The Application of a Systems Engineering Process to the Re-engineering of an Air Defense System

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AGENDA
- Introduction
- Organizational Processes
- Re-Engineering Project
- Lessons Learned
- Next Steps
- Conclusion
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Oerlikon Aerospace

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System Integrator of an Air Defense System
Certified as Level 2 - Software Engineering Institute in 1997

- Has also met 8 of the 17 Level 3 Goals
- ISO 9001 since 1993
- NATO Secret Organization
- Over 120 Systems and Software Engineers

OERLIKON AEROSPACE

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Organizational Processes

- Systems & Software Engineering
- Document Inspection
- Configuration Management
- Quality Assurance
- Lessons Learned
- Staffing, Performance Management
- Documentation Management
- Contract Management
- Procurement Management

Engineering Process Asset Library

- Policies
- Process Descriptions
- Guides, Forms and Templates
- Examples of Documents Produced
  - Business Cases
  - Proposals
  - Engineering Plans
  - Specifications
- Tailored Processes
- Process and Product Measures
- Lessons Learned
- Charter of Process Engineering Groups
- Training Material
- Historical Data
- **SYSTEMS ENGINEERING PROCESS (SEP)**
  - Systems Engineering Capability Maturity Model
  - Generic Systems Engineering Process from Software Productivity Consortium (SPC)
  - The SEP activities can be performed:
    - Concurrently
    - Iteratively
    - Recursively

**MANAGEMENT ACTIVITIES OF OA SEP**

- **STEP 110**
  - Understand Context
- **STEP 120**
  - Analyze Risk
- **STEP 130**
  - Plan Increment Development
- **STEP 140**
  - Track Increment Development
- **STEP 150**
  - Perform Increment Closure
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Management Activities of OA SEP

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Step 110 - Understand Context

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VIEW OF A PROCESS STEP

STEP 111 - Define Approach

Inputs
- System Engineering Folder (SEF)
- Customer Requirements
- External System Definition
- Subsystem/Component Status (Feedback)
- User Requirements
- Technology Base
- System Status (Feedback)
- Technical Release (Feedback)
- System Context (Feedback)
- Information Sources (SW, insights, historical data, policies, etc.)

Outputs
- Define key system/increment objectives
- Identify system/increment constraints
- Identify system/increment stakeholders
- Develop alternatives

Systems Engineering Folder (SEF)
- Approach Definition

Entry Criteria
- Signed contract or authorisation
- Resources
- Stakeholders
- Management authorisation

Exit Criteria
- Increment-level objectives
- Alternatives, constraints, and stakeholders
- Legacy inherited
- Appropriate changes

STEP 210 - Analyze Needs
STEP 220 - Define Requirements
STEP 230 - Define Functional Architecture
STEP 240 - Synthesize/Allocated Architecture
STEP 250 - Evaluate Alternatives

STEP 260 - Verify and Validate Work Products
STEP 270 - Control Tech. Baseline
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TECHNICAL ACTIVITIES OF OA SEP

- Analyse Needs
- Define Requirements
- Define Functional Architecture
- Synthetize Allocated Architectures
- Evaluate Alternatives
- Verify and Validate Work Products
- Control Technical Baseline

OVERVIEW OF LAUNCHER CONTROL UNIT

- Coordinates operation of sensors
  - Radar, FLIR, TV, wind sensor.
- Controls missile launch and guidance
- Guides missile flight with laser beam
- Tracks missile with infrared detectors
- Tracks targets
- Controls turret servo systems
- Interfaces with other sub-systems (consoles)
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MAIN OPERATOR CONSOLES FUNCTIONS
- Radar console display and controls:
  - Radar Operation
  - C³ Network Management
- Electro-optical console display and controls:
  - Optical Sensors (FLIR, TV)
  - Missile Launch/Guidance

RE-ENGINEERING PROJECTS
- Divided in Two Increments
  - Increment One: System Definition Increment
    - Output:
      - System Requirement Specifications
  - Increment Two: Sw/Hw Development Increment
    - Outputs:
      - Set of Design and Equipment Specifications
      - Qualified Pre-Production Unit
Step 110 - Understand Context

