

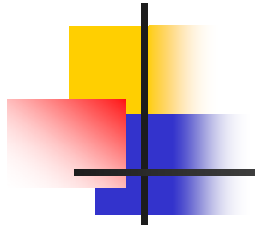


Results from Studies of the Module Set Process

Presentation to the
Quality Modular Building Task Force

October 19, 2000

Dr. Michael A. Mullens, PE - UCF



Agenda

- Background & Approach
- Findings
- Conclusions



Motivation

- At 1999 Quality Modular Buildings Task Force meeting, you asked us to study the Set & Finish process.



Set & Finish: Definitions

- Set – “placement of modular home sections on a permanent foundation”
- Set-Day – “working day when factory built modules are installed onto a permanent foundation and other critical components are assembled to comprise a weather-tight structure”
- Finish – all remaining activities required to complete the home



Primary Set & Finish Activities

- Set-Day

- Modules placed on foundation
 - Structure made weathertight
- } *4-8 hours*

- Finish

- Exterior finishing
 - Interior electrical
 - Plumbing
 - HVAC
 - Interior finishing
 - Exterior final
 - Appliances
 - Closing
- } *1-8 weeks*

Source: MHTI



Primary Set & Finish Activities

- Set-Day
 - Modules and other major components installed
 - Roof components erected
 - Ship loose shingles and flashings installed
 - Temporary waterproofing materials at vulnerable locations on sidewalls
 - Entry ways secured.

Source: MHTI



Scope

- Focus on set-day activities
- Consider finish activities performed by set crew during or immediately after module set
 - Complete siding



Objectives

- Describe how Set & Finish is being done
- Identify possible opportunities for improvement



Set Studies

- 1-3 days per study
- 3 person research team
- Monitored all set activities
- For each activity, documented:
 - Start & stop times
 - Manpower used
 - Problems encountered
 - Best practices
- Video recording of key activities



Jose



Gauhar



Mike





Set Studies

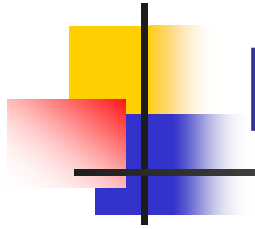
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- 3 person research team
- Monitored all set activities
- For each activity, documented:
 - Start & stop times
 - Manpower used
 - Problems encountered
 - Best practices
 - Communications/feedback
- Video recording of key activities

Elemental Data

Activity	Time		Duration	Labor	Labor	Notes
	Start	End	Hr:Min	Qty.	Hr:Min	
3/1/00						
<i>Set Module C:</i>						
Strip plastic wrap	2:16 PM	2:18 PM	0:02	1	0:02	
Strip plastic wrap		2:16 PM	2:18 PM	0:02	1	0:02
Drill holes in rim joist for crane cable & release tie-downs		2:15 PM	2:25 PM	0:10	1	0:10
Pull & secure crane cable under Module C		2:18 PM	2:33 PM	0:15	2	0:30
Set module on foundation, position & check		2:33 PM	2:45 PM	0:12	3	0:36
Remove plastic wrap		2:45 PM	2:50 PM	0:05	2	0:10

This module had been partially stripped by the builder in the staging area at the bottom of the hill.

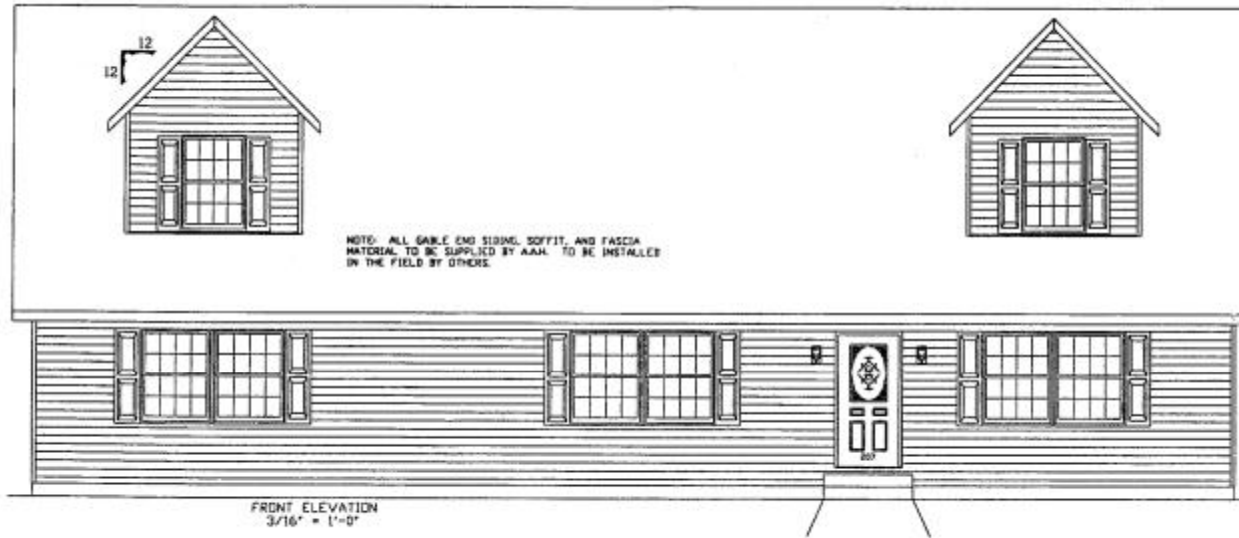
Left on due to rain.



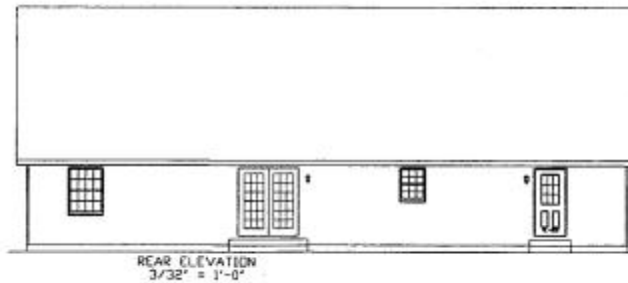
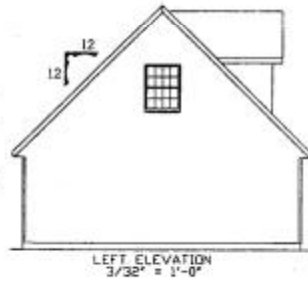
Home Design Profile

	Modules	
<u>Style</u>	<u>2</u>	<u>4</u>
Cape	4	
Ranch		1
Colonial		1

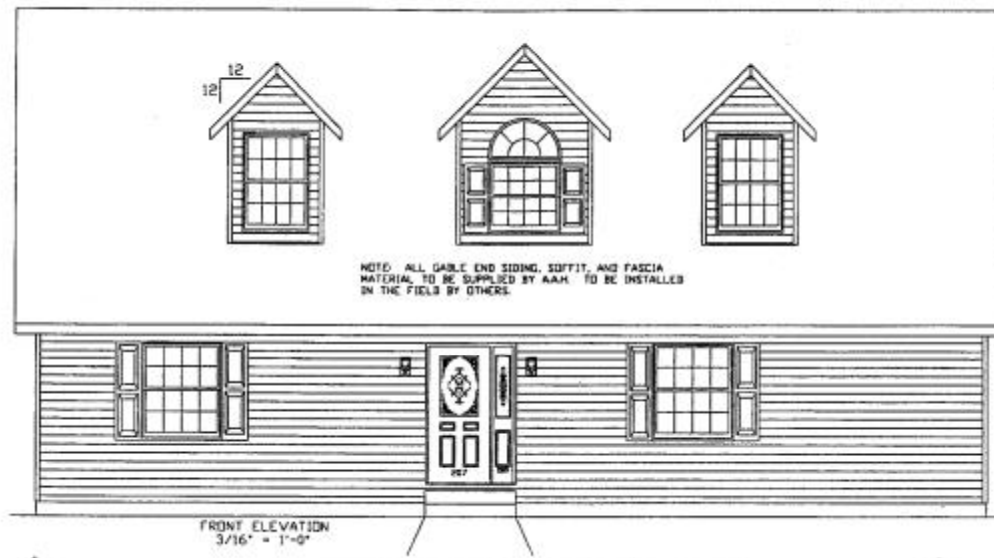
Cape: Elevation View



ROOF VENTILATION: (AREA = 1650 sq.ft.)
 REQUIRED
 1650
 300 = 5.5 sq.ft. (792 sq.in.) / 396 SOFFIT
 396 ROOF
 SUPPLIES
 SOFFIT - 22 truss spaces = 825 = 493 sq.in.
 ROOF - 7 vents = 81 sq.in./vent = 467 sq.in.



Cape: Elevation View



ROOF VENTILATION: (AREA = 1265 sq.ft)

REQUIRED:

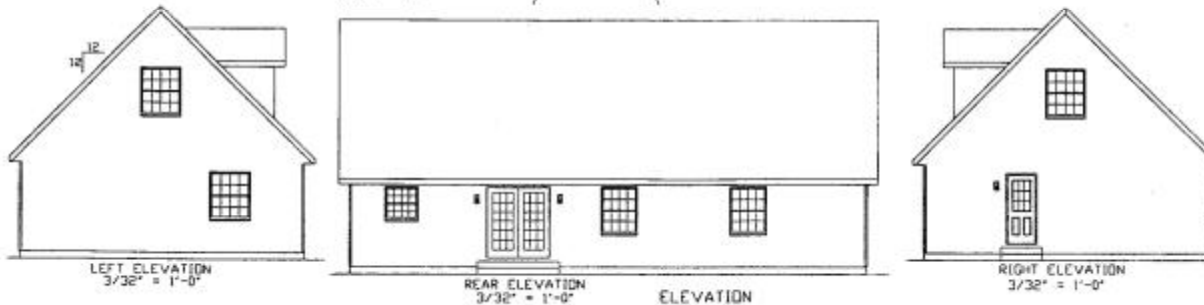
$$\frac{1265}{300} = 4.2 \text{ sq.ft. (604.8 sq.in.)} / \begin{matrix} 302.4 \text{ SDF} \\ 302.4 \text{ ROO} \end{matrix}$$

SUPPLIED:

$$\begin{matrix} \text{SOFFIT} - 18 \text{ truss spaces} \times 22.5 = 405 \text{ s} \\ \text{ROOF} - 5 \text{ vents} \times 61 \text{ sq.in./vent} = 305 \text{ s} \end{matrix}$$

