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Disparities in Weather Education Across Professional Flight Baccalaureate Degree Programs

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Abstract

The required meteorology coursework for 22 accredited professional flight baccalaureate degree programs was examined and compared. Significant differences were noted in both the number of required meteorology courses as well as the number of required meteorology credit hours. While all programs required at least one three-credit meteorology course, not all programs required an *aviation-specific* meteorology course. In addition to the required number of meteorology courses and credit hours, topics within the aviation-specific meteorology courses were also examined. The study showed the topics of "flight hazards" and "aviation weather reports and charts" were identified most frequently in course descriptions, followed third by "weather applications to flight." However, based on the course descriptions alone, it was unclear if the meteorological theory of flight hazards was addressed in the courses or if the courses only addressed the interpretation of weather hazards charts. To improve and standardize aviation-meteorology education in professional flight-degree programs, a recommendation was made to either provide aviation-meteorology curriculum guidelines through the University Aviation Association (UAA) Curriculum Committee or to form a separate UAA Aviation-Meteorology Education Committee.

Introduction

Weather was cited as the primary cause for 3.6% of the 1,181 general-aviation, fixed-wing accidents occurring in 2009; however, these accidents accounted for 11.2% (26 total) of all *fatal* accidents in the same category, making weather-related accidents the most lethal of all general-aviation accidents (AOPA, 2010). Statistically, weather-related general-aviation accidents had a lethality of 62% in 2009, down from an average of 75% over the previous nine years (AOPA, 2010). While these sobering statistics are not directly connected to professional-flight degree programs, they do bring attention to the threat weather continues to pose to general aviation and flight training. The good news is that with proper education in aviation meteorology and flight planning, weather-related aviation accidents are arguably the most avoidable, thus highlighting the importance of aviation-meteorology education to the quality of professional-flight degree programs.

Aviation-meteorology education can be fundamentally broken into two broad categories, *hazard mitigation* and *hazard avoidance*. The first category focuses on piloting techniques to mitigate the impact of weather hazards once encountered by the aircraft. Two examples of this category include: 1) decreasing airspeed below the aircraft's maneuvering speed to reduce the risk of damage during encounters with turbulence or thunderstorms; and 2) maintaining proper aircraft configuration, attitude and airspeed to avoid wing stalls during an icing event. This category of meteorology education focuses primarily on piloting technique *during* the flight rather than flight planning prior to the flight.

This leads us to the second broad category of aviation-meteorology education, *hazard avoidance*, which focuses on both weather theory and weather flight planning. More specifically, this category of meteorological education seeks to improve each pilot's knowledge of the fundamental causes of hazardous weather and the visual cues necessary to identify and avoid hazardous weather. In addition to meteorology theory, hazard avoidance also includes developing an understanding of the weather resources available to the pilot to ensure proper flight planning and to improve aeronautical decision making (ADM). This broad category of aviation-meteorology education is closely related to Lester's (2004) first step in the self-briefing process, "weather awareness." Weather awareness can be viewed as more than merely an understanding of weather for the day. Instead, it should be viewed as a life-long learning process of improving the pilot's individual understanding of meteorology and staying current with available weather products. This includes, for example, an understanding of the strengths and weaknesses of various weather products as well as an understanding of which FAA products are designated primary products, i.e. for operational decision making, and those that are designated as supplementary, i.e., only for enhanced situational awareness (FAA, 2010). This life-long, meteorology-education process begins in the classroom and only ends after a pilot's final flight. This paper focuses on the variability with which this second category of meteorology education, *hazard avoidance*, is addressed in professional-flight degree programs.

Purpose

The FAA weather certification process clearly recognizes weather education as a fundamental aspect of any pilot certificate level. For example, nearly 17% of the Pilot Handbook of Aeronautical Knowledge (PHAK) text is devoted to weather theory and weather services. Likewise, Gleim and Gleim (2010) provided over 800 sample FAA private pilot knowledge exam questions of which 16% pertained directly to aviation weather and aviation-weather services. While the meteorology training information contained in these instructional documents provides some basic theory, the majority of the material focuses on how to access weather data and

interpret charts. The meteorology theory is, in many cases, over-simplified and even outdated. Fortunately, meteorology education in professional flight-degree programs typically goes beyond the basic aviation-meteorology certification requirements. However, the extent to which this is accomplished is by no means standard. The quantity and depth of education provided in the areas of aviation-meteorology theory and weather flight planning varies widely across accredited professional flight-degree programs. The purpose of this paper is to provide a comparative analysis of the aviation-meteorology education requirements for accredited professional flight baccalaureate programs. In addition, this paper makes recommendations for future actions that could potentially improve and standardize the quality of aviation-meteorology education as well as prepare students for anticipated changes to weather support and information systems.

