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The Value of a Collegiate FAR Part 141 Jeopardy-Crew Resource Management (CRM)-Simulation Event

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On July 19, 1989, United Airlines Flight 232 Captain Al Haynes was thrust into a safety-of-life situation resembling a no-notice, jeopardy crew resource management (CRM) event with impending consequence for 285 passengers and crew. It was only through his exhibited, democratic leadership, and the cooperation he was able to elicit from each crewmember, that 175 of those onboard his crippled DC-10 survived. Throughout a grave emergency with an airplane so damaged it was judged un-flyable, Captain Haynes maintained a cockpit environment where crewmembers were encouraged to make suggestions, tried each other's suggestions, and iterated until they found workable solutions to the catastrophic event (Haynes, 1991; National Transportation Safety Board [NTSB], 1990). This successful outcome, based principally on using CRM to survive a potentially un-survivable accident, is widely recognized as the formal adoption point of CRM in the U.S. airline industry. While some airlines were using these techniques already, this accident solidified CRM as a meaningful, life-saving advantage which heretofore was both under-recognized for its value and underutilized (Kanki, Helmreich, & Anca, 2010).

Currently, no U.S. airline grades, nor does the Airline Pilots Association (ALPA) endorse grading CRM training as jeopardy events, even at a Pass/Fail level. A jeopardy event is a formal, graded, career-influencing event; whereas, a non-jeopardy event may also be a formal event; however, it is not graded. Significant research completed approximately 20 years ago by the Air Transport Association (ATA, 1995), Holt, Boehm-Davis, and Hansberger (2001), and George Mason University (2001) (as cited in Kanki et al., 2010), showed not only is it possible to fairly evaluate CRM in a jeopardy environment but doing so also provides a viable, evaluative resource. Reputable air carriers, such as Air Canada, have been relying on graded, career-influencing, jeopardy events since 2001 (Kanki et al., 2010). Interestingly, the Federal Aviation

Administration's (FAA) Airline Transport Pilot (ATP) Practical Test Standards (PTS) allow an examiner the privilege of applicant Pass/Fail judgment solely on CRM (FAA, 2008). To date, jeopardy-CRM-simulation events have not been included in Federal Aviation Regulations (FAR) Part 141 collegiate professional pilot curricula. A decision to introduce a jeopardy-CRM-simulation event into a collegiate curriculum could be viewed as provocative, yet positioned against U.S. air transport industry norms.

The Oklahoma State University (OSU) professional pilot leadership felt that the positives of incorporating a jeopardy-CRM-simulation event into the OSU professional pilot curriculum significantly outweighed the negatives; specifically, the aspect of learning how to transition from a single-pilot/Pilot in Command mentality to multi-pilot/CRM mentality was perceived as vital. This article explores the construction, administration and results of the first jeopardy-CRM-simulation event in a collegiate FAR Part 141 curriculum. The events described herein occurred at OSU during the fall 2015 senior-level, professional pilot CRM course. The author was the professor for this course. Based on the observations and conclusions from conducting the jeopardy-CRM-simulation events, the ultimate purpose of this article is to encourage other collegiate aviation programs to consider the inclusion of a jeopardy-CRM-simulation event in their professional pilot curriculum.

The principal questions this article explores are:

- Can the value of a collegiate, CRM FAR Part 141 curriculum-simulation event be maintained, or increased, as a jeopardy event?
- Does adding a live Air Traffic Control (ATC) service to a jeopardy-CRM-simulation event add additional value to the student experience?

For the CRM course this article describes, three simulation events had been written into the syllabus to complement the academic discussion throughout the semester. The first two simulations were non-jeopardy events and were designed to encourage working-together behaviors among the randomly assigned student crews and to expose the students to multi-engine piston and regional jet operations. The third simulation event, upon which this article is focused, was a jeopardy event conducted in a multi-engine, piston simulator and centered on the students' demonstration of CRM principles.

The incorporation of live ATC into a collegiate, jeopardy event is not common currently. The PilotEdge™.net service provider revealed only one other university using their service in an academic environment. The professor contacted this university and learned that while PilotEdge™.net was being used in the university's instrument curriculum, it was not being used in a jeopardy-event manner.

The simulator employed for the jeopardy-CRM event was a Redbird MCX, motion simulator AATD (Advanced Aviation Training Device) configured to represent OSU's multi-engine fleet of Piper PA-44-180 Seminoles. The Redbird contains conventional "steam gauge"/"6-pack", primary-flight instrumentation supplemented with emulations of a Garmin GNX-430 and a GNX-530 navigation/communication system. In the non-jeopardy event conducted in the Redbird earlier in the semester, the students were faced with handling engine-out scenarios and using the appropriate checklists in a challenge-and-response setting to effect a safe-scenario conclusion. This earlier non-jeopardy Redbird event had the corollary benefit of exposing all students to the Redbird simulator prior to it being used for a jeopardy event.

The jeopardy event was designed to be a crew-conducted, IFR (Instrument Flight Rules) flight transiting from one airport to another while adhering to standard ATC and FAA instrument

flight protocols. The event was explicitly not focused on multi-engine abnormal operations. The idea for adding the live PilotEdge™.net ATC component came from OSU Flight Center Director, Mr. Lance Fortney. Although the author was familiar with VATSIM (Virtual Air Traffic Simulation Network, <https://www.vatsim.net/>), which is a serious, hobby-based, web-based ATC emulation, he was unaware of the professional, fee-for-service, live ATC service provided by PilotEdge™.net.

To increase the realism of the jeopardy event, a palette of 35 ATC-inserted events or maladies (henceforth referred to as “ATC events”) was submitted by the OSU professional pilot leadership to PilotEdge™.net for random insertion in each jeopardy-CRM-simulation event. The palette was mutually condensed, after discussion between OSU and PilotEdge™.net, to 17 ATC events compatible with the PilotEdge™.net virtual world. The PilotEdge™.net controllers were instructed to randomly choose, at their discretion, at least one ATC event for insertion into each jeopardy-CRM-simulation event. The ATC events added a real-world component to the experience that could not be known in advance or necessarily shared between the crews to their advantage. The extra, customized ATC event attention to be afforded to each crew added a small surcharge to the negotiated PilotEdge™.net fee.

Two significant responsibilities in the execution of the jeopardy-CRM-simulation event were assigned by the professor to the students. First, the students constructed and proposed the grading rubric that would be used by both the professor and the non-flying pair students from each crew to grade the pair of students flying. Second, the CRM-based roles of Pilot Flying (PF) and Pilot Monitoring (PM) were to be declared by each student crew in advance of the jeopardy event. These roles were to be maintained while the crews negotiated the anticipated flow of normal IFR operations and reacted to the random, ATC-inserted event(s).

It was desired to randomly break the class into an even number of student crews with four members each (two pairs of pilot/copilot); however, with a class of 26 students, this was not mathematically possible. Students were thus randomly divided into five crews of four members each, and two crews of three members each, for a total of seven crews. The crew assignments were purposely random to replicate what could be expected in airline service when crew assignments are not under the control of the individual airline employee. Each pilot/copilot pair flew one of 14 sorties spread over a five-day window so each pilot/copilot pair would have an independent, unique experience; 45 minutes was allocated for each student pilot/copilot pair.

Based on the data presented in this article, the enthusiasm exhibited by the PilotEdge™.net controllers, the performance demonstrated by the students, their exuberant reaction to the simulator events upon exiting the jeopardy event, and their reflections offered one year later, it is the author's assertion that the value of a collegiate, CRM FAR Part 141 curriculum-simulation event can be maintained, and even increased as a jeopardy event; *and*, additional value is added if a live ATC service (such as PilotEdge™.net) is employed.

Literature Review

To construct the scenario for the jeopardy-CRM-simulation event, which respected current FAA and airline CRM Standard Operating Procedures (SOP), the following literature sources were referenced and utilized:

FAA Advisory Circulars (ACs):

- 120-35D, Flightcrew Member Line Operational Simulations: Line-Oriented Flight Training, Special Purpose Operational Training, Line Operational Evaluation (FAA, 2015a).
- 120-51E, Crew Resource Management Training (FAA, 2004a).

- 120-71A, Standard Operating Procedures for Flight Deck Crewmembers (FAA, 2003).
- 120-92B, Safety Management System for Air Service Providers (FAA, 2015b).

FAA Handbooks:

- FAA-H-8023-3A, Airplane Flying Handbook (FAA, 2004b).
- FAA-H-8083-25B, Pilot's Handbook of Aeronautical Knowledge (FAA, 2016).

FAA Practical Test Standards:

- FAA-S-8081-5F, Airline Transport Pilot and Aircraft Type Rating Practical Test Standards for Airplane (FAA, 2008).

U.K. (United Kingdom) Civil Aviation Authority, Civil Aviation Publications (CAP):

- 720, Flight Crew Training: Cockpit Resource Management and Line-Oriented Flight Training (LOFT) (CAP, 2002).
- 737, Flight Crew Human Factors Handbook (CAP, 2014).

Textbooks:

- Crew Resource Management, 2nd Edition (Kanki et al., 2010).
- The Pilot Factor: A Fresh Look Into Crew Resource Management, Plane & Simple Solutions (Marcellin, 2014).

Aircraft-Specific Pilot Operating Guides:

- Matrix CRJ200 Simulator Scenario and Cockpit Flow Guides (AvSoft, 2012).
- PA-44-180 Seminole Aircraft Information Manual (Piper Aircraft Corporation, 2012).

FAA AC 120-35D and AC 120-51E were the primary sources referenced in the construction of both the scenario by the professor and the construction of the grading rubric assembled by the students (FAA, 2015a; FAA, 2004a). These two sources provide the CRM regulatory training requirements, definitions, training topics, relationship to International Civil Aviation Organization (ICAO) standards, research background, basic concepts, implementation suggestions, assessment techniques and specific guidance on the administrative construction of CRM and LOFT training scenarios. However, the ACs do not stipulate specific, detailed, operational scenario content on which crews should be trained. The specific content material for the scenarios is encouraged by both ACs to be drawn from employee/crew inputs, recurring operational problems, trouble areas on check rides and SOP execution, and elements of normal line operations covered in aircraft flight manuals (FAA, 2004a; FAA, 2015b).

A recurring theme in both texts and in the ACs, especially 120-35D and 120-51E, was First Officer (FO) assertiveness and the captain's willingness to be receptive to inputs from the FO; this key concept needed careful incorporation into the jeopardy-CRM-simulation event scenario (Kanki et al., 2010; Marcellin, 2014; FAA, 2015a; FAA, 2004a). A second recurring theme presented in AC 120-51E was effective CRM training may saturate a crew but not overwhelm them (FAA, 2004a). A challenging, jeopardy-CRM-simulation event scenario within the experience base of the students was designed to respect and incorporate both of these themes.

