252 – Truth in the index

Team Information

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Teams must:

- Provide a detailed, step-by-step description of their problem-solving approach to ensure reproducibility by another examiner.
- List all tools used to arrive at their conclusions.

Tools used:

Name:	Magnet AXIOM	Publisher:	Magnet Forensics
Version:	9.4.1.45125		
URL:	https://www.magnetforensics.com/		

Name:	JAVA	Publisher:	oracle
Version:	21.0.7		
URL:	https://www.oracle.com/		

Name:	Lucene-core	Publisher:	Apache Lucene
Version:	10.0.0		
URL:	https://lucene.apache.org/		

Name:	HashTab	Publisher:	Implbits Software
Version:	6.0.0		
URL:	https://implbits.com/		

Name:	Hxd	Publisher:	Maël Hörz
Version:	2.5.0.0		
URL:	https://mh-nexus.de/		

Step-by-step methodology:

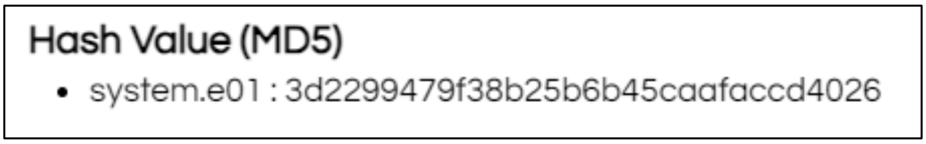
문제 설명

국가기밀 유출 혐의를 받고 있는 (주)네오포인트시큐리티 직원 A 씨는 압수수색 직전 갑작스럽게 잠적하였다. 수사관들은 회사 내 파일 서버를 확보하였으나, 사건과 관련된 문서들은 찾을 수 없었다. 내부 포렌식 조사 중 서버에서 외부 저장장치에 있는 문서를 열람한 흔적을 확인하였고, 해당 저장장치는 A 씨가 가져간 것으로 추정된다. 다행히 서버에는 문서 보관 및 열람 시 생성된 색인 파일 일부가 남아 있었으며, 이를 통해 단서를 확보하려 한다.

Questions

1. 피의자가 열람한 PDF 문서들의 원본 경로 정보를 확인하시오. (30 점)
2. 확보한 색인 파일의 필드 이름들을 나열하시오. (50 점)
3. 확보한 색인 파일을 통해 열람된 PDF 문서들의 내용을 최대한 복구하시오. (120 점)
4. 복구한 문서를 통해 피의자 A 씨의 도주 위치(나라, 도시)를 특정하시오. (50 점)

문제 풀이에 앞서, dfchallenge.org에 공지된 문제 해시와 다운로드 받은 문제 해시를 비교함으로써 분석 대상이 동일한 파일임을 증명한다.



[그림 1] dfchallenge.org에 공지된 문제 해시(MD5) 값.

[그림 2] HashTab을 통해 확인한 문제 해시(MD5) 값.

1. 피의자가 열람한 PDF 문서들의 원본 경로 정보를 확인하시오.

피의자는 외부 저장 장치를 이용하여 사내의 문서를 허가 없이 열람하였다. 이를 확인하기 위해 Magnet AXIOM 을 이용하여 해당 PC 를 조사하였으며, 결과는 다음과 같다.

해당 문서를 확인하기 앞서, 피의자가 문서 반출에 사용한 외부 저장 장치(이하 USB)를 식별하고자 한다. PC 분석 결과 동일한 외부 저장장치를 2 회 연결하였으며, 이는 2025-07-20 AM 10:18, 10:23(UTC+0)로 5 분의 간격으로 연결하였다. 이벤트 로그 분석 결과, 해당 외부 저장장치는 [표 1] 같이 식별되었다. 상기 저장장치는 Microsoft-Windows-Partition 이벤트 ID 1006 을 통해 확인되었으며, 두 차례 연결 시점 모두 동일한 하드웨어 정보를 나타내어 같은 장치임이 입증되었다.

이벤...	생성한 날짜/시간	이벤...	이벤트 설명 요약	작업	총 용량...	제조업체
1006	2025-07-20 AM 10:23:26.344	22	Storage Device RevuAhn UX200P Connected.	Connected	248074076160	RevuAhn
1006	2025-07-20 AM 10:18:43.244	20	Storage Device RevuAhn UX200P Connected.	Connected	248074076160	RevuAhn

[그림 3] 피의자가 연결한 외부 저장장치 이벤트로그.

제조사	RevuAhn
모델명	UX200P
시리얼 번호	0170011400B0
저장 용량	248GB (231GB 사용 가능)
파일 시스템	exFAT
USB 식별자	VID_13FE&PID_6000

[표 1] 피의자가 문서 반출에 사용한 USB 분석 결과.

PC 의 디지털 포렌식 분석 과정에서 Windows 점프리스트(JumpList) 아티팩트를 조사한 결과, USB 를 통해 총 6 개의 문서에 접근한 사실이 확인되었다.

점프리스트는 Windows 7 이후 운영체제에서 사용자가 최근 열어본 파일 목록을 자동으로 기록하는 시스템 아티팩트로, 파일 경로, 접근 시간, 응용프로그램 정보 등이 포함되어 있어 사용자의 파일 접근을 확인할 수 있다.

	앱 ID	잠재...	연결된 경로	인수	볼륨 이름	볼륨 일련번호	대상 파일 생성 날짜...
	9d1f905ce5044aee	Edge Browser	E:\credential\000024.pdf		UX200P	4E7EBEC1	2025-07-19 PM 1:54:02.000
	9d1f905ce5044aee	Edge Browser	E:\credential\000332.pdf		UX200P	4E7EBEC1	2025-07-19 PM 1:53:58.000
	9d1f905ce5044aee	Edge Browser	E:\credential\000364.pdf		UX200P	4E7EBEC1	2025-07-19 PM 1:53:58.000
	9d1f905ce5044aee	Edge Browser	E:\credential\000379.pdf		UX200P	4E7EBEC1	2025-07-19 PM 1:53:57.000
	9d1f905ce5044aee	Edge Browser	E:\credential\000744.pdf		UX200P	4E7EBEC1	2025-07-19 PM 1:53:54.000
	9d1f905ce5044aee	Edge Browser	E:\credential\000761.pdf		UX200P	4E7EBEC1	2025-07-19 PM 1:53:54.000

[그림 4] 피의자가 열람한 PDF 문서 정리.

피의자는 모두 9d1f905ce5044aee라는 앱을 이용하여 열람한 것을 알 수 있다. 이는 Magnet AXIOM의 분석 결과와 같이, Edge Browser를 이용하여 열람한 것을 확인할 수 있으며, 이는

[그림 5]와 같이 forensics wiki의 list of jump list ids를 통해 교차검증할 수 있다.

파일 경로	앱 ID	크기(byte)	액세스 시간 (UTC+0)
E:₩credential₩000024.pdf	9d1f905ce5044aee	1,860	2025-07-20 AM 10:19:17.000
E:₩credential₩000332.pdf	9d1f905ce5044aee	2,422	2025-07-20 AM 10:19:39.000
E:₩credential₩000364.pdf	9d1f905ce5044aee	17,326	2025-07-20 AM 10:19:52.000
E:₩credential₩000379.pdf	9d1f905ce5044aee	1,450	2025-07-20 AM 10:20:03.000
E:₩credential₩000744.pdf	9d1f905ce5044aee	67,242	2025-07-20 AM 10:20:17.000
E:₩credential₩000761.pdf	9d1f905ce5044aee	896	2025-07-20 AM 10:20:26.000

[표 2] 피의자가 열람한 PDF 속성 정리.

9d1f905ce5044aee	Edge Browser	7/6/2016	Ovie Carroll

[그림 5] forensics.wiki를 통해 확인한 Edge Browser(9d1f905ce5044aee).

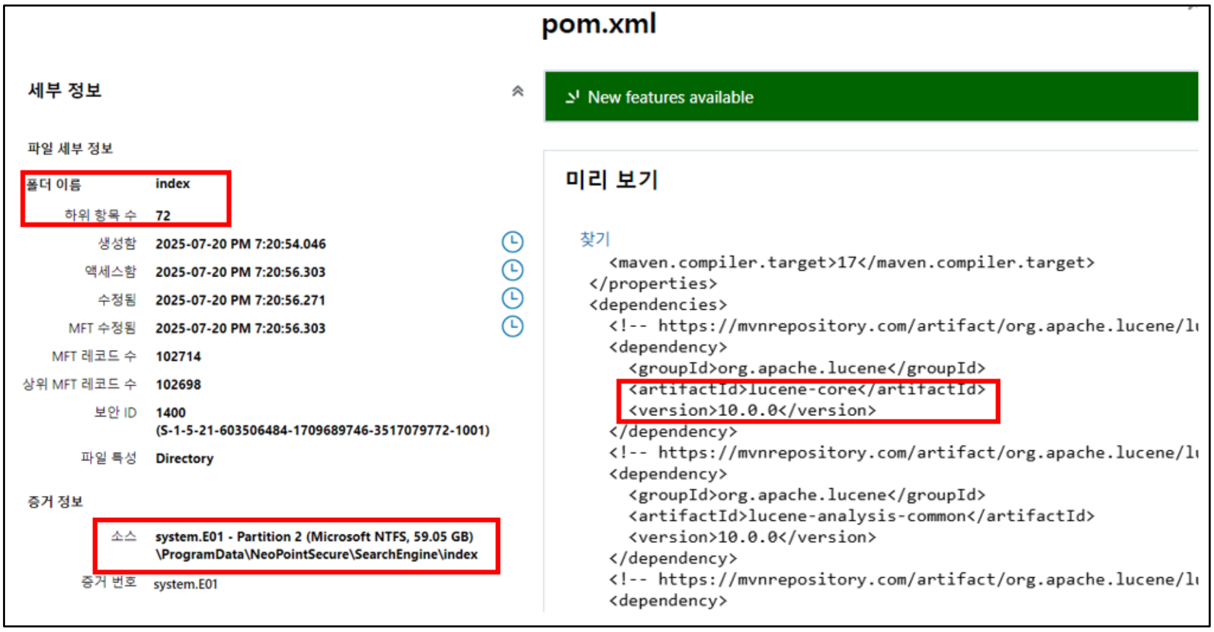
이를 통하여 피의자가 열람한 PDF의 원본 경로는 [표 3]과 같이 정리할 수 있다.

파일 경로
E:₩credential₩000024.pdf
E:₩credential₩000332.pdf
E:₩credential₩000364.pdf
E:₩credential₩000379.pdf
E:₩credential₩000744.pdf
E:₩credential₩000761.pdf

[표 3] pdf의 원본 경로 정리.

2. 확보한 색인 파일의 필드 이름들을 나열하시오.

피의자의 컴퓨터에서[그림 6]과 같이 "ProgramData₩NeoPointSecure₩index"경로에서 72 개의 색인 파일이 발견되었다. 이는 NeoPointSecure₩pom.xml 을 통하여, Apache Lucene[1]을 이용한 색인 파일임을 특정할 수 있었으며, 버전 정보는 10.0.0 이다



[그림 6] ProgramData₩NeoPointSecure₩index의 세부 정보와 pom.xml.

