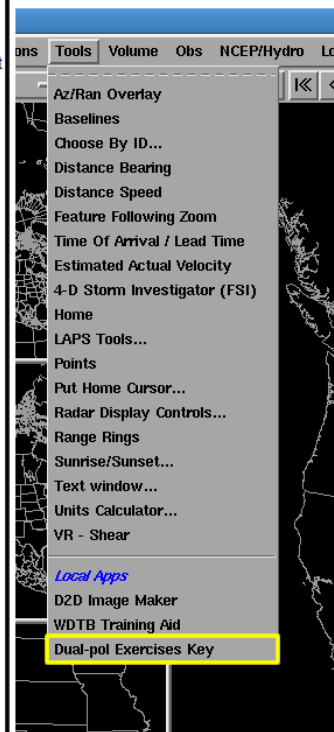# Dual-Pol WES Exercises Overview

This document contains 4 jobsheets that step you through a dual-pol radar analysis in case review mode on the WES. All events are from central Oklahoma from the WSR-88D Dual-Pol KOUN. Each jobsheet in this document is specific to a particular high impact event and you don't have to work through them in any particular order. While completion times will vary from person to person, expect these exercises to take roughly 7 hours to work (including the self-contained answer keys). The jobsheets are:

1. **Winter Weather: ~90 min analysis time + 26 min answer keys**

2. **Heavy Rain: ~60 min analysis time + 22 min answer keys**

3. **Tornadoes and Hail: ~100 min analysis time + 60 min answer keys**

4. **Bow Echo: ~40 min analysis time + 20 min answer keys**

Answer Keys

Answer keys are provided on a question by question basis, and are loaded directly off the WES! They each consist of a narrated video screen capture, demonstrating how Paul Schlatter from WDTB would have answered each question on his WES. It's up to you *when* you want to view the answer key for each question, either immediately after you fill out the answer or at the end of the jobsheet. In any case, please load the answer key launch page right off the tools menu (right graphic below). A firefox window will open containing links to each of the jobsheet answer keys (left graphic below). These videos contain narration, so make sure your WES machine has a working sound card to hear the audio from each video screen capture answer key.

Dual-Pol WES Exercises Answer Key

This page has the links to view camtasia presentations of the answers to each of the questions that make up the dual-pol operations coures WES exercises. Each link below will launch an external window containing the answer(s) to the jobsheet and questions listed.

Winter Weather Jobsheet (12/24/09, 2/26/10, 3/20/10)	Heavy Rain Jobsheet (June 14, 2010)	Tornado/Hail Jobsheet (May 10, 2010)	Bow Echo Jobsheet (May 19, 2010)
Question 1 Key	Question 1 Key	Question 1 Key	Question 1 Key
Question 2 Key	Question 2 Key	Question 2 Key	Question 2 Key
Question 3 Key	Question 3 Key	Question 3 Key	Questions 3-4 Key
Question 4 Key	Question 4 Key	Question 4 Key	Question 5 Key
Questions 5-6 Key	Question 5 Key	Question 5 Key	Question 6 Key
Question 7 Key	Questions 6-7 Key	Question 6 Key	Question 7 Key
Question 8 Key	Question 8 Key	Question 7 Key	Question 8 Key
Question 9 Key	Question 9 Key	Questions 8-9 Key	Question 9 Key
Question 10 Key	Question 10 Key	Question 10 Key	
Questions 11-13 Key	Question 11 Key	Question 11 Key	
Question 14 Key	Question 12 Key	Question 12 Key	
Question 15 Key		Question 13 Key	
Question 16 Key		Question 14 Key	
Questions 17-18 Key		Question 15 Key	
		Question 16 Key	
		Question 17 Key	
		Question 18 Key	
		Question 19 Key	
		Question 20 Key	
		Question 21 Key	
		Question 22 Key	
		Question 23 Key	
		Question 24 Key	

Tools Volume Obs NCEP/Hydro Lo

Az/Ran Overlay
Baselines
Choose By ID...
Distance Bearing
Distance Speed
Feature Following Zoom
Time Of Arrival / Lead Time
Estimated Actual Velocity
4-D Storm Investigator (FSI)
Home
LAPS Tools...
Points
Put Home Cursor...
Radar Display Controls...
Range Rings
Sunrise/Sunset...
Text window...
Units Calculator...
VR - Shear

Local Apps
D2D Image Maker
WDTB Training Aid
Dual-pol Exercises Key

Jobsheet #3: Tornado and Hail Outbreak

Objective:

- Using the knowledge gained from training modules and with the aid of all training aids, integrate an analysis of dual-pol radar products into a tornadic supercells event.

