



Using Aircraft as a Sensor on Contaminated Runways

In any analysis of aviation accidents, Runway Excursions (RE) are usually identified as the top cause of aircraft hull losses. Many of these accidents occur on runways where braking performance is degraded by runway surface contaminants.

Airbus and its subsidiary NAVBLUE have developed a new technology to use the aircraft itself as a sensor to measure the available runway braking action, and subsequently share that data to the benefit of oncoming traffic.



RUNWAY EXCURSIONS AND THEIR CAUSES

In the world of commercial jets, it is well known that Runway Excursions (RE) are one of the top three types of accident.

Accident statistics show that RE caused 35% of hull-losses and 14% of fatal accidents between 1998-2017. Given this status, Airbus and other manufacturers are investing in development of technology to reduce RE accidents.

Product features such as Airbus' ROPS (Runway Overrun Prevention System) are already in service and providing real time energy and landing performance monitoring information to flight crews.

However, accurate knowledge of the runway condition is also key for the validity of landing performance computations, and a clear case can be made for the need to improve pilot awareness of runway surface conditions.

Indeed, national Safety bodies including the NTSB of the USA and the UK AAIB have identified the need to develop "an operationally feasible airplane-based braking ability / runway surface condition measurement and communication system".

Today's Means of Measuring Runway Surface Conditions

Today, there are typically three methods available by which runway surface conditions are evaluated:

- Runway contaminant type and depth observations
- Ground surface friction measurements
- Braking action reports from pilots

Contaminant type and depth observations are in general physically conducted by airport personnel on the runway surface. The conditions are assessed through a combination of visual observations and spot-checks. However, it can be a difficult task to consolidate what may be differing conditions across the entire width and length of the runway into a succinct runway condition report.

“ IATA data show that 25% of Runway Excursions occur on contaminated runways ”

“ During raining or freezing/melting conditions, the validity of runway condition information may become outdated soon after it is issued ”

In addition, during active precipitation and/or freezing/melting conditions, the validity of the information may become outdated soon after it is issued.

Ground surface friction measurements provide a more quantitative approach to taking measurements along certain points on a runway. However, as noted by the NTSB, they are useful for identifying trends in runway surface condition but are not recommended for use in predicting aircraft stopping performance.

This is due to the lack of correlation with aircraft braking performance, as well as variability in equipment design and calibration.

While the airport operator is responsible for generating the Runway Condition Codes for a runway, pilots are responsible for providing accurate braking action reports. Indeed, providing braking action reports is a significant role that pilots play in preventing runway excursions for all airplanes.

Braking action reports contain the pilot's assessment of the manner in which an aircraft responds to the application of wheel brakes. The latest terminology for these reports is identified by rulemaking activity from the ICAO, the FAA, and the EASA, and is explained in Table 1.

Under these new rules, which are expected to become the applicable worldwide standard in November 2020, pilots will be required to radio braking action reports to ATC whenever they are requested, or if the pilot has assessed braking action is less than previously reported. ATC will be required to relay information to airport operators, and depending on the situation, to other pilots in approach.

The forthcoming rules also define the expected response from airports if runway surface conditions deteriorate enough that two consecutive reports of 'Poor' conditions are received. In this case, the airport will be expected to re-assess the runway conditions. Additionally, if "Less Than Poor" braking action is reported, the runway will be closed to further operations until the airport operator can improve the runway's condition.

These reports thus play an important part in the cycle of runway surface condition assessment and reporting.



DEFINITION OF TERMINOLOGY FOR PILOT BRAKING REPORTS AND RUNWAY CONDITION ASSESSMENT

The definition of standards for runway condition terminology was initiated in 2005 by the FAA with several airlines.

Subsequently, the TALPA Aviation Rulemaking Committee (ARC) was formed by the FAA to make recommendations on improving safety of operations on wet or contaminated runways, for both take-off and landing. This committee consisted of airlines/ aircraft manufacturers, airport operators, dispatchers and regulators.

The overall aims of TALPA were to identify an improved way of assessing runway conditions based on contaminant type, in order to provide operators with effective means of anticipating braking performance.

Two major outcomes of this activity have been the definition of the Runway Condition Assessment Matrix (RCAM), and the Runway Condition Code (RWYCC). The RCAM is a matrix with assessment criteria, allowing identification of an RWYCC using a set of observed runway surface conditions and pilot reports of braking action.

