TECHNOLOGY EVALUATIONS FOR TEST TEAM REMOTE PRESENCE AT NASA LANGLEY RESEARCH CENTER

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Presentation Outline

• Objective
• Cultural Differences
• Facility Survey
• Investigated Technologies
• Potential Application
• Issues
• Future Steps
Objective

• The objective of the remote presence project is to assess existing technologies that may allow us to provide routine participation in research activities from geographically remote locations.

• The scope began as very broad and, as the investigation progressed, narrowed to:
  • From a Ground Test Facility perspective
    • Both aeronautical AND structural test facilities
  • Accessing data remotely to aid in guiding the direction of the test
    • **NOT** getting data to a remote computer for reduction
Data Types

Data
- Structural testing data
- Aeronautical testing data
- Cyclic/Trending data
- Preliminary point data

Video
- Video feed
- Sharing Desktop or Applications

Audio
- Voice over IP
- Telephone

Facility Types

Closed-Circuit Wind Tunnels
- National Transonic Facility
- 14x22
- Transonic Dynamics Tunnel
- 0.3 m Transonic Cryogenic Tunnel

Blow-down Wind Tunnels
- 8' High Temperature Tunnel
- Supersonic Combustion Ramjet Test Complex
- Langley Aerothermodynamics Laboratory
- Supersonic Wind Tunnel
- Low Speed Aeroacoustics Wind Tunnel

Structural Test Facilities
- Combined Loads Test System
- Landing and Impact Research Facility

Data Acquisition Systems:
- Blue = TestSLATE
- Yellow = OADAS
- Green = Pacific Instruments
- Purple = Custom Software
Cultural Differences

- Security
  - Sensitive Data (Proprietary/SBU)
    - Customers (Proprietary) require secure transfers
    - Federal Government (SBU) requires specific secure transfers
  - Non-Sensitive Data
    - Not too concerned about confidentiality

- Availability of data to the customer
  - There are differences in ‘what data gets to the customers at what point in time’ across facilities
  - We are investigating ‘technical possibilities.’ When to implement them is out of scope of our effort

- People found it hard to think outside of the way they do things.
  - No well formed requirements for this type of capability
  - Will take experience through cyclical development cycle to better define what capabilities to pursue
Facility Survey

• Closed-Circuit Wind Tunnels
  • Continuous wind flow with hours of testing
  • Usually perform multiple runs per day
  • Engineers in control room are in charge of the operations
    • Can decide to skip certain batches/runs based on test data

• Blow-down Wind Tunnels
  • Short duration tests of less than 5 minutes. Vacuum driven airflow.
  • Testing frequency much more varied than closed-circuit wind tunnels. Some do only one run per day, some do a couple runs per day.

• Structural Test Facilities
  • Force loading and measurements
  • Typically long duration test runs
Most Beneficial Data Feedback Frequency

- Real Time
  - 14x22 NTF
  - COLTS
  - 0.3 m TCT
  - TDT*
  - SCRAMJET
  - Long Duration Tests

- Hourly Update
  - LAL
  - SWT
  - LSAWT
  - Medium Duration Tests

- Daily Update
  - 8’ HTT
  - TDT*
  - LandIR
  - Short Duration Tests
### Specific Technologies Investigated

#### Technologies

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Specific Data Technologies Investigated

- DataTurbine
  - Java-based data transport tool for streaming heterogeneous data in real time
  - Three major components
    - Data acquisition devices (sources)
    - A Ring Buffered Network Bus (RBNB) server—think of this as “the cloud”
    - Data utilization applications (sinks)
  - Users typically use and manipulate their preferred clients
- Matlab OPC Toolbox
  - TestSLATE provides data to an OPC server that Matlab can retrieve
  - Matlab allows remote data access to OPC server via TCP/IP connection
  - Matlab integrates with DataTurbine nicely due to Java basis
- aeroCOMPASS
  - A commercial web-based collaborative document and data sharing site
    - An Alfresco system (similar to SharePoint)
Specific Technologies Investigated

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• Matlab OPC Toolbox                             | • UWAL Plot
• aeroCOMPASS                                     | • WinPlot
|                                           | • FFMPEG
• RTSP stream from video server                | • rbnbPlot
• Matlab                                        | • RDV
• WebEx                                         | • Matlab
• Vidyo                                         | • LabVIEW Web UI
• Tricaster                                     | • Custom Client
• Remote Desktop                                |                                                      |
• Hauppauge WinTV7 Extend                      |                                                      |
Specific Video Technologies Investigated

