

## Imaging Educational Course DICOM Dose SR (,etc.)



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presented at AAPM  
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## NOTE and DISCLAIMER

- The live presentation contains materials not included in this handout.
- This is done to avoid the distribution of sample data which might or might not be representative of clinical results.
- Data is shown to illustrate formats and approximate statistical distributions.  
*Values should not be used clinically.*

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## Application to all imaging modalities

- Today's focus is on interventional fluoroscopy
  - Some procedures require significant radiation dose.
  - Reasonable standards are available.
  - Equipment is relatively new.
- Standards based CT dose reporting is available
  - Not discussed in detail today.
- Straightforward extension to other modalities
  - General radiography and fluoroscopy
  - Mammography

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## Stakeholders

- **Patients**
- **Patient surrogates**
  - Health care professionals
  - Facilities
  - Professional organizations
  - Health and regulatory authorities
- **Imaging equipment suppliers**

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## Purposes of dose monitoring

- Any imaging procedure
  - Detect facility variance with expected performance.
  - Detect system or operator variance with facility norms.
- Interventional procedures
  - Detect individual patients at risk for tissue reactions.
- Collect data to obtain state of practice.

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## What is clinically needed?

- Simple statement of stochastic radiogenic risk from a procedure.
- Real time map of dose distribution on the patient's skin and in critical organs.
- Dose is one input used for estimating risk.

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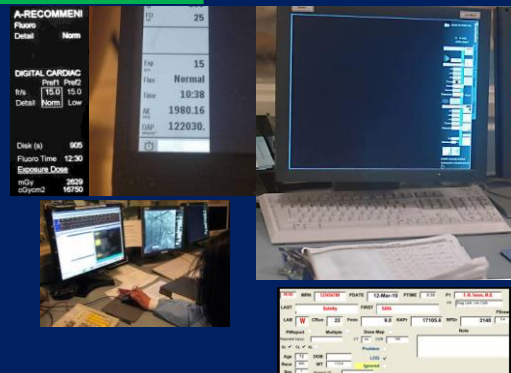
## Available in 2011

- Patient and procedure characteristics
  - Technical parameters
  - Fluoroscopy time
  - Numbers of images
  - Air Kerma Area Product ( $P_{KA}$ )
  - Reference Point Air Kerma ( $K_{a,r}$ )
- ~~Real time skin dose maps~~

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## Manual process



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## Proprietary reports

- Most manufacturers can supply some forms of proprietary radiation report to a facility.
  - Summary data
  - Examination level data
  - Irradiation level data
- Difficult to compare data from systems supplied by different manufacturers.

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## DICOM header

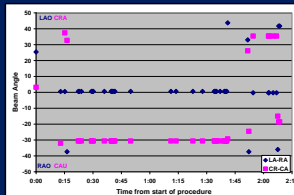
- Positive
  - Saved with images in PACS
  - Public fields are defined in the DICOM data directory
- Negative
  - Only saved if images are saved
  - No requirements on contained fields
  - Private fields are common

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## DICOM header & MPPS

*MPPS Example is from a different procedure*



Cumulative fluoroscopy time: 00:01:41 hh:mm:ss  
 Cum. DAP (fluoroscopy): 9871 mGycm<sup>2</sup>  
 Cum. DAP (exposure): 37449 mGycm<sup>2</sup>  
 Total DAP: 47320 mGycm<sup>2</sup>  
 Cum. Air Kerma: 736 mGy  
 Total number of runs: 11  
 Total number of images: 677

Run nr	Procedure	Time hh:mm	Speed kVp	kV	mA	ms	Rot	Ang	SD [cm]	Nr. of images
1	Left Coronary 15fr	7:53 PM	15	77	763	7	RAO 36	CAUD 3	94	46
2	Left Coronary 15fr	7:57 PM	15	90	773	8	LAO 4	CAUD 37	100	57

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## Standards based dose reporting

- Does not require a “special” relationship with the equipment vendor to obtain or interpret data.
- Content of reports are ideally specified by all stakeholders.
- Facilitate data collection irrespective of the make and model of the equipment.

