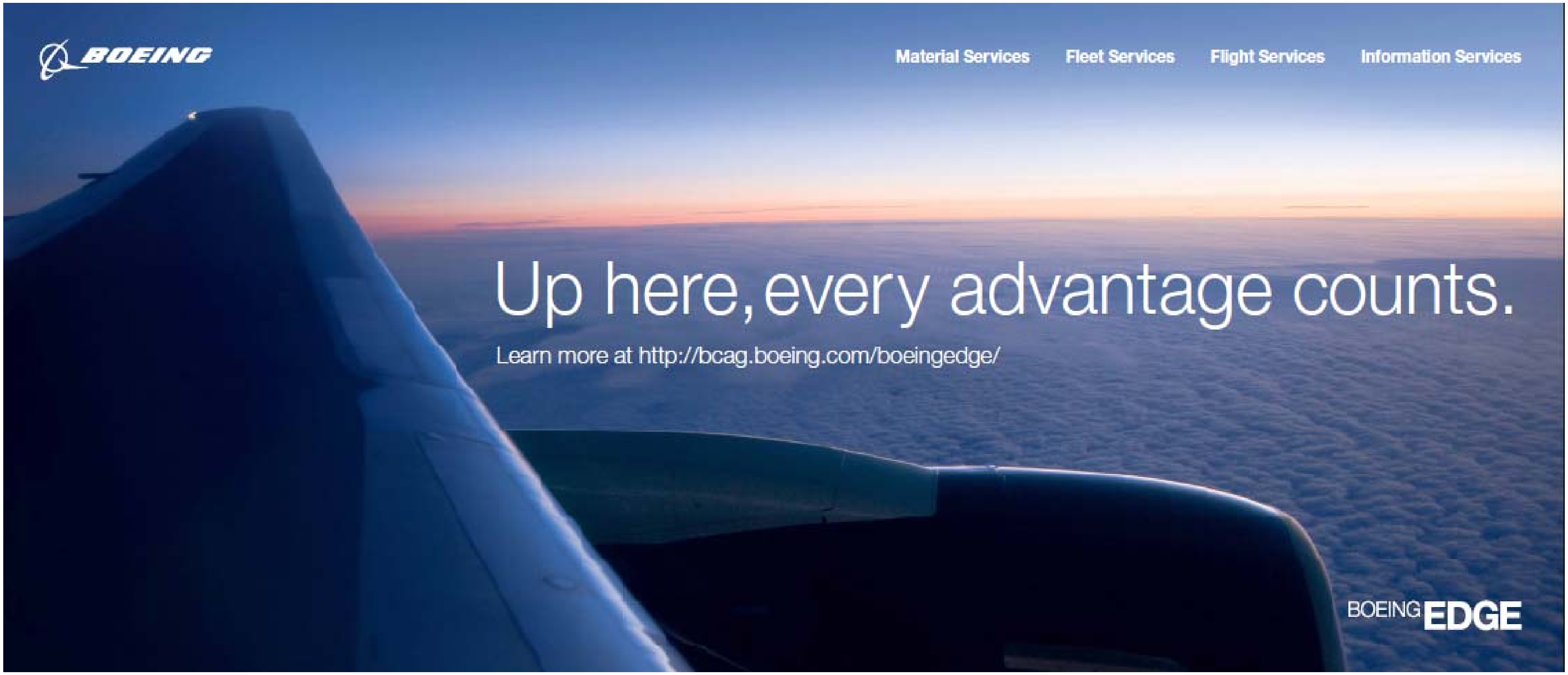

A New Approach to Fuel Analysis and Reporting

Michael E. Irrgang

AGIFORS OpsCtl

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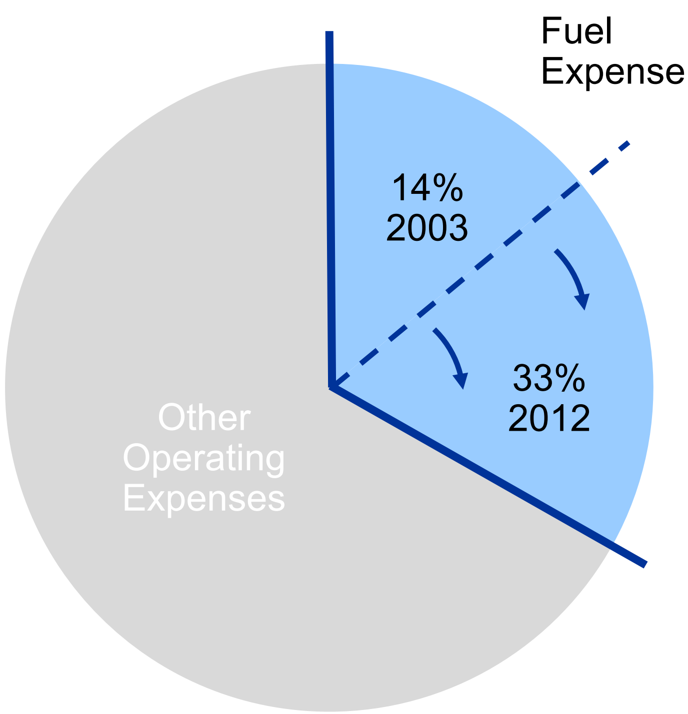
Background: Understanding the business problem

- Airline customers are asking for fuel analysis & reporting consulting & systems
  - **~ 35% of airline operational costs are linked to fuel**
- Fuel prices have nearly quintupled in the last 10 years
- Airlines have traditionally allocated very few resources (human, analytics) to a very complex problem
- The existing approach to fuel and flight planning analysis doesn't fully hit the potential
  for fuel savings



Source: IATA (2013)

Fuel costs and environmental regulations are major drivers in airline profitability.

