

# Live, Virtual, Constructive Architecture Roadmap Implementation (LVCAR-I) - Improved Interconnectivity Using Gateways/Bridges

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The Johns Hopkins University  
Applied Physics Laboratory  
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**APL**  
*The Johns Hopkins University*  
APPLIED PHYSICS LABORATORY

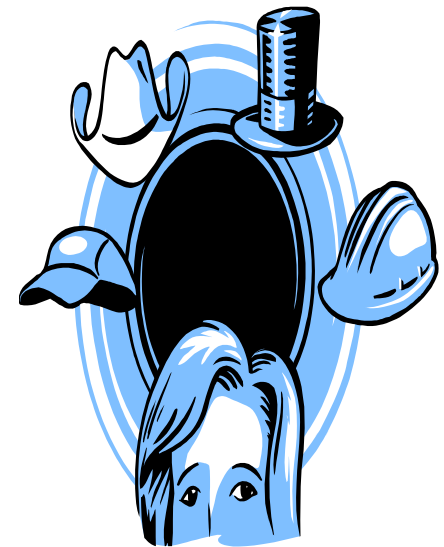
# LVCAR-I Drivers



Growing Demand for  
LVC Interoperability

Redundancy of  
Tools, Gateways &  
Repositories

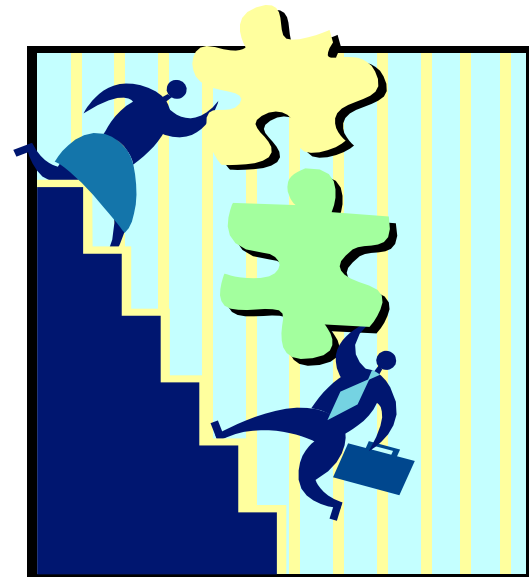
Numerous, Parallel  
Architectures  
(HLA, DIS, CTIA, TENA)