Case Data: 10 May 2010 in central Oklahoma.

Available Data: KOUN radar and LAPS gridded data

Analysis Duration: 100 min
Answer Keys Duration: 60 min

Instructions:

1. Clear out all panes prior to starting this jobsheet, if there are not already blank.
2. Left click on the D2D clock in the lower right part of D2D
3. Using the "Set Time" window, set the D2D clock to **2010 May 10 2130 UTC** (don't bother changing the seconds) and check the "Freeze Time at This Position" box.
4. Set Map Scale to "WFO"
5. Click on the koun menu and load "All Tilts Base Data"
6. While in the same pane as the All Tilts products, click on the Volume menu, then "Std Env Data Package", then "LAPS"
7. Set frames to 56
8. Modify map backgrounds and data magnification as you see fit

9. We'll start with an "early" supercell at far range from the radar. Zoom in on the supercell located at **76 nm and 001 deg** so it fills the pane.
10. Examine Z and SRM and loop through the 4 frames to get a good feel for the storm.
11. **Get to the 2126 UTC scan!**

Question 1: At <u>2126 UTC</u> and the 0.5 deg elevation angle, scan several bins around each range and azimuth to determine the general value from each radar product listed in the table fill. Using those radar product values, select from the list of potential echo types below the most likely echo type for each range and azimuth. Enter it in the row below each range and azimuth.

- **Giant Hail Mixed With Rain**
- **Hail mixed with Rain**
- **Hail Not Mixed With Rain**
- **Giant Hail Not Mixed With Rain**
- **Pure Heavy Rain**

0.5 deg Products	Z	ZDR	CC	KDP
74 nm @ 357°	dBZ	dB		deg/km
Dominant Precip Type:				
75 nm @ 000°	dBZ	dB		deg/km
Dominant Precip Type:				
74 nm @ 002°	dBZ	dB		deg/km
Dominant Precip Type:				

Question 2: Use All tilts at 2126 UTC, flipping between Z and ZDR to find enhanced regions of ZDR above the 0C level. Use cursor sampling to get an idea of the environmental 0C level and where ZDR is high significantly above it. What is the temperature at the top of the ZDR column with this storm?

Top of ZDR Column Temp: _____ degC

Question 3: Where is the ZDR column located relative to the BWER?

Time to Switch Storms

1. You can clear out the All Tilts Base Data pane. We'll move a little later when supercell fest is well underway.
2. Left click on the D2D clock in the lower right part of D2D
3. Using the "Set Time" window, set the D2D clock to **2010 May 10 2212 UTC** (don't bother changing the seconds) and check the "Freeze Time at This Position" box.
4. Set Map Scale to "WFO"
5. Click on the koun menu and load "All Tilts Base Data"
6. While in the same pane as the All Tilts products, click on the Volume menu, then "Std Env Data Package", then "LAPS"
7. Set frames to 56
8. Modify map backgrounds and data magnification as you see fit

9. In the All Tilts base data pane, loop through 0.5 deg frames at 4 panels and/or Panel Combo/Rotate, getting a broad scale view of the base products Z, ZDR, CC, and KDP. For this event, feel free to utilize velocity/SRM and spectrum width. There is a plethora of supercells!

10. When ready, go the 0.5 deg elevation angle in your 4 panel layout at **2159 UTC,** zoom far into the storms located at **14 nm and 292 degrees**, and answer the following questions.

Question 4: Use All Tilts at 2159 UTC, and toggle between Z and ZDR for the southern storm. Identify the updraft and ZDR column (Hint: the top of the ZDR column is on the 15.6 deg elevation angle). How high does the ZDR column go in feet MSL? What temperature is height at?

ZDR Column Height: _____ ft MSL

ZDR Column Temp: _____ degC

Question 5: Use All Tilts at 2159 UTC and toggle between Z (button 1) and SRM (button 5), then toggle to ZDR (button 2). Examine the vertical structure of the mesocyclone and ZDR column. At the 15.6 deg elevation angle, what is the strength of the shear signature with the mesocyclone associated with southern BWER/ZDR column? Does it have good height continuity?

