

# IEOR 4615: Service Engineering

## Spring 2013, First Class: January 22

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# IEOR 4615: Service Engineering

## Spring 2013, Ward Whitt

### **Logistics**

- **Lectures** Tu&Th, 4:10-5:25pm, 644 Mudd
- **Courseworks and course webpage:**  
[www.columbia.edu/~ww2040/4615S13/IEOR4615S13.html](http://www.columbia.edu/~ww2040/4615S13/IEOR4615S13.html)
- Homework done in 3-person **teams**
- **Recitations and Homework**, F, 10:00-11:00am
  - Posted on **Courseworks**
  - Same Room, 644 Mudd
  - Homework assigned and turned in on Fridays
  - Show how to use Excel plus tools and data from the Mandelbaum repository
- **Midterm Exam**, but **no final exam, project?**

# Course Focus

- **Service Systems (Staffing, Allocation of Resources)**
  - Telephone Call Centers
  - Hospitals
- **Data**
  - Data Repository and Analysis Tools from Service Engineering Course, by Avishai Mandelbaum, the Technion, <http://iew3.technion.ac.il/serveng/>
  - Build on IEOR 3600 (elementary Statistics)
  - Data Analysis (Excel)
- **Stochastic Queueing Models**
  - Build on IEOR 3106/4106 (Prerequisite!)

# Today's OUTLINE

## 1. Brief Discussion of the Data

1. Data Repository and Analysis Tools from Service Engineering Course, by Avishai Mandelbaum, the Technion, <http://iew3.technion.ac.il/serveng/>
2. Sample plots

## 2. Overview of Services (Fitzsimmons, Ch. 1-3)

1. Role of Services in the Economy
2. The Nature of Services
3. Service Strategy

## 3. Psychology of Waiting (Maister paper)

**(NEXT CLASS: Queueing Models)**

# The Importance of Data and Measurements

- **Lord Kelvin:** “We can not understand (manage) that which we can not **measure** (quantify).”
- **Robert Herman** (“Father” of Transportation Science): Far too little reliance on **Data**, the language of nature, in formulating models for the systems of the deepest importance to human beings, namely those in which we are actors.
- **Empirical “Axiom”:** The **Data** One Needs is Never There For One To Use (Always Problems with Historical Data)
- **Columbia Institute** for **Data** Science and Engineering

# Project DataMOCCA/SEESat

## Avishai Mandelbaum, the Technion



- Data MOdel for Call Center Analysis
- Service Enterprise Engineering Statistics
- Project Partners: **Technion, Wharton, Companies**
- Goal: Designing and Implementing a (universal) data-base/data-repository and interface for storing, retrieving, analyzing and displaying **Call-by-Call**-based data/information
- Enables the Study of:
  - **Customers**: Wait Time, Abandonment, Retrials
  - **Service Providers/Agents**: Service Duration, Activity Profile
  - **Managers/System**: Loads, Queue Lengths, Trends

# SEESat

- **System Components:**
  - **Cleaned data:** operational histories of **individual** calls - **export, import**
  - **Daily / monthly / yearly reports and flow-charts** for a complete operational view
  - **Graphs and tables**
    - in customized resolutions (**month, days, hours, minutes, seconds**)
    - for a variety of (pre-designed) **operational measures** (arrival rates, abandonment counts, service- and wait-time distribution, utilization profiles,...), and for **new user-defined** measures
- Currently Four **Databases** (some public, some for research):
  - **US Bank** (220/40M calls, 1000 agents, 2.5 years).
  - **Israeli Telecom** (800 agents, 3.5 years; 55GB; ongoing)
  - **Israeli Bank** (500 agents, 1.5 years; ongoing).
  - **Hospital** (from 7 hospitals, 1-4 years, different levels of information)

# What do you see?

**Need to have expectations**

Experience and **Models** Help Greatly

# Common Call Center Reports from Automatic Call Distributor (ACD)

## Command Center Intraday Report

Date  
06/13 - Tue

Updated Through: All Day

		Recvd	Answ	Abn %	<u>ASA</u>	AHT	<u>Occ %</u>	On Prod%	On Prod FTE	Sch Open FTE	Sch Avail %
<b>Total:</b>		129,960	126,321	2.8%	31	318	90.9%	88.4%	1531.7	1586.0	96.6%
INQ	Charlotte	20,577	19,860	3.5%	30	307	95.1%	85.4%	222.7	234.6	95.0%
INQ	Columbus MCSC	7,973	7,773	2.5%	36	314	94.9%	89.8%	89.2	94.5	94.4%
INQ	Phoenix	17,102	16,757	2.0%	31	298	92.7%	91.8%	187.3	194.8	96.2%
INQ	Scranton	1,257	1,254	0.2%	6	515	78.6%	28.9%	28.5	35.1	81.2%
INQ	Tampa	9,174	8,859	3.4%	42	366	91.5%	93.6%	123.1	125.9	97.8%
CEN	Bourbonnais	6,070	5,937	2.2%	33	362	86.7%	90.2%	86.0	88.4	97.3%
CEN	Bristol	10,667	10,505	1.5%	25	355	95.1%	93.1%	136.3	139.6	97.6%
CEN	Columbus Claims	5,258	5,153	2.0%	27	293	86.7%	89.8%	60.5	62.2	97.3%
STH	Atlanta	7,514	7,338	2.3%	40	318	82.1%	89.5%	98.6	99.8	98.8%
STH	Sherman	19,669	18,833	4.3%	46	252	93.8%	90.6%	175.5	174.9	100.4%
STH	Wilmington	10,422	9,888	5.1%	21	285	89.9%	92.1%	108.7	114.6	94.8%
WST	Visalia	14,277	14,164	0.8%	10	382	87.2%	85.0%	215.2	220.6	97.6%

