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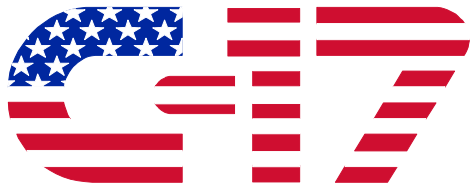

Semi-prepared Airfields

Richard B. Smith

AFCESA/CESC

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C-17, Semi-prepared Airfields Overview

- C-17 SPAM: Phase I Shortfalls
- C-17 SPRO: Phase II Site Selection
- C-17 SPRO: JA/ATT Lessons Learned
- OEF Requirements

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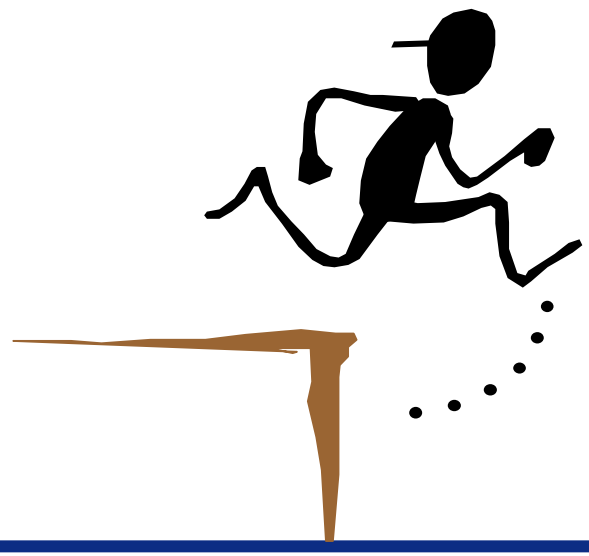
SPAM Phase I Shortfalls



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C-17 Phase I Shortfalls
Semi-prepared Airfields

1) Soil Types / Climatic Conditions
   - Tests have been conducted on a limited number of soil types (non-cohesive)
   - All flight tests of unstabilized airfields are located in arid regions
   - Emphasis has been rolling resistance in loose, non-cohesive materials
   - Impact: Low confidence level that data is applicable to sites worldwide

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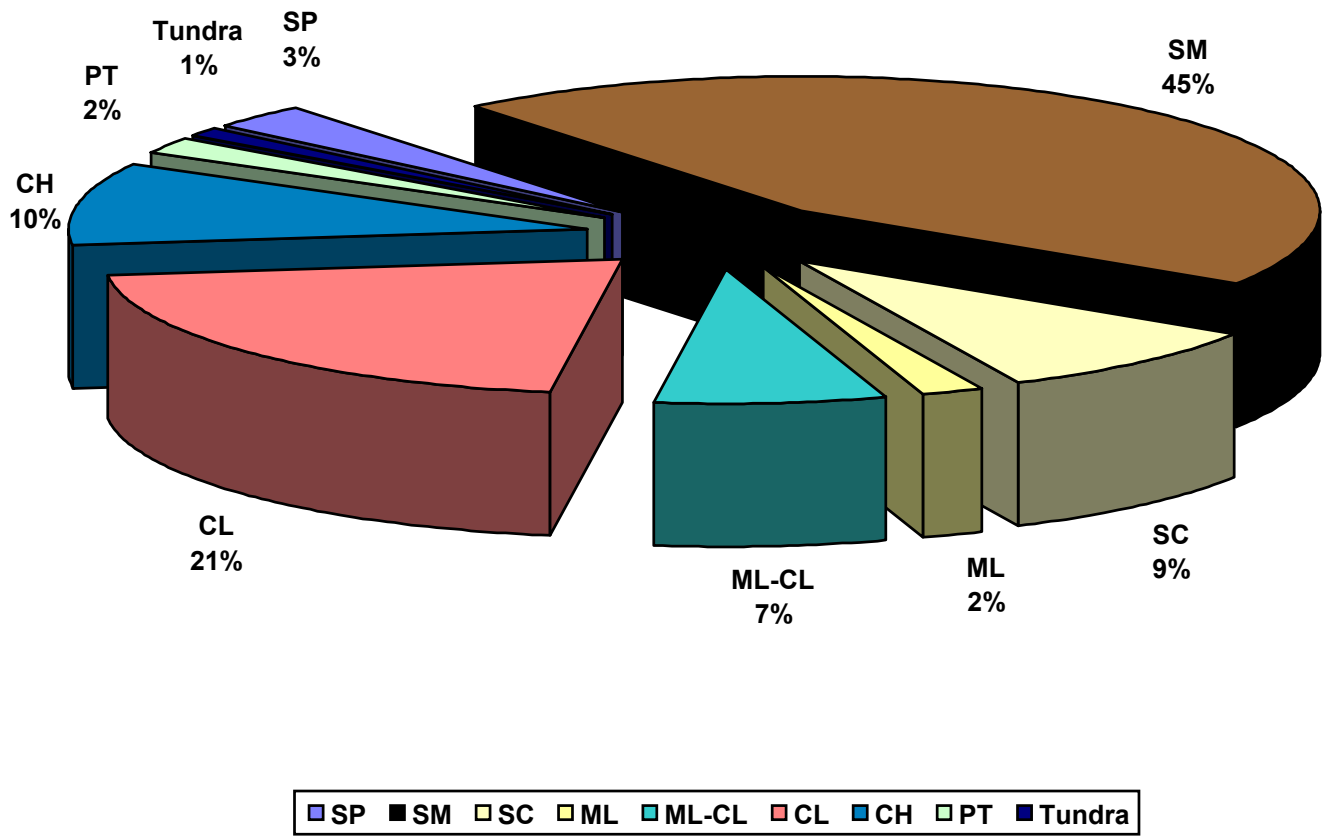
C-17 Phase I Shortfalls
World Soil Type Distribution

