

Launch Weather Decision Support System: A Comprehensive Meteorological Package for Range and Spaceport Operations

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Launch Weather Decision Support System (LWDSS)

Purpose

- Provide instrumentation and forecasting services to commercial spaceports that do not have meteorological resources
- Provide instrumentation to ranges in support of their meteorological staff
- Provide forecast support from T-5 days through T-0 and recovery
- Monitor and alert on Lightning Launch Commit Criteria (LLCCs) in real-time
- Monitor local launch requirements including toxic and blast modeling
- Reduce weather related scrubs

Includes

- Local Weather Radar
- Electric Field Mills
- National Lightning Network data
- Radiometer
- Radar Wind Profiler
- Sodars
- High-res WRF model
- Remote and on-site forecast support

Profiling System – Updates Every 5 mins

Radiometer



Sodar

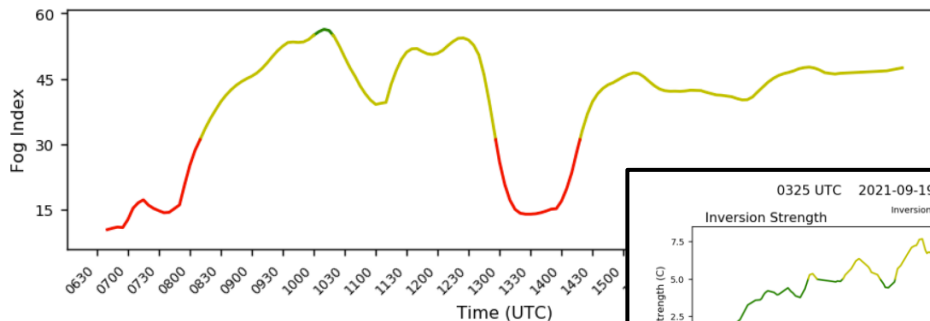


Radar Wind Profiler

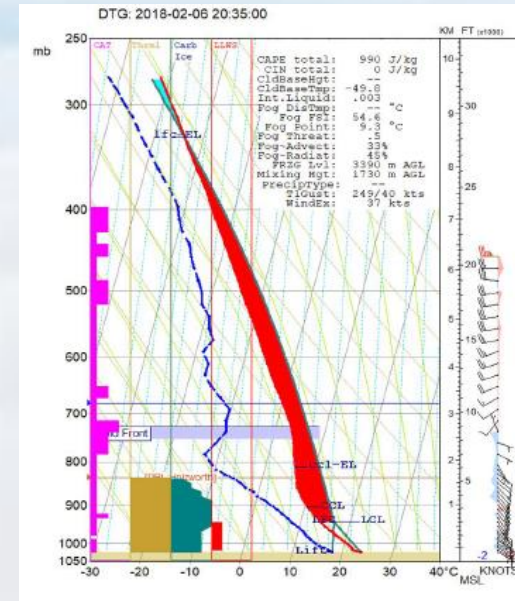
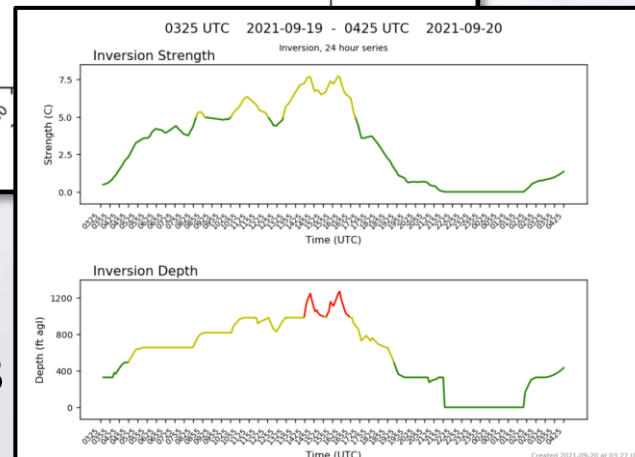


