FSEMC
Future Concepts for Simulators

To	SimSoft Working Group	**Date**	July 29, 2008
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Subject

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Attachments

Subject	Source
1. ARINC 610 Analogy Article	Oxford Aviation Academy
2. Chapter 6 Documentation	The Boeing Company
3. Chapter 6 Output Process	FedEx
4. Tony-ARINC 610 Comments	USAF
5. Booher - ARINC 610 Comments	USAF
6. Campbell - ARINC 610 Comments	USAF
7. Grimm - ARINC 610 Comments	USAF
8. Bad examples – what can happen when the ARINC 610 implementation for a particular aircraft equipment is incomplete, incorrect, or not provided	Swiss Aviation Training

Comments & Inquiries

The staff welcomes comments on the attached material. Comments should be directed to Sam Buckwalter.

Attachment 1

ARINC 610 – Analogy Article

Table of Contents:

1. Introduction

1.1. [[What:]]

[[Text in double square brackets – [[text]] – is by the author and is intended for editorial review, not for inclusion in the published article.]]

[[This introduction is written primarily so that comment can be sought from outside of the Working Group and consequently explains some of why this is being done. However, an Introduction IS required for the section as it is an unusual inclusion in an ARINC document and so needs some explanation.]]

[[In some cases, explanatory text has been included that is not strictly part of the analogy example. While the content/meaning of the extra text may exist in other sections of ARINC 610, it was felt important in covering some simulation terms to include further examples or explanatory text to give a more complete explanation.]]

1.2. [[Who:]]

[[This is written principally by Colin Bascombe of Oxford Aviation Academy (formerly known as GCAT Flight Academy) as member of the ARINC 610 Working Group and comment is welcomed from all.]]

1.3. Why:

During discussions at the Working Group meeting, where representatives from avionics manufacturers, aircraft systems manufacturers, aircraft manufacturers, simulator manufacturers, and simulator users were present, it quickly became apparent that common terms used by the different groups can mean different things to each group and that terms in common use and well understood in the simulation industry are confusing to those in other industries where the term either does not exist or is used in a different context.

Further to this, several aircraft manufacturers advised that they spend considerable time and effort each time they commission an item of avionics or aircraft system explaining ARINC 610, its terms and its consequences, to their suppliers because the suppliers are not simulator-aware and do not understand the simulation terms being presented.

During an ARINC 610 Working Group discussion, a delegate used an analogy to illustrate a problem – he talked of the differing effects of Total Freeze and Flight Freeze on a beer tap. It was apparent that by the use of this analogy there was a much better and, possibly more importantly, a *common* understanding of these terms among the delegates.

It was decided that a section be written that used analogy to try to explain the fundamental terms used in ARINC 610.

The problem that the use of analogy is attempting to ease can best be appreciated by using an analogy:

Consider a food recipe that has been written with the knowledge that it will be translated into many different languages and used by many different chefs in many different countries.

With this in mind the descriptions of the ingredients have been written without using the local names for the ingredients to avoid confusion – for example ingredients such as aubergine / eggplant.

The first instruction in the recipe is to peel the round orange-coloured ingredient: The chefs in country A start by peeling carrots, the chefs in country B start by peeling oranges…

1.4. An Analogy For Widespread Understanding

The raison d'être of an analogy is that it facilitates the understanding of a detail to an audience not necessarily familiar with the intrinsic system. For instance, analogies are often drawn between electronic components and hydraulic components in order to explain the operation of basic electronic components to those new to electronics; the basis being that most people can visualize the effects on a fluid flow due to their every-day experiences with water, but not, because they have no innate experience of it, the flow of electrical current.

Analogies of simulation-specific functions need to be understandable by the largest number possible in the intended audience. The audience in this case comprises representatives from disparate sections of the aviation community and so, to avoid the possibility of inadvertently using a term or function that is already used in aviation, the basic analogy has been chosen to be from outside of aviation.

The analogies given here will be with reference to an invented car/automobile vehicle. It is hoped most of the audience are familiar with vehicles and operating them.

The Analogy Vehicle is imaginary rather than based upon an existing vehicle because to be useful in explaining some simulation terms and functions it needs to have a varied specification with some items and functions not necessarily normally found in vehicles seen on the road! However, Analogy Vehicle will be fully ARINC 610 compliant.

Whilst it will be attempted to use a consistent Analogy Vehicle model so that any of the terms' analogies can be read in conjunction with any of the others, it may be necessary to have items or functions in one term's analogy that contradict with another's.

Where appropriate, a "simulation" term or function in square brackets – [term/function] – will follow a term used for the Analogy Vehicle as an example of where the analogy is pertinent in the simulation area. Please note that these will be examples only and that the analogy may be relevant to other simulation terms or functions.

Analogies will either attempt to describe a single term or function (e.g. Altitude Freeze) or describe the difference in effect between the use of two or more terms or functions (e.g. between Total Freeze and Flight Freeze).

All 22 [[list changed?]] terms in Table [[tbd]] will be covered. Where appropriate they will be covered by comparing their effect with the effect of another term rather than in their own right.

2. Total Freeze

The term Total Freeze, whilst appearing to be straightforward, is actually poorly understood because its "meaning" in simulation may not be as intuitive as those familiar with it in simulation assume. Also, its meaning is subtly different in civil as opposed to military simulation.

The intuitive interpretation of Total Freeze is simply to freeze everything: all inputs, all outputs, all processing, all controls, etc. Whilst this is essentially the effect seen by the instructor and crew in the simulator, it is not what is required of equipment.

In flight simulation, Total Freeze is intended to stop the simulation from reacting to pilot or instructor input, however it does NOT stop all processing. It can be considered to disassociate inputs from outputs, but the outputs remain valid. This means that displays, etc., remain valid during a Total Freeze and so if a display requires, say, valid ARINC 429 data and a refresh clock signal, these need to be active during the Total Freeze.

So, consider Analogy Vehicle: Let's assume it is being driven normally along a highway and that Total Freeze is now applied.

- As far as the driver is concerned the vehicle stops moving along the road and none of his controls respond: The driver tries to turn on the windscreen wipers [fuel transfer pump], but nothing happens – the switch looks like it is now in the ON position but there is no wiper action;
- The driver looks at his speedometer [altimeter] and sees that the vehicle speed shown is constant at the speed the driver was travelling at when the freeze was applied;
- The driver looks at his Sat-Nav [EICAS] and the map is still shown, but the map is no longer moving under the vehicle symbol and the ETA estimation is getting later;
- The driver turns the steering wheel [sidestick/control wheel] but the road wheels [aileron surfaces] do not turn to follow it and the vehicle does not turn [heading];
- The driver presses the accelerator pedal [control wheel] and though it can be pressed to the floor (it is an electronic accelerator consisting of a spring and a potentiometer), the engine revs [N1] stay the same on the rev counter – they stay the same when the driver removes his foot completely from the pedal, too;
- While all his instruments tell him the vehicle's engine is still running, the driver cannot hear it nor is any fuel being used from the tank to keep it running;
- The driver stops feeling the bumps in the road [motion cues]. Note that the driver does not feel a jolt as the Total Freeze is applied (as though the driver has hit a wall, say), instead the feeling of movement is phased out over a couple of seconds to the neutral, all stop, position.

Consider now when Total Freeze is removed.

- Because the driver did not put the windscreen wiper switch back to the OFF position, the windscreen wipers now start to operate;
- The speedometer continues to display the same speed (initially, anyway – see following);
- The map starts moving again under the vehicle symbol from where it was when it was frozen on the Sat-Nav and the ETA estimation is now constant (initially, anyway – see following);

- The road wheels [aileron surfaces] now turn to follow where the steering wheel [sidestick/control wheel] had been turned to at the end of the freeze, and the vehicle turns [heading];
- Because the driver no longer has his foot on the accelerator the engine revs begin to decay and the vehicle begins to slow…
- The fuel level in the tank once again falls;
- The driver begins again to feel the bumps in the road [motion cues].

Consider some simulator systems where the effect of Total Freeze may not be intuitive:

Flight controls – while, mainly for safety reasons, the pilot controls are able to be moved (there are no “locks” on the controls in an aircraft and the simulator manufacturer allows the control loading to run during Total Freeze) the aircraft flight controls system should ignore any movement once Total Freeze is set. Similarly, the flight controls system should freeze its outputs to flight control surfaces so that their positions are effectively frozen to the simulator flight software. The flight control system should maintain data busses and signals in the state they were in when Total Freeze was set, so if a bus was valid and transmitting valid data, this should remain so.

EICAS – this should remain operational and, other than ignoring inputs from display function controls, etc., remains largely unaffected by Total Freeze.

Altimeter – consider an altimeter that receives both altitude and baro reference information on a data bus. It can “ignore” Total Freeze completely as the operation of the device in and out of Total Freeze is identical. It’s inputs will not change whilst in Total Freeze because the devices driving it will have frozen their (valid) outputs.