Methodology

Professional flight-degree programs were selected from the list of over 200 degree-granting aviation institutions provided in the 2012 Flight Training College Aviation Directory (AOPA, 2011). For consistency, only Aviation Accreditation Board International (AABI) accredited professional flight baccalaureate degree programs, that also required flight as part of their curriculum, were evaluated. In total, 22 degree programs met these criteria. These institutions are identified in Table 1.

Once the degree programs were identified, the degree requirements and meteorology-course descriptions for each were collected from the most current course catalog available on each institution's official web site. Information collected included: required number of meteorology credit hours; course descriptions for all required meteorology courses; prerequisite courses for all required meteorology courses; and a binary determination of the aviation specificity of each required meteorology course (i.e., whether or not the meteorology course was specific to aviation). The course descriptions were then imported into Excel and a simple manual content analysis was performed by searching for key words and phrases to identify the frequency with which common topics appeared in the course descriptions. Since common topics were often described using different phraseology, some subjectivity was required in the binning process.

Results

The analysis results were divided into three separate areas of focus. The first and simplest evaluation was to determine the required meteorology credit hours for each program. Second, the number of required meteorology courses by type (aviation specific or general meteorology) was examined for each degree program.

The type of course was determined from the course description and/or course title depending on the detail provided in the course catalog. Finally, the topics addressed in the aviation-meteorology courses were evaluated and compared to determine common subject content among the various courses.

Table 1: *Professional Flight Baccalaureate Degree Programs Used for the Study*

College/University	State	Degree Title
Auburn University	AL	Professional Flight Management
Arizona State University	AZ	Aeronautical Management Technology (Professional Flight)
ERAU (Daytona Beach)	FL	Aeronautical Science (Professional Pilot)
ERAU (Prescott)	AZ	Aeronautical Science (Professional Pilot)
Florida Institute of Technology	FL	Aeronautical Science - Flight
Jacksonville University	FL	Aviation Science
University of Dubuque	IA	Flight Operations (Professional Aeronautics)
Kansas State University (Salina)	KS	Professional Pilot
LA Tech University	LA	Professional Aviation
Western Michigan University	MI	Aviation Flight Science
St. Cloud State University	MN	Aviation Professional Flight
St. Louis University	MO	Flight Science
University of Central Missouri	MO	Professional Pilot
Rocky Mountain College	MT	Aeronautical Science (Professional Pilot)
University of Nebraska (Omaha)	NE	Professional Flight
University of North Dakota	ND	Commercial Aviation (Fixed wing)
Kent State University	OH	Flight Technology
Oklahoma State University (Stillwater)	OK	Professional Pilot
SE Oklahoma State University	OK	Professional Pilot
University of Oklahoma	OK	Professional Pilot
Middle Tenn. State University	TN	Professional Pilot
Hampton University	VA	Flight Education

Credit-Hour Analysis

Of the 22 professional flight programs evaluated, the credit-hour requirement for meteorology instruction varied between three and eight credit hours. Twelve (55%) programs required only three credit hours of meteorology instruction, while nine (41%) programs required a minimum of six semester credits hours of meteorology instruction. Figure 1 details the number of accredited professional flight baccalaureate programs requiring the specified number of meteorology credit hours. Though not conclusive, the disparity in required meteorology credit hours suggests

a wide range in variability in either the quantity of meteorology topics discussed or the depth to which the topics are covered. It should be noted that the AABI accreditation process does not mandate the number of meteorology-instruction credit hours required; it only specifies that the professional-flight curriculum must address outcomes appropriate to meteorology and environmental issues (AABI, 2012).

