NATIONAL ADVANCED MOBILITY CONSORTIUM

Success Factors for Modular Open System Architectures

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Agenda

- Interoperability & Modular Open Systems Architectures
  - Potential benefits for government systems
- Criteria for success for government MOSAs
  - (very brief) Lessons learned from efforts such as VICTORY
- NAMC robotic & autonomous system (RAS) interop. team
  - Purpose, intent, problems addressed

- Take-away messages (bottom line up front)
  - MOSA promotes interoperability (but not “free” & not “magic”)
  - Lessons learned from efforts provide a notional MOSA roadmap
  - NAMC team recommended a MOSA strategy for RAS (next talk)

Keys to success: Scoped **architecture** definition, clear **specifications** & acceptance criteria (**verifiable agreements**), maturation & change management **processes**, supporting **tools,** strong **organization** with **objectivity** and **trust** of COI

Interoperability

- **Interoperability**: the ability for "entities" to be interchanged, repurposed, or put together to form different systems.
  - Entities: may be systems, sub-systems, hardware components (boxes, devices, sensors), software components (services, apps, modules)
- **Interoperation**: interactions between interfaces, many types
  - **Physical**: "plugging together" mechanical, electrical, power interfaces
  - **Logical**: exchanging data (transport to application layers), sharing common semantics, exposing configuration, control, health interfaces
- Variables: which modules are to be interchanged, in what contexts, by whom, and with what kind of integration effort
- There's that word… ***architecture***…
  - Defines the common language; breakdown into functions, entities and interfaces; constraints/rules; design patterns/structures, use cases
    - Line between architecture and design can be murky & controversial

MOSA is a ***kind*** of architectural approach that promotes interoperability

Modular Open System Architectures

- **Modular**: modules & interfaces that can be "recomposed"
- **Open**: function and interface details are provided openly to a community, and if ***matured*** & ***standardized*** can benefit community
- **Benefits**: MOSAs can promote ***competition***, ***reduce*** life-cycle ***costs*** (maintenance, upgrade, extension), decrease ***cycle times***, create an environment of ***innovation***, and allow end-user ***flexibility***
- **Difficult news**: market forces do not automatically drive toward government open architectures – it requires intervention
  - Government applications represent tiny markets compared to commercial
  - Commercial model (open standards "on their dime") does not work as well
  - Government specific requirements; information assurance, security, safety, surety, harsh environments, specialized behaviors
- **Good news**: It is still very much worth it! A roadmap will help…

Succeeding at MOSA for Government Systems

- Series of MOSA projects has revealed ***common threads***
  - Vehicular Integration of C4ISR/EW Interoperability (VICTORY)
  - Integrated network enhanced telemetry (iNet)
  - Various other commercial and defense efforts (ask me)
- Collected "lessons learned" can provide a roadmap
- Pathway to success; three major criteria
  - Properly scoped ***architecture*** aligned to the problem domain
  - The right ***technical artifacts*** to support the user community
  - A strong ***organization*** to oversee the work and execute ***processes***

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Properly Scoped Architecture

- Architecture: ***Functional*** & ***structural breakdown***, ***interfaces***
  - Identify entities standardization (functions, interfaces)
  - ***Scope***; take on problems that can be solved (and which need solving)
- Keys:
  - A government champion holds the ***vision,*** and garners input from and respect of the ***community of interest*** and ***subject matter experts***
  - **Prioritizing** goals / problems, identify **supporting architectural elements**
- Avoid pitfalls
  - Overreaching (trying to solve too many problems at once)
  - Identifying interfaces for standardization not relevant to goals
  - Assuming or selecting implementation technologies too early
  - Believing a technology will solve integration problem, as opposed to discipline in architecture, interface definitions & verifiable agreements

Architect's Prayer: Grant me the serenity to accept the structures and interfaces I cannot control, the courage to standardize those that I can, and the wisdom to know the difference

The Right Technical Artifacts

- Artifacts that will promote successfully use of a MOSA
  - Architecture and specification (standard) documentation
    - Enough clarity and technical detail, with well-understood options (choices of designers)
    - Matured (validated) before being deemed “ready” for use
  - Reference implementations to be used as a starting point
  - Acceptance test procedures and documentation methods
  - Tools (to test, verify, and document compliance / conformance)
- Keys: **clear specifications** & **testable acceptance criteria**, validated specifications, tools for **compliance testing** & **documentation**
- Avoid pitfalls:
  - Allowing unconstrained options, or loopholes – lessens interoperability
  - Not involving practitioners (SMEs), or ignoring existing standards
  - Ambiguity, lack of clarity, conflicts, under or over specification
  - Not maturing specifications, letting users find problems
  - Selection of technologies inappropriate to the environment / use case

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A Strong Organization to Execute Processes

- Roles needed
  - **Champion**: government lead holding the vision
  - **Standards organization**: standards body or consortium
    - Hosts, organizes, publicizes, and moderates the working groups
  - **Government steering group**: stakeholders / COI leaders
    - Make policy, approve direction, and provide funding
  - **Commercial representation**: vendors and integrators who support the effort
  - **Technical support / execution**: experts in MOSA and standards to execute processes
    - Lead working groups / task teams, collect and collate inputs, formalize docs, manage change, validate and mature specifications, develop reference impl., compliance verification tools, training material, & demos
  - **Outreach / Marketing**:
    - Garner support, educate COI, assist programs with adoption, get input from COI
  - **Certification Authority:** (optional / controversial)
- Keys: independence/objectivity, trust, & enforceable commitments
- Avoid pitfalls:
  - Relying too heavily on volunteer (unpaid) labor for critical tasks
  - Perceived conflict of interest in the execution team
  - Not listening closely to the COI and SMEs
  - Not executing due diligence (validation/maturation, compliance tests, etc.)