World USCS Soil Type Distribution (% Area)



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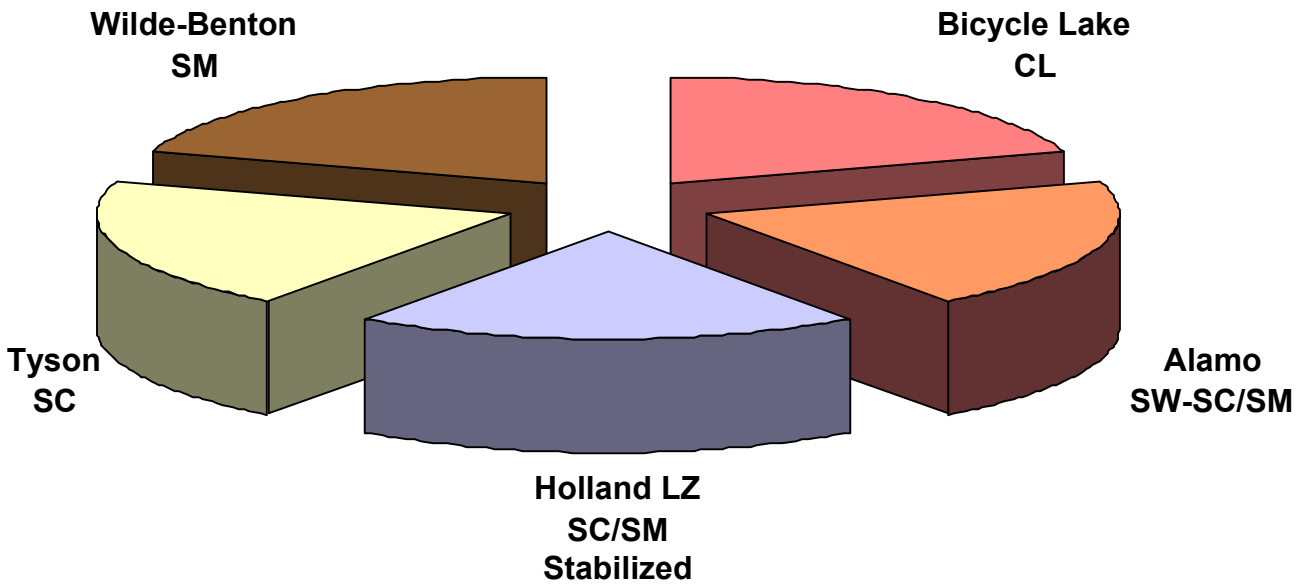
C-17 Phase I Shortfalls
Test Sites by Soil Type