Boeing's Perspective on Fuel Efficiency

No "Silver Bullets" – But Many Small Opportunities Can Add Up To Significant Savings

Savings Opportunity	
¢:	$1 per flight
$:	5
$$:	10
$$$:	50
$$$$:	100

Taxi Out
- Pushback time $
- Engine start $
- APU use $
- Runway selection ¢
- Taxi path, speed, stops $
- V speeds ¢
- Configuration $
- Departure route $$

Climb
- Profile $
- Route $
- Speed $
- TOC $

Descent
- Diversion $$$
- TOD $$
- Profile $$
- Route $$
- Speed $
- Configuration ¢

Taxi In
- Braking ¢
- Thrust reverse $
- Exit ¢
- Taxi path, speed, stops ¢
- Engine $
- APU $
- Gate ¢

Departure
- Gear up ¢
- Flaps up ¢
- Climb profile $
- Route $
- Speed $

Cruise
- Route $$$
- Speed/ Cost Index $$
- Altitude $$
- Configuration $
- Fuel distribution ¢
- Cost index $
- Ride quality ¢
- Electrical Load $
- Anomaly resolution $

Arrival
- Profile $$
- Route $$
- Speed $
- Flaps ¢
- Gear $
- Runway selection $
- Gate ¢

Flight Planning
- Route $$
- Crew $$
- Fuel load $$$$
- Cost index $
- Release ¢
- Disruption Mgmt $$$$

Gate
- Fuel update $$$
- APU use $$
- Flt plan update $$
- Payload W/B $
- Line Maintenance $$
- Anomaly resolutions $

Gate
- Manpower $
- Equipment $
- Services $

Post Flight
- Arrival Fuel $$$$
- Log entries ¢
- MX actions $
- Aircraft Turn $$$

Internal Variables
- Crew status
- Airplane status
- AP position, trajectory
- MMEL
- Cargo
- Passenger
- MX Plans
- Spares availability
- Gate/Hub resource stats
- AP performance
- Ops spec
- Flight schedule
- Cabin status
- Etc.

External Variables
- Weather
- Winds
- Traffic
- NOTAMS
- PIREPS
- ATC
- Nav data
- Nav procedures
- Airport config/status
- Etc.

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How Is Fuel Consumption Measured? Analyzed?

Examples

- What's the best fuel metric to use?

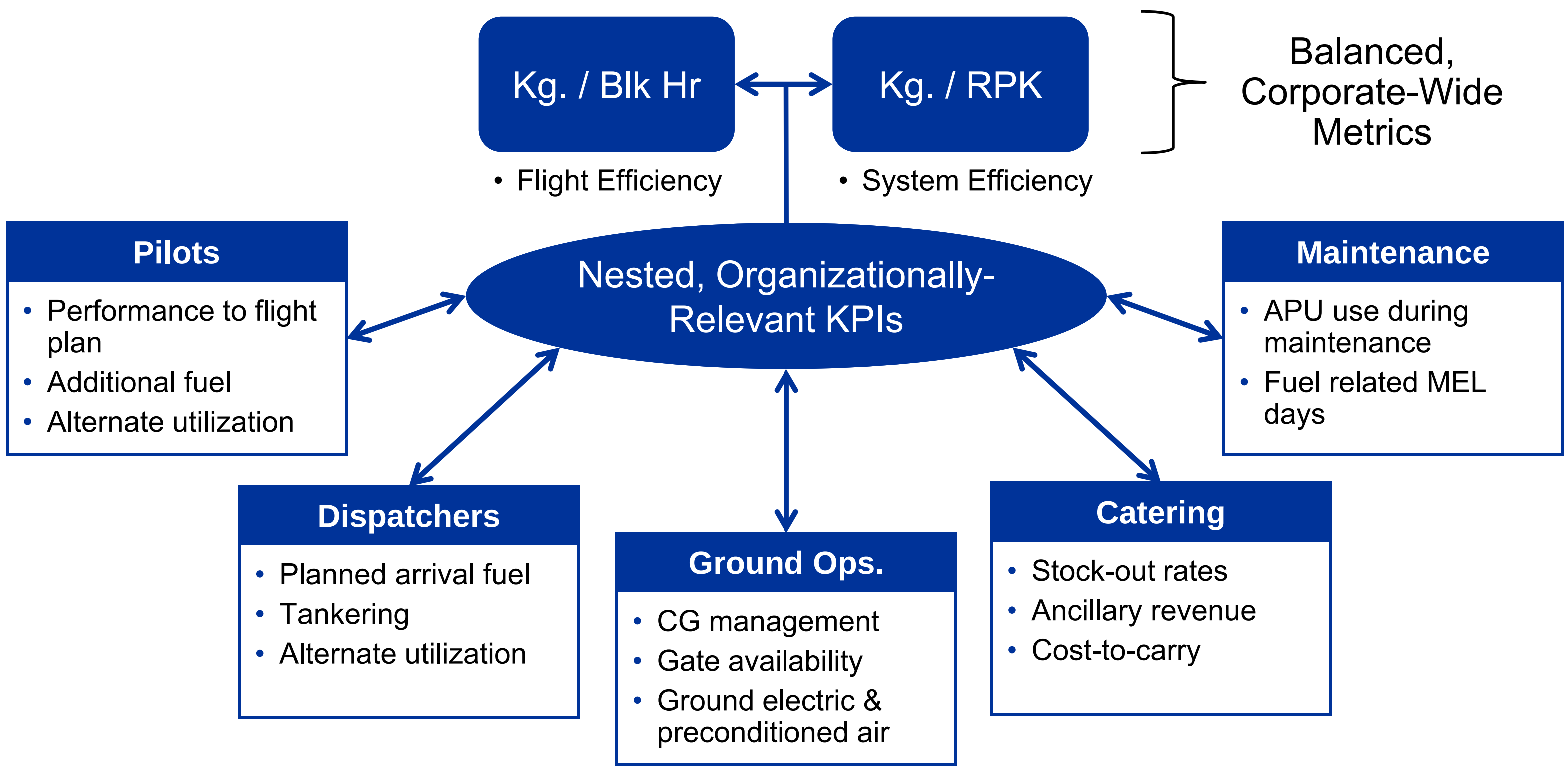
Metric	Pros / Cons
Kg. / ASK	▲ Broad, clear measure ▼ Fleet dependent results ▼ Difficult to isolate payload effects
Kg. / RPK	▲ Scales with weight ▲ Allows specific route analysis ▼ Load factor influenced
Kg. / Blk Hr	▲ Directly measurable ▲ Includes ground/taxi time ▼ Masks root cause (ground vs. flight)
Kg. / Flt Hr	▲ Directly measurable ▲ Focused on flight profile ▼ Excludes ground / taxi impacts
Norm. Cruise Consumption	▲ Readily available FOQA data ▲ Airplane specific bias ▼ Can mask weight errors ▼ Lacks flight profile/route effects
ASK / Blk Hr	▲ Includes seat density effects ▲ Includes ground delay effects ▼ Indirect measure of fuel perf

