Project Management for Research and Development:

*Using Tailored Processes to Assure Quality Outcomes*

Innovation Methodologies Track
Saturday, September 19, 2015.
4:00 -4:50 p.m. EDT
Lory Mitchell Wingate  
MBA, PMI PMP, INCOSE ESEP  
lorymitchellwingate@gmail.com  
https://www.linkedin.com/in/lorymitchellwingate

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Lory Mitchell Wingate has achieved notable success in program and project management within policy research, aerospace engineering, production and support, and scientific research organizations. With over 25 years of experience in both for-profit and non-profit companies, Wingate possesses detailed knowledge and expertise in project management and has developed a strong method for combining the best practices from several disciplines into a winning formula for the management of research and development. She has an MBA in information technology management, is a Certified Project Management Professional (PMP), and a Certified Expert Systems Engineer (INCOSE).
Outline

- Introduction
- Research and Development (R&D)
- Research Methods
- Project Management Activities
- Related Critical Disciplines
- Application of Tailoring
- Other Considerations
- Summary
Introduction

During this session, we will review:

• the underlying principles and components that make up
  – Research and Development (R&D) Activities and Methods
• the enabling application of disciplined approaches for R&D
  – Project Management Methods & Related Disciplines
• the importance and application to R&D projects of
  – Measurements
  – Risk Management
  – Facilitating the Creative Team
Outline

• Introduction
• Research and Development (R&D)
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Phases of R&D

Basic Research  Oriented Basic Research  Applied Research  Early Development  Late Development  Pre-Production
R&D Attributes

- Level of Expected Change
  - Basic Research
  - Applied Research
  - Early Development
  - Late Development
  - Pre-production
  - Production/implementation
  - Operations

- Level of Creativity
  - Low
  - High

- # of Required Iterations
  - Unknown
  - Known/expected outcomes

- Known

Slide: 8
9/29/2015
Life Cycle Approach

Strategic Plan & Initiatives
  ↓
Portfolio Management

Program Management  Project Management  Strategic R&D Project Mgmt

Operations Mgmt
  ↓
Incremental Process Innovation

Upgrade Project Mgmt
  ↓
Agile Project Mgmt

Upgrade Project Mgmt
  ↓
Traditional Project Mgmt

R&D Project Mgmt
  ↓
Basic Research – Radical Innovation
Spiral HW/SW Development – Incremental Innovation

Technical Challenge

High
• Incremental R&D
  ➢ Evolutionary progression
  ➢ Enhancements to existing capability – outside known technology

• Radical R&D
  ➢ Leap-frog
  ➢ Paradigm-shifting
  ➢ Departure from existing capability

Low
• Production/Operations
  ➢ Day-to-day operating
  ➢ Recreating articles
  ➢ Replacements
  ➢ Repairs
  ➢ Off-the-shelf

• Upgrades/Enhancements
  ➢ Slight modification – inside known technology
  ➢ Incremental improvement in current capability

Performance Timeframe

Annual
Multi-Year
Life Cycle Activities

Life Cycle Progression

Discipline Levels
Outline

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Typical Steps in Research

• An individual or group decides to investigate something.
• A research area is identified.
• An unbiased question to answer or a hypothesis is formed.
• The current body of knowledge is evaluated through review of documents and information, observation, experiences, discussions, or other methods.
• An approach to experimentation or testing is set up.
• Appropriate measurements are chosen.
• Experiments or tests are run.
• Results are first reviewed for quality and integrity.
• Results are analyzed and interpreted.
• Question or hypothesis is revised, and/or the outcomes are documented.
Research Methods

- **Definition**
  - Exploratory
  - Explanatory
- **Expected Outcomes**
  - Known
  - Unknown
- **Quality**
  - Subjective
  - Objective
- **Measures**
  - Quantitative
  - Qualitative

- **Socratic Method**
- **Mixed Method**
- **Scientific Method**
## Research Methods

<table>
<thead>
<tr>
<th></th>
<th>Scientific</th>
<th>Modern Socratic</th>
<th>Classical Socratic</th>
<th>Mixed</th>
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<tbody>
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<td>Pre-designed Question</td>
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<td>Predictable Answers</td>
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<td>Empirically Testable</td>
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<td>Deconstructive Phase</td>
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<td>Constructive Phase</td>
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<tr>
<td>Quantitative</td>
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<tr>
<td>Qualitative</td>
<td>X</td>
<td></td>
<td></td>
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<tr>
<td>Correct Answer Expected</td>
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<tr>
<td>Interactions expected</td>
<td>X</td>
<td>X</td>
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<td>X</td>
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<tr>
<td>Objective Results</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>
Application of Methods to Research Types

