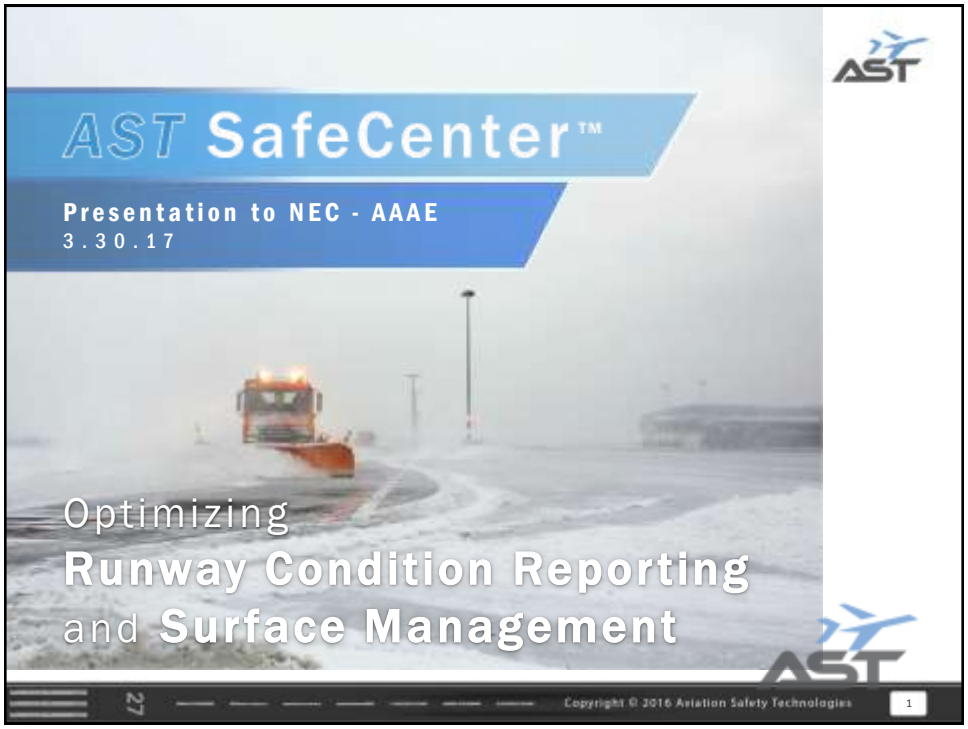

Agenda

- The Challenge of Surface Conditions
- AST SafeCenter™: A New Solution to a Global Aviation Problem
- How's it work
- FAA and AST: Roadmap into the Future
- Benefits and Business Value

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Surface Friction: A Long-Term Industry concern

- Runway over-runs are among the most frequently reported accidents
- Runway over-runs do not often result in causalities to passengers or crew
  - Despite this fact, landing overruns are still considered a major threat to aviation safety
- Civil Air Navigation Services Organization: “Two runway excursion occur weekly on a worldwide basis”.
  - “Landing overrun accidents in slippery conditions continue to occur…”

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Problem with Current Techniques

- Current means of measuring surface conditions can be inaccurate & misleading
  - Subjective – not objective
  - Variable – not data-based
- PIREPS are inherently subjective assessments and can lead to unnecessary runway closures and operational impacts
- Obsolete FICONs and METAR information is often the norm
  - Can be unreliable
- Conventional ground device measurements don't correlate to airplane braking capability or other ground devices
  - FAA methodology to address deficiencies carry significant implementation risk

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Three Areas of Impact

Safety issues

Excursions are among the most-frequently reported accidents

- Do not often result in casualties, but still considered a threat to aviation safety

Poor information > inefficient surface management > mismatch of runway availability and airport demand

Airports can close runways prematurely

- Can incur unnecessary maintenance costs – staff, equipment, resources, and environmental impacts (chemical treatments)

Airports can wait too late to close runways

- Can create excursions or other events

Impacts on brand and reputation

What are you known for?

- Airlines and Airports can become known for weather-related issues, eroding flier satisfaction

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Satellite View

Pilots:

- **Directional control operating several hundred thousand pounds of machinery in slippery conditions**
- **Vital information on surface conditions and weather**
- Increased spacing, slower ground speeds
- RTO Considerations

Passengers:

- Reliability issues when subjective and potentially erroneous assessments are made during irregular operations

Airports:

- Maintaining safe operating environment during challenging conditions
- RCAM/RwyCC, enhanced FICON-NOTAM reporting: concerns over unexpected issues associated with implementation
- PIREPS: Subjectivity increases safety risks and operating costs

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NTSB Recognition

- NTSB recommendation to 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. If feasible, require operators of transport-category airplanes to incorporate use of such equipment and related procedures into their operations."