Fog

0630 UTC - 1930 UTC 2021-10-09
Fog Index, 12 hour series



Inversions



Soundings

Launch Weather Decision Support System



Weather
Radar



Radio-
meter



Radar
Wind
Profiler



Surface
Data



Sodar



Lightning
Sensors



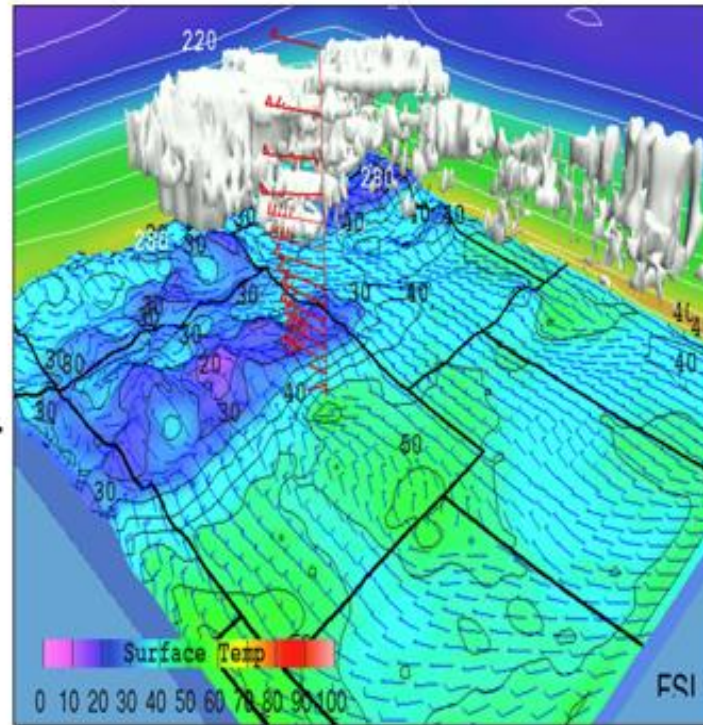
NOAA



NCEP

Optimize Safety & Efficiency

Local Scale Weather Forecast



Decision Support Products
Local Launch Requirements



Launch &
Landing



Spaceport
Operations



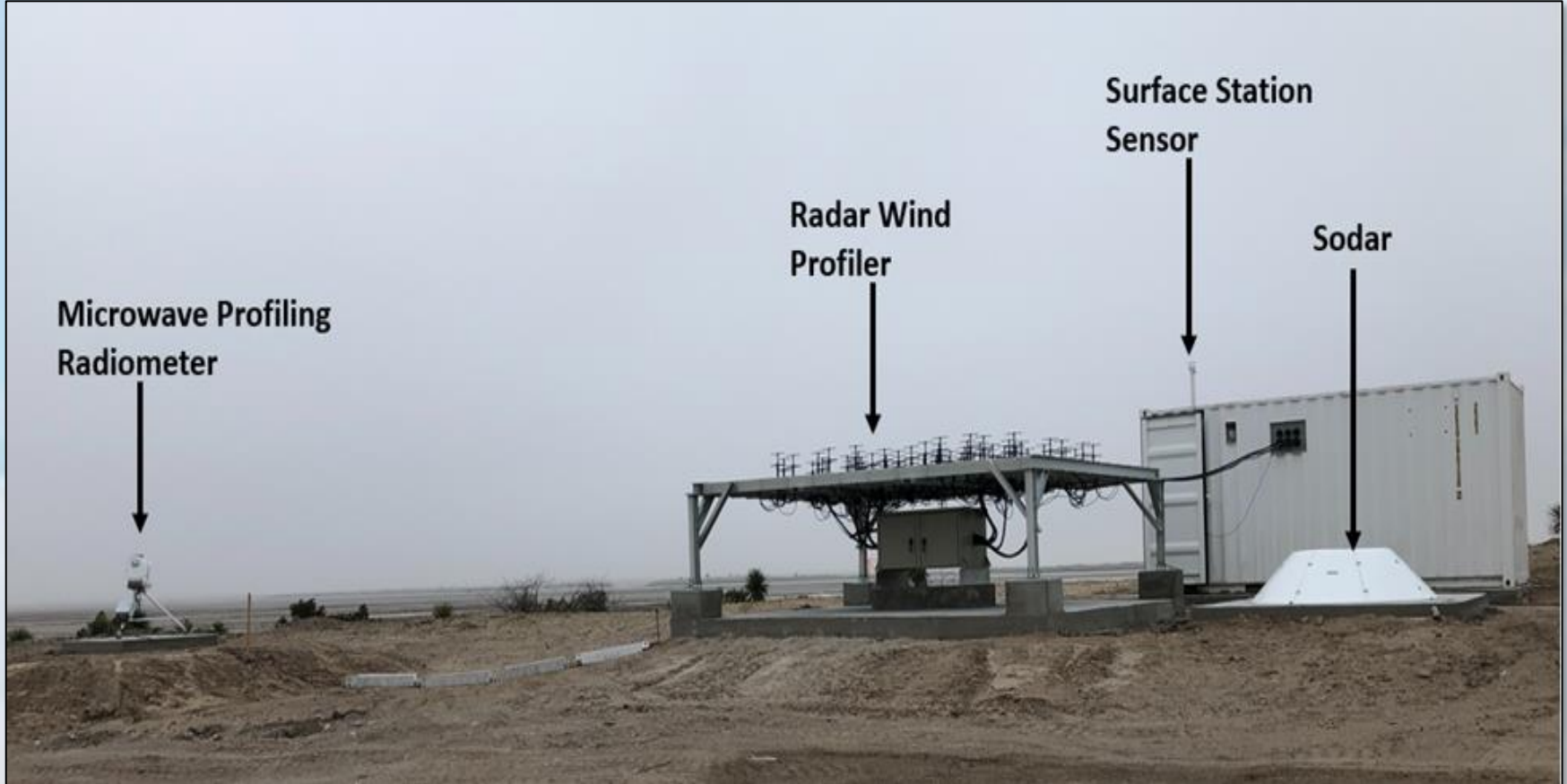
Launch
Commit
Criteria



Launch
Safety &
Efficiency

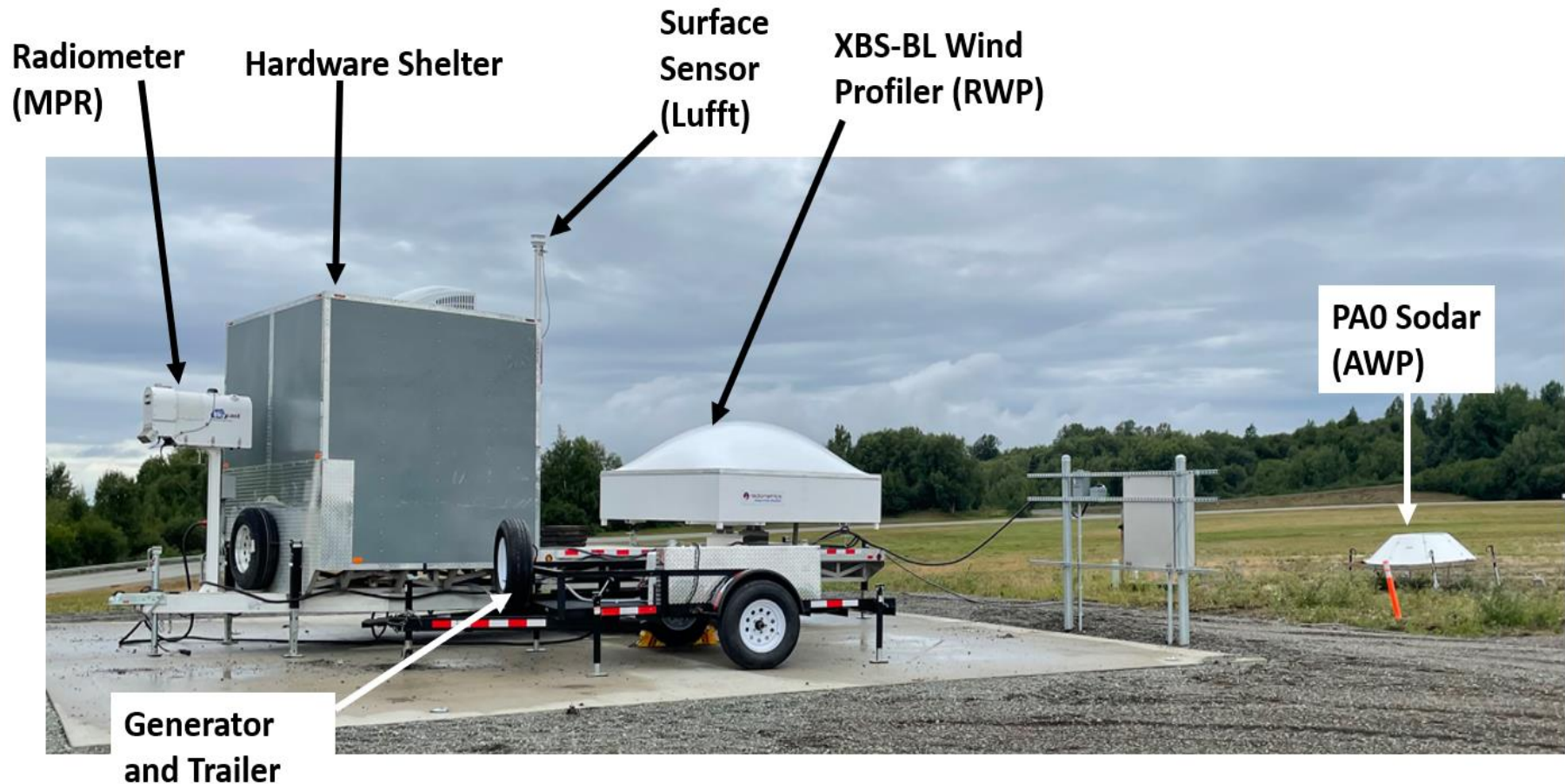


