Enabling System-of-Systems Capabilities Via Modular Open System Maturity Model

Cyrus Azani

Open Systems Joint Task Force/TRW

November 2002

The Purpose: Open System Integration within CMMI

The integration of Open System practices within the CMMI framework is aimed at enabling organizations to:

- Understand specific practices required for launching open system improvements
- Identify process areas that contribute to Modular Open System Process maturity
- Provide valuable information to technical staff and process improvement groups to:
  - Identify open system strengths and weaknesses of an organization and its system integrators, contractors and suppliers
  - Determine the risks of selecting among different contractors for awarding business and to monitor performance
  - Provide a set of specific evaluation criteria against which the contractors proposals will be evaluated

AGENDA

- Explain the Modular Open System Process (MOSP) and related practices
- Propose and discuss an Open System Maturity Model that enables SoS capabilities
- Gather inputs to determine how the Modular Open System Process should be integrated within the CMMI framework
  - Should it be incorporated as a separate discipline with its own maturity levels?
  - Should it become a new process area?
  - Should open system considerations be integrated within the existing process areas?
  - Should MOSP become a technical note/supplement to CMMI?
  - Other suggestions/considerations?

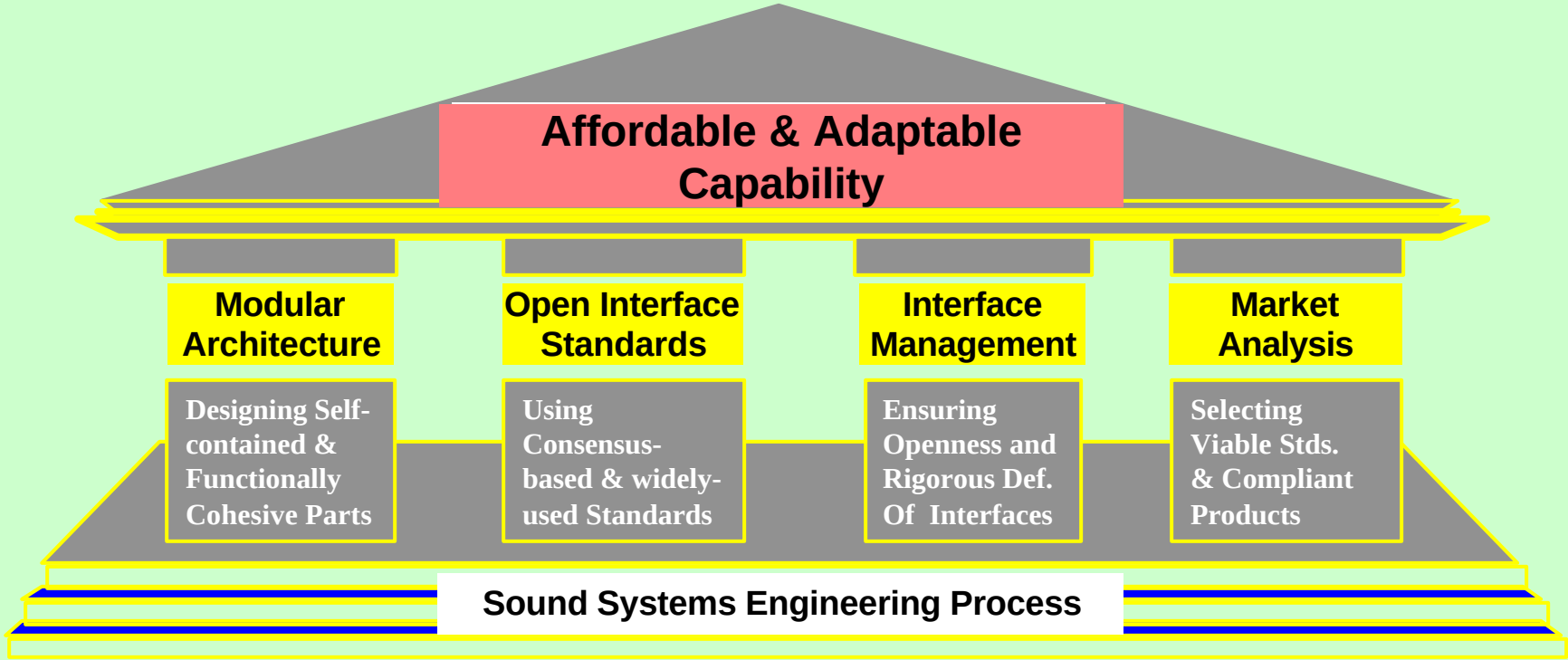
Why Open systems?

- Shift in customer taste/expectation
- Evolving needs/requirements
- Rapidly changing technologies
- Growing need for situational awareness
- Rising significance of Real-Time information
- Aging legacy of stove-pipe systems
- System development cost escalation trends
- Rising support and maintenance costs
- Increased complexity (e.g., Increasing Operator Workload / Information Overload)
- Reducing decision time line and response time
- Emerging standards

What is an Open System?