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## Available: August 2011



- DICOM Supplement 94 (2005) introduces a Radiation Dose Structured Report (RDSR) and its syntax.
- IEC PAS 61910-1 (2007) defines the minimum set of required fields
- IHE REM Profile (2009) provides implementation protocols
- IEC 60601-2-43, 2<sup>nd</sup> Edition (2010) requires implementation of RDSR

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## IEC PAS 61910-1

- *Focus on fluoro guided interventions.*
  - Includes most of projection radiography
- Two compliance levels available based on expected doses for normal use.
- X-ray generator is the data source.
- Specification includes both network and “sneaker-net” data transfer.
- *Evolution to IEC Standard in progress*

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## IHE in one slide



- IHE helps vendors implement & test functions that span multiple systems
- Profiles are implementation guides
  - how to use existing standards
  - to address a specific problem scenario
- Connectathons are test events
  - managed testing of Profile implementations
- IHE helps users purchase & integrate multi-system solutions
  - list required IHE Profile support in RFPs

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## Radiation Dose Structured Report

- DICOM object that is designed to be handled independently from any images.
- **All irradiations are reported**
- Attribute : Value pairs as defined in DICOM
- Expandable format with all public fields.
- Object to be managed & transported like other DICOM objects (e.g. store in PACS, query/retrieve, put on CD, USB, etc.)
- Streaming is included in the specification.

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## 2011 RDSR implementation

- Available from a very limited number of fluoroscopic systems.
- Based on current DICOM and PAS
- Available only at the end of the procedure.
- Extraction from system is not easy.
- Very few AGENTS capable of accepting and managing RDSR.

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## Radiation Dose Structured Report (RDSR)

- Header
  - Patient, examination, and system information.
  - Summary dose metrics
- Each Irradiation Event
  - Geometry
  - Technical Settings of equipment
  - Dose metrics

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## Single image exam

RDSR Header	Complete
Patient, Facility, Exam Descriptors	
System Descriptors (including calibration)	
Dose Summaries	
IRRADIATION EVENT	Image UID
Generator Factors	
Beam Geometry Descriptors	
Dose Detail	

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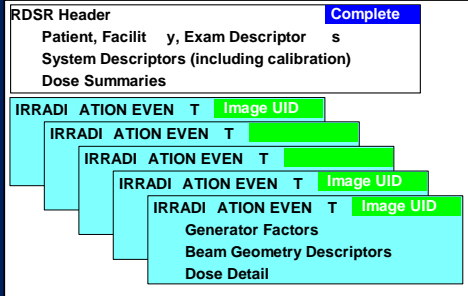
## Multiple irradiation procedure: 1<sup>st</sup>

RDSR Header	Partial
Patient, Facility, Exam Descriptors	
System Descriptors (including calibration)	
Dose Summaries	
IRRADIATION EVENT	Image UID
Generator Factors	
Beam Geometry Descriptors	
Dose Detail	

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## Multiple irradiation procedure: Final



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## Extract of processed RDSR I

### Header

Name	Patient03	Plane	Single Plane	Gycm2
DeB	1949-01-20	DAP Total [Gym2]	0.006972	68.7
Sex	M	Dose(RP) Total [Gy]	1.03154	
Manufacturer:	WAPPLER	Fluoro DAP Total [Gym2]	0.0031836	31.8
Report created:	2010-09-14 08:50:14	Fluoro Dose(RP) Total [Gy]	0.41676	
Procedure reported:	Projection X-Ray	Total Fluoro Time [s]	264	
Observer Type:	Device	Acquisition DAP Total [Gym2]	0.0037884	37.9
Device Observer Name:	AXISCATH5	Total Acquisition Time [s]	54	
Device Observer Manufacturer:	WAPPLER	RP Definition	15cm from Isocenter toward Source	
Device Observer Model Name:	EDISON			
Device Observer Serial Number:	180106			
Scope of Accumulation:	Study			
Source of Dose Information:	Dosimeter			

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## Extract of processed RDSR II

