2006 CCRTS Command and Control Research and Technology Symposium
"The State of the Art and the State of the Practice."

A Three-tier Knowledge Management Scheme for C2 Software Engineering Support and Innovation

(CCRTS Paper #C-064)

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Presentation Outline

I. Introduction
II. Problems and Issues
III. Technical Approach
IV. Engineering Practice
V. Conclusion

I. Introduction

I.1. Problem Statement

I.2 Software Engineering (SE) Process Concerns

I.3 Knowledge Management (KM) in SE

I. Introduction (2)

I.1 Problem Statement

How to maintain proper levels of knowledge in transition of software innovations to C2 systems, in terms of

- Knowledge from
  - Subject Matter Experts
  - Software Engineers – developers, reviewers, testers, …
- Knowledge about
  - System configuration
  - Operational environment
  - Technology in existing systems
  - Technology in newer systems

Our approach: **A three-tier knowledge management scheme**

- **Conceptual exploration**
- **Prototype evaluation**
- **Product development**

I. Introduction (3)

I.2. Software Engineering (SE) Process Concerns

- **Insertion of new technology into existing systems**
  - Enhance the C2 system's operational capabilities
- **Transformation of legacy systems into net-centric systems**
- **Installation of new systems**
  - Replace outdated systems
  - Add novel capabilities
  - Support closing gaps in required capabilities

Bridging software development and operation communities

I. Introduction (4)

I.3. Knowledge Management (KM) in SE

- **Knowledge acquisition** – how to acquire and retain knowledge from existing personnel and subject matter experts (SME)
- **Knowledge maintenance** – how to keep the knowledge up-to-date and validated over time, and avoiding knowledge evaporation and obsolesce
- **Knowledge sharing** - how knowledge is disseminated/communicated to the team of collaborators and shared by all stakeholders
- **Knowledge enhancement** – how to turn weak knowledge into strong knowledge that is useful for C2 software engineering support tasks

I. Introduction (5)

I.3. Knowledge Management (KM) in SE (2)

"Knowledge management is an approach to discovering, capturing, and reusing both **tacit** (in people's heads) and **explicit** (digital or paper based) knowledge as well as the cultural and technological means of enabling the knowledge management process to be successful [Rec05]."

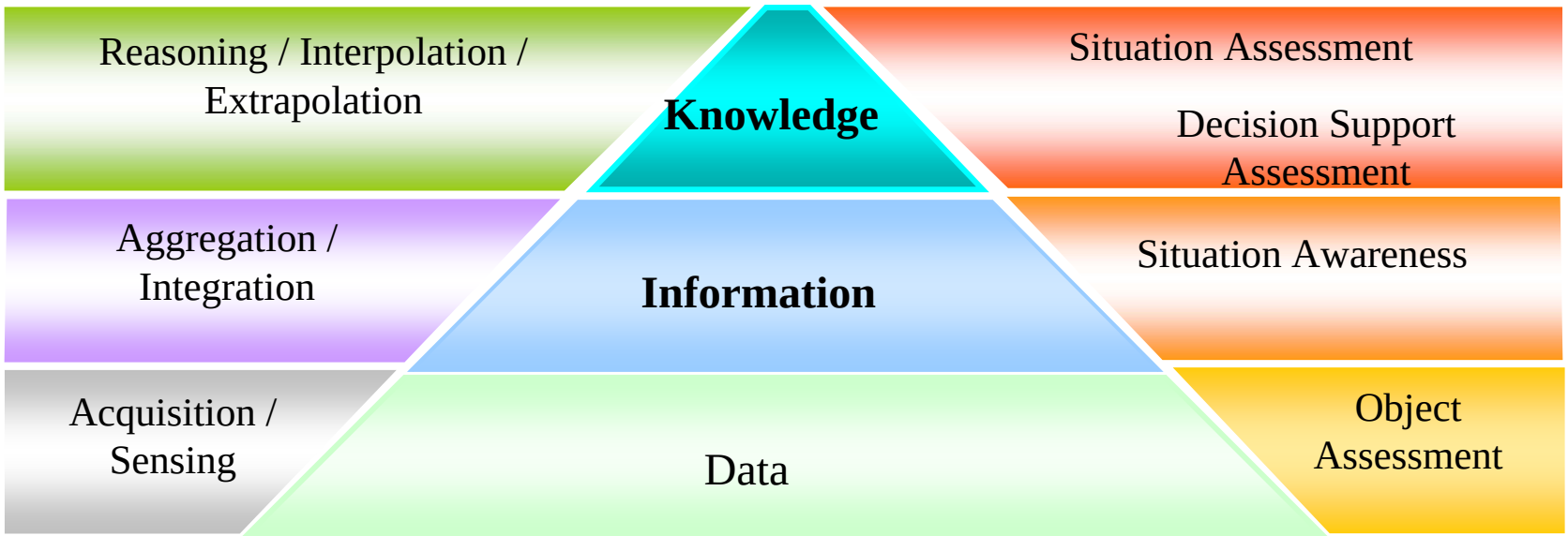
"Knowledge is a fluid mix of framed *experience*, *values*, *contextual information*, and *expert insight* that provides a framework for evaluating and incorporating new experiences and information.