- **VLC**
  - Free, open source cross-platform multimedia player
  - Works with various streaming protocols to stream audio and video
  - Can be used independently or with DataTurbine for “TiVo” capability

- **FFMPEG**
  - Free cross-platform application to record, convert, and stream audio and video
  - Can be used independently or with DataTurbine for “TiVo” capability

- **Matlab**
  - Standard license has capability of manipulating prerecorded videos
  - Additional Toolboxes available to acquire and process images/video from hardware
  - Potential for sending video streams through DataTurbine as well as data
    - This capability has yet to be investigated/evaluated
Specific Video Technologies Investigated

- WebEx
  - Current agency offering for teleconferencing
  - Allows sharing of desktop, applications, web browsers, etc. by one person at a time
  - Has whiteboard capability for annotation of shared objects
  - Requires secure NASA login for SBU information
    - Can invite non-NASA personnel to join conference
  - Requires a telephone in order to get audio
  - Non-presenting participants have no direct control over what they see
  - Secure, encrypted connection using SSL from anywhere
    - Runs on 3G, 4G, Wi-Fi, etc.
    - Can join conferences from mobile devices
Specific Video Technologies Investigated

- Vidyo
  - New agency offering for teleconferencing
  - Allows sharing of desktop, applications, web browsers, etc. by each person
    - Each person can only share one thing
    - User chooses which ‘one thing’ they want to see but can’t manipulate it at this time
  - Currently no whiteboard ability—Expected later this year
  - Requires secure NASA login for SBU information
    - Can invite non-NASA personnel to join conference
  - Uses Voice over IP, similar to Skype—No telephone required for audio
  - Secure, encrypted connection using SSL from anywhere
    - Runs on 3G, 4G, Wi-Fi, etc.
    - Can join conferences from mobile devices, but currently requires an account
Specific Video Technologies Investigated

• Tricaster
  - Portable HD Video Studio that can stream audio and video to the network
  - Able to stream from one of 3 connected cameras or the display of a remote computer
  - Remote users don’t have the ability to control what they see

• Remote Desktop
  - Remotely log into computer and use it as if you were there
  - Requires a dedicated workstation in the control room
  - Remote users need NAMS account request for credentials for VPN access
  - Would require a conference room for more than one remote customer to view
  - Wouldn’t be able to connect to a computer in control room from offsite

• Hauppauge WinTV7 Extend
  - Ability to stream from video capture card to web server on local network
**Specific Technologies Investigated**

## Technologies

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Specific Client Platforms Investigated

- University of Washington Aeronautical Laboratory Plot (UWAL Plot)
  - Specifically mentioned as a preferred client by Boeing
  - Facilities that have a free license file can use the plotting software—as can their customers
  - Capable of real time data plotting
    - Will read an updated file when instructed to by a web server
- WinPlot
  - Developed at Marshall Space Flight Center
  - Used extensively at Marshall for propulsion analysis on SSME’s, Delta Program, etc.
  - Capable of real time data plotting
    - Can import ASCII text files
Specific Client Platforms Investigated

- **rbnbPlot**
  - Free plotting package included with DataTurbine
  - Can display data as tables or plots
    - Plots cannot be overlaid for comparison
  - Can display images and video in same window as tabular/graphical data
    - Can’t handle audio or any form of encapsulation
- **Real Time Data Viewer (RDV)**
  - Free Java interface for viewing and analyzing data locally or from DataTurbine server
  - Capable of displaying textual and numerical data, still images, and video
    - Can’t handle audio or any form of encapsulation
    - Plots can be overlaid for comparison
  - Playback rate can be adjusted so data is presented slower or faster than real time to aid in analysis
Specific Client Platforms Investigated

- **Matlab**
  - Can serve as a sink to plot and analyze data from DataTurbine server
  - Analyzed data can be placed back on DataTurbine server
  - Would require familiarity with DataTurbine to do effectively

- **LabVIEW WebUI**
  - Based on Microsoft Silverlight
  - Can develop web-based thin client applications to allow users to remotely monitor data through a secure web browser
  - Being phased out in coming years due to Microsoft’s lack of Silverlight development

