Technical Report: Camera Selection for Jetson-Based YOLO Detection System

Executive Summary

This report evaluates camera options for a computer vision system with the following requirements: clear video capture at 15-meter distance, compatibility with NVIDIA Jetson platform, real-time YOLO object detection processing, and minimum 1.5-meter physical separation between camera and processing unit. After comprehensive analysis of eight camera solutions, the e-con Systems GMSL camera series emerges as the optimal choice for this application.

Project Requirements

Primary Specifications

- Detection range: 15 meters minimum
- Platform: NVIDIA Jetson (Nano/Xavier/Orin series)
- Processing: Real-time YOLO object detection
- Physical constraint: Minimum 1.5-meter cable distance between camera and Jetson

Performance Considerations

- Frame rate: Minimum 30 fps for real-time detection
- Resolution: Sufficient pixel density for object identification at 15 meters
- Latency: Low latency critical for real-time processing
- Reliability: Industrial-grade stability for continuous operation

Camera Technologies Overview

Interface Types Evaluated

USB 3.0 Interface USB cameras provide widespread compatibility and straightforward integration with Jetson platforms through V4L2 and OpenCV libraries. Standard USB 3.0 cables are limited to approximately 3 meters, requiring active extension cables or USB-over-Ethernet adapters for longer distances. This introduces potential reliability concerns and additional complexity.

HDMI Interface HDMI cameras offer excellent cable extension capabilities up to 10 meters with standard cables, or 50+ meters using HDMI-over-Cat6 extenders. However, this approach requires an additional HDMI capture device (USB capture dongle or HDMI-to-CSI adapter), which introduces additional latency and system complexity.

MIPI CSI-2 Interface CSI cameras provide the lowest latency connection to Jetson platforms through direct ribbon cable connections to the CSI ports. Standard CSI ribbon cables are typically limited to 30-100 centimeters, making them unsuitable for applications requiring 1.5+ meter separation without additional extension hardware.

GMSL (Gigabit Multimedia Serial Link) Interface GMSL technology utilizes coaxial cables to transmit high-bandwidth video over longer distances (15+ meters) while maintaining low latency. This automotive-grade technology provides robust signal integrity and is specifically designed for embedded vision applications. GMSL cameras connect to Jetson platforms through deserializer boards that interface with the native CSI-2 ports.

Detailed Camera Evaluation

1. ELP USB Camera Series

Price Range: 40-80 USD

Technical Specifications:

- Resolution: 720p to 1080p (model dependent)
- Frame Rate: 30-60 fps
- Interface: USB 2.0/3.0
- Lens Options: Fixed or varifocal available
- Sensor: Various CMOS sensors

Advantages:

- Low cost enables rapid prototyping and testing
- Wide availability and multiple vendor options
- Simple integration with Jetson using standard V4L2 drivers
- Compatible with OpenCV and GStreamer frameworks
- Varifocal lens models available for distance optimization

Limitations:

- Image quality varies significantly between models and manufacturers
- Consumer-grade components may lack reliability for industrial applications
- USB extension requires active cables or repeaters, introducing potential failure points
- Low-light performance typically inferior to professional cameras
- Autofocus mechanisms may be unreliable for computer vision applications

Distance Extension Solution: Active USB 3.0 extension cables (up to 5 meters) or USB-over-Cat6 extenders (up to 50 meters). Cost: 20-100 USD depending on solution.

15-Meter Detection Capability: Marginal. Performance heavily dependent on lighting conditions, lens selection, and specific model quality.

Suitability Rating: 6/10. Acceptable for proof-of-concept and budget-constrained projects but may require replacement for production deployment.

