



ArcGIS Full Motion Video

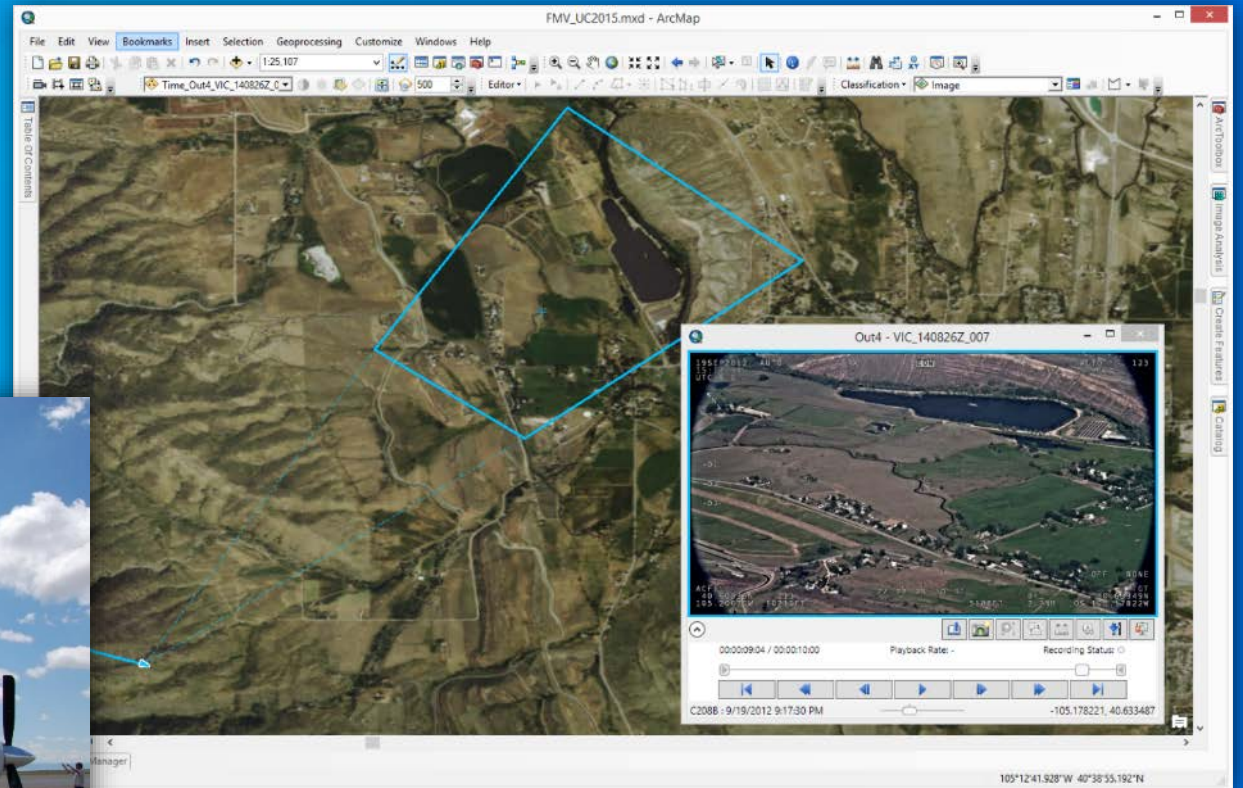
Raster Development Team

Alex Muleh

ArcGIS Full Motion Video

Agenda

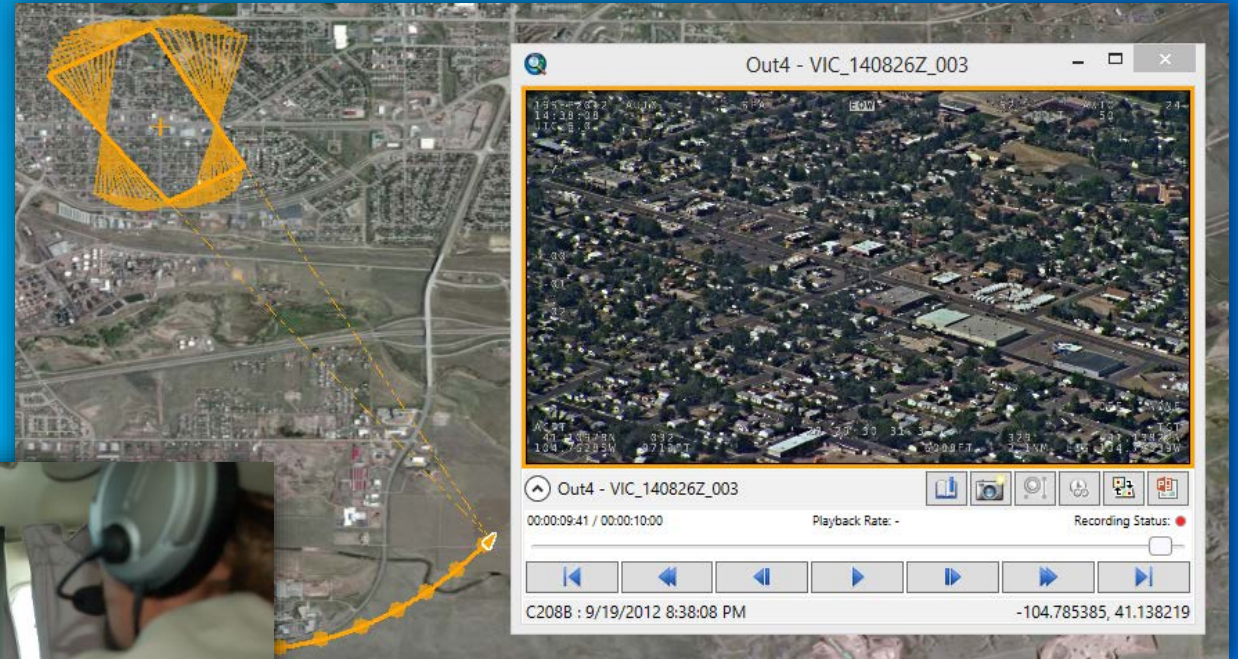
- What is Full Motion Video (FMV)?
- Getting started with Esri FMV
- Esri Full Motion Video Products
- What's New!
- Demos



ArcGIS Full Motion Video

What is full motion video (FMV)?

- A sequence of images captured at a rate of 1hz (one frame per second) or higher
- The lead standards board for Full Motion Video is the “Motion Imagery Standards Board” or MISB

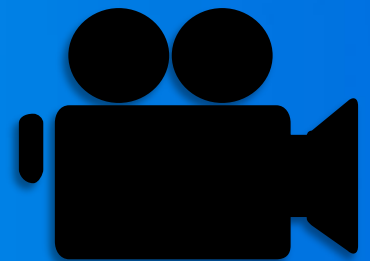


Full Motion Video is often abbreviated "FMV"

ArcGIS Full Motion Video

Concepts – Space, Time, and Video

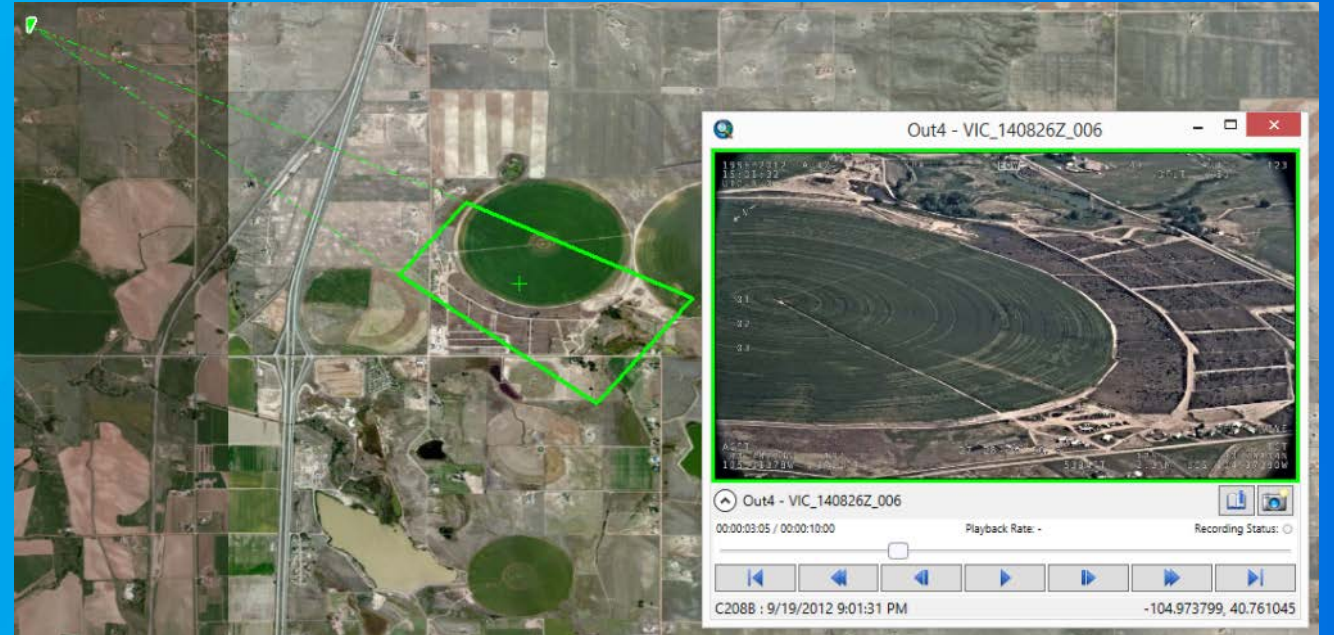
- “When” and “Where”: Full Motion Video captures images in time and space
 - Time: Each frame in a video is captured at an instant in time. *By displaying the frames in sequence, at the rate captured, we see motion and change*
 - Space: The sensor is oriented in a particular direction, capturing imagery of a location. *By using direct georeferencing information, we can establish the location of the imagery*
- Synchronous vs. Asynchronous Metadata
 - Asynchronous metadata is acquired without regard to a particular frame



ArcGIS Full Motion Video

Concepts – Maps and FMV

- We can register a Full Motion Video to a map
 - Shared time and coordinate system
 - Map and FMV are synchronized as time passes
 - Features and events are captured using ArcMap



