NTSB Meetings

July 2015
Kevin Mickey, President
## Ben Diachun, VP Engineering
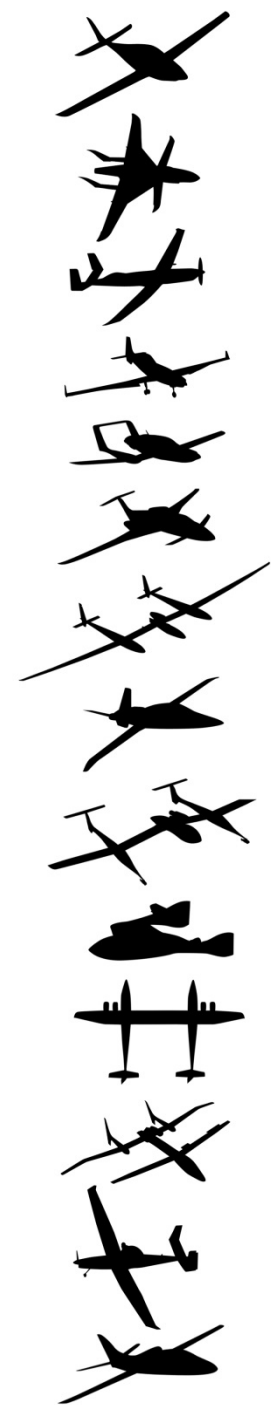
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Scaled Composites History

- Founded by Burt Rutan 33 years ago
- Develops "proof-of-concept" aircraft
  - Prototypes/demonstrators – not mass production
  - Relies on efficient design/building for simplicity and safety
  - Designs are further refined through test flights
  - Test flights conducted under experimental permits/certificates
- Successfully designed & tested 30 manned aircraft
- Recognized for breakthrough aircraft
  - *Proteus & GlobalFlyer*
  - *SpaceShipOne*
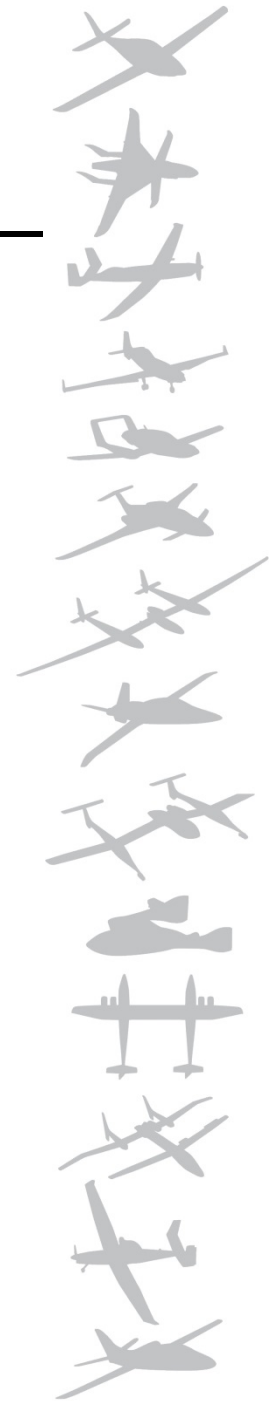
Scaled's Culture & People

- Carefully selects employees with multi-disciplinary expertise
  - Roughly half are pilots
  - Allows participation in different aspects of projects
  - Safer and more efficient than "siloed" approach
  - Test pilots are also engineers, often involved in designing the prototype being flown