Clock – the clock in the civil simulator is usually set to UTC, as it is in most aircraft, and it does NOT freeze in Total Freeze. This means that time-related calculations will be affected by Total Freeze. For instance, the time to TOC calculated by the FMC will remain the same (say 10 minutes) but the time AT the TOC pseudo-waypoint will slip later by the amount of time Total Freeze has been in effect. (It is generally acceptable for the display of these times to remain frozen and for them to update when Total Freeze is released rather than to service them during the freeze if this is easier for the avionics manufacturer to implement.) This is where military simulation differs because in a military simulator “Time” is also frozen such that a scenario being flown, for example in a multi-force scenario, can be frozen at an instant in time allowing all the elements of the simulation that may be located in different places to remain synchronised.

3. Flight Freeze

Flight Freeze freezes the simulator in space – its position relative to the Earth, its latitude, longitude, attitude, altitude, and heading are frozen. No functions are frozen.

To make comparison between Total Freeze and Flight Freeze a little easier, the same items are presented here as were presented for Total Freeze.

So, consider Analogy Vehicle: Let's assume it is being driven normally along a highway and that Flight Freeze is now applied.

- As far as the driver is concerned the vehicle stops moving along the road but all of his controls continue to work: The driver tries to turn on the windscreen wipers [fuel transfer pump], and they start operating normally – the switch looks like it is now in the ON position and there is normal wiper action;
- The driver looks at his speedometer [altimeter] and sees the vehicle speed is constant at the speed the driver was travelling at when the freeze was applied;
- The driver looks at his Sat-Nav [EICAS] and the map is still shown, but the map is no longer moving under the vehicle symbol and the ETA estimation is getting later;
- The driver turns the steering wheel [sidestick/control wheel] and whilst the road wheels [aileron surfaces] turn to follow it, the vehicle does not turn [heading];
- The driver presses the accelerator pedal [control wheel], it can be pressed to the floor (it is an electronic accelerator consisting of a spring and a potentiometer) and the engine revs [N1] increase on the rev counter – they reduce to idle when the driver removes his foot completely from the pedal, too;
- All his instruments tell him the vehicle's engine is still running, although the driver cannot hear it, and fuel is being used from the tank to keep it running;
- The driver stops feeling the bumps in the road [motion cues]. Note that the driver does not feel a jolt [motion cues] as the Flight Freeze is applied (as though the driver has hit a wall, say), instead the feeling of movement is phased out over a couple of seconds to the neutral, all stop, position.

Consider now when Flight Freeze is removed.

- Because the driver did not put the windscreen wiper switch back to the OFF position, the windscreen wipers continue to operate;
- The speedometer continues to display the same speed (initially, anyway – see following);
- The map starts moving again under the vehicle symbol on the Sat-Nav and the ETA estimation is now constant (initially, anyway – see following);
- The driver turns the steering wheel [sidestick/control wheel], the road wheels [aileron surfaces] turn to follow it and the vehicle turns [heading];
- Because the driver no longer has his foot on the accelerator the engine revs have already decayed to idle and now the vehicle begins to slow…
- The fuel level in the tank continues to fall;
- The driver begins again to feel the bumps in the road [motion cues] and hear the engine sounds.

4. Fuel Freeze

Fuel Freeze freezes the fuel quantity in the aircraft. It does not affect engine indications for such as fuel flow. It does not stop the crew redistributing the fuel to different tanks using aircraft systems. It does not stop fuel slosh effects with aircraft movement. And it does not stop the instructor redistributing the fuel or changing the contents of the tanks from the IOS. It can be considered to be a "Fuel Consumption Freeze" as neither the engines nor the APU(s) consume any fuel from the tanks when Fuel Freeze is ON.

So, consider Analogy Vehicle: Let's assume it is being driven normally along a highway and that Fuel Freeze is now applied.

- The contents of the fuel tank is no longer being depleted;
- The driver presses the accelerator pedal and the engine revs [N1] increase on the rev counter and the on-board computer reports that the fuel consumption [fuel flow] has increased;
- The driver stops and adds 10 gallons of fuel to the tank [instructor IOS input] and the fuel gauge [Total Fuel Quantity] increases by 10 gallons.

Consider now when Fuel Freeze is removed.

- The contents of the fuel tank is now being depleted normally;
- The driver presses the accelerator pedal and the engine revs [N1] increase on the rev counter and the on-board computer continues to report that the fuel consumption [fuel flow] has increased;
- The driver stops and adds 10 gallons of fuel to the tank [instructor IOS input] and the fuel gauge [Total Fuel Quantity] increases by 10 gallons.

5. Latitude/Longitude Freeze / Position Freeze

Latitude/Longitude Freeze, also known as Position Freeze, freezes the simulator in space but not attitude, altitude, or heading – its position relative to the Earth, its latitude and longitude, are frozen. The aircraft altitude and heading are not frozen. No functions are frozen.

So, consider Analogy Vehicle: Let's assume it is being driven normally along a highway and that Latitude/Longitude / Position Freeze is now applied.

- The driver looks at his speedometer [altimeter] and sees the vehicle speed continues to vary as the driver operates the accelerator and brake pedals;
- The driver looks at his Sat-Nav [EICAS] and the map is still shown, but the map is no longer moving under the vehicle symbol and the ETA estimation is getting later;
- The driver turns the steering wheel [sidestick/control wheel], the road wheels [aileron surfaces] turn to follow it and the vehicle turns [heading];
- The driver continues to feel the bumps in the road [motion cues].

Consider now when Latitude/Longitude / Position Freeze is removed.

- The speedometer continues to display the speed relative to operation of the accelerator and brake pedals;
- The map starts moving again under the vehicle symbol on the Sat-Nav and the ETA estimation is now constant;
- The driver turns the steering wheel [sidestick/control wheel], the road wheels [aileron surfaces] continue to turn to follow it and the vehicle turns [heading];
- The driver continues to feel the bumps in the road [motion cues].

6. Altitude Freeze

Altitude Freeze freezes only the aircraft's altitude. Vertical speed and all other flight attributes are unaffected.

So, consider Analogy Vehicle: Let's assume it is being driven normally along a highway and that Altitude Freeze is now applied.

- The driver looks at his speedometer [altimeter] and sees the vehicle speed is constant at the speed the driver was travelling at when the freeze was applied as the driver operates the accelerator and brake pedals;
- The driver switches the engine off, but the speed remains constant, the driver switches it back on again;
- The driver looks at his Sat-Nav [EICAS], the map is still shown and is moving under the vehicle symbol, and the ETA estimation is constant;
- The driver turns the steering wheel [sidestick/control wheel], the road wheels [aileron surfaces] turn to follow it and the vehicle turns [heading];
- The driver continues to feel the bumps in the road [motion cues].

Consider now when Altitude Freeze is removed.

- The speedometer begins again to display the speed relative to operation of the accelerator and brake pedals;
- The driver switches the engine off and the speed immediately begins to decay, the driver switches it back on again;
- The map continues moving under the vehicle symbol on the Sat-Nav and the ETA estimation remains constant (except that if the speed [altitude] now begins to change the ETA will be affected);
- The driver turns the steering wheel [sidestick/control wheel], the road wheels [aileron surfaces] continue turn to follow it and the vehicle turns [heading];
- The driver begins again to feel the bumps in the road [motion cues].

7. Weight Change

Weight Change flags that the mass of the aircraft has been changed artificially, so not due to fuel burn, ice accretion, etc.; it usually signifies a step-change in mass.

So, consider Analogy Vehicle: Let's assume it is being driven normally along a highway and that Weight Change is asserted.

- Several cases (or passengers!) [payload] suddenly fall from the vehicle;
- The driver feels the suspension unload [motion cues] as the weight of the vehicle is reduced;
- The driver looks at his on-board computer [FMS] and sees that the ETA estimation has now changed as the vehicle can now travel faster [higher] to its destination.

The most common use of a step change in weight during flight is change of fuel load. For instance, a LOFT (Line Oriented Flight Training) exercise might begin with a heavy weight take-off and, instead of waiting for the fuel to burn off in real time, the instructor will re-set the fuel to a lower level more in keeping with the expected level toward the end of the flight.

So, consider Analogy Vehicle: Let's assume it is being driven normally along a highway and that Weight Change again is asserted.

- Half the fuel in the fuel tank suddenly disappears;
- The driver feels the suspension unload [motion cues] as the weight of the vehicle is reduced;
- The driver looks at his on-board computer [FMS] and sees that the ETA estimation has now changed as the vehicle can now travel faster [higher] to its destination;
- The on-board computer [FMS] now warns there is a danger of running out of fuel.

8. Latitude/Longitude Change

Latitude/Longitude Change flags that the latitude and/or longitude of the aircraft has been changed artificially, so not due to normal flight; it signifies a step-change in position relative to the Earth.

So, consider Analogy Vehicle: Let's assume it is being driven normally along a highway and that Latitude/Longitude Change is asserted.

- The vehicle is suddenly somewhere else!
- The driver sees no change in speed or engine parameters;
- The driver looks at his Sat-Nav [EICAS], the map continues to be shown and is moving under the vehicle symbol, but the position of the map has jumped;
- Several stops along the journey that had been programmed into the Sat-Nav have now disappeared as those stops have been now effectively passed;
- The driver looks at his on-board computer [FMS] and sees that the ETA estimation is different now and correct for the new position of the vehicle along its journey to its destination;

A common use of a Latitude/Longitude change during flight is positioning the aircraft for interception of the ILS for a landing. The instructor will reposition the aircraft for a proper intercept often without informing the crew – the crew would only notice a subtle change in position if they were monitoring their position on the EHSI as none of the freezes would be asserted, so as far as they are concerned they continued flying normally.

