Facilities and equipment are provided at Ames Research Center. The description below contains the main elements and functions required for daily tasks

1.1. Video:

Edit and mixing room based around a ProTools digital workstation. This room is typically used for narration recording, creating sound design, music production, mixing tracks, producing audio podcasts, supporting live interviews with radio stations and media outlets, including use of a dedicated ISDN line. The room also includes a telephone hybrid for incorporating phone line inputs. A separate VO room is used as a sound booth, typically for narration or radio interviews, and is located directly adjacent.

Field production is supported with 1/3" inch HD cameras, along with tripods, LCD field monitors, and portable lighting instruments using fluorescent, incandescent, or LED elements. In addition, two 10k HMI lights are available.

A small 20 x 30' studio room provides a permanent location for sound-bites, webcasts, product shots, and live shots to NASA TV and commercial broadcasters. Lighting is accomplished with fluorescent, incandescent, and LED instruments on stands because there is currently no ceiling grid. Multiple HD cameras, lenses, and accessories, including a teleprompter are available. The control room is based around a 10-input HDSDI switcher also capable of direct computer input for graphics. Audio mixing is routed through the Audio room, and delivered back to the control room for integration with video and transmission to external sources.

Field production is supported with 1/3" inch HD cameras, along with tripods, LCD field monitors, and portable lighting instruments shared with the studio mentioned above. In addition, two 10k HMI lights are available. A small 4-input HDSDI switcher is available for live multi-camera set-ups in the field.

A variety of scan converters and signal conversion units are available for use in any facility or in the field. Also available are several small hand-held radios for communication in the field.

Two Avid Media composer rooms are provided for virtually all editorial and post-production needs. Tape decks are provided for accessing and digitizing Beta-SP, Digital Beta, DVCAM, HDCAM, and DVCPro HD media. A separate room is set up as an archival digitizing station for the same tape formats.

A dedicated room is set aside as the equipment storage room. This room opens onto the building's rear loading dock for access to the government-provided van used to transport crew and equipment to other locations.

All the above rooms are adjacent to each other on the ground floor of the building.

Main auditorium: This 350+ seat facility has a dedicated PA system, including amplifiers and speakers and a 24-track mixer. Currently microphone inputs include a dedicated podium mic, plus 5 wireless lavaliers, and two hand-held microphones. A telephone hybrid is wired into the system as well. Distribution feeds are created here for media to a distribution box for live events. In the lobby area is a smaller system used for live Q & A input to other NASA Centers and NASA Headquarters for live press conferences over NASA TV. By June of 2015 an upgraded LED lighting stage lighting system will be in place, along with a new controller and numerous pre-set scenes for typical events that are easily called up by the operator.

A wireless PL system is available for use in any location as necessary.

1.2. Photo:

The dedicated Photo studio is 28' x 17'. It is equipped with multiple pull-down backgrounds in different colors. It is suitable for product shots and portraits. Studio flash equipment and small hot shoe flashes and accessories, including stands, are available.

A customer service area is provided for meetings with clients. A computer and large monitor allow the archivist and customers to review on-line imagery to make requests for copies, or for assembling a custom retirement album. No printing is done by the group.

Although all imagery is currently acquired digitally, a limited archive of negatives is stored in a room adjacent to the studio. In it are negatives, typically of 4 x 5, 35mm, or 2-1/4 formats, dating back to the late 1980s. A substantial collection of older imagery is stored at the local Federal Records Center, and is available to the archivist on an as-needs basis

Two scanners are provided, and together they support scanning negatives ranging from 35mm up to 8x 10 negatives.

The cameras provided are Nikon digital SLRs, equipped with a variety of zoom and fixed-focal length lenses and electronic flashes and battery packs. They are used both in the studio, and for photojournalistic coverage, as well as location portraits and science documentation in labs and test facilities.

Field lighting equipment is the same as that used in the studio.

Photoshop and Lightroom software are provided to the staff for image processing. Cumulus is the database software. PCDMagic is used for converting old ProPhotoCD files to modern formats.

All Photo work areas are located on the ground floor of the building, and are adjacent to one another, including an equipment storage room near the rear loading area. While the staff members may specialize in one area, each may be required to assist in other technical areas as needed. For example, the video editor may be able to operate a camera in the auditorium during a particular live event; the video writer/producer may operate the switcher during the same event. Or, the photographer may have to locate an image in the digital archive and send it to a customer.

2. Scope of Work

All work is divided between the Video and Photo groups who typically are organized under separate task orders. Audio-Visual work is performed by the Video group.

2.1. <u>Video</u>

Video provides day-to-day support to the Center and NASA Headquarters as needed.

The following areas will comprise the Core contract effort for video. The majority (approximately 85%-100%) of each employee's daily work for video staff will fall under these areas. Additional requirements for surge support will be described beginning in section 2.2.

2.1.1. Audio-Visual

- Basic video projection, sound reinforcement, and lighting for events primarily occurring in the N201 Main Auditorium, using the existing NASA-provided equipment for these functions. The contractor will be expected to monitor each function during events and adjust as necessary. Prior to presentations in the N201 Auditorium, customers may require assistance in transferring media files, such as PowerPoint, movies, audio, or still images to computers that feed the projector and sound system. Communication with the customer is required to establish adequate preparation time before all events.

- Provide assistance to customers in transferring media files, such as PowerPoint, movies, audio, or still images to computers that feed the projector and sound system. Communication with the customer is required to establish preparation time before all events.

- Set up small video projectors, screens, and/or public address systems in other locations besides the main auditorium.

- Determine technical requirements and supervise arrangements for projection, audio, and playback systems for events (indoor or outdoor) for audiences of several hundred to thousands. Includes working with NASA service groups (electrical, facilities, safety, etc.) to insure successful execution. Additional labor and equipment would be brought in under an ODC. (See section below)

- Attend on-site meetings and project reviews as necessary

2.1.2. Video/Multimedia

Generally produce video and multimedia products using existing broadcast production equipment. The contractor shall provide the following:

- Research and scripting for science-themed videos

- Single or multiple-camera location videography support, including use of portable lighting with multiple instruments in variable color temperatures, and adjustable scan rates to accommodate video displays as necessary.

- Direct electronic capture of video and computer displays

- Ad-hoc basic engineering troubleshooting as necessary with existing NASA equipment and transmission systems for all phases of broadcast production and post-production, including transmissions to NASA TV.

- Provide live single- or multiple-camera coverage of live events such as presentations, conferences and media events. Programs may also include graphics, video files, or audio inputs. Programs may originate **in other locations besides the main auditorium**, and thus requires transportation and set-up of all necessary equipment, as well as coordination with other Ames and NASA organizations for transmission and distribution.

- Digital, non-linear editing and post-production services including existing Media Composer and potentially other government-owned non-linear systems. Includes format conversions, adjustment and matching of video and audio signal parameters, use of text and graphics to create titles and interstitial and transition graphics. Follows standard ATSC guidelines.

- Transfer and reformat of video media between standard professional or consumer formats as necessary to meet archiving, transmission, or limited on-site duplication requirements.

- Limited quantity duplication of video media in small quantities, including simple labeling of media and cases and packaging.

- Single- or multiple-camera coverage of live events such as all-hands events, conferences and presentations in the main auditorium. Such events are often distributed inside Ames via analog and digital distribution by another organization working closely with the Ames Video Group. Programs may include presentation slides or video roll-ins.

- Produce 2-D electronic graphics for video. Elements typically include type, graphic shapes, photos, video windows, etc., and may move in the frame to provide visual interest and additional information layers in edited programs. Simpler graphics, typically including titles, slates, and lower-thirds (identifying name, title, affiliation of subjects who appear on screen) are used for live events.

- Digitize video, motion picture and audio clips for web sites, presentations and interactive media

2.1.3. Audio

The contractor shall provide the following:

- Studio recording support for narration or sound effects tracks.

- Location audio recording support for documentary-style video shoots

- Perform digital, non-linear editing and mixing using files from a variety of digital or analog sources using digital multi-track software synchronized to video playback.

- Create sound design for video and multimedia, including creating original recordings and drawing for existing libraries.

- Technical support and coordination for live audio interviews conducted over telephone or ISDN lines. Typically involves pre-event discussion with external media counterparts to confirm technical approaches.

- Technical audio support and coordination for simple webcast events (Skype, USTREAM, Google Hangout, etc.) involving inputs from microphones, telephone, ISDN, or web interfaces. Typically involves pre-event discussion with external media counterparts to confirm technical approaches.

- Technical audio support for live television events and presentations in the main Auditorium. May include inputs from multiple microphones, telephone interfaces, ISDN, or web, and requires simultaneous mixes for both in-house PA systems and video recordings and transmissions.

- Digitize video, motion picture and audio clips for web sites, presentations and interactive media

2.1.4. General Production Support

The contractor shall provide the following:

- General production planning, including reserving facilities and scheduling use of locations.

- Acquiring production releases as necessary for non-NASA individuals appearing in videos produced by the contract. Releases are approved by the Ames Legal Office in Code D.

- Documentation of, and full rights to, NASA for any media necessary for NASA productions, and obtained through outside organizations. This media typically includes stock footage, imagery, music, or sound effects. Specific language and formats for such documentation will be provided by NASA Ames or NASA Headquarters Office of Legal Counsel). Includes accurate files and record-keeping for NASA reference.

- Generate budgets and cost estimates as necessary; provide accurate budget and expenses tracking per project.

- Maintain and care for government-provided equipment; provide repair services as necessary.

- Plan and schedule productions using standard NASA-provided calendar software.

- Provide acquisition services to secure additional resources for any necessary video/multimedia labor and equipment as necessary, including staging, setting, rigging, lighting and electrical work for large or unique events.

- Provide services to meet NASA accessibility requirements (Section 508) for events or products.

2.1.5. Archiving Support

The contractor shall provide the following:

- Perform archiving and database management using provided data formats and terms specified in NASA STD 2882.
- Insure proper metadata is associated with media files, for both source files and finished products.
- Perform archive searches to locate specific camera original material, or finished masters.
- Digitizing of archival videotapes for preservation of content.
- Upload imagery and associated metadata to websites.
- Organize, label and store physical media assets, such as video tape, motion picture, audio tape, disks, drives, etc. on Ames premises.
- Digitize video, motion picture and audio clips for preservation.

2.2 Video Surge Support

Some events and requests require more than the typical support described above. In some cases these requests simply need more of the same type of support, resources, labor, equipment, or services used in daily work; other requirements may need more complex levels of support, and in some cases the additional support may be needed in a short amount of time.

The following areas will comprise the IDIQ portion of the contract requirements for Video. The work will comprise approximately 15% of each employee's daily work for video staff will fall under these areas. At times, additional personnel and support may be required as noted above.

2.2.1 Audio-Visual

- Secure projection, audio, and media playback systems for events (indoor or outdoor) for audiences of several hundred to thousands. Includes working with NASA service groups (electrical, facilities, safety, etc.) to insure successful execution. Such systems usually require additional labor for transportation, set-up, operation, and removal.

2.2.2 Video/Multimedia

- Single- or multiple-camera coverage of live NASA TV or web events such as news conferences and presentations. Programs typically include graphics, pre-produced roll-ins, satellite feeds, and audio inputs from multiple sources. Programs may originate in other locations besides the main auditorium, and thus require transportation and set-up of all necessary equipment, as well as coordination with other Ames organizations for transmission and distribution. While similar events may take place more routinely, the complexity of these higher-profile events require additional labor, equipment, and technical services, especially those being broadcast or recorded for NASA TV, or streamed live via the web.

- Arrange for microwave transmissions as necessary, including C-band and Ku-band, as well as other specialized methods.

- Specialized videography, including elements such as filtration, lighting, optical, and speed manipulation.

- Generate 2-D and 3-D computer-generated animation and graphics, including art direction and necessary technical support. Typical products may be needed to illustrate scientific concepts, or provide graphic representation of systems, organizations, or processes that cannot be done via video or still media elements.

- Multimedia scripting and authoring, primarily for authoring video disks.

2.2.3 Audio

- Audio engineering and support for live broadcast or webcast television events such as press conferences and presentations. These events may include inputs from multiple microphones, telephone interfaces, ISDN, or web, and requires simultaneous mixes for both in-house PA systems and video recordings and transmissions. Events with additional complexity may require additional labor, equipment, or services not available with existing in-house resources.

2.3 Photo

The Photo group provides daily support to Ames on a daily basis.

The following areas will comprise the Core contract effort for photo. The majority (approximately 85%-100%) of each employee's daily work for photo *staff will fall under these areas. Additional requirements for surge support will be described beginning in section 2.4.*

2.3.1 Photographic Support

The contractor shall provide the following:

- Capture images, under varying conditions of lighting, weather, and positioning, of a variety of test objects (e.g., aircraft, aircraft components, instrumentation, test rigs, laboratory set-ups, wind tunnel models, gun ranges, flight simulators, etc.) before, during, and after testing

- Documentation photography for special events, visits, and award ceremonies.

- Individual and group photos, either in studio or on location.

- Support aeronautical, biomedical and related programs in specialized situations that include aircraft-to-aircraft, aircraft-to-ground, and wind tunnel tests using ultraviolet lighting and/or laser sheet lighting to document the air flow around the model.

- Photograph accident scenes, Center facilities, construction activities, awards, portraits, news events, and other miscellaneous subjects

2.3.2 Archive Support –

- Identify, caption, record, code, file, and preserve photographic originals and captured digital images in accordance with NASA and Ames procedures, including NASA STD 2882. Includes identifying classified and proprietary material in accordance with the NASA and Ames criteria, and controlling access to such materials in the archive. This includes a tracking system for recording materials withdrawn from the files, such as NASA originals and duplicate negatives

- Establish and maintain protective handling procedures and controls to ensure correct identification of physical pictures (film), as well as proper filing, location and retrieval of images.

- Operate and maintain the photographic archive storage retrieval systems such as a database/content management system to allow for quick and efficient imagery location and retrieval.

- Arrange for sending and retrieving film products from the Federal

Records Center and the National Archives in Washington, DC. Establish and maintain appropriate procedures and records to document the transmittal of such material

- Help users search the storage retrieval systems to locate images of specified subject matter

- Assemble photographic print albums for special occasions, such as employee retirement.

2.3.3 Digital Archive Support – typical of daily work
The contractor shall provide the following:

- Maintain and operate the digital archive.

- Scan existing negatives into a standardized digital format

- Create and use an image classification system to describe and identify images according to subject matter, events, and other descriptors

- Digitize images written to transportable media and archive images

- Send digital archives to the National Archives for storage

2.3.4 Electronic Imaging Laboratory Support – typical of daily work

- Operate the image scanning station, which includes electronic scanners and electronic imaging workstations.

- Scan negative and positive images, ranging from 35mm to 8" x 10"

- Use computers equipped with programs such as Adobe Photoshop, Lightroom, Illustrator and Pagemaker, to color correct, retouch, assemble, edit, and create new images.

2.4 Photo Surge Support

Some events and requests require more than the typical support described above. In some cases these requests simply need more of the same type of support, resources, labor, equipment, or services used in daily work; other requirements may need more complex levels of support, and in some cases the additional support may be needed in a short amount of time.

The following areas will comprise the IDIQ portion of the contract requirements for Photo. The work will comprise approximately 15% of each *employee's daily work for video staff will fall under these areas. At times, additional personnel and support may be required as noted above.*

2.4.1 Photo

- Provide additional photography labor and equipment. Typically this would be primarily event photography, although a small amount of technical photography capability may be needed.