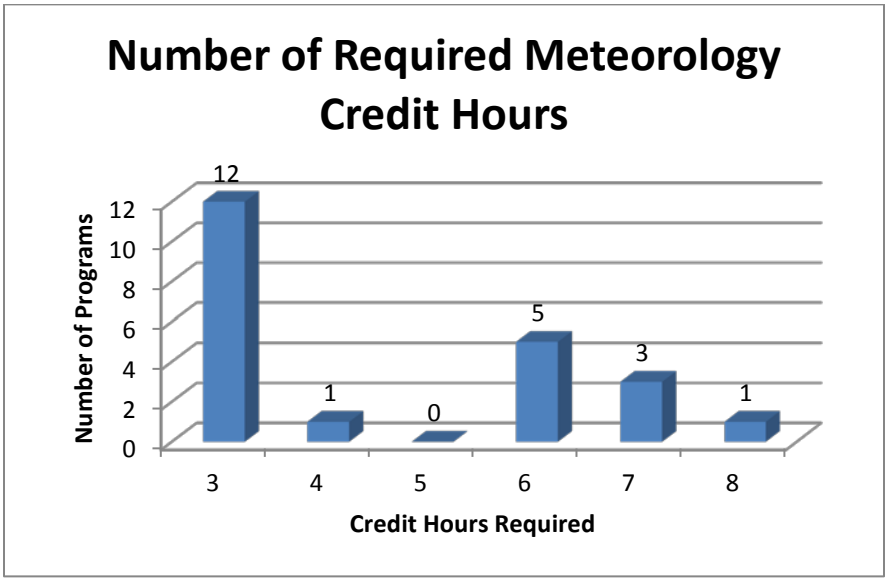

Figure 1. The number of AABI accredited professional-flight baccalaureate programs that require the specified number of meteorology course credit hours.

Meteorology-Course Analysis

As would be expected given the variability in required credit hours, the actual number of meteorology courses also varied widely. Thirteen (59%) programs required four or fewer meteorology credit hours, which were all accomplished in one single-semester course. The remaining nine (41%) programs required six or more meteorology credit hours, which were accomplished in two or more single-semester courses.

Another interesting comparison showed that although all programs in the study required at least one meteorology course, not all programs required an *aviation*-meteorology course; that is, not all required a meteorology course focused on aviation-specific weather hazards and issues. A deeper examination of course descriptions and titles indicated four (18%) programs in the study did not require any aviation-specific meteorology classes, while three (14%) did not offer an aviation-specific meteorology course. Figure 2 shows the analysis of the number of degree programs that required the specified number of meteorology credit hours.

Eleven (50%) of the programs required only a single aviation-specific meteorology course. However, six (27%) degree programs required a two-course meteorology sequence where the first course was a prerequisite general-meteorology course, and the second course in the sequence was an aviation-specific meteorology course. Only one (5%) program offered and required two aviation-specific meteorology courses, while three (14%) programs offered a third non-required advanced aviation-meteorology course beyond the general meteorology and aviation-specific meteorology course sequence. Consistent with the credit-hour analysis, these results also suggest a potentially wide range of variability in either the quantity of aviation-meteorology topics discussed or the depth to which the topics are covered.

