EDC Case Studies

BDR Cost Estimation

STATE OF FLORIDA
DEPARTMENT OF TRANSPORTATION

These BDR cost estimation case studies are not real FDOT projects.* The project sites have been selected because of their unique project constraints and ability, from a training point of view, to show various prefabricated accelerated bridge construction (or ABC) options.

There are two objectives for the case studies:

1. Develop a viable prefabricated ABC alternative to compare with conventional construction.
2. Demonstrate a logical procedure for estimating both direct and indirect costs for the prefabricated alternative.

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Case Studies

Department of Transportation
Structures Design Office

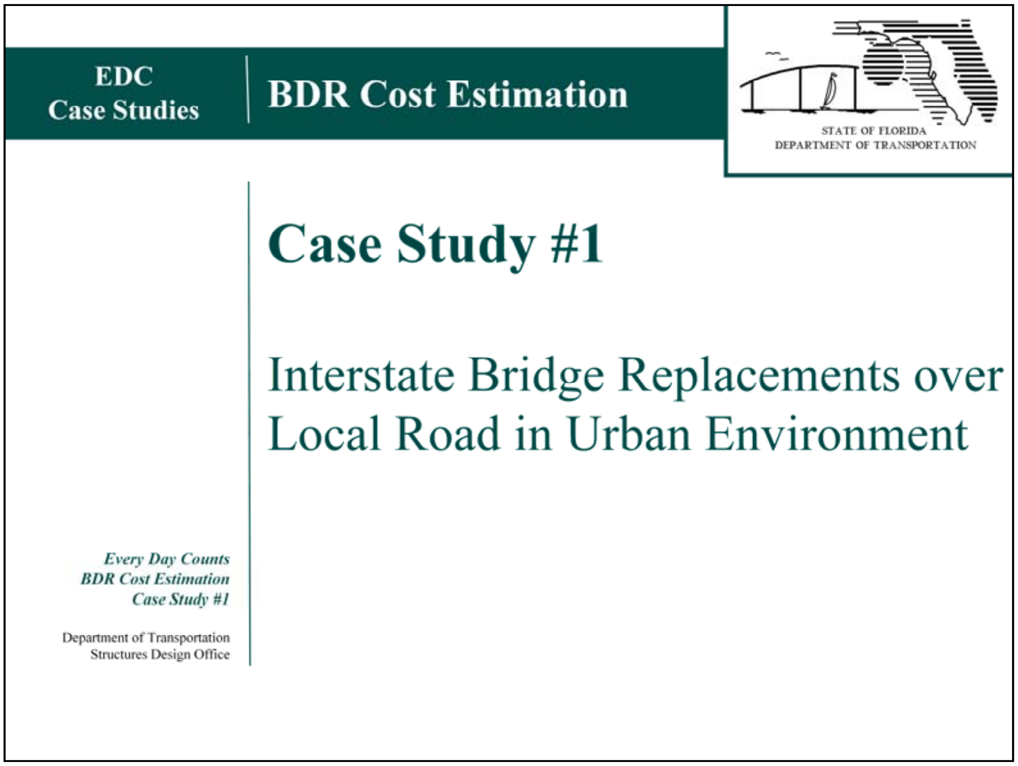
* Case studies developed by: PARSONS BRINCKERHOFF

➢ These bridge development cost estimation case studies are not real FDOT projects. The project sites have been selected because of their unique project constraints and ability, from a training point of view, to show various prefabricated accelerated bridge construction (or ABC) options.

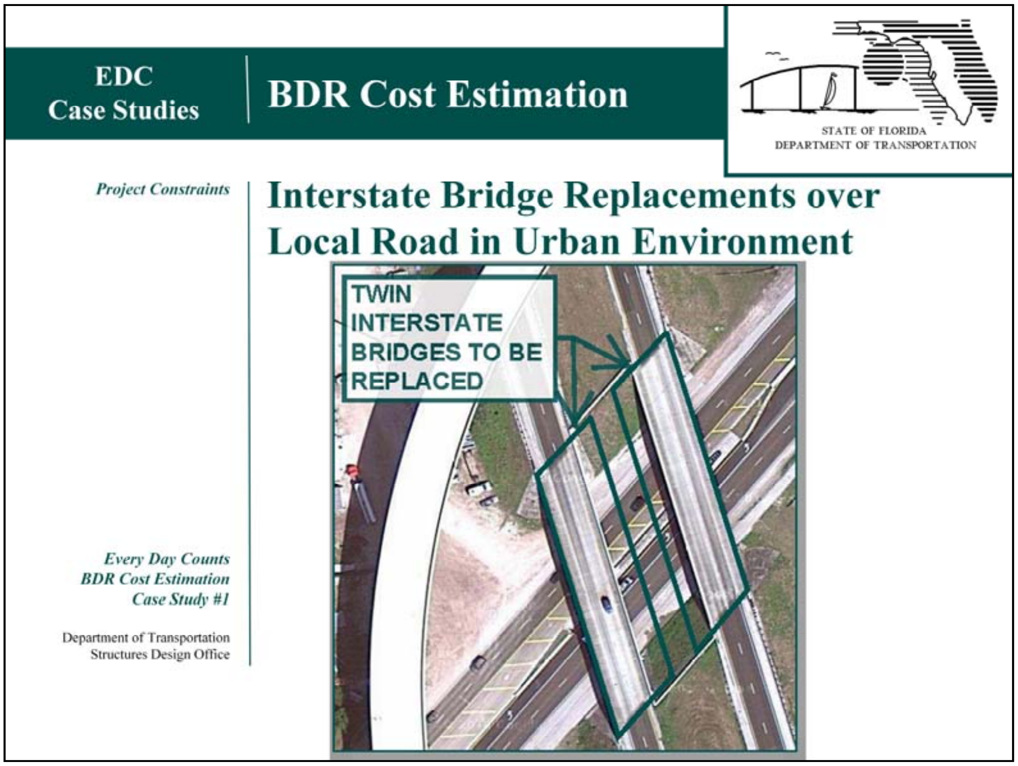
➢ There are two objectives for the case studies:

➢ The first objective is to develop a viable prefabricated accelerated bridge construction scenario to compare with a conventional construction approach. The prefabricated alternative will demonstrate the factors which influence its selection and determine which bridge components are well-suited for prefabrication.

