Datums for a Dynamic Earth

Based on a paper given at the American Society of Agricultural and Biological Engineers (ASABE) Conference in Reno, Nevada June 2009

Rollin Strohman Ph.D.
Tom Mastin L.S

Background

- The Agricultural and Biological Engineers (ASABE) Precision Agriculture group was discussing standards
  - One standard being considered was
    - all Field control should be on Absolute “unchanging” Coordinates
      - *This brought about a paper presented at the American Society of Agricultural and Biological Engineers (ASABE) Conference in Reno, Nevada June 2009*
        - » *“Datums for a Dynamic Earth”*

Precision Agriculture

- Precision Agriculture is a generic term for
  - Using Precision Machine Control
  - Using positioning systems for crop and soil studies
  - Using GIS and remote sensing for farm management

Precision Agriculture Control

- In regards to: precision machine control
  - Looking at maintaining repeatability
  - Is it possible to create the row in the same location ± 1 foot
    - Year after year
- Is it possible to ??
  - Give coordinates that will define your property boundary using GPS
  - Dig up water valves based on locations done in the 1980's

GPS Precision

- Plain GPS =10-20m (33 to 66ft)
- Corrected GPS
  - WAAS =1.5m (5 ft)
  - Coast Guard = 1 to 3m (3.3 to 9.9ft)
  - Omnistar
    - VBS = 1m (3.3ft)
    - XP = 0.15m (0.5ft)
    - HP = 0.10m (0.33ft)
  - John Deere
    - Starfire SF1 = 0.75m (2.5ft)
    - Starfire SF2 = 0.25m (0.8ft)
  - CPD
    - RTK =0.02m (.06ft)
    - Static =0.01m (0.03ft)

Problem Solved?

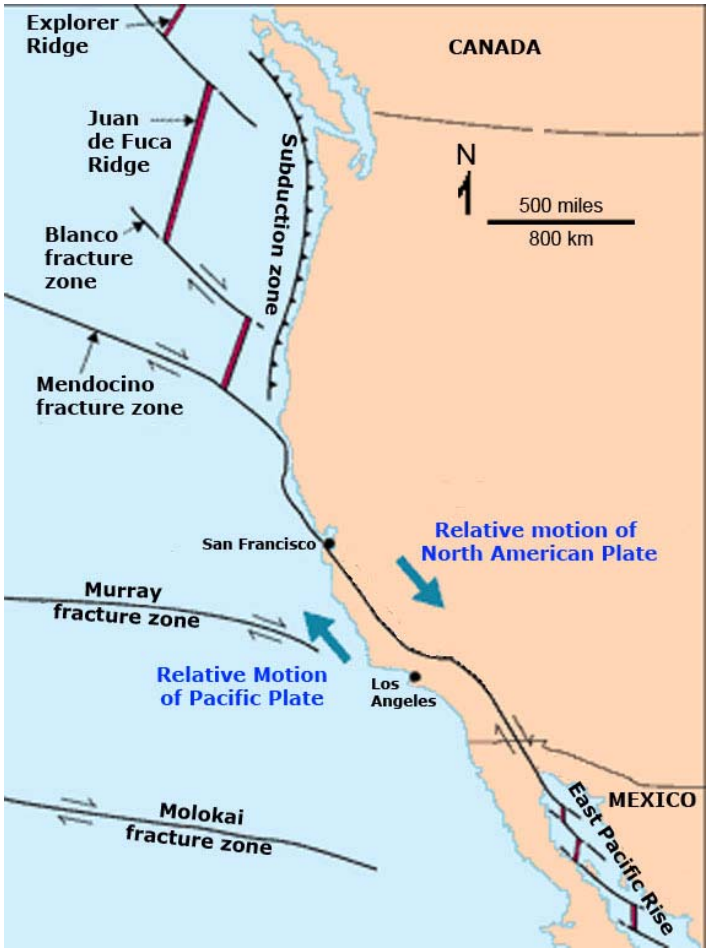
- Corrected GPS
  - XP = 0.15m (0.5ft)
  - HP = 0.10m (0.33ft)
- John Deere
  - Starfire SF1 = 0.75m (2.5ft)
  - Starfire SF2 = 0.25m (0.8ft)
- CPD
  - RTK =0.02m (.06ft)
  - Static =0.01m (0.03ft)

Earth is Dynamic

- Not only does the earth
  - Orbit
  - Spin
  - Wobble
- It also Modulates & changes shape

