

## **CCTV supervision or surveillance - what's in a name ?**

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**Abstract.** Extensive literature search revealed poorly evidenced Human Factors guidelines for CCTV systems. Case studies were done to get more insight in relevant Human Factors issues. A task taxonomy was found on surveillance. Do CCTV tasks in process control significantly differ from surveillance tasks? And is this so distinctive that it requires different Human Factors guidelines for CCTV system design? This study shows it is distinctive when looking at tasks. A task related concept of 'scene' is introduced instead of other workload measures covering image content or complexity.

**Keywords.** Closed Circuit Television (CCTV), control center design, supervision, surveillance.

### **1. Introduction**

In the past years, many new applications of CCTV (Closed Circuit Television) emerged, such as CCTV as part of the control process on ships and in locks. Research on Human Factors (HF) is falling behind (Schreibers et al., 2012), although publications on privacy and legal matters can be found widely. The lack of HF interest is remarkable, because a CCTV system can be seen as a human-machine system, consisting of an observed reality, cameras, transmission, displays, image presentation, workplace(s) and operator tasks including cognitive information processing (Pikaar & Lenior, 2014).

A pooled fund study with 13 companies and governmental organizations let HF specialists develop HF guidelines for CCTV systems. Key question: what should an operator be able to see, detect, or read reliably on CCTV images and therefore, what HF requirements should be met by the CCTV system? The study was limited to live image processing of digital systems (see Pikaar & Lenior (2014) for a description). This paper focuses on the differences between the case studies in the field of surveillance versus the ones in process control. Do these differences ask for separate Human Factors guidelines for CCTV system design?

### **2. Methods**

The study consisted of a literature search, case studies (Schreibers & Bouchier, 2014), some laboratory experiments (Bennis et al., 2014), and finally the development of HF Guidelines (Pikaar & Lenior, 2014). This paper discusses literature and case studies.

Review of published guidelines and literature was done to get a state of the art overview on HF and CCTV, including an inventory of technological aspects. Because a lot can be learned from current practice, eight case studies were selected. The case studies have been analyzed systematically by four experienced HF professionals (Eur. Erg.) using a standardized situation analysis protocol. Each situation analysis consisted of two visits on site and included observations, analysis of operator task performance, and semi-structured interviews with operators.

### 3. Results

#### 3.1 Literature

Over 40 literature sources related to HF guidelines for CCTV systems were studied including journals, guidelines, and technical reports. Most sources focused on security and traffic control (APTA, 2011; Cohen et al. 2009; FHWA, 1999). The level of available design guidance points to “things you should think of”, however without design requirements. In general, the evidence for statements, conclusions, and guidelines is rather thin. There are only a few laboratory experiments reported (Ford et al., 2009; Howard et al., 2009; Keval, 2009; Stedmon et al., 2011) and very few field studies (particularly from the UK: Wood, 2007; Keval, 2009). No sources on remote control tasks such as lock and bridge control or remote process supervision were found (Schreibers et al., 2012). This was a surprise because many applications in this area can be found in practice.

No guidance on large screen display technology and video walls was found. Several sources provide guidelines on image size (EN 50132-7, 2012; APTA, 2011; Cohen, 2009; MIL-STD-1472G, 2012; FHWA, 1999; Damjanovski, 2005). However, little attention was paid on *correct* handling of image sizes related to viewing distances. Guidelines given did not discuss screen or image resolution, tasks performed, or other human factors aspects.

Some guidelines were found on the number of live stream images. Most sources mention an acceptable maximum of 12-16 images (EN 50132-7, 2012; Wallace et al., 1997; Velastin, 2003; Wood & Clarke, 2006). Some sources mention that the probability of detecting an incident is substantially reduced when there are more than 100 cameras per operator (Gill et al., 2005; Dubbeld, 2005). Operator work load is often expressed as camera-monitor ratio or the amount of screens/ images per operator. This type of guidance is not task related and highly dependent on technology. For example: how to deal with three stitched images resulting in one image?

The literature study revealed many open issues concerning HF guidelines in CCTV.

#### 3.2 Case studies

Eight cases in traffic, industry, and security have been analyzed to gain insight in the operator tasks and current CCTV instrumentation. Type of tasks and HF in CCTV design varied over the case studies. Some characteristics of four typical case studies have been summarized in Annex 1. In literature, CCTV surveillance tasks are usually divided in monitor, detect, recognize, and identify (Cohen et al., 2009). Can this taxonomy also be used in process supervision & control tasks?