The FAA handbooks, and in particular Chapter 2 of the FAA Pilot's Handbook of Aeronautical Knowledge, gave overall philosophical guidance on the application of CRM principles (FAA, 2016). A key concept from this source, respected in the breadth of the jeopardy-CRM-simulation event scenario construction, was "Expert (pilots) take the first workable solution they can find. While it may not be the best of all possible choices, it often

yields remarkably good results” (FAA, 2016, pp. 2-21). The jeopardy-CRM-simulation event scenario was designed to elicit this type of professional-level, decision behavior from the students.

The U.K. CAP documents corroborated the FAA material by emphasizing principles espoused in the FAA documentation, as well as emphasizing the flip-side of leadership which is followership (CAP, 2002; CAP, 2014). Additionally, both textbook references either directly emphasized followership or referred to it in different terms (Kanki et al., 2010; Marcellin, 2014). An author-assimilated definition of the key FO skill set of followership includes these attributes:

- Mastering the required operational (flying) skill set as quickly as possible.
- Showing interest and giving attention to the captain.
- Constructively interacting with and seeking to influence the captain.
- Appropriately voicing operational concern until there is acknowledgement of at least an acceptable solution, and preferably a better solution, than could be expected individually.

The jeopardy-CRM-simulation event scenario was designed to offer continuous followership opportunity.

Additional key, CRM elements, and Line Operational Evaluation (LOE) criteria were identified from manufacturers’ Pilot Operating Handbooks (POH). Each of these CRM/LOE POH extractions was incorporated as a required, crew action in the jeopardy-CRM-simulation event rubric. Examples included briefings and normal operations checklists (AvSoft, 2012; Piper Aircraft Corporation, 2012).

Methodology

This section will examine the jeopardy-CRM-simulation event objectives that were demonstrated by the students, the rubric for the event that was assembled by the students, and the

considerations made in the scenario set-up. The rationale for the choices made in each sub-section is also offered.

Jeopardy-CRM-Simulation Event Objectives

The following macro objectives were communicated, in advance of the jeopardy event, to the students both in the classroom orally and via a published lesson plan:

- Demonstration of CRM principles.
- Random crew assignment.
- Peer grading completed by crews.
- IFR flight with IFR flight plan filed prior to assigned reporting time.
- Emphasis on briefings (in particular: Captain's Crew Formation, and Crew/Passenger Safety briefings, and the FO's Approach and Landing briefings).
- Normal ATC protocols starting with clearance delivery.
- Expectation of at least one ATC event.

The lesson objectives were balanced with the FAA AC 120-35D and AC 120-51E CRM guidelines, which focused on SOPs, familiar operating environments, leadership, followership, and completion of tasks in a positive, supportive, and effective cockpit environment (FAA, 2015a; FAA, 2004a). The concept of FO assertiveness is common to both ACs but is not necessarily easy to assimilate or apply, nor is this concept prescriptive in its application. The jeopardy event needed to be structured so both cockpit crew members felt comfortable contributing and the FO had a role in which assertiveness was not only helpful but also needed and expected.

An IFR flight scenario was selected as it is the standard operating environment most airline and corporate employers will expect their flight crew to operate in at all times. For younger, less-experienced pilots, the IFR environment is possibly more reassuring because it has the appeal of positive control. While this is certainly a safer operating environment, it does not necessarily stress or stretch the situational awareness function since the aircraft's position with GPS-based, moving map display is continuously known and observed by both cockpit crew and ATC. An IFR flight scenario during which this positional certainty could be challenged, and even compromised if the crew became distracted, was desired to stress how critically important it is for a crew to never relinquish or abdicate situational awareness outside of the cockpit. Careful selection of a route of flight involving a situational-awareness challenge was desired to provide ample opportunity for crew demonstration of CRM principles. A coastal California flight was selected that offered the introduction of new terrain and open-water challenges, both of which were unfamiliar to almost all of the student crews.

In class, prior to the simulation events, particular attention was paid to the importance and tone of the captain's initial crew formation brief. As presented in Kanki et al. (2010), the three tenants of the captain's brief were to include (a) establish competence, (b) disavow perfection, and (c) engage the crew. Articulation of these tenants was left to the discretion of each crew to interpret for content. Additionally, each captain was expected to emphasize safety, effective communications, and cooperation. A minimum of two other briefs was expected (a) crew/passenger-safety brief, and (b) approach/landing briefs. Each of these three briefs was to be a graded item.

Adding live ATC into the jeopardy-CRM-simulation event had the potential to not only increase the value of the students' engagement, but also add real-life dynamics that were

difficult, if not impossible, to simulate repeatedly and fairly across multiple crews. The alternative of a professor-simulated ATC presence, although easier to execute, could have been perceived by the students as reducing the impartiality of the overall experience since it would be impossible to treat all crews identically. The dynamics of IFR flight do not support identical repeatability in a student-planned-and-executed scenario; therefore, a live ATC presence offered a practical, and most valuably, impartial alternative.

Class-Approved Rubric

Two class periods were allocated for the students, as a group, to identify CRM evaluation categories and incorporate a five-point, professor-provided, grading scale and then develop these into a jeopardy-event grading rubric. The objective of allowing the students to contribute to the grading rubric was to obtain early student buy-in of what was worth evaluating.

The students identified four CRM categories, authored a definition for each, and added specific subordinated components they wanted to see demonstrated to show satisfaction of each category. The students decided that each category should be equally weighted for a total of 20 possible points. For full-point attainment, each of the subordinated components needed to be observed behaviors. Figure 1 shows the resulting rubric approved by the professor.

Evaluator Name: _____	Date: _____
PIC: _____	
FO: _____	last updated: 29 Oct 2015

AVED 4703 Class-Approved Rubric

● **Objectives:**

Demonstration of CRM skills: Leadership/Followership and completion of tasks in a positive, supportive, and effective cockpit environment

● **CRM Evaluation Categories:**

____ **Crew Briefings:** Captain in initial briefing and Pilot Flying for all subsequent briefings sets a positive tone while encouraging open communication and definition of roles.

Components:

- Open, positive, and acknowledged communication between crew members
- Roles and responsibilities defined

____ **Effective communication:** Verbalize status and plans, including specific boundaries and backup plans.

Components:

- Assures planning is agreed to by appropriate crew
- Crew is assertive when voicing concerns, deviating from the original plan, and nearing/reaching agreed-to boundaries
- Informs appropriate personnel of emergency situations
- Keeps cabin crew and passengers informed and updated

____ **Teamwork:** Be effective leaders and team members. Captain and FO complete tasks effectively and efficiently. Sum of their efforts exceeds what would be expected individually.

Components:

- Effective/efficient in timely division of tasks
- Each team member is effective in coordinating and completing tasks

____ **Situational Awareness:** The crew adapts to things around them in any situation. They stay ahead of the airplane and developing situation(s) to ensure a safe flight.

Components:

- Be aware of and incorporate changing aircraft / crew / environmental conditions and conflicting traffic into a continuously updated and accurate view of current and future aircraft location and state
- Safe flight outcome is never in doubt

____ **TOTAL** (out of 20 possible points)

● **Grading Scale:**

- 1) **Not Observable** – Category was not satisfied or unacceptable behavior / language was used
- 2) **Marginal** – Satisfaction of one category component was unsatisfactory or not met
- 3) **Acceptable** – On balance, the category and components were met
- 4) **Superior** – At least one category component was exceeded (with the other at least acceptable)
- 5) **Outstanding** – All category components were exceeded

1 - of - 1

Figure 1. The student-constructed, jeopardy-event grading rubric contained four evaluation categories each with subordinated components. The subordinated components illuminated behaviors the students expected would be necessary to evidence satisfaction of the category. The grading scale shown at the bottom was supplied to the students by the professor; the students chose to incorporate it without modification. Each captain (Pilot Flying) and FO (Pilot Monitoring) were evaluated during the jeopardy event by their non-flying crew members and by the professor using this rubric.

The grading scale in the lower left of Figure 1 shows meeting the category and its associated components earned a score of 3 (*acceptable*), a “C” on a traditional A-F grading scale ranging from 5 (*A*) to 1 (*F*). Detailed observations were tallied by the professor and compared across the crews in an attempt to ensure subjective, but fair grades were assigned based solely on the rubric.

Jeopardy-CRM-Simulation Event Scenario Set-Up

Five considerations determined the set-up of the jeopardy-CRM-simulation event scenario (a) the escape from a “flat land” mentality, (b) the non-orchestration of which roles would be assumed by crew members, (c) the creation of a challenging weather scenario coupled with terrain and aircraft performance implications, (d) the palette of ATC-inserted events and their introduction into the sorties, and (e) the detail of the information disseminated to the crews in advance.

Escape from flat land. The primary objective in the set-up of the jeopardy scenario was to remove the crews from their flat-land comfort zone and encourage a “big picture” evaluation of the pending flight. Except for Appalachia, the vast bulk of the eastern half of the U.S. enjoys FAA Maximum Elevation Figures (MEFs) of less than 3,000 ft above Mean Sea Level (MSL) – this large expanse is essentially flat land and void of any natural barriers, with the Great Lakes being an obvious exception (charted MEFs in non-mountainous areas indicate the lowest, guaranteed-safe altitude that a pilot can fly without impacting either terrain or man-made obstructions with at least a 100 ft altitude buffer). Flying on the U.S. West Coast offers the opportunity for both terrain and water barriers. A short flight (39 Nautical Miles [NM] straight line distance) between Camarillo Airport (KCMA) and Santa Barbara Airport (KSBA) was

selected to introduce terrain barriers to the North and East and water barriers to the West and South.

Figure 2 depicts the direct route of flight and illustrates the described terrain and water barriers. On FAA aeronautical charts, the MEFs are shown as large, blue, abbreviated figures in each 30-arc-minute Latitude/Longitude grid square. For example, in the square which contains KCMA airport, the 6⁷ equals an MEF of 6,700 ft MSL. The MEFs in the region of the jeopardy flight substantially exceed those typically associated with flat land (3,000 ft MSL). Note the 9² just to the north of the grid square containing the 6⁷ equals an MEF of 9,200 ft MSL.

Purposefully flying lower than a published MEF while in the clouds where the pilots cannot see forward places the aircraft in grave jeopardy of colliding with either terrain or man-made obstructions.

