Smarter Cities

ITSで実現した環境政策
ストックホルム事例

Stockholm Congestion Charging Scheme

日本アイ･ビー･エム株式会社
未来価値創造事業
理事　竹内淳一

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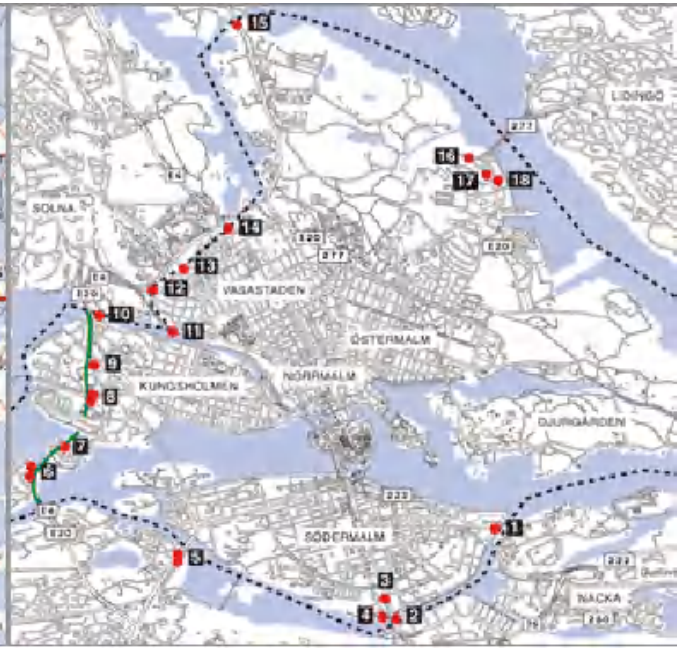
ストックホルム　交通状況

ストックホルム市概要

人口	760,000人 (年間平均20,000人増)
交通量	50数万台(平日)
面積	188km^2
平均通勤時間	18%増 (2005年と2004年を比較)

観光ガイドのコメント「ストックホルム中心部では、車の運転はお勧めできない。」



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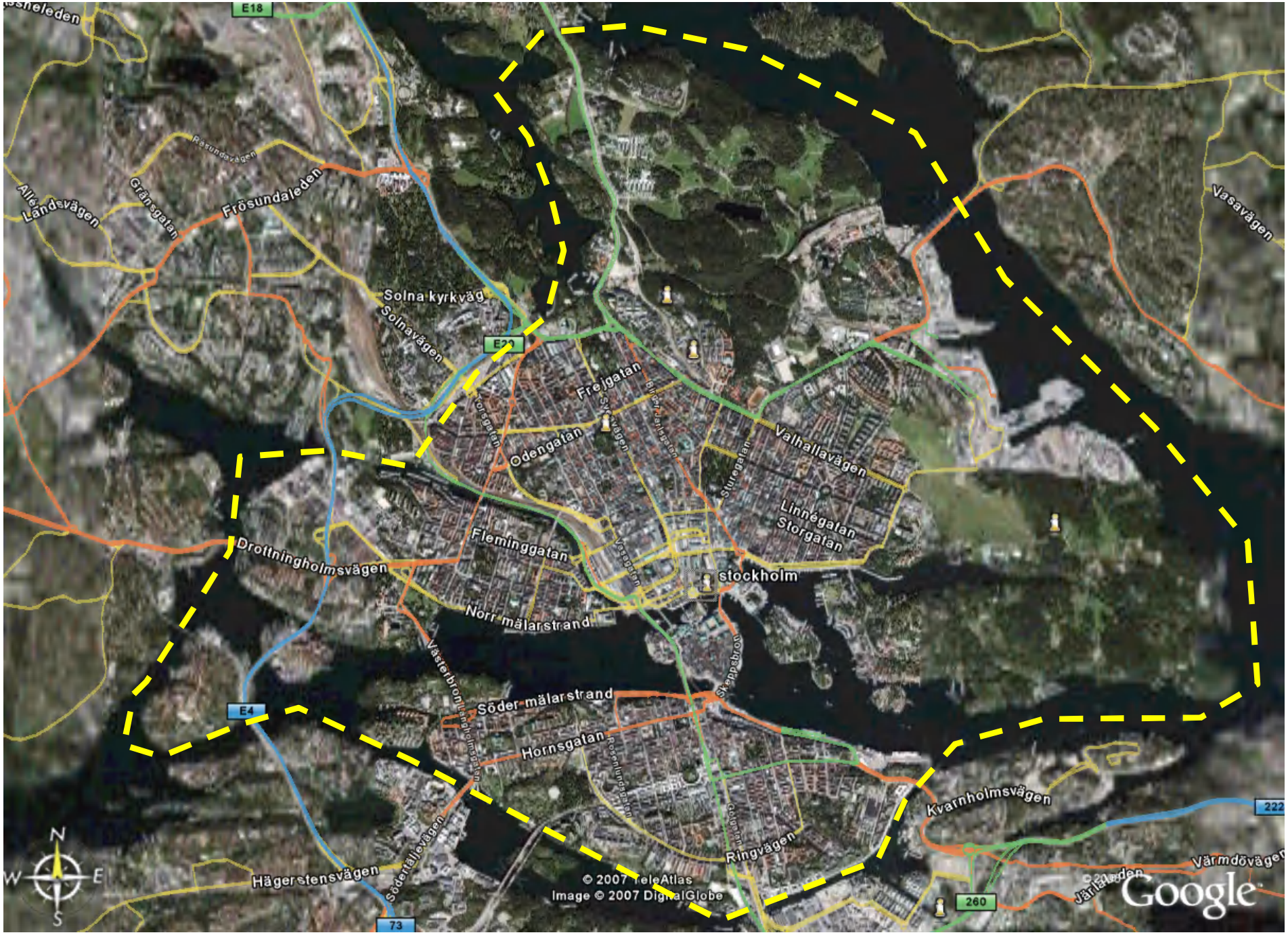

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計画概要

- 実施目的: **大気汚染、自動車公害の緩和**
  公共交通機関利用者数の増加
  交通量削減（ラッシュアワー時の市内交通量10-15%）

- 回収金の用途: ストックホルム市の公共交通インフラ整備、その他社会基盤の改善

- 期待される税収額: 年間12億スウェーデンクローネ（約200億円）

- 導入・運用責任: スウェーデン国家道路局（SNRA）（ストックホルム市）

- 計画準備: 公共交通機関拡大
  －16の路線の新設, 18のバス路線の増便、
  －パーク・アンド・ライドの新設
  －IBMとシステム、サービス・オペレーションの調達（2004年7月）

- 予算:38億クローネ（約640億円）

SNRA（Swedish National Road Administration）

Vägverket

・全国道の計画・建設・運営・維持管理に責任
－道路交通システムの環境への影響　－道路交通安全　－交通渋滞の緩和
－障害者のためのアクセシビリティー改善　－ｻｰﾋﾞｽ・レベルや効率性の地域格差是正への貢献