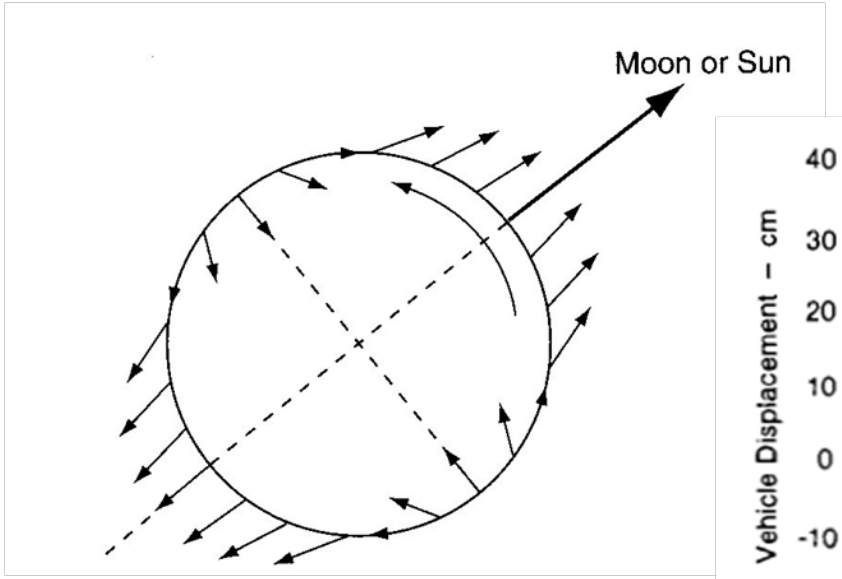
Dynamic Earth

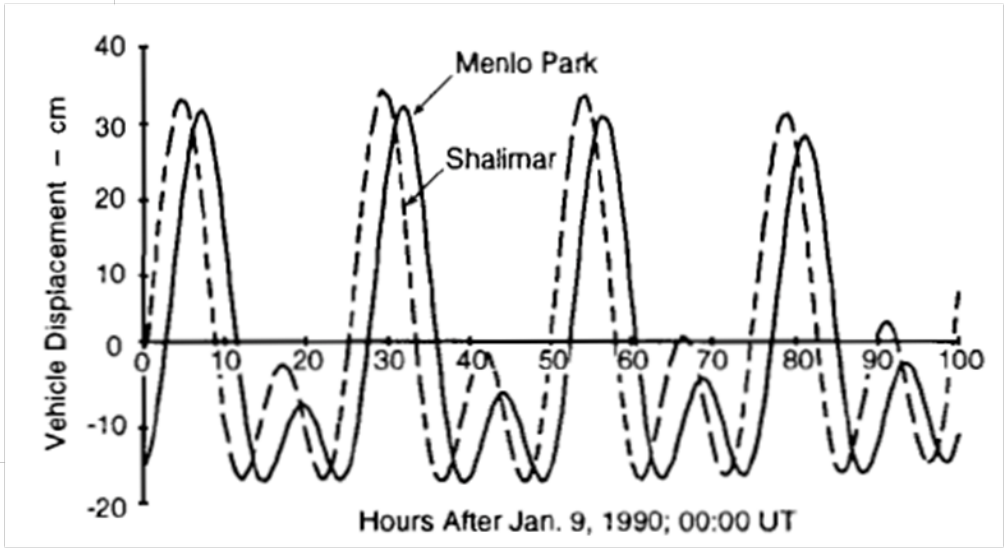
- Plate Tectonics
- San Andreas Fault



Tides

- Earth Tides
  - The earth's surface elevation changes due to
    - Forces of attraction between earth, moon & sun





Subsidence

- More then 17,000 Square miles in 45 states
  - Have been directly effected by subsidence
  - San Joaquin Valley
    - Dropped 30 feet in 75 years

Other rapid impacts

- Earthquakes
- Volcanos

Haiti

Mt. St. Helens

Paso Robles

Not to Mention

- Slides

Positioning on the Earth's surface

- Topographic Surface
- Ellipsoidal Surface
- Geoid Surface

Earth's Shape

- Earth is best represented as an
  - Oblate triaxial Ovaloid
- Earth is generally mathematically represented as an oblate spheroid
  - Ellipsoid of Revolution

Datums -

- A Geodisist way to look at the earth
  - Datum is a mathematical model and parameters that define and fix a coordinate system that is realized by measurements between and positions assigned to a reference frame of physical monuments

Datums we like?

