A COMPARISON OF TWO TAKEOFF AND CLIMB OUT FLAP RETRACTION STANDARD OPERATING PROCEDURES

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Abstract

Takeoff and climb out flap retraction is a procedure that is conducted following takeoff to retract the flaps and slats from a takeoff configuration to a clean-up-and-away configuration. During this period the aircraft accelerates from the takeoff V2 speed to 250 knots and generally includes a thrust reduction from the takeoff thrust setting to the climb thrust setting. Timing of the flap retraction is critical to avoid overspeed or underspeed. Also, due to the vicinity of terrain and traffic, the aircraft performance and airspace must be carefully monitored while staying responsive to Air Traffic Control voice communication. As a result the design and certification of these procedures must resolve multiple conflicting objectives.

This paper describes a formal analysis of alternate takeoff flap retraction procedures for the BAE 146 (Avro) aircraft. One procedure requires a "callout" by the Pilot Flying (PF) for each stage of flap retraction. The other procedure delegates flap retraction to the Pilot Monitoring (PM). A formal analysis of the procedures using the Human Machine Interaction Sequence Diagram (HMI-SD) method yielded equal utility. Overall, the Callout procedure is more robust to interruption and provides a better shared mental model between the crew members. However, the Delegate procedure can be completed on average 4.5 seconds faster providing more time for monitoring or performing other tasks. The implications and limitations of the formal procedure analysis is discussed.

Introduction

The airline cockpit is a heavily proceduralized environment in which all operations are governed by standardized procedures performed the same way in each operational circumstance by the flightcrew. This ensures that any pilot can be paired with any other pilot and perform seamlessly. Adhering to procedures helps pilots increase the likelihood of safe and efficient airline operations.

Each procedure defines unambiguously: (1) the objectives, (2) the conditions when the task is conducted (time and sequence), (3) by which crew member, (4) the sequence of events and actions, and (5) what type of feedback is provided (callout, indicator) [1] [2]. Well-designed procedures can be performed in the allowable operational time window (AOTW) in a logical sequence that minimizes the likelihood of interruptions or waiting time for information. It should also be robust to variations in aircraft performance or airspace constraints.

The design and qualification of procedures for a specific aircraft is a critical activity performed by the manufacturer, the airline and the certification regulatory authority. The traditional approach to the design and inspection of the procedures is an *adhoc* process that is reliant on subject matter experts (SMEs). Due to the complexity of the procedures and the need to trade off multiple conflicting performance objectives, and without a formal method for specifying the procedure and measuring its characteristics, comparing alternate procedures while establishing strengths/weaknesses can be a challenge.

This paper demonstrates a formal process for comparison of two procedures using Human Machine Interaction Sequence Diagram (HMI-SD) and Multi-Attribute Utility Theory [3].

Takeoff flap retraction is a procedure that is conducted after takeoff to retract the flaps and slats from a takeoff configuration to a clean-up-and-away configuration (i.e. 24^0 to 18^0 to 0^0 flaps). During this period the aircraft accelerates from the takeoff V2 speed to 250 knots and generally includes a thrust reduction from the takeoff thrust setting to the climb thrust setting (Figure 1). Timing of the flap retraction is critical to avoid overspeed or underspeed. Also, due to the vicinity of terrain and traffic, the aircraft performance and operating airspace must be carefully monitored while staying responsive to Air Traffic Control (ATC) voice communication.

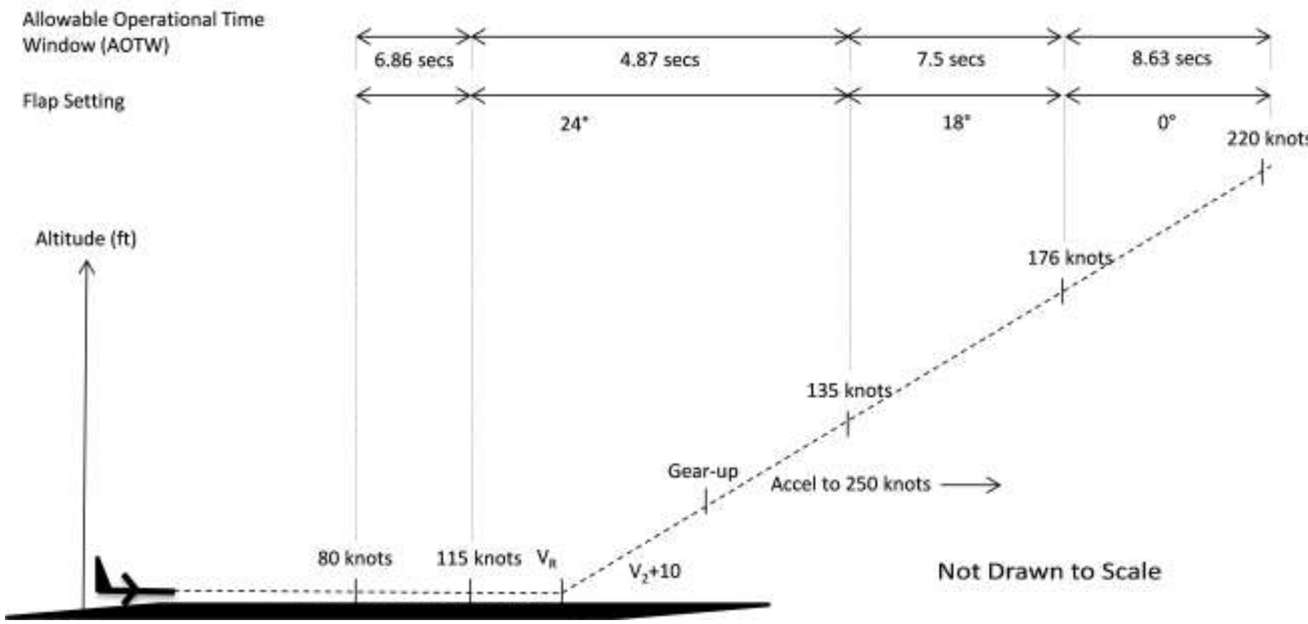

Figure 1 Takeoff and Climb Out Flap Retraction Procedure

Two procedures for flap retraction during takeoff and climb out for the Avro aircraft were analyzed. Both Procedure 1 and Procedure 2 are performed via the coordination between the Pilot Flying (PF) and the Pilot Monitoring (PM). Procedure 1 is performed with the PF calling out for a specific stage of flap retraction at the appropriate speed (and after reaching safe altitude) triggering the actions of the PM who then executes the order after double-checking safe conditions exist. When the stage of flap reaches the called for stage, the PM communicates it to the PF, and so on until the flaps are set to 0^0. Procedure 2 is performed by delegating the entire flap retraction to the PM after observing a positive acceleration on the speed tape (and also a safe altitude). At the end of Procedure 2, the PM reports the clean configuration of the aircraft (i.e. flaps set to 0^0) to the PF.

