Low Light Camera AE Q&A Telecon Transcript

1. **When you say extreme low light, are you looking specifically for CMOS type low-light detectors? Are you open to other camera technologies and thermal bands?**
   First, no we aren't looking for specifically CMOS type low light detectors. It's intended to be broadly open so if you have a different technology to offer a moonless night image, then propose it, we are interested. For other bands, let's say the answer is yes, though our primary focus is the visual bands. Keep in mind what we were saying about the why, why do we want to see in the visual bands, what are we trying to do with it and observe on the scene? And if you can offer us advantages or comparable capabilities, then we would certainly consider the other bands. We wouldn't toss it out just because it's in a different band. We would consider the mission we were trying to accomplish with the visual bands and does your solution offer us any advantage over the other visual band competitors.

2. **Is color low light CMOS preferred?**
   Sort of, our users would desire color at extreme low light, say limited starlight if possible. However, if you propose black and white and not color, but offer us twice the sensitivity so we can read a sign at say 50% more distance, that's of value. Don't be afraid to limit it, if your niche is a little narrower, but you offer more performance that's a tradeoff we need to present to our users as a potential solution.

3. **What are the total projected cameras for this project? Will this be used in the day, dusk? what other type of sensors will be utilized with the LLL Camera?**
   For the total projected cameras, we can't really give an estimate there, the answers yes. The more broadly applicable the solution, potentially many hundreds as we move cameras from our existing solutions to current state of the art. Addressing the day dusk part of it, we would say while the initial request was for moonless nights, that's our primary focus, but it doesn't necessarily exclude dusk or day if we can use the same camera system to adjust to those light conditions. In more general terms, the narrower your solution, the more advantage it needs to give in that narrow case to compete with a broader based or broadly capable solution that is maybe not as performant. What other type of sensors will be used with the camera, probably trigger sensors at various types. Our criteria listed that talks about start-up time is based on that, so a simple case would be a magnetic sensor in the road to go off when a vehicle passes over to tell a camera to turn on to enable to take pictures or video. That kind of sensor would be used with the low light camera is the intent.

4. **Are battlefield IR laser pointers, illuminators, designators needed to be detected by the lowlight camera i.e., 830nm to 1064nm?**
   Not needed, no but if you offer that capability, it will be an add on or a positive for a competitor who offers the same thing without.

5. **If we have two different sensor technologies to submit, should we put both into one submission, or make two separate submissions?**
   From the evaluation point of view, we would prefer them to be in two separate submissions. We certainly will evaluate them if they're both in one paper but if they're different it makes it easier to evaluate and compare against other potential solutions if they're separate submissions and where one people may say "hey I like that" and the other "we have something that already does that".

6. **"SUBMISSIONS SHOULD INCLUDE TEXT, NOT TO EXCEED TWO (2) PAGES AND DIAGRAMS, ALSO NOT TO EXCEED TWO (2) PAGES" Meaning 2 pages of text AND 2 of diagrams?**
   2 pages text and 2 pages of diagrams, totaling in 4 pages. We are capping text at 2 pages and allowing for 2 additional pages of diagrams if you have them.

7. **Is the image processing (detect and classify) a part of the work along with the requested optical subsystem design?**
   No, the part we would consider as part of this request is your interfaces to which you could attach a processing subsystem. That is part of, but not the entirety of why the HD-SDI was listed. It would provide an uncompressed, we hesitate to use the term raw because it's not true sensor raw but an uncompressed image flow to any image processing whether that be image enhancement, or AI/ML type applications which theoretically could perform better with an uncompressed or near raw sensor input.

