I/ITSEC Tutorial
Return on Investment (ROI) for Modeling and Simulation

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Standard Form 298 (Rev. 8-98)  Prescribed by ANSI Std Z39-18
This tutorial will present Return-on-Investment (ROI) concepts and processes that can be used to determine the ROI of a model or simulation in any functional area by enabling the student to:

- apply ROI terms, guidelines and formulas to their own M&S projects
- evaluate all costs / resources associated with an M&S program
- identify alternative methods of achieving goals
- calculate the ROI of an M&S program based on quantitative and qualitative criteria
1. Introduction to Return-on-Investment
   1.1. What Is ROI and Why Is It Important?
   1.2. ROI for Modeling and Simulation

2. Process for Quantifying M&S
   2.1. Requirements Definition
   2.2. Nine ROI Factors for M&S

3. Evaluating an M&S Application
   3.1. Designing Metrics for the Nine Factors
   3.2. Functional Implications of the Nine Factors
   3.2.1. Quantitative Metrics
   3.2.2. Qualitative Metrics
Simulation and acquisition programs (that used M&S) failures have raised concerns about why these investments so often fail to live up to expectations.

M&S during Vietnam

Comanche

Crusader

M&S in the Gulf War Casualties Count

Rise and Fall of JSIMS

M&S – Negative or Positive ROI?
A performance measure used to evaluate the efficiency of an investment or to compare the efficiency of a number of different investments.

<table>
<thead>
<tr>
<th>Investment</th>
<th>Alternative(s)</th>
<th>ROI</th>
</tr>
</thead>
<tbody>
<tr>
<td>People</td>
<td>Individual</td>
<td></td>
</tr>
<tr>
<td>Money</td>
<td>Individual On Individual</td>
<td></td>
</tr>
<tr>
<td>Time</td>
<td>Small Organization</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Multiple Organization</td>
<td></td>
</tr>
</tbody>
</table>

- **Virtual Simulation**
- **Constructive Simulation**
- **Live Simulation**

http://dictionary.reference.com/browse/ROI
Why Should I Care about ROI?

Justifies the investment to decision makers

Provides justification for oversight of funding the investment throughout its life cycle

Establishes a baseline to monitor, measure and evaluate the investment
Effectiveness: How much — bang for the buck — will we get out of this project?

Impact: Will the benefits to USAF, DoD, federal government, country or society justify the overall investment in this project?
Questions for an ROI Analysis

Efficiency: Is this the most we can get for this much investment?

Financial: Can we afford this? Will it pay for itself?
ROI is not a silver bullet - nor is there a Consumer Report for ROI products and services.

ROI a rather diverse collection of methods, skills, tools, activities and ideas.

No single —right” way to conduct a ROI analysis.
Design Metrics

Remember the perspective of who the ROI is for.

Internal to the Program

Program Manager

External to the Organization

Press

Other

Environmentalist

User

Using Organizations

Budget

Timelines

Programs

News

Using Organizations

User Environmentalist
Areas for M&S Return on Investment

Reuse
Readiness
Efficiency
Risk Reduction
Effectiveness
Money
Environment
Lives
Time
Extended Air Defense Simulation (EADSIM)
First Deployed in 1989

Used by:
- Combat developers
- Materiel developers
- Operational commanders

Interfaces:
- Aggregate Level Simulation Protocol (ALSP)
- Distributed Interactive Simulation (DIS)
- High Level Architecture (HLA)

EADSIM used during DESERT SHIELD/DESERT STORM:
- To analyze attrition, Suppression of Enemy Air Defense (SEAD) missions and refueling operations
- BGEn Glosson stated that EADSIM "saved lives and equipment."
- 32nd Army Air Defense Command used EADSIM to analyze proper positioning of PATRIOT in Israel and Turkey

EADSIM is now being used at more than 390 subscriber sites around the world.

http://www.smdc.army.mil/FactSheets/EADSIM.pdf
Areas for M&S Return on Investment

B2 Bomber

- Limited Number of Aircraft – 21 Operational (1 Test)
- Operation Construct – Stateside Basing
  - Construct Leads to Long Missions
  - Longest Single Sortie was 44 hours
  - Crew – 2 Pilots
  - Cost to Fly Aircraft
- Train via Simulation

"B2 pilots’ greatest challenge is endurance… in training they spend as long as 50 hours in simulators.”  Maj Gen Przybyszlawski
Efficiency

Provides Joint Terminal Air Controller (JTAC) with Predator video to provide terminal attack control without direct eyes on target

Areas for M&S Return on Investment

ROVER
Remote Operations Vehicle Enhanced Receiver

Predator

Provides Joint Terminal Air Controller (JTAC) with Predator video to provide terminal attack control without direct eyes on target
Jet Blue
—That is a very difficult maneuver, especially since pilots are not given simulator time to practice it. As of Monday this event will be part of simulator training.”

