Developing a schedule model from a cost modeler's perspective

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All data shown in this presentation is notional

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Introduction

Who we are

Space Systems Command

Financial Management Cost & Earned Value Division

USCM 2021 ICEAA Presentation

Abstract

Cost estimators need to utilize and develop estimating methods for project components beyond cost. Schedule is one of those components. The Space Systems Command (SSC) Financial Management Cost organization, known for the development of the Unmanned Space Vehicle Cost Model (USCM), started development of a Schedule Model in 2018. This journey has yielded some exciting new methods, products, and processes. It has also brought challenges as we could not address schedule exactly as we would with cost.

Title & Theme

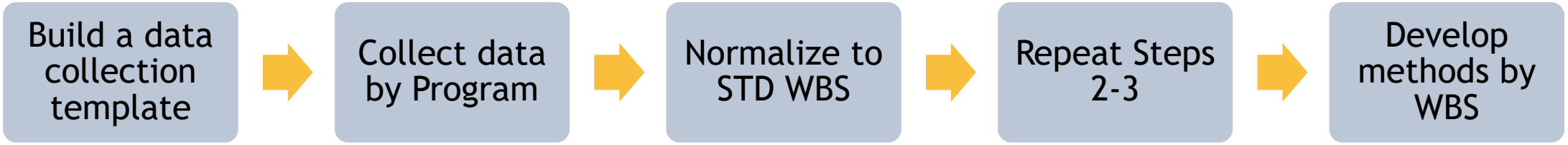
Developing a schedule model from a cost modeler's perspective

The Cost Modeler's Perspective

Common best practices from the cost community

- Use of data collection templates
- Utilizing techniques such as regressions for estimating
- Collecting and storing historical data
- Using the rigor of a WBS to organize data and methods
- Well established process (e.g. normalization, CER development, etc.)

Simplified process for developing a cost model



Uniqueness of Schedule Data

Schedule report ≠ Cost report

- A cost report, regardless of fidelity, always sums to a total -- schedules do not behave this way

Complexity

- Schedule data has more dimensions and parameters associated with each date or duration which make each “data point” more complex than the equivalent “cost data point”

“Complete” schedules don’t exist

- Schedules will often drop milestones after they have passed making collection more challenging whereas cost reports retain all elements from start to finish
- No single authoritative source exists for schedules

Terminology: SRA = Schedule Risk Analysis, IMS = Integrated Master Schedule

Agenda

Section	Presentation	Paper
✓ Background	X	X
❑ Development Approach		X
❑ Model Overview	X	X
❑ Estimating Model • Data Collection • Data Storage • Methods	X	X
❑ Schedule Summarization		X
❑ Task Search	X	X
❑ Conclusion	X	X

- This presentation is a high level overview of the paper
- Recommend reading the paper for a more comprehensive description
- Lessons Learned shared throughout both presentation and paper

Schedule Model Overview

Elements of the Model	End Users	Benefits
Schedule Estimating Model	Cost estimators	• Data driven methods used to phase cost estimates • Data driven uncertainty for schedule inputs/assumptions in cost estimates
	Schedulers	• Data driven uncertainty bounds in SRAs
Schedule Summarization Framework	Schedulers	• Consistent means of summarizing an IMS (for SRAs)
Schedule Task Search	Cost estimators	• Faster data collection to develop Schedule Estimating Relationships
	Schedulers	• Access to historical analogous tasks similar to tasks on the critical path (for SRAs)