The procedures were documented in HMI-SDs. Characteristics for the two procedures were read from the HMI-SD and from the Monte Carlo simulation of the procedures. Attributes were scored and utility for the procedures was calculated. A summary is below:

- Callout procedure has 18 HMI loops, and Delegate procedure 15 HMI loops
- Callout procedure has a buffer time of 3.6 seconds, while the Delegate procedure has a buffer time of 7.9 seconds
- Both procedures can be completed more than 95% of the time in the operational allowable time window
- Callout procedure has a better Shared Mental Model (SMM) between the flightcrew members
- Both procedures are missing one communication item
- Callout Procedure has an overall utility of 0.775 and the Delegate Procedure 0.770. Utility is based on weights assigned to attributes by SMEs.

Overall, the Callout procedure is more robust to interruption and provides a better shared mental model between the crew members. However, the Delegate procedure can be completed on average 4.5 seconds faster providing more time for monitoring among other tasks.

This paper is organized as follows: the next section describes the flap retraction phase of flight and the required procedure along with the hazards associated with incorrect flap retraction. The Methods section describes the HMI-SD method for the specification and evaluation of the procedures as well as the value hierarchy and multi-attribute analysis. The results, section 4, describes the formal comparison of the procedures. The limitations and implications of the analysis are discussed in the Conclusions, Limitations, and Future Work section.

The Takeoff and Climb Out Flap Retraction Procedure

Flap retraction is part of the takeoff and climb out procedure. Flaps are extended on the ground before takeoff to increase the lift at low speeds. Once the aircraft has achieved a stabilized climb and a safe airspeed and altitude, the flaps are retracted to achieve the optimum lift and drag configuration.

Table 1 Flap Limitations

Flap Setting [degrees]	Maximum Airspeed [knots]
18 takeoff and approach	220
18 low speed hold	175
24	180
30	170
33	155

Flap retraction remains a manual task performed by the flightcrew due to the hazards and complexity associated with the maneuver. Since flaps are relatively small movable surfaces hinging to the aircraft wings, their robustness to aerodynamic forces is less than that of the remaining control surfaces. Operation of flaps under high speed conditions causes structural damage. As a result, flaps retraction and extension are limited by maximum permissible speeds (Table1).

Table 1 is an example for flaps maximum speed limitations for the Avro aircraft. Note that the higher the angle of flaps, the lower the maximum permissible speed. Pilots must closely monitor speed during the takeoff procedure to make sure the retraction occurs before the aircraft reaches the maximum allowable speed for that configuration.

Another hazard linked to flap retraction during takeoff relates to the stall speed (V_S). This speed is the slowest airspeed at which the aircraft can sustain a sufficient lifting force. One of the benefits of the flaps is that they lower the stall speed. Extended flaps provide a comfortable margin above V_S , but retracting flaps will bring this critical value back to a higher number. As a result, when retracting flaps, pilots make sure their speed is at a safe margin above the stalling speed for the next stage of flaps.

Lastly, it is critical to retract the stages of flaps in sequence to avoid abrupt loss of lift in dangerous proximity to the ground. This is the reason why flaps are retracted at a company appointed safe altitude above ground level.

A typical aircraft can take off with different flap settings. The company calculates a margin below the maximum allowable speeds for flap operation and provides its pilots with data on safe flap retraction as shown in Table 2. This compiled table is called the "flap retraction schedule" for an Avro taking off with a mass of 38,000 kg. To explain, in a scenario where pilots are flying an Avro with flaps set to 24^o, this table informs them that at this takeoff mass, the speed at which flaps are to be retracted from 24^o to 18^o is 135kts. That speed is referred to as V_{F18}.

Table 2 Flap Retraction Schedule for Avro

TAKEOFF, 38'000 kg				
T/O FLAP	18^o	24^o	30^o	33^o
V_R	126	115	106	102
V_2	135	124	116	112
V_{F24}	N/A	N/A	124	
V_{F18}	N/A	135		
V_{F70}	176			

Also, due to the vicinity of terrain and traffic, the aircraft performance and airspace must be carefully monitored while staying responsive to ATC voice communication.

Method of Analysis: HMI-SD and Multi-Attribute Utility Analysis

Procedures and Human-Machine Interaction (HMI)

A procedure is performed by a sequence of operator actions: (1) Observe and Orient, (2) Decide, and (3) Act [4], [5], and [6]. Each execution of these three steps is known as an HMI-loop. The initiation of each HMI-loop is triggered by a sensory cue (i.e.

visual, aural, tactile, or smell) or a memory cue (i.e. portion of a procedure trained and stored in Long-Term Memory).

The Observe and Orient cues may come from the environment, from the machine including the automation. In modern “hermetically sealed” flight decks, the cues are largely derived from displays on the automation that are sourced from environmental or machine sensors.

The Decide step determines the selection of the appropriate action(s). When the action is prompted directly by a cue (e.g. a label indicating the next action), or the decision is based on habit, the decision-making is trivial and reliable. When decisions are made without visual cues for an infrequent circumstance they may require the application of memorized procedural rules or reflection and reasoning. These decisions are less reliable.

The Act step involves manipulating the input devices on the automation or machine.

A typical procedure may involve between 20 and 200 HMI-loops. In general, the HMI-loops must be completed in the prescribed sequence (e.g. a display page must be accessed before an entry can be made). In this way, delays in completing an HMI-loop ripple forward through the procedure and result in delays in completing the procedure within the allowable operating time window (AOTW).

