RITA Research and Innovative Technology Administration

Operational and Organizational Models for Certificate Management Entities

April 19, 2012
Washington, DC

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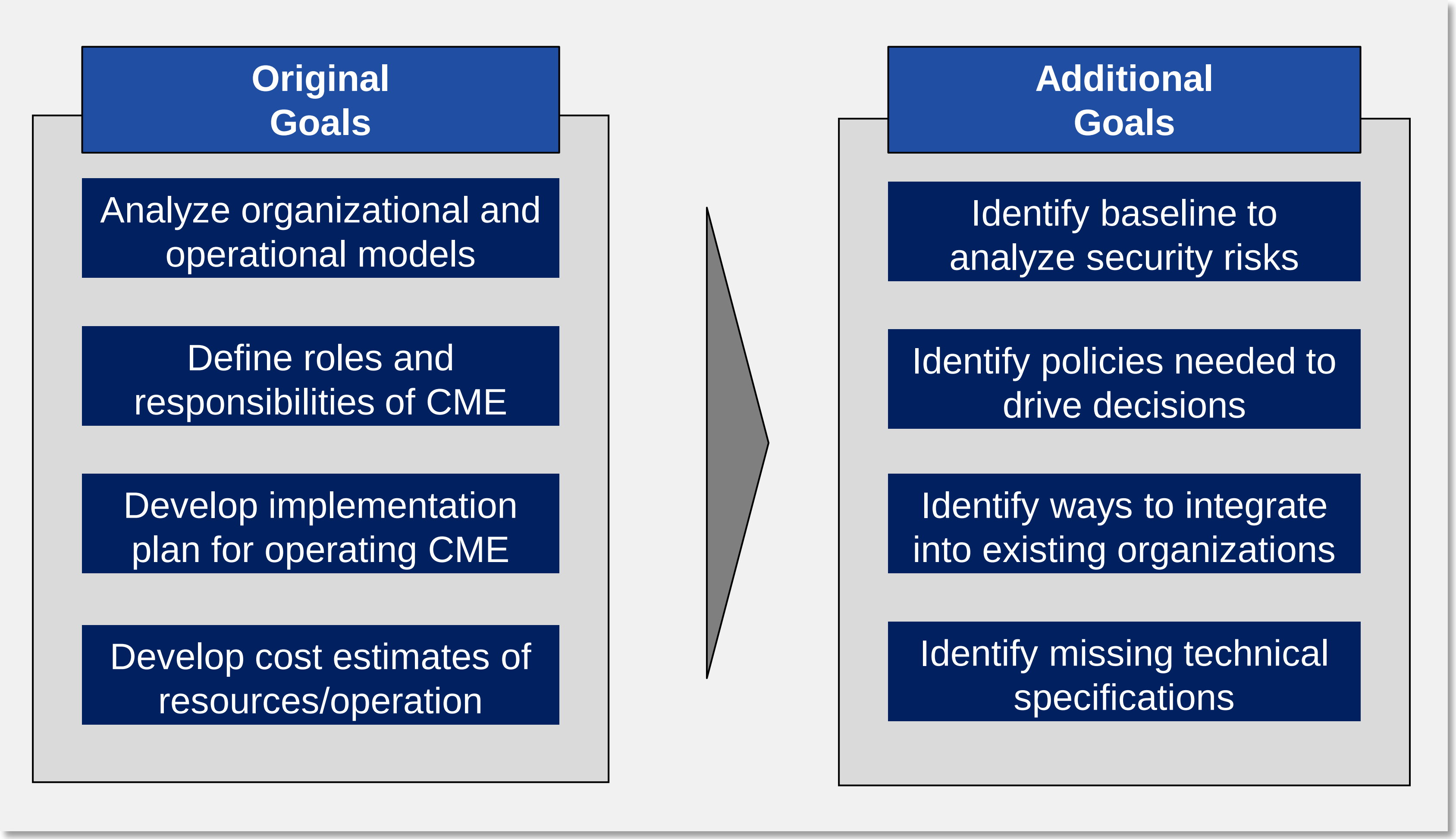
Project Description

- Analyze alternative approaches and models for Certificate Management Entities (CMEs) for the Connected Vehicle Program
- All approaches balance the **security of communications** with protection of the system's users' **privacy**
- CMEs perform the **back-end processes** to ensure the security of communications and protect the privacy of system users
- **User trust** is built by system users receiving valid messages from other system users
- Any viable CME structure must be **cost-effective, efficient, and scalable**

