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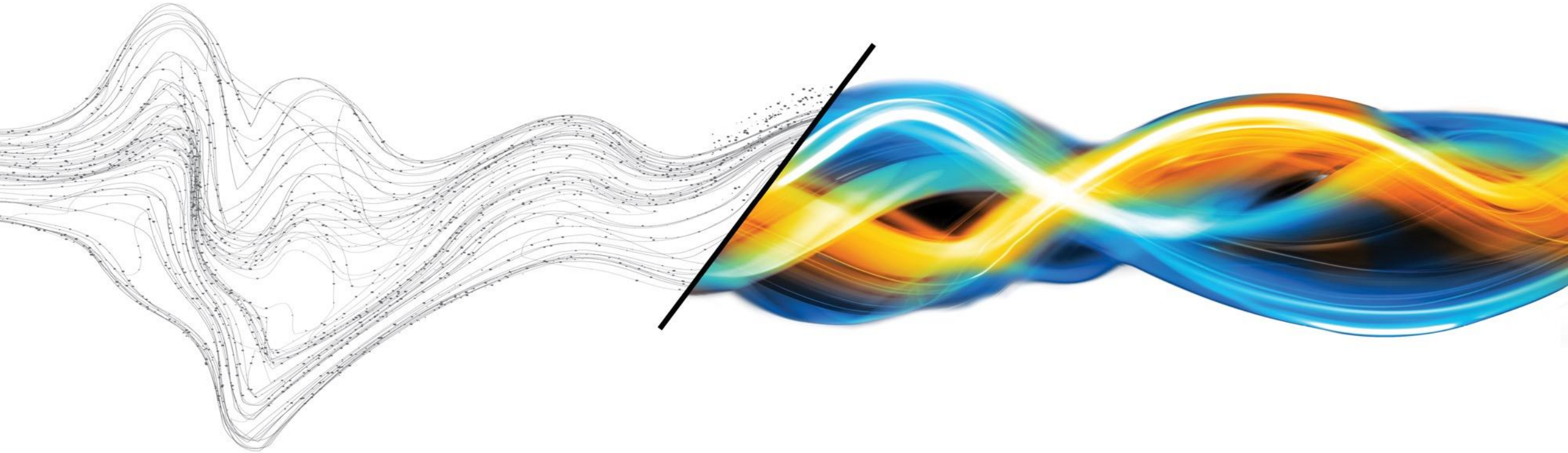


Toward a Future with No Surprises – Reducing Uncertainty in Aviation

Goran Stojkovic, Boeing Global Services

June 25, 2018

Agenda

- A Snapshot of Commercial Aviation
- Introducing Boeing AnalytX
- Analytics Enabled Airplane – *Information Networks in Flight*
- Analytics Empowered Airline – *A View Over the Horizon*
- Peopled Supported by Analytics – *Situational Awareness*
- What Next?

The airline industry is operationally and logistically complex

The entire system depends on the flow and application of massive amounts of information

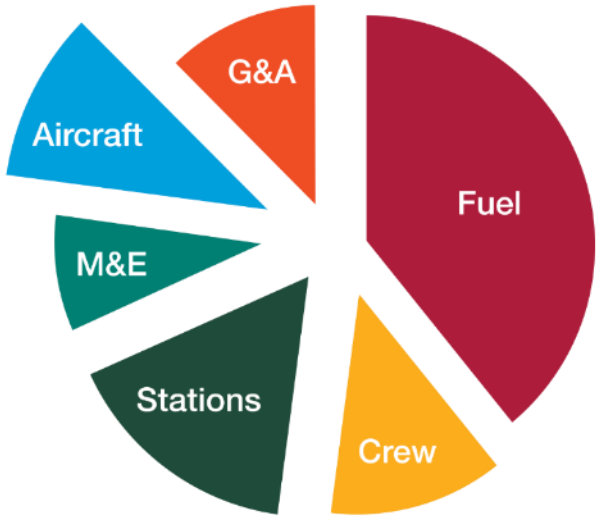
If a country, aviation would rank 21st in GDP - close to Switzerland

- **Traffic -** 3.81 billion passengers in 2016
- **Flights -** Averaged 100,821 flights per day in 2017
- **Jobs -** 62.7 million jobs supported and 9.9 million direct
- **Cargo -** 51 million metric tons flown in 2014

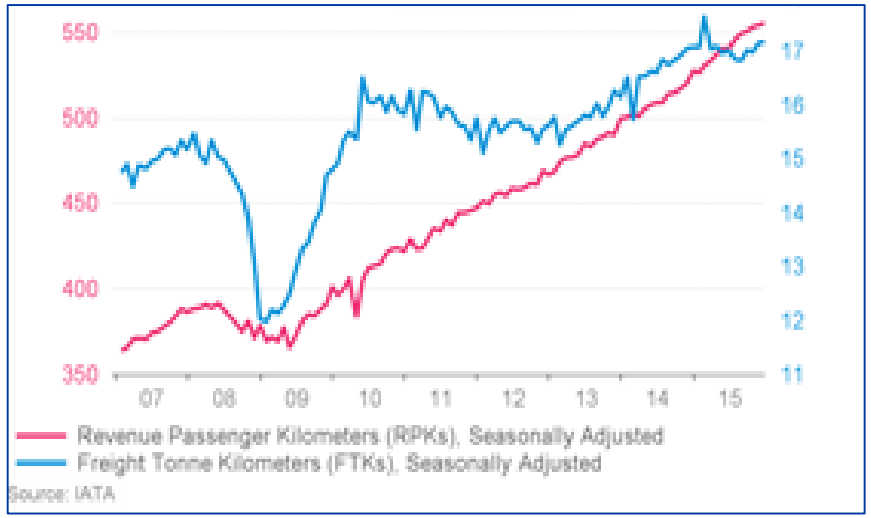
Aviation Industry – Breakdown

From 6.9 to 1,000 TB/YR of data from the worldwide fleet results in new opportunities

