Visual Acuity and Task-Based Video Quality in Public Safety Applications

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Acknowledgement

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VQiPS

- Video Quality in Public Safety
  - A working group under DHS
  - Practitioners, researchers, industry
  - Hosts annual workshops
  - Always looking for volunteers
  - http://www.pscr.gov/projects/video_quality/vqips/vqip

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Video Quality

- Our goal is to develop recommendations for public safety practitioners
  - Minimum requirements to meet their needs
- What is quality in public safety applications?
  - MOS is not appropriate for public safety
  - Video must be useful—we have taken a task-based approach
- We wish to avoid specific use cases
  - For efficiency, one set of recommendations should apply to police, fire fighters, EMS, etc.

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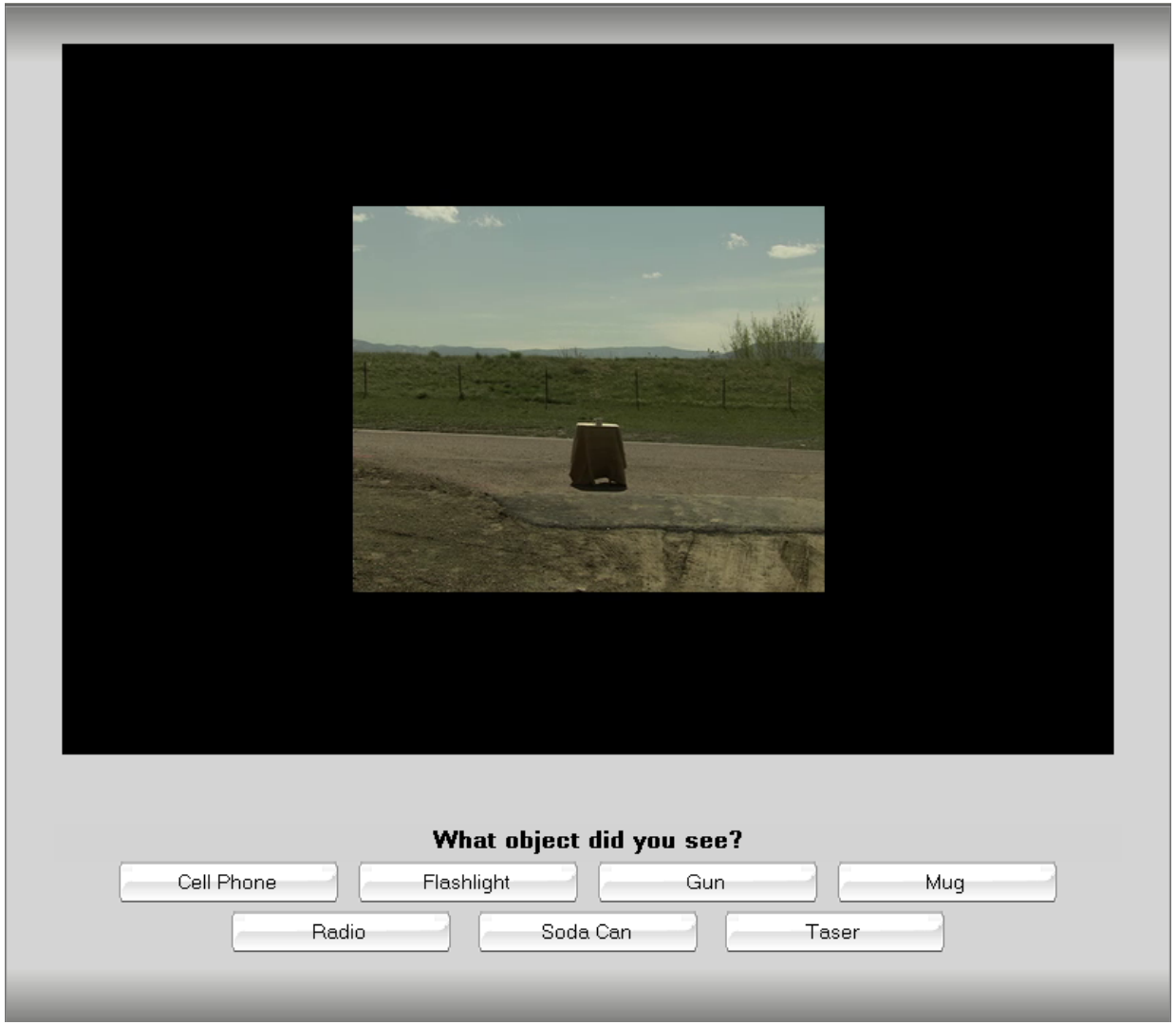
Example: The Object Recognition Task

- The object recognition task is common across public safety applications
- Forced Choice



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Generalized Use Classes (GUC's)

- Developed by Video Quality in Public Safety (VQiPS) working group
- Three parameters describe scene content
  - Target size: Large or small?
  - Motion: High motion or low motion?
  - Lighting level: Bright, dim or variable?
- Two parameters for how the video is used
  - Usage Timeframe: Live or recorded video?
  - Discrimination Level: Do you need positive ID, characteristics, classification, or just general awareness?

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Test Design Problem

- The scene content and use parameters define 96 different GUC's
- We wish to examine 10 different video systems of varying resolution and bitrate
- The direct approach would require task-based quality assessment under 960 different conditions
  - A prohibitive amount of subjective data

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Test Design Solution

- Use a quality metric to separate scene content parameters from use parameters
  - One test measures the quality supplied by each video system applied to each type of scene
    - This test measures performance of the object recognition task in parallel to provide a basis for judging our metric
  - A second test measures the quality required for each desired use (e.g. Positive ID, target classification, etc.)