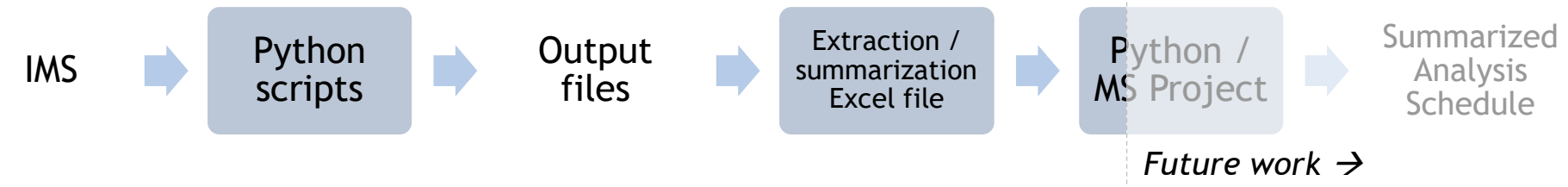
Objectives

- Provide data driven approaches for addressing schedule analysis
- Develop better processes for utilizing schedule data

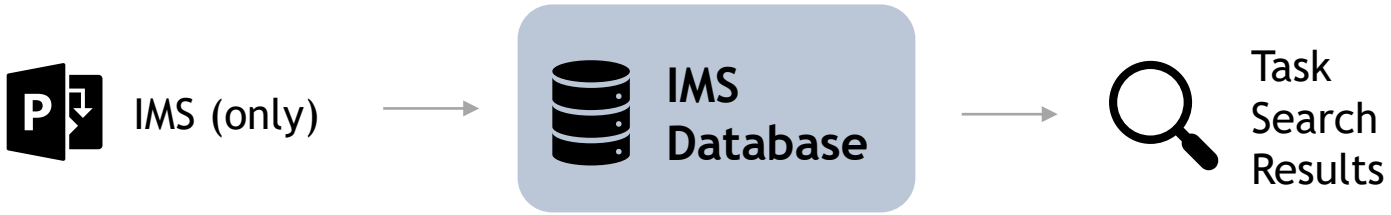
Schedule Model Overview (cont.)

Schedule Estimating Model

Schedule Summarization Framework



Schedule Task Search



Collecting Schedule Data

Lesson Learned: Data collection needs to be focused around the desired metrics

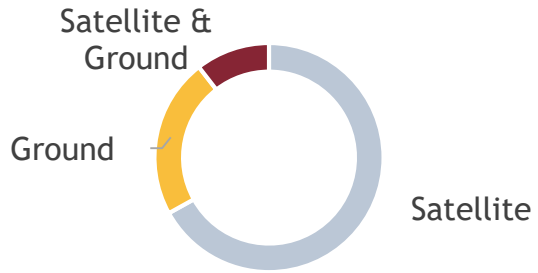
Process for identifying & collecting schedule data

Template Statistics

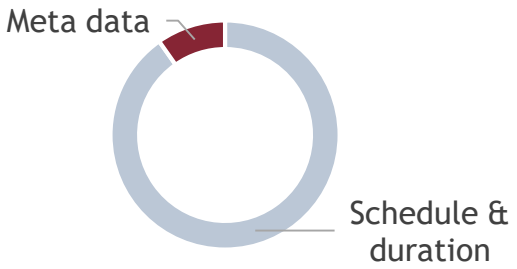
124

Parameters

Database will calculate add'l fields based on these parameters



Breakout of Satellite vs Ground system parameters



Schedule data is not the only focus.

Data Collection Template Headers

About

- Data collection template captures schedule and related meta data
- Status: Continually evolving

Lesson Learned: Data sourcing needs to be very rigorous

Specificity in data collection is required

Field name	Example
type description	Launch
Value	1/1/2023
Original_name	Launch Date
Date Type (B = Baseline / F = Forecast / A = Actual)	F
Date Accuracy (P = Precise / E = Estimated)	E
Source document	ABC IMS Schedule SV 1 Consolidated Jan 2022.pdf
Date of source	1/31/22
Notes	Day is estimated. Only month and year are known.

