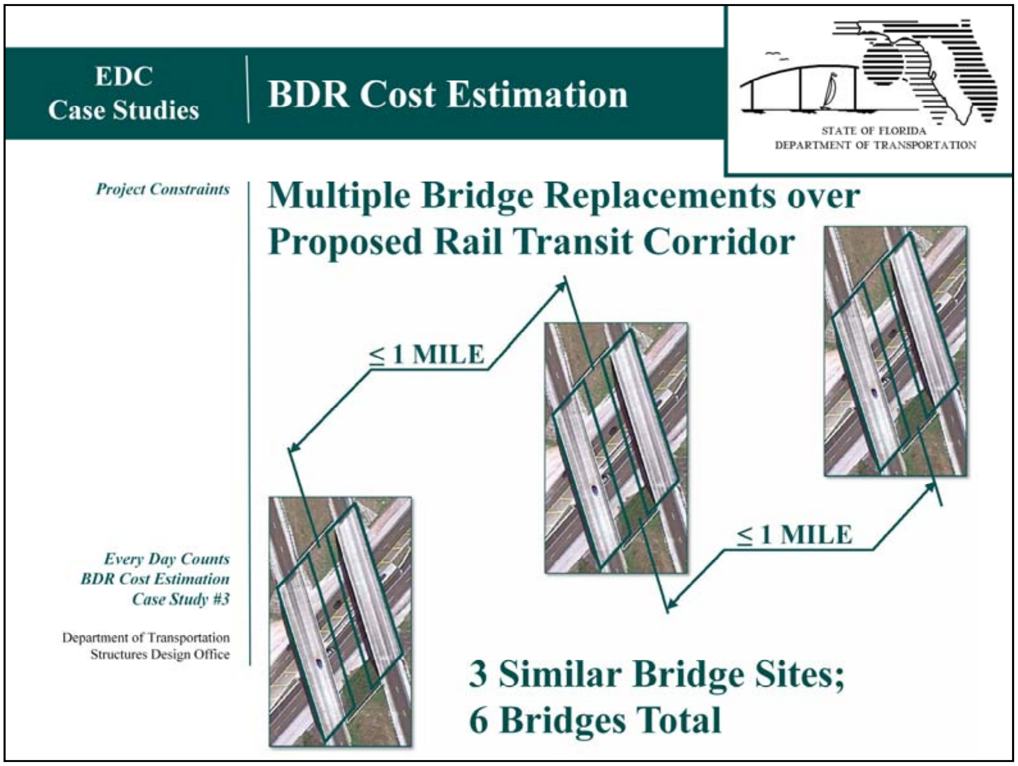
➢ Case Study #3 represents multiple bridge replacements over a local road which is being upgraded to accommodate a proposed rail transit corridor.

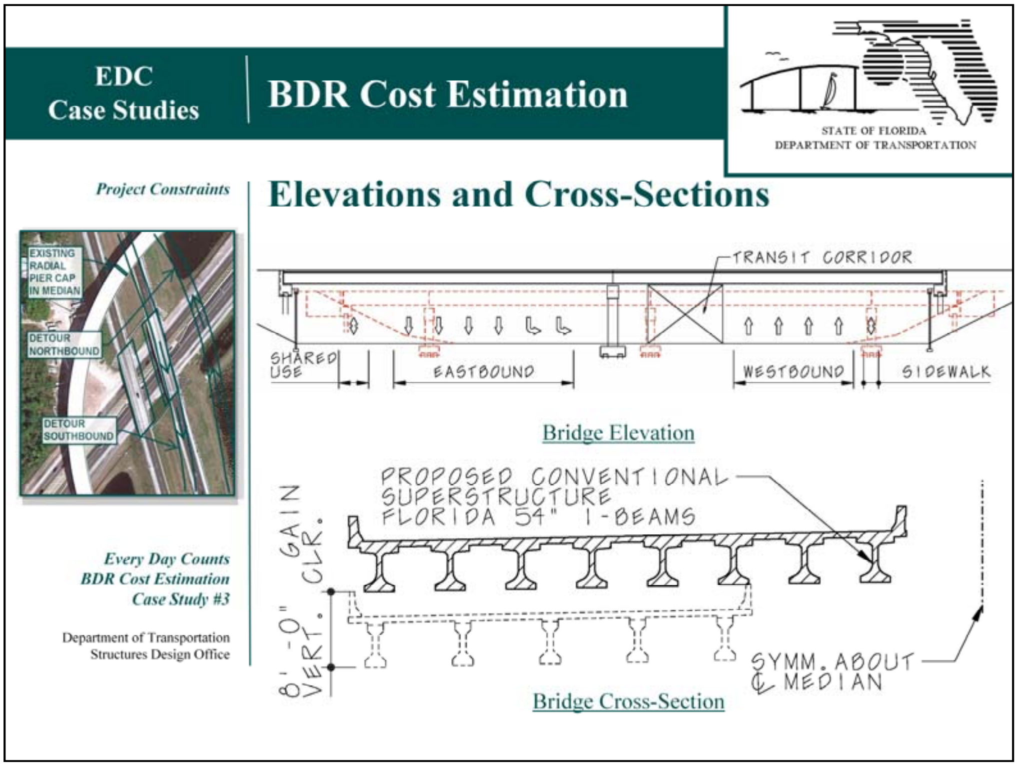
➢ The scenarios presented here will use the identical bridge solutions as Case Study #2, however rather than applying the solution to a single location, it will apply to multiple bridge construction sites.