9. Altitude Change

Altitude Change flags that the altitude of the aircraft has been changed artificially, so not due to normal flight; it signifies a step-change in altitude.

So, consider Analogy Vehicle: Let's assume it is being driven normally along a highway and that Altitude Change is asserted.

- The vehicle speed [altitude] is suddenly different;
- The driver sees a jump in the reading on the speedometer;
- The cruise control [autopilot] starts to bring the speed back to its previous setting.

The last item, above, illustrates an important concept: Whilst a system may be affected by and have to take account of a simulator function, altitude change not due to normal flight in this case, it does not always hold that the system is expected to be stable after the change. Altitude change is so far-reaching in its effect on virtually all aircraft systems that complete stability after it cannot be expected. Indeed, some effects cannot be determined without crew intervention: Consider an aircraft flying under autopilot control with the autopilot in Alt Hold mode. After an altitude change, should the autopilot try to regain the previous altitude at which it was holding, or should it hold at the new altitude? Without crew intervention the answer cannot be known. In cases such as these it is acceptable to force a crew input – in this case disconnecting the autopilot after the altitude slew forces the crew to take control and resolve the anomaly.

10. Airspeed Change

Airspeed Change flags that the airspeed of the aircraft has been changed artificially, so not due to normal flight; it signifies a step-change in airspeed and can include changes from or to 0 kt.

So, consider Analogy Vehicle: Let's assume it is being driven normally along a highway and that Airspeed Change is asserted.

- The vehicle speed [airspeed] is suddenly different;
- The driver sees a jump in the reading on the speedometer;
- The cruise control [autopilot] starts to bring the speed back to its previous setting.

Be aware that the step change may be from an initial value of 0 kt and can usually be set to any value between 0 kt and Vne. Whilst the change can be from an in-flight speed to 0 kt, this is rarely done (flying with zero airspeed is usually not sustainable) however a change from a taxying speed to 0 kt may be more likely to be used.

11. Heading Change

Heading Change flags that the heading of the aircraft has been changed artificially, so not due to normal flight; it signifies a step-change in heading.

So, consider Analogy Vehicle: Let's assume it is being driven normally along a highway, is just crossing an intersection, and that Heading Change is asserted.

- The vehicle direction [heading] is suddenly different and the driver finds himself driving along the other road at the intersection;
- The driver sees no changes on his instruments other than a jump in the Sat-Nav [EHSI] image that is set to "Direction Of Travel Up";
- The Sat-Nav [FMS] starts to recompute the route taking into account the change of road;
- The driver feels no jolt as the direction changes [motion cues].

Contrary to the effect of an altitude change, a heading change will generally not cause an autopilot disconnect; the autopilot will re-acquire the set heading. (Often an instructor will activate a heading change function to bring the aircraft heading closer to the heading that has been set and so the effect is to shorten the turn both in time and space.)

12. Temperature/Pressure Change

Temperature/Pressure Change flags that the temperature and/or pressure of the environment has been changed artificially, so not due to weather effects; it signifies a step-change in temperature and/or pressure.

So, consider Analogy Vehicle: Let’s assume it is being driven normally along a highway and that Temperature/Pressure Change is asserted.

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[[Not sure an analogy is required for Temperature/Pressure Change as its interpretation is as intuitive and straightforward within simulation as it is outside of it.]]

13. Wind Change

Wind Change flags that the wind direction and/or wind speed of the environment has been changed artificially, so not due to weather effects; it signifies a step-change in wind direction and/or wind speed.

So, consider Analogy Vehicle: Let's assume it is being driven normally along a highway and that Wind Change is asserted.

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[[Not sure an analogy is required for Wind Change as its interpretation is as intuitive and straightforward within simulation as it is outside of it.]]

14. Reposition to Specified Conditions

Reposition to Specified Conditions flags that the simulation is being reset to a known state. This function may include many of the functions discussed so far, though if the condition is on-ground freezes that had been set by the reposition would normally be released at its finish.

So, consider Analogy Vehicle: Let's assume it is being driven normally along a highway and that Reposition to Specified Conditions is asserted.

- The vehicle is suddenly back on the driveway in the same condition it was in prior to the journey [Take-Off Reposition];
- The Sat-Nav [FMS] is back at the start of the journey with all the stops on the way (including those that had been passed) restored in the route;
- The fuel tank returns to the level it was at the start of the journey;
- The vehicle's on-board service interval computer resets back as though the journey had not yet happened;
- The spare wheel that had been fitted because of a flat tyre [Engine Flame Out] is back in its holder and the tyre that had a puncture is OK again. The on-board service interval computer, that notes when tyres fail, is reset back to no record of the failure.

15. Internal System Status Reset

Internal System Status Reset flags that the simulation status is being reset.

So, consider Analogy Vehicle: Let's assume it is being driven normally along a highway and that Internal System Status Reset is asserted.

- The vehicle's on-board service interval computer resets back as though the vehicle is freshly serviced;
- The spare wheel that had been fitted because of a flat tyre [Engine Flame Out] is back in its holder. The on-board service interval computer, that notes when tyres fail, is reset back to no record of the failure.
- The engine's "time running above idle" timer resets back to 0.

16. Speed Times

Speed Times flags that there is an abnormal condition set with respect to some function(s) versus time; it signifies a step-change in the “speed” of the passing of time.

Common “Speed Up” functions include fuel use and ground speed while common speed up factors include x 2, x 4, and x 10. Factors of less than 1 can also be found and these serve to slow the simulation.

So, consider Analogy Vehicle: Let’s assume it is being driven normally along a highway and that Speed Times is asserted (both ground speed and fuel use are sped up).

- As far as the driver is concerned the vehicle continues moving along the road, but much faster, and all of his controls continue to work: The driver tries to turn on the windscreen wipers [fuel transfer pump], and they start operating normally – the switch looks like it is now in the ON position and there is normal wiper action;
- The driver looks at his speedometer [IAS] and sees the vehicle speed is constant at the speed the driver was travelling at when Speed Times was applied;
- The driver looks at his Sat-Nav [EICAS] and the map is still shown and the map is moving under the vehicle symbol much faster and the ETA estimation is getting earlier;
- The driver turns the steering wheel [sidestick/control wheel], the road wheels [aileron surfaces] turn to follow it, the vehicle turns [heading] and the speed along the road returns to normal;
- The driver straightens the steering wheel [sidestick/control wheel], the road wheels [aileron surfaces] turn to follow it to centre, the vehicle returns to straight [constant heading] and the speed along the road becomes much faster again*;
- The driver presses the accelerator pedal [control wheel], it can be pressed to the floor (it is an electronic accelerator consisting of a spring and a potentiometer) and the engine revs [N1] increase on the rev counter – they reduce to idle when the driver removes his foot completely from the pedal, too. The driver sees the speedometer [IAS] increase and decrease normally;
- All his instruments tell him the vehicle’s engine is still running normally, the driver can hear it, and fuel is apparently being used from the tank normally to keep it running;
- The fuel tank contents reduce at a much faster than normal rate and the on-board computer [FMS] takes this into account and computes how much will be left at the end of the journey taking the increased consumption into account;
- The driver continues to feel the bumps in the road [motion cues]. Note that the driver does not feel a jolt [motion cues] as the Speed Times is applied and the bumps still feel the same.

(*Ground Speed Up is usually automatically suspended when the aircraft is in a turn to allow the FMS and EFCS systems to work with a normal rate / radius of turn.)

Consider now when Speed Times is removed.

- As far as the driver is concerned the vehicle continues moving along the road, but now at a normal rate, and all of his controls continue to work: The windscreen wipers [fuel transfer pump] continue to operate normally – the switch looks like it is now in the ON position and there is normal wiper action;

- The driver looks at his speedometer [IAS] and sees the vehicle speed is constant at the speed the driver was travelling at when Speed Times is removed;
- The driver looks at his Sat-Nav [EICAS] and the map is still shown and the map is moving under the vehicle symbol at a normal rate and the ETA estimation is now constant;
- The driver turns the steering wheel [sidestick/control wheel], the road wheels [aileron surfaces] turn to follow it, the vehicle turns [heading] and the speed along the road remains normal;
- The driver straightens the steering wheel [sidestick/control wheel], the road wheels [aileron surfaces] turn to follow it to centre, the vehicle returns to straight [constant heading] and the speed along the road remains normal;
- The driver presses the accelerator pedal [control wheel], it can be pressed to the floor (it is an electronic accelerator consisting of a spring and a potentiometer) and the engine revs [N1] increase on the rev counter – they reduce to idle when the driver removes his foot completely from the pedal, too. The driver sees the speedometer [IAS] increase and decrease normally;
- All his instruments tell him the vehicle's engine is still running normally, the driver can hear it, and fuel is apparently being used from the tank normally to keep it running;
- The fuel tank contents reduce at a normal rate and the on-board computer [FMS] takes this into account and computes how much will be left at the end of the journey;
- The driver continues to feel the bumps in the road [motion cues]. Note that the driver does not feel a jolt [motion cues] as the Speed Times is removed and the bumps still feel the same.

17. Snapshot Take

Snapshot Take flags that the current status of all systems is to be recorded.