C-17 Aircraft Testing Soil Classification by Test Site



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C-17 Phase I Shortfalls
World Soil Types

Climatic Zone							
USCS Soil Type	Tropical 19%	Dry 31%	Humid Mesothermal 12%	Humid Microthermal 18%	Polar 15%	Undifferentiated Highlands 5%	For All Climatic Zones
GW							
GP							
GM	<0.1	<0.1					<0.1
GC	0.4	<0.1				<0.1	0.4
SW							
SP	1.0	1.9	0.2	0.2	<0.1	<0.1	3.3
SM	7.6	16.6	4.2	6.6	5.6	3.5	44.1
SC	3.0	3.0	0.8	0.4	0.7	0.2	8.1
ML	<0.1	<0.1	0.4	0.6		<0.1	1.0
ML/CL	0.2	3.4	0.7	1.8		0.4	6.5
CL	2.7	3.9	3.2	5.3	5.4	0.7	21.2
OL							
MH							
CH	4.0	1.9	2.5	1.7		0.1	10.2
OH							
Pt	0.1	<0.1	0.1	1.0	0.5	0.1	1.8
Rk		0.3					0.3
Los							
Salt							
Tundra				0.3	2.7		3.0
Total	19	31	12	18	15	5	100

Phase I sites were located in an arid environment.

These sites provided 6.9% world coverage.

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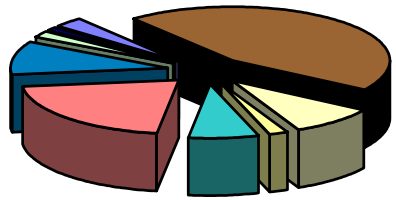
C-17 Phase I Shortfalls
Semi-prepared Airfields



1) Soil Types / Climatic Conditions (cont)
   - Need to test other soil types / climates
     - Distresses in cohesive soils must be evaluated (ruts caused by sinking vs loose till)
     - Need to test wet climates
     - Additional sites will provide data to determine other unanswered questions (Shear,RCR,etc)
     - Test sites located in other regions are limited due to size (C-130 LZs) and will require construction effort to expand size

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C-17 Phase I Shortfalls
World Soil Types

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OH							
Pt	0.1	<0.1	0.1	1.0	0.5	0.1	1.8
Rk		0.3					0.3
Los							
Salt							
Tundra				0.3	2.7		3.0
Total	19	31	12	18	15	5	100

Completing tests at Wilde-Benton on SM soil would increase coverage by 16.6% to 23.5%.

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C-17 Phase I Shortfalls
World Soil Types

Climatic Zone							
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Pt	0.1	<0.1	0.1	1.0	0.5	0.1	1.8
Rk		0.3					0.3
Los							
Salt							
Tundra				0.3	2.7		3.0
Total	19	31	12	18	15	5	100

Completing tests on SM soil in wet environment would increase coverage by 21.9% to 45.4%.

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C-17 Phase I Shortfalls
World Soil Types

	Climatic Zone						
USCS Soil Type	Tropical 19%	Dry 31%	Humid Mesothermal 12%	Humid Microthermal 18%	Polar 15%	Undifferentiated Highlands 5%	For All Climatic Zones
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OH							
Pt	0.1	<0.1	0.1	1.0	0.5	0.1	1.8
Rk		0.3					0.3
Los							
Salt							
Tundra				0.3	2.7		3.0
Total	19	31	12	18	15	5	100

Completing tests on CL soil in wet environment would increase coverage by 11.9% to 57.3%.