Data shown is notional

Schedule Database

About

- Used to store data captured using the data collection template
- Provides reporting that corresponds with desired metrics

696 Programs

6956 Dataset Rows

Data Maintenance

Data Maintenance:

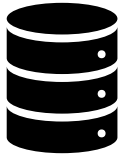
Progam Description	Data entry for Program descriptions
Progam Viewer	View Meta Data
Bulk Import	Import multiple records within an excel file
Data Clean Up	Review/validate multiple entries for milestones
Data Validation	Validate milestones that are not in correct order of occurance
Program Name Maintenance	Validate Program Names
SSC Programs	Designate programs as SSC programs
Missing Data	Generate report of missing meta data

Template:

Export Template	Allows user to export a template file for bulk impor

Screenshot

Schedule Database Lessons Learned



Excel is insufficient for storage and reporting for this project

- All prior schedule studies utilize Excel as data repository
- Data storage via Excel was not going to suffice given the functionality desired

Reporting structure is hard to get right on the first try

- Don’t spent too much time on the initial report structure and incorporate a feedback mechanism in the report development process

Data needs to be maintained

- The Schedule Database has built-in data validation functionality to help identify holes in the data and inconsistent entries

Schedule Methods

About

Developed 3 satellite system specific metrics with more in the queue

Motivation

Each method seeks to provide a data driven analysis where none existed

Metric	Domain	Status
Duration between Long Lead and Production award	Space	Developed
Launch growth from baseline to actual	Space	Developed
Time between sequential launches	Space	Developed
Time between software increments	Ground/SW	In progress
Time between software deliveries	Ground/SW	In progress
TVAC related metrics	Space	Idea phase
IA&T duration	Space	Idea phase
Time to ILC or time between ILC and launch	Space	Idea phase

Metric Development Process

Identify Metric → Collect data used relevant to metric → Integrate into Schedule Database → Conduct Analysis "Sprint" → Continue Analysis / Document Results → Final Review Stage

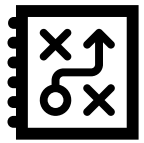
Lessons Learned in Developing Schedule Methods

Common Issues

- Milestones we needed to collect were not always included in our primary data source type (e.g. an IMS)
- Errors in source data