Project Goals



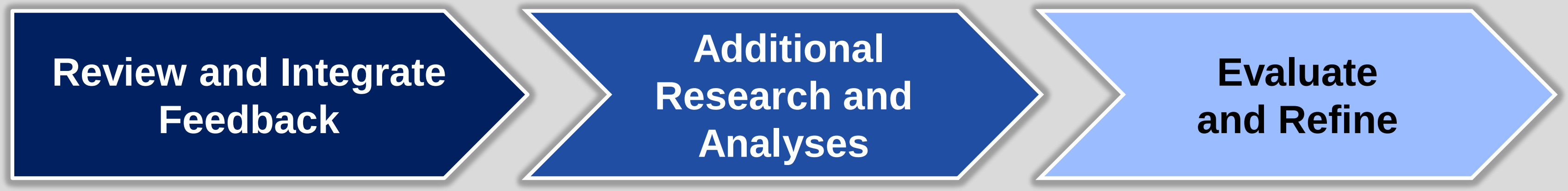
Original Goals

- Analyze organizational and operational models
- Define roles and responsibilities of CME
- Develop implementation plan for operating CME
- Develop cost estimates of resources/operation

Additional Goals

- Identify baseline to analyze security risks
- Identify policies needed to drive decisions
- Identify ways to integrate into existing organizations
- Identify missing technical specifications

Project Approach



Review and Integrate Feedback

Additional Research and Analyses

Evaluate and Refine

- Reviewed all documentation
- Documented the perspectives of multiple stakeholder groups:
- Researched comparative industry practices and organizations
  - Federal PKI Policy Authority
  - International Registration Plan
  - E-ZPass toll system
  - Smart Grid

- Analyzed sub-functions and activities
- Narrowed list of acceptable models
- Built in requisite elements to models:
- Analyzed different oversight structures
- Developed policy and technical assumptions
- Defined outstanding questions and decisions

- Detailed development of three models
- Analyzed security baseline and privacy protections for:
  - Electronic Health Records
  - Electronic Voting
  - Standard PKI systems
- Detailed all implications of outstanding questions
- Evaluated each model against DOT criteria

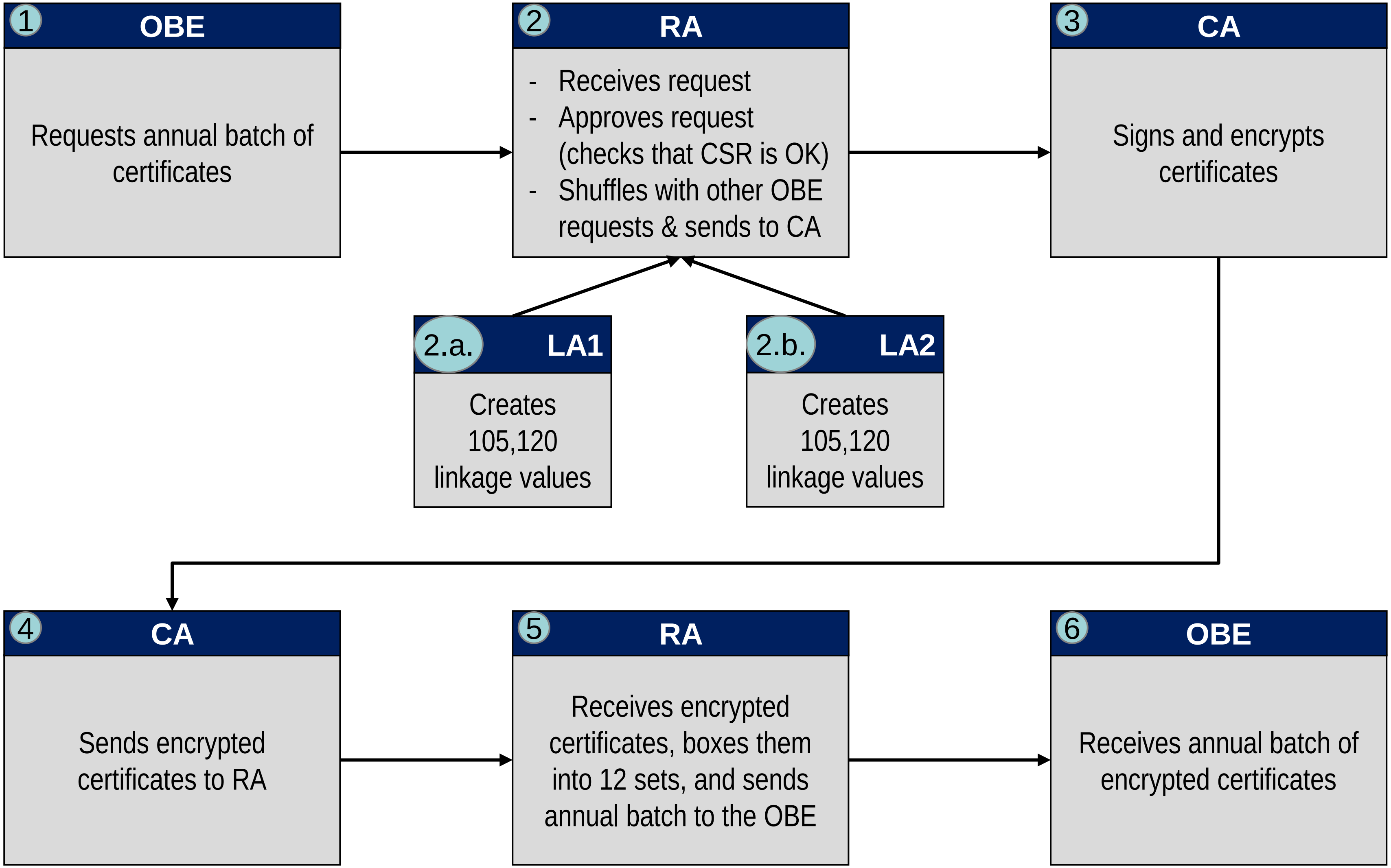
Principles of Certificate Management

- A CME is an organization responsible for some of the functions and activities of certificate management
- A Public Key Infrastructure (PKI) scheme was selected for communications security
- The Activation system is the only part of the system that may collect PII, if that decision is made

