Systems and Technology Guidance

LEVEL 2 TO LEVEL 3

Why Systems and Technology are Important

Use of the appropriate processes for design and implementation of TSM&O systems will ensure that the needs of the region are appropriately addressed, that systems are implemented in an efficient manner, and interoperability with other systems is achieved.

Improvement Target

<table>
<thead>
<tr>
<th>From</th>
<th>Systems engineering employed and consistently used for ConOps, architecture and systems development (L2)</th>
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<tbody>
<tr>
<td>To</td>
<td>Systems and technology standardized, documented and trained statewide, and new technology incorporated (L3)</td>
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<tr>
<td>By</td>
<td>Developing tools, procedures and training to support standardized systems engineering process</td>
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Key Sub-dimensions

- Regional Architecture
- Systems Engineering/Testing/Validation
- Standards/Interoperability
Regional Architecture Action Plan (L2 to L3)

Strategy Summary

Monitor ongoing system developments as well as changing needs to ensure that the architecture is both followed and updated as needed.

Key Actions

<table>
<thead>
<tr>
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<th>Action</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Develop procedure to identify changes in plans for TSM&amp;O system development including new systems, maintenance, upgrade and replacement of existing systems, and/or other changes.</td>
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<td>B</td>
<td>Develop an advisory procedure to review submitted changes and recommend modifications to ensure conformance with the Regional Architecture.</td>
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<tr>
<td>C</td>
<td>Develop and execute memoranda of understanding among all participating agencies.</td>
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</tr>
</tbody>
</table>

**ACTIONS**

**Action A:** Develop procedure to identify changes in plans for system development including new systems, maintenance, upgrade and replacement of existing systems, and/or other changes.

Rationale: The TSM&O Regional Architecture is a living plan that must be continuously updated as individual systems in the region are planned, designed, implemented and upgraded. It is necessary to continuously monitor these activities to assess their impact on the regional architecture.

A.1 Review needs for updating existing architecture in terms of systems, technology, procedures and role changes since the original architecture.

A.2 Using the Architecture Review Committee, develop procedures in the form of required reports and presentations that provide the information it needs to ensure that the Regional Architecture is up-to-date and relevant.

A.3 Focus on use of systems architecture regarding the complete range of ongoing systems additions, modifications, and maintenance to ensure concepts of operations, new systems procedures, roles and interoperability are maintained for full effectiveness.

Responsibility and Relationships: Periodic reviews are the responsibility of the Architecture Review Committee which is convened by the Architecture Lead. Both project personnel and managers of organizations within the region that are stakeholders in the architecture development and implementation are involved.
**Action B: Develop an advisory procedure to review submitted changes and recommend modifications to ensure conformance with the Regional Architecture**

**Rationale:** During its periodic meetings, the Architecture Review Committee must review changes submitted by the individual agencies submitting their updated plans.

- **B.1** Assess the impact of these changes on the Regional Architecture as it affects interconnections, interoperability and standards.

- **B.2** Provide (when necessary) feedback to the developers of the individual agencies, requesting conformance with regional standards and other regional needs.

- **B.3** Update the Regional Architecture to reflect these changes.

**Responsibility and Relationships:** Periodic reviews are the responsibility of the Architecture Review Committee which is convened by the Architecture Lead. Both project personnel and managers of organizations within the region that are stakeholders in the architecture development and implementation are involved.

**Action C: Develop and execute memoranda of understanding among all participating agencies**

**Rationale:** Part 940 of the Code of Federal Regulations—Intelligent Transportation System (ITS) Architecture and Standards—specifies that projects entering the design phase must follow a systems engineering approach commensurate with the project scope and requires the identification of participating agencies’ roles and responsibilities including the execution of memoranda of understanding among the participants.

- **C.1** Using the Architecture Review Committee, define operational and funding responsibilities and agreement to follow applicable regional standards.

- **C.2** Conduct a review of systems and technology interoperability regarding voice and data across all participants.

- **C.3** Create and execute memoranda of understanding among all agencies participating in the regional integration of their systems.

