Attachment to -

A P P E N D I X

PROPULSION SYSTEM REVIEW

Inlet

The final U-2R inlet system design will incorporate the opened up area inlet and a recontoured duct. This design should provide improved inlet recovery, reduced distortion, and improved stall margin for the installed engine over the U-2C inlet system.

The values of inlet recovery Pt2/Pto, used in checking the installed engine performance estimated by Lockheed, vary from a minimum of .966 to a maximum of .976 depending on EGT and altitude. As indicated in the main text of this report, these values have already been measured in actual flight test with the opened up area inlet on the U-2C aircraft, and show nearly a 1% improvement in inlet recovery over and above the smaller U-2C inlet. These tests did not include recontouring of the duct which is expected to reduce distortion(hence improve engine stall margin).

Engine

Performance of the U-2R is based on the improved performance of the Pratt & Whitney J75-P-13B engine over the older P-13 version. This improved engine performance is obtained primarily by an increase in turbine inlet temperature and engine airflow.

A listing of all the detailed changes to the J75-P-13 which make up the P-13B version of the engine are included in Attachment II.

Estimated installed engine performance presented in Reference 1 was calculated from preliminary engine performance information released by Pratt & Whitney in December of 1965. Since that time, a detailed specification has been released by Pratt & Whitney for the J75-P-13B engine. From the engine performance presented in this specification, values of estimated installed engine performance were calculated by D/TECH using the calculation procedure outlined in the specification. These values were plotted and are presented in Figure A-1, for comparison with the earlier Lockheed estimates.

The installed performance losses applied to the specification engine performance to derive the estimated installed engine performance are as follows:

Attachment to - [redacted] 25X1

25X1 [redacted]

Inlet Pressure Loss (% of ideal ram total pressure)	2.5 to 3.5%
Tailpipe Pressure Loss (% of turbine discharge total pressure)	1.5%
Bleed Air Extraction (High pressure compressor discharge)	6.5 lb/min.
Horsepower Extraction (Low Pressure spool)	10 HP
Horsepower Extraction (High pressure spool)	15 HP

These losses represent a current best estimate and are probably slightly in excess of those which will actually occur in the U-2R. Installation losses will be closely monitored as the program progresses in order to identify any increase which might be detrimental to installed engine performance. 25X1

[redacted]

It is strongly recommended that a contract study be undertaken by Pratt & Whitney Aircraft to evaluate various means of reducing [redacted] from the J75-P-13B engine, 25X1 so that an optimum system can be developed which will provide 25X1 sufficient [redacted] reduction, but at the same time minimize inevitable penalties in weight and currently estimated vehicle performance. Such a study should involve an evaluation of various means of cooling the tailpipe and the use of various types of exhaust ejectors and convectively cooled and transpira- 25X1 tion cooled plugs. Typical polar plots of the [redacted] intensity should be developed for the various systems studied 25X1 [redacted] Performance and weight penalties for each system should be determined accurately.

A series of four reports summarizing the experience in this area acquired by Pratt & Whitney to date is listed in Attachment I. From a cursory review of these reports, it would appear that either an ejector or a convectively cooled plug bullet exhausting 25X1 to a low pressure field nozzle may show the most promise for the J75 engine. Transpiration cooled plugs, while providing a very cool [redacted] of hot engine hardware, require a very substantial supply of cooling air at a supply pressure higher than engine tailpipe pressure. For a turbojet engine this would require compressor bleed air. In the case of the J75 engine, this would probably require bleeding air from the second or third stage of the compressor. A fairly extensive modification of the engine would be required since a bleed air system would have to be added, component rematching would be required, and compressor high speed stall margin would probably be adversly affected at altitude.

Attachment to - [redacted]

AIRCRAFT PERFORMANCE

DRAG

The drag polar for the U-2R (Fig. A-2) is a direct buildup from the drag polar for the U-2C (Fig. A-3), which, for this analysis, is assumed to be correct as presented by Lockheed.