- NAD 27
- NGVD 29
- NAD 83
- NAVD 88
- WGS 84

How we make datums workable

- Projections
  - Convert 3D model to 2D model
- Coordinate Systems
  - Series of Projections

What Datum Systems Use

- GPS
  - WGS84 [G1150]
- National Spatial Reference System
  - NAD83 (NSRS2007)
- CORS *(Official)*
  - ITRF00
  - NAD83(CORS96)
- OmniStar
  - VBS - NAD83
  - HP & XP - ITRF2005

Who Uses What Coordinate System

- Land Surveyors
  - NAD83 - State Plane Coordinates
- Geophyisists
  - ITRF 2005 or IGS05
- Military
  - WGS84
- Earthquake Group (North America)
  - SNARF
- People who don’t care about high precision
  - UTM
- People in California who don’t care about high Precision
  - Teale Albers

Datum Positions

- NAD83
  - Tied to the North American Plate
  - Adjustments
    - 1986 (Original)
    - 1991.35 (HARN/HPGN/1992)
    - NSRS2007
- WGS84
  - Tied to a worldwide framework
  - Adjustments
    - G730
    - G1150

How do we relate to NAD83

- We use the National Spatial Reference System (NSRS)
  - 300,000 Horizontal Control Points
  - 600,000 Vertical Control Points
  - National Geodetic Surveys (NGS) has
    - Data sheets
      - Coordinate values for Position
      - Datum Position
      - Projection Position

How do we relate to WGS 84

- WGS 84
  - For Civilians
    - Use GPS
  - Can use Transformation software to “compute” value from NAD83 Position
    - Transformations are estimations

California Geographic Information Association

- Geodetic control provides a common reference system for establishing coordinates for all geographic data. All NSDI framework data and users‘ applications data require geodetic control to accurately register spatial data. The National Spatial Reference System is the fundamental geodetic control for the United States.

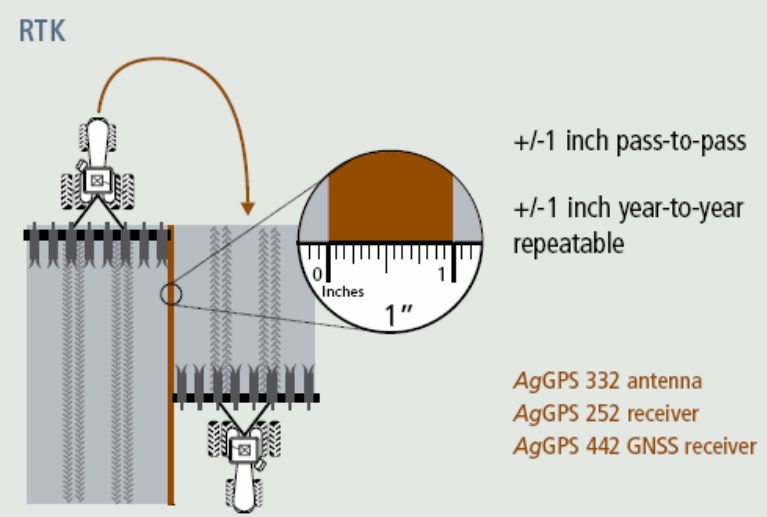
From the California Geospatial Framework Data Draft Plan

