Surdex 2009 NAIP Summary Briefing
10 December, 2009

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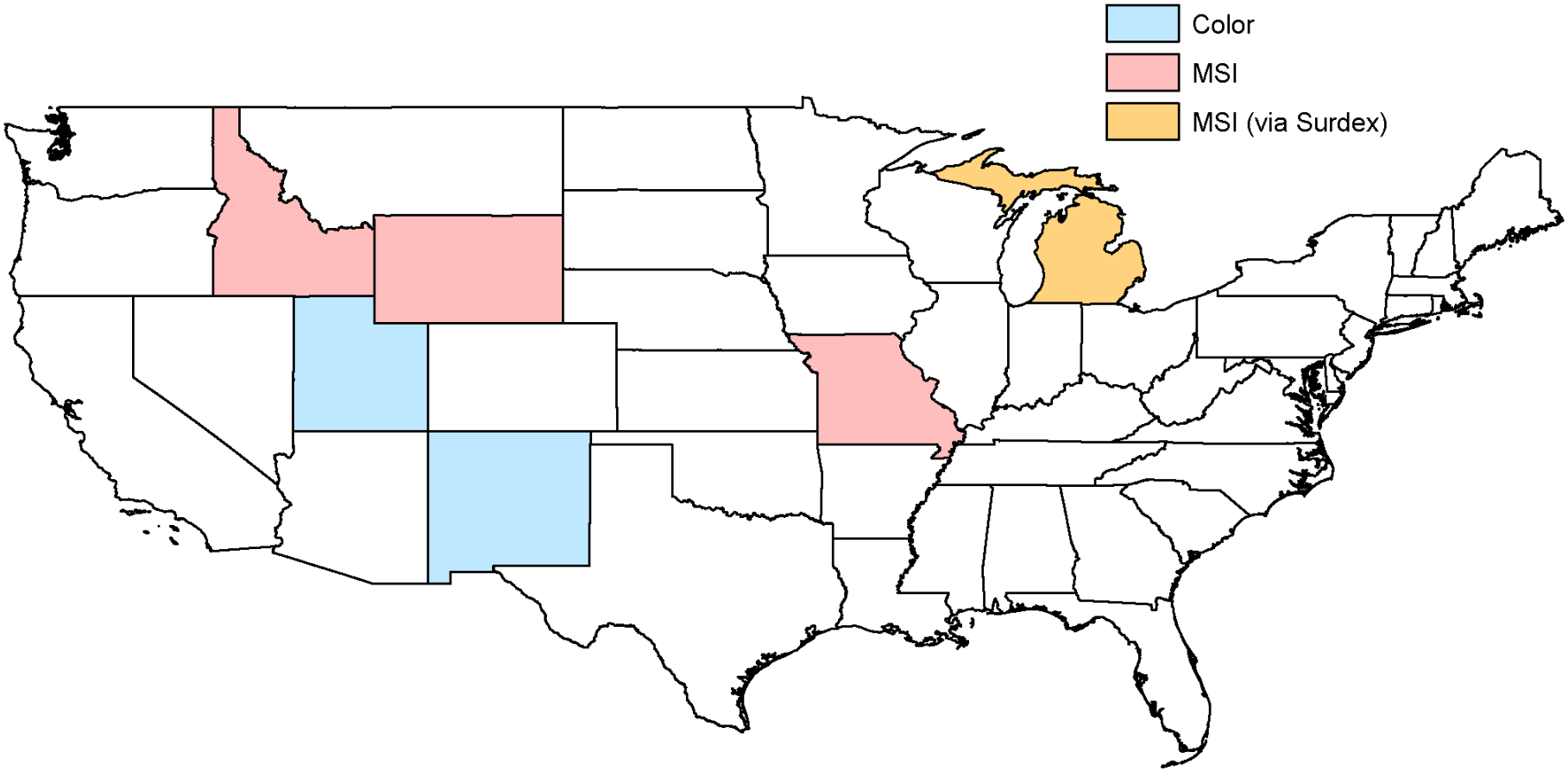
Presentation Outline

- Surdex's NAIP09 project
- Improvements in 2009
- Acquisition phase
- Production phase
- Accuracy results
- Lag analysis
- Lessons learned
- Recommendations
- Wrap-up

State Project Areas – All DMC Acquisition



State Project Areas

State	Type	DOQQs	Counties	Sq Mi	Season
Idaho	MSI	6,553	44	87,502	10 Jun – 15 Aug
Michigan	MSI(1)	4,844	83	64,595	17 Jun – 12 Aug
Missouri	MSI(2)	5,018	115	73,386	15 Jun – 31 Jul
New Mexico	Color	8,028	33	123,439	15 May – 15 Aug (5)
Utah	Color(3)	5,992	29	86,484	15 Jun – 15 Aug (6)
Wyoming	MSI(4)	7,356	23	100,568	1 Jul – 15 Aug
TOTALS		**37,791**	**327**	**535,974**	

[1] Michigan State DNR procured 4-band DOQQs directly from Surdex
[2] Missouri NRCS procured CIR CCMs directly from Surdex
[3] Utah NRCS procured CIR CCMs directly from Surdex
[4] Wyoming NRCS/BLM procured CIR CCMs and stereopairs directly from Surdex
[5] Early start granted (~1 week)
[6] Partial early start granted (~1 week) – though weather mitigated advantage

Improvements in 2009

- Increased project monitoring and metrics
  - Continual focus on supporting effective management
- Improved image processing
  - “90%” of colorimetry established before production
  - Proprietary pan-sharpening
- Improved automated seamline and seamline edit
- Global balancing – largely replacing 3rd party tools
- Nearly all production processes operate within same GUI
  - Image processing, ortho, seamline, QC
  - Only AT (Z/I ISAT) in separate interface

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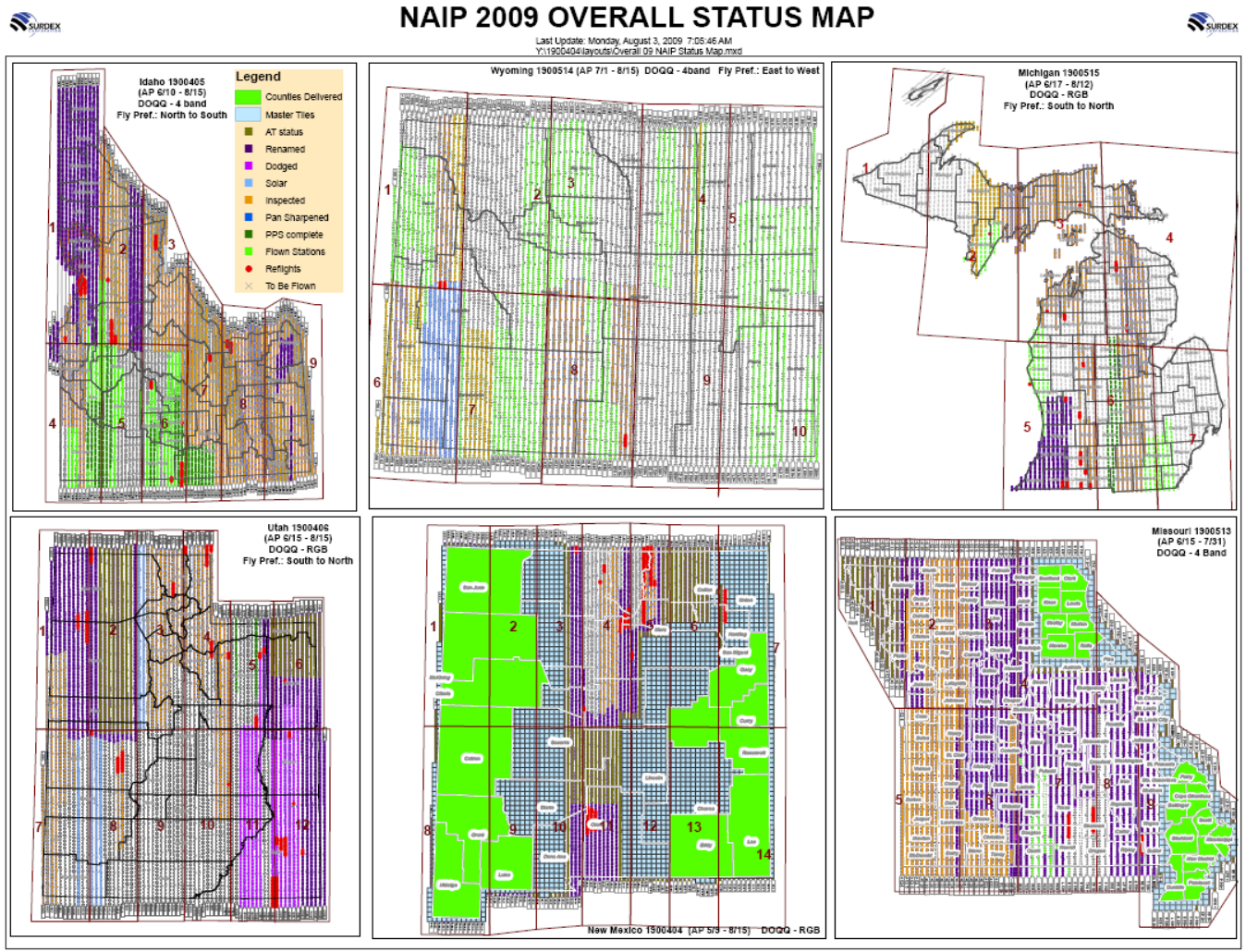
Internal Daily Report Graphic

