Runway Excursion Risk Assessment Diagram

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Abstract

ICAO SMM[1] defines Safety Assurance as "something that gives confidence". There is a clear lack of confidence when assessing the risk of a runway excursion in our operations, due to the amount of risk factors involved, the combination between them, and the imprecision of some of them. Based on recommendations made by the Flight Safety Foundation we have created a diagram that aims to summarize most of these parameters, creating a tool that allows to define a universal Runway Excursion Risk Indicator. Applying this Diagram to the Operation it is easy to identify critical airports, calculate the impact of inoperative thrust reverser or contaminated runways, and numerically assess the risk of each factor involved in an unstable approach.

Introduction

The problem we have solved

- A definition of a simple and universal Runway Excursion Risk Indicator, improving the actual risk assessment performed using the common risk indicators related to the unstable approaches.
- A creation of a graphical tool to calculate the impact of most of the risk factors involved in a runway excursion.
- A process to perform quick risk assessment of our current or future destinations and propose effective risk mitigation actions based on targets for this Indicator.

Why isn't the problem already solved?

- An unstable approach is a common precursor of a runway excursion, but some studies show that even a 100% rate for stable approaches would only reduce the total number of runway excursions by up to 10%[2]. That means that indicators only based on events involved in an unstable approach do not give enough information about the real risk.
- The impact and the combination of risk factors, such as contaminated runways, braking performance limitation factors, and any approach parameter deviation, are difficult to assess. Thus, it is hard to get an accurate value for the Safety Margin of any single risk factor.
- Since traditional runway excursion risk assessment is performed using indicators based on particular fleet SOP deviations in the approach phase, they are not suited for comparing the risk of suffering a runway excursion between operators.

Why is our solution effective?

- Based on risk factors rather than SOP deviations, integrating them in one single diagram, and combining parameters obtained from different sources, such as manufacturers, aerodromes, and flight data, allows the creation of a simple tool that may be used by all the operators in order to perform an accurate runway excursion risk assessment.

- By calculating the Runway Excursion Risk Indicator for every aerodrome, the operator can easily identify critical runways and quickly propose risk mitigation actions. The value of this Indicator is a universal value, independent of the operator, manufacturer or aerodrome, and it defines a risk comparison method between operators.

Paper structure

- The rest of this paper first discusses related work in Section 2, and then describes our implementation in Section 3. Section 4 describes how we evaluated our solution and presents the results. Finally Section 5 presents our conclusions and proposes future work.

Related Work

The Runway Overrun Prevention System (ROPS)

- Following the importance of this issue, the industry has recognized the need to make significant efforts in this direction. It is the case of ROPS developed by Airbus. This system allows a permanent real time protection, with a Go Around oriented warning function during approach and a stop oriented active protection function on ground. Since it is a protection system its performance will be limited to the case when a reaction is required, being kept in the background when the parameters are not close to the limit. Continuously monitoring these parameters, even if they are far from the limit, would give a picture of current landing performance in the whole operative scenario, acting as a preventive system and adding an additional safety barrier beyond the active protection proposed by Airbus.

The Runway Excursion Risk Awareness Tool [3]

- The importance of developing effective mitigation for overruns cannot be overstated by regulators and international organizations. It is the case of Flight Safety Foundation which made great efforts on developing a toolkit that may help crew to improve awareness of factors that can increase the risk of a runway excursion. This tool effectively assesses the risk of each contributing factor involved by indicating a number of warning symbols. Although this is a preventive tool, it is not intended to calculate the risk for each flight. Besides the checklist performed by Flight Safety Foundation, a set of recommended mitigations are proposed. These recommendations have been the main guide for developing our solution.

Implementation

The Runway Excursion Risk Assessment Diagram

Our solution consists of a graphical tool that combines information from different sources: specific aircraft information, runway conditions, and approach parameters, all in order to improve and simplify the runway excursion risk assessment process. In particular:

- To perform a numeric risk assessment giving a Runway Excursion KPI for each flight, airport and operation.

- To calculate the impact and the safety margins for each parameter usually involved in a runway excursion.
- To contribute in the investigation of runway excursion incidents and accidents, helping to find root causes and combined risk factors.
- The construction of this diagram is detailed step by step in order to help the reader to build it using his own data, and finally multiple applications are described on the evaluation process.

Parameters considered

i. Groundspeed [V]

ii. Real available landing distance [D]

iii. Maximum deceleration available [a_{max}]

Obtaining the parameters

iv. Groundspeed [V].

v. A valid range for [V] is between zero and V_{mo}

vi. Real available landing distance [D].

vii. A valid range for [D] is between zero and the total runway length considered

viii. Maximum deceleration available [a_{max}]

It could be calculated, for example, from a combination of the following factors:

- Runway conditions / type of contamination
- Runway slope
- Type of braking / Auto Braking
- Thrust reverser
- Aircraft flap/slat configuration
- Aircraft weight

Depending on the aerodrome, the aircraft and the conditions considered a set of parameters [a_{max}] would be determined. As an operator we would eventually get a set of parameters [a_{max}] for each fleet type and airport.

Data source

Obtaining the maximum deceleration available [a_{max}] is the key to determine your limit and calculate your safety margin. However, there are several ways to get these values and it should not be a difficult task. In Figure 1 we present a list of possible data sources for each mentioned factor that contributes to the maximum deceleration available.

FACTOR	SOURCE
Runway conditions / Type of contamination	Aerodrome / Aircraft Manufacturer
Runway slope	Aerodrome
Type of braking / Auto Braking	Aircraft Manufacturer
Thrust Reverse	Aircraft Manufacturer
Aircraft Flap/Slat configuration	Aircraft Manufacturer
Aircraft Landing weight	Aircraft Manufacturer

Figure 1: Possible sources for getting values of the maximum deceleration available

Although the accuracy of the parameters obtained is important, our tests proved that the results are consistent for slight variations of these parameters, and in most cases high-precision values are not needed to perform a day-to-day risk assessment.

Creating the Data Base

Combining the parameters obtained ([V], [D], and a set of [a_{max}]) allow the creation of a data base.

Previous investigations[4] define a data base sort criteria that can be applied in this case, using the parameters above to create a table or a diagram. Each value of [a_{max}] defines a table or a *curve* applying the following kinematic equation.

$$[V] = \sqrt{2 \cdot [a_{max}] \cdot [D]}$$

For a valid range of parameter [D] a value of [V] can be calculated, giving a table of values as a result that can be used for plotting a diagram.

The Diagram

Plotting the kinematic equation in a diagram we obtain a curve for each maximum deceleration available. Each curve gives the landing distance [D] needed for decelerate from groundspeed [V] to stop applying the maximum deceleration available [a_{max}] calculated from a particular braking condition. An example is shown in Figure 2.

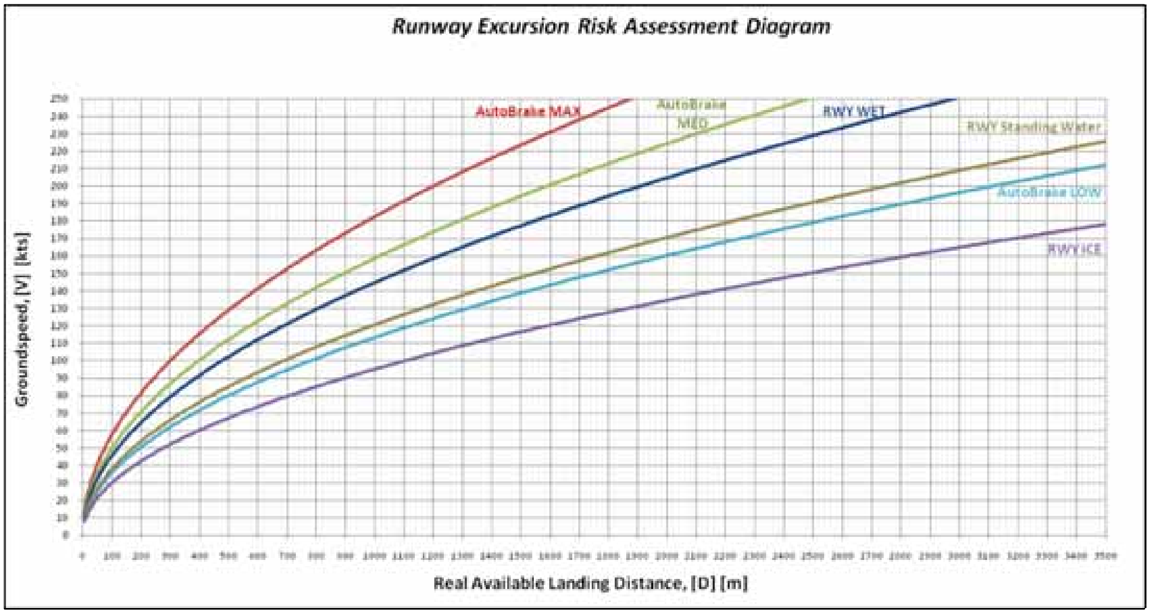

Figure 2: Example of a Runway Excursion Risk Assessment Diagram

Flight data can be used for every flight to capture the value of the Air Distance used during the flare and the Groundspeed value at touchdown. Using the runway length a single dot (*Touchdown point*) can be plotted in the diagram. Figure 3 shows an example of a Touchdown point and the resulting distances from the flare to the aircraft stop.

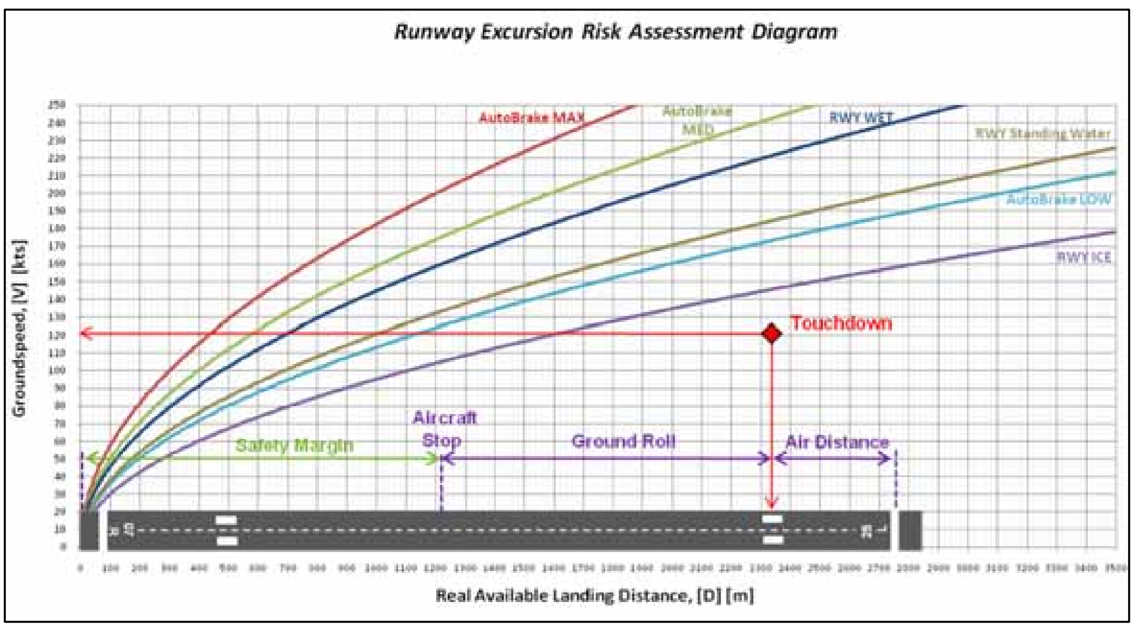

Figure 3: Example of a Touchdown Point and the Information Obtained from the Diagram

The Risk Zone

Since each curve represents a maximum deceleration rate for a particular condition, two areas are defined. The area *above* each curve represents excessive values for Air Distance used and Groundspeed at touchdown which may cause a runway excursion if the braking conditions are the same that those used to calculate this particular curve.

Taking a set of curves, three zones are defined (see Figure 4): a *Safety Zone* where all touchdown values can avoid a runway excursion, a *Runway Excursion Zone* where the values are beyond the limit allowed by the curve calculated using the maximum deceleration rate, and finally a *Risk Zone* where a runway excursion may be suffered depending on the braking conditions applied.

