# NASA - Software Estimating Tool (N-SET)

*A NASA Research Project*

NASA Cost Analysis Symposium

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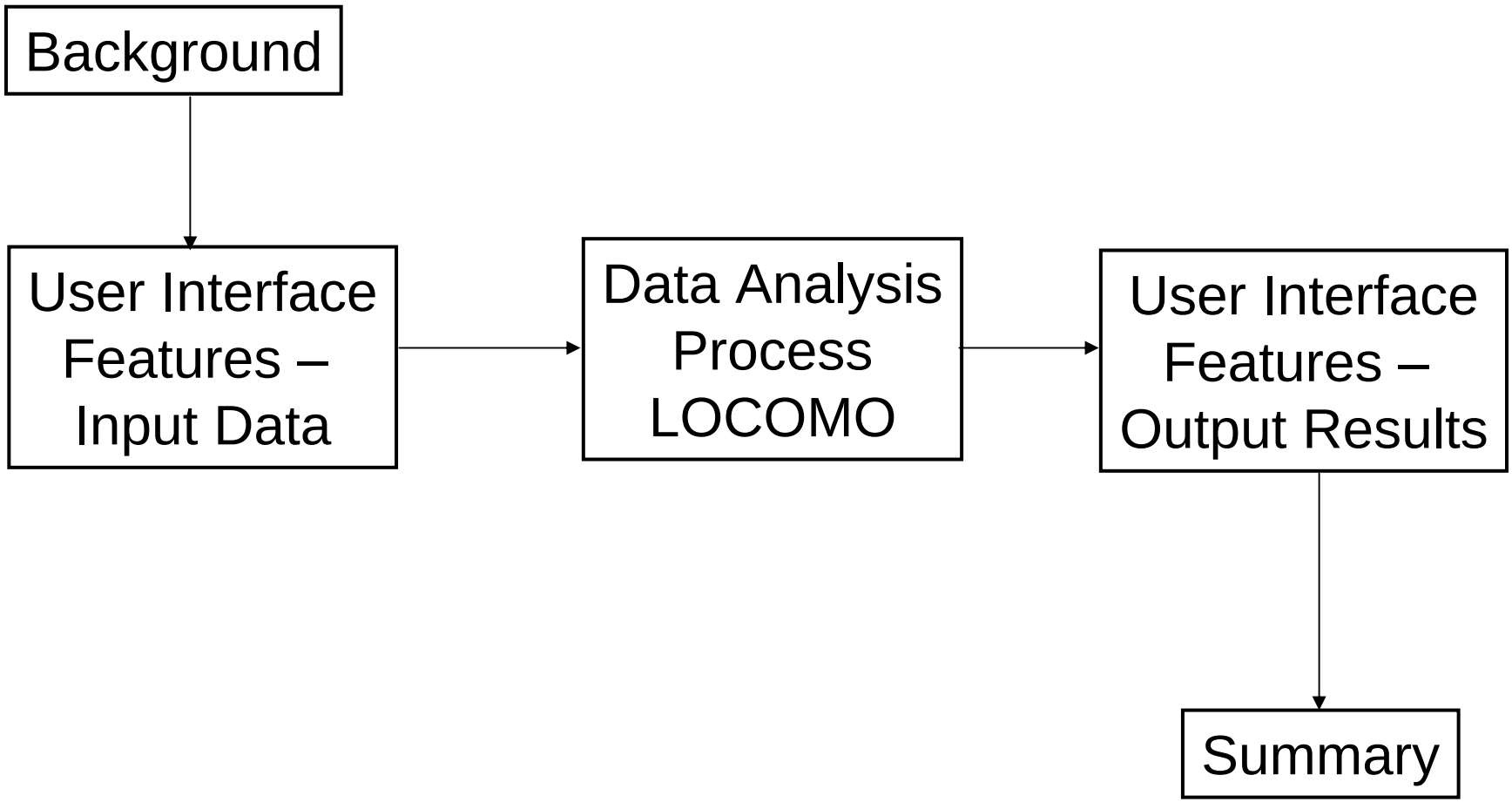
# Briefing Structure



# Topics

- Background
  - Project Overview
  - Project Description
  - Approach
- User Interface Features – Input Data
- Data Analysis Process (*Dr. Tim Menzies*)
- User Interface Features – Output Results
- Summary
  - Benefits and Beneficiaries
  - Deliverables and Schedule
  - Next Steps

# Project Overview

- **NASA Research Project funded by HQ IPAO**
  - FY05 and FY06

- **The Problem**: NASA is unable to estimate software size/cost early in a project because the software requirements/architecture are not complete and cost model inputs, primarily size, are not available

- **The Purpose** is to develop an early life cycle software estimation tool so that it can be used by the entire NASA community, including NASA contractors without restriction