Our View: Fuel efficiency is too complex for any single metric to be sufficient

Metrics Best Practice

Examples

- "Nested Tree" of balanced, meaningful KPIs



Irrelevant metrics will make any efficiency program ineffective

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Strengths and Weaknesses of KPI-based Systems

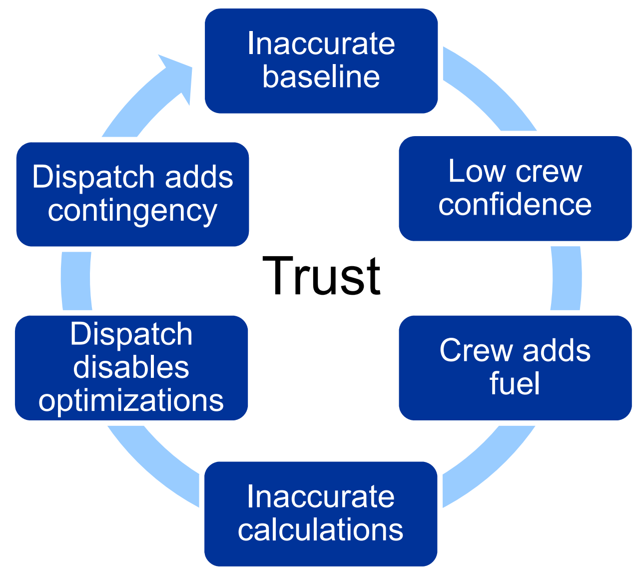
- KPI-based systems dominate the market in fuel management systems today
  - **5-10 vendors in the marketplace**
  - **Systems installed in >30 airlines**
- Strengths
  - **Give a good view of trends in fuel consumption in the airline**
  - **Can control and "solve" certain fuel efficiencies**
    - Excess APU usage
    - Insufficient use of single engine taxi
    - Excessive variance between planned vs. actual Zero Fuel Weight (ZFW)
      - Leads to major incidence of fuel burn variances
- Weaknesses
  - **Easy to misinterpret meaning of KPI trends**
    - E.g. Does "improved" burn per flight hour mean that we are doing better? Or does it just mean longer stage lengths or lower payloads? Etc., etc. …
  - **Require significant fuel efficiency expertise to properly summarize results**
  - **Often easy for pilots/dispatchers to circumvent controls on extra fuel requests, for example**

KPI-based systems cannot tell you if the airline is "better" or "worse"

What Is One of the Most Serious Fuel Issues?