2.4.2 Archive

- Provide additional labor to archive and distribute still images, using the same software and equipment used in daily work. This work would specifically add imagery to on-line systems, databases, and NASA websites, as well as make copies distribute them via disks or email.

3 General Requirements

Both groups are based on small core staffs who work on-site at Ames full-time. Virtually all necessary equipment is supplied for the vast majority of daily work required. Should additional labor, equipment, or services be required, they are obtained through the contract on a per-project ("surge") basis as necessary.

Because of the dynamic environment within Ames, surge support may be needed with a short turnaround requirement—sometimes as little as 24 hours. The ability to provide **more** of the same type of resources and labor available at Ames, and/or **additional** needs beyond the group's on-site capability is critical, especially without delays that impact the success of the project's timelines.

Generally speaking, the video staff should have long-standing familiarity and experience with broadcast-quality High Definition video formats and production, post-production, duplication, and network-based transmission techniques. Experience in rapid and efficient production is important. Experience in working with broadcast network staff, especially in production and engineering is important to the group's success with NASA TV. Headquarters. They will be required at times to work successfully in science labs, test facilities, and onboard aircraft. These assignments will require skills and experience in manipulating camera controls, lighting, and audio techniques to suit Ames' and NASA's unique environments. At times they may be required to find ways of using equipment or techniques to solve production problems that are extremely unique to NASA's research activities. Some assignments will take place at remote locations that may include other states or foreign countries. All members must be free to travel to support assignments as necessary.

The photo staff should have long-standing familiarity with and professional experience in documenting tests in science labs, test facilities, and onboard aircraft. These assignments will require skills and experience in manipulating camera controls, and lighting to suit Ames' and NASA's unique environments. At times they may be required to find ways of using equipment or techniques to solve image acquisition or manipulation problems that are extremely unique to NASA's research activities. Some assignments will take place at remote locations that may include other states or foreign countries. All members must be free to travel to support assignments as necessary.

Generally, both group's staff members should be pro-active in caring for and managing the equipment and facilities, to keep them as ready as possible for upcoming projects. They should also be pro-active in keeping facilities, work areas, and storage areas clean and organized.

4 Technical Requirements

The pertinent technical documents are NASA STD 2818 and 2822, both provided separately as attachment A and attachment B to this Statement of Work.

5 Deliverables

Because the group primarily responds to incoming requests from around the Center, the chief deliverable is to provide staff and support on a daily basis who can produce the various end-products. Typical end products include:

5.1 Video

- Video News Files (source footage for news editors)
- Reporter packages (narrated, 2-minute stories)
- Source footage assemblies for NASA TV or commercial media (usually 5 minutes or less)
- Scripted communications videos (3 to 10 minutes) involving more sophisticated writing, production and editing techniques
- Live or live-to-tape multi-camera events for broadcast, including electronic insertion of slides, pre-edited video segments, and incoming video or audio feeds.
- Technical documentation of science activities.
- Accurate entry of metadata and additional background information
- Documentation for any media obtained through outside organizations. Specific language and formats for such documentation will be provided by NASA Ames or the Agency Office of Legal Counsel). Includes accurate files and record keeping for NASA reference.

5.2 Video

- Staff portraits (in studio or other work locations)
- Group photos
- Event documentation (VIP visits, award ceremonies, etc.)
- Technical documentation of science activities.
- Standard retirement albums
- Custom collections assembled and delivered digitally
- Accurate entry of metadata and additional background information

Schedules for delivering products varies considerably. Some may require same-day turnaround, others may have lead times of weeks or months. In every case, the direction for and specific information about each assignment is provided by the Task Requester in writing. In some cases requirements may change as work progresses, and the staff may have to make revisions as requested with the understanding that if such changes may affect the group's ability to deliver a finished production, that will be communicated to the Task Requester for discussion with the end client.

NOT MEASUREMENT SENSITIVE

National Aeronautics and
Space Administration

NASA-STD-2818
April 01, 2011

DIGITAL TELEVISION STANDARDS for NASA

Version 3.0

NASA TECHNICAL STANDARD

FOREWORD

This standard is approved for use by the National Aeronautics and Space Administration (NASA) Headquarters and all NASA Centers and is intended to provide a common framework for consistent practices across NASA programs. It was developed by the NASA Digital Television Working Group (DTVWG) and by the NASA Office of the Chief Information Officer, Architecture and Infrastructure Division, to assist the development and implementation of Digital Television (DTV) systems that support the Agency.

Since the 1980s, the technology and equipment used for the acquisition, contribution, production and distribution of television has been moving from the traditional world of analog signals, recording formats and signal processing into the digital realm. Digital video systems, starting with cameras and recorders for image acquisition, through systems for program contribution and production, to final signal distribution are now in use in most television facilities. The commencement of commercial terrestrial DTV broadcasting in October of 1998 signified the initial availability of end-to-end DTV capability in the United States. This culminated with the end of full power analog broadcasting in June of 2009.

The U.S. standard for terrestrial DTV broadcasting established by the Federal Communications Commission (FCC) is based on work recorded in document A/53 prepared by the Advanced Television Systems Committee (ATSC). In addition to specifying a method for broadcasting a digital representation of the traditional U.S. 525 line interlace scan television format, the ATSC A/53 document detailed many new television formats and variations for both Standard and High Definition Television (SDTV and HDTV). Although the FCC adopted most aspects of the ATSC recommendations when it established the standard for U.S. DTV broadcasting, it declined to specify the use of any particular picture format or formats. However, the formats listed in table 3 of the ATSC A/53 document are generally accepted in the television industry as the formats to be used for broadcasting. The result of this action has been that instead of just one format of television for all uses, there are now many different available types and levels of quality of DTV.

During the era of a single analog U.S. standard video signal format, American National Standards Institute (ANSI)/Society of motion Picture and television Engineers (SMPTE) 170M-1994, there has been no real need for NASA to develop Agency-wide television signal standards. The fact there were so many new and different picture formats and signal processing methods available demonstrated the reason for NASA to establish standards for DTV. These standards were needed so there may be common methods developed for the acquisition and production of DTV information and for the distribution and interchange of DTV signals and video products within, and external to, the Agency.

Requests for information, corrections, or additions to this standard should be directed to the NASA DTV Program Office, Marshall Space Flight Center (MSFC), Huntsville AL 35812. Requests for general information concerning standards should be sent to the NASA Technical Standards Program Office, Office of the Chief Engineer, NASA Headquarters, Washington DC 20546. This and other NASA standards may be viewed and downloaded from our NASA Standards Homepage: http://standards.nasa.gov.

Linda Y. Cureton
Chief Information Officer

REVISION HISTORY

Version 1.0: Original approved document, April 4, 2000.

Version 2.0: Update to include corrections and additional DTV guidelines, September 18, 2007.

Version 3.0: Update with additional DTV guidelines and quality parameters, April 1, 2011.

TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

TABLES

APPENDICES

DIGITAL TELEVISION STANDARDS FOR NASA

1. SCOPE AND APPLICABILITY

1.1 Scope. The DTV system standards described in this document are associated with those industrial or professional systems used to produce full motion and full resolution digital video imagery that is suitable for critical closed circuit or broadcast use and which is normally distributed over wide bandwidth communications systems designed for the transmission of television. It is not the intention of the DTVWG or of the Office of the Chief Information Officer to imply or endorse the use of any specific commercial vendor standards, designs or hardware.

For the purposes of this document, the uses for video acquisition, contribution, production and distribution within NASA are considered as falling into one of two broad categories: *Engineering* and *Publication*. *Engineering* video is defined as video imagery that is acquired primarily for the purpose of being used by NASA or other authorized personnel, either in real-time or post-event, to observe, analyze, or document a NASA technical or operational activity. Examples of *Engineering* video include imagery of space launch and space flight activities, flight vehicle tests, laboratory and facility testing, scientific experiments, and training. *Publication* video is defined as video imagery that is acquired primarily for the purpose of being integrated into live television segments or edited programs that are created for disseminating information concerning NASA activities within the agency and/or for release to the news media or the public. Examples of these programs include educational or training videos, televised briefings or press conferences, video-file material, live-shots and video coverage of other NASA events. Acquisition for *Publication* video often strives for high artistic as well as high technical imaging performance. It is also noted that *Publication* video programs may be produced partially or in their entirety using video imagery originally acquired for *Engineering* purposes. NASA organizations must carefully determine their requirements and then select and use appropriate equipment and systems which are compliant with this standard for satisfying their particular video imagery needs.

These DTV standards shall apply to all NASA Center systems infrastructure used to acquire, produce and distribute *Engineering* and *Publication* video. It is recognized that the specific analysis needs or unique constraints associated with certain flight, test or laboratory imaging could require the use of specialized imagery systems which may not precisely adhere to these DTV standards. If any programs or projects that use specialized systems require NASA Center DTV infrastructure services, they shall be required to convert their non-standard signals or products to meet the NASA DTV infrastructure standards at an interface point.

This document does not, at this time, discuss or provide standards for the implementation of digital video other than regular full motion and full resolution systems or which use other than wide band communications systems designed specifically for standard video transmission. This includes systems used for video surveillance, for very high speed imagery, for teleconferencing video or for the streaming distribution of live video or on-demand video segments to viewers over a computer intranet or the Internet. It is expected that future versions of this or other similar documents will address NASA standards for these other types of digital motion imagery.

1.2 Applicability. This standard recommends engineering practices for NASA programs and projects. It may be cited in contracts and program documents as a technical requirement or as a reference for guidance. Adherence to this standard and its provisions is the responsibility of program/project management and the performing organization. It is recognized that some specific circumstances, such as activities jointly pursued with a commercial or international partner, may involve or require the use of DTV equipment which varies from these standards. However, organizations are otherwise obliged to use systems which adhere to the guidance within this document unless there are specific functional or performance requirements of a particular DTV application, project or program which prohibit using these standards. Inquiries regarding exceptions to this standard should be directed to the NASA DTV Program Control Board. Information about requesting an exception is available from the DTV Working Group voting member at each center.

2. ACRONYMS AND DEFINITIONS

2.1 Acronyms

2.1.1	AES/EBU	Audio Engineering Society/European Broadcasting Union
2.1.2	ANSI	American National Standards Institute
2.1.3	ATSC	Advanced Television Systems Committee
2.1.4	AAC	Advanced Audio Coding
2.1.5	AVC	Advanced Video Coding
2.1.6	CCD	Charge Coupled Device
2.1.7	CODEC	EnCOder/DECoder or COmpression/DECompression
2.1.8	DCT	Discrete Cosine Transform
2.1.9	DTV	Digital Television
2.1.10	DTVWG	Digital Television Working Group
2.1.11	DVD	Digital Versatile Disk
2.1.12	FCC	Federal Communications Commission
2.1.13	GOP	Group Of Pictures
2.1.14	HDSDI	High Definition Serial Digital Interface
2.1.15	HDTV	High Definition Television
2.1.16	IEEE	Institute of Electrical and Electronic Engineers
2.1.17	ISO	International Organization for Standardization
2.1.18	MPEG	Moving Pictures Experts Group
2.1.19	NTSC	National Television Standards Committee
2.1.20	SDI	Serial Digital Interface
2.1.21	SDTV	Standard Definition Television
2.1.22	SMPTE	Society of Motion Picture and Television Engineers

2.2 Definitions.

2.2.1 Acquisition. The initial capture of video imagery.

2.2.2 Acquisition Equipment. Equipment used for the initial capture of video imagery. It can be Production Level quality, but in the case of High Definition Television (HDTV) field camcorders, it may have to compromise some aspects of image quality in order to have a one-piece camcorder configuration.

2.2.3 Contribution Level. A lower quality of video distribution between facilities but which is still acceptable for use for production or post-production.

2.2.4 Distribution Level. A lower quality of video distribution between facilities or from facilities to users acceptable for final user viewing, but not for production or post-production.

2.2.5 Engineering Video. A category of NASA video acquired primarily to observe, analyze, or document a technical or operational activity. Engineering Video is further divided into Critical and Non-Critical sub-categories.

2.2.6 HDTV (High Definition Television). Video with $\geq$ 720 active scan lines.

2.2.7 Interlace Scan. Video scanning method where each image frame is scanned in two parts or fields. One field consists of the odd numbered scan lines, the second of the even numbered scan lines. Sometimes referred to as 2:1 scanning.

2.2.8 Pixel. In digital television, the smallest element in the makeup of an image.

2.2.9 Production, Post-Production. Manipulation of images by switching, special effects, or editing to create a video program. Production is generally real-time creation for immediate release. Post-production is generally not real-time and is associated with editing for creation of recorded video programs.

2.2.10 Production Level. The highest quality of video used within a facility for live programming or for the manipulation of video imagery after acquisition (post-production)

2.2.11 Progressive Scan. Video scanning method where the each image frame is scanned in one continuous pass without dividing the frame into fields (see Interlace Scan). Sometimes referenced to as 1:1 scanning.

2.2.12 Publication Video. A category of NASA video acquired primarily for the purpose of disseminating information concerning activities within the agency or to the news media and the public. Publication Video is further divided into Critical, Non-Critical and Informal sub-categories.

2.2.13 Scan Line. Smallest vertical unit of a video picture, which runs horizontally across the screen. Pixels make up scan lines.

2.2.14 SDTV (Standard Definition Television). Video with <720 active scan lines. For U.S systems, this is 480 or 486 active scan lines.

2.2.15 Segmented Frame. Video scanning method where each image frame is initially scanned in one continuous pass (see Progressive Scan), but then divided into two fields for recording or transmission, one field consisting of the odd numbered scan lines, the second consisting of the even numbered lines.

2.2.16 Video Frame. Total scan lines that comprise a complete video picture. Analogous to a frame of film in a motion picture.

3. NASA DTV STANDARDS

This document establishes three major categories of NASA DTV standards:

- Acquisition and Production Picture Formats
- Video/Audio Signal Sampling Representation and Compression
- Interfaces

The DTVWG has engaged in considerable analysis, testing and debate regarding these areas and has arrived at the conclusions detailed in this section. Rationale for these choices is contained in the appendices to this document.

The Foreword of this document states that these NASA standards are needed so there may be common methods developed for the acquisition and production of DTV information and for the distribution and interchange of DTV signals and video products within, and external to, the agency. These standards are also intended to establish minimum levels for functional and quality performance characteristics considered acceptable for critical NASA video requirements. This position has been taken to help avoid the type of problems that have occurred in producing video products of historic events due to the use of lower quality recording formats such as VHS, 8mm and U-Matic to acquire NASA video in the past. Thus these standards provide guidance to NASA organizations for the selection of hardware and software to satisfy DTV requirements. DTV equipment and systems do exist in the marketplace which vary in functional capabilities and/or do not meet the performance specifications of these standards for critical applications. NASA organizations may be tempted to use equipment other than that which meets these standards due to its lower cost or because of other considerations such as the compact size or low weight of some available items. However, as stated earlier in section 1.2 Applicability, organizations are otherwise obliged to use systems which adhere to the guidance within this document unless there are specific functional or performance requirements of a particular DTV application, project or program which prohibit using these standards.