- "Question, don't defend"
  - Every employee responsible for quality and safety
  - Uses industry-recognized methods to assess safety
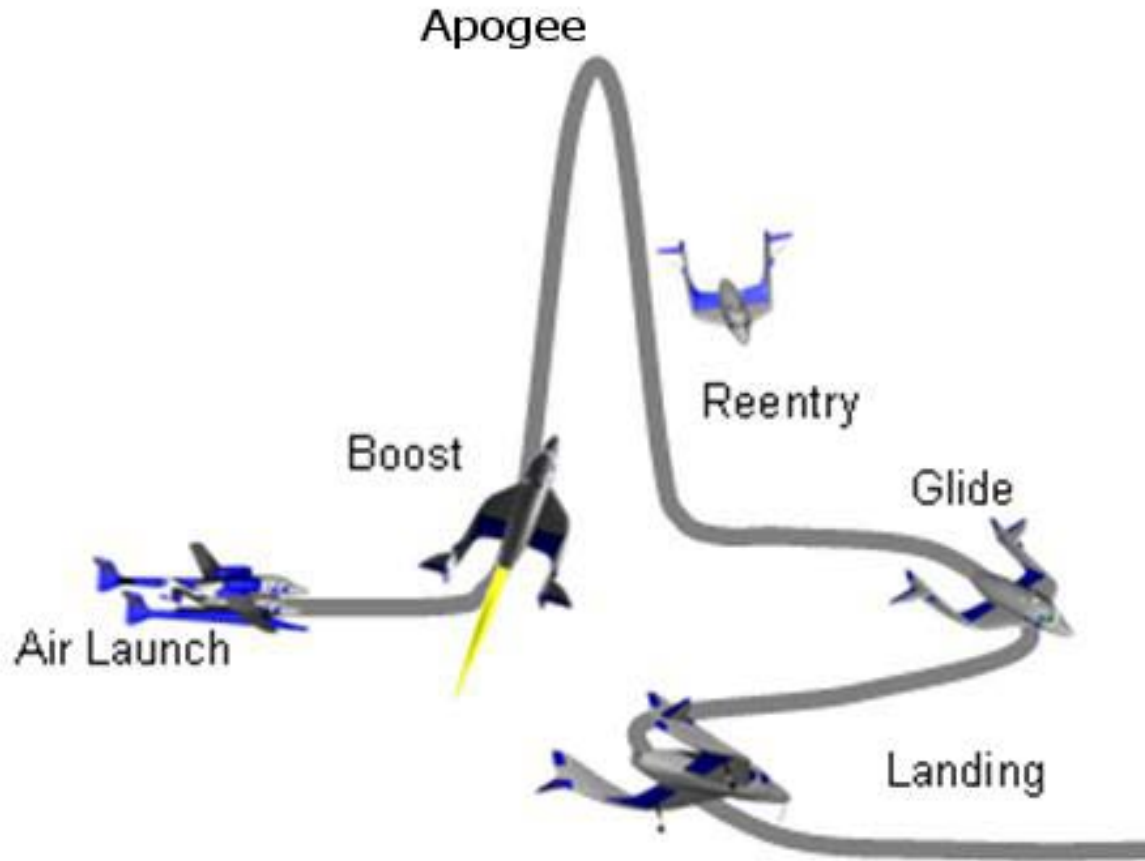
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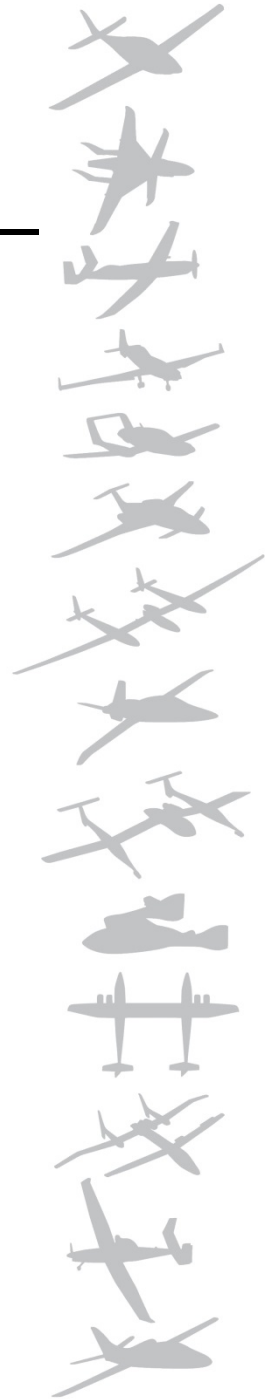
SpaceShipTwo – Background

