

# ETMS/ATMS System Requirements

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Feature Described: Slot Credit Substitutions (SCS)

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Remarks:

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## Revision History

### Main Changes for Version 1.4

1. Modified requirement 14. The trigger to turn bridging on at an airport will be the issuance of a revised program for that airport, not the issuance of a SUB OFF command. When substitution is turned off, any SCS request will be rejected by EDCT. A SUB OFF command followed by a revision must turn all bridging back on. A SUB OFF command followed by a SUB ON command with no revision leaves the bridging status unchanged.

### Main Changes for Version 1.3

1. Removed examples of FAA bridging subs on/off commands.
2. Added examples of new slot list and sub show reports.
3. Modified format of SCS BRIDGING OFF command.

### Main Changes for Version 1.2

1. Removed the requirement to have FAA versions of the bridging subs on/off commands.
2. Clarified requirement 13 to say that the 30-minute timer is reset each time a new bridging off message is received.
3. Added a requirement (20) to have the authorization checking for the FAA SCS OFF/ON command to be node-specific (i.e., restricting it from the regular specialist).
4. Added a new requirement (29.9) to restrict the use of the 20-minute window in the same packet as an SCS request.
5. The issues section on 20-minute window was rewritten to reflect the understanding from the CDM meeting.

6. The error check for overlapping SCS requests (29.6) was rewritten to reflect the intended implementation.
7. The logic for computing the earliest possible arrival time was rewritten to reflect the agreement of the SCS workgroup to use the LRTA or LGTA if no ERTA was available.
8. The SCS algorithm issue has been deleted.
9. The criteria for flights eligible to use in a bridge was expanded to eliminate ground-stopped flights (22.4).
10. The goals of the bridging algorithm were changed to allow it to move flights more than the maximum move up time when it needs to (23)

## 1. Background

The situation commonly occurs during GDPs where a user has a flight  $f_0$  with a slot at time  $t_0$ , and flight  $f_0$  cannot use its slot because it is delayed or cancelled. In most cases a user will have another flight  $f_1$  with a slot at time  $t_1$  that can use the slot at time  $t_0$ , while flight  $f_0$  can use the slot at time  $t_1$ . A basic simplified substitution can address this situation.

Sometimes, though, a user may have no flights that can use the slot at time  $t_0$  because no other flight can be moved early enough to arrive at that time. Under current procedures a user can make no direct use of the slot at time  $t_0$  and must hope for compression or other action on the part of the FAA for the user to receive any compensating benefit for the loss of the earlier slot. In the worst case, a user may be willing to cancel flight  $f_0$  if it could be sure it would receive benefit from this cancel, but does not cancel because it cannot be sure.

Slot Credit Substitutions (SCS) provide a mechanism for a user to substitute in these situations by using other flights to bridge the slot from an unusable time to a time it can be used to the user's advantage. The general concept of an SCS is as follows:

1. A GDP is in place.
2. A user identifies an opportunity where they already have an open slot at time  $t_0$  due to delay or cancellation, or could create an open slot at time  $t_0$  by canceling a flight ( $f_0$ ), but cannot move another flight directly into that slot. The user identifies a flight ( $f_1$ ) that they would like to move up, and a time range (from  $t_1$  to  $t_2$ ) in which they would like flight  $f_1$  to arrive.
3. The user submits a sub message that says: "I will yield my slot at time  $t_0$  to the system if I can move flight  $f_1$  up into a slot sometime from  $t_1$  to  $t_2$ ."
4. ETMS examines all the available flights in the time range  $t_0$  to  $t_2$  to see whether it can create a bridge from the time that the user is yielding ( $t_0$ ) to a time that the user can use (somewhere from  $t_1$  to  $t_2$ ). That is, ETMS tries to move other users' flight earlier to get a later slot time for the requesting airline.
5. If a bridge is available, ETMS
  - Selects one or more flights to be the bridging flights and moves them up into to new slots
  - Assigns the resulting opened slot to flight  $f_1$
  - Updates the ETMS databases to reflect the bridging subs as well as the SCS
  - Sends a reply to the requesting user with the updated slot list for its flights

- Sends a notice to any other users whose flights were used to bridge of the changes to their flights (also in the slot list format)
6. If a bridge is not available, ETMS rejects the SCS and sends a suitable error message back to the requesting user.
  7. If the SCS was accepted, the next ADL update reflects the new slot assignments and EDCTs.

