



OCCUPANT SAFETY OPPORTUNITIES WITH NEW GENERATION AIRCRAFT

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OCT 2020



KEY TAKE-AWAYS

1. NEW AAM / SMALL AIRCRAFT OPPORTUNITIES IN THE FUTURE
2. CERTIFICATION COSTS ARE NOT ALIGNED WITH SAFETY BENEFITS USING TRADITIONAL DYNAMIC SEAT APPROACH FOR SMALL AIRPLANES – ALTERNATIVE APPROACHES ARE NEEDED IF WE WANT TO IMPROVE OCCUPANT SAFETY
3. PERFORMANCE-BASED RULES ALLOW FOR INNOVATIVE ALTERNATIVE APPROACHES TO OCCUPANT SAFETY



NEW AAM / SMALL AIRCRAFT OPPORTUNITIES IN THE FUTURE

NEW GENERATION VTOL AIRCRAFT

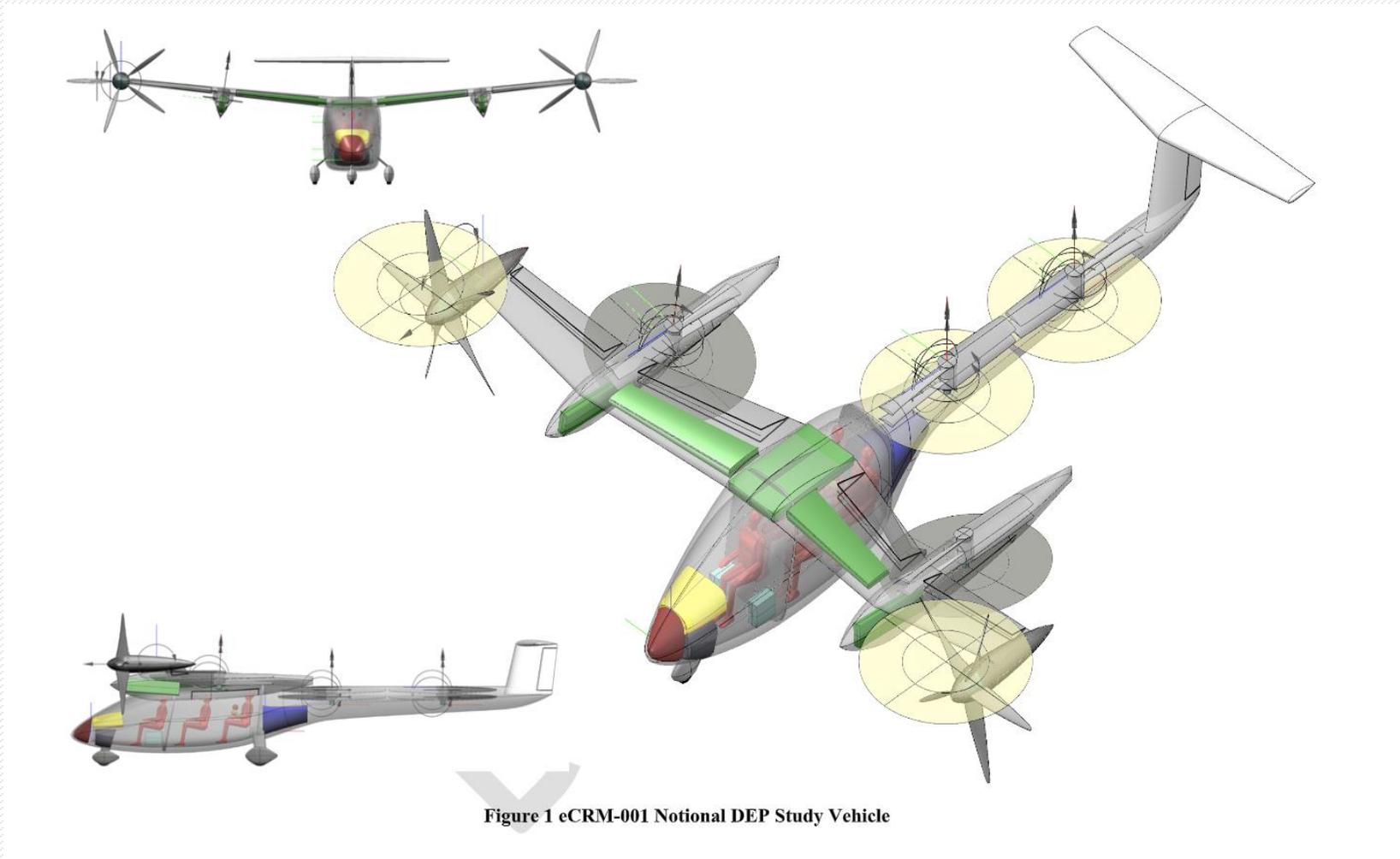


Figure 1 eCRM-001 Notional DEP Study Vehicle

CONCEPT / POWERTRAIN / AIRCRAFT / POINT / DEFINITION

NEW GENERATION AIRCRAFT



CERTIFICATION COST IS NOT ALIGNED WITH SAFETY BENEFITS USING TRADITIONAL DYNAMIC SEAT APPROACH FOR SMALL AIRPLANES – TIME FOR AN ALTERNATIVE APPROACHES IF WE WANT TO IMPROVE OCCUPANT SAFETY





TRADITIONAL OCCUPANT PROTECTION APPROACH

- The large variations in accident scenarios don't align well with the dynamic seat testing scenarios for low weight, inertia, wing/disk loading aircraft
- Expect VTOL aircraft to have the same variation in accident scenarios
- Seats can be the most expensive component in a 2/6 place airplane after the engine and avionics
- Safety benefit from dynamic seats don't align with cost of showing compliance
 - Energy absorbing seats are the right idea
 - Level of required precision does not provide associated safety value
- More emphasis on maintaining survivable space for occupants
- Alternatives being developed in ASTM F-44 are key to safer aircraft

TRADITIONAL OCCUPANT PROTECTION APPROACH



PUTTING ALL YOUR EGGS IN THE DYNAMIC SEAT BASKET WORKS IF —

- There is a open landing area representative of test condition in 562
- The pilot impacts exactly like the test condition in 562
- All occupants are 170 lbs
- All occupants are wearing their seat belt correctly



PERFORMANCE-BASED RULES ALLOW FOR
ALTERNATIVE INNOVATIVE APPROACHES TO
OCCUPANT SAFETY

DYNAMIC SEAT PART 23-63



Sec. 23.562

Emergency landing dynamic conditions.

(a) Each seat/restraint system for use in a normal, utility, or acrobatic category airplane, or in a commuter category jet airplane, must be designed to protect each occupant during an emergency landing when--