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C-17 Phase I Shortfalls
World Soil Types

	Climatic Zone						
USCS Soil Type	Tropical 19%	Dry 31%	Humid Mesothermal 12%	Humid Microthermal 18%	Polar 15%	Undifferentiated Highlands 5%	For All Climatic Zones
GW							
GP							
GM	<0.1	<0.1					<0.1
GC	0.4	<0.1				<0.1	0.4
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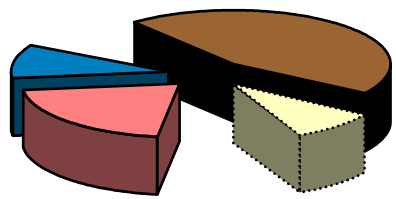
ML/CL	0.2	3.4	0.7	1.8		0.4	6.5
CL	2.7	3.9	3.2	5.3	5.4	0.7	21.2
OL							
MH							
CH	4.0	1.9	2.5	1.7		0.1	10.2
OH							
Pt	0.1	<0.1	0.1	1.0	0.5	0.1	1.8
Rk		0.3					0.3
Los							
Salt							
Tundra				0.3	2.7		3.0
Total	19	31	12	18	15	5	100

Completing tests on CH soil in wet environment would increase coverage by 8.3% to 65.6%.



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C-17 Phase I Shortfalls
Semi-prepared Airfields

1) Soil Types / Climatic Conditions (cont)

- Increases in mission capability per different soil types/climates
- Test sites to date provide 6.9% world coverage

Four additional sites greatly increase capability

- Complete Wilde-Benton (SM, arid) increase to 23.5%
- Test SM soil in humid climate, increase to 45.4%
- Test CL soil in humid climate, increase to 57.3%
- Test CH soil in humid climate, increase to 65.6%

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C-17 Phase I Shortfalls
Semi-prepared Airfields

2) RCRs
- Need data on other soil types and moisture conditions.
- Ability to measure mid-range RCRs would enable STTs or engineers to determine appropriate runway length requirements. Big impact on engineering effort required to construct LZ.
- Correlation of RCR values obtained by Bowmonk did not correlate well to aircraft values
- Need reliable method to measure surface friction that will correlate well with RCR values actually experienced by the aircraft.

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C-17 Phase I Shortfalls
Semi-prepared Airfields

3) Soil Shear Strength
   - Failure of pavement traditionally determined by slow moving or static aircraft (taxiing)
   - C-17 braking action (during landing) has proven to be more critical
     - Accelerated failure, increased dust and FOD, and loose till all impacted C-17 operations
   - Impact: Current methods of determining allowable passes or operations may be invalid
   - Need device/procedure to rapidly and accurately measure shear resistance
   - Need to update design/evaluation programs

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C-17 Phase I Shortfalls
Semi-prepared Airfields

4) Culverts
   - In many cases, the best engineering solution to drainage problems may be to install culverts underneath aircraft operational surfaces
   - Need to determine criteria for the size and location (depth below surface) of culverts
5) Evaluation of Stabilized LZs
   - LZ surfaces treated with stabilizing agents such as cement or lime provide a strong surface. Rapid yet simple procedures to evaluate their load bearing capability do not exist.
   - Need to develop an evaluation procedure for these.

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C-17 Phase I Shortfalls
Semi-prepared Airfields

6) FOD / Dust Potential

- FOD damage to engines is high, particularly when aircraft backs up and/or turns
- Dust signatures during ground operations are extensive
- Impact: Dust signature may be detrimental to contingency military operations, FOD potential may be unacceptable
- Need procedures and materials to mitigate dust signature

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C-17 Phase I Shortfalls
Semi-prepared Airfields

6) FOD / Dust Potential (cont)

- Need to determine FOD potential
  - Characteristic of soil material properties
  - Aircraft operations
    - Surface gradient criteria
    - Pilot procedures to mitigate, aircraft maneuvering procedures
- Need to know maximum allowable aggregate size, impacts strength of surface as well as FOD

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C-17 Phase I Shortfalls
Semi-prepared Airfields

7) Rolling Resistant Material (Till)

- Current methods to measure may be inadequate
- How and where we measure
  - Location on LZ in relation to aircraft operations determines impact.
  - Need a method to longitudinally measure and locate problem areas on runway.
- Aircraft take-off data reflect the problem
- Need to develop method to measure rolling friction and correlate to RFF

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C-17 Phase I Shortfalls
Semi-prepared Airfields

8) Rapid Stabilization

- Current methods to stabilize surfaces are time consuming to construct and maintain.
- Units tasked to construct and maintain semi-prepared airfields do not have equipment that will allow rapid and consistent stabilization of the surface.
- Need to evaluate techniques to rapidly stabilize airfields that will reduce construction time, maintenance time, and equipment requirements.