8. **What are your desired ISR range and field of view?**
   We want to see what you guys can tell us what your maximum ranges are based on the capability of the system you're proposing. That's more tradeoffs so the primary sponsor of this is looking at ground based ISR, say from 100 meters to 5km ish as kind of an initial trade space you might say. That said, there are others possibly listening today that are interested in the proposals from this effort who may have other requirements. So, part of that is based on lenses, we specifically did not specify what lens would be attached, other than if it's a preferably modular attachable lens using an existing standard. As an example, but not necessarily something we want, we have kits with sensors that attach to C and CS mount lenses that makes for a very nice modular system, acknowledge the limitations of that as a system, but makes for a mix and match modular sensor box. We would prefer that kind of system as an outcome here. That said, there are difficulties in non-fixed lenses attached to a sensor and if your proposal is a fixed set of lenses and sensors, not detachable, then we would want it to move towards a family of cameras that are available in different lens sizes or lengths. To make it more general, we are interested in tactical ground intelligence, surveillance, and reconnaissance missions primarily. Whatever capabilities and technical specs that your system can provide is what we would be evaluating. However, some of our other Government partners will have access to this too that they perhaps may show some level of interest in communicating with you. Don't be afraid to propose alternatives. If you have two different paths, propose both. Maybe one is the one we say "that's the one that looks the best" once we see it.

9. **Can you elaborate on the financial compensation?**
   We must come back later, but the intent was to sponsor some prototypes that we could look at and evaluate for future solutions, but the end state desired is a commercially available product that we can buy from you instead of a unique SOCOM sponsored end to end development. Or if it's a solution that integrates with another vendor that you don't have the production capabilities, perhaps we can point you in the right direction so you can build a partnership with the other company that does help you save costs or keep up with production or manufacturing challenges. Don't feel that if you can't produce at X amount of quantity, lets focus on the technology and the cost first.

10. **Are these meant to be disposable units, or retrieved after use?**
    These are meant to be units that could be left behind. They would not be deliberately left behind if they're easily retrievable, but they're intended to be commercially available

technology that we are not afraid to leave it behind other than the expense, and that becomes a decision of the operational commander.

11. **Is there a list of basic (objective and threshold) requirements? E.g., detection range, communication range, spectrum (comm freq) limitations, etc.**
Not other than what we already listed. We are reaching out to you guys to see what your objectives and thresholds are, and what the state of the art is compared to ours. The reason we are very vague is we are very sensitive of broadcasting publicly what we can and cannot do. So, you tell us what you can do, we are spinning it back on you. Also, for frequency or spectrum if you are talking about communications, that's part of a separate package, not part of this. And ranges often have to do with lenses, what lens you attach to the sensor, so partly we are leaving that up to you. Our desired is a family of interchangeable standardized lenses to a public standard so that that is mission configurable. If that is difficult or expensive to accomplish, then propose a solution and say why.

12. **Is classification desired as Metadata only, or is imagery expected to be provided (transmitted back)?**
This project is to provide imagery back. Processing of that imagery is intended to be an add on to the output's camera. A lot of folks are doing good work by directly connecting processers to sensors and from the engineering efficiency of the task point of view, that is truly the optimum. If you're trying to field gear across lots of different missions that is somewhat modular in application, that's difficult to do it that way because it stove pipes the systems together and we would prefer that we be able to mix and match added on processing of the imagery. Hence the request for some of those outputs.

13. **How much funding is available for the prototype effort?**
If you can get the gist of this Q&A session, you'll be able to conclude that we are looking to zero in on a lot of capability, as well as, considering cost as an independent variable. We are looking for low cost, but we understand the development of prototypes is more expensive than buying off the shelf.
There is some money available, otherwise we wouldn't be able to do this project, but we don't know that we can say how much is in total available. Part of that will depend on our user's feedback – if they stomp their foot and say something is more important than our bosses will go forward and scrounge up and get more sponsorship money.

14. **Is there a target unit price (order of magnitude, at quantity) - drastically impacts sensor selection?**
We don't think up front we can give you an order quantity. Our intent is that, in the end (not directly at the end of this project), but the outcome being commercially available product that is not just sold to SOCOM but perhaps broader DOD and Law Enforcement community. We have some commonly available block cams and lenses in kits right now that need updating. So, whatever comes out of this will feed into our efforts for broadly updating or adding additional sensor capability to existing ISR tasks. Again, this is an opportunity for all you guys that aren't associated with big companies to be inserted in our consideration for us to use your product in our portfolio. So, take advantage of that and depending on what the performance specs, size, weight, power, and cost is this is a good chance for us to give you a try and fair shot at it. We recommend doing the proposal and submitting the figures without fear – who knows what will happen. You can always add in there what your tradeoffs are and propose more than one

solution. You can say: this is the price at quantities of 5,000, this is the price of quantities at 500. And then we will take that into consideration.