1. Generated Daily
2. Acquisition
3. Production phases
4. CCM delivery



Surdex's Image Processing Approach

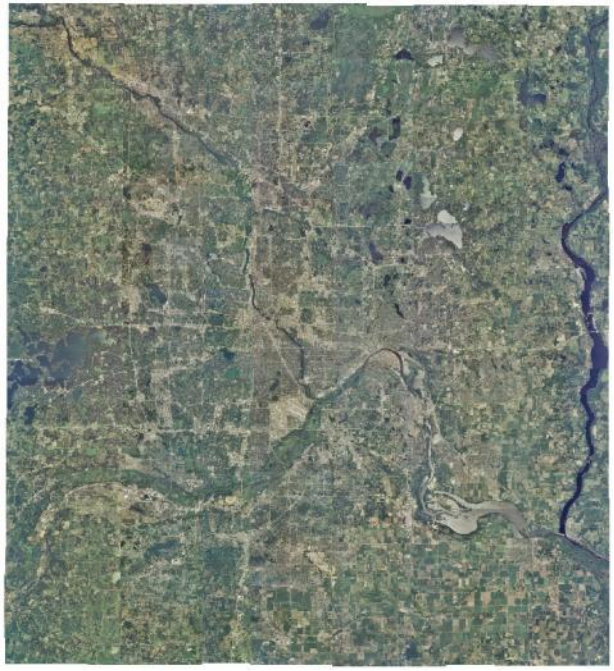
- Technicians sort raw images into groups
  - Common scene characteristics/parameters
  - Geopositioned using ABGPS/IMU – geocoded "collage"
  - 1,000's of images can be loaded at once
- Processing prototyped in WYSIWYG environment
- Batch-processing in distributed environment
  - 12bpp processing – option to output to 8bpp
  - 4-band processing to output color and CIR
- All ortho and mosaic functions in same GUI

Image Processing Flow Example
(MN NAIP08, Twin Cities Area)

1. Grouping of images
2. Gamma correction
3. Correct to color metrics

Solar correction to offset sun illumination

Dodging to remove local variations



Pre-Production vs Final Product – “WYSIWYG”

Mosaic of delivered DOQQs

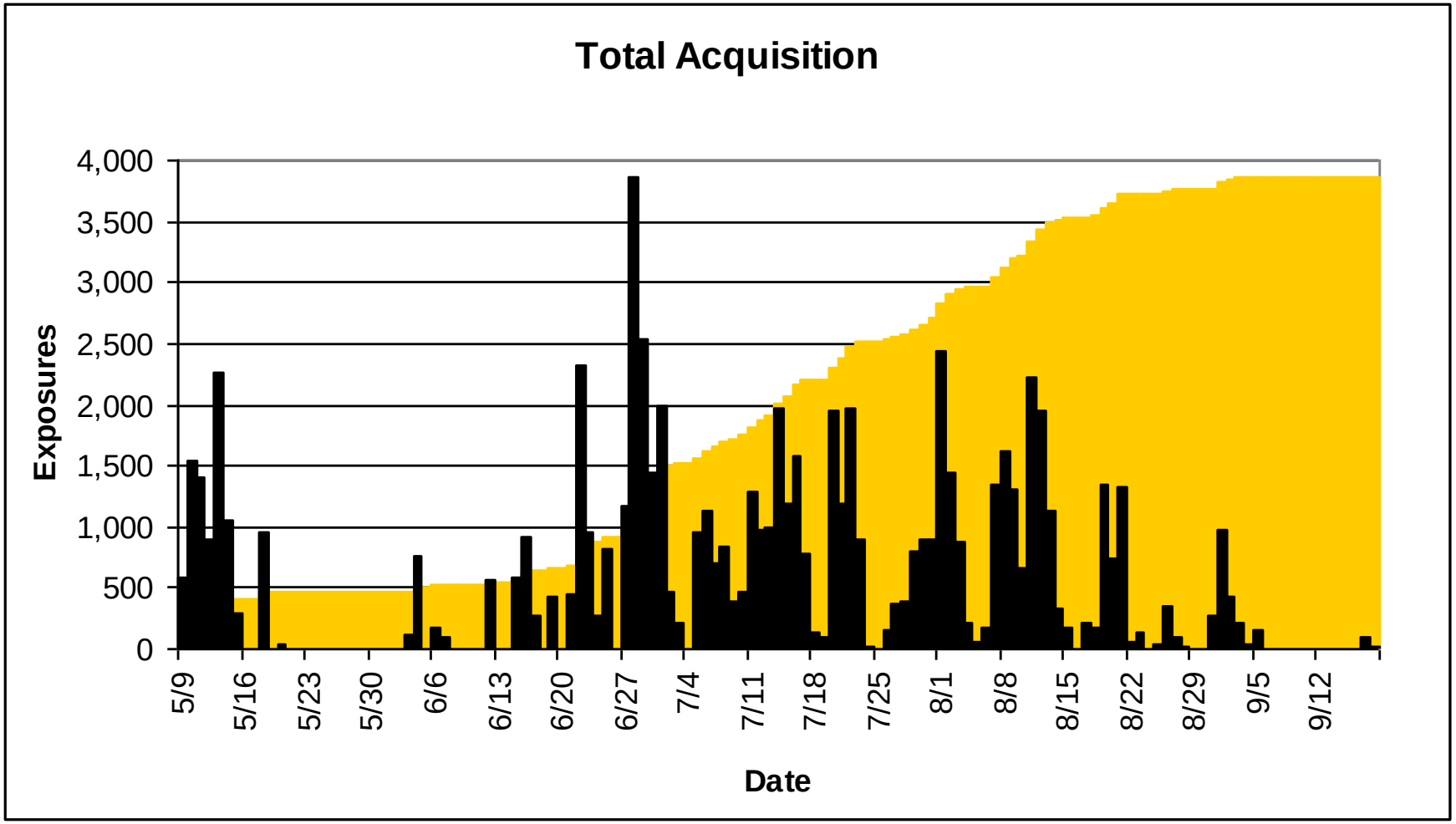
Acquisition Phase

- Resources
  - Surdex: 3 Cessna Conquests with RVSM
  - MJ Harden: Cessna Conquest (w/o RVSM)
- Design
  - NM, UT, WY, UT, Eastern MO flown at ~34,000 feet
  - Western MO and all of MI flown at ~28,000 feet (non-RVSM)
  - 60% forward, 30% side
  - ~75,000 exposures, ~128,500 FLM, ~1,000 hours
- Approach
  - Surdex – concentrate on Western States and help in MO, MI
  - MJH – Western MO, most of MI (non-RVSM)

Acquisition Experience

- 90 days flown in total window of 133 (67% of days)
- Surdex Conquests (3):
  - Each flew ~40% of all possible days
  - ~960 total hours (on-line + ferry) – ~15% ferry
  - “Net” of ~3.1 Conquests required
  - *Total of 10 phase inspections during project (May-Aug)*
- Stats
  - ~650 sq mi of coverage per hour of flight
  - Average of ~850 exposures/day (~6,000 sq mi)
  - Maximum of ~3,800 in a single day (~27,000 sq mi)
- Extensions (all weather-related)
  - UT,MO,WY,ID: 2 weeks (single extension)
  - MI: 6 weeks (2 extensions)