∆V (|Max in| + max out): _____ kts
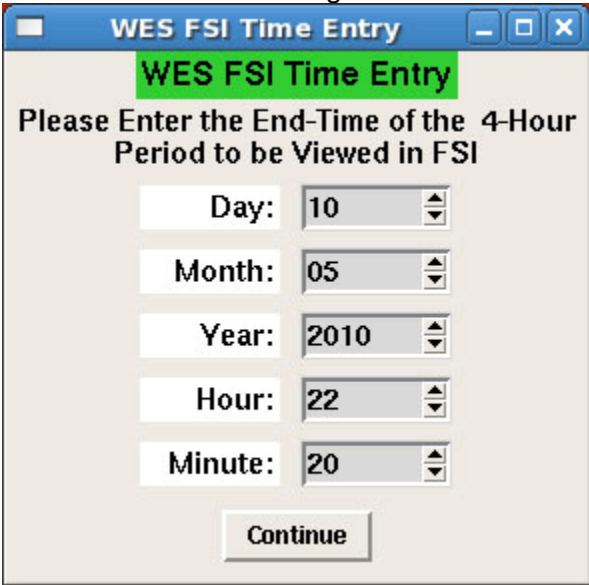
Good Height Continuity: Yes / No

Question 6: **In your own words, briefly discuss the location of the ZDR column, mesocyclone, and BWER relative to each other and to the precip core.**

Question 7: Provide a list of the signatures and attributes of the radar data that point to the strength of the updraft located at/near 15 nm and 281 deg at this time.

Instructions for FSI of this Supercell

1. Load FSI off the tools menu into your All Tilts display
2. Right click on the storm at 14 nm and 292 degrees

WES FSI Time Entry

Please Enter the End-Time of the 4-Hour
Period to be Viewed in FSI

Day: 10
Month: 05
Year: 2010
Hour: 22
Minute: 20

Continue

Figure 13: FSI time entry window for May 10ᵗʰ, 2010 event. Enter
the numbers just as they are shown in the graphic.

3. Set the FSI Time Entry to match the image above (Fig. 6).
4. Get to the 14.0 deg elevation angle (which is actually 15.6 deg) at 220246 UTC
5. Cut your cross section just like the one below in Figure 7.
6. Toggle between Z (Z button) and ZDR (D button) and focus on the cross section. Pick your jaw up off the desk, then answer the following questions.
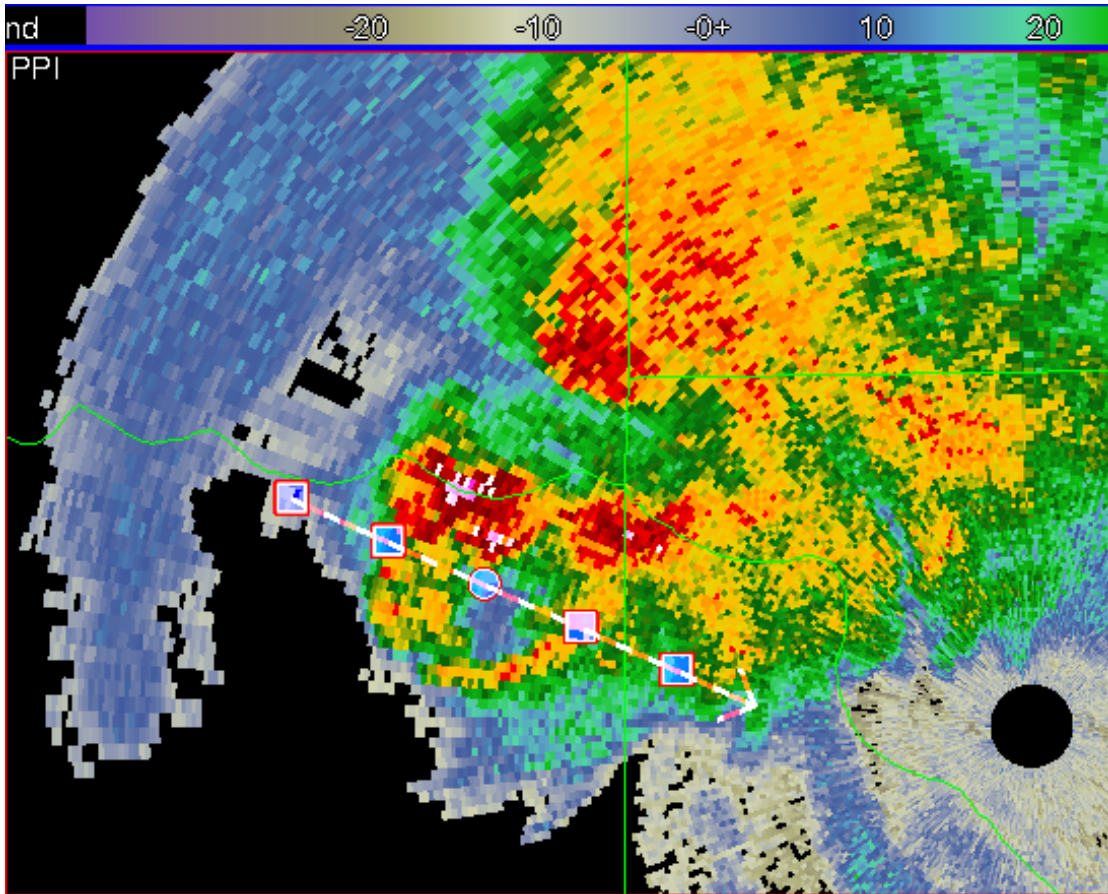
Figure 14: Top left pane of FSI, Reflectivity image at 220246 UTC 10 May 2010 and 15.6 degrees elevation angle (though in FSI it's reported at 14 deg).