### Irradiation Events

Date/Time	vent	Tyrg. Proto	DAP	Dose (RP)	gantry angles		patient table						
					PRI	SEC	FPS	#	KVP	SID	TL	TLAT	TH
9:10:36 AM	Fluoros	FL Low	3.41E-05	4.23E-03	-0.1	0.0	10	69	77	1002	71	878	160
9:12:54 AM	Fluoros	FL Low	4.60E-06	6.20E-04	-0.1	0.0	10	9	77	1044	73	869	160
9:32:16 AM	Fluoros	FL Low	8.83E-05	1.29E-02	42.3	0.0	10	75	90	1103	-59	432	160
9:34:19 AM	Fluoros	FL Nrrr	3.91E-04	6.59E-02	45.0	31.2	10	240	120	1165	-78	703	132
9:34:51 AM	Station	Coro Hi	1.04E-03	1.66E-01	45.0	31.2	10	101	107	1132	-22	453	132
9:35:52 AM	Fluoros	FL Nrrr	1.84E-04	3.26E-02	54.0	-28.9	10	110	124	1199	-22	466	132
9:36:06 AM	Station	Coro Hi	8.72E-04	1.55E-01	54.0	-28.9	10	83	123	1199	9	400	132
9:36:53 AM	Fluoros	FL Nrrr	2.74E-04	4.50E-02	-23.5	-18.5	10	264	91	1145	8	378	132
9:37:31 AM	Fluoros	FL Nrrr	9.06E-05	1.49E-02	-23.5	-16.8	10	94	90	1145	-65	433	132
9:37:52 AM	Station	Coro Hi	4.30E-04	7.05E-02	-23.5	-16.8	10	92	96	1145	-85	415	132
9:38:46 AM	Fluoros	FL Nrrr	4.49E-05	7.09E-03	-23.5	32.7	10	59	88	1125	-92	429	132
9:38:56 AM	Fluoros	FL Nrrr	6.13E-05	9.70E-03	-23.5	32.7	10	66	90	1125	-71	452	132
9:39:10 AM	Fluoros	FL Nrrr	5.44E-05	8.61E-03	-11.1	32.7	10	68	90	1125	-72	452	132
9:39:23 AM	Station	Coro Hi	3.61E-04	5.72E-02	-11.1	32.7	10	84	96	1125	-72	452	132
9:44:01 AM	Fluoros	FL Nrrr	1.04E-04	1.59E-02	31.0	17.4	10	86	92	1103	14	433	132
9:44:12 AM	Station	Coro Hi	5.63E-04	8.57E-02	31.0	17.4	10	95	106	1103	31	464	132
9:44:43 AM	Fluoros	FL Nrrr	1.00E-05	1.52E-03	-28.3	-1.2	10	9	93	1103	-38	485	132
9:45:00 AM	Fluoros	FL Nrrr	1.24E-04	1.93E-02	-28.3	18.6	10	119	91	1115	-38	485	132
9:45:14 AM	Station	Coro Hi	5.19E-04	8.07E-02	-28.3	18.6	10	101	96	1115	-64	451	132

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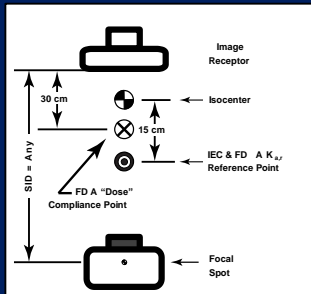
## IEC NWI to upgrade PAS to standard.

- Working group is being formed
- Known issues
  - Detailed relationship of patient and X-ray beam during a complete procedure.
  - Describing beam motion and characteristics during a single irradiation.
  - Technical nomenclature describing settings
  - Clinical nomenclature describing procedures (Multi- specialty – Payer Dictionary ?)
  - Calibration protocol for dose metrics (AAPM)

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## Verification of displayed "dose"



AAPM TG-190



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## IEC-RDSR expectations

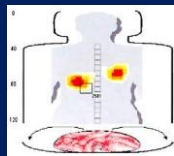
- Extraction of multiple RDSRs onto a memory stick while in clinical mode.
- Near real-time streaming of data to facilitate dose mapping.
- Possibly better definition of patient-system geometry.
- Deployment to all forms of X-ray imaging systems.

