Organizational Results Research Report

August 2009
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Union Pacific Sedalia and Jefferson City Subdivisions

Freight & Passenger Rail Analysis

Phase 2

Prepared by University of Missouri - Columbia and Missouri Department of Transportation

Final Report

RD09-049

Union Pacific Sedalia and Jefferson City Subdivisions Freight & Passenger Rail Analysis
Phase 2

Prepared for
Missouri Department of Transportation
Organizational Results

by

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The investigation was conducted in cooperation with the U. S. Department of Transportation, Federal Highway Administration.

16. Abstract
The objective of this study was to analyze a list of rail enhancements that addresses current passenger and freight rail performance on the Union Pacific line from St. Louis to Kansas City in order to improve on-time passenger service and reduce freight delays.

Amtrak delay data for January 1, 2008 – June 30, 2009 was obtained in order to evaluate both the sources of delay and the location of delay. Researchers found that the 2008 data FTI (Freight Train Interference) has the highest percentage of delay minutes (53.38%), followed by DSR (Temporary Speed Restrictions = 15.09%) and PTI (Passenger Train Interference = 9.90%). The top three causes contribute to 78.17% of the overall Amtrak delay. In general, the delay profile for 2008 was the same as for 2005, however, there were significant differences in the first half of 2009, specifically, FTI delay was reduced by almost 50% and the overall delay minutes are on pace to be 33% of the total minutes in 2005 and 2008.

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Study Objective:

To analyze a list of rail enhancements that addresses current passenger and freight rail performance on the Union Pacific line from St. Louis to Kansas City in order to improve on-time passenger service and reduce freight delays.

System Analysis:

The Amtrak delay data for January 1, 2008 – June 30, 2009 was obtained in order to evaluate both the sources of delay and the location of delay. As can be observed in Figure 1, for 2008 data FTI (Freight Train Interference) has the highest percentage of delay minutes (53.38%), followed by DSR (Temporary Speed Restrictions = 15.09%) and PTI (Passenger Train Interference = 9.90%). The top three causes contribute to 78.17% of the overall Amtrak delay. In general, the delay profile for 2008 was the same as for 2005, however, there were significant differences in the first half of 2009, specifically, FTI delay was reduced by almost 50% and the overall delay minutes are on pace to be 33% of the total minutes in 2005 and 2008 (see Tables B1 and B2 in the Appendix).

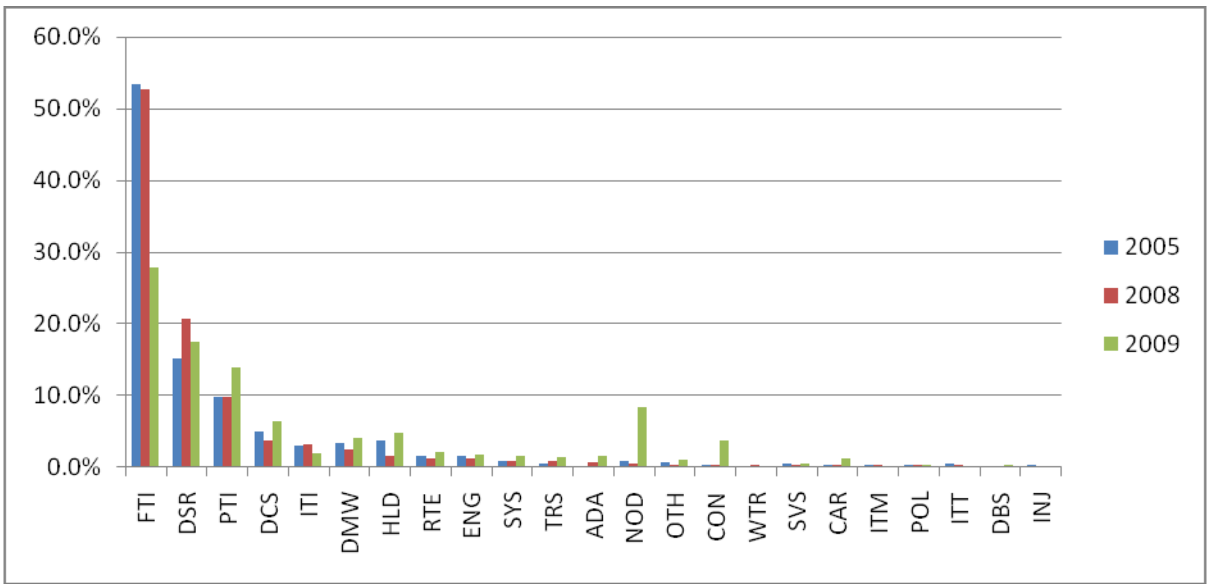


Figure 1 - 2005, 2008, 2009 (only Q1, Q2) Amtrak Total Delay by Type

One delay to note is the TRS delay (Trespasser Incidents – which are comprised of crossing accidents, vehicle on track and "near-miss" delays). TRS delay contributes a relatively small, due to their infrequent occurrence, but an increasing percentage of the overall delay (0.5% in 2005, 0.7% in 2008 and 1.4% in 2009). However, TRS delays are the highest per incidence line delay as shown in Table 1 (compared to train interference delays (both FTI and PTI) that average approximately 15 minutes per incident).

