DRISI

CALTRANS DIVISION OF RESEARCH, INNOVATION AND SYSTEM INFORMATION

Research Results

Evaluation of Next Generation CCTV Encoders for ITS Field Elements

Updating and Evaluating Caltrans ITS CCTV Infrastructure

Rural

DECEMBER 2023

Project Title:
Evaluation of Next Generation CCTV Encoders for ITS Field Elements

Task Number: 3873

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WHAT WAS THE NEED?

Caltrans is currently installing Intelligent Transportation System (ITS) closed-circuit TV (CCTV) sites in multiple areas around the state. New methods and efficiencies of transmitting video from the field sites to the Transportation Management Center (TMC) are being developed to improve the quality of the video stream significantly. Multiple manufacturers produce these "next-generation" encoders and provide Caltrans engineers with specifications and marketing materials. Unfortunately, not all manufacturer specifications measure attributes using the same methodologies, and some products do not meet their advertised manufacturer specifications. In addition, many manufacturers now produce products that provide high throughput but cannot stream video at the ultra-low-speed throughputs needed at remote sites in rural areas of the state.

In rural districts, many CCTV sites' communication options are limited to plain old telephone service (POTS) for data transport, often at 10 kbps or less. As the video industry pushes the limits of higher bandwidth and increased compression, Caltrans must monitor whether the next-generation video encoders will be able to function in low-bandwidth conditions.

Caltrans needed equipment evaluation research under Caltrans rural operating conditions to determine if CCTV video encoders would meet Caltrans performance measures.

WHAT WAS OUR GOAL?

To determine and evaluate which next-generation video encoder equipment will be viable as rural ITS field equipment options as Caltrans adds to and refreshes its ITS assets.

Caltrans

DRISI provides solutions and knowledge that improves California's transportation system

WHAT DID WE DO?

This project attempted to determine how video encoder equipment performs under real-world Caltrans rural operating conditions. Due to the COVID-19 pandemic and the ensuing equipment shortage due to supply-chain issues, some tasks were either curtailed or not able to start. Although the research team was disappointed that the proposed tasks were modified, the tasks the team was able to work on included:

- Project management
- Assess current Caltrans rural operating conditions and knowledge gaps
- Select and procure hardware
- Bench test hardware based on simulated field conditions
- Final report

WHAT WAS THE OUTCOME?

Characterizing how the video streams from a given encoding device may perform under various network conditions involves carefully considering the device's range of features and relevant configuration parameters. We explored these features and parameters for each selected device, examined how varying network conditions may affect the resulting stream, and presented qualitative and quantitative data collected during testing to facilitate optimal device configuration for sites using various types of bandwidth. We also drew comparisons between devices and their range of encoding modes and parameters and other features to facilitate optimal device selection for rural CCTV sites.

WHAT IS THE BENEFIT?

Caltrans-specific evaluation allowed next-generation video encoder equipment testing under simulated Caltrans field conditions. This research now gives Caltrans a better understanding on how to select the right equipment for the given limitations of bandwidth at a given field site.

LEARN MORE

Final Report is available at TBD – waiting for Final Report URL.

