

# MIT Bus and Rail Corridor Service Options

## Outline

- Corridor Objectives and Strategies
- Express
- Local
- Limited Stop Overlay on Local Service <sup>1,2</sup>
- Deadhead
- Metro Rail in Santiago, Chile

1. Stacey Schwarcz, "Service Design for Heavy Demand Corridors: Limited-Stop Bus Service." MST Thesis, MIT, September 2004
2. Harvey Scoria, "Design And Evaluation Of BRT and Limited-Stop Services." MST Thesis, MIT, September 2010.

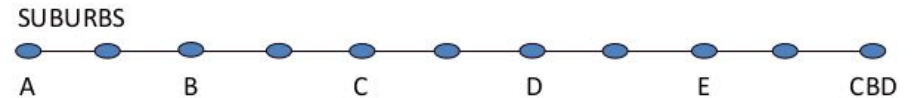
# MIT Strategies

- Express Service
  - Downtown orientation
  - Zonal Express
  - Limited Stops on Express Segment
- Local Service
  - Short Turns/Lines
  - Restricted Zonal
  - Semi-Restricted Zonal
  - Limited Stop Zonal
- Light Direction Strategies
  - Complete Deadheading
  - Partial Deadheading

# MIT Corridor Design Objectives

- Design Objectives
  - To reduce cost for providing existing level of service, or
  - To improve the level of service without increasing resources on existing, longer high-frequency corridors
- Operational Objectives
  - Increase the operating speed
  - Reduce the vehicle miles of service
  - Reduce unnecessary slack time at terminals
  - Maintain high, uniform vehicle loadings on all segments
- Issues
  - Service Quality Impacts
    - Changes in wait time, walk distance, and need to transfer
  - Ridership Changes
    - What ridership changes will result from level of service impacts?

# MIT Local and Express Service: Local



SCHEDULE Route 1					
A	B	C	D	E	CBD
7:00 A.M.	7:08	7:15	7:25	7:32	7:45
7:10	7:18	7:25	7:35	7:42	7:55
7:20	7:28	7:35	7:45	7:52	8:05
7:30	7:38	7:45	7:55	8:02	8:15
7:40	7:48	7:55	8:05	8:12	8:25
7:50	7:58	8:05	8:15	8:22	8:35
8:00	8:08	8:15	8:25	8:32	8:45

# Local and Express Service: Express

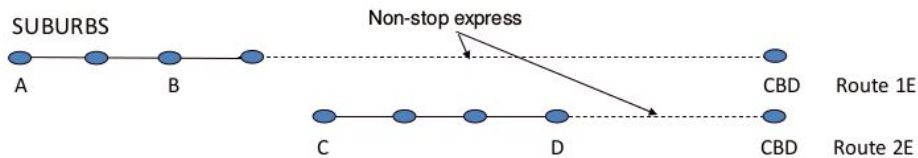


SCHEDULE Route 1E					
A	B	C	D	E	CBD
7:10 AM	7:18	----	----	----	7:35
7:30	7:38	----	----	----	7:55
7:45	7:53	----	----	----	8:10
8:00	8:08	----	----	----	8:25
8:15	8:23	----	----	----	8:40
8:30	8:38	----	----	----	8:55

# Issues In Designing Express Services

- **Downtown Routing**
  - Minimize time on local streets
- **Adding Stops to Express Portions**
  - Minimize impact on capacity and running time
- **Reverse Commuting**
  - Maximize potential for reverse commuting traffic
- **Fares**
  - What fare premium is appropriate?
- **Local Service Interaction**
  - Is parallel local service viable?
  - Is express time advantage and frequency sufficient to attract (almost) all downtown riders?