Several levels of these standards have been established related to the use of the NASA video being acquired. In section 1.1 of this document, the major categories of *Engineering* and *Publication* video were defined. These two categories can be further divided into *Critical, Non-Critical* and *Informal* video. These two categories are further divided into *Critical, Non-Critical* and for *Publication Video* only, *Informal* video sub categories. Systems used for *Critical* video acquisition normally require the highest technical imaging performance and thus require the highest standards. Some less critical video, which may include imagery not meant to capture important details or aspects of the activity or which is not intended for further elaborate post production use may have reduced image performance requirements. Less stringent technical standards can be applied to this *Non-Critical* sub-category. These lower standards can also allow the use of less expensive equipment to meet these less critical needs. For *Publication* video, a third sub-category, *Informal Publication Video*, can be defined. It is recognized that some video may be considered important documentation of a historic event or otherwise newsworthy, even though it may be of lower quality or may have been acquired using non-professional or non-traditional means including low cost consumer equipment, hand-held mobile devices or captured from the Internet. Thus *Informal Publication* video may not only have lower quality performance, but may also differ in basic picture format. Such *Informal* video is not considered adequate for any NASA *Engineering* application. The tables in this section list the standards for these different sub-categories where applicable.

The referenced applicable standards are published by organizations such as the American National Standards Institute (ANSI), the Audio Engineering Society/European Broadcasting Union (AES/EBU), the Institute of Electrical and Electronic Engineers (IEEE), and the Society of Motion Picture and Television Engineers (SMPTE). Moving Picture Experts Group (MPEG) standards are published by the International Organization for Standardization (ISO).

3.1 Acquisition and Production Picture Formats

The tables in this section list the DTV picture format standards selected for acquisition and production of standard and high definition television. Selection of a DTV picture format includes the selection of an individual frame size in horizontal and vertical pixels, the image aspect ratio, the scanning method used and the frame rate. For the acquisition of most high definition video, the NASA standard shall be 720 progressive (720P) at 59.94 frames per second. For the transfer of motion picture film based imagery material to high definition video or for the acquisition of selected *Publication* category video which specifically requires the highest static image resolution, an optional alternative to 720P is to use 1080 progressive or segmented frame at 23.98, 29.97 or 59.94 frames per second. For the acquisition of standard definition video, the NASA standard shall be 480 interlace at 29.97 frames per second. Acquired video used for *Informal Publication* may vary from these picture formats.

TABLE IA. High Definition Television Format

ACTIVE PICTURE PIXEL SIZE (H x V)	PICTURE ASPECT RATIO	SCANNING METHOD	FRAME RATE	APPLICABLE STANDARD
1280 X 720*	16:9	Progressive (1:1)	59.94 Hz	SMPTE 296M-2001

*Also acceptable for many applications are acquisition equipments or systems that process or record HDTV using fewer than 1280 horizontal luminance samples down to ¾ square pixel format (i.e. 960 pixels) using sub sampling, off-set pixels or similar techniques to reduce bandwidth requirements. The horizontal resolution of the camera or recorder output signal shall be scaled to a full 1280 pixels.
Note: For HDTV distributed for final viewing, terrestrial broadcast standards for 720P stipulate using 1280 horizontal pixels.

TABLE IB. Optional HDTV Format for Film Transfer and Special Publication

ACTIVE PICTURE PIXEL SIZE (H x V)	PICTURE ASPECT RATIO	SCANNING METHOD	FRAME RATE	APPLICABLE STANDARD
1920 X 1080**	16:9	Progressive (1:1) or Segmented Frame	23.98 Hz, 29.97 Hz or 59.94 Hz	SMPTE 274M-2003

**It is recommended that equipment or systems that process or record 1080P HDTV using fewer than 1920 horizontal luminance samples not be used for acquisition to maintain the highest quality of master video transfers from film.
Note: It is expected that video material acquired in this format would typically be transferred to another picture format for production or for final distribution.

TABLE II. Standard Definition Television Format

ACTIVE PICTURE PIXEL SIZE (H x V)	PICTURE ASPECT RATIO	SCANNING METHOD	FRAME RATE	APPLICABLE STANDARD
720 X 480/486 (Non-Square Pixel)	**4:3 or 16:9**	**Interlace (2:1)**	**29.97 Hz**	**ANSI/SMPTE 125M-1995 (4:3) ANSI/SMPTE 267M-1995 (16:9)**

Note: SDTV distributed for final viewing may also be encoded using fewer than 720 horizontal pixels (e.g. 704, 640, 544, 528, 480 or 352) to reduce bandwidth requirements, however terrestrial broadcast standards for 480I stipulate using 704 or 640 horizontal pixels.

3.2 Video/Audio Signal Sampling Representation and Compression

The tables in this section list the DTV standards for signal sampling representation and compression.

TABLE III. Video Signal Sampling Representation – HDTV and SDTV

FUNCTION	SIGNAL SAMPLING REPRESENTATION	WORD LENGTH
Acquisition for Critical Engineering or Publication	**Complete chroma information sampling on every video line. Signal representation may be 4:4:4, 4:2:2, 4:1:1, 3:1:1, etc. Luminance or chroma image sub-sampling or resolution filtering may be performed per the specific recording format**	**8 bit minimum**
Acquisition for Non-Critical Engineering or Publication and Informal Publication	**4:4:4, 4:2:2, 4:1:1 or 4:2:0. Luminance or chroma image sub-sampling or resolution filtering may be performed per the specific recording format**	**8 bit minimum**
Video Editing or Duplication Using 3:1:1, 4:1:1 or 4:2:0 Acquisition Formats	**Editing and duplication may be accomplished if transfers and manipulation of the recorded bit stream occur unaltered in a native (e.g. DV) or "dub" mode such that no decoding and re-encoding of the video signal is performed.**	**8 bit minimum**
Production and Postproduction	**4:4:4 or 4:2:2; No luminance or chroma image sub-sampling. No resolution filtering.**	**8 bit minimum**
Intra/Inter-Center and External Transfer for Critical Contribution	**4:2:2; No luminance or chroma image sub-sampling. No resolution filtering.**	**8 bit minimum**
Intra/Inter-Center and External Transfer for Non-Critical Contribution	**4:2:2 or 4:2:0**	**8 bit minimum**
Distribution for Viewing	**4:2:0**	**8 bit**
Archiving	**Use a production quality format for completed video programs. May use an acquisition format for unaltered original material or material "cuts only" edited from an acquisition format.**	**8 bit minimum**

TABLE IV. Video Compression – HDTV and SDTV

FUNCTION	COMPRESSION
Acquisition for Critical Engineering or Publication	Dependent upon the characteristics of the specific recording format and compression method used, but shall be intra-frame based. If using intra-frame 4:2:2 MPEG-2 or DV, shall use a video data rate of no less than 100 Mbps for HDTV and no less than 30 Mbps for SDTV. If using 4:1:1 DV shall use a video data rate of no less than 25 Mbps for SDTV. Also may use systems that employ other codecs at data rates which provide equal or better performance. See Annex VQ for further video quality recommendations.
Acquisition for Non-Critical Engineering or Publication and Informal Publication	Dependent upon the characteristics of the specific recording format and compression method used. May be intra-frame or GOP based, 4:2:2, or 4:2:0. See Annex VQ for further video quality recommendations.
Video Editing or Duplication Using 3:1:1, 4:1:1 or 4:2:0 Acquisition Formats	Editing and duplication may be accomplished if transfers and manipulation of the recorded bit stream occur unaltered in a native (e.g. DV) or "dub" mode such that no decoding and re-encoding of the video signal is performed.
Production and Post-Production	Uncompressed or intra-frame compression less than or equal to 5:1 if 4:2:2 MPEG-2 or DV. Also may use systems that employ other codecs at data rates which provide equal or better performance. See Annex VQ for further video quality recommendations.
Intra/Inter-Center and External Transfer for Critical Contribution	HDTV: If MPEG-2, 4:2:2 Profile @ High Level; GOP size less than or equal to 15 frames; video data rate greater than or equal to 30 Mbps. SDTV: If MPEG-2, 4:2:2 Profile @ Main Level; GOP size less than or equal to 15 frames; video data rate greater than or equal to 8 Mbps. Also may use systems that employ other codecs at data rates which provide equal or better performance. See Annex VQ for further video quality recommendations.
Intra/Inter-Center and External Transfer for Non-Critical Contribution	HDTV: If MPEG-2, 4:2:0 Profile @ High Level; GOP size less than or equal to 15 frames; video data rate greater than or equal to 24 Mbps. SDTV: If MPEG-2, 4:2:0 Profile @ Main Level; GOP size less than or equal to 15 frames; video data rate greater than or equal to 6 Mbps. Also may use systems that employ other codecs at data rates which provide equal or better performance. See Annex VQ for further video quality recommendations.
Distribution for Viewing	HDTV: If MPEG-2, Main Profile @ High Level; GOP size user defined; video data rate greater than or equal to 12 Mbps. If MPEG-4, High Profile@Level 4.1, GOP size user defined (typically 15 frame); video rate greater than or equal to 12 Mbps. SDTV: If MPEG-2, Main Profile @ Main Level; GOP size user defined; video data rate greater than or equal to 3 Mbps. (If sub-sampled) Also may use systems that employ other codecs at data rates which provide equal or better performance. See Annex VQ for further video quality recommendations.
Archiving	Use a production quality format for completed video programs. May use an original acquisition format for unaltered original material or material "cuts only" edited from an acquisition format.

TABLE V. Audio Signal Sampling Representation and Compression

FUNCTION	APPLICABLE STANDARD
Acquisition, Production, Post-Production and Archiving	**AES3, 48 KHz audio signal sampling or the native format of unaltered Acquisition material.**
Intra/Inter-Center and External Transfer for Critical Contribution	**MPEG-1 Layer 2 (ISO 11172-3) at a rate greater than or equal to 128 Kbps per channel or Advanced Audio Coding (AAC) (MPEG-2 Part 7 / MPEG-4 Part 3) at a rate greater than or equal to 96 Kbps per channel.**
Intra/Inter-Center and External Transfer for Non-Critical Contribution	**ATSC/Dolby AC-3 (Dolby Digital), MPEG-1 Layer 2 (ISO 11172-3) or AAC.**
Distribution for Viewing	**ATSC/Dolby AC-3 (Dolby Digital), MPEG-1 Layer 2 (ISO 11172-3) or AAC.**

3.3 Interfaces

Standardized data transfer interfaces need to be established for distribution of DTV within and between the NASA Centers and for the release of digital video to external NASA customers, the news media and the public. Interfaces are also needed for receiving digital video from flight vehicles such as the International Space Station (ISS) and the vehicles of future programs. The initial specification of signal interfaces for transmission applications are listed in the tables below. These define interfaces for the transfer of uncompressed or compressed DTV between a source and a destination or between a source and a transmission path. That path may involve an interface to a transport or network mechanism, such as with TCP/IP, or directly to a physical media, such as with a cable or fiber. Further specification of other interfaces will be developed appropriate to specific applications, based on the standards presented in the previous sections.

TABLE VI. Uncompressed Signal Transmission – HDTV and SDTV

FORMAT	INTERFACE DATA RATE	WORD LENGTH	APPLICABLE STANDARD
HDTV	**1483.5 Mbps**	**10 bit**	**SMPTE 292M-2004**
SDTV	**270/360 Mbps**	**10 bit**	**ANSI/SMPTE 259M-1997 Levels C & D**
HDTV and SDTV	**Up to 10.2 Gbps**	**8, 10 or 12 bit**	**High Definition Multimedia Interface (HDMI) V1.3 or higher**

TABLE VII. Compressed Signal Transmission – HDTV and SDTV

FORMAT	INTERFACE DATA RATE	WORD LENGTH	APPLICABLE STANDARD
HDTV and SDTV	**270 Mbps**	**8 bit minimum**	**Digital Video Broadcasting Asynchronous Serial Interface (DVB-ASI)**
HDTV and SDTV	**Varies**	**8 bit minimum**	**MPEG Transport Stream (MPEG-2 Part 1 / ISO 13818-1) for both MPEG-2 and MPEG-4 transmission**
SDTV	**100/200/400/800 Mbps**	**8 bit minimum**	**Institute of Electrical and Electronic Engineers (IEEE) 1394**

APPENDIX A

DISCUSSION OF PICTURE FORMATS

HDTV

In making the original choice of a HDTV picture format for NASA, several constraints were considered. One assumed constraint was that available equipment would typically not work to more than one format, so a single HDTV picture format standard would need to be chosen. Another constraint, given existing standards, was the need to be able to transfer signals using equipment that conformed to the SMPTE 292M-1996 High Definition Serial Digital Interface (HDSDI). Another desire was to assure compatibility with the broadcast television community by choosing from among the picture formats defined by the ATSC.

Since these original studies, some of these assumptions have been challenged. Equipment exists that can operate in more than one picture format standard. However, the transferring of imagery from one HDTV standard to another, while possible, may introduce image degradation or other problems. So it is still considered desirable to use one agency picture format standard for acquisition, contribution and production rather than having centers, projects, programs or organizations choose their own, and perhaps different, standards. Most professional equipment still uses the HDSDI interface, although the DVB-ASI interface can also be used for the transfer of compressed HDTV signals. Plus, in addition to normal terrestrial and satellite transmission methods, options for transferring contribution video now include real-time or non-real-time transmission as serial streams or as files over computer networks using the Internet Protocol. The desire for commonality with the broadcast television community cannot be completely fulfilled since that group does not use a single picture format standard. Another recognized factor is that broadcasters often acquire or produce video in one format and distribute to the public in another, particularly with scripted programs. So having an agency standard HDTV picture format in common with broadcasters is not possible for all cases.

As defined by the ATSC, HDTV has three major picture formats:1280 X 720 progressively scanned at 24, 30 or 60 frames per second (FPS) (720P@24/30/60);1920 X 1080 progressively scanned at 24 or 30 FPS (1080P@24/30); and 1920 X 1080 interlace scanned at 30 FPS (1080I@30). The last format is sometimes referred to as 1080I@60 by some in the video industry by referring to the *field* per second or vertical refresh rate of the image. Note that the frame rates may be even integer or slightly offset values such as 29.97 and 59.94 FPS to ease compatibility with the existing NTSC infrastructure. However the integer values are often listed for brevity even though the actual frame rate used may be an offset value. All standard HDTV formats use a square pixel representation and a 16:9 image aspect ratio. Interlace scan HDTV was first developed in the late 1970s. It was initially an analog method with 1125 total lines per frame of which 1035 were active image lines, although the number of active lines was later increased to 1080. The image is scanned using a two to one interlace method similar to the existing NTSC 525 line system. With this method, two fields, one for the even numbered lines and one for the odd lines, are sequentially scanned to capture each video frame. Since this method also displays the two fields in sequence, it provides an image refresh rate that is twice the actual frame rate. Some refer to this characteristic as a type of analog compression which was very useful during the era of picture tube displays. With the progressive method, each complete video frame is captured in one continuous scan. The display refresh rate using this method is normally the same as the frame rate. A variant of progressive scan is segmented frame, which initially scans the entire image but transfers the image in two segments similar to interlace fields. Although acquisition and production is done in several different formats, all HDTV broadcast distribution in the U.S. is done in either 720P@59.94 or 1080I@29.97.