Accepting the U-2C drag polar, and taking into consideration the configuration changes between the U-2C and the U-2R, the estimated drag increments appear reasonable. It should be understood that the profile drag coefficient change ΔC_D = -0.001 for the U-2R (when related to the U-2C) does not necessarily signify a lower aerodynamic drag than the aerodynamic drag of the U-2C, since any drag coefficient, C_D, is related to a particular reference area, S. (For an airplane, S is referred to as the "wing reference area".) A measure of drag is the parameter $f=C_DS$, which is referred to as the "equivalent flat plate area". Comparing the U-2C and U-2R flat plate areas at $C_L=0$:

$f = 0.0197 \times 600 = 11.82$ sq. ft. for the U-2C

$f = 0.0187 \times 1000 = 18.70$ sq. ft. for the U-2R

From above comparison it can be said that the U-2R has 58% more equivalent flat plate area than the U-2C at $C_L = 0$.

The large increase in profile drag, i.e., Drag at $C_L = 0$ of the U-2R (58%) has been offset somewhat by the effect of the larger wing area at the cruise lift coefficient (and therefore the drag due to lift). The U-2R, because of a larger wing area, cruises at a lower lift coefficient than the U-2C. A lower lift coefficient, C_L, means a proportionately lower drag due to lift (induced drag) to total drag, as compared to the U-2C.

For example: The U-2C maximum power cruise is at $C_L = 1.0$, and the $C_D = 0.056$. At this cruise condition the total equivalent flat plate area is: $f=0.056 \times 600 = 33.6$ sq. ft.

The U-2R maximum power cruise is at $C_L = 0.75$, where the $C_D = 0.0334$ and the total $f=0.0334 \times 1000 = 33.4$ sq. ft.

It can be said from the above example, that the maximum power cruise equivalent flat plate area of the U-2R is slightly lower than the one for the U-2C. However, since the absolute drag in pounds is a function of the local density of air, equivalent flat plate area, and of the velocity squared, and since the U-2R cruises at a higher speed than the U-2C, it consequently has a higher maximum power cruise drag.

25X1

25X1

Attachment to -

Conclusions

The increase in wing area, for the U-2R versus the U-2C, has proportionately reduced the induced drag (drag due to lift), and increased proportionately the profile drag.

The U-2R cruises at a higher speed than the U-2C.

U-2R BUFFET BOUNDARIES

Lockheed has investigated various simple methods to increase the cruise lifting capability for the U-2 while not exceeding the buffet boundaries. This investigation was made to determine which of the following three approaches should be taken:

Increasing lift coefficient, increasing wing area, or increasing Mach number.

Increasing wing area was found to be the most successful, since the present airfoil characteristics of the U-2C are very satisfactory. The U-2C buffet boundary (Fig. A-4) is used as the basis for defining the U-2R cruise Mach number. Figure A-4 is based on recent U-2 flight test data.

The maximum altitude and maximum range cruise lift coefficients, C_L, for the U-2R are 0.75 and 0.5 correspondingly. At these values of C_L, the Mach numbers are 0.72 and 0.73 correspondingly. From Figure A-4 it can be seen that these lift coefficients and Mach numbers allow sufficient margin from stall and Mach buffet.

U-2R CLIMB SCHEDULE

The climb schedule, or climb speed versus altitude, for the U-2R is similar to that for the U-2C.

The climb to altitude is realized at a constant indicated airspeed (IAS) of 160 knots, up to the altitude at which the true airspeed is that for which the Mach number is 0.72 (0.70 for the U-2C). After M = 0.72 has been realized, the Mach number is held constant for higher altitudes.

Figure A-5 presents the calculated climb speed versus altitude. The true airspeed values for this graph were obtained by correcting the 160 KIAS of the climb schedule for "position error", and "compressibility", in accordance with the U-2C Flight Handbook.

