Using XML and Java Technologies for Astronomical Instrument Control

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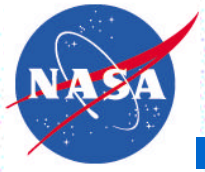
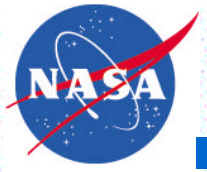
NOTE: Derived from prior work of Troy Ames, NASA/Goddard Space Flight Center and Ken Sall, Craig Warsaw, and Lisa Koons of Commerce One



Agenda

- Project Background
- Technologies Used
- XML Uses and Examples
- Framework Architecture
- Benefits of the Architecture

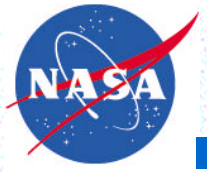


IRC Project Goals

- Instrument Control Software
  - Extensible framework for the distributed control and monitoring of remote instruments
    - Control = commanding of the instrument
    - Monitoring includes quick-look visualizations of data
  - Promote reuse by design
    - Reuse = use for controlling multiple kinds of instruments
  - Easy to develop, modify, maintain, and extend
  - Platform independent
- Develop reliable, robust instruments
  - Easy for scientists to use
  - Clear interface between hardware and software
  - Support for iterative development

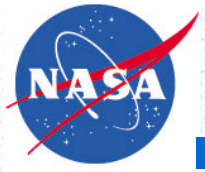
Instrument Remote Control Project (IRC)

- NASA Goddard Space Flight Center (GSFC)
  - Advanced Architectures and Automation Branch (Code 588)
  - Infrared Astrophysics Branch
- Commerce One
- Center for Astrophysical Research in Antarctica (CARA)
  - University of Chicago, Yerkes Observatory
- Stratospheric Observatory for Infrared Astronomy (SOFIA): NASA, USRA, DLR
  - HAWC: High-resolution Airborne Wideband Camera
  - SAFIRE: Submillimeter And Far Infrared Experiment



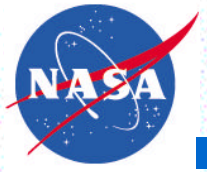
Technology Used in IRC

- Java ™ Technology
  - High productivity rate for development
  - Support for reusable components
  - Rich set of APIs
    - Networking
    - Graphics
    - GUI
    - Security
  - Platform independence
  - Many tools available
- XML – Extensible Markup Language
  - Metalanguage -- a language for describing other languages
    - Document Type Definition (DTD) or schema defines specific dialect
  - Structured, hierarchical data
    - Human readable
    - Machine-understandable
  - Platform independent
  - Many tools available



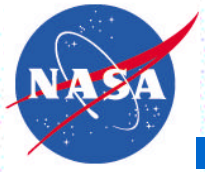
XML Uses In IRC Framework

- Instrument Markup Language (IML) - to describe instruments
  - Logical command set
  - Command arguments, constraints, and units
  - Field data types and valid values/ranges
  - Logical data streams (telemetry)
  - Command and Data formats
  - Communication mechanisms
- Pipeline Algorithm Markup Language – to describe data analysis pipeline algorithms
  - Reuses many of the constructs in IML



IML History

- First IML Prototype DTD (Feb '99)
  - HAWC Simulator
  - ASCII commands
  - Simple telemetry
  - One port type (TCP)
- Engineering Test DTD (Fall '99)
  - Detector downselect candidate for SPIRE
  - Binary commands
  - Complex telemetry with parsing delegate
  - Several port types (DMA, Serial, TCP)
- XML Schema (currently testing)