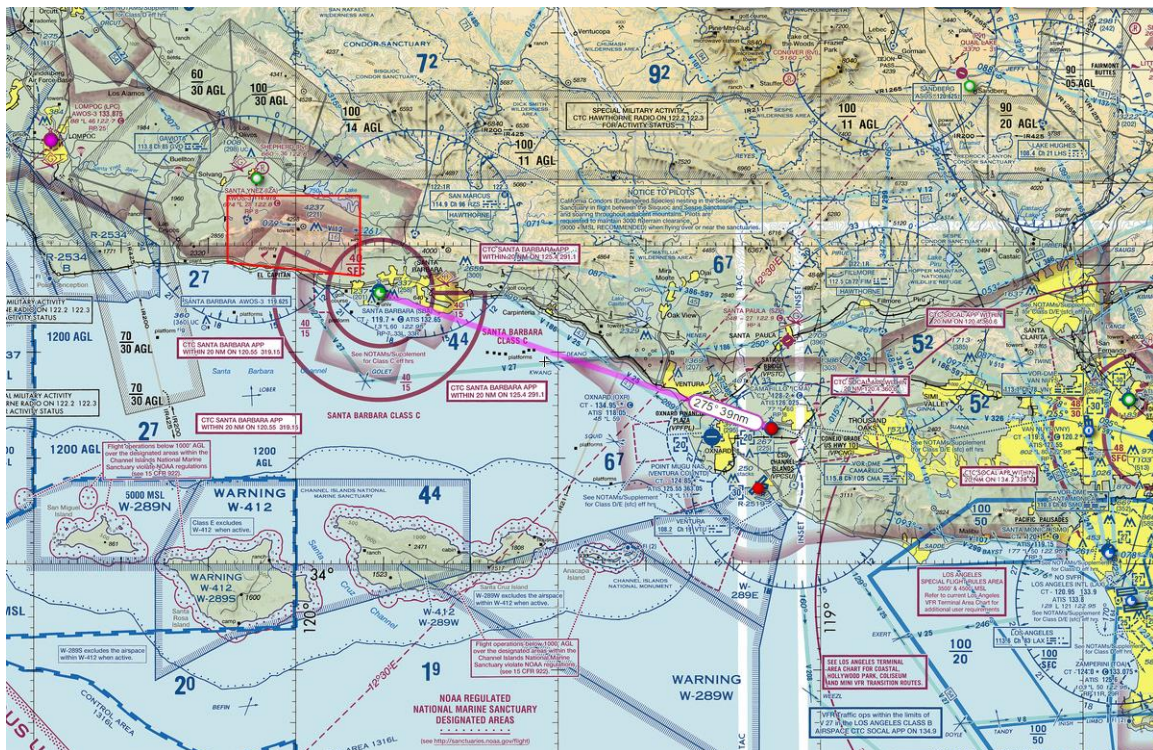


Figure 2. The jeopardy-event route of flight, excerpted from SkyVector™ FAA sectional chart, shows the straight line distance on a True Course of 275° for 39 NM between Camarillo Airport (KCMA) and Santa Barbara Airport (KSBA) as a magenta line (note a substantial portion of this route of flight is over water).

Figure 3 is essentially the same geographic footprint as Figure 2 but on the appropriate FAA IFR Low Enroute Altitude chart.

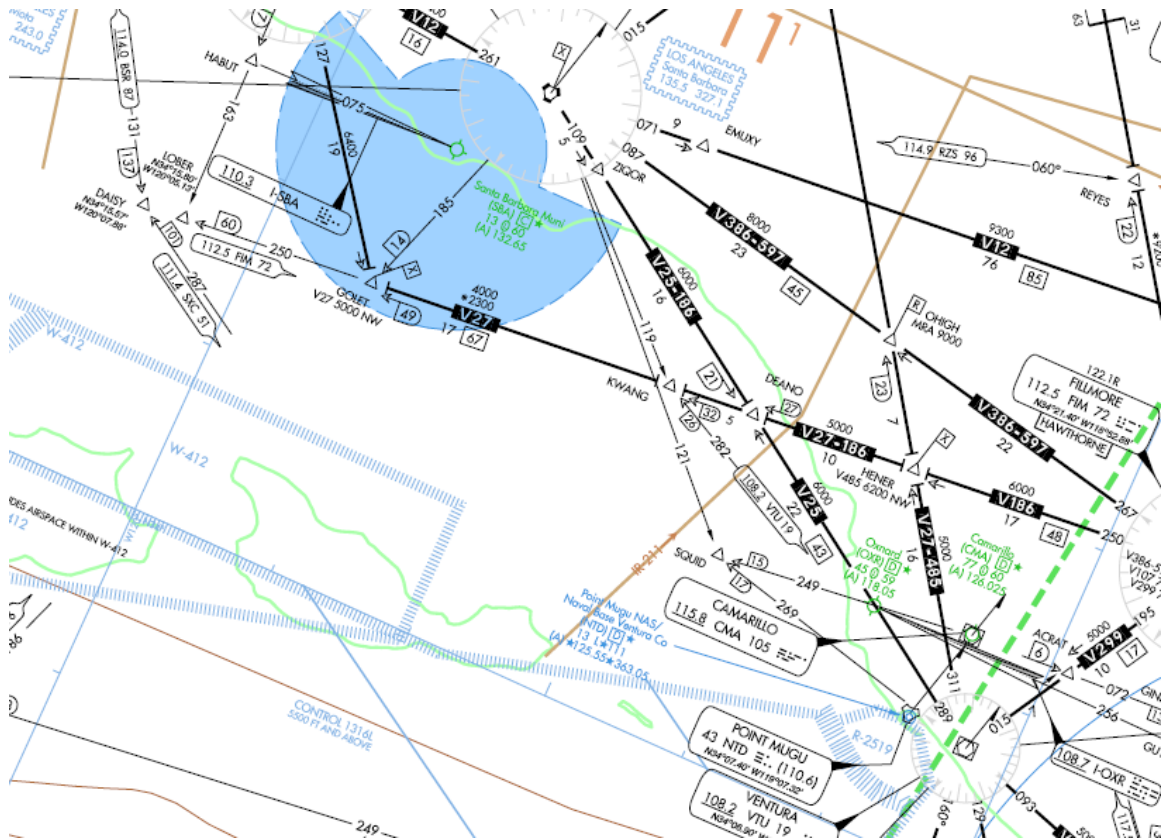


Figure 3. From an IFR perspective, it is not obvious that a substantial portion of the jeopardy-event route of flight between KCMA and KSBA is over water. The West Coast (and island boundaries) are depicted by a thin, continuous, green line (not the heavy, green-dotted line in the lower right of the figure); the same shade of green is used to show the locations of civil airports. If a crew on an IFR flight plan only referenced this chart, it is possible they may not have realized a direct route of flight between KCMA and KSBA would take them over the ocean.

The most direct route of flight would be a straight line replicating Figure 2. This would require GPS navigation which was available to the crews. One close-to-direct, traditional, IFR route would be to depart KCMA, join V25 direct to DENNO intersection, thence direct to KSBA. An alternative would be to proceed from DENNO on V27 to KWANG intersection and

then direct KSBA. The route of flight filed by each crew was left to their discretion. Most crews filed GPS direct from KCMA to KSBA.

Non-Orchestration of crew member roles. The class included 26 students which had been divided into five, four-person crews and two, three-person crews. Each crew was scheduled for a 90-minute simulator session over a three-day window. Within the 90 minutes, two sorties were to be flown during which the first pair of flying crew members would be evaluated by their non-flying crew member counterparts and then the roles reversed. The professor specifically did not orchestrate which crew position would be staffed by which student, rather the crews were given the prerogative to decide who would fly as captain and who would fly as FO. Imposed predications included the captain would be the Pilot Flying (PF), the FO would be the Pilot Monitoring (PM), the FO would handle all external to the cockpit and radio communications, and the FO was instrument rated. In the two cases with only three students per crew, one crew member was required to fly twice, but this crew member was not permitted to fly in the same crew role twice.

Nomenclature for crew assignment was alpha-numerical starting with 110SU and concluding with 720SU so the assignments could double as ATC call signs. Crew 11 contained the first pilot/copilot pair from Crew 1, while Crew 12 contained the remaining pilot/copilot pair from Crew 1. The nomenclature had the added benefits of encouraging semester-long student associations with their crew, pre-sequencing assignments into the simulator in numerical order, and quickly identifying an OSU-student crew to the PilotEdge™.net controllers. Whichever pair of students not flying was to be observing (and grading) the flying pair of students from their crew.

Weather. The weather for the scenario was provided to the crews beforehand in standard FAA meteorological syntax. Each crew received the below weather briefing prior to the start of their jeopardy event:

Weather (increment as appropriate for each day, starting with 30 Nov, then to 01 Dec, and finally 02 Dec)

Synopsis. Low Pressure East / Northeast of KSBA; Expect IMC Low Ceilings, Low Visibilities, Moderate to Heavy Rain, Fog NW Winds Across Entire North LA Coastal Region; Southern End San Joaquin Valley MVMC/VMC; Mojave Valley VMC

METAR.

KCMA 301800Z 29012G18 ½SM R26/2000V4000FT VV080 -R FG BR 13/12 A2981

KSBA 301800Z 27015G20 3/4SM OVC006 +R 12/11 A2979

TAF.

KSBA 301130Z 301212 25020KT 1SM +SHRA OVC010

FM1930 29015G25KT 1/2SM +SHRA OVC010 PROB80 2024 1/2SM TSRA

OVC005CB

FA.

FT 3000 6000 9000 12000

KSBA 2720 2929-2 3035-6 3140-11

No active Advisories, Icing, Notices to Airmen or TFRs (Temporary Flight Restrictions)

These conditions decoded are as follows:

Synopsis. Low Pressure East / Northeast of KSBA; expect Instrument Meteorological Conditions (IMC) low ceilings, low visibilities, moderate to heavy rain, fog north west (NW) winds across entire north Los Angeles (LA) coastal region; southern end San Joaquin Valley Marginal Visual Meteorological Conditions (MVMC)/Visual Meteorological Conditions (VMC); Mojave Valley VMC

Current conditions (METAR). KCMA – Winds 290°/12 Knots; Gusts 18 Knots; ½ SM Visibility; Runway 26 Visual Range 2,000 ft variable to 4,000 ft; Indefinite Ceiling to 800 ft; Light Rain, Fog, Mist; Temp 13°C / Dew point 12°C; Altimeter setting 29.81

KSBA – Winds 270°/15 Knots; Gusts 20 Knots; ¾ SM Visibility; Overcast 600 ft Ceilings; Heavy Rain; Temp 12°C / Dew point 11°C; Altimeter setting 29.79

Forecast conditions (TAF). KSBA – For the 24 hour period following 12Z: Winds 250°/20 Knots; 1 SM Visibility; Heavy Rain Showers; Overcast 1,000 ft Ceilings. From 1930Z: Winds 290°/15 Knots Gusts 25 Knots; ½ SM Visibility; Heavy Rain Showers; Overcast 1,000 ft Ceilings; 80% Probability between 2000-2400Z ½ SM Visibility; Thundershowers; Overcast 500 ft Ceilings; Cumulonimbus clouds

Winds at altitude (FA). Northwesterly, average of 30 Knots, Freezing Level approximately 5,000 ft

The weather scenario was purposefully set up to examine whether or not the crews would correctly evaluate the performance of their aircraft, with the poor-weather conditions and the limitations imposed by geography, and correctly select an alternate airport away from the coast. Additionally, since the current weather conditions at KCMA prevented a legal return to the airport (due to low ceilings and, in particular, visibilities inferior to those required for the applicable approaches in use; i.e., RNAV/GPS Y RWY 26, or VOR 26), the weather scenario was also constructed to see if any of the crews would elect a “No-Go” weather decision.

Inserted ATC events. Figure 4 outlines the final palette of 17 ATC events negotiated with PilotEdge™.net. Only the PilotEdge™.net controllers were able to insert an ATC event and only at a time of their choosing.

