



U.S. AIR FORCE

I/ITSEC Tutorial

Return on Investment (ROI) for Modeling and Simulation

Dr. Edward Degnan
Division Chief, M&S Foundations Division
407-208-5779, DSN 970,
edward.degnan@afams.af.mil

Report Documentation Page				Form Approved OMB No. 0704-0188	
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE NOV 2010		2. REPORT TYPE		3. DATES COVERED 00-00-2010 to 00-00-2010	
4. TITLE AND SUBTITLE I/ITSEC Tutorial: Return on Investment (ROI) for Modeling and Simulation				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) USAF/AFAMS,3051 Technology Pkwy,Orlando,FL,32766				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited					
13. SUPPLEMENTARY NOTES Interservice/Industry Training, Simulation, and Education Conference (I/ITSEC) 2010, 29 Nov ? 2 Dec, Orlando, FL.					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT Same as Report (SAR)	18. NUMBER OF PAGES 77	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

Tutorial Objective

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**

Tutorial Outline

- 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**

M&S – Negative or Positive ROI?

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



Crusader

Comanche



**M&S in the Gulf War
Casualties Count**



**Rise and Fall of
JSIMS**

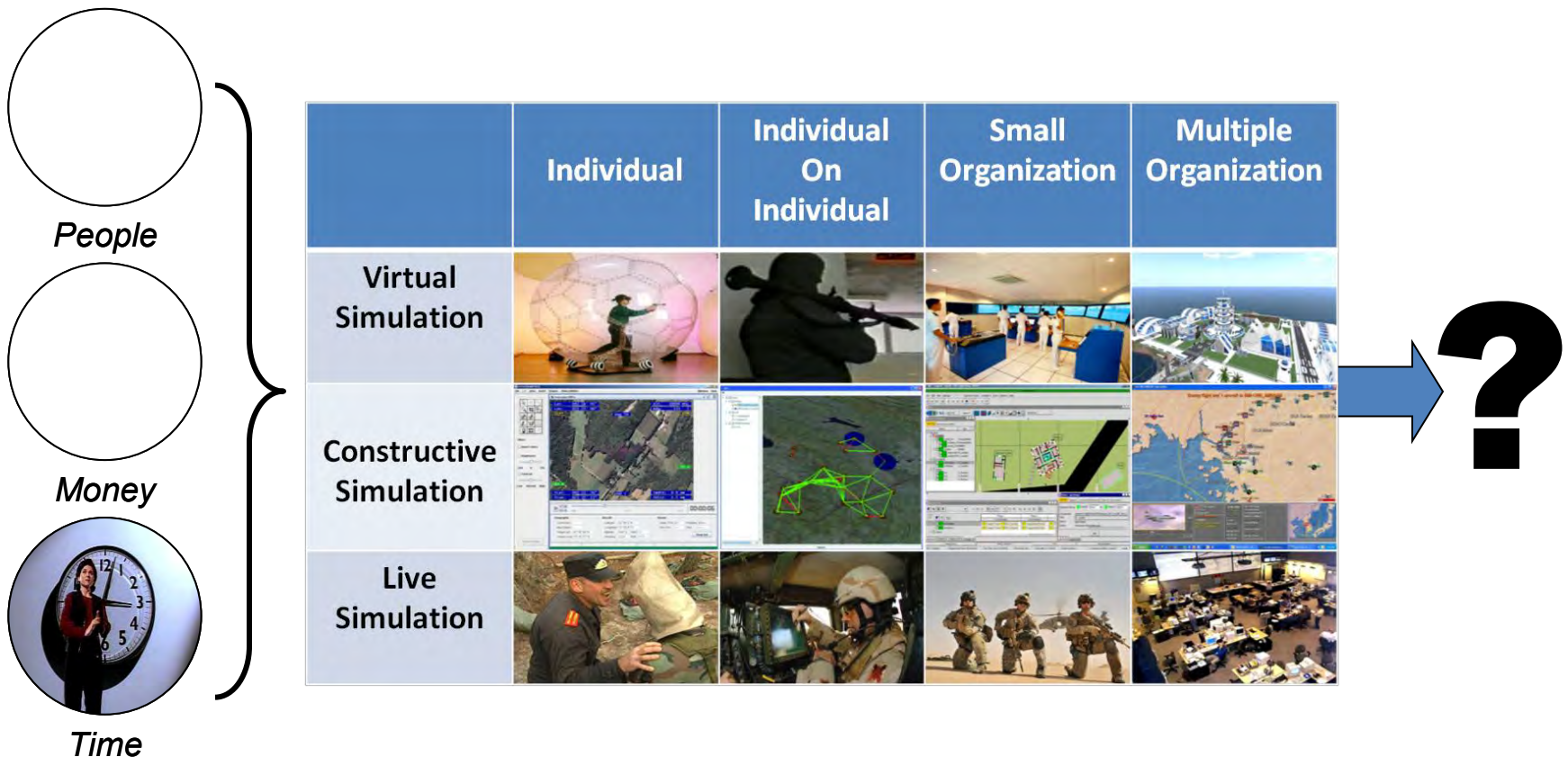
What is ROI?

A performance measure used to evaluate the efficiency of an investment or to compare the efficiency of a number of different investments.

Investment

Alternative(s)

ROI



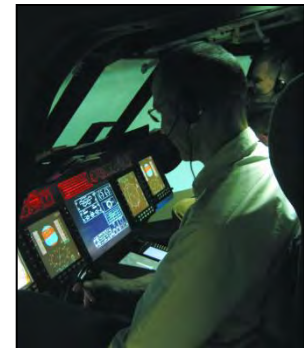
Why Should I Care about ROI?

Justifies the investment to decision makers



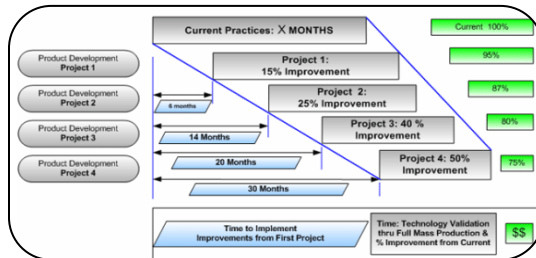
Provides justification for oversight of funding the investment throughout its life cycle

Establishes a baseline to monitor, measure and evaluate the investment

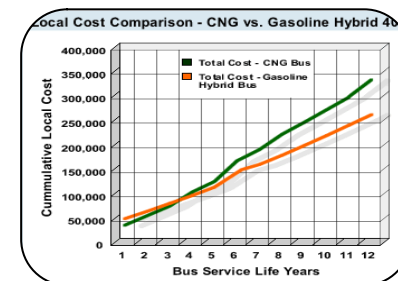
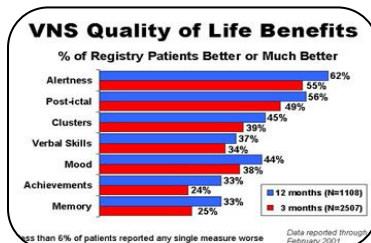


Questions for an ROI Analysis

Effectiveness: How much —bangfor 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?



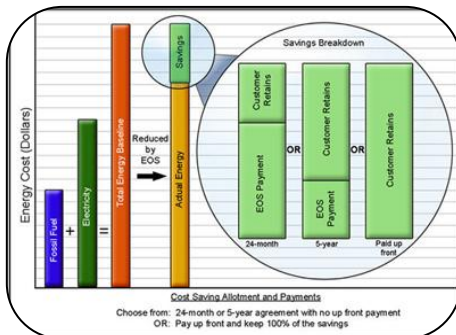
Questions for an ROI Analysis

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

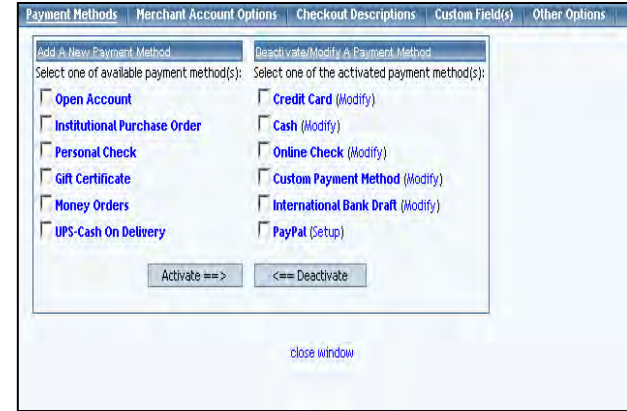
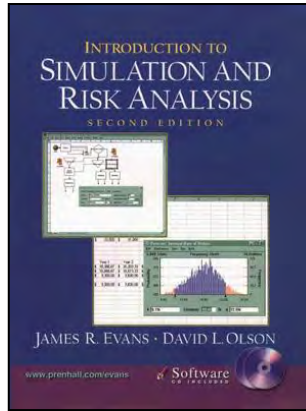


Alternatives to Bluetooth				
	Bluetooth	HomeRF	IEEE 802.11b (Wi-Fi)	IrDA
Primary Use	Cable replacement and ad hoc device-to-device connections	Home or small office LANs	Corporate or campus LANs	Cable replacement and ad hoc device-to-device connections (narrow angle)
Max Speed	1 Mbps	10 Mbps	11 Mbps	4 Mbps
Range	30 feet	150 feet	300 feet	3 feet
Through walls	Yes	Yes	Yes	No
Requires base station	No	No	Yes	No
Interference susceptibility	Medium	Medium	High	None
Power Reqs	Low	High	High	Low
Cost to build	\$8 now	\$70-\$120	\$100-\$300	\$2

Financial: Can we afford this? Will it pay for itself?



Conducting an ROI Analysis



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

No single —right’ way to conduct a ROI analysis.