http://www.airlinesafety.com/editorials/JetBlueLAX.htm
**Effectiveness**

- Wind Tunnel Effects
- Airframe Loads
- Carriage Loads
- Store Separation
  - Internal Carriage
  - External Carriage
- Fuel Tank
  - Design
  - Loads
  - Jettison
- Aircraft lift fan/secondary inlet design

- Eliminated tests for high speed data
- Improved data quality and reduced risk
- Computed trajectories beyond tunnel hardware movement constraints
- Screened test configurations, reducing testing costs
- Total savings = $ Millions

Areas for M&S Return on Investment

- New procedures had to be written and tested
  - A coast-to-coast network of simulators, computers and experts was formed
  - Everything was tested in the simulator before being passed up to the crew

- Oxygen tank No. 2 blew up
- Command modules normal supply of electricity, light & water was lost
- 200,000 miles from Earth

http://liftoff.msfc.nasa.gov/Academy/History/APOLLO-13/MISSION-REPORT.HTML
Areas for M&S Return on Investment

Electric Boat, by using M&S, took 7 years off development of the submarine.

Areas for M&S Return on Investment

- Invested $1.4 billion to purchase additional simulators and upgrade existing ones.

- Estimates aircraft flight hours will be reduced by 270,000 hours over the next 6.5 years.

- Save $2.3 billion in aircraft fuel, airframe use, wear and tear and aircraft maintenance.

Environment

GAO-02-727T Military Training

Encroachment had affected every training range’s capabilities, requiring workarounds—or adjustments to training events. A more complete assessment of training resources should include assessing the potential for using virtual or constructive simulation technology to augment live training.

Ft Hood Environmental Restrictions

- 199,541 total land
- 154,053 acres with training restrictions - 77% of training land
- 30,827 acres of maneuver land without training restrictions

GAO-02-727T Military Training

Due to restrictions, weapons or testing threats are prohibited.

Defense Threat Reduction Information Analysis Center

Population Density - Noise
Clean Air
Archaeology
Endangered Species
Clean Water – Erosion Control

Areas for M&S Return on Investment

http://www.gao.gov/htext/d03621t.html
# Areas for M&S Return on Investment

## Training

<table>
<thead>
<tr>
<th>Area</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reuse</td>
<td>Increase # of users and applications for the simulation</td>
</tr>
<tr>
<td>Efficiency</td>
<td>Proficiency level after a simulation event</td>
</tr>
<tr>
<td>Readiness</td>
<td>Increased preparedness to a greater number of situations</td>
</tr>
<tr>
<td>Lives</td>
<td>Reduced deaths &amp; injuries through simulations</td>
</tr>
<tr>
<td>Risk Reduction</td>
<td>Reduced accidents during high-risk training</td>
</tr>
<tr>
<td>Effectiveness</td>
<td>Increased performance in real-world situation</td>
</tr>
<tr>
<td>Time</td>
<td>Optimize training for the audience</td>
</tr>
<tr>
<td>Money</td>
<td>Optimize or reduce the cost of training</td>
</tr>
<tr>
<td>Environment</td>
<td>Use simulation for training that can not be done</td>
</tr>
</tbody>
</table>

## Acquisition

<table>
<thead>
<tr>
<th>Area</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reuse</td>
<td>Increase # of users and applications for the simulation</td>
</tr>
<tr>
<td>Efficiency</td>
<td>Lower cost due to simulation use</td>
</tr>
<tr>
<td>Readiness</td>
<td>Faster delivery of new materials to the warfighter</td>
</tr>
<tr>
<td>Lives</td>
<td>Simulation testing prior to human conducting live testing</td>
</tr>
<tr>
<td>Risk Reduction</td>
<td>Remove more of the unknowns in the testing cycle</td>
</tr>
<tr>
<td>Effectiveness</td>
<td>Able to, as a minimum, keep project on time and budget</td>
</tr>
<tr>
<td>Money</td>
<td>Maintain or reduce development time</td>
</tr>
<tr>
<td>Environment</td>
<td>Maintain or reduce acquisition costs</td>
</tr>
<tr>
<td>Analysis</td>
<td>Offset restrictions caused by environment constraints</td>
</tr>
</tbody>
</table>