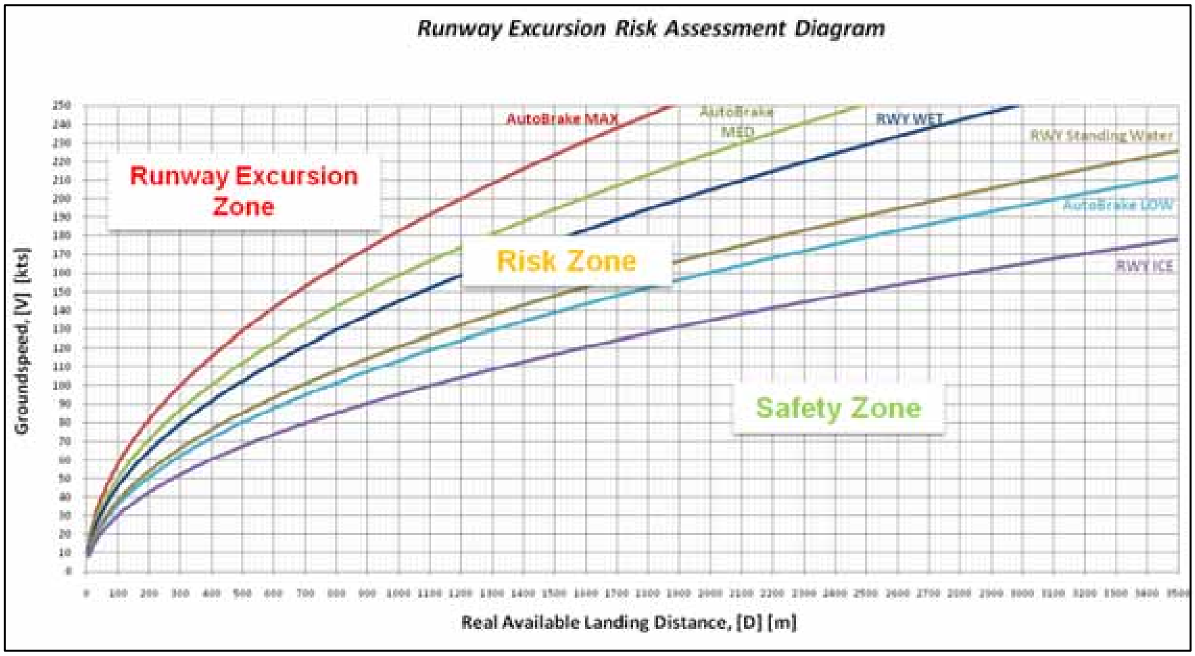

Figure 4: The Risk Zone

The Runway Excursion Risk Indicator (RWY EXC KPI)

A valid RWY EXC KPI can be calculated for each flight, by taking the distance between its Touchdown Point and a curve. This value represents the *risk of suffering a runway excursion if the braking conditions are the same as those used to calculate this particular curve* (Figure 5).

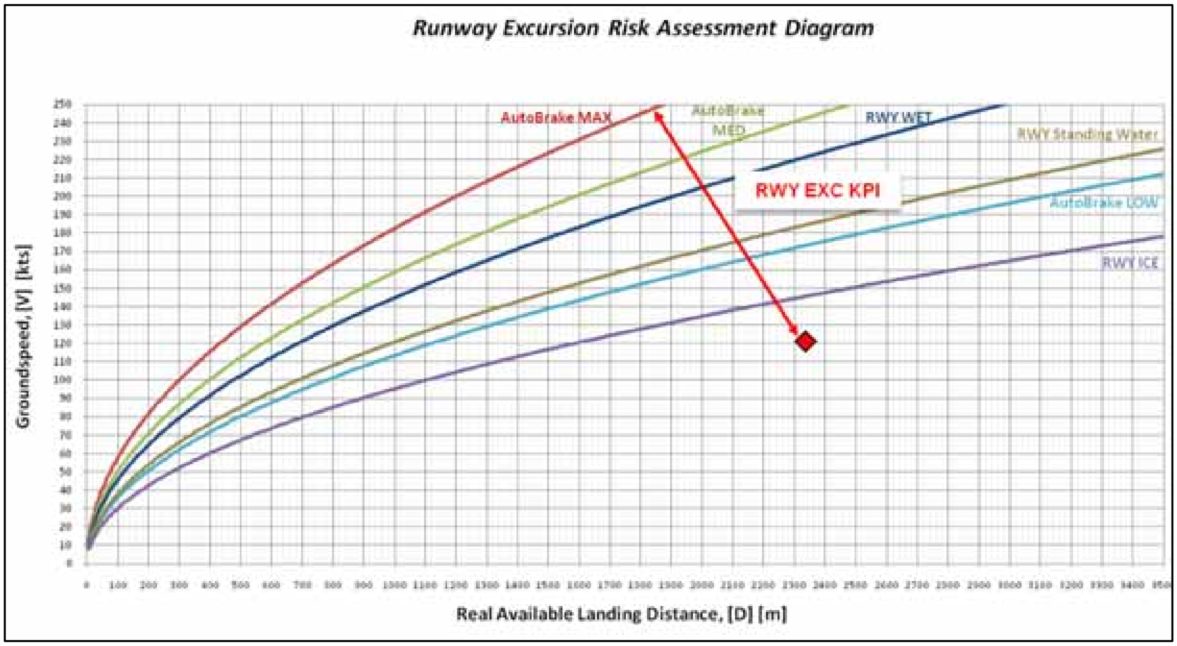

Figure 5: Definition of the RWY EXC KPI

It is important to highlight that, if the units used to draw the diagram are constant ([m], [kts], for example), the RWY EXC KPI value is *universal* and not dependent on the aircraft type, airport or operator:

- Every flight can be summarized by the groundspeed at touchdown, the y-coordinate of the touchdown point in the diagram. As an instance, a single-engine light aircraft will have a lower value than a commercial passenger jet.
- Every runway length combined with the air distance used during the flare can be used to calculate the real available runway length, the x-coordinate of the Touchdown Point in the diagram. Longer runways have higher values of the x-coordinate.
- Every braking type or runway condition defines a curve. Taking information about the braking performance from the manufacturer, a set of curves can be drawn.

Even if the curves may be different between aircraft models, a distance between the Touchdown Point and a curve can be calculated, and this value always represents a runway excursion risk indicator for a particular braking condition.

Evaluation

How we tested our solution

Three tests have been designed to show the potential of the tool, considering real risk assessments performed in our operation and closing the loop by presenting the actions taken from the results obtained.

Real flight data and specific manufacturer information have been used to design the diagram and plot the results. For confidentiality reasons, airports and flights have been de-identified. Specific actions taken from the tests may suffer significant differences depending on the fleet considered. Thus we encourage the reader to build their own diagram using fleet manufacturer specifications and their own flight data from the FDM/FOQA program.

Building the Diagram

Maximum deceleration available [a_{max}]: 10 different situations are considered depending on the braking performance limitation. Thus 10 values for the maximum deceleration available parameter are defined:

- Maximum pedal application in dry conditions
- Using Auto Brake Medium in dry conditions
- Using Auto Brake Low in dry conditions
- Maximum pedal application in wet conditions
- Maximum pedal application in slush ½” conditions
- Maximum pedal application in slush ¼” conditions
- Maximum pedal application in water ½” conditions
- Maximum pedal application in water ¼” conditions
- Maximum pedal application in compacted snow conditions
- Maximum pedal application in ice conditions

Further situations may be considered, for example MEL items that reduce the braking performance (Spoilers INOP, Brake INOP, …). Each situation defines a curve eventually.

Data source: Airbus Performance Engineering Program (PEP, Ground Distance values)

Contextual criteria: Maximum deceleration available may present slight variations depending on the context. Thus following default contextual criteria are used for defining the curves in the diagram:

- Fleet: A320-200
- Landing weight: 54000 kg
- Runway slope: 0.0%
- Runway surface: Smooth
- landing configuration: CONF 3
- Reverse: operative/full reverse application
- OAT: 15ºC

This criterion is limited to the parameters used to design the curves. For simplification reasons these curves remain constant during the tests even if the context changes.

Data accuracy and limitations:

- We suggest contacting the manufacturer to get information about the accuracy of the data supplied. In general terms the parameters calculated during the evaluation process proved to be robust for slight variations of data supplied.

- The braking impact of ground spoilers and reverse thrust is not constant and strongly related to the airspeed. However a constant value has been used during the tests for simplification. Slight variations on the resulting curves have proved to have a negligible impact on the risk assessment final results.

Plotting the samples

Parameters:

- Groundspeed at touchdown
- Latitude and Longitude at touchdown

Calculation: Remaining Runway Distance is calculated using the value of Latitude and Longitude of the runway threshold, the total runway length, and the Latitude and Longitude of the aircraft at touchdown.

Data source: FDM/FOQA

Data accuracy: The remaining runway distance for each flight may present random inaccuracy due to the sampling rate and the inherent raw data accuracy. This accuracy has proved to be limited to 100 meters. This inaccuracy can be covered by using greater safety margins when performing the risk assessment.

Data plotting: For each airport and runway considered, flight samples are plotted in the diagram using the parameters Groundspeed and Remaining runway distance captured at touchdown. As a result a *cloud* is plotted in the diagram, and a *cloud centroid* can be calculated and plotted as well. Please notice that the number of samples is related to the number of arrivals to that runway. We suggest taking a significant number of samples to get accurate results.

Performance indicator: The RWY EXC KPI defined in the previous section will be used as the main performance indicator for each runway. This KPI will be calculated using the *cloud centroid* as a representative value for the whole sample used. Another interesting indicator is the samples distribution, or the *cloud shape*, which can be used for landing performance investigations.

Additional information: In order to help the reader to understand the samples distribution, a sketch of the runway has been superimposed onto the diagram.

Test 1.

Demonstration of an improved Runway Excursion risk assessment

Scope

The scope of this test is to compare the current runway excursion risk assessment, based on events involved in an unstable approach, with the risk assessment performed using the diagram and the RWY EXC KPI. To make this comparison we have calculated a *TOP 5 critical airports* diagram for each risk assessment technique (due to confidentiality reasons all airport names will be substituted for codes).

Performance metrics

In this test an *unstable approach* is defined as a flight with one or more events during this flight phase. An *event* will be defined by any SOP deviation, assuming a unique A320 fleet applying the standard manufacturer

SOP included in the FCOM. The number of *unstable approaches per 1000 arrivals* to an airport is used in the traditional risk assessment technique as the metric for the runway excursion risk on this airport.

For the new risk assessment technique the metric is a *score* calculated using the distance from the *centroid* (described in previous chapters) to the MAX PEDAL curve, thus giving a RWY EXC KPI for the best conditions, in order to get a similar format and compare with the traditional risk assessment technique. The shorter the distance, the higher the score for the runway excursion risk on this airport.

Test description

Since an unstable approach is usually determined by a flight with one or more events defined by SOP deviations in this flight phase, for the traditional risk assessment technique we obtain the diagram shown in Figure 6.

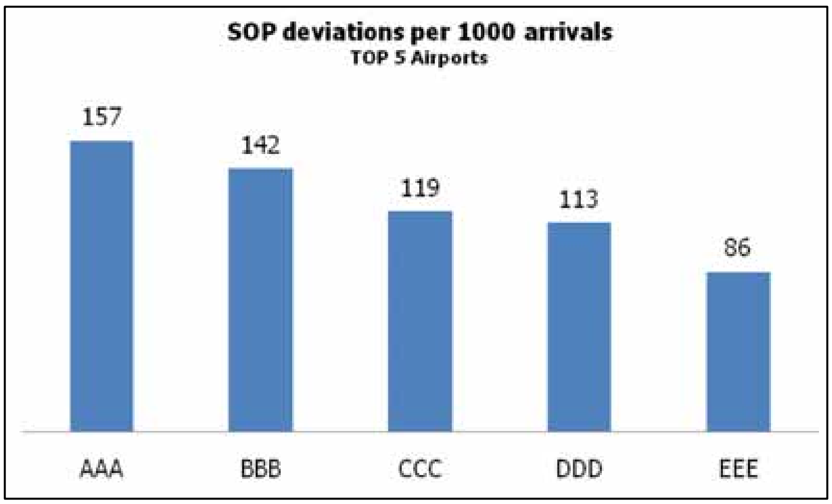

Figure 6: Example of a traditional Risk Assessment Technique

In order to get a similar diagram applying the new risk assessment technique, we capture the values for the groundspeed and the remaining runway distance at touchdown for each flight, thus a dot can be plotted on the diagram. As a result we obtain a *cloud* of dots for each airport (Figures 7 to 11). These diagrams include the *cloud* in red, the *cloud centroid* in blue, and a table with three values for the RWY EXC KPI considering three different braking conditions (only the MAX PEDAL KPI will be used for the RWY EXC KPI in this test).