It originates in the **minds of the knower**.

In organizations, it often becomes embedded not only in documents or repositories but also in organizational routines, processes, practices, and norms."

I. Introduction (6)

I.3. Knowledge Management (KM) in SE (3)



The Data-Information-Knowledge Hierarchy

I. Introduction (7)

I.3. Knowledge Management (KM) in SE (4)

Effects of Good Knowledge Management:

- **Ensure efficiency and reliability of C2 software innovation**
- **Avoid un-mature insertion of technology**
- **Avoid unnecessary interruption to C2 system's operations**

Minimizing software defect incidents

Knowledge does not simply exist – people create it.

Sharing knowledge is far more difficult than sharing information

II. Problems and Issues

II.1 Problems in C2SES KM

II.2 Representation of knowledge

II.3 Coupling of KM and SE processes

II.4 A systematic plan of action

C2SES – Command and Control Software Engineering and Support
KM – Knowledge Management
SE – Software Engineering

II. Problems and Issues (2)

II.1. Problems in C2SES KM

- Liquidity of knowledge - Knowledge moves with people
  when employees leave for other opportunities or for retirement, they carry away certain amount of knowledge (e.g., in the form of experiences) no matter how well the knowledge has been documented.
- Latency of knowledge - To gain knowledge requires time
  when new employees are hired and they need to get up to speed by acquiring technical and subject matter knowledge, which often takes a long time.
- Lack of knowledge sharing protocol – The power of knowledge lies on its sharing
  domain experts need to pass their knowledge to team players. To do that they need to know exactly to where and to whom the knowledge should be passed.
- Loss of knowledge locations, traces, and links – Knowledge must be properly kept
  The easy accessibility feature of knowledge is often overlooked
  Knowledge may be misplaced,
  Knowledge may be not clearly documented

II. Problems and Issues (3)

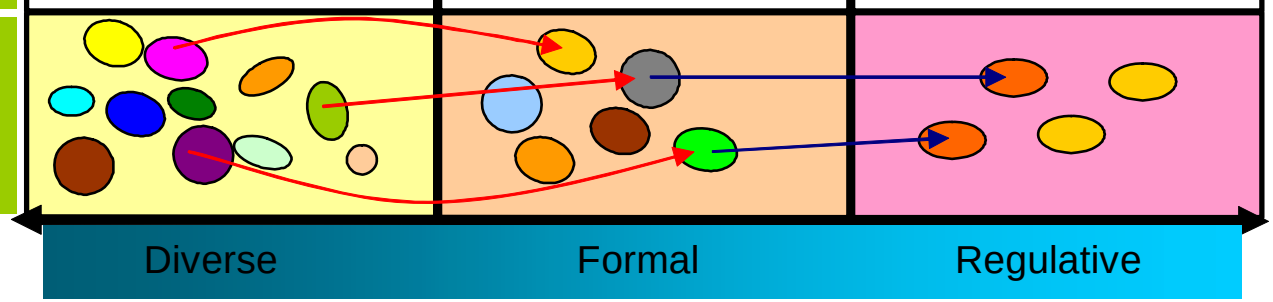
II.2. Representation of Knowledge

An ***Active***, ***Affective***, and ***Dynamic*** (AAD) representation [Ma97]