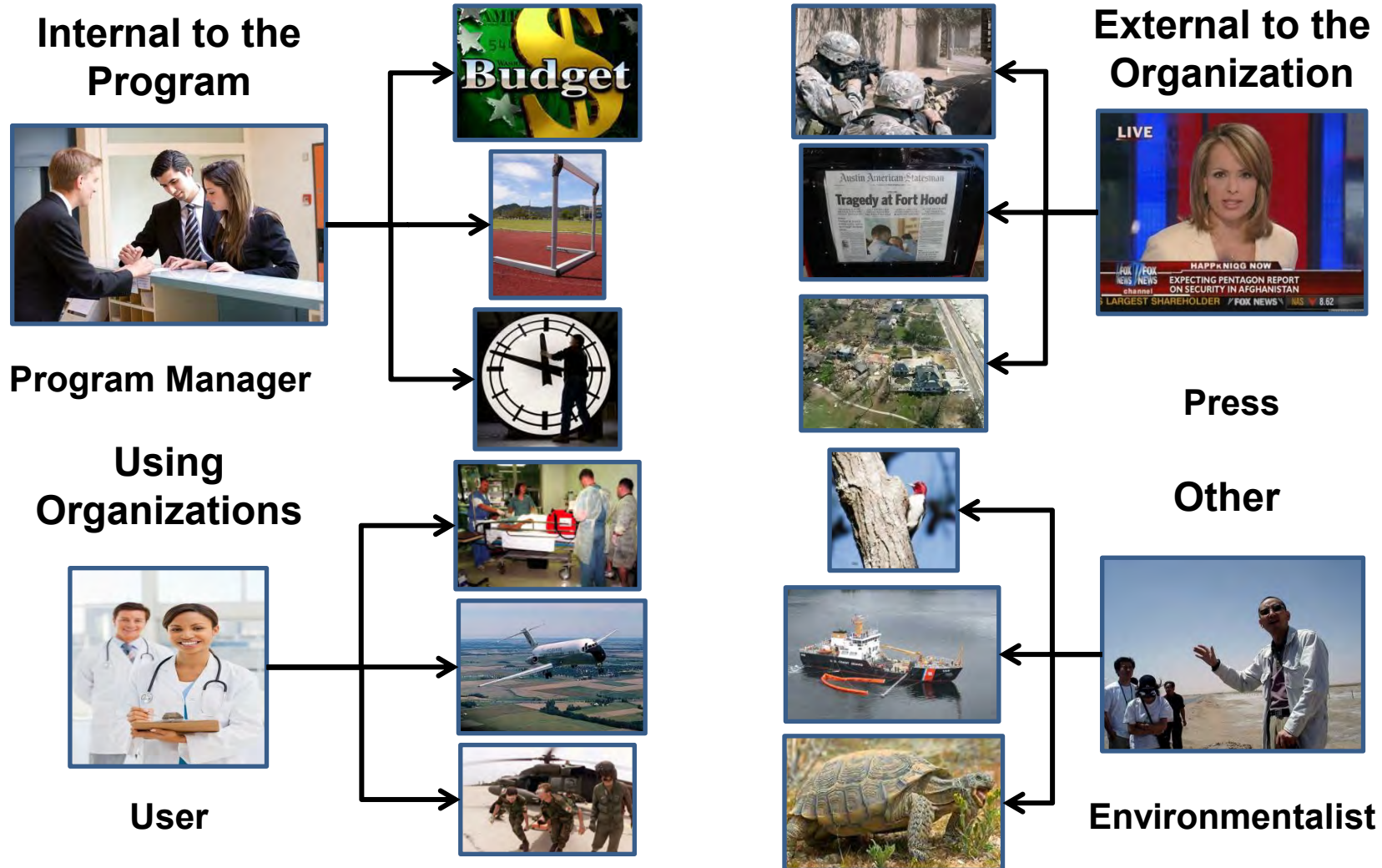


ROI is not a silver bullet - nor is there a Consumer Report for ROI products and services.



Design Metrics

Remember the perspective of who the ROI is for.



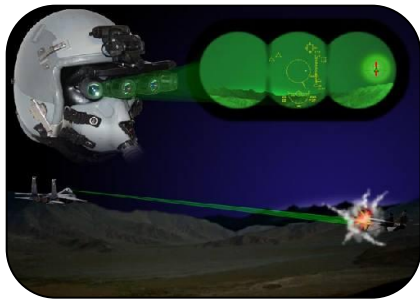
Areas for M&S Return on Investment



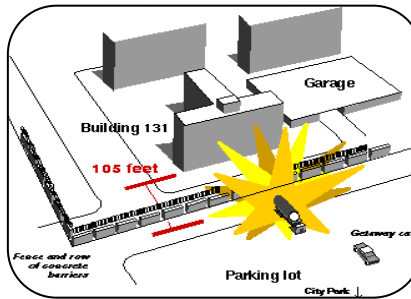
Reuse



Readiness



Efficiency



Risk Reduction



Effectiveness



Money



Environment



Lives



Time

Areas for M&S Return on Investment



Readiness

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 Przybyslawski

Areas for M&S Return on Investment



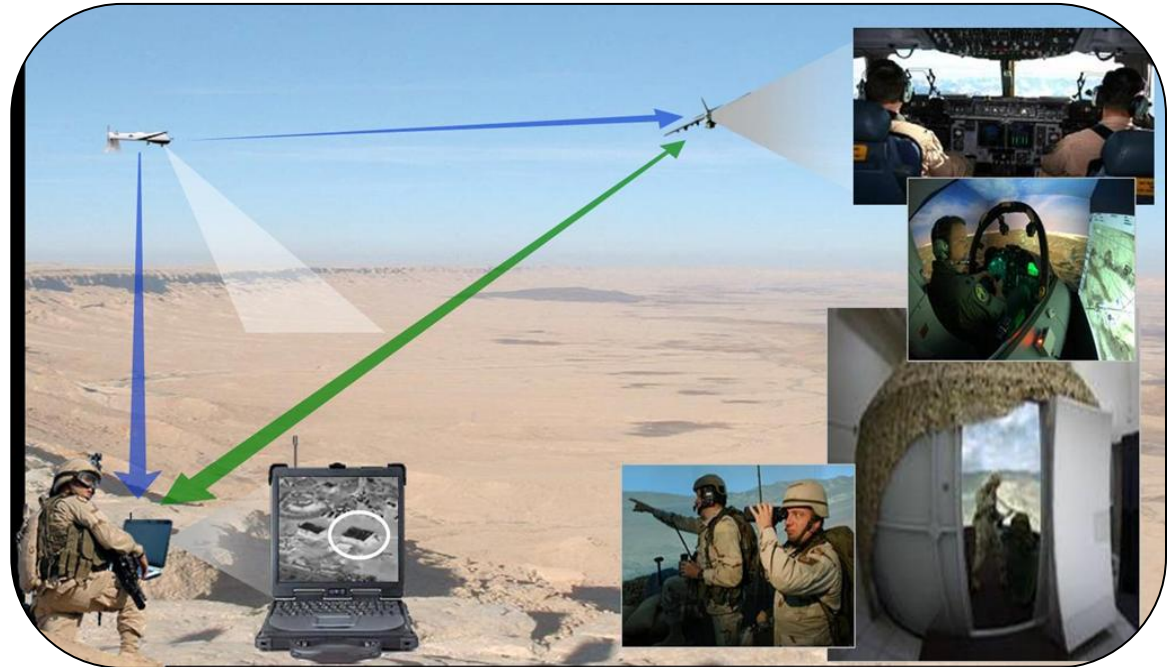
Efficiency



Predator

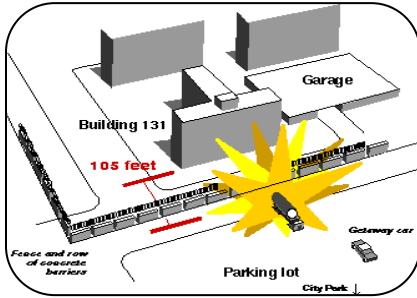


ROVER
Remote Operations
Vehicle Enhanced
Receiver



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



Risk Reduction

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.”



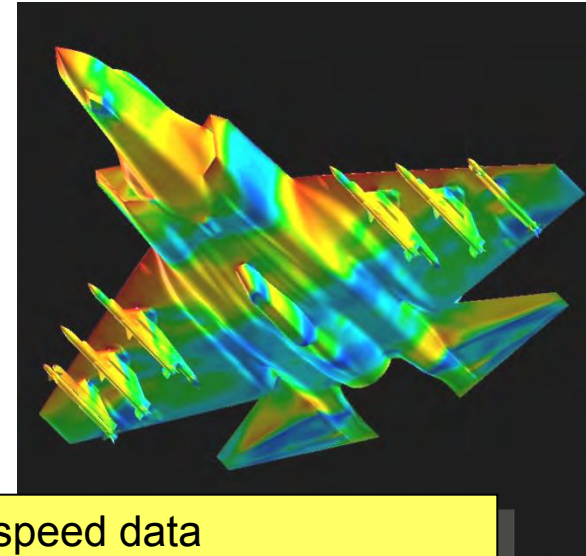
Areas for M&S Return on Investment



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**

Joint Strike Fighter Applications Arnold Engineering and Development Center

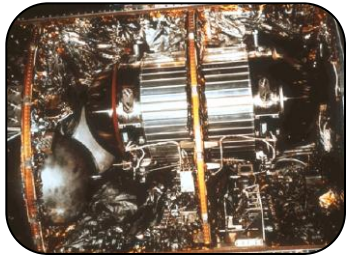


- Eliminated tests for high speed data
- Improved data quality and reduced risk
- Computed trajectories beyond tunnel hardware movement constraints
- Screened test configurations, reducing testing costs
- Total savings = \$ Millions

Areas for M&S Return on Investment



Lives



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



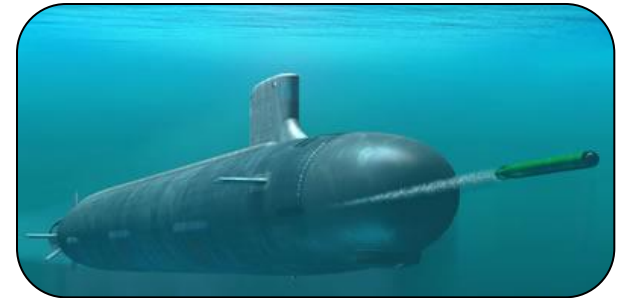
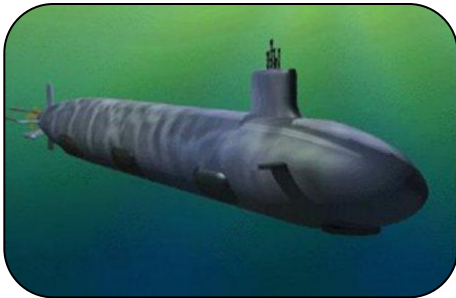
- New procedures had to be written and tested
 - A coast-to-coast network of simulators, computers and experts was formed
 - Everything was tested in the simulator before being passed up to the crew

Areas for M&S Return on Investment



Time

Virginia Class Submarine



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

Areas for M&S Return on Investment



Money



**Air Mobility Command
(AMC)**



- 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.