A series of tests were conceived and conducted by the DTVWG to compare available interlace scan and progressive scan HDTV equipment. The 1080I@30 and 720P@60 formats were compared. A report on the results of these tests can be found on the NASA DTV web site (https://share.nasa.gov/teams/msfc/dvwg/default.aspx - Digital Television Working Group/Standards/Shared Documents) or can be obtained from the NASA DTV Project Office. The tests demonstrated comparable resolution and quality of the two formats when images were viewed in real time. Interlace video displayed some image artifacts that are introduced by the scanning method, but these are not significant for most general viewing. No similar artifacts appeared to be introduced by progressive scanning. However, when the video was captured and analyzed in still frame (and additionally in still field for interlace video), significant differences between the scanning methods became apparent. It was shown that interlace artifacts can alter the appearance of an object. It has been determined by research, and verified by equipment manufacturers, that the scanning characteristics of the Charge Coupled Device (CCD) image sensors used in higher quality interlace HDTV cameras cause considerable distortion of fine detail image material that appears 1-2 video lines (pixels) tall. Better quality progressive scan HDTV cameras also use CCD sensors, but the scanning characteristics of these devices are different. Similar image detail distortions do not occur when true progressive scan image sensors are used. Additional tests were performed to assess the results of transcoding from one format to the other. These tests showed that progressive scan source video transcodes to interlace without generating additional artifacts, but that artifacts existing in interlace scan source video carry over when transcoded to progressive. Both formats produced excellent results when down converted to 525 line interlace scan video. The artifacts associated with interlace scanning effectively negate some of the originally expected resolution advantage of 1080I@30 over 720P@60. The results of this testing plus knowledge gained from other research has proven to the DTVWG the general superiority of the progressive scan method over the traditional interlaced method for HDTV acquisition and production particularly for *Engineering* video requirements. It is also generally accepted within the television production and broadcast communities that progressive scan master recordings are superior for transcoding to all DTV formats. Thus, progressive scan HDTV was chosen by the DTVWG to ultimately be the NASA standard for acquisition. These tests were performed several years ago, but the method of scanning with CCD image sensors has not changed. The test results with CCD sensors are still valid. Complementary Metal Oxide Semiconductor (CMOS) sensors are fundamentally different from CCDs. CMOS sensors are becoming more common, especially in smaller format cameras. The scanning method used for CMOS sensors differs from CCDs to the point where many of the interlace artifacts from CCD scanning methods are not apparent, but will still have inter-field jitter for freeze frame applications.

The tests mentioned in the previous paragraph were performed in 1999. Although these tests were done some time ago, as of this writing, the method of scanning with CCD image sensors has not changed. The test results with CCD sensors are still considered valid. Complementary Metal Oxide Semiconductor (CMOS) sensors are fundamentally different from CCDs. CMOS sensors have become more common, especially in smaller format cameras. The scanning method used in CMOS sensors differs from CCDs such that many of the interlace artifacts from CCD scanning methods are no longer apparent in real time, but still display inter-field jitter when using freeze frame.

The DTVWG considered the use of the 1920 X 1080 progressive @ 60 FPS (1080P@60) format (thought to be the “Holy Grail” of HDTV). 1080P@60 is defined under SMPTE 274M but was not included as one of the initial ATSC standard distribution formats. The available equipment that supports this format is normally used only in very high end applications. Use of this format with current technology usually requires either the use of a form of mezzanine compression or use of a dual HDSDI link connection (SMPTE 372M) although the television industry has also worked to develop a serial digital interchange standard based on a data transfer rate of approximately 3 Gbps (SMPTE 424M). Since the use of 1080P@60 acquisition is not currently practical for most NASA applications (and budgets), it is not to be considered for the principal HD picture format standard at this time. The use of 1080P@60 is allowed as an optional format for selected applications. Broad use of 1080P@60 remains a goal when and if future developments allow the practical use of this format.

Some within NASA had originally suggested the initial use of 1080I@30 HDTV equipment and then to transition to a progressive format later. It was argued that, at that time, interlace equipment was already widely available, that 1080I provides much higher spatial resolution than existing NTSC and that the 60 Hz field rate provides high temporal resolution. This course of action was not recommended by the DTVWG because of the issues associated with interlace scanning artifacts, the demonstrated advantages of progressive scanning and of the problems and expense that could be associated with performing an additional format transition. The DTVWG recommended no further acquisition of interlace scan HDTV equipment and limiting the use of this format to that equipment which may have already been purchased within the agency. The DTVWG continues to recommend the use of a progressive scan HDTV acquisition standard. It is acknowledged that some projects and programs, specifically the Space Shuttle and the ISS, have continued to use 1080I equipment. This compromise to use 1080I on orbit was made due to the requirements of international partners, who also arranged for much of this acquisition and video signal processing equipment to be flight certified.

The task at hand was to choose a progressive scan format that, assuming a long-term goal of migrating to 1080P@60, may be considered an interim HDTV format. However, a consideration needed to be that this might also remain the permanent NASA HDTV format if 1080P@60 does not become a practical alternative in the future. The choice then appeared to be between 1080P@24/30, which favors higher spatial resolution, and 720P@60, which favors higher temporal resolution.

The DTVWG originally noted that few available HDTV displays had the resolution capability to be able to show a dramatic image difference between 1080P and 720P. That has changed as monitors of several display technologies capable of displaying 1080P have become more prevalent. Also noted is that some playback systems and displays convert 720P or 1080I input signals to 1080P for display, similar to how some standard definition DVD Video systems convert the 480I recordings and display 480P or 1080I. However, many HDTV camcorders and some broadcasters horizontally sub-sample the video, reducing any spatial resolution advantage of originating in 1080. Also noted is that 1080P@24/30 can exhibit substantial flicker if displayed in its native format, although newer high refresh rate monitors can mask this effect. More likely, 1080P@24/30 would often have to be converted to 1080I@30 for distribution or display, thus losing some of the benefit of progressive scanning.

The capability of the 720P@60 format to acquire 60 progressively scanned frames per second is a very important consideration. Many researchers and operational groups have expressed a preference for a high television frame rate, and as well for progressive scanning. 720P@60 provides double the temporal resolution of the 1080P@30 format. This attribute is very useful in that it allows this format to capture twice as much information about fast moving events. In commercial broadcasting, this format has shown an advantage in the coverage of high motion events such as sports. Since most HDTV monitors can now display 720P@60 in its native format, all of the temporal as well as spatial information captured by this format can be used.

The DTVWG studied some practical equipment considerations. As this document was originally being prepared, there were two sources of cameras and video recorders for 1080P@24/30. There were four manufacturers of 720P@60 cameras, and two of these made video recorders in the format. Available routing and distribution equipment could support either format. Some HDTV signal processing, test and production equipment could operate in 1080P@24/30 whereas nearly all such equipment could operate in 720P. With respect to choosing the 1080P@24/30 format, one manufacturer indicated there was a degree of backward compatibility to their existing formats afforded due to an ability to playback recordings of interlace scan SDTV and HDTV material on proposed 1080P@24/30 equipment. An opinion supporting this approach was expressed by some due to this proposed capability to play old tapes on newer equipment. Overall, the DTVWG did not consider this to be a significant factor due to the limited amount of NASA owned interlace scan HDTV equipment. Based on discussions with two major manufacturers of HDTV equipment, it was considered unlikely that future 1080P@60 equipment will provide any such backward compatibility. The DTVWG assumed that some degree of temporal and/or spatial transcoding would be required to convert any existing material to 1080P@60, regardless of which interim HDTV format was chosen. The DTVWG also believed it would more likely be desired to play any existing interlace scan recordings, either standard or high definition, on native format equipment and perform sophisticated motion compensated de-interlacing and any needed up conversion in a separate processor to more effectively transcode this material to a progressive scan high definition format for further production. The overall costs associated with the implementation of either the 720P or 1080P format were expected to be similar.

Another consideration was looking at which HDTV formats are being adopted by others. The International Telecommunications Union (ITU) has issued standards that establish both 1280 X 720 and 1920 X 1080 as common image formats. Some broadcast networks have chosen 1080I@30 as their broadcast distribution standard while others have chosen 720P@60. However, it should be noted that progressive formats such as 720p@24 and 1080P@24 are being commonly used as a video replacement for motion picture film for the acquisition and production for many episodic television productions which are subsequently distributed using 720P@60 or 1080I@30. No network has chosen 1080P as a broadcast standard although some high definition optical discs are recorded in a 1080P@24 format. Other US Government agencies, notably the Department of Defense, have standardized on 720P@60. Although there was no clear guidance derived from this particular study, any influence of this factor would seem to lead NASA to follow the choice of other US Government agencies.

It is the opinion of the DTVWG that the temporal resolution advantage of 720P@60 would generally be of more value for a broader range of NASA motion imagery acquisition applications than other HDTV formats. As an interim standard format, 720P@60 provides progressive scanning, the highest available frame rate and much higher spatial resolution than standard NTSC video. The DTVWG also considers 720P@60 to be a suitable permanent HDTV format if acquisition using 1080P@60 never becomes a practical and affordable reality. As a result, the DTVWG has selected 720P to be the initial NASA HDTV standard picture format for most new video acquisition. An offset frame rate of 59.94 Hz, rather than the integer rate of 60, has been chosen to facilitate real time down or up conversion to or from the legacy NTSC format.

Some special, selected DTV applications can take advantage of the additional spatial resolution of 1080P@24/30 where the lower frame rate of that format is not an issue. One of these is the transfer of motion picture film based material to video. Another is the acquisition of selected video material in the *Publication* category that strives for very high static image quality. For these specific uses, the 1080P format using a frame rate of either 23.98, 29.97 and also 59.94 as appropriate for the specific material, is an optional video acquisition alternative to 720P. However, using 1080 acquisition may not provide a significant improvement in many cases. Ongoing DTVWG tests of available cameras have indicated that effective results using 1080 acquisition requires the use of high end equipment with large (i.e. 2/3 inch) image sensors and high quality lenses in order to produce a readily visible improvement over 720P. With semi-professional and consumer equipment, often very little, if any, difference can be seen between 720P, 1080I and 1080P. In practical terms, the resolution of this lower cost gear, which typically uses smaller three chip or single chip imagers and low to medium quality lenses, looks more like very good quality standard definition than real high definition video.

Once video material has been acquired, further decisions are required about the format to be used for contribution, production and final distribution of the video. In most cases, contribution video should remain in the original acquisition picture format. This is also normally true for production and post production as well, although if productions use a mixture of progressive and interlace source material, it is sometimes preferred to produce in 1080I since many types of equipment used to transcode 1080I to a progressive format actually drop the resolution to 540P during the processing thus reducing the quality of the interlace video. The choice of a final distribution format may depend on the distribution media or method. In many cases, distribution in the normal broadcast picture format standards of 720P@60 or 1080I@30 is appropriate. In some circumstances, distribution in 720P or 1080P@24 or 30 may make more sense, such as if the final product is encoded as an MPEG-4, Windows Media or Quicktime file.

SDTV

The DTVWG acknowledges that traditional interlace scan, 525 line, 29.97 frame per second video will be a part of NASA imaging systems for many years to come. Although progressive scan video has been demonstrated to be superior, the continued use of the vast amount of existing equipment as a source of NASA video imagery cannot be excluded. In recent years, acquisition and production equipment has been commonly available which digitally represents this originally analog standard, typically using 720 X 480 active pixels. Note that this SDTV acquisition and production format differs slightly from any of the ATSC distribution formats in that it uses 720 pixels per horizontal line, rather than 704 or 640 (square pixel). This is not really a problem or a constraint, as the number of horizontal pixels would normally be resized as needed within a broadcast distribution encoder. Digital 525 line acquisition and production equipment usually conforms, or can be readily adapted to, the SMPTE 259M Serial Digital Interchange (SDI) Standard. There are many NASA video requirements that can continue to be adequately satisfied using this format. Thus the digital representation of traditional 525 line interlace scan video, 480I at a frame rate of 29.97 Hz, is to be the NASA SDTV standard picture format.

There are variations of SDTV standards which specify a 16:9 image aspect ratio instead of the normal 4:3. It is presumed that wide aspect SDTV would be useful for display on wide aspect monitors and could also be more suitable for up-conversion for use in HDTV production. An alternative method of generating 16:9 aspect video imagery using existing 4:3 aspect equipment is to use the “shoot and protect” technique. This means to shoot the video using the full standard 4:3 aspect ratio, but ensure that important portions of the image fall within a central 16:9 area of the frame. This ensures an up-conversion done by cropping the top and bottom of the frame will not lose important content. As an option to standard 4:3 aspect ratio equipment, the use of 16:9 capable SDTV systems, which use either an anamorphic squeeze technique or which black out upper and lower portions of a 4:3 frame, are allowed under this standard.

There are also standards for progressive scan SDTV, also known as Extended Definition Television (EDTV). This technique demonstrated superior performance to regular interlace scanning, however, only a small amount of progressive scan SDTV equipment has been available. The DTVWG concluded that adopting a progressive scan STDV standard may be a confusing and unneeded intermediate step between interlaced scan SDTV and the progressive scan HDTV standard. Thus, a progressive scan SDTV format was not included in this standard.

APPENDIX B

DISCUSSION OF VIDEO/AUDIO SIGNAL SAMPLING REPRESENTATION AND COMPRESSION

Video Signal Sampling Representation

There are many video signal sampling structures used to digitize video. These structures are used to reduce the amount of raw image data to be processed without severely affecting the image content. Generally, the chroma (color) information is not sampled at the same resolution as the luminance (black & white) portion of the picture. The human eye perceives most resolution from luminance information. This allows color information to be sub-sampled, compared to luminance, without an apparent loss of image detail. As image luminance information and information in the green color spectrum is almost equal, luminance can be used to derive the green information. Red and blue information is then often sub-sampled to reduce overall bandwidth requirements. There are sampling structures that perform full bandwidth sampling, but these are primarily used for very high end video, still or computer graphics imaging systems. This type of sampling is expressed as 4:4:4, indicating that within a 4 X 4 block of luminance pixels, there is also a 4 X 4 block of both red and blue. For production video systems, 4:2:2, with a 4 X 4 luminance sample and two 2 X 2 blocks of red and blue is the preferred standard. Acceptable acquisition formats for critical use sometimes use less than 4:2:2, but always perform complete color information sampling on every line of video. 4:1:1 and 3:1:1 are other common sampling structures for acquisition formats. 4:1:1 is used by SDTV systems such as DV, DVCAM, DVCPRO and Digital 8mm. The sampling structure used by the Sony HDCAM format is 3:1:1. The 4:1:1 and 3:1:1 formats provide a compromise between cost, complexity, resolution and bandwidth requirements for acquisition systems. The most important factor in sampling video for critical acquisition, contribution or production is to perform some sampling of all color signal information components on every scan line. This is necessary to have sufficient color information for further post production processing of the video. The 4:2:0 method samples the red or blue color components on every other video line. This method is used in consumer and lower quality industrial acquisition formats. It is also used for distribution to users including Blu-Ray, DVD Video, direct broadcast satellite, ATSC terrestrial broadcast and QAM cable TV transmissions. 4:2:0 sampling is generally considered acceptable for distribution of a finished product for user viewing, but not for the acquisition, contribution or production of video for *Critical Engineering* or *Publication* applications because of the limitations introduced by the reduction in color information. Although it is acknowledged that for certain acquisition requirements, such as airborne or spaceflight applications, the use of smaller and lighter equipment may be necessary. Typically, this type of equipment uses 4:2:0 sampling and/or long GOP compression and its use does result in a performance compromise.

Data word length refers to the number of bits used to represent the voltage level of a signal sample. In all cases, the minimum word length for NASA DTV systems shall be 8 bits. The formats of the SDI and HDSDI transmission standards allow use of word lengths up to 10 bits. Use of more than 8 bit words to represent a signal sample provides a higher fidelity video signal with a better signal to noise ratio. Equipment that uses a word length of 10 bits or more is highly recommended for production systems and may also be used for acquisition or contribution systems. Most available distribution systems and media use 8 bit words, which shall be the minimum NASA standard for the distribution of signals, programs and media for final viewing.