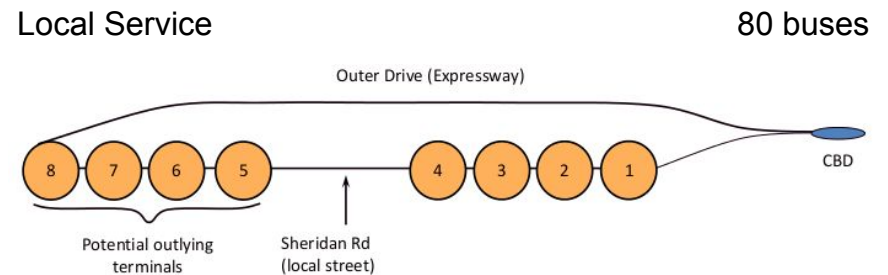
# Zonal Express Service



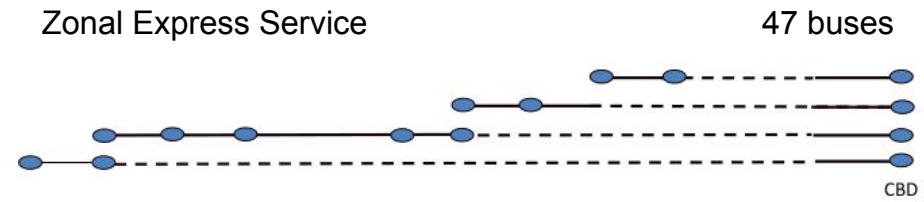
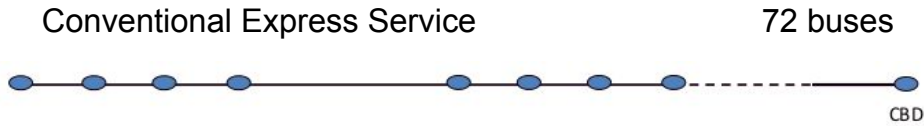
SCHEDULE Route 1E					
A	B	C	D	E	CBD
7:00 A.M.	7:08	----	----	----	7:32
7:20	7:28	----	----	----	7:52
7:40	7:48	----	----	----	8:12
8:00	8:08	----	----	----	8:32

SCHEDULE Route 2E					
A	B	C	D	E	CBD
----	----	7:05	7:13	----	7:30
----	----	7:20	7:28	----	7:45
----	----	7:35	7:43	----	8:00
----	----	7:50	7:58	----	8:15
----	----	8:05	8:13	----	8:30

# Zonal Express Service in the Sheridan Road corridor (simplified)



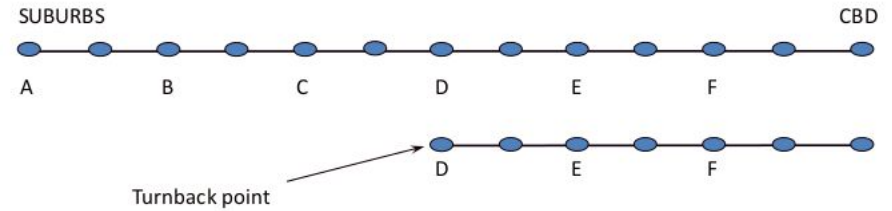
# MIT Zonal Express Service in the Sheridan Road corridor (simplified)



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9

# MIT Short-Turning Local Service

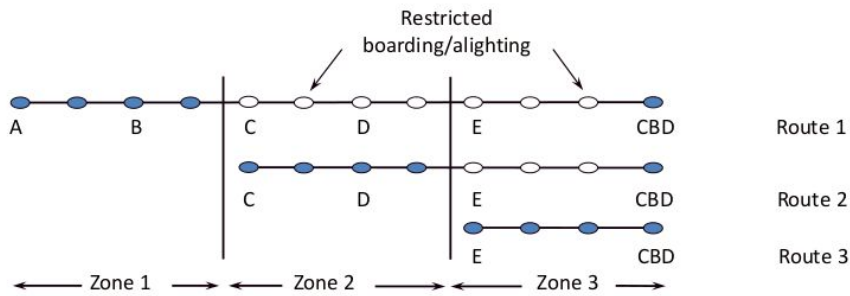


SCHEDULE - Inbound						
A	B	C	D	E	F	CBD
7:00 A.M.	7:08	7:15	7:18	7:25	7:32	7:45
			7:25	7:32	7:39	7:52
7:15	7:23	7:30	7:33	7:40	7:47	8:00
			7:40	7:47	7:54	8:07
7:30	7:38	7:45	7:48	7:55	8:02	8:15
			7:55	8:02	8:09	8:22

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# MIT Restricted Zonal Local Service



- Inbound buses do not stop except to let passengers alight; boarding prohibited.
- Outbound buses do not stop except to let passengers board; alighting prohibited.

