NRSC Special Study

Report on Synchronization Outages for 2Q2004

Network Reliability Steering Committee

Study Objectives

- **Review the 2Q2004 Synchronization Outages**
- **Compare it to the findings of the 2002 NRSC Report Timing Outage Summary**
- **Propose Recommendations**

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Summary

3 Synchronization Outages with Multiple Causes

50% **BITS Equipment Failure (2 outages)**

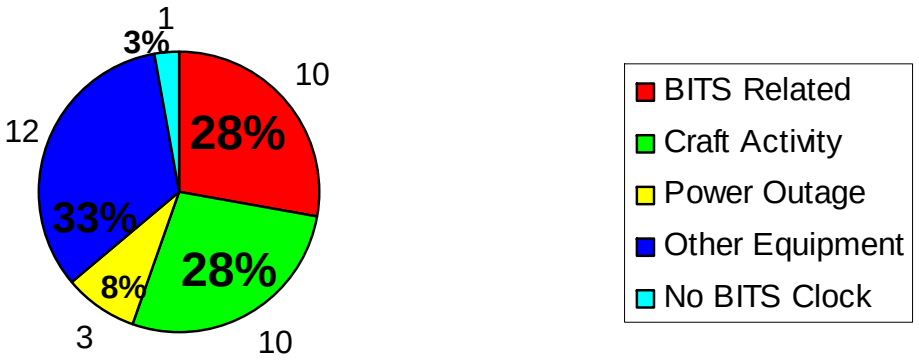
- Failure of BITS Controller to Switch Sides
- Inadequate Diagnostics

50% **Procedural Errors (2 outages)**

- Manual Restore of BITS Controller Card
- Timing Source links cut

BITS – Building Integrated Timing Source

Comparison to the 2002 NRSC Study



28% **BITS Equipment Failures**

- **Faulty Failover (Controller Card)**
- **Failure of Simplex Line Card**
- **Lack of Facility Redundancy**

28% **Procedural Error by Craft**

Recommendations

Network Operators should:

1. Conduct Office Inspections on the Synchronization Network

2. Review and Implement Six NRIC Synchronization Best Practices

Office Inspection Recommendation

1. Upgrade all BITS clocks

- ✓ Full A/B Power redundancy with separate fuses/circuit breakers for each power feed

2. Protect BITS with fully protected power (UPS) and generator

- ✓ Provide separate power feeds (A/B) that are fused separately at the Building Distributed Fuse Bay

3. Verify Important D4 channel banks configurations

- ✓ Special CCS (common channel signaling) considerations (e.g., daisy-chaining)

4. Verify Diverse Timing Leads per Shelf

- ✓ Terminate timing leads on different BITS Timing Output Cards

5. Verify BITS Switchover capability

- ✓ Conduct 5 Separate Tests (see “The Details)

6. Consult and Verify Office Timing Design during Office Modifications

- ✓ special consideration during office rearrangement, expansion or consolidation.

7. Conduct a one-time Physical Audit of Timing Redundancy

- ✓ provide special attention to SS7 link diversity should be conducted

8. Share BITS Outage Data with Vendor

Office Inspection – "The Details"

1. Upgrade all BITS clocks to models capable of full A/B Power redundancy with separate fuses or circuit breakers for each power feed in the chassis
2. Verify that BITS is on fully protected power (UPS) with generator, and via separate power feeds (A/B) that are fused separately at the BDFB/BDCBB – Building Distributed Fuse (Circuit Breaker) Bay
3. If D4 channel banks are used for transporting common channel signaling, there are special timing considerations:
   - If CCS links traverse D4 channel banks, the redundant CCS links should use diverse D4 shelves and the power and BITS timing to those shelves should be fully diverse. A common practice has been to daisy-chain BITS leads through groups of D4 shelves creating a common failure point, which must be avoided.
4. Verify that timing leads on each shelf terminate on different BITS Timing Output Cards
5. Periodic tests for BITS switchover should be executed where applicable
   - Verify Power Diversity (A/B) – Test on A alone, B alone.
   - Verify Synchronization Input Source(s) – (e.g., Primary Reference Clock, GPS)
   - Verify Timing Generators (e.g., Stratum clock cards) – Test that can switch between Source 1 and Source 2
   - Verify Redundant Output – verify switching between redundant Timing Output cards
   - Verify Proper Alarm Functionality – verify proper alarm functionality on failure conditions (e.g, redundancy failure, redundant source failure, timing lead termination failure, etc.)
6. Office Timing Design needs special consideration during office rearrangement, expansion or consolidation.
7. A one-time physical audit of timing redundancy, with special attention to SS7 link diversity should be conducted
8. Any outages, which are determined to have the BITS clock as a contributing cause; whether supplier/service provider/other attributable, should be shared with the BITS clock supplier to assist that supplier in improving the quality of their product.