FINAL
FOR PRODUCTION

0 - 100 0000



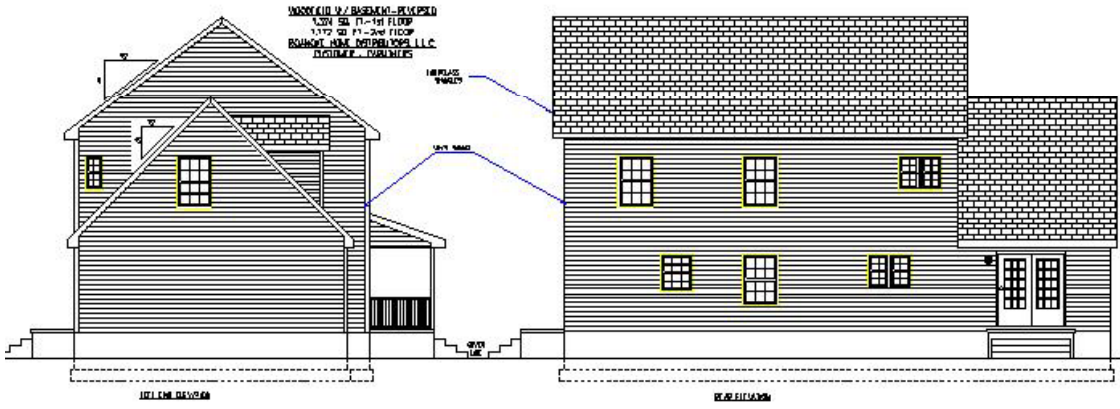
Cape: Perspective View



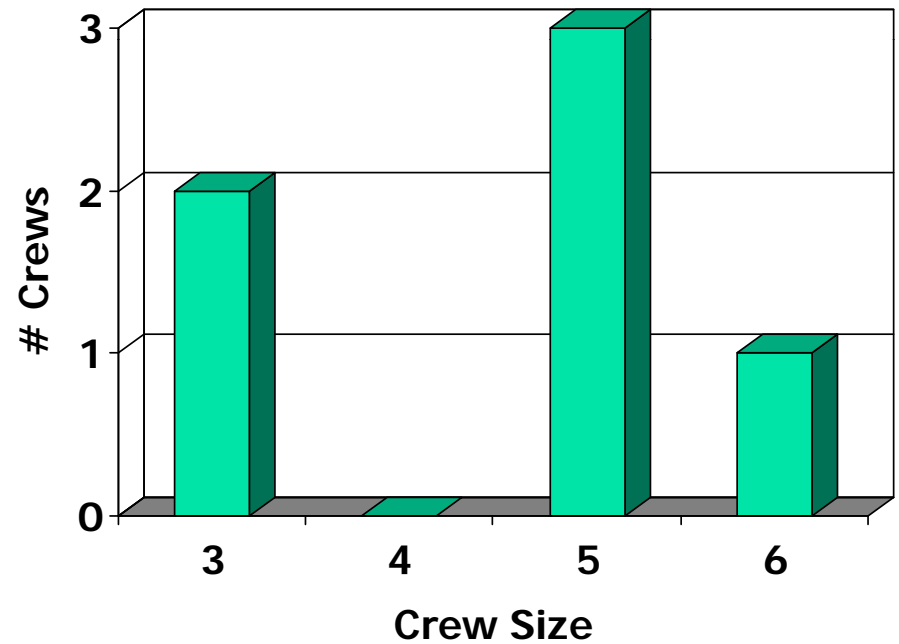
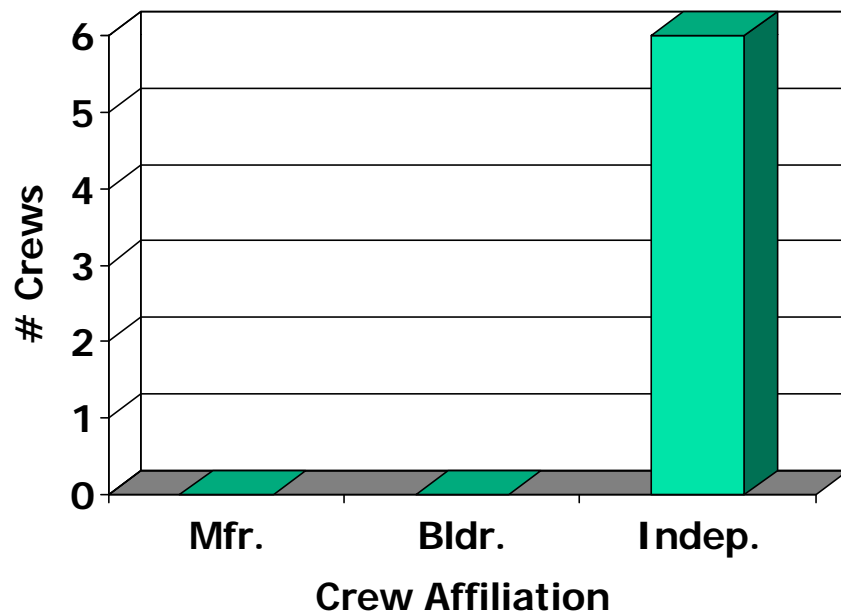
Ranch: Perspective View



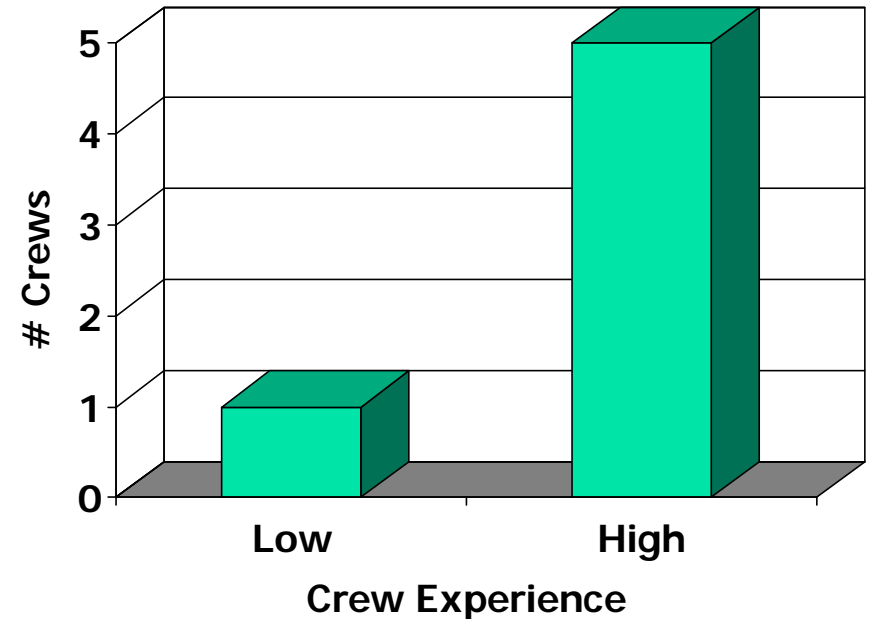
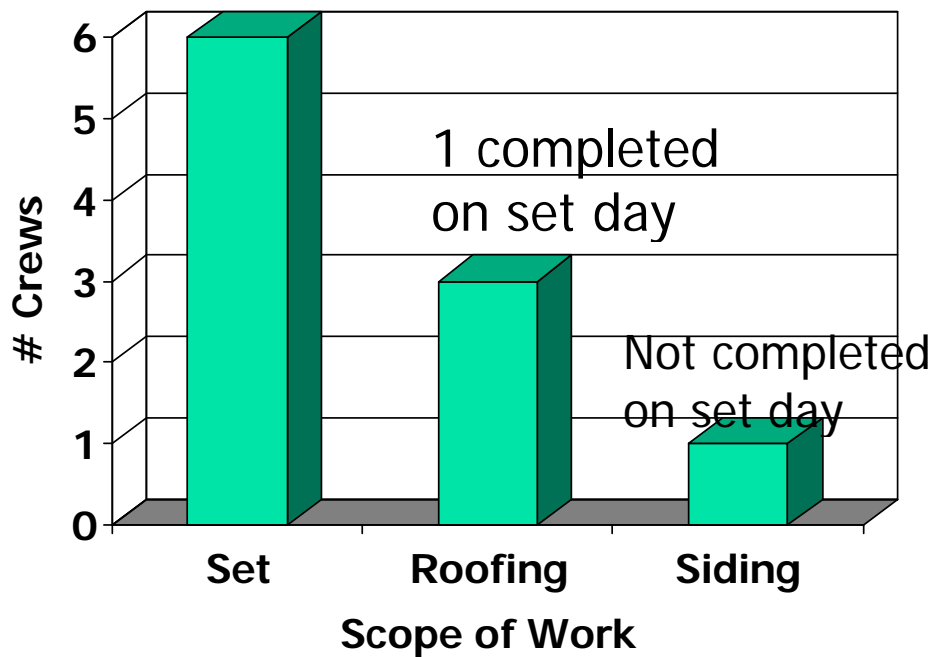
Colonial: Elevation View



Set Crew Profile: Affiliation & Size



Set Crew Profile: Scope of Work & Experience





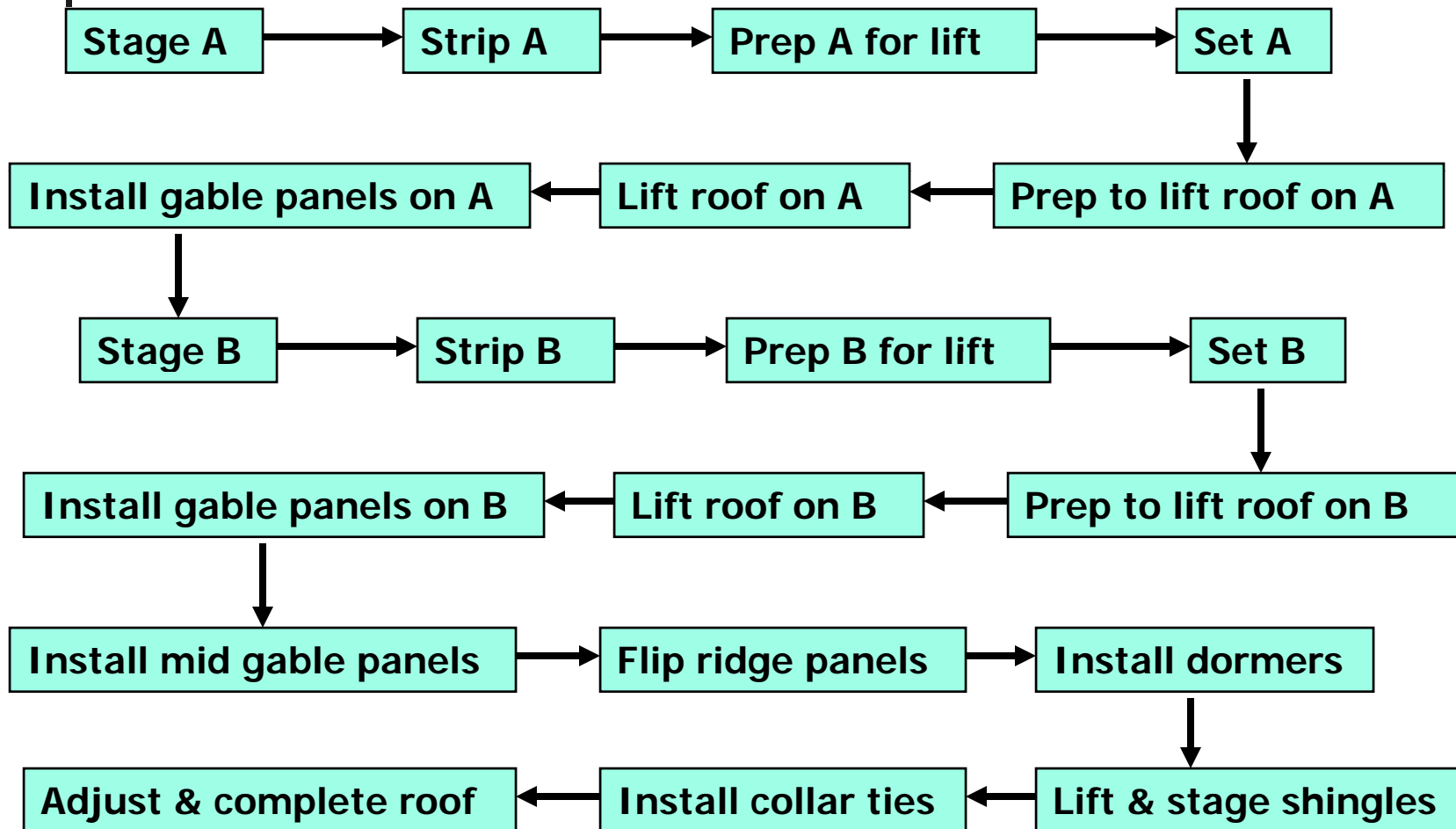
Manufacturer's Potential Role in Set & Finish Process

- Delivery only (Firm 2,3)
- Factory set crews (Firm 1)
 - Set
 - Selected finish activities (siding, drywall)
- Builder

Manufacturers that provide set services are flexible:

- Allow builders to purchase only what they need
- Supplement internal set crews with independent crews when needed