<http://www.amc.af.mil/news/story.asp?id=123031427>

Areas for M&S Return on Investment

Due to restrictions, weapons or testing threats are prohibited.
Defense Threat Reduction Information Analysis Center



Environment

Population
Density - Noise

Clean Air

Archaeology

Clean Water –
Erosion Control

Endangered
Species



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

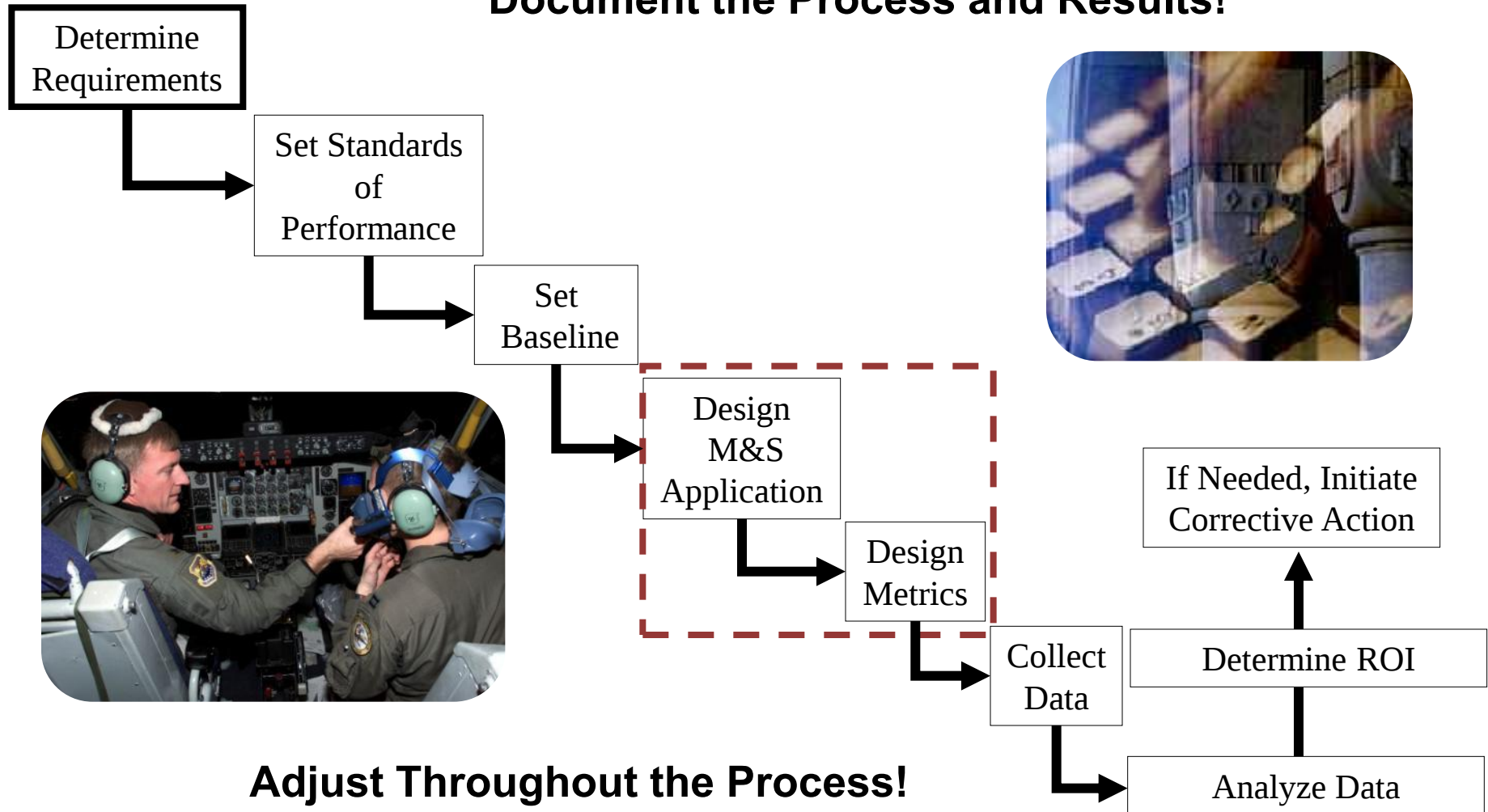
Encroachment had affected every training range's capabilities, requiring work-arounds—or adjustments to training events. A more complete assessment of training resources should include assessing the potential for using virtual or constructive simulation technology to augment live training.

Areas for M&S Return on Investment

								
Reuse	Efficiency	Readiness	Lives	Risk Reduction	Effectiveness	Time	Money	Environment
Training								
Increase # of users and applications for the simulation	Proficiency level after a simulation event	Increased preparedness to a greater number of situations	Reduced deaths & injuries through simulations	Reduced accidents during high-risk training	Increased performance in real-world situation	Optimize training for the audience	Optimize or reduce the cost of training	Use simulation for training that can not be done
Acquisition								
Increase # of users and applications for the simulation	Lower cost due to simulation use	Faster delivery of new materials to the warfighter	Simulation testing prior to human conducting live testing	Remove more of the unknowns in the testing cycle	Able to, as a minimum, keep project on time and budget	Maintain or reduce development time	Maintain or reduce acquisition costs	Offset restrictions caused by environment constraints
Analysis								
Increase # of users and applications for the simulation	Greater accuracy based on the use of a simulation	Increase the timeliness of analytical information	Removing some areas of human error prior to decisions	Look at larger number of what ifs	Fill in void when subject matter experts are unavailable	Provide answers faster	Reduce costs for development of analytical products	Analyze situations that can not be done live

Process for Quantifying M&S

Document the Process and Results!



Process for Quantifying M&S

Determine
Requirements

Document the Process and Results!



Adjust Throughout the Process!

Determine Requirements

Describe the Problem

Crisis Management Issues - Example



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.



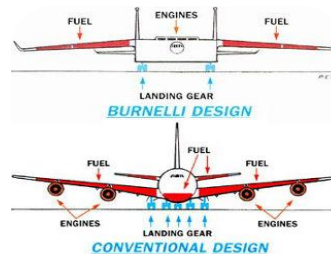
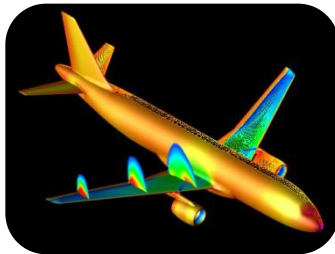
Determine Requirements

Example – Perspective Implications

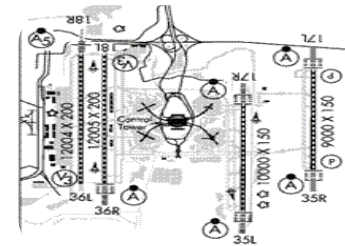
Training Example – How do I prepare employees for an aviation incident /accident?



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?



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**

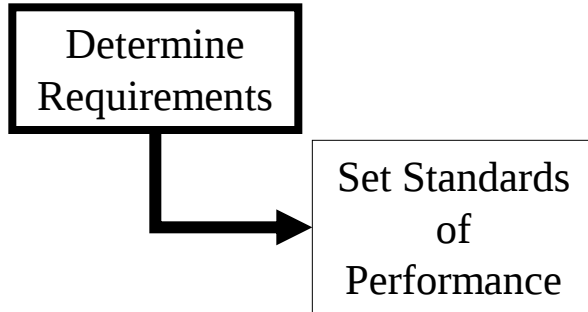


**Medevac
Teams**

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

Process for Quantifying M&S

Document the Process and Results!



Adjust Throughout the Process!

Standards of Performance



The manner in which something or somebody functions, operates or behaves in terms of established criteria



Standards of Performance

Example

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



IX. AREA OF OPERATION: EMERGENCY OPERATIONS

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

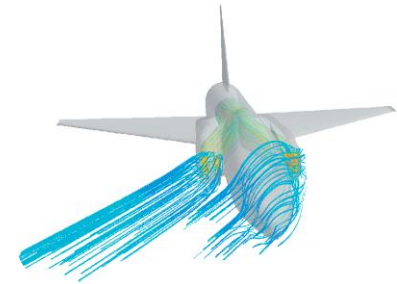
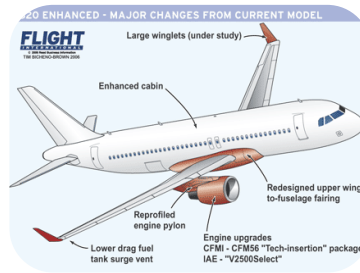
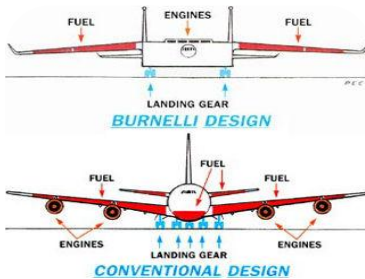
Objective. To determine that the applicant:

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.

Standards of Performance

Example

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)

Aircraft Category	1.3 Times the Stall Speed in Knots	Maximum Speed (Circling Approaches)	Typical Aircraft in This Category
A	less than 91 knots	90 knots	small single engine
B	91 to 120 knots	120 knots	small multi engine
C	121 to 140 knots	140 knots	airline jet
D	141 to 165 knots	164 knots	large jet/military jet
E	above 166 knots		special military

Standards of Performance

Example

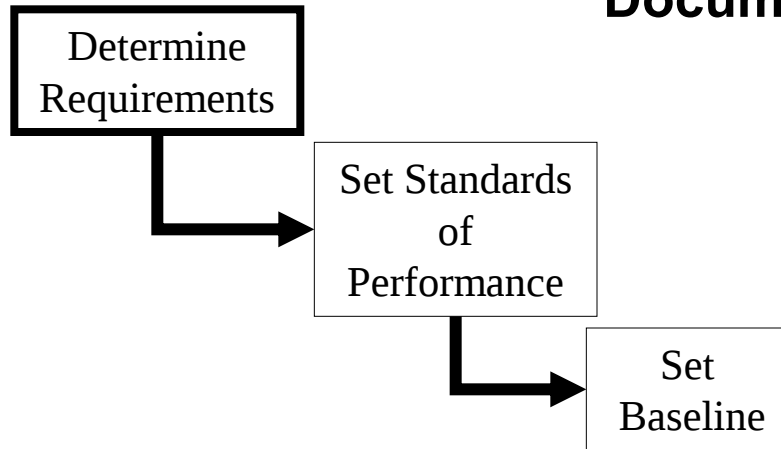
Analysis Example – How do I react in the event of a crisis at an airport?



- 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!

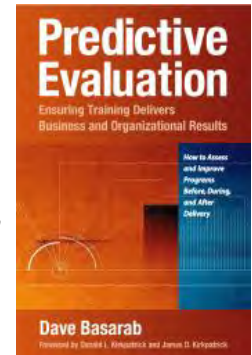


Adjust Throughout the Process!

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.