Overall Acquisition History



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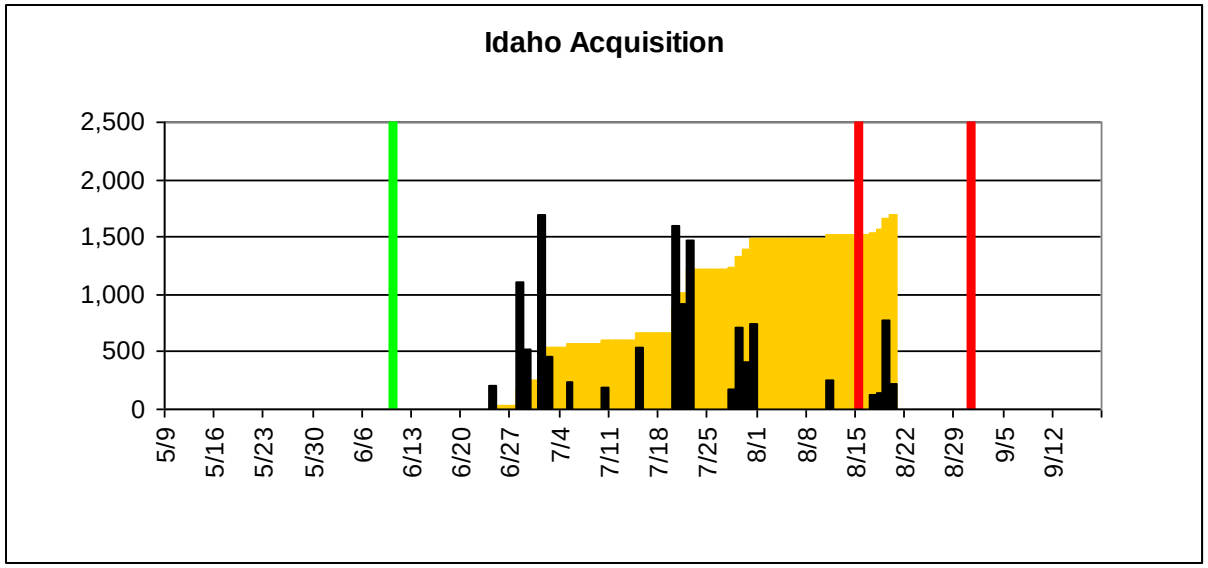
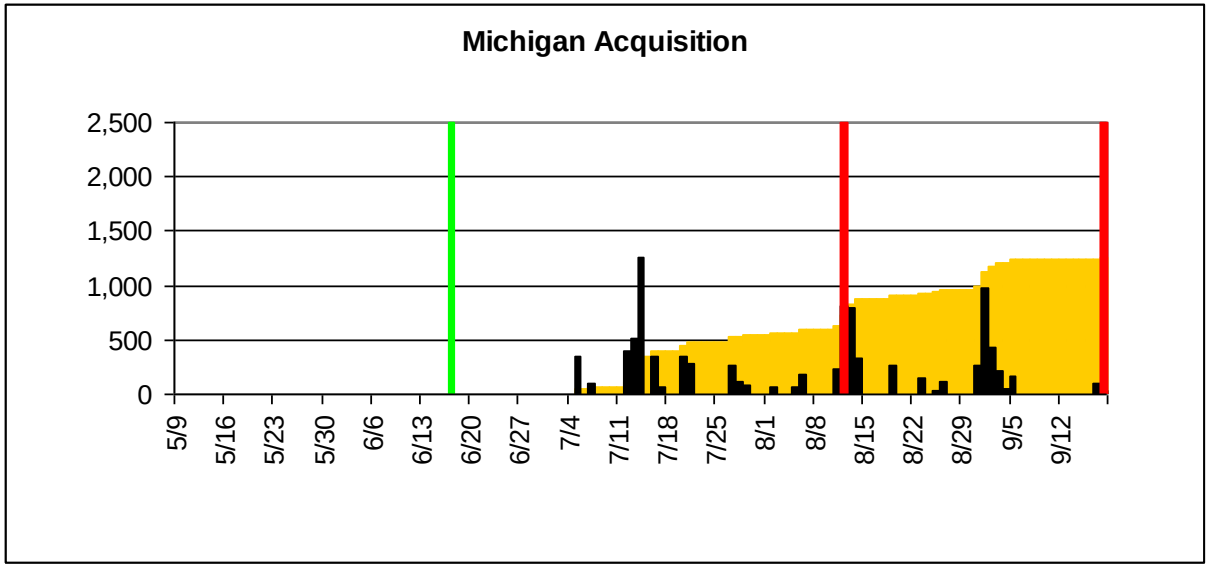


Slow Start
2 Week Extension
(89.9% at extension)



Most Problematic
Slow Start
Weather Problems
6 Week Extension
(58.3% at extension)

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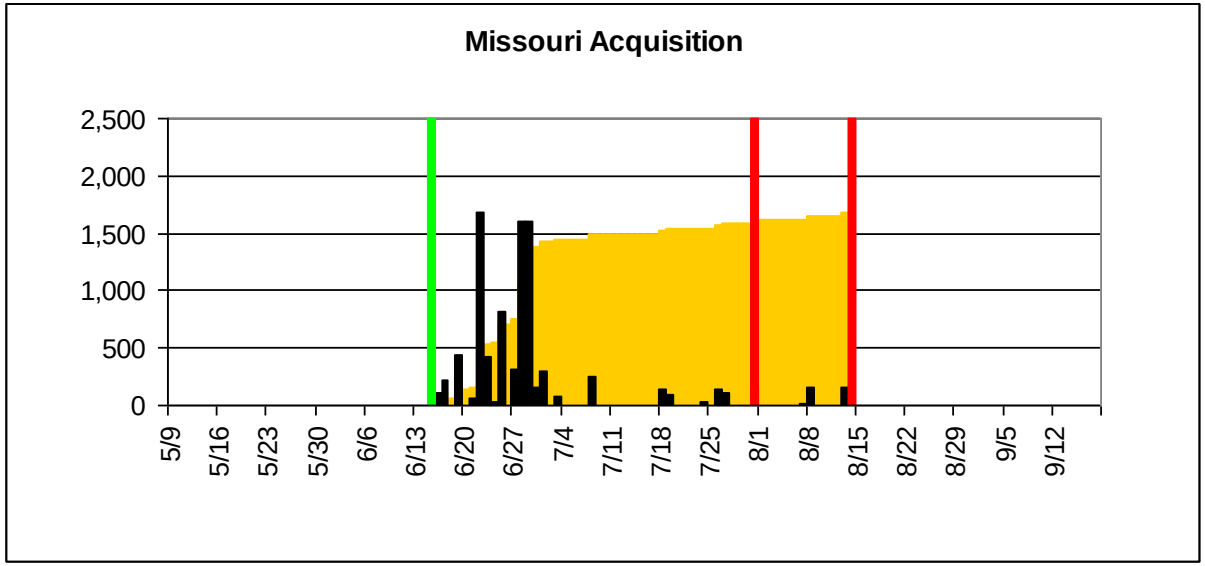
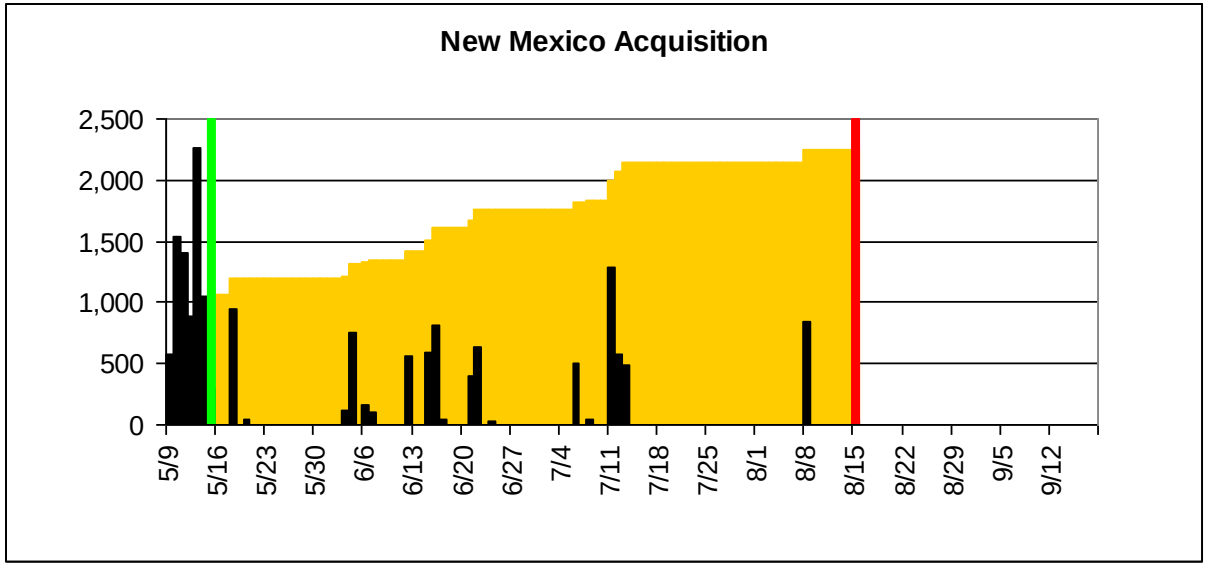


Good Start
Slow Completion
Weather
2 Week Extension
(96.3% at extension)