12 cc's



(Charlotte)

6/13/00 - Tue

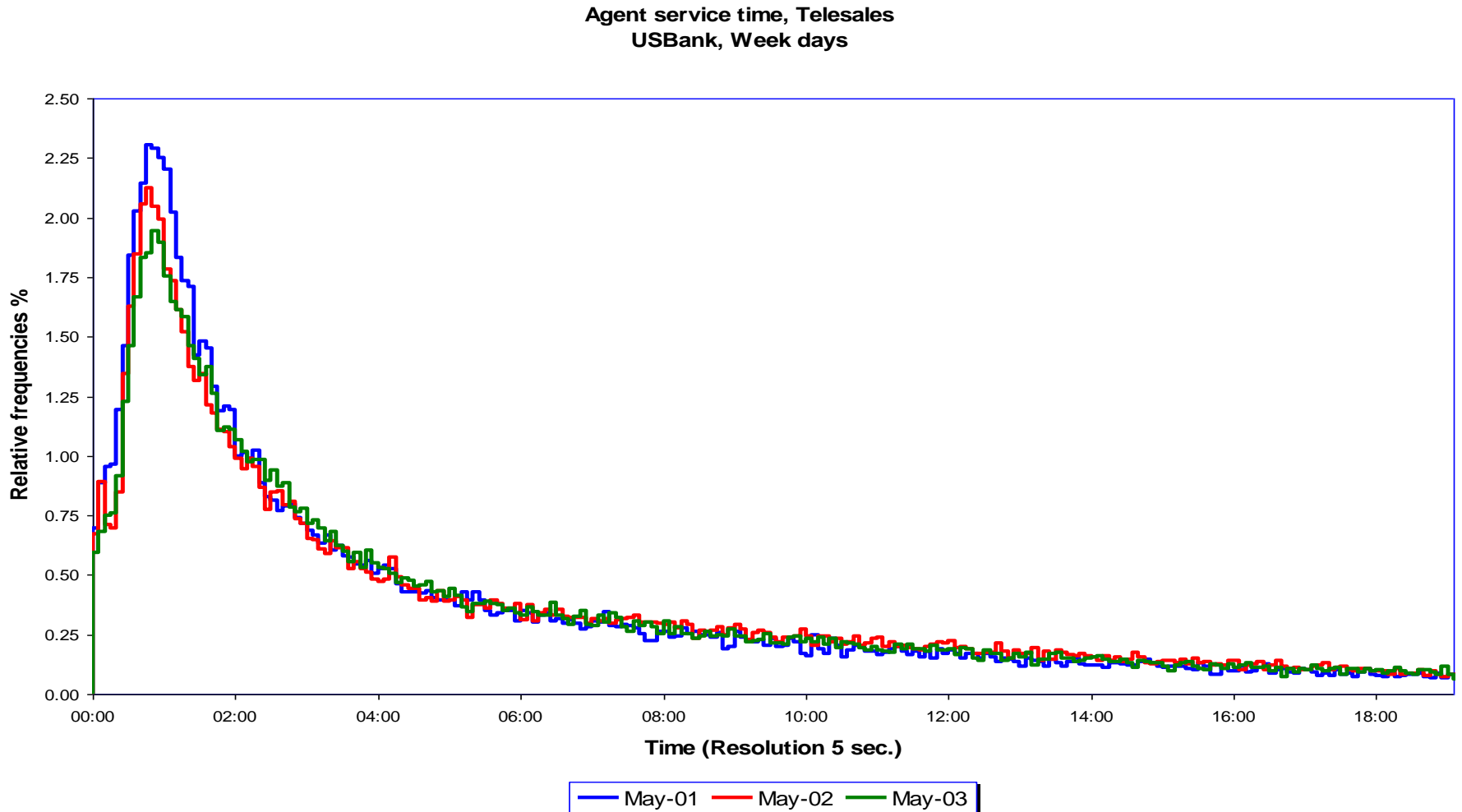
[REDACTED] - Center										
Time	Recvd	Answ	Abn %	<u>ASA</u>	AHT	<u>Occ %</u>	On Prod%	On Prod FTE	Sch Open FTE	Sch Avail %
0	20,577	19,860	3.5%	30	307	95.1%	85.4%	222.7	234.6	95.0%
8:00	332	308	7.2%	27	302	87.1%	79.5%	59.3	66.9	88.5%
8:30	653	615	5.8%	58	293	96.1%	81.1%	104.1	111.7	93.2%
9:00	866	796	8.1%	63	308	97.1%	84.7%	140.4	145.3	96.6%
9:30	1,152	1,138	1.2%	28	303	90.8%	81.6%	211.1	221.3	95.4%
10:00	1,330	1,286	3.3%	22	307	98.4%	84.3%	223.1	229.0	97.4%
10:30	1,364	1,338	1.9%	33	296	99.0%	84.1%	222.5	227.9	97.6%
11:00	1,380	1,280	7.2%	34	306	98.2%	84.0%	222.0	223.9	99.2%
11:30	1,272	1,247	2.0%	44	298	94.6%	82.8%	218.0	233.2	93.5%
12:00	1,179	1,177	0.2%	1	306	91.6%	88.6%	218.3	222.5	98.1%
12:30	1,174	1,160	1.2%	10	302	95.5%	93.6%	203.8	209.8	97.1%
13:00	1,018	999	1.9%	9	314	95.4%	91.2%	182.9	187.0	97.8%
13:30	1,061	961	9.4%	67	306	100.0%	88.9%	163.4	182.5	89.5%
14:00	1,173	1,082	7.8%	78	313	99.5%	85.7%	188.9	213.0	88.7%
14:30	1,212	1,179	2.7%	23	304	96.6%	86.0%	206.1	220.9	93.3%