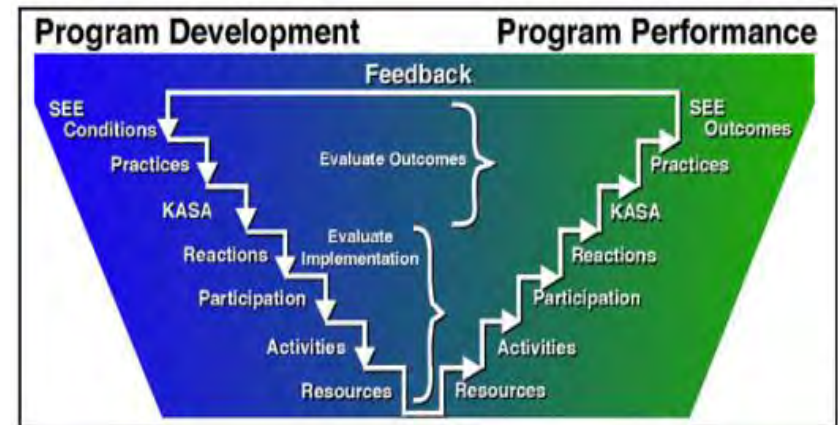
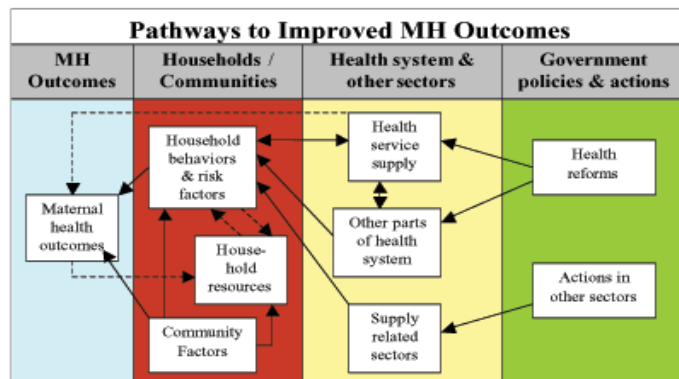


Figure 1: Pathways to Improved Maternal Health Outcomes



Source: PRSP Sourcebook, Claeson, et al.

Accounts for secondary outcomes and assumptions.

Baseline Example

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**.

Baseline Example - Survey



National Aviation Operations Monitoring Service (NAOMS) NASA Airline Study



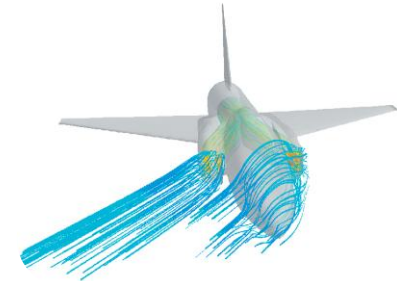
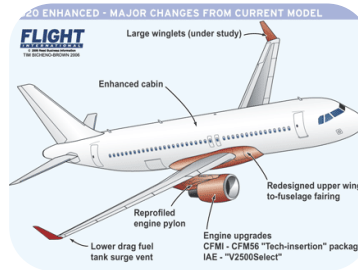
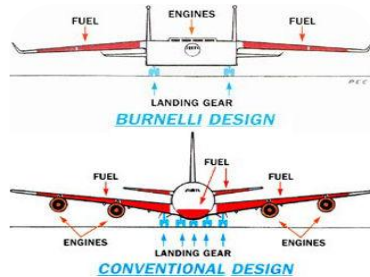
- **Air Carrier Questionnaire: Section B –Safety Events”**
- **Aircraft mechanical & equipment (ER1-ER7) maintenance, equipment failures, fire, smoke**
- **Turbulence: Wake and en route (TU1-TU2):**
 - **Weather (WE1-WE6) Icing, diversions, ATC Wx issues & windshear**
 - **Passenger-Related Events (CP1-CP3) 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**

Baseline Example – Survey Results

- 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?

A screenshot of a "PPA Safety Only Inspection Checklist - Passenger Cars & Light Trucks" form. The form is divided into sections for "EXTERNAL INSPECTION", "UNDER THE HOOD INSPECTION", "INTERNAL INSPECTION", and "ROAD TEST". It includes various checkboxes and fields for recording inspection results.

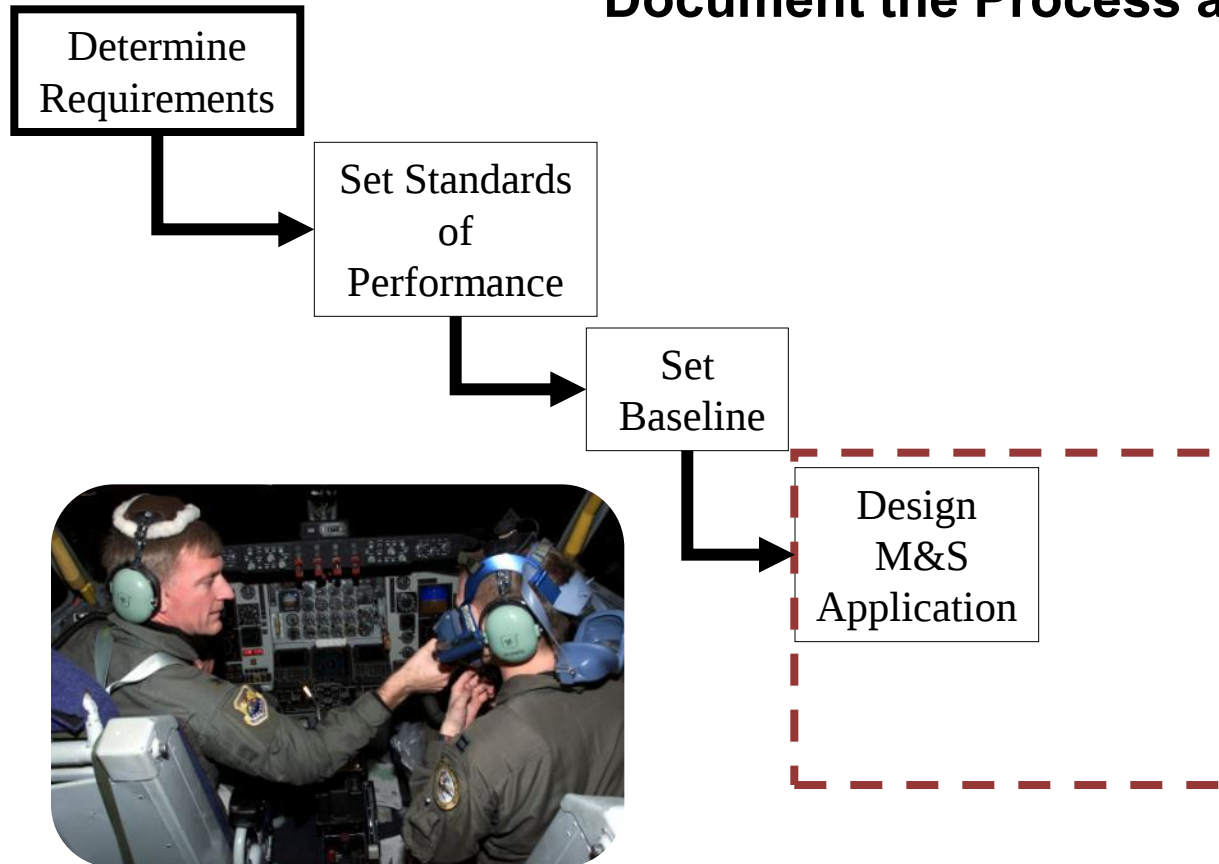
Reports



Previous Studies

Process for Quantifying M&S

Document the Process and Results!



Adjust Throughout the Process!

Simulation Application Requirement



United States General Accounting Office
GAO Report to Congressional Requesters

November 1997 HUMAN FACTORS
FAA's Guidance and Oversight of Pilot Crew Resource
Management Training Can Be Improved

GAO/RCED-98-7

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



Determine Requirements

Example – Who is the CRM Audience?

Training 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.

Determine Requirements

Example – Who is the CRM Audience?

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



Pilot



**Flight
Attendant**



**Ground
Controller**



**Air Traffic
Controller**

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

Acquisition

Training

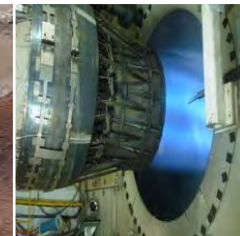
Education

Planning

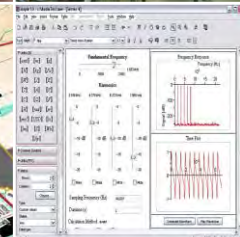
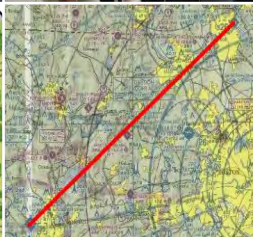
Experimentation

T&E

**Live
Simulation**



**Constructive
Simulation**

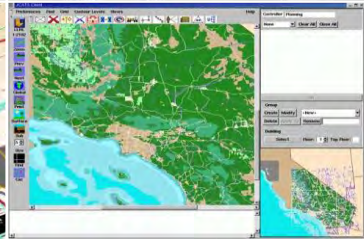


**Virtual
Simulation**



Simulation Application Options

Establish Alternatives

	Individual	Individual to Individual	Small Organization	Multiple Organizations
Live Simulation				
Constructive Simulation				
Virtual Simulation				

Design M&S Application

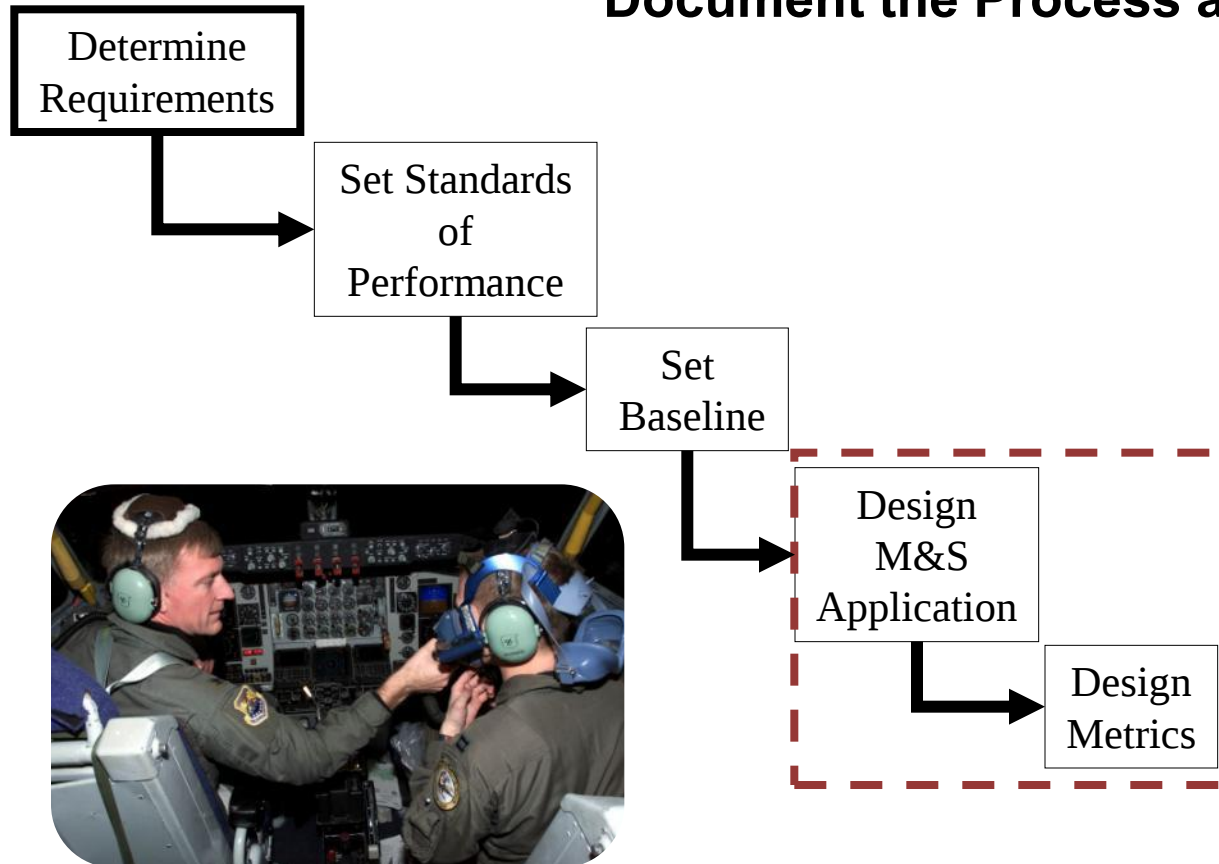
Crisis Management Issues - Example



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.