➢ The goal in doing this is to evaluate economies of scale as they relate to prefabricated bridge elements and systems.

➢ This case study builds on Case Study #1 and Case Study #2. If you have not viewed these earlier case studies, please do so now.



- ➢ The underlying assumptions for this case study are:
- ➢ Three interchanges, located within close proximity along a local road alignment, will be let as one construction contract;
- ➢ All six bridges require replacement as they lack the required horizontal and vertical clearances; and
- ➢ Due to the urban setting of the project, the adjacent facilities are high capacity freeways with traffic demands similar to the interstate.



- The conventional construction approach replaces the existing bridges at all three interchanges with identical two-span structures as discussed in Case Study #2.
- Like Case Study #1 and Case Study #2, it is assumed the bridges at these three sites can only be widened to the inside of the median. Also like Case Study #1 and Case Study #2, it is assumed that a six foot outside shoulder is required throughout construction. These project constraints eliminate phased construction as an option and require detour bridges at all three sites.

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Prefabricated Alternative

Prefabricated Alternative

Step C – Prefabricated Alternative – Solutions

Strategies for Overcoming Project Constraints	
Objective	**Solution**
Raising interstate profile by eight feet	Detour bridge required during build up of approach roadway
Reduce user impacts (limit detour time)	Use full-span superstructure erection, using SPMTs with near-site fabrication
Reduce construction time	Remove superstructure construction from critical path during construction
Use economies of scale	Utilizing SPMTs at multiple locations provides an opportunity to make their use more efficient, reducing cost

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➢ The prefabricated bridge alternative will be identical to that used in Case Study #2, except for one big difference: economies of scale can be utilized to reduce the cost of the prefabricated alternative by spreading the mobilization costs of the SPMTs over six bridges.

➢ Using SPMTs at multiple construction locations provides the contractor the option to more efficiently organize their use. It is anticipated that superstructure placements could be staggered closely enough time wise, so the SPMTs would not need to be remobilized for each bridge move. Furthermore, the use of SPMTs at multiple construction locations also allows the contractor the option to remove the existing spans for demolition at the side of the road.

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Compare Alternatives

Direct Cost Comparison

Summary of Direct Costs - Taken from "Bottom-Up" Cost Estimate

Item	Construction Type		Delta	Reason
	Conventional	Prefabricated		
Detour, SPMTs	$ 8,736,711	$ 11,086,476	$ 2,349,765	Addition of SPMTs
Contractor General Conditions	$ 2,448,344	$ 1,081,128	$ (1,367,216)	Schedule Reduction
Substructure	$ 4,386,434	$ 4,254,326	$ (132,108)	Schedule Reduction
Superstructure	$ 6,031,483	$ 5,359,982	$ (671,501)	Schedule Reduction, Location
Direct Cost Total	**$ 21,602,972**	**$ 21,781,912**	**$ 178,940**	--

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- Prefabrication shortens schedule from 60 months to 28 months
- Difference in total direct costs < 1%

➢ Direct costs for each alternative have been calculated by a construction estimator and are presented here.

➢ These reflect the direct cost for all six structures. Looking at the first row, a notable cost differential can be seen. As in Case Study #2, the prefabricated alternative includes detours as well as SPMTs, hence this cost is more.

➢ The next row represents the contractor's general conditions, and favors the prefabricated alternate. This is due to the construction schedule reducing by 32 months.