Functions: The high level CME functions

Certificate Authority (CA)	Registration Authority (RA)	Linkage Authority (LA)	Misbehavior Detection & Mgmt (MDM)
▸ Central signing authority for all certificates ▸ Distributes certificates to RA	▸ Communicates directly with On Board Equipment (OBE) ▸ Coordinates with CA and LA to distribute certificates to OBE	▸ Creates linkage values ▸ Encrypts and sends linkage values to RA	▸ Reviews misbehavior reports to identify malfeasance and malfunction ▸ Reviews Certificate Revocation Lists (CRLs)

CME Process Flow (Certificate Batch Development)



1 **OBE**

Requests annual batch of certificates

2 **RA**

- Receives request
- Approves request (checks that CSR is OK)
- Shuffles with other OBE requests & sends to CA

2.a. **LA1**

Creates 105,120 linkage values

2.b. **LA2**

Creates 105,120 linkage values

3 **CA**

Signs and encrypts certificates

4 **CA**

Sends encrypted certificates to RA

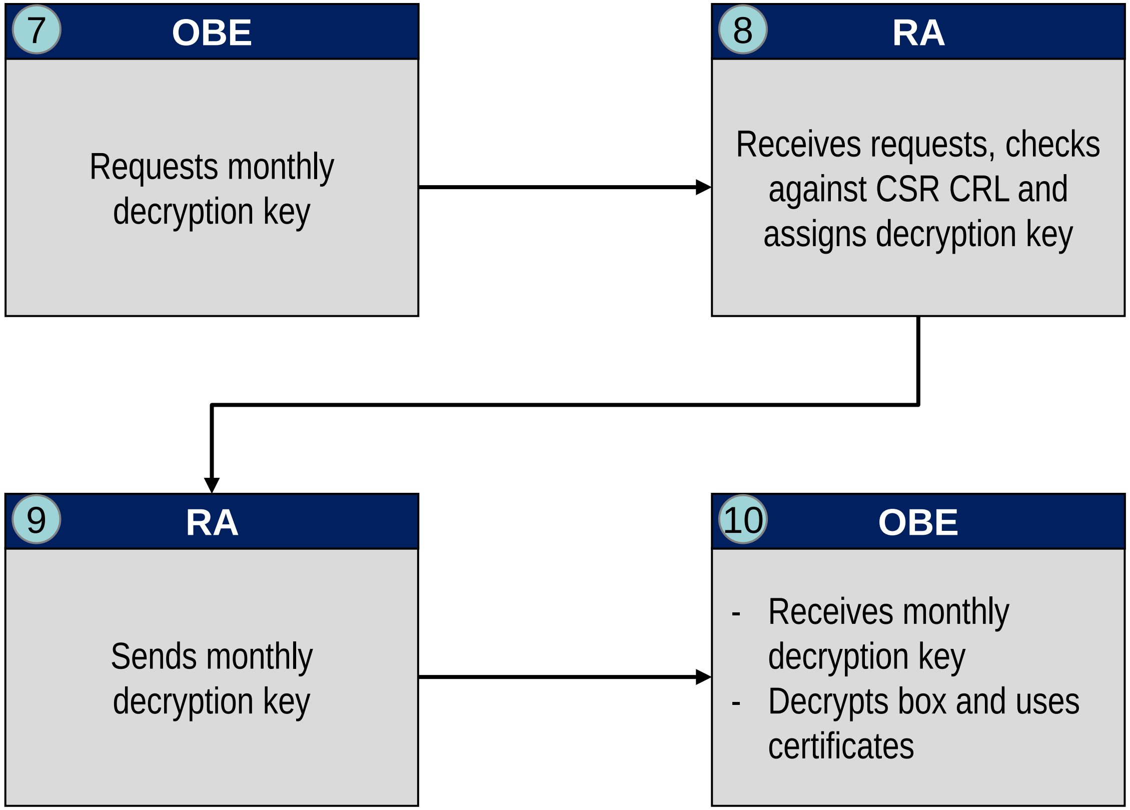
5 **RA**

Receives encrypted certificates, boxes them into 12 sets, and sends annual batch to the OBE

6 **OBE**

Receives annual batch of encrypted certificates

CME Process Flow (Certificate Decryption)