2. Marshall Electronics CV502-WPMB

Price Range: 200-300 USD

Technical Specifications:

- Resolution: 1920 x 1080 (Full HD)
- Frame Rate: 60 fps maximum
- Interface: HDMI, 3G-SDI
- Sensor: 2.5MP CMOS
- Lens: Fixed wide-angle, weatherproof housing

Advantages:

- Broadcast-quality optics provide superior image clarity
- Excellent low-light performance (0.4 lux minimum illumination)
- Weatherproof design suitable for outdoor deployment
- HDMI output simplifies cable extension (standard HDMI cables up to 10 meters)
- Professional build quality ensures reliability
- IP67-rated enclosure

Limitations:

- Requires HDMI capture device for Jetson integration
- Capture card introduces 30-100ms additional latency
- Limited to 1080p resolution (no 4K option)
- Fixed lens reduces flexibility for focal length optimization
- Higher cost compared to consumer USB cameras

Distance Extension Solution: Standard HDMI cable (5-10 meters) or HDMI-over-Cat6 extender (up to 50 meters), plus USB HDMI capture dongle (15-130 USD) or HDMI-to-CSI adapter (50-100 USD).

15-Meter Detection Capability: Good. Broadcast optics and sensor quality provide adequate detail at 15 meters under proper lighting conditions.

Suitability Rating: 7/10. Professional quality justifies cost, but capture card requirement adds complexity and latency.

3. Marshall Electronics CV506

Price Range: 300-400 USD

Technical Specifications:

- Resolution: 1920 x 1080 (Full HD)
- Frame Rate: 60 fps maximum
- Interface: HDMI, IP streaming
- Sensor: 2.5MP CMOS
- Lens: Mini-PTZ with 3x optical zoom

Advantages:

- Optical zoom capability enhances 15-meter detection performance
- Pan-tilt functionality enables field-of-view adjustment
- Excellent image quality with professional optics
- Multiple output options (HDMI and IP)
- Superior low-light performance
- Remote control capability

Limitations:

- Highest cost in HDMI camera category
- Requires HDMI capture device for Jetson integration
- Mechanical PTZ components add potential failure points
- Additional complexity if PTZ control integration desired
- Power requirements higher than fixed cameras

Distance Extension Solution: Identical to CV502-WPMB: HDMI cable plus capture device.

15-Meter Detection Capability: Good to Excellent. Optical zoom significantly improves object detail at distance.

Suitability Rating: 7/10. Premium features beneficial for specific applications but may be excessive for standard detection tasks.

4. Mokose HDMI Camera

Price Range: 50-100 USD

Technical Specifications:

- Resolution: 1080p or 4K (model dependent)
- Frame Rate: 30-60 fps
- Interface: HDMI
- Sensor: Various CMOS sensors (typically Sony IMX series)
- Lens: Fixed or manual zoom options

Advantages:

- Competitive pricing for 4K capability
- HDMI interface simplifies cable extension
- Adequate image quality for computer vision applications
- Multiple resolution options available
- C-mount versions available for lens flexibility

Limitations:

- Quality control inconsistent across batches
- Generic branding with limited manufacturer support
- Requires HDMI capture device
- Documentation often limited or poorly translated
- Long-term reliability uncertain

Distance Extension Solution: HDMI cable plus capture device (same as Marshall cameras).

15-Meter Detection Capability: Adequate with 4K models. 1080p models marginal depending on object size.

Suitability Rating: 6.5/10. Reasonable budget option for HDMI approach but quality variability presents risk.

5. Basler ace Camera Series

Price Range: 400-800 USD (model dependent)

Technical Specifications:

- Resolution: 1.6MP to 20MP depending on model
- Frame Rate: 17-150 fps (resolution dependent)
- Interface: USB 3.0 (USB3 Vision standard)
- Sensor: Sony IMX or other industrial sensors
- Lens Mount: C-mount (lens not included)

Advantages:

- Industrial-grade reliability and build quality
- Excellent image sensors with superior signal-to-noise ratio

- C-mount system enables precise lens selection for application requirements
- Comprehensive SDK (Pylon) with extensive documentation
- Excellent technical support and long product lifecycles
- Precise camera control and parameter adjustment
- Wide operating temperature range

Limitations:

- Significantly higher cost than consumer cameras
- Pylon SDK adds software complexity compared to V4L2
- USB 3.0 interface requires careful cable extension planning
- Lenses purchased separately (50-300 USD additional cost)
- May be excessive capability for basic YOLO applications

Distance Extension Solution: Active USB 3.0 cables (up to 5 meters, 20-50 USD) or USB3 Vision repeaters (up to 20 meters, 100-200 USD).

15-Meter Detection Capability: Excellent. Industrial sensors and lens selection capability optimize for distance detection.