# Call Center Measurements: Call-by-Call Data

vru_line	call_id	customer_id	priority	type	date	vru_entry	vru_exit	vru_time	q_start	q_exit	q_time	outcome	ser_start	ser_exit	ser_time	server
AA0101	44749	27644400	2	PS	990901	11:45:33	11:45:39	6	11:45:39	11:46:58	79	AGENT	11:46:57	11:51:00	243	DORIT
AA0101	44750	12887816	1	PS	990905	14:49:00	14:49:06	6	14:49:06	14:53:00	234	AGENT	14:52:59	14:54:29	90	ROTH
AA0101	44967	58660291	2	PS	990905	14:58:42	14:58:48	6	14:58:48	15:02:31	223	AGENT	15:02:31	15:04:10	99	ROTH
AA0101	44968	0	0	NW	990905	15:10:17	15:10:26	9	15:10:26	15:13:19	173	HANG	00:00:00	00:00:00	0	NO_SERVER
AA0101	44969	63193346	2	PS	990905	15:22:07	15:22:13	6	15:22:13	15:23:21	68	AGENT	15:23:20	15:25:25	125	STEREN
AA0101	44970	0	0	NW	990905	15:31:33	15:31:47	14	00:00:00	00:00:00	0	AGENT	15:31:45	15:34:16	151	STEREN
AA0101	44971	41630443	2	PS	990905	15:37:29	15:37:34	5	15:37:34	15:38:20	46	AGENT	15:38:18	15:40:56	158	TOVA
AA0101	44972	64185333	2	PS	990905	15:44:32	15:44:37	5	15:44:37	15:47:57	200	AGENT	15:47:56	15:49:02	66	TOVA
AA0101	44973	3.06E+08	1	PS	990905	15:53:05	15:53:11	6	15:53:11	15:56:39	208	AGENT	15:56:38	15:56:47	9	MORIAH
AA0101	44974	74780917	2	NE	990905	15:59:34	15:59:40	6	15:59:40	16:02:33	173	AGENT	16:02:33	16:26:04	1411	ELI
AA0101	44975	55920755	2	PS	990905	16:07:46	16:07:51	5	16:07:51	16:08:01	10	HANG	00:00:00	00:00:00	0	NO_SERVER
AA0101	44976	0	0	NW	990905	16:11:38	16:11:48	10	16:11:48	16:11:50	2	HANG	00:00:00	00:00:00	0	NO_SERVER
AA0101	44977	33689787	2	PS	990905	16:14:27	16:14:33	6	16:14:33	16:14:54	21	HANG	00:00:00	00:00:00	0	NO_SERVER
AA0101	44978	23817067	2	PS	990905	16:19:11	16:19:17	6	16:19:17	16:19:39	22	AGENT	16:19:38	16:21:57	139	TOVA
AA0101	44764	0	0	PS	990901	15:03:26	15:03:36	10	00:00:00	00:00:00	0	AGENT	15:03:35	15:06:36	181	ZOHARI
AA0101	44765	25219700	2	PS	990901	15:14:46	15:14:51	5	15:14:51	15:15:10	19	AGENT	15:15:09	15:17:00	111	SHARON
AA0101	44766	0	0	PS	990901	15:25:48	15:26:00	12	00:00:00	00:00:00	0	AGENT	15:25:59	15:28:15	136	ANAT
AA0101	44767	58859752	2	PS	990901	15:34:57	15:35:03	6	15:35:03	15:35:14	11	AGENT	15:35:13	15:35:15	2	MORIAH
AA0101	44768	0	0	PS	990901	15:46:30	15:46:39	9	00:00:00	00:00:00	0	AGENT	15:46:38	15:51:51	313	ANAT
AA0101	44769	78191137	2	PS	990901	15:56:03	15:56:09	6	15:56:09	15:56:28	19	AGENT	15:56:28	15:59:02	154	MORIAH
AA0101	44770	0	0	PS	990901	16:14:31	16:14:46	15	00:00:00	00:00:00	0	AGENT	16:14:44	16:16:02	78	BENSION
AA0101	44771	0	0	PS	990901	16:38:59	16:39:12	13	00:00:00	00:00:00	0	AGENT	16:39:11	16:43:35	264	VICKY
AA0101	44772	0	0	PS	990901	16:51:40	16:51:50	10	00:00:00	00:00:00	0	AGENT	16:51:49	16:53:52	123	ANAT
AA0101	44773	0	0	PS	990901	17:02:19	17:02:28	9	00:00:00	00:00:00	0	AGENT	17:02:28	17:07:42	314	VICKY

