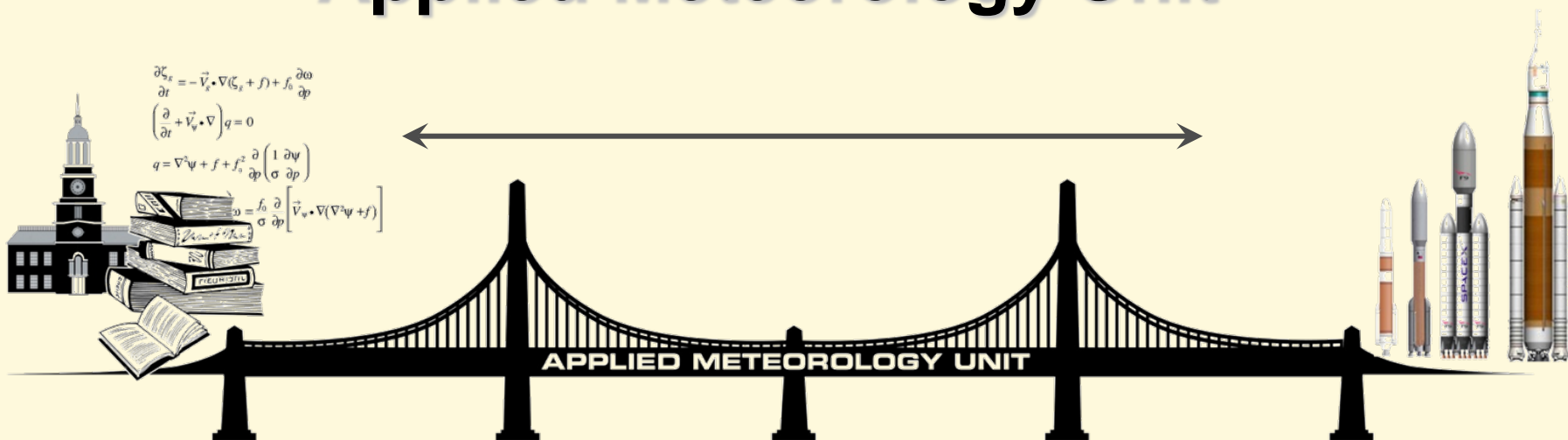


An Overview of the Applied Meteorology Unit



Supporting America's Space Program through Infusion of Weather Technology into Operations

Overview

- AMU History
- Working Relationships
- Functional Purpose
- Tasking Process
- Project Examples
 - Formal Prioritized Tasks
 - Mission Immediate Tasks
 - Optional Tasks
- Summary





Timeline of AMU History



Recommendation of AMU-type organization

Report of the Space Shuttle Weather Forecasting Advisory Panel to the NASA Associate Administrator for Space Flight

Concept approved by National Space Transportation System

AMU contract re-competed and awarded to ENSCO, Inc.

AMU contract re-competed and awarded to ENSCO, Inc.

1986

1988

1989

1991

1996
2001
2006

2011

2012

National Research Council supports 1986 Shuttle panel recommendation

Interagency MOU
NASA | USAF | NWS
Contract award to ENSCO, Inc.