In surveillance tasks, the operator has no direct influence on the processes to be observed and CCTV is his source for situation awareness. Initially, no triggers are available. Operator's actions always start with monitoring until an event comes up. Detection and recognition tasks follow, even sometimes identification (see figure 1), like in social security or traffic management in tunnels. For process supervision including control tasks (supervision), the operator is part of the operating system and CCTV supports his situation awareness. Here the operator's actions are often based on an external trigger (like

a phone call, an alarm message, or a next step in the process he is supervising). Monitoring is particularly not part of the human task: detection is sometimes followed by recognition and sometimes followed by identification. Examples are opening a bridge, operating a lock, or pumping goods from/ to truck – tank. Actually, most cases have a mix of surveillance and supervision tasks, however always with the main focus on either one of them (see figure 1).

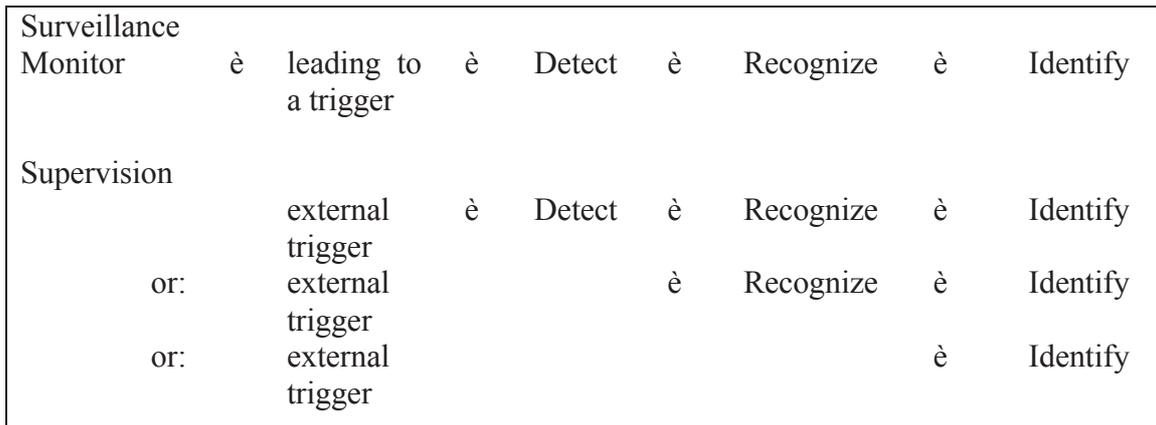


Figure 1: Task taxonomy, applied to surveillance and supervision tasks

Another difference between surveillance and process supervision tasks was the amount of cameras in the system. Predominantly process supervision applies less than fifty cameras versus mainly surveillance tasks over a hundred cameras.

There is also a difference in display technology. For surveillance, image reduction and image distortion occur due to limited transmission and storage capacities relative to a large number of camera views. For process supervision, usually lossless systems are engineered.

Finally, workplace lay-out differed substantially. In all cases, CCTV images were presented on a video wall and were accompanied by two or more other screens on the operator’s desk. Those screens were used for CCTV operation, detailed image analysis, or other tasks. Sometimes, images were presented twice: either one in large format on a common video wall and one copy on a dedicated monitor (lock control) or both large and regular sized images on the personal video wall (tunnel supervision). The enlarged image was used for zooming in for detailed analysis or to focus on a process step as a memory aid. In all cases, the quality of the copy-images was lower due to resolution incompatibilities. In two cases (security control, tunnel traffic control), individual video walls were applied which is intriguing from HF point of view.

#### 4. Discussion and Conclusion

Eight different cases were analyzed based on process supervision and surveillance tasks, in view of creating HF guidelines. Should HF guidelines for the design of CCTV systems be based on this distinction?

