DEPARTMENT OF THE AIR FORCE
WASHINGTON

OFFICE OF THE UNDER SECRETARY

April 9, 1971

MEMORANDUM FOR DR. McLUCAS

SUBJECT: A Not-Too-Thorough and Loose Survey of Possible Photobird Mixes

I. General Assumptions

a. Requirements for quarterly surveillance and area search will remain the same as at present.

b. It will be permissible (and most likely desirable) to reduce the number of GAMBIT or HEXAGON vehicles per year providing, of course, that the present requirements can be met by new combinations.

c. The costs and schedules as outlined here are reasonably correct (although there is room for large deviations without affecting the conclusions or recommendations).

d. There is now, or shortly will be, a requirement for an Ultra High Resolution (UHR) system. Any decision on an interim system should examine the effect on the paths leading to a UHR system.

e. The baseline system consists of 4 GAMBIT and 4 HEXAGON vehicles.

f. AXUMITE and FASTBACK were not considered because they appeared too provocative for many crises situations. If this judgment is faulty, new considerations would be proper.

g. Knowledge of weather conditions gives considerable advantage to the flexible systems like FASTBACK, AXUMITE, SPIN SCAN and some to PINTO. On the other hand systems like FROG and Solid State Arrays have 365 days a year access.

h. Vulnerability considerations were neglected. These considerations might favor a mix of more birds rather than fewer birds and would tend to favor FASTBACK, AXUMITE, SPIN SCAN and PINTO.

i. CORONA 6-pack was not considered in favor of PINTO. GAMBIT 6-pack was also not considered.

II. Cost Assumptions - Non Recurring

		Million $
A.	Baseline	None (already sunk)
B.	SPIN SCAN	$ 70
C.	PINTO	40
D.	FROG	165
E.	Electronic RO plus RV	320
F.	FROG plus RV's	210
G.	UHR plus Readout	450
H.	Solid State Array (plus Relay)	[redacted]
I.	Configuration C (plus Relay)	

(b)(1)
(b)(3)

[redacted]

(b)(1)
(b)(3)

III. Cost Assumptions - Recurring (End Position)

		Each	Overhead	Total
A.	4 HEXAGON, 4 GAMBIT	--	--	$350M
B.	4 SPIN SCAN (only)	$10M	$ 5M	45M
C.	6 PINTO (only)	15M	5M	95M
D.	2.8 FROG	30M	18M	105M
E.	2.8 FROG plus RV	47M	18M	152M
F.	2.8 EROG plus RV	55M	18M	172M
G.	2.8 UHR plus RV	66M	18M	202M
H.	1.5 EOI	[redacted]		
I.	2.5 EOI			

(b)(1)
(b)(3)

IV. <u>Assumptions - Acquisition Time</u>

PINTO - 24 months
FROG - 30 months
SPIN SCAN - 32 months (source selection)
G - 3 pack - 33 months
G^6 - VHR - 48 to 52 months
EOI - Configuration A - 48 to 52 months
EOI - Configuration C - 52 to 56 months
Tape Storage - 60 to 64 months

V. <u>Mixes Considered</u>

A. Baseline - 4 GAMBIT, 4 HEXAGON

B. Add 4 SPIN SCAN to A for crises.

C. Add 6 PINTO's, making possible reduction of 2 HEXAGONS.

D. Add 2 FRO GAMBIT, reduce HEXAGON to 2 and reduce GAMBIT to 2 in Multi-Boy configuration.

E. Phase in FRO followed by Electronic Read Out (Tape Storage or Silicon Vidicon). Phase out GAMBIT and HEXAGON (with 2-year overlap). See Appendix I.

F. Phase out G and H as above but substitute with a vehicle doing G^3 mission for 20 days, releasing 2 buckets, and FRO for 3 months at higher altitude. See Appendix I.

G. Same as F but uses 90" optics instead of G^3 optics to obtain Very High Resolution. See Appendix I.

H. Add Solid State Array. Phase out 4 vehicles, (various combinations of HEXAGON and GAMBIT) depending upon GSD selected. Thus if 8" GSD is selected all 4 GAMBITS might be phased out. If 18" GSD is selected 2 HEXAGONS and 2 GAMBITS might be phased out. We will consider the latter mix.

I. Same as H but a configuration "C" is designed with a 10-mile (approximately) stripping capability, and a fine or "zoom" capability for limited areas. Even though it is continuously on orbit and relays in real time, this swath width is probably marginal to replace all HEXAGONS. Probably more than two birds on orbit are needed to replace HEXAGON. For crisis situations, more than the two birds would also be better. The zoom capability would include the ability to collect four of five small areas, the size of area reduced to as small as pointing accuracy permits (probably 1/10 of a milliradian). See Appendix II.