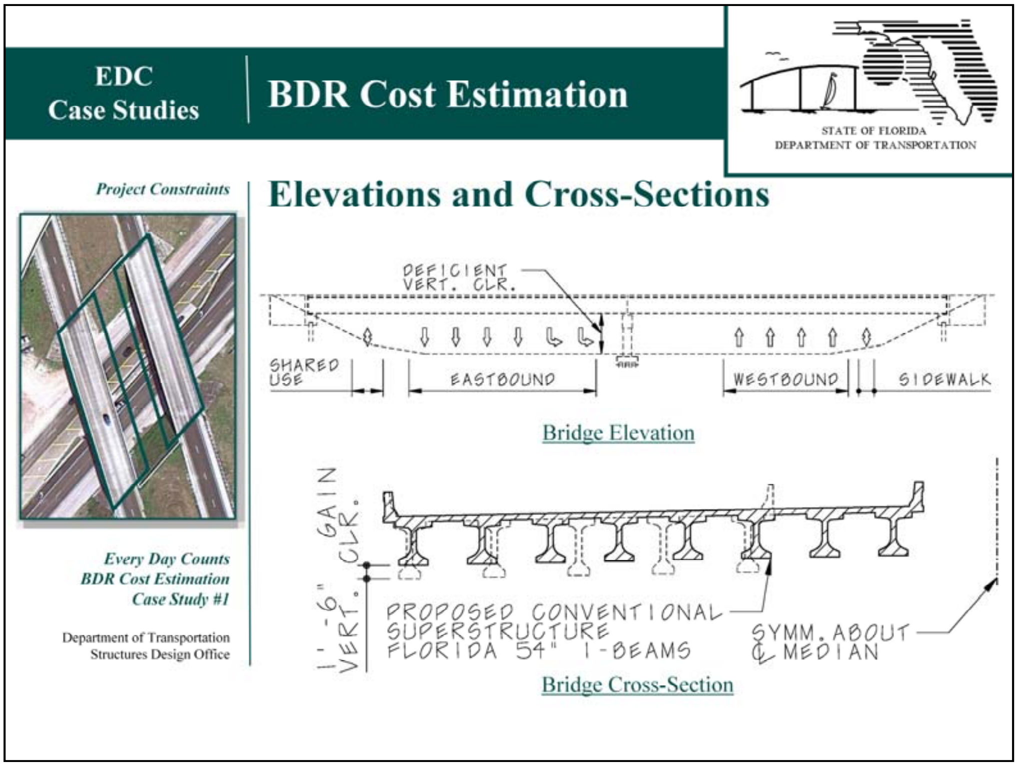
➢ The second objective is to demonstrate a logical procedure for estimating both direct and indirect costs for the prefabricated alternative.



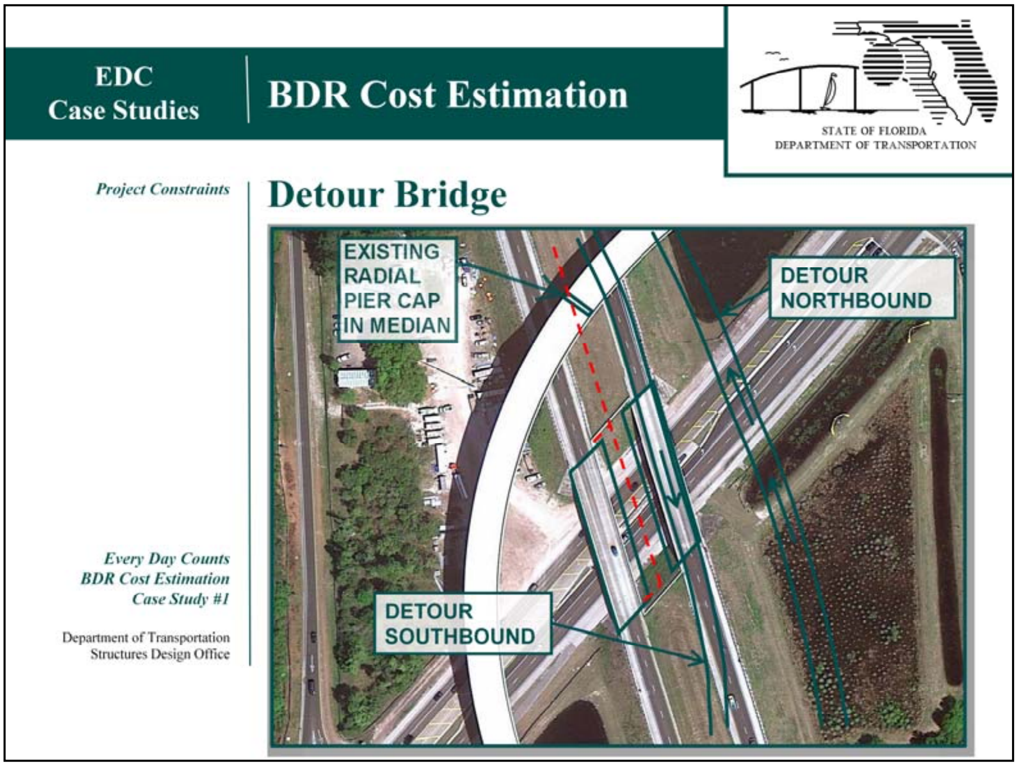
- Case Study #1 represents interstate bridge replacements over a local road in an urban environment
- This project poses challenges related to deficient vertical clearance, inability to shift alignments and profiles, and maintaining traffic while upgrading both facilities.



- This aerial view shows existing twin bridges over a local road. Both are identical two-span bridges with fill slope abutments.
- The local road below is currently a four lane facility including a single turning lane at the bridge location. As can be seen in the aerial view, the single turning lane widens to two lanes beyond the bridge.
- The existing bridges carry a four-lane interstate.
- The following upgrades are being made to the intersecting facilities:
    - The local road below is to be upgraded to eight lanes with two turning lanes underneath the bridge for the eastbound movement. A shared use path, and a sidewalk will also be added to the cross-section.
    - The interstate bridges will be widened to accommodate upgrading from a four lane facility to six lanes. Due to the close proximity of the existing flyover ramp, the vertical profiles of the interstate and local road cannot be modified. Hence a more shallow superstructure is required.



- An elevation of the existing bridge along with the existing configuration of the local road below is shown.
- Improvements to the local road can be seen if we superimpose the proposed configuration on top of this one.
- Also, given the extensive upgrades to the local road, and widening of the interstate bridges, it is desired to have the required minimum vertical clearance, while at the same time maintaining the current interstate vertical profile.
- Here is the current cross-section of the existing bridge. It consists of five AASHTO Type VI girders.
- Using the conventional construction approach, there are two options available for the new superstructure to gain the vertical clearance required.
    - The first option is to use prestressed Florida I-Beams which can span a longer distance at a shallower depth compared to the existing AASHTO Type VI girder.
    - The second option is to use a steel plate girder superstructure, which can also span a longer distance at a shallower depth.
- Again, superimposing the new cross-section on top of the existing one, we can see that 18” of vertical clearance will be gained by using a 54” Florida I-Beam. Although a 7’-6” spacing is required, using prestressed girders is commonly more economical than using fewer steel girders at a larger spacing.



