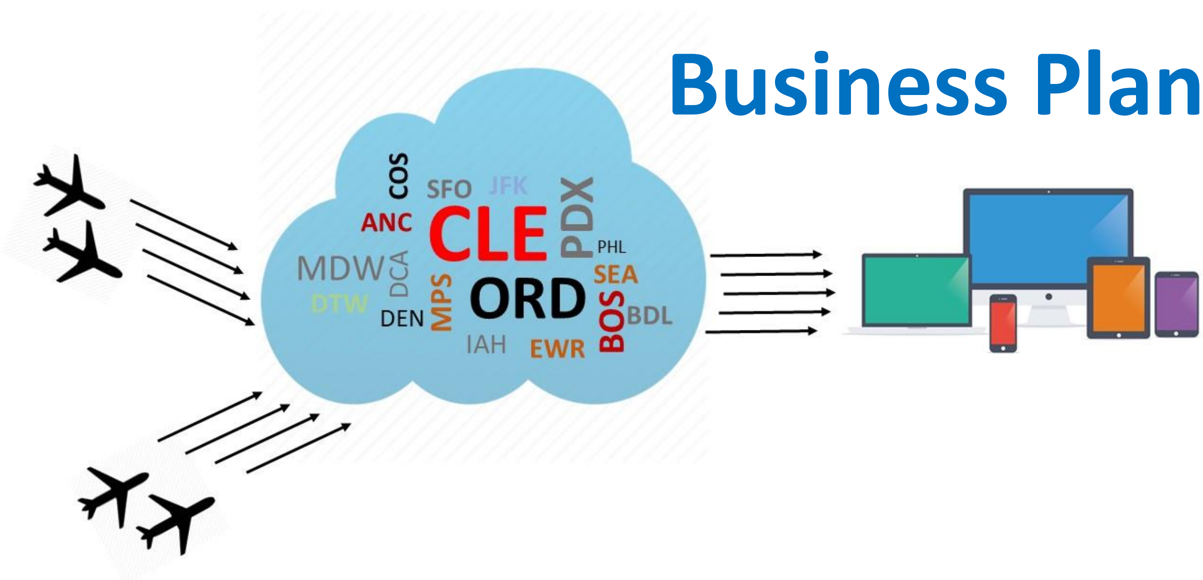
KONGSBERG AERONAUTICAL

"We are in the business of making airlines operate more efficiently and safer"

Business Plan



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Executive Summary

Airlines rely upon information about "Braking Action", a term describing an aircraft's ability to stop before the end of slippery runways. Accurate information about Braking Action has been an aviation recurring problem for decades. The accident report of a Southwest Airlines aircraft overrun accident in 2005 has served as a catalyst in a renewed effort to solve this problem. Kongsberg Aeronautical has developed, in collaboration with United Airlines, a cutting-edge technology that uses the aircraft itself to more accurately assess Braking Action and in ***real-time***, a system in compliance with NTSB's recommendation in its subsequent Southwest Airlines accident report.

Information from the Kongsberg Aeronautical system will come as a subscription service to airlines, whereas information is distributed and integrated through typical flight planning and/or situational awareness software programs used by airlines and supplied by third-party program providers. Information is generated by a proprietary and patented program function installed on, and reads flight data on-board aircraft. Results are transmitted directly from aircraft to a ground station and relayed to Kongsberg Aeronautical cloud computing solution for added information before it is transmitted and integrated airline user programs. This is an automatic end-to-end system that takes less than a second from information leaves the aircraft to the value-added information is found/displayed at user level.

Kongsberg Aeronautical's system is based upon developing a network of participating airlines that will have their fleet of aircraft feed information upon landing into to an information pool managed by Kongsberg Aeronautical's cloud computing solution. In addition to accuracy, the system provides high information frequency in real-time. This enables airlines to improve contingency planning, resulting in improved operation efficiency and safety assurance.

We are currently collaborating with United Airlines, which has our system, Dynatron, installed on their fleet of Boeing B737, about 300 aircraft, and in contact with additional airlines in the US.

In terms of market, airlines take use of a multitude of third-party services to streamline, utilize, and optimize flight operations to stay competitive. Information and tools for decision-support are widely used for flight planning, navigation, network operations, herein customized weather. The market is global and not confined to winter operations. For example wet and rain conditions share similar operational challenges. North America and Europe have traditionally been the largest markets. However in wake of the strong growth in Asia, this geographical region is equally interesting and important.

Our system is highly scalable. Our cloud computing solution is hosted by Amazon Web Services and capacity is not restricted. All access and data input are web and API configured and additional aircraft, regardless of geographical region, can be routed to our cloud solution. Installation of the on-board program function is handled by the various airline IT and

engineering department, whereas it is easily installed by use of a PC card in one of the aircraft management system slots.

Braking action is currently assessed in form of pilot report or a qualitative description of the runway surface. These methods do not provide the desired accuracy. Our system uses the aircraft itself and provides accuracy and objectivity that is referenced to aircraft manufacturer guidance material. Although our on-board program function is covered by patent, it is difficult to straight forward infringe. In the development we have acquired substantial (proprietary) application know-how outside the patent in order to make the system operate as intended, a know-how not easily obtained. The combination of patents, application know-how, and a cloud solution based proprietary quality assurance system, grant us a competitive advantage.

We plan to serve a market currently comprising about 20 000 aircraft of which two-thirds are single-aisle. According to Boeing Current Market Outlook, by 2036 this will double and single-aisle represent about 75 %.   Given pricing, there is a market potential in excess of NOK 500 million annually, in which the company targets at least 30 to 40 % market penetration.

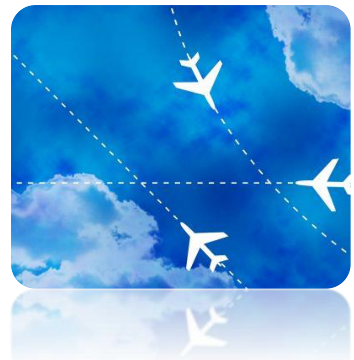
The company's automatic end-to-end system yields a gross margin of 80-90%, and its operational requirements are lean.

Company management consist of Trond Are Johnsen, MBA, as General Manager. He has managed the project development and collaboration with United and FAA, as well developed all proprietary functions associated with the system. He possesses a substantial network within the US airline industry. Along with him in capacity of an advisory board is Dag Arild Hansen, MSc. and Svein Solberg. Hansen has extensive background and management of technology, Solberg is retired commercial pilot, former Director of Flight Operations, as well as inspector with the Norwegian Civil Administration (Luftfartstilsynet). The company intends to strengthen the engineering/technology side with a person to be responsibility for technology and systems, herein integration with airline user applications.

Kongsberg Aeronautical is looking for funding of NOK 11-13 million structured in two tranches, whereas the first tranche comprises NOK 5-6 million intended to complete cloud computing programming requirements and operations

Description of the Business

On a daily basis airlines rely upon a multitude of third-party systems and services to streamline, utilize, and optimize flight operations to stay competitive. These services cover everything from ground handling support, IT functions, to system software and programs for flight planning, navigation, network operations, various information services, herein weather information.



Mainly the use of IT and associated systems and services has seen a considerable increase in conjunction with that aircraft have become increasingly computerized over the past two decades. Aircraft computerization has also enabled a "new wave" of possibilities in using what is termed FOQA[1] data to not only assure/improve safety, but also enhance/improve efficiency.

Kongsberg Aeronautical has taken use of the possibility embedded in these technological advances within the aviation industry to develop a new and improved method to assess runway braking capability when exposed to snow, rain etc. This,- termed Braking Action, a critical flight operational information used as a part of planning flights, as well as destination monitoring while aircraft are en route. This serves part of a market segment of decision support system utilized by airlines to optimize their flight operations, and assure regulatory compliance.

Such information is to a large extent distributed and integrated through various types of flight operational planning, or situational awareness applications. Flight Explorer, a system provided by Sabre Airline Solutions is such a tool.

The customers are airlines, this in a market that sees world air travel continue to grow[2]. However in an [airline] industry that has seen and still undergoes structural changes. In North America and Europe there have been a substantial consolidation among legacy or network carriers, albeit somewhat ahead in North America. This means that fewer airlines represents a larger portion of the market. Furthermore, new entrants appear as well, first and foremost in the Low Cost Carrier (LCC) segment, where Asia has seen quite a few of these.

Our market is what is termed "single aisle[3]" aircraft. Currently they represent about two thirds of current world fleet. By 2036 the share is expected to be about 75% of a world fleet that by then has nearly doubled in size and Asia representing about half of all deliveries.

With various business models both, Legacy carriers and LCCs attempt to capture travelers in this growing market, and competition is strong. This demands a strong focus on efficiency and operating cost. Improved aircraft design, herein engine technology is driving forces, however operational efficiency is also embedded in smart decisions. Having the right information, at the

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[1] Flight Operation Quality Assurance , also known as flight data monitoring (FDM), of flight data analysis

[2] Boeing Current Market Outlook 2017 – 2036. Boeing and Airbus are fairly coherent in their maret outlooks

[3] Category of B737 and A320 family aircraft

right time, and at the right place is crucial for making the right decisions. Braking Action forms part of this decision support information picture.

Based on the collaboration with United Airlines our goal is first to create a foothold in North America with an end-to-end system by use of our industry network and contacts. Subsequently we further roll-out and target Europe and Asia.

The Company

Formed in 2012, the company wanted to further develop its technology, know-how, and proprietary rights to market and sell Braking Action information to airlines that was more accurate and timely, a long-time recognized industry problem. The company is based upon retired commercial airline pilot Capt. Oddvard Johnsen's long-time effort in improving aviation safety and the idea of using the aircraft itself to properly assess the weather impact on runway conditions, and subsequent stopping capabilities. As expressed by one of the Directors at United Airlines; "Real time Braking Action is the Holy Grail of flight operations".

Partnering up with Continental Airlines and later the merged United Airlines, and based upon the company's proprietary rights, herein a patent, we developed an on-board program function that captures the essence of the runway conditions and transmits this to a ground station. After the development, involving extensive testing and program adjustments, the program function was uploaded to whole of United's fleet of B737, currently about 300 aircraft.

The accident report[4] of Southwest Airlines flight 1248, a B737 that overran the runway upon landing in December 2005 at Chicago Midway, served as a catalyst as it addresses the inaccuracy of Braking Action information as a contributing factor to the accident. In the report NTSB also recommended looking possible ways to use the aircraft itself to provide more accurate Braking Action information. Our collaboration with United Airlines was in line with the accident report recommendation, and therefore of interest of Federal Aviation Administration which was looking for new technology and systems to address this recurring problem. We entered into a Cooperation Research & Development Agreement (CRDA) with FAA's William J. Hughes Technical Center in 2012 to validate the system, whereas FAA would make resources available to help out with this.

So far, information derived from our on-board system has been sent to and stored at a flight data warehouse. A Proof of Concept Agreement (POC) with United now involves programming an "intercept" function at ground station level and parse and send the relevant information to a data cloud solution Kongsberg Aeronautical has developed. This will process, refine, and turn data into valuable information that in real-time can be relayed to airlines' flight operational tools.

[4] National Safety Transportation Board (NTSB)

The Product

Based on its new and cutting-edge technology, using the aircraft as an information node in a network, the first of Kongsberg Aeronautucal's offerings will be information to airlines' flight operational units about runway slipperiness (braking capability) caused by weather exposure such as snow, ice, rain etc., also termed Braking Action. For these units, such as national operational centers and dispatch, this information is crucial when it comes to planning flights and en-tour monitoring flights with respect to assessing landing stopping distances. This is also valid in configuring aircraft, herein weight (payload) and weight restrictions in event of aborted take-off.