- FAA issued Grant to Aviation Safety Technologies (AST) to determine feasibility of NTSB recommendation
  - AST's Final Report on file with FAA and available for release to interested parties
- AST's algorithm uses data downloaded from aircraft to determine the presence of friction limits and the friction consumed at that those friction limits
- AST's sensor technology measures contaminant type, depth and coverage

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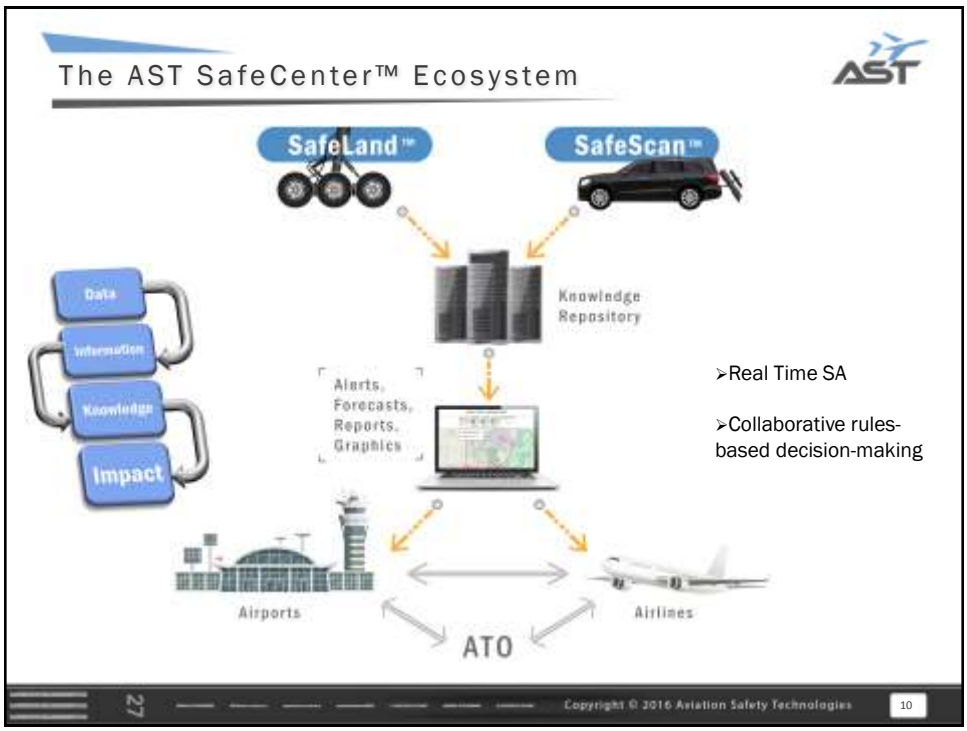
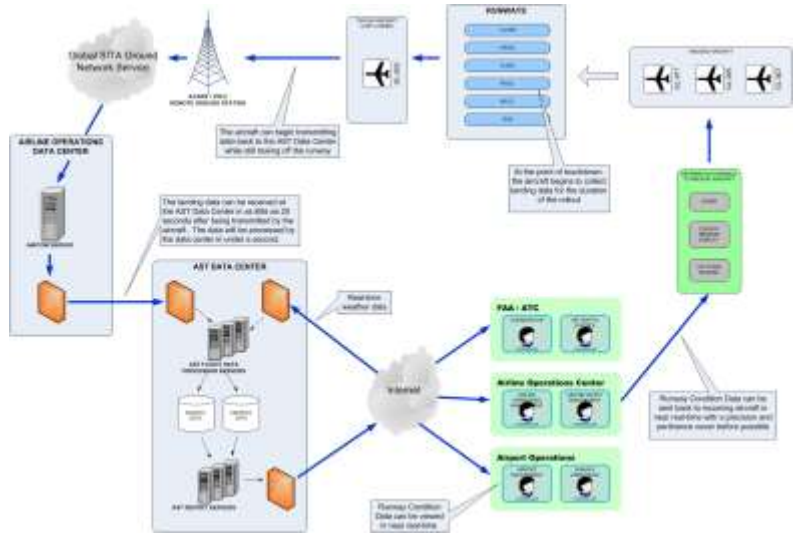


- Real Time SA
- Collaborative rules-based decision-making

SafeLand – How's it Work?