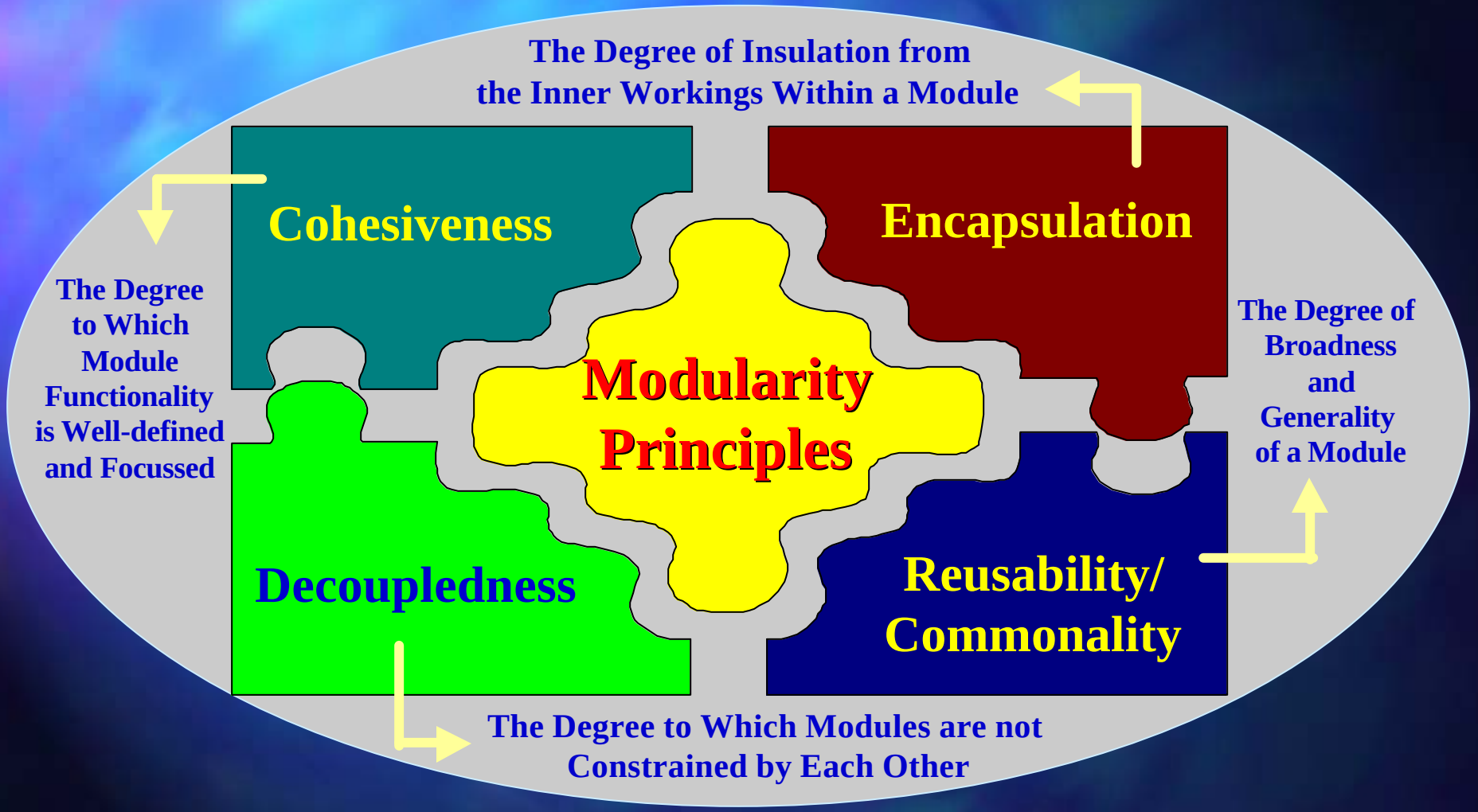
- Open System: A system that uses modular architecture and implements open standards for appropriate key interfaces.
- Open Standard: A widely implemented standard, the use of which is non-proprietary.
- Interface Standard: A standard that specifies the physical and logical characteristics of an interface.
- Key Interface: The interface of a module that is characterized by the need to be interoperable, easily changed, replaced or isolated because of complexity, obsolescence, or cost.