발견된 Lucene 색인 파일들은 [표 4]와 같이 다양한 유형으로 구성되어 있다. 세그먼트 메타데이터 파일과 각종 인덱스 파일들이 체계적으로 저장되어 있으며, 이는 대량의 데이터가 검색 가능한 형태로 가공되었음을 보여준다. 이 중 필드 이름이 저장되어 있는 .fnm 확장자의 파일을 분석하여 피의자가 어떤 종류의 데이터를 어떤 필드명으로 분류하여 저장했는지 확인할 수 있다

이름	확장자	설명
세그먼트 메타데이터 파일	(없음)	인덱스의 모든 세그먼트 정보와 전체 구조를 관리
세그먼트 정보 파일	.si	각 세그먼트의 메타데이터 (문서 수, 코덱 정보 등)
복합 세그먼트 파일	.dfs	작은 세그먼트의 모든 인덱스 데이터를 하나로 압축
복합 파일 엔트리	.dfe	.cfs 파일 내부의 각 구성 요소 위치 정보
필드 데이터 메타	.fdm	저장된 필드의 메타데이터
필드 데이터 파일	.fdt	문서의 실제 저장된 필드 값들
필드 데이터 인덱스	.dfx	.fdt 파일 내 각 문서 위치 정보
필드 이름 파일	.fnm	인덱스에 사용된 모든 필드명 정보
규범 값 데이터	.nvd	문서 점수 계산을 위한 정규화 값
규범 값 메타	.nvm	.nvd 파일의 메타데이터

[1] Lucene은 대용량 텍스트 데이터를 빠르게 검색하기 위한 오픈소스 검색 엔진 라이브러리로, 문서나 데이터를 미리 분석하여 색인(인덱스) 파일로 저장한 후 고속 검색을 가능하게 한다.

용어 벡터 데이터	.tvd	각 문서의 용어 빈도 정보
용어 벡터 메타	.tvm	.tvd 파일의 메타데이터
용어 벡터 인덱스	.tvx	용어 벡터 데이터의 위치 정보
문서 빈도 파일	.doc	각 용어가 포함된 문서 ID 목록
위치 정보 파일	.pos	용어가 문서 내에서 나타나는 위치
페이로드 및 오프셋 메타	.psm	위치 정보의 메타데이터
용어 인덱스 파일	.tim	용어 사전의 실제 데이터
용어 인덱스 포인터	.tip	.tim 파일 내 용어 위치 정보
용어 메타데이터	.tmd	용어 관련 메타데이터

[표 4] NeoPointSecure 색인 파일의 확장자별 기능.

.fnm 파일은 Lucene 인덱스의 필드 정보를 저장하는 핵심 파일로, [표 5]와 같이 각 필드의 이름과 속성을 기록한다. 이 파일을 분석함으로써 피의자가 어떤 데이터를 어떤 필드명으로 분류하여 인덱싱했는지 파악할 수 있다. .fnm 파일의 내부 구조는 Lucene의 공식 파일 포맷 스펙에 따라 다음과 같이 정의된다.

오프셋	크기	설명
0x00	VInt	FNMVersion (always -2)
-	Vint	FieldsCount
-	-	Field Entry (repeated FieldsCount times)
-	String	FieldName (UTF-8)
-	Byte	FieldBits

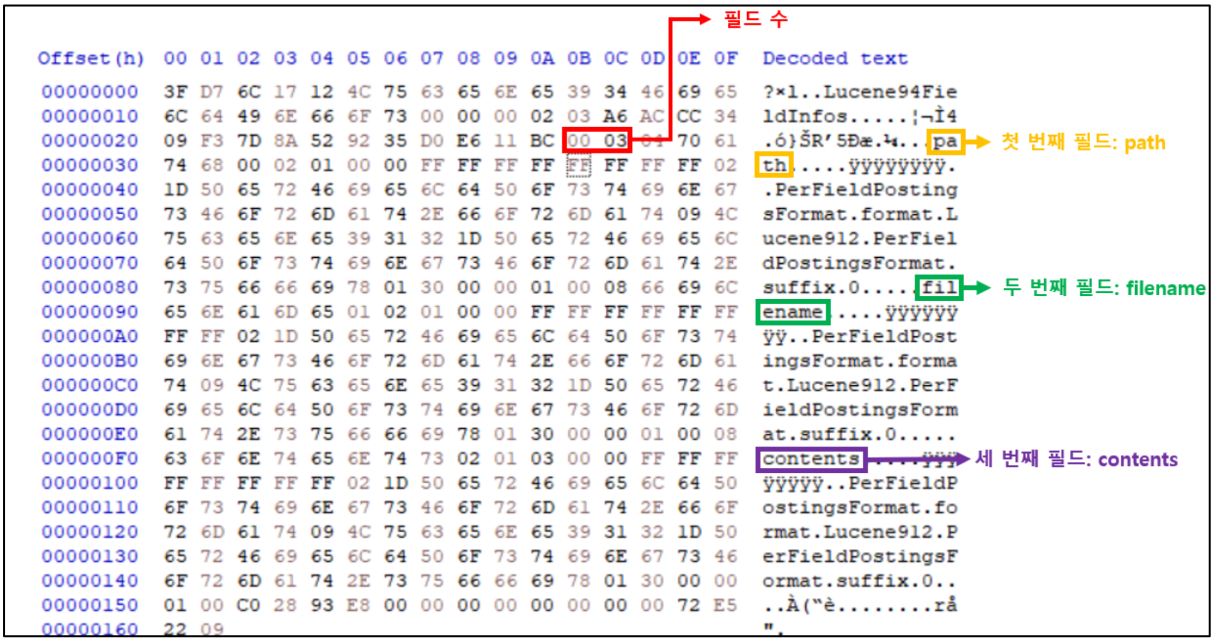
[표 5] lucene.fnm 파일의 내부 구조.

각 필드의 FieldBits는 [표 6]과 같이 해당 필드의 인덱싱 방식과 저장 옵션을 나타내는 플래그로 구성되어 있으며, 이를 통해 필드별 처리 방식을 확인할 수 있다.

비트	값	설명
0	0x01	Indexed field (1) / Non-indexed (0)
1	0x02	Has term vectors (1) / No term vectors (0)
2	0x04	Term positions stored with term vectors
3	0x08	Term offsets stored with term vectors
4	0x10	Norms omitted for indexed field
5	0x20	Payloads stored for indexed field

[표 6] fieldbits 플래그의 의미.

위 표를 토대로 ProgramData₩NeoPointSecure₩SearchEngine₩index₩_e.fnm 경로의 _e.fnm을 분석하여 색인 파일의 필드 이름을 분석하면, [그림 7]과 같이 나타낼 수 있으며, 이는 path, filename, contents 3개이다.

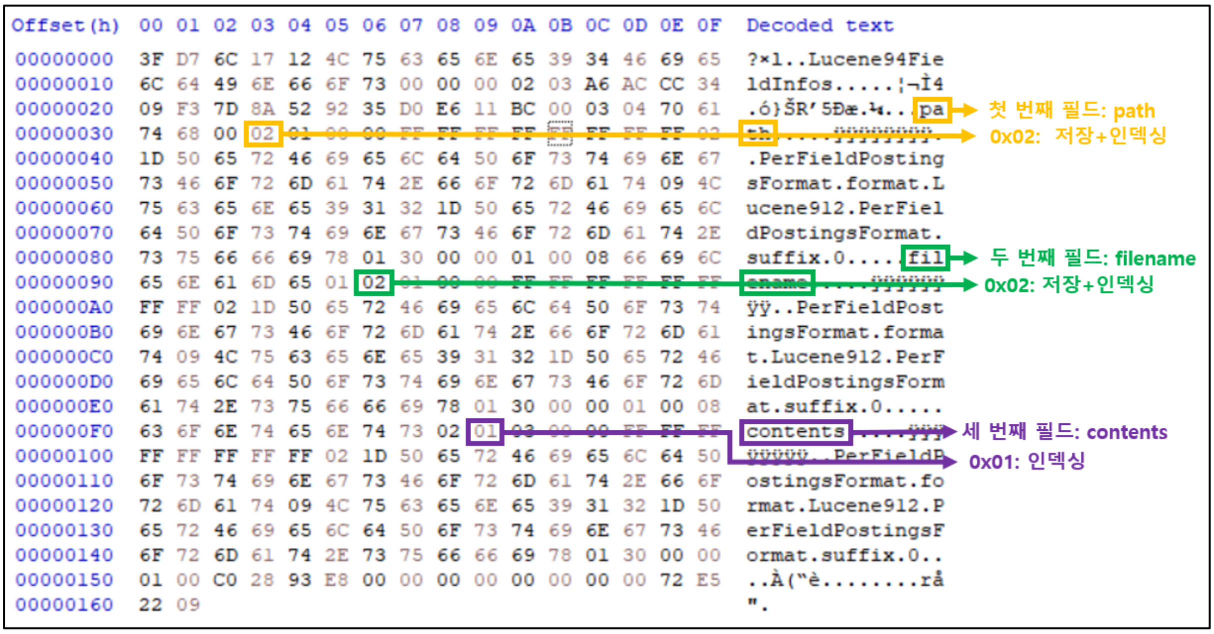


[그림 7] _e.fnm 파일 분석 결과.

답: path, filename, contests

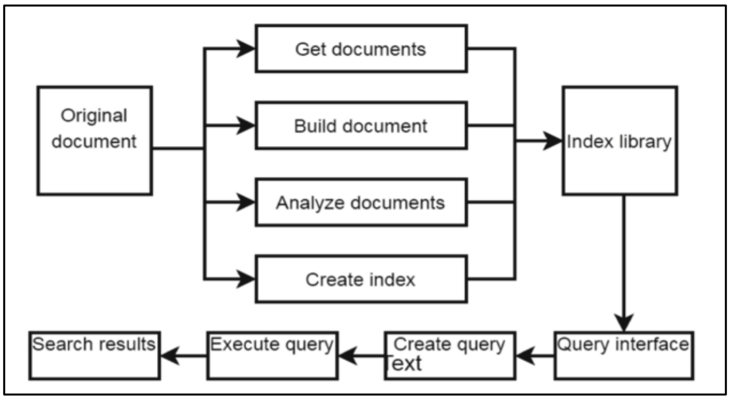
3. 확보한 색인 파일을 통해 열람된 PDF 문서들의 내용을 최대한 복구하시오.

Lucene 검색 엔진은 문서 검색을 위해 텍스트 데이터를 다양한 형태로 저장한다. 분석 대상 인덱스에서는 contents 필드가 저장되지 않고 검색용으로만 인덱싱되어 있어 완전한 원문 복구는 불가능하다. 대신 인덱싱된 용어들을 추출하여 문서의 주요 내용을 부분적으로 복구하는 방식을 사용한다. 분석 결과 [그림 8]과 같이, path 필드와 filename 필드의 플래그가 0x02로 설정되어 저장 및 인덱싱이 모두 활성화되었으나, contents 필드는 0x01로 설정되어 인덱싱만 수행된다. 이는 원본 인덱싱 과정에서 contents 필드에 Field.Store.NO 옵션이 적용되며, .fdt 파일에는 path와 filename 정보만 저장되고 실제 문서 내용은 보존되지 않는다.