Suitability Rating: 8/10. Premium solution justified for production systems requiring maximum reliability and image quality.

6. Basler aceA5472-17uc

Price Range: 600-800 USD

Technical Specifications:

- Resolution: 5472 x 3648 pixels (20 megapixels)
- Frame Rate: 17 fps at full resolution
- Interface: USB 3.0 (USB3 Vision)
- Sensor: Sony IMX183 CMOS (1-inch format)
- Lens Mount: C-mount
- Pixel Size: 2.4 x 2.4 micrometers

Advantages:

- Exceptional resolution provides outstanding detail at 15-meter distance
- Large 1-inch sensor format improves low-light performance and dynamic range
- Industrial reliability with MTBF exceeding 100,000 hours
- Precise triggering capabilities for synchronized multi-camera systems
- Region of interest (ROI) and binning modes enable higher frame rates
- Hardware trigger support for precise timing control

Limitations:

- 17 fps at full resolution insufficient for real-time YOLO processing
- Requires resolution reduction or ROI mode to achieve 30+ fps
- Highest cost among evaluated USB cameras
- Lens cost adds 50-300 USD to system cost
- USB 3.0 bandwidth fully utilized at maximum resolution

Distance Extension Solution: USB3 Vision repeaters recommended for reliability (100-200 USD).

15-Meter Detection Capability: Excellent. 20-megapixel resolution provides exceptional object detail even at maximum range.

Suitability Rating: 7.5/10. Exceptional image quality but frame rate limitation requires operating at reduced resolution for real-time YOLO. Cost may be prohibitive for many applications.

Recommended Operating Mode for Real-Time YOLO:

- Resolution: 1920 x 1080 (ROI mode)
- Expected Frame Rate: 60+ fps
- Maintains excellent image quality while achieving real-time performance

7. e-con Systems GMSL Camera Series

Price Range: 300-500 USD

Available Models:

- NileCAM87: 4K resolution, 44 fps, Sony IMX585 sensor (8.4MP)
- NileCAM81: 4K resolution, 60 fps, ON Semi AR0821 sensor (8MP), HDR capability
- NileCAM25: Full HD, 65 fps, global shutter, motion blur reduction
- STURDeCAM20: Full HD, 30 fps, IP67 rated, extended temperature range

Technical Specifications (NileCAM87):

- Resolution: 3840 x 2160 (4K UHD)
- Frame Rate: 44 fps maximum
- Interface: GMSL2 with CSI-2 output
- Sensor: Sony IMX585 CMOS (8.4MP)
- Cable: 15-meter coaxial cable included
- Power: Power-over-Coax (PoC) capability

Advantages:

- 15-meter coaxial cable included, eliminating extension cable requirements
- Native GMSL-to-CSI deserializer boards designed specifically for Jetson platforms
- Lowest latency among all evaluated options (direct CSI connection)

- No additional capture hardware required
- Automotive-grade signal integrity maintains quality over full cable length
- Multiple camera support: up to 8 cameras simultaneously on single Jetson
- Power-over-Coax reduces wiring complexity
- Comprehensive Linux driver support with V4L2 interface
- Designed explicitly for embedded vision applications
- HDR capability (select models) handles challenging lighting conditions
- Global shutter option (NileCAM25) eliminates motion artifacts

Limitations:

- Platform-specific: only compatible with Jetson (not PC-compatible)
- Requires specific Jetson models: AGX Xavier, Xavier NX, AGX Orin, Orin NX, Orin Nano
- Not compatible with Jetson Nano (original model)
- Mid-range pricing compared to budget USB options
- Deserializer board included but adds minor system complexity

Distance Extension Solution: No extension required. System includes 15-meter coaxial cable as standard. Cables up to 30 meters available as custom option.

15-Meter Detection Capability: Excellent. 4K resolution (8MP) provides more than sufficient pixel density for object detection and classification at 15-meter range.

Jetson Integration:

- Direct connection to Jetson CSI-2 interface via deserializer board
- Standard V4L2 driver interface
- Compatible with OpenCV, GStreamer, and NVIDIA DeepStream SDK
- Typical latency: 30-60ms (camera sensor to Jetson memory)
- No frame buffering or capture card delays

Suitability Rating: 9.5/10. Purpose-designed solution perfectly aligned with project requirements. The included 15-meter cable, native Jetson support, and optimal specifications make this the ideal choice for the stated application.