Quick Start
Monsoons
Finished Just In Time

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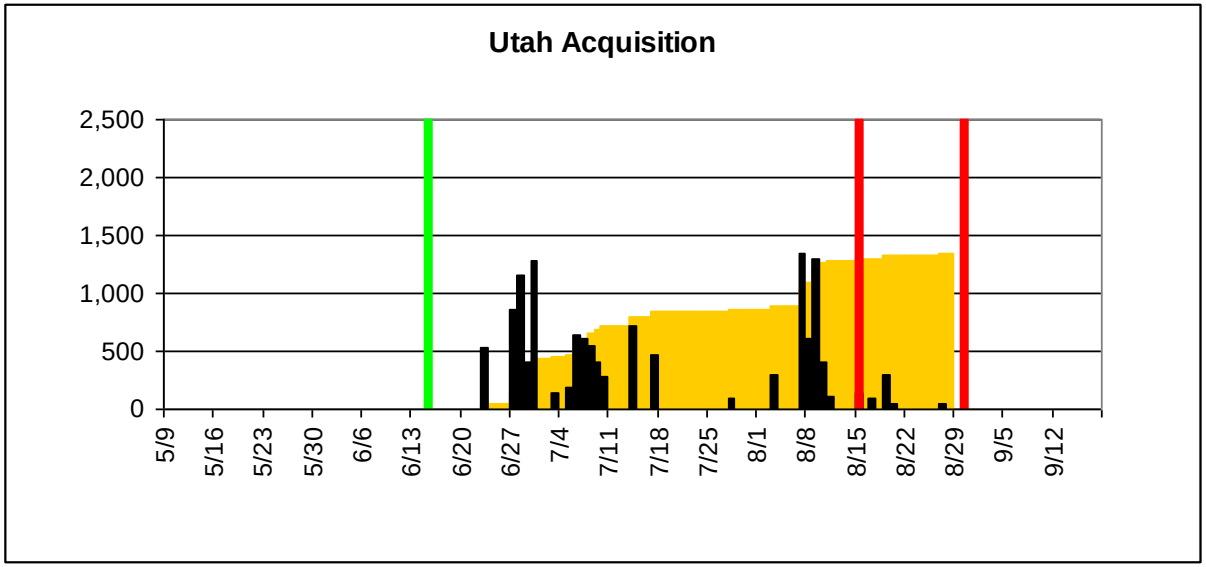
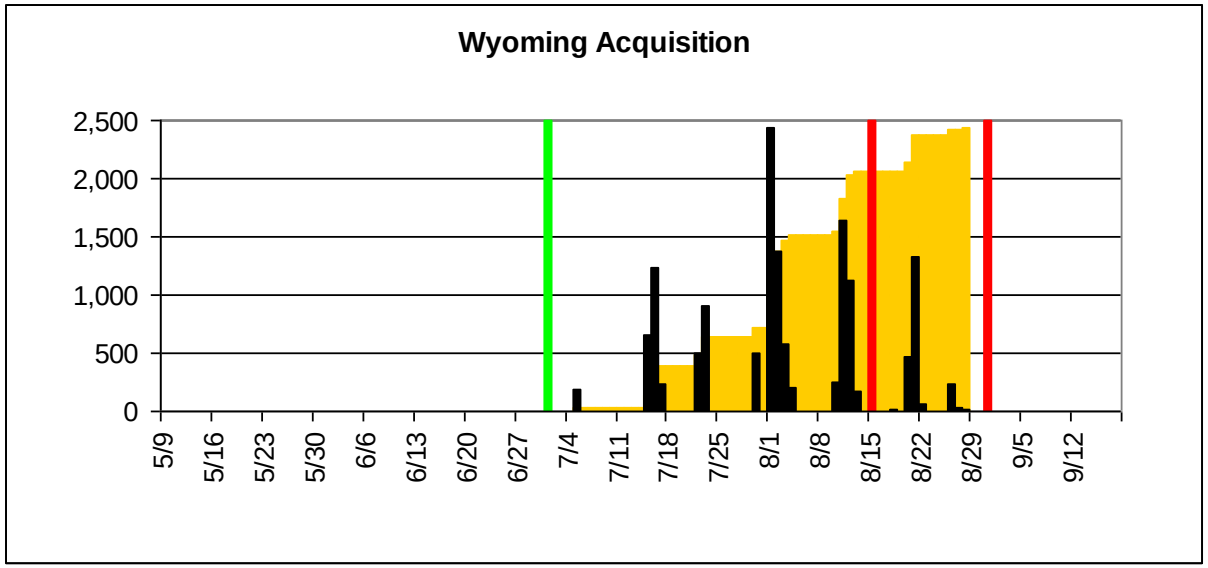


Good Start
Monsoons
2 Week Extension
(96.2% at extension)



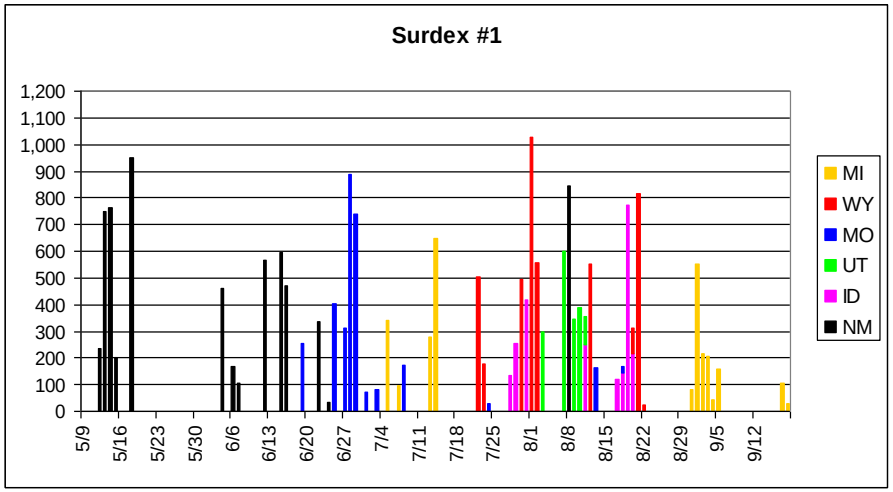
Slow Start
Weather
2 Week Extension
(84.7% at extension)

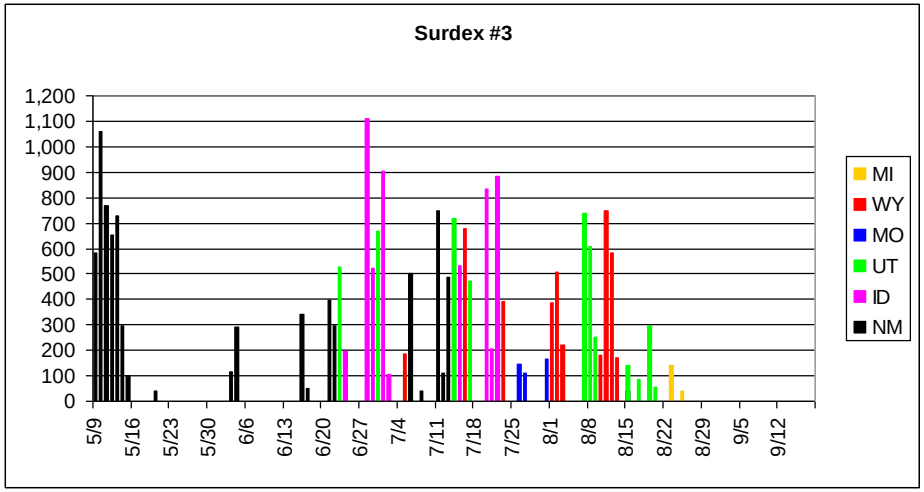
Acquisition Workload

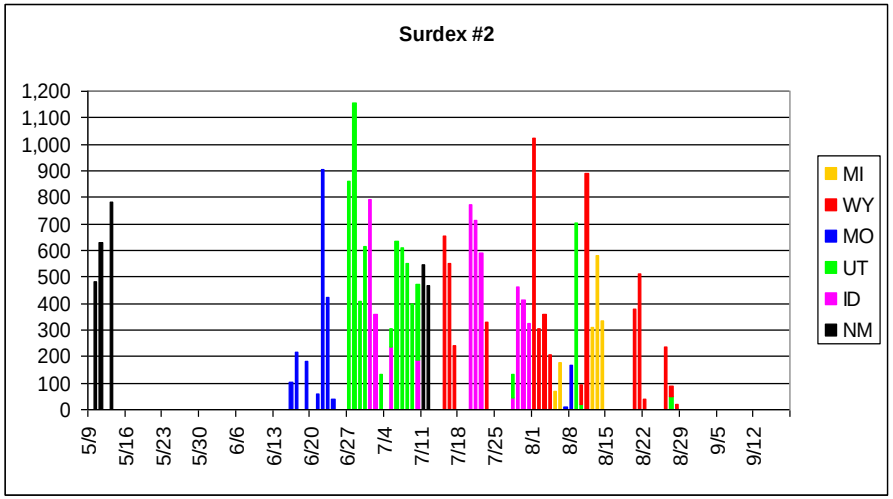
- All Surdex Conquests flew in each of the 6 states
  - MJ Harden Conquest only flew in MO & MI (non-RVSM)
- Coordination challenges in NM (White Sands)
- Some ATC restrictions
  - No more than 1 or 2 aircraft allowed at times

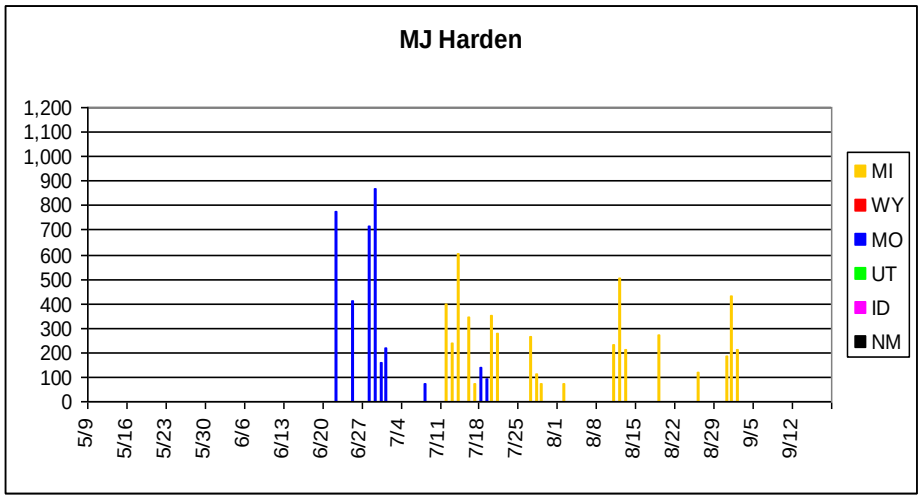
Aircraft	ID	MI	MO	NM	UT	WY	Exposures	Percent
Surdex 1	18.5%	29.4%	34.4%	37.2%	13.4%	30.0%	20,637	27.5%
Surdex 2	39.1%	15.6%	23.1%	17.3%	50.7%	41.4%	23,809	31.7%
Surdex 3	42.4%	1.9%	4.6%	46.5%	35.9%	28.7%	22,261	29.6%
MJH		53.1%	37.9%				8,436	11.2%
Exposures	12,500	9,384	9,095	17,020	13,001	14,172	75,172	