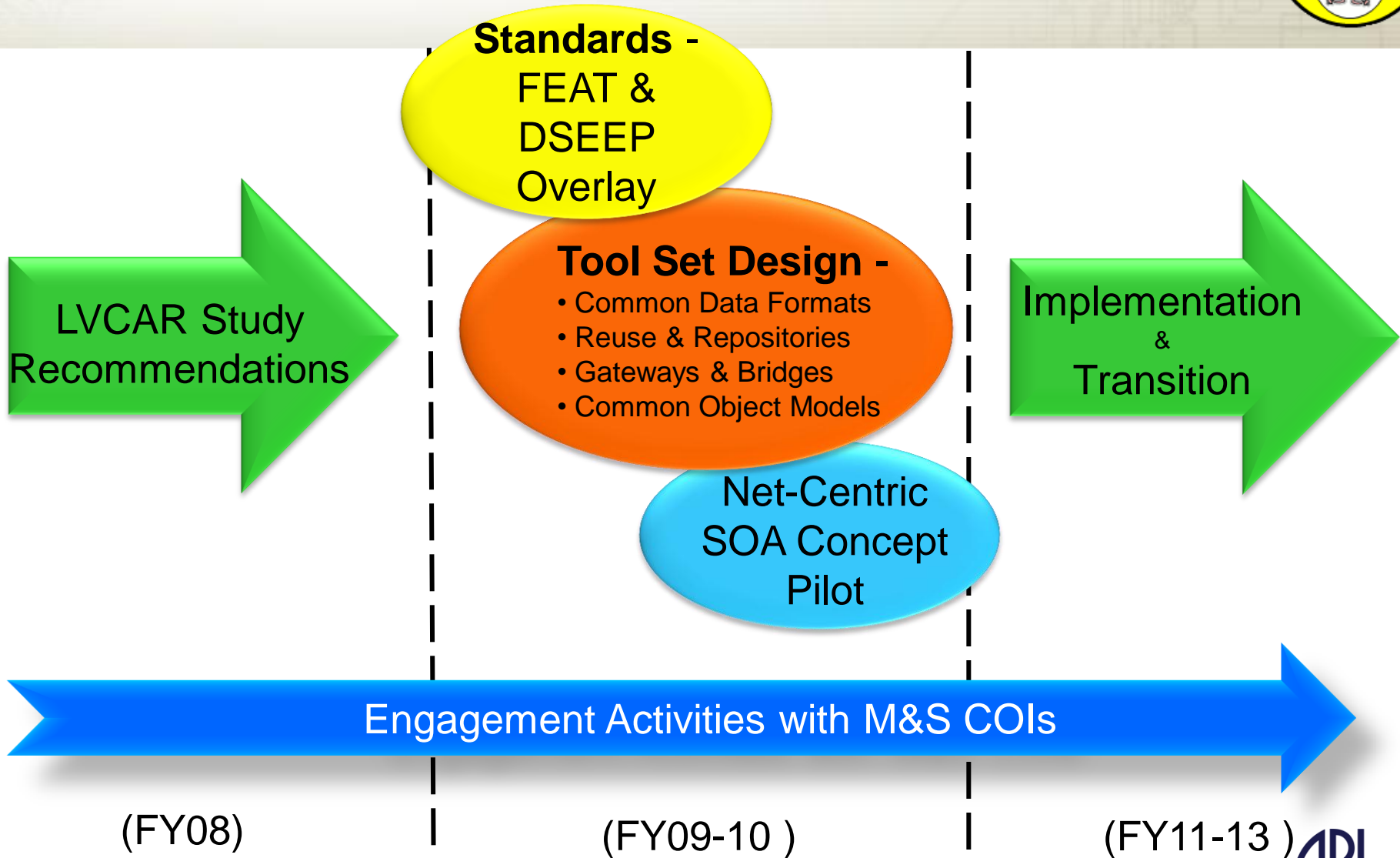
# LVCAR Study Framework



- ***Purpose:***  
“Develop a future vision and supporting strategy for achieving significant interoperability improvements in LVC simulation environments.”
  
- ***Focus:***
  - Technical Architecture
  - Business Models
  - Standards Evolution
  - Management Process
  
- ***Precepts:***
  - Do no harm
  - Interoperability is not free
  - Start with small steps
  - Provide central management



# LVCAR Progression



# Gateways Background



- **Simulation is a critical enabler for system acquisition programs, providing vital capabilities for such functional disciplines as analysis, test, and training**
- **The advent of modern networking technology and the development of supporting protocols and architectures has led to widespread use of distributed simulation**
  - **Facilitates efficient use of existing M&S assets**
- **The number of distributed simulation applications that include multiple simulation architectures and Simulation Data Exchange Model (SDEM) representations are increasing**
- **Gateways provide the most widely used means of addressing interoperability concerns in multi-architecture LVC environments**

# Gateway Challenges



- **Despite the many documented success stories associated with the use of gateways to facilitate LVC interoperability, there are also some significant issues that impact technical, schedule, and cost risk**
- **Examples of known gateway issues include:**
  - **No central “marketplace” of gateways**
    - **Few mechanisms for user to determine what reuse opportunities are available**
    - **No mechanisms for direct comparisons of gateways**
    - **Integrators committing to building their own**
  - **Gateways built for specific needs**
    - **Increased intellectual expenditure on ad hoc solutions**
    - **Not built for reuse/not built for extensibility**
    - **Extensive duplication of existing gateway capabilities**
  - **Broad proliferation of gateways**
    - **Redundant maintenance costs**
  - **Developer or integrator lock-in**
    - **Expensive to exchange/upgrade/replace gateways**
    - **Increased lifecycle costs**



# Addressing Gateway Challenges

- **The Live-Virtual-Constructive Architecture Roadmap (LVCAR) was established in the spring of 2007, continuing for approximately sixteen months**
  - **DoD-sponsored**
  - **Intended to examine the differences among the major simulation architectures from a technical, business, and standards perspective, and to develop a time-phased set of actions to improve interoperability within multi-architecture simulation environments in the future**
  - **Resulted in a final report and supporting documentation that collectively totaled over a thousand pages**
- **The implementation of LVCAR recommendations began in the spring of 2009**
  - **Organized into three areas: “Common Capabilities,” “Architecture Convergence,” and “Gateways and Bridges”**
  - **Gateway issues (on previous chart) were identified based on community outreach during LVCAR development**