This means of performing runway condition assessment, and format for pilot reports, has been in place in the US since October 1st 2016.

To advance global rulemaking based on the RCAM / RWYCC approach, ICAO has issued State Letters 2016/12 and 2016/29. Additionally, EASA has issued Notice of Proposed Amendment (NPA) 2016-11 in order to align with ICAO. A decision is expected to be published by EASA in Q3 2018.

Table 1: Runway Condition Codes (RWYCC) definitions for contaminated runways

Note: Runway Condition Code 6 identifies normal braking behaviour on a dry and uncontaminated runway

Description of vehicle deceleration, or directional control observation	Pilot reported braking action	Runway Condition Code (RWYCC)
	N/A	6
Braking deceleration is normal for the wheel braking effort applied AND directional control is normal	GOOD	5
Braking deceleration OR directional control is between good and medium	GOOD TO MEDIUM	4
Braking deceleration is noticeably reduced for the wheel braking effort applied OR directional control is noticeably reduced	MEDIUM	3
Braking deceleration OR directional control is between medium and poor	MEDIUM TO POOR	2
Braking deceleration is significantly reduced for the wheel braking effort applied OR directional control is significantly reduced	POOR	1
Braking deceleration is minimal to non-existent for the wheel braking effort applied OR directional control is uncertain	LESS THAN POOR	0

“ Making an accurate braking report can be difficult for a pilot because it relies on their subjective experience of the landing ”

“ BACF uses the data recorded by the aircraft during its deceleration roll to identify the braking level ”

DIFFICULTIES INVOLVED IN MAKING BRAKING ACTION REPORTS

Aeroplane deceleration results from several forces: aerodynamic drag forces, generated by the airframe and in particular the ground spoilers; reverse thrust, if available; wheel braking.

In general, a braking action report should characterize the availability (or lack thereof) of wheel braking. The difficulty for a pilot is in differentiating in real-time, which portion of the total deceleration is coming from the wheel-brakes. This difficulty is compounded by the typical use of autobrakes on contaminated runways. As the autobrake commands an overall airplane deceleration rate, the pilot is able to detect a lack of wheel-braking when the target deceleration is not achieved, however it is still difficult to differentiate how much each component is contributing to the deceleration.

Once the aircraft decelerates to lower speeds (generally below 60kt), pilots often use manual braking and at these speeds the aerodynamic drag and reverse thrust forces are negligible. It is often in this zone where pilots are able to more easily “feel” the runway by using the brake pedals to understand the braking action.

Given these complexities, making an accurate report can be a difficult task for a pilot, and braking report quality can become subject to differences of subjectivity between different pilots. To resolve this and provide objective and consistent braking action reports, Airbus has developed technology which uses aircraft data measured during the ground run to identify the available braking action.

USING THE AIRCRAFT AS A SENSOR TO MEASURE RUNWAY CONDITION

Braking Action Computation Function

Airbus has been developing a new aircraft function to address the need identified by the NTSB and other national aviation Safety bodies, for “an operationally feasible airplane-based braking ability / runway surface condition measurement and communication system”.

The implementation of this function on Airbus aircraft is called the “Braking Action Computation Function’ (BACF”.

The fundamental principle of the function is, post landing, to use the data measured by the aircraft during its deceleration roll to identify the braking action level. By using the aircraft performance model, it is possible to differentiate the part of deceleration coming from either aerodynamic, thrust reverse, or wheel-braking.

Subsequently, by comparing the actual wheel braking performance to models of wheel-braking performance under different “reference” runway conditions, the runway state which most closely resembles the experienced deceleration is determined.

Additionally, using GPS data available from the aircraft navigation systems, it is possible to identify which section of the runway the aircraft is on when a runway state is identified. The function can identify several states at different points on the runway.

A few seconds after the aircraft speed has decreased below 30kts, details about the runway state become available to the pilot on a dedicated MCDU page **(fig.1)**. If the pilot felt that the runway was slippery, or in a different condition to that communicated by Air Traffic Services (ATS), this information can be accessed by the pilot and radioed to ATS at an appropriate moment.



(fig.1)
Example MCDU screen
with runway state outputs
from the BACF

RunwaySense by NAVBLUE

As shown in **(fig.2)**, in addition to the information available to the pilot through the MCDU, the data calculated by BACF is also sent automatically by ACARS message to NAVBLUE.