So, consider Analogy Vehicle: Let's assume it is being driven normally along a highway and that Snapshot Take is asserted.

- The vehicle's on-board "CCTV" system takes a picture (its field of view and scope includes the cockpit and the view out of the window).
- The picture is stored.

18. Snapshot Recall

Snapshot Recall flags that the current status of all systems is to be recalled.

So, consider Analogy Vehicle: Let's assume it is being driven normally along a highway and that Snapshot Recall is asserted.

- The vehicle is returned to the position on the road where the picture was taken.
- The vehicle is returned to the exact state as shown in the picture the CCTV system took earlier.
- Because the driver has selected a different gear ratio [Flap Position] since the picture was taken, the on-board computer display [IOS] shows an indication [Controls Not In Agreement (CNIA) page] that the gear lever [Flap Lever] needs to be moved to the correct position for when the picture was taken.
- The picture remains stored, available for re-use if required.

19. Multiple Snapshot

Multiple Snapshot is a requirement that more than one Snapshot take and recall be possible. It requires that the equipment be able to interface with the simulator Host to dump and reload system memory when the equipment may only have memory sufficient for a single Snapshot. Note that the Multiple Snapshot system may be utilised also to service the single Snapshot function requirement.

So, consider Analogy Vehicle: Let's assume it is being driven normally along a highway and that Snapshot Recall of the Snapshot from yesterday's journey is asserted.

- The "CCTV" system offers the driver [Instructor] a photo album of pictures [IOS Snapshots Taken page] from which to choose.
- The vehicle is returned to the position on the road where the chosen picture was taken.
- The vehicle is returned to the exact state as shown in the chosen picture.
- Because the driver has selected a different gear ratio [Flap Position] since the chosen picture was taken, the on-board computer display [IOS] shows an indication [Controls Not In Agreement (CNIA) page] that the gear lever [Flap Lever] needs to be moved to the correct position for when the picture was taken.

20. Fault Memory Clear

Fault Memory Clear is a requirement that the abnormal clearing of equipment Fault Memory be possible. If the equipment Fault Memory would normally only be clearable with the aircraft in a maintenance configuration, the simulator functionality to be able to clear the memory when not in that maintenance configuration is required.

So, consider Analogy Vehicle: Let’s assume it is being driven normally along a highway and that Fault Memory Clear is asserted.

- The vehicle’s on-board service interval computer resets back as though the vehicle is freshly serviced;
- The spare wheel that had been fitted because of a flat tyre [Engine Flame Out] is back in its holder. The on-board service interval computer, that notes when tyres fail, is reset back to no record of the failure.

21. Fault Logging Parameter Set

Fault Logging Parameter Set is a requirement that the abnormal setting of equipment Fault Memory Parameters be possible. If the equipment Fault Memory would normally only be able to be set with the detection of an actual fault, the simulator functionality to be able to set the parameter independent of an actual fault detection is required.

So, consider Analogy Vehicle: Let’s assume it is being driven normally along a highway and that Fault Logging Parameter Set is asserted.

- The vehicle’s on-board service interval computer reports a flat tyre [Engine Flame Out] had already occurred.

22. Fault Memory Download

Fault Memory Download is a requirement that the Fault Memory be downloadable to the simulator Host.

So, consider Analogy Vehicle: Let’s assume it is being driven normally along a highway and that Fault Memory Download is asserted.

- The vehicle’s on-board service interval computer downloads its entire fault memory.

23. Fault Memory Upload

Fault Memory Upload is a requirement that the Fault Memory be uploadable from the simulator Host.

So, consider Analogy Vehicle: Let's assume it is being driven normally along a highway and that Fault Memory Upload is asserted.

- The vehicle's on-board service interval computer uploads its entire fault memory;
- The vehicle's on-board service interval computer reports a flat tyre [Engine Flame Out] had already occurred.

Attachment 2

Attachment 2

Chapter 6 –Documentation

6.1 Introduction

As airframe manufacturers develop the next generation of aircraft, it is not uncommon for changes to be made to the avionics and aircraft systems as part of the overall design. Changes in this area may result in the adoption of new signal protocols and/or bus architectures. If this occurs, it is likely a new implementation strategy will need to be developed to support any ARINC 610-related functionality.

During the development phase of a new program, it is important that an airframe manufacturer discuss ARINC 610 issues with the avionics and systems suppliers and determine if any related ARINC 610 functionality needs to be implemented. If an analysis results in a requirement to incorporate additional functionality, a well documented interface plan will need to be produced.

COMMENTARY

> It is recommended that a representative from the simulator manufacturer community be involved in the development of the interface documents. Simulator manufacturers have extensive experience in dealing with these issues; therefore, they would be a good resource to tap. The selected simulator manufacturer should represent the interests of the training device manufacturers as a whole.

6.2 Format

For aircraft designs that employ Integrated Modular Avionics (IMA) or similarly integrated aircraft systems, the airframe manufacturer will need to produce and distribute an overall interface document to all suppliers considering ARINC 610 functionality in their product design. Any specific information relating to a supplier's system will need to be documented separately.

Export control of data and the safeguard of Intellectual Property (IP) need to be addressed. To meet these concerns, the document supplier must assure that the material has proper labeling and that a process exists to control distribution.

6.3 Content

The content of the documentation should be sufficient in detail to fully describe the interface requirements. This may include the following information:

a. General design philosophy

b. Expected target system interaction to each of the simulator functions

c. Description of input parameters to the simulator host from the target system

d. Description of output parameters from the simulator host to the target system

e. Timing diagrams that show signal hold times, latencies, transmit frequency, etc.

f. Additional resources required to implement the interface; e.g., memory buffers

Each target system will have its own set of requirements to meet compliance with this specification. It is recommended that a description of the target system's reaction to each of the Simulator Functions outlined in Table 4-2 be provided. If no additional functionality needs to be included, it should be noted as such. For those instances where there is an impact, sufficient detail should be provided to help the end user understand how the system will react, and if there are any boundary conditions that need to be adhered to.

Attachment 3

6.0 Process Outputs -

6.1 Function Analysis

This section describes the expected outputs from the ARINC 610 function review and analysis process. This includes the information to describe how a simulator manufacturer or user accesses simulator functions that are required to support the efficient operation of the training device.

The equipment or system in question must be analyzed to determine how it is affected by each of the simulator functions described in table 5-2. The results of this analysis will generally lead to one of three outcomes for each of the functions:

- The equipment or system is not affected by the simulator function and is compliant with ARINC 610 for that function;
- The equipment or system may be made to operate in a compliant manner with ARINC 610 by manipulation of inputs to the aircraft equipment by the host simulation.
- The equipment or system has embedded support of the simulator function that renders it compliant with ARINC 610 when used in a simulator environment.

Where chart driven models or binary format software is supplied or used in lieu of actual aircraft hardware, it is assumed that this format of the equipment will have the same ARINC 610 compliance as the actual aircraft hardware. Where this is not the case, any special care or additional information relevant to the use of this type of model should also be provided.

The equipment or system manufacturer or supplier shall prepare and provide a document that describes each of the analysis outcomes for each of the simulator functions. This document should be provided to the simulator manufacturer and be made available to operators of simulators and training devices that use the equipment or system.

6.2 Format of the Analysis Document

The document should be prepared in the equipment or system manufacturer's standard format. No specific style or structure is required. It is suggested that the document be of a form similar to the outline below:

1. Introduction
2. Reference Documents
3. Simulator Function Analysis

Function 1
Function 2
Function 3
.
.
.
3.n Function n

4. Special Considerations, if any
5. Conclusions

6. Contacts for Questions or Clarifications

6.2.1 Introduction

This section should be a brief introduction to the piece of equipment itself. It can include a short description of its function and operation.

6.2.2 Reference Documents

This section should list any reference documents needed to amplify or explain the text in the remainder of this document. This would likely include ICD's and software description documents of some sort. It is suggested that, if possible, where ICD type data is referred to, that it be directly included in this document if possible. This will allow for the easy application of the equipment or system without recourse to multiple documents. This should also help eliminate or reduce errors of integration, thereby saving all parties cost and effort.

6.2.3 Simulator Function Analysis

This section can be considered the main section of the document and its primary purpose for existence. A separate subsection should be provided for each simulator function describing the equipment or system's compliance with ARINC 610 for that function.

If the equipment or system is not affected by the simulator function, then it is compliant with ARINC 610 for that function. A simple statement to that effect is all that is required.

If the equipment or system may be made to operate in a compliant manner with ARINC 610 by manipulation of inputs to the aircraft equipment by the host simulation, then the equipment or system manufacturer must state which inputs must be manipulated and in what manner. Sequencing or timing information, if relevant, should also be provided. If inputs are dependent on other external parameters, then these parameters and their relationships to the inputs should be described. If useful, timing diagrams may also be provided.

If the equipment or system has embedded support of the simulator function that renders it compliant with ARINC 610 when used in a simulator environment then a description of how that support can be accessed and operated must be provided. It would be expected that this type of information would be provided in the format of an ICD. Any limitations on the operation of that support must also be described.

6.2.4 Special Considerations

Any special considerations in the operation of the equipment or system in the simulation environment should be described in this section. If the equipment or system is provided in binary format software or as a chart driven model, the documentation requirements described in ARINC 441 and 442 may be included here or referenced here. As a minimum, the data regarding simulator functions should be repeated in this section.

