Logistics Management in Air Transportation - Cheat sheet

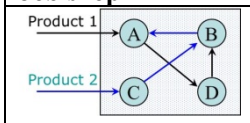
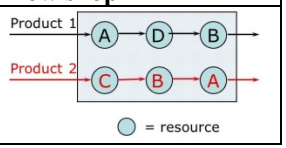
FUNDAMENTALS

Competitive Dimensions	Operational Capabilities
Price	Low cost process
Product quality and reliability	High quality process; Consistent quality
Time	Delivery speed; On-time delivery; Development speed
Flexibility	Customization; Variety; Volume flexibility

Productivity: maximize output for a given amount of input; **Efficiency**: minimize cost

Product-Process Matrix

	1	Very low	Low, many	High, stand.	Very high, commod.
Project					
Job shop					
Batch					
Assembly /flow					
Continuous					

Job shop	Flow shop
	

Process Classification by Customer Interface

- Make to Stock (MTS)
- Make to Order (MTO)
- Assemble to Order (ATO)
- Engineer to Order (ETO)

PROCESS ANALYSIS

Process measures:

- Cost
- Quality measures
- Time (Flow measures)
- Flexibility measures
- Capacity

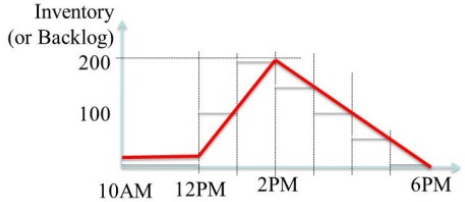
Process flow diagrams:

- Linear flow chart,
- Swim-lane (deployment) flow chart,
- Gantt chart

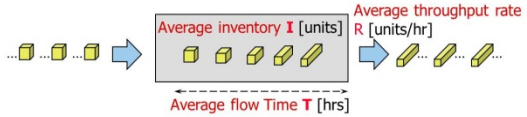
Utilization:

$$\text{Utilization} = \frac{\text{Throughput Rate}}{\text{Capacity Rate}} = \frac{\text{Actual output rate}}{\text{maximum output rate}} \le 100\%$$

Inventory build-up:



Little's Law: I = R*T, i., avg. inventory = avg. throughput rate * avg. flow time.



Batching

Line balancing while taking into account set up times.

B = Batch size

Capacity given batch size = $\frac{B}{Setup\ Time + B*(time\ per\ unit)}$

OPERATIONS AND FINANCE

Inventory:

- Flow units (I)
- $ value (I)
- Days-of-supply (T)
- (annual) Turns (1/T)

Financial reports:

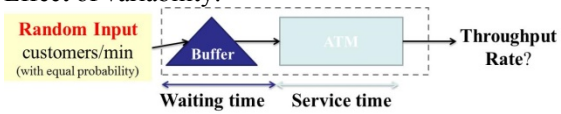
- R=COGS (Cost of Goods Sold)
- I=COGI (Cost of goods in inventory)
- $\text{Gross margin} = \frac{\text{Sales - Cost}}{\text{Sales}}$
- COGI = Average Inventory* Unit Cost
- Annual inventory holding cost = COGI * annual inventory holding rate
- Inventory holding cost per term $= \frac{\text{Annual inventory holding costs}}{\text{Inventory turns}}$
- Inventory holding cost per unit $= \frac{\text{Inventory holding costs per turn}}{\text{Average Inventory}}$ $= \frac{\text{unit cost} * \text{inventory holding rate}}{\text{annual turns}}$
- Economic value created = Invested Capital * (ROIC – WACC)
- ROIC : return on invested capital
- WACC : weighted average cost of capital
- Need to build the ROIC tree
- Typically,
  - If capacity constrained, will explore: utilization / downtime; production yields; set-up time etc.
  - If demand constrained; will explore: variety / customization; after-sales service / support => innovation.
- $productivity = \frac{revenue}{cost} = \frac{revenue}{Flow\ rate} \cdot \frac{Flow\ rate}{Resource} \cdot \frac{Resource}{cost}$ = yield * efficiency*cost
- In airlines:
  - ASM: available seat miles

- RPM: revenue passenger miles
- Load factor=RPM/ASM
- Yield: revenue per revenue passenger mile=passengers*fare/RPM
- $labor\ prod. = \frac{revenue}{RPM} \cdot \frac{RPM}{ASM} \cdot \frac{ASM}{Employees} \cdot \frac{Employees}{cost}$

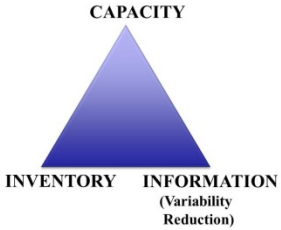
VARIABILITY

2 types: predictable and unpredictable.