# LVCAR Gateways Effort – Block 1 Activities

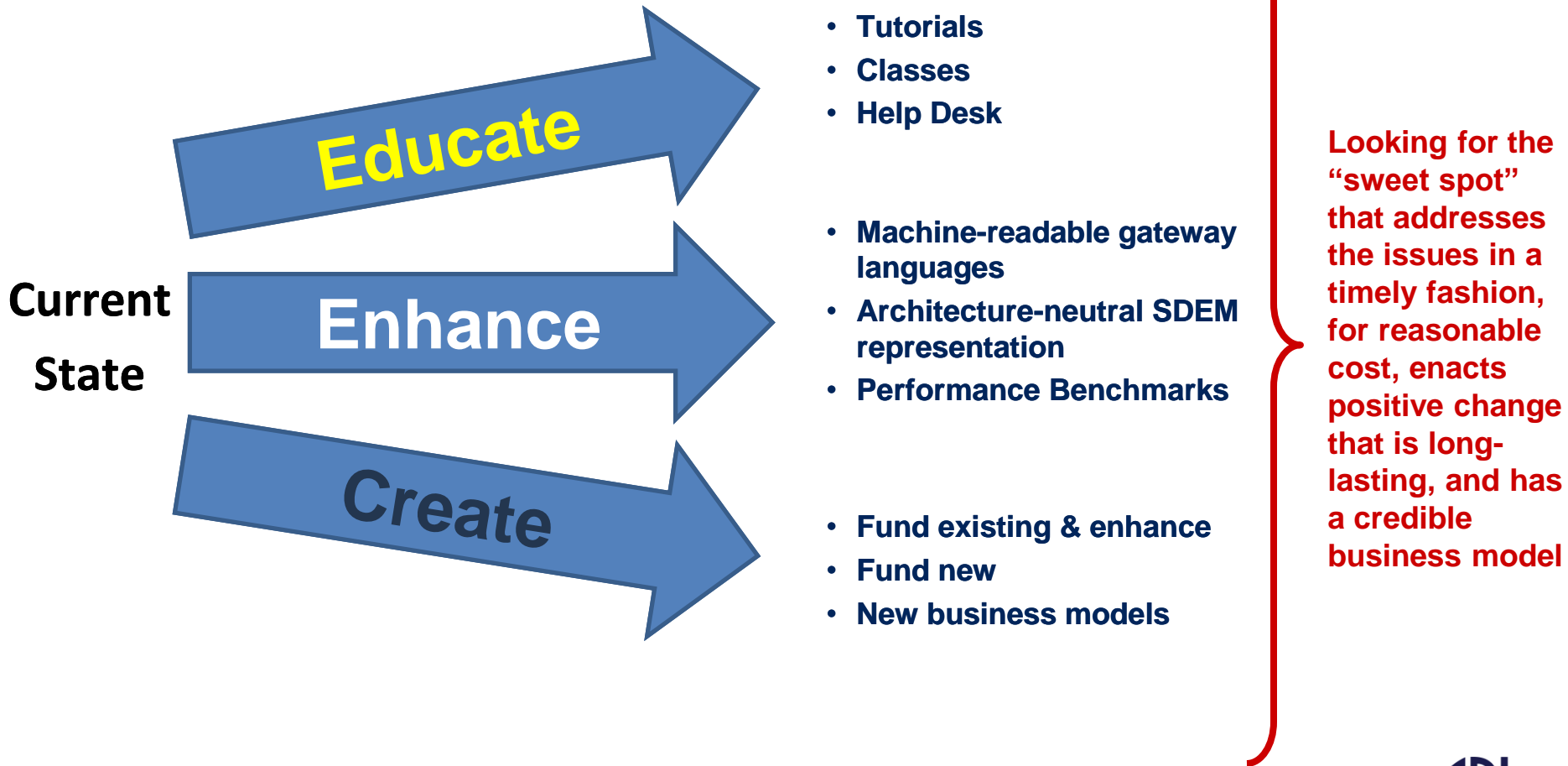


- **The Gateways component to the LVCAR Implementation (LVCAR-I) project initially focused on two products:**
- **Gateways Characterization Report**
  - **Designed to identify areas where gateway capabilities are not well aligned with user needs**
  - **Identified capabilities offered by a wide range of different existing gateways, based on on-line questionnaires and site visits to numerous user sites**
  - **Mapped user requirements to these capabilities to identify gaps**
  - **Final report delivered to the Modeling and Simulation Coordination Office (MSCO) sponsor in May 2010**
- **Gateways Execution Plan**
  - **Identification of viable strategies to address gateway issues and capability gaps**
  - **Final report delivered to the MSCO sponsor in June 2010**