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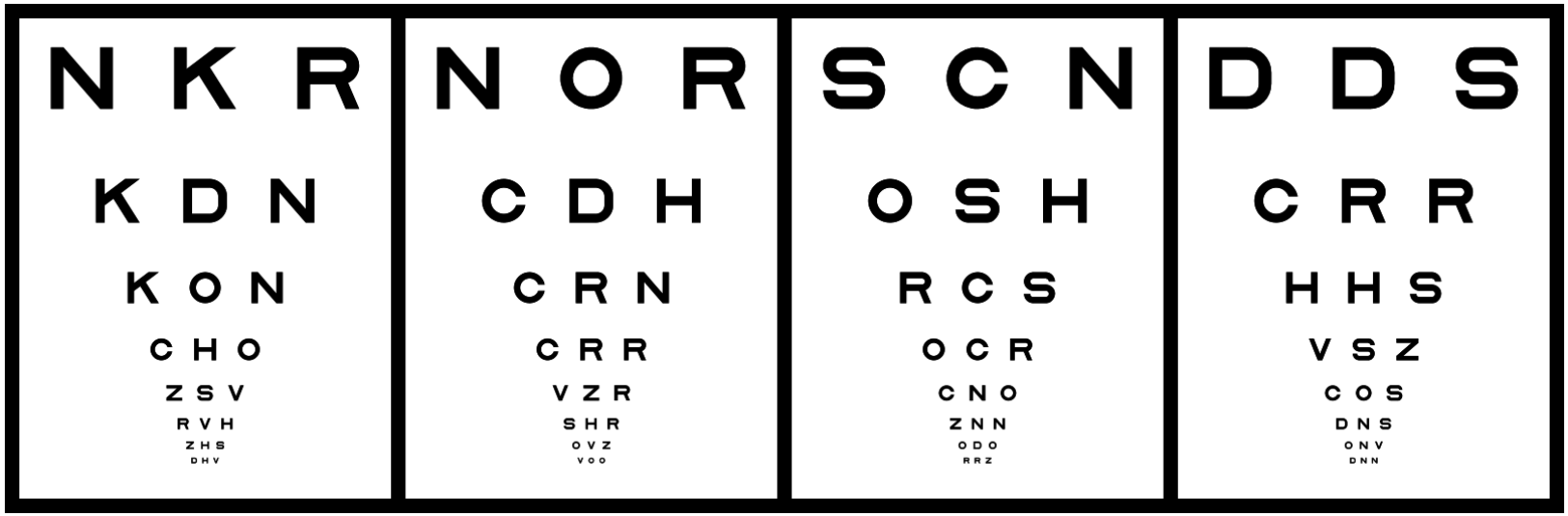
Visual Acuity

- A metric that incorporates a recognition task
- Can be measured “in the field”
- Determined by the smallest Sloan letters than can be reliably recognized on a reduced LogMAR chart



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Test Details

- Scene content parameters
  - Lighting: Outdoor, bright, dim w/ flashing, flashing only
  - Motion: Stationary, walking speed
  - Target Size: Small, large
- Items: Gun, taser, radio, flashlight, cell phone, mug, soda can
- Processing parameters (HRC's)
  - Resolutions: CIF, VGA
  - Bitrates: five choices for each resolution
  - All clips were encoded with H.264, main profile

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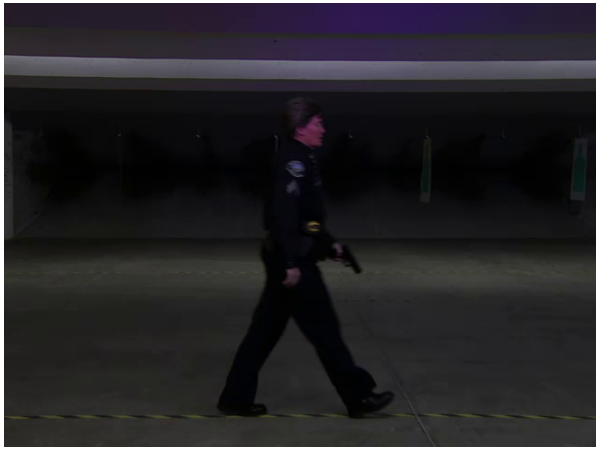
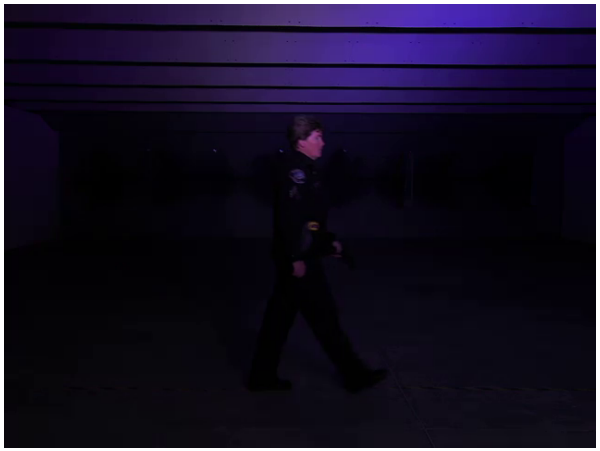
Lighting Examples

Outdoor

Bright



Dim w/ Flashing



Flashing Only

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Motion and Target Size Examples

Walking, Large Target

Walking, Small Target

Stationary, Large Target

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More Test Details

- For a given scenario group, scenes were held as constant as possible
  - Only the target object changes
  - Combats memorization
- Acuity charts were synthetically inserted into test sequences
  - Motion and lighting were carefully simulated
- Collected data from 39 viewers
  - Asked to read acuity charts and identify objects for each sequence
- Methods described in ITU-T Recommendation P.912