Table 1 – TRS Delay (i.e. crossing related delays)

	Percentage of Overall Delay	Delay per Incident (minutes)
2005	0.5%	94
2008	0.7%	45
2009 (Q1, Q2)	1.4%	43

Figures 2 (2005 data) and 3 (2008 data) show the allocation of Amtrak delay to source location, differentiating between delay that occurs on the rail line and that which occurs at a station.

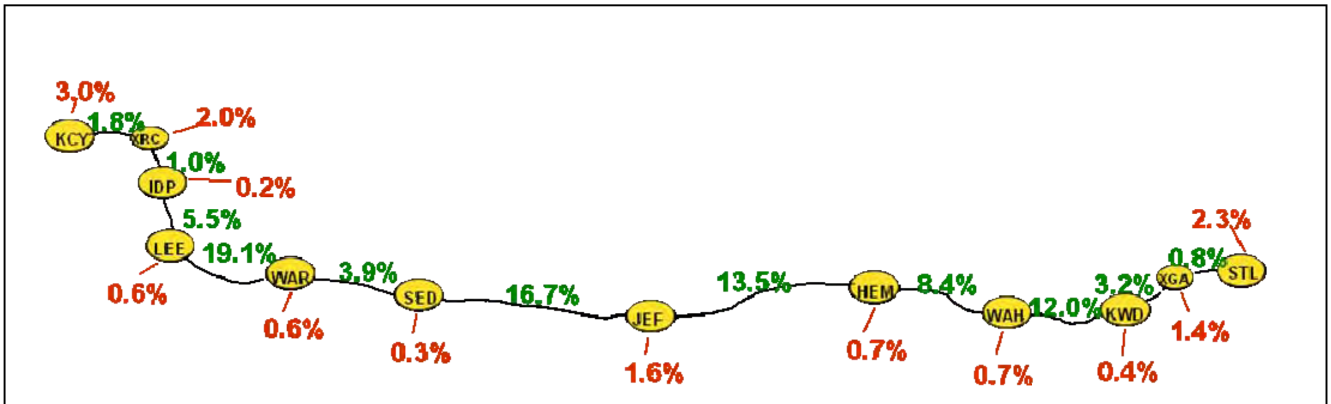


Figure 2 - % of Total 2005 Amtrak Delay - **Line Delay in Green** & **Station Delay in Red**

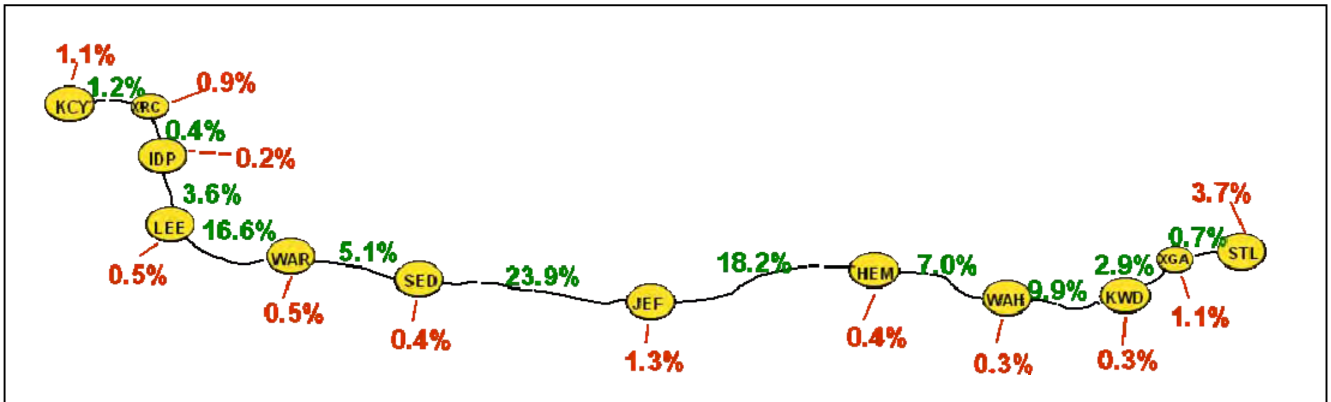


Figure 3 - % of Total 2008 Amtrak Delay - **Line Delay in Green** & **Station Delay in Red**

Comparing the location of delay between 2005 and 2008 reveals that the general location of significant delays have not changed; however, there has been a general shift in the overall magnitude of delay to the Sedalia-Jefferson City and Jefferson City-Hermann links. Table 2 provides a summary of the top 4 locations of Amtrak delay and how it has changed over the past 3 years. Table 3 presents the delay per mile of rail in each section, ranking them in order of greatest delay per mile. Detailed delay results can be found in Tables B3 (All delay) and B4 (FTI and PTI delay) in the Appendix.