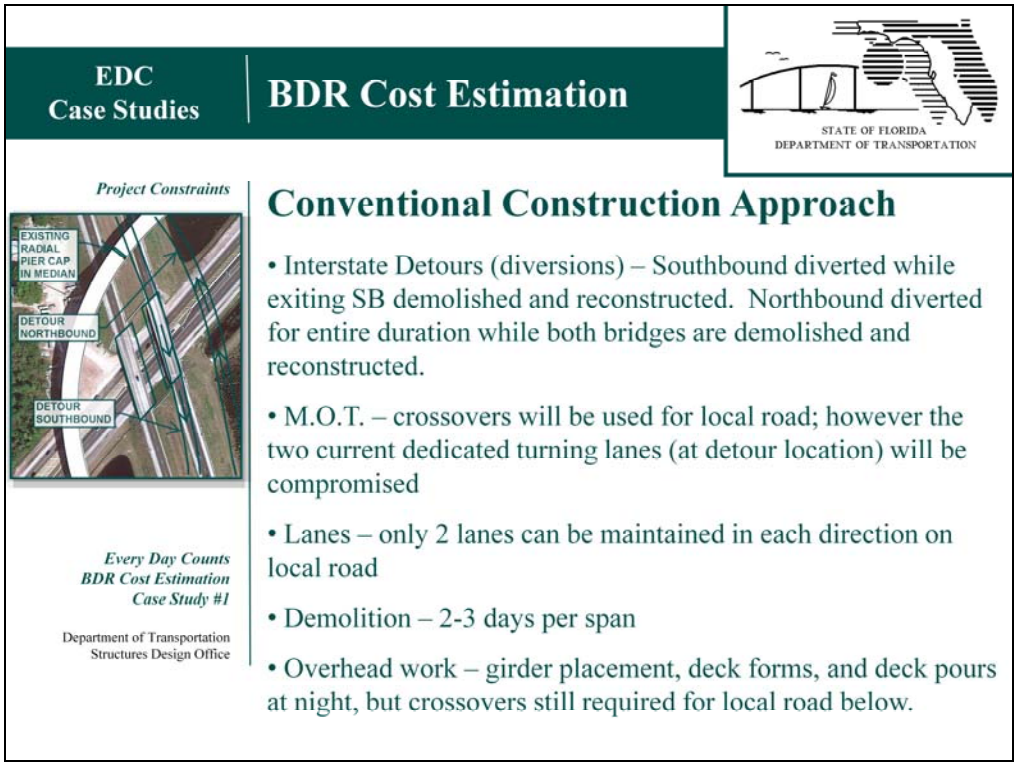
➢ The challenge for this project is determining a method to demolish the existing bridges and construct the new ones while minimizing impacts to interstate traffic and the local road below.

➢ The bridges can only be widened to the inside of the median, or high side of the cross-section, due to vertical clearance issues discussed in the previous slides.

> ➢ With this segment of the interstate currently experiencing lengthy backups from commuter traffic, as well as being a hurricane evacuation route, the Department was concerned that if a vehicle was to breakdown or be involved in an accident during construction, the interstate would be down to only one lane of traffic, causing gridlock and jeopardizing response time from emergency service vehicles from nearby hospitals and fire departments. With this special situation in mind, the Department decided to maintain two active lanes of traffic and a six foot outside shoulder in both directions at all times throughout construction.
>
> ➢ Phased construction would require "overbuilding" the bridge widths to maintain two active lanes, and would interfere with the existing radial hammerhead pier cap of the flyover, as it does not provide the minimum required vertical clearance for the temporary travel lanes. This scenario is depicted by the dashed red lines on the slide.
>
> ➢This eliminates phased construction as an option.

➢ Due to these constraints, a detour bridge will be constructed to temporarily divert northbound traffic, and allow southbound traffic onto the current northbound alignment. The detour for northbound traffic will be shifted slightly away from the existing bridges to provide the contractor adequate access to the site.

➢ Maintenance of traffic for the local road below will be accomplished with night time crossovers in order to divert traffic from underneath spans in which work is being performed.

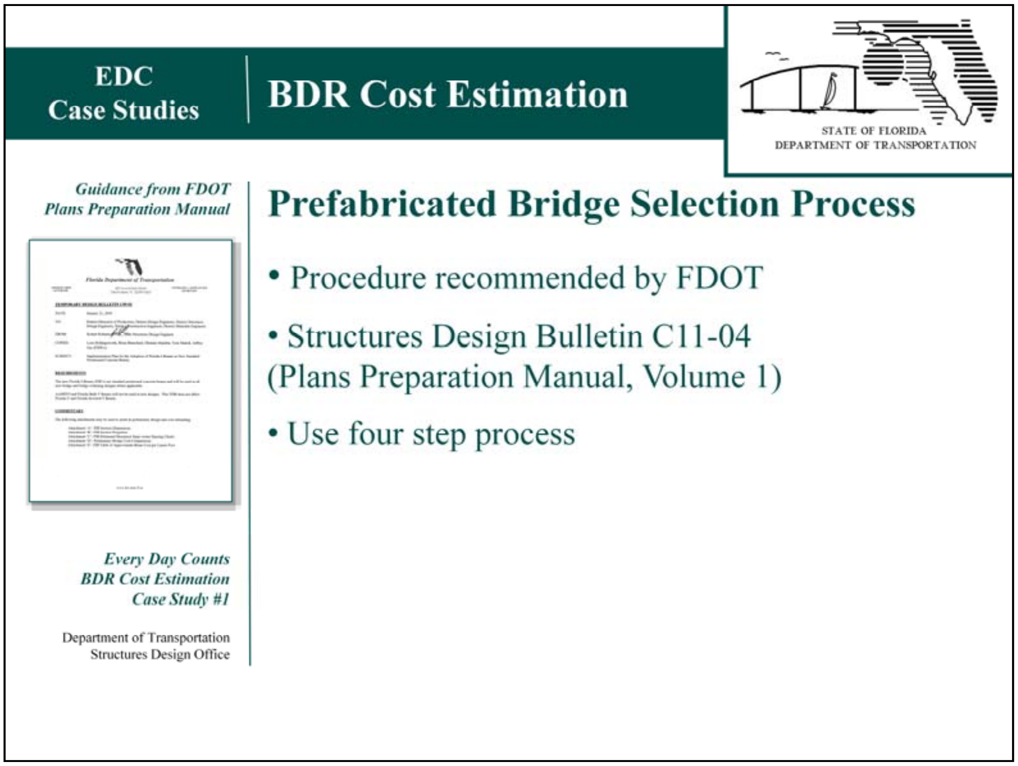


This slide summarizes traffic impacts for the conventional construction approach:

➢ Northbound interstate traffic will be required to use the detour for the duration of the project. Southbound interstate traffic will be temporarily diverted to the northbound alignment while the new southbound bridge is constructed.

➢ Demolition of the existing bridges will take 2 to 3 days per span.

➢ To summarize the conventional construction option; it replaces the entire substructure and superstructure of the twin interstate bridges with wider structures to accommodate an additional lane. They will be two-span bridges using wrap around MSE wall abutments to replace the existing fill slopes.



➢ The Florida Department of Transportation has implemented a procedure to determine if prefabricated bridge elements and systems should be incorporated into a project.

➢ The bulletin outlines a four step procedure which is to be followed for all Bridge Development Reports.

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Prefabricated Alternative

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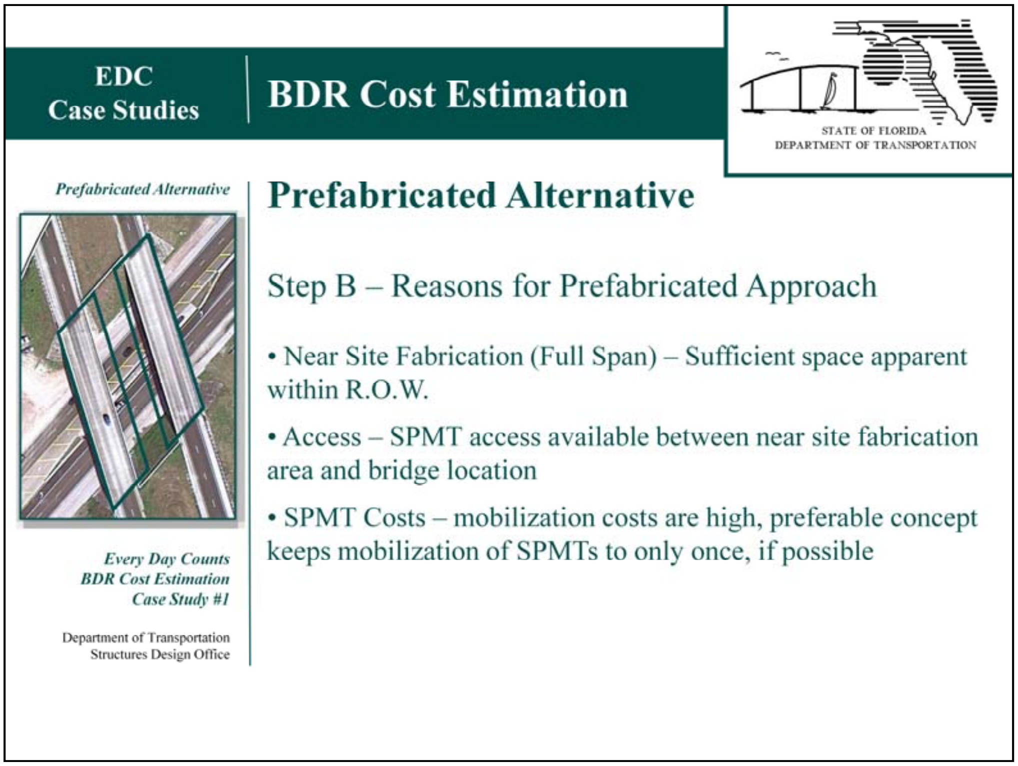
Prefabricated Alternative