<p>Taxi:</p> <ul style="list-style-type: none"> • Intersection departure <p>Departure:</p> <ul style="list-style-type: none"> • Altitude restrictions <p>Enroute:</p> <ul style="list-style-type: none"> • Re-route • Unpublished hold • Loss of radar coverage • Diversion due to: <ul style="list-style-type: none"> • Widespread (pop-up) TFR • Airport closure 	<p>Approach:</p> <ul style="list-style-type: none"> • Circle due to single runway closure • Temporary airport closure (10, 20, 30, or 45 min) • Change of approach due to unplanned equipment failure (simulated-localizer outage) • Issue full approach instead of vectors to final due to temporary radar outage • Unannounced vectors through localizer • Visibility at intended airport drops below minimums <p>Landing:</p> <ul style="list-style-type: none"> • Go-Around • Runway sidestep or runway change • Exiting a parallel runway to hold short • Blocked or closed taxiways
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Figure 4. The 17 negotiated ATC events were cataloged in five phases of flight. Each represented a real-life disruption to normal operations that could occur on an IFR flight. The PilotEdge™.net controllers had the prerogative of choosing which ATC event to insert and when to insert the ATC event in each sortie. Each crew was to experience at least one ATC event during its sortie.

Information disseminated to the crews. The information disseminated to the crews in advance of the jeopardy event included specific particulars with respect to (a) route of flight, (b) required crew briefings, (c) crew-coordination prerogatives (i.e., who would be captain/FO), (d)

flight plan construction and filing instructions with PilotEdge™.net, (e) sortie call sign, (f) weather conditions (as shown previously), and (g) a summary which reminded crews that CRM skills are independent of seat assignment and include the principles of FO advocacy and assertion, as presented in Kanki et al. (2010, p. 171). These particulars were disseminated in writing three weeks in advance of the jeopardy events. It is worth noting that call signs were assigned to all 14 crews in advance and also provided to PilotEdge™.net in advance for two reasons (a) ease of bookkeeping for which crew was flying (since the sorties did not occur in numerical order), and (b) flagging the PilotEdge™.net controllers of a sortie where they needed to randomly insert an ATC event.

Results and Discussion

This section offers eight specific data streams presented as results, an interpretation of the significance of each data stream, observations and comments on the four student-assembled rubric categories, and a summary of the resulting grades the crews earned.

Specific Result Data Streams

This section is organized around Figures 5-12:

- Figure 5 – Sortie length.
- Figure 6 – Time consumed from ATC clearance delivery radio call to start of taxi.
- Figure 7 – Time consumed from start of taxi to start of take-off.
- Figure 8 – Flight time from take-off to landing.
- Figure 9 – Correlation between sortie length and flight time.
- Figure 10 – Correlation between time consumed from clearance delivery to take-off and flight time.

- Figure 11 – Chronologically, by crew, the experienced PilotEdge™.net ATC event/aircraft malady.
- Figure 12 – God’s eye view exemplar of the PilotEdge™.net flight track for Crew 72.

Due to an unanticipated OSU airport facility power outage, instead of the planned three days, the 14 jeopardy sorties spanned a five-day window from November 30 to December 4, 2015. The power outage directly affected Crew 31 whose initial sortie was unexpectedly terminated after approximately 10 minutes and had to be restarted two days later. The power outage indirectly affected Crew 32 whose event was also subsequently delayed by two days; the two-day delay did not appear to affect either crews’ performance or outcome.

Sortie length. Figure 5 charts the sortie length experienced by each crew measured from the first ATC radio call, to clearance delivery, to taxiing clear of the active runway upon landing at KSBA or divert destination. Student sorties ranged from a low of 25 minutes (min) to a high of 55 min; the average length was 40 min (noted by a vertical line annotated by a “ μ ”) with a standard deviation of 9 min (shown by the dotted line box surrounding the average). This average/standard deviation convention will be used on all appropriate succeeding figures.

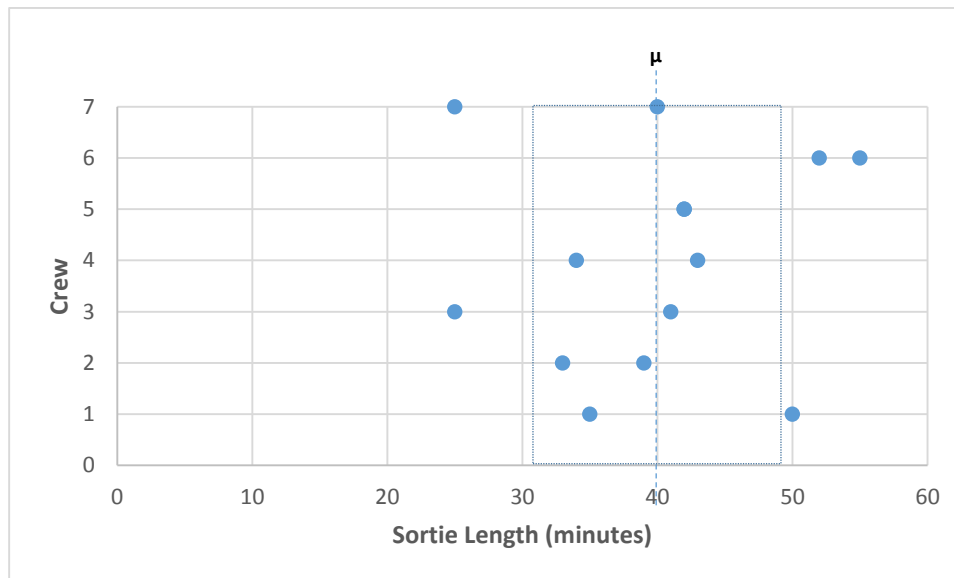


Figure 5. Jeopardy-event sortie length (in minutes) from the first ATC radio call, to clearance delivery, to taxiing clear of the active runway upon landing at KSBA or divert destination is shown on the horizontal axis vs. pairs of pilots/copilots in the respective crews shown by crew number on the vertical axis. There are two data points for each crew as each data point represents one pilot/copilot pair. The sortie length mean ($\mu = 40$ min) is shown by the vertical, dotted line. The width of the surrounding, dotted-line box shows the first standard deviation ($\sigma = 9$ min) from the mean. All data on this plot lies within two standard deviations from the mean. One pilot/copilot pair from Crew 7 and one pilot/copilot pair from Crew 3 and both pairs of pilots/copilots from Crew 6 could be considered outliers from their peers in the time consumed to complete their jeopardy events. Crew 3 and Crew 7 pilot teams consumed significantly less than the norm time, while Crew 6 consumed more than the norm time.

Each of the four data points that appear as outliers has a simple explanation. Crew 32, at 25 min, was efficiently working together and wisely asked to be released from ATC hold due to a surging left engine, thus shortening their flight time and exposure to further consequence. Crew 72, also at 25 min, was efficiently working together; however, their flight time was shortened by an undetected, engine failure and subsequent stall/spin into the ocean while maneuvering for approach during an aggressive, power application to the remaining engine. In fairness to Crew 72, their failure to detect an engine failure on approach was likely masked by simulation-set turbulence levels and the lack of real-life, visual, and audible clues of a propeller turning more slowly than expected for the phase of flight. Crew 62, at 52 min, experienced a significantly longer sortie time due to their ATC event being the unexpected closure of the

KSBA destination and their choice to divert to Oxnard Airport (KOXR). Lastly, Crew 61's sortie time of 55 min (the longest of all crews) was artificially inflated due to an excessive crew-induced, 14-min delay between request for clearance delivery and start of taxi; most crews required about five minutes to transition between these two phases of flight.

The following three figures divide the sortie length into its respective three component functions (a) Figure 6 – the time consumed from the first radio call to ATC (clearance delivery) to request for taxi, (b) Figure 7 – the time consumed for taxi, concluding with take-off, and (c) Figure 8 – the time consumed from take-off to landing. This division was necessary to reveal whether or not crews were consuming approximately the same time to complete each of the three respective components of the overall sortie.

Time consumed from ATC clearance delivery radio call to start of taxi. Figure 6 graphs the time needed for each crew to obtain, process, and understand the ATC clearance they received from KCMA clearance delivery prior to their radio call to the KCMA ground controller for taxi permission. The average time consumed for this function was 5 min with a standard deviation of 3 min. A standard deviation of 3 min with a mean of 5 min shows significant dispersion (note one crew exceeded more than two standard deviations from the mean); this dispersion suggests a significant difference in either circumstance or ability to obtain, understand, and successfully read back an ATC clearance.

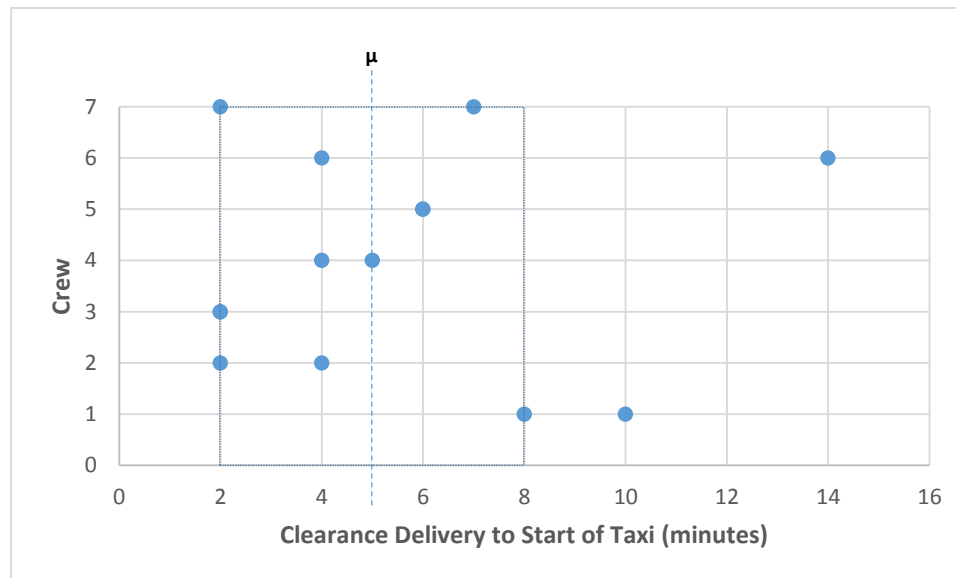


Figure 6. The time consumed from clearance delivery to start of taxi in min is shown on the horizontal axis of this plot vs. pairs of pilots/copilots in the respective crews on the vertical axis. The mean time consumed by crews from clearance delivery to taxi was $\mu = 5$ min with the first standard deviation from the mean of $\sigma = 3$ min. One pilot/copilot pair from Crew 6 was a stand-out in consuming significantly more time for this phase of flight than their peers (14 min). The data here is more dispersed than shown in Figure 5, suggesting differing levels of proficiency with interpreting assigned ATC clearances.