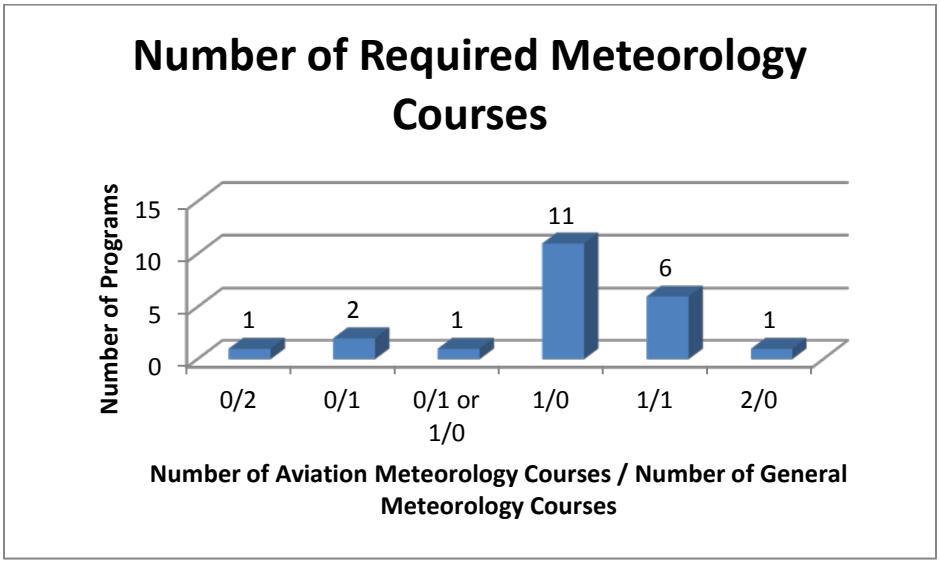

Figure 2. The number of AABI accredited professional-flight baccalaureate programs that require the specified number of meteorology courses. The courses may be either aviation-meteorology courses (left side of the slash) or general-meteorology courses (right side of the slash).

Course-Topic Analysis

Course descriptions taken from each institution's undergraduate catalog were examined to determine the specific topics addressed in each course. For consistency, the course-topic analysis examined *only* those required meteorology courses that were aviation specific, *i.e.*, required general-meteorology course topics were not investigated in this study. In total, 20 aviation-meteorology courses were examined.

Using a simple, manual content-analysis technique, each course description was examined for key phrases to identify the frequency with which various topics

occurred among the course descriptions. In total, nineteen common topic areas were identified as shown in the first column of Table 2. The third column of Table 2 shows the frequency with which the topic occurred in the course descriptions. The frequency is given by the number (and percentage) of course descriptions that included the designated topic. To be considered a common topic for this study, at least two course descriptions had to include the topic. Unique topics covered by only one institution are listed in the final row of Table 2. Since common topics often used slightly different phraseology, some judgment had to be made regarding which bin each topic best fit. The list of key words and/or phrases that were applied to the specific topic designator is shown in the second column of Table 2. In some instances, the same phrase was included in two separate categories. For example, the phrase "pressure system structure," which was taken from one of the course descriptions, was counted in both "pressure and winds" and "mid-latitude cyclones/weather systems."

The analysis clearly demonstrated the majority of all examined aviation-specific courses focused on flight hazards and aviation weather charts. This is not surprising since these topics typically distinguish an aviation-meteorology course from a general-meteorology course. What is surprising is that eight (40%) of the aviation-meteorology courses evaluated made no explicit reference to flight hazards in their course descriptions. While the topic of "fight hazards" was clearly identified in twelve (60%) of the twenty aviation-meteorology courses examined, there was no means to determine the extent to which the topic was covered from the descriptions alone. For example, were students merely taught to interpret aviation hazards charts, such as AIRMETS and SIGMETS, or were students introduced to the theory and causal factors of the hazards? This could be a potential area of further study but would require access to actual syllabi and possibly interviews with course instructors.

Tied with "flight hazards," the topic of "aviation weather reports and charts" occurred most frequently in the course descriptions. These included interpreting both meteorological codes (e.g., METARS, TAFS, PIREPS) and aviation weather charts (e.g., Graphical AIRMETs, SIGMETS). While the ability to correctly decode or interpret aviation-weather products is essential to safe flight and therefore necessary for any course in aviation meteorology, this ability is generally technical in nature and provides little theoretical insight regarding the causes of the weather. Thus, the topic of "aviation weather reports and charts" does not promote the development of higher cognitive skills in professional pilots, such as analysis and evaluation. In fact, the topic of "weather analysis" was only explicitly mentioned in three (15%) of the twenty course descriptions examined.

The topic of "weather applications to flight" occurred in seven (35%) of the courses examined. This topic occurred most frequently in course descriptions that were relatively short in length, suggesting the phrase was intended to encompass a wide-range of topics in aviation meteorology. As further evidence of this intent, there only four (20%) course descriptions in the study that did not include a specific reference to either "flight hazards" or "aviation weather reports and charts;" however, all four of these did include the topic of "weather applications to flight." Thus, all twenty (100%) of the course descriptions examined included at least one of the top three most frequently occurring topics.

Also of interest, the topic of weather "flight planning" was explicitly identified in only five (25%) of the course descriptions examined. It is somewhat surprising this topic was not identified in a greater percentage of course descriptions given its importance. That is, improving weather flight planning is directly tied to improving a pilot's ADM, which is (or should be) the primary goal of any aviation-meteorology coursework.