## Analysis

<table>
<thead>
<tr>
<th>Area</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reuse</td>
<td>Increase # of users and applications for the simulation</td>
</tr>
<tr>
<td>Efficiency</td>
<td>Greater accuracy based on the use of a simulation</td>
</tr>
<tr>
<td>Readiness</td>
<td>Increase the timeliness of analytical information</td>
</tr>
<tr>
<td>Lives</td>
<td>Removing some areas of human error prior to decisions</td>
</tr>
<tr>
<td>Risk Reduction</td>
<td>Look at larger number of what ifs</td>
</tr>
<tr>
<td>Effectiveness</td>
<td>Fill in void when subject matter experts are unavailable</td>
</tr>
<tr>
<td>Money</td>
<td>Provide answers faster</td>
</tr>
<tr>
<td>Environment</td>
<td>Reduce costs for development of analytical products</td>
</tr>
<tr>
<td>Analysis</td>
<td>Analyze situations that can not be done live</td>
</tr>
</tbody>
</table>
Process for Quantifying M&S

Document the Process and Results!

Determine Requirements

Set Standards of Performance

Set Baseline

Design M&S Application

Design Metrics

Collect Data

Analyze Data

If Needed, Initiate Corrective Action

Determine ROI

Adjust Throughout the Process!
Process for Quantifying M&S

Document the Process and Results!

Determine Requirements

Adjust Throughout the Process!
Within the United States civilian and military aviation system there are numerous crisis situations that occur each year that receive both local and national attention.
Determine Requirements

Example – Perspective Implications

Training Example – How do I prepare employees for an aviation incident /accident?

Acquisition Example – How do I design a safer aircraft?

Analysis Example – How do I react in the event of a crisis at an airport?
**Determine Requirements**

**Example – Identify Users**

- **Training Users**
- **Acquisition Users**
- **Analysis Users**
Determine Requirements
Example – Describe the Problem

Training Example – How do I prepare employees for an aviation incident /accident?

Aircraft crew members need to recognize, evaluate and respond to emergency situations on an aircraft with an appropriate crew resource management course of action.
Document the Process and Results!

- Determine Requirements
- Set Standards of Performance

Adjust Throughout the Process!
Standards of Performance

The manner in which something or somebody functions, operates or behaves in terms of established criteria.
IX. AREA OF OPERATION: EMERGENCY OPERATIONS

A. TASK: EMERGENCY APPROACH AND LANDING - (ASEL and ASES) REFERENCES: FAA-H-8083-3; POH/AFM.

Objective. To determine that the applicant:
1. Exhibits knowledge of the elements related to emergency approach and landing procedures.
2. Analyzes the situation and selects an appropriate course of action.
3. Establishes and maintains the recommended best glide airspeed, ±10 knots.
4. Selects a suitable landing area.
5. Plans and follows a flight pattern to the selected landing area considering altitude, wind, terrain, and obstructions.
6. Prepares for landing, or go-around, as specified by the examiner.
7. Follows the appropriate checklist.
Acquisition Example – How do I design a safer aircraft?

The FAA provides the following categorizations of aircraft.

1. Categorization by Stall Speed (which determines the basis of landing or approach speed): Table 1 - Aircraft Approach Category Source: FAA, 1976, United States standards for Terminal Instrument Procedures, 3d ed, FAA Handbook 8260.3B)

<table>
<thead>
<tr>
<th>Aircraft Category</th>
<th>1.3 Times the Stall Speed in Knots</th>
<th>Maximum Speed (Circling Approaches)</th>
<th>Typical Aircraft in This Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>less than 91 knots</td>
<td>90 knots</td>
<td>small single engine</td>
</tr>
<tr>
<td>B</td>
<td>91 to 120 knots</td>
<td>120 knots</td>
<td>small multi engine</td>
</tr>
<tr>
<td>C</td>
<td>121 to 140 knots</td>
<td>140 knots</td>
<td>airline jet</td>
</tr>
<tr>
<td>D</td>
<td>141 to 165 knots</td>
<td>164 knots</td>
<td>large jet/military jet</td>
</tr>
<tr>
<td>E</td>
<td>above 166 knots</td>
<td></td>
<td>special military</td>
</tr>
</tbody>
</table>
Standards of Performance Example

Analysis Example – How do I react in the event of a crisis at an airport?

• Current FAA standards for rescue and firefighting equipment are included in both FARs and Advisory Circulars.

• Aircraft rescue and firefighting indexes are, in accordance with FAR Part 139.315, designated by an index letter (i.e., A, B, C, D, or E) that represents the size of the largest aircraft the airport is prepared to handle in the event of a fire or rescue situation.

• Part 139.315 further states that “if there are five or more average daily departures of air carrier aircraft in a single index group, the longest index group with an average of 5 or more daily departures is the index required for the airport. In addition, if there are less than five average daily departures of air carrier aircraft in a single index group serving that airport, the next lower index from the longest index group with an air carrier aircraft in it is the index required for the airport.”
Process for Quantifying M&S

Document the Process and Results!