Fixed Installation at SpaceX Boca Chica



- Data integrated and sent to SpaceX main processing console
- Blast/toxic fallouts, sound propagation
- Max-Q
- Nowcasting

Mobile Installation at Elmendorf AFB



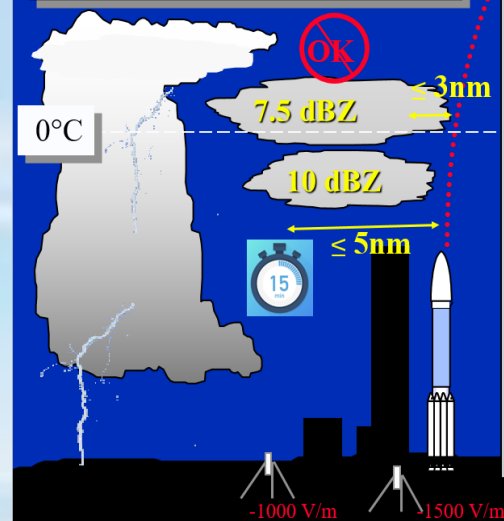
Similar Applications and Users

- San Jose State University (fire plume dynamics)
- University of Colorado – Boulder (fire weather)
- University of San Diego – Scripps Institute, Western Wx and Water (atmospheric rivers, wind dynamics)
- University Alabama – Huntsville (supercells and tornadic storms)
- United States Air Force, Alaska (aviation weather)

LLCCs

- 38 rules developed by NASA and adopted by the FAA to avoid lightning related accidents
- Some LLCCs are observations, other instrument measurements
- Examples: the LLCCs specify criteria for avoiding flight near or through dangerous clouds using:
 - Time from latest discharge
 - Distance from the cloud
 - Cloud thickness and temperature
 - Cloud Maximum Radar Reflectivity (MRR)
 - Ground-Based Field Mill Measurements

DON'T launch if the flight path will carry the vehicle within 3 nm of a debris cloud within the "3 hour period"