Recommended Model Selection:

- General applications: NileCAM87 (best balance of resolution and frame rate)
- Variable lighting conditions: NileCAM81 (HDR capability critical)
- Fast-moving objects: NileCAM25 (global shutter eliminates rolling shutter artifacts)
- Outdoor/harsh environments: STURDeCAM20 (IP67 rating, extended temperature range)

8. Arducam IMX477

Price Range: 50-70 USD

Technical Specifications:

- Resolution: 4056 x 3040 (12.3 megapixels)
- Frame Rate: 40 fps at full resolution
- Interface: MIPI CSI-2 (4-lane)
- Sensor: Sony IMX477 (same as Raspberry Pi HQ Camera)
- Lens Mount: C-mount or CS-mount versions
- Pixel Size: 1.55 x 1.55 micrometers

Advantages:

- Excellent resolution for price point
- Native CSI interface provides low latency
- Large sensor format (7.857mm diagonal) improves image quality
- Wide community support and documentation
- Compatible with Raspberry Pi Camera software ecosystem
- C-mount enables professional lens selection
- Popular in maker and research communities

Limitations:

- Critical limitation: CSI ribbon cable typically limited to 30-100 centimeters
- Does not meet 1.5-meter distance requirement without significant modifications
- Extension options require HDMI-CSI bridge or custom PCB solutions
- Extension hardware adds 80-150 USD to system cost
- Added complexity negates low initial camera cost
- Bridge solutions introduce latency comparable to HDMI capture cards

Distance Extension Solution: Requires HDMI-CSI bridge (e.g., Auvidea B101) at camera end, HDMI cable for distance, and deserializer at Jetson end. Total additional cost: 100-200 USD. This solution defeats the purpose of CSI's low-latency advantage.

15-Meter Detection Capability: Good. 12-megapixel resolution adequate for detection at 15 meters.

Suitability Rating: 5/10. Does not meet the 1.5-meter cable distance requirement without expensive modifications that eliminate its cost advantage.

Comparative Analysis

Resolution vs. Frame Rate Trade-offs

For real-time YOLO object detection, the optimal balance typically falls between 1080p (2MP) and 4K (8MP) resolution at 30-60 fps. Higher resolutions provide better object detail at distance but reduce frame rates and increase computational load on the Jetson.

Recommended Minimum Specifications for 15-Meter Detection:

- Resolution: 1920 x 1080 (adequate) to 3840 x 2160 (optimal)
- Frame Rate: 30 fps minimum, 60 fps preferred
- Pixel Density at 15m: Minimum 10 pixels per meter of object width

Latency Considerations

End-to-end latency for YOLO detection systems comprises:

1. Camera sensor exposure and readout: 16-33ms (depending on frame rate)
2. Interface transmission: 1-5ms (CSI/GMSL) or 30-100ms (USB/HDMI capture)
3. Jetson processing: Variable based on YOLO model and Jetson model
4. Display/output: 16-33ms

The interface transmission latency represents the primary differentiator among camera solutions. CSI and GMSL interfaces provide the lowest latency, critical for real-time applications requiring rapid response.

Cost Analysis

Solution	Camera Cost	Extension Cost	Additional Hardware	Total System Cost
ELP USB	40-80 USD	20-50 USD	None	60-130 USD
Marshall CV502	200-300 USD	20-50 USD	15-130 USD (capture)	235-480 USD
Marshall CV506	300-400 sUSD	20-50 USD	15-130 USD (capture)	335-580 USD
Mokose HDMI	50-100 USD	20-50 USD	15-130 USD (capture)	85-280 USD
Basler ace	400-800 USD	50-200 USD	50-300 USD (lens)	500-1300 USD
Basler aceA5472	600-800 USD	50-200 USD	50-300 USD (lens)	700-1300 USD
e-con GMSL	300-500 USD	0 USD (included)	None	300-500 USD
Arducam IMX477	50-70 USD	100-200 USD	50-150 USD (lens + bridge)	200-420 USD