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計画概要

- 実施時期： 2006年1月より試験運用開始（7ヶ月間）
  9月17日　住民投票で継続・中止検討

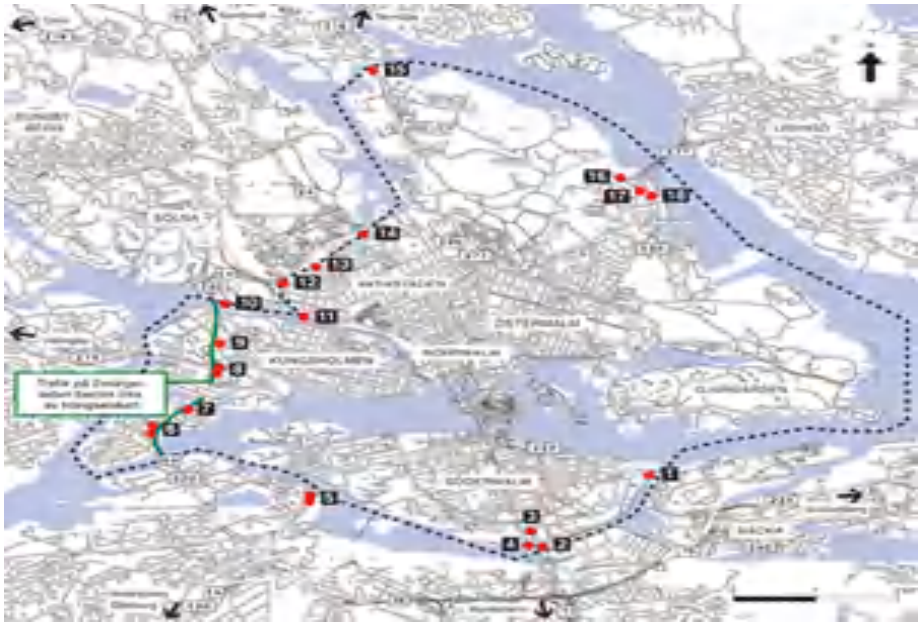
- 実施対象： ストックホルム市中心部24km^2 の範囲、約70万台の車両所有者

- 課税地点： 18ヶ所のコントロールポイント（下図参照）

- 課税時間帯： 月曜から金曜までの午前7時半から午後6時半

- 課税額： 1回につき10～20クローネ*
  最大60クローネ
  夜間/休日　非課金
  （約170～340円）＊時間帯により金額変動

- 支払方法： 口座引き落し
  銀行振替
  インターネット決済
  コンビニでの支払い



*1クローネ：17円換算

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テスト運用時の効果（まとめ）

- 交通量が10-22%削減
- 旧市街地の小売業売上げが6%上昇
- 1日あたりの公共交通機関の利用者数1日当たり4万人増加 (6%増加)
- 排ガスが、8～14%減少
- 二酸化炭素などの温室効果ガスは、旧市街地で40%減少
- （事前準備）バス増強(新規197台バス、新路線16路線)、 P&R駐車場増設

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契約時期について

2004年7月　契約

2006年1月　サービスイン

会社名	役割
IBM	全体管理、設計、構築、導入、運用
Q-free	道路装置(Radio transmitters, Cameras) タグの提供
stokab	ゲートウエイの導入
Bravida	ファイバーネットワーク導入
Post	タグの配布
Raitan, Nordia	決済サービス
Manpower	お客様サービス窓口

サーバー	ソフト
System p	Center Computer System SAP、IBM DB2, Websphere, Tivoli
System x　Blade	Gateway

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IBM on demand solution chosen for congestion charging

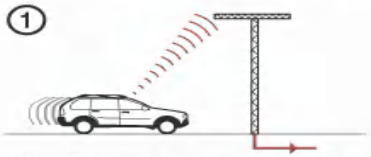
The Swedish National Road Administration has awarded IBM a contract to build an on demand solution for a full-scale congestion charging test in Stockholm, that will include wireless RFID technology.

System integration

Paying after use is an option and there are different ways to pay available; the Internet is one, chains of commercial service providers is another.

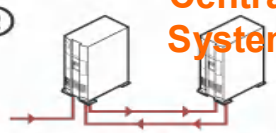
Design, build and 7-month operate

A This is how it will work when the vehicle has a tag



The driver passes a gateway without slowing down. The gateway registers that this vehicle has passed, and distributes information to central computers.

Central System



Through the computer system, vehicle information is matched with registered vehicle data and a fee is added to the vehicle owner's account.

Operation

Manpower will provide customer services.

Posten will distribute the tags.

IBM will build, integrate, implement and run the congestion charging system.

Q-free will deliver the tags, radio transmitters and cameras.

Road side equipment

Bravida will install the gateways.

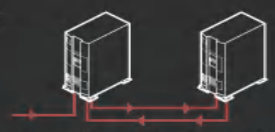
Stokab will provide the optical fibre networks connecting gateways and central computers.

This is what the tag looks like. The tag is attached inside the car, behind the inside rear mirror.

B

If the vehicle does not have a tag the driver can pay up to five days after use.

The vehicle passes a gateway without slowing down. The gateway takes a picture of the vehicle's licence plate.



In central computers, the registration number is matched with registered vehicle data and a fee is added to the vehicle owner's account.

Paying after use is an option and several means of payment are possible, e.g. the Internet or selected chains of service providers.