Analysis sprints allowed us to go fast

- Enabled us to establish scope and go/no-go position early on

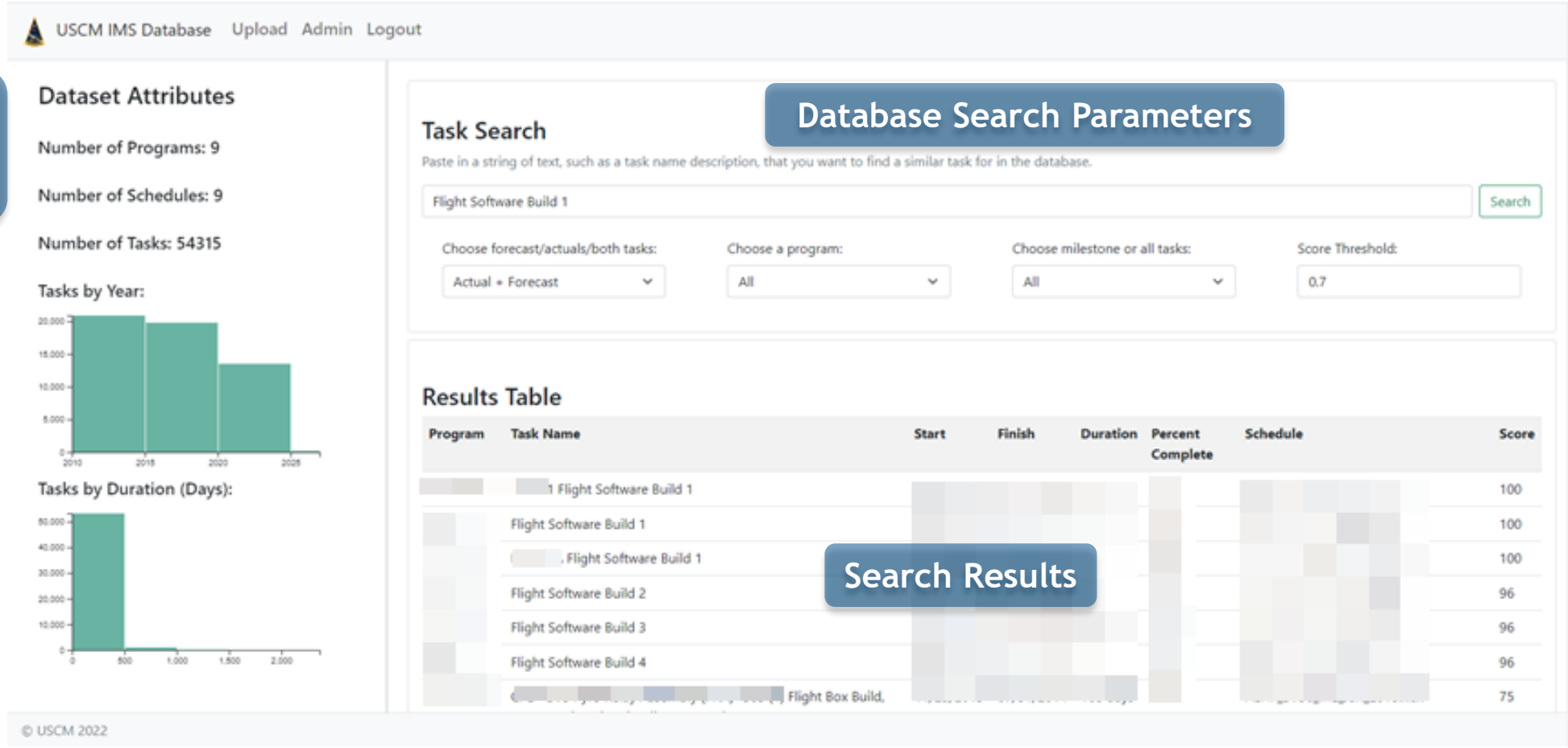


Other Challenges

- Process necessitates modifications to templates and reporting
- Explanation of “why” (e.g. why did the schedule slip) was not part of scope but is a lingering element

Schedule Task Search (i.e. IMS Database)