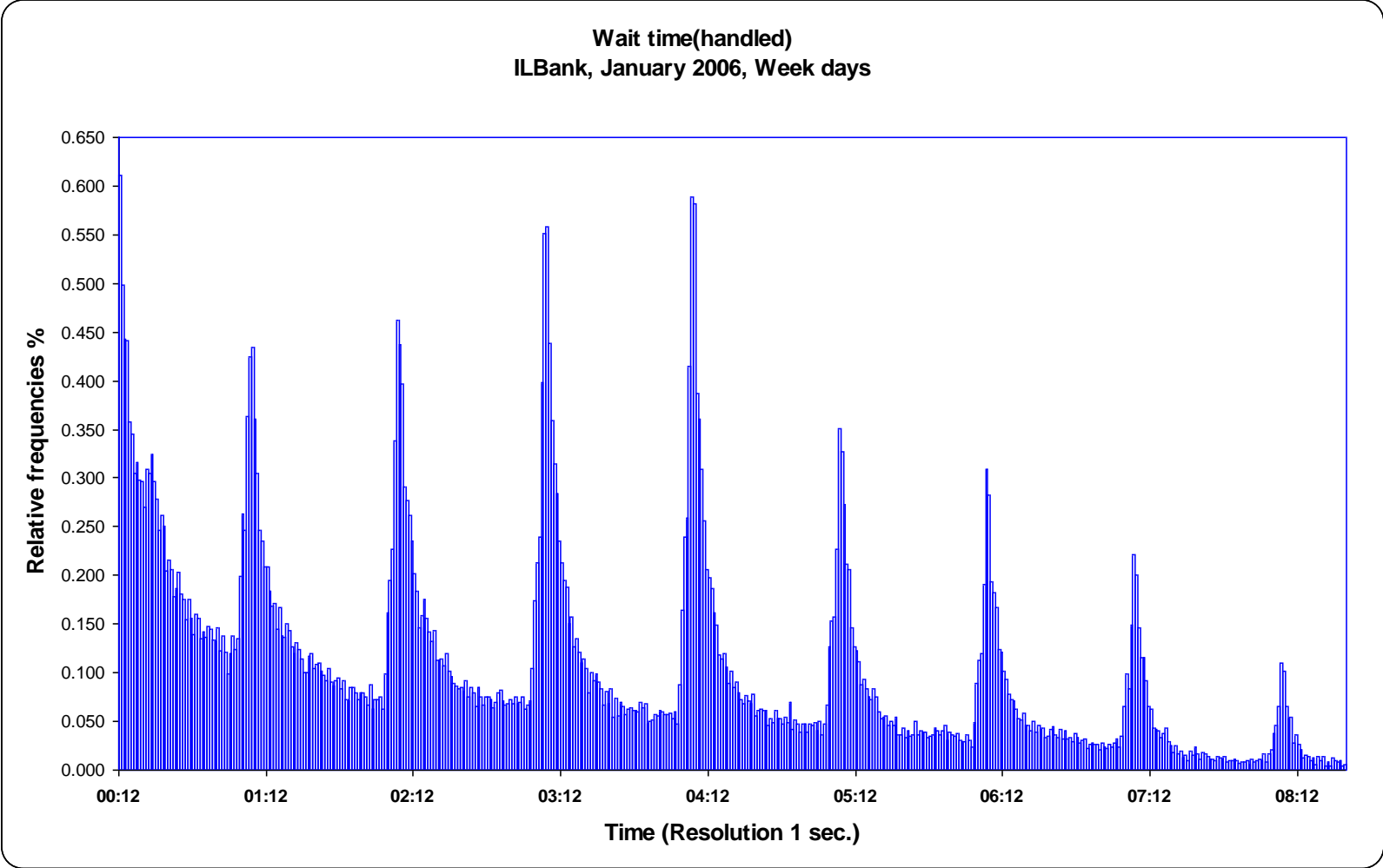
# Empirical Distribution (Histogram) of Service Times

## US Bank: Three Days in May 2001



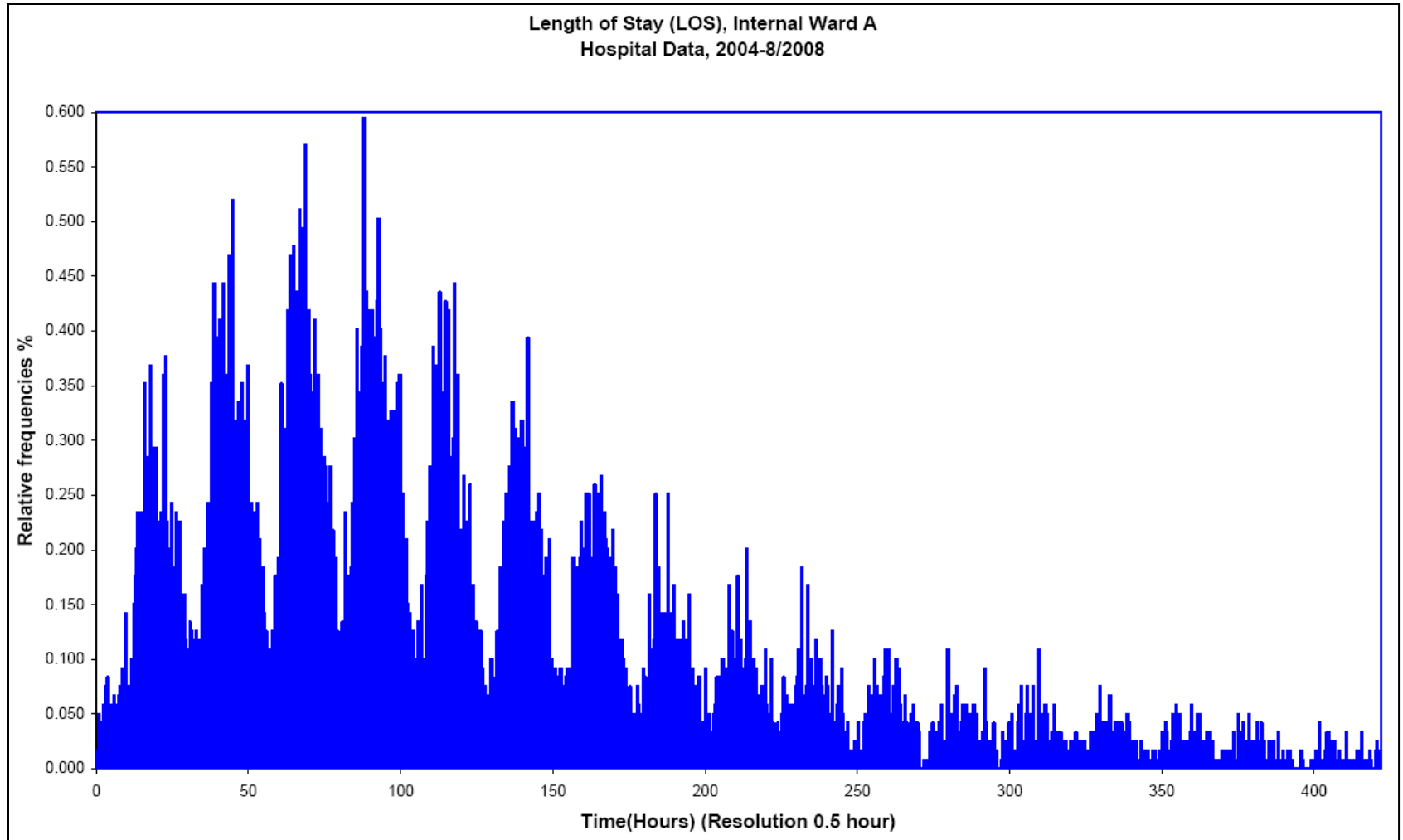
# Empirical Distribution (Histogram) of Waiting Times