The AOTW is calculated using the operational environment constraints such as the time to accelerate to a required airspeed, the time to descend to an altitude, or the time before the next ATC instruction.

Human Machine Interaction Sequence Diagram (HMI-SD)

HMI-SDs can be used to document and simulate procedures [3]. The diagram has two dimensions: the vertical axis that represents time and the horizontal axis that represents the agents (Figure 2).

Time-to-Complete Procedure

The observe & orient, decide, and act actions all have associated time distributions (e.g. N~(μ, σ). For each interaction in the HMI-loop a random number is generated according to its respective time distribution. The aggregated time constitutes the procedure time and the HMI-SD model, composed of all HMI-loops, is run in a Monte Carlo simulation to estimate the overall time to complete the procedure.

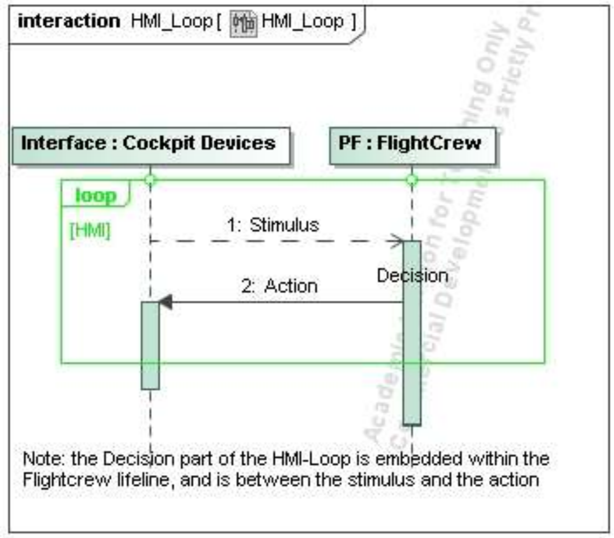

Figure 2 HMI-SD with Observe/Orient, Decide, and Act Loop

Allowable Operational Time Window

The HMI-SD model is run in a Monte Carlo simulation to generate information about the time it takes a sample of pilots to perform a procedure or some part of it. This distribution is referred to as Time-to-Complete the procedure (left side in Figure 3). In parallel each procedure has, by definition, an Allowable Operational Time Window (AOTW) that represents the time in which the procedure must be completed. This time can also be variable and is shown by a time distribution (right side in Figure 3). In the HMI-SD of Figure 4, the AOTW interval is shown by the double headed arrow Between HI1 and HI7. The flightcrew are expected to have completed a specific number of HMI loops (here 3) by the end of that time window.

The difference between the 95%-tile of the time-to-complete the procedure and the 5%-tile of the AOTW distribution, represent the Buffer Time. This is the excess time in which the procedure can absorb delays in any of the HMI-loops.

Figure 3 Distribution for Time-to-Complete Procedure, AOTW, and Buffer Time Generated by Monte Carlo Simulation

Shared Mental Model

In addition to the sequence and timing of HMI-Loops in a procedure, the procedure must also ensure a shared mental model between human operators. Each operator must share the same understanding of the state of the flight, the future plans, and any actions taken to configure the machine or automation. For example, critical procedures (e.g. takeoff), are briefed prior to execution and "callouts" are made by one operator to let the other verify a setting or know an action has been taken. These interactions are shown in the HMI-SD by interactions 4 and 6 in Figure 4. Together with HMI-Loop2, HMI-Loop 3 constitute a Shared Mental Model (SMM-1) as shown by Figure 4.

Further, the way a message and a feedback is communicated between the flightcrew is defined by the airline using a specific communication structure fitting a specific situation and set of devices used for the procedure. In this paper, a simplified version of this structure is used to demonstrate this aspect. This version is: one crew identifies a condition for an action, then calls for it to be done. The other crew does the called for action, then calls for it done. When one step is missing in this structure (check, call to be done – do, check, call done]), it is called a missing item.

Note that the shared mental model in scope of this research includes the crew common perception of a correct aircraft state. Variations of this scope will be included in the next versions of HMI-SD.

Scoring Procedures from the HMI-SD

The following properties of a procedure can be measured directly from the HMI-SD:

- Number of interactions
- Number of HMI-loops
- Number of HMI-loops not supported by salient/ unambiguous visual cues
- Allowable Operational Time Window (AOTW) in seconds
- Sub-procedure Time-on-task (from Monte Carlo simulation)
- Procedure Time-to-Complete (from Monte Carlo simulation)
- Cumulative Buffer time (from Monte Carlo simulation)
- Probability of Failure to Complete (PFtC)
- Shared Mental Model (SMM) loops
- Communication Ratio
- Missing Communication Items

Multi-Attribute Utility Analysis of Procedures

Discussions with SMEs designing and certifying standard operating procedures have identified the following attributes for assessing the performance of a procedure:

1. Ease-of-Performance
   a. Number of interactions
   b. Number of HMI-loops
   c. Number of HMI-loops <u>not</u> supported by salient visual cues (i.e. do not rely on Long-Term or Working Memory)
2. Hazard Mitigation
   a. Probability of Failure to Complete (PFtC) Procedure within the Allowable Operating Time Window (AOTW)
   b. Number of Sub-procedures failing to complete within the AOTW
3. Robustness to Disruptions
   a. Shared Mental Model
   b. Missing Communication Items
   c. Buffer Time

The measures used to assess the attributes are listed above. Ease-of-Performance is based on the complexity of the interactions required to complete the procedure. The lower the number of interactions and HMI-loops the easier to train, learn and perform the procedure. A key component is the degree to which the pilot performing the procedure relies on salient cues to observe/orient, decide and act.

