Transitioning the Opportune Landing Site System to Initial Operating Capability

AFRL's 2007 Technology Maturation Conference

Multi-Dimensional Assessment of Technology Maturity

13 September 2007

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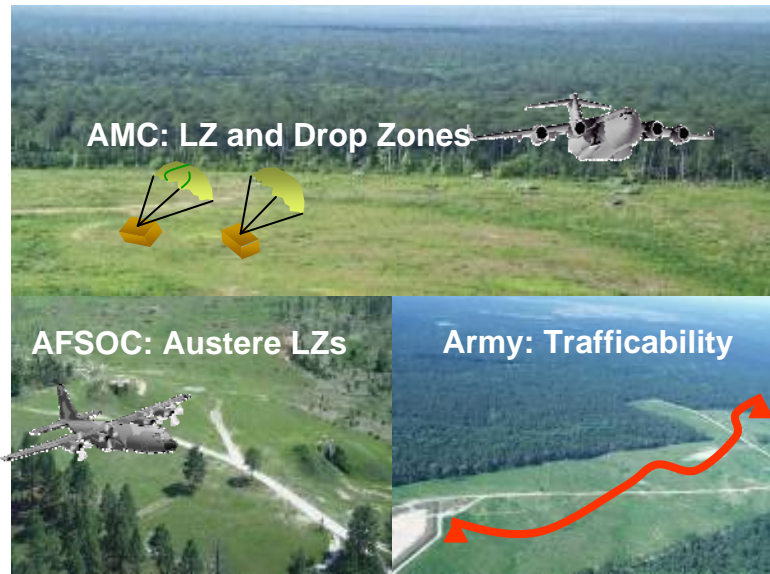| Bob McCarty	SynGenics Corporation
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Outline

- **OLS Program Overview**

- **Systems Engineering Support**

- **Technology Maturation Planning**

- **Conclusions**

Outline

- **OLS Program Overview**

- Systems Engineering Support

- Technology Maturation Planning

- Conclusions

OLS Program Overview

AMC: LZ and Drop Zones

AFSOC: Austere LZs

Army: Trafficability

Technology Investment Schedule

	FY04	FY05	FY06	FY07
Military Utility Study	■			
Data Collections		■		
Soil Type Automation		■		
Soil Strength Algorithm Dev		■		
Soil Strength Alg Validation	■			
Algorithm Integration/Demo				■
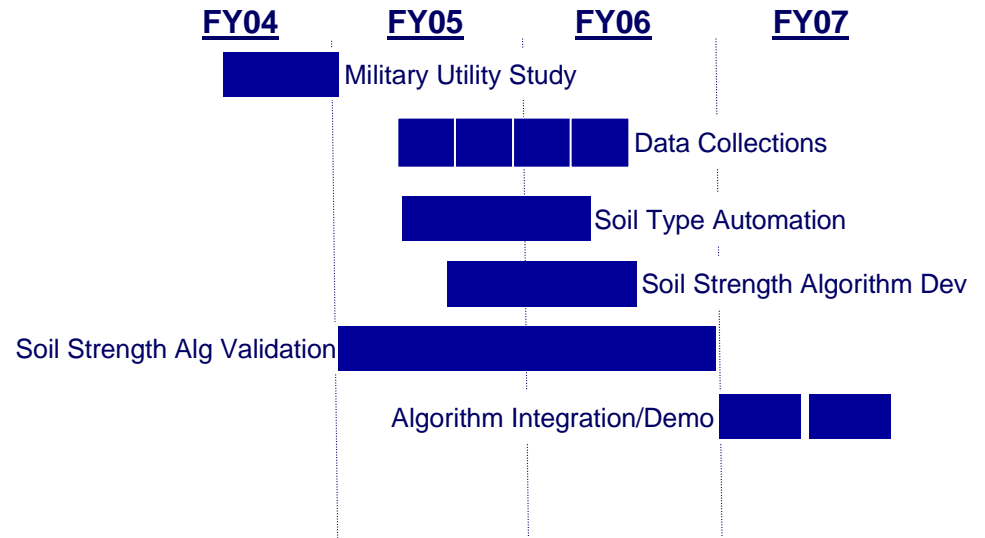
Description	Benefits to the War Fighter
• **Determine area/soil suitability for landing or drop zone and trafficability**	• Enable remote surveys
Technology	• Reduce threat exposure
• **Multi-spectral - flat, dry, obstacle and vegetation free** • **Soil type plus soil moisture automation yields CBR**	• Compress mission planning cycle • Fewer site visits • Reduce manpower

OLS Program Objectives

- **Enable Warfighter Access *Anywhere* in the Battlespace**

- **Provide Alternate Method of Site Evaluation**
    - o **Sites Currently Evaluated Physically by Military Personnel, Often under Hostile Conditions**
    - o **Reduce Initial Search Time**
    - o **Limit Number of Necessary Evaluations to Fewest Areas**
    - o **Eventually Eliminate Need for Physical Evaluations**

OLS Program Overview
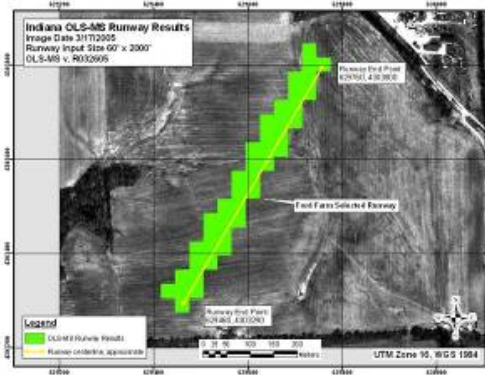
- **Approach:**
  - Test/Validate OLS Tool for Landing Suitability
  - Tie Landing Suitability with Soil and Weather Models
  - Test/Validate OLS Signatures via Field Surveys
  - Demonstrate Capabilities of the OLS System
  - Perform a Military Utility Study to Determine CONOPS
- **Product:**
  - Validated/Demonstrated Warfighter Tool
- **Schedule:**
  - August 2004 to September 2007
  - OLS Software Delivered at End of Program
    - At Technology Readiness Level 5