Question 8: Using the FSI cross section from Figure 14, find the maximum height of the ZDR column, in feet MSL.

ZDR Column Height: _____ ft MSL

Question 9: In the cross section that matches Figure 14, toggle to ZDR and make certain the cross section passes through the 15.6 deg ZDR maximum. In the ensuing cross section, roughly how wide is the ZDR column (in Nmi)? (Hint, a ZDR column is defined as positive ZDR above the melting layer)

ZDR Column Width: _____ nm

From Updraft Stength to Hail Detection

1. You can close FSI, go back to D2D.
2. I am sure you are anxious to see what kind of hail this storm produced. For that, let's skip forward in time to the **2212 UTC** scan, which should be the latest one in your All Tilts Base Data display pane.

Question 10: Go the 0.5 deg elevation angle and zoom into the area surrounding 9 nm range, 330 deg azimuth. Toggle between Z, ZDR, CC, and KDP and scan several bins around each range and azimuth to determine the general value from each radar product listed in the table.

0.5 deg Products	Z	ZDR	CC	KDP
9 nm @ 327-336°				
15 nm @ 332°				

Question 11: Relative to storm structure and location of the updraft at 0.5 deg, where is the radar signature at 9 nm between 327 and 336 degrees located? You can use All Tilts and any of the base products (1-7 on the keys) to help determine this. Examples: In the middle of the updraft, in the precipitation core, along the reflectivity gradient adjacent to the updraft, etc.

Question 12: Relative to storm structure and location of the updraft at 0.5 deg, where is the radar signature at 15 nm @ 332 degrees located? You can use All Tilts and any of the base products (1-7 on the keys) to help determine this.

Question 13: Given the values of the radar products you found in Question 10 and the location of the signatures relative to storm structure, enter into the table from the following list of choices what you think is the most likely dominant radar echo type at those range and azimuths:

- **Giant Hail Mixed With Rain**
- **Hail mixed with Rain**
- **Hail Not Mixed With Rain**
- **Giant Hail Not Mixed With Rain**
- **Pure Heavy Rain**
- **Biological Scatterers**

0.5 deg Products	Most Likely Echo Type
9 nm @ 327-336°	
15 nm @ 332°	

Question 14: Briefly explain in the space provided below why you selected the echo types in Question 13.

Question 15: Toggle to HCA output at 0.5 deg (button 8). Fill out the table using HCA output, if multiple types exist, list them all:

0.5 deg Products	HCA Output Echo Types
9 nm @ 332°	
15 nm @ 332°	

Question 16: How did the HCA output compare to your base data analysis of echo type? Briefly explain the reason for any differences if they exist.