With the exception of aviation-weather equipment, the remaining topics were considered general meteorology topics, i.e., topics not specific to aviation. The relatively low number of occurrences of these individual topics in course descriptions can most likely be attributed to differences in the verbosity of the course descriptions themselves. The course descriptions that were significantly more verbose tended to include more general-meteorology topics than those that did not. A second possible reason is that these more general topics were covered in prerequisite meteorology courses.

In summary, a review of topics taken from course descriptions indicated the aviation-meteorology courses examined expectedly placed a strong emphasis on weather flight hazards and aviation-weather products. However, it is unclear as to whether the courses focused only on product interpretation, or if the courses also examined the theoretical underpinnings of the topics. This question is especially pertinent because "aviation meteorology charts and codes" was tied with "flight hazards" as the most frequently occurring topic. While product interpretation and decoding are fundamental to safe flight, professional flight-degree program students should also be exposed to meteorology material that goes beyond basic technical skills to include material that helps them better analyze and evaluate a broad range of weather information.

Discussion

As demonstrated in the analyses above, wide variability potentially exists in both the aviation-specific meteorology topics addressed in accredited professional flight

Table 2. *Consolidated Topic List*

Topic Designator	**Other Phrases/Terms Included in Topic**	**Number (%) of Courses**
Flight Hazards	Turbulence; icing; fog; wind shear; thunderstorms; obstructions to visibility; severe weather avoidance	12(60%)
Aviation Weather Reports and Charts	Flight-planning weather information; primary and supplementary aviation weather products; meteorological codes, aviation bulletins; forecasts, prognoses; weather maps; data formats, forecast products; weather products needed to enhance flight safety;	12(60%)
Weather Applications to Flight	Low and high altitude weather from pilots viewpoint; effect of meteorological elements on air operations; meteorology as it applies to flight; effects of meteorological elements on air operations	7(35%)
Mid-latitude Cyclones/ Weather Systems	Pressure system structure; frontal systems; synoptic weather systems	6(40%)
Weather Observations	Observations of weather elements; surface observations; upper-air observations; measurement of meteorological elements; observations of special significance to aviation	5(25%)
Flight Planning	Making informed weather-sensitive decisions	5(25%)
Air Masses and Fronts	Advection, frontal systems; air mass characteristics, frontal weather	5(25%)
Stability/Convection	Weather stability	4(20%)
Pressure and Winds	Pressure system structure	3(15%)
Jet Streams		3(15%)
Weather Services	Weather information systems; navigating today's on-line environment	3(15%)
Weather Analysis	Analysis of atmospheric phenomena; analyzing	3(15%)
Weather Forecasting	Basic prediction techniques	3(15%)
Satellite and Radar		2(10%)
Av. Weather Equip.	Airborne weather radar	2(10%)
Atmos. Circulation.		2(10%)
Atmos. Moisture	Water in the atmosphere	2(10%)
Atmos. Structure		2(10%)
Thermal Wind		2(10%)
Other Topics	Volcanic ash/space weather; baroclinic instability; human factors; thickness; kinematics; winter weather; atmospheric composition; NOTAMS; international weather patterns and information formats; responsibilities of ATC in weather observing and reporting	

baccalaureate degree programs as well as the extent to which they are covered. However, the study results are only suggestive and not necessarily conclusive due to several limiting factors. This section discusses the limitations of the study as well as makes recommendations to address the potential disparities in weather education

Limitations of the Study

The analysis presented here only examined the meteorology courses required by each degree program. However, meteorology topics are often covered in non-meteorology courses. For example, specific meteorology topics, such as meteorological codes, are often addressed in flight courses and even air traffic control courses. This may be especially true for the programs that required no aviation-specific meteorology courses. No attempt was made to evaluate non-meteorology courses in each of the program's curricula to parse out all weather-related topics.

The course-topic analysis was completed using only publicly available data from each institution's official website; that is, no attempts were made to obtain course syllabi for additional details. The official course descriptions varied significantly in the level of detail for each of the institutions. Some course descriptions were very vague, perhaps intentionally, consisting of fewer than fifteen words, while others were significantly more detailed, consisting of over 100 words. Therefore, the topic analysis may not provide a complete picture of the actual topics presented in each of the courses examined.