Current Operations

Tanker Airlift Control Center (TACC) Identifies Need to Operate Off Hard Surface	**Special Tactics Team (STT) Makes Initial Cut**	**TACC Redefines Operation**	**STT Input**

TACC Task for Site Survey	**STT Does Survey**	**STT Report Results**

TACC Evaluates Results	**TACC Task Mission**	**TACC Tasks STT for Operation**	**STT Deploys for Operation**
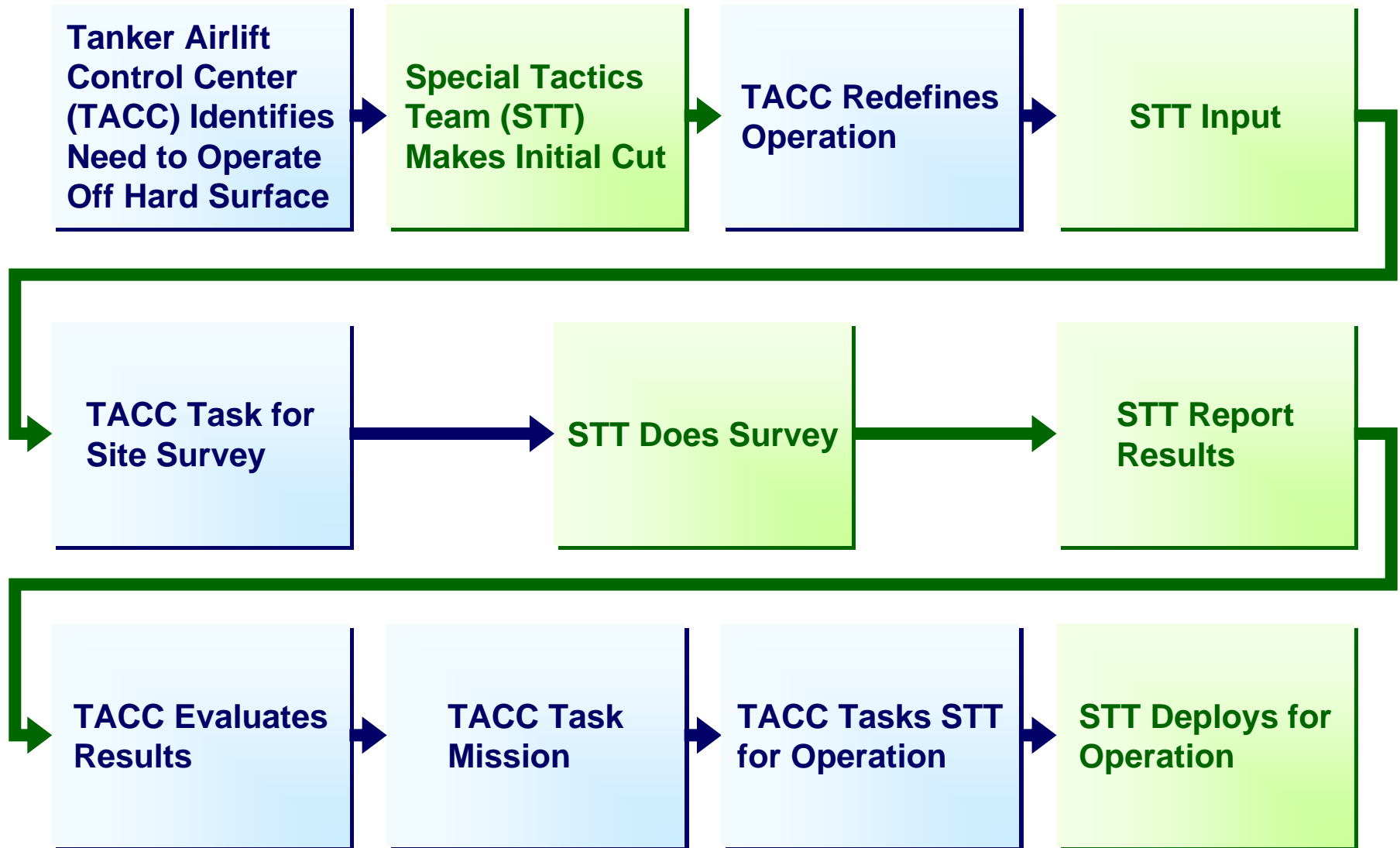
(Green = Operations Done in Field)

OLS Full Operational Capability

Tanker Airlift Control Center (TACC) Identifies Need to Operate Off Hard Surface

Special Task Team (STT) Makes Initial

OLS System Operates

Redefines

STT Input

TACC Task for Site Survey

STT Does Survey

STT Report Results

TACC Evaluates Results

TACC Task Mission

TACC Tasks STT for Operation

STT Deploys for Operation

(Green = Operations Done in Field)