Tornadic Debris Signature Analysis

1. Time to go tornado hunting. Clear all panes or swap to a clear pane, and left click on the D2D clock in the lower right part of D2D
2. Using the "Set Time" window, set the D2D clock to **2010 May 11 0000 UTC** (don't bother changing the seconds) and check the "Freeze Time at This Position" box.
3. Set Map Scale to "WFO"
4. Click on the koun menu and load "0.5 Base Data"
5. While in the same pane as the 0.5 deg base products, click on the Volume menu, then "Std Env Data Package", then "LAPS"
6. Set frames to 40
7. Off the Maps menu, load "Urban Boundaries" and "Cities". Modify the map colors and data magnification as you see fit

8. We will only look at 0.5 deg products here in the interest of time, which is okay because if tornado debris is sampled by the radar, it should occur in the lowest available data.
9. You may feel a strong temptation to spend a long time perusing one of the roughly 10 simultaneously occurring supercells, please refrain from doing so and try to stay on task since time is limited. Plus, going through this in the order listed will also enable you to get an unbiased look at early tornadic signatures, in some cases well before a single-pol radar clearly indicates a damaging tornado.
10. Step backwards in time to **22:21 UTC,** zoom into the supercell located at **10 nm and 000 deg**. Answer the following questions.

Question 17: At 2221 UTC, and only using Z and SRM (buttons 1 and 5), find the area most likely to contain a tornado associated with the storm located at 10 nm and 000 deg. What is the range and azimuth of where you would think a tornado is most likely to be found?

In Z/SRM analysis, tornado most likely at:

_____ nm and _____ deg

Question 18: Follow-up to Question 17—from Z and SRM, what is your confidence level (0-100%) that at this time there is a tornado doing damage?

_____ % confidence in damaging tornado

Question 19: Focus and zoom into 5 nm at 335 deg azimuth. Only pay attention to reflectivity values greater than 30 dBZ and very near the strong inbound velocities in SRM. What is a mean value of ZDR and CC in this area of high reflectivity and strong shear?

ZDR: _____ dB

CC: _____

Question 20: Based on your answer to Question 19, at 2221 UTC what echo type(s) are likely in the area within a few gates surrounding 5 nm and 335 azimuth and in reflectivity values above 30 dBZ? Underline ONE OR MORE of the following:

Pure Rain / Giant Hail / Tornadic debris / Hail mixed with Rain / Biological Scatterers

Switch Storms Once Again

1. Time to examine a different storm a bit further from radar, but **DO NOT clear out** the 0.5 deg pane. We'll be using it again in a few minutes.
2. Swap Panes.
3. Set the D2D clock using the "Set Time" window to **2010 May 10 2230 UTC** (don't bother changing the seconds) and check the "Freeze Time at This Position" box.
4. Go to WFO scale
5. Load All Tilts Base Data
6. While in the same pane as the All Titls base products, click on the Volume menu, then "Std Env Data Package", then "LAPS"
7. Set frames to 56
8. Zoom in on the storm located at **35 nm @ 188 deg**.
9. Find the **2225 UTC** volume scan

Question 21: Using Z/SRM and ZDR All Tilts, list the location and the temperature at the maximum height of any ZDR columns associated with this storm at 2225 UTC. One or more may exist.

ZDR Column	Range	Azimuth	Temp at Top
1.	nm	deg	degC
2.	nm	deg	degC
3.	nm	deg	degC

Question 22: Where, in a storm relative sense, is the primary/strongest ZDR column located at 2225 for the storm examined in Question 21? Is this what you expect given the storm type? Feel free to examine SRM too.

10. **You can clear this all tilts base products pane if you'd like.**
11. Swap panes to the **0.5 deg base products display**
12. Go backwards in time to **2212 UTC**, and this time zoom all the way into the supercell located at **48 nm, 201 deg**, which is the same storm as you analyzed for Questions 21 and 22, only this time we will look for tornadic debris signatures. Feel free to update storm motion for SRM.

Question 23: Fill out the table below for each volume scan time listed and do them in chronological order, examining only this supercell.

