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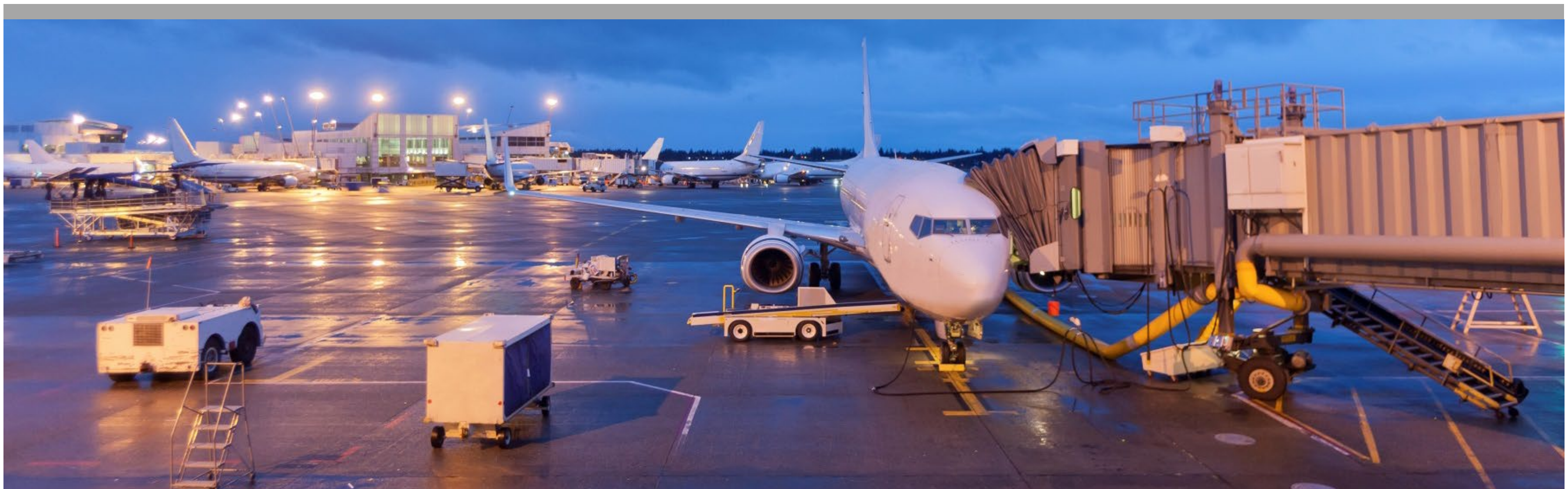

PARAS 0043 March 2023

Security Operations Center Planning and Design

National Safe Skies Alliance, Inc.

Sponsored by the Federal Aviation Administration

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National Safe Skies Alliance (Safe Skies) is a non-profit organization that works with airports, government, and industry to maintain a safe and effective aviation security system. Safe Skies' core services focus on helping airport operators make informed decisions about their perimeter and access control security.

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The Program for Applied Research in Airport Security (PARAS) is an industry-driven program that develops near-term practical solutions to security problems faced by airport operators. PARAS is managed by Safe Skies, funded by the Federal Aviation Administration, and modeled after the Airport Cooperative Research Program of the Transportation Research Board.

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The results of PARAS projects are available to the industry at no charge. All deliverables are electronic, and most can be accessed directly at www.sskies.org/paras.

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SUMMARY

This guidebook provides a comprehensive approach to concept planning, designing, and building a Security Operations Center (SOC). It is applicable to both standalone SOCs and combined Airport Operations Centers (AOC).

An SOC enables an airport to manage security in a collaborative environment through sharing data and managing threats in a holistic manner, while systematically supporting the forecasting and planning of security needs with improved processes, facilities, and technology. This document will help guide airports of all sizes and complexities to improve the conceptualization of an upgraded space, building/remodeling of an existing space, or creating a greenfield space.

PARAS ACRONYMS

ACRP	Airport Cooperative Research Program
AIP	Airport Improvement Program
AOA	Air Operations Area
ARFF	Aircraft Rescue & Firefighting
CCTV	Closed Circuit Television
CFR	Code of Federal Regulations
DHS	Department of Homeland Security
DOT	Department of Transportation
FAA	Federal Aviation Administration
FBI	Federal Bureau of Investigation
FEMA	Federal Emergency Management Agency
FSD	Federal Security Director
GPS	Global Positioning System
IED	Improvised Explosive Device
IT	Information Technology
MOU	Memorandum of Understanding
RFP	Request for Proposals
ROI	Return on Investment
SIDA	Security Identification Display Area
SOP	Standard Operating Procedure
SSI	Sensitive Security Information
TSA	Transportation Security Administration

ABBREVIATIONS, ACRONYMS, INITIALISMS, AND SYMBOLS

ACS	Access Control System
CIP	Capital Improvement Program
ConOps	Concept of Operations
EOC	Emergency Operations Center
GIS	Geographic Information System
HVAC	Heating, Ventilation, and Air Conditioning
ISO	International Organization for Standardization
LED	Light-Emitting Diode
NIST	National Institute of Standards and Technology
PPF	Pixels per Foot
PSIM	Physical Security Information Management Systems
ORAT	Operational Readiness, Activation, and Transition
ROM	Rough Order of Magnitude
SOC	Security Operations Center
STC	Sound Transmission Class
VMS	Video Management System
VSS	Video Surveillance System

SECTION 1: INTRODUCTION

Security Operations Centers (SOC) enable Airport Security Program (ASP) compliance through monitoring, detection, investigation, and response to security threats across the airport. Areas of responsibility can include physical, cyber, infrastructure, and organizational security concerns, contributing to a complex system. This guidebook will examine SOC planning and designing with forethought on adaptability and versatility. The guidance is applicable to airports of all sizes and levels of complexity.

SOCs have evolved significantly over the last few decades due to continued advances in technology and monitoring applications. A key change is the shift from simply monitoring an operation and responding to system requirements to taking a more proactive role in analyzing and assessing data to create a greater analytical and predictive response to regular security activities.

The SOC can often create a holistic and collaborative mission-critical center. While many airports' organizations typically have separate monitoring functions running in parallel and independent of each other, current trends lean towards integrated operations that bring multiple functions under one roof. This adjustment to shared space has allowed organizations to leverage efficiencies at multiple levels. However, it is important to recognize that it does come with challenges such as change management and cultural transformation. This guidebook will help readers navigate decisions for their particular airport.

The guidance will assist airports through all phases of planning and designing an SOC, whether it is standalone, collocated, or part of an AOC.

1.1 Airport Interview Summaries

Research for the guidebook included data collection from two large hub, one medium hub, and two small hub airports. Each airport had either recently (within the past five years) modified, updated, designed or conceptualized an SOC or an AOC that included security functions. Each had a unique approach and solution to their new or updated center. The highlights of the five airport interviews and a brief description follows:

LARGE AIRPORT 1

This airport repurposed an old FedEx building for their new facility. Repurposing existing space has many pros and cons and is likely the first level of upgrade/improvement that airports consider for security and collaboration centers. With the EOC located right next to the AOC, it is a very large space and houses the operational groups for security, airfield operations, dispatch, police, facilities, and emergency operations.

LARGE AIRPORT 2

This airport built a new SOC approximately four years ago that is solely for security. It was purposely designed as a separate location on the airfield campus away from other disciplines. A Concept of Operations (ConOps) was developed during planning for the facility.

MEDIUM AIRPORT

This airport has a near-term project planned to repurpose existing space and a long-term plan to build a greenfield space. The concept planning, including a ConOps, and initial design for repurposing the existing space are complete. It is a medium-sized space that will house operational groups for security, airfield operations, landside operations, facilities/planning, and dispatch/call center.

SMALL AIRPORT 1

This small airport just completed a state-of-the-art greenfield AOC. The center was mostly designed internally and did not have a formal ConOps. The center houses operational groups for security, airport operations, and maintenance.

SMALL AIRPORT 2

The facility for this small airport was built as part of a new terminal that opened in early 2021. The airport wanted a larger center to better handle new security and Customs and Border Protection (CBP) protocols. The center houses operational groups for security and airport operations.

1.2 Best Practices and Lessons Learned

The need for larger space and technology improvements were common drivers for the facilities. All of the airports interviewed did some level of concept planning, either internally with the design team or with a consultant team. Key best practices and lessons learned for planning include:

- Include all departments at the airport in planning
- Bring in experts during the planning phases
- Plan 25–30% more space than you think you will need, especially for larger centers
- Do not focus solely on infrastructure and technology; also include staffing levels and responsibilities
- Document expectations during planning and design to guide the designers and construction team throughout the process
- Create a technical advisory committee that includes all tenants to gain buy-in from decision makers and ensure all stakeholders needs are addressed
- Collaboration and coordination with other departments is essential, particularly for technology integrations
- Commissioning onsite is necessary; remote commissioning is not sufficient
- Include a testing environment for technology vendors
- Account for time to install furniture, fixtures, and equipment in planning and scheduling
- For greenfield sites, consider the location in relation to underground infrastructure, and ensure it is remote enough to be safe from issues such as evacuation
- Ensure noise, particularly from heating, ventilation, and air conditioning (HVAC) systems, is considered during planning
- If feasible, use a raised floor for accessible electricity

SECTION 2: OPERATIONAL PLANNING

ConOps development is at the center of operational planning. A ConOps documents existing conditions, establishes goals, and describes how those goals are to be reached. For example, it may detail a current center that is too small, not in the right location, and without the appropriate level of personnel or technology, and then provide documented guidance for change.

If the project is tied to the airport's Master Plan, some high-level planning may have already been done and the airport can move forward to verify needs both internally and externally. If it is not, developing a ConOps is necessary and should include determining facility requirements, IT infrastructure, discussions with stakeholders, identifying needs for security improvements, and human factors such as lighting, acoustics, and work stations.[1]

A ConOps is a living document and should be reviewed and updated throughout the project to address changes and ensure the project is meeting the intended goals. For more information on developing a ConOps, see Section 3 of PARAS 0004 – Recommended Security Guidelines for Airport Planning, Design, and Construction.[2]

2.1 Concept Planning

Concept planning needs to occur during the scoping and development process. The facility's size, style, location, etc. should all be considered as part of this process. Once a preferred concept is established, decisions can be made regarding the findings. As with any project, SOCs need to be designed in phases or steps. Typical construction projects generally follow a 30%, 60%, 90%, and 100% document/design process. This translates well to SOC concept planning and design. Each step in the decision process needs to be thoroughly analyzed and executed to ensure enough information is carried over to the next step.[3]

COLLABORATION NEEDS

Space constraints are often the driver for the facility concept, but optimizing collaboration, including all applicable stakeholders' needs, should also be considered. Facility concepts and their collaboration considerations include:

- **Standalone Facility:** This option usually includes only security-related personnel. Collaboration with other stakeholders/disciplines occurs via communication channels such as phones and radios, as well as shared technologies and data. It may include the badging office within the footprint or be co-located to it. This helps with intersecurity collaboration but can create a vulnerability, as the badging office is typically on the public side of the airport.
- **AOC Facility:** This option brings multiple disciplines together, usually on a shared floor. This is an ideal collaboration arrangement, especially when irregular operations occur. Data is easily shared and face-to-face planning can be done quickly, which may reduce the impact or length of an event. However, introducing more personnel increases the level of activity, noise, and possible distractions.