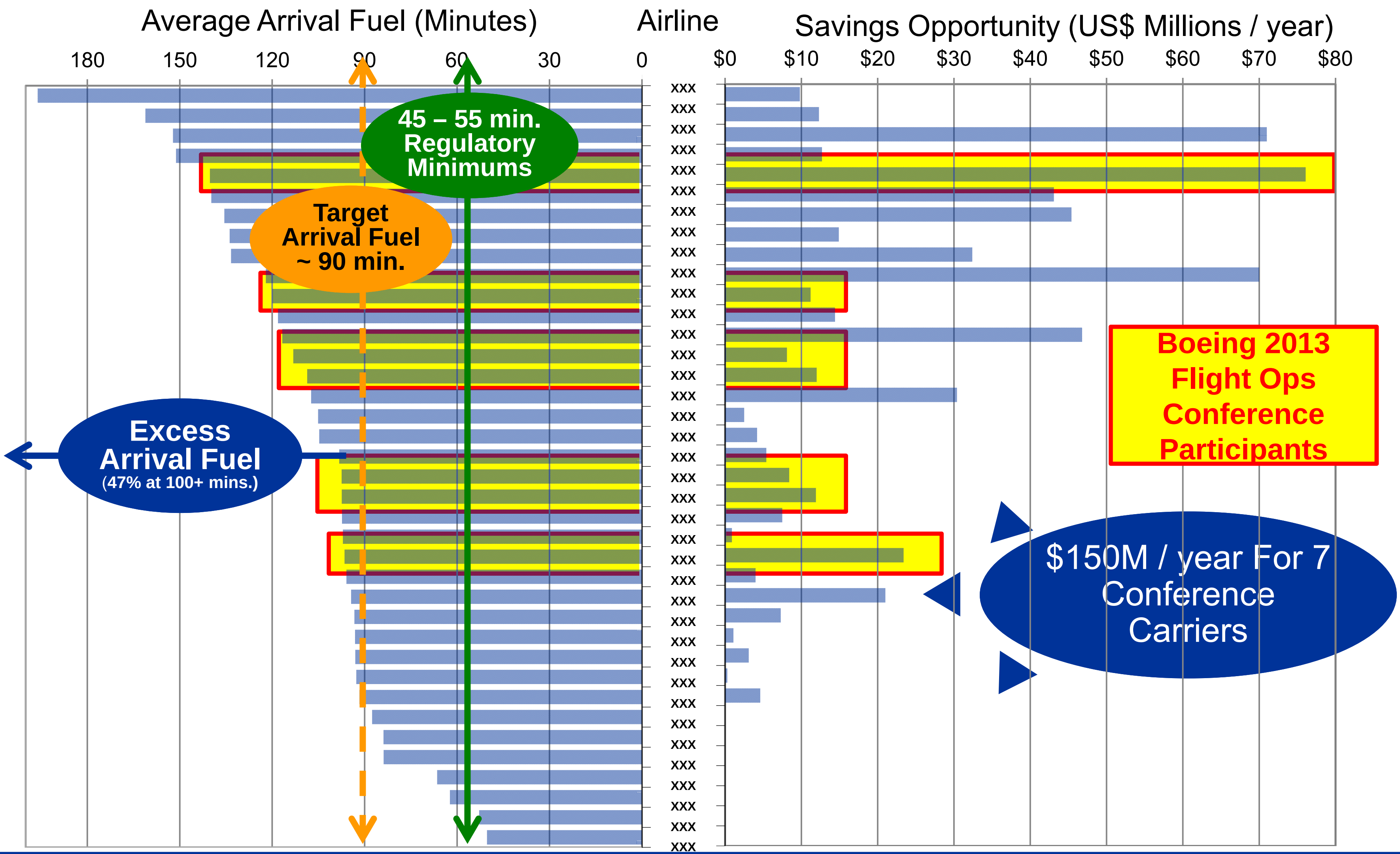
- Excess arrival fuel can increase fuel consumption by 1-2%
- Example: an airline with 100 737-NGs will spend ~$900 million per year in fuel
  - **A 15 minute reduction in arrival fuel will save ~$7 million per year!**
- Excess arrival fuel is often a function of lack of confidence in flight plans
  - **The simplest cause of lack of trust is planned vs. actual weight variance, causing over/underburns**
  - **A more complex cause is institutionalized error in the flight planning process**

Arrival Fuels: Root Causes



KPI-based systems cannot tell you if your alternate fuel and your arrival fuel have been minimized/optimized