(1) Proper use is made of seats, safety belts, and shoulder harnesses provided for in the design; and(2) The occupant is exposed to the loads resulting from the conditions prescribed in this section.

(b) Except for those seat/restraint systems that are required to meet paragraph (d) of this section, each seat/restraint system for crew or passenger occupancy in a normal, utility, or acrobatic category airplane, or in a commuter category jet airplane, must successfully complete dynamic tests or be demonstrated by rational analysis supported by dynamic tests, in accordance with each of the following conditions. These tests must be conducted with an occupant simulated by an anthropomorphic test dummy (ATD) defined by 49 CFR part 572, subpart B, or an FAA-approved equivalent, with a nominal weight of 170 pounds and seated in the normal upright position.

(1) For the first test, the change in velocity may not be less than 31 feet per second. The seat/restraint system must be oriented in its nominal position with respect to the airplane and with the horizontal plane of the airplane pitched up 60°, with no yaw, relative to the impact vector. For seat/restraint systems to be installed in the first row of the airplane, peak deceleration must occur in not more than 0.05 seconds after impact and must reach a minimum of 19g. For all other seat/restraint systems, peak deceleration must occur in not more than 0.06 seconds after impact and must reach a minimum of 15g.(2) For the second test, the change in velocity may not be less than 42 feet per second. The seat/restraint system must be oriented in its nominal position with respect to the airplane and with the vertical plane of the airplane yawed 10°, with no pitch, relative to the impact vector in a direction that results in the greatest load on the shoulder harness. For seat/restraint systems to be installed in the first row of the airplane, peak deceleration must occur in not more than 0.05 seconds after impact and must reach a minimum of 26g. For all other seat/restraint systems, peak deceleration must occur in not more than 0.06 seconds after impact and must reach a minimum of 21g.