Set Process: Cape





Site Prior to Set



Staging the Module

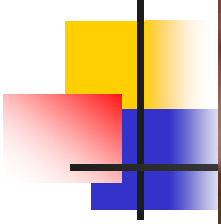


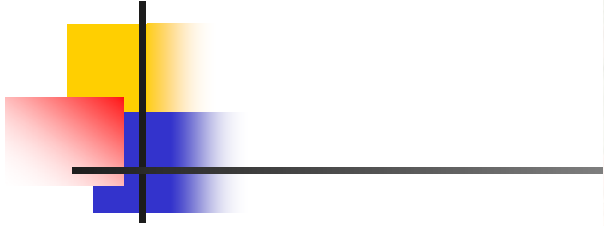
Stripping the Module



Prep for Lift







Lifting Module



Aligning Columns During Set



Lifting the Roof



Installing Gable End Panels



Installed Gable End Panel



Setting 2nd Module



Installing Attic Floor Decking



Installing Mid Gable End Panel



Flipping Ridge Panel



Installing Dormers



Installing Collar Ties



Adjust for Roof Racking



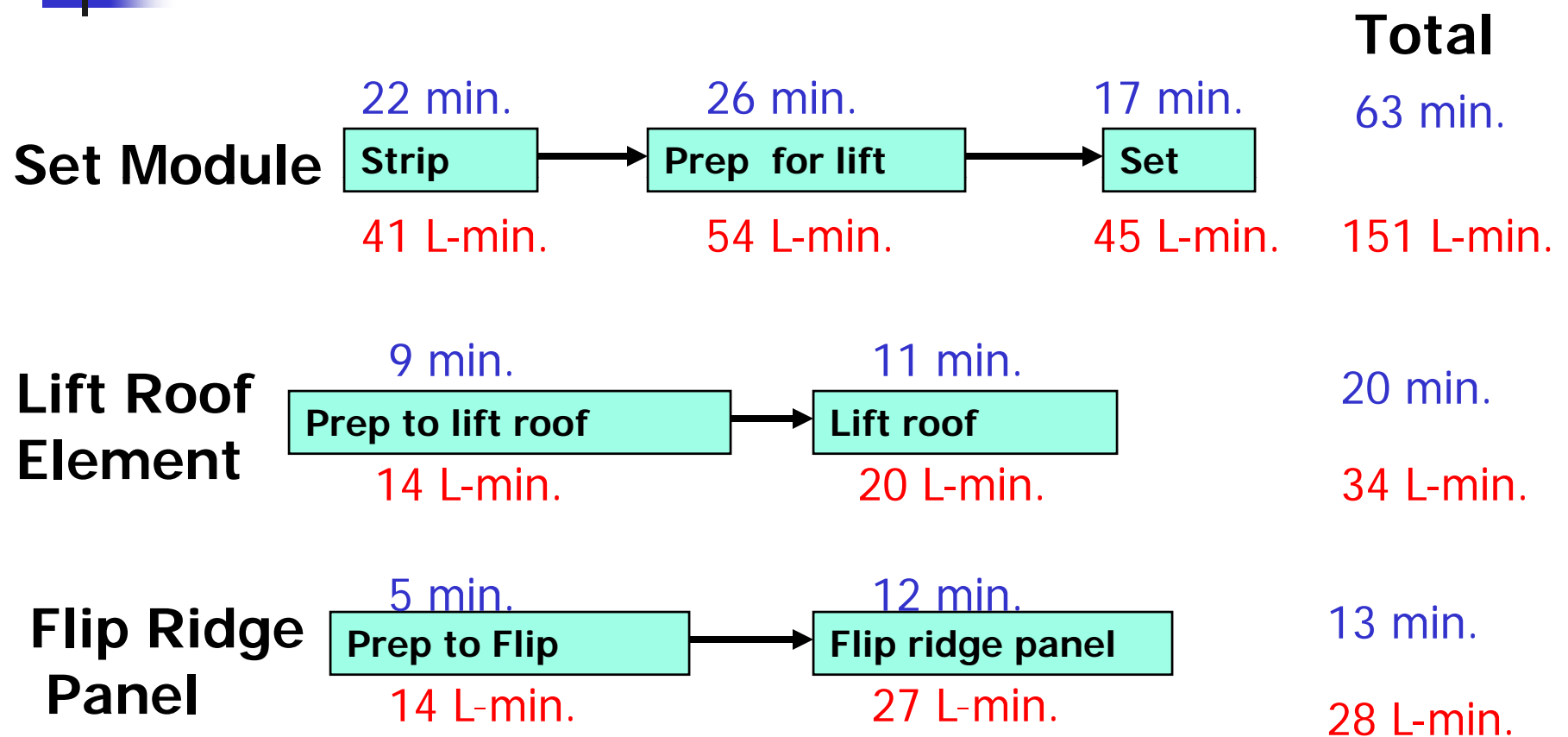
Installing Interior Walls in Attic



Completed Set

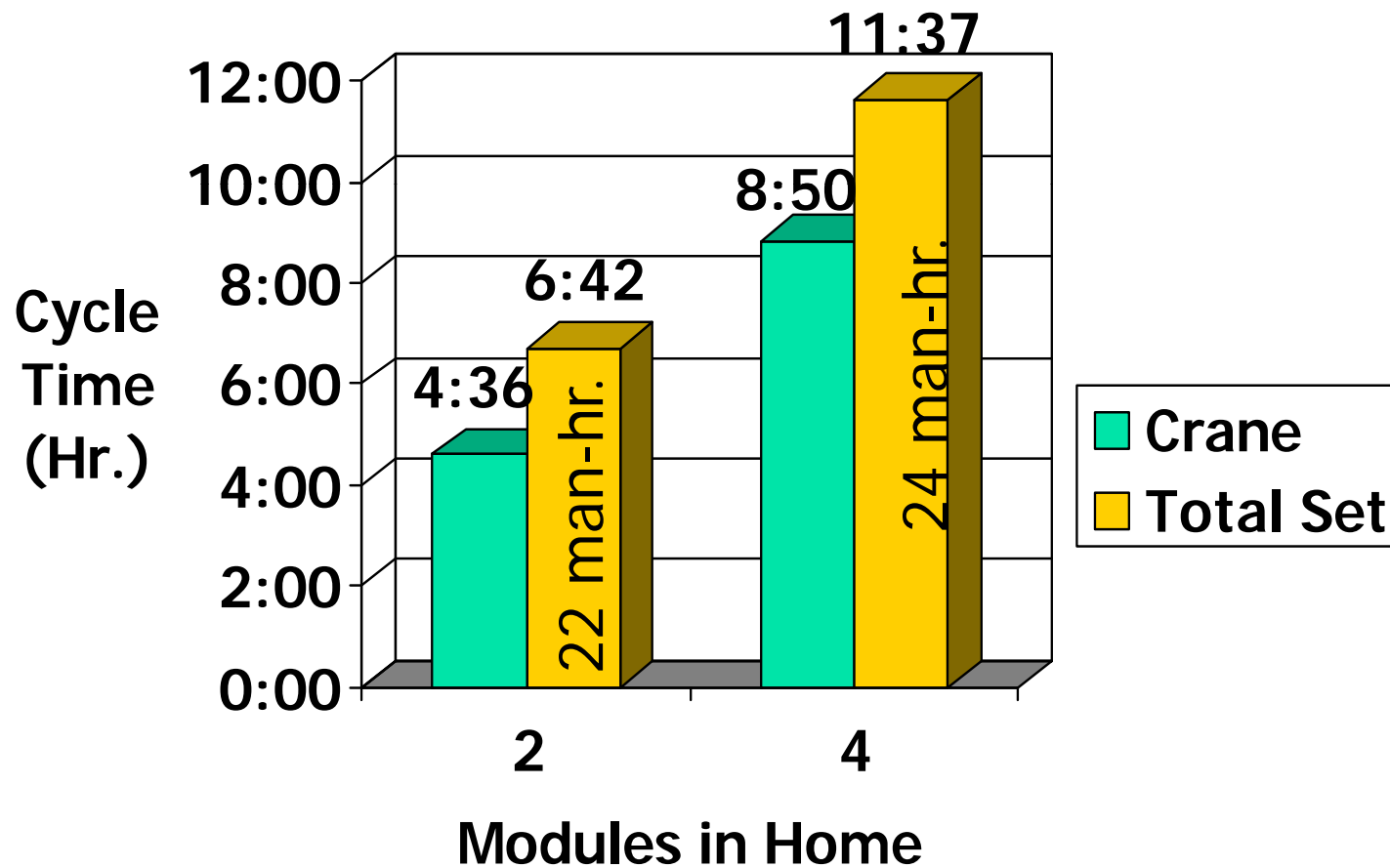


Elemental Cycle Time & Labor Productivity



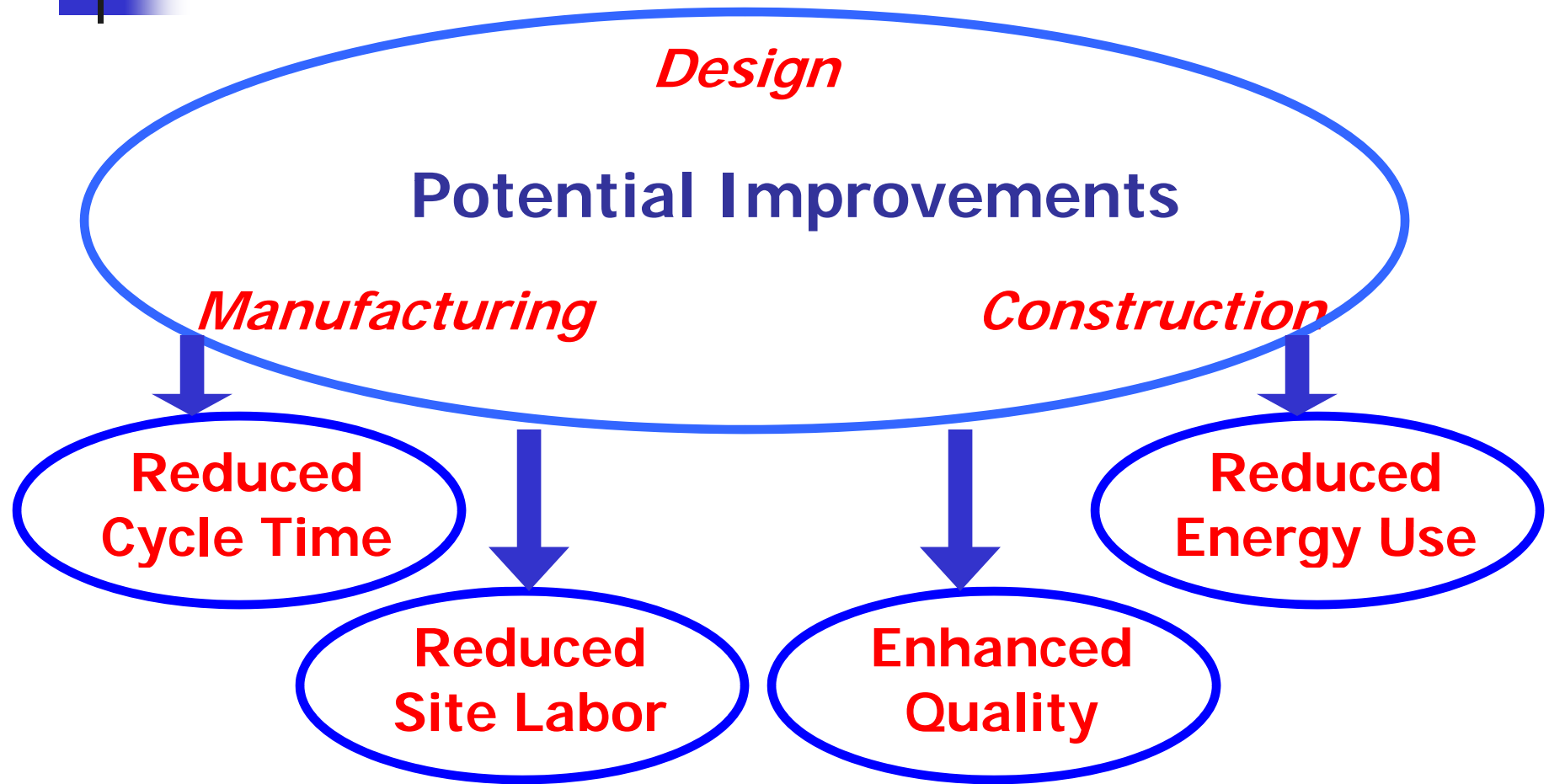
Note: Elements are not additive.

Cycle Time and Productivity





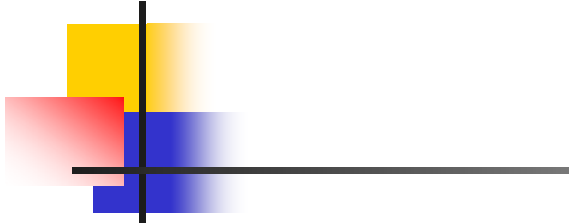
Opportunities for Improvement





Design Improvements

- Design product for ease of manufacturing & construction
 - Eliminate/combine components
 - Eliminate potential construction interferences
 - Eliminate/redesign perimeter framing around module insets
 - Allow knee wall to extend when roof is lifted



Combine Modules



Setting Module C





Setting Module D

Potential Savings:

Site Time .9 hr.

Crane Time .9 hr.

Site Labor 2.6 L-hr.

Factory Labor 5 L-hr.



Eliminate Unnecessary Components



Eliminate Unnecessary Construction Interferences



Eliminate Unnecessary Construction Interferences



Potential Savings:

Site Time .7 hr.

Crane Time .7 hr.

Site Labor 2.0 L-hr.