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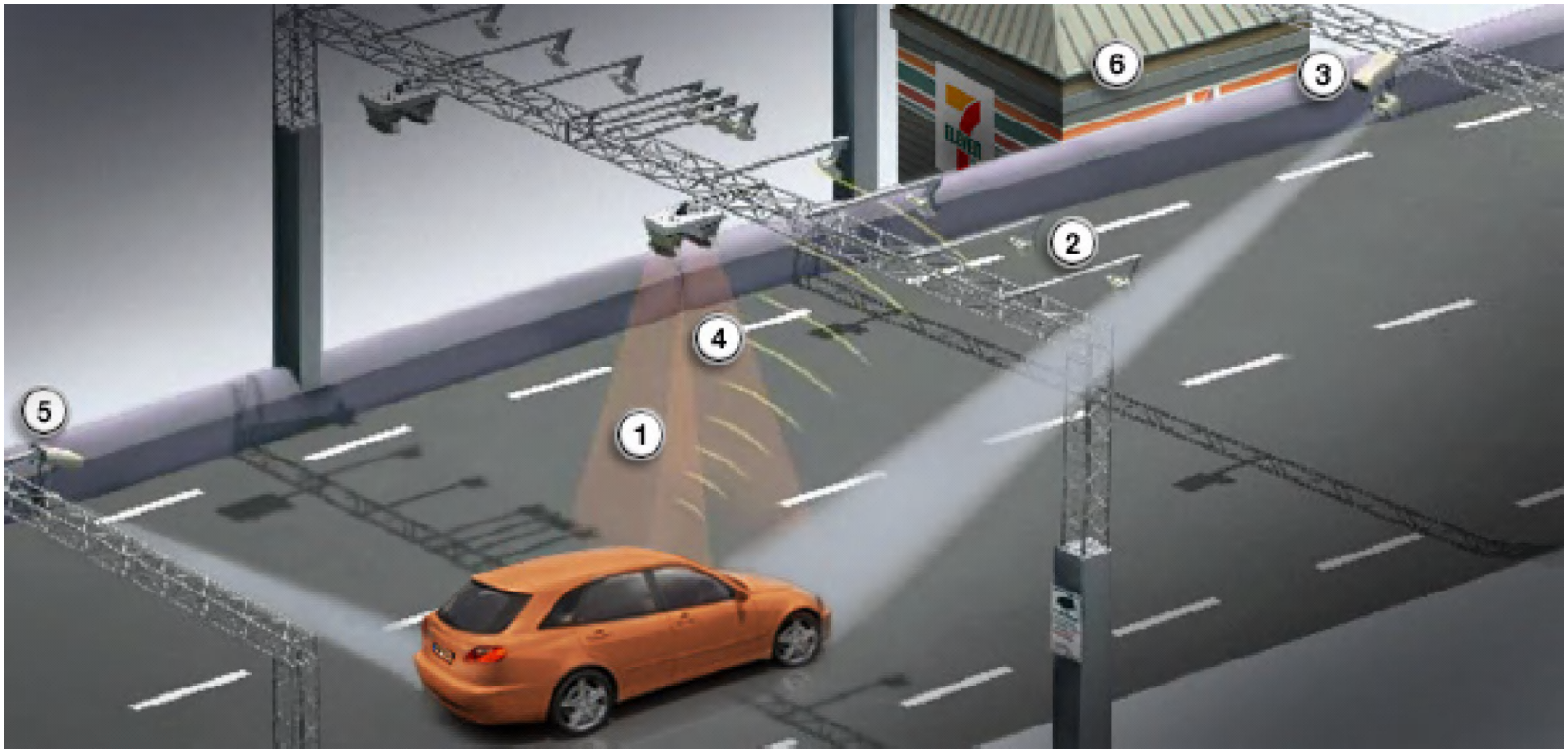
デザイン



①第1レーザーセンサー：自動車を感知し、②・③のトリガーとする

②車載端末用アンテナ：車載端末からの信号を受信し、日付・時間・税額を記録

③前部用カメラ：②と同時に前部ナンバープレートを撮影

④第2レーザーセンサー：自動車を感知し、⑤のトリガーとする

⑤後部用カメラ：後部ナンバープレートを撮影

⑥車所有者の銀行口座からの引き落とし、インターネット決済、コンビニ支払いなど

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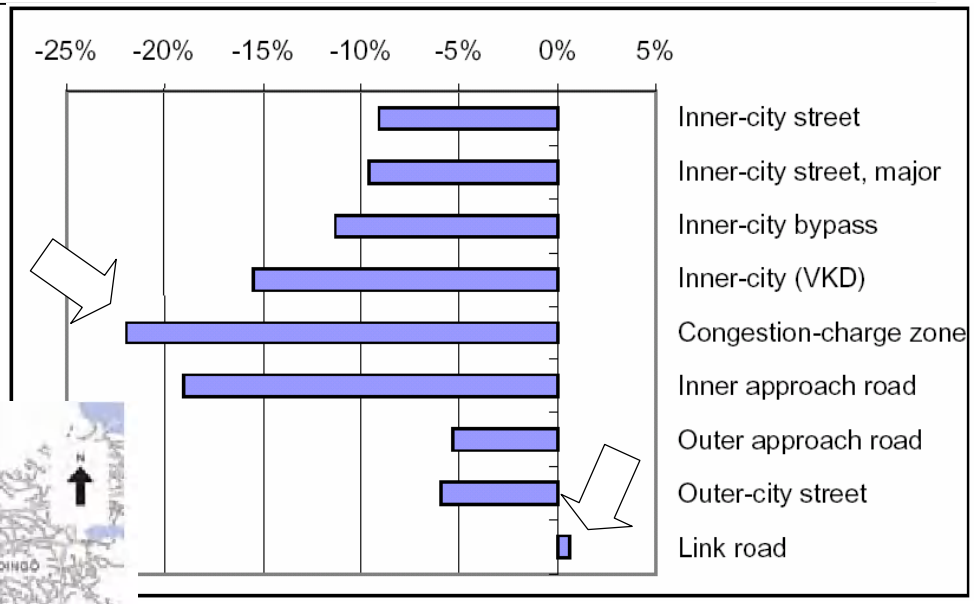
評価 http://www.stockholmsforsoket.se/templates/page.aspx?id=12555

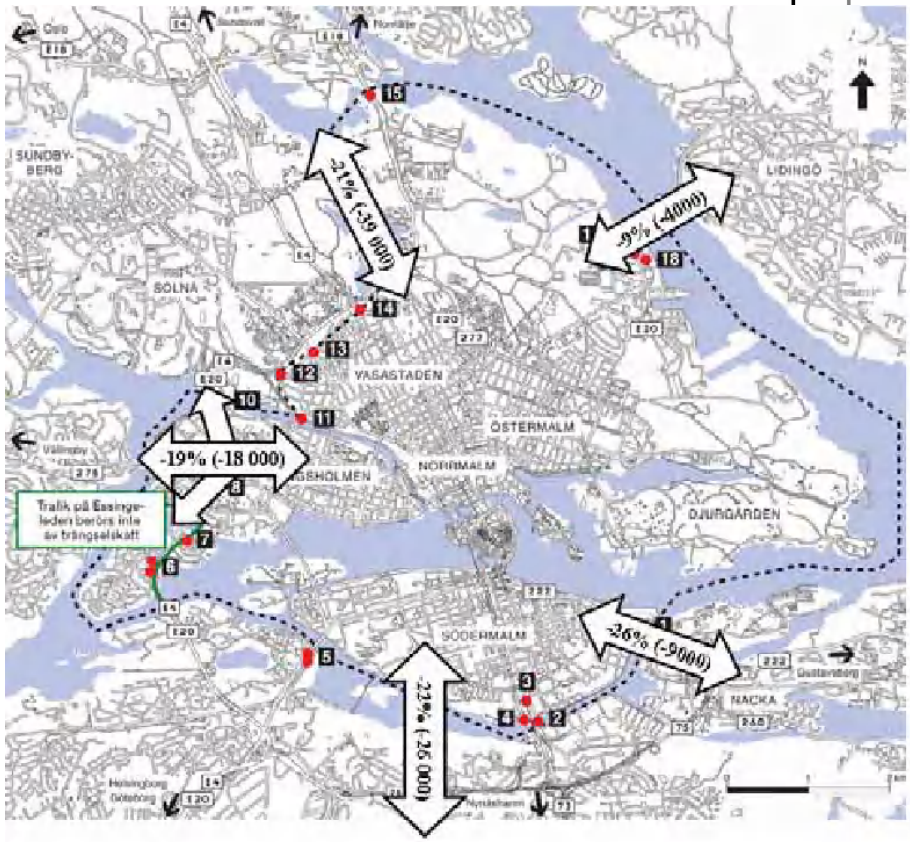
交通量　ー当初想定よりも減少

10-15%　削減目標(ゾーン内:課金時間)