Test performance

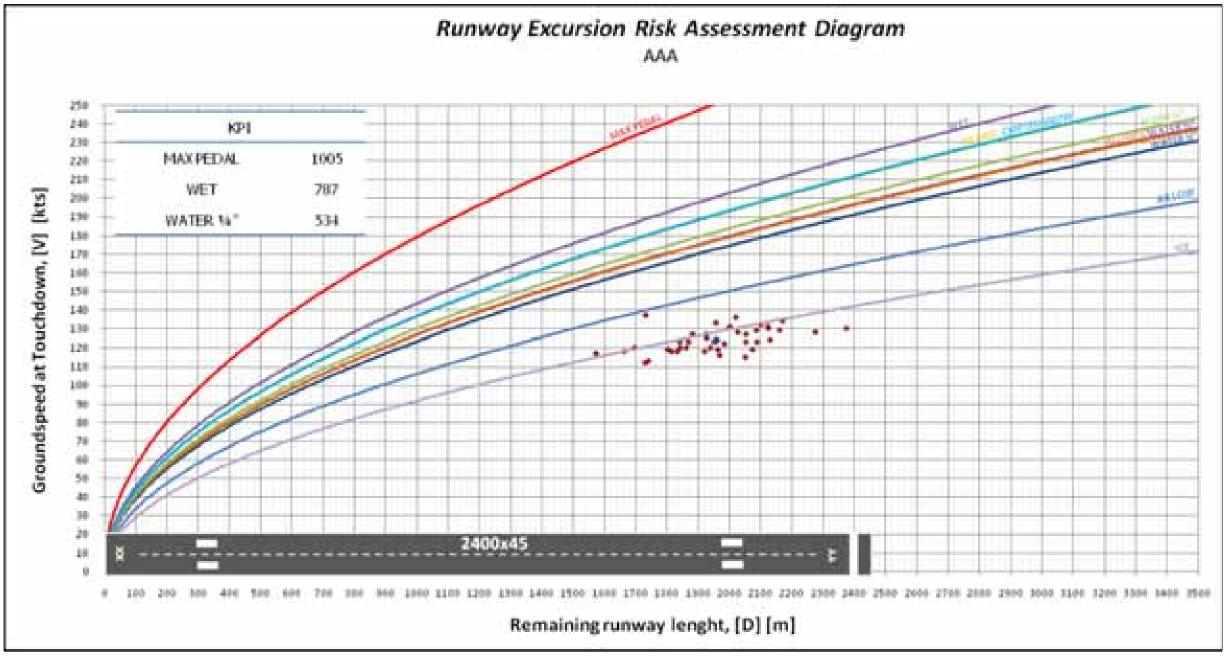

Figure 7: Airport AAA *cloud* and *cloud centroid*

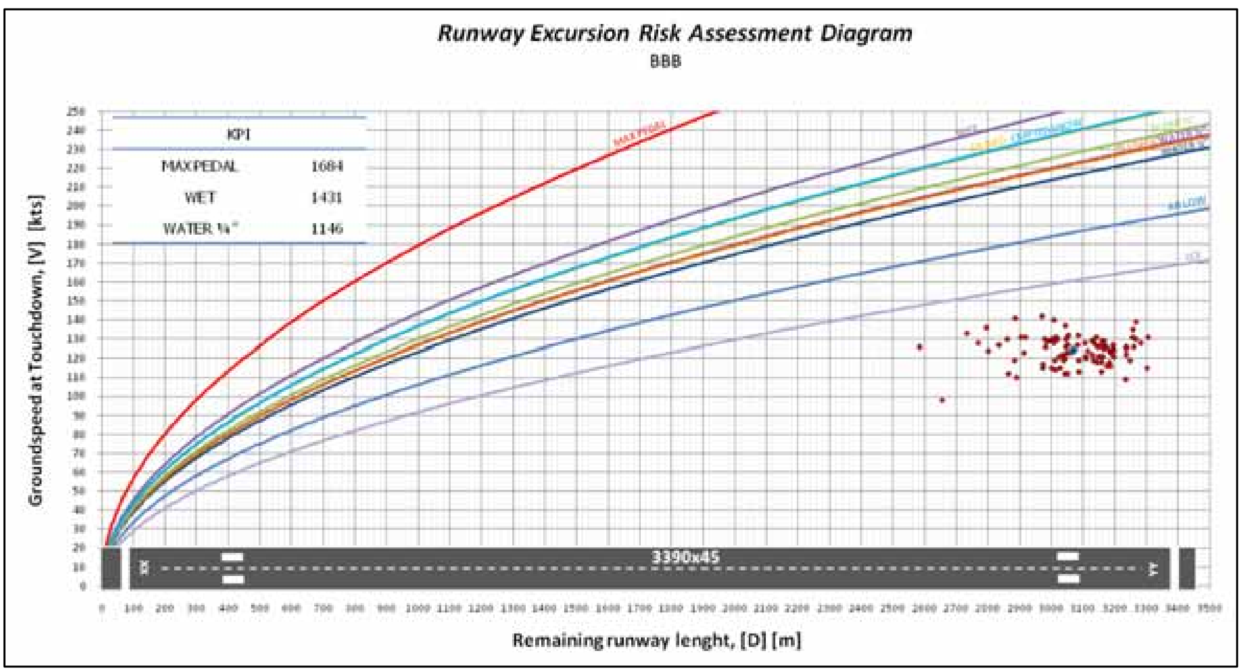

Figure 8: Airport BBB *cloud* and *cloud centroid*

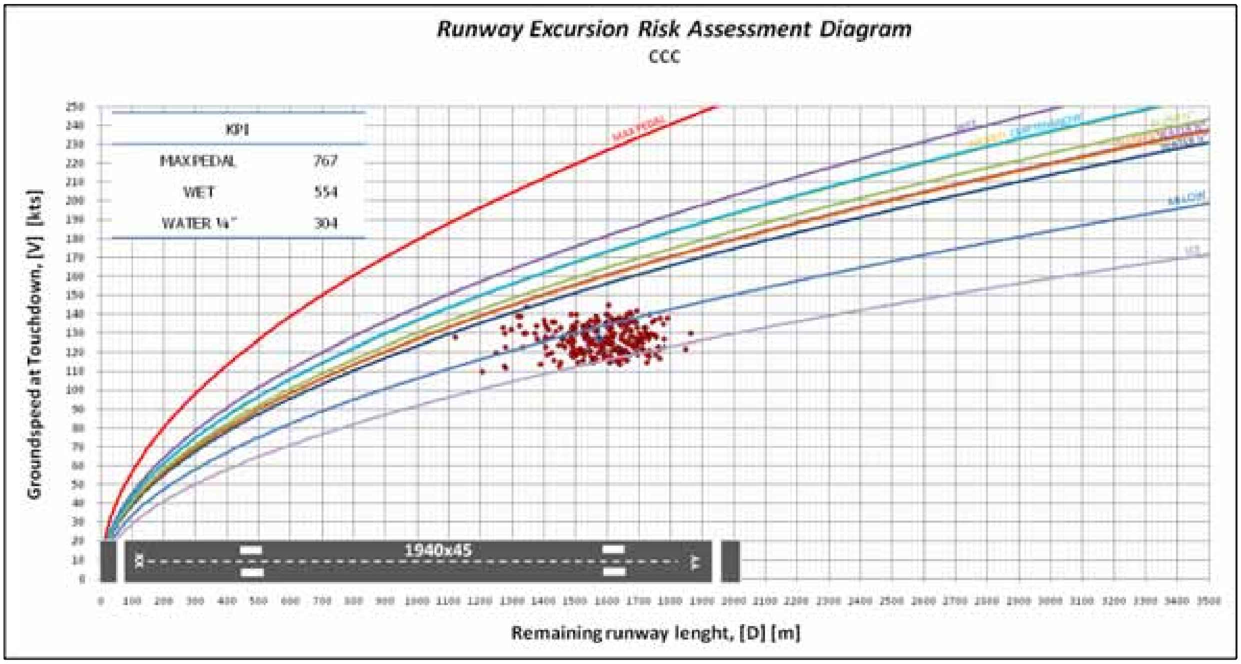

Figure 9: Airport CCC *cloud* and *cloud centroid*

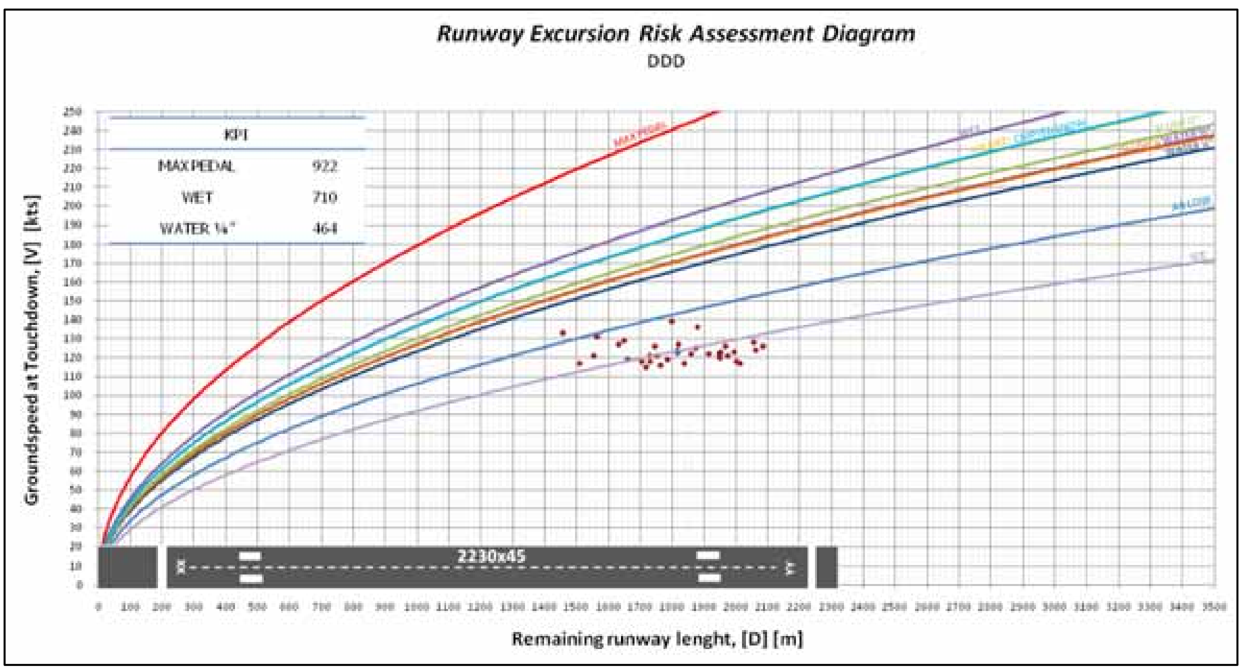

Figure 10: Airport DDD *cloud* and *cloud centroid*

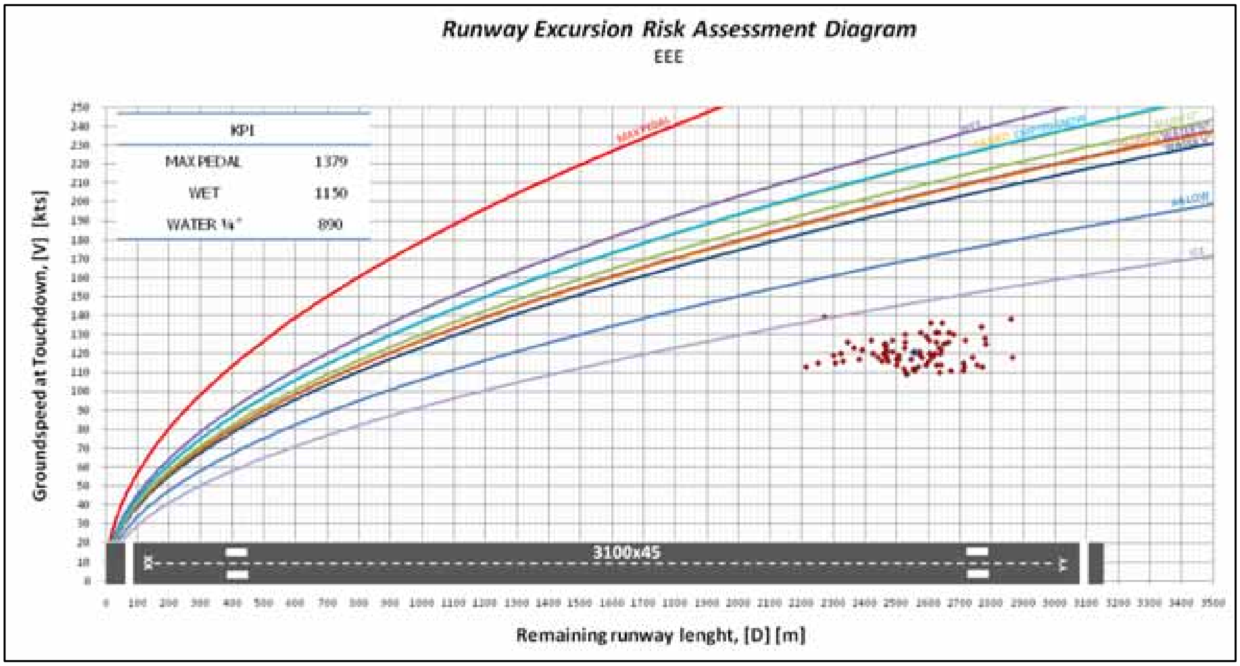

Figure 11: Airport EEE *cloud* and *cloud centroid*

Ordering the airports using the RWY EXC KPI calculated we obtain the result for the new risk assessment technique (Figure 12).