- Scientific
- Humanities/Social Sciences
- Creative/artistic

Approach

Subjective

Objective

Results

Qualitative

Quantitative
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Standard PMI Project Management Activities
Different Types of Projects

Strategic Plan & Initiatives

Portfolio Management

Program Management
- Operations Mgmt
  - Incremental Process Innovation
- Upgrade Project Mgmt
  - Traditional Project Mgmt
  - Agile Project Mgmt
- R&D Project Mgmt
  - Basic Research – Radical Innovation
  - Spiral HW/SW Development – Incremental Innovation

Project Management
- Upgrade Project Mgmt
  - Agile Project Mgmt

Strategic R&D Project Mgmt
- Agile Project Mgmt
Management Methods

- **XP**
- **ASD**
- **EVO**
- **Agile**
- **Crystal**
- **Scrum**
- **RAD**
- **DSDM**
- **Unified Process**
- **FDD**
- **PLM**

Levels:
- **High** (Architecture Design Maturity)
- **Low** (Architecture Design Maturity)
- **High** (User Involvement During Development)
- **Low** (User Involvement During Development)
- **Low** (Levels of Change Accepted Out of Cycle)
- **High** (Levels of Change Accepted Out of Cycle)

- **Long - 24 Months**
- **Short - 1 Week**

- **Development Tempo**
Level of Project Formality

- Informal
- Semi-Formal
- Formal

Basic Research → Applied Research → Development → Production
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Complementary Disciplines Strengthen R&D Efforts

• The disciplines which provide the best all-around approach for R&D are:
  
  - **Project Management** Flexible methods
    • provide structure to assess R&D progress
  
  - **Systems Engineering**
    • provides structure to measure progress, assess risk, assure quality
    • assures the many stand-alone development activities come together as a cohesive whole
  
  - **Industrial Engineering**
    • focuses on efficiency, optimization, and impacts throughout the entire demand and supply processes
## Complimentary Disciplines
### Value on R&D Projects

<table>
<thead>
<tr>
<th>Disciplines</th>
<th>Project Management</th>
<th>Systems Engineering</th>
<th>Industrial Engineering</th>
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<tbody>
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<td>Analysis</td>
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<tr>
<td>Architecture</td>
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<td>Audits/ Reviews</td>
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<td>X</td>
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<td>Baseline Devel and Mgmt</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Budget/ Cost</td>
<td>X</td>
<td></td>
<td></td>
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<tr>
<td>Change/ Config Control</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Forecasting</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Interface Mgmt</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Modeling/ Simulation</td>
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<td></td>
<td>X</td>
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<tr>
<td>Performance Measures</td>
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<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Requirements/ Specifications</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Risk</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Schedule</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Systems Analysis</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Test/ Verification/ Validation</td>
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<td></td>
<td>X</td>
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<tr>
<td>Trade Studies</td>
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<td></td>
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<tr>
<td>WBS/Structure</td>
<td>X</td>
<td>X</td>
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</table>
Systems Engineering Activities

- **Management Processes**
  - Lifecycle Analysis
  - Organization (WBS)
  - Baseline (Scope, Schedule, Cost)
  - Functional Architecture
  - Physical Architecture
  - Change and Configuration Management

- **Technical Processes**
  - Requirements Definition
  - System Design
  - Specifications
  - Modeling, Simulation, Trade Studies
  - Interface Control
  - Technical Performance Measures
  - Technical Audits and Reviews
  - Risk Management
  - Test, Verification and Validation
Key Systems Engineering Activities

For R&D Projects

• Management Processes:
  – Life Cycle Analysis – Setting strategy, trajectory, high-level goals
  – Organization – Developing the WBS, communicating results
  – Baseline – Scheduling and budgeting as relates to use of labor and materials resources needed to support prototyping and other experiments
  – Functional Architecture – Documenting experimentation methods
  – Physical Architecture – Preparing simulations, models, or prototypes
  – Change and Configuration Management – Required reviews, tracking design modifications and retests as appropriate to reduce risk and track progress toward goals

In ALL cases, a R&D workbook must be kept to document the work that is done, results of tests, changes implemented, etc.
Key Systems Engineering Activities