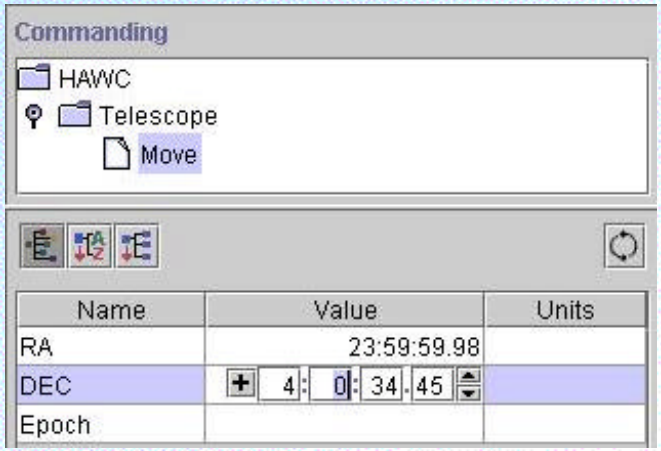


High-Level IML File Structure

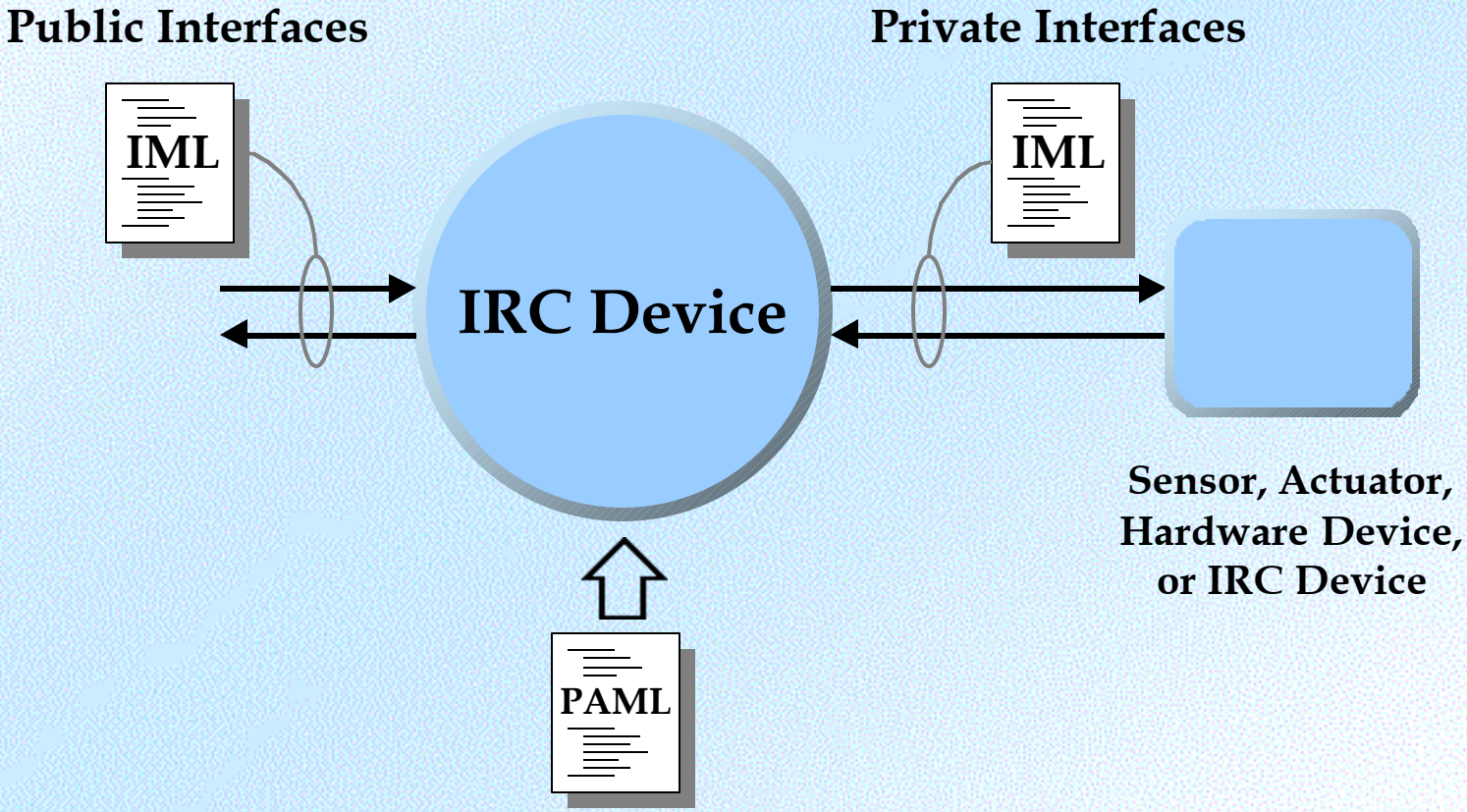
```
<Instrument name="HAWC" ... >
  <Instrument name="Telescope" >
    <CommandInterface name="Telescope Commands">
      <Command ... />
    </CommandInterface>
    <DataInterface name="Telescope Status" >
      <DataElement ... />
    </DataInterface>

    <Port name="Telescope Command Port" portType="TCP" >
      <Format name="Command Format" formatType="command" .../>
      <InterfaceReference reference="Telescope Commands" />
    </Port>
    <Port name="Telescope Status Port" portType="Serial" >
      <Format name="Status Format" formatType="data" ... />
      <InterfaceReference reference="Telescope Status" />
    </Port>
  </Instrument>
</Instrument>
```

