Utilizing Technology in Environmental Work

Innovative drone use for environmental monitoring and compliance

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Port of Tacoma

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Why Drones (UAS)?

Advantages-

- Real-time, up-to-date, high-resolution data
- Repeatability
- Promotes inspector safety
- Time & cost efficient
- Innovative
- Transparency in projects
- Ability to easily reach inaccessible areas
- GIS integration

Drone Deployment at Port of Tacoma

PLANNING & PROGRAM DEVELOPMENT

- FAA compliance
- Airspace coordination
- Internal SOPs
- Equipment and training

EQUIPMENT & TRAINING

- DJI Mavic 3E drone
- RGB camera
- Future thermal/ multispectral ssnsors
- FAA Part 107 certified staff

FLIGHT OPERATIONS

- GIS-based flight planning
- Routine BMP and outfall inspections
- Post-storm assessments
- Construction monitoring

DATA INTEGRATION & ANALYSIS

- Geotagged imagery
- GIS overlays
- Inspection reports
- AI-based forecasting

CONTINUOUS IMPROVEMENT

- Field feedback loops
- SOP refine-ments
- Expansion to watershed-scale monitoring

Program Timeline

2022

- Pitched idea to team
- FAA Part 107 license
- Research
- Business justification
- Developed use cases

2023

- Brought idea to leadership
- Conducted IT Assessment
- Extensive research
- Budgeting process
- Purchased hardware

2024

- Implemented pilot program
- Purchased software
- Insurance
- Sharepoint site (Environmental Drone Program)
- Started Projects

2025+

- Automated flight plans
- AI Workflows
- GIS integration
- Drone dock solution approved for 2026 & beyond
- SOP refinements and port-wide drone policy implementation

Case Studies of Drone Applications at Port of Tacoma

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Case Studies & Results

Illicit Discharge Detection

Utilized a drone to verify unauthorized discharge into a ditch next to Port property and collaborated with the City of Tacoma to address the issue

Erosion Monitoring

Example:

Construction Site Compliance

Weekly aerial inspections improved BMP tracking and contractor accountability

Infrastructure Mapping

On-site validation of assets and the georeferencing of new ones

Quantitative Results

Inspections are done 60% faster, cover three times more area, and improve safety and audit readiness

Erosion Emergency Work

March 2025-

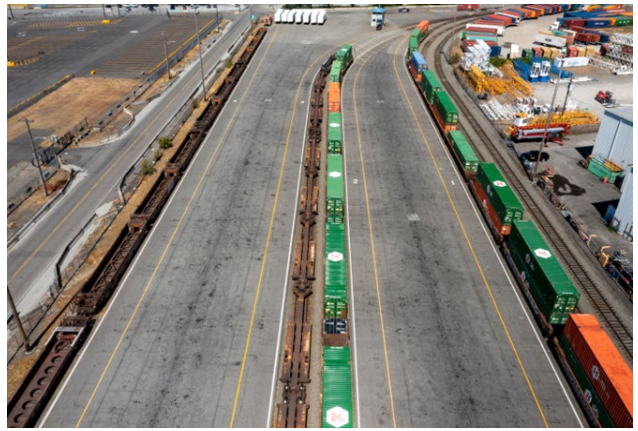
Routine drone flyover captured severe erosion adjacent to container terminal and failure of outfall structure, resulting in an emergency declaration to resolve the issue

Case Studies: SW Permit Compliance Use

Drone technology supports a wide range of permit compliance activities across Port properties