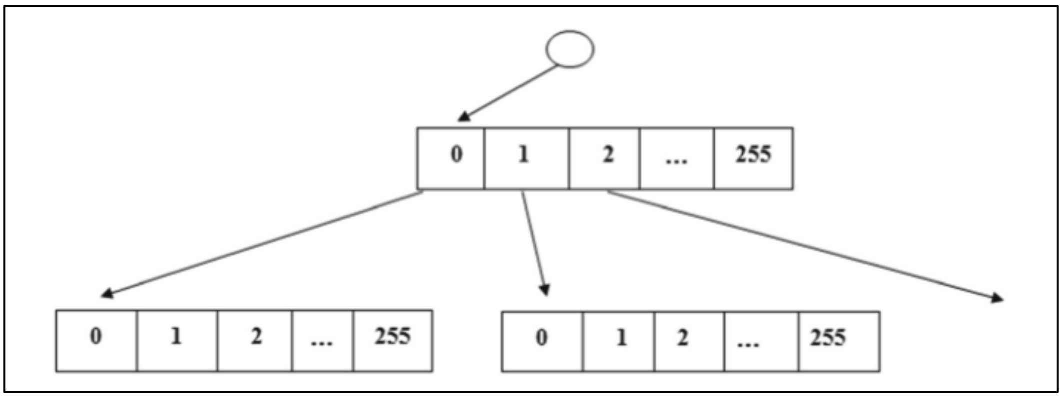
[그림 8] _e.fnm의 Field.Store.Yes flag 분석 결과.

Lucene은 문서를 검색 가능한 형태로 변환하기 위해 인덱싱 프로세스를 수행한다. 전체 과정은 [그림 9]와 같이 문서 획득, 문서 구성, 문서 분석, 인덱스 생성의 단계로 구성되며, 최종적으로 검색 인터페이스를 통해 질의 처리와 검색 결과 제공이 이루어진다.



[그림 9] Lucene의 전문 검색 처리 과정.

Terms Dictionary 파일(.tim/.tip)은 인덱싱된 모든 용어를 저장하는 데이터 구조로, 트리 기반의 다중 키워드 검색 알고리즘을 사용한다. 키워드들은 트리 구조로 조직화되며, 루트 노드에서 시작하여 경로상의 문자열들이 연결되어 하나의 키워드를 형성한다. 각 노드는 바이트 단위로 구성되며, 한 바이트가 8비트이므로 트리의 각 계층에서 최대 256개의 노드를 가질 수 있다. 용어 검색 과정은 루트 노드에서 잎 노드까지의 바이트 매칭 과정으로, 이를 통해 검색 속도가 향상된다.



[그림 10] 키워드 트리 구조.

Postings 파일(.doc/.pos)은 각 용어가 어떤 문서들에 나타나는지를 기록하는 역색인 구조다. .doc 파일은 문서 번호와 빈도 정보를 .pos 파일은 용어의 위치 정보를 저장한다. 이 구조를 통해 특정 문서에 포함된 모든 용어를 역추적할 수 있다. Field Info 파일(.fnm)은 각 필드의 속성 정보를 저장하며, contents 필드의 플래그 0x01은 해당 필드가 인덱싱만 되고 저장되지 않음을 나타낸다.

본 문제 해결을 위해 Java 와 Lucene Core 10.0.0 라이브러리를 이용하여 복구 도구를 제작하였으며, DirectoryReader 와 LeafReader 클래스를 활용한 역색인 구조 분석을 수행한다. 복구 과정은 세 가지 알고리즘을 순차적으로 적용하여 최적의 결과를 도출한다. 해당 도구의 코드는 [별첨 1]로 첨부한다.

첫 번째 복구 방법은 인덱싱 시점에 Field.Store.YES 옵션으로 저장된 원본 내용을 직접 추출하는 방식이다. DirectoryReader 의 storedFields().document(docId) 메서드를 통해 문서의 저장된 필드에 접근하며, "contents" 필드에서 완전한 원본 텍스트를 획득한다. 이 방법은 토큰화나 분석 과정 없이 원본 그대로의 텍스트를 복구할 수 있어 가장 높은 품질의 결과를 제공한다. 단어의 순서, 문장 구조, 특수문자 등이 모두 보존되어 100% 완전한 복구가 가능하다.

```java
private RecoveryResult recoverDocument(int docId) throws IOException {
    Document doc = reader.storedFields().document(docId);

    String filename = doc.get("filename");
    String path = doc.get("path");
    String storedContent = doc.get("contents");

    if (filename == null) {
        filename = "document_" + docId + ".txt";
    }

    RecoveryResult result = new RecoveryResult();
    result.docId = docId;
    result.filename = filename;
    result.path = path;

    if (storedContent != null && !storedContent.trim().isEmpty()) {
        result.content = storedContent;
        result.status = RecoveryStatus.STORED_FIELD_RECOVERY;
        return result;
    }
```

[그림 11] DirectoryReader를 통한 저장된 필드 접근 및 원본 내용 추출.

두 번째 복구 방법은 인덱싱 시점에 TermVector 정보가 저장된 경우 이를 활용하는 방식이다. 각 세그먼트별로 LeafReader 인스턴스를 획득한 후, leafReader.termVectors().get(localDocId, "contents") 메서드를 통해 해당 문서의 텀 벡터에 접근한다. PostingsEnum.POSITIONS 옵션을 사용하여 각 용어의 위치 정보를 추출하며, TreeMap 을 활용하여 위치별로 용어를 정렬한다. 이를 통해 원본 텍스트의 단어 순서를 복원하여 의미있는 문장 구조를 재구성할 수 있다.

```java
private String recoverFromTermVectors(int docId) throws IOException {
    try {
        for (LeafReaderContext context : reader.leaves()) {
            if (docId >= context.docBase && docId < context.docBase + context.reader().maxDoc()) {
                int localDocId = docId - context.docBase;
                LeafReader leafReader = context.reader();

                Terms termVector = leafReader.termVectors().get(localDocId, "contents");
                if (termVector != null) {
                    return reconstructFromTermVector(termVector);
                }
            }
        }
    } catch (Exception e) {
        // Term Vector가 없는 경우
    }
    return null;
}
```

[그림 12] LeafReader를 통한 Term 벡터 접근 및 추출.

세 번째 복구 방법은 역색인의 용어 사전을 활용한 방식으로, 가장 기본적인 복구 알고리즘이다. MultiBits.getLiveDocs() 메서드를 통해 삭제되지 않은 유효한 문서들을 식별한 후, 각 세그먼트별로 LeafReader 인스턴스를 획득하여 인덱스에 접근한다. Contents 필드에 대해 leafReader.terms() 메서드를 호출하여 해당 필드의 전체 용어 사전에 접근하고, TermsEnum 반복자를 통해 각 용어를 순차적으로 처리한다. 각 용어에 대해서는 PostingsEnum.advance() 메서드를 사용하여 특정 문서 ID에 해당 용어가 포함되어 있는지 확인하는 방식으로 문서별 용어 추출을 구현한다. 추출된 용어는 BytesRef.utf8ToString() 메서드를 통해 UTF-8 문자열로 변환되며, 길이 2 자 이상의 의미있는 용어만을 필터링하여 TreeSet 에 저장함으로써 중복 제거와 정렬을 동시에 수행한다. 세그먼트 기반 처리를 위해 글로벌 문서 ID 에서 각 세그먼트의 docBase 를 차감하여 로컬 문서 ID 로 변환하는 과정을 거쳐 문서별 용어 복구를 수행한다.

```java
private String recoverFromTerms(int docId) throws IOException {
    Set<String> documentTerms = new TreeSet<>();

    try {
        for (LeafReaderContext context : reader.leaves()) {
            if (docId >= context.docBase && docId < context.docBase + context.reader().maxDoc()) {
                int localDocId = docId - context.docBase;
                LeafReader leafReader = context.reader();

                Terms terms = leafReader.terms("contents");
                if (terms != null) {
                    TermsEnum termsEnum = terms.iterator();
                    BytesRef term;

                    while ((term = termsEnum.next()) != null) {
                        PostingsEnum postings = termsEnum.postings(null);

                        if (postings != null && postings.advance(localDocId) == localDocId) {
                            String termText = term.utf8ToString();
                            if (termText.length() >= 2 && termText.matches("^[a-zA-Z가-힣0-9\\._-]+$")) {
                                documentTerms.add(termText);
                            }
                        }
                    }
                }
                break;
            }
        }
```

[그림 13] PostingsEnum을 통한 용어 매칭 및 필터링.

[별첨 1]의 도구를 이용하여 복구를 시도했을 때, 총 631개의 파일 중 631개의 파일을 텀 벡터 복구를 통해 성공하였다.

저장 필드 복구	0
텀 벡터 복구	631
텀 기반 복구	0

[표 7] 복구 결과 요약.

이를 통해, 피의자가 열람한 PDF 6개는 다음과 같다.

page 1 m as o n pa ci f ic grays harbor t h u r s t o n l e w i s montesano aberdeen hoquiam westport tenino bucoda centralia chehalis pe ell grand mound 12020000 12025000 12025700 12026150 12026400 12027500 12031000 12035000 12035380 12035400 12036000 12037400 12036000 basin boundary stream gaging station explanation washington che ha l i s sout h f o rk newau ku m newau kum new aukum river r iv e r south fork n fk hana ford creek cr cr c loq ua llu m cre ek wisk a h sch afer big anderson cr grays harbor wyno och ee we st fo rk east f ork e fk w fk m fkhum ptulip s hoquiam satsop east fork satsop r iver m fk sa ts op r iver w fk satsop r iver chehal is cheha lis river r r i ver ri ver r river ri v er rive r river river skookumc huck skookumchuck reservoir wynoochee lake 12021800 12025100 12020800 12024400 12024000 willapa bay ocean pacific figure 7 location of surface water stations in the chehalis river basin

[표 8] 복구된 E:₩credential₩000024.pdf.

page 1 financial manager directed counterintelligence assassinations and kidnappings security operations acquired armored vehicles and weapons collected taxes responsible for security managed afo cells drug trafficker for afo arellano felix organization named a kingpin 2004 jesus abraham labra aviles chuy labra efrain perez pasuengo rigoberto yanez guerrero gilberto higuera guerrero jorge aureliano felix all 6 individuals have been indicted by the southern district of california indictment 97 cr 252ok arellano felix family in mexican custody august 2004 in mexican custody june 2004 in mexican custody june 2004 ramon eduardo arellano felix named a kingpin 2000 deceased february 2002 benjamin arellano felix named a kingpin 2000 in mexican custody march 2002 eduardo ramon arellano felix named a kingpin 2004 francisco javier arellano felix named a kingpin 2004 department of the treasury office of foreign assets control name in red text denotes sdntk previously designated foreign narcotics kingpin designation act tier ii individuals arellano felix organization major lieutenants in mexican custody march 2001 in mexican custody april 2002 in mexican custody march 2000 armando martinez duarte