If applicable this section may discuss alternate approaches to compliance with ARINC 610 and provide additional information as to how these approaches may be implemented.

6.2.5 Conclusions

This section should include any conclusions the equipment or system manufacturer may wish to present.

6.2.6 Contacts for Questions or Clarifications

This section should describe a method to contact the equipment or system manufacturer if the simulator manufacturer or user requires answers to questions or any particular assistance in the operation of the equipment or system in the simulator environment. If the equipment or system manufacturer has a particular process to be followed for technical assistance then a description of that process may be included. Telephone numbers, email addresses and URL's should be provided.

Attachment 4

TOBY CRAIG COMMENTS FOR ARINC 610B

THE FREEZES AND RESETS FOR OUR F-16 PROGRAM ARE DESCRIBED IN THE SRD IOS SECTION BELOW.

A. EXCERPT FROM F-16 MTC SPEC. FREEZES, RECORDING, AND RESETS AREAS IN BOLD TEXT.

3.3.4 INSTRUCTOR-OPERATOR STATION

The MTC shall include one Instructor-Operator Stations (IOS) per MS to create, modify, setup, initiate, execute, manage, monitor, evaluate, and record mission scenarios for all modes of MTC operation, including single-ship, local multi-ship, and *DMO* training and mission operations, and maintenance engine run training. Each IOS shall be designed to support and control training and mission operations for all or any subset of the MS elements and the other mission event MTC elements (i.e. SFES, BDS, MOC) on the local network at the MTC site that are allocated for the event. The capability to use multiple IOSs together to control a multi-ship mission event shall be included. Via *periods processing*, IOS operation at different security levels shall be supported, facilitating simultaneous events at different security levels. Within a security partition, each IOS shall be assignable to support simultaneous single-ship mission events. The IOS shall include multiple sets of software media, appropriately marked, as necessary to support these requirements. Each IOS shall include the capability to generate full-color hardcopy output for all IOS-displayable data on an included printer. Each IOS printer shall also be accessible by other MTC users (other IOSs, MOC, BDS, SGS) that are connected via LAN to the MTC partition to which the IOS printer is connected. The IOS shall include a subset of components and software common with the SGS element to enable the IOS to be used for scenario generation when not being used to support training and mission operations.

3.3.4.1 Scenario Setup and Management

The IOS shall include the capability to access, select, load, initialize, and initiate the execution of scenarios and mission planning data stored by the SGS (or IOS scenario generation capability), or stored by the instructor or pilot on removable storage media. Each IOS shall include the capability to initialize all or any subset of the event-allocated MS elements to on-ground or in-flight conditions at any geospatial location in the selected scenario. The IOS shall include mission control functions to support reset, mission recording, mission monitoring, and performance evaluation. The IOS shall have the capability to raise and lower arrestment systems on applicable airfields. The IOS shall include the capability for each event-allocated MS to bypass simulated aircraft system delays, including engine start, inertial navigation system alignment, built-in-test checks, subsystem/weapon warm-up times, etc. The IOS shall include the capability to reset event-allocated MS timer and initialization parameters, including weapon time outs and restoring previously loaded mission data. The IOS shall include the capability for instructors and operators to change and modify scenarios during the mission.

3.3.4.2 Entity Management

The IOS shall include a full range of SFES control capabilities for the instructor to reposition entities, add and activate selectable entities, delete entities, define entity profiles, and modify entity state and behavior in *real-time*. **Threat control features**

shall include the selection of pre-defined threat maneuvers, profiles during a simulation or engagement. The IOS shall include the capability, in *real-time* without a freeze, to assume control of any local SFES-generated airborne or ground moving entity in the scenario. The capability to release control of one entity and assume control of another at the operator's discretion shall be included with no disruption to *real-time* simulation. Entity control capabilities and associated displays shall represent the appropriate operational characteristics with representative simulation fidelity and functionality, including dynamic performance, radar/sensors, weapons, countermeasures, electromagnetic/EO/IR signature, and voice and data communications. The IOS shall include a selectable entity out-the-window display view and enhanced situational awareness displays to facilitate operator perceptions of entity affiliations and formation elements despite reduced hardware fidelity. (**Objective:** The IOS shall include aircraft-like stick and throttle controls to facilitate instructor control of threats. The stick shall also function as a joystick control to graphically select and slew the geographic position of entities within the *synthetic environment*.) The IOS shall include the capability to freeze the position (lat/long/altitude) of any locally-generated virtual or constructive entity during *real-time*, freeze or reset weapons and expendable stores station counts, adjust weapons hit/miss criteria by overriding MS crash and kill results (e.g. "shields up"), and shall be able to reset the states of inactive and killed entities to an active status. The IOS shall include the capability for the instructor to serve as a surrogate for (i.e. role-play) airborne and ground-based command and control entities**. The IOS shall include capabilities that allow the instructor to accomplish basic Weapons Director or Air Operations Center (AOC) "desk" functions, such as TST inputs, functions to the scenario (broadcast and tactical control) in all modes of operation and to input other tactical information through simulated radio voice and data link commands.** Instructor-controlled datalink commands shall activate symbology for Link 16 hostile, unknown, suspect, friendly, neutral, and Precise Participant Location and Identification (PPLI) tracks. Such support shall model the limitations and capabilities of the source data in terms of timeliness, accuracy, and resolution. The IOS shall support instructor role-play of air traffic control functions with appropriate communications capabilities and approach vector and glideslope displays for instructor-selected airfields.

3.3.4.3 Scenario Monitoring and Evaluation

The IOS shall support instructor scenario monitoring and evaluation capability to assess performance (tasks and tactics) and facilitate *real-time* instruction for any single or selected set of local event-allocated MS elements during local and *DMO events*. This capability includes the conduct of formal pilot qualification and mission evaluations from the IOS by a flight examiner. The IOS shall include flexible visualization capability with at least 1500 square inches of total viewable display space on no less than two and no more than eight COTS flat-panel displays. The content of any display shall be selected and scaled/sized according to instructor preferences, with instructor-settable default configurations. The selectable content on each display shall include: simulator control functions and menus; any combination of the MS cockpit displays and instrument indications; a forward-looking OTW visual view, and a *real-time* battlespace visualization display view as described below. The IOS shall include the capability to monitor any combination of all simulated aircraft radio (voice and data) communications, observe all system sensor outputs, and monitor on-board stores status for each event-allocated MS. The IOS shall support collection of mission data for transfer to, presentation and analysis at the BDS during debrief. The data to be collected shall include weapons launch/shot data (target range/aspect, kill/damage results, etc.), maneuvers, countermeasures, and other data as derived through analysis of training requirements and subject matter expert discussions during the design process. The IOS shall also be designed to support data collection for and interfaces to readiness and performance measurement systems incorporated in the future [NOTE: This capability is being developed through ongoing research by AFRL on the Warfighter Readiness Assessment and Performance Measurement Tracking System (WRAPMTS) Applied Technology Demonstration program, and will be implemented through changes incorporated via DMO standards updates].

a. ***Real-time* Battlespace Visualization Display View.** The IOS shall include a three-dimensional *real-time* visualization display view of the synthetic battlespace, from any entity perspective (MS cockpits, any selected friendly, neutral, or hostile entity in the scenario), a "stealth" (repositionable/slewable) perspective, and entity offset (i.e. "attached to") perspective, with an overhead "God's eye" perspective as default [NOTE: Air Combat Maneuvering Instrumentation (ACMI) performance may be used as a guide]. This display view shall portray entities with readily discernable symbology appropriate for the entity type, entity orientation, and selectable (on/off by entity) numerically represented geospatial position (lat/long/alt). The view shall be configurable to show the three-dimensional motion of entities in the scenario with variable-length history "trails" (from 0 seconds (i.e. no trail) to continuous (until the view eyepoint is changed)). The view shall include the capability to zoom in and out, to three-dimensionally rotate the view aspect and offset distances (when applicable), and to turn on/off entity trails. Reset-able and configurable declutter filters shall be included to selectively and cumulatively remove from the view: (1) entity types, (2) classes of entities, and (3) entities based on geospatial criterion associated with the selected eyepoint (on-ground, in-air, beyond visual range, within a specified range, within a specified region or airspace, etc). The view shall include the capability to selectively visualize the *real-time* radar scan volumes for any entity or set of entities within the scenario.

b. Malfunction Controls. The IOS shall include the capability to insert malfunctions during generation, setup, or execution of scenarios (preprogram or manually input) for all event-allocated MS elements. The IOS shall have the capability to select individual or multiple malfunctions (per simulated aircraft system or multiple systems) and to delete/clear malfunctions individually or all at once. **A reset mode to clear all malfunctions and reset the simulation to the configuration prior to the malfunction(s) shall be included. The IOS shall support the capability for the instructor to induce variations into MS cockpit instrumentation (e.g., oil pressure, FTIT, etc) without triggering predefined malfunctions or affecting aircraft system performance, with the intent of verifying that the pilot is cross-checking cockpit indications.**

c. **IOS Voice Communications.** In addition to simulated radio **communications/monitoring capabilities, the MTC shall include a secure, private, local voice communication capability, initiated from any event-allocated IOS or MS element to or among any other event-allocated IOS or MS elements.**