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11

# MIT Restricted Zonal Local Service

SCHEDULE - Route 1					
A	B	C	D	E	CBD
7:00	7:08	(7:15)*	(7:24)	(7:30)	7:42
7:15	7:23	(7:30)	(7:39)	(7:45)	7:57
7:30	7:38	(7:45)	(7:54)	(8:00)	8:12

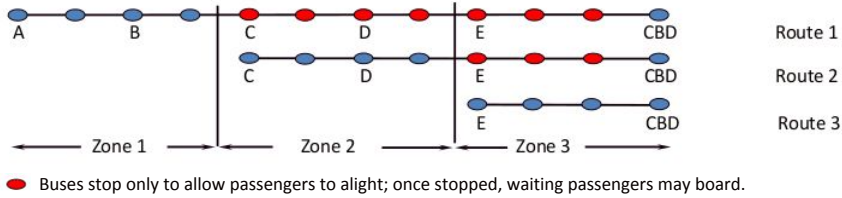
SCHEDULE - Route 2					
A	B	C	D	E	CBD
		7:10	7:20	(7:27)*	7:39
		7:22	7:32	(7:39)	7:51
		7:34	7:44	(7:51)	8:03

SCHEDULE - Route 3					
A	B	C	D	E	CBD
				7:25	7:39
				7:35	7:49
				7:45	8:59

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12

# MIT Semi-Restricted Zonal Local Service (Inbound only)



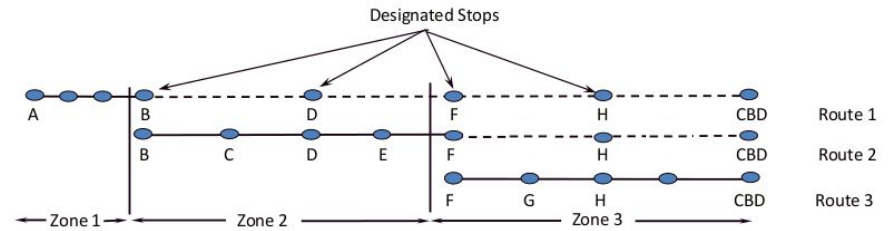
• Buses stop only to allow passengers to alight; once stopped, waiting passengers may board.

SCHEDULE - Inbound						
A	B	C	D	E	CBD	
7:00	7:08	(7:15)*	(7:24)	(7:30)*	7:42	Route 1
		7:10	7:20	(7:27)*	7:39	Route 2
				7:25	7:39	Route 3
7:15	7:23	(7:30)*	(7:39)*	(7:45)*	7:57	Route 1
		7:22	7:32	(7:39)*	7:51	Route 2
				7:35	7:49	Route 3
				7:45	8:59	Route 3
7:30	7:38	(7:45)	(7:54)	(8:00)*	8:12	Route 1
		7:34	7:44	(7:51)*	8:03	Route 2
				7:55	8:09	Route 3

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13

# MIT Limited Stop Zonal Local Service (Inbound only)

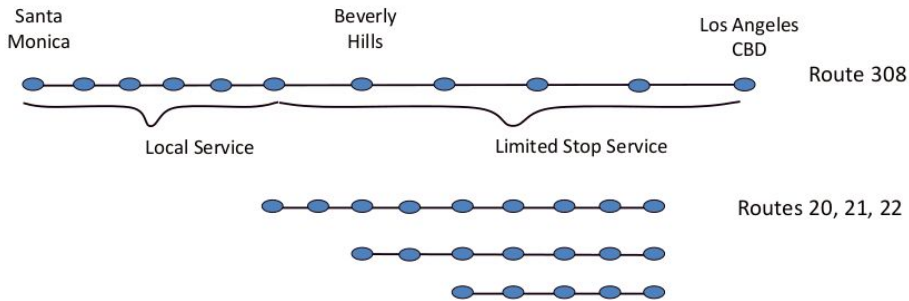


SCHEDULE - Inbound										
A	B	C	D	E	F	G	H	I	CBD	
7:00 AM	7:12	-----	7:19	-----	7:26	-----	7:33	-----	7:40	Route 1
	7:13	7:17	7:22	7:27	7:31	-----	7:38	-----	7:45	Route 2
					7:30	7:35	7:40	7:45	7:50	Route 3
7:15	7:27	-----	7:34	-----	7:41	-----	7:48	-----	7:55	Route 1
	7:28	7:32	7:37	7:42	7:46	-----	7:53	-----	8:00	Route 2
					7:45	7:50	7:55	8:00	8:05	Route 3