Video Signal Compression

Video compression is employed to enable the very high bit rate of uncompressed video to be reduced so that transmission or recording systems with limited bandwidth capabilities can be used or so many video signals can be fit within a given bandwidth. Compression for DTV uses multiple standards, depending upon the specific requirements and application. Unlike the compression normally used for data files, most digital video compression is lossy. A video signal that is compressed, transmitted, decompressed and then reconstructed is no longer identical to the original signal. Typically, the higher the amount of compression used results in a lower fidelity reconstructed video signal.

Many video compression systems in common use are based on the use of some form of Discrete Cosine Transform (DCT) encoding. Other available systems use wavelet or fractal based encoding. Current systems for compressing DTV operate at data rates that range from less than 12 to 360 Mbps for HDTV and from less than 3 to nearly 100 Mbps for SDTV. The compression format used by many types of signal distribution equipment is MPEG-2, which is also the standard codec used for digital broadcast, cable, satellite and DVD Video distribution. The DTV working group has tested various MPEG-2 equipment and has developed recommendations for the selection of parameters such as the composition of the Group of Pictures (GOP) and data rate. Other available equipment uses different compression formats including newer standard codecs such as H.264/MPEG-4 Part 10 Advanced Video Coding (AVC) and VC-1 plus some proprietary codecs. These newer codecs can provide similar performance to MPEG-2 at significantly lower bit rates, although there may also be an increase in encoder and decoder complexity and processing time. High definition optical disc formats can use several different codecs including MPEG-2 and AVC. Available equipment for acquisition, contribution and production use a variety of video compression techniques so attempting to establish specific agency standards for these systems is not really practical, although some guidelines for various quality levels have been developed based on testing and experience.

In order to maintain high quality, production systems must use higher data rates and low ratio, intra-frame compression on non sub-sampled or resolution filtered video. If using intra-frame 4:2:2 MPEG-2 or DV compression, production equipment should use a compression ratio of 5:1 or less. For acquisition systems, it is often necessary to use somewhat more compression than production equipment, but it is preferred to also use intra-frame compression to better capture temporal information because video can have significant changes from frame to frame that severely challenge inter-frame (GOP type) compression systems. Compression requirements for contribution video are less stringent than for acquisition or production. A HDTV signal compressed to about 30-45 Mbps using 4:2:2 MPEG-2 with a long GOP can be used as a contribution source, such as for media release or for input to production systems. This also represents a good range of target rates so that E-3 (34.368 Mbps) and T-3 (44.736 Mbps) long haul transmission services can be used. DTVWG tests have shown that low motion NASA SDTV can be compressed using 4:2:2 MPEG-2 with a long GOP to as low as 8 Mbps and still be used as a contribution source. Compressing a HDTV signal to 19.4 Mbps, or less, using the ATSC A/53 transmission standard results in a picture which is suitable for real-time viewing, but which has typically lost too much information to be usable as a contribution input for production. The compression of progressive source material has been shown to be more efficient than the compression of interlace material. Tests have shown that the viewing quality of 4:2:0 MPEG-2 compressed 720P can be adequate with average rates of 12 Mbps. Low motion, sub-sampled SDTV 4:2:0 MPEG-2 compressed to as low as 3 Mbps can still provide good viewing quality. However whenever possible, a data rate higher than these minimums should be used.

Video Recording Formats

Tape, disk and solid state formats can be used for recording DTV and there are multiple variations of each type available. Video tape recording formats are typically restricted by the signal sampling and compression designs of specific vendor equipment. For many years, video tape was the principal recording method used, however, more and more video recording is now being performed using other methods. Data tape, solid state and magnetic or optical disk based formats can be more flexible regarding signal sampling and compression choices, depending more on how the compressors are integrated to the system design. A vendor that packages a codec with his system may only offer support of certain compression schemes. Other vendors market their products as a general purpose recorder able to accept almost any data format.

There have been several professional digital video tape formats that supported recording HDTV. Some early reel-to-reel and large cassette formats are no longer available. As of this writing, there are still a few tape formats in use. Panasonic produces the HD-D5 format which was originally designed as a SMPTE 125/259M recorder for standard definition component serial digital video at 270 Mbps. With the addition of a codec and SMPTE 292M inputs and outputs, the D5 became a HDTV intra-frame recorder. There is no sub-sampling of luminance or chroma in HD-D5. Sony makes HDCAM, which is a 145 Mbps, 1080 line based HDTV recording system. HDCAM initially captures a 4:2:2 sampled picture at full 1920 X 1080 resolution and then performs sub-sampling. Horizontal resolution is reduced from 1920 to 1440 pixels in luminance and from 960 to 480 pixels in each of the color channels. The end result is a picture that is sampled at 3:1:1 based on a 1440 X 1080 picture. HDCAM-SR is a higher quality variant of this format that records 1080 video at full resolution. Panasonic has DVCPRO-HD, which uses ¼" tape and records at approximately 100 Mbps. It is capable of working in both interlace and progressive modes, although for 1080, the horizontal resolution is reduced from 1920 to 1280 pixels in luminance.

As SDTV became popular, several other video recording formats were introduced. These included tape formats such as DV, DVCAM, DVCPRO, DVCPRO-50, Digital-S, Digital Betacam, Betacam SX and MPEG-IMX. Other consumer formats which record directly to DVD-Video, hard disc drives or solid state memory also appeared. The most common signal interface for professional SDTV digital recorders is SMPTE 259M. There are other available interfaces, such as Institute of Electrical and Electronic Engineers (IEEE) 1394 (AKA Firewire and iLink). IEEE 1394 is primarily used as an interface between DV based acquisition/recording equipment and desktop computer based non-linear editors. IEEE 1394 cannot normally be routed over long distances which preclude its use as a primary interface for distribution.

Other professional acquisition formats are available that record using other than tape media. Some can also record either SDTV or HDTV. Sony has the XDCAM/XDCAM-HD format which records 480 or 1080 video on optical discs. The Panasonic P2 and Grass Valley Infinity formats record 480, 720 or 1080 video on solid state memory. The Ikegami Editcam uses a hard disc drive pack or solid state memory to record HD video.

As the development of DTV equipment has progressed, there have been lower cost HDTV acquisition systems developed and introduced for the consumer and industrial markets. These include the HDV and AVCHD camcorder formats which have been available in both interlace and progressive models. HDV is based on the DV tape format but uses the MPEG-2 codec to compress an HDTV signal to fit within the 25 Mbps recording capability of the DV tape. Tests were performed by the DTVWG on several higher grade HDV camcorders to gauge their performance. In general, the camera performance of these units was quite good, even though they used very small image sensors and lower cost lenses. However, the performance of the recording portion was not. The recordings showed considerable compression artifacts. The AVCHD format uses the AVC codec and also highly compresses an HDTV signal. AVCHD typically uses solid state, hard drive or optical disc recording. These HDV and AVCHD systems are not considered suitable acquisition formats for critical NASA HD requirements, principally because they use 4:2:0 signal sampling and also employ a very high amount of inter-frame video compression which causes visible image artifacts. It is tempting to use this equipment because of its compact size and relatively low cost, however, due to the color sampling limitations the use of equipment in these formats should be limited to non-critical applications. It is expected that the development of HDTV acquisition systems will continue and that other formats using AVC, VC-1, MJPEG-2000 or other codecs will appear.

There are a number of separate units which record using other media. Some record video directly to optical disc. There are also several recorders available which use hard discs drives and a variety of different codecs. Some fixed units are PC based and others are rack mount units. Compact units which use an IEEE 1394 interface can serve as a portable outboard recorder attached to DV based camcorders. Lower cost units typically use 4:2:0 sampling and a high amount of inter-frame compression resulting in distribution quality recordings at best. Other units have HD-SDI inputs and record a very high quality full resolution intra-frame 4:2:2 signal. Most of these intra-frame recorders are compliant with NASA Standard 2818 for Critical recording and can be used as a substitute for a high quality video tape recorder.

A primary issue with both SDTV and HDTV acquisition formats which use less than full resolution and other than 4:2:2 sampling such as DV, DVCAM, DVCPRO, HDCAM, HDV and AVCHD plus many hard drive, solid state and optical disc recorders, is the inability of these formats to withstand multiple decoding and re-encoding cycles without degrading the image. As discussed earlier, the process of encoding a video signal eliminates some of the original image information. The more an image is compressed, the more information becomes irretrievably lost. Performing successive decode and re-encode cycles, as is done when transferring a signal between devices that use compression, will result in picture degradation. If the production processing needed to fulfill a particular video requirement is limited to simple cuts-only editing and duplication, then using an acquisition format to produce a video product is acceptable. Studio versions of acquisition recorders have “dub” mode capability, which allows a bit-for-bit clone of the original material to be made when editing and duplicating. However, complex video production incorporating keying, animation, graphics and other effects often requires multiple cycles to and from tape, even when non-linear editing is employed. Manufacturer tests from Panasonic, and anecdotal information from Sony and Turner Entertainment indicates HDCAM and DVCPRO-HD begin to develop compression artifacts starting with the 5th decode/encode cycle. Testing by Turner Entertainment indicated that a HDTV recorder that does not sub-sample luminance and chroma and which keeps compression at 5:1 or less, showed no compression artifacts after 20 decode/encode cycles.

Several hard disc based recorders, including the P2 and Infinity solid state, XDCAM (SD) optical disc and Editcam hard disc formats meet or exceed the NASA standards for acquisition systems for ***Critical*** *Engineering* and *Publication* applications.

Available component digital video *tape* recording formats that also meet or exceed these standards include:

HDTV: HD-D5, D12 (DVCPRO-HD), HDCAM-SR (for 1080P only).

SDTV: Preferred 4:2:2 Systems: D1, D5, D10 (MPEG-IMX), Digital Betacam and DVCPRO-50. Allowed 4:1:1 Systems: Digital 8mm, DV, DVCAM, D7 (DVCPRO).

Of the available non-tape portable camcorders and recorders using disk drives or solid-state memory, these formats are known to meet or exceed NASA standards for acquisition systems for ***Critical*** *Engineering* and *Publication* HDTV applications: Grass Valley Infinity (disk or Compact Flash (CF) card); AJA KiPro and KiPro Mini; Convergent Designs Flash XDR and Nano-Flash CF card recorders; Panasonic P2 recorders and camcorders in AVC-I 100 Mbps; and Fast Forward Video Elite HD

Audio Signal Sampling and Compression

The digital audio production standard is AES3 (also called AES/EBU). AES3 defines a high fidelity uncompressed stereo audio signal with an approximate data rate of 3 Mbps. This is more than adequate for most normal agency use. However, there may be a requirement for six or more production audio channels. Since most video recorders can record no more than four audio channels, and most distribution infrastructures can distribute only two audio channels, a technique for adding additional production grade audio tracks to allow six or more channels of sound is needed. The Dolby E system is a popular solution available to accomplish this. One significant feature of Dolby E is that the interface to other equipment is at the normal AES3 level. Dolby E allows up to eight channels of audio to be compressed into an AES3 channel. Using AES3 as a common standard allows Dolby E or another similar system to be added without modification to existing digital audio systems.

One digital standard for audio that accompanies a long haul contribution video signal is MPEG-1 Layer 2 (ISO 11172-3). This compression method can incorporate digital audio input signals sampled at several rates, including 32, 44.1 and 48 KHz. Using this method, the audio data rate can be reduced significantly and still maintain quality suitable for production use. It has been demonstrated that 16 bit, 48 KHz sampled audio can be reduced to 128Kbps with no readily detected change from the original signal. Another newer standard is Advanced Audio Coding (AAC) (MPEG-2 Part 7 / MPEG-4 Part 3). This method is also very versatile. It can transmit excellent quality 16 bit, 48 KHz sampled audio at a data rate of 96 Kbps per channel.

The FCC standard for audio to accompany U.S. broadcast DTV is Dolby AC-3 (also called Dolby Digital). AC-3 provides the capability to transmit compressed digital mono, stereo or multi channel audio. AC-3 includes a system for multiplexing up to five full bandwidth audio channels and one reduced bandwidth low frequency effects (subwoofer) channel into a single digital signal. Called 5.1 channel audio, this encoded signal has been processed such that it is not possible to decode the sound into 6 discrete channels of sufficient fidelity for production. AC-3 processing takes advantage of psycho-acoustic characteristics of human hearing to reduce bandwidth. The result is that individual channels will often be missing large amounts of audio information, however, the lack of sound in one channel can be masked by sound on another.

APPENDIX C

DISCUSSION OF INTERFACES

Interfaces for DTV is an area within the video industry that continues to evolve. As this situation becomes more stable with the maturity of regular DTV program production and distribution, it may be necessary to update existing or to introduce new interface standards for NASA. Listed below are examples of the information needed to specify interfaces:

- Electronic Medium
  - Satellite
  - Terrestrial

- Recorded Medium
  - Video Tape Formats
  - Disc, Solid State or Other Media Formats

- Signal Characteristics
  - Physical Interface
  - Electrical Interface
  - Signal Protocol
  - Transmission Type
  - Transmission Protocol

There exist signal standards for the transfer of uncompressed DTV from one piece of equipment to another. SMPTE 292M-2004 is the High Definition Serial Digital Interface (HDSDI) standard for HDTV and uses a data transfer rate of approximately 1.5 Gbps. SMPTE 259M-1997 is the Serial Digital Interface (SDI) standard for SDTV and nominally transfers at a rate of 270 Mbps but can also be used at 360 Mbps. Another newer uncompressed DTV interface standard is the High Definition Multimedia Interface (HDMI). This standard, which continues to develop through several versions, is now used in most consumer equipment for connections such as from an optical disc player to a flat panel display.

There also exist standards for the transfer of compressed DTV between equipment. One of these is the Digital Video Broadcasting - Asynchronous Serial Interface (DVB-ASI) standard which defines a method for transferring compressed video over a standard 270 Mbps SMPTE 259M SDI interface. There is also the Institute of Electrical and Electronic Engineers (IEEE) 1394 (also called Firewire and iLink) interface standard which is often used to connect equipment that uses the DV or HDV standard. Another common protocol for transfer of compressed video as files or using a variety of communication schemes and rates is the MPEG Transport Stream (MPEG-2 Part 1 / ISO 13818-1).

Other interfaces for DTV systems internal to NASA will need to be defined for several areas. One of these is between systems for receiving from or for transmitting to spacecraft and systems that provide ground video distribution and processing services. As spacecraft develop DTV capabilities, those systems will need to provide interfaces compliant with the ground DTV system standards. This rule will also need to apply to other NASA program or project spacecraft, aircraft, test facility and laboratory video as well. If particular imaging requirements make the use of non-standard or unique video systems necessary, the signals generated by these systems will need to be converted in order for these projects to be able to use the video recording, production and distribution services provided by the standards based ground infrastructure. This includes services to support the distribution of information as required by the NASA Charter. Programs or projects that use non-standard video methods will probably also need to provide the equipment used to distribute, record and display that imagery in its native format.

Another internal area needing DTV interface definition is for the transfer of video between NASA Centers. While the responsibility for providing inter-center video distribution services belongs to the NASA Integrated Services Network (NISN), the technical specifications for the interface to these services will be defined by the DTVWG and used by all of NASA to assure a quality DTV interchange capability. The current inter center Multi Channel DTV capability plus some mission video support systems which transfer video packaged in the Internet Protocol as well as systems which use more traditional video transmission techniques have been configured with equipment that uses the standard DTV signal interfaces described above.

Definition of interfaces for the transfer of DTV external to NASA is also necessary. External interfaces include other government agencies, NASA partners such as CSA, ESA, JAXA and RSA, universities, industry and the news media. In many cases, this only requires informing those organizations in which picture format NASA DTV will be distributed and which signal transfer interface is to be used, but in others it may require negotiating specific signal conventions, formats or conversion responsibilities.