Aircraft Acquisition Sequence by State



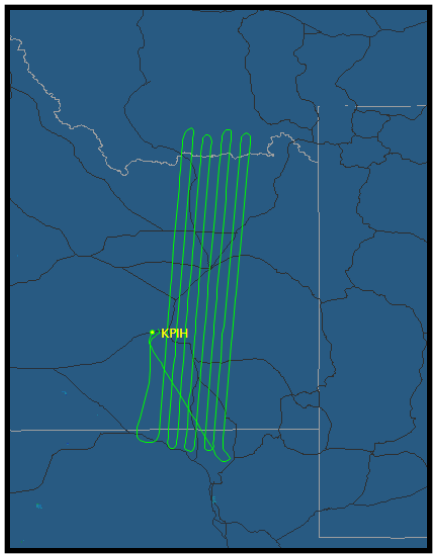




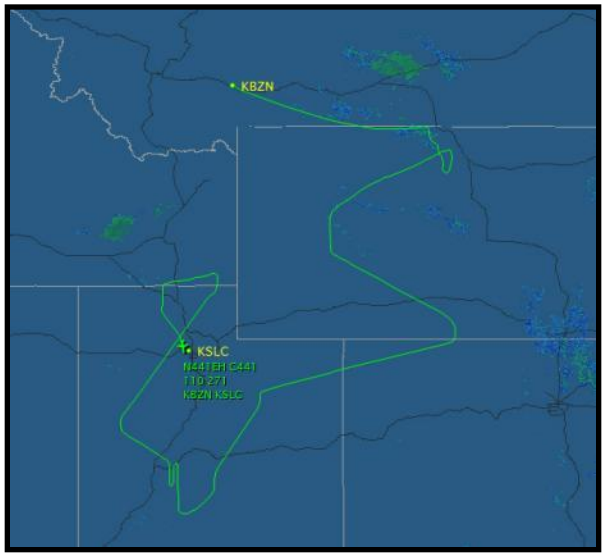


Examples of Missions…Not Always Optimal!

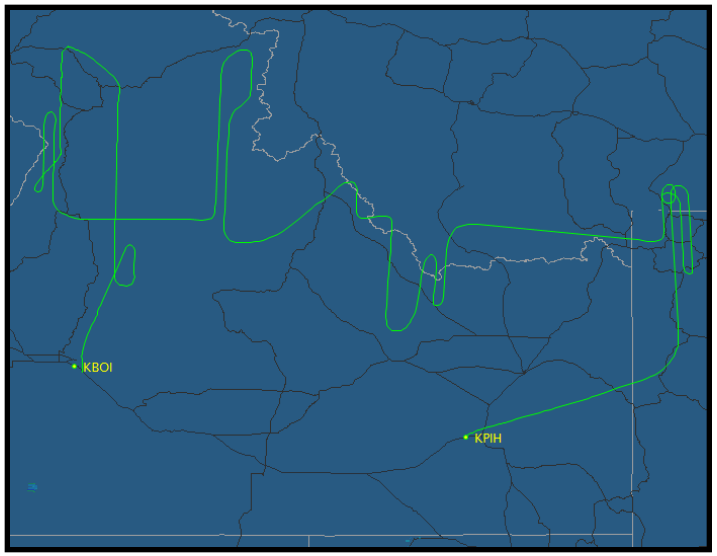
Clean Mission in ID



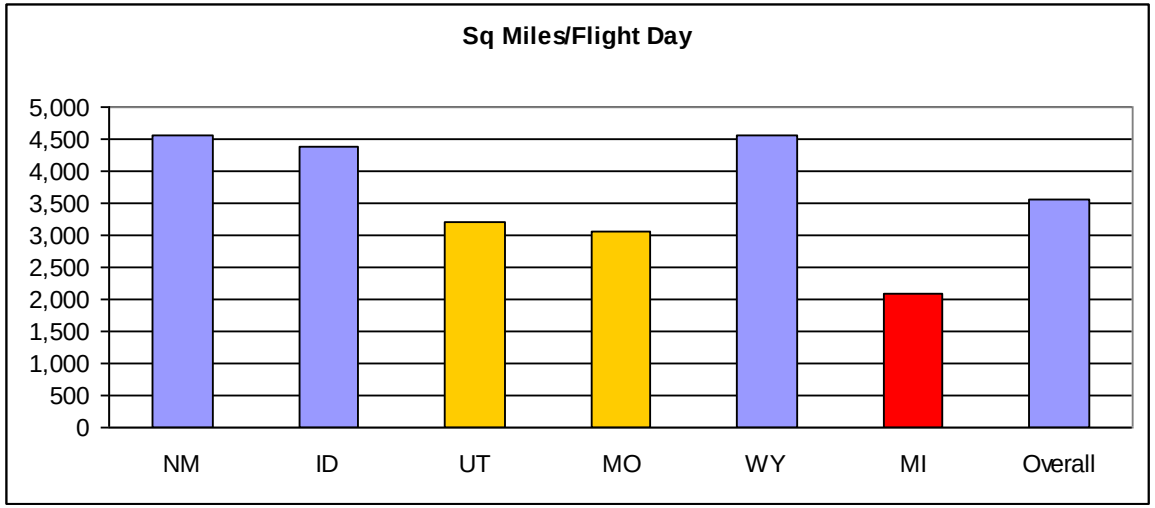
Cleanup in WY & UT



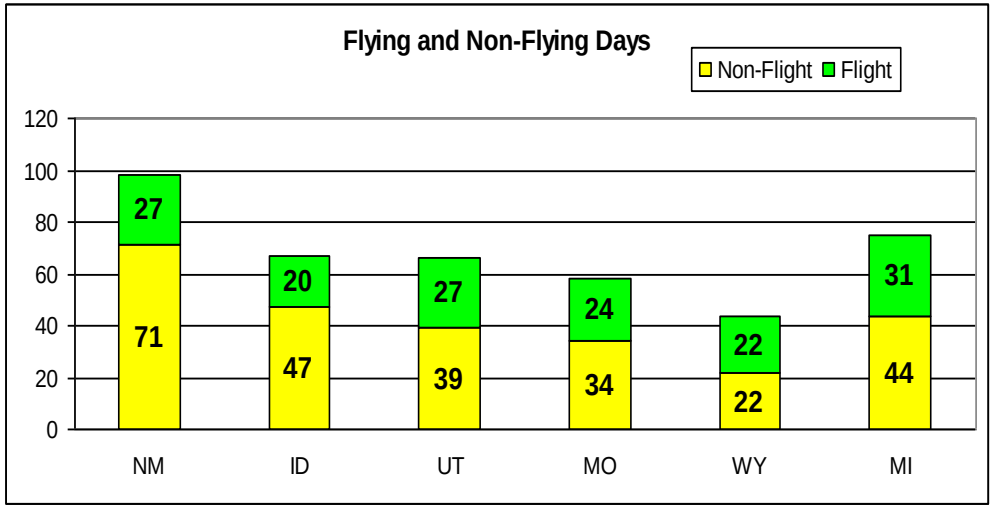
Cleanup in ID & WY



Weather Impacts on Performance



MI was lowest performance based on sq miles/flight day

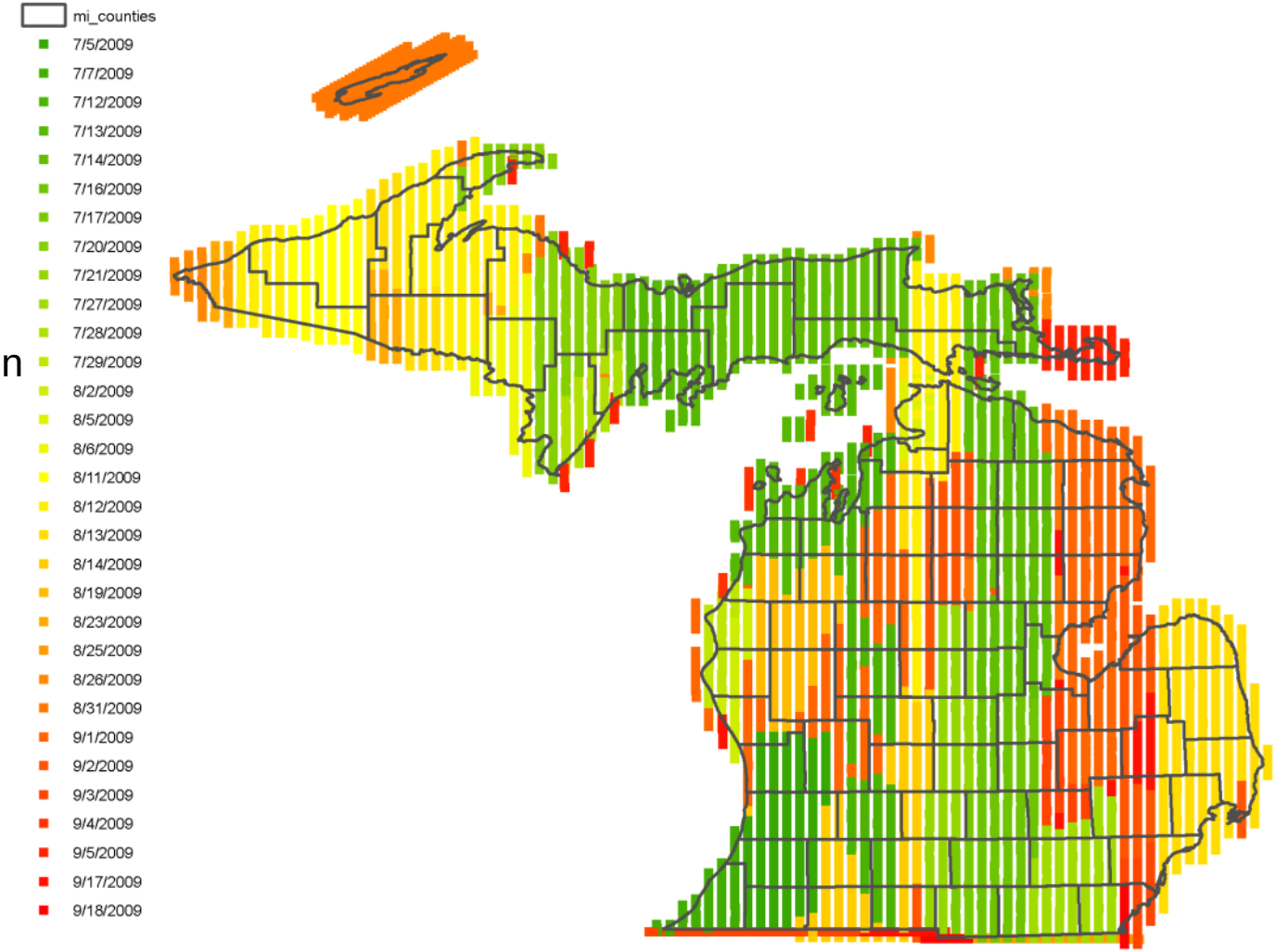


Needed long window in NM to work around monsoons

(Note: based on first-flown and last-flown dates)

