Commercial Aviation Safety Team

Safety Enhancement 30
Revision-5

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"Mode Awareness and Energy State Management Aspects of Flight Deck Automation"

Final Report

Automation has contributed substantially to the sustained improvement in air carrier safety around the world. Automation increases the timeliness and precision of routine procedures, and greatly reduces the opportunity to introduce risks and threatening flight regimes. In short, automation has been very positive for safety.

Nevertheless, in complex and highly automated aircraft, automation has its limits. More critically, flight crews can lose situational awareness of the automation mode under which the aircraft is operating or may not understand the interaction between a mode of automation and a particular phase of flight or pilot input. These and other examples of mode confusion often lead to mismanaging the energy state of the aircraft or to the aircraft's deviating from the intended flight path for other reasons.

The Loss of Control (LOC) Joint Safety Analysis Team (JIMDAT), chartered by the Commercial Aviation Safety Team (CAST), identified these issues as factors or problems in several major accidents in the United States and around the world. Subsequently, a Joint Safety Implementation Team recommended in Safety Enhancement (SE) 30 that CAST charter a JIMDAT sub-team to address mode confusion in cooperation with a working group chartered earlier by the Performance-Based Aviation Rulemaking Committee (PARC), which was in the midst of a more broadly based study of issues related to automation.

In late 2005, CAST chartered the SE-30 Data Review Team to undertake this task. CAST directed the team to restrict its work to the issues of mode confusion and mode awareness, and to work closely with PARC, which continued to address a more comprehensive range of automation issues. The SE-30 Data Review Team was charged with producing a prototype automation policy, or an "exemplar," for air carriers.

The ultimate objective of any policy exemplar would be to help minimize the frequency with which pilots experience mode confusion and undesirable energy states. This, in turn, required some assurance that crews understand the functions of the various modes of automation. Accordingly, this report presents a policy exemplar based on a set of common industry practices that are known to be effective, against which operators may compare their existing policies and identify any appropriate changes in their policies. In addition, the exemplar includes practical guidance that air carriers could include in their policies in order to help pilots respond effectively to particular types of automation anomalies. The suggested guidance is intended only as examples of effective responses to selected circumstances. The suggested guidance does not necessarily identify the only proper response.

Note, too, that the terminology used in this document and in the examples reflects terminology for Airbus and Boeing aircraft. Air carriers may need to amend the terminology to apply this document to their own fleet mixes, the need for consistent language within a single air carrier, or other unique characteristics. However, the use of Airbus and Boeing terminology is reasonable for this type of document, since Airbus and Boeing products account for 80 percent of in-service air transport aircraft in the world (as of mid-2008).

Part One: Methodology and Central Findings

The Team reviewed automation policies from 16 air carriers to identify common concepts in order to build a set of industry practices that could establish a baseline for an industry-wide automation policy. Appendix A summarizes the automation policies that 16 air carriers voluntarily submitted to the Team, but does so without identifying the individual carriers.

To identify which of these policies might be effective and to identify any voids that might exist in common practices, the Team reviewed hundreds of reports from the Aviation Safety Reporting System (ASRS) and from other public data sources, including the FAA's Accident and Incident Data System (AIDS), and the National Transportation Safety Board's Accident and Incident Database.

The final dataset included 480 incident and accident reports during Part 121 operations by US air carriers, of which 50 cases from the preceding 5 years were studied in detail. The 50 reports dealt solely with automation incidents involving energy state management and mode awareness, and allowed the Team to conduct a "gap analysis" between guidance in air carrier automation policies and pilot actions described in the reports. Appendix B outlines the methodology in detail. Appendix C summarizes each of the 50 incidents that the team examined in detail. Appendix D summarizes the characteristics of each of the 50 cases in a tabular format. Appendix E shows the results of the gap analysis in a matrix that scores each of the 50 detailed cases against common policy elements among the 16 air carriers.

The Team found that a fundamental problem applied to almost all cases in the dataset: the flight crew did not comprehend what the automation was doing, or did not know how to manipulate the automation to eliminate the error. In such cases, when the crew changed automation levels they often exacerbated the problem. This problem applied with all automation modes and it applied regardless of whether the crew induced the event or the event was precipitated by a problem with the automation system. *In all 50 cases, pilots were unable return the aircraft to the desired flight path in a timely manner*. This was due to two root causes: inadequate training and system knowledge; and the unexpected incompatibility of the automation system with the flight regime confronting pilots in their normal duties.

For example, the crew may have made a manual input to the flight controls that would have been appropriate with the autopilot disengaged. However, if the auto thrust system in fact was still engaged and was in a mode that did not support the flight control input, the resulting flight path or energy state was often undesirable, to say the least.

Yet, among the 16 air carrier automation policies, the most common concept as stated by one carrier simply directed crews to "use the level of automation that will best support the desired operation of the aircraft." This concept is fine if the crew understands what the automation is doing at the time of the problem onset, and is then able to determine if the current or another automation level will better suit the operation. However, nearly all incident reports shared one common factor: regardless of whether an error was pilot-induced or was a function of the automation system, pilots did not understand what the automation was doing, or did not know how to use the automation to eliminate an error. Consequently, the Team's recommendations emphasize specific elements that should be incorporated into automation policies and then should be systematically reinforced.

The Team identified a core philosophy that should permeate any air carrier's policy on automation. That is, while recognizing that automation has brought major improvements to safety, the Team strongly recommends that air carriers should promulgate and systematically reinforce a philosophy of "fly the airplane." If pilots recognize that they do not understand the nature of an anomaly and do not precisely understand the solution, pilots should not choose to continue in an unstable or unpredictable flight path or energy state while attempting to correct an anomaly. Instead, crews should revert to a more direct level of automation until the aircraft resumes the desired flight path and/or airspeed. This may ultimately require the crew turning off all automation systems and flying the aircraft manually. When the aircraft once again is flying the desired flight path and/or airspeed, the crew can begin to reengage the automation, as appropriate. Below is a recommended statement to be included in carriers' automation policies and which should be systematically reinforced.

> At any time, if the aircraft does not follow the desired vertical flight path, lateral flight path or airspeed, do not hesitate to revert to a more direct level of automation. For example, revert from FMS guidance to non-FMS guidance, or when operating in a non-FMS guidance but with A/THR or A/T engaged, disengage and set thrust manually.

In addition to this recommended philosophical foundation, the Team developed a broad set of elements that should be incorporated in operators' automation policies, based on the based on the analysis of the dataset. The policy recommendations are organized according to seven broad topics that automation policies should address: Philosophy; Levels of Automation; Situational Awareness; Communication; Verification; Monitoring; and Command-and-Control. The Team further recommends that carriers assess their policies against these seven categories, fill any identified gaps, and ensure that each element is regularly reinforced in operating procedures and training programs.

Part Two: SE-30 Recommended Automation Policy Exemplar

1. Philosophy and Approach to the Use of Automation

An automation policy should begin with a description of the organization's philosophy and approach to the use of automation.

1.1 Fly the airplane

First and foremost, though automation has brought major improvements to safety, air carriers should promulgate and systematically reinforce the philosophy of "fly the airplane." If pilots recognize that they are uncertain about the autoflight modes or energy state, they should not allow the airplane to continue in an unstable or unpredictable flight path or energy state while attempting to correct the situation. Instead, pilots should revert to a better understood level or combination of automation until the aircraft resumes the desired flight path and/or airspeed. This may ultimately require that pilots turn off all automation systems and fly the aircraft manually. When the aircraft again is flying the desired flight path and/or airspeed, pilots can begin to reengage the automation as appropriate. This type of statement in the automation policy would help the pilot to know how to correctly interact with automation to reduce workload and increase safety and efficiency.

1.2 Adopt "CAMI" or "VVM" procedure

Include references to and descriptions of generalized procedures, such as the CAMI or VVM, that have been developed by various air carriers as effective means for pilots to validate the arming/engagement of the AFS and to monitor functions/mode changes.

- CAMI procedure for the pilot flying:
  → ***C***onfirm airborne (or ground) inputs to the FMS with the other pilot.
  → ***A***ctivate inputs.
  → ***M***onitor mode annunciations to ensure the autoflight system performs as desired.
  → ***I***ntervene if necessary.
  or
- VVM policy for both flightcrew members:
  → ***V***erbalize.
  → ***V***erify.
  → ***M***onitor.

General approaches like these are easy to train and review on the line and have been shown to help flightcrews in their overall approach to the use of automation.

1.3 Other topics

Carriers also should consider including other statements on automation philosophy to provide operational guidance to pilots.

- Appreciate specified capability, limitations, and failure susceptibility of the automation,
- Be wary of autoflight states when crew coordination, communication, and monitoring of automation is more important.
- Resist situations when automation can increase pilot workload or degrade performance, and
- Avoid over-reliance on automation to the detriment of manual flying skills.

2. Choice of Systems or "Levels" of Automation

Automation policy should include information to guide pilots on making choices about how to combine and use automated systems. Some airlines have defined "levels of automation" to help with this. However, a definition alone is not adequate for this topic. Below is a list of recommended topics that could add substance to a definition and that could provide practical guidance for pilots.

2.1 Use the Appropriate Automation for the Task.

On highly automated and integrated aircraft, several combinations, or levels, of automation may be available to perform a given task in either FMS modes and guidance or non-FMS modes and guidance.

- The most appropriate level of automation depends on the task to be performed, the phase of flight and the amount of time available to manage a task. A short-term or tactical task, such as responding to an ATC direction to go briefly to a different altitude or heading, the task should be accomplished in the FCU/MCP; this allows the crew to maintain head-up flight. A long-term or strategic task that changes most or all of the remaining flight should be accomplished in the FMS CDU, which requires more head-down time by one pilot.

- The most appropriate level also may depend on the level with which the pilot feels most comfortable for the task or for the prevailing conditions, depending on his/her knowledge and experience operating the aircraft and systems. Reverting to hand-flying and manual thrust control actually may be most appropriate, depending on conditions.

- The PF should retain the authority and capability to select the most appropriate level of automation and guidance for the task. Making this selection includes adopting a more direct level of automation by reverting from FMS guidance to selected guidance (that is, selected modes and targets through the use of either the FCP or MCP); selecting a more appropriate lateral or vertical mode; or reverting to hand-flying (with or without FD guidance, with or without A/THR or A/T), for direct control of aircraft vertical trajectory, lateral trajectory, and thrust.

2.2 Ensure that pilots possess required skills and knowledge.
Some airlines have also included statements in their automation policies about the requirement for pilots to be skilled in and knowledgeable about the use of certain combinations of automated systems or all possible combinations of systems. Understanding and interacting with any autoflight system ideally requires answering the following fundamental questions:

- How is the system designed?
- Why is the system designed that way?
- How does the system interact and communicate with the pilot?
- How does the pilot operate the system in normal and abnormal situations?

Ensure that pilots fully understand the following aspects in the use of automation:

- Integration of AP/FD and A/THR or A/T modes (that is, pairing of modes), if applicable;
- Mode transition and reversion sequences; Integration of AP/FD and A/THR or A/T modes (that is, pairing of modes), if applicable;
- Mode transition and reversion sequences; and
- Pilot-system interaction for
    - pilot-to-system communication (that is, for target selections and modes engagement) and
    - system-to-pilot feedback (that is, for cross-checking the status of modes and accuracy.

2.3 AP - A/THR Integration:
Integrated AP-A/THR or AP-A/T systems pair AP pitch modes (elevator control) with the A/THR or A/T modes (thrust levers/throttle levers). Integrated AP - A/THR or AP-A/T systems operate in the same way as a pilot who hand-flies with manual thrust.

• Elevator is used to control pitch attitude, airspeed, vertical speed, altitude, flight-path-angle, and vertical navigation profile or to capture and track a glideslope beam.
• Thrust levers or throttle levers are used to maintain a given thrust or a given airspeed.

Throughout the flight, the pilot’s objective is to fly either:

• Performance segments at constant thrust or at idle, as on takeoff, climb or descent; or
• Trajectory segments at constant speed (as in cruise or on approach).

Depending on the task to be accomplished, airspeed is maintained either by the AP (elevators) or the A/THR (thrust levers) or A/T (throttles levers), as shown in **Table 1** below.

Table 1.
AP – A/THR & A/T Mode Integration

	A/THR or A/T	A/P
	Thrust levers/ Throttle levers	**Elevators**
Aircraft Performance is controlled by:	**Thrust or idle**	**Speed**
Aircraft Trajectory is controlled by	**Speed**	**V/S Vertical profile Altitude Glide slope**

2.4 Automation Design Objectives: - -

The AFS provides guidance to capture and maintain the selected targets and the defined flight path, in accordance with the modes engaged and the targets set by the flight crew on either the flight control unit (FCU)/mode control panel (MCP) or on the flight management system (FMS) control and display unit (CDU).

The FCU/MCP constitutes the main interact between the pilot and the autoflight system for *short-term guidance* (i.e., for immediate guidance such as radar vectors).

The FMS CDU constitutes the main interface between the pilot and the autoflight system for *long-term guidance* (i.e., for the current and subsequent flight phases).

Two types of guidance (modes and associated targets) are available on aircraft equipped with either a flight management guidance system (FMGS) or flight management computer (FMC), featuring both lateral and vertical navigation, le:

- Selected guidance:
  The aircraft is guided to acquire and maintain the targets set by the crew, using the modes engaged or armed by the crew (i.e., using either the FCU or MCP target setting knobs and mode arming/engagement pushbuttons)
- FMS guidance:
  The aircraft is guided along a pilot-defined FMS lateral navigation (LNAV) and a vertical navigation (LNAV) flight plan, speed profile, altitude targets/constraints

2.5 Engaging Automation:

Before engaging the AP, ensure sure that:

- Modes engaged (check FMA annunciations) for FD guidance are the correct modes for the intended flight phase and task;
- Select the appropriate mode(s), as required; and confirm,
- FD command bars do not display any large displacements; if large displacements are commanded, continue to hand fly until FD bars are centered prior to engaging the AP;

Engaging the AP while large commands are required to achieve the intended flight path may result in the AP overshooting the intended vertical target or lateral target, and/or surprise the pilot due to the resulting large pitch / roll changes and thrust variations.

2.6 Other topics related to the choice of automation levels

Include other statements to help pilots choose the appropriate level of automation.

- Use optimum automation combination or "level" for comfortable workload, high situation awareness, and improved operations capability (passenger comfort, schedule, and economy).
    - Do not try to solve automation problems with conditioned responses from the same level of automation.
    - Prioritize correctly (e.g. avoid programming during critical flight phases).

3. Situation Awareness

Policies should include statements about the importance of maintaining situation awareness and, particularly, mode and energy awareness.

3.1 Mode and Energy Awareness

Situation awareness requires that pilots know the available guidance at all times. The FCU/MCP and the FMS CDU are the primary interfaces for pilots to set targets and arm or engage modes. Any action on the FCU/MCP or on the FMS keyboard and line-select keys should be confirmed by crosschecking the corresponding annunciation or data on the PFD and/or ND (and on the FMS CDU). At all times, the PF and PNF should be aware of the status of the guidance modes being armed or engaged and of any mode changes throughout mode transitions and reversions.

3.2 Monitor the use and operation of the automated systems.

- Check and announce the status of the FMA, such as the status of AP/FD modes and A/THR or A/T mode.
- Observe and announce the result of any target setting or change (on the FCU/MCP) on the related PFD and/or ND scales; and
- Supervise the AP/FD guidance and A/THR or A/T operation on the PFD and ND (pitch attitude and bank angle, speed and speed trend, altitude, vertical speed, heading, or track).

3.3 Other topics on situation awareness.

- Remain alert for signs of deteriorating flying skills, excessive workload, stress, or fatigue (avert complacency).
- Ensure at least one crewmember monitors the actual flight path.
- Consider "hand flying" in manual mode for immediate change of flight path.

- Brief the plan for using automation before takeoff and rebrief in flight as the situation dictates.

4. Communication and coordination

Topics related to communication and coordination to consider in developing the automation policy are statements to help flightcrews:

- Announce automatic or manual changes to autoflight status (or update other pilot at first opportunity),
- Brief and compare programmed flight path with charted procedure/ active routing,
- Coordinate (verbalize) before executing any inputs which alter aircraft flight profile,
- Make callout 1,000 feet before clearance altitude and verbally acknowledge,
- Utilize the "point and acknowledge" procedure with any ATC clearance.
- Brief special automation duties & responsibilities, and
- Actively listen for traffic, communication & clearances.

5. Verification

Include statements about verifying and cross-checking automation selections and anticipating subsequent aircraft performance in an automation policy.

5.1 Know Your Modes and Targets.
At a high level, the goal of verification can be generalized as "know your modes and targets." The AP control panel and FMS control display unit/keyboard are the prime interactions for pilots to communicate with aircraft systems (to arm modes or engage modes, and to set targets). The PFD, particularly the FMA section and target symbols on the speed scale and altitude scale, and ND are the primary interactions for the aircraft to communicate with pilots. These interfaces confirm that aircraft systems have correctly accepted the pilot's mode selections and target entries.

Any action on the autopilot control panel or on FMS keyboard/line-select keys should be confirmed by cross-checking the corresponding annunciation or data on the PFD and/or the ND. The PF and PNF (PM) should be aware of the following:

- Modes armed or engaged;
- Guidance targets set;
- Aircraft response in terms of attitude, speed, and trajectory; and
- Mode transitions or reversions.

When flightcrews perform an action on the FCU/MCP or FMS CDU to give a command, the pilot expects a particular aircraft reaction and, therefore, must have in mind the following questions:

- Which mode did I engage and which target did I set for the aircraft to fly now?
- Is the aircraft following intended vertical and lateral flight path and targets?
- Which mode did I arm and which target did I preset for the aircraft to fly next?

To answer such questions, pilots must understand the certain controls and displays:

- FCU/MCP mode selection keys, target-setting knobs, and display windows;
- FMS CDU keyboard, line-select keys, display pages, and messages;
- Flight modes annunciator (FMA) on the PFD; and

- PFD and navigational display (ND) displays and scales (that is, for cross-checking guidance targets).

5.2 Specific topics related to verification

Include statements to help pilots verify and cross-check inputs and aircraft responses.

- Cross-check raw data and computed data, as appropriate.
- Verify (both pilots) entered waypoints and confirm FMS data against printed charts.
- Maintain effective cross-check of system performance with desired flight path,
- Verify programming that alters route, track, or altitude, and cross-check proper mode annunciation,
- Cross-Check (verify) result of selections, settings, and changes.
- If a transition is selected or built, verify between pilots that it matches clearance and that it produces desired track.

6. System and Crew Monitoring

Monitoring automation is simply carefully observing flight deck displays and indications to ensure the aircraft response matches your mode selections and guidance target entries, and the aircraft attitude, speed, and trajectory match expectations.

- During the capture phase, observe the progressive centering of FD bars and the progressive centering of deviation symbols (during localizer and glideslope capture). This enhances supervision of automation during capture phases and cross-check with raw data, as applicable, to enable early detection of a false capture or capture of an incorrect beam.

- If the aircraft does not follow the desired flight path or airspeed, do not hesitate to revert to a more direct level of automation, as recommended by the airplane manufacturer or as required by the operator's SOPs.

- In the event of an uncommanded AP disconnection, engage the second AP immediately to reduce pilot workload.

The effective monitoring of these controls and displays promotes increases pilot awareness of the modes being engaged or armed and the available guidance (flight path and speed control). Active monitoring of controls and displays also enables the pilot to anticipate the sequence of flight modes annunciations throughout successive mode transitions or mode reversions. Carriers should also consider the following types of statements to help provide operational guidance to pilots.

- Scan indications to ensure aircraft performs "as expected;"
- Monitor Status (indications and mode annunciations);
- Monitor ALT capture mode to ensure commands for smooth level-off at assigned altitude are followed when using ALT capture mode of A/P - F/D, or VNAV;
- Maintain One "head up" at all times/low altitude; avoid distraction from duties;
- Do not let automation interfere with outside vigilance;
- Maintain continuous lookout during ground movement & VMC flight;
- PF and PNF monitor each other's actions; and

- Do not use any navigational system displaying an inoperative flag or some other failure indication.

7. Workload and System Use

Consider including statements on workload and system use to provide some operational guidance to pilots, such as the following.

- Ensure PF has responsibility for flight path; remain prepared to assume control (abnormal conditions).
- Intervene if the flight status is not "as desired"; revert to lower automation level; disengage any A/F system not operating "as expected."
- Encourage manual flying for maintaining proficiency when flight conditions permit,
- Clearly establish who controls Aircraft under what Conditions.
- Allow for switch of PF & PNF duties if control properly maintained PF and PNF monitor each other's actions.
- Designate one pilot to control (abnormal conditions).

8. Summary

The SE-30 Data Review Team has identified seven broad topics that should be addressed in automation policies. Only a specific air carrier knows what is best for its own circumstances, but the seven topics provide a basic exemplar, based on current practices that are known to be effective and incident analysis by an expert panel.

For the optimum use of automation, carriers should promote the following, in which the central point remains "fly the airplane."

- Understanding the integration of AP/FD and A/THR-A/T modes (pairing of modes).
- Understanding all mode transition and reversion sequences.
- Understanding pilot-system interfaces for:
  - pilot-to-system communication (for mode engagement and target selections)
  - system-to-pilot feedback (i.e., for mode and target cross-check)
- Awareness of available guidance (AP/FD and A/THR or A/T status and which modes are armed or engaged, active targets).
- Alertness to *adapt the level of automation to the task and/or circumstances, or to revert to hand flying or manual thrust/throttle control, if required.*
- Adherence to the aircraft specific design and operating philosophy and the air carriers SOPs.
- If doubt exists regarding the aircraft flight path or speed control, *do not attempt to reprogram the automated systems.*
- Selected guidance or hand flying together with the use of navaids raw data should be used until time and conditions permit reprogramming the AP/FD or FMS.
- If the aircraft does not follow the intended flight path, check the AP and A/THR or A/T engagement status.
  - If engaged, disconnect the AP and/or A/THR or A/T using the associated disconnect push button(s), to revert to hand flying (with FD guidance or with reference to raw data) and/or to manual thrust control.

- In hand flying, the FD commands should be followed. otherwise the FD bars should be cleared from display, AP and A/THR or A/T.

Appendix A

Attributes of Policies Among 17 U.S. Air Carriers

	17 AIR CARRIERS																	
ATTRIBUTES	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	Sum
PHILOSOPHY																		
Avoid over-reliance on automation to detriment of manual flying skills.	X		X	X										X				4
Correctly Interact with automation to reduce workload, increase safety & efficiency	X			X	X				X	X	X		X	X		X		9
Be wary of Autoflight "Uptempo" – when crew coordination, communications, & monitoring of automation are more important										X				X				2
Appreciate specified capability, limitations & failure susceptibility of automation			X	X											X			3
Resist distraction degradation; automation can actually increase pilot workload or degrade performance			X	X					X						X	X	X	6
"CAMI" Procedure: **C**onfirm FMS inputs with other pilot; **A**ctivate input; **M**onitor mode annunciations to ensure auto-flight system performs as desired; & **I**ntervene if necessary										X			X	X				3
Total Present of 6 Attributes	2	0	3	4	1	0	0	0	2	3	1	0	2	4	2	2	1	27
LEVELS OF AUTOMATION	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	Sum
Well-trained PF selects automation at most appropriate level to fit dynamic circum-stances of changing environ-ment		X	X	X			X		X	X	X		X	X	X	X	X	12
Use lowest level of automation mode suitable for the required maneuver			X															1
Fly aircraft using highest level of auto-mation, consistent with require-ment to maintain basic flying skills.													X			X	X	3
Do not solve auto-mation problem with a con-ditioned response from the same level of auto-mation									X							X		2
Level 1: Everything off; relying on raw data; no automation active.	X		X						X	X				X	X		X	7
Level 2: A/P off; optional use of FD & A/Ts while "hand flying" the airplane.			X						X	X				X	X		X	6
Level 3: Control via flight guidance system; on or optional use of A/P & A/Ts; "tactical use of auto-mation"			X				X		X	X				X	X		X	7
Level 4: Use of FD, A/P, A/Ts plus FMS for vertical & lateral path guidance"strategic use of automation"			X						X	X				X	X		X	6
Prioritize correctly (e.g., avoid programming during critical flight phases)		X		X												X	X	4
Possess Knowledge & proficiency in selection & use of all automation levels; skills required to shift between levels	X			X						X	X		X	X	X		X	8
Total Present of 10 Attributes	2	2	6	3	0	0	2	0	6	6	2	0	3	6	6	4	8	56
SITUATIONAL AWARENESS	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	Sum
Maintain Situational Awareness, including mode awareness	X		X	X						X			X	X	X		X	8

Ensure at least one crewmember monitors actual flight path.			X	X														2
Consider "Hand Flying" in manual mode for immediate change of flight path	X	X	X							X				X	X			6
Use optimum automation level for comfortable workload, high SA, & improved ops capability (pax comfort, schedule & economy)	X		X	X			X			X	X		X	X	X	X	X	11
Remain alert for signs of deterioration of flying skills, excessive workload, stress & fatigue			X												X	X		3
Maintain Positional Awareness; regain manual control before aircraft enters undesired state	X		X				X			X				X		X		6
Brief plan for using automation before takeoff; re-brief in flight as situation dictates			X	X						X			X		X			5
Total Present of 7 Attributes	4	1	7	4	0	0	2	0	0	5	1	0	3	4	5	3	2	41
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	Sum
Both pilots should actively listen for traffic, communication & clearances.								X										1
Utilize the “point and acknowledge” procedure with any ATC clearance.								X										1
1,000 feet before clearance altitude, PNF will state, e.g., “23 for 24” & PF will verbally acknowledge.								X										1
Announce automatic or manual changes to A/F status (or update other pilot at first opportunity)	X		X					X					X		X		X	6
Coordinate (verbalize) between both crewmembers before executing any inputs which alter aircraft flight profile.			X					X		X			X		X		X	6
Brief special automation duties & responsibilities	X		X	X							X		X	X	X		X	8
Brief & compare programmed flight path with charted procedure & active routing		X		X			X			X	X				X		X	7
Total Present of 7 Attributes	2	1	3	2	0	0	1	5	0	2	2	0	3	1	4	0	4	30
VERIFICATION	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	Sum
Maintain effective cross-check of AFS performance & desired flight path	X									X			X	X			X	5
Cross-check raw vs. computed A/F data	X	X								X							x	4
Cross-Check (verify) result of (selections, settings, & changes)	X	X	X	X						X	X		X	X				8
If a transition is selected or built, pilots verify that it matches clear-ance & produces desired track.										X			X				X	3
Verifiy programming that alters route, track, or altitude and proper mode annunciation		X					X						X	X	X		X	6
Both pilots verify entered waypoints & confirm FMS data against printed charts.			X							X							X	3
Total Present of 6 Attributes	3	3	2	1	0	0	1	0	0	5	1	0	4	3	1	0	5	29
Monitoring	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	Sum
Maintain Situational Aware-ness, including mode awareness	X									X			X					3
Ensure at least one crewmember monitors actual flight path.																		0

Consider "Hand Flying" in manual mode for immediate change of flight path		X								X	X		X	X	X			6
Use optimum automation level for comfortable workload, high SA, and improved ops capability (passnger comfort, schedule & economy)										X					X			2
Remain alert for signs of deterioration of flying skills, excessive workload, stress and fatigue								X										1
Maintain Positional Awareness; regain manual control before aircraft enters undesired state	X									X				X	X			4
Brief plan for using automation before takeoff; re-brief in flight as situation dictates	X	X	X	X						X	X			X				7
Total Present of 7 Attributes	2	2	1	1	0	0	0	1	0	4	2	0	1	3	3	0	0	20
COMMAND & CONTROL/WORKLOAD	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	Sum
Clearly establish who controls Aircraft under what conditions	X				X	X		X			X	X	X		X			8
Allow for switch of PF & PNF duties if control properly maintained	X							X			X							3
PF has responsibility for flight path; remain prepared to assume control (abnormal conditions)*	X							X					X		X			4
Designate one pilot to control (abnormal conditions)*	X											X						2
Encourage manual flying for maintaining proficiency when flight conditions permit	X		X					X			X	X	X	X				7
Resolve any discrepancy immediately		X						X										2
Intervene if status not "as desired"; disengage any A/F system not operating "as expected"*	X			X	X			X	X			X	X	X	X			9
Exercise positive control; revert to lower automation level (e.g., under heavy workload at low altitude)			X		X	X						X	X	X	X			7
Total Present of 8 Attributes	6	1	2	1	3	2	0	6	1	0	3	5	5	3	4	0	0	42
SUM, By Airline	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	Sum
Total Present of 51 Attributes	21	10	24	16	4	2	6	12	9	25	12	5	21	24	25	9	20	245

Appendix B: Methodology

Data Gathering

Basic text mining techniques were applied by the FAA's Aviation Safety Information & Analysis System (ASIAS) to identify potentially relevant reports from multiple data sets. The team selected four databases for review: NTSB Accidents, Pilot Deviations (PDS), Aviation Safety Reporting System (ASRS), and the Accident / Incidents Database System (AIDS). Analysts from ASIAS accessed the four databases and filtered them for FAR Part 121 records. ASIAS then searched the new data set for key words and phrases. These efforts identified about 1,700 records, of which 1,100 were forwarded to the JIMDAT SE-30 Team for review. The Team reviewed each of the 1,100 records to assess relevance and to determine whether the information was adequate for analysis. This produced a final data set of 480 records.