NAVBLUE will collect and display the results on a web-service platform called RunwaySense. The users of this service are expected to include airports, airline operational centres, and air traffic control.

This technological approach is similar to the various mobile traffic applications which share traffic data in real-time to allow drivers to see and avoid traffic jams.

Indeed, the goal of this new Airbus-NAVBLUE technology is to provide a platform where airspace users are sharing reports in real-time to better understand how the runway condition is trending, and to allow the airport to anticipate and mitigate slippery conditions. The more aircraft which participate in the sharing, the better the real-time map of conditions becomes.

“ The goal is for airspace users to share reports in real-time, to better understand how the runway condition is trending ”

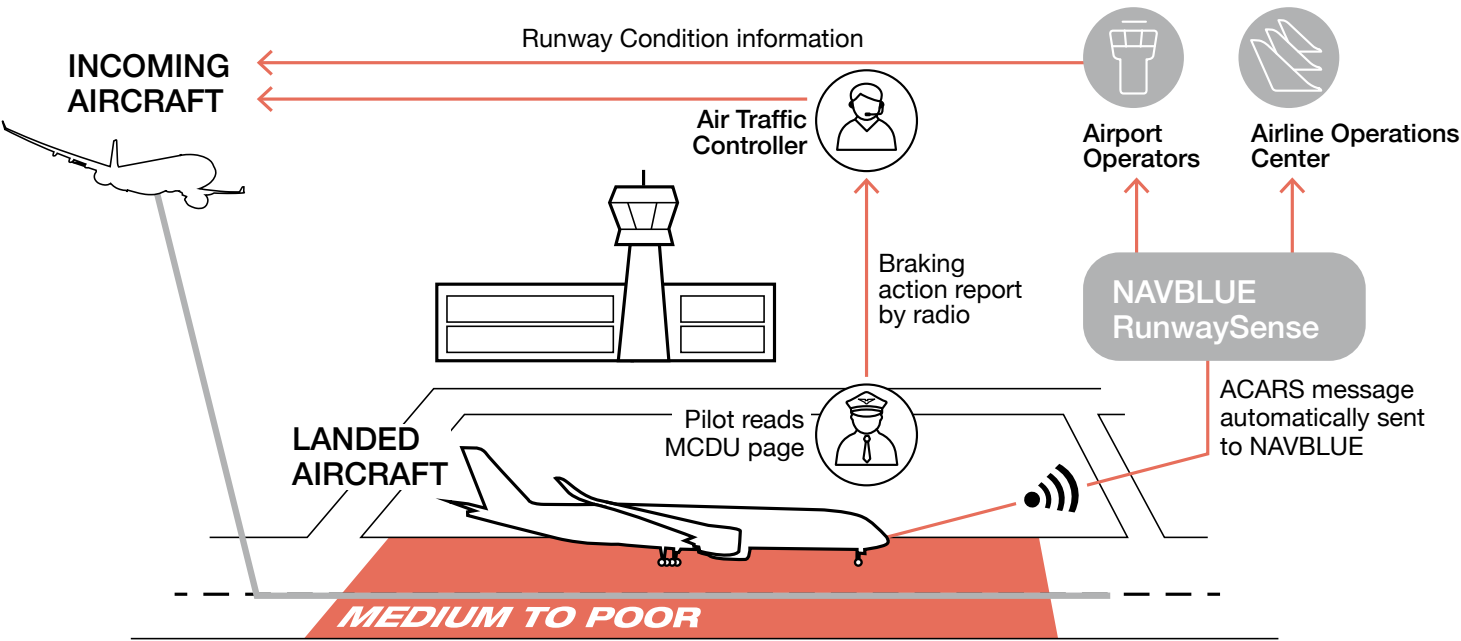
AIRCRAFT

Using Aircraft as a Sensor on Contaminated Runways

Users of the service will be able to view runway condition information across a whole airport, or, as shown in **(fig.3)**, on an individual runway. Airport level information will provide a high level status of the airport across the different runways, whilst runway level information will enable users to check runway condition trends versus different climatic conditions such as winds, temperatures and humidity.