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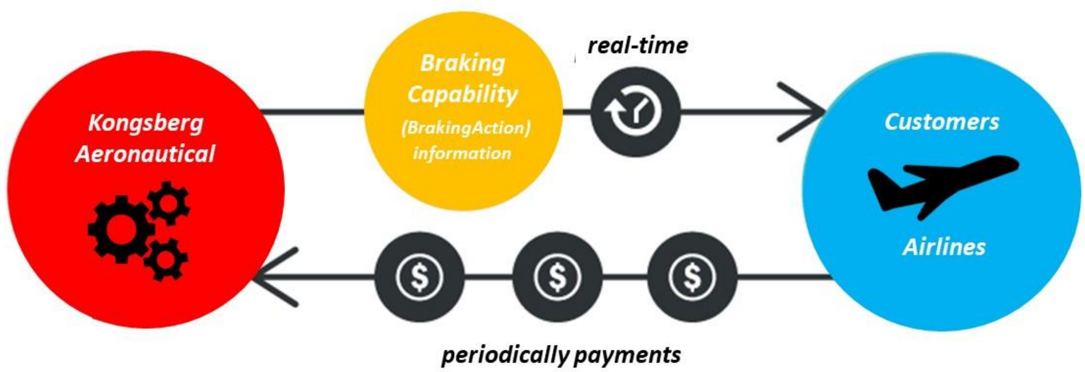

Airlines will receive/access the information through any of their web based on-line flight planning or situational awareness tools (programs) used by their operational centers and dispatch departments, or handheld devices. These tools or applications, are typical integrators for flight operational information. Kongsberg Aeronautical strategically wants channel its information through such programs as airlines want to the extent possible having their operational people work in as few systems as possible, a way of "one-stop-shopping" in terms of graphical user interface.

Kongsberg Aeronautical will work and collaborate with providers of these operational programs used by airlines. Flight Explorer, a program by Sabre Airline Solutions, is one of such web based online programs. WSI Fusion, part of The Weather Company[5], is another program used by major airlines. These web-based online will be integrated with Kongsberg Aeronautical'

[5] Acquired and now a part of IBM in 2016

s cloud computing solution that will contain real-time information, as well as historic information, from its network of information feeding aircraft.

The cloud computing solution is set up on Amazon Web Services (AWS) server, and link to all network aircraft which will feed information via an API[6] to data cloud. In the data cloud each and every flight will be corresponded with a flight tracker data-feed from FlightAware Inc, and assigned relevant runway used. Data from the aircraft will then undergo a three-tier quality assurance test (proprietary) before an information file is generated and transmitted to an airlines' pertinent application/tool at the operational unit. The information file is coded in accordance with criticality, thus it will determine whether it will be a "push" message (critical) or "access" for update.

A key feature in the cloud solution is the collective information from the fleet of many airlines. This means all customers can draw on the common pool of information. An example would be Seattle, where Alaska Airlines is a big operator, while e.g. United and Southwest somewhat smaller. The aggregate of these are though more than each of them. The opposite is valid in Denver, where United is a large operator. By using the collective information all customers get a higher frequency of information to draw from

The on-board system, based on Kongsberg Aeronautical intellectual and proprietary rights, was developed in collaboration with Continental Airlines and the later merged United Airlines. Features of the algorithm is covered by patent; however, the full algorithm contains substantial application know-how. The algorithm is programmed in Teledyne Control's AGS tool, and installed on the aircraft ACMS[7]. A key quality of the program function is that it "reads" flight data [in real-time], and the data transmitted from the aircraft contains only calculated results, results that have no bearing upon the actions of the pilots. Flight data is extremely sensitive and pilot unions are very reluctant to have third parties having access to these.

Our value proposition is based on the ability to provide critical information that is more accurate, frequent, and timely and have following operational impact:

- Fuel savings
- Better planning
- Safety

All of these impacts are rooted in managing weather, more precisely change or deteriorating weather conditions. A substantial part of all air traffic delays is caused by weather.

Fuel savings are achieved by the ability to make and implement contingency plans earlier during flight, herein potential needs to use alternate airports. Furthermore, taking a delay by keeping aircraft on ground is more economically than leaving aircraft in holding patterns or change flight plans during flight. Fuel represents more than 30 percent of aircraft operational

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[6] Application Process Interface

[7] Aircraft Management System.

cost. A calculation based on fuel prices of USD 1,45 per US gallon shows potential savings of USD 3 to 4 million annually for an operator the size of United Airlines. At time of writing this, fuel is about USD 1.95 per US gallon.

Network airline operators very much based on “hub and spoke” strategy, relies on flight connections and passenger transfer. Any type of disruption and knock on impacts thereof requires re-planning. Although our system will not reduce potential disruptions, early knowledge about such provides increased lead time to plan and find better and more efficient alternatives.

Take-off and landing are the most critical phases of flight, and being able to stop before the end of the runway is imperative. There are a number factors contributing to assuring safe take-off and landings. Hhowever knowing braking capability, or Braking Action, is a crucial one. For flight planning (dispatch) Braking Action is used to configure the aircraft, herein weight (payload), take-off speeds end engine settings. En route and a within a certain time before landing, pilots and flight operations (dispatch) are required to ensure they are able to land safely at destination airport. One of the most important precautionary assessment they do is ensure landing distance is within runway length. For this Braking Action is used and applied in stopping distance guidance material from the aircraft manufacturer. Having Braking Action information that is more accurate, frequent, and timely ensures safer operations.

As seen having Braking Action information that is more accurate, frequent, and timely, has a multilevel impact on an airlines flight operation, ranging from the direct impact on fuel, contingency planning, to ensuring safety of operations.

New Products

The collection of aircraft information feed from participation airlines, combined with the additional information we add-on, will all be stored in a data base. This data base will eventually be quite potent in developing products based upon data-mining, trend or other statistical analysis. We foresee the ability to create other alert and hazard detection system targeting e.g. airport operators.

Competitive Analysis

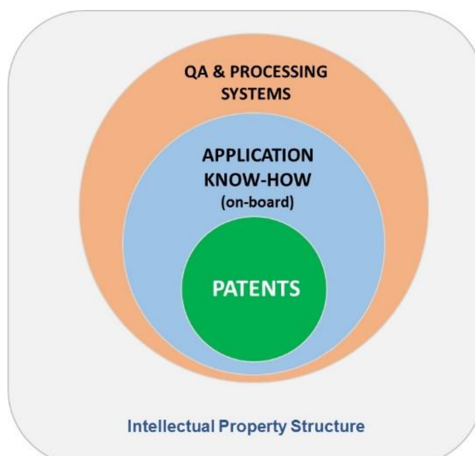
To understand the competitive advantage, it is important to have some knowledge of how Braking Action is currently assessed, and thereby understand why proper assessment an industry problem for decades has been, and still is. Currently there are two primary ways for assessing; pilot reports and qualitative descriptions of surface conditions. Pilot reports are highly subjective assessments of how pilots feel the conditions while braking, which they usually report by radio to airport tower control. Qualitative descriptions involve describing whether it is wet, rain, snow etc., and to what extent the runway is exposed (covered) of such. It is also important to know that what is known as "friction measurement equipment", usually systems towed after vehicles up and down the runway is no longer allowed to report runway conditions due to its inaccuracies, and as Boeing has stated; has no correlation to their guidance material.

The inaccuracy of these methods is also the reason why NTSB has recommended exploring possibilities of using the aircraft itself to provide such information.

Our system is based on using the aircraft itself, performing calculations based on Boeing's "airplane braking coefficient" and further applied in guidance material from Boeing. Our competitive advantage is further founded on the following:

- Patent
- Application Know-how
- Data management
- Quality Assurance function

Central functions of the on-board aircraft algorithm are coverd by patent in terms of acquisition and data processing. However, equally important is the application know-how in making the system actually function on-board. The algorithm was developed and tested using a database containing 10 years of flight data[8] before a trial version was uploaded. Further development took place by applying various proprietary filters and streamlining to eliminate "dynamic noise" that interferes with input data processing.



Another advantage with program function is data management where all functions takes place on-board, and only results are transmitted to the ground station. From a practical point of view, it means less data for transmission, which makes it easier and simpler to process through the ACARS[9]

[8] Continental Airlines
[9] Aircraft Communications Addressing and Reporting System - a digital datalink system for transmission of short messages between aircraft and ground stations via airband radio or satellite.

system from the aircraft to ground station. Flight data is also a matter of high sensitivity. Pilots and their unions strongly "safeguard" flight data. It is not given that flight data will be released for commercial use and applications. Since our system does not relay any flight data, and the results do not bear any upon actions of pilots, we very much avoid the sensitivity issue.

All information from the aircraft is sent to our data cloud function where it further undergoes a quality assurance function. This is a three-tier final QA process to ensure the correctness of the information.   It is proprietary and developed from the analysis of more than one hundred thousand landings.

As seen, the various elements of competitive advantage are very much locked-in to each other and at different levels of acquisition and processing functions.

Competition – New technology.

There has been effort from various public institutions and research facilities to consider this, however with very much an academic approach. There is however a company, AST Inc., that has developed a system utilizing flight data for such purpose. We are quite familiar with their system and how it works. Our view is that it is to complex and try to encompass to many variables, containing many parameters with imperfect data input that makes this system not reliable. Our perception is that many industry experts share the same opinion.

Market Strategy & Implementation

To support a sustainable business- and revenue model, our overall goal is to build our real-time information services to cover extensive network of airports in North America, Europe, Asia, and Latin America. Targeting single aisle air aircraft[10], which primarily operates in a point-to-point routes intracontinental, our aim is to include all major airline operators in these geographical regions and have their aircraft fleet fitted with our on-board program function and feed information into our cloud computing solution.

Our objectives are to get a foothold in the US and North America before we target Europe and Asia. Latin America is seen as a natural follow-up due to substantial north-south traffic between North America and Latin America operated by single-aisle aircraft.

In the US we are currently working with United Airlines, a collaborating partner in the development of the system, which has Dyanron installed on their fleet of B737, about 300 aircraft. We are also in talks with Sun Country Airlines, a smaller B737 operator based in Minneapolis. We want to further include American Airlines, Southwest Airlines, Delta Airlines, Alaska Airlines, and possible JetBlue. These airlines represent more than 70 % of the US airline traffic.

In Europe the consolidation of the airlines industry has not reached the extent in the US. However we will initially focus large operators such as Lufthansa, KLM/Air France and IAG (British Airways & Iberia). Ryanair and EasyJet are also large Low-Cost Carriers, along with Norwegian [Air Shuttle]. It is also natural to approach SAS since they operate to a large extent in geographical regions with strong winters.

Asia is the biggest growing market in the world and there are quite a few start-ups taking place. For us it is natural to target China and their four major airlines: China Southern Airlines, China Eastern Airlines, Air China, and Hainan Airlines, all operating substantial fleets of single-aisle. Furthermore, Malaysia based Air Asia Group with their affiliates in Japan, Indonesia, Philippines, Thailand and India.

In Latin America we would first and foremost target COPA, LATAM, AVIANCA, and Aeromaexico

This is a business-to business (B2B) market. Our target market is airlines in the geographical areas above. The marketing- and sales process are somewhat elaborate and usually involves several organizational layers and cross-functional technical groups. Building relationships are important.

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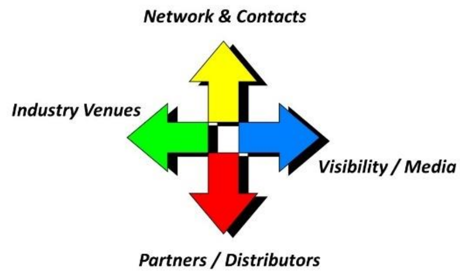
[10] Primarily B737 and A320 family aircraft

We foresee our marketing tactics built along four avenues:

- Network and Contacts
- Partners/Distributors
- Visibility/Media
- Industry Venues



Throughout the years we have built a strong network within the airlines and aviation community, particularly in the US. Working with United Airlines, one of the world largest airlines, has provided us with not only contacts and network within United, but also to other airlines as well. Since this started out as a development project based upon safety and been presented in venues concerned with safety, the interest for the project has been observed from other airlines as well. Today we possess network and contact at flight- and technical operational at American Airlines, Delta Airlines, Alaska Airlines, as well Sun Country Airlines. We intend to use this network and contacts to build the necessary report and relationship with the various airlines. Safety is very much a “door opener”, as it is very difficult to say no to safety. With the leverage of collaborating with United, we see this as a key to reach other airlines, also in Europe.