THE FUNDAMENTAL BUILDING BLOCKS OF OPEN SYSTEMS



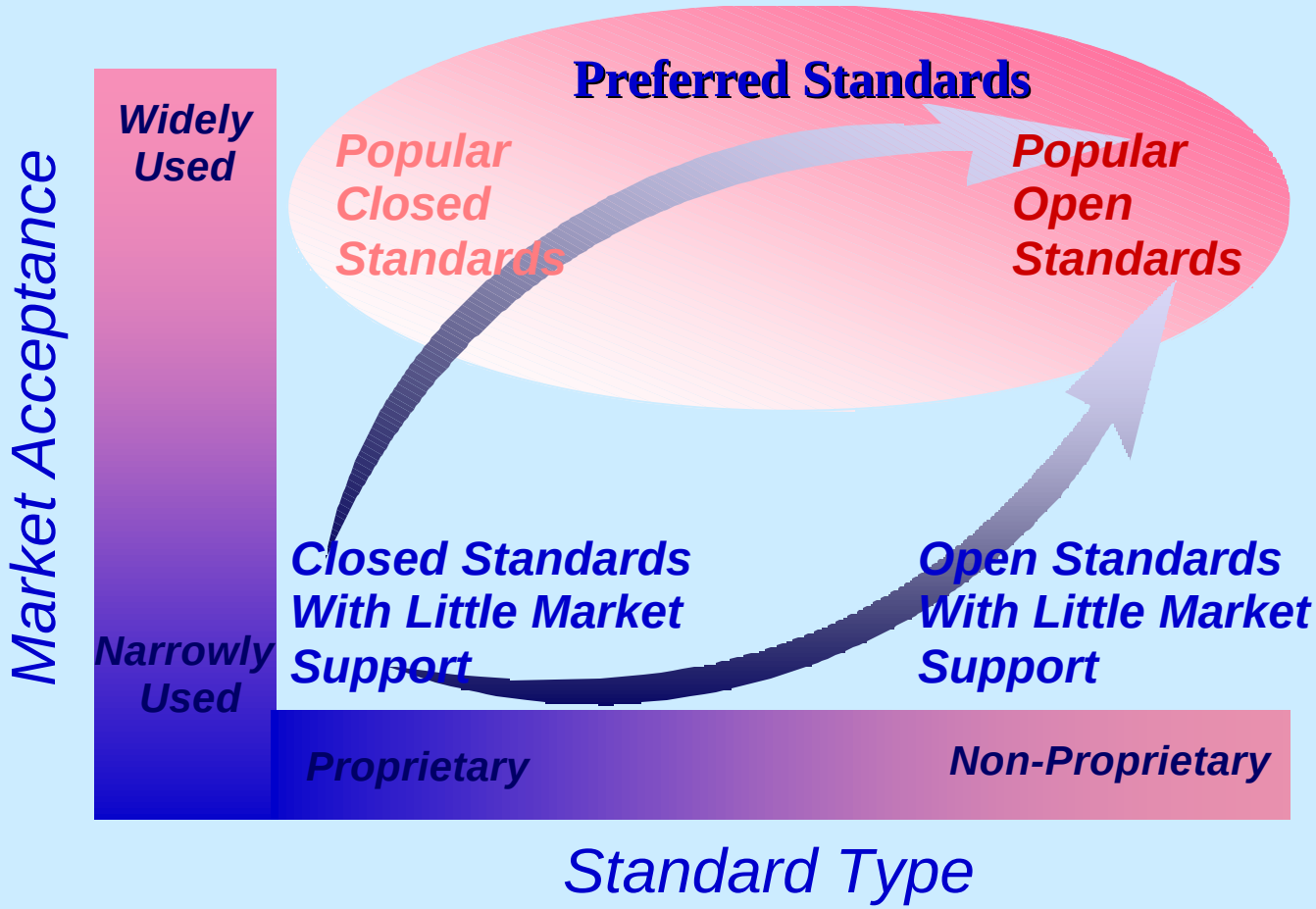
Proposed by Cyrus Azani at OSJTF/TRW

Open Systems are Based on Modularity Principles



Proposed by Cyrus Azani at OSJTF/TRW

Type of Standards

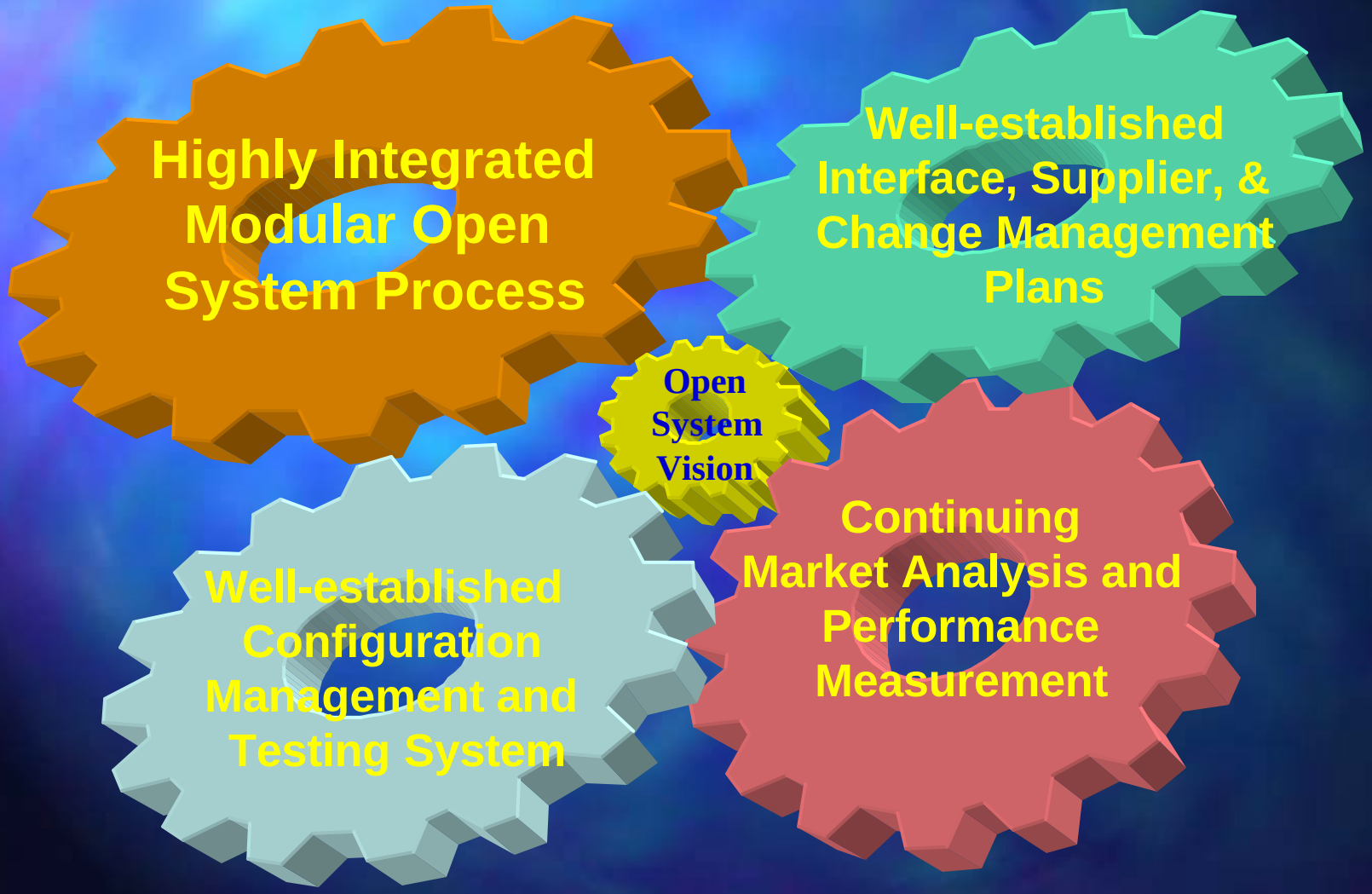


Modular Open System Process

- A set of business and engineering activities, methods, practices, and transformations that organizations use to develop and maintain affordable, producible, interoperable, and adaptable systems and associated products (e.g., design documents, architectures, test cases, user manuals, interface management plans, etc.).
- A Means of predicting the likely outcomes to be expected from the next system or product development project the organization undertakes
- A common process that applies to the development of adaptable product or service in the engineering development domain