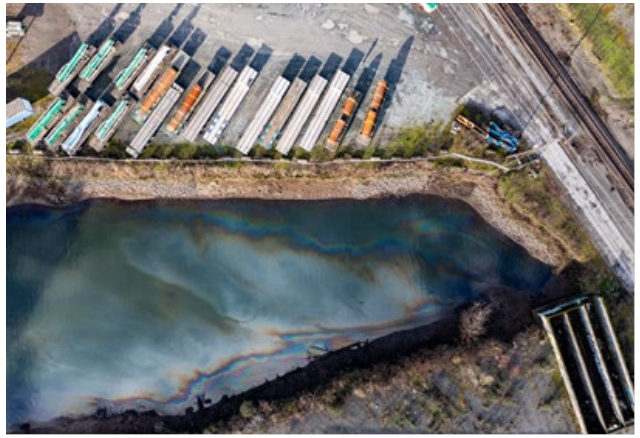
Outfall & IDDE Inspections

Stormwater Asset Inspections



Source Control & Industrial Site Inspections

Sand & Gravel Inspections



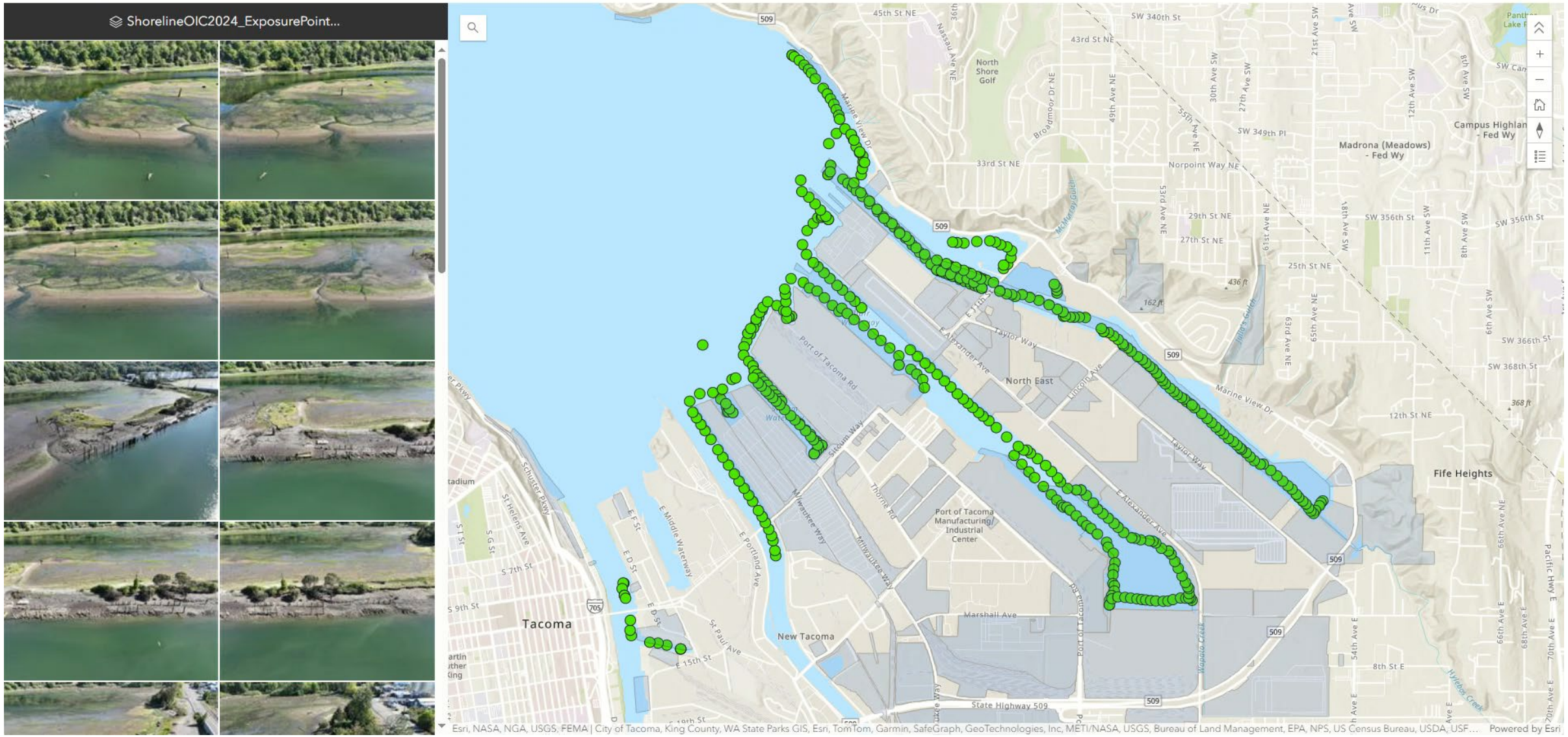
Spill Tracing Investigations

Derelict Vessel Investigations

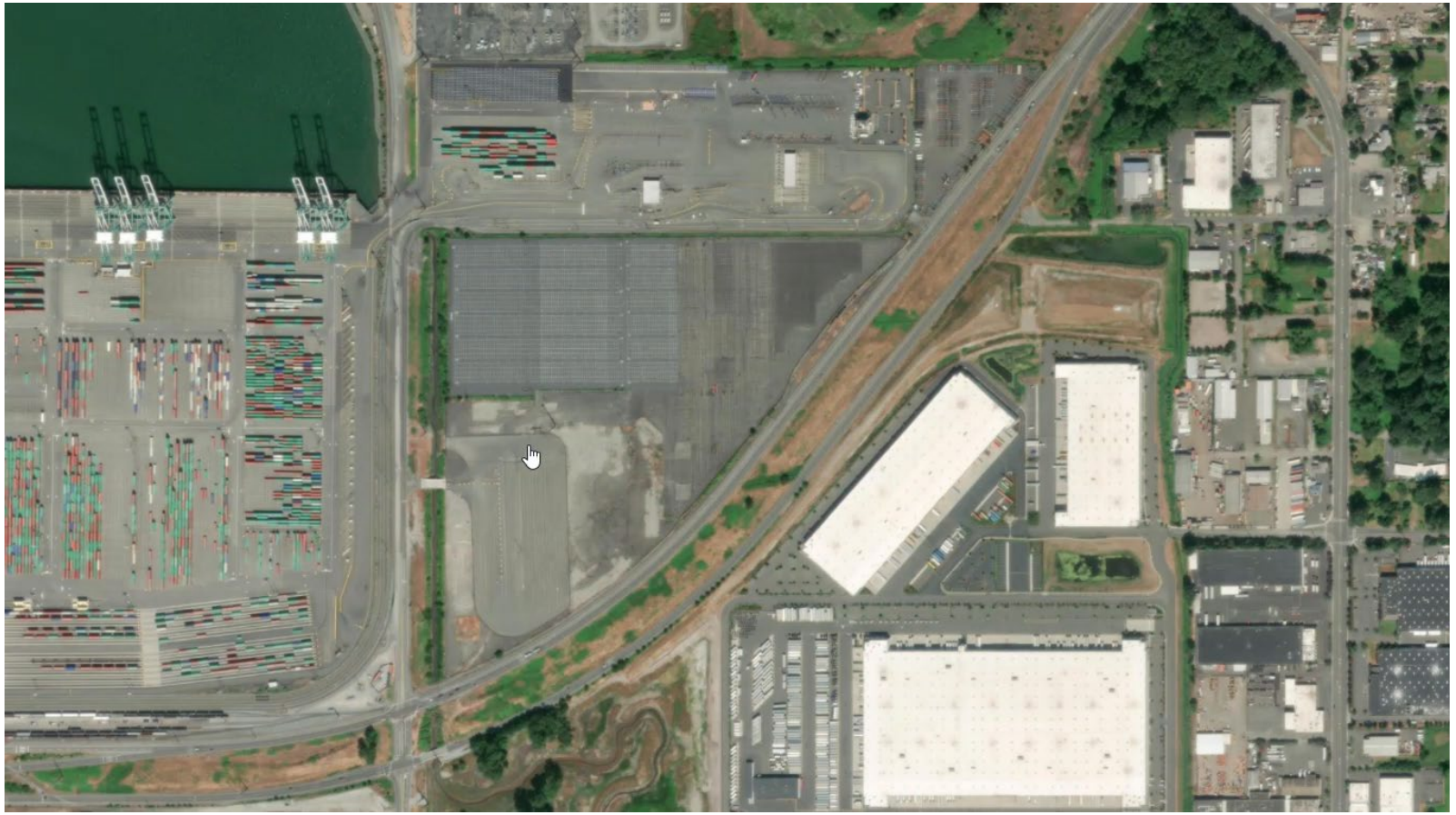
These case studies demonstrate the versatility of drones in supporting safe, efficient, and compliant environmental operations

Case Studies: Shoreline Surveys

Shoreline OIC 5-24



Case Studies: Environmental Cap Inspections



Pilot of testing crack detection deep learning package within ArcGIS Pro

Drone Technology for Inspections

- Drones equipped with high-resolution cameras and thermal sensors enable quick, safe, and non-invasive environmental cap inspections.

AI-Assisted Image Analysis

- Artificial intelligence processes drone imagery to detect cracks, material degradation, and heat anomalies accurately and efficiently.

Benefits of Drone-Based Inspections

- This approach improves safety, accelerates reporting, and reduces costs by enabling early detection and timely maintenance.

Future Directions & Compliance Mapping

How does this innovative technology shape the future of our work?

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What's Next?

Emerging technologies are expanding the role of drones in stormwater and environmental operations

Skydio X10D Dock Solution
Aiming for Q1 2026 implementation

- **Predictive Analytics**:
  - Using AI to detect patterns in runoff, predict BMP failures, detect change and anomalies
- **Operational Readiness**:
  - Weatherproof system with built-in thermal capabilities that can be launched remotely
- **Autonomous Flights**:
  - Exploring pre-programmed missions, integrated AI workflows, work order generation and real-time alerts

Compliance Crosswalk

Envisioning how the autonomous drone dock helps serve the POT/NWSA Environmental department