Our information will be channeled (distributed) through existing flight planning /situational awareness applications/tools. This suits airlines very well, since it confines information into few applications. We will work with Sabre Airline Solutions, a Dallas based technology company, where their Flight Explorer product, which integrates a multitude of aeronautical information, is used by many airlines. United Airlines is among them. WSI, a part of the Weather Company, is now part of IBM, has a product Fusion, which is similar to Sabre’s Flight Explore. Fusion is also a program that is used by several major airlines. We have been in contact with WSI. With the progress of technology, and for this purposes connectivity, we see the use of handheld devices becoming more popular also for this type of information. Honeywell has entered the market of providing weather information and do this through an iPad platform. We have also been in contact with Honeywell regarding this, and they have shown an interest in prototyping information from our system through their application. The use of these partners/distributers is key getting into airline systems for technical purposes as well as taking use of their account sales managers.

Visibility/media is based on building recognition and PR in the market place. So far, we have had two articles featured in an industry magazine, AeroSafety World, a publication by the non-profit organization Flight Safety Foundation. This magazine is distributed to members in more than 100 countries. Flight Safety Foundation members include most “western” airlines, Boeing, Airbus, and other industry groups. In this magazine we have planned a “trilogy” of focused articles, of which two has so far featured. The first covering the start with Continental Airlines, challenges, and early results. The second looking into to the validation process with FAA. The third, not yet published, will feature data-flow and real-time information systems to the users at airlines. We are awaiting the completion of the cloud computing solution and the feeds from United. We also intend to take use of publications such as Air Transport World, Aviation Week etc., as these reach many airline managers who have certain influence in selection and decision making.

Participating, or even presenting at industry venues is seen as a valuable tool to meet industry people and establish contacts for leads. Representing United Airlines, we presented the collaborating project, its progress, and findings at an Aviation Safety Infoshare in Baltimore. Aviation Safety Inforshare is a closed by invitation venue hosted by FAA to bring people across the aviation industry to share and exchange safety experience. The venue in Baltimore included representatives from Europe and Asia as well. Aviation Safety Infoshare is not the only venue, Flight Safety Foundation also host various conferences serving as meeting places for industry professionals. We intend to take part in such and others as well.

Development & Technology Plan

Our information service is based upon a fully automatic and seamless end-to-end system comprising the following elements and functions:

- On-board aircraft program function transferring information aircraft to ground station
- Ground station data transmission intercept, and relay to cloud computing system via API.
- Cloud computing solution processing information and storing received data
- Relay of value added information to partner/distributor web/handheld application
- Integration with web/handheld user application located at airlines network operations

For these elements and functions we have the following technology plan:

On-board program function

The current on-board program function is programmed in Teledyne Controls software application language for its on-board data bus. This version is applicable to most B737. Rolling-out this to other airlines requires that a PC card containing the program function will be connected to the new aircraft ACMS. This will usually be done in connection with maintenance

Airbus aircraft are normally fitted with a data bus from Safran. Their functionality is the same as Teledyne, however application software program is different. Algorithm is the same, but we need to work with Safran or an airline avionics engineer with knowledge about this system.

For either data buses, we need to work with airlines engineering and IT department to conduct the installation.

Ground station transmission intercept

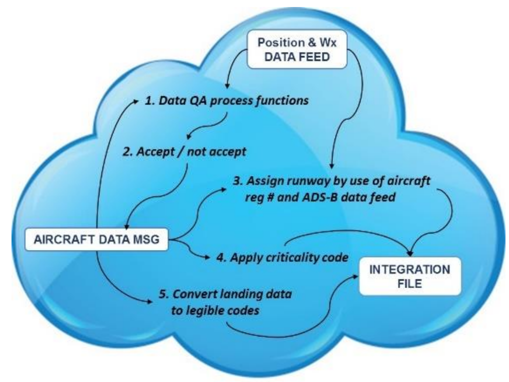
This is a function which is the sole responsibility of the airlines, however need guidance to set-up the routing to connect to our cloud computing system through an API. Airlines will only "push" messages. The message will have standardized in JSON format.

Cloud computing solution.

Our strategy is to take use of standard solutions. The cloud computing solution is using Amazon Web Services (AWS), a solution regarded as one of the most secure web hosting providers. Using AWS means also standard programing languages. Another advantage with AWS is pricing, whereas pricing is based usage rather than fixed rates. The same is valid for data storage

The functions taking place inside the cloud computing solutions are:

- Adding runway identifier and weather information (METAR) to the feed from the aircraft.
- Runway identifier is a function our own created airport database with GPS perimeter positions and a GPS flight tracker feed we receive from FlightAware Inc.
- New file containing runway identifier and METAR is subjected to our proprietary QA function.
- Result file (after QA function) is transmitted to distributor/partner application through an API and integrated with their web or handheld tools use by airline. Files are in JSON format



- All software applications will be coded and programmed on a Microsoft platform.

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The Management

The company will structure its organization to control its proprietary systems and value-added functions. The table below has organized and provides a functional overview of this management

SECTION	FUNCTIONS	DESCRIPTION
Product	On-board system data transfer	*Maintain on-board program software, reconfigure for other on-board data bus program language, and work with airlines to upload software and properly route data from aircraft.*
	Data server & application integration	*Manage data center solution (hired) and associated application software that receives, processes, and transmits integration files to airline user applications. Guide on integration issues with third-party flight operational application providers.*
	New products	*Use stored data from aircraft to customize and develop new associated products, e.g. airport runway maintenance planning systems.*
Marketing	Sales & distribution management	*Manage distribution through third-party providers and their applications. Sales and after-sales activities will be directed towards customers, users, stakeholders, as well as the third-party application providers.*
	Public Relations	Comprises writing and providing articles to industry publications and do presentations at industry venues.
	Promotional	*Maintain corporate web sites and other promotional material.*
Administration	Contracts management	*To "glue" all elements of functions together there is a need for various legal agreements and contracts to assure rights to use data, protect proprietary rights and indemnifications etc.*

Currently the company is in a start-up phase with Trond Are Johnsen as General Manager. As support and in advisory capacity are Dag Arild Hansen and Svein Solberg. Data server application systems development is by the hired services of Contango Consulting AS

The company intends to keep the organization as lean as possible at the same time retain needed operational knowledge and know-how associated with proprietary functions in-house. More general functions will be outsourced to suppliers that can perform those more cost efficient.

Trond Are Johnsen

General manager. Johnsen holds a MBA from Pacific Lutheran University, Washington, USA. He has experience in business development, herein technology development and customization to market needs.

In this project, he has taken part and managed the project from its start, penned all patents, developed all the proprietary algorithms used in the system, and design the technical structure and user interface. He has sound technical understanding combined with the business knowledge.

Johnsen also possess a substantial network within aviation industry in the US.

Advisory board

The company retains an advisory board, currently with members selected from its shareholders. Its purpose is to provide know how and expertise in the commercialization phase.

Dag Arild Hansen

Master of Science (Siv ing) in cybernetics engineering from Norwegian University of Science and Technology (NTNU). In capacity of positions such as Business Development Manager and Technical Project Manager, Hansen has extensive experience from various projects, herein international, including contract management and negotiations in the US.

He currently runs his own consulting company, Eolicada Energi AS, and is among others involved in wind power plant development projects with business and technical management.

Svein Solberg

Also, member of the Board of Directors.

Former Norwegian Air Force pilot and retired commercial pilot (Braathens SAFE). At Braathens SAFE he also held the position as director for flight operations. Upon his retirement from commercial flying, he also served as senior flight operations inspector with Norwegian Civil Administration (Luftfartstilsynet). Solberg is well acquainted with the various aspects and challenges of operating an airline. Furthermore, Solberg had an active role in the start-up and development of Røros Flyservice AS, an airport ground handling company, which later was acquired by Aviatior Airport Alliance AB

As the company evolves commercially, it will fill managerial positions within technology and sales/marketing.

Manager Technology

This person will have the overall responsibility of managing and administering updates, maintenance of the company's technological structure related to the product, which comprises the on-board system and its way to the data center solution, and the redistribution to user applications. This person will liaise with the technical and engineering departments of the airlines, data center solution providers, and third-party application suppliers.

In terms of background, this person has likely an engineering background and experience and knowledge from system-/program development as well as data management.

We foresee this being a position located in Norway

Manager Sale/Marketing

This person will have the responsibility for the follow-up of customers and third-party application partners. The latter because sales and marketing functions can have strong elements of overlap.

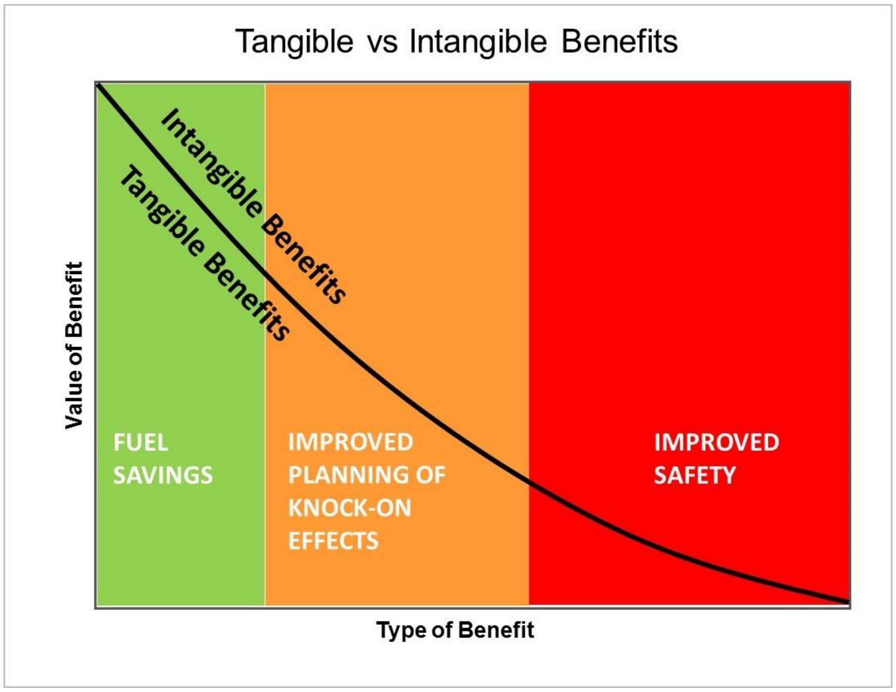
For this position, the company would need a person with sound flight operational knowledge and experience from sales position into airlines.

We foresee this being a position located in the US, whereupon a similar position will evolve for Europe when the company will move into that market.

Financials

Pricing

In terms of pricing, there are no equivalent products to compare to. The nearest form of a third-party service is various weather and other aeronautical information that is packaged and streamlined into applications to help airline network operations to optimize.



We have not tested the market in terms of pricing, however assessed and calculated the potential extra benefits achieved from using the system. From this we have derived at a price we term “per aircraft per month equivalent”. We believe the market will accept a monthly subscription rate equivalent of USD 450, - per month per aircraft.

This is based on value proposition and that these elements comprise tangible as well as intangible benefits. Modelling safety and knock-on effects are difficult on behalf of airlines are difficult. Nevertheless, airline operations are all about safety and its importance is widely recognized. Fuel savings however is easier. We have developed a model and calculated a network operator like United potentially have fuel savings ranging from USD 3-5 million annually. This is calculated at a fuel cost of USD 1,45 per US gallon. Current fuel price is about USD 1,95 per USD gallon. Fuel prices tend not to vary much from geographical region to another.