In addition, the course-topic analysis only examined topics covered in aviation-specific meteorology courses. The general-meteorology courses were not examined. As mentioned earlier, six (30%) degree programs required a general-meteorology course as a prerequisite for the aviation-specific meteorology course. As a result, many of the more basic topic areas, such as atmospheric composition and structure, were likely included in the general-meteorology courses and therefore not duplicated in the aviation-specific meteorology course descriptions. Therefore, while the course-topic analysis is not conclusive, it does nonetheless provide some insight to the potential range of weather topics addressed within accredited professional-flight degree programs.

Recommendations

Currently no professional organizations provide program-specific guidelines for aviation-meteorology education in accredited professional flight-degree programs beyond what the FAA requires for certification. The AABI accreditation criteria do

not specify what topics must be covered, only that degree curricula address outcomes appropriate to meteorological and environmental issues (AABI, 2012, criterion 2.4). The AABI Criteria Manual does, however, state the degree program must be developed with advice from appropriate industry associations and professionals in the field (AABI, 2012, paragraph 4.5). The guidance for standardizing aviation-meteorology instruction could, therefore, come from an appropriate professional society, and one logical professional society would be the University Aviation Association (UAA).

The UAA could potentially provide guidance for aviation-meteorology instruction through either their Curriculum Committee or through the creation of a special aviation-meteorology committee. The Curriculum Committee is charged with the task of facilitating the development of model curricula and guidelines, to include learning outcomes and methods of assessment, for both two- and four-year collegiate aviation programs (UAA, 2012). As such, the committee could assist in standardizing weather education by providing guidelines and model curricula for aviation-meteorology coursework in professional flight-degree programs. This would be similar in practice to how the American Meteorological Society (AMS) provides recommended topic areas for meteorology degree programs through a detailed information statement (AMS, 2010) despite not being an accrediting body.

A second option would be the creation of a special Aviation-Meteorology Education Committee. This committee would be similar in function to the UAA special committee on Air Traffic Control (ATC) Education, which serves to: 1) provide a centralized focal point for communication about ATC education issues, techniques and technology; 2) promote and encourage innovation in ATC curriculum and the use of ATC education technology; 3) explore new ATC technology through research and development; and 4) promote involvement of collegiate programs (UAA, 2012). A special committee on aviation-meteorology education could have largely the same goals. That is, the committee could serve to: 1) provide a centralized focal point for communication about aviation-meteorology education issues, techniques and technology; 2) promote and encourage innovation in aviation-meteorology curricula; 3) explore new and developing aviation-meteorology products and information dissemination technology; and 4) promote involvement of collegiate programs

The creation of a UAA special committee on aviation-meteorology education versus the integration of aviation-meteorology education into the UAA Curriculum Committee offers the advantage of being able to address more than curricular issues. The committee could also address current and future advances in weather data, products, and information dissemination systems. For example, over the past 5 years there has been an explosion in the usage of smart phones and computer

tablets by flight students. Students now have unprecedented access to weather information through easily accessible applications (i.e., "apps"), not all of which provide weather information that is FAA certified for primary or supplementary use. A special committee on aviation meteorology could provide a means to exchange ideas, from a pedagogical perspective, regarding how best to communicate and exploit the technology in the classroom. Likewise, initiatives such as the Next Generation Air Transportation System (NextGen) will potentially change the way weather data is communicated and accessed (JPDO, 2010). One such change is the anticipated use of objective probability-based weather products in decision-support tools (Guinn and Barry, 2012; JPDO, 2010). The committee could exchange ideas for addressing these anticipated changes in the classroom. Yet another topic of discussion could be the proper use of weather data fed directly to the cockpit. All of these topics would benefit greatly from the exchange of ideas among both meteorology and professional flight instructors. Additionally, by preparing professional flight students for these anticipated technology changes, the committee will likely help make transitions to newer technology smoother and safer for the profession as a whole. Equally important, the committee could aid in promoting the development of life-long learning skills in aviation meteorology within the professional aviation community.

Summary

An evaluation of course requirements and descriptions suggests there are potential disparities in both the amount of required meteorology education as well as the content of the meteorology courses across all AABI-accredited professional flight baccalaureate programs. Professional societies may be able to help minimize these disparities through committees devoted to aviation-meteorology education in professional flight-degree programs. One logical professional society to host these committees would be the UAA.

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