Step A – Questionnaire, Significant Responses

FDOT Structures Bulletin C11-04, Questionnaire:	
Question	Answer
Will prefabrication reduce traffic impacts?	Yes
Does project site have sufficient R/W for near-site fabrication yard?	Yes
Are lifting weights practical given assumed equipment, access, and construction method?	Yes

Using the aforementioned guidance from the Structures Design Bulletin, the Step A questionnaire was completed for this specific case study. Answers to this questionnaire can assist the engineer in identifying which elements of the bridge are best suited for prefabrication, given the project constraints. Of the answered questions for this specific case study, a few which are relevant are listed here.

- ➢ The answers to all three of these questions is “yes”.



For the next step in the decision making process, Step B, the following methods will be investigated to accomplish the goal of reduced user impacts:

- Sufficient area within the right-of-way for near-site prefabrication is available, with relatively-level access from the assembly site to the bridge location.
- Cost of initial SPMT mobilization for the existing bridge removal and re-mobilization for placement of a new bridge is high, so the use of SPMTs must achieve maximum efficiency. This can be accomplished by utilizing SPMTs to demolish and place the new bridges within a short time lapse between the operations.

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Prefabricated Alternative

Step C – Prefabricated Alternative – Solutions

Strategies for Overcoming Project Constraints	
Objective	**Solution**
Eliminate detour bridge and reduce traffic impacts	Full-span superstructure erection, using SPMTs with near-site fabrication
Gain vertical clearance	Shallow girder superstructure
Widen end bents while maintaining interstate traffic	Widen and reuse existing end bents. Assure capacity not exceeded by using lighter steel superstructure with beam seat locations which do not coincide with existing girders
Remove fill slope at end bents	Top-down constructed soil nail wall
Construct new pier while maintaining interstate traffic	Construct new columns immediately adjacent to existing bridge, and use them to support an integral straddle cap, which will be fabricated with the girders

➢ Step C involves developing a preliminary prefabricated alternative and comparing it against conventional construction.

➢ The table presented here lists a few objectives for the prefabricated alternative to satisfy project constraints.

➢ Alongside each objective is a preliminary solution, which will be used to formulate the prefabricated alternative.

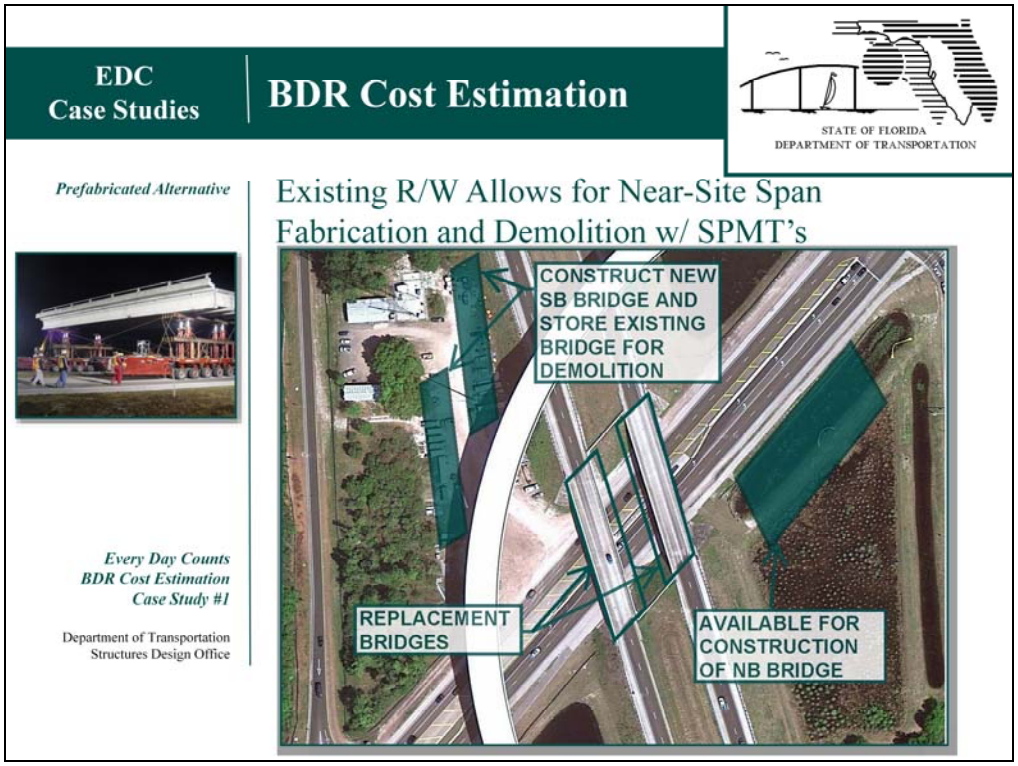
➢ The first objective is to eliminate the detour bridge and reduce traffic impacts.

➢ In order to gain the vertical clearance required at the site, shallower girders will be utilized.