Flight Operations: Arrival Fuels

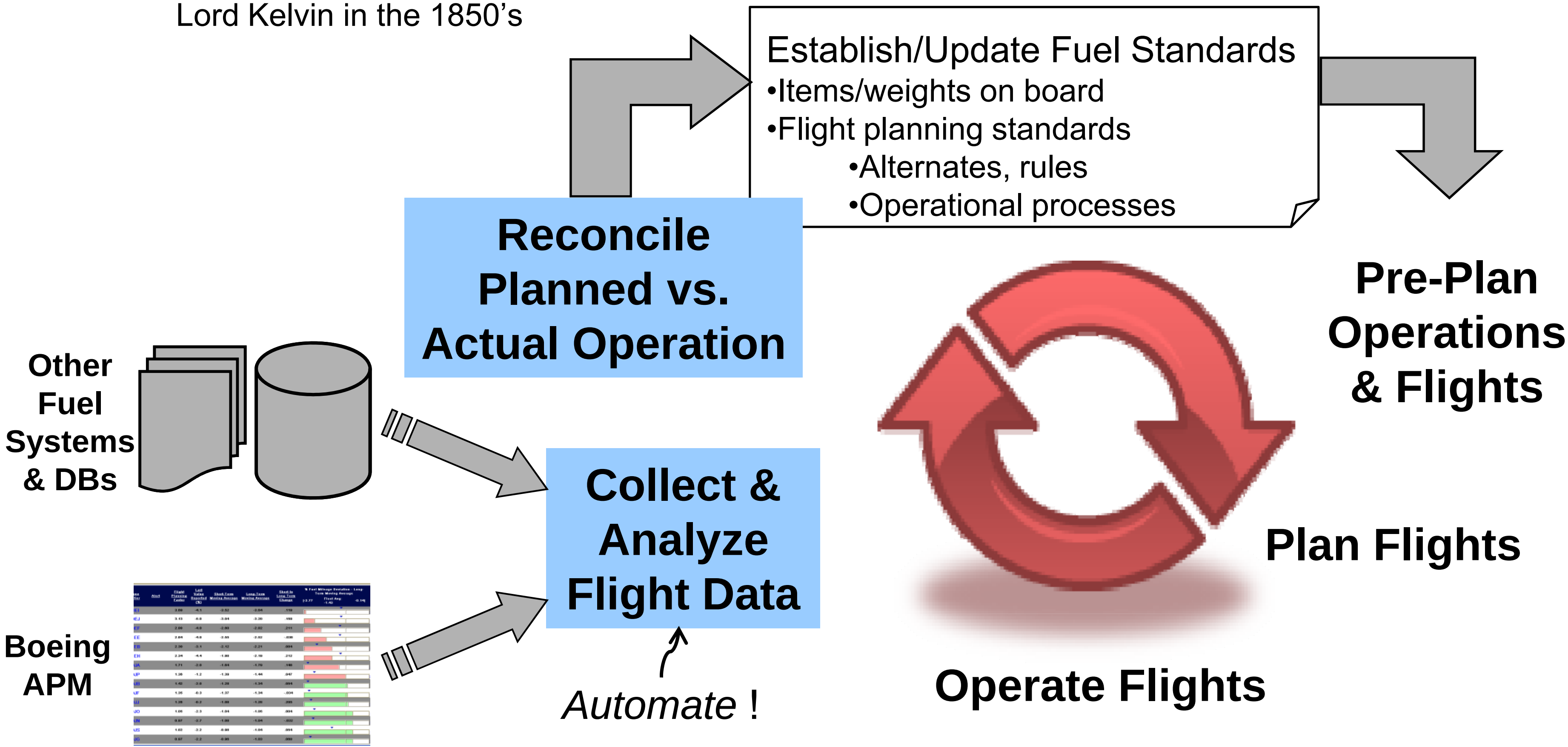


Savings opportunities likely $700M+ across conference participants

Source: Boeing AHM (1/1/12 – 8/15/12); 500,000+ records

Fuel Optimization – The Knowledge Loop

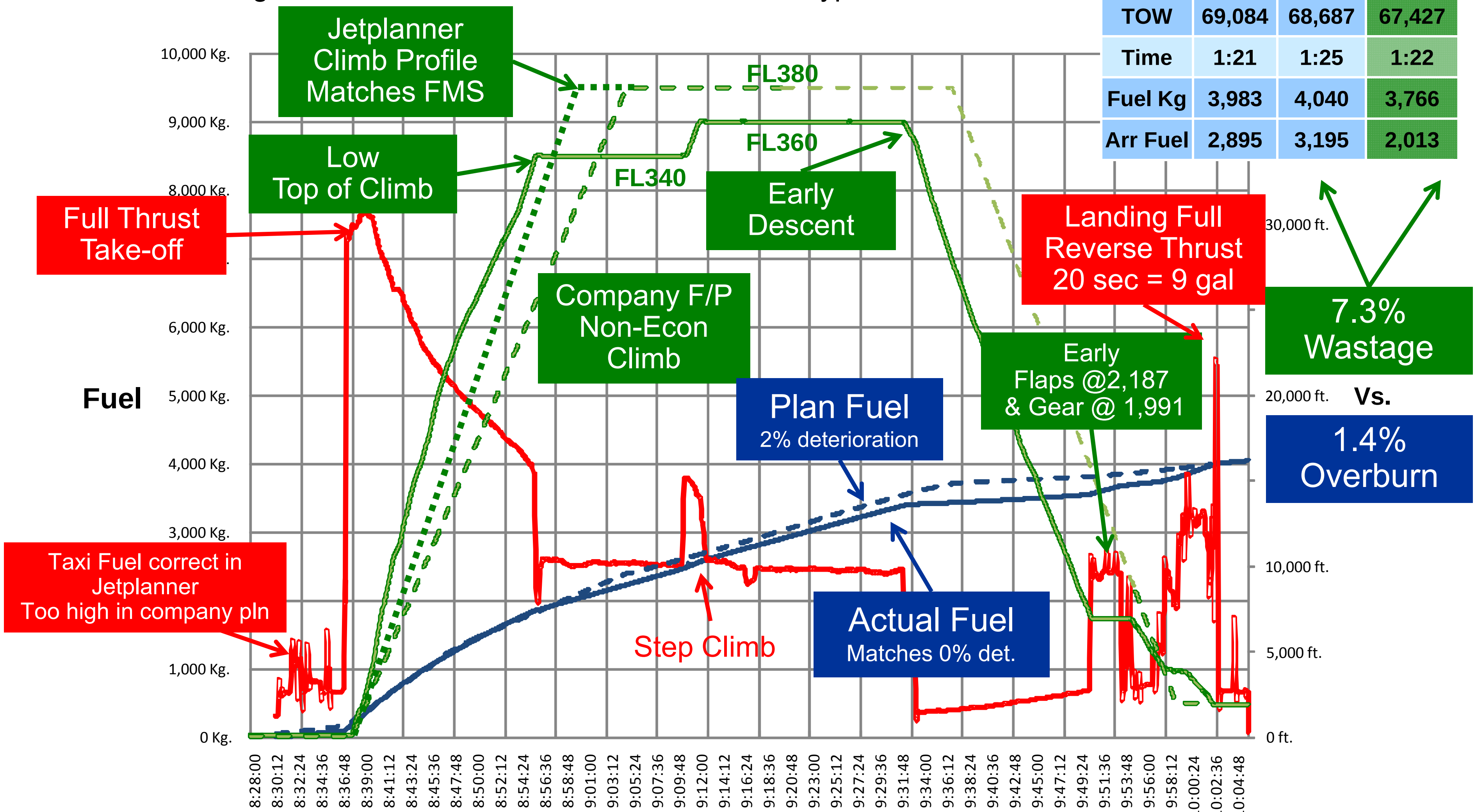
- It’s all about better monitoring, analysis, management & planning data
  - Fuel, time, weight & distance variance
  - Real-time & post-operation consumption patterns
  - “To measure is to know. If you cannot measure it, you can not improve it.” – legendary physicist Lord Kelvin in the 1850’s