These requirements have been derived as the results of a long process. A number of meetings were held over several years with airline representatives, Volpe, and Metron to define the concept, issues and approach. More recently, Metron has orchestrated several human-in-the-loop experiments using their Jupiter simulation environment during which representatives from several airlines (AAL, NWA, USA, and UAL) and the ATCSCC were able to experiment with and refine the concepts.

These requirements draw heavily on these documents:

- CDM memorandum *Slot Credit Substitutions* by Roger Beatty, Ken Howard, and Dan Morin dated February 3, 2002.
- Memorandum *Requirements for Implementation of Slot Credit Substitutions* by Michael Brennan dated August 31, 2002.

SCS is an enhancement to the simplified substitution process implemented in ETMS 7.2. It is critical to have a full understanding of the simplified subs requirements prior to reading this document. The following document specifies those requirements.

- CDM Memorandum *Requirements for Simplified Subs – Rev 11* by Ken Howard dated November 21, 2000.

## 2. Functional Requirements

### Basics

The first requirements cover the fundamentals of how an SCS message is submitted. In essence, SCS messages will be added to the simplified sub packets in as consistent a manner as possible.

1. **ETMS Shall accept an SCS request from any user authorized to do simplified substitutions.**
2. **ETMS shall accept an SCS request from a user in a simplified subs (SS) message packet.**
3. **ETMS shall accept more than one SCS request in a packet, subject to error checks defined below.**
4. **ETMS shall accept other existing SS messages (FX and FM) in combination with SCS messages in an SS packet, subject to error checks.**
5. **SCS requests shall be formatted in a manner consistent with other existing SS messages.**

The next requirement defines the information that must be provided in an SCS message.

6. **The user shall provide the following information for an SCS:**
  - 6.1. **The name of slot that the user is giving up (“yielded slot”).**
  - 6.2. **The earliest time at which the user will accept a slot in return (“earliest acceptable time”).**
  - 6.3. **The latest time at which the user will accept a slot in return (“latest acceptable time”).**

- 6.4. The flight that the user would like to substitute into the new slot. [NOTE: The user may assign the same flight to the new slot that was assigned to the yielded slot.]**

The next requirement defines the basic steps ETMS must take with an SCS. The details for each step are further defined in later requirements.

- 7. When ETMS processes an SS packet that includes an SCS message, it shall:**
  - 7.1. Check the complete SS package for errors.**
  - 7.2. Attempt to create the bridge from the yielded slot time to the requested time range.**
  - 7.3. If no errors are detected and a bridge can be created,**
    - 7.3.1. Send a response to the requesting user indicating the updated slot assignments.**
    - 7.3.2. Send a message to any other users whose flights are moved as a result of the bridge.**
    - 7.3.3. Update the ETMS databases with the results of the SCS. (This will make the changes reflect in the ADL files.)**
  - 7.4. If any errors are detected and/or if a bridge cannot be created,**
    - 7.4.1. Send detailed error messages to the requesting user.**
    - 7.4.2. Reject the entire packet and perform no database updates.**

If at all possible, an error message should be issued indicating when an SCS failed because too many users had their “bridge-off” status set (see next section).

### Bridging On/Off Message

It is possible that one user’s SCS could interfere with a set of subs that another user is in the midst of creating. A mechanism must be provided for a user to inhibit changes to their own flights while they are planning their own subs. This mechanism is the *bridging off* message.