This capability shall be designed to remain fully operable during all MTC element states, with battery backup during power failures or power cycle activities. In addition, the MTC shall interface to a *DMO* O&I contractor provided Voice Over Internet Protocol (VOIP) communication capability IAW the *DMO System Standards* to support voice communications among instructors and operators at other *DMO Federate Systems* during *DMO events*.

d. **Mark Points. The IOS shall include the capability for the instructor to designate multiple specific points during the mission scenario timeline, known commonly as mark points, for reference during the mission and brief/debrief (B/DB) activities.** Mark points shall be discretely selectable by the instructor at any time (e.g. to designate a scenario event such as weapons release or RWR spike), automatically at instructor settable regular time intervals, or both. For each mark point, the entity state of each event-allocated MS element and SFES entity shall be captured and stored, to support a subsequent reset of all event-allocated MS elements and SFES entities to that point in the scenario. The data capture shall result in no instructor- or pilot-perceptible scenario discontinuities. Additionally, the capability shall be included for the instructor to record a voice memo associated with the selected mark point for retrieval during mission playback or debrief activities. Data storage supporting data capture for a minimum of 20 mark points per scenario shall be included.

e. Freeze and Reset. Individually or simultaneously, the IOS shall have the capability to freeze any or all local MS and SFES elements in the scenario; and to subsequently unfreeze any or all of the elements and continue the mission, or to reset and restart all elements at: (1) the point of freeze, (2) the start of the scenario, or (3) at any instructor-selected mark point in the mission.

f. Mission Recording. The capability shall be included with appropriate IOS controls, and in accordance with *DMO Standards*, to record data for entire missions or instructor-selected mission segments, encapsulating all mission activities and formatted appropriately for post-mission playback and debriefing at the BDS. To allow mission reconstruction, visualization, and replay during debriefing, the information recorded shall include:

(1) Intercom and radio communications;

(2) State data on all scenario entities; and

(3) For each local MS element participating in the scenario:

(a) Cockpit control and switch positions,

(b) Cockpit displays (including: HUD, Color Multi-Functional Displays (CMFD), and RWR), and

(c) Correlated visual OTW and helmet-mounted sensor and cueing device (e.g. NVG, HMCS) displays.

The IOS shall include on-line accessible storage capacity to store recorded data for at least 20 hours of mission time (e.g. ten 2-hour missions). Hardware and software to archive on-line stored mission data to COTS removable storage media shall be included.

Example Scenario Descriptions for Responding to Mission Capability Subfactor 1 (System Performance and Fidelity) Integrated System Performance Element

Offerors are expected to narratively describe the application and capabilities of each element of the MTC System in support of specific example local and DMO missions described below. Each example mission is expected to be thoroughly addressed, describing a robust application of the capabilities of the proposed MTC System. As appropriate to each mission, the capabilities described are expected to include:

- user friendly scenario generation capabilities of the Scenario Generation Station (SGS); (e.g. addressing interfaces in/out of the SGS, instructor controls, flexibility, etc.)
- event setup activities associated with DMO missions (e.g. reconfiguration process/rapidity for different security partitions, DMO portal activities, etc.);
- Brief-Debrief Station (BDS) features and capabilities for pre-mission briefing activities (e.g. display briefing data, maps, photos, line up cards, etc. at BDS);
- Mission Simulator (MS) pre-mission configuration, initialization and setup procedures (e.g. emphasizing flexibility, rapidity, and ease-of-use features being proposed, mission-specific hardware (NVG, HMCS, etc.) configuration, etc.; this should also include the process to select and load the visual/sensor database(s), and accomplish aircraft block/engine cockpit reconfiguration changes);
- control of the mission using the Instructor-Operator Station (IOS), including malfunctions, communication, mark points, freeze and reset, recording of data for instructor feedback of pilot performance and illustrating control differences between local and DMO missions (e.g. emphasizing ease-of-use features, flexibility, instructor options, configurability, etc.);
- the applied use and IOS control of a robust synthetic environment, including interactions with hostile, neutral, and friendly entities, control of such entities, and the effects of weapons and passive and active countermeasures (e.g. emphasizing ease of use features, flexibility, instructor options, configurability, observable damage effects, etc.);
- the use of MS capabilities for sensor operations and precision-guided weapons employment (e.g. pointing out fidelity-critical performance, special effects that enhance realism, etc.);
- use of the Mission Observation Center (MOC) features and capabilities (e.g. describing use of interactive communication features, display options, etc.);

- use of BDS features and capabilities for mission debriefing (e.g. describing post-mission BDS setup process/rapidity, flexibility and ease-of-use features, training-oriented capabilities, etc.);

Each capability that is described should trace back to a performance commitment in the offeror's proposed MTC System/Subsystem Specification (SSS). Areas where the offeror has established a commitment to exceed a SRD threshold should be addressed thoroughly. Offerors are encouraged to add mission details (e.g. specific threats, weapons, environmental conditions) consistent with describing "a robust application of the capabilities of the proposed MTC System" and to illustrate unique capabilities that exceed threshold requirements (with appropriate commitment reflected in SSS).

Abbreviations/Acronyms Used:

3D	Three Dimensional
AWACS	Airborne Warning and Control System
BDS	Brief/Debrief Station
BVR	Beyond Visual Range
CAP	Combat Air Patrol
CAS	Close Air Support
CGF	Computer Generated Forces
DMO	Distributed Mission Operations
EID	Emitter Identification
EP	Emergency Procedure
FAC	Forward Air Controller
FDL	Fighter Data Link
HARM	High-speed Anti-Radiation Missile (e.g. AGM-88)
HMCS	Helmet Mounted Cueing System
HTS	HARM Targeting System
IADS	Integrated Air Defense System
IAW	In Accordance With
Inst	Instruments
IOS	Instructor/Operator Station
JDAM	Joint Direct Attack Munition (e.g. GBU-31, -38)
JTAC	Joint Terminal Attack Controller
LGB	Laser Guided Bomb (e.g. GBU-10, -12, -24, -27)
MOC	Mission Observation Center
MOUT	Mission Operations in Urban Terrain
MS	Mission Simulator
MTC	Mission Training Center
NVG	Night Vision Goggles
OCA	Offensive Counter Air
PGM	Precision Guided Munition
SAM	Surface-to-Air Missile
SCL	Stores-Countermeasures Loadout
SEAD	Suppression of Enemy Air Defenses
SFES	Synthetic Forces and Entities Simulation
SGS	Scenario Generation Station
SSS	System/Subsystem Specification
STADGE	STAndard DMT Geographic Extent
TEWS	Tactical Electronic Warfare Systems
TP	Targeting Pod
VFR	Visual Flight Rules
VID	Visual Identification
WCMD	Wind Corrected Munition Dispenser (e.g. CBU-103, -104, -105, -107)
WVR	Within Visual Range

B. Excerpt from F-16 MTC Spec. Below are examples of scenario's that were created as part of the F-16 RFP.

<u>1. Mission #1 Suppression of Enemy Air Defenses</u>

Objective: Execute a 4-ship night SEAD DMO mission in support of a strike package of F-15Es and F-16 strikers. Will employ R7 HTS pod, Advanced Targeting pods (SNIPER/LITENING AT), Link-16, Air-to-Air and HARM Missile load out on two Mission Simulators (MSs); and JDAM/LGBs and on the other two. Mission has a primary SAM of interest with several mobile SAMs to challenge the pilots in the target area(s). Engage air-to-air threat when present on ingress and egress.

Mission Initialization:

– DMO entities: F-15E strikers (4-ship MTC); AWACS (MTC); F-16 4-ship strikers (External DMO CGF controlled by F-15E MTC).
– SFES entities: Various red air threats; red force IADS and ground threats.
– Weather: VFR night.
– MS config: MS #1 thru #4 as F-16C Block 50 (F110-GE-120 engine), ALQ-184 EA pods on centerline (station 5), standard ALE-47 chaff/flare loads. R7 HTS pod on the port intake station and SNIPER targeting pod on the starboard intake station.
– SCL: (MS #1, #2) Wingtip AIM-120Cs, AIM-9Xs on stations 2 and 8, and AGM-88s on 3 and 7, 370 gallon fuel tanks on 4 and 6. (MS #3, #4) Wingtip AIM-120Cs, AIM-9Xs on stations 2 and 8, and JDAMs or LGBs on 3 and 7, 370 gallon fuel tanks on 4 and 6.
– Database: Theater database with robust IADS representation, and enemy airfield with targets for strikers and strike package. Database should include two target areas: one in a mountainous area and another in flat-to-hilly terrain.
– Initialize to: On runway, with option to initialize in air at orbit point prior to push into target area.

Mission Profile:

– Accomplish pre-mission DMO briefing with participating federate systems.
– Instructor to initialize mobile SAM targets.
– Engine start and ground weapons checks.
– Four-ship departure or in-flight initialization as decided in pre-mission briefing.
– Weapons checks, boresight check, FENCE check.
– Instructor to control red force IADS acquisition skill/reaction time parametrics, as provided.
– Instructor to control red air threats on ingress and egress to complicate the problem for pilots. Extent of control exercised during mission should include selection of attack geometries, speeds, altitudes, and weapons.
– Execute ingress/attack at appropriate altitude for target scenario (mountainous or other), using appropriate tactics.
– Egress IAW current tactics for threat/target scenario/

– Accomplish a DMO mission debrief followed by a local mission debrief.