This data shows significant time differences between the three crews on the left and right sides of the graph. The three crews on the left needed 2 min to process the same data compared with the three crews on the right who required between 8-14 min. There is more dispersion with this data than shown for the complete sortie in Figure 5 suggesting that crews were at differing levels of comfort and proficiency with the clearance delivery function. Both Crew 11 and Crew 12 struggled with the ATC clearance and required additional radio call clarifications from ATC. Crew 61 is the outlier in this data with 14 min between receipt of clearance and start of taxi; this crew struggled with every aspect of the ATC clearance including route, departure heading, departure clearance frequency, altitude, and transponder code and also required three separate clarification radio calls from ATC before understanding the clearance.

Time consumed from start of taxi to take-off. Figure 7 plots the taxi time which was measured from the request-for-taxi radio call to the moment of take-off. Average taxi time by this definition was 5 min with a standard deviation of 3 min. While there is also greater than two standard deviations of dispersion in this data, the differences have either a crew-based or ATC-based explanation. The outlier Crew 42's ATC event was a closed taxiway at KCMA requiring a reposition to the next available taxiway and then a back taxi on the active runway to the departure end of the runway. Similarly, Crew 61's ATC event was a runway change at KCMA requiring a full, runway-length taxi to the opposite end of the airport. At the other end of the spectrum, Crew 71 required only one minute to complete taxi because they were already positioned at the departure end of the active runway and, among other shortcuts, they neglected to complete a take-off safety brief before requesting take-off clearance from the tower. Removing these three data points leaves a more uniformly distributed taxi time of 2-7 min. Taxi-time differences were not based so much on ability; rather, they were driven more circumstantially by ATC.

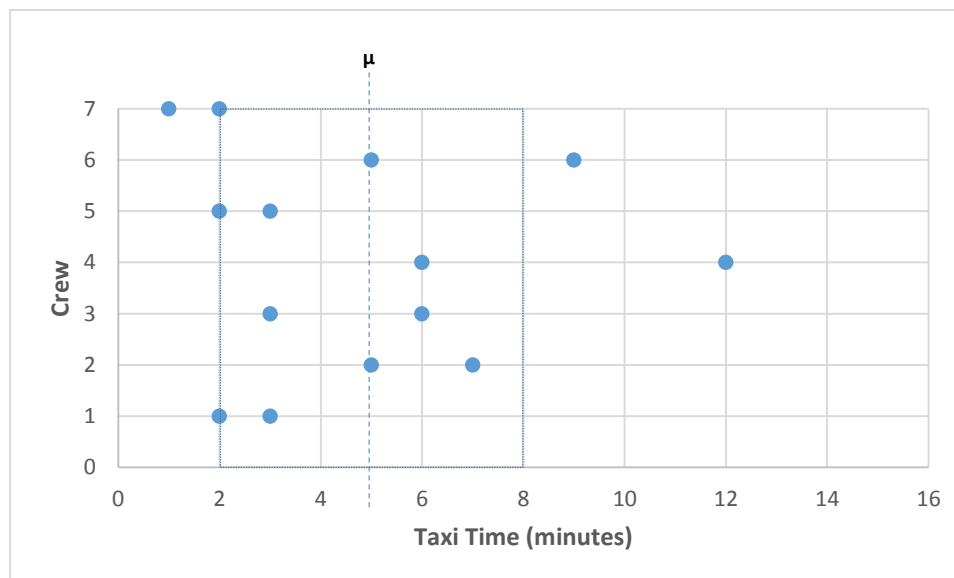


Figure 7. The time consumed from the request-to-taxi radio call to the point of take-off in min is defined as “Taxi Time”. This is shown on the horizontal axis of this plot vs. pairs of pilots/copilots in the respective crews on the vertical axis. The mean time consumed by crews to taxi was $\mu = 5$ min with the first standard deviation from the mean of $\sigma = 3$ min.

Flight time. Figure 8 shows the actual flight time. The average flight time was 30 min with a standard deviation of 7 min. The longest flight time, as noted earlier in the discussion of Figure 5, was experienced by Crew 62 at 43 min due to a divert to KOXR. The data shown in Figure 8 is not nearly as dispersed as either data shown in Figure 6 or Figure 7. Differences in flight times are principally attributed to the ATC event experienced by the crews. The most common ATC event requested was to complete a hold. Other requests that elongated flight times included route and/or approach changes, altitude change requests, and circling to land at the conclusion of a completed instrument approach.

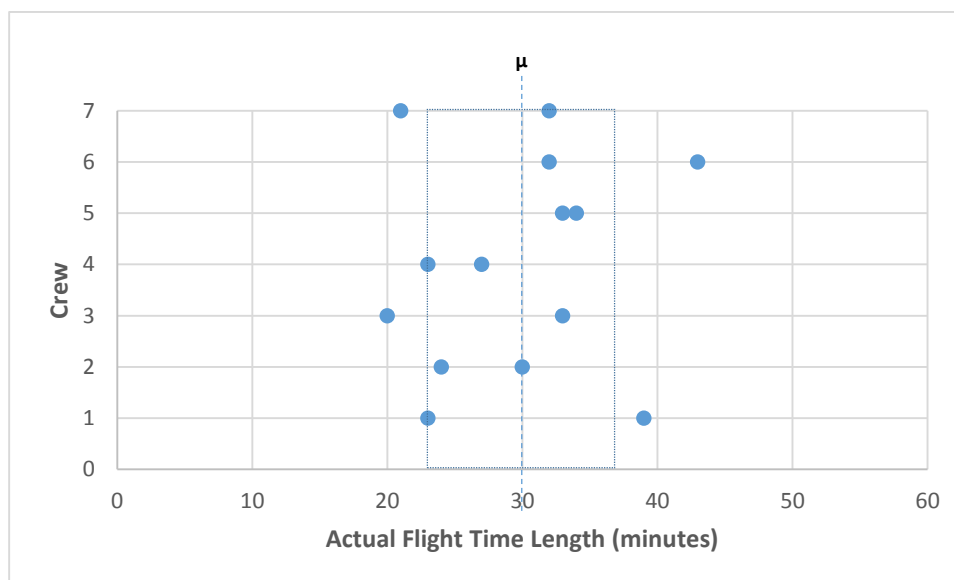


Figure 8. Flight time from take-off to landing is shown on the horizontal axis vs. pairs of pilots/copilots in the respective crews on the vertical axis. The mean time consumed by crews from take-off to landing was $\mu = 30$ min with the first standard deviation from the mean of $\sigma = 7$ min.

To cross check the cumulative validity of Figures 6 through 8 representing an accurate decomposition of Figure 5, the sum of the average clearance delivery to start of taxi time of 5 min (Figure 6), plus the average taxi-to-take-off time of 5 min (Figure 7), plus the average flight time of 30 min (Figure 8) equaled the average sortie time of 40 min (Figure 5). Of the three data streams comprising overall sortie length, only the time required from clearance delivery to start of taxi (Figure 6) revealed dispersion due to differences in ability.

Two potential correlations were explored to determine if the jeopardy-CRM-simulation event results were different from what would be expected in normal flight operations. First was the relationship between overall sortie length and actual flight time; a strong correlation was expected here as these times are typically directly proportional. Second was the relationship between the actual flight time and the time required to obtain and process the first ATC clearance from clearance delivery, as well as the time required to taxi and commence the take-off roll.

Little to no correlation was expected here as the combination of the two tasks should have been independent of the length of the flight.

Correlation between sortie length and flight time. Given the relative lack of dispersion in sortie length (Figure 5) and actual flight time (Figure 8) as well as the similarity of the data in the two plots, it was anticipated that when these two result streams were examined for the potential of correlation there would be a strong correlation. Figure 9 shows there was in fact a meaningful, strong, linear correlation ($r = 0.86$) between a crew's sortie length (Figure 5 data now plotted on the horizontal axis) and their actual flight time (Figure 8 data now plotted on the vertical axis).

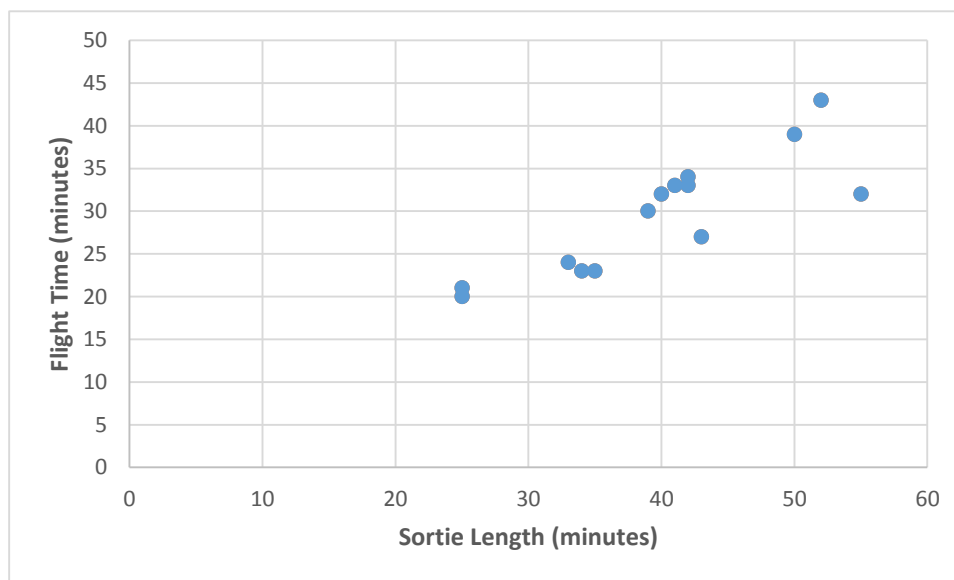


Figure 9. A comparison between sortie length on the horizontal axis vs. flight time on the vertical axis illustrates an anticipated, strong, linear correlation ($r = 0.86$). There is a directly proportional, positive relationship between a crew's overall sortie length and their corresponding flight time indicating the longer the overall sortie, the longer the subordinated flight time.

Correlation between time consumed from clearance delivery to take-off and flight time. Figure 10 shows the overall time consumed from clearance delivery to take-off (the sum of Figures 6 and 7 now shown on the horizontal axis) compared with flight time (Figure 8 now

shown on the vertical axis). When no correlation was expected in this comparison, a positive, weak, linear correlation ($r = 0.17$) existed between the sum of a crew's flight time and the crew's time required to obtain a clearance, taxi, and execute a take-off.