**Responsibility and Relationships:** The Architecture Review Committee, which is convened by the Architecture Lead, representing organizations within the region that are stakeholders in the architecture development and implementation.
Examples/References:

- Part 940 of the Code of Federal Regulations (CFR) requires the development of a regional architecture. It requires all projects receiving federal funding to conform to the approved architecture. It indicates that: "If the final design of the ITS project is inconsistent with the regional ITS architecture, then the regional ITS architecture shall be updated as provided in the process defined in §940.9(f) to reflect the changes." Many agencies have determined that periodic updates of the architecture will minimize the likelihood that projects will not conform to the architecture. See: http://law.justia.com/us/cfr/title23/23-1.0.1.11.47.html
- "National ITS Architecture": http://www.iteris.com/itsarch/
- "Turbo Architecture: A Tool for Leveraging the National ITS Architecture": http://www.tfhrc.gov/pubrds/mayjun00/turbo.htm
- An online course that provides an introduction to the National ITS Architecture is available at http://www.citeconsortium.org ("Introduction to the National ITS Architecture")
- A good example of a memorandum of understanding can be found at: http://lawrenceks.org/web_based_agendas/2009/06-02-09/06-02-09h/pl_tac_approved_ldcmpo_cooperative_agreement.pdf
- The requirements for a memorandum of understanding are defined by USDOT in its Code of Federal Regulations Part 940, ITS Architecture and Standards: http://law.justia.com/us/cfr/title23/23-1.0.1.11.47.html
Systems Engineering/Testing/Validation Action Plan (L2 to L3)

Strategy Summary

Develop tools and procedures to support the systems engineering process including testing and validation

Key Actions

| A | Invest in tools and training for maintaining configuration management during system development |
| B | Invest in required tools and equipment for testing and validating system operability |
| C | Create a Configuration Control Board (CCB) to monitor TSM&O system development, testing and validation process on a continuing basis |
| D | Develop procurement standards to ensure that all contractors selected for system design, implementation, operation and maintenance are fully qualified to execute the systems engineering process |
| E | Develop process for maintaining and improving staff capabilities including maintenance of contact with best available IT, systems, communications and device technology |

ACTIONS

Action A: Invest in tools and training for maintaining configuration management during system development

Rationale: As ITS and Emergency Management systems develop and are augmented or changed, it is essential to document and manage the configuration of the functional and physical attributes of software in order to perform systematic control of changes for the purpose of maintaining software integrity and traceability throughout software development life cycles.

A.1 Identify required tools (primarily configuration management software) and training required to facilitate configuration management during the system development process.

A.2 Acquire the required tools, including needed training, to ensure their effective use.

A.3 Ensure that all individuals participating in the system development process have appropriate training and access to the required tools. This includes provision of appropriate training for maintenance personnel. The appropriate level of familiarity and training should also be provided to program management personnel.
A.4 Ensure continued use of the tools as the system transitions from implementation to maintenance as a standard operating procedure.

**Responsibility and Relationships:** Senior management personnel overseeing system implementation are responsible for budgeting for the acquisition of the tools, and ensuring their use and involving program managers and agency technical staff.

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**Action B:** Invest in required tools and equipment for testing and validating system operability

**Rationale:** Testing and validation are processes for verifying that a product or system meets specifications and that it fulfills its intended purpose.

B.1 Identify required hardware and software tools, and training required to facilitate validation and testing of system capabilities and operation during the system development process.

B.2 Acquire the required tools, including needed training, to ensure their effective use.

B.3 Ensure that all individuals participating in the system development have appropriate training and access to the required tools.

B.4 Ensure continued use of the tools as the system transitions from implementation to maintenance. This includes provision of appropriate training for maintenance personnel.

B.5 Consider the use of an independent verification and validation service.

**Responsibility and Relationships:** Senior management personnel overseeing system implementation are responsible for budgeting for the acquisition of the tools, and ensuring their use and involving program managers and agency technical staff.

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**Action C:** Create a Configuration Control Board (CCB) to monitor TSM&O system development, testing and validation process on a continuing basis

**Rationale:** A Configuration Control Board is composed of technical and administrative representatives who are empowered to approve all engineering and architectural changes being made to a system during its implementation, operations and maintenance.

C.1 Identify Configuration Control Board membership.
C.2 Schedule monthly meetings for CCB.

C.3 Develop change form with description of the change, justification, and estimate of time and cost impacts.

C.4 Develop procedure to precede CCB meetings with an agenda and submissions of change forms.

C.5 CCB meets to approve or disapprove requested changes.

Responsibility and Relationships: Members of the CCB are at a level within the participating organizations to authorize the use of additional funds if required to implement the recommended changes. Project managers from both the Contractor and the Agency must be included.

