Situated Information Search & Access
for Space Station & Shuttle
Mission Operations Personnel

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Situation Awareness for Mission Operations

- **Situation awareness** (both current and historical) is critical to mission operations
  - **Current awareness**: Real-time telemetry and communication feeds provide the basis for *current* situation awareness
  - **Historical awareness**: Mission documents, reports, logs, data provide the basis for *historical* situation awareness

- **Effective decision-making** depends on an accurate knowledge of the current operating situation and historical precedents
- **Information retrieval** is an essential component of the decision-making process
Flight Controller’s Information Retrieval Process

- **search**
  - gather situational awareness information

- **assemble**
  - information from multiple, heterogeneous sources

- **skim**
  - assembled information to determine relevance

- **discard**
  - irrelevant information

- **integrate**
  - remaining information to synthesize the “big picture”

- **act**
  - in a manner consistent with assessed situation

Largely a manual process
### Current Practice

Every flight controller must access thousands of pieces of info spread over numerous data bases, documents, spreadsheets, emails, web sites, etc.
What’s wrong with the current information infrastructure?

- Information access is document-centric, not situation-centric (i.e., event-, issue-, or activity-centric)
- After an situation occurs, no breadcrumb trail remains to tie information together
- Situation-relevant information is fragmented across many different sources
- Interrelationships between information are not captured

Information Lacks Context!
Information Context

Context encompasses all operationally-relevant information connected with a given event/issue

Information associated with an operational event/issue

Event: *In-flight Anomaly*

IFI

Problem Report

Anomaly Report

Part

Action Request

Procedure

Flight Note

Just the tip of the iceberg!
Search Tools for Mission Operations

- **Purpose:**
  - Improve Flight Controller situational awareness:
    - Enhance Flight Controller access to widely dispersed operations info
    - Situate information presented in relation to other relevant information

- **Approach:**
  - **Integrate Search**
    - Search across multiple information sources simultaneously
      - *Flight control resources, engineering resources, other data resources*
    - Search across heterogeneously formatted information
      - *Databases, documents, web sites*
  - **Improve Search**
    - Modern full-text search (vs. title-only search)
    - Query expansion using synonyms/acronyms/taxonomies
  - **Contextualize Search**
    - Situate search results by recovering web of interrelationships
    - Enable issue/activity/event-centered search vs. document-centered search
Context Recovery

- Recover relationships among information:
  1. Analyze document text for explicit references to other documents, events, activities, or issues
  2. Perform inter-document similarity analysis to determine implicit relationships among documents
...This chit implements a Resolution to the primary ALS heater failure described in Anomaly #447. Based on information described in EFN F0121902, temperature instability began at ...

...This chit revises the policy established in Chit 004361. Temperature instability was observed shortly after the primary ALS heater failure was detected...

EFN F013094

CITES

EFN F0121902

SIMILAR-TO

similar terms
Actual Cross-referencing in Chits/FNs/ARs

Opportunities:
• Hyperlinking
• Navigation and search

Also part #, s/n references
XSearch System: Search Results Page

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<tr>
<th>XRef</th>
<th>Type</th>
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<td>EVA-Critical ORUs to remain powered in the event of a Contingency EPS Load Shed, RS EVA 18 &amp; 19</td>
<td>CLOSED 2007/134:15:45</td>
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<td>EFN</td>
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C: Cites  
B: Cited By  
S: Similar To
## Cross References for Chit # 003774

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Cross-reference Tabs Displaying PRACAs, IFIs, and Parts

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Flight Note Containing Part # Cross-references

Title: Revision to Thursday Stowage Note

Due to the EVA Tool Restow activity today there were changes in the following procedure call outs:

EMU-BATT DSCHRG-INIT
12-0025 1.615 EMU BATTERY DISCHARGE USING SSC IN DOS MODE
1. PGSC, 760XD COMPUTER (P/N SDZ39129262-301, S/N 6016, B/C 00000452M) - A/L101 (M-02 Bag EVA PREP AND OPS, S/N 1038, B/C 003019J)
2. BCM-PCS Interface Cable (P/N SEG33112972-301, S/N 1002, B/C 00012394J) - NOD1 (SPCE Maintenance Ziploc (0.5 CTB: SPCE Maintenance Kit, S/N 1075, B/C 003957J))
3. Common Tp Screwdriver 3" (P/N SSDE43B) - NOD1D4_G2 (Drawer 3 of ISS IVA TOOLBOX)
4. EMU Advanced Battery (P/N SV819600-02-00, S/N 2053, B/C EMUH06J) - A/L1A1 (EMU 3009)
5. EMU Advanced Battery (P/N SV819600-02-00, S/N 2062, B/C EMUH08J) - A/L1F1 (EMU 3010)

The following procedure was added to the tasklist:

Wireless Video Systems Files Transfer and Downlink:
1. 760XD laptop (P/N SDZ39129262-301, S/N 6016 B/C 00000452M) - A/L101 (M-02 Bag EVA PREP AND OPS, S/N 1038, B/C 003019J)
2. US DC Power Cable, 10ft (P/N SEZ39129260-309, S/N 6029, B/C 00017100J) - A/L101 (M-02 Bag EVA PREP AND OPS, S/N 1038, B/C 003019J)
3. US DC POWER SUPPLY 120V (P/N SEG39129272-303, S/N 6007, B/C POC01039J) - A/L101 (US DC Power Cable, 10ft (M-02 Bag: EVA PREP AND OPS, S/N 1038, B/C 003019J))
4. DC POWER SUPPLY ADAPTER CABLE 10' (P/N SEG39129263-301, S/N 6002, B/C 00000348M) - A/L101 (US DC Power Cable, 10ft (M-02 Bag: EVA PREP AND OPS, S/N 1038, B/C 003019J))
5. 3.0 GB Hard Drive (P/N SEZ39129266-301, S/N 5020) - LAB1O5_E1 (1.0 CTB: LF-1 laptop equipment bag (2 of 3), S/N 1119, B/C 004113J)
6. PCMCIA 1GB Micro Drive - LAB1D3 or Crew Pref
Similarity Search

- **Goal**: Find Chits (or Flight Notes or Anomalies) that are similar to a given Chit/FN/AR

- **Method**: Use well-known statistical methods from the field of *Information Retrieval* to analyze text and determine the degree of similarity between two blocks of text (TF-IDF *vector space method*)
• Model document in a multi-dimensional vector space
• Each dimension represents a term (found within some document)
• Each chit is represented as a point in the space described by a vector: 
  \(<t_1, t_2, t_3, t_4, \ldots, t_n>\)
• Dimensions normalized by frequency of occurrence
• Similarity between two points is measured by the cosine of the angle between their two vectors.
**Ultimate Goal:**
*Build Up Integrated Semantic Data Model*

- Provides unifying context for all mission operations information
- Supports semantic search and inference capabilities
- Leverages Semantic Web R&D