Radiometric Data Accountability, Validation, and Selection in Real-Time

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The design goal for providing real-time Tracking Data System accountability, validation, and selection is described.

I. Introduction

A principal responsibility of the DSN Tracking System Analysis Group (TRAG) is to provide a source of validated radiometric data, with all associated information required for processing, for both flight projects and nonreal-time data users (Ref. 1). This article describes the TRAG design goal for providing a complete and validated data source with a minimum of manual intervention. The functions described will be part of the Mark III A 360/75 tracking software subsystem.

II. Goals

Accountability. Be able to detect outages in real-time so that significant outages can be filled prior to completion of a current tracking pass. Provide with the data a description of the quantity of each data type available.

Validation. Be able to detect bad or marginal data in real time to enable rapid failure isolation. Provide with the data a measure of the data quality.

Selection. Provide a means for a data user to specify the time span, data types, sample rate, and minimum quality of the data passed to the user.

III. Design

The elements of the design are shown in Fig. 1. Principal inputs to the system are the radiometric data itself, tracking predictions of the data, and manual tolerances and limits. Principal output is a central alarm display and summary formats for TRAC personnel, and summary and point-by-point information provided with the data to the user.

A. Accountability

Two sections of the SFOF tracking software subsystem are involved in real time accountability. The first is the Teletype Tracking Data Outage Program (TYDOP) which can be considered to be part of the teletype tracking data input processor (TYDIP). This software element computes the sample rate of the incoming data and places it on to the system data record (SDR) for each point it can be determined. TYDOP will also determine gaps in the incoming data and produce a record of all outstanding outages which can be displayed on request. This outage summary will automatically be updated when a data recall fills an outage. Entries in the outage summary can also be manually deleted if judged to be insignificant. TYDOP will also pass outage and data stoppage alarms on to the tracking alarms processor (TAP).

The second software element is a portion of the master file program (MFP) which computes accountability statistics on a data-type basis for each active stream. It formats this information as pass summaries included with the data on the SDR and will also send this information to TAP for a continually updated real-time display of the pass status.

B. Validation

The principal real-time analytical tool is the pseudoresidual program. The pseudoresidual process involves comparing the incoming metric data with a prediction of the data produced automatically by the tracking predict subsystem. The name "pseudo" references the fact that the residual is computed from an *a priori* predict while a "true" residual is computed from an *a posteriori* fit to the data. The computation starts with a straight difference of observed data minus predict. The resulting "raw" residual is then detrended and a running noise estimate computed on the detrended residual.

There will be three forms of output from pseudoresiduals: listing and plots, alarms, and a quality indication.

The listings and plots were the only output of the 7044 pseudoresidual program. The 360/75 will add additional flexibility in output selection and will make the listing or plots available on DTV. The listings can also be sent to character printers (teletype machines).

The alarms will be computed by comparing the raw residual, the residual mean, and the computed noise to standard or manually entered tolerance limits. Resulting alarms will be sent in text form to a character printer and to TAP to become part of the summary display. The occurrence of an alarm would direct the attention of the real-time tracking system analyst to the residual listing to assist in analyzing the problem.

The quality indicator is desired as an automatic means of labeling obviously bad data and of indicating the relative quality of good data compared to some standard. A prototype doppler quality indicator proposed for the 1971 era is shown in Table 1. Referring to the table, values from 2 to 7 indicate that a doppler point is a blunder point and give its relative size and sign. Values from 8 to 15 give the relative quality of the data, based on noise, compared to some standard. The comparison is the ratio of the calculated estimated noise, based on the last 15 detrended residuals including the current point, over a predicted nominal noise based on a noise model. How useful the 8 through 15 values of the doppler quality indicator will be will depend heavily on the noise model. The noise model is currently under development by DSIF personnel. It will be a function of data sample rate, and uplink and downlink signal level.

The doppler quality indicator will consist of 16 bits accompanying each data point on the system data record and project data files. The first four bits will be the value of K (Table 1), and the last four bits will be a value from Table 1.

C. Selection

Data selection will take place in a software block called the data selector and project file generator which is functionally part of the MFP. Currently the only selection capability is spacecraft, station, and a time span. It is the desire to add selection by sample rate, data type, and quality.

Sample rate selection will involve selecting every *n*th point to arrive at the requested sample rate (the requested rate must be lower than or equal to the rate already on the SDR). Sample rate selection will also require mapping data condition codes and the quality indications on the points in between the selected points. This is so that there will not be a loss of information at the selected sample rate.

The quality selection would cause only data above a certain Quality Indicator value to be passed on to the project data file.

IV. Implementation

It is hoped to have the system described implemented in time to support *Mariner* Mars 1971 orbital operations. This would be with the doppler quality indicator in a prototype R & D basis.

Reference

1. Heller, J., and Miller, R. B., "DSN Tracking System Operations," in *The Deep Space Network*, Space Programs Summary 37-65, Vol. II, pp. 122–125. Jet Propulsion Laboratory, Pasadena, Calif., Sept. 30, 1970.