➢ While the substructure costs are similar for both options, the superstructure costs favor prefabrication.

➢ Overall, the direct costs differ by less than 180 thousand dollars or less than 1% of the total costs and we can conclude that neither alternative has an advantage over the other.

➢ This is a different outcome from Case Study #2 and demonstrates how economies of scale can impact the direct cost.

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Compare Alternatives

Economies of Scale – Case Study 2 vs. 3

- Conventional Alternative: 2.8 x CS #2 Direct Cost
- Prefabricated Alternative: 2.7 x CS #2 Direct Cost
- Case Study #2 Cost Difference: Prefabricated 5% Higher
- Case Study #3 Cost Difference: Prefabricated 1% Higher

Items Most Influenced by Economies of Scale		
SPMTs	2.0 x CS #2 Direct Cost	Prefabricated Alternative
Contractor General Conditions	2.1 x CS #2 Direct Cost	Both Alternatives
Prefabricated Superstructure	2.8 x CS #2 Direct Cost	Prefabricated Alternative

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- Let’s now evaluate the effect of economies of scale on direct cost.
- Although the quantities for Case Study #3 are 3 times that for Case Study #2, the overall direct costs were only 2.8 times for the conventional alternative and 2.7 times for the prefabricated alternative.
- This indicates that the prefabricated alternative benefitted more from economies of scale. Whereas the direct cost for the prefabricated alternative was 5% higher than the conventional alternative in Case Study #2, it is only 1% higher than the conventional alternative in this Case Study due to the economies of scale.
- The items most influenced by economies of scale are the SPMTs. With six bridge moves within three nearby sites, remobilization costs are avoided when compared to the single site in Case Study #2. This dramatically reduces the direct costs to only two times that of Case Study #2.
- A similar savings is achieved in contractor general conditions by time efficiencies through economies of scale.
- Although to a lesser extent, the prefabricated superstructure also benefits through increased worker productivity and efficient use of equipment on multiple units built sequentially near site.
- It should be noted that the Contractor's Learning Curve and production rates can be benefitted by the economy of scale of a project. Contractor's Learning Curve is a term typically used in segmental construction and refers to the time and repetition it takes to reach maximum production efficiency. This phenomenon also is equally applicable to all types of prefabricated construction. These increased production rates were factored-in for the prefabricated superstructure in this case study.

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Compare Alternatives

Cost Summary

Summary Table:

Alternate	Direct Costs	Indirect Costs							Direct + Indirect
		Lane Closures		Detour Time		Facility Closure		Σ Indirect	
		Days	$/Day	Days	$/Day	Days	$/Day		
Conventional	$ 21,602,972	54	$ 1,037	1500	$ 12,426			$18,694,998	**$40,297,970**
Prefabricated	$ 21,781,912			900	$ 12,426	12	$ 26,804	$11,505,048	**$33,286,960**

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Case Study #3

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- Conventional construction has higher indirect cost
- Overall, prefabricated construction has the potential to save $7M

➢ The combination of direct and indirect costs associated with each construction scenario is shown here.

➢ As expected, conventional construction has a higher indirect cost.

➢ When looking at the summations, the prefabricated alternative is $7M dollars less than conventional construction, and supports the indication that prefabricated elements should be considered for the project.

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Assessment Matrix

Selection Factor	Factor Weight (%)	PREFABRICATED		CONVENTIONAL	
		Score (0 to 5)	Weighted Score*	Score (0 to 5)	Weighted Score*
Total Direct Costs	55	5	275	5	275
Total Indirect Costs	20	2	40	1	20
Factor 3 - *Constructability*	5	3	15	5	25
Factor 4 - *Traffic Impacts*	0		0		0
Factor 5 - *Construction Duration*	10	5	50	3	30
Factor 6 - *Durability*	0		0		0
Factor 7 - *Environmental Impacts*	0		0		0
Factor 8 - *Aesthetics*	0		0		0
Factor 9 - *Project Risk*	10	3	30	5	50
Factor 10 - *Other*	0		0		0
TOTAL (Σ Factor Weights = 100%)	100	--	***410***	--	400
TOTAL (Excluding Indirect Cost Factor)**	80	--	370	--	***380***

• Indirect costs make prefabricated construction slightly more favorable

➢ This slide presents the assessment matrix prepared for this case study.

➢ Looking at the last two rows of the table, when excluding indirect cost, conventional construction is slightly more favorable. However when accounting for both direct and indirect costs, the prefabricated alternative is slightly more favorable.