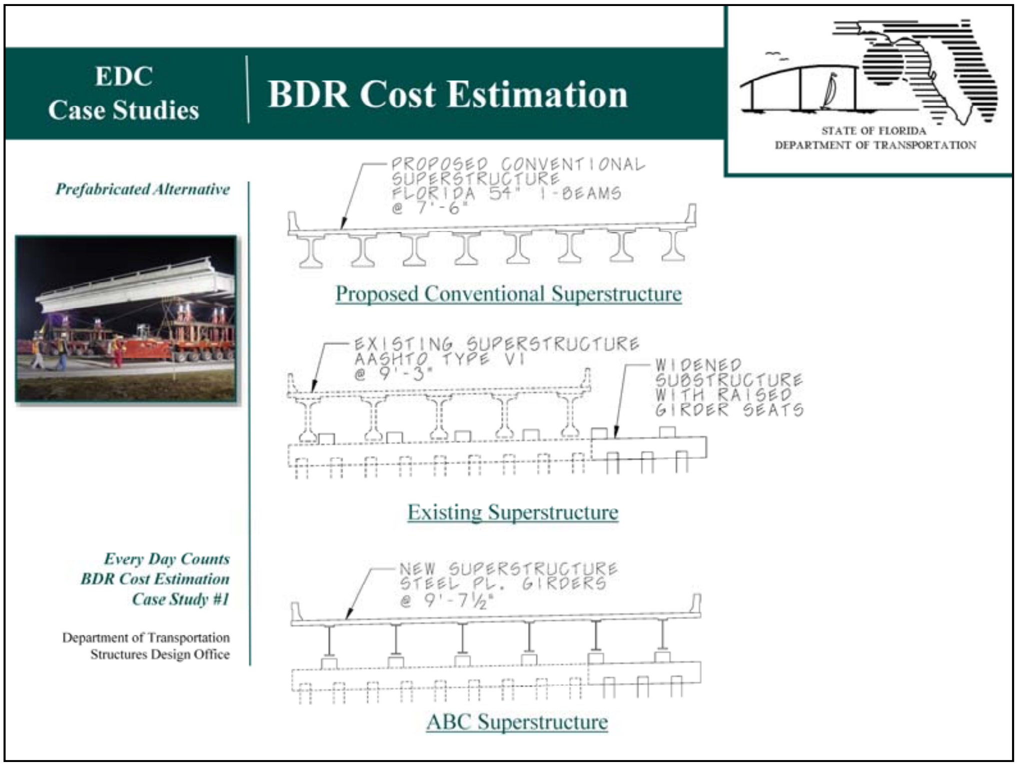
➢ Assume that the existing end bents are in good condition and will be reused and widened to accommodate the additional lane for the interstate, without impacting traffic. To assure capacity of the existing end bent is not exceeded, a lighter steel superstructure will be used.

➢ The existing fill slopes will be removed with the existing bridges in place, without impacting traffic, by constructing soil nail retaining walls using a low-headroom fill-slope undercutting process.

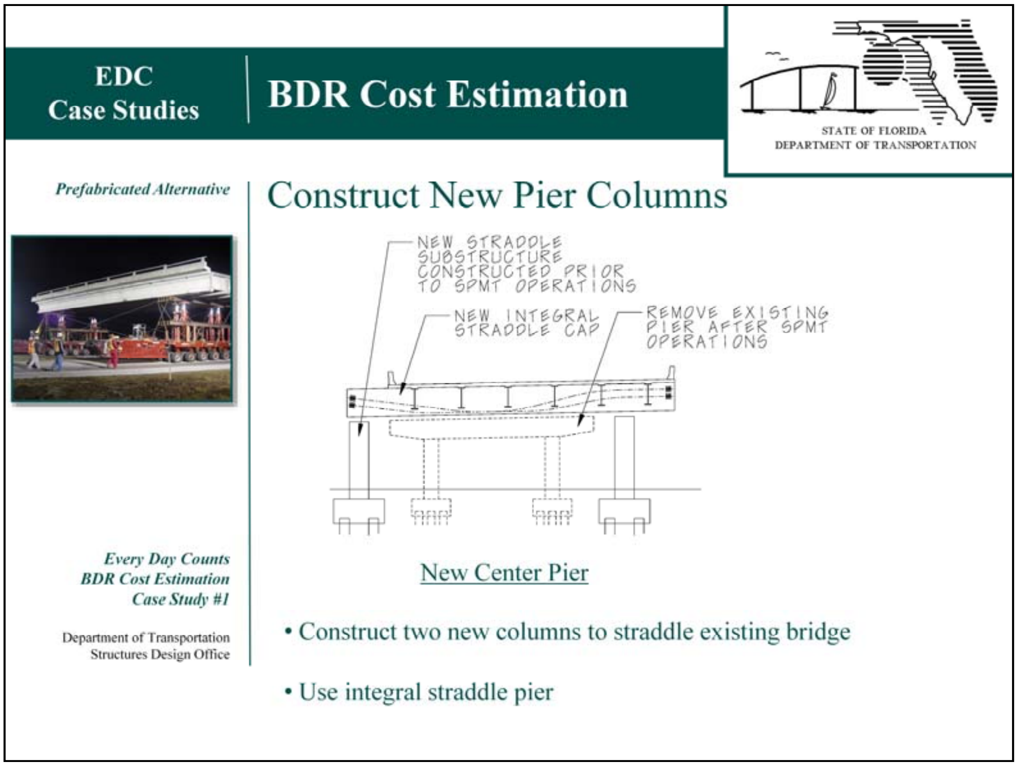
➢ New center pier foundations will straddle the existing piers with columns outside the existing bridge footprint. They will support an integral straddle cap which will be constructed with the new superstructure, and placed on top of the new columns with SPMTs.



- Under the full-span fabrication scenario, the entire superstructure will be fabricated in the available areas adjacent to the site. The existing spans will be removed with SPMTs, then the new fully assembled superstructure will be moved into place, also using SPMTs.
- This operation is assumed to occur during a nighttime closure and interstate detour.



- The largest obstacle for full-span fabrication is constructing new substructures to receive the new superstructure without impacting traffic. New substructures will be constructed next to the existing footprint to support the new, wider superstructure.
- This will be accomplished using the following assumption:
    - The existing end bents will be reused, but widened to accommodate the six lane configuration. This is made possible by using steel girders located between the existing bearing seats. This is not possible for the proposed conventional construction, as to span this distance while gaining vertical clearance, prestressed Florida I-beams are required at a tight spacing, as depicted in the diagram.
    - The steel superstructure used for the ABC alternative can use a wider girder spacing while assuring existing end bent piles are not overloaded.
    - Using a continuous steel superstructure also facilitates an integral straddle pier solution.

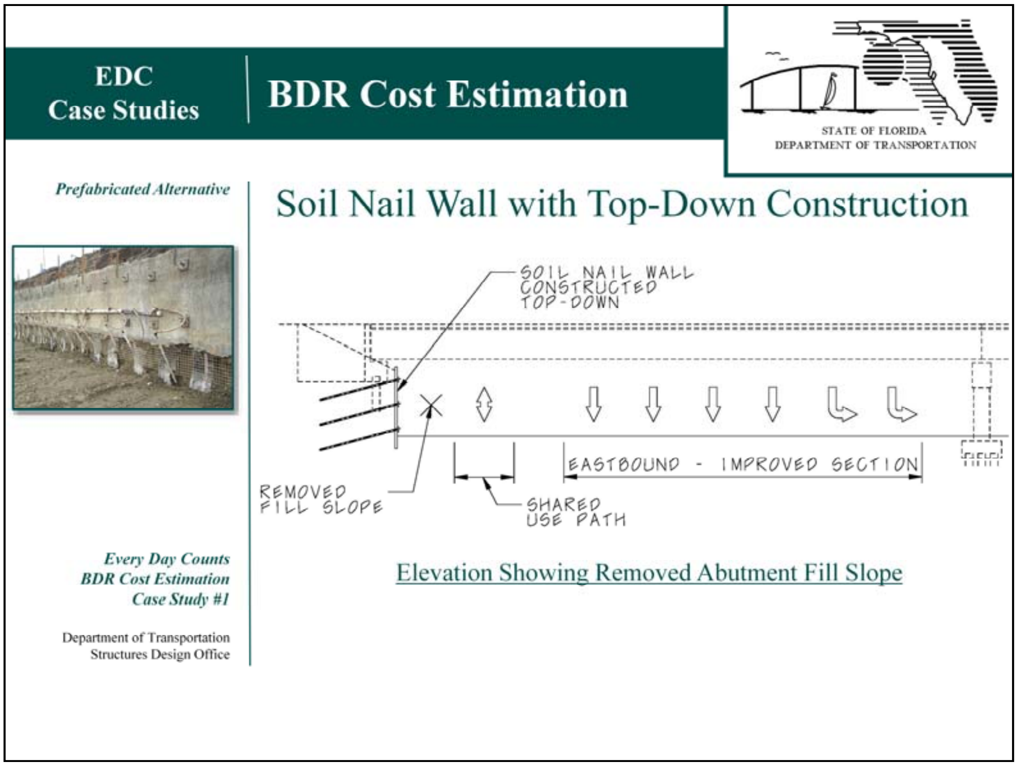


➢ The slide indicates how the new substructure will be constructed to straddle the existing bridge.