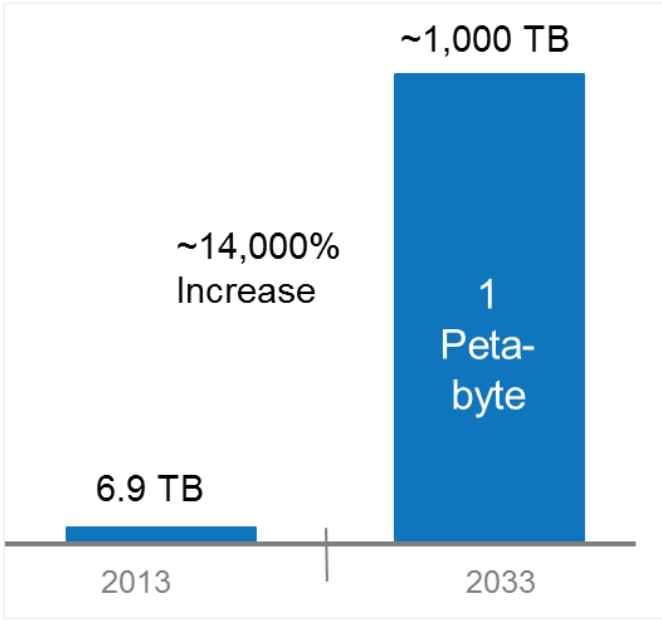
Airline Expenses ($700B in 2016)



Air Freight and Passenger Volumes



Airplane Data Generation (TB/year)



Boeing AnalytX – Opening a world of limitless possibilities

Boeing AnalytX represents the collective efforts of over eight hundred analytics professionals and thousands of subject matter experts working together to develop and deliver a new generation of analytics empowered aerospace products and services.

Boeing AnalytX - Our Missions

Working to open a future of limitless possibilities

Analytics Enabled Aircraft, Systems, and Platforms

Increasing data generation and onboard analytics capabilities.

Analytics Empowered Owners, Operators, and Agencies

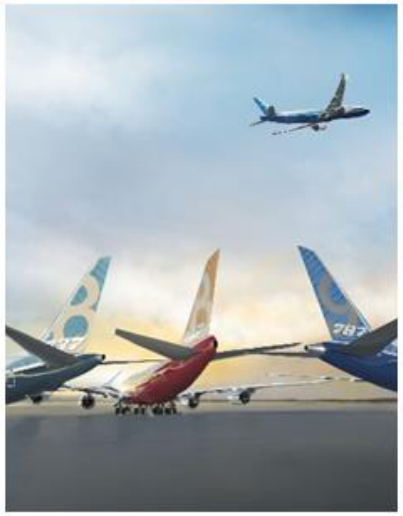
Help people deliver higher efficiencies and performance for their group and organization.

Boeing Powered by Analytics

Continuous improvement of Boeing products, customer support, and operations.

Analytics is a key part of our entire operation

We use analytics to improve our own operations and provide analytics solutions to our customers

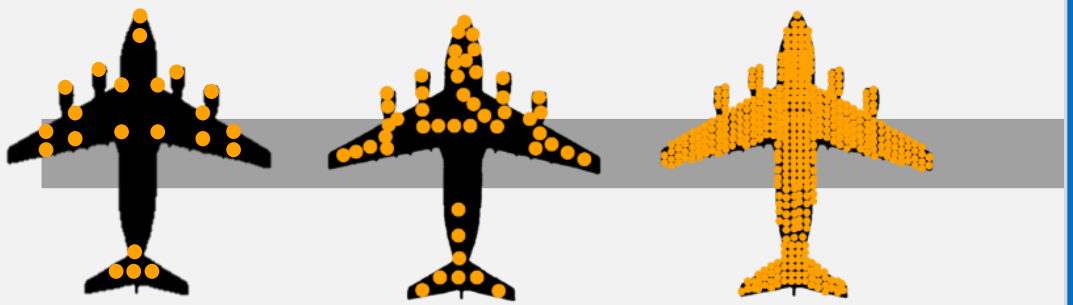
Airplane Design	Production	Operate	Maintain	Supply Chain	Customer Support
					