For R&D Projects

• **Technical Processes:**
  - Requirements definition – requirements elicitation, decomposition
  - System design – posing questions and/or forming hypotheses and identifying the appropriate decision points for when the work should no longer be pursued
  - Specifications – MOP, TPM, TRL
  - Modeling, simulation, trade studies – searching relevant literature, discussions, comparative development activities across disciplines
  - Interface control – ICDs
  - Technical performance measures - KPI, MOE, KPP, prioritizing and setting up experiments, technical audits and reviews, stopping work when appropriate
  - Risk management – risk register
  - Test, verification, validation – testing, recording measurements, making calculations, verification, validation, and quality checks
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Key Questions to Ask

- What is the R&D strategic goal and life cycle phase?
- What is the level of investment that is expected?
- What is the rough time frame of the R&D and what cycle/tempo will be employed?
- What is the intended approach (Socratic, Scientific, Mixed)?
- What is the anticipated trajectory(ies) of the R&D?
- What is the hypothesis, idea, or question to be pursued?
  - What are the known experiments and tests that will be completed?
  - What are the key decision points?
- What level of controls will be enacted (reviews, measures, etc.)?
  - What measures of effectiveness and performance will be used?
- How will risk/opportunities be assessed and mitigated?
Research Trajectories

Test #1: Change in collection system
- Result: Negative
- Stop or Test #2: Change in collection system
- Result: Negative Result: Positive
- Next Generation Wind Farm Capability

Test #1: Change in substation
- Result: Negative
- Stop or Test #2: Change in substation
- Result: Negative Result: Positive

Components
- Standard power collection system
- State-of-the-Art power collection system
- Standard communications Network
- State-of-the-Art communications network
Definition of Experiments/Tests

- Which experiments and tests are chosen and why depends on the project:
  - Life cycle location
  - Project size
  - Dollar amount associated with the R&D
  - Trajectory
  - Desires of the researcher
Types of Experiments and Tests

- Modeling and simulation
- Pilot or case studies
- Sampling (random, systematic, stratified)
- Empirically through observation
- Interrogation or Interview (including surveys, etc.)
Measuring Technical Performance

CUSTOMER

Measures of Effectiveness

PROJECT TEAM

Key Performance Parameters

Risk Management Plan

Measures of Performance

Technical Performance Measures

Test and Verification

Validation
Measuring Success

Life Cycle Phase

Research
Development
Production/Construction

Overall Project Outcome
New/Revised Process
New Concept or Idea

Light
Medium
Strong/Heavy

Level of Control

Types of Control
Trend/Variance Analysis
TRL Analysis
Governance
Reviews
TV&V

Formal
Informal
Approach
Continuum of Reviews

- SRR/ASR
- SDR
- SFR
- PDR
- CDR
- TRR
- PRR
- SVR
- SAR
- ORR

Requirements Reviews
Design Reviews
Verification Reviews
Technical Readiness Levels

Production/construction

Development

Applied Research

Basic Research

TRL Level 1

TRL Level 2

TRL Level 3

TRL Level 4

TRL Level 5

TRL Level 6

TRL Level 7

TRL Level 8

TRL Level 9
### Risk Management

#### Risk Identification

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<th>Category</th>
<th>Risk Title</th>
<th>Risk Number</th>
<th>Risk Source</th>
<th>Threat Effect</th>
<th>Responsible Role</th>
<th>Probability</th>
<th>Impact</th>
<th>Composite Index</th>
<th>Rating</th>
<th>Other Considerations</th>
<th>Priority</th>
<th>Contingency</th>
<th>Risk Treatment</th>
<th>Mitigation Strategy</th>
<th>Trigger</th>
<th>Other</th>
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<td>FOC</td>
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<td>1.0</td>
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<td>yes</td>
<td>yes</td>
<td>9/29/2015</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Risk Assessment

- **Probability**: 5 represents the maximum possible impact of the occurrence of the risk (usually in terms of financial loss).
- **Impact**: 0 through 25, where 0 represents a zero occurrence of the risk event actually occurring.

#### Risk Mitigation

- **Risk Treatment**: Major risk options include: 1. Design and implement new business processes with adequate built-in risk control and containment measures from the start. 2. Periodically reassess risks that are accepted and ongoing processes as a normal feature of business operations and modify mitigation measures. 3. Transfer risks to an external agency (e.g., an insurance company). 4. Avoid risks altogether (e.g., by closing down a particular high-risk business area).