15. **"Integrated in ground sensor kits" seems to imply covert placement/deployment. Is this a correct assumption?**

Maybe – it runs the gamut. We have mission sets that are used for many different things and the desire is sensors that can cover as many parts of that envelope as possible. That said, some parts may need narrow solutions. And one of those areas of the mission envelope is disguised and hidden cameras/sensors. Camera systems can be used low light or zero light, multiple ways, one is what you're alluding to, but one could be working at a warehouse, making sure nobody comes in at night. Its protection and security purposes. If we can use the same camera core and selection of lenses, and the user can configure it for a security mission and for a covert mission, we would prefer that. That way I would have one item in the inventory. At the end of the day, it's the end user's creativity and the use of the camera – so it's not necessarily implied covert placement and deployment; it could be, but it has multiple uses.

16. **What is the schedule you are looking to achieve?**

We would say we're not looking a whole lot further than the outcome of this event to see what is possible. If your timeline is super short or super long, and you feel that is an advantage or something we need to know when considering, put it in your proposal. Because if it's that we won't have anything for 5 years, we need to know that while deciding what to purpose. And if its available in 3 months as a production item, that's also important.

17. **Would you provide guidance on the desired array size and frame rate?**

Array size is often a tradeoff. The resolution you can get with an array size and the ultimate sensitivity of your sensor. Of course, you can do pixel binning and techniques like that. But it's a tradeoff and we acknowledge that, and that's part of the outcome we'd like to see. If your solution may have two variants – here's what we can give you with a standard definition kind of array size and here's what we can give you with a 4K image. Put in both paths and say what the tradeoff is because for some things we may want super high resolution so we can distinguish features or text, in others, what we should really care about is super sensitivity (just detect that there is a person there at all).

For frame rate, most surveillance activities do not require super high frame rates. You're more interested in finding out what activity is going on in your area of interest, and that doesn't typically require super high frame rates. So, the emphasis would be on getting clear images, rather than, driving the frame rate higher. That said – we have seen some interesting processing applications that require very high frame rates, and if that is something you are saying you could do, and that's your competitive advantage then propose it and tell us why.

18. **Can you restate potential applications?**

No, we are not asking for devices mounted to personnel. This is ground op ISR, typically placed on an object or a tripod, often disguised in some way, but not always. The reference to a head mounted device was because in the criteria we used to reference the Army's IVAS program. That program is using head mounted sensors. We looked at the sensor performance from that program and were impressed at the SWAP and performance they could get out of those head mounted sensors, but we would desire them not to be used as a head mounted device. That was part of the problem, we saw these well performing sensors, but they were not set up in a way that we could use it. But we are not going to deploy a head mounted device on a tripod

somewhere. We could use it in ground ISR, but it's not as applicable because you need the processing – the thing that accepts your imaging to be directly mounted to your sensor. And typically, we've tried to make them modular and separate them from the sensor for a variety of reasons.

19. **What is the range of ambient light conditions that the system is required (threshold/objective) to operate?**

General conditions are moonless nights. That's where we desire to go. We've seen some sensors that seem to offer that kind of performance, so that seemed to be pushing the boundaries of commercially available sensors, especially this SWAP and since we're not funding this as $1mil research project, we're seeing how far we can push the boundaries of ambient light. And remember, the application is probably outdoors, so preferably it's been weatherized a little bit – so if you have some sensitive sensor or optics, that humidity is going to affect its performance, you may want to consider protective enclosure. For the first stage, we're not focusing so much on ruggedness, but if there is anything about your design that is extra sensitive to these conditions, that certainly needs to be considered because the product is "Panasonic Toughbook" ruggedized. Where it's a commercially hardened device, so we can take it out in the rain, we can drop it and its going to be okay and will survive without needing factory recalibration of some kind – so to give you a target of how hardened you want to make it.