One can endlessly argue on definitions of process supervision and surveillance. So, what’s in a name? It is far more relevant to look at the specific tasks. In case of surveillance: CCTV is part of the operator’s main task and often comprises looking for something not very well specified without an initial trigger. For supervision tasks, a trigger of an ongoing process leads to CCTV tasks, most often quite well specified. With this distinction in tasks, different guidelines should be applied. For example, monitoring can ask for a large physical display area or many cameras and images to cover for optimal

situation awareness, while identification tasks demand other specifications regarding size, quality, and amount of images. In the reviewed cases, operators with mainly surveillance tasks had many images as opposed to operators with mainly process supervision tasks. For supervision an external trigger leads to a smaller amount of images necessary at one moment.

Regarding the amount of images, literature reports an acceptable maximum of 12-16 images. The results of the analysis indicate that task and image complexity are presumably more important factors for HF guidelines than the amount of images. For an appropriate guideline, a new task related concept of 'scene' has been developed (Pikaar et al., 2013). A scene is a logical and meaningful set of visual information, to be monitored with a specific aim. The construct of a scene can be used as a tool to analyze task complexity, as a guidance for the number of scenes an operator can handle, and to determine the relationship between task complexity and the movement in images regarding workload. Depending on characteristics of the scene, a low or high number of scenes can be viewed simultaneously. Factors like a considerable amount of movement in a scene, a high level of expected incidents, or a complex environment lead to a lower acceptable amount of scenes to be viewed simultaneously. In ongoing follow-up research the concept of scenes is being developed further.

In relation to task complexity, different guidelines for supervision or surveillance tasks may also apply to the organization of the work, like work rest schemes. Due to limited task variety, stricter work-rest-schemes for surveillance operators will be needed for optimal performance as opposed to process supervision operators, who alternate CCTV-related tasks with other tasks.

In addition, different guidelines are applicable on image quality. Surveillance applications appeared to have lower image quality. One would say that the surveillance operator, being a 'heavy user' of live stream images, would need a high image quality to control his mental workload (Parasuraman et al., 2009) and to facilitate timely detection. While process supervision & control is often characterized by less time pressure, process supervision tasks, and the operator knows what kind of events to look for in a specified area in advance. Moreover, it is questionable to what extent image quality influences task performance. The concept of image quality is also being researched further (Bennis et al., 2014).

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## References

- APTA CCTV Standards Working Group (2011). Selection of cameras, digital recording systems, digital high-speed networks and train lines for use in transit-related CCTV systems (Technical Report APTAIT-CCTV-RP-001-11). Washington DC: APTA standards development program – recommended practice.
- Bennis, A., Landman, R.B., & Lenior, D. (2014). CCTV mediated observation versus non-mediated observation: investigating perceived image quality with different test systems. In: O. Broberg, et al. (Eds.) Proceedings of the XI conference on Human Factors in Organizational Design and Management (pp. this issue). Copenhagen.
- Cohen, N., Gattuso, J. & MacLennan-Brown, K. (2009). CCTV operational requirements manual (Publication 28/09). Sandridge, UK: Home Office Scientific Development Branch.