Effect of variability:



The OM triangle:

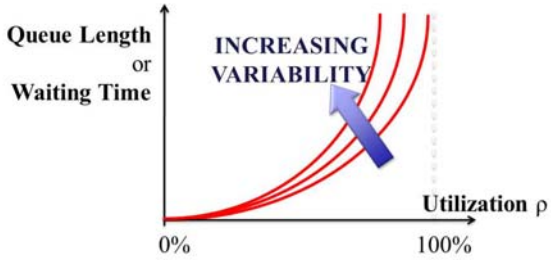


λ	Long-run average input rate
1/λ	(Average) Customer inter-arrival time
μ	Long-run average processing rate of a single server
1/μ	Average processing time by one server
c	Number of servers in the resource pool

- Average number of persons in the system:
- $I = I_q + I_s$

Pollaczek-Khinchin (PK) Formula: Average Inventory = $I_q \cong \frac{\rho^2}{1-\rho}\frac{C_a^2+C_s^2}{2}$ (that is, inventory= capacity * variability), where ρ= utilization=input rate/ capacity rate, C_a and C_s are coefficient of variation of arrivals and service.

$$CV = \frac{\text{Standard Deviation}}{\text{Mean}}$$



Single server: M/M/1

$$I_q = \frac{\rho^2}{1-\rho} = \frac{\lambda^2}{\mu(\mu-\lambda)}$$

$$T_q = I_q / \lambda$$

M/D/1

$$I_q = \frac{\rho^2}{1-\rho} \times \frac{1}{2} = \frac{\lambda^2}{2\mu(\mu-\lambda)}$$

$$T_q = I_q / \lambda$$

Multi server: $\lambda \leq c\mu$

$$I_q \cong \frac{\rho^{\sqrt{2(c+1)}}}{1-\rho} \times \frac{C_a^2 + C_s^2}{2}$$

NEWSVENDOR AND REVENUE MANAGEMENT

Generate demand distribution: use historical data

$$\text{A/F ratio} = \frac{\text{Actual demand}}{\text{Forecast}}$$

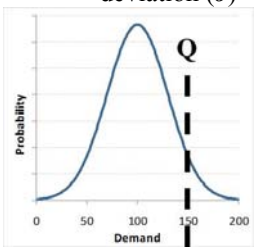
$$\text{Expected actual demand} = (\text{Expected A/F ratio}) \times \text{Forecast}$$

$$\text{Standard deviation of actual demand} = (\text{Standard deviation of A/F ratios}) \times \text{Forecast}$$

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \mu)^2}$$

Normal distribution:

- Characterized by mean (μ) and standard deviation (σ)



Q=μ+z*σ

C_o = Overage cost

C_U = Underage cost

Using marginal analysis:

- Expected loss on the Q^{th} unit = $C_o \cdot F(Q)$
- Expected gain on the Q^{th} unit = $C_u \cdot (1-F(Q))$
- Solving: $C_o \times F(Q) = C_u \times (1 - F(Q))$
- $F(Q) = \frac{C_u}{C_o + C_u}$

With normally distributed demand, order $\mu + Z * \sigma$ units; find Z based on the critical ratio using the normal dist. table.

Measures:

- **In-stock probability**: Probability **all** demand is satisfied
- **Stockout probability**: Probability **some** demand is lost = $1 - F(Q)$
- **Expected lost sales**: The expected number of units by which demand will exceed the order quantity. Expected lost sales = $\sigma L(z)$, the Loss function: $L(z) = \int_z^{\infty}(d-z)f(z)dz$ =Normdist(z,0,1,0)-z·(1-Normsdist(z))
- **Expected sales**: The expected number of units sold. Expected sales = μ − Expected lost sales.