7 OBE

Requests monthly decryption key

8 RA

Receives requests, checks against CSR CRL and assigns decryption key

9 RA

Sends monthly decryption key

10 OBE

- Receives monthly decryption key
- Decrypts box and uses certificates

Security Baselining for CME

PKI Design Baseline

- CMEs feature a separated CA and RA function and the LA functions
- This adds complexity to traditional PKI design

Vulnerability Baseline

- PKI design indicates that no level of vulnerability is acceptable
- Comparative industries protect against vulnerabilities in different ways

ICAO (ePassports)

The International Civil Aviation Organization

- Passive Authentication is the Baseline Security Method
- Advanced Security Methods include Extended Access Control, Data Encryption

Payment Card Industry (PCI)

The PCI Data Security Standard (PCI DSS)

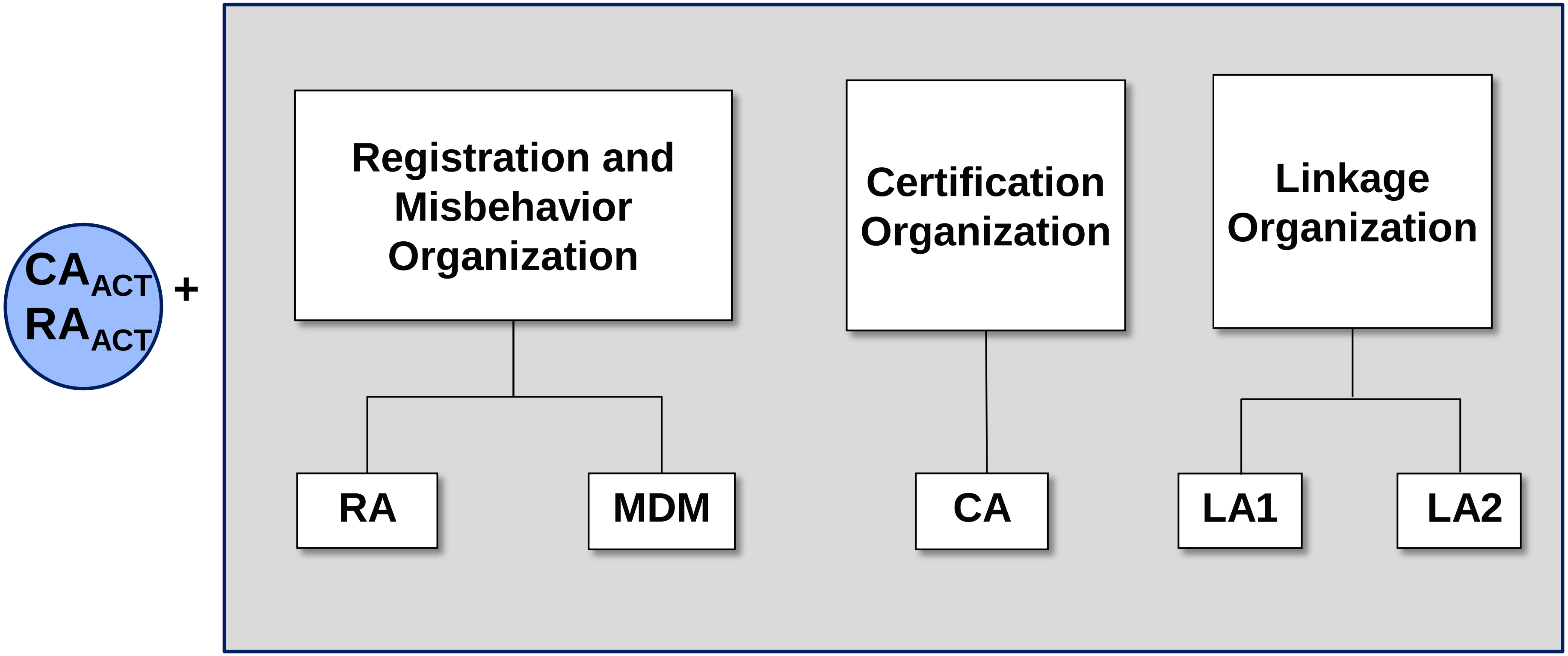
- Routine audits, external vulnerability scans, and specific SW/HW controls
- Merchants with high transaction rates require more security measures

Department of Defense

The Dept. of Defense certificate policy (CP)

- Subscribers have certification practice statements (CPS)
- Can trust outside participants by cross certifying with Federal PKI Policy Authority