NASA Standard 2818 Annex AR

Interim Aspect Ratio Guidelines
For
NASA Video Acquisition and Television Production

The guidelines in this annex are provided for the acquisition of NASA video imagery and the production of NASA television programs both for engineering and publication use during the era of the transition in use from traditional 4:3 to wide screen 16:9 aspect ratio acquisition equipment and displays. The principle reason for this guidance is to assist NASA organizations to create new video products that can be viewed on either traditional or wide aspect displays without losing important image content.

1.0 Acquisition of New Video Imagery:

1.1 All new image material being acquired in a wide screen 16:9 aspect ratio, in either Standard Definition (SD) or High Definition (HD), should be "protected for 4:3" as much as practical. This means that placing important image content in the far left or right of the image should be avoided so that the vital information is retained if the image is later cropped to a traditional 4:3 aspect ratio.

1.2 All new image material being acquired in a traditional 4:3 aspect ratio using legacy Standard Definition equipment should be "protected for 16:9" as much as practical. This means that placing important image content in the very top or bottom of the image should be avoided so that the vital information is retained if the image is later cropped to a wide screen 16:9 aspect ratio.

2.0 Production of Television Programs:

Programs may be live productions or edited pieces intended for later playback using various media or distribution methods. Typically, programs are created in either SD using legacy capabilities or in HD where those capabilities exist. Programs, whether live or recorded, are also often up or down-converted to different picture formats for additional distribution.

2.1 Standard Definition Programs:

All SD programs should be produced in 4:3 aspect ratio.

2.1.1 The complete image of new or legacy 4:3 aspect SD source material is to be normally used as is.

2.1.2 Wide screen SD source material is to be cropped to 4:3 and, if necessary, trans-coded to the SD production picture format (such as from 480p to 480i).

2.1.3 Wide screen HD source material is to be cropped to 4:3 and down-converted to the SD production picture format.

2.1.4 Creation of high definition versions of a new or legacy 4:3 aspect ratio SD productions will normally be done by up-converting the image to the HD format and "pillar boxing" (adding side bars) to create a wide screen 16:9 aspect image. An alternative for previously "letter-boxed" SD material is to crop the image to 16:9 and then scale and up-convert to an HD picture format. This method avoids the "window-boxed" effect that occurs when up-converting "letter-boxed" SD material.

2.1.5 Internet and Mobile/Handheld format versions of new or legacy 4:3 aspect ratio SD programs can be created by down-converting the image to a required picture format resolution (such as 320H X 240V). If needed, wide screen versions can be created by either cropping or adding side bars to create a wide screen image and down-converting to the required resolution (such as 640H X 360V for Internet or 416H X 240V for ATSC M/H).

2.2 High Definition Programs:

All HD programs should be produced in 16:9 aspect ratio.

2.2.1 Traditional 4:3 aspect ratio source material should be either cropped to 16:9 or "pillar-boxed" (add side bars) to change the image aspect ratio to 16:9 plus scaled or up-converted as necessary to the specific HD production picture format.

2.2.2 Wide screen SD source material should be up-converted to the specific HD production picture format.

2.2.3 The complete image of HD source material is to be normally used as is or, if necessary, trans-coded to the specific HD production picture format (such as from 1080i to 720p).

2.2.4 Creation of SD 4:3 aspect ratio versions of an HD production can be done in two ways: One is by cropping the image to 4:3 and down-converting the program to SD. This method provides a full screen 4:3 aspect ratio image, but may result in the loss of important parts of the image if 4:3 protection was not done for the 16:9 source material. Alternatively, the HD program can be down converted to SD in a "letter-boxed" format with bars at the top and bottom of the 4:3 display. This method retains the complete original image, which may be important for some uses, but central image content will be displayed smaller and at a lower resolution than when a 4:3 crop method is used.

2.2.5 Internet and Mobile/Handheld format versions of HD productions can be created in a cropped 4:3 aspect ratio (such as 320H X 240V) or in a wide screen aspect ratio (such as 640H X 360V for Internet or 416H X 240V for ATSC M/H).

2.2.6 Overlay or stand alone graphics added to a wide screen production should be "protected for 4:3" so that the vital information is retained if the program is later cropped to a traditional 4:3 aspect ratio.

NASA Standard 2818 Annex VQ

Additional Video Quality Guidelines For NASA Video Signal Sampling Representation and Compression

The guidelines in this annex are intended to expand upon the material presented in Tables III and IV of NASA Standard 2818 to provide additional guidance concerning performance criteria for video signal sampling representation and compression used during the acquisition or for the transmission of NASA video imagery. The principle reason for this guidance is to provide better definition of minimum acceptable video quality to assist NASA organizations in the development or selection of equipment for the acquisition of video, for the transmission of video signals and for the production of television and video products.

1.0 Measurement of Video Quality:

The NASA Digital Television Working Group (DTVWG) has recognized the need to provide more direct, definitive and easy to understand standards, measures and guidelines for video quality for the various categories of video defined in NASA Standard 2818. This has been difficult to achieve because objective and repeatable measurement of video quality has typically required somewhat complex testing. Plus there are many characteristics and factors to consider that affect the quality of video. These include: the complexity and lighting of the scene being imaged; the characteristics and quality of the video camera lens and imager system; camera or lens motion; camera operating settings and technique; the quality of signal processing; the type and quality of video signal encoder and decoder; the quality of the display; etc. Due to these various factors, specifying minimum digital video quality is, unfortunately, not as easy as just specifying a particular minimum data rate when using a particular codec. The impact of these other factors must be considered.

It has often been observed that systems used for video compression or transcoding vary widely in performance. Also, the performance of a particular system will vary based on the image content being processed. A system may look perfect on one scene and have obvious artifacts on another, even though the data rate and other settings are the same.

In the past, performance assessments of video systems have been conducted by using panels of viewers who evaluated quality by making rigorous, disciplined observations. NASA Standard 2818 has indirectly specified quality performance by suggesting minimum bitrates when using particular video compression methods and sampling conventions. There now exist some sophisticated, albeit pricey, video quality test equipment which has helped this situation by providing semi-automated ways to make these measurements without the need for panels of human viewers. Two available video quality analysis systems are the Tektronix PQA and the Video Clarity Clearview. These systems can be very useful to gauge the quality of signal processing when encoding and subsequently decoding digital video for transmission or storage, or for when transcoding video from one format to another. Typical test methods involve use of a variety of standard scenes or sequences as an input which is compared with the output after processing. Some of the measurements generated employ picture quality algorithms which attempt to reproduce characteristics of human visual perception and observations by panels of viewers. These measurements include calculations that use the Differential Mean Opinion Score (DMOS) which models the results of observations of trained, expert viewers, and others based on the Sarnoff Just Noticeable Difference (JND) model, including the Tektronix Picture Quality Rating (PQR) and the Video Clarity JND, which simulate the results of observations by non-expert viewers. Another test method measures pixel to pixel and frame to frame changes that can be expressed as a Peak Signal to Noise Ratio (PSNR). These methods have been used to establish these additional guidelines for NASA video which are better indicators of quality than merely specifying sampling conventions, compression methods and data rates.

The DTVWG has developed test sequences representative of NASA video requirements that provide a range of complexity of material including imagery that is relatively easy to encode and decode and other scenes that are more challenging. Testing has been performed using three scenes. Two of the scenes are meant to exercise video systems with high detail (spatial resolution) and fast movement (temporal resolution). One of these scenes shows a fountain in a park setting and the other a waterfall. Both of these scenes are meant to challenge video compression systems to gauge their ability to handle more demanding requirements. Another scene shows two crew members during ingress to a NASA high-altitude research aircraft. This scene represents moderate spatial and temporal resolution and is representative of many typical NASA video documentation requirements. Copies of these test sequences can be obtained by contacting the DTV Project Office at the Marshall Space Flight Center.

In some cases, it is not possible to use reference sequences to test equipment. One example is if a camcorder being tested does not have a separate digital signal input. Another is where there is no external recorder that matches an internal camcorder recording format that can be used to record the test sequences. In these cases, a test method is to use a high quality, preferably uncompressed, external recorder connected to the camcorder via an uncompressed digital output port. Images of scenes similar to the normal test sequences are then shot and recorded on both the internal and high quality external recorders. The high quality recording is then ingested in the measurement system and becomes the reference sequence. The internal camcorder recording is also ingested in to the measurement system as the test recording. A comparison is then made to measure the performance of the internal recorder relative to the high quality external recorder. This method also allows a separate evaluation to be made of the performance of just the camera portion of the camcorder.

2.0 Video Quality Performance Criteria:

The following tables present quality performance criteria for the various categories and uses of NASA video. For each of the test sequences, minimum measurements for PQR/JND, DMOS and PSNR are provided. Although the tests used to develop these criteria were performed using 720P material, the results are also applicable to other picture formats.

Acquisition for Critical Engineering or Publication (These performance criteria represent the capabilities of 10 bit, 4:2:2, all I frame systems that do not subsample, such as AVC-Intra.)			
Scene	PQR/JND	DMOS	PSNR
Fountain	≤ 1.0 average	≤ 0.8 average	≥41.5 db average
Waterfall	≤ 0.8 average	≤ 0.7 average	≥40.5 db average
Crew Ingress	≤ 0.3 average	≤ 0.15 average	≥46 db average

Acquisition for Critical Engineering or Publication (These performance criteria represent the capabilities of 8 bit, 4:2:2, all I frame systems that also use horizontal sub sampling, such as DVCPRO-HD.)			
Scene	PQR/JND	DMOS	PSNR
Fountain	≤ 1.2 average	≤ 1.6 average	≥37.5 db average
Waterfall	≤ 1.6 average	≤ 2.6 average	≥36.5 db average
Crew Ingress	≤ 0.35 average	≤ 0.2 average	≥45 db average

Acquisition for Non-Critical Engineering or Publication (These performance criteria represent the capabilities of 8 bit, 4:2:0, long GOP systems, such as AVCHD.)			
Scene	PQR/JND	DMOS	PSNR
Fountain	≤ 2.0 average	≤ 4.2 average	≥37db average
Waterfall	≤ 3.4 average	≤ 13.7 average	≥31.0db average
Crew Ingress	≤ .95 average	≤ 1.0average	≥40.5 db average

Production and Post Production (These performance criteria represent the capabilities of intermediate compression system used in video editors, such as ProRes422HQ.)			
Scene	PQR/JND	DMOS	PSNR
Fountain	≤ 0.35 average	≤ 0.12 average	≥49db average
Waterfall	≤ 0.4 average	≤ 0.2 average	≥49db average
Crew Ingress	≤ 0.2 average	≤ 0.05 average	≥51.5 db average

Intra/Inter Center and External Transfer for Contribution of Critical Video (These criteria represent the desired performance using 4:2:2, long GOP encoders and decoders.)

Scene	PQR/JND	DMOS	PSNR
Fountain	≤ 0.35 average	≤ 0.12 average	≥49db average
Waterfall	≤ 0.4 average	≤ 0.2 average	≥49db average
Crew Ingress	≤ 0.2 average	≤ 0.05 average	≥51.5 db average

Intra/Inter Center and External Transfer for Contribution of Non-Critical Video (These criteria represent the desired performance using 4:2:0, long GOP encoders and decoders.)			
Scene	PQR/JND	DMOS	PSNR
Fountain	≤ 3.5 average	≤ 15 average	≥33.1db average
Waterfall	≤ 5.6 average	≤ 40.4 average	≥29.2db average
Crew Ingress	≤ 1 average	≤ 1.1 average	≥40.2 db average

Note-These measurements are directly from the one pass Adtec encoder tests done for the HDTV encoder shootout. To get a true picture, we would need to do an MPEG-4 encode at 12 Mbps video rate, then turn that around through another pass done at MPEG-2.

Distribution for Viewing (These criteria represent the desired performance using 4:2:0, long GOP encoders and decoders.) (Typical for 720P using MPEG2 at 12 Mbps.)			
Scene	PQR/JND	DMOS	PSNR
Fountain	≤ 3.5 average	≤ 15 average	≥33.1db average
Waterfall	≤ 5.6 average	≤ 40.4 average	≥29.2db average
Crew Ingress	≤ 1 average	≤ 1.1 average	≥40.2 db average

Note-Digital broadcast, cable and satellite television typically measures 3-5 PQR/JND for moderate and 5-9 for challenging material … indicating that current "broadcast quality" TV is significantly rate limited and actually not very good compared with typical as acquired video.

NASA TECHNICAL STANDARD	NASA-STD-2822
National Aeronautics and Space Administration Washington, DC 20546-0001	Approved: 09-03-2013

STILL AND MOTION IMAGERY METADATA STANDARD

MEASUREMENT SYSTEM IDENTIFICATION:
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FOREWORD

This Standard is published by the National Aeronautics and Space Administration (NASA) to provide uniform engineering and technical requirements for processes, procedures, practices, and methods that have been endorsed as standard for NASA programs and projects, including requirements for selection, application, and design criteria of an item.

This Standard is approved for use by NASA Headquarters and NASA Centers, including Component Facilities and Technical and Service Support Centers.

This Standard establishes a comprehensive guide for all image records produced by or for NASA and also defines applicable requirements for metadata as required by Federal law.

NASA has been managing and retaining image records from the late 1950s to the present. NASA and its affiliates, like all Federal agencies, has a requirement to provide for the safekeeping of records that document the Agency's mission and to transfer those records to the National Archive and Records Administration (NARA) based on record retention schedules developed between NASA and NARA.

The management and retention of NASA still and motion imagery collections have evolved over the years and are documented in paper log books, spreadsheets, and, most recently, in stand-alone computerized databases. The metadata or information about the imagery varies from catalog to catalog, depending on the needs of the personnel who are responsible for the custodial care of the image records.

This Standard has been developed by the NASA Metadata Working Group under direction of the NASA Imagery Experts Program (NIEP).

Requests for information, corrections, or additions to this Standard should be submitted via "Feedback" in the NASA Standards and Technical Assistance Resource Tool at https://standards.nasa.gov/.

Larry N. Sweet
NASA Chief Information Officer

Dec. 16, 2013
Date

TABLE OF CONTENTS

APPENDICES

LIST OF FIGURES

LIST OF TABLES

STILL AND MOTION IMAGERY METADATA STANDARD

1. SCOPE

This Standard establishes requirements and responsibilities related to metadata for the National Aeronautics and Space Administration (NASA) still and motion image records. It contains the required core metadata set and a recommended extended metadata set, along with guidelines to assist NASA organizations in complying with the Standard. The Standard does not address Section 508 compliance for image records.

1.1 Purpose

The purpose of this Standard is to establish a comprehensive guide for all image records produced by or for NASA

1.2 Applicability

Compliance with this Standard is mandatory for all NASA Centers and affiliates that support imagery tasks and for NASA projects and/or programs that manage and retain image records. The individual NASA Centers and affiliates are responsible for implementation and enforcement.

This Standard is applicable to all still and motion image records created by and/or acquired for NASA and its affiliates.

This Standard is approved for use by NASA Headquarters and NASA Centers, including Component Facilities and Technical and Service Support Centers, and may be cited in contract, program, and other Agency documents as a technical requirement. This Standard may also apply to the Jet Propulsion Laboratory or to other contractors, grant recipients, or parties to agreements only to the extent specified or referenced in their contracts, grants, or agreements.

Any decision to waive or vary from this Standard requires the concurrence of the NASA Imagery Experts Group, Configuration Control Board.