Recommendation:

Review and Implement
NRIC Synchronization Best Practices

Synchronization Best Practices

- **Establish a Synchronization Coordinator**
  - Rewrite BP 7-P-0604 (rewrite)
- **Assess Synchronization Needs**
  - Rewrite BP 7-P-0605 (rewrite)
- **Engineer, Design & Install with Sync Plan Integration**
  - Rewrite 7-P-0759 (minor change)
- **Develop Management Tools to Track Intra-Office Diversity**
  - BP 6-6-0760 (no change)
- **Verify Synchronization Plan and Intra-office Diversity**
  - BP 6-6-0761 (no change)
- **Consult Synchronization Plan for all Office Modifications**
  - New Proposed Best Practice

Establish a Synchronization Coordinator

BP 7-P-0604 (rewrite)

Service Providers should establish an authority who has responsibility for the network synchronization. This authority should be known and accessible to the Service Providers 7x24 Network Operations Center and the contact information for the synchronization authority should be published in the forums in which the Service Provider participates (e.g., the forums, organizations and groups promoting inter-operability, operations, reliability and service restoration, like NRIC, ATIS, NCS, etc.). Service Providers should consider implementing a mailbox (e.g., sync@<serviceprovider>.tld)

Assess Synchronization Needs

BP 7-P-0605 (rewrite)

Service Providers should assess the synchronization needs of the network elements and interfaces that comprise their networks to develop and maintain a detailed synchronization plan.

- **Comment and Reference: The synchronization plan should include interfaces, customers (both retail and wholesale) and network peers . The plan should encompass all SERVICES provided by and used by the Service Provider. The plan should include: synchronization hierarchy, failure avoidance, redundancy and backup for resilience, FMECA and SPOFA. Synchronization performance expectations (24hr slip rate) should be determined in both primary and backup operation scenarios. Timing loop analysis must be performed in the primary arrangement and in all potential failure scenarios.**

Engineer, Design and Install with Synchronization Plan Integration

BP 6-6-0759 (minor change)

Network Operators and Service Providers should ensure that engineering, design, and installation processes address how new network elements are integrated into the office and network synchronization plan.

Develop Management Tools to Track Intra-Office Diversity

BP 6-6-0760 (no change)

Network Operators and Service Providers should develop management/records keeping tools that accurately track the diversity of internal wiring for office synchronization, including timing leads and power.

Verify Synchronization Plan and Intra-office Diversity

BP 6-6-0761 (no change)

Network Operators and Service Providers should conduct periodic verification of the office synchronization plan and the diversity of timing links, power feeds and alarms.

Consult the Synchronization Plan for all Office Modifications

BP 7-P-xxxx (New Best Practice)

Service Providers and Network Operators should consult and potentially update the synchronization plan whenever facility (e.g., all intra-/inter-office or inter-provider interconnect circuits) rearrangements, additions, deletions, changes or consolidations are planned. The change procedure should include post-change validation and test cases specific to verifying the synchronization performance is as planned.

NRSC Action Request

1. Accept the New and Modified Best Practices

2. Make Recommendations to the Industry

A. Conduct Office Inspections on the Synchronization Network

B. Review and Implement Six NRIC Synchronization Best Practices

Backup Resource

Summary of 2004 Synchronization Outages

1. A Timing Output Composite Automatic (TOCA) card in the Building Integrated Timing Source (BITS) office timing equipment failed. At the same time, the Matrix Controller Automatic-Module (MCA) card, which controlled switching to the hot spare, was out of service and not reporting alarmed conditions causing the timing for the systems on that card not to switch to the back-up TOCA card location. (BITS Related)

2. A switch became CCS7 isolated when a technician mistakenly cut the timing leads from the office clock while performing preparation work for a future activity. (Craft Related)

3. While personnel were attempting to restore MCB 1 (Master Clock Board) there was a failure on MCB 0. Investigation found that MCB 0 was faulty and had alarmed several times in the recent past. (BITS and Craft– No Robust Diagnostics, Inability of MCA to Switch to Protect)