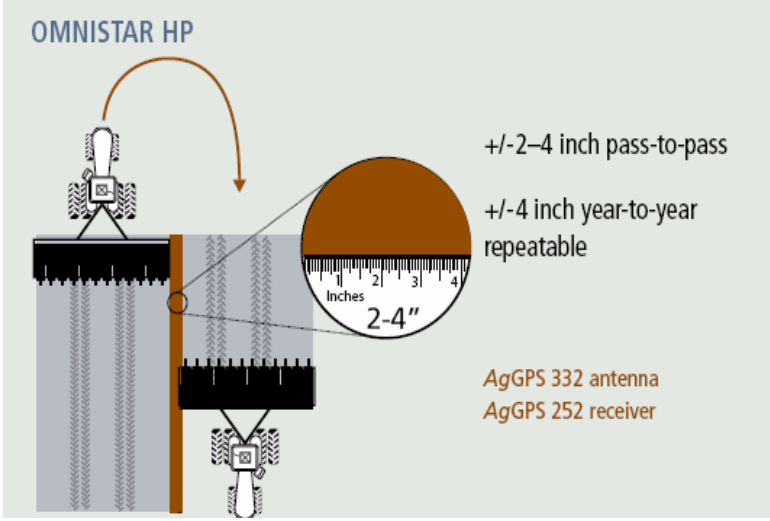
Positions of Monterey

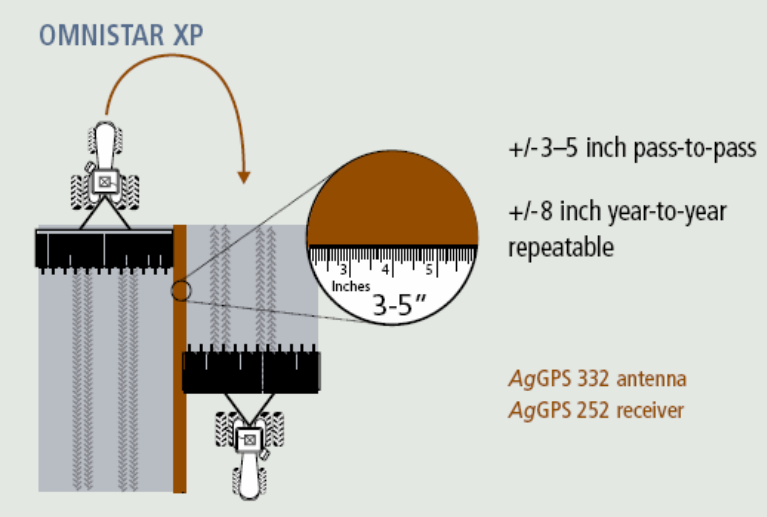
Back to the Original Question

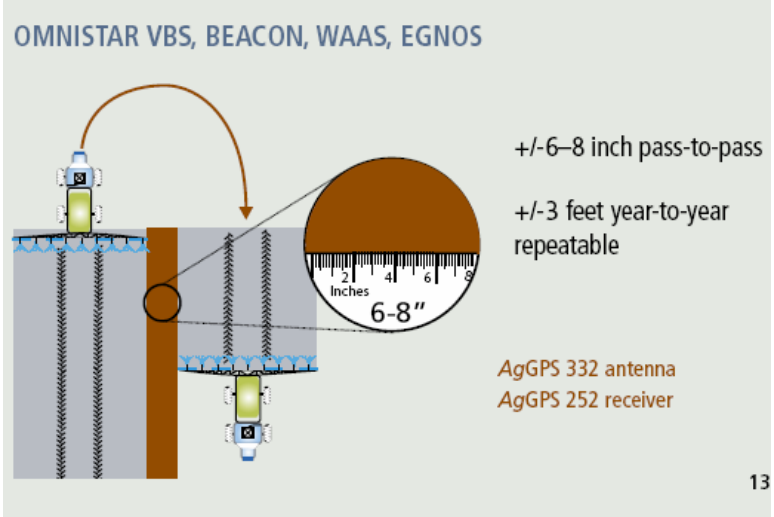
- Can I get Repeatability
- Can I get 1 foot repeatability over 10 years
  - If I use OmniStar
    - No
  - If I use Deere StarFire
    - No
  - If I use NGS NSRS
    - Maybe not
  - If I use CORS Station
    - Maybe not
  - If I use City of SLO Network
    - Possibly
  - If I use my own Local Control
    - Possibly

Not everyone agrees with me









The National Geodetic Survey 10 year plan
Mission, Vision and Strategy
2008 – 2018

- ***Official NGS policy as of Jan 9, 2008***
  - ***Modernized agency***
  - ***Attention to accuracy***
  - ***Attention to time-changes***
  - ***Improved products and services***
  - ***Integration with other fed missions***
  - ***Vetted through NSPS/AAGS***

- ***2018 Targets:***
  - ***NAD 83 and NAVD 88 re-defined***
  - ***Cm-accuracy access to all coordinates***
  - ***Customer-focused agency***
  - ***Global scientific leadership***

Borrowed from David Doyle's
Fundamentals of the National Spatial
Reference System

PREDICTED POSITIONAL FOR CHANGES DATUMS IN 2018 (Computed at R 15 (pid HV1789)

HORIZONTAL = 1.06 m (3.5 ft)
ELLIPSOID HEIGHT = - 1.30 m (- 4.3 ft)
Predicted with HTDP