9
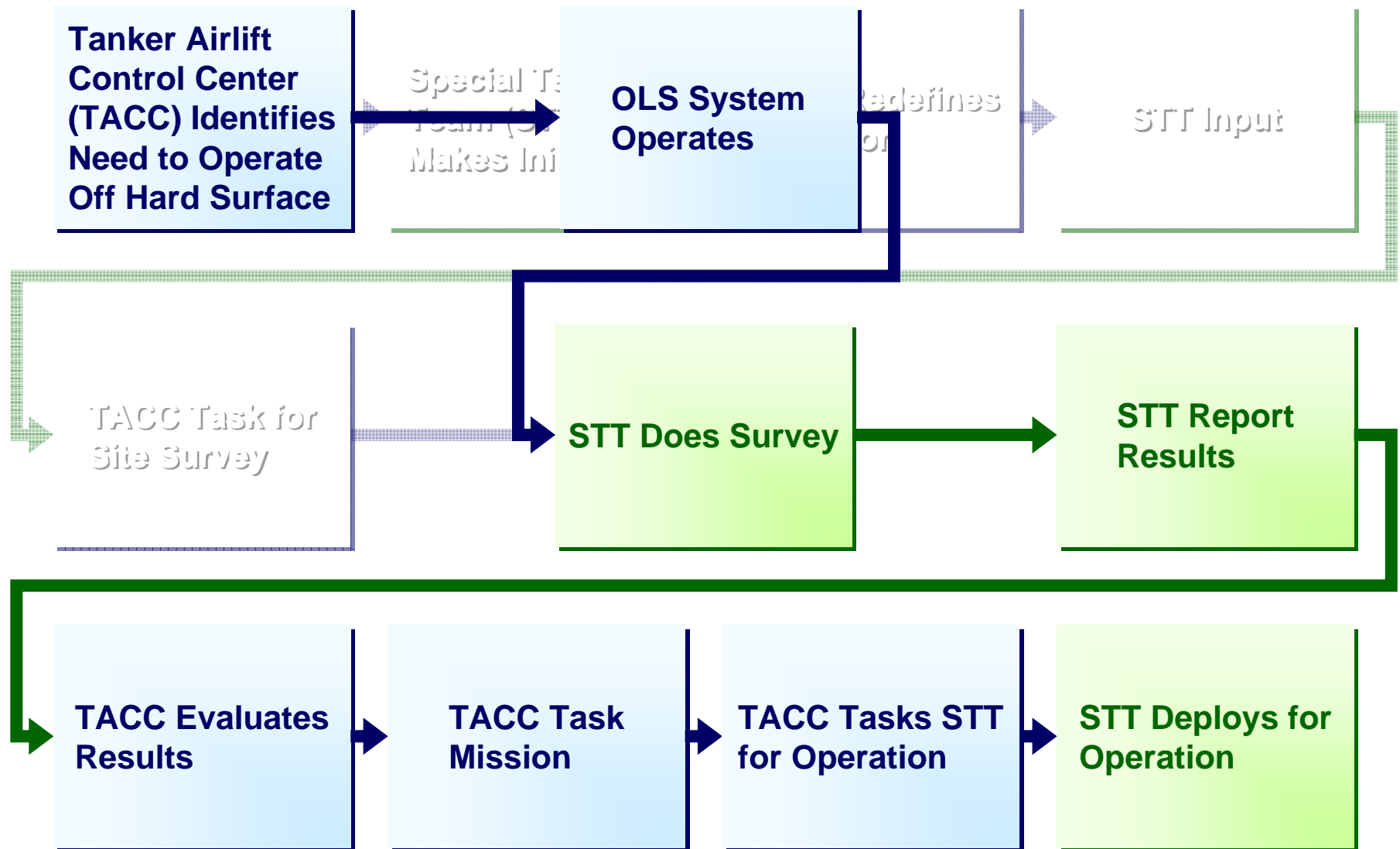
OLS Future Operational Capability
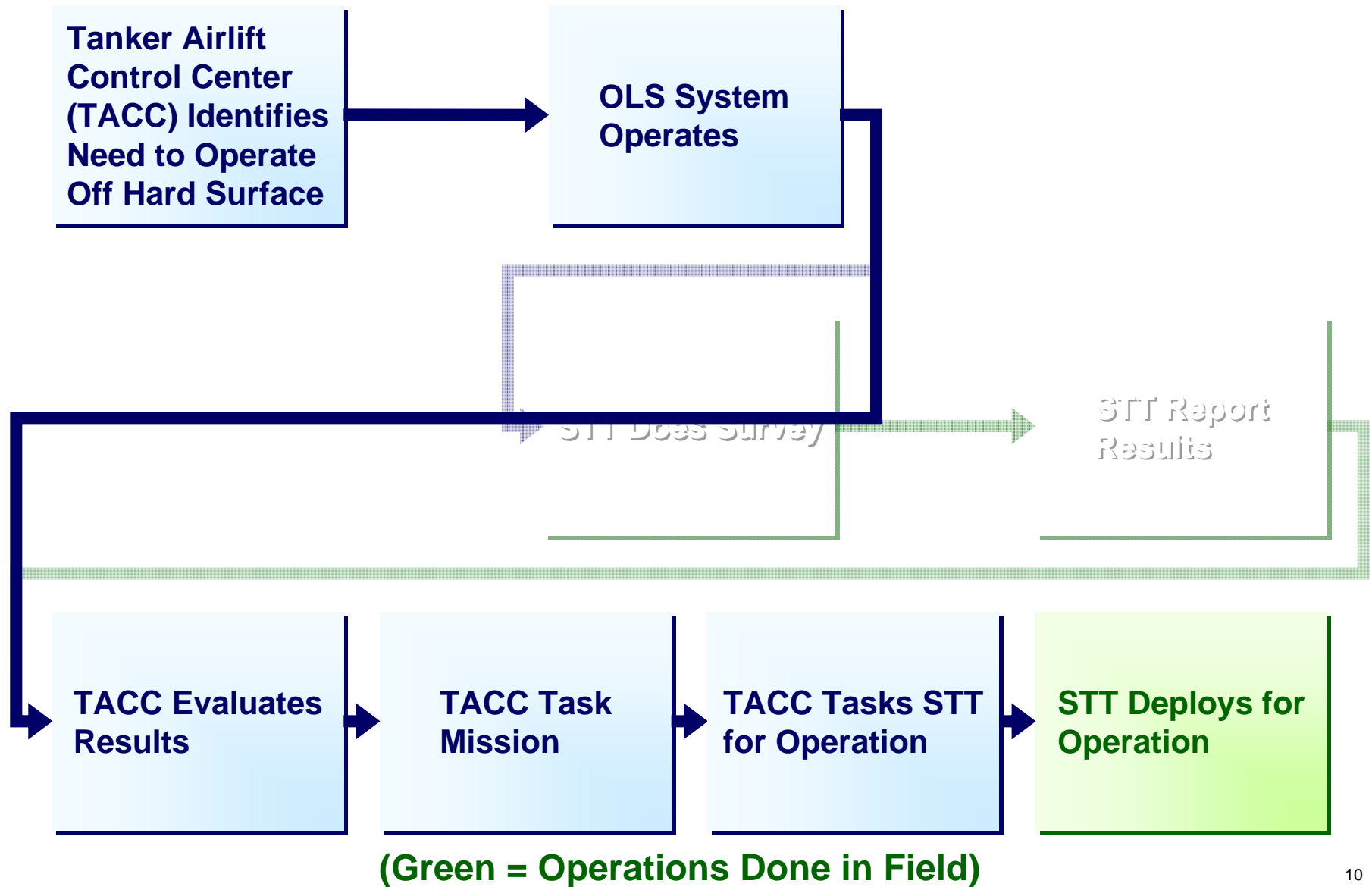
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┌─────────────────────┐                    ┌─────────────────────┐
│ Tanker Airlift      │                    │                     │
│ Control Center      │ ───────────────▶   │ OLS System          │
│ (TACC) Identifies   │                    │ Operates            │
│ Need to Operate     │                    │                     │
│ Off Hard Surface    │                    │                     │
└─────────────────────┘                    └─────────────────────┘
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STT Does Survey → STT Report Results

```
┌─────────────────┐    ┌─────────────┐    ┌─────────────────┐    ┌─────────────────┐
│ TACC Evaluates  │ ─▶ │ TACC Task   │ ─▶ │ TACC Tasks STT  │ ─▶ │ STT Deploys for │
│ Results         │    │ Mission     │    │ for Operation   │    │ Operation       │
└─────────────────┘    └─────────────┘    └─────────────────┘    └─────────────────┘
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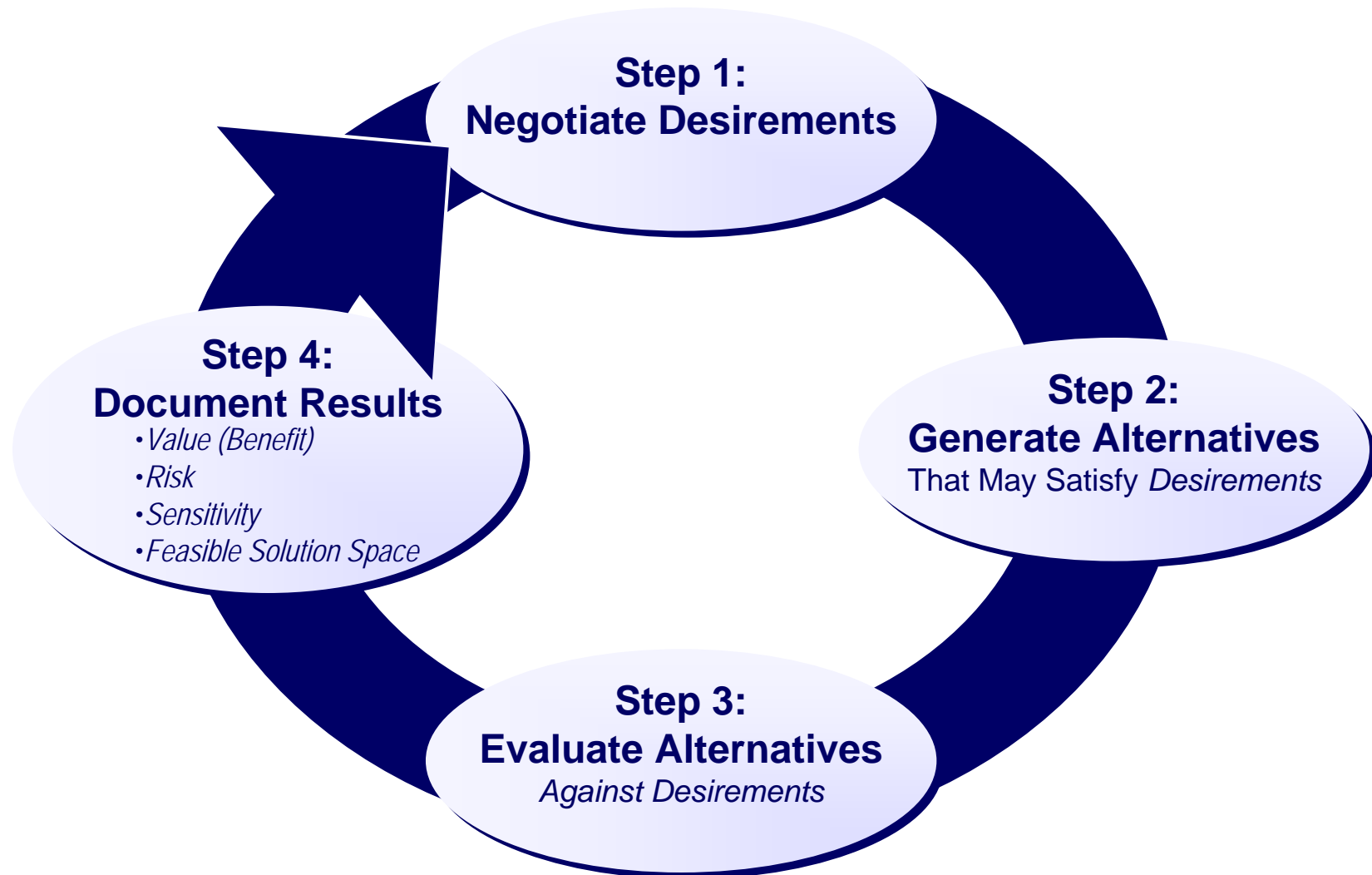
(Green = Operations Done in Field)

Outline

- OLS Program Overview

- **Systems Engineering Support**

- Technology Maturation Planning

- Conclusions

Systems Engineering Support
Systems Engineering Tailored for S&T (SETFST)

Step 1:
Negotiate Desirements

Step 2:
Generate Alternatives
That May Satisfy *Desirements*

Step 3:
Evaluate Alternatives
Against Desirements

Step 4:
Document Results
- *Value (Benefit)*
- *Risk*
- *Sensitivity*
- *Feasible Solution Space*
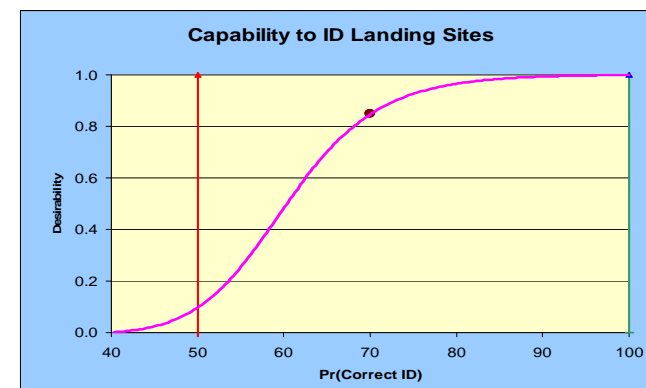
1. Negotiate Desirements

- **Term "Desirement" More Effective than Traditional Requirement**
  - Better Able to Express Intent than Requirement
- **Desirement Characterized by**
  - Name and Description
  - Unit of Measure
  - Definition of How it Will be Measured
  - An Objective Value (Point of Full Customer Satisfaction)
  - A Limit Value Separating Acceptable from Unacceptable (Pass/Fail)
  - A Desirability Function (*d*-curve)

Rqmt #	Requirement Name	Units of Meas.	Objec-tive	Thres-hold(s)	d at Thresh	Where d=0.00	Requirement Description	Assumption, How Tested or Other Clarification	Customer Comments	Prior-ity
P01	Capability to ID Landing Sites	Pr(Correct ID)	100	95			...suitable landing zone (LZ) in an area, given that a suitable LZ exists in the area...a measure of accuracy without consideration of bearing strength	Percentage of Correct LZ IDs [Pr(CrIDs)]. Pr CrIDs = (Area in Correct LZ ID'd) ÷ (Total Area of LZs in region analyzed)	Exit criterion and KPP. "Suitable" means in compliance with AFI13-217, ETL97-9, ETL02-19, ETL04-7. Must address existing runways and roads.	High
P02	Capability to Determine Bearing...	Predicted/ Actual	1	0.5 and	0.2 and	0.2 and	FASST-predicted CBR ÷ Actual LZ CBR. Predictions made at 85% confidence level.	Validation of OLS predictions through sampling on LZ and comparison of DCP-measured CBRs by skilled combat control teams (CCTs).	Exit criterion and KPP for final system. Until there is very high confidence in the OLS soil-strength predictions, it is unlikely that aircraft will be authorized to land without a site survey. 11/29/06 Action: CRREL ascertain confidence level CE community has in field CBR of site based on field sampling by CCT.	High
