“This presentation consists of L-3 STRATIS general capabilities information that does not contain controlled technical data as defined within the International Traffic in Arms (ITAR) Part 120.10 or Export Administration Regulations (EAR) Part 734.7-11.”
The flight system shall support the DOR tone capability in the SDST, including wideband DOR tones at X-band.

The flight software shall command the transponder as defined by the transponder documentation.

The flight system shall accommodate PCM / PSK / PM modulation for the X-band downlink.

The flight software shall provide the capability to command an “active” telecom side which determines the “active” transponder in use and the uplink channel.

The flight software shall configure the transponder telemetry inputs in accordance with the active FS side whenever the transponder is powered ON. Reference transponder ICD for selection table.

The flight software shall provide the capability to command an “active” telecom side which determines the “active” transponder in use and the uplink channel.

The flight software shall provide the capability to command the X-Band exciter for the active transponder.

The flight software shall provide the capability to command the X-Band Subcarrier for the active transponder.

The flight software shall provide the capability to command the X-Band telemetry modulation mode to SUBCARRIER or BPSK for the active transponder.

The flight software shall provide the capability to command the X-Band Squarewave Telemetry Modulation Index to one of 128 discrete values (0x00 to 0x7F) for the active SDST.

The flight software shall provide the capability to command the X-Band Sinewave Telemetry Modulation Index to one of 16 discrete values (0x0 to 0xF) for the active SDST.

The flight software shall provide the capability to command X-Band Ranging for the active transponder.

The flight software shall provide the capability to set the Ranging Modulation Index for the active transponder.

The flight software shall provide the capability to command X-Band Differential One-Way Ranging (DOR) Mode for the active transponder.

The flight software shall provide the capability to command the X-Band convolutional encoding mode of TLM_OFF, rate 7 1/2, or BYPASS for the active transponder.

The flight software shall provide the capability to command the Ranging Mode to BASEBAND or EXTERNAL for the active transponder.

The flight software shall provide the capability to command the X-Band Subcarrier to one of the following frequencies: 281.25 KHz squarewave, 281.25 KHz sinewave, 25 KHz squarewave, or 25KHz sinewave.

The flight software shall provide the capability to command the X-Band Squarewave Telemetry Modulation Index to one of 128 discrete values (0x00 to 0x7F) for the active SDST.

The flight software shall provide the capability to command the X-Band Sinewave Telemetry Modulation Index to one of 16 discrete values (0x0 to 0xF) for the active SDST.

The flight software shall provide the capability to command the X-Band telemetry modulation mode to SUBCARRIER or BPSK for the active transponder.

The flight software shall provide the capability to enable or disable the X-Band exciter for the active transponder.

The flight software shall provide the capability to enable or disable c mode for the active transponder.

The flight software shall provide the capability to enable or disable X-Band Ranging for the active transponder.

The flight software shall provide the capability to set the Ranging Modulation Index for the active transponder.

The flight software shall provide the capability to command X-Band Differential One-Way Ranging (DOR) Mode for the active transponder.

The flight software shall provide the capability to command the X-Band convolutional encoding mode of TLM_OFF, rate 7 1/2, or BYPASS for the active transponder.

The flight software shall provide the capability to command the Ranging Mode to BASEBAND or EXTERNAL for the active transponder.

The flight software shall provide the capability to command the X-Band Subcarrier to one of the following frequencies: 281.25 KHz squarewave, 281.25 KHz sinewave, 25 KHz squarewave, or 25KHz sinewave.

The flight software shall provide the capability to command the X-Band Squarewave Telemetry Modulation Index to one of 128 discrete values (0x00 to 0x7F) for the active SDST.

The flight software shall provide the capability to command the X-Band Sinewave Telemetry Modulation Index to one of 16 discrete values (0x0 to 0xF) for the active SDST.

The flight software shall provide the capability to command the X-Band telemetry modulation mode to SUBCARRIER or BPSK for the active transponder.