- Determine Requirements
- Set Standards of Performance
- Set Baseline

Adjust Throughout the Process!
Baseline

Conducted prior to the beginning of the event. Point of comparison for monitoring and evaluation data.

Focuses on the intended outcomes of a project.

Accounts for secondary outcomes and assumptions.
Training Example – How do I prepare employees for an aviation incident /accident?

Collect information on the current state of formal and informal training or education for employees who would deal with an aviation incident /accident.

Conduct interviews to gather information to benchmark the levels of knowledge, experience and training for each individual.

Conduct a qualitative survey on individual perception of being prepared for an aviation incident /accident.
National Aviation Operations Monitoring Service (NAOMS)
NASA Airline Study

• Air Carrier Questionnaire: Section B – Safety Events

• Aircraft mechanical & equipment (ER1-ER7) maintenance, equipment failures, fire, smoke

• Turbulence: Wake and en route (TU1-TU2):
  - Weather (WE1-WE6) Icing, diversions, ATC Wx issues & windshear
  - Passenger-Related Events (CP1-CP3) Disruption, medical emergency
  - Airborne Conflicts (AC1-AC3) Bird strikes, NMACs
  - Ground Events (GE1-GE10) Near collisions, hydroplaning, off runway events

• Aircraft handling (AH1-AH15) Variety of pilot-related issues:
  - Overweight, stalls, unusual attitudes, tail strikes, etc.
  - Altitude Deviations (AD1-AD2) Descend below MSA, deviation from assigned altitude
  - Air Traffic Control (AT1-AT2) Difficulty contacting ATC, high & fast clearances
1) Engine/Nacelle smoke/fire/fumes involving electrical components/wiring
2) Smoke, fire or fumes originated in cargo/baggage area
3) Cargo/baggage smoke/fire/fumes involving electrical components/wiring
4) Passenger compartment smoke/fire/fumes involving electrical components/wiring
5) Flights/attempted flights with wrong type of fuel
6) Severe turbulence resulting in occupant injury
7) Airplane went off end of runway
8) Hit/collided with runway/taxiway lights
9) Hit animal other than bird
10) Collided/nearly collided with ground vehicle on ramp/apron
11) Nearly collided [with another aircraft] while on runway
12) Began takeoff without ATC clearance at airport with active control tower
13) Near collision [with terrain or ground obstruction while airborne]
14) Airplane crossed runway threshold during landing approach with gear up
15) Airplane landed with gear up
Baseline Example

Acquisition Example – How do I design a safer aircraft?

Accident Reports

OSHA Studies

Aviation Incident Reports
Baseline Example

Analysis Example – How do I react in the event of a crisis at an airport?
Process for Quantifying M&S

Document the Process and Results!

- Determine Requirements
- Set Standards of Performance
- Set Baseline
  - Design M&S Application

Adjust Throughout the Process!
Of 169 accidents examined, 30 percent were caused in part by the pilots’ performance. Pilots incorrectly used the principles of Crew Resource Management (CRM) - an approach to improving safety through coordination of the cockpit crew, flight attendants, dispatchers and air traffic controllers.

**Requirement** - Train pilots and crew in CRM

**Baseline** - Results from GAO report

**Standard** - Reduce percentage of accidents due to CRM

**M&S Application** - Train pilots & crew in CRM through simulation
Aircraft crew members need to recognize, evaluate and respond to emergency situations on an aircraft with an appropriate crew resource management course of action.

Determine Requirements

Example – Who is the CRM Audience?

Trainig Example – How do I prepare employees for an aviation incident /accident?

- Pilot
- Flight Attendant
- Ground Crew
- TSA
- Ground Controller
- Air Traffic Controller
- Local Medical Responders
- On Site Responders
- Ticket Agents
- Local SWAT Teams
- Local Police Aviation
- Medevac Teams
Aircraft crew members need to recognize, evaluate and respond to emergency situations on an aircraft with an appropriate crew resource management course of action.
Design M&S Application
Training Example

Two Components of the Simulation

Realistic Scenario

True Physical Environment
# Simulation Application Options

## Establish Alternatives

<table>
<thead>
<tr>
<th>Acquisition</th>
<th>Training</th>
<th>Education</th>
<th>Planning</th>
<th>Experimentation</th>
<th>T&amp;E</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Constructive Simulation</strong></td>
<td>![Constructive Simulation Image]</td>
<td>![Constructive Simulation Image]</td>
<td>![Constructive Simulation Image]</td>
<td>![Constructive Simulation Image]</td>
<td>![Constructive Simulation Image]</td>
</tr>
</tbody>
</table>
# Simulation Application Options