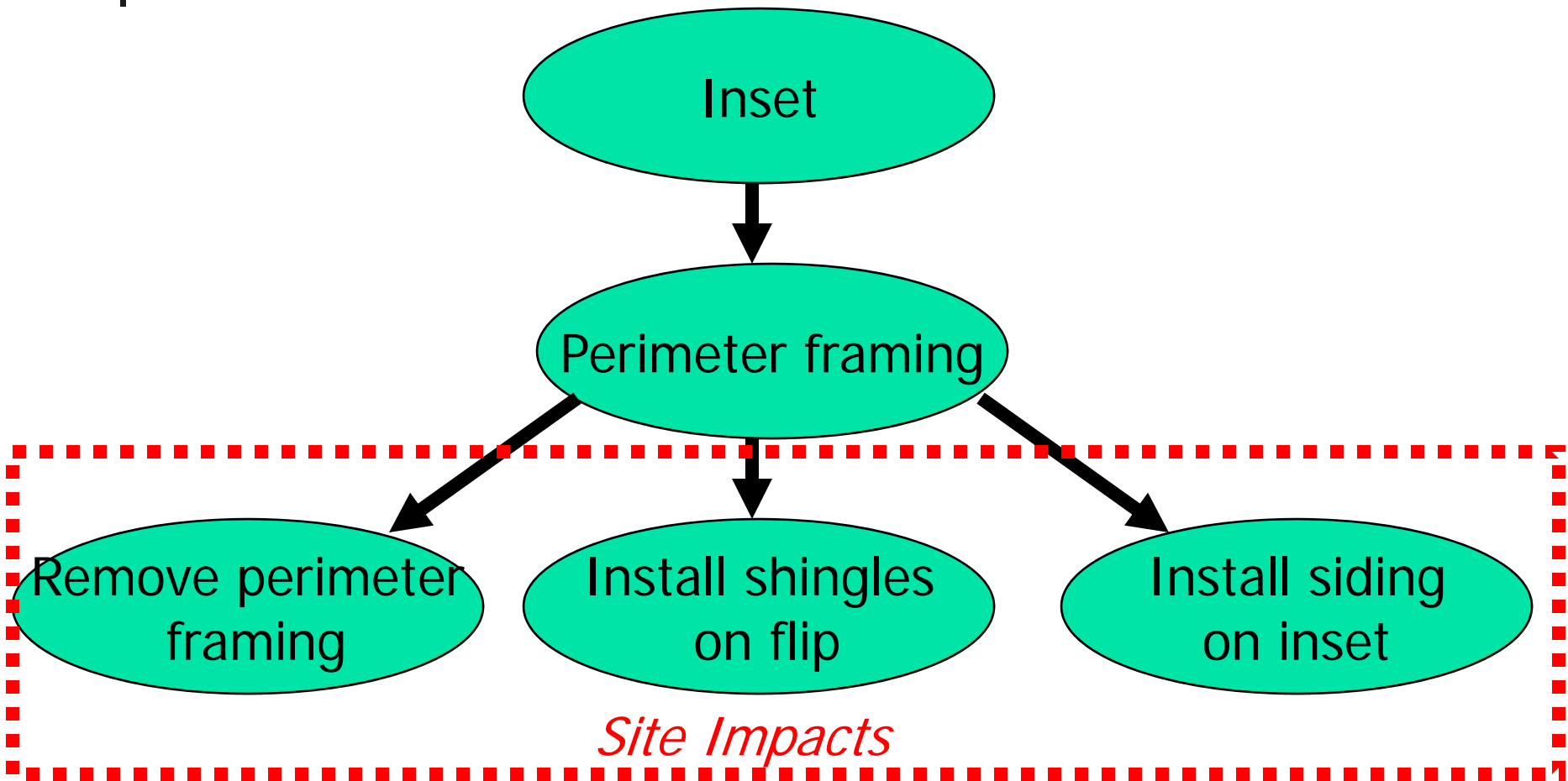
Factory Labor 0 L-hr.

Module Inset





Site Impacts of Design



Eliminate/Redesign Perimeter Framing on Module Insets



Potential Savings:

Site Time .8 hr.

Crane Time 0 hr.

Site Labor 1.3 L-hr.

Factory Labor ??



Releasing Knee Wall





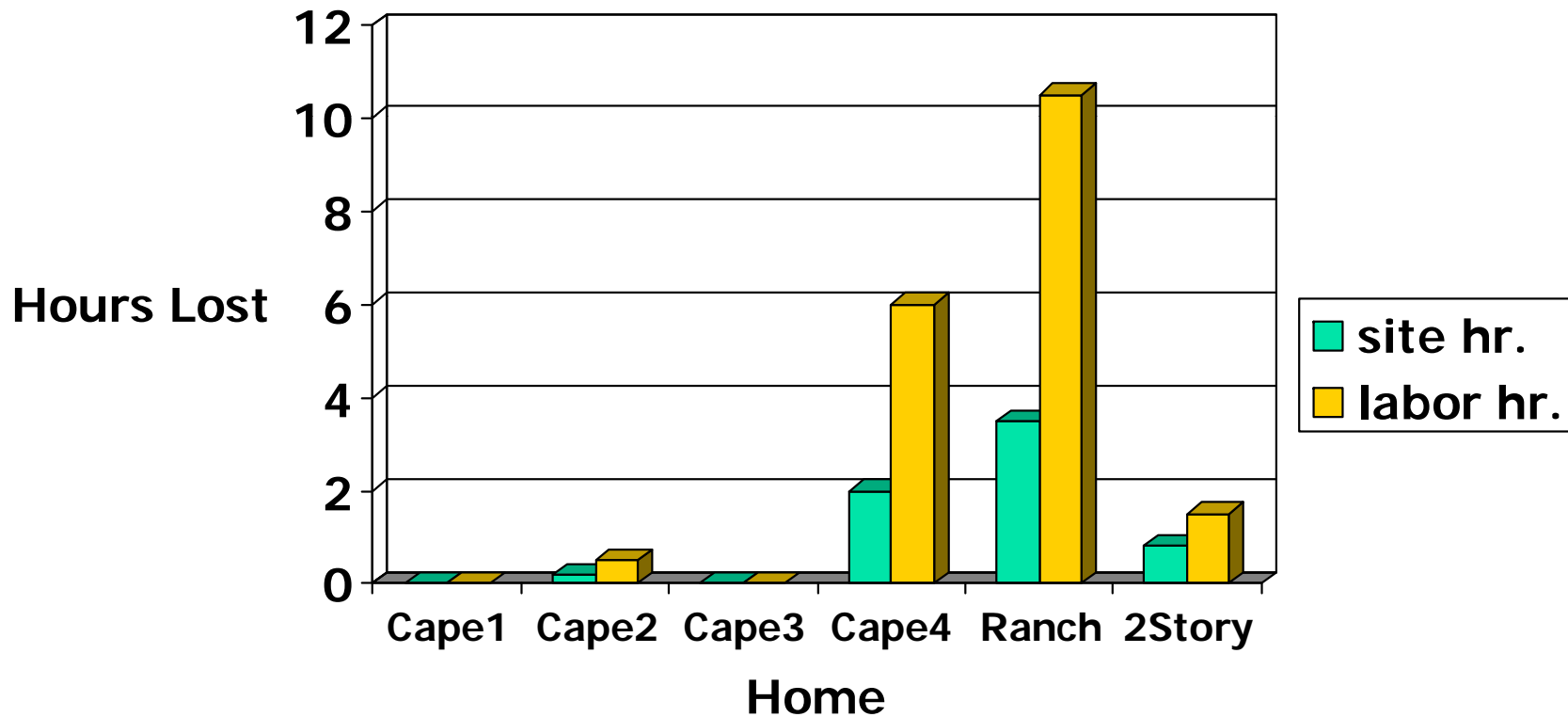
Manufacturing Improvements

- Improve quality – particularly roofs
- Move work back to the factory
 - Shingles
 - Siding
- Move some work to site

Improve Roof Quality



Lost Time Due to Roof Alignment Problems



Note: No crane time lost



Move Work from Site to Factory

- Shingles
 - Shingle flip eaves & ridges

Suggestions shift builder's cost structure

- Reduce set & finish cost on site
- Add factory labor content – increase module price
- Should reduce total costs
 - Insets
 - End walls
 - Marriage wall seal
 - Use marriage wall gasket instead of batt insulation
 - Install gasket in factory

No Shingles on Flip Eave



Potential Savings:

Site Time .5 hr.

Crane Time 0 hr.

Site Labor 1.1 L-hr.

Factory Labor -??

No Shingles on Flip Ridge



Potential Savings:

Site Time 1.5 hr.

Crane Time 0 hr.

Site Labor 5.5 L-hr.

Factory Labor -??

No Siding on 2nd Story



Potential Savings:

Site Time 6.0 hr.

Crane Time 0 hr.

Site Labor 6.0 L-hr.

Factory Labor - ??

No Siding on Inset



Potential Savings:

Site Time 2.0 hr.

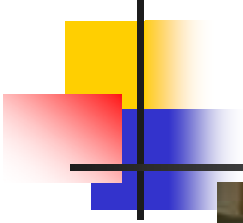
Crane Time 0 hr.

Site Labor 2.0 L-hr.

Factory Labor - ??

No Siding on End Wall





Marriage Wall Gasket: Factory Installed



Potential Savings:

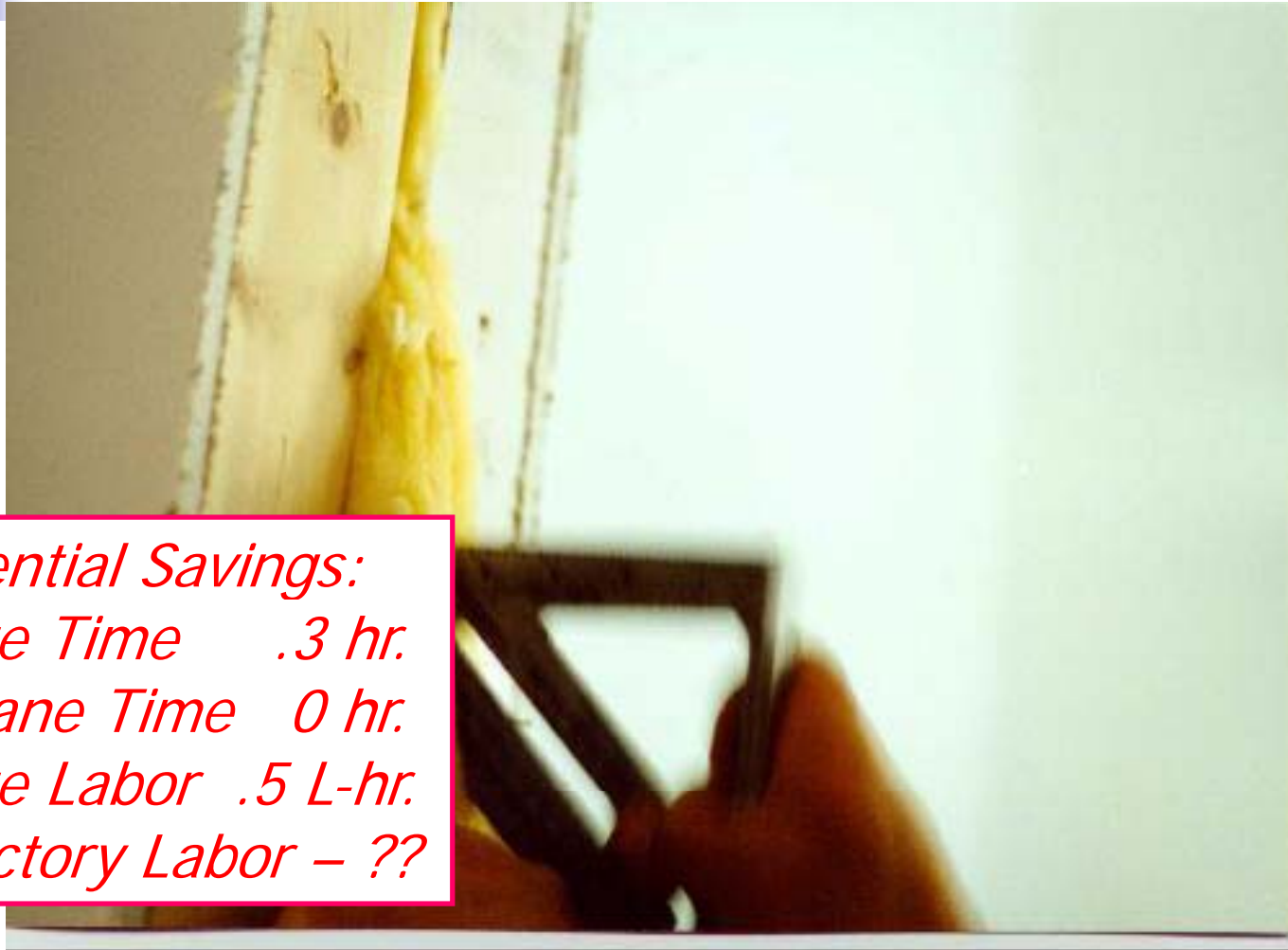
Site Time .1 hr.

Crane Time .1 hr.

Site Labor .2 L-hr.

Factory Labor - ??

Marriage Wall Sealed After Set



Potential Savings:

Site Time .3 hr.

Crane Time 0 hr.

Site Labor .5 L-hr.

Factory Labor – ??



Move Some Factory Work to Site

- Some cleaning
- Drywall finishing?