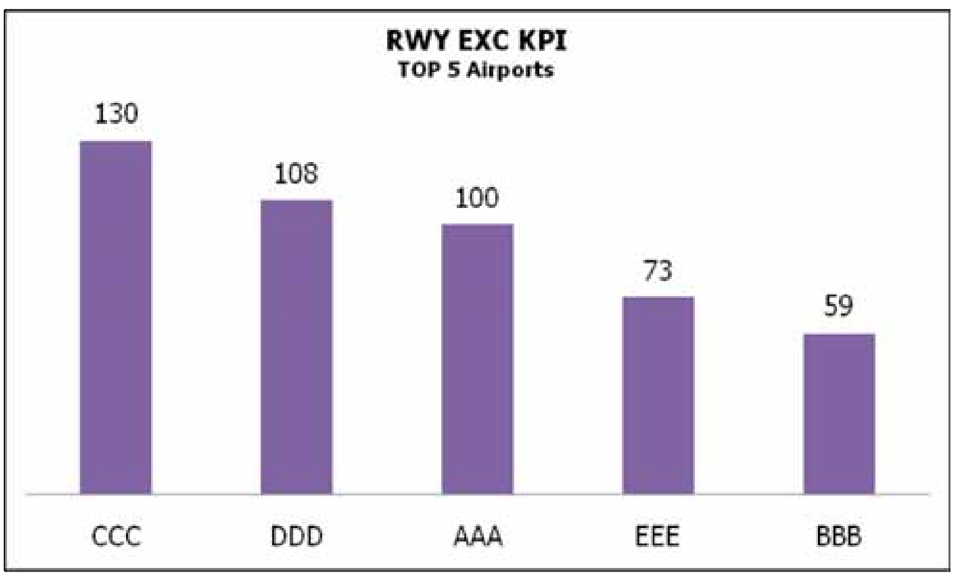

Figure 12: Example of the New Risk Assessment Technique

Interpretation

The new result shows significant differences compared with the one obtained using the traditional risk assessment technique. The new order highlights airport CCC as the most critical one, with a RWY EXC KPI 30% higher than airport AAA, and 200% higher than airport BBB.

A deeper analysis of each airport diagram helps to understand *how* and *why* an airport runway excursion risk indicator has changed. First of all the runway picture superposed onto the diagrams demonstrates that the runway length is the factor that contributes the most to new risk indicator calculation. Airport CCC has the shorter runway length, thus the risk of having a runway excursion is higher. Additionally there are significant differences on the *cloud shapes* that further contribute to the centroid and *perimeter dots* risk indicator calculation. This analysis will be further developed in the following tests, highlighting the relation between *risk factors*, such as tailwind and glide slope deviation, and the *cloud shape*, thus giving a quantitative value to the contribution of these factors to the runway excursion risk.

This new approach to the runway excursion risk assessment is directly focused on the *illness* (accident) more than the *symptoms* (events), giving a more realistic vision of the risk and the safety margins. In the example above time and efforts would be spent to the reduce the number of events on airports AAA and BBB applying the traditional risk assessment technique, avoiding an efficient resources allocation for mitigating the risk on airports CCC and DDD.

Another important result is the *universal* property of the RWY EXC KPI. Since the traditional risk assessment is based on events, it is strongly related to the aircraft type, manufacturer, and operator SOP, thus adding serious difficulties to perform a multi-fleet risk assessment or a risk comparison between different operators. The new risk indicator is based only on values at touchdown that can be directly obtained from the DFDR. As far as these values are available and the curves built, a distance can be calculated and directly used for a risk comparison.

Test 2.

Relation between common risk factors and the Runway Excursion risk

Scope

In the previous test we introduced the importance of *cloud shape* on the runway excursion risk calculation. In this test the impact of the most common risk factors and runway excursion incident precursors on the *cloud shape* is demonstrated, thus allowing a numeric quantification of the contribution of each risk factor to the runway excursion risk indicator.

Performance metrics

Distance from the *cloud centroid* to the curves will be directly used as a RWY EXC KPI, specifying the braking conditions that define the curve used for the distance calculation.

New values must be restored from the DFDR in order to perform this test. In this particular case a snapshot of the parameters at 50ft HAA (Height Above Airfield) has been taken to give a picture of the approach. Filtering the cloud by these parameters a new *cloud* is shown, thus a new centroid, allowing a new RWY EXC KPI calculation for the filtered selection.

The percentage of increase or decrease on the KPI is used as the metric for the contribution of each factor to the runway excursion risk.

Test description

Risk factors and runway excursion incident precursors considered:

- Glide slope deviation

- V_{REF} deviation
- Tailwind
- Landing weight
- Landing flap configuration
- Visual approach / Instrument approach
- Reverse inoperative
- Runway surface (smooth or grooved)
- Runway condition/contamination

To get a realistic value for the contribution of each factor it is recommended to repeat this test for a significant number of airports and take average values. However, in this test only two airports are used for simplification. The results obtained may have significant variations from those obtained in similar tests, for that reason we recommend the reader to focus on the technique rather than the numeric results, and we invite him to perform the test with his own data.

The results for each factor considered are shown in the Test Performance (Figures from 13 to 24).