VI. Costs of Mixes

The table shows the various options and costs by fiscal year.

VII. Caveats

1. Prices are very loose. This is meant to be a first look at possible combinations.

2. No firm conclusions should be, nor indeed need they be, drawn based upon the precise costs shown. The ordering of the various options should, however, be essentially correct.

3. Only the 1600-pound SPIN SCAN was considered. The others do not have high enough resolution. A trade-off sacrificing resolution for lower cost is definitely appropriate.

4. No booster procurement costs for those using excess ATLAS boosters were included. This is not too bad since by the time they are used up new systems will probably be phased in.

5. I believe all the costs are too low. The baseline is probably closest to being correct although there is some rubber in HEXAGON and perhaps a little in GAMBIT. The recurring costs for options D, E, F, G, H, or I will be more like \$38M, \$60M, \$70M, \$80M, \$100M and \$100M instead of the \$30M, \$47M, \$55M, \$66M, \$66M and \$66M listed. The lower numbers are from the project office and are optimistic. It is safe to say they are low. Mine will probably be too low also.

VIII. Conclusions

Even though the costs are not firm, certain observations and conclusions can be drawn.

1. The estimated costs for each fiscal year are greatly affected by the timing and speed with which the new systems are phased in and old systems phased out. The charts shown use the best figures available including Colonel Knolle's estimates for the dual mode system. They are probably low due to inflation (he used 1970 dollars) and the usual optimism. Nevertheless one can draw the following inferences.

a. To save money in the steady state condition one must learn how to do away with HEXAGON (\$240M for 4 birds a year). GAMBIT reduction gives a lesser savings (\$120M for 4 birds a year).

b. Any system which does away with HEXAGON will require large non-recurring costs in advance of the savings.

2. To meet the crisis requirement we can:

a. Add SPIN SCAN
b. Add PINTO
c. Add FROG
d. Add AXUMITE
e. Add FASTBACK
f. Add any one of three different dual mode systems

g. Add EOI (configuration A or B)
h. Add EOI (configuration C)

3. AXUMITE and FASTBACK were not considered because as presently proposed they (a) lack performance (resolution), (b) might be subject to political constraints, especially in a crisis and, (c) do not seem to be able to serve as a stepping stone to a more desirable and less costly mix than the present photobird population. Weather and vulnerability considerations, neglected in this memorandum, may alter this conclusion.

4. SPIN SCAN obtains a useful crisis capability with a low investment but with the least long term savings and least growth potential. It will cost $55 million more per year than the base line system ($405 million versus $350 million). It provides for 4 crises a year, each of 30 days duration with a best resolution of 2½ feet. SPIN SCAN adds $300 million to total 7-year cost.

5. PINTO, using bucket recovery, has the least risk although FRO risks are considerably reduced from last year when the Fubini committee examined it. PINTO also has the least ultimate annual operating cost ($375 million versus $405 million for SPIN SCAN and $350 million for baseline). It yields essentially the same capability as SPIN SCAN since with 32 buckets a year -- light buckets in 4 birds, there should be no hesitancy in pulling one bucket down or launching a new bird. It adds $200 million to total cost over 7 years. The low cost is made possible by reduction of 2 HEXAGON vehicles.

6. FROG is attractive because it provides more capability than any of the preceding. FROG has a lowest annual cost of any of the preceding options ($340 million compared to $360 million baseline), and a lower total cost over 7 years ($160 million more than baseline). It does have a large FY 1972 and FY 1973 impact. This could be spread out over three years for a total increased program cost of about 2 additional HEXAGON vehicles. FROG will have a full near-real-time capability: -- daily, continuous world wide access.

7. The dual mode systems are quite attractive because they meet all the requirements and end up with a single vehicle meeting all imagery requirements. Options F and G are most attractive, Option G yielding a UHR capability whereas Option F does not. Option F gives a very low ultimate annual operating cost ($172 million a year). While Option E is still lower in annual operating costs, it requires $500 million more in total cost. Options E, F and G, however, have large impacts on the next few fiscal years.

8. The EOI systems can follow the configuration A or B route, as presently proposed, or a new route (configuration C) which can eventually do away with HEXAGON and GAMBIT and provide a UHR capability. The EOI has the highest buy-in cost and Configuration A & B has highest operating cost. It is also probably the path that will provide an interim capability later than the other path.