Table 2 – Highest Rail Line Section Overall Delay

Rail Line Section	2008	2005	Absolute Change	Relative Change
1. Jefferson City to Sedalia	23.9%	16.7%	7.2%	43.1%
2. Hermann to Jefferson City	18.2%	13.5%	4.7%	34.8%
3. Warrensburg to Lees Summit	16.6%	19.1%	-2.5%	-13.1%
4. Kirkwood to Washington	9.9%	12.0%	-2.1%	-17.5%

Table 3 – Rail Line Section Minutes of Delay per Mile

Rank	Rail Line Section	Minutes Delay per Mile
1	Warrensburg to Lees Summit	504.5
2	Hermann to Jefferson City	504.4
3	Jefferson City to Sedalia	476.4
4	St. Louis to Kirkwood	337.8
5	Washington to Hermann	295.9
6	Lees Summit to Independence	292.8
7	Kirkwood to Washington	261.0
8	Sedalia to Warrensburg	214.9
9	Independence to Kansas City	189.5

Alternative Analysis:

The following presents the simulation results for eight rail improvement alternatives as defined below. Figure 4 illustrates where the alternatives are located relative to the amount of Amtrak delay on the rail line. For this study a performance baseline is assumed based on the scenario where all track from STL to KC is double track (implying that the Sedalia subdivision is improved by double tracking it and both the Gasconade and Osage bridges are double track). The results are given based on the overall percentage delay reduction with respect to the baseline scenario for both freight and passenger trains that is obtained for the improvement alternative.

Projects simulated that have been identified to improve Amtrak reliability & freight flow:

1. Knob Noster Passing Siding Extension – $8,500,000. Extends the existing siding to 9,000' and breaks up a 27 mile segment with no usable siding.

2. Webster Universal Crossover - $4,400,000. Increases ability to sort freight and passenger trains into and out of St. Louis Area.

3. Osage River Bridge - $33,800,000. Uses new steel for bridge. Removes the last remaining one-track segment between St. Louis and Jefferson City.

4. Combination of Projects 2, 3 - $38,200,000.

5. Combination of Projects 1, 2, 3 - $46,700,000.

6. Build Passing Siding at Kingsville - $11,550,000. Build a new 9000' siding to the east of Kingsville. Breaks up a 25-mile segment with no passing siding.

7. Hermann Universal Crossover - $5,200,000. Closes an 18.2 mile gap on double mainline track with no crossovers.

8. 3rd Mainline Track in Jefferson City Yard - $9,700,000. Increases fluidity through Jefferson City yard by maintaining bi-directional freight operations with Amtrak operations and improves station ease use.

9. Track / Control Enhancements for higher Amtrak speeds (Lees Summit to Pleasant Hill – increase to 90-MPH) - $56,600,000. Complete track / signal / control upgrades to increase Amtrak train speed from 79 to 90+ m.p.h. on a significant segment between Lees Summit and Pleasant Hill.

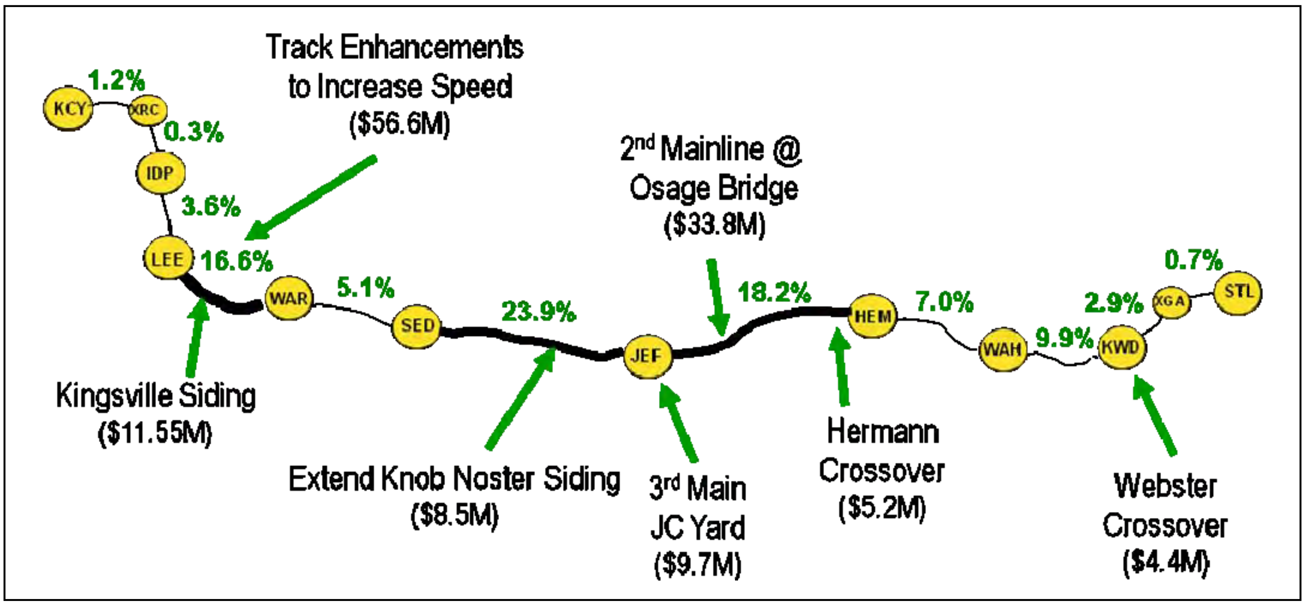


Figure 4 – Location of Alternatives relative to % total Amtrak Delay (2008 data)

Table 4 presents the results of the simulation analysis. All of the alternatives provide significant reduction in overall delay. It should be noted that the large percentage improvements obtained for Project 9 (Increase Amtrak Speed between Lees Summit and Pleasant Hill) do not necessarily reflect reduction in delay. Rather, most of the improvement is due to reduced transit time and the ability to utilize that speed to reduce freight/passenger train interference.