Test performance

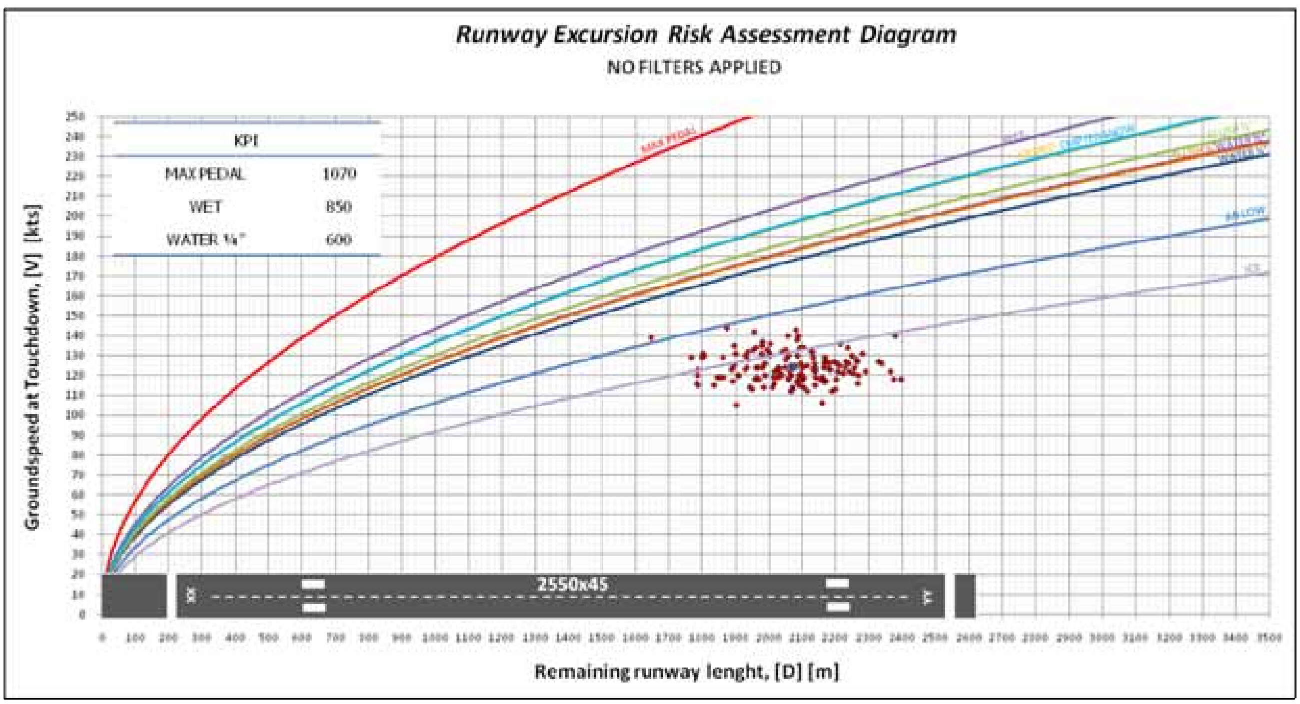

Figure 13: Whole Distribution of Touchdown Points

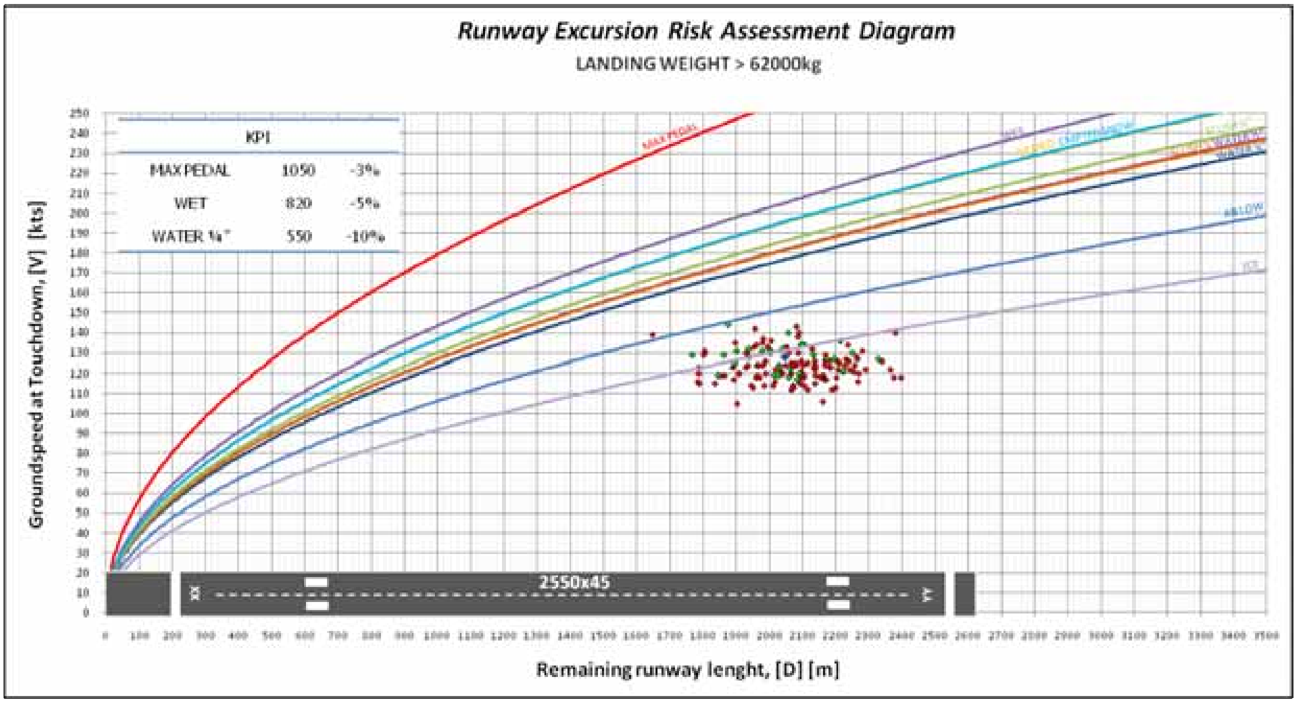

Figure 14: Samples With a High Landing Weight

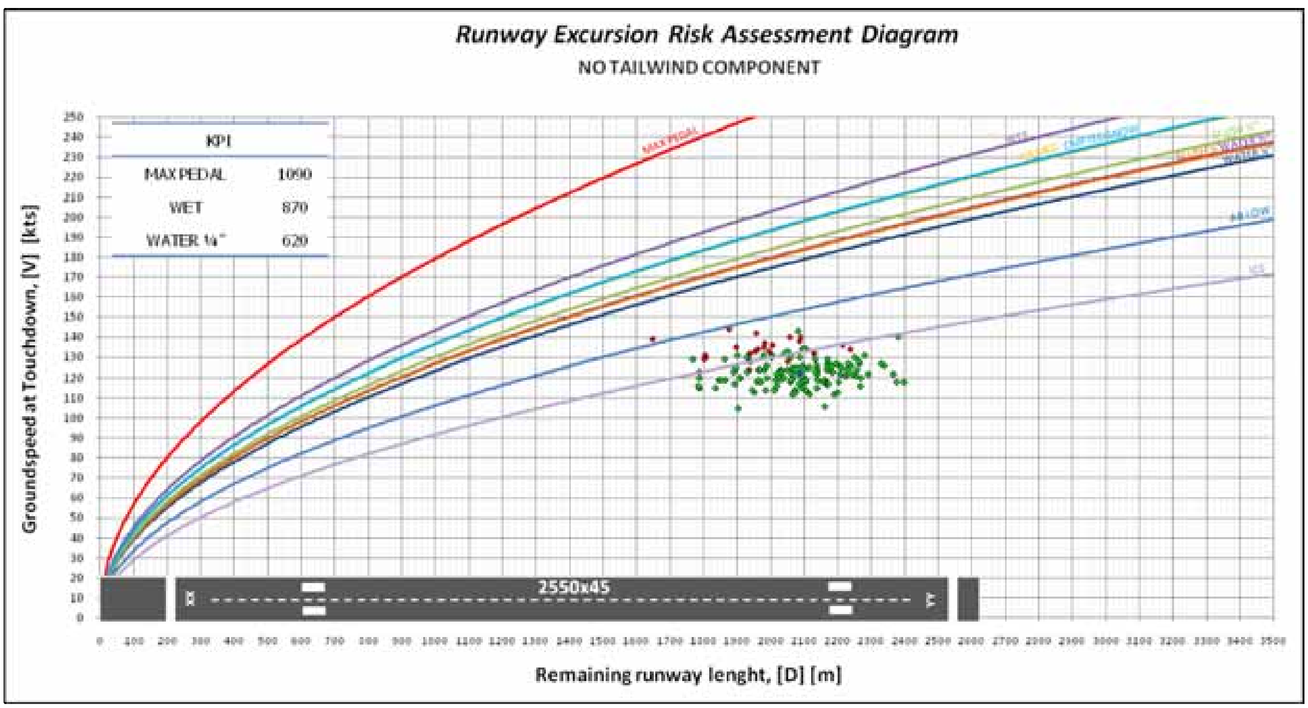

Figure 15: Samples With No Tailwind Component

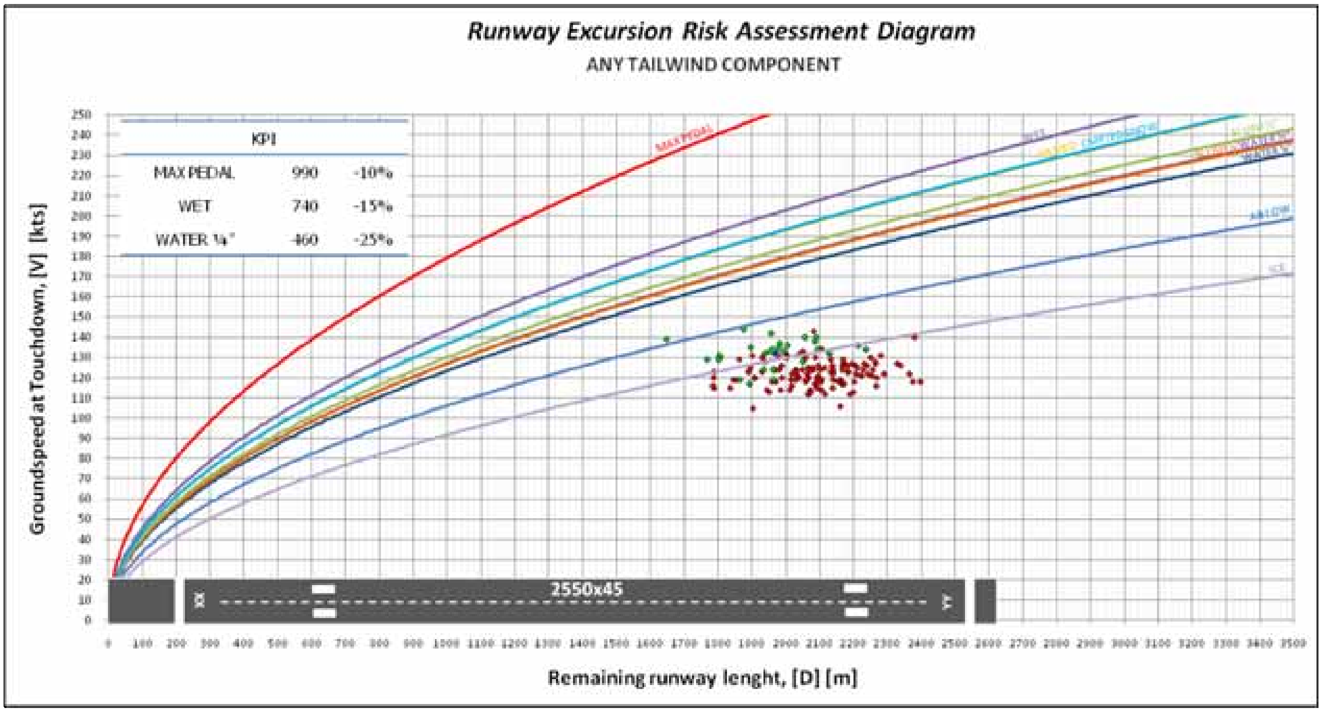

Figure 16: Samples With Any Tailwind Component

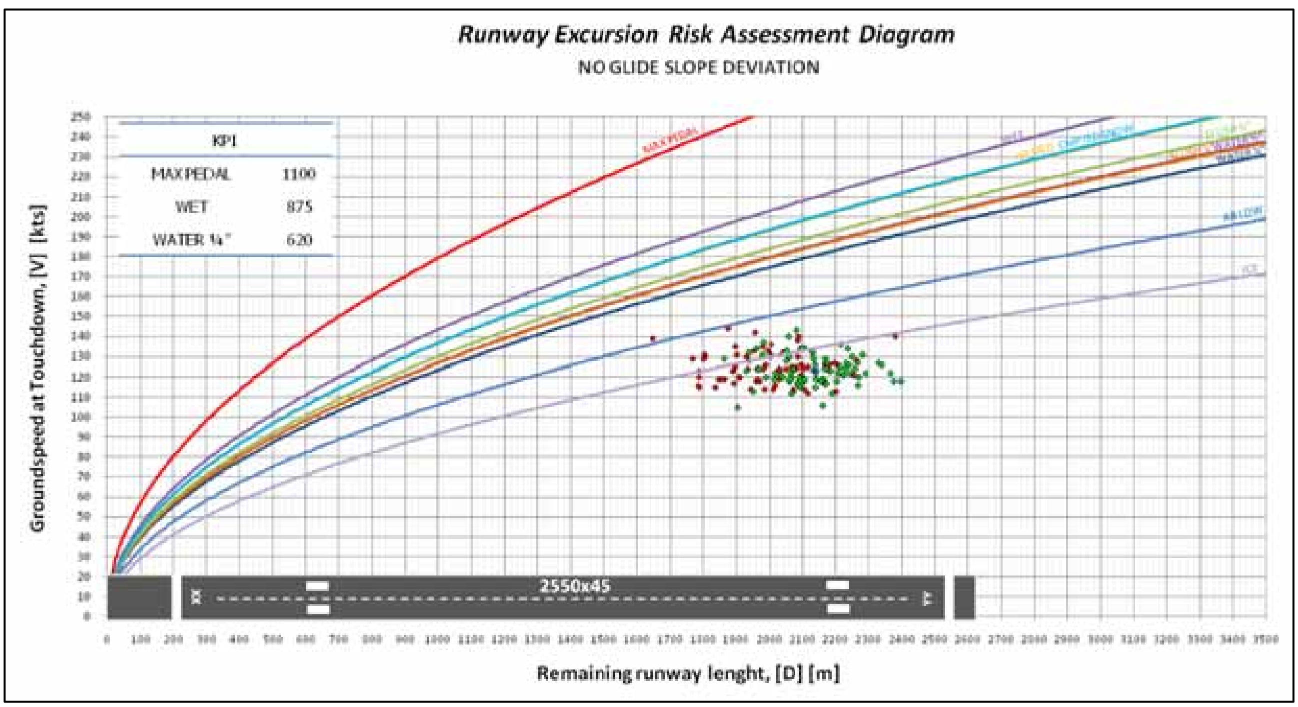

Figure 17: Samples With No Glide Slope Deviation at 50ft

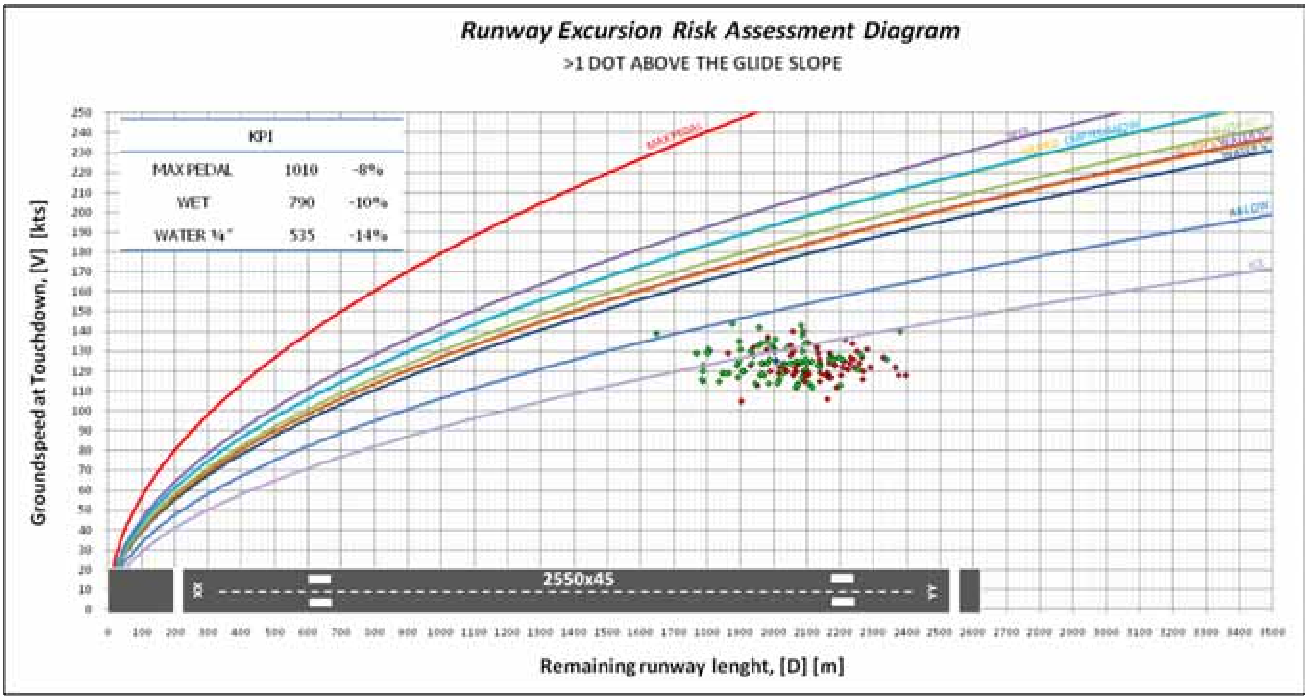

Figure 18: Samples Above Glide Slope at 50ft

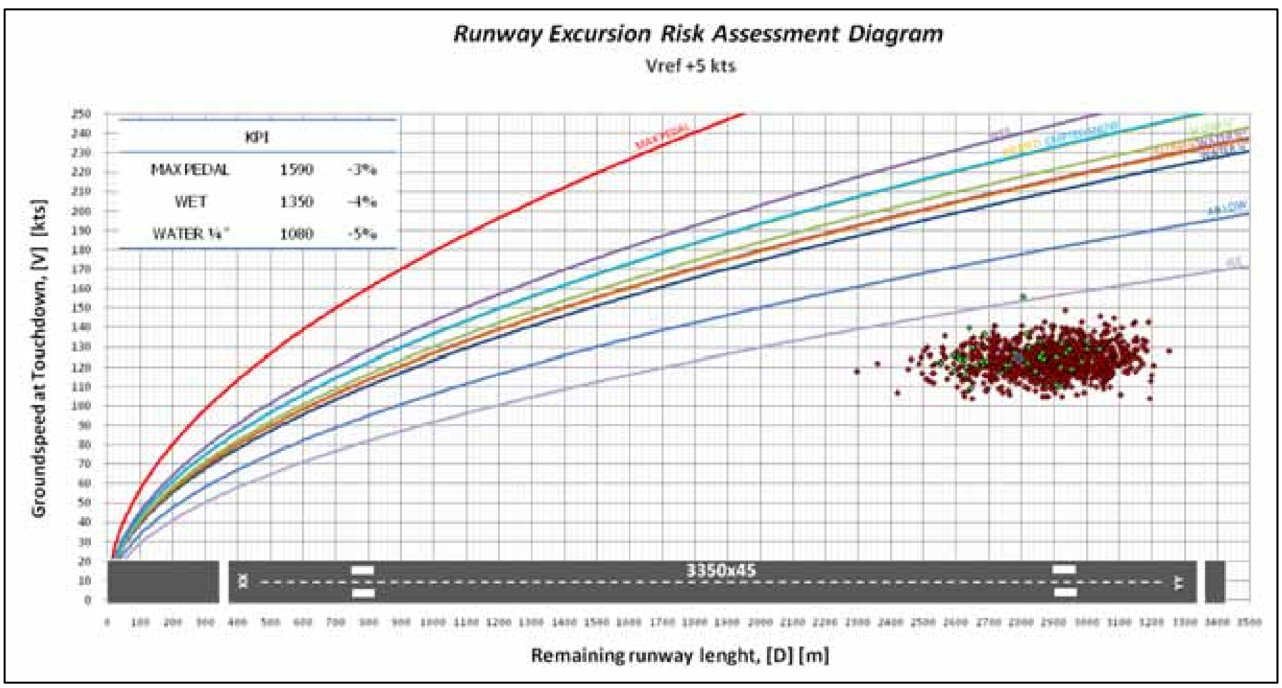

Figure 19: Samples With V_{REF} Deviation at 50ft

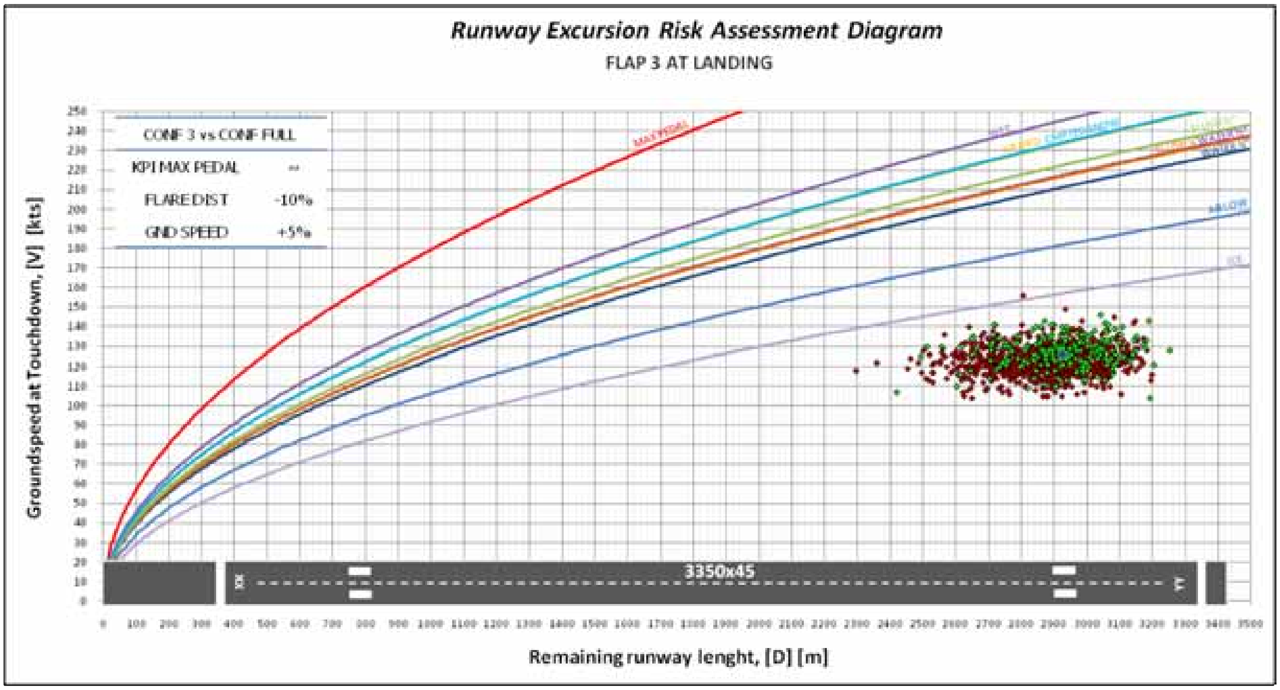

Figure 20: Samples Landing in CONF 3

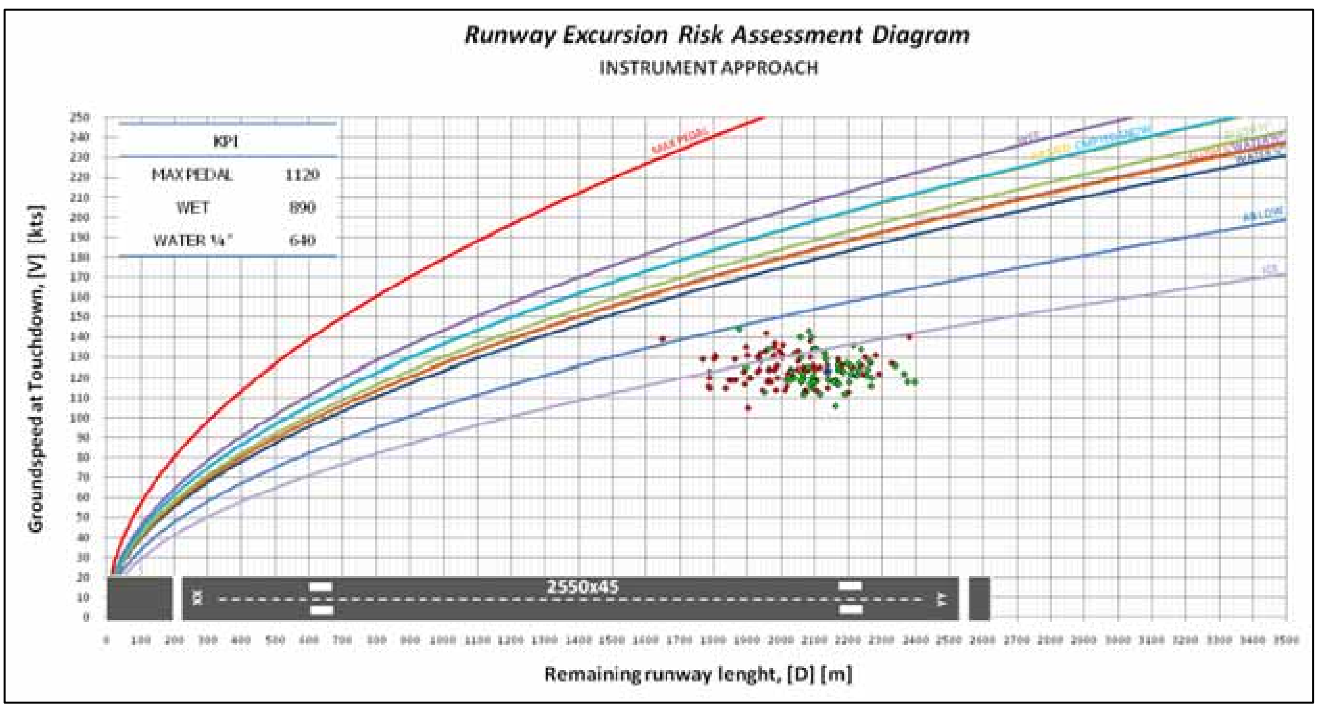

Figure 21: Samples Applying an Instrument Approach

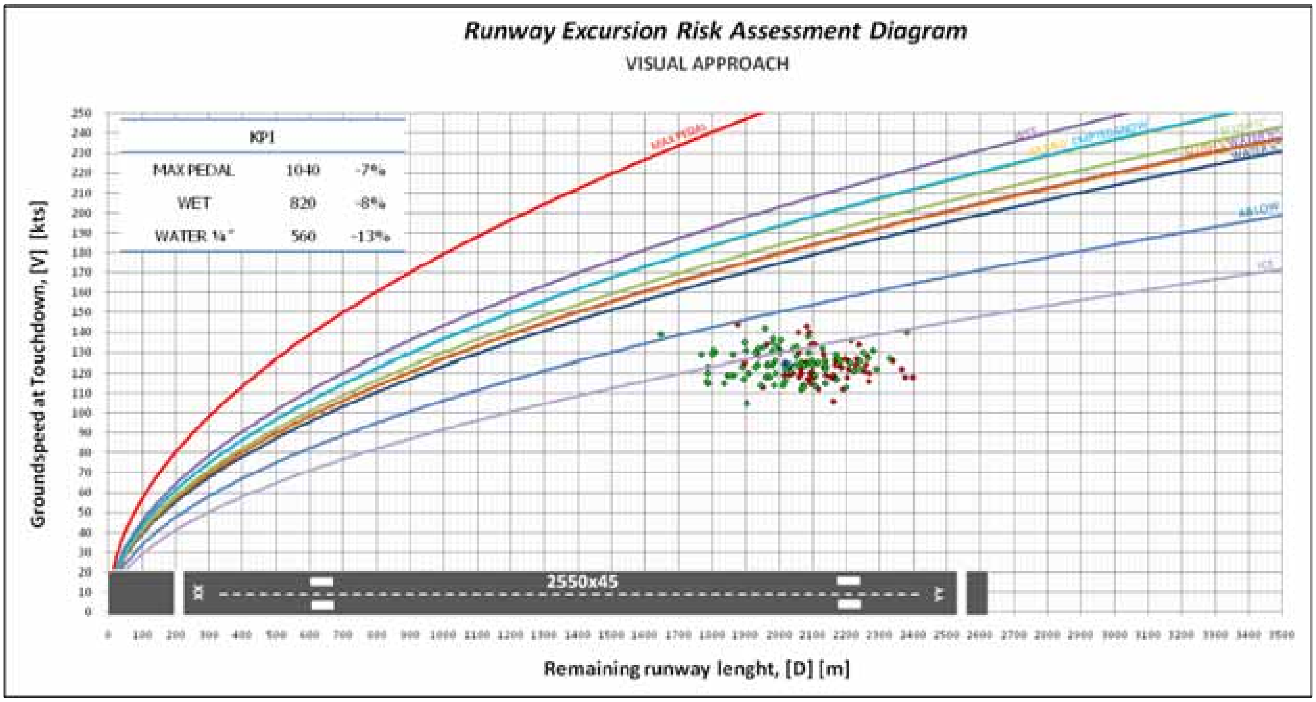

Figure 22: Samples Applying a Visual Approach

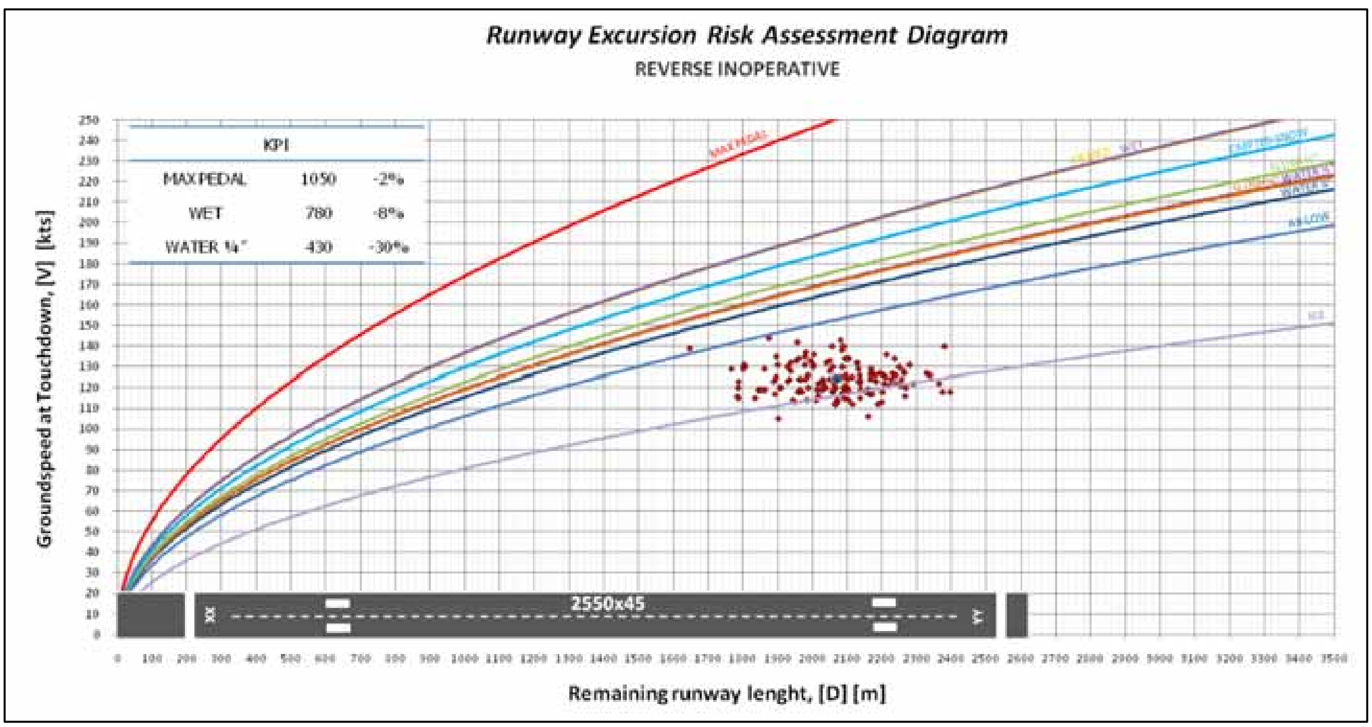

Figure 23: New Curves for Reverse Inoperative Condition

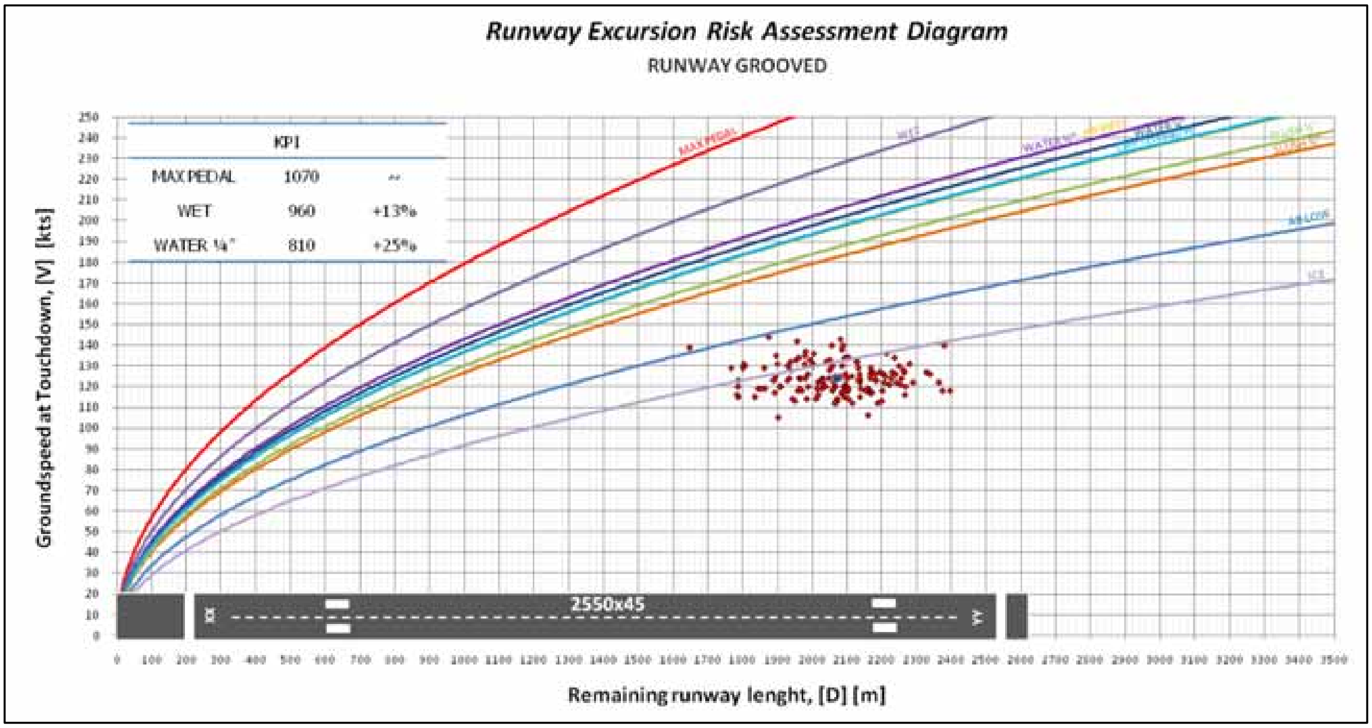

Figure 24: New Curves for a Runway Grooved Situation

These tests can be summarized in a table (Figure 25), ordering the factors by their impact to the RWY EXC KPI.

RWY CONDITIONS	DRY	WET	WATER 1/4"
Tailwind	-10%	-15%	-25%
Above G/S	-8%	-10%	-14%
Visual App	-7%	-8%	-13%
Landing weight	-3%	-5%	-10%
V_{REF} dev	-3%	-4%	-5%
Reverse Inop	-2%	-8%	-30%
Grooved RWY	NEG	13%	25%
CONF 3	NEG	NEG	NEG

Figure 25: Risk Factors and Their Impact to the RWY EXC KPI

Interpretation

