BMT Fleet Technology

Runway Friction Characteristics Measurement and Aircraft Braking

Sponsor: EASA
Location: Paris, France
By BMT FTL:

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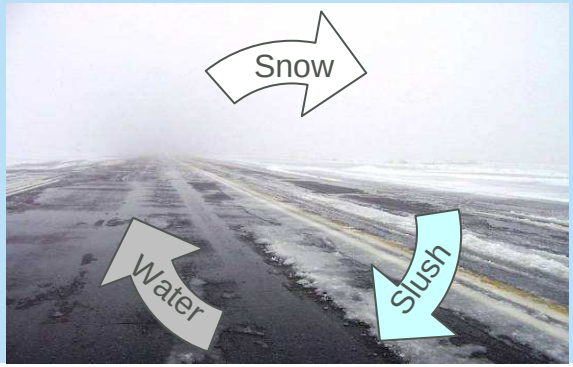
11th March 2010

Surface Condition Assessment and Report Transmission

- **EASA RuFAB Team Objectives**
  - Identify or advise in closing the Knowledge gaps
  - Focus – Global Applicability
- **Summary of Findings and Recommendations**
  a) Runway Condition Assessment
  (parameter observation & measurement)
  b) Condition Reporting
  c) Condition measurement technologies
  d) Friction-related information.



‘External’ Initiatives - ICAO-FTF

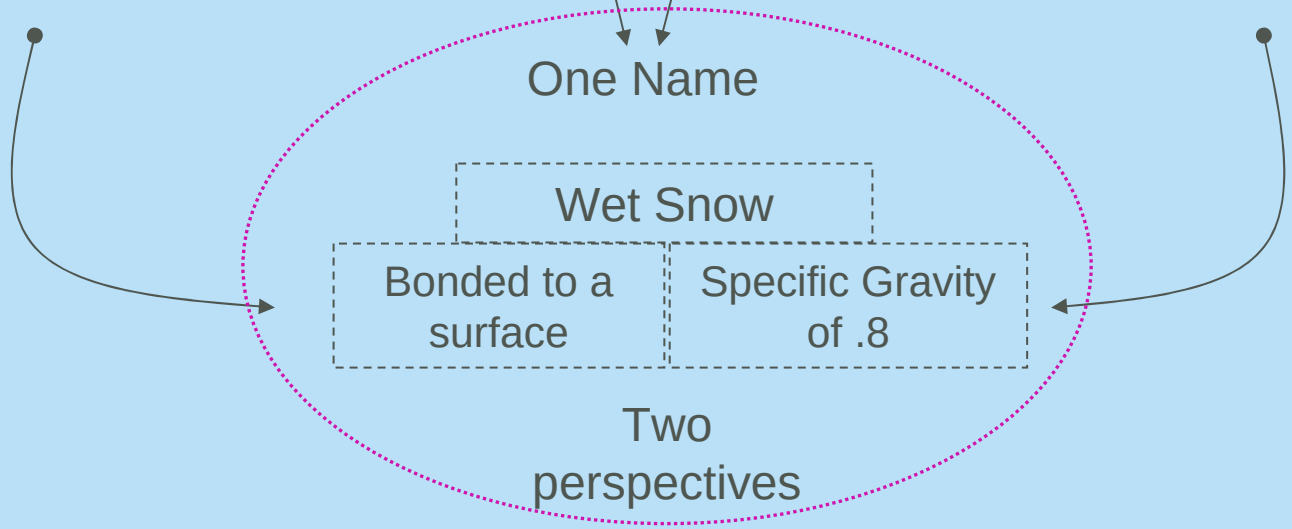
Hypothesizing Two harmonized sets of definitions

One set for RIs to identify the different contaminants and deposits, and significant changes thereof

The other set for evaluating aircraft performance

Identifiable under operational conditions

Physical parameter definitions.



Taxonomies & Definitions

Finding: Clear direction required

Recommendations

- **One label, two applications**
- **Existing definitions combined with pragmatism.**

Frozen Contaminants		
Term	Relevance for AC Performance	Recognizable Characteristics
Slush	Assumed SG: .85 (source: EASA CS25.1583)	Water-saturated snow with a heel-and-toe slapdown motion against the ground will be displaced with a splatter (source: ICAO)
Frost	Higher friction than Ice (source: RuFAB Project Team)	A condition where ice crystals formed from air borne moisture condense on a surface whose temperature is below zero. Frost differs from ice in that the frost crystals grow independently and, therefore, have a more granular texture (source: Transport Canada)
Loose Snow	Assumed SG: .34 (source: ICAO)	Sometime called 'Dry' snow. Snow which can be blown if loose or, if compacted by hand, will fall apart upon release (source: ICAO & EASA CS25.1583). Snow that is not bonded to the AMS and will compact under vehicular traffic (source: RuFAB Project Team)
Wet Snow	Assumed SG: .5 (source: EASA CS25.1583)	Snow that will stick together when compressed but will not readily allow water to flow from it when squeezed (source: EASA CS25.1583)
Compact Snow	Assumed SG: .8 (source RuFAB Project Team)	Snow which has been compressed and will not compress further under vehicular traffic or aircraft wheels, at representative operating pressures and loadings (sources: EASA CS25.1583 & RuFAB Project Team)
Ice	Lower friction than Frost (source: RuFAB Project Team)	A frozen liquid with a continuous surface and includes the term "black ice" and the condition where compacted snow transitions to a polished surface with the density of ice (sources: Transport Canada & EASA CS25.1583)
Non-Frozen Contaminants		
Damp	n/a	A surface is Damp when it is non-reflective and moisture is present (source: Transport Canada & RuFAB Project Team)
Wet	Liquid depth no more than 3mm	A Wet surface has liquid present and is reflective (Source: EASA CS25.1583 & RuFAB Project Team)
Standing Water	Liquid depth greater than 3mm (source: EASA CS25.1583)	Sometimes called 'Flooded'. Includes localized and continuous surface coverage, whether during precipitation or not (source: RuFAB Team)