Command Example

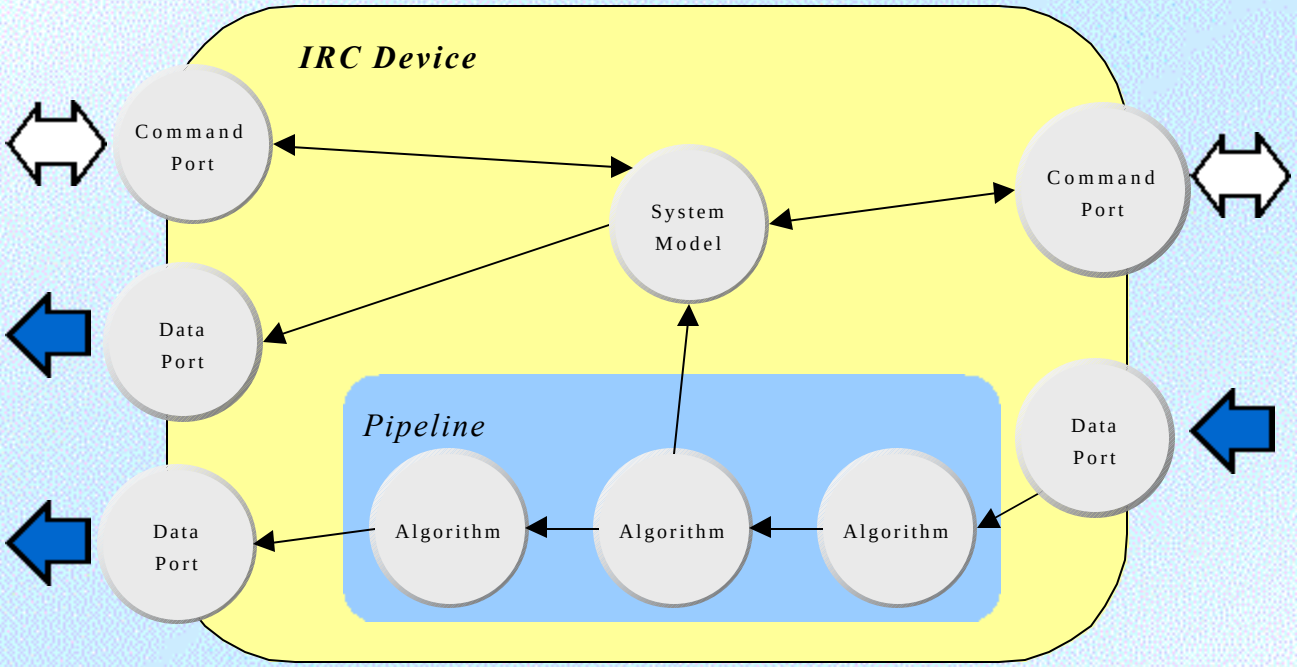
```
<Command name="Move" >
  <Field name="RA" type="Sexagesimal" >
    <RangeConstraint low="00:00:00.0" high="23:59:59.99"
   />
  </Field>
  <Field name="DEC" type="Sexagesimal" >
    <RangeConstraint low="-89:59:59.99" high="89:59:59.99"
   />
  </Field>
  <Field name="Epoch" type="Float" />
</Command>
```