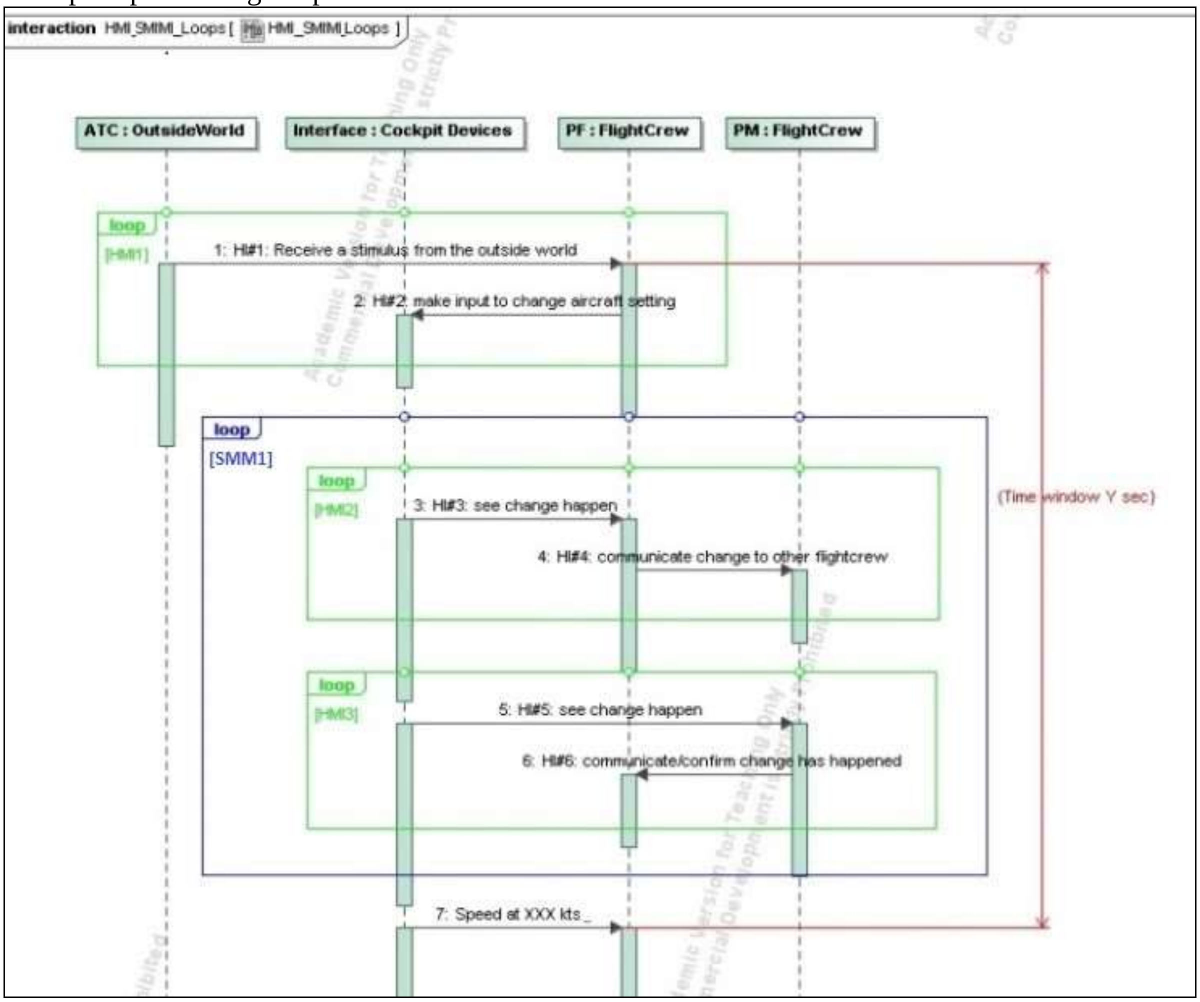

Figure 4 HMI-SD Section with HMI-loops, SMM-loop, and AOTW

Hazard mitigation is the probability of completing the procedure within the AOTW and the number of sub-procedures with negative values of buffer time (i.e. sub-procedure was not completed within the AOTW for the sub-procedure).

Robustness to disruptions has three components. First, the degree to which the procedure ensures a SMM. That is, crew members share the same operational picture and do not perform interactions that are not confirmed or are hidden from each other. Second, the number of missing communication items. Third, the degree to which the procedure allows excess time to complete in order to absorb disruptions and interruptions (e.g. ATC communications).

The overall utility of each attribute can be expressed as follows:

U = Weight of Attribute * Value for Attribute

Weights are derived from SMEs using a pair-wise comparison method.

Comparison of Two Alternate Takeoff and Climb Out Flap Retraction Procedures

Procedures

Two flap retraction procedures have been proposed (See Fig 5 & 6). Both procedures are initiated when the aircraft achieves 80 knots. Both procedure are the same through the decision speed (V_1), the rotation speed (V_R), Gear-up and confirmation of (autopilot) navigation modes.

The next step is the flap retraction. For the Callout procedure, the PF issues requests to the PM to retract flaps from 24 degrees to 18 degrees, then to 0 degrees (i.e. clean configuration). During this procedure, both pilots are monitoring the airspeed for the appropriate conditions. For example, for the retraction from 24^0 to 18^0, the appropriate speed is V_{F18}=135 kts. The PM moves the flap lever and confirms when the flap setting is achieved (“FLAP at 18”). Note that the convention on callouts is that they are differentiated from the rest of the procedure interactions by the capitalized words between double quotes.

For the Delegate procedure, the PF requests “CLIMB SEQUENCE” and the PM unilaterally sets the flap setting at the appropriate conditions. When the sequence is complete, the PM alerts the PF with a “FLAP AT ZERO” callout.

Both procedures end with the after takeoff checklist.

