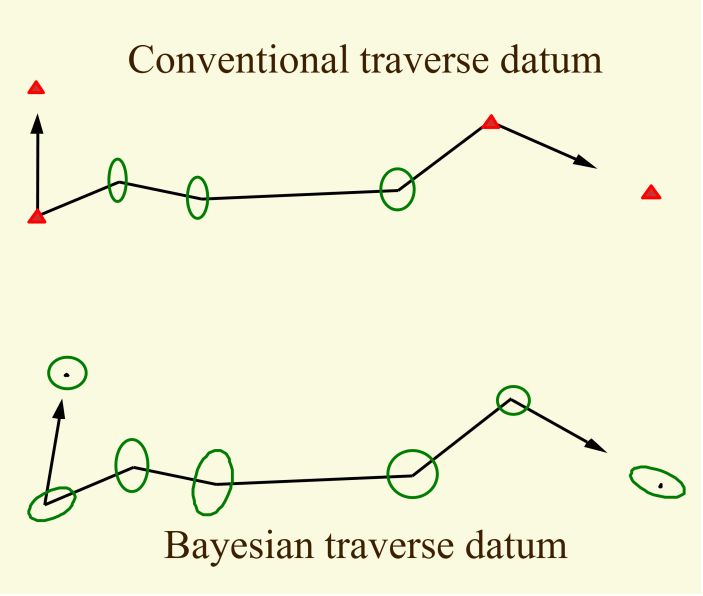
least squares

- What are the constraints for different survey jobs?
  - These are what need to be held fixed. Can be:
    - Minimum constrained: enough to avoid crashing at matrix inversion (datum defect)
    - Over constraints: possible distortion if there are errors in the fixed coordinates. Shows errors if fixed coordinates are good.

TABLE 4.1 Minimum datum constraints

Type of observations	Rank defect	Examples of what to hold fixed
Levelling, ΔHs	1	Height of 1 point
2D Triangulation, directions	4	E and N of 2 points
2D Trilateration, distances	3	E and N of 1 point & azimuth of 1 line
2D network or traverse, distances and directions	3	E and N of 1 point & azimuth of 1 line or EN of 1 pt and E or N of another pt
2D network or traverse, distances, directions and azimuths	2	E and N of 1 point
3D network, ΔHs, directions, slope distances, and ZAs	4	ENH of 1 point & azimuth of 1 line

    - If nothing is held fixed, then it is considered a free net.
- What are the applications of free nets?
  - With no parameters or observations held fixed:
    - EEs are more spread throughout points. More like relative error ellipses.
    - Smaller residuals as network is able to adjust and not affected by large errors in fixed coords. No large datum biases.
  - Involves scaling, rotating and shifting the network, utilising **Caspary's Method**.
  - Typically applied to high precision, engineering surveys with local datums, but NOT used for control surveys on MGA (or similar)
- What are some advanced least squares techniques?
  - **Bayesian Least Squares**: parameters have input standard deviations and correlations.



    - All coordinates move within the vicinity of their error ellipses.
    - Similar to SCIMS NSW - GNSS CORS networks, with PU (positional uncertainty = wrt GDA2020) and LU (local uncertainty. = wrt nearby marks)

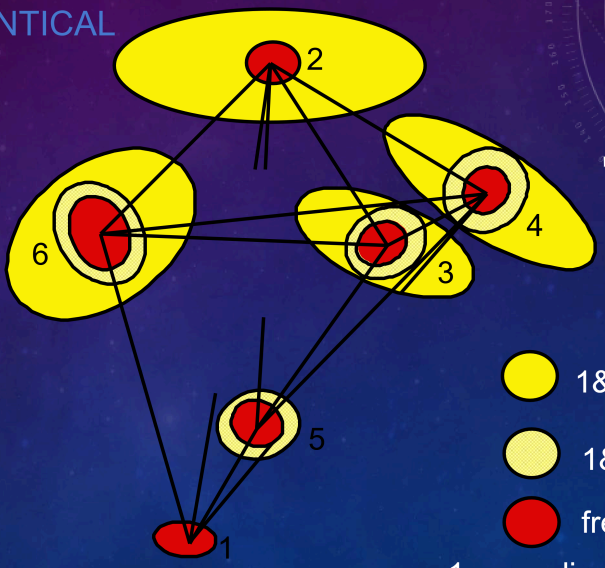
    - Can be more realistic as fixed coordinates are imperfect and have some uncertainty, even if the standard deviations and error ellipses are slightly higher.
- **Minimum sum of v/s** (L1 norm, or robust adjustments)
    - Able to detect large outliers/gross errors from incorrect mark names, booking errors, etcs.
    - NOT suited for adjusted coordinates, and mostly crash-proof as no inversion is required. (i.e not a replacement for LS) 'Garbage in, garbage out'
- **3D Considerations**:
    - Working with distances, consider:
        - slope distances into 3D network adjustment,
        - ground mark to ground mark for GPS comparisons (Hi and Ht)
        - Map grid distance (2d surveys), ellipsoidal distance (geodetic), horizontal distance (local surveys)
    - Conversions between coordinates from one datum to another; adjusting survey networks on geodetic datums; geocentric coords (GDA) & map grid (MGA)

3D	2D + H
Lat, long, ortho or ell height	Flat earth, arbitrary coordinates & north
Map Grid E, N, ortho Ht	Horiz or grid dists, & directions
Directions, slope distances, ZA, levelling Δh, GPS	MGA one scale factor for region or line scale factors?
Software …	Heights by levelling or Δh (from ZA & dist)
	Fixit or similar

- How do error ellipses change depending on what is held fixed?
    - Very datum dependent, and affected by large **datum biases**. Error ellipses:
        - Of a point with a fixed azimuth will be very skinny, pointing towards the other fixed point.
        - Will have the semi-minor axes typically facing the fixed points, with the semi-major stretched out.

DATUM DEPENDENCE

IN EACH SOLUTION IDENTICAL DATA IS USED



2D net, input dists only