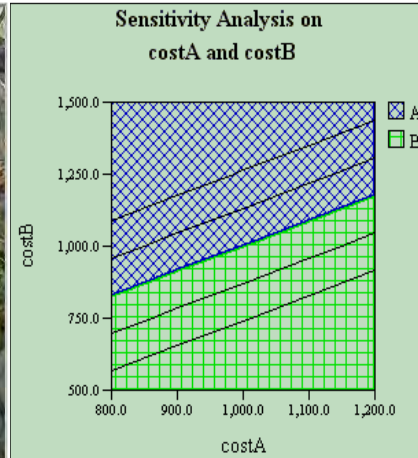
Process for Quantifying M&S

Document the Process and Results!



Adjust Throughout the Process!

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?*



VS.

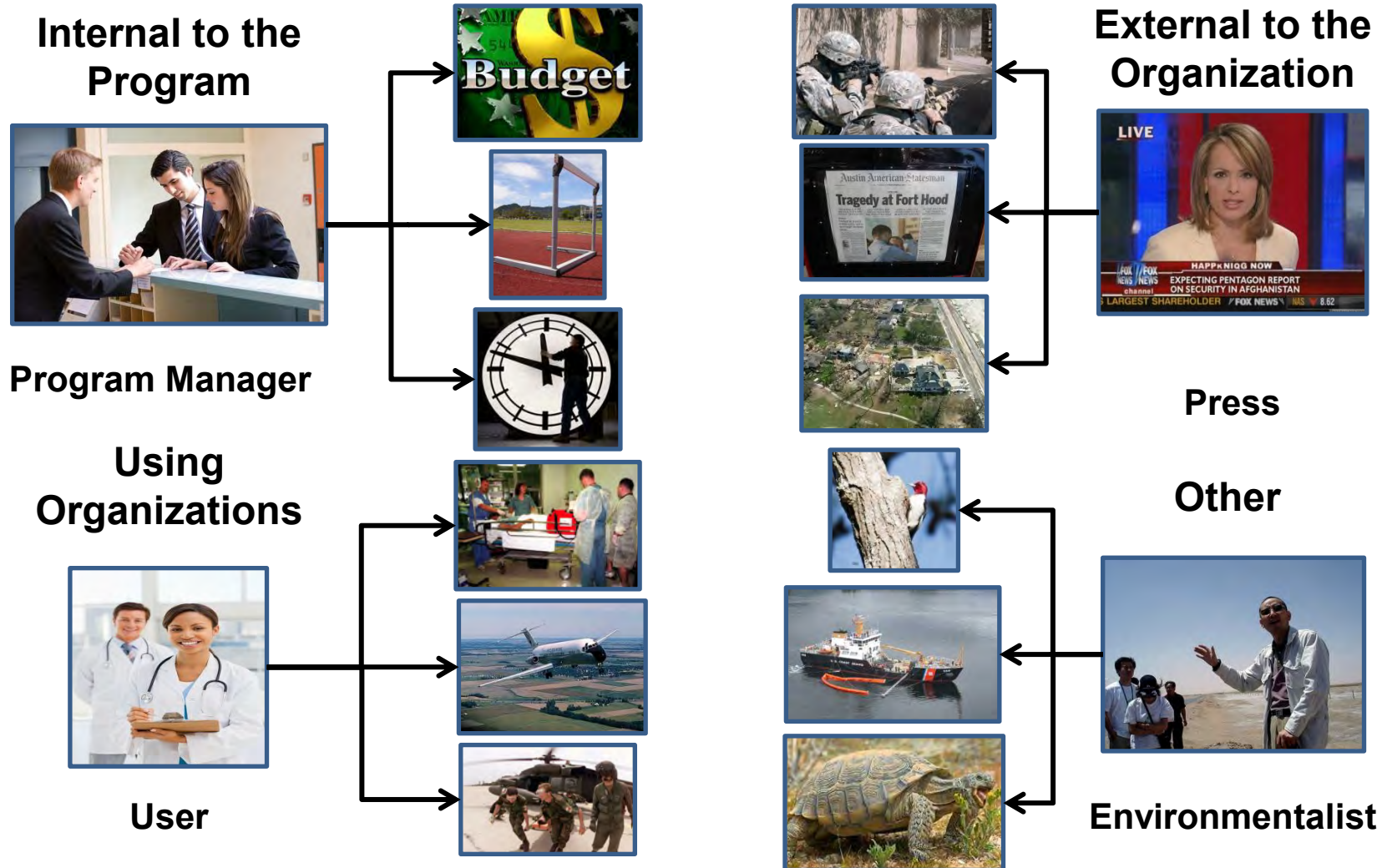


Foundational Differences:

- (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.**

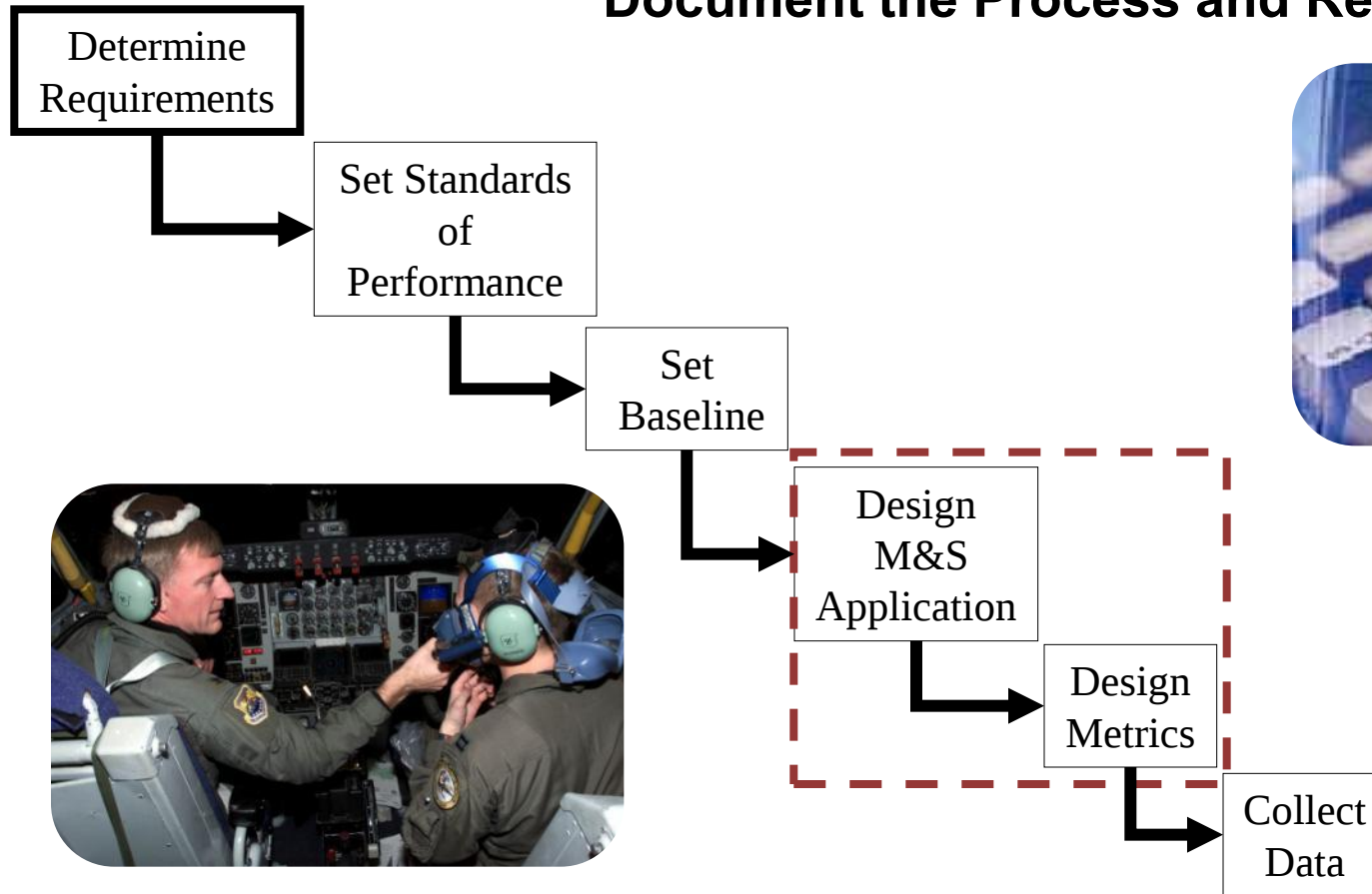
Design Metrics

Remember the perspective of who the ROI is for.



Process for Quantifying M&S

Document the Process and Results!



Adjust Throughout the Process!

Collect Data Training Example

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



Collect Data Training Example

		Prior to the Simulation Exercise	Relook of Answers	Post Simulation Results
1	Our CRM plan addresses communications.			
2	I am prepared for a crisis situation.			
3	I make decisions with input from others.			
4	My actions would be consistent in a crisis.			
5	I would delegate during a crisis.			
6	I would keep focused through resolution.			
7	I know what questions to ask in a crisis.			
8	I know how to execute actions in a crisis.			
9	I understand the implications of the CRM system.			
10	Our procedures are well thought out.			
11	Contingencies are planned for.			
12	Our emergency response system is effective.			
13	I know how to take charge in a crisis.			
14	I am prepared to handle a crisis.			

