An Advanced Technology for Aircraft Overrunning Runway—

Engineered Material Arresting System (EMAS)

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June 6, 2012 Beijing, China

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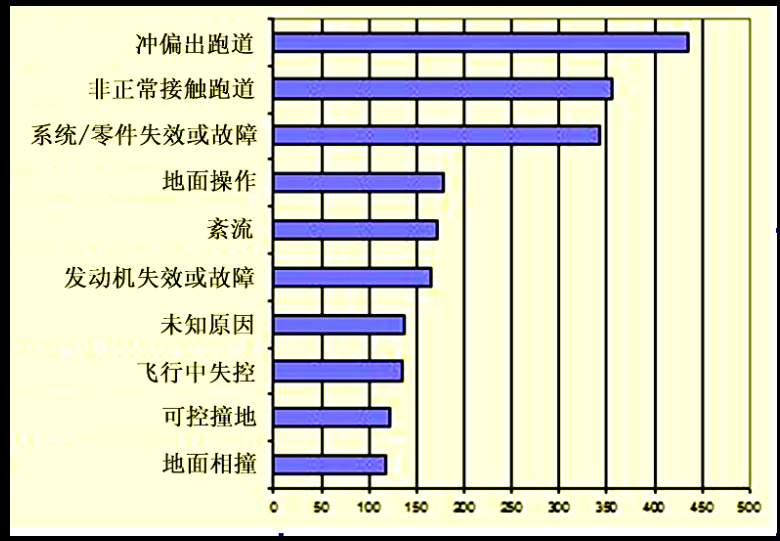
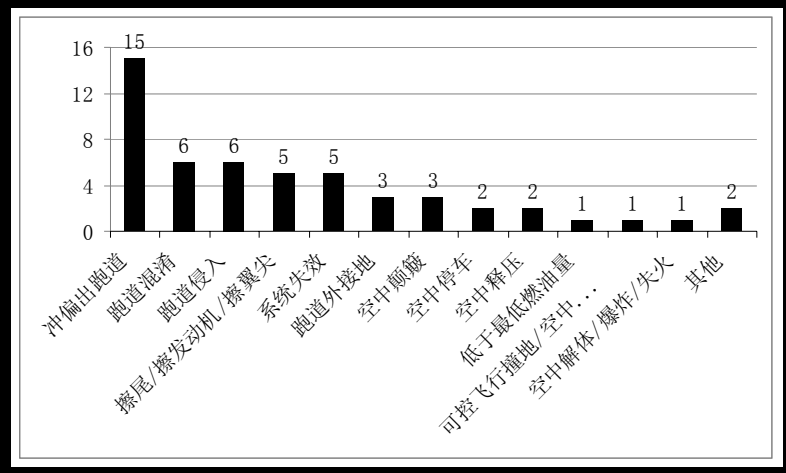
Runway Overrun and Veer-off -- One of the Major Challenges to Aviation Safety

- 1998~2007, number of accidents due to runway overrun and veer-off is in No.1 place in the global statistics.
- 2005~2008, number of incidents due to runway overrun and veer-off is also in No.1 place in Chinese statistics.





Tragic Consequence Resulted from Overrun

May 22, 2010, India, B737, overrun off the cliff, 158 fatalities

Dec. 22, 2009, Jamaica, B737, overrun, 40 injuries

Particular Threat to Aviation Safety in China

- In western China, there are many high altitude airports. Even having standard Runway End Safety Area (RESA) in place, beyond RESA always are steep cliffs, which poses particular threat to aviation safety in China.
- So do some airports near water bodies or residential areas.