The presence of each risk factor has been depicted as a new filtered *cloud* allowing the calculation of the impact to the KPI. The position and shape of the filtered *cloud* explains the relation between each factor and the impact to risk. An approach to that relation is shown in Figure 26 based on the results obtained on the test and considering the resulting *cloud*s as ellipses for simplification. This test has been repeated in several airports giving similar trends. However, we noticed significant variations on the numerical results since some factors may have their impact mitigated or enhanced depending on the geographical context.

The results in Figure 25 have been put in order by their impact to the risk in dry conditions. Tailwind has proved to be the factor with more impact to the KPI, significantly increased by the presence of water on the runway or other braking performance limitation factors. This result is explained by the position of the filtered *cloud*, which has two complementary contributors: a higher groundspeed at touchdown and a longer flare distance. Another double-way contribution is observed in Visual Approaches, where in addition to a longer flare distance, there is an increased dispersion in the position and groundspeed at touchdown compared with the Instrument Approach, increasing the final value of the KPI.

Other factors affect the *curves* rather than the *cloud*. Is the case of those which are related to the braking performance, such as the use of the thrust reversers or the grooved runway. Inoperative reverse shows a significant impact to the risk in those cases with contaminated runways. Graphically speaking the effect is similar to the tailwind, presenting a double effect enhanced by the presence of braking performance limitation factors.