Data Extraction Parameters

ASIAS and Data Review Team members applied several constraints (business rules) to establish the data set. Those rules included the following:

- Reports would be limited to FAR Part 121 operations
- Reports would include both incidents and accidents (fatal and non-fatal)
- Mechanical failure reports would not be included in the final data set
- The focus of the final reports would be on crewmembers interacting with cockpit automation.
- The reports would cover 2000 through 2006.

Discrimination of data sets

Few records were selected from the NTSB, PDS, or AIDS data. Of those that existed, most were too dated or too fragmentary. The ASRS data base, although promising, contained report narratives of vastly differing quality. Many contained insufficient information upon which to base a conclusion regarding a root cause or delineation of contributing factors. Consequently, all 480 records selected for the analysis came exclusively from ASRS. The Team recognized that ASRS records are likely to be incomplete, but the ASRS records were thorough enough to enable the Team to identify a large number of repeatable instances.

Comparison to current industry practices

The Team developed an *exemplar* for each event's causative path and sub-path. The Team re-examined the relevant issues of why the event was selected and retained. The team prepared a matrix of causations similar to one air carrier's limited in-house study focusing on internal Aviation Safety Action Program (ASAP) reports.

- "X" Axis - Phases of flight – (TO/Climb, Level Off/Cruise, Descent/Approach)
- "Y" axis - Data Contributing factors – Xs
- Look at high occurrence/high risk groupings

Gap Analysis

The team requested and received the current automation policy statements from 16 air carriers. The goal was to identify *"gaps"* between industry practices and unresolved problem statements generated by JIMDAT's review of "new" incident vs. historical accident data.

- Was the crew using automation?
- Was the crew using it appropriately?
- Did the crew communicate the expected outcome?
- Did the crew monitor the expected outcome?
- Was the outcome as expected?

Subject Matter Expert Review

The team's challenge was to understand the proper interface between the flight crew and automation. A team of subject matter experts from several air carriers and two manufacturers selected 50 ASRS reports for more detailed, root-cause analysis.

Appendix C

Narratives to 50 ASRS Pilot Reports Analyzed in Detail

Event No.	NASA ASRS Code	NARRATIVE and JIMDAT SE-30 TEAM / SME ANALYSIS (red indicates significant information bearing on outcome)
1	265962b	**Synopsis** An Airbus flight crew failed to meet an altitude crossing restriction during a night operation. **Narrative** The crew was descending on the XXX 8 arrival into destination with a clearance to cross INT 1 at 13,000 feet. The FMC was properly programmed with the arrival and altitude over INT 1. LNAV and VNAV were engaged, and the aircraft was descending properly (the altitude crossing at INT 1 was projected to be 13,000 feet by the computer.) As a line check airman doing initial operating experience (IOE) with a new captain, the pilot monitoring (PM) began to discuss the LDA "A" approach into destination (they were at FL240 at the time), because it was very important for new captains to know the FMC thoroughly. During this discussion, both pilots were engaged in looking at ways to select the approach, tune the radios, and build waypoints associated with the LDA and/or ILS back-ups. During this discussion, neither pilot was watching the aircraft very well, because of their interest in the approach, and because the aircraft was engaged in VNAV. Just past INT 1, their discussion ended, and their attention went back to the aircraft situation, as they anticipated flight below 10,000 feet and the checklists. Much to their amazement, they were descending to 13,000 feet from 17,000 feet. They had missed the crossing by over 4,000 feet! The computer was still in VNAV and LNAV, with appropriate annunciations on the FMA. The PM immediately knew what had happened. The Airbus FMC deleted crossing altitude on STARS whenever a runway is changed, or a different approach is selected at destination. They had initially given the computer a hard crossing altitude at INT 1, but during their discussion they had selected the runway 22 ILS, re-selected the runway 22, and re-selected the ILS at destination, and the computer automatically de-selected and disregarded their hard altitude crossing. This was exactly what it was programmed to do, and in the PM's opinion, it was a very dangerous program. He constantly warned new pilots about this trap in the airbus FMC. It had now caught him. They descended to 13,000 feet as rapidly as possible, and nothing was said by them or ATC. They landed at destination uneventfully. Solution: the airbus programming needs to be modified so it will not delete altitudes that are put in by the pilot, and of course, someone should be monitoring the aircraft at all times. This last was tough to do on an IOE flight with advanced cockpits. Supplemental information from report 266453: The PF manually pushed over, disengaged the autothrottles and deployed full speed brake. They crossed INT 1 a couple of thousand feet high. It was late at night, with minimum traffic, and no conflict was generated. This incident reinforced the requirement that someone must be flying the plane! **JIMDAT Analysis:** Applicable (mode awareness) **Comments:** Crew lost situational awareness in the arrival procedure by shifting to the approach procedure for enroute briefing/training
2	277912b	**Synopsis**

		A B757-200 flight crew exceeded a speed restriction of 250 KIAS below 10000 ft. **Narrative** Departing the county airport on the XXX FMS departure, autothrottles were inoperative. About the time the crew reached 250 knots, they received a turn toward INT 1, direct when able, and a climb clearance (the captain, pilot flying (PF) believed to be 13,000 feet). The PF started the turn, engaged flight LEVEL CHANGE, set climb power, and engaged the autopilot. The aircraft began a climb and all appeared normal. About this time, they got a right reverser isolation valve message which distracted the PF for a few seconds. On return to the flight instruments, a scan of the flight instruments showed a speed of 260 KIAS. The PF re-checked the command bug and saw it at 250, the nose was continuing to come up, and he assumed the FMC was going to hold the selected speed. The first officer, pilot monitoring (PM), had the QRH out and was telling the PF what the book said; initially both pilots thought it said they might get an uncommanded engine in reverse. The lapse in the PF's attention to the airspeed was minimal. When he next noticed it they were at 290 KIAS and accelerating. He immediately disengaged the autopilot, eased the nose up and reduced power, getting the speed down to 250 KIAS in short order. Departure control called about this time with a "maintain 250 KIAS" call. This would not have happened if the PF had strictly minded the store and let the first officer handle the problem. What actually happened to cause the excursion was the application of too much power at once for the FMS/Autopilot to properly control with autothrottles. FLIGHT LEVEL CHANGE feeds in power gradually. Using manual throttles, setting full climb power, and hitting flight level change was too much. The PF had been on advanced/automated aircraft for about 12 years and his basic flying skills had deteriorated somewhat, autothrottles caused him not to know basic power settings etc. The PF intended to do more flying "raw data" and manual throttles when conditions permit, in the hope he could keep from doing this sort of thing in the future. **JIMDAT Analysis:** Applicable (energy state management) **Comments:** Crew had allowed skills to deteriorate could not associate power setting (EPR; fuel flow; etc.) with configuration to get in ball park; some distraction
3	**278778b**	**Synopsis** An MD-11 flight crew experienced a stick-shaker activation during level-off and in a 25 degree bank during radar vectoring on approach. **Narrative** During arrival into destination, stick shaker activation occurred during intermediate level-off. Autopilot and autothrottles were operative and on. Assigned speed was 210 knots. FMS generated a minimum speed called a "foot," and this "foot" was indicated on the airspeed indicator on the "primary flight display" (PFD). Company policy was that "foot" plus 5 knots was minimum maneuvering speed. The "foot" indicated 203 knots, so 210 knots was 2 knots above minimum maneuvering speed. As the aircraft approached the 8,000 foot assigned altitude, the crew was assigned a new heading. The first officer, pilot flying (PF), took his left hand from its "monitoring" position on the throttles to select the new heading. The aircraft rolled to approx 25 degrees of bank. The PF recalled being surprised that the bank limiter (also in auto) had not prevented a 25 degree bank at that airspeed. Simultaneously, the aircraft leveled at 8,000 feet, and as his hand returned to the throttles, he noticed only a small increase from idle, and slow forward movement. He then returned his attention to the PFD and noticed the airspeed dropping rapidly through the foot. He overrode the throttles with a moderate force, anticipating engine spool-up. His input was insufficient to prevent further decay in airspeed. As he was increasing thrust, the airspeed dropped to about 192 knots, and stick shaker activation occurred. He rolled level, and performed a stall recovery while the captain extended the slats.

		Analysis: autothrottle response was much too gradual. Since they were operative, does the software not respond rapidly enough in this situation? "Foot" plus 5 knots may not be an adequate maneuvering speed in all situations. Human reaction time should be considered, as well as other factors. Autobank limits need to be reviewed. The PF didn't think the software worked the way the manual said it would. Callback conversation with reporter revealed the following information: callback to reporter revealed that he had submitted this report to the union, and was in the process of detailing a report to his company. He indicated that there were no previous events of this nature, at least to his knowledge, with the MD-11. He stated that he had thought that the bank angle limiter would not allow 25 degrees of bank at Vref minimum maneuvering plus 5 knots, thinking that it would be based on airspeed and configuration at that altitude. The pilot's operating manual confirmed that bank is dependent upon airspeed, stall and buffet margins. He replied, when questioned, that yes, the flaps and slats were retracted for fuel savings considerations. The auto thrust response when the aircraft leveled off was too slow and the first officer stated that his action of applying some thrust was too slow as he saw the throttles move but expected a faster movement than he got. The throttles tended to be sluggish from idle position when transitioning from speed on pitch control to speed on thrust control. Reporter summed up his concerns with: the speed of "foot" plus 5 was too low. ("foot" was the minimum maneuver speed for configuration). Could this have indicated a possible problem with the software of the ATS system? Better education and information was required for the flight crews on the auto bank angle limits. **JIMDAT Analysis:** Applicable (energy management) **Comments:** Crew procedural error; systems knowledge; configuration options for fuel savings may be questionable
4	**296218b**	**Synopsis** A B757-200 **flight crew** failed to intercept an airway. **Narrative** On departure from origin the crew was cleared direct to INT 1 by Departure Control. They were then switched to Center frequency. As they approached INT 1, Center gave them a heading 20 degrees to the left to intercept J225. At the same time, Center cleared them to climb to FL230. The captain was the pilot flying (PF) the aircraft, and made the entry into the FMC for the intercept. He then made the necessary entries to commence the climb to FL230. While doing this, the aircraft flew through the radials of J225 without capturing. The first officer, pilot monitoring (PM), and the PF both saw this, and the PF started a turn back to the airway. At the same time, Center advised them they were almost 5 miles east of J225. He gave them a left turn back and stopped their climb at 16,000 feet. As they approached J225, Center cleared them direct to FIX 1 and resumed their climb to FL230. They then proceeded to destination. The PF felt that the lack of experience of both pilots in the B757 contributed greatly to the overshoot. Before the 757, the PF flew the B727 and the first officer was a captain on the F28. Both pilots had been on the aircraft for about 2 months. In the PF's briefing, he emphasized this point so that they would be especially aware and careful. This was the first leg of a 4-day trip, and since both pilots were operating a bit slower than they would have liked, it might have been wiser not to use so much of the "magic." The PF felt he also should have just flown the aircraft instead of making all the entries. Good procedure is the PF flies, the pilot monitoring (PM) does all the computer entries, and executes upon the PF checking and agreeing. The PF made sure they did this for the remainder of the trip. He had flown this leg many times over the years. A new work environment, a first officer and captain new in the equipment made even doing something they had done many times before feel totally new. Callback conversation with the reporter revealed the following information: the reporter and the first officer were both new to the B757. They had never flown together before in any aircraft, and had only met at the school house in a refresher program. The reporter believed

		that he failed to hit LNAV to direct the aircraft to intercept the radial. The reporter had to fly and type at the same time while the first officer was verifying the location of the intersection on a chart. There was always one more button to push on these fancy aircraft. Supplemental information from report 296783: the flight area high altitude area chart should have been reissued. It was much less cluttered and easier to read in the crowded northeast corridor. The commercial high altitude #8 chart was a spaghetti bowl in this area and difficult to pinpoint position, especially in a hurry. Callback conversation with the reporter revealed the following information: the reporting first officer recently downgraded to the B757 first officer seat after 14 years as an F28 captain. Both he and the captain were brand new to the 757 and each other. His air carrier tried to avoid pairing 2 new crew members but sometimes the system failed. The reporter believed that the captain did not push the LNAV button hard enough and that both of them did not check to see that LNAV was initiated. The reporter had not heard from the FAA on this incident. From the pre-takeoff briefing and a brief social encounter, the first officer believed the captain to be "very professional." The first officer said "LNAV available" but did not check to see that it was properly engaged. **JIMDAT Analysis:** Applicable **Flight Phase:** DEP/SID/CLIMB **Category:** Lateral Deviation (mode awareness) **Comments:** **Trigger:** None **Contributing Factors:** • Cross-check – Pilots did not confirm VNAV was activated • Monitor – Pilots did not monitor the intercept
5	**299148b**	**Synopsis** Altitude deviation due to altitude undershot. Flight crew misused autopilot, misinterpreted FMC data and missed crossing altitude restriction. **Narrative** While on a routine flight to destination, the crew was asked by Center to climb to FL410, or if unable, to maintain FL370 and stand by for a re-route. Both the captain and first officer were new to this aircraft model and, after selecting a higher altitude on the CDU/FMS and entering it, the maximum altitude shown on CDU was FL409. They then notified ATC that they could accept FL410. They began a climb to FL410 and as they passed FL399 they noticed the airspeed was extremely low (210 KIAS). They were in VERTICAL SPEED mode on the MCP with about 1,400 fpm selected. At the time, the captain, pilot flying (PF), noticed the low speed, they were 15 nm from their crossing restriction of FL410 at INT 1. They leveled off and then began a shallow descent to accelerate. They then again tried to climb, but airspeed began to decline. After passing their fix (INT 1) at FL399 they decided to notify ATC. They were vectored off course and leveled at FL390. They did a 360 degree turn and re-intercepted INT 1 after approximately 10 minutes of vectoring at FL410. First lesson: Do not use vertical speed mode to climb at high altitude as this could lead to stall or upset. Second lesson: be cautious of the maximum altitude message. The computer is not always correct.

		Third lesson: notify ATC in a timely manner if deviation is imminent. **JIMDAT Analysis:** Applicable **Flight Phase:** DEP/SID/CLIMB **Category:** Vertical Deviation (energy state management) **Comments:** **Trigger:** None **Contributing Factors:** • S.O.P. – High altitude; stall buffet; performance issues • Over-confidence – over-reliance on automation (but automation indicated performance issue) • Training
6	**475218b**	**Synopsis** A B777 crew inadvertently had autothrottle off and autopilot on during the takeoff roll. **Narrative** After receiving takeoff clearance for runway 13R from origin tower, the first officer, pilot flying (PF), advanced the throttles to spool up the engines. That accomplished, he hit the TOGA switch for takeoff thrust and the autothrottles did not respond, so he advanced the throttles manually and began the takeoff roll. The captain, pilot monitoring (PM), discovered the autothrottle paddle switches in the off position and turned them on. The PF pushed TOGA again, but the aircraft had already accelerated through 50 knots and the autothrottles would not engage. The captain continued pushing switches on the MODE CAL panel. At Vr, the PF attempted to rotate the aircraft to the takeoff attitude, but the elevator would not move. The aircraft rapidly accelerated through V2. Runway 13R was cut back, and there were men and equipment working on the end of the runway. The PF never considered stopping because of their speed and the equipment, so he pulled much harder on the yoke. Suddenly, the elevator snapped loose and the nose rotated rapidly. The master warning sounded, and the EICAS indicated AUTOPILOT DISCONNECT. The PF's immediate concern was to slow the rotation rate before they struck the tail. That accomplished, he canceled the master warning and flew the departure. This event should not have been possible. The captain was relatively new on the aircraft, and that was a contributing factor. His system knowledge was such that he continued to attempt autothrottle engagement beyond 50 knots. In this critical phase of flight, the captain selected the autopilot switch instead of the autothrottle switch. The PF was concentrating on the takeoff roll and did not notice the autopilot was engaged. His reaction was to assume the elevator had jammed. He pulled the required 35 lbs. of force to disconnect the autopilot simply because there was no other option. They had to takeoff because it was too late to stop. On such a sophisticated aircraft, there should be logic that prevents the autopilot from engaging on the takeoff roll. This could have been an accident if they had attempted to stop. It also could have caused a tail strike and damaged the aircraft. Callback conversation with reporter revealed the following information: the reporter said that there was no problem with the aircraft. Autothrottles were never turned off other than for irregular procedures. In this case, maintenance had turned them off and due to a rushed departure the crew missed the fact that they were off during checklist completion. The experience level of the captain on the aircraft was less than that of the reporter. There had been a very rapid training of crews and many had similar low flight times since training was completed. In the crew debriefing, it was agreed that nothing more than the manual application of takeoff thrust was needed and that uncoordinated manipulation of the MODE

		CONTROL PANEL switches was not SOP nor advisable as was demonstrated by the problems it caused. The company has included this scenario in their recurrent training syllabus. There is an investigation being made to see if the autopilot can be biased out so it cannot be engaged on the ground. **JIMDAT Analysis:** Applicable **Flight Phase:** APPROACH/LDG **Category:** Autopilot Activated on Takeoff Roll (mode awareness) **Comments:** Requires Boeing B777 SME review **Trigger:** None **Contributing Factors:** • Over-confidence – over-reliance on automation **SME Review** • JIMDAT Analysis confirmed? • Trigger o When TOGA was selected throttles did not advance, • Contributing Factors o Over reliance on automation o Missed switch position on setup o Lack of system knowledge o Switch was not in expected configuration o AP can be engaged while on the ground • Degree of risk? High • What actions would have prevented the occurrence of this event? o Train crews to set throttles manually. o Disallow the AP engagement while on the ground (design) o Better flight deck setup o Put AT arm switch position on the checklist • Could we address this with a Policy or Procedural change? Yes, but may not be the best solution.
7	**480293b**	**Synopsis** A B777 crew had autoflight and autothrottle an**omalies** **in Class B airspace.** **Narrative** The event did not involve any aircraft or ATC violation. The scenario was related solely for advisory of an FMC malfunction. The aircraft was on final approach to runway 6L at destination, cleared to descend from FL090 to 4,000 feet. FLT LEVEL CHANGE was selected on the autopilot. The first officer was the pilot flying (PF). At +/-4,500 feet, the captain and first officer set the local altimeter to 1025 hectopascals. ATC issued a speed reduction to 210 knots. "Flaps 1 degree" was selected. SPEED and FLT LEVEL CHANGE annunciation was selected on the FMA. A yellow box appeared around the first officer's and captain's altimeters, indicating WINDOW and the aircraft leveled off at 4,150 feet. The crew then noted the ALT HOLD button illuminated. The first officer re-selected FLT LEVEL CHANGE, but the aircraft still did not descend to 4,000 feet. At this time, both the captain and first officer observed the airspeed decelerate below 190 knots with autothrottle engaged, and the speed in the MCP set to 210 knots, FLT LEVEL CHANGE selected. ATC was vectoring the aircraft toward a localizer intercept and requested the crew to "report established." The first officer added power, requested "flaps 5 degrees" and announced "autopilot coming off." The aircraft was hand-flown down to 4,000 feet and accelerated to 210

		knots. The yellow box around the altimeter indicator windows disappeared, and after approximately 60 seconds, the autopilot was re-engaged (selected) and the aircraft resumed normal speed and altitude (glideslope tracking) control. Less attention to situational awareness or an increased distraction level could have resulted in a mishap. **JIMDAT Analysis:** Applicable **Flight Phase:** APPROACH/LDG **Category:** Excess power/speed (energy state management) **Comments:** Requires Boeing B777 SME review **Trigger:** None **Contributing Factors:** None **SME Review** • JIMDAT Analysis confirmed? o Trigger? o Contributing Factors? 1. Resetting altimeter during altitude capture/acquire. 2. Possible AT computer lag o Degree of risk? LOW • What actions would have prevented the occurrence of this event? NONE • Could we address this with a Policy or Procedural change? NONE
8	**486854b**	**Synopsis** An A319 crew had a runaway autothrust system that exceeded speed limitations of the aircraft and the ATC environment. **Narrative** An autothrust incident occurred while operating an Airbus 319 in service from origin to destination. This event caused the first officer and captain to exceed an aircraft flap limitation speed of 230 knots and to inadvertently accelerate to an approximate airspeed of 310 knots below 10,000 feet. At the time of their arrival in the terminal area, weather conditions were VFR during the descent and approach phase of the flight. The captain was the pilot monitoring (PM) and the first officer was the pilot flying (PF). All autopilot, autothrust and aircraft systems were operating normally at that time. In compliance with the instructions given by Approach Control, the crew descended to an altitude of 4,000 feet msl and proceeded from INT 1 intersection on a northeast course toward the airport. Approx 8 miles west of the airport, the PM informed the Approach Controller that the crew had runway 10L in visual contact. The controller acknowledged the transmission and cleared them for a visual approach to runway 10L. As the first officer continued the descent toward runway 10L, he rested his left hand on the autothrust levers. Aircraft speed was approximately 220 knots with a flap setting of 1 degree. Approx 3 miles west of the runway 10L final approach fix, it became obvious that they were slightly high on the approach for landing on runway 10L, due to a slight quartering tailwind at their alt. The PM determined that it might be necessary to request s-turns on final to lose altitude, but before he could speak to the Approach Controller, the first officer inadvertently raised the thrust levers out of the C/L detent. At the instant the PM observed this action, he advised the first officer to immediately return the thrust levers to the C/L detent. The PM also noted that he had barely retarded the thrust levers 1/8 inch back from the C/L detent. The first officer returned the thrust levers to the C/L detent, but the aircraft began to accelerate as thrust significantly increased. No ECAM message or menu action was present on the ENG/WARNING display and the autothrust column of the primary

		flight display was blank. As the aircraft accelerated through 230 knots, master warning and master caution lights illuminated, the PFD OVERUSED indication came into view and the aural warning was initiated. In response to these warnings, the PM stated to the first officer, "I have the aircraft." The PM pulled the SELECTED SPEED knob in an effort to reset the AUTOTHRUST SPEED mode of the system, but this action proved unsuccessful. At that point, the aircraft had quickly accelerated to approx 250 knots. The PM retracted the flaps and scanned the PFD, the flight control unit and the ECAM warning display for any enhanced information that would explain the uncommanded autothrust acceleration. He also advised the Approach Controller that they were experiencing difficulties. The company Airbus 319/320/321 Pilot Operating Handbook clearly stated that one must retard the thrust levers to the idle detent in order to disconnect the autothrottle system. The first officer had only removed the thrust levers from the C/L detent and had not retarded the thrust levers more than 1/8 inch. The thrust levers had never been retarded to the idle detent. With no ECAM warning message or PFD information regarding the status of the autothrust system, the crew was at a loss to explain why the aircraft was accelerating. As their speed approached 300 knots, the captain was about to override the autothrust acceleration by retarding the thrust levers. Prior to accomplishing this action, however, he reset the autothrust P/B and control over the autothrust system was re-established. At this point in time, their speed had reached approximately 300-310 knots. By resetting the autothrust P/B, they were able to recover control over the autothrust system. Thrust was reduced to idle, and the selected speed target of 170 knots was met. They advised Approach Control that they had successfully addressed their problem and accomplished a normal landing on runway 10L.
		
		Callback conversation with reporter revealed the following information: the incident was under investigation by the air carrier, the manufacturer and the FAA. Similar operations had been unsuccessful in duplicating the problem. The reporter did not know what maintenance had done to return the aircraft to service. The reporter was concerned that a duplication could place a crew in a dangerous position, and he would like to see some positive action taken.
		