P03	Low Incidence of False Positives	Pr(Incor-rect ID)	0	0.0001	0.98	0.005	Probability of designating an unsuitable landing site as a suitable LZ. Suitability as defined for this criterion excludes bearing strength.	Removed soil strength 11/29/06. Together with P01, measures accuracy.	Exit criterion and KPP. Risk is that operators will not use the system if the failure rate is too high	High
P04	Repeatability	Pr(Identify ing Same Site)	100	100			Percentage of time OLS returns the same results using the same entry parameters (given area at a particular time).	Software validation based on acceptance testing.	Exit criterion and KPP.	High
P05	Fidelity	Scale: 1 to 6	6	4			Level of detail available from OLS; ability to have the same level of detail as we have today from a site-survey team, not just a go / no-go decision.	6-Pt Satisfaction Scale: 6 = very satisfactory; 5 = satisfactory; 4 = marginally satisfac.; 3 = marginally unsat.; 2 = unsatisfactory; 1 = very unsatisfactory	Exit criterion and KPP.	Med

Capability to ID Landing Sites (Desirability vs Pr(Correct ID))

2. Generate Alternatives
That May Satisfy Desirements

- **SETFST Alternatives Similar to Traditional Alternatives**
- **Subject-Matter Experts Work Together to Conceptualize Different Possible Solutions**
- **Expected Outcomes**
  - **Mapped to Desirements**
  - **Translated to Desirability Units**
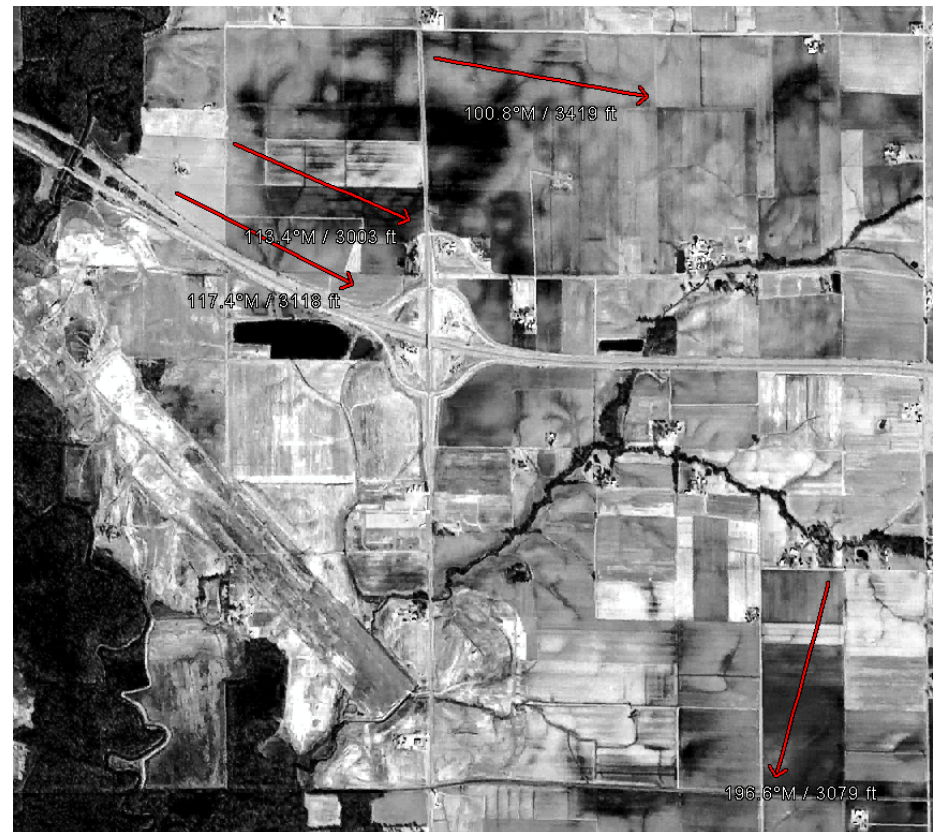
3. Evaluate Alternatives
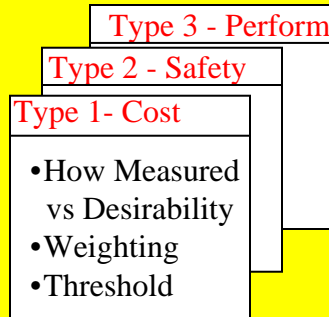## Against Desirements

- **Analysis**
  - Evaluation of Alternatives with Rigorous Mathematics
  - Sensitivity Analysis Bounds Feasible Solution Space
  - Enables Exploration of Space for Best-Value Solutions
- **Composite Desirability (*D*) for Evaluation of Alternatives**
  - Alternative's Ability to Satisfy Full Range of Desirements
  - Risk in Quantitative Terms
  - Sensitivity
  - Failure for One Desirement Means Failure for All
- **Sensitivity Analysis Shows Highly Leveraged Alternatives**
  - Where Small Changes Deliver Large Changes in Results
 - Where Large Changes Produce Little Change in Results

4. Document Results

- **Depends Upon the Problem Under Study**
- **Includes Information Decision-Maker Needs**
  - o **Feasible Solution Space**
  - o **Value and Risk**
  - o **Results of Sensitivity Analysis**
  - o **Conclusions and Recommendations**
- **Usually Includes an Executable Program Plan**
  - o **At the Corporate Level, or**
  - o **At the Technology Directorate Level**
  - o **At the Program Level**

SETFST Process Overview

1. Negotiate Desirements

Type 3 - Perform
Type 2 - Safety
Type 1- Cost

- How Measured vs Desirability
- Weighting
- Threshold

- **Define Desirability vs How Measured and Threshold for Each Desirement**

Threshold d-Limit

1

Desirability

0

How Measured