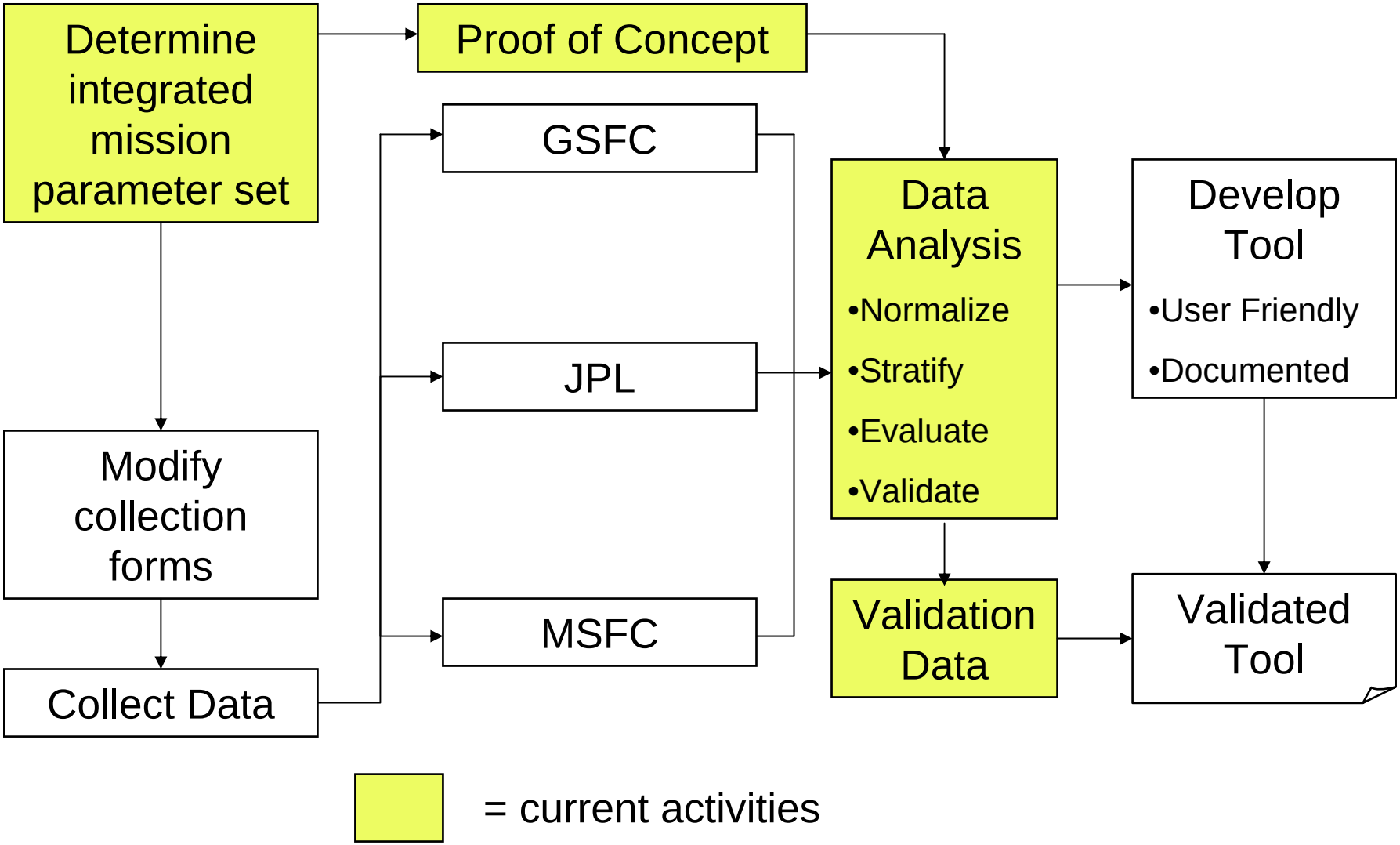
# Project Overview (cont)

- The objective is to leverage existing assets that will allow us to establish a capability to help cost analysts create software estimates early in a program development
- Team has over 100 years of cross organizational cost data collection and cost model development experience
- Integrated development team includes:
  - Task Sponsor: Tom Coonce (NASA HQ IPAO)
  - Task Manager: Sherry Stukes (JPL)
  - Technical Lead: Jairus Hihn (JPL)
  - Task Engineer:  Michael Luna (JPL)
  - University Collaboration: Tim Menzies (West Virginia University)

# Project Description

- Develop an early lifecycle software cost estimation tool leveraging existing data and capabilities
- Collect additional software data from:
  - Jet Propulsion Laboratory
  - Goddard Space Flight Center
  - Marshall Space Flight Center
- Analyze, normalize, evaluate, stratify, and validate data
- Create a calibrated, validated, and documented tool initially using available data and subsequently using newly collected data