Cable Distance Solutions Summary

USB Cameras:

- Active USB 3.0 cables: 5 meters maximum, 20-50 USD
- USB-over-Cat6 extenders: 50+ meters, 60-150 USD
- Reliability concerns with long extensions

HDMI Cameras:

- Standard HDMI cables: 10 meters, 10-30 USD
- HDMI-over-Cat6 extenders: 50+ meters, 40-100 USD
- Requires capture device: 15-130 USD additional

CSI Cameras:

- Standard ribbon cables: 30-100 centimeters only
- Extension requires bridge solutions: 100-200 USD
- Negates CSI latency advantage

GMSL Cameras:

- Included 15-meter coaxial cable: 0 USD additional
- Extended lengths available: 30+ meters
- No extension hardware required

Technical Recommendations

Optimal Solution: e-con Systems GMSL NileCAM87

The e-con Systems GMSL camera series, specifically the NileCAM87 model, represents the optimal solution for this application based on the following technical justifications:

Alignment with Requirements:

1. **Detection Range:** 4K (8MP) resolution provides 3840 pixels horizontal. At 15 meters with a 90-degree horizontal field of view, this yields approximately 5-10 pixels per centimeter of object width, sufficient for robust YOLO detection of objects 20cm and larger.

2. **Jetson Compatibility:** Native CSI-2 interface through GMSL deserializer provides direct integration with Jetson's ISP (Image Signal Processor), enabling hardware-accelerated processing and lowest possible latency.

3. **Real-Time Processing:** 44 fps at 4K resolution exceeds the 30 fps minimum requirement for real-time YOLO. The Jetson Orin can process YOLOv5/YOLOv8 models

at 4K resolution at 30-60 fps depending on model size.

4. **Cable Distance:** The included 15-meter coaxial cable exceeds the 1.5-meter minimum requirement by an order of magnitude, providing installation flexibility without any additional hardware or cost.

Technical Advantages:

Signal Integrity: GMSL technology uses differential signaling over coaxial cable with embedded clock recovery, providing superior electromagnetic interference (EMI) immunity compared to USB or HDMI. This ensures consistent image quality over the full 15-meter distance without signal degradation.

Latency Performance: Direct CSI-2 connection to Jetson ISP provides end-to-end latency of approximately 30-60ms (sensor to memory), compared to 80-150ms for USB capture solutions and 100-200ms for HDMI capture solutions. This 2-3x latency reduction is significant for real-time detection applications requiring rapid decision-making.

System Simplicity: Single-cable solution (with Power-over-Coax) eliminates multiple connection points and potential failure modes. No capture cards, no extension cables, no additional power supplies at camera location.

Scalability: The GMSL architecture supports up to 8 cameras on a single Jetson AGX Orin, enabling future expansion for multi-camera detection systems without platform changes.

Software Integration: Standard V4L2 driver interface ensures compatibility with OpenCV, GStreamer, and NVIDIA DeepStream SDK without proprietary software requirements. This simplifies software development and maintenance.

Alternative Recommendations

Budget-Constrained Applications (Under 150 USD): If budget constraints preclude the e-con GMSL solution, the ELP USB camera with varifocal lens represents the most practical budget option. Select models with:

- Minimum 1080p resolution
- Manual focus varifocal lens (6-12mm or 5-50mm)
- USB 3.0 interface
- Active USB extension cable (5 meters)

Expected limitations: Image quality marginally adequate at 15 meters, lower reliability, may require camera replacement for production deployment.

Maximum Image Quality Priority: For applications requiring absolute maximum image quality and where cost is secondary, the Basler aceA5472-17uc provides superior performance. Recommended configuration:

- Operate in 1920x1080 ROI mode for 60+ fps
- High-quality C-mount lens: 16mm or 25mm focal length
- USB3 Vision repeater for cable extension
- Expected total cost: 900-1200 USD

This configuration provides exceptional image quality while maintaining real-time frame rates but at 3x the cost of the e-con GMSL solution.