ArcGIS Full Motion Video

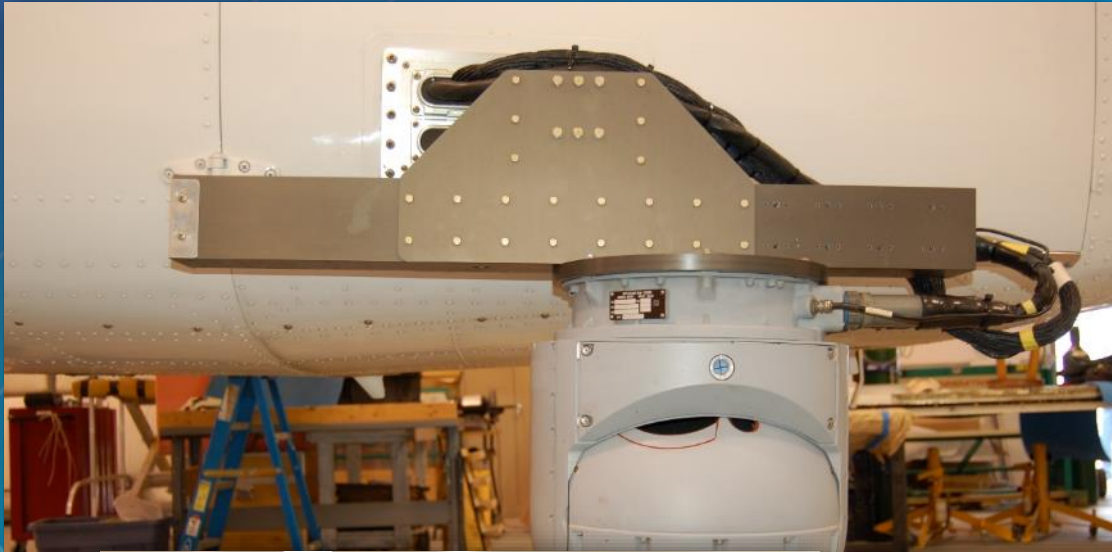
Concepts – Where does FMV data come from?

- Unmanned Aerial Vehicles (UAV's)
- Orbital sensors (overhead sensors)
- Fixed Wing and Helicopter
- Vehicle mounted cameras
- Hand-held mobile devices and cameras
- Stationary (persistent surveillance)



Concepts – Where does FMV data come from?

L3 Wescam MX-15HDI



ArcGIS Full Motion Video

Concepts – How is FMV data captured?

- Sensors
 - Location (X,Y,Z) of a sensor may be fixed or dynamic
 - Orientation of the sensor may be controlled independently of the platform
 - Sensor may be rotated or elevated



Motion Industry Standards Board

Who is MISB?

- The MISB was established for the DoD, intelligence community (IC), and National System for Geospatial-Intelligence (NSG).
 - “To formulate, review, and recommend standards for motion imagery, associated metadata, audio, and other related systems for the DoD, IC, and NSG.”
 - “The goal of the MISB is to promote technologies that are standards-based in order to ensure interoperable solutions...”



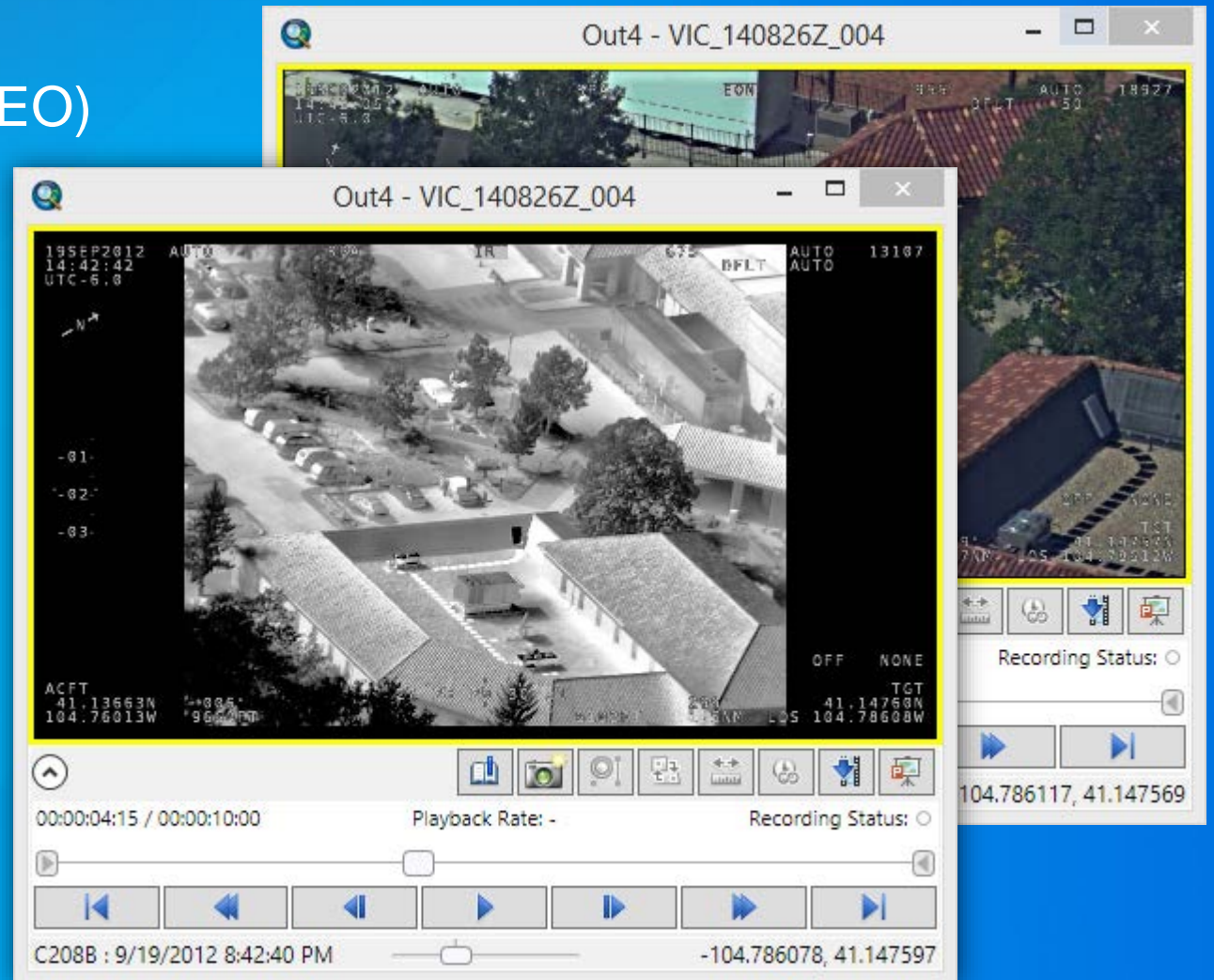
<http://www.gwg.nga.mil/>

Courtesy of <http://www.gwg.nga.mil/misb>

ArcGIS Full Motion Video

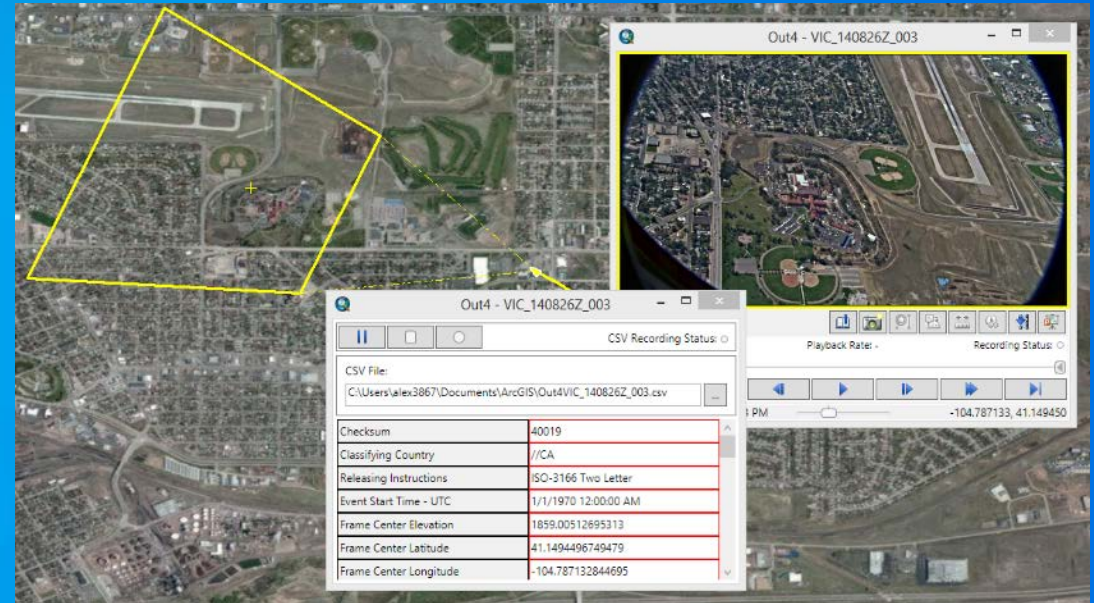
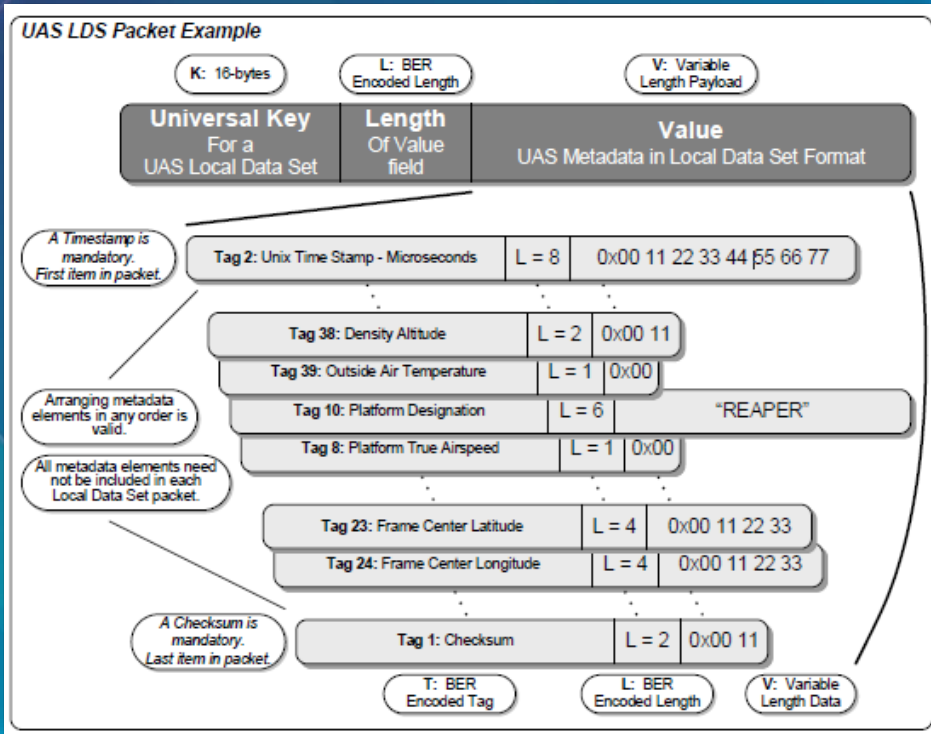
MISB Supported Motion Imagery Types