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C-17 Phase I Shortfalls
Semi-prepared Airfields

9) Tire Pressures

- Tire pressures used during load cart tests vary from those used during flight tests and may also vary from AMC planned operations
- Tire pressure has significant influence on structural capacity of airfield and speed of degradation
- Impact: Data from load cart tests may not be applicable to actual aircraft operations
- Need to research data reliability
- Need to evaluate impact of reduced tire pressures to see impact on maintenance or runway length requirements

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C-17 Phase I Shortfalls
Semi-prepared Airfields

10) Maintenance of Airfields

- Maintenance of damaged airfields is time consuming and equipment intensive. This greatly impacts aircraft operations.
- Repairs accomplished on airfields during Phase I tests were inadequate, due to inadequate equipment and lack of sufficient water.
- Need to investigate maintenance techniques and materials that could increase throughput of aircraft.
- Need to develop and test methods for rapid runway repairs of semi-prepared airfields.

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C-17 Phase I Shortfalls
Semi-prepared Airfields

11) Surface Roughness

- Semi-prepared airfields are generally much rougher than paved airfields and generate larger impact forces during landing and ground operations.
- Model used to predict aircraft performance during ground operations and categorize in terms of its roughness severity has not been validated by actual RQC tests.
- Need to perform RQC test to validate data from Phase I.
- Need to perform aircraft ground tests over various surface roughness conditions and determine impact on aircraft.

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C17 SPRO Phase II Site Selection & Progress

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C-17 SPRO Phase II Projects

1) Rogers Lake Bed:
   - Aircraft structural response, runway roughness
2) JA/ATT Participation:
   - Learn through experience at existing sites such as Ft Polk, Ft Bragg, and Ft Irwin
   - Extend to worldwide coverage by collecting data from sites with different soil/climate types
3) Lab Projects:
   - Soil Stabilization
   - Investigate better methods to measure and predict Allowable passes, RCR, and RFF
4) T-1 Flight Test Verification:
   - Test and analysis of data (wet/dry world-wide coverage)

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C-17 SPRO Phase II
Candidate Test Sites

Initial list of candidates based upon predominant regional soil types, and strength information obtained from:

- Assault Zone Survey Repository maintained by HQ AMC TACC

Priority given to ALZs that would benefit Army installations/training sites …

SPO solicited FORSCOM input

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C-17 SPRO Phase II
Candidate Test Sites

First Run Potential Phase II Test Sites
Army FORSCOM Input to C-17 SPO

~~Holland/Sicily~~	Ft Bragg, NC	stabilized
Luzon	Camp Mackall, NC	
Golden Eagle	Ft Campbell, KY	
Belvedere	Ft Drum, NY	
~~McKenna~~	Ft Benning, GA	wet lands
~~Pinon Canyon~~	Pinon Canyon, CO	gravel
~~Peason Ridge~~	Ft Polk, LA	stabilized
~~Blackstone~~	Ft Pickett, VA	concrete
Pacemaker	Ft Lewis, WA	
Cole/Rattlesnake	Ft Chaffee, AR	

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C-17 SPRO Phase II
Candidate Test Sites

Second Run Potential Phase II Test Sites

Luzon	Camp Mackall, NC	Site Visits Sep 98
Golden Eagle	Ft Campbell, KY	
Belvedere	Ft Drum, NY	
Cole/Rattlesnake	Ft Chaffee, AR	
Added Sites		
All American	Camp Robinson, AR	Site Visits Sep 98
Green Eagle	Ravenna Range, OH	
strip	Altus AFB, OK	(visit not req'd) Phase 1
Schoonover	Ft Hunter-Liggett, CA	
Pacemaker	Ft Lewis, WA	Site visits Nov 98
WonJu	Ft Pickett, VA	