Construction Site Improvements

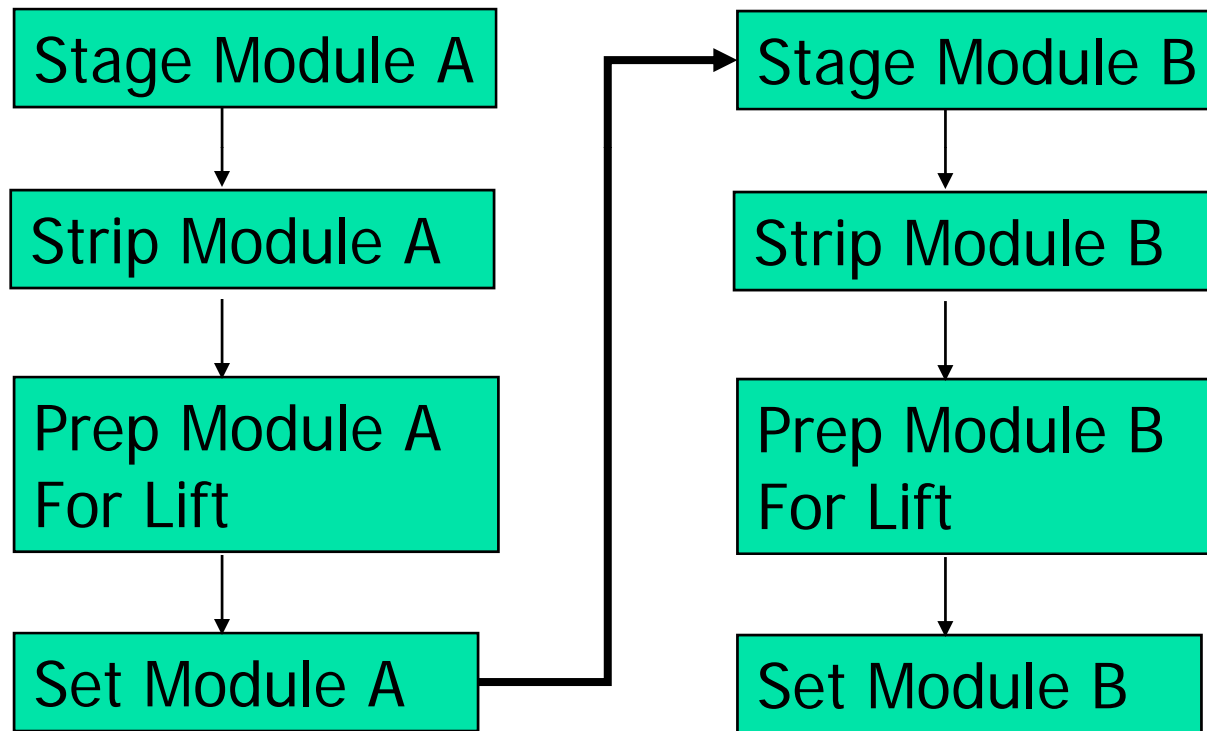
- Module staging locations
 - Provide 2 module staging locations next to crane
 - Provide pre-staging locations for modules near site
 - Confirm staging locations with crane operator
- Provide good access
- Provide a bulldozer on site to move modules
- Utilize driver to strip module



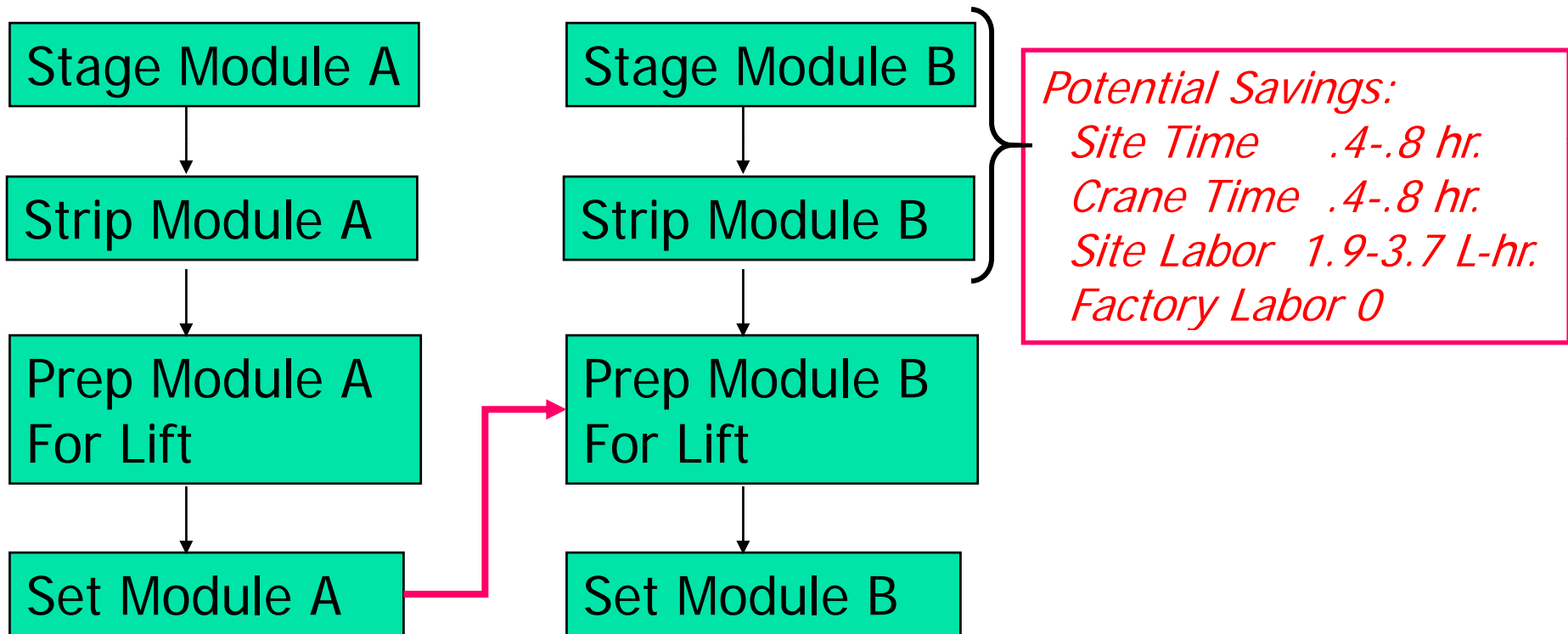
Typical Staging for 1 Module




Process Flow with 1 Module Staging Location



Provide Staging for 2 Modules Adjacent to Crane

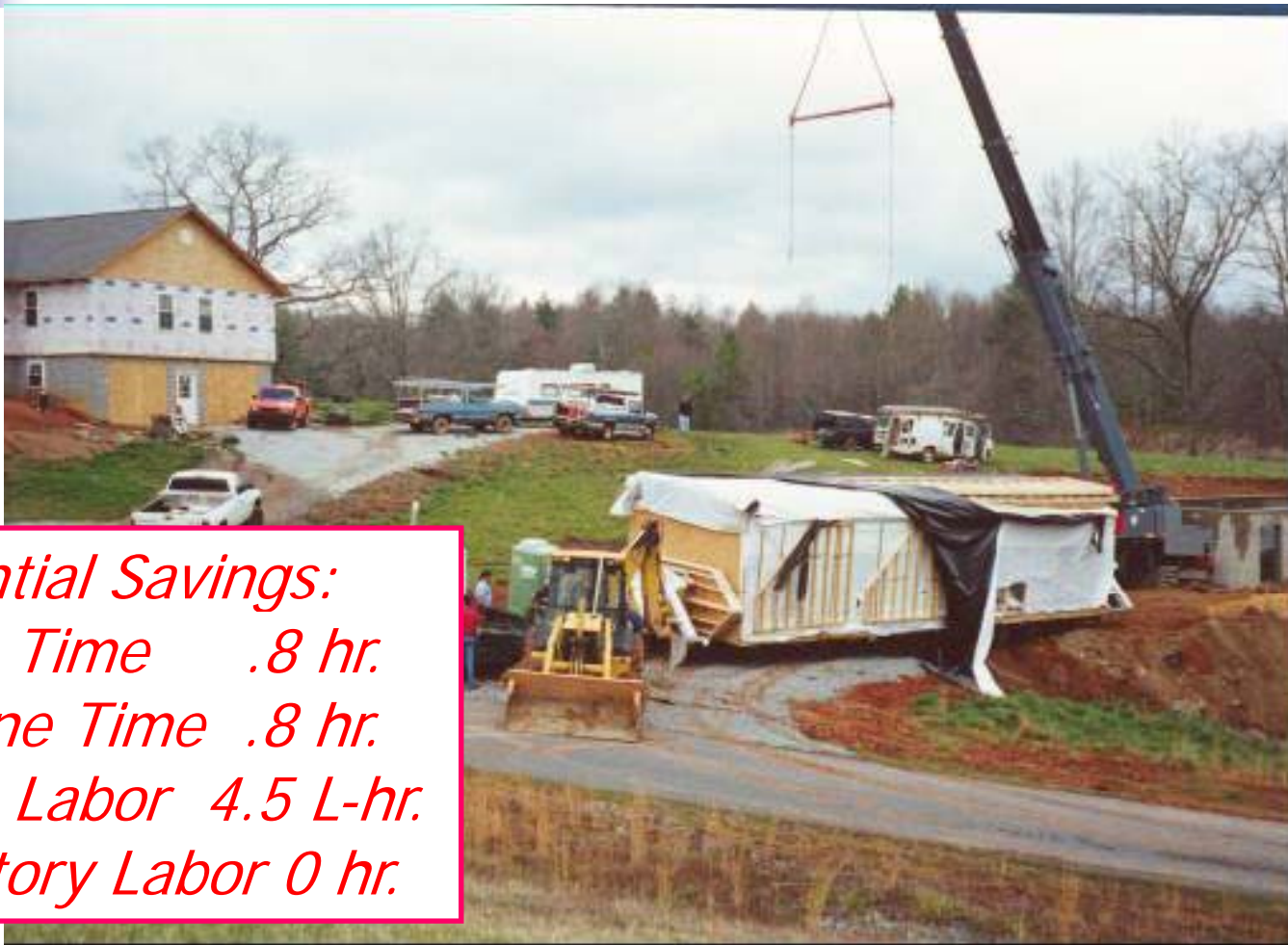




Have Crane Operator Verify Module Staging before Set-Day

- Two home sets (33%) were delayed because crane operator vetoed initial module staging locations
 - Delay 1:
 - Site time 1.9 hr.
 - Crane time 1.9 hr.
 - Labor 5.8 labor hours
 - Delay 2:
 - Site time .4-.8 hr.
 - Crane time .4-.8 hr.
 - Labor 1.9-2.7 labor hr.

Stuck! Provide Proper Access



Potential Savings:

Site Time .8 hr.

Crane Time .8 hr.

Site Labor 4.5 L-hr.

Factory Labor 0 hr.

Stuck! Provide Bulldozer



Potential Savings:

Site Time .4-.8 hr.

Crane time .4-.8 hr.

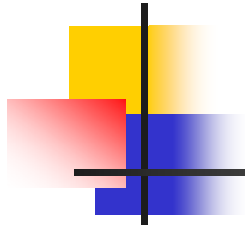
Site Labor 1.9-3.7 L-hr.

Factory Labor 0 hr.