Example: Flight Plan as Benchmark

Airline: XXX Flight: XXX Route: XXX-XXX Date: 8-Jan-13 Type: 737-900ER

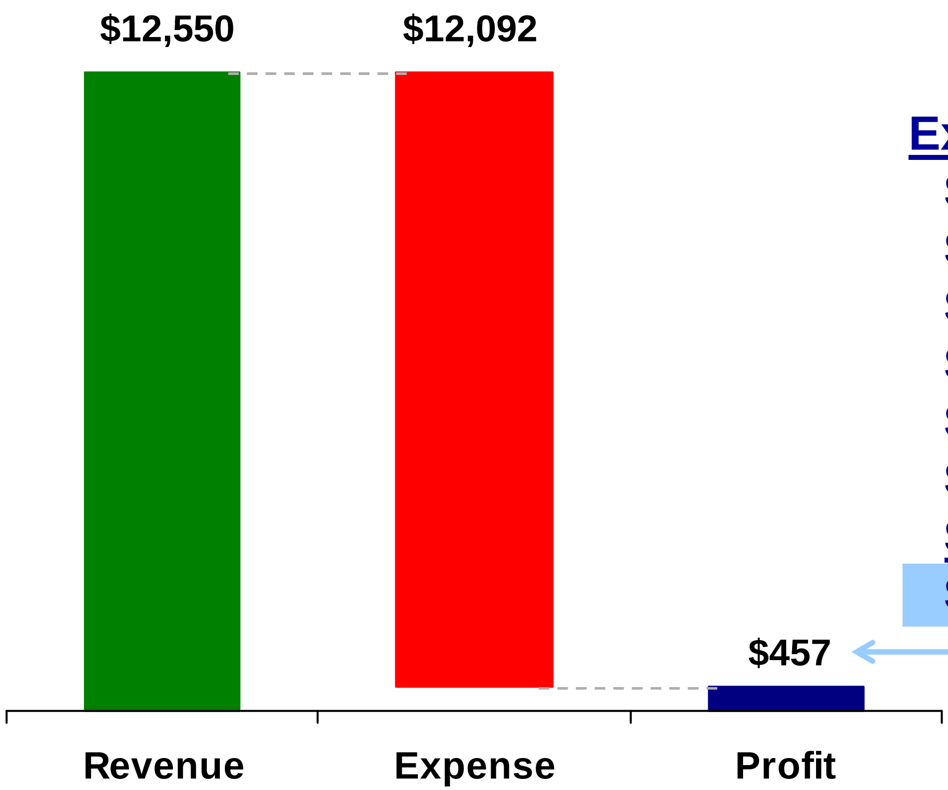
Flight	Plan	Actual	Optimal
TOW	69,084	68,687	67,427
Time	1:21	1:25	1:22
Fuel Kg	3,983	4,040	3,766
Arr Fuel	2,895	3,195	2,013



Flight Plan Buffers can mask fuel efficiency opportunities

Example: The Power of Small Fuel Reductions

Typical Narrow Body Flight(1)



Example Fuel Inefficiencies ($/flight)(2)

- $67: Extra 30 minutes APU run
- $26: Dual engine taxi-out (8 mins)
- $28: CG 2% off optimum
- $93: Fly 2000' below optimum (1.5 hrs)
- $140: Suboptimal descent
- $47: Extra 2,000 lbs arrival fuel
- $6: Dual engine taxi-in

$407 Total

Small opportunities can add up to significant savings and improved profitability

Note: (1) Southwest Airlines as example (2012 10K)
(2) 737NG used as example; $3.50/gal fuel

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Example: The Power of Small Fuel Reductions

Example 777-300 ER Flight[1]

Example Fuel Inefficiencies ($/flight)[2]

- $126: Extra 30 minutes APU run
- $ 70: Dual engine taxi-out (10 mins)
- $197: CG 2% off optimum
- $611: Fly 2000' below optimum (3.4 hrs)
- $350: Suboptimal descent
- $663: Extra 2,300 kgs. arrival fuel
- $ 97: Dual engine taxi-in

$2,114 Total

Small opportunities can add up to significant savings and improved profitability

Note: (1) Source Boeing proprietary economic models; 6.5 hr flight
(2) 777-300ER used as example; $3.20/gal fuel

How Could a New Approach Be Better?