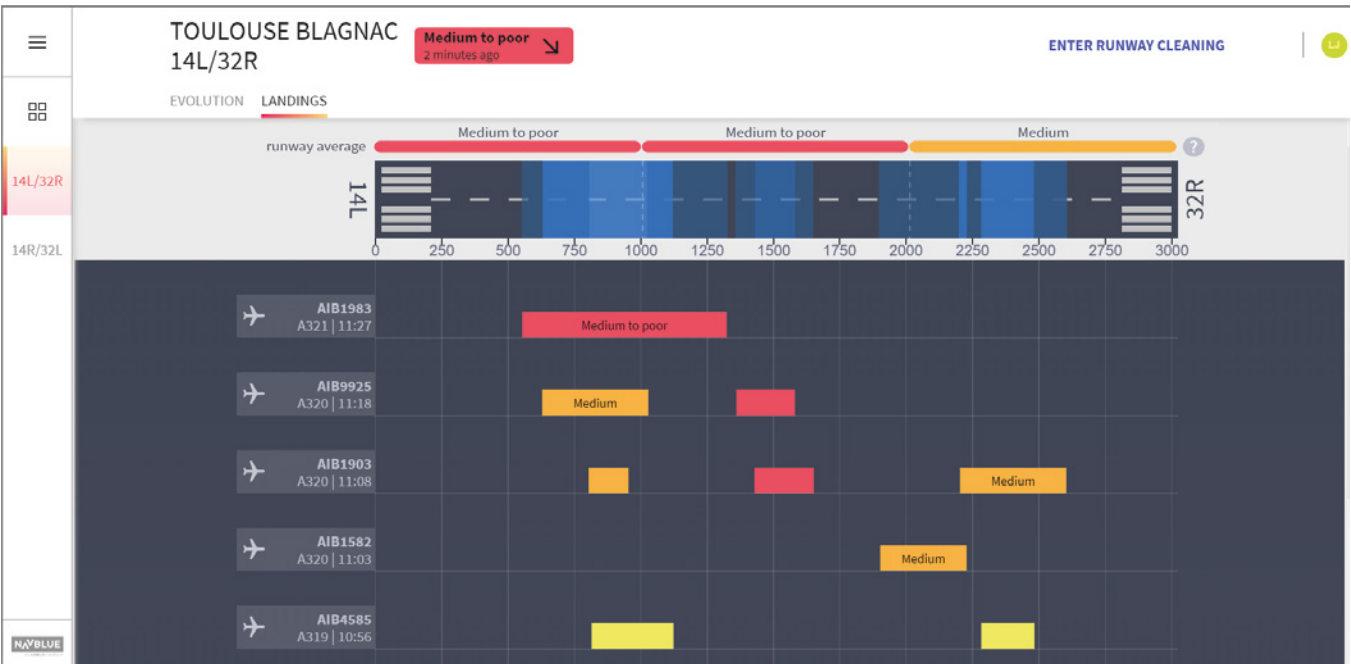
(fig.2)

Integration of BACF & NAVBLUE's RunwaySense within airport and airline operations



(fig.3)

NAVBLUE's RunwaySense app illustrating a detailed view of a runway, including runway state information from recently landed aircraft



DEVELOPMENT & TESTING

The development of prototype BACF technology was started by Airbus in 2015. Subsequently, in-service testing with selected airlines has been ongoing since November 2017.

With over 50,000 in-service flights monitored to date, the function has indeed demonstrated its ability to detect runway contamination and identify the runway condition.

The most relevant experience during the in-service trials occurred when data from BACF equipped aircraft landing at a European airport during snowy weather was reviewed and found to have consistently identified a change in braking action following increased snowfall.

As shown in **(fig.4)**, with an initial covering of 2 mm of wet snow, the ATC was reporting “GOOD TO MEDIUM” (RWYCC 4) runway conditions to oncoming aircraft.