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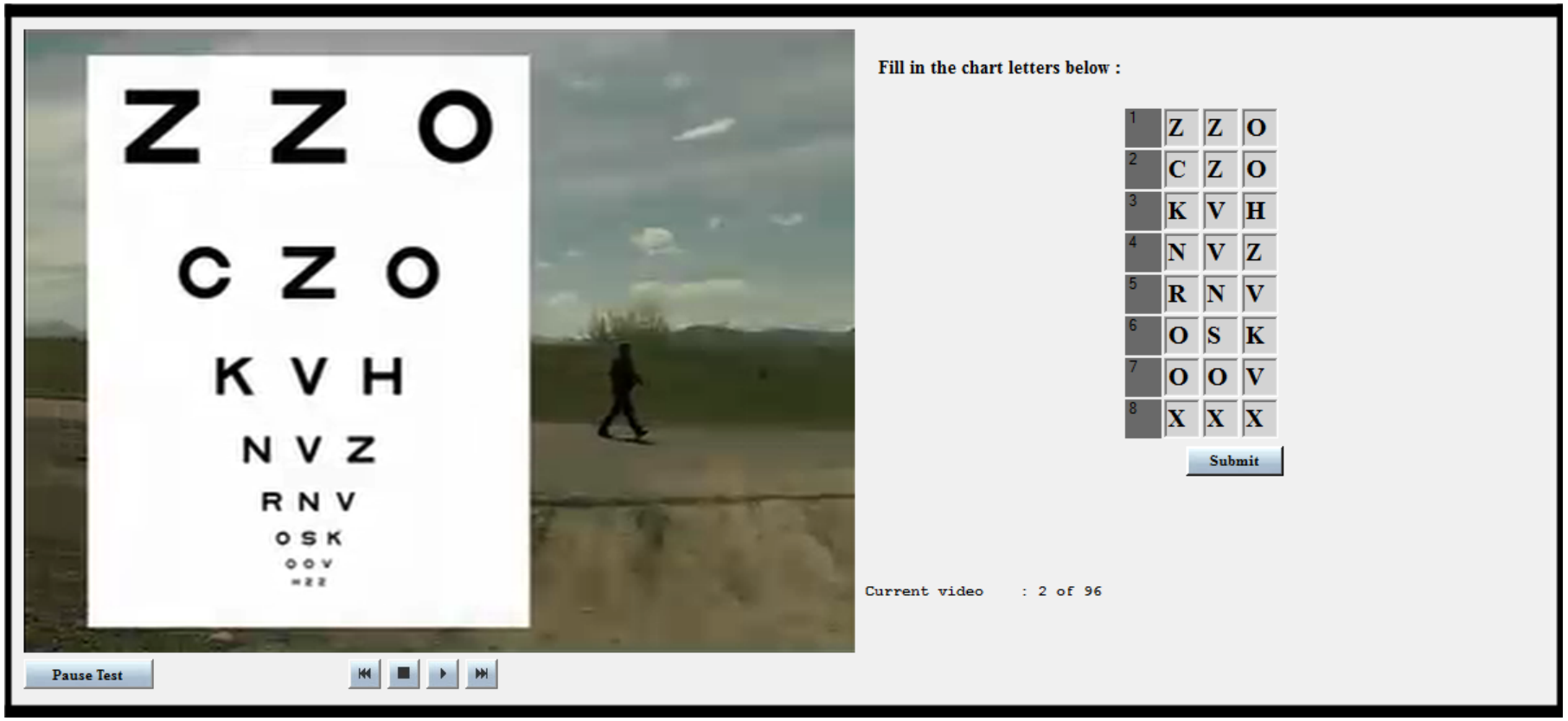
Test Interface – Visual Acuity



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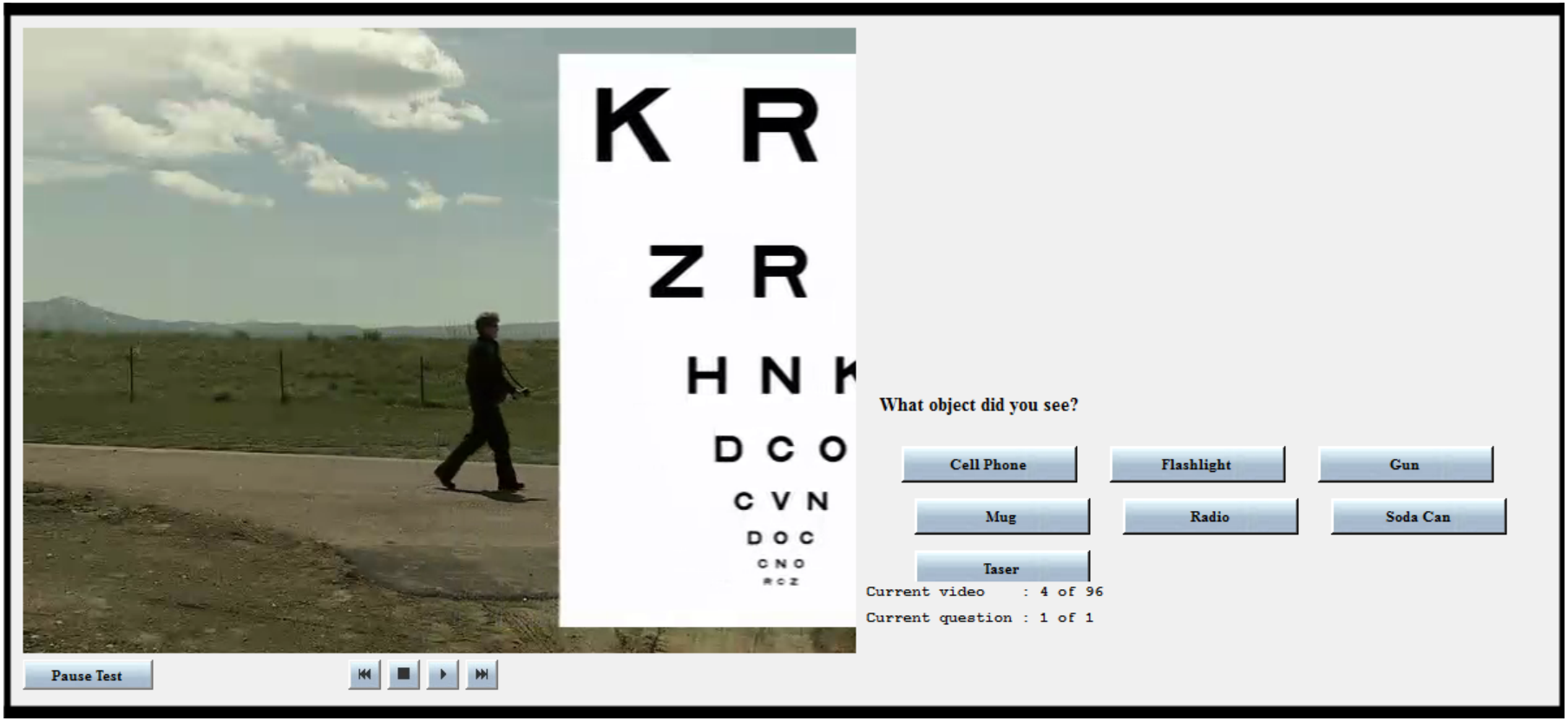
Test Interface – Object Recognition