Existing Synchronization BPs

- 6-5-0604 Each Service Provider should appoint a Synchronization Coordinator for their company who will perform the responsibilities contained in SR-2275. Telcordia Notes on the Networks are available at <http://telecom-info.telecordia.com/site-cgi/ido/index.html>. Each Service Provider should provide the name of their Synchronization Coordinator to the NIIF (<http://www.atis.org/atis/clc/niif>) for inclusion in its Company Specific Contact Directory.
- 6-5-0605 Service Providers should comply with the synchronization standards addressed in the ANSI Standard T1.101 entitled "Digital Network Synchronization". Documentation is available through <http://www.atis.org/atis/docstore>.
- 6-6-0759 Network Operators and Service Providers should ensure that engineering, design, and installation processes address how new network elements are integrated into the office synchronization plan.
- 6-6-0760 Network Operators and Service Providers should develop management/records keeping tools that accurately track the diversity of internal wiring for office synchronization, including timing leads and power.
- 6-6-0761 Network Operators and Service Providers should conduct periodic verification of the office synchronization plan and the diversity of timing links, power feeds and alarms.

Communications Industry

- Synchronization References -

Synchronization References

North America

Specification	Area	Description
GR-2830-CORE	PRS	PRS Generic Criteria
GR-378-CORE	BITS	Generic Requirements for Timing Signal Generators
GR-1244-CORE	BITS	Clocks for the Synchronized Networks: Common Generic Criteria
ANSI T1.101-1999	Sync	Synchronization Interface Standards
GR-436-CORE	Sync	Digital Network Synchronization

ITU Synchronization Standards European, South American & Pacific Rim Markets

Specification	Area	Description
G.811	PRS	Timing Characteristics of Primary Reference Source
G.812	SSU	Timing Requirements for Slave Clocks for use as Node Clocks in Synchronized Networks
G.810	Sync	Definitions and Terminology for Synchronized Networks
G.813	Sync	Timing Characteristics of SDH Equipment Slave Clocks
G.824	Sync	Control of Jitter and Wander within Digital Networks which are based on the 1.544 kbit/s Hierarchy
G.703	E1	Physical/Electrical Characteristics of Hierarchical Digital Interface
G.704	Sync	Synchronous frame structures used at 1.544, 6312, 2048, 8488 and 44736 kbit/s hierarchical levels

ETSI Synchronization Standards
European, South American & Pacific Rim Markets

Specification	Area	Description
ETS 300 462-1	Sync	Transmission and Multiplexing; Generic requirements for synchronization networks; Part 1: Definitions & terminology for synchronization networks
ETS 300 462-2	Sync	Transmission and Multiplexing; Generic requirements for synchronization networks; Part 2: Synchronization network architecture
ETS 300 462-3	Sync	Transmission and Multiplexing; Generic requirements for synchronization networks; Part 3: The control of jitter & wander within synchronization networks
ETS 300 462-5	Sync	Transmission and Multiplexing; Generic requirements for synchronization networks; Part 5: Timing characteristics of slave clocks suitable for operation in SDH equipment
ETS 300 462-6	PRS	Transmission and Multiplexing; Generic requirements for synchronization networks; Part 6: Timing characteristics of primary reference clocks
DEG/TM-01080	Sync	Synchronization Network Engineering

Comments for BP 6-5-0679

Links that are considered critical and considered redundant (e.g., CCS links), should be designed for diversity as well as redundancy. The diversity should have no common points of failure, including power and signal supplies to the elements.

Example: where CCS links traverse D4 channels banks, the D4 channel bank are often shelves in bays. The first level of diversity is that the CCS links are on different interfaces to different D4 channel banks, the channel banks aggregate link (DS-1) connects to diverse M13 multiplexes or DCS frames, continuing through the multiplexing levels across diverse transport paths. This could be called NE diversity.

The second level of diversity examination is to eliminate commonality of supply to the equipment, verifying that the BITS input for each D4 is provided by a different BITS connection and are connected to different amplifiers with redundant timing sources. The power (typically -48VDC) for the channel banks should be provided by different BDFB/BDCBB. The two levels of diversity must be considered during design and implementation. The two levels of diversity must be fully documented so that any office rearrangement must consider the two level diversity requirement. Periodic review of critical circuit arrangements should be performed to verify that office optimizations and rearrangements have not disrupted the planned diversity.