		JIMDAT Analysis: Applicable
		
		Flight Phase: APPROACH/LDG
		
		Category: Excess power/speed (energy state management)
		
		Comments: Requires Airbus SME review
		
		Trigger: None
		
		Contributing Factors:
		• S.O.P. – PF (FO) inadvertently moved throttles out of C/L detent
		
		SME Review:
		• JIMDAT Analysis confirmed?
		  o Trigger? "TAKEOFF FLEX MCT" mode will command "climb thrust plus" autothrust in the climb detent from a 250 KIAS climb until 20 feet above the runway! It acts like a thrust limiter. (On older aircraft you would select "CLIMB THRUST," then "MCT," etc.
		  o Contributing Factors? Must have pickled A/T off by moving thrust levers 1/8" back; little effect; putting them back would have aggravated the problem
		  o Degree of risk? (note: "PFD OVERSPEED occurs in FLAPS 1 configuration if speed is over 230 KIAS)
		• What actions would have prevented the occurrence of this event?
		  o Do not solve an automation problem with more automation – pulled "SELECTED SPEED"
		  o Could we address this with a Policy or Procedural change? Suspect this air carrier rarely takes the aircraft out of A/T mode; the line pilot never sees

		what the manufacturer recommends – an "always use A/T" policy causes pilots to be reluctant to intervene
9	497303b	**Synopsis** A B737-300 crew did not comply with a crossing restriction issued by ATC on descent into destination. Narrative Prior to descent into destination, the first officer, pilot flying (PF), left the cockpit to use the lavatory. While in the back, he noticed that the aircraft started to descend. He returned to the cockpit and when he took over, ATC gave the crew a crossing restriction at INT 1 of 10,000 feet and 250 knots, which was in the FMC. However, the captain, pilot monitoring (PM), had the aircraft in a CRUISE DESCENT, so when the PF selected a PATH DESCENT the FMC promptly informed him they were 5,000 feet high. The PF elected to use the FGS to try to catch up. However, with tailwinds it became obvious that this was not going to work. He asked the captain to inform ATC that they could not make the restriction. The captain instead asked the PF to use LEVEL CHANGE instead of VERTICAL SPEED. The PF tried this, and the aircraft ended up in an overspeed situation and they disengaged the autopilot to regain control. The captain told ATC that they could make the altitude, but not the airspeed. The PF informed the PM that he did not think that was possible, but radio congestion and ground speed did not help and they ended up high. There was no conflict with other aircraft and ATC did not question the situation. The PF believed that a contributing factor was the fact that the PF left the cockpit at a critical time and that the captain put the aircraft in a CRUISE DESCENT instead of CAPTURE. And, the PF did not believe CRM worked in this situation. Looking back, if the captain had informed ATC as requested, and they had talked about it later, being that time was critical, and this would have been the safest and most conservative thing to do, a possible conflict would have been avoided. Supplemental information from report 497080: the first officer was pilot flying (PF) when ATC cleared the crew to cross INT 1 intersection at 10,000 feet. The FMC went to VNAV SPEED versus VNAV PATH and the aircraft was 2,000 feet high at INT 1. ATC said to delete the 250 speed restriction and to try to make INT 1 at 10,000 feet. The altitude at INT 1 was approximately 12,000 feet msl. The captain, pilot monitoring (PM), was making the in-range call to company, passenger arrival PA, and accomplishing in-range call during descent, and was not monitoring vertical path. **JIMDAT Analysis:** Applicable **Flight Phase:** DEP/SID/CLIMB **Category:** Vertical deviation (mode awareness & energy state management) **Comments:** None **Trigger:** None **Contributing Factors:** • CRM – PF left cockpit at critical time; PM put VNAV in CRUISE DESCENT vs. CAPTURE • VERTICAL SPEED mode vs. PATH mode • Monitoring - pilot monitoring (PM), was making the in-range call to company, passenger arrival PA, and accomplishing in-range call during descent, and was not monitoring vertical path.
10	509560b	**Synopsis** A B737-300 flight crew did not perceive a gradual climb and conflict with another air carrier

		while under Center control. **Narrative** The aircraft was cruising at FL270, approximately 90 nm southwest of FIX 1 (autopilot and autothrottle on). The crew was given a "pilot's discretion" descent to FL250 (which was set in the altitude window) and asked to keep their airspeed fast. The captain, pilot flying (PF), deselected VNAV (which put the aircraft in SPEED mode where aircraft varies pitch to maintain airspeed) and rotated selected speed from 310 knots to 325 knots. Approx 2 minutes later, Center called out traffic at 10 nm (FL280). At approx 6-8 nm, the crew received a yellow TCAS II alert. All 3 heads (including the jump seat rider) went outside. The crew acquired the traffic at 4-5 nm. As the PF watched the traffic, he noticed the vertical distance between the two aircraft was decreasing. At that point, he looked inside and noticed the autopilot had climbed the aircraft to FL275. The PF disconnected the autopilot and returned the aircraft to FL270 as the traffic was approx 2 - 2 1/2 nm from them, displaced laterally 2 - 2 1/2 mi and 800-1000 feet vertically. Analysis: by having the altitude window set at FL250, the crew received no altitude deviation warning as the aircraft climbed. A little known fact (and one the PF had forgotten) is that placing autothrottle in SPEED mode causes the autopilot to vary pitch to maintain airspeed. By selecting a greater speed, the aircraft at some point started a very slow, insidious pitch up that was not caught until the traffic was acquired visually. All eyes were looking outside to acquire conflicting traffic. Causes (3) This problem, like all accidents or near accidents, occurred because of an unlucky chain of events: the altitude window was set to a lower altitude, a bad computer program allowed/caused the autopilot to leave an altitude when in ALT HOLD mode without any warning, and thirdly all eyes outside for close-in traffic. Fix: the first (altitude window set to lower altitude) and third causes (all eyes outside) were normal pilot functions and can't be changed. The one cause that should be changed is the computer program that causes an aircraft to leave an altitude when in ALT HOLD without selecting a vertical mode (LEVEL CHANGE or VERTICAL SPEED or VNAV through computer input by the pilot). Important note: if in VNAV and altitude window is not set to another altitude, de-selecting VNAV to get SPEED mode causes mode annunciator to change to ALT HOLD but by having a different altitude selected, autopilot changes to a PITCH mode. Why 2 autopilots should always stay in ALT HOLD unless commanded by a vertical mode as stated above. Supplemental information from report 509162: The pilot had just finished his 3-day trip and had to run and catch his commute. He was looking forward to a nap since he had been up since early morning. He was informed that the flight was full and he would have to ride the jump seat. The trip was uneventful until the first TA. He was in the center jump seat at the time, during cruise, drifting in and out of consciousness until he heard a "traffic, traffic" TA and looked up at the captain's ADI and noticed traffic at the 12 o'clock position and closing. He could not tell if the traffic was above or below them as the symbol +/- was on the lubber line and could not be distinguished. While still trying to gain his full attention to the event, he noticed the target descending and the TA converted to an RA. The captain responded to the RA and descended. Only at that point did they all realize they were at FL272 and climbing. At that time, the other aircraft stated that he was responding to an RA, at which point the controller asked what the jumpseater aircraft's altitude was. At that time, they had returned to FL270 and that was what was reported to ATC. At that point he noticed that FL250 was selected in the altitude selector on the MCP. The Center controller asked the other aircraft "how close did he come to you?" and he responded with "500 feet." it appeared that ATC had issued them a clearance to descend at pilot's discretion to FL250. The captain had dialed in FL250 in the MCP and did not have a pitch mode engaged. To him, it appeared that inefficient use of the FMC/FMS contributed to this event. As for his part in this, he did not

		want to be there (in the cockpit) because he was tired and anxious to get home. **JIMDAT Analysis:** Applicable **Flight Phase:** DESCENT **Category:** Vertical Deviation (energy state management & mode awareness) **Comments:** Boeing SME should analyze; PF seems to have incorrectly rationalized function of SPD mode (thrust should vary, not pitch, to control speed). **Trigger:** None **Contributing Factors:** S.O.P. – PF set FL250 in MCP with no pitch mode engaged **SME Review** • JIMDAT Analysis confirmed? • Trigger? o Deselecting VNAV. • Contributing Factors? o Increase in airspeed o Changed altitude on mode control panel o Crew was looking outside for traffic o Failure to fly and monitor o Design of the CWS function • Degree of risk? HIGH • What actions would have prevented the occurrence of this event? o Selecting an appropriate pitch mode rather than deselecting VNAV o Pilot flying should have maintained mode awareness o Add crew training to improve understanding of CWS AP mode • Could we address this with a Policy or Procedural change? o Additional guidance on pitch mode changes • SME Comments Comments made by crew on "bad computer program" are incorrect. The system functioned the way it was designed.
11	**525434b**	**Synopsis** A B757 flight crew descended below the planned altitude crossing restriction at INT 1 intersection during the FMS visual approach to destination. **Narrative** The crew had been cleared for the FMS visual runway 28R at destination airport by destination Approach Control, and advised to contact destination tower. Destination tower subsequently gave them clearance to land on runway 28R. The aircraft was between INT 2 and INT 1 intersections, where the published minimum crossing altitude for INT 1 intersection on the FMS visual approach was 1,800 feet msl. The first officer, who was the pilot flying (PF) at the time, had set the altitude on the MCP at 1,000 feet msl, which was approximately 1,000 feet AGL. During the descent on the approach, the crew was advised that they would have traffic on the parallel runway, runway 28L. At the time, they were trying to obtain visual contact with the reported traffic and pick up the airport visually. The first officer had informed the captain, pilot monitoring (PM), that he had never flown into destination before, so the PM was trying to assist him in making visual contact with the airport by reference to other visual clues. Before reaching INT 1 intersection, the PM noticed that the aircraft had descended several hundred feet below the 1,800 foot msl required crossing altitude for INT 1 intersection. He brought this to the attention of the first officer and the PF immediately began making a correction to get back onto the proper descent profile. Destination tower then called

		to inform them tower had a low altitude alert on their aircraft. The crew acknowledged the report and proceeded with the approach to a normal landing. There were several factors that the PM believed led the crew into this situation. After landing, he discussed what had happened with the first officer. The PM learned that in order to obtain a higher rate of descent, the PF had selected the FLIGHT LEVEL CHANGE mode on the VERTICAL NAV portion of the MCP rather than VNAV. In VNAV mode, all of the altitude constraints on the approach would have been honored by the FMC, whereas in the FLIGHT LEVEL CHANGE mode, only the altitude selected in the altitude window of the MCP would be honored. This was set at 1,000 feet msl. Distractions such as reported traffic approaching the parallel runway, responding to configuration changes and checklist requests by the PF, and trying to help the first officer visually pick up the runway all contributed to the PM's lack of altitude awareness, but perhaps the biggest factor was from the complacency of being in visual conditions, knowing they had safe ground clearance, having been cleared to land, and being focused mainly and establishing visual contact and alignment with the runway of intended landing. One factor that would have prevented descent below 1,800 feet msl was if the altitude window had been set to 1,800 feet msl on the MCP. Other than that, altitude awareness must be maintained as a priority on visual approaches, as if they are being flown in inst conditions. **JIMDAT Analysis:** Applicable **Flight Phase:** APPROACH/LDG **Category:** Altitude Deviation (energy state management) **Comments:** **Trigger:** None **Contributing Factors:** • CRM – • Procedural error in inserting 1,000 feet in MCP (possibly inserted to verify "stable approach" criteria?) • Distraction - reported traffic approaching the parallel runway, responding to configuration changes and checklist requests • Complacency – Visual approach
12	**526009b**	**Synopsis** A B737-800 crew, descending into destination, slowed to 250 knots without advising ATC. **Narrative** The crew was flying into destination on the FIX 1 Two arrival. The FMC was programmed for the descent to arrive at INT 1 at 11,000 feet and 250 knots. The initial descent clearance was to descend to FL240 at 290 knots. The first officer was pilot flying (PF) and started a CAPTURE descent. The profile was captured normally. As the aircraft approached the level-off at FL240 the crew got a frequency change. The captain, pilot monitoring (PM), took the change and checked in with the next controller. He responded by giving them a clearance to cross INT 2 at or above 14,000 feet, to cross INT 1 at 11,000 feet and 230 knots, as well as the altimeter setting. The PM read back the clearance as the first officer programmed the FMC. The first officer was confused about the clearance and took some time setting up the descent. During the time that it took to level off, change frequencies, and set up the new descent, the crew was high on the profile and had slowed to 250 knots. The first officer was not correcting the slow speed or high profile fast enough and the PM suggested going to VERTICAL SPEED to get back on profile. In the few moments it took to work this out, the controller asked their speed. The PM told him 250 knots. ATC asked them to speed up to 300 knots and asked why they had slowed. The PM told him that the airplane had slowed because they had gotten the descent clearance late and the airplane was attempting to make

		the INT 1 restriction. ATC asked the air carrier x airplane behind them if they had any problems with the descent and they said they had no problems. He then requested they descend at 320 knots. The crew complied with all his requests. ATC told them they should not slow because he had airplanes behind them. The PM told him that the crew was about to tell ATC their speed when he asked. He was not impressed, and again asked why it had happened. He wondered if it was an FMC malfunction. The PM told him that it was energy management. The crew got no indication from the controller of any separation infractions; he just seemed annoyed. They were then handed off to destination Approach Control. Looking back, the PM realized that he should have done a better job monitoring the PF. They should not have let the FMC slow the aircraft during the level off. When the PM noticed the speed though, he should have told ATC right away. The first officer and the captain debriefed the problem after the flight and agreed to send in a report. Their debrief revealed that the first officer was concerned about the descent speed because of a restriction on the use of speed brakes above 300 knots on this aircraft. He was hesitant to speed up to make the speed restriction because of his concern for the speed brake restriction. The captain was concerned about being high on the profile and the need to speed up and get down. He did not accurately convey this point to the first officer. The first officer did not tell the captain of his concern for the speed brake restriction. They were both initially confused about the change to the profile, and were too slow in responding to the change. The new descent clearance contained two altitude restrictions, one speed restriction and an altimeter setting. They all came after a frequency change that occurred as the aircraft was leveling off during a PROFILE DESCENT. The captain saw the need to keep going down and to keep the speed up. The first officer did not sense the urgency and the captain neglected to point this out to him. They did not match the level of automation to the situation. All these helped to contribute to the speed deviation. **JIMDAT Analysis:** Applicable **Flight Phase:** STAR/ARRIVAL/HOLD **Category:** low speed (energy state management) **Comments:** **Trigger:** Profile Descent **Contributing Factors:** • CRM – both pilots confused about departing from profile • Automation mode - V/S mode might have helped • Communications – PF and PM concerns were not articulated to each other (speed up and get down vs. speed brake restriction) • Monitoring – PM felt he should have not let the PF get slow
13	**528352b**	**Synopsis** An A320 flight crew was slow to disconnect their autopilot so as to complete the turn required on the departure procedure out of origin. **Narrative** The SID at origin required an immediate right turn at the 1.8 DME, so as to complete a nearly 180 degree heading change within 4.0 DME. With the airplane on autopilot during the initial climb to 5,000 feet, the aircraft did not initiate its turn until approx 2.3 DME. The result was that the crew was unable to complete the turn by 4.0 DME, and they overshot by .8 mi. ATC immediately noticed the overshoot and requested that they expedite the turn. The first officer, pilot flying (PF), disconnected the autopilot and completed the turn manually, but was unable to tighten the turn to comply with the 4.0 DME restriction. He should have taken more prompt corrective action rather than to rely solely on the FMC database and sluggish autopilot. Better callouts by the captain, pilot monitoring (PM) could have helped to identify a potential

		deviation before it developed into an exceedence. The training received on the A319/A320 places heavy emphasis on the use of automation, and in fact discourages hand-flying the aircraft in some circumstances. In the PF's opinion, this emphasis on reliance of the airplane's flight management/ guidance system and autopilot may result in a reluctance of flight crewmembers to take positive corrective action (by hand-flying the plane) when a constraint or restriction could be exceeded.
		
		JIMDAT Analysis: Applicable
		
		Flight Phase: DEP/SID/CLIMB
		
		Category: Vertical Deviation (energy state management)
		
		Comments: Need Airbus SME to review possible automation capability issue
		
		Trigger: None
		
		Contributing Factors:
		• Over-confidence - Over-reliance on automation
		• Should pilots have selected a lower level of automation (HDG SEL) to have more turn performance in intercepting the depicted outbound course?
		• Monitoring – better call-outs
		
		SME Review:
		• JIMDAT Analysis confirmed?
		    o Trigger? We don't know for certain what they did.
		    o Contributing Factors? Pre-planning would help identify unique SID requirements and compatibility with aircraft performance envelope.
		    o Degree of risk? HIGH (if in vicinity of mountainous terrain).
		• What actions would have prevented the occurrence of this event?
		    o Pre-brief a complex departure
		    o Might have had to fly in manual mode – this procedure was not designed for automation (Moody departure at SJC)
		    o FAA should review PDARS data to revise this procedure.
		    o Don't clean up immediately; leave flaps/slats extended if necessary – may violate "clean up on schedule" S.O.P. but it's better than the alternative! Then you might be able to remain in Level III – "SELECTED SPEED" mode with more maneuverability.
		    o Some carriers would depict notes on a "10-7" page.
		• Could we address this with a Policy or Procedural change?

14	**530710b**	**Synopsis** A B757 crew, departing origin, overshot the turn restriction and exceeded 250 knots below 10,000 feet. **Narrative** This was a departure runway from runway 22L. The aircraft was in the climbing right turn to 100 degrees heading with a light load, thus it had a high initial climb rate. The crew got "ALT CAPTURE" prior to selecting climb power. Because of this, the thrust mode stayed in ERP (full climb power) during the level-off at 3,000 feet. Airspeed reached 260 knots before the captain noticed it (the first officer had not seen the problem). The captain, pilot monitoring (PM), promptly pulled the power to idle, and selected SPEED mode on the auto throttles. He also told the first officer to make sure he kept the bank angle right at 30 degrees. With the high airspeed, and 50-plus knot tailwinds at 3,000 feet that evening, the crew exceeded the 4 DME turn restriction on the departure procedure. Before the captain could inform the

controller of their deviation, he called and gave them a continued turn to 120 degrees, informed them of the deviation, also of a possible spacing conflict with a FIX 1 departure. At no time did they receive a TCAS traffic, or RA. The flight continued to the destination without further incident.

Contributing factors: first officer, pilot monitoring (PM) workload for the following reasons: rain - on the takeoff roll the aircraft flew into a rain shower, and went IMC quickly after takeoff. This focused some of the PM's attention on the radar during the climb. Transponder - prior to handing the crew off to departure, the tower informed the PM the transponder had not been turned on prior to takeoff, thus taking a little more of his attention. Ground communication - the handoff from tower to departure usually comes about the time the crew is selecting climb power and retracting the flaps. The THRUST mode programming for not going to speed (SPEED mode) when "climb power" and flight LEVEL CHANGE were selected on the THRUST MODE SELECT panel and APFDS (auto pilot flight director) system. Once again, this happens if ALTITUDE CAPTURE happens prior to climb power selection. According to the flight director programming, when a turn of more than 180 degrees is dialed in the flight director on many of the company's older B757s, the flight director will indicate the shortest turn, not the turn in the desired direction, thus taking a little more of the captain's attention to slew the heading around as the aircraft turns. Wind - 50 plus knot tailwinds at 3,000 feet in the initial turn. Climb checklist - running the climb checks while doing all of the above items. The captain had flown the B757 for 6 yrs, and had been a captain for 7 months. He was aware of all of the contributing factors he listed, but allowed himself to get distracted from monitoring the flight modes. Also, this was his third trip with this first officer. He knew he had been a B737 captain for another carrier. For this reason, the captain let his guard down a little, and did not catch the A/T mode problem until too late to avoid the airspace deviation. Also, he had considered deploying the speed brakes to slow the aircraft more rapidly and tighten the turn, but did not. Looking at this with hindsight it might have avoided the incident.

JIMDAT Analysis: Applicable

Flight Phase: DEP/SID/CLIMB

Category: Excess Speed (energy state management)

Comments: request Boeing SME review and comment.

Trigger: None

Contributing Factors:

- Distraction - possible distraction caused by slewing heading bug for large-amplitude turn
- Complacency – PF thought PM, as former captain, would provide greater support/experience
- CRM – prioritization of CLIMB checklist

SME Review

- JIMDAT Analysis confirmed?
- Trigger?
  - Not following correct procedure for low altitude level-off
- Contributing Factors?
  - Distraction - possible distraction caused by slewing heading bug for large-amplitude turn
  - Complacency – PF thought PM, as former captain, would provide greater support/experience
  - CRM – prioritization of CLIMB checklist
  - Light airplane, high rate of climb and high workload

<table>
<tr><td></td><td></td><td>
Design of thrust management system
Degree of risk? LOW
What actions would have prevented the occurrence of this event?
Selecting speed mode when the crew got altitude capture
Could we address this with a Policy or Procedural change?
Require low altitude level-off procedure
</td></tr>
<tr><td>15</td><td>532213b</td><td>
Synopsis

An A330 flight crew, on final to destination, exceeded normal approach speed, landing long.

Narrative

During the descent/approach into destination, with the captain serving as the pilot flying (PF), he turned the aircraft onto final inside the outer marker, thereby never capturing the localizer and glideslope. He then disconnected the autopilot and began a safe, about 1 dot low, initial descent. The autothrust system had an utterly ridiculous component which then matched thrust with the flight director command, not considering what the aircraft was actually doing. Thus, thrust surged to 4,000 PPH fuel flow and 180 knots, even though the pilots were trying to fly a commanded 135 knots and descent. The first officer, pilot monitoring (PM), then switched off both flight directors as per company SOP, and the speed started decreasing (idle power). The captain instructed the PM to switch the flight directors back on. He did, and the power increased to 4,000 PPH fuel flow and speed returned to 180 knots. The PM again switched the flight directors off. (He had set in an MCP altitude of 3,000 feet, their missed approach level.) The thrust decreased, as did the speed. The captain then instructed the PM to turn the flight directors back on. He complied, and thrust returned to that needed to hold 180 knot flight director altitude. At 500 feet AGL, the PM suggested a go around. The captain demurred. The PM suggested this at least one more time as they continued. The captain again refused, but retarded the thrust levers to idle (at about 300 feet AGL). The aircraft crossed the runway threshold at about 165 knots, 30 knots faster than appropriate. The aircraft landed slightly long. Observation: The PM could have assisted the captain more by selecting vertical speed -1000 early in the approach. He could have helped himself by listening to the PM.

JIMDAT Analysis: Applicable

Flight Phase: APPROACH/LDG

Category: Excess Speed (energy state management)

Comments: Need Airbus SME to explain how this phenomenon is properly handled.

Trigger: None

Contributing Factors: Questionable S.O.P.

SME Review
JIMDAT Analysis confirmed?
Trigger? Incorrect mode – in “SELECTED SPEED” for 180 KIAS (blue bug) “MANAGED SPPED” A/T mode for 135 KIAS Vref (magenta bug); Pilot failed to follow procedures for visual approach; FD commands were driving pitch up to the glide path (Some FDs have TCS (Touch Control Steering) feature)
Contributing Factors? piling up factors – (a) turned inside the Outer Marker, (b) fatigue, (c) “get home-it is,” (d) numerous 50-knot airspeed excursions
Degree of risk? High. This could have resulted in a CFIT/ALAR event; failure to go around with unstable approach at 500’ AGL
What actions would have prevented the occurrence of this event? Not beginning the approach inside the OM
</td></tr>
</table>

		• Could we address this with a Policy or Procedural change? Back to basics…"Pitch to the glideslope and power to airspeed."
16	**533158b**	**Synopsis** A B737-300 crew had an altitude deviation in Center Class A airspace after the autopilot reverted to control wheel steering mode. **Narrative** The first officer was pilot flying (PF), for this leg. The crew was at FL280 and a speed restriction was issued by Center to 280 KIAS. The controller cleared them to descend at pilot's discretion to FL240 and resume normal speed. The "B" flight autopilot was engaged in VNAV and LNAV modes. When the clearance was received and acknowledged by the captain, pilot monitoring (PM), he set FL240 in the mode controller altitude window, which the PF acknowledged per SOP. The PF then de-selected VNAV and put 300 KIAS in the MCP speed window. The autothrottles moved forward in response to the new commanded speed. It was not the PF's intent to start down to FL240 yet, since they were still about 80 miles from top of descent. The PF then moved his attention away from the MCP to get his charts for the arrival into destination, and the captain performed similar tasks. After about 30 seconds, the captain asked the PF if he knew they were in CONTROL WHEEL STEERING mode. The PF stated no, it was not his intent. At this point, he became aware the "B" autopilot was in CONTROL WHEEL STEERING mode on the EADI and the aircraft was no longer at FL280 but, because of the throttle advance, had climbed. The PF immediately disengaged the autopilot and autothrottles and started a descent to FL240. The captain called leaving FL280 for FL240 to Center. At FL240 the PF re-engaged the autopilot in the LNAV and VNAV modes. When leveled at FL240, the Center controller thanked them for a good job and gave them a frequency change to the next sector. The next day, they flew the same route in a different aircraft. Again, it was the first officer's leg, and again they received the same clearance. The PF recreated the same commands of the autopilot and MCP. When a new altitude was selected in the MCP mode and VNAV was de-selected, the autopilot immediately reverted to CONTROL WHEEL STEERING MODE. Because a new altitude was selected in the altitude window, an altitude deviation alarm was not sounded until the aircraft approached the alarm parameters for the new altitude. There was no alarm for the old altitude. The PF had flown the B737-300/500 for over 4 years and was not prepared for this response in the autoflight system. He expected the autopilot to remain in ALTITUDE HOLD until a descent mode was selected - either VNAV, LEVEL CHANGE, or VERTICAL SPEED. Because he had only selected a SPEED mode, the autoflight system reverted to control wheel steering. The lack of deviation alarm was another "gotcha." The first officer is now very aware of these autoflight limitations, and hopes his experience can prevent others from falling into the same trap. **JIMDAT Analysis:** Applicable **Flight Phase:** DESCENT **Category:** Vertical Deviation (mode awareness) **Comments:** Need Boeing SME to investigated CWS reversion in this sequence. **Trigger:** None **Contributing Factors:** Procedural error: PF de-selected VNAV and set a new assigned SPEED in the MCP expecting to remain level – throttles increased and aircraft climbed **SME Review** • JIMDAT Analysis confirmed? • Trigger? o Deselecting VNAV. When you de-select a pitch mode, the A/P goes to CWS