20. **What is the desired resolution and frame rate? What are the sensor wavelength requirements? What are the optics specs (e.g., field of view, size, weight)?**

Resolution and frame rate we went over, most ISR applications do not require high frame rate, most sensors will give you a standard 30-60, or less and is desirable. We have seen, if you can crank it down and use less power there are plenty of applications where that's more desirable than a high frame rate. Focus should be on whether we can capture a clear image to pass on to the analyst who is working with the image to try and figure out what is going on and what is important in the image.

Sensor wavelength: we are focused on the visual bands. But if you can meet the mission by adding more spectrum or in a different band then it will be evaluated along with can the operator do what he was intending to do with the visual band camera with your sensor.

Optic specs: that we left up to you, our intent was if we can get it to be able to attach commercially available lenses with a commercially available interphase spec. We mentioned as an example, CS and CS mount – but that is not to indicate that we are wedded to that. That's why we didn't list it as a requirement. Outside of that, if you think it would work better with a fixed lens, not interchangeable, then propose that. We desire that the outcome will be in the future it is available in a variety of lenses, sizes, and shapes because mission requirements will differ. The ground ISR is focused anywhere from 100 meters to 5 kilometers – and the more of that area we can cover with the same set up the better, so we don't have to have more narrowly tailored solutions.

21. **Are there more detailed performance metrics for the low light camera prototype evaluations?**

Not really, we didn't specify a hard threshold of what we want you to produce because we don't know how far industry can push that. So, we are looking for, what can you give me out of industry in that price box. There's not a hard pass line that if you don't meet it you fail. You are competing against the solutions proposed by everyone else. Rather than a hard cut off.

22. **Is the "detect and classify" function embedded in the camera? If so, what are the functional requirements of that (e.g., alarming, bounding boxes, etc.)?**

No, we are not doing detect and classify as part of this project. We want the outputs from the camera to support such efforts done by other processing or boxes. It may be your same company, or it may be a different company. Desire is to make that a modular function to our sensors and processing in the future for any solution provider with minimal to no integration work - we could plug it in and do the processing that we want. However, if your camera solution does have that imbedded, we would look at it too because we would be looking at the power consumption, the tradeoff of energy. The tip of the edge as opposed to the back end. It's a balance of saving energy and mission duration too. And if we have a processor on the front end on images all the time, what is that consumption rate? We're more focused on the image that you can collect than the output of that input camera

23. **What are target detection requirements (e.g., animal size, vehicle size, etc.)?**

That's really going to depend on lenses and a bunch of other stuff. We wouldn't focus on that because that's not a criterion that we will evaluate. That's a result of what happens when we can combine everything together. But it will be traditional, military ISR stuff, presence of, type of activity. Personal, animal, vehicle, that's what all of this will be used for in the end.

24. **Is the submission length 2- or 4-pages total?**

4 total, 2 of text, and 2 additional pages are available for graphs and charts because we recognize that it's difficult to squeeze in legible graphs, charts, and other illustrations into your two pages available for text. Don't feel like you must fit everything in with perfect text. If your proposal is attractive enough to be chosen, then you will have the opportunity to brief us.

25. **What is the minimum image resolution required (threshold/objective) for a system with 10-4 lux or better sensitivity?**

We don't have a hard threshold there, it's a tradeoff. Feel free to propose multiple tradeoffs or paths, or even multiple submissions if you have significantly different paths to get there. Part of this is we don't know what is possible with all the tradeoffs – so your answers here will tell us what is possible.

26. **What is the significance of the requirement for TCP/IP vs. prior IVAS requirements calling for MIPI?**

For IVAS, they're integrating the sensor into a helmet mounted or otherwise mounted over the eyes system for individual soldiers and the processing is directly attached at the camera source. For ground ISR, we may be offsetting cameras from radios and processing quite some distance, little bit different environment. That was the basis, for TCP/IP we can direct connect the cameras with that into a variety of processing, recording, and forwarding subsystems, commercial tactical radios, and the data streams then can be processed, recorded, forwarded easily from that point. Other interfaces, the call for HD-SDI was if we want an uncompressed output, maybe the interface assumes you're right next to your sensor, which it may be, but we have plenty of configurations where the processing may be offset by 50 or 100 meters from the camera itself. We could connect that over a tactical network radio, and ethernet line using compressed video, or if our additional processing we want an uncompressed signal at range, there's not, as far we can tell a lot of other good solutions than HD-SDI. That said, if you propose that to put maybe an output at the same place because it's inherent in your design, or doesn't

add much cost, then that's great because it offers us one more option that we can do with the system that we couldn't otherwise.