## Israeli Bank: Weekdays in January 2006



# Empirical Distribution (Histogram) of Response Times

## Israeli Hospital: Length of Stay in 2008



# ***Service Management***

***Operations, Strategy and Information Technology***

James A. Fitzsimmons  
and Mona J. Fitzsimmons

Fourth Edition, 2004, McGraw Hill, Irwin

***Book on Reserve in Engineering Library:***

***Book chapters posted***

***Broad View, Gives Perspective***

# Book Contents

## *Part One: Understanding Services*

*1. The Role of Services in an Economy*

*2. The Nature of Services*

*(today)*

*3. Service Strategy*

## Part Two: Designing the Service Enterprise

4. New Service Development

5. ***The Service Encounter***

6. Service Quality (IEOR 4412)

7. E-Service

8. Service Facility Location

9. The Supporting Facility

# Book Contents *continued*

## Part Three: Managing Service Operations

10 Managing Supply and Demand (IEOR 4601)

***11. Managing Waiting Lines***

12. Managing Service Supply Relationships

13. Managing Facilitating Goods

14. Managing Projects

## Part Four: Toward World-Class Service

15. Productivity and Quality Improvement

16. Growth and Globalization of Services

## Part Five

***17. Forecasting Demand for Services***

***18. Queueing Models and Capacity Planning***

## Appendices

# Chapter 1

## Definition

- A **service** is a *time-perishable, intangible* experience performed by a customer acting in the role of co-producer. (p.4)
- **Not** a good or product

### Distinctive Characteristics of Services (Ch. 2)

1. Customer **participates** in service process (not like making cars)
2. Created and consumed **simultaneously** (Inability to inventory)
3. A service is a **perishable** quantity (e.g., hotel room for a night)
4. Services are ideas and concepts, so **intangible**; products are things.
5. Properties 1 and 4 lead to **heterogeneity**