Proposed by Cyrus Azani at OSJTF/TRW

Prerequisites for Mature Open System Capability



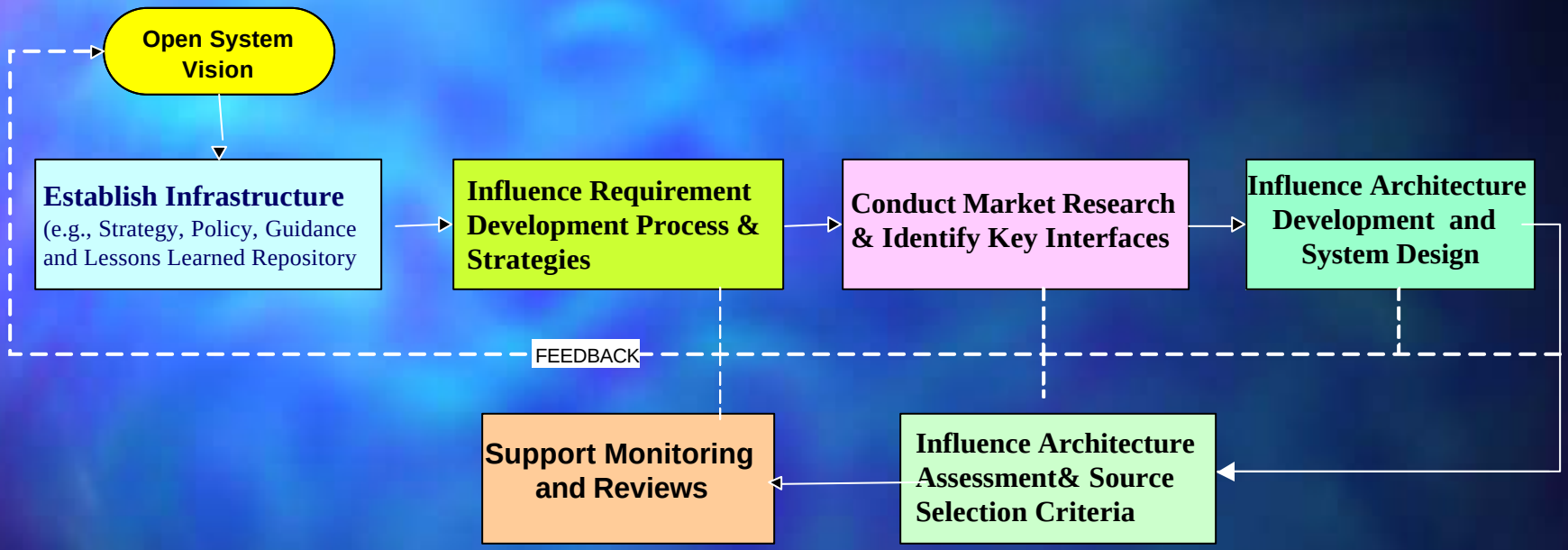
Proposed by Cyrus Azani at OSJTF/TRW

The Open System Vision

Affordable, Producible, Sustainable, Interoperable, and Growing System Capability based on Modular Architecture and Open Standards for Appropriate Key Interfaces

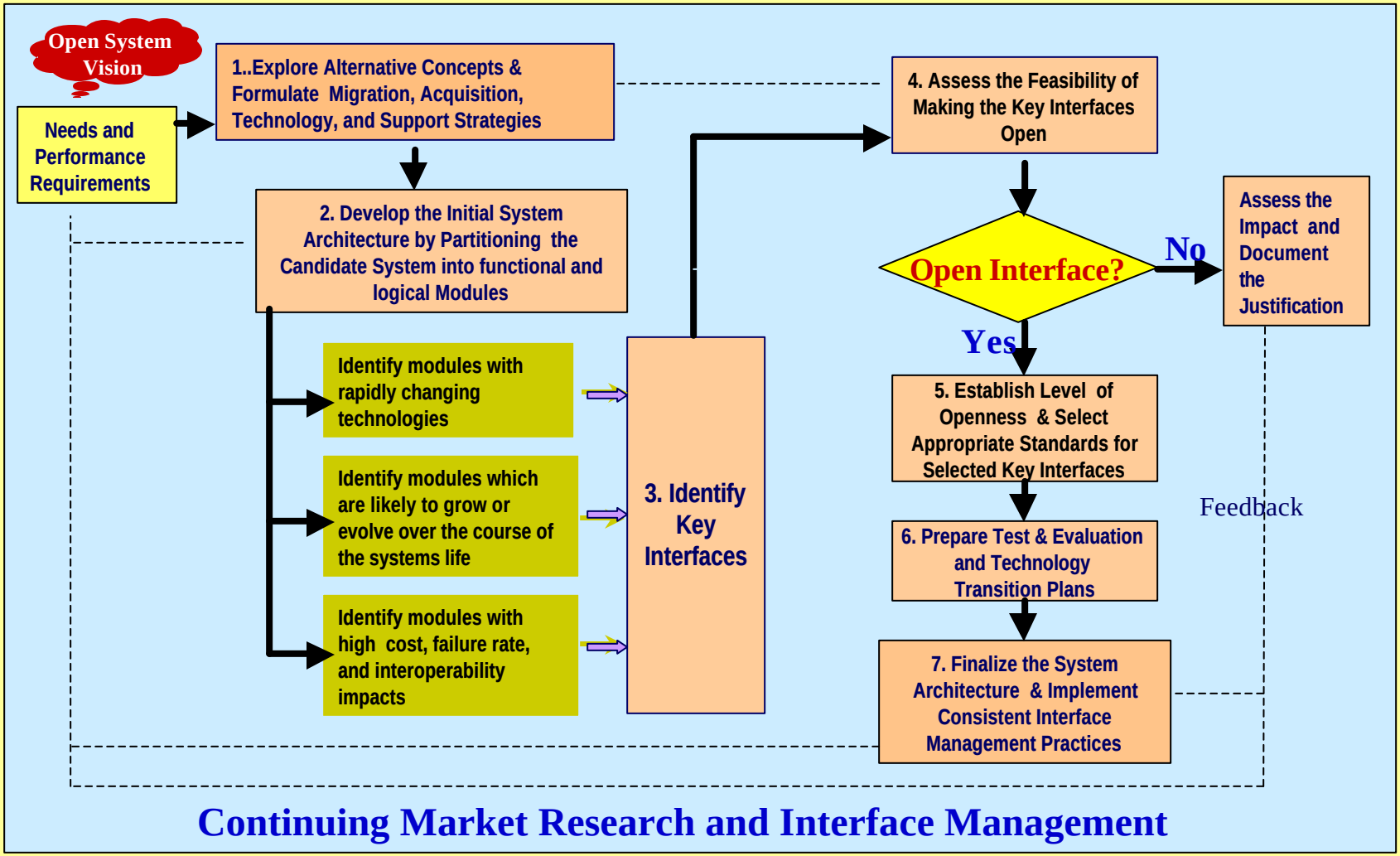
Proposed by Cyrus Azani at OSJTF/TRW

Core Tasks For Implementing A Modular Open System Process



Proposed by Cyrus Azani at OSJTF/TRW

The Modular Open System Process



Suitable Environment & Sound Systems Engineering Process

Proposed by Cyrus Azani at OSJTF/TRW

Examples of Requirements and Needs that Could More Effectively Met by Openness of Systems

- Requirements that seek dominant performance and require access to the latest technology
- Unstable longer-term requirements that are addressed as evolving increments
- When technologies/engineering for full capability still need to be developed
- When products or spare parts are competitively produced and the organization must maintain continuing access to multiple sources of supply
- When there is desire to mitigate the intensity and magnitude of risks associated with proprietary standards and sole source of support throughout a system life cycle
- When system of systems integration and interoperability requirements unequivocally call for compliance with specific open standards
- When a system has to have connectivity with other systems to properly function
- Need for commonality of hardware, software, and support systems
- Need for continuing integration and change
- Need for design flexibility, modularity, and interface control

Open System Capability

- The range of expected results that will most effectively be achieved by following a modular open system process.
- Measures an organization’s Modular Open System Process improvement achievement.