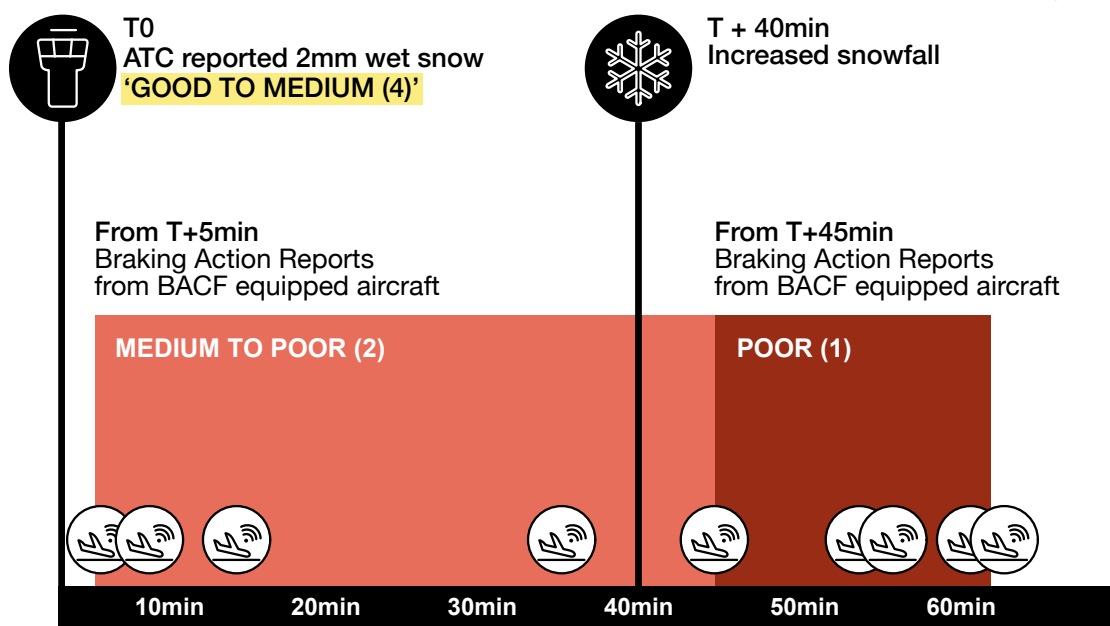
After that report, and over the course of approximately 35 minutes, 4 different aircraft equipped with BACF landed on the runway and recorded “MEDIUM TO POOR” (RWYCC 2) braking action. This demonstrated the advantage in accuracy gained by using aircraft as a sensor.

At around 40 minutes after the initial ATC report, the snowfall increased. Runway condition measurements subsequently recorded by five aircraft measured “POOR” (RWYCC 1) braking action. This highlighted the potential benefits for airports to receive real-time measurement data, for the management of operational safety.

“ With over 50,000 in-service flights to date, the function has indeed demonstrated its ability to identify the runway condition ”

(fig.4)

In-service testing in snow conditions illustrated the advantage of using aircraft as a sensor to identify the runway state



COMMERCIAL AVAILABILITY

Technical Availability

Initial availability of the BACF will be for A320 Family aircraft. A controlled Entry Into Service (EIS) is scheduled to start from September 2018 with six candidate airlines, leading to retrofit availability in mid-2019 and line-fit availability by the end of 2019.

A330 family aircraft will be the second program for which the function will be made available. Initial installation is expected to occur in 2020.

Selection of the function will be possible during the aircraft definition process. It will also be available for retrofit, by downloading an Airline Operations Centre (AOC) application onto the Air Traffic Service Unit (ATSU).

Decisions regarding availability of BACF on A350 XWB and A380 programs will be concluded over the course of 2019.

The function will not be available for A300/A310 aircraft.

Commercial Conditions

BACF and the RunwaySense collaborative web-platform are integrated as part of the overall RunwaySense Service from NAVBLUE.

The operational & safety benefit comes from sharing the data. To maximise the facilitation of the information, Airbus & NAVBLUE decided to make the BACF software Free of Charge (FOC) provided that airlines share the BACF ACARS messages through the RunwaySense platform.

The BACF software consists of an ATSU AOC application and will be available as an Airbus Service Bulletin.

All airlines which contribute will have basic access to the RunwaySense web platform where they can visualize and track all the BACF reports sent by their aircraft. Airlines can also choose to receive additional information about flight conditions at key airports in their route network.

For airport and ATC users, access to the NAVBLUE RunwaySense web platform will be possible through a paid subscription.

CONTRIBUTORS:

Fabien MOLL

BACF Project Leader
Design Office

Logan JONES

Runway Safety Specialist
NAVBLUE

Lars KORNSTAEDT

Aircraft Performance Expert
Flight Operations Support

Adrien CHEN

Director Product Safety
Enhancement
Product Safety

Runway Excursions (RE) are a top cause of accidents. IATA data show that 25% of them occur on contaminated runways. Measuring the runway condition is therefore a key element in preventing RE events.