27. **Are you looking for a finished product - or is a camera still under development OK if it meets most of the specs?**

   That depends on the definition of development. We are not trying to sponsor new sensor plane development from scratch. The idea behind this was we had seen a variety of sensors demonstrated to us over the past couple of years that offer outstanding performance and specifically some of the IVAS competitors, but there are other competitors as well. The intent was that after this you could at least have a bench top demonstration of the subsystems or parts hooked up and working to evaluate performance of some final fielded item. Hopefully that gives some definition to in development: yes, as far as that's not a complete current camera that can be sent to the field. At the end of this it should at least be all the pieces are complete and available, and you can hook them together on a lab bench to show us the performance regarding all our criteria.

28. **Are the specs and acquisition costs set in stone?**

   No, we would call them soft or squishy. The why behind it like we said at the beginning, we do have a higher end commercial based color low light solution, but it starts at about 5x the cap that was listed in this effort. Our intent here is to make something inexpensive enough to be widely deployed and less exquisite you might say. The further away you get from our proposed criteria, the harder it is to recommend. At the same time if you give us some capability that isn't available elsewhere, we will take it to our end users, and they would certainly consider it. But it's tradeoffs size, weight, power, and cost. If your systems heavy but it outperforms everything than that's a factor we need to consider, or it needs to be powered by shore line power or something as opposed to batteries, that's something that needs to be considered too.

29. **Are you only interested in visible light cameras or are you also interested in IR hyperspectral imaging sensors?**

   We would say yes, we are interested in hyperspectral, it offers us additional capabilities. The baseline is visual spectrum optical. If you can offer additional capabilities that gives the users much more capability than have otherwise, absolutely. The focus is at the end of the project, have something to demonstrate that we can proceed to assist to a commercial solution that we can buy. That said, if you are showing us something that is fascinating to our folks, and they say, "yeah please go forward with that development for future years", we would move that to a different, maybe separate forum and go from there. Part of the purpose of this is to survey the industry as to what is available, because we are just too small and not enough people to know everything that could be done.

30. **Do you prefer IR or a traditional image camera?**

   No, we don't have a preference. We always try to select the best equipment that meets a mission. So based on what we know that equipment selection is made.

31. **Do you have a pixel resolution or frame format?**

   No, what is selected is a series of tradeoffs. High resolution is desirable, increased sensitivity is desirable – each one of those, the higher you go, the more tradeoffs you encounter. So, tell us what your tradeoffs are and if you have more than one path, propose more than one and tell us what the tradeoffs for each are. And we will evaluate them each on their merits and desirability to our end users when they see it.

32. **How quickly would you need 100+ cameras? What is the timeline for production?**

We don't have that kind of answer at this point. It depends because we don't know what your system is. This includes understanding of what needs to be fabricated or bot integrated. So that is tough to answer. We are focused on the outcome of the eventual selectees doing a bench or field demonstration. We are saying how far can this be pushed or what can we get out of it, and at that point we will consider what production limitations are and what not.

33. **What is the 5x cost camera are you currently using for this, make and model?**

We are trying to not name specific brands out there, but if you're looking for references for this kind of thing, the major makers in the semi-pro market like Sony and Cannon and others make several different sets of expensive low light or reasonably expensive low light sensor cores. It's in that arena. 5x the cost, don't focus on that as much as working on your solution, because it may perform better than the one that cost 5x, so it doesn't necessarily have to be 5x or less. It's tradeoffs again. Listing that was more of a rationale for our price range between desired $500 and $5,000, is to say we do have something more expensive. We are trying to find out what industry can produce at a significantly lower cost that allows us to deploy it much more broadly.

34. **Is there a power limitation?**

We listed input powers. 5-36 volts DC. The minimum acceptable was 10-16 volts DC. We listed some total power draw limitations as well. It says 1 watt and minimal acceptable is 12 watts – these are based on existing solutions, so don't be worse than existing solutions. Hopefully outcome of this is either much better performance or much better swap. That's a tradeoff obviously.