ORTHOMETRIC HEIGHT = - 0.39 m (- 1.3 ft)
Predicted with HTDP and USGG2003

Borrowed from David Doyle's Fundamentals of the National Spatial Reference System

Repeatability with NSRS

- Repeat a position I established in 1992
  - In 1992 used NAD83(1991.35)
- Option 1
  - Tie into 2007 Control (Say Monterey)
  - Use Horizontal Time Dependent Positioning Software (HTDP)
    - Convert today's coordinate to 1992
- Option 2
  - Use the control and coordinates that were originally used

Monterey

- What if I am using City Control to tie into NSRS

Pt.No.	Northing	Easting	General Locatic
8201	2303632.897	5772249.792	MONTEREY

;SPC CA 5 - 2,303,634.87 5,772,248.28

Difference of 2.2ft 1.5ft

```
1        National Geodetic Survey,    Retrieval Date = FEBRUARY  7, 2010
 FV1478 ***********************************************************************
 FV1478  DESIGNATION -  MONTEREY
 FV1478  PID         -  FV1478
 FV1478  STATE/COUNTY-  CA/SAN LUIS OBISPO
 FV1478  USGS QUAD   -  SAN LUIS OBISPO (1994)
 FV1478
 FV1478                        *CURRENT SURVEY CONTROL
 FV1478  ______________________________________________________________________
 FV1478* NAD 83(2007)-  35 17 37.70262(N)    120 38 44.37447(W)      ADJUSTED
 FV1478* NAVD 88     -       141.5    (meters)     464.      (feet)  GPS OBS
 FV1478  ______________________________________________________________________
 FV1478  EPOCH DATE  -         2007.00
 FV1478  X           -  -2,656,570.418 (meters)                      COMP
 FV1478  Y           -  -4,483,856.208 (meters)                      COMP
 FV1478  Z           -   3,664,581.552 (meters)                      COMP
 FV1478  LAPLACE CORR-           4.08  (seconds)                     USDV2009
 FV1478  ELLIP HEIGHT-         106.886 (meters)          (02/10/07) ADJUSTED
 FV1478  GEOID HEIGHT-         -34.58  (meters)                      GEOID09
 FV1478
 FV1478  ------- Accuracy Estimates (at 95% Confidence Level in cm) --------
 FV1478  Type    PID    Designation                      North   East  Ellip
 FV1478  ----------------------------------------------------------------------
 FV1478  NETWORK FV1478 MONTEREY                           0.94   1.43   8.39
 FV1478  ----------------------------------------------------------------------
 FV1478
 FV1478.The horizontal coordinates were established by GPS observations
 FV1478.and adjusted by the National Geodetic Survey in February 2007.
 FV1478
 FV1478.The datum tag of NAD 83(2007) is equivalent to NAD 83(NSRS2007).
 FV1478.See National Readjustment for more information.
 FV1478.The horizontal coordinates are valid at the epoch date displayed above.
 FV1478.The epoch date for horizontal control is a decimal equivalence
 FV1478.of Year/Month/Day.
 FV1478
 FV1478.The orthometric height was determined by GPS observations and a
 FV1478.high-resolution geoid model.
 FV1478
 FV1478.The X, Y, and Z were computed from the position and the ellipsoidal ht.
 FV1478
 FV1478.The Laplace correction was computed from USDV2009 derived deflections.
 FV1478
 FV1478.The ellipsoidal height was determined by GPS observations
 FV1478.and is referenced to NAD 83.
 FV1478
 FV1478.The geoid height was determined by GEOID09.
 FV1478
 FV1478;                      North         East      Units Scale Factor Converg.
 FV1478;SPC CA 5      -   702,149.314 1,759,384.795   MT  0.99996689   -1 30 29.0
 FV1478;SPC CA 5      - 2,303,634.87  5,772,248.28    sFT  0.99996689   -1 30 29.0
 FV1478;UTM  10       - 3,908,168.028   714,086.906   MT  1.00016487   +1 21 38.8
```

What do we do?

- Precise location requires defining
  - Datum
  - Adjustment
  - Date
- State Law requires certain actions if indicating using NAD83 or NSRS data
  - Tie into a minimum of two B order or better control
  - Use the epoch as defined by NGS for those control points

Where are we going

- We don’t know
  - There are groups like
    - UNAVCO
    - NGS
    - NGA
  - That are actively monitoring Datum and earth movement
    - Through CORS and other Stations
- There has been talk of getting rid of NAD83
  - In favor of ITRF or something else
  - It seems to be likes meters