EASA RuFAB Project Team Observations
Missing Definitions

- **Additional work needed to account for:**
  - Sand
  - Sand on other contaminants
  - First application and Residual Ice control chemicals
  - Layered contaminants
  - Rubber build-up
  - Infrequent frozen materials such as frozen airborne industrial residues
  - Unclassified (etc.).

Knowledge gap

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Lack of operational friction measurement?

- **Without it how will we discern ‘black’ ice ?**

Black ice on runway at Sandspit Airport, BC, Canada, Nov. 2005

Black ice under trace of loose snow at Stephenville Airport NF, Canada Jan. 2010.

EASA RuFAB Project Team Recommendations
Practical Contaminant Definition

pragmatism

- **'Frost' has a different impact compared to Ice**

Loose Snow	Assumed SG: .34 (source: ICAO)	Sometime called 'Dry' snow. Snow which can be blown if loose or, if compacted by hand, will fall apart upon release (source: ICAO & EASA CS25.1583). Snow that is not bonded to the AMS and will compact under vehicular traffic (source: RuFAB Project Team)

- **RIs can recognise Loose snow but cannot measure 'dryness (SG)'**

- **'Damp' should be defined so that it is not confused with 'Wet'**

– RIs can discern reflective from non-reflective.

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EASA RuFAB Project Team Recommendations

Runway Condition Assessment (cont.)

- **Human factors and the availability of runway occupancy time have a significant influence on the reliability and accuracy of condition reports**
  - Regulators should assist airports in mitigating the influence of human factors on the accuracy of condition reports.

To close the **Knowledge gap**

- **Visibility of the surface conditions**
  - **Visual field of range**
  - **Ambient visibility**
    - **precipitation**
    - **illumination of the surface at night**
    - **fog/freezing fog**
  - **Depth perception**
  - **Contaminant feature contrast**
    - **Low light reducing shadows**
    - **Bright sunlight creating glare**
    - **Contaminant reflectivity**
      - **reduced for 'black' ice**
      - **Refraction in frost**
  - **Eyesight**
- **Vehicle speed**
- **Proximity to contaminant**
  - **Single or 'up & back' runway inspection path**
- **Perception of urgency**
  - **ATC or supervisory time constraints**

- **Perception of personal safety**
  - **Proximity of aircraft**
  - **Proximity of maintenance vehicles**
  - **Surface traction**
  - **vehicle condition**
- **Distractions**
  - **UHF/cellular communications**
  - **Monitoring of VHF aeronautical traffic**
  - **Operation of friction measurement equipment**
  - **Vehicle and or equipment malfunction**
  - **FOD**
  - **Bird or wildlife activity**
  - **Edge light and centreline lighting condition**
- **Training**
- **Experience**
- **Fatigue**
- **Contaminant definitions**
- **Reporting format**

EASA RuFAB Project Team Recommendation

Runway Condition Assessment (cont.)

Insufficient Runway Inspection Access

- Regulators should provide direction to air navigation service providers and airports to ensure adequate runway access and occupancy time for completion of runway condition inspections

Clear direction is required.

EASA RuFAB Project Team Recommendation
Runway Condition Assessment (cont.)

Re-inspect the runway upon significant change

- **When the RI reasonably suspects that one or more of the following parameters has been exceeded:**

Measurable Parameter		Estimated Change in Condition
a.	Maintained path width	≥ ± 3m
b.	Offset of the maintained path from the centerline (if any)	≥ ± 3m
c.	Contaminant type	Reclassification of ≥ 10% of reportable path surface
d.	Contaminant depth	≥ ± 10%
e.	Contaminant location	≥ ± 100m for ≥ 25% of contaminant deposition
f.	Contaminant spread	≥ ± 10%
g.	Friction measurement	≥ ± .05 of measurement scale (μ, g, CRFI, etc.)

Clear direction is required.

EASA RuFAB Project Team Recommendations

Runway Status

To maintain or not to maintain

– that is the Policy question

- Should runways be closed for maintenance when contaminant thresholds are reached?

or

- Should airports report the conditions and pilots make informed landing/takeoff decisions?

Clear direction is required.

EASA RuFAB Project Team Finding

Runway Condition Reporting

&^%$#@ happens year-round !!!

- **Winter**

  Regulated requirements

  Formal airport reporting procedures

Summer

No regulated requirements

No formal airport procedures

San Palo Brazil

Clear direction is required.

EASA RuFAB Project Team Finding

Runway info ------ to ------→ Pilots

- **Airports are not fully aware of air carriers' and pilots' requirements for surface condition information**

Knowledge gap

- **Airports exercise caution and often provide overly detailed condition reports**

- **Results:**
  - Inconsistency in reporting
  - Information 'bottle jams'
- **Current regulations and guidance lack sufficient detail for unambiguous interpretation**

Knowledge gap

Clear direction is required.