		mode. The correct S.O.P. is to select a mode you do want vs. what you don't want. When control pressure is released, A/P holds existing attitude • Contributing Factors? o Increase in airspeed o Changed altitude on mode control panel o Failure to fly and monitor o Design of the CWS function • Degree of risk? HIGH • What actions would have prevented the occurrence of this event? o Selecting an appropriate pitch mode rather than deselecting VNAV o Pilot flying should have maintained mode awareness o Add crew training to improve understanding of CWS AP mode • Could we address this with a Policy or Procedural change? o Additional guidance on pitch mode changes
17	**535228b**	**Synopsis** A B737-800 flight crew miscalculated FMS programming and undershot intermediate crossing restrictions on the INT 1 one STAR. **Narrative** Enroute from origin to destination the crew was stepped down from their cruise altitude several times. The last cruise altitude was FL190. The Check Captain was in the right seat conducting an IOE for the captain in the left seat. The captain was using the "CRUISE DESCENT" VNAV mode to accomplish descent to the new altitudes. While descending in this "CRUISE DESCENT" VNAV mode, the crew was cleared to descend via the INT 1 one arrival. The captain set 10,000 feet in the MODE CONTROL PANEL to enable the aircraft to descend and cross INT 1 at 10,000 feet msl. The Check Captain reviewed the altitude constraints and waypoints loaded in the FMS and checked that the aircraft was in a VNAV PATH DESCENT. He believed that the FMS was properly programmed to comply with the STAR, however, he did not note that they were still in "CRUISE DESCENT" mode. The LEGS page showed the proper waypoints and altitude constraints, and the FMA indicated a VNAV PATH DESCENT. When the FMS transitioned (at FL190) from the "CRUISE DESCENT" mode to the appropriate PATH mode, the aircraft was approximately 2,300 feet high to cross INT 2 at 11000 ft. The aircraft had strong tailwinds (75-100 knots) and the B737-800 had a restriction prohibiting speed brake extension at indicated airspeeds above 300 knots. They were descending at about 320 KIAS at this point. The Check Captain immediately notified ATC that they would be unable to meet the altitude constraints on the arrival and asked for a vector if necessary. At the same time, they began to slow to allow speed brake extension at 300 KIAS. The controller remarked that "you'd better push it on over...that's why we gave you 19,000 feet way back there..." or something to that effect. The Check Captain advised that they would cross INT 1 at 10,000 feet. If the speed brake restriction had not prohibited their use at 320 KIAS, they could have made the constraints in spite of being high early on in the profile. The subtle difference between how VNAV "CRUISE DESCENT" and VNAV PATH DESCENT is annunciated contributed to the Check Captain's failure to recognize the deviation high off the desired path early in the descent. Supplemental information from report 535230: The IOE Captain selected FL190 on the FMC cruise page. The EFIS map showed a new top of descent position for FL190, however, "CRUISE DESCENT" mode took precedence, and when the aircraft crossed the top of descent point it was approximately 2,300 feet high on the profile to cross INT 2 at 11,000 feet and INT 1 at 10,000 feet. Without the speed brake restriction, all altitudes would have been met. Callback conversation with reporter revealed the following information: reporter acknowledged that he did not properly plan for the new STAR procedure and that this IOE check ride was also a distractor. In order to "get ahead" of the FMS, it was discussed that the

		crew would add anti-ice "on" and add another 30 knots tailwind to "further trick" the FMS to ensure that they were able to meet the tightly positioned crossing restrictions. **JIMDAT Analysis:** Applicable **Flight Phase:** ARRIVAL/STAR/HOLD **Category:** Excess Speed & Vertical Deviation (energy state management) **Comments:** Procedural error; request Boeing SME comment on "subtle difference" between Cruise Descent and VNAV Path; SME comment on automation "work-arounds." **Trigger:** Cruise Descent **Contributing Factors:** Procedural error: PF selected FL190 on the FMC CRUISE page. The EFIS map showed a new top of descent position for FL190, however, "CRUISE DESCENT" mode took precedence, and when the aircraft crossed the top of descent point it was approximately 2,300 feet high on the profile to cross INT 2 at 11,000 feet and INT 1 at 10,000 feet. **SME Review** • JIMDAT Analysis confirmed? • Trigger? o Using VNAV cruise descent • Contributing Factors? o FMA system design in respect to annunciations. o Over reliance on automation o Winds • Degree of risk? MEDIUM • What actions would have prevented the occurrence of this event? o Not using cruise descent near top of descent o Manually computing descent to backup the automation • Could we address this with a Policy or Procedural change? o Policy of 50 miles from top of descent do not allow the use of cruise descent
18	**536359b**	**Synopsis** An A300 cargo flight crew missed their altitude crossing restriction by 500 feet because of an FMC level-off response to an overspeed condition 15 miles north of destination. **Narrative** The flight was inbound to destination on the FIX 1 arrival. The first descent clearance was to FL240, maximum forward speed. The subsequent clearance was to cross 15 nm north of FIX 1 at 12,000 feet, expect direct FIX 1. The captain entered the constraint into the FMS while still proceeding on the INT 1 transition at maximum forward speed. The aircraft autoflight system was engaged in the PROFILE mode and indicated that the aircraft would make the crossing restriction. Several miles later they were cleared direct FIX 1 with the same crossing restriction. After entering the DIRECT TO in the FMS and completing calculations, the autoflight system then nosed the aircraft over to make the restriction. While going through approximately 16,000 feet, aircraft airspeed rapidly went into redline, triggering the overspeed warning and the autoflight system to level off the aircraft to regain airspeed control. The captain selected a lower level of automation and continued the descent. The level-off caused the crew to miss the crossing restriction by 500 feet. Just as they realized their inability to make the restriction, ATC asked if they were going to make it and the first officer, pilot monitoring (PM), responded that they were not. With no further comment, the controller handed the aircraft over to Approach Control. Fully automated flight sequences

		were sometimes not able to handle quick changes and profiles other than “standard.” Maximum forward speed, and the direct clearance caused the aircraft to descend at a faster rate causing the overspeed. Full automation is not programmed to handle “expect” clearances. Perhaps going to a lower level of automation earlier would have prevented the overspeed and subsequent level-off. **JIMDAT Analysis:** Applicable **Flight Phase:** DESCENT **Category:** Excess Speed & Vertical Deviation (energy state management) **Comments:** Airbus SME comment required; possible automation-induced energy state management issue **Trigger:** Missed Crossing Restriction **Contributing Factors:** Procedural error; PF selected PROFILE DESCENT mode at maximum forward speed, causing overspeed warning and speed protection level-off **SME Review** • JIMDAT Analysis confirmed? o Trigger? The parameters were “maxed out” – you couldn’t get any more “limiting” o Contributing Factors? Over-confidence; fell for ATC clearance “trap” o Degree of risk? LIGHT TO MODERATE – pilots sacrificed maneuverability through poor energy state management; could lead to being “boxed in” if a greater emergency occurred (TCAS RA, EGPWS escape maneuver, etc.) • What actions would have prevented the occurrence of this event? Keep an “ace in the hole.” Don’t give up all your “tools.” Better Captain Upgrade training – TWA had a 6-month IOE process. • Could we address this with a Policy or Procedural change? Emphasize situational awareness; pilots must realize they cannot really maneuver at Vmmo
19	**541533b**	**Synopsis** An A319 crew, on approach to destination, experienced an unexplained thrust increase and climb with localizer capture. **Narrative** The aircraft was on approach to runway 36R at destination, 8 nm south of INT 1 intersection. The first officer was the pilot flying (PF) with the autopilot on. The crew was given an intercept heading and “cleared for approach” at 3,600 feet msl. The first officer armed the autopilot for approach. As soon as the localizer captured, the autothrust increased, and the aircraft started to climb like it was trying to capture the glideslope. The first officer disconnected the autopilot to recapture the altitude. The aircraft climbed to 4,300 feet before the crew quickly recovered to 3,600 feet. The crew also slightly overshot the localizer course during this recovery. Once they were back to 3,600 feet and on the localizer course, they re-engaged the autopilot then re-selected the ILS approach. The remainder of the approach was normal. Evidently the autopilot sensed a false glideslope. **JIMDAT Analysis:** Applicable **Flight Phase:** ARRIVAL/STAR/HOLD **Category:** Excess Power/Speed (energy state management) **Comments:** requires Airbus SME comment - possible software or S.O.P. issue?

		Trigger: None
		
		Contributing Factors: None
		
		SME Review
		• JIMDAT Analysis confirmed?
		  o Trigger?
		  o Contributing Factors?
		    1. Software has been corrected
		    2. Crew trapped error, but at 3,000 feet AGL you would not expect to have G/S capture until 9 miles out.
		    3. UA places high value on 3:1 crosscheck for situational awareness
		  o Degree of risk?
		• What actions would have prevented the occurrence of this event?
		• Could we address this with a Policy or Procedural change?

20	**542504b**	**Synopsis**
		
		An A319 crew, on approach to destination, experienced an unexplained thrust increase and climb when the autoflight system was armed to fly the approach.
		
		Narrative
		
		The crew was cleared to intercept the ILS 3R localizer approaching destination at 3,000 feet on a 010 degree heading, and was told to fly 170 knots until the outer marker. The A319 had just captured the 3,000 foot altitude, the APPROACH push button was armed for the approach, and the aircraft was approximately 14 miles from the runway. Autopilot #1 was activated with autothrust also activated. APPROACH mode was activated and a speed 170 knots selected. Within 2 or 3 seconds of arming the approach, the A319 thrust went to TOGA and initiated a steep climb. The captain, pilot flying (PF), surveyed the situation, and decided to disengage the autopilot and autothrust. The aircraft had climbed to approximately 4,500 feet before he took control of the aircraft and descended back to 3,000 feet. Once on the ground, the crew made several phone calls to the training department. The people in training thought that this was a problem of the past. Apparently the A319 would do exactly what was described when the aircraft was more than 10 miles from the runway. It sensed a glideslope well above the aircraft altitude, and made inputs to intercept. Training thought the software was changed, and so they did not emphasize this type of scenario during training. A bulletin describing this to Airbus pilots was needed, as well as changes to the software.
		
		JIMDAT Analysis: Applicable
		
		Flight Phase: ARRIVAL/STAR/HOLD
		
		Category: Excess Power/Speed (energy state management)
		
		Comments: requires Airbus SME comment - possible software issue.
		
		Trigger: None
		
		Contributing Factors: None
		
		SME Review
		• JIMDAT Analysis confirmed?
		  o Trigger? None
		  o Contributing Factors?
		    1. 1,500’ altitude gain to get it under control?
		    2. Don’t know if he was clean and slow, or had flaps extended (1, 2 or 3)
		    3. Not enough data to know how slow they got for given configuration

		4. 14 miles from the facility/glideslope should have been at 4,500' 5. Did "Alpha Floor Protection" kick in with corresponding pitch up/steep climb? 6. TOGA – power goes to takeoff thrust setting! o Degree of risk? Not conclusive • What actions would have prevented the occurrence of this event? o Operationally, most pilots "fear" Alpha Floor Protection (i.e., they want to avoid it at all costs) • Could we address this with a Policy or Procedural change? Not enough information
21	**543549b**	**Synopsis** A B737-300 crew descended below the charted altitude restriction on the INT 2 STAR into destination. **Narrative** Flying to destination, the first officer, pilot flying (PF), was given clearance for the profile descent (the INT 2 One arrival). Even though he had seen this type profile years ago flying into another destination, this was the first one he had actually flown in quite some time. He put 8,000 feet in the altitude window, which is the restriction at INT 2. At the time, the aircraft was southwest of FIX 1. At the time the clearance was received, the crew was at FL250. As he customarily did, the PF selected the DESCENT page on the FMC to monitor the vertical speed required to meet any altitude restriction. As opposed to waiting for an idle descent, he normally initiated the descent prior to the vertical speed requiring 2,000 fpm by selecting the CAPTURE mode. This mode selects a 1,000 fpm descent until the aircraft intercepts an idle descent glide path whereupon the thrust levers retard to idle and the autopilot initiates the idle descent. After accomplishing this task, he started to brief the approach to runway 9L in accordance with company policy. His attention was diverted while doing so, and he did not realize that the aircraft had descended below the "at or above" restriction at FIX 2 which was FL220. ApproachingFL210, the VNAV mode disengaged giving a warning light which drew the captain's attention and the crew discovered the deviation. The first officer immediately stopped the descent manually and corrected to altitude. The crew was probably 4-5 DME southwest of FIX 2 at the time. Initially, both the captain and PF were unsure why the automation, with the restrictions entered into the FMC, did not comply with the profile descent. The more the PF thought about it, the more he realized if he had let the aircraft descend at the selected IDLE DESCENT POINT instead of using the CAPTURE mode, the problem would have been avoided. In addition, with a profile descent clearance being somewhat out of the ordinary for him, he should not have allowed himself to be distracted by briefing the approach without ensuring the automation was actually complying with the published altitude restriction on the arrival. The PF admittedly was probably too complacent, feeling comfortable with the FMC and doing something he normally does on descents without considering how this one was a little different from what he had been accustomed to. **JIMDAT Analysis:** Applicable **Flight Phase:** ARRIVAL/STAR/HOLD **Category:** Power/Airspeed Loss (energy state management) **Comments:** **Trigger:** Profile Descent **Contributing Factors:** • Complacency – PF was comfortable on descents; did not recognize this was out of ordinary • Distraction – briefed approach before verifying automation would respect altitude restriction • Proficiency – had not flown profile descent in a while

<table>
<tr><td>22</td><td>546623b</td><td>

Synopsis

An A320 captain forgot to activate the APPROACH phase before activating the MANAGED SPEED autopilot feature during a visual approach, resulting in the aircraft automatically going to climb thrust.

Narrative

This flight was scheduled to destination. There was an FAA inspector on the jump seat conducting an enroute check. Destination was conducting visual approaches to runway 28R&L. The descent and approach went fine until the captain, pilot flying (PF) requested the first officer, pilot monitoring (PM), to select MANAGED SPEED. Both pilots suddenly realized they had forgotten to activate and confirm the APPROACH phase, because the commanded speed went to the green dot (210 knots) and autothrottle to climb thrust. They immediately corrected, the PF closed the thrust levers (now manual thrust), but now he had a great deal of excess energy to dissipate. He almost went around, but made a couple of s-turns on the final approach with tower's concurrence. He was stabilized by 500 feet AGL and made a smooth landing in the touchdown zone, on speed. The PF didn't believe any violations occurred, but the inspector was not impressed! The PF had flown this aircraft almost 34 (?) years, and this was the first time he had been bitten by this mistake. Why they forgot to activate the APPROACH phase he couldn't explain. He was reluctant to say they were distracted by being observed, but maybe. He did believe, however, that the design of this software is very poor and he knew of many Airbus pilots who had experienced this. He doubted he would forget again.

JIMDAT Analysis: Applicable

Flight Phase: APPROACH/LDG

Category: Power/Airspeed Loss (energy state management)

Comments:

Trigger: None

Contributing Factors:

- Over-confidence – PF had never made this mistake before
- Cross-check – PF and PM failed to execute/confirm mode selection
- Distraction – Visual approaches
- Monitoring - PM failed to check for APPROACH mode selection before responding to PF's call for MANAGED SPEED
- CRM -

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<tr><td>23</td><td>546716b</td><td>

Synopsis

A Fokker 100 pilot became distracted during approach and failed to notice the autothrottles were not engaged. The aircraft slowed below minimum approach speed.

Narrative

The aircraft was abeam the airport at 6,000 feet, 210 knots and heading 190 degrees. The captain was the pilot flying (PF). Approach Control indicated that the crew should expect a short approach. They received a descent clearance to 3,000 feet. The PF selected 180 knots, activated the speed brakes momentarily, and requested flaps 8 degrees. Shortly thereafter the PF requested flaps 15 degrees. He asked the first officer, pilot monitoring (PM), to advise Approach Control that the runway was in sight. The first officer complied. Approach Control stated that a regional jet was at the crew's 9 o'clock position. The PF could not find the traffic. Approach Control stated that they should expect a left turn. This was followed almost immediately by another transmission directing the crew to turn left to 90

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		degrees, along with a visual approach clearance. The autopilot was engaged, as were, the PF believed, the auto throttles. The PF turned his attention to the FLIGHT mode panel and dialed a left turn to 90 degrees. As he scanned the primary flight display, he saw a long decreasing airspeed trend line. The indicated airspeed was at or slightly below Vma. The PF corrected by swiftly and smoothly adding power. Safe airspeed was achieved swiftly. The PF believed that ALPHA MODE PROTECTION had engaged. The rest of the flight continued safely and normally. In his own review of what caused this event, several failures on the PF's behalf became evident. He had disconnected the autothrottles in order to effect a smooth airspeed reduction from approximately 300 knots back to 210 knots. During the subsequent descent to 3,000 feet, he selected the autothrottles back on by arming the autothrottles switch on the flight mode panel. He failed to ensure that the green select light under the indicated airspeed knob was illuminated. Because of this, he would not have been sure that the selected mode was active. He was no longer flying the aircraft. He failed to adequately communicate with the first officer that the autothrottles were off when he intended them to be off. Likewise, he did not effectively communicate when he intended for them to be back on. He did not seek a confirmation from the first officer on either occasion. He allowed himself to be distracted. He failed to set priorities. He was overly indulged in spotting traffic. The traffic posed no threat to their safety. However, in a misplaced effort to get the job done he allowed his attention to digress from the real job of flying the aircraft. He placed an over-reliance on automation. He failed to confirm mode selection of the autothrottles. He failed to keep scanning. In analyzing the failures that led to this event, it has given him a greater awareness of the following: 1) prioritization of tasks. 2) CRM. Effective communication is speaking and receiving a response. 3) automation - always confirm that the commanded mode is active. Continue to scan instrumentation. **JIMDAT Analysis:** Applicable **Flight Phase:** APPROACH/LDG **Category:** Power/Airspeed Loss (energy state management) **Comments:** **Trigger:** None **Contributing Factors:** • Over-confidence – PF place high reliance on automation • Cross-check – PF failed to confirm mode selection of autothrottles • Distraction – PF paid too much attention to traffic that posed no threat • Communication – PF failed to announce autothrottles were off when he wanted them to be off or when he wanted them to be back on • CRM -
24	**563893b**	**Synopsis** A B737-300 crew, in cruise at FL370, discovered the autopilot was in CONTROL WHEEL STEERING instead of in LNAV, as assumed. **Narrative** After leveling off at FL370, the captain, pilot monitoring (PM), needed to use the restroom. Sometime during the process of putting on oxygen and the captain leaving the flight deck, the aircraft was cleared direct to the FIX 1 VOR. The first officer, pilot flying (PF), remembered doing the direct intercept on the FMC and executing the command, and noting the aircraft making a slight right turn. Seeing the aircraft turn, the PF assumed the intercept was complete, and directed his attention to the cockpit door, and the captain exiting, and the flight attendant entering the cockpit. After the captain returned to the cockpit and pinned the door, and put his headset on, Center called with a frequency change and acted as though they had been calling and they missed the call. Upon switching to the new center frequency,

		the crew was asked if they were going direct to INT 1. After checking the FMC and MCP, the PF noted that the aircraft was in CONTROL WHEEL STEERING on the autopilot and not navigating to any fix, but their heading was close to a heading that was direct INT 1. The captain told Center no, but the crew could go direct INT 1. Center cleared the crew direct to INT 1 and noted that they were off course to FIX 2. Looking back on the event, the captain and PF concluded that they could have been in CONTROL WHEEL STEERING mode for 1 or 2 reasons. The first was the LNAV system kicked off by itself, which is unlikely. The most likely way was that when given the direct to FIX 2, the PF entered the intercept and executed the command and while the aircraft started its turn he reached up and pushed the LNAV button on the MCP, not seeing the light on, and disengaged LNAV and put the aircraft in CONTROL WHEEL STEERING. The PF must have noted the turn in direction from the initial execution of the original execution of the intercept, and because of the distraction of the captain leaving the cockpit did not notice that the aircraft was in CONTROL WHEEL STEERING. Whenever the cockpit door was opened, the PF turned in his seat and focused his total attention to the door until it was secure again. The mistake he made was not going back and ensuring that the intercept was done correctly. Any time changes in NAV or planning took place when a secondary distraction was diverting the crew's attention, they needed to recheck their work after the secondary distraction was over. Never assume that everything is okay because the aircraft initially responded to an input in a manner you expected. Supplemental information from report 564075: after returning to the cockpit and getting settled into his seat, the captain must have missed a radio call about the time the first officer was putting his oxygen mask away. The next call was to switch to Center. That controller advised the crew they were off course to FIX 2 and wanted to know if they were given direct to INT 1. The crew now believed what happened was a series of small errors that led to the course deviation. When they were given the clearance, the PF executed it in the CDU and the crew thought that out of habit he also pressed the LNAV button on the MCP. This happened as the captain distracted him by leaving the cockpit and thus requiring him to put his oxygen mask on, then the flight attendant entered the cockpit. With these distractions, he didn't realize at the time that by pressing the LNAV button he actually disengaged the LNAV. This, it is believed, is how they ended up in CONTROL WHEEL STEERING. After the captain returned to the cockpit he then missed a radio call. By the time he heard the next call the aircraft had obviously had been off course for a little while. The captain also failed to notice the CONTROL WHEEL STEERING annunciator on the AFDS. **JIMDAT Analysis:** Applicable **Flight Phase:** CRUISE **Category:** Lateral Deviation (mode awareness) **Comments:** None **Trigger:** None **Contributing Factors:** • Situational awareness - if a pilot leaves the cockpit, he should receive a brief upon return, noting any change in clearance, and any mode changes accomplished by the PF • S.O.P. - "policy manual" procedures should cut across all fleets, whereas fleet-specific procedures could go in FCOM

25	**566842b**	**Synopsis** B757-200 crew got on the back side of the power curve, and was required to descend to recover airspeed. **Narrative** Due to intermittent turbulence at FL370, the crew decided to climb to FL410. The FMC indicated it could be done and ATC and PIREPs indicated the ride was smooth. The climb took a bit of time during the last 1,500 feet to FL410 due to turbulence. The aircraft was at turbulence penetration speed. The crew remarked that they might want to let ATC know about the slow climb. Also, the aircraft had the left engine anti-ice locked open due to an MEL restriction. After level-off at FL410, the aircraft accelerated slowly to cruise speed. Aircraft weight was about 184,000 lbs. Several minutes later, after level-off, the first officer told the captain he was going to take care of some other things, and to watch the aircraft. A few minutes later, the first officer heard him say, “how did we get so slow?” The aircraft had slowed some 35 knots for no reason. All proper modes were engaged. The crew asked for, and received, a descent to FL370 to recover the lost airspeed. They used a maximum thrust setting until descent clearance was received. There was no stall warning generated, nor was the aircraft indicating any buffet. No harsh maneuvers were made to regain airspeed. The crew re-checked the aircraft weight and balance, and the numbers worked out. The FMC weight agreed with a manually calculated weight. The FMC still indicated a maximum altitude of 41,500 feet. The only thing the crew could figure was that 1 of 2 things could have happened: some kind of mountain wave, or there was not enough thrust available from the left eng due to the anti-ice being on. There was no altitude restriction listed, or warning that the crew might not be able to fly at altitude for a given weight. The only power correction applied to climb settings. **JIMDAT Analysis:** Applicable **Flight Phase:** CRUISE **Category:** Vertical Deviation (energy state management) **Comments:** FMC may have been “tricked” by the MEL on the left engine anti-ice valve and may not have taken loss of thrust into consideration **Trigger:** Back side of "Lift vs. Drag" Curve **Contributing Factors:** • Situational awareness - High altitude; high gross weight; insufficient thrust • Monitoring - PM should have closely monitored thrust vs. airspeed
26	**570020b**	**Synopsis** Flight crew of B737-300 equipped with single FMC deviated from cleared routing on SID transition. **Narrative** Takeoff weight was 89,000 lbs. The clearance was SID 9 FIX 2 transition direct destination, expect FL230. Takeoff and climb-out were normal, however, the aircraft was light and temperature was cool, so the aircraft was climbing at a high rate. As the crew was leveling at 5,000 feet as per departure procedure, they received clearance to 15,000 feet unrestricted. While on the 120 degree heading, and climbing through 9,000 feet, clearance was received to proceed direct FIX 1 VOR (at pilot’s discretion), cross the FIX 1 VOR at or above 12,000 feet, and resume the departure. The aircraft was about 3.5 miles from the FIX 1 VOR when the captain, pilot flying (PF), turned towards the VOR. The crew was basically on top of the VOR and the first officer, pilot monitoring (PM), believed he attempted to use LNAV, but it did

		not engage. The PM believed he then used raw data, which the PM had tuned in, to track outbound on the FIX 1 339 degree radial to INT 1 intersection. When the PF saw that they were tracking outbound on the 339 degree radial and coming up on INT 1 intersection, he tuned in FIX 2 VOR and the 191 degree radial inbound (011 degree course). Just a few moments before, the aircraft leveled at the crew's cruise altitude of FL230. The PM looked down and saw that his CDI was centered at the 011 degree course at INT 1.He noted that they were on about a 360 degree heading or so, pretty close to where they should have been. At this point, he looked away and started to get his charts out for destination. When he looked up about 1 - 1 1/2 minutes later, both the captain and he realized that they in fact had gone through the course at INT 1 intersection. They were about 10-12 degrees northwest of the FIX 2 191 degree radial. The captain immediately turned to correct the course. Within 15 seconds of their discovery, Center asked them if they were on a heading. The PM responded no, and then Center cleared them direct FIX 2 VOR. No other comments were received from ATC. The PM believed a factor that contributed to this was that the FMC did not realize that the aircraft had crossed the FIX 1 on the departure and it gave erroneous information for the climb and LNAV mode. The PM also believed that LNAV was not engaged as they were in HEADING SELECT when crossing INT 1, thus they did not turn at INT 1 to track the FIX 2 190 degree radial inbound. The PM learned that he should be more cognizant of the LNAV/autopilot modes, even if he was not flying. Supplemental information from report 570018: The autopilot was on. The crew was having trouble with the FMC, which would not go to FIX 1. This made the PF begin to troubleshoot the FMC and stop flying the airplane. It is company procedure for him (PF) to input the FMC with autopilot on. He was so ingrained with LNAV flying off of the FMC, that when unable to engage it and forced to transition to heading and VOR/localizer, he failed to monitor raw data (radial/DME, first officer's HSI, etc.) and continued to monitor the FMC. The captain thought he was on the PROGRESS page from FIX 1, with the next point INT 1, but was really on LEGS page, next FIX 1, then INT 1. Being the PF and trying to fix the FMC distracted him from flying the aircraft. He can't wait for the B737-700 with moving map displays like in the -300/-500's! Next time he has a problem with the FMC that requires him to transition to NAV with other than LNAV, he will direct the pilot monitoring (PM) to fix the FMC. He wondered if this would be against the company procedures. The PF guessed a problem with programming the FMC should be handled like any other problem. The PF should fly; the pilot monitoring (PM) should fix it. That is what he will do next time. **JIMDAT Analysis:** Applicable **Flight Phase:** DEPARTURE/SID/CLIMB **Category:** Lateral Deviation (mode awareness) **Comments:** None **Trigger:** None **Contributing Factors:** • Situational awareness - The captain thought he was on the PROGRESS page from FIX 1, with the next point INT 1, but was really on LEGS page; was in HDG SEL mode when he thought LNAV was engaged • Distraction - PF and tried to fix FMC; this distracted him from flying the aircraft. • Company S.O.P. (cockpit duties) – seems to infer PF should make inputs to FMS unless there is a problem • CRM crew coordination – used raw data, but exhibited over-reliance on automation • Monitoring - PM should have monitored LNAV/autopilot modes, even if he was not flying.
27	**575000b**	**Synopsis** A B737-700 flight crew deviated from cleared RNAV departure route due to malfunction of

		single FMC system. **Narrative** There was a course deviation on the LNAV departure. The first officer was the pilot flying (PF) on the flight to destination. He was on day 2 of his UOE, and the captain was the check airman flying in the right seat. The flight was being observed by FAA inspector. The crew was cleared via the INT 1 2 LNAV departure, which the first officer thoroughly briefed, and the route was closed and verified correct in the MCDU. The flight pushed back and was off. Company LNAV departure procedures were followed to the letter, and the aircraft leveled at 7,000 feet msl. Between INT 2 and INT 1, Departure Control cleared them to INT 3. The first officer asked the captain to enter INT 3 in the MCDU, and he did. The captain asked the first officer if he wanted the captain to execute INT 3. He verified INT 3 was in the proper position and said to execute. The PM executed INT 3 and it was highlighted in the MCDU, and a magenta line formed on the EFIS display from present position to INT 3, and the aircraft began a left turn to INT 3. Shortly after that, both CDUs blanked and flashed back on. INT 3 was no longer highlighted. Several route discontinuity blocks appeared on the LEGS page, and INT 3 was no longer displayed on the EFIS display. The aircraft sequenced its bank and continued turning left toward an unknown fix. The captain told the first officer that "the box had dropped INT 3, and we needed to turn right." The first officer selected HEADING mode on the MCP and began an immediate right turn. At this time, Departure Control asked "company number where are you going?" The captain answered, the aircraft was in a right turn towards INT 6. The crew could no longer identify INT 3, and INT 6 was the next fix. Departure control instructed them to go direct INT 3. By this time, the first officer had re-established INT 3 in the MCDU, executed it and engaged LNAV. We proceeded towards INT 3, but the EFIS display now showed a magenta line to INT 3, INT 6 and back to INT 3. The first officer corrected the problem, and no further problems occurred. The FAA inspector indicated that it appeared that the aircraft had a software problem. The crew proceeded to destination and landed. During the debrief of the flight, the inspector, again, stated that he was of the opinion that the software had failed, and it appeared to him that we were doing everything possible to correct the problem. He stated that he thought first officer's situational awareness could have been better, but he reacted as rapidly as possible, and he would be available to verify the facts of the problem. The inspector signed the first officer's UOE forms, and told us to continue our use. The captain called the number requested of him to call, and was answered with a recorded message. He left a brief message describing the situation. He then called the chief pilot and relayed the events. He made a write-up in the aircraft logbook, maintenance performed several tests, and signed off the aircraft for service. The captain contacted a company ATC specialist and relayed the events to him. The first officer and captain both made phone calls to company the safety committee and answered the questions. In retrospect, the captain felt they were reacting to identifying a problem and correcting the problem as fast as humanly possible. He felt he should have immediately asked for a vector due to an LNAV failure. He was confident the problem was not induced by pilot action. He had never seen this kind of problem before, and had not had any problems with any LNAV departures. He thought the first officer did a very nice job in the briefing and execution of our LNAV departure procedures. This was the second day of his UOE and under the circumstances, the captain thought he did an admirable job. Result: a growing distrust of LNAV departures. Recommendation: extreme vigilance of all LNAV procedures and immediate declarations of LNAV failure to ATC and request vectors. **JIMDAT Analysis:** Applicable **Flight Phase:** DEPARTURE/SID/CLIMB **Comments:**