[표 9] 복구된 E:₩credential₩000332.pdf.

page 1 22 mir principal expedition 19 many international elements the first mir crew launched on a space shuttle orbiter solovyev and budarin began their work in conjunction with a visiting u.s crew and departing mir 18 international crew two of their evas involved deployment and retrieval of international experiments and they ended their stay by welcoming an incoming interna tional crew commander anatoly solovyev flight engineer nikolai budarin crew code name rodnik launched in atlantis sts 71 june 27 1995 landed in soyuz tm 21 september 11 1995 75 days in space highlights the only complete mir mission of 1995 with an all russian crew mir 19 had mir 19 crew officially take charge solovyev and budarin officially assumed their duties aboard mir on june 29 the mir 18 crew moved their quarters to atlantis for the duration of the sts 71 mission once there they would continue their investigations of the biomedical effects of long term space habitation 77,78 triple cooperation on june 30 the ten members of the mir 18 mir 19 and sts 71 crews assembled in the spacelab on atlantis for a ceremony during which they exchanged gifts and joined two halves of a pewter medallion engraved with likenesses of their docked spacecraft the crews began transferring fresh supplies and equipment from atlantis to mir they also moved medical samples equipment and hardware from mir to atlantis for return to earth new equipment included tools for an eva to be performed by the cosmonauts to free the jammed spektr solar array another commodity loaded onto mir was water generated by atlantis fuel cells 79 tests of docking effects on july 1 gibson and precourt fired atlantis's steering jets to change the station's attitude to evaluate the integrity of the mir atlantis docking mechanism and tunnel adapter during orbital maneuvers and to test the effect of jet plumes on the station's solar arrays 80 goodbye again after a farewell ceremony aboard mir on july 3 the atlantis and mir 18 crew departed and began preparations on atlantis for the next day's undocking after the hatches of both spacecraft were closed harbaugh began depressurizing the transfer tunnel to equalize it with the vacuum of space before the separation of atlantis from mir the cosmic ballet on july 4 solovyev and budarin donned their flight suits entered soyuz tm 21 and undocked from mir to a stationkeeping position from which they photographed mir and atlantis still docked about 15 min later atlantis undocked from mir when gibson released the hooks that held the two craft together and allowed the docking system springs to nudge atlantis away as atlantis slowly flew around the station soyuz tm 21 redocked and the two craft continued to sp k2 mir k tm a t l kr june 29 july 4 1995 continued mir mission chronicle november 1994 august 1996 page 2 23 take pictures of each other and mir gibson called this set of celestial maneuvers a cosmic ballet however the soyuz module had to redock a few minutes sooner than planned when the mir onboard computer which controls station attitude and solar array pointing malfunctioned the station complex about 10 off the correct attitude was becoming unstable and starting to drift the cosmonauts had to get back quickly to regain attitude control of the station tsup controllers left the station in free drift while the cosmonauts replaced attitude control hardware in the computer 81,82,83 kvant 2 kristall mir kvant soyuz tm 21 spektr mir 18 crew completes 115 day mission after atlantis left the russian space station the homeward bound mir 18 crew continued their medical and scientific investigations in the spacelab module in atlantis payload bay they used the lower body negative pressure unit and a baroreflex neck cuff to test cardiovascular orthostatic function response to microgravity they also continued their daily exercise sessions on the treadmill during atlantis reentry and landing on july 7 they rode in special recumbent seats that allowed them to take the force of reentry in a reclining position after the landing at kennedy space center's shuttle landing facility they were flown in an air force c 9 medevac plane to ellington field in houston they followed up their spaceborne biomedical investigations with medical tests at johnson space center 84 first eva of mir 19 before their launch solovyev and budarin had trained to use the new tools created for releasing the stuck spektr solar array on july 14 they exited the kvant 2 hatch and made their way to spektr using the strela boom they quickly cut the offending restraint and all but one section of spektr's jammed solar array deployed 85 then they were able to route the power input to the complex they inspected the z port docking mechanism and found no signs of damage or pollution clearing the port for relocation of the kristall module before reentering the kvant 2 hatch they inspected one of that module's solar arrays which was not tracking the sun correctly the eva ran 5 hr and 34 min about 20 min over the originally budgeted time 86,87 sp k2 mir k tm a t l kr july 4 17 1995 principal expedition 19 page 3 24 kristall kvant 2 mir kvant soyuz tm 21 spektr kristall relocated once more in a 90 min session on july 17 kristall was transferred by means of its lyappa arm to the z docking port from the x port where progress m 28 would dock later in the month 88 the rearrangement placed kristall in the proper position for the next atlantis docking during sts 74 in october figure 8 shows the resulting configuration of the complex solovyev inspected the air seal at the z port and found it intact 89 problems during second mir 19 eva the primary purpose of the second space walk july 19 was to deploy the belgian french miras mir infrared spectrometer on the far end of the spektr module but minutes after the eva began solovyev's orlan dma suit cooling system malfunctioned and the tsup ordered him to stay attached by an umbilical to kvant 2 the miras deployment had to be postponed but budarin was able to do some preparatory work alone he also retrieved the american cosmic ray detector trek which had been on the kvant 2 surface since 1991 and switched out cassettes of sample construction materials as part of an ongoing space exposure experiment his time outside totaled 3 hr 8 min but the trou bles were not all over after closing the kvant 2 eva hatch the cosmonauts found a 2 mm gap in the seal through which air was escaping they had to work with the hatch to get it tightly shut 90,91 sp k2 mir k kr tm july 17 22 1995 6 2 95 configuration y y z z x x figure 8 the mir complex as configured after multiple relocations of kristall to accommodate spektr docking and subsequent relocation to the y port on june 2 1995 spektr is shown at the bottom of the complex in this orientation mir mission chronicle november 1994 august 1996 page 4 25 sp k2 mir k kr tm july 22 september 4 1995 sp k2 mir k kr tm september 4 5 1995 kristall kvant 2 progress m 28 mir kvant soyuz tm 21 spektr progress m 28 arrives launched by a soyuz booster from baikonur on july 20 progress m 28 module bore 2.4 t of food and water fuel and oxidizer and science equipment including about 335 kg for use during euromir 95 two days later using the kurs system progress m 28 docked at the x port of the base block 92 installation of miras during third eva on july 21 the cosmonauts opened the kvant 2 hatch again and retrieved

the cooling umbilical left outside in their last eva using the strela boom they made their way to the spektr module on which they installed the 220 kg miras spectrometer this final eva of mir 19 lasted 5 hr 35 min 93 interior work throughout august with their evas completed the mir 19 crew turned their attention to experiments in life sciences and astrophysics and smelting experiments in the gallar furnace they unloaded the cargo brought by the progress module and monitored the automatic refueling by progress of the base block propellant tanks they also per formed station maintenance and repairs including installation in kvant 2 of new gyrodynes brought up on progress they repaired the seals on other gyrodyne cases with a lute type sealer called germetik 94,95,96 kristall kvant 2 mir kvant soyuz tm 21 spektr progress m 28 undocks packed with trash and obsolete equipment progress m 28 left the x port on september 4 and splashed down into the pacific thus clearing the way for soyuz tm 22 to dock with the next mir crew principal expedition 19

[표 10] 복구된 E:₩credential₩000364.pdf.

page 1 from s.han npsecure.com to tang.tran1212 protonmail.com subject re final doc delivery move date 1 july 2025 21 42 tang attached is the final draft you asked for cleaned and recompiled with the internal keys removed i've included the recent diagrams under secure.zip as you requested be cautious opening them as discussed i'm moving on august 1st i'll be unreachable from then use only the fallback protocol until i resurface the guesthouse is near the marble mountains same area we used in 2023 no passports needed check in is remote i'll forward the flight ticket to the old protonmail thread as backup keep everything encrypted i'll use blue mango as the id string in comms steve

[표 11] 복구된 E:₩credential₩000379.pdf.