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## ACTOR expectations

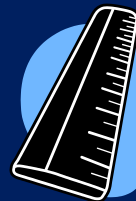
- Skin dose maps
  - Retrospective and real-time
- Tracking patients over multiple procedures and facilities
- Interfaces with external databases
- Automated process control
  - Statistical quality management
  - Automated alerts



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## Metrics and comparisons



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## Data has many uses

- Clinical dose awareness
  - Single procedure
  - Patient totals
- Statistical QA
  - Facility against “norms”
  - By laboratory
  - By operator
  - By procedure type
- Radiation protection
 

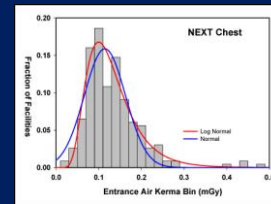
e.g. Actual kV histogram is available for shielding design

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## Diagnostic Reference Levels

- Intended to monitor performance of high-volume standardized procedures.
- Reasonable DRLs are available.
  - Better statistical descriptors would be helpful.

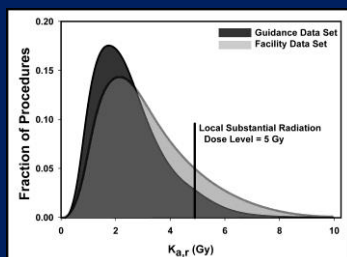


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## Advisory Data Sets (NCRP-168)

- Intended for inherently variable procedures.
- Additional analysis for regions with possible deterministic effects.



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## Simulation of RDSR

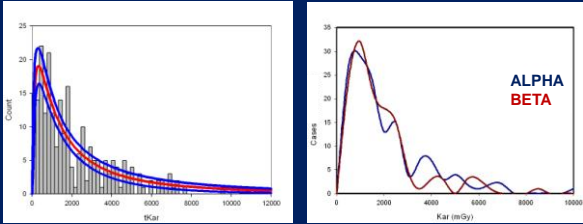
- The following are representative data.
- Data elements represent some of those available in the RDSR.
- Such analysis can be done using RSDRs and ACTORS when they become clinically available

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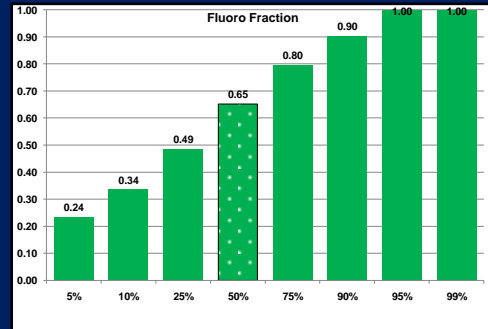
### Exam: Total $K_{a,r}$



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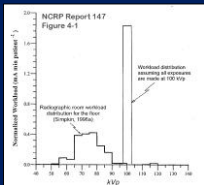
### Exam: Fluoro fraction of $K_{a,r}$



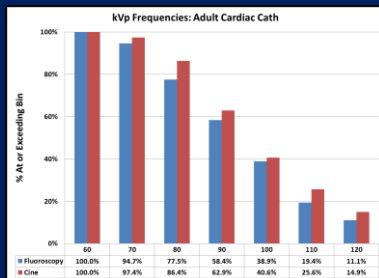
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### Medical Physics Considerations



#### Single irradiation techniques



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### External standards

- Sources
  - Professional literature
  - DRL statements
  - ‘Not to exceed’ statements (regulatory)
- Current validity
  - May not reflect current practice due to inherent lag times.
  - Possibilities of medical specialty bias.
  - Facility, regional, and national variations in patient/procedure mix.

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## Location of reference data centers

- **Professional associations**
  - Specialized requirements could impede intra-specialty cooperation
- **Payers**
  - Data may be affected by patient pool
- **Public health agencies**
  - Minimal HIPAA issues
- **IAEA – SAFRAD**
- **Regulatory**
  - UK “misadministration” centre

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## Dose measurements

When you can measure what you are speaking about, and express it in numbers, you know something about it;

but when you cannot measure it, when you cannot express it in numbers,

your knowledge is of a meager and unsatisfactory kind.



1902  
Skiameter  
of Benoist

*Lord Kelvin (1824-1907)*

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