		Category: Lateral Deviation (mode awareness) **Trigger:** **Contributing Factors:** • Software • Crew situational awareness
28	**596513b**	**SYNOPSIS** An A320 flight crew exceeded 250 knots below 10,000 feet during departure from origin. **NARRATIVE** The aircraft was climbing to 5,000 feet on autopilot while the first officer, pilot flying (PF), was tracking the 185 degree radial off of origin in HEADING mode. Going through 4,300 feet msl, the aircraft was climbing at over 4,300 fpm. The PF disconnected the autopilot to hand-fly the level-off, in fear that the autopilot was going to climb through 5,000 feet. The PF leveled the aircraft off at 5,000 feet and MANAGED SPEED mode did not slow the aircraft at 250 KIAS. The autothrust stayed in a climb power setting and the airspeed climbed to 280 KIAS before the autothrust was disconnected and the speed brought back to 250 KIAS. The aircraft was above 250 KIAS for no longer than 10-15 seconds. ATC did not say anything, and no altitude or lateral deviations took place. The rest of the flight progressed normally. **JIMDAT Analysis:** Applicable **Flight Phase:** DEPARTURE/SID/CLIMB **Comments:** Need Airbus SME to analyze. Why did MANAGE SPEED mode not control airspeed to 250 KIAS after level-off below 10,000? **Category:** Vertical Deviation (energy state management) **Trigger:** Excessive rate of climb **Contributing Factors:** • Automation – FMGC in HDG/MANAGED SPEED modes, then A/P disconnected with autothrust in CLIMB mode • Monitoring – PM did not monitor PF's energy state transition **SME Review** • JIMDAT Analysis confirmed? o Trigger? "High rate of climb in close proximity to level-off altitude" o Contributing Factors? 1. Very light aircraft 2. May have had a high rate of climb established and then received a 5,000 foot level-off 3. PF started shallowing climb rate before the autothrottles went into auto capture mode, so FMS stayed in CLIMB THRUST 4. PF should either have pulled power back or disconnected flight directors from SPEED mode (Level I – disconnect A/P and A/T; Level II – hand fly using FDs and A/Ts; Level III – engage A/P and A/T with LNAV & VNAV ; Level IV – MANAGED CLIMB or MANAGED DESCENT) 5. A/Ts will manage the vertical rate in MANAGED CLIMB until the selected altitude is reached, then they go for speed. o Degree of risk? Low risk of NMAC due to speed excursion • What actions would have prevented the occurrence of this event? o Should have been in either MANAGED SPEED or SELECTED SPEED in climb

		below 10,000 feet. o PM should have made "1,000 feet to go" call-out o Airbus recommends to go to Level I, regain control, then build automation back o PF should annunciate his intention if he can talk and fly o A/P on and A/T off is not prohibited o Pilots need to learn to trust systems (gain confidence) through better knowledge • Could we address this with a Policy or Procedural change? o Airbus has a 25-day training "footprint" starting with Day One manual flying (heading, altitude and airspeed control) o U.S. Airways has 8 4-hour periods o UA has 8 FTDs
29	**597418b**	**SYNOPSIS** Heading track deviation by a B737 flight crew after receiving a visual approach clearance to runway 25L at destination. **NARRATIVE** The crew was flying the STAR into destination. Approximately 2 nm prior to FIX 1, the controller asked the crew if they had the field in sight. The crew called the field in sight, and ATC cleared them for the visual approach to runway 25L. ATC then pointed out traffic on left base for the crew to follow and instructed them to cross FIX 1 at 8,000 feet. When the crew received the visual clearance, the first officer, pilot flying (PF), had programmed the FMC to go direct to FIX 2. The captain, pilot monitoring (PM), was searching for the traffic and when he saw they were not proceeding to FIX 1, he began to reprogram the FMC to turn back to FIX 1. The controller then gave the crew a turn to 320 degrees to intercept final and said they had been told to fly to FIX 1. The crew maintained 8,000 feet until intercepting final and continued the approach to landing, traffic not being a factor. In retrospect, the first officer was so quick to reprogram the FMC that the captain did not catch it right away because he was looking for traffic. However, the clearance for the visual did not initially include flying over FIX 1. Programming the FMC at this point on the approach was a hindrance to the crew's performance and the clearance was nonstandard. If the captain had called the traffic in sight (which he had in view) and verified with ATC, this clearance this would not have been an issue. Instead of reprogramming the FMC to go back to FIX 1, the captain thought he should have stayed "heads up." **JIMDAT Analysis:** Applicable **Flight Phase:** ARRIVAL/STAR/HOLD **Comments:** SME should evaluate re-programming the FMS this close-in; would it have been better to revert to a lower level of automation? **Category:** Lateral Deviation (mode awareness) **Trigger:** Task saturation – Visual Clearance **Contributing Factors:** • Distraction – PF distracted by searching for visual traffic • Automation – re-programming FMC close-in increased task saturation • Monitoring – PM did not monitor PF's adherence to clearance **SME Review** • JIMDAT Analysis confirmed? • Trigger? o Secondary clearance that conflicted with the first

		• Contributing Factors? o Pilot flying should not have been programming FMC o Lack of communications as to what was programmed into the FMC and that the captain had traffic in sight (CRM) • Degree of risk? LOW • What actions would have prevented the occurrence of this event? o If inconsistent clearances are received crew needs to ask for clarification o Verbalize, verify and monitor Could we address this with a Policy or Procedural change? NONE – already covered in the Boeing manual
30	**598403b**	**SYNOPSIS** The flight crew of a B777-200, fatigued by an extended international flight schedule and inability to obtain adequate sleep during breaks, got behind the airplane on approach to destination and had to struggle to establish a stabilized condition. **NARRATIVE** This was the 4th day of a 5-day Pacific event. The captain had not slept very well at the hotel for the first 2 days of the layover. This was a 17-hour time zone change. The first officer was also experiencing the same sleep deprivation problems. This was the end of a 9-hour duty day that went roundtrip from overseas destination stateside and back. Both pilots had commented on the way back about how tired they were. All was normal until the approach controller became overloaded and turned them through the final at a 60 degree heading and forgot them. The aircraft was heading 300 degrees to intercept runway 33R. ATC turned the crew to 270 degrees and flew them through the final approach course. A new controller came on and turned them back to final and cleared them for approach. The captain, pilot flying (PF), disengaged the autopilot to get the aircraft down and back to final and this overloaded the first officer, pilot monitoring (PM), who was very tired. In the process, the APPROACH mode did not get armed and the flaps were not set at the lower setting for the speed the PF had called for. The crew flew through the final about 1/4 of a mile and got about 10 knots below the selected flaps speed. The autothrottles were in THROTTLE HOLD instead of SPEED. The PF was able to correct right away and get on a stable approach at about 7 nm out. The rest of the approach and landing were normal. The aircraft was never in danger, but this had the potential for a more serious problem. This was the first time this had happened to the captain and he felt fatigue was a major issue. **JIMDAT Analysis:** Applicable **Flight Phase:** APPROACH **Comments:** Mode awareness and procedural errors due to fatigue and distraction **Category:** Lateral Deviation (mode awareness) and slow airspeed (energy state management) **Trigger:** Task saturation **Contributing Factors:** • Fatigue • CRM - crew did not cross-check APPROACH mode and autothrottles in SPEED vs. THROTTLE HOLD • S.O.P. – crew forgot to arm APPROACH mode and PM did not respond to PF's call for flaps • Distraction – both pilots distracted by ATC vectors • Monitoring – PM did not monitor automation modes, flap positions and speeds
31	**598817b**	**SYNOPSIS**

A B737-500 flight crew continued their CAT II approach onto runway 14R after their EGPWS signaled a “pull up” at 200 feet AGL, after it had signaled “terrain” at 300 feet AGL while the crew suspected a map shift at destination.

NARRATIVE

Destination weather was reported 200’ overcast, 1/4 statute miles visibility in fog and drizzle, RVR runway 14R 1600 feet variable to 1800 feet. The captain was pilot flying (PF) an autocoupled CAT II approach to an autoland. The crew intercepted the localizer at approximately the 16.5 DME outside INT 1 intersection at 5,000 feet msl. After the aircraft intercepted glideslope at INT 1, the PF engaged “B” autopilot, and proceeded down the approach at 180 KIAS. The FMC suddenly dumped, but rebooted about 5 seconds later. The first officer, pilot monitoring (PM), reselected auto on NAV #2 for an FMC update, and the course line matched up with the localizer. At the FIX 2 locator outer marker, the marker beacon sounded and the blue light flashed, but the PF noticed that the aircraft was still about 2.5 mi prior to the fix on the map display. The PF announced that the map was still off quite a bit. He configured the aircraft for landing, completed the final descent checklist, and was stable at 40 degrees flaps at 1,000 feet AGL. Then, while on profile passing approx 300 feet AGL, the EGPWS sounded with “terrain.” The PF confirmed with the localizer and glideslope that they were still on profile, and after a moment realized that the EGPWS warning was due to the map shift. At 200 feet AGL, EGPWS sounded “pull up.” At about the same time, the approach lights were in view, and the PF elected to continue the approach to an uneventful autoland. The outcome was that the crew did not execute a go-around with the warning. The landing was normal and the approach was normal. The crew was at the end of a long day, and still had one more leg to go, so there was a sense of urgency to land the aircraft. The visibility was dropping also, and with a go-around there was a possibility that the visibility would be worse the second time around. Also under consideration was the fact that the FMC was not reliable. The PF deemed the situation safe to continue the approach. It was confusing for a moment, and procedures called for a go-around. If the aircraft was not right on profile and stable, with the NAVAIDs properly identified and proper CAT II operations in effect on that runway, the PF would have gone around.

Supplemental info from report 599017: The PM decided to go back to NAV #2 auto due to a large map shift of the FMC (around 2-3 mi left of course). The FMC updated its position back to the localizer course. The PM went back to manual with a normal ident. The aircraft continued the approach and, at around 300 feet AGL, the crew got a terrain warning from EGPWS. All indications from the localizer and glideslope were normal on all 3 ADIs. The crew figured this was due to the map shift and continued. Human factors: late at night, tired, bad weather, FMC problem. The crew discussed this after landing and decided they should have gone around per the flight manual.

JIMDAT Analysis: Applicable

Flight Phase: DEPARTURE/SID/CLIMB

Comments: Crew should have gone around, selected a lower level of automation (i.e., raw data); crew did not follow SOP

Category: Lateral Deviation (mode awareness)

Trigger: Map Shift

Contributing Factors:

- Automation – map shift caused erroneous visual display
- Deviation from S.O.P. – crew failed to execute EGPWS escape maneuver
- CRM – PM did not challenge PF decision to continue
- Fatigue

		• Perceived sense of urgency • Poor weather
32	**602417b**	**SYNOPSIS** Enroute to destination, a B737-300 first officer changed the FMS arrival route without advising the captain and was challenged by Approach. **NARRATIVE** Before push, the first officer, pilot monitoring (PM), loaded the correct route in the FMS. The route was checked and briefed. At some point in the flight, the first officer changed the arrival from the STAR 1 to the STAR 2. The captain, pilot flying (PF), did not notice him make the change. Discovered: at INT 1, the approach controller cleared the aircraft direct STAR 1. As the crew did not have STAR 1 in their route, they could not understand why they were being cleared there. The controller asked what arrival the crew was flying. He then gave them a vector off the arrival to intercept the runway 25R localizer. Contributing factors: PF has had no training on the LNAV system. There are too many arrivals into destination that are very close to each other. They look the same. At no time did the Center or Approach Control say what arrival the crew was to fly after they took the crew off the filed route and gave them direct to a fix (last fix was INT 1). It did not help to have the same fixes on different arrivals. FIX 1 is on 3 different arrivals as is STAR 2. There are 18 arrivals. Prevention: the same fix on different arrivals should not be used. It is asking for confusion between the arrivals. Flights should be cleared onto the arrival to be used by the controller who is in contact with that flight just prior to starting the arrival, the same as being cleared for an approach. Controllers don't just let crews fly an approach. Why should an arrival be different? The programming of flight plans by the company in the FMC is not very good. Crews have to make a lot of corrections, so it is not unusual for a first officer to have to make a lot of changes to the route. When making changes is common, it is easy to make mistakes or miss something. The company needs to do a better job in this area. The LNAV system is a single system. It is programmed by 1 person. If each pilot had an independent LNAV system and programmed it, discrepancies in the route would show up. With a single system, there is no backup. “Garbage in, garbage out.” Supplemental info from report 602530: The crew was cleared by origin clearance delivery to fly the STAR 1 RNAV arrival into destination. This was the arrival that was programmed into the FMS. When at cruise, the PM went to check the arrival against the LEGS page, and the PM grabbed the STAR 2 RNAV. Where the PM made his mistake was: after INT 1, the PM deleted the intersections on the STAR 1 arrival and typed in the intersections on the STAR 2 arrival. Prior to reaching INT 2 intersection, the crew was cleared “direct STAR 2 then direct INT 1 then direct STAR 1.” The controller never stated at any time that the crew was cleared via the “STAR 1 arrival to destination” like they normally do. If he had, the crew might have caught their mistake. **JIMDAT Analysis:** Applicable **Flight Phase:** ARRIVAL/STAR/HOLD **Comments:** Single FMC at First Officer position; not conducive to crew coordination/situational awareness. Need SME to evaluate. **Category:** Lateral Deviation (mode awareness) Trigger: None Contributing Factors: • Automation – single FMS • CRM – PM changed arrival enroute without coordinating with PF

		• Communications – ATC placed crew on vectors without announcing arrival to be flown **SME Review** • JIMDAT Analysis confirmed? • Trigger? o FO making changes to FMC without verifying with the Captain. • Contributing Factors o Carrier's weak automation policy. o Clearance confusion o Single CDU o Captain not trained in LNAV system • Degree of risk? HIGH • What actions would have prevented the occurrence of this event? o Crew should not have changed the arrival o Verbalize, verify and monitor o The controlled should have restated the arrival they were rejoining. • Could we address this with a Policy or Procedural change? o Train all flight crew members in the use of LNAV o Follow Boeing guidance to verify before executing
33	**602438b**	**SYNOPSIS** A B767-200 crew had a track deviation departing (location) on the SID after the crew did not back up FMC position with raw data. **NARRATIVE** At liftoff from origin on runway 17 the crew got GPWS terrain warnings. They were vectored to intercept the SID. On their map display it appeared they would intercept just prior to INT 1. The controller asked where they thought they would intercept the departure. The captain, pilot flying (PF), told him just before INT 1. He said the aircraft was already west of J53 approaching military airspace, and vectored the aircraft back to the east. The PF immediately selected VOR 1 manually and confirmed their position west of J53. The crew quickly intercepted J53 and continued with manual VOR navigation. The PF advised Center (the next controller) they were no longer /E, but were VOR navigation only. The crew did a navigation accuracy check off of VOR 2 (144 degrees/68 nm) while their inertial NAV showed (158 degrees/96 nm), a 14 degrees/28 nm error! On deck at destination, the navigation accuracy error was 29 nm. The crew believed aircraft position shifted at automatic update on the takeoff roll. This would account for the terrain warning at liftoff. The captain had never heard of or seen anything like this in a B757 or B767. Maintenance thought a recent lightning strike might have something to do with it. Learning point: a navigation accuracy check after takeoff is a good idea, and should definitely be performed if a GPWS warning occurs at liftoff. **JIMDAT Analysis:** Applicable **Flight Phase:** DEPARTURE/SID/CLIMB **Comments:** Possible map shift ? Need SME to evaluate guideline for navigational accuracy check after takeoff. **Category:** Lateral Deviation (mode awareness) **Trigger:** None **Contributing Factors:** • CRM – Failure to perform pre-takeoff navigational accuracy check • Monitoring – failure to back up IRU with raw data

		SME Review • JIMDAT Analysis confirmed? • Trigger? Not enough data • Contributing Factors? Not enough data • Degree of risk? Not enough data • What actions would have prevented the occurrence of this event? • Could we address this with a Policy or Procedural change? o Navigational accuracy check should be done prior to TO (Note guidance in AC 90-100A for RNAV should be applied to all departures using an RNAV system)
34	**603496b**	**SYNOPSIS** A B737 flight crew had a last minute change which resulted in a crossing restriction not being met. **NARRATIVE** Passing over INT 1 for the STAR 1 at FL180 the crew was cleared for the STAR 2 to runway 24R at destination. The crew had briefed and loaded the FMCs for the STAR 1 runway 25R at destination. In trying to accommodate the last minute change, the STAR 2 arrival was loaded but the INT 1 transition was not selected. INT 3 intersection was not loaded. The aircraft crossed INT 2 between 10,000 feet and 11,000 feet as depicted. The controller informed the crew that they did not cross INT 3 at or above 12,000 feet. He was correct. The attempt to accommodate the controller's change of arrival caused the crew to rush their cockpit duties which resulted in the mistake. In the future, the PF will refuse to accept a change in arrival once the crew has begun the descent for another. Pilots simply require more planning. This region is known for last-minute arrivals and runway changes, coupled with maintaining abnormal airspeed requests while on the approach. The lack of airspace management and planning continues because pilots are too often willing to accommodate them. The PF will request vectors for another sequence in the future. **JIMDAT Analysis:** Applicable **Flight Phase:** Arrival/STAR/Hold **Comments:** Crew rushed; correct re-programming of FMS inhibited by last-minute runway/arrival change. **Category:** Vertical Deviation (energy state management) **Trigger:** Late Runway Change **Contributing Factors:** CRM - FMS re-programming error
35	**612730b**	**SYNOPSIS** A320 flight crew was late in complying with climb from SID altitude constraint. **NARRATIVE** Flying the SID, the first officer failed to continue the climb from the 4 DME 2,000 foot restriction to an assigned altitude of 15,000 feet. The delay of climb occurred because the first officer became distracted. He was hand-flying the airplane, and never quite reached 2,000 feet. The airplane's (autothrust) response was to increase power which caused the speed to increase past what was selected. During his fixation on this, the first officer flew past the 4 DME fix without resuming the climb. Supplemental info from report 612729: on many previous departures from this location the

<table>
<tr><td></td><td></td><td>controller usually assigns an unrestricted climb to 15,000 feet. Anticipating this to happen, which it did not, the crew's flight directors commanded the pre-planned climb to 15,000 feet. Not hearing the controller assign the usual climb directions, the captain, pilot monitoring (PM), pushed the LEVEL OFF button to have the flight directors and PF level off at 2,000 feet. This additional distraction delayed the climb for approximately 2 minutes.

JIMDAT Analysis: Applicable

Phase of Flight: Departure/SID/Climb

Comments: Need SME evaluation. Why autothrust speed increase while hand flying?

Category: Mode Awareness

Trigger: Crew Overrode Pre-planned Vertical Profile

Contributing Factors:
• CRM - Failure to cross-check; PM pushed level-off button without coordinating with PF
• Distraction while hand-flying – autothrust commanded speed increase
• Complacency – PM anticipated customary unrestricted climb

SME Review
• JIMDAT Analysis confirmed?
o Trigger? "Late change." Crew was expecting a certain clearance (unrestricted climb inside 4 DME) and did not readily adapt to the new situation
o Contributing Factors?
1. What was field elevation? Where were thrust levers? Was this a FLEX MCT mode takeoff? Was the FMS in OPEN CLIMB vs. MANAGED CLIMB?
2. FMS had apparently been programmed to climb – pilot delayed climb by hand-flying and creeping slowly up to, but short of, 2,000 foot level-off
3. Pilots were solving an automation problem with more automation (pushing level-off button) – the FMS went from CLIMB mode into SPEED mode
4. Pilots delayed climb for 2 minutes trying to figure out what was happening
o Degree of risk?
1. MSA within 25 nm was 3,800 feet – significant risk of CFIT or NMAC
• What actions would have prevented the occurrence of this event?
• Could we address this with a Policy or Procedural change?</td></tr>
<tr><td>36</td><td>613077b</td><td>SYNOPSIS

A B767 crew had a stick shaker activation when the crew did not realize the autothrottles were disengaged.

NARRATIVE

On descent into destination, leveling off at 3,500 feet, the crew got a slight/momentary stick shaker. The autothrottles (had) kicked off. The crew, looking for traffic, didn't notice the autothrottle disengaged. The captain, pilot flying (PF), added power and lowered more flaps, and rolled out of the turn. No altitude loss or other problems occurred.

Supplemental info from report 613241: as pilot monitoring (PM), the first officer did not catch that autothrottles were disengaged as the aircraft leveled at 3,500 feet while rolling out on base turn. His head was down checking the identifiers for the LOC when the crew got a momentary stick shaker. Airspeed was low for current flaps, and the captain made an aggressive power input, called for more (20 degrees from 15 degrees) flaps, and the aircraft continued normally. The first officer will make it a point now of checking for not only "ALT CAPTURE" annunciation, but also the AUTOTHROTTLE indication.</td></tr>
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		JIMDAT Analysis: Applicable **Phase of Flight:** Descent **Comments:** Stick Shaker **Category:** Mode Awareness **Trigger:** Scanning Outside **Contributing Factors:** • CRM/Automation – Autothrottle disengagement • PM – failure to monitor level-off • Distraction – looking for traffic
37	**615162b**	**SYNOPSIS** Flight crew of B747-400 overshot cleared altitude during a SID with potential conflict with other traffic. **NARRATIVE** The flight was climbing out of (airport of origin). The first officer was pilot flying (PF) and the captain was performing pilot monitoring (PM) duties. It was a typical (airport of origin) departure, with multiple altitude clearances. The aircraft was cleared to 6,000 feet via the SID. Approaching 5,000 feet, the captain asked for a higher altitude. The aircraft was then cleared to 7,000 feet. As the aircraft neared 6,000 feet (the transition altitude), the captain announced "two nine nine two?" then reset both of his altimeters and looked over at the first officer and watched him set his altimeter. While the captain was resetting his altimeters, he felt the nose pitch up. When the captain sat back upright (he didn't recall the exact altitude, but he thought it was somewhere around 6,300-6,500 feet), he noticed that the rate of climb was quite high, exceeding 3,100 fpm. The captain said loudly, "seven thousand ft!?" He didn't see the first officer immediately respond, so the PM grabbed the throttles and immediately retarded them, and simultaneously pushed the nose over. The aircraft went through 7,000 feet and peaked at 7,300 feet before descending again. As the aircraft reached its peak, the controller admonished the crew and told them to descend to 7,000 feet and turn left about 15 degrees. In the controller's comments, it seemed that he thought the crew had not set their altimeters, but that was not the cause of the altitude bust. There were no TCAS II advisories of any kind. But the relief pilot told the captain later that he saw another aircraft ahead at 8,000 feet on the NAV display, but he couldn't recall the distance because he couldn't recall what scale the NAV display was set at. Later in the discussion, the first officer told the captain he got fixated on trying to top a cloud that was dead ahead of the aircraft and lost situational awareness about the altitude. That was the reason he pulled the nose up passing through 6000 feet. After landing, the captain had a discussion with the crew and told both of them that he'd made many mistakes in his career, but in almost all of them someone else on the crew caught it before it became a problem. "That's why we have a crew." He also added, "we're all entitled to make mistakes, but we're also all entitled to be backed up by the rest of the crew, and in that respect, the captain thought he and the relief pilot both failed the first officer." "while you made a technical error," the captain added, "I made an SOP error and we both made a CRM error by not being where we should have been to be able to back you up," and for that he apologized. An additional lesson the captain learned for himself was that in a situation like this, where it was apparent the PF had lost his situational awareness, and where time was critical, the captain should have immediately taken the airplane. The short delay in waiting for a response from the first officer after the captain's callout is what made the difference in this case, the captain believed. Supplemental info from report 614896: just after departure, the aircraft was level at 5,000 feet with no speed restrictions. The aircraft's condition was "high speed with a resulting high

		energy state." The departure occurred after an early morning ("body clock") departure, xx:xx morning wake-up. Recommendations: A lower energy state would have been better. A slower speed would have been fine until clear of complex traffic and departure maneuvering. Callback conversation with reporter regarding report 615162 revealed the following info: the captain advised that he didn't remember exactly what the status of the autoflight system was. As a result, it was difficult to analyze the resulting performance of the aircraft and crew. He suggested that perhaps the PF had become fixated on climbing over the cloud about which he was concerned, and had the nose at such a high attitude, that even with a level-off command on the flight command bars the throttles would have maintained a high thrust in order to maintain the speed commanded, even though an altitude capture had occurred. If the PF was "outside" looking at the cloud, he would not have seen the command bars indicating a lowering of the nose for the level off and the throttles would not have come back due to the speed command. The captain remained convinced the issue was CRM-related and not a matter of workload constraints. **JIMDAT Analysis:** Applicable. **Phase of Flight:** DEP/SID/CLIMB **Comments:** Need SME to evaluate the first officer's intention to pull up over the cloud and interfere with automation. **Category:** Vertical Deviation (energy state management) **Trigger:** Crossing Restriction **Contributing Factors:** • CRM – failure to use all resources (including relief pilot) effectively • PF Loss of situational awareness • Distraction – PM setting altimeters • SOP error – failure to monitor level-off • Possible fatigue (body clock issue) • Unnecessarily high energy state **SME Review** • JIMDAT Analysis confirmed? o Trigger? Distraction to the detriment of altitude awareness o Contributing Factors? 1. Not using the automation 2. Resetting the altimeter (low transition altitude) 3. WX 4. Possible circadian low o Degree of risk? MEDIUM • What actions would have prevented the occurrence of this event? o Using the autopilot o Better altitude awareness by both crew members o Better crew coordination • Could we address this with a Policy or Procedural change? o Appropriate use of automation in high workload environments
38	**615854b**	**SYNOPSIS** The captain of B767-300 on an enroute check turned off the autopilot and autothrottles when he became concerned about being high without approach clearance. He forgot to push up the throttles manually and got a stall warning with an accompanied loss of assigned altitude.