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14

# MIT Wilshire Boulevard Corridor



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# MIT Limited Stop Overlay on Local Service: Research Objectives

- Establish guidelines for the addition of limited-stop service
- Create a procedure and model for evaluation and design
- Apply the model to CTA case studies

Stacey Schwarcz, "Service Design for Heavy Demand Corridors: Limited-Stop Bus Service." MST Thesis, MIT, September 2004

Harvey Scorcio, "Design And Evaluation Of BRT and Limited-Stop Services." MST Thesis, MIT, September 2010.

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## MIT Key Elements of Limited-Stop Service Design

- Stop Reduction
- Running Time Savings
  - Dwell times
  - Traffic and traffic signal delay
- Frequency split
- Resources: neutral or increased?

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17

## MIT CTA Limited-Stop Routes

- 3/X3,4/X4, 49/X49, 55/X55, 80/X80, 9/X9, 54A/54B/X54
- Average Route Length: ~8 miles; range: 7.5 to 16 miles
- Stop Reduction: 60-70% of existing stops
- Run Time reductions range from 13-26%
- Frequency split: 50-60% local service initially; based on MIT research, changed to 60-67% express, maintaining at least 15-minute headway on local service

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18

## MIT Model Overview

- Model Assumptions
  - Demand is fixed (or adjusted using frequency elasticity model)
  - Local Stop Spacing is fixed
  - Total Dwell Time for the route does not change based on the stop spacing, frequency configuration, or boardings
    - Scorcia's update relaxes these assumptions and assigns demand probabilistically.
- Makes use of AVL and APC data to determine running times and the O-D demand matrix
- Evaluates a specific user defined stop spacing and headway configuration
- Calculates travel time components for each O-D pair

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19

## MIT Model Overview

- Assignment
  - Stop Choice (can be modeled based on user surveys or smart card home address information)
  - Route Choice (at combined stops only)
  - Local captive, choice, and limited-stop only riders
  - Based on minimum weighted travel time
    - Access Time=3, Wait Time=2, In Vehicle Time=1  
(Loosely based on the Chicago Area Transportation Study)
- Calculates evaluation measures
  - Net passenger minutes of total travel time, number of limited-stop only riders

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20

- Success of limited-stop service depends on
  - Running time savings
  - Frequency split between local and limited-stop service
  - Demand pattern: trip end concentration and trip length
  - Large number of limited-stop-only or choice riders
- Eliminating stops affects access time: the number of limited-stop only riders decreases as stop spacing increases
- Eliminating stops on CTA routes has had moderate impacts (13-26%) on running times
- Potential Strategy for Limited-Stop Service
  - Increase stop spacing while maintaining low frequency service on the local

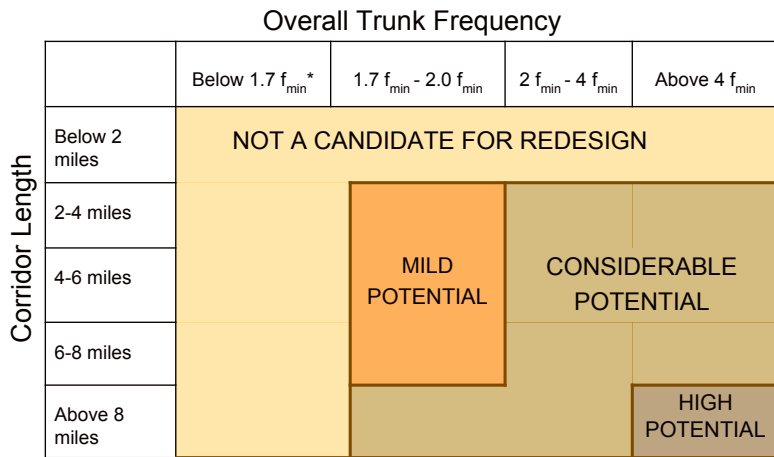
**Strategies**

- Deadhead all vehicles on route:
  - Possible with one (or more) routes of short turn or zonal route system
- Deadhead some vehicles on route
  - Deadhead every other bus (or 2 out of every 3) with remainder in service