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AST SafeLand™

- Utilizes landing aircraft as **real-time runway condition measurement devices**

  - Uses real-time data, downloaded directly from aircraft, to run landing simulations and measure **"Experienced Friction"** as a function of the actual braking applied
  - Measured range is from zero to the Friction Limit (an aircraft calling for more deceleration without deceleration being delivered)
  - Landing reports are generated for all runways where your aircraft is landing, with minimal latency (60 seconds from end of roll out)
  - Reports presented in new TALPA nomenclature – Good, Good to Medium, Medium, Medium to Poor, etc.
  - Reports also in 0-6 RwyCC nomenclature
- AST awarded FAA Grant DFACT-14-C-00004
- FAA accepted AST Final Report detailing SafeLand system

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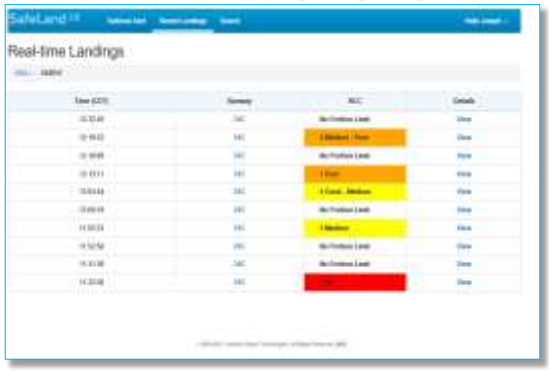
AST SafeLand™

- The world's first Runway Condition Code (RwyCC) service using real-time data from landing aircraft
- Supplements (eventually replacing) subjective assessments with objective reports:
  - Improves safety through situational awareness
  - Increases operational efficiency through more runway uptime



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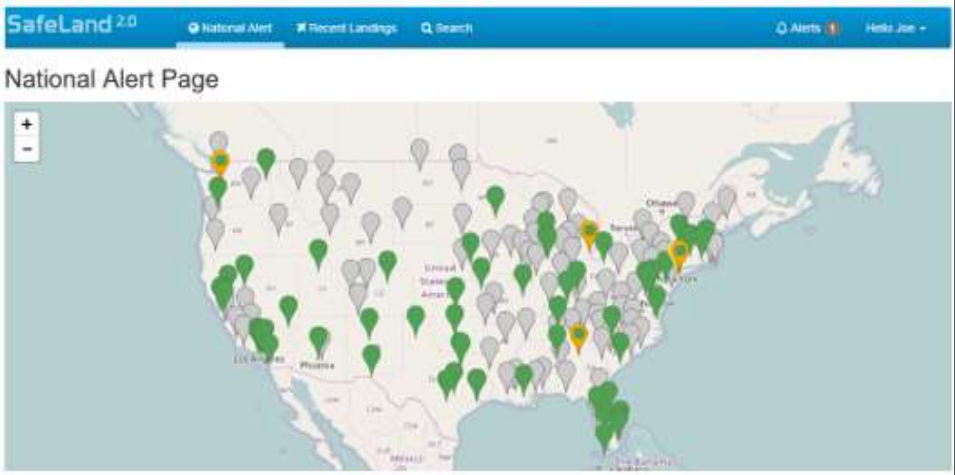
Simple Navigation



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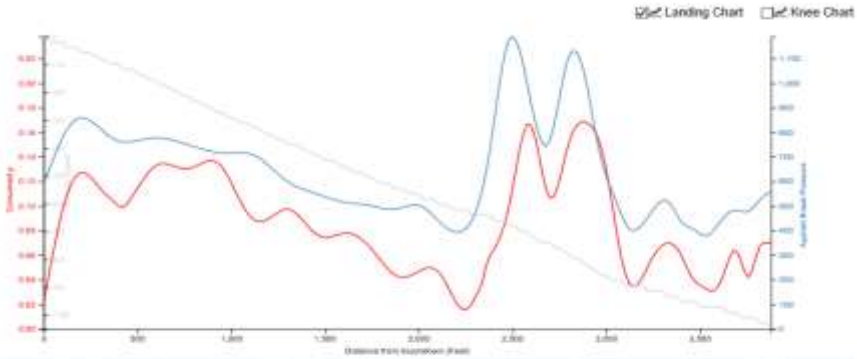
Landing Chart – Admin only