9. At present, it is not likely that solid state array systems will achieve considerably more area coverage per pass than now indicated; certainly it will be less than film. At least 2 birds in Configuration C will be needed on orbit to replace HEXAGON. Configuration C will have about the same buy-in cost as A & B but will be much cheaper because all HEXAGON and GAMBITS could possibly be deleted.

10. There are three paths to follow:

a. Opt for a crisis capability (PINTO or SPIN SCAN look best) in addition to present capability and present mix. This introduces the least impact on immediate fiscal years but does not give long term savings nor UHR capability. These are low risk options. Growth provisions would be delayed pending development of newer sensor technology.

b. Opt for a film readout path with potential for growth to dual mode systems. This has acceptably low risk for the immediate future but has high impact on the next few fiscal years. A sub option would be to take this course but delay or stretch out the growth.

c. Opt for the solid state array. This does not provide as fast an interim capability as the preceding options. This has the highest risk and cost but has a most attractive eventual capability (the newer silicon tubes will probably also have the solid state array advantages).

IX. Recommendations

1. Before selecting an interim system, be careful to consider what we will want in the future -- lower costs, UHR, better survivability and the like.

2. A need for a UHR capability be acknowledged and taken into consideration.

3. As a first priority consider the two paths leading to growth to a future attractive mix:

a. Film readout path to dual mode system.

b. EOI path to Configuration C.

4. Of the two paths the FRO path should be preferred at this time because:

a. It gives the earliest capability.

b. It has lesser risk.

c. It has the smaller immediate impact.

d. The growth to a dual mode system can be deferred to a suitable fiscal year or stretched out in time.

e. It has low cost possibilities

5. If the FRO path be selected, some funding of EOI and comparable technology be continued -- approximately 25 million a year appears adequate. Optics, CMG work should also be continued.

6. If the FRO path is selected but the growth to dual mode is deferred or stretched out, funding for critical components of the growth should be added. This would include the optics, relay system (based upon modification [redacted], new silicon vidicon type sensors and some miscellaneous work amounting to about $25 million per year. (b)(1) (b)(3)

7. If the EOI path is selected, (taking into account the later availability than other options) direct development of Configuration C is recommended because:

a. It gives larger area coverage

b. Permits UHR where needed

c. Is somewhat less costly

d. In the end position, it has a low annual cost. On the debit side, it is less well defined than Configuration A or B.

8. If policy dictates the minimum cost addition without regard to either UHR or future reduction in birds (definitely not recommended) then the choice between PINTO and SPIN SCAN is a close one based upon cost and performance. The conclusions of this memorandum outline the differences for a choice between these. There is probably an advantage to PINTO.

9. If the minimum cost addition is selected, R&D should be continued on FRO, Tape Storage, Solid State Arrays and Silicon Vidicons to provide for future low cost and UHR options.

10. The course I like best is to take the FROG path keeping the EOI (Configuration C) technology in order to gain its advantages in the future. We would continue FROG

through the phase out of GAMBIT and HEXAGON. The $100 million a year savings can then be used to phase in the Configuration C, which appears to be the best system in the end.

Harry Davis

HARRY DAVIS
Deputy Under Secretary
(Systems Review)

Attachments

TOP SECRET
Handle Via BYEMAN
Control System

	FY 71	FY 72	FY 73	FY 74	FY 75	FY 76	FY 77	7 Year Total	REMARKS
A. PRESENT MIX									
4 G (5 G Bought for FY 71/72)	140	120	120	120	120	120	120		
4 HEXAGON	240	240	240	240	240	240	240		
TOTAL	380	360	360	360	360	360	360	2,540	
. ADD 4 SPIN SCANs									
HEXAGON	240	240	240	240	240	240	240		
GAMBIT-3	140	120	120	120	120	120	120		
NON-RECURRING	10	40	20						
RECURRING		20	40	40	40	40	40		
O&M			5	5	5	5	5		
TOTAL	390	420	425	405	405	405	405	2,855	
C. ADD 6 PINTO DEL 2 H									
HEXAGON	240	240	200	160	160	160	160		
GAMBIT-3	140	120	120	120	120	120	120		Cheaper than SPIN SCAN because it deletes two HEXAGONs
NON-RECURRING	10	20	10						
RECURRING		45	95	95	95	95	95		
TOTAL	390	425	425	375	375	375	375	2,740	