250m away from runway end in an airport in western China

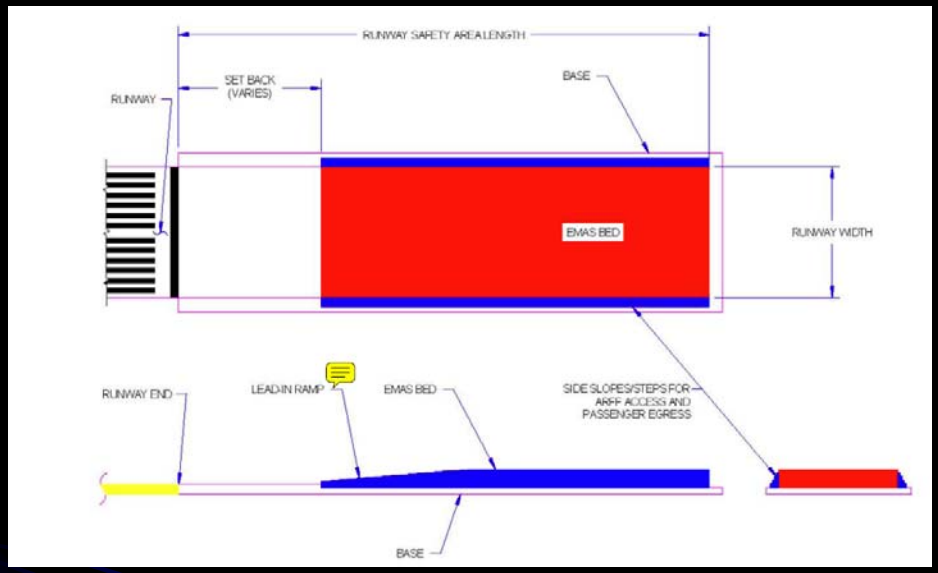
What's Solution?

- International standards:
  - Building RESA with standard length
  - The standard length increased again and again
- What to do with an airport not meeting new standard, or with dangerous geography beyond RESA?
  - USA invented technology: Engineered Material Arresting System (EMAS） built within existing RESA, as an alternative method of compliance to the RESA standard