Callouts during takeoff		
Condition	PF	PM
At 80 knots		"80 KTS, THRUST SET"
	"CHECK"	
At V_1		"V_1"
At V_R		"ROTATE"
When positive rate of climb is confirmed		"POSITIVE RATE"
	"GEAR UP"	
Selection and/or confirmation of lateral navigation modes as required.	"NAV (HDG)"	
		"CHECK"
At posted flap retraction speeds	"FLAP (XX)"	
PM monitors posted flap retraction speeds, select flaps to Flap Position XX, monitors flap retraction on EICAS and confirms		"FLAP at (XX)"
PF checks new flap position and confirms	"CHECK"	
Accelerating through F0 speed	"FLAP ZERO, AFTER TAKEOFF CHECK"	
		"AFTER TAKEOFF CHECK COMPLETE"

Figure 5 Callout Flap Retraction Procedure

Callouts during takeoff		
Condition	PF	PM
At 80 knots		"80 KTS, THRUST SET"
	"CHECK"	
At V_1		"V_1"
At V_R		"ROTATE"
When positive rate of climb is confirmed		"POSITIVE RATE"
	"GEAR UP"	
Selection and/or confirmation of lateral navigation modes as required.	"NAV (HDG)"	
		"CHECK"
At aircraft acceleration; PF orders	"CLIMB SEQUENCE"	
PM monitors posted flap retraction speeds, select flaps accordingly, monitors flap retraction on EICAS and confirms		"FLAP AT 0"
PF checks flap at 0	"AFTER TAKEOFF CHECK"	
PM performs AFTER TAKEOFF CHECK		"AFTER TAKEOFF CHECK COMPLETE"

Figure 6 Delegate Flap Retraction Procedure

Assumptions

For this case study, the AOTW was assumed to be the time to reach the maximum allowable speed for flaps 18. That is 220 kts. Buffer time is calculated using the difference between the Monte Carlo simulation distribution Mode+3σ and the time for the flap retraction speeds from the flap retraction schedule. The schedule provides with the appropriate speeds. Time windows for each sub-procedure (mainly defined by the flap retraction) are computed by formulating additional assumptions on aircraft acceleration and speed given the aircraft weight and engines thrust.

HMI-Sequence Diagrams

The HMI-SD for the procedures are shown in the Appendix. The properties of the procedures are summarized in Table 3.

The scoring for each attribute is defined by the symbol v_{ji} where “j” indexes the procedure number (Callout: j=1, Delegate: j=2), and “i” indexes the attribute used in the multi-attribute utility analysis.

The interactions are the single arrows flowing horizontally between the lifelines and composing the HMI-loops – and subsequently the SMM-loops (refer to Figure 4). When compared to the Delegate procedure, the Callout procedure has more interactions (44 as opposed to 38), HMI-loops (18 as opposed to 15), and SMM-loops (7 opposed to 5) reflecting the greater interaction between the flightcrew in this procedure.

The Number of HMI-loops not supported by salient cues, the AOTW, the ratio of the number of failing sub-procedures to the total number of sub-procedures, and the PFtoC are equal for both procedures. They are 0, 27.95 sec, 0.33, and 0 respectively.

The level of communication between the flightcrew measured by the ratio $\frac{\#\,\text{Interactions}}{SMM\,\text{loops}}$ (6.3) and the cumulative buffer time (3.94) are lower for the Callout procedure when compared with scores for the Delegate procedure (7.6, and 7.9 respectively).

Both procedures lack one communication item – that is the callout to confirm the landing gear was up and stowed.

For all of the procedures’ properties to be consistently scaled down to a value between 0 and 1, each property result was normalized using SME determined value functions. The normalized values are shown in Table 3 below. For the desirable properties (ex: Shared Mental Model loops), an increasing linear value function was used where bounds were defined and labeled “hi” and “low” for each property.

$$\frac{(x) - low}{hi - low}$$

For detrimental properties (ex: Missing Cues) a decreasing linear value function was used, also with SME defined lower and upper bounds.

$$\frac{hi - (x)}{hi - low}$$

Table 3 Properties of Procedures from HMI-SD and Relating Attributes Values

* **	Attribute	Call-out Procedure	Normalized	Delegate Procedure	Normalized	Notes
	Number of Interactions	44	-	38	-	
v_{j1}	Number of HMI-loops	18	0.75	15	0.80	
v_{j2}	Number of HMI-loops not supported by salient/ unambiguous visual cues	0	1	0		
	AOTW [sec]	27.95	-	27.95		
	Procedure Time-to-Complete	μ= 25.87 σ=0.67		μ= 21.40 σ=0.51		
v_{j3}	Probability of Failure to Complete (PFtoC) in Time	0	1	0		Both procedures can be completed within the AOTW
v_{j4}	Failing Sub-Procedures over Total Number of Sub-Procedures	1/3	0.67	1/3	0.67	Failing sub-procedures have Buffer < 0
	Relative SMM	7/8	-	5/6	-	Ratio of actual SMM to ideal SMM
v_{j5}	Communication Ratio $\left[\frac{\#\,Interactions}{SMM\ loops}\right]$	44/7 = 6.3	0.62	38/5 = 7.6	0.33	
v_{j6}	Cumulative Buffer Time (secs)	3.6	0.36	7.9	0.79	Does not include negative buffer
v_{j7}	Missing Communication Items	1	0.67	1	0.67	The callout to confirm landing gear retraction is missing from both procedures

* Grayed rows do not directly contribute the multi-attribute utility calculations

** Callout procedure: j=1, Delegate Procedure: j=2

Utility Weights

Weights were elicited from SMEs using a pair-wise comparison method (Table 4).

Table 4 Properties of Procedures from HMI-SD

Attribute	Symbol	Relative Weights	Overall Weights
Ease-of-Performance	$W_I = 0.2$		
HMI-Loops	w_1	0.5	0.1
HMI-Loops not Supported by Salient/Unambiguous Cues	w_2	0.5	0.1
Hazard Mitigation	$W_{II} = 0.5$		
Sub-procedures Buffer < 0	w_3	0.5	0.25
PFtC	w_4	0.5	0.25
Robustness to Disruption	$W_{III} = 0.3$		
Communication Ratio	w_5	0.4	0.125
Buffer Time	w_6	0.2	0.06
Missing Communication Items	w_7	0.4	0.125

Utility Calculation

Utility for the procedures was calculated using the overall weights expressed in the rightmost column of Table 4, and the normalized utility of the attributes are in the columns labeled “Normalized” for its respective procedure in Table 3.