## Establish Alternatives

<table>
<thead>
<tr>
<th></th>
<th>Individual</th>
<th>Individual to Individual</th>
<th>Small Organization</th>
<th>Multiple Organizations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Live Simulation</strong></td>
<td><img src="image1.png" alt="Image" /></td>
<td><img src="image2.png" alt="Image" /></td>
<td><img src="image3.png" alt="Image" /></td>
<td><img src="image4.png" alt="Image" /></td>
</tr>
<tr>
<td><strong>Constructive Simulation</strong></td>
<td><img src="image5.png" alt="Image" /></td>
<td><img src="image6.png" alt="Image" /></td>
<td><img src="image7.png" alt="Image" /></td>
<td><img src="image8.png" alt="Image" /></td>
</tr>
<tr>
<td><strong>Virtual Simulation</strong></td>
<td><img src="image9.png" alt="Image" /></td>
<td><img src="image10.png" alt="Image" /></td>
<td><img src="image11.png" alt="Image" /></td>
<td><img src="image12.png" alt="Image" /></td>
</tr>
</tbody>
</table>
Within the United States civilian and military aviation system there are numerous crisis situations that occur each year that receive both local and national attention.
Process for Quantifying M&S

Determine Requirements

Set Standards of Performance

Set Baseline

Design M&S Application

Design Metrics

Adjust Throughout the Process!

Document the Process and Results!
Design Metrics

Quantitative - Relating to the measurement of quantity

Qualitative - A personal understanding that is based on qualities
Comparing Qualitative and Quantitative Methods

Foundational Similarities:

(1) All qualitative data can be measured and coded using quantitative methods.

(2) Quantitative metrics can be generated from qualitative inquiries.

Example: *Comparison on Realism: How real does it look to you on a scale of 1-5?*

Foundational Differences:

(1) Difference between qualitative & quantitative research stems from underlying strategies.

(2) Quantitative research is viewed as confirmatory and deductive in nature.

(3) Qualitative research is considered to be exploratory and inductive.
Design Metrics

Remember the perspective of who the ROI is for.

Internal to the Program

- Program Manager
- Using Organizations
- User

Budget

External to the Organization

- Press
- Other
- Environmentalist
Process for Quantifying M&S

Document the Process and Results!

1. Determine Requirements
2. Set Standards of Performance
3. Set Baseline
4. Design M&S Application
5. Design Metrics
6. Collect Data

Adjust Throughout the Process!
Training Example – How do I prepare employees for an aviation incident /accident?
<table>
<thead>
<tr>
<th></th>
<th>Prior to the Simulation Exercise</th>
<th>Relook of Answers</th>
<th>Post Simulation Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Our CRM plan addresses communications.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>I am prepared for a crisis situation.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>I make decisions with input from others.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>My actions would be consistent in a crisis.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>I would delegate during a crisis.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>I would keep focused through resolution.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>I know what questions to ask in a crisis.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>I know how to execute actions in a crisis.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>I understand the implications of the CRM system.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Our procedures are well thought out.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Contingencies are planned for.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Our emergency response system is effective.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>I know how to take charge in a crisis.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>I am prepared to handle a crisis.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Overall Resource Utilization

### Labor Hours

<table>
<thead>
<tr>
<th>Item</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time to Input Scenario into the Simulation</td>
<td></td>
</tr>
<tr>
<td>Task 1</td>
<td>20</td>
</tr>
<tr>
<td>Task 2</td>
<td>10</td>
</tr>
<tr>
<td>Task 3</td>
<td>12</td>
</tr>
<tr>
<td>Task 4</td>
<td>4</td>
</tr>
<tr>
<td>Time to Create Scenario</td>
<td></td>
</tr>
<tr>
<td>Task 1</td>
<td>40</td>
</tr>
<tr>
<td>Task 2</td>
<td>20</td>
</tr>
<tr>
<td>Task 3</td>
<td>38</td>
</tr>
<tr>
<td>Task 4</td>
<td>10</td>
</tr>
<tr>
<td>One Time Exterior Digitization of an Airport</td>
<td></td>
</tr>
<tr>
<td>Task 1</td>
<td>142</td>
</tr>
<tr>
<td>Task 2</td>
<td>142</td>
</tr>
<tr>
<td>Task 3</td>
<td>121</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>559 hours</strong></td>
</tr>
</tbody>
</table>