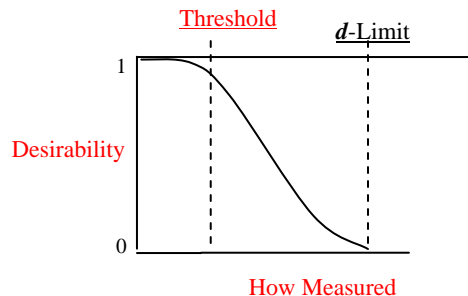
- **Weight desirements to Signify Relative Importance**

2. Generate Alternatives

- Design Concept A
- Design Concept B

3. Evaluate Alt's vs Desirements

- For Each Design
  - Estimate EXPECTED Performance for Each desirement

  - Estimate Performance "SPREAD" for Each Desirement

Concept A   **Concept B**

Expected   Spread

1   1

~ d   Threshold   ~ d   Threshold

0   0

How Measured
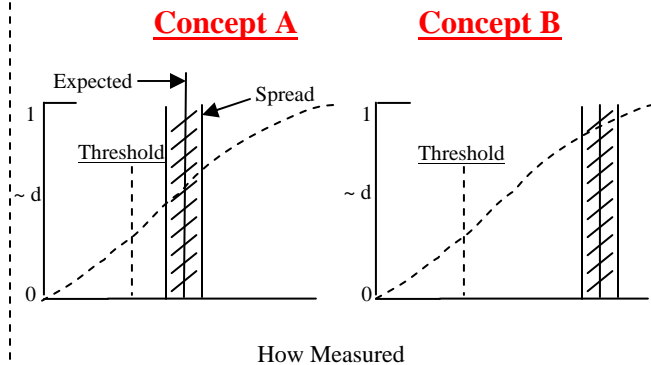
3a. Compute Desirability, Risk Optimize Best Alternative

$$CSI^A = \left(\prod D_G^{W_G}\right)^{1/\Sigma W_G}$$

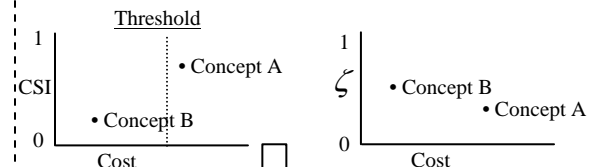$$\zeta^A = 1 - e^{-\Sigma \zeta_G}$$

where:

CSI^A = Customer Satisfaction Index for Concept A

ζ^A = Probability of Failure to Meet Threshold for Concept A

3b. Explore Trade Space
- Performance s Cost
- Risk vs Cost
- Sensitivities

1   Threshold
CSI   • Concept A
    • Concept B
0
Cost

1
ζ • Concept B
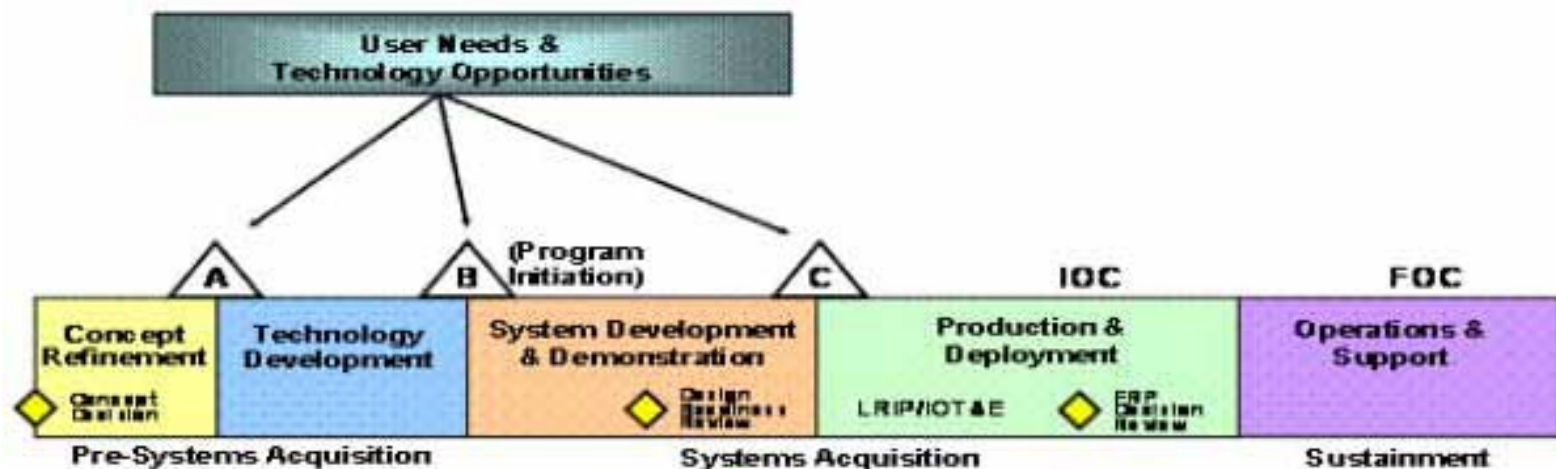   • Concept A
0
Cost

4. Recommend/Document
- Based on Desirability
- Based on Risk

SETFST Goals for OLS Program

- **Enable Successful 2007 Demonstration**
  - o **"M/S A Like" Decision for Technology Development**

- **Forge Tech Maturation Plan for Successful Transition**
  - o **"M/S B Like" Decision for System Development/ Demonstration**
  - o **"M/S C Like" Decision for Production and Deployment**

OLS Desirements
For Milestone A-Like Decision

For Technology Development

Rqmt #	Requirement Name	Units of Meas.	Objec-tive	Thres-hold(s)	Requirement Description	Assumption, How Demonstrated or Other Clarification	Customer Comments	Prior-ity
Type:	**Performance**							
P01	Capability to ID Landing Sites	% of Suitable LZs Correctly Identified	100	50	Probability of designating a suitable landing zone (LZ) in a geographical region, given that a suitable LZ exists in the region—a measure of accuracy without consideration of bearing strength.	Percentage of Correct LZ IDs [Pr(CrIDs)]. Pr CrIDs = (Area in Correct LZ ID'd) ÷ (Total Area of LZs in region analyzed). Comparison of software analysis results with inspection and observation results for St. Clair County, IL (Task 1)	Exit criterion and KPP.	High
P02	Capability to Determine Bearing Strength of ID'd LZs	Predicted/ Actual CBR	1	1.05	FASST-predicted CBR ÷ Actual LZ CBR. Predictions made at 85% confidence level.	Validation of OLS predictions through field sampling and comparison of software predictions with DCP-measured CBRs. (Task 2)	Exit criterion and KPP.	High
P04	Repeatability	Pr(Same Answer)	100	90	Percentage of time OLS returns the same results using the same entry parameters (given area at a particular time).	Software validation based on acceptance testing. (Task 3)	Exit criterion and KPP.	High

OLS Desirements
For Milestone A-Like Decision

For Technology Development

- **8 Desirements Total**

- **Including 4 Exit Criteria**

- **3 of Which are Key Performance Parameters (KPPs)**
  - **Capability to Correctly ID Landing Sites**
  - **Capability to Correctly Determine Soil Strength**
  - **Repeatability**