2. MTC Reconfiguration

Describe the reconfiguration process to split the MTC into two 2-ship partitions running in different security partitions, to support running the next two example missions concurrently.

3. Mission #2 Two-ship Urban Close Air Support

Objective: Train day or night CAS operations to support a ground commander in an urban environment. Accomplish CAS fundamentals in low-high threat environments using low-high altitude tactics. Train the employment of HMCS/NVG and a variety of PGM weapons (JDAMs, LGBs, AGM-65), rockets and/or internal gun against geo-specific and geo-typical inserted targets.

Mission Initialization:

- DMO entities: None (local mission)
- SFES entities: IADS and ground threats incorporating small arms, AAA, a mix of single digit SAMs (e.g. SA-2/-3/-6/-7/-9) with additional double-digit SAMs depending on the proficiencies and learning objectives of the sortie. A maximum amount of ground vehicle targets, including multiple vehicles and human models moving among the 3D buildings in the MOUT area, with observable small arms fire.
- Weather: VFR day or VFR night. Insert weather, smoke haze for subsequent resets.
- MS config: MS #1 and #2 as F-16C Block 50 (F-110-GE-120 engine), SNIPER pod with VDL.
- SCL: JDAM and LGB standard configurations with 370-gallon fuel tanks on stations 4 and 6.
- Database: One of the DMO STADGE databases with a high resolution urban area.
- Initialize to: On runway, ready for takeoff, with option to initialize in air at orbit point prior to push in to target area.

Mission Profile:

- Accomplish local pre-mission briefing.
- Instructor to initialize targets. F-16s will perform ground alert, and proceed to the MOUT area for JTAC directed (role-played by IOS) targeting using available techniques (comm., Link-16, IR pointer, laser, ROVER, etc).
- Engine start and ground weapons checks.
- Two-ship departure or initialize at orbit point (instructor discretion).
- Weapons checks, boresight check, FENCE check.
- Use common urban grid or Target Reference Points (TRP) in an urban area.

- Once the pilots check in and work with JTAC (role-played by instructor) the pilots will coordinate to ID, obtain clearance and destroy target(s) following joint procedures.
- Weapons deliveries from any altitude (0-40K’) IAW current tactics for threat/target scenario. Reload/change weapons for more training.
- Accomplish post-mission local debrief.

4. Mission #3 Single-ship Instrument Emergency Procedures (concurrent with mission #2)

Objective: Train a wide range of ground, take-off, and in-flight emergencies, including compound emergencies. Missions will be typical Inst/EP qualification checks. EPs to be trained may include any combination of the available emergency procedures listed in the system requirements.

Mission Initialization:

- DMO entities: None (local mission).
- SFES entities: Instructor-inserted during mission appropriate for EP situation being trained.
- Weather: VFR day or VFR night, instructor selectable clouds/visibility.
- MS config: MS #4 as F-16C Block 50 (F110-GE-120 engine), ALQ-184 EA pods, standard ALE-47 chaff/flare loads. R7 HTS pod on the port intake station and SNIPER targeting pod on starboard station.
- SCL: Various weapon loads as relevant to EP(s) being trained. 370-gallon fuel tanks stations 4 and 6.
- Database: MTC Local airfield database.
- Initialize to: On runway, with option to initialize in air.

Mission Profile:

- Instructor discretion based on specific EPs being trained.
- Instructor will pre-plan during scenario generation the trigger conditions for specific malfunctions and modify them as required during the mission to arrive at the appropriate flight conditions.
- Instructor will manually insert additional malfunctions "on-the-fly" during the mission.
- There will be no pre-mission briefing or post-mission debriefing. Instructor will provide pre-mission instructions and iterative feedback throughout mission.

5. MTC Reconfiguration

Describe the reconfiguration process to reconstitute a 4-ship configuration for Mission #4 from the 2-ship partitions supporting Missions #2 and #3. Note that the reconfigured MTC is to be in a Block 42 configuration.

6. Mission #4 Advanced Intercept Day – Offensive Counter-Air (Block 40)

Objective: Execute a 4-ship DMO day or night OCA mission employing air-to-air weapons in both BVR and WVR modes. Accomplish air combat fundamentals, tactical communications, radar employment, and employment versus maneuvering and non-maneuvering bandits in a force protection OCA role. Use all weapons and sensors to accomplish intercepts and kill threat aircraft. Demonstrate proficient use of: AIM 120C, AIM 9X, A/A targeting pod, chaff, flares, radar, TEWS, FDL, and communications systems. Interact appropriately with blue force package and respond appropriately to threat systems in a red IADS.

Mission Initialization:

- DMO entities: AWACS MTC.
- SFES Entities: Selectable formations, attack geometries and waves of threat aircraft attempting to hit strike package IAW Mission Profile.
- Weather: VFR day or VFR night.
- MS config: MS #1 thru #4 as F-16C Block 42 (F100-PW-220 engine), ALQ-184 EA pods, standard ALE-47 chaff/flare loads. R7 HTS pod on the port intake station and LITENING AT targeting pod on the starboard intake station.
- SCL: Selectable A/A missile configurations with optional fuel tanks.
- Database: Korean Peninsula STADGE
- Initialize to: Inflight at logical CAP point

Mission Profile:

- Accomplish pre-mission DMO briefing with participating AWACS MTC.
- Execute 4-ship intercepts on multiple target types to accomplish the following tasks:
  - ✓ Setup/display manipulation
  - ✓ System Cueing
  - ✓ Lock/shot verification
  - ✓ VID/EID
  - ✓ Admin (radar setup, ranges, etc.)
  - ✓ Crew coordination
  - ✓ Radar/FDL/TP/TEWS/chaff-flare employment
  - ✓ Maneuvering bandits
  - ✓ Intercept flow
  - ✓ Mutual support
  - ✓ Contingencies
  - ✓ Package coordination
- IOS will be used to take over both air and ground attack threats as necessary during the mission to accomplish the desired learning objectives.
- Expect to restart this mission several times using mark points and resets.
- Accomplish a DMO mission debrief followed by a local mission debrief.

Attachment 5

Booher comments for ARINC 610B IAW B1 SPEC

These are the lists of flight functions for the B-1 trainer from the Specification.

Paragraph 3.1.2

From Pre-flight to Post-flight including:

Engine start

Taxi

Takeoff

Climb

Cruise

Aerial refueling

Penetration,

Weapon delivery

Damage assessment strike

Landing.

Abnormal and Emergency Procedures

Instrument approaches

Paragraph 3.2.1.2 Simulated Environment

Outside air pressure and temperature and winds

Topography of earth

An electromagnetic environment

Wind shears, gusts and turbulence

Various atmospheric and visibility conditions,

Icing,

Various runway conditions

Various airfield and radio facilities within the CONUS and magnetic variation

Paragraph 3.2.1.3 The WST shall operate in integrated and independent modes.

Paragraph 3.7.3.1

Ground preflight

Takeoff/climb

Aerial refueling rendezvous – integrated mode

Cruise

Terrain following, penetration/climb out

TACAN/ILS approach

Emergencies/malfunctions

Post flight

Paragraph 3.7.5

Threat scenario

Instructional data, including malfunction scenario, initial condition sets

Radio/Navigation aids scenario

Simulator unique avionics mission data

Communications and traffic control messages

Magnetic variation

Paragraph 3.2.1.10.2 Crash override

Paragraph 3.7.1.3.2 Fidelity Critical Areas (John, most of these are the same as a commercial aircraft)

Small perturbation aerodynamics

Low speed flight characteristics

Aerodynamic ground effects

Aircraft attitude changes due to thrust (including asymmetric) changes

Individual landing gear strut dynamics

Asymmetric braking

Nose wheel steering, rudder steering effectiveness, and stabilizer effectiveness

Ground to air rotation transition

Crosswind takeoff and landing characteristics

Synchronization of motion, visual and cockpit cues.

Aircraft reaction to wing sweep, gear, flaps/slats, spoilers, speed brakes, weapon bays doors, and external weapons carriage and release

Aerial refueling

Skidding or runways

Stores delivery/jettison

Aircraft reaction to C.G. shift due to fuel management.

Paragraph 3.7.1.3.3 Weight and balance effects

The simulation of weight variation and center of gravity of flight characteristics shall be included. The effects of fuel depletion, fuel transfer, fuel addition, weapons load and wing sweep angle shall be simulated to automatically change gross weight, center of gravity, moments and products of inertia along and about the three aircraft axes. These effects shall be so reflected in the appropriate indicators and applicable flight properties. …..(Para 3.7.1.3.7) Weight and balance effects from transferred fuel in aerial refueling shall be simulated.

Paragraph 3.7.2.2.1.4.8 Jettison

… Simultaneous three bay doors opening

… Conventional weapon jettison

… Missile jettison

Paragraph 3.7.2.2.1.4.9 Manual Functions

Weapon selections

Bay door operation launcher rotation

Weapon release and jettison

Section 3.7.4 covers some IOS functions such as:

Reset/Initialization

Malfunction Insertion

Freeze

WST Freeze

Position and Flight Freeze

AI Position Freeze (DIS) – Defensive instructor station, I think.