25X1

U-2R RATE OF CLIMB CORRECTION

From the graph of true climb airspeed versus altitude, Figure A-5, a rate of climb correction factor (to account for the acceleration term VdV/dh) was computed for the corresponding values of altitude.

The rate of climb correction factor $\Delta C/C$, to account for acceleration, is presented in Figure A-6.

The rate of climb correction factor is obtained from the following equation:

$$\Delta C/C = 0.0886 \; V \, dV/dh$$

where V and dV are in knots and dh in feet.

The corrected rate of climb, R/C_c, is obtained from the following equation:

$$R/C_c = \frac{R/C}{1 + \Delta C/C}$$

where R/C is the uncorrected rate of climb.

It will be noticed from Figure A-6, that the correction to rate of climb is equal to zero above 52,750 feet of altitude. This is caused by the climb schedule, which calls for a constant speed above this altitude (dV/dh=0).

U-2R SAMPLE CLIMB COMPUTATION

The climb performance in terms of rate of climb, time to climb, distance gained during climb and fuel used, were computed by the detailed classical methods. Two climb conditions from thrust available considerations were calculated; without and with "Badlands". "Badlands" is defined as the region between 40,000 and 60,000 feet of altitude, where the Exhaust Gas Temperature (EGT) of the engine has to be limited to 485°C to prevent encountering difficulties such as engine roughness, compressor stall, or flame-out. It is not at all clear that this EGT limit is necessary for the U-2R.

The sample calculations Figures A-7 and A-8 are without and with "Badlands" respectively. The sample configuration presented is for the "Overload" or maximum fuel condition (T.O.G.W. = 36,750 lbs.)

All climb computations were made by considering the initial climb weight equal to the take-off gross weight less a fuel allowance for warm-up, acceleration and take-off (15 gallons recommended in the U-2C Flight Handbook.)

The thrust values for maximum power climb and respective fuel flows used in the computations, were those obtained from Lockheed (Ref. 1).

Rates of climb were computed for the corresponding altitudes and climb speeds, and corrected for acceleration. Time to climb increments were calculated based on the corrected rate of climb. Fuel used, and distance gained, were calculated based on the average fuel flows and climb speeds. Graphical results of these computations are presented in the section titled "U-2R Climb Performance With and Without "Badlands".

U-2R CLIMB PERFORMANCE WITH AND WITHOUT "BADLANDS"

The climb performance for the U-2R was computed by the methods shown in the "U-2R SAMPLE CLIMB COMPUTATION" section of this report. Three take-off gross weights were investigated with and without the effect of the so-called "Badlands".

Overload Take-Off Weight - The overload take-off gross weight assumes full fuel capacity for the U-2R. This configuration would give a T.O.G.W. = 36,750 lbs. for the airplane being 17,400 lbs. heavy in the empty condition.

The climb performance for the U-2R in the "Overload" condition without "Badlands" has been independently calculated by Lockheed and D/TECH/OSA. The two separate calculations are in perfect agreement, and a plot of these results are presented in Figure A-9.. The rate of climb variation with altitude is presented only for the D/TECH calculations since Lockheed did not present these results in Reference 1.

The "Badlands" effects (485°C EGT limitation between 40,000 and 60,000 ft.) on climb are presented also in Figure A-9 for comparison. It should be noted that due to the heavy configuration, and consequently high value of lift coefficient required during the climb, the drag is also higher. A high drag means that there is little excess thrust (T-D) left for climb. The excess thrust available for climb, between 40,000 and 60,000 feet, is further decreased by the 485°C EGT limitation. For this configuration, the excess thrust becomes equal to zero at approximately 59,200 feet of altitude. This means that the airplane will have to "burn-off" weight (fuel) by cruise-climbing at 485°C EGT until it reaches 60,000 feet of altitude, where the 485°C EGT restriction is removed. The weight at 60,000 feet will be approximately 32,455 lbs. At this altitude, the engine has a "thrust recovery" or, in other words, the airplane has now an excess thrust available to climb again until the drag is equal to the thrust available. The climb after reaching 60,000 feet of altitude due to "Thrust Recovery" has been termed a "Secondary Climb." 25X1

Attachment to -

The climb performance for the "Secondary Climb" is presented in Figure A-10. The "Secondary Climb" is required for any airplane T.O.G.W. which is required to cruise-climb below 60,000 feet of altitude (due to the 485°C EGT limitation between 40,000 and 60,000 feet).

