



# Personal Identity Verification (PIV) in Enterprise Physical Access Control Systems (E-PACS)

**Version 3.0**

**March 26, 2014**

# Revision History

| Document Version | Document Date | Revision Details |
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# Table of Contents

# Figures



# Tables

# 1. INTRODUCTION

## 1.1 Background

A Physical Access Control System (PACS) allows federal entities to assign different access requirements based on the risk of the physical asset being accessed. In this way, a PACS is used to mitigate the risk of a physical security breach. One important facet of a PACS is the authentication mechanisms supported.

Homeland Security Presidential Directive-12 [HSPD-12] requires a common identification standard for federal employees and contractors (i.e., an identity credential that can be interoperable government-wide) to be used to gain secure access to federally-controlled information systems and facilities. This resulted in the Personal Identity Verification (PIV) Card,[1] which Federal Information Processing Standard 201 [FIPS 201] and associated documents technically define. Per HSPD-12 and Office of Management and Budget (OMB) Memorandum M-05-24, *Implementation of HSPD-12 – Policy for a Common Identification Standard for Federal Employees and Contractors*, agencies are required to issue a PIV Card to federal employees and contractors who require long-term access to federal resources (i.e., facilities and/or information systems) and to other individuals requiring access following an agency risk-based decision. As of Quarter 1 Fiscal Year (FY) 2014, the Federal Government has issued 4,498,673 PIV Cards to federal employees (97% of total federal employees) and 926,227 PIV Cards to federal contractors (91% of total federal contractors).

In addition, the Federal Government has implemented guidance, entitled *Personal Identification Verification Interoperability (PIV-I) for Non-Federal Issuers*, to allow for the issuance of identity cards that can technically interoperate with Federal Government PIV systems and can be trusted by Federal Government relying parties. This resulted in the PIV Interoperable (PIV-I) Card, a credential that may be issued to populations that do not fall under the scope of HSPD-12 but require access to federal facilities and information systems where interoperability is desired. In situations where a PIV-I Card is used, it must be cross-certified with the Federal Public Key Infrastructure (FPKI) to establish trust and interoperability. To-date, the FPKI has approved five PIV-I Card Issuers and one PIV-I Bridge (who in turn has approved three PIV-I Card Issuers).[2]

The emergence of PIV Cards and PIV-I Cards has created a new set of challenges for PACS implementations, including but not limited to new and stronger authentication technologies (mechanisms), non-local card issuance, the requirement for interoperability, and new federal guidance.

In February 2011, OMB issued Memorandum M-11-11, *Continued Implementation of Homeland Security Presidential Directive (HSPD) 12 – Policy for a Common Identification Standard for Federal Employees and Contractors* [OMB M-11-11], which mandates the following for federal agencies:

1. Effective immediately, all new systems under development must be enabled to use PIV credentials;
2. Effective the beginning of Fiscal Year (FY) 2012, existing physical and logical access control systems (LACS) must be upgraded to use PIV credentials;
3. Procurements for services and products involving facility or system access control must be in accordance with HSPD-12 policy and the Federal Acquisition Regulation;
4. Agency processes must accept and electronically verify PIV credentials issued by other federal agencies; and

[1] A description of the PIV Card and its characteristics can be found in Section 2.

[2] A current list of PIV-I providers can be found at https://www.idmanagement.gov/approved-piv-i-entities.

5. The government-wide architecture and completion of agency transition plans must align as described in the Federal Chief Information Officers (CIO) Council's Federal Identity, Credential, and Access Management (FICAM) Initiative.

In response to the large number of issued PIV Cards and the growing interest in PIV-I Cards, their new authentication mechanisms, and the [OMB M-11-11] mandate, the FICAM Initiative is publishing this document to provide guidance for leveraging PIV and PIV-I credentials in a federal agency PACS.

A variety of other federal documents[3] have been published that directly or indirectly affect a PACS implementation in this regard, including but not limited to:

- Office of Management and Budget (OMB) Memorandum M-04-04, *E-Authentication Guidance for Federal Agencies* [OMB M-04-04];
- Homeland Security Presidential Directive 12, *Policy for a Common Identification Standard for Federal Employees and Contractors* [HSPD-12];
- Federal Information Processing Standards 201, *Personal Identity Verification (PIV) of Federal Employees and Contractors* [FIPS 201];
- National Institute of Standards and Technology (NIST) Special Publication (SP) 800-53, *Recommended Security Controls for Federal Information Systems and Organizations* [NIST SP 800-53];
- NIST SP 800-79, *Guidelines for Accreditation of Personal Identity Verification Card Issuers* [NIST SP 800-79];
- NIST SP 800-116, *A Recommendation for the Use of PIV Credentials in Physical Access Control Systems (PACS)* [NIST SP 800-116]; and
- *Federal Identity, Credential, and Access Management (FICAM) Roadmap and Implementation Guidance* [FICAM Roadmap].

## 1.2 Purpose and Audience

The sole purpose of this document is to provide detailed technical and security guidance for leveraging PIV and PIV-I authentication mechanisms in a federal agency PACS to comply with directives such as [OMB M-11-11] and to provide interoperability across the federal enterprise, respectively. This document distinguishes between those authentication mechanisms which do and do not meet the control objectives of HSPD-12 and the vision and goals of the ICAM segment architecture. This document was developed by the Identity, Credential, and Access Management Subcommittee (ICAMSC) of the Information Security and Identity Management Committee (ISIMC) under the authority of the Federal CIO Council.

The primary audiences for this guidance are (a) technical staff with responsibilities such as developing and integrating PACS components, selecting PACs solutions, and determining the most appropriate local use of PIV and PIV-I in a local PACS; and (b) PACS original equipment manufacturers (OEM).

The secondary audiences for this guidance are (a) procurement officials who need technical guidance for citation in PACS procurements that intend to implement the mandates within [OMB M-11-11]; and (b) security managers who perform Federal Information Security Management Act (FISMA) information system risk management of PACS solutions.

[3] For NIST documents (Special Publications, Federal Information Processing Standards, Interagency or Internal Reports), see http://csrc.nist.gov/publications/. For OMB Memoranda, see http://www.whitehouse.gov/omb/memoranda_default.

## 1.3 Scope

The scope of this guidance document is limited to the following:

1. Leveraging PIV and PIV-I authentication mechanism in a PACS:
    a. to implement strong security controls; and
    b. to provide interoperability between different facilities.
2. Providing authentication patterns to illustrate uses of PIV and PIV-I authentication and differentiating the authentication patterns that are deemed acceptable for target state use;
3. Understanding the risks and appropriate use of the various PIV and PIV-I authentication mechanisms; and
4. Reconciling PIV and PIV-I authentication mechanisms against levels of assurance specified in various documents such as [NIST SP 800-116], [NIST SP 800-53], [OMB M-04-04], [OMB M-11-11], [FIPS 201], and the Interagency Security Committee (ISC) *Facility Security Level Determination Standard* [Facility Security Level Standard].

A discussion of and guidance for aspects of a PACS other than leveraging PIV and PIV-I Cards are out of scope for this document. Additional guidance about implementing PACS (including processes for conducting risk assessments, incorporating federal security requirements, implementation planning, and solution design and implementation) can be found the [FICAM Roadmap]. Other aspects of a PACS (e.g., how to implement and manage core PACS components such as readers, controllers/panels, head ends, servers, client work stations; defining and managing access control policies; integrating add-on functions such as closed circuit televisions (CCTVs), intrusion detection systems, life safety systems, and IT support infrastructure) are out of scope for this document.[4]

In addition, this document focuses on off-card biometric comparison and does not address the optional biometric on-card comparison (OCC) introduced in [FIPS 201-2].

While this guidance applies explicitly to those agencies required to comply with HSPD-12, other communities (e.g., Intelligence Community [IC]) are encouraged to leverage the technical and security guidance provided to the extent possible to promote strong authentication. There is intent for this guidance document to be consistent with authoritative documents. If there is an inconsistency, the applicable authoritative document takes precedent.

## 1.4 Document Organization

This document is divided into four parts. Section 1 provides a high-level introduction as well as purpose and scope. Sections 2-7 describe the current PACS landscape, as well as current standards and guidance that directly or indirectly affect PACS. Section 8, *Enterprise PACS Security Functions*, describes specific and measurable security controls that impact the successful operations of PACS as a security countermeasure. The remainder of the document analyzes common authentication patterns, providing insights, clarifications and guidance, especially in light of Section 8.

[4] Please see other sources for a broader, deeper treatment of these out-of-scope topics. See *Appendix D: Document References*, as a starting point for identifying sources.

## 2. PIV AND PIV-I CARDS

This document focuses on use of PIV and PIV-I Cards in a PACS. The Cards are defined as follows:

- **PIV Card** - an identity card that is fully conformant with federal PIV standards (i.e., FIPS 201 and related documentation). Only cards issued by federal entities can be fully conformant. Federal standards ensure that PIV Cards are interoperable with and accepted by all Federal Government relying parties to authenticate identity.
- **PIV-I Card** - an identity card that meets the PIV technical specifications to work with PIV infrastructure elements such as card readers, and is issued in a manner that allows federal and non-federal relying parties to accept the card to authenticate identity. PIV-I credentials provide identity proofing (or identity certainty). PIV-I Cards are issued by non-federal issuers whose proofing process must be commensurate with PIV that binds a card to a person. PIV-I does not assert that a background investigation was performed. Additional investigation requirements may be necessary based on actual assignment and asset risk. PIV-I credential requirements are defined in *X.509 Certificate Policy for the Federal Bridge Certification Authority (FBCA)* [FBCA CP].

Both PIV and PIV-I conform to the following NIST publications:

- **[NIST SP 800-73]** – provides PIV Card technical interoperability specifications. PIV-I Cards must adhere to the [NIST SP 800-73] data model and card edge requirements;
- **[NIST SP 800-76]** – provides PIV Card biometric technical guidance. PIV-I Cards must conform to [NIST SP 800-76]; and
- **[NIST SP 800-78]** – provides PIV Card technical guidance regarding digital credentials present on the PIV Card. This is where much of the trust in the identity credential will be established. PIV-I Cards must ensure their digital credentials meet [NIST SP 800-78] technical requirements.

Table 2-1 compares the requirements for each Card type.

***Table 2-1, PIV-I Guidance Document Comparison of PIV and PIV-I Cards***

| | **Policy Comparison** | **PIV** | **PIV-I** |
|---|---|---|---|
| Identity Verification | National Agency Check with Inquiries (NACI) or Tier 1 investigation | ● | |
| Trust model | FIPS 201 Conformant | ● | |
| | PIV Object Identifier (OID) on PIV Authentication Certificate (trust model)[5] | ● | |
| | FBCA PIV-I Hardware equivalent Authentication Certificate[6] | | ● |
| | FBCA PIV-I Content Signing equivalent object signing certificate | | ● |
| | Content Signing Extended Key Usage (EKU) for PIV Card issuers | ● | |
| | Content Signing EKU for PIV-I Card issuers | | ● |
| | PIV Card Authentication Certificate | ● | |
| | PIV-I Card Authentication Certificate | | ● |
| | **Technical Comparison** | | |
| Authentication Assurance Level | NIST SP 800-63-1, Assurance Level 4[7] | ● | ● |
| Card Edge and data model | Card Stock on GSA APL[8] | ● | ● |
| | PIV Application Identifier (AID) | ● | ● |
| | Command edge and NIST SP 800-85 conformant[9] | ● | ● |
| | NIST SP 800-73 conformant Global Unique Identifier (GUID) present in the Cardholder Unique Identity (CHUID) | ● | ● |
| | RFC 4122 conformant Universal Unique Identifier (UUID) required in the GUID data element of the CHUID[10] | | ● |
| | RFC 4122 conformant UUID present in the Authentication Certificates[11] | | ● |
| | Visually distinguishable from PIV Card | | ● |
| | Asymmetric Card Authentication Key (PKI-CAK) presence | Required[12] | Required |
| | Symmetric CAK (SYM-CAK) presence | Optional | |

[5] http://www.idmanagement.gov/sites/default/files/documents/CommonPolicy.pdf

[6] The FBCA establishes certificate equivalence for Non-Federal Issuers. This is achieved by a mapping of one organization's policy with other organization's policy, and the issuance of a cross-certificate to associate one policy OID with another.

[7] This Assurance Level is only ensured when using the PKI certificates in these credentials.

[8] Conformant form factor.

[9] Contact and contactless command edge conformant defined in [NIST SP 800-73-2] part 2 requires support for specific ISO/IEC 7816 commands. Card edge and data model verified through NIST SP 800-85 test tools (further efforts are expected to address exceptions for Non-Federal Issuers).

[10] [NIST SP 800-73] does not require use of RFC 4122 to generate a valid GUID for PIV Cards; but it is required for PIV-I Cards.

[11] UUID value will be in subjectAltName extension of the PIV Authentication Certificate and Card Authentication Certificate.

[12] [FIPS 201-2] requires Asymmetric CAK key and corresponding certificate in PIV Card.

# 3. PACS OVERVIEW

A PACS follows a straightforward operational process to authenticate users using one or more of a predefined set of credentials and then makes authorization decisions based on a predefined set of rules governing access. Prior to [FIPS 201], the Federal Government commonly implemented PACS that authenticated users using a proprietary, single-use card that typically contained a locally unique identifier. When this card is presented at an electronic reader, the identifier is checked against a proprietary, internal "white list" to make authorization decisions to a facility at an intended point of entry (e.g., door, turnstile). While this mode of operation tends to be the most common and uncomplicated method of managing access to controlled areas, it has vulnerabilities as described in [NIST SP 800-116]:

> "The physical access control systems (PACS) deployed in most federal buildings are facility-centric rather than enterprise-centric and utilize proprietary PACS architectures. Therefore, many issued identification (ID) cards operate only with the PACS for which they were issued. In addition to the lack of interoperability, deployed PACS technology presents the following challenges:
>
> 1. **Scalability** – some deployed systems are limited in their capability to process the longer credential numbers necessary for Government-wide interoperability.
> 2. **Security** – deployed PACS readers can read an identifying number from a card, but in most cases they do not perform a cryptographic challenge/response exchange. Most bar code, magnetic stripe, and proximity cards can be cloned easily. The technologies used in these systems may offer little or no authentication assurance.
> 3. **Validity** – deployed PACS control expiration of credentials through an expiration date stored in a site database. There is no simple way to synchronize the expiration or revocation of credentials for a federal employee or contractor across multiple sites.
> 4. **Efficiency** – use of PACS Personal Identification Numbers[13] (PINs), public key infrastructure (PKI), and biometrics (BIO) with deployed PACS is managed on a site-specific basis. Individuals must enroll PACS PINs, keys, and biometrics at each site. Since PACS PINs, keys, and biometrics are often stored in a site database, they may not be technically interoperable with PACS at other sites."[14]

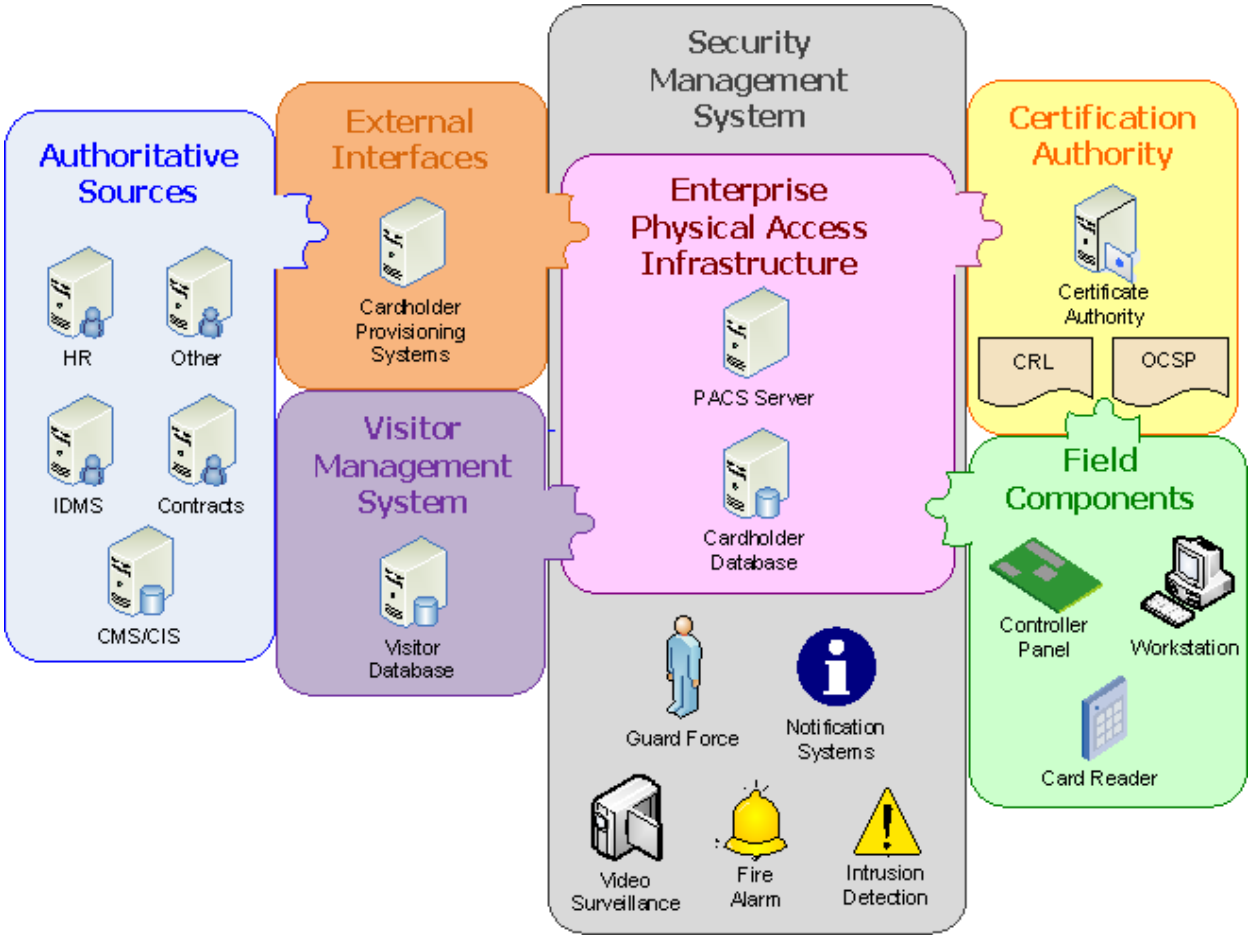
Figure 3-1[15] illustrates that a PACS is an essential part of a security management system, and requires interfaces with other parts of the overall identity management and security infrastructure. Supporting solution components, and key design characteristics can be found in [FICAM Roadmap] Section 10.2.

[13] "PACS PIN" refers to a PIN that is managed and authenticated by a particular PACS. PACS PIN is distinct from the PIV/PIV-I PIN authenticated by PIV or PIV-I Cards.

[14] http://csrc.nist.gov/publications/nistpubs/800-116/SP800-116.pdf

[15] [FICAM Roadmap]

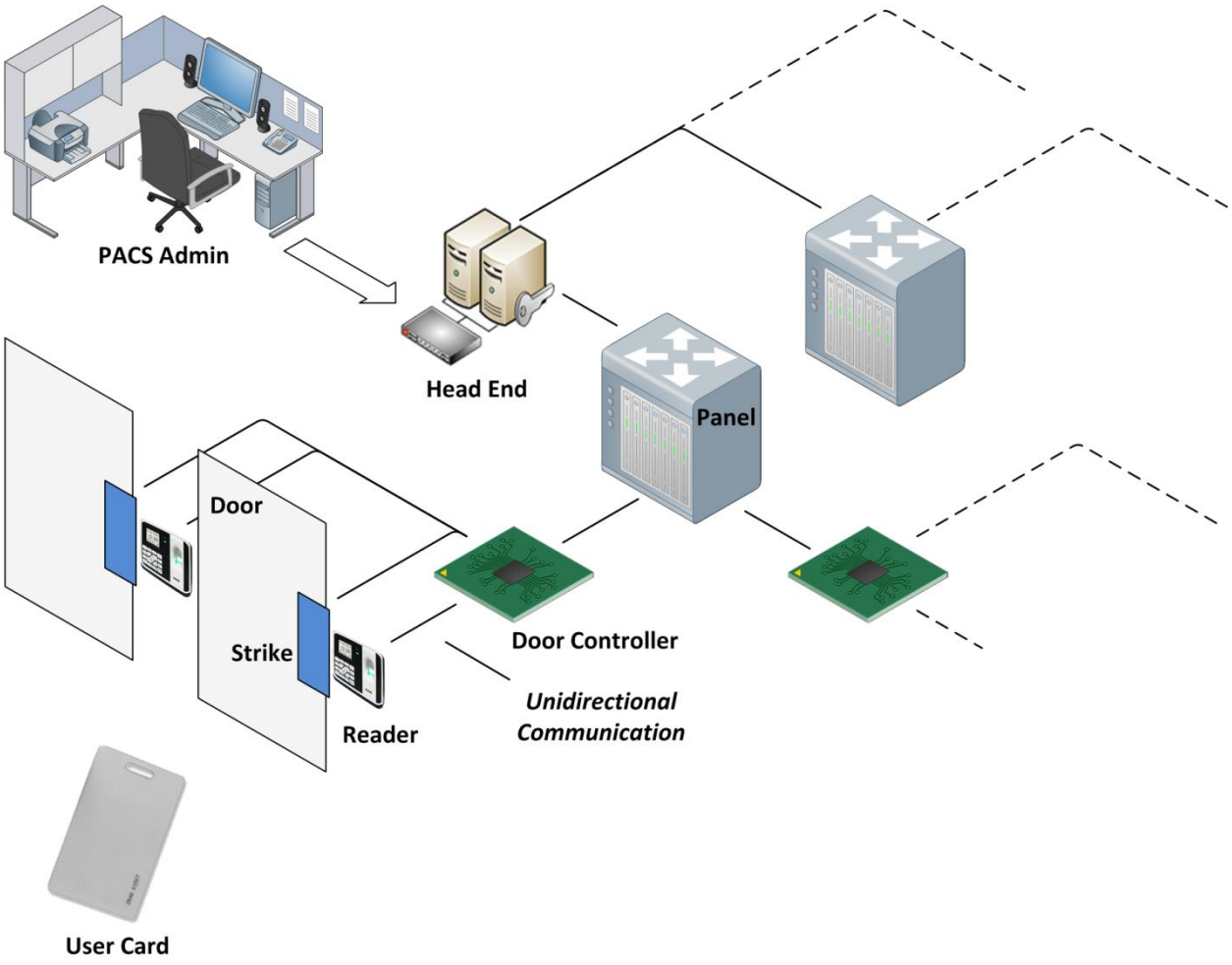
*Figure 3-1, FICAM Roadmap Overview of PACS within the Overall Infrastructure*



## 3.1 Current PACS Architecture

A typical current PACS architecture will look similar to that shown in Figure 3-2. While different PACS vendors may name their components differently, the essential functionality of all systems is the same.

***Figure 3-2, Typical Current PACS System***



### 3.1.1 PACS and the Introduction of PIV and PIV-I Cards

The introduction of PIV and PIV-I Cards represents major steps forward in standardization of access control within the Federal Government. There are now standard identity cards that are recognizable and able to be trusted by all government agencies. While using a PIV or PIV-I Card in existing PACS will require changes, it may not necessitate a complete replacement of the PACS components. Figure 3-3 shows where these changes may affect the system.

***Figure 3-3, FIPS 201 Changes to PACS***

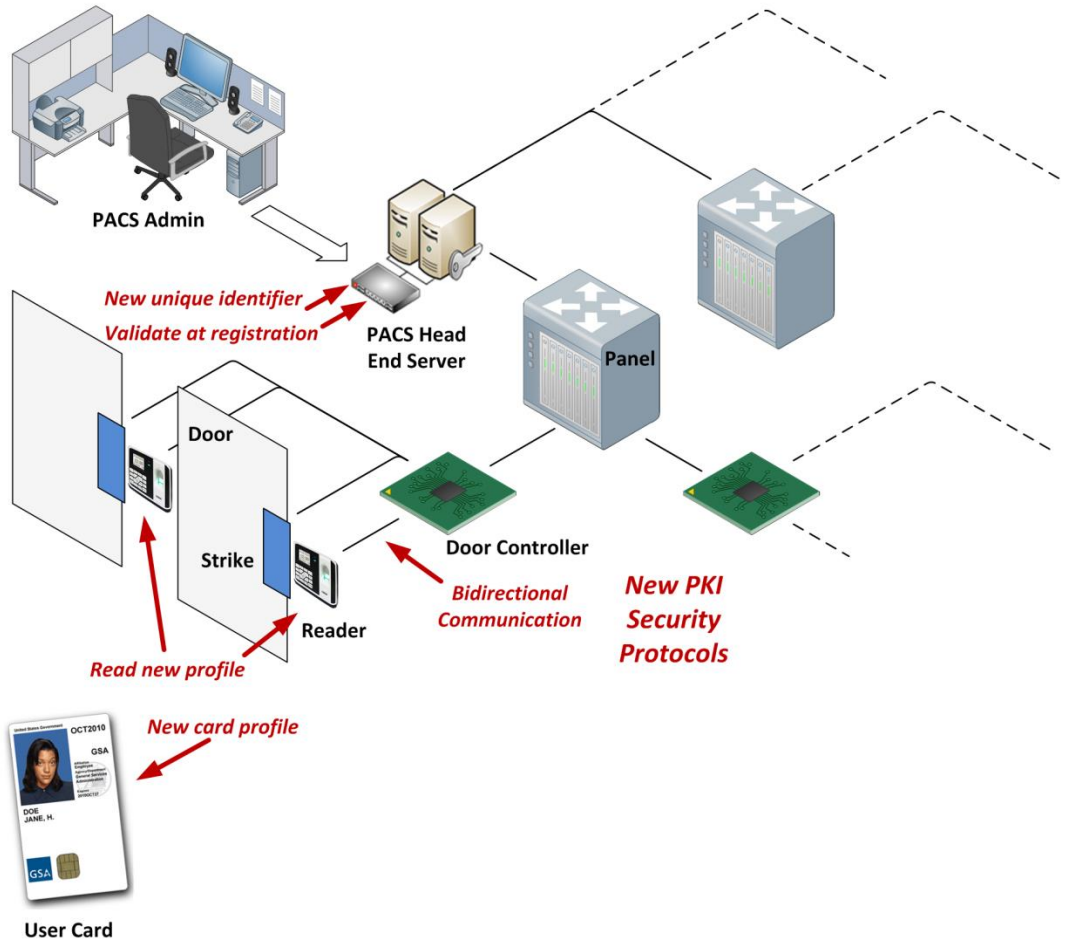



Figure 3-3 provides only a notional representation of an upgraded PACS. Other architectural models may be followed to reach the target state and the design objectives outlined in the FICAM Roadmap. For example, Figure 3-3 shows user registration data being entered by the PACS Administrator at registration; however, other PACS architectures may allow an agency to use enterprise identity management systems to be used as authoritative identity sources, which push registration data downstream to the PACS Head-End Server.

Upgrading or replacing an existing PACS to enable it to properly use a PIV or PIV-I Card as the user identity card requires a few significant changes:

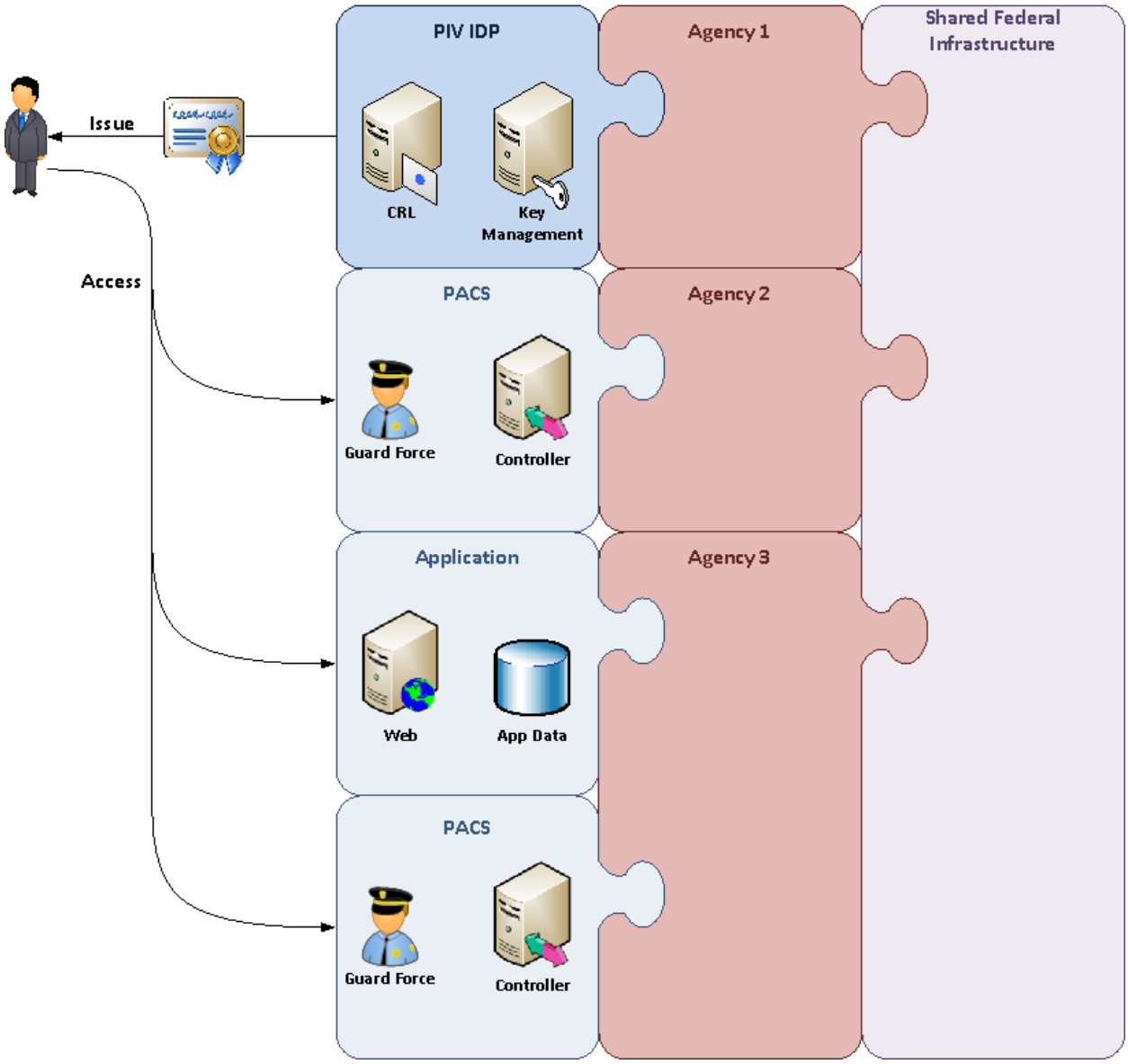
1. PIV and PIV-I Cards are an [ISO/IEC 14443] type smart card with a contactless interface that operates at 13.56 megahertz (MHz). In addition, some authentication mechanisms require using the contact interface. The most common identity cards in use today are contactless proximity cards which operate at 125 kilohertz (kHz). This incompatibility in communication protocol and the need in some cases to support the contact interface will require replacement of the readers.
2. The PIV and PIV-I Cards employ a new profile for representing the data on the card. The system must therefore add functionality to read and interpret this new profile.
3. The PACS must be changed to use the Federal Agency Smart Credential - Number (FASC-N) Identifier on the PIV Card as defined in [NIST SP 800-73-3] Part 1 Section 3.1.2.
4. Each PIV-I Card contains a unique identifier called a UUID. The UUID value is in accordance with [RFC 4122] as defined in NIST SP 800-73 section 3.3. This functionality must be added to extract this UUID from the card data, and to use it in the access control decision process.
5. To ensure secure use of PIV and PIV-I Cards, some level of authentication and validation must be performed as part of the registration process and in real-time during the access attempt, requiring the ability to extend beyond the immediate physical security boundary in order to retrieve validation objects such as CRLs or Online Certificate Status Protocol (OCSP) responses.
6. The communication protocols between PACS components must be able to process much larger data elements (i.e., the signed Cardholder Unique Identifier [CHUID]).
7. The PACS must support bidirectional communications in order to perform challenge/response activities with PIV and PIV-I Cards. This may include updating physical cabling links between the reader and controller/panel and shifting away from the Wiegand Protocol commonly used for unidirectional communication today.
8. The PACS must integrate with the agency's overall ICAM infrastructure, such as enterprise identity management and credentialing systems to provision authoritative identity and credential information and to shared PKI validation components.