The Analytics Enabled Airplane

The Analytics Enabled Airplane – Networks in Flight

Modern airplanes are information networks existing within the airline's network

Data density is growing rapidly



Sensors

Today *Future*

Machine Generated Data

ACMS
Maintenance Messages
Flight Deck Effects
Alerts
QAR/CPL

Plus

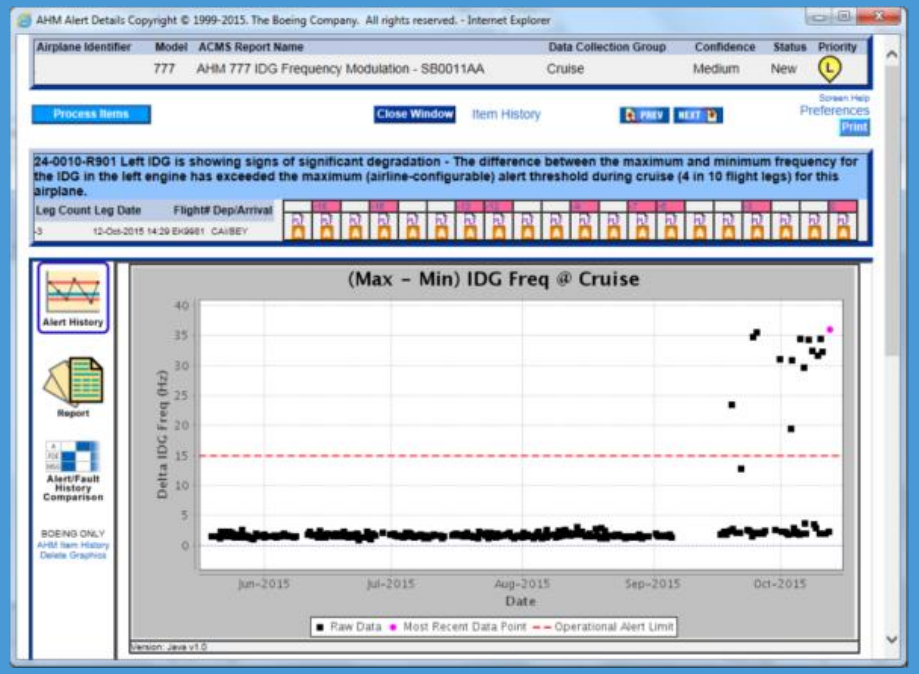
Human Recorded Data

Logbook
Component Removals
Schedule Interruptions
Maintenance Tasks
Non Routine cards

Analytics is more than graphs, neural nets, and statistics

These are the tools we use to improve the quality of operations in the physical world

777 Integrated Drive Generator – Analytics spots an issue before it leads to a costly repair



Predictive alerts created using analytics identified this issue before it created an in-service delay or cancellation and saved up to $300,000 in repair costs.

Analytics Enabled Airplane

End-to-End data analysis creates new opportunities

Automate Relevant Linkage:

- Integrated Data
- Correlated Features

Characterize Behavior:

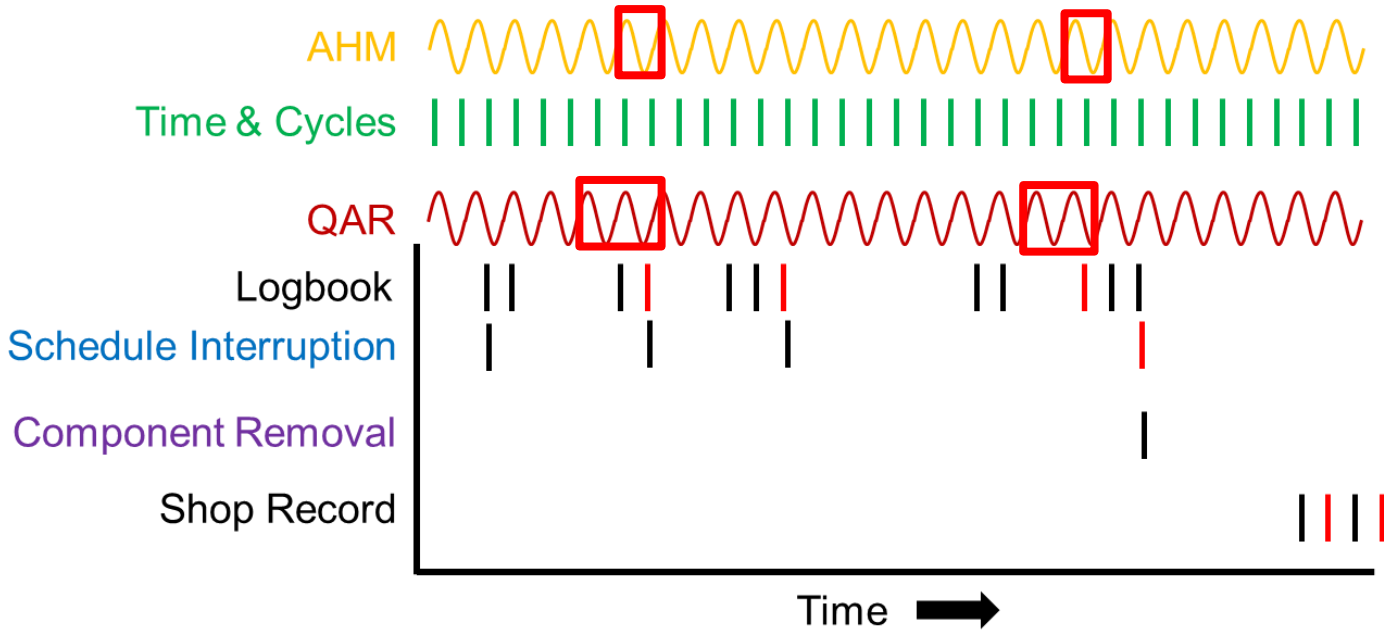
- Pattern Analysis
- Engineering Knowledge

Generate Alerts:

- Monitor Data Streams
- Automate Diagnostics

Create Prognostics:

- Machine Learning, Statistics, Engineering Models
- Proactive Alerting



Decision Support:

- Supporting Evidence
- Risk Assessment

The Analytics Empowered Airline

An airline is a complex business network

Goal to achieve end-to-end operational visibility and optimization

Reduce fuel consumption

Optimize crew utilization

Increase asset availability

Leverage real-time information

Minimize disruption impact

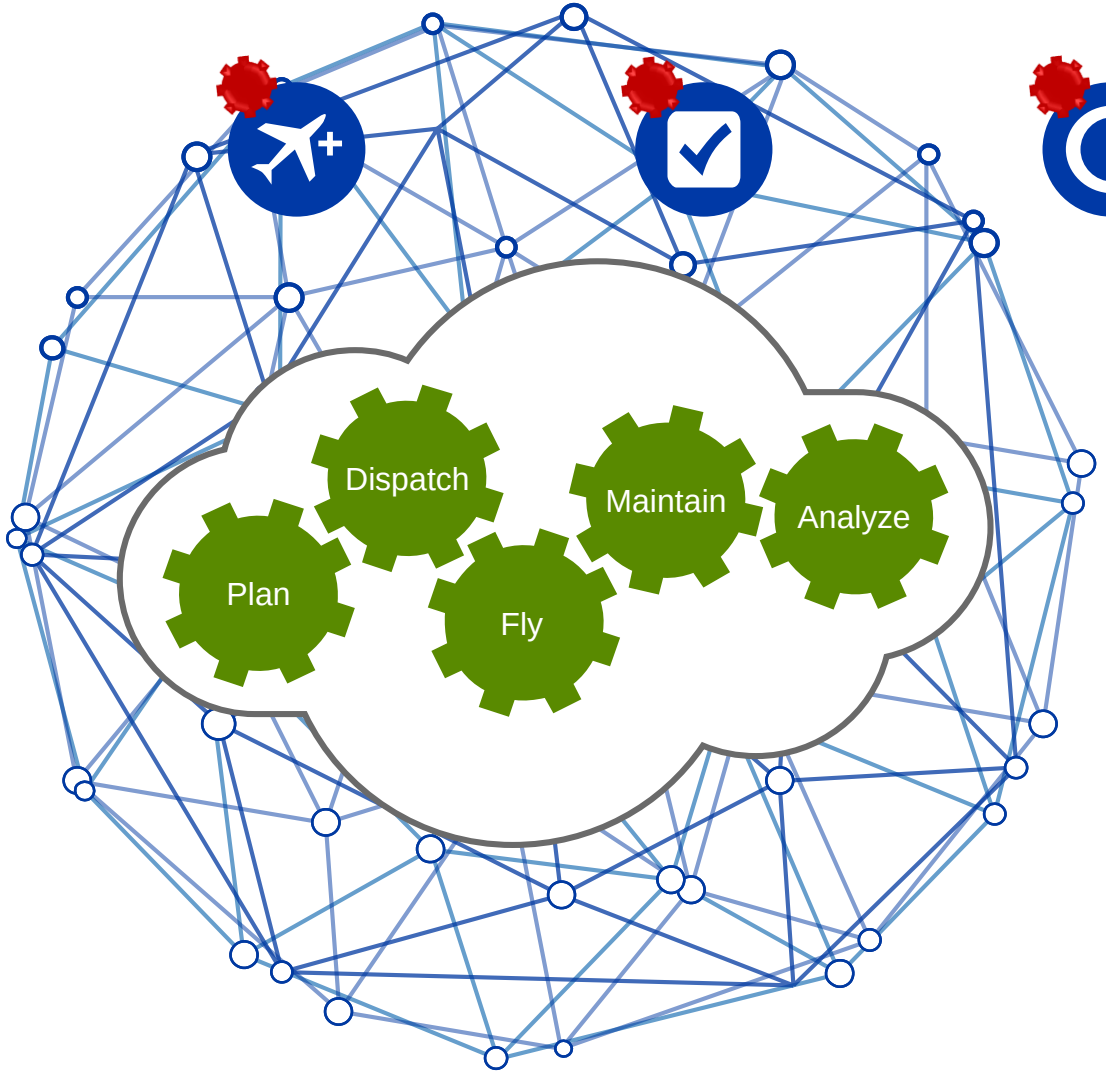
Improve operator efficiency

Everything is in motion

Airlines operate 24/7. They are getting ready for, or carrying out, the day-of-operations

Reduce f
consumption

Optimize
crew utilization



Improve operator efficiency

Increase asset availability

Minimize disruption impact

Leverage real-time information

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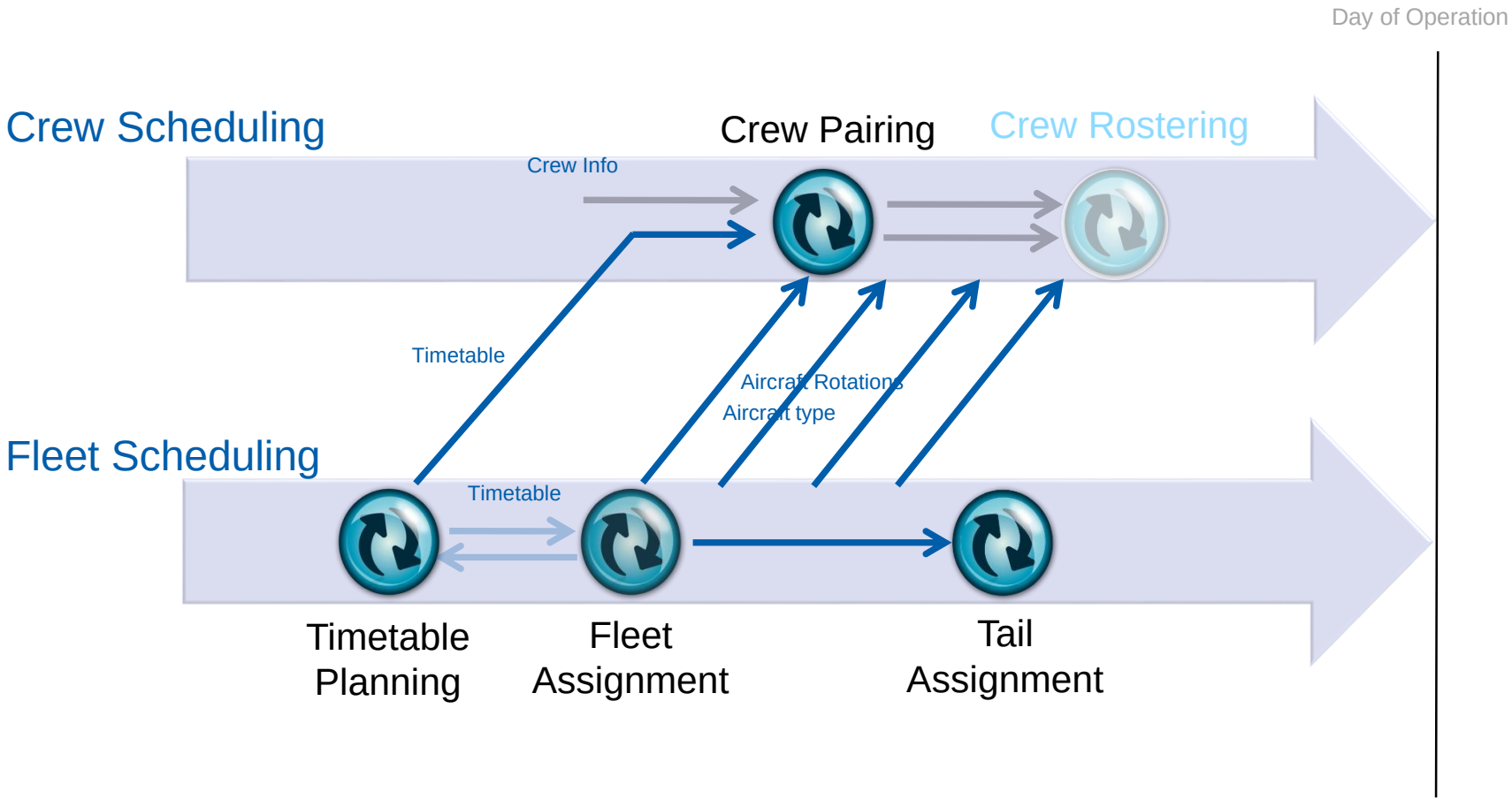
Traditional operations planning (Crew & Fleet)