Collect Data Training Example

Overall Resource Utilization

1. COMPONENT AIR FORCE		FY 2005 MILITARY CONSTRUCTION PROJECT DATA (computer generated)		2. DATE	
3. INSTALLATION AND LOCATION AVIANO AIR BASE, ITALY			4. PROJECT TITLE FLIGHT SIMULATOR		
5. PROGRAM ELEMENT 27596	6. CATEGORY CODE 171-212	7. PROJECT NUMBER ASHE986013	8. PROJECT COST (\$000) 2.834		
9. COST ESTIMATES					
ITEM	I/M	QUANTITY	UNIT	COST	
PRIMARY FACILITY				1,926	
FLIGHT SIMULATOR	SM	560	3,365	(1,884)	
ANTI-TERRORISM/FORCE PROTECTION	SM	560	75	(42)	
SUPPORTING FACILITIES				570	
UTILITIES	LS			(366)	
PAVEMENTS	SM	3,500	40	(340)	
SITE IMPROVEMENTS	LS			(204)	
COMMUNICATION SUPPORT	LS			(350)	
PASSIVE FORCE PROTECTION	LS			(10)	
SUBTOTAL				2,496	
CONTINGENCY (5.0 %)				125	
TOTAL CONTRACT COST				2,621	
SUPERVISION, INSPECTION AND OVERHEAD (6.5 %)				170	
TOTAL REQUEST				2,792	
TOTAL REQUEST (ROUNDED)				2,834	
EQUIPMENT FROM OTHER APPROPRIATIONS (NON-ADD)				(36,045.0)	
10. Description of Proposed Construction: Construct facility with oversized door and removable panels for equipment change outs. Support space for admin. training support machinery and maintenance functions. Simulator room will have raised computer flooring, soundproofing, demolition, and all utilities required. Provide 15 cm (5.9") concrete pavements. Must comply with regional force protection standards.					
11. REQUIREMENT: 1,349 SM ADEQUATE: 0 SM SUBSTANDARD: 157SM					
PROJECT: Construct a new flight simulator facility. (Current Mission)					
REQUIREMENT: Provide Flight Simulator facility to support aircrew training activities. The project must include adequate space for administration and records, classrooms, and other supporting spaces. AT/FP costs on this project are higher than standard DoD guidance due to stricter EUCCOM force protection standards requiring screening from direct fire weapons.					
CURRENT SITUATION: 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.					
IMPACT IF NOT PROVIDED: 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					
ADDITIONAL: 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, 560 SM, for a complete four-ship facility. This project complies with space criteria outlined in AFH 32-1084, "Facility Requirements." Project requires US/Italian Mixed					

Labor Hours

Time to Input Scenario into the Simulation

Item	Hours
Task 1	20
Task 2	10
Task 3	12
Task 4	4

Time to Create Scenario

Task 1	40
Task 2	20
Task 3	38
Task 4	10

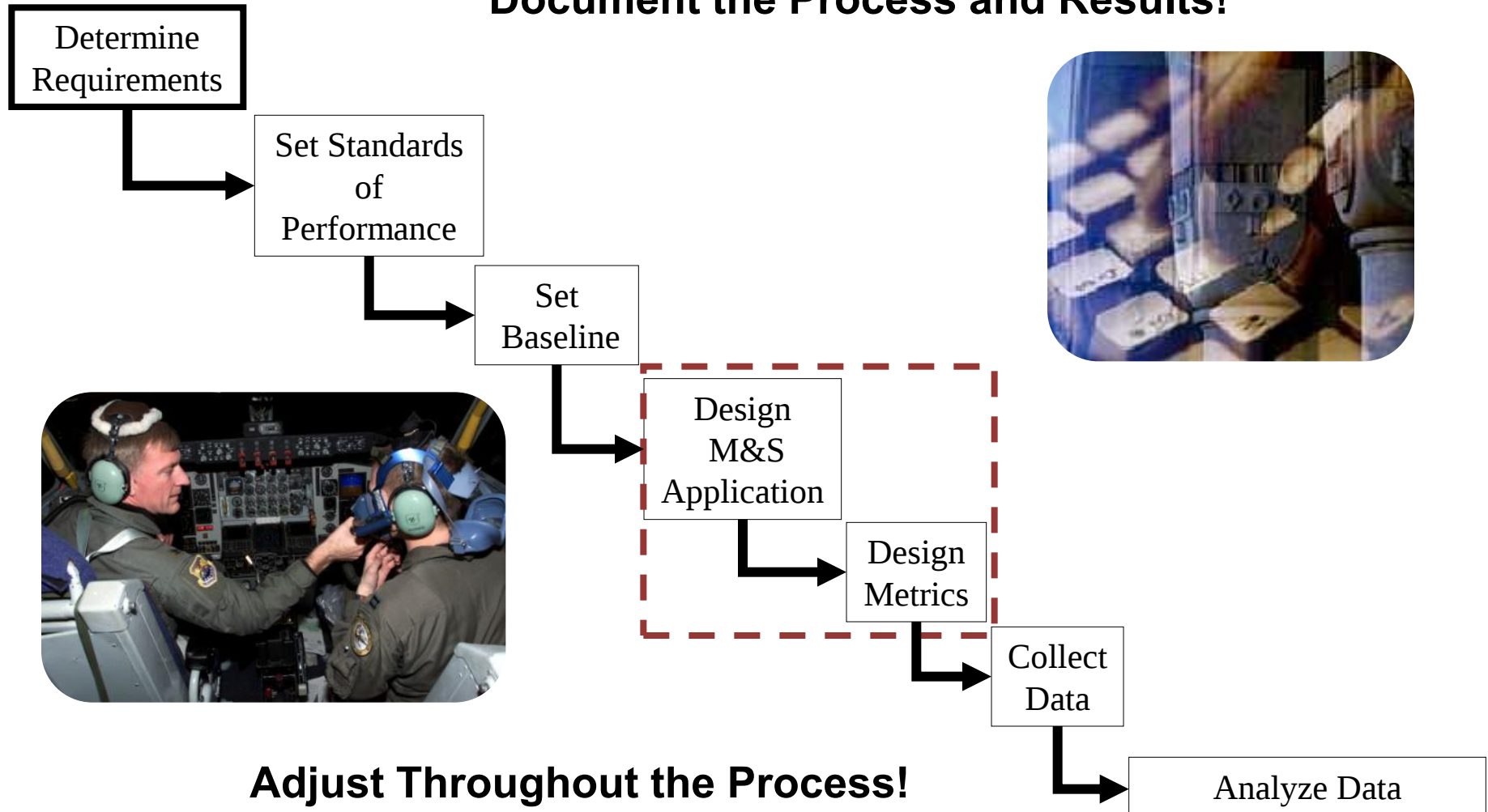
One Time Exterior Digitization of an Airport

Task 1	142
Task 2	142
Task 3	121

Total 559 hours

Process for Quantifying M&S

Document the Process and Results!



Analyze Data Training Example

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

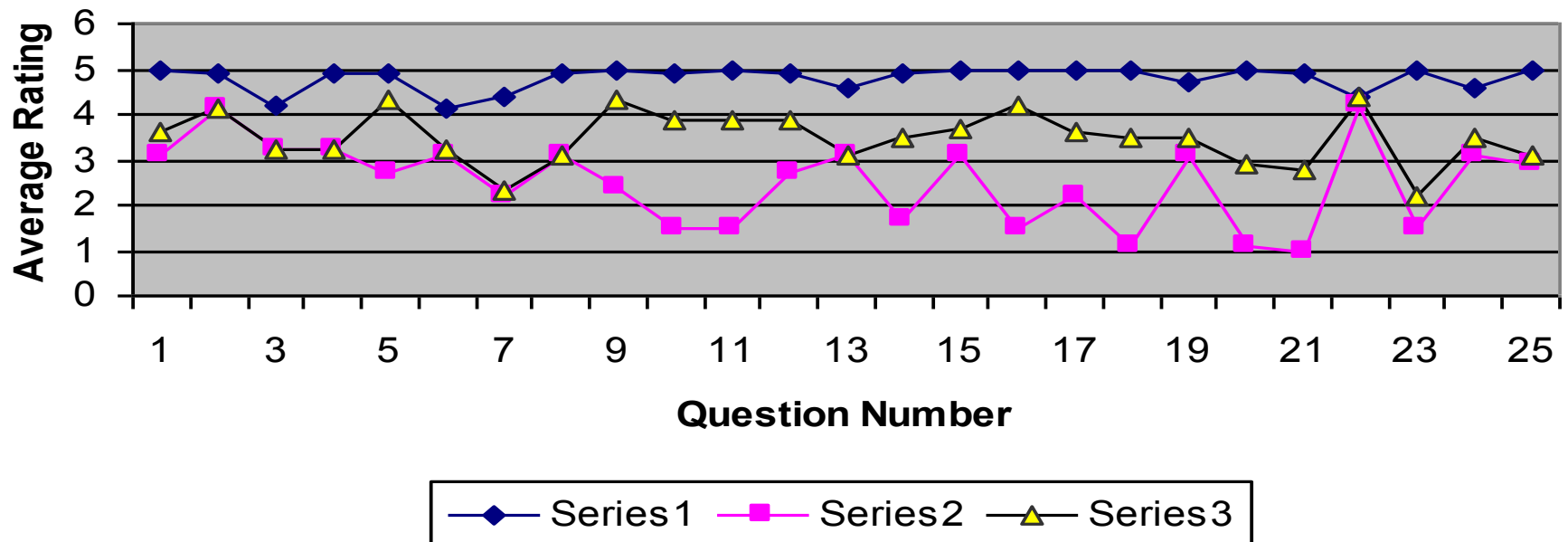


Analyze Data Training Example

		Prior to the Simulation Exercise	Relook of Answers	Post Simulation Results
1	Our CRM plan addresses communications.	5	3.1	3.6
2	I am prepared for a crisis situation.	4.9	4.1	4.1
3	I make decisions with input from others.	4.2	3.2	3.2
4	My actions would be consistent in a crisis.	4.9	3.2	3.2
5	I would delegate during a crisis.	4.9	2.7	4.3
6	I would keep focused through resolution.	4.1	3.1	3.2
7	I know what questions to ask in a crisis.	4.4	2.2	2.3
8	I know how to execute actions in a crisis.	4.9	3.1	3.1
9	I understand the implications of the CRM system.	5	2.4	4.3
10	Our procedures are is well thought out.	4.9	1.5	3.9
11	Contingencies are planned for.	5	1.5	3.9
12	Our emergency response system is effective.	4.9	2.7	3.9
13	I know how to take charge in a crisis.	4.6	3.1	3.1
14	I am prepared to handle a crisis.	4.9	1.7	3.5

Analyze Data Training Example

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

Analyze Data Training Example

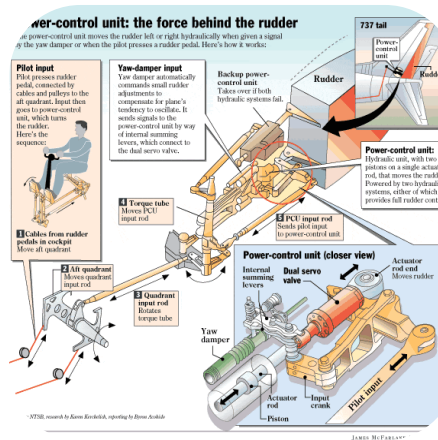
Actions to be Taken by the Staff Based on the Simulation Exercise:

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

Analyze Data Training Example

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 .