Weather Produces Production Difficulties (MI)

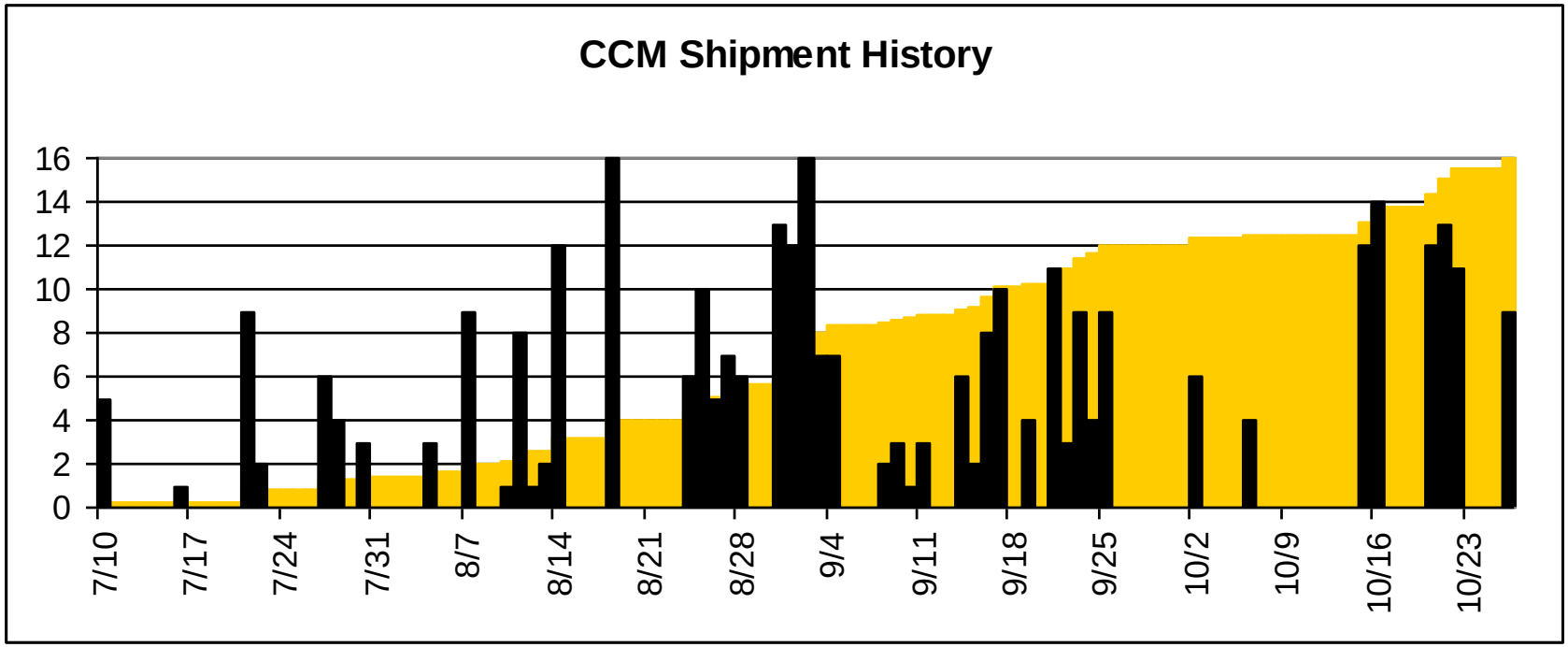
Fractured Acquisition
Slows Production



Production Phase

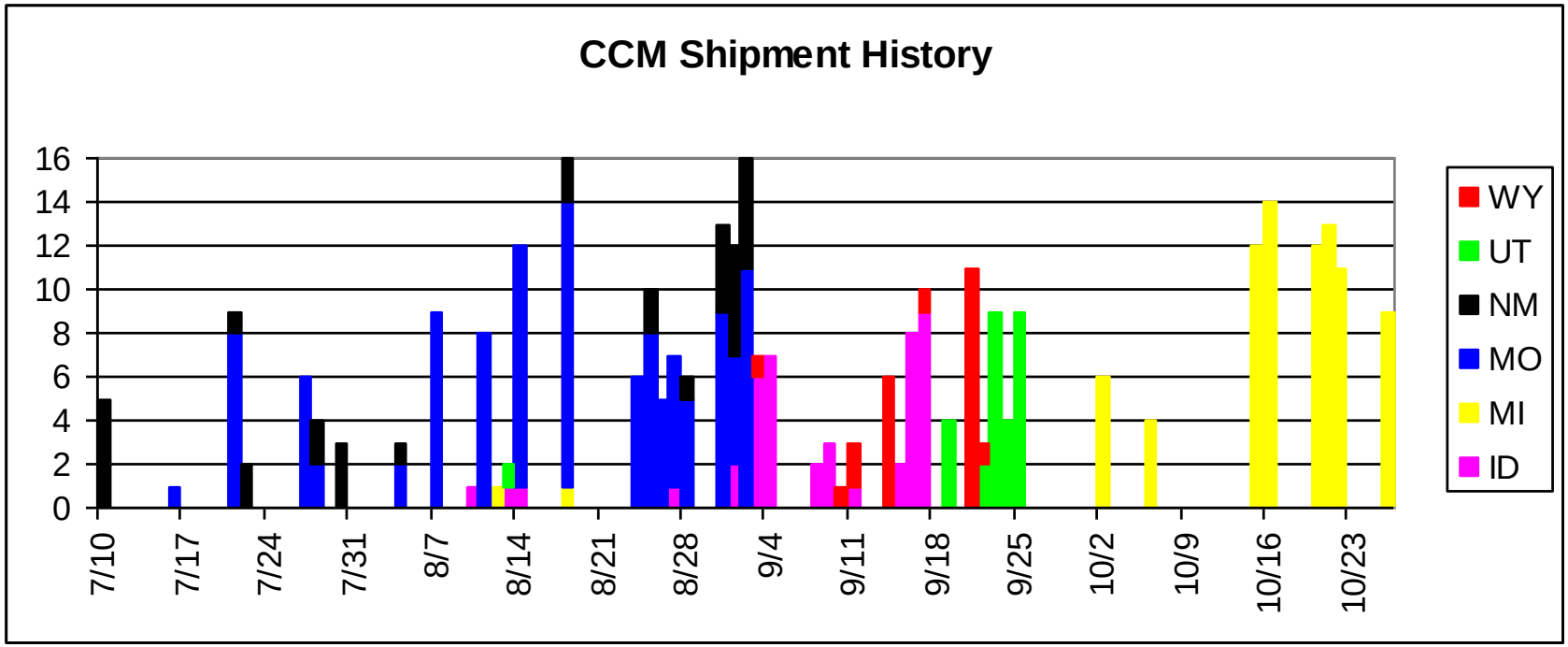
- ***All production done by Surdex***
- All CCMs delivered ahead of final schedule
  - Completion ranged from 4-13 days ahead
  - Average of 9 days ahead
  - Average of ~35 days delivery after final acquisition
- Surdex and APFO agreed to re-establish color for UT
  - State was already (largely) delivered
  - Surdex re-processed to new color reference
  - Re-delivery complete
- Large counties in Western states
  - Somewhat slower turn-around due to large size (as anticipated)
  - Often held up by flights or re-flights crossing multiple counties