Modular Open System Performance Capabilities

The actual results achieved by an organization that follows a Modular Open System Process. Some Examples are:

- More effective response to change
- Ease of technology insertion
- Growth capability
- Improved interoperability
- Less integration risks
- Lower development cycle time
- Vendor independence
- Reduced total ownership costs

Bottom Line: Greater chance to more effectively adapt an organization and its constituent systems to changes in the internal and external environment.

Open System Maturity

- Measures an organization's overall open system maturity and the extent to which a specific modular open system process is explicitly defined, managed, measured, controlled, and effective.
- As an organization gains in open system maturity, it institutionalizes its Modular Open System Process within its knowledge and corporate infrastructure and culture to ensure its endurance and effectiveness.

Open System Maturity Model

- A Staged Representation Model that identifies the practices that are basic to implementing effective modular open system process and advanced open system practices.
- Assigns to those practices associated maturity levels ranging from negligible to mature and well-managed organization-wide application of open systems.
- Identifies the path through the various practices for achieving higher levels of open system maturity and improvement of organizational adaptability.

Open System Maturity Levels

- Level 1: Insignificant (Individual Component) Openness
- Level 2: Partial (Subsystem) Openness
- Level 3: Sensible (Individual System) Openness
- Level 4: Broad (System of Systems) Openness
- Level 5: Complete (Total Organization) Openness

OS Maturity Level 1: Insignificant Openness

Characteristics/Expected Results:

- The organization has identified the benefits of open systems and has adopted open standards for a few key interfaces within one or more components comprising a subsystem (e.g., use of open interface standard for a display processor)
- Open system application at this level is characterized by:
  - No Modular Open System Process management discipline
  - Scattered open interfaces due to individual system engineer preference
  - Firefighting (e.g., reacting to immediate interoperability or integration problems)
  - Excessive risk taking
  - Lack of short and long-term open system strategies and plans (reactionary management philosophy)
  - Orientation towards proprietary products, interface, and systems
  - Absence of organization-wide policies for open system implementation
  - Over the budget and schedule products and systems.

Characterized by openness of a few components within a subsystem

Proposed by Cyrus Azani at OSJTF/TRW

OS Maturity Level 2: Partial (Subsystem) Openness

Focus Areas / Expected Results:

- An open system czar has been appointed and his/her areas of responsibility have been assigned
- A plan to assess the feasibility of the open system strategy has been prepared
- Open system policies and procedures for their implementation have been established
- Limited open system training is provided
- Some of obstacles toward open system implementation have been identified and removed
- Stakeholders responsible for implementation or being impacted by open systems are identified
- Some resources for open system implementation have been allocated
- A basic Modular Open System Process has been established to implement open systems in selected subsystems
- Suppliers are encouraged to use open interfaces for certain components
- Earlier successes in open system implementation are repeated as limited lessons are gathered, analyzed, and documented

Characterized by openness of appropriate key interfaces within limited subsystems

OS Maturity Level 3: Sensible (Individual Systems) Openness

Focus Areas/ Expected Results:

- A roadmap for implementing the open system strategy has been prepared
- An organization-wide open system training program has been established to ensure adequate open system knowledge and skills
- Limited measures for tracking the progress on open systems implementation are established
- A well-defined Modular Open System Process based on sound system engineering processes, and common and organization-wide understanding of activities, roles, and responsibilities has been established
- Modular Open System Process has been integrated with the overall acquisition and system engineering processes
- The criteria for selecting interface standards have been established
- Within certain systems, the requirements and key interfaces that necessitate openness have been identified, and the feasibility of using open standards for such interfaces have been assessed
- Cost, schedule, and functionality within established systems are under control, and progress is successfully being tracked
- Verification and validation testing mechanisms have been developed