  - **Ability to Accept User-Defined Parameters (not a KPP)**

OLS Desirements
For Milestone B-Like Decision

For System Development and Demonstration

- **18 Desirements Total**

- **Including 6 Exit Criteria**

- **4 of Which are Key Performance Parameters (KPPs)**
  - Capability to Correctly ID Landing Sites
  - Capability to Correctly Determine Soil Strength
  - Low Incidence of False Positives
  - Repeatability
  - Ability to Accept User-Defined Parameters (not a KPP)
  - Degree of User Confidence Inspired (not a KPP)

OLS Desirements
For Milestone C-Like Decision

For System Production and Deployment

- **23 Desirements Total**

- **Including 18 Exit Criteria**

- **9 of Which are Key Performance Parameters (KPPs)**
  - **Too Numerous to List Here**
  - **KPPs/Exit Criteria for M/S A and B Remain in this Set of Desirements**
  - **Definition of Failure Becomes More Stringent for Later Milestones**
    - **e.g. Capability to ID Landing Site**
      - **50% for Milestone A**
      - **85% for Milestone B**
      - **95% for Milestone C**

Outline

- OLS Program Overview

- Systems Engineering Support

- **Technology Maturation Planning**

- Conclusions

OLS Tech Maturation Plan (TMP)

- **OLS TMP Based on AFMC Instruction**
  - o Advanced Technology Demonstration (ATD) Programs
- **Written Jointly**
  - o Boeing
  - o US Army Engineer and Research Development Center (ERDC)
  - o SynGenics
- **Outlines How to Enable Development Decision**
- **Paints Long Range Vision for Production/Deployment**
- **Guide for OLS Follow-On S&T Program Manager**
- **Way Ahead for Acquisition Program Manager**
- **Ensures Delivery of Best Value with Acceptable Risk**

Technology Maturation Plan

- **Technology Demonstration Plan**

- **Acquisition Strategy**

- **Technology and Transition Agent Bridge**

- **Deployment Strategy**

- **Signature Pages**

Technology Demonstration Plan
Types of Maturity Measures

Technology Participants	Missions/Pgms Supported by OLS
Relevant Mission Area Needs	Major Technology Milestones
Program Objective	Deliverables
Program Approach	Technology not Delivered
Tech Devel Required for SDD	Risk Analysis
Target Acquisition Programs	Funding
Product/Payoff/Exit Criteria	Technology Protection Plan
Programs Critical to OLS	

Acquisition Strategy
Types of Maturity Measures

Target Acquisition Programs	Functional Strategies
Stakeholders	Technical
Capability Requirements Documents	Business
Projected Availability Dates	Financial
System Development and Demonstration	Logistics
	Test

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- **Conclusions**

Conclusions

- **"Work Accomplished to Define Desirements Provided Direction for the OLS Program"**

- **"Helped Direct Team's Efforts more Productively"**
  - **Both Comments by Boeing Principal Investigator**

- **SETFST Process Critical to Tech Mat Planning**
  - **Definition of Set of Key Desirements for Each Milestone**
    - **Corresponding to Acquisition Life Cycle Decisions**
  - **Many Aspects are Key to Effective Tech Mat Planning**
    - **Technology Maturity Assessment Has to be Multi-Dimensional**