Cost structure

The service is based upon an information being transmitted to a cloud computing solution, added value, before relayed to a web based or handheld application tool. The variable cost associated with this is the flight tracker data feed and METAR required for every landing. FlightAware price each of these per “query”. The cost for each of these is “a fraction of a cent”, with reduce cost per query with increased volume. We have used 0,5 US cent per query, thus totaling 1 US cent per landing. We have also used an average of 4 daily landings per aircraft. Furthermore, cost will incur with the use distribution channel (partners). We expect this cost will be a function (percentage) of the traffic going through their system and have used 5 % of invoiced value. A licensing fee associated with the use of the on-board patent is 6 % of invoiced value. Using these parameters our variable cost per aircraft, based on a USD 450, - per aircraft per month subscription rate amounts to:

- ***Distribution channel (partner) 5 %*** ***USD 23,00***
- ***Licensing fee 6 %*** ***USD 27,00***
- ***FlightAware data feed*** ***USD 1,50***

- ***Total variable cost per month per aircraft*** ***USD 18,00***

This will yield an estimated gross margin per aircraft per month of ca USD 400, -, or about USD 4 800 per year

Following table provides an overview of revenue and gross margin at different levels of participating airlines.

Participating aircraft	NOK[11] x 1000 per year	
	Revenue	Gross Margin
1 000	14 400	12 672
4 000	57 600	50 688
10 000	144 000	126 720
11 400[12]	165 160	144 460

Operational cost and Break-Even analysis

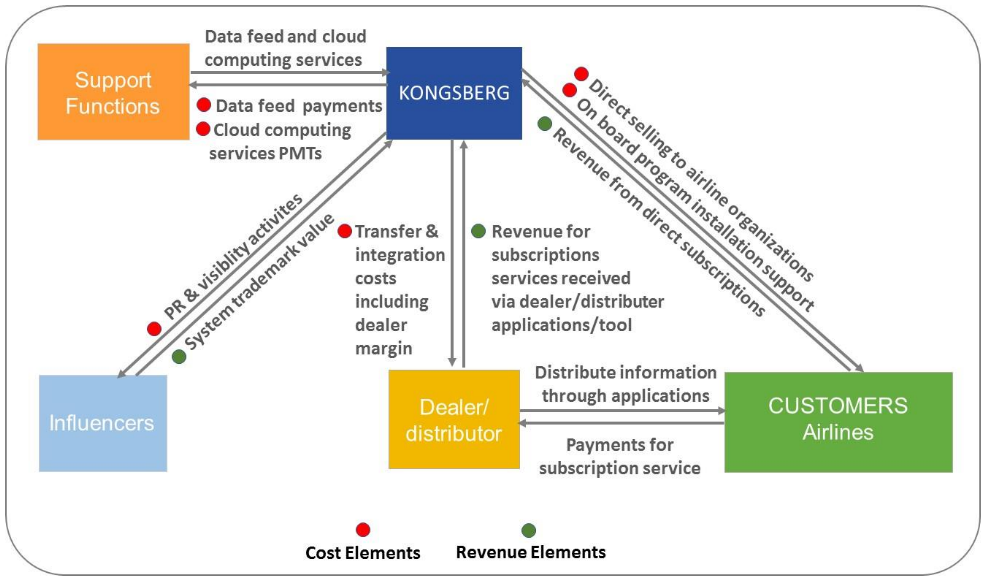
The organization required to run the operation is lean and in line with the management plan. Dependent upon how the organization is geared-up to different activity levels, we see an early phase break-even point at about 500 aircraft based upon a subscription rate of USD 150 per aircraft per month.   With a fully geared-up organization to serve the full market potential in North America, Europe, Asia, and Latin America, the break-even point is assessed to be about 1000 aircraft, again given a subscription rate of USD 150 per aircraft per month.

[11] USD/NOK exchange rate 8,00

[12] 40 % market penetration of aircraft fleets in North America, Europe, Asia and Latin America in 2025 based upon Boeing Market Outlook

The illustration shows the operational structure in terms of revenue- and cost element drivers for the company.

The service is distributed through third party application provider, here called dealer/distributor. There are several third-party providers, thus airlines, the customers, may have the option of choice which application tool they may prefer the service provided. This also means that there may be two revenue channels, dependent upon choice, either a directly direct set up with the airlines, or through the third-party supplier services. Either way, the dealer/distributer will be remunerated for its distribution services through its application.



Selling will mainly take place directly with the airlines, although a relationship with dealer/distributor's sales account responsible will be initiated and maintained.

For new customers and addition of aircraft fleets to the information feed system, initial work with airlines' engineering departments are required to install on board system and assure proper routing of landing data from aircraft.

Apart from landing information data feed from airlines, the company will acquire aircraft positioning data from FlightAware, a Houston based company, which provides live position data using aircraft ADS-B system. Their service is priced per query and is a fraction of a US cent per query. The company will also take use of Amazon Web Services as well, a service priced according to usage. During the initial phase the management and maintenance of the cloud computing solution will be contracted out until the company recruits personnel for this.

Aviation operational safety, which is a founding element of this service, has cross-border collaboration and stakeholders ranging from aircraft manufacturers, public agencies, airlines professional groups etc. In the forefront of this has been North America and Europe. Among these stakeholders are many "influencers" and the company sees it important to build and maintain recognition for the corporate brand and value of the system among these influencers.

Profit & Loss Projections

Our projections are based upon the among others the following assumptions:

- *Monthly subscription rate equivalent of USD 450, per aircraft per month*
- *Enter into the first commercial agreements in North America the winter season of 2018/2019 and further expand the depth of the customer base in North America throughout 2019 and early 2010*
- *Start working the European and the Asian market medio 2019 with impact of this effort seen in 2020 and 2021*
- *Operating expenses, particularly from 2019 and onwards, comprising added legal expenses in connection with the various commercial and partnership agreements*
- *Personnel addition with a manager technology/IT from last quarter 2018 and another person on marketing/support towards the end of 2019*
- *Hired help to make on-board program algorithm applicable to the Safran data bus found on Airbus A320s*
- *IFU grant of NOK 500 000 approved by Innovasjon Norge will be received in 2018*
- *Eligible Skattefunn for 2017 of NOK 230 000 will be received in October 2018, while Skattefunn for 2018, assessed to NOK 370 000 will be received in October 2019*

NOK 1 000	**2018**	**2019**	**2020**	**2021**
Sales Revenue		4 000	20 000	42 000
Grants & Other Revenue	730	370		
Gross Margin	730	4 000	18 200	38 600
Operating Expenses	2 700	4 300	4 700	5 500
Net result	**-1 970**	**-300**	**13 500**	**33 100**

APPENDIX A

Board of Directors

All the Board of Directors representatives are from the shareholder side of the company.

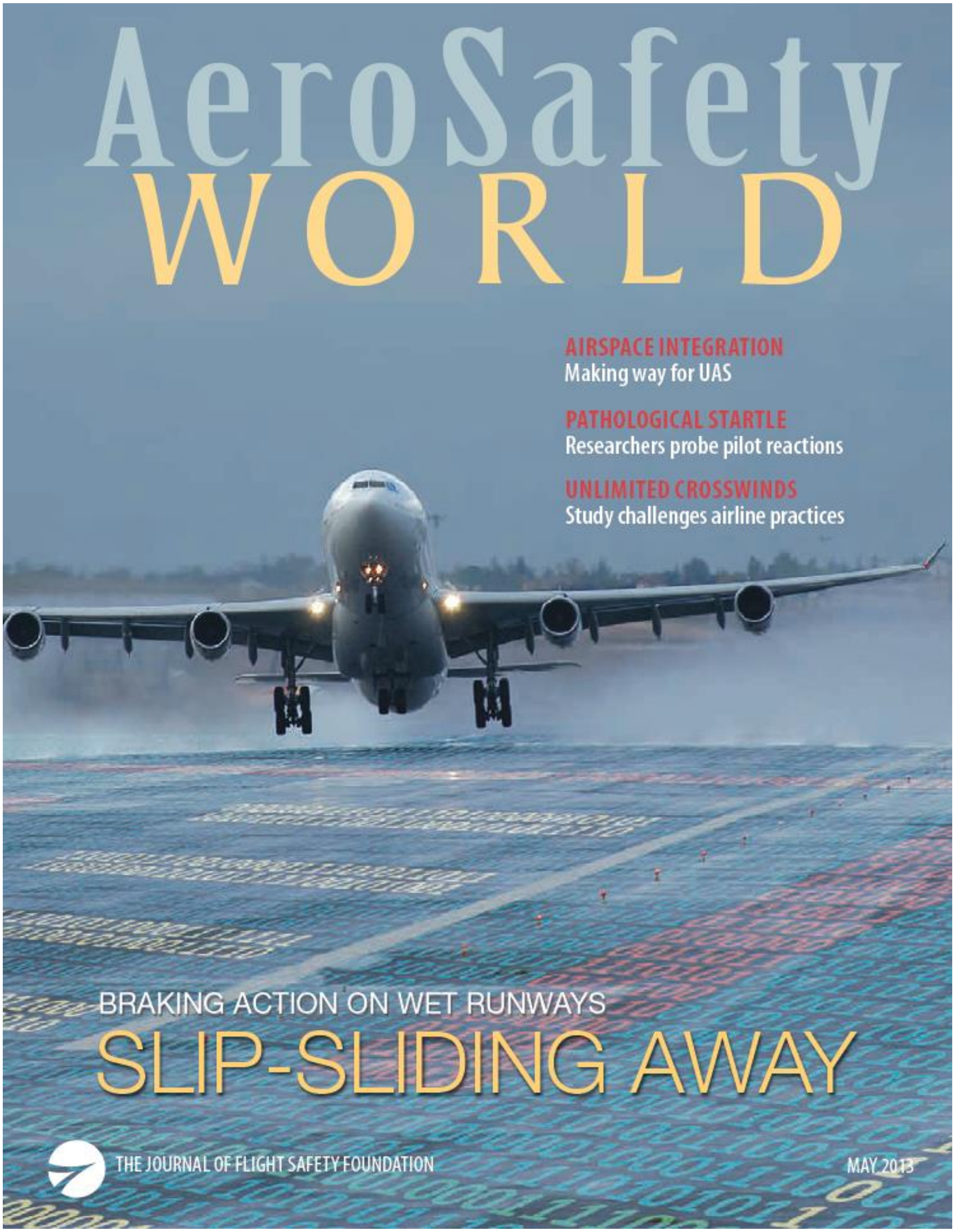
APPENDIX B

Shareholders

Shareholder	**Number of Shares**	**Percentage**
Kongsberg Safety Systems AS	564 350	37,6 %
BRM Gruppen AS[13]	160 100	10,7 %
Ringas AS[14]	149 988	10,0 %
Roar Fiksdal	139 634	9,3 %
Andreas Arnesen	101 398	6,8 %
Svein Thorsen	97 565	6,5 %
Reiert Invest AS	76 446	5,1 %
Jørgen Skabo	73 670	4,9 %
DaCap AS[15]	46 850	3,1 %
Barnstormer Invest AS[16]	43 620	2,9 %
Torstein Stormoen	17 120	1,1 %
SVS Holding AS[17]	10 000	0,7 %
Ingerid Skabo	8 030	0,5 %
Bendik Strand Skaslien	5 255	0,4 %
Etrinell AS	2 871	0,2 %
Similia AS[18]	2 263	0,2 %
Sølvi Engeland	840	0,1 %
Total Shares	**1 500 000**	

[13] Bård Rieber-Mohn, Board member
[14] Dag C. Weberg, Chairman of the Board
[15] Dag Arild Hansen, Field expert
[16] Trond Are Johnsen, General Manager
[17] Svein Solberg, Board member and field expert
[18] Torleiv I Holst, Board member

APPENDIX C:


AeroSafety
WORLD
AIRSPACE INTEGRATION
Making way for UAS
PATHOLOGICAL STARTLE
Researchers probe pilot reactions
UNLIMITED CROSSWINDS
Study challenges airline practices
BRAKING ACTION ON WET RUNWAYS
SLIP-SLIDING AWAY
THE JOURNAL OF FLIGHT SAFETY FOUNDATION
MAY 2013

BY JOE VIZZONI

Your Slip Is Showing

FOQA data can detect airports where runways are likely to be slippery and help pilots compensate.