- Panchromatic/Electro Optical (EO)
- Multispectral (MSI)
- Infrared (IR)
- Hyperspectral (HSI)

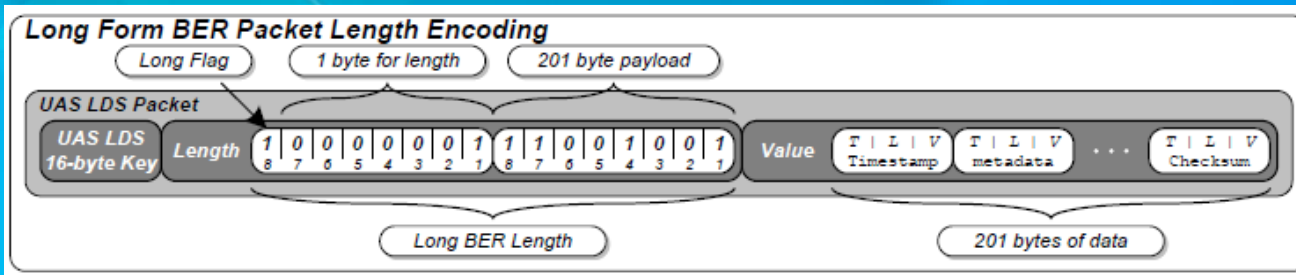


Motion Industry Standards Board (MISB)

What does MISB video metadata look like?



A "shopping list" of your required FMV metadata.



<http://www.gwg.nga.mil/misb>

Courtesy of <http://www.gwg.nga.mil/misb>

Motion Industry Standards Board (MISB)

MISB Approved Compression Types

- H.264
 - Best quality for low bandwidth
 - 2 to 1 performance advantage over MPEG-2
 - Higher cost (less of a factor than it used to be)
- MPEG-2
 - Mature technology
 - Widely supported
 - Lower cost
- JPEG 2000
 - 2-3 times the bandwidth of H.264 and MPEG-2
 - Very useful with large frame images



Motion Industry Standards Board (MISB)

I'm building a new motion imagery system. What do I have to do to be MISB compliant?

To be MISB compliant, any new motion imagery system must:

- 1) Be digital
- 2) Produce a compliant MPEG-2 Transport Stream (TS)
- 3) Use MPEG-2, MPEG-4 Part 10 (H.264/AVC), or JPEG 2000 image compression
- 4) Produce non-destructive (not “burned in”) metadata
- 5) Comply with MISB Standards 0601, 0102, and 0604

<http://www.gwg.nga.mil/misb>

Courtesy of <http://www.gwg.nga.mil/misb>

Motion Industry Standards Board (MISB)

I'm building a new motion imagery system. What I should avoid doing?

Do not build:

- 1) Analog systems
- 2) Digital systems that use interlaced scanning
- 3) “Burned in” metadata
- 4) MISB EG 0104 (deprecated)
- 5) Systems that utilize file formats not covered by the MISB.
- 6) Systems that utilize proprietary file formats, metadata encodings or compression algorithms

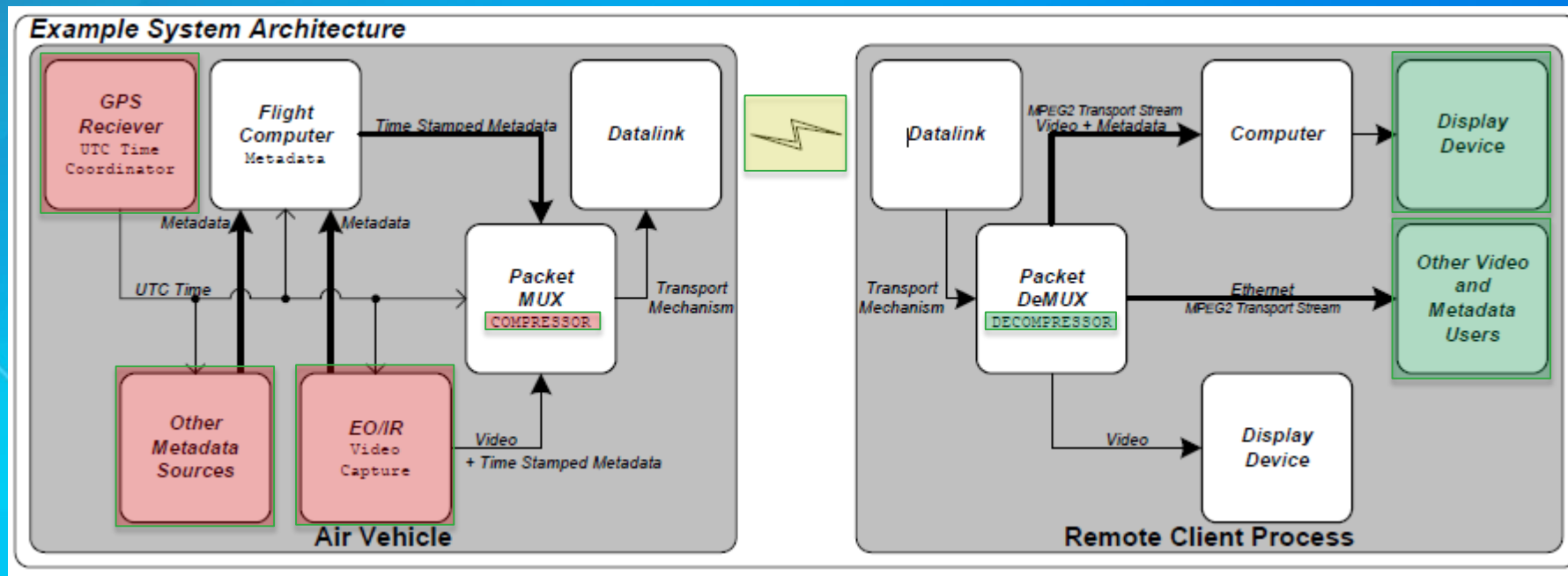
<http://www.gwg.nga.mil/misb>

Courtesy of <http://www.gwg.nga.mil/misb>

Motion Industry Standards Board (MISB)

Data Collection and Dissemination

- “Metadata is collected, processed, and then distributed to a flight computer through the most appropriate interface.” – Standard060105.pdf



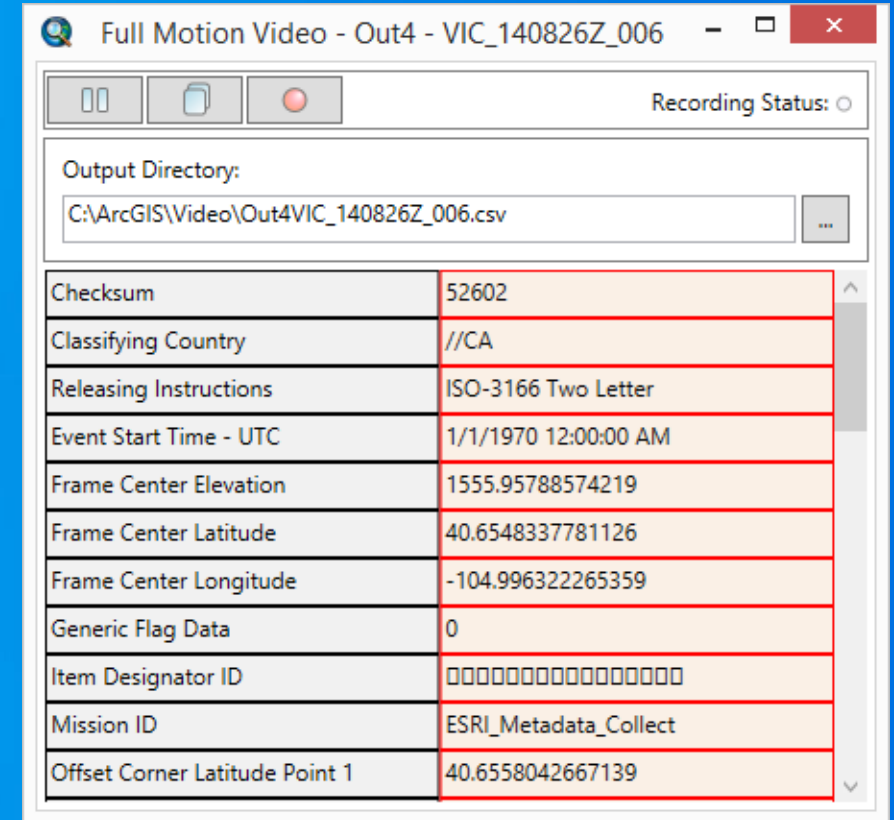
Courtesy of <http://www.gwg.nga.mil/misb>

Motion Industry Standards Board (MISB)

MISB Minimum Guidelines

- Record digitally, no analog
- Use MPEG-2, H.264, or JPEG 2000 compression
- Comply with the MISB minimum metadata set 0902
- Add metadata elements as needed for the task
- Do not “burn in” your metadata
- Do not use proprietary formats