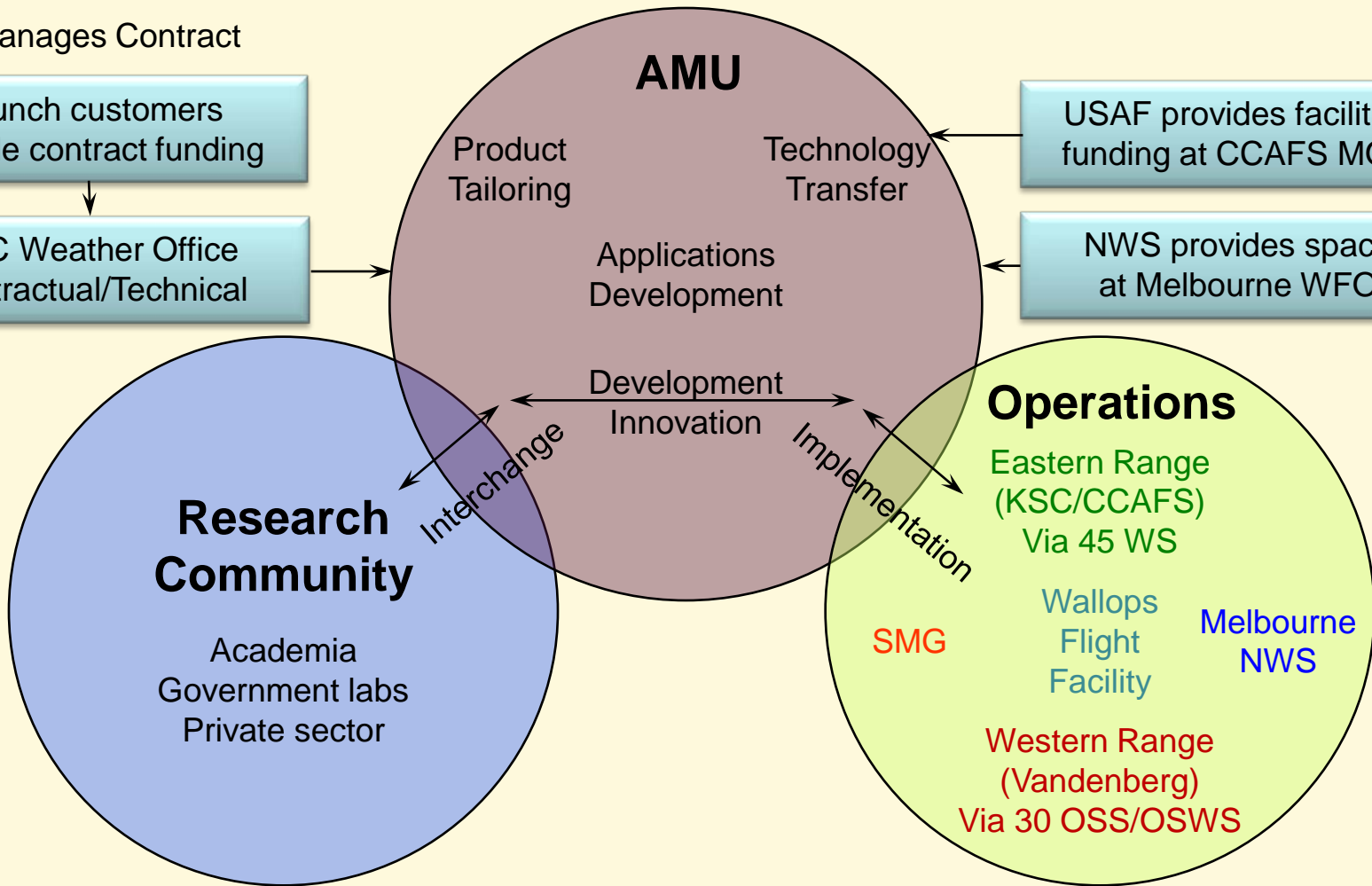
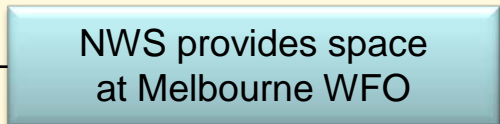
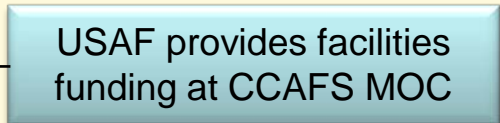
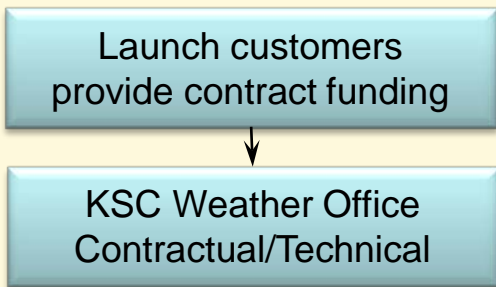
Six-month contract extension



Working Relationships



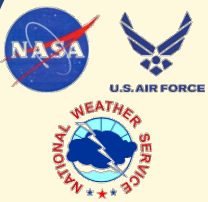
NASA Manages Contract



Functional Purpose

- Bridge gap between research and operations
 - Enhance system safety
 - Increase launch opportunities
 - Reduce down-time and schedule impacts due to weather
 - Minimize costs
- Methodology
 - Test, evaluate and develop new technology, techniques and processes
 - Transition improved capability to operational customers
 - Facilitate technical exchange between research and operations
 - Provide technical expertise to assist in effective operation, maintenance and modernization of existing resources