EASA RuFAB Project Team Recommendations
Runway Condition Assessment

- **Current runway surface condition assessment and reporting processes should be updated**
  - Direction and advice should be provided to airports regarding interpretation and accuracy in assessing contaminant criteria

  - Input into runway condition assessment processes should be sought from the aviation community

To close the **Knowledge gap**

  - There should be formal review and update by committee of condition assessment and reporting requirements
  - An independent person or group should be appointed to act as facilitator for the committee work to ensure that all required technical inputs are provided.

EASA RuFAB Project Team Recommendations
Runway Condition Reporting (cont.)

- **Regulatory requirements are needed:**
  - Contaminant definitions
  - AMS assessment frequency
    - Inspection intervals
    - Report availability
    - Significant condition change
    - Cancelling out-of-date condition reports
  - Runway Inspector qualifications – only qualified staff should inspect runways
  - Estimating techniques for reportable conditions.

EASA RuFAB Project Team Recommendations
Runway Condition Reporting (cont.)

- **Regulatory requirements are needed:**
  - RI Training and testing
    - Standards for subjects, training records, requalification, etc.
  - Auditing of airports' internal runway inspection instructions and procedures
  - Establish a Working Group of RI Trainers
    - Multi-nation representation
    - Develop guidelines
    - Formalize a uniform training approach.

EASA RuFAB Project Team Findings

Runway Condition Reporting (cont.)

There is inconsistency in direction to airports regarding (details provided in Report):

- **Frequency**
- **Scheduling**
- **Accuracy**
- **Criteria for issuing new reports**
- **Condition parameters**
  - Contaminant location terminology
  - Measurement uniformity
  - ‘Remaining’ contaminants
  - Contaminant distribution terminology
  - Layered contaminant reporting requirements

Clear direction is required.

EASA RuFAB Project Team Finding
Runway Condition Reporting (cont.)

- **Current ICAO SNOWTAM format needs clarifying and revision**

- **Information is insufficient and amendment is required**

Examples:

•Condition definitions are ambiguous and do not match those used elsewhere

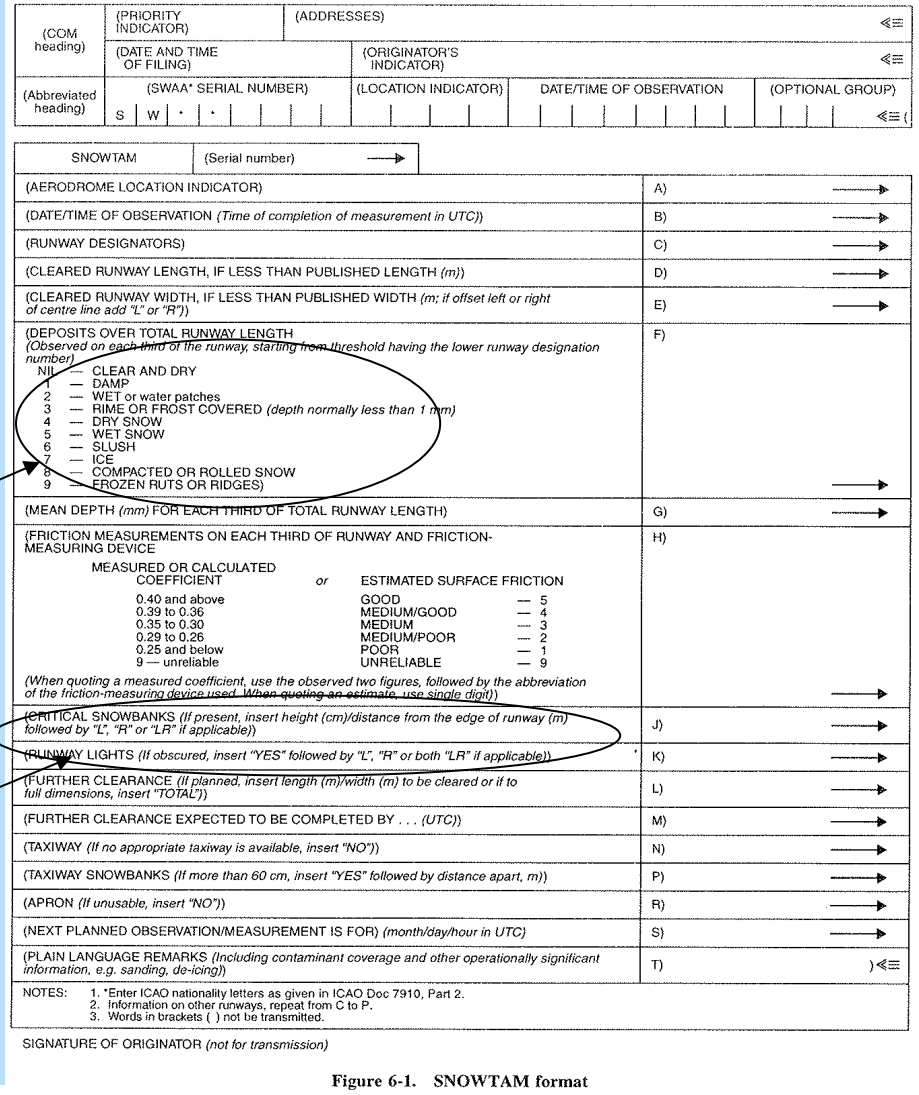
  •Rime

  •Rolling snow

  •Frozen ruts or ridges

•Absence of Snowbank (windrow) longitudinal position reporting

•Contaminant layering is not addressed.