IMAGES

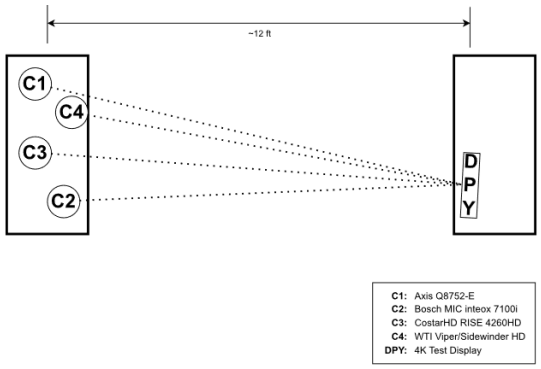


Image 1: Physical test setup of equipment

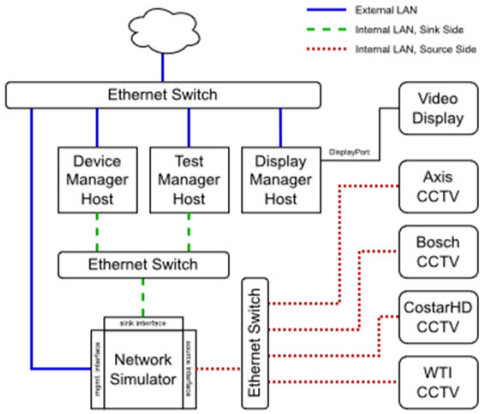
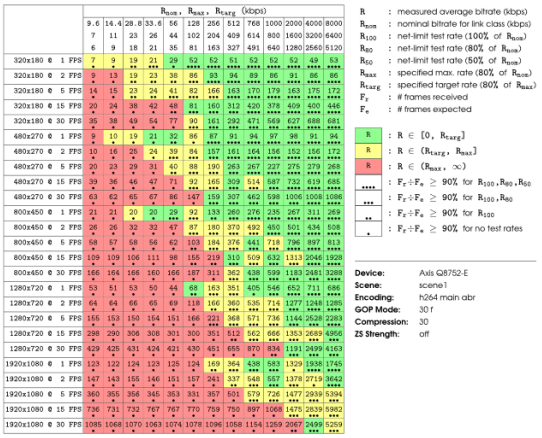