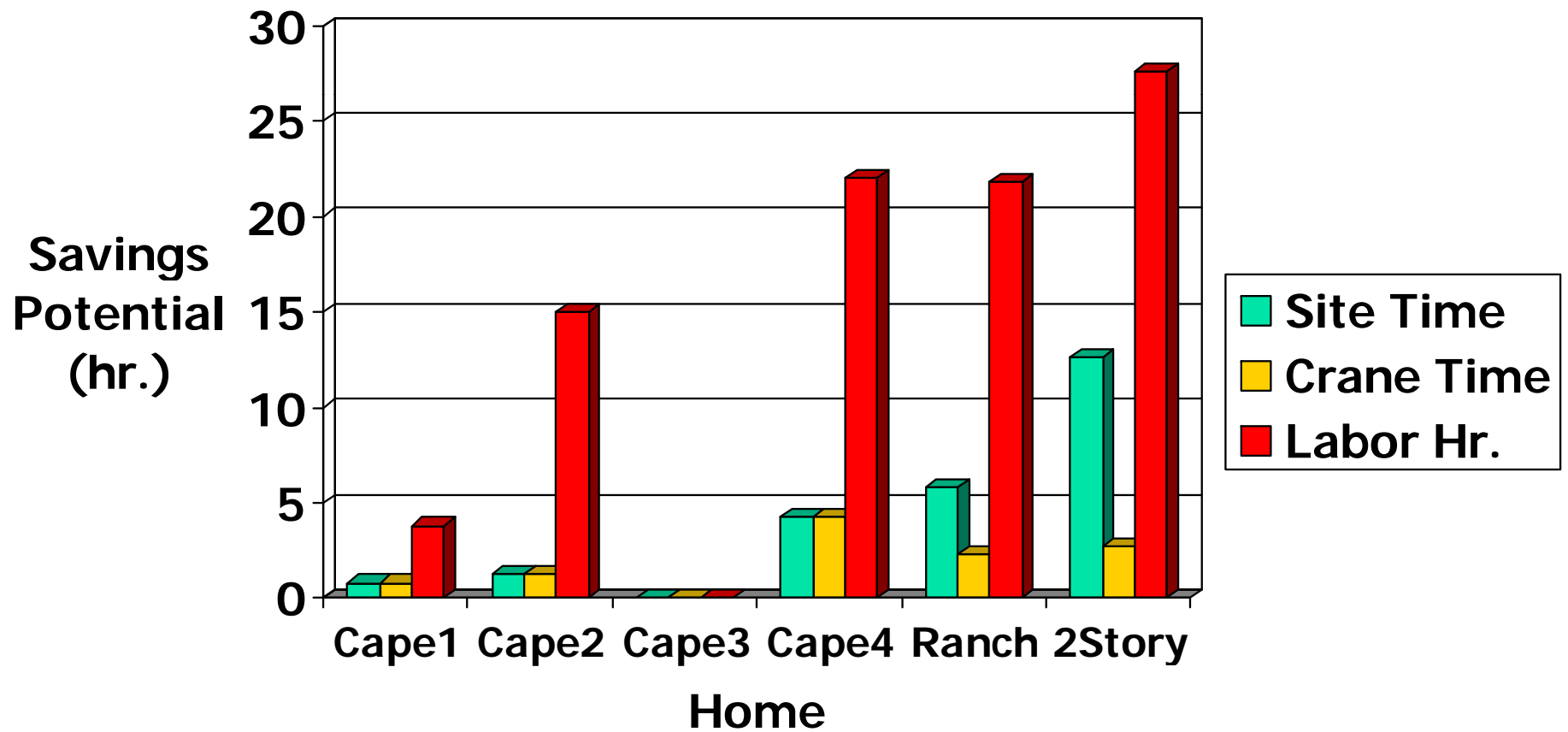


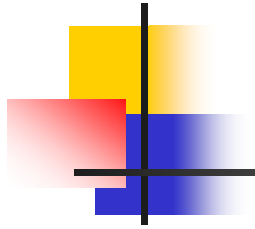
Use Driver to Help Strip Module

- Potential savings
 - Site time .7 hours
 - Crane time .7 hours
 - Labor 1.5 labor hours

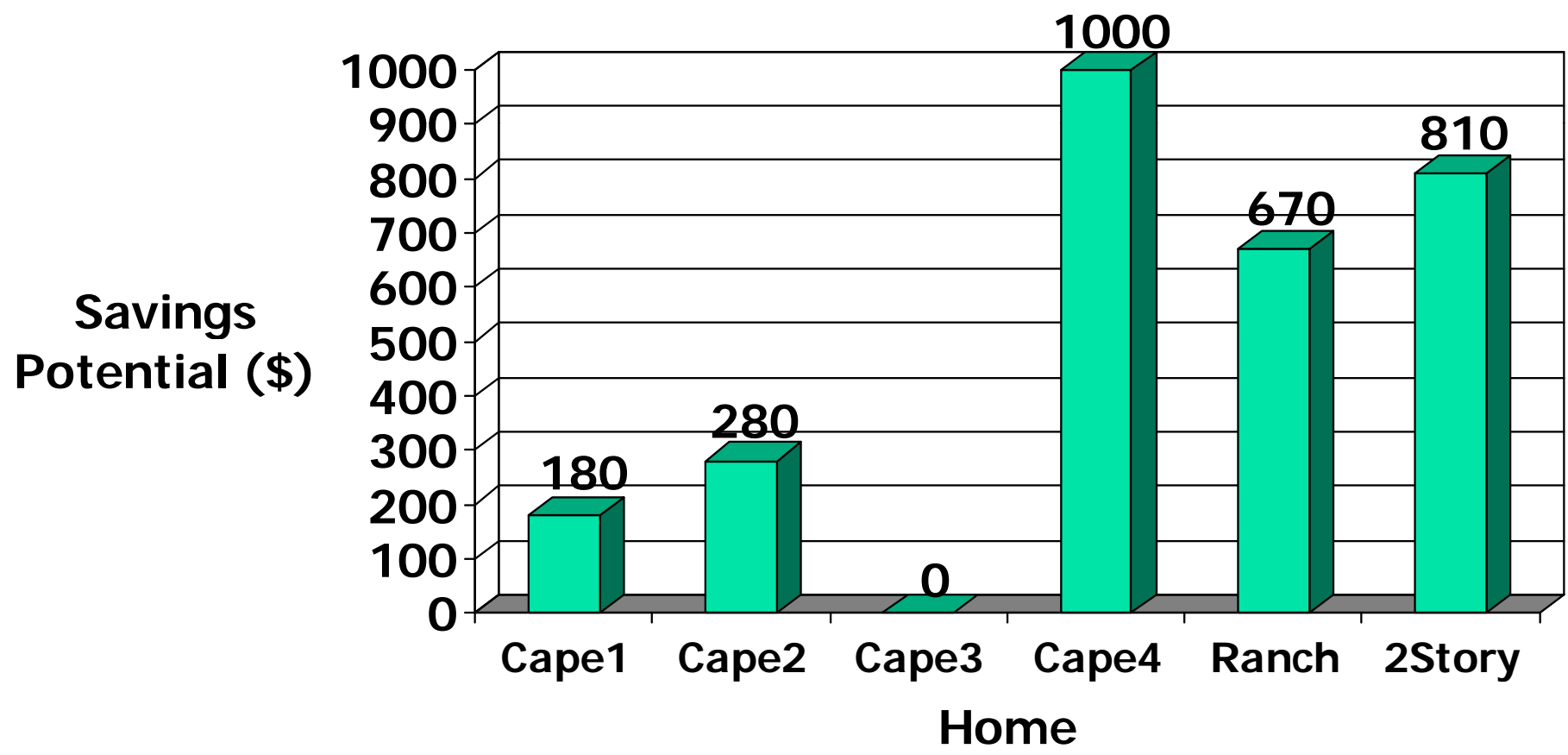


Improvement Summary





Improvement Summary





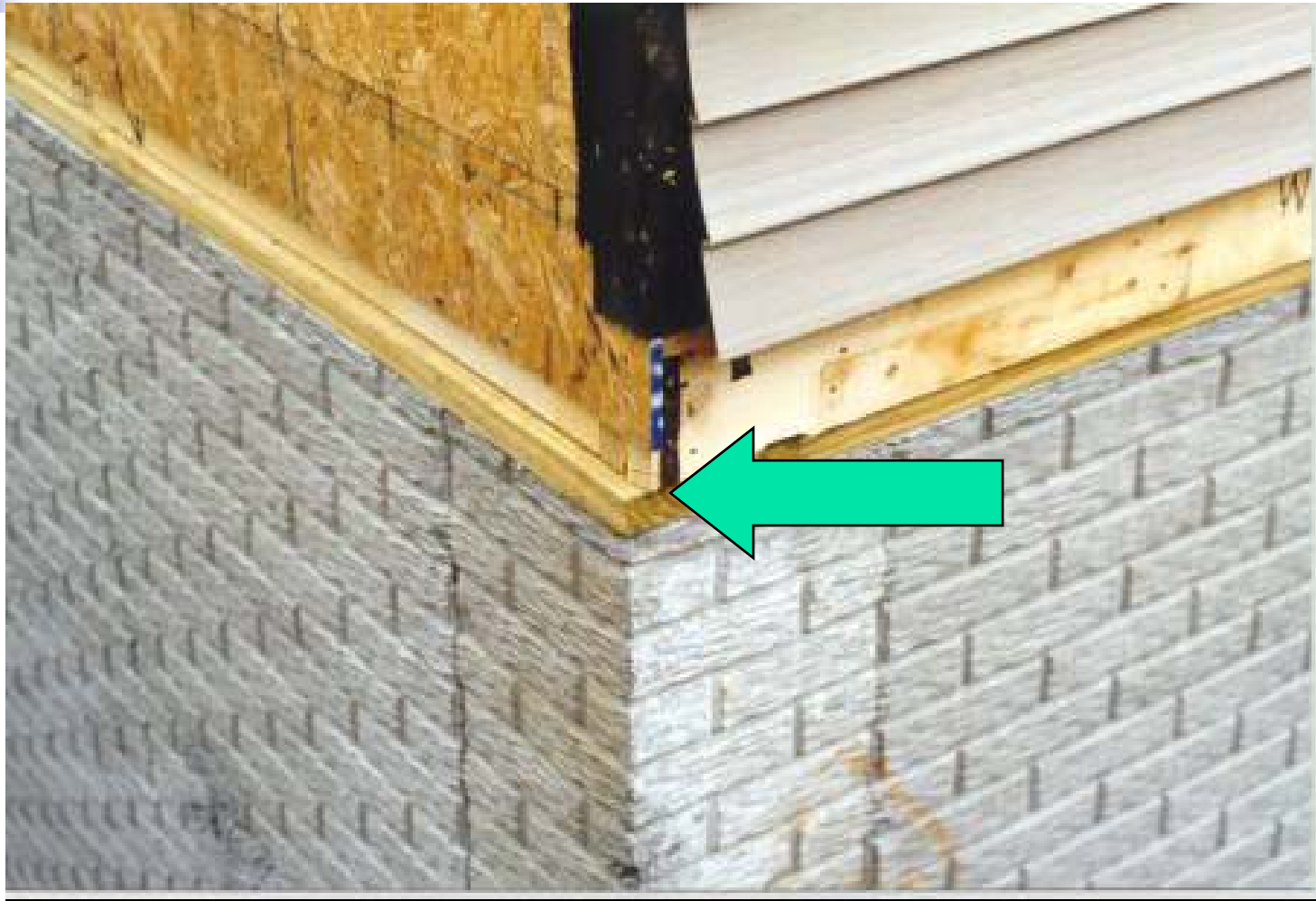
Improving Fit & Energy Efficiency

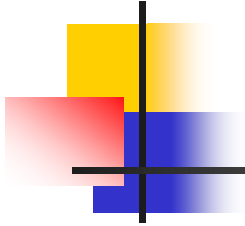
- Accuracy of foundations
- Accuracy of set
- Accuracy of modules
- Gasket placement
- Gasket attachment to module
- Gasket crushing
- Poorly fitting gable end panels
- Insulation under floor pulled away