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NOTES: 1. *Enter ICAO nationality letters as given in ICAO Doc 7910, Part 2.
2. Information on other runways, repeat from C to P.
3. Words in brackets ( ) not be transmitted.

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Figure 6-1. SNOWTAM format

EASA RuFAB Project Team Finding (Collaboration)

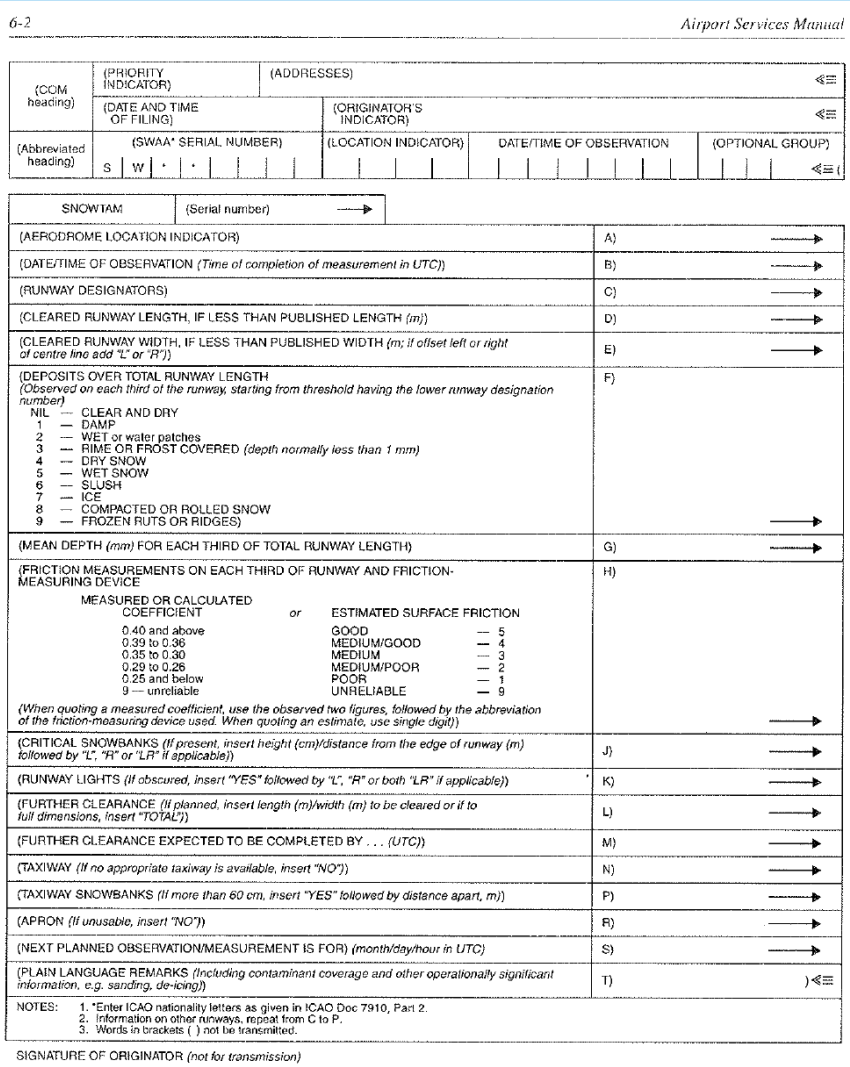
Runway Condition Reporting

1. Inconsistency in ICAO documentation

a) Annex 6 does not cross-reference definitions in Annex 14, Volume 1, Annex 15, and the Airport Services Manual

1. Contaminated runway
2. Contaminants

b) Annex 15 and other documents re. “Contaminated runway” threshold limits.



6-2 *Airport Services Manual*

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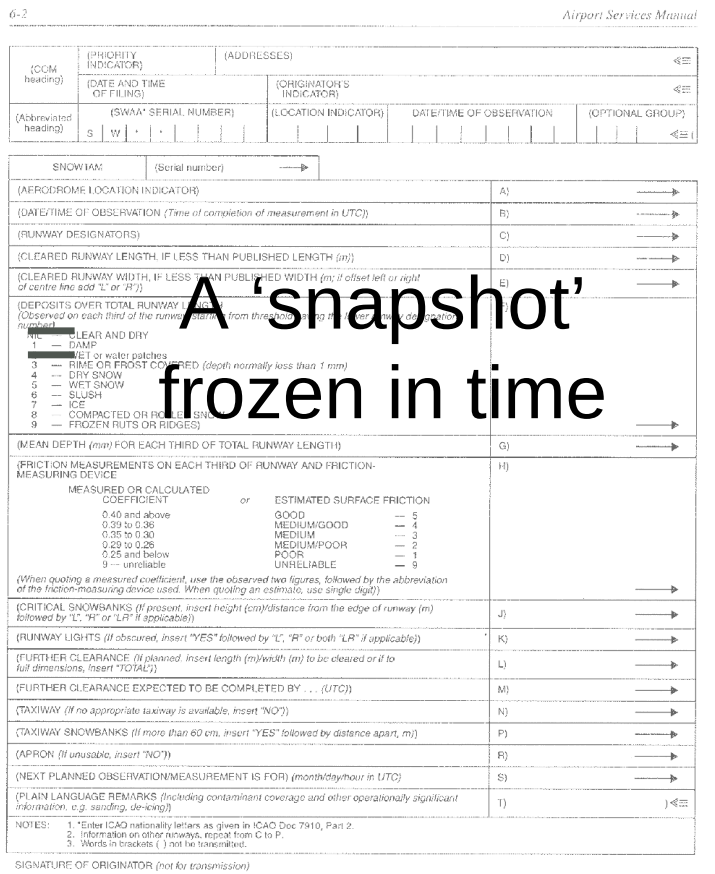
EASA RuFAB Project Team Finding
Runway Condition Reporting

- **Requirement**: Report essential conditions

  - Maintained path width
  - Offset (if any) of maintained path
  - Contaminant type
  - Contaminant depth
  - Contaminant location
  - Contaminant distribution
  - Maintenance status

- Friction / Braking Action (if available).