- 8. ETMS shall accept a bridging off message from a user. The message shall specify the applicable airport.**
- 9. When ETMS receives a bridging off message, it shall exempt any flights for that user from use in creating a bridge for another user’s SCS at that airport.**
- 10. ETMS shall accept a bridge on message from a user. The message shall specify the applicable airport.**
- 11. When a bridging on message is received, ETMS shall enable all flights for that user for use in creating a bridge for another user’s SCS at that airport.**
- 12. ETMS shall apply a bridging on/off message to any flight that the sending airline is authorized to substitute.**

The next requirement prevents a user from leaving their bridging off indefinitely.

- 13. If a user does not turn bridging on within a configurable time, initially 30 minutes, of turning it off, ETMS shall automatically turn bridging on for that user at that airport and send a notification to the user. ETMS shall reset the timer any time a new bridging off message is received.**

When the FAA revises or compresses a program, ETMS will automatically reset all bridging to on.

- 14. ETMS shall automatically turn bridging on for all users at an airport when FAA revises or compresses a program.**

The FAA must be able to turn bridging off permanently for certain users.

- 15. ETMS shall allow FAA to turn bridging off permanently using a run-time parameter for the following classes of users:**

- 15.1. A specific user.**

- 15.2. All general aviation flights.**

- 15.3. All military flights.**

- 16. If bridging has been turned off “permanently”, ETMS shall not allow it to be turned on using the dynamic bridging-on message or when FAA issues an EDCT SUB OFF message (see requirement 14).**

All users and FAA will be kept informed of the bridging off status as follows.

- 17. ETMS shall indicate any users whose bridging is currently turned off in the following places: (This will include both dynamic and permanent bridging-off.)**

- 17.1. The header of the ADL.**

- 17.2. The EDCT LIST report, see example in interface section below.**

- 17.3. The EDCT SUB SHOW report, see example in interface section below.**

### FAA Subs Off

The FAA already has a mechanism for turning subs off during a GDP. This freezes the data temporarily when a program, is being re-computed. ETMS needs to apply the sub off to SCS processing as well as regular subs. Furthermore, it is possible that SCS in itself might cause difficulty for FAA in achieving the goals of a program. Therefore a new mechanism will be provided to allow FAA to turn off only SCS subs.

- 18. ETMS shall reject any SCS messages when subs are turned off (EDCT SUB OFF).**

- 19. ETMS shall provide a new command to allow FAA to turn SCS subs off and on (e.g., EDCT SCS OFF/ON). The command may be applied to an individual airport or to all airports. ETMS shall send a notification to all users when this happens.**

- 20. ETMS shall perform node-specific authorization checking for the SCS OFF/ON command.**

- 21. ETMS shall show the status of SCS subs in the following places:**

- 21.1. The header of the ADL.**

- 21.2. The EDCT LIST report, see example in interface section below**

- 21.3. The EDCT SUB SHOW report, see example in interface section below.**

### Creating a Bridge

To create a bridge, ETMS must first identify what flights are eligible for use in creating the bridge then pick the specific flights. If sufficient flights cannot be found, the bridge will fail. The exact algorithms for selecting the flights is not specified here, but rather the general requirements that the algorithm must meet.