Characterized by openness of appropriate key interfaces within selected systems

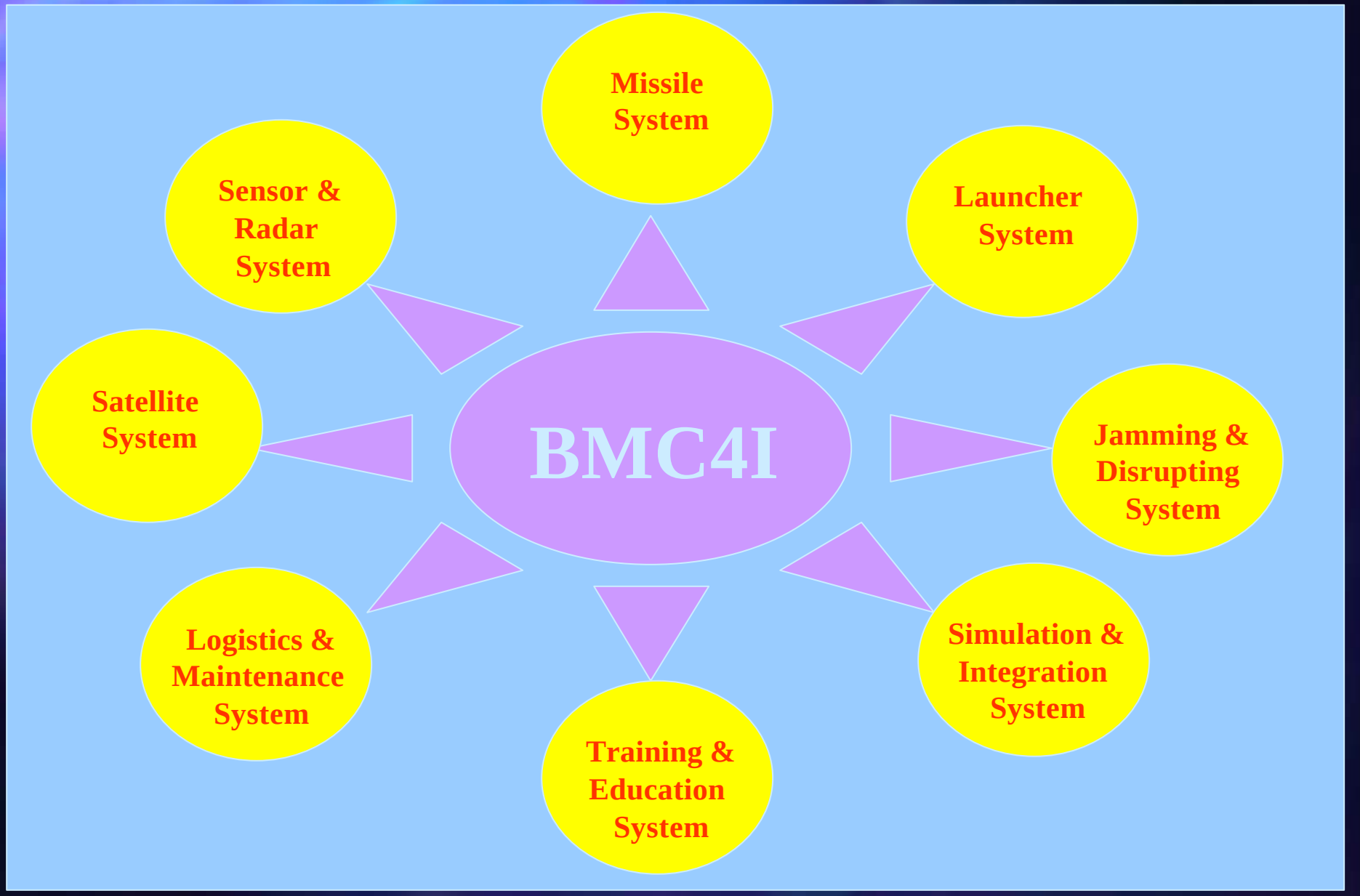
OS Maturity Level 4: Broad (System of Systems) Openness

Focus Areas/ Expected Results:

- An interface management plan has been established
- Concurrent development of requirements, systems, and processes
- An organization-wide repository of open system lessons learned exis
- System of systems requirements that necessitate openness (e.g., reuse and commonality of products across domains, interoperability, ease of integration, etc.) have been identified, and use of open standards for appropriate key interfaces within such systems are being consciously assessed
- SoS network of modular open system architectures have been developed and appropriate key interfaces within selected systems and system of systems are defined by open standards
- Selection of interface standards is based on well-defined criteria and priorities
- Metrics for measuring the openness of systems and processes have been established and being used
- Organization is capable to predict total cost of ownership, development cycle time, and system capabilities at different blocks of improvement within reasonable margin of error.
- Most of the benefits of open systems are being realized
- Quantitative open system objectives and indicators have been established

Characterized by openness of appropriate key interfaces within and among selected systems

EXAMPL OF A LEVEL 4 OPEN SYSTEM CAPABILITY: A SECURED NETWORK OF MODULAR OPEN ARCHITECTURES FOR a SoS SPACE DEFENSE SYSTEM



OS Maturity Level 5: Complete (Total Organization) Openness

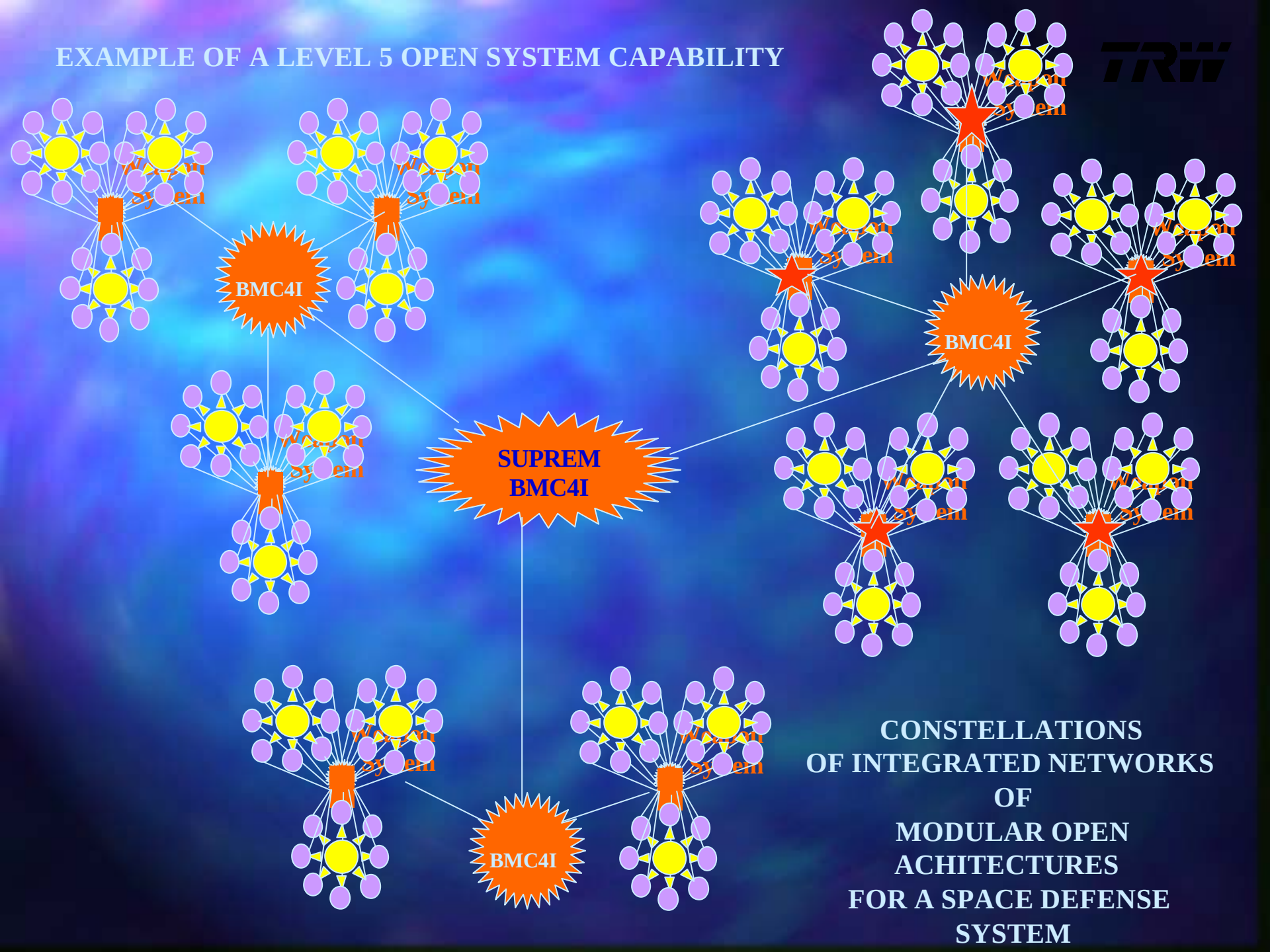
Focus Areas / Expected Results:

- A disciplined, standardized and creative Modular Open System Process is established and been institutionalized within the overall organization structure and culture
- The organization has integrated the SoS networks of modular open system architectures into an organization-wide integrated network of modular open system infrastructure
- The Modular Open System Process is being continuously improved, and is managed as a regular business activity
- Pursuit of a pro-active management philosophy in open system development and sustainment, and in monitoring the progress on implementing a standardized modular open system process
- Well-defined roles and responsibilities for adopting and influencing open standards across the organization.
- Lessons learned on open system application are disseminated widely and effectively
- Negligible difference is observed between targeted and actual open system benefits and organization-wide openness provides capability to:
  - Develop affordable, long-lasting, and adaptable systems and products
  - Continuously and affordably modernize systems and processes
  - Effectively connect systems and organizational stakeholders, and create commonality and reuse across systems
  - Lower sustainment risks and manage suppliers at the interface level
  - Share knowledge and lessons learned

Characterized by openness of all the appropriate key interfaces within all the systems in the organization

Proposed by Cyrus Azani at OSJTF/TRW

EXAMPLE OF A LEVEL 5 OPEN SYSTEM CAPABILITY



CONSTELLATIONS OF INTEGRATED NETWORKS OF MODULAR OPEN ACHITECTURES FOR A SPACE DEFENSE SYSTEM

Open System Maturity Model Application

The proposed model can be used by programs and organizations of all sizes involved in engineering and development of :

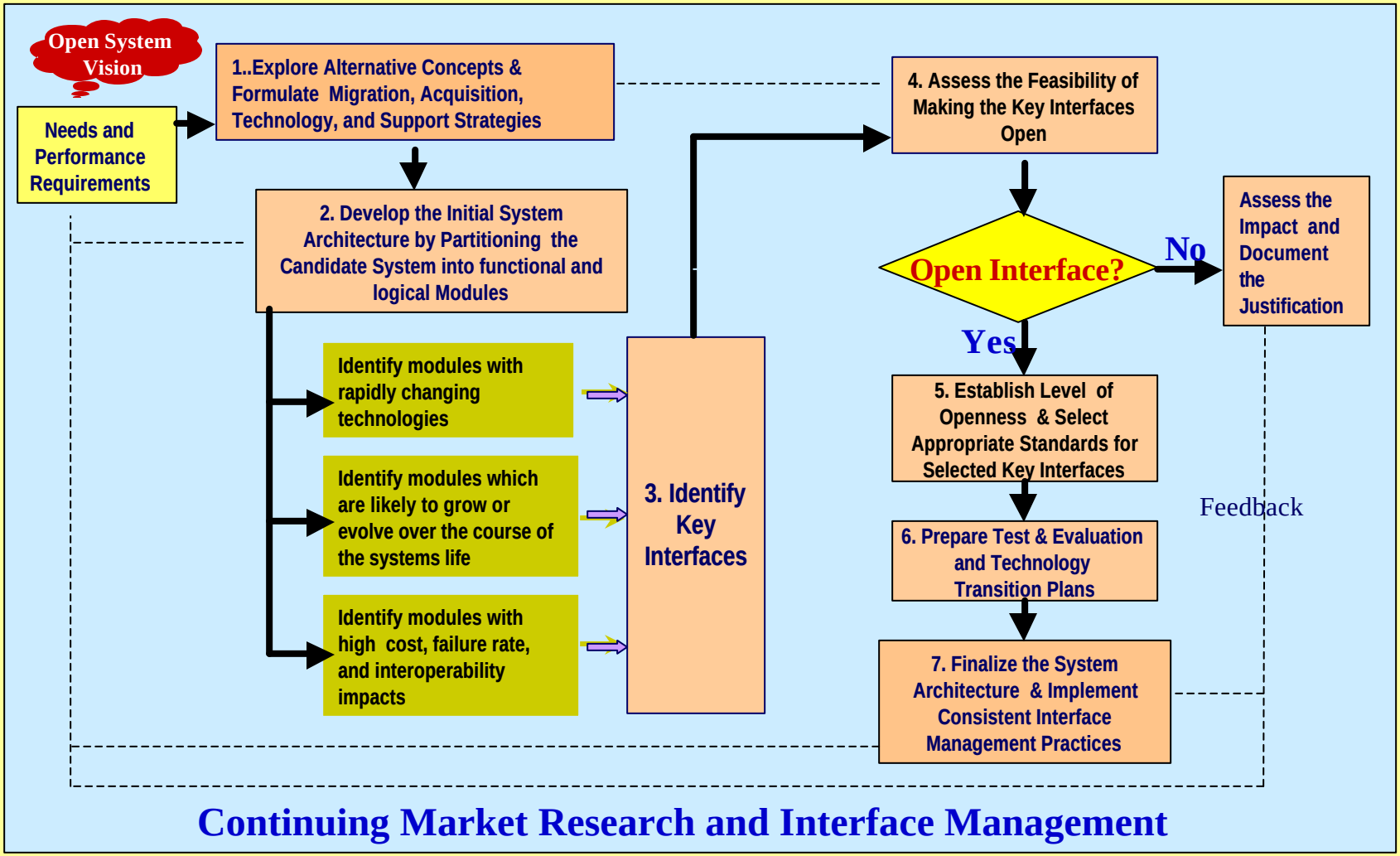
- New as well as reengineering of legacy systems
- Mechanical, electrical, electronic, hydraulic, social, and biological systems
- Tools and facilities

Going Back to the Purpose

- How should the Modular Open System Process be integrated within the CMMI framework?
  - Should it be incorporated as a separate discipline with its own maturity levels?
  - Should it become a new process area?
  - Should open system considerations be integrated within the existing process areas?
  - Should MOSP become a technical note/supplement to CMMI?
  - Other suggestions/considerations?