## 3.2 Target PACS Architecture

Figure 3-4 depicts the target concept for cross-agency access. A PIV Card issued to a user by any agency or a PIV-I Card issued by any trusted issuer can be used for access to various systems at other agencies that have integrated with the Shared Federal Infrastructure – this includes Enterprise PACS (E-PACS)[16]. Figure 3-4 is adapted from the technical layer of the FICAM segment architecture ([FICAM Roadmap] Section 3.2.5), which depicts the target concept for cross-agency access.

[16] http://www.idmanagement.gov/sites/default/files/documents/FICAM_Roadmap_and_Implementation_Guidance_v2%200_20111202_0.pdf

*Figure 3-4, FICAM Roadmap Federal Enterprise Target Conceptual Diagram*




The target state for E-PACS includes the following steps:

1. After a determination is made to authorize the cardholder to have access to a facility, the cardholder's credential is provisioned into the PACS. Provisioning may include providing the user with an access account, assigning privileges for access, or access rights to a facility/area.
2. A Cardholder desires access to a facility/area and presents his card to the card reader on the attack side (or non-secure side) of the access point.
3. The Cardholder presents his/her PIV or PIV-I Card (contact or contactless interface) to the card reader. The Cardholder is authenticated using one or some combination of authentication mechanisms discussed in Section 4 (see Section 8, and Table 8-3 in particular for more discussion).

4. Upon successful authentication of the card, the cardholder, and subsequent authorization by the PACS, the controller/panel releases the locking mechanism, the entry point opens, and the Cardholder is granted access to the facility/area. If authorization is unsuccessful, the access attempt is denied and the locking mechanism remains locked.
5. The PACS creates a record of the access event based on local audit policy.

# 4. SMARTCARD AUTHENTICATION MECHANISMS

PIV and PIV-I Cards contain four electronic identification and authentication mechanisms, which alone or in conjunction with other authentication mechanisms can establish confidence (to varying levels of assurance) in the identity of the cardholder:

- **PIV Authentication Certificate**[17] **–** (PKI-Auth[18]) allows PKI-based authentication only accessible via the contact interface when the user PIN is provided;
- **Biometric**[19] – (BIO or BIO-A, if attended) authentication of the cardholder's fingerprints or the optional iris images using biometric templates on the card, including verification of the signature and signer;
- **Cardholder Unique Identifier (CHUID)**[20] – contact or contactless read of the CHUID object, including verification of the signature and signer; and
- **Card Authentication Key (PKI-CAK)** – allows cryptographic authentication of the card via contact or contactless interface. This is a mandatory certificate on the PIV[21] and PIV-I Card. CAK may also be a symmetric key on PIV Cards.[22]

[FIPS 201] and [NIST SP 800-116] offer detailed information in regards to authentication mechanisms and levels of confidence. This document leverages information from [FIPS 201] and builds upon guidance from [NIST SP 800-116] for PACS.

[NIST SP 800-116] summarizes six possible authentication mechanisms using the PIV Card to establish confidence in the identity of the cardholder. Due to the technical interoperability, these six authentication mechanisms can be used with the PIV-I Card as well. Table 4-1 lists the authentication mechanisms, their authentication factors[23], and which interface(s) they can be used with. See Table 6-1 and Section 8 for further discussion. Note the following about Table 4-1:

1. The PIV/PIV-I PIN is required to be presented to the card when BIO, BIO-A or PKI-Auth mechanisms are used. The PIN is considered as a factor (what you know) only when the PACS has active cryptographic proof that it can trust the card to which the PIN was presented (CAK, PKI-Auth) and the BIO information comes from that same card.
2. Rows in gray do not appear in the original [NIST SP 800-116] Table 7-1.

[17] For PIV Cards only; the equivalent certificate for a PIV-I Card is called the Authentication PKI Certificate, per the PIV-I for Non-Federal Issuers document.

[18] Referred to as "PKI" in [NIST SP 800-116].

[19] Off-card biometric comparison of the fingerprint template and the optional iris image is accessible only after providing the correct PIN and only via the contact interface..

[20] The CHUID authentication mechanism has been deprecated in FIPS 201-2, and it is expected that it will be removed from the standard in its next revision. Therefore, it is recommended that agencies transition from the use of CHUID.

[21] Required per [FIPS 201-2].

[22] For discussion of symmetric key management, please see Appendix A.

[23] The level of assurance for one factor is not the same for the global levels of assurance defined by [OMB M-04-04]. See Table 8-3 for more details.

*Table 4-1, PIV/PIV-I Authentication Mechanisms*

| PIV Authentication Mechanism | Have | Know | Are | Authentication Factors[24] | Interface |
|---|---|---|---|---|---|
| **PKI-Auth + BIO-A** | Smartcard with crypto key (High Assurance Factor) | PIN with crypto proof (Medium Assurance Factor) | Observed Fingerprint or Iris (Medium Assurance Factor) | 3 | Contact |
| **PKI-Auth + BIO** | Smartcard with crypto key (High Assurance Factor) | PIN with crypto proof (Medium Assurance Factor) | Fingerprint or Iris (Low Assurance Factor) | 3 | Contact |
| **CAK[25] + BIO-A** | Smartcard with crypto key (High Assurance Factor) | PIN with indirect verification assumption (Low Assurance Factor) | Observed Fingerprint or Iris (Medium Assurance Factor) | 3 | Contact |
| **CAK + BIO** | Smartcard with crypto key (High Assurance Factor) | PIN with indirect verification assumption (Low Assurance Factor) | Fingerprint or Iris (Low Assurance Factor) | 3 | Contact |
| **BIO-A** | Card (Low Assurance Factor) | | Observed Fingerprint or Iris (Medium Assurance Factor) | 2 | Contact |
| **PKI-Auth** | Smartcard with crypto key (High Assurance Factor) | PIN with crypto proof (Medium Assurance Factor) | | 2 | Contact |
| **BIO** | | | Fingerprint or Iris (Low Assurance Factor) | 1 | Contact |
| **CAK** | Smartcard with crypto key (High Assurance Factor) | | | 1 | Contact/Contactless |
| **CHUID + VIS** | Printed Security feature on the Smartcard (Low Assurance Factor) | | | 1 | Contact/Contactless |

[24] Low assurance factor indicates that there is no cryptographic verification that the information comes from (or is verified by) the card.

[25] Asymmetric CAK is required for PIV Cards per FIPS 201-2. Symmetric CAK is optional and may be used in addition to the required Asymmetric CAK. Only Asymmetric keys provide interoperability between PACS and unrelated credential issuers.

For PIV and PIV-I Cards, the authentication mechanisms are defined as follows (see Section 8 for more discussion):

A. **VIS**: Visual authentication entails inspection of the topographical features on the front and back of the PIV or PIV-I Card. The human guard checks to see that the PIV or PIV-I Card looks genuine, compares the cardholder's facial features with the picture on the card, checks the expiration date printed on the card, verifies the correctness of other data elements printed on the card, and visually verifies the security feature(s) on the card. The effectiveness of this mechanism depends on training, skill, and diligence of the guard (e.g., to match the face in spite of changes in beard, mustache, hair coloring, eye glasses).
B. **CHUID + VIS[26]:** The controller/panel controlling access to the door receives frequent updates from the PACS server and validates the CHUID on the PIV or PIV-I Card. In order to achieve single factor authentication, the asymmetric signature of the CHUID must also be validated[27].
C. **CAK:** Authentication of card is completed using the CAK, a unique cryptographic key that may be used on a contactless or contact card in a challenge/response protocol. The PACS obtains the CAK certificate from the PIV or PIV-I Card, validates the certificate (check the certificate's expiration date, signature validation, revocation status) and sends a challenge to the card to verify that the card holds the private key corresponding to the certificate. The certificate and rights to access the facility are provisioned in the PACS. For example, when the symmetric CAK is present and used (non-interoperable mechanism), the card reader obtains the diversification element from the card, calculates the card diversified key, and uses the key in a challenge/response to verify the card is authentic.
D. **BIO:** The PIN is presented to the card allowing the reader to read the reference biometric information and to attempt a match with the live sample. The cardholder provides a live fingerprint or an optional iris biometric sample, which is validated against the biometric information embedded within the PIV or PIV-I Card. The PACS verifies the signature on the biometric data object. This authentication mechanism does not include authentication of the PIV or PIV-I Card.
E. **BIO-A:** Biometric authentication performed in the presence of a human guard is called BIO-A. The PIN is presented to the card allowing the reader to read the reference biometric information and to attempt a match with the live sample. In addition to the steps in process D, a Security Officer supervises the use of the PIV or PIV-I Card and the submission of the PIN and the biometric sample by the cardholder.
F. **PKI-Auth[28]:** The Cardholder provides PIN for validation by the PIV or PIV-I Card. The PIV or PIV-I Card validates the PIN allowing use of the PKI-Auth Key. The PACS validates the certificate (check the certificate's expiration date, signature validation, revocation status) and sends a challenge to the card to verify that the card holds the private key corresponding to the certificate.[29] As a result of the successful cryptographic challenge/response, the successful PIN presentation is confirmed to the PACS.

[26] The CHUID authentication mechanism has been deprecated in FIPS 201-2, and it is expected that it will be removed from the standard in its next revision. Therefore, it is recommended that agencies transition from the use of CHUID. The VIS authentication mechanism provides little to no assurance and is only acceptable in combination with CHUID.

[27] [NIST SP 800-116]

[28] Referred to as "PKI" in [NIST SP 800-116].

[29] See PIA-5. Certificate validation may be performed by integrated validation services.

G. **CAK + BIO:** This includes an integration of the steps from options C and D. The verification of the PIN can be trusted because the PIV or PIV-I Card is authenticated by the CAK.[30]
H. **CAK + BIO-A:** This includes an integration of the steps from options C and E. The verification of the PIN can be trusted because the PIV or PIV-I Card is authenticated by the CAK.
I. **Card PIN**: The presentation of the PIN to the card is not considered a factor by the PACS unless the PACS can validate that the card is a valid PIV or PIV-I Card. As such, it does not appear in the table as an independent mechanism. There are only two mechanisms for determining that a card is a valid PIV or PIV-I Card, and both use cryptographic challenge/response:
    a. CAK, which does not require a PIN but indicates the card can be trusted; and
    b. PKI-Auth, which requires the correct PIN for the card to execute the authentication.

The following authentication-related differences between PIV and PIV-I Cards should be noted:

1. The PIV Card includes a FASC-N to uniquely identify it, and thus avoid identifier collisions. However, the FASC-N structure does not support its use beyond the U.S. Government. Therefore, PIV-I Cards include an RFC 4122 generated UUID in accordance with [NIST SP 800-73] Section 3.3 in the GUID field of the CHUID, as well as in the subject-alt-name extension of the authentication certificate in accordance with [PIV-I Profile]. RFC 4122 UUID construction and format rules ensure that the risk of PIV-I identifier collision is infinitesimal.
2. The PIV-I Certificate for Authentication is issued under the Common Policy's PIV Policy. All certificates issued under this policy conform to [PIV-I Profile].
3. The PIV Certificate for Authentication is issued under the PIV Policy defined in the Common Policy. All certificates issued under this policy conform to [PIV Profile].

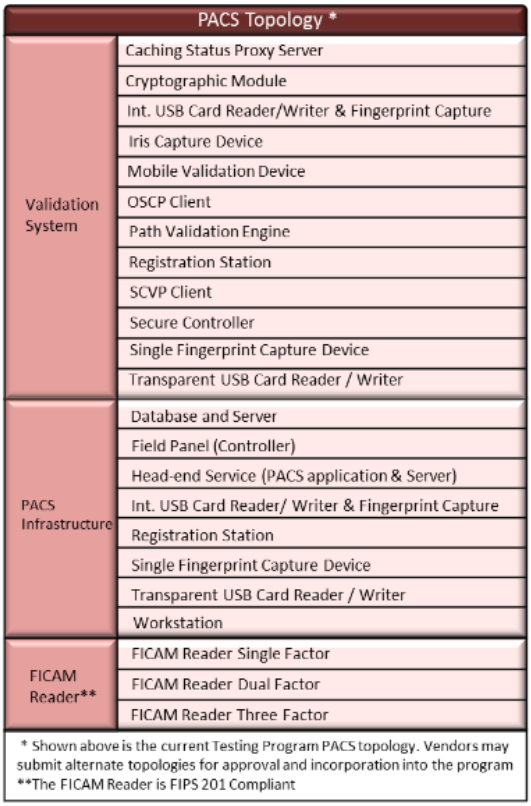
[30] [NIST S P800-116] Appendix C uses the acronym CBP to define the combined authentication mechanisms of CAK + BIO or CAK + BIO-A. In addition, [NIST S P800-116] Appendix C specifies what authentication mechanism (or combination) can be used to move from one area (Uncontrolled, Controlled, Limited, Exclusion) to another.

# 5. GSA'S APPROVED PRODUCTS LIST (APL)

OMB designated GSA as the Executive Agent for government-wide acquisitions for the implementation of HSPD-12. Per OMB memorandum M-06-18, *Acquisition of Products and Services for Implementation of HSPD-12* [OMB M-06-18], federal agencies are directed to purchase only products and services that are compliant with the federal policy, standards and numerous supporting technical specifications.[31] In support of these mandates, GSA established the GSA FIPS 201 Evaluation Program Approved Products List (APL).[32] More information about the GSA APL including its product categories and approval procedures can be found at http://fips201ep.cio.gov/.

The GSA APL identifies functional categories that may or may not be useful or relevant to PACS, as it supports the entire FIPS 201 spectrum, including enrollment, card production, issuance systems, and card readers for both logical and physical access applications. Specific categories have been identified that do support PACS. These categories include:[33]

***Figure 5-1, FIPS-201/FICAM Testing Program PACS Product Categories***




[31] [OMB M-06-18]

[32] More information about the GSA APL, including its product categories and approval procedures, can be found at http://fips201ep.cio.gov/index.php. The current APL can be found at http://www.idmanagement.gov/approved-products-list-apl.

[33] The FIPS-201/FICAM Testing Program product categories may be found at http://www.idmanagement.gov/redesigned-apl-categories.

It is important to note that GSA performs testing for security, conformance, functionality, and interoperability with other components within specific configurations. Selecting individual components on the APL outside of the specified configurations does not assure that the system will perform in a way that results in a holistic, secure system as described in [NIST SP 800-116] and as required by [OMB M-11-11].

# 6. PACS THREATS

As [NIST SP 800-116] notes, the PIV System protects the trustworthiness of PIV Cards[34], and data objects through PIV Card access rules and digital signatures. Overall trust in the execution of a PIV authentication mechanism is also dependent on correct operation of the PIV or PIV-I Card, the PACS, and the PIV or PIV-I Card validation infrastructure, and, to a degree, on protecting the confidentiality, integrity, and availability of the communication channels among them. Attacks may, therefore, be directed against any of these components, with varying difficulty and potential impact. There are many different attacks that can be perpetrated against a PACS. Table 6-1 summarizes the most common of these threats.

[34] And by extension, PIV-I Cards.

*Table 6-1, Summary of Common PACS Threats*

| # | PACS Threat | Description | Countermeasure | Comment | Likelihood without Counter measure | Likelihood with Counter measure |
|---|---|---|---|---|---|---|
| | | | **Human-Exploitation Threats** | | | |
| 1 | Social Engineering | Attacker persuades a cardholder to give them possession of the card. | See PAT-1. | See also [NIST SP 800-116]. | Moderate | Low |
| 2 | Use of Unreported Lost or Stolen Card | Attacker steals or finds a card and uses it to gain access, before it is reported lost or stolen. | Use an authentication mechanism that requires PIN or biometric verification of user's identity. See PAT-1. In addition, establish a robust policy and process for reporting lost/stolen cards. | See also [NIST SP 800-116]. | High | Low |
| | | | **Card-based Threats** | | | |
| 3 | Identifier Collision | An identifier collision occurs when the identifier used by the PACS is present in more than one card. This can only happen as the result of a PACS design flaws, such as truncating identifiers. | PACS should not truncate identifier and should do a complete verification of card identifiers enrolled in its database. Verification of the digital signatures of the card data objects prevents this from being possible. See PIA-3.3. | Using a strong hash is possible under some circumstances for the PACS but only when uniqueness of identifiers and signatures have been verified at least once. See also [NIST SP 800-116]. | Moderate | Low |
| 4 | Use of Terminated Card | Attacker uses a card that has not been de-authorized from the PACS | PACS should verify cards which have been revoked by issuers using CRL, OSCP, or other available mechanism. See PIA-3.5. | Issuers must publish revoked cards but there is a window of time between which the card may be revoked by the issuer and the PACS not aware of it. See also [NIST SP 800-116]. | High | Low |
| 5 | Visual Counterfeiting | Attacker mimics the appearance, but not the electronic behavior, of an actual card. A replica may be created by color photocopying or graphic illustration methods and color printing to blank stock. | Use one or more printed security features such as (e.g., Holograms, ghost image, microtext, laser engraving, faded area). See PIA-3.3. In addition, use the electronic features on the card (see Section 10). | Increases the cost of card issuance and may require equipment for security officers to verify the card surface. See also [NIST SP 800-116]. In addition, VIS inspection of a card alone is not sufficient to grant access (see Section 10). | High | High to Moderate |

| # | PACS Threat | Description | Countermeasure | Comment | Likelihood without Counter measure | Likelihood with Counter measure |
|---|---|---|---|---|---|---|
| 6 | Skimming | Attacker uses a concealed contactless PIV Card reader with a sensitive antenna to obtain the free-read data from the card, which includes the CHUID and the certificates. | Use active card authentication which is not subject to CHUID replay attacks even on un protected channels. See PIA-3.3. In addition, use of the RFID sleeve protects the card from skimming while in the sleeve. | May also happen with the contact interface as shown by many ATM attacks. See CHUID replay attack in this table. See also [NIST SP 800-116]. | Low | Low |
| 7 | Sniffing | Attacker uses a long-distance receiver to capture the entire message transaction between the contactless reader and the card. | Use active card authentication which is not subject to CHUID replay attacks even on un protected channels. See PIA-3.3. | May also happen with the contact interface as shown by many ATM attacks. See CHUID replay attack in this table. See also [NIST SP 800-116]. | Low | Low |
| 8 | Electronic Cloning | Attacker obtains a card and makes a copy of it, then uses it to gain access. | Use card active authentication (PKI-Auth or PKI-CAK). See PIA-3.3. | See also [NIST SP 800-116]. | Moderate | Low |
| 9 | Electronic Counterfeiting | Injecting various FASC-N or UUID numbers to the PACS in attempts to discover a valid and authorized identifier.<br><br>An alternate form of this attack is to guess multiple identifiers repeatedly. The alternate is mitigated by limiting the number of guesses (i.e., rate metering). | Verification of digital signatures (up to the trusted root) should be done on all data objects. This may require more verifications in a Federated Environment (e.g., name restrictions). See PIA-3.3. | Verification should be done (at a minimum) when the credential is first registered and the integrity of the data object should be verified at time of use (same data than when registered). See also [NIST SP 800-116]. | Moderate | Low |

| # | PACS Threat | Description | Countermeasure | Comment | Likelihood without Counter measure | Likelihood with Counter measure |
|---|---|---|---|---|---|---|
| 10 | Use of Expired Card | Attacker obtains an expired card (e.g., from a trashcan) and uses it to gain access. | Check expiration date of the credential. Physically destroy expired cards[35]. See PIA-4. | The CHUID as well as certificates contain expiration dates. Expiration dates for the specific mode of authentication must be checked (i.e. in CHUID mode, check CHUID expiration; in PKI-CAK mode, check CAK certificate). | High | Low |
| 11 | Biometric Object Substitution | In the simplest form the attacker puts their own biometric object on a forged card. The attacker may also substitute a forged biometric on an otherwise valid card.<br><br>In a more complex form the attacker may put their own valid biometric object on someone else's card in order to exploit someone else's privileges. | Verify the signature on the biometric object mitigates the simple forms of this attack by ensuring the biometric object is not forged.<br><br>Countering the more complex form of this attack requires verification that the biometric object was issued with the other objects on the card (i.e., not substituted later). There are two potential countermeasures:<br>-verify the security object on the card<br>-authenticate another object on the card in addition to the biometric and verify that the identifiers for both objects are the same.<br><br>See PIA-3.4. | Biometric objects are signed by the issuer, effectively binding the biometric object to the appropriate identifiers. This attack does not affect the trustworthiness of this binding or undermine biometric based authentication as long as the signature on the biometric object is verified.<br><br>The more complex form is only useful to reduce the overall assurance when multiple authentication mechanisms are used together. | Low | Low |

[35] See [GSA MSO] for steps for destroying a card.

| # | PACS Threat | Description | Countermeasure | Comment | Likelihood without Counter measure | Likelihood with Counter measure |
|---|---|---|---|---|---|---|
| 12 | CHUID Replay Attack | Attacker installs listening device near PACS device (e.g., door) to capture access information, and the replays the captured information to the PACS device. | Use authentication mechanism not subject to replay, such as PKI-CAK or PKI-Auth. See PIA-3.3. | Use of the CHUID is subject to replay. | Moderate | Low |
| | | | **Information-based Threats** | | | |
| 13 | Trust Anchor Compromise | Attacker tells PACS that a bad CA should be trusted. | Trust anchors, like any software updates, should be protected against change by unauthorized users. See PSC-2. | | Moderate | Low |
| 14 | Provisioning Attack | Attacker inserts bad accounts into the PACS to gain access. | Access to PACS data base needs to be controlled using tokens of equal or higher assurance than the access control tokens themselves. See PAU-4and PAU-5. | Conduct background investigations and require certifications on system by administrator. | Moderate | Low |
| 15 | Insider Attack with Electronic Counterfeiting | Attacker obtains identifiers from the Head End, which stores mappings of identifiers to access privileges. Attacker then uses the identifiers to obtain access privileges. | Identifiers should be as random as possible (e.g. UUID) and not structured (e.g. FASC-N). The data base in which they reside should be protected. Best practices encrypt this data. The best countermeasure is to make sure no identifier used alone (with no factor) allows access. See PIA-3.3. | Identifiers can also be obtained from the token themselves (identifier harvesting attacks).<br><br>Identifiers are not authenticators, and by themselves represent zero factors of authentication. | Moderate | Low |
| | | | **Man-in-the-Middle Threats** | | | |
| 16 | Biometric Spoofing | Attacker obtains a copy of a cardholder's fingerprint from an object that the cardholder has previously touched, fabricates a replica finger using plastic or some other molded substance, and then places the "fake" finger on the biometric reader to gain access. | Use liveness detection or biometric technology more resistant to spoofing (e.g., vein patterns). Combine biometric with another factor. | It is relatively easy to collect someone's fingerprint pattern, even outside of the PACS environment. There is no standard to verify/qualify live detection. | Moderate | Low |

| # | PACS Threat | Description | Countermeasure | Comment | Likelihood without Counter measure | Likelihood with Counter measure |
|---|---|---|---|---|---|---|
| 17 | Controller/Panel Impersonation | Attacker pretends to be the Controller/Panel and propagates decisions to other components (e.g., tells Head End to tell Controller/Panel to open door). | Protect communication between PACS components and require authentication between elements. | Best practice is to sign and encrypt communications between PACS components. Line supervision provides limited integrity. | Low | Low |
| 18 | Head End Impersonation | Attacker pretends to be the Head End and directs Controller/Panel to take actions (e.g., open door). | Protects communication between PACS components. PACS components should not allow access (or make a decision) for an area of higher assurance than the one in which they are. | This may not prevent an insider to tamper with an element for others to have access to the area.<br><br>Best practice is to sign and encrypt communications between PACS components. Line supervision provides limited integrity. | Low | Low |
| | | | **System-based Threats** | | | |
| 19 | Reader Compromise | Attacker inserts device at the PACS reader to affect desired behavior or capture information from the reader that can be used to gain access. | Reader components should be protected against tampering using hardware and software integrity and authenticity controls. | No sensitive information should be stored on the edge. | Moderate | Low |
| 20 | Controller/Panel Compromise | Attacker logs into the Controller/Panel as trusted role and changes the Controller/Panel to gain access. | Controllers/Panels or secure readers should not allow access in an area of higher protection than the area they are in. | Use of tamper detection is also required for all critical components in a PACS. | Moderate | Low |
| 21 | Physical PACS Manipulation | Attacker tampers with PACS components directly to gain access. | Protects all PACS components with tamper detection switches and protection mechanisms. | Telecom closets and wiring runs should also be protected. Line supervision provides limited integrity. | Moderate | Low |

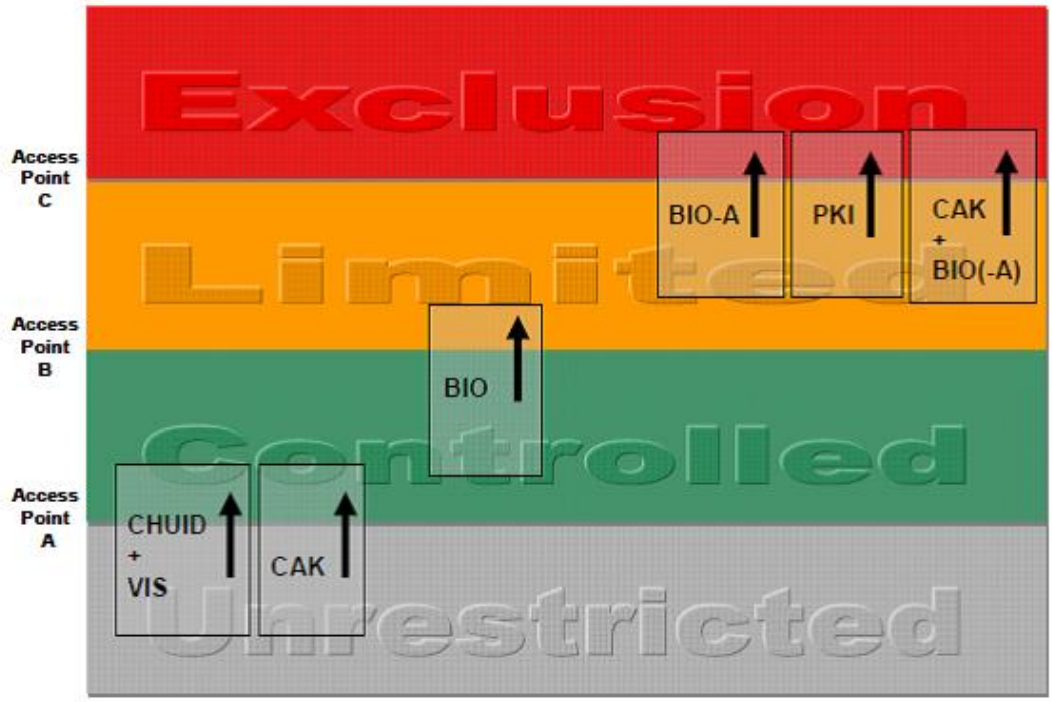
| # | PACS Threat | Description | Countermeasure | Comment | Likelihood without Counter measure | Likelihood with Counter measure |
|---|---|---|---|---|---|---|
| 22 | Exceptions Attack | Attacker causes a PACS exception to occur, in order to gain access (e.g., CHUID too big) | All software in all elements should be coded to prevent such exceptions. Software and hardware should never lower the security when an exception happens (e.g., Power Fail does not allow the door to open, buffer overflow does not allow access). | Software should be written by programmers following the following security principles: Authentication, Authorization, Data validation, Session management, Logging, Error handling, Cryptography, Performance, Code quality. | Moderate | Low |
| 23 | Denial of Service Attack | Attacker attempts to make the network unavailable to the PACS so the PACS cannot receive fresh revocation data, for example. This attack could allow someone in with a recently-revoked credential. | Trigger an alarm indicating Denial of Service attack. In addition, use cached revocation data during the attack. | If you're not caching, you are subject to a Denial of Service attack. | Moderate | Moderate |
| 24 | Environmental Attack | Attacker does something to the environment (e.g., start a fire, turn power off) in order to initiate a PACS action (e.g., unlock doors to allow escape from fire). | PACS should be able to modify its access rules based on the security conditions. Exception conditions rules should be defined ahead of time. | Most facilities react to fail/safe by allowing doors to automatically open allowing people to get out. | High | High to Moderate |

# 7. SUMMARY OF EXISTING PACS GUIDANCE

## 7.1 NIST SP 800-116 Risk Model

NIST Special Publication 800-116, *A Recommendation for the Use of PIV Credentials in Physical Access Control Systems (PACS)* [NIST SP 800-116], introduces the concept of Unrestricted, Controlled, Limited, and Exclusion security areas to facilitate risk-based PIV authentication as needed for different areas within a facility. In addition, [NIST SP 800-116] specifies the authentication mechanisms commensurate for each security area. Figure 7-1 illustrates the innermost use of each PIV authentication mechanism. A mechanism may be used at the interface it straddles (e.g., BIO on the interface between Controlled and Limited) and also at any interface below this one (e.g., BIO also on the interface between Unrestricted and Controlled). All permitted combinations of mechanisms and interfaces are shown in [NIST SP 800-116] Appendix C. The permitted combinations follow from general rules, such as "In a traversal from Unrestricted to Exclusion, one factor must be presented to cross the first interface, two to cross the second interface, and three to cross the third interface" where the presented factors are viewed cumulatively beginning with the Unrestricted-to-Controlled interface.