Implementation Considerations

Lens Selection for 15-Meter Detection

For cameras with C-mount capability (Basler, some Arducam, some ELP), lens selection significantly impacts detection performance:

Field of View Calculation:

- Horizontal FOV = 2 × arctan(sensor_width / (2 × focal_length))
- For 15-meter detection range, optimal FOV depends on detection area size

Recommended Focal Lengths:

- Wide area coverage (10m x 15m): 6-8mm lens
- Medium area (5m x 8m): 12-16mm lens
- Narrow area (2m x 3m): 25-35mm lens

Lens Quality Considerations:

- Minimum specifications: Multi-coated optics, f/1.4 or faster aperture
- Budget: 50-100 USD
- Professional: 150-300 USD
- Superior optics at longer focal lengths improve detection accuracy

Lighting Requirements

Adequate illumination is critical for reliable detection at 15-meter distance:

Minimum Illumination Levels:

- Indoor: 300-500 lux for reliable detection
- Outdoor daylight: Generally adequate (10,000+ lux)

- Outdoor nighttime: Supplemental lighting required (LED floodlights recommended)

Camera Specifications:

- Minimum illumination rating: 0.1 lux or better
- HDR capability recommended for variable lighting environments
- Auto-exposure with customizable parameters

Jetson Platform Selection

The camera choice impacts optimal Jetson platform selection:

e-con GMSL Cameras:

- Requires: Jetson Xavier NX (minimum), AGX Xavier, Orin NX, or AGX Orin
- Not compatible: Jetson Nano (original)
- Recommended: Jetson Orin NX (16GB) for 4K YOLO processing

USB/HDMI Cameras:

- Compatible: All Jetson models including Nano
- Recommended: Jetson Xavier NX or better for 4K processing
- Jetson Nano adequate for 1080p processing

Software Configuration

Driver Installation: For e-con GMSL cameras, install BSP (Board Support Package) provided by e-con Systems. This includes kernel drivers and device tree modifications.

Recommended Software Stack:

1. JetPack SDK (current version)
2. OpenCV with CUDA support
3. GStreamer with hardware acceleration plugins
4. NVIDIA DeepStream SDK for optimized YOLO inference
5. TensorRT for model optimization

Camera Configuration:

- Set exposure manually for consistent YOLO performance
- Disable auto white-balance during training data collection
- Configure ROI if not using full sensor area
- Enable hardware ISP for optimal performance

Performance Optimization

YOLO Model Selection for Real-Time Processing:

- YOLOv5s or YOLOv8n: 60+ fps on Jetson Orin at 1080p
- YOLOv5m or YOLOv8s: 30-45 fps on Jetson Orin at 1080p
- YOLOv5l or YOLOv8m: 15-30 fps on Jetson Orin at 1080p

Resolution Trade-offs:

- 1920x1080: Maximum frame rate, adequate for most applications
- 2560x1440: Balanced resolution and performance
- 3840x2160: Maximum detection accuracy, reduced frame rate

DeepStream Pipeline Optimization: Utilize NVIDIA DeepStream SDK for production deployments to achieve:

- Hardware-accelerated video decode
- TensorRT inference optimization
- Multi-stream processing capability
- Reduced CPU utilization

Risk Analysis

Technical Risks by Solution

ELP USB Cameras:

- Risk: Inconsistent image quality between units
- Mitigation: Purchase multiple units for testing, select best performer
- Risk: USB extension reliability
- Mitigation: Use high-quality active cables, implement connection monitoring

HDMI Cameras (Marshall, Mokose):

- Risk: Capture card latency impacts real-time performance
- Mitigation: Select low-latency capture devices (Elgato Cam Link 4K), test end-to-end latency
- Risk: Additional failure point in system
- Mitigation: Industrial-grade capture cards, redundant systems for critical applications

Basler Cameras:

- Risk: High initial investment
- Mitigation: Justified for production deployments, consider refurbished units for prototyping
- Risk: SDK complexity

- Mitigation: Allocate development time for Pylon SDK integration, leverage Basler technical support

e-con GMSL Cameras:

- Risk: Platform lock-in (Jetson-specific)
- Mitigation: Acceptable for embedded vision applications, standard for automotive/robotics industries
- Risk: Deserializer board failure
- Mitigation: Professional-grade components, low historical failure rates, spare boards for critical applications

Arducam IMX477:

- Risk: Does not meet cable distance requirement
- Mitigation: Not recommended for this application without significant modifications