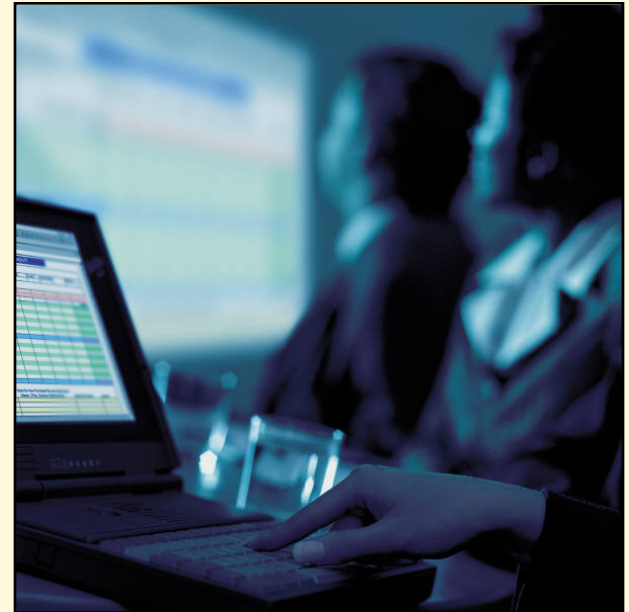




Tasking Process



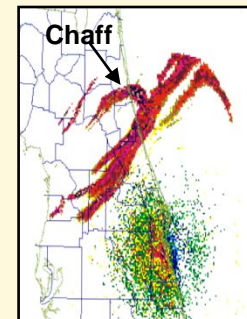
- Formal Prioritized Tasks
 - Quasi-Annual Cycle
 - Survey spaceflight operations weather community
 - Input from NASA, USAF and NWS
 - Technical interchange meetings
 - NASA, USAF and NWS meet to select tasks and set priorities by consensus
 - Selected tasks prioritized and approved by KSC Weather Office
 - Formal tasking issued by AMU Chief
 - Additional reviews as required



Tasking Process

- Mission Immediate Tasks
 - Time Critical
 - Customer initiated after a significant event
 - Verbal tasking issued by AMU Chief
 - Must meet these criteria:
 - Results needed as soon as possible
 - Unique AMU expertise and capabilities are required
 - Minimal interference with formal prioritized tasks

- Optional Tasks
 - Case-by-case basis
 - Formal tasking issued by AMU Chief
 - Must meet these criteria:
 - Externally funded
 - No interference with formal prioritized tasks
 - Approved by NASA

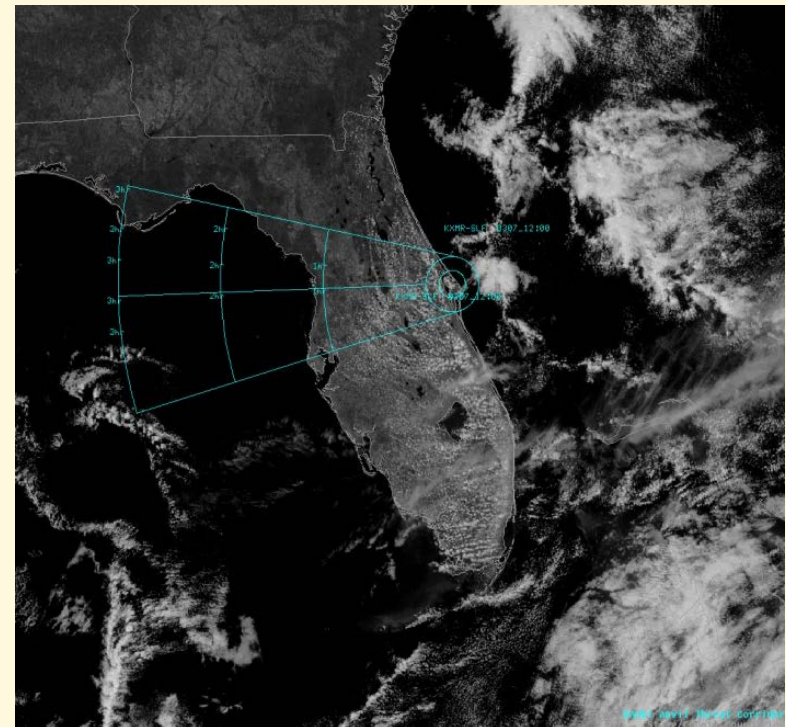


Delta II Explosion

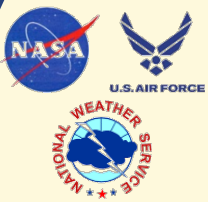
Formal Prioritized Project Examples

Anvil Forecasting

- Improve predictions of triggered lightning threat to space launch vehicles using Anvil Threat Sector tool
 - Derives average winds at anvil cloud altitude from sounding, 50 MHz DRWP, and model point data
 - Overlays graphic on satellite or radar displays showing 1-, 2-, and 3-hour ranges
 - Displays out to 12 hours with RAP, 60 hours with NAM and 96 hours with GFS models
 - Graphical user interface (GUI) available on 45 WS & SMG MIDDS and AWIPS