  - **Drove Team to Identify System Development Stakeholders**

Backup Charts

OLS Desirements
For Milestone B-Like Decision

For System Development and Demonstration

Rqmt #	Requirement Name	Units of Meas.	Objec-tive	Thres-hold(s)	d at Thresh	Where d=0.00	Requirement Description	Assumption, How Tested or Other Clarification	Customer Comments	Priority
Type: Performance										
P01	Capability to ID Landing Sites	Pr(Correct ID)	100	85	0.85	40	Probability of designating a suitable landing zone (LZ) in an area, given that a suitable LZ exists in the area--a measure of accuracy without consideration of bearing strength		Exit criterion and KPP. OLS-estimated soil should help ground personnel decide where to sample.	High
P02	Capability to Determine Bearing Strength of ID'd LZs	Predicted/ Actual CBR	1	1.05			FASST-predicted CBR ÷ Actual LZ CBR. Predictions made at 85% confidence level.	Validation of OLS predictions through sampling on LZ and comparison of DCP-measured CBRs by skilled combat control teams (CCTs).	Exit criterion and KPP.	High
P03	Low Incidence of False Positives	Pr(Incor-rect ID)	0	0.2	0.50	0.5	Probability of designating an unsuitable landing site as a suitable LZ--a measure of accuracy.		Exit criterion and KPP.	High
P04	Repeatability	Pr(Identify ing Same Site)	100	100			The degree to which the system provides the same answer for an area given data input for a particular time.	Software validation based on acceptance testing.	Exit criterion and KPP Software verification based on test plan.	High

OLS Desirements
For Milestone C-Like Decision

For System Production and Deployment

Rqmt #	Requirement Name	Units of Meas.	Objec-tive	Thres-hold(s)	d at Thresh	Where d=0.00	Requirement Description	Assumption, How Tested or Other Clarification	Customer Comments	Prior-ity
Type: Performance										
P01	Capability to ID Landing Sites	Pr(Correct ID)	100	95			Probability of designating a suitable landing zone (LZ) in an area, given that a suitable LZ exists in the area--a measure of accuracy without consideration of bearing strength	Percentage of Correct LZ IDs [Pr(CrIDs)]. Pr CrIDs = (Area in Correct LZ ID'd) ÷ (Total Area of LZs in region analyzed)	Exit criterion and KPP. "Suitable" means in compliance with AFI13-217, ETL97-9, ETL02-19, ETL04-7. Must address existing runways and roads.	High
P02	Capability to Determine Bearing Strength of ID'd LZs	Predicted/ Actual CBR	1	0.5 and 1.05	0.2 and 0.5	0.2 and 1.1	FASST-predicted CBR ÷ Actual LZ CBR. Predictions made at 85% confidence level.	Validation of OLS predictions through sampling on LZ and comparison of DCP-measured CBRs by skilled combat control teams (CCTs).	Exit criterion and KPP for final system. Until there is very high confidence in the OLS soil-strength predictions, it is unlikely that aircraft will be authorized to land without a site survey. 11/29/06 Action: CRREL ascertain confidence level CE community has in field CBR of site based on field sampling by CCT.	High
