Development of Standard Data Format for 2-Dimensional and 3-Dimensional (2D/3D) Pavement Image Data

Project Progress Report

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Outline

- RFP Requirements
  - NO. DTFH6115Q00022
- Approaches & Current Status
- Survey Summary & Future Plan
- Video Demo, File Format

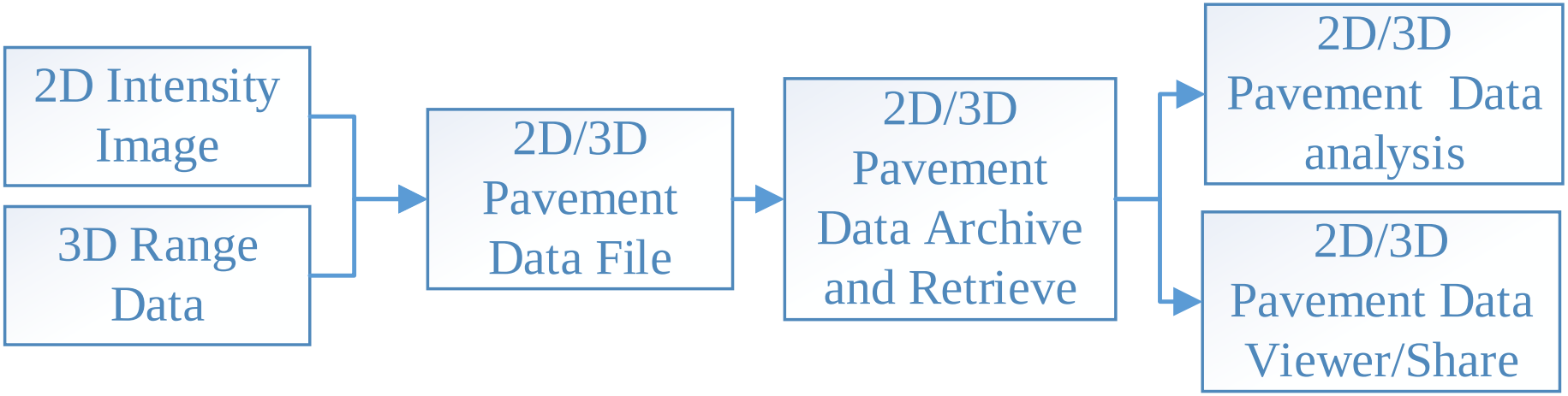
Objective in RFQ

- Establish a recommended standard data format for 2D/3D pavement image data
  - Share various sources of data between users, software tools, & electronic platforms
  - Facilitate workable protocols for condition surveys
  - Promote the demand of new 2D/3D technologies
  - Accelerate the development potential of analysis tools for pavement condition

Objective in RFQ (Cont.)

- Support the structure of the AASHTO standards, separating collection from analysis
- Develop verification protocols in the AASHTO standards
- Use for standard viewer software
- Apply analysis algorithms from anyone to 2D/3D digital images from different sources

Pavement Imaging Data Flow



Data Collection

Data File Required in RFQ

Database Management

Applications

Project Tasks

- Task 1—Kickoff Meeting
- Task 2—Research Current Practices
- Task 3—Evaluate Data Items and Formats
- Task 4—Develop Metadata and Proposed Standards

Work Plan

	Months											
	1	2	3	4	5	6	7	8	9	10	11	12
Task 1 Kickoff Meeting		RP										
Task 2 Research Current Practices												
Task 3 Evaluate Data Items and Formats						RP	RP					
Task 4 Develop Metadata and Proposed Standards										MD		STD

RP = Draft and Final Summary Report to FHWA

MD = Draft and Final Metadata Format to FHWA

STD = Draft and Final Data Standard to FHWA

Task 1 Kickoff Meeting

- Completed on August 7, 2015

Task 2 Study Current Practices

- Review Common Pavement Image Data and Data Formats (**in progress**)
  - Data collection technology
  - Data items collected and protocols
  - Data format
  - Data management practices
- Survey of TPF-5(299) Participating Highway Agencies and Technology Suppliers (**about completed**)

Task 3 Evaluate Data Items &Formats

- Identify and Select Best Practices of Image Data Collection (**in progress**)
- Evaluate Data Items Collected and Data Formats (**in progress**)
- Prepare and Submit Interim Report