- **Mitigation Strategy**: Example strategies include: * Avoidance (eliminate withdrawal from or not becoming involved): * Reduction (optimize mitigate): * Sharing (transfer - source to secure): * Retention (accept and budget).
Measurement and Controls for R&D

Key Points

• Regardless of the life cycle, a project should apply all of the measures, albeit, at different levels of control and effort (tailoring)
• Measures can be applied in an infinite variety of ways depending on the desires of the customer, other stakeholders, and the systems engineer
  – Metrics need to be carefully chosen and then validated to make sure they are measuring useful information
• If the project scope and trajectory are well documented, and a clear set of tests, experiments, and anticipated outcomes (if appropriate) have been established, then a set of subordinate schedules can be sequentially developed
• All R&D projects need to be able to demonstrate how one arrived at a conclusion, to have the steps be repeatable, and to arrive at the same results
• Change and configuration control minimizes unintended consequences
Specific Techniques for R&D Projects

- Document the work so others may follow
  - Communicate with interested stakeholders about what they want to know to keep them engaged
- Set up the overarching project schedule, and then use a one to three month rolling wave approach for management of the project
  - Make the hard decisions, move in a different direction, or stop work when appropriate
- Choose a small number of carefully chosen and validated measures
  - Make sure it is known why the metric is being collected
  - Use the MOE, MOP, KPP to align with strategy and trajectories
  - Utilize TPMs within the rolling wave to help break through branch points
  - Use risk management to decide which tests and experiments to do first
  - Ensure reviews are as informal as possible, and do them as often as required
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R&D Team Dynamics

Need to meet pre-defined targets or achieve incremental changes

Low
High

Need to implement existing processes

Low
High

Leadership Skills

Need to break down existing barriers

Low
High

Management Skills

Need to change the paradigm or make radical changes

Low
High

Ability to influence the Project Objective

Low
High

Team Supervisor

Technical Lead

Team Manager

Team Leader

Ability to Inspire R&D Performance

Low
High

Responsibility for Staff Objectives Setting

Low
High

9/29/2015
R&D Learning Environment

<table>
<thead>
<tr>
<th>Free Time</th>
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<tbody>
<tr>
<td>Does the individual have free discussion time to explore ideas and brainstorm with individuals internal to the organization?</td>
</tr>
<tr>
<td>Does the individual have free discussion time to explore ideas and brainstorm with individuals external to the organization?</td>
</tr>
<tr>
<td>Does the individual have free discussion time to explore ideas and brainstorm with individuals across disciplines?</td>
</tr>
<tr>
<td>Is the R&amp;D project scheduled with free time?</td>
</tr>
<tr>
<td>Is the R&amp;D Project scheduled with free time at the right locations along the development path?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Free Speech</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does the individual regularly participate in cross-disciplinary seminars, colloquia, lectures, discussions, or other information sharing forums?</td>
</tr>
<tr>
<td>Does the individual understand the boundaries for information sharing?</td>
</tr>
<tr>
<td>Is free speech and the flow of new ideas is uninhibited and unhindered?</td>
</tr>
<tr>
<td>Are new ideas allowed to flow up to the strategic level of the organization for evaluation?</td>
</tr>
<tr>
<td>Are there impact-free communications channels in place to discuss R&amp;D outcomes?</td>
</tr>
</tbody>
</table>
### Focus on Outcomes

<table>
<thead>
<tr>
<th>Question</th>
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</thead>
<tbody>
<tr>
<td>Is the progress the R&amp;D project makes toward the strategic goal what is measured?</td>
</tr>
<tr>
<td>Are informal discussions with the stakeholders held at the culmination of every experiment or test?</td>
</tr>
<tr>
<td>Are the stakeholders involved in decision making at the each of the gate?</td>
</tr>
</tbody>
</table>

### Collaborative Physical Environment

<table>
<thead>
<tr>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does the physical environment provide for a significant amount of interdisciplinary interactions?</td>
</tr>
<tr>
<td>Are their private spaces that allow for uninterrupted focused reflection and creation?</td>
</tr>
</tbody>
</table>
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Summary

Project Management for R&D

• All activities, no matter what they are, follow some level of discipline and an underlying set of processes.
• There is a set of standard project management and related discipline processes that, when applied to sets of activities or tasks, have been shown to be effective in leading to successful R&D outcomes.
• Standard PMI and INCOSE processes can be applied to activities regardless of the industry or discipline: science, technology, arts, adventure, etc.
• Measures can be applied in an infinite variety of ways depending on the desires of the customer, other stakeholders, and the Project Manager.
Interested in learning more?

Purchase information:
“Project Management for Research and Development”


Includes diagrams, surveys, checklists, and question-answer forms in each chapter.
Questions?