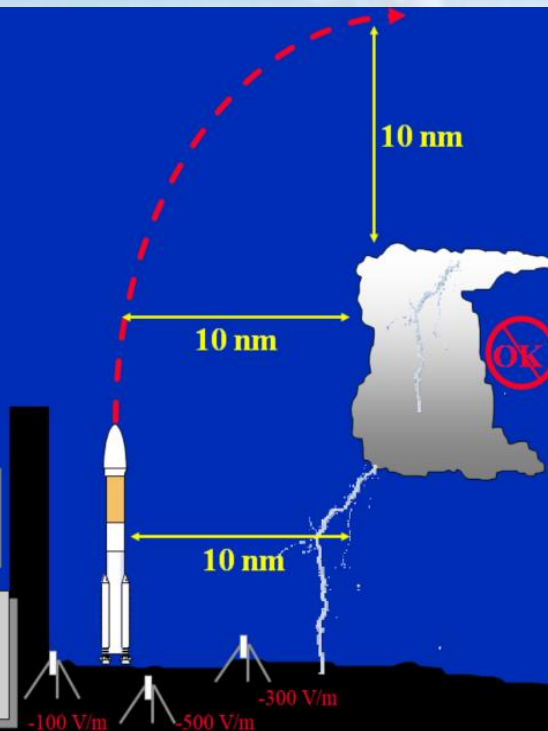


Unless:

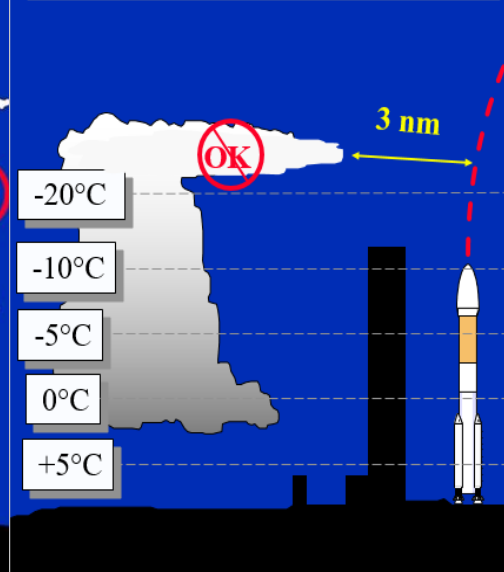
1. There is at least one working field mill at a horizontal distance of less than or equal to 5 nm from the debris cloud; AND
 2. The absolute values of all electric field measurements at a horizontal distance of less than or equal to 5 nm from the flight path, and each field mill has been less than 1000 V m⁻¹ for at least 15 minutes; AND
 3. The MRR from any part of the debris cloud less than or equal to a slant distance of 5 nm from the flight path has been less than +10 dBZ for at least 15 minutes;
- OR
1. The portion of the debris cloud at a slant distance of less than or equal to 5 nm from the flight path is located entirely at altitudes where the temperature is colder than 0 °C; AND,
 2. The MRR is less than +7.5 dBZ at every point at a slant distance of less than or equal to 1 nm from the flight path.

DON'T launch for 30 min after any type of lightning occurs w/i 10 nm of the flight path **UNLESS...**

- (1) The cloud that produced the lightning is not w/i 10 nm of the flight path; **AND**
- (2) There is at least 1 working field mill w/i 5 nm of each such lightning flash; **AND**
- (3) All field mills w/i 5 nm of the flight path and at the mill specified in (2) have been between +1000 V/m and -1000 V/m for 15 min