Image 2: Network architecture of test setup



	R_{nom}, R_{max}, R_{targ} (kbps)											
	9.6	14.4	28.8	33.6	56	128	256	512	768	1000	2000	4000	8000
	7	11	23	26	44	102	204	409	614	800	1600	3200	6400
	6	9	18	21	35	81	163	327	491	640	1280	2560	5120
320x180 @ 1 FPS	7 ****	9 ****	19 ****	21 ****	29 ****	62 ****	62 ****	61 ****	62 ****	62 ****	62 ****	49 ****	63 ****
320x180 @ 2 FPS	9 ****	13 ****	19 ****	23 ****	38 ****	86 ****	93 ****	94 ****	89 ****	86 ****	91 ****	86 ****	86 ****
320x180 @ 5 FPS	14 ****	15 ****	23 ****	24 ****	41 ****	82 ****	166 ****	163 ****	170 ****	179 ****	163 ****	175 ****	172 ****
320x180 @ 15 FPS	20 ****	24 ****	38 ****	42 ****	48 ****	81 ****	160 ****	312 ****	420 ****	378 ****	409 ****	400 ****	446 ****
320x180 @ 30 FPS	35 ****	38 ****	49 ****	54 ****	77 ****	90 ****	161 ****	292 ****	471 ****	569 ****	627 ****	688 ****	681 ****
480x270 @ 1 FPS	9 ****	10 ****	19 ****	21 ****	32 ****	86 ****	87 ****	91 ****	94 ****	97 ****	98 ****	91 ****	94 ****
480x270 @ 2 FPS	10 ****	16 ****	28 ****	24 ****	39 ****	86 ****	157 ****	161 ****	164 ****	156 ****	152 ****	156 ****	172 ****
480x270 @ 5 FPS	20 ****	23 ****	29 ****	31 ****	40 ****	88 ****	190 ****	263 ****	267 ****	227 ****	275 ****	279 ****	268 ****
480x270 @ 15 FPS	39 ****	36 ****	46 ****	47 ****	71 ****	92 ****	165 ****	309 ****	514 ****	587 ****	732 ****	619 ****	685 ****
480x270 @ 30 FPS	63 ****	62 ****	65 ****	67 ****	86 ****	147 ****	159 ****	327 ****	462 ****	538 ****	1006 ****	1008 ****	1086 ****
800x450 @ 1 FPS	21 ****	21 ****	20 ****	20 ****	29 ****	92 ****	133 ****	260 ****	276 ****	235 ****	267 ****	311 ****	269 ****
800x450 @ 2 FPS	26 ****	26 ****	32 ****	32 ****	47 ****	87 ****	180 ****	370 ****	492 ****	450 ****	501 ****	436 ****	508 ****
800x450 @ 5 FPS	58 ****	57 ****	58 ****	56 ****	62 ****	103 ****	184 ****	376 ****	441 ****	718 ****	796 ****	897 ****	813 ****
800x450 @ 15 FPS	109 ****	109 ****	106 ****	111 ****	98 ****	155 ****	219 ****	310 ****	509 ****	632 ****	1313 ****	2046 ****	1928 ****
800x450 @ 30 FPS	166 ****	166 ****	166 ****	160 ****	166 ****	187 ****	311 ****	362 ****	638 ****	599 ****	1183 ****	2481 ****	3288 ****
1280x720 @ 1 FPS	53 ****	51 ****	53 ****	50 ****	44 ****	68 ****	163 ****	351 ****	405 ****	546 ****	652 ****	711 ****	686 ****
1280x720 @ 2 FPS	64 ****	64 ****	66 ****	65 ****	69 ****	118 ****	166 ****	360 ****	535 ****	714 ****	1277 ****	1248 ****	1285 ****
1280x720 @ 5 FPS	155 ****	153 ****	150 ****	154 ****	151 ****	166 ****	221 ****	368 ****	571 ****	736 ****	1144 ****	2528 ****	2283 ****
1280x720 @ 15 FPS	298 ****	290 ****	306 ****	308 ****	301 ****	300 ****	351 ****	512 ****	562 ****	666 ****	1353 ****	2689 ****	4956 ****
1280x720 @ 30 FPS	429 ****	425 ****	431 ****	424 ****	421 ****	430 ****	451 ****	655 ****	870 ****	836 ****	1191 ****	2499 ****	4163 ****
1920x1080 @ 1 FPS	123 ****	122 ****	124 ****	123 ****	125 ****	124 ****	169 ****	364 ****	438 ****	583 ****	1329 ****	1938 ****	1745 ****
1920x1080 @ 2 FPS	147 ****	143 ****	155 ****	146 ****	151 ****	157 ****	241 ****	337 ****	548 ****	557 ****	1378 ****	2719 ****	3642 ****
1920x1080 @ 5 FPS	360 ****	355 ****	356 ****	345 ****	353 ****	331 ****	357 ****	501 ****	579 ****	726 ****	1477 ****	2939 ****	5394 ****
1920x1080 @ 15 FPS	736 ****	731 ****	732 ****	767 ****	767 ****	770 ****	759 ****	750 ****	897 ****	1068 ****	1475 ****	2839 ****	5982 ****
1920x1080 @ 30 FPS	1085 ****	1068 ****	1070 ****	1063 ****	1074 ****	1078 ****	1096 ****	1058 ****	1154 ****	1259 ****	2067 ****	2499 ****	5259 ****

R : measured average bitrate (kbps)
R_{nom} : nominal bitrate for link class (kbps)
R_{100} : net-limit test rate (100% of R_{nom})
R_{80} : net-limit test rate (80% of R_{nom})
R_{50} : net-limit test rate (50% of R_{nom})
R_{max} : specified max. rate (80% of R_{nom})
R_{targ} : specified target rate (80% of R_{max})
F_r : # frames received
F_e : # frames expected

R : $R \in [0, R_{targ}]$
R : $R \in (R_{targ}, R_{max}]$
R : $R \in (R_{max}, \infty)$
**** : $F_r \div F_e \geq 90\%$ for R_{100}, R_{80}, R_{50}
*** : $F_r \div F_e \geq 90\%$ for R_{100}, R_{80}
** : $F_r \div F_e \geq 90\%$ for R_{100}
* : $F_r \div F_e \geq 90\%$ for no test rates

Device: Axis Q8752-E
Scene: scene1
Encoding: h264 main abr
GOP Mode: 30 f
Compression: 30
ZS Strength: off

Image 3: Stream quality analysis for Axis Q8752-E TCP streaming test