Pilot statements such as "it was as slippery as grease" and "I thought I wouldn't be able to stop in time" would normally be associated with stopping on winter-contaminated runways. These are, rather, pilot responses upon landing in *rain* and on a *wet* runway. They form part of the pilot feedback in a test program related to aircraft braking action. In fact, the test program revealed that some wet runways have equal or worse braking action than snow- or ice-covered runways.

The Program

The braking action test program came about in 2010 at legacy Continental Airlines, which has been merged with United Airlines, and

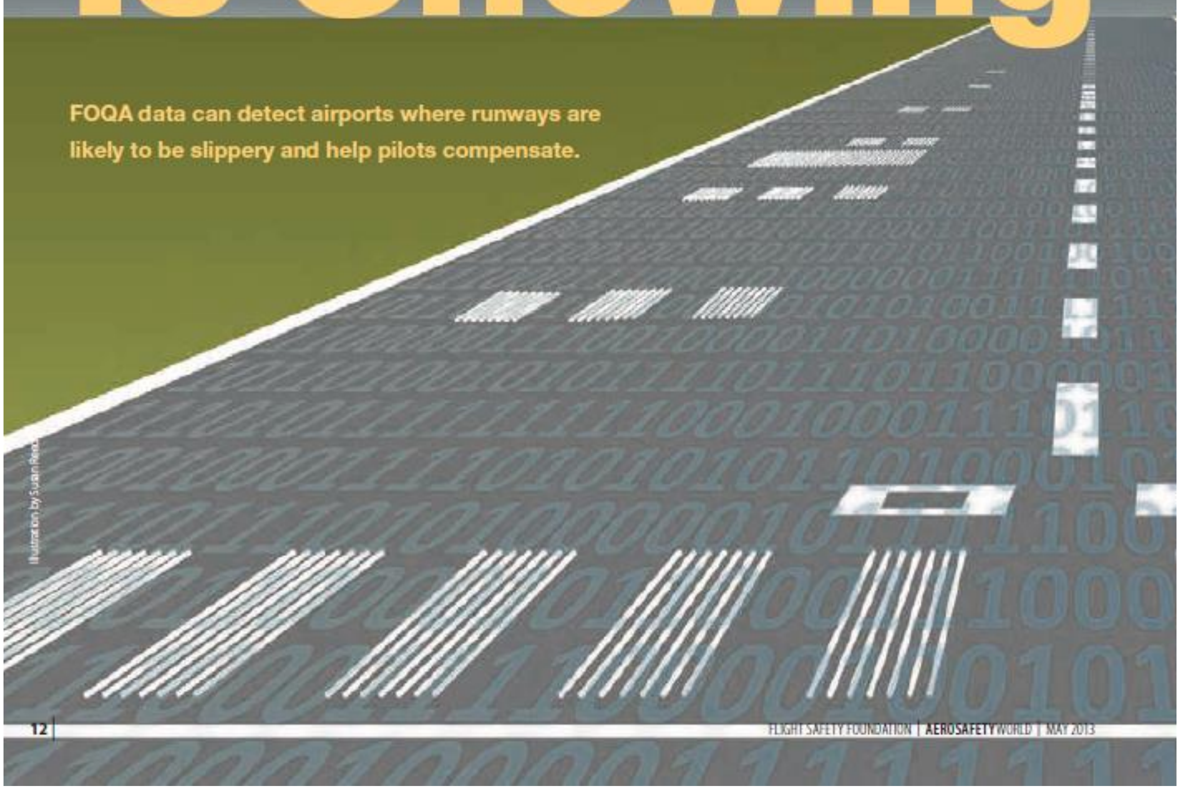


Illustration by Susan Reed

was based on using the aircraft itself and flight data to better assess braking action. In cooperation with Kongsberg Aeronautical, which possessed an algorithm developed for the purpose that it could easily be adapted and downloaded into the aircraft, the airline's flight operational quality assurance (FOQA) group saw this as an exciting safety project and subsequently initiated the test program. Due to the inherent sensitivity of FOQA data and its use, representatives of pilots as well as operational management were summoned to take part in decisions and approve the framework for the test program.

Sensitive Issues

When it came to sensitivity in the use of flight data, one factor proved essential and favorable. The algorithm and the subsequent program loaded onto the aircraft fleet did not require flight data downloading from the aircraft or any other distribution of flight data. The program was designed to obtain braking action information purely through onboard calculation processes. Only the resulting braking action information was transmitted by a downlink.

The braking action information generated by the system on the aircraft was not influenced by the pilot. The information did not reflect on the skill and airmanship of the pilot.

According to established practices, the FOQA group did not have direct contact or communication with pilots. All crew contact was through the Air Line Pilots Association, International (ALPA) as a gatekeeper.

With a clear understanding of the framework for the test program, the next step was to set up a system to assess, receive and evaluate feedback from pilots.

Management of Test Data and Pilot Feedback

Braking action data were processed, handled and communicated for feedback from pilots (Figure 1, p. 14). The following steps and phases further detail the procedure:

- The FOQA group checked daily incoming data from flights and looked for landings that qualified as being within the determined runway slipperiness threshold.
- Landings found to be within the runway slipperiness threshold were then tested against the weather conditions prevailing at the time of landing. By using METARs (the international standard code format for hourly surface weather observations) for the airport, the FOQA group could easily assess whether the landing information likely represented a slippery runway landing.
- To ensure the anonymity of the crew and avoid potential traceability, only a de-identified METAR eliminating the date was used to match the flight.
- In the next phase, the FOQA group approached the ALPA gatekeeper with the landing details. He contacted the crew to receive their feedback.
- The ALPA gatekeeper relayed the feedback and comments to the FOQA group.

The system comprising detection, verification and the final validation by the pilot worked well, and the pilot statements referred to earlier represent some of the feedback results.

'Friction-Limited' Braking Action

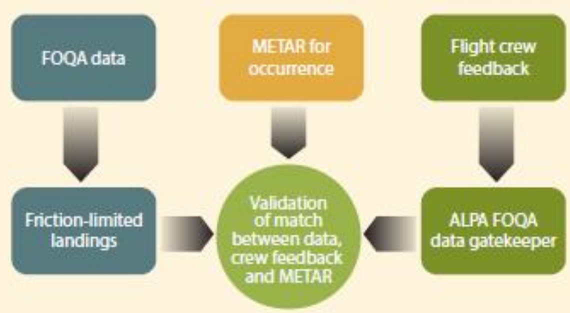
Setup of the on-board algorithm and program is, in broad terms, targeted to detect when aircraft encounter "friction-limited" braking situations. Detecting when an aircraft encounters friction-limited braking is a key constituent in determining maximum braking capability for an aircraft. The test program defined braking action as "dry," "good," "medium" (fair) or "poor" and assigned numerical equivalents of the airplane braking coefficient.

For practical purposes throughout the test program and in pilot contact, the feedback process was focused solely on landing situations in which braking action was classified as being less than "good." This was to avoid adding to pilots' workload for routine landings, when the test was designed to focus on difficult occasions.

A Pilot's Dilemma

Although it is common knowledge that wet runways may be slippery, the issue of slippery runways traditionally has been associated with winter operations and winter contaminants.

FOQA for Wet and Slippery Runways Test Program



ALPA = Air Line Pilots Association, International; FOQA = flight operational quality assurance; METAR = international standard code format for hourly surface weather observations

Source: Joe Vizzoni

Figure 1

However, recently the wet runway issue has received increased attention, and for good reason. Early in this test, program data showed that airports where runways were neither grooved nor crowned for water drainage had increasingly higher risk of being slippery when wet. Various types of deposits on the runways compounded the problem.

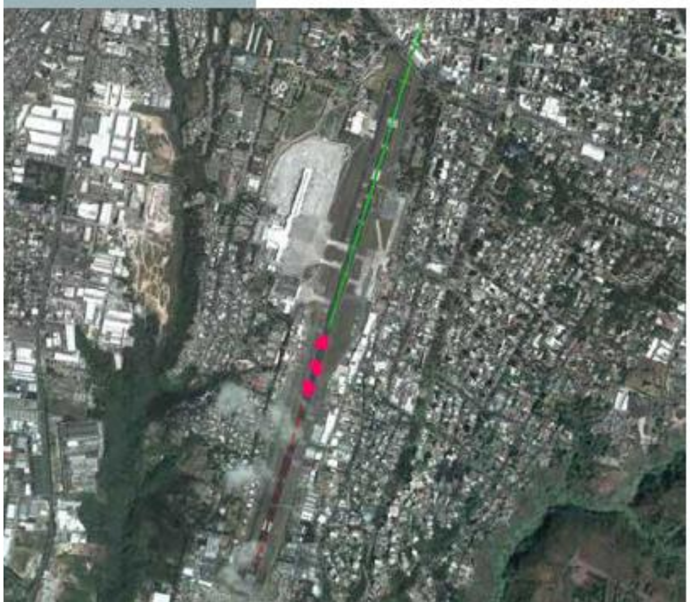
Ideally, airport management should ascertain proper runway design and maintenance programs to ensure proper friction. In reality, this is not always the case, and the test program revealed substantial variations. A pilot's job is to make the right decisions and land the aircraft safely given the prevailing conditions. Therefore knowledge of, and access to, crucial information is of utmost importance for the pilot.

Test Program Findings

One unexpected outcome of the test program was the finding that a few airports recurrently presented slippery conditions. The METAR analysis confirmed conditions to be rain and/or wet runways. Pilot feedback also supported the finding that conditions were slippery. Some of the pilot statements quoted earlier originate from these airports, primarily located in Central America, where the runways are typically neither grooved nor crowned. A history of overrun accidents further added to a perception of these airports being at higher risk.

To conduct further in-depth analysis, the FOQA group plotted, using a global positioning system tool, the number of slippery landings on maps of the runways to enhance situational awareness of the problem. The photograph (p. 15) shows an example of one of the airports where aircraft encounter friction-limited situations. For practical purposes, the illustration only shows encounters at groundspeeds less than 70 kt. This also is the phase of the stopping run when engine reverse thrust and aerodynamic drag have less impact on the deceleration and leave most of the stopping to the wheel brakes. The photograph shows consistency and further supports the findings.

© Tim de Groot/AirTeamImages



Satellite photo of Guatemala Airport. Magenta areas indicate positions where the on-board program recurrently indicated friction-limited braking. These positions were defined by the global positioning system, enabling comparison of multiple flights.

Google Maps

FOQA Alert

In response to a slippery landing that needed pilot feedback, the ALPA gatekeeper asked the crew for recommendations in addition to their feedback.

A frequent issue was the emphasis on idle reversers. Although never compromising safety, the company recommended, to an extent, idle reverser usage for fuel savings years ago when fuel prices were on the rise. It seemed that too many pilots relied on brakes when reverser usage was more appropriate, especially at the beginning of the landing roll.[1] What surfaced with this test program was potential increased risk with such a policy at certain airports when conditions involved rain and/or wet runways.

Finding that a significant number of pilots addressed the problem and approached it from virtually the same viewpoint, it became apparent that issue had to be pursued. In one of the company's monthly safety meetings, it was decided to bring up the issue. The safety meeting normally involves participants from ALPA, fleet managers, the safety group, etc. At the meeting, the ALPA gatekeeper presented the case supported by the pilot recommendations, the data and in-depth analysis from the FOQA group. This became then an action item.

In considering the action item, the options were to issue a pilot bulletin or insert a 10-7/FOQA alert — a notification that describes a problem and recommends a response — into the pilots' approach plate for an airport. Due to the seriousness of the issue, the pilot bulletin was considered less appropriate because it would likely be forgotten within six months. The 10-7, on the other hand, represented information in a more permanent form and was used for some of the airports revealed to be at higher risk in the test program.

The 10-7/FOQA Alert Era

The braking action test program continues at an increasing scale and according to its original intent. A little more than two years after the 10-7 implementation, there has been a substantial reduction in pilot statements such as "slipperier than grease" for those airports that were subject to the 10-7.