- *Active* - best understood in action
- *Affective* - takes into consideration not only the cognitive and rational dimensions but also emotional dimensions
- *Dynamic* - based upon ongoing reinterpretation of data, information, and assumptions

II. Problems and Issues (4)

II.3. Coupling of KM and SE processes

SE Processes	Exploration	Evaluation	Execution
Key Actions	- Idea exploration, generation and capturing - High level planning and estimating	- Feasibility study - Risk definition and mitigation - Project planning	- Detailed planning and tracking - Software development, implementation, and testing - Maintenance, and upgrading
Knowledge Features	- Competitiveness - Technical trends - State of Art	- Cost, risk - Technique feasibility, and reliability - Funding, equipment, facility	- Team capability and experiences - Technical supports, - Contracts and procedures
Knowledge Models			

II. Problems and Issues (5)

II.4. A systematic plan of action

Knowledge Relevance in C2SES

***Tangible (hard)* knowledge**

(1) software products
(2) data repositories
(3) developing, testing, and maintenance standards and procedures, etc.

***Intangible (soft)* knowledge**

(1) intellects/subject matter experts, and war-fighters
(2) system administrators, project managers
(3) software engineers, sub-contractors, collaborators
(4) operational environment and its variations, etc.

Knowledge Handlers in C2SES

A systematic account of existence of knowledge.
An explicit formal specification
A hierarchical structuring of knowledge
A set of agents that share the knowledge