page 1 a 1 concept exploration and refinement ce r concept area 1 ca 1 mid term review december 1 2004 advanced programs group orbital sciences corporation page 2 a 2 looking for the solution without listening to the problem is working in the dark page 3 a 3 ca 1 midterm agenda exploration objectives architecture overview definition system element requirements trade studies analysis for super system cev technology requirements exploration programmatic and technical risk assessment page 4 a 4 exploration objectives page 5 a 5 the primary governing document goal and objective the fundamental goal of this vision is to advance u.s scientific security and economic interests through a robust space exploration program in support of this goal the united states will implement a sustained and affordable human and robotic program to explore the solar system and beyond extend human presence across the solar system starting with a human return to the moon by the year 2020 in preparation for human exploration of mars and other destinations develop the innovative technologies knowledge and infrastructures both to explore and to support decisions about the destinations for human exploration and promote international and commercial participation in exploration to further u.s scientific security and economic interests page 6 a 6 the recommendations for implementation exploration campaign must be aligned with the findings of the commission to inspire innovate and discover managed as a significant national priority nasa's relationship to the private sector its organizational structure business culture and management processes all largely inherited from the apollo era must be decisively transformed to implement the new multi decadal space exploration vision the successful development of identified enabling technologies will be critical to attainment of exploration objectives within reasonable schedules and affordable costs regular visible demonstrations of ongoing progress and success an affordable plan that does not require huge peaks in annual funding page 7 a 7 exploration systems flow exploration system ca 1 cev development ca 2 requirements missions vision the system of systems is derived from and subject to the exploration vision page 8 a 8 exploration objectives decomposition and maturation objectives vision missions functions requirements system hardware exploration vision is being decomposed to system hardware page 9 a 9 ce r vision to objectives exploration campaign technology development and infrastructure vision goals agendas objectives support us interests solar system exploration science human presence earth based technology destination technology security economic origins of solar system evidence of life in space observation habitable planets exploration duration long term habitation long term spaceflight resource utilization mobility manufacturing integrate test facilities launch site infrastructure security applications international alliances education technology competition commercial participation economic strength level of automation space research exploration transport goals and objectives are independent of spiral technology transfer page 10 a 10 preliminary mission categories to meet objectives test missions t 1 cev flight test t 2 human rated lv t 3 in space crew transport t 4 crew lander t 5 launch vehicle t 6 in space cargo transport t 7 cargo lander t 8 habitat t 9 power t 10 resource utilization t 11 mobility t 12 in space comm t 13 navigation t 14 in space support deployment missions d 1 deploy support assets to moon and lunar surface d 2 deploy support assets to lunar libration points d 3 deploy support assets to mars and mars orbit d 4 deploy support assets to mars libration points d 5 deploy support assets to earth orbit d 6 deep space other destination deployment assembly missions a 1 lunar surface assembly a 2 lunar orbit assembly a 3 mars surface assembly a 4 mars orbit assembly a 5 earth orbit assembly human missions h 1 short duration lunar habitation h 2 long duration lunar habitation h 3 short duration mars habitation h 4 long duration mars habitation h 5 deep space other destination habitation supplemental science msns s 1 telescope imagery s 2 mapping s 3 sample return s 4 aerobraking aerocapture demonstration s 5 deep space scientific probes assembly missions with a primary objective of major infrastructure assembly performed by humans or robots human missions with a primary objective of demonstrating short or long term human habitation of a destination beyond leo includes the science conducted by humans in parallel with the habitation demonstration missions are being developed to ensure that all agendas will be satisfied page 11 a 11 ce r vision to missions exploration campaign technology development and infrastructure vision goals agendas objectives missions support us interests solar system exploration science human presence earth based technology destination technology security economic origins of solar system s1 s3 s5 security applications international alliances education technology competition commercial participation economic strength evidence of life h2 h4 h5 s1 s2 s3 s5 in space observation h2 h4 h5 s1 s2 habitable planets h1 h3 s1 s3 s5 space research h2 h4 h5 exploration duration h1 h5 d1 d2 d4 d5 d7 d8 a1 a3 t6 t13 exploration transportation h1 h3 h5 d3 d6 d7 d8 t1 t12 t13 long term habitation t6 t9 t11 t14 a1 a5 h1 h5 long term spaceflight t1 t5 d1 d6 d8 s4 resource utilization h2 h4 h5 s3 t10 mobility h1 h5 level of automation a1 a3 h1 h5 launch site infrastructure manufacturing integrate test facilities missions directly support goals and objectives technology transfer page 12 a 12 support provide earth based support program level 0 provide in space support demonstrate technology system level 1 segment level 2 transfer crew from dv to s transfer crew from s to dv transfer crew from ev to dv provide exploration surface support launch crew from e to ev transport crew transport cargo provide power provide isru infrastructure support life provide logistics conduct in space science conduct surface science provide mobility support mission command control communicate process provide logistics provide navigation provide communication transport investigate conduct science transfer crew from dv to ev transfer crew from ev to e transfer cargo from dv to s transfer cargo from s to dv transfer cargo from ev to dv launch cargo from e to ev transfer cargo from dv to ev transfer cargo from ev to e support life provide communication conduct life sciences demonstrate isru capabilities demonstrate precision landing demonstrate excavation techniques demonstrate human robotic interoperability demonstrate drilling techniques goal level 1 explore exploration campaign system and segment functions functions required to support the missions are identified e earth ev earth vicinity dv destination vicinity s surface page 13 a 13 support provide earth based support program level 0 provide in space support demonstrate technology system level 1 segment level 2 transfer crew from dv to s transfer crew from s to dv transfer crew from ev to dv provide exploration surface support launch crew from e to ev transport crew transport cargo transport investigate conduct science transfer crew from dv to ev transfer crew from ev to e goal level 1 explore exploration campaign system and segment functions level 3 functions support life communicate navigate provide power accelerate decelerate monitor control perform abort page 14 a 14 provide earth based support provide in space support demonstrate technology system level 1 element level 3 navigate provide power communicate provide exploration surface support support life transport crew transport cargo monitor analyze collect samples conduct science accelerate decelerate monitor control perform mapping control navigate provide power communicate support cargo accelerate decelerate monitor control perform imaging analyze solar wind flares analyze micrometeorites assess risks to astronauts train provide medical administer equip provide weather support maintain organize plan mission provide facilities process crew process hw provide logistics provide fuel provide power provide spares provide consumables provide misc supplies derived functions at level 3 perform abort page 15 a 15 mapping functions to missions program level 0 system level 1 id category and mission segment level 2transfer crew to launch pad launch crew from e to ev transfer crew from ev to orbiting station transfer crew from ev to dvtransfer crew from dv to ds provide surface transport provide surface eva provide in space eva transfer crew from ds to dvtransfer crew from dv to evtransfer crew from ev to estransfer crew from cm to vehicle ship a1 lunar assembly missions x x x x x x x x x x a2 lunar orbit assembly missions x x x x x x x a3 mars assembly missions x x x x x x x x x x a4 mars orbit assembly missions x x x x x x x a5 earth orbit assembly missions x x x x x x h1 short duration lunar habitation x x x x x x x x x x h2 long duration lunar habitation x x x x x x x x x x h3 short duration mars habitation x x x x x x x x x x h4 long duration mars habitation x x x x x x x x x x h5 deep space other destination habitation x x x x x x x x x x transport crew assembly human transport 69 functions mapped to 37 missions page 16 a 16 in space cargo transport system of systems sos cargo lander exploration surface infrastructure systems launch vehicle system of systems level 0 earth ground systems robotic science systems cargo container system level 1 segment level 2 in space crew transport crew lander human rated lv in space systems cev crew transport systems cargo transport systems power resource utilization surface comm habitat logistics in space science surface science surface transport earth ground support command control comm processing in space support navigation in space comm element level 3 launch abort system crew module exploration campaign system breakdown structure page 17 a 17 mapping functions to hardware program level 0 system level 1 segment level 2 functions transfer crew to launch padlaunch crew from e to ev transfer crew from ev to orbiting station transfer crew from ev to dvtransfer crew from dv to ds provide surface transport provide surface eva provide in spaceeva transfer crew from ds to dvtransfer crew from dv to evtransfer crew from ev to estransfer crew from cm to vehicle ship transfercargoto id architecture element cev crew exploration vehicle cev x x xxx sem space exploration module x x xx hrlv human rated launch vehicle x eelv evolved expendable launch vehicle mcs modular containment systems ll lunar lander x x pf processing facilities x c3 c3 facilities x x x x x x x x egsf earth ground support facilities x x lh lunar habitat s storage facilities x se science equipment ur unpressurized rovers x pr pressurized rovers x cf communications facilities x x rui resource utilization infrastructure npf nuclear power facility cs communications satellites x x x x x x x ns navigational satellites x x x x x x x transport crew transport 69 functions mapped to 23 level 2 segments page 18 a 18 exploration objectives decomposition and maturation objectives vision missions functions requirements system hardware this process makes sure we have captured and implemented the total vision ensures that we the contractor fully understand what system must do reveals that the vision starts now not when hardware begins flying page 19 b 1 campaign overview mission definitions page 20 b 2 orbital's primary ground rule missions and operations drive the concept refinement process development plan crew transport systems cargo transport systems exploration surface infrastructure earth ground systems in space systems robotic science systems exploration campaign lunar exploration missions operations requirements systems engineering page 21 b 3 mission operations flow extended duration lunar habitation legend lunar surface earth surface h1 extended duration lunar habitation s cm lv l lv lv rx in spect process l v core solids upp er stage interstage paylo ad f airing adap ters integrate lv stack lv elemen ts integrated test cert wet dress rehearsal t erminal coun t demo adap ters leo llo s cm a receive inspect process las crew module sem l ander sem leo operatio ns as required tl i ini tiatio n lu nar o rbit insertion cm manned lan der m anned sem lv s combined ops fo llowed by l ander s eparation fr om crew mod ule sem continue cm se m in llo cond uct surface stay ev a limited s cience site pr eparation for long duratio n m sns ro botic deplo ymen ts 1 ascent note event sequen cing land er is launched tbd days p rior to crew launch f low is for early extended duration m ission with limited to no pre positioned su rface assets human lunar mission 3 14 days d uratio n to demonstrate techno log ies suppo rting hu man exploratio n o f space a abort system s cm a s cm a jettison abort system s cm phasin g pr ox op s rendezvou s docking controlled by cm l cm l 6 lau nch 2 7 8 9 10 11 descent 12 l 13 14 descent m odu le remains on lun ar surface 15 s cm phasing prox o ps rendezvou s dockin g w crew mod ule sem te i in itiati on 16 s cm un crewed ascent m odu le disp osal 17 18 s cm s cm sem cr ew mo dule separation 19 crew mo dule descent 20 cm 21 cm cm un man ned l lan der unmanned recovery crew cm for future missions v2 2 s l s l lau nch 1 s leo operatio ns as required 2 tl i ini tiatio n 3 lu nar o rbit insertion 4 s lan der separation from sem 5 l l continue lander in llo to dock with arriving crew l l l l descent m odu le l ascent m odu le page 22 b 4 missions generate functions cev transfer state cev earth orbit state cev launch state cev earth return state cev crew escape state cev crewed on pad state cev recovery state cev un crewed on pad state cev integrated lv state cev prelaunch ground processing state cev storage state integrate cev to lv integrate lv to pad crew hatch secure on pad cev escape end of escape burn in flight cev escape early cev separation 2in rise off of pad crew disembarked zero earth relative velocity lv sep tli stage separation tli stage sep initiate tei burn dock stable lunar orbit cev post recovery ground processing state turnaround complete cev lunar docked state cev lunar crewed orbit state cev lunar un crewed orbit state release dock to cev release cev tli burn lunar landing state de orbit burn lunar surface state take off touchdown dock remove from storage return to storage return to processing remove from pad on pad abort page 23 b 5 mission operations flow long duration lunar habitation legend lunar surface earth surface l l p l h2 long duration lunar habitation p cm lv l lv lv rx in spect process l v core solids upp er stage interstage payload fairing adap ters integrate lv stack lv elemen ts integrated test cert wet dress rehearsal t erminal coun t demo adap ters leo llo s cm a receive inspect process abo rt system crew mo dule sem leo operatio ns as required tl i ini tiatio n lu nar o rbit insertion cm manned lan der manned power source lau nch vehicle s combined ops fo llowed by lan der separation fro m crew m odu le and sem continue cm se m in llo backup land er activatio n and checkou t l 1 2 ascent note assumptions habitati on modules sl eep living sci ence mnx logi stics 2 lunar landers on surface 1 for exploration surface crew evacuation 1 for s urface crew backup a lso used by arriving crew most recently used lander becomes backup 2 power generation sources 1 tacan vor w dme collocated with base 1 mobile crane regolith excavation and drilling equipment pressurized unpressuriz ed r overs robotic exploration sci ence collecti on assets human lunar mission 14 95 days d uratio n to demonstrate techno log ies suppo rting human exploratio n o f space a abort system s cm a s cm a jettison abort system backup land er ascen t to l lo l lan der o n orbit checkou t readiness check s cm phasin g pr ox op s rendezvou s docking controlled by cm l cm l 3 4 lau nch 5 6 7 8 9 precision lan din g 10 l l 12 end sur face stay dep art crew 13 s cm l phasing prox o ps rendezvou s d ockin g with sem te i in itiati on 14 s cm l lan der return to surface 15 17 s cm s cm sem cr ew mo dul e separation 18 crew mo dule descent 19 cm 20 l h h h hab mod ule r rovers p u p lunar base s sem ru rp surface stay w crew overlap 11 short and lo ng range excursions h cm sem separation from l ander 16 cm cm un man ned l lan der unmanned recovery crew cm for future missions v1 3 page 24 b 6 mission operations flow deploy assets to lunar surface legend lunar surface earth surface continue lander in ll o to dock w ith ar riving car go d1 deploy support assets to lunar surface s c lv l s c lv lv rx in spect process l v core solids upp er stage interstage payload fairing adap ters lv integrate lv stack integrated test cert wet dress rehearsal t erminal coun t demo adap ters leo llo rx in spect process lan der cargo 2 sems s c l l s c leo operatio ns as required tl i ini tiatio n lu nar o rbit insertion cargo mo dule lan der sem lau nch vehicle s c l cargo separation from sem continue sem in llo mission tbd c l lan der carg o precision landing lan der de stacks cargo onto lun ar surface c l 12 13 c lan der avai labl e fo r fu tu re ascent rend ezvo us w ith other cargo or crew mod ule c l 14 note d1 m i ssion s wi ll u ltim ately depl oy habitation mo dules tunn els adapters power generation sou rces m ining and drilling eq uip men t rego li th m anip ulati on equ ipm ent t est science gathering eq uip men t surface m obility units pressurized un pressurized m obility mo dules communication s e quipment l unar t acan equivalent equ ipment backup lan ders storage contain ers corr ective preven tive m nx parts supp lies surface dep loyments of pr epositioned or replacement h abitatio n mod ules p ower gen eration sources su rface mobility un its resource extraction equ ipment etc 1 7 8 9 10 s lv l s s leo operatio ns as required 2 lau nch 1 6 lau nch 2 tl i ini tiatio n 3 lu nar o rbit insertion 4 l s lan der separation from sem 5 continue sem in llo mission tbd c lan der cargo prox o ps dockin g 11 v1 3 page 25 b 7 mission operations flow lunar surface assembly legend lunar surface earth surface a1 lunar surface assembly missions s cm lv l lv lv rx in spect process l v core solids upp er stage interstage payload fairing adap ters integrate lv stack lv elemen ts integrated test cert wet dress rehearsal t erminal coun t demo adap ters leo llo s cm a receive inspect process abo rt system crew module sem leo operatio ns as required tl i ini tiatio n lu nar o rbit insertion cm manned lan der m anned sem lau nch vehicle s combined ops fo llowed by l ander separation fr om crew mod ule sem continue cm se m in llo l lan der activation and checkou t cond uct assembly habitat modules power stations isru equipment comm eq uip men t etc l 1 2 ascent note event sequen cing l ander dep icted on lunar surface was pr eviou sly deployed du rin g a d1 deployment m ission l unar lander is activated checked out and deployed to ll o p rio r to crew m odu le launch f low is for early extended duration mission with limited to no pre positioned su rface assets lu nar su rface assembly missions of hab itation modu les infrastructure elements etc a abort system s cm a s cm a jettison abort system lan der ascent to llo l lan der o n orbit checkou t readiness check s cm phasin g pr ox op s rendezvou s docking controlled by cm l cm l 3 4 lau nch 5 6 7 8 9 descent 10 l 11 l 12 e nd sur face stay co nfigu re for departure 13 s cm l phasing prox o ps rendezvou s dockin g w crew mod ule sem te i in itiati on 14 s cm l lan der return to surface 15 16 s cm s cm sem cr ew mo dule separation 17 crew mo dul e descent 18 cm recovery crew cm for future mission s 19 cm cm un man ned l lan der unmanned v1 3 page 26 b 8 exploration campaign overview initial lunar missions h1 1st crewed flight to lunar surface d1 deliver c o nuclear power system precision landing navaid d1 deliver c o mobile crane h1 5 day stay h1 7 day stay position power cable a1 assemble hab module 2pcs connect power d1 d1 deliver 2 halves of hab module d1 d1 deliver 2 halves of sci module h1 14 day stay use med surface hab note power system remains attached to ascent stage for contingency departure a1 assemble sci module 2pcs connect to power hab d1 semi annual supply rover sci equip h2 h2 d1 supply 20 30 day stays use med surface hab h2 h2 h2 h2 h2 45 day stays use med surface hab 60 day stays use med surface hab 75 day stay use lg surface hab d1 semi annual supply regolith moving sci equip d1 supply d1 semi annual supply consum sci equip d1 supply d1 semi annual supply additional hab module sci equip d1 a1 assemble hab module 2pcs connect to power hab h1 5 day stay 2017 2018 2019 2020 2021 2022 2023 2024 2025 page 27 b 9 the exploration system and updates crew transport systems in space systems robotic and science systems exploration surface infrastructure earth ground systems cargo transport systems page 28 b 10 exploration system crew transfer system cts segment crew module functions the cm provides crew habitation from launch to lunar orbit and return to the earth surface the cm will rendezvous and dock with the lunar lander in lunar orbit the cm will operate uncrewed in lunar orbit while the crew is on the moon in addition the cm provides the communication and navigation assets to transfer data voice video to other mission assets and the ground launch abort system functions the las provides the abort capability during earth ascent up to 200,000 ft after which sem provides high altitude abort capability space exploration module functions the sem provides the propulsive capability to transfer the cm or lunar lander from leo to lunar orbit and return to earth the sem also provides additional consumables and power to the cm heavy lift launch vehicle functions the hllv provides the necessary lift capability to launch the cm sem lunar lander and other mission elements into leo lunar lander functions the ll provides crew habitation from lunar orbit to the lunar surface and return to lunar orbit the ll provides surface eva capability for the crew the ll provides the communication and navigation assets to transfer data voice video to other missions assets and the ground page 29 b 11 lunar habitation mission system elements lander launch crew launch tli provided by sem lunar rendezvous of lander and cm tei provided by sem sem expended cm reentry crew recovery crew landing surface eva crew ascent leo lunar surface lunar orbit page 30 b 12 habitation mission alternatives multiple outpost capability tbd day capable outpost anywhere on lunar surface outpost at next site of interest or continue at previous site earth is logistics hub lunar logistics base establish single lunar base and provide for distributed exploration capability rovers for local exploration lander hops for more distant exploration moon is logistics hub lunar orbiter provide 90 day capable lunar orbiter with surface excursion capability anywhere on lunar surface multiple short excursions to lunar surface 2 crew llo is the logistics hub page 31 b 13 exploration philosophies to be evaluated minimum effort to attain spiral objectives do not establish permanently occupied lunar base plan to end substantial lunar operations so funds can be used for spiral 4 minimum number of launches to meet exploration vision operations feasibility and cost limit annual launches to about 10 12 hllvs define exploration campaign with this constraint permanently crewed lunar outpost mars mission analog using lunar orbiter and surface habitat page 32 b 14 logistics hub trade earth surface l1 llo lunar surface preliminary evaluation of logistics hub extends nasa work in this area objective is complete lunar coverage must provide operational flexibility must account for cost considerations page 33 c 1 system and element requirements page 34 c 2 exploration requirements decomposition and maturation objectives vision missions functions requirements system hardware exploration vision is being decomposed to requirements page 35 c 3 the cts shall provide a crew exploration vehicle cev to deliver four crew from the earth's surface to the moon and return them to earth the cev shall transfer four crewmembers from earth to the moon and safely return them the cev shall be capable of returning four de conditioned crewmembers from the moon to earth the exploration program shall conduct human lunar expeditions as early as 2015 but beginning no later than the year 2020 nasa shall conduct the first extended human expedition to the lunar surface as early as 2015 but no later than the year 2020 in preparation for human exploration of mars and other destinations related trades exploration crew size in space crew transport lunar lander functionality lunar base location nasa l0 1.3 l1 1.2 orbital l0 requirement gradually increase human lunar stay times to understand conditions for crew health safety and performance for exploration of mars and other destinations nasa shall conduct human lunar expeditions to further science orbital objective orbital l1 requirement orbital l2 requirement vision to missions to requirements orbital mission h1 extended duration lunar habitation human lunar mission 3 14 days duration to demonstrate technologies supporting human exploration of space orbital function transport crew from earth to destination surface transport crew from destination surface to earth nasa level 0 may 2004 page 36 c 4 technical crew size ess0160 ess0250 lunar mission duration ess0140 ess0150 ess0260 lunar mission location ess0140 ess0150 ess0260 flight rate ess0170 ess0180 monthly lunar mission opportunity ess0190 ess0300 spiral 2 definition states no pre deployed surface systems on lunar surface ess0160 rationale glossary programmatic 2014 cev ioc epr0520 2010 cev flight test epr0540 2015 2020 human lunar mission epr0510 separate crew from cargo epg0830 ess technical and programmatic driving requirements page 37 c 5 cvs0030a this high level of ascent success probability forces the use of shuttle derived or saturn derived launch systems versus eelv launch systems cts0125h this forces an airlock of full cabin depressurization capability onto the cts as opposed to only having eva capability from lunar lander i.e 2 systems that must provide eva capability cts0130g this would also force the cts to have an airlock if cts0125h was not already a requirement cts0360g during spiral 3 this requires the same interface mechanism to be used for in space docking as for ground on surface docking of exploration elements this may not be feasible cev0250g this forces the cev propulsion system s and their consumables to be used rather than allowing use of another element's systems e.g lunar lander thrusters or consumables cts spiral 1 2 3 driving requirements spiral 1 sp iral 1 2 3 sp iral 2 3 page 38 c 6 ess0160 conduct human exploration on the lunar surface with 4 crew members tbr 12 ess0250 and an objective of 6 crew members tbr 15 0.0 25000.0 50000.0 75000.0 100000.0 125000.0 150000.0 175000.0 200000.0 225000.0 250000.0 0 1 2 3 4 5 6 7 8 crew size gross weight lb cm gross weight las gross weight sem gross weight lv total payload mass sensitivity to requirements drivers ess0140 the ess shall conduct extended duration human exploration missions threshold of 4 days with an objective of 14 days to any designated location in the polar region of the moon tbr 1 requirement sensitivities hllv leo payload capability page 39 c 7 ess technical ess0260 mission duration 42 to 98 days looks reasonable for lunar exploration but is insufficient as a mars precursor ess0260 specifying lunar south pole for spiral 3 is likely premature or requiring global lunar access in spiral 2 is unnecessary ess0650 orbital debris restrictions for earth orbit should have similar orbital debris requirements for lunar and trans lunar orbits ess programmatic epr0520 contractor architecture will determine when test flights should be performed epr0560 these interfaces should be generic enough to include docking mating and both in space and on surface epr0620 there is no equivalent program requirement like this for advancing the u.s economic and security interests glossary need definition of cargo in context of separation of crew and cargo guideline epg0830 feedback on emsd requirements page 40 c 8 trade studies and analysis for super system and cev page 41 c 9 system trades earth vicinity launch and departure moon vicinity operations earth to moon cislunar moon to earth cislunar earth vicinity return and entry level of isru reliance exploration logistics hub location mars exploration approach abort and safe haven options number of launches required to demonstrate spiral capability page 42 c 10 abort and safe haven trades issues and design drivers for moon and mars ascent abort are not well understood despite design experience for earth page 43 c 11 lunar base location trade determine fixed location on lunar surface for long duration missions trading three alternate locations against baseline mare tranquilitatis alternates aristarchus oceanus procellarum south pole aikin basin current trade status balancing safety concerns for landing against increased science and technology demonstration key discriminators conditions for safe landing terrain lighting approach anytime return page 44 c 12 lunar base location versus ascent abort safe haven trades earth l1 sh sh sh llo 3 4 5 1 2a 2b 2c 1 return to base 2a 2c abort to lunar surface safe haven 3 abort to low lunar orbit 4 abort to l1 5 abort to earth our big problem to solve lunar base location and ascent abort requirements capability must be compatible where should we put the safe haven s page 45 c 13 technology requirements page 46 c 14 technology requirements human habitation missions page 47 c 15 enhancing technologies page 48 c 16 high priority technologies enabling autonomous rendezvous systems nuclear power generation space radiation protection mico meteoroid protection lightweight ablator tps integrated vehicle health management systems enhancing isru nuclear propulsion inflatable structures closed loop life support greenhouse food production page 49 c 17 exploration programmatic and technical risk assessment page 50 c 18 assessment of significant risks technology readiness mission success criteria human space flight safety page 51 c 19 0 0 0 0 0 0 0 0 0 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 the spiral transition problem 1 2 spiral 1 development spiral 2 development budget spiral 3 development a strategy for spiral transitions is needed nasa exploration budget spiral 2 production page 52 c 20 architecture fom assessment page 53 c 21 safety and mission success 7 of 9 abort modes identified are architecturally executable 41 critical events identified and ranked for the h1 lunar mission using 2 launch hllv lunar orbit rendezvous scenario tbd inter element design redundancies being evaluated based on top level fmeca and safety analyses results with focus on preventing minimizing loc tbd hours to return to earth mission abort page 54 c 22 affordability variance from nasa budget 1,000 500 0 500 1,000 1,500 2,000 2,500 3,000 3,500 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 orbital's architecture requires about 76 of nasa's planned budget c o s t b y y e a r 2 0 0 5 2 0 1 0 2 0 1 5 2 0 2 0 d e ve lo p m e n t p ro d u c tio n o p e ra tio n s f a c ilit ie s page 55 c 23 effectiveness and extensibility system applicability evolvability to mars systems evolvable for mars missions hllv cm sem technologies evolvable for mars missions closed loop life support nuclear power autonomous rendezvous cryogenic fluid management information management lightweight ablator tps in space navigation radiation shielding system complexity 17 interfaces among spiral 2 elements 7 simple 6 intermediate 4 complex mission complexity 6 major elements 4 unique 2 dockings 19 day mission 10 days on surface page 56 c 24 development risk and schedule only 3 new technologies required for spiral 2 missions precision lunar landing lox methane propulsion space radiation protection no high risk technologies required for spiral 2 missions only 7 technologies trl 6 today all can be trl 6 by 2008 fsd start 2014 ioc is not threatened by technology development risk 7 moderate 43 minimum risk developments 2014 ioc is not threatened by system development risk cev hllv page 57 c 25 summary what we accomplished mapped the vision to objectives missions functions requirements and elements started manifesting the exploration campaign missions what we learned observed coupling of lunar base selection and lunar abort safe haven capability it's primarily a transportation and logistics problem lunar mars operations need to be compatible and traceable need a budget strategy at spiral transitions to ensure