(3) To account for floor warpage, the floor rails or attachment devices used to attach the seat/restraint system to the airframe structure must be preloaded to misalign with respect to each other by at least 10° vertically (i.e., pitch out of parallel) and one of the rails or attachment devices must be preloaded to misalign by 10° in roll prior to conducting the test defined by paragraph (b)(2) of this section.

(c) Compliance with the following requirements must be shown during the dynamic tests conducted in accordance with paragraph (b) of this section:

(1) The seat/restraint system must restrain the ATD although seat/restraint system components may experience deformation, elongation, displacement, or crushing intended as part of the design.(2) The attachment between the seat/restraint system and the test fixture must remain intact, although the seat structure may have deformed.

(3) Each shoulder harness strap must remain on the ATD's shoulder during the impact.

(4) The safety belt must remain on the ATD's pelvis during the impact.

(5) The results of the dynamic tests must show that the occupant is protected from serious head injury.

(i) When contact with adjacent seats, structure, or other items in the cabin can occur, protection must be provided so that the head impact does not exceed a head injury criteria (HIC) of 1,000.(ii) The value of HIC is defined as--

...and about another page and a half of “how to” prescriptive language.

DYNAMIC SEAT PART 23-64



§ 23.2270 Emergency conditions.

(a) The airplane, even when damaged in an emergency landing, must protect each occupant against injury that would preclude egress when—

- (1) Properly using safety equipment and features provided for in the design;
- (2) The occupant experiences ultimate static inertia loads likely to occur in an emergency landing; and
- (3) Items of mass, including engines or auxiliary power units (APUs), within or aft of the cabin, that could injure an occupant, experience ultimate static inertia loads likely to occur in an emergency landing.

(b) The emergency landing conditions specified in paragraph (a)(1) and (a)(2) of this section, must—

- (1) Include dynamic conditions that are likely to occur in an emergency landing; and
- (2) Not generate loads experienced by the occupants, which exceed established human injury criteria for human tolerance due to restraint or contact with objects in the airplane.

(c) The airplane must provide protection for all occupants, accounting for likely flight, ground, and emergency landing conditions.

(d) Each occupant protection system must perform its intended function and not create a hazard that could cause a secondary injury to an occupant. The occupant protection system must not prevent occupant egress or interfere with the operation of the airplane when not in use.

(e) Each baggage and cargo compartment must...

Doesn't tell you how to design and test the seat – defines the intended safety outcome.

PERFORMANCE-BASED RULES

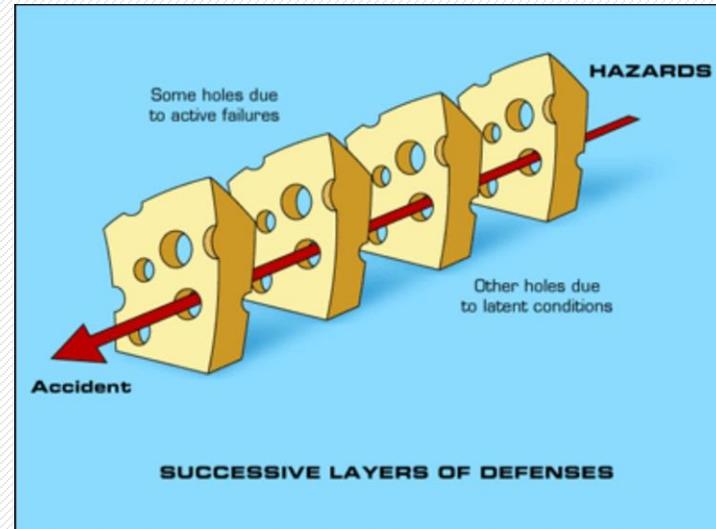


AVAILABILITY

- NEW CS-23/PART 23
- EASA's SC-VTOL

BENEFITS

- NOT LOCKED INTO CS/PARTS 23/27-562 "DYNAMIC SEAT" REQUIREMENTS - CAN PROPOSE ALTERNATIVE APPROACHES USING COMBINATIONS OF 562 AND OTHER SAFETY FEATURES





THE HISTORIC APPROACH TO SAFETY IS TO PREVENT THE ACCIDENT. BUT THE PROJECTED LARGE NUMBERS OF SMALL AIRCRAFT/OPERATIONS WILL LIKELY DRIVE US TO NEED AN APPROACH MORE LIKE THE AUTOMOTIVE INDUSTRY.