Requirements are numbered and indicated by the word "shall." Explanatory or guidance text is indicated in italics beginning in section 4.

1.3 Tailoring

Any decision to waive or vary from this Standard requires the concurrence of the NASA Imagery Experts Group, Configuration Control Board. Tailoring of this Standard for application to a specific program or project shall be formally documented as part of program or project requirements and approved by the Technical Authority.

1.4 General Guidance

This document establishes at minimum, the necessary metadata for image records and is intended to be the foundation for the management and retention of all NASA image records. The metadata Standard is compliant with Dublin Core® Metadata Initiative (DCMI) specifications. This Standard is subject to change upon revision of the laws governing Federal records retention.

These requirements apply to all NASA image records. All NASA Centers and facilities are responsible for keeping up to date with applicable Federal requirements.

For this Standard, an image record refers to all still and motion imagery, regardless of physical form or characteristics, made or received by NASA in connection with the transaction of business and retained or appropriate for retention by NASA as evidence of the organization, functions, policies, decisions, procedures, operations, or other activities of NASA or because of the informational value of data in them. (44 U.S.C Chapter 33, Disposal of Records). Refer to NPR 1441.1, NASA Records Retention Schedules, for clarification of the image record type and retention.

2. APPLICABLE DOCUMENTS

2.1 General

The documents listed in this section contain provisions that constitute requirements of this Standard as cited in the text.

2.1.1 The latest issuances of cited documents shall apply unless specific versions are designated.

2.1.2 Non-use of specific versions as designated shall be approved by the responsible Technical Authority.

The applicable documents are accessible via the NASA Standards and Technical Assistance Resource Tool at **https://standards.nasa.gov/** or may be obtained directly from the Standards Developing Organizations or other document distributors

2.2 Government Documents

Adopters of this Standard shall be familiar with information in these applicable documents. All internet sources were retrieved on November 21, 2013.

National Archives

44 U.S. C. Chapter 33, Disposal of Records
http://www.archives.gov/about/laws/disposal-of-records.html#def

NASA

NPR 1441.1	NASA Records Retention Schedules http://nodis3.gsfc.nasa.gov./displayDir.cfm?t=NPR&c=1441&s=1D

Office of the Federal Register

	Electronic Code of Federal Regulations, Title 36, Part 1237-Audiovisual, Cartographic, and Related Records Management http://www.ecfr.gov/cgi-bin/text-idx?c=ecfr&SID=9bba95f14e09c5fd79419f74efd282d6&rgn=div5&view=text&node=36:3.0.10.2.26&idno=36

2.3 Non-Government Documents

None.

2.4 Order of Precedence

This Standard establishes the requirements and responsibilities related to metadata for NASA still and motion image records but does not supersede or waive established Agency requirements found in other documentation.

2.4.1 Conflicts between this Standard and other requirements documents shall be resolved by the responsible Technical Authority.

3. ACRONYMS AND DEFINITIONS

3.1 Acronyms and Abbreviations

®	registered trademark
ARC	Ames Research Center
AVI	audio video Interleave
CCSDS	Consultative Committee for Space Data Systems
CMS	Content Management System
CMYK	cyan, magenta, yellow, black
DCMI	Dublin Core® Metadata Initiative
DFRC	Dryden Flight Research Center
DPX	digital picture exchange
EXIF	Exchangeable Image File Format
FL	Florida
GRC	Glenn Research Center

GISS	Goddard Institute of Space Studies
GFSC	Goddard Space Flight Center
ICC	International Code Council
ISO	International Organization for Standardization
ISS	International Space Station
IV&V	independent verification and validation
JPG	joint photographic expert group
JPL	Jet Propulsion Laboratory
JSC	Johnson Space Center
KSC	Kennedy Space Center
LRC	Langley Research Center
MAF	Michoud Assembly Facility
MIME	Multipurpose Internet Mail Extensions
MLP	Mobile Launch Platform
mm	millimeter
MOV	QuickTime movie
MSFC	Marshall Space Flight Center
MXF	material exchange format
NAI	NASA Astrobiology Institute
NARA	National Archive and Records Administration
NASA	National Aeronautics and Space Administration
NHQ	NASA Headquarters
NIEP	NASA Imagery Experts Program
NLSI	NASA Lunar Science Institute
NPD	NASA Policy Directive
NPR	NASA Procedural Requirements
NRRS	NASA Records Retention Schedules
OAIS	Open Archival Information System
OV	Orbiter Vehicle
SI	Système International
SMPTE	Society of Motion Picture & Television Engineers
SSC	Stennis Space Center
sRGB	standard red, green, blue
STS	Space Transportation System
STSCI	Space Telescope Science Institute
TIF	tagged image file (format)
TR	technical report
U.S.C.	United States Code
VAB	Vehicle Assembly Building
VIRIN	Visual Information Record Identification Number
WFF	Wallops Flight Facility
WSTF	White Sands Test Facility

3.2 Definitions

Camera RAW: Image file format of the uncompressed data acquired by a camera sensor.

Dublin Core® Metadata Initiative: A metadata element standard of generic resource descriptions that provides a set of rules for describing content.

Exchangeable Image File Format (EXIF): Metadata elements of descriptive information embedded in an image record by the device that acquired the content.

Internet Media Type: (also referred to as Multipurpose Internet Mail Extensions (MIME) type) An identifier for file formats that identifies the type and encoding of the data file.

Metadata: Structured information that describes, explains, locates, or otherwise makes it easier to retrieve, use, or manage an image record.

Metadata Element: A term used as part of a standard that describes content and provides structured information about an image record.

Material Exchange Format (MXF): Object-based file format that wraps video, audio, and other bitstreams optimized for content workflow and management.

Section 508: An Amendment to the Rehabilitation Act of 1973 that requires Federal agencies to make their electronic and information technology accessible to people with disabilities.

4. REQUIREMENTS

a. All organizations defined in section 1.2 in this Standard shall establish an implementation schedule for the metadata Standard for the management and retention of NASA image records.

b. This implementation schedule shall be completed and operational by January 2016.

c. All image records acquired before the January 2016 date shall have this Standard applied to them when the image record is converted, digitized, or transformed into a new image record.

(1) The original image record's metadata, descriptors, or naming identifications shall be retained in the new image record's metadata.

(2) All available information from the original image record shall be retained as part of the file's metadata.

For example, when a still negative from the Shuttle Program is scanned, the new image shall have this Standard applied. These requirements apply to a motion picture film that is scanned or a video tape that is digitized.

4.1 Core Metadata Set and Elements

All NASA image records shall include the core metadata set elements listed (and described) in Table 1, Core Metadata Elements.

The core metadata set is the minimum complement of required metadata elements for NASA image records necessary to meet National Archive and Records Administration (NARA) standards for Federal records retention (Electronic Code of Federal Regulations, Title 36, Part 1237- Audiovisual, Cartographic, and Related Records Management). The set is not intended to limit the amount of metadata for image records. Organizations responsible for the management and retention of NASA image records can use as many metadata elements as they elect, as long as the minimum core set is provided. For a list of the elements and examples see Appendix A in this Standard.

Table 1—Core Metadata Elements

Element	Description
Copyright	Information about rights held in and over the image record. The rights information includes a statement about the property rights associated with the image record, including intellectual property rights.
Creator	The entity primarily responsible for making the image record. A creator can be a person, an organization, or a service.
Date Taken	Point in time associated with the acquisition or origin of the image record.
Description	The explanation of the image record. It can include, but is not limited to, an abstract, a table of contents, a graphical representation, a free-text account, or a generic narrative of the image record.
Disposition	Instructions for the disposition of the image record in accordance with the NASA Records Retention Schedule.
File Format	The Internet Media Type or MIME file format, physical medium, or dimensions of the image record.
Image Record Identifier	The unique identifier associated with each image record. Section 5 in this Standard describes the naming convention for the image record identifier.
Location	Named place specified by its geographic position of the subject matter in the image. Where appropriate, named places or time periods can be used in preference to numeric identifiers such as sets of coordinates or date ranges. Latitude and longitude coordinates are not required.
Media Type	Describes the visual representation of the file. Identifies the image record as a moving or still image with a description such as 35-mm motion picture color film.
Title	Name given to the image record.
Use Restrictions	Information about who can access the image record or an indication of its security status. Can include information regarding access or restrictions based on privacy, security, or other policies.

4.2 Extended Metadata Set and Elements

The extended metadata set consists of recommended metadata elements that are not required for Federal records retention. The set does not encompass all of the possible elements that can be associated with image records but consists of additional elements that can help with the imagery workflow and provide assistance with the management and retention of image records.

EXIF metadata elements are considered optional. The EXIF elements are not listed here because they are defined by other standards and because the use of EXIF elements can vary by *manufacturer. Elements in both the core and extended sets, however, may be embedded into the image record through the use of customizable EXIF features by the device that acquires the image record.*

Table 2, Extended Metadata Elements, contains the element name and a brief description. All NASA image records may have these elements. For a list of the elements and examples, see Appendix B in this Standard.

Table 2—Extended Metadata Elements

Additional Identifiers	Supplementary identifiers for the image record.
Color Space.	The description of the range of colors, or gamut, that a camera can see, a printer can print, or a monitor can display
Creator Contact Information	All necessary information to contact the creator of the image record.
Creator Tool	The name of the first known tool used to create the image record.
Instructions	Any of a number of instructions from the provider or creator to the receiver of the item.
Keywords	An index of terms or subject classifications.
Language	Language of the image record.
Publisher	The entity responsible for making the image record available. A publisher can be a person, an organization, or a service.
Rights Statement	A web uniform resource locator for a statement of the ownership and usage rights for the image record.
Scene List	An inventory of the scenes that comprise the image record.
Script	Dialogue and instructions for a film or television program.
Source	Defines the specific content, i.e., still image or motion image footage, that makes up the image record. The image record can be derived from the source in whole or in part.
Total Runtime	The interval of time of a motion image or video from start to finish.

5. NAMING CONVENTION

One of the primary issues with managing imagery is being able to provide a unique identifier for each image record.

a. NASA imaging providers shall label all image records with a unique identifier.

The naming convention provides the means for each organization that creates and manages image records for NASA to assign a unique identifier for each image record.

b. When an image record is transferred between organizations, the image record identifier shall not be changed.

c. The NASA Center name shall be the first field.

Use the official acronym of the NASA Center or location. Examples are in section 5.1.1 in this Standard.

d. The second field shall be the date of the image record, written as either year or year/month/day.

See section 5.1.2 in this Standard for examples.

e. Organizations shall assign a unique identifiable sequential number using the options of a third or fourth field.

A media identifier and/or item number may be used in the creation of the image record identifier.

5.1 Naming Convention Fields

5.1.1 NASA Center

The Center location or affiliate site shall be where the image record was initially acquired, as listed below:

Ames Research Center	ARC
Dryden Flight Research Center	DFRC
Glenn Research Center	GRC
Goddard Institute of Space Studies	GISS
Goddard Space Flight Center	GSFC
Independent Verification and Validation (IV&V) Facility	IVV
Jet Propulsion Laboratory	JPL
Johnson Space Center	JSC
Kennedy Space Center	KSC
Langley Research Center	LRC
Marshall Space Flight Center	MSFC
Michoud Assembly Facility	MAF
NASA Astrobiology Institute	NAI
NASA Headquarters	NHQ
NASA Lunar Science Institute	NLSI
Space Telescope Science Institute	STSCI
Stennis Space Center	SSC
Wallops Flight Facility	WFF
White Sands Test Facility	WSTF

5.1.2 Date

a. The date the image record was acquired shall be written as year, e.g., 2013, or as year/month/day, e.g., 20130529.

b. When the image record file format is changed or is migrated to a new storage medium, the date shall not be changed.

5.1.3 Media Identifier

The media identifier, when used, should be a unique identifier assigned by the organization that created the image record. It may be a program, project, mission identifier, vehicle zone coordinate, creator's name, or a combination of these.

5.1.4 Item Number

The item number is a sequential number. The number should be a unique identifiable number for each image record.

5.2 Naming Convention Use

The naming convention provides options to the variety of organizations that acquire and manage NASA image records. The following examples are provided to assist with the naming of the image record. The examples in this section have been created with the data from current still and motion imagery content.

<u>*Glenn Research Center*</u>

A GRC example with data taken from a still image from GRC ImageNet is the use of NASA Center, date as year, and item number. The current naming of C-2012-192 would become GRC-2012-192 after the Standard is implemented.

GRC-2012-192

GRC-	*2012-*	*192*
Center Name	*Date*	*Item Number*

The image was taken at Glenn Research Center in the year 2012 with the 192 item number assigned.

<u>*Johnson Space Center*</u>

A JSC example with data taken from a still image on Imagery Online is the use of NASA Center, date as year, and item number. The current naming for JSC2012e226645 would become JSC-2012-e226645 after the Standard is implemented.

JSC-2012-e226645

JSC	*2012*	*e226645*
Center Name	*Date*	*Item Number*

The image was taken at Johnson Space Center in the year 2012 and is an electronic still image with the 226645 item number assigned.

An example for a motion image or video with data taken from Imagery Online is the use of NASA Center, date as year, media identifier, and item number. The current naming of iss035m020862317 would become JSC-2013-iss035-m020862317 after the Standard is implemented.

JSC-2013-iss035-m020862317

JSC-	*2013-*	*iss035-*	*m020862317*
Center Name	*Date*	*Media ID*	*Item Number*

The image was transmitted to JSC in the year 2013 from the International Space Station's (ISS') Expedition 35 crew. It is motion image with the 020862317 item number assigned.

<u>Kennedy Space Center</u>

The KSC example of a still image is the use of the NASA Center, date as year/month/day, along with the media identifier and item number for engineering imagery. The current naming for 133-OV103-810-01-20100909 would become KSC-20100909-133_OV103_810-01 after the Standard is implemented.

KSC-20100909-133_OV103_810-01

KSC-	*20100909-*	*133_OV103_810-*	*01*
Center Name	*Date*	*Media ID*	*Item Number*

The image was acquired at KSC on September 9, 2010. It was taken of STS-133 Shuttle Discovery's (OV-103's) nose panel (Orbiter zone 810), and it is image number 1 of the area.

On the same day, a Public Affairs photographer took images of the Orbiter mate. The naming convention used was the NASA Center, date as year, and the item number.

KSC-2010-5246

KSC-	*2010-*	*5246*
Center Name	*Date*	*Item Number*

The image was taken at KSC in the year 2010 and was the 5,246 image released by KSC Public Affairs that year.

APPENDIX A

CORE SET TABLE

A.1 Purpose and/or Scope

The purpose of this appendix is to provide guidance in the form of Table 3, Core Set Table.

A.2 Core Set Table

Table 3—Core Set Table

Element Name	Example	DCMI
Copyright	No copyright protection is asserted for this photograph.	dcterms:rightsHolder
Creator	NASA/KSC/Adam Baum, Ames Video Production Group	dc:creator
Date Taken	07/01/2008	dc:date
Description	Space Shuttle Atlantis, atop the mobile launcher platform, rolls back into high bay 1 of the Vehicle Assembly Building from Launch Pad 39A.	dc:description
Disposition	Permanent. Cut-off records at close of program/project or in 3-year blocks for long-term programs/projects. Transfer to records center storage.	dcterms:provenance
File Format	RAW, JPG, TIF, MOV, AVI, DPX, Other	dc:format
Image Record Identifier	GRC-2012-192, JSC-2012-e226645, JSC-2013-iss035-m020862317, KSC-20100909-133_OV103_810-01, KSC-2010-5246	dc:identifier
Location	Vehicle Assembly Building, KSC, FL	dc:coverage
Media Type	Digital still image, Digital motion image, 35-mm motion picture film	dc:type
Title	STS-117 Space Shuttle Atlantis roll back.	dc:title
Use Restrictions	Restricted NASA internal use only; Restricted pending review; Released to public	dc:rights

APPENDIX B

EXTENDED SET TABLE

B.1 Purpose and/or Scope

The purpose of this appendix is to provide guidance in the form of Table 4, Extended Set Table.