III. Technical Approach

III.1 A collaborative team organization

III.2 A notion of continuous improvement process

III.3 A three tier software engineering support structure

III. Technical Approach (2)

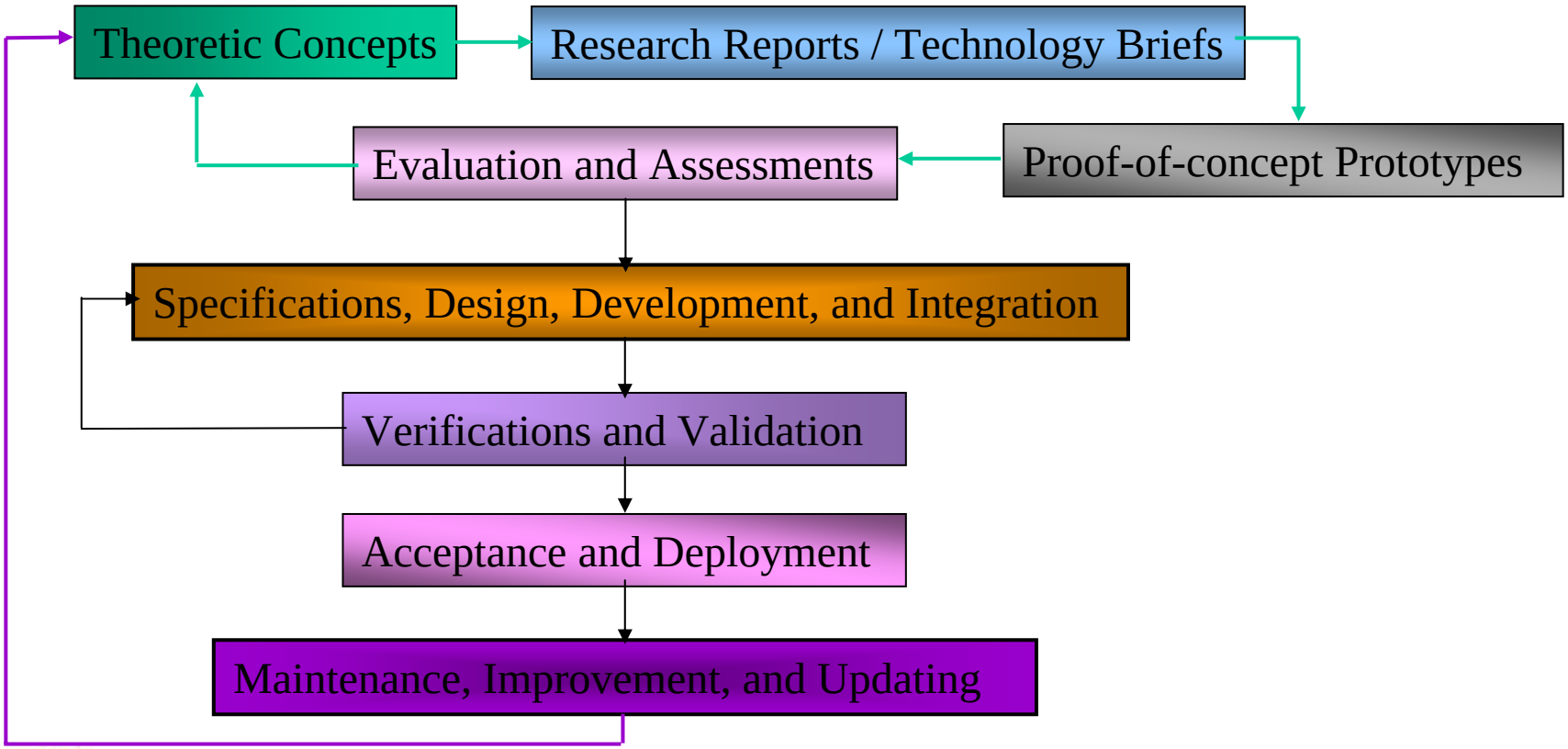
III.1 A collaborative team organization

The most notable part of Knowledge Management in C2 Software Engineering is the people

- Researcher
- System Engineers
- Project Managers
- Software Engineers
- Developers
- Testers
- … …

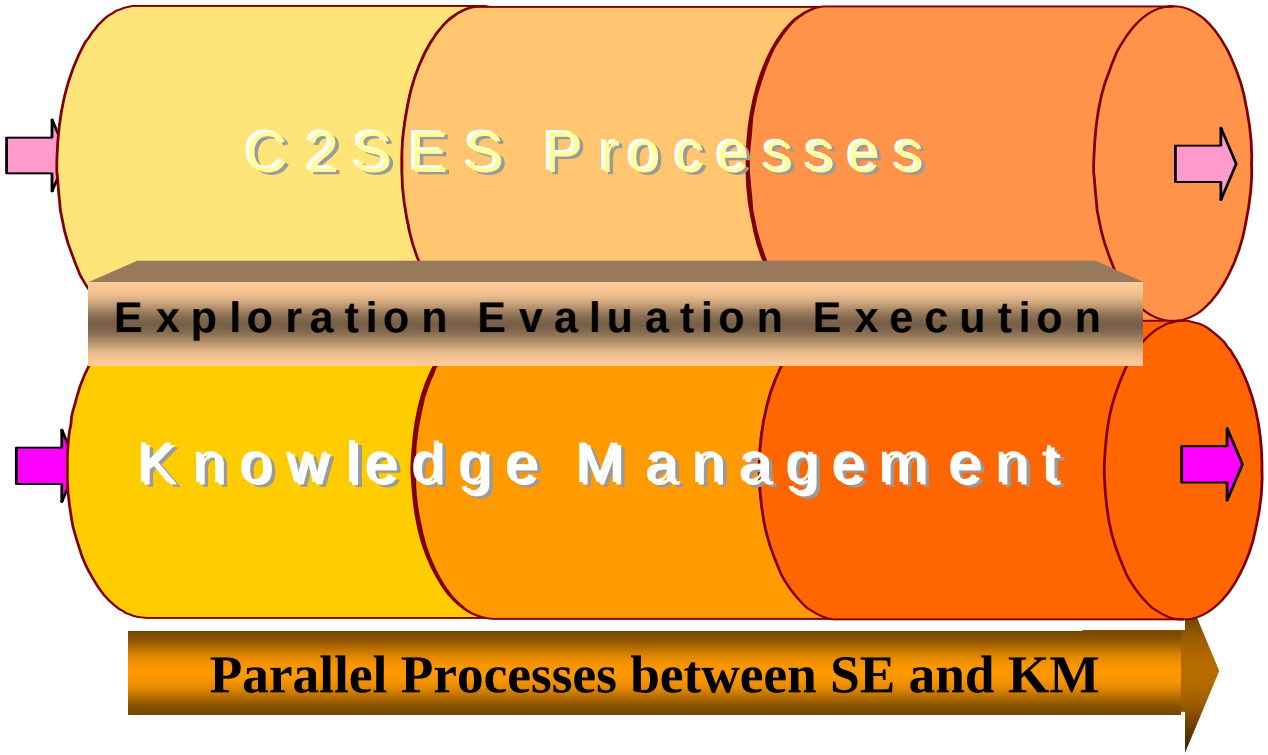
III. Technical Approach (3)