# Services *versus* Products

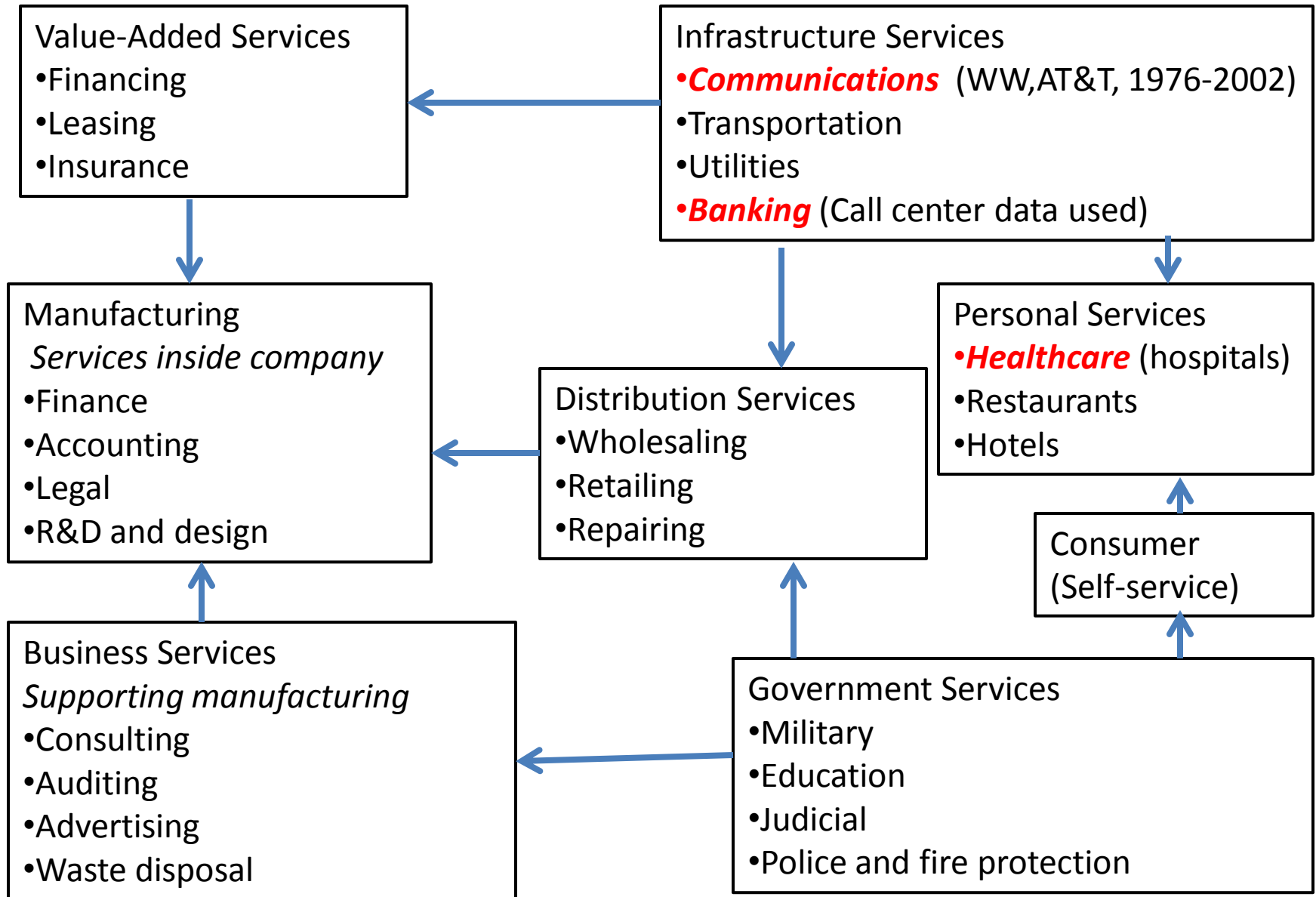
## Traditional Industrial Engineering

- IEOR 3402: **Production** Inventory Planning and Control
- IEOR 4000: **Production** Management
- *IEOR 4001: Design & Mgt. of **Prod.** and Service Systems*
- IEME 4310: The **Manufacturing** Enterprise
- IEOR 4405: **Production** Scheduling
- *IEOR 4412: Quality Control and Management*
- *IEOR 4520: Applied Systems Engineering*
- *IEOR 4601: Dynamic Pricing and Revenue Management*

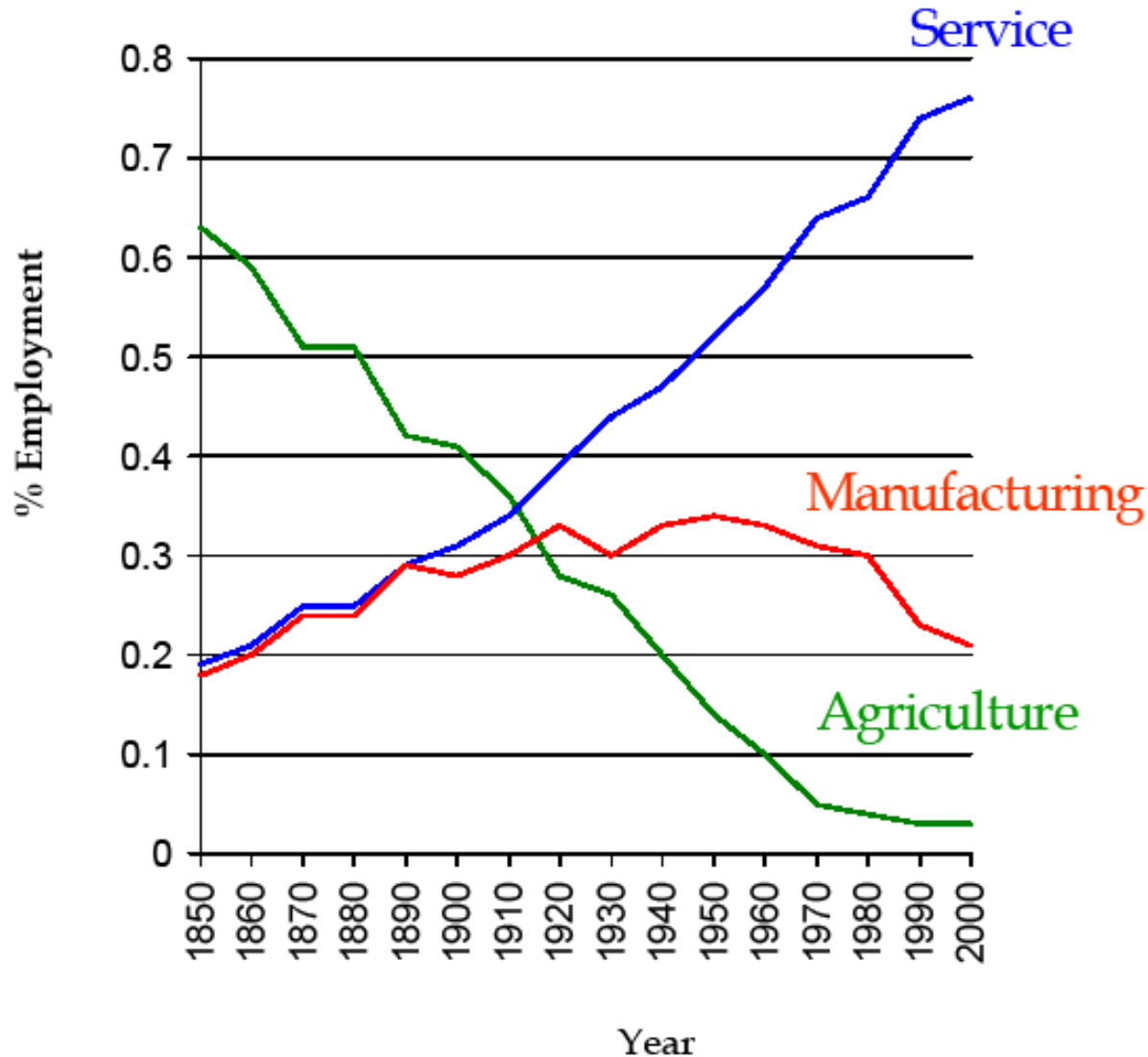
(***Italics***: Applies to **Both**)