The Callout procedure:

$$Utility_{Callout\ Procedure} = \sum_{1}^{7} w_i * v_{1i}$$

➔ U =(0.1*0.75)+(0.1*1)+(0.25*1)+(0.25*0.67)+(0.125*0.62)+(0.06*0.36)+(0.125*0.67)

$$\Rightarrow Utility_{Callout\ Procedure} = 0.775$$

The Delegate procedure:

$$Utility_{Delegate\ Procedure} = \sum_{1}^{7} w_i * v_{2i}$$

$\Rightarrow U =$(0.1*0.80)+(0.1*1)+(0.25*1)+(0.25*0.67)+(0.125*0.33)+(0.06*0.79)+(0.125*0.67)

$$\Rightarrow Utility_{Delegate\ Procedure} = \mathbf{0.770}$$

Conclusions, Limitations, and Future Work

Conclusions

Comparison of procedures for the purpose of design and/or regulatory certification evaluation is a challenge due to the complexity of the procedures and the conflicting objectives.

This paper describes an analysis of the procedures for the takeoff flap retraction procedure. The analysis documented the procedure in a formal model, the HMI-SD, and used the properties of the model in addition to the executable model to generate statistics for each procedure.

Given this set of SME defined weights, the utility for the two procedures was equivalent. Different weights would yield a different result.