		NARRATIVE This was a route check for the captain. The captain was the pilot flying (PF), flying into destination. Through FL180, an approach briefing for an ILS runway 14 at destination was completed. During the approach briefing, the "fatigue factor" was discussed by the check airman at the first officer position, pilot monitoring (PM). The Approach & Descent checklist also was completed. While being vectored at approx 3,000 feet, the crew was asked by ATC to slow to approach speed for another aircraft landing runway 1R. About 9 miles out, the crew was given a heading to intercept runway 1L. The configuration of the aircraft was gear down, flaps 30 degrees. Both the captain and check airman were "heads down," selecting and identifying the ILS frequency for runway 1L. Repeated attempts made by the check airman to get a lower altitude were unsuccessful. The crew was still at 3,000 feet and getting very high. The PF turned off the autothrottles and autopilot. It is unclear if the PF announced this. Before intercepting the ILS to runway 1L, PF got a stick shaker at 3,000 feet. Power was added by the PF, but not as aggressively as by the check airman. There was no significant altitude loss. We were finally cleared for the approach. An uneventful approach and landing were made. Contributing factors: 1) fatigue: PF was unable to sleep on either rest breaks. PF was unable to nap on layover before the flight. 2) in the past on the B727, any time an approach got "tight," turning the autopilot off and flying always worked better for the PF. In the 2 years on the B767, PF has become more used to the autothrottles than he realized. **JIMDAT Analysis:** Applicable **Phase of Flight:** Approach **Comments:** Over-reliance on automation **Category:** Vertical Deviation and airspeed loss (energy state management and mode awareness) **Trigger:** Crossing Restriction **Contributing Factors:** • CRM: both pilots "head down" • Fatigue • Complacency - over-reliance on Automation
39	**631015b**	**Synopsis** A B747-400 crew did not comply with an ATC issued crossing restriction in Center Class A airspace. **Narrative** The first officer was PF. The crew was inbound destination, FL330, from FIX 1. The crew was given clearance to cross 65 nm northwest of INT 1 intersection at FL230. The PF set 23,000 feet in the altitude window. The captain, pilot monitoring (PM), worked the FMC. The crew was direct INT 1 with several abeam fixes preceding INT 1 on the LEGS page. The aircraft was in VNAV PATH. The captain created INT 1/-65/230 as a fix, and very shortly afterward, the aircraft started a descent. When Center called to confirm the clearance, the aircraft was passing FL260, approaching the 65 nautical mile fix. The aircraft was well high of the crossing restriction. Possible causes: 1) Distractions. During and after the direct clearance, the crew was extremely busy with flight attendant calls (from passenger problems, medical and behavioral, connecting gate/hurricane updates, commuting info, etc.), off-duty crew returning to cockpit, several radio frequency changes, approach briefings, etc. 2) Fatigue. This was a fully augmented crew, but the PM had very poor/little sleep during his first half break, as well as the night before, with the effect of time zone changes/circadian rhythm, etc. 3) Automation

Complacency. “The FMC does such a perfect job of flying the aircraft, pilots usually set it and forget it” is a non-factor. 4) Summary. As all pilots do, the PF normally checked and double checked the automation. In this case, this would involve manually computing the descent rate/speeds/progress, etc., to ensure meeting the crossing restriction. But on this occasion, distractions and tiredness equaled poor prioritizing and a failure to check. The PF had no recommendation except to reemphasize the critical need to set correct priorities, to overcome the distractions and tiredness and 'automation complacency,' to fly the aircraft first.

Supplemental information from report 630901: at top of descent, the aircraft started the descent in VNAV PATH. Somewhere in the descent to FL230, the pitch mode changed to VNAV SPEED. The pilots failed to recognize the pitch mode change and also failed to recognize that they would be high at the fix. The pilots did not properly separate PF from PM duties, or properly prioritize tasks because of distractions during that stage of the descent. Distractions: there was a lot of conversation between the cabin and cockpit. The entire crew was catching up on duties delayed because of problems earlier with a sick passenger, a verbally abusive passenger, and 2 other minor inflight passenger incidents. Also, the crew was checking flights because a hurricane had just hit the coast. Also, the pilots let the off duty crew back in the cockpit at that time.

JIMDAT Analysis: Applicable.

Phase of Flight: Descent

Comments: Need SME to evaluate change from VNAV PATH to VNAV SPEED and associated pitch change.

Category: Vertical Deviation (energy state management and mode awareness)

Trigger: Crossing Restriction

Contributing Factors:

- Failure to program the FMS for a profile descent and verbalize intentions to PM
- Distraction: flight attendant calls (passenger problems, medical and behavioral, connecting gate/hurricane updates, commuting info, etc.), off-duty crew returning to cockpit, several radio frequency changes, approach briefings, etc.
- Fatigue
- Complacency

SME Review

- JIMDAT Analysis confirmed?
  - o Trigger?
    Passive reaction to a challenging descent clearance
  - o Contributing Factors?
    1. Subtle mode change from VNAV PATH to VNAV SPEED that went unrecognized
    2. Distractions
    3. Fatigue
    4. Automation complacency
    5. Inappropriate task prioritization
  - o Degree of risk? MEDIUM
- What actions would have prevented the occurrence of this event?
  1. Better vertical awareness by crew members
  2. Better use of drag devices (better energy management)
  3. Prioritization of tasks
  4. Initially using Flight Level Change
- Could we address this with a Policy or Procedural change? NONE

40	**631071b**	**SYNOPSIS**

		An A319 crew was cleared for a visual Approach to runway 35L at destination, but flew an approach that was not within the stabilized approach criteria of their company. **NARRATIVE** The captain and first officer had never flown with each other before. Destination was landing runways 16L, 16R, 35L, and 35R. Sky was clear, visibility 10 miles and winds 150 degrees at 6 knots. After flying origin-destination, the aircraft was on a STAR to a visual approach runway 35L at 15-20 miles from the airport. Approx 13-15 nautical miles outside the outer marker (FIX 1), the crew was cleared for the visual approach. The autopilot was off, 10,000 feet msl and descending, 250 knots slowing toward 210 knots. The aircraft went direct to the outer marker as a dogleg base to final (heading approximately 330 degrees) with 7,000 feet set in the altitude window, ILS runway 35L in the FMGC's (FIX 2 "from" point) and approach armed. Approx 1.5 nautical miles outside the outer marker, the aircraft was configured with speed brakes extended, 2,000 feet above ILS glideslope and 180 knots. Crossing the outer marker, the landing gear was down, aircraft altitude was 3,000 ft, the autopilot was in "MANAGED SPEED" and the PF directed that a missed approach altitude of 10,000 feet be set in the altitude window, reverting the vertical mode to -1,300 fpm. The PF "S"-turned, attempting to capture the glideslope. The workload spiked in a surprisingly short period of time. The single event which absolutely sealed this approach as unsalvageable (not stabilized by 500 feet AGL) occurred (the PM believed) just as the PM had finished the landing checklist, just inside the outer marker. The PF pulled the altitude knob for what PM believed was an attempt to gain OPEN DESCENT which the PM did not see. As the PM looked back up, he heard the engines spooling up with climb power and the FMAs indicated THRUST CLIMB and OP CLIMB in the autothrust and vertical columns respectively. This caught him completely off guard. He wondered how this could be. Nevertheless, the PF pulled the power levers to the idle stop, kicking off the autothrust system, and continued the approach at 1,000 feet AGL. The PM made the normal callout with "except final flaps" and the PM verbalized (what seemed to him to be the obvious) fast, rate of descent, above the PAPI glideslope, and observed speed brakes were still extended. That is as much as the PM said, nothing more. The captain had bent the SOP's so far that the PM was playing catch-up ball. He believed that his expectation was the aircraft was so far from stabilized parameters that the crew would definitely go around at 500 feet. Between 1,000 feet and 500 feet AGL, the crew finished configuring. The PM called 500 feet, and the captain stated "final flaps full" and continued the approach. The PM said the problem was the approach was far from stabilized, and the PF continued so PM asked if the PF was going to go around, and the PF demurred, so the PM said, incredulously, "you're going to land this?" to which he simply said "yeah." The aircraft landed from an unstabilized approach. From 1,500 feet to 200 feet AGL, the aircraft was above PAPI glideslope (all white). At 1,500 feet AGL, the aircraft was approximately Verve +30 knots, slowing to Verve +15-20 knots at 500 feet AGL and the PF held Verve +15-20 knots to touchdown. The PF used 1,300-1,500 fpm rate of descent most of the way inside the outer marker. Speed brakes were not retracted until approximately 700 feet AGL. Engines were not spooled until approx 350 feet AGL. In my opinion (as PF) the unstabilized approach developed for several reason: misperceptions/preconceived notions – the crew was lulled into 'this is just another easy visual approach.' In fact, with a 10-12 knot tailwind, and intercepting glideslope from above this approach, SOP's were bent and broken. The biggest problem with breaking SOP for the PM was it left him without a good idea of what to expect next. So the PM was left completely reacting instead of being proactive. The PF did not articulate what actions he was taking or planning to take to remedy the situation. The PM failed to inquire effectively. PM let the PF down by not being more assertive. The PM had been trying to strike a good balance between being the back seat driver, questioning every deviation, and being too flexible. The realization started for him about 3-4 nautical miles outside the outer marker when the PM was thinking he would drop the gear now, extend full speed brakes, go down fast, go to MANAGED SPEED once on glideslope. As one captain said, "the first officer will go along with something the captain is doing until it gets to a point of discomfort, which is usually after

		many SOP's have been busted." This was the first leg of the trip and the PM was trying to get an idea of how this captain ran his cockpit and crew. Later, at the gate, the crew discussed what had happened. In answer to the PM's question of why he didn't go around, the PF simply stated the safety of that approach to 12,000 feet of runway was never in question. The PM said he couldn't believe the crew landed and that his expectation was a go-around. Again, the PM felt the PF demurred. For the remainder of the trip, the PM stopped assuming an SOP response, and clearly stated what his expectations were, to clear up any misunderstanding early on. The PM's feeling for the rest of the trip, although very congenial, was exceptionally guarded toward SOP deviation. The PM elected to go along with the captain's decision to land, but the PM believed it was because he felt it was safer to continue, since the PM saw no imminent danger, rather than argue or insist on a go-around he clearly wasn't keen on executing. Also, the PM felt that taking stick priority and executing a go-around was not warranted, and would have made the situation far worse. To be completely frank, the PM was befuddled when the PF did not initiate a go-around, which is probably why the PM never simply said "We are far, far from stabilized. We must go around." The PM was simply completely reactive by this point. Next time around, the PM will vocalize sooner, starting with something like, "I am concerned we are getting too far behind. I am uncomfortable." The PM apologized to the captain for not giving him his best. He considered himself a far better first officer and PM than he demonstrated here, and stated it wouldn't happen again.
		
		JIMDAT Analysis: Applicable.
		
		Phase of Flight: Approach
		
		Comments: Need SME to evaluate various modes (OPEN DESCENT, THRUST, OP, MANAGED SPEED) for appropriate use.
		
		Category: Vertical Deviation (energy state management and mode awareness)
		
		Trigger: Crossing Restriction
		
		Contributing Factors:
		• Failure to program the FMS for a profile descent and verbalize intentions to PM
		• Sub-optimal CRM; PF failure to coordinate the approach
		• Ineffective communications; PM did not communicate concerns with appropriate emphasis
		• Complacency - failure of PF to verbalize and require cross-check of selected/appropriate mode with PM
		• Non-adherence to S.O.P. – failure to go around when approach exceeded stabilized parameters
		
		SME Review
		• JIMDAT Analysis confirmed?
		  o Trigger? Captain was way behind the aircraft
		  o Contributing Factors?
		    1. Crew exhibited misunderstanding of how the system works
		    2. Pilot Flying (hand flying) should not have been manipulating MCP (crew duties)
		    3. PF directed MAP altitude of 10,000 be set in altitude window in MANAGED SPEED mode without being in G/S mode and capturing glideslope (mode management)
		    4. PF wanted to increase rate of descent; autothrottles will go to IDLE mode in OPEN DESCENT. He should have selected V/S mode.
		    5. Altitude window was set to 10,000 – the vertical nav mode could have been in OPEN DESCENT or OPEN CLIMB depending upon where ALT SEL is set
		    6. Biggest clue to possible go-around – tailwind at the field; wind speed was probably higher at altitude.

		o Degree of risk? Relatively HIGH. How do we characterize the risk? (error rate, etc.?) • What actions would have prevented the occurrence of this event? o Back to basics (3:1 mental calculation to crosscheck automation algorithm) o There was "at risk" behavior – must monitor o Murphy's Law - The busier you get on a non-stabilized approach, the more likely it is to go badly o Old adage – the first and last legs on a multi-leg trip should reflect the highest adherence to S.O.P. – the first establishes the atmosphere in the cockpit and the last will allow the pilots to make their "commute flight!" • Could we address this with a Policy or Procedural change?
41	**634595b**	**SYNOPSIS** A B737-300 crew with an FMC, but no glass NAV displays, missed a descent crossing altitude assignment. **NARRATIVE** It's what you know that isn't so that leads to error. Descending to FL190 the first officer was acquiring ATIS and the captain, the pilot flying (PF), received clearance to cross FIX 1 at 11,000 feet. The crew had already been cleared direct to FIX 1. The PF set the altitude in the MCP and advised the first officer, the pilot monitoring (PM), of the restriction when he returned to ATC frequency. The first failure was not programming the FDC, yet believing it was properly programmed to compute the descent profile from FL190. The PF looked at the deviation below the actual computed path (about 6,100 feet low) and erroneously reasoned this was about right for the aircraft position. Two asides: with the adoption of the full up LNAV system, the captain had not been manually computing descent points as strenuously as he used to, and since the captain failed to program the crossing restriction, there was no trigger to have the PM check the accuracy. Also, from experience, the captain expected FIX 1 at 11,000 feet; it is almost a constant, yet it is not noted in commercial charts. It is on the "moose sheets," the captain believes. This ambiguity kept him from programming the FDC earlier in cruise. Leaving FL190, Center asked if the crew was going to make FIX 1 at 11,000 feet. Believing he was on the correct profile to accomplish this at 280 KIAS, the captain thought "what a nanny state, I'm right where I'm supposed to be" and had the first officer answer in the affirmative. Shortly thereafter, the first officer realized the aircraft was high and said something like, "You only have 8 miles." He was somewhat soft-spoken at times, and the captain did not hear him clearly. In his mindset, the captain interpreted this as a comedic remark lampooning Center's oversight of their "on profile" descent. With some more communication, the captain finally realized they wouldn't make the restriction. Closing on FIX 1, Center asked about the aircraft's altitude, combined with a frequency change to Approach Control. The first officer didn't respond to Center, switched to approach, but didn't call them, waiting for the aircraft's level off (this was the captain's post-event understanding). The PF called "on approach" (thinking they were on Center frequency) because the first officer was not responding "leaving 13,000 feet for 11,000 feet," believing honesty was the best policy in this situation. The aircraft was over FIX 1 at this point. The aircraft continued to destination, and made a normal approach and landing. So, first there was a breakdown in crew coordination, followed by ineffective communication. The first officer had tried earlier in cruise to get ATIS at destination. The captain believed he was getting it at the first opportunity. Descending into a new destination on the STAR, the captain reflected on the crew interface using LNAV with the "round dial 3/500's" The duty period section didn't accurately reflect the lack of sleep the captain had recently experienced. Nominally he'd gotten 6 hours of sleep per day, too much homework, not enough hours per day. Since midnight EDT the prior Sunday, the captain had 2 days of 4 hours of sleep. One occurred on a (destination) p.m. and the other at home, with circadian disruption, the captain supposed. So the root cause, the reason the descent became a bad plan poorly executed, is most likely fatigue. The PF had gotten "are you going to make the restriction?" calls before. He reckoned the pilots were evenly split between having actually been distracted, and passing the proper descent point

		and being a few miles prior to the point. Thus his initial reaction as they were in the descent. The captain supposed he'd be "spring loaded" to boards and 320 KIAS if he were to hear another. Prevention: diligently check all FDC programming and solutions. **JIMDAT Analysis:** Applicable **Phase of Flight:** Descent **Comments:** Need SME to evaluate FDC vs. FMC issue (FDC = FMC?), programming crossing restriction in LNAV; **Category:** Vertical Deviation (energy state management) **Trigger:** Crossing Restriction **Contributing Factors:** • Failure to program the FMS for a profile descent and verbalize intentions to PM • Sub-optimal CRM; failure to coordinate the descent • Ineffective communications; PM did not communicate concerns with appropriate emphasis • Failure for PF to verbalize and require cross-check of selected/appropriate mode with PM • Fatigue issues **SME Review** • JIMDAT Analysis confirmed? o Trigger? Crew did not program the FMC for the crossing restriction o Contributing Factors? 1. Fatigue 2. FO was off ATC frequency when clearance was received o Degree of risk? MEDIUM • What actions would have prevented the occurrence of this event? o ATIS delivery via ACARS o Flight crew should have confirmed the profile descent was programmed • Could we address this with a Policy or Procedural change? NONE
42	**638758b**	**SYNOPSIS** With an unarmed approach coupler, an A319 pilot in command allowed the flight to get below the glide slope at 800 feet msl while on an ILS approach to runway 25L at destination. **NARRATIVE** After a well executed STAR into destination (speed restrictions were what the captain, pilot flying (PF) would have chosen), while descending and slowing from 3,500 feet to 1,900 feet just slightly above glide slope, the PF called for LOC mode and it was captured. The PF was in "OPEN DESCENT" at about 2,500 feet, called for the gear and Before Landing checklist as the he slowed to 180 knots to the marker as ATC requested. One mile from the marker, the PF called for "MANAGED SPEED" to slow and told the first officer, pilot monitoring (PM), to put the altitude window to 1,000 feet (but was not sure if the first officer actually put in 1,000 feet or something lower; the PF did not verify the altitude as everything was very normal and stabilized) to prevent an autothrottle and autopilot level off at the marker altitude of 1,900 feet. The PF did realize he was still in "OPEN DESCENT" but was 1/2 dot above the glide slope and the airplane was slowing to "MANAGED SPEED," and full flaps were extended at about 1,500 feet. All the while, the airplane stayed on the glide slope even though the PF had not armed the approach mode. While still in "OPEN DESCENT" at about

		800 feet, the PF saw he was slightly below glide slope, kicked off autopilot, and brought the nose up. He was surprised to see that his speed had slowed to ref-10 so he pushed the nose down to increase airspeed and got the glide slope warning. He took off the autothrottles, brought up the power, and leveled off at about 500 feet, caught the glide slope, and continued the approach. Landing was normal. The PF received no stall warning and no call from the tower. The aircraft did end up going 2 dots below the glide slope, and as slow as ref-12. This was because the PF did not call to arm the approach mode when he should have. Seeing the airplane descending on the glide slope on a clear day, the PF was lulled into a false sense of security. Also, the PF allowed the PM to leave him in open descent when the PF should have been in "VERTICAL SPEED" just outside the marker and just above the glide slope. The PF has never had a problem with a stabilized approach before from the low energy side. A lesson learned. Next time the PF will go around. **JIMDAT Analysis:** Applicable **Phase of Flight:** Approach **Comments:** Appears to be classic mode confusion: OPEN DESCENT vs. MANAGED SPEED vs. VERTICAL SPEED **Category:** Vertical Deviation and loss of airspeed (mode awareness and energy state management) **Trigger:** Late runway change **Contributing Factors:** • Sub-optimal CRM; failure to go-around when stabilized approach parameters exceeded • Breakdown in monitoring (PM did not catch inappropriate mode) • Failure for PF to verbalize and require cross-check of selected/appropriate mode with PM • Some indication of over-confidence (never had a problem before with stabilized approach from "low energy" side
43	**649590b**	**SYNOPSIS** Unstabilized manually flown approach to destination runway 32 was continued to landing despite pilot flying request for go-around. **NARRATIVE** After crossing the XXXXX intersection, destination Approach Control changed runway for landing, and cleared crew to intercept the LOC for runway 32, which was 317 degrees. At the time, there were Visual meteorological Conditions, ATIS was reporting ceilings at 4,800 feet, tops at 6,000 feet. The captain, pilot monitoring (PM), had changed the FMC for the first officer, pilot flying (PF). The PF was flying with autopilot off. After intercepting the LOC tracking inbound, cleared down to 3,000 feet, cleared for the approach, the controller wanted the crew to keep their speed up (180 knots) to the marker. During the approach, the PF was bracketing to maintain approx 1/2 dot on the LOC. In doing so, PF got a little low causing the tower controller to warn the crew that the 'low altitude warning' went off. He informed the crew of a new altimeter setting and PF leveled off. The aircraft was outside the marker, at 2,800 feet, and low inside the marker at 1 1/2 dots right of course. The PF wanted to execute a missed approach, but the PM took over the controls, wanting to salvage the approach. As the aircraft descended through 1,000 feet, landing flaps were not set and about 1/3 - 1/2 dot right of course. The aircraft broke out at about 600 feet above, in Visual meteorological Conditions again. The ATIS was not even close. The captain said to the PF "your aircraft.' PF said 'you land -- you have it.' The captain repeated his instruction. The PF took the controls and landed uneventfully. Several factors affecting this approach, mostly human, but weather played a part. In an electric aircraft like the B737-800, pilots let all of the avionics do 'all' of

		the work. In doing so, pilot skills get rusty, as in this instance, causing a sloppy approach and failure to correct aggressively enough for strong crosswinds. A sloppy approach caused the tower "low altitude" warning to go off. Believing the ceilings were at 4,000 feet led the PF to want to fly a manual approach. Practicing manual approaches are best performed in Visual meteorological Conditions, so if a real manual approach to minimums ever has to be performed, it can be accomplished uneventfully. Due to the crew's arrival time, they had not picked up the most current ATIS info. **JIMDAT Analysis:** Applicable **Phase of Flight:** Approach **Comments:** Over-reliance on automation to detriment of flying skills **Category:** Vertical Deviation and unstable approach (energy state management) **Trigger:** Late runway change **Contributing Factors:** • Sub-optimal CRM • Failure to update ATIS • Failure for PM to actively monitor and call out deviations • Failure of PF to use automation if flying skills were insufficient
44	**650942b**	**SYNOPSIS** Captain of Canadair RJ returned from physiological break to discover incipient stall due to unmonitored airspeed following minor thrust reduction by first officer. Autopilot was disconnected and recovery of airspeed and aircraft control resulted in loss of 4,000 feet from assigned altitude of FL390. **NARRATIVE** During established cruise flight, Mach .75, FL390, the captain exited the cockpit to use the lavatory. After approx 2-4 minutes, the captain returned to the cockpit, and while in the process of closing and securing the cockpit door, the autopilot disconnected and the aircraft entered a slight roll (approx 5-12 degrees max). The captain's initial thought was that the first officer disconnected the autopilot, yet the captain immediately turned to him and the PFD (the first officer had canceled the autopilot disconnect audible warning). He looked bewildered and the PFD indicated the low speed and an indicated airspeed approximately 5 knots above stall. The captain immediately set maximum thrust and simultaneously instructed the first officer to push the nose over. Still standing, his observance was the pitch attitude reduction. Indicated airspeed increase and rate of descent were not progressing as the captain desired, and he issued several additional instructions to push the nose down and then knelt on his seat and pushed nose down on his yoke, telling the first officer, "Captain was assisting" the recovery procedure. The captain declared an emergency descent with ATC to FL290 when conditions permitted. During the recovery process, the first officer indicated he was having difficulty with the aircraft trim and the crew received a "trim in motion" aural. The captain instructed him to stop trimming to ascertain if the issue was automation or manual by the first officer. The pitch trim indicator was showing some erratic movement, i.e., +4 units down to +1 units quickly. The captain flew the aircraft to ascertain its controllability (approximately FL350) and it appeared to handle well, yet his perception at the time was it was 'sluggish' in pitch. The first officer told him that he had no idea as to the cause of the low speed condition, that he hadn't touched the thrust or intentionally slowed the aircraft. Based upon these factors, the captain's initial impression was some type of pitch anomaly, and the captain elected to divert to ZZZ (nearest suitable airport).