Model 1: Registration Authority/Misbehavior Integrated



CA_{ACT} RA_{ACT} +

Registration and Misbehavior Organization

Certification Organization

Linkage Organization

RA

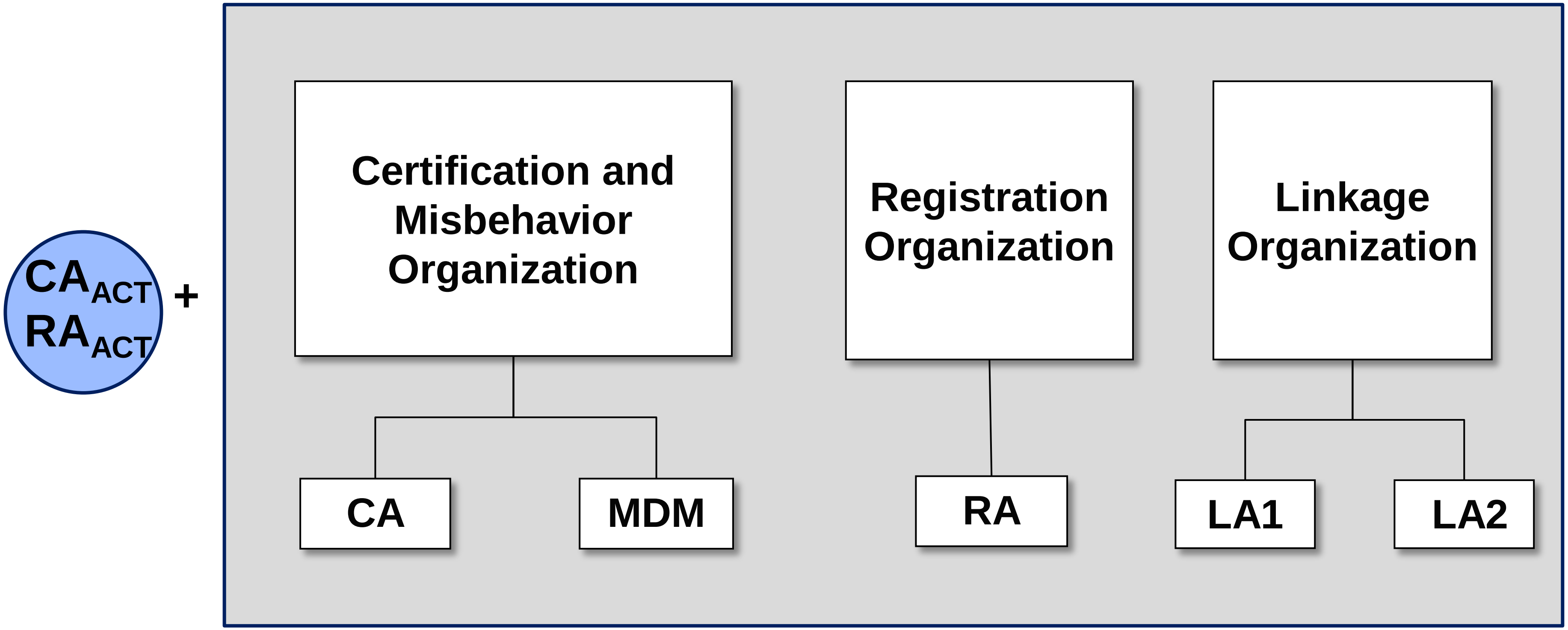
MDM

CA

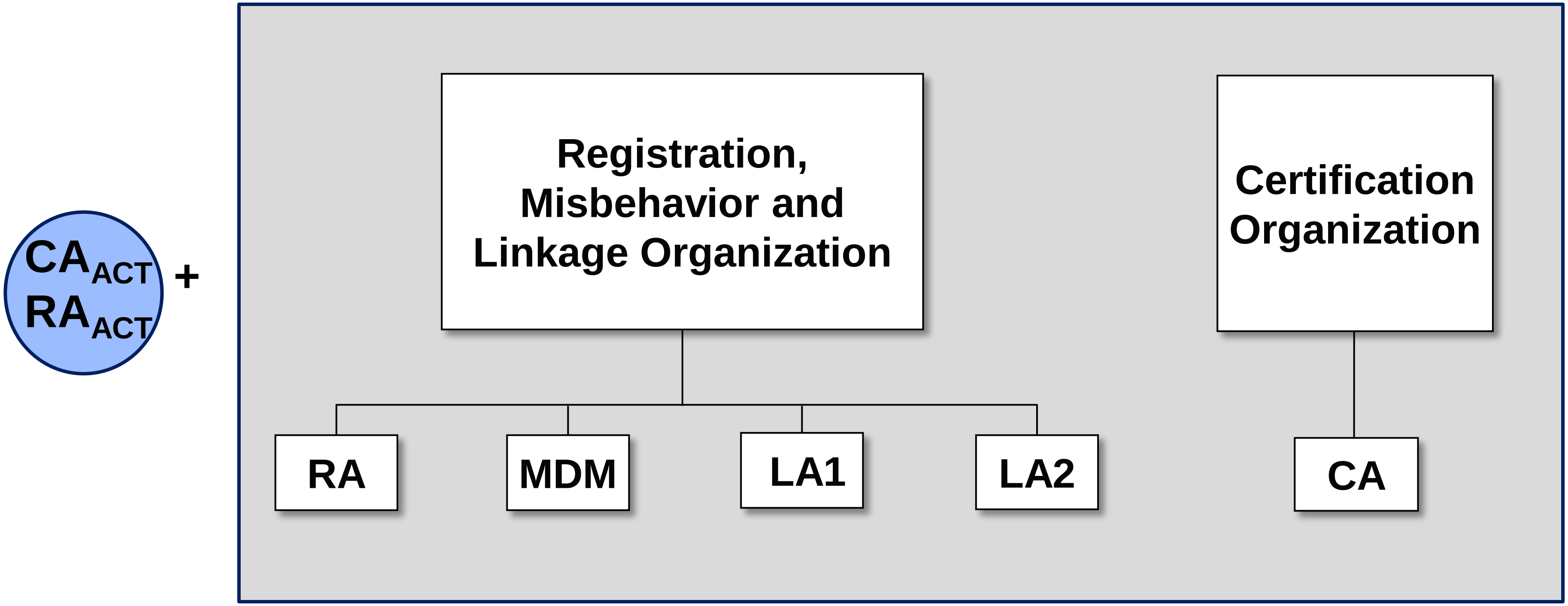
LA1

LA2

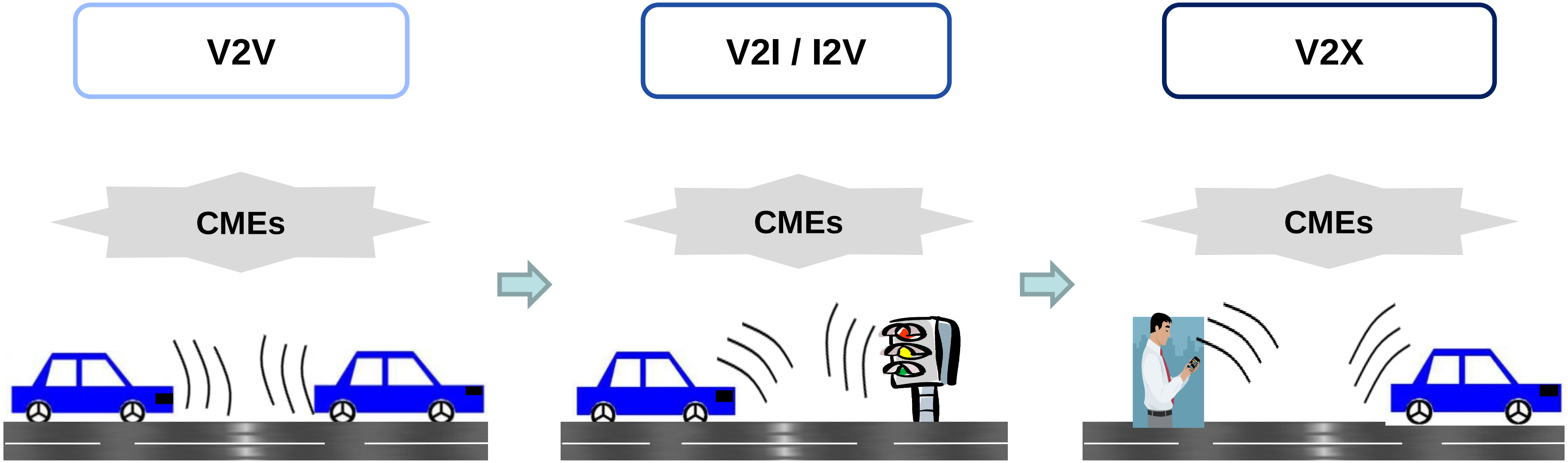
Model 2: Certificate Authority/Misbehavior Integrated


CA$_{ACT}$
RA$_{ACT}$
+
Certification and Misbehavior Organization
CA
MDM
Registration Organization
RA
Linkage Organization
LA1
LA2

Model 3: Registration/Misbehavior/Linkage Integrated


CA_{ACT}
RA_{ACT}
+
Registration, Misbehavior and Linkage Organization
Certification Organization
RA
MDM
LA1
LA2
CA

Connected Vehicle Environments



V2V

V2I / I2V

V2X

CMEs

CMEs

CMEs

- **V2V** communication represents the base level environment
- CMEs' structures may not have to change for future expansion

- **V2I / I2V** communication involve both safety messages and exchanges of data

- **V2X** communication involve the incorporation of devices such as cell phones into the communication system

Personal Privacy Protection and Auditing

- Each industry has standards for security systems that participants are required to abide by
- Audits determine what levels of security breaches are unacceptable
- Some industries require extra security levels based on affiliation

Electronic Voting Systems

- Generally required that ex-convicts are screened to be able to vote
- Real time audit logs ensure vote count accuracy by producing a printout of individual votes without PII for recounts

Electronic Health Records

- Protections such as Wireless Intrusion and Prevention Systems (WIPS) and file integrity monitoring identify and prevent unauthorized data access
- Compliance audits can lead to license revocation/fines

Payment Card Industry

- Payment Card Industry Data Security Standards calls for routine audits, external vulnerability scans, and specific software and hardware controls
- Merchants with high transactions require more security measures and face greater penalties for non-compliance

Physical, Technical, and Procedural Controls

- Controls are implemented in PKI systems to address risk associated with both internal and external threats