35. **Can you consider opening a SBIR for this topic next year? We have a solution, but it could still use some R&D.**

Yes, we could talk to the R&D office POC's and see for next generation ISR and see what SBIRs are related or what we can open for this topic. That's not off the table.

36. **Nothing works in the vis band without illumination in total moonless nights, even the best CMOS sensors will struggle at 1/4 moon.**

Sensors do struggle in moonless nights, yes and no. We have observed over that last couple of years a variety of sensor makers showing us starlight capable sensors that produce an image with just starlight. That was part of the impetus to say okay we've seen that sensor and maybe in a form factor or different product that we can't use in ground ISR but if somebody can produce the sensor that can do this, surely, we can push forward a ground ISR camera application for the same type of application. That's part of what we are coming with request for sensitivity. If you believe your product is going to only function with quarter moon, then submit that product and we will look at it. Maybe a competitor can beat it, maybe not. We'll find out.

37. **Can these sensors have active illumination? or is that a negative**

Requiring it, is a negative. Ultimately, if we're focusing on harder and harder solution sets you want to be as passive as possible with as little active emissions of any kind as possible. So that's the direction we would like to go, that said, you could use active illumination, that's an additional feature that our operators could then use and use it in more types of missions, so it increases the attractiveness of a given solution. The active illumination itself is not part of this project

38. **Assuming these (like UGS) should be self-powered. What is the expected duration of operation on self-contained power?**

We do not expect you to design a power or battery subsystem into your camera system. We expect power inputs, hence the listing for voltage ranges and some other items. The intent is, if we want power built into it, we can work on that later, otherwise it's going to be supplied by a separate battery pack attached and we will provide sufficient power for mission duration. That said, you are correct in assuming they will be battery powered, ground ISR is mostly done by people carrying things someplace and so the more batteries you have those young men carrying, the worse they are off. Power efficiency is important, and duration may be anywhere from one day to six months or more. That's kind of a rough range and given the power specs we have listed as desired; we can achieve those ranges with those specs. If you can better that let us know and emphasize it because our folks are always looking for something that uses less power.

39. **Does the solution have to have shock/vib packaging? Right now, we just have a technical proof of concept**

The future fielded solution will certainly need a level of shock/vib packaging. This is not required for this project.

40. **At starlight light levels, what frame rate is needed?**

Any framerate the sensor can show us. This is not to be flippant, but we desire to find out how far the current state of cost constrained solutions can get us. The intent is a general-purpose sensor(s) cost effective enough to be widely used (also outside SOCOM). We acknowledge specific framerates may require design and performance tradeoffs. If you think these may be value added or perhaps your solution can be field adjusted for the tradeoffs, please do state these options in your proposed solutions.

41. **Can you give us some examples of tests you're planning on performing in September? Are you interested in detecting / getting crisp images of fast-moving things?**

Q 1) Specific tests have not been planned. This will be the opportunity for those down selected to demonstrate their technology and give technical briefings to the government (including end user representatives) audience. Q 2) We are interested in crisp images of fast-moving items though we recognize the design tradeoffs involved. The primary/initial sponsor for this project is focused on ground ISR so the definition of fast is constrained to this domain. Others participating as observers may be interested in other definitions of fast so please do describe other possibilities if there is something unique or value added your solution can achieve.

42. **What's the target of interest?**

Anything of interest the sensor can show us. This is not to be flippant, but we desire to find out how far the current state of cost constrained solutions can get us. The intent is a general-purpose sensor(s) cost effective enough to be widely used (also outside SOCOM). We acknowledge specific targets may require design and performance tradeoffs. If you think these may be value added, please do state these options in your proposed solutions as they may be of follow up interest to our users.

43. **Do you just want the 'image/video' or do you want any processing on this image, such as GPS denied navigation, image characterization, SLAM, etc.**

This project is about the image/video. We desire additional processing, like the examples mentioned, to be added as a modular add on capability but will be addressed through other projects or avenues. That said, the additional processing has implications for the I/O of the image/video. We picked two standard interfaces as preferred. If you believe the future add on

processing to better served by a different interface, please state the interface and what/how it enables this future capability.