Launch Support

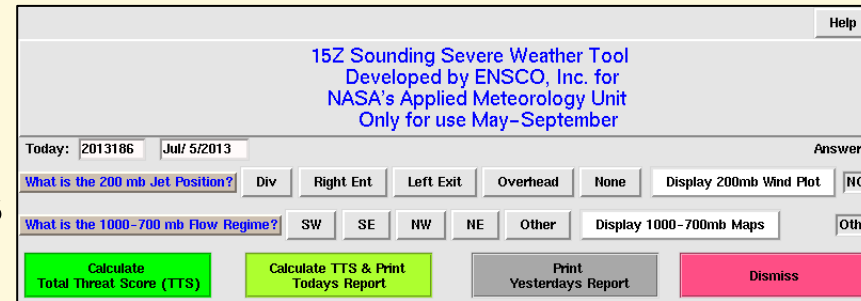


Formal Prioritized Project Examples

Severe Weather



- Protect people and property at KSC/CCAFS using the objective Severe Weather Forecast tool
 - Climatological warm season severe weather threat
 - Forecasters use for daily operations to protect resources
 - Uses sounding stability parameters associated with past severe weather events in East-Central Florida
 - GUI on 45 WS MIDDs automatically accesses sounding parameters
 - Provides frequency of occurrence of reported severe weather



Total Threat Score (TTS) Categories

<= 14	15-19	20-24	25-29	30-34	35-39	>= 40
0%	1%	6%	21%	57%	72%	92%

Reported Severe Occurrences

The TTS for the 14:24 Z sounding on 12 Jul is 29.

Based on the TTS of 29, severe weather was reported 21% of the time.

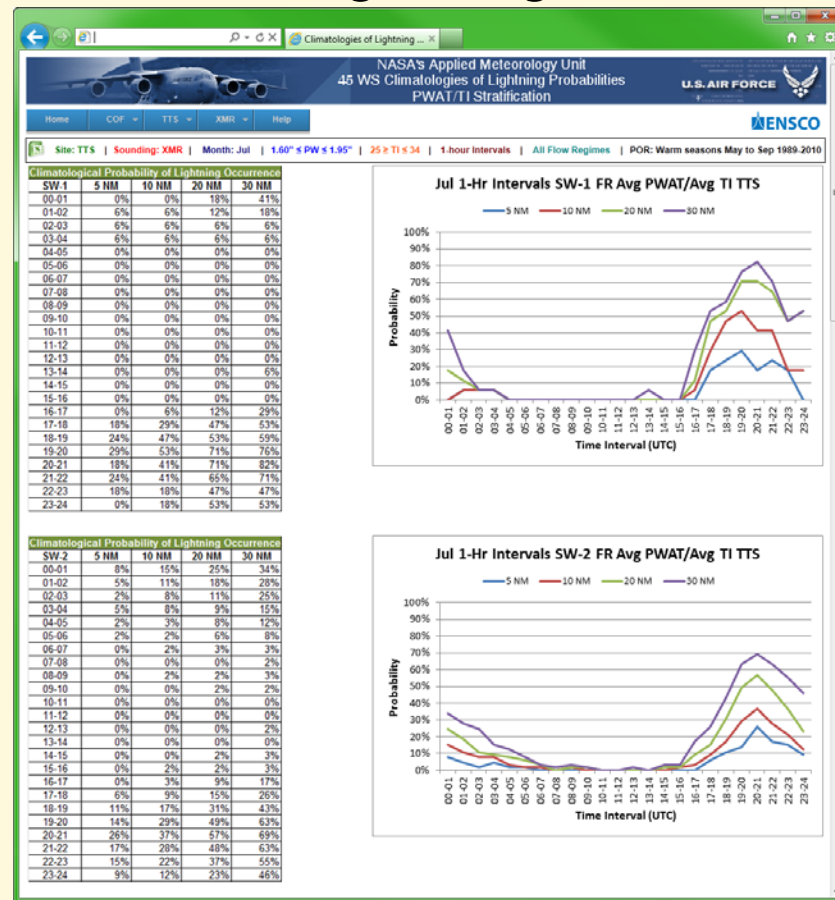
OK

Daily Operations & Launch Support

Formal Prioritized Project Examples

Lightning Climatologies

- Determine timing and probability of lightning for daily operations planning using warm season lightning tool
 - SLF, XMR, COF and airports in NWS MLB county warning area
 - Stratified by:
 - Month (May-Sep)
 - Synoptic-scale flow regimes over Florida peninsula, stability and moisture from soundings
 - 5-, 10-, 20-, and 30-NM radius rings from center of runways
 - 1-, 3-, and 6-hour increments
 - HTML-based GUI
 - Works in most web browsers
 - Displays tables and graphs with monthly probability and timing values