22%の削減を達成

ただし、一部の道路では若干の増加





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評価

交通量 ー 交通量

2005年と比較して2006年の課金時間帯の交通量は減少している。 特に一般車両の減少が著しい。 リンク道路については、交通量の増加があった。

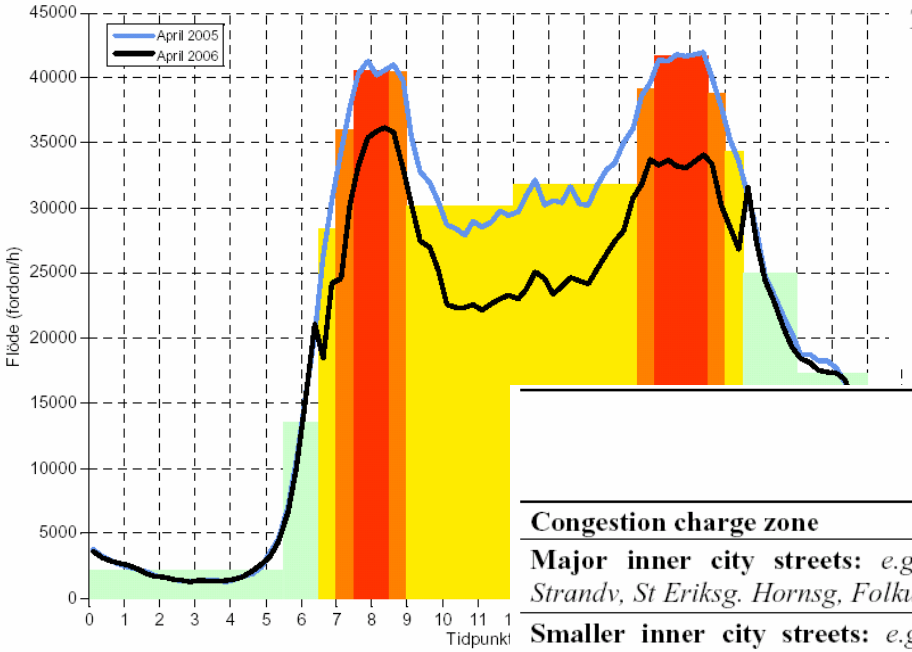

Table 1: Vehicles recorded by mode of transport on all 16 approach routes in to and out of central Stockholm during the congestion charging period (06.30–18.29)

Mode of transport in and out	Change Number	%
Car	- 89,167	- 30 %
Light goods vehicle	- 10,136	- 22 %
Lorry	- 1,465	- 13 %
Motorcycle/moped	- 545	- 54 %
Total	*-101,313*	*- 28 %*

	Morning peak (07.00-09.00)	Afternoon/ evening peak (16.00-18.00)	Charge period (06.30-18.29)	Full 24 hrs
Congestion charge zone	-16%	-24%	-22%	-19%
Major inner city streets: *e.g. Vallahallav, Strandv, St Eriksg. Hornsg, Folkungag, etc.*	-7%	-10%	-10%	-7%
Smaller inner city streets: *e.g. Norrlandsg, Lindhagensg, Scheeleg, Katarinav, etc.*	-8%	-13%	-10%	-8%
North-south axis/inner city through-routes: *e.g. Söderledstunneln, Centralbron Bridge and Klarastrandsleden*	-2%	-10%	-12%	-8%
Outer approach roads: *e.g. Nynäsv, Solnav, Huddingev, Stocksundsbron Bridge, etc.*	-3%	-4%	-5%	-5%
Outer link roads: *e.g. Bergshamravägen, Örbyleden, Magelungsvägen, etc.*	4%	4%	1%	0%
Outer-city roads: *e.g. Gamla Tyresöv, Skärholmsv, Lugnets Allé, Skälbyv, etc.*	-5%	-4%	-5%	-5%

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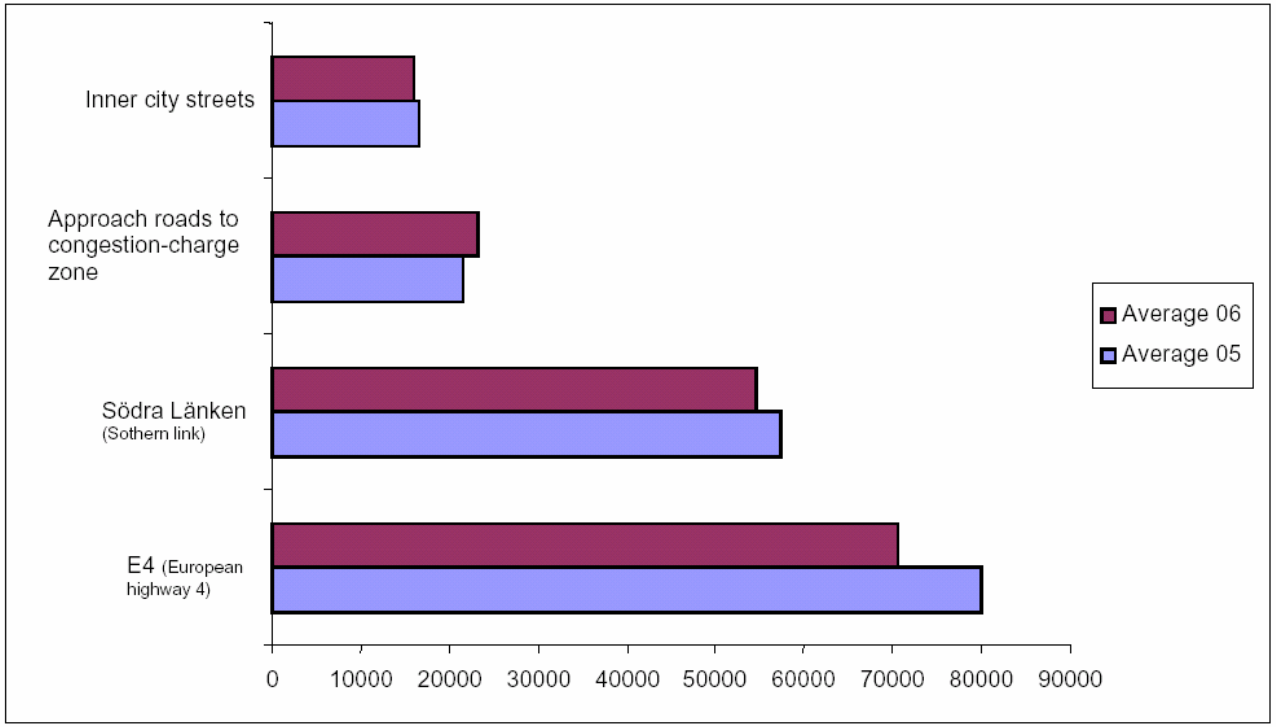
評価