- **Custom Client**
  - A custom sink could be developed to operate however we want and distributed to customers
  - Would require time, money, and familiarity with DataTurbine and programming languages
### Free

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*Blue = Most promising near term options*
Most Promising Near Term Options

**Data**
- DataTurbine (DT) + Matlab OPC Toolbox
- aeroCOMPASS

**Audio/Video**
- Matlab + DT
- VLC + DT
- FFMPEG + DT
- Vidyo
- WebEx
TestSLATE Aeronautic Data Flowchart

Objective

Cultural Differences

Facility Survey

Investigated Technologies

Potential Application

Issues

Future Steps

Sources → TestSLATE → Data Acquisition System → Raw Data

Data Red. → OPC Server

“Cyclic data” (10 Hz)

This connection is possible but not currently in place

“Point Data”
Getting Data to Remote Customers

Objective
Cultural Differences
Facility Survey
Investigated Technologies
Potential Application
Issues
Future Steps

Facility Control Room
OPC Server
Matlab OPC Client
DataTurbine Source
DMZ
DataTurbine Server
Anywhere
Customer Client/Viewer
DataTurbine Sink
### Example of Remote Presence System—Configuration File

|   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 1 | Source | SGCN | SGFTN | CTCN | TCFTN | PTCN | PTFTN | FBCN | FBFTN | OSCN | OASFTN | ASCN | ASFTN | ACFTN | ACMN | IMCN | IMFTN |
| 2 | Strain Gauges | SG01 | Data.AI.NF1ACH01 | TC1 | Data.AI.NF1ACH09 | PT1 | Data.AI.NF1ACH19 | FB01 | Data.AI.NF1ACH24 | CS01 | Data.AI.NF1ACH39 | AS01 | Data.AI.NF1ACH51 | AC1 | Data.AI.DTC01P01 | IM1 | Data.AI.DTC01P07 |
| 3 | Thermocouples | SG02 | Data.AI.NF1ACH02 | TC2 | Data.AI.NF1ACH10 | PT2 | Data.AI.NF1ACH20 | FB02 | Data.AI.NF1ACH25 | CS02 | Data.AI.NF1ACH40 | AS02 | Data.AI.NF1ACH52 | AC2 | Data.AI.DTC01P02 | IM2 | Data.AI.DTC01P08 |
| 4 | Pressure Transducers | SG03 | Data.AI.NF1ACH03 | TC3 | Data.AI.NF1ACH11 | PT3 | Data.AI.NF1ACH21 | FB03 | Data.AI.NF1ACH26 | CS03 | Data.AI.NF1ACH41 | AS03 | Data.AI.NF1ACH53 | AC3 | Data.AI.DTC01P03 | IM3 | Data.AI.DTC01P09 |
| 5 | Force Balances | SG04 | Data.AI.NF1ACH04 | TC4 | Data.AI.NF1ACH12 | PT4 | Data.AI.NF1ACH22 | FB04 | Data.AI.NF1ACH27 | CS04 | Data.AI.NF1ACH42 | AS04 | Data.AI.NF1ACH54 | AC4 | Data.AI.DTC01P04 | IM4 | Data.AI.DTC01P10 |
| 6 | Optical Sensors | SG05 | Data.AI.NF1ACH05 | TC5 | Data.AI.NF1ACH13 | PT5 | Data.AI.NF1ACH23 | FB05 | Data.AI.NF1ACH28 | CS05 | Data.AI.NF1ACH43 | AS05 | Data.AI.NF1ACH55 | AC5 | Data.AI.DTC01P05 |
| 7 | Audio Sensors | SG06 | Data.AI.NF1ACH06 | TC6 | Data.AI.NF1ACH14 | PT6 | Data.AI.NF1ACH24 | FB06 | Data.AI.NF1ACH29 | CS06 | Data.AI.NF1ACH44 | AS06 | Data.AI.NF1ACH56 | AC6 | Data.AI.DTC01P06 |
| 8 | Accelerometers | SG07 | Data.AI.NF1ACH07 | TC7 | Data.AI.NF1ACH15 | PT7 | Data.AI.NF1ACH25 | FB07 | Data.AI.NF1ACH30 | CS07 | Data.AI.NF1ACH45 | AS07 | Data.AI.NF1ACH57 |
| 9 | Inertial Measurement Units | SG08 | Data.AI.NF1ACH08 | TC8 | Data.AI.NF1ACH16 | PT8 | Data.AI.NF1ACH26 | FB08 | Data.AI.NF1ACH31 | CS08 | Data.AI.NF1ACH46 | AS08 | Data.AI.NF1ACH58 |
| 10 |   |   | Data.AI.NF1ACH12 | TC9 | Data.AI.NF1ACH17 | PT9 | Data.AI.NF1ACH27 | FB09 | Data.AI.NF1ACH32 | CS09 | Data.AI.NF1ACH47 | AS09 | Data.AI.NF1ACH59 |
| 11 |   |   |   | TC10 | Data.AI.NF1ACH18 | PT10 | Data.AI.NF1ACH28 | FB10 | Data.AI.NF1ACH33 | CS10 | Data.AI.NF1ACH48 | AS10 | Data.AI.NF1ACH60 |
| 12 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 13 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
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| 16 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
Example of Remote Presence System—Data