IRC Device Configuration

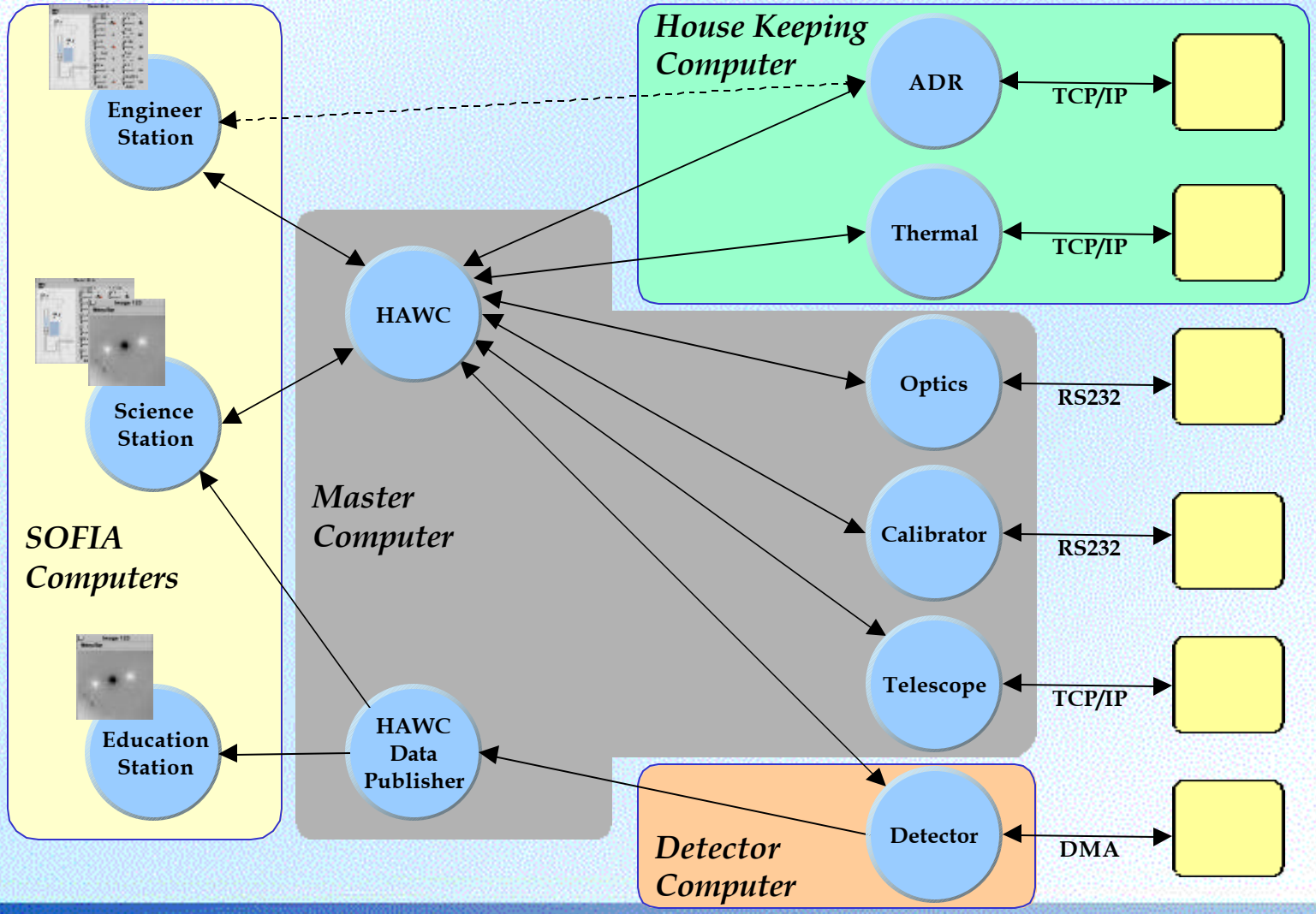


Example Device Internal Configuration

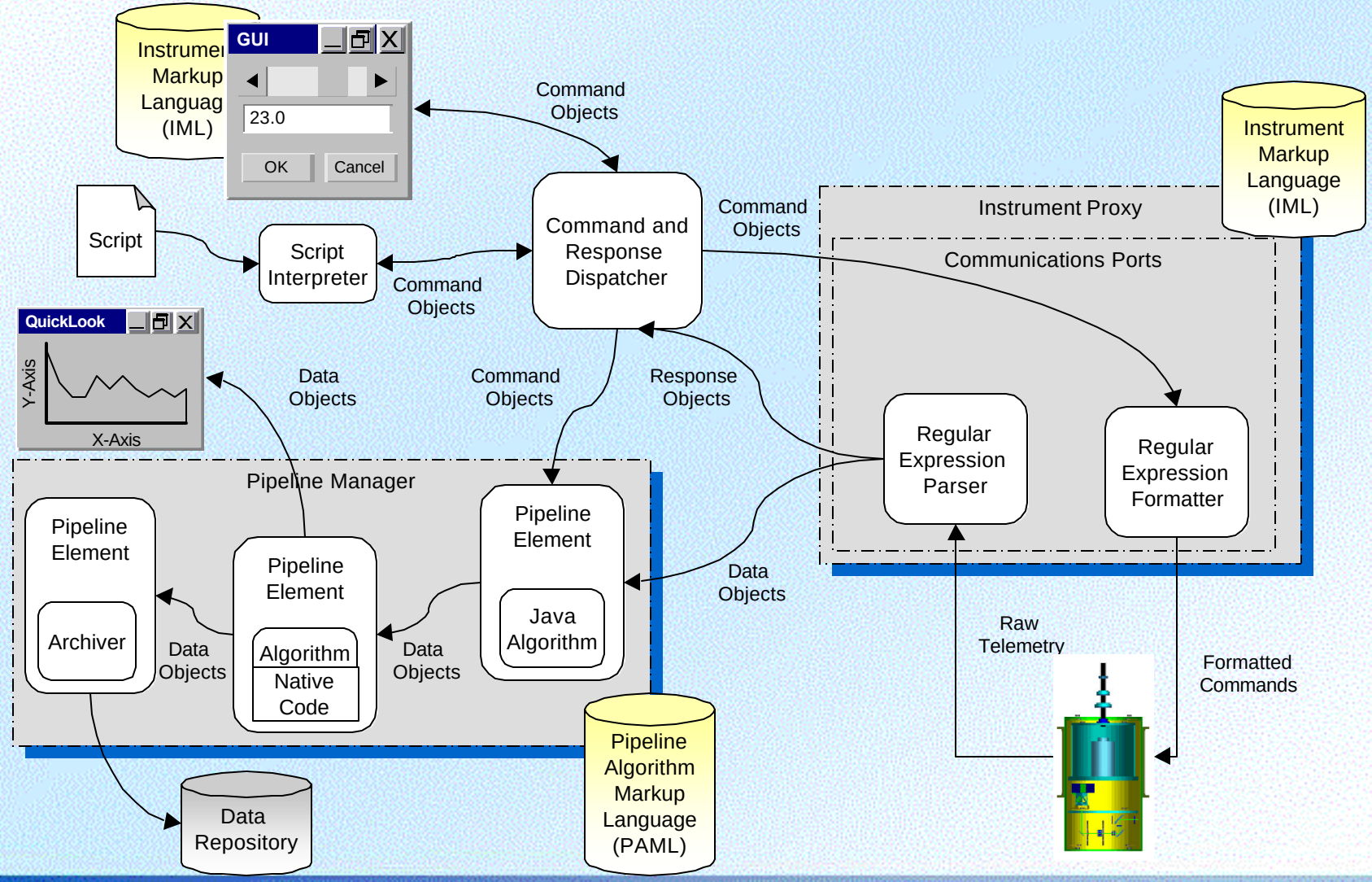


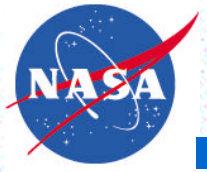
- This is an example internal configuration of an IRC device.
- Commands and responses typically flow through one port while the data flows through separate ports.
- An internal pipeline might provide data through one data port while the System Model might route interim data through a second data port.

Example Instrument Device Architecture



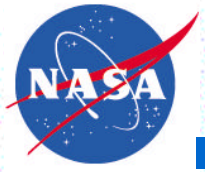
Example Detailed Device Internals





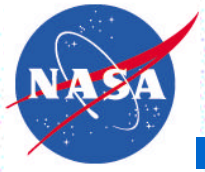
IRC Project Status

- Demonstrated feasibility of approach
- First engineering test of instrument complete
- Currently testing an enhanced IRC framework
  - IML conversion to XML Schema
  - IRC Device for distribution architecture
  - Easier algorithm development
  - More generic algorithms provided
- Applying IRC
  - HAWC
  - FIBRE (a prototype of SAFIRE)
  - SAFIRE



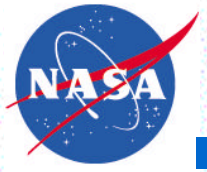
The Vision: Instrument Design

- Hardware Engineer defines instrument
  - Uses custom editor to hide XML details
- Data Analysis Pipeline
  - Select from library of algorithms
  - New algorithms can be created by instrument designer or end user (using Java, scripts, native code, IDL, …)
  - Create and save baseline pipeline configurations
- Graphical User Interface
  - Default GUI may be sufficient for engineering testing
  - In general, need to be able to customize GUI
- Define calibration and other scripts



The Vision: Value Proposition

- Generic architecture
- Driven by descriptions
- Significant code reuse
- Anticipate 10% to 30% customized code
- Savings of 70% to 90% over traditional development paradigms



For More Information

- NASA/Goddard IRC website (papers, presentations, DTD):
  - http://pioneer.gsfc.nasa.gov/public/irc
- NASA/Goddard XML for Astronomy website
  - http://pioneer.gsfc.nasa.gov/public/xml
- Listed on XML.org
  - http://www.xml.org/ - both DTD and XML Schema listed
- Contact:
  - Troy Ames: Troy.Ames@gsfc.nasa.gov, (301) 286-5673
  - Julie Breed: Julia.Breed@gsfc.nasa.gov, (301) 286-5049