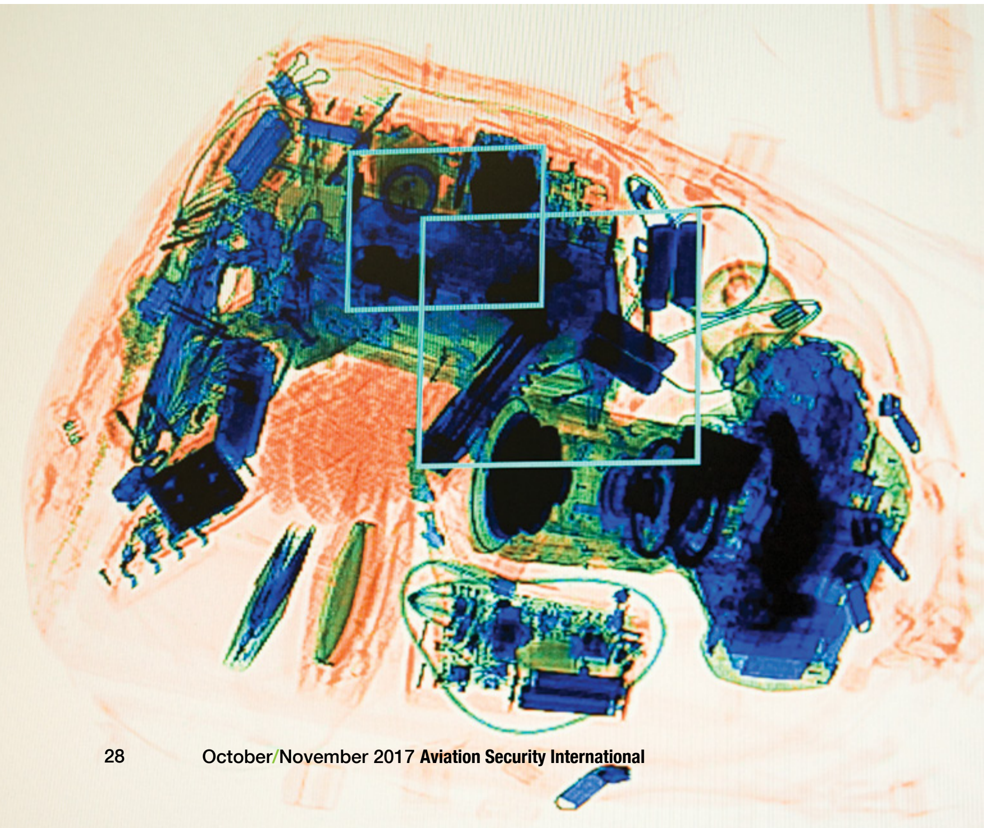
CENTRALISED IMAGE PROCESSING:

THE IMPACT ON SECURITY CHECKPOINTS

Remote screening of hold baggage has been in use since the beginning of this century and is common practice in larger airports. Remote screening of cabin baggage, however, is relatively new. Centralised image processing (CIP) has the potential to dramatically increase an airport's capacity and the efficiency of passenger screening and is therefore a valuable tool with which to tackle the increasing air passenger traffic numbers, which, according to IATA, are forecasted to double by 2035. **Milena Kuhn** gives an introduction and overview of CIP, discusses the potential benefits and pitfalls, and compares different CIP implementation possibilities regarding effectiveness, efficiency and human factors.

Over the last eight years, remote cabin baggage screening (RCBS) via the use of centralised image processing (CIP) has been implemented at a number of European airports. It has been shown to potentially increase detection performance, throughput, capacity and employee satisfaction. Implementing CIP at security checkpoints hence holds many potential advantages; however, there is no 'one-size-fits-all' approach. Therefore, it is critical to evaluate and plan to select the most appropriate CIP approach for each airport. In a research project funded in part by the Federal Office of Civil Aviation (FOCA) of Switzerland, the Center for Adaptive Security Research and Applications (CASRA) systematically evaluated (via a multi-method approach) the advantages and disadvantages of CIP for checkpoint security based on important insights gathered from the experiences of pioneers and early adopters.