<http://www.gwg.nga.mil/misb>

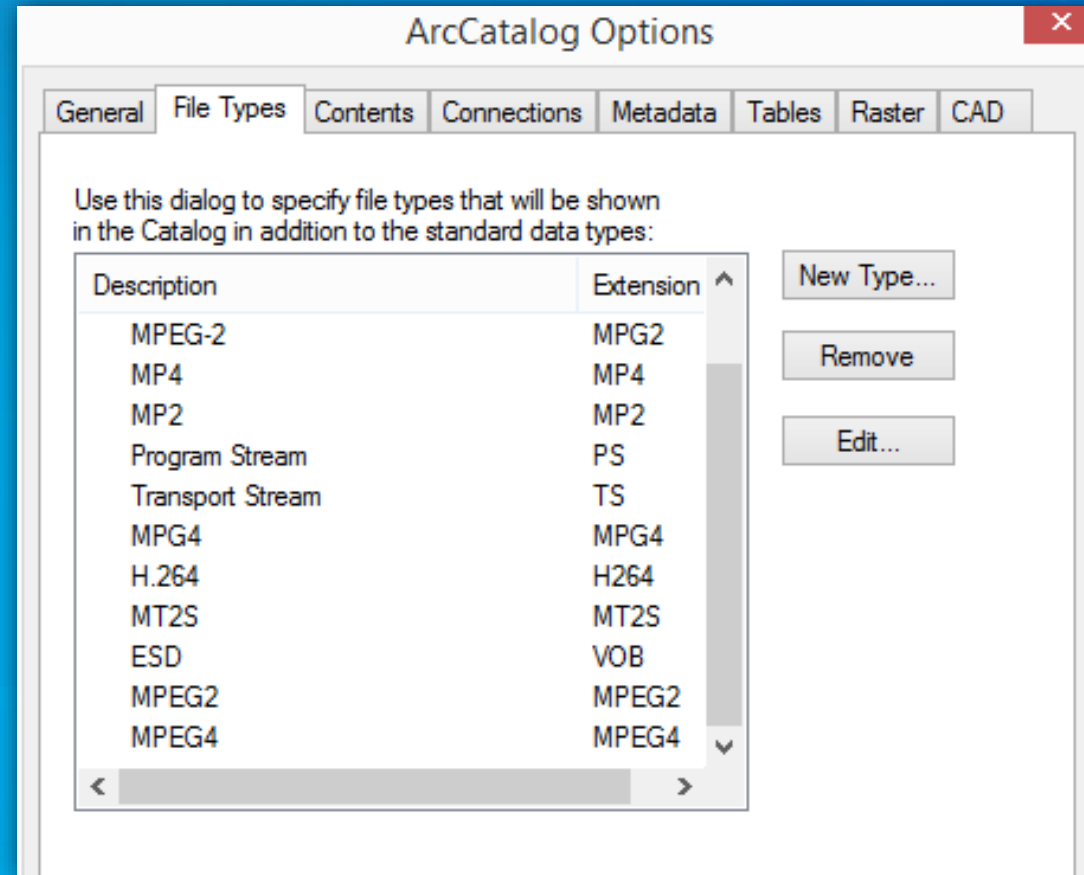


Courtesy of <http://www.gwg.nga.mil/misb>

ArcGIS Full Motion Video

Capabilities – Esri Supported FMV Formats

- PS, MPEG-2 Program Stream
- TS, MPEG-2 Transport Stream
- MPG, MPEG File
- MPEG, MPEG File
- MP2, MPEG-2 File
- MPG2, MPEG-2 File
- MPEG2, MPEG-2 File
- MP4, MPEG-4 File
- MPG4, MPEG-4 File
- MPEG4, MPEG-4 File
- H264, H.264 Video File
- VOB, ESD File
- MT2S, MT2S

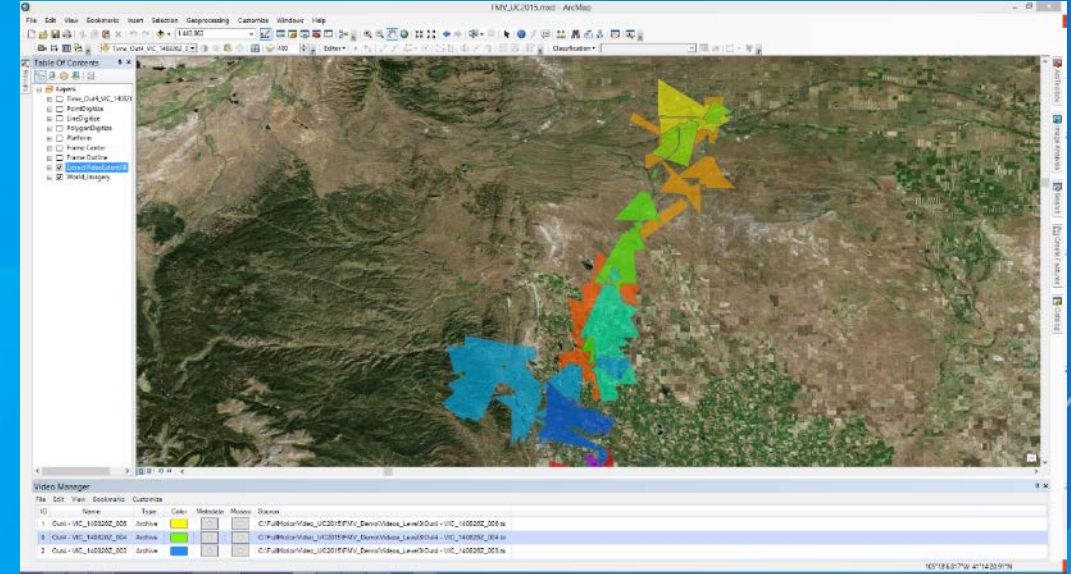
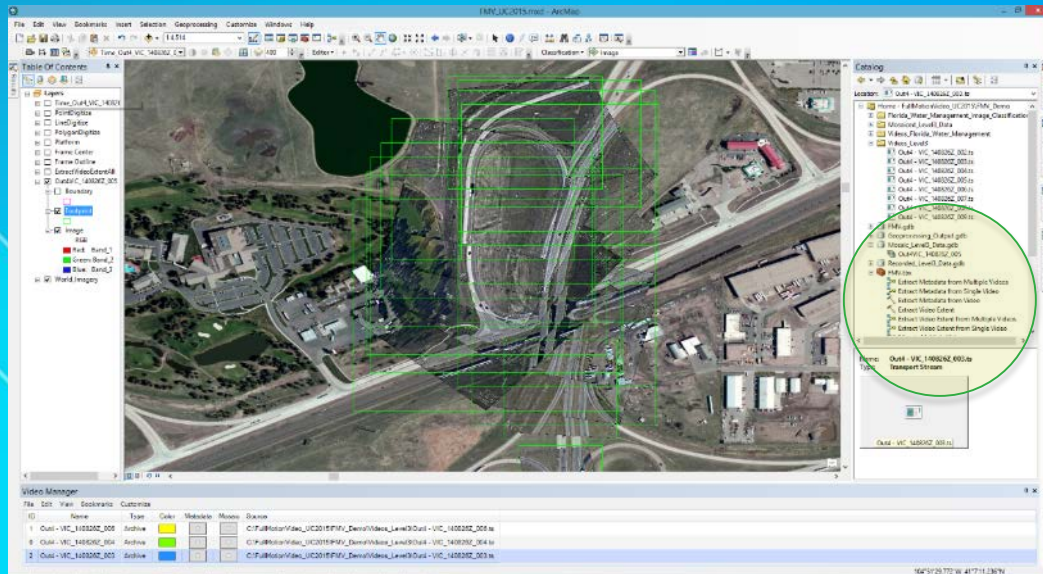
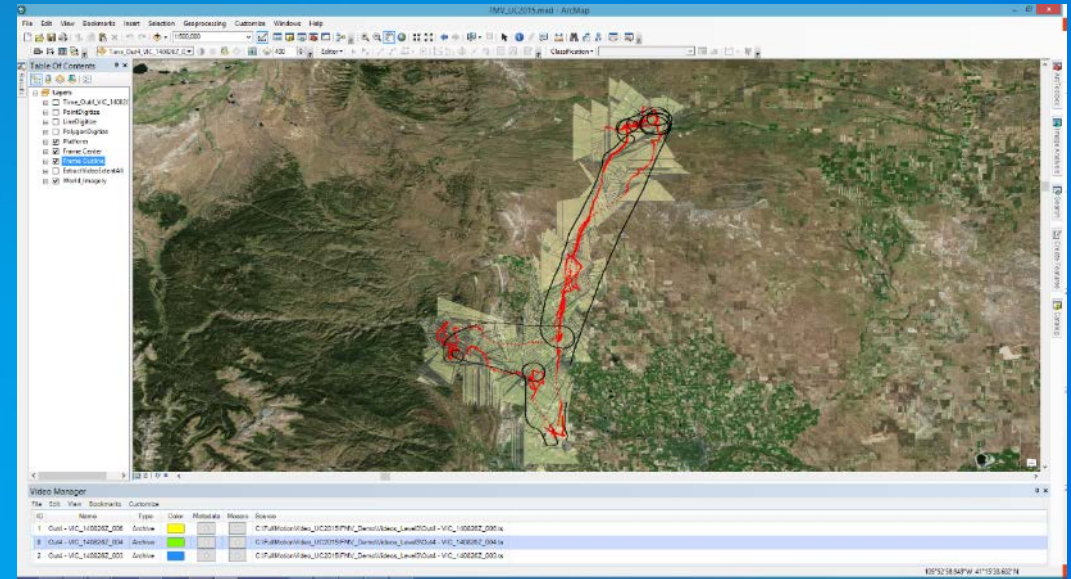