Task 4 Develop Metadata & Standards

- 4.1 Develop Data Format Requirements (**in progress**)
- 4.2 Develop File Structure and Data Format (**in progress**)
- 4.3 Evaluate and Incorporate Compression Algorithms for 2D/3D Image Data (**in progress**)

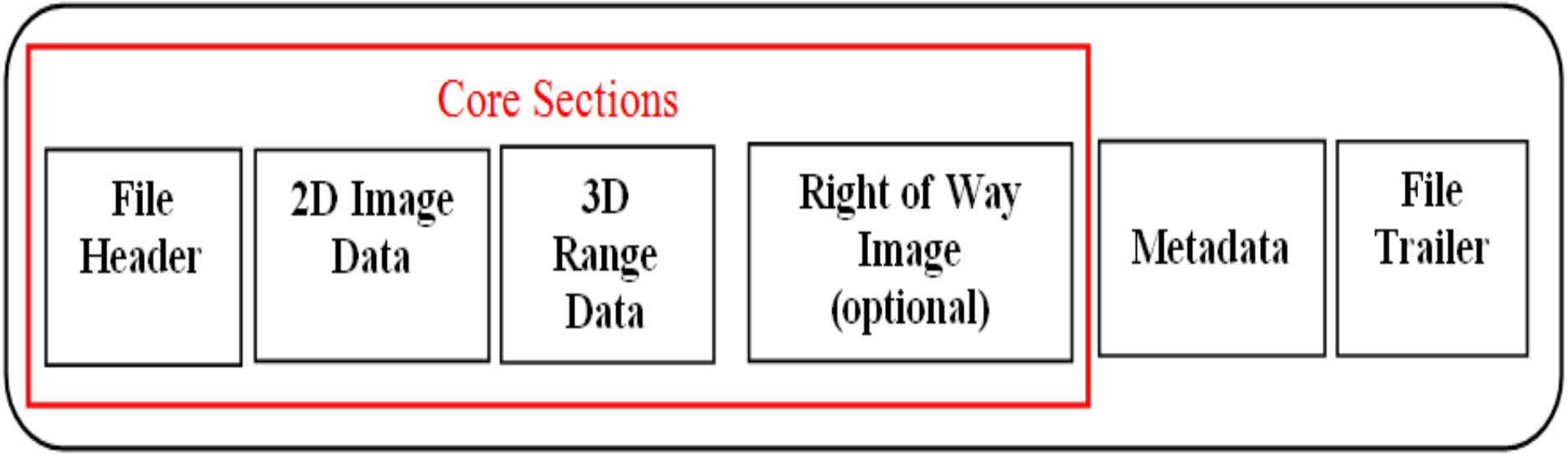
Task 4 Develop Metadata & Standards

- 4.4 Develop Guidelines for the Development of Future Pavement Viewer Software (**in progress**)
- 4.5 Develop Guidelines for Future Database Management
- 4.6 Recommendation of Developing Web-Based Validation Software
- 4.7 Draft Proposed Standards

Guiding Principles

- Simplicity
- Low barrier for adoption
- Encoding/decoding Speed
- Backward & forward compatibility
- Extensibility: new technologies

File Structure



1. Backward compatibility - read & display a file written based on gen 1 definition
2. Forward compatibility - read & display newer format in the future

File Header

- Core Properties of 2D/3D Data
  - Reading 2D/3D data: file format version, image size, resolution, bit depth, compression algorithm name, storage offset
  - Fast archiving and retrieving for database management

File Header Item Examples

- Data reading/writing

Variable Name	Data Type	Data Details
Version	4-byte String	Identifies the version number of the file format
3D Compression Method	1-byte String	Identifies compression algorithms, such as 1: PNG; 2: JPEG; 3:JPEG2000.
3D Width	Int32	Pixel numbers in transverse direction
3D length	Int32	Pixel numbers in longitude direction

- Database management

Variable Name	Data Type	Data Details
Route Name	8-byte String	Name of the highway
Direction	2-byte String	Direction of travel
Lane identification	2-byte String	Lane index
GPS Longitude	12-byte String	GPS longitude value

Options of Data Definitions (Example)

- GPS date encoding options
  - IEEE-754 FP
  - Fixed point value, 32 or 64 bit
  - Mapping of an integer to degree range
  - Degrees, minutes, seconds stored as an integer data type
- Selection of GPS encoding type?
  - The ideal data type to store in SQL
  - Decimals with proper precision