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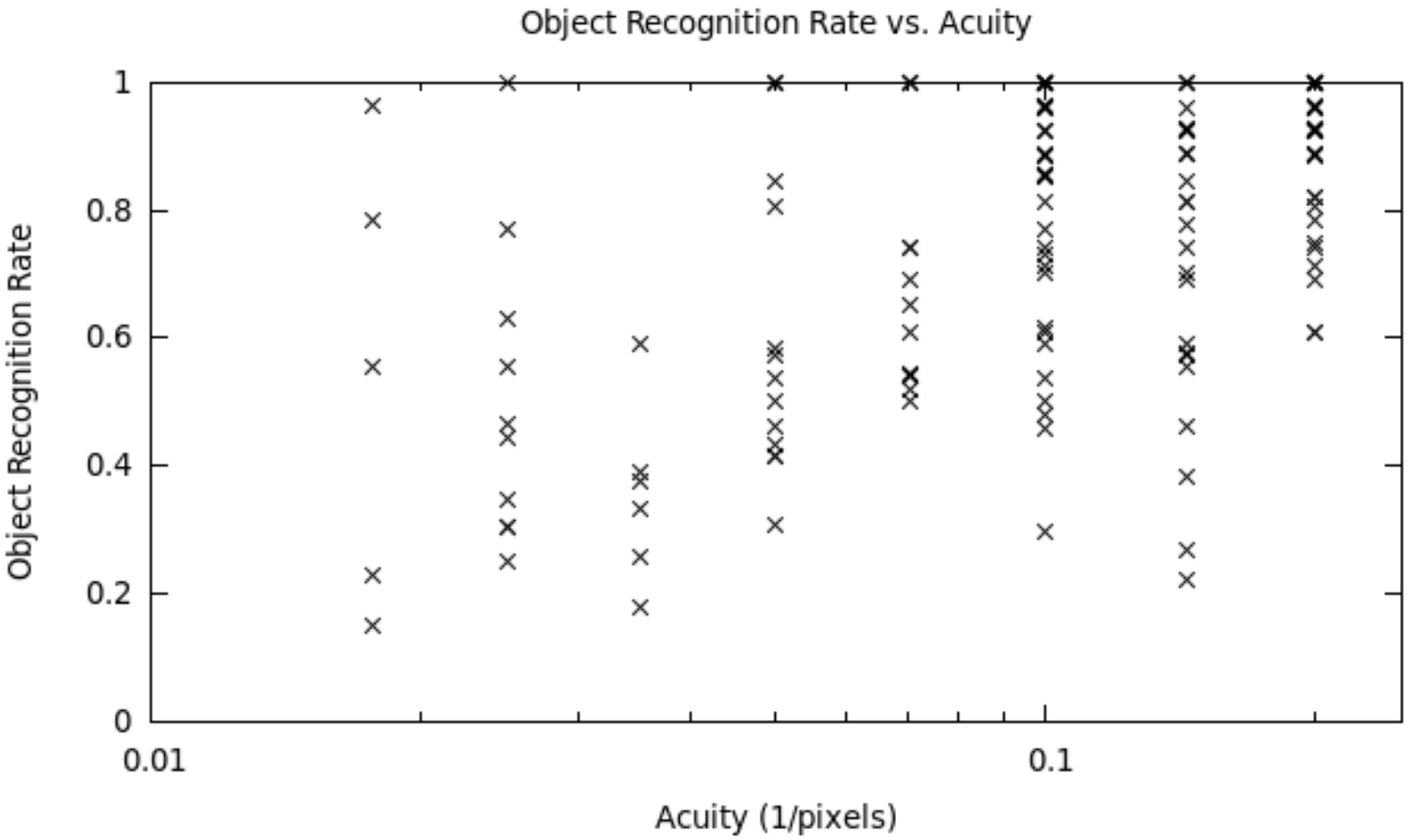
Results

- Viewers were treated as statistically equivalent
- Acuity is the inverse of the height (in pixels) of the smallest characters correctly recognized 90% of the time