Physical Controls

- Address the physical design elements of PKI equipment and security of facilities and stored data
  - Department of Defense

Procedural Controls

- Address the methods by which processes are carried out by the PKI. Other controls (such as personnel controls) were rolled into this category during analysis
  - Federal Bridge Certification Authority

Technical Controls

- Address the specific hardware and software security specifications as well as how certain technical processes, such as those associated with public and private keys, are carried out
  - SAFE-BioPharma
  - CertiPath

Large Scale Implementations

Analog to Digital TV

- Estimated 70-80 million TVs
- Customers who did not switch to DTV would no longer receive channels
- Authorized list of coupon-eligible converter boxes provided by the National Telecommunications Information Administration (NTIA) for DTV transition

Seatbelts

- Mandatory for all vehicles since the mid 1960's
- Drivers who do not participate by using a seatbelt are usually fined
- DOT "Safety incentive grants" for use of seat belts are available to states for having a higher rate of seatbelt usage than the national average and for engaging in innovative projects related to seatbelt safety

Emissions

- Mandatory for all vehicles beginning in 1967
- Drivers without valid emissions inspection stickers can be fined or have their licenses revoked (applies to states that require frequent emission checks)
- Tax credits for drivers of hybrid cars were created by the Energy Policy Act of 2005

CME Oversight Options

Public (Federal) Oversight

- Increased costs
- Increased approvals
- Possible streamlined coordination among dispersed
- Increased resistance
- Difficult to leverage commercial industry and opportunities

Hybrid Oversight

- Combination of public and private standards, regulations, policies, and oversight
- Can leverage the most effective models and funding sources
- Can also be leveraged with state and local options and systems
- May not imply same standards across entire system

Private Oversight

- Must still comply with federal regulations and policies
- More flexibility
- Independent organizations develop standards and practices
- Extensive opportunities for developing commercial applications
- Additional possibilities for investment and funding
- May spur independent economic activity

Approach to Cost Estimation

Challenges and Constraints in Cost Estimation for CMEs

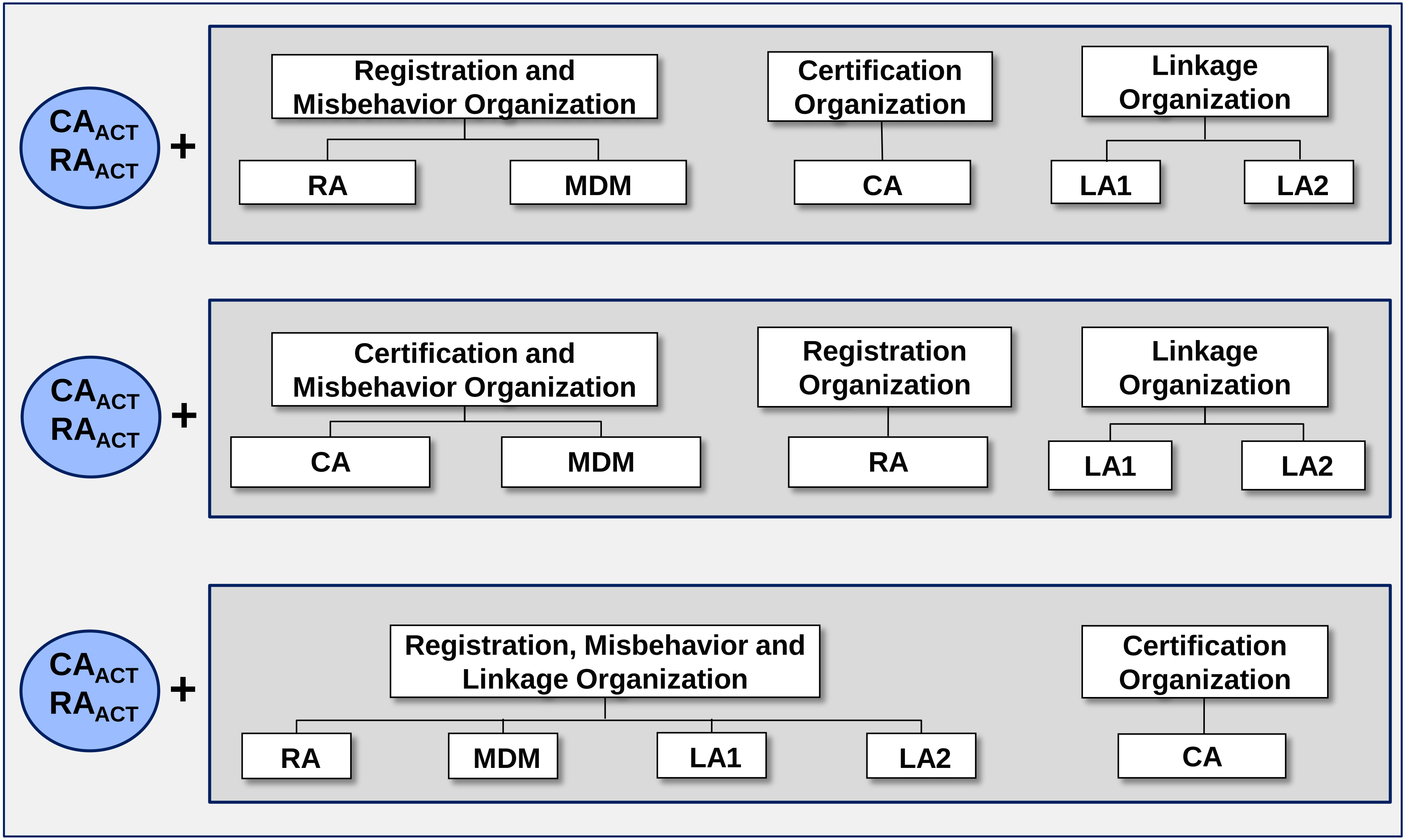
- Size and scope of the program
  - 250 million vehicles at full implementation, five-minute certificates
- Largest PKI set in the world today is ~6.5 million users
- Longest running commercial PKI platform to date has issued 103 million certificates
- Additional security and technical requirements
  - Certificate lifespans require thousands of Hardware Security Modules (HSM) and potentially several hundred thousand servers
- The proposed organizational structures differ largely from current PKI organizations