Airport Landing Detail Data



Airport	Date - Time (GMT)	Runway	RwyCC
KATL	01/25/2017 00:17:55	28	No Friction Limit

Air Temp	Est. Surface Temp	Wind Speed	Wind Dir.	Precip. Intensity	Precip. Type	Dew Point
14° C	8° C	9 Knots	320	None	None	1° C

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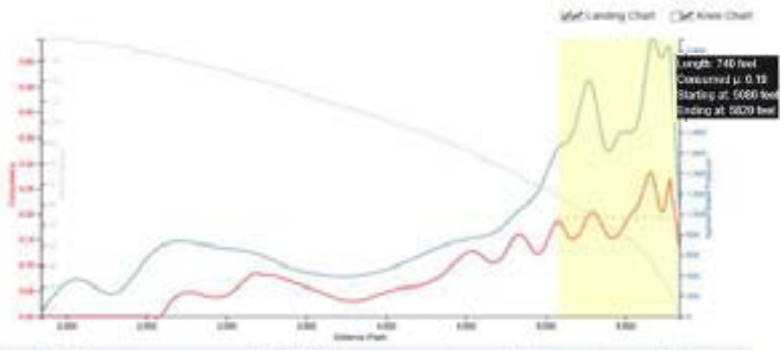
Landing Chart with Friction Limit

Airport Landing Detail Data



Airport	Date - Time (EST)	Runway	RwyCC
KDTW	03/06/2017 12:30:26	22R	4 Good - Medium

Air Temp	Wind Speed	Wind Dir.	Precip. Intensity	Precip. Type	Dew Point
52° C	16 Knots	190.0	Light	Rain	8° C

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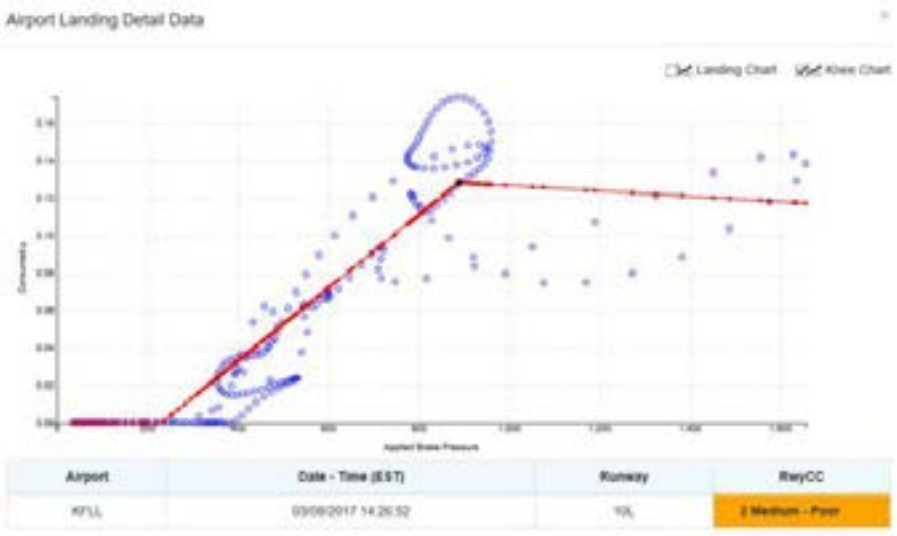
Knee Chart (Admin only)



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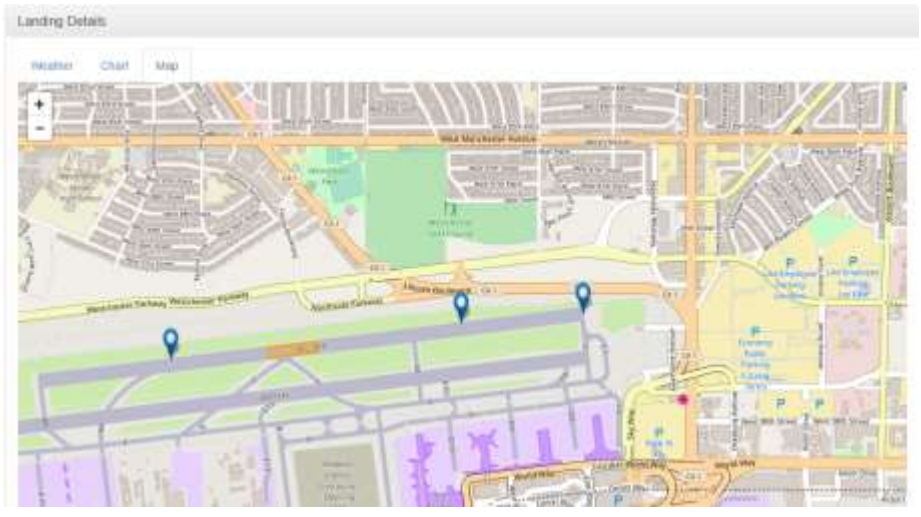
Airport Map Depicting FL Location & Rwy Exits