Database Contents Overview



Purpose
Provide rank ordered schedule task name search results

Technologies
Python
Machine Learning
Django
NLP

Status
Prototype

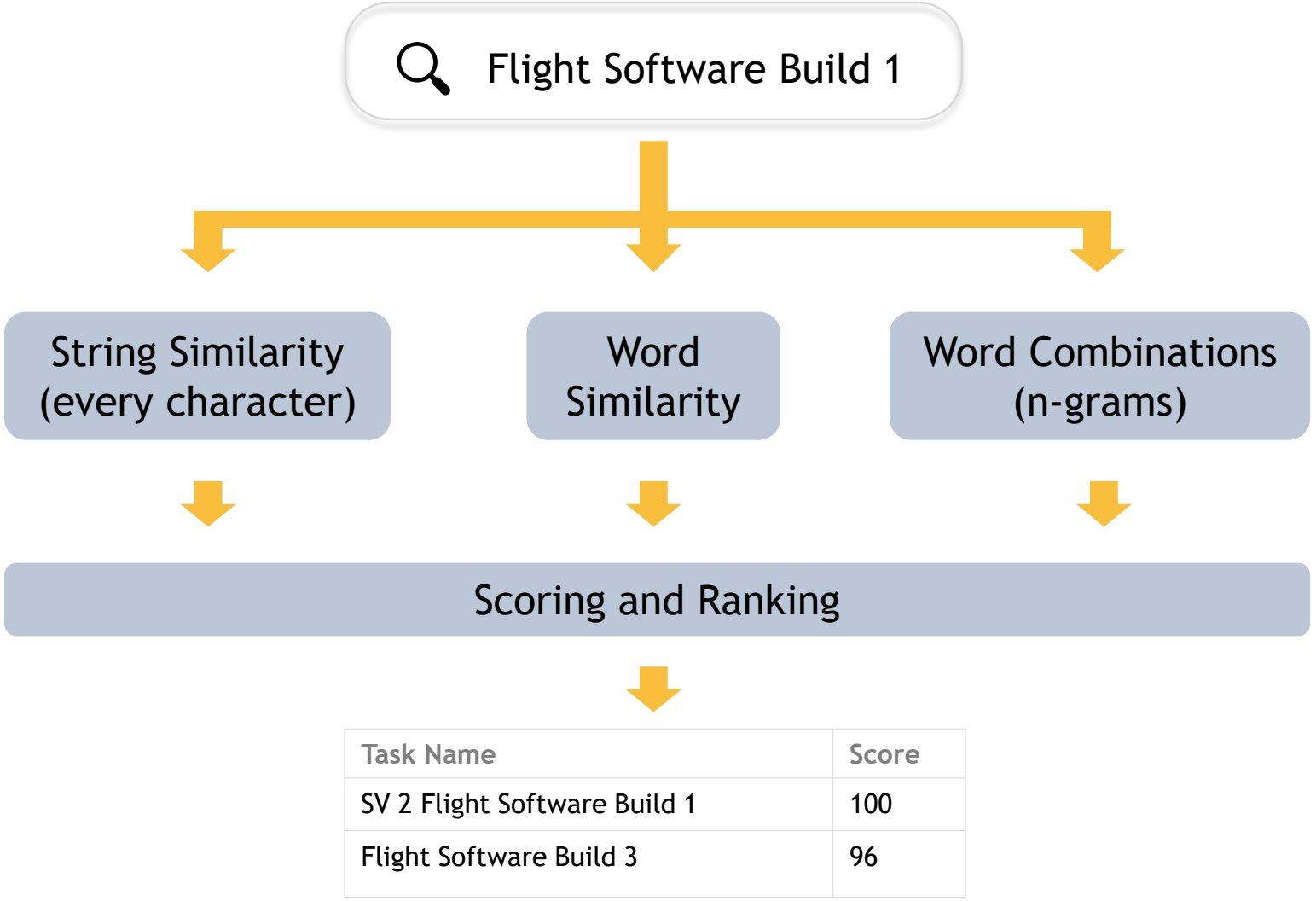
The Engine in Search Engine

1. User searches on a term

2. Natural Language Processing techniques are applied

3. Results from each technique are scored and ranked

4. Results provided to user to analyze

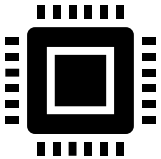


Task Name	Score
SV 2 Flight Software Build 1	100
Flight Software Build 3	96

Lessons Learned in developing search algorithms

Search capabilities are necessary

- Search algorithms are not a commonplace solution in the cost estimating community
- The use of search is incredibly efficient when compared to the approach of first mapping tasks to a standard structure



Natural Language Processing can be computationally expensive

- The computational complexity, memory requirements, and other considerations can require evaluating tradeoffs and alternate approaches to those originally developed

Concluding Thoughts

Summary

- Lots of (analytical) opportunities with schedule data and method development
- There are many best practices from the cost community that can be leveraged to perform schedule research
- Unique processes need to be developed because schedule ≠ cost
- Recommend reading the paper to learn more about SSC's Schedule Model

Way Forward

- Schedule Estimating Model: continued data collection and method development
- Task Search: Improve search algorithms and architecture; add more data
- Summarization: Optimize for faster results
- Socialize results with community

Acknowledgements

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Resources and References

- Space Systems Command (https://www.ssc.spaceforce.mil/Connect-With-Us/Space-Systems-Command-Front-Door)
- USCM public website (www.uscmonline.com)
- Summarizing Schedules using Hidden Markov Models and Natural Language Processing (https://www.nasa.gov/sites/default/files/atoms/files/07_machine_learning_for_schedule_summarization_nasa_final.pdf)
- USCM11 ICEAA 2021 presentation (https://www.iceaaonline.com/wp-content/uploads/2021/06/MLD07-ppt-Kwok-USCM11-%E2%80%93-an-Evolution-of-Techniques.pdf)