Table 4 - Simulation Results

Projects	Overall % Reduction in Delay	
	Union Pacific	**Amtrak**
1 – Extend Knob Noster Siding	30.9%	42.2%
2 – Webster Universal Crossover	32.9%	19.3%
3 – Osage River Bridge	36.8%	17.9%
4 – Projects 2 & 3 combined	43.7%	23.3%
5 – Projects 1, 2, & 3 combined	58.5%	44.7%
6 – Build Kingsville Siding	26.5%	24.0%
7 – Hermann Universal Crossover	19.9%	17.4%
8 – 3rd Mainline in Jefferson City Yard	25.5%	11.4%
9 – Track/Control to Increase Amtrak Speed to 90 mph (Lees Summit to Pleasant Hill)	50.8%	72.9%

(Note: Overall % Reduction in Delay relative to:
Double Tracking Lee Summit to Jefferson City and Osage/Gasconade Bridges)

Figures 5 and 6 show the dominant project options based on the criteria of maximizing the delay reduction while minimizing project cost. It can be observed that from Amtrak's perspective project alternatives 2, 1, 5, and 9 provide increasing delay reduction at the lowest cost. From UP's perspective, projects 2, 3, 4, 5 provide increasing delay reduction at the lowest cost.

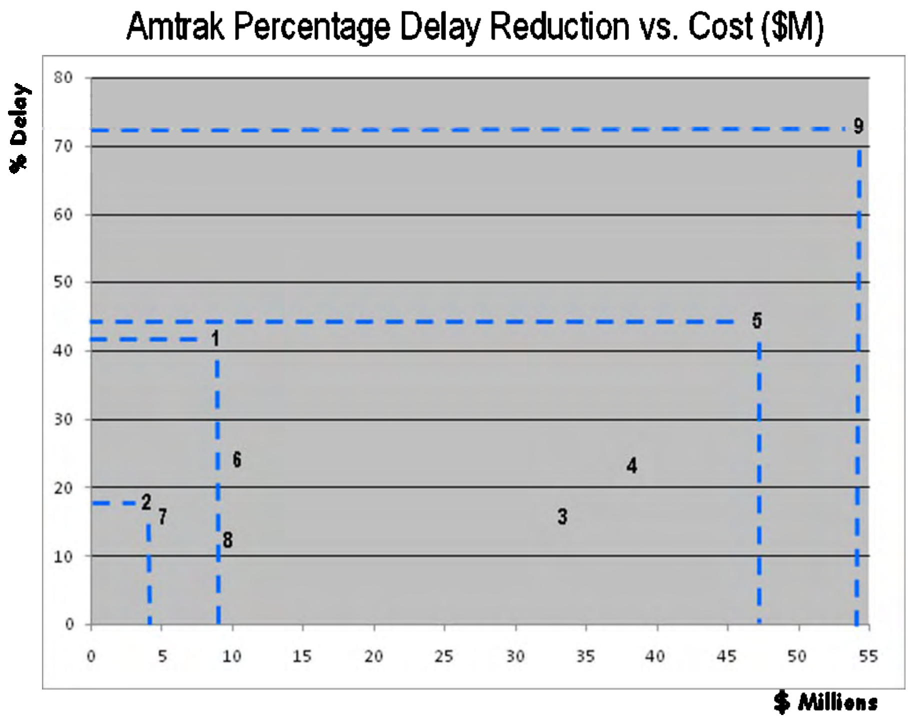


Figure 5 – Location of Alternatives relative to % total Amtrak Delay (2008 data)

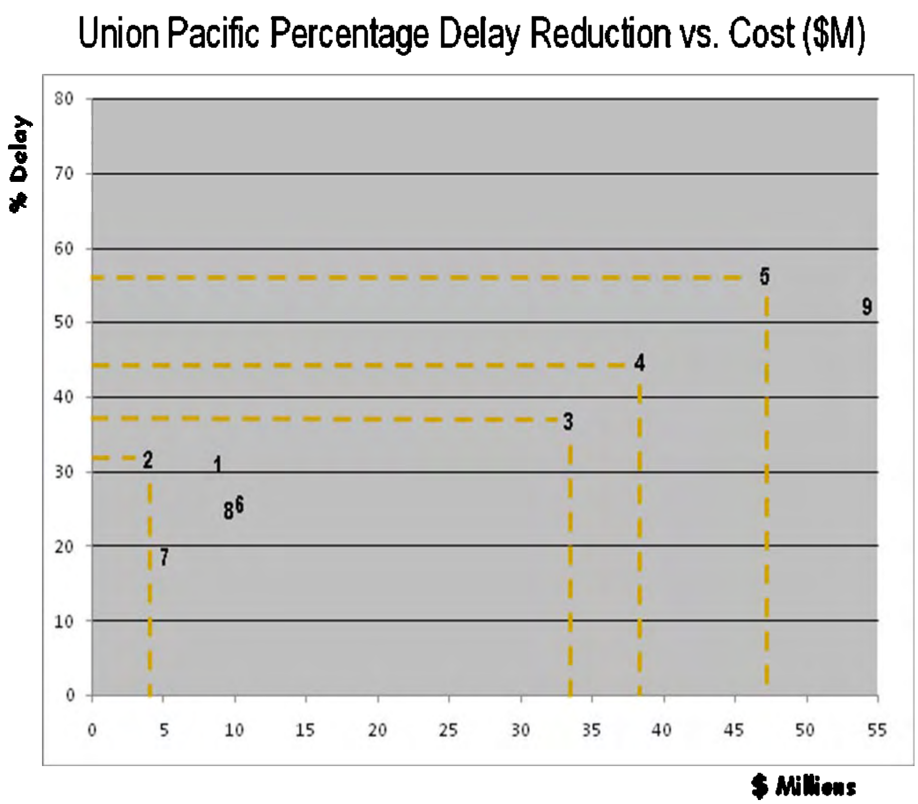


Figure 6 – Location of Alternatives relative to % total Amtrak Delay (2008 data)

Finally, Table 5 presents the results from a delay reduction per dollar invested perspective. When examined in this manner, project alternatives 1, 2, 6, and 7 all provide significant delay reduction per dollar invested for both passenger and freight operations.