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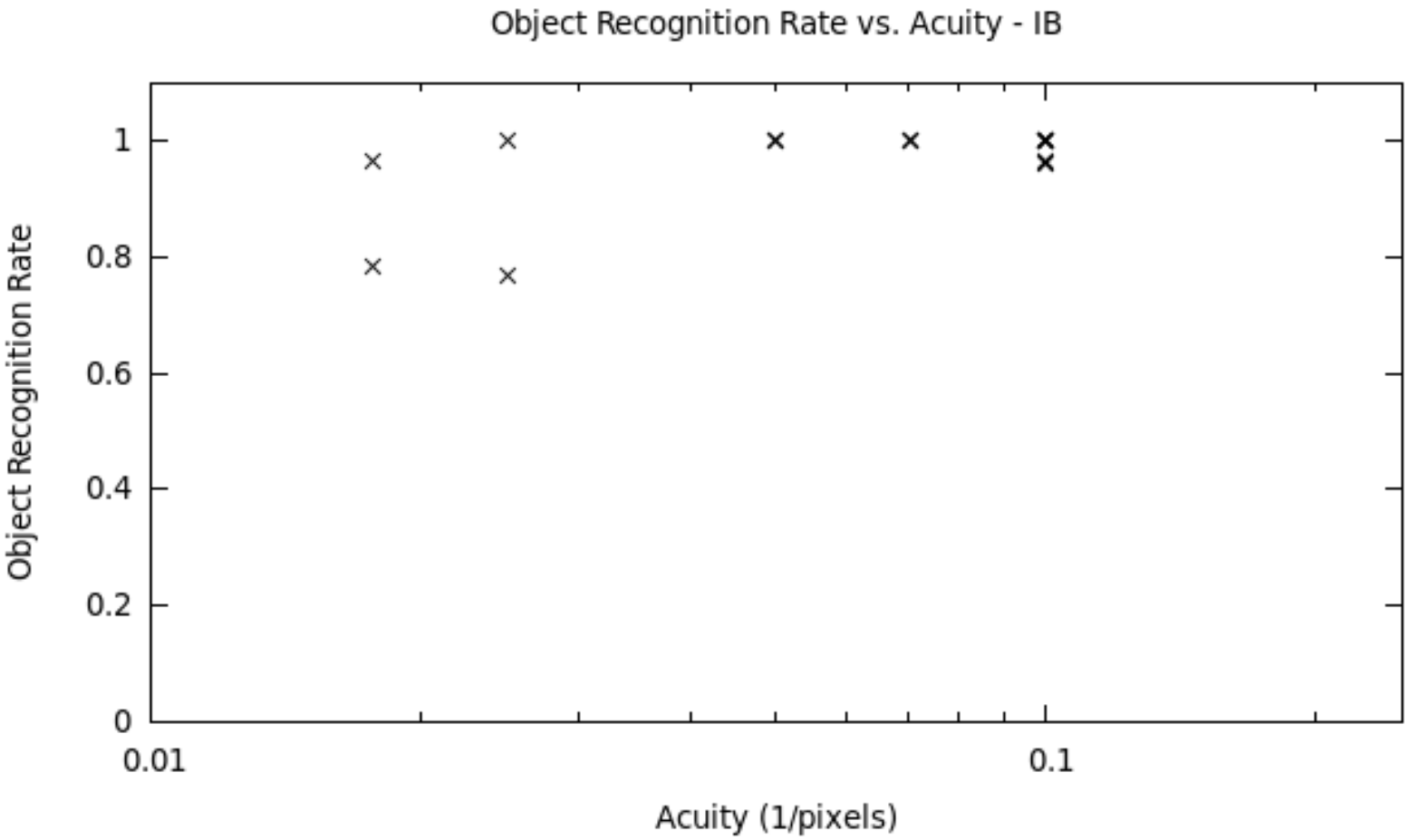
Outliers

- Bright light, high motion, large targets
  - Shows low acuity with high recognition rate