➢ The piles, pile cap, and columns can all be constructed with live traffic on the existing bridge.

➢ When the existing superstructure is removed with SPMTs, the existing beam pedestals could be quickly demolished prior to placement of the new superstructure.

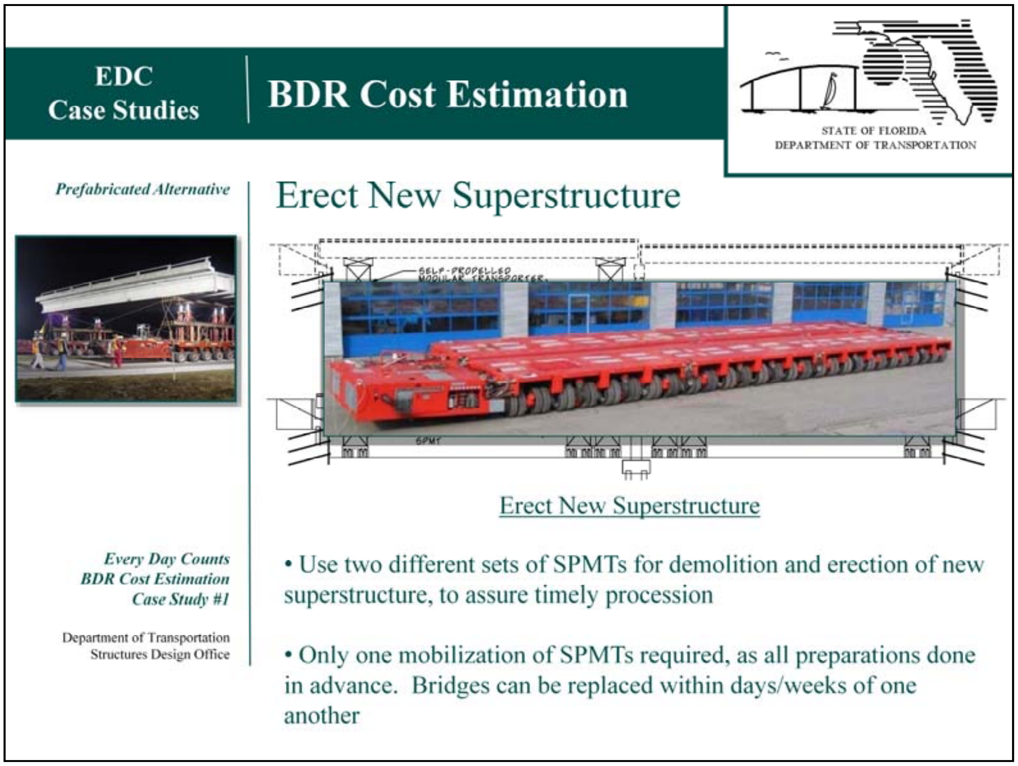
➢ The remainder of the existing pier can be demolished after the new superstructure is in place.



➢ This slide indicates how the existing fill slope will be removed without impacting the current structure, while concurrently allowing the widening of the local road below:

➢ A soil nail wall is proposed immediately in front of the existing end bents. Soil nailing is a low-headroom technique used for retaining soil or stabilizing slopes. They can be installed using minimum space without disruption to the area behind the wall.

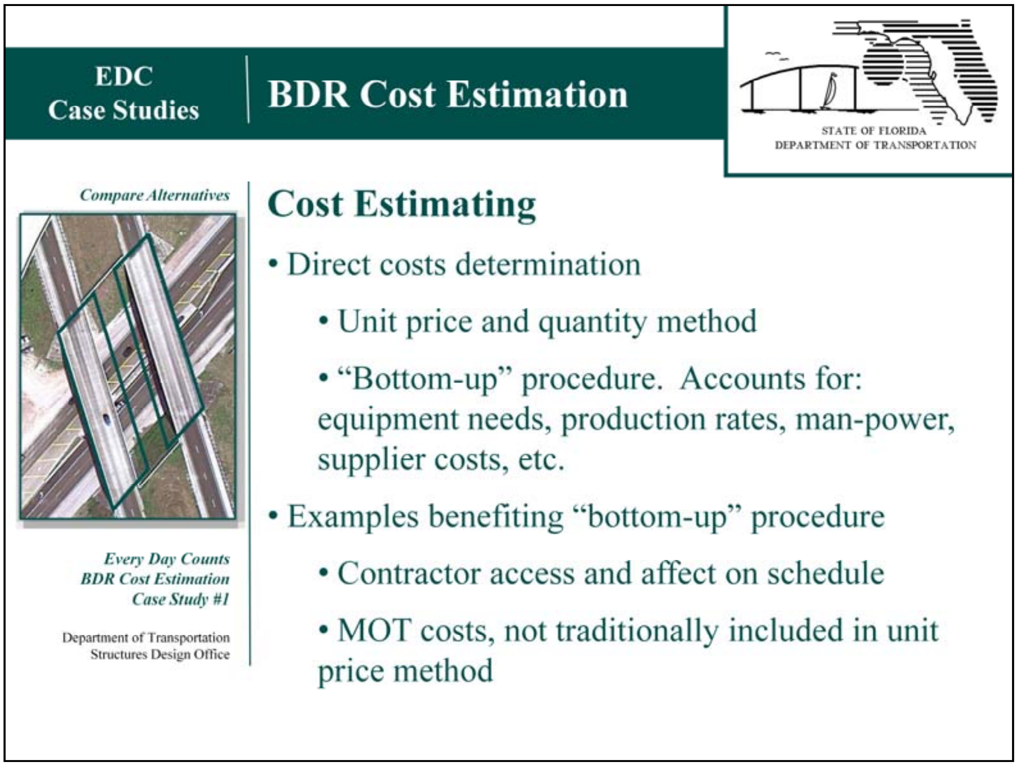
➢ Installation of the wall would presumably occur after widening the abutment, but before removal of the existing superstructure.



➢ For this case study, it is assumed each existing span will be removed using the same set of SPMTs.

➢ This will assure a speedy delivery of the new superstructure within the allotted timeframe.

➢ Only one mobilization of SPMTs will be required, as all preparations for each bridge can be done concurrently. This will allow the SPMT process for each bridge to be done within days of one another within the same traffic control phase of work.



➢ Now that a viable prefabricated alternative has been developed, a cost estimate must be prepared.

➢This slide will discuss two methods available for estimating direct costs, and demonstrate the need to perform an in-depth construction cost estimate when considering prefabricated bridge elements and systems for accelerated bridge construction.