Table 5 - % Delay Reduction Per $M invested

	% UP Delay Savings / $M	**% Amtrak Delay Savings / $M**	**Cost**
1 – Extend Knob Noster Siding	3.63%	4.96%	$8.5M
2 – Webster Universal Crossover	7.48%	4.39%	$4.4M
3 – Osage River Bridge	1.09%	0.53%	$33.8M
4 – Projects 2 & 3 combined	1.14%	0.61%	$38.2M
5 – Projects 1, 2, 3 combined	1.25%	0.96%	$46.7M
6 – Build Kingsville Siding	2.29%	2.08%	$11.55M
7 – Hermann Universal Crossover	3.83%	3.35%	$5.2M
8 – 3rd Mainline in Jefferson City Yard	2.62%	1.14%	$9.7M
9 – Track/Control to Increase Amtrak Speed to 90 mph (Lees Summit to Pleasant Hill)	0.90%	1.29%	$56.6M

Note: objective is to maximize the Delay Savings / $M

Summary:

All of the proposed improvement alternatives provide better overall performance from both the freight and passenger rail operations. From a delay reduction per dollar invested perspective, alternatives 1, 2, 6, and 7 provide the highest relative benefit.

<u>APPENDIX A</u> – Work Plan

UP Sedalia and Jefferson City Subdivisions Freight & Passenger Rail Capacity Analysis – Phase 2

Objective and Results Expected:
The objective of this project is to conduct an analysis of potential rail enhancements for the Sedalia and Jefferson City Union Pacific Subdivisions between St. Louis and Kansas City in order to determine which enhancements provide the greatest performance improvement (reduce train delay) per dollar invested. This analysis will result in a final report containing a prioritized list of rail enhancements that can be used within MoDOT's ARRA proposal.

This work plan outlines four major tasks to accomplish these results:

Task 1 (Month 1) – Assessment
Update assessment of the Kansas City – St. Louis Union Pacific rail line constraints / variability associated with passenger / freight flow.

Task 2 (Months 1-2) – Revise Rail Simulation Model
Revise the capacity / variability analysis model used to explore constraints. Modeling approach will utilize a simulation-based candidate analysis to examine alternatives to improving overall capacity.

Task 3 (Months 2-3) - Alternative Analysis
Conduct capacity enhancement analysis respect to performance and economic criteria and generate prioritized list with respect to MoDOT and UP alternatives.

Task 4 (Month 3) – Final Report
Write final project report and present results to MoDOT containing a prioritized list of rail enhancements to improve on-time passenger service and reduce freight delays.

Task 1: St. Louis – Kansas City UP Rail Assessment

Data will be collected from MoDOT, Amtrak and Union Pacific to up-date the assessment that was performed in the phase 1 study.

Task 1 DELIVERABLE: Updated constraint analysis for the UP STL-KC line including significant locations and sources of delay.

Task 2: Revised Rail Simulation Model

The Arena Simulation model developed previously will be revised to incorporate the proposed list of rail enhancements. Specifically:

1. Gasconade River Bridge (Implemented) - Project added double track to existing bridge and approaches on each side of 5 miles total. Project was completed in October of 2008.

2. New California Passing Siding (Implemented) - Ground breaking held in April and project will be completed in 2009.

3. Knob Noster Passing Siding Extension – Would extend existing siding to 9,000' and break up 27 mile segment with no usable siding.

4. Webster Universal Crossover - Would increase ability to sort freight and passenger trains into and out of St. Louis Area.

5. Higher Amtrak speeds - Increase Amtrak train speed from 79 to 90+ m.p.h. on a significant segment between St. Louis and JC, most likely in Washington/ New Haven/Hermann areas.

6. Extend Strasburg Passing Siding - Extend existing siding to 9000' to east. Would break up 25-mile segment with no passing siding.

7. Osage River Bridge - Assumes use of re-cycled bridge span. Would remove the last remaining one-track segment between St. Louis and Jefferson City.

8. Hermann Universal Crossover - Closes 18.2 mile gap on double mainline track with no crossovers.

9. 3rd Mainline Track in Jeff City Yard - Will increase fluidity through Jeff City yard by maintaining bi-directional freight operations with Amtrak operations and ease use of station.

Task 2 DELIVERABLE: A revised simulation model that is capable of analyzing the rail enhancements proposed.

Task 3: Alternative Analysis

The simulation model developed will be used to analyze the proposed alternatives and the rail enhancement alternatives will be prioritized based on their ability to improve overall line performance (both passenger and freight train delay) with respect to investment requirements.