- **Expected left over inventory**: The expected number of units left over after demand (but before salvaging)
- **Expected profit**
- **Fill rate:** the fraction of demand that can purchase a unit.

Revenue management:

- ***Strategic*** pricing
- ***Operational*** pricing: Day-to-day adjusting of prices to address demand realization and updating of expectations
- **Revenue Management**: A technique to maximize revenue by matching fixed supply with uncertain demand

Early vs late arrivals:

- Cu = the premium (high price – low price)
- Co = the early arrival price

Overbooking:

- Cu = the price (insufficient number of units overbooked)
- Co = the penalty (too many units overbooked)

Booking limits are nested

If later arrivals pay higher price than advance selling, we have: Revenue = units released * Advance price + Expected sales * high price

FORECASTING

Qualitative methods: Executive judgment; Historical analogy; Delphi method; Grass roots; Market research; Panel consensus; Leader indicators;

Quantitative methods:

- **Time series analysis:**
- Evaluation: MAD=$\frac{1}{n}\sum|E_t|$
- Simple MA (moving average) $F_t=\frac{1}{n}\sum_{i=t-1}^{t-n} A_i$
- ES (exponential smoothing): $F_t = \alpha A_{t-1} + (1-\alpha)F_{t-1}$ or $F_t = F_{t-1} + \alpha \cdot (A_{t-1} - F_{t-1})$
- Linear regression:

$$a = \bar{y} - b\bar{x}$$

$$b = \frac{\sum xy - n(\bar{y})(\bar{x})}{\sum x^2 - n(\bar{x})^2}$$

Risk Management

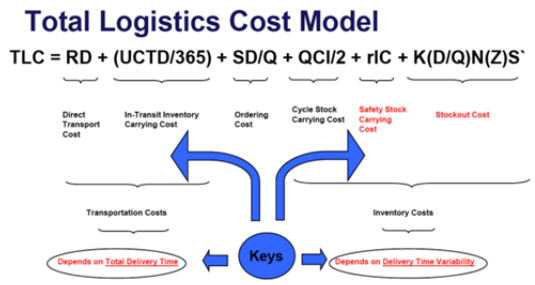
- Mitigating Risk (such as pooling strategies)
- Transferring Risk
- Avoiding Risk
- Sharing Risk (such as efficient contracts)
- Retaining Risk (making a conscious decision to accept the risk)

Four versions of risking pooling:

- location pooling
- product pooling
- lead time pooling
  - delayed differentiation (HP case)
  - consolidated distribution
- capacity pooling

Logistics and Inventory

Total Logistics Cost Function



TLC (Q, r: T, S_T) = RD_i + ($UCTD_i$/365) + (SD_i/Q) + (QCI/2) + rIC + K(D_i/Q) N(Z)S^l

where:

TLC = total logistics cost

R = Transportation Rate per Unit between Origin and Destination

D = Annual Demand for some good 'i'

U = Carrying Cost of In-transit Inventory

C = Value per Unit

T = Transit Time of Transportation Alternative

S = Fixed Ordering Cost per Order

Q = Order Quantity

I = Carrying Cost of Warehoused Inventory

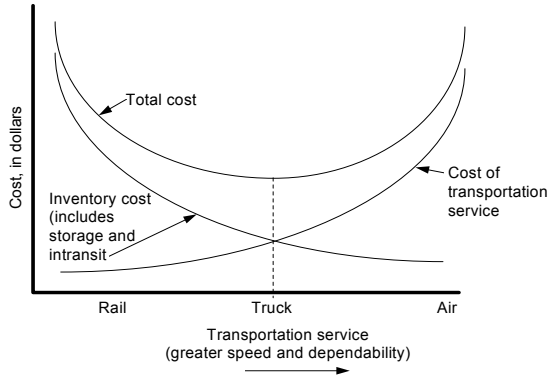
r = Safety Stock

K = Stockout Cost per Unit

N(Z) = Unit Loss Integral

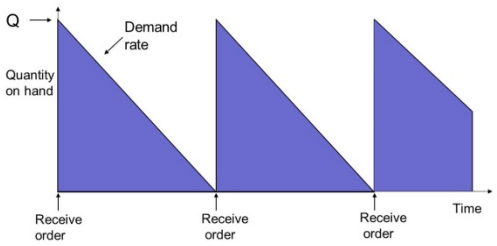
S^l = Standard Deviation of Demand During Transit Time