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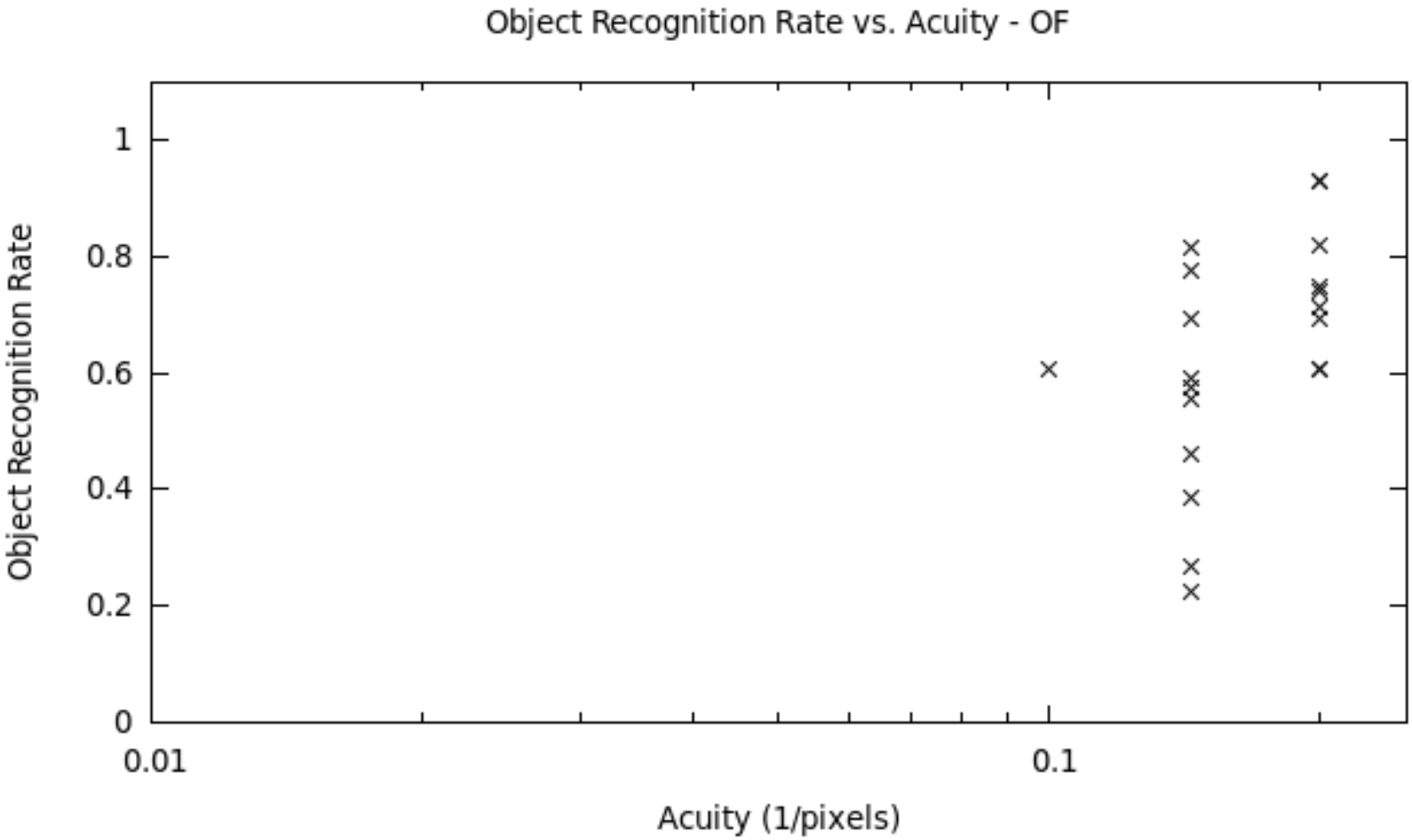
Outliers (cont.)

- Bright light, high motion, small targets
  - Shows high acuity with low recognition rate



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Conclusions

- The relationship between acuity and recognition rate varies greatly with target size
  - Intuitively, recognizing a small target should require more acuity
  - We hypothesize that recognizing a small target is a fundamentally different task from recognizing a large target
  - VQiPS should have treated target size as a use parameter rather than a scene content parameter
    - Target size may not be independent from discrimination level
- In other GUC's acuity tracks recognition rate relatively well
  - Especially with low light—lighting parameter dominates

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Beyond Object Recognition

- New tasks designed for most recent test

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Recommendations

Scenario	General Elements	Classification	Characteristics (75-percent perfect)	Positive ID (90-percent accuracy)
Bright light, low motion, large target	64 kbps, CIF	64 kbps, CIF	64 kbps, CIF	128 kbps, CIF
Bright light, low motion, small target	128 kbps, VGA	128 kbps, VGA	128 kbps, VGA	128 kbps, VGA
Bright light, high motion, large target	64 kbps, CIF	64 kbps, CIF	128 kbps, CIF	*1024 kbps, CIF
Bright light, high motion, small target	128 kbps, VGA	128 kbps, VGA	128 kbps, VGA	256 kbps, VGA
Dim light, low motion, large target	128 kbps, CIF	128 kbps, CIF	256 kbps, CIF	512 kbps, CIF
Dim light, low motion, small target	256 kbps, VGA	256 kbps, VGA	512 kbps, VGA	512 kbps, VGA
Dim light, high motion, large target	128 kbps, CIF	256 kbps, CIF	512 kbps, CIF	*1024 kbps, CIF
Dim light, high motion, small target	512 kbps, VGA	512 kbps, VGA	1024 kbps, VGA	*2048 kbps, VGA
Variable light, low motion, large target	256 kbps, CIF	512 kbps, CIF	512 kbps, CIF	*1024 kbps, CIF
Variable light, low motion, small target	256 kbps, VGA	1024 kbps, VGA	1024 kbps, VGA	*2048 kbps, VGA
Variable light, high motion, large target	256 kbps, CIF	1025 kbps, CIF	*1024 kbps, CIF	*1024 kbps, CIF
Variable light, high motion, small target	512 kbps, VGA	512 kbps, VGA	*2048 kbps, VGA	*2048 kbps, VGA