Normal Take-off Weight - The U-2R "Normal" take-off weight is defined as a T.O.G.W. = 30,130 lbs. This configuration calls for a normal wing fuel weight of 11,930 lbs.

The Normal Take-off Weight configuration climb performance with and without "Badlands" is presented in Figure A-11.

It will be noticed from Figure A-11, that for this T.O.G.W. the airplane can climb directly to maximum altitude (without having to cruise-climb below 60,000 feet), even with the 485°C EGT restriction between 40,000 and 60,000 feet of altitude. This is possible because the weight is sufficiently low (consequently the drag), and the airplane has excess thrust (T-D) throughout the "Badlands" region.

Reduced Fuel Take-off Weight - The U-2R "Reduced" fuel take-off weight is defined as a T.O.G.W. = 26,790 lbs. This configuration calls for a fuel loading of 9,390 lbs. This fuel weight was chosen by Lockheed to make a maximum altitude mission performance comparison between the U-2C and U-2R for a range of 3,000 n.m. (including credit for descent). The "Reduced" fuel take-off configuration climb performance with and without "Badlands" is presented in Figure A-12.

Figure A-12 also shows (as in the other configurations), that for the airplane with 485°C EGT limitation between 40,000 and 60,000 feet, the rate of climb increases upon reaching 60,000 feet of altitude. This is caused by the removal of the EGT limitation for altitudes above 60,000 feet (thrust is recovered since EGT is not restricted to 485°C).

U-2R MAXIMUM ALTITUDE CRUISE

The maximum altitude (maximum thrust) cruise was estimated for two conditions:

a. For maximum thrust which would allow maximum altitude cruise above 60,000 feet.

b. For maximum thrusts corresponding to an EGT limit of 485°C between 40,000 and 60,000 feet of altitude (or so called "Badlands Cruise").

Cruise Above 60,000 Feet - The maximum altitude cruise calculations for altitudes above 60,000 feet (EGT not limited to 485°C), were made by first generalizing the engine data, i.e., data to vary proportionally with atmospheric pressure ratio, so that the cruise could be most efficiently performed at a constant C_L. This generalization was made for 60,000 and
25X1 [redacted] feet of altitude. Table A-1 presents the computed data. As it can be seen from Table A-1, the data "generalizes" within approximately 1% or less from the results which are obtained if individual thrust, fuel flows and altitudes are used in the calculation of specific range (nautical miles per pound of fuel). Once the engine data has been found to "generalize" the maximum altitude (maximum thrust) cruise "Range Factor" can be computed as shown in Table A-2. A maximum altitude cruise speed of [redacted] was chosen to 25X1
allow adequate buffet margin (see section on "U-2R Buffet Boundaries"). Choosing an arbitrary airplane weight of 26,000 lbs., the lift and drag coefficients were calculated for altitudes between 60,000 and 70,000 feet. A plot of maximum thrust available and drag versus altitude is shown in Figure A-13. From Figure A-13 it can be seen that at
25X1 [redacted] the thrust available equals the drag at 69,500 feet of altitude. At this altitude, the lift coefficient is computed for the weight of 26,000 lbs., and found to be 0.742. This value for maximum altitude cruise lift coefficient compares well with the Lockheed quoted value of $C_L = 0.75$ (Ref. 1). The Range Factor may now be obtained by multiplying the specific range (nautical miles per pound of fuel), at that altitude and speed, by the airplane weight. The specific range was obtained from Figure A-14, which is the plotted data of specific range shown in Table A-1. The Range Factor for maximum altitude cruise for altitudes above 60,000 feet was
25X1 found to be [redacted] which is in excellent agreement with the data presented in Reference 1.