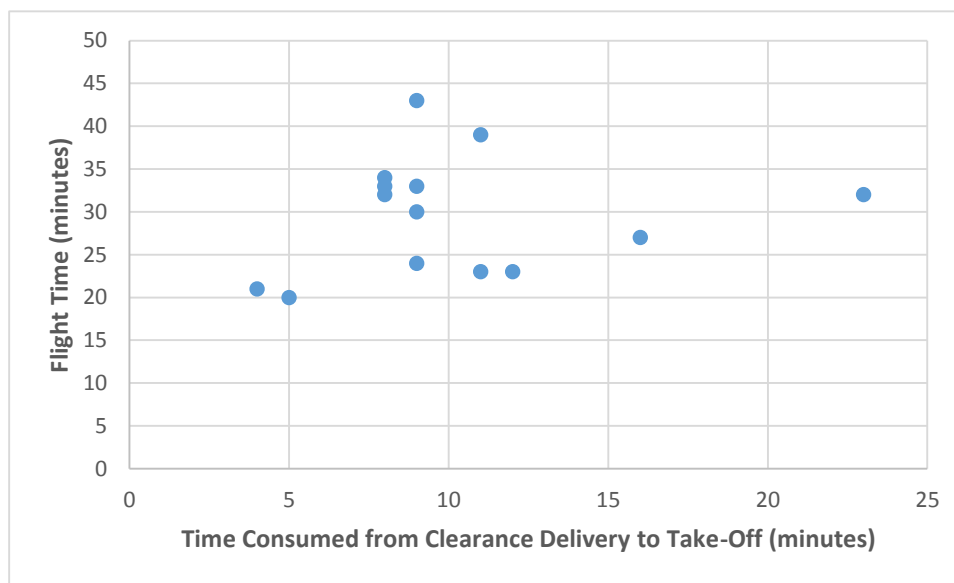


Figure 10. A comparison between the time consumed from clearance delivery to take-off on the horizontal axis vs. flight time on the vertical axis yields an unanticipated, weak, linear correlation ($r = 0.17$). A visually intuitive examination of this data shows a fairly tight cluster around 10 min consumed from clearance delivery to take-off which appears independent of flight time; this does not suggest a directly proportional, positive relationship between a crew's overall time consumed from clearance delivery to take-off and their corresponding flight time. The data dispersion away from the cluster indicates an inconsistent relationship between the time consumed to move from clearance delivery to take-off and flight time.

More obvious in Figure 10 than the statistically weak correlation is the significant dispersion of the data outliers versus the concentration of the data around 10 min and the disassociation of the largest consumed time from clearance delivery to take-off with the longest flight time (right most data point). The comparison shown in Figure 10 corroborates the data shown in Figure 6 because it also shows a significant dispersion around a norm of approximately 10 min. Similar to Figure 6, Figure 10 illustrates the significant differences in the crew's ability

to efficiently move through the clearance delivery, taxi, and take-off functions, spanning from a low of 4 min to a high of 23 min.

A possible partial explanation for the weak, overall positive correlation shown in Figure 10 was a modest negative correlation ($r = - 0.38$) between time consumed from clearance delivery to take-off and overall jeopardy-event grade earned by the crew, indicating the more time a crew consumed to complete these functions correlated with a lower overall jeopardy-event grade for that crew. Overall, poorly performing crews were taking longer to complete the clearance delivery/taxi/take-off functions than highly performing crews, skewing the data shown in Figure 10.

ATC event/aircraft malady. Figure 11 compares chronologically, by crew, the PilotEdge™.net ATC event for each sortie and whether or not there was a professor-inserted aircraft malady. One sortie, Crew 41, did not experience an ATC event; instead, an aircraft malady (engine failure) was substituted by the professor in order to examine the crew's CRM ability in handling an enroute distraction. Three other crews (61, 72 and 32) performed so well, the professor elected to insert a failed engine to keep the pace and challenge consistent with their peers; this was a high compliment to the CRM proficiency of these three crews.

Date (2015)	Crew	ATC Event	Aircraft Malady
30-Nov	11	Hold / Circle to Land	None
30-Nov	12	Re-route Vectors to ILS 07	None
30-Nov	51	Hold	None
30-Nov	52	Amended Route to V25 / Climb to 6000 ft	None
1-Dec	61	KCMA Runway Change to 08 / SBA ILS 07	Left Engine Fail, Enroute
1-Dec	62	Hold	None
1-Dec	71	Hold / Circle North East to 15L	None
1-Dec	72	Hold	Left Engine Fail, Approach
2-Dec	21	KSBA Runway Change to ILS 07	Right Engine Fail, Enroute
2-Dec	22	KSBA Closed—Drone Activity / Hold	None
2-Dec	41	None	Right Engine Fail, Enroute
2-Dec	42	KCMA Taxiway A Blocked / KSBA 25 Animal on Runway	None
4-Dec	31	KCMA Intersection Take-Off	Right Engine Fail, Enroute
4-Dec	32	Hold / KSBA Runway 25 Debris, Circle 15L	Left Engine Surging, Enroute

Figure 11. The variety of the PilotEdge™.net-inserted ATC events is shown tallied for each pair of pilots on each crew and organized chronologically. Correspondingly, and where appropriate, the professor-inserted aircraft malady is also shown. Engine failures were introduced for only two reasons (a) the crew was performing so well that an increment of additional stress was desired to see the impact on the CRM skills of the students (Crews 61, 72 and 32), and (b) the sortie had either experienced their ATC event on the ground at the departure airport (Crews 61 and 31) or was nearing the completion of their enroute phase without having to handle with an ATC event yet (Crews 21 and 41).

The significance of this tabulation is while “Hold” was a popular ATC event, the PilotEdge™.net controllers chose a diversity of other ATC situations. As the sorties chronologically progressed, the controllers became even more creative by adding a second ATC event or creating new ones such as “Go-Around Due to Animal on Runway.” These choices revealed the PilotEdge™.net ATC controllers also enjoyed adding realism into the jeopardy events.

Flight track. Figure 12 illustrates the PilotEdge™.net website was able to trace each sortie (shown is the God’s eye view for Crew 72). While the fidelity of the plot was low (modest update rate of one data point per minute), the ATC “Hold” event approximately midway between the KCMA departure and KSBA destination and the left turn stall/spin into the dead left engine upon power application in the KSBA approach segment of the sortie are both clearly evident.

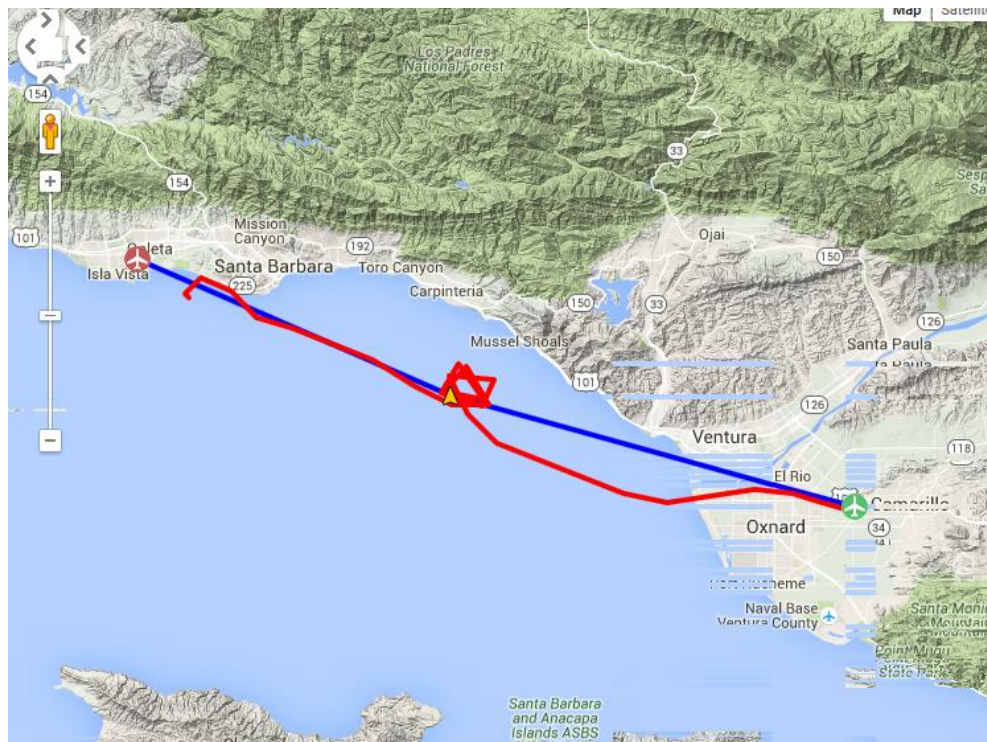


Figure 12. God’s eye view screenshot of PilotEdge™.net trace of Crew 72’s flight. The crew’s initial adherence to assigned course and then deviation south of assigned course is easily observed. The hold at KWANG intersection (the yellow triangle approximately midway between KCMA and KSBA) is also visible; however, the slow update rate of one data point per minute makes observing the integrity of the hold impossible. The standard/right hand turns are visible. From KWANG, Crew 72’s approach to KSBA tracks well with the published VOR 25 profile. The left “hook” flight path trace prior to reaching KSBA is the result of a full power application and resulting left turn stall/spin from the undetected failure of the left engine.

An overall observation of this jeopardy-CRM-simulation event was the excellent enthusiasm demonstrated by the 26 crew members. They flexed their CRM and multi-engine/instrument flying skills and exited the simulator challenged but not overwhelmed. Their positive attitudes were a significant, unanticipated, and pleasing result of the jeopardy event.

Rubric Observations by the Professor

The following observations were provided to the students, both orally and in writing, in a question-and-answer format during a formal jeopardy-event debrief at the conclusion of the fall 2015 semester. Each of the Figure 1 rubric categories (Crew Briefings, Effective Communications, Teamwork, and Situational Awareness) are discussed below.

Crew briefings. Overall, this category was either rated strongly or weakly for each crew. If the required briefs were given, they were almost always well done and the crew scored well. The four crews who scored poorly omitted multiple briefs and/or gave incomplete briefs, missing key facts.

The crew formation briefing given by the captain of Crew 11 was outstanding, short, effective, and so well done it was provided as a handout to the rest of the class at the jeopardy-event debrief (see Appendix for this particular briefing). This captain diligently followed the advice offered in Kanki et al. (2010, p. 100) to cover three macro points in an initial crew formation brief (a) establish competence, (b) disavow perfection, and (c) engage the crew. Other captains' crew formation briefs were well done but none as succinctly nor as effectively as this first one from Crew 11's captain. At the other end of the briefing spectrum, while it is completely acceptable to enjoy one's job and the experience at hand, being overly casual in a professional environment is inappropriate. A take-off safety brief, when about to launch into IMC that would legally prevent a return to land at the departure airport, stating, "If an engine fails we'll find a place to land and all that stuff" shows a gross disrespect for the seriousness of the weather conditions.

Fewer than half of the crews delivered an approach brief during the short-cruise portion of the sortie. The crews who were planning ahead and recognized the brevity of the overall flight, completed this critical review/brief of the pending instrument approach before contacting approach control. Idle time during a short cruise should have been a warning flag to the other crews to use this time more productively. If an assigned approach was changed, then the crew should have briefed the new approach (this is especially important if ATC requests a circling approach or transition from the sanctity of the IFR vertical guidance protection to a visual

approach that lacks vertical guidance). Three crews were challenged with this very change of an assigned-approach scenario; however, only Crew 32 adapted to the changing IFR-to-Visual Flight Rules (VFR) environment and properly briefed a visual approach.