B.2 Extended Set Table

Table 4—Extended Set Table

Element Name	Examples	DCMI
Additional ID	KSC-07PD-2045, iss031e065030	dcterms:isVersionOf
Color Space	Adobe 1998, sRGB, CMYK	dcterms:isFormatOf
Creator Contact Information	NASA Headquarters, 300 E Street SW, Washington, DC 20024-3210	dc:contributor
Creator Tool	Adobe Photoshop, Apple FinalCut Pro	dcterms:accrualMethod
Instructions	Use embedded ICC Profile when printing.	dcterms:instructionalMethod
Keywords	STS-117, Shuttle, Atlantis, VAB, MLP	dc:subject
Language	English, Spanish, French, Chinese	dc:language
Publisher	Published by NASA	dc:publisher
Rights Statement	Using NASA Imagery and Linking to NASA Web Site	dcterms:accessRights
Scene List	STS-133 launch from pad surface, STS-134 launch from VAB roof	dcterms:isReferencedBy
Script	Link to content	(Link to content)
Source	Betacam tape number 1990-008, digital still image file number KSC-2011-1756	dc:source
Total Runtime	01:20:41, 1 hour: 20 minutes: 41 seconds	dcterm:PeriodOfTime

APPENDIX C

BEST PRACTICE GUIDELINES

C.1 Purpose and/or Scope

The purpose of this appendix is to provide guidance in the form of best practice guidelines.

C.2 Best Practice Guidelines

The best practice guidelines presented demonstrate how metadata should be integrated into the image workflow or lifecycle. The guidelines are not included here as procedures but are intended as examples to help organizations managing NASA image records to comply with the metadata Standard and Federal Record Retention Schedule.

To make the process effective, it is best to look at how the metadata should be associated with or embedded in the image record during the lifecycle of the content. Having the metadata process built into the imagery lifecycle provides an efficient means to manage and retain image records.

The process of acquiring metadata starts when the customer requests a service at the beginning of the image lifecycle (figure 1, Image Lifecycle). The who, what, why, when, and where of the task from the customer requirements, along with the metadata created when the imagery is acquired, has to be ingested with the image record. During the processing, the metadata is verified before the imagery is distributed and entered into a Content Management System (CMS). With the imagery and metadata entered into a CMS, it can be made available for use by the entire NASA community. Image records are managed for future projects and retained in accordance with NPR 1441.1, NASA Records Retention Schedules.

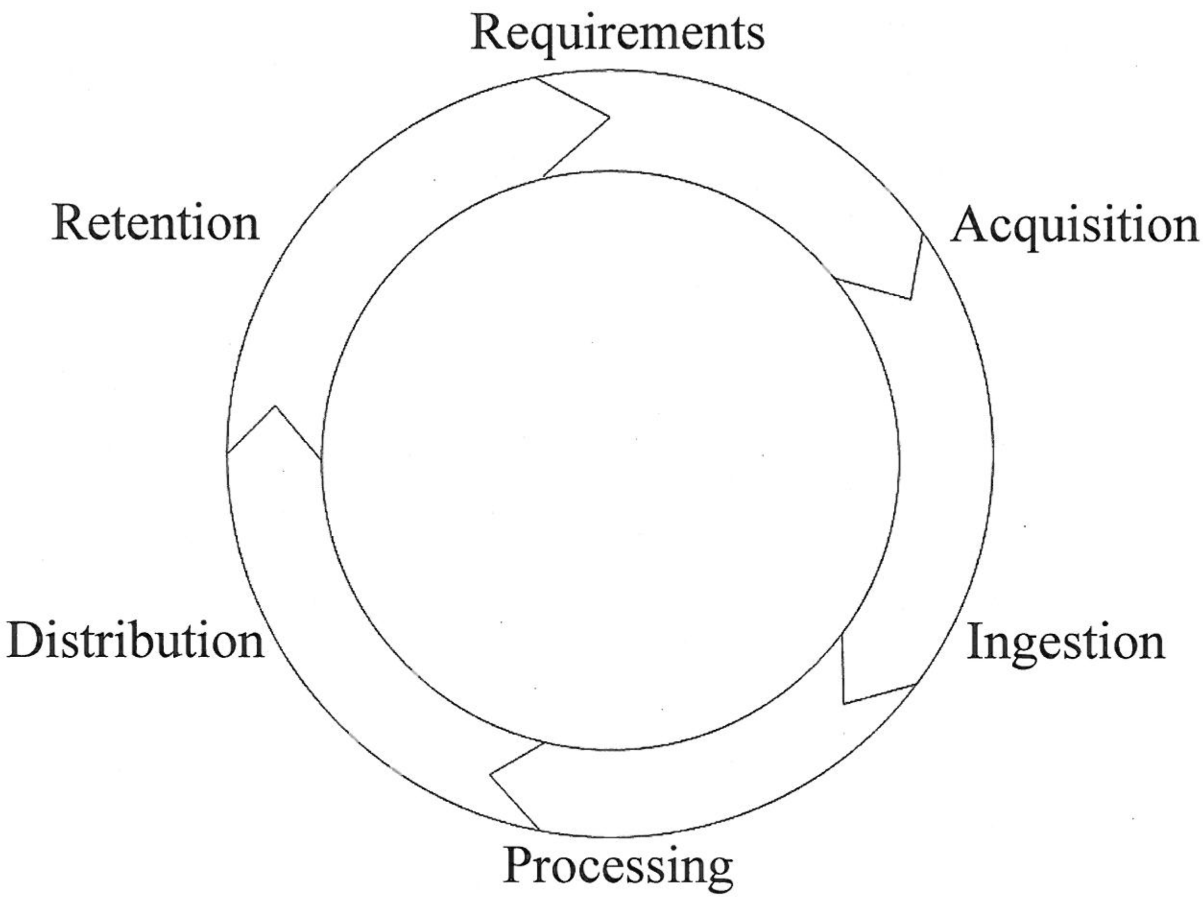

Figure 1—Image Lifecycle

When the lifecycle breaks down, imagery is distributed and stored in a way that increases the cost while reducing the value of the image record. The guidelines are intended to help organizations develop and maintain an image lifecycle to properly acquire, ingest, process, distribute, and retain image records.

C.2.1 Motion Imagery Guideline

Digital motion imagery is used to acquire a variety of content from live television and web streams to Hollywood productions that can take a year or more to finish. A large variety of cameras and file formats is also being used to acquire video to meet every demand. For the motion image guideline, the workflow is described using the MXF file format. Refer to figure 2, Metadata Workflow, for more details on this example of a metadata workflow.

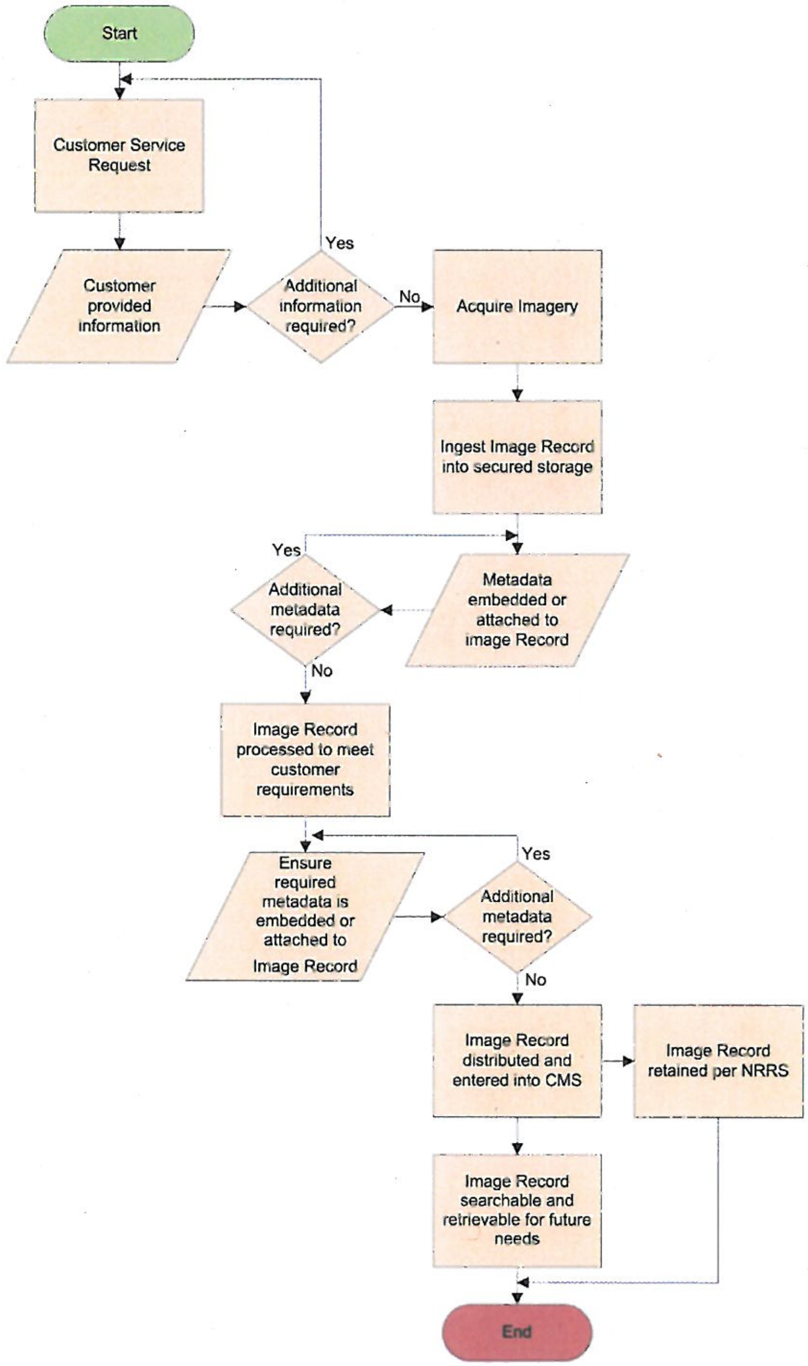

Figure 2—Metadata Workflow

Many cameras on the market use MXF files for recording video. It is a generic container that allows for a variety of data to be wrapped with the motion image record. Part of that data is the metadata used throughout the image lifecycle.

The videographer has the option with MXF-supported video cameras to add or import the name of the task, creator, location, along with other metadata directly into the device with the image record when it is being acquired.

After the imagery is ingested into a secured storage area, additional metadata should be added during post production. As the motion imagery clips are being edited, metadata tags should be added to describe what is taking place in the video and make future search and retrieval easier. The technician/editor enters the remaining required core metadata elements. (See section 4 of this Standard.)

The imagery can then be transcoded into the appropriate format for distribution and entered into a CMS. The workflow can vary for live events, with the image record being tagged during playout and the remaining required metadata entered when the imagery is loaded into the CMS for management and retention.

The CMS makes the imagery available to the customer as well as retrievable for future productions. The image record can also be transferred to NARA in accordance with the record retention schedule.

C.2.2 Still Imagery Guideline

Digital still cameras have a variety of features that can facilitate the capturing of metadata along with the image file. For the still image guideline, the workflow is described using the Nikon D3x camera and the features it provides. (Refer to figure 2 for more details on this example of a metadata workflow.)

The process of gathering metadata begins with the first discussion with the customer. Whether it is through an email request or a phone call, the customer service person receiving the requirements transfers all pertinent information to the photographer to assist with the acquisition of the imagery.

Before the photographer leaves for the job, the customizable metadata elements in the camera, such as the file name, copyright, and image comment, along with time and date, are set to ensure the data are acquired along with the image file. The image file format is set to camera RAW to allow for the TIF file to be created and transferred to NARA as part of the retention process.

While the images are being acquired, the photographer has the option of audio tagging images with additional information as needed. The photographer can add the names of any people in the field of view or, if taking images for engineering purposes, could name and describe the item or part that is being photographed.

Once the photographer has acquired the images, these are downloaded to a secured work area on a server. The photographer can batch rename the images if required to provide for a consistent image naming or Image Record Identifier, as well as to ensure the creator, description, and location metadata are entered with the image files along with any pertinent data that were acquired with the imagery.

A photography laboratory technician should check to make sure the appropriate metadata from the job have been entered by the photographer. If the data are not present, the technician contacts the photographer to update the image files.

The technician then retrieves the images from the photographer's folder and transfers them to the photography laboratory folder on the server. The technician prepares the imagery to meet the customer request and, as part of the process, enters the remaining required core metadata elements. (See section 4 in this Standard.) The imagery should then be entered into a CMS for distribution so the customer can review or download the imagery. Customers can also make selections for other products as desired.

Once the imagery is in the CMS, it can be searched for and retrieved. The proper retention schedule can be applied to the image record for transfer to NARA.

APPENDIX D

REFERENCE DOCUMENTS

D.1 Purpose and/or Scope

The purpose of this appendix is to provide guidance in the form of a list of reference documents with which the adopters of this Standard should be familiar in the course of managing imagery.

Access to the International Organization for Standardization (ISO) and Society of Motion Picture & Television Engineers (SMPTE) documents is available to NASA civil servants and contractors through the NASA Standards and Technical Assistance Resource Tool (https://standards.nasa.gov/) The documents are also available through the ISO (http://www.iso.org/) and SMPTE (http://standards.smpte.org/) web sites.

D.2 Reference Documents

All internet sources were retrieved on November 21, 2013.

D.2.1 Government Documents

Department of Defense

	How to Create a VIRIN http://www.defenseimagery.mil/learning/howto/virin.html

NASA

NPD 1383.1	Release and Management of Audiovisual Products http://nodis3.gsfc.nasa.gov./displayDir.cfm?t=NPD&c=1383&s=1C
NPD 1440.6	NASA Records Management http://nodis3.gsfc.nasa.gov./displayDir.cfm?t=NPD&c=1440&s=6H

National Archives

	44 U.S.C. Chapter 31, Records Management by Federal Agencies http://www.archives.gov/about/laws/fed-agencies.html

D.2.2 Non-Government Documents

Consultative Committee for Space Data Systems (CCSDS)

CCSDS 650.0	Reference Model for an Open Archival Information System (OAIS) http://public.ccsds.org/publications/AllPubs.aspx

DCMI

	DCMI Metadata Terms http://dublincore.org/documents/dcmi-terms/

ISO

ISO 14721	Space data and information transfer systems – Open archival information system (OAIS) – Reference model, Second Edition http://www.iso.org/
ISO 15489-1	Information and documentation – Records management – Part 1: General http://www.iso.org/
ISO 15836	Information and documentation – The Dublin Core metadata element set, Second Edition http://www.iso.org/
ISO 16363	Space data and information transfer systems – Audit and certification of trustworthy digital repositories, First Edition http://www.iso.org/
ISO/TR 15489-2	Information and documentation – Records management – Part 2: Guidelines http://www.iso.org/
ISO/TR 15801	Document management – Information stored electronically – Recommendations for trustworthiness and reliability http://www.iso.org/

SMPTE

Standard 377-1	Material Exchange Format (MXF) File Format Specification http://standards.smpte.org/