Having established the maximum altitude cruise lift coefficient and an airplane weight associated with an altitude (26,000 lbs. and 69,500 feet), the entire maximum altitude cruise above 60,000 feet is now defined, since the airplane will cruise at a constant W/δ, and at a constant Range Factor.

The variation of altitude versus weight, for maximum altitude cruise above 60,000 feet (no "Badlands") is presented in Figure A-15. The Range Factor is constant [redacted] 25X1
irrespective of weight up to a weight of approximately 32,455 lbs. Heavier weights will force the airplane to cruise inside the "Badlands" (below 60,000 feet). 25X1

[redacted]

25X1

Attachment to - 25X1

Cruise in the "Badlands"

If a 485°C EGT limitation exists between 40,000 and 60,000 feet, the maximum thrust between these altitudes will be decreased considerably. The reduction in thrust available has significant effects upon the performance of the U-2R when the airplane has a high take-off gross weight. An extreme example of this condition is the "Overload" take-off configuration. For this configuration, the maximum thrust available equals the drag at 59,200 feet of altitude, and the airplane has to cruise-climb at 485°C EGT limited maximum altitudes until it has used enough fuel to be at a weight of approximately 32,455 lbs., at which time it will have reached 60,000 feet of altitude. At 60,000 feet of altitude the airplane is out of the so-called "Badlands", and the EGT (and consequently the thrust) can be increased, which enables the airplane to go through a "Secondary-Climb" (See section on U-2R Climb Performance With and Without "Badlands" - Secondary Climb from 60,000 Feet).

To determine the cruise performance in the "Badlands", the maximum allowable weight for level flight at various altitudes, between 40,000 and 60,000, was determined. This was done by matching the 485°C EGT limited thrust to the corresponding drag (T-D), and computing the Range Factors by dividing the fuel flows (in pounds per hour) by the cruise speed (in knots), and multiplying the results by the appropriate weights. The cruise performance for maximum altitude in the "Badlands" is presented in Figure A-15.

As shown in Figure A-15, the Range Factor is not constant and is much higher than the Range Factor for maximum altitude cruise above the "Badlands". This is caused by the 485°C EGT limitation itself which restricts the altitude and fuel flow to that approaching "maximum range" (lift coefficient for maximum lift to drag ratio). The variation of altitude and Range Factor versus weight, for maximum altitude cruise in the "Badlands" (485°C EGT limitation), is also presented in Figure A-15. Also shown in Figure A-15, is the "Secondary Climb" required once the airplane has used sufficient fuel (therefore reduced weight) to reach 60,000 feet of altitude (See section on climb).

U-2R MAXIMUM RANGE CRUISE

The maximum range cruise of the U-2R can be of two categories (as was also shown for the maximum altitude cruise), depending on the T.O.G.W.: Cruise above "Badlands", and cruise in the "Badlands". 25X1

25X1 [redacted]
Attachment to - [redacted] 25X1

For T.O.G.W. configurations that permit the airplane to reach 60,000 feet of altitude without cruise-climbing in the "Badlands", the maximum range cruise was estimated at lift coefficient for maximum lift to drag ratio ((L/D) Max.) approximately equal to $C_L = 0.5$. At this lift coefficient, the cruise speed was estimated to be [redacted] to allow an adequate buffet margin (See section on U-2R BUFFET BOUNDARIES). 25X1

The range factor for optimum cruise (or maximum range) was computed as shown in Table A-3. For an arbitrary airplane weight of 26,000 lbs., the drag was calculated at 25X1 [redacted] and at altitudes from 60,000 to 70,000 feet. From the drag values obtained in this computation, the specific fuel consumption (SFC) were obtained from the Lockheed furnished installed engine performance (for thrust values equal to the calculated drag, at [redacted] and corresponding altitudes). 25X1

A plot of the drag and SFC values given in Table A-3, was plotted versus altitude, and presented in Figure A-16. Referring back to Table A-3, the fuel flows at the various altitudes were obtained by multiplying the SFC with the drag at corresponding altitudes. The specific range values (nautical miles per pound of fuel) were obtained by dividing the airspeed (V) by the fuel flows. The range factors (R.F.) is the product of specific range times weight.