Significant **commonality**; significant **differences**

# Role of Services in an Economy (p. 5)



# Historical Trend in United States



# Chapter 2

## Service Classification

- Concepts of service management should be applicable to all service organizations. (p.18)
  - For example, hospital administrators could learn from restaurants and hotels.
- But services are ***not*** all the same:

# The Service Process Matrix (Fig 2.1)

**Degree of interaction and customization**

		Low	High
Degree of Labor Intensity*	Low	<p><i>Service factory:</i></p> <ul style="list-style-type: none"><li>•Airlines</li><li>•Trucking</li><li>•Hotels</li><li>•Resorts</li></ul>	<p><i>Service shop:</i></p> <ul style="list-style-type: none"><li>•Hospitals</li><li>•Auto repair</li><li>•Other repair services</li></ul>
	High	<p><i>Mass service:</i></p> <ul style="list-style-type: none"><li>•Retailing</li><li>•Wholesaling</li><li>•Schools</li><li>•Retail commercial banking</li></ul>	<p><i>Professional service:</i></p> <ul style="list-style-type: none"><li>•Physicians</li><li>•Lawyers</li><li>•Accountants</li><li>•Architects</li></ul>

\*Ratio of labor cost to capital cost

# Nature of the Service Act (Fig 2.3)

		Direct recipient of the service	
		People	Things
Nature of the service act	Tangible actions	<p><i>Services directed at people's bodies:</i></p> <ul style="list-style-type: none"> <li>•Healthcare</li> <li>•Passenger transportation</li> <li>•Beauty salons</li> <li>•Exercise clinics</li> <li>•Restaurants</li> </ul>	<p><i>Services directed at goods:</i></p> <ul style="list-style-type: none"> <li>•Freight transportation</li> <li>•Repair and maintenance</li> <li>•Laundry and dry cleaning</li> <li>•Veterinary care</li> </ul>
	Intangible actions	<p><i>Services directed at people's minds:</i></p> <ul style="list-style-type: none"> <li>•Education</li> <li>•Broadcasting</li> <li>•Information services</li> <li>•Theaters</li> <li>•Museums</li> </ul>	<p><i>Services directed at intangible assets:</i></p> <ul style="list-style-type: none"> <li>•Banking</li> <li>•Legal services</li> <li>•Accounting</li> <li>•Securities</li> <li>•Insurance</li> </ul>

Thinking creatively about the service may identify more convenient forms of delivery; e.g., lectures available on line.

# Service-to-Customer Relationship (Fig 2.4)

Type of relationship between service organization  
and its customers

		“Membership” Relationship	No formal relationship
Nature of the service delivery	Continuous Delivery of service	<ul style="list-style-type: none"><li>•Insurance</li><li>•Telephone subscription</li><li>•Electric utility</li><li>•Banking</li></ul>	<ul style="list-style-type: none"><li>•Radio station</li><li>•Police protection</li><li>•Lighthouse</li><li>•Public highway</li></ul>
	Discrete Transactions	<ul style="list-style-type: none"><li>•Long distance phone calls</li><li>•Theater series tickets</li><li>•Transit pass</li><li>•Wholesale buying club</li><li>•Airline frequent flyer</li></ul>	<ul style="list-style-type: none"><li>•Toll Highway</li><li>•Pay phone</li><li>•Movie theater</li><li>•Public transportation</li><li>•Restaurant</li></ul>

Services have the opportunity to build long-term relationships.

# Customization and Judgment (Fig 2.5)

**Extent of customization permitted by service**

		High	Low
Extent to which service personnel exercise judgment in providing service	High	Surgery Taxi Service Gourmet restaurant	Education (large classes) Preventive health programs Family restaurant
	Low	Telephone service Hotel services Retail banking Cafeteria	Public transportation Movie theater Spectator sports Institutional food service

An opportunity exists to tailor the service to the needs of the customer.

# Nature of Demand and Supply (Fig 2.6)

## Extent of demand fluctuations over time

		Wide	Narrow
Extent which supply is constrained	Peak demand can be met without major delay	<ul style="list-style-type: none"><li>•Electricity</li><li>•Telephone</li><li>•Hospital maternity unit</li><li>•Police emergencies</li></ul>	<ul style="list-style-type: none"><li>•Insurance</li><li>•Legal services</li><li>•Banking</li><li>•Laundry and dry cleaning</li></ul>
	Peak demand often exceeds capacity	<ul style="list-style-type: none"><li>•Tax preparation</li><li>•Passenger transportation</li><li>•Hotels and motels</li></ul>	<ul style="list-style-type: none"><li>•Fast-food restaurant</li><li>•Movie theater</li><li>•Gas station</li></ul>

Managing supply is a major focus of the course.