- 22. ETMS shall consider a flight is a candidate if all of the following conditions are met:**
  - 22.1. The flight is not cancelled, active, or completed.**
  - 22.2. The flight is controlled; that is, has an assigned arrival slot.**
  - 22.3. The flight is not a pop-up; that is, control type is not FA.**
  - 22.4. The flight is not ground stopped; that is, control type is not GS.**
  - 22.5. The flight has a slot time that is later than the yielded slot, and earlier than the latest acceptable time.**
  - 22.6. The flight belongs to a user that does not have its bridging-off flag set.**
  - 22.7. The flight's current ETD is later than the minimum notification time (a configurable time, initially defined as 30 minutes from the current time).**
  - 22.8. The flight's current slot time is later than its ERTA.**
  - 22.9. The flight is not subbed by another message in the packet containing the SCS.**
- 23. ETMS shall then select the specific flights to be used for the bridge. The algorithm shall:**
  - 23.1. Attempt to give each bridging flight a desired move up time (a configurable time, initially defined as 30 minutes).**
  - 23.2. If the bridge cannot be created using only the desired move up time, attempt to create the bridge by decreasingly smaller times down to the minimum move up time (a configurable time, initially defined as 10 minutes).**
  - 23.3. If the bridge still cannot be created, attempt to create it by using times increasingly larger than the desired move up time (e.g., 31, 32, etc.).**
  - 23.4. If the bridge still cannot be created, use times smaller than the minimum move up time (e.g., 9, 8, 7, etc.).**
  - 23.5. Not assign a bridging flight to a slot earlier than its earliest achievable ETA (see definition in the Issues section).**
  - 23.6. Not assign a delay reduction to a bridging flight that causes it to violate the minimum notification time for departure.**
  - 23.7. Give the requesting airline the earliest possible slot time in the acceptable time range.**
  - 23.8. Select the bridging flights in a manner so as not to systematically favor any user.**

### Implementing the SCS

When an SS packet is found to be error free and all SCS requests in that packet can be accommodated with bridges, ETMS will update its databases to reflect the changes and send the changes out to the affected users. Once the database is update, all ETMS outputs, including the ADL files for FSM, will reflect the changes.

- 24. For any flight that is assigned to an SCS slot, ETMS shall update the database as follows:**
  - 24.1. Assign the new slot to the flight.**
  - 24.2. Assign a new CTA to the flight that equals the slot time.**

- 24.3. Assign a new CTD to the flight that equals the new CTA minus the current ETE. (Current ETE will be defined as current ETA – ETD. This will reflect the airline-provided ETE, if LRTD and LRTA have been sent, or the ETMS-modelled ETE if not.)
- 24.4. Assign a control type of “SCS”.
- 25. For any flight that is used as a bridge for an SCS, ETMS shall update the database as follows:
  - 25.1. Assign the new slot to the flight.
  - 25.2. Assign a new CTA to the flight that equals the slot time.
  - 25.3. Assign a new CTD to the flight that equals the new CTA minus the current ETE.
  - 25.4. Assign a control type of “BRG”.
- 26. For any flight modified by a regular simplified sub FX or FM in the same packet as the SCS message, ETMS will update the database according to the current simplified sub processing.
- 27. When an SS packet containing an SCS message has been processed successfully, ETMS shall generate a response to the requesting user formatted exactly like the current simplified sub response; that is,
  - 27.1. A message indicating the packet was processed successfully.
  - 27.2. A single slot list containing each flight changed by the packet showing the following fields:
    - 27.2.1. Aircraft ID (ACID)
    - 27.2.2. Assigned arrival slot (ASLOT)
    - 27.2.3. Departure airport (DEP)
    - 27.2.4. Control time of departure (CTD)
    - 27.2.5. Control time of arrival (CTA)
    - 27.2.6. Control type (CTL\_TYPE)
    - 27.2.7. Exempt flag (EX)
    - 27.2.8. Cancel flag (CX)
    - 27.2.9. Slot hold flag (SH)
    - 27.2.10. Earliest runway time of arrival (ERTA)
    - 27.2.11. Initial gate time of departure (IGTD)
- 28. When an SS packet containing an SCS message has been processed successfully, ETMS shall generate a message to any user whose flights were used as part of a bridge. The message will be formatted like other simplified sub update messages (e.g., FA DELAY, EDCT UPDATE), that is,
  - 28.1. A message indicating that flights were modified as part of a bridge.
  - 28.2. A single slot list containing all flights for that user that were changed (showing the same fields as listed in requirement 25.2)

## Error Checking and Responses

The next requirements cover the new error checks specific to the SCS message. These error checks will be in addition to the error checks already performed for simplified subs. ETMS will continue to perform packet-level error checking as specified for simplified subs; that is, if any error is found, the entire packet will be rejected with no changes to the ETMS database.