Accuracy of Foundation, Set & Module



Accuracy of Foundation, Set, & Module





Result of Inaccuracy

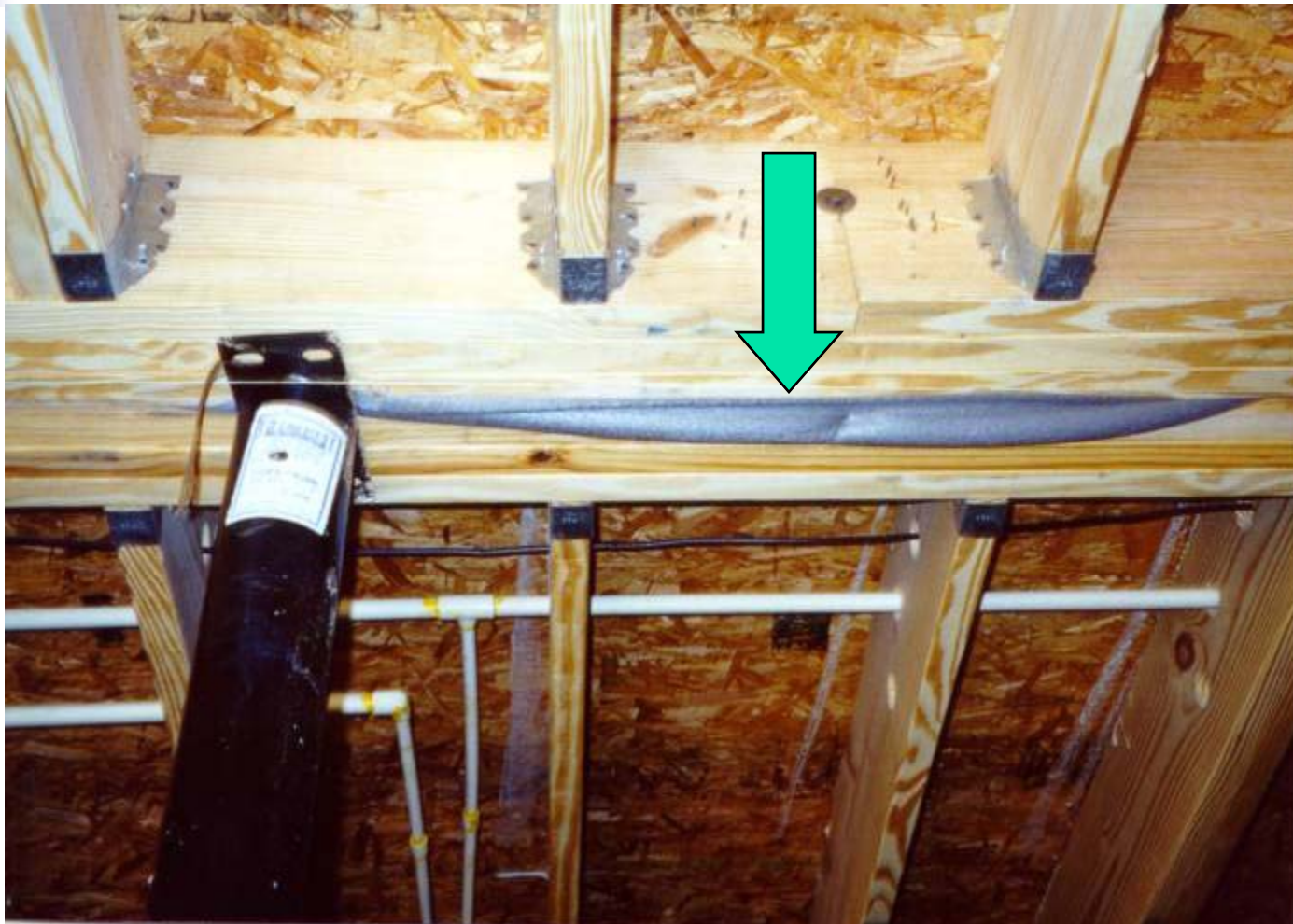




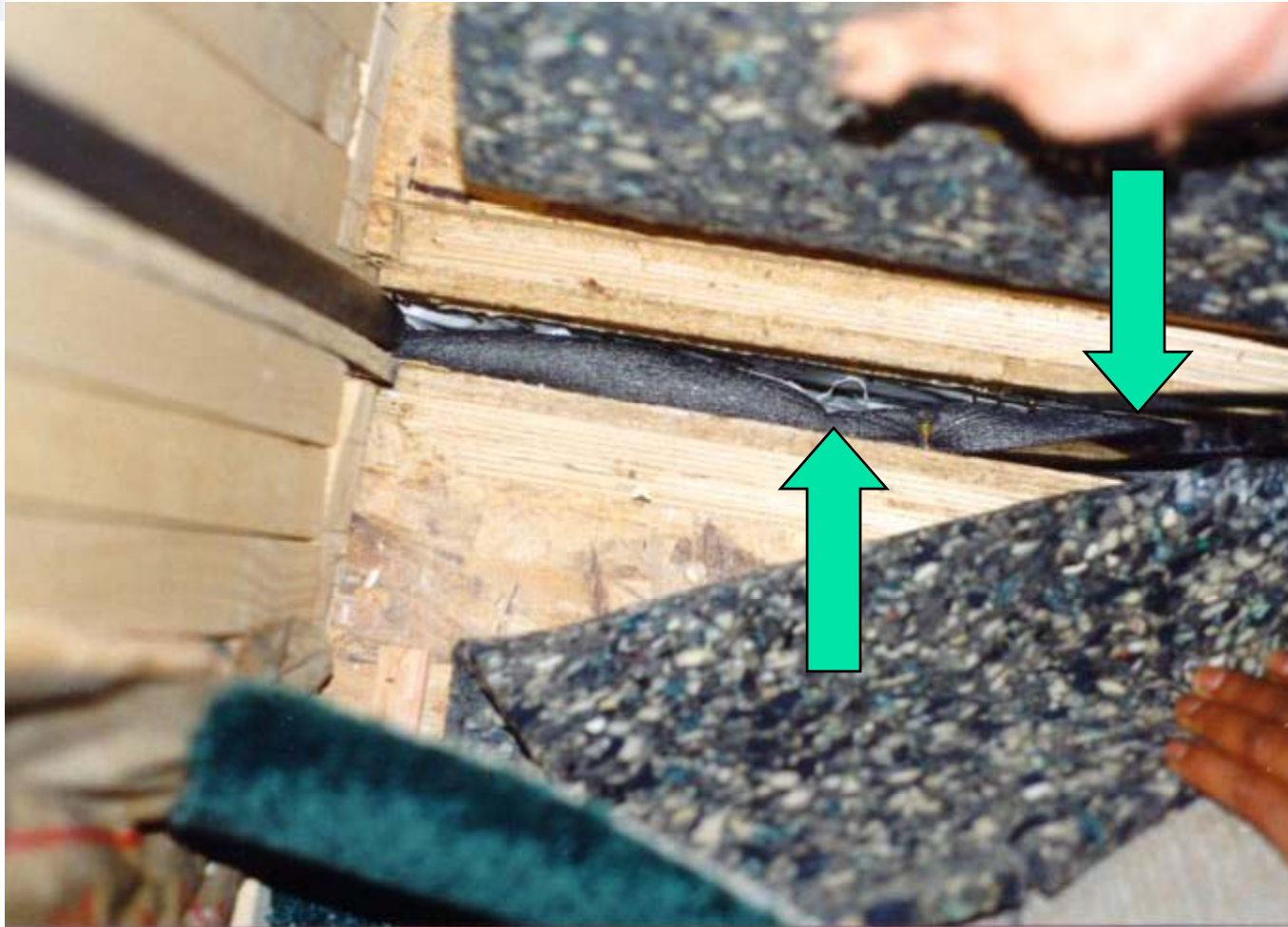
Result of Inaccuracy



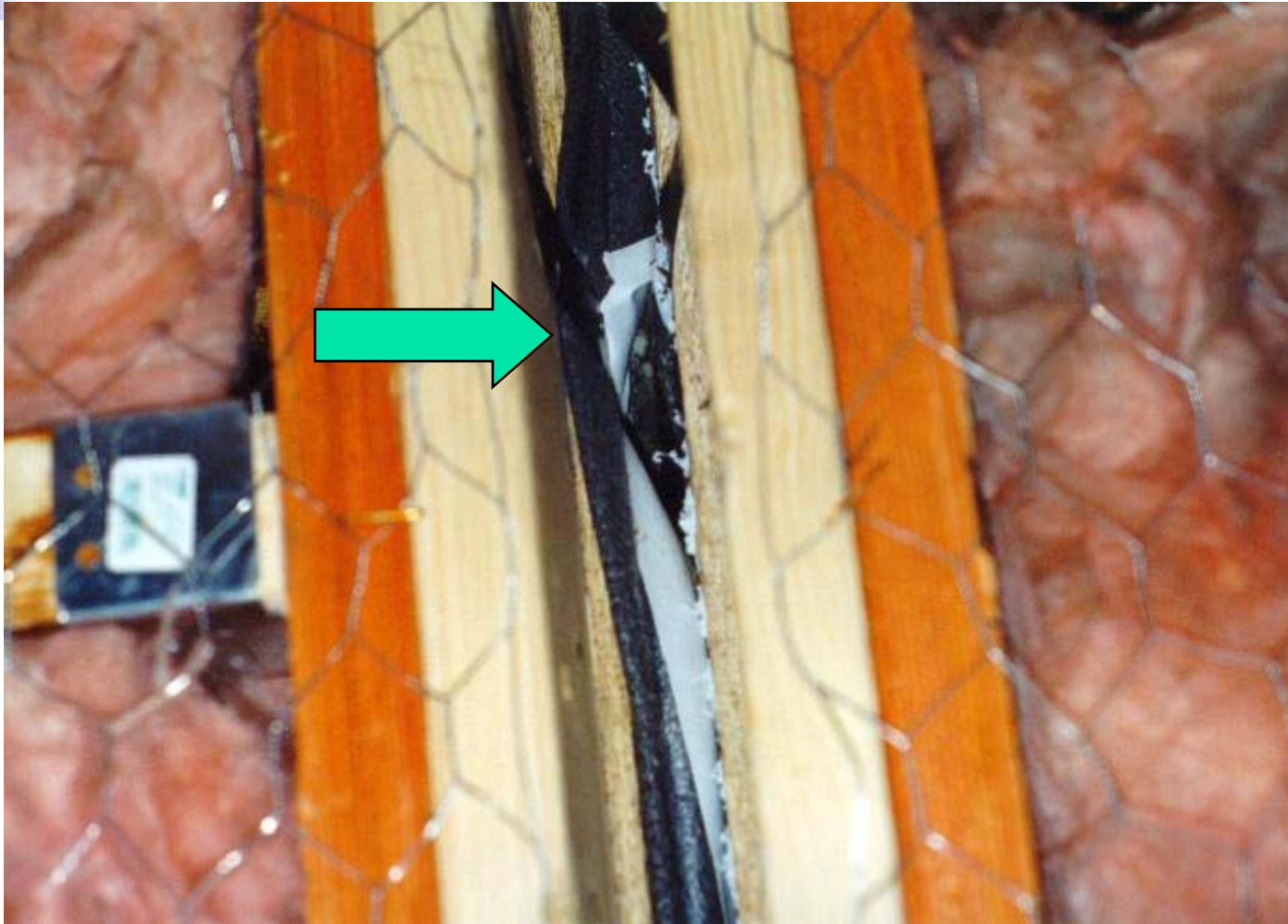
Gasket Placement

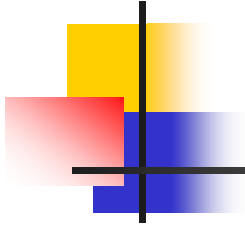


Gasket Crushed

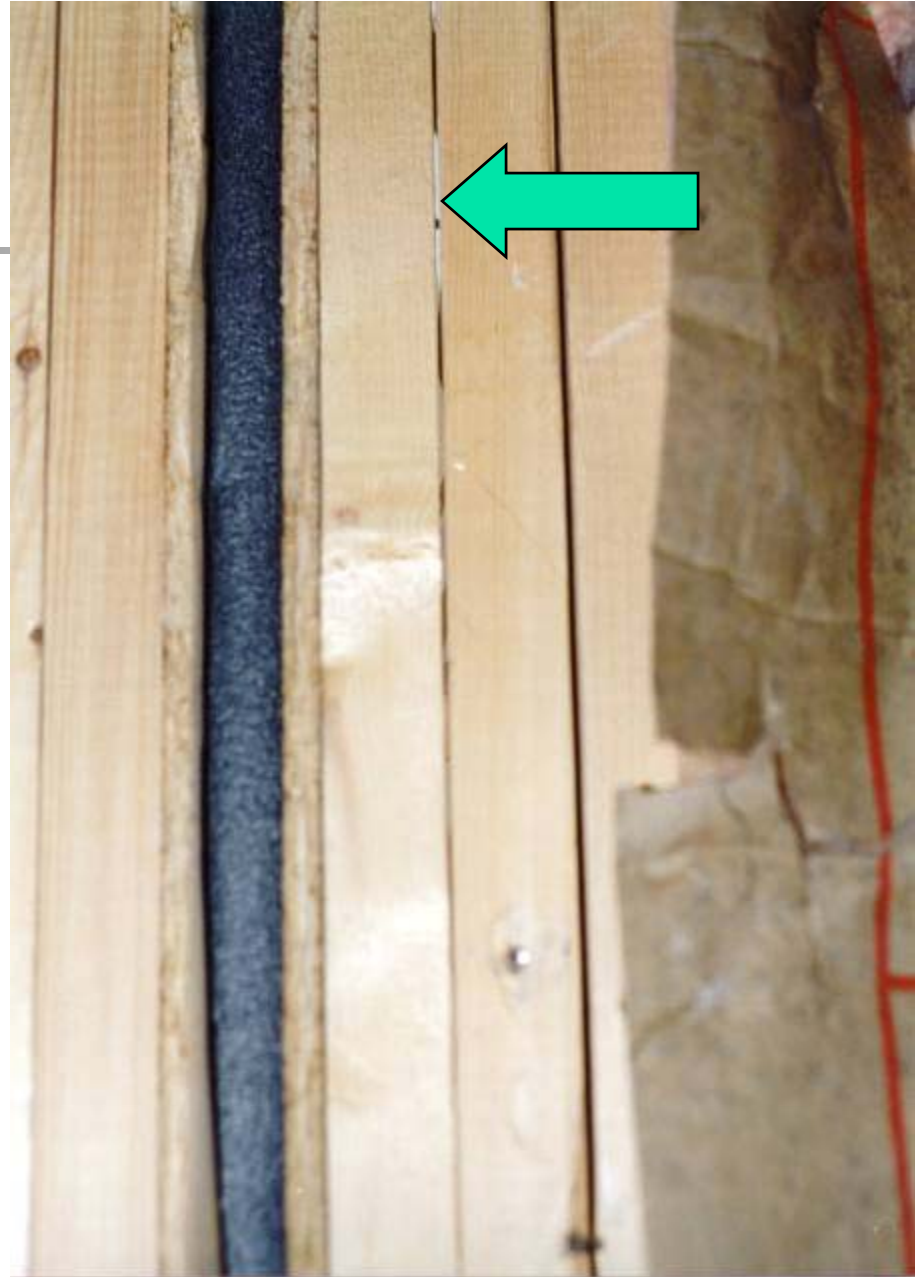


Gasket Crushed





Air Infiltration Through Studs



Gap at Joint of Gable Panels

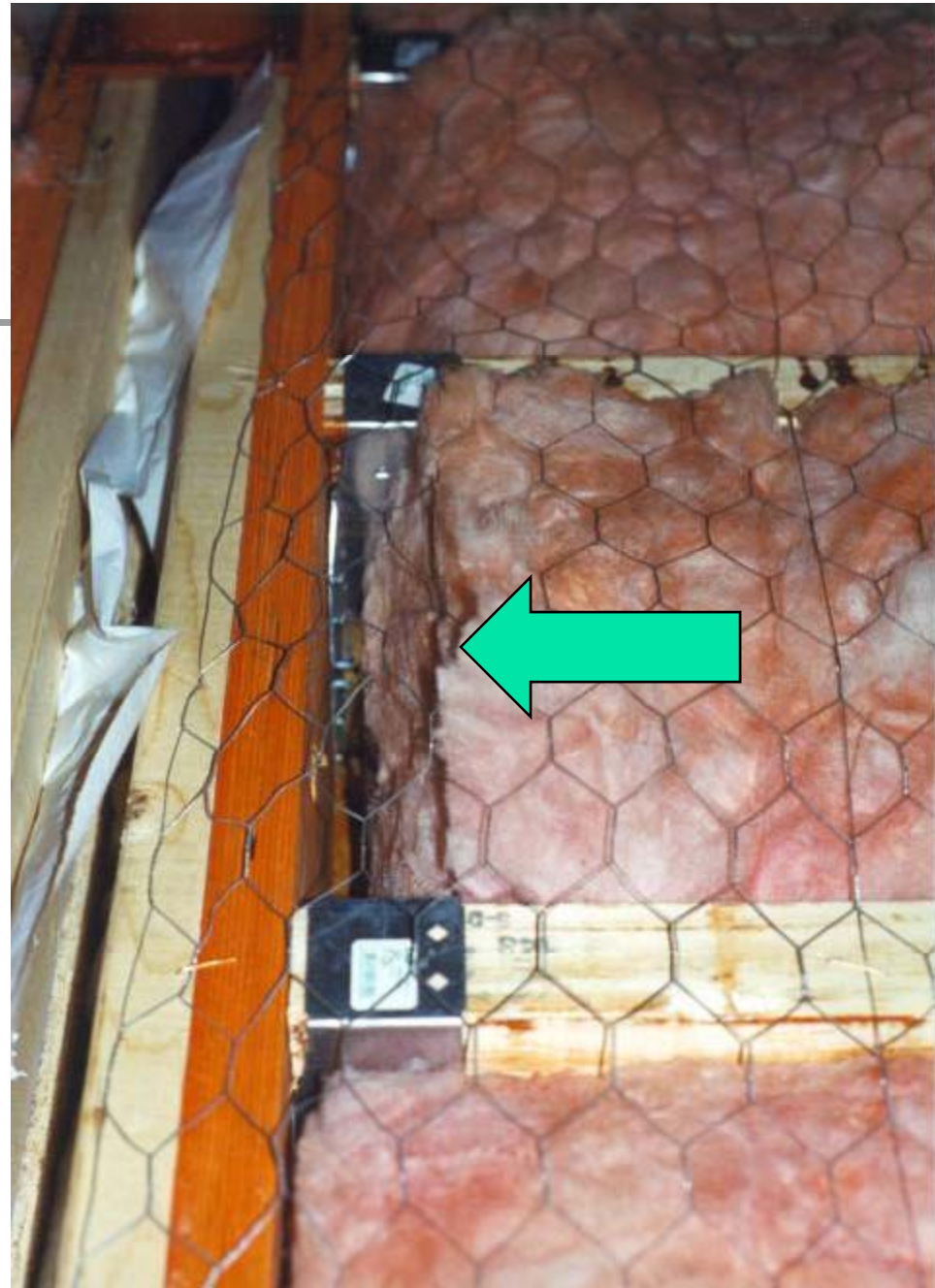