# Approach


Determine integrated mission parameter set
Proof of Concept
GSFC
JPL
MSFC
Data Analysis
•Normalize
•Stratify
•Evaluate
•Validate
Develop Tool
•User Friendly
•Documented
Modify collection forms
Collect Data
Validation Data
Validated Tool
= current activities

# User Interface Features

## Input Data

- Required Input
  - User information
  - Project descriptive information
  - Technical parameters
- Technical Parameters based on:
  - Generally available information
  - Information available in CADRe
- Features
  - Pull-down menus
  - Context sensitive definitions

# Sample User Interface Screen

Mike’s Splash Screen

# Sample User Interface Screen

Mike’s Splash Screen

# Sample User Interface Screen

Mike's Splash Screen

# LOCOMO: building “local” cost models for N-SET

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**Cleveland, Ohio**

# Motivation

- Should you let an electrician fix your pipes?
  - No- the skill of electricians and plumbers comes from different training.
- Should you build one cost model to cover all your projects?
  - Not sure… lets check

# An experiment

- Take a “partial description” of a project
  - E.g. we use “standard analysts” (in COCOMO speak; “acap=1”)
- Go to a log of old projects
  - E.g. the nasa93 COCOMO-I data sets.
- Find some projects “near” the partial descriptions
  - E.g. find the 20 “nearest neighbors” in nasa93 to acap=1
- Build some cost models from those 20
- Compare those cost models to other “partial descriptions”

# e.g. COCOMO models learned from 20 nearest neighbors to acap=1

**acap = 1**

**Median performance statistics**

| a, | b, | mmre, | pred(30) |
|---|---|---|---|
| 4.21, | 1.07, | 19.5, | 79.1 |
| 4.31, | 1.06, | 19.6, | 80 |
| 4.35, | 1.06, | 19.9, | 79.4 |
| 3.3 , | 1.14, | 20.1, | 80.6 |
| 4.29, | 1.06, | 20.2, | 77.8 |
| 4.5, | 1.05, | 20.3, | 70.3 |
| 4.35, | 1.06, | 20.4, | 75.5 |
| 3.97, | 1.09, | 20.7, | 81 |
| 3.72, | 1.09, | 24.1, | 66.7 |
| 3.9, | 1.1, | 25.6, | 72.0 |

**10 times,**

- **Randomize order**
- **Train = 1 .. 10**
- **Test = 11 .. 20**
- **Using the training set, apply Boehm's local calibration method**
- **Using the test set, apply the calibrated model**

**Goal: Keep it Simple For the Users**

**Details hidden from users.**

**All automatic ("under the hood")**

**"A" values different to standard COCOMO Values (≤ 3.2)**

**PRED(30) = % of tests whose predicted is within 30% of actual**

**"PRED, MMRE" are statistical measures of predictive success**

**MMRE = mean magnitude relative error**
**= abs(actual - predicted) / actual**

e.g. COCOMO models learned from 20 nearest neighbors to acap=1

**time = 1.1, rely=1.2**

| a, | b, | mmre, | pred(30) |
|---|---|---|---|
| 4.82, | 1.05, | 46.8, | 73.2 |
| 4.87, | 1.05, | 47.9, | 73.2 |
| 4.84, | 1.05, | 48.5, | 72.9 |
| 4.77, | 1.06, | 49, | 72.5 |
| 4.84, | 1.05, | 50.6, | 72.2 |
| 4.91, | 1.05, | 52.4, | 71.8 |
| 5.02, | 1.04, | 54.9, | 71 |
| 5.11, | 1.04, | 57.2, | 70.5 |
| 5.09, | 1.04, | 59.2, | 69.6 |
| 5.06, | 1.04, | 60.9, | 68.6 |