JARM Mode Freeze (DIS)

Parameter Freeze (FIS Only)

Crash Override

Paragraph 4.2.8.10 Checklist Procedures Test

APU Power/APU Cooling

Starting Engines

Before Taxi

Taxi

Before Takeoff

Takeoff/Climb

Level Off

Equipment Set Checklist

Air Refueling

Rendezvous and Pre-contact

TER/FLY In flight check

Low Level Descent

CSS Enabling

TER FLW Interruption/Climb

TER FLW Resumption

Descent/Before landing

Transition Landing Pattern

HF Frequency Preset

Alert Cocking

Landing

After Landing

Engine Shutdown

Air refueling preparation for contact

Air refueling disconnect

Heading calibration

Airborne instrument landing approach

Loading avionics computer

Scramble

Uncocking

Non-nuclear weapons status check

Non-nuclear pre-arm

Non-nuclear bomb run

Non-nuclear post release

Post air refueling

ACUC in flight restart

CITS Start-up

CITS Parameter monitor

CITS fault-detection isolation

CITS parameter entry

Interior Inspection Power Off Checklists

Attachment 6

Attachment 6

Brian Campbell Comments for ARINC 610B

Here are some of the avionics controls for the F-15C

2.1.3 Freeze and Restart

2.1.3.A The simulator shall have the ability to freeze and restart from any mission point.

2.1.3.A.1 During freeze, the cockpit equations of motion algorithms shall not change the simulated aircraft position or attitude.

2.1.3.A.2 During freeze, simulation time shall not increment and all simulated threat systems shall freeze in position, attitude, and data processing.

2.1.3.A.3 During freeze, all cockpit controls, indicators, and displays, shall still function normally.

2.1.3.A.4 During restart, all frozen operations shall resume from the instant freeze was enabled.

Kill override to prevent crew station from being killed by terrain or weapon impacts

The IOS shall monitor and adjust instrument indications

The IOS shall provide the capability to reset consumables.

Attachment 7

Attachment 7

Fred Grimm comments for ARINC 610B

Here are some suggestions for external control of the following:

1) Ability to perform “Look and Enter” on critical variables
2) External control of the real-time clock, frame rate, and top-of-frame.
3) Warm-start or reset/reboot capability
4) Ability to reset the Kalman filter
5) Ability to cause the system to report malfunctions
6) Probably not supportable by ARINC, but provide ability to route the video to an external source via ARINC. Example: A smart MFD merges video inputs and overlays for a display. We may need to get to that video after the merging process so that we can record/playback that data.

Attachment 8

ARINC 610C Report Attachment 3

Bad examples – what can happen when the ARINC 610 implementation for a particular aircraft equipment is incomplete, incorrect or not provided.

Flight Management Computers

Simulator functions:
- Latitude/longitude reposition
- Altitude reposition

Effect:
- Aircraft has suddenly moved to a position inconsistent with the previous flight parameters (airspeed, vertical speed, wind speed etc.)

Possible consequences:
- Complete loss of Flight Plan
- Loss of V speeds
- Erroneous winds that take a long time to wash out
- Erroneous track indications on the map
- Map vs visual discrepancies
- Map shift errors (a/c position does not equal FMS position)
- FMS POSITION DISAGREE warnings
- GPS PRIMARY LOST warnings
- Failure to transition to desired flight phase
- FMS becomes confused when repositioning into a later stage of the flight plan.
- Independent FMS operation

Workarounds include:
- Switching off DME and GPS inputs to the FMC during reposition and freezes
- Downgrading the GPS accuracy
- Forcing a realign of the IRS
- Manually entering new position in FMS

But these actions can adversely affect the FM selected nav mode or navigation performance index and may not correct flight phase.

Detail:

If the FMC does not support ARINC 610 for position changes then the data on the position page may need to be manually updated to sync the FM with its inputs to avoid spurious effects. Other effects from changes in position data include wrong flight phase, wind build-up, and discrepancies in the reported map position.

If simsoft is available then the FM knows when position changes have occurred and is able to synchronise itself with position inputs to avoid these spurious effects.

The overall impact of the above negative results in a great deal of wasted time in the cockpit, increases the level of frustration experienced by the instructor/students, and compromises confidence in the training device.

Flight Management Computers

Simulator functions:

- Fuel change
- Gross weight change

Effect:

- Fuel weight and/or gross weight changes suddenly and not in accordance with known fuel usage.

Possible consequences:

- Slewing of FM fuel weight according to fuel controller quantity, causing incorrect gross weight

Workarounds include:

- Manual input of fuel parameters (if permitted) in FMC

Detail:

Changing the fuel weight or aircraft Gross Weight on the instructor station does not automatically update it on the FMC and it may get confused with the new information being passed to it. In the case of a fuel change, the FMGEC fuel weight may start "slewing" towards the amount sensed by the fuel controller causing the G/W to move off the correct weight.

Either the crew would have to manually update the FM each time with the new parameters so that they are consistent, or the equivalent keystrokes would have to be replayed.

If simsoft is available in the form of a Fuel Change or Weight Change then this is avoided and the FM syncs with the new values with no obvious effects.

Flight Management Computers

Simulator functions:

- Flight plan save (not available)

Effect:

- Instructor is unable to save a flight plan for later use

Possible consequences:

- Following reposition or completion of flight, flight plan is deleted and cannot be retrieved
- Flight plan must be manually and completely reentered

Workarounds:

- Pin programming may provide function to retain flight plan after landing, for example

Detail:

If the FMC does not support ARINC 610, it is very difficult to do flight-plan load/save. It could mean having to re-enter a flight plan every time you reposition the aircraft, which is very inconvenient. A way round it was to record every key stroke at the MCDU associated with the crew entering a flight plan, and then playing this back each time the flight plan is to be reloaded. This is time consuming, distracting as the crew can watch the FM being updated each time, and is not a very reliable method.

If simsoft is provided in the form of a Flight Plan Load/Save function, then all that the host simulation software needs to do is to tell the box to save the flight plan before a reposition or otherwise on demand from the instructor and then later tell the box to reload it whenever required.

Terrain Awareness Systems (e.g. EGPWS)

Simulator functions:

- Latitude/longitude reposition
- Altitude reposition

Possible consequences:

- Erroneous position sent to GPWS system causing wrong callouts.
- Wrong GPWS mode
- Spurious reactive windshear warnings

Workarounds:

- Cumbersome data input manipulation (altitude input) may kid the box that the complete flight has taken place

Detail:

Lack of Arinc-610 functionality causes erroneous Ground Proximity Warning Systems (GPWS) callouts. Ground Proximity Warning Systems are designed to function in various sub-modes based on a normal and typical sequence in the phase of flight (i.e. Take Off-Climb-Cruise-Descent-Approach). In general, they are unable to handle mode transitions elegantly outside of this “normal flow”. For instance, in a simulator environment a Take Off mode may be followed immediately by a reposition to an Approach configuration mode which could cause erroneous GPWS callouts.

The GPWS expects in normal flight to be flown from ground to above 2500ft and then on a descent. In the simulator the box therefore has to be reset after each flight and between each reposition by increasing the radio altimeter input to above 2500 ft and then back down to the required reposition height, otherwise the box would incorrectly warn in the wrong mode as it could misinterpret the actions of the pilot (such as warn against SINK RATE on a landing after having just done a take off but not reach cruise height, or not provide altitude callouts for a landing if it has just performed a landing) and would be in the wrong flight phase. During the repositions or slews the box could also produce spurious warnings as its sees its input values changing.

This may force the crew to adhere to the normal flow of flight in order to receive the correct callouts causing appreciable wasted training time.

Simsoft should be provided to suspend GPWS operation during repositions and to be initialised to a new flight phase and/or GPWS mode according to the new situation.

All Aircraft Systems

Simulator functions:

- Snapshot save/recall

Effect:

- Instructor performs simulator function to save current situation, continues session, then later recalls previously saved state. When not all aircraft systems support this save/recall feature, inconsistencies will arise

Possible consequences:

- Electronic checklists may not reflect previous state (checked/unchecked items)
- Selectable displays may not show same configurations as before
- Flight phase wrong
- Latched messages not reset
- Flight plan not valid

Workarounds:

- Data that is not correctly recalled must be manually entered / set
- Manipulation of input data may help to reset some equipment

Detail:

The instructor may wish to save a particular state of the current lesson, for example before a specific type of approach, in order to be able to reproduce the exact same conditions multiple times for training purposes. The expectation will be that all parameters important to the trained scenario will be stored. This includes all aircraft equipment.

For example, there will be a need to return to the same flight plan as before, at the same point in that plan. The correct flight phase should be returned to, with the same data entered corresponding to that phase (for example approach phase could have items entered such as flap setting, QNH, wind, decision height etc.) Newer equipment that might be affected are positional map applications such as the Electronic Flight Bag where selected charts should be redisplayed. Another newer technology is the electronic checklist which needs to be reset to the saved point (checked / unchecked items returned to the previous state).

The more items which are not correctly retrieved (or not saved for later retrieval), the more time it will take after a recall for the instructor and pilots to be able to continue training and there may still be no guarantee that the state is exactly as before.