CCM Shipment History



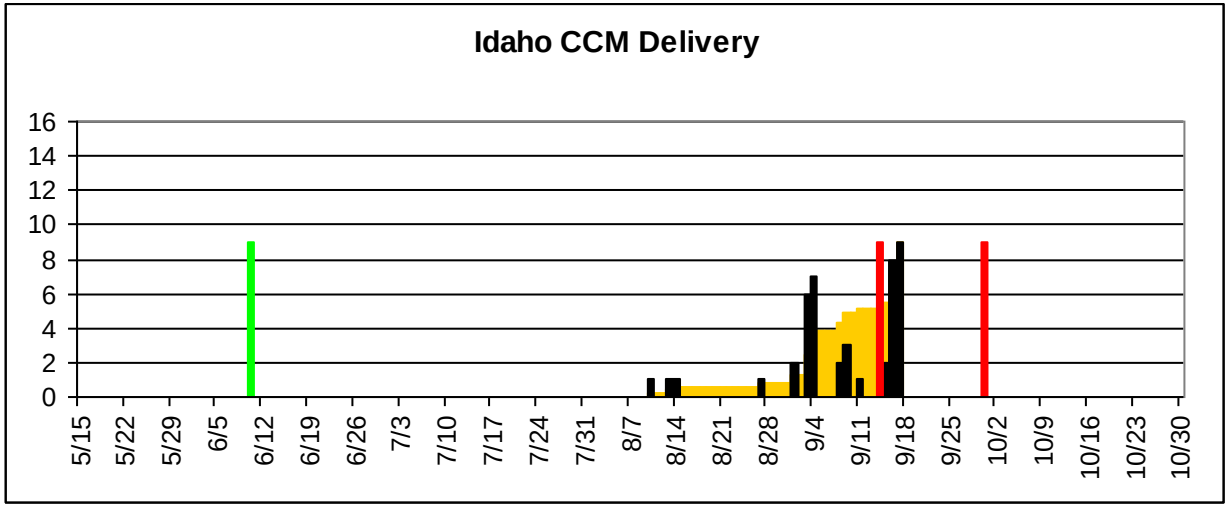
Note mostly linear cumulative pattern – steady progress throughout