***Figure 7-1, Innermost Use of PIV Authentication Mechanisms***

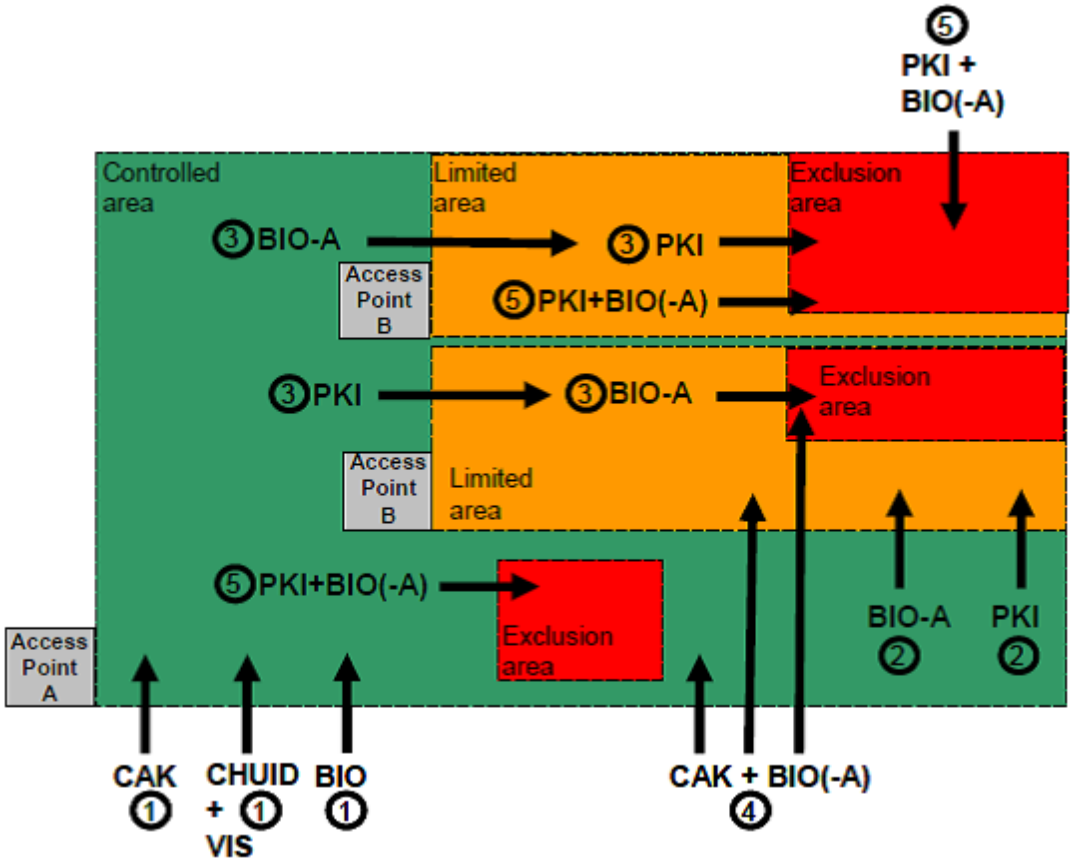



Since the areas accessible by different access points within a facility do not always have the same security requirement, the appropriate authentication mechanism should be selected to be consistent with the overall security requirements of the protected area. A given facility may need multiple authentication mechanisms.

Visual (VIS) Inspection, Cardholder Unique Identifier (CHUID), Card Authentication Key (CAK), Biometric (BIO), Attended Biometric (BIO-A), and PIV Authentication Key (PKI-Auth) are PIV authentication mechanisms defined in FIPS 201.

Figure 7-2[36] shows various authentication methods (and combinations) using PIV credentials to access the various type of areas defined in [NIST SP 800-116]. For example, accessing an Exclusion area requires three-factor authentication. One combination is to use PKI+BIO(-A)[37], as shown in option 5, to move from an Unrestricted area to an Exclusion area. Care should be taken when using such combinations. For example, using a BIO to access the Controlled area (option 1) should not be followed by a BIO-A when going into a Limited area. Using a PKI (option 2) provides more identity assurance for the subject.

***Figure 7-2, Examples of Mapping PIV Authentication Mechanisms***




[36] [NIST SP 800-116]

[37] BIO(-A) indicates that either unattended (BIO) or attended (BIO-A) biometric authentication is allowed. The abbreviation BIO(-A) combines both options.

The [NIST SP 800-116] risk-based model is defined in terms of maturity levels as follows[38]:

- **Maturity Level 1**—Ad hoc PIV verification.
- **Maturity Level 2**—Systematic PIV verification to Controlled areas. PIV Cards and currently deployed non-PIV PACS cards are accepted for access to the Controlled areas at this level.
- **Maturity Level 3**—Access to Exclusion areas by PIV or exception only. Non-PIV PACS Cards are not accepted for access to the Exclusion areas at this level.
- **Maturity Level 4**—Access to Limited areas by PIV or exception only. Non-PIV PACS Cards are not accepted for access to the Limited or Exclusion areas at this level.
- **Maturity Level 5**—Access to Controlled areas by PIV or exception only. Non-PIV PACS Cards are not accepted for access to any areas at this level.

[38] Currently, [NIST SP 800-116] addresses just PIV.

# 8. ENTERPRISE PACS SECURITY FUNCTIONS

[NIST SP 800-53] provides a general framework for applying security controls to any federal information system, regardless of its mission. As a federal information system, an E-PACS is subject to these controls[39] and the NIST Risk Management Framework[40] to ensure that it is correctly protected. This includes any common controls an agency may provide across its portfolio of information systems, where applicable.

In addition to the need to be secured, an E-PACS itself has an important security mission of its own: to protect federal facilities and their employees, contractors, and visitors. Because of this need, this document augments the controls defined in [NIST SP 800-53] for how the E-PACS itself should be protected by providing an additional set of security controls specific to E-PACS services. This type of supplemental controls specific to a particular community or system type is allowed per [NIST SP 800-53] and is called an overlay. The supplemental controls in this section should be considered the overlay for E-PACS to ensure that appropriate security measures are in place and that the E-PACS provides adequate protection.

The security controls listed in this Section follow the framework established in [NIST SP 800-53]. The controls are organized into the classes of technical, operational, and management controls, and the control families are modeled after those in [NIST SP 800-53]. The prefix 'P' has been added to [NIST SP 800-53] control families when control family discussion pertains to E-PACS. For example, the Identification and Authentication (IA) control family is specified as PIA when applicable to E-PACS. Table 8-1 below provides an overview of the control families from [NIST SP 800-53] and a mapping of the control families that have specific control requirements applicable to E-PACS. The overlay controls outlined in this Section should be applied as security measures in accordance with an agency's risk assessment.

[39] See [OMB M-10-15], which clarifies that 1) PACS are IT systems, even on a stand-alone network; and 2) you have to perform the activities of the NIST Risk Management Framework, including security authorization, on them. In addition to the clarifications in [OMB M -10-15], current FISMA guidance can also be found in OMB M-14-04, *Fiscal Year 2013 Reporting Instructions for the Federal Information Security Management Act and Agency Privacy Management* [OMB M-14-04].

[40] As described in SP 800-37, revision 1, *Guide for Applying the Risk Management Framework to Federal Information Systems*, NIST, February 2010. [NIST SP 800-37]

*Table 8-1, SP 800-53 Security Control Families*

| Class | ID | Control Family | NIST SP 800-53 | E-PACS |
|---|---|---|---|---|
| Technical Controls | AC | Access Control | ✓ | ✓ PAC |
| | AU | Audit and Accountability | ✓ | ✓ PAU |
| | IA | Identification and Authentication | ✓ | ✓ PIA |
| | SC | System and Communications Protection | ✓ | ✓ PSC |
| Operational Controls | AT | Awareness & Training | ✓ | ✓ PAT |
| | CM | Configuration Management | ✓ | ✓ PCM |
| | CP | Contingency Planning | ✓ | ✓ PCP |
| | IR | Incident Response | ✓ | |
| | MA | Maintenance | ✓ | |
| | MP | Media Protection | ✓ | |
| | PE | Physical and Environmental Protection | ✓ | ✓ PPE |
| | PS | Personnel Security | ✓ | |
| | SI | System and Information Integrity | ✓ | |
| Management Controls | CA | Security Assessment and Authorization | ✓ | ✓ PCA |
| | PL | Planning | ✓ | ✓ PPL |
| | PM | Program Management | ✓ | |
| | RA | Risk Assessment | ✓ | ✓ PRA |
| | SA | System and Services Acquisition | ✓ | |

Note that the E-PACS security controls use a three letter designator, “P”, followed by the two letter designator of the corresponding [NIST SP 800-53] Security Control Family.

Each facility has a Facility Security Level (FSL) that is determined based on risk. Security controls may be used to satisfy the FSL requirements in multiple ways, and not every control is appropriate for every FSL. The control listing shows the extent to which each security control is appropriate.

## 8.1 Technical Controls

Technical security controls (i.e., safeguards or countermeasures) for an E-PACS are primarily implemented and executed by PACS through mechanisms contained in the hardware, software, or firmware components of the system or interconnected systems.

### *8.1.1 Identification and Authentication*

The security controls in the Identification and Authentication (I&A) family specify the full set of controls to completely authenticate the cardholder.

**Table 8-2, Summary of Identification and Authentication Controls**

| Class | Family | ID | Control |
|---|---|---|---|
| T | PIA | PIA-1 | Identification and Authentication Policy Implementation |
| T | PIA | PIA-2 | Authentication Modes |
| T | PIA | PIA-3 | Identity Factor Authentication |
| T | PIA | PIA-3.1 | Accepting Device (AD) |
| T | PIA | PIA-3.2 | Validation of Trusted Origin (VTO) |
| T | PIA | PIA-3.3 | Active Authentication (AA) |
| T | PIA | PIA-3.4 | Protection of Authenticator (POA) |
| T | PIA | PIA-3.5 | Revocation Check (RC) |
| T | PIA | PIA 3.6 | Expiration Check (EC) |
| T | PIA | PIA-4 | Signature Validation |
| T | PIA | PIA-5 | Full Path Validation |
| T | PIA | PIA-6 | Cross-Agency Interoperable Authentication |
| T | PIA | PIA-7 | Card Revocation Check Mechanisms |
| T | PIA | PIA-8 | Provisioning via Import |
| T | PIA | PIA-9 | Provisioning via Registration |
| T | PIA | PIA-10 | PIN Caching |

#### *8.1.1.1 PIA-1: Identification and Authentication Policy Implementation*

***Control:*** The E-PACS implements the identification and authentication measures specified in the Facility Access Control Policy,[41] including: authentication modes, accessing populations, time of day restrictions, and threat level restrictions and exceptions.

***Detailed Guidance:*** The Facility Access Control Policy (PPL-1) documents the policy that the E-PACS enforces during identification and authentication (PPL-3, PPL-4, PPL-5, and PPL-6). This control specifies that the E-PACS implement the documented policy.

#### *8.1.1.2 PIA-2: PACS Authentication Modes*

***Control:*** The E-PACS supports one or more PIV-enabled authentication modes.

***Detailed Guidance:*** There are three types of authentication factors – a) "something you have", for example, possession of the PIV Card; b) "something you know", for example, knowledge of the PIN; and c) "something you are", for example, presentation of live fingerprints by a cardholder. There are many ways these factors can be used in combination to authenticate a cardholder. Broadly, these are categorized as 1-factor, 2-factor and 3-factor. Each specific combination is an authentication mode.

Table 8-3 enumerates the E-PACS-enabled authentication mechanisms.

"CL?" indicates that the Authentication Mode is available on the contactless interface. All Authentication modes are available on the contact interface. "Int?" indicates that the Authentication Mode is interoperable across cards from other PIV issuers.

Any reference data used by the PACS as an authenticator (the PIN and/or BIO and/or symmetric key) must be protected by the PACS in accord with PIA-3.4. Without this protection, it is not a valid authentication factor.

[41] The Facility Access Control Policy does not need to be a separate document and could be incorporated into other standard security documentation, such as an overall facility security policy or a Facility Security Plan.

*Table 8-3, PACS-enabled Authentication Mechanisms*

| Factors | PACS-enabled Authentication Mechanism | Max Confidence | CL? | Int? | Factors |
|---|---|---|---|---|---|
| No Factor | PIN to PIV/PIV-I[42] (without cryptography) | No Confidence | CL | ✓ | |
| | CHUID (FASC-N, UUID) | No Confidence | CL | ✓ | |
| One Factor | CHUID+VIS | Little or No Confidence | CL | ✓ | Have |
| | BIO | Some Confidence | - | ✓ | Are |
| | CAK | Some Confidence | CL | | Have |
| | CHUID[43] + PIN to PACS | Some Confidence | CL | ✓ | Know |
| | CHUID + BIO to PACS | Some Confidence | CL | ✓ | Are |
| Two Factor | CHUID + PIN to PACS + BIO to PACS | High Confidence | CL | ✓ | Know + Are |
| | CAK + PIN to PACS | High Confidence | CL | | Have + Know |
| | CAK + BIO to PACS | High Confidence | CL | | Are + Have |
| | BIO-A | High Confidence | - | ✓ | Have + Are |
| | PKI-Auth | High Confidence | - | ✓ | Know + Have |
| Three Factor | PKI-Auth + BIO | Very High Confidence | - | ✓ | Know + Are + Have |
| | PKI-Auth + BIO to PACS | Very High Confidence | - | ✓ | Know + Are + Have |
| | CAK + BIO | Very High Confidence | - | | Know + Are + Have |
| | CAK + BIO to PACS + PIN to PACS | Very High Confidence | CL | | Know + Are + Have |

[42] Note that PIN to PIV/PIV-I is not an authentication mechanism. Rather, PIN to PIV/PIV-I is only a component of PKI-Auth, BIO, or BIO-A.

[43] CHUID is not a factor without VIS. CHUID provides a possible index (e.g., FASC-N, UUID, GUID, human - entered). Here, for example, the CHUID is used as an index for PIN to PACS.

### 8.1.1.3 PIA-3: Identity Factor Authentication

***Control:*** When authenticating an identity factor, the E-PACS performs a complete factor authentication that includes the following five authentication elements:

1. **Accepting Device** – device that interacts with card or cardholder for authentication purposes.
2. **Verification of Trusted Origin** – ensuring that the authenticators come from a trusted source.
3. **Active Authentication** – authentication that requires activity by the card or cardholder such as a challenge/response, submitting a biometric sample, or a PIN challenge.
4. **Protection of Authenticator** – ensuring that the integrity and confidentiality of authenticators are not compromised.
5. **Revocation Check** – ensuring that authenticators have not been revoked.

***Detailed Guidance:*** Though there are clear differences between the various types of have, know, and are identity factors, they each require the same five elements for a full and complete authentication. Omitting any of the authentication elements introduces a vulnerability that would permit a counterfeit or cloned card to be incorrectly authenticated (i.e., falsely accepted).

Each of the five authentication elements is given a control. These are enumerated in PIA-3.1 to PIA-3.5. Table 8-4 highlights the authentication elements applied to have, know, and are factors.

***Table 8-4, Authentication Elements***

| | **Have Factors** | **Know Factors** | **Are Factors** |
|---|---|---|---|
| **Authentication Mode:** | • CHUID + VIS<br>• PKI<br>• CAK | • PIN to PIV/PIV-I[44]<br>• PIN to PACS | • BIO-A<br>• BIO<br>• BIO to PACS |
| **PIA-3.1**<br><br>**Accepting Device** | • Smart Card Reader | • PIN PAD | • Biometric Reader |
| **PIA-3.2**<br><br>**Verification of Trusted Origin** | • Verify signature on the CHUID and validate associated Content Signer Certificate<br>• PKI - Signature Check on PKI Certificate<br>• PKI-CAK (Asymmetric) - Signature Check on CAK Certificate<br>• SYM-CAK (Symmetric) – knowledge of shared secret<br>• See PIA-5 | • PIN to PIV/PIV-I – trust transferred by PIV Authentication Private Key<br>• PIN to PACS – Secure connection to authoritative reference | • Verify signature on the biometric and validate associated Content Signer Certificate<br>• BIO to PACS – Protected storage for Biometric Reference Template<br>• See PIA-5 |

[44] PIN to PIV/PIV-I is a knowledge factor only if the identity card is verified as a PIV or PIV-I Card through another authentication mechanism such as CAK or PKI-Auth.

| | Have Factors | Know Factors | Are Factors |
|---|---|---|---|
| **PIA-3.3**<br><br>**Active Authentication** | • Challenge Response | • PIN to PIV/PIV-I – Verified on Card, crypto channel transfers trust to PACS<br>• PIN to PACS – Verify in PACS | • Biometric Match |
| **PIA-3.4**<br><br>**Protection of Authenticator** | • Protection from Modification by non-vetted entities<br>• Protection from duplication is desired, and is typically achieved by active authentication (see PIA-3.3) | • PIN to PIV/PIV-I – provided by FIPS 140-2 Level 2 Module<br>• Encrypted (or controlled access) at rest,<br>• Secure delivery to comparison element | • Encrypted (or controlled access) at rest,<br>• Secure delivery to comparison element |
| **PIA-3.5**<br><br>**Revocation Check** (within 18 hours) | For all PIV factors, revocation checking is always accomplished by performing PDVal and revocation checking on PKI-CAK or PIV Authentication certificates. | | |

#### *8.1.1.4 PIA-3.1: Accepting Device (AD).*

***Control:*** The E-PACS has Accepting Devices that support I&A requirements documented in the Facility Access Control Policy.

***Detailed Guidance:*** The accepting device, commonly called a "reader," accepts the factor presented by the cardholder. Examples of ADs are card readers (contact and/or contactless), PIN pads, fingerprint readers, iris scanners, and other biometric devices. As with any PACS, the accepting devices are equipped with internal tamper switches, mount tamper switches, line voltage monitoring, and other protections preventing attacks attempting to manipulate or copy the data collected or physical location of the device.

#### *8.1.1.5 PIA-3.2: Validation of Trusted Origin (VTO).*

***Control:*** The E-PACS verifies (1) the issuer, (2) that the reference authenticator is created by the issuer and (3) that the reference authenticator is not altered.

***Detailed Guidance:*** This control establishes trust in both the issuer and the reference authenticator created by the issuer. See also PIA-5.

Where a digital certificate is provided for the reference authenticator (e.g., for a PIV Authentication Key, a Card Authentication Key, or a Biometric Object), signature validation and PDVal is performed on the digital certificate to establish VTO.

Where secret key cryptography is used, ensures that the PIV or PIV-I Card contains the shared secret (the secret or symmetric key) to establish VTO. This is accomplished by establishing a mutually authenticated session based on the secret or symmetric key.

To mitigate substitution attacks, an E-PACS ensures that the public key presented for authentication is the same one registered in the PACS database record for that credential. One way this can be achieved is using

a secure hash. Without this check, an attacker can easily copy a known good CHUID and put his own PKI credentials on the card, defeating the access control decision process.

#### *8.1.1.6 PIA-3.3: Active Authentication (AA).*

***Control:*** The E-PACS verifies that the factor presented (1) matches the reference authenticator and (2) is genuine and is not altered, cloned, forged, replayed or spoofed.

***Detailed Guidance:*** Every authentication compares or "matches" a factor presented to the AD with a reference authenticator. This operation may be implemented or protected by one or more cryptographic mechanisms. The techniques for active authentication vary by factor. Examples of Active Authentication include:

1. Have: Challenge/Response (applies to both public and secret keys).
2. Have: VIS. In general VIS is a very weak form of AA, and is much weaker than any of the other environments. VIS is appropriate for facilities that require little or no confidence in the asserted identity.
3. Know: PIN to PIV/PIV-I (the PIV or PIV-I Card matches the presented PIN with the reference PIN stored on the card). PIN to PIV/PIV-I is a knowledge factor only if the identity card is verified as a PIV or PIV-I Card through another authentication mechanism such as CAK or PKI.
4. Knowledge: PIN to PACS (the PACS "matches" the presented with the registered PIN value securely stored in the PACS). See PIA-3.4.
5. Biometric: BIO and BIO-A (the PACS matches the biometric template provided by the PIV Card with the live scan biometric presented by the cardholder).
6. Biometric: BIO to PACS (the PACS matches the biometric template securely stored in the PACS with the live scan biometric presented by the cardholder). See PIA-3.4.
7. Have, Know, Biometric: CAK plus BIO(-A) specifically requires the PACS to confirm that the PIN activated BIO(-A) read is explicitly from the same card as the CAK challenge/response at the time of authentication.

#### *8.1.1.7 PIA-3.4: Protection of Authenticator (POA).*

***Control:*** The E-PACS protects the integrity and confidentiality of the reference authenticator used by PIA 3.3.

***Detailed Guidance:*** The POA authentication element assures that the reference authenticator used in PIA-3.3 is adequately protected. The E-PACS protects the authenticator where it is stored (at rest) and where it is transmitted (in motion.) There are four cases:

Case 1: The reference authenticator is carried by the PIV or PIV-I Card and provided by it to the PACS to perform the authentication. The PACS trusts that the PIV or PIV-I Card has correctly protected the Authenticator. Examples include:

1. Digitally-signed and PIN-protected biometric reference templates.

Case 2: The reference authenticator is carried by the PIV or PIV-I Card and used by it to perform the authentication. The PACS trusts that the PIV or PIV-I Card has correctly protected the Authenticator, and that it has correctly performed the authentication. Examples include:

1. PIV Authentication Key
    a. PIN to PIV/PIV-I (trust that the PIV or PIV-I Card has authenticated the PIN is transferred to the PACS as a result of the PIV authentication Key challenge).

2. Card Authentication Key

Case 3: The referenced authenticator is registered in the PACS system. The PACS trusts itself to correctly protect the authenticator. Examples include:

1. PIN to PACS
2. BIO to PACS

Trust and integrity in these modes require the PACS to provide the following capabilities:

1. Digital signatures binding the credential number to the BIO and/or PIN (or an equivalent secure process).
2. Protection of the PIN and BIO with encryption at rest.
3. Secure communications from the PIN or BIO capture device to the system element that performs the comparison.
4. Use of FIPS 140-2 validated cryptographic services.
5. The PACS does not cache the PIV or PIV-I Card's PIN. The PACS ensures that the PIN to PACS value is unique and distinct from the PIV or PIV-I Card's PIN. See PIA-10.
6. The PIN and BIO authenticators used in PIN to PACS and BIO to PACS constitute a long-term derived credential. As such, the PACS follows the requirements detailed in [NIST SP 800-63-1] Section 5.3.5.

Case 4: The PACS uses symmetric CAK between the card and the system. Symmetric CAK supports single or mutual authentication. This mode is an option offered by PIV, but is not interoperable across the federal enterprise (see Appendix A). Special handling of keys is needed to ensure integrity of this mechanism:

1. There is a secure key distribution mechanism to ensure all parts of the PACS receive and protect the symmetric keys appropriately.
2. All symmetric keys managed by the PACS are stored in and processed using FIPS 140-2 validated modules.
3. It is recommended that these keys be stored in a FIPS 140-2 Level 2 hardware device.
4. Diversification of card keys as well as rollover of the master keys should be used.

#### *8.1.1.8 PIA-3.5: Revocation Check (RC).*

***Control:*** The E-PACS verifies that the credential presented has not been revoked.

***Detailed Guidance:*** The RC authentication element verifies that the credential created by the issuer is accepted. RC is important because the issuer may have revoked the credential. There are two cases:

General Case: The organization that issued the PIV or PIV-I Card is different than the organization that operates the E-PACS. (This is the general case.) The E-PACS performs an RC on the PIV Authentication Certificate (or the equivalent PIV-I Authentication Certificate or CAK Signature Certificate.) Further, if the reference authenticator has its own certificate (e.g. a certificate for the fingerprint biometric), then the E-PACS also performs a RC on the reference authenticator's certificate, if applicable.

The E-PACS may perform the RC check at the time of access. As a performance optimization, the E-PACS may instead choose to perform RC checks in advance on "anticipation of access." Whichever strategy is used, the E-PACS positively determines that at the time of authentication, the RC status information is not older than 18 hours, the mandated maximum allowed by the FPKI Common Policy.

Special Case: An organization may have an Enterprise IdM in place. In this environment, it is possible to have direct provisioning and de-provisioning of access records that are tightly bound to Human Resources processes. This provides a faster (and potentially more secure) way of managing revocation, as the organization does not have to wait on PKI to propagate CRL status information that may be over 18 hours stale. This method must be in addition to PKI status checking per PIA-3.2 and PIA-5.

Whenever a RC check is performed, an Expiration Check is also performed (see PIA-3.6).

#### *8.1.1.9 PIA-3.6: Expiration Check (EC).*

***Control:*** The E-PACS verifies that the credential has not expired.

***Detailed Guidance:*** The EC authentication element verifies that the credential created by the issuer is accepted. EC is important because the credential may no longer be valid, and issuers will not revoke expired credentials if they are compromised after expiration. The E-PACS checks the expiration data in the CHUID, the CAK Certificate, or the Authentication Certificate according to the mode of authentication in use. In any of these cases, the signature of these objects is also verified (see PIA-4).

#### *8.1.1.10 PIA-4: Signature Validation*

***Control:*** The E-PACS verifies the signatures of any signed objects involved in authentication (e.g., authenticating acceptance devices, the card or the card holder).

***Detailed Guidance:*** Signature validation of a data object provides validation of origin (trust in the creator of the data object) as well as a proof of data integrity (the data object has not been invented or modified since its creation). Signature validation may be achieved for static data objects by a verification of the hash value of the data objects against the hash value of the same data object stored after a full signature validation.

This control substantially overlaps with control 3.2, Validation of Trusted Origin (VTO). However, signature validation is central to all PKI-based authentications; this duplication allows signature validation to be explicitly recognized as a control in its own right.

#### *8.1.1.11 PIA-5: Full Path Validation*

***Control:*** The E-PACS uses PDVal for signed objects involved in authentication (e.g., authenticating acceptance devices, the card or the card holder).

***Detailed Guidance:*** Full path validation is central to all PKI-based authentications; this allows path validation to be explicitly recognized as a control in its own right, taking into account all possible revocations of intermediate CAs. PDVal is performed at the time of use or with a frequency in accordance with federal common policy. The PDVal status can then be cached to improve performance at time of access.

PDVal is performed at time of use or with a frequency in accordance with local policy using cached status values. Depending on the local policy, PDVal may additionally require:

1. Policy Mapping
2. Basic Constraint Checking
3. Name Constraint Checking

The E-PACS includes an enterprise Certificate Path Validation (CPV) component that conforms with *NIST Recommendation for X.509 Path Validation*, May 3, 2004 that processes X.509 certification paths composed of X.509 v3 certificates and X.509 v2 CRLs.

The CPV component supports the following features:

1. Name constraints;
2. Policy Mapping;
3. Basic Constraint Checking;
4. Name Chaining;
5. Signature Chaining;
6. Certificate Validity;
7. Key usage, basic constraints, and certificate policies certificate extensions;
8. Full CRLs; and
9. CRLs segmented on names.

Defined in [RFC 5280].

The CPV component verifies that digital signatures and public keys in the certification path chain in accordance with [RFC 5280], using the appropriate algorithm as detailed in the certificate. That is, the CPV component verifies that the signature on each certificate in the path verifies using the public key in the preceding certificate, and the signature on the first certificate in the path verifies using a trust anchor's public key.

The CPV component verifies that issuer and subject names in certification paths chain in accordance with [RFC 5280]. That is, the CPV component verifies that the issuer of each certificate in the path was the subject of the preceding certificate, and the issuer of the first certificate in the path is the name associated with the trust anchor public key.

Note that full path validation includes checks of the expiration, revocation, and signature for each certificate in the path, implementing PIA 3.4, PIA-3.5, PIA-3.6, and PIA-4.

#### *8.1.1.12 PIA-6: Cross-Agency Interoperable Authentication*

***Control:*** The E-PACS supports authentication of PIV and PIV-I Cards from other issuers via:

1. PKI, or
2. PKI-CAK

The E-PACS may support the authentication of PIV and PIV-I Cards from other issuers via:

1. SYM CAK
2. CHUID + BIO
3. CAK + BIO
4. PKI + BIO
5. PIN to PACS[45]
6. BIO to PACS

[45] PIN values are not automatically interoperable.

The relative assurance levels of these mechanisms are specified in Table 8-3.

***Detailed Guidance:*** The E-PACS supports Asymmetric Card Authentication Key to maximize interoperability with PIV-I Cards.