- 29. ETMS shall require the following conditions to accept an SS packet containing an SCS request. ETMS shall reject the entire SS packet if any of the conditions are violated.**
    - 29.1. The yielded slot must be currently occupied by a flight that the requesting user is authorized to substitute.**
    - 29.2. The yielded slot must be owned by a flight that is not a former pop-up. (NOTE: A pop-up may not participate in an SCS due to the fact that it has no slot.)**
    - 29.3. The yielded slot must be in the future.**
    - 29.4. The earliest acceptable time must be later than the time of the yielded slot.**
    - 29.5. The earliest acceptable time must be earlier than or equal to the latest acceptable time.**
    - 29.6. The bridging time range, defined as the time from the yielded slot to the latest acceptable time (t0 to t2), for multiple SCS requests in the same packet must not overlap.**
    - 29.7. A flight must be assigned to the slot created by the SCS request.**
    - 29.8. All existing SS conditions are met (most importantly, the one flight – one slot correlation must be preserved).**
    - 29.9. There must be no use of the 20-minute window in a packet containing an SCS request.**
  - 30. When ETMS rejects an SCS message due to an error, it shall send an explanatory message to the requesting user indicating the specific error or errors, and what message caused the error.**
- If ETMS cannot create a bridge, it is not really an error, but is treated in all respects the same. The entire packet is rejected, and an explanatory message is sent.
- 31. If ETMS cannot create a bridge for an SCS request, it shall send a message to the requesting user indicating what SCS request failed, and why it failed.**
  - 32. If the bridge fails because too many flights had their bridging turned off, ETMS shall indicate this in the response.**

## **3. Performance Requirements**

### Accuracy

33. N/A

### Recoverability

34. N/A

### Reliability

35. N/A

## Size

36. N/A

## Speed

37. ETMS shall generate a response to an SCS request within 10 seconds of it being received.

## 4. Hardware Requirements

38. N/A

## 5. Design Issues/Suggestions

### SCS Message Formats

Most interface changes fit into the current interfaces in a very consistent manner. The only new requirement is the SCS request itself. Metron has implemented a particular format as part of the HITL development that separates the SCS request from any flight assignments. A format that explicitly associates the SCS request with the flight that is being assigned to the new slot would ease of implementation in ETMS. We would like to propose the following approach.

As in the Metron prototype, there would be a new message type called SCS. Like the Metron message, it identifies the yielded slot, the earliest acceptable time, and the latest acceptable time. In addition, it identifies the flight the airline would like to put into the new slot. The flight identification portion is just like a normal CDM message. Example:

```
SCS UNA1277 DFW SFO 03241701 SFO242040A 242050 242120
```

This sample would be interpreted as follows:

- SCS – This is an SCS request message type.
- UNA1277 – The ID of the flight to be subbed into the new slot.
- DFW – The origin of the flight.
- SFO – The destination of the flight.
- 03241701 – The original departure date/time for the flight.
- SFO242040A – The yielded slot.
- 242050 – The earliest acceptable time.
- 242120 – The latest acceptable time.

Viewed in the context of a simplified sub packet, this message serves the same purpose as an FM message: it assigns a flight to a new slot. ETMS can pretty much apply the same packet-level error checking that it does now with very little change. This format also makes the intent of the user very clear.

Consider an example. UNA airlines has two flights bound for SFO:

UNA1763 from ATL has a slot at 2040.