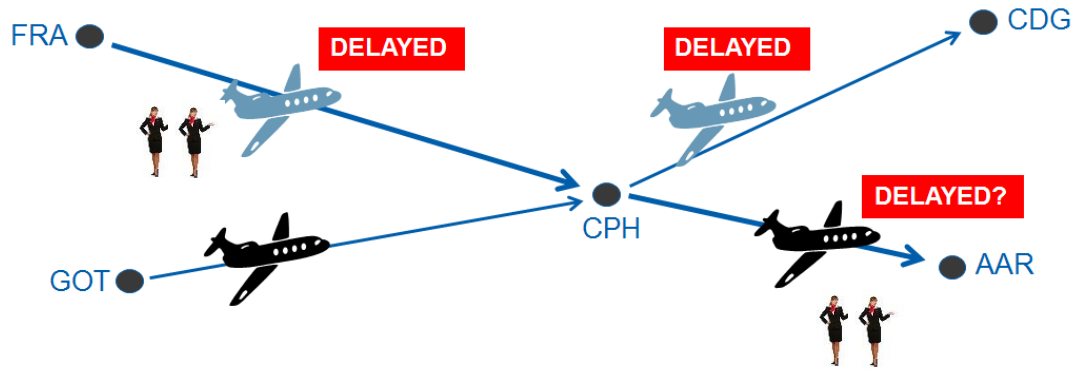
Siloed, sequential scheduling



Operational risk and missed opportunities

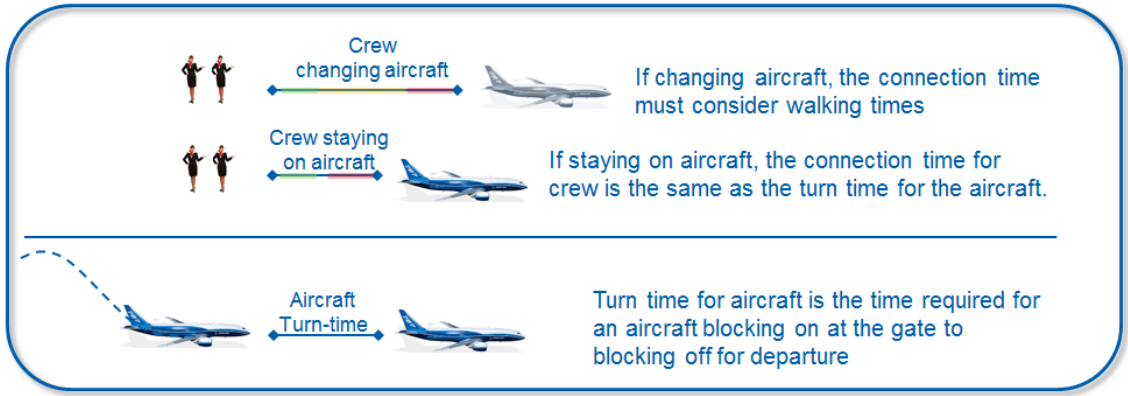
Schedule Robustness

Reduce risk of delay propagation and risk of crew being delayed in terminal



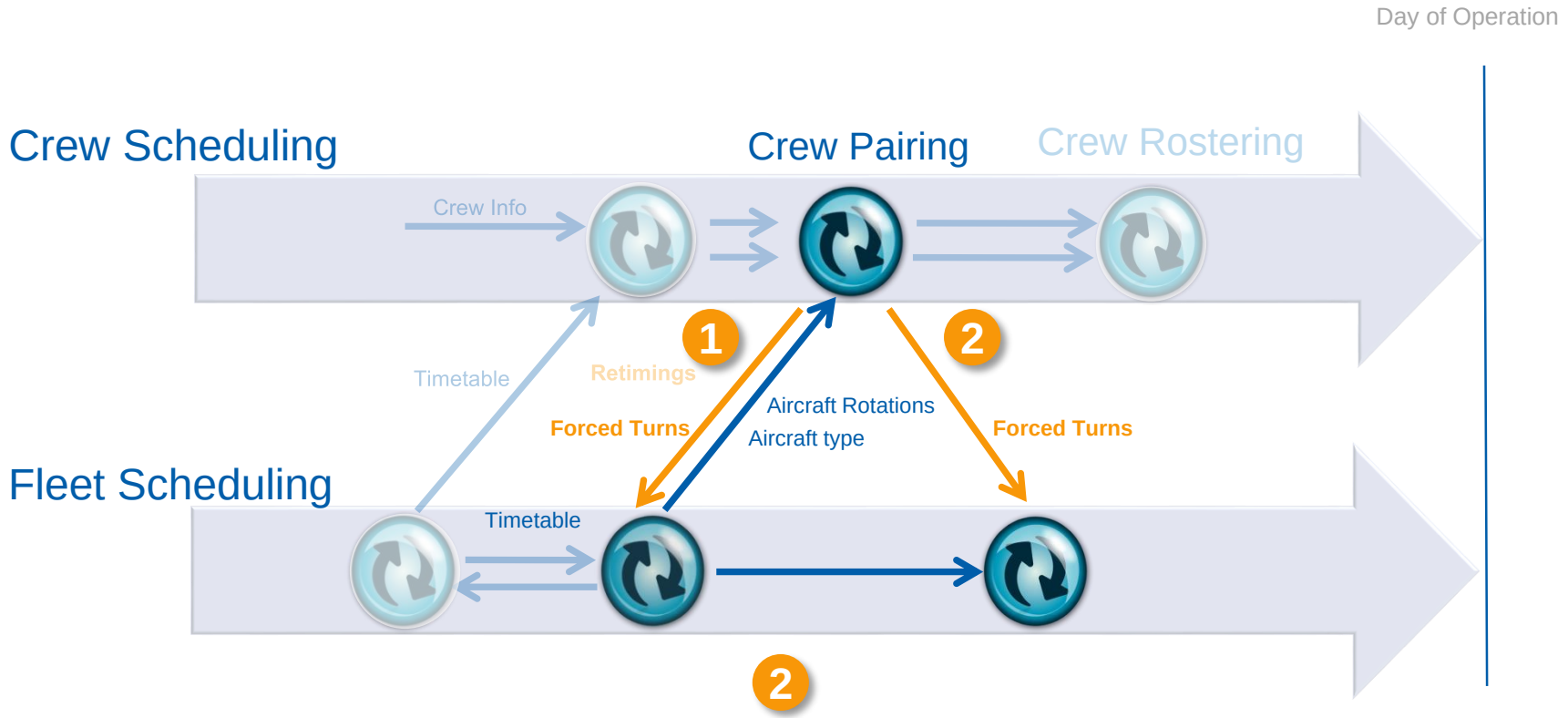
Schedule Efficiency

Create more efficient duties with shorter connections by staying on aircraft



Integrated operations planning (Crew & Fleet)

Reducing operational risks



Feedback to Fleet Assignment