#### *8.1.1.13 PIA-7: Card Revocation Check Mechanisms*

***Control:*** The E-PACS supports verifying that the PIV Card has not been revoked using the PIV Authentication Key's digital certificate or the Card Authentication Key's digital certificate.

***Detailed Guidance:*** OCSP, SCVP, and CRL checks are all mechanisms to verify that a digital certificate used for cryptographic authentication has not been revoked. FIPS 201 requires that all PIV Card issuers support the retrieval of validity data. FIPS-201 requires that all PIV Card issuers support HTTP, lightweight directory access protocol (LDAP), and OCSP as access methods for the retrieval of validity data.

An organization may have an Enterprise IdM in place. In this environment, it is possible to have direct provisioning and de-provisioning of access records that are tightly bound to Human Resources processes. This provides a faster (and potentially more secure) way of managing revocation, as the organization does not have to wait on PKI to propagate CRL status information that may be over 18 hours stale. This method must be in addition to PKI status checking.

#### *8.1.1.14 PIA-8: Provisioning via Import*

***Control:*** The E-PACS supports batch import of identity records from a trusted source.

***Detailed Guidance:*** The E-PACS accepts import of records from a source it trusts and that complies with the security requirements described in the detailed guidance of PIA-9.

#### *8.1.1.15 PIA-9: Provisioning via Registration*

***Control:*** The E-PACS supports registration of a PIV or PIV-I Card from an internal or external source.

***Detailed Guidance:*** In-person registration includes a biometric verification of the cardholder. The Facility Access Control Policy may require gathering attributes beyond those available from the card (e.g. Joint Personnel Adjudication System (JPAS) clearance information). It is recommended that the PACS always record the following from a PIV or PIV-I Card:

1. CHUID;
2. PIV Authentication Certificate; and
3. Card Authentication Certificate (if available).

Provisioning via Registration satisfies controls PIA-3.1, PIA 3.2, PIA 3.3, PIA 3.4, PIA 3.5, and PIA-3.6 specifically for the PIV Authentication Key and for the biometric object (the fingerprint template).

Special Case: The E-PACS supports off-site, remote visitor request workflow process. This function provides a web-based workflow tool to enable visitors to remotely submit the following information to the security office:

1. CHUID;
2. PIV Authentication Certificate;
3. Card Authentication Key Certificate;
4. Sponsor information; and

5. Date and time of visit.

An effective visitor request workflow ensures, prior to provisioning the PIV Card to the E-PACS, that:
1. PIA-3.2 and PIA-5have been satisfied;
2. The visit request is approved by the sponsor and the security administrator; and
3. Access control privileges within the E-PACS are assigned by the security administrator.

#### *8.1.1.16 PIA-10: PIN Caching*
***Control***: The PACS does not cache the PIV or PIV-I Card's PIN.

***Detailed Guidance***: The PACS ensures that the PIN registered for PIN to PACS authentication modes is unique and distinct from the PIV or PIV-I Card's PIN. This is enforced at the time of registration of the bearer's credential to the PACS for use in PIN to PACS authentication modes.

The PACS does not cache the PIV or PIV-I Card PIN as a result of active authentication as described in PIA-3.3.

### *8.1.2 Access Control*
The Access Control family of security controls addresses the controls for how facility access control decisions are made, given that the card holder has successfully been identified and authenticated.

***Table 8-5, Summary of Access Control Controls***

| Class | Family | ID | Control |
|---|---|---|---|
| T | PAC | PAC-1 | Enforcement of Rules of Access |
| T | PAC | PAC-2 | Access Control Exception Procedures |
| T | PAC | PAC-3 | Exclusion List Check |

#### *8.1.2.1 PAC-1: Enforcement of Rules of Access*
***Control:*** The E-PACS enforces the access rules specified in the Facility Access Control Policy.

***Detailed Guidance:*** The Facility Access Control Policy documents the rules of access (PPL-5). This control enforces the documented rules of access. This policy defines the relationship between the credential, the individual it represents, and the mechanisms used to enforce associated access rights. Examples for access rules include:

1. Time and schedule;
2. Role/group access;
3. Force Protection Condition (FPCON) management; and
4. Escalation of authentication factors based on time/schedule.

#### *8.1.2.2 PAC-2: Access Control Exception Procedures*
***Control:*** The E-PACS procedures and practices address the possible causes of access denial.

***Detailed Guidance:*** The use of PIV technology, together with one or more authentication factors, introduces complexity which may ultimately lead to incorrect access denied decisions (false rejects). The E-PACS Facility has mechanisms that enable legitimate cardholders to improve their performance (e.g. reduce false rejects). However, the mechanisms should not be so powerful that attackers are able to exploit them to obtain incorrect access control decisions (false accepts).

The E-PACS has procedures and practices that manage this risk by preventing fraudulent users from gaining access (e.g. for gaining access based on visual verification after a proper access denied decision based on card revocation.) In contrast, legitimate users are encouraged to cooperate with the system to improve the false rejection rates of any factor (e.g. biometric, contactless, length of authentication).

#### *8.1.2.3 PAC-3: Exclusion List Check*

***Control:*** The E-PACS verifies that the PIV or PIV-I Card has not been excluded by a PACS system administrator.

***Detailed Guidance:*** A site or PACS system can maintain a list of cards/cardholders that should not be granted access, regardless of whether the card is still valid or has been revoked. Such a list is called an "exclusion list"[46] and can originate from multiple sources.

### *8.1.3 Audit and Accountability*

***Table 8-6, Summary of Audit and Accountability Controls***

| Class | Family | ID | Control |
|---|---|---|---|
| T | PAU | PAU-1 | Audit and Accountability Policy and Procedures |
| T | PAU | PAU-2 | Audit Log Record Contents |
| T | PAU | PAU-3 | Card Usage Logging |
| T | PAU | PAU-4 | Card Registration Logging |
| T | PAU | PAU-5 | System Operation Logging |
| T | PAU | PAU-6 | System Configuration Logging |
| T | PAU | PAU-7 | Audit Analysis Capability |

#### *8.1.3.1 PAU-1: Audit and Accountability Policy and Procedures*

***Control:*** The E-PACS logs auditable events as documented in the Facility Access Control Policy.

[46] An agency should follow existing facility security policies in coordination with General Counsel and Human Resources for issues related to maintaining an exclusion list.

***Detailed Guidance:*** PPL-8 specifies that the Facility Access Control Policy documents auditable events. This control specifies that the E-PACS implements the documented policy and that audit controls are protected from unauthorized modification (tampering).

#### *8.1.3.2 PAU-2: Audit Log Record Contents*

***Control:*** The E-PACS collects and records the following information for auditable events:

1. Date and time;
2. Element on which the event occurred;
3. Triggering event;
4. Credential Identifier;
5. Action Taken; and
6. Additional Information.

***Detailed Guidance:*** Some types of information may not apply for certain events. For instance, there may not be data in the event record for (4) Credential Identifier or (5) Action Taken for a power failure event. The recorded information:

1. *Date and time*: a system sequence may be used if a clock is not available. This is required so that the order of events within the E-PACS can be sorted or sequenced.
2. *Element on which the event occurred*: For a reader, enough information to identify the specific reader. For a controller/panel, enough information to identify the specific controller/panel.
3. *Triggering event*: card presented, power failure, tamper detected, reader software update, reader mode changed, etc.; or external event from integrated systems such as Video Analysis or Intrusion Detection Systems.
4. *Credential Identifier*: One of: (1) Credential identifier, (2) Credential not recognized, or (3) Not a credential event (e.g. power failure). The credential identifier exactly matches or correlates to a credential identifier under which that Card was registered.
5. *Action Taken*: (e.g. access granted or denied, identity authenticated or denied, PDVal required)
6. *Additional Information*: (e.g. reader mode, credential type, number of retries)

#### *8.1.3.3 PAU-3: Card Usage Logging*

***Control:*** The E-PACS logs the following events:

1. PIA-3.2, Verification of Trusted Origin
2. PIA-3.5, Path Validation
3. PAC-1, Enforcement of Rules of Access (e.g. Authorization decisions)
4. Mappings, transforms, or translation of numbers or identifiers used by different parts of the system. (This is often called credential number processing and transmission )

***Detailed Guidance:*** Any record generated by a credential-related event is traceable to the credential that was registered by the system. Examples: single number, multiple indexes and numbers for same credential, transformation of number, etc.

Records are sufficient to support reporting such as:

1. Card activity (e.g., 3 days of card activity);and
2. Last known location card was used.

#### 8.1.3.4 PAU-4: Card Registration Logging

***Control:*** The E-PACS logs, collects, and records events at the time the card is registered to the system.

***Detailed Guidance:*** The systems records the following events at card registration.

1. PIA-3.2, Verification of Trusted Origin
2. PIA-3.5, Path Validation as appropriate
3. Authentication Factor(s) verified (e.g. PIV Authentication Key, PIN, and/or biometric)
4. Status of background investigation
5. Status of suitability

#### 8.1.3.5 PAU-5: System Operation Logging

***Control:*** The E-PACS logs security-relevant events initiated by the Head End System.

***Detailed Guidance:*** Security-relevant events initiated by the Head End System include, but are not limited to:

1. Periodic certificate PDVal and revocation status checking as defined in PIA-3.2, Verification of Trusted Origin, PIA-5, Path Validation;
2. Any modification to the status of a credential in the PACS Identity Management System (IDMS);
3. Push of credential status throughout the PACS;
4. Individual and group reporting of alarms (e.g., door force, door prop);
5. Badge holder tracking by group or individual;
6. What date individuals were provisioned or de-provisioned and by whom;
7. Verification of software driven configuration changes; and
8. All readers and their modes.

#### 8.1.3.6 PAU-6: System Configuration Logging

***Control:*** The E-PACS logs configuration changes to all system hardware, software and firmware components.

***Detailed Guidance:*** Configuration changes to all system hardware, software, and firmware components include:

1. Verification of software driven configuration changes;
2. Any modification of the status of the PACS;
3. System time;
4. Software updates; and
5. Admin actions.

#### 8.1.3.7 PAU-7: Audit Analysis Capability

***Control:*** The E-PACS provides a capability to analyze and correlate audit logs.

***Detailed Guidance:*** Audit logs may be collected and recorded on different devices (PACS Head End, Controllers/Panels,). The E-PACS aggregates, sorts, and correlates the multiple logs. The goal is to be able to trace all activity of a given card in chronological order. One aspect of this is the ability to determine the most recent known location for the card.

### 8.1.4 System and Communications Protection

*Table 8-7, Summary of System and Communications Protection Controls*

| Class | Family | ID | Control |
|---|---|---|---|
| T | PSC | PSC-1 | Communication Between System Elements |
| T | PSC | PSC-2 | Trust Anchor Protection |

#### 8.1.4.1 PSC-1: Communication between System Elements

***Control:*** The E-PACS protects communication between system elements and prevents introduction of untrusted elements.

***Detailed Guidance:*** The E-PACS protects the integrity and authenticity of all identifiers and reference authenticators in transmission. Cryptographic mechanisms, in accordance with FIPS 140-2, are the most common way of protecting integrity and authenticity (reference PIA-3.4 for examples). Other methods to detect tampering include balanced impedance wiring or similar hardware mechanisms.

#### 8.1.4.2 PSC-2: Trust Anchor Protection

***Control:*** The E-PACS provides a trust store for Root and Issuing Certification Authorities as authorized for the PACS per local policy.

***Detailed Guidance:*** The E-PACS allows for Create, Read, Update and Delete (CRUD) management of trust store. This mechanism is used to provide management of the minimum set of trust anchors necessary to operate the E-PACS. This trust store is managed based on local security policy. It is strongly recommended that this trust store not be the standard vendor trust store, and that the vendor automatically updates this trust store so that it is turned off to mitigate the risk of low assurance certificate authorities being accepted by the E-PACS.

The E-PACS supports X.500, HTTP and LDAP Uniform Resource Identifiers (URIs) for CRL location.

The E-PACS supports OCSP.

The E-PACS provides the ability to specify multiple SCVP servers that are utilized in priority order.

The E-PACS supports cryptographic algorithms required by [NIST SP 800-78].

## 8.2 Operational Controls

Operational security controls (i.e., safeguards or countermeasures) for an E-PACS are primarily implemented and executed by people rather than the PACS.

### 8.2.1 Configuration Management

***Table 8-8, Summary of Configuration Management Controls***

| Class | Family | ID | Control |
|---|---|---|---|
| O | PCM | PCM-1 | Configuration Administration |
| O | PCM | PCM-2 | Component Installation and Configuration |
| O | PCM | PCM-3 | Configuring Reader Authentication Modes |

#### 8.2.1.1 PCM-1: Configuration Administration

***Control:*** The E-PACS has the ability to enforce administrative privilege for configuration management operations.

***Detailed Guidance:*** The E-PACS authenticates administrators to the head-end software using a process of equivalent or greater assurance than the authentication modes supported by the system.

#### 8.2.1.2 PCM-2: Component Installation and Configuration

***Control:*** The E-PACS has the ability to manage the system through configuration management methods.

***Detailed Guidance:*** Initial configuration of hardware settings (e.g., dual in-line package (DIP) switches) is performed at installation and not for management of the hardware tree.

Each PACS physical component (e.g. system and door controller/panel, readers) is separately defined and addressable within the server user interface.

The E-PACS supports configuration downloads to each component. The system provides sufficient logging for verification of download's status.

#### 8.2.1.3 PCM-3: Configuring Reader Authentication Modes

***Control:*** The E-PACS supports bi-directional communications to all readers that support dynamically configurable authentication modes.

***Detailed Guidance:*** All E-PACS using dynamically configurable readers support bidirectional communications with the system.

Where multiple authentication modes are supported, the following are met:

(1) Bidirectional communication with the reader is supported.

(2) For multi-factor readers, applicant's system allows modification of an individual reader or groups of readers' authentication mode from the server or a client/workstation to the server.

(3a) This support is present in the following administrative scenarios: The site administrator arbitrarily decides that all readers or a subset of readers must require either more or fewer authentication factors for which the readers are presently configured.

(3b) Based on temporal access rules the administrator set: The system supports dynamic assignment of individuals (or groups of individuals) and resources (doors) on a time based schedule.

(3c) Based on Force Protection Condition (FPCON)[47], Maritime Security (MARSEC)[48] or other similar structured emergency response protocol for which the vendor claims support: There isn't a requirement for an administrator's physical presence at a reader to be considered compliant.

(3d) if a time delay of longer than 120 seconds is required for a reader to change modes; it is considered non-compliant.

### 8.2.2 Contingency Planning

***Table 8-9, Summary of Contingent Planning Controls***

| Class | Family | ID | Control |
|---|---|---|---|
| O | PCP | PCP-1 | Continuity of Operations |

#### 8.2.2.1 PCP-1: Continuity of Operations

***Control*:** The E-PACS provides testable methodologies for backup and restoration of databases.

***Detailed Guidance:*** Testable methodologies include, but are not limited to:

1. Onsite and remote backup support;
2. Automatic v. manual backup options;
3. Destination media supported;
4. Perform backups/restores for supported options;
5. Kill power and test resiliency;
6. Kill network; and
7. Trust store and authenticator recovery.

### 8.2.3 Physical and Environmental Protection

***Table 8-10, Summary of Physical and Environmental Controls***

| Class | Family | ID | Control |
|---|---|---|---|
| O | PPE | PPE-1 | Secure Processing Protection |

#### 8.2.3.1 PPE-1: Secure Processing Protection

***Control:*** The E-PACS performs all security relevant processing on the secure side of the physical security boundary.

[47] See http://www.fas.org/irp/doddir/dod/i2000_16.pdf for FPCON details.

[48] See http://www.uscg.mil/safetylevels/whatismarsec.asp for MARSEC details.

***Detailed Guidance:*** No security relevant decisions are made by system components that do not belong to the cardholder's credential when they are on the attack side of the door. This specifically applies to the door reader. Security relevant processing includes:

1. PKI PDVal (PIA-3.2);
2. Nonce generation (PIA-3.3);
3. Challenge/response (PIA-3.3);
4. Biometric matching for 1:1 verification (PIA-3.3);
5. Certificate revocation and status checking (PIA-3.5);
6. Credential identifier processing; and
7. Authorization decisions.

Certain compensating controls may be applied such as tamper switches and [FIPS 140-2]-certified cryptographic processing within the reader itself.

### 8.2.4 System and Information Integrity

No additional controls in this system family are identified for PACS at this time. However, the controls in [NIST SP 800-53] do apply to PACS. In addition, IP-based systems may have additional concerns such as geo-location, authentication and integrity of devices.

### 8.2.5 Awareness & Training

***Table 8-11, Summary of Awareness and Training Controls***

| Class | Family | ID | Control |
|---|---|---|---|
| O | PAT | PAT-1 | Security Awareness and Training Policy and Procedures |
| O | PAT | PAT-2 | Security Training Records |
| O | PAT | PAT-3 | Contacts with Security Groups and Associations |

Training for users and guards on using biometrics in the system or card tearing may need to be described.

#### 8.2.5.1 PAT-1: Security Awareness and Training Policy and Procedures

***Control:*** An organization establishes, conducts, and complies with PACS-related training policies and procedures.

***Detailed Guidance:*** There is no detailed guidance at this time.

#### 8.2.5.2 PAT-2: Security Training Records

***Control:*** An organization maintains training records.

***Detailed Guidance:*** There is no detailed guidance at this time.

#### 8.2.5.3 PAT-3: Contacts with Security Groups and Associations

***Control:*** An organization establishes and maintains contacts with Security Groups and Associations.

***Detailed Guidance:*** There is no detailed guidance at this time.

## 8.3 Management Controls

Management security controls (i.e., safeguards or countermeasures) for an E-PACS focus on the management of risk and the management of information system security. These controls require ongoing management over time.

### 8.3.1 Security Assessment and Authorization

***Table 8-12, Summary of Security Assessment and Authorization Controls***

| Class | Family | ID | Control |
|---|---|---|---|
| M | PCA | PCA-1 | Fire, Life and Safety Certifications |
| M | PCA | PCA-2 | UL 294 Assessment |
| M | PCA | PCA-3 | FIPS 201 APL |
| M | PCA | PCA-4 | FIPS 140 Validation |
| M | PCA | PCA-5 | Facility Assessment |
| M | PCA | PCA-6 | Security Authorization |

#### 8.3.1.1 PCA-1: Fire, Life and Safety Certifications

***Control:*** The E-PACS obtains appropriate certifications required to comply with federal and local fire, life and safety requirements.

***Detailed Guidance:*** System owner determines appropriate life safety requirements for their facility and obtain all applicable certifications. Building codes from the National Fire Prevention Association (NFPA) such as NFPA 72 and NFPA 101 Life Safety Code is consulted during the planning stages of an access control project. These codes require that an access control system be connected to the Fire Alarm Control Panel. In addition, for government owned and leased facilities which are under GSA, the GSA fire and safety office of the particular region are also consulted, as well as the Federal Protective Service (FPS) since fire alarm monitoring is usually done by the FPS Mega Centers.

#### 8.3.1.2 PCA-2: UL 294 Assessment

***Control***: The E-PACS obtains external certification such as those provided by Underwriters Laboratory Inc., standard UL-294.

***Detailed Guidance:*** The E-PACS has the following core certifications as appropriate to components within the system. These certifications are achieved prior to listing on the APL: (1) UL assessment (UL 294 at a minimum).

#### 8.3.1.3 PCA-3: FIPS 201 APL

***Control:*** The E-PACS incorporates components listed on the GSA FIPS 201 APL at all points in the system where products from an APL category are appropriate.

***Detailed Guidance:*** It is important to note FIPS 140 Validation status when choosing products from the APL (see PCA-4, PIA-3.4). When implementing system components, the E-PACS only implements tested version numbers. When the APL updates the approved versions, the E-PACS is also updated to support the latest tested bug fixes.

Special Case: if a serious security exploit has been identified that requires an update to E-PACS systems, it may be necessary to update system components beyond the latest approved version listed on the APL.

#### 8.3.1.4 PCA-4: FIPS 140 Validation

***Control:*** The E-PACS incorporates FIPS 140 Validated components at all points in the system where cryptographic processing occurs.

***Detailed Guidance:*** See [FIPS 140] for detailed guidance.

#### 8.3.1.5 PCA-5: Facility Assessment

***Control:*** The E-PACS is subject to a facility assessment to ensure the configuration, architecture, and validation components follow E-PACS guidance. In general facility assessments are treated like a pre-operational audit and done by a third party to the facility owner and integrator.

***Detailed Guidance:*** An E-PACS facility assessments cover:

Facility Architecture

1. Ensure proper authentication is used based on the facility security level and agency's determination of risk for each area within the facility.
2. System complies with mandatory requirements and guidance
3. Supports current APL products

System Configuration

1. Fitness for use
2. Proper controls and policies are in place to detect errors, monitor access and prevent intrusion
3. Products and specific version

Validation Components

1. Proper PKI configuration settings
2. Cached responses are being refreshed periodically

#### 8.3.1.6 PCA-6: Security Authorization

***Control:*** The E-PACS obtains a security authorization.

***Detailed Guidance***: The E-PACS meets security authorization requirements of FISMA and [NIST SP 800-37] as applicable.

### 8.3.2 Planning

*Table 8-13, Summary of Planning Controls*

| Class | Family | ID | Control |
|---|---|---|---|
| M | PPL | PPL-1 | Facility Access Control Policy |
| M | PPL | PPL-2 | Policy Specifies Assurance Level |
| M | PPL | PPL-3 | Policy Specifies Authentication Modes |
| M | PPL | PPL-4 | Policy Specifies Accessing Populations |
| M | PPL | PPL-5 | Policy Specifies Rules of Access |
| M | PPL | PPL-6 | Policy Specifies Time of Day Restrictions for Access |
| M | PPL | PPL-7 | Policy Specifies Threat Level Restrictions and Exceptions |
| M | PPL | PPL-8 | Policy Specifies Auditable Events |

#### 8.3.2.1 PPL-1: Facility Access Control Policy

***Control:*** The E-PACS includes a documented Facility Access Control Policy.[49]

***Detailed Guidance:*** It is difficult to measure the effectiveness of an E-PACS if the policy fit is expected to enforce is not clearly documented. This and the following controls explicitly specify what the policy documents.

#### 8.3.2.2 PPL-2: Policy Specifies Assurance Level

***Control:*** The E-PACS Facility Access Control Policy specifies the PACS Assurance Level required for protecting this facility in accordance with the ISC Facility Security Level determination.

***Detailed Guidance:*** Facilities have varying requirements for facility protection, and therefore for the assurance of the implemented security controls. The required Facility Security Level is specified as one of:

1. Level I - Low
2. Level II - Medium
3. Level III - High
4. Level IV – Very High
5. Level V – Very High, considered critical to national security

[49] The Facility Access Control Policy does not need to be a separate document and could be incorporated into other standard security documentation, such as an overall facility security policy or a Facility Security Plan.

#### *8.3.2.3 PPL-3: Policy Specifies Authentication Modes*

***Control:*** The E-PACS Facility Access Control Policy specifies what Authentications Modes are required and permitted for each security area (re: [NIST SP 800-116], unrestricted, controlled, limited, exclusion).

***Detailed Guidance:*** See [NIST SP 800-116] for detailed guidance.

#### *8.3.2.4 PPL-4: Policy Specifies Accessing Populations*

***Control:*** The E-PACS Facility Access Control Policy specifies the various populations of individuals for whom access to the facility is controlled.

***Detailed Guidance:*** The policy defines the populations that are relevant for its operation. These populations will often be drawn from the following list: Employee, Contractor, Temp Worker, Visitor, Security Guard, Local Security Administrator, System Administrator, and Security Administrator.

For example, the E-PACS may include three specific populations: regular, visitor, and guest:

- **Regular**: individuals with a card that may be issued by the local authority or another source that is trusted by the E-PACS, and who regularly access the facility.
- **Visitor**: an external user[50] that is requesting short term access to an agency facility.
- **Guest**: individuals who do not bring a card from a source that is trusted by the E-PACS.

#### *8.3.2.5 PPL-5: Policy Specifies Rules of Access*

***Control:*** The E-PACS Facility Access Control Policy specifies the rules of access for each population of individuals for whom access to the facility is controlled.

***Detailed Guidance:*** There is no detailed guidance at this time.

#### *8.3.2.6 PPL-6: Policy Specifies Time of Day Restrictions for Access*

***Control:*** The E-PACS Facility Access Control Policy specifies time of day restrictions for access.

***Detailed Guidance:*** There is no detailed guidance at this time.

#### *8.3.2.7 PPL-7: Policy Specifies Threat Level Restrictions and Exceptions*

***Control:*** The E-PACS Facility Access Control Policy specifies restrictions and exceptions for access that are based on the threat level.

***Detailed Guidance:*** There is no detailed guidance at this time.

#### *8.3.2.8 PPL-8: Policy Specifies Auditable Events*

***Control:*** The E-PACS Facility Access Control Policy specifies the events recorded in the audit log.

***Detailed Guidance:*** There is no detailed guidance at this time.

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[50] An external user is any individual attempting or requesting access to agency facilities or systems that is not an employee, contractor, or primary affiliate of the agency. External users may be PIV holders from another agency, business partners, or private citizens.

### 8.3.3 Risk Assessment

*Table 8-14, Summary of Risk Assessment Controls*

| Class | Family | ID | Control |
|---|---|---|---|
| M | PRA | PRA-1 | Assess risk in accordance with ISC Guidance on PACS |
| M | PRA | PRA-2 | Use a risk-based methodology to Determine security area designation for physical spaces in each facility. |

As indicated in [HSPD-12], agencies were to begin using the common identification standard in November 2006 to gain physical access to federally-controlled facilities and logical access to federally-controlled information systems. [OMB M-11-11] states that DHS and GSA will work together to provide agencies with guidance for implementing the government-wide architecture defined in [FICAM Roadmap]. This includes a DHS partnership with the GSA Public Building Service (PBS) to ensure that implementation of physical access requirements for federal buildings, under PBS' purview, are implemented in accordance with [Facility Security Level Standard] and NIST guidelines.

*Table 8-15, Matrix of mappings*

| Authentication Factors | NIST SP 800-116 | Example Areas |
|---|---|---|
| 0 | Unrestricted | Badging Lobby, Visitors Center, Roadways, Cafeterias, Gift Shop, Recreation Facilities, Employee General Access to Buildings. |
| 1 | Controlled | Building, Program or Code Has Requested Accountability Controls, Access to Program Area Not Storing CNSI, No MEI Facility, LAN Closet, Electrical Closet, Hazmat Supplies, Admin Building, Facility Services, HQ. |
| 2 | Limited | Special Program Area Storing CNSI, MEI Facility, Other Very Sensitive Documents or Equipment, SEB, Mishap Investigation Facility, Lab Space. |
| 3 | Exclusion | Most-sensitive areas such as those containing trade secrets. |

# 9. PACS COMPONENTS

Table 9-1summarizes the basic, core components of current PACS implementations. The terms listed below are used throughout the remainder of this document for consistency.

***Table 9-1, Core PACS Components***

| Component Name | Description |
|---|---|
| **Contact Reader:** | A smart card reader that communicates with the Integrated Circuit chip in a smart card using electrical signals on wires touching the smart card's contact pad. The PIV contact interface is standardized by International Organization of Standards / International Electrotechnical Commission (ISO/IEC) 7816-3. [ISO/IEC 7816]. The reader may also include a keypad for PIN entry and/or a biometric sensor as integral components. |
| **Contactless Reader:** | A smart card reader that communicates with the Integrated Circuit chip in a smart card using Radio Frequency (RF) signaling. The PIV contactless interface is standardized by ISO/IEC 14443 [ISO/IEC 14443]. Use of 125khz card is not part of the PIV standard[51]. The reader may also include a keypad for PIN entry and/or a biometric sensor as integral components. |
| **Door Reader Interface** | This functional interface, which can be in the Door Reader or the Controller/Panel, comes in different configurations. FIPS 201 does not specify which protocols can be used for this interface, provided the necessary data can be communicated to the Controller/Panel. Typical deployed implementations support transmitting a small amount of data (on the order of 10 to 15 bytes), but FIPS 201 defines data elements which are much larger. Therefore, depending on the agency's implementation strategy, an upgrade to the Door Reader to Controller/Panel interface may also be required. At a minimum, a 14 decimal digit FASC-N Identifier will be supported in most cases. Note that any change to this interface may also necessitate changes to the physical wiring and cabling infrastructures. |
| **Controller/Panel** | A device located within the secure area that, among other functions, communicates with multiple PIV Card readers and door actuators, and with the Head End System. The PIV Card readers provide cardholder information to the Controller/Panel, which it uses to make access control decisions and release door locking mechanisms. The Controller/Panel communicates with the Head End System to receive changes in access permissions, report unauthorized access attempts and send audit records and other log information. Most modern controllers/panels can continue to operate properly during periods of time in which communication with the Head End is disrupted and can journal transactions so that they can be reported to the Head End when communication is restored. |
| **Head End System**<br><br>(Sometimes referred to as **Access Control Server**)**:** | A system including application software, database, a Head End server, and one or more networked personal computers. The Head End server is typically used to enroll an individual's name, create a unique ID number, and assign access privileges and an expiration date. The server is also used to maintain this information and refresh the Controller/Panel(s) with the latest changes. In addition to taking care of PIV Card registrations, the server may also support alarm monitoring, operator control, system configuration, transaction logging, report generation, graphic assessment, and back up of the controller/panel database. Caching status proxy may also reside in the head end. |
| **Door** | A door is a managed breach in a secure perimeter that is controlled by the PACS. For the purposes of this document, it has an Attack Side and a Secure Side. |

[51] See [OMB M-10-15].

| Component Name | Description |
|---|---|
| **Servers/External Interfaces** | Because PACS are now using credentials issued by external providers, they have to interface with external systems such as:<br><br>a. PIV issuance provider;<br>b. Interfaces to the equivalent of a no-fly-list;<br>c. PKI services; and<br>d. Other Head Ends. |
| **Infrastructure** | Distributed substructure of a large-scale organization that facilitates related functions or operations, e.g., telecommunications infrastructure. With regard to PACS, components include conduit, cabling, power supplies, battery backup, electrified door hardware, door position switches, and remote exit devices, as well as connectivity with other life safety systems that will ensure egress in the event of an emergency. |
| **Certificate Path Validation** | Performs certificate path validation functionality. This validates that the trust chain for the credential is not revoked, expired, or otherwise compromised. See PIA-5 |

# 10. AUTHENTICATION PATTERNS

This section outlines the common authentication patterns (also called use cases) associated with the use of PIV or PIV-I in PACS. The patterns are aligned with [NIST SP 800-116] authentication mechanisms as they pertain to gaining access to security areas (see Figure 7-1).