Effective communication. Satisfaction of this category was strong for most crews with one significant exception, clearance delivery (reference the discussion surrounding Figure 6). Negotiating the clearance delivery function seemed to be new ground for most crews evidenced immediately by the lack of appreciation of ATC's articulation "Clearance on Request" translated as "ATC will call back when they have the requested clearance," i.e., the crew does not need to prompt ATC again. Multiple crews prompted ATC, although this was neither necessary nor helpful.

While it is not yet a FAR to write down ATC clearances, paragraph 4-4-7 of the Aeronautical Information Manual (AIM) encourages pilots to "make a written record of your clearance" and to read back "those parts of ATC clearances and instructions containing altitude assignments, vectors, or runway assignments as a means of mutual verification." Many crews did not understand or correctly read back, the first time, this departure clearance:

"Cleared to Santa Barbara Airport, after Departure Maintain heading 275, Expect Radar Vectors to the Ventura 282 radial, KWANG, Direct, 4,000', Departure 124.7, Squawk (assigned 4-digit code)"

Many crews required either a full or partial retransmission of the clearance. Students who were struggling with the clearance delivery function were attempting to interpret what they had been cleared to do before reading back the clearance. The more typical and professional approach that ATC expects is to read back ATC clearances promptly. If there is confusion about a clearance the crew should wait to discuss privately after reading the clearance back to ATC.

Asking for a read back, or worse, multiple read backs, is asking ATC to do their job multiple times and is considered unprofessional. Clearance delivery may have been difficult for these students because the OSU airport does not have this ATC function, so the dialog and phraseology may have been unfamiliar to them.

While immersed in IMC, multiple crews were advised by ATC of traffic, the crew's typical reply was "Roger," or "Looking for Traffic" when actually the ability to complete the ATC request was impossible. A much more helpful response that would enable ATC to understand the bigger weather picture would have been a reply that states the crew cannot look for traffic because they are in IMC. Such a reply would have had the added aircrew benefit of ensuring ATC realized the crew must depend upon ATC's traffic-separation ability.

Refreshingly and impressively, almost all of the students flying as FO exhibited competent ATC communications. There was one FO (from Crew 52), however, who was so smooth, so polished, so relaxed, that all who were privileged to be listening thought that we were in the company of a current Airline Transport Pilot FO!

Teamwork. Overall, this category was evaluated as strong across the crews. ATC events the crews needed to surmount included hold, reroute, changed runway assignment, change in approach, temporarily closed destination due to drone activity (or more disconcerting, but real life - no reason offered by ATC), loss of radar service, circle to land to a different runway, and go-around—animal-on-runway. All were handled in stride by the crews, with the superior crews not abdicating to ATC their locational awareness; instead, in situations of duress, they took proactive steps to either navigate toward land from over the ocean or navigate toward the nearest airport. Specifically noted, positive, teamwork examples include:

- Each crew, of their own volition and without suggestion or provocation by the professor, placed the stronger instrument pilot, not as the captain, but as the FO. Multiple crews reported they made this choice with the knowledge the event was not to be graded on quality of flight path per se, but rather the ability to work together to solve challenges; this choice repeatedly proved to be wise. Since the FO was responsible for all ATC communications, this division of cockpit duties allowed the weaker, instrument pilot to fly the airplane while the stronger, instrument pilot concentrated on proper ATC protocol and situational awareness thus helping the weaker pilot. The role that most FOs naturally assumed was unexpectedly of a Certified Flight Instructor Instrument (CFII); this was an unanticipated, mastery-of-the-moment action by the students. The crews who performed the very best (32 and 52) modeled these behaviors with a finesse far beyond their certificated experience levels (no student had yet earned their Certified Flight Instructor [CFI], nor CFII certificates).
- Numerous, appropriate, assertive, and outstanding FO challenges to ATC were observed. For example, Crew 21 suggested alternate taxi instructions to those given. Crew 32 correctly acted on their precepts with a surging engine, identified the ailing engine, altered their plans, and asked ATC to release them from their overwater hold so that they could proceed back to land. Crew 41, when experiencing an engine failure, immediately squawked “7700”, declared an emergency, and from their current overwater location, requested ATC vectors to the nearest land.

- The Crew 51 captain executed three turns in holding so perfectly, that each subsequent turn overlaid the last; these turns were performed in winds exceeding 20 KTS. This performance was directly visible on the Redbird flight-tracking software.
- On a non-precision approach, in accordance with the Instrument Rating PTS, crews who promptly descended to Minimum Descent Altitude (MDA) - 0 / + 100' significantly raised their chances of avoiding a missed approach.
- Only one crew was mentally prepared for and briefed the fact that even though KSBA VOR 25 approach is correctly classified as a straight-in approach, it is effectively misaligned with Runway 25 as the final approach course of 279° is 29° from the expected 250° heading normally associated with Runway 25. This approach requires a left 29° turn at the conclusion of a successful instrument approach for a straight-in landing. All the crews who had not briefed this turn were unprepared and surprised this left turn was necessary.

Specifically noted, less than positive, teamwork examples include:

- Intercepting and tracking VORs seemed to overly challenge many crews. This is curious since centering the VOR CDI (Course Deviation Indicator), when in the 'TO' mode, is identical to centering a GPS-driven CDI.
- Three crews left the landing gear down well beyond the point at which the landing gear should have been retracted; in two instances, the landing gear remained extended for the entire flight.
- From an IFR flight perspective, there were multiple instances of (a) not adhering to ATC clearances, (b) navigation in incorrect GPS modes, (c) not knowing runway

remaining lengths, and (d) flying excessive hold leg lengths well beyond that required.

- From a CRM perspective, if crewmembers avoided using each others' strengths to their advantage, they either omitted backing each other up on assigned ATC clearances or failed to properly execute an assigned clearance.

Situational awareness. This category was a continuous challenge for most crews who found themselves immersed in IMC in a strange geographic environment. The most common ailment was allowing communications to move up the “Aviate/Navigate/Communicate” priority structure, supplanting navigate, and worse aviate. While it is both reassuring and comforting to talk with another human on the radio, this should never be done if the ability to navigate or simply aviate (fly the airplane) is being compromised in the process of communicating. Navigation always seems to be the default and the immediate casualty, and given the implicit navigation reassurance of GPS, this was evidenced by six crews. These crews allowed the navigation function to creep into the hands of ATC because the crews were inappropriately talking with ATC prior to navigating.

In the context of this jeopardy event, the crew members should have considered the following to properly interpret the implications of the supplied weather conditions and the geographic location:

- Big Picture – Geographic location of the intended flight was the southern California coast where there are 8,900 ft MSL Mountains to the North / North East, and ocean to the West and South. This presents limited route flexibility for a non-turbocharged, light piston twin aircraft, and especially if flying in an emergency on a single engine.

- Overall Weather – Low IMC at KCMA, IMC at KSBA, IMC and strong NW winds across route of flight. Takeoff at KCMA conditions were below KCMA instrument approach minimums. If an immediate return was required, it could not be completed legally. In fact, both airports were below approach minimums for expected runways of use. A pilot could not even see full length of either runway. These are poor weather conditions commonly known in the industry as “hard IFR”.
- Preflight weather “Go”/“No-Go” Decision – The situation presented to the crews included “hard/low” IFR (IMC), below landing minimums at the departure airport (KCMA) for a 39 NM transit to below landing minimums at the arrival airport (KSBA) which virtually guaranteed an IMC missed approach with the nearest, suitable, and legal alternates approximately 80 NM away over mountains with greater than 9,000 ft MSL minimum enroute altitudes in a light piston twin with a single-engine service ceiling of approximately 5,000 ft MSL. Under any normal, operational consideration, these conditions would dictate a prudent, “No-Go” decision. Crew 31, Crew 32 and Crew 22’s captain were the only nine students who recognized the weather conditions at departure from KCMA, while legal for departure, were illegal to return to land at KCMA and therefore declared a “No-Go” weather decision. They were also the only ones to recognize the forecasted weather at the KSBA destination was below the minimums for the desired landing runway, guaranteeing diversion to an alternate airport. Curiously, in spite of their keen weather awareness at the departure airport, neither crew selected a suitable, legal alternate airport.
- Winds Aloft (FA) – The FA report purposefully did not include an icing advisory nor a cloud top report. The absence of these reports should have been an indication to crews

for possible VMC-on-Top conditions. Cloud tops were purposefully set at 4,000 ft MSL in the simulator to allow a modicum of VMC relief to the pilot flying in cruise conditions at or above 4,000 ft MSL.

- Choice of Flight Planned Alternate Airport – If “Go” is decided upon for IFR flight, the necessity of declaring an alternate airport is a legally-required, critical decision. The weather conditions offered were significantly inferior to that stated in FAR 91.169(b)(2)(i) which, if exceeded, required an alternate airport. An alternate airport was required and, to satisfy FAR 91.169, would have needed to be selected inland on the other side of the coastal mountains in the San Joaquin Valley or Mojave Valley, both of which were approximately 80 NM away. Crew 41 correctly deduced this situation and filed their flight plan correctly with an appropriate, legal, alternate airport in the San Joaquin Valley.
- Engine Failure – In addition to the weather, the propensity for continued flight with the failure of an engine in a multi-engine aircraft should be a strong consideration for the “Go”/“No-Go” decision and/or route selection. The indicated weather was below non-precision approach minimums at KSBA and required either the execution of a precision approach (now with an undesirably strong tailwind) or an emergency diversion to a suitable airport. In a single-engine scenario, an emergency diversion should have been avoided at all costs. If chosen, however, the offered weather conditions should have suggested that any emergency diversion be back to the South East and not continued out over open-ocean, or into the face of 30 KT NW headwinds, or towards high terrain. Given the limited, single-engine performance of piston light twins, including the aircraft flown for the event (PA-44-180 Seminole), an engine failure would not permit climbing

over the surrounding terrain since the terrain significantly exceeded the single-engine service ceiling; therefore, accessing a suitable diversion airport was impossible. An engine failure in this scenario would have been a grave emergency without a legal way out.

Grading

Each of the four CRM rubric scores assigned by the professor were corroborated with those provided by the non-flying crew members. Figure 13 shows the raw, rubric score (out of a possible 20 points) earned by each pair of pilots along the horizontal axis and the final jeopardy grade assigned to each pair of pilots (converted to a traditional 5.0 collegiate grade point scale). The average, raw, rubric score was a 16 of 20 possible points with a standard deviation of 2 points.