GAMBIT HEXAGON
HANDLE VIA BYEMAN

~~TOP SECRET~~
Handle Via BYEMAN
Control System

		FY 71	FY 72	FY 73	FY 74	FY 75	FY 76	FY 77	7 Year Total	REMARKS
D. ADD 3 FROG DEL. 2 H AND 2 G-3										
HEXAGON		240	240	200	160	160	160	160		
GAMBIT-3		140	120	90	60	60	60	60		
NON-RECURRING		10	95	45	5					Has larger R&D than above and greater short-term fiscal impact.
RECURRING			40	100	100	100	100	100		
[redacted]										
TOTAL		390	[redacted]		325	320	320	320	[redacted]	(b)(1) (b)(3)
ADD FROG→ERO, DEL. ALL H, G-3										
HEXAGON		240	240	200	160	100	40			Less expensive than [redacted]
GAMBIT-3		140	120	90	60	40	15			
NON-RECURRING	FRO	10	95	45	5					
	ERO			30	45	30	10			Has 2 developments - FRO and tape storage camera.
RECURRING	FRO		40	100	100	70	10			
	ERO				40	95	135	150		Ends up with cheapest recurring costs of all options.
[redacted]										
RELAY			[redacted]							Big fiscal impact in FY 72 and 73.
TOTAL		390	[redacted]							(b)(1) (b)(3)

(b)(1) (b)(3)

HANDLE VIA [illegible] CONTROL SYSTEM

	FY 71	FY 72	FY 73	FY 74	FY 75	FY 76	FY 77	7 Year Total	REMARKS
F. ADD FROG + RV (TIIID) DEL. ALL H, G-3									
HEXAGON	240	240	100	40					
GAMBIT-3	140	120	40	15					Slightly more expensive then E in on-going annual costs.
NON-RECURRING	10	100	40	10					
RECURRING		50	120	170	170	170	170		Fiscal impact only in FY 72.
[redacted]									
RELAY	[redacted]								
TOTAL									
ADD VHR + RV, GO TO HIGH ORBIT FOR SEARCH, DELETE H/G-3									
HEXAGON	240	240	240	200	160	40		(b)(1) (b)(3)	
GAMBIT-3	140	120	120	90	60	15			Gives a VHR capability.
NON-RECURRING	20	100	160	100	20				More expensive than E or F in annual costs but considerably less than baseline.
RECURRING			55	125	180	200	200		
[redacted]									
RELAY	[redacted]								Big impact on fiscal year 72, 73, and 74.
TOTAL									

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		FY 71	FY 72	FY 73	FY 74	FY 75	FY 76	FY 77	7 Year Total	REMARKS
H.	EOI (CONFIGURATION A) DELETE 2 H, 2 G									
	HEXAGON	240	240	240	240	240	200	160		
	GAMBIT-3	140	120	120	120	120	90	60		Cost estimate for EOI is probably low.
	NON-RECURRING	60	80	90	90	40				
	RECURRING		9	27	75	90	90	90		
	[redacted] (b)(1) (b)(3)									
	RELAY		[redacted] (b)(1) (b)(3)							
	O&M		6	6	6	6	6	6		
	TOTAL	440	[redacted] (b)(1) (b)(3)							
	EOI (CONFIGURATION C) DELETE ALL H, G-3									
	HEXAGON	240	240	240	200	160	40			
	GAMBIT-3	140	140	140	90	60	15			
	NON-RECURRING	60	80	90	90	40				
	RECURRING		15	62	125	150	150	150		Gives a VHR capability.
	[redacted] (b)(1) (b)(3)									
	RELAY		[redacted] (b)(1) (b)(3)							
	O&M		6	6	6	6	6	6		
	TOTAL	440	[redacted] (b)(1) (b)(3)							

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J. COMBINED FROG
"C" CONFIGURATION PROGRAM

	FY 71	FY 72	FY 73	FY 74	FY 75	FY 76	FY 77	7 Year Total
HEXAGON	240	240	100	40				
GAMBIT-3	140	120	40	15				
NON RECURRING (FROG)	10	100	40	10				
NON RECURRING (EOI)	[redacted] (b)(1) (b)(3)							
RECURRING (FROG)		50	120	170	170	170	0	
RECURRING (EOI)				[redacted] (b)(1) (b)(3)				
GROUND STATUS (FROG)		5	10					
GROUND STATUS (EOI)				[redacted] (b)(1) (b)(3)				
RELAY (FROG)		20	25	5	5	10	2	
RELAY (EOI)				[redacted] (b)(1) (b)(3)				
O&M				6	6	6	6	
TOTAL	[redacted] (b)(1) (b)(3)							