交通量　ー　週末交通量

週末の交通量は、市街地・郡域とも減少したが、市中心部の課金エリアに向かう道路の交通量は増加した。

	Inner city	County
Peak periods	-14%	-4%
Full 24 hours	-14%	-2%



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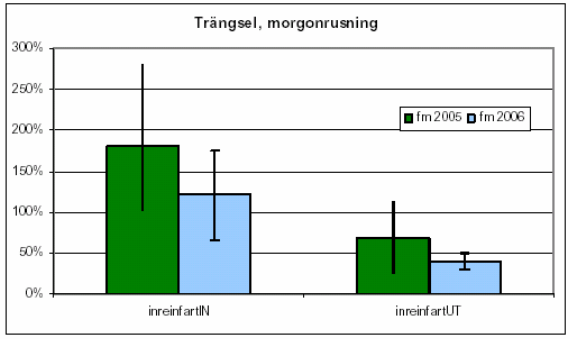
評価

移動時間

移動時間は、バイパス以外は減少している。
（棒グラフ：通行標準時間と実通行時間の比　　線：比の最大最小）



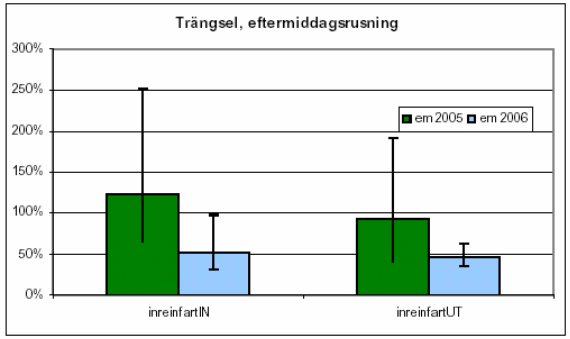
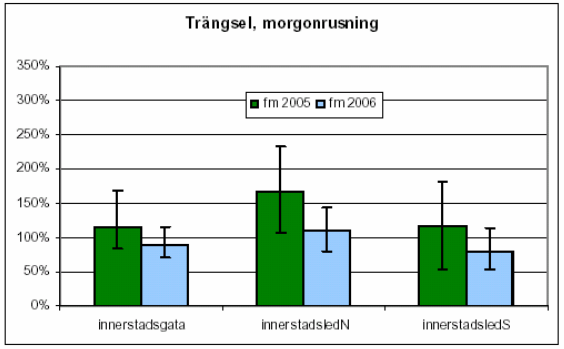


Figure 6: Percentage prolongation of journey time on inner approach roads – spring 2005 compared with spring 2006. Left figure: morning rush hour. Right figure: afternoon rush hour.



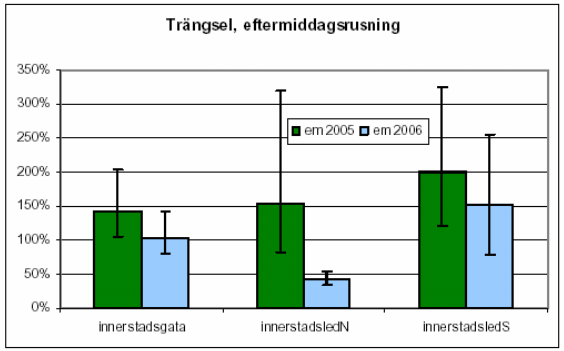


Figure 7: Percentage prolongation of journey time on streets and through-roads in the charge zone – spring 2005 compared with spring 2006. Left figure: morning rush hour. Right figure: afternoon rush hour.

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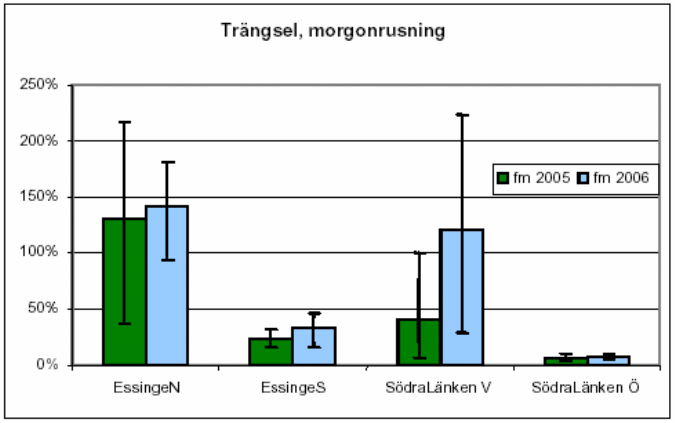
評価

移動時間



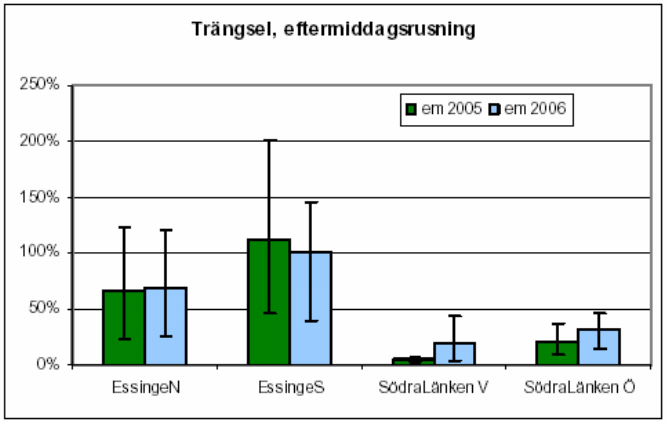


Figure 8: Percentage prolongation of journey time on the Essingeleden and Södra Länken bypasses – spring 2005 compared with spring 2006. First figure: morning rush hour. Second figure: afternoon rush hour.

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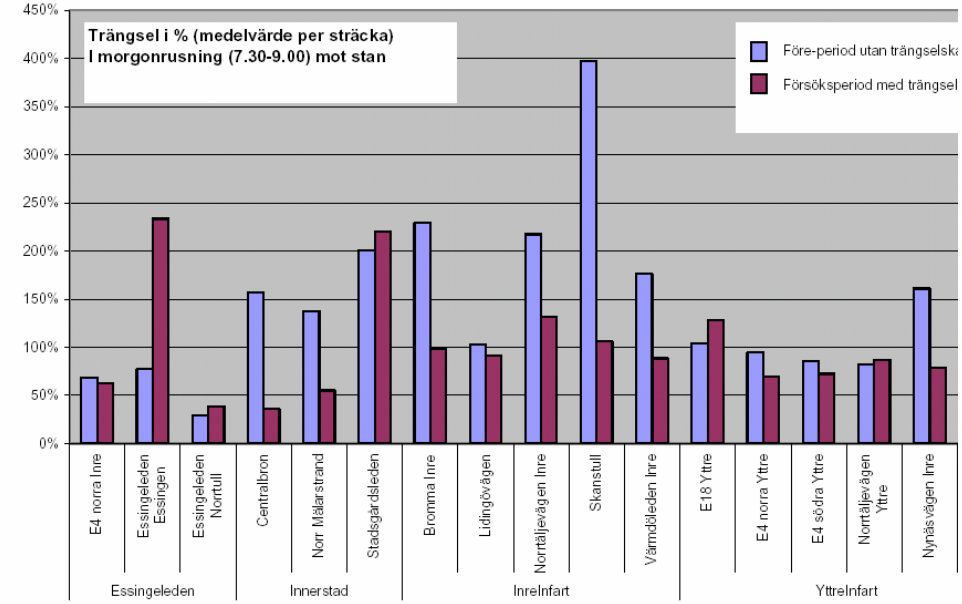
評価