To further look into the impact of the 10-7 and use of idle reversers, the FOQA group has run an analysis. Where METAR data indicated rain and/or wet runway conditions in landings, their reverser usage was analyzed before and after the 10-7 implementation and showed significant changes. Thrust reverser usage has been more selective. Deployment of reversers upon landing is normal procedure, but in line with policy, the use of reverse thrust by increasing the engine revolution speed has varied. Prior to the 10-7 era, it was normal to see engine speed about 40 percent, which is virtually "idle," even when conditions were rainy or wet. After introduction of the 10-7, the standard engine speed used in rainy or wet conditions was about 80 percent, which is maximum use of reverser thrust.

This action item demonstrates encouraging results. First, it serves as a useful tool for pilots operating in airports that are less than ideal in design and maintenance. Second, in a cost-conscious environment, it also shows that

Selections From a 10-7 Issued for a Runway

- The runway is not grooved and standing water is likely to be present when raining.
- Braking action is likely to be fair–poor when the runway is wet.
- Select and use the maximum autobrake setting.
- Make every attempt to touch down at the 1,000-ft point.
- Use maximum reverse thrust.

—JV

rather than issuing generalized notifications and procedures, proper use of technology and cooperation by pilots can enable a clinical approach and more detailed procedures, better balancing safety with economic considerations.

Safety Culture and Environment

Continental Airlines had a long history of using flight/FOQA data to proactively enhance safety and efficiency, which has continued after the merger with United. Although the braking action test program and the initial 10-7 FOQA alert may seem ordinary, the process epitomized what is needed to build a platform of understanding, trust and cooperation to create the right culture and environment for working with sensitive information such as FOQA data.

For all parties in this test project, the focus has always been on safety. Nevertheless, it has been important to safeguard the corporate safety culture and environment by having proper systems, routines and procedures. When this test program surfaced, the operational management took a keen interest, provided the "green light," and then supported the test program. This was important and provided the proper framework for the project's more active participants.

ALPA and the FOQA groups have had a long relationship and developed good rapport through many years of cooperation. The intriguing part was to have a third party working within the traditional format of the FOQA group and ALPA. It has been a success.

The Future

Although there has been an increasing focus on rain and wet runways, the braking action test program was not specifically set up to find runways prone to higher risk in rain. It was part of a general move to better and more accurately assess the braking capability of aircraft, in particular during challenging winter conditions.

The on-board system developed is now downloaded onto all United's Boeing 737NGs, representing a significant network. Today, this aircraft network furnishes braking action information daily, albeit not yet for operational purposes but only for FOQA group analysis.

United's pilots will continue to serve a pivotal role in the system verification by providing valuable feedback. A print function has been programmed on the flight deck and activated for response, thereby simplifying participation by pilots. The test program will continue to be focused on runway conditions where braking action is assessed to be less than good by the numerical scale of airplane braking coefficient.

In terms of the future viability of the system, the algorithm and program have proved stable and reliable. Currently the system is undergoing a validation in cooperation with the U.S. Federal Aviation Administration. Access to and availability of FOQA data provide new opportunities to improve safety and efficiency of airline operations. By the same token, it is important that the necessary framework be in place to pursue desired results, such as those that have been evident in this project.

Joe Vizzoni has been a part of this test program and all the processes described from its start. He is a first officer with United Airlines on the Boeing 757 and 767 and also has experience as an aerospace engineer, of which nine of 14 years were with Boeing.

Note

1. Thrust reversers are most efficient at higher speed, so to reduce the kinetic energy of a landing aircraft, it is best to apply them at once, thus carrying forward less energy toward the end of the runway.

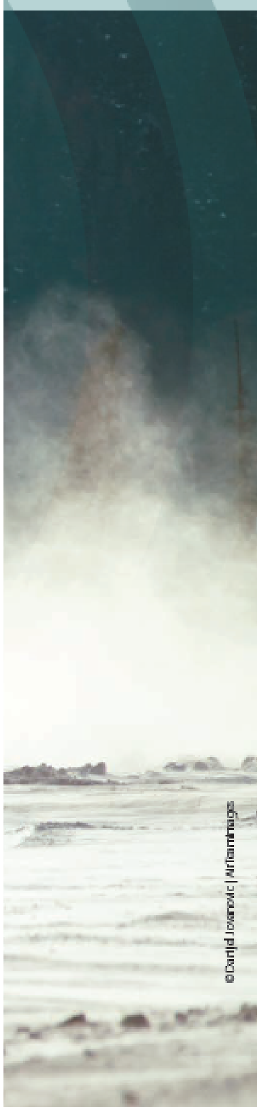
Objective Assessment

An on-board system in development would enable airline pilots to anticipate runway surface condition and braking capability.

BY TROND ARE JOHNSEN

Advances in technology and aviation industry safety initiatives have significantly reduced commercial air transport accidents, but runway safety–related events generally, and runway excursions specifically, persist. Accurately assessing runway surface condition and braking capability have not received the same technological focus as contributing factors in other types of accidents. This article presents progress to date on an on-board system in development that would intercept flight data parameters for real-time analysis early in the landing roll, reference stored data representing the specific airplane's known landing performance and apply an algorithm that helps the flight crew to objectively recognize the actual runway condition and to accurately assess their airplane's braking capability.

Potential delivery modes for this information include near–real time "data push" integration into flight operations/dispatcher flight following tools, existing landing analysis systems and directly informing the flight crew.



Southwest Airlines Flight 1248, which overran the runway while landing at Chicago Midway International Airport on a snowy night in December 2005, has come to exemplify the shortcomings in the reporting of braking capability on contaminated runways. This accident, which resulted in the death of a young passenger in an automobile that was struck by the Boeing 737-700 after the aircraft crashed through a blast fence and an airport perimeter fence, has served as a catalyst for several industry initiatives and renewed thinking.

Flight Safety Foundation has addressed runway safety repeatedly, and recommended in 2009's *Reducing the Risk of Runway Excursions: Report of the Runway Safety Initiative*[1] that "a universal, easy-to-use method of runway condition reporting should be developed to reduce the risk of runway excursions."

The U.S. National Transportation Safety Board (NTSB), in its Flight 1248 accident report, recommended that the U.S. Federal Aviation Administration (FAA) "demonstrate the technical and operational feasibility of outfitting transport category airplanes with equipment and procedures required to routinely calculate, record and convey the airplane braking ability required and/or available to slow or stop the airplane during the landing roll."[2]

In cooperation with United Airlines, Kongsberg Aeronautical has tested the prototype on-board system, similar to the one proposed in this NTSB accident report, and which also responds to the conclusions and recommendations of the FSF initiative. Installed on United's fleet of Boeing 737s, the system has been subjected to a validation program in cooperation with the FAA William J. Hughes Technical Center. The validation has shown that the Kongsberg Aeronautical system performs as expected and intended.

Outfitting transport category airplanes to use flight data to calculate braking ability may seem a straightforward undertaking, but it is not. There are technical as well as practical issues involving ease of use to consider, including:

- Comprehensiveness of assessment system or model;
- Applicability to guidance materials' advisory data for stopping distance; and,
- Data gathering, flight data integrity and confidentiality.

As to comprehensiveness, the landing roll is a dynamic process with a multitude of factors, including ambient conditions, contributing to the airplane's braking capability at different phases. To single out the braking factors associated with the tire-surface interface is an intricate task.

One scientific approach to this challenge might be to mathematically model and emulate the landing roll and all of its constituent factors for defined ambient conditions. It would hardly be a viable and practical solution, however, because it would be challenging to create a model capable of covering all of the variables and assessing interrelatedness of the factors. Furthermore, being able to obtain the required quality of input parameters would be difficult, even if all the needed input parameters could be acquired.

The objective of any assessment system or model should be to capture the essence of the landing roll, in terms of stopping capability, for use in conjunction with the stopping distance guidance information from the aircraft manufacturers.

As to applicability, airlines base their operational assessment of stopping distances primarily on airplane manufacturers' guidance, which is contained in the quick reference handbook, flight crew operations manual and the flight planning and performance manual. Boeing, for example, has classified its airplane braking coefficient and associated braking action categories as *dry*, *good*, *medium* and *poor*, and provided the corresponding landing distances.[3] This complies with the FAA's Takeoff and Landing Performance Assessment Aviation Rulemaking Committee (TALPA ARC) recommendation for an industry initiative except that the TALPA ARC called for two more intermediary categories — *good to* *medium* and *medium to poor*. Although guidance information details stopping distances down to exact feet, it is important to understand that the data are not absolute; they are based to an extent on empirical data as well as extrapolations.

Thus, providing data for input to a model at a level of accuracy beyond what is required for the aircraft manufacturers' guidance material would be meaningless.

As to data gathering, agreements between airlines and their pilot unions strictly govern the use of flight data; integrity, confidentiality and the framework for managing flight data are important. When flight data change hands and are transferred to a third party in full or in part, the data may become susceptible to compromise and breach of confidentiality, either intentionally or unintentionally. Any effort to reduce the amount of flight data subject to transfer is desirable in terms of both integrity and confidentiality.

Start of a Partnership

A braking action test program was launched at Continental Airlines (since merged with United Airlines) in 2010 by the carrier's flight operational quality assurance group. The program's testing was conducted in cooperation with Kongsberg Aeronautical, which provided the algorithm that was adapted and uploaded into the Boeing 737 test aircraft. The program, which was designed to obtain braking action information through on-board calculations, was quickly streamlined and dynamic noise was eliminated from the source data.

Early results of the braking action test contributed to identifying operational safety action items, which were featured in *AeroSafety World* in 2013.[4] Subsequently uploaded on all of United's 737NGs, the Kongsberg Aeronautical system now acquires data daily on every flight in this fleet. It is a "read only" system located within the aircraft condition monitoring system (ACMS) software and uses flight data from previous landings to calculate maximum braking capability. At the end of each landing roll, only the calculated braking

Pilot Version of Matrix

Braking Action Report PIREPs			
Term	**Definition**	**Associated Runway Surface Condition**	**Runway Condition Code**
Dry		**Any temperature and:** • Dry	6
Good	Braking deceleration is normal for the wheel braking effort applied. Directional control is normal.	**Any temperature and:** • Wet surface (smooth, grooved or PFC runway) • Frost **Any temperature and ⅛ in (3.2 mm) or less of:** • Water • Slush • Dry snow • Wet snow	5
Good to Medium	Brake deceleration and controllability is between *good* and *medium*.	**At or below -13°C (9°F) and:** • Compacted snow	4
Medium	Braking deceleration is noticeably reduced for the wheel braking effort applied. Directional control may be slightly reduced.	**Any temperature when:** • Wet (when runway is reported as "slippery when wet") **At or below -3°C (27°F) and greater than ⅛ in of:** • Dry or wet snow **Above -13°C and at or below -3°C and:** • Compacted snow (any depth, depth not reported)	3
Medium to Poor	Brake deceleration and controllability is between *medium* and *poor*. Potential for hydroplaning exists.	**Any temperature and greater than ⅛ in of:** • Water • Slush **Temperature above -3°C and:** • ⅛ in and greater of dry or wet snow • Compacted snow (any depth, depth not reported)	2
Poor	Braking deceleration is significantly reduced for the wheel braking effort applied. Directional control may be significantly reduced.	**At or below -3°C and:** • Ice	1
Nil	Braking deceleration is minimal to nonexistent for the wheel braking effort applied. Directional control may be uncertain.	**Any temperature and:** • Wet ice • Water on top of compacted snow • Dry or wet snow over ice **Temperature above -3°C and:** • Ice	0

PFC = porous friction course; PIREPs = pilot reports

Source: Trond Are Johnsen

Table 1

action information, in deidentified form, was transmitted to a ground station for the research. The transmitted information therefore could not reflect on the skill and airmanship of the pilots.