** Important step in the installation process*

ArcGIS Full Motion Video

FMV Geoprocessing Tools

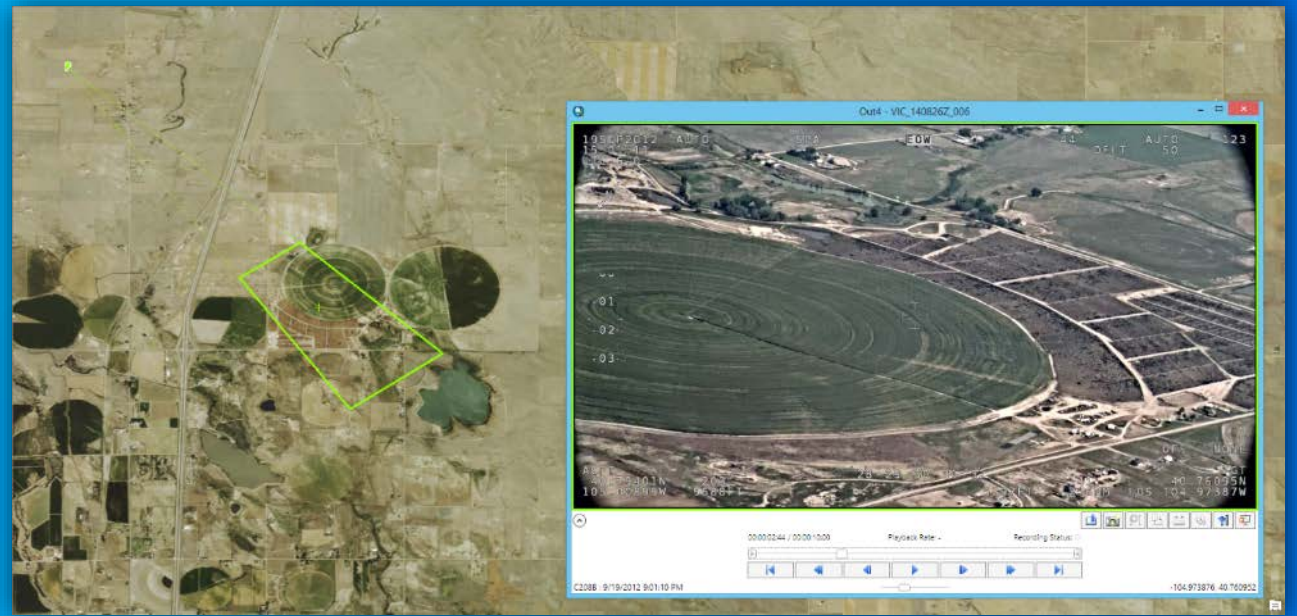
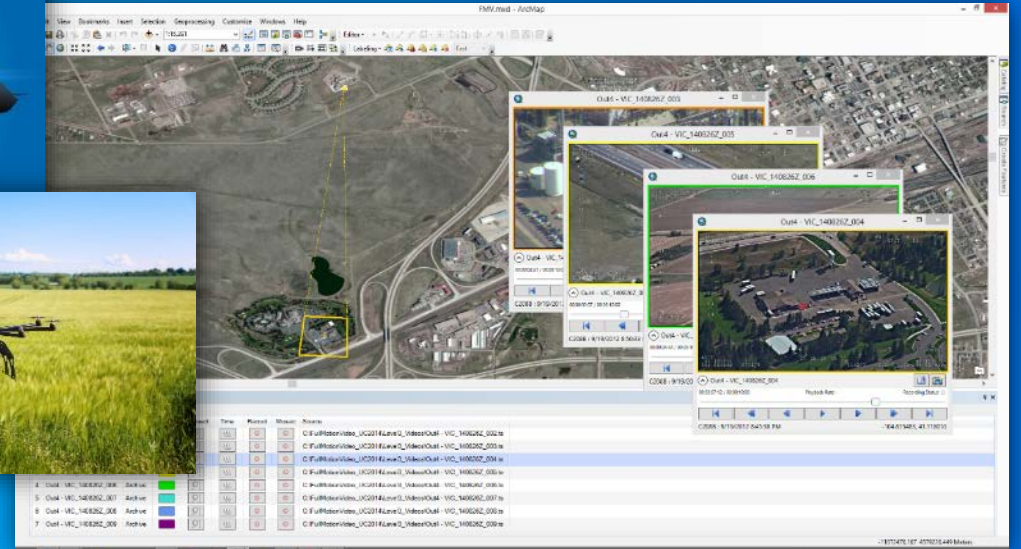
- Extract Metadata from Video
- Extract Video Extent
- Mosaic Video
- Video Multiplexer (Coming soon!)



ArcGIS Full Motion Video

What's new!

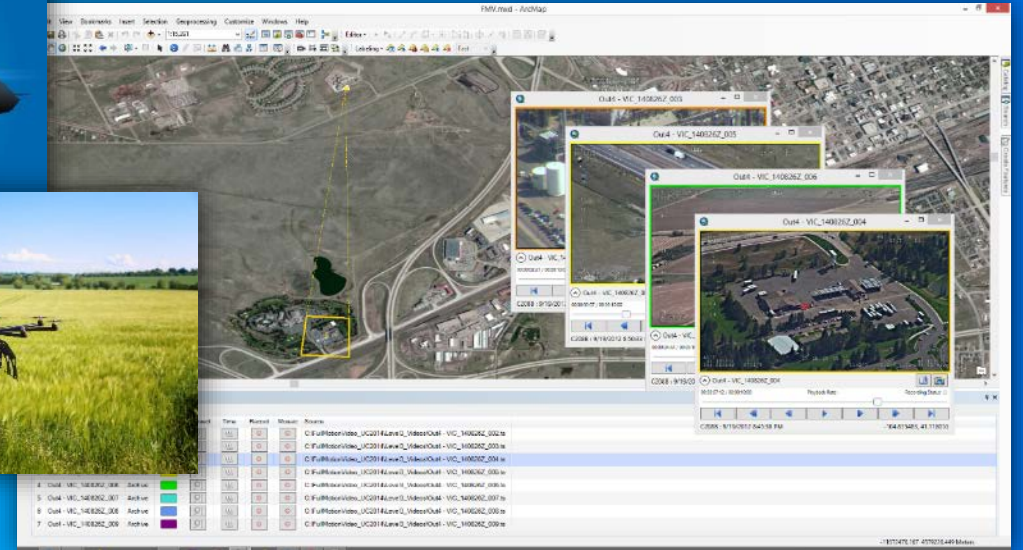
- Live stream recording
- Pan and zoom for live streams
- Video Clip and Ship
- Measure distances directly on a video
- Improved performance...and more!



ArcGIS Full Motion Video

What's new in FMV 1.2.1!

- Pan and Zoom
- Easily export new video clips
- Live stream Recording
- Slow motion playback
- Measure distances directly on a video
- Accuracy option, uses DEM/DTED information to increase video-to-map and map-to-video accuracy
- One-click PowerPoint integration – easily create reports from FMV data
- Performance improvements
 - Hardware acceleration and software only modes
 - Linear resampling and high resolution modes



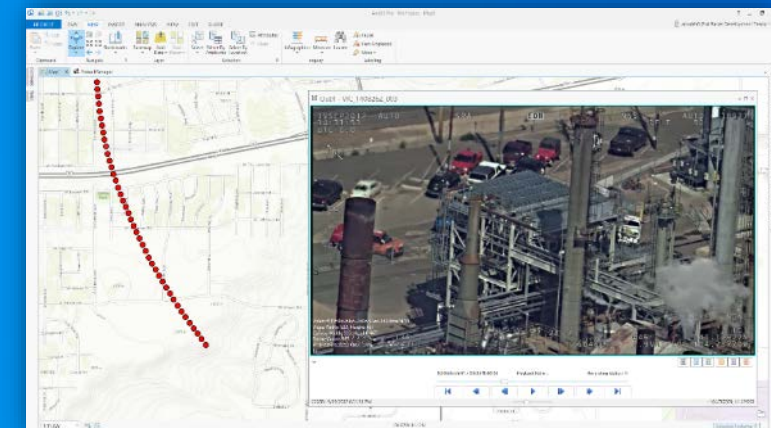
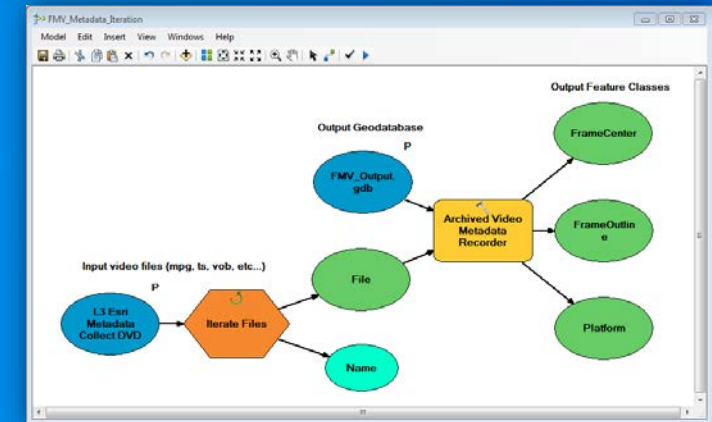
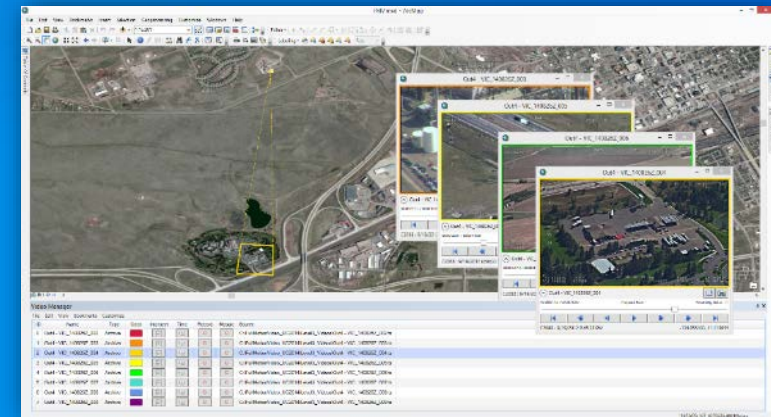
ArcGIS Full Motion Video

Esri FMV Today and the road ahead!

- Currently Released Products
 - FMV Add-in for ArcGIS Desktop 10.1, 10.2, 10.3
 - FMV Geoprocessing Tools for 10.2, 10.3
- Upcoming Products
 - New FMV Add-in and GP Tools
 - Very large file support, Video Multiplexer, and more!
 - FMV support for ArcGIS 10.4 (2015)
 - FMV for ArcGIS Pro (February of 2016)



Non-MISB metadata support





Video Multiplexer

Preparing your videos and metadata for the
ArcGIS Full Motion Video Add-in

What is the problem?

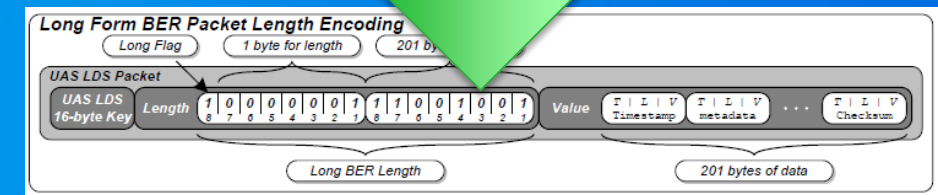
Non-MISB Metadata Support

- FMV reads geo-referencing information from a video file
 - Encoded using MISB specifications
- Not all video files have this information encoded
 - Metadata may...be stored in external file
 - Metadata may...not include all relevant fields
 - Metadata may...have non-MISB headings
- Need a workflow for preparing videos for full FMV functionality

Input video and metadata file...