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A 'snapshot' frozen in time

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EASA RuFAB Project Team Recommendations
Runway Condition Reporting

3. Revise and Harmonize ICAO SNOWTAM format

A. Change CLEARED' to MAINTAINED (D&E)

B. Report maintained path off-set (if any) (E)

C. Change L/R to magnetic headings (E&J)

D. Facilitate reporting of contaminants over each third (F)

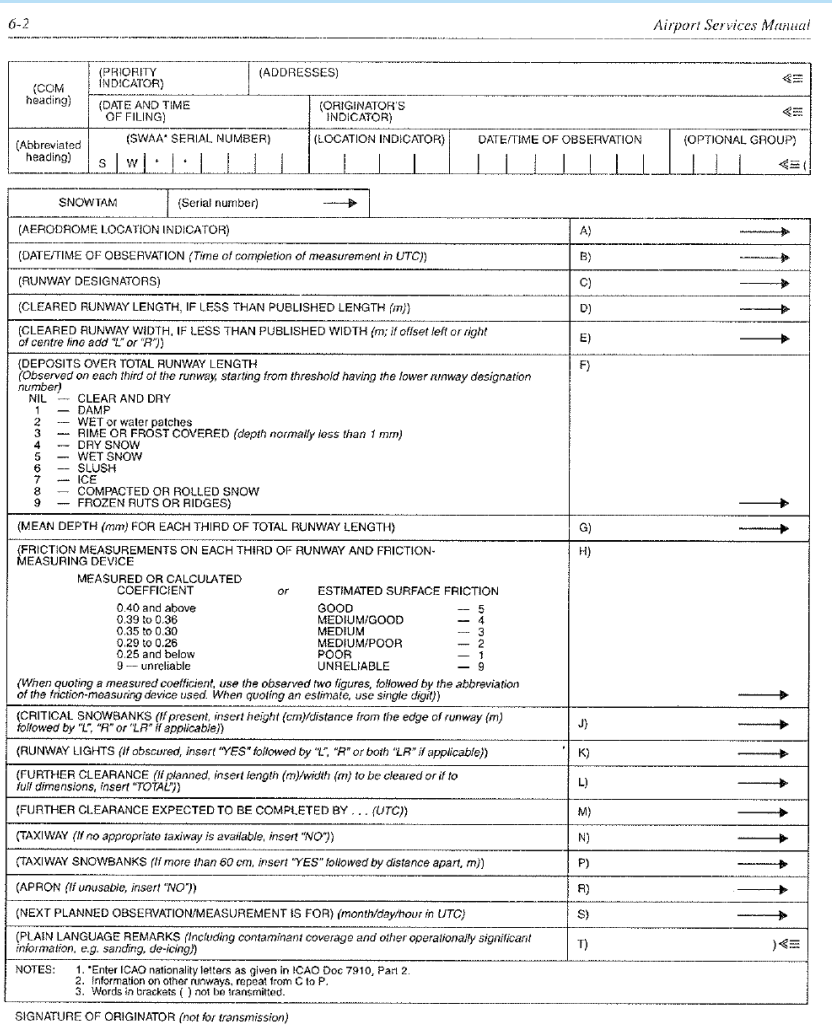
E. Update contaminant definitions (F)

F. Update friction/braking action reporting requirements (H)

G. Facilitate reporting of snowbank locations (J&H)

H. Update guidance on reporting layered contaminants

I. Update overall reporting guidance.



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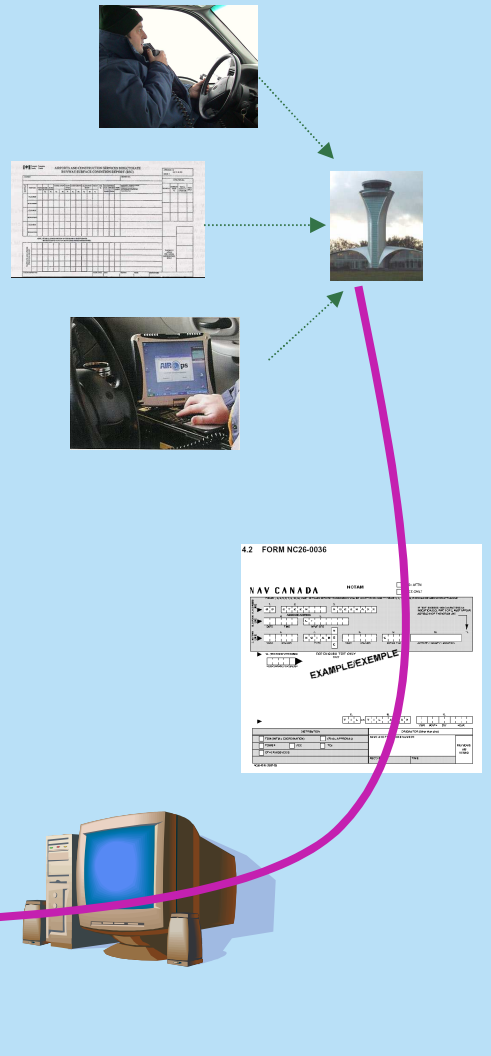
EASA RuFAB Project Team Observation