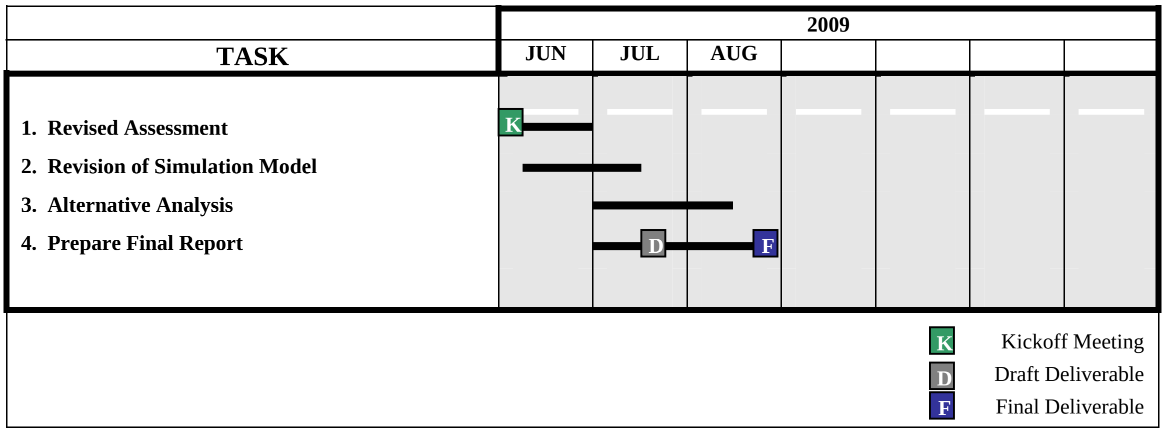
Task 3 DELIVERABLE: A draft final report submitted to MoDOT summarizing the results of the analysis and the list of prioritized alternatives.

Task 4: Final Report

A final report will be prepared that summarizes the methodology, analysis results, and prioritized list of rail enhancement alternatives.

Task 4 DELIVERABLE: A final report in accordance with the schedule shown on the following page.

Project\Deliverable Schedule:



<u>APPENDIX B</u> – Amtrak Delay Data

Table B1 – Amtrak Delay by Type for Calendar Years 2005, 2008 and 2009 (Q1 & Q2)

	2005	2008	2009
FTI	53.4%	52.7%	27.8%
DSR	15.1%	20.6%	17.5%
PTI	9.7%	9.6%	13.9%
DCS	4.9%	3.6%	6.5%
ITI	2.9%	3.0%	1.8%
DMW	3.2%	2.4%	4.0%
HLD	3.6%	1.5%	4.8%
RTE	1.5%	1.1%	2.0%
ENG	1.4%	1.1%	1.7%
SYS	0.8%	0.7%	1.6%
TRS	0.5%	0.7%	1.4%
ADA	0.0%	0.6%	1.6%
NOD	0.8%	0.4%	8.3%
OTH	0.5%	0.3%	1.1%
CON	0.2%	0.3%	3.7%
WTR	0.0%	0.3%	0.1%
SVS	0.4%	0.2%	0.4%
CAR	0.2%	0.2%	1.2%
ITM	0.2%	0.2%	0.0%
POL	0.2%	0.2%	0.3%
ITT	0.3%	0.1%	0.0%
DBS	0.0%	0.1%	0.2%
INJ	0.1%	0.0%	0.0%
Total Delay (minutes)	107,300	123,425	18,524

Table B2 – Amtrak Delay Report Codes

CODE:	EXPLANATION OR EXAMPLES:
ADA	Passenger-Related delays specifically related to disabled passengers (wheelchair lifts, exercising guide dogs, etc.)
CAR	Car Failure (includes HEP failure, legitimate HBD or DED actuations, set out / pick up defective / repaired cars)
CON	Hold for Connection (holds for train or bus connections, including en-route holds; includes connection delay at Initial Terminal)
CTI	Commuter Train Interference (meets, overtakes)
CUI	Customs and Immigration
DBS	Debris Strike (emergency braking, damage, set-outs from same; also debris blocking track ahead)
DCS	Signal Delays (false wayside detector actuations, defective road crossing protection, bad wayside or cab signals from unknown cause or from signal, power-switch or CTC system failure, efficiency tests of the crew; drawbridge stuck open)
DMW	M/W Work (holding for defect repair or M/W forces to clear; inability to contact M/W Foreman on radio; routed around the M/W work.)
DSR	Temporary Speed Restrictions (slow orders, slows through M of W site)
DTR	Detour Delays (all delay or time lost while operating on a detour, regardless of cause)
ENG	Engine Failure (HEP failure, HBD or DED actuations, cab signal failure on engine, set out / pick up defective / repaired engines, operating with freight engine, undesired emergency applications, air problems)
FTI	Freight Train Interference (meets / overtakes, bad signals known to be caused by freight trains, holds due to freight derailments, non-scheduled stop to pick-up/drop-off freight train crew)
HLD	Passenger-Related (multiple spots, checked bags, smoke breaks, disorderly, any other passenger-related delay; <u>except</u> for disabled passengers, see delay code "ADA".)
INJ	Injury Delays (injured or sick passenger or employee)
ITE	Initial Terminal Delay -- Engineering Causes (track, signals, M of W work, etc.)
I T I	Initial Terminal Delay -- Late-Arriving Inbound Train (causing late release of equipment or late crew rest -- if mechan.-failure delay is not involved)
ITM	Initial Terminal Delay -- Mechanical Failure (car or locomotive)
ITT	Initial Terminal Delay -- Transportation (eg., freight / passenger / commuter-train interfer., dispatching-related, late bulletins, etc.)
MBO	Drawbridge openings for marine traffic. (Note: replaces code "DBB" which is no longer used.)
NOD	Wait for time at station, kill time to prevent early arrival at station.
OTH	Miscellaneous (unable to make normal speed, heavy train, engine(s) isolated for fuel conservation, person pulling emergency cord)
POL	Police Related (DEA; police / fire department holds on right-of-way, bomb threat delays)
PTI	Passenger Train Interference (meets, etc. - does <u>*not*</u> include commuter trains)
RTE	Routing (crossover moves, lining manual or spring switch, run via siding, late track bulletins, inability to contact DS, dispatcher holds)
SVS	Servicing (fuel, water, toilet / trash dumping, inspection; switching private/ office, express cars, or section of train, normal engine change)
SYS	System (late crew, unscheduled re-crew, lone engineer copying authorities or restroom break, hold due to passenger train derailment; alleged crew rules violation; delayed-in-block after station stop)
TRS	Trespasser Incidents (includes crossing accidents, trespasser or animal strikes, vehicle on track ahead; "near-miss" delays; bridge strikes by vehicles or boats)
WTR	Weather (includes heat / cold orders, floods, washouts and detours around same; earthquake related delays; also, autumn-leaf-caused delays such as slippery rail due to wet leaves or burning leaves caught in truck of car)