From Table A-3, it can be seen that the "Optimum" range factor is approximately 10,452, and that the "Optimum Altitude" for this weight is approximately 61,500 feet. These results are in very good agreement with values obtained by Lockheed, and presented in Reference 1.

25X1
[redacted]

U-2R MAXIMUM ALTITUDE MISSION PROFILES WITH AND WITHOUT BADLANDS

Maximum altitude mission profiles were assembled for the three configurations investigated in the Climb Section (Overload, Normal and Reduced T.O.G.W.). The missions were assembled by piecing together the climb and cruise performance applicable to each configuration. The time, airplane weight and distance traveled, at any altitude throughout the mission, were obtained for the airplane without and with "Badlands" between 40,000 and 60,000 feet of altitude.

Without Badlands - The mission profiles were assembled from the climb performance curves shown in Figures A-9, A-11, and A-12, and the Maximum Altitude Cruise data presented in Figure A-15. For mission profiles for airplane without "Badlands", the airplane does not have to make a "Secondary Climb" from 60,000 feet for any of the three configurations, and the Range Factor for maximum altitude cruise is 8580 throughout the cruise portion of the mission. Figures A-17, A-18, and A-19, present the mission profiles without "Badlands" in terms of time, airplane weight, and range versus altitude (from take-off). Two end altitudes are shown for each mission, depending on the fuel reserve allowed.

With Badlands - The mission profiles were assembled from the climb performance curves shown in Figures A-9, A-10, A-11 and A-12, and the Maximum Altitude Cruise data presented in Figure A-15. For the "Overload" configuration, the airplane has to cruise-climb up to 60,000 feet of altitude (cruise in the "Badlands"). The Range Factor variation with weight, for this segment of the mission, is shown in Figure A-15. For the "Overload" configuration, the airplane has to initiate a "Secondary Climb" (Figure A-10) to maximum altitude for maximum thrust (once it has reached 60,000 ft.). After the airplane has reached the maximum altitude of the "Secondary Climb" (See Figures A-10 and A-15), the cruise at maximum altitude can be accomplished. The Range Factor for this cruise portion will be at a constant value of 8580, regardless of the weight and altitude.

For the two other configurations ("Normal" and "Reduced" T.O.G.W.), the airplane weight is low enough that the impact of "Badlands" is not as severe as in the "Overload" configuration. The airplane will be able to climb directly to maximum altitude without having to cruise-climb ~~in the "Badlands"~~. The assembling of the mission profiles for the "Normal" and "Reduced" take-off gross weight configurations, is identical to the manner the missions were assembled for the airplane without "Badlands". The only exception is that the climb curves for 485°C EGT limitation between 40,000 and 60,000 feet of altitude (Figures A-11 and A-12) are utilized for the climb portion of the mission.

Figures A-20, A-21, and A-22 present the mission profiles with "Badlands" in terms of time, airplane weight, and range versus altitude (from take-off). Two end altitudes are shown for each mission, depending on the fuel reserves allowed.

Maximum altitude mission profiles for intermediate take-off gross weights (between "Overload" and "Reduced") may be estimated fairly accurately by interpolating between the climb profiles shown in Figures A-9, A-11, and A-12, and obtaining maximum altitude cruise performance from Figure A-15.

For some heavy configurations (approaching the "Overload" condition) with "Badlands", there will be a cruise-climb portion under 60,000 feet of altitude, and a "Secondary Climb" from 60,000 feet. The data to be used for these portions are presented in Figure A-15 and A-10.