Runway Condition Information Transmission

Precious time is consumed in distributing runway condition information reports

- **RIs send voice report, written report, or computerized condition report to ATC**
- **ATC transposes reports into NOTAM format**
- **ANS distributes NOTAM over ATIS, internet, etc..**



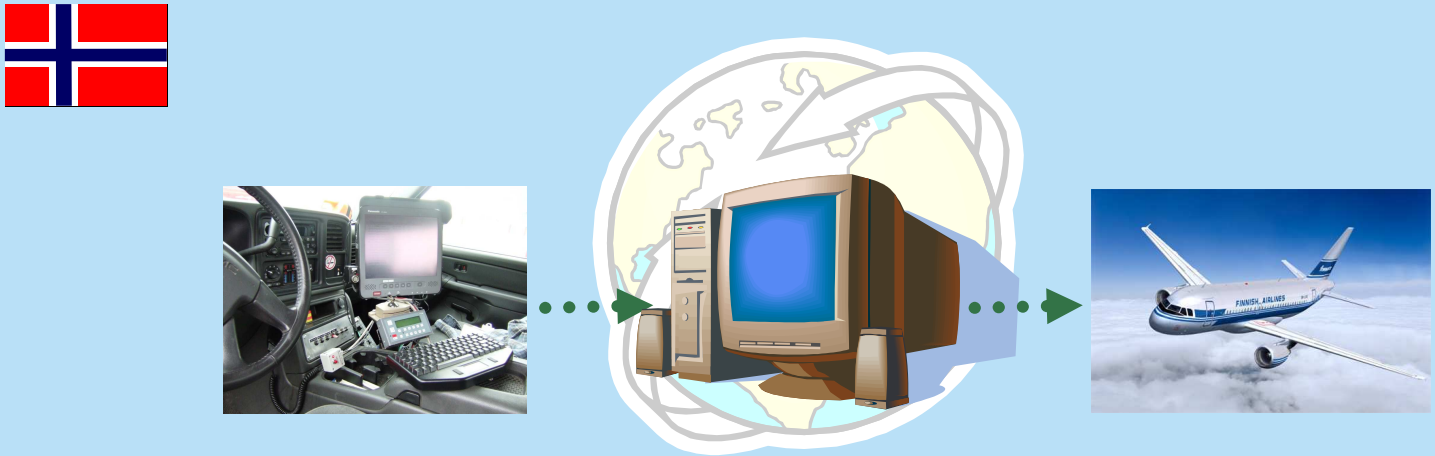
EASA RuFAB Project Team Recommendations

Runway Condition Information Transmission

- **The impact on flight operations and performance of the Norwegian (and Swedish trialed) RI computerized NOTAM transmission process should be assessed**
  - Positive results should be followed up with formal procedural standards and regulatory commentary to encourage similar initiatives

AVINOR system

by default, the State-of-the-Art



BMT Fleet Technology

EASA RuFAB Project Team Observation

Runway Condition Determination

• **Current condition reports contain (with very few exceptions) only <u>estimated</u> contaminant parameter values**

Exception – friction measurements (now being deemphasised)

- Maintained path width – estimated to nearest 6m or 12m

- Contaminant depths
  - measured with ruler
  - compared with known thickness
  - estimated

- Contaminant location – subjective description
  - scattered, covered, etc.
  - general distance to runway feature

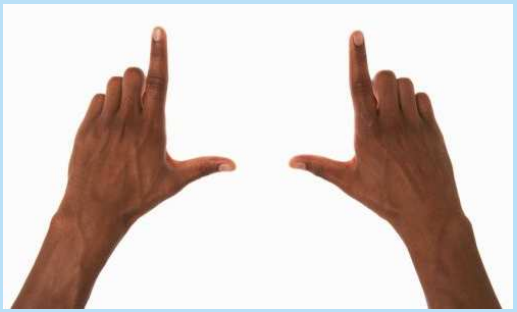
- Contaminant distribution
  - estimation to nearest 20%.

BMT Fleet Technology

EASA RuFAB Project Team Observation

Runway Condition Measurement Technology

- **TALPA-ARC & ICAO-FTF place more emphasis on contaminant parameter reporting**
- **Measuring contaminant parameters will enhance accuracy and reliability of reports**
- **Measurements will supplement, not replace observations**



VS.

Progress requires moving from subjective assessment to objective measurement.

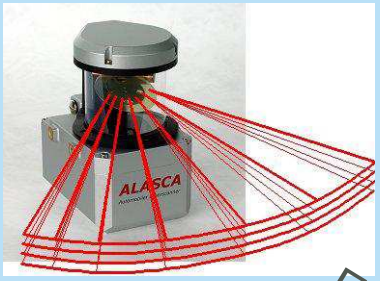
EASA RuFAB Project Team Findings

Runway Condition Measurement Technology (cont.)