Team	Remediation	Water Quality	Habitat & Permitting	Air Quality	Planning
Regulatory Drivers	MTCA/CERCLA, Sediment Management Standards	MS4 Phase 1, ISGP, CSWGP, Sand & Gravel, Programmatic Ditch permit	SEPA/NEPA, HPA/ JARPA, ESA consultations	**Policy-driven**: NWPCAS, CAIP 2026-2030, PSCAA	SEPA/NEPA, Shoreline Master Program
Map (GIS Layers)	Cleanup units, sediment caps, monitoring wells	Storm system, BMPs, sampling points, drainage basins, inspection routes	Habitat sites, mitigation units, monitoring transects	Electrical infrastructure, asset conditions, emission sources, ZE infrastructure	Zoning, parcels, buffers, tree canopy, planned projects
UAS/GeoAI	Cap condition, shoreline change, construction monitoring	Outfall patrol, construction monitoring, site & infrastructure inspections, IDDE imagery	Seasonal orthomosaics, armor segmentation, vegetation monitoring/management, construction monitoring	Imagery for siting, change detection in sites and logistics	Orthos for exhibits, corridor change detection (sea level rise)
Records	GIS Layers, Maximo (work order tracking)	GIS Enterprise, sampling DBs, Maximo (work order tracking)	GIS layers, mitigation ledgers	CAIP docs, emission inventories	GIS Enterprise, Strategic Plan docs
KPIs	% caps inspected, anomaly resolution time	Inspection coverage, CA cycle time	Mitigation performance, ledger accuracy	CAIP milestone progress, ZE adoption rate	Exhibit cycle time, GIS Attachment coverage

"Data to Decisions" Pipeline-

Capture
- Automated BVLOS missions with preplanned flight corridors and missions

Process
- ArcGIS Drone2Map produces orthomosaics/3D deliverables

Publish
- Publish deliverables to ArcGIS

Analyze
- Established workflows utilize GeoAI tools to run analysis such as detection/segmentation and change-detection to classify anomalies

Action in Workflows
- Maximo work orders with attached evidence; condition codes; retention

Deeper Dive: Water Quality Regulatory Compliance Mapping

Permit	Section	Topic	Expected Outcomes	Deliverables
Phase 1 Municipal Separate Storm Sewer System Permit	S6.E.3	IDDE & Mapping	Post-storm and dry-weather UAS patrols of outfalls/ditches capture geotagged evidence of flow, discoloration, or debris; ArcGIS updates maintain outfall/conveyance mapping (e.g., ≥12-inch outfalls; ≥ 8-inch connections).	• Rapid outfall/ditch patrol evidence • Anomalies logged • ArcGIS map updates to maintain required inventories
	S6.E.6	Operations & Maintenance	Routine orthos/obliques document BMP condition and maintenance needs; evidence attaches to Maximo work orders, creating auditable O&M records.	• Photo/orthomosaic proof of BMP condition • Maximo WOs with attachments for auditable maintenance records
	S6.E.4 S6.E.5	Construction & Post-Construction	UAS imagery verifies ESC BMPs and post-construction controls; supports field oversight and as-built documentation.	• BMP verification • As-built imagery • Turnover documentation
	S6.E.8	Monitoring	Repeatable aerials provide spatial context for any required discharge monitoring and TMDL implementation (imagery complements- not replaces- sampling).	
	S9	Reporting & Recordkeeping	Structured, time-stamped, geotagged products in ArcGIS support the MS4 Annual Report (due March 31) and 5-year retention	• Consistent, metadata-rich imagery layers to support March 31 submittal and 5-year recordkeeping.
Industrial Stormwater General Permit	S3	SWPPP & Quarterly Visual Monitoring	Dated, geotagged photos of outfalls, yards, housekeeping areas, and structural BMPs fulfill visual documentation and SWPPP updates	• Quarterly visual evidence • Corrective action “before/after” sets • Improved DMR context
	S7 S8	Inspections & Corrective Actions	Standardized photo sets and change-detection support CA levels, verify fixes, and streamline Ecology inspections.	
	S9	Reporting & Records	ArcGIS-stored evidence and links to Maximo Wos improve DMR context and audit readiness for Port-held and tenant sites.	
Construction Stormwater General Permit	S4	ESC BMP Verification & Inspections	Aerials document perimeter controls, inlet protection, stabilized entrances, and stockpiles; post-storm checks provide defensible evidence sets.	• Routine inspection photos and post-storm sets that corroborate field sampling and SWPPP conformance
	S4 S5	Monitoring Context & Reporting	While sampling is performed on the found, UAS imagery provides site-wide context for DMRs and correction-action narratives	

Lessons Learned & Key Takeaways

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Challenges & Lessons Learned

- **Regulatory & Legal**: Navigating FAA rules, privacy concerns, and data retention policies
- **Environmental Constraints**: Wind, rain, and lighting conditions affecting flight quality
- **Data Overload**: Managing large image datasets, ensuring quality control, and integrating with GIS or asset management systems
- **Training & Buy-In**: Building internal capacity and gaining stakeholder support

Key Takeaways

Why Drones Matter for Environmental Monitoring:

- Drones enhance environmental monitoring **efficiency** and **accuracy**
- They support compliance, safety, and proactive environmental management

- Resources are available upon request for those looking to adopt similar programs


Thank you
Questions & Discussion
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