Time Prediction for Building All House Panels

$$T_{min} = \sum_{i=1}^{n} \frac{(10N_L + 7N_F + 120N_P + 20L_t + 10L_{WT} + 4L_S + 7L_W + 240HI + F_X)_i}{60P}$$

1. We precut all materials first, including sheet cutouts for doors, windows, apertures, and any other cutouts from sheet. This applies to framing, sheet, and even sill gasket, drip cap, and exterior trim.
   a. Interior panels and trim are not included, as these are done after panels are installed because they are tongue and groove
2. **Final nail-off is not included - just panel building.**
3. Total build time (in minutes) of all panels means modular panels 1 through n, where n=48 for the Rosebud model. It depends on these parameters:
   a. N_L - Number of lumber piece cuts involved in the build of panel i, where either a whole two-by lumber of its part count as 1. Each piece of lumber takes 15 seconds to pick-and-place. This includes all lumber - including exterior trim, but not panels or interior trim. For a window module - 16. To optimize this time, we have a hand cart with lumber holder modification such that a lumber picking takes one trip..
   b. N_F - Number of fasteners. This is determined by the screw schedule. Star drive screws, 3" or 3-⅛". This applies to both frame fastening and sheet fastening, assuming each fastener takes approximately 7 seconds to screw in. With 24"-48" rough screw schedule - just need 9 screws for plywood but about 3 N_L for the lumber, so about 55.
   c. N_P - Number of exterior plywood panels involved, typically 1 because each panel cannot have seams on the outside. This determines the time for exterior siding installation. These are typically 4x8 foot sheets of exterior plywood, or cutouts thereof. The process involves bringing them in from a central supply and attaching to the module being built. Panels are brought into place on a dolly. Each fit into place in 2 minutes including moving over from repository.
   d. L_t - length of tape seams in feet. This determines the water protection taping time per panel. This includes house wrap tape, but more so window/door tape. Assumes about 20 seconds per foot to cut and stick tape on. For example, a 3x5 window may have 16 feet of tape, and more on corners for about 20 feet - so 400 seconds or about 7 minutes to tape up. House wrap tape typically installs fast, but it's included here as only a small length of it is used per panel (above sill gasket cut)
   e. L_{WT} - Length of exterior window trim in feet, which determines time to install this trim. Door trim is not included. 10 seconds is the install of trim is screw time (7 sec/foot for screwing) at an 8" trim screw schedule. This is done immediately around the window and is easy to locate - so this is essentially determined by raw screwing time. For example, a 3x5 window takes 210 seconds for the trim (16' frame + 5' pseudo frame).
   f. L_S - Length of sill gasket. This involves stapling the sill gasket on one side of panel at 4 seconds per staple. Thus, 36 seconds for a 9 foot wall section.
   g. L_w - Size of window rim in feet - such as 3x5 window is 15 feet. This measures the actual window install time at 7 seconds per flange screw for a total of 105 seconds.
   h. HI - House wrap and insulation units. Just accounted as 2 for 1 housewrap and 1 insulation unit. With precut batts or rolls, this is 4 minutes for each step to insert, staple, or both, for a total of 8 minutes.
   i. F_X - Fudge factor. Any delay such as getting additional materials. Brisk walk is 350 feet per minute. Thus, one could walk 5 times back and forth in the workshop, or 2 trips for missed parts. So let's give a material mistakes cap at 4 wrong parts retrieved, or 2 minutes for 4 such trips - so F_X=120
   j. P is the number of people doing the build.

Panel Production

1. Time Predictions for Data collection
   a. This is important for detailed data collection - testing vs predictions based on number of cuts and number of steps
      i. Develop a formula for build time
   b. Spray time: based on one cup holds one liter of paint. 22 gallons total - for 88 refills. 88 refills * 3 minutes = 4.4 hours. Halve the time by using **2 sprayers! 2.2 hours** . Touchup in place. 2 minutes per spraying. 1 minute to reload and thin. Need more buckets.
      i. Paint coverage - 300-400 sf / gal. 2400 sf (2 ceilings). 19' of wall * 100 = 1900 + 2 ceilings = 2900 sf
         1. At 300/gal - need 10 gallons. 40 refills. $100.
         2. Exterior Stain - 150-300 sf / gal. exterior walls 1900 sf
            a. 150 sf / gal - need 12 gallons. *$23/gal = $276. Test coverage rate.
            b. 4:4:4 but up to 6:3:3. Seed Home 1 was 3:1:3 for Oak:Brown:Spirits, 1-3 coats for different darkness
         3. Interior Stain - 200/sf prediction. 500 sf - needs 2.5 gallons. Formula is 3:1 stain to spirits. Special Walnut stain.
2. Test Samples
   a. Sample wall joint for water infiltration - trimming the tongue-and-groove.
   b. Sample paint color
3. Special Panels - cutting all the necessary features into the panels
4. Overall Integration

Time Prediction for House Panels

According to $T_{min} = \sum_{i=1}^{n} \dfrac{(10N_L + 7N_F + 120N_P + 20L_t + 10L_{WT} + 4L_S + 7L_W + 240HI + F_X)_i}{60P}$:

The build time for an 8' window panel is 34 minutes:

1. $N_L = 16$
2. $N_F = 55$
3. $N_P = 1$
4. $L_t = 20$
5. $L_{WT} = 21$
6. $L_S = 8$
7. $L_W = 16$
8. $HI = 2$
9. $F_X = 120$

The build time for an 9' wall panel is 17 minutes:

1. $N_L = 12$
2. $N_F = 31$
3. $N_P = 1$
4. $L_t = 0$
5. $L_{WT} = 0$
6. $L_S = 9$
7. $L_W = 0$
8. $HI = 2$
9. $F_X = 60$

Build Time Calculations - 16.4 hours

- 38 plain * 17 minutes = <u>5 have apertures</u> such as vents so will need precut time.
  - 646 minutes = **10.8 hours**
- 10 complex* 34 minutes
  - 340 minutes = **5.7 hours**
- **Total:**
  - **16.5 hours prediction**
- Simplest formula: 1 hour per panel, means 48 hours
- If we use jigs - then time is 24 hours. That would be something to shoot for with inexperienced people.
- But more likely buffer - ½ hour per simple, 2 hour per complex panel.
- 14 hours for simple, 10 hours for complex. 24 hours total.
- Only if we have super organization will this be optimized:
  - 2 worktables per team - on 4x8 panels on sawhorses
  - 6 teams of 2. One person cuts materials, other person screws. Start with lumber and panels precut.