### Collect Data

**Training Example**

1. **COMPONENT**: FY 2005 MILITARY CONSTRUCTION PROJECT DATA
2. **DATE**: (computer generated)
3. **LOCATION AND LOCATION CODE**: AVIATION AIR BASE, ITALY
4. **PROJECT TITLE**: FLIGHT SIMULATOR
5. **PROGRAM ELEMENT NUMBER**: 2720
6. **CATEGORY CODE**: 171.212
7. **PROJECT NUMBER**: ARN506013
8. **PROJECT COST ($000)**: 2.844
9. **COST ESTIMATES**:
   - **ITEM**: PRIMARY FACILITY, FLIGHT SIMULATOR, ANTI-TERROISM FORCE PROTECTION, SUPPORTING FACILITIES, UTILITIES, PAYMENTS, SITE IMPROVEMENTS, COMMUNICATION SUPPORT, PASSIVE FORCE PROTECTION
   - **UNIT**: HS, SM
   - **COST**: $1.906
10. **COST ESTIMATES**:
    - **TOTAL CONTRACT COST**: $1.621
    - **SUPREVISION, INSPECTION AND OVERHEAD**: $170
    - **TOTAL REQUEST (MODIFIED)**: $2,782
    - **THE TOTAL REQUEST (HUNTED)**: $2,834
    - **EQUIPMENT FROM OTHER APPROPRIATIONS (NON-ADD)**: $36,045.0

11. **Description of Proposed Construction**: Construct facility with oversized door and removale panels for equipment change outs. Support space for admin. training support machinery and maintenance functions. Simulator room will have raised computer flooring, soundproofing, demil, and all utilities required. Provide 15 on 5.5 concrete pavements. Must comply with regional protection standards.

12. **Requirement**: 1,149 SM Adequate: 0 SM Substandard: 157SM

13. **Project**: Construct a new flight simulator facility. (Current Mission)

14. **Requirement**: Provide Flight Simulator facility to support aircrew training activities. The project will include adequate space for administration and records, classrooms, and other supporting spaces. AV/PP costs on this project are higher than standard DOG guidance due to stricter EU/COM force protection standards requiring screening from direct fire weapons.

15. **Description of Proposed Construction**: The current flight simulator is housed in one building with the classrooms and administrative spaces in separate portable buildings. The lack of an adequate base facility for this requirement represents a serious deficiency toward pilot readiness.

16. **Description of Proposed Construction**: Without this project, vital training requirements will continue to be performed in substandard conditions thus seriously compromising pilot readiness and mission in the Southern European Regions

17. **Description of Proposed Construction**: This facility is eligible for NATO funding. The NATO funded portion ($1M) provides for a two-ship facility. This US cost share provides the other two ships, 550 JM, for a complete four-ship facility. This project complies with space criteria outlined in AIR 32-1084, “Facility Requirements.” Project requires 03/Italian Mixed
Document the Process and Results!

- Determine Requirements
- Set Standards of Performance
- Set Baseline
- Design M&S Application
- Design Metrics
- Collect Data
- Analyze Data

Process for Quantifying M&S

Adjust Throughout the Process!
Training Example – How do I prepare employees for an aviation incident /accident?
<table>
<thead>
<tr>
<th></th>
<th><strong>Question</strong></th>
<th><strong>Prior to the Simulation Exercise</strong></th>
<th><strong>Relook of Answers</strong></th>
<th><strong>Post Simulation Results</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Our CRM plan addresses communications.</td>
<td>5</td>
<td>3.1</td>
<td>3.6</td>
</tr>
<tr>
<td>2</td>
<td>I am prepared for a crisis situation.</td>
<td>4.9</td>
<td>4.1</td>
<td>4.1</td>
</tr>
<tr>
<td>3</td>
<td>I make decisions with input from others.</td>
<td>4.2</td>
<td>3.2</td>
<td>3.2</td>
</tr>
<tr>
<td>4</td>
<td>My actions would be consistent in a crisis.</td>
<td>4.9</td>
<td>3.2</td>
<td>3.2</td>
</tr>
<tr>
<td>5</td>
<td>I would delegate during a crisis.</td>
<td>4.9</td>
<td>2.7</td>
<td>4.3</td>
</tr>
<tr>
<td>6</td>
<td>I would keep focused through resolution.</td>
<td>4.1</td>
<td>3.1</td>
<td>3.2</td>
</tr>
<tr>
<td>7</td>
<td>I know what questions to ask in a crisis.</td>
<td>4.4</td>
<td>2.2</td>
<td>2.3</td>
</tr>
<tr>
<td>8</td>
<td>I know how to execute actions in a crisis.</td>
<td>4.9</td>
<td>3.1</td>
<td>3.1</td>
</tr>
<tr>
<td>9</td>
<td>I understand the implications of the CRM system.</td>
<td>5</td>
<td>2.4</td>
<td>4.3</td>
</tr>
<tr>
<td>10</td>
<td>Our procedures are is well thought out.</td>
<td>4.9</td>
<td>1.5</td>
<td>3.9</td>
</tr>
<tr>
<td>11</td>
<td>Contingencies are planned for.</td>
<td>5</td>
<td>1.5</td>
<td>3.9</td>
</tr>
<tr>
<td>12</td>
<td>Our emergency response system is effective.</td>
<td>4.9</td>
<td>2.7</td>
<td>3.9</td>
</tr>
<tr>
<td>13</td>
<td>I know how to take charge in a crisis.</td>
<td>4.6</td>
<td>3.1</td>
<td>3.1</td>
</tr>
<tr>
<td>14</td>
<td>I am prepared to handle a crisis.</td>
<td>4.9</td>
<td>1.7</td>
<td>3.5</td>
</tr>
</tbody>
</table>
Results of Pre/Post Survey