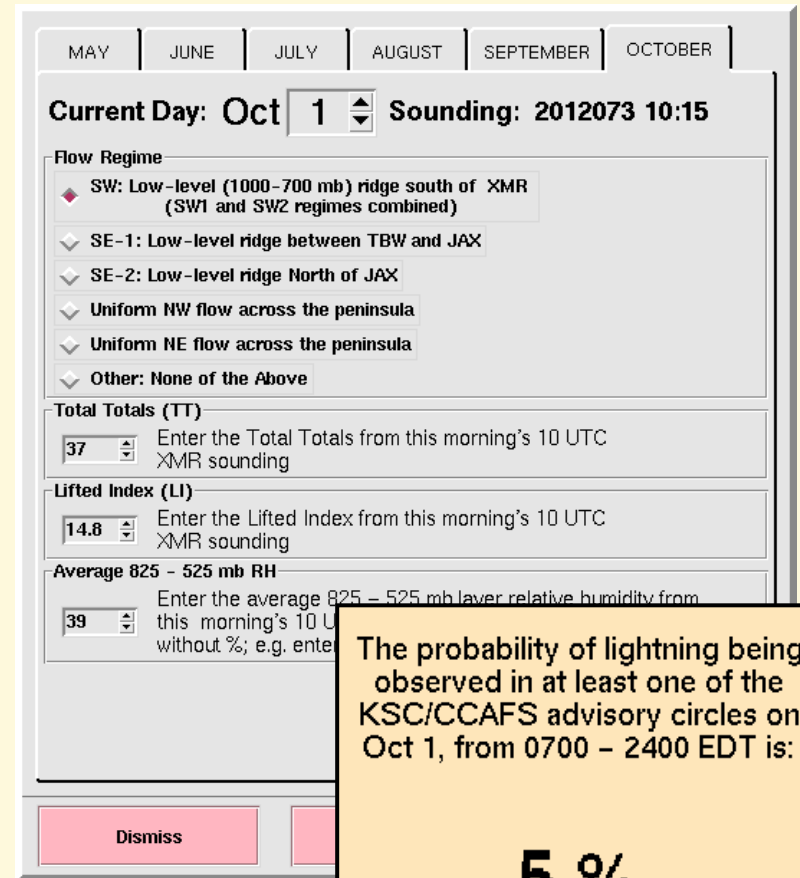


Daily Operations & Launch Support

Formal Prioritized Project Examples

Objective Lightning

- Determine probability of lightning at KSC/CCAFS for daily operations planning
 - Six equations, one for each warm season month
 - Use sounding stability values, persistence, flow regime, and daily climatology
 - GUI on 45 WS and SMG MIDDs
 - Forecasters enter persistence, flow regime
 - Stability, moisture automatically gathered by GUI from sounding
 - Provides probability of lightning for each day in the warm season



MAY | JUNE | JULY | AUGUST | SEPTEMBER | OCTOBER

Current Day: Oct 1 Sounding: 2012073 10:15

Flow Regime

- SW: Low-level (1000-700 mb) ridge south of XMR (SW1 and SW2 regimes combined)
- SE-1: Low-level ridge between TBW and JAX
- SE-2: Low-level ridge North of JAX
- Uniform NW flow across the peninsula
- Uniform NE flow across the peninsula
- Other: None of the Above

Total Totals (TT)

37 Enter the Total Totals from this morning's 10 UTC XMR sounding

Lifted Index (LI)

14.8 Enter the Lifted Index from this morning's 10 UTC XMR sounding

Average 825 - 525 mb RH

39 Enter the average 825 - 525 mb layer relative humidity from this morning's 10 UTC sounding without %, e.g. enter 39

Dismiss

The probability of lightning being observed in at least one of the KSC/CCAFS advisory circles on Oct 1, from 0700 - 2400 EDT is:

5 %

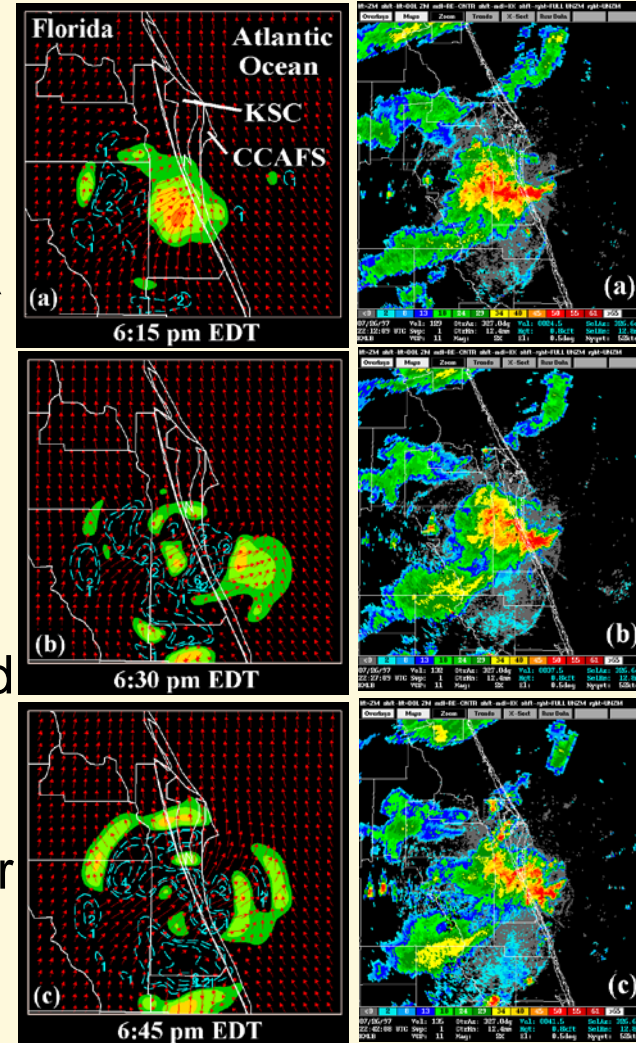
OK

Daily Operations & Launch Support

Formal Prioritized Project Examples

Data Integration into Models

- Improve daily & launch forecasts by configuring and implementing a real-time Local Data Integration System
 - Ingests and assimilates all available data onto a high-resolution analysis grid
 - Visible & infrared satellite imagery
 - All Florida WSR-88D radars
 - Rapid Update Cycle model grids
 - Textual data from MIDDS
 - Depicts mesoscale aspects of clouds and winds over KSC & CCAFS
 - Forecasters have access to timely high-resolution products that enhance weather nowcasts and short-range (< 6 hr) forecasts for operational requirements

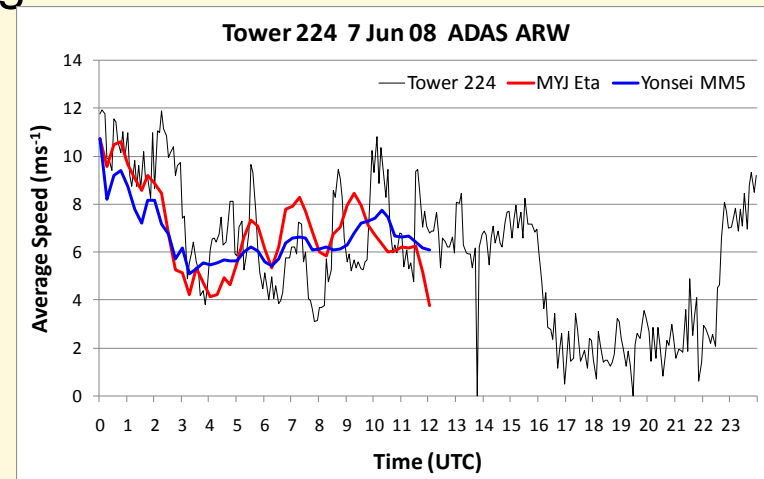
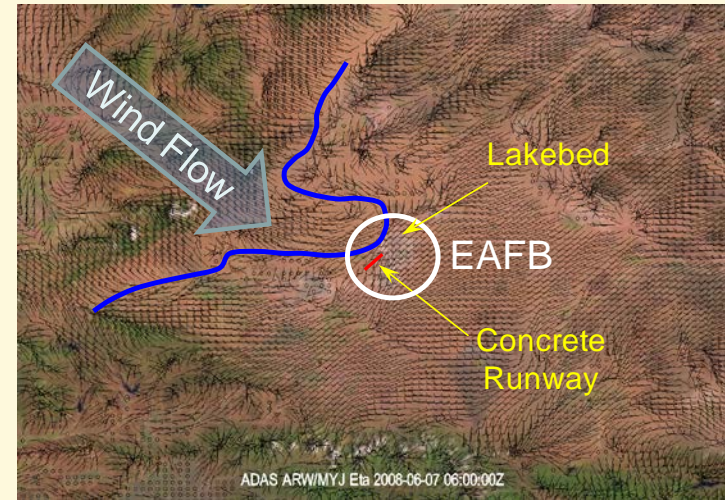


Daily Operations & Launch Support

Formal Prioritized Project Examples

Local Prediction with Computer Models

- Increase safety of space shuttle landings at Edwards AFB by predicting runway “wind cycling”
 - Surface winds could rapidly change posing a hazard to space shuttle landings
 - Determined the skill of different Weather Research and Forecasting (WRF) model configurations
 - Tested WRF with:
 - Two dynamical cores
 - Two “hot start” options
 - Six physics options
 - SMG implemented best configuration determined by AMU