UNA1277 from DFW has a slot at 2150

UNA would cancel the ATL flight if it could get delay reduction on the DFW flight. They submit a packet which requests an SCS sub for the DFW flight then moves the ATL flight down into the vacated slot and cancels it. This packet could appear as:

```
SS UNA0324161500.01
SCS UNA1277 DFW SFO 03241701 SFO242040A 242050 242120
FM UNA1763 ATL SFO 03241520 T5 241715 T6 242150 A2 SFO242150
FX UNA1763 ATL SFO 03241520
```

## Other Interface Changes

A quick pass at what the other interface changes should look like.

Airline bridging subs message:

- Sent just like a SLOT HOLD message
- Format: EDCT BRIDGING OFF ATL or EDCT BRIDGING ON ATL
- Note: we know from the sending address to whom the message applies.

New EDCT Commands for FAA:

- EDCT SCS OFF ATL
- EDCT SCS ON ATL

Notification to airline when they are part of a bridge:

- SCS BRIDGING UPDATE FOR ATL
- followed by slot list

Notification to airline when their bridging has been turned on due to a time-out:

- SCS BRIDGING OFF AT ATL HAS TIMED OUT. BRIDGING IS NOW ON.

Notification to airline when SCS is turned off by FAA:

- SCS HAS BEEN TURNED OFF FOR ATL
- SCS HAS BEEN TURNED OFF FOR ALL AIRPORTS

Notification to airline when SCS is turned on by FAA:

- SCS HAS BEEN TURNED ON FOR ATL
- SCS HAS BEEN TURNED ON FOR ALL AIRPORTS

EDCT LIST report:

Number of airports currently controlled: 1

DEST	TIMES	CONTROL	FLIGHTS	SUBS	SCS
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ATL            /18/23            EDCT+FA            164            ON    ON

Bridging status at ATL:

- Carriers which have turned bridging OFF:  
COA

Number of sectors currently controlled: 0

EDCT SUB SHOW report:

Airport SUB Processing Activated SCS Processing Activated Current Time:16:37:15 on 2/13/2003

ATL    Yes                            Yes

Bridging status at ATL:

- Carriers which turned bridging OFF:  
COA

ADL changes:

- No new flight data fields.
- New values for CTL\_TYPE: BRG and SCS.
- New lines in START\_SUB\_FLAG data block:
  - SCS ON/OFF
  - BRIDGING OFF AAL (optional)
  - BRIDGING OFF GA (optional)
  - BRIDGING OFF MILITARY (optional)

### Earliest ETA Definition

ETMS must go the great lengths to assure that a bridging flight is not assigned to a slot that it cannot make. An easy part of this is making sure that the minimum notification time is not violated (i.e., new departure time is far enough in the future for the airline to effect the change). The harder part is making sure that the arrival time is achievable. The following algorithm has been agreed to by the CDM SCS workgroup:

- If flight has ERTA, set EETA to ERTA (airline has sent earliest ETA),
- Else if flight has an LRTA, set EETA to ERTA,
- Else if flight has LGTA, set EETA to LGTA – 10 minutes,
- Else if flight has an IGTA, set EETA to IGTA – 10 minutes (this covers almost every other case),
- Else, set EETA to current ETA (this should never happen, but gives the code a fall-back in case).

## 20-minute Window

The 20-minute window will be phased on in concert with the phasing in of SCS as follows. The FAA will only proceed to the next phase after reviewing analysis results and further collaboration with the CDM community.

1. In the initial implementation of SCS, airlines will not be allowed to use the 20-minute window in the same sub packet as an SCS request.
2. After approximately 6 months, pending further analysis, airlines who use SCS will be dis-allowed from using the 20-minute window in any substitution. In addition, the window will be reduced to 10 minutes for all users.
3. Eventually, all airlines will have converted to SCS.

To facilitate these changes, ETMS will make the window size a run-time parameter.

## Required ERTA

An idea has also been promoted airlines would only be allowed to do SCS subs if they send ERTA. This is a policy decision. The only technical impact is that ETMS would have to have configuration data specifying which users are allowed to do SCS. This could be the same authorization parameter used to govern the use of the 20-minute window, if that route is chosen.

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