Suggest changes to existing rotations that improves crew solution
Prior to production planning rotations are iterated

Input to Aircraft Scheduling Department

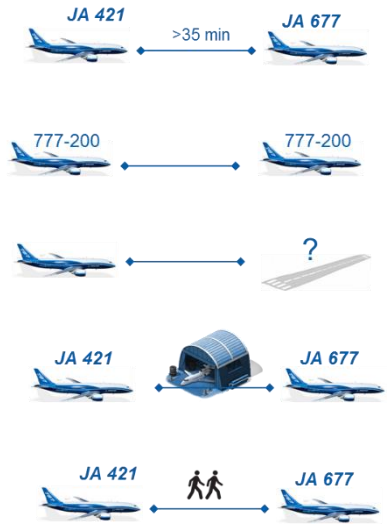
Identify forced turns without considering existing rotations.
Communicate findings to scheduling department and iterate

Analytics approach

Expanding the traditional crew pairing problem

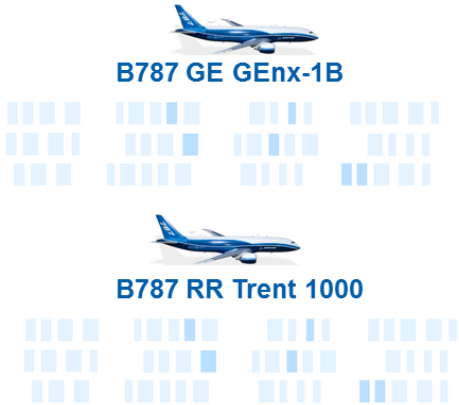
Additional constraints

- Aircraft Turn-time
- Aircraft Type
- Plane count constraints
- Aircraft Maintenance slots
- Commercial turns