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Web Tool

- http://www.pscr.gov/outreach/vqips/vqips_guide/rec_tool_vid_reqs.php

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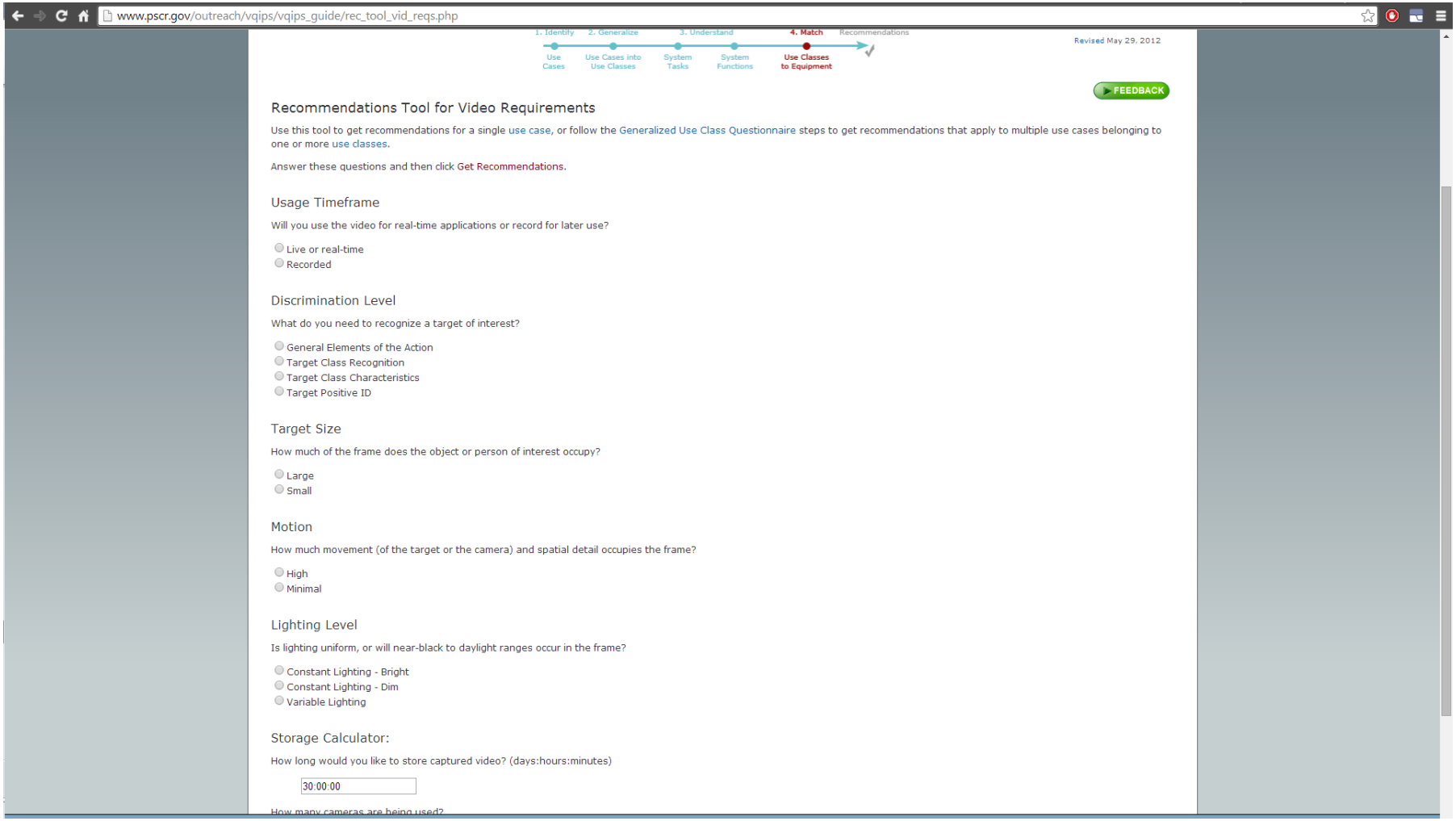
Web Tool - Inputs



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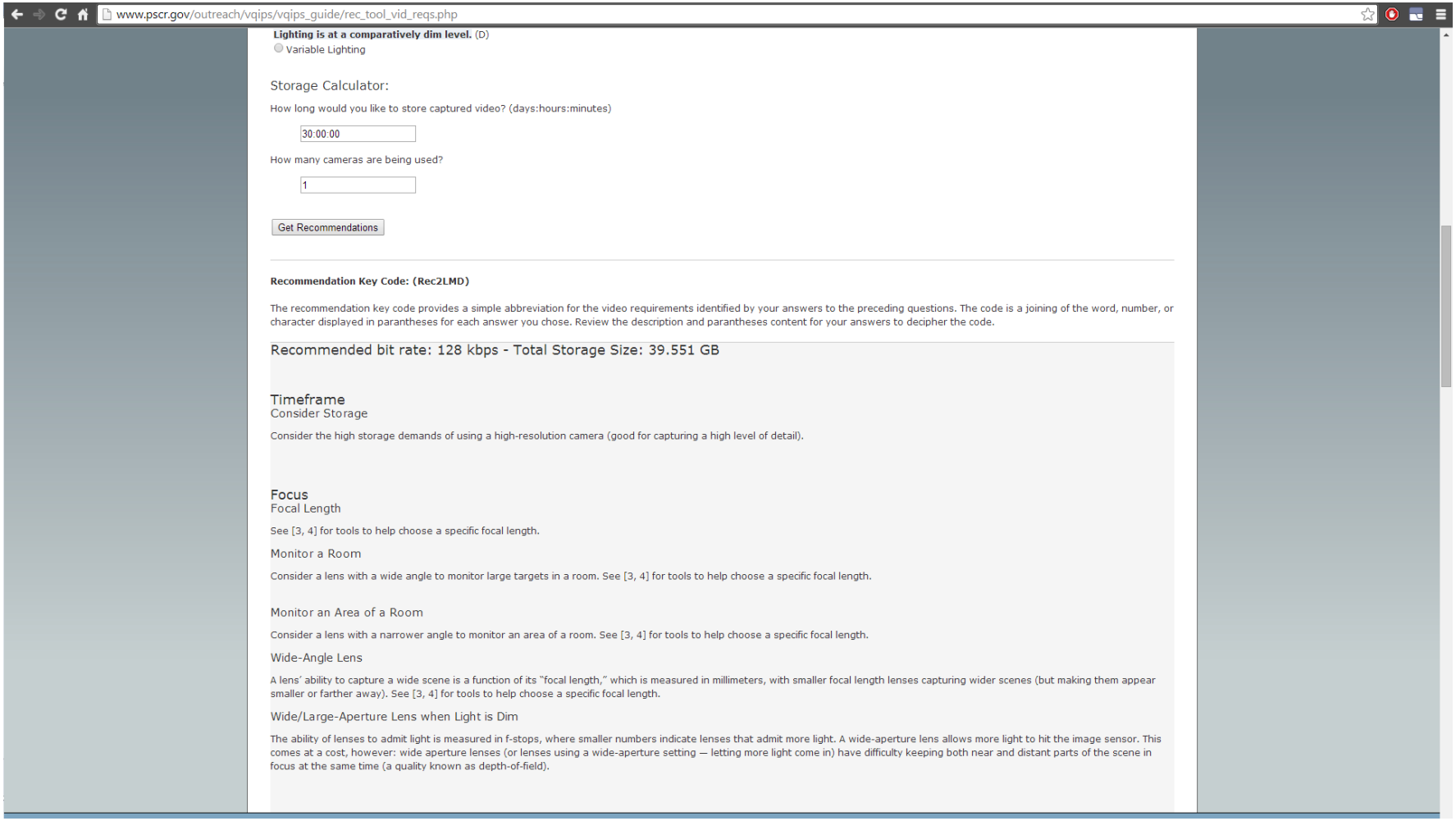
Web Tool - Outputs