- Typically 2 to 4 FTEs / airline focused on fuel efficiency
  - **No bandwidth for sufficient analysis / interpretation of KPIs**

Today's Practices	How a New Methodology Could Help
• Use flight plan as benchmark (proxy)	• Use OEM aircraft performance benchmark
• Evaluate flight planning rules and practices (alternates, fuel add, etc,)	• Evaluate flight planning rules, practices and optimization performance
• Manual, discrete analyses on typical opportunities (top-down approach)	• Automated, detailed analyses across more opportunities (bottoms-up approach)
• Difficult to infer and value discrete sub-optimal airplane configurations	• Identify and value sub-optimal airplane configurations (e.g., +20 sec full flaps)

- ▼ Proxy baseline (flight plan to actual)
- ▼ Labor intensive; inward / trend focus
- ▼ Top-down approach; key opportunities

- ▲ OEM baseline (aircraft performance)
- ▲ Automated; peer group benchmarking
- ▲ Bottom-up approach; all opportunities

A new approach could put greater and better emphasis on alternate selection and arrival fuel!

A Paradigm Shift in Fuel Performance Analysis

Old

The Old Understanding of the Problem

We don't know if we are fuel efficient unless we track KPIs

Pilots add extra fuel if flight plans are unreliable (have fuel burn variances)

Leading to the old solution

If we have a fuel performance analysis system, we can establish & manage KPIs as well as improve our fuel management

Eliminate fuel burn variance by minimizing planned vs. actual wt. variance

New

Analyzing the Flight Profile

- QAR data
- Company Flight Plan
- "Ideal" flight plan
- Loadsheet data
- Flight Following data

Basic Analytics

- Identify hidden planning buffers to optimize flight plan
- Identify closest reasonable alternate
- Identify potential flight inefficiencies

Advanced Analytics

- "learning system" of achievable likely flight plan parameters
- Use air (enroute / terminal area) delays to calculate necessary contingency fuel amounts, optimizing arrival fuel

The problem with the old approach: minimizing variances did not ensure flying the best, most optimal flight

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Buffers & Inefficiency Exposed: Examples

- Hidden Buffers in Flight Planning
  - **Fuel Factors (aka. Bias, Performance Factors)**
  - **Limited company-selected "Canned" Routes**
  - **Taxi fuel coded as high burn rate or too many minutes**
  - **Alternate distance, if too far, or only on-line stations**
  - **Alternate burn rate, if coded too high or at wrong altitude**
  - **Contingency Fuel (Country specific rules, 3-10%)**
  - **Holding Fuel, should reflect real expected congestion if greater than statutory 30 min.**
  - **Extra Fuel, as requested by Dispatch, Mx, Pilot**
  - **TOD-ON (OOOI) planned fuel, if planned too many kg., hides poor descent procedures**
- Potential Inefficiency in Flight Execution
  - **Climb Profile: If actual TOC differs from planned TOC**
  - **Actual Cruise Altitude vs. Planned Cruise: Flying higher is worse than flying lower**
  - **Overflying Top of Descent (TOD)**
  - **Planned versus actual TOD->ON (OOOI): Planned descent fuel**
  - **Early Gear and Flaps configuration (too distant/high) in favorable weather and traffic conditions: Ideal energy management for better landing fuel efficiency**
  - **Reverse Thrust, if runway length long, dry, and if aircraft is narrowbody**
  - **Payload weight errors affecting fuel consumption**