# Method of Service Delivery (Fig 2.7)

		Availability of service outlets (Location)	
		Single site	Multiple sites
Nature of interaction	Customer travels to service firm	<ul style="list-style-type: none"> <li>•Theater</li> <li>•barbershop</li> </ul>	<ul style="list-style-type: none"> <li>•Bus service</li> <li>•Fast-food chain</li> </ul>
	Service provider travels to customer	<ul style="list-style-type: none"> <li>•Pest control service</li> <li>•Taxi</li> </ul>	<ul style="list-style-type: none"> <li>•Mail delivery</li> <li>•AAA emergency repairs</li> </ul>
	At arm's length	<ul style="list-style-type: none"> <li>•Credit card company</li> <li>•Local TV station</li> </ul>	<ul style="list-style-type: none"> <li>•National TV network</li> <li>•Telephone company</li> </ul>

# Chapter 3

- Competition
- Service Strategy
- Information (& Inf. Technology)

F. X. Frei, P. T. Harker, L. W. Hunter, *Innovation in Retail Banking*, Report from Financial Institutions Center, Wharton, 1998. (Reading in homework 1)

# The Strategic Service Vision (Tab 3.1)

Target Market Segments		Service Concept		Operating Strategy		Service Delivery System
Common characteristics of important market segments?		Important elements of the service?		Important elements of the strategy?		Key features of service delivery system?
How to segment market?	How well is the service concept positioned in relation to customer needs and competitor offerings?	How should these elements be perceived?		On which will most effort be concentrated?	Does the service delivery system support the operating strategy?	Role of people, technology, equipment, layout, procedures?
Importance and needs of segments?		How do customers perceive the service concept?	Cost benefit analysis	Where will investments be made?		What capacity is provided?
How well being met?		How affect design, delivery?		How to control quality and cost		Evaluate success in ensuring quality, differentiating service from competitors and providing barrier to entry by competitors?
				Expected results?		

# Strategic Service Vision of **Southwest Airlines** at startup (1967-71)

- **Target market segments**

- Intrastate (Dallas, Houston, San Antonio, about 250 miles) business travelers with carry-on luggage who currently drive by auto or are frustrated by poor service of other airlines

- **Service concept**

- On-time performance and frequent departures are critical and meals are unnecessary on short flights (less than one hour)

- **Operating strategy**

- Fast airport gate turnaround to make productive use of expensive aircraft and have frequent departures

- **Service delivery system**

- Cabin crew with interpersonal skills to create “fun” atmosphere; no assigned seating; rely on carry-on luggage.

# Competitive Environment of Services (Ch 3)

- Low barrier to entry
- Limited opportunities for economy of scale
- Erratic fluctuations in time of demand
- No size advantage in dealing with suppliers
- Product substitution
- Customer loyalty to other firms
- Exit barriers for other firms

# Competitive Service Strategies (Ch 3)

- **Cost Leadership**
  - Seek low-cost customers
  - Standardize a custom service
  - Reducing personal element in service delivery
  - Reducing network costs
  - Taking service operations offline
- **Differentiation** (uniqueness to win customer loyalty)
  - Making the intangible tangible
  - Customizing the standard product
  - Reducing perceived risk
  - Extra personnel training
  - Controlling quality
- **FOCUS** (serving a particular target market)

# ***“The Psychology of Waiting Lines”***

By David Maister

*pp. 113-123 in **The Service Encounter**,  
J. A. Czepiel, M. R. Solomon and F. C.  
Surpenant (editors), D. C. Heath&Co., 1985.*

Paper posted

# How Does a Customer Feel About Waiting?

- “Waiting is frustrating, demoralizing, agonizing, aggravating, annoying, time consuming and incredibly expensive.”
- “Products are consumed, Services are experienced’ (Levitt)
- Maister proposes **testable propositions**.
  - Customer **perceptions** are important! Psychology is important.
  - Queue management is **NOT** all models!

# The First and Second Laws of Service

- **S = P – E**
  - Satisfaction
  - Perception
  - Expectation
    - Mirrors at hotel elevators
    - Restaurant promised waiting times
- **It's hard to play catch up ball.**
  - Halo effect created by early stages of any service encounter
    - Waiter: “If they sit down in a good mood, it is easy to keep them happy. If they sit down disgruntled, it is almost impossible to turn them around. They are looking to find fault and criticize.”
  - Money, time and attention spend on improving the early stages of service are most rewarding

# Propositions about the Psychology of Waiting

- ***Occupied time*** feels shorter than unoccupied time.
  - Hand out menus in restaurants, turn waiting area into bar. Sport team playing highlights of previous game. “Put me back so-and-so is about to score.”
- People want to ***get started***.
  - Hand out menus in restaurants; first contact most important: preprocess waits are perceived as longer.
- ***Anxiety*** makes waits seem longer.
  - Have we been forgotten? Did we choose the wrong line?
  - Attendant at airport: “Don’t worry folks, you will all get on.”
- ***Uncertain waits*** are longer than known, finite waits.
  - Appointment syndrome; subway announcement system

# Propositions about the Psychology of Waiting

- ***Unexplained waits*** are longer than explained waits.
  - Doctor's receptionist: "an emergency has taken place;"  
airplane pilot: on-board announcements
  - Waiting in ignorance creates a sense of powerlessness
- ***Unfair waits*** are longer than equitable waits.
  - Agitation in wait for crowded subways; issuing number at deli counter
- The more ***valuable the service***, the longer the customer will wait.
  - Post-process waits (hotel checkout, get off landed flight)
- ***Solo waits*** feel longer than group waits.
  - Line might turn into service encounter (amusement parks)

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