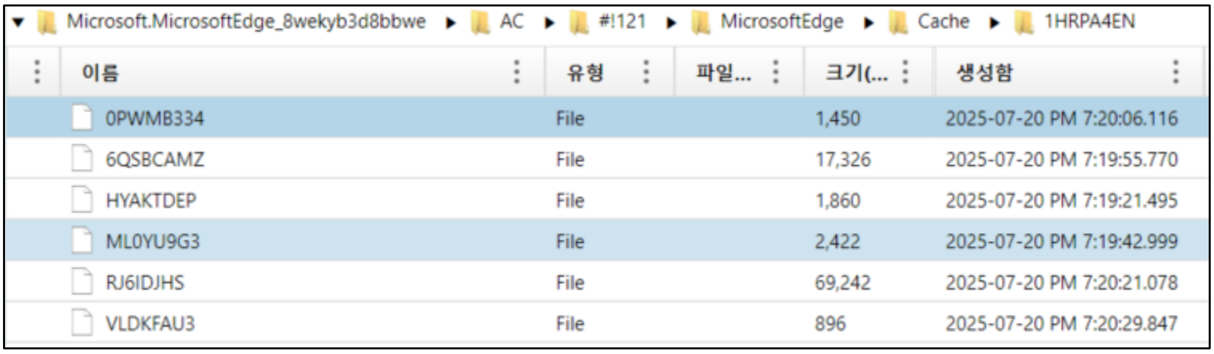
sustainability what problems we are still working establish strong link between the exploration architecture and u.s science security and economic interests define requirements for the other architecture segment and elements evaluate more efficient methods of conducting the exploration missions