Analyze Data Training Example

Overall Resource Utilization

1. COMPONENT AIR FORCE	FY 2005 MILITARY CONSTRUCTION PROJECT DATA (computer generated)		2. DATE
3. INSTALLATION AND LOCATION AVIANO AIR BASE, ITALY		4. PROJECT TITLE FLIGHT SIMULATOR	
5. PROGRAM ELEMENT 27596	6. CATEGORY CODE 171-212	7. PROJECT NUMBER ASHE986013	8. PROJECT COST (\$000) 2.834
9. COST ESTIMATES			
ITEM	U/M	QUANTITY	COST
PRIMARY FACILITY			1,926
FLIGHT SIMULATOR	SM	560	(1,884)
ANTI-TERRORISM/FORCE PROTECTION	SM	560	(42)
SUPPORTING FACILITIES			570
UTILITIES	LS		(166)
PAVEMENTS	SM	3,500	(140)
SITE IMPROVEMENTS	LS		(104)
COMMUNICATION SUPPORT	LS		(150)
PASSIVE FORCE PROTECTION	LS		(10)
SUBTOTAL			2,496
CONTINGENCY (5.0 %)			125
TOTAL CONTRACT COST			2,621
SUPERVISION, INSPECTION AND OVERHEAD (6.5 %)			170
TOTAL REQUEST			2,792
TOTAL REQUEST (ROUNDED)			2,834
EQUIPMENT FROM OTHER APPROPRIATIONS (NON-ADD)			(36,045.0)
10. Description of Proposed Construction: Construct facility with oversized door and removable panels for equipment change outs. Support space for admin. training support machinery and maintenance functions. Simulator room will have raised computer flooring, soundproofing, demolition, and all utilities required. Provide 15 cm (5.9") concrete pavements. Must comply with regional force protection standards.			
11. REQUIREMENT: 1,349 SM ADEQUATE: 0 SM SUBSTANDARD: 157SM			
PROJECT: Construct a new flight simulator facility. (Current Mission)			
REQUIREMENT: Provide Flight Simulator facility to support aircrew training activities. The project must include adequate space for administration and records, classrooms, and other supporting spaces. AT/FP costs on this project are higher than standard DoD guidance due to stricter EUCCOM force protection standards requiring screening from direct fire weapons.			
CURRENT SITUATION: 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.			
IMPACT IF NOT PROVIDED: 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			
ADDITIONAL: 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, 560 SM, for a complete four-ship facility. This project complies with space criteria outlined in AFH 32-1084, "Facility Requirements." Project requires US/Italian Mixed			

Time to Create Each Scenario

Item	Costs
Task 1 (40 hrs)	\$2800
Task 2 (20 hrs)	\$3000
Task 3 (38 hrs)	\$1900
Task 4 (10 hrs)	\$400
Total	\$8100

One Time Exterior Digitization of an Airport

Item	Costs
Task 1 (142 hrs)	\$18886
Task 2 (142 hrs)	\$11502
Task 3 (121 hrs)	\$8288
Total	\$38316

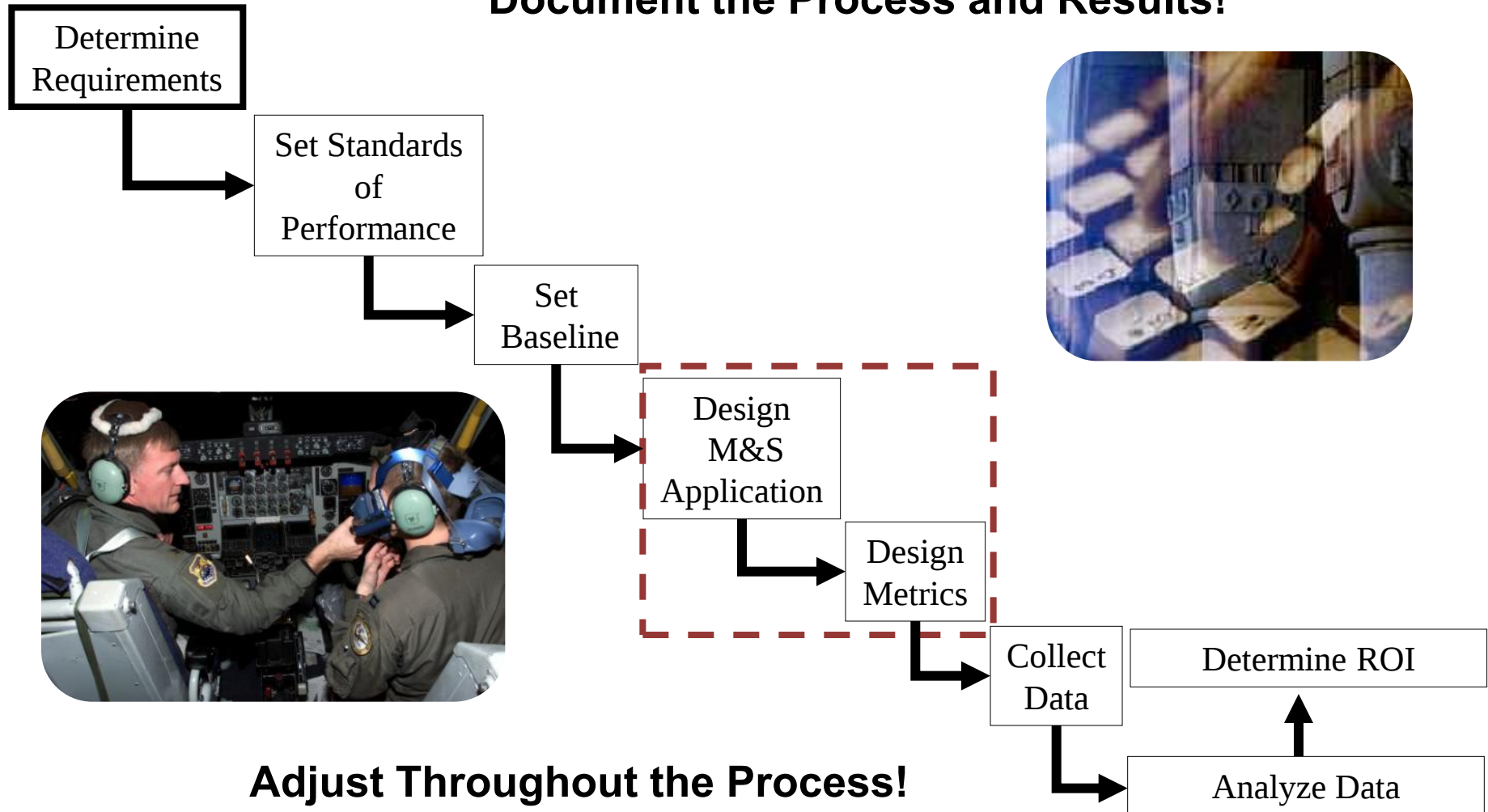
Time to Input Scenario into the Simulation

Item	Costs
Task 1 (20 hrs)	\$560
Task 2 (10 hrs)	\$280
Task 3 (12 hrs)	\$360
Task 4 (4 hrs)	\$160
Total	\$1360

Total Cost: \$36,092,776

Process for Quantifying M&S

Document the Process and Results!



ROI Example - Training

Multiple Configurations



Reuse



Individual Trainer Configuration



Team Role Trainer



Seminar Configuration



Conference Configuration

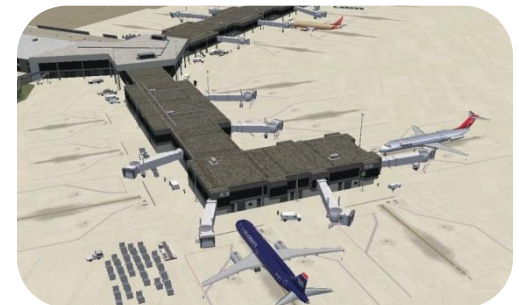
Rehearsal Configuration



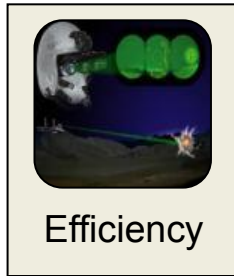
Situation Tool



Analysis Configuration



ROI Example - Training



VS.



- **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

ROI Example - Training



Readiness



Effectiveness

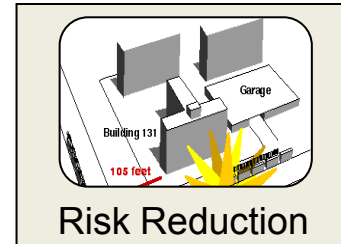
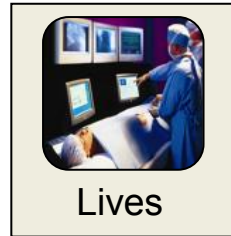
During the one simulation and after-action review session, the staff **identified 38 actions** that needed to be addressed. All 38 were addressed which led to an additional 24 actions.

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.