Table 10-1, summarizes all of the authentication patterns contained within the section, organized by the number of authentication factors provided by the pattern. The number of authentication factors dictates if a pattern is sufficient to move through the various security areas within a facility.[52] Following the summary table, this section is divided into two subsections, which distinguish between 1) those authentication mechanisms which are considered acceptable for target state use because they meet the control objectives of HSPD-12 and the vision and goals of the ICAM segment architecture; and 2) those mechanisms which are only sufficient for legacy or transitional use while an agency moves towards the target state. Within each pattern, the document provides a description of the pattern and insights and considerations. Each pattern lists unmitigated threats specific to it. Note that some threats apply to all patterns.

[52] This table shows an example area movement per authentication pattern. For a complete listing and discussion of all area movement permutations, see [NIST SP 800-116] Table 7-2.

*Table 10-1, Summary of Patterns to Moving Between NIST SP 800-116 Security Areas*

| # | | Pattern Name | Interface | | Authenticators | Vulnerabilities | | | | | | | | | | | | Meets HSPD-12 objectives? | Example NIST SP 800-116 Area Movement |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Contact Interface | Contactless Interface | Authentication factor(s) | 1. Electronic Cloning | 2. Electronic Counterfeiting | 3. Visual Counterfeiting | 4. Use of Expired Card | 5. Use of Terminated Card | 6. Use of Lost or Stolen Card | 7. Skimming | 8. Sniffing | 9. Social Engineering | 10. Biometric Object Substitution | 11. Identifier Collision | 12. Biometric Spoofing | | |
| **Patterns with No Factors** | | | | | | | | | | | | | | | | | | | |
| 1 | | VIS | | | | | | ✓ | | ✓ | ✓ | | | | | | | No | None |
| 2 | | Partial CHUID | C | CL | | ✓ | ✓ | | ✓ | ✓ | ✓ | | | | | ✓ | | No | None |
| 3 | | Primitive CHUID | C | CL | | ✓ | ✓ | | | ✓ | ✓ | ✓ | ✓ | | | | | No | None |
| 4 | | CHUID | C | CL | | ✓ | | | | ✓ | ✓ | ✓ | ✓ | | | | | No | None |
| 5 | | Enhanced CHUID | C | CL | | ✓ | | | | | ✓ | ✓ | ✓ | | | | | No | None |
| 6 | | Primitive BIO | C | | | | ✓ | | | ✓ | ✓ | | | | ✓ | | ✓ | No | None |
| **Patterns with One Factor** | | | | | | | | | | | | | | | | | | | |
| 7 | | Enhanced CHUID + VIS | C | CL | Have | ✓ | | | | | ✓ | ✓ | ✓ | | | | | No | Unrestricted to Controlled |
| 8 | | Asymmetric CAK | C | CL | Have | | | | | | ✓ | | | ✓ | | | | Yes | Unrestricted to Controlled |
| 9 | | SYM CAK | C | CL | Have | | | | | | ✓ | | | ✓ | | | | No | Unrestricted to Controlled |
| 10 | | BIO | C | | Are | | | | | | | | | | | | ✓ | No | Unrestricted to Controlled |
| 11 | | CHUID + PIN to PACS | C | CL | Know | | | | | | | | | ✓ | | | | No | Unrestricted to Controlled |
| 12 | | CHUID+ BIO to PACS | C | CL | Are | | | | | | | | | | | | ✓ | No | Unrestricted to Controlled |
| 13 | | BIO-A to PACS | C | CL | Are | | | | | | | | | | | | | No | Unrestricted to Controlled |
| **Patterns with Two Factors** | | | | | | | | | | | | | | | | | | | |
| 14 | | BIO-A | C | | Have + Are | | | | | | | | | | | | | No | Unrestricted to Limited |
| 15 | | PIV-Auth | C | | Have + Know | | | | | | | | | ✓ | | | | Yes | Unrestricted to Limited |
| 16 | | Asymmetric CAK + PIN to PACS | C | CL | Have + Know | | | | | | | | | ✓ | | | | Yes | Unrestricted to Limited |
| 17 | | SYM CAK + PIN to PACS | C | CL | Have + Know | | | | | | | | | ✓ | | | | No | Unrestricted to Limited |
| **Patterns with Three Factors** | | | | | | | | | | | | | | | | | | | |
| 18 | | Asymmetric CAK + BIO-A | C | | Have + Know + Are | | | | | | | | | | | | | Yes | Unrestricted to Exclusion |
| 19 | | SYM CAK + BIO-A | C | | Have + Know + Are | | | | | | | | | | | | | No | Unrestricted to Exclusion |
| 20 | | PIV-Auth + BIO-A | C | | Have + Know + Are | | | | | | | | | | | | | Yes | Unrestricted to Exclusion |

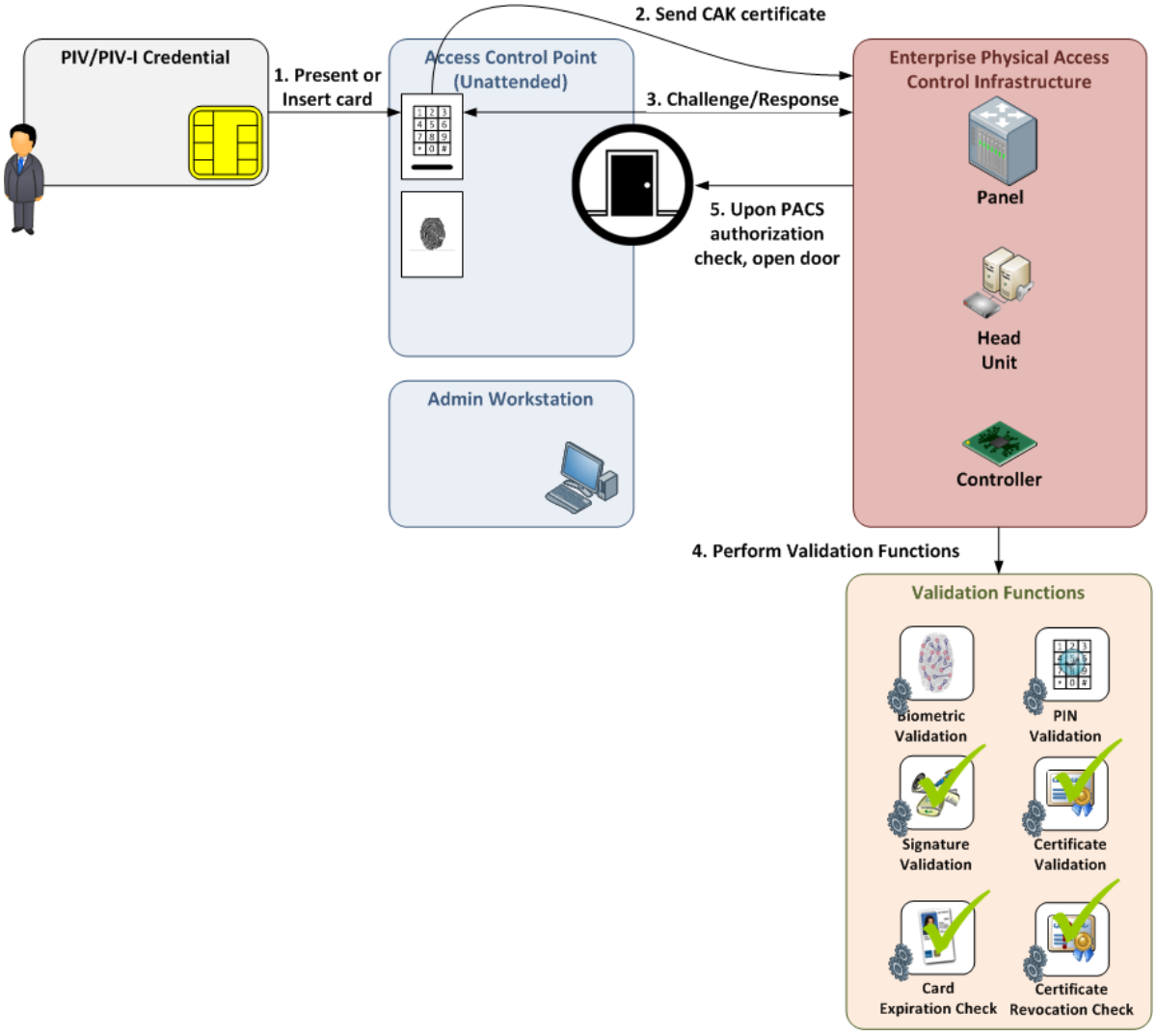
## 10.1 Acceptable Target State Authentication Patterns

This section outlines the authentication mechanisms which are considered acceptable for target state use. Each of these mechanisms meets the minimum requirements for strong authentication through the use of challenge/response cryptography. Additionally, these mechanisms meet current policy and architectural guidance to implement ICAM infrastructure that supports interoperability across the federal enterprise.

### *10.1.1 Pattern #8: PKI-CAK*

The PACS uses the asymmetric CAK (from the CAK certificate) in a challenge/response protocol. The PACS validates the CAK certificate (which should use PDVal), checks the CAK certificate's revocation status, and checks the CAK certificate's expiration date.


#### *10.1.1.1 Use Case Diagram*



#### 10.1.1.2 Description

This pattern can use the contact or contactless interface.

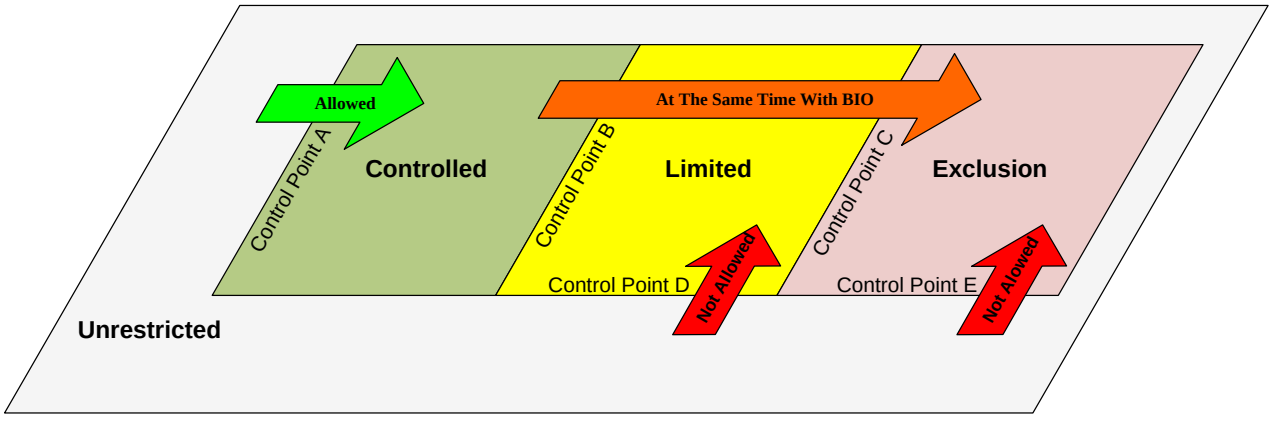
1. Present or insert PIV or PIV-I Card to card reader.
    a. PKI-CAK certificate is read from the PIV or PIV-I Card.
2. The PKI-CAK certificate is sent to the E-PACS Infrastructure.
3. Perform Challenge / Response:
    a. PKI-CAK certificate is sent to the PACS cryptographic validation function.
    b. PACS sends challenge to card (based on the public key in the CAK certificate).
    c. Card sends a response using private key on the chip.
    d. The PACS signature validation function validates the card response.
4. The PACS performs validation functions.
    a. PKI-CAK certificate PDVal and revocation check (see PIA-5).
    b. The PKI-CAK certificate expiration date is checked to ensure that the card has not expired (see PIA-3.6).
5. Upon successful challenge/response and PDVal/revocation check, the PACS checks whether the authenticated cardholder is authorized to enter.
    a. Upon authorization, the door is unlocked.

#### 10.1.1.3 Unmitigated Threats

| Unmitigated PACS Threats |
|---|
| Social Engineering |
| Use of Unreported Lost or Unreported Stolen Card (until card is revoked) |

#### 10.1.1.4 Appropriate Use

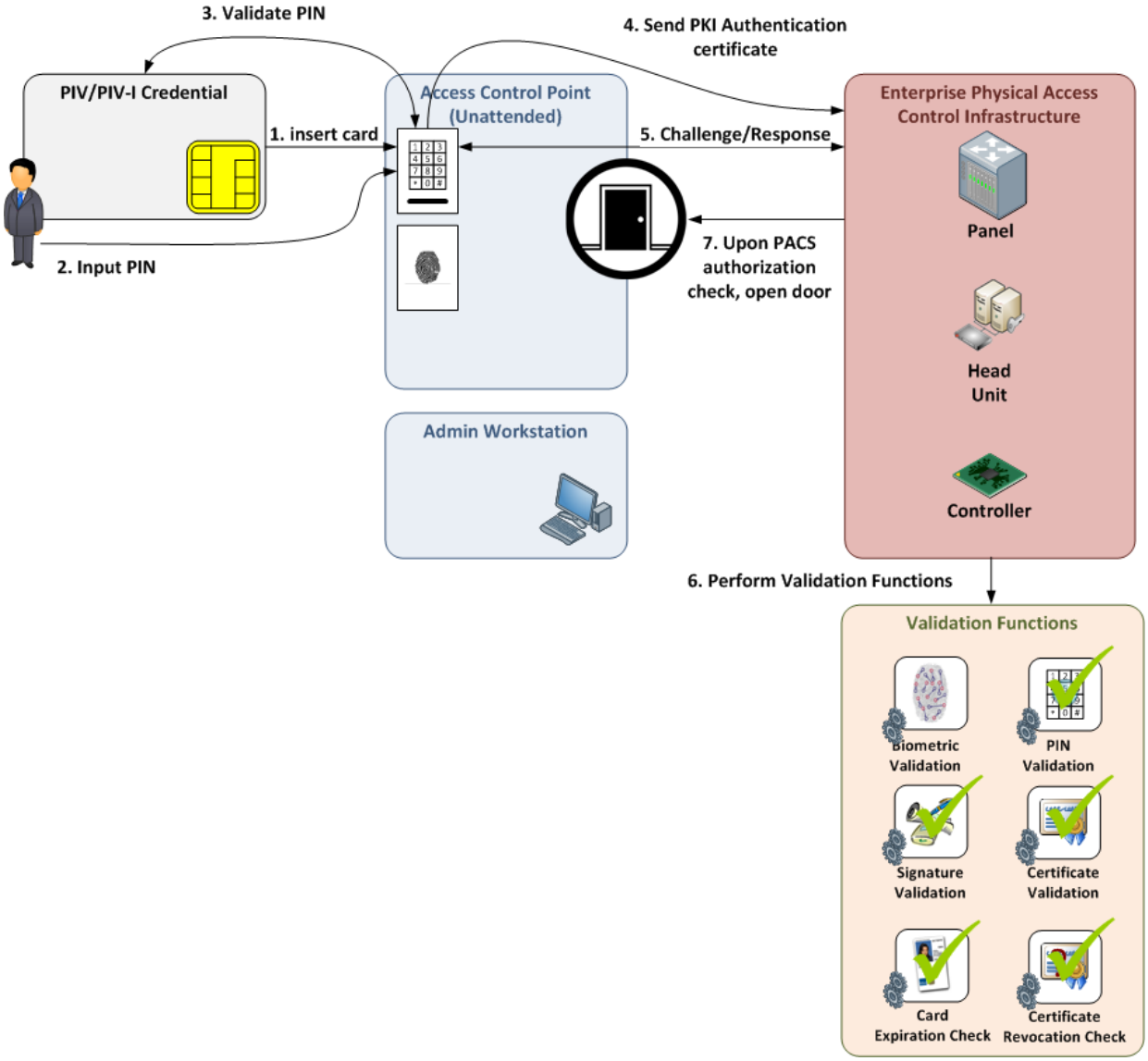
This pattern is one-factor authentication. Therefore, this pattern is sufficient for moving from an Unrestricted area into a Controlled area.



### 10.1.2 Pattern #15: PKI-Auth

The PACS uses the private key (from the PIV Authentication certificate[53]) in a challenge/response protocol. The PACS validates the PIV Authentication certificate (which should use PDVal), and checks the PIV Authentication certificate's revocation status. The PACS also checks the PIV Authentication certificate's expiration date.


#### 10.1.2.1 Use Case Diagram




[53] Or Authentication PKI Certificate in the case of a PIV-I Card.

#### 10.1.2.2 Description

This pattern can use the contact interface. The PIV Card and the PIV-I Card carry a mandatory asymmetric authentication private key and corresponding certificate. The following steps are used to perform authentication using the card's asymmetric authentication key:

1. Insert PIV or PIV-I Card into card reader.
2. Enter PIN.
3. Verify PIN Accepted; (if possible) notify remaining attempts after/if failed PIN.
4. The PIV Authentication certificate is sent to the E-PACS Infrastructure.
5. Challenge / Response:
    a. PIV Authentication certificate is sent to the PACS cryptographic validation function.
    b. PACS sends challenge to card (based on the public key in the PIV Authentication certificate).
    c. Card sends a response using private key on the chip.
    d. The PACS signature validation function validates the card response.
6. The PACS performs validation functions.
    a. PIV Authentication certificate PDVal and revocation check (see PIA-5).
    b. The PIV Authentication certificate expiration date is checked to ensure that the card has not expired (see PIA-3.6).
7. Upon successful challenge/response and PDVal/revocation check, the PACS checks whether the authenticated cardholder is authorized to enter.
    a. Upon authorization, the door is unlocked.

Some of the characteristics of the PKI-based authentication mechanism are as follows:

1. Requires the use of online certificate status checking infrastructure
2. Highly resistant to credential forgery
3. Strong resistance to use of unaltered card by non-owner since PIN is required to activate card
4. Applicable with contact-based card readers.

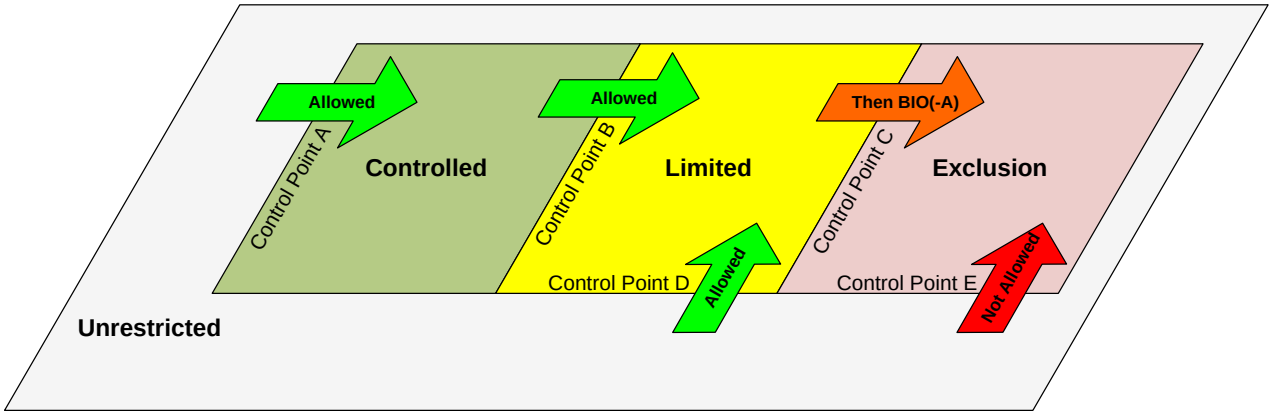
#### 10.1.2.3 Unmitigated Threats

| Unmitigated PACS Threats |
|---|
| Social Engineering |

### *10.1.2.4 Appropriate Use*

This pattern is two-factor authentication (PKI and PIN). Factor one is possession of a PIV Card, verified by the PACS by the active authentication (the challenge response) together with the verification of trusted origin (the path validation). Factor two is knowledge of the PIV PIN. Although the PACS does not see or verify the PIN directly, it knows that the PIV or PIV-I Card will not use the Authentication Key to respond to the challenge unless the PIN has been presented to it and verified. Thus, in responding to the challenge, the PIV or PIV-I Card is able to "transfer the trust" that the Cardholder knows and correctly presented the PIN.

Because it is two-factor authentication, this pattern is sufficient for moving from an Unrestricted area or into a Controlled or Limited area, or between Controlled and Limited areas.

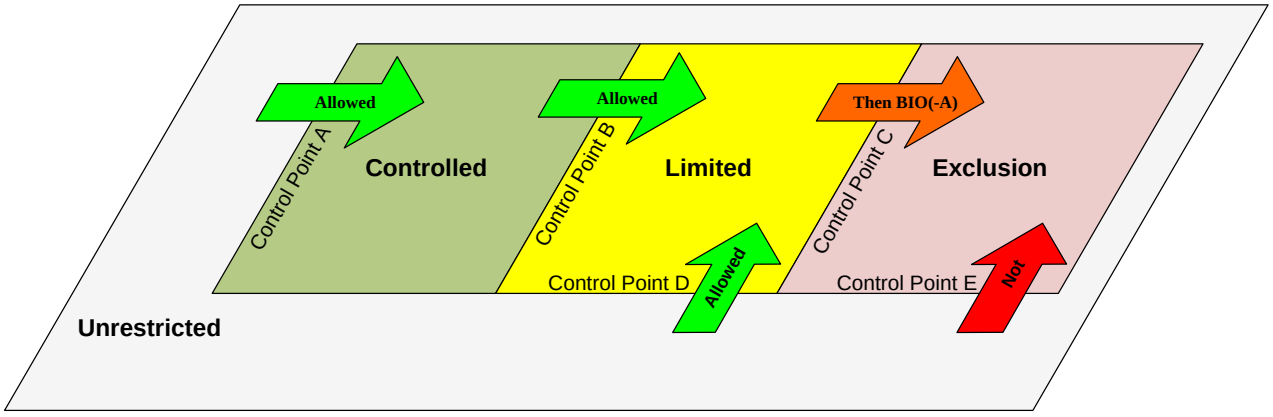


### *10.1.3 Pattern #16: PKI-CAK + PIN to PACS*

This pattern can be achieved by combining Pattern #8: PKI-CAK, PKI-CAK and Pattern #11: CHUID + PIN to PACS, CHUID + PIN to PACS. Please review those patterns to understand this combined pattern. Note that in this pattern, the identifier comes from the PKI-CAK certificate instead of the CHUID. The credential number found in the certificate for the PKI-CAK must be transmitted to support PIN to PACS. Entry is allowed only after the PACS verifies that the authenticated cardholder is authorized to enter.


#### *10.1.3.1 Appropriate Use*

This pattern is two-factor authentication; therefore, it is sufficient for moving from an Unrestricted area into a Controlled or Limited area or between Controlled and Limited areas.

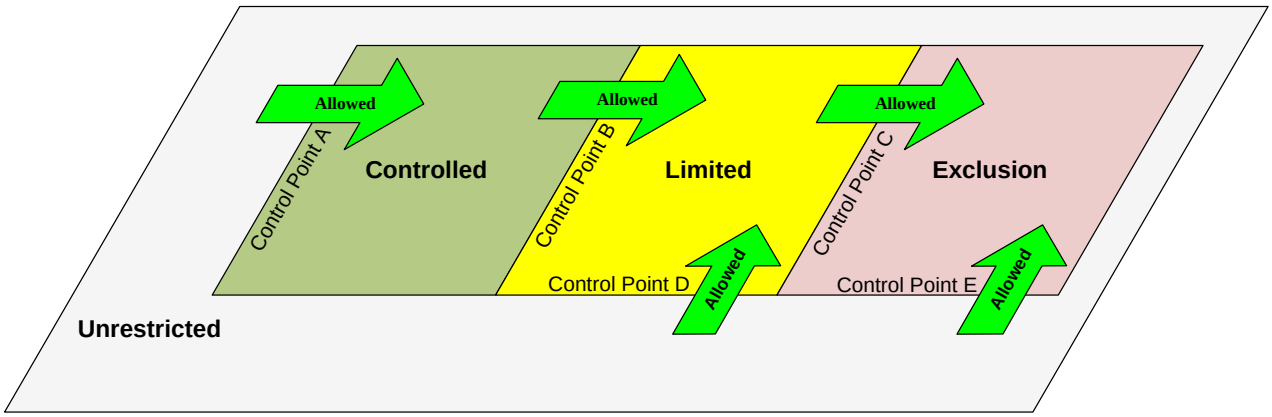


### *10.1.4 Pattern #18: PKI-CAK + BIO(-A)*

This pattern can be achieved by combining Pattern #8: PKI-CAK, PKI-CAK and either Pattern #10, BIO, or **Error! Reference source not found.**, BIO-A. Please review those patterns to understand this combined pattern. PKI-CAK plus BIO-A specifically requires the PACS to confirm the PIN activated BIO-A read is explicitly from the same card as the PKI-CAK challenge/response at time of authentication. The credential number found in the certificate for the PKI-CAK must match the credential number found in the biometric. The contact interface should be used because there are risks if PKI-CAK is contactless and BIO is contact. Entry is allowed only after the PACS verifies that the authenticated cardholder is authorized to enter.


#### *10.1.4.1 Appropriate Use*

This pattern is three-factor authentication; therefore, it is sufficient for moving from an Unrestricted area into a Controlled, Limited, or Exclusion area. It may also be used to move between Controlled and Limited areas or between Limited and Exclusion areas.

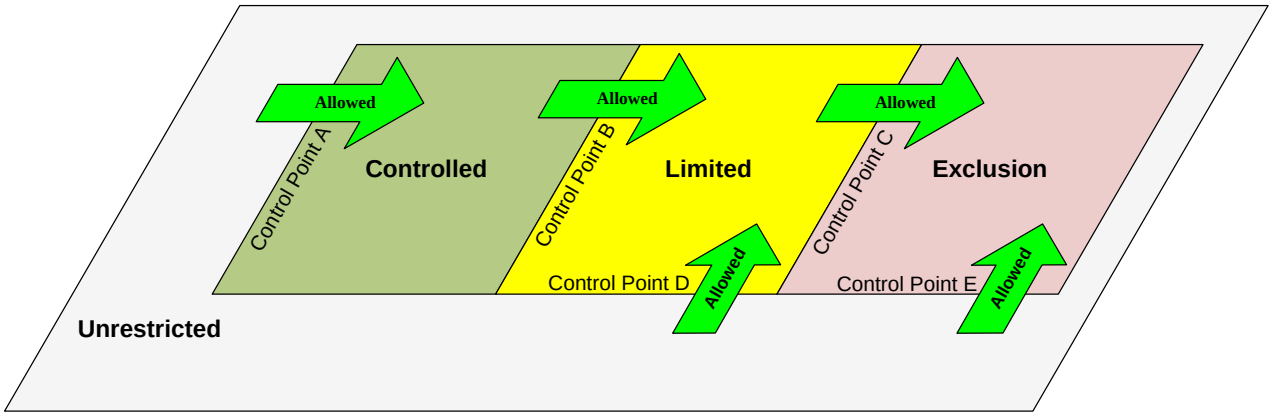


### *10.1.5 Pattern #20: PKI-Auth + BIO(-A)*

This pattern is similar to Pattern #18: PKI-CAK + BIO(-A). However, in this pattern, the PKI-Auth certificate replaces the PKI-CAK certificate in all steps. The credential number found in the certificate for the PIV Authentication certificate must match the credential number found in the biometric. Entry is allowed only after the PACS verifies that the authenticated cardholder is authorized to enter.


#### *10.1.5.1 Appropriate Use*

This pattern is three-factor authentication; therefore, it is sufficient for moving from an Unrestricted area into a Controlled, Limited, or Exclusion area. It may also be used to move between Controlled and Limited areas or between Limited and Exclusion areas.



## 10.2 Legacy/Transitional State Authentication Patterns

This section outlines the authentication mechanisms that may be in use currently for PACS but do not meet the minimum expectations for strong authentication and agency interoperability. If an agency is using any of these mechanisms, it should work immediately to move toward one of the patterns outlined in Section 10.1.

### *10.2.1 Pattern #1: VIS*

A PIV or PIV-I Card is used solely as a flash pass for guard inspection. None of the on-card authentication mechanisms (e.g., CHUID, PKI-Auth) are utilized, and PACS validation functions are not performed for the VIS pattern.

The VIS pattern provides zero-factor authentication and therefore is not sufficient for use on its own. While VIS can be combined with other authentication mechanisms (e.g., Enhanced CHUID, BIO, CAK, or PKI) to achieve one-factor authentication (see Pattern #7, Enhanced CHUID +VIS), these combinations are also unsatisfactory to meet target state requirements for strong authentication and interoperability.

#### *10.2.1.1 Description*

When a cardholder attempts to pass through an attended access control point, a guard performs visual inspection of the cardholder's credential. The visual inspection should include evaluating the security features present on the card (e.g., hologram) to determine if the PIV or PIV-I card is genuine and verifying the identity of the cardholder based on a comparison of topographical features of card (e.g., photograph, name, employment identifier, expiration date, serial number, issuer identification, etc.) to the cardholder.[54] Upon satisfactory verification, the guard allows the cardholder to pass through the access point. In the field, visual inspection is typically conducted quickly, and there is a great deal of variation in what features and information on the card are reviewed and how they are validated prior to granting access. For this reason, there is low resistance to counterfeiting and forgery in environments with or without card readers.

#### *10.2.1.2 Unmitigated Threats*

| Unmitigated PACS Threats |
|---|
| Use of Terminated Card |
| Use of Unreported Lost or Stolen Card |
| Visual Counterfeiting |

[54] Optional electronic facial image may be used for generating a visual image on the monitor of a guard workstation.

### 10.2.2 Pattern #2: Partial CHUID

The PACS is not capable of transmitting the full CHUID from the reader to the panel and truncates the CHUID before it is sent to the panel for cardholder validation.