- Originated in 2006 to create a prototype for Virgin Galactic's program goals

- Evolved from SS1 design
  - Simple, proven technologies
  - Feather system

- Explanation of SS2 nominal flight procedures

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SpaceShipTwo – Background

Apogee

Reentry

Boost

Glide

Air Launch

Landing

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Probable Cause Of Accident

- Unanticipated early unlock of the feather locks

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SS2 Crew Was Well-Trained

- PF04 pilot and copilot were fully qualified
    - Thousands of hours of flight time
    - Prior flights in SS1 and SS2
    - Highly-credentialed aerospace engineers

- Extensive training for PF04
    - Review and revision of documentation
    - Numerous formal and informal simulator sessions
    - Other training (high-G/unusual attitude, WK2, CRM)

- No evidence of personal issues/distractions

SS2 Was Carefully Designed

- Used proven technologies to limit potential failures
- Feather system was rigorously evaluated
  - Safety-critical for reentry
  - Avoided complex components that could increase risk
- Feather locks were a fundamental design feature
- Design was successfully tested 50+ times
- Feather system successfully actuated on 9 test flights
- Case study – Glide Flight 16

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Feather Procedures

- Awareness of need for locks during start of boost
  - Repeatedly discussed by engineers and test pilots
  - Test pilots understood early unlock could be catastrophic
- Feather unlock procedure was fundamental to SS2
- 1.4 Mach number provided safe margins
- Scaled/VG evaluated alternatives
  - Procedural mitigation offered advantages
- Procedure was repeatedly documented
- "Challenge-response" procedure not practical
- Repeatedly practiced in sims without incident
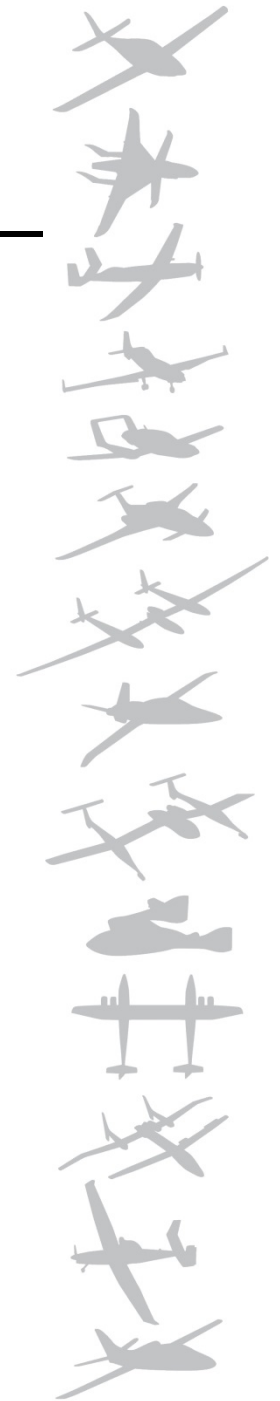
Scaled's Safety Culture

- Scaled's safety principle: Question, never defend

- Communicates lessons learned across projects

- Performs incremental envelope expansion in flight test programs to help mitigate risks
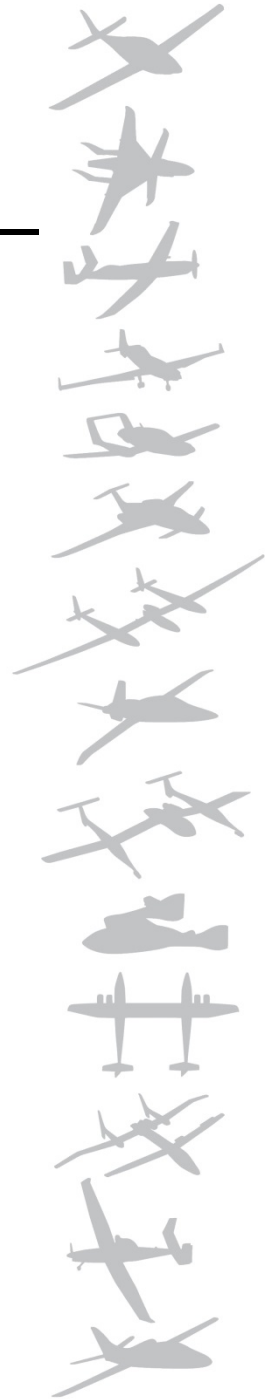
Scaled's Safety Culture