[표 12] 복구된 E:₩credential₩000744.pdf.

page 1 flight confirmation e ticket booking reference vj a98343 passenger steve han flight vietjet air vj879 date friday 1 august 2025 departure icn incheon international airport 10 35 am arrival dad da nang international airport 13 45 pm seat 18c checked baggage 20kg status confirmed issued by vietjet air via klook travel note no passport verification required at check in vietnam domestic exemption protocol active

[표 13] 복구된 E:₩credential₩000761.pdf.

또한 해당 파일의 경우, Microsoft Edge를 통하여 열람하였기에, [그림 14]와 같이 Edge가 색인한 증거 또한 찾을 수 있었으며, 이를 통해 교차검증을 진행할 수 있었다.

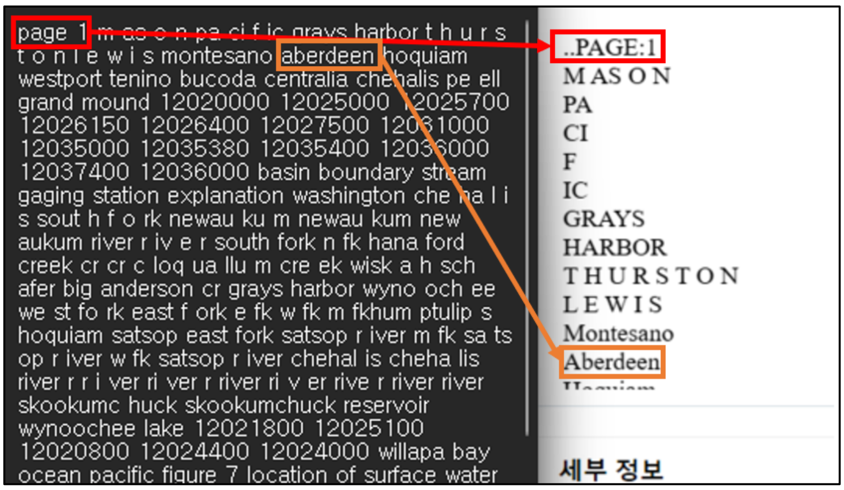


Microsoft.MicrosoftEdge_8wekyb3d8bbwe ▸ AC ▸ #!121 ▸ MicrosoftEdge ▸ Cache ▸ 1HRPA4EN

이름	유형	파일...	크기(...	생성함
0PWMB334	File		1,450	2025-07-20 PM 7:20:06.116
6QSBCAMZ	File		17,326	2025-07-20 PM 7:19:55.770
HYAKTDEP	File		1,860	2025-07-20 PM 7:19:21.495
ML0YU9G3	File		2,422	2025-07-20 PM 7:19:42.999
RJ6IDJHS	File		69,242	2025-07-20 PM 7:20:21.078
VLDKFAU3	File		896	2025-07-20 PM 7:20:29.847

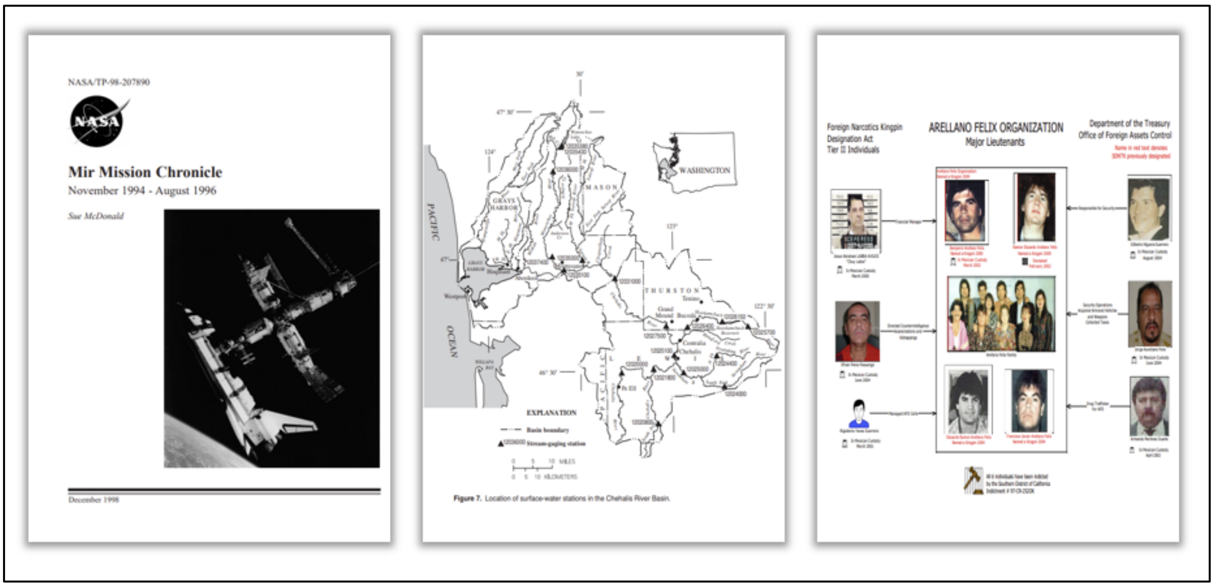
[그림 14] Edge의 Cache에서 발견된, 색인 파일 6개.

교차 검증 결과, [그림 15]와 같이, HYAKTDEP파일과 추출한 0000024.pdf파일을 비교하였을 때, 추출한 문자열과 일치하는 것으로 교차검증을 완료할 수 있다.



[그림 15] HYAKTDEP파일과 추출한 0000024.pdf파일의 비교 결과.

또한, 일부 파일은 구글 검색을 통하여 찾을 수 있었다. 이는 [그림 16]과 같고, [표 14]와 같이 정리할 수 있다.



[그림 16] 구글 검색을 통하여 찾아낸 원본 파일.

lucene 색인으로 저장된 이름	Edge 색인으로 저장된 이름	검색을 통하여 확인한 제목
000024.pdf	HYAKTDEP	Location of surface-water stations in the Chehalis River Basin.
000332.pdf	ML0YU9G3	ARELLANO FELIX ORGANIZATION
000364.pdf	6QSBCAMZ	Mir Mission Chronicle

[표 14] 2가지 색인과 검색을 통하여 확인한 제목 정리.