Metadata Section

- Existing metadata data formats
  - Rigid: fixed sized fields and records, such as Weigh-In-Motion (WIM) data in the FHWA Traffic Monitoring Guide
  - Flexible: self-documenting structures with variable lengths and structure, such as the Extensible Markup Language (XML) standard
  - Hybrid: with merits of both approaches, such as ASTM E2560-13

Compression Algorithms

- Recommendation of Compression Methods
  - Lossy: such as JPG, JPEG2000
  - Lossless: such as PNG
  - Hybrid: with the merits of both

Guidelines for Viewer Software

- Two levels of design
  - Single File Viewer: display 2D/3D images in a single file
  - Route Viewer – display several to several 100 meters in length for a single-lane pavement
- Viewer software: not required in the contract

Database Management

- File Header
  - Fixed in size/length
  - Provide information for database management software
- Other information
  - Metadata at the end of file for (flexible in size)

Other Tasks

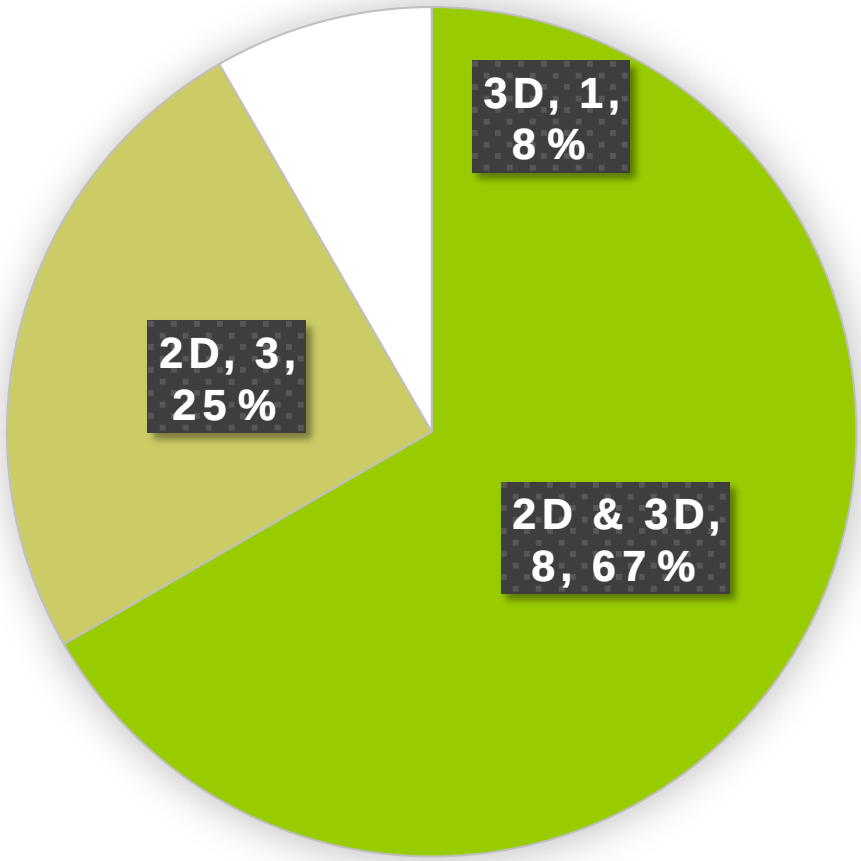
- Recommendation of developing web-based validation software
- Development of draft proposed standards for AASHTO, ASTM or other standards organizations as directed by the TPOC