Cost Elements

Major Cost Elements

- Start-up (design, development, and implementation)
- Annual operation and maintenance
- Auditing security and privacy procedures across all functions and resources
- Software acquisition and maintenance
- Hardware and networking infrastructure
- Secure facilities
- Creation and auditing of policies and procedures
- Management of the certificate lifecycle

CME Organizational Models



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Registration, Misbehavior and Linkage Organization

RA

MDM

LA1

LA2

Certification Organization

CA

Impact of Organizational Models on Cost

- Organizational models may have a limited impact on cost
  - Technical requirements drive software and hardware procurement
  - Combined functions can lead to the sharing of facilities and human resources
  - Cross-training of personnel across functions may be possible within policy, technical, and procedural controls needed

Model 1: RA/MDM Integrated

- RA and MDM could share personnel and facilities costs
- CA and LAs would not realize cost savings

Model 2: CA/MDM Integrated

- CA and MDM would be able to leverage shared personnel
- RA would not realize cost saving efficiencies under this model

Model 3: RA/MDM/LA Integrated

- CA may be able to operate in a virtual environment

Outstanding Issues and Decisions to be Made

Credentialing

Where and how much PII to collect:

- No PII **(policy)**
- PII during Activation (new or existing system) **(policy)**
- PII connected to certificates **(policy)**

Misbehavior

- How malfeasance is identified (global processing) **(technical)**
- Penalties **(policy)**
- What behavior requires suspension vs. revocation **(policy)**

Oversight and Ownership

What will the industry oversight structure be:

- Public **(policy)**
- Private **(policy)**
- Hybrid **(policy)**

Outstanding Issues and Decisions to be Made

Implementation Planning

- Policy decisions over time **(policy)**
- Built in versus after market devices **(policy)**
- Technological requirements **(technical)**
- Roll out strategy – coverage prioritization **(policy/technical)**

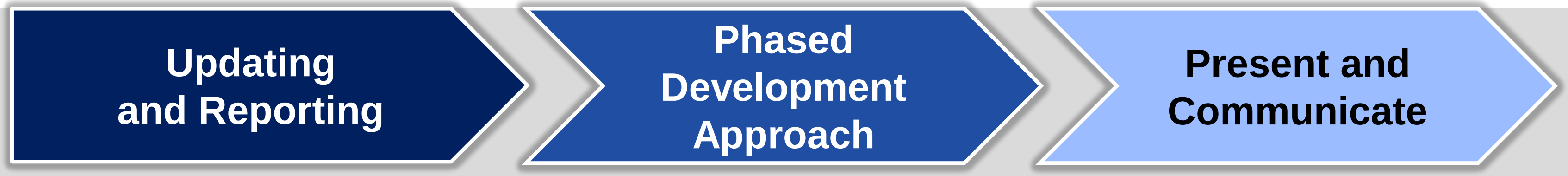
Certificate Policy

- What the policy will say regarding roles, rules governing obtaining certificates, technical and audit requirements **(policy)**

Certificate Length and Download

- Lifespan of certificates is five minutes **(technical)**
- Certificates are downloaded annually **(technical)**

Next Steps



Updating and Reporting

- Incorporate DOT feedback into March 2012 Report
- Develop proceedings of April workshops
- Additional analysis of outstanding questions and topics
- Additional cost model scenarios and analysis

Phased Development Approach

- Collaborate with technical teams developing the approach
- Build in requisite elements to phased roll out model:
  - Security baseline
  - Implementation scenarios
  - Governance models
  - Cost estimates
  - Roles and responsibilities

Present and Communicate

- Update analyses and reports based on feedback
- Evaluate all models and updated scenarios against criteria
- Develop public meeting materials for presentation to stakeholders
- Present findings and analyses to USDOT and external stakeholders