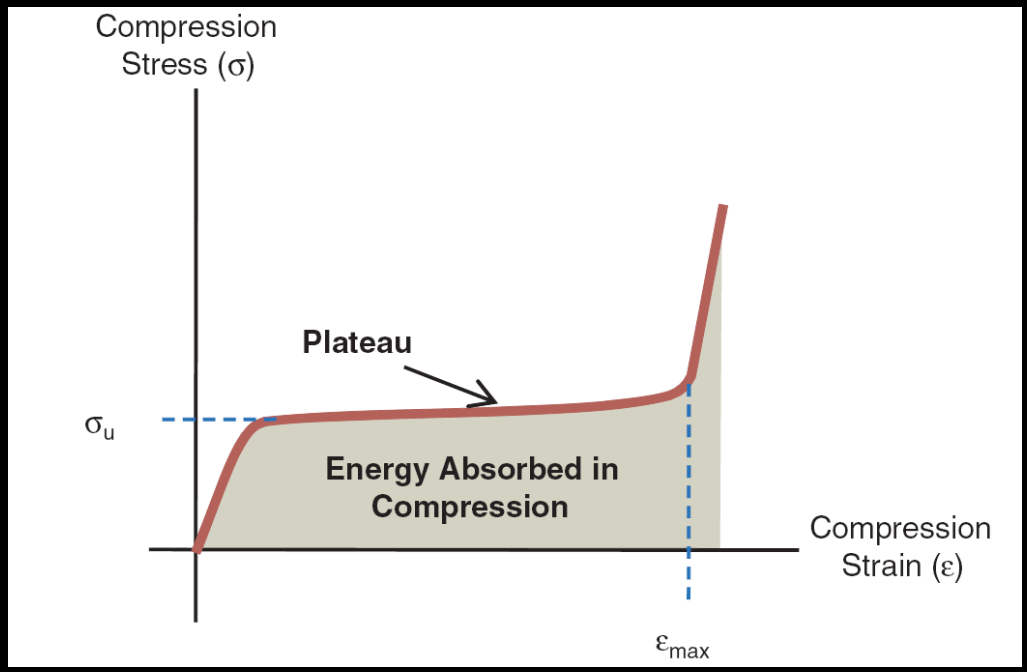
What's EMAS

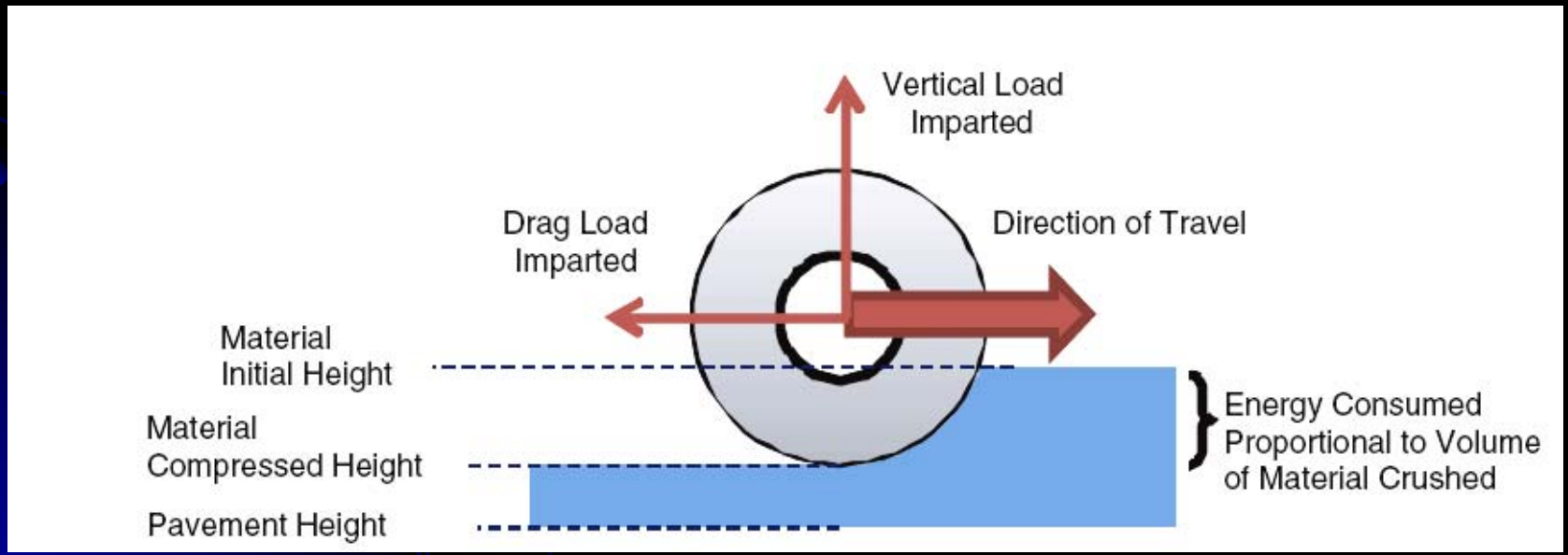
- Foam concrete, laid on RESA ground, as wide as runway, up to 70cm high, up to more than one hundred meters long
- When overrunning aircraft travels in EMAS bed, the wheels crush the foam concrete, by which the aircraft is gradually slowed down to complete stop within the bed, without damage to aircraft or injury to occupants.
- Vehicle moving in the bed will damage it, but human will not.

What's EMAS


RUNWAY SAFETY AREA LENGTH
SET BACK (VARIES)
RUNWAY
BASE
EMAS BED
RUNWAY WIDTH
RUNWAY END
LEAD-IN RAMP
EMAS BED
SIDE SLOPES/STEPS FOR ARFF ACCESS AND PASSENGER EGRESS
BASE

Arresting Principle





Standard for EMAS

- FAA AC 150/5220-22A， 2005， “Engineered Materials Arresting Systems (EMAS) for Aircraft Overruns”
  - able to arrest aircraft with exit speed up to 70 knots for standard design, or up to 40 knots for non standard design
  - Not cause major structural damage to the aircraft or imposing excessive forces on its occupants
  - Enable safe ingress and egress of rescue and fire fighting vehicle
  - not cause control problems for aircraft undershoots which touch down in the EMAS bed
  - Validation may be based either on passage of an actual aircraft or an equivalent single wheel load through a test bed.

Application Till Now

- At the present, USA’s product is only one product all over the world
- 55 sets installed in 35 airports in US and 8 aircrafts arrested
- Installed in Spain, South America and 2 sets in Jiuzhai-Huanglong Airport in Sichuan Province, China

ICAO's Policy on EMAS

- In September 2011, in Proposed Amendment to the International Standards and Recommended Practices Aerodrome Design and Operations Annex 14, Volume I to the Convention on International Civil Aviation:
  - 3.5.5 Notwithstanding the provisions in 3.5.3 and 3.5.4 a) and b), the length of a runway end safety area may be reduced where an arresting system is installed with demonstrated performance that provides a level of protection at least equivalent to the prescribed runway end safety area.
- So, EMAS will become an internationally recognized safety measure after November 2012.