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AST SafeLand™

- An evolutionary and collaborative process between AST and its airline and airport clients
  - Working closely with Pilot Community to improve how surface conditions are understood, measured, and acted upon
  - Provides alerts to pilots about changing trends in runway friction, or status quo
- AST collaborates with pilots to proactively augment knowledge base
  - Pilots given quick feedback on Friction Limited (FL) landings and the consumed friction on those landings **via ACARS**
  - Pilots and Dispatchers obtain a data-based summary of FL landings – standardized and normalized
- AST's Landing Reports become more valuable as more reports are received
  - Goal is to eventually light up the entire fleet and expand to Regional Partners
  - In the meantime – a methodical roll-out at an airline's preferred pace
  - Eventually, AST reporting will be provided to ATC

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Operational Realities – Why SafeScan™

- PIREPS only cover the "used" portion of runway
- Roll-out section of take-off runway is not reported, leading to sub-optimal overrun risk during rejected take-offs
- Low-frequency airports do not have a sufficient number of landings to make high-quality, verifiable assessments
- Visibility into condition of *whole airport surface* brings value to operators
- Introduction of new processes:
  - TALPA, SAFO Issued (landing distance assessment, reinforced FICON / NOTAM process), NTSB recommendations to FAA

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SafeScan – Covers the entire airport surface

- AST's new runway contaminant sensor technology that can uplink runway condition data into SafeCenter displays and computational models
- Sensor Data can define surface characterization for roll-out end of departure runway, turn-offs, taxiways and ramps-the entire airport surface

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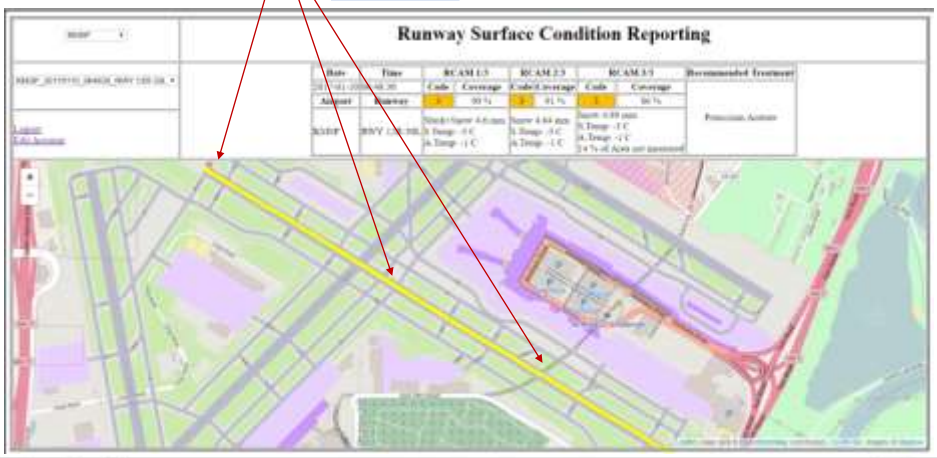
From Guesswork to KNOWLEDGE

Snow 4.6mm – 4.64mm – 4.89mm

~1/16th. In.