- **Systems Safety Assessment**
  - Used industry-standard methodology and FAA guidance
  - Included functional hazard, fault tree, and common mode analyses
  - More rigorous than hazard analysis required for experimental rockets
  - Analyzed human and software error in accordance with FAA guidance
    - Assumed that standard tasks would be performed correctly
    - Quantified human error in responding to functional hazards

- **FRRs**

- **Pre-flight checks**

Compliance With Regulations

- Operated under a valid FAA Experimental Permit
  - Confirmed by the FAA, in writing, post-accident
- Scaled worked closely with the FAA throughout
  - Numerous pre-application consultations
  - Draft permit applications and systems safety assessments
  - Permit issued in May 2012
    - Condition relating to updated hazard analysis satisfied before PF01
    - Permit renewed without that condition in May 2013
- July 2013 waiver
  - Not requested by Scaled
  - Did not explicitly list conditions
  - Waiver renewed; FAA continued to work with Scaled
- FAA representatives present at test flights, simulator sessions
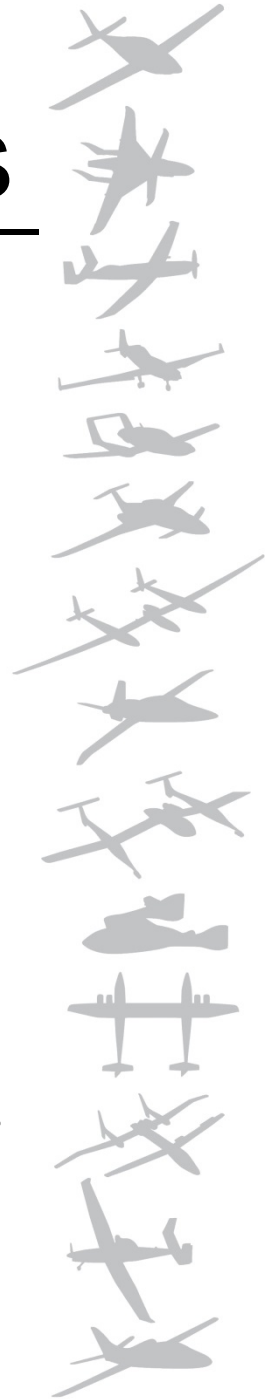
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Recommendations

- Scaled is committed to learning from the accident

- Recommendations for enhanced safety procedures
  - Training, Communication, and Documentation
    - Any possibility of immediate catastrophic loss of the vehicle
    - Test pilot compliance with training/currency requirements
    - Flight test training sim session data relating to human performance
    - Vehicle and procedure changes
  - Human Performance and Procedures
    - Evaluating mitigations for single crew actions w/potential catastrophic loss
    - Human performance expert
    - Human performance limitations in systems safety assessments
  - Emergency Response
    - Improve understanding of local assets; criteria for enhanced response

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Actions Already Implemented

- Following the accident:
  - Grounded all test aircraft and conducted return-to-flight FRRs
  - Instituted formal recurring return-to-flight FRRs
  - Test pilots now report to the Director of Flight Operations
  - Evaluated parachutes and established standard configuration
  - Standardized parachute training and instituted initial and recurrent training requirements
  - Aircrew training now documented in a central online folder

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Questions