THIS STARTS EOI IN 1974
END POSITION REACHED IN 1978 - SAME AS FY 77 OPTION 5 - NAMELY [redacted] (b)(1) (b)(3)

(b)(1)
(b)(3)

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APPENDIX I

DUAL MODE SYSTEMS

There are three options in the dual mode system:

1. Option 1 is the cheapest in operating cost ($150 million per year in the steady state). It uses a tape storage camera and a data relay. A data relay based (b)(1) upon [redacted], orbit and control will easily suffice. (b)(3) It depends upon the development of either the tape storage camera or one of the newer (and more exacting silicon sensors - more exciting because of better signal to noise, contrast, dynamic range, ruggedness and inherent long life). Option 1 envisages a FROG evolving into the Electronic Readout (ERO). It uses a Titan IIIB.

Option 1 eventually eliminates all G^3 and HEXAGON vehicles but requires a huge investment during the overlap years.

2. Option 2 uses bucket recovery for the high resolution and is kicked to higher orbit for FRO. It requires more film than Option 1, therefore requires a TITAN IIID.

It has the advantage of not requiring a new camera development but is slightly more expensive to operate than Option 1.

3. Option 3 is like Option 1 or 2 but uses 90" optics instead of the GAMBIT optics. It gives UHR plus all the other requirements. It needs either a TITAN IIID or a TITAN IIIF depending upon the availability of a Tape Storage device or substitute. The TITAN IIID option was costed. If a TITAN IIIF option were used the cost would increase by $2 million(per bird).

Film readout systems have made a great deal of progress since the Fubini committee examined them. The Fubini committee pointed out there were a number of uncertainties which could delay the introduction of film readout systems. Since then, all of the problem areas appear to have been solved, much sooner than predicted. Consequently, it is believed that the phasing for the FRO systems shown is not too optimistic.

Further, the date for starting a UHR system was moved up three years from Colonel [redacted] estimates, but the (b)(3)
development was stretched about one year so that the availability of Colonel [redacted] UHR dual mode system was (b)(3)
advanced two years.

APPENDIX II

CONFIGURATION C

Configuration C is a postulated coarse-fine EOI system. It would have a stripping mode covering about ten miles swath width and a group of sensors to provide a high resolution, limited area mode. It would require less bandwidth than Configuration A or B. If desired the stripping can be done faster than real time by tilting forward. A minimum of two vehicles on orbit are needed to cover crises, search, surveillance, High Resolution and Ultra High Resolution requirements. No other vehicle is needed. Expected life of three years requires two to be built each year, however failures (including launch failures) will require, in my judgment, about 2½ starts per year.

The development of Configuration C is estimated to cost about the same as Configuration A or B. The operation of Configuration C should also be about the same, although there there may be some savings in data relay and in recording film. This savings may be balanced by higher operating costs (a number of on-line interpreters are required). Configuration C has the advantage of censoring the collection at the source and recording only objects of interest. The CIA estimates that [redacted] could be achieved, (b)(1)
however resolution is not the only (nor the most important) (b)(3)
parameter to measure the intelligence value of imagery. Contrast and high signal-to-noise are at least equally important. The Solid State array can have significantly better signal-to-noise, contrast and dynamic range than any system built upon film.

Configuration C has many advantages:

1. All GAMBIT and HEXAGON can be phased out if several (perhaps more than four) are on orbit at all times. The larger number has some vulnerability advantages and may mitigate production problems.

2. Having more than two on orbit (probably four will be necessary) also has (a) response time advantages because of more frequent access, (b) permits maintaining reliability because the production base is kept gainfully employed, and, (c) gives flexibility to decrease or increase our collection capability as the need and our interpretation ability fluctuates.

3. The ultimate operating cost would be about equal to the cheapest film readout option.

4. Its high signal-to-noise allows processing to better resolution than the nominal Ground Sampling Distance.

5. Its sensitivity to the red (difficult to achieve in film) gives much higher contrast signals since most objects have more reflected radiance and most atmospheric scattering tends to be accentuated in the blue end.

6. Contrast is at least as important as resolution.

7. The course recommended, namely build the FROG for the interim, phase down HEXAGON and GAMBIT, continue EOI technology, gives some increase in the next few years but delays the EOI impact until the HEXAGON and GAMBIT are phased out.

On the other hand, Configuration C has some disadvantages:

1. It is far from being defined, although contractors are beginning to look at this.

2. It cannot be available in time to be called an interim capability.

3. It has a large buy-in cost.

Incidentally, the table showing the costs does not show a path from FROG to phase out of GAMBIT and HEXAGON to the phase in of a Configuration C.