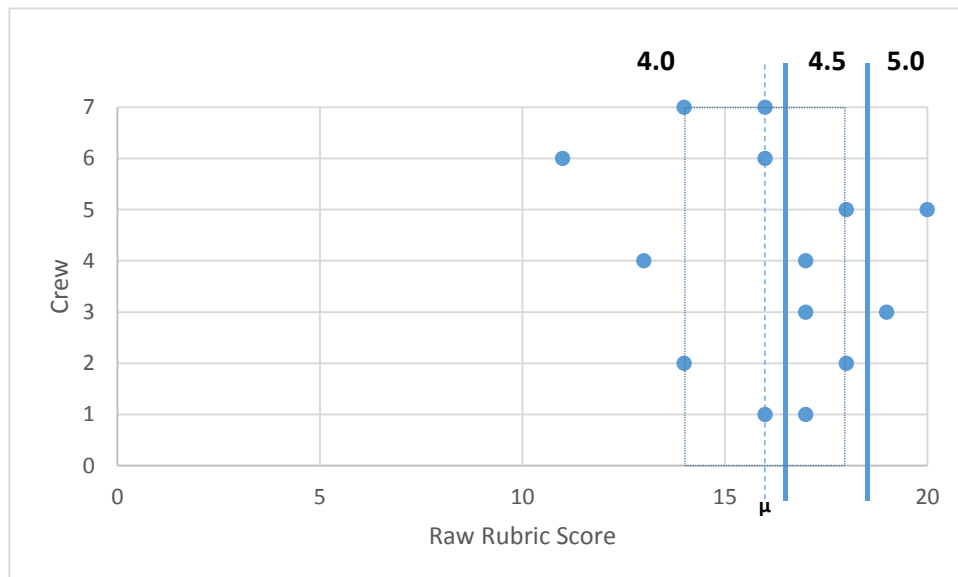


Figure 13. Raw rubric scores earned by each pair of pilots are shown along the horizontal axis with the crews along the vertical axis. Each horizontal lane on the graph represents one numbered crew. A total of 20 possible points could be earned. The average raw rubric score was $\mu = 16$ points with the first standard deviation from the mean of $\sigma = 2$ points. Recall that each numbered crew was self-divided by the students into two pairs of pilots. Final assigned jeopardy-event grades ranged from 4.0 to 5.0 on a traditional, collegiate 5.0 grade scale (4.0 = “B” and 5.0 = “A”). The location of the grade point barriers was decided by the professor to reward crews of equally yoked performance. Two crews (52 and 32) earned a 5.0, five crews earned a 4.5, while the remaining seven crews were assigned a 4.0.

Two crews (32 and 52) operated without any graded discrepancies, they earned a 5.0. Five crews (11, 22, 31, 41, and 51) also did well, but with minor discrepancies, and earned a 4.5. The remaining seven crews scored at the average or below and were assigned a 4.0. Each crews' strengths, and where appropriate weaknesses, were qualitatively documented. Statistically, based solely on the spread of the raw rubric scores, it could be argued that the two lowest scoring crews (42 and 62) should have received less than a 4.0.

Conclusion

Discussion of Results

This article opened with a double query: "Can the value of a collegiate CRM FAR Part 141 curriculum-simulation event be maintained, or increased, as a jeopardy event?" / "Does adding a live Air Traffic Control (ATC) service to a jeopardy-CRM-simulation event add additional value to the student experience?"

To explore these value questions more thoroughly, students who participated in the CRM class were solicited for their opinions one year after completing the class. The opinions of the nine students who responded to the question, "Would you please reflect on what you saw/felt/observed/gained from participating in a jeopardy-CRM-simulation PilotEdge™.net event one year ago?" are offered below:

- Crew 12 Captain – "The jeopardy event in CRM class was the closest I have come in the classroom to the cockpit. It provided a sense of realism unparalleled by any of my other ground school classes. PilotEdge™.net really forces the pilot and copilot to work as a team and communicate effectively in order to complete the tasks at hand. It is an extremely effective tool that I would highly recommend other students participate in!"

- Crew 22 FO – “It is my opinion that the use of PilotEdge™.net in conjunction with the jeopardy CRM simulation in the RedBird added a level of realism that could not be replicated any other way in a CRM training environment. While I personally was challenged by the aspect of having a crew member who displayed great difficulty maintaining basic aircraft control, I did not find that alone saturating. I believe this is because I had already begun training for my CFI certificate and understood how to teach and monitor the aircraft and knew where the thresholds were for me to take over control of the aircraft. I concentrated more heavily on the scenario at hand, communication with my partner, and communications with ATC which forced me to approach the event with a higher level of belief that it was a real flight that needed to be conducted with the utmost professionalism. This element is commonly lost when operating in a simulator since there is no chance of being hurt, damaging an aircraft, and normally no ATC to answer to or be monitored by.”
- Crew 31 Captain – “I would agree that the event was indeed challenging, but not overwhelming. It was actually my first time flying a simulator of any kind and with few hours of training in the multi at the time, and with my copilot having none at the time; the event really stressed the importance of teamwork and effective communication, as well as something that we emphasized significantly throughout the course, which was: FLY THE PLANE FIRST, and then worry about communicating/navigating. Also, I enjoyed being given all the pre-flight stipulations because it allowed us to also work as a crew outside of the sim itself; and if you recall, and if I recall correctly, we were the only group that actually elected to not takeoff based on the given weather stipulations.”
- Crew 31 FO – “I felt the CRM event proved to be a very valuable real world experience. Having the opportunity to use the PilotEdge™.net live ATC during the flight made it

extremely ‘real world’ and gave us an opportunity to practice our communication skills as well as practicing situational awareness. I also enjoyed having the opportunity to practice the CRM skills we learned throughout the year in class and actually putting them into practice. Any time you can take the course material and apply it to a ‘real world’ scenario that makes the class so much more valuable as a whole. I learned a lot during this event and definitely foresee using the CRM skills we learned in my future aviation career.”

- Crew 32 Captain – “I liked this event because it placed me in a real situation, with a real crew—both real copilot and real ATC, it was a positive experience and while we were very busy—we were not overstressed. I also appreciate that we were exposed to multiple, simultaneous experiences in the simulator that thankfully I have not had, nor do I want to have, in real life.”
- Crew 41 Captain – “Being in an unfamiliar geographical environment with live ATC and asked to accomplish tasks with a randomly assigned classmate while under pressure raised my awareness and performance. This felt real to me, and more real than I was expecting it to be.”
- Crew 42 Captain – “This event was beneficial because it gave me a preview of the airline world to which I aspire. I feel like I have a leg-up from this experience because I have been exposed to a graded-CRM event long in advance of my employment. I would like to recommend more frequent, shorter, graded, CRM simulator sessions and that each student pilot be equally qualified in the aircraft—so we can concentrate on CRM and not basic aircraft functionality.”
- Crew 42 FO – “Initially I was skeptical of the value of either a CRM-jeopardy event or the value of PilotEdge™.net; however, I really enjoyed the whole experience and was surprised

at how real it seemed. Now, as a CFI, PilotEdge™.net would be a great, economical tool with ‘real world’ learning value for my students, especially my instrument students.”

- Crew 71 Captain – “We were paired with a partner who we did not know very well which forced us to learn how the other person operates in a short amount of time. I liked this because as an airline pilot you will always be flying with someone new and you need to learn how to work with them to be effective in everyday operations, especially in emergency situations.”

Based on the data shown, the unanticipated identification of a potential curriculum weakness in the Clearance Delivery function, the observable CRM performance of the students and the positive attitudes they exhibited—particularly as each sortie closed, the enthusiasm of the PilotEdge™.net controllers, and the actual students’ opinions one year later, the conclusion to both preliminary queries is ‘YES’.

Implications of Results

The value of a collegiate, FAR Part 141 CRM-simulation event can be maintained as a jeopardy event, and incorporating a live ATC service in a jeopardy-CRM-simulation event adds additional value to the student experience. Live ATC introduces a “real world” element that cannot be duplicated fairly or impartially by a single grader who is also sharing the role of ATC, and allowing the live ATC controllers to randomly insert ATC events replicates the variability of life and gives each sortie an authentic expectation of the unknown. Both of these are positive facets in evaluating the ability of crew members working-together relationships in a CRM environment. OSU has embraced these findings, and therefore, all of OSU’s future professional pilot seniors will be given the opportunity for a LOE-jeopardy-CRM-simulation event prior to graduation from the OSU FAR Part 141 program.

Recommendations for Future Research

A longitudinal study approach that is applied to this research and collected over multiple cycles of this course delivery could corroborate the observations made on the first course delivery and show whether or not institutional curriculum changes based on the course results are having the desired effects on student performance.

Additional curriculum changes beyond those discovered during the execution of CRM class could be methodically explored in the live ATC environment to determine their value and applicability prior to potentially disruptive, ad hoc, trial-and-error experimentation in real-world IFR operations.

Acronyms

AATD – Advanced Aviation Training Device

AC – Advisory Circular

AGL – Above Ground Level (height in feet)

AIM – Aeronautical Information Manual

ALPA – Airline Pilots Association

ATA – Air Transport Association

ATC – Air Traffic Control

CAP – (U.K.) Civil Aviation Publication

CDI – Course Deviation Indicator

CFI – Certified Flight Instructor

CFII – Certified Flight Instructor Instrument

CRM – Crew Resource Management

FA – Winds Aloft Forecast

FAA – Federal Aviation Administration

FAR – Federal Aviation Regulations

FO – First Officer

ft – Feet

GPS – Global Positioning System

ICAO – International Civil Aviation Organization

IFR – Instrument Flight Rules

IMC – Instrument Meteorological Conditions

KCMA – Camarillo Airport, California

KOXR – Oxnard Airport, California

KSBA – Santa Barbara Airport, California

LA – Los Angeles, California

LOE – Line Operational Evaluation

LOFT – Line-Oriented Flight Training

MEF – Maximum Elevation Figure

min – Minute

MDA – Minimum Descent Altitude

METAR – Routine Aviation Weather Report

MSL – Mean Sea Level (height in feet above)

MVMC – Marginal Visual Meteorological Conditions

NM – Nautical Mile

NW – Northwest

OSU – Oklahoma State University

PF – Pilot Flying

PIC – Pilot in Command

PM – Pilot Monitoring

POH – Pilot Operating Handbook

PTS – Practical Test Standard

SM – Statue Mile

SOP – Standard Operating Procedure

TAF – Terminal Area Forecast

TFR – Temporary Flight Restriction

U.K. – United Kingdom

U.S. – United States

VFR – Visual Flight Rules

VMC – Visual Meteorological Conditions

VOR – Very High Frequency, Omni-Directional, Radio Receiver

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Appendix

Crew 11 Captain's Crew Formation Brief

Establish Roles

- Pilot Flying (PF): Flies, throttles
- Pilot Monitoring (PM): Radios, navigation, flaps, throttle assistance

Open, positive cockpit

- I'm in charge, but not perfect
- If you see something wrong, speak up
 - Be as specific as conditions allow
 - Point out problems
 - Suggest solutions
 - Provide reasons for your concern
- Your communication is not limited to problems, I encourage you to speak up at any time
- We will have key decision points along the way and I'd like your input in those decisions:
 - "Go"/"No-Go"?
 - Proceed with takeoff?
 - Enroute, proceed to destination?
 - Proceed with approach?
 - At minimums, proceed with landing?
- Challenge-Response checklists
 - PM gives challenge, PF gives response
 - If I am not configuring something correctly, let me know
 - Use of "I concur/I do not concur" when configuring aircraft