This test demonstrates the capability of the graphical tool to calculate the contribution of the risk factors to the KPI, improving the assessment performed by predefined operational events. We encourage the reader to use his own data to create a diagram and perform specific risk calculations.

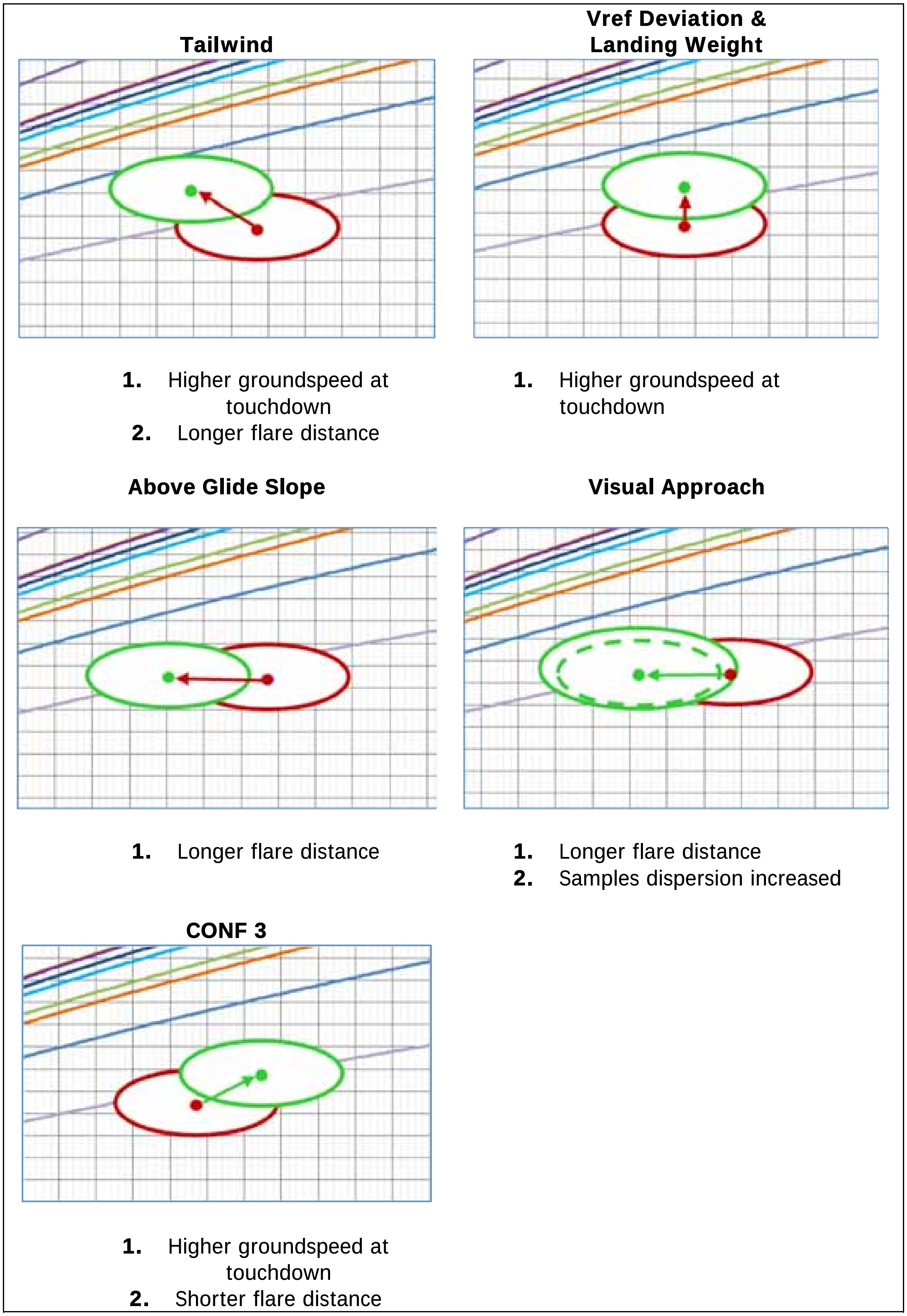

Figure 26: Graphical Interpretation of the Relation Among the Risk Factors And the RWY EXC KPI

Context and Limitations

The results in Figure 26 show the average impact of each risk factor, based on real flight data taken from two sample airports, and not using generic theoretical models. Rather than accurate values, the results above show the importance of each risk factor, improving a risk assessment based only on operational events.

The risk factors considered are an example and they are not limited to other risk factors involved in a runway excursion. We propose the reader to consider other risk factors and apply the filters in the diagram to perform specific risk assessments.

Some risk factors may be combined in the same flight so it is not recommended to calculate the final risk impact by an arithmetical addition when considering hypothetical cases with combined risk factors.

Test 3.

Example of a predictive runway excursion risk assessment and definition of accurate mitigation actions.

Scope

To show a real example of a quick risk assessment performed in a new runway and propose effective risk mitigation actions based on a target for the RWY EXC KPI.

Performance metrics

Performance will be measured by the KPI calculated considering the new mitigation actions and the resulting operative limitations.

Test description

This assessment takes place in an airport with the characteristics described in Figure 27.