Braking action reports from pilots are one of the three main ways of identifying runway contamination levels. These contain the pilot's assessment of the manner in which an aircraft responds to the application of wheel brakes.

Making an accurate report can be a difficult task for a pilot, and braking report quality can become subject to differences of subjectivity between different pilots.

To resolve this and provide objective and consistent braking action reports, Airbus has developed technology which will use aircraft data recorded during the landing roll to identify the available braking action.

In 2018, Airbus & NAVBLUE will start commercialisation of the technology and associated web service to objectively measure & disseminate runway braking action information.

This service will allow airports, airlines, and ATC to understand how the runway condition is trending, and will allow airports to anticipate and mitigate slippery conditions.

The technology will first be available in 2018 for A320 family aircraft, followed by A330 aircraft types in 2020. Decisions about availability on A380 and A350 XWB aircraft will be concluded over the year 2019.

Safety first

The Airbus magazine contributing to the enhancement of the safety of aircraft operations by increasing knowledge and communication on safety related topics.

Safety first, #26 July, 2018. Safety first is published by Airbus S.A.S. - 1, rond point Maurice Bellonte - 31707 Blagnac Cedex/France.

Publisher and Editor: Yannick Malinge, Chief Product Safety Officer.

Concept Design by Airbus Multi Media Support 20180451. Reference: X00D16031905 Issue 26.

Photos by Airbus, P. Pigeyre, g-stockstudio, H. Goussé, I. Howarth, F. Lancelot.

Cover: J. Darcy.

This brochure is printed on Stucco.

This paper is produced in factories that are accredited EMAS and certified ISO 9001-14001, PEFC and FSC CoC. It is produced using pulp that has been whitened without either chlorine or acid. The paper is entirely recyclable and is produced from trees grown in sustainable forest resources. The printing inks use organic pigments or minerals. There is no use of basic dyes or dangerous metals from the cadmium, lead, mercury or hexavalent chromium group.

© Airbus S.A.S. 2018 – All rights reserved.
Proprietary documents.

By taking delivery of this Brochure (hereafter "Brochure"), you accept on behalf of your company to comply with the following guidelines:

» No other intellectual property rights are granted by the delivery of this Brochure than the right to read it, for the sole purpose of information.

» This Brochure and its content shall not be modified and its illustrations and photos shall not be reproduced without prior written consent of Airbus.

» This Brochure and the materials it contains shall not, in whole or in part, be sold, rented, or licensed to any third party subject to payment.

This Brochure contains sensitive information that is correct at the time of going to press.

This information involves a number of factors that could change over time, effecting the true public representation. Airbus assumes no obligation to update any information contained in this document or with respect to the information described herein.

Airbus S.A.S. shall assume no liability for any damage in connection with the use of this Brochure and of the materials it contains, even if Airbus S.A.S. has been advised of the likelihood of such damages.

Safety first is published by the Product Safety department. It is a source of specialist safety information for the use of airlines who fly and maintain Airbus aircraft. It is also distributed to other selected organizations and is available on digital devices.

Material for publication is obtained from multiple sources and includes selected information from the Airbus Flight Safety Confidential Reporting System, incident and accident investigation reports, system tests and flight tests. Material is also obtained from sources within the airline industry, studies and reports from government agencies and other aviation sources.

All articles in Safety first are presented for information only and are not intended to replace ICAO guidelines, standards or recommended practices, operator-mandated requirements or technical orders. The contents do not supersede any requirements mandated by the State of Registry of the Operator's aircraft or supersede or amend any Airbus type-specific AFM, AMM, FCOM, MMEL documentation or any other approved documentation.

Articles may be reprinted without permission, except where copyright source is indicated, but with acknowledgement to Airbus. Where Airbus is not the author, the contents of the article do not necessarily reflect the views of Airbus, neither do they indicate Company policy.

Contributions, comment and feedback are welcome. Enquiries related to this publication should be addressed to:

Airbus

Product Safety department (GS)

1, rond point Maurice Bellonte
31707 Blagnac Cedex - France
Fax: +33(0)5 61 93 44 29

safetycommunication@airbus.com

Safety first app available here