The Partial CHUID pattern provides zero-factor authentication and therefore is not sufficient for use.

#### 10.2.2.1 Description

When a card is presented to a reader, the PACS cannot process the full CHUID data object due to transmission limitations.[55] The PACS reads select fields of the CHUID, and the collected partial string is used to compare the cardholder to a record in the PACS user database to determine whether the cardholder should be granted access. In addition to reading only part of the CHUID field, the PACS does not validate the CHUID signature and signing certificate or the revocation status of the associated authentication certificate and the card's expiration date, since it may have not been included in the Partial CHUID. It is possible for more than one user to have the same partial CHUID string and gain access to unauthorized buildings and areas.

#### 10.2.2.2 Unmitigated Threats

| Unmitigated PACS Threats |
|---|
| Electronic Cloning |
| Electronic Counterfeiting |
| Use of Expired Card |
| Use of Terminated Card |
| Use of Unreported Lost or Stolen Card |
| Identifier Collision |

[55] Wiegand communications typical for PACS are limited to 48 bits, which is insufficient to transmit the full CHUID.

### 10.2.3 Pattern #3: Primitive CHUID

The PACS uses the CHUID from the card and checks the card's expiration date but does not validate the signature on the CHUID or the CHUID signing certificate and does not check the revocation status of the associated Authentication certificate.

The Primitive CHUID pattern provides zero-factor authentication and therefore is not sufficient for use.

#### 10.2.3.1 Description

When a card is presented to a reader, the PACS electronically reads the full CHUID and checks the expiration date to validate that the card has not expired. The PACS evaluates one or more of the CHUID data elements (e.g., FASC-N, GUID) to determine whether the cardholder should be granted access and unlocks the door upon successful authorization.

#### 10.2.3.2 Unmitigated Threats

| Unmitigated PACS Threats |
|---|
| Electronic Cloning |
| Electronic Counterfeiting |
| Skimming |
| Sniffing |
| Use of Terminated Card |
| Use of Unreported Lost or Stolen Card |

### 10.2.4 Pattern #4: CHUID[56]

The PACS uses the CHUID from the card and validates the CHUID signature, the CHUID signing certificate, and card expiration date; however, the PACS does not check the revocation status of the associated Authentication certificate.

The CHUID pattern provides zero-factor authentication and therefore is not sufficient for use.

#### 10.2.4.1 Description

When a card is presented to a reader, the PACS electronically reads the full CHUID and validates the digital signature to ensure that the CHUID is signed by a trusted source and is unaltered. PDVal is used to verify that the certificate and the trusted issuer are not revoked. The PACS checks the expiration date to validate that the card has not expired and then evaluates one or more of the CHUID data elements (e.g., FASC-N, GUID) to determine whether the cardholder should be granted access and unlocks the door upon successful authorization.

#### 10.2.4.2 Unmitigated Threats

| Unmitigated PACS Threats |
|---|
| Electronic Cloning |
| Skimming |
| Sniffing |
| Use of Unreported Lost or Stolen Card |
| Use of Terminated Card |

[56] This pattern matches the CHUID authentication process defined in FIPS 201-2. The CHUID authentication mechanism has been deprecated in FIPS 201-2, and it is expected that it will be removed from the standard in its next revision. Therefore, it is recommended that agencies transition from the use of CHUID.

### 10.2.5 Pattern #5: Enhanced CHUID

The PACS uses the CHUID from the card and validates the CHUID signature, the CHUID signing certificate, and card expiration date (like Pattern #4: CHUID) but also checks the revocation status of the associated Authentication certificate.

The Enhanced CHUID pattern provides zero-factor authentication and therefore is not sufficient for use. While Enhanced CHUID can be combined with VIS to achieve one-factor authentication (see Pattern #7, Enhanced CHUID + VIS), this combination and the Enhanced CHUID pattern are both unsatisfactory to meet target state requirements for strong authentication and interoperability.

#### 10.2.5.1 Description

When a card is presented to a reader, the PACS electronically reads the full CHUID and the PIV Authentication certificate (for PIV) or Authentication PKI Certificate (for PIV-I). The PACS validates the digital signature to ensure that the CHUID is signed by a trusted source and is unaltered and verifies that the signing certificate and the trusted issuer are not revoked. It then performs a revocation check of associated authentication certificate and compares the FASC-N in the CHUID and the Authentication certificate to confirm they match. The PACS checks the expiration date to validate that the card has not expired and then evaluates one or more of the CHUID data elements (e.g., FASC-N, GUID) to determine whether the cardholder should be granted access and unlocks the door upon successful authorization.

#### 10.2.5.2 Unmitigated Threats

| Unmitigated PACS Threats |
|---|
| Electronic Cloning |
| Skimming |
| Sniffing |
| Use of Unreported Lost or Stolen Card (until card is revoked) |

### 10.2.6 Pattern #6: Primitive BIO

The PACS validates a livescan biometric sample from the cardholder against the biometric retrieved from the card and checks the card expiration date. However, the PACS does not validate the signature on the biometric object or the content signer certificate and does not check the revocation status of the associated Authentication certificate.

The Primitive BIO pattern provides zero-factor authentication and therefore is not sufficient for use.

#### 10.2.6.1 Description

When a card is presented to a reader and the PIN is entered, the PACS verifies the PIN and electronically reads the biometric and the CHUID from the card. The PACS obtains a livescan biometric from the cardholder, validates it against the biometric retrieved from the card and checks the expiration date on the CHUID to validate that the card is not expired. The PACS then checks whether the cardholder should be granted access and unlocks the door upon successful authorization.

#### 10.2.6.2 Unmitigated Threats

| Unmitigated PACS Threats |
|---|
| Biometric Spoofing |
| Biometric Object Substitution |
| Use of Terminated Card |
| Use of Unreported Lost or Stolen Card |
| Electronic Counterfeiting |

### 10.2.7 Pattern #7: Enhanced CHUID + VIS

The Enhanced CHUID + VIS pattern is a combination of Pattern #5: Enhanced CHUID and Pattern #1: VIS. In addition to using CHUID-based authentication where the PACS performs all the necessary validations (described in Pattern #5: Enhanced CHUID),,the guard performs a visual inspection of the cardholder's credentials at an attended access control point (described in Pattern #1: VIS).

The Enhanced CHUID + VIS pattern provides one-factor authentication; however, it is not sufficient for use because it does not meet the target state requirements for strong authentication and interoperability.

#### 10.2.7.1 Description

CHUID-based PIV or PIV-I Cardholder authentication is augmented by visual identity verification of cardholder to mitigate some risk factors of either design pattern alone. It should be noted that the two authentication steps are not two factors of authentication, as CHUID and VIS similarly fulfill the "something you have" factor of authentication. Entry is allowed only after the PACS verifies that the authenticated cardholder is authorized to enter.

#### 10.2.7.2 Unmitigated Threats

| Unmitigated PACS Threats |
|---|
| Electronic Cloning |
| Skimming |
| Sniffing |
| Use of Unreported Lost or Stolen Card (until card is revoked) |

### 10.2.8 Pattern #9: SYM-CAK

The PACS uses the symmetric CAK from the card in a challenge/response protocol, validates the revocation status of the PIV Authentication certificate, and it also checks the certificate expiration date to ensure that the card is not expired.

The SYM-CAK pattern provides one-factor authentication; however, it is not sufficient for use because it does not meet the target state requirements for interoperability.

#### 10.2.8.1 Description

When a card is presented to a reader, the PACS reads the PIV Authentication certificate and the card identifier (diversification element) from the card. The diversification element is used in conjunction with the system master key to calculate the specific key associated with the cardholder. The PACS sends random challenge data, the card responds, and the PACS performs the same encryption for comparison. It then checks the PIV Authentication certificate for revocation and the PIV authentication certificate expiration date to validate that the card is not expired. The PACS verifies that the authenticated cardholder should be granted access and unlocks the door upon successful authorization.

#### 10.2.8.2 Unmitigated Threats

| Unmitigated PACS Threats |
|---|
| Social Engineering |
| Use of Unreported Lost or Unreported Stolen Card (until card is revoked) |

### 10.2.9 Pattern #10: BIO

The PACS validates a livescan biometric sample provided by the cardholder against the biometric on the card, the biometric signature, and the content signer certificate. The PACS also checks the revocation status of the associated PIV Authentication certificate and the PIV Authentication expiration date.

The BIO pattern provides one-factor authentication; however, it is not sufficient for use because it does not meet the target state requirements for strong authentication.

#### 10.2.9.1 Description

When a card is presented to a reader and the PIN is entered, the PACS verifies the PIN and electronically reads the biometric, the CHUID, and PIV Authentication Certificate (if not cached) from the card. The PACS obtains a livescan biometric sample, validates it against the biometric on the card, and performs full PDVal to check the revocation status of the content signer certificate. In addition, the PACS evaluates the FASC-N or UUID to verify the binding between the PIV Authentication certificate and biometric, checks the revocation status of the associated PIV Authentication certificate, and checks the certificate expiration date. Upon match and verification, the PACS verifies that the authenticated cardholder should be granted access and unlocks the door upon successful authorization.

#### 10.2.9.2 Unmitigated Threats

| Unmitigated PACS Threats |
|---|
| Biometric Spoofing |

### 10.2.10 Pattern #11: CHUID + PIN to PACS

The PACS uses a PIN entered by the cardholder and verifies it against the associated PIN stored in the PACS. It also validates the associated PIV Authentication certificate, checks its revocation status and expiration date using the PIV Authentication certificate that was previously registered during the initial setup of the PIN in the PACS database.

The CHUID + PIN to PACS pattern provides one-factor authentication; however, it is not sufficient for use because it does not meet the target state requirements for strong authentication and interoperability..[57]

#### 10.2.10.1 Description

When a card is presented to the reader, the PACS electronically reads the CHUID and prompts the user to enter a PIN. The PACS uses the unique identifier from the CHUID to access the PIN stored in the PACS database and validates it against the PIN presented by the cardholder. It then checks the revocation status of the associated PIV Authentication certificate, performs full PDVal of the PIV Authentication certificate, and checks the PIV Authentication expiration date to ensure that the card is not expired. After the PIN validation process is complete, the PACS determines whether the cardholder should be granted access and unlocks the door upon successful authorization.

#### 10.2.10.2 Unmitigated Threats

| Unmitigated PACS Threats |
|---|
| Social Engineering |

[57] [NIST SP 800-116] does not address this use case, and as such does not provide guidance on movement through areas.

### 10.2.11 Pattern #12: CHUID + BIO to PACS

The PACS validates a biometric sample provided by the cardholder against the biometric for the cardholder stored in the PACS database. The PACS performs all necessary validation functions using the PIV Authentication certificate that was previously registered at the time the biometric was set up in the PACS. The PACS validates the associated PIV Authentication certificate and checks the revocation status and expiration date of the PIV Authentication certificate.

The CHUID + BIO to PACS pattern provides one-factor authentication; however, it is not sufficient for use because it does not meet the target state requirements for strong authentication and interoperability.

#### 10.2.11.1 Description

When the card is presented to a reader, the PACS electronically reads the CHUID and the PIV Authentication certificate (if it has not been cached). The PACS obtains a livescan biometric from the cardholder, uses a unique identifier from the CHUID to access the biometric stored in the PACS database, and validates the biometric against what was retrieved in the PACS database. The PACS checks the revocation status of the associated PIV Authentication certificate, as well as the PIV Authentication certificate's expiration date to ensure that the card has not expired. The PACS then checks whether the cardholder should be granted access and unlocks the door upon successful authorization.

#### 10.2.11.2 Unmitigated Threats

| Unmitigated PACS Threats |
| --- |
| Biometric Spoofing |

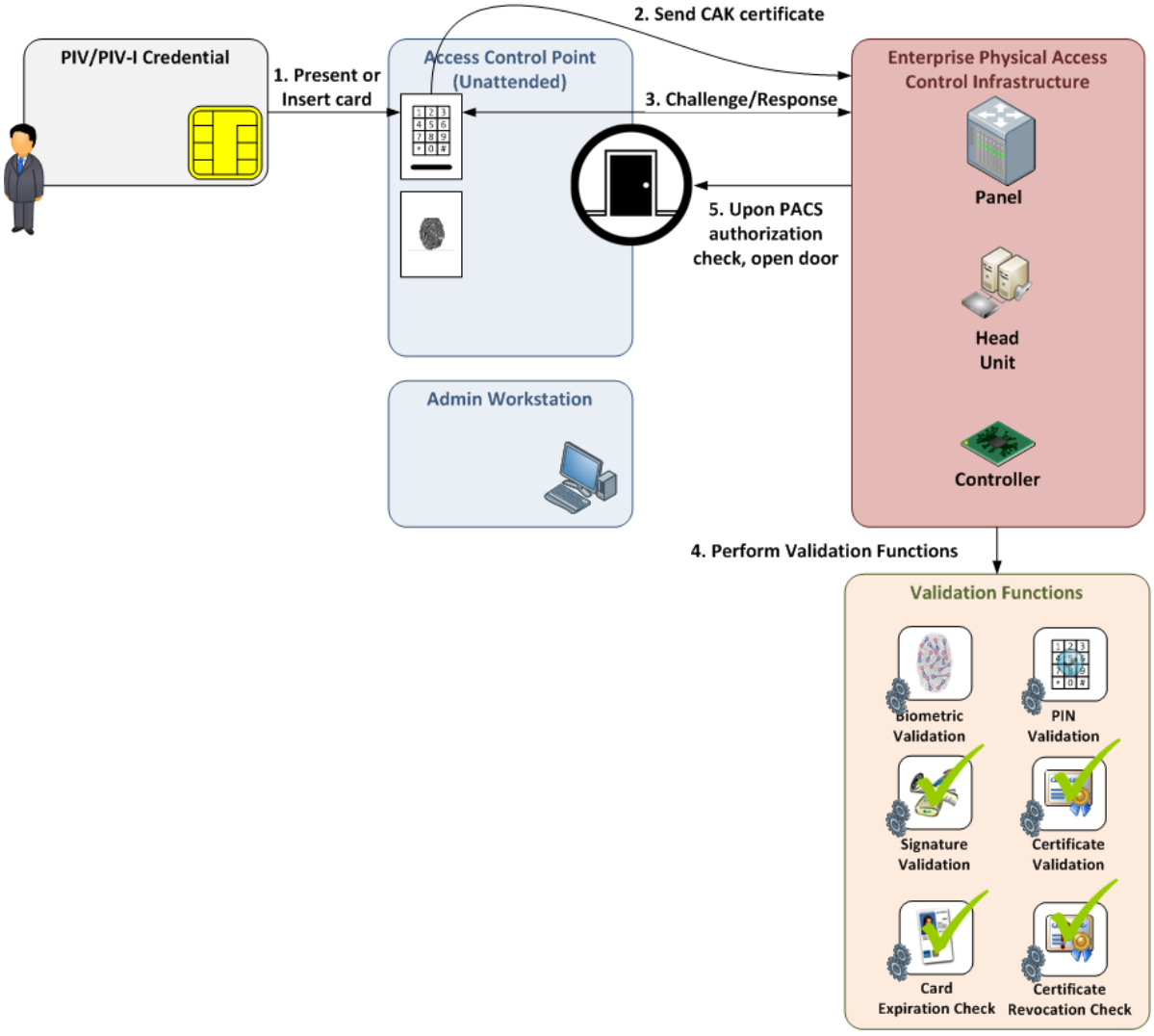
### *10.2.12 Pattern #13: BIO-A to PACS*

The BIO-A to PACS pattern can be achieved by combining

Pattern #8: PKI-CAK

The PACS uses the asymmetric CAK (from the CAK certificate) in a challenge/response protocol. The PACS validates the CAK certificate (which should use PDVal), checks the CAK certificate's revocation status, and checks the CAK certificate's expiration date.


#### *10.2.12.1 Use Case Diagram*




#### *10.2.12.2 Description*

This pattern can use the contact or contactless interface.

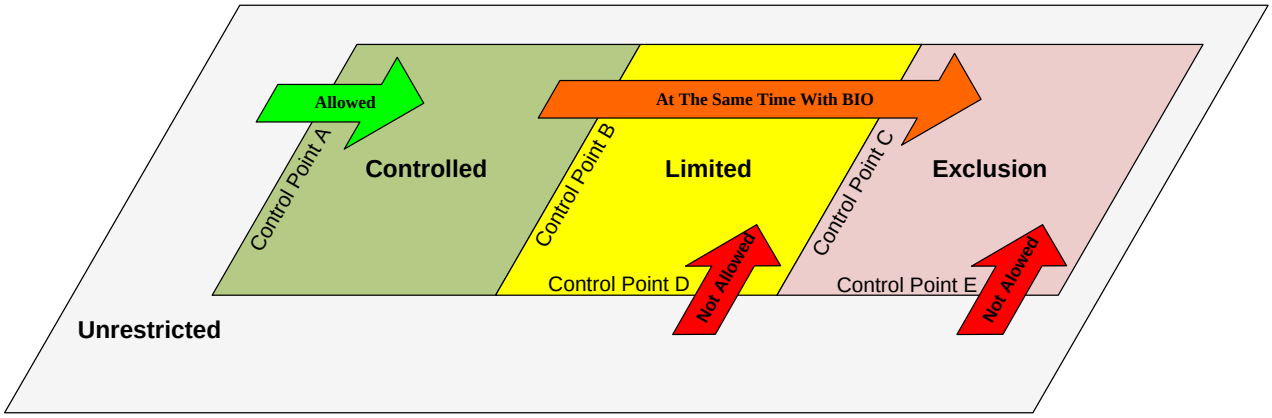
6. Present or insert PIV or PIV-I Card to card reader.
    b. PKI-CAK certificate is read from the PIV or PIV-I Card.
7. The PKI-CAK certificate is sent to the E-PACS Infrastructure.
8. Perform Challenge / Response:
    a. PKI-CAK certificate is sent to the PACS cryptographic validation function.
    b. PACS sends challenge to card (based on the public key in the CAK certificate).
    c. Card sends a response using private key on the chip.
    d. The PACS signature validation function validates the card response.
9. The PACS performs validation functions.
    a. PKI-CAK certificate PDVal and revocation check (see PIA-5).
    b. The PKI-CAK certificate expiration date is checked to ensure that the card has not expired (see PIA-3.6).
10. Upon successful challenge/response and PDVal/revocation check, the PACS checks whether the authenticated cardholder is authorized to enter.
    b. Upon authorization, the door is unlocked.

### *10.2.12.3 Unmitigated Threats*

| Unmitigated PACS Threats |
|---|
| Social Engineering |
| Use of Unreported Lost or Unreported Stolen Card (until card is revoked) |

### *10.2.12.4 Appropriate Use*

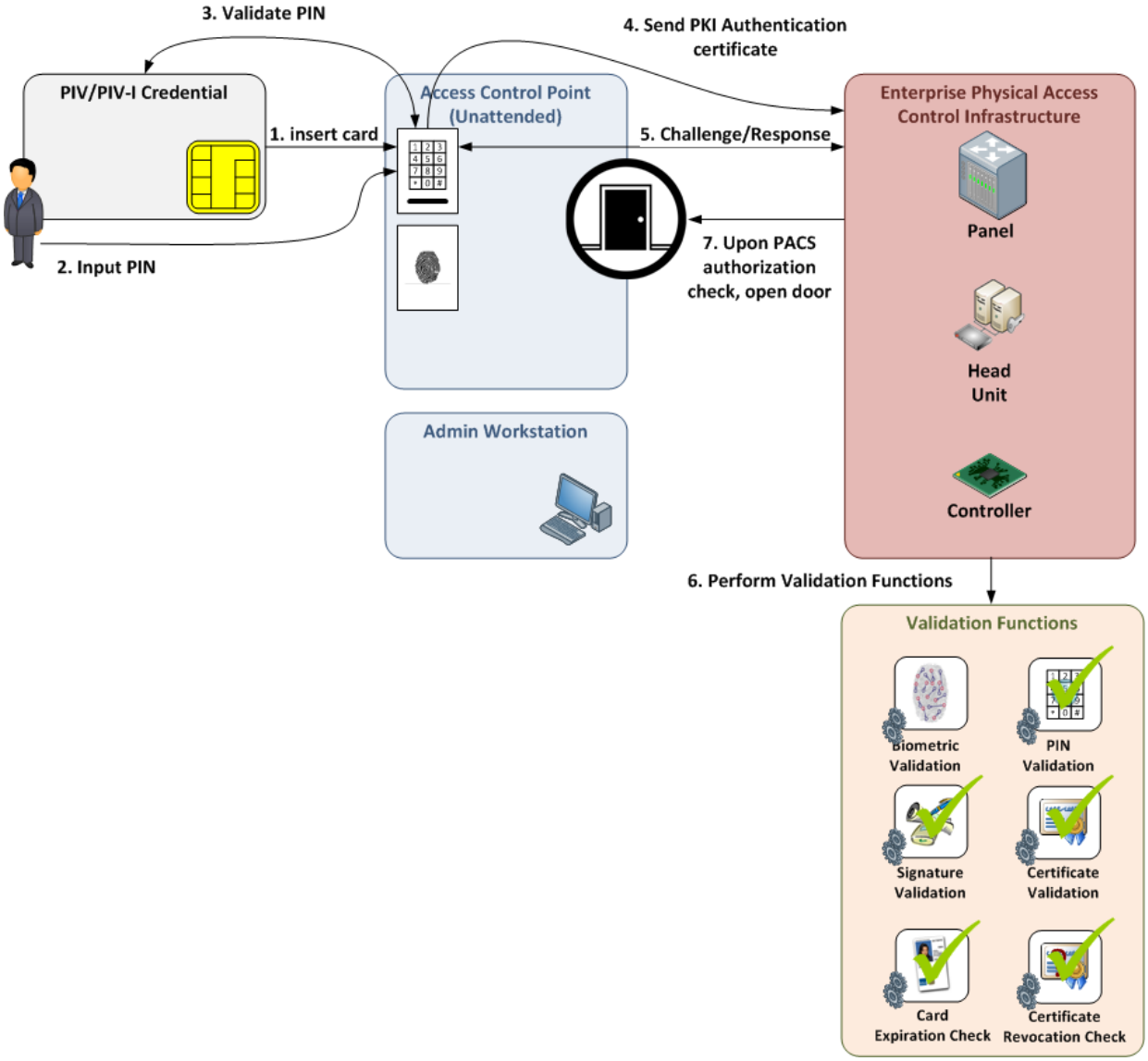
This pattern is one-factor authentication. Therefore, this pattern is sufficient for moving from an Unrestricted area into a Controlled area.



### *10.2.13 Pattern #15: PKI-Auth*

The PACS uses the private key (from the PIV Authentication certificate) in a challenge/response protocol. The PACS validates the PIV Authentication certificate (which should use PDVal), and checks the PIV Authentication certificate's revocation status. The PACS also checks the PIV Authentication certificate's expiration date.


#### *10.2.13.1 Use Case Diagram*




#### *10.2.13.2 Description*

This pattern can use the contact interface. The PIV Card and the PIV-I Card carry a mandatory asymmetric authentication private key and corresponding certificate. The following steps are used to perform authentication using the card's asymmetric authentication key:

8. Insert PIV or PIV-I Card into card reader.
9. Enter PIN.
10. Verify PIN Accepted; (if possible) notify remaining attempts after/if failed PIN.
11. The PIV Authentication certificate is sent to the E-PACS Infrastructure.
12. Challenge / Response:
    a. PIV Authentication certificate is sent to the PACS cryptographic validation function.
    b. PACS sends challenge to card (based on the public key in the PIV Authentication certificate).
    c. Card sends a response using private key on the chip.
    d. The PACS signature validation function validates the card response.
13. The PACS performs validation functions.
    a. PIV Authentication certificate PDVal and revocation check (see PIA-5).
    b. The PIV Authentication certificate expiration date is checked to ensure that the card has not expired (see PIA-3.6).
14. Upon successful challenge/response and PDVal/revocation check, the PACS checks whether the authenticated cardholder is authorized to enter.
    b. Upon authorization, the door is unlocked.

Some of the characteristics of the PKI-based authentication mechanism are as follows:

5. Requires the use of online certificate status checking infrastructure
6. Highly resistant to credential forgery
7. Strong resistance to use of unaltered card by non-owner since PIN is required to activate card
8. Applicable with contact-based card readers.

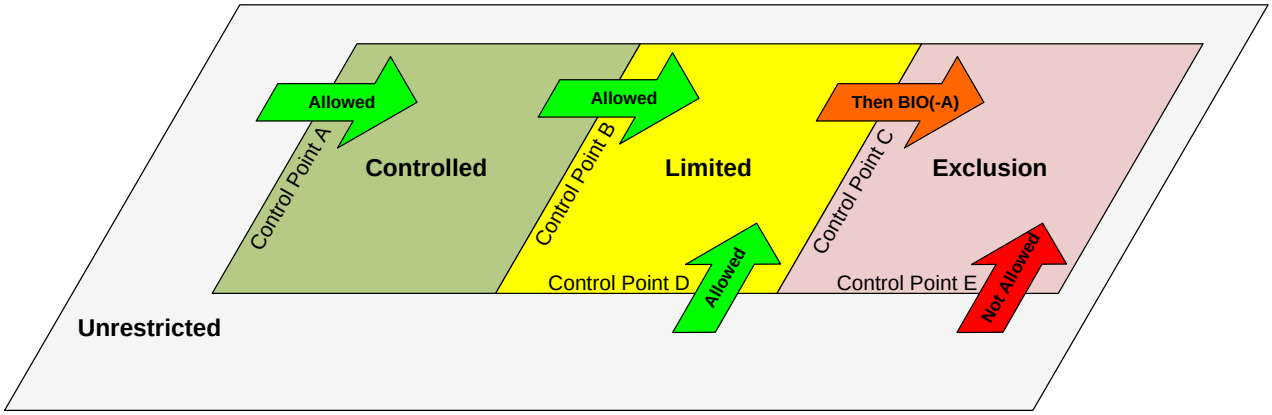
#### *10.2.13.3 Unmitigated Threats*

| Unmitigated PACS Threats |
|---|
| Social Engineering |

### *10.2.13.4 Appropriate Use*

This pattern is two-factor authentication (PKI and PIN). Factor one is possession of a PIV Card, verified by the PACS by the active authentication (the challenge response) together with the verification of trusted origin (the path validation). Factor two is knowledge of the PIV PIN. Although the PACS does not see or verify the PIN directly, it knows that the PIV or PIV-I Card will not use the Authentication Key to respond to the challenge unless the PIN has been presented to it and verified. Thus, in responding to the challenge, the PIV or PIV-I Card is able to "transfer the trust" that the Cardholder knows and correctly presented the PIN.

Because it is two-factor authentication, this pattern is sufficient for moving from an Unrestricted area or into a Controlled or Limited area, or between Controlled and Limited areas.

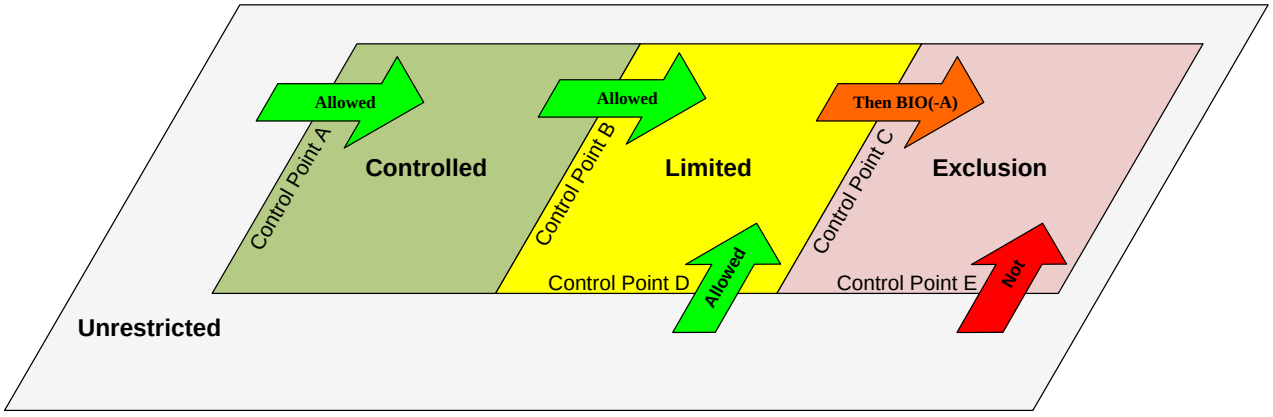


### *10.2.14 Pattern #16: PKI-CAK + PIN to PACS*

This pattern can be achieved by combining Pattern #8: PKI-CAK, PKI-CAK and Pattern #11: CHUID + PIN to PACS, CHUID + PIN to PACS. Please review those patterns to understand this combined pattern. Note that in this pattern, the identifier comes from the PKI-CAK certificate instead of the CHUID. The credential number found in the certificate for the PKI-CAK must be transmitted to support PIN to PACS. Entry is allowed only after the PACS verifies that the authenticated cardholder is authorized to enter.


#### *10.2.14.1 Appropriate Use*

This pattern is two-factor authentication; therefore, it is sufficient for moving from an Unrestricted area into a Controlled or Limited area or between Controlled and Limited areas.