Series 1 – Pre-simulation answers
Series 2 – Post simulation
Series 3 – 6 Months Post simulation
Line between points are to show a trend & do not indicate continuity
Actions to be Taken by the Staff Based on the Simulation Exercise:

Information was derived from multiple transcripts that were created from the videotaping of the simulation exercise sessions and after-action reviews.

- Modified crew hours and legs by year
- Changed crew activities during aircraft icing
- Increased awareness and information about bird strikes
- Changed procedures to avoid collision with ground vehicle
- Increased training with ground proximity warning system
- Developed scenarios to practice water landings
- Redefined CRM for medical issues & passenger disturbance
- Increased training for near midair collisions
During one iteration of simulation runs and after-action review session, the various crews identified 38 actions that needed to be addressed. Actions ranged from a simple policy change to a complete revision of some aspects of CRM plans and procedures.

Example of one action - What technical information is available to assist both the crew and ground support advisors?

- Several crew members felt a number of informational items were distractors and unimportant.
- Ground controllers explained why items are extremely important—timing & location aspects.
Overall Resource Utilization

Time to Create Each Scenario

<table>
<thead>
<tr>
<th>Item</th>
<th>Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task 1 (40 hrs)</td>
<td>$2800</td>
</tr>
<tr>
<td>Task 2 (20 hrs)</td>
<td>$3000</td>
</tr>
<tr>
<td>Task 3 (38 hrs)</td>
<td>$1900</td>
</tr>
<tr>
<td>Task 4 (10 hrs)</td>
<td>$400</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$8100</strong></td>
</tr>
</tbody>
</table>

One Time Exterior Digitization of an Airport

<table>
<thead>
<tr>
<th>Item</th>
<th>Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task 1 (142 hrs)</td>
<td>$18886</td>
</tr>
<tr>
<td>Task 2 (142 hrs)</td>
<td>$11502</td>
</tr>
<tr>
<td>Task 3 (121 hrs)</td>
<td>$8288</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$38316</strong></td>
</tr>
</tbody>
</table>

Time to Input Scenario into the Simulation

<table>
<thead>
<tr>
<th>Item</th>
<th>Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task 1 (20 hrs)</td>
<td>$560</td>
</tr>
<tr>
<td>Task 2 (10 hrs)</td>
<td>$280</td>
</tr>
<tr>
<td>Task 3 (12 hrs)</td>
<td>$360</td>
</tr>
<tr>
<td>Task 4 (4 hrs)</td>
<td>$160</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$1360</strong></td>
</tr>
</tbody>
</table>

Total Cost: $36,092,776
Document the Process and Results!

- Determine Requirements
- Set Standards of Performance
- Set Baseline
- Design M&S Application
- Design Metrics
- Collect Data
- Determine ROI
- Analyze Data

Adjust Throughout the Process!
ROI Example - Training

Multiple Configurations

- Individual Trainer Configuration
- Team Role Trainer Configuration
- Seminar Configuration
- Conference Configuration

- Rehearsal Configuration
- Situation Tool
- Analysis Configuration
ROI Example - Training

- Efficiency for the 232,271 individuals in USA required to receive CRM training
  - 43,681 airline transport pilots
  - 78,670 flight attendants
  - 29,430 air traffic controllers
- Prior to 1998 CRM was optional for airlines
- FAA provided two methods for CRM training—classroom or simulator
- GAO - CRM just taught in a classroom without experiential experience is less effective
- Simulation can run any time
- Now FAA mandated training

450 Commercial Airports
Numerous Types of Commercial Aircraft
Each individual can be trained in their own environment
During the one simulation and after-action review session, the staff identified 38 actions that needed to be addressed. All 38 were addressed which led to an additional 24 actions.

Actions ranged from a simple policy change to a complete revision of the plans.