- **No 'Common Off The Shelf' instrumentation available**
- **Extensive R & D in aviation and roadway condition sensing with positive results**

- Inspection vehicle mounted

ALASCA Layered laser scanner assessed in the IST (Finland) FRICTI@N Project



Examples

- Imbedded or near runway

Vaisala DSC111 (Spectro sensor) evaluated for Ontario Ministry of Transportation

- Aircraft mounted.

Forward-Looking Interferometer development sponsored by NASA

EASA RuFAB Project Team Observation

Runway Condition Measurement Technology (cont.)

Possible Condition Sensing

Various Technologies have been examined (details in Report)

Contaminant Depth is Least Addressed

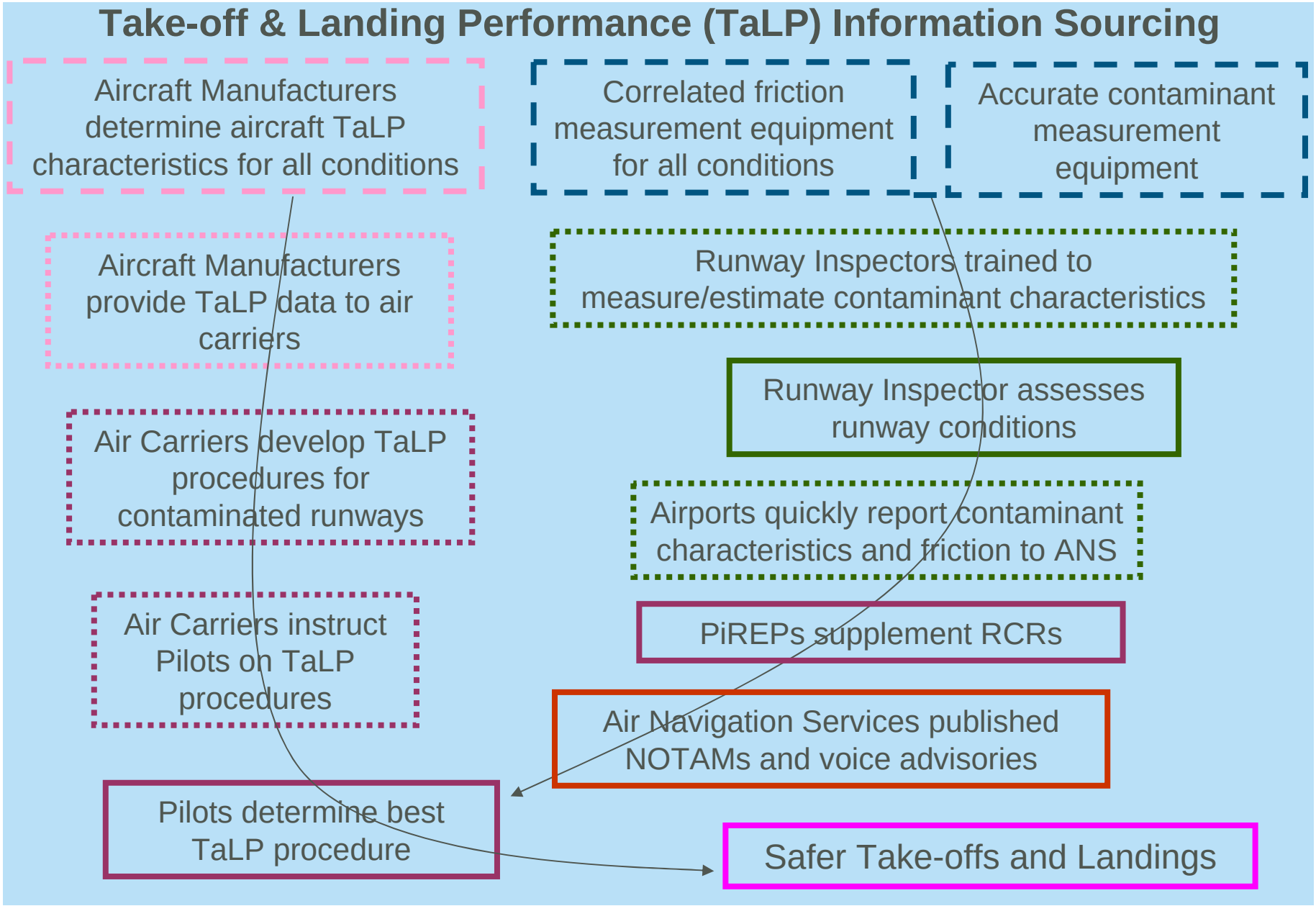
	Maintained Path Width	Contaminant Type	Contaminant Location	Contaminant Depth
Spectral analysis imaging (SPAR)	Yes	Yes	Yes	
Near infrared imaging (Vaisala DSC111)	Yes	Yes	Yes	
Infrared temperature sensing (Vaisala DST111)		Yes	Yes	
Lateral laser scanning (IST ALASCA)	Yes	Yes	Yes	Yes
Vehicle mounted radar (IST or similar)	Yes		Yes	
Differential GPS (COTS)			Yes	
Stereo polarization imaging (IST Road Eye sensor or similar)	Yes	Yes	Yes	
Contaminant Impact energy measurement (Vestabill modified Mu-meter)		Yes		Yes
Forward Looking Interferometer (NASA/Georgia Tech/Hampton University)	Yes	Yes	Yes	
Laser Depth Profiling (SnowMetrix)				Yes