RUNWAYS		
Direction	Length [m]	Surface
01R/19L	2100	Asphalt
01L/19R	2550	Asphalt

Figure 27: Airport Description

Runway 01R/19L is not used. However, due to works on runway 01L/19R, runway 01R/19L is the only solution for this destination. As a change in the operation, a risk assessment must be performed in order to guarantee an acceptable level of safety.

The assessment starts by plotting the points in the diagram for the current landings performed in runway 01L. We obtain the result shown in Figure 28, considering operative reverse and smooth runway surface for the curves.

Runway 01L and 01R have similar visual references and we will assume that they have similar meteorological and geographic conditions. For that reason a similar dot distribution can be considered for the new scenario, correcting the remaining runway length by 450m. The new hypothetical result is shown in Figure 29.

Finally we will consider as a hypothetic worst case inoperative thrust reversers in the new scenario. As detailed in Test 2, this braking performance limitation is translated in a deformation of some curves. This case is shown in Figure 30.

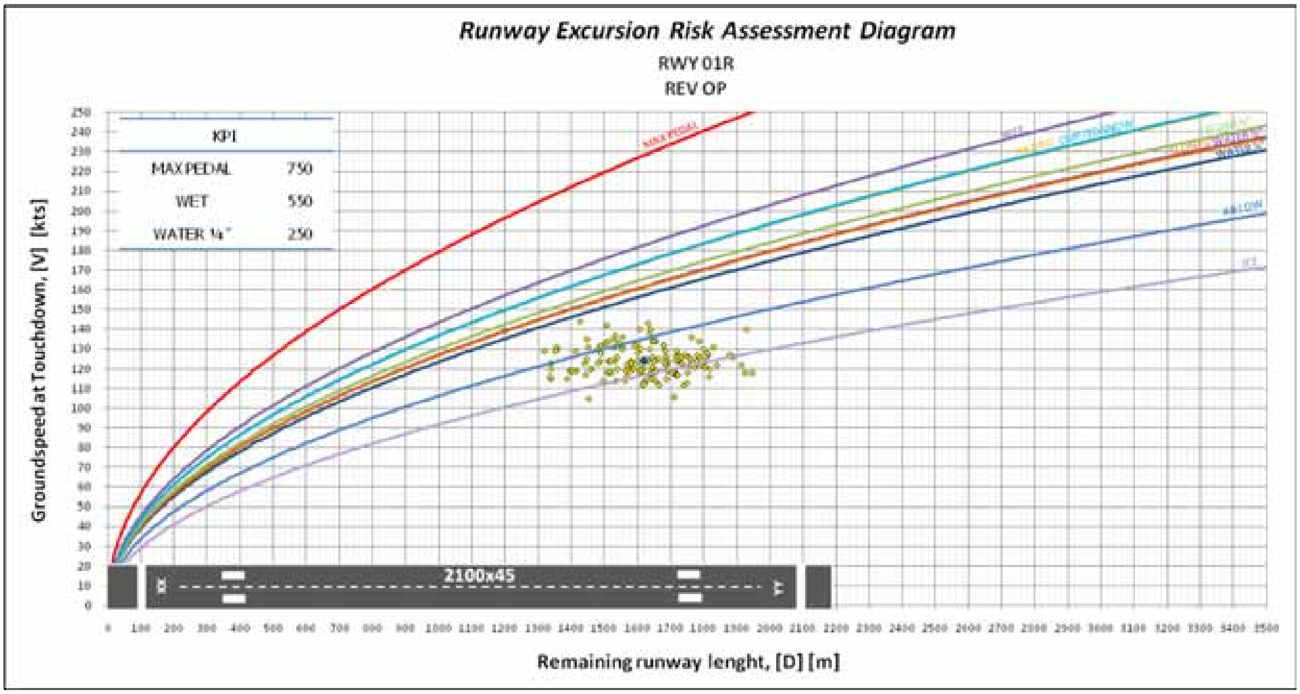

Figure 28: Current Distribution of Touchdown Points in Normal Braking Conditions

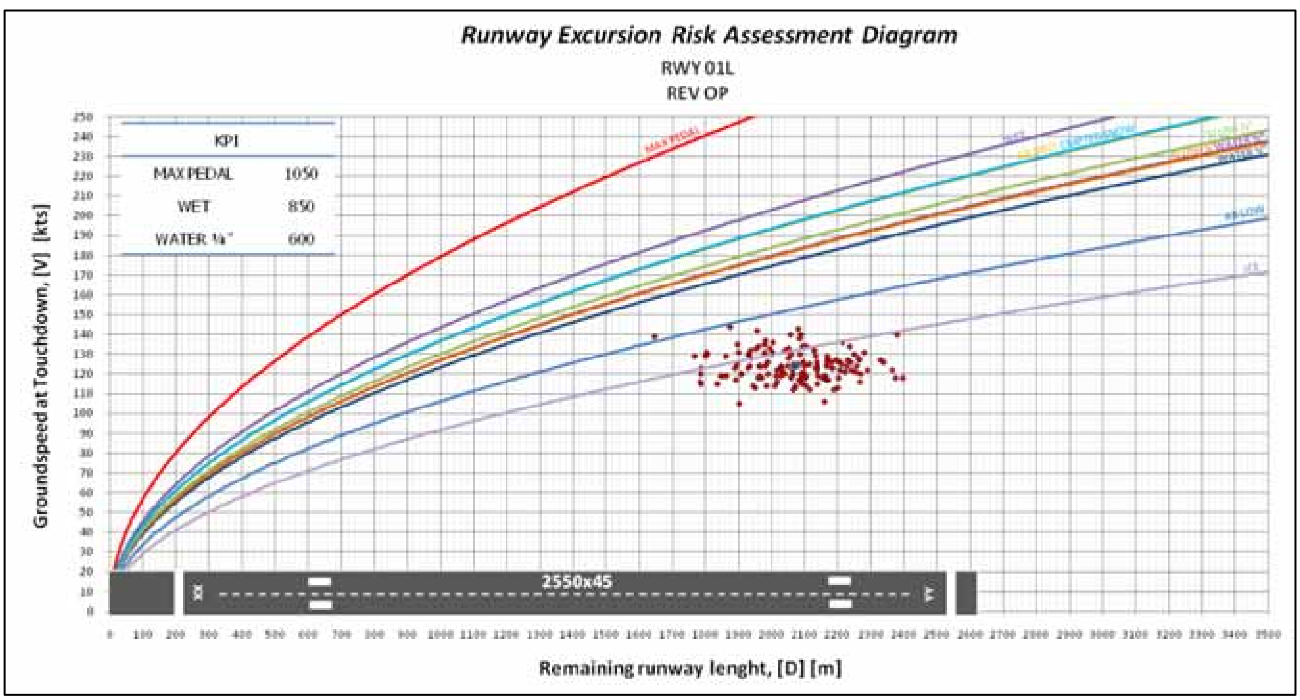

Figure 28: Current Distribution of Touchdown Points in Normal Braking Conditions

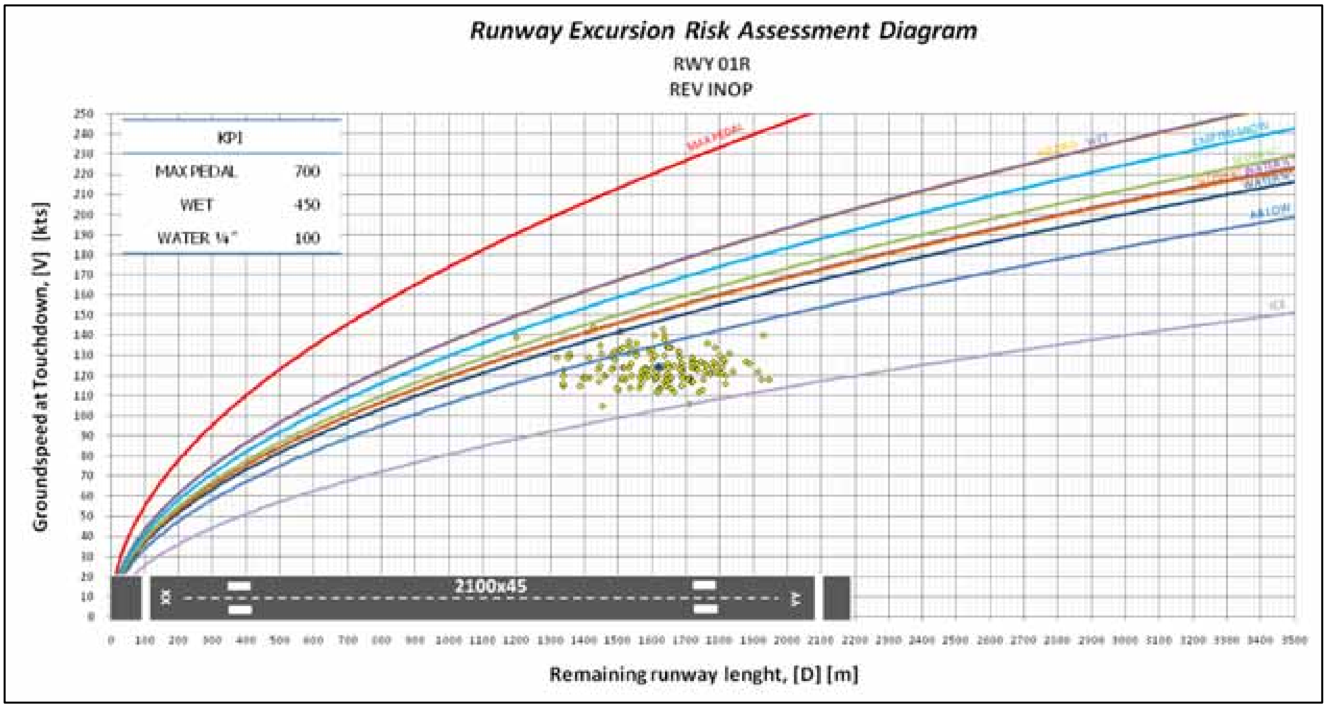

Figure 30: Hypothetical Distribution of Touchdown Points Considering Restrictive Braking Conditions

Interpretation

The worst case considered shows a significant KPI reduction for maximum pedal application in dry conditions. This reduction is even worse in the case of wet runway or standing water on runway surface. Near 30% of the samples lay beyond the *Auto brake Low* condition's curve. Assessing the new dot distribution, and the consequent KPI reduction, the need to implement additional safety barriers for the new scenario was considered.

Since 30% of the samples would mean a runway excursion incident in the new runway applying Auto brake Low throughout the ground roll, a new info note was issued to all crew recommending the use of *Auto brake Medium* during the operation in runway 01R/19L. In most cases the use of Auto brake Low would not mean a runway excursion incident since a braking pedal action would be applied by the crew. However, hard braking events would be reduced and the safety margins would be significantly increased.

Further operative limitations, like avoiding landings with inoperative reverses or standing water on the runway surface, were not considered. Even if the KPI is significantly reduced on these conditions, more than 98% of the samples still lay in the safety zone for the standing water curve.

This predictive risk assessment procedure helped to have a quick overview of the new scenario, highlighting which factors had more impact to the risk and finally proposing accurate mitigation actions without overprotecting the operation, improving the traditional risk assessment technique which has proved to be limited when assessing new scenarios with no flight data available.

5. Conclusions and Future Work

The problem we have contributed to solving

There is a lack of visibility on the real risk when performing a risk assessment based on events defined on the approach phase, sometimes eclipsing the risk factors which contribute the most to the real problem, thus creating serious difficulties to define accurate and not overprotective mitigation actions.

Our solution to the problem

A new risk assessment technique, based on safety margins rather than SOP deviations, using a graphical tool that allows a simply way to detect hot-spots and calculate the contribution of each risk factor considered.

Why our solution is worthwhile

Hot-spots and risk factors detected by the graphical tool allow to define quick and accurate actions to mitigate the real problem, thus saving time and money by not overprotecting the operation.

Our solution is global and can be used by operators, aerodromes and regulators which have access to the parameters defined above. This paper gives instructions of how to build a diagram and gives some examples of real applications and actions proposed, closing the loop for a complete risk assessment.

What to do next

In order to improve our solution an automated process for plotting the diagram and calculating the KPI from raw data should be done. Standards or common use of the tool will help to create a robust process which will simplify the creation of an automated tool.

A related problem is to define common bases to compare the risk of having a runway excursion between operators. The KPI defined in this paper allows defining these bases and would help to create Regulator standards eventually.

A harder version of this problem is the investigation of the risk factors and root causes of an accident and incident related to a runway overrun. Applying our solution to that problem gives a new approach to investigation process and allows reproducing the chain of facts directly on the diagram with amazing results.

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