ROI Example - Training



Number of incidents and fatalities during the last ten years

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

–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

ROI Example - Training

American Airlines Example



Time



Money

Cost for a new simulator is \$14 to \$15 million	
14 different simulators	\$126 million
107 simulator technicians and 8 engineers	\$1.9 million per year Ten Years \$19 million
Annual maintenance budget - \$800,000	\$800 thousand Ten Years \$8 million
<i>Ten-Year Costs</i>	\$153 million

ROI Example - Training

American Airlines Example



Time



Money

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



ROI Example - Training

American Airlines Example



Time



Money

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

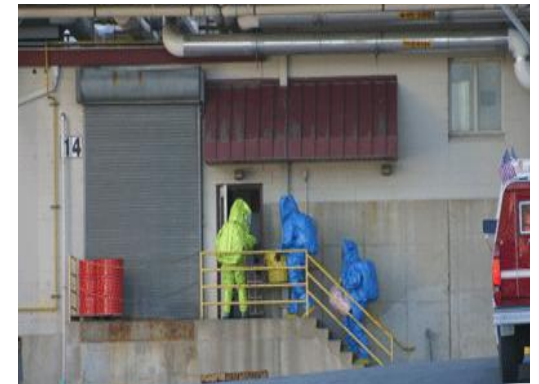
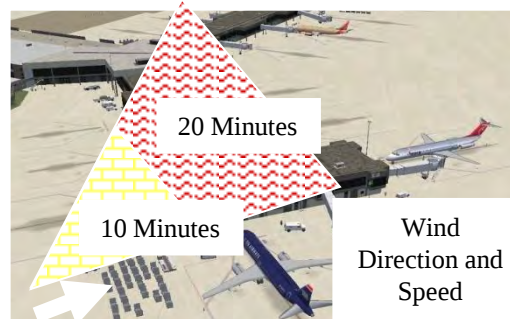
Overall ROI – \$1,282,600,000 – \$103,000,000 (less \$50M) = \$1,179,600,000

ROI
Per Year Savings
\$179,600,000

ROI Example - Training

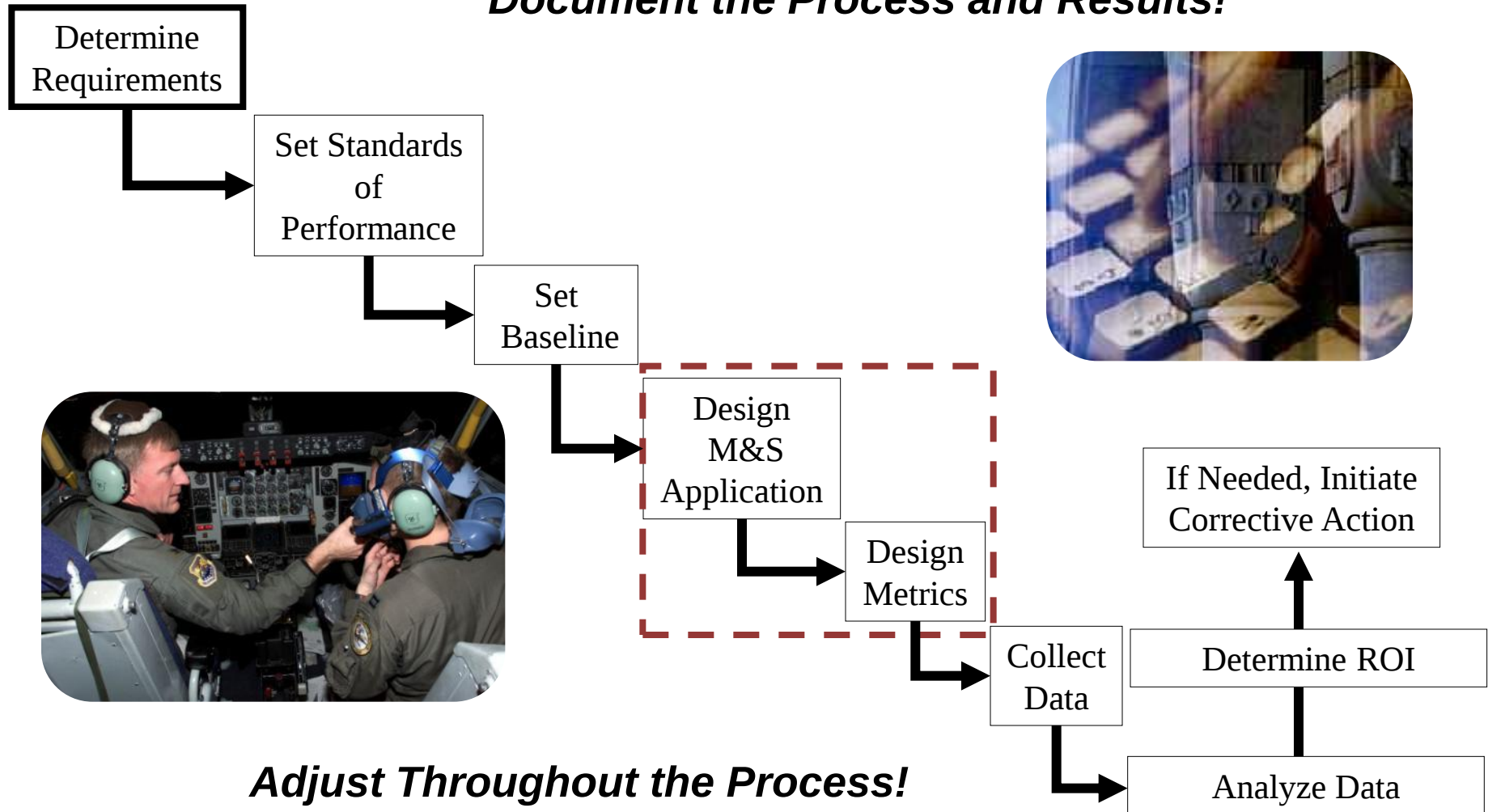


Situation Tool



Process for Quantifying M&S

Document the Process and Results!



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



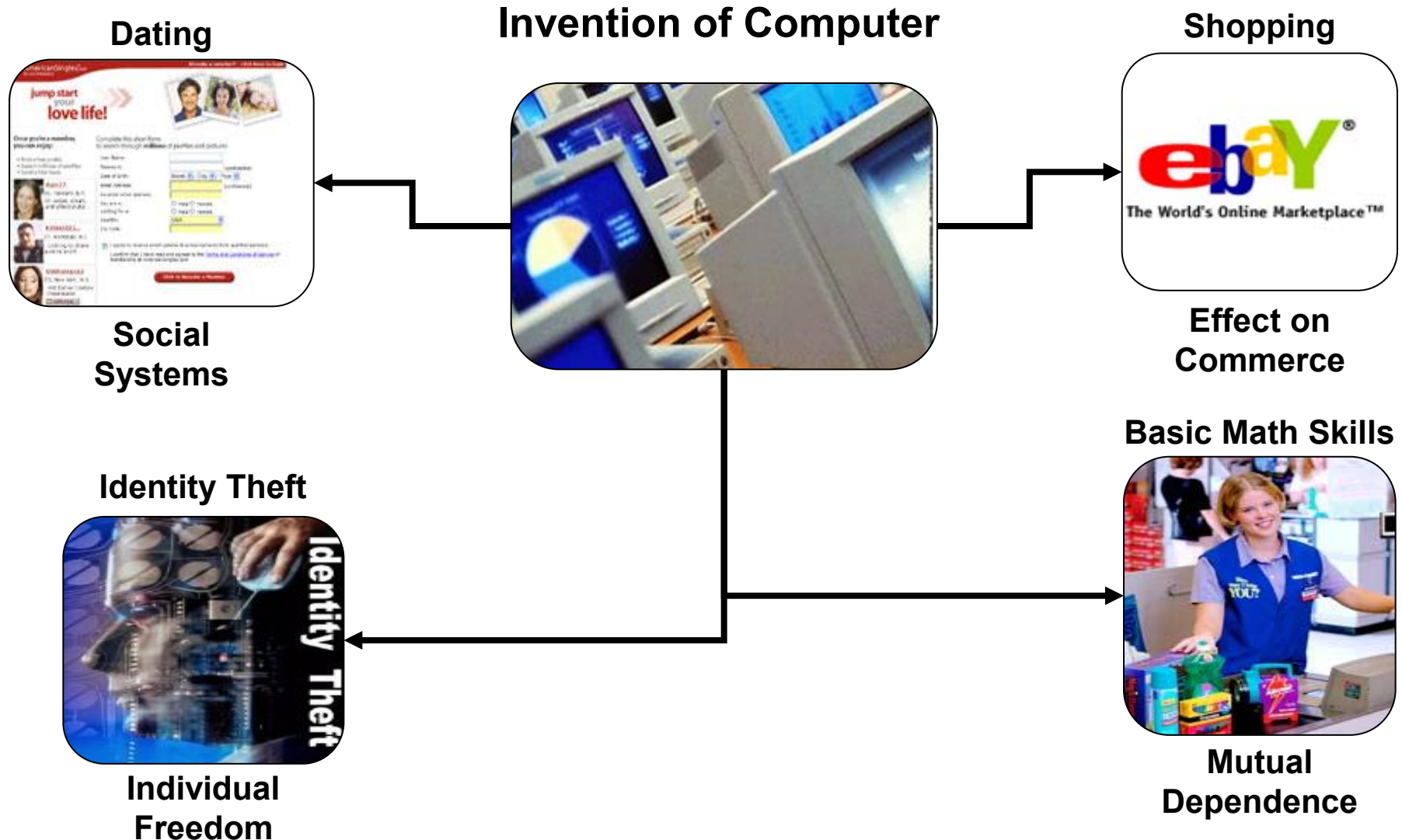


CAUTION

**WATCH
YOUR STEP**

Other ROI Aspects

Unknown Secondary Effects



Any Questions?

References

- Bolten, J.G., Carrillo, M., Conley, R.E., Massey, H.G., & Robbert, A.A. (2006). Maintaining the balance between manpower, skill levels, and PERSTEMPO. RAND Corporation, Project Air Force, contract F49642-01-C-0003 and FA7014-06-0001.
- Brown, C. D., Ph.D., Grant G., Col, Kotchman, D., LTC, Reyenga, R., Col, & Szanto, T., LTC (2000). Building a business case for modeling and simulation [Opinion]. Acquisition Review Quarterly—Fall 2000, 311-327.
- Department of Defense Instruction 7041.3. Economic analysis for decisionmaking, Enclosure 3: Procedures for economic analysis (1995, November 7).
- Fletcher, J. D. (n.d.). Measuring the cost, effectiveness, and value of simulation used for military training [On-line]. Institute for Defense Analyses, Alexandria, VA. Available: www.siaa.asn.au/get/2410061680.pdf
- Degnan, Edward, (2000) A Study of Using Simulation Technology to Improve Crisis Management Capabilities in Schools
- FAA Report Number: AV-2009-039: Actions taken and needed to improve FAA's runway safety area program (2009)
- 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).
- Gordon, S. C., Dr. (n.d.). Determining the value of simulation [On-line]. Available: <http://www.scs.org/getDoc.cfm?id=1126>
- National Research Council of the National Academies. (2006). Defense modeling, simulation, and analysis: Meeting the challenge, 15-16. Committee on Modeling and Simulation for Defense Transformation. Board on Mathematical Sciences and Their Applications, Division on Engineering and Physical Sciences. Available: <http://www.nap.edu/catalog/11726.html>
- NAVAIR Scientific and Technical Report : Metric for Modeling and Simulation (M&S) Investments (November 2008)
- Power, G., Maj Gen (n.d.). State of the union in Air Force M&S. Headquarters, U.S. Air Force.
- Rench, M. E. & Johnson, S. (2001). Cost benefit analysis for human effectiveness research: distributed mission training-aircrew. HSIAC-TR-2001-016, Report for Air Force Research Laboratory, Human Effectiveness Directorate, Wright-Patterson AFB, OH.