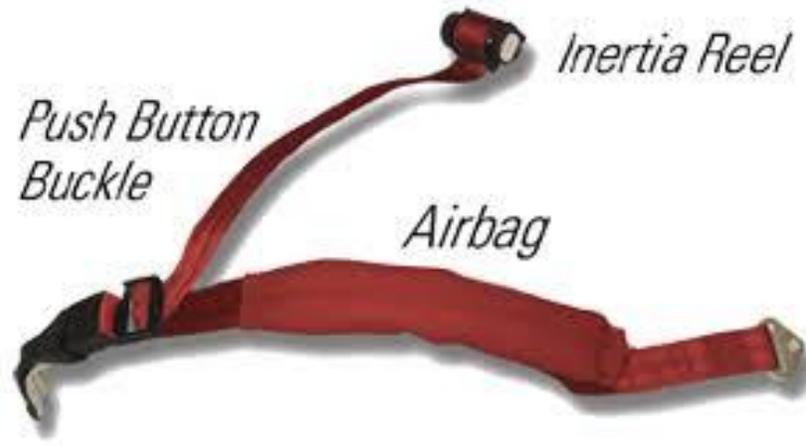
WE NEED A NEW APPROACH



- Unlike large aircraft, small aircraft including airplanes, helicopters, and current small VTOL designs are light, and their accidents scenarios will continue to have a lot of variation.
- The target approach for the new AAM market segment to prevent all accidents; this is the right idea and important target; but it's unrealistic to count on this approach based on history.
- Given the projected operations, are an order of magnitude higher than current transport operations, so accidents will happen.
- We need to plan on accidents and start thinking more like the automotive industry where the goal is to protect the occupants and allow them to walk away from the accident.

WE NEED A NEW APPROACH

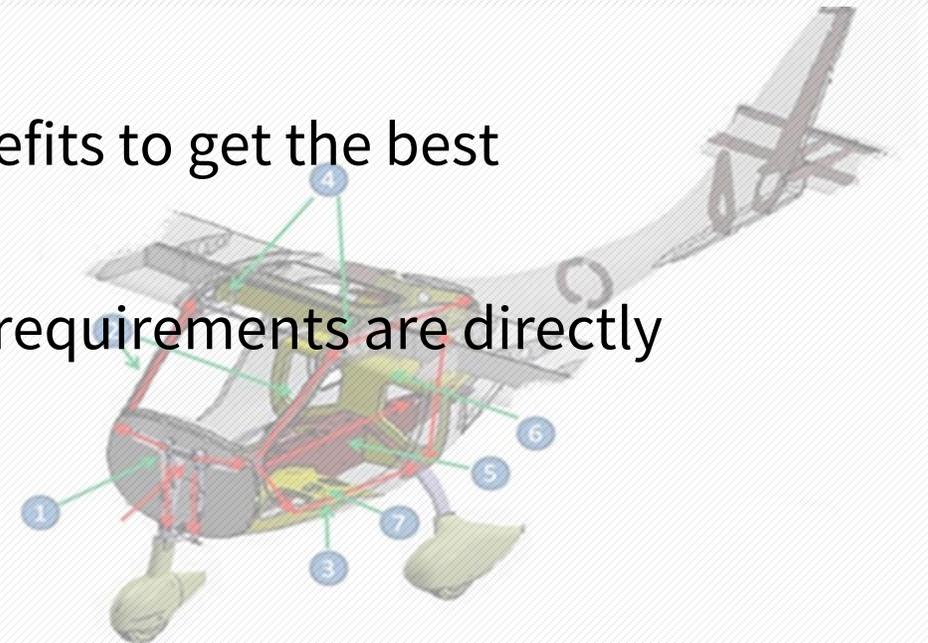
- The cost verses safety benefit isn't the only consideration driving the need for innovation
- The cost of weight or weight sensitivity is high on electric aircraft; so –
 - Occupant protection needs to be included in the initial design
 - Must allow for innovative occupant protection for best safety value



GOING FORWARD



- Crashworthiness needs to be a primary design consideration instead of an after thought
- Instead of the current focus on just a seat, need multiple features that create a system for occupant protection to account for the variability in accident scenarios
- Must consider certification cost verses safety benefits to get the best overall system
- Level of precision and confidence in certification requirements are directly related to –
 - Risk allowances
 - Cost
 - Safety continuum





QUESTIONS

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