Summary of Survey

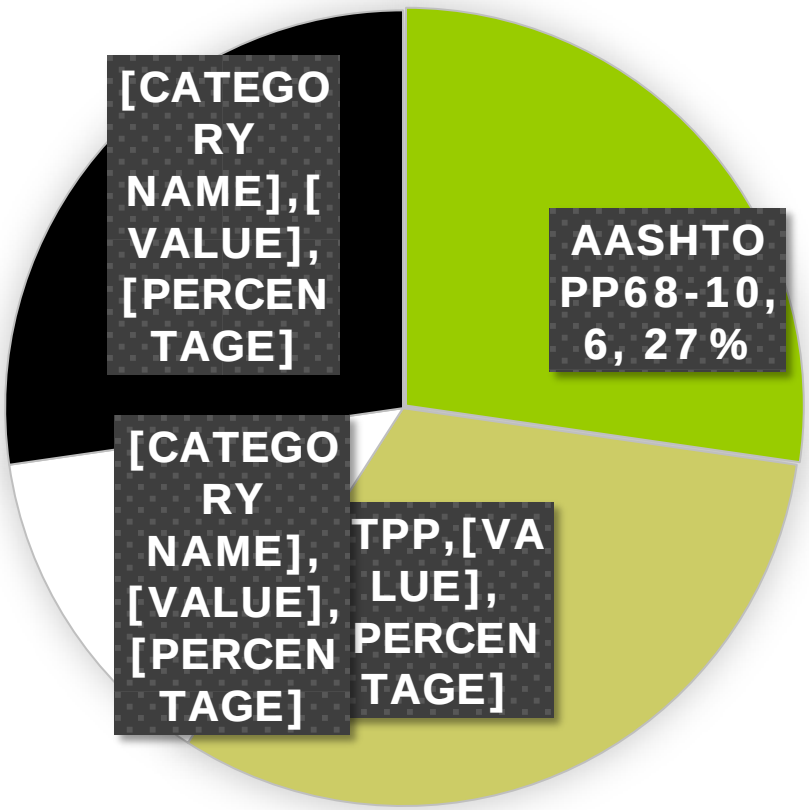
- 15 Participated
  - 10 DOTs
  - 4 Vendors
  - 1 Academia
- 14 Responded
  - 11 DOTs
  - 3 Vendors