Launch & Landing Support

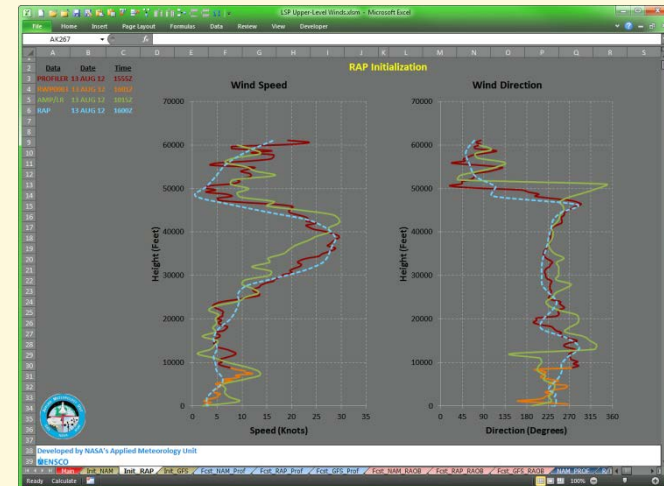
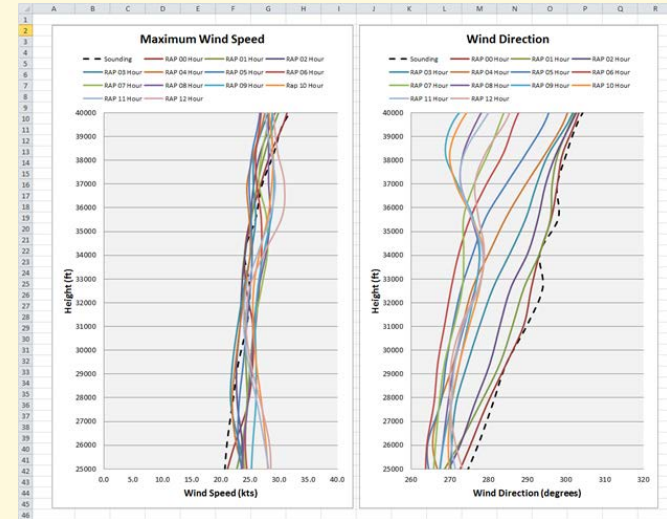


Formal Prioritized Project Examples

Upper Winds for Launch



- Support launch customers at Eastern and Western Ranges
 - Decision aids provide launch directors with assessment of observed and forecast upper-level winds
 - Requested by LSP at ER
 - Requested by 30 OSS at WR
 - Integrates multiple data sources
 - Local rawinsonde (XMR & VBG)
 - Doppler Radar Wind Profiler (KSC)
 - Numerical forecast models
 - Uses AMU-developed Excel GUI's
 - Automatically retrieves data
 - Automatically plots Excel charts



Launch Support

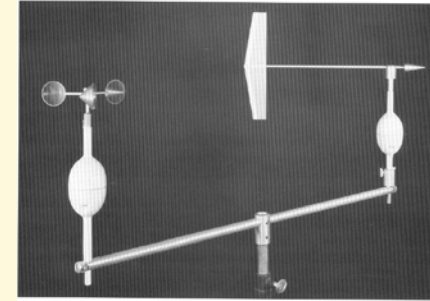
Formal Prioritized Project Examples

Wind Sensor Comparison

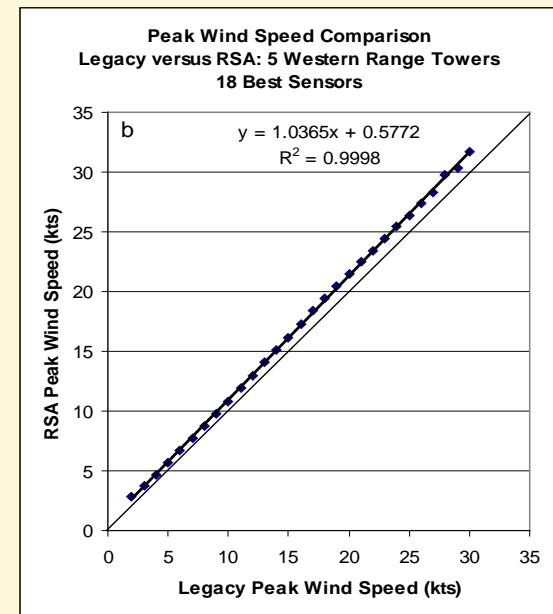
- Assess impact to ground launch wind constraints by comparing mechanical & ultrasonic wind sensors at the Eastern and Western Ranges
 - Address concern over technology change → mechanical to ultrasonic
 - Used one-minute data from 5 towers on each range
 - Determined bias and variance of average and peak speeds for ultrasonic with respect to mechanical
 - Determined a small, systematic, positive bias in ultrasonic peak speed