Other functionality

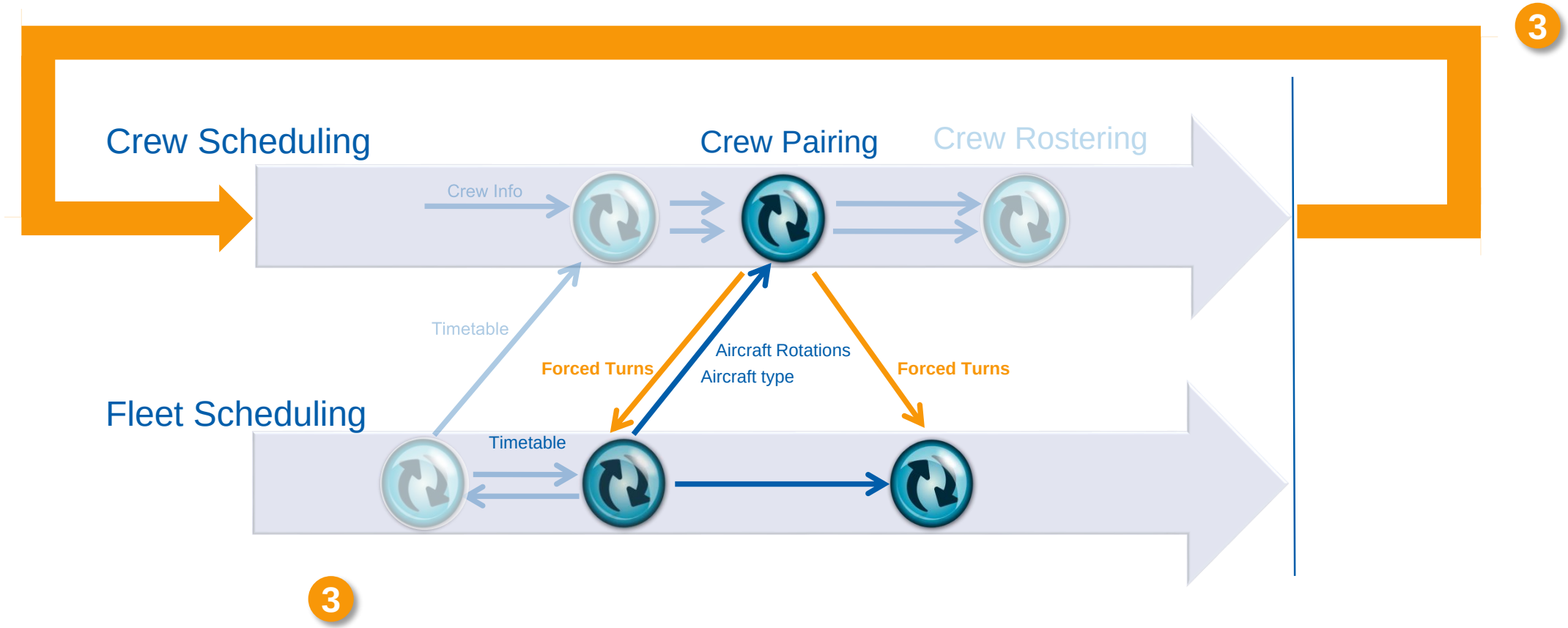
- Configurable aircraft groups. *Specify groups of aircraft types within which alternate turns can be created, e.g., engine types*



- Hub configuration. *Limit alternate turns to specific hubs.*

Integrated operations planning (Crew & Fleet)

Reducing operational risks



Feedback Loop from Post Operations to Planning

Implement “look back” methods and tools to improve schedule planning and robustness (e.g., block times, connection times)

Value of integrated operations planning

Airline Testimonial — Crew & Fleet Integration (from Crew)

	Jeppesen (NO Tail Integration)	*Jeppesen (WITH Tail Integration)*	*Var*
Duty Days (per Rank)	2594	2535	-2.27%
Avg. BT per Duty	5:03	5:10	2.31%
Aircraft Changes (per Rank)	158	153	-3.16%
Hotel Nights (per Rank)	1359	1354	-0.37%
DH Time (per Rank)	148:00	123:25	-16.61%
Crew Cost (USD)			-1.57%

More Productivity!

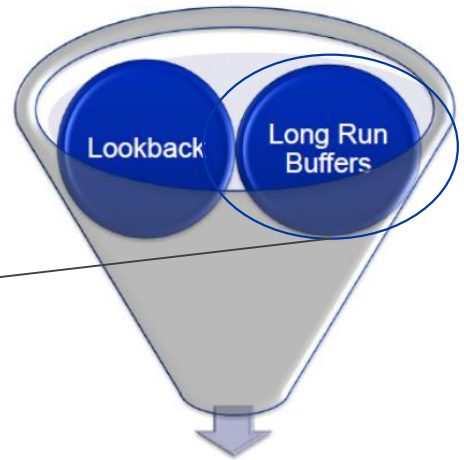
Better Quality!!

Cost Savings!!!

Airline Testimonial
Dynamic Aircraft Rotations

- Reduction of Duty Days by 0.5 %
- Reduction of Allowances by 2.5 %
- Reduction of Hotel Nights by 5.5 %
- Reduction of Crew Aircraft changes by 22 %
- Reduction of premium (synthetic) by 1.2%