Action D: Develop procurement standards to ensure that all contractors selected for system design, implementation, operation and maintenance are fully qualified to execute the systems engineering process

Rationale: Qualifications of contractors providing hardware, software and systems integration services must be reviewed to determine the quality of the products to be provided. The Capability Maturity Model (CMM) is a five-step rating that is used to evaluate the effectiveness of an organization’s software development process.

D.1 Meet with appropriate procurement personnel to ensure that the requirements for a specific CMM rating can be included in the agency’s evaluation of proposers.

D.2 Working with appropriate experts, select a CMM level on which to base contractor selection.

D.3 Develop model procurement specifications to be included in all procurements related to contractor qualifications.

D.4 Working with procurement personnel, identify alternative types of procurement (low-bid, consultant, system manager, and design-bid) to be used in connection with various types of high-tech projects.

Responsibility and Relationships: This effort should be led by agency’s project manager. Participants include procurement personnel and may require participation by senior management.
Action E: Develop process for maintaining and improving staff capabilities including maintenance of contact with best available IT, systems, communications and device technology

**Rationale:** ITS technology and systems for TSM&O are developing rapidly, often independently in other jurisdictions. It is important to stay abreast of best practice.

**E.1** Identify key staff members responsible for implementation, operations and maintenance of technology associated with operations.

**E.2** Establish budget allowing staff members to participate in appropriate conferences and meetings.

**E.3** Encourage participation on appropriate technical committees of national associations and subscribe to appropriate technical journals for review by relevant personnel.

**E.4** Develop approach to support training and capability improvement for IT staff.

**E.5** When possible request presentations from manufacturers and consultants regarding technical advances in their areas of specialization.

**Responsibility and Relationships:** Senior management must provide needed budget for tracking of new technology, and encouraging participation by key staff members in professional and technical activities.

**Examples/References:**

- Configuration management tools were used extensively during the development of the Maryland Coordinated Highways Action Response Team (CHART) ATMS (Advanced Traffic Management) system. These tools were used to provide the traceability needed to ensure that all requirements were included in the specifications, and subsequently tested. The tools were invaluable when applied to a system such as CHART, which had several hundred requirements that must be tracked. This can be found at: [http://www.chart.state.md.us/](http://www.chart.state.md.us/)

- A variety of tools may be required to support the validation in addition to the configuration management tools. For example, a traffic management system is often required to process data received from conventional traffic detectors (radar, inductive loop, etc.). Validation testing must ensure that data is being correctly received and processed from these detectors. One tool that has been developed to support these tests is a detector simulator, which uses a simulation program to model traffic flow, and then translates the traffic flow into detector actuations, which in turn are transmitted to the traffic management system under test. A good summary of the configuration management tools that are used to identify the tests to be performed based on the system requirements, can be found at: [http://www.daveeaton.com/scm/CMTools.html](http://www.daveeaton.com/scm/CMTools.html)

- A Configuration Control Board (as described by the reference) was established during the development of the Maryland CHART System. This $30 million development project avoided
schedule slippage and major cost overruns through the efforts of the CCB, which required that all changes (no matter how small) had to be documented and submitted to the Board for approval prior to their implementation. The CCB is described in the following reference: “System Engineering for Intelligent Transportation Systems”: http://ops.fhwa.dot.gov/publications/seitsguide/index.htm

- The use of a CMM level as a criterion for contractor selection (this was not the only criterion) was successfully implemented by the Louisiana Department of Transportation and Development (DOTD) in its procurement of a statewide traffic management system by limiting offerers to a few highly qualified systems integration firms. It is described in the online course offered by the Consortium for ITS Training and Education (CITE), titled “Introduction to Systems Engineering”: http://www.citeconsortium.org

- Organizations that serve as sources of information regarding advances in the field of management and operations include:
  ✓ Institute of Transportation Engineers (ITE): http://www.ite.org/
  ✓ ITS America: http://www.itsa.org/
  ✓ American Association of State Highway and Transportation Officials (AASHTO), subcommittee on Systems Operations and Management (SSOM): http://ssom.transportation.org/Pages/default.aspx
  ✓ Transportation Research Board (TRB): http://www.trb.org/Main/Home.aspx