# Strategy Dimensions



# LVCAR Gateways Effort – Block 2 Activities



- Develop a *Gateways Capability Description* document, which formally delineates the various capabilities that individual gateways can offer to user programs, along with specific levels of implementation for each unique capability
- Assess the *Architecture-Neutral Data Exchange Model (ANDEM)*, developed by the Joint Composable Object Model (JCOM) Program, to support Simulation Data Exchange Model (SDEM) mapping and/or translation in gateways
- Develop a set of *Gateway Performance Benchmarks (GPBs)* to identify specific gateway performance measures, along with use cases that describe how and where these measures should be applied

# Gateways Capability Description - Example



Functional Capabilities		SDEM Translations	
Reference ID	Capability Definition	Examples	Levels of Implementation
<b>FC-ST-1</b>	Capability to perform unit conversion on a single attribute (SDEM element).	For example, if a gateway can translate meters to feet, or a similar direct algorithmic conversion.	0 = No unit conversion 1 = Single attribute conversion for 5 or less defined types 3 = Single attribute conversion for less than 15 fixed types 5 = Conversion between arbitrary units
<b>FC-ST-2</b>	Capability to perform complex data type conversions from single to multiple, multiple to single or different numbers of multiple attributes. This includes coordinate systems with different number of components.	For example, if a gateway can translate between coordinate systems with different number of components, such as Euler angles (3 elements) to quaternions (4 elements), or articulated parts verses single frame reference.	0 = No multiple attribute conversion 1 = Multiple attribute conversion for 5 or less fixed types 3 = Multiple attribute conversion for less than 15 fixed types 5 = Arbitrary multiple attribute coordinate conversion

# ANDEM



- **Defines a format for SDEM representation that is independent of the underlying metamodels associated with major simulation architectures (e.g., HLA, DIS, TENA, & CTIA)**
- **The original purpose of ANDEM was to define an intermediate format for storage of SDEM components**
- **ANDEM has now been extended to support a broader set of requirements, which includes the use of ontologies to support machine reasoning and improved semantic-level interoperability**
- **The Resource Description Framework (RDF)/Extensible Markup Language (XML) representation of ANDEM was assessed as a potential common intermediate format for defining the SDEM mappings necessary to meet LVC interoperability requirements**
  - **Major finding was that it worked well in this context, and could be useful for gateway configuration purposes as well**