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NAMC RAS Interoperability Team

- Task: recommend a strategy for transitioning an existing specification (the IOP) into use in the practice of ground-based robotics and autonomous systems in order to obtain interoperability
- Work product: strategy document
  - Define scope and goals (e.g. interoperability)
  - Evaluate options: standards management and business model
  - Recommend a management plan for the IOP standards
  - Recommend a Business model
    - How programs should write requirements against the standards
    - How providers should make claims of “compliance”
    - How compliance should be tested and verified
- Next discussion describes the project and recommendations

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Conclusions

- Take-away messages
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Backup Slides

Succeeding with Architecture, Frameworks, and Standards

- Question: how do you create a “successful” standard?
  - Architecture
  - Framework
  - Operating Environment

- Lessons learned
- Pitfalls

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Representative SwRI Efforts

- SwRI has had significant experience in developing architectures, frameworks, and standards
  - Boeing 787 flight test system integration
    - Multi-vendor environment, high performance
  - iNet: Military flight test system integration
    - Joint Navy, Air Force, and Army "architecture"
  - VICTORY: C4ISR/EW and platform integration
    - Army ground vehicle electronics integration with large number of stakeholders
  - Others: DARPA MoBIES and AVM (ongoing)

- We have refined an overall approach and set of guidelines for success in architecture and standards development
  - We feel these can be generalized and applied to other efforts

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Philosophy

- The difficult problem: integrating systems of systems, where the whole is greater than the sum of its parts, and no individual player can solve the entire problem

- Lesson learned through practice: With large, complex systems, success has more to do with creating an environment of trust, open exchange of ideas, and consensus than it has to do with new technology, language, tools, and specific processes

Keys to Success: Architecture

- Define the “architecture” clearly first
  - Identify clearly the decomposition of systems, boundaries, and what is to be “standardized” and what is not
  - Define scope: identify what you are and are not solving
  - Define common language: develop (and maintain) a non-ambiguous, agreed upon set of terms (taxonomy). Ensure that the terms are used consistently in all meetings and documents
- Maintain the architecture definition
  - Things will change, but document them well
- Avoid pitfalls
  - The language and tools you use to write down the architecture is not as important as the content

Keys to Success: Organization

- Organization
  - A “champion” (government) who holds the vision, work interactively with “core team” to define architecture and set up organization
- Independent, but talented support team
  - Trust is key, so the support team must not have any perceived “stake” in the decisions, or profit in any way from the outcome
  - The best standard defined by a vendors will be suspect
  - Support team must be able to be contractually held to deliverables / deadlines
  - Specifications will be facilitated by the core team, but defined by domain experts for each type of interface
- Avoid pitfalls:
  - Include practitioners in the discussion, and listen to their experience
  - Do not be “hands off” in specification development. Engage in and understand the technical details
  - Plan cost and schedule realistically

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Keys to Success: Trust

- Environment of trust
  - Ensure that all have access to the same information (a common portal or document base)
  - Hold "open" (with proper access) meetings with documented minutes and actions
  - Ask opinions in open environment
- Consensus process
  - Perhaps the most difficult aspect, consensus can only be achieved if all parties feel heard, and you are willing to be flexible without sacrificing your vision
  - There is no "formula" for consensus, but you know it when you get it
- Avoid pitfalls
  - Do not let a single vendor or organization define specifications in closed settings, then "pull them out of the hat"

Keys to Success: Specifications

- Concentrate on agreements, not technology
  - Resist the urge to create or find a new technology to solve the problem. Success is more about trust and agreements between stakeholders than about technology
  - Patience: engineers want to start coding, but the specification (design) must come first
  - Good enough and well understood trumps optimized
- Define interface specifications
  - Information exchanges: first define data content and functions (before format encoding, protocol): Get the logical aspects down first, then move to details
  - Specify as little internal component behavior as possible to allow for innovation
  - Listen to domain experts, and put together “task teams” guided by core team to solve problems
  - Data models are important, and must be non-ambiguous
- Avoid pitfalls
  - Be wary of unproven tools and techniques
  - Concentrate on specifications and maturation, not new technology

Keys to Success: Process

- Validation: quality control on specifications
  - Build a "validation" step into the process
  - Have a individuals who did not write the specifications develop against the first revision, and provide formal feedback
  - Provide validation results to everyone, including source code (do not allow proprietary implementations for validation)
  - "Mature" specifications based on validation

- Verification: determination of compliance
  - Develop "compliance test procedures" as part of the process (requirements map to test criteria)
  - Further scrutinizes, matures specifications

- Avoid pitfalls
  - Ambiguity is your enemy, but so is over-specification
  - Finding the balance is difficult, but key

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Keys to Success: Take-Aways

- Architecture
- Organization
- Trust
- Consensus
- Agreements on interfaces
- Mature specifications through validation
- Plan for verification and compliance testing