Motivation for a Visualization Methodology

Studying characteristics of information flow in large Requirements sets

>40 documents
>20,000 tests or requirements
>25,000 linkages

Quickly communicate regarding patterns involving hundreds or thousands of requirements
Graphs and Networks

A very brief review of terms

Directed Edge

Old idea (Euler, 1731) but still very useful

Undirected Edge

Commonly used in network analysis and visualization

Nodes

Core to network analysis and topology
Tools for Visualization

• **GUESS**
  – Standard and well-known graph tool
  – Freely available and very flexible
  – All examples in this presentation are from GUESS

• **Extensions and programming**
  – Gython/Jython/JavaSwing for search/queries
  – Quick way to write analysis scripts
  – JavaSwing allows for quick and elegant user interfaces

• **ICD for DB to Guess/GRV translation**
  – Simple way to generate GUESS datasets and record analysis results back into a managed database.
  – Supports most Access/RDB variable types
  – Provides for multi-user and configuration management

• **New tools coming**
  – Second generation of Guess by same developer (not yet available)
  – 3-D visualization (Walrus: too many limitations for this application)
• Flight system requirements/test network for operational S/C
• Dealing with large models requires care and some computer time
• This model has 20K nodes and 25K edges
Layouts

- **GEM**
  - Reliable, usually useful, slow for large models
  - Most examples in this presentation are GEM layouts (Oh wow)

- **Spring/physics**
  - Poor results on the larger models.
  - May be better for dynamical models

- **Circle/Radial**
  - Not useful for requirement/test networks

- **MDS**
  - Fast but ugly

- **BINPACK**
  - Fast and useful in some cases, but still a bit ugly
  - Separates subnets which can improve clarity

- **Research opportunities**
  - Hierarchical algorithm taking advantage of known network structure
  - Fast but not yet ready for prime time.
Simple jython script with rdb interface
~150 sloc using swing java dialogs
Searching Using GRV

Swing Java/Jython script

~145 sloc
Outward Signs of Internal Troubles

• Patterns associated with difficulties
  – Hourglass (multiple inheritance)

Traceability is key to both requirements development and requirements verification. Each project has unique approaches to traceability and verification.
Pitfalls of Multi-Parenting

Three parents/Six children
Direct links to children from unrelated grandparents

Validation difficulties
Testing considerations
Time-phasing of development
Connectivity Studies

• Neighbors exploration

Select a node
The cutting edge

- Connection statistics to support mathematical approaches
  - Methods for determinants of 20K by 20K connection matrices (sparse) – Fiedler number \( \det(D-A) \)
  - Validation of methodology across multiple projects

### A Matrix

\[
\begin{pmatrix}
0 & 1 & & & \\
1 & 0 & 1 & & \\
1 & 0 & 1 & 1 & 1 \\
1 & 0 & & & \\
1 & 0 & & & \\
1 & 0 & & & \\
\end{pmatrix}
\]

### Laplacian (D-A)

\[
\begin{pmatrix}
1 & -1 & & & \\
-1 & 2 & -1 & & \\
-1 & 4 & -1 & -1 & -1 \\
-1 & 1 & & & \\
-1 & 1 & & & \\
-1 & 1 & & & \\
\end{pmatrix}
\]

### Eigenvalue:
From linear algebra
\( Lx = \lambda x \) where \( \lambda \) is an eigenvalue
And \( x \) is a non-null eigenvector
Because \( L \) is symmetric the eigenvalues are all real
\( \lambda = \{0, 0.486, 1, 1, 2.428, 5.086\} \)

Fiedler number = 0.486
implying somewhere between an expander (1) and a tree form (1/6)
Stuff that is not yet done

• Hierarchical layout script
  – Group Req by document <- easy
  – Position based on level <- easy
  – Sort to minimize edge crossings <- hard!
And Stuff that is Almost Done

- Fully automatic bidirectional database/graphing tools
  - ICD a first step (third version)
  - Core jython scripts for GUESS are working well
  - Minor development to complete an Access/RDB interface
Summary

• Graphical approaches can be useful tools alongside traditional methods
• It is possible to visualize large models and quickly draw meaningful conclusions
• Jython/swing java tools are fast enough for even a very large models (20K nodes)
• Plenty left to explore for the imaginative.