➢ Current cost estimating guidelines are based upon average historical unit prices from bid tabulations. These predetermined unit prices are then applied to a material quantity, and a construction estimate is produced. This is convenient for engineers preparing cost estimates, as it's an all inclusive number, accounting for the cost of equipment, labor, material, overhead, contingencies, and contractor profit. The engineer also requires little formal training in completing construction cost estimates.

➢ This method of estimating is less accurate when considering prefabricated ABC construction, especially where there is little or no historical bid data. This process is similar to that used by contractors, and identifies equipment needs, production rates, man-power requirements, and supplier costs.

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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 vs. SPMT	$ 2,481,758	$ 1,008,766	$ (1,472,992)	Elimination of Detour
Contractor General Conditions	$ 1,169,525	$ 464,223	$ (705,302)	Schedule Reduction
Walls & Approach Slabs	$ 494,644	$ 532,182	$ 37,538	Higher Cost of Soil Nail Wall
End Bents	$ 333,825	$ 206,775	$ (127,050)	Decreased Quantity
Piers	$ 388,305	$ 258,022	$ (130,283)	Decreased Quantity
Superstructure	$ 2,010,495	$ 2,870,718	$ 860,223	Integral Straddle, Steel Girders
Direct Cost Total:	**$ 6,878,552**	**$ 5,340,686**	**$ (1,537,866)**	--

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Case Study #1

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• $1.5M savings using prefabricated alternative even though bridge material costs are $0.6M higher

• Attributed to eliminating detour bridge and reducing contractor schedule from 28 months to 12 months

➢ Using a construction estimator, direct costs for each alternative have been calculated. These costs account for material, equipment, time, and labor. The rightmost two columns provide the cost delta between the alternatives, and list the predominant reason for the cost differential.

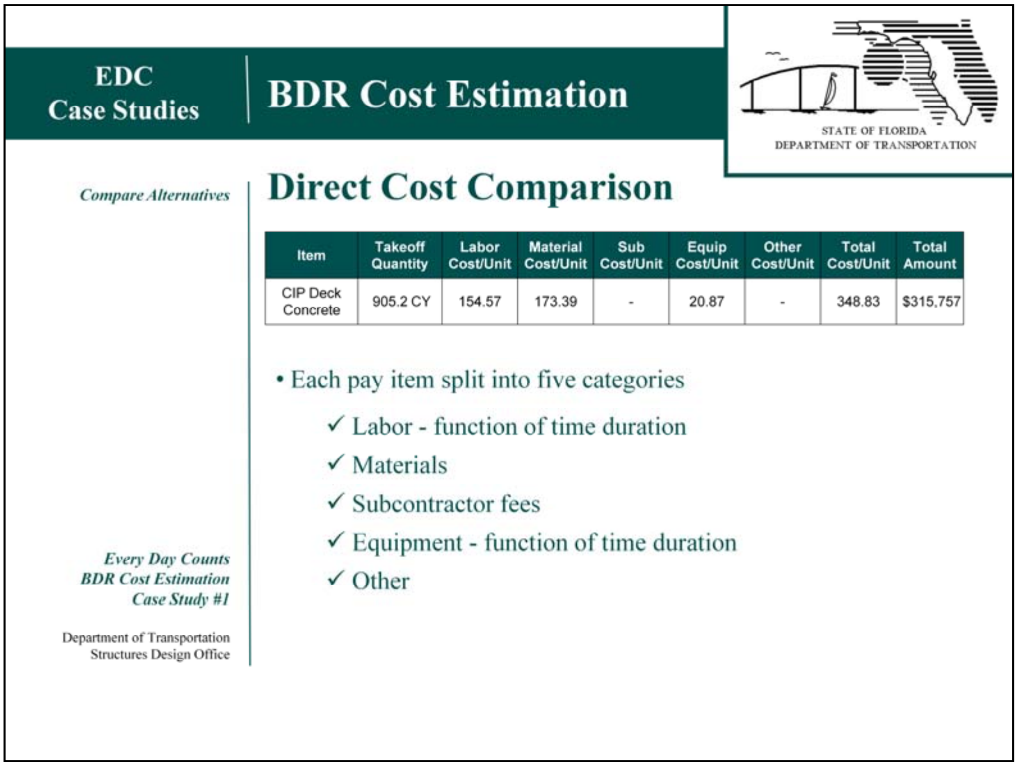
➢ Looking at the first row of the table, the most notable cost differential can be seen. This is the direct cost associated with construction of the detour for conventional construction versus cost of using SPMTs for the prefabricated alternate. The detour is approximately 2.5 million dollars, and includes costs to build the detour roadway approaches, deliver and return the prefabricated detour bridge, construct detour end bents, piers, and superstructure, as well as maintaining the detour throughout it use. Direct costs for the SPMTs include temporary falsework for near-site fabrication, site ground condition upgrades for the SPMT riding surface, cost for the SPMT's themselves, and traffic barrier protection for the fabrication site. This cost favors the prefabricated alternate by 1.5 million dollars.

➢ The second row of the table represents the contractor's general conditions, and reflects labor associated for permanent employees such as the project manager, the superintendent, and field engineers. It also accounts for field offices and other overhead items incurred by the contractor. This item is also in favor of the prefabricated alternate, and is a result of the significantly reduced construction schedule. Under the conventional construction approach, the bridges must be built one at a time, in order to maintain traffic. This results in a construction schedule of 28 months. Using the prefabricated alternate, the schedule can be reduced to approximately 12 months; less than half of the conventional alternate.

➢ Rows three to six have been set up to reflect individual elements of the bridge. The largest cost differential can be seen in row six, which is the superstructure cost. This item is in favor of conventional construction, and is anticipated, as the prefabricated alternative uses an integral straddle cap, as well as steel girders. Note that some pier costs associated with the prefabricated option are moved into the superstructure costs as a result of the integral straddle cap.

➢ In spite of the increased superstructure costs, as well as the use of SPMTs, the prefabricated alternate is expected to save approximately 1.5 million dollars in direct cost over conventional construction.

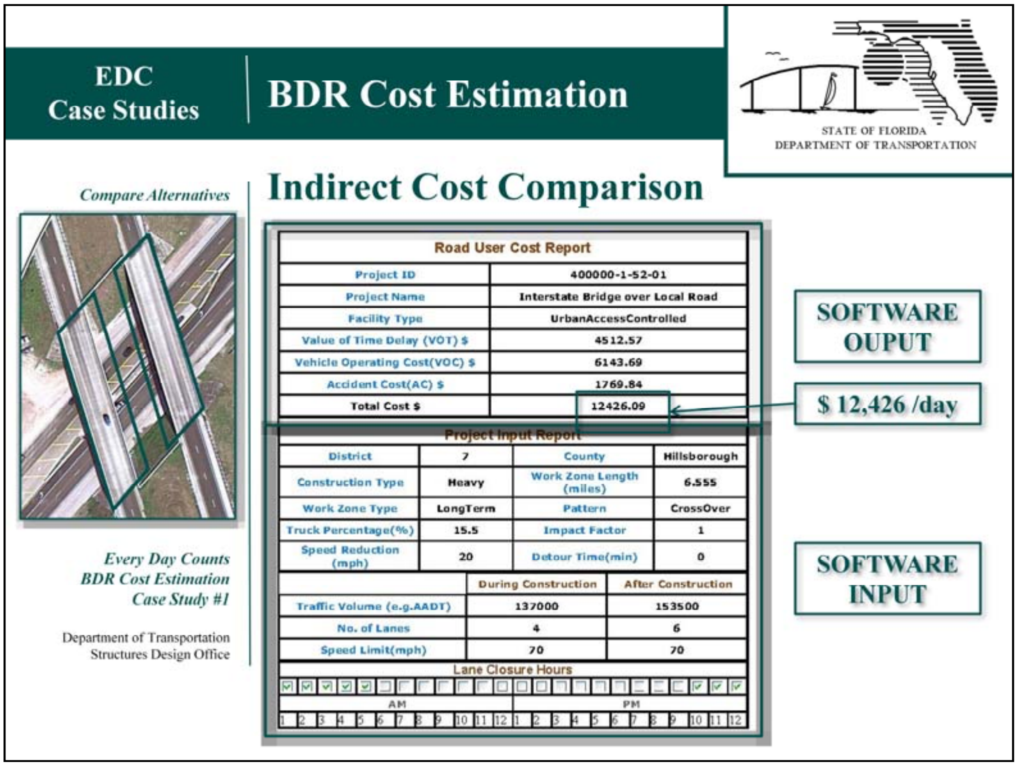
➢ The important information to gain from this slide is that although direct costs for the bridges themselves are higher for the prefabricated approach, the savings associated with eliminating the detour and schedule reduction more than compensates for this.