**Median performance statistics**

- **High-reliability systems,**
- **Some time pressure on development**

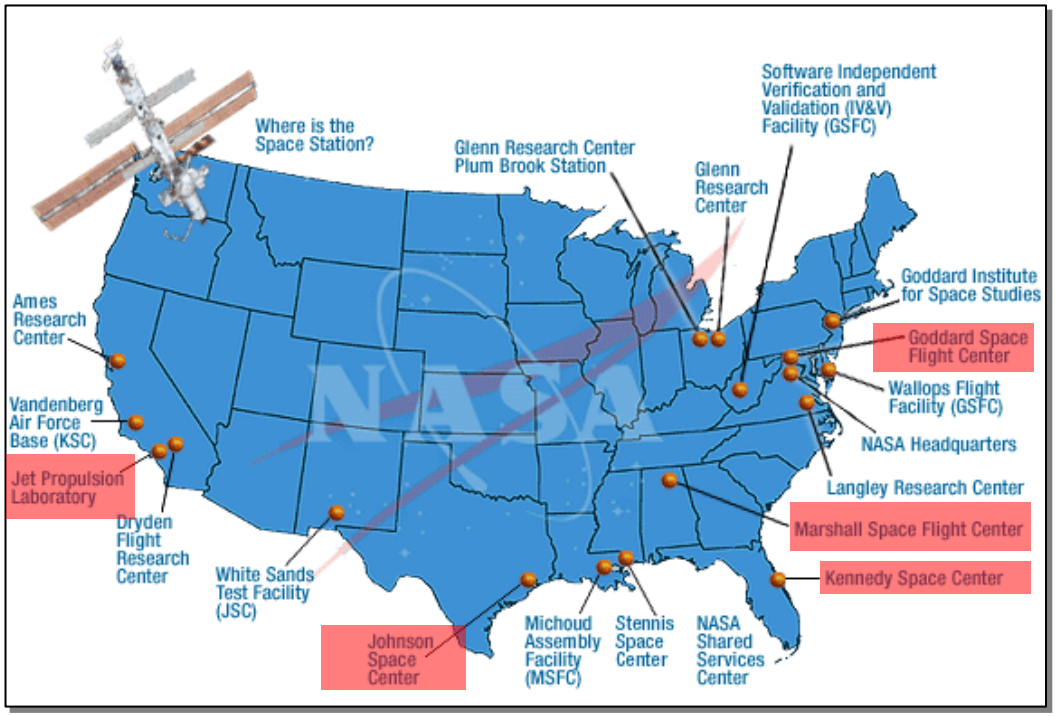
**"A" values very different to those seen before**

**PRED(30) = % of tests whose predicted is within 30% of actual**

**MMRE = mean magnitude relative error**
**= abs(actual - predicted) / actual**

# Urgent need to collect more localized data from local sites

- Current NASA initiative:
  - Tune cost models to specific NASA Center products
- LOCOMO:
  - proof positive that such tunings are essential



# Why use LOCOMO?

- LOCOMO.cost = $0
  - http://unbox.org/wisp/trunk/locomo
- LOCOMO based on COCOMO
  - COCOMO: white box
  - Other commercial tools: black box
- LOCOMO: uses NASA-specific data
  - Other commercial tools: mostly DOD
    - Often over-estimate NASA projects since they assume MIL standards
    - MIL assumes more documentation/ testing/ security requirements than NASA
- Estimation with smallest number of variables
  - In our example, only 1 or 2
    - Other tools: dozens to hundreds of variables
  - So, given minimal project information
    - Can still get project estimates
  - And, with more data,
    - Can select more relevant data and get better estimates

# LOCOMO: next steps

- Apply this to different NASA sites
- Assess manual vs automatic stratifications
  - Manual: “earth orbit”, “deep space”, “mars projects”
  - Automatic: LOCOMO
  - Which is better?
- Many studies inside “the guts” of LOCOMO
  - Effects on variance of automatic stratification
  - Why pick “20” nearest
    - Why not 5? Or 50?
  - What does “nearest” mean?
    - ? Log transform on the numerics

# User Interface Features

## Output Results

- Estimate reflecting the responses to the input screen
  - Effort months
  - Schedule duration
- Assumes size and attribute factor is “learned” from the data
- Uses COCOMO I as the basis of estimate, but is hidden from the user

# User Interface Features (cont)

## Output Results

- Statistical characteristics of the model
  - Y-intercept
  - Exponent
  - Range
  - Standard deviation
  - $R^2$
  - Mean, Median, and Mode

# Benefits and Beneficiaries

| Beneficiary | Benefit |
|---|---|
| IPAO | Data and metrics for use in Independent Cost Estimates (ICEs) and Source Selection evaluations. Tool consistent with CADRe data. |
| NASA HQ | Can be used to develop “Should Cost” estimates. |
| NASA Centers | Will help with analogy for proposals and other types of estimate preparation. |
| NASA Support Contractors | Will provide general information about historical programs so that they can do a better job of preparing their products and estimates for NASA. |

# Deliverables and Schedule

- Deliverable Items
  - Estimating Tool (Excel based, open source)
  - Calibrated and validated tool
  - Tool documentation
  - User Guide
  - List of technical parameters to be included in CADRe
- Schedule
  - User Focus Group meeting – Jul 06
  - Data Collection – On-going
  - Update User Interface (Focus Group feedback) – Aug 06
  - Update LOCOMO learning based on new data – Sept 06

# Next Steps

- Collect additional software data
  - Jet Propulsion Laboratory
  - Goddard Space Flight Center
  - Marshall Space Flight Center
  - Kennedy Space Center
  - Glenn Research Center
- Analyze, normalize, evaluate, stratify, and validate data
- Run LOCOMO learning tool on additional stratified data sets
- Dynamically link the learning tool into the N-SET input data and produce formatted output report
- Perform validation exercise on randomly selected data
- Document the process and tool (N-SET)