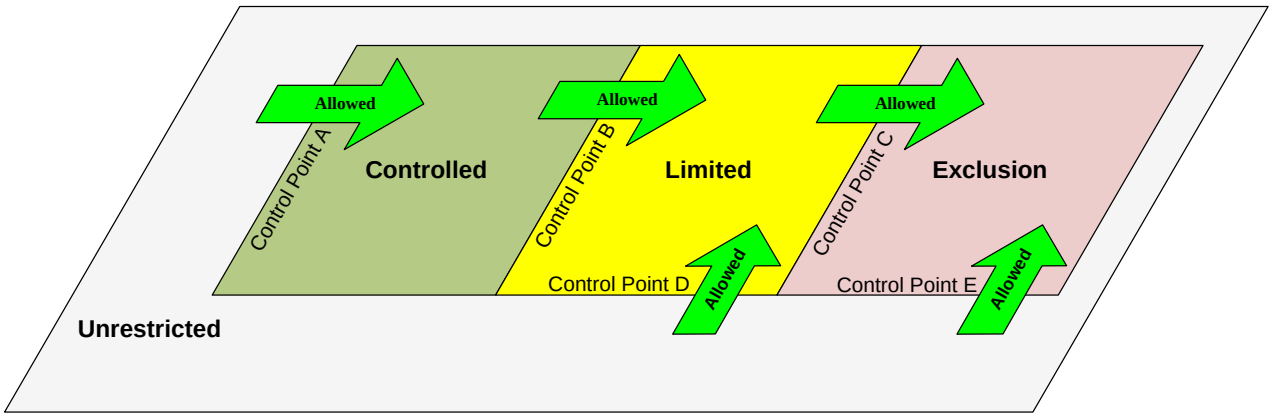


### *10.2.15 Pattern #18: PKI-CAK + BIO(-A)*

This pattern can be achieved by combining Pattern #8: PKI-CAK, PKI-CAK and either Pattern #10, BIO, or **Error! Reference source not found.**, BIO-A. Please review those patterns to understand this combined pattern. PKI-CAK plus BIO-A specifically requires the PACS to confirm the PIN activated BIO-A read is explicitly from the same card as the PKI-CAK challenge/response at time of authentication. The credential number found in the certificate for the PKI-CAK must match the credential number found in the biometric. The contact interface should be used because there are risks if PKI-CAK is contactless and BIO is contact. Entry is allowed only after the PACS verifies that the authenticated cardholder is authorized to enter.


#### *10.2.15.1 Appropriate Use*

This pattern is three-factor authentication; therefore, it is sufficient for moving from an Unrestricted area into a Controlled, Limited, or Exclusion area. It may also be used to move between Controlled and Limited areas or between Limited and Exclusion areas.

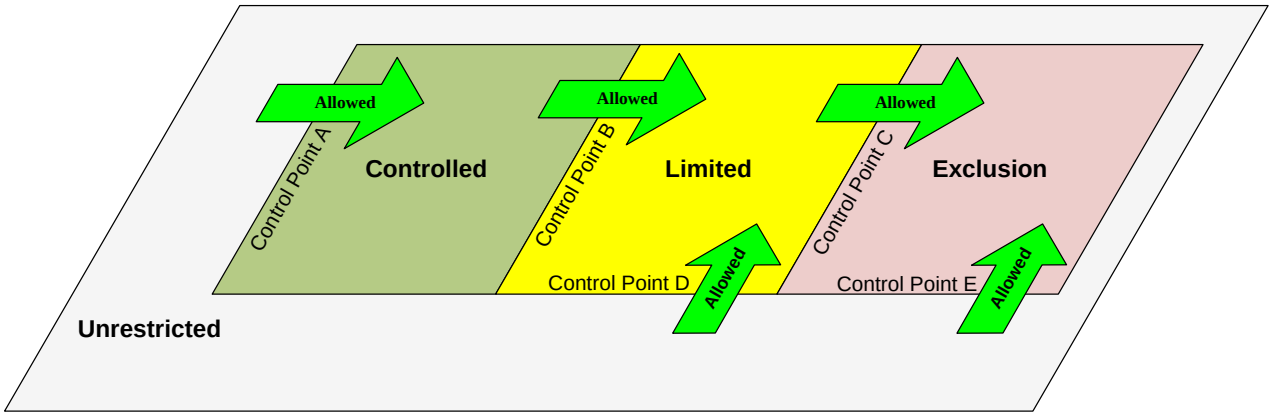


### *10.2.16 Pattern #20: PKI-Auth + BIO(-A)*

This pattern is similar to Pattern #18: PKI-CAK + BIO(-A). However, in this pattern, the PKI-Auth certificate replaces the PKI-CAK certificate in all steps. The credential number found in the certificate for the PIV Authentication certificate must match the credential number found in the biometric. Entry is allowed only after the PACS verifies that the authenticated cardholder is authorized to enter.


#### *10.2.16.1 Appropriate Use*

This pattern is three-factor authentication; therefore, it is sufficient for moving from an Unrestricted area into a Controlled, Limited, or Exclusion area. It may also be used to move between Controlled and Limited areas or between Limited and Exclusion areas.



## 10.4 Legacy/Transitional State Authentication Patterns

This section outlines the authentication mechanisms that may be in use currently for PACS but do not meet the minimum expectations for strong authentication and agency interoperability. If an agency is using any of these mechanisms, it should work immediately to move toward one of the patterns outlined in Section 10.1.

Pattern #1: VIS, VIS and Pattern #12: CHUID + BIO to PACS CHUID + BIO to PACS. In addition to using biometric authentication where the PACS performs validation steps, the guard supervises submission of the cardholder biometric (to prevent use of fake/synthetic fingerprint), thus increasing the level of trust in the biometric factor. The guard may also visually verify the card used, but this is not considered an additional factor.

The BIO-A to PACS pattern provides one-factor authentication; however, it is not sufficient for use because it does not meet the target state requirements for strong authentication and interoperability.

#### *10.4.1.1 Unmitigated Threats*

There are no unmitigated threats in this pattern.

| Unmitigated PACS Threats |
| --- |
| |

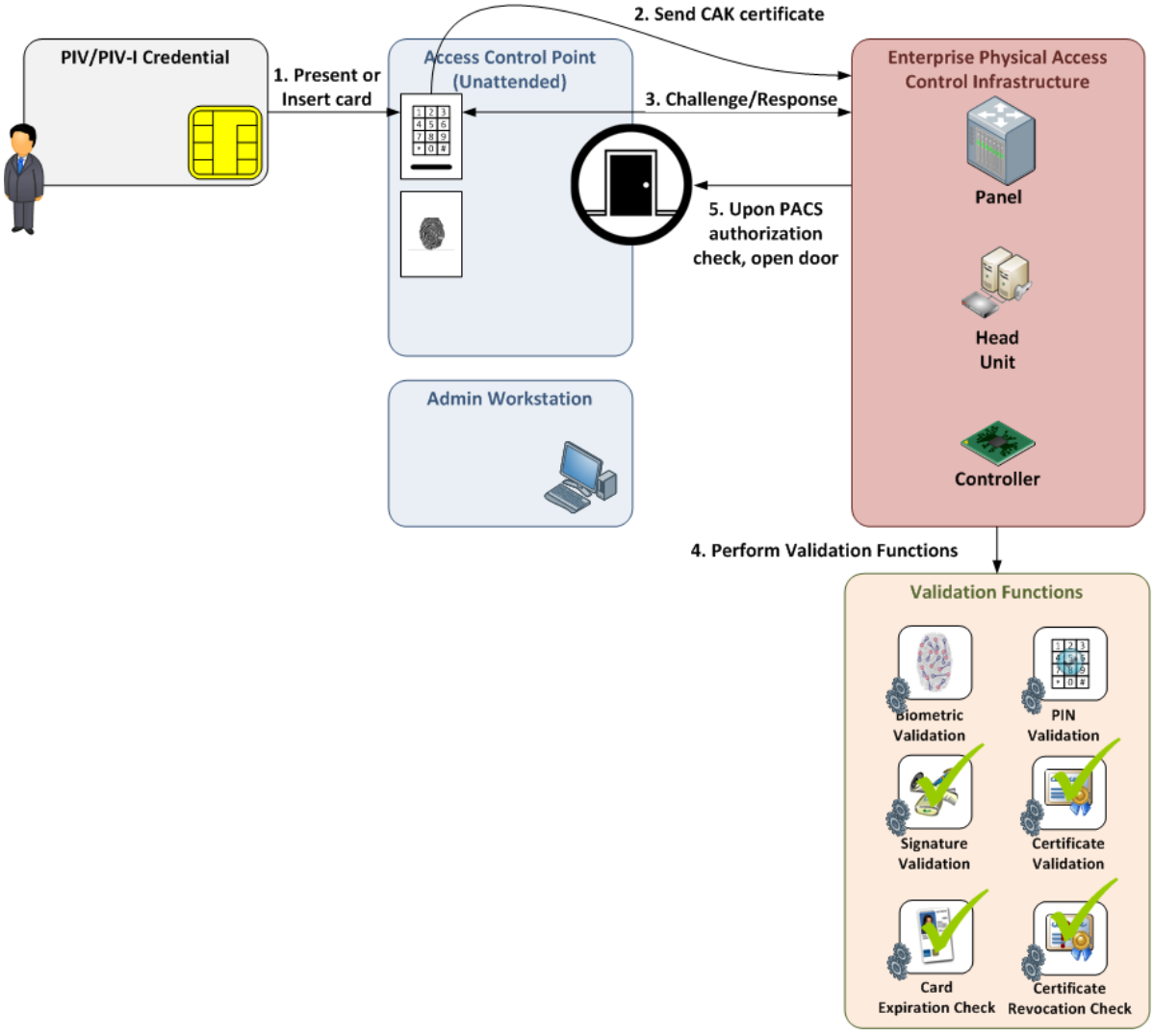
### *10.4.2 Pattern #14: BIO-A*

This pattern can be achieved by combining

Pattern #8: PKI-CAK

The PACS uses the asymmetric CAK (from the CAK certificate) in a challenge/response protocol. The PACS validates the CAK certificate (which should use PDVal), checks the CAK certificate's revocation status, and checks the CAK certificate's expiration date.


#### *10.4.2.1 Use Case Diagram*




#### *10.4.2.2 Description*

This pattern can use the contact or contactless interface.

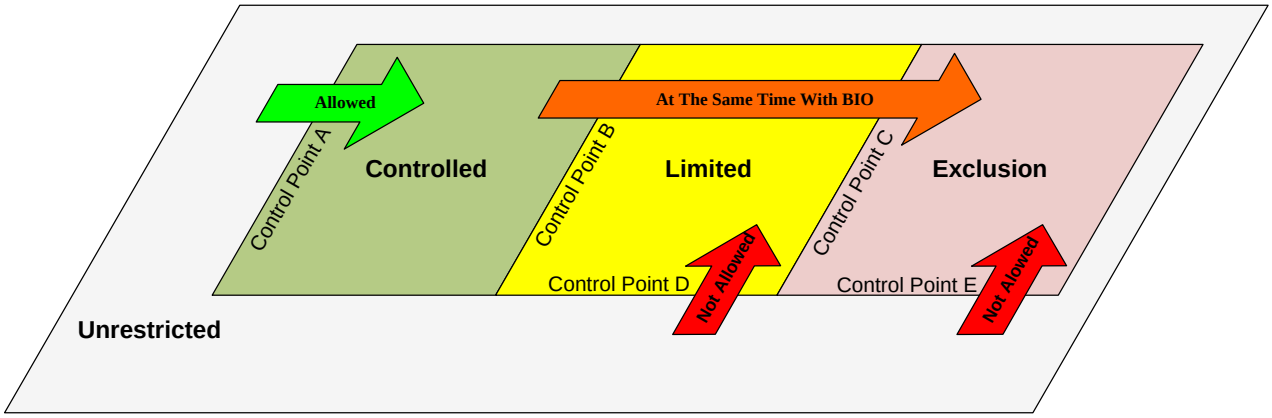
11. Present or insert PIV or PIV-I Card to card reader.
    c. PKI-CAK certificate is read from the PIV or PIV-I Card.
12. The PKI-CAK certificate is sent to the E-PACS Infrastructure.
13. Perform Challenge / Response:
    a. PKI-CAK certificate is sent to the PACS cryptographic validation function.
    b. PACS sends challenge to card (based on the public key in the CAK certificate).
    c. Card sends a response using private key on the chip.
    d. The PACS signature validation function validates the card response.
14. The PACS performs validation functions.
    a. PKI-CAK certificate PDVal and revocation check (see PIA-5).
    b. The PKI-CAK certificate expiration date is checked to ensure that the card has not expired (see PIA-3.6).
15. Upon successful challenge/response and PDVal/revocation check, the PACS checks whether the authenticated cardholder is authorized to enter.
    c. Upon authorization, the door is unlocked.

#### *10.4.2.3 Unmitigated Threats*

| Unmitigated PACS Threats |
|---|
| Social Engineering |
| Use of Unreported Lost or Unreported Stolen Card (until card is revoked) |

#### *10.4.2.4 Appropriate Use*

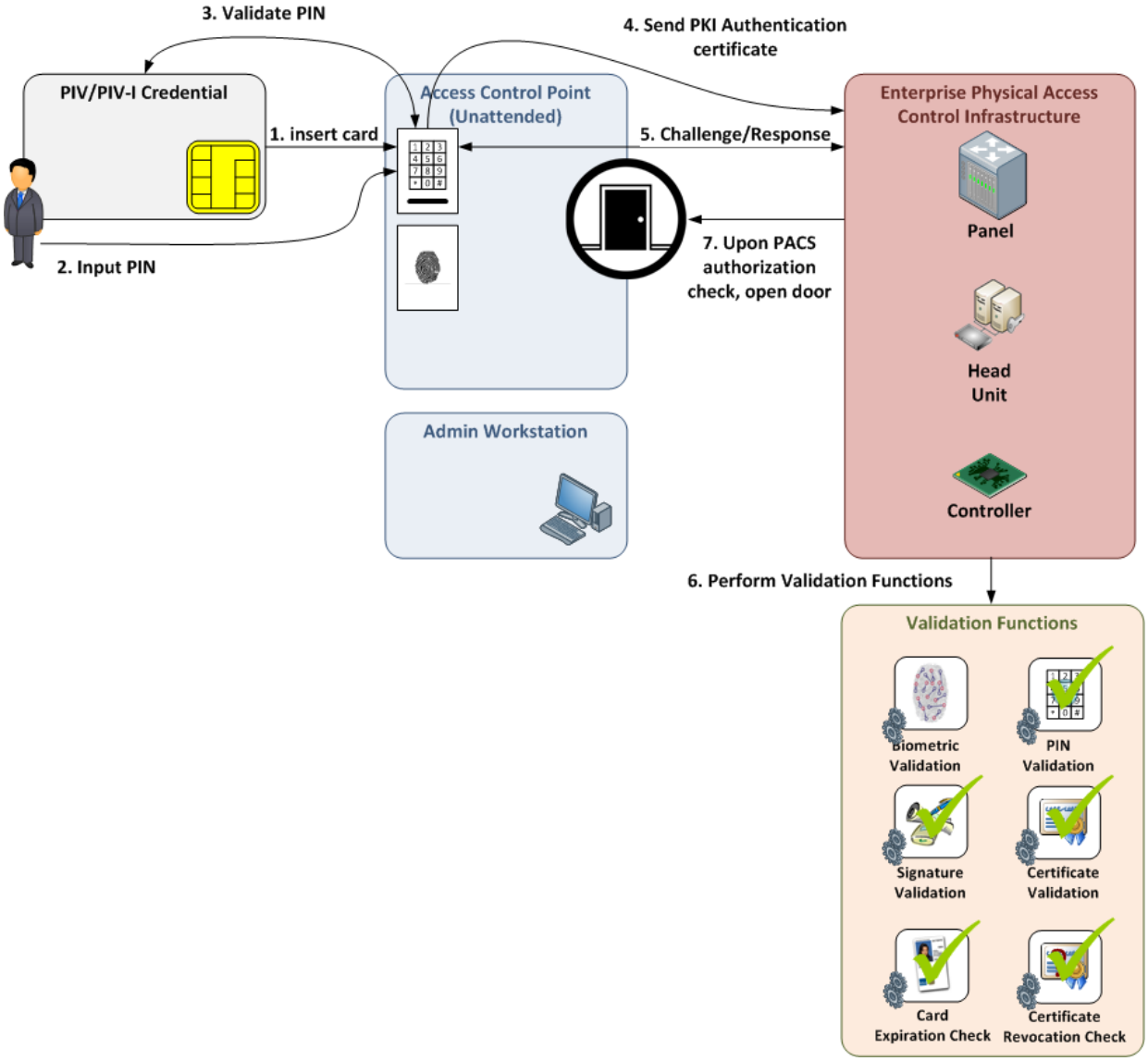
This pattern is one-factor authentication. Therefore, this pattern is sufficient for moving from an Unrestricted area into a Controlled area.



### 10.4.3 Pattern #15: PKI-Auth

The PACS uses the private key (from the PIV Authentication certificate) in a challenge/response protocol. The PACS validates the PIV Authentication certificate (which should use PDVal), and checks the PIV Authentication certificate's revocation status. The PACS also checks the PIV Authentication certificate's expiration date.


#### 10.4.3.1 Use Case Diagram




#### 10.4.3.2 Description

This pattern can use the contact interface. The PIV Card and the PIV-I Card carry a mandatory asymmetric authentication private key and corresponding certificate. The following steps are used to perform authentication using the card's asymmetric authentication key:

15. Insert PIV or PIV-I Card into card reader.
16. Enter PIN.
17. Verify PIN Accepted; (if possible) notify remaining attempts after/if failed PIN.
18. The PIV Authentication certificate is sent to the E-PACS Infrastructure.
19. Challenge / Response:
    a. PIV Authentication certificate is sent to the PACS cryptographic validation function.
    b. PACS sends challenge to card (based on the public key in the PIV Authentication certificate).
    c. Card sends a response using private key on the chip.
    d. The PACS signature validation function validates the card response.
20. The PACS performs validation functions.
    a. PIV Authentication certificate PDVal and revocation check (see PIA-5).
    b. The PIV Authentication certificate expiration date is checked to ensure that the card has not expired (see PIA-3.6).
21. Upon successful challenge/response and PDVal/revocation check, the PACS checks whether the authenticated cardholder is authorized to enter.
    c. Upon authorization, the door is unlocked.

Some of the characteristics of the PKI-based authentication mechanism are as follows:

9. Requires the use of online certificate status checking infrastructure
10. Highly resistant to credential forgery
11. Strong resistance to use of unaltered card by non-owner since PIN is required to activate card
12. Applicable with contact-based card readers.

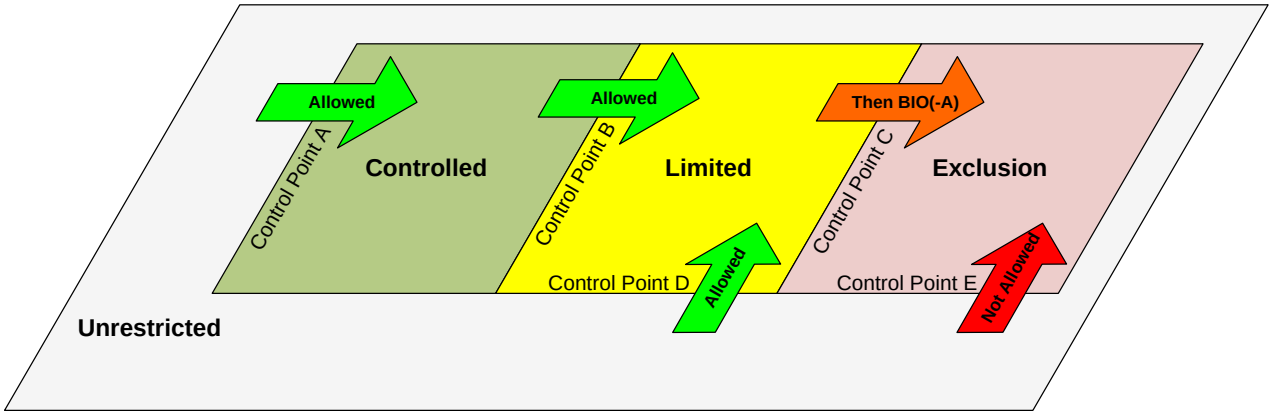
#### *10.4.3.3 Unmitigated Threats*

| Unmitigated PACS Threats |
|---|
| Social Engineering |

#### *10.4.3.4 Appropriate Use*

This pattern is two-factor authentication (PKI and PIN). Factor one is possession of a PIV Card, verified by the PACS by the active authentication (the challenge response) together with the verification of trusted origin (the path validation). Factor two is knowledge of the PIV PIN. Although the PACS does not see or verify the PIN directly, it knows that the PIV or PIV-I Card will not use the Authentication Key to respond to the challenge unless the PIN has been presented to it and verified. Thus, in responding to the challenge, the PIV or PIV-I Card is able to "transfer the trust" that the Cardholder knows and correctly presented the PIN.

Because it is two-factor authentication, this pattern is sufficient for moving from an Unrestricted area or into a Controlled or Limited area, or between Controlled and Limited areas.

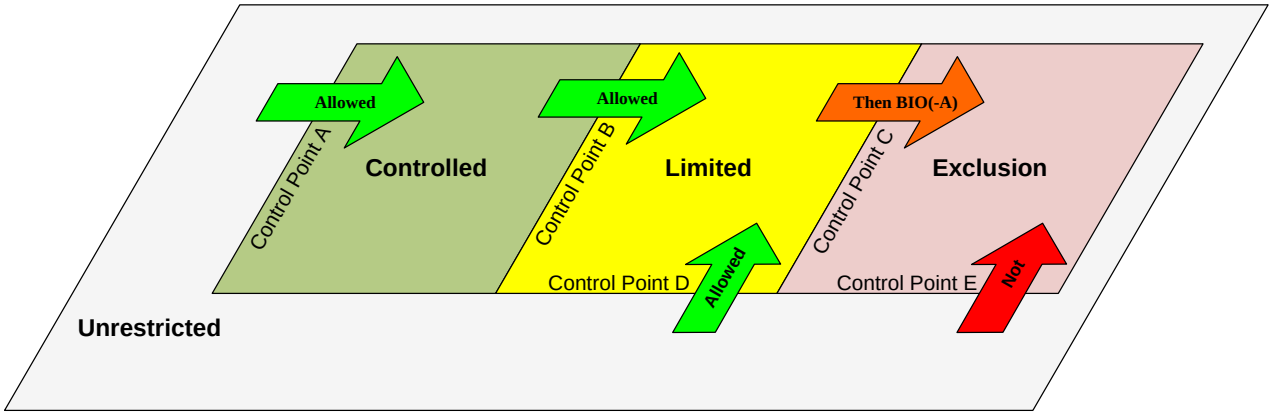


### *10.4.4 Pattern #16: PKI-CAK + PIN to PACS*

This pattern can be achieved by combining Pattern #8: PKI-CAK, PKI-CAK and Pattern #11: CHUID + PIN to PACS, CHUID + PIN to PACS. Please review those patterns to understand this combined pattern. Note that in this pattern, the identifier comes from the PKI-CAK certificate instead of the CHUID. The credential number found in the certificate for the PKI-CAK must be transmitted to support PIN to PACS. Entry is allowed only after the PACS verifies that the authenticated cardholder is authorized to enter.


#### *10.4.4.1 Appropriate Use*

This pattern is two-factor authentication; therefore, it is sufficient for moving from an Unrestricted area into a Controlled or Limited area or between Controlled and Limited areas.

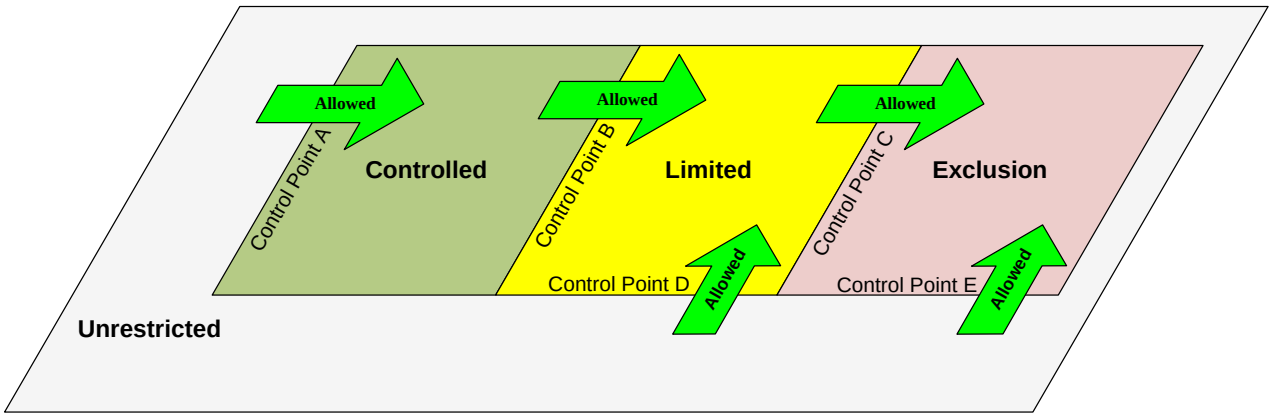


### *10.4.5 Pattern #18: PKI-CAK + BIO(-A)*

This pattern can be achieved by combining Pattern #8: PKI-CAK, PKI-CAK and either Pattern #10, BIO, or **Error! Reference source not found.**, BIO-A. Please review those patterns to understand this combined pattern. PKI-CAK plus BIO-A specifically requires the PACS to confirm the PIN activated BIO-A read is explicitly from the same card as the PKI-CAK challenge/response at time of authentication. The credential number found in the certificate for the PKI-CAK must match the credential number found in the biometric. The contact interface should be used because there are risks if PKI-CAK is contactless and BIO is contact. Entry is allowed only after the PACS verifies that the authenticated cardholder is authorized to enter.


#### *10.4.5.1 Appropriate Use*

This pattern is three-factor authentication; therefore, it is sufficient for moving from an Unrestricted area into a Controlled, Limited, or Exclusion area. It may also be used to move between Controlled and Limited areas or between Limited and Exclusion areas.

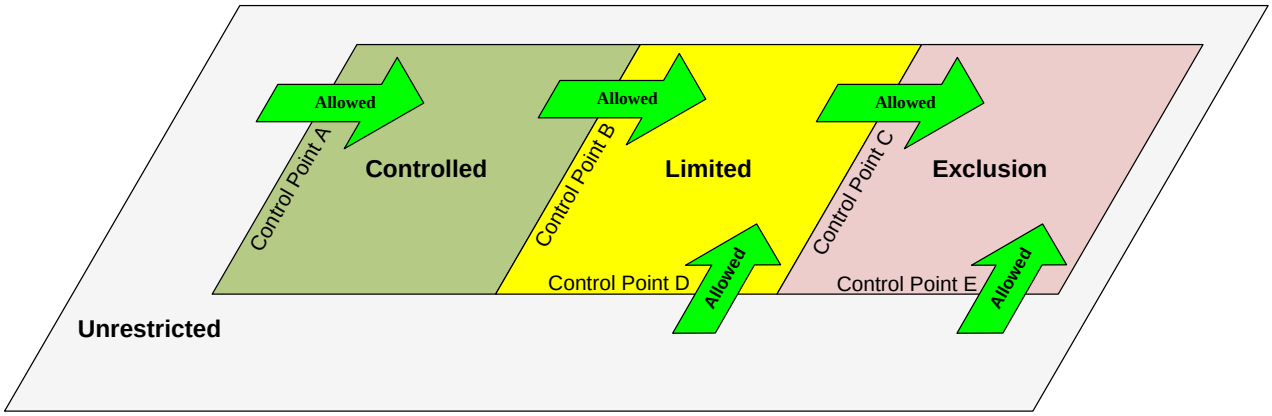


### *10.4.6 Pattern #20: PKI-Auth + BIO(-A)*

This pattern is similar to Pattern #18: PKI-CAK + BIO(-A). However, in this pattern, the PKI-Auth certificate replaces the PKI-CAK certificate in all steps. The credential number found in the certificate for the PIV Authentication certificate must match the credential number found in the biometric. Entry is allowed only after the PACS verifies that the authenticated cardholder is authorized to enter.


#### *10.4.6.1 Appropriate Use*

This pattern is three-factor authentication; therefore, it is sufficient for moving from an Unrestricted area into a Controlled, Limited, or Exclusion area. It may also be used to move between Controlled and Limited areas or between Limited and Exclusion areas.



## 10.6 Legacy/Transitional State Authentication Patterns

This section outlines the authentication mechanisms that may be in use currently for PACS but do not meet the minimum expectations for strong authentication and agency interoperability. If an agency is using any of these mechanisms, it should work immediately to move toward one of the patterns outlined in Section 10.1.

Pattern #1: VIS, VIS and Pattern #10: BIO, BIO. In addition to using biometric authentication with the PACS performing all validation steps, the guard supervises submission of the cardholder PIN and biometric (to prevent use of fake/synthetic fingerprint).

Though VIS is zero-factor authentication and BIO is one-factor authentication, combining these two patterns results in two-factor authentication. Although this pattern provides two-factor authentication, it is not sufficient for use because it does not meet the target state requirements for strong, electronic authentication.

### *10.6.1 Pattern #17: SYM-CAK + PIN to PACS*

This pattern can be achieved by combining

Pattern #9: SYM-CAK, SYM-CAK and Pattern #11: CHUID + PIN to PACS, CHUID + PIN to PACS. Please review those patterns to understand this combined pattern. Note that in this pattern, the identifier comes from the PIV Authentication certificate instead of the CHUID. The credential number found in the certificate for the PIV Authentication certificate must be transmitted to support PIN to PACS. Entry is allowed only after the PACS verifies that the authenticated cardholder is authorized to enter.

The SYM-CAK + PIN to PACS pattern provides two-factor authentication; however, it is not sufficient for use because it does not meet the target state requirements for interoperability.

### *10.6.2 Pattern #19: SYM-CAK + BIO(-A)*

This pattern can be achieved by combining

Pattern #9: SYM-CAK, SYM-CAK and either Pattern #10, BIO, or **Error! Reference source not found.**, BIO-A. Please review those patterns to understand this combined pattern. SYM-CAK plus BIO(-A) specifically requires the PACS to confirm the PIN activated BIO(-A) read is explicitly from the same card as the symmetric CAK challenge/response at time of authentication. The credential number found in the certificate for the PIV Authentication certificate must match the credential number found in the biometric. The contact interface should be used because the BIO information is available only on the contact interface. Entry is allowed only after the PACS verifies that the authenticated cardholder is authorized to enter.

The SYM-CAK + BIO(-A) pattern provides three-factor authentication; however, it is not sufficient for use because it does not meet the target state requirements for interoperability.

# APPENDIX A: USE OF SYMMETRIC KEYS WITH PACS CREDENTIALS

This appendix provides guidance for credential issuers willing to use symmetric keys in PACS credentials. The use of symmetric keys is not advocated by HSPD-12, as the requirement of protecting symmetric keys does not provide easy interoperability between independent operators and systems. This appendix does not provide the pros and cons of using a symmetric key over an asymmetric key, but rather describes the minimum security precautions required from a system using symmetric keys.