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[1] Benaman, 24
[2] **PARAS 0004:** Section 3
https://www.sskies.org/images/uploads/subpage/PARAS_0004.Recommended_Security_Guidelines_.FinalReport_.v2_.pdf
[3] Benaman, 23

Some AOCs also include outside stakeholders such as airlines, TSA, and CBP. If the AOC will be used daily by more than just airport staff, a working group of interested stakeholders might be needed to review and vet design concepts.

- **Co-located/Adjacent Facilities:** This is a standalone SOC that is located very near to other stakeholders/disciplines. This concept enables face-to-face sharing of data and collaborative response to events such as irregular operations.

Regardless of the design option, the needs of other stakeholders/disciplines should be considered to optimize collaboration efforts. Including all the interested parties will help gain buy-in and ensure holistic and successful concept planning.

2.2 Budget

Budgets can be set once the concept planning is underway and SOC needs are determined. Or, if the budget is known prior to concept planning, then the budget will influence those planning decisions and management may need to settle for improvements rather than having the ability to optimize the center for their goals. Setting aside capital funds in an airport's Capital Improvement Program (CIP) is not unusual in either funding approach. If a cap was set prior to planning, a ConOps may help support the case for increased funding. Going through a deliberate and thoughtful process will provide airport operators with the information needed to make appropriate budget decisions.[4]

For more details, refer to ACRP Research Report 189: *Design Considerations for Airport EOCs*.[5]

2.3 Concept and Development Planning Options

This section contains planning options to:

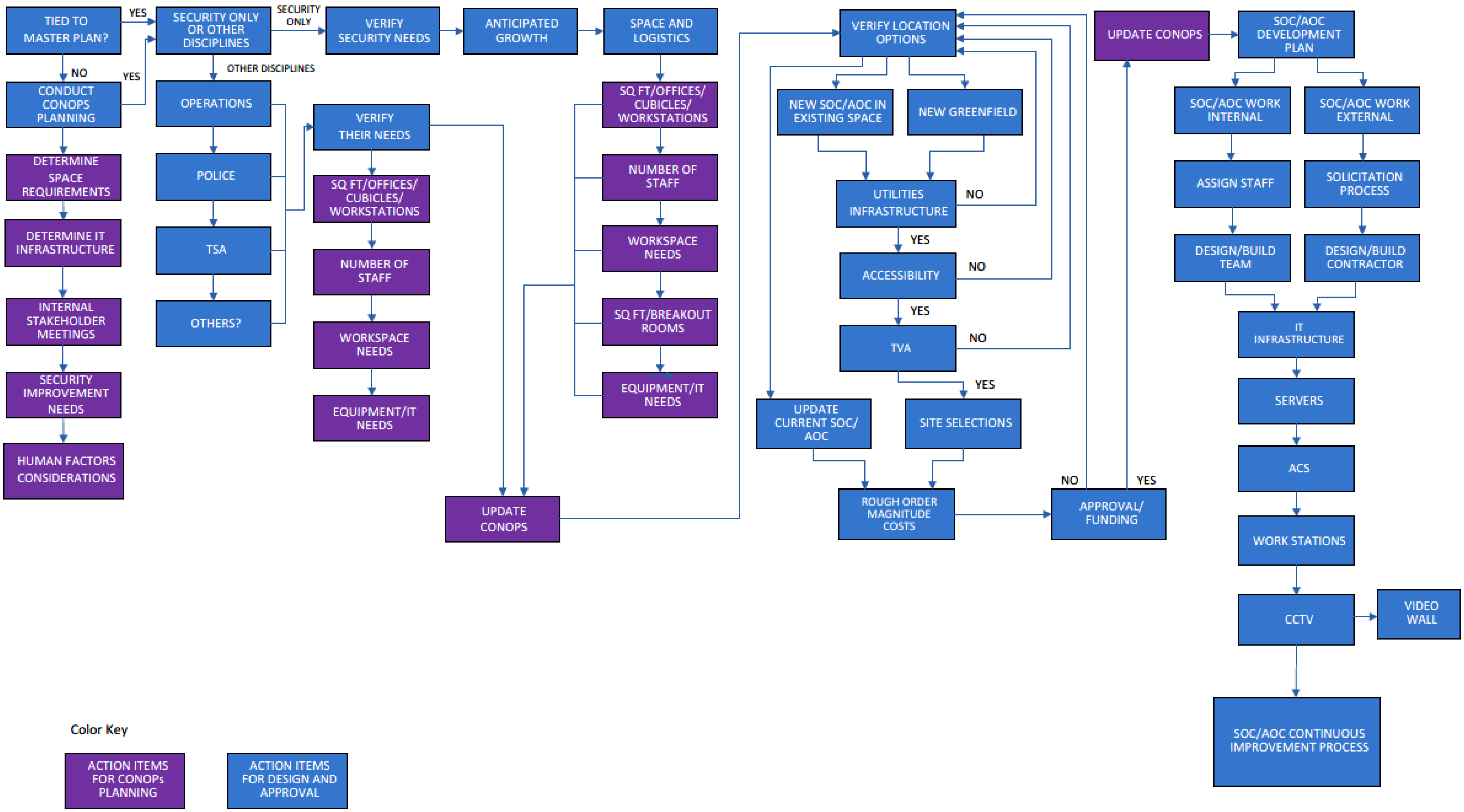
1. Update the current SOC
2. Relocate to and repurpose existing space
3. Build a greenfield facility

This section also includes a Decision Tree flow chart (Figure 2-1), which walks the airport through the process of concept planning, identifying stakeholders, space needs, infrastructure, approvals and design-build. The Decision Tree can be utilized for any of the three options above. A description of each of the three options is also included.

Section 5 details implementation roadmaps for the three options. See Appendix A for checklists of the tasks and decisions inherent in each of the options to help airports navigate the planning, budgeting, approval, and design process.

[4] Benaman, 18
[5] **ACRP Research Report 189:** Section 4, pages 18–22
https://crp.trb.org/acrpwebresource2/wp-content/themes/acrp-child/documents/214/original/acrp_r189.pdf

Figure 2-1. SOC Concept and Development Planning Decision Tree



Source: Benaman, 23

OPTION 1: UPDATE CURRENT SOC

The airport has an existing SOC and they wish to make updates and improvements to the facility. Consider the following and reference the Decision Tree as needed:[6]

- If it is tied to the Master Plan, some high-level planning may have been done and the airport can move forward to verify needs both internally and externally.
- If it is not tied to a Master Plan, the airport should develop a ConOps, which includes determining facility requirements, determining IT infrastructure needs, identifying areas for security improvements, and human factors such as lighting, acoustics, and proper workstations.
- Once the Master Plan concepts or ConOps is complete, the airport can begin to consider the needs of external stakeholders.
- The airport should determine the needs of all stakeholders who will operate at the SOC. Considerations include staffing, anticipated growth, floor plan needs and size, workstations, equipment and IT. If it is a multidiscipline AOC, the airport must determine total needs for internal and external stakeholders.
- If it is a standalone SOC, will it be co-located to other functional disciplines? If so those other stakeholders should be included in the planning process.
- Once personnel and space needs are determined and verified, the ConOps can be updated and the airport can continue towards verifying location options.
- If it is determined that the airport will remain in the existing SOC, a rough order of magnitude (ROM) of costs needs to be documented.
- The next step is approval. If approval is achieved, the ConOps gets updated again and the SOC development plan is put into action for design and implementation.
- During SOC plan development, select the project delivery method, designer, and contractor to carry out the project.
- Elements of the project to be designed and implemented include staff planning, space planning, IT infrastructure, server needs, Access Control System (ACS), workstations, and CCTV, which may or may not be tied to monitors or a video wall.

OPTION 2: RELOCATE TO EXISTING SPACE

The airport desires to move to a new but existing facility on or off the airport campus. Consider the following and reference the Decision Tree as needed:[7]

- If it is tied to the Master Plan, some high-level planning may have been done and the airport can move forward to verify needs both internally and externally.
- If it is not tied to a Master Plan, the airport should develop a ConOps, which includes determining facility requirements, determining IT infrastructure needs, identifying areas for security improvements, and human factors such as lighting, acoustics, and proper workstations.
- Once the Master Plan concepts or ConOps is complete, the airport can begin to consider the needs of external stakeholders.
- The airport should determine the needs of all stakeholders who will operate at the SOC. Considerations include staffing, anticipated growth, floor plan needs and size, workstations, equipment and IT. If it is a multidiscipline AOC, the airport must determine total needs for internal and external stakeholders.

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[6] Benaman, 24
[7] Benaman, 24, 27

- Once personnel and space needs are determined and verified, the ConOps can be updated and the airport can continue towards verifying location options.
- If it is determined the airport will want to use an existing facility (which will likely be modified to the tailored needs of an SOC), then other verifications need to be made for utility needs, accessibility and finally a TVA should be conducted for ranking survivability.
- Once these tasks are satisfactorily complete and the site selection(s) are finalized, a ROM of costs needs to be documented for each potential site (if more than one).
- The next step is approval. If approval is achieved, the ConOps gets updated again and the SOC development plan is put into action for design and implementation.
- If the approval is not achieved, return to verifying location options and proceed through the appropriate steps until approval for funding is achieved.
- Once approval is achieved, the ConOps gets updated again and the SOC development plan is put into action for design and implementation.
- During SOC plan development, select the project delivery method, designer, and contractor to carry out the project.
- Elements of the project to be designed and implemented include staff planning, space planning, IT infrastructure, server needs, ACS, workstations, and CCTV, which may or may not be tied to monitors or a video wall.

OPTION 3: BUILD A NEW GREENFIELD SPACE

The airport desires to construct a new greenfield SOC. Consider the following and reference the Decision Tree as needed:[8]

- If it is tied to the Master Plan, some high-level planning may have been done and the airport can move forward to verify needs both internally and externally.
- If it is not tied to a Master Plan, the airport should develop a ConOps, which includes determining facility requirements, determining IT infrastructure needs, identifying areas for security improvements, and human factors such as lighting, acoustics, and proper workstations.
- Once the Master Plan concepts or ConOps is complete, the airport can begin to consider the needs of external stakeholders.
- The airport should determine the needs of all stakeholders who will operate at the SOC. Considerations include staffing, anticipated growth, floor plan needs and size, workstations, equipment and IT. If it is a multidiscipline AOC, the airport must determine total needs for internal and external stakeholders.
- Once personnel and space needs are determined and verified, the airport should update the ConOps and continue towards verifying location options.
- If it is determined the airport will continue with building a greenfield, then other verifications need to be made for utility needs, accessibility and finally, a TVA should be conducted for ranking survivability.
- Once these tasks are satisfactorily complete and the site selection(s) are finalized, a ROM of costs needs to be documented for each potential site (if more than one).
- The next step is approval. If approval is achieved, the ConOps gets updated again and the SOCdevelopment plan is put into action for design and implementation.