SafeScan™



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From Guesswork to KNOWLEDGE

SafeScan™

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AST SafeScan™

SafeScan™

- Utilizes vehicle-mounted mobile infrared spectroscopy sensors to detect contaminants *at any point across the entire airport surface:*
  - Runways, taxiways, ramps – everywhere
  - Detects and measures all types of contaminants – wet, snow, ice, slush
  - Measures depth to 1/1000th inch
  - Measures coverage area, surface, and ground temperatures
- For runways, calculates Runway Condition Code (RwyCC) automatically for each 1/3 of the entire runway length
  - Provides real time display to airport personnel on any device
- Formats measurements in an output that enables both manual and automated uploading of FICON reports
- Certified compliant to AC 150/5200-30D (Sec.3.3.2) provision, which requires mobile sensors to meet performance standards of SAE ARP 5623

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Alerts, Forecasts, and Reports

- You control who has access to the information
- Both on-the-field and management views
- Browser *and* mobile
- Integrates with your existing systems or viewable in its own GUI
- Enables better tactical decision-making and SA:
  - Maintenance decisions
  - Better information for treatment type
  - Easy to deploy, train and use – important for both part-time and temp

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FAA Mandates

- TALPA ARC recommendations have been implemented in 2016-17:
  - Runway Condition Assessment Matrix (RCAM) and Runway Code Conditions (RwyCC) mandates
  - But currently based on **human** measurements of contaminant coverage, type and depth
  - This process carries its own unique risk set
- Landing Distance Assessments and Braking Action Reporting
- Once the first PIREP is received, runway assessments then revert to pilots' subjective reporting
  - Limitations to airport upgrading RwyCC
- How effective is the industry's ability to meet safety margins efficiently?
  - Can the NOTAM system keep up? FICON reporting too burdensome?
  - What are adverse impacts and unintended consequences?

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FAA and AST: Setting a New Standard

The standards challenge today:

The FAA can only confirm that a measurement or calculation is compliant when there is an existing standard to comply with. Currently, no FAA standard exists for AST's SafeLand Technology.

The solution moving forward:

AST has been asked by the FAA to work with standards bodies to help develop relevant standards on surface management. These new standards will help guide airports and airlines in meeting the FAA's new Runway Code Conditions (RwyCC) mandates while using emerging technologies

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FAA and AST: A Collaborative Roadmap

- Today, AST's subject matter experts are actively helping to develop new standards for landing friction reporting and mobile sensors of airport surface contamination
- Goal is to develop a standard methodology that aviation industry can use to meet FAA's new Runway Code Conditions (RwyCC) mandate while incorporating new technologies
- **Society of Aircraft Performance Operations Engineers (SAPOE)**
  - AST's Brian Chapman is a Founding Member of this committee, which recently voted unanimously to establish surface friction standard recommendations to the FAA
- **American Standards for Testing and Materials (ASTM)**
  - AST's Dr. Zoltan Rado is Chairperson of this international organization, which has formed the ASTM E17 Subcommittee to develop a standard for the practice of measuring winter contaminants on runways and roads
- **FAA ATRD 15**
  - AST's Dr. Zoltan Rado is a member of this TALPA oversight committee

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At the Forefront of a New Standard

- AST SafeCenter™ technology is vendor-agnostic – works with any aircraft manufacturer
- Proven partnership with FAA
  - AST has already successfully completed an FAA Grant validating AST's technology – Final Reports are available from the FAA and AST
  - "It's a wonderful technology," *Patrick Doyle, FAA Official, August 2016*
- Complies with all standards that currently exist
  - Runways: Uses existing sensors on landing aircraft and downloads data directly from those sensors (FAA approved)
  - Other Surfaces: Uses standards-based mobile infrared laser technology
- Subject matter expertise
  - AST team is led by Dr. Zoltan Rado, world-renowned researcher with expertise in vehicle-to-surface interaction; dynamic frictional characteristics and braking; surface dynamics and characteristics; aviation-automotive safety; modeling and simulation; finite element analysis; and vehicle crash safety research

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The AST Journey Continues

- Multi-Million Dollar Investment Evolution
  - 8 years including 3 years for FAA review; R&D and continuous compliance support
  - Key product enhancements (Friction Limits)
  - We've developed collaborative and constructive relationships with airports, airlines, and FAA
  - 1500 Commercial Transport Aircraft (Airbus and Boeing) reporting 5,400 flights daily for 6 major US airlines
  - Nearly 3M landings in the database (mature product for initial commercialization)
- Resources acquired to move to full-time model (from shared services model)
  - Advanced software engineering talent
  - Management, Sales, Marketing, and Legal Support
  - Dr. Zoltan Rado has joined full-time
  - Aircraft Performance Engineer on-boarded
  - 24/7 operational support with SLA commitment to airlines