- Damjanovski, V. (2005). *CCTV. Networking and digital technology*. Burlington: Elsevier.
- Dubbeld, L. (2005). The role of technology in shaping CCTV surveillance practices. *Information, communication & society*, 8, (1), 84-100.
- EN 50132-7 (2012). *Alarm systems - CCTV surveillance systems for use in security applications. Part 7: application guidelines*.
- FHWA (1999). *Preliminary human factors guidelines for traffic management centers* (Publication no. FHWA-JPO-99-042). McLean, VA: US Department of transportation - Federal Highway Administration.
- Ford, C.G., McFarland, M.A., Stange, I.W. (2009). Subjective video quality assessment methods for recognition tasks. *Proceedings of the SPIE 2740*.
- Gill, M., Allen, J., Jessiman, P., Kilworth, J., Swain, D., Spriggs, A., Hemming, M., Kara, D., & Little, R. (2005). *Control room operation: findings from control room observations* (Home office online report: 14/05).
- Howard, C.J., Troscianko, T., Gilchrist, I.D., Behera, A., Hogg, D.C. (2009). Searching for threat: factors determining performance during CCTV monitoring. In: Waard, D. de, Godthelp, J., Kooij, F.L., Brookhuis, K.A. (Eds.). *Human factors, security and safety*, pp. 107. Maastricht: Shaker publishing.
- Keval, H.U. (2009). *Effective, design, configuration, and use of digital CCTV*. Thesis. University College of London.
- MIL-STD-1472G (2012). *Design Criteria Standard-Human Engineering*. Department of Defence.
- Parasuraman, R., Visser, E. de, Clarke, E., McGarry, R., Hussey, E., Shaw, T., Thompson, J.C. (2009). Detecting threat-related intentional actions of others: effects of image quality, response mode and target cuing on vigilance. *Journal of experimental psychology: applied*, 15, (4), 275-290.
- Pikaar, R.N. (Ed.) (2013). *Human Factors Guidelines for the design of CCTV-systems*. ErgoS, HAN University, Intergo, **vhp** human performance, p/a Enschede: ErgoS Human Factors Engineering.
- Pikaar, R.N., & Lenior D. (2014). *Human factors guidelines for CCTV control center design. Introduction to a symposium*. In: O. Broberg, et al. (Eds.) *Proceedings of the XI conference on Human Factors in Organizational Design and Management* (pp. this issue). Copenhagen.
- Reinstra, S. & Groot, N. de (2014). *How to sell a room without a view?* In: O. Broberg, et al. (Eds.) *Proceedings of the XI conference on Human Factors in Organizational Design and Management* (pp. this issue). Copenhagen.
- Schreibers, K.B.J., Landman, R.B., Pikaar, R.N. (2012). *Human Factors of CCTV; Part 1. Technology and Literature review*. ErgoS, HAN University, Intergo, **vhp** human performance, p/a Enschede: ErgoS Human Factors Engineering.
- Schreibers, K.B.J. & Bouchier, J.L. (2014). *CCTV - Case study traffic management highway tunnel*. In: O. Broberg, et al. (Eds.) *Proceedings of the XI conference on Human Factors in Organizational Design and Management* (pp. this issue). Copenhagen.
- Stedmon, A.W., Harris, S., Wilson, J.R. (2011). Simulated multiplexed CCTV: the effects of screen layout and task complexity on user performance and strategies. *Security journal*. 24, (4), 344-356.
- Velastin, S.A. (2003). *Getting the best use out of CCTV in the railways*. London: Rail and Safety Board.
- Wallace, E., Diffley, C., Baines, E., & Aldridge, J. (1997). *Ergonomic design considerations for public area CCTV safety and security applications*. In: Seppälä, P., Luopajarvi, T., Nygård, C., Mattila, M. (Eds.). *From Experience to Innovation. Proceedings of the International Ergonomics Association congress*. Tampere.
- Wood, J. & Clarke, T. (2006). *Practical guidelines for CCTV ergonomics*, In: Pikaar, R.N., Koningsveld, E., & Settels, P. (Eds.): *Meeting diversity in ergonomics*. Amsterdam: Elsevier.
- Wood, J. (2007). *CCTV Ergonomics: Case studies and practical guidance*. In: Pikaar, R.N., Koningsveld, E., & Settels, P. (Eds.): *Meeting diversity in ergonomics*. Amsterdam: Elsevier.

*Annex 1 – Summary of task variables and technical specifications of four typical analyzed case studies*

Cases è Task variables ê		Lock control	Jetty supervision	Tunnel supervision	Security
Operator	Super- vision & control	Lock control Traffic management, lockage process	Supervise activities jetties Start process control action, verify by CCTV	Open/ close traffic lane Incident handling	Entrance control
	Surveil- lance	Security	Monitoring	Observe traffic situation	
Camera-monitor ratio		38:5	30:9	120:6	100:11
Native image resolution		752 x 582 *	unknown	unknown	704 x 576
Monitor amount	Primary	4	9	6	8
	Secondary	1	2	-	3
Monitor size	Primary	30" split screen: 3 x 4	32" full screen	46" split screen	20" most quad
	Secondary	19" full screen	37" full screen	-	17" most quad
Monitor resolution	Primary	2560 x 1600 split screen: 640 x 533	1366 x 768	1920 x 1080 split screen: general: 480 x 360 detail: 960 x 720	1600 x 1200 split screen: 800 x 600
	Secondary	1280 x 1024	1366 x 768	-	1280 x 1024
Viewing distance (cm)	Primary	90-160	230-670	220	110
	Secondary	90	230-670	-	60
Critical detail	Primary	1-5 cm	5-20% **	2% **	2-100%
	Secondary	1-5 cm	5-20% **	-	2-100%

\*: image cropped to 640 x 533; \*\*: percentage of screen height