Table B3 - 2008 Amtrak Delay Summary - ALL DELAYS

			West Bound		East Bound		Overall		
From	To	Miles	Freq	Total Minutes	Freq	Total Minutes	Overall Freq	Overall Total Minutes	Percent
STL	XGA	1.8	47	445	44	352	91	797	0.65%
XGA	KWD	11.1	124	1328	310	2232	434	3560	2.88%
KWD	WAH	46.7	708	4698	840	7490	1548	12188	9.87%
WAH	HEM	29.3	715	4379	755	4292	1470	8671	7.03%
HEM	JEF	44.5	1472	12078	1360	10368	2832	22446	18.19%
JEF	SED	61.8	1159	11325	1567	18119	2726	29444	23.86%
SED	WAR	29.5	201	1580	474	4761	675	6341	5.14%
WAR	LEE	40.6	521	3716	1417	16767	1938	20483	16.60%
LEE	IDP	15.2	333	2512	313	1939	646	4451	3.61%
IDP	XRC	3.7	41	363	13	68	54	431	0.35%
XRC	KCY	6.1	30	418	93	1008	123	1426	1.16%
	Line Totals	290.3	5351	42842	7186	67396	12537	110238	89.32%
At Station									
STL							127	4577	3.71%
XGA							136	1295	1.05%
KWD							124	408	0.33%
WAH							138	393	0.32%
HEM							134	512	0.41%
JEF							305	1573	1.27%
SED							155	547	0.44%
WAR							139	654	0.53%
LEE							220	601	0.49%
IDP							63	199	0.16%
XRC							102	1068	0.87%
KCY							43	1360	1.10%
						Station Total	1559	8610	6.98%
							Overall Total	123425	100.00%

Table B4 - 2008 Amtrak Delay Summary - FTI & PTI DELAY ONLY

			West Bound		East Bound		Overall		
From	To	Miles	Freq	Total Minutes	Freq	Total Minutes	Overall Freq	Overall Total Minutes	Percent
STL	XGA	1.8	15	140	22	250	37	390	0.51%
XGA	KWD	11.1	41	714	98	1152	139	1866	2.43%
KWD	WAH	46.7	106	1521	215	3723	321	5244	6.82%
WAH	HEM	29.3	116	2260	92	1666	208	3926	5.10%
HEM	JEF	44.5	346	6359	284	5385	630	11744	15.26%
JEF	SED	61.8	518	8511	978	15267	1496	23778	30.91%
SED	WAR	29.5	67	1070	331	4180	398	5250	6.82%
WAR	LEE	40.6	198	2646	1079	15149	1277	17795	23.13%
LEE	IDP	15.2	89	1812	77	1329	166	3141	4.08%
IDP	XRC	3.7	31	236	4	36	35	272	0.35%
XRC	KCY	6.1	18	174	64	866	82	1040	1.35%
	Line Totals	290.3	1545	25443	3244	49003	4789	74446	96.76%
At Station									
STL							7	196	0.25%
XGA							76	781	1.02%
KWD							1	12	0.02%
WAH							1	3	0.00%
HEM							1	1	0.00%
JEF							12	329	0.43%
SED							5	63	0.08%
WAR							2	148	0.19%
LEE							2	39	0.05%
IDP							1	12	0.02%
XRC							75	899	1.17%
KCY							1	10	0.01%
						Station Total	177	2297	2.99%
							Overall Total	76939	100.00%

APPENDIX C – General Description of the Rail Simulation Model

Guided Transporters

The basis of the simulation model of this rail corridor is the guided transporter. At each terminal operation, an entity (or train type) is created following a probabilistic inter-arrival rate and requests a guided transporter, which has associated with it a length (in generic units), default velocity, and acceleration/deceleration rate. The transporters then follow a path defined by nodes and arcs connected between two nodes. When an entity is created, it requests the transporter that resides at the closest proximity in the model to the terminal.