		Callback conversation with the reporter revealed the following info: at the time the reporter left the cockpit, a cabin attendant was in the cockpit per company security SOP. The flight attendant should have been seated and strapped in per SOP but was not. In addition, the first officer had not donned his oxygen mask as required by the FARs, although the reporter felt he was in the process of doing so when he left the cockpit. The first officer had apparently not monitored the effects of his thrust reduction mentioned in the narrative, intended to reduce airspeed slightly to the cruise mach of 0.75. Indicated airspeed at that time was approximately 227 KIAS. When the captain returned, the first officer was turned physically away from the instrument panel and engaged in conversation with the flight attendant. The airspeed had dropped off to just under 180 KIAS. In quick succession, the autopilot disconnected and simultaneously the stick shaker and autopilot warnings sounded. The recovery events detailed in the original narrative then occurred. Reporter noted that this air carrier's CA RJs are equipped with both laterally and vertically compliant FMCS systems but that autothrottles are not part of their installation. He felt that autothrottles would have prevented the incident, notwithstanding the first officer's unprofessional lack of attention to the aircraft. He emphasized that no loss of separation occurred, notwithstanding their descent through at least 4 potentially occupied RVSM altitudes. Also, he transmitted the emergency descent and was cleared through FL290 if necessary by ZZZ. **JIMDAT Analysis:** Applicable **Phase of Flight:** Cruise **Comment:** **Category:** Vertical Deviation (energy state management) **Trigger:** Back side of "Lift vs. Drag" Curve **Contributing Factors:** • Complacency • Sub-optimal CRM; no cross-check with Captain out of cockpit • Possible distraction (flight attendant in cockpit) • Lack of adherence to S.O.P. (O2 mask and FA seated, strapped in)
45	**659914b**	**SYNOPSIS** Flight crew of a Canadair RJ failed to reprogram FMC for runway change on departure from originating airport. The crew recovered from track deviation with the assistance of the departure controller. **NARRATIVE** Prior to pushback the crew received clearance for runway 8R and the SID RNAV departure. On taxi out the crew received instruction to taxi to runway 26L. Both the first officer and captain, while performing the "takeoff brief," overlooked the runway change. TOGA was selected once cleared for takeoff, updating the FMS position. On rotation, the new procedure was implemented. "Gear up, speed mode, NAV mode," was called for. The flight director started a slow turn to the left. The captain, pilot flying (PF), momentarily followed it, noticing that there was no info on his MFD. He corrected his heading to the initial departure procedure heading. Then PF immediately notified the tower that the crew had lost NAVs and would need vectors. A 275/280 degree heading was given, then the aircraft was handed off to Departure Control. After checking in with Departure Control, the crew was asked if they could continue. They responded that they thought that they could. Departure Control then gave them a turn to the north. With the autopilot engaged, and the "After Takeoff" check complete, the PF reentered the runway and sequenced the fixes. The PF noticed that the aircraft had not strayed very far from the (SID) departure. The crew informed ATC that they had navigation capability again. The aircraft was cleared on course. No further events out of the normal procedures occurred. Neither the captain nor the first officer knew that the loss of

		navigation was due to not updating the FMS after a runway change and not catching the error before takeoff. The pilots believe that this was the case after careful discussion. This was the fourth day flying with a fairly new first officer with only a few months on line. The pilots were fatigued and the captain believes that to be a strong contributing factor. **JIMDAT Analysis:** Applicable **Phase of Flight:** Departure/SID **Comment:** FMS required re-programming **Category:** Lateral Deviation (mode awareness) **Trigger:** Late runway change **Contributing Factors:** • Fatigue • Sub-optimal CRM; no cross-check • Over-confidence; lack of aeronautical knowledge
46	**665181b**	**SYNOPSIS** B737-800 is unable to maintain airspeed at FL390 while maneuvering for weather. **NARRATIVE** The crew slowed to .76 mach to work through thunderstorms. Autothrottles did not hold speed. The crew went to maximum continuous power - still above minimum maneuvering speed. Speed would not recover. After several minutes, it continued to deteriorate. The aircraft was getting very near stick shaker. The captain, pilot monitoring (PM), ordered first officer, pilot flying (PF), to descend. The radio was very busy. The crew was at FL384 before getting clearance to FL370. The controller did not seem alarmed. **JIMDAT Analysis:** Applicable **Phase of Flight:** Cruise **Comment:** Performance issues – maneuvering at high weights, high altitude, steep bank angles, etc.? **Category:** Vertical Deviation (energy state management) **Trigger:** Back side of "Lift vs. Drag" Curve **Contributing Factors:** • Over-confidence; lack of aeronautical knowledge • Performance-related; aircraft could not be slowed to Mach 0.76 at high altitude and bank angles without sacrificing stall margin
47	**665350b**	**SYNOPSIS** Flight crew of MD80 unable to maintain cruise mach at FL320. Forced to descend to avoid stall. **NARRATIVE** While approaching VOR 1 with Center, FL320, ram air temp -1 degree, weight approximately 138,000 lbs, on top of clouds, mach .76, mach autothrottles, the captain, pilot flying (PF), noticed a light airframe vibration like a landing light or spoiler panel out. He commented on this to the first officer, pilot monitoring (PM). Both pilots did a quick check of gear doors,

		MCP, spoilers and ice detection rings. The shudder became more pronounced, with airspeed declining. The PF called for engine and airfoil anti-icing. The first officer contacted Center for FL260. The aircraft was cleared, and the PF disconnected the autopilot and autothrottles, and began a 1,000 fpm descent with MCL selected manually. At FL315, the crew got 1 stall aural and 1 claxon/red light. They never got a "speed low" or stick shaker. Airspeed now was accelerating in a continued controlled descent. The crew could have leveled at FL290 with plenty of airspeed, but continued to FL280 and mach .76 with engine and airfoil anti-ice on. The PF felt that perhaps they had picked up enough ice in the climb to give a flawed EPR rating, with less thrust than autothrottles would have normally provided. At no time were there visual signs of icing either below the wiper or on the ice detection ring on either side! **JIMDAT Analysis:** Applicable **Phase of Flight:** Cruise **Comment:** Computer/performance issues **Category:** Vertical Deviation (energy state management) **Trigger:** Back side of "Lift vs. Drag" Curve **Contributing Factors:** • Over-confidence • Performance-related; aircraft too heavy for warm conditions aloft (roughly ISA + 49) • Mis-diagnosed as icing-related
48	**665968b**	**SYNOPSIS** An A300 in the profile descent mode indicated proper FMA altitude capture annunciations, but failed to capture the programmed altitude. **NARRATIVE** The aircraft was on arrival to FIX 1, on STAR arrival. The first officer was the pilot flying (PF). The aircraft was cleared to descend to FL240, and the aircraft was in the PROFILE DESCENT mode. The captain, pilot monitoring (PM), was reviewing the arrival chart when the altitude deviation warning went off. The captain looked away from the chart to see the aircraft was now at FL236. The first officer was looking down at his chart. The PM immediately took control of aircraft, clicked autopilot off, and climbed back up to FL240. Approach didn't say anything and the event was over within 5 to 10 seconds. The aircraft will not always perform properly while in PROFILE MODE. Complacency, especially in profile mode, should be avoided, especially prior to aircraft level off. Additionally, the crew was awake for approximately 24 hours at the time of the event. Callback conversation with reporter revealed the following info: reporter stated that in this event both the MCP altitude set and the FMC contained FL240 as the constraining altitude. The aircraft was slightly past the constraint point and was attempting to meet the fix requirement but dropped the altitude for some unknown reason. The autopilot did not overspeed trying to meet the constraint. **JIMDAT Analysis:** Applicable **Phase of Flight:** STAR **Comment:** older Airbus; possibility that FMC has received software mods? **Category:** Vertical Deviation (energy state management) **Trigger:** None specific

		Contributing Factors:
		• Fatigue
		• Distraction
		• Complacency
		• Possible software modification
		
		SME Review
		• JIMDAT Analysis confirmed?
		  o Trigger? Failure to monitor PROFILE descent mode
		  o Contributing Factors?
		    1. Airbus has "hockey sticks" only in some modes within 200 nm of the fix; feature will not be active until then. For a long-range descent, the pilot must do the "3:1" calculation in his head.
		    2. Did they do a VS change? You don't necessarily know what really happened. (If so, this would have cancelled the PROFILE descent)
		  o Degree of risk?
		• What actions would have prevented the occurrence of this event?
		  o Company policy adjustment
		  o "1,000 foot above" call-out
		  o Pilots avoiding distraction during last 1,000 feet
		  o Modification of the algorithm for an appropriate level-off rate (software programmed to cross at precise point – should allow some flexibility)
		  o Better monitoring
		  o Only one pilot should be "heads down"
		  o One carrier prefers arrival briefings to be done before descent; "verbalize" technique is harder in a high density environment
		• Could we address this with a Policy or Procedural change? Yes

49	**670863b**	**SYNOPSIS** Flight crew of B757-200 experiences failure of autoflight system to meet crossing restriction at intersection on arrival to (location). **NARRATIVE** At FL360 the crew was cleared to cross XXXXX intersection at FL310. The captain, pilot flying (PF), entered that restriction into the FMC legs page and reset the altitude alerter to FL310. Both of these were confirmed by the first officer. The PF also rechecked the target descent speed and entered the expected crossing restriction for YYYYY. The aircraft was still several miles away from XXXXX at this time. As the aircraft approached the top of descent point, the PF monitored the autopilot as it started the descent to FL310. Everything looked fine, as it was stable in the descent with idle thrust and on VNAV profile, so the PF turned his attention to getting out his approach charts. After about 20 seconds, the PF looked back at the instruments and noticed the airplane was holding almost level at FL345, airspeed was 25 knots below target and the VNAV path indicator was showing that the aircraft was below the path, yet it was almost over the XXXXX waypoint. The PF pointed out this discrepancy to the first officer, pilot monitoring (PM), and asked if he had any idea why the autopilot was leveling. The PF also quickly checked that the flight directors were on, VNAV and LNAV were engaged, and the autopilot was engaged. The FMC showed that the XXXXX restriction of FL310 was still in the descent page and the altitude alerter on the autopilot panel was properly set to FL310. Without taking more time to figure it all out, the PF disconnected the autopilot and autothrottle and made a rapid descent to FL310. He estimated that the aircraft crossed XXXXX about FL338 and was level at FL310 a few miles past XXXXX. After leveling at FL310, the crew rechecked everything and could not find any reason for the autopilot to behave the way it did. The airplane probably began to gradually level off around FL352, about the time the PF turned his attention away. Because the level off was gradual and the autothrottles did not increase, it was not noticeable to the crew while they were doing other

		things. The speed had decreased because the autothrottles had not increased with the level off, but they were just starting to move forward when the PF disconnected them. It was also strange that the VNAV path should show the aircraft below path when it was actually high. Somehow the VNAV path had changed without any input from the crew. It was as though it decided to ignore the XXXXX restriction, but that restriction was still in the FMC. As the aircraft was leveling at FL310, ATC asked if the crew had been given XXXXX at FL310. The crew said that they had received that restriction, but that they had experienced automation problems. The controller said it was no problem. The pilots did not get any TCAS indications and there was no indication that any other aircraft was in any way affected by their actions. Even when they reviewed the situation on the ground, they still could not figure out why the aircraft started to descend just fine but then acted the way it did. This aircraft has the new Pegasus computer navigation system and it might have had something to do with that. This was only the PF's second flight with this new system. In the future, the PF will take more care to monitor the aircraft -- not only at the start of descent and near the restriction, but also throughout the descent. The PF thinks he will also enter a waypoint a few miles ahead of the actual crossing restriction points to allow for correction if this problem shows up again. When it leveled off that close to the waypoint, it eliminated the crew's ability to correct in time to make the restriction. Callback conversation with the reporter revealed the following info: reporter had no further explanation for the anomaly. He stated the restriction was programmed well in advance of the resulting top of descent point and the descent started in appropriate synchronization with the VNAV path visual indicator. The auto flight system performed correctly after it was re-engaged and he felt a write-up without a better understanding of what happened or a subsequent recurrence was of limited value. He clarified that his suggestion the Pegasus software may be at fault was merely in recognition of the fact that the aircraft differed in that respect from the B757s in which he had flown previously. There was no specific anomaly that pointed directly to the software. **JIMDAT Analysis:** Applicable **Comments:** Need SMEs to examine Pegasus software issue(s) **Category:** Vertical Deviation (energy state management) **Trigger:** Crossing Restriction **Contributing Factors:** • Crew distracted • Low energy state (airspeed slowing; throttles back) • Suspected software anomaly (Pegasus) **SME Review** • JIMDAT Analysis confirmed? o Trigger? 1. Potential trigger is an FMC malfunction o Contributing Factors? 1. PF function not accomplished – looked away to enroute chart after initiating descent 2. Crew distracted 3. Pilot speculated in future to use automation to solve automation problem (artificial waypoint entry) 4. Earlier monitoring and error detection o Degree of risk? MEDIUM • What actions would have prevented the occurrence of this event? 1. Closer monitoring of vertical raw data Could we address this with a Policy or Procedural change? NONE
50	**678219b**	**SYNOPSIS**

A B737-300 flight crew reports Approach Control changed runway and transition clearance after passing FIX 1 on the Standard Terminal Arrival Route to (destination). Track deviation and vector (was necessary) to prevent loss of separation.

NARRATIVE

On initial radar contact with Approach Control (STAR transition), the aircraft was cleared to descend via the STAR for runway 24R. Prior to FIX 1, the runway was changed to runway 25L. The FMC was reprogrammed for runway 25L. Overhead FIX 1, with the aircraft tracking to FIX 2 for runway 25L, Approach Control re-cleared the aircraft for runway 24R. The captain, pilot monitoring (PM), notified the first officer, pilot flying (PF), of the runway change and loaded waypoint FIX 3 and runway 24R. The PF began a gentle turn to approximately 330 degrees to resume/intercept the arrival to runway 24R (the FMC was indicating a turn to the north - 360 degrees to FIX 3 - which seemed too excessive). As the pilots were discussing this navigation situation, Approach Control queried them as to where they were heading, and assigned them a vector of approximately 260 degrees to intercept the runway 24R localizer. Traffic for the south complex (runway 25L) was held up until the aircraft crossed below them. The remainder of the approach/landing to runway 24R was uneventful. The first officer believed confusion for the arrival began when Approach Control re-cleared the aircraft for runway 24R (the preferential runway for this company) at FIX 1. In hindsight, Approach Control was probably expecting the aircraft to track FIX 1 - INTERMEDIATE FIX - FIX 3. The aircraft was near/overhead FIX 1 at the time of the new approach clearance, the FMC had “lead-turned” FIX 1, and the aircraft was tracking towards FIX 2 for runway 25L. Since at this point, the pilots had no FMC solution to transition to runway 24R, the PF began a turn north of the aircraft’s current track, while the PM reprogrammed the FMC for FIX 3 to track for runway 24R. This last-minute runway change at FIX 1, where the arrival branches off on three different tracks (runway 24/runway 5R/runway 25L) led to the confusion on the approach between the aircraft and ATC, and led to the navigational discrepancy as the aircraft’s navigational computer had already begun tracking for FIX 2 for the runway. While a runway change to runway 24 is much appreciated, this late on the arrival a vector to intercept the runway 24R LOC would have been more helpful (and is what we eventually received from Approach Control). Supplemental information from ACN 678218: the radios at this time were completely “garbaged up” with people stepping on top of each other, Approach Control “stressing out,” and everybody getting frustrated. Judging by the tone, frustration, and speed at which the controller talked, it was apparent that ATC blamed the aircraft for not complying with their instructions, while they failed to realize the illegal clearance they gave the aircraft. Add to this the huge distractions of numerous frequency changes, and the ever-increasing radio chatter on Approach Control's frequency, and it's not hard to see how things can get messed up very quickly. All the PF asked is that they do one of two things, either give the aircraft a heading to fly, or a vector direct to a fix on the other transition.

JIMDAT Analysis: Applicable

Phase of Flight: STAR

Comment: Several runway changes caused crew confusion

Category: Lateral Deviation (mode awareness)

Trigger: Late Runway Change

Contributing Factors:

- Runway change X 2
- FMS feature – new leg tripped; “lead turn” in progress
- FMS re-programming
- Time/actions compression – omitted pilot cross-check
- Communications/ATC Frequency congestion

APPENDIX D

Selected Characteristics of 50 ASRS Cases Analyzed in Detail

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Selected Characteristics of the 50 ASRS Cases Analyzed in Detail

Case	Category	Trigger	Mode	Risk (in this case)	Phase
1	Vertical Deviation (Mode Awareness)	Crossing Restriction	LNAV & VNAV	High - Intervene	Descent
2	Vertical Deviation (Energy State Management)	Engine Malfunction	LNAV & VNAV Flight LVL CHG Mode	Low - Monitor	Departure, SID, Climb-out
3	Low Speed (Energy State Management)	Improper Config Control	A/P & A/Ts On; FDs On	High - Intervene	Approach & Landing
4	Lateral Deviation (Mode Awareness)	Failure To Verify LNAV Intercept	N/A	Low - Monitor	Departure, SID, Climb-out
5	Vertical Deviation (Energy State Management)	Back side of "lift-Vs drag" curve	Vertical Speed Mode on MCP; 1400 FPM slected	High - Intervene	Departure, SID, Climb-out
6	A/P activated on takeoff Roll (Mode Awareness)	Failed to Engage A/Ts or Improper A/T Mode	A/P Inadvertently Engaged on T/O Roll	High - Intervene	T/O
7	Low Speed (Energy State Management)	None	A/P, LNAV, VNAV & A/T Mode; Speed & Flight Level Change Modes on MCP	Low - Monitor	Approach & Landing
8	Excess Power - Speed (Energy State Management)	Excessive Climb Rate	A/F On; A/T On	Low - Monitor	Approach & Landing
9	Vertical Deviation (Energy State Management & Mode Awareness)	Crossing Restriction	PATH vs Cruise Descent Mode; LVL CHG vs V/S	Low - Monitor	Descent
10	Vertical Deviation (Energy State Management & Mode Awareness)	Improper VNAV Mode Selected	LNAV & VNAV Mode, Then Speed Mode	High - Intervene	Descent
11	Vertical Deviation (Energy State Management)	Crossing Restriction	Flight Level Change selected VS VNAV	Low - Monitor	Approach & Landing
12	Low Speed (Energy State Management)	Profile Descent	A/P On; A/Ts off; Profile Desecnt Mode	Low - Monitor	Arrival/Star, Hold
13	Lateral Deviation (Energy State Management)	Unknown	A/F On; A/T On	High - Intervene	Departure, SID, Climb-out
14	Excess Power - Speed (Energy State Management)	Failed to Engage A/Ts or Improper A/T Mode	APFDS - Level Change mode; ERP	Low - Monitor	Departure, SID, Climb-out
15	Excess Power - Speed (Energy State Management)	Failed to Engage A/Ts or Improper A/T Mode	A/F - FDs on; A/T On	High - Intervene	Approach & Landing
16	Lateral Deviation (Mode Awareness)	Improper VNAV Mode Selected	LNAV & Speed Modes	High - Intervene	Descent
17	Excess Speed & Vertical Deviation (Energy State Management)	Crossing Restriction	VNAV - Cruise Descend Mode	Moderate - Develop Mitigation Strategy	Arrival/Star, Hold
18	Excess Power - Speed (Energy State Management)	Crossing Restriction	A/F - Profile Descent Mode	Moderate - Develop Mitigation Strategy	Descent

Case	Category	Trigger	Mode	Risk (In this case)	Phase
19	Excess Power - Speed (Energy State Management)	Software Error	A/F Approach Mode; A/T On	Low - Monitor	Approach & Landing
20	Excess Power - Speed (Energy State Management)	Unknown	A/F Approach Mode; A/T On	Moderate - Develop Mitigation Strategy	Approach & Landing
21	Vertical Deviation (Energy State Management)	Profile Descent	A/F - Profile Descent Mode	Low - Monitor	Arrival/Star, Hold
22	Excess Power - Speed (Energy State Management)	Failure To Arm Approach Mode	A/F On; A/T On	Low - Monitor	Approach & Landing
23	Power - Speed Loss (Energy State Management)	Failed to Engage A/Ts or Improper A/T Mode	A/P On; A/T Off	Moderate - Develop Mitigation Strategy	Approach & Landing
24	Lateral Deviation (Mode Awareness)	Improper VNAV Mode Selected	CWS vs LNAV Mode	Low - Monitor	Cruise
25	Vertical Deviation (Energy State Management)	Back side of "lift-Vs drag" curve	N/A	High - Intervene	Cruise
26	Lateral Deviation (Mode Awareness)	Single FMS	HDG SEL vs LNAV Mode	Low - Monitor	Departure, SID, Climb-out
27	Lateral Deviation (Mode Awareness)	Unknown	LNAV Mode, Then HDG Mode	Moderate - Develop Mitigation Strategy	Departure, SID, Climb-out
28	Vertical Deviation (Energy State Management)	Excessive Climb Rate	A/T - Managed Speed; A/P Off	Low - Monitor	Departure, SID, Climb-out
29	Lateral Deviation (Mode Awareness)	Incorrect Cockpit Priorities	N/A	Low - Monitor	Arrival/Star, Hold
30	Lateral Deviation (Mode Awareness & Slow Speed)	Failure To Arm Approach Mode	N/A	Moderate - Develop Mitigation Strategy	Approach & Landing
31	Lateral Deviation (Mode Awareness)	Map Shift	EGPWS Warning	High - Intervene	Approach & Landing
32	Lateral Deviation (Mode Awareness)	Single FMS	N/A	High - Intervene	Arrival/Star, Hold
33	Lateral Deviation (Mode Awareness)	Map Shift	EGPWS Warning	High - Intervene	Departure, SID, Climb-out
34	Vertical Deviation (Energy State Management)	Late Runway Change	N/A	Moderate - Develop Mitigation Strategy	Arrival/Star, Hold
35	Mode Awareness	Crew Over-rode Planned Vertical Profile	A/T On; A/P Off	High - Intervene	Departure, SID, Climb-out
36	Mode Awareness	Failed to Engage A/Ts or Improper A/T Mode	A/P On; A/T Off	High - Intervene	Descent
37	Vertical Deviation (Energy State Management)	Failure To Use Automation	Unknown	Moderate - Develop Mitigation Strategy	T/O
38	Vertical Deviation & Loss of A/S (Energy State Management & Mode Awareness)	Failed to Engage A/Ts or Improper A/T Mode	FMS - A/P & A/T Off	High - Intervene	Approach & Landing

Case	Category	Trigger	Mode	Risk (In this case)	Phase
39	Vertical Deviation & Loss of A/S (Energy State Management & Mode Awareness)	Crossing Restriction	FMS - A/P & A/T On	Moderate - Develop Mitigation Strategy	Descent
40	Vertical Deviation (Energy State Management & Mode Awareness)	Improper VNAV Mode Selected	A/F - Managed Speed A/T - Thrust Climb; OP Climb	Moderate - Develop Mitigation Strategy	Approach & Landing
41	Vertical Deviation (Energy State Management)	Crossing Restriction	FMC but no Glass Nav Displays	Moderate - Develop Mitigation Strategy	Descent
42	Vertical Deviation & Loss of A/S (Energy State Management & Mode Awareness)	Failure To Arm Approach Mode	A/F - Open Descent	Moderate - Develop Mitigation Strategy	Approach & Landing
43	Vertical Deviation (Energy State Management)	Late Runway Change	FMC - A/P Off	High - Intervene	Approach & Landing
44	Vertical Deviation (Energy State Management)	Back side of "lift-Vs drag" curve	FMCS & A/P On; no A/T	High - Intervene	Cruise
45	Lateral Deviation (Mode Awareness)	Late Runway Change	FMS	Low - Monitor	Departure, SID, Climb-out
46	Vertical Deviation (Energy State Management)	Back side of "lift-Vs drag" curve	A/P & A/T	High - Intervene	Cruise
47	Vertical Deviation (Energy State Management)	Back side of "lift-Vs drag" curve	A/P & A/T	High - Intervene	Cruise
48	Vertical Deviation (Energy State Management)	Profile Descent	Profile Descent	Low - Monitor	Arrival/Star, Hold
49	Vertical Deviation (Energy State Management)	Crossing Restriction	A/P & A/T on: FDs on; LNAV & VNAV on	Moderate - Develop Mitigation Strategy	Cruise
50	Lateral Deviation (Mode Awareness)	Late Runway Change	N/A	Low - Monitor	Arrival/Star, Hold

Appendix E

Results of Gap Analysis:

Did Pilots Employ Policy Attributes In the 50 ASRS Cases?

GAP ANALYSIS Phase II – Did Pilots Employ Policy Attributes/Dimensions?