- Publications that track new technology include:
  ✓ ITE and TRB reports
  ✓ Thinking Highways: http://www.thinkinghighways.com/
  ✓ Traffic Technology International: http://www.ukipme.com/mag_traffic.htm
  ✓ ITS International: http://www.itsinternational.com/
Standards/Interoperability Action Plan (L2 to L3)

Strategy Summary
Coordinate application of TSM&O standards and interoperability statewide/regionally and for planning

Key Actions

- **A** Develop a five-year plan for the implementation of systems and standards needed to facilitate statewide/regional interoperability
- **B** Analyze database standards to ensure their uniform application in a manner that permits seamless exchange of information among agencies
- **C** Develop protocols and systems (if needed) to permit regional visibility of the status of transportation systems managed by individual participating jurisdictions

**ACTIONS**

**Action A:** Develop a five-year plan for the implementation of systems and standards needed to facilitate statewide/regional interoperability

**Rationale:** Standards developed for the ITS industry are used for harmonizing data communications, database exchanges, and information displays among diverse systems. The appropriate use of these standards will ensure the ability for interoperability of various systems, as well as simplifying interchange of field and central system hardware and software.

**A.1** Develop a five-year plan for the standardization of systems (both existing and planned) within the region in order to achieve desired levels of interoperability.

**A.2** Identify the systems included in the plan, and provide a precise definition of the desired level of interoperability for the region. Identify needed standards, and provide a phased implementation plan and budget for the modification of the systems included in the plan to achieve these standards.

**A.3** Estimate anticipated regional benefit of the regional standardization.

**A.4** Ensure input of plan into programming, budgeting and project planning processes.

**Responsibility and Relationships:** The development of the plan is the responsibility of the Architecture Review Committee and should involve all agencies within the region involved in the development of high technology systems. Outside technical assistance may be used as necessary.
Action B: Analyze database standards to ensure their uniform application in a manner that permits seamless exchange of information among agencies

**Rationale:** While database standards currently exist for transportation applications, they include many alternative ways of representing the same data.

**B.1** Analyze the available database standards to arrive at a single representation for each data item required for regional interoperability.

**Responsibility and Relationships:** The development of the standards is the responsibility of the Architecture Review Committee and should involve all agencies within the region involved in the development of high technology systems. Outside technical assistance may be used as necessary.

Action C: Develop protocols and systems (if needed) to permit regional visibility of the status of transportation systems managed by individual participating jurisdictions

**Rationale:** A protocol is a convention or standard that controls or enables the connection, communication, and data transfer across a network between computing endpoints, including the operational rules that dictate the information that can be shared among agencies and released to the media and general public.

**C.1** Determine standards needed to support seamless interchange of transportation system status including incidents, traffic flow and mass transit operations.

**C.2** Develop protocols required for information sharing.

**C.3** Allocate resources for long-term support of the operation and maintenance of the regional system.

**C.4** Implement systems and/or software as needed to provide integrated seamless displays of transportation status regionally.

**Responsibility and Relationships:** The development of the protocols is the responsibility of the Architecture Review Committee and should involve all agencies within the region involved in the development of high technology systems. Outside technical assistance may be used as necessary.
Examples/References:

- The Minnesota DOT sponsored a regional workshop to initiate the process of regionally planning for the use of standards. The workshop brought together the potential users of standards within the state of Minnesota with the objective of increasing awareness of their benefits and opportunities for application. This workshop provides a mechanism for initiating the development of a standards review activity: [http://ntl.bts.gov/lib/jpodocs/brochure/9r701!.pdf](http://ntl.bts.gov/lib/jpodocs/brochure/9r701!.pdf)
- The standard dealing specifically with the subject of message sets and data dictionaries is AASHTO-ITE TM 3.0, Standards for Traffic Management Center-to-Center Communications: [http://www.standards.its.dot.gov/Factsheets/Factsheet/17](http://www.standards.its.dot.gov/Factsheets/Factsheet/17)
- An overview of the ITS standards program can be found at: [http://www.standards.its.dot.gov/Factsheets/All](http://www.standards.its.dot.gov/Factsheets/All)
- An example of one such regional development is the Regional Integrated Traffic Information System (RITIS) developed for the Washington DC region. RITIS provides seamless displays of transportation system status within the DC region and disseminates this information to local transportation agencies and the media. RITIS is described at: [http://www.cattlab.umd.edu/?portfolio=ritis](http://www.cattlab.umd.edu/?portfolio=ritis)