DAS/Control Room View

Remote Client View

Objective

Cultural Differences

Facility Survey

Investigated Technologies

Potential Application

Issues

Future Steps

| NF1ACH12 | = 102.813 |
| NF1ACH13 | = 205.313 |
| NF1ACH14 | = 298.750 |
| NF1ACH16 | = 400.313 |
| NF1ACH16 | = 498.125 |
| NF1ACH17 | = 599.063 |
| NF1ACH18 | = 698.750 |
| NF1ACH19 | = -10240.000 |
| NF1ACH20 | = -803.438 |
Potential Application with WebEx

Control Room
- WebEx
- Telephone
- TestSLATE

DMZ/Internet
- DataTurbine Server
- Firewalls

Remote Customer
- WebEx Client
- Telephone
- VLC
- rbnbPlot
Potential Application with Vidyo

Control Room
- Vidyo
- TestSLATE

DMZ/Internet
- DataTurbine Server
- Firewalls

Remote Customer
- Vidyo Client
- VLC
- rbnbPlot
Potential Application with **DataTurbine**

- **Control Room**: TestSLATE
- **DMZ/Internet**: DataTurbine Server, Firewalls
- **Remote Customer**: VLC, rbnbPlot

**Objective**
- Cultural Differences

**Facility Survey**
- Investigated Technologies

**Potential Application**
- Issues

**Future Steps**
Issues That Need To Be Understood

- Security concerns from multiple perspectives
  - Technical
    - DataTurbine doesn’t currently have a way to be encrypted
    - Can it be used from facility to facility with minimal change?
    - What does it take to provide a ‘menu’ of data formats? (DataTurbine can present ‘anything,’ but how do we get it in/out?)
  - Cultural
    - Specific facility policies on when data is released to customers
    - Breaking the mold—People may not see benefit in the short term
  - Institutional
    - Agency policy and physical network architecture
Resources That Need To Be Considered

- Ease of Use/Training
  - End user perspective
    - What do I need to download?
  - Facility perspective
    - How does it get configured?
    - What does it take to run this thing? People with expertise = $$$
      - Needs to be a part of the test planning from initiation
Future Steps

- Data points in aero database presented by OPC
- Is Matlab/OPC the best approach to get from the data acquisition system to DataTurbine?
  - Is it worth the license fee? What are those costs?
  - What would it take/cost to go directly from OPC to DataTurbine? Is that a good option?
  - Would other options like UDP be easier and/or more beneficial?
- Now that we know the general capabilities, refine the clients and capabilities
  - Matlab generalization of the configuration file (ini file)
  - User interface environment enhancements
  - Security studies
  - Encryption possibilities
- Demonstration with non-SBU test in a facility using TestSLATE
Take Home Message

• There are technologies available that can help provide remote presence capabilities

• There are different testing paradigms which would benefit from different tools (real time, hourly, or daily feedback)

• TestSLATE/DataTurbine combination is the low-hanging fruit for introducing this capability to the customers and facility cultures. We still need to understand the practicality of interfacing with the number of different data systems at NASA Langley Research Center

• More investigation is needed to understand the security and flexibility of DataTurbine in Langley’s environment for offsite usage in particular