TimeStamp	PlatformHeading	PlatformHeading	PlatformHeading	PlatformHeading	PlatformHeading	PlatformHeading	PlatformHeading	PlatformHeading	PlatformHeading
1433429777800780	276.689403								
1433429777960930	276.22797								
1433429778121090	275.854429								
1433429778281250	275.579767								
1433429778480460	275.371023								
1433429778640620	275.239185								
1433429778800780	275.206226								
1433429778960930	275.283131								
1433429779121090	275.392996								
1433429779281250	275.502861								
1433429779480460	275.623713								
1433429779640620	275.78851	0.900906	5.108798	27.405438	-82.127266	169.906157	52.301213		
1433429779800780	275.953307	0.824	5.372784	27.405438	-82.12732	169.619287	52.301213		
1433429779960930	276.052186	0.813013	5.679495	27.405438	-82.127373	169.332418	52.301213		
1433429780121090	276.096132	0.75808	5.81225	27.405438	-82.127443	168.758679	52.301213		
1433429780320310	276.129091	0.867946		27.405444	-82.127502	168.471809	52.301213		
1433429780480460	276.173037	1.1536		27.405444	-82.127556	168.184939	52.301213		
1433429780640620	276.173037	1.38432		27.405444	-82.127609	168.184939	52.301213		

Out4 - VIC_140826Z_002.ts
Out4 - VIC_140826Z_003.ts
Out4 - VIC_140826Z_004.ts
Out4 - VIC_140826Z_005.ts
Out4 - VIC_140826Z_006.ts
Out4 - VIC_140826Z_007.ts
Out4 - VIC_140826Z_008.ts
Out4 - VIC_140826Z_009.ts



MISB compliant metadata

Video Multiplexer

Typical Video Metadata Files

- Comma Separated Values (.csv) file.
- Headings may or may not follow MISB guidelines.
- Each entry must have a time reference.
- Time values must be Unix-based UTC timestamps *.

TimeStamp	PlatformHeading	PlatformPitch	PlatformRoll	SensorLatitude	SensorLongitude	SensorAltitude	HorizontalFOV
1433429777800780	276.689403	0.043947	6.382946	27.405409	-82.126628	174.209201	52.301213
1433429777960930	276.22797	0.043947	6.613361	27.405412	-82.126687	173.635462	52.301213
1433429778121090	275.854429	0.076907	6.503494	27.405414	-82.12674	173.348592	52.301213
1433429778281250	275.579767	0.175787	6.283761	27.40542	-82.126794	173.061723	52.301213
1433429778480460	275.371023	0.29664	5.932798	27.405422	-82.126864	172.487984	52.301213
1433429778640620	275.239185	0.42848	5.558947	27.405425	-82.126917	172.201114	52.301213
1433429778800780	275.206226	0.736106	5.174413	27.405428	-82.126976	171.627375	52.301213
1433429778960930	275.283131	0.999786	4.933317	27.40543	-82.12703	171.627375	52.301213
1433429779121090	275.392996	1.109653	4.910428	27.405433	-82.127084	171.340505	52.301213
1433429779281250	275.502861	1.08768	4.922636	27.405433	-82.127153	170.766766	52.301213
1433429779480460	275.623713	1.032746	4.878384	27.405438	-82.127212	170.479896	52.301213
1433429779640620	275.78851	0.900906	5.108798	27.405438	-82.127266	169.906157	52.301213
1433429779800780	275.953307	0.824	5.372784	27.405438	-82.12732	169.619287	52.301213
1433429779960930	276.052186	0.813013	5.679495	27.405438	-82.127373	169.332418	52.301213
1433429780121090	276.096132	0.75808	5.81225	27.405438	-82.127443	168.758679	52.301213
1433429780320310	276.129091	0.867946	5.789361	27.405444	-82.127502	168.471809	52.301213
1433429780480460	276.173037	1.1536	5.723746	27.405444	-82.127556	168.184939	52.301213
1433429780640620	276.173037	1.38432	5.745109	27.405444	-82.127609	168.184939	52.301213

1433429777800780 = GMT: Thu, 04 Jun 2015 14:56:17 GMT

* microseconds that have elapsed since midnight (00:00:00), January 1, 1970

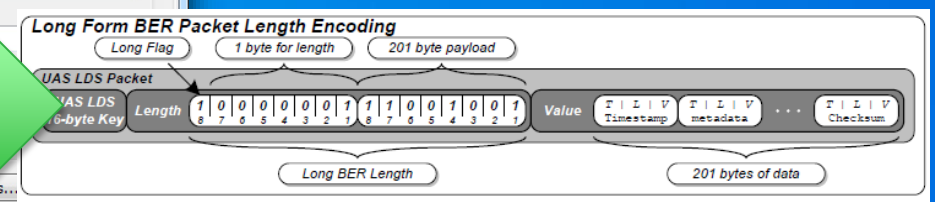
Video Multiplexer

Non-MISB Metadata Support

- Metadata File
- Output Video
- File Mapping File
- Calculate Corners?
- Time Shift Observations

Input video and metadata file...

TimeStamp	PlatformHeading	PlatformPitch	PlatformRoll	Sensor
1433429777800780	276.689403	0.043947	6.382946	2
1433429777960930	276.22797	0.043947	6.613361	2
1433429778121090	275.854429	0.076907	6.503494	2
1433429778281250	275.579767	0.175787	6.283761	2
1433429778480460	275.371023	0.29664	5.932798	2
1433429778640620	275.239185	0.42848	5.558947	2
1433429778800780	275.206226	0.736106	5.174413	2
1433429778960930	275.283131	0.999786	4.933317	2
1433429779121090	275.392996	1.109653	4.910428	2
1433429779281250	275.502861	1.08768	4.922636	2
1433429779480460	275.623713	1.032746	4.878384	2
1433429779640620	275.78851	0.900906	5.108798	2
1433429779800780	275.953307	0.824	5.277784	2
1433429779960930	276.052186	0.813013	5.277784	2
1433429780121090	276.096132	0.75808	5.277784	2
1433429780320310	276.129091	0.867946	5.277784	2
1433429780480460	276.173037	1.1536	5.277784	2
1433429780640620	276.173037	1.38432	5.277784	2



Video Multiplexer GP Tool

MISB compliant metadata and video

Use the MISB field-mapping template to specify your field names

Non-MISB Metadata Support

- Put metadata field names into the third column to match MISB fields.
- FMV uses red fields for geo-referencing
- *If yellow fields are set, image corners can be calculated.*

MISB Tag	MISB Tag Name	My column headings
2	UNIX Time Stamp	TimeStamp
5	Platform Heading Angle	PlatformHeading
6	Platform Pitch Angle	PlatformPitch
7	Platform Roll Angle	PlatformRoll
13	Sensor Latitude	SensorLatitude
14	Sensor Longitude	SensorLongitude
15	Sensor True Altitude	SensorAltitude
16	Sensor Horizontal Field of View	HorizontalFOV
17	Sensor Vertical Field of View	VerticalFOV
18	Sensor Relative Azimuth Angle	SensorRelativeAzimuth
19	Sensor Relative Elevation Angle	SensorRelativeElevation
20	Sensor Relative Roll Angle	SensorRelativeRoll
21	Slant Range	
23	Frame Center Latitude	FrameCenterLatitude
24	Frame Center Longitude	FrameCenterLongitude
25	Frame Center Elevation	
26	Offset Corner Latitude Point 1	OffsetCornerLatitudePoint1
27	Offset Corner Longitude Point 1	OffsetCornerLongitudePoint1
28	Offset Corner Latitude Point 2	OffsetCornerLatitudePoint2
29	Offset Corner Longitude Point 2	OffsetCornerLongitudePoint2
30	Offset Corner Latitude Point 3	OffsetCornerLatitudePoint3
31	Offset Corner Longitude Point 3	OffsetCornerLongitudePoint3
32	Offset Corner Latitude Point 4	OffsetCornerLatitudePoint4
33	Offset Corner Longitude Point 4	OffsetCornerLongitudePoint4

After multiplexing the video contains MISB-compliant metadata

Non-MISB Metadata Support

- Sensor location is present
- Frame corners are missing
- Minimum sensor and platform fields are present, so frame corners can be calculated...

MISB Tag	MISB Tag Name	My column headings
2	UNIX Time Stamp	TimeStamp
5	Platform Heading Angle	PlatformHeading
6	Platform Pitch Angle	PlatformPitch
7	Platform Roll Angle	PlatformRoll
13	Sensor Latitude	SensorLatitude
14	Sensor Longitude	SensorLongitude
15	Sensor True Altitude	SensorAltitude
16	Sensor Horizontal Field of View	HorizontalFOV
17	Sensor Vertical Field of View	VerticalFOV
18	Sensor Relative Azimuth Angle	SensorRelativeAzimuth
19	Sensor Relative Elevation Angle	SensorRelativeElevation
20	Sensor Relative Roll Angle	SensorRelativeRoll
21	Slant Range	
23	Frame Center Latitude	FrameCenterLatitude
24	Frame Center Longitude	FrameCenterLongitude
25	Frame Center Elevation	
26	Offset Corner Latitude Point 1	OffsetCornerLatitudePoint1
27	Offset Corner Longitude Point 1	OffsetCornerLongitudePoint1
28	Offset Corner Latitude Point 2	OffsetCornerLatitudePoint2
29	Offset Corner Longitude Point 2	OffsetCornerLongitudePoint2
30	Offset Corner Latitude Point 3	OffsetCornerLatitudePoint3
31	Offset Corner Longitude Point 3	OffsetCornerLongitudePoint3
32	Offset Corner Latitude Point 4	OffsetCornerLatitudePoint4
33	Offset Corner Longitude Point 4	OffsetCornerLongitudePoint4

The screenshot displays the ArcMap interface with a video player window titled '01425_A'. The video player shows a satellite view of a landscape with a white arrow pointing to a specific location. Below the video player is a 'Video Manager' window with a table of video files:

ID	Name	Type	Color	Metadata	Mosaic	Source
0	01425_A	Archive				D:\TestPackage\01425_A.ts
2	01425_B	Archive	Red			D:\TestPackage\01425_B.ts

Below the video manager is a playback control bar showing '00:00:00:46 / 00:00:02:27', 'Playback Rate: -', and 'Recording Status: O'. The main window also shows a 'Table Of Contents' panel with a list of metadata fields and their values:

Field Name	Value
Checksum	21922
Platform Heading Angle	275.272155761719
Platform Pitch Angle	3.82335877418518
Platform Roll Angle	9.61333084106445
Sensor Horizontal Field of View	52.301212310791
Sensor Latitude	27.4054380168232
Sensor Longitude	-82.1414709473688
Sensor Relative Azimuth Angle	352.8332879657
Sensor Relative Elevation Angle	-53.4920289150868
Sensor Relative Roll Angle	0
Sensor True Altitude	157.932403564453
Sensor Vertical Field of View	31.0011444091797
UNIX Time Stamp	6/4/2015 2:57:03 PM

The calculate corners option: The video is now fully geo-referenced!

Non-MISB Metadata Support

- Video and metadata are now MISB compliant and prepared for the FMV Add-in
- Frame corners and center are now added to the metadata

The screenshot displays the ArcMap interface. On the left, a metadata table is visible, listing various parameters for the video file '01425_B'. The table includes fields such as Checksum, Frame Center Elevation, Frame Center Latitude, Frame Center Longitude, and four sets of Offset Corner coordinates (Latitude and Longitude). Other parameters include Platform Heading Angle, Platform Pitch Angle, Platform Roll Angle, Sensor Horizontal Field of View, Sensor Latitude, Sensor Longitude, Sensor Relative Azimuth Angle, Sensor Relative Elevation Angle, Sensor Relative Roll Angle, Sensor True Altitude, Sensor Vertical Field of View, and UNIX Time Stamp.