Pavement Image Data

Data Collection Technology

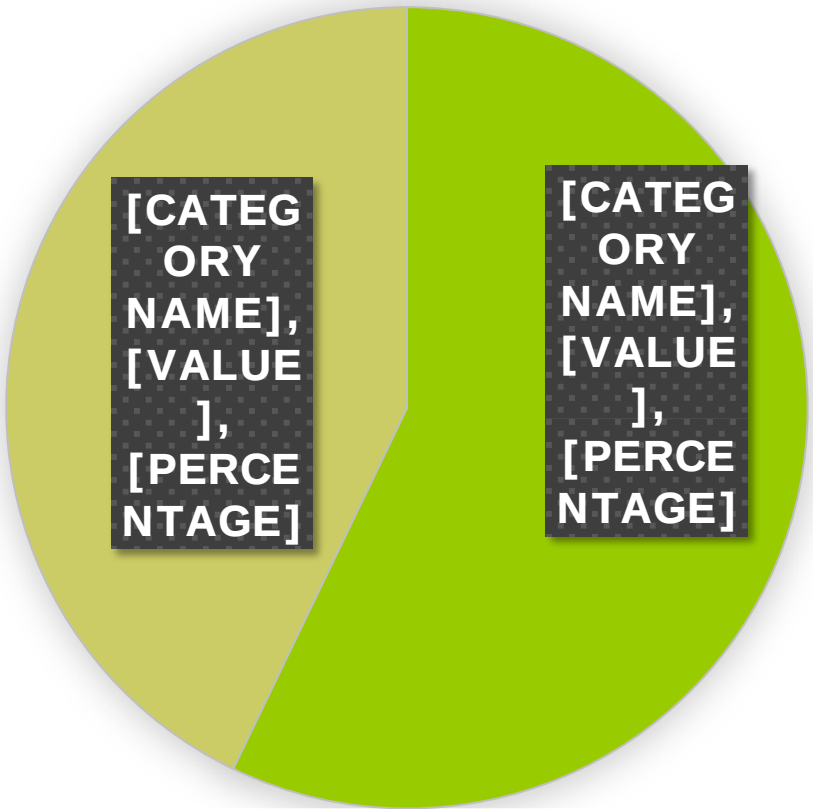


Data Collection Protocols

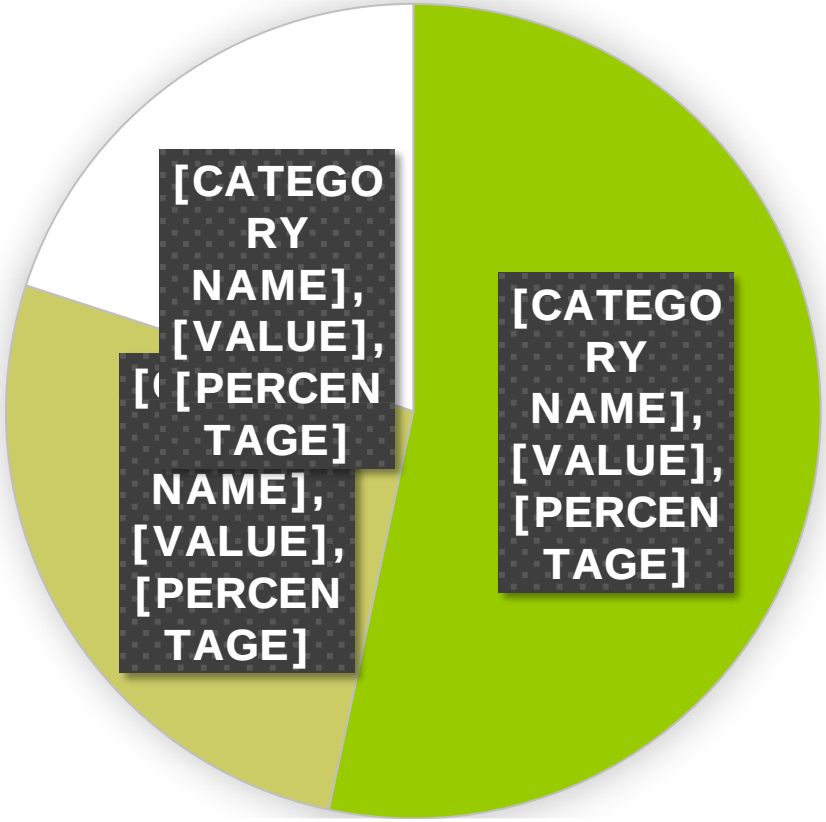


Longitudinal Profile Data

Data Collection Technology

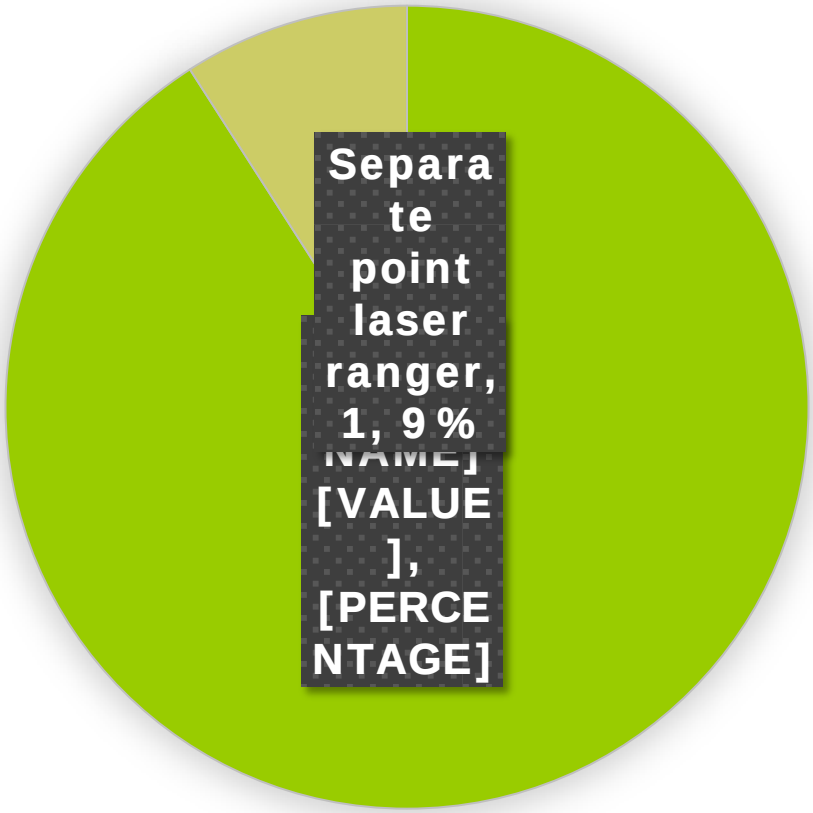


Data Collection Protocols

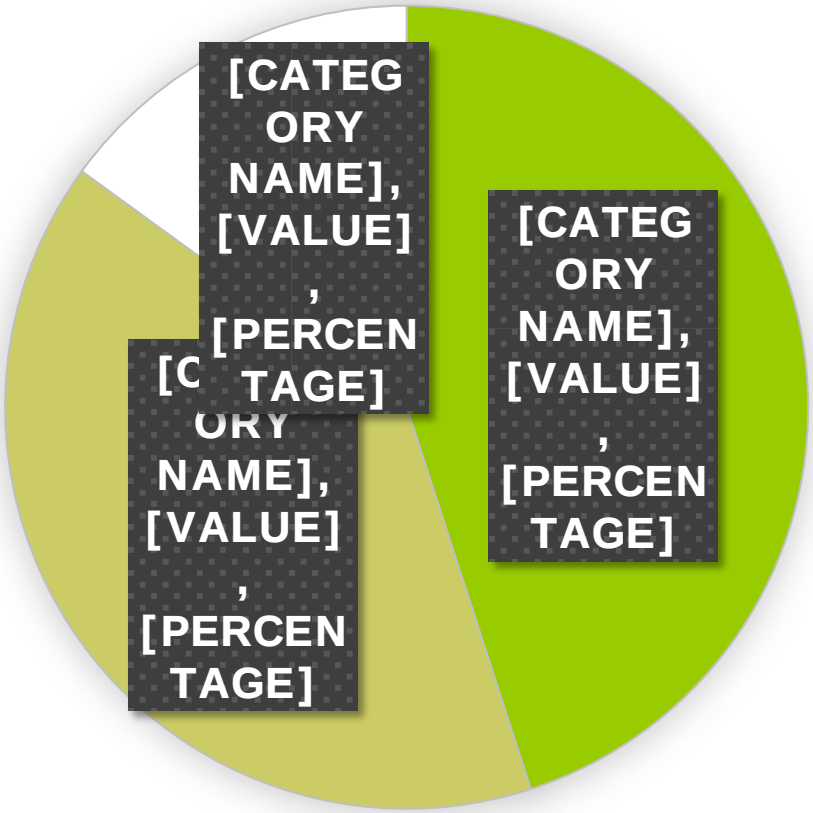


Transverse Profile Data

Data Collection Technology

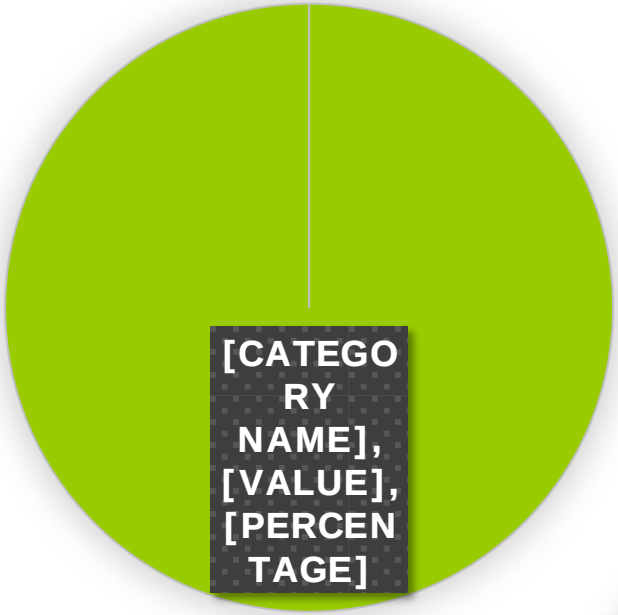


Data Collection Protocols

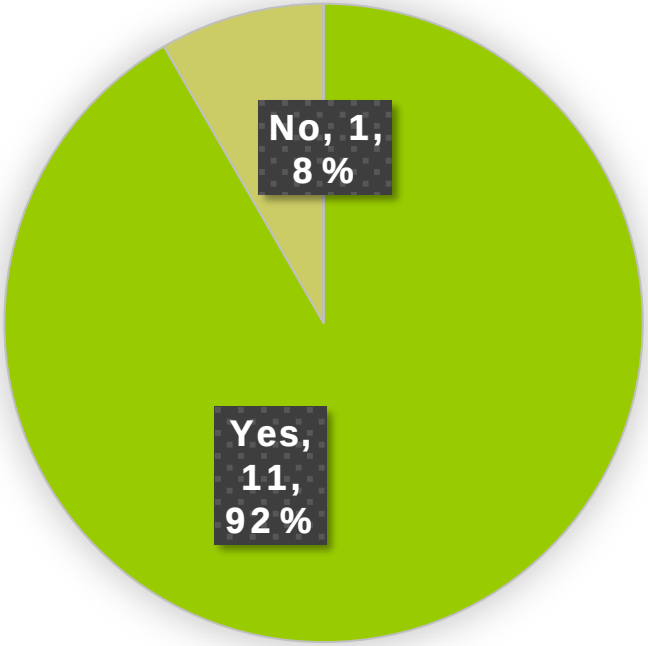


Other Data

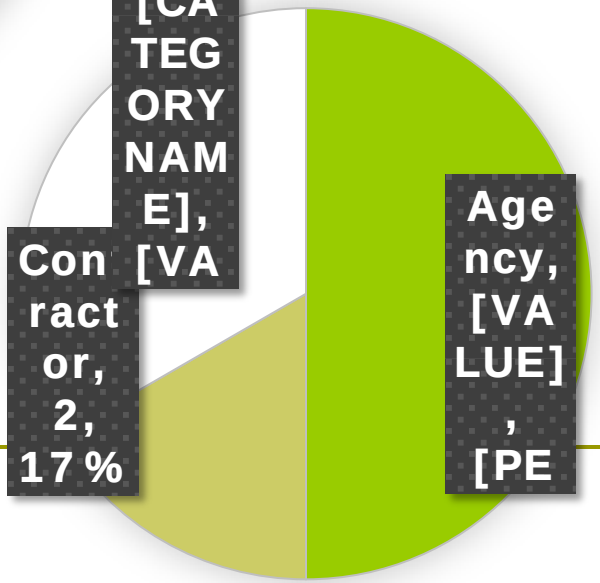
Peripheral Data collection (Y/N)



IMU data collection (Y/N)



Data Collection Crew



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Data Management

- Preferred report length: 26.4 feet (5)
- Store 2D & 3D into one file: 9
- Location Reference