Gap at Joint of Gable Panel





Insulation Gap in Floor Cavity



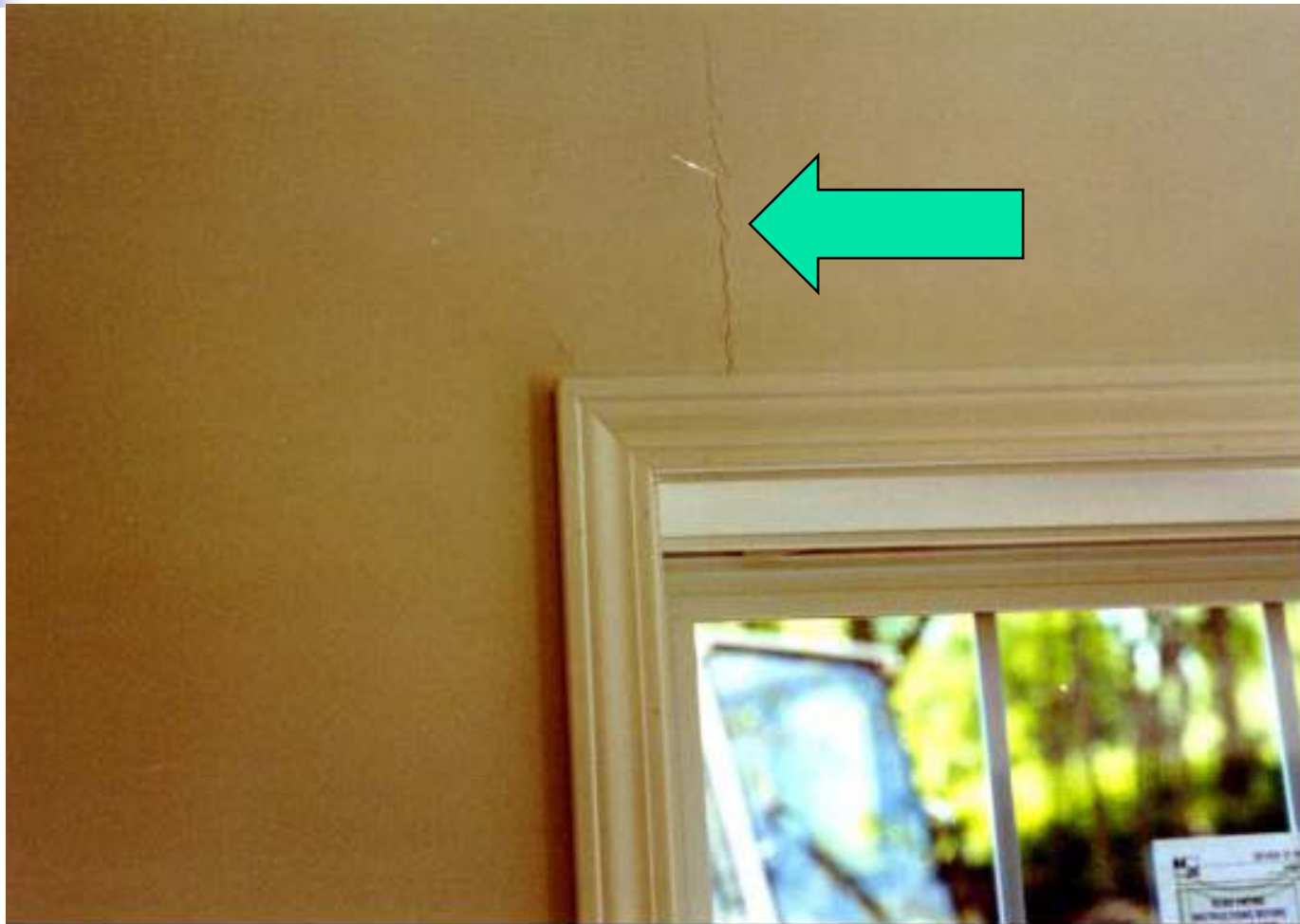


Best practices

- Radio to communicate with crane operator
- Factory installed lifting straps made of nylon webbing on roof panels (folds and flips), shiploose dormers, etc.
- OSB attic decking partially installed

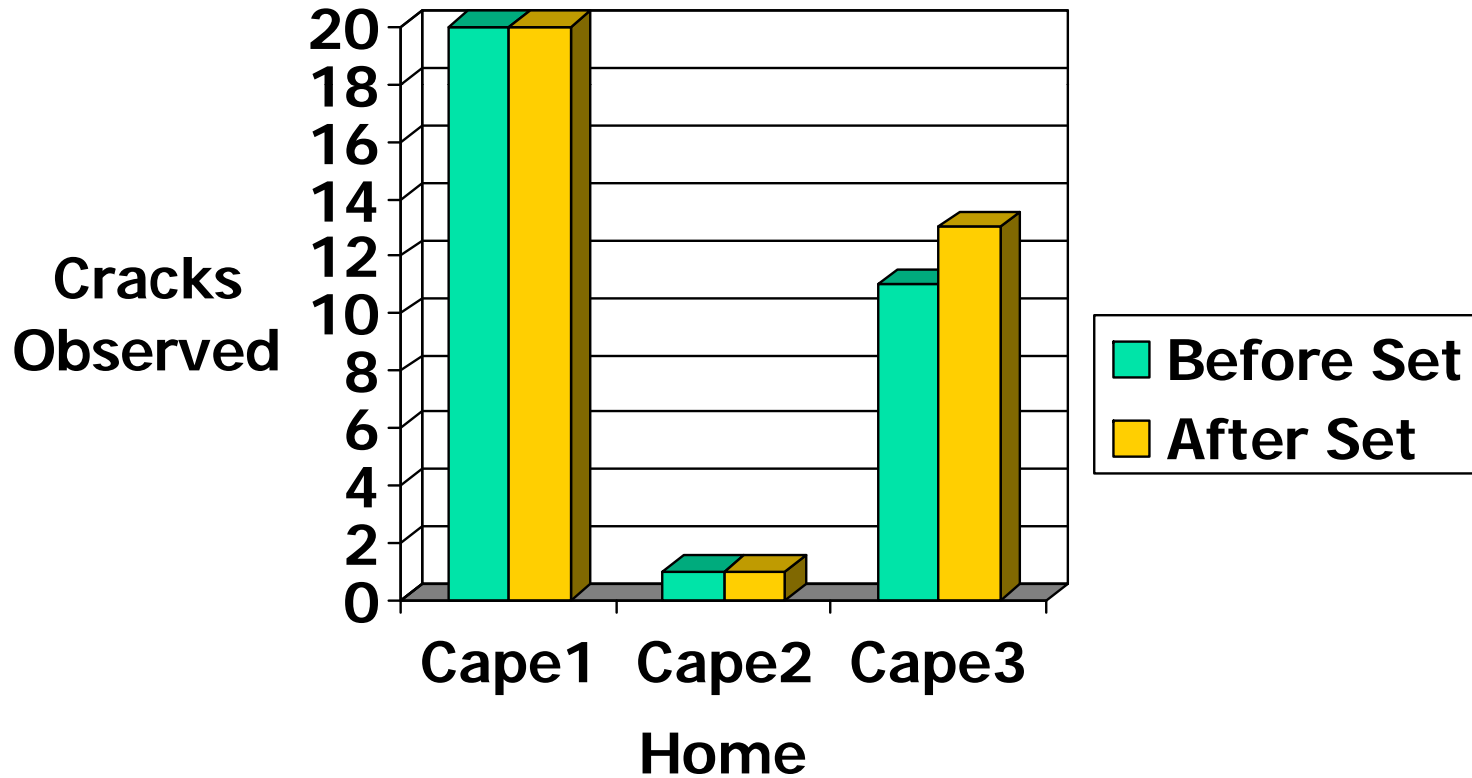


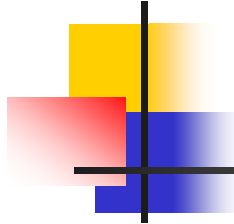
Drywall Cracks





Drywall Cracks





Any Questions

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