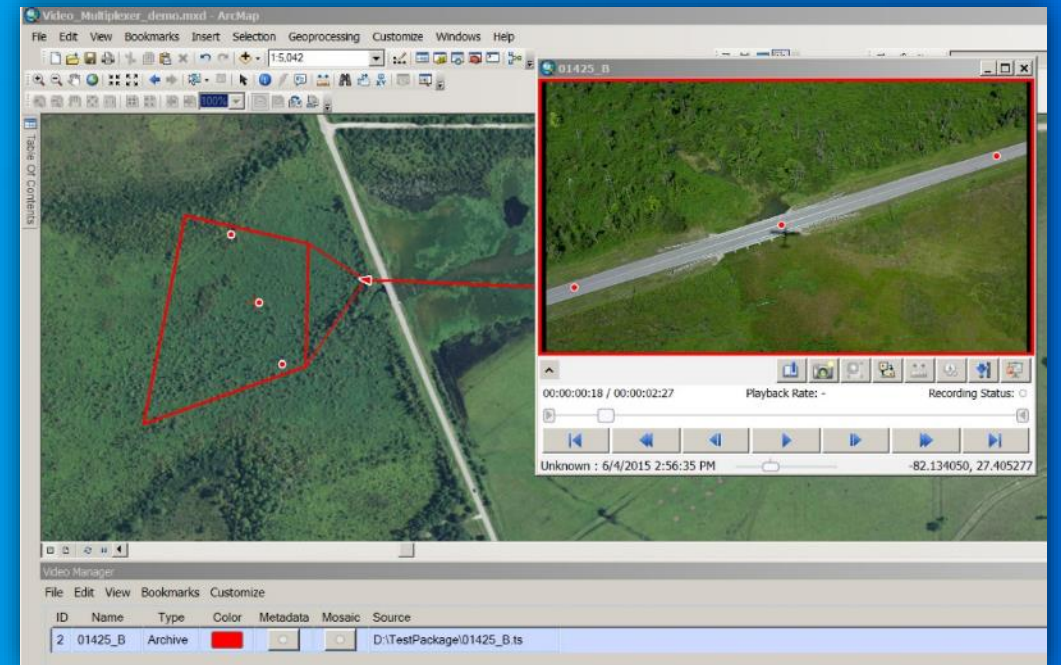
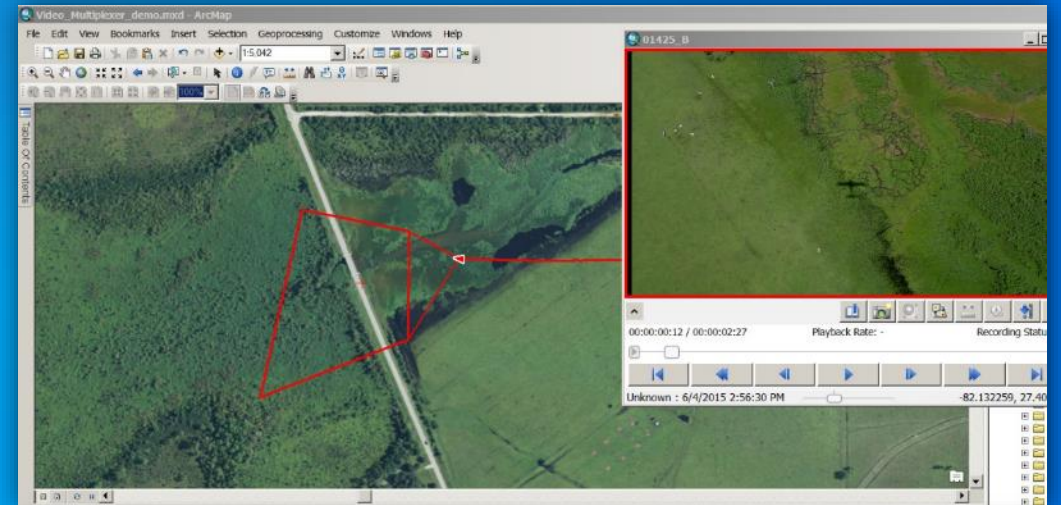
Checksum	24522
Frame Center Elevation	17.9476623535156
Frame Center Latitude	27.4052753659921
Frame Center Longitude	-82.1385331741248
Offset Corner Latitude Point 1	27.4037601219966
Offset Corner Latitude Point 2	27.4063488545629
Offset Corner Latitude Point 3	27.4059940768903
Offset Corner Latitude Point 4	27.4045085884415
Offset Corner Longitude Point 1	-82.1399339737097
Offset Corner Longitude Point 2	-82.1394235516388
Offset Corner Longitude Point 3	-82.1378693965437
Offset Corner Longitude Point 4	-82.137894574314
Platform Heading Angle	277.062957763672
Platform Pitch Angle	2.36213254928589
Platform Roll Angle	8.97549343109131
Sensor Horizontal Field of View	52.301212310791
Sensor Latitude	27.4055430001605
Sensor Longitude	-82.1371468911586
Sensor Relative Azimuth Angle	349.97536198934
Sensor Relative Elevation Angle	-52.0948609579796
Sensor Relative Roll Angle	0
Sensor True Altitude	171.293197631836
Sensor Vertical Field of View	31.0011444091797
UNIX Time Stamp	6/4/2015 2:56:49 PM

On the right, a video player window titled '01425_B' is shown, displaying a video frame of a landscape. A red rectangle highlights a specific area within the video frame, and a red arrow points to it. The video player interface includes playback controls and a recording status indicator.

Time Synchronization Issues

Non-MISB Metadata Support

- At 0:13 seconds the frame crosses the road, but the road is not seen in the video.
- At 0:18 seconds the video crosses the road. Digitized points reflect the time shift.



Time Synchronization

Non-MISB Metadata Support

- Time shift observations can be recorded in a CSV file
- Enter one observation for a consistent shift
- Enter multiple observations for a differential linear shift

.CSV File

elapsed time	time shift
0:13	-5
elapsed time	time shift
13	-5
1:13	-7
1:35	-8
2:13	-9

Video Multiplexer

Video Multiplexer

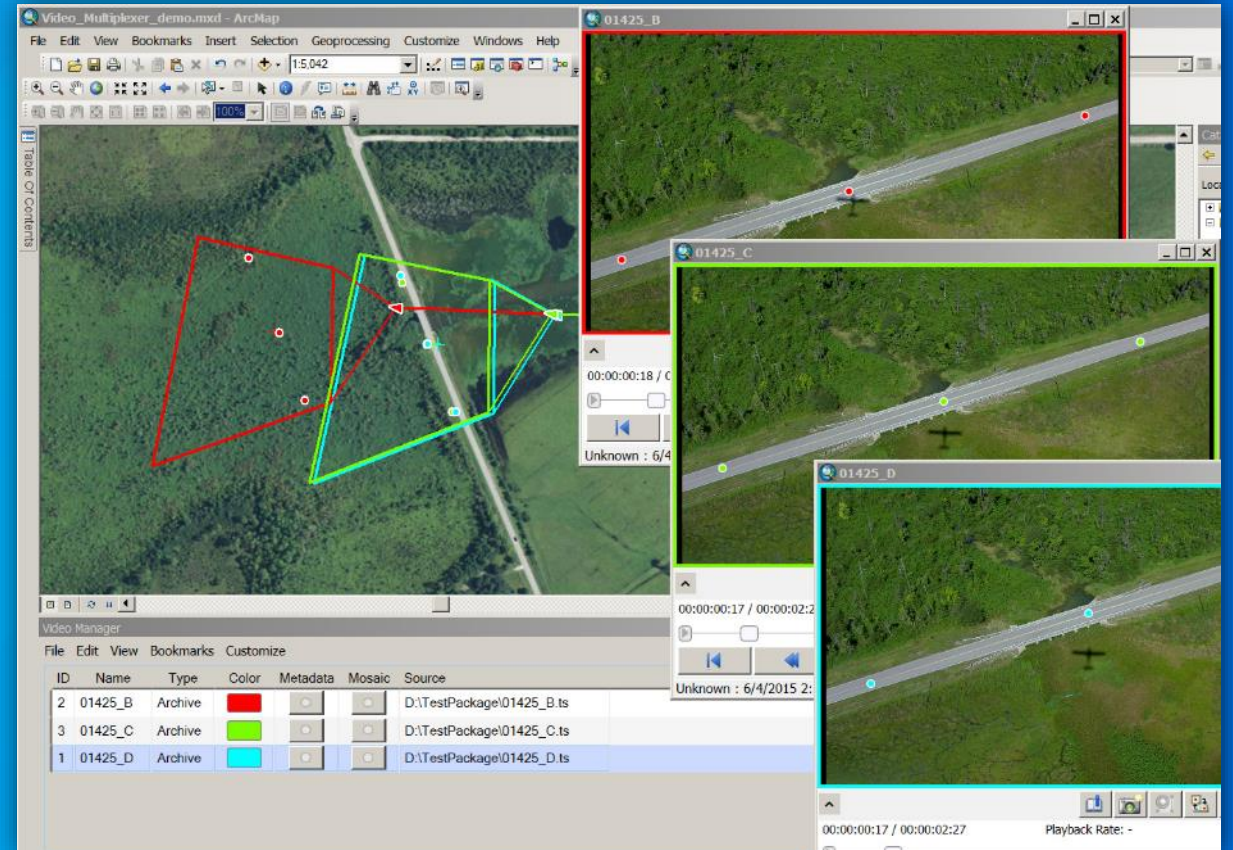
- Input Video File (e.g. in_video.ts)
- Input Metadata File (e.g. in_video_metadata.csv)
- Output Video File (e.g. out_video.ts)
- Metadata Field Mapping File (e.g. MISB_field_mapping.csv) (optional)
- Calculate coordinates using sensor information (optional)
- Average elevation (meters) (optional)
- Time Shift Observations File (e.g. time_shifts.csv) (optional)