Deployment Considerations

Environmental Factors:

- Indoor controlled environment: All evaluated cameras suitable
- Outdoor or variable temperature: Select STURDeCAM20 (IP67, -40°C to 85°C) or ruggedized enclosures
- Vibration/shock: Industrial cameras (Basler, e-con) preferred, secure mounting critical

Power Requirements:

- USB cameras: Powered by Jetson USB port (typically adequate)
- GMSL cameras: Power-over-Coax from deserializer board (powered by Jetson carrier board)
- High-power cameras: May require external power supply, factor into system design

Maintenance and Support:

- Consumer cameras (ELP, Mokose): Limited manufacturer support, plan for replacement
- Professional cameras (Basler, e-con, Marshall): Multi-year warranties, responsive technical support
- Spare parts: Stock spare cameras and cables for production systems

Conclusion

Based on comprehensive technical evaluation, the e-con Systems GMSL camera series, specifically the NileCAM87 model, represents the optimal solution for Jetson-based YOLO object detection at 15-meter range with minimum 1.5-meter camera-to-processor separation.

This recommendation is supported by:

1. **Perfect Requirement Alignment:** The included 15-meter coaxial cable directly solves the cable distance requirement without additional hardware or complexity.

2. **Optimal Technical Specifications:** 4K resolution at 44 fps provides the ideal balance between detection accuracy at 15 meters and real-time processing capability.

3. **Superior System Integration:** Native GMSL-to-CSI interface provides the lowest latency of all evaluated solutions, critical for real-time detection applications.

4. **Cost-Effectiveness:** At 300-500 USD including cable, the total system cost is competitive with USB solutions requiring extension hardware and significantly less than Basler industrial cameras while providing comparable image quality.

5. **Proven Technology:** GMSL is the established standard for automotive and robotics vision applications, providing confidence in long-term reliability and performance.

6. **Scalability:** Multi-camera capability enables future system expansion without architectural changes.

Alternative recommendations are provided for budget-constrained applications (ELP USB cameras) and maximum-quality requirements (Basler aceA5472-17uc), but these alternatives involve significant compromises in either image quality, reliability, cost, or system complexity compared to the e-con GMSL solution.

For production deployment of Jetson-based YOLO detection systems with the stated requirements, the e-con Systems GMSL camera represents the optimal choice that balances technical performance, system simplicity, reliability, and cost-effectiveness.

Appendix A: Technical Specifications Summary

Recommended Solution: e-con Systems NileCAM87

Parameter	Specification
Resolution	3840 x 2160 (8.4 MP)
Frame Rate	44 fps maximum
Sensor	Sony IMX585 CMOS
Sensor Size	1/1.2 inch (13.3mm diagonal)

Pixel Size	2.9 µm x 2.9 µm
Interface	GMSL2 to MIPI CSI-2
Cable Length	15 meters (coaxial, included)
Power	Power-over-Coax (PoC)
Operating Temperature	0°C to 70°C
Lens	Fixed or customizable
Jetson Compatibility	Xavier NX, AGX Xavier, Orin NX, AGX Orin
Software Support	V4L2, GStreamer, OpenCV, DeepStream
Latency	30-60ms (sensor to memory)
Price	400-500 USD

Appendix B: Procurement Information

Primary Recommendation

Product: e-con Systems NileCAM87 GMSL Camera Kit **Includes:** Camera module, 15-meter coaxial cable, GMSL deserializer board for Jetson **Vendor:** e-con Systems (www.e-consystems.com) **Lead Time:** Typically 2-4 weeks **Support:** Technical support included, comprehensive documentation available

Budget Alternative

Product: ELP USB Camera with Varifocal Lens **Model:** ELP-USBFHD06H-BL40 (or similar) **Additional Required:** Active USB 3.0 extension cable (5 meters) **Vendor:** Amazon, AliExpress, or direct from manufacturer **Lead Time:** 1-2 weeks **Support:** Limited, community forums primary resource

Maximum Quality Alternative

Product: Basler aceA5472-17uc + Lens + USB Extension **Components Required:**

- Basler aceA5472-17uc camera
- C-mount lens (16mm or 25mm recommended)
-