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R&D of the Hangke Company

- Since 2010, the Hangke Company has been conducting R&D on EMAS in accordance with the FAA AC
- Both military and civil actual aircraft validation tests were conducted

Certification of CAAC

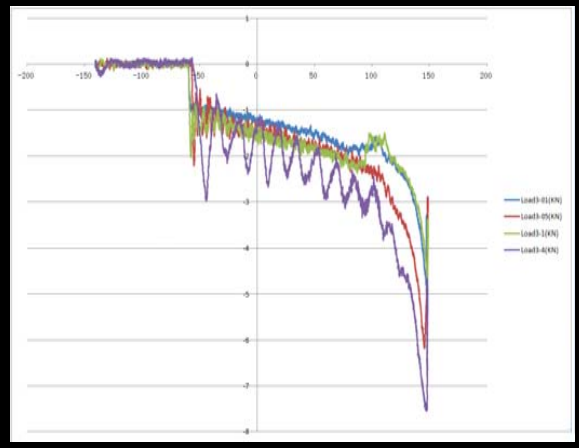
- In April 2011, CAAC Certification Team was constituted, working at theories, material performance, simulation model, single wheel load tests, actual aircraft tests, production quality assurance system etc. in compliance with the relevant standards.

Key Techniques

- 2 key techniques in EMAS:
  - Manufacturing process producing foam concrete meeting mechanical property and durability requirements
  - Simulation model capable of calculating stopping distance and evaluating safety of occupants and aircraft landing gears.
    - Calculating aircraft speed decay curve, deceleration curve, stopping distance, loads imposed on landing gears and their strengths, based on material properties, bed geometry, aircraft type, exit speed, weight of aircraft and so on.
- The Hangke Company developed these 2 techniques.