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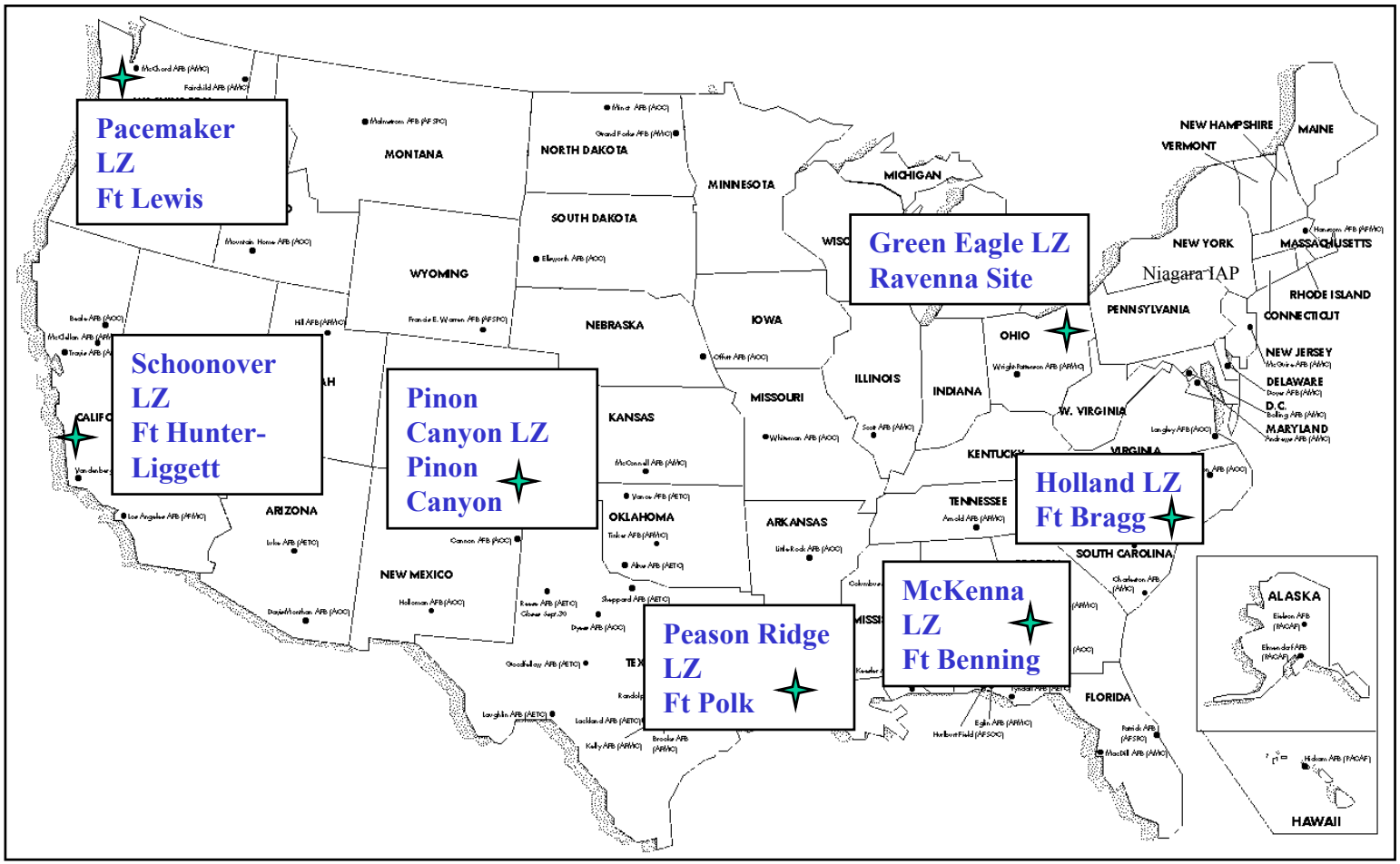
C-17 SPRO Phase II
Test Sites Dropped



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C-17 SPRO Phase II
Candidate Test Sites

Recommended Phase II Test Sites
Based on Soil Types/Strengths, Accessibility, Site Support , FORSCOM Use, Etc...