Employing a streamlined version of the Boeing aircraft braking coefficient calculation, the on-board prototype system detects *friction-limited braking situations* — situations in which increased brake pressure does not yield increased deceleration, which is the point of maximum braking capability. Braking capability/braking action assessment also is aligned with the guidance material/advisory data for landing distance from the manufacturer.

Cooperation With FAA

Based on the promising results demonstrated through the early 737 tests, the FAA's technical center established a cooperative research and development agreement (CRDA) with Kongsberg Aeronautical in 2012 to jointly evaluate uses for braking action information in real-time, runway-slipperiness condition reporting. The research will assist the FAA Terminal Area Safety Research Program in investigating whether flight data on landing airplanes can provide an accurate and timely assessment of runway slipperiness to prevent runway accidents.

The current system does not capture all of the previously noted dynamic aspects of an airplane's landing roll. It does, however, capture the essence of the landing roll, thereby providing relevant and clear information — quality input parameters to the system that enhance the landing distance advisory data provided by airplane manufacturers. The essence of the CRDA was to analyze and discuss a few of the system's features that differentiate it from conventionally conducting a scientific, full emulation of the landing roll. Among these features are the following:

- Use of a portion of the runway;
- Simplified ambient conditions;
- The impact of runway slope; and,
- Transferability to other aircraft.

For a better understanding of these aspects within the validation process, a brief discussion follows.

Portion of Runway

Do flight crews need to consider the full length of the runway or just a portion to be able to assess braking capability? As noted, separating deceleration force associated with the tire-surface interface from other braking factors is complex. Incorporating this factor in the early phase of an actual landing roll at first sounds more academically interesting than practically valuable. There are several arguments that support such an approach, however.

Any landing, regardless of runway surface condition or the application of braking force at the early phase of the landing roll, can "feel good" to pilots because aerodynamic drag and reverse thrust produce deceleration forces subjectively perceived to result from the brake application. The diminishing impact of the drag will be felt when speed slows below 100 kt. Although present throughout the landing roll, the deceleration benefit from aerodynamic drag therefore can be disregarded for practical purposes at lower ground speeds.

Reverse thrust works much like a parachute and is more effective at higher speed. A common practice is to stow the thrust reversers when the aircraft speed decreases to between 80 and 60 kt. Therefore, the deceleration benefit from reverse thrust also can be disregarded for practical purposes at lower ground speeds.

Winter conditions can create situations in which the friction heating of tires throughout the landing roll affects the tire-surface interface by reducing braking action toward the end of the landing roll. This is particularly valid with snow or icy conditions. In fact, in a number of runway overrun accident reports, pilots describe how they considered braking action good initially and believed that it deteriorated. The United 737 braking action test program did not involve runway overruns, but similarly received reports from participating pilots who described feeling "apprehension" when conditions became slippery as the landing roll progressed.

These tests showed that using just a portion of the runway to make instantaneous assessments could provide the flight crew ample information, essentially revealing critical aspects of braking ability in real time.

Simplified Ambient Conditions

There is a trade-off for flight crews between knowing ambient weather conditions in great detail and having the ability and time to properly assess them. Reports of meteorological conditions, such as temperature, air pressure, wind speed and wind direction, only provide approximate information and may not always be current. Wind and wind direction, air pressure, etc. have a declining impact on stopping capability as the aircraft slows during the landing roll. Accounting for the weather-condition impact at the initial phase of the landing roll would be complicated and, likely, in vain. The reason is that the end portion of the landing roll provides the information critical to understanding braking ability. Therefore, a simplified approach to gathering data on ambient weather conditions has proved sufficient in the Kongsberg Aeronautical system.

Runway slope also normally is taken into consideration among ambient conditions for takeoff and landing safety analysis by means of advisory data. However, runway slope is not a consideration in this system because the slope has, for practical purposes, an inconsequential effect. Runway slope rarely exceeds 2 percent, and most U.S. airports have slopes of less than 1 percent.

Aircraft Transferability

Braking coefficient values are the same for all types/sizes of aircraft. This principle was considered in TALPA ARC recommendations. Aircraft of different sizes may nevertheless experience differences in braking action, given the same objective runway surface conditions. This analysis did not include regional jets, but the analysis shows that there are commonalities and transferability between aircraft within categories, such as the 737 series and the Airbus A320 series. When comparing estimated landing distance, given similar braking action conditions and using aircraft manufacturer guidance material, there are clear parallels for these two aircraft series.

Pilot reports and feedback formed part of the initial phase of the braking action test program. Pilots evaluated situations in which the Kongsberg Aeronautical system detected braking action conditions that were less than good.[5] Landing data and their feedback revealed consistency with actual and prevailing weather conditions, indicating that the system was performing as expected and intended.

As part of today's Phase 2 validation process, FAA engaged the University of Massachusetts and a research group to perform an extensive analysis to assess the correlation between prevailing weather conditions and braking capability as derived from the system.

Because slippery runways are not just a winter problem, the analysis included airports in tropical locations. A foundation for the analysis was one year of information acquired from United's 737 fleet, with the associated and system-calculated airplane-based braking action figures. Historic weather information was consulted to obtain prevailing conditions for each airport that corresponded to the date and time of every landing that involved friction-limited braking conditions.

In summary, unless aircraft manufacturers can derive certified, perfect landing/stopping distances for any given variation of runway conditions, the aviation industry's primary goal must be to develop a system in compliance with guidance material and advisory data. Today, such advisory data is sorted into six "braking action" categories, according to the TALPA ARC matrix (Table 1, p. 38). Any attempt to furnish braking capability information with higher accuracy — beyond the level of advisory data — will not serve any practical purpose. Capturing the essence of the braking coefficient from the aircraft itself during each actual landing roll, however, could provide near-real time information to the flight crew.

Beyond Validation

In aviation, a system has no value unless it can provide the right data to the right users at the right time. This requires schemes for distribution and integration with appropriate user tools and interfaces. At United Airlines, upcoming and post-validation activities involve an early-phase integration with dispatcher tools.

The real potential in the Kongsberg Aeronautical system lies in pooling information from, ideally, all aircraft in service, although obtaining data from several large airlines may prove sufficient. With a common information pool, all airlines could benefit. The power of the system is in the aggregation of the collected information.

Even though airlines fiercely compete for the business of the traveling public, the aviation industry has a longstanding history of cooperation when it comes to safety. With such technology becoming available, it is time to more accurately and efficiently assess runway surface condition and braking capability through joint effort and cooperation among airlines.

Trond Are Johnsen is the general manager of Kongsberg Aeronautical, and has managed the test program since its beginning. His background includes development of technology from early phase to user applications.

Notes

1. Flight Safety Foundation. *Reducing the Risk of Runway Excursions: Report of the Runway Safety Initiative*. May 2009. Available at <flightsafety.org>.
2. NTSB. Accident Report NTSB/AAR-07/06, *Runway Overrun and Collision; Southwest Airlines Flight 1248, Boeing 737-7H4, N471WN; Chicago Midway International Airport, Chicago, Illinois; December 8, 2005*. Adopted Oct. 2, 2007.
3. These landing distances take into account air distance and safety margins for conditions other than *dry*.
4. Vizzoni, Joe. "Your Slip Is Showing." *AeroSafety World* Volume 8 (May 2013): 12–16.
5. Ibid.

APPENDIX D

Establish a minimum standard for 14 *Code of Federal Regulations* Part 121 and 135 operators to use in correlating an airplane's braking ability to braking action reports and runway contaminant type and depth reports for runway surface conditions worse than bare and dry. (A-07-63)

Demonstrate the technical and operational feasibility of outfitting transport-category airplanes with equipment and procedures required to routinely calculate, record, and convey the airplane braking ability required and/or available to slow or stop the airplane during the landing roll. If feasible, require operators of transport-category airplanes to incorporate use of such equipment and related procedures into their operations. (A-07-64)

4.2 Previously Issued Recommendation Resulting From This Accident Investigation and Classified in this R

As a result of the SWA flight 1248
the following urgent safety recommendati

Immediately prohibit all 14 *Code*
from using reverse thrust credit
(A-06-16)

This recommendation (previously
on May 8, 2007) is classified "Closed—U
Recommendation A-07-57 in section 2.3 of th

BY THE NATIONAL TRANSPORTA

Mark V. Rosenker
Chairman

Robert L. Sumwalt
Vice Chairman

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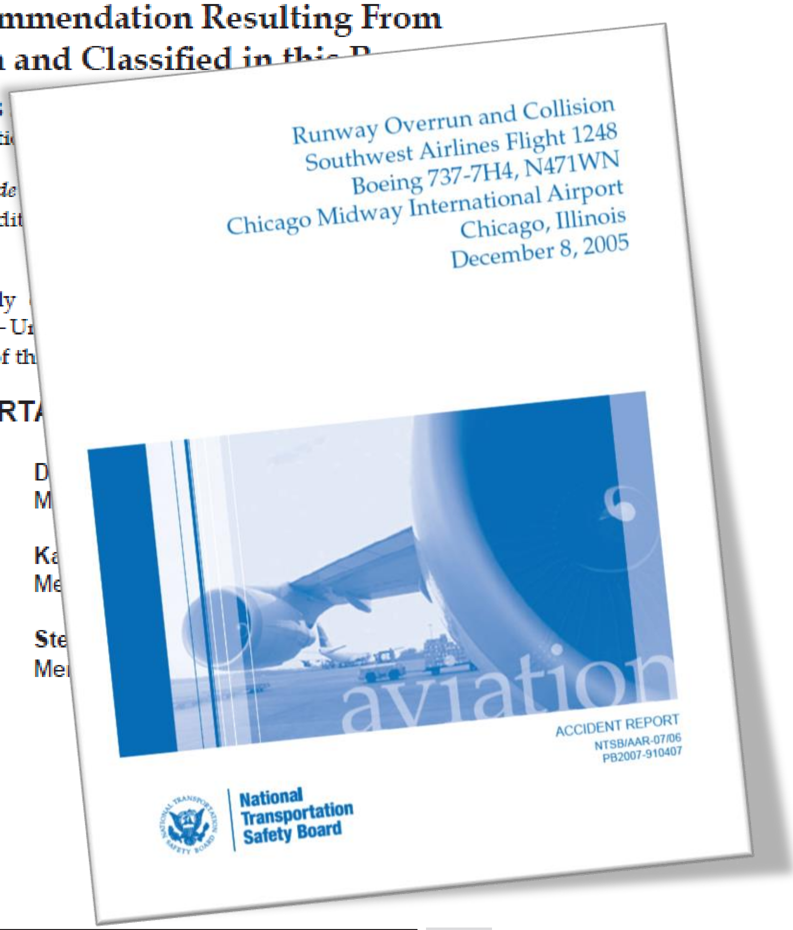
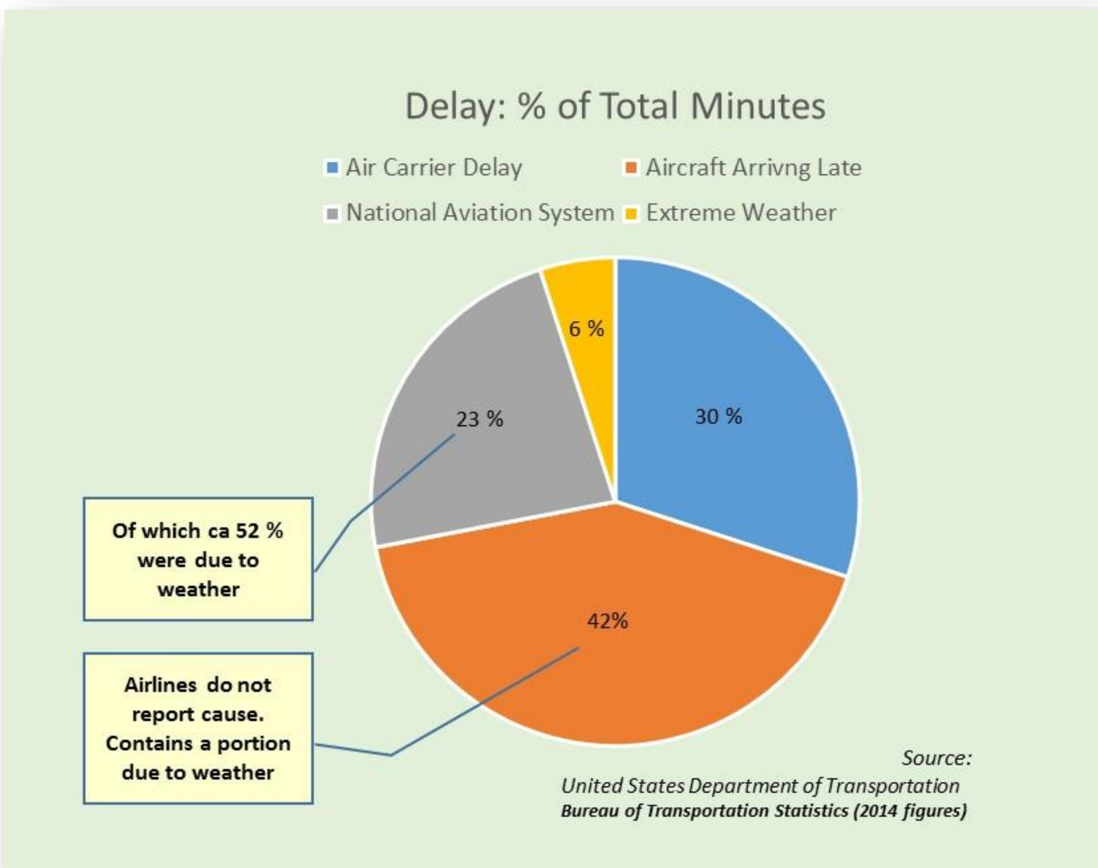
Adopted: October 2, 2007