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Now What?

- Broadband in public safety makes video more useful than ever
  - But video is still very demanding
- We are now developing a network optimization algorithm for managing multiple video streams over an LTE network with limited resources
  - Requires two major ingredients
    - Relationship between resources and quality
    - An optimization algorithm

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Problem Statement

- Goal is to distribute network resources to users in the best way possible.
  - Our research provides a lot of guidance
  - Must be balanced against local priorities
- Studying a variety of optimization algorithms
  - Iterated Conditional Modes (ICM)
  - Simulated annealing
  - Metropolis-Hastings Algorithm

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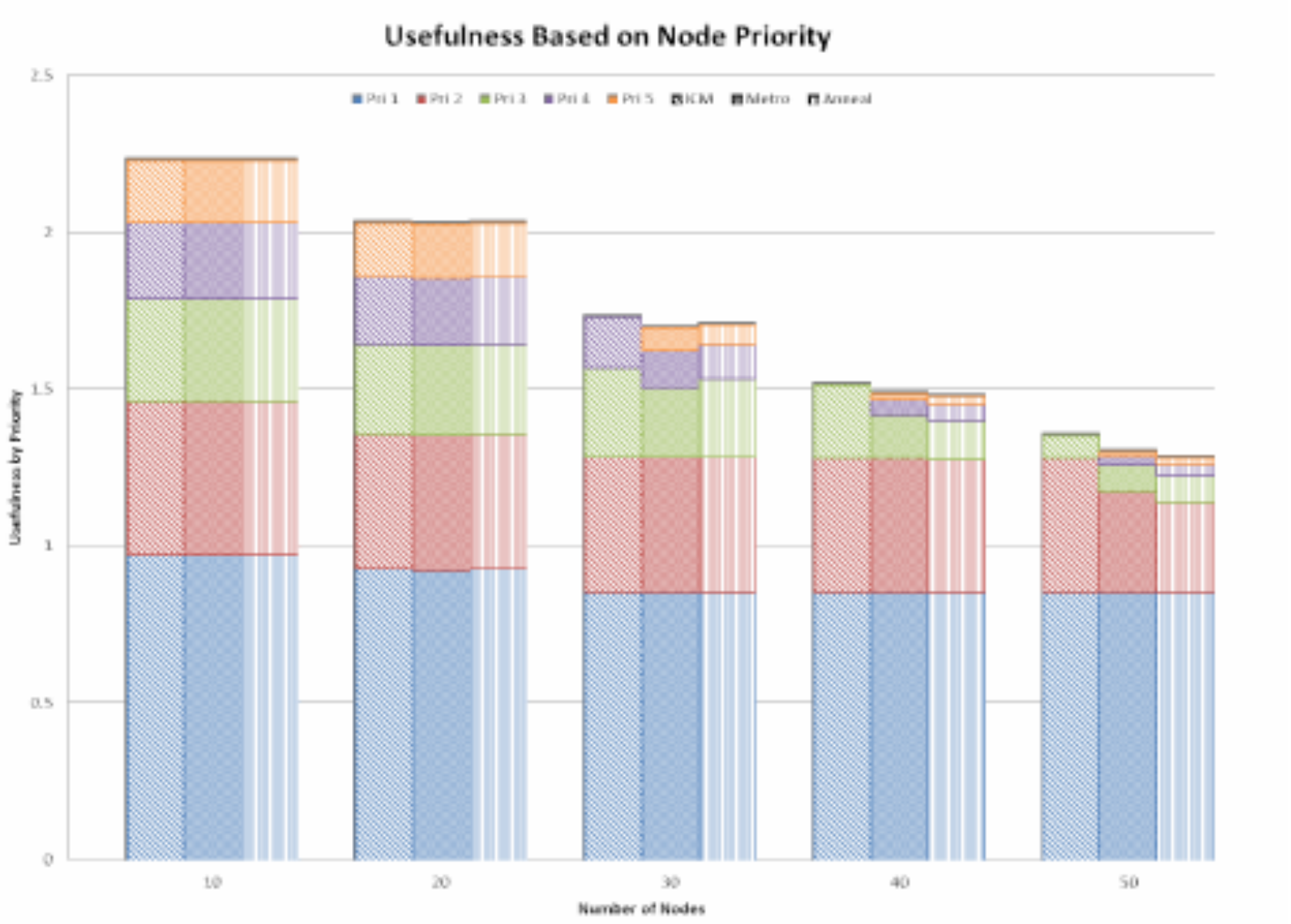
Preliminary Results



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Questions?

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