Ultrasonic

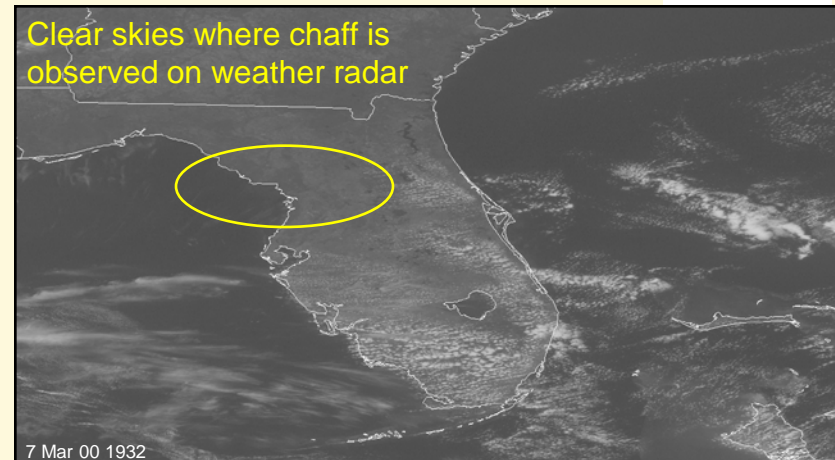
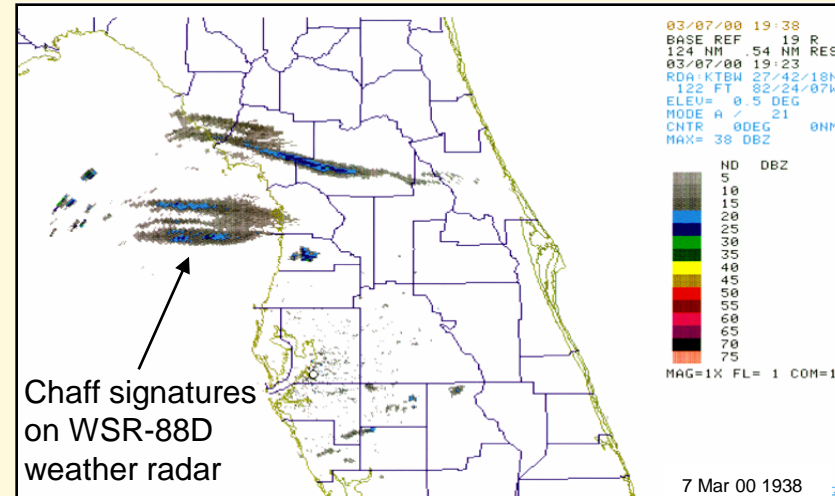


Legacy Mechanical



Launch Support

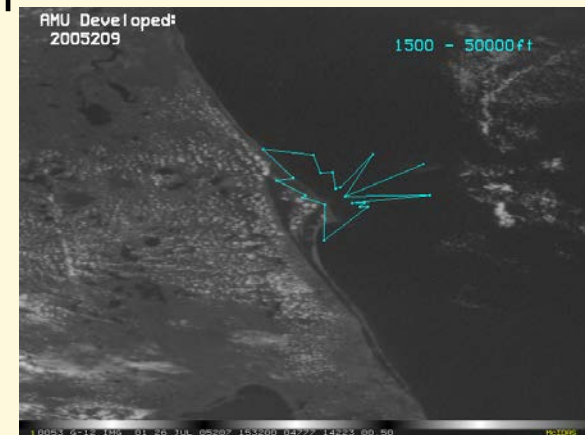
- Determine cause of weather radar signatures during STS-56 launch
 - Analyzed weather radar cross-sections for the WSR-88D and WSR-74C radars
 - Identified chaff dropped from military aircraft in Gulf of Mexico as cause
 - Developed methodology for chaff diagnosis and transferred to 45 WS operations
 - Avoided major expensive study



Optional Project Example

Weather Evaluation for Shuttle Imaging

- Columbia Accident Investigation Board stated that imaging system must provide at least 3 useful views of shuttle from launch to SRB separation
 - Determined technologies that can provide high resolution cloud fields to LWOs
 - Developed statistical model that calculates probability of obtaining 3 views, based on upgraded camera network embedded within simulated cloud fields
 - Developed a satellite-image overlay in MIDDS that helped LWO provide day-of-launch guidance to the Shuttle Launch Director about effects of clouds on views



Launch Support



Summary



- NASA and NRC report conclusions led to establishment of the AMU in 1991
 - Governed by inter-agency MOU
 - Staffed by ENSCO, Inc.
- AMU develops, evaluates, tailors and transitions weather technology for operational support to America's Space Program
- AMU provides products to customers that help them:
 - Enhance system safety and minimize costs
 - Increase launch and landing opportunities
 - Reduce down-time and schedule impacts due to weather
- AMU tasks assigned by customers through NASA:
 - Formal Prioritized, Mission Immediate, and Optional Tasks