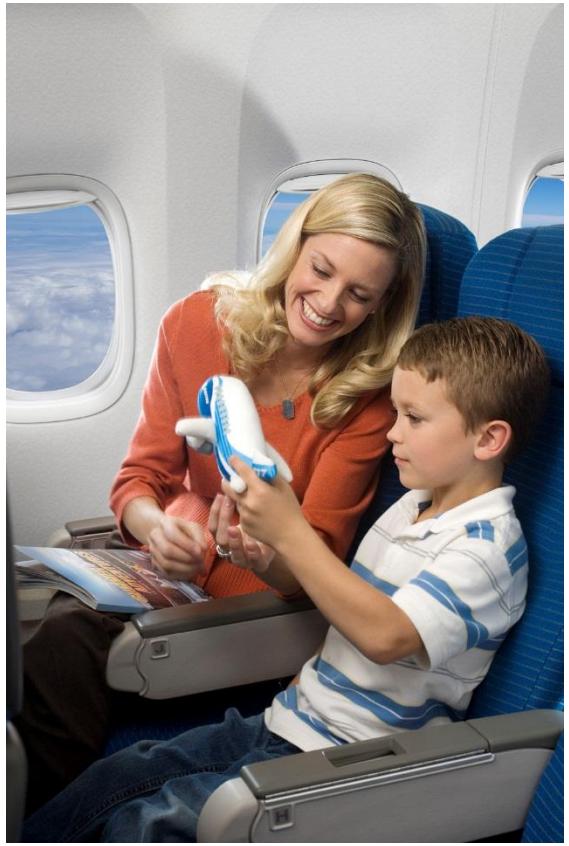
Airline Testimonial

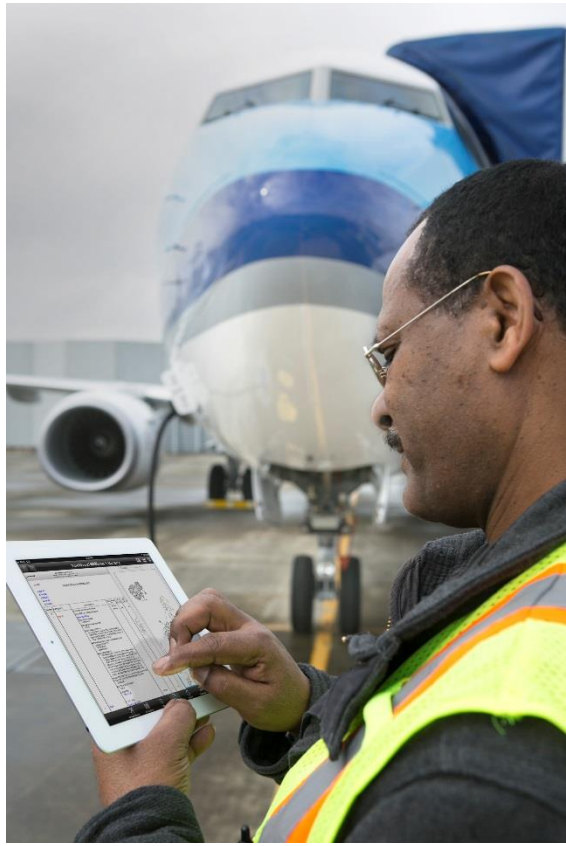


$9M Annual Cost Savings

Reduced schedule uncertainty

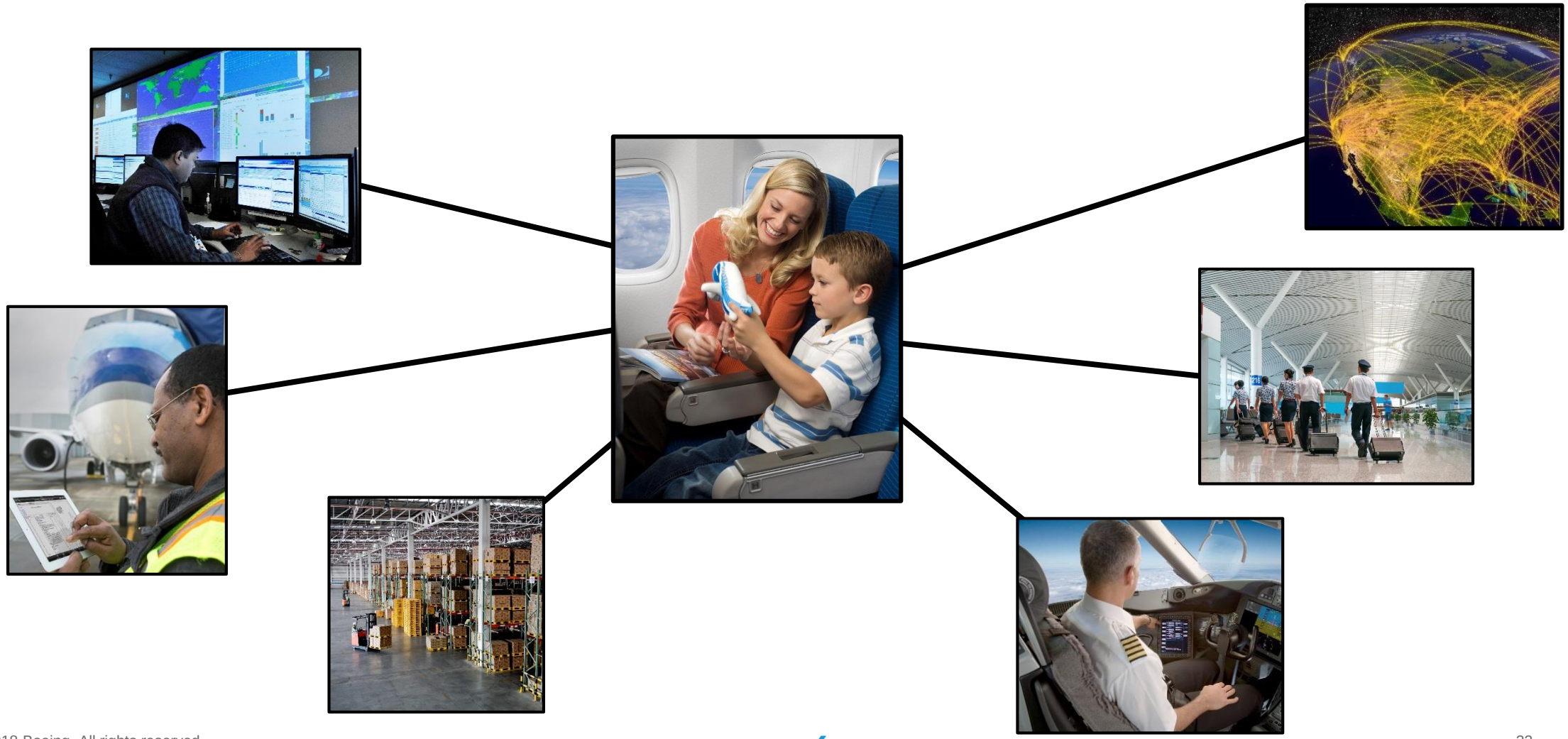
People empowered by analytics





Enjoy the flight

Information Technology and Analytics are helping orchestra the entire operation for you



It takes more than analytics to create value – it takes a team

Data Analytics Expertise

Aviation Knowledge

Teaming & Collaboration

Business Solutions