Overall, the Callout procedure is more robust to interruption and provides a better shared mental model between the crew members. However, the Delegate procedure can be completed on average 4.5 seconds faster providing more time for monitoring and dealing with other potential tasks.

The sub-procedure from 115 knots to 135 knots could not be completed in the AOTW for the sub-procedure. This needs to be evaluated further.

Limitations & Future Work

This analysis used discrete values for the AOTW. A more accurate model would use stochastic process applying statistical distributions that account for aircraft performance changes and wind. Also, the long-term memory items for checking the speeds was not included in this version of the HMI-SD.

The shared mental model in scope of this research includes the crew common perception of a correct aircraft state. Variations of this scope will be included in the next versions of HMI-SD.

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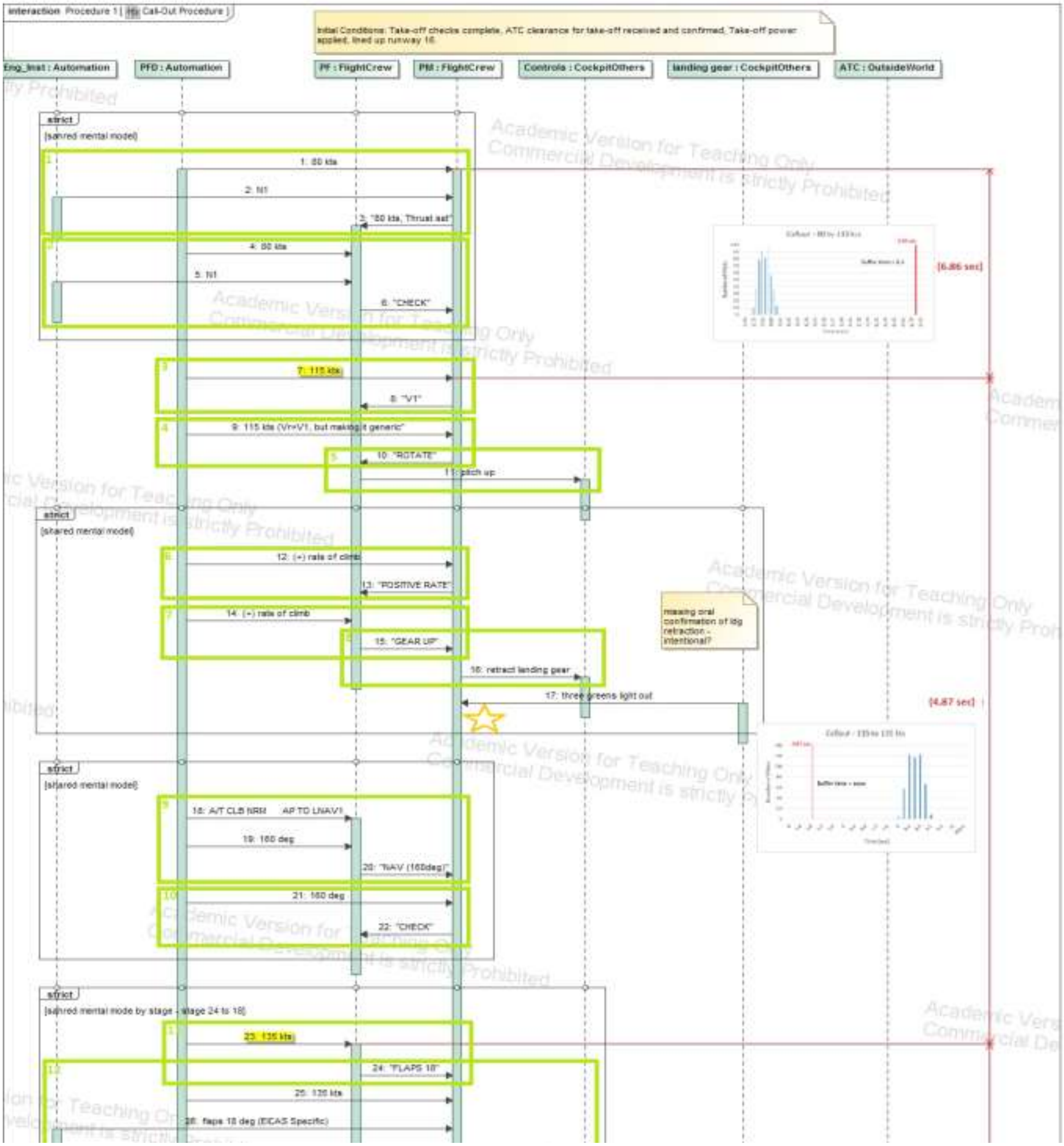
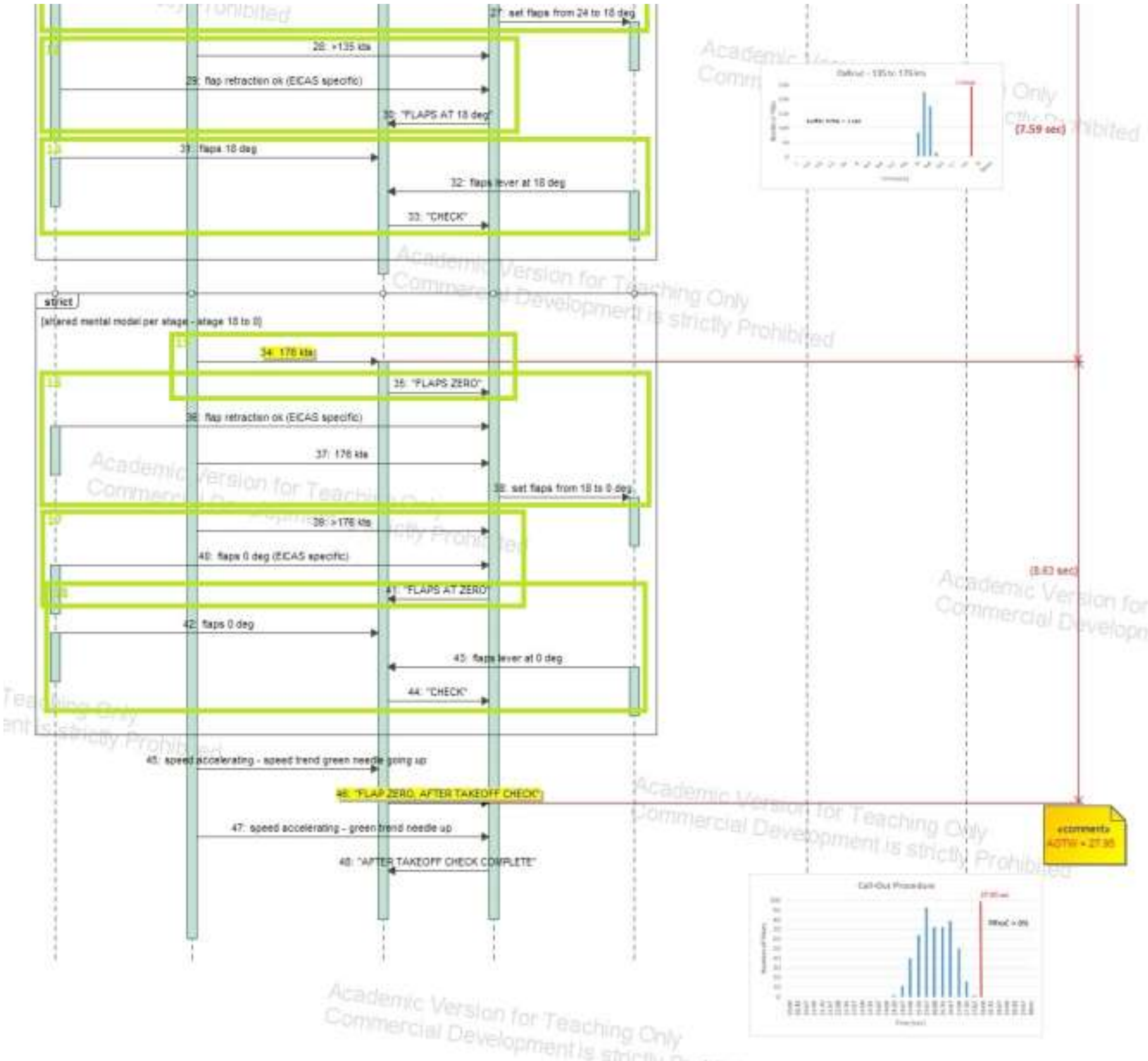
Appendix