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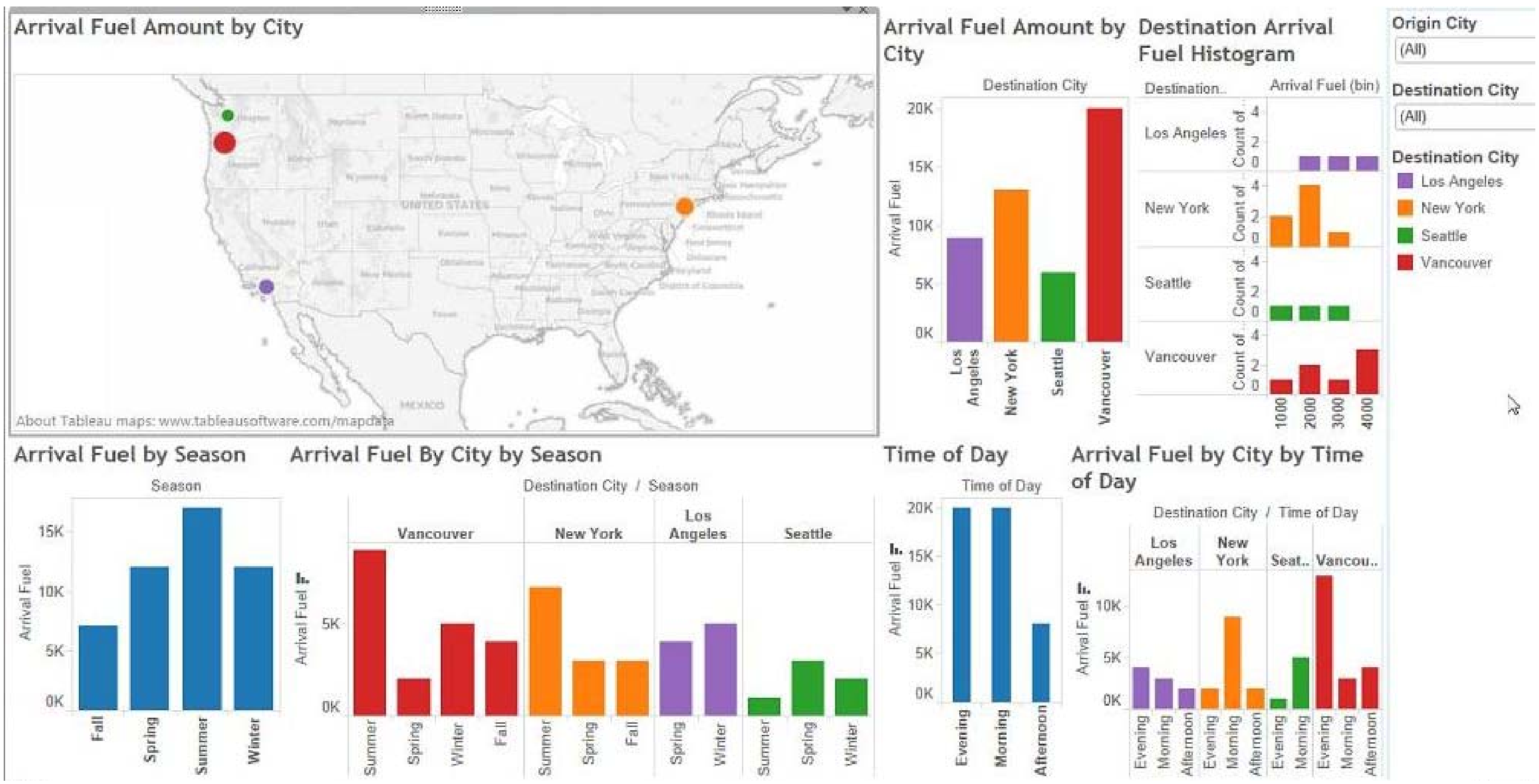
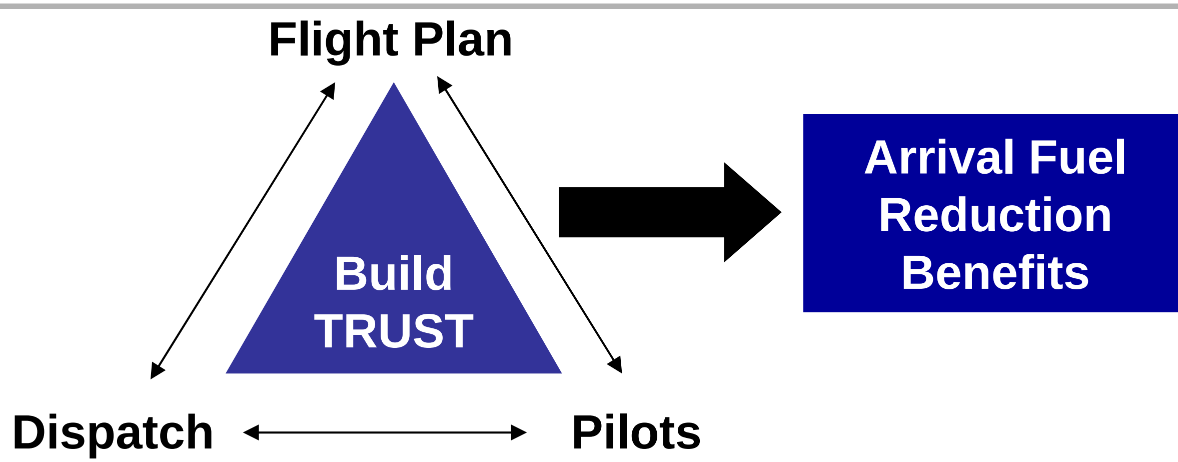
Examples: Analysis & Planning Decision Support

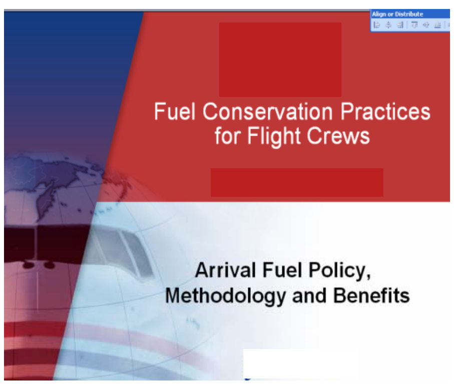
- Prototype with fabricated data …



Arrival Fuels – Provide Training & Feedback



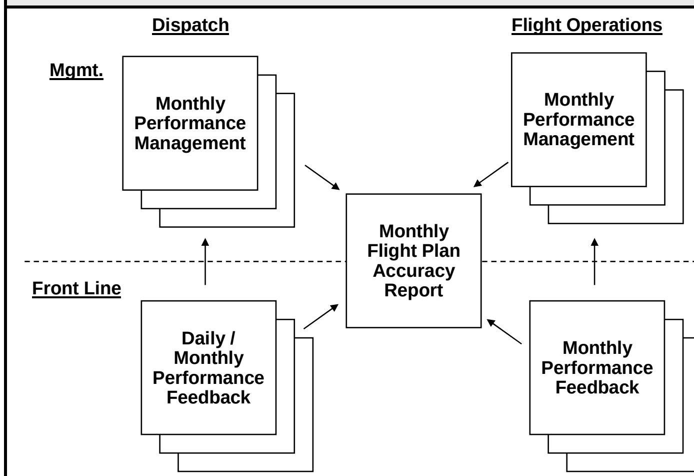
Pilot / Dispatch Training



"Why / How We Will Do It?"

+

Performance Data / Feedback



"How Are We Performing?"