- Changed the notification to the press procedures
- Changed plan so that an emergency on an aircraft mobilizes the entire community
- Created a responsibility list for all administrators to follow while incident is occurring
- Changed procedures for dealing with passengers
- Further delineated responsibilities between pilots, flight attendants & air traffic controllers

Over the last ten years since the FAA mandated simulation-based CRM training, there have been 382 reported incidents with only 12 incidents caused by improper use of CRM.
Number of incidents and fatalities during the last ten years

<table>
<thead>
<tr>
<th>Incidents</th>
<th>98</th>
<th>99</th>
<th>00</th>
<th>01</th>
<th>02</th>
<th>03</th>
<th>04</th>
<th>05</th>
<th>06</th>
<th>07</th>
<th>08</th>
<th>09</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>33</td>
<td>26</td>
<td>25</td>
<td>34</td>
<td>34</td>
<td>45</td>
<td>33</td>
<td>42</td>
<td>37</td>
<td>37</td>
<td>28</td>
<td>8</td>
<td>382</td>
</tr>
<tr>
<td>CRM Related Cause</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>1?</td>
<td>12</td>
</tr>
<tr>
<td>Fatalities</td>
<td>1</td>
<td>12</td>
<td>92</td>
<td>531</td>
<td>0</td>
<td>22</td>
<td>14</td>
<td>22</td>
<td>50</td>
<td>1</td>
<td>0</td>
<td>49</td>
<td>794</td>
</tr>
<tr>
<td>% CRM Related</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3%</td>
</tr>
</tbody>
</table>

Everything that could go wrong on that flight to Buffalo on that wintery night did. We had a pilot who had not been trained on how to handle emergency procedures. He had never received simulator training for stall warnings, and reacted exactly opposite the way he should have, pulling back on the stick rather than pushing it forward to increase airspeed. It's a fatal mistake.”

Former FAA Chief Michael Goldfarb
NSTB Hearing May 12, 2009 -Colgan Air, Inc. Flight 3407

2009 New York Crash
### American Airlines Example

Cost for a new simulator is $14 to $15 million

<table>
<thead>
<tr>
<th>14 different simulators</th>
<th>$126 million</th>
</tr>
</thead>
<tbody>
<tr>
<td>107 simulator technicians and 8 engineers</td>
<td>$1.9 million per year</td>
</tr>
<tr>
<td>Annual maintenance budget - $800,000</td>
<td>$800 thousand</td>
</tr>
<tr>
<td>Ten Years $19 million</td>
<td></td>
</tr>
<tr>
<td>Ten Years $8 million</td>
<td></td>
</tr>
</tbody>
</table>

**Ten-Year Costs** $153 million
Simulators Usage: 18 - 20 hours per day – 917,280 hours per year (2 positions per hour)

Train 9,000 American Airlines’ pilot workforce

Re-certification at least every nine months

12 hours of simulation time per pilot

Over 10 years, 13 times per pilot – 156 hours

Required re-certification – 936,000 hours

Initial certification, changing seat or aircraft – 230,000 hours

Sell simulation time at $500 per hour; 100,000 hours – $50 million
American Airlines Example

| Ten Year Costs | $153 million |

Per hour for a 737 – $2,200

Required re-certification – 268,000 flight hours

Initial certification, changing seat or aircraft – 115,000 flight hours

Total – 583,000 flight hours X $2,200 = $1,282,600,000

Overall ROI – $1,282,600,000 – $103,000,000 (less $50M) = $1,179,600,000

ROI Example - Training

ROI

Per Year Savings

$179,600,000
ROI Example - Training

Situation Tool

20 Minutes
10 Minutes
Wind Direction and Speed

Environment
Process for Quantifying M&S

Document the Process and Results!

Determine Requirements → Set Standards of Performance → Set Baseline → Design M&S Application → Design Metrics → Collect Data → Analyze Data → Determine ROI → If Needed, Initiate Corrective Action

Adjust Throughout the Process!
Contents of an ROI Evaluation Plan

Document the Process and Results!

- Title Page
- Table of Contents
- Executive Summary
- Purpose of the Report
- Background of the Simulation Being Evaluated
- Methodology for Conduct of the ROI
- Baseline Data Point
- Metrics
- Outcomes and Performance Measures
- Staffing
- Data
- Data Analysis
- Interpretations and Conclusions
- Recommendations
CAUTION
WATCH YOUR STEP
… a bomber pilot is totally detached from the disruption and rearrangement of lives, families, and businesses caused by the bombs below. Likewise, creators of technologies have little awareness of how their inventions are the catalyst for social, cultural, political, and economic changes. Scant attention is given to the ethical issues, side effects, and concomitant transformations that accompany inventions until after widespread implementation with unexpected results. 

McLuhan (1964)
Any Questions?


GAO-02-727T: Military training: DoD needs a comprehensive plan to manage encroachment on training ranges, Committee on Government Reform, U.S. House of Representatives (statement of Barry W. Holman, Director, Defense Capabilities and Management) (2002).