Volume Scan Time	Tornado Debris Signature?	Range/Azimuth of TDS, if Applicable
2212 UTC	**Y / N**	**nm @** °
2216 UTC	**Y / N**	**nm @** °
2221 UTC	**Y / N**	**nm @** °
2225 UTC	**Y / N**	**nm @** °
2229 UTC	**Y / N**	**nm @** °
2234 UTC	**Y / N**	**nm @** °
2238 UTC	**Y / N**	**nm @** °

Final Task: Identify all TDSs from a single scan

1. You will all be proficient at identifying tornadic debris signatures after this next task. On the 0.5 deg base data pane, move forward to **2250 UTC. Zoom into the domain shown in figure 15** (next page)**.**

Question 24: Examining ONLY the domain in Figure 15 at 2250 UTC, give the range and azimuth of all tornadic debris signatures you can find at this single volume scan time. Use any methods you see fit. There will be several.

TDS Signature	Range	Azimuth
1.	**nm**	**deg**
2.	**nm**	**deg**
3.	**nm**	**deg**
4.	**nm**	**deg**

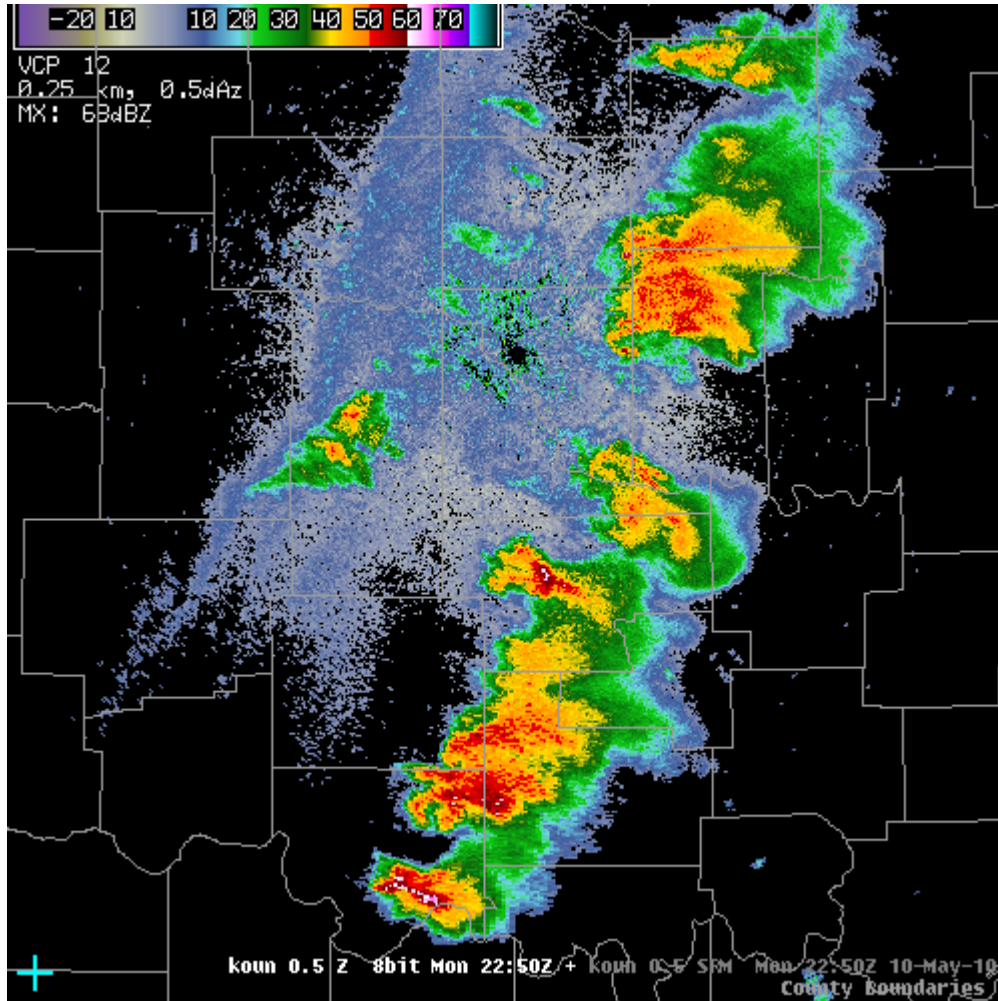| 5.	nm	deg
6.	nm	deg
7.	nm	deg

Figure 15: 10 May 2010 22:50 UTC 0.5 deg reflectivity image zoomed into the search domain for TDS signatures. Only search for TDSs on your WES workstation for the storms shown in this graphic and time.