III.2 A notion of continuous improvement processes



III. Technical Approach (4)

III.3 A three tier software engineering support structure



IV. Engineering Practice

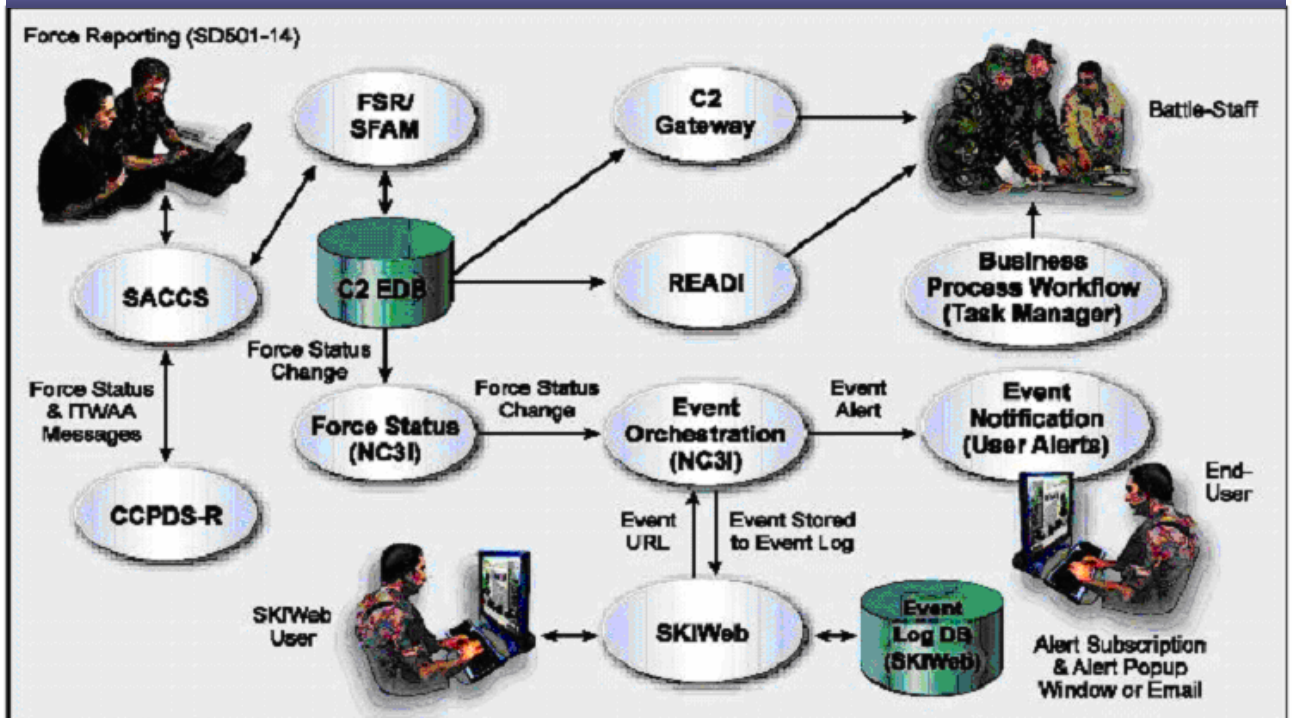
IV.1. C2SES Organizational Structure

IV.2. Coupling C2SES and KM Processes

VI.3. Tools and Mechanisms for KM in C2SES

IV. Engineering Practice (2)

IV.1. C2SES Organizational Structure

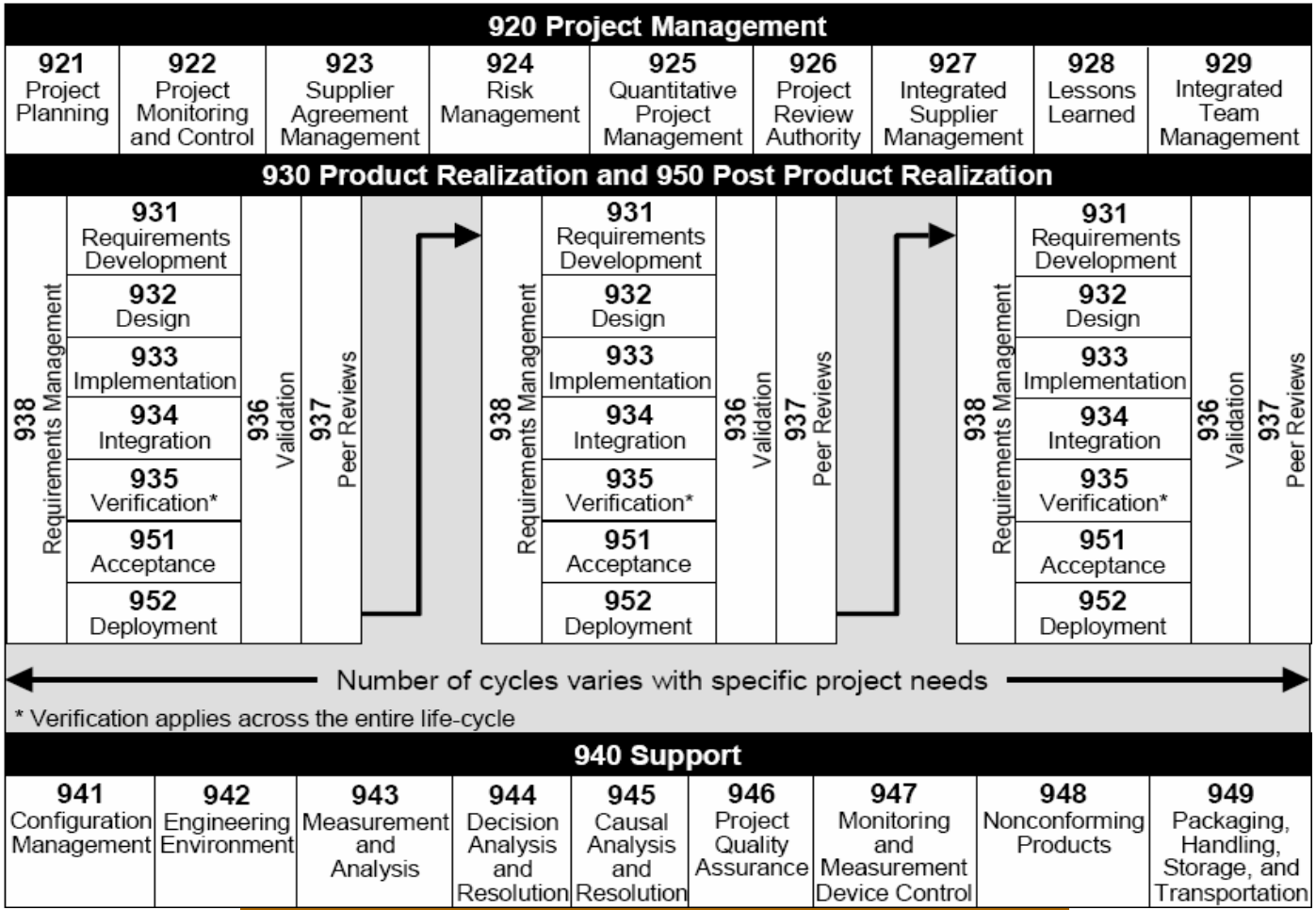


- CCPDS-R to be replaced by STARS in FY07
- SFAM/READI merging with FSR in FY06 (150K LOC needing repair or replacement)
- SKIWeb undergoing continuous improvement to a truly
- NC3I improvements to include authoritative data sources monitor NCES status
- Task manager moving to caretaker status—review of COTS

C2SES Applications Function and Flow

IV. Engineering Practice (3)

IV.2. Coupling C2SES and KM Processes



C2SES Evolutionary Life-Cycle Model

IV. Engineering Practice (4)

IV.2. Coupling C2SES and KM Processes (2)