GPSを用いた評価

50台の通勤利用する車にGPSを搭載し、移動時間や交通流量などの調査を行った。
朝ピーク時間の市街地道路の移動時間は減少（午後、夕刻の減少量は少ない）
複数の幹線道路では、移動時間が増加
全体的な、渋滞の改善は成功。（最混雑道路の改善もされている。）

Examples of monitoring results – morning peak-period congestion on key routes



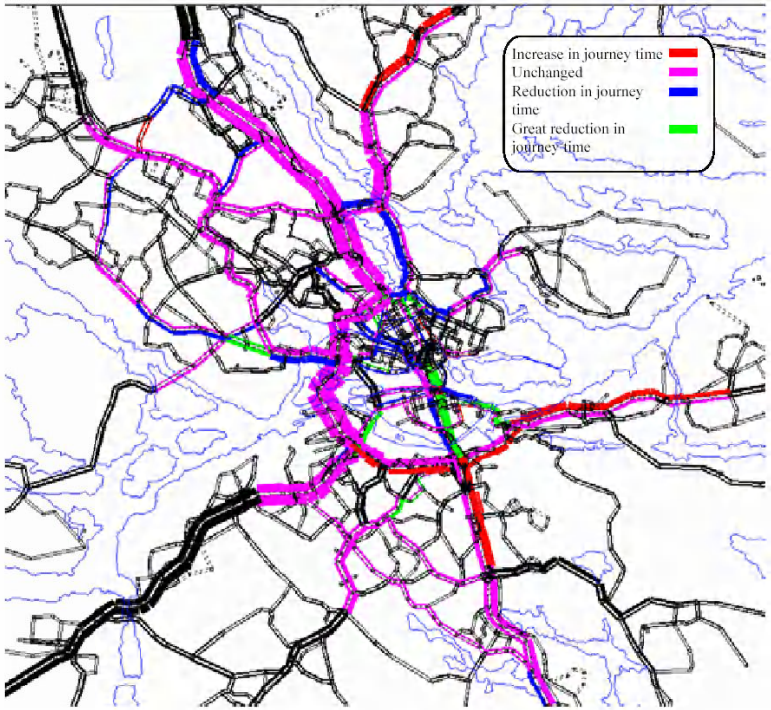


Figure 5: Difference in journey time along various monitoring routes, 2005–2006.

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評価

公共交通機関利用

公共交通機関の利用者数は増加。 また、域内での平均スピードは若干増加
（事前）バスの運行パターンの変更、バス台数増加 (新規197台バス、新路線16路線)

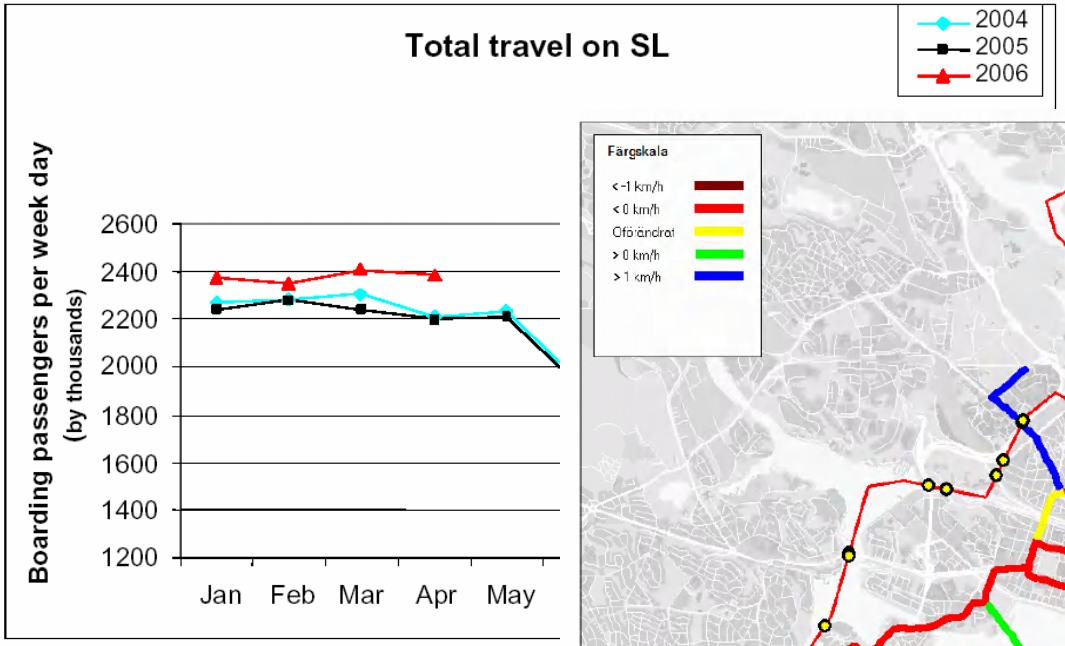

Figure 1. Travel on public transport by mo 2006.