Table 1. Proposed values for prototype doppler quality indicator

Value	Meaning
0	Not available
1	Receiver or synthesizer out of lock
2	$3K\,\sigma'_{est} \leq R_i$
3	$-3K\,\sigma'_{est} \geq R_i$
4	$2K\,\sigma'_{est} \leq R_i < 3K\,\sigma'_{est}$
5	$-2K\,\sigma'_{est} \geq R_i > -3K\,\sigma'_{est}$
6	$K\,\sigma'_{est} \leq R_i < 2K\,\sigma'_{est}$
7	$-K\,\sigma'_{est} \geq R_i > -2K\,\sigma'_{est}$
8	$\infty > \frac{\sigma_{est}}{N_e} \geq 5.0$
9	$5.0 > \quad \geq 4.0$
10	$4.0 > \quad \geq 3.0$
11	$3.0 > \quad \geq 2.0$
12	$2.0 > \quad \geq 1.5$
13	$1.5 > \quad \geq 1.0$
14	$1.0 > \quad \geq 0.5$
15	$0.5 > \frac{\sigma_{est}}{N_e} \geq 0.0$

K = stored or input constant (usually 3).

R = difference between i^{th} raw residual and a least squares fit to the last N (usually 15) raw residuals.

$\sigma'_{est} \equiv \sigma_{est_{i-1}}$ = calculated noise estimate on last N (usually 15) prior to this point.

$\sigma_{est} \equiv \sigma_{est_i}$ = calculated noise estimate shifted to include current point.

N_e = predicted noise estimate calculated from a noise model.

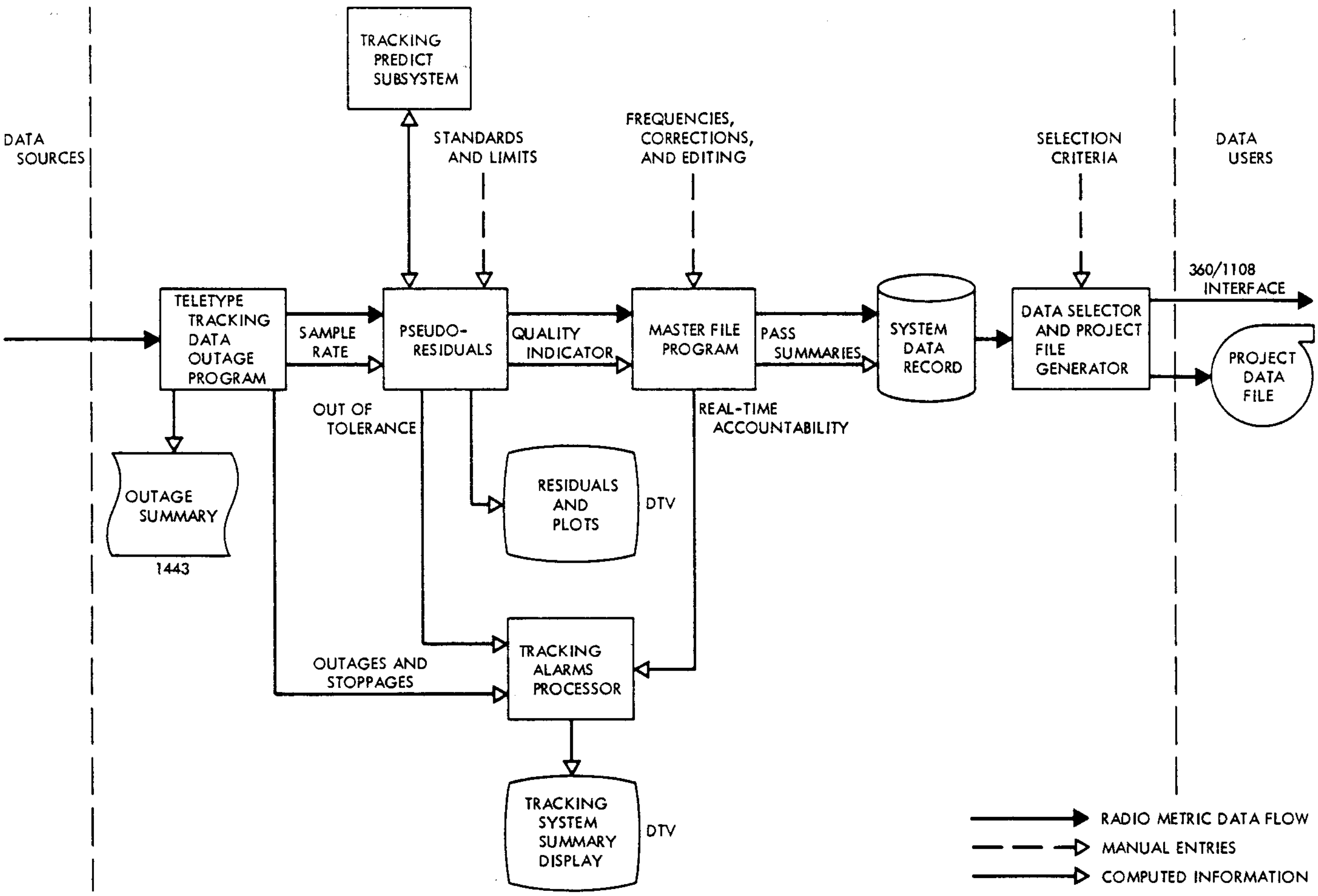

Fig. 1. Tracking system data accountability, validation, and selection