Tool	Application
PCTR	Policy Compliance and Tailoring for the Defined Process
e-Toolkit and PAL	Organizational Process Assets Repositories
Lessons Learned Database	Organizational Repository for Lessons Learned
Self Assessment Tool (SAT)	SEI CMMI Self Assessment
Risk Manager's Assistant	Risk Management
Software Development Plan Template (SM 921.3)	Software Development Plan Development (this plan)
Software Change Request Database	Change Management
Wiki Repository	Requirements Traceability
JDeveloper or Eclipse	Design Modeling, Debugger, Graphical User Interface (GUI) Builder
Java 2 Standard Edition Java Development Kit (J2SE JDK) 1.3	Compiler
Office of Cost Estimation and Risk Analysis (OCERA) Code Counter	Code Counter
McCabe	Cyclomatic Complexity

C2SES software development resource management (excerpt)

IV. Engineering Practice (5)

IV.2. Coupling C2SES and KM Processes (3)

Product	Validation Method
Requirements	Technical reviews to ensure the customer and users review the requirements. Customer and user participation in technical working groups and simulations and models. Requirements are also validated against the customer/user requirements to ensure they correctly reflect the customer and users needs.
Design	Technical reviews to ensure the customer and users review the design. Incremental demonstrations of the prototype to the customer and users to obtain feedback, including delivery of prototypes to the customer and users for more thorough review.
Implementation	Participation in code walkthroughs (not peer reviews, since the customer and user are not "peers").
Test	Peer reviews to ensure system-level tests are derived from customer needs (i.e., Concept of Operations (CONOPS)). Acceptance tests.
User Documents	Delivery of draft versions to the customers and users for initial feedback.

C2SES Product Validation Methods

Table 4. Software Data File (SDF) Contents

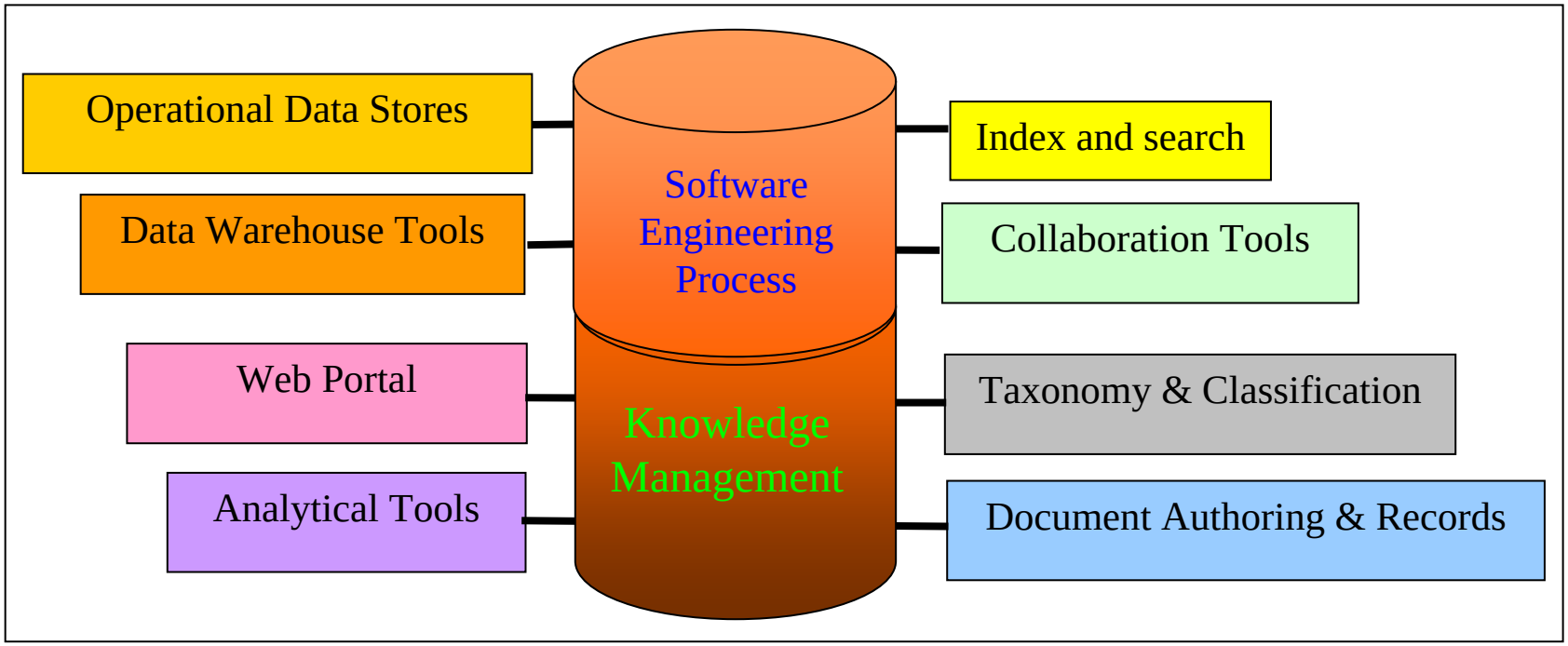
IV. Engineering Practice (6)