- Sub Step 111 - Define the Approach
  Activity 1 - Define Objectives of the Increment
    - Reduce production, life-cycle costs and part obsolescence
    - Improve growth potential (e.g. graceful degradation)
  Activity 2 - Identify Project Constraints
    - Interface with existing components (e.g. missile, e-o)
    - HCI conflicting requirements from users/customers
  Activity 3 - Identify Project Stakeholders
    - Current customer representatives and Current users
    - Marketing and business development
    - Senior management and Team members

Activity 4 - Develop Project Alternatives
  - Rehost functions on new hardware or incorporate new requirements
  - Select a development life-cycle
    - Vee (Forsberg)
  - Conduct Pilot project
  - Select Alternative Technologies (e.g. trade-off analysis)
  - Identify COTS
    - communication bus
    - processors
    - displays
Step 110 - Understand Context

- Sub Step 112 - Estimate the Situation
  - Put project knowledge together by documenting assumptions, decisions and their rationale
- Sub Step 113 - Review Context
  - Review estimate of the situation with stakeholders
  - Obtain commitment to go ahead
    - Go - No Go decision point
  - Agree on strategy
  - Commit resource allocation

Step 120 - Analyze Risks

- Risk Management Plan
  - Risk Descriptions and Impacts
    - Budget overrun, schedule delays, integration risks due to concurrency, new technologies
    - Documented, updated and stored in a database
  - Mitigation Strategies
    - Pilot projects, engineering models, mock-ups
    - Analyses
    - Component and subsystem modeling
    - Training
    - Reviews with stakeholders
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**Step 130 - Plan Increment Development**
- Systems Engineering Management Plan (SEMP)
  - Revision of alternative solutions
  - Definition of TPMs, requirement management approach, training plan, CM, QA, technical and project reviews.
  - Description of the increment, e.g. reverse engineering
  - Look ahead of next increment, e.g. forward engineering
    - Problems, needs and constraints (SEP 210)
    - Function definition (SEP 220, 230)
    - Functional allocation (SEP 240)
    - Definition of system (SEP 250)
- Development of the Organizational Breakdown Structure (OBS)
- Development of the Work Breakdown Structure (WBS)
- On-going execution of risk aversion

**Step 140 - Track Increment Development**
- Formal reviews
- Update the SEMP

**Step 150 - Perform Increment Closure**
- On-going capture of work products (e.g. developmental configuration management)
- Capture Lessons learned from the increment
- Baseline work products
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Step 200 - Technical Activities

- Step 210 - Analyze Needs
  - Legacy system requirements were known
  - Comments, suggestions, deficiencies were captured
  - Potential customer’s requirements were captured
  - Compile, analyze, prioritize
  - Operational scenarios and environment re-assessed
  - Review with stakeholders in parallel with Risk Management Plan
  - Performed iteratively
- Step 260 - Verify and Validate Work Products
  - Requirements and verification requirements, stored in a database

A SEP INCREMENT (THE REAL LIFE)

- SEP-100 Manage Development Effort
  - Understand Context
- SEP-200 Define System Increment
  - Analyze Needs
  - Define Requirements
  - Define Functional Architecture
  - Synthesize Allocated Architecture
  - Evaluate Alternatives
- Track Increment Development
- Define System Plan
LESSONS LEARNED

- Use Pilot Projects to Mitigate Risk
  - Members of Pilots projects have a Safety Net for "mistakes"
    - Selection of participants that knew the system process
    - Other participants were coached
  - Success of Pilots facilitates adoption of technologies
- Size of Increments
  - Manageable length so to be able to assess progress.
  - Well identified deliverables: % of completion can be assessed.
- Experienced Project Manager
  - First time use of an incremental process
- Series 100 steps were performed in sequence while series 200 steps were performed in multiple iterations

NEXT STEPS

- Integrate SEP with Project Management Process and Software Development Process (e.g. risk management)
- Define Project Metrics and Process Tailoring Guidelines
- Apply SEP to detailed design & development phase
- Map SEP to CORE® Systems Engineering Tool

Conclusion

- Process was found very useful in planning activities, collecting and managing technical information
- Pilot projects helped in better understanding the SEP
- Experienced project managers are still required
  - The systems engineering process cannot be followed blindly