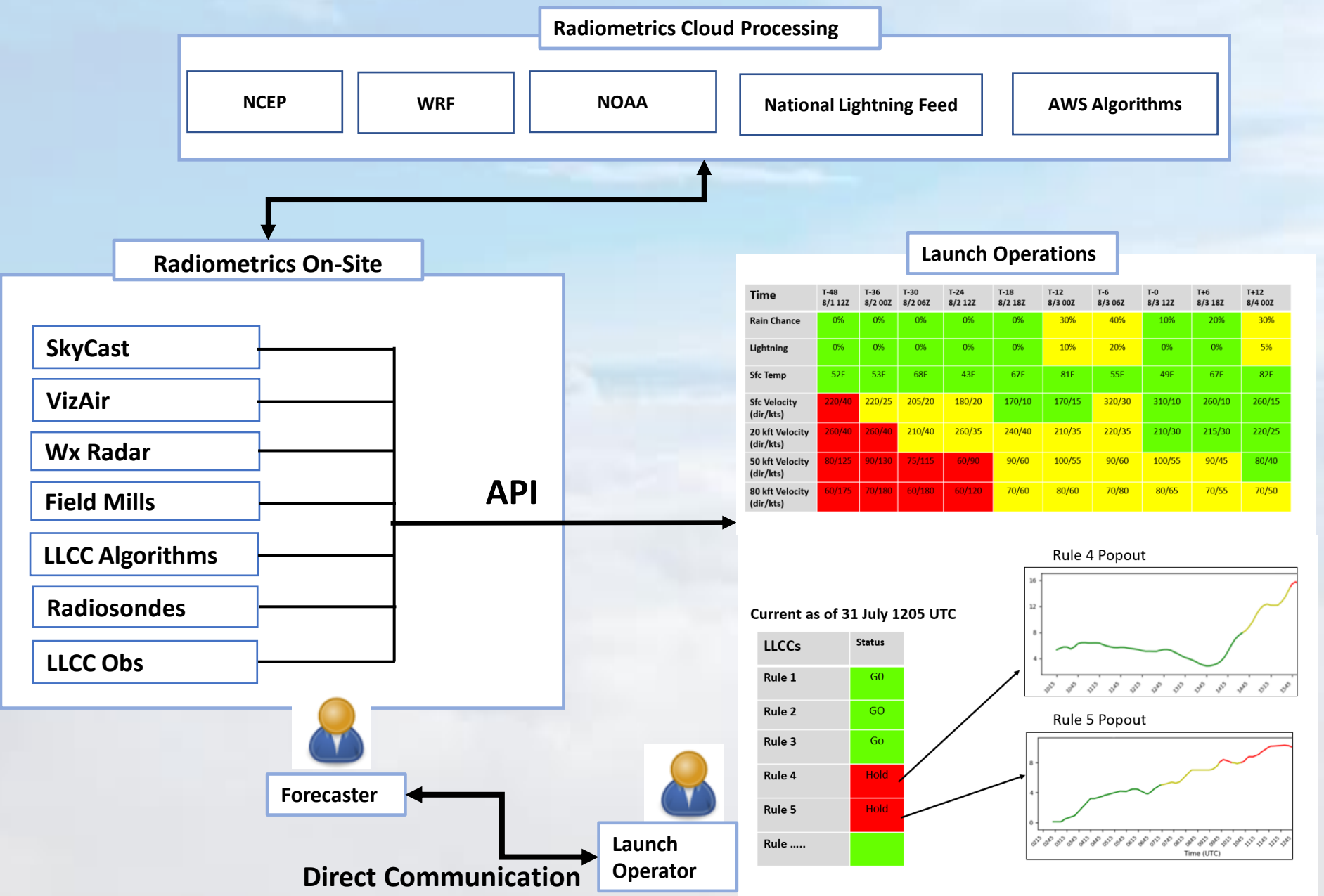
DON'T Launch if a flight path will carry a launch vehicle less than or equal to 3 nm from any attached anvil cloud



UNLESS

- (1) The portion of the attached anvil cloud at a slant distance of less than or equal to 5 nm from the flight path is located entirely at altitudes where the temperature is colder than 0 °C;
- AND,
- (2) The MRR is less than +7.5 dBZ at every point at a slant distance of less than or equal to 1 nm from the flight path

LWDSS Architecture



Summary

- Weather has significant impacts on launch delays and scrubs
- Weather-related launch constraints fall into 3 categories:
 - User Constraints
 - Public Safety Restrictions
 - Lightning Launch Commit Criteria
- LWDSS can be tailored as a fixed or mobile system to provide LLCC evaluation and launch weather decision assistance products
- Can provide instrumentation to ranges for launch support that have existing meteorological staff
- Can provide instrumentation and full meteorological services for spaceports



Thank You!

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