This appendix does not provide explicit description of the various cards (or card data models) providing symmetric keys, as they can be very different between a PIV Card (where CAK has historically been optional and can be symmetric), a PIV-I Card (CAK must be present and must be asymmetric), or Facility Access cards such as iClass, Mifare, DesFire and similar proprietary cards available in the open market.

FIPS 201-2 allows the CAK to have two keys in the same card, one mandatory asymmetric (providing interoperability) and one optional symmetric for use within the issuing agency (providing mutual authentication and a secure session). The symmetric CAK does not support interoperable use across the federal enterprise.

Useful guidance on key management can be found in [NIST SP 800-57] Parts 1 and 2.

## A.1 Use of Symmetric Keys with PACS Credentials

Symmetric keys can be used to provide security services such as confidentiality (e.g. secure session key). Integrity (Message Authentication Code), or Authentication. The following section addresses mainly authentication when a symmetric key is used to authenticate a card, but many existing protocols do provide for the other security functions (integrity as well as confidentiality) as a byproduct of the mutual authentication process. The detailed protocol is not described hereafter and is assumed to be known (as the authentication key itself) by the parties (card and reader).

Smart Card systems have used symmetric key mechanisms for decades quite successfully and have developed various techniques allowing applications to get some benefits of symmetric algorithms[58] while addressing inherent implementation issues. Smart Cards are very good at protecting keys (symmetric as well as asymmetric) but the two main issues that need to be addressed when using symmetric keys in a PACS are:

1. Protection of the key in the system (and its elements) using smart cards; and
2. Minimizing the consequences of a given key being exposed.

The following provides guidance on these two issues. It does not try to provide guidance on systems willing to share symmetric keys, as doing so increases tremendously the risk of a given key being exposed, putting at risk all cards and all systems relying on the same shared key. As a consequence, symmetric keys should not be used in an “open” system (having multiple independent authorities) as the requirement of sharing a “master” key between systems does not allow for easy protection of the “master” key.

[58] Mainly speed of execution over asymmetric algorithms for the same key strength.

## A.2 Key diversification in smart card systems

The process of diversification of symmetric keys in credentials is a mechanism which uses a main (or master) key in the PACS application (Reader/Terminal/controller/panel) with a unique derived key stored in each credential. When the credential is personalized (or activated to work with a given PACS), it receives a unique symmetric key which is calculated by the personalization system using the master key of the system and a unique reference from the credential (e.g., its credential number, a card manufacturing number, a diversification number) .[59]

When the a credential is later presented to a reader, the PACS calculates the credential key by deriving the credential key from the master key using the diversification value the credential provides. This diversification mechanism limits the exposure of a compromised key of a given credential (no other credential is at risk), and does not put the master key of the PACS application at risk either.

Many smart card data models provide for multiple keys (symmetric of asymmetric) for the same function with can be selected by the card itself (based on its environment), or by the terminal dealing with the card (from a table of key identifiers defined in the application). The PIV data model defined so far is restricted to one key per function, and the key which to be defined in advance without providing any protocol selection for potential multiple keys for a given type of key.[60] Because of this data model restriction in PIV (which does not allow a card to have multiple independent derived keys), the use of symmetric keys, even when diversified, is limited to closed non interoperable systems.

## A.3 Master key life span in a PACS

No key should be used forever. All keys (symmetric and asymmetric) should have a given life span. It is very important to define how long a given key is going to be used and have the means in a system to roll over new keys when the old ones expire. PIV provides such mechanisms for the asymmetric keys of the card (certificates valid for 3 years) but does not impose a requirement for symmetric keys when they are used.

This document recommends limiting the life span of a given master key to maximum of five years in all PACS systems. This arbitrary value is based on the fact PIV Cards are issued for five years and they do not allow having more than one symmetric key available. Facility Access cards which do not have the restrictions of the PIV data model (either shorter life span or possibility to update the symmetric key in the card), or PIV Cards in which the issuer keeps the possibility of updating (securely) the symmetric key value should consider to have a shorter life span (e.g. three years or less).

As a consequence, a given PACS may have more than one master key at any time to deal with. Based on the issuing date (or any other parameter available in the card identifier and used to select a given master key over another one), the PASC will know which master key to use to derive the card corresponding key.

It is also possible to use multiple master keys in a given PACS even at the same time. This would, in principle, limit the risk of a given master key of the set being compromised, and as such limit the number of

[59] A very simple mechanism to create diversified keys with algorithms which do not have weak keys (e.g., Advanced Encryption System [AES]) is to use the unique credential number, pad (or hash) it to the block length of the algorithm and cipher it using the master key of the system. The resulting value can be used as the diversified key for the credential.

[60] The Protocol for Lightweight Authentication of ID (PLAID) protocol version 8 (RSA 1024) allows to define up to 32 768 authentication keys in one card system.

cards to reissue[61]. This is only a theoretical protection as if multiple master keys are all protected the same way, in the same system, and as such all would likely be compromised at the same time. This technique only prevents a given master key from being "guessed" by an attacker.

## A.4 Protection of secrets (e.g. master keys) in a PACS

The other issue that needs to be addressed in systems using symmetric keys is the protection of the master key within the system itself. As in systems using asymmetric keys for card authentication, the process themselves (e.g. cryptographic functions) as well as the general parameters used (e.g. trusted roots, date and time) have to be protected against tampering. However, in systems requiring mutual authentication (e.g. symmetric as well as asymmetric key based systems) the private/secret key (e.g. master key of the system) requires protection at all time against exposure.

The following describes possible technical architectures for any type of private (or secret) key that needs to be protected in a PACS environment.

1. The master key of a system should be protected using FIPS 140-2 level 3 devices at all times. The master key should never leave such a device, and be loaded securely[62]. The master key in the device should be erased or locked from use when such device is removed from the PACS system (e.g., maintenance, tests). Example of such devices are:

    a. A Hardware Security Module (HSM) attached to the PACS (only one element with the Master key shared over a network);

    b. A secure FIPS 140-2 level 3 approved device in Controllers/Panels where master keys are securely loaded from the PACS Head End; and

    c. A secure FIPS 140-2 level 3 in the readers (on the secure side of the reader). This could be a removable Secure Application Module (e.g. smart card) , or a fixed component in the reader, but in any case, the master key should be erased or locked against use when the reader (or the SAM) is not operational in the PACS system. The master key could be loaded securely in the device when the device is operational (i.e., connected to a PACS).

2. The master key of a system should be shared by as few elements as possible. For example, if the master key is protected in a Controller/Panel, it may be acceptable to have the calculated card derived key send (securely) to a protected element (also FIPS 140-2 certified) used by a door reader for the final authentication process and a secure session usage.

Many architectural possibilities are possible to protect such keys, and the above is only guidance on some basic principles to abide by. In addition to the basic security principles explained in this appendix, other requirements such as key availability and overall performance should be taken in consideration during design.

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[61] When a master key is compromised, all cards which have a derived key from this master key cannot be trusted anymore as it would allow an attacker to generate cards with valid derived keys.

[62] It is also a good practice to have some kind of secure backup mechanism in case the device protecting the master key breaks down.

## A.5 Registration of credentials using symmetric keys in PACS

As explained earlier, the use of symmetric keys does not provide easy interoperability between independent systems. Moreover, beside the master key itself, it requires the PACS to know the diversification mechanism used for the credentials, as well as the rule of master key assignment to a given credential (see earlier point on multiple master keys over time).

This section has no specific recommendation, but just indicates the need for a given PACS to know all these specific "details" before it can use any credential based on symmetric keys. This is why this section applies mostly to closed systems (PIV or PIV-I Cards used by their own issuer or Facility access cards). All these credentials are known by the issuer and does need any generic interoperable method or be registered in a given PACS.

Nevertheless, it is highly recommended to use the strong identity verification available in the PIV/PIV-I data model to verify the validity of the credential and the legitimate user both at registration time in the PACS and from time to time (e.g. every month or quarter, or on a statistical basis). [63]

[63] Doing such verification using the asymmetric keys of the PIV data model (PKI-Auth or even PKI-CAK) would allow detection that a master symmetric key has been compromised in the system.

# APPENDIX B: GLOSSARY

| Term | Definition |
|---|---|
| Access Control | The process of granting or denying requests to access physical facilities or areas, or logical systems (i.e., computer networks or software applications). See also "Physical Access Control System." |
| Asymmetric Keys | Two related keys, a public key and a private key that are used to perform complementary operations, such as encryption and decryption or signature generation and signature verification. |
| Authentication | The process of establishing confidence in the identity of users or information systems. That is, achieve sufficient confidence in the binding between the entity and the presented identity. |
| Authentication Certificate | An authentication mechanism that is implemented by an asymmetric key challenge/response protocol using the authentication key of the Card and a contact reader. |
| Authentication Factors | Authentication systems are often categorized by the number of factors that they incorporate. The three factors often considered as the cornerstone of authentication are:<br><br>*Something you know* (for example, a password)<br>*Something you have* (for example, an ID badge or a cryptographic key)<br>*Something you are* (for example, a thumb print or other biometric data)<br><br>Authentication systems that incorporate all three factors are stronger than systems that only incorporate one or two of the factors. |
| Authentication Mechanism | The authenticator(s) used to sufficiently prove the user is who he/she says he/she is. |
| Authentication Pattern | A description of a specific implementation of an authentication mechanism. Patterns are sometimes called use cases. The authentication patterns in this Guidance document are neutral in that recommended and not recommended patterns are presented. |
| Authenticator | The means used to confirm the identity of a user, process, or device (e.g., user password or token). |
| Biometric | A measurable physical characteristic used to recognize the identity of an individual. Examples include fingerprints and facial images. A biometric system uses biometric data for authentication purposes. |
| Card Authentication Key (CAK) | An authentication mechanism that is implemented by an asymmetric key challenge/response protocol using the Card authentication key of the Card and a contact or contactless reader. |
| Card Management System (CMS) | An application that manages the issuance and administration of multi-function enterprise access smart cards. The CMS manages cards, as well as data, applets and digital credentials, including PKI certificates related to the cards throughout their lifecycle. |
| Cardholder Unique Identifier (CHUID) | The PACS Implementation Guidance [PACS] defines the CHUID data object; this description is refined in NIST SP 800-73. The PIV Card shall include the CHUID as defined in NIST SP 800-73. The CHUID includes an element, the Federal Agency Smart Credential - Number (FASC-N), which uniquely identifies each card. CHUID elements specific to this standard are described below in Section 4.2.1. The format of the CHUID signature element is described in Section 4.2.2. The PIV CHUID shall be accessible from both the contact and contactless interfaces of the PIV Card without card activation. The PIV FASC-N shall not be modified post-issuance. |

| Term | Definition |
|---|---|
| Certificate<br><br>(X.509 Certificate) | A set of security-relevant data issued by a security authority or a trusted third party, that, together with security information, is used to provide the integrity and data origin authentication services for the data. The digital representation of information at least:<br>1) identifies the certification authority issuing it,<br>2) names or identifies its subscriber,<br>3) contains the subscriber's public key,<br>4) identifies its operational period, and<br>5) is digitally signed by the certification authority issuing it.<br><br>The public key for a user (or device) and a name for the user (or device), together with some other information, rendered unforgeable by the digital signature of the certification authority that issued the certificate, encoded in the format defined in the ISO/ITU-T X.509 standard. |
| Certificate Revocation List (CRL) | A list of revoked public key certificates created and digitally signed by a Certification Authority. |
| Challenge/Response Protocol | An authentication protocol where the verifier sends the claimant a challenge (usually a random value or a nonce) that the claimant combines with a shared secret (often by hashing the challenge and secret together) to generate a response that is sent to the verifier. The verifier knows the shared secret and can independently compute the response and compare it with the response generated by the claimant. If the two are the same, the claimant is considered to have successfully authenticated himself. When the shared secret is a cryptographic key, such protocols are generally secure against eavesdroppers. When the shared secret is a password, an eavesdropper does not directly intercept the password itself, but the eavesdropper may be able to find the password with an off-line password guessing attack. |
| Compensating Control | A management, operational, and/or technical control (i.e., safeguard or countermeasure) employed by an organization in lieu of a recommended security control in the low, moderate, or high baselines that provides equivalent or comparable protection for an information system. |
| Countermeasures | Actions, devices, procedures, techniques, or other measures that reduce the vulnerability of an information system. Synonymous with security controls and safeguards. |
| Credential | A set of data presented as evidence of a claimed identity and/or entitlements. |
| Cryptographic (Crypto) | Use of a crypto-algorithm program by a computer to authenticate or encrypt/decrypt information. |
| Digital Signature | A nonforgeable transformation of data that allows the proof of the source (with non-repudiation) and the verification of the integrity of that data. |
| Enterprise PACS (E-PACS) | The FICAM Initiative established the notion of an Enterprise PACS “from that need to leverage US Government investments in HSPD-12 compliance, FIPS 201, and PIV Card technology for physical access solutions across agency and organizational boundaries." Enterprise PACS allows Federal government personnel and their contractors to authenticate their identities as visitors to other agencies' facilities using secure, PKI-enabled Federal PIV Card standards. This is done using cards (e.g., PIV Cards, PIV-I Cards) already issued by their own organizations, which are subjected to fine-grained authorization decisions made by the agency or organization they are visiting, and by leveraging many aspects of existing PACS infrastructure. |
| Federal Agency Smart Credential - Number (FASC-N) | The FASC-N is the primary identification string to be used on all government issued credentials. The key to credibility, non-repudiation and reciprocity is the definition and acceptance of a credential token identification numbering schema for use across all Federal Agencies that is uniquely assigned to one and only one individual. For deployed systems, this is the FASC-N. For emerging systems, it is the GUID. Both are contained in the CHUID for consistent means of access by PACS solutions allowing for ease of migration. The responsibility for issuing this number to federal personnel is decentralized |

| Term | Definition |
|---|---|
| | to the various federal agencies, with the ultimate responsibility for ensuring uniqueness residing with each agency's CIO, or other duly designated agency official. For the FASC-N, this is achieved through an assigned Agency Code and subordinate system code and credential number. |
| Federation | An association of users, service providers, and identity service providers. |
| Full Path Validation | See Path Discovery and Validation (PDVal) |
| Global Unique Identifier (GUID) | The GUID is a mandatory data field defined within the Cardholder Unique ID (CHUID) as specified in [NIST SP 800-73] Part 1. For PIV-I Cards, the GUID field must contain an RFC 4122- conformant UUID value to support large Non Federal Issuer populations. |
| Identity Management Systems (IDMS) | An automated system of hardware (servers) and software (programs) that provides the workflow management (services) of identity functions, as normatively described in [FIPS 201]. An IDMS is separately layered and/or compartmentalized within one system and/or a modular component of an agency's centralized system/enterprise. The IDMS will be encapsulated in an environment that is secure, auditable and protect the privacy of personal information. The IDMS establishes the centralized Chain-of Trust that is then integrated into the components of a FIPS 201 enterprise. |
| Key | A value used to control cryptographic operations, such as decryption, encryption, signature generation, or signature verification. |
| Level of Assurance (Assurance Level) | The degree of confidence in the process of identity validation and verification used to establish the identity of the entity to which the credential was issued, and the degree of confidence that the entity that uses the credential is that entity or the entity to which the credential was issued or assigned. In terms of [OMB M-04-04] and [NIST SP 800-63-1], four levels:<br><br>Level 1: LITTLE OR NO confidence<br><br>Level 2: SOME confidence<br><br>Level 3: HIGH confidence<br><br>Level 4: VERY HIGH confidence |
| Line Supervision | Taking steps to ensure that the line being used for the access control system has sensors and/or resistors to make sure the line isn't being compromised. |
| Livescan Fingerprinting | The technique and the technology used by law enforcement and private facilities to capture fingerprints and palm prints electronically, without the need for the more traditional method of ink and paper. |
| National Agency Check with Written Inquiries (NACI) | The basic and minimum investigation required for all new federal employees and contractors, which consists of searches of the OPM Security/Suitability Investigations Index (SII), the Defense Clearance and Investigations Index (DCII), the Federal Bureau of Investigation (FBI) Identification Division's name, fingerprint files, and other files or indices when necessary. This investigation also includes written inquiries and searches of records covering specific areas of an individual's background during the past five (5) years (inquiries sent to current and past employers, schools attended, references, and local law enforcement authorities). Coverage includes employment (five (5) years); education (five (5) years and highest degree verified); residence (three (3) years); references; law enforcement (five (5) years); and NACs. |
| Non-repudiation | The ability to protect against denial by one of the entities involved in an action of having participated in all or part of the action. |
| Partial CHUID | Design pattern where Because a PACS cannot transmit a full CHUID from the reader to the panel, the CHUID is truncated before it is sent to the panel. For example, the weigand |

| Term | Definition |
|---|---|
| | line is limited to 48 bits so it will not take a full CHUID because there isn't enough room to transmit certain information/fields. |
| Path Discovery and Validation (PDVal)<br><br>(Also called “Full Path Validation”) | Certificate validation consists of two phases: trust path discovery and trust path validation. Trust path discovery is the process of discovering a chain of cross-certificates and CA certificates running from the relying party's trust anchor to the end-entity's certificate. A trust path may be discovered dynamically each time as needed or it may be constructed once and stored (or "cached"); PDVAL products may vary in how they choose to implement this operation.<br><br>Trust path validation is the process of examining each certificate that comprises the trust path, examining policies, constraints, and consulting the issuing CA's CRL or OCSP responder to determine each certificate's validity status at that moment. It is expected that even if a trust path is cached, all certificates in the trust path are validated in real-time at the beginning of each transaction.<br><br>See also Full Path Validation, PIA-5. |
| Personal Identity Verification – Interoperable (PIV-I) Card | An identity card that meets the technical standards to work with PIV infrastructure elements such as card readers, and is issued in a manner that allows federal relying parties to trust the cards. |
| Personal Identity Verification (PIV) Card | A government-issued credit card-sized identification that contains a contact and contactless chip. The holder's facial image will be printed on the card, along with other identifying information and security features. The contact chip will store a PKI certificate, the Cardholder Unique Identifier (CHUID), and a fingerprint biometric, all of which can be used to authenticate the user for physical access to federally controlled facilities and logical access to federally-controlled information systems. A PIV Card is fully conformant with federal PIV standards (i.e., Federal Information Processing Standard (FIPS) 201 and related documentation). Only cards issued by federal entities can be fully conformant. Federal standards ensure the PIV Cards are interoperable with and trusted by all Federal government relying parties. |
| Physical Access Control System (PACS) | Protection mechanisms that limit users' access to physical facilities or areas to only what is appropriate for them. These systems typically involve a combination of hardware and software (e.g., a card reader) and may involve human control (e.g., a security guard). A PACS may support many more functions that are out of scope for this document. |
| PIV-Enabled | A PACS or an authentication mechanism that conforms to [FIPS 201]. For example, a PIV-enabled PACS accepts any PIV Card to prove identity. |
| Primitive Authentication Pattern | An authentication pattern that does not include signature validation and revocation check steps, which would/should otherwise be done in a more robust version of the same pattern. |
| Primitive CHUID | Design patter where a CHUID is used without verifying its signature. Verification a signature should include doing PDVal. |
| Revocation and Status Checking | Actions taken to determine whether a PKI certificate has been revoked or has expired, and therefore is no longer valid. |
| Risk Assessment | The process of identifying risks to organizational operations (including mission, functions, image, or reputation), organizational assets, individuals, other organizations, and the Nation, arising through the operation of an information system. Part of risk management, incorporates threat and vulnerability analyses and considers mitigations provided by security controls planned or in place. Synonymous with risk analysis. |
| Security Controls | The management, operational, and technical controls (i.e., safeguards or countermeasures) prescribed for an information system to protect the confidentiality, integrity, and availability of the system and its information. |

| Term | Definition |
|---|---|
| Segment Architecture | A key objective of the FICAM segment architecture is to implement a holistic approach for government-wide identity, credential and access management initiatives that support access to federal IT systems and facilities. By the end of FY 2012, it is intended that Federal Executive agencies will implement a coordinated approach to ICAM across E-Government interactions [Government-to-Government, Government-to-Business, Government-to-Citizen, and Internal Effectiveness and Efficiency (IEE)] at all levels of assurance as defined in OMB M-04-04. The FICAM segment architecture also provides a framework that may be leveraged by other identity management architectural activities within specific communities of interest. The aim is a standards-based approach for all government-wide identity, credential and access management to ensure alignment, clarity, and interoperability. |
| Symmetric Keys | A shared secret between two or more parties that can be used to maintain a private information link. Since both parties share the same key for encryption and decryption, the keys need to be kept secret. Once somebody else knows the key, it is not safe anymore. |
| Threat | Any circumstance or event with the potential to adversely impact organizational operations (including mission, functions, image, or reputation), organizational assets, or individuals through an information system via unauthorized access, destruction, disclosure, modification of information, and/or denial of service. Also, the potential for a threat-source to successfully exploit a particular information system vulnerability. |
| Token | Something that the claimant possesses and controls (typically a key or password) used to authenticate the claimant's identity. |
| Universally Unique Identifier (UUID) | The UUID is a unique identifier that can be placed in multiple data fields to uniquely identify the card. For example, the UUID is found in the GUID field of the CHUID, the subjectAltName extension of PIV-I Authentication and PIV-I Card Authentication certificates, and within signed objects on the card (in place of the FASC-N in PIV Cards). The UUID is defined in RFC 4122. On PIV Cards, the GUID may contain a UUID. On PIV-I Cards, the GUID must contain a UUID. The UUID provides a unique numbering scheme. However, the UUID does not require a central organization to manage the namespace. |
| Vulnerability | Weakness in an information system, system security procedures, internal controls, or implementation that could be exploited or triggered by a threat source. |

# APPENDIX C: ACRONYMS

| Acronym | Definition |
|---|---|
| AA | Active Authentication |
| AD | Accepting Device |
| AES | Advanced Encryption Standard |
| AID | Application Identifier |
| APL | Approved Products List |
| App | Application |
| BIO | Biometric |
| BIO-A | Biometric Attended |
| C&A | Certification and Accreditation |
| CA | Certification Authority |
| CAK | Card Authentication Key |
| CCTV | Closed Circuit Television |
| CHUID | Cardholder Unique Identifier |
| CIO | Chief Information Officers |
| CMS | Card Management System |
| CPV | Certificate Path Validation |
| CRL | Certificate Revocation List |
| CRUD | Create, Read, Update and Delete |
| DHS | Department of Homeland Security |
| DIP | Dual In-line Package |
| EKU | Extended Key Usage |
| E-PACS | Enterprise Physical Access Control System |
| FASC-N | Federal Agency Smart Credential - Number |
| EC | Expiration Check |
| FBCA | Federal Bridge Certification Authority |
| FICAM | Federal Identity, Credential and Access Management |

| Acronym | Definition |
|---|---|
| FIPS | Federal Information Processing Standards |
| FISMA | Federal Information Security Management Act |
| FPCON | Force Protection Condition |
| FPKI | Federal Public Key Infrastructure |
| FPS | Federal Protective Service |
| FSL | Facility Security Level |
| FY | Fiscal Year |
| GSA | General Services Administration |
| GUID | Global Unique Identifier |
| HSM | Hardware Security Module |
| HSPD | Homeland Security Presidential Directive |
| HTTP | HyperText Transfer Protocol |
| ICAM | Identity, Credential, and Access Management |
| ICAMSC | Identity, Credential, and Access Management Sub-Comimttee |
| IdM | Identity Management |
| IDMS | Identity Management System |
| IdP | Identity Provider |
| IEC | International Electrotechnical Commission |
| IR | Incident Response |
| ISC | Interagency Security Committee |
| ISIMC | Information Security and Identity Management Committee |
| ISO | International Organization of Standards |
| IT | Information Technology |
| JPAS | Joint Personnel Adjudication System |
| kHz | Kilohertz |
| LACS | Logical Access Control System |
| LDAP | Lightweight Directory Access Protocol |
| MA | Maintenance |

| Acronym | Definition |
|---|---|
| MHz | Megahertz |
| MP | Media Protection |
| NACI | National Agency Check with Inquiries |
| NFI | Non-federal Issuer |
| NFPA | National Fire Prevention Association |
| NIST | National Institute of Standards and Technology |
| OCC | On-card Comparison |
| OCSP | Online Certificate Status Protocol |
| OEM | Original Equipment Manufacturer |
| OID | Object identifier |
| OMB | Office of Management and Budget |
| PAC | PACS Access Control |
| PACS | Physical Access Control System |
| PAT | PACS Awareness and Training |
| PAU | PACS Audit and Accountability |
| PBS | Public Building Service |
| PCA | PACS Security Assessment and Authorization |
| PCM | PACS Configuration Management |
| PCP | PACS Contingency Planning |
| PDVal | Path Discovery and Validation. |
| PIA | PACS Identification and Authentication |
| PIN | Personal Identification Number |
| PIV | Personal Identity Verification |
| PIV-I | Personal Identity Verification - Interoperable |
| PKI | Public Key Infrastructure |
| PLAID | Protocol for Lightweight Authentication of ID |
| PM | Program Management |
| POA | Protection of Authenticator |

| Acronym | Definition |
|---|---|
| PPE | ACS Physical and Environmental Protection |
| PPL | PACS Planning |
| PRA | ACS Risk Assessment |
| PS | Personnel Security |
| PSC | PACS System and Communication Protection |
| PSI | PACS System and Information Integrity |
| RC | Revocation Check |
| RF | Radio Frequency |
| RFC | Request for Comment |
| SA | System and Services Acquisition |
| SCVP | Server-based Certificate Validation Protocol |
| SP | Special Publication |
| UL | Underwriters Laboratory |
| URI | Uniform Resource Identifier |
| UUID | Universally Unique Identifier |
| VIS | Visual |
| VTO | Validation of Trusted Origin |

# APPENDIX D: DOCUMENT REFERENCES


| | |
|---|---|
| [Facility Security Level Standard] | *The Risk Management Process for Federal Facilities: An Interagency Security Committee Standard* http://www.dhs.gov/sites/default/files/publications/ISC_Risk-Management-Process_Aug_2013.pdf<br><br>The appendices of this document are designated For Official Use Only (FOUO). Contact Department of Homeland Security Interagency Security Committee for more information. |
| [FBCA CP] | *X.509 Certificate Policy for the Federal Bridge Certificate Authority (FBCA)* http://www.idmanagement.gov/fpkipa/documents/FBCA_CP_RFC3647.pdf |
| [FICAM Roadmap] | *Federal Identity, Credential, and Access Management (FICAM) Roadmap and Implementation Guidance* http://www.idmanagement.gov/documents/FICAM_Roadmap_Implementation_Guidance.pdf |
| [FIPS 140-2] | National Institute of Standards and Technology Federal Information Processing Standards 140-2, *Security Requirements for Cryptographic Modules* http://csrc.nist.gov/publications/fips/fips140-2/fips1402.pdf |
| [FIPS 180] | National Institute of Standards and Technology Federal Information Processing Standards 180, *Secure Hash Standard (SHS)* http://csrc.nist.gov/publications/fips/fips180-3/fips180-3_final.pdf |
| [FIPS 200] | National Institute of Standards and Technology Federal Information Processing Standards 201, *Minimum Security Requirements for Federal Information and Information Systems* http://csrc.nist.gov/publications/fips/fips200/FIPS-200-final-march.pdf |
| [FIPS 201] | National Institute of Standards and Technology Federal Information Processing Standards 201, *Personal Identity Verification (PIV) of Federal Employees and Contractors* http://nvlpubs.nist.gov/nistpubs/FIPS/NIST.FIPS.201-2.pdf |
| [GSA MSO] | USAccess Program, *PIV Card Issuer Operations Plan,* General Services Administration Managed Services Office http://www.fws.gov/humancapital/HSPD12/PCI_Operations_Plan%20.pdf |
| [HSPD-12] | Homeland Security Presidential Directive 12, *Policy for a Common Identification Standard for Federal Employees and Contractors* |
| [ISO/IEC 7816] | International Organization for Standardization (ISO) / International Electrotechnical Commission (IEC) 7816, *Identification Cards – Integrated Circuit Cards Parts 1-15 http://www.iso.org/iso/iso_catalogue.htm* |

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[NIST SP 800-21] National Institute of Standards and Technology Special Publication 800-21, *Guideline for Implementing Cryptography in the Federal Government* http://csrc.nist.gov/publications/nistpubs/800-21-1/sp800-21-1_Dec2005.pdf

[NIST SP 800-37] National Institute of Standards and Technology Special Publication 800-37, *Guide for Applying the Risk Management Framework to Federal Information Systems* http://csrc.nist.gov/publications/nistpubs/800-37-rev1/sp800-37-rev1-final.pdf

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[NIST SP 800-57] National Institute of Standards and Technology Special Publication 800-57, *Recommendation for Key Management* http://csrc.nist.gov/publications/nistpubs/800-57/sp800-57-Part1-revised2_Mar08-2007.pdf

[NIST SP 800-63-1] National Institute of Standards and Technology Special Publication 800-63-1, *Electronic Authentication Guidance* http://csrc.nist.gov/publications/PubsSPs.html

[NIST SP 800-73] National Institute of Standards and Technology Special Publication 800-73, *Interfaces for Personal Identity Verification (4 Parts)* http://csrc.nist.gov/publications/PubsSPs.html

[NIST SP 800-76] National Institute of Standards and Technology Special Publication 800-76, *Biometric Data Specification for Personal Identity Verification,* http://csrc.nist.gov/publications/nistpubs/800-76-1/SP800-76-1_012407.pdf

[NIST SP 800-78] National Institute of Standards and Technology Special Publication 800-78, *Cryptographic Algorithms and Key Sizes for Personal Identification Verification (PIV)* http://csrc.nist.gov/publications/nistpubs/800-78-3/sp800-78-3.pdf

[NIST SP 800-79] National Institute of Standards and Technology Special Publication 800-79, *Guidelines for Accreditation of Personal Identity Verification Card Issuers* http://csrc.nist.gov/publications/nistpubs/800-79-1/SP800-79-1.pdf

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