Network Links and Networks

Guided transporters travel along pre-set networks of arcs connected by nodes. The arcs are defined as Network Links and have a length and associated direction that describes the angle between two links. In the model, the first step is to choose and define the important control points or nodes and the links connecting nodes. Network links can be defined as bi-directional or one-way, but are always only one transporter unit wide. This implies transporters cannot pass at any point in the middle of a link. To avoid deadlock, node specific logic is developed based on each unique combination of siding, track, and depot configurations.

Transport Modules

As entities travel through and finish model logic they come to transport modules, which tell the transporter the direction to travel next. Within this module it is necessary to specify what transporter is controlled, the destination intersection or station of the transporter, and the velocity at which the transporter travels. This velocity take precedence over the default velocity specified when defining the transporter.

Model Assumptions and Logic:

Terminal Operations

There are many activities occurring within the Saint Louis and Kansas City terminal operations. Based on factors such as load importance, train crew age, or train destination, trains can be sequenced before entering the terminal areas or held for long periods of time within terminal yards. All terminal operations are capture in this model by the arrival parameters used. That is, inter-arrival times of trains follow a probability distribution and account implicitly for the sequencing, congestion, and dispatching behavior of the terminals.

Priority

As provided by Union Pacific, there are approximately six levels of priority for trains on the Saint Louis-Kansas City corridor. Priority is based on a function of crew age, type of train, destination location, and other factors. However, in this modeling effort it was decided to generalize priority to be solely determined by train type. Currently there are more than fifteen different types of trains that travel the route, but priority was generalized by the most prominent train types. Furthermore, priority did not affect the simulation for like-directional trains because overtaking like-directional trains was not allowed. Therefore, priority is only taken as a significant issue for Passenger trains, as they are given the highest priority by Union Pacific and are the only type of train that travels against opposing traffic. The following train types are shown with their respective priority. In the model, we created these different trains to represent the priority levels.

Priority / Transporter	Train types
1 / Amtrak Train	Passenger Train
2 / Train 2	Z-Inter-modal
3 / Train 3	K-Inter-modal, Q-Priority Manifest, N-Double Stack, I-Inter-modal , A-Automobile
4 / Train 4	M-Manifest
5 / Train 5	Commodity: O-Ore, G-Grain, R-Rock
5 / Coal Train	C-Coal

Parameters:

Input/Arrivals

Train inter-arrival rates were approximated from historical data in order to most accurately reflect the behavior of the real system. Therefore, all Union Pacific train data between STL and KC for 2005 was analyzed. The time interval between arrivals for all train priority types were analyzed using Arena's Input Analyzer to fit a probability distribution to the inter-arrival times. The following chart shows the input distributions and parameters for each train type used in the model.

Train Type	Input Distribution (min)
Westbound Amtrak	24 hours at 7:30 AM , 2:30 PM
WB Train 2	Gamma (115, 1.45) + 1
WB Train 3	Gamma (605, .895) + 12
WB Train 5	Exponential (146) + 1
WB Coal Train	Described under next heading
Eastbound Amtrak	24 hours at 7:30 AM , 4:30 PM
EB Train 2	Normal (1050, 731)
EB Train 3	Exponential (132)
EB Train 4	Weibull (801,1.44)
EB Train 5	Exponential (99.2)
EB Coal Train	Described under next heading

West Labadie Coal Plant

Based upon data supplied by Union Pacific, the percentage of coal traffic was approximated for that which originates from the Kansas City terminal and exits the Jefferson City subdivision at MP 43.3, the location of an Ameren UE Corporation coal plant in West Labadie, Missouri. Conversely, the rate at which trains exit this plant and travel back to the Kansas City terminal were approximated. The data shows that, on average, 15 percent of all commodity trains enter the West Labadie plant. The exit rate of trains leaving this plant was approximated based on the historical data and Arena's Input Analyzer was used to determine that the departure rate can be approximated as a Weibull distribution with a mean value of inter-departure time of 939 minutes and an offset value of 16 minutes.

Amtrak stations stop times

Delay times at the various Amtrak depots along both the Sedalia subdivision and Jefferson City subdivision were approximated using 2005 delay data supplied by Amtrak. The following chart shows the various stops traveling from Saint Louis to Kansas City and the associated delay times.

STATION	Delay Distribution (min)
Saint Louis Station	Uniform (5,8)
Kirkwood Station	Uniform (3,6)
Washington Station	Uniform (0,3)
Hermann Station	Uniform (0,3)
Jefferson City Station	Uniform (3,6)
Sedalia Station	Uniform (0,3)
Warrensburg Station	Uniform (0,3)
Lee's Summit Station	Uniform (0,3)
Independence Station	Uniform (0,3)
Kansas City Station	Uniform (5,8)

Transporter Sizes

Most sidings on the Sedalia subdivision are large enough to accommodate freight trains up to approximately 8000 feet in length. Therefore, size was not found to affect the model and therefore was abstracted to a common value for all trains, except for passenger trains.

Replication Parameters

The model does not take long to reach steady state operation, therefore, the base model and all alternatives were run with 5 replications of 31 days to create a large sample size of possible events. Each replication includes an initial 24 hours of warm-up to load the system and reach steady state.

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Organizational Results
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