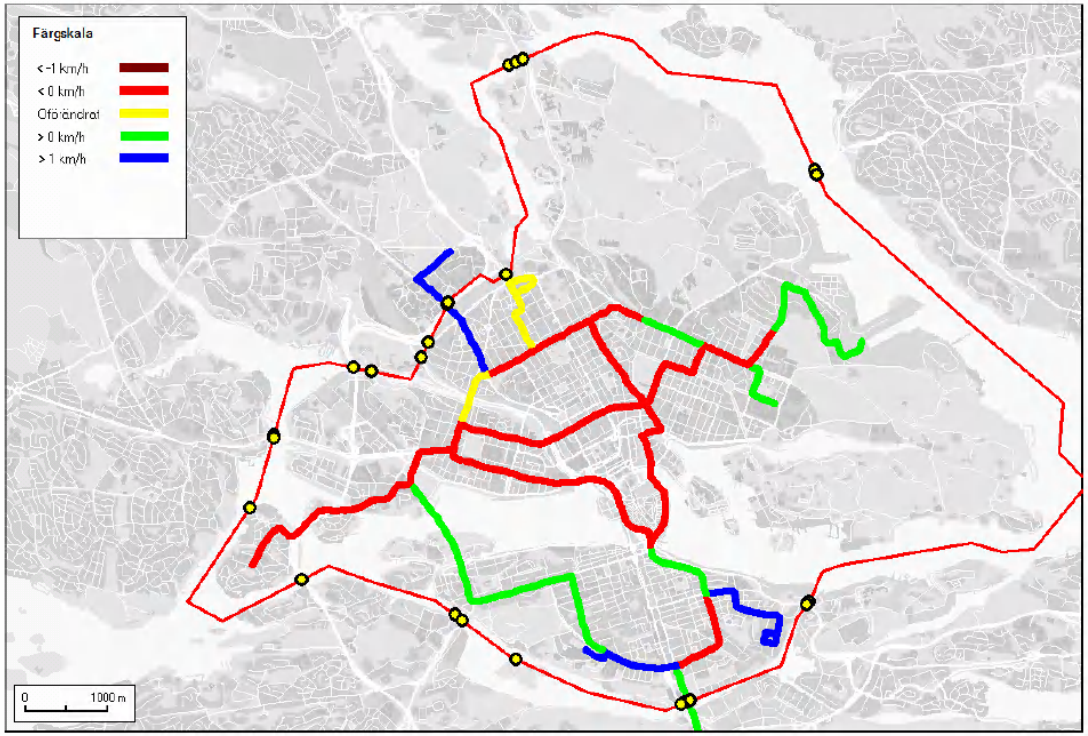

Figure 3. Changes in average speed on trunk route network 7.30-8.30 a.m., spring 2006 compared with spring 2005.

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評価

駐車

パーク＆ライド駐車場の利用が上昇。
公共交通機関への利用促進が進んだ。

Table 1 Number of parked vehicles and number of park-and-ride parking spaces in 2005 compared with 2006. Selected park-and-ride facilities in Stockholm County were studied.

	Total	SL	Stockholm Parkering
Number of parked vehicles, spring* 2005 (average per month)	7,751	5,742	2,009
Number of parked vehicles, autumn** 2005 (average per month)	8,418	6,367	2,051
Number of parked vehicles, Oct-Dec 2005 (average per month)	8,542	6,464	2,078
Number of parked vehicles, Jan-March 2006 (average per month)	8,764	6,297	2,467
Number of parked vehicles, spring* 2006 (average per month)	9,559	6,924	2,635
Increase in number of parked vehicles from spring* 2005 to spring* 2006 (average per month)	1,824	1,198	626
Increase in number of parked vehicles from spring* 2005 to spring* 2006 (percent)	23%	21%	31%
Occupancy level, spring* 2005	78%	81%	69%
Occupancy level, autumn** 2005	76%	78%	70%
Occupancy level, spring* 2006	74%	78%	66%
Number of new parking spaces from spring* 2005 to spring* 2006	2,886	1,832	1,054
Increase in number of parking spaces from spring* 2005 to spring* 2006 (percent)	29%	26%	36%
Proportion of increase between spring* 2005 and spring* 2006 in number of parking spaces that were part of the Stockholm Trial	About 80%	About 80%	About 80%

*Average during the months of April and May **Average during the months of September and October

Table 2. Number of parked vehicles and park-and-ride parking spaces in 2005 compared with 2006 at a selection of Stockholm Parkering's multi-storey car parks.

	Total	Inside zone for congestion tax	Outside zone for congestion tax
Number of parked vehicles, spring 2005 (average per month)	1,063	874	189
Number of parked vehicles, spring 2006 (average per month)	1,131	952	179
Change in number of parked vehicles from spring 2005 to spring 2006 (average per month)	68	78	-10
Change in number of parked vehicles from spring 2005 to spring 2006 (percent)	1%	1%	-1%
Occupancy rate, spring 2005	71%	78%	52%
Occupancy rate, spring 2006	74%	81%	50%
Change in number of parking spaces for rent from spring 2005 to spring 2006	+46	+46	0
Change in number of parking spaces for rent from spring 2005 to spring 2006 (percent)	3%	4%	0%

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評価

移動手段と目的

車の利用者が減少し、公共交通機関の利用者が増加。
車を利用していた人のうち減少率が若干多いのはビジネス、買い物客等。

Table 1 Number of trips passing across the charge zone at least once, with respective mode of transport, during one weekday day.

Number of trips across the charge zone during one weekday day						
	By foot	Cycle	Car	Public transport	Other	Total
TPS 2004	21,000	40,000	377,000	709,000	41,000	1 188,000
TPS 2006	22,000	9,000	286,000	734,000	27,000	1 078,000
Change in percentage	(+6%)	-78%	-24%	(+4%)	-34%	-9%
Statistically significant difference	No	-31,000	-92,000	25,000	-14,000	-110,000
Estimated seasonal/weather variation	-	-	*-5%*	*-1%*	-	

Table 2 Number of car trips through charge zone at least once on a weekday day, with specified objective.

Number of car trips through charge zone during one weekday day							
	Work/ school	Business trip	Purchase/ service	Leisure	Going home	Other	Total
TPS 2004	100,000	51,000	44,000	43,000	110,000	29,000	377,000
TPS 2006	78,000	36,000	32,000	33,000	87,000	19,000	286,000
Change in percentage	-22%	-30%	-27%	-23%	-21%	-33%	-24%
Statistically significant difference	-22,000	-15,000	-12,000	-10,000	-23,000	-9,000	-91,000
Estimated seasonal variation							*-5%*

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評価

交通安全

効果が明確に現れなかったが、5-10%の交通事故者が減少すると予測される。
（交通量の削減によりスピード増加があるがそれを差し引いても効果があると予測）

Table 1. Change in number of police-reported cases of injury and traffic accidents

Indicator	Before trial period with congestion tax[1]	During trial period with congestion tax[2]	Change	Hypothesis	Hypothesis confirmed
Police-reported fatalities and personal injuries	1,087	1,044	Decrease not significant	Will decrease within the congestion-tax zone	No
Accidents involving rear-end collisions	162	184	Increase not significant	Will decrease	No

[1] Mean value for first quarters 2003-2005
[2] Denotes first quarter 2006

Table 2. Change in estimated number of personal injury accidents

Indicator	Change in estimated number of PIAs within the congestion-tax zone	Total change in estimated number of PIAs within the county	Hypothesis	Hypothesis confirmed
Vehicle kilometres travelled (VKT)	Reduction of 9-18% based on VTI's calculations	Reduction of about 2% based on calculations by Swedish Road Administration, Consulting Services	Will decrease	Yes, within congestion-tax zone
Traffic volumes	Reduction of 4-5%[1]	Reduction of 0-11%[2]	Will decrease	Yes
Travel speed	Believed to increase.[1] Size of increase cannot be established	Believed to increase. Size of increase cannot be established	Will increase	Yes
Point speed	Increase by about 3%[1]	Varies between decrease of 1% and increase of 5%	Will increase	Yes

[1] Denotes road types: inner-city streets and inner-city routes. Changes within these links do not give a comprehensive/total picture of developments within the congestion-tax zone.
[2] Denotes road types: inner-city streets, inner-city routes, Route E4/Essingeleden bypass, inner approach, outer approach and link road.