Luzon, Camp Mackall, NC	SM	CBR 30
Belvedere, Ft Drum, NY	CL	CBR 18
Golden Eagle, Ft Campbell, KY	CH	CBR 25
WonJu, Ft Pickett, VA	MH	CBR 9
All America, Little Rock AFB, AR	SM	CBR 40
Cole, Ft Chaffee, AR	CL (w/lime)	CBR 55
Strip, Altus AFB, OK	CL	CBR 5-12

Sites not selected based upon 7,000' requirement

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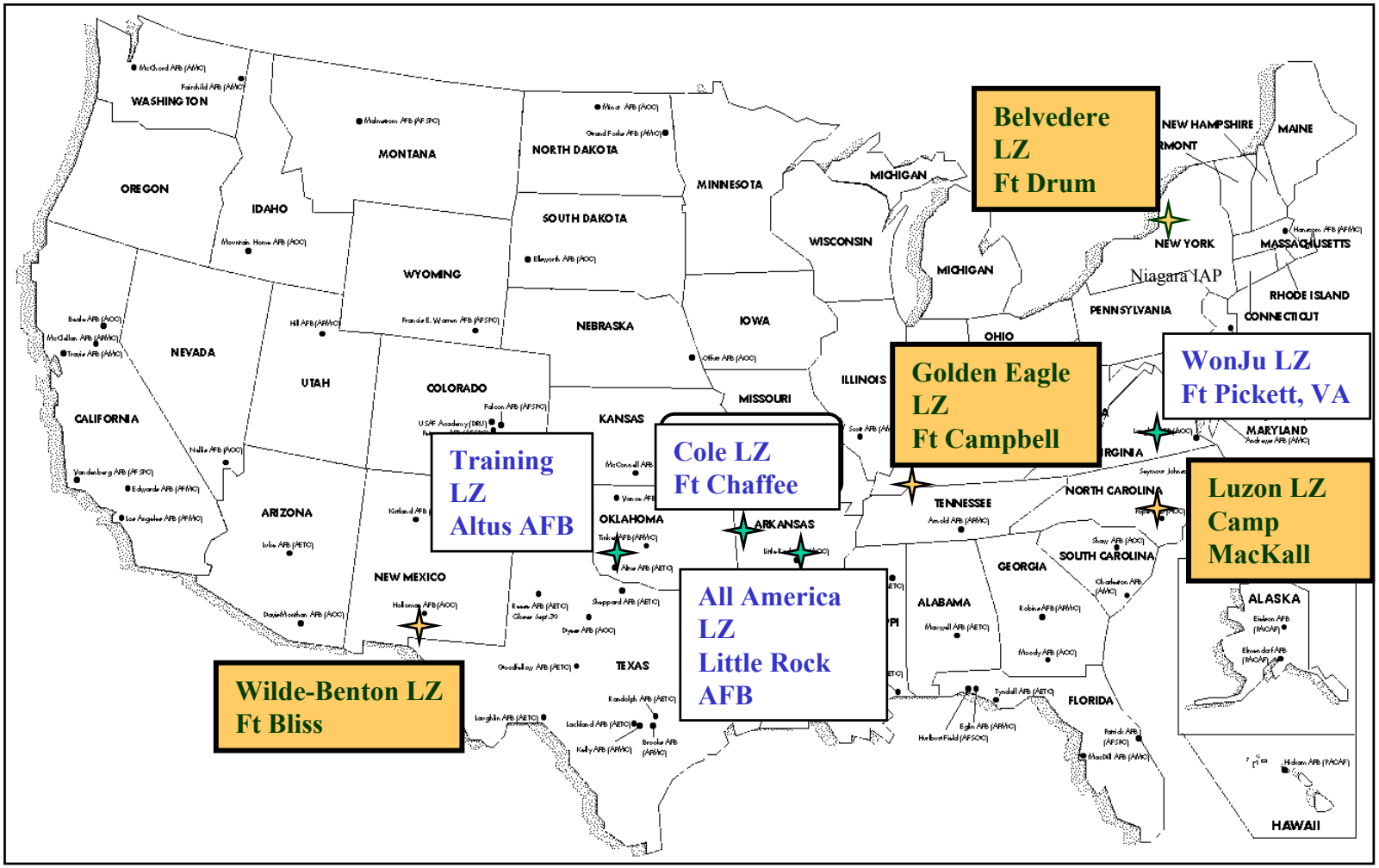
C-17 SPRO Phase II
Potential Test Sites