OK Cancel Environments... Show Help >>

Time Synchronization

Non-MISB Metadata Support

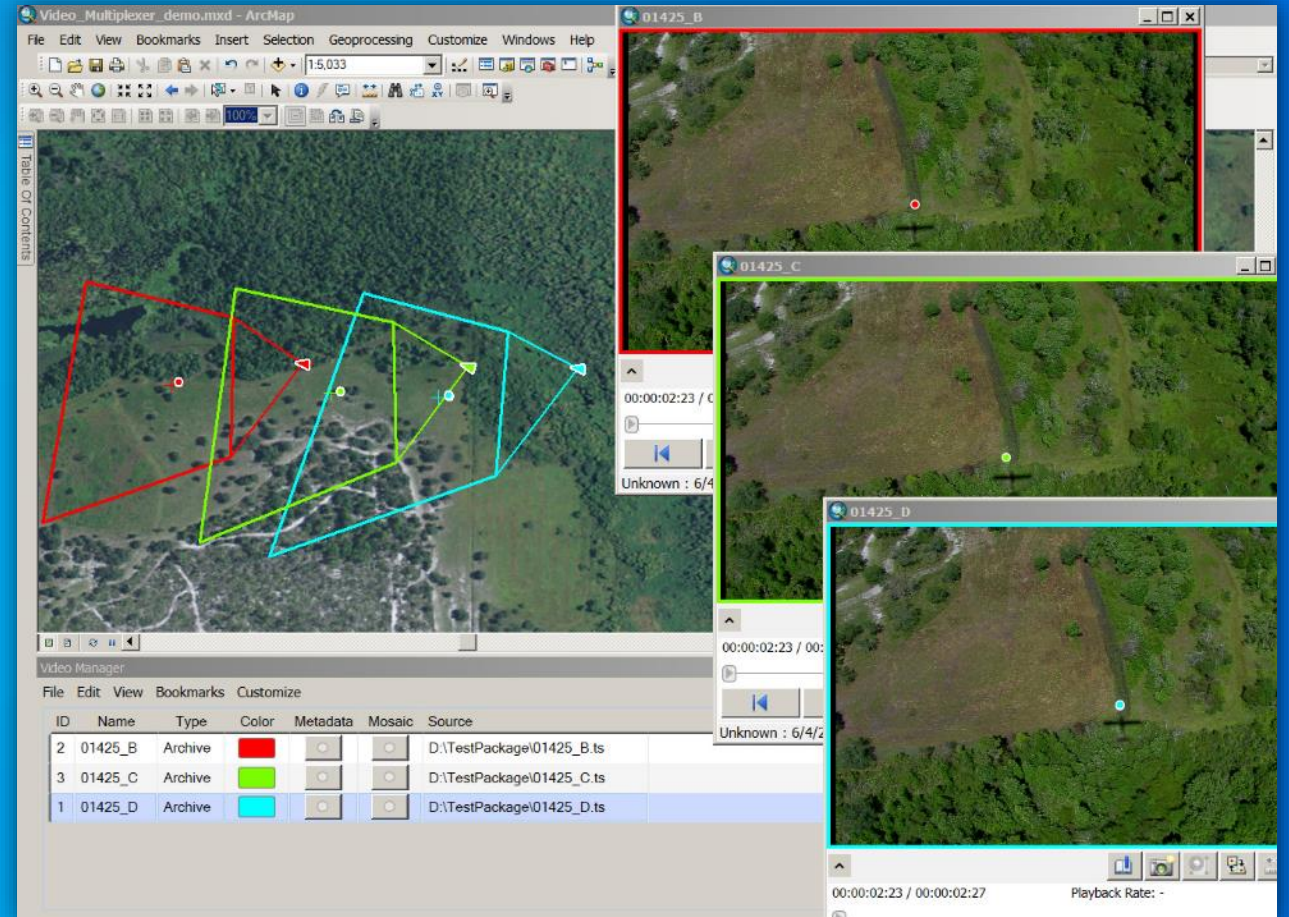
- The workflow...
 - Make multiple time-adjusted videos.
 - Pause each video while observing a common feature (e.g. a road)
- The results
 - Red is the original video
 - Green is a 5 second consistent time shift
 - Blue is a 5-9 second differential time shift.



Time Synchronization – Testing the results of the time-shift

Non-MISB Metadata Support

- Do the time warp again and pause all videos near the end.
- Footprints show differences in geo-referencing
- Blue has the best results

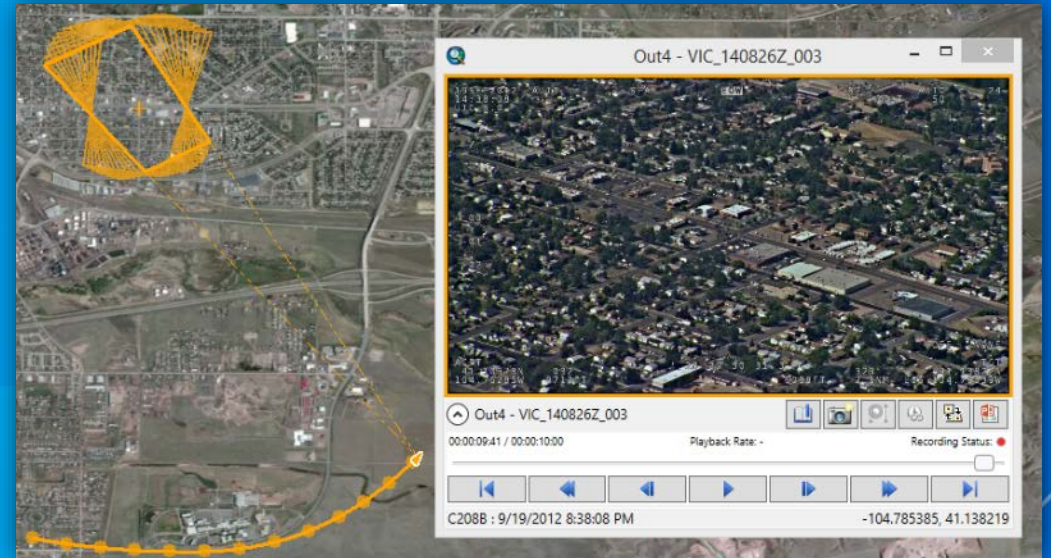
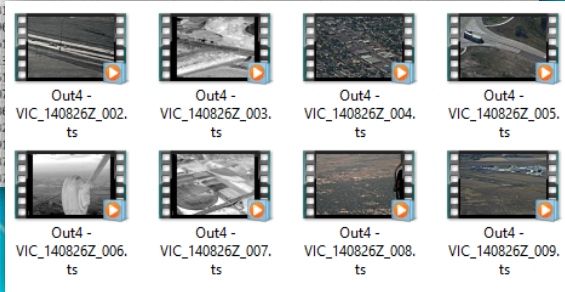


Video Multiplexer in Summary

Why we're so excited about it!

- Works with non-MISB metadata to make your videos MISB-compliant (Ready for the FMV Add-in)
- Calculates frame center and corner data *automatically*
- Fixes time synchronization issues

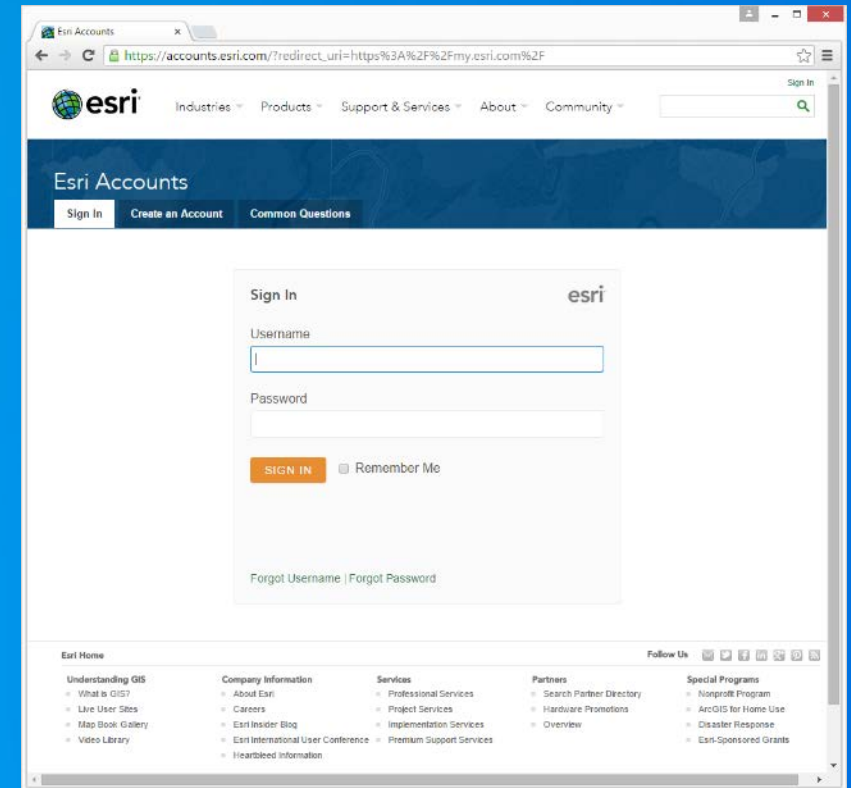
TimeStamp	PlatformHeading	PlatformPitch	PlatformRoll	SensorLatitude	SensorLongitude	SensorAltitude	HorizontalFOV
1433429777800780	276.689403	0.043947	6.382946	27.405409	-82.126628	174.209201	52.301213
1433429777960930	276.22797	0.043947	6.613361	27.405412	-82.126687	173.635462	52.301213
1433429778121090	275.854429	0.076907	6.503494	27.405414	-82.12674	173.348592	52.301213
1433429778281250	275.579767	0.175787	6.283761	27.40542	-82.126794	173.061723	52.301213
1433429778480460	275.371023	0.29664	5.932798	27.405422	-82.126864	172.487984	52.301213
1433429778640620	275.239185	0.42848	5.558947	27.405425	-82.126917	172.201114	52.301213
1433429778800780	275.206226	0.736106	5.174413	27.405428	-82.126976	171.627375	52.301213
1433429778960930	275.283133						
1433429779121090	275.392999						
1433429779281250	275.502866						
1433429779480460	275.623717						
1433429779640620	275.78851						
1433429779800780	275.953303						
1433429779960930	276.052188						
1433429780121090	276.096113						
1433429780320310	276.129099						
1433429780480460	276.173033						
1433429780640620	276.173033						



Where can my organization get the Esri FMV software?

FMV 1.2.1 and GP Tools 1.1 are both downloaded from my.esri.com.

1. Open your Organization account in My.Esri.com (Got to <https://my.esri.com/welcome>)
2. Click the Downloads tab
3. Click the "View Downloads" button that corresponds the version of ArcGIS Desktop you're using (i.e. 10.3)
4. Select "Additional Product" drop down towards the bottom of the page
5. The FMV tools are on that list. Click the Download button to begin downloading the software.



Download FMV Software

ArcGIS FMV

Demos





Understanding our world.