S_T = Standard Deviation of Demand During Lead Time



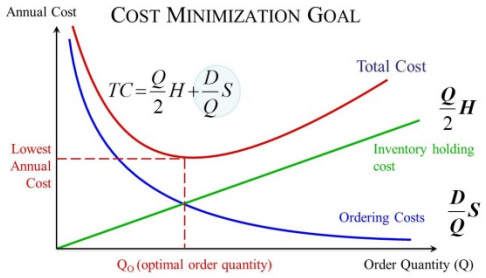
Inventory Management

Economic Order Quantity (EOQ):



D	Annual Demand Rate
Q	Lot or batch size
S	Set-up cost per lot/batch, or average cost of processing/placing an order

C	Unit cost
H	Annual holding and storage cost per unit of average inventory
i	Percent carrying cost (e.g., "interest" rate)



Minimize $TC = \frac{Q}{2}H + \frac{DS}{Q}$

⇨ $Q_{OPT} = \sqrt{\frac{2SD}{H}}$; $TC_{OPT} = \sqrt{2SDH}$;

z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0	0.5000	0.5040	0.5080	0.5120	0.5160	0.5199	0.5239	0.5279	0.5319	0.5359
0.1	0.5398	0.5438	0.5478	0.5517	0.5557	0.5596	0.5636	0.5675	0.5714	0.5753
0.2	0.5793	0.5832	0.5871	0.5910	0.5948	0.5987	0.6026	0.6064	0.6103	0.6141
0.3	0.6179	0.6217	0.6255	0.6293	0.6331	0.6368	0.6406	0.6443	0.6480	0.6517
0.4	0.6554	0.6591	0.6628	0.6664	0.6700	0.6736	0.6772	0.6808	0.6844	0.6879
0.5	0.6915	0.6950	0.6985	0.7019	0.7054	0.7088	0.7123	0.7157	0.7190	0.7224
0.6	0.7257	0.7291	0.7324	0.7357	0.7389	0.7422	0.7454	0.7486	0.7517	0.7549
0.7	0.7580	0.7611	0.7642	0.7673	0.7704	0.7734	0.7764	0.7794	0.7823	0.7852
0.8	0.7881	0.7910	0.7939	0.7967	0.7995	0.8023	0.8051	0.8078	0.8106	0.8133
0.9	0.8159	0.8186	0.8212	0.8238	0.8264	0.8289	0.8315	0.8340	0.8365	0.8389
1	0.8413	0.8438	0.8461	0.8485	0.8508	0.8531	0.8554	0.8577	0.8599	0.8621
1.1	0.8643	0.8665	0.8686	0.8708	0.8729	0.8749	0.8770	0.8790	0.8810	0.8830
1.2	0.8849	0.8869	0.8888	0.8907	0.8925	0.8944	0.8962	0.8980	0.8997	0.9015
1.3	0.9032	0.9049	0.9066	0.9082	0.9099	0.9115	0.9131	0.9147	0.9162	0.9177
1.4	0.9192	0.9207	0.9222	0.9236	0.9251	0.9265	0.9279	0.9292	0.9306	0.9319
1.5	0.9332	0.9345	0.9357	0.9370	0.9382	0.9394	0.9406	0.9418	0.9429	0.9441
1.6	0.9452	0.9463	0.9474	0.9484	0.9495	0.9505	0.9515	0.9525	0.9535	0.9545
1.7	0.9554	0.9564	0.9573	0.9582	0.9591	0.9599	0.9608	0.9616	0.9625	0.9633
1.8	0.9641	0.9649	0.9656	0.9664	0.9671	0.9678	0.9686	0.9693	0.9699	0.9706
1.9	0.9713	0.9719	0.9726	0.9732	0.9738	0.9744	0.9750	0.9756	0.9761	0.9767
2	0.9772	0.9778	0.9783	0.9788	0.9793	0.9798	0.9803	0.9808	0.9812	0.9817
2.1	0.9821	0.9826	0.9830	0.9834	0.9838	0.9842	0.9846	0.9850	0.9854	0.9857
2.2	0.9861	0.9864	0.9868	0.9871	0.9875	0.9878	0.9881	0.9884	0.9887	0.9890
2.3	0.9893	0.9896	0.9898	0.9901	0.9904	0.9906	0.9909	0.9911	0.9913	0.9916
2.4	0.9918	0.9920	0.9922	0.9925	0.9927	0.9929	0.9931	0.9932	0.9934	0.9936