P03	Low Incidence of False Positives	Pr(Incor-rect ID)	0	0.0001	0.98	0.005	Probability of designating an unsuitable landing site as a suitable LZ. Suitability as defined for this criterion excludes bearing strength.	Removed soil strength 11/29/06. Together with P01, measures accuracy.	Exit criterion and KPP. Risk is that operators will not use the system if the failure rate is too high	High
P04	Repeatability	Pr(Identify ing Same Site)	100	100			Percentage of time OLS returns the same results using the same entry parameters (given area at a particular time).	Software validation based on acceptance testing.	Exit criterion and KPP.	High
P05	Fidelity	Scale: 1 to 6	6	4			Level of detail available from OLS; ability to have the same level of detail as we have today from a site-survey team, not just a go / no-go decision.	6-Pt Satisfaction Scale: 6 = very satisfactory; 5 = satisfactory; 4 = marginally satisfac.; 3 = marginally unsat.; 2 = unsatisfactory; 1 = very unsatisfactory	Exit criterion and KPP.	Med

OLS Desirements
For Milestone C-Like Decision

For System Production and Deployment - Continued

Rqmt #	Requirement Name	Units of Meas.	Objec-tive	Thres-hold(s)	d at Thresh	Where d=0.00	Requirement Description	Assumption, How Tested or Other Clarification	Customer Comments	Prior-ity
Type: Performance										
P07	Flexibility and Longevity	Scale: 1 to 6	6	4			Ability of OLS to function even if Landsat or other asset relied upon as a data source is no longer available.	6-Pt Satisfaction Scale: 6 = very satisfactory; 5 = satisfactory; 4 = marginally satisfac.; 3 = marginally unsat.; 2 = unsatisfactory; 1 = very unsatisfactory	Exit criterion and KPP. Want open-ended system than can be upgraded; evolutionary acquisition.	High
P08	Ground Survey Personnel Time Required	Manhours	0	15			Time required for support by site-survey personnel on the ground to ensure that an OLS-identified is safe.		Exit criterion and KPP. Desired end state is no boots on the ground. 11/29/06: sampling to verify LZ ID'd by OLS iaw revised sampling plan. Reduction of time reduces danger to ground personnel.	High
P09	Capability to Operate in All Weather	Scale: 1 to 6	6	4			Ability of OLS to function in all weather conditions, regardless of cloud cover or precipitation, obscuration by terrain, etc.	6-Pt Satisfaction Scale: 6 = very satisfactory; 5 = satisfactory; 4 = marginally satisfac.; 3 = marginally unsat.; 2 = unsatisfactory; 1 = very unsatisfactory	Exit criterion and KPP for spiral endpoint. Need capability to look through weather to land AMC-X right here right now.	High
U3	Requires Minimal User Interaction	Scale: 1 to 6	6	5			Amount of user interaction required for the OLS to function effectively. The default is that input would be provided from MPS; however, capability for user to input data should be provided.	6-Pt Satisfaction Scale: 6 = very satisfactory; 5 = satisfactory; 4 = marginally satisfac.; 3 = marginally unsat.; 2 = unsatisfactory; 1 = very unsatisfactory	Exit criterion and KPP. For 2030 timeframe, AMC needs a planning process so that various scenarios are considered up front and all fixed facilities, LZs, and options are identified with associated information.	Med