➢ This slide gives an example of how pay items have been set up to determine direct cost.

➢ Each pay item has five potential costs associated with it, consisting of the labor required, material costs, subcontractor fees, equipment costs, and a miscellaneous category entitled “other”. Construction durations are factored into the cost where appropriate.

➢ The example shown here is the determination of cast-in-place deck concrete. It can be seen that labor, material, and equipment costs have been accounted for.



- ➢ Now we will move onto calculating indirect costs.
- ➢ Indirect costs can be calculated using the Department’s software.
- ➢ The snapshot shown here indicates results for this case study. At the bottom of the snapshot, input for the program is shown. Input parameters represent current and future traffic volumes, the area of construction, and other characteristics of the construction site as they impact traffic.
- ➢ Results of the program are given at the top of the slide. Total cost is a summation of three factors: the value of time delay, vehicle operating costs, and accident costs. Therefore the total indirect cost associated with the interstate for this construction is $12,426 dollars per day.
- ➢ It should be noted that although not presented here, indirect cost for local traffic below the bridge should be calculated as well. As expected, this indirect cost is substantially less than that for the interstate, and is estimated at $1,037 dollars per day.
- ➢ Indirect cost for the prefabricated alternate will also differ from that shown here, as interstate traffic will be detoured at a slower speed, and the local road will be temporarily closed during the SPMT operations.

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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	$ 6,878,552	18	$ 1,037	500	$ 12,426			$ 6,231,666	**$ 13,110,218**
Prefabricated	$ 5,340,686			2	$ 22,495	2	$ 26,804	$ 98,598	**$ 5,439,284**

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Case Study #1

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Structures Design Office

- Indirect cost for conventional construction much larger
- Prefabricated construction less than half of conventional

➢ This slide combines the direct and indirect costs associated with each construction scenario.

➢ As expected, conventional construction has higher indirect costs versus the prefabricated alternative, and further increases its cost.

➢ When looking at the summations, the prefabricated alternative is less than half of conventional construction.

➢ The overall result is a compelling reason to consider prefabricated bridge alternatives, particularly in areas with high traffic volumes.

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Compare Alternatives

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Assessment Matrix

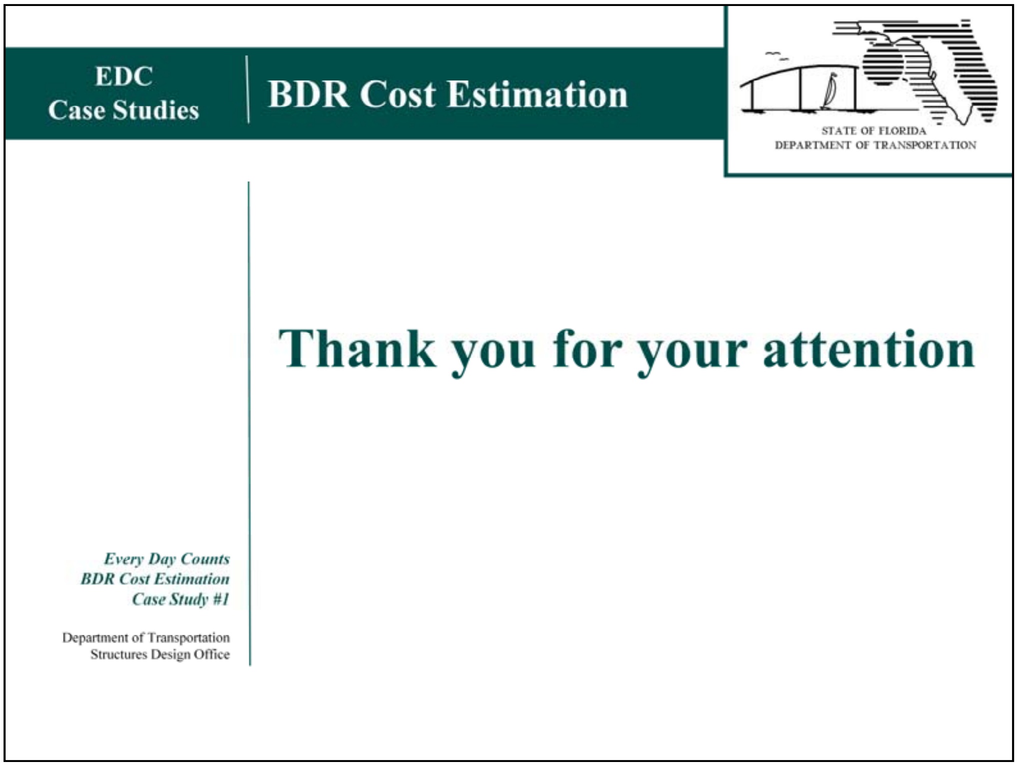
Selection Factor	Factor Weight (%)	PREFABRICATED		CONVENTIONAL	
		Score (0 to 5)	Weighted Score*	Score (0 to 5)	Weighted Score*
Total Direct Costs	55	5	275	4	220
Total Indirect Costs	20	4	80	1	20
Factor 3 – *Constructability*	5	3	15	5	25
Factor 4 - *Traffic Impacts*	0		0		0
Factor 5 - *Construction Duration*	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	2	20	5	50
Factor 10 - *Other*	0		0		0
TOTAL (Σ Factor Weights = 100%)	100	--	***440***	--	345
TOTAL (Excluding Indirect Cost Factor)**	80	--	***360***	--	325

- Combined direct and indirect costs, prefabricated more favorable
- Excluding indirect costs, prefabricated slightly more favorable

➢ The last task for Step C is to create an assessment matrix. It is somewhat similar to preparing cost estimates, as it aims to identify parameters relevant to a specific project. However rather than focusing on costs alone, the criteria are defined in terms of an overall score, with each criteria possessing its own significance. This is yet another useful tool in the decision making process.

➢ This case study has been divided into the categories shown, each with its relative significance to the project. Looking at the last two rows of the table, when accounting for direct and indirect costs, the prefabricated alternative is more favorable. Even when excluding indirect costs, the prefabricated alternate remains more favorable than conventional construction.

➢ It is at this point that a meeting with the Department would take place as outlined in Step C.



- This concludes the presentation. Thank you for your attention.