HMI SD for Airline SOPs for Takeoff and Climb Out Flap Retraction

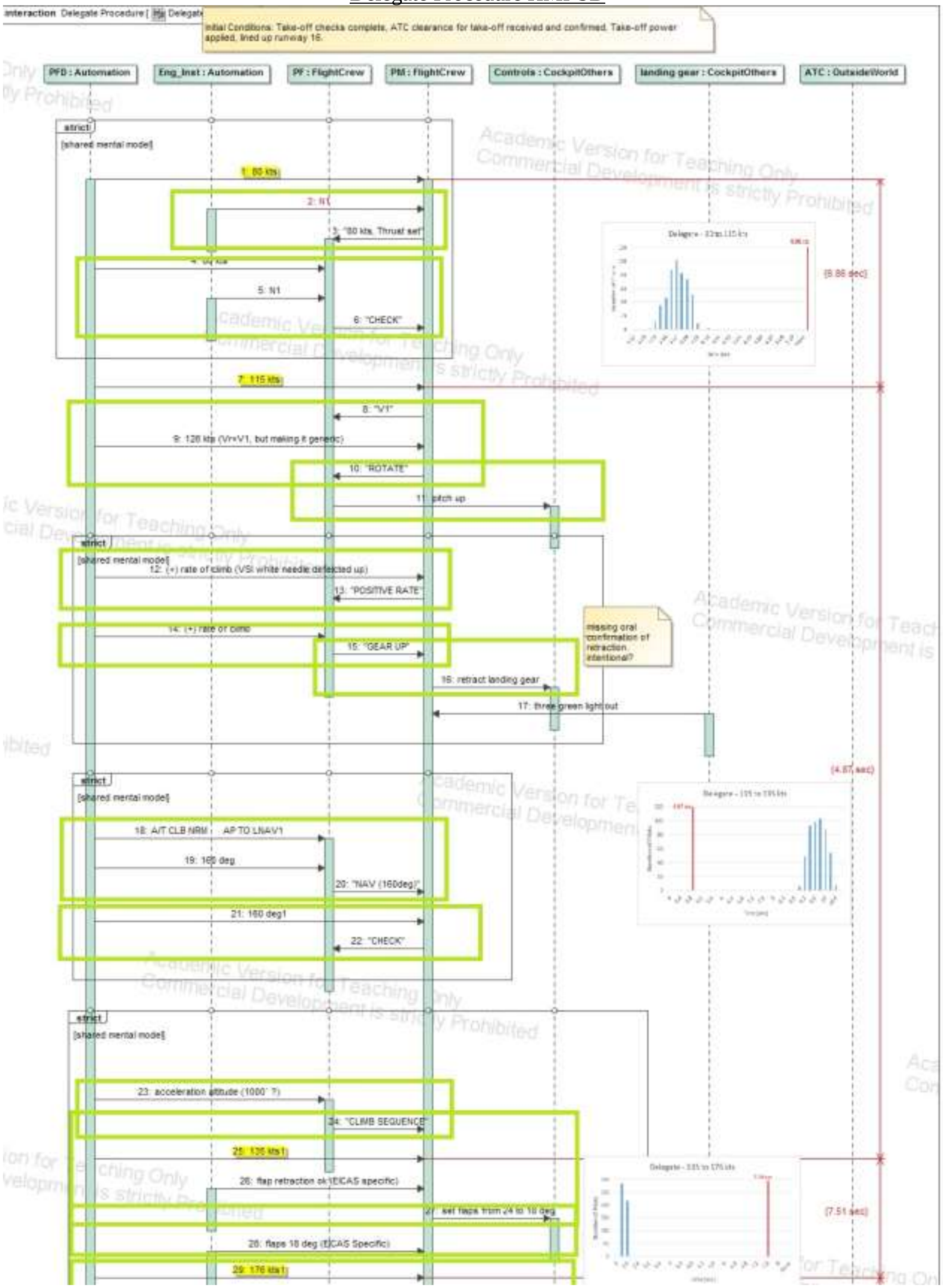
Callout Procedure HMI-SD

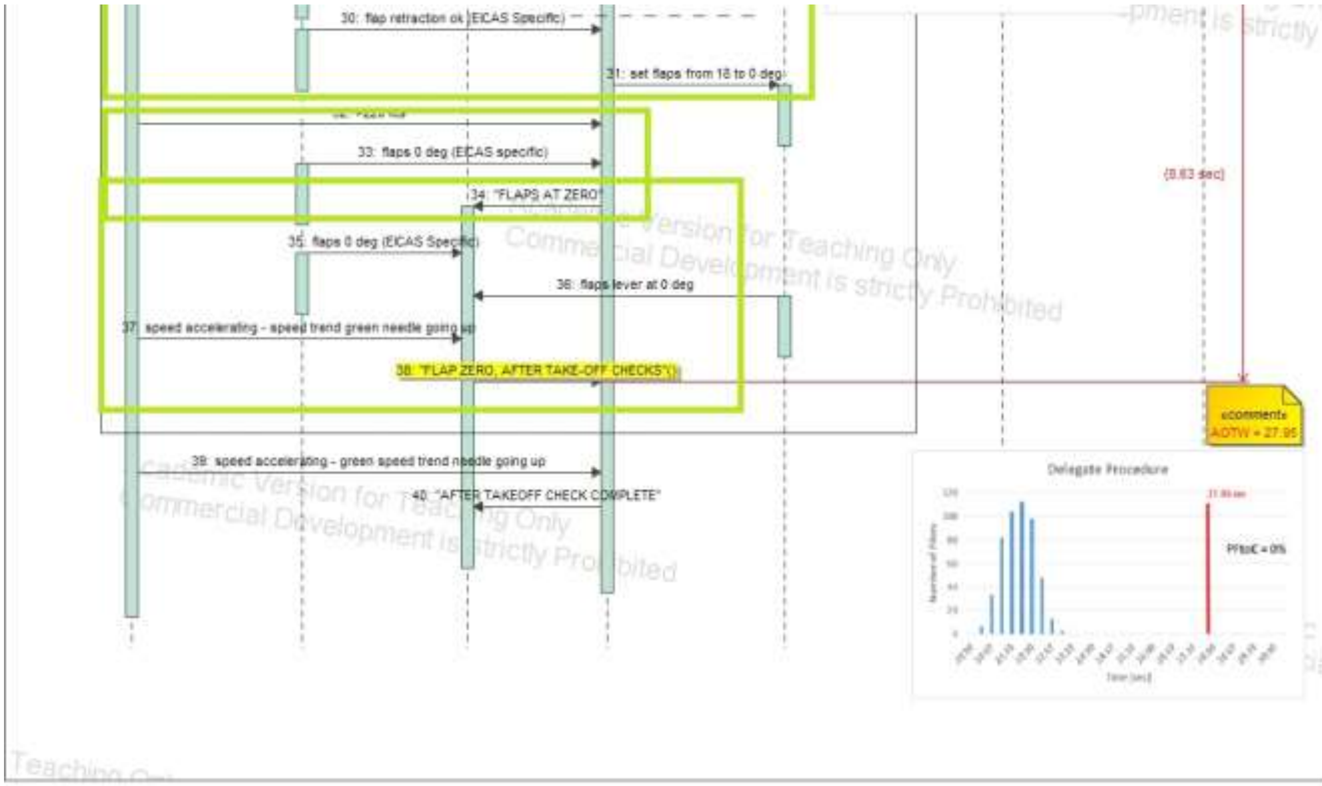




27: set flaps from 24 to 18 deg
28: >135 kts
29: flap retraction ok (EICAS specific)
30: "FLAPS AT 18 deg"
31: flaps 18 deg
32: flaps lever at 18 deg
33: "CHECK"
(7.59 sec)
strict
[shared mental model per stage - stage 18 to 0]
34: 176 kts
35: "FLAPS ZERO"
36: flap retraction ok (EICAS specific)
37: 176 kts
38: set flaps from 18 to 0 deg
39: >176 kts
40: flaps 0 deg (EICAS specific)
41: "FLAPS AT ZERO"
42: flaps 0 deg
43: flaps lever at 0 deg
44: "CHECK"
45: speed accelerating - speed trend green needle going up
46: "FLAP ZERO, AFTER TAKEOFF CHECK"
47: speed accelerating - green trend needle up
48: "AFTER TAKEOFF CHECK COMPLETE"
Call-Out Procedure

Delegate Procedure HMI-SD





30: flap retraction ok (EICAS Specific)
31: set flaps from 18 to 0 deg
33: flaps 0 deg (EICAS specific)
34: "FLAPS AT ZERO"
35: flaps 0 deg (EICAS Specific)
36: flaps lever at 0 deg
37: speed accelerating - speed trend green needle going up
38: "FLAP ZERO, AFTER TAKE-OFF CHECKS"()
39: speed accelerating - green speed trend needle going up
40: "AFTER TAKEOFF CHECK COMPLETE"
(8.63 sec)
«comment»
AOTW = 27.95
Delegate Procedure
PFtoC = 0%