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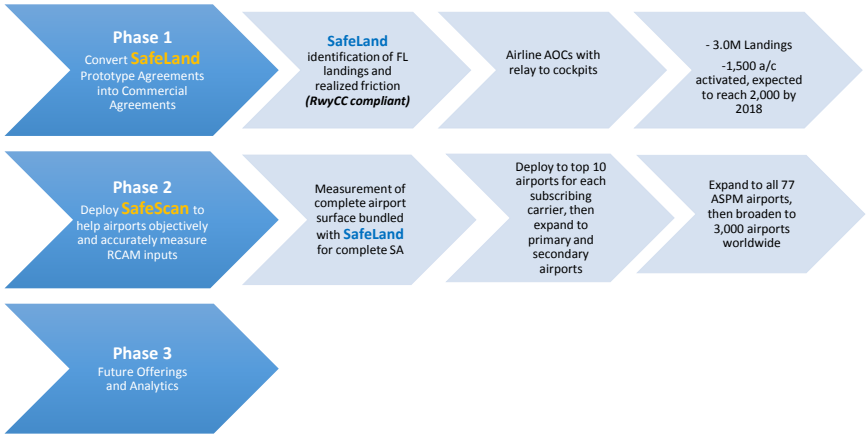
AST Product Roadmap



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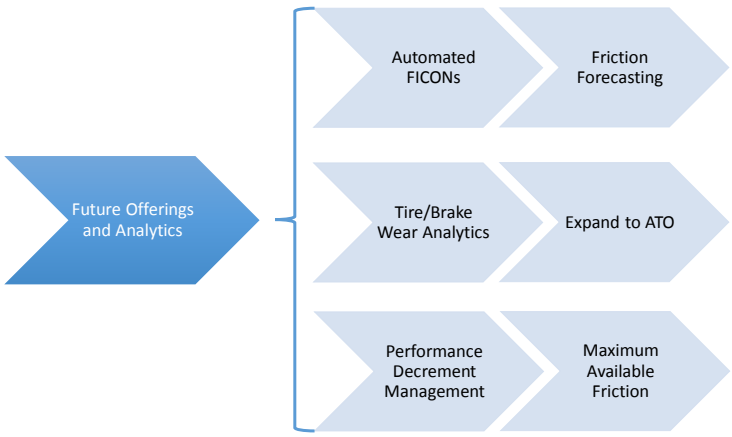
Phase 3 Developmental Roadmap



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Details Behind Road Map

- The FAA has no established standards, at this time, for measurement of friction using aircraft data using ground-based computer systems nor for the use of optical contaminant type and depth measurements
  - AST uses existing sensors on the aircraft **(FAA approved)**
  - AST downloads data directly from those sensors **(FAA approved)**
  - AST meets SAE ARP standards for airport surface measurement
  - No limitations to airports and carriers to use AST SafeCenter technologies
- Full subscription authorizes internal use by airport of SafeLand's de-identified airplane landing reports and SafeScan's sensor reports; and authorizes distribution by AST to AST subscribers

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A Win-Win-Win in Surface Management

AST aligned with industry's focus on **reliability**

Enhanced situational awareness using **objective measurements** – proactive planning – conformity to FAA new reporting requirements – all operating phases of surface measurement and management

For Airlines

- Schedule Reliability
- Operational efficiency
- Increased payload
- Operational SA
- Enhanced Customer Experience

Provides flight data to AST in exchange for Landing Reports

For Airports

- Safety-Risk Reduction
- Better Aircraft Movement Area Management
- Accurate Contaminant Measurement
- Operational SA
- Enhanced Customer Experience

AST Subscription Service

For FAA - ATC

- Better Monitoring
- Better Predictability
- Reduced Workload
- Operational SA

AST Subscription Service

AST provides collaborative working model for future development and regulatory oversight

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Economic Waterfall of Benefits

Benefits	Economic Impacts	Economic Waterfall to Subscribers
Reduced risk of runway excursions	Reduces costs associated with incidents Reduces insurance premiums	Proportional reduction in subscribers share of excursions)
Higher Payload when applying clutter	Reduces operational costs	$13,000/revenue per flight (B737/B757) Payload impact only - does not include return fare or downline impact
Optimized landing set-up: Friction influencing thrust reverser vs. braking And Optimized chemical treatment of runways and airport surfaces	Reduces operating costs (fuel/chemical) Environmental benefit	$$
Fewer and shorter runway closures due to surface conditions	All time-based costs, passenger delay, and rebooking costs	Reduction in delay/cancellations Weather costs influence 40% of typical trunk carrier's irregular (non-schedule) costs
Reduction in diversions	Operating costs	Reduction in diversion related costs

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