  - Mile post & GPS coordinate: 11
  - Link-node: 2
- Data Management
  - Database: 6
  - Simple inventory: 6
- Data Transfer
  - Network-based file server: 11
  - Electronic media: 8
  - Web based: 5

Data Format

- Preferred 2D image type
  - Gray 8 bits: 9
  - Color 24 bits: 2
- 3D data dynamic range: 16 bits (7)
- 2D & 3D image compression: JPG
- Right-of-Way data format: JPG
- LiDAR data: 2 agencies recommend "including LiDAR into the data format"

Recommendations for File Header

- Add millisecond to time data: 12 byte string
- Reserve fields for the future & vendor specific
- Lane identification: 2 byte string
- GPS: 12 byte string
- 2/3D Compression Method(s): 4 byte string using compression name
- Add Vehicle Number: 8 Byte string
- Add Operator Name: 32 Byte string
- Route Name: 12 byte according to HPMS standard

Key Feedback from the Survey

- "A universal standard that everyone will WANT to use."
- "Need to be very clear about the purpose(s) of this effort"
- "Need to respect the intellectual property of those involved"

Feedback from the Survey

- "Why ROW data in this standard?"
  - ROW data: an optional item
  - Time and distance stamps in file header: for synchronization between ROW and image data

— Standard Data Format Demo —

Preliminary data format based on the proposal and survey feedback

Purposes of the Demo

- Demonstrate technical feasibility
  - Write various image data (with different resolution & size and metadata) using the standard data format
  - Read standard formatted image data using one program
- Identify Key Issues for Improvements