# Gateways Performance Benchmarks – Example



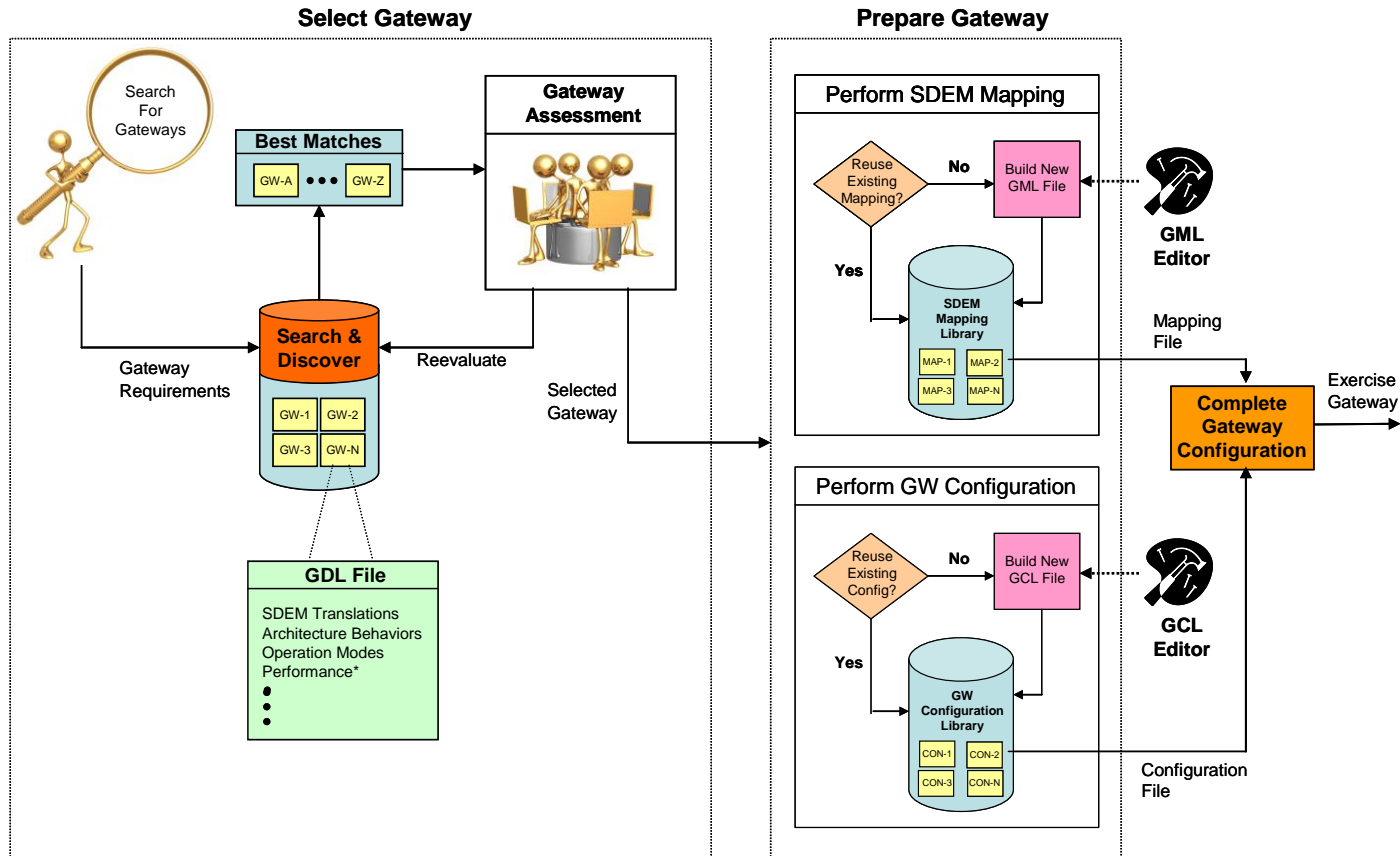
Performance Metric Element	Definition	Possible Means of Measure
<b>Resource Utilization</b>	Loading levels for system resources:	
	• <i>Memory</i>	Percent of available megabytes or number of pages input and output
	• <i>Central Processing Unit (CPU)</i>	Percentage used for both average and maximum, and number of instructions per second required
	• <i>Disk</i>	Percentage used, and number of access operations required
	• <i>Input / Output (I/O)</i>	Number of operations for both input and output
	• <i>Database</i>	Number of database accesses per second
	• <i>Network</i>	Percentage of bandwidth used
<b>Speed / Response Time / Latency</b>	Time required to process inputs	Input/output response time and queue lengths (#messages/tasks waiting)
<b>Throughput</b>	System processing capability	Processing rate for messages, data streams, or packets
<b>Scalability</b>	Ability for multiple system components to process data flow efficiently	Multiple system tested using parameterized filtering
<b>Endurance / Robustness / Stability</b>	System component reliability and uptime	Mean time between failures
<b>Performance-Related Accuracy</b>	Minimizing output errors that are due to performance characteristics	Percentage of correct output data

# LVCAR Gateways Effort – Block 3 Activities



- Develop a *Gateway Configuration Model* that identifies an explicit set of gateway requirements, and discusses how the emerging gateway products and processes will address those requirements
- Develop a common *Gateway Description Language (GDL)*, in a machine-readable format/syntax, for describing both user gateway requirements and the capabilities that individual gateways can offer
  - Supports user discovery of needed gateway capabilities
- Develop a common *Gateway Mapping Language (GML)* to formalize format and syntax of mappings between different SDEMs
  - Reduces number of required mappings, and supports reuse of mapping data
- Develop initial repository for GDL-based gateway descriptions. Incorporate applicable search and requirements-to-capabilities matching algorithms
- Develop initial tools for GDL and GML file creation/editing
- Socialize draft GPBs with gateway developer organizations. Incorporate feedback and prepare formal specification
- Develop Gateways tutorial

# LVCAR Process View



\* Based on *Performance Benchmarks Specification*

# LVCAR Gateways Effort – Future Activities



## **FY12:**

- **Develop a Gateway Configuration Language (GCL) which standardizes the format and structure of gateway configuration files**
  - **Supports reuse of gateway configuration files**
- **Continue development of supporting automated tools**
- **Capability demonstrations with “early adopter” gateway organizations**

## **Potential:**

- **Gateway Testing Laboratory (GTL)**
- **Gateway language standardization**



# Questions and Feedback