z	-0.09	-0.08	-0.07	-0.06	-0.05	-0.04	-0.03	-0.02	-0.01	0.00
-2.4	0.0064	0.0066	0.0068	0.0069	0.0071	0.0073	0.0075	0.0078	0.0080	0.0082
-2.3	0.0084	0.0087	0.0089	0.0091	0.0094	0.0096	0.0099	0.0102	0.0104	0.0107
-2.2	0.0110	0.0113	0.0116	0.0119	0.0122	0.0125	0.0129	0.0132	0.0136	0.0139
-2.1	0.0143	0.0146	0.0150	0.0154	0.0158	0.0162	0.0166	0.0170	0.0174	0.0179
-2	0.0183	0.0188	0.0192	0.0197	0.0202	0.0207	0.0212	0.0217	0.0222	0.0228
-1.9	0.0233	0.0239	0.0244	0.0250	0.0256	0.0262	0.0268	0.0274	0.0281	0.0287
-1.8	0.0294	0.0301	0.0307	0.0314	0.0322	0.0329	0.0336	0.0344	0.0351	0.0359
-1.7	0.0367	0.0375	0.0384	0.0392	0.0401	0.0409	0.0418	0.0427	0.0436	0.0446
-1.6	0.0455	0.0465	0.0475	0.0485	0.0495	0.0505	0.0516	0.0526	0.0537	0.0548
-1.5	0.0559	0.0571	0.0582	0.0594	0.0606	0.0618	0.0630	0.0643	0.0655	0.0668
-1.4	0.0681	0.0694	0.0708	0.0721	0.0735	0.0749	0.0764	0.0778	0.0793	0.0808
-1.3	0.0823	0.0838	0.0853	0.0869	0.0885	0.0901	0.0918	0.0934	0.0951	0.0968
-1.2	0.0985	0.1003	0.1020	0.1038	0.1056	0.1075	0.1093	0.1112	0.1131	0.1151
-1.1	0.1170	0.1190	0.1210	0.1230	0.1251	0.1271	0.1292	0.1314	0.1335	0.1357
-1	0.1379	0.1401	0.1423	0.1446	0.1469	0.1492	0.1515	0.1539	0.1562	0.1587
-0.9	0.1611	0.1635	0.1660	0.1685	0.1711	0.1736	0.1762	0.1788	0.1814	0.1841
-0.8	0.1867	0.1894	0.1922	0.1949	0.1977	0.2005	0.2033	0.2061	0.2090	0.2119
-0.7	0.2148	0.2177	0.2206	0.2236	0.2266	0.2296	0.2327	0.2358	0.2389	0.2420
-0.6	0.2451	0.2483	0.2514	0.2546	0.2578	0.2611	0.2643	0.2676	0.2709	0.2743
-0.5	0.2776	0.2810	0.2843	0.2877	0.2912	0.2946	0.2981	0.3015	0.3050	0.3085
-0.4	0.3121	0.3156	0.3192	0.3228	0.3264	0.3300	0.3336	0.3372	0.3409	0.3446
-0.3	0.3483	0.3520	0.3557	0.3594	0.3632	0.3669	0.3707	0.3745	0.3783	0.3821
-0.2	0.3859	0.3897	0.3936	0.3974	0.4013	0.4052	0.4090	0.4129	0.4168	0.4207
-0.1	0.4247	0.4286	0.4325	0.4364	0.4404	0.4443	0.4483	0.4522	0.4562	0.4602
0	0.4641	0.4681	0.4721	0.4761	0.4801	0.4840	0.4880	0.4920	0.4960	0.5000