IV.2. Coupling C2SES and KM Processes (4)

Section	Purpose
Cover Sheet	A cover sheet for each build or release of software that includes a high level description of the CI, component, or unit name, the responsible engineer, and due date and date complete columns for each section of the SDF..
Requirements	List of software requirements applicable to the CI, component, or unit name. Include either copies of the applicable requirements or pointers to the applicable requirements. Requirements Traceability Matrix showing requirements applicable to the CI, component, or unit name.
Design	Design diagrams, design documents, interface descriptions, and/or threads and use cases applicable to the CI, component, or unit name.
Implementation	Location of the source code, make files, build scripts, and executables, preferably from a controlled CM library system, applicable to the CI, component, or unit name.
Test	Unit test plans, test cases, procedures, and test results indicating pass or fail for the CI, component, or unit name. Integration test and subsequent tests are stored in the TDF, not the SDF.
Problem Reports	List of problem reports submitted against the CI, component, or unit name which includes the status of each problem report. Copies of each PR may be included.
Reviews and Audits	Review material (presentations) and review results (agendas, minutes, and action items) from requirements, design, implementation, and test peer reviews, PDR and CDR technical reviews, management reviews, technical working groups, and non-conformances from audits.
Notes	Additional information deemed relevant to the CI, component, or unit name which is useful to developers, maintainers, or reviewers.

IV. Engineering Practice (7)

IV.3. Tools and Mechanisms for KM in C2SES



C2SES knowledge management tools and their links

IV. Engineering Practice (8)

IV.3. Tools and Mechanisms for KM in C2SES (2)

C2SES Documents

Documents are handled in accordance with Northrop Grumman practices to the extent applicable.

Document ID	Title
PRM	NGMS Policy & Requirements Manual
SPM	NGMS Standard Process Manual
MET	NGMS Metrics Manual
PPM	NGMS Procurement Policy Manual
COM	NGMS Contracts Manual
IEP	NGMS Integrated Enterprise Processes

C2SES Uses of Northrop Grumman Documents

IV. Engineering Practice (9)

IV.3. Tools and Mechanisms for KM in C2SES (3)

Applicable Standards and Other References

Documents identified in Table 2-3 are standards applicable to the program.

Title
Software Engineering Institute (SEI) Capability Maturity Model Integration (CMMI)
International Organization for Standardization (ISO) 9001:2000
Aerospace Standard (AS) 9100
Guide for Information Technology, Software Life-Cycle Processes, Implementation Considerations, Institute of Electrical and Electronic Engineers (IEEE)/Electronic Industries Association (EIA)-12207

V. Conclusion

The three-tier knowledge management scheme

keeps a balance among the factors of

(1) Smoothly and timely transforming legacy systems to updated, innovative, and modern systems

(2) Maintaining continual, un-interrupted operation of the C2 software system

(3) Minimizing software defect incidents

(4) Reducing or keeping C2 software maintenance and innovation at a controllable level of cost

V. Conclusion (2)

Principles of Research:

Knowledge comes from people

knowledge is broader, deeper, and richer than data or information

Knowledge is a mix of experience, value, contextual information, and expert insights

Knowledge provides a framework for evaluating new experiences and information.

Focus:

A systematic plan of knowledge management for technology innovation to C2 software systems.

Insights:

Technology can help capture some knowledge, but it is not the ultimate answer.

The key to knowledge management is **people** and **process**.

Questions ?

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