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C-17 SPRO Phase II Progress

- Monitor C-17 operations during Joint Airborne/Air Transportability Training (JA/ATT) Exercises
- Follow-on with more detailed testing as LZ upgrades are completed
  - Three sites (Luzon, Golden Eagle, and Belvedere) have issues (wet lands, terrain restraints, and construction costs) which limit the length of the LZ expansions. Army decided to expand Luzon and Golden Eagle to 4,600'and to perform wet tests at Wilde-Benton LZ.
- At a site visit reviewing the design of Golden Eagle upgrade, C-17 SPO revealed that 7,000' LZs would be required for wet testing

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C-17 SPRO Phase II Progress

- Design and construction of the expansion of Rhine-Luzon was completed. Have since conducted JA/ATT exercises there.
- Expansion of Golden Eagle and Belvedere have not been completed. Wet lands and terrain restraints, as well as funding limitations. Want to hold cost under $500k.
- AFCESA conducted infiltration tests at Wilde-Benton. Wells can probably provide enough water at Wilde-Benton LZ to construct the apron upgrade but not enough to perform wet testing.

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C-17 SPRO Phase II Progress

Must have 7,000’ runway to perform wet tests !

All landing zones this size are located in arid environments out West.

Its too costly to lengthen those in the East.

Overseas Airfields ?

Test 1,000’ to 2,000’ wet sections ?

Moisture controlled lake bed tests ?

Alternate methods to measure deceleration ?

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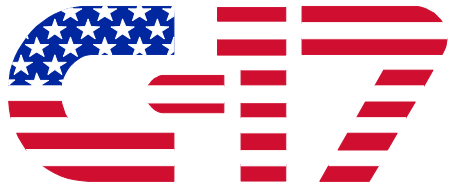

SPRO
JA/ATT Testing

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C-17 SPRO Phase II
JA/ATT Testing

OBJECTIVES:

- **Measure A/C weight, stopping distance, takeoff length**
- **Measure structural strength (DCPs)**
- **Measure Rutting**
- **Measure Loose Till**
- **Measure SPACI**
- **Monitor Maintenance Procedures**

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SPRO

JA/ATT Lessons Learned

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JA/ATT Lessons Learned

Monitored exercises at Bicycle Lake, Geronimo, Holland, and Rhine-Luzon LZs

1. Current ETL guidance works, but must be simplified:

   - Rewrite/shorten and simplify ETL (few read and understand)

   - Working on How-to Video to assist Special Tactics Teams (STTs) and engineering units in determining suitability of LZs for C-17 operations

2. Guidance on Bowmonk friction device needs to be updated:

- Minimum decelerometer values listed in ETL for determination of RCR were based upon 40 mph.
- Due to LZ ground vehicle accident, speed on LZs is now limited to 25 mph.
- Bowmonk readings at 25 mph do not produce acceptable decelerometer values.

JA/ATT Lessons Learned

3. JA/ATT operations have demonstrated the need to perform tests on other soil types/climate conditions:

- Estimates on C-17 capabilities were all based on a limited number of soil types and in an arid (maybe worst case) environment.
- Limited operations monitored during JA/ATTs indicate that previous estimates may be too conservative. Semi-prepared airfields with other soil types or in more humid environments may have more capability than indicated by Phase I sites.

JA/ATT Lessons Learned

4. JA/ATT operations have provided an opportunity to evaluate maintenance and repair activities.

   - Repairs performed on airfields during Phase I were inadequate, due to unavailability of adequate equipment and water at most sites.
   - JA/ATTs have provided opportunities to document repair activities; in terms of time, manpower, equipment, and before and after measured soil strengths.