APPENDIX E

According to Airlines for America, formerly known as Air Transport Association of America and an American trade association that represents the largest airlines, flight delays cost USD 25 billion in 2016.

Congested air space and weather are major constituents.



APPENDIX F

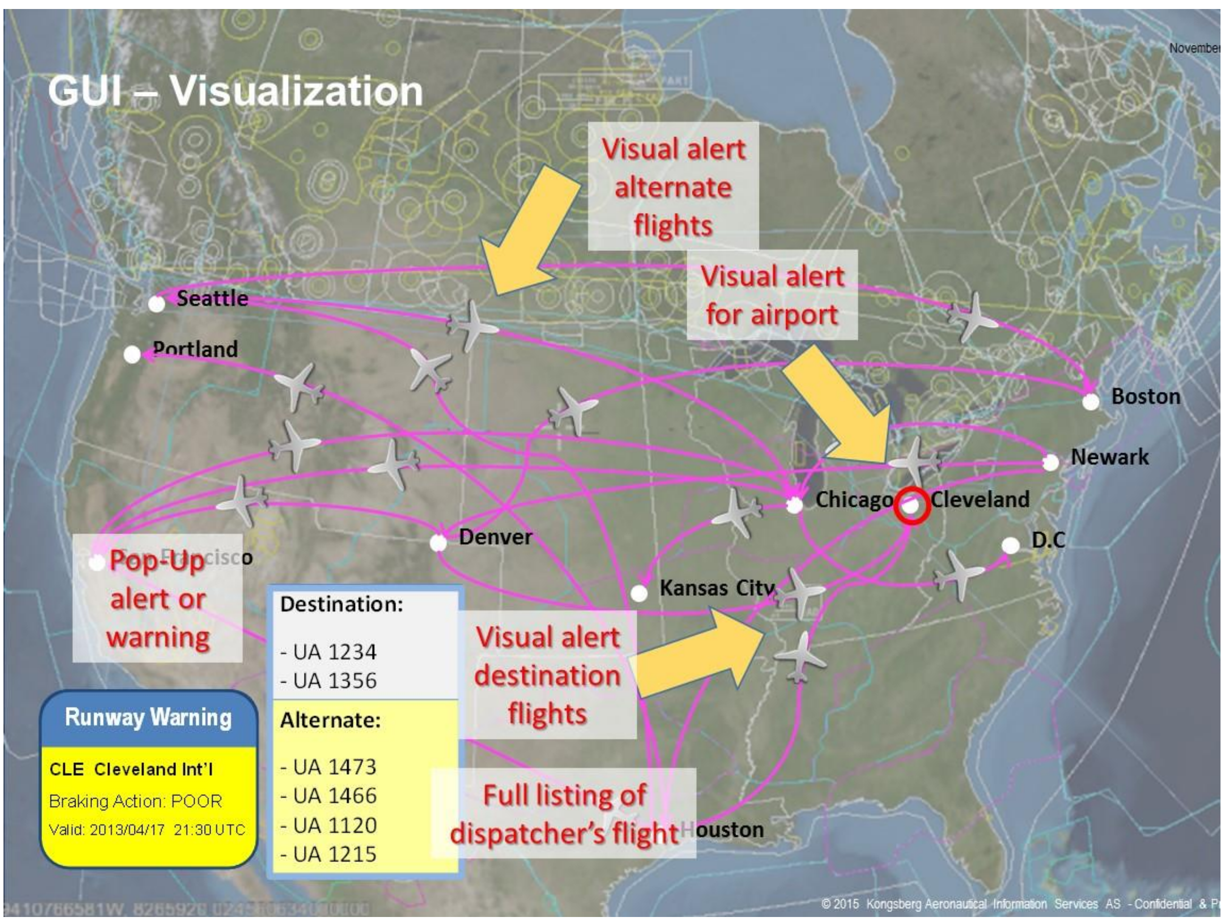
Graphical User Interface – Illustration

This illustrates in a simplified form interface of a desk top situational awareness program/application. Typically, a Flight Dispatcher monitor 15 – 20 flights during different phases of flight at any given time. For illustration purposes about 15 is this view.

A hypothetical Braking Action information of “POOR” in Cleveland is imposed in various forms to exemplify how this can be communicated to the Flight Dispatcher and subsequently the pilot individually or in combination. The illustration shows:

- A pop-up window with an alert or waring
- A visual alert in form of a red highlight (flashing) on the airport concerned
- A visual alert or marker on all flights having, in this case Cleveland, as destination.
- A visual alert or marker on all flights having, in this case Cleveland, as alternate destination. Such a flight, although not having the airport concerned as destination, would need to “re-dispatch” in event something should change at destination airport
- A window with listing of all fights with concerned airport as destination or alternate airport

Information will be filtered in such a fashion that Flight Dispatcher receives only critical and for flights only pertinent his/her monitoring responsibility.

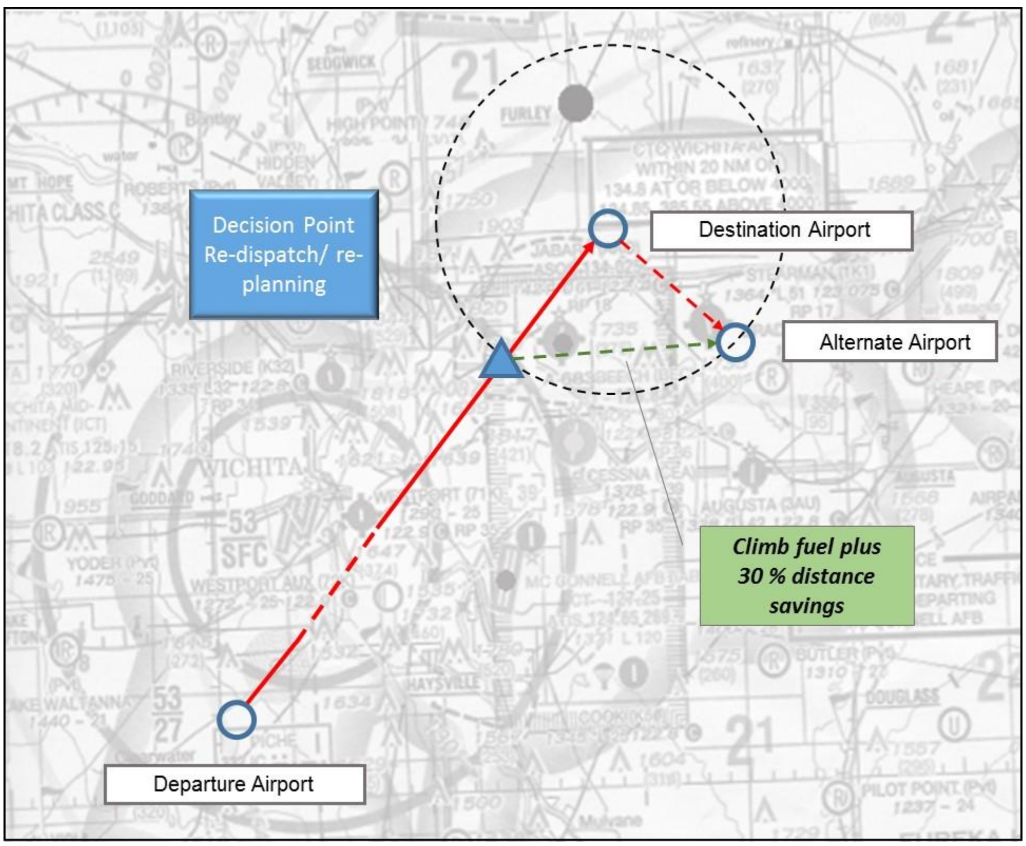


APPENDIX G

Flight Contingency Planning

Provide Braking Action information that is accurate, frequent, and timely, herein the ability to furnish flight operations with critical information earlier, will substantially improve contingency planning in event of deteriorating runway conditions.

The illustration below is a scenario where use of alternate airport is needed. An earlier situational awareness will yield fuel savings through avoidance of a missed approach and distance savings. Cost of such events for e.g. a B737 is about USD 650- 700 at current fuel price. With an event frequency of about 1- 1.5 % and an event avoidance of 25% due to the system, an airline such as United may see potential fuel savings of USD 3.5 - 4 mil per year. Airlines such as American, Delta and Southwest may see similar savings.



APPENDIX H

US Patent: 7 941 261 – Brake function based on controlling according to acceleration

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(1 of 6)

United States Patent	**7,941,261**
Johnsen	**May 10, 2011**

Brake function based on controlling according to acceleration

Abstract

A brake controller function to optimally brake a wheel of a vehicle in motion, such as an aircraft. The brake pressure control self regulates by means of applying brake pressure in accordance with vehicle acceleration information and the change in acceleration over time in the horizontal plane. Vehicle acceleration and information about its change enable a brake pressure control function to determine the brake pressure associated with maximum obtainable retardation for a vehicle at that given point in time. By continuously monitoring acceleration change and detecting retardation pinnacles, the culmination and turning points of retardation, with their associated brake pressure, maximum braking ability is assured at any given time. By applying acceleration data in real time as a controls reference in a brake logic control function to increase or reduce brake pressure, such a brake control function will assure a brake pressure perfectly fit with net of all the forces that a vehicle is subjected to. It will ensure optimal brake level with respect the vehicle tire/pavement surface interface.

Inventors:	***Johnsen; Oddvard*** (Lier, **NO**)
Family ID:	**34859261**
Appl. No.:	**10/599,783**
Filed:	**April 15, 2005**
PCT Filed:	**April 15, 2005**
PCT No.:	**PCT/NO2005/000116**
371(c)(1),(2),(4) Date:	**October 10, 2006**

http://patft.uspto.gov/netacgi/nph-Parser?Sect1=PTO2&Sect2=HITOFF&p=1&u=%2Fnetahtml%2FPTO%2Fsearch-bool.html&r=1&f=G&l=50&co1=AND&d=PTXT&s1=Oddvard&s2=Johnsen&OS=Oddvard+AND+Johnsen&RS=Oddvard+AND+Johnsen

The patent describes a brake controller logic utilizing g-force or acceleration to provide optimum braking. In its claims, this “logic” is “reversed”, thus taking use of the same principle to find the maximum braking capability. This is the basis for the current onboard algorithm and program software.