		PHILOSOPHY Attribute					
ASRS Event	(note)	Avoid over-reliance on automation to detriment of manual flying skills	Correctly Interact with automation to reduce workload, increase safety & efficiency	Be wary of Autoflight "Up tempo" – when crew coordination, communications, & monitoring of automation are more important	Appreciate specified capability, limitations & failure susceptibility of automation	Resist Distraction degradation; automation can actually increase pilot workload or degrade performance	**"CAMI"** Procedure **C**onfirm FMS inputs with other pilot when airborne; **A**ctivate input; **M**onitor mode annunciations to ensure autoflight system performs as desired; **I**ntervene if necessary
678219b		N/A	N/A	**NO**	**NO**	**NO**	**NO**
670863b		N/A	N/A	N/A	**NO**	**NO**	**NO**
665968b		N/A	N/A	N/A	**NO**	**NO**	**NO**
665350b	**1, 2**	**NO**	**NO**	N/A	**NO**	N/A	N/A
665181b	**1, 2**	**NO**	**NO**	N/A	**NO**	NA	NA
659914b		N/A	**NO**	N/A	**NO**	**NO**	**NO**
650942b	**2**	**NO**	**NO**	N/A	**NO**	**NO**	N/A
649590b		**YES**	**NO**	N/A	N/A	N/A	N/A
638758b		N/A	**NO**	N/A	N/A	N/A	**NO**
634595b		**YES**	**NO**	N/A	N/A	N/A	**NO**
631071b	**1**	**NO**	**NO**	N/A	N/A	N/A	**NO**
631015b	**1**	**NO**	**NO**	N/A	**NO**	**NO**	**NO**
615854b		**NO**	**NO**	N/A	**NO**	**NO**	**NO**
615162b		N/A	**NO**	N/A	N/A	N/A	N/A
613077b		**NO**	**NO**	N/A	N/A	N/A	**NO**
612730b	**1**	**NO**	**NO**	N/A	**NO**	NA	NA
603496b		N/A	N/A	**NO**	N/A	**NO**	**NO**
602438b	**4**	N/A	N/A	N/A	**YES**	N/A	N/A
602417b		N/A	**NO**	N/A	**NO**	N/A	**NO**
598817b		**NO**	**NO**	**NO**	**NO**	N/A	**NO**
598403b		**NO**	**NO**	N/A	**NO**	NA	NA
597418b		N/A	**NO**	**NO**	N/A	**NO**	**NO**
596513b		**NO**	**NO**	**NO**	**NO**	N/A	**NO**
575000b		N/A	**YES**	N/A	N/A	N/A	**YES**
570020b		**YES**	**NO**	**YES**	N/A	**YES**	**NO**
566842b		**NO**	**NO**	N/A	**NO**	NA	**NO**
563893b		N/A	**NO**	N/A	N/A	**NO**	**NO**
546716b		**NO**	**NO**	N/A	**NO**	NA	**NO**
546623b		N/A	**NO**	N/A	N/A	N/A	**NO**
543549b		N/A	**NO**	N/A	**NO**	N/A	N/A
542504b		N/A	**YES**	N/A	N/A	N/A	NA
541533b		N/A	**YES**	N/A	N/A	N/A	NA
536359b	**3**	**NO**	**NO**	N/A	**NO**	N/A	NA
535228b		**NO**	**NO**	N/A	**NO**	N/A	NA
533158b		N/A	**NO**	N/A	**NO**	N/A	NA
532213b	**4**	**NO**	**NO**	**NO**	**NO**	N/A	**NO**
530710b		**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
528352b		**NO**	**NO**	**NO**	**NO**	N/A	NA
526009b		N/A	**NO**	N/A	**NO**	N/A	N/A
525434b		N/A	**NO**	N/A	**NO**	N/A	**NO**
509560b		N/A	**NO**	N/A	**NO**	**NO**	**NO**
497303b		N/A	**NO**	N/A	N/A	N/A	**NO**
486854b		N/A	**NO**	**NO**	**NO**	N/A	**NO**
480293b	**5**	N/A	N/A	N/A	**NO**	N/A	**YES**
475218b		N/A	**NO**	N/A	**NO**	N/A	**NO**
299148b		**NO**	**NO**	N/A	**NO**	NA	NA
296218b		N/A	**NO**	N/A	N/A	N/A	**NO**
278778b		**NO**	**NO**	N/A	**NO**	NA	NA
277912b		**NO**	**NO**	N/A	**NO**	**NO**	N/A
265962b		N/A	**NO**	**NO**	**NO**	N/A	N/A
TOTALS		**23 NO** **3 YES** **24 N/A** **11% success**	**39 NO** **3 YES** **8 N/A** **7% success**	**12 NO** **1 YES** **37 N/A** **8% success**	**33 NO** **1 YES** **16 N/A** **3% success**	**14 NO** **1 YES** **35 N/A** **7% success**	**28 NO** **2 YES** **20 N/A** **7% success**

Event (note)		LEVELS OF AUTOMATION Attributes							
		Well-trained PF selects automation at *most appropriate level* to fit dynamic circumstances of changing environment	Level 1 Everything off; relying on raw data; no automation active.	Level 2 A/P off; optional use of FD & A/Ts while "hand flying" the airplane.	Level 3 Control via flight guidance system; or optional use of A/P-A/Ts; "tactical use of automation"	Level 4 Use of FD, A/P, A/Ts & FMS for vertical & lateral path guidance; "strategic use of automation"	Do not solve automation problem with a conditioned response from same level of automation	Prioritize correctly (e.g., avoid programming during critical flight phases)	Possess skills required to shift between levels
678219b		NO				✓	N/A	NO	NO
670863b	6	N/A				✓	N/A	NO	YES
665968b	6	YES				✓	N/A	N/A	YES
665350b		NO				✓	N/A	N/A	N/A
665181b		NO			✓		N/A	N/A	N/A
659914b		N/A				✓	N/A	N/A	N/A
650942b		NO			✓		N/A	N/A	N/A
649590b		NO	✓				N/A	N/A	N/A
638758b		NO			✓		N/A	N/A	NO
634595b	8	NO				✓	N/A	N/A	NO
631071b	6	NO			✓		N/A	N/A	NO
631015b		YES				✓	N/A	N/A	N/A
615854b		NO	✓				N/A	N/A	NO
615162b		NO	✓				N/A	N/A	N/A
613077b		YES			✓		NO	N/A	YES
612730b		NO		✓			NO	NO	NO
603496b		N/A				✓	N/A	NO	N/A
602438b		N/A	✓				N/A	N/A	N/A
602417b		N/A		✓			N/A	N/A	N/A
598817b		NO				✓	NO	N/A	N/A
598403b		NO		✓			NO	N/A	NO
597418b		N/A			✓		NO	NO	N/A
596513b	7	NO			✓		N/A	N/A	NO
575000b		YES				✓	N/A	YES	YES
570020b		NO				✓	N/A	NO	N/A
566842b		NO				✓	N/A	N/A	N/A
563893b		N/A				✓	N/A	N/A	N/A
546716b		N/A				✓	N/A	N/A	NO
546623b		N/A				✓	N/A	N/A	N/A
543549b		N/A				✓	N/A	N/A	N/A
542504b		YES			✓		YES	N/A	YES
541533b		YES			✓		YES	N/A	YES
536359b		NO				✓	N/A	N/A	NO
535228b		N/A				✓	N/A	N/A	N/A
533158b	1	NO			✓		N/A	N/A	NO
532213b		NO			✓		NO	NO	NO
530710b		NO				✓	NO	NO	NO
528352b		NO				✓	N/A	N/A	NO
526009b		NO				✓	NO	N/A	N/A
525434b		YES				✓	N/A	N/A	N/A
509560b		NO			✓		N/A	N/A	NO
497303b		N/A				✓	YES	N/A	N/A
486854b		N/A		✓			NO	NO	NO
480293b		N/A			✓		N/A	NO	N/A
475218b		NO			✓		NO	N/A	N/A
299148b		NO				✓	N/A	N/A	N/A
296218b		NO				✓	N/A	N/A	N/A
278778b		NO			✓		N/A	N/A	NO
277912b		NO			✓		N/A	N/A	N/A
265962b		YES				✓	N/A	NO	N/A
TOTALS		28 NO 8 YES 14 NA 22%	4	4	16	26	10 NO 3 YES 37 N/A 23%	11 NO 1 YES 38 N/A 8%	17 NO 6 YES 27 N/A 26%

Event	SITUATIONAL AWARENESS (SA) Attributes						
	Maintain Situational Awareness, including mode awareness	Ensure at least one crewmember monitors the actual flight path.	Consider "Hand Flying" in manual mode for immediate change of flight path	Use optimum automation level for comfortable workload, high SA, and improved ops capability (passenger comfort, schedule & economy)	Remain alert for signs of deterioration of flying skills, excessive workload, stress and fatigue (avert complacency)	Maintain Positional Awareness; regain manual control before aircraft enters undesired state	Brief plan for using automation before takeoff; re-brief in flight as situation dictates
678219b	N/A	N/A	N/A	NO	NO	NO	YES
670863b	NO	NO	N/A	N/A	N/A	N/A	NO
665968b	NO	NO	YES	YES	N/A	NO	N/A
665350b	NO	N/A	NO	N/A	N/A	NO	N/A
665181b	NO	N/A	NO	N/A	N/A	NO	N/A
659914b	N/A	YES	N/A	N/A	NO	NO	NO
650942b	NO	NO	N/A	N/A	NO	NO	N/A
649590b	N/A	YES	N/A	NO	N/A	N/A	N/A
638758b	NO	NO	NO	NO	N/A	NO	N/A
634595b	NO	YES	N/A	NO	NO	NO	N/A
631071b	NO	YES	YES	NO	N/A	NO	N/A
631015b	NO	NO	N/A	YES	NO	NO	N/A
615854b	NO	NO	N/A	NO	YES	NO	N/A
615162b	N/A	YES	YES	NO	N/A	YES	N/A
613077b	NO	YES	YES	YES	N/A	NO	N/A
612730b	NO	N/A	YES	NO	N/A	NO	NO
603496b	N/A	N/A	N/A	N/A	N/A	NO	N/A
602438b	NO	NO	N/A	N/A	N/A	NO	NO
602417b	NO	N/A	N/A	N/A	N/A	N/A	NO
598817b	YES	YES	N/A	NO	NO	NO	NO
598403b	NO	NO	NO	NO	NO	NO	N/A
597418b	NO	NO	NO	NO	N/A	NO	NO
596513b	NO	YES	YES	NO	N/A	YES	N/A
575000b	YES	YES	YES	YES	N/A	N/A	YES
570020b	NO	NO	NO	N/A	N/A	N/A	N/A
566842b	NO	YES	N/A	NO	N/A	NO	N/A
563893b	NO	NO	N/A	N/A	N/A	N/A	N/A
546716b	NO	N/A	N/A	N/A	N/A	N/A	N/A
546623b	NO	N/A	YES	YES	N/A	N/A	N/A
543549b	NO	NO	N/A	YES	N/A	N/A	N/A
542504b	YES	YES	YES	YES	N/A	YES	N/A
541533b	YES	YES	YES	YES	N/A	YES	N/A
536359b	NO	N/A	N/A	NO	N/A	NO	N/A
535228b	NO	NO	N/A	NO	N/A	NO	NO
533158b	N/A	N/A	N/A	NO	N/A	NO	N/A
532213b	NO	NO	NO	NO	N/A	NO	N/A
530710b	NO	NO	YES	NO	NO	NO	NO
528352b	N/A	N/A	NO	NO	N/A	NO	NO
526009b	NO	NO	NO	NO	N/A	N/A	N/A
525434b	NO	NO	N/A	YES	N/A	NO	N/A
509560b	NO	NO	YES	NO	N/A	NO	N/A
497303b	NO	NO	N/A	N/A	N/A	NO	N/A
486854b	NO	NO	NO	N/A	NO	NO	N/A
480293b	YES	YES	YES	YES	YES	YES	N/A
475218b	NO	N/A	N/A	N/A	N/A	NO	NO
299148b	NO	YES	N/A	NO	N/A	NO	N/A
296218b	NO	NO	NO	YES	N/A	NO	NO
278778b	NO	N/A	N/A	N/A	N/A	NO	N/A
277912b	NO	NO	N/A	N/A	N/A	N/A	N/A
265962b	NO	NO	N/A	YES	NO	N/A	N/A
TOTALS	39 NO 5 YES 6 N/A 11% success	23 NO 14 YES 13 N/A 38% success	8 NO 13 YES 24 N/A 38% success	23 NO 12 YES 15 N/A 34% success	10 NO 2 YES 38 N/A 17% success	34 NO 5 YES 11 N/A 13% success	12 NO 2 YES 35 N/A 14% success

Event (note)		COMMUNICATIONS Attributes						
		Both pilots should actively listen for traffic, communication & clearances.	utilize the "point and acknowledge " procedure with any ATC clearance.	1,000 feet before clearance altitude, PNF will state, e.g., "23 for 24" & PF will verbally acknowledge.	Announce automatic or manual changes to A/F status (or update other pilot at first opportunity)	Coordinate (verbalize) between both crewmembers before executing any inputs which alter aircraft flight profile.	Brief special automation duties & responsi-bilities	Brief and compare programmed flight path with charted procedure/ active routing
678219b		YES	N/A	N/A	YES	YES	N/A	YES
670863b		N/A	N/A	N/A	N/A	YES	N/A	YES
665968b		N/A	N/A	NO	N/A	N/A	N/A	N/A
665350b	2	N/A	N/A	N/A	N/A	YES	N/A	NO
665181b		N/A	N/A	N/A	N/A	N/A	N/A	NO
659914b		N/A	N/A	N/A	N/A	N/A	N/A	NO
650942b		N/A	N/A	N/A	NO	NO	N/A	NO
649590b		NO	N/A	N/A	N/A	N/A	N/A	NO
638758b		N/A	N/A	N/A	NO	NO	N/A	N/A
634595b		N/A	N/A	N/A	YES	NO	N/A	NO
631071b		N/A	N/A	N/A	NO	NO	N/A	N/A
631015b		N/A	N/A	N/A	N/A	N/A	N/A	NO
615854b		N/A	N/A	N/A	NO	NO	N/A	N/A
615162b		N/A	N/A	NO	N/A	N/A	N/A	N/A
613077b		N/A	N/A	N/A	N/A	N/A	N/A	N/A
612730b		N/A	N/A	N/A	N/A	NO	N/A	NO
603496b		N/A	N/A	N/A	NO	NO	N/A	NO
602438b		N/A	N/A	N/A	N/A	N/A	NO	NO
602417b		N/A	N/A	N/A	N/A	NO	N/A	N/A
598817b		N/A	N/A	N/A	N/A	N/A	N/A	N/A
598403b		N/A	N/A	N/A	N/A	NO	N/A	NO
597418b		N/A	N/A	N/A	NO	NO	N/A	NO
596513b		N/A	N/A	NO	NO	NO	N/A	N/A
575000b		N/A	N/A	N/A	YES	YES	N/A	YES
570020b		N/A	N/A	N/A	NO	NO	N/A	NO
566842b		N/A	N/A	N/A	N/A	YES	N/A	YES
563893b		N/A	N/A	N/A	N/A	N/A	N/A	N/A
546716b		N/A	N/A	N/A	NO	NO	N/A	N/A
546623b		N/A	N/A	N/A	N/A	N/A	N/A	N/A
543549b		N/A	N/A	N/A	N/A	NO	N/A	N/A
542504b		N/A	N/A	N/A	N/A	N/A	N/A	N/A
541533b		N/A	N/A	N/A	N/A	N/A	N/A	N/A
536359b		N/A	N/A	N/A	N/A	N/A	N/A	N/A
535228b		N/A	N/A	N/A	N/A	NO	N/A	NO
533158b		N/A	N/A	N/A	NO	NO	N/A	N/A
532213b		N/A	N/A	N/A	NO	NO	N/A	N/A
530710b		N/A	N/A	NO	N/A	N/A	NO	N/A
528352b		N/A	N/A	N/A	NO	NO	NO	NO
526009b		N/A	N/A	N/A	N/A	NO	N/A	N/A
525434b		N/A	N/A	N/A	NO	NO	N/A	N/A
509560b		N/A	N/A	N/A	NO	N/A	N/A	NO
497303b		N/A	N/A	N/A	NO	N/A	N/A	N/A
486854b		N/A	N/A	N/A	NO	N/A	N/A	N/A
480293b		N/A	N/A	N/A	N/A	N/A	N/A	N/A
475218b		N/A	N/A	N/A	N/A	N/A	N/A	N/A
299148b		N/A	N/A	N/A	N/A	N/A	N/A	NO
296218b		N/A	N/A	N/A	N/A	NO	N/A	N/A
278778b		N/A	N/A	N/A	N/A	N/A	N/A	NO
277912b		N/A	N/A	N/A	N/A	N/A	N/A	N/A
265962b		N/A	N/A	N/A	N/A	N/A	N/A	N/A
TOTALS		1 NO 1 YES 48 N/A 50% success	5O N/A 0% success	4 NO 46 N/A 0% success	15 NO 3 YES 32 N/A 17% success	21 NO 5 YES 24 N/A 19% success	3 NO 0 YES 47 N/A 0% success	18 NO 4 YES 27 N/A 18% success

Event		VERIFICATION Attributes					
		Maintain effective cross-check of AFS performance with desired flight path	Cross-check raw vs. computed A/F data	Cross-Check (verify) result of *selections, settings, & changes*	If a *transition* is selected or built, verify between pilots that it matches clearance & produces desired track.	Verifiy programming that alters route, track, or altitude and *proper mode annunciation*	Both pilots verify entered waypoints & confirm FMS data against *printed charts.*
678219b	9	NO	NO	NO	NO	NO	NO
670863b		NO	NO	NO	N/A	YES	NA
665968b		NO	N/A	NO	N/A	N/A	N/A
665350b		NO	NO	NO	N/A	N/A	N/A
665181b		NO	NO	NO	N/A	N/A	N/A
659914b		YES	YES	YES	NO	NO	NO
650942b		NO	NO	NO	N/A	NO	N/A
649590b		N/A	N/A	N/A	N/A	N/A	N/A
638758b		NO	NO	NO	N/A	NO	N/A
634595b		NO	NO	NO	N/A	NO	NO
631071b		NO	N/A	NO	N/A	NO	N/A
631015b		NO	NO	NO	N/A	NO	NO
615854b		N/A	N/A	NO	N/A	N/A	N/A
615162b		NO	NO	N/A	N/A	N/A	N/A
613077b		NO	NO	N/A	N/A	N/A	N/A
612730b	9	NO	N/A	NO	NO	NO	NO
603496b		NO	NO	NO	NO	NO	NO
602438b		NO	NO	NO	NO	N/A	N/A
602417b		N/A	N/A	N/A	NO	NO	NO
598817b		YES	YES	YES	N/A	N/A	YES
598403b		NO	NO	NO	N/A	N/A	N/A
597418b		NO	NO	NO	NO	NO	NO
596513b		NO	NO	N/A	N/A	N/A	N/A
575000b		YES	YES	YES	N/A	YES	YES
570020b		NO	NO	NO	N/A	NO	N/A
566842b		YES	YES	YES	N/A	YES	N/A
563893b		NO	NO	NO	N/A	N/A	N/A
546716b		NO	NO	NO	N/A	NO	N/A
546623b		YES	N/A	N/A	N/A	N/A	N/A
543549b		NO	N/A	NO	N/A	NO	N/A
542504b		YES	N/A	YES	N/A	N/A	N/A
541533b		YES	N/A	YES	N/A	N/A	N/A
536359b		NO	NO	NO	N/A	NO	N/A
535228b		NO	NO	NO	N/A	NO	N/A
533158b		NO	NO	NO	N/A	N/A	N/A
532213b		NO	NO	NO	N/A	NO	N/A
530710b		NO	NO	NO	N/A	N/A	N/A
528352b		YES	YES	YES	YES	N/A	N/A
526009b		NO	N/A	NO	N/A	N/A	`N/A
525434b		NO	NO	NO	N/A	NO	N/A
509560b		NO	NO	NO	N/A	NO	N/A
497303b		NO	NO	NO	N/A	N/A	N/A
486854b		NO	NO	NO	N/A	NO	NO
480293b		YES	YES	YES	N/A	YES	N/A
475218b		N/A	N/A	NO	N/A	N/A	N/A
299148b		NO	NO	NO	N/A	NO	N/A
296218b		NO	NO	NO	N/A	NO	N/A
278778b		NO	N/A	NO	N/A	N/A	N/A
277912b		NO	NO	NO	N/A	NO	N/A
265962b		NO	NO	NO	N/A	N/A	N/A
TOTALS		37 NO 9 YES 3 N/A 20% success	31 NO 6 YES 12 N/A 16% success	26 NO 8 YES 6 N/A 24% success	7 NO 1 YES 42 N/A 13% success	23 NO 3 YES 24 N/A 11% success	9 NO 2 YES 39 N/A 18% success

Event	MONITORING Attributes						
	PF and PNF monitor each other's actions; call out dis-crepancies	Scan indications to ensure aircraft performs "as expected"	pilots will not use any navigational system displaying an inoperative flag or failure indication.	monitor ALT capture mode to ensure commands for smooth level-off at assigned altitude are followed when using ALT capture mode of A/P - F/D,	Monitor Status (indications and mode annunciations)	Maintain One "head up" at all times/low altitude; avoid distraction from duties; do not let automation interfere with outside vigilance	Maintain continuous lookout during ground movement & VMC flight
678219b	NO	NO	N/A	N/A	NO	NO	N/A
670863b	YES	NO	N/A	NO	NO	N/A	N/A
665968b	NO	NO	N/A	NO	NO	N/A	N/A
665350b	YES	NO	N/A	N/A	YES	N/A	N/A
665181b	YES	NO	N/A	N/A	YES	N/A	N/A
659914b	NO	NO	N/A	N/A	YES	N/A	N/A
650942b	NO	NO	N/A	N/A	NO	N/A	N/A
649590b	NO	N/A	N/A	N/A	N/A	N/A	N/A
638758b	NO	NO	N/A	N/A	NO	N/A	N/A
634595b	NO	NO	N/A	N/A	NO	N/A	N/A
631071b	NO	NO	N/A	NO	NO	N/A	N/A
631015b	NO	NO	N/A	NO	NO	N/A	N/A
615854b	NO	NO	N/A	N/A	N/A	NO	N/A
615162b	YES	YES	N/A	NO	NO	YES	YES
613077b	NO	NO	N/A	NO	NO	YES	YES
612730b	NO	NO	N/A	NO	NO	N/A	N/A
603496b	NO	NO	N/A	N/A	NO	NO	N/A
602438b	N/A	NO	NO	N/A	NO	N/A	N/A
602417b	NO	YES	N/A	N/A	N/A	YES	YES
598817b	YES	YES	NO	N/A	YES	N/A	N/A
598403b	NO	NO	N/A	N/A	NO	N/A	N/A
597418b	NO	NO	N/A	N/A	N/A	NO	NO
596513b	NO	NO	N/A	YES	NO	N/A	N/A
575000b	YES	YES	N/A	N/A	YES	N/A	N/A
570020b	NO	NO	N/A	N/A	N/A	NO	N/A
566842b	NO	NO	N/A	N/A	NO	N/A	N/A
563893b	NO	NO	N/A	N/A	NO	N/A	N/A
546716b	NO	NO	N/A	N/A	NO	NO	YES
546623b	N/A	YES	N/A	N/A	N/A	N/A	N/A
543549b	NO	NO	N/A	N/A	N/A	N/A	N/A
542504b	YES	YES	NO	YES	YES	N/A	N/A
541533b	YES	YES	NO	YES	YES	N/A	N/A
536359b	NO	NO	N/A	NO	NO	N/A	N/A
535228b	YES	NO	N/A	N/A	NO	N/A	N/A
533158b	NO	NO	N/A	N/A	NO	NO	N/A
532213b	NO	NO	N/A	NO	NO	NO	N/A
530710b	YES	NO	N/A	N/A	N/A	N/A	N/A
528352b	NO	NO	N/A	N/A	NO	N/A	N/A
526009b	NO	NO	N/A	N/A	N/A	N/A	N/A
525434b	NO	NO	N/A	NO	NO	N/A	YES
509560b	NO	NO	N/A	NO	NO	N/A	N/A
497303b	NO	NO	N/A	N/A	YES	N/A	N/A
486854b	NO	NO	N/A	N/A	NO	N/A	N/A
480293b	N/A	N/A	N/A	N/A	N/A	N/A	N/A
475218b	NO	NO	N/A	N/A	N/A	N/A	N/A
299148b	YES	NO	N/A	NO	NO	N/A	N/A
296218b	NO	NO	N/A	N/A	NO	N/A	N/A
278778b	N/A	NO	N/A	N/A	NO	N/A	N/A
277912b	NO	NO	N/A	N/A	N/A	N/A	N/A
265962b	NO	NO	N/A	NO	N/A	N/A	N/A
TOTAL	35 NO 11 YES 4 N/A 24% success	41 NO 7 YES 2 N/A 15% success	4 NO 46 NA 0% success	13 NO 3 YES 34 N/A 19% success	29 NO 8 YES 13 N/A 22% success	6 NO 3 YES 39 N/A 33% success	1 NO 5 YES 44 N/A 83% success

Event		COMMAND & CONTROL/WORKLOAD Attributes					
Event		Clearly establish who controls aircraft under what conditions	Allow for switch of PF & PNF duties if control properly maintained	PF is responsible for flight path; remain prepared to assume control (abnormal conditions)	Designate one pilot to control (abnormal conditions)	Encourage manual flying for maintaining proficiency when flight conditions permit	Intervene if status not "as desired"; revert to lower automation level disengage any A/F system not operating "as expected"
678219b		YES	N/A	YES	N/A	N/A	NO
670863b	6	YES	N/A	YES	N/A	N/A	YES
665968b	6	YES	N/A	YES	N/A	N/A	YES
665350b		N/A	N/A	YES	N/A	N/A	NO
665181b		N/A	N/A	YES	N/A	N/A	NO
659914b		N/A	N/A	YES	N/A	N/A	YES
650942b		N/A	NO	NO	N/A	N/A	NO
649590b		NO	NO	N/A	N/A	NO	N/A
638758b		N/A	N/A	NO	N/A	N/A	NO
634595b		YES	N/A	YES	N/A	N/A	NO
631071b		YES	N/A	NO	N/A	N/A	NO
631015b		YES	N/A	YES	N/A	N/A	NO
615854b		YES	N/A	N/A	N/A	N/A	N/A
615162b		YES	N/A	YES	N/A	YES	YES
613077b		YES	N/A	YES	N/A	YES	YES
612730b		YES	N/A	NO	N/A	YES	NO
603496b		YES	N/A	YES	N/A	N/A	NO
602438b		N/A	N/A	N/A	N/A	N/A	NO
602417b		N/A	N/A	N/A	N/A	N/A	N/A
598817b		N/A	N/A	NO	N/A	N/A	NO
598403b		N/A	N/A	YES	N/A	N/A	YES
597418b		N/A	N/A	N/A	N/A	N/A	NO
596513b		N/A	N/A	N/A	N/A	N/A	YES
575000b		YES	N/A	YES	N/A	N/A	YES
570020b		NO	N/A	NO	N/A	N/A	NO
566842b		YES	N/A	YES	YES	N/A	YES
563893b		N/A	N/A	N/A	N/A	N/A	N/A
546716b		N/A	N/A	N/A	N/A	N/A	NO
546623b		N/A	N/A	YES	N/A	N/A	YES
543549b		N/A	N/A	N/A	N/A	N/A	N/A
542504b		YES	N/A	YES	N/A	YES	YES
541533b		YES	N/A	YES	N/A	YES	YES
536359b		N/A	N/A	N/A	N/A	N/A	NO
535228b		N/A	N/A	N/A	N/A	N/A	NO
533158b		N/A	N/A	N/A	N/A	N/A	YES
532213b		YES	N/A	YES	N/A	N/A	NO
530710b		N/A	N/A	YES	N/A	N/A	YES
528352b	10	N/A	N/A	N/A	N/A	N/A	NO
526009b		N/A	N/A	NO	N/A	N/A	NO
525434b		N/A	N/A	N/A	N/A	N/A	NO
509560b		N/A	N/A	YES	N/A	N/A	YES
497303b		N/A	N/A	YES	N/A	N/A	NO
486854b		N/A	N/A	N/A	N/A	NO	NO
480293b		N/A	N/A	N/A	N/A	N/A	N/A
475218b		NO	N/A	NO	NO	N/A	NO
299148b	10	N/A	N/A	N/A	N/A	N/A	YES
296218b		N/A	N/A	N/A	N/A	N/A	NO
278778b		N/A	N/A	YES	N/A	N/A	NO
277912b		N/A	N/A	N/A	N/A	YES	YES
265962b		N/A	N/A	N/A	N/A	N/A	N/A
TOTALS		3 NO 15 YES 32 N/A 83% success	2 NO O YES 48 N/A 0% success	8 NO 22 YES 20 N/A 73% success	1 NO 1 YES 48 N/A 50% success	2 NO 6 YES 42 N/A 75% success	25 NO 17 YES 8 N/A 40% success

Footnotes to Phase IV of the Gap Analysis:

Note 1: Training deficiency – general
Note 2: Training deficiency – Performance envelope
Note 3: ATC
Note 4: "Back to Basics"
Note 5: Triggered by altimeter change during level-off capture
Note 6: Reversion from Level 4 to 1
Note 7: Reversion from Level 3 to 2
Note 8: Failure to program FMS
Note 9: "Rushed"
Note 10: ESM issue