Standard Data Format Demo

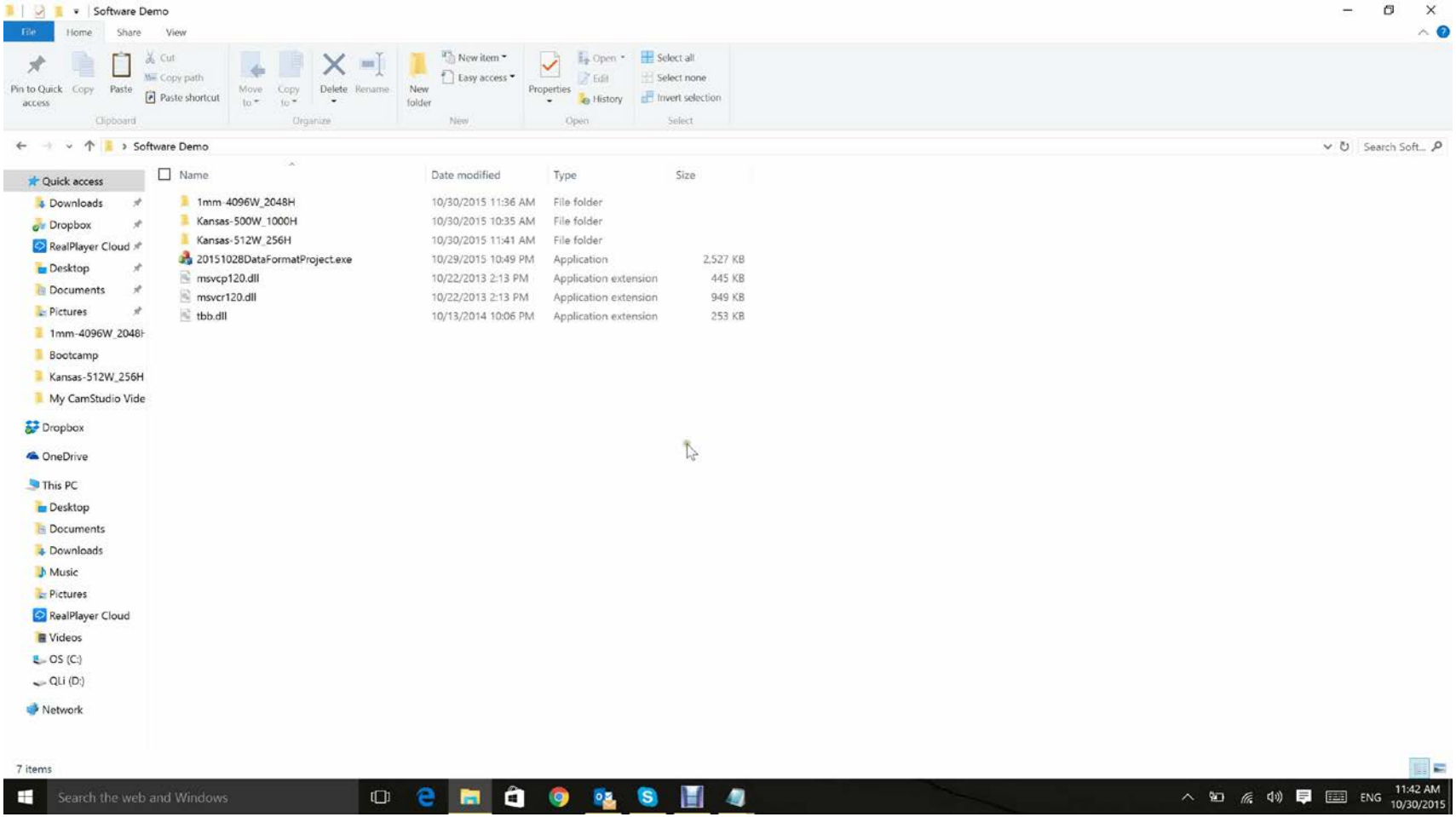
- Data Encoding (Writing)
  - Inputs: raw 2D/3D data and metadata
  - Output: single compressed binary file
- Data Decoding (Reading)
  - Input: compressed binary file
  - Outputs: decoded 2D/3D data and metadata

Data Encoding (Writing)

- Three data sets from different vendors

Name	Date modified	Type
1mm-4096W_2048H	10/30/2015 11:46 AM	File folder
Kansas-500W_1000H	10/30/2015 10:35 AM	File folder
Kansas-512W_256H	10/30/2015 11:45 AM	File folder

Demo Video, Data Format



Data Compression

- One millimeter resolution, one lane-width

2D-4096x2048.csv	25,436 KB
3D-4096x2048.csv	32,770 KB
metadata.csv	1 KB

Encoded_File.299	1,664 KB

- Without Compression
  - 1 mile =1609.34 meters
  - 1609/2.048= 785.64453 (images)
  - 785.64453x(25436+32770)=45,729,225.51KB
- With Compression
  - 785.64453x1664= 1,307,312.49KB

Key Challenges

- Proprietary intellectual protection vs. Open standard data format for wide implementation
  - Compression algorithms for 16-bits: dll files?
  - Or Open the algorithms for encoding and decoding
- Various Platform
  - Various programming languages
  - Various Operation Systems

Comments?

Thank You!

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