WHAT IS CIP?

Centralised Image Processing (CIP) refers to the networking of baggage images generated by X-ray machines. It allows a loosening of the conventional 1:1 ratio between X-ray machine and X-ray screener, introducing a more efficient way of working. While the concept of CIP is widely associated with the screening of hold baggage, the name 'CIP' is mainly used in connection with the screening of cabin baggage at security checkpoints. One of the main advantages of CIP is that security screeners do not necessarily need to sit next to an X-ray machine to evaluate images, which allows an airport to be more spatially flexible when organising the task of image analysis.

CIP IMPLEMENTATIONS

The main motivation of airports and authorities to implement or to support the implementation of CIP at security checkpoints is the need to increase efficiency and capacity. However, implementing CIP can often lead to many changes compared to conventional cabin baggage screening (Figure 1), which mainly concerns the spatial and structural organisation of the checkpoint, but also the degree of necessary networking and automation processes.

After analysing several real-life implementations of CIP at European airports, three main implementation types could be identified by CASRA (Figure 2):

a. Matrix-screening/remote local screening
b. Remote screening in a remote room close to the checkpoint
c. Remote screening in a remote room further away from the checkpoint

In all these implementation scenarios, screeners can receive images for analysis from any number of machines at the checkpoint because the images are centrally saved and redistributed to the active image analysis stations. The main difference between the different CIP implementations lies in the location of the security screeners, i.e. (a) within the checkpoint, (b) in a remote room close to the checkpoint, or (c) in a remote room further away from the checkpoint. Before we dive into further details on the differences (see Table 1), let us first have a look at what it means to change a conventional checkpoint into a checkpoint operating with CIP.

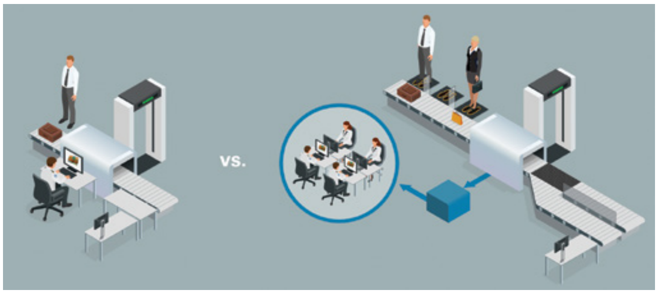


Figure 1: Conventional vs. CIP checkpoint lane

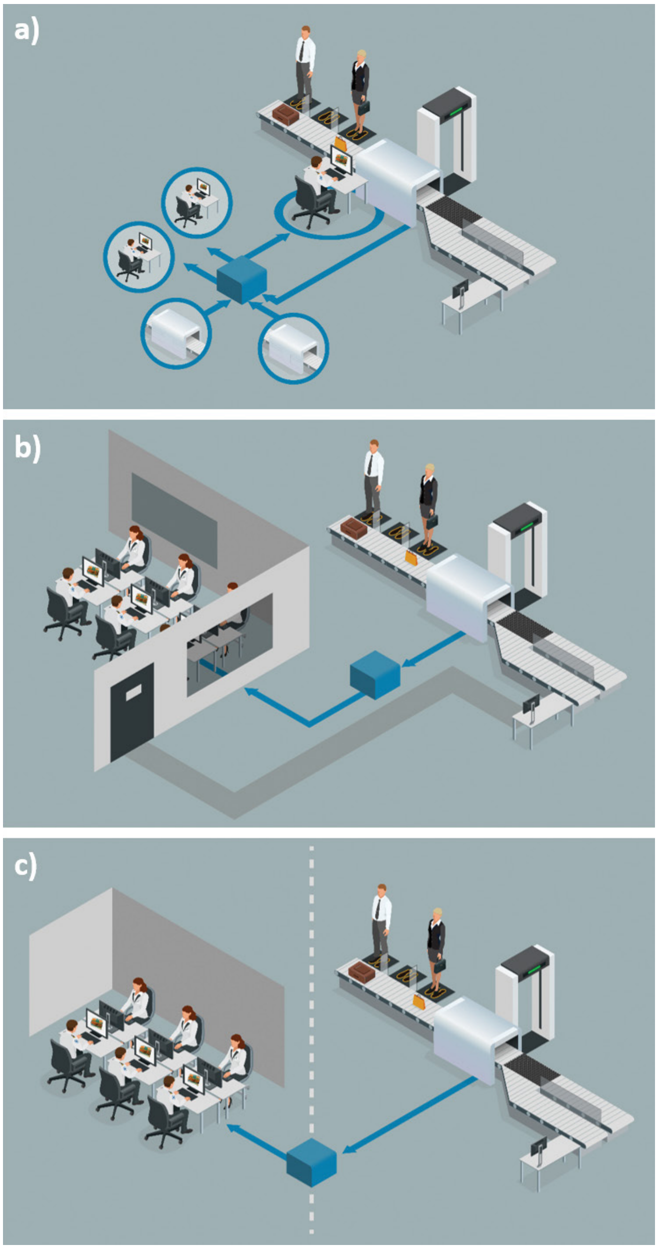


Figure 2: Three main CIP implementations

CHECKPOINT COMPONENTS AND POTENTIAL CHECKPOINT MODIFICATIONS

Implementing CIP at a checkpoint does not simply mean that screeners are placed somewhere else; it may also include several other modifications of the checkpoint setup that are necessary to reach the respective objectives of CIP implementation. In general, the modifications aim to allow for a flexible location of the security screener in relation to the X-ray machine and to support maximum throughput numbers per checkpoint lane.

To enable X-ray machines to run at full capacity, passengers and the divesting of their belongings need to be organised in a manner that allows the conveyor belt to be continuously loaded without unnecessary gaps between trays or having to stop the conveyor belt. This is achieved by increasing the number of divesting stations to allow passengers to load their baggage and personal belongings in parallel ('parallel loading'). Parallel loading also allows faster passengers to pass slower passengers, making the process of divesting more efficient. The redressing area needs to be enlarged accordingly to prevent a bottleneck created by the increase of passengers redressing at any given time.

Any type of X-ray machine can be integrated into a CIP implementation, i.e. single-view, dual-view and 3D. Often, machines are additionally equipped with a camera, which takes a picture of the tray before it progresses into the tunnel. This image is a useful source of information for the screeners conducting image analysis; for example, to determine whether LAGs are placed inside or outside a bag. Independently of where a screener is situated, the image analysis is conducted with CIP software, which allows the identification of a suspicious object by marking and categorising areas of the image. If the bag is not cleared (either because an item has been identified as suspicious or because the analysis was not completed in time resulting in a timeout), it is forwarded to the recheck station. At the recheck station, a security agent can access the X-ray image, the photo, as well as the markings and categorisations of the screener by scanning the tagged tray (most often RFID tags are used).

MATCHING OBJECTIVES TO IMPLEMENTATION SCENARIOS

Objectives and requirements vary between different airports based on size, passenger numbers, passenger distribution, available space, etc., resulting in varying maximisation and optimisation goals:

Capacity Maximisation with Remote Screening in a Remote Room

In this first scenario, the aim is to maximise throughput of passengers per time, and thus maximise the capacity of the security checkpoint. There are generally more screeners than X-ray machines in use at the same time, e.g. up to five screeners are at work to analyse all the images generated by three X-ray machines.

Airport case studies showed that this objective is best achieved by conducting image analysis in a separate screening room, where the number of screeners can be adapted flexibly and increased without being limited by the available checkpoint lanes (as is the case with matrix-screening). If the remote rooms are located within a reasonable walking distance from the checkpoint, rotations of team members (similar to a screening team at conventional checkpoints) between the remote room and the checkpoint are possible. However, rotating within teams somewhat restricts the flexibility of setting the ratio between screeners and X-ray machines.

Efficiency Maximisation with Matrix-Screening

In this second scenario, the aim is to maximise throughput of passengers per screener. Hence, the airport wants to use only as many screeners as necessary to screen all bags at any given time, which means that there are generally fewer screeners than X-ray machines in use simultaneously.

Airport case studies showed that this objective is best achieved by introducing a local matrix-screening solution, which, for example, allows five lanes and thus five X-ray machines to be operational, but only three screeners are needed to analyse all images. This differs to the use of a separate screening room, as no additional supervisors are necessary when screening within the checkpoint, which makes this scenario more efficient than screening in remote rooms.

Optimisation of the Two Approaches

In this last scenario, the aim is to combine the advantages of the first and second scenarios. Hence, the airport wants to use screeners and X-ray machines flexibly. This is especially practical for airports with a fluctuating passenger distribution. Airport case studies showed that this objective is best achieved by introducing a remote screening room, which is used for image analysis during busy, high-peak times and screening stations within the checkpoint for matrix-screening, which can be used during less busy, low-peak times.

COMPARISON OF CIP IMPLEMENTATIONS

Optimising efficiency and capacity are not the only objectives that airports and authorities strive for when implementing CIP. Some first pilot studies and evaluations (e.g. pilot studies conducted by Southampton University) showed that CIP is expected to increase checkpoint security effectiveness and improve efficiency measures (see Table 1). For example security screeners rejected slightly more bags when in a CIP setting compared to conventional screening (with remote room screening having higher reject rates than matrix-screening), and they took slightly longer for visual inspection. However, their effectiveness (more correct responses on TIP-images containing prohibited items) increased, and the reduced speed for a single image interpretation was by far outweighed by the gain in efficiency due to proficient image distribution to screeners and the optimisation of the number of lanes in operation.

	Conventional screening	Matrix-screening	Remote room close to checkpoint	Remote room further away from checkpoint
Effectiveness				
Screener effectiveness	Baseline	More correct responses on TIP images containing prohibited items than conventional screening	More correct responses on TIP images containing prohibited items than matrix-screening	
Efficiency				
Screener efficiency	Baseline	More non-TIP alarms than conventional screening	More non-TIP alarms than matrix-screening	
Extra supervisors necessary	No	No	Yes	Yes
Flexible deployment of screening personnel	Not possible	Possible	Possible	Possible
Visual inspection time	Baseline	Longer compared to conventional screening	Longer compared to matrix-screening	
Employee				
Rotation of screener position within team	Possible	Possible	Possible	Not possible
Interaction with team and passengers	Possible	Partially possible	Partially possible	Not possible
Communication (screener to rest of team)	Verbal communication possible	No verbal communication possible	No verbal communication possible	No verbal communication possible
Group pressure	Possible	Reduced	Highly reduced	Highly reduced

Table 1: CIP Implementation Comparison Based on First Pilot Studies

Furthermore, working conditions for screeners and other security personnel will change with the implementation of CIP and should be well planned and communicated to the staff. The limited verbal communication possibilities between the screener and the rest of the team has been identified as the most worrisome change for screeners when they were told that the airport plans to switch to a CIP setting. However, after some trial time the new way of communicating has been accepted by the staff, and the quieter and less distracting working conditions of a remote screening room were appreciated. If possible, rotations between the screening position and other positions in the team should be maintained, as it gives the staff the opportunity to sit down occasionally and reduces the problem of having screeners conducting image analysis for too long. Therefore, placing remote rooms close to checkpoints permits rotation within teams, but it requires additional space next to a growing checkpoint area, which represents a key challenge of implementing CIP at security checkpoints.

CONCLUSION

CIP is very effective at handling expected increases in passenger volumes, or reducing personnel and fixed costs in the long term. While it requires some checkpoint reorganisation, the one-time investment will pay out during the first few years (as has been seen with other CIP implementations at European airports). This is especially relevant if new X-ray equipment is acquired in order to have a reduced number of lanes running at full capacity, as opposed to having many lanes that run below capacity.

Therefore, analyse your starting point well and work out the current and future requirements of your checkpoint to find the best-suited CIP implementation, together with a compatible CIP software that can be easily integrated.

CASRA will continue with research on the socio-technical system of CIP and the role of human factors. The goal of the research project co-funded by the Federal Office of Civil Aviation (FOCA) in Switzerland is to better understand the different CIP implementations and how they compare in terms of effectiveness, efficiency, and employee and passenger satisfaction.

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