정답: [표 8~13]

4. 복구한 문서를 통해 피의자 A 씨의 도주 위치(나라, 도시)를 특정하시오.

앞서 복구한 문서를 통하여, 피의자 A 씨의 도주 경로를 파악할 수 있었으며, 이는 0000761.pdf 의 복구 결과를 통하여 알 수 있다. 이는 위 [표 13]과 같으며, 이를 정리하면, [표 14]와 같으며, 피의자의 영문 이름은 Steve Han 이며, 베트남 다낭으로 도주 위치가 특정되었다.

항공편 정보 분석	
항공사	베트젯항공(VietJet Air)
편명	VJ879
예약 참조번호	VJA98343
승객명	Steve Han
출발지 및 목적지 정보	
출발지	ICN (인천국제공항, 대한민국)
목적지	DAD (다낭국제공항, 베트남)
출발시간	2025 년 8 월 1 일 금요일 10:35 AM
도착시간	2025 년 8 월 1 일 금요일 13:45 PM
좌석 및 수하물 정보	
좌석	18C
위탁수하물	20KG
예약상태	확정(Confirmed)

[표 15] 비행기 표 정리.

국가	베트남(Vietnam)
도시	다낭(Da Nang)

[표 16] 문제 4번 정답. (피의자의 도주 위치 특정)

```java
package DFC252;

import org.apache.lucene.analysis.Analyzer;
import org.apache.lucene.analysis.standard.StandardAnalyzer;
import org.apache.lucene.document.Document;
import org.apache.lucene.index.*;
import org.apache.lucene.search.*;
import org.apache.lucene.store.Directory;
import org.apache.lucene.store.FSDirectory;
import org.apache.lucene.util.BytesRef;
import org.apache.lucene.util.Bits;

import java.io.*;
import java.nio.file.*;
import java.util.*;
import java.util.stream.Collectors;

/**
 * Lucene 인덱스에서 PDF 문서 내용 복구 도구
 */
public class LuceneContentRecovery {

    private final Path indexPath;
    private final Path outputDir;
    private DirectoryReader reader;
    private Directory directory;
    private IndexSearcher searcher;

    public LuceneContentRecovery(String indexPath, String outputPath) throws IOException {
        this.indexPath = Paths.get(indexPath);
        this.outputDir = Paths.get(outputPath);

        if (!Files.exists(this.outputDir)) {
            Files.createDirectories(this.outputDir);
        }

        this.directory = FSDirectory.open(this.indexPath);
        this.reader = DirectoryReader.open(directory);
        this.searcher = new IndexSearcher(reader);
```

```
    }

    public static void main(String[] args) {
        String indexPath = args.length > 0 ? args[0] :
"C:₩₩Users₩₩dlwls₩₩Desktop₩₩NeoPointSecure₩₩SearchEngine₩₩index";
        String outputPath = args.length > 1 ? args[1] :
"C:₩₩Users₩₩dlwls₩₩Desktop₩₩NeoPointSecure₩₩SearchEngine₩₩recovered_content";

        try {
            LuceneContentRecovery recovery = new LuceneContentRecovery(indexPath,
outputPath);
            recovery.recoverAllDocuments();
            recovery.close();
        } catch (Exception e) {
            System.err.println("복구 중 오류 발생: " + e.getMessage());
            e.printStackTrace();
        }
    }

    public void recoverAllDocuments() throws IOException {
        System.out.println("Lucene 문서 내용 복구 도구");
        System.out.println("인덱스 경로: " + indexPath.toAbsolutePath());
        System.out.println("출력 경로: " + outputDir.toAbsolutePath());
        System.out.println("총 문서 수: " + reader.numDocs());
        System.out.println();

        int storedFieldCount = 0;
        int termVectorCount = 0;
        int termBasedCount = 0;
        int failedCount = 0;

        for (int docId = 0; docId < reader.maxDoc(); docId++) {
            Bits liveDocs = MultiBits.getLiveDocs(reader);
            if (liveDocs != null && !liveDocs.get(docId)) {
                continue;
            }

            try {
                RecoveryResult result = recoverDocument(docId);
```

```
            switch (result.status) {
                case STORED_FIELD_RECOVERY:
                    storedFieldCount++;
                    System.out.printf("[%d] %s - 저장 필드 복구 (%d chars)%n",
                        docId, result.filename, result.content.length());
                    break;
                case TERM_VECTOR_RECOVERY:
                    termVectorCount++;
                    System.out.printf("[%d] %s - 텀 벡터 복구 (%d chars)%n",
                        docId, result.filename, result.content.length());
                    break;
                case TERM_BASED_RECOVERY:
                    termBasedCount++;
                    System.out.printf("[%d] %s - 텀 기반 복구 (%d terms)%n",
                        docId, result.filename, result.termCount);
                    break;
                case FAILED:
                    failedCount++;
                    System.out.printf("[%d] %s - 복구 실패%n",
                        docId, result.filename);
                    break;
            }

            if (result.status != RecoveryStatus.FAILED && !result.content.trim().isEmpty()) {
                saveRecoveredContent(result);
            }

        } catch (Exception e) {
            failedCount++;
            System.err.printf("[%d] 복구 중 오류: %s%n", docId, e.getMessage());
        }
    }

    System.out.println();
    System.out.println("복구 결과 요약:");
    System.out.printf("저장 필드 복구: %d개 문서%n", storedFieldCount);
    System.out.printf("텀 벡터 복구: %d개 문서%n", termVectorCount);
    System.out.printf("텀 기반 복구: %d개 문서%n", termBasedCount);
```

```
        System.out.printf("실패: %d개 문서%n", failedCount);
        System.out.printf("총 처리: %d개 문서%n", storedFieldCount + termVectorCount +
termBasedCount + failedCount);
    }

    private RecoveryResult recoverDocument(int docId) throws IOException {
        Document doc = reader.storedFields().document(docId);

        String filename = doc.get("filename");
        String path = doc.get("path");
        String storedContent = doc.get("contents");

        if (filename == null) {
            filename = "document_" + docId + ".txt";
        }

        RecoveryResult result = new RecoveryResult();
        result.docId = docId;
        result.filename = filename;
        result.path = path;

        if (storedContent != null && !storedContent.trim().isEmpty()) {
            result.content = storedContent;
            result.status = RecoveryStatus.STORED_FIELD_RECOVERY;
            return result;
        }

        String vectorContent = recoverFromTermVectors(docId);
        if (vectorContent != null && !vectorContent.trim().isEmpty()) {
            result.content = vectorContent;
            result.status = RecoveryStatus.TERM_VECTOR_RECOVERY;
            return result;
        }

        String termBasedContent = recoverFromTerms(docId);
        if (termBasedContent != null && !termBasedContent.trim().isEmpty()) {
            result.content = termBasedContent;
            result.status = RecoveryStatus.TERM_BASED_RECOVERY;
            result.termCount = termBasedContent.split("₩₩s+").length;
```

```
            return result;
        }

        result.status = RecoveryStatus.FAILED;
        result.content = "";
        return result;
    }

    private String recoverFromTermVectors(int docId) throws IOException {
        try {
            for (LeafReaderContext context : reader.leaves()) {
                if (docId >= context.docBase && docId < context.docBase + context.reader().maxDoc()) {
                    int localDocId = docId - context.docBase;
                    LeafReader leafReader = context.reader();

                    Terms termVector = leafReader.termVectors().get(localDocId, "contents");
                    if (termVector != null) {
                        return reconstructFromTermVector(termVector);
                    }
                }
            }
        } catch (Exception e) {
            // Term Vector가 없는 경우
        }
        return null;
    }

    private String reconstructFromTermVector(Terms termVector) throws IOException {
        Map<Integer, String> positionTermMap = new TreeMap<>();

        TermsEnum termsEnum = termVector.iterator();
        BytesRef term;

        while ((term = termsEnum.next()) != null) {
            String termText = term.utf8ToString();

            PostingsEnum postings = termsEnum.postings(null, PostingsEnum.POSITIONS);
            if (postings != null && postings.nextDoc() != PostingsEnum.NO_MORE_DOCS) {
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                    int freq = postings.freq();

                    for (int i = 0; i < freq; i++) {
                        int position = postings.nextPosition();
                        positionTermMap.put(position, termText);
                    }
                }
            }

            if (!positionTermMap.isEmpty()) {
                return positionTermMap.values().stream()
                    .collect(Collectors.joining(" "));
            }

            return null;
        }

        private String recoverFromTerms(int docId) throws IOException {
            Set<String> documentTerms = new TreeSet<>();

            try {
                for (LeafReaderContext context : reader.leaves()) {
                    if (docId >= context.docBase && docId < context.docBase +
context.reader().maxDoc()) {
                        int localDocId = docId - context.docBase;
                        LeafReader leafReader = context.reader();

                        Terms terms = leafReader.terms("contents");
                        if (terms != null) {
                            TermsEnum termsEnum = terms.iterator();
                            BytesRef term;

                            while ((term = termsEnum.next()) != null) {
                                PostingsEnum postings = termsEnum.postings(null);

                                if (postings != null && postings.advance(localDocId) ==
localDocId) {
                                    String termText = term.utf8ToString();
                                    if (termText.length() >= 2 && termText.matches("^[a-zA-Z가-
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힣0-9₩₩._-]+$")) {
                                    documentTerms.add(termText);
                                }
                            }
                        }
                    }
                    break;
                }
            }
        } catch (Exception e) {
            System.err.println("용어 추출 중 오류: " + e.getMessage());
        }

        if (!documentTerms.isEmpty()) {
            return documentTerms.stream()
                .collect(Collectors.joining(" "));
        }

        return null;
    }

    private void saveRecoveredContent(RecoveryResult result) throws IOException {
        String originalName = result.filename;
        String outputFileName;

        int lastDot = originalName.lastIndexOf('.');
        if (lastDot > 0) {
            outputFileName = originalName.substring(0, lastDot) + "_recovered.txt";
        } else {
            outputFileName = originalName + "_recovered.txt";
        }

        outputFileName = sanitizeFileName(outputFileName);

        Path outputFile = outputDir.resolve(outputFileName);

        try (BufferedWriter writer = Files.newBufferedWriter(outputFile)) {
            writer.write(result.content);
        }
```

```
    }

    private String sanitizeFileName(String fileName) {
        return fileName.replaceAll("[<>:₩"/₩₩₩₩|?*]", "_");
    }

    public void close() throws IOException {
        if (reader != null) {
            reader.close();
        }
        if (directory != null) {
            directory.close();
        }
    }

    private static class RecoveryResult {
        int docId;
        String filename;
        String path;
        String content = "";
        RecoveryStatus status;
        int termCount = 0;
    }

    private enum RecoveryStatus {
        STORED_FIELD_RECOVERY,    // 저장된 필드에서 복구
        TERM_VECTOR_RECOVERY,     // 텀 벡터에서 복구
        TERM_BASED_RECOVERY,      // 텀 기반 복구
        FAILED
    }
}
```

[별첨 1] LuceneContentRecovery 소스 코드.