**Issues**

- Can a vehicle be saved by deadheading?
- Will there be adverse public reaction?
  - easier if by different route

**MIT Key Factors in Determining the Potential Benefit of Route Redesign of a Corridor**

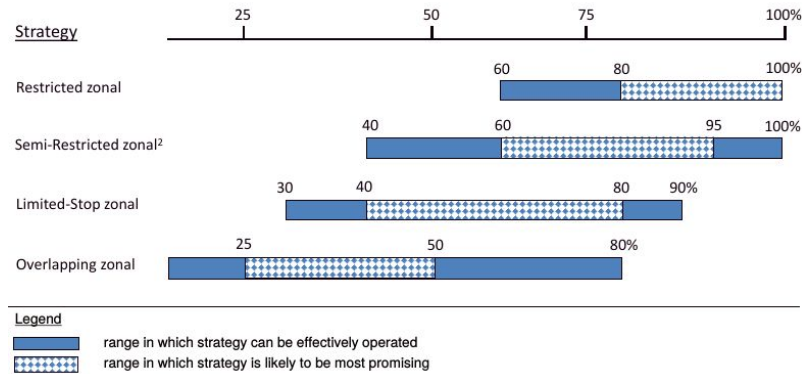


\* $f_{min}$  = minimum acceptable frequency for a peak period radial route

**MIT General Characteristics**

	Short-Turn	Restricted Zonal	Semi-Restricted Zonal	Limited-Stop Zonal
Need for schedule coordination and strict adherence	valuable in AM vital in PM	none	none	unnecessary in AM valuable in PM
Reliance on overtaking	none	strong	moderate	strong
wait time	higher in outer part lower in inner	higher	higher in outer part lower in inner	higher in outer part lower in inner (key stops)
in-vehicle time reduction	none	considerable	moderate	considerable
typical walk distance impact to peak direction travelers	none	none	none	up by 0.2 mi. for some passengers
difficulty in public comprehension	little	greatest	considerable	moderate
ideal corridor length	short	long	medium-long	long
fraction of local (non-CBD) travel	moderate to high	small	moderate	moderate to high
outer segment volume	low	low	low	any

# MIT Strategies Best Suited to Different Ratios of Peak Volume to Uptown Boardings<sup>1</sup>



1 For inbound direction. When the peak direction is outbound, use the ratio of peak volume to uptown alightings (PV/UA). The same figures apply.  
 2 Can be operated inbound only.

# MIT Can this happen in Metro too?

## Diagnostic

- Passenger Congestion (boarding and alighting)
- Vehicle Congestion (entering stops)
- Bunching affecting waiting times
- Unreliability affecting passengers
- Unreliability affecting operators
- Crowdedness

Opportunity for improving the level of service significantly in a cost-effective way.

# MIT Metro of Santiago, March 2007



What can we do cost-efficiently?  
Capacity needs to be increased.

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# MIT Skip-Stop Operation

## Objectives

- Decrease running times
- Increase frequency at key stations
- Minimize required transfers
  - Analyze the OD matrix

## Constraints

- Tracks prevent overtaking
- ATO/ATP enables skipping stops safely and quickly

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# MIT Skip-Stop Operation: Results

- Increased frequency by 2 trains per hour
- Decreased operations cost by skipping stations
  - decreased electric energy consumption due to less frequent acceleration
  - decreased braking (less mechanical wear)

	kW hr / year	USD / year	Percent
Line 2	3,352,654	351,568	6
Line 4	1,640,000	171,936	4
Line 5	2,420,000	253,699	6
<b>Total</b>	<b>7,412,654</b>	<b>777,203</b>	<b>5</b>

- Decreased running time
  - 44 to 36 minutes in Line 4
  - 26 to 24 minutes in Line 5
- Improved ride comfort
- Improved perception of service quality
  - 59% believe their trips are faster
  - 71% have a favorable view of the scheme

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