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評価

交通量

規制時間内に一般自動車、小型商用車、重貨物車が減少し、バスが増加したが、全体の交通量は減少した。

Table 1: Vehicles recorded by mode of transport on all 16 approach routes in to and out of central Stockholm during the congestion charging period (06.30–18.29)

Mode of transport in and out	Change Number	%
Car	- 89,167	- 30 %
Light goods vehicle	- 10,136	- 22 %
Lorry	- 1,465	- 13 %
Motorcycle/moped	- 545	- 54 %
Total	*-101,313*	*- 28 %*

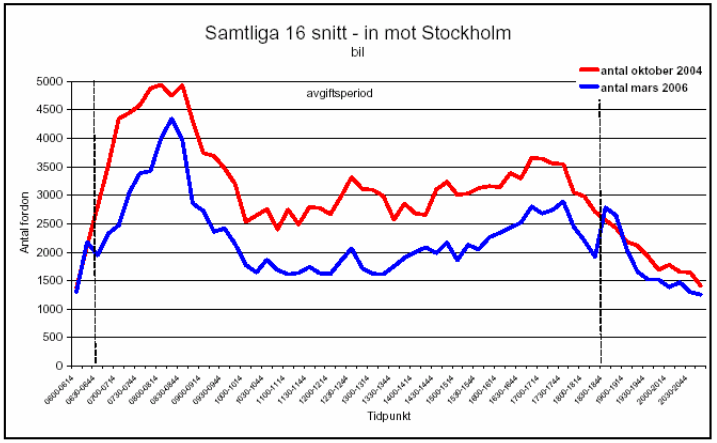

Figure 1: Number of private cars travelling into central Stockholm during the period 06.00–20.59

Table S1 *Traffic mileage within the charge zone without and with the congestion charge and percentage changes in this. Divided into time periods and vehicle types.*

Zone / Time period	Without congestion charge: Pass.car	LCV	HGV	Bus	*Total*
0600-0900	318,689	49,238	12,406	7,366	*387,699*
0900-1500	584,455	105,466	30,028	12,451	*732,400*
1500-1800	393,950	50,743	6,920	9,687	*461,300*
1800-0600	546,258	38,630	6,640	12,072	*603,600*
0000-2400	*1,843,352*	*244,077*	*55,994*	*41,576*	*2,185,000*

Zone / Time period	With congestion charge: Pass.car	LCV	HGV	Bus	*Total*
0600-0900	257,761	40,665	11,847	9,926	*320,200*
0900-1500	474,255	92,538	27,396	14,611	*608,800*
1500-1800	319,960	40,943	6,445	11,752	*379,100*
1800-0600	486,627	33,412	5,928	12,934	*538,900*
0000-2400	*1,538,603*	*207,558*	*51,616*	*49,223*	*1,847,000*

Difference in %				
Pass.car	LCV	HGV	Bus	*Total*
-19.1	-17.4	-4.5	**34.8**	*-17.4*
-18.9	-12.3	-8.8	**17.3**	*-16.9*
-18.8	-19.3	-6.9	**21.3**	*-17.8*
-10.9	-13.5	-10.7	**7.1**	*-10.7*
-16.5	*-15.0*	*-7.8*	**18.4**	*-15.5*

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評価

大気汚染減少と公共交通機関利用者増加

交通量削減により、大気汚染は減少した。 特に市中心部の減少量が大きい。
（寿命が5年のびる。）

	Inner city:		City of Stock-holm:		Greater Stock-holm*:	
	tons/year	per cent	tons/year	per cent	tons/year	per cent
Nitrogen oxides. NO_X	45	-8.5 %	47	-2.7 %	55	-1.3 %
Carbon monoxide. CO	670	-14 %	710	-5.1 %	770	-2.9 %
Particles. PM_{10} total	21	-13 %	23	-3.4 %	30	- 1.5 %
"erosion particles"	19	-13 %	21	-3.3 %	28	-1.5 %
"ex-haust parti-cles"	1.8	-12 %	1.8	-4.4 %	2.1	-2.4 %
Volatile organic compounds .VOC	110	-14 %	120	-5.2 %	130	-2.9 %
ben-zene. C_6H_6	3.4	-14 %	3.6	-5.3 %	3.8	-3.0 %
Carbon dioxide. CO_2	36,000	-13 %	38,000	-5.4 %	41,000	-2.7 %

** defined as an area of 35 km x 35 km across central Stockholm.*

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評価

投資対効果

4年で投資対効果がプラスになる。（税収）

Table 3: Social cost-benefits, in millions of SEK per year.

(SEK million, per year)	Congestion tax	Increased bus traffic	Total
Shorter journey times	523	157	680
More predictable journey times	78	0	78
Change in mode of travel	-13	24	11
Congestion tax payments	-763	0	-763
Total effect: road-users	***-175***	***181***	***6***
Reduced climate gas emissions	64	0	64
Health and other environmental benefits	22	0	22
Improved traffic safety	125	0	125
Total effect: other factors	***211***	***0***	***211***
Congestion tax revenue	763	0	763
Public transport revenue	184	0	184
Fuel tax revenue	-53	0	-53
Wear and tear on infrastructure	1	0	1
Maintaining public transport standards[12]	-64	0	-64
Total public sector income and expenses excl. operating and investment costs	***831***	***0***	***831***
Total social cost-benefit surplus excl. operating and investment costs[13]	***867***	***181***	***1048***

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住民投票の結果

過半数が、継続賛成。
最終結果は、2007/6にスウェーデン議会で可決され8月から恒久運用開始。

ストックホルム市の461の自治区の結果

継続賛成	243,055	51.3 %
継続反対	215,731	45.5 %
白票	9,535	2.0 %
無効*	5,825	1.2 %
有効票数	474,146	
有権者数	620,915	
投票率		76.4 %

ストックホルム郡の他の14自治市の結果

有効票	賛成	反対
324 786	39.8 %	60.2 %

http://www.streetsblog.org/2006/09/19/stockholm-votes-for-congestion-charge-and-its-opponents/

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当時のブログ記事から

都会に住んでいる人 ：チャージされないし、町が静かになる = 大賛成
郊外に住んでいる人 ：お金をはらってでも すいているなら車で行きたい = 賛成
郊外のその他の人 ：お金は取られるし、メリットない = 反対

そもそもこの案を最初に出したリーダーはもうストックホルムの国会のメンバーから外れている。しかし 面白いことに最初は反対モードだった国民も いつの間にか賛成モードになっている。（多数党の意見と国民の意見の不一致）

次の選挙で選ばれた党がこの案を反故にする可能性がある。 しかし、完全に無視することはなくて、たとえば郊外に環状道路を建設するだとか、チャージの費用を安くするだとか 妥協案にでる可能性がある。

郊外の人も 都心の人も利益を得られるような政策をどのように作るかがポイント。この点が十分に議論されていなかったのでストックホルムでは混乱した。

TUESDAY, SEPTEMBER 19TH, 2006

Stockholm Voters Approve Congestion Charging

But Reject the Political Party That Supported It. Result: Gridlock Over Gridlock.

NYは同様のスキームを市議会で可決したが州議会で否決 (2008.4)

http://www.streetsblog.org/2006/09/19/stockholm-votes-for-congestion-charge-and-its-opponents/

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