CCM Shipment History, Coded by State

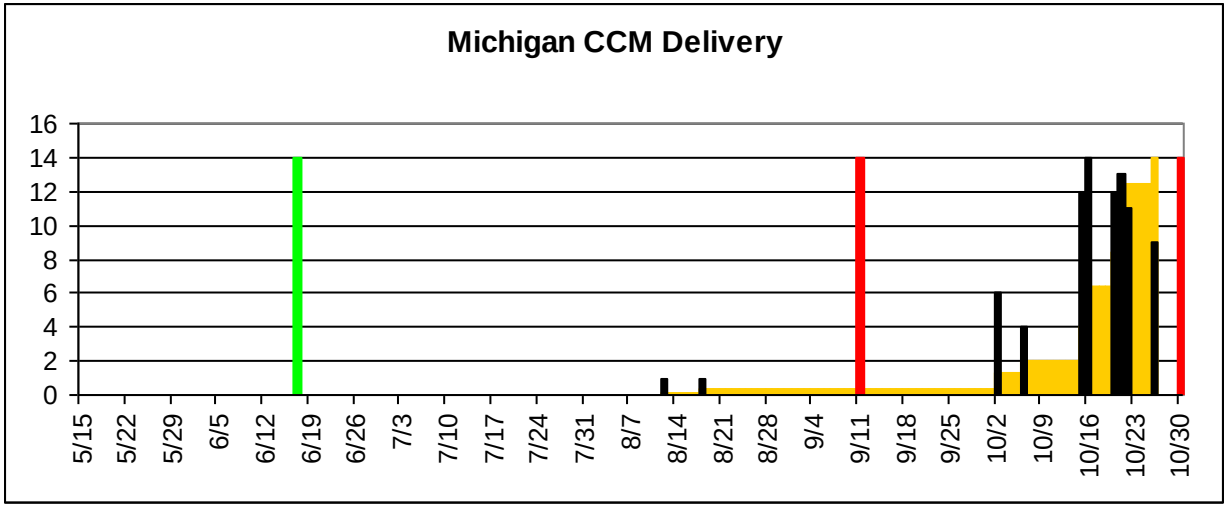


Note: Does not include re-processing of UT counties

CCM Delivery by State

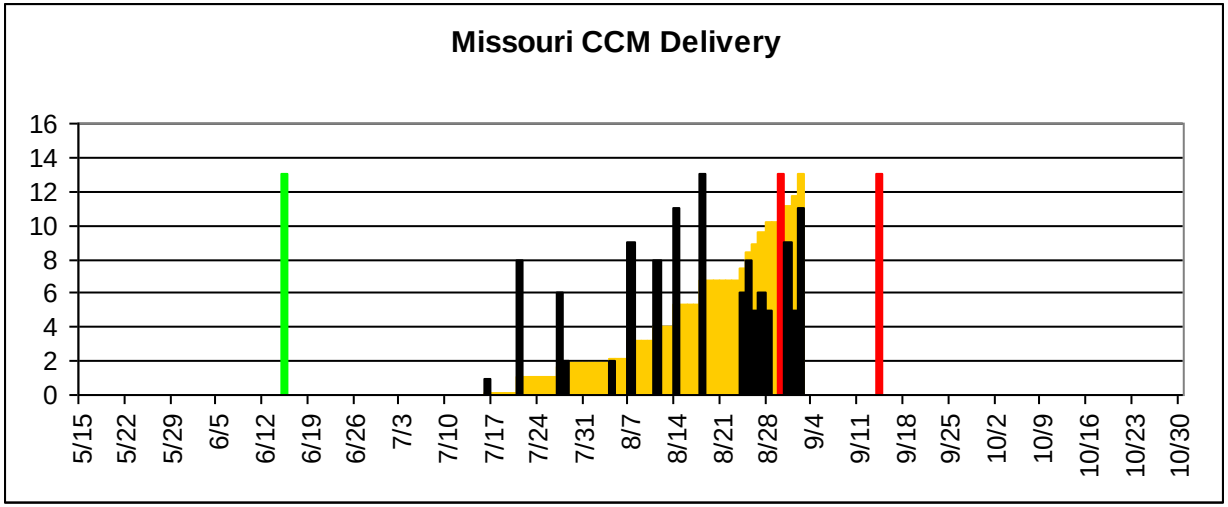


13 days before final date
38 days first-to-last

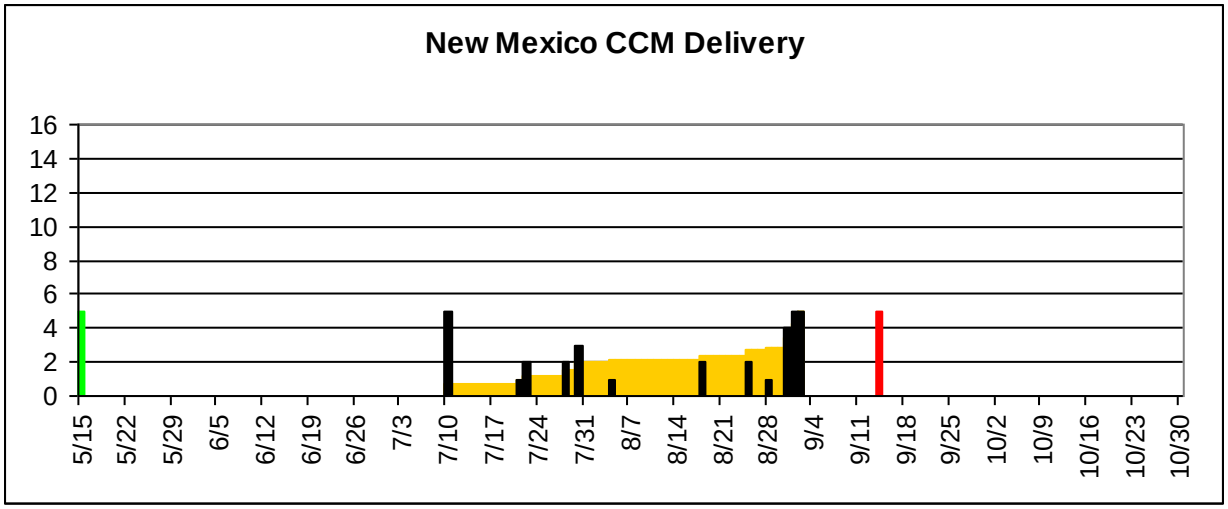


4 days before final date
75 days first-to-last

CCM Delivery by State

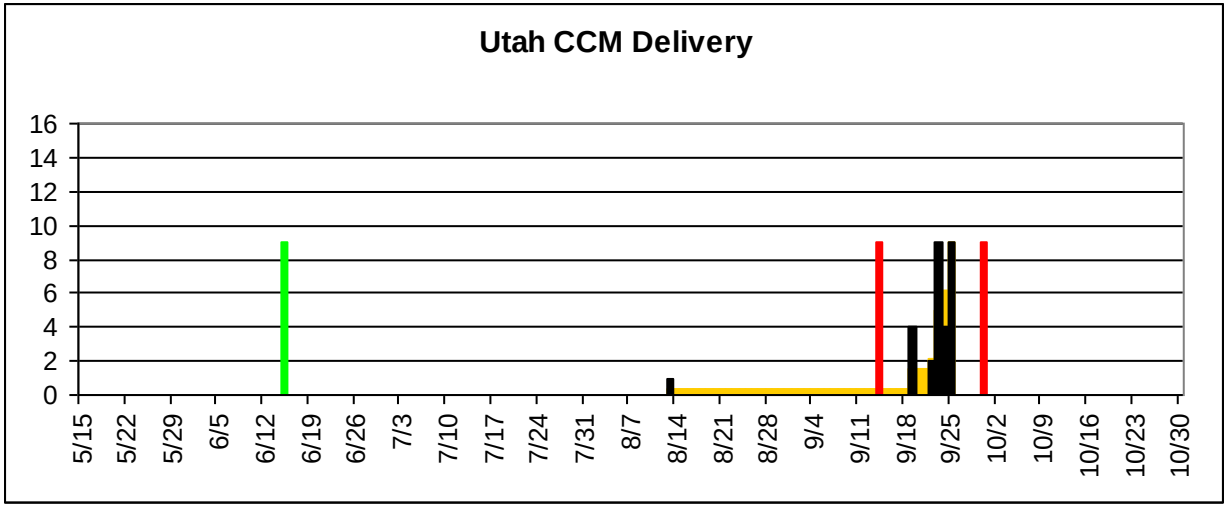


12 days before final date
48 days first-to-last

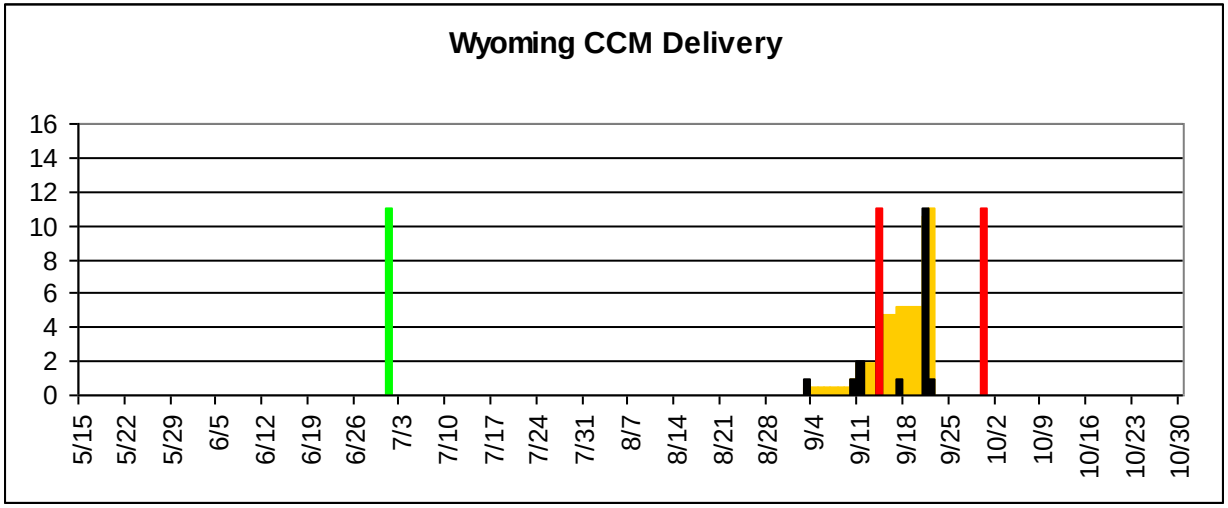


4 days before final date
54 days first-to-last

CCM Delivery by State



5 days before final date
43 days first-to-last



8 days before final date
19 days first-to-last

Accuracy

- Ground control
  - Some ground survey undertaken (ID, WY, MI)
  - NAIP prime contractors have agreed to share control
- NSSDA methodology used to verify product accuracy
  - 20 pts measured on each CCM against control imagery
  - Control imagery known to be better than 6m CE95
  - Over 6,500 points checked
- *Overall accuracy on the order of ±2.73m (CE95)*

Accuracy Results (All Units are Meters)

State	Control	Control Imagery	Points	RMSEr	CE95
ID	Surveyed	B&W DOQQs (2000)	901	1.70	2.94
MI	Surveyed	B&W & Color DOQQ (1993-1999)	1,547	1.73	3.00
MO	Statewide	2007 NAIP	2,324	1.28	2.19
NM	2005 Statewide	2005 1m Statewide	658	1.29	2.12
UT	2007 NAIP	B&W DOQQ (1999+)	901	1.89	3.28
WY	Surveyed	2006 NAIP	480	1.66	2.86
			6,511	**Ave = 1.59**	**Ave = 2.73**

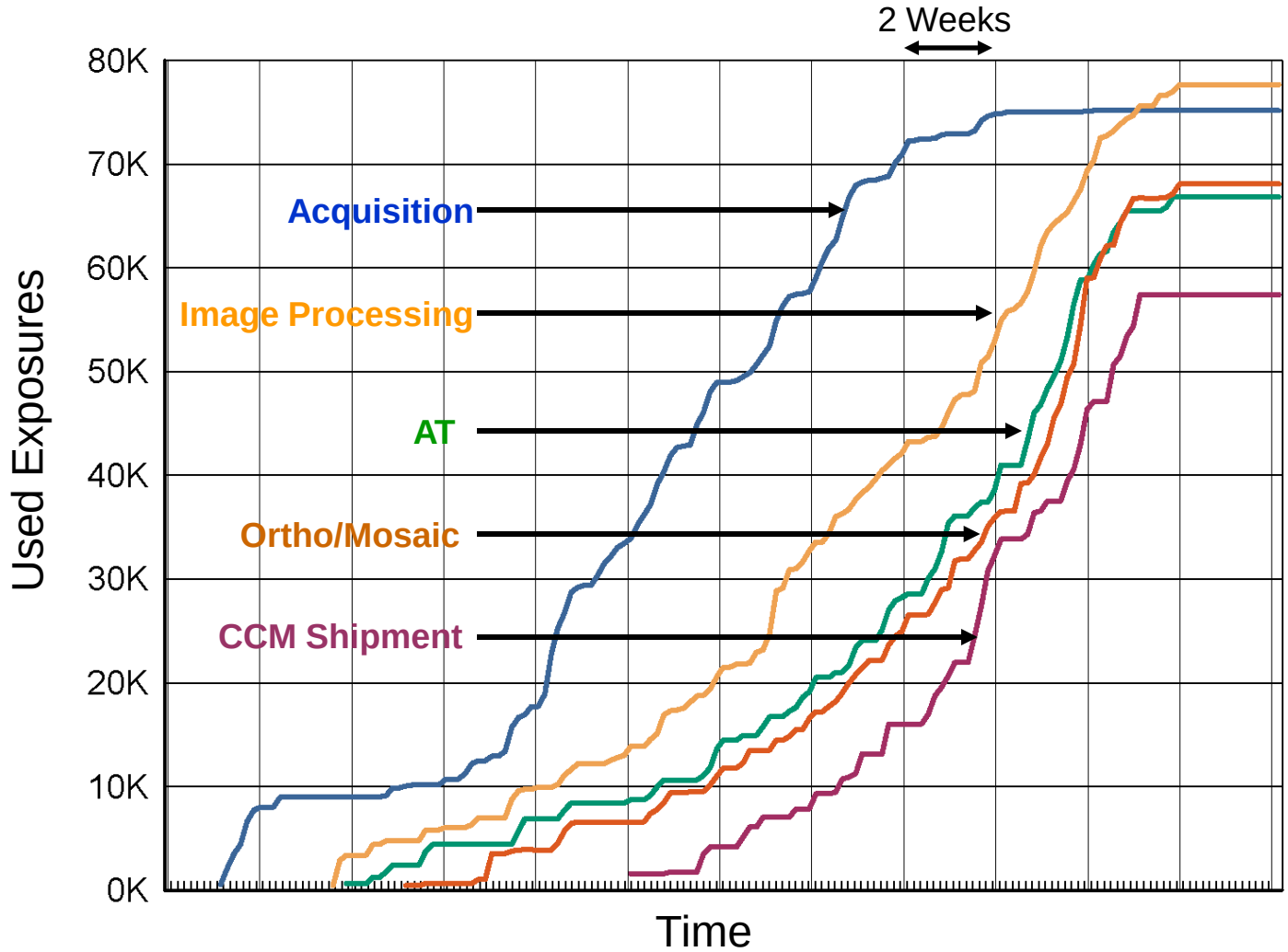
"2.2(b) Absolute Horizontal Accuracy. All DOQQ tiles shall have 95% of well-defined points tested fall within 6.0 meters of true ground."

71% better than 1.5m
97% better than 2.75m
100% better than 6.00m

Lag Analysis

- Addresses key phases of project
  - Normalized, cumulative histograms of each phase
  - Determine overall lag between phases
  - Helps isolate choke points for process improvement
- Phases (completion points)
  - Acquisition
  - Image processing
  - AT
  - Ortho & mosaicking
  - Shipment of CCM
- Report automatically generated on a daily basis

Example Overall Lag Chart (All States)



Lag Analysis Results

- Judged at ~50% completion level (steady state)
  - Image Processing (~4 weeks)
  - AT (~2 weeks)
  - Ortho/Mosaic (< 1 week)
  - CCM Production, QC, Shipment (< 1 week)

- Image Processing is the critical phase
  - More up-front resources required due to new approach
  - R&D in higher automation underway

Lessons Learned

- New, proprietary, image processing approach
  - Improved processing before production
    - Better quality product
    - Resulted in quicker AT – improved automated points, less cleanup
  - Slightly caught off-guard by level of effort
    - R&D effort to increase automation already underway
  - All CCM schedules met
- Independent QC of CCMs
  - Image quality review
  - Seamline review
  - Accuracy assessment

Recommendations

- Should partners and/or USDA state offices have a say in reference image process?
  - We can absorb another week of approval delay without impacting production
  - Prevent re-work
  - Better meet expectations of partners
- Should we use an area of images vice a single reference image?
  - Avoid extrapolating colorimetry over larger area
- Should USDA offer color <u>and</u> CIR CCMs for MSI states?
  - 3 states (MO, UT, WY) requested this from Surdex
  - Minor additional effort

Mosaics of New Mexico (~17,000 Exposures)

Yellowstone National Park Area (WY)

Old Faithful Area in Yellowstone