Back up Slides

The Modular Open System Process



Suitable Environment & Sound Systems Engineering Process

Proposed by Cyrus Azani at OSJTF/TRW

Modular Open System Process Steps and Activities

1: Explore Concepts & Formulate Open System and other Strategies

1.1 Identify stakeholder needs

1.2 Identify, explore, and assess alternative solution concepts

1.4 Select the preferred solution concept

1.3 Use dynamic models to assess the cost, schedule, support and performance impacts of making the preferred alternative open

1.5 Formulate acquisition, technology, and support strategies

1.6 Develop detailed acquisition plans

Modular Open System Process Steps and Activities cont.

2. Develop System Architecture

2.1 Select or develop reference model(s)

2.2 Decompose required capabilities into modular functions

2.3 Identify major modules and interfaces based on the reference model

2.4 Reassign or reallocate modules to functions

2.5 Identify technologies applicable to each module

2.6 Recursively repeat steps 2.2 through 2.5 as required

2.7 Document the system architecture

Modular Open System Process Steps and Activities cont.

3. Identify Key Interfaces

3.1 Identify modules with rapidly changing technologies

3.2 Identify modules which will evolve over the life of the system

3.3 Identify modules whose cost need to be controlled

3.4 Identify modules that impact/determine interoperability

3.5 Identify modules with high failure rate

3.6 Group the interfaces into key and non-key interfaces based on the characteristics identified in steps 3.1 through 3.5

Modular Open System Process
Steps and Activities cont.

4. Assess the Feasibility of Using Open Standards for the Key Interfaces

4.1 Review business and technical requirements and objectives

4.2 Establish standard selection preference and criteria

4.3 Select the key interfaces that may be defined by open and other types of standards using the preference criteria established

4.4 Prepare documentation to justify the selection of non-open standards

4.5 Document and report on the progress

Open System Process
Steps and Activities cont.

5. Establish Level of Openness and Select Appropriate Standards

5.1 Review market research findings

5.2 Review 5.2 and finalize standards selection criteria

5.3 Select open standards based on the criteria established

5.5 Establish level at or above which interfaces are open

5.5 Establish configuration management procedures and processes

Open System Process
Steps and Activities cont.

6. Prepare Test & Evaluation and Technology Transition Plans

6.1 Review the program's business and technical objectives

6.2 Select applicable discovery and confirmation tests needed

6.3 Establish appropriate test plans

6.4 Conduct the tests and ensure the openness of key interfaces

6.5 Review and assess test results reported from all sources

6.6 Document and report on the progress

Open System Process
Steps and Activities cont.

7. Finalize the System Architecture & Implement Consistent Interface Management Practices

7.1 Review the initial system architecture

7.2 Revise the architecture based on step 3-6

7.3 Establish configuration management procedures and processes

7.4 Establish an interface management plan

7.5 Iterate the process as many times as needed

7.6 Monitor the system performance and take corrective actions

The Interface Management Plan

Is a configuration management plan that:

- documents a system's internal and external interfaces and their requirement specifications;
- lists the key interfaces within a system;
- identifies preferred and discretionary interface standards and profiles;
- provides justification for selection and procedure for upgrading standards; and
- describes the certification s and tests applicable to each interface or standard.

Generic Goals and Practices (L5)

Generic Goals:

- **GG 5 Institutionalize an Optimizing MOSP**

  The MOSP is institutionalized as an optimizing process

Generic Practices:

- **GP 5.1 Ensure Continuous MOSP Improvement**

  Ensure continuous improvement of the Modular Open System Process in fulfilling the relevant requirements and business objectives of the organization.

- **GP 5.2 Correct Root Causes of Problems**

  Identify and correct the root causes of developing closed systems (e.g., ignorance, rigid mindset, lack of resources, lack of management commitment, absence of well-defined process, lack of policy and guidance, etc.)

Generic Goals and Practices (L4)

Generic Goals:

- **GG 4 Institutionalize a Quantitatively Managed MOSP**

  The MOSP is institutionalized as a quantitatively managed process to increase the percentage of organizational systems that are adaptable, affordable, upgradeable, and interoperable

Generic Practices:

- **GP 4.1 Establish Quantitative Objectives for the Modular Open System Process**

  Establish and maintain quantitative objectives for implementing MOSP

- **GP 4.2 Stabilize Subprocess Performance**

  Stabilize the performance of critical MOSP subprocesses to remove variability in achieving the established MOSP performance objectives.

Generic Goals and Practices (L3)

Generic Goals:

- **GG 3 Institutionalize a defined Modular Open System Process**

  The MOSP is institutionalized as a defined process

Generic Practices:

- **GP 3.1 Establish a defined MOSP**

  Establish and maintain the description of a defined MOSP

  The organization should have a standard MOSP, as well as have guidelines for tailoring the standard MOSP to meet the needs of a project or organizational function.

- **GP 3.2 Collect MOSP Improvement Information**

  Collect work products, measures, measurement results, and improvement information derived from planning and performing the MOSP to support the future use and improvement of the organization's processes and process assets.

Generic Goals and Practices (L2)

Generic Goals:

- **GG 2 Institutionalize a Managed MOSP**

  The MOSP is institutionalized as a managed process.

Generic Practices:

- **GP 2.1 Establish Open System Policy**

  Establish and maintain organizational policy for planning and performing MOSP

- **GP 2.2 Plan the MOSP**

  Establish and maintain a plan for performing the MOSP