For all cruise portions, the time, fuel, and distance has to be calculated in small increments (about a 1,000 pounds in change of airplane weight) and then add these increments.

The small changes in weight represent the fuel used during that segment. Cruise portions may be calculated in the following fashion:

$$\Delta \text{Fuel} = W_1 - W_2 \qquad \text{Lbs.}$$

$$\left(\frac{\text{N.M.}}{\#}\right)_{\text{AVE.}} = \frac{\text{R.F.}_1 + \text{R.F.}_2}{W_1 + W_2} \qquad \text{R.F. from Figure A-15}$$

$$\Delta \text{Distance} = \left(\frac{\text{N.M.}}{\#}\right)_{\text{AVE.}} \times (W_1 - W_2) \quad \text{N.M.}$$

$$\Delta \text{Time} = \frac{\Delta \text{Distance}}{\text{Cruise Speed in Knots}} \qquad \text{Hours.}$$

The maximum cruise altitudes are obtained from Figure A-15 at weights W_1, W_2, W_3 and so on.

Initial Climb Weight = T.O.G.W. - Take-off Fuel

Total Fuel Used = Take-off Fuel + Climb Fuel + Cruise Fuel

25X1

25X1

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Total Time = Time to Climb + Time to Cruise

Total Distance = Distance gained in Climb + Distance gained in Cruise

End Mission Weight = T.O.G.W. - Total Fuel Used

= Weight Empty + Fuel Reserves

Missions profiles similar to those shown in Figures A-17 through 22 may then be plotted from the calculated data.

25X1

Approved For Release 2005/05/16 : CIA-RDP89B00739R000400080003-8

Attachment II to-
25X1

J75-P-13B ENGINE DESIGN CHANGES

The following differences between the current configuration of the J75-P-13 engines and the advanced P-13B proposal are herewith defined.

1. First Turbine Disk - having increased rupture strength at elevated temperatures. (Ref. P&W Msg #1778 discussion).

2. First Tubine Blades - P/N 457001, PWA47 coated U700 material, a bill of material feature in J75-P19W engines.

3. First Turbine Vanes - Change in area only.

4. Second Turbine Vanes - P/N 367052. Upgraded material to WI52, a JT4 commercial part. Area change.

5. Compressor Inlet Case - Revision in annulus area, OD of case identical to present engine, smaller diameter of inner passage. Housing covers, gearing and pump revisions to be made to fit within the smaller area. Aircraft duct will be affected.

6. Combustion Chambers - Hastaloy X stellite swirlers as used on J75-P-13, 19W bill of material.

7. Fuel Control - J75-P-13, JFC25-15 control incorporating revised P_b bellows, linkage clearance revisions.

8. Bleed Valves - P/N 348720, J75-P-17 bill of material, to be installed test flight to determine need for bleeds.
   Note: All of the above parts are fully qualified.

Item 1, the first stage turbine disk has already been ordered by our customer as additional protection against inadvertent overtemperature.

The thrust increase will be accomplished largely by an increase in airflow and turbine inlet temperature. The airflow increase is accomplished by using a revised inlet case with bigger annulus airflow area and vane camber. The engine turbine inlet temperature increase is made possible by using new materials in the combustion chambers, first stage turbine disk and blades, and second stage nozzle guide vane assembly. We will revise the first and second stage turbine nozzle guide vane areas to provide as much stall margin as possible at maximum altitude. The EGT equivalent to the increased operating temperature is 665°C.

25X1

Attachment II to-

As noted in the tabulation above, the engine will require intercompressor bleed valves for low thrust, descent conditions because the rematched engine will operate much closer to stall under these conditions.

The weight increase on existing P-13 engines converted to the P-13B is about 40 pounds. Since present engines are being delivered at nominal weight of 4790#, a nominal (not guaranteed spec weight) weight of 4830# may be used. Since new P-13B engines would include additional changes which are currently used in other J75's, a weight increase of 70# above present P-13 should be used. Note that present P-13 specification weight is 4950#.