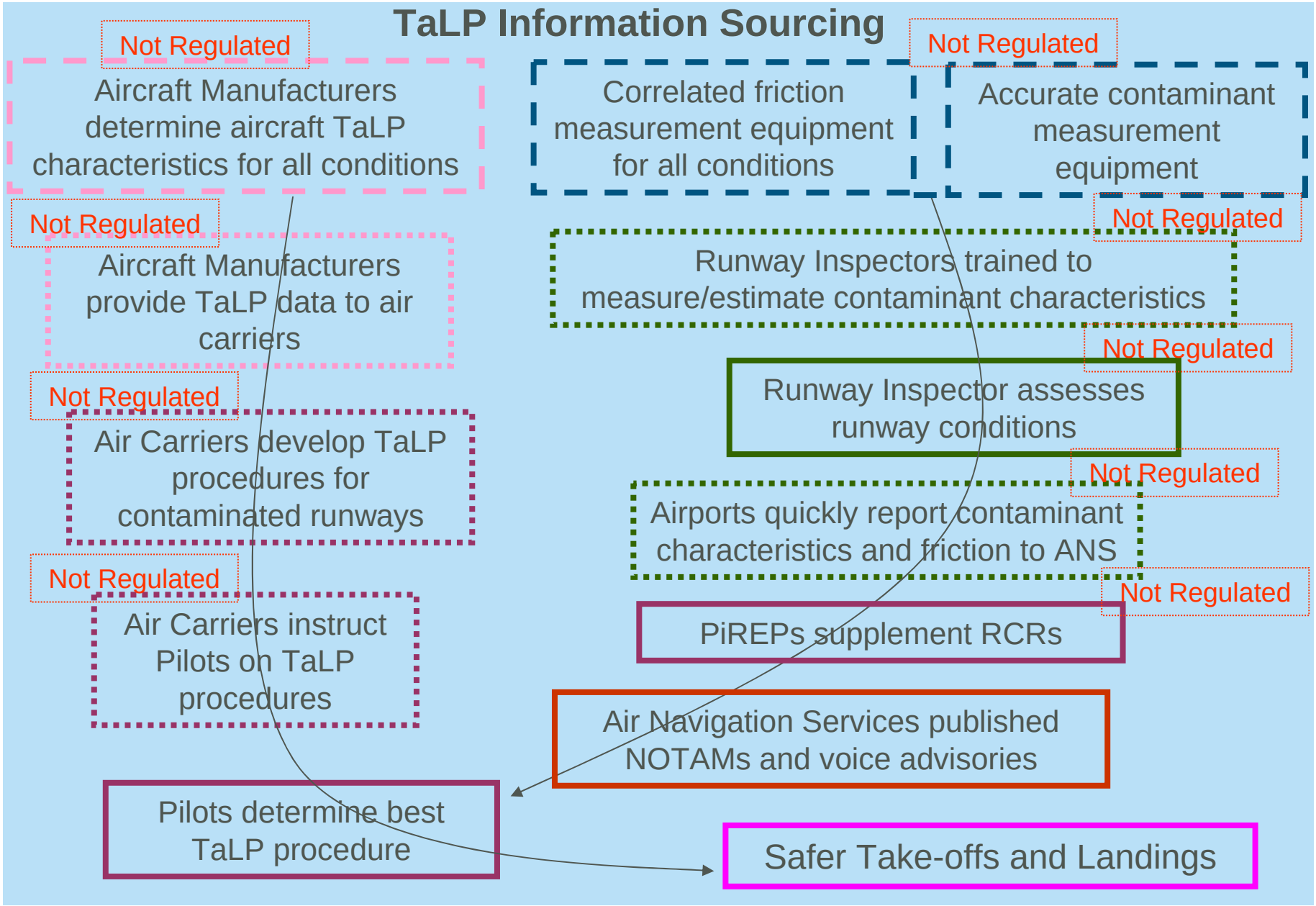
EASA RuFAB Project Team Recommendations

Runway Condition Measurement Technology

- **Equipment and technology** which can identify and quantify contaminants **should be fostered**
  - **The aviation community should work closely together** to identify measurement requirements (details provided in Report)
- Direct sensor data or values derived through analysis of sensed data should provide values with **minimum accuracies** (details provided in Report)
- A **committee should be established to develop a performance specification** for a device(s) or technolog(ies)y that would meet operational runway surface condition reporting requirements
- **Development** of surface contaminant condition measurement technologies **should be encouraged** and where appropriate, fostered and evaluated (applies to technologies referenced in the Report and others).

Take-off & Landing Performance (TaLP) Information Sourcing




TaLP Information Sourcing
Not Regulated
Aircraft Manufacturers determine aircraft TaLP characteristics for all conditions
Not Regulated
Aircraft Manufacturers provide TaLP data to air carriers
Not Regulated
Air Carriers develop TaLP procedures for contaminated runways
Not Regulated
Air Carriers instruct Pilots on TaLP procedures
Pilots determine best TaLP procedure
Not Regulated
Correlated friction measurement equipment for all conditions
Not Regulated
Accurate contaminant measurement equipment
Not Regulated
Runway Inspectors trained to measure/estimate contaminant characteristics
Not Regulated
Runway Inspector assesses runway conditions
Not Regulated
Airports quickly report contaminant characteristics and friction to ANS
Not Regulated
PiREPs supplement RCRs
Air Navigation Services published NOTAMs and voice advisories
Safer Take-offs and Landings

Any Questions?

Thank you!