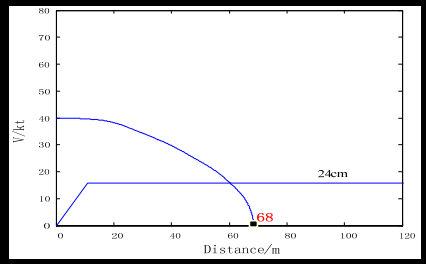
Achieved 2 Key Techniques

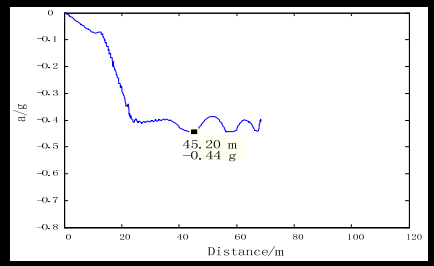
Block of the foam concrete



Mechanical performance

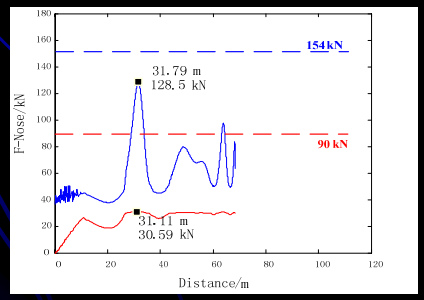
Bed geometry and speed decay curve

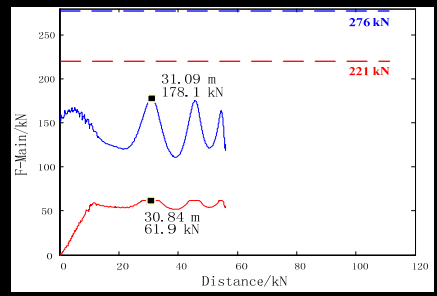




Deceleration curve

Drag load, vertical load and limit loads of nose gear





Drag load, vertical load and limit loads of main gear

Single Wheel Load Validation Test

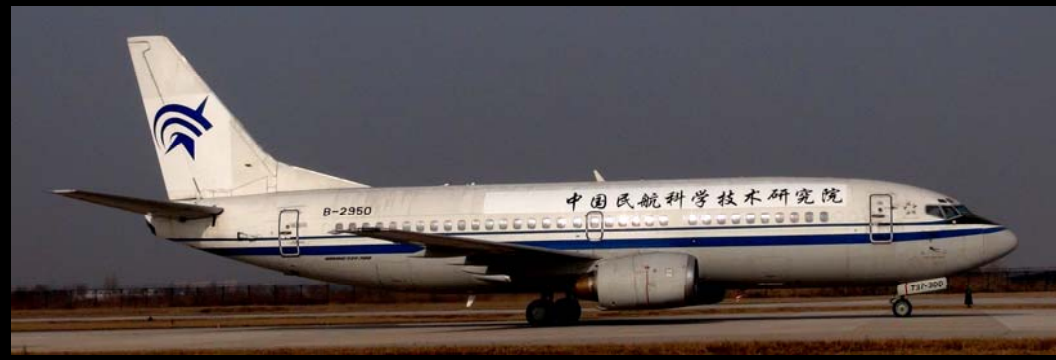
- A single wheel load test device built, actual wheel, actual weight, actual bed and load measuring system incorporated
- A number of tests conducted, the simulation model greatly improved by the test results

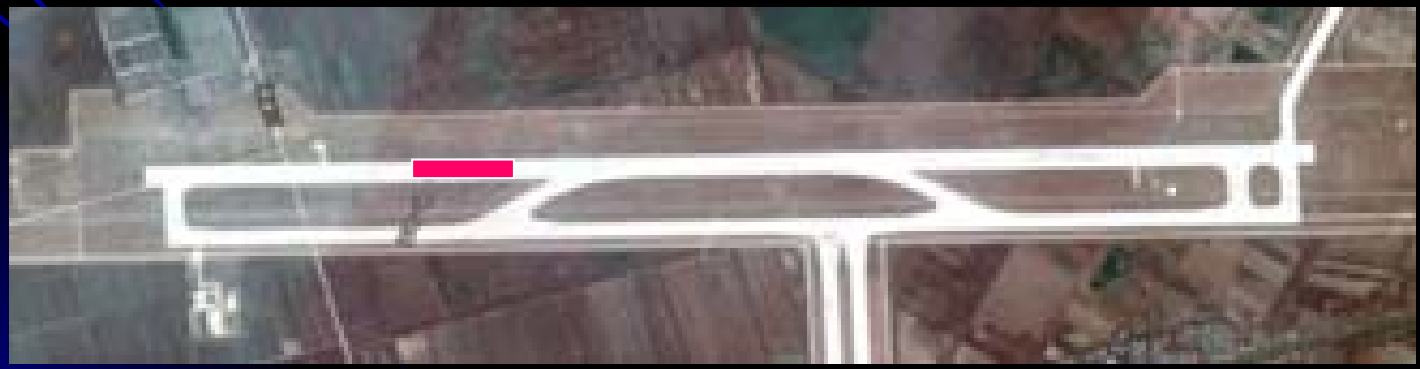
Test Video

Photos After Test

Actual Aircraft Validation Test

- Venue: the second runway in Tianjin Airport
- Type of test aircraft: B737-300
- Material: 24cm and 31cm high





Measuring Devices on Board

Calibration of the Load Measuring System

Test Video

After Arrestment

Results of the Tests

- 6 tests conducted, 2 short beds, 4 full scale beds up to 145m long
- Entrance speeds ranged from 24 ~ 61 knots
- Neither injury to people on board nor damage to the landing gears as revealed by detailed visual inspection and nondestructive inspection after each test
- The actual stopping distances differ from the simulated ones by less than 5%
- The maximum deceleration <2g vs. limit of 4g for human safety
- Load peaks imposed on landing gears < the ultimate loads
- Fire fighting vehicle is able to move in, move out and move inside the beds
- Bed withstands a jet blast produced by the aircraft at distance of 25m away at takeoff power

Standard Design Scenario per the FAA AC

- After validated, the simulation model can be used to design EMAS for individual airport
- Standard design scenario per the FAA AC
  - Aircraft weight: MTOW
  - Exit speed: 70 kts
  - Engine thrust: no
  - Reverse thrust : no
  - Braking: poor braking with the braking coefficient of 0.25

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Application prospect

- EASM can enhance airport safety, particularly for the airports with short RESA or dangerous geography beyond RESA, at a reasonable cost
- Certification team of CAAC is finalizing the certification.
- Annual Conference of CAAC of 2012 requires at least 2 sets installed in China in 2012. Tuofeng Airport in Yunnan Province is planning to be the first to install.
- ~50 airports in China may need EMAS as a rough estimate
- The Hangke Company is willing to provide EASM to any demanding airports both home and abroad.

Thank you

Question or comment?