[8] Benaman, 27

- If the approval is not achieved, return to verifying location options and proceed through the appropriate steps until approval for funding is achieved.
- Once approval is achieved, the ConOps gets updated again and the SOC development plan is put into action for design and implementation.
- During SOC plan development, select the project delivery method, designer, and contractor to carry out the project.
- Elements of the project to be designed and implemented include staff planning, space planning, IT infrastructure, server needs, ACS, workstations, and CCTV, which may or may not be tied to monitors or a video wall.

2.4 Site Evaluation and Threat and Vulnerability Assessment

There are many considerations for selecting a site, whether it is updating the existing space, relocating to and repurposing an existing site, or establishing a new greenfield site. While the different types of projects have many similarities, there are differences that must be accounted for in each one. Since an airport's SOC is considered critical infrastructure, conducting a Threat and Vulnerability Assessment (TVA) is recommended.

ACRP Research Report 189: *Design Considerations for Airport EOCs* covers this topic in detail.[9]

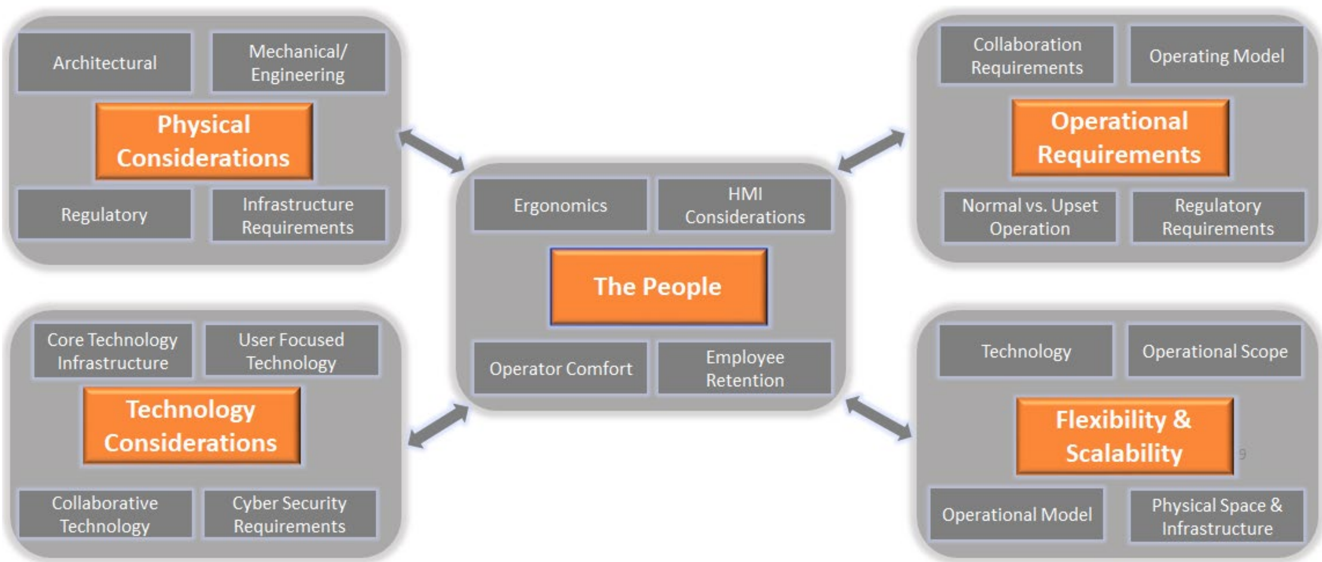
[9] **ACRP Research Report 189:** Section 5 https://crp.trb.org/acrpwebresource2/wp-content/themes/acrp-child/documents/214/original/acrp_r189.pdf

SECTION 3: SOC LAYOUT PLANNING

The layout of an SOC can be critical in assisting smooth operational processes. The physical layout should reflect the organizational processes to be supported within the SOC. It is critical to complete full operational planning, including adjacency study of critical facilities, staff positions, and equipment prior to determining any layout selections to ensure the desired process and goals are supported by the facility.

The five key elements of effective space planning within the SOC are outlined in Figure 3-1: the people, physical considerations, technology considerations, operational requirements, and flexibility and scalability. All five elements have a direct impact on the layout of the future facility and should be taken into consideration early in the planning process. More detail can be added as the design of the SOC progresses. These design elements provide comprehensive recommendations for the main user groups (operators, supervisors etc.) and project stakeholders (management, executives, architects, building owners etc.).

Figure 3-1. The Five Key Elements of an Effective Control Center Design



The People: Operators working in the facility are central to the layout. The related elements that must be considered within the design are ergonomics, operator comfort, and the human-machine interface (HMI). These elements should create a comfortable, safe, and enjoyable work environment. More detail is provided in Section 3.2, Human Factors and Ergonomics.

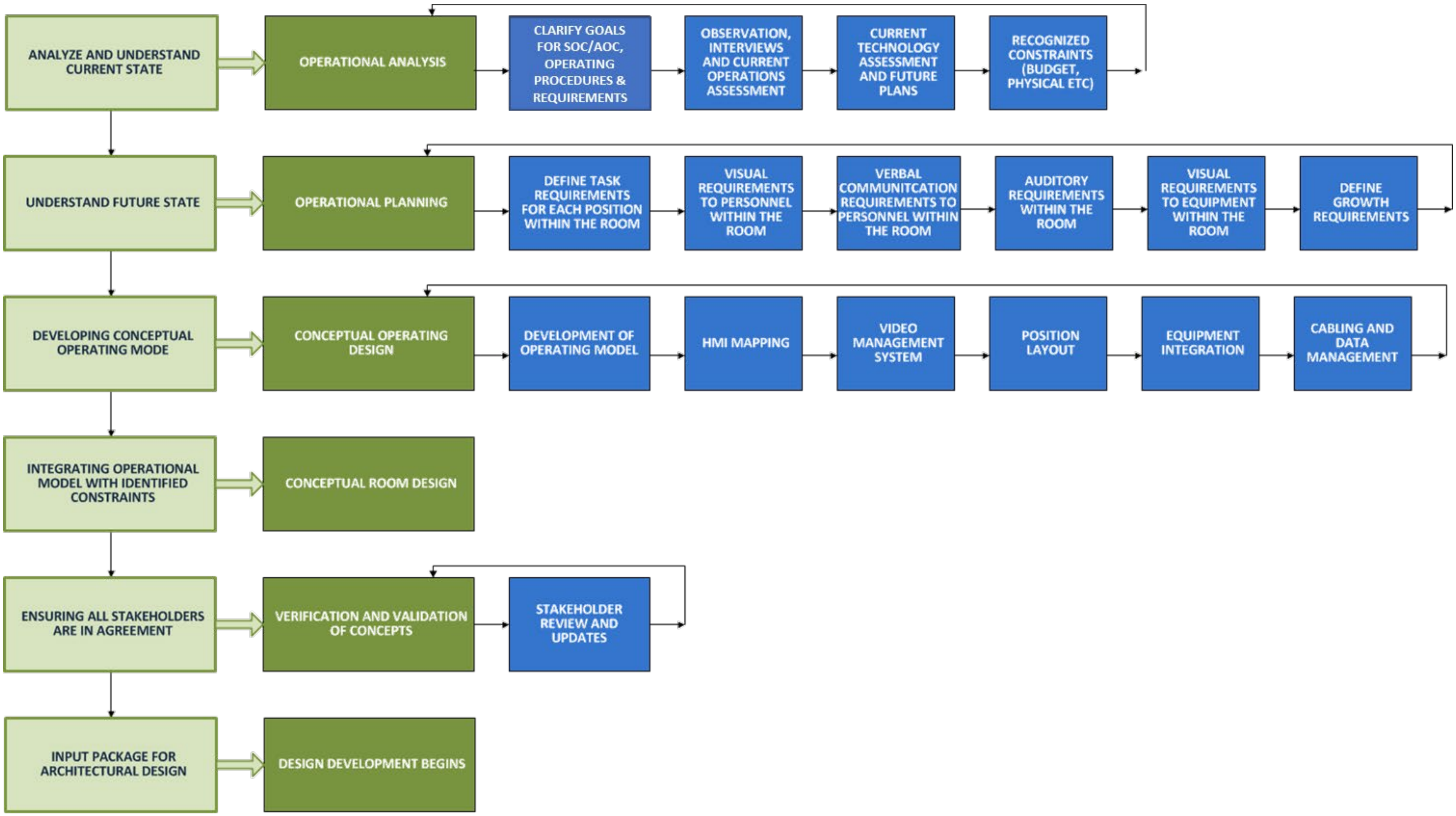
Physical Considerations: The building housing the SOC is a crucial element in the design of the overall facility. Architectural elements may or may not changeable, mechanical/engineering requirements and infrastructure requirements of the entire building will factor into the facility design and function, and overall regulatory requirements must be addressed early in the planning process.

Operational Requirements: An SOC is a unique working environment and the operational requirements must be treated as such. A specific operating model should be identified and followed, while considering any regulatory requirements. How the operation within the facility changes during normal versus irregular scenarios must also be considered, as well as the collaboration requirements both within and outside of the center. See Section 3.1 for more details.

Technology Considerations: The technology within the center is vital to its operation. This includes the technology infrastructure, the cybersecurity requirements, the collaboration needs, and the user-focused technology. The type of technology selected has a direct impact on the layout and operation of the center. See Section 4 for a discussion of technology in the SOC.

Flexibility and Scalability: All the above elements must also be evaluated and designed for the SOC to function under existing conditions and to allow for future growth and expanded roles as demands on the facility change. In Section 6, these elements are described in the context of futureproofing and scalability.

Figure 3-2. Ergonomic Approach to SOC Designs



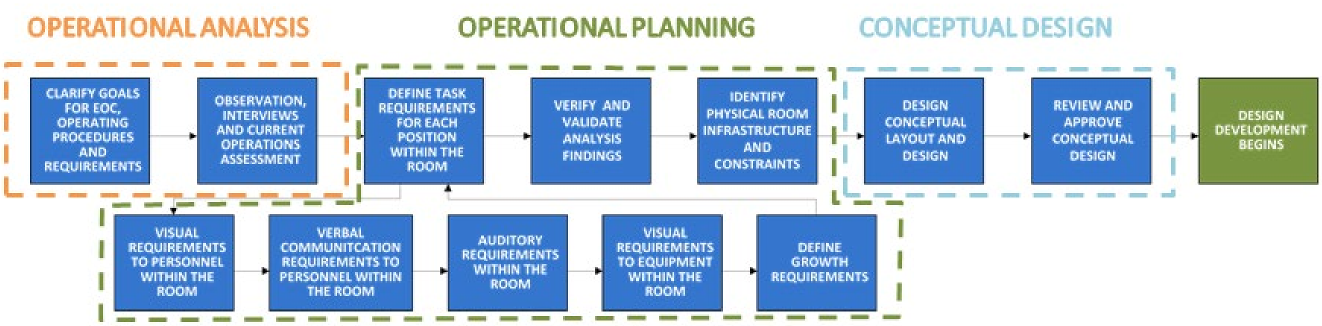
3.1 Operational Requirements

When in operation, the SOC can be a stressful setting where difficult decision making must happen as quickly and accurately as possible. The wide range of irregular scenarios that could occur also requires that the SOC has flexibility in its capabilities. It is important that attention is paid to optimizing the ergonomic design of all relevant aspects of the system.

3.1.1 Programmatic Requirements

The programming and design process should be aimed at identifying and achieving institutional-driven goals in addition to accommodating all requirements identified during the operational analysis and operational layout planning phases of design. Programmatic requirements for mission-critical operations typically include mission goals, performance, operational requirements, space needs, functional adjacencies, and technical requirements. Additionally, programmatic requirements may include provisions for long-term future use, expansion, or facility flexibility. A Programmatic Process chart is shown in Figure 3-3.[10]

Figure 3-3. Programmatic Process for SOC Design



Source: Benaman, 53

It is suggested, if applicable, that programming the SOC be an inclusive process to engage all stakeholders of the facility (management, users, operators, construction, etc.). Early engagement will allow the needs and requirements of the stakeholders to be documented and implemented, and an ongoing feedback loop throughout the programming and design process is advised. It is recognized that this programming may not be feasible for some depending on the stage of their project or the design and procurement processes within their organizations.[11]

3.1.2 Operational Analysis

Information gathered from stakeholders will vary. All information is useful in developing an SOC that is responsive to organizational objectives and user needs. In general, stakeholders may be expected to provide programmatic information as follows:[12]

EXECUTIVE AND OPERATIONAL MANAGEMENT

- What are the functional objectives?
- Are there technical or aesthetic institutional standards to incorporate?

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[10] Benaman, 53
[11] Ibid., 53
[12] Benaman, 53, 55

- What are the overall tasks to be performed?
- What is the planned staffing for activation?
- What ancillary spaces are required to fully support operations?
- What are the current operational challenges to be addressed?
- How do the room parameters change between short- and long-term activations?
- What are the individual staff responsibilities and required interactions with other operators, supervisors, and managers?

OPERATORS

- What are the positions within the control center?
- What are the individual task loads for each position?
- What equipment are they currently using?
- How is their time during an average hour divided among each piece of equipment?
- How does that change during a long-term activation?
- What types of errors typically occur and how frequently do they occur?
- When do the operators experience highs and lows in energy and awareness?

IT AND SYSTEMS INTEGRATORS

- What equipment is used or proposed for use in the control center?
- Where is the equipment best located?
- What challenges are anticipated in setting up, operating, and maintaining the equipment?
- How will the systems be integrated with remote operations, facilities, and equipment?

3.1.3 Operating Model

When designing the SOC, it is important to first review the current operating model to highlight which processes are working well and which could be better optimized, as discussed in Section 2. This review includes current technology used and planned upgrades, operational goals, and shift length. Once the current operating state is fully determined, it is important to outline the future operating plans. This includes identifying the visual requirements needed for each task or position, future position planning, and the communication needs of each group within the SOC. How will they be communicating and who are they speaking with? Facilitating this communication in the layout can cut down on noise and distractions within the center.[13]

Before a conceptual plan can be developed, the individual positions within the room and their equipment requirements need to be identified. This is also the time to determine if agnostic workstations and/or free seating is appropriate for operations. The amount of equipment and identification of primary, secondary, and tertiary sources of information will directly affect the furniture requirements within the room. Once layout of the equipment for each position has been identified, the optimal furniture can be selected and an appropriate layout designed.[14]

[13] Benaman, 55
[14] Benaman, 56

3.2 Human Factors and Ergonomics

Ergonomics and human factors directly impact the efficiency and safety of SOC operations.

Human factors and ergonomics use a human-centered design approach that incorporates the interactions among three interrelated categories: physical, cognitive, and organizational considerations. These concepts are explained below.[15]

3.2.1 Standards

The International Organization for Standardization (ISO) has a series of standards related to the ergonomic principles for designing various arrangements of rooms and spaces in a control suite. These standards provide guidance on physical layout, design of workstations, and ambient environmental considerations. The following standards are available:[16]

- **ISO 11064-1:2000 Ergonomic design of control centers - Part 1: Principles for the design of control centers:**

  This specifies ergonomic principles, recommendations, and requirements to be applied in the design of primarily non-mobile control centers. It addresses the expansion, refurbishment, and technological upgrades of control centers.
- **ISO 11064-2:2000 Ergonomic design of control centers - Part 2: Principles for the arrangement of control suites:**

  This specifically addresses the ergonomic design principles for the arrangement of rooms and spaces in a control suite. It includes identification of functional areas, space provisions for each functional area, operational links between functional areas, and optimal layouts. The ergonomic design principles are based on an analysis of functions and tasks that must be performed in the SOC.
- **ISO 11064-3:1999 Ergonomic design of control centers - Part 3: Control room layout:**

  This includes ergonomic design requirements, recommendations, and guidelines for primarily non-mobile control room layouts, workstation arrangements, off-workstation visual displays, and control room maintenance.
- **ISO 11064-4:2013 Ergonomic design of control centers - Part 4: Layout and dimensions of workstations:**

  This specifies ergonomic design principles, recommendations, and requirements for the design of SOC seated, visual display–based workstations with emphasis on layout and dimensions, along with some consideration of standing workstations.
- **ISO 11064-3:1999 Ergonomic design of control centers - Part 3: Control room layout:**

  This presents ergonomic design principles, requirements, and recommendations for displays, controls, and their interaction in the design of control-center hardware and software.
- **ISO 11064-6:2005 Ergonomic design of control centers - Part 6: Environmental requirements for control centers:**

  This presents environmental requirements for the thermal environment (in temperate regions), air quality, lighting environment, acoustic environment, vibration, aesthetics and interior design, and

[15] Benaman, 51
[16] Benaman, 52

recommendations for the ergonomic design, upgrade, or refurbishment of control rooms and other functional areas within the SOC.

- **ISO 11064-7:2006 Ergonomic design of control centers - Part 7: Principles for the evaluation of control centers:**

  This establishes ergonomic principles for the evaluation of control centers, including the control suite, control room, workstations, displays and controls, and work environment.
- **ANSI/HFES 100:2007 Human Factors Engineering of Computer Workstations:**

  This standard provides specific guidance for the design and installation of computer workstations, including displays, input devices, and furniture. The standard can be applied to a range of environments, and it accommodates a wide variety of users.
- **Canadian Standards Association (CSA)-Z412-00 (R2016) - Guideline on Office Ergonomics:**

  This guideline provides step-by-step instructions of the ergonomics process for the optimal design of office systems where computers are being used, including the design of jobs and work organization, layout of the office, environmental conditions, and workstation design. It is intended predominately for office workers and employers who are responsible for health and safety or ergonomics programs in the workplace.

3.2.2 Physical Ergonomics

Physical ergonomics focuses on the body's response to physical work demands and the impact of the physical work environment (repetition, vibrations, workstation arrangement, etc.) on staff. Considerations for physical ergonomics include biomechanics, anthropometric data (i.e., body measurements and proportions), and employee habits. When designing with physical ergonomics in mind, it is important to identify primary, secondary, and tertiary tasks at the workstation. These categories should be reviewed in normal and critical operational modes, and the workstations should be set up to accommodate the most ergonomic positioning in both operational scenarios.[17]

ACRP Research Report 189: *Design Considerations for Airport EOCs* covers this topic in detail.[18]

3.2.3 Cognitive Ergonomics

Cognitive ergonomics refers to the mental processes around a combination of tasks. It is a study of how we observe information and understand its implications, and how that determines the decisions we make. It is important to recognize the constraints of human cognitive abilities and accommodate those within a functional design. This is particularly important in a mission-critical facility where multiple processes and alarms are monitored by one person. Understanding memory, perception, reasoning, and motor response in relation to operational needs is critical. Such considerations are especially important given that SOC operating conditions are likely to present multiple stressors, especially time stress and multitask loading.[19]

Cognitive ergonomics also considers situational awareness, which is critical to the effective performance of the SOC.

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[17] Benaman, 51

[18] **ACRP Research Report 189:** Section 6, pages 61–66 https://crp.trb.org/acrpwebresource2/wp-content/themes/acrp-child/documents/214/original/acrp_r189.pdf

[19] Benaman, 51

3.2.3.1 Alarm Management

Alarm management is a critical element of cognitive ergonomics, and is important to consider in terms of overall situational awareness. While each SOC will have multiple core control systems (security, building access, cyber, etc.) it is critical that multiple levels of alarm management be available to the operators, including:

- Visual alarms at each workstation
- Visual alarms visible by entire room
- Audible alarms

Having the ability to display alarms in multiple ways allows for a better classification of alarms and ensures the appropriate level of attention is given to a specific alarm, either by the operator or the entire room.

VISUAL ALARMS

Since there are several different control systems being used, it is recommended that an audio-visual alarm management matrix be developed in the detailed phase of the design. These alarms should be integrated in the video management system (VMS) to allow for display of alarms in at least the following levels:

- Alarm displayed on core control system
- Alarm prioritized on the display configuration of the operator (e.g., alarm prioritizes the system affected on the center screen on an operator position)
- Alarms displayed on a common viewing screen (e.g., building management systems alarms, threat detection systems and similar)

By using a VMS, the alarms can also be tied to a specific video input that can be associated with security monitoring systems. This will allow for the automatic prioritization of the video of the specific area where an alarm is triggered.

ROOM-LEVEL VISUAL ALARMS

If the SOC will have multiple positions, it is recommended that each operator position have an integrated visual alarm management system. The system should be triggered either manually by the operator that is requesting assistance or is responding to a specific event, or it can be integrated to be triggered automatically by a control system, thus eliminating the operator position. This approach allows for other personnel in the room to be aware of a specific alarm that an individual operator may be dealing with.

AUDIBLE ALARMS

Audible alarms should be kept to a minimum, and typically should be confined to an individual operator position. Too many audible alarms may result in an increased level of noise, which will impact the overall operation. Where audible alarms are necessary, a manual override button that activates visual alarms should be available. It is recommended these visual alarms be programmed as a unique color or pattern of lighting to indicate it is a manual activation.

3.2.3.2 Acoustics

In an office environment, noise causes disturbances and can reduce productivity and contribute to stress. Noise can impact people physically, physiologically, and psychologically. SOC environments are unlikely to experience noise levels high enough to cause physical damage, but they may have physiological and psychological effects affecting blood pressure and heart rates, and causing hearing loss, annoyance, decreased performance, and increased stress levels. The psychological impact of noise is more subjective and not always related to a dB level, as it is often affected by the perceived necessity of the noise.

Understanding how operators work within a given area will determine how acoustics need to be addressed. Noise level is believed to be one of the biggest disruptors of performance, yet it is often one of the last issues addressed in the design of buildings. The goal of acoustic treatment is to maximize the operators' awareness of alarms and processes being monitored while minimizing noisy distractions. It is important that auditory alarms are discriminable from one another and against the background noise level.[20]

The ideal ambient noise level in a mission-critical environment is 30–35dB. The potential for building components (walls, ceilings, doors, windows, etc.), to contribute to minimizing sound transmission from space to space is significant. HVAC sound levels for meeting spaces should not exceed a Noise Criteria/Room Criteria (NC/RC) of 30dB.[21]

Some of the greatest challenges to effective operation are minimizing distractions and maintaining clear verbal communication. Poor room acoustics will exacerbate these challenges. With multiple simultaneous conversations, the most important measure is to create a high level of noise absorption. Typical acoustical panel ceilings are effective, as well as carpeted floors. Beyond these routine approaches, sound absorbing panels can be added to walls. Parallel walls can create a condition called "flutter echo," where the sound oscillates rapidly between the two walls. Absorptive materials with a Noise Reduction Coefficient (NRC) of 50%–80% applied to the upper portion of one of each parallel wall can address this concern.[22]

Sound masking, a low-level constant ambient noise, can help focus listening and dampen distracting outside conversations and noises. While this is sometimes achieved, often inadvertently, by the hum of mechanical equipment, systems are available that usually utilize ceiling-mounted speakers with sound that is designed and can be controlled for this purpose.[23]

Walls should be designed to contain sound in individual rooms and avoid noise from exterior sources. Extending partitions to the underside of floor or roof decks above is much more effective than relying on ceiling materials. Sound gaskets should be installed on doors. Sound Transmission Class (STC) is a rating of how well a building partition (e.g., wall, ceiling, floor) reduces sound transmission. For normal privacy levels, STC 52–55 is recommended, with STC greater than 55 for confidential conditions.[24] A typical steel stud partition with gypsum board facing has an STC rating of 40. Performance can be increased with acoustical blankets in the stud space, with resilient channels or offset studs, and with special membranes. Other partition construction materials, such as concrete masonry, can be effective in reducing sound penetration, but might need treatments such as gypsum board over resilient channels to address the full range of sound frequencies.[25]

Generally speaking, acoustical separation between positions has more negatives than positives. Partitions between workstations are typically not recommended as they reduce sightlines and can create

[20] Benaman, 66
[21] Ibid,. 66
[22] Benaman, 79
[23] Ibid., 79
[24] Weissenburger, 2004.
[25] Benaman, 79

another surface for noise to bounce off of. Use of microphones and headsets reduce broadcasting noise beyond those who need to hear it. Breakout spaces can be used to relocate groups that might be loud enough to be a distraction to others.[26]

Acoustical controls should be considered on a case-by-case basis. It is recommended that an acoustical study be done to recommend the correct materials and solutions.

3.2.3.3 Lighting

Lighting in workspaces is a critical but is often overlooked. Proper lighting design makes completing tasks easier and can also improve physical and mental health of team members. Lighting requirements should be considered at the room level in order to provide overall circadian support, with additional task light requirements per operator. Lighting and lighting design can be highly complex and customizable. While general guidelines are discussed below, a lighting study is highly recommended during the design process.

LIGHTING DESIGN

Consideration should be given to the different visual demands expected of the SOC operators and their ability to perceive information from electronic screens and written text. Lighting should be designed to allow flexibility through dimming controls and zoning in different task areas. Illuminance levels on works surfaces should be maintained at recommended levels. This can be best achieved using a combination of ambient and task lighting.[27]

Five foot-candles (fc) are adequate for corridors, 30–50 fc at desk level is appropriate for private office lighting, and 30 fc is recommended in conference rooms. Specific detailed work can benefit from up to 100 fc, best achieved where necessary by localized task-lighting.[28]

How lighting is designed is also important. Light fixtures should be selected to avoid glare at viewing angles that can be visually distracting or that can reflect off monitors. This is accomplished by careful selection of fixtures and lenses. But maximum cutoff of light angles is not necessarily ideal. Visual perception is most comfortable and effective in response to appropriate contrast levels. It is best to provide general illumination of wall and ceiling surfaces so that the eye does not have to constantly adjust between the well-lit work surface and a relatively dark background.[29]

LEDs can result in energy savings and less frequent replacement. The technology can also can offer a range of color choices. LED lighting is evolving to include applications that can change color throughout the day, with warmer light in the early morning and evening (mimicking light sunrise and sunset), and cooler in the daytime. Such systems could aid visual comfort during long term events.[30]

Lighting consumes a great deal of energy. Automated sensors that detect both occupancy and vacancy can ensure that lights are used when they are needed.[31]

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[26] Benaman, 79
[27] Benaman, 66
[28] Benaman, 78
[29] Benaman, 78
[30] Ibid., 78
[31] Ibid., 78

DYNAMIC OR CIRCADIAN LIGHTING

There is an emerging trend towards dynamic or circadian lighting solutions that promote the health and wellbeing of operators, while helping to reduce fatigue.

The circadian system is largely responsible for the energy changes we experience throughout the day. This internal system is regulated by the brain's hypothalamus and is affected by the natural variations in daylight throughout the day.

Instead of completely removing the blue wavelength in the provided lighting, these new lighting solutions recognize the need for blue wavelength light during specific times of the day and will slowly adjust between short wavelength and long wavelength light throughout the shift to support the circadian system of the operators as programmed. These lights, in addition to an effective fatigue management program and adequate thermal, air quality and noise control, can significantly enhance employee health and situational awareness in the workplace.

During abnormal periods of high stress and need for increased problem-solving mental acuity, studies have found that the opposite is true of blue light. By shifting room lighting to very specific shades of blue lighting during these situations, studies have proven the human brain becomes more relaxed and able to take on greater mental challenges, collaborate better with teammates, and stay functioning efficiently for longer periods of time before becoming fatigued.

3.2.3.4 Fatigue Management

Fatigue management is an important consideration in any 24/7 application. It has a direct impact on the performance of the operators as well as their overall wellbeing. A fatigue management assessment of the current operation (if available) is recommended, with the findings incorporated into the overall SOC design. In addition, development of a fatigue management plan is recommended. The plan should be evaluated periodically throughout the life of the operation.

Many organizations create their own fatigue-management tools, based on the specific needs of their industry. These can include internal education on recognizing fatigue and self-monitoring checklists. When creating a fatigue-management program there are several things that should be considered:

- An effective program is dependent on understanding the benefits of the program, the factors that influence fatigue, and the impact on employee effectiveness.
- Employee training in recognizing and identifying the signs of fatigue is critical in a program that relies on self-monitoring.
- A program is only as effective as the level of management support that is offered.
- Effective countermeasures should be identified to combat fatigue. While programs can be in place to help prevent fatigue through scheduling of shifts and sufficient breaks, there is no way to predict social causes of fatigue (e.g., a restless night). Caffeine, exercise, and napping can be effective countermeasures.
- Annual reviews of fatigue-related incidents should be scheduled to maintain an effective program and identify potential improvements.

3.2.4 Organizational Ergonomics

Organizational ergonomics focuses on the interaction among humans, technology, and other elements in a system. This category of ergonomics looks at social interactions and patterns of communication, leadership, and teamwork considerations. This is a critical element of SOC design to ensure adequate task loading and effective communication flow in both normal and irregular operations.[32]

The SOC often requires a separate organizational structure from the rest of the airport, especially in facilities functions. Frequently during the design process, the various functional areas are not thought of as a common team. Focus should include designing for separate functions and interactions between those functions within the same control room.

SUPPORT SPACES

Design considerations for SOC support spaces, including restrooms, break rooms, rest areas, and storage spaces are discussed in detail in ACRP Research Report 189: *Design Considerations for Airport EOCs*.[33]

3.2.4.1 Personnel Circulation Requirements

The overall circulation of personnel within the control room should adhere to the following recommendations, where possible:

- Adequate provisions should be made to ensure movement of personnel does not distract from control operations.
- The building layout should enable orderly evacuation.
- Circulation routes should be reviewed to ensure cross-circulation can be avoided.
- Fixed items such as electrical panels, HVAC ducting, etc. should be located at a distance from swinging doors to avoid pinch points
- Door swing designs should consider the potential for building occupants to be overcome by fire, smoke, etc. Egress routes should be evaluated to ensure building codes are met.
- For wheelchair users, clearances for building corridors should accommodate the maximum wheelchair width plus clearance for the user's elbows. It should be noted that some states have stricter requirements than the federal ADA requirements. The recommended minimum clearances are:
    - 48 inches for length of wheelchair (including footrest and clearance)
    - 36 inches for width of wheelchair and clearance
    - Additional space for turning a wheelchair should be provided at appropriate locations throughout the control room. The recommended diameter for turning is 60 inches.

3.2.4.2 Natural Elements

Access to daylight, exterior views, and natural elements such as plants are important features of a quality indoor work environment. Studies show that such conditions improve productivity and performance and reduce stress.[34]

In the case of an SOC, protective design measures might reduce or eliminate the possibility of installing windows or skylights. However, the presence of windows can be beneficial for employees and should be

[32] Benaman, 51
[33] **ACRP Research Report 189:** Section 7, pages 75–76 https://crp.trb.org/acrpwebresource2/wp-content/themes/acrp-child/documents/214/original/acrp_r189.pdf
[34] **Sciencedirect.com:** https://www.sciencedirect.com/science/article/abs/pii/S2352710219313105

considered wherever possible. For SOCs with windows, daylight must be well controlled. Direct solar penetration should be avoided by using barriers such as overhangs, sunshades, and window blinds.

Plant life is more easily incorporated into the SOC. Living walls or potted plants can be placed throughout the control room and break areas.

SECTION 4: TECHNOLOGY REQUIREMENTS AND RECOMMENDATIONS

This section will help the reader understand the typical technology requirements for SOCs, including security systems for the site itself, facility requirements and standards, security support systems such as PSIM, and video wall technology considerations.

4.1 Facility Security

Whenever possible, the physical security of the SOC and facility property should comply with Interagency Security Committee guidelines for federal facilities (note that some states may have stricter requirements). This framework will provide an appropriate level of physical and electronic security to protect the SOC. In general, SOC security should be designed utilizing a layered approach to countermeasures, with security and access restrictions increasing as a person moves inward.

Higher security spaces, such as telecommunications server rooms, should use multifactor readers, such as biometric readers with integrated card authentication, to maintain auditability. All controlled doors should have video surveillance on each side of the portal for easy alarm viewing and clearance.

Access privileges should be based on job responsibilities so that only personnel with a genuine need may access higher security areas. Intrusion detection should be considered if the facility is not operating 24/7.

All packages arriving at the SOC should be screened prior to delivery. If a local mailroom is provided, then it should have an isolated HVAC system and screening area. This area should also be an isolated fire zone. Alternatively, mail could be screened at an offsite location. If the SOC is part of a multidiscipline AOC or adjacent to a shared mailroom, screening technology should be considered due to the higher volume of deliveries and the higher threat target of a shared facility.

The facility should have visitor and secured parking areas, with access control implemented at entry and egress points for the secured parking area and/or the facility. Only personnel who work at the location should have access privileges. Visitors should register for a visitor badge or be escorted to enter the SOC. Blue light emergency phones should be installed at any location that staff regularly access outside of the secure boundary.

Lighting should be sufficient for video surveillance of the site. Lighting levels should allow for standard color camera usage (0.2 lux minimum) without the need for IR illumination.

Surveillance cameras should be designed to support the following resolutions:

- Identification-level resolution (80 Pixels per Foot [PPF] horizontal at target distance) for all site entry and egress points
- Recognition-level resolution (40 PPF horizontal at target distance) for any gathering areas inside the secured site
- Observation-level resolution (20 PPF horizontal at target distance) for all secured facility areas as well as 50 feet around the building envelope in unsecured space

4.2 Physical Security Information Management (PSIM) Systems

A PSIM is software that aggregates and normalizes disparate security systems and their associated data for the purpose of providing a common command and control platform.

Enabling command and control is an important feature of a PSIM. It is not enough for a system to monitor the status of connected subsystems. The system must also be able to control associated devices of the subsystems integrated with it. The combination of real-time status monitoring and granular control of associated devices allows the PSIM to perform many of its essential functions such as:

- **Automated Response** – A PSIM can be preconfigured to cause actions to happen automatically as a result of a defined event. For example, the system could be configure to call up a camera based on a door event. Given the breadth of data available to a fully integrated PSIM, automated responses can involve multiple systems and actions, such as changing or revoking access privileges, notifying personnel via emergency management systems, or automatically creating work orders to correct equipment maintenance issues.
- **Incident Management** – A PSIM can be configured with a Play List or Play Book for an event. When the event occurs, the Play Book automatically initiates and tracks the workflow, which typically involves a combination of automated responses and user inputs to resolve the event. This process allows for uniform and methodical handling of events, enabling operators to respond quickly and correctly without missing critical steps in the process.
- **Incident Reporting** – A PSIM can consolidate relevant data from integrated systems into a single cohesive incident report. This report may include audio, video, access records, response report (Play Book record) and any other pertinent data, and will be saved in a single location for after-action review or extraction.
- **Historical Analysis** – With all subsystem data and events stored or referenced in a common database, a PSIM can perform historical analysis of events and operator actions. This allows management to recognize trends in system or operator behaviors and correct deficiencies.

The PSIM should integrate with all available video assets to allow for the highest level of situational awareness. This includes integration with a VMS so that the information can be displayed on a common set of Geographic Information System–based maps. The ideal video surveillance system (VSS) or VMS integration into the PSIM allows for full video functionality (based on permissions) through the PSIM, eliminating the need for secondary computer workstations. Video call-up capabilities should include pre-event, live, and post event video. This functionality should be available for all systems events.

4.3 Technology at the Workstation

The operator workstation should be flexible and consider future equipment modifications. As operational needs change and tasks loads increase or decrease, the workstations should be able to adjust functionality.

FREE SEATING

Free seating is a concept in which a user can leave a desk at which they are working and log on to another free desk with their access rights. After login, the system switches to the current user's screen preferences and content so that they can immediately continue working at the new workstation. This functionality is useful if a workstation fails for any reason, or part of the control and monitoring center become unusable. With the free seating concept, an authorized user can access and operate any of the connected computers/sources.

CONSOLE DISPLAY MANAGEMENT

The display configuration is a common change to a workstation as resolution and display size increase. The displays should be installed on a flexible mounting system that is independent of the console work surface. This will prevent damage to the workstation by eliminating the need to attach/detach the mounting system from the work surface. The display mount should allow for quick access to add/remove displays without the need for tools, and should enable the number of displays to be increased in the future (e.g., adding double tier displays, large overview monitors).

EQUIPMENT INTEGRATION

Workstations should allow for flexible equipment integration. While the workstation structure and cable management are part of the core design, equipment storage should be flexible for future addition or removal of equipment such as PCs, remote switches, rackmount units, or other types of equipment that may be required in the future. The equipment mounts should have their own cable management and should be aesthetically designed avoid to impacting the overall look of the workstation.

CABLE MANAGEMENT

Workstations should have multiple pathways of cable management to allow for the separation of power and data within the console frame. In addition, cable management should be flexible so that additional cable raceways can be added after installation in case of increase in data/power requirements or addition of secure feeds.

4.4 Thin Clients and Server-Based Computing

Space requirements, power consumption, and heat output can be minimized at each workstation by leveraging a thin client, which is a simple computer that relies on server-based applications, processing, and storage. The thin client located at each workstation is network connected back to a Virtual Desktop Infrastructure server host. Each workstation should be able to create its own flexible display of visual information that user can customize for their needs.

Thin clients can be cost effective to purchase and manage, as each workstation requires fewer local capabilities and resources, and administration tasks are mostly conducted at the central server. However, utilizing thin clients will required increased server sizes. Ensuring that network bandwidth can support all operational needs and that connectivity is reliable are also critical considerations.

4.5 Audio-Visual Technology Considerations

The visualization system requirements focus on video and content distribution throughout the SOC. The system will be required to distribute any specified window of content, from any workstation in the SOC, to a flexible resolution window in the video wall.

The video wall greatly improves situational awareness for all stakeholders. The preferred technology for this solution is the direct view LED video wall, which uses LED-lit screens with edge-to-edge picture, as shown in Figure 4-1. This technology provides a high-resolution, flexible canvas with no mullions to divide the image like those found in an LCD-type video wall. LED walls typically have low maintenance and a long lifespan.

Figure 4-1. Direct View LED Video Wall

The content to be distributed will be available to any authorized workstations connected to the SOC network, either physically or wirelessly. The general content will be multimedia including spreadsheets, presentations, streaming video from both the VSS and broadcast television, and virtual presence conferencing content.

The visualization system should reside in a closed IP audio-visual network that is physically located in the facility. Content will be delivered to the network by client workstations utilizing audio-visual over IP encoders by means of a physical network connection present at each client workstation. The visualization system should act as a virtual switching matrix allowing any of the IP content streams to be switched or directed to a scalable resolution window inside of the video wall canvas.

Selecting the right video wall processor is critical to integrated operations within the SOC. A video wall processing solution that allows for easily recalled user-defined layouts and resolutions that match those found at the workstations is recommended to avoid aspect ratio issues and to reduce the number of actions required for operational changes during everyday use.

Video wall wireless media gateways can be leveraged to enable laptop or mobile users to share content on displays without being hardwired to a connection port. Some manufacturers of wireless media gateways allow for up to 32 user devices to be connected to the gateway at the same time, and up to four of those 32 to share their screens to the video wall simultaneously.

4.5.1 Video Surveillance and Management System

A VSS is a critical part of a multifaceted physical security system, and is typically used in conjunction with intrusion detection, access control, and alarm management systems to provide visual verification and situational awareness of the activity related to an alarm event.

Some key considerations for a VSS include video analytics and storage via a VMS.

Video analytic software monitors for prohibited behavior such as wrong-way travel, entry into a prohibited area, crowd gathering, facial recognition, license plate recognition, etc. When properly applied, video analytics can provide real enhancements to video surveillance.

A critical adjunct function of a VSS is the VMS, which is essential for reviewing video history, or for producing a video for forensic review of an event or for evidence in litigation. The most effective VMS provides for open architecture and in-depth integration with the cameras and the system encoders. Open architecture is also critical in ensuring compatibility between the VMS and the IP-based cameras on the system, as well as the ability to integrate with a PSIM.

4.6 Cybersecurity and Data Protection

The critical nature of the SOC's systems and the sensitivity of data handled by the SOC necessitate a strong cybersecurity and data security program within the SOC. In-depth discussion on developing and maintaining a cybersecurity program is outside the scope of this document. The following resources may provide further support in this area.

- **NIST Special Publication 800-53: Security and Privacy Controls for Information Systems and Organizations**[35]
  "This publication provides a catalog of security and privacy controls for information systems and organizations to protect organizational operations and assets, individuals, other organizations, and the Nation from a diverse set of threats and risks, including hostile attacks, human errors, natural disasters, structural failures, foreign intelligence entities, and privacy risks."

- **NIST Special Publication 800-53A: Assessing Security and Privacy Controls in Federal Information Systems and Organizations**[36]
  "This publication provides a set of procedures for conducting assessments of security controls and privacy controls employed within federal information systems and organizations. The assessment procedures, executed at various phases of the system development life cycle, are consistent with the security and privacy controls in NIST Special Publication 800-53, Revision 4."

- **CISA Transportation Systems Sector Cybersecurity Framework Implementation Guide**[37]
  This guide "and its companion workbook provide an approach for Transportation Systems Sector owners and operators to apply the tenets of the NIST Cybersecurity Framework to help reduce cyber risks… Organizations that lack a formal cybersecurity risk management program could use the guidance to establish risk-based cyber priorities."

- **PARAS 0007: Quick Guide for Airport Cybersecurity**[38]
  "This Quick Guide is intended to help airport executives and managers understand that they are accountable for cybersecurity issues and must measure and improve their cybersecurity programs and capabilities. It provides meaningful and actionable information for airport managers to evaluate and improve their own cybersecurity efforts. The assessment tool that accompanies this document measures the airport's cybersecurity risks and program maturity, and should be universally usable by large and small airports without additional software or hardware."

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[35] NIST SP 800-53: https://csrc.nist.gov/publications/detail/sp/800-53/rev-5/final
[36] NIST SP 800-53A: https://csrc.nist.gov/publications/detail/sp/800-53a/rev-5/final
[37] CISA Transportation Systems Sector Cybersecurity Framework Implementation Guide: https://www.cisa.gov/publication/tss-cybersecurity-framework-implementation-guide
[38] PARAS 0007: https://www.sskies.org/paras/reports/

SECTION 5: IMPLEMENTATION ROADMAP

This section provides roadmaps for each of the three SOC options discussed in Section 2.3:

1. Update the current SOC
2. Relocate to an existing space
3. Build a greenfield facility

The roadmaps are broken down by task and include task timeframes and the order of dependencies. For example, technology planning and procurement should start early in concept planning because of the length of time needed to procure and go live with technology systems, and construction cannot start until design is complete. Each roadmap starts with concept planning and ends with construction and technology tasks completed.

Throughout the roadmap process, the reader should refer to the concept in Section 2.3 and revisit the ConOps at various milestones to determine if updates are needed. For example, a change in the size of the facility may affect the number of personnel working in the SOC. Findings during site selection or the TVA may result in an increase or decrease in cost to the project. The ConOps should be regarded as a continuous improvement plan as the project moves forward.

These timelines assume no egregious impacts to the project. Each airport understands their own planning, design, and construction process, and timelines should be adjusted accordingly.

5.1 Roadmap for Updating Current SOC

CONCEPT PLANNING

Concept planning begins day 1 of the project and is expected to take three to six months. The ConOps may be updated periodically throughout the project as necessary.

TVA

Even when updating an existing SOC, the facility should be assessed to identify potential improvements such as exterior lighting, improved access control systems, additional cameras, or hardening exterior walls. This is considered a best practice for critical facilities.

The TVA could begin one month into concept planning and may take two months.

DESIGN

Design should begin at the end of concept planning and may take four to six months.

TECHNOLOGY

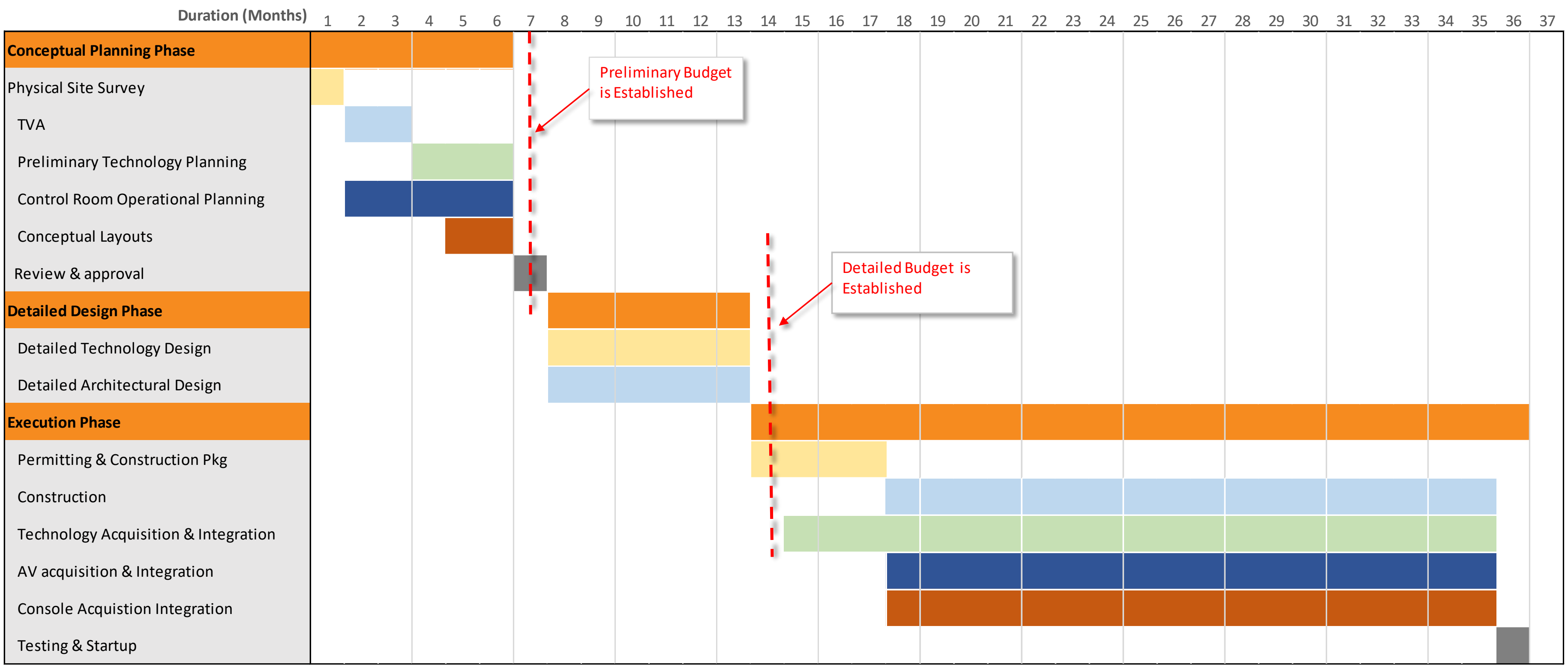
Technology updates can be a lengthy process depending on which systems are being replaced or added. The airport needs to factor in establishing system requirements, writing and advertising an RFP, selection, and implementation, including testing and cutover.

The technology task should begin three months into concept planning and last the project timeline through construction completion, which may be one and a half to two years.

CONSTRUCTION

Construction should begin at the end of design and may take six to twelve months.

Figure 5-1. Update Existing Facility Implementation Timeline



5.2 Roadmap for Relocating to Existing Space

CONCEPT PLANNING

Concept planning begins on day one of the project and is expected to take six to twelve months. The ConOps may be updated periodically throughout the project as necessary.

SITE SELECTION

Site selection may include more than one option. Results of the TVA may help drive the selection. The results of the site selection may also trigger a review of the ConOps, and updates should be made accordingly.

Site selection should begin six months into concept planning and may take four to six months.

TVA

The TVA could begin one month into site selection and may take one to two months.

DESIGN

Design should begin at the end of site selection and may take six to twelve months.

TECHNOLOGY

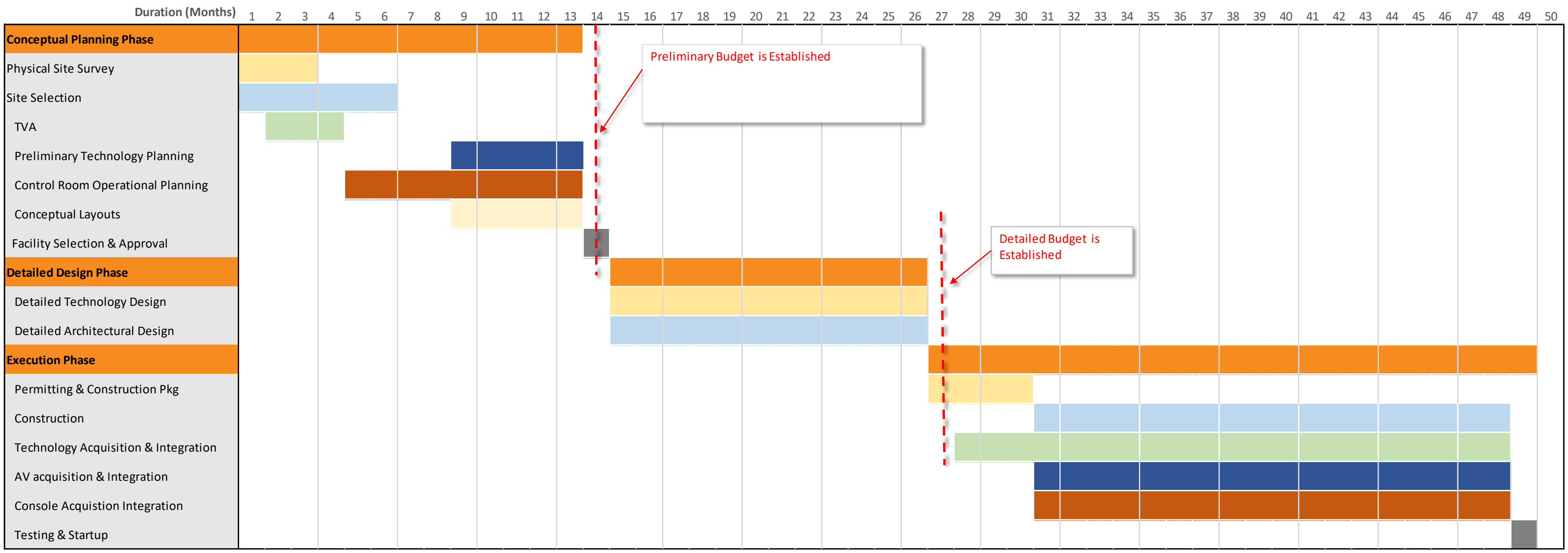
Technology updates can be a lengthy process depending on which systems are being replaced or added. The airport needs to factor in establishing system requirements, writing and advertising an RFP, selection, and implementation, including testing and cutover.

The technology task should begin six months into concept planning and last the project timeline through construction completion, which may be two and a half to three years.

CONSTRUCTION

Construction should begin at the end of design and may take twelve to eighteen months

Figure 5-2. Move to Existing Facility Implementation Timeline



5.3 Roadmap for Building a Greenfield Facility

CONCEPT PLANNING

Concept planning begins on day one of the project and is expected to take twelve to eighteen months. The ConOps may be updated periodically throughout the project as necessary.

SITE SELECTION

Site selection may include more than one option. Results of the TVA may help drive the selection. The results of the site selection may also trigger a review of the ConOps, and updates should be made accordingly.

Site selection should begin eight months into concept planning and may take six to twelve months.

TVA

The TVA should begin two months into site selection and may take two to four months.

DESIGN

Design should begin at the end of site selection and may take six to twelve months.

TECHNOLOGY

Technology updates can be a lengthy process, depending on which systems are being replaced or added. The airport needs to factor in establishing system requirements, writing and advertising an RFP, selection, and implementation, including testing and cutover.

The technology task should begin six months into concept planning and last the project timeline through construction completion, which may be three to three-and-a-half years.

CONSTRUCTION

Construction should begin at the end of design and may take twelve to eighteen months.

Figure 5-3. Greenfield Facility Implementation Timeline

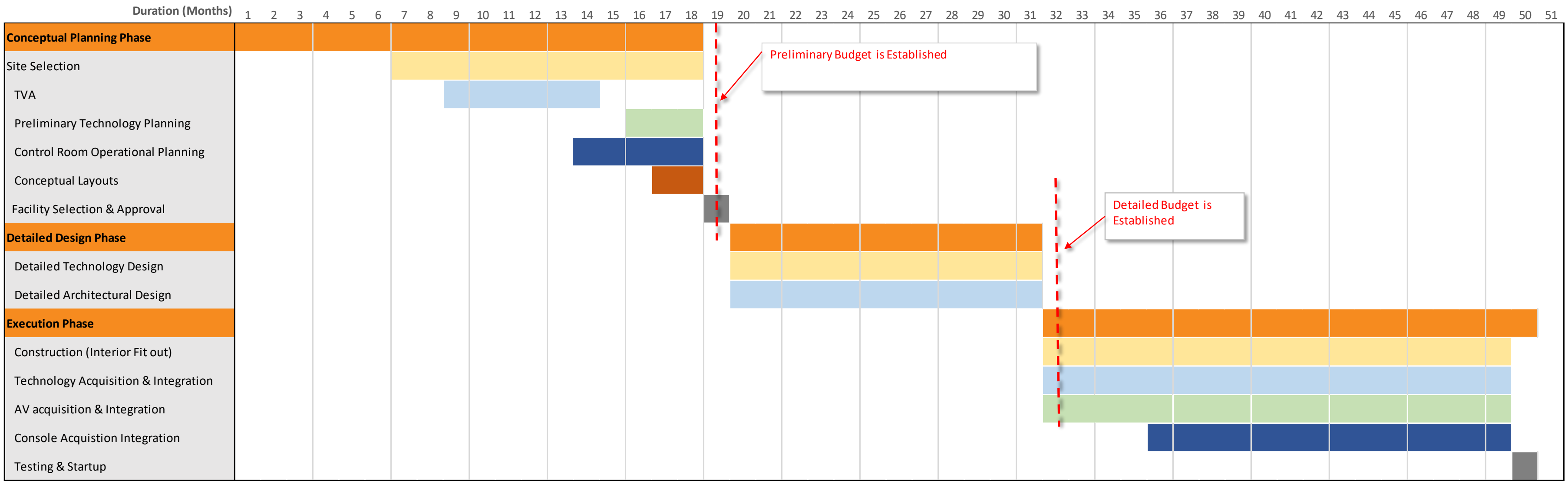
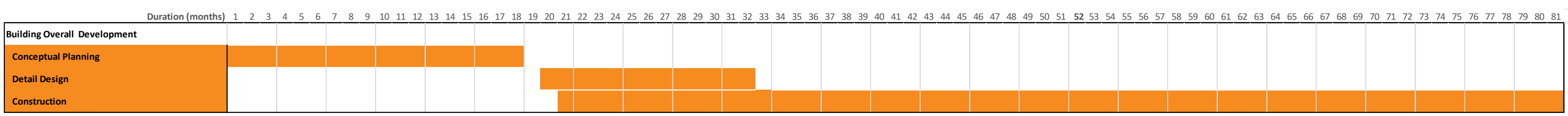


Figure 5-4. Greenfield Facility Total Building Construction



5.4 Operational Readiness, Activation, and Transition

Operational Readiness, Activation, and Transition (ORAT) is a change management process framework that is used to promote the facilitate the transition from an existing facility or service to a new one, ideally with minimal impact on operations for customers and employees.

ORAT takes processes that are already part of a typical construction project, adds new concepts, and brings them together into a comprehensive transition program. ORAT combines processes such as, but not limited to:

- ConOps
- Integration and Configuration Planning
- Move Planning
- Operations Planning
- Acceptance Testing
- Commissioning
- Employee/User Training
- Refinement of Policies and Procedures
- Refinement of Division of Labor

Ideally, the ORAT process is incorporated early in the design phase of a project and goes through several iterations along with the project. It ends when all systems are optimized to the operational requirements, the users' needs, and the updated policies and procedures, and when the organization has successfully commenced full-scale operations.

Consultants are often employed to tailor and lead the ORAT process, but it is still heavily owner driven. To be successful, ORAT requires the participation and commitment of the owner's executive management and all major user groups throughout the project.

ORAT is a large and growing field. For an example of how it can be applied at airports, see Port of Seattle: "How Do You Test an Airport Building?"[39] This article provides an overview of how Seattle-Tacoma International Airport implemented a new International Arrivals Facility using ORAT.

[39] Port of Seattle: How Do You Test an Airport Building? https://www.portseattle.org/blog/how-do-you-test-airport-building

SECTION 6: FUTUREPROOFING AND SCALABILITY

No matter the degree of planning, changes and unexpected developments will occur over time. Section 2 of this Guidebook should be used periodically to help the airport evaluate current and future needs.

Factors such as emerging demands, new stakeholders, and airport growth can increase space and equipment needs. When space and budget allow, it is best to design the facility to be larger than the minimum requirements. A 10% growth factor over the 25-year lifespan of a facility is typically used, but up to 30% is recommended. It is important to state this goal in the early design phases. Site selection, building orientation, exits, structure, and exterior wall materials are all considerations when designing with expansion in mind.[40]

6.1 Construction Elements

Flexible construction methods can be used to enable growth within a SOC. The use of raised flooring, suspended ceilings, movable walls, and modular power cabling allows for easy reconfiguration of a control center as operations grow and change.

- **Raised Flooring** – Raised flooring creates a flexible infrastructure that can be easily reconfigured. It allows for quick access to cabling and network components under the control room to accommodate upgrading or rerouting with minimal service interruption.
- **Suspended Ceilings** – Acoustic ceiling tiles offer a way to conceal and access pipes, ducting, and wiring. Additionally, higher STC-rated ceiling panels can be used to suppress airborne sound within the control room.
- **Architectural or Movable Walls** – Movable walls enable a control center to meet the current projected needs with the assurance that the design can be easily changed to meet new operational needs over the projected lifespan of the facility.
- **Modular Power** – A modular power distribution system allows for the housing of three 20A circuits into one cable housing, with a single interface connection for all three circuits. The flexible cabling eliminates the need to have fixed conduit under the raised floor, which allows for the reconfiguration/expansion of positions without having to redo the conduit.

6.2 Adaptability to Changing Operational Requirements

Ensuring adaptability to changing operational requirements means assuming that different roles, functions, or interactions will be needed in the future due to changes in the operational scope of the facility. In anticipation of these changes, each workstation should be agnostic, meaning that each workstation's specific role in the room is determined by the person occupying it, and not by the technology integrated into the workstation. This is a departure from the traditional operating model, where function-specific equipment is installed locally at the workstation, and an operational change would require a complete redesign of the workstation.

The key to adaptability is to consider it early in the planning process, as the types of technology and workstation planning will directly impact future flexibility. Recommendations for designing an agnostic workstation include:

[40] Benaman, 80

- **Server-Based Computing** – Store all PCs remotely in a common IT room and use a content management switch, receivers, and transmitters to manage the data access for each position.
- **Operator Display Content Management** – The layout of display screens should be flexible. Instead of using a single screen for each feed, use large screens to incorporate multiple feeds into a single display by leveraging content management systems.
- **Workstations** – The console should be built with potential future changes in mind. For example, the addition of equipment storage without affecting the frame structure, and changes in monitor array and quantity without requiring additional lift columns or changes to the work surface.

New and existing personnel must remain comfortable with the technology and be properly trained. Having IT personnel permanently stationed in the SOC helps with adaptability, especially with changes in technology. More details on technology considerations are outlined in Section 4.

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APPENDIX A: CONCEPT AND DEVELOPMENT PLANNING CHECKLISTS

CHECKLIST: UPDATE CURRENT SOC

Following are steps that can be considered if the airport has a current SOC and only wishes to make updates and improvements to that facility.

- ❑ ConOps or a Master Plan has been completed:
  - ❑ Space requirements have been determined
  - ❑ IT infrastructure needs have been accounted for (current and future)
  - ❑ Security features are included
  - ❑ Workplace ergonomics have been defined for best possible operations (lighting, acoustics, workstations, break room, restrooms, etc.)
  - ❑ Internal stakeholders have been consulted and involved in the planning
- ❑ Requirements have been verified by stakeholders for space, workstations, and equipment, and appropriate accommodations
- ❑ Number of internal and external stakeholder staff expected
- ❑ Floor plan considerations
- ❑ Workstations, equipment, and IT
- ❑ Anticipated growth requirements
- ❑ ConOps has been updated accordingly
- ❑ A ROM of costs to update current SOC has been calculated and documented
- ❑ The ROM is approved
- ❑ ConOps has been updated again
- ❑ SOC design and implementation plans are initiated
- ❑ Select project delivery method, designer, and contractor to carry out the project
- ❑ SOC update elements include these:
  - ❑ IT infrastructure
  - ❑ Server needs
  - ❑ ACS
  - ❑ Workstations
  - ❑ CCTV (including whether to tie this to monitors or a video wall)
  - ❑ Restrooms/lockers
  - ❑ Adjacencies such as break and conference rooms
  - ❑ Others

CHECKLIST: RELOCATE TO EXISTING SPACE

Following are steps that can be considered if the airport wants to move to a different facility on or off the airport campus.

- ❑ ConOps or a Master Plan has been completed:
  - ❑ Space requirements have been determined
  - ❑ IT infrastructure needs have been accounted for (current and future)
  - ❑ Security features are included
  - ❑ Workplace ergonomics have been defined for best possible operations (lighting, acoustics, workstations, break room, restrooms, etc.)
  - ❑ Internal stakeholders have been consulted and involved in the planning
- ❑ SOC requirements have been verified by stakeholders for space, workstations, and equipment, and appropriate accommodations
- ❑ Determine total number of staff expected
- ❑ Floor plan considerations
- ❑ Workstations, equipment, and IT
- ❑ Anticipated growth requirements
- ❑ ConOps has been updated accordingly
- ❑ The new site has been evaluated and can accommodate the space, layout, and operational needs of the airport's SOC
- ❑ Other verifications have been completed regarding sufficiency of utilities and accessibility
- ❑ A TVA has been conducted to rank survivability
- ❑ A ROM calculation has been completed for each site(s)
- ❑ The preferred site has been selected
- ❑ The ROM for the site and project are approved
- ❑ ConOps is updated again
- ❑ SOC design and implementation plans are initiated
- ❑ Select project delivery method, designer, and contractor to carry out the project
- ❑ SOC update elements include these:
  - ❑ IT infrastructure
  - ❑ Server needs
  - ❑ ACS
  - ❑ Workstations
  - ❑ CCTV (including whether to tie this to monitors or a video wall)
  - ❑ Restrooms/lockers
  - ❑ Adjacencies such as break and conference room
  - ❑ Others

CHECKLIST: BUILD A NEW GREENFIELD SPACE

Following are steps that can be considered if the airport wants to construct a new greenfield SOC.

- ❑ ConOps or a Master Plan has been completed:
  - ❑ Space requirements have been determined
  - ❑ IT infrastructure needs have been accounted for (current and future)
  - ❑ Security features are included
  - ❑ Workplace ergonomics have been defined for best possible operations (lighting, acoustics, work stations, break room, restrooms, etc.)
- ❑ Stakeholders have been consulted and involved in the planning
- ❑ SOC stakeholders space requirements have been verified for workstations, equipment, and appropriate accommodations
- ❑ Determine total number of staff expected
- ❑ Floor plan considerations
- ❑ Workstations, equipment, and IT
- ❑ Anticipated growth requirements
- ❑ ConOps has been updated accordingly
- ❑ Other verifications have been completed regarding sufficiency of utilities and accessibility
- ❑ A TVA has been conducted to rank survivability
- ❑ A ROM calculation has been completed for each potential site
- ❑ The preferred site has been selected
- ❑ The ROM for the site and project are approved
- ❑ ConOps is updated again
- ❑ SOC design and implementation plans are initiated
- ❑ Select project delivery method, designer, and contractor to carry out the project
- ❑ SOC design elements include these:
  - ❑ IT infrastructure
  - ❑ Server needs
  - ❑ ACS
  - ❑ Workstations
  - ❑ CCTV (including whether to tie this to monitors or a video wall)
  - ❑ Restrooms/lockers
  - ❑ Adjacencies such as break and conference rooms
  - ❑ Others

APPENDIX B: GUIDELINE TOPICS AND RELATED RESEARCH

SITE SELECTION AND FACILITY DESIGN

- Madigan, Michael L. "2016 Emergency Response: A Guidebook Intended for Use by First Responders during the Initial Phase of a Transportation Incident Involving Dangerous Goods/Hazardous Materials." *First Responders Handbook*, 2017, 227–45. https://doi.org/10.1201/b22284-14.
  - Repurposing of other space
- Federal Highway Administration, and Nancy Houston, Common Issues in Emergency Transportation Operations Preparedness and Response: Results of the FHWA Workshop Series § (2007).
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  - Repurposing of other space and TVA
- Stevens, Donald, Thomas Hamilton, Marvin Schaffer, Diana Dunham-Scott, Jamison Medby, Ed Chan, John Gibson, et al. "Implementing Security Improvement Options at Los Angeles International Airport." Infrastructure, Safety and Environment, 2006, 1–66. https://doi.org/10.7249/db499-1.
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- A Design Language for EOC Facilities: "Some thoughts on basic design approaches by Art Botterell," (http://flghc.org/)
  - Also applicable to Space Planning

- Stambaugh, Hollis, Maria Argabright, Heidi Benaman, and Mike Cheston. “A Guidebook for Integrating NIMS for Personnel and Resources at Airports.” ACRP, 2014. https://doi.org/10.17226/22471.
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    - Roles and responsibilities

INTEROPERABILITY WITH AOC, EOC, OR OTHER “CENTERS”

- Dave, R.K. “TIFAC-IDRiM Conference, Oct. 2015.” In Emergency Operations Center (EOC) Design, Operation and Management, 1–6. New Delhi: Information Technology Research Academy, Media Lab Asia, 2015.

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    - Also applicable to site planning and space planning
- Integrated Security System Standard for Airport Access Control. (RTCA DO-230K, June 2017) Available from RTCA at https://standards.globalspec.com/std/14338878/RTCA%20DO-230.

SPACE PLANNING AND LAYOUT, INCLUDING HUMAN FACTORS

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    - Includes guidelines on site selection
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    - Co-location with other centers. Also applicable